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ANTARCTICA IN THE GLOBAL EARTH SYSTEM:  
**FROM THE POLES TO THE TROPICS**

**Abstract Book**



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## **Mini Symposium: Tropical Antarctic Teleconnections, August 22, 2016, 9:30 AM - 11:00 AM**

### ***The role of tropical climate variability in the cessation of the Antarctic Peninsula warming***

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Since the 1950s research stations on the Antarctic Peninsula have recorded some of the largest increases in near-surface air temperature in the Southern Hemisphere. This warming is of wide cross-disciplinary interest as it has contributed to the regional retreat of glaciers, disintegration of floating ice shelves and a 'greening' through the expansion in range of various flora. Several interlinked processes have been suggested as contributing to the warming, including stratospheric ozone depletion, local sea ice loss, an increase in the westerly winds, and changes in the strength and location of low-high latitude atmospheric teleconnections. We have used a stacked and normalized surface air temperature anomaly record based on data from six coastal stations to investigate the broad-scale changes that have taken place across the Peninsula since 1979, which is when high quality atmospheric analyses and sea ice data became available. The stacked record shows a significant change of trend around 1998-1999 between warming (0.23 C per decade) and later cooling (0.41 C per decade) periods, with both trends significant at  $p < 0.05$ . The switch in trend occurred through a strengthening of the Polar Front Jet, which we link to a decrease in tropical Pacific sea surface temperatures associated with more frequent La Nina-like conditions. The change in jet structure has led to more cyclonic conditions in the Drake Passage, and the resultant easterly winds over the northern Peninsula have advected sea ice towards the coast, thus amplifying the effects of the circulation changes. The change has implications for the sensitive ecological and physical environment of the Peninsula.

# ***Large-scale atmospheric environment that develop Mesoscale Convective Systems in Southern Brazil: the influence of Antarctica on subtropical extreme events***

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Mesoscale Convective Complexes (MCC) are meteorological events that happen around the world occurring often in South America, in particular Southern Brazil. The consequences of these events include severe thunderstorms and other natural hazards. This study will analyze the large-scale atmospheric environment favorable to develop MCCs in Southern Brazil during the time period of 1998 to 2007 and explore possible links between the Antarctic region and its influence on subtropical extreme events as MCCs. The variables used include CAPE (Convective Available Potential Energy), dewpoint temperature, temperature, geopotential height, and precipitable water between 2,5 to 5,5 hours before the development of MCCs from the National Center for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR). Empirical Orthogonal Function components were built to analyze the atmospheric environments of MCC groups that occurred in Southern. Temperature and geopotential height were used for the EOF resulting in four principal components. Based on these principal components and the meteorological variables, mean atmospheric environments were created to understand the atmospheric parameters that indicate the development of MCCs. From the observed 303 MMCs between 1998 and 2007, 96 were located in Southern Brazil, 168 in South America and 39 in the South Atlantic Ocean. The MCC groups of Southern Brazil are on the order of 20.000 km<sup>2</sup> larger and an additional hour during the lifecycle than MCCs from other regions of South America. The four EOFs suggest that the mean wind field shows a coupled low-level jet (LLJ) with jet streak between 10 and 12 m s<sup>-1</sup> and upper-level jet (ULJ) with jet streak  $\geq 32$  m s<sup>-1</sup>, improving the convection and cloud development to build a MCC. Moreover, 75% of the principal components analyzed indicate the presence of polar fronts (cold air masses that come from the Weddell and Bellingshausen seas), acting in Southern South America, which are responsible of strengthening the convection when coupled with a LLJ and ULJ. The presence of polar fronts in the environment that develop MCCs in Southern Brazil is a distinction atmospheric behavior of this region, as it was not found in the atmospheric environment related to MCCs in the USA and in other regions of South America. Therefore, it is possible to suggest that the role of polar fronts in improving convection could be one of the reasons that results in MCCs with larger area and longer lifecycle in Southern Brazil, rather than in the USA and in other regions of South America. There are also two humidity sources to develop MCC in the Southern Brazil: the Amazon Forest, normally associated with MCC in South America, and the South Atlantic Ocean, which acts as a source in 75% of the principal components analyzed, where anticyclonic circulation (from a permanent high pressure center) transported humidity from the South Atlantic to the South America.

## ***Simulated Response of Antarctic Atmospheric Circulation and Sea Ice to recent Tropical SST Trends***

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The recent trends in Antarctic sea-ice cover – a global increase masking a dipole between the Ross and Bellingshausen-Weddel seas – are still not well understood, and not reproduced by coupled climate models such as the CMIP5 ensemble. We here explore the potential role of atmospheric circulation changes in the Amundsen Sea remotely forced by tropical SST anomalies, an explanation that has been recently advanced.

As a first check on this hypothesis, we compare the historical atmospheric circulation trends simulated by atmospheric GCMs either coupled with a global ocean or with imposed observed SSTs (AMIP experiment from CMIP5); the latter being in theory able to reproduce changes caused by natural SST variability. While the fully coupled models simulate in aggregate trends that project on the SAM structure, strongest in summer, the AMIP simulations (with imposed SSTs) add in the winter season a pronounced signature of an Amundsen Sea Low (and a PNA signature in the northern hemisphere), consistent with a Niña-like trend in the tropical Pacific.

We then use a specific coupled GCM setup, in which the surface winds over the tropical Pacific are strongly nudged towards the observed ones, including their interannual variability. The model thus reproduces the observed ENSO-like variability but has no constraints outside of the Tropical Pacific.

The winter trend in the Amundsen-Sea Low is then reproduced, as well as a dipole in sea-ice cover (but no global increase).

Further analysis shows that the sea-ice dipole is forced by anomalous surface heat fluxes caused by atmospheric circulation changes in early winter. In late winter, the surface heat fluxes turn to a negative feedback, but the sea ice anomalies are maintained by the ice-albedo feedback.

## ***Southern annular mode change in the last glacial maximum derived from pmip2 simulations***

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The increasing trend of the Southern Annular Mode (SAM) in recent decades has influenced the climate change in the southern hemisphere. How will the SAM respond to the increase of greenhouse gases in the future still remains uncertain. Understanding the variability of the SAM in the past under colder climate such as the Last Glacial Maximum (LGM) helps understand the response of the SAM for the future warm climate. We analyzed the changes in the SAM for the LGM in comparison to the pre-industrial (PI) simulations using 5 coupled ocean-atmosphere models (i.e. NCAR Community Climate System Model version 3 (CCSM), LASG/IAP Flexible Global Ocean-Atmosphere-Land System Model (FGOALS), L'Institut Pierre-Simon Laplace-CM4 (IPSL), Model for Interdisciplinary Research on Climate version 3.2 (MIROC), and third climate configuration of the Met Office Unified Model with Met Office Surface Exchanges Scheme version 2 (HadCM)) from the second phase of Paleoclimate Modelling Intercomparison Project (PMIP2). In CCSM, MIROC, IPSL, and FGOALS, the variability of the simulated SAM appears to be reduced in the LGM than the PI with a decrease in the standard deviation of the SAM index. Overall, four out of five models suggest the weaker variability of the SAM in the LGM, in consistent with the weaker southern hemisphere polar vortex and westerly winds at the surface found in some proxy records and model analyses. The weakening of the SAM in the LGM is associated with the increase in the vertical propagation of Rossby waves in southern high latitudes.



## ***South pacific circulation changes and their connection to the tropics and regional Antarctic warming during austral spring***

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After 1979, statistically significant warming in Antarctica is only observed during austral spring (September–November; SON) and is located across West Antarctica and the Antarctic Peninsula. We show that the SON warming across West Antarctica is confined primarily to western West Antarctica near the Ross Ice Shelf and is strongest in September, while the warming across the Antarctic Peninsula is located primarily along the western coast and is strongest in October. The western West Antarctica warming is tied to a deepening of the Amundsen Sea low in September, while western Antarctic Peninsula warming is related to increasing pressure in the South Atlantic during October. Both circulation changes are associated with increased warm, poleward flow to the continent, but they are connected to different aspects of tropical Pacific variability. The increasing pressure in the South Atlantic is tied to a shift toward increased La Niña-like conditions in the tropical Pacific, while the deepening of the Amundsen Sea low is more strongly tied to a shift in the Pacific Decadal Oscillation (PDO) toward its negative phase since the 1990s. The SON-average circulation changes are related to an eastward propagating Rossby wave train that brings cold, offshore flow to portions of central and eastern West Antarctica during October and November, explaining the absence of significant warming across eastern West Antarctica during SON.

## ***Teleconnection between Antarctic Sea Ice Extent Variability and atmospheric circulation over Southern Indian Ocean.***

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Teleconnection between variability of Antarctic sea ice extent (SIE) and tropical climate has been intensely analyzed for a long time among the scientists and researchers. The key objective of this study is to investigate the inter-annual relationship between the SIE in the India Ocean sector (20-90oE) and the Indian monsoon rainfall with the effect of Mascarenes High (MH). The sector is selected based on preliminary climatological analysis which shows significant relationship with MH region. The study is carried out for 35 years from 1979 to 2013 using ERA Interim, National Snow and Ice Data Center (NSIDC). The results show the time series of SIE during High (Low) ice phase (HIP/LIP) years are significant positive correlation to the Indian monsoon rainfall particularly in Peninsular India region with correlation coefficient 0.66 and 0.61 respectively. In additional, results also show that the correlation between SIE and MSLP at MH region during HIP years is stronger (lower) when there is 2 month lag (AMJ). Furthermore, composite analysis also reveals that there are other possible factors that may influence the teleconnection process.

Keywords: Antarctic sea ice extent, High ice phase, Low ice phase, Mascarenes High, Indian Monsoon,teleconnection.

## ***Modeling El Niño diversity and tropical teleconnections to Antarctica***

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Although tropical teleconnections to Antarctica associated with the El Niño – Southern Oscillation (ENSO) have long been identified, ENSO events occur on a wide continuum of amplitude, seasonality, and duration. This diversity impacts the characteristics associated with these teleconnections through variability in Rossby wave propagation, the sub-tropical jet stream, and the modulation of the eddy-driven mean meridional circulation. In all cases, the Southern Annular Mode (SAM) modulates the ENSO teleconnection through transient eddy interaction, reinforcing or weakening atmospheric circulation anomalies in the South Pacific Ocean. As the teleconnections originate in the tropics, the location of warm or cool sea surface temperature (SST) anomalies in the tropical Pacific Ocean control how ENSO events develop and their eventual effects on the high-southern latitudes. Numerical simulations using the National Center for Atmospheric Research Community Atmosphere Model (CAM) have been performed based on the tropical forcing of two types of warm phase ENSO events (El Niño), where positive SST anomalies are located in the central (CP) or eastern (EP) tropical Pacific. CAM simulates the wide spatial and temporal variability associated with the SAM during both types of El Niño forcing. Analysis reveals a higher degree of SAM persistence in the EP simulations, supporting previous findings that EP events perturb the atmospheric state toward SAM- events through the propagation of eddy momentum to the high latitudes. However, CAM only accurately simulates other known impacts on atmospheric circulation (e.g., blocking in the SE Pacific Ocean) when the observed SAM phase is matched, especially for CP events. Seasonal preferences for in-phase events (El Niño – SAM-) are verified for CP (during winter) and EP (during summer) with dynamical support through anomalous equatorward momentum flux on the equatorward side of the eddy-driven jet. A SAM+ high latitude regime with El Niño (out-of-phase events) inhibits eddy behavior in the mid-latitudes and limits the propagation of the tropical teleconnection. Thus, high latitude circulation variability is demonstrated to be the product of both tropical and high-latitude forcing.

## ***Climatic interpretation from the stable water isotope composition of firn-cores from the northern Antarctic Peninsula***

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A clear trend to warming it has been observed at the Antarctic Peninsula especially at the coastal regions, as shown by meteorological records. Moreover, an extraordinary historical maximum of surface air temperature was registered on early autumn in 2015 (+16.5°C) at two stations from the north-east Antarctic Peninsula. Collapse of ice shelves has been reported from both west and east coast of the Antarctic Peninsula, triggering an accelerated flow and discharge of continental glaciers into the ocean. On the other hand and in an apparently contradictory behavior, sea ice extent around Antarctic has reached an historical maximum in the past years. The forcing mechanism behind this coupled ocean and atmospheric instability has been linked to altered pattern of atmospheric circulation, as shown by the positive anomaly of the southern annular mode (SAM). A direct evidence of the ocean and atmospheric warming can be observed from the estimated surface mass balance (SMB) of the region, where a negative trend of the West Antarctic Ice Sheet (WAIS) has been determined for the last decades. However, regions like the northern Antarctic Peninsula are still a challenge for regional climate models, due to its particular conditions like complicated topography and scarce direct observations at non-coastal areas. Here we show how that the stable water isotope composition of firn cores, offers an insight of climatic variability from remote and relatively high altitude zones, where no direct observations are possible and models are not able to differentiate. We focus on the north tip of the Antarctic Peninsula and especially in the region between the Chilean Station O'Higgins at the coast and the Plateau Laclavere (63°27'15"S / 57°41'53"W) located at 1130 m a.s.l. on the local east-west divide. Several firn cores were retrieved between 2008 and 2016 from this zone, and later analyzed with a 5 cm resolution for determination of oxygen and deuterium isotope ratios. The interpretation of isotope information is not straightforward, as there is no clear seasonality as normally expected. Nonetheless, combined isotope ratio, deuterium excess, meteorological and backward trajectories data shows that precipitation of this region is highly dependent on the conditions of the near ocean (humidity, surface temperature and sea ice extent), and which combined lead to the determination of a high inter-annual variability on accumulation rates. For the last 10 years, the accumulation fluctuated from around 1000 to over 2500 kg m<sup>2</sup>/a. Air temperature estimation is more complicated to extract from the data, but in combination with meteorological and satellite observation from the nearby ocean, show a complicated seasonal relationship, with transport of relatively warmer air parcels to high altitudes during winter due to the influence of sea ice. During winters with less extent of sea ice, a direct relationship is observed between air-temperature and the second order parameter of deuterium excess. We recognized that stable water isotope information by itself is not enough for a more detailed interpretation, analysis of complementary chemical species (MSA, H<sub>2</sub>O<sub>2</sub>, ions) are currently been carried out which should improve our interpretation.



## **S02. Evolution of the physical and biological environment of Antarctica and the Southern Ocean over the 21st and 22nd centuries, Meeting Room 406/407, August 22, 2016, 9:30 AM - 11:00 AM**

### ***Emission of Biogenic Hydrocarbons from Antarctic Mosses: Implications for biosphere-atmosphere interactions, biotic feedbacks, and the future of the Antarctic atmosphere***

**Todd Rosenstiel**<sup>1</sup>, Hannah Prather<sup>1</sup>, Anna Magnuson<sup>2</sup>, Scott Kiel<sup>1</sup>, Angelica Casanova-Katny, Sarah Eppley<sup>1</sup>  
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The emission of biogenic volatile organic carbon (BVOC) from plants is a fundamental component of terrestrial biosphere-atmosphere interactions, and is a key mechanism by which plant metabolism drives the oxidative chemistry of the lower atmosphere. Although often overlooked, mosses are the dominant terrestrial vegetation in many of the ice-free maritime regions of Antarctica, with over 100 species found across the continent. Despite their local abundance in some regions, the potential roles of Antarctic mosses in shaping current and future biosphere-atmosphere interactions are poorly understood. Furthermore, a comprehensive characterization and quantification of BVOC emissions from Antarctic moss species, and moss-dominated communities, remains unexplored. Here we present a series of field- and laboratory-based studies aimed at quantifying the chemical diversity and magnitude of BVOC emissions from locally abundant mosses on King George Island, Livingston Island and Deception Island. Characterization of BVOC emissions from locally abundant Antarctic moss species, including *Sanonia uncinata*, *Chorisodontium aciphyllum*, *Meesia uliginosa*, and *Polytrichastrum alpinum* revealed a surprising chemical diversity of emitted BVOCs, including substantial emissions of the atmospherically important volatile hemi-terpene isoprene from *P. alpinum*. Results from this study suggest that BVOC emissions from Antarctic mosses and moss-dominated communities are a fundamental, yet poorly understood, component of biosphere-atmosphere interactions in this system, especially for terrestrial communities occurring in the rapidly warming Western Antarctic Peninsula. Given the significant role that terrestrial BVOC emissions play in influencing regional and global atmospheric chemistry in many of Earth's ecosystems, consideration of BVOC emissions in Antarctica will likely be an important aspect of understanding the transformation of this system. The impacts of continued near-surface warming on moss community dynamics, moss BVOC emissions, and linkages to atmospheric chemistry will be discussed, as will the possible role of biotic feedbacks, including biogenic aerosol formation, in contributing to future environmental change in Antarctica.

## ***Biogenic Volatile Organic Compounds (BVOCs): A comparison between Tropical and Antarctic emissions.***

**Mohd Shahrul Mohd Nadzir**<sup>1,4</sup>, Neil Harris<sup>2</sup>, Andrew Robinson<sup>2</sup>, Mohd Talib Latif<sup>3,4</sup>, Haris Hafizal Abdul hamid<sup>4</sup>, Zamzam Tuah Ahmad Ramly<sup>4</sup>, Mhd firoz Khan<sup>1</sup>, Conar Bolas<sup>2</sup>, Thian Lai Goh<sup>4</sup>

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Atmospheric concentrations of Biogenic Volatile Organics Compounds (BVOCs) and ground-level ozone, O<sub>3</sub> were measured in the Southern ocean and Peninsular Antarctic coastal area during 22 days of the Malaysian Antarctic Scientific Research Cruise 2016. The highest isoprene concentrations were found in high near the coast of Port William, Greenwich Island and Deception Island. With smaller enhancements in coastal regions of Darbeux Island. C<sub>3</sub>H<sub>8</sub> was the most abundant biogenic VOCs during the entire measurement. Other VOCs are expected to shows low concentrations during the cruise. A significant correlation is expected between C<sub>3</sub>H<sub>8</sub> and satellites chlorophyll-a from MODIS and SeaWifs. While, ground-level O<sub>3</sub> was high over Southern Ocean compared to the Peninsular Antarctic. This caused by the interaction of CO<sub>2</sub> intake by the ocean and involved in photo-chemical reaction with VOCs and led to the ozone formation. Statistical tests showed strong Spearman correlations between C<sub>3</sub>H<sub>8</sub> and ground-level O<sub>3</sub> compounds, suggesting ground-level ozone may produce by C<sub>3</sub>H<sub>8</sub>. Log-log plots of C<sub>3</sub>H<sub>8</sub>/other BVOCs show that both chemical reactions and dilution into the background atmosphere contribute to the composition of these halocarbons at each sampling point. We used the correlation to make a crude estimate of the regional emissions of isoprene over the Southern Ocean and Peninsular Antarctic. Finally, we note that satellite-derived chlorophyll-a (chl-a) products always agree well with BVOCs, particularly in coastal regions of high chl-a, meaning that satellite chl-a may be a good proxy for marine productivity. A ground based measurement of C<sub>3</sub>H<sub>8</sub> over tropical rainforest Borneo has been measured during Borneo Atmospheric Land Interactions (BALI) project 2015. Based on the result C<sub>3</sub>H<sub>8</sub> from Borneo forest was higher than Peninsular Antarctic. Thus, tropical region like Malaysia may or can be the 'main gate' of these reactive gases released to the atmosphere via 'deep convection' process. These gases may travel to the temperate and Polar Regions like Antarctic and affect the polar climate.

## ***Islands in the ice: Expansion and increased ecological connectivity of Antarctica's ice-free areas under climate change***

**Jasmine Lee**<sup>1,2,3</sup>, Iadine Chades<sup>2</sup>, Richard Fuller<sup>1</sup>, Justine Shaw<sup>1,3</sup>, Ben Raymond<sup>3</sup>, Thomas Bracegirdle<sup>4</sup>, Aleks Terauds<sup>3</sup>

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Though making up only 0.32% of the continent, permanently ice-free areas in the Antarctic are home to over 99% of its biodiversity, including arthropods, nematodes, lichens, fungi and tardigrades. In addition, many vertebrates including pinnipeds and penguins rely on ice-free areas at certain times of the year for breeding. Despite intensive research on climate change impacts around the world, almost nothing is known about how ice-free areas might be affected, which is critical to understanding the impacts on Antarctic species and their movements. Unlike most of the world, where climate change is set to fragment species distributions, in Antarctica we might expect ice-free areas to increase in size and become more connected. Consequently dispersal and gene-flow among regions that have maintained genetic and evolutionary distinctiveness for up to 60 million years could lead to rapid biotic homogenization, extinctions, and the further spread of invasive species, which are already posing a substantial threat to Antarctic biodiversity in some regions. Here we present a framework for understanding climate change impacts on Antarctic ice-free areas. Using newly-available regionally specific climate predictions, we show how the distribution and connectivity of Antarctic ice-free areas changes under IPCC5 climate change scenarios, and explore the ecological implications of these changes for Antarctic terrestrial biodiversity. We demonstrate potentially large increases in total ice-free area extent and disrupted patterns of connectivity among those patches. This work represents an essential first step for predicting the movements of both native and invasive species under climate change and for informing conservation planning and management in the region.

## ***Future oceanography of the Ross Sea***

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The Ross Sea is critically important in regulating Antarctic sea ice, global carbon dioxide concentrations, and is biologically productive, which makes future changes in the region's physical environment of global concern. We examined the effects of projected changes in atmospheric temperatures and winds on aspects of the ocean circulation likely important to primary production using a 5-km horizontal resolution regional ocean/sea ice/ice shelf model of the Ross Sea. A 20% increase in wind speed, with no other atmospheric changes, reduced summer sea ice area by 11%, opposite the observed trend of the past three decades. Increased winds with spatially uniform decreased atmospheric temperatures increased sea ice concentrations, on-shelf transport of Circumpolar Deep Water (CDW), vertical mixing of modified Circumpolar Deep Water (MCDW), High Salinity Shelf Water (HSSW) volume and (albeit small) Ross Ice Shelf (RIS) basal melt. Winds and atmospheric temperatures from the SRES A1B scenario forcing of the MPI ECHAM5 model produced decreases in on-shelf transport of CDW and vertical mixing of MCDW for 2046-2050 relative to the end of the 20th century. The duration of shallow mixed layers over the continental shelf increased by 8.5 and 19.2 days in 2050 and 2100, and mean summer mixed layer depths decreased by 12 and 44%. The RIS basal melt increased slightly by 2046-2050 (6%) and 2096-2100 (9%). Advection of lower salinity water into the model domain did not significantly affect sea ice extent or on-shelf CDW transport for the 2046-2050 or 2096-2100 simulations. However, freshening reduces vertical mixing of MCDW, enhances the RIS basal melt rate relative to the 20th century simulation for 2046-2050 (17%) and 2096-2100 (22%), and leads to a major reduction in the volume of HSSW produced. These results suggest that the annual phytoplankton production in the future will increase and become more diatomaceous. Other components of the Ross Sea food web, however, will likely be severely disrupted, creating significant but unpredictable impacts on the ocean's most pristine ecosystem.



## ***Dynamics of the climate-active gas dimethylsulphide (DMS) in relation to sea-ice changes at the Western Antarctic Peninsula***

**Jacqueline Stefels**<sup>1</sup>, Maria van Leeuwe<sup>1</sup>, Desiree den Os<sup>1</sup>, Alison Webb<sup>1</sup>, Theo Elzenga<sup>1</sup>, Hugh Venables<sup>2</sup>, Michael Meredith<sup>2</sup>

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The Western Antarctic Peninsula is among the most rapidly warming areas in the world. This has led to reductions in sea-ice extent and duration of the sea-ice season. In turn, sea-ice reductions have important consequences for the biogeochemical cycles of carbon and sulphur that feed back onto climate. Sea ice contains enormous amounts of algae, the biomass of which can be three orders of magnitude higher than in the underlying water. Extreme physiological conditions within the ice favour the production of specific protective compounds. An important compound in this respect is dimethylsulfoniopropionate (DMSP), the precursor of the climate-active gas dimethylsulfide (DMS), which is in turn a precursor of cloud condensation nuclei. In spring, high concentrations of DMS can be observed during the period of sea-ice melt and associated release and growth of phytoplankton. In addition, this peak of algal biomass in the pelagic is a potential vehicle for the biological carbon pump. The biochemical coupling between sea-ice and the pelagic and between these events in spring and the following summer is largely unknown.

We will present data from a time-series of DMS and associated compounds at the Rothera Time Series (RaTS) site (Western Antarctic Peninsula) that started in January 2013 and is still on going. Data are related to the phytoplankton community structure, process rates within the small food web and physicochemical characteristics of the area, with the aim of understanding the impact of changing sea-ice conditions on the carbon and sulphur budgets.

## ***High-resolution insight into the role of the Antarctic and the Southern Ocean in a high-carbon future***

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Efforts to determine the future uptake of carbon and heat by the Southern Ocean have been hampered by the enormous computational resources required to simulate ocean biogeochemistry in eddy-resolving coupled climate models. We compare the response of the Southern Ocean with respect to the uptake of heat and carbon to a doubling of atmospheric carbon dioxide in a suite of high to low resolution coupled climate model simulations developed and run at NOAA's Geophysical Fluid Dynamics Laboratory. The three different configurations of the Geophysical Fluid Dynamics Laboratory (GFDL) coupled climate models include the eddy-resolving GFDL-CM2.6 with a nominal ocean resolution of 0.1° (4-10km); the eddy-permitting GFDL-CM2.5, with a nominal resolution of 0.25° (8-28km); and the standard resolution GFDL-CM2.1 (1°), in simulations in which the atmospheric CO<sub>2</sub> increases at 1% per year until doubling is achieved after 70 years. CM2.6 is coupled to a computationally-efficient biogeochemical module (Mini-BLING, Galbraith et al. 2010, 2015) with a reduced set of biogeochemical variables that allows an analysis of the uptake of carbon by the Southern Ocean, as well as the effects on nutrient storage and transport and potential acidification impacts. We evaluate this suite of simulations against the Earth System Model simulations generated in support of CMIP5, the results of the Southern Ocean State Estimate and against other observationally-based metrics.

## **S29. From the top: Higher trophic predators as ecosystem sentinels, Meeting Room 410, August 22, 2016, 9:30 AM - 11:00 AM**

### ***Exploitation of Antarctic krill *Euphausia superba* by three air-breathing predators with contrasting foraging strategies – implications for fisheries feedback management***

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The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) regulates the fishery for Antarctic krill. In the southwest Atlantic sector where all harvesting currently takes place, a 620,000 ton interim catch limit has been spatially distributed across four management subareas. This limit represents ~1% of the estimated stock in the area, and is thought to provide a highly precautionary catch limit. The limit has also been spatially subdivided within the four management subareas (small-scale management units; SSMU) to prevent potential overharvesting; reaching the limit for a SSMU results in its closure. After 20 years of this management strategy, CCAMLR has agreed to move towards an ecosystem-based feedback management (FBM) approach to regulate the fishery, which is expected to utilize indicators of reproductive and foraging success of several key krill-dependent predator species such as Antarctic fur seals and various penguin species to adaptively manage quotas. Thus, understanding interactions between predators, krill and the fishery are therefore crucial in determining whether variability in predator indices can be used in any FBM approach. Our study integrates spatial and temporal data collected in 2015/2016 of three key krill predators; post-breeding male Antarctic fur seals, breeding chinstrap penguins and commercial fishers. We present data at two spatial scales; the first is a brief, coarse-scale overview of predator movements in relation to krill fishing effort across CCAMLR management subarea scales in which over 95% of krill are caught. The second is a fine-scale characterization of the spatial and temporal overlap between the three predators at the South Orkney Islands. We show movement in relation to krill abundance and oceanographic conditions measured in the study region via concurrently-conducted ship surveys. We instrumented 29 Antarctic fur seals with satellite-relayed-data-loggers (SRDL's) which provided location, dive and water column temperature information; 2 of these individuals were fitted with conductivity, temperature and depth (CTD) SRDL's to characterize in more detail the oceanographic properties of the water column they exploited. We also instrumented 122 chinstrap penguins at two field sites with archival fastloc GPS devices and time depth recorders that also logged water temperature. Both fur seals and penguins visited regions that were exploited by the fishery. Additionally, fur seals also moved further west and south, as far as Adelaide Island and Chinstraps also foraged further offshore around the South Orkneys, in areas not used by the fishery. The nature of spatial interactions between these three krill predators requires further investigation, particularly in terms of krill biomass removal and the response of each predator to krill, prior to CCAMLR implementing any FBM approach. Certainly spatial overlap is evident between natural predators and the fishery, but the level of functional overlap requires better quantification.

## ***Combining individual-based modelling and dynamic energy budget theory: a way forward for incorporating top predators in ecosystem models***

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Colony breeding marine mammals and seabirds are generally not well represented in ecosystem models, despite these groups playing important top-down roles in ecosystems. We are exploring how to efficiently fill this gap for Southern Ocean ecosystem models using individual-based modelling and dynamic energy budget theory to model the population trajectories of an important Southern Ocean top predator, the southern elephant seal (*Mirounga leonina*). Both individual-based models and dynamic energy budget theory provide tools with which to capture both the colony-breeding, and capital- or income-breeding of marine mammals and birds. Models which combine both these methods have not yet been developed for colony breeders. This is predominantly due to the complex life-histories of these species.

We present a preliminary model for the southern elephant seal based on behavioural and life history data from a longitudinal study at one of its breeding locations on sub-Antarctic Macquarie Island. The model, built in the open-source agent-based modelling framework NetLogo, integrates the stochasticity of individual-based models with the deterministic nature of dynamic energy budget theory to investigate population-level responses to perturbations – such as changes in the location and availability of prey. Our results so far show promise in informing the representation of capital breeders in ecosystem models for the Southern Ocean. The model framework we have developed is designed to be flexible and hence applicable to other colony-breeding predator species such as seabirds.



## ***Comparison of aerial and ship-board surveys from platforms of opportunity in the Southern Ocean***

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Population assessments of megafauna in the Southern Ocean are vital in order to identify potential vulnerabilities, to describe critical habitat and to assess the recovery status of formerly heavily exploited species. Currently, populations of large whales in the Southern Ocean are thought to be recovering after decades of extensive hunting. However, population estimates are either lacking or are decades out of date. Dedicated transect surveys for Antarctic megafauna are costly in terms of time, and competition for vessel time in the Southern Ocean is intense. Therefore, vessels travelling the Southern Ocean are often used as platforms of opportunity for marine megafauna assessments. These data collections usually provide information on encounter rates (ER; individuals / km) of target species along the cruise track.

During four voyages of RV Polarstern to the Southern Ocean, we conducted dedicated Distance Sampling surveys for cetaceans from the ship's crow's nest. Distance Sampling is an established method for wildlife population estimation, which enables local density estimation (individuals/km<sup>2</sup>) of target species by taking into account the effectively covered search area. In addition, we used the on-board helicopters for ad hoc design-based aerial Distance Sampling surveys into the wider surroundings of the ship. Apart from results on cetacean density, these concurrently collected datasets provide a unique opportunity for a method evaluation. We used these data sets to evaluate the efficiency of both methods, to compare returned results and make inferences about data quality. We compared effective strip widths, ERs and local density (LD) estimates obtained from both methods for minke whales (*Balaenoptera bonaerensis* / *acutorostrata*) and large baleen whales. Comparisons were made on both a survey scale as well as for spatially and temporally defined units (STUs) of concurrent survey coverage.

Using the pooled dataset of all surveys, the helicopter survey ERs for large whales were estimated at 103% of those obtained from the ship-based surveys and for minke whales at 68%. Large whale LDs from helicopter surveys were estimated at 217% of those from ship-based surveys and for minke whales at 58%. 12 STUs were defined with concurrent helicopter and crow's nest effort. A linear regression model of ER estimates from both platforms showed the helicopter ER of large whales to be at 54% of the ER projected by the ship-based dataset. Minke whale ER of helicopter surveys was estimated at 7% of those produced by the ship-based survey dataset. However, the LD estimates showed that the helicopter data were at 160% of ship-based LDs for large whales and at 4% of ship-based LDs for minke whales.

Our study shows that the choice of survey platform potentially introduces a specific bias into the standard methodology for cetacean surveys. Large whales seem to avoid or behave more conspicuous in the presence of the ship, resulting in lower ERs than during helicopter surveys, whereas minke whales seem to be attracted by the vessel, resulting in significantly higher ERs in ship surveys than in helicopter surveys.

## ***Implementing a sea ice-based survey to characterise toothfish interactions in McMurdo Sound***

**Steve Parker**<sup>1</sup>, Sophie Mormede<sup>2</sup>, Stuart Hanchet<sup>1</sup>, Laura Ghigliotti<sup>3</sup>, Simonepietro Canese<sup>4</sup>

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We developed and implemented a random, stratified, vertical longline survey conducted through the annual sea ice in McMurdo Sound to determine the age composition, diet, reproductive status, and local abundance of Antarctic toothfish (*Dissostichus mawsoni*). A pilot season was carried out in 2014, where the methodology for a standardised hook and line survey was defined and some initial biological samples were collected. In 2015, seven randomized locations were surveyed. Data suggest that the toothfish in McMurdo Sound were abundant relative to historical catch rates, had a very similar size distribution, were relatively old (median age in 2014 was 24 years), and their diet was varied consisting of euphausiids and fish (mainly *Pleuragramma antarcticum*), though many had empty stomachs. These data will be synthesised with parallel studies on the diets of Weddell seals and killer whales, as well as linking movement patterns of toothfish and mammalian predators to the distribution of *P. antarcticum* in McMurdo Sound and in Terra Nova Bay. The resulting data will contribute to the development of ecosystem models that could be used to inform management strategies to respond to the potential ecosystem effects of fishing and the likely interacting effects of climate change.

## ***Validating oceanographic data obtained from Weddell seals using SMRU CTD in the Ross Sea***

**Daniel Costa**<sup>1</sup>, Kim Goetz<sup>3</sup>, Patrick Robinson<sup>1</sup>, Jennifer Burns<sup>2</sup>

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Electronic tags and their associated sensors that can be placed on a variety of marine animals has not only increased our understanding of their movement patterns but is providing insights into the physical oceanography of the regions that are difficult or even impossible to sample using standard approaches. These electronic tags are providing oceanographic data in areas where traditional shipboard and Argo-float coverage is limited or absent. The Southern Ocean is one region where ship time is limited (especially in the winter), and Argo floats are unable to work in ice and have a propensity to be advected away from the Antarctic Continent. However, data on the accuracy and stability of these tags are limited. We therefore validated the temperature and salinity data acquired from Conductivity Temperature and Depth – Satellite Relay Data Loggers (CTD-SRDL, manufactured by SMRU) deployed on Weddell seals in the Western Ross Sea. This was done by comparing the temperature and conductivity values reported by 44 tags in a water bath at 5 temperatures between -2 and 25 °C and 5 baths with salinities between 16 & 37 PSU. In the field we attached 16 tags to a Seabird CTD and compared the values reported from the tags to those recorded by the Seabird. We compared temperature and conductivity values transmitted from SRDL tags (n=9) deployed on seals to data collected in the vicinity of the seals using the Seabird CTD collected within 2 days and 5 km of the seal data. In the lab we found that the tags performed within the stated accuracy of  $\pm 0.005$  °C for all temperatures except those below 0 °C, which is outside the manufacturer calibration range. We observed an offset of  $0.019 \pm 0.014$  °C in temperature and  $0.037 \pm 0.024$  mScm<sup>-1</sup> in conductivity between CTD data collected from the animals compared to the Seabird CTD profiles collected in the same area. Finally, after a 9-10 month deployment the instruments showed a shift in temperature of  $0.002 \pm 0.001$  °C and salinity  $0.005 \pm 0.048$  mScm<sup>-1</sup>. While our observations confirm that the conductivity data reported by the SRDL tags is offset when attached to the animal, this offset can be corrected by comparing the animal collected data to known CTD profiles or to deep stable water masses. Finally, our data show that these tags are relatively stable even after enduring 9-10 months in the harsh fast and pack ice environment inhabited by Weddell seals.

## **S06. Glaciers and ice sheet mass balance, Meeting Room 405, August 22, 2016, 11:30 AM - 1:30 PM**

### ***Significant mass loss recorded in Glaciar Bahía del Diablo, Vega Island, Antarctic Peninsula***

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During the last Antarctic summer campaign carried out in February 2016, the monitoring of the Bahía del Diablo glacier was realized, as every year. Preliminary results indicate an important loss of mass of the glacier. The mass balance for the year 2015/16 yielded approximately -600 mm water equivalent, being the major loss registered in the last 16 years since the mass balance program began. This loss is in contrast with the last 6 mass balances, which were positive or negative but nearly zero.

This very low mass balance record for Bahía del Diablo Glacier is consequence of the low annual precipitation nearby the glacier. Precipitation measured in the highest point of the glacier was 350mm and precipitation measured at the bottom, approximately at sea level, was 110 mm for the mass balance period. The average precipitation for these sites during previous years was approximately 550 mm for the highest point and 330 mm for sea level point. It is remarkable the difference between average precipitation and last measurement.

Although the full record for the summer (until end of February) is not available, estimated mean summer temperature up to February 25th was about +0.95 °C, using data records from Marambio Station (Argentina) to calculate February temperatures.

Being mean summer temperature directly linked to the glacier mass balance, this warm season favored the negative mass balance and the low annual precipitation also increased the mass loss.

## ***Long-term monitoring of the glaciers in Wordie Bay, Antarctic Peninsula, using multi-mission SAR time series***

**Peter Friedl**<sup>1</sup>, Kathrin Höppner<sup>1</sup>, Matthias Braun<sup>2</sup>, Rainer Lorenz<sup>1</sup>, Erhard Diedrich<sup>1</sup>

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The Antarctic Peninsula is one of the world's most affected regions by Climate Change. Dense and long time series of multi-mission SAR data enable detailed studies of the rapid glaciological changes in this area.

We present first results of a case study at the former Wordie Ice Shelf, located at the south-western side of the Antarctic Peninsula. Since the ice shelf disintegrated in a series of events during the 1980s, only disconnected and retreating tidewater glaciers have remained. Due to the loss of the buttressing force of the ice shelf, the former tributary glaciers reacted with an acceleration of their flow speeds in order to adapt to the new boundary conditions. While the loss of the ice shelf itself does not affect sea level, the increased outflow of the glaciers and the associated mass loss contribute to global sea level rise. Most of the studies conducted at Wordie Bay so far covered only relatively short investigation periods and compared their results on a bi-temporal basis. Hence it is yet neither well known how long this process of adaption to the new boundary conditions exactly lasts nor how much ice mass loss and sea level rise is caused by this process in total.

We provide completest possible time series of glaciological parameters (e.g. glacier extends, grounding line positions, flow speeds, glacier mass flow, glacier elevation/volume changes and contributions to global sea level rise) for the glaciers in Wordie Bay, ranging from the early 1990s to today. The glaciological parameters are determined by applying differential interferometric synthetic radar (DInSAR) methods as well as intensity tracking and differential range offset tracking. For this purpose large datasets of previously active (e.g. ERS, ALOS PALSAR) as well as currently recording SAR sensors (e.g. Sentinel-1, TerraSAR-X, TanDEM-X) are processed together with data from other sources (e.g. photogrammetry, laser/radar altimetry, ground penetrating radar and SMB simulations).

The usage of long-term series of SAR data allows us to obtain more precise series of glacier monitoring measurements, which is assumed to contribute to a better understanding of the climate-triggered glaciological processes on the Antarctic Peninsula and the Wordie Bay respectively.

# ***Unlocking the archive - Photogrammetric measurements from historical aerial photography extend the record of glacier change on the Antarctic Peninsula***

**Adrian Fox**<sup>1</sup>, Lucy Clarke<sup>2</sup>, Karolina Fieber<sup>3</sup>, Pauline Miller<sup>4</sup>, Jon Mills<sup>3</sup>

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The Antarctic Peninsula (AP) is known to have had a rapidly changing climate over the last half century with strong regional warming and an increasing number of positive-degree-days. Research has shown variations in the response of individual glaciers, but an overall pattern of frontal retreat by most glaciers in the region (e.g. Cook et al., 2005). There are very few detailed measurements of glacier mass changes over decadal scales, which hinders understanding of the contribution of AP glaciers to cryospheric sea-level change and modelling of future changes and impacts.

There are over 30,000 historical aerial photographs for the AP held by the British Antarctic Survey and US Geological survey reaching back to the 1940s and 1950s, but these are an under-used resource for measuring glacier change. However, modern photogrammetric techniques coupled with campaigns to scan the analogue photographs have recently made them more accessible for accurate, detailed measurements of glacier mass change.

This study relates historical aerial photographs to either recent GPS/INS supported aerial photography acquired by British Antarctic Survey, or sub-metre resolution Digital Globe WorldView stereo satellite imagery, to unlock this archive for rigorous 3-D photogrammetric measurement.

The study includes nine glaciers with high quality aerial photography from multiple epochs and about 20 widely-distributed glaciers where a single earliest epoch is compared to recent data. Well-established photogrammetric methods are used to generate accurate glacier surface DEMs, which are then differenced to measure glacier change.

This paper/poster will discuss the methods used, the achievable accuracy and present results.

Cook, A.J.; Fox, A.J.; Vaughan, D.G.; Ferrigno, J.G.. 2005 Retreating glacier fronts on the Antarctic Peninsula over the past half-century. *Science*, 308 (5721). 541-544. 10.1126/science.1104235

## ***Mass balance of Antarctica from combined GRACE and CryoSat inversion***

**Rene Forsberg**<sup>1</sup>, Sebastian Simonsen<sup>1</sup>, Louise Sørensen<sup>1</sup>  
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The combination of space-based remote sensing data, especially gravity field changes from GRACE and elevation changes from satellite altimetry, may yield a time series of Antarctic mass balance with both high temporal and spatial resolution, highlighting the varying individual mass loss behaviour of major glaciers systems, while still keeping a “correct” overall ice sheet wide mass loss, within the uncertainty of the glacial-isostatic effects. Although the GIA errors continue to be large in Antarctica, especially affecting the GRACE data, the temporal changes in mass balance are well determined, and show significant acceleration both over the Antarctic Peninsula and the Pine Island/Thwaites glacier systems in East Antarctica.

In the presentation we outline recent results from the GRACE, CryoSat and IceSat missions 2003-2015, and outline the basis of a high resolution point mass estimation method, which allows a simultaneous use of mass change and altimetry data, when combined with firn compaction and density models. We estimate an overall mass balance of Antarctica since 2010 to be on the order of -135 GT/yr, representing nearly a doubling of mass loss since the 2003-9 period, with an error of the actual mass balance values of  $\pm 50$  GT or so due to uncertainty in GIA corrections.



## ***Annual Antarctic ice sheet flux from Landsat 8***

**Ted Scambos**<sup>1</sup>, Alex Gardner<sup>2</sup>, Mark Fahnestock<sup>3</sup>, Geir Moholdt<sup>4</sup>, Terry Haran<sup>1</sup>, Marin Klinger<sup>1</sup>, Twila Moon<sup>4</sup>  
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Continent-wide ice sheet mass flux mapping using Landsat 8 imagery for the 2013-14, 2014-15 and 2015-16 season and the BedMap 2 ice thickness data reveals that major regional changes in ice flux but relatively small changes in total flux over the study period when compared with earlier InSAR-based continental mappings. The annual (and potentially sub-annual) flux assessments are made possible by the high acquisition rates, excellent geolocation, and high radiometric sensitivity of the Landsat 8 sensor and data (panchromatic band 8, 15 meter pixels, 12-bit resolution, and multiple acquisitions of each scene center each year). Increases in ice flux in the Amundsen Sea Embayment, Getz Ice Shelf, and southwestern Peninsula region are largely offset by ice flux reductions along the Ronne Ice Shelf drainage, Dronning Maud Land coast, northern Peninsula, and Totten Glacier. Total flux across the grounding line is slightly higher but within error relative to the Rignot et al. 2012 continent-wide ice flow speed mapping (based on their ~2006-2008 data). The grounding line used is a multi-sensor determination combining InSAR, satellite laser altimetry, and satellite image determinations. Regional variations in the Ross Ice Shelf and Siple Coast drainages, and in the interior of the major outlet glaciers, demonstrate the value of frequent assessment of glacier flux and ice flow as a means of understanding complex ice sheet flow systems.

## ***Measurements of snow sublimation rate at Vostok station (Antarctica)***

**Alexey Ekaykin**<sup>1,2</sup>, Vladimir Lipenkov<sup>1</sup>, Vitaly Zarovchatsky<sup>3</sup>

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During 5 summer seasons and 2 winters of Russian Antarctic Expedition at Vostok Station (Antarctica), 2011-2015, we conducted direct measurements of the snow sublimation. We established that the sublimation rate depends on two parameters: surface air temperature and wind speed. During the cold period of year (March-October with the average day air temperature below  $-45^{\circ}\text{C}$ ) the sublimation rate is near zero, or even condensation of water vapor on the snow surface occurs (in total up to 0.2 mm w.e.). The total sublimation during the warm period of year (November – February) is about 2.3 mm w.e. However, this value does not take into account the sublimation of the snow particles during the wind-driven snow transport. With this factor, total sublimation could be 4-5 mm w.e. Taking into account the present-day snow accumulation rate at Vostok, 23 mm w.e. / year, we estimate the annual precipitation amount in this area as 25-28 mm w.e. The work was supported by Russian Science Foundation, grant 14-27-00030.

## ***Commitments to future retreat of the Antarctic ice sheet***

**Rob DeConto**<sup>1</sup>, David Pollard<sup>2</sup>

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The agreement reached at the COP21 United Nations Conference on Climate Change is aimed at limiting future increases in global mean temperature below 2°C. Here, we use a continental ice sheet/shelf model with new treatments of meltwater-enhanced calving (hydrofracturing) and marine terminating ice-cliffs, to explore future commitments to sea-level rise given limits of global mean warming between 1 and 3°C. In this case, ice-sheet model physics are validated and calibrated against past ice-sheet response to temperatures warmer than today during the Pliocene (3 Ma) and Last InterGlacial (130-115 ka). The ice-sheet model is coupled to highly resolved atmosphere and ocean-model components, with imposed limits on future warming designed to mimic the idealized global warming limits discussed at COP21. Both the short and long-term response of the Antarctic Ice Sheet is discussed in light of the range of allowances agreed in Paris, as are implications for long-term commitments to sea-level rise over the coming centuries and millennia.

## **S10. Subglacial aquatic environments, Meeting Room 408, August 22, 2016, 11:30 AM - 1:30 PM**

### ***A history of Antarctic subglacial lake exploration***

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Antarctic subglacial lakes have been regarded as extreme habitats for microbial life and keepers of important ice and climate records since 1996, when Lake Vostok was first shown to be a large deep body of water beneath central East Antarctica. We now know that there are nearly 400 Antarctic subglacial lakes; that some are connected hydraulically; and that the ice sheet's dynamics are affected by their presence in some places. After two decades of planning, involving the development of drilling techniques for lake access, environmental contamination protocols, instrument design and logistics set up, major progress has been made in attempts to directly measure and sample subglacial lakes, and to comprehend their role in ice-sheet flow. In March, an international meeting was held at the UK's Royal Society to share the results and experiences of the initial exploration programmes, and to plan future research. The scientific goals are ultimately to identify and understand life in these extreme environments and to acquire climate records from lake-floor sediments. In this plenary talk I will provide an overview of subglacial lake research based on findings presented at the Royal Society. I will also offer a vision for future exploration in the context of internationally-agreed scientific priorities, required engineering, enhanced logistics, environmental protection and international cooperation and collaboration. I will also discuss the role played by SCAR in building the research to its current state, and how it remains essential to the development of research in the coming decade.

## ***An extensive subglacial lake and canyon system in Princess Elizabeth Land, East Antarctica***

**Stewart Jamieson**<sup>1</sup>, Neil Ross<sup>2</sup>, Jamin Greenbaum<sup>3</sup>, Duncan Young<sup>3</sup>, Alan Aitken<sup>4</sup>, Jason Roberts<sup>5</sup>, Donald Blankenship<sup>3</sup>, Sun Bo<sup>6</sup>, Martin Siegert<sup>7</sup>

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The subglacial landscape of Princess Elizabeth Land in East Antarctica is poorly constrained due to a paucity of ice-thickness measurements. This is problematic given that knowledge of the bed is important for understanding ice sheet and landscape evolution. We analyse a series of satellite imagery datasets, in conjunction with ice-penetrating radar data, to reveal ice surface expressions of macro-scale landforms beneath the ice sheet. We find evidence that a large, previously undiscovered, subglacial drainage network lies hidden beneath the East Antarctic Ice Sheet in Princess Elizabeth Land. Two distinct linear morphologies are apparent: a feature that is 140 x 20 km in dimension, and multiple narrow (ca. 10 km) sinuous features that appear connected and may extend for over 1,100 km from central PEL to the coast. We hypothesise these surface features relate to a large subglacial lake in the interior of PEL linked to a large-scale canyon system. The canyons bifurcate as they drain northwards to the coast between the Vestfold Hills and the West Ice Shelf, and are more focussed as they reach southwards to the head of the Lambert Glacier. The presence of canyons is confirmed at a few localities by radar data from the ICECAP project but no data exist over the proposed subglacial lake. The alignment of our mapped canyons and deep features identified in the radar data inland of the West Ice Shelf indicate that there may be a route for draining water from the interior of Princess Elizabeth Land to the grounding line. We suggest the lake and canyons represent a tectonically-controlled valley system incised by rivers prior to continental-scale Antarctic glaciation at 14Ma since which time it is likely to have been modified by subglacial water flow. An international aerogeophysical survey programme (ICECAP2) is now focussed on confirming the presence of these features and mapping them in detail.

## ***ICECAP-2 aerogeophysical observations of Princess Elizabeth land, east Antarctica***

**Bo Sun**<sup>1</sup>, Jamin Greenbaum<sup>2</sup>, Donald Blankenship<sup>2</sup>, Martin Siegert<sup>3</sup>, Naresh Pant<sup>4</sup>, Jingxue Guo<sup>1</sup>, Xiangbin Cui<sup>1</sup>, Bangbing Wang<sup>5</sup>, Laura Lindzey<sup>2</sup>, Lin Li<sup>6</sup>, Devsamridhi Arora<sup>4</sup>, Gregory Ng<sup>2</sup>, Thomas Richter<sup>2</sup>  
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The International Collaborative Exploration of Central East Antarctica through Airborne geophysical Profiling, part two (ICECAP-2) program is the second phase of an ongoing, multinational effort to characterize the East Antarctic subglacial environment begun by the ICECAP-1 consortium in 2008. Here we present results from the 2015/2016 survey of Princess Elizabeth Land (PEL), previously Antarctica's largest unexplored subglacial environment. The survey, consisting of 44,000 line-km of ice sounding radar, gravity, magnetics, and laser altimetry data, reveals that PEL hosts an assortment of previously-unidentified subglacial lakes and complex geomorphology, and confirms the presence and extent of a 1,100 km-long system of canyons connecting the Lambert Rift to the Leopold and Astrid Coast. The survey characterizes a subglacial lake situated within the southern section of the canyon system, likely one of the largest known lakes in Antarctica. Flight operations were managed by the Polar Research Institute of China conducted from Zhongshan Station with China's BT-67 research aircraft Snow Eagle with close participation of scientists from China, the US, India, and the UK. The China-led interior PEL survey was closely coordinated with the Australian ICECAP-2 aircraft which focused on the coastal extent of PEL.

# ***Geophysical investigations of the subglacial embayment in the Institute Ice Stream of West Antarctica***

**Muhammad Jeofry**<sup>1,3</sup>, Neil Ross<sup>2</sup>, Martin Siegert<sup>3</sup>

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The Weddell Sea (WS) sector of the West Antarctica is at a physical threshold of marine ice sheet instability and may be increasingly vulnerable under changing ocean conditions. Several studies have used numerical ice-sheet models to project future ice-sheet dynamics in this region. The models, however, are unable to appreciate and constrain complexities at the grounding line associated with the rough bed topography and inherited landscape. We will discuss evidence from radio-echo sounding (RES), which produces two-dimensional images of the subglacial terrain, on the nature of the ice sheet base around the grounding line in the WS. Using data from several airborne programmes, such as Operation IceBridge, the NERC Institute Ice Stream (IIS) survey and ImageGRADES, we illustrate the form of the grounding line in several locations. At one site adjacent to the Institute Ice Stream, where there has been considerable debate on the location of the grounding line, we reveal a hitherto unknown subglacial embayment. We also reveal an open connection between the embayment and the ice shelf cavity. Grounding line retreat across this region, if it were to happen, would likely be influenced heavily by this embayment, affecting the time and rate of migration in a manner unaccounted for in ice-sheet models. We also combined the new data to produce a new digital elevation model of the WS region, from which we discuss additional grounding line complexities.



## ***Coupled abiotic and biological cycling of elements in subsurface brine in Antarctic Lake Vida, Victoria Valley.***

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Redox cycling in iron-saturated anoxic brines played a central role in the biogeochemical evolution of life on Earth. Similar brines are thought to exist elsewhere in the solar system and may harbor life. To investigate biogeochemical cycling in a terrestrial analog we determined the iron, nitrogen and sulfur redox chemistry and isotopic signatures in frozen Lake Vida, East Antarctica. The lake's encapsulated cryogenic brine contains rich chemistry that is the subject of this study. Results suggest iron speciation in the anoxic brine is unusually high in Fe(III). Fe isotopes revealed highly depleted values that are similar to a subglacial brine from Blood Falls system, where biological iron reduction was implicated. The presence of large amounts of Fe(III) indicates dynamic iron redox cycling beyond Fe reduction. Furthermore, extremely low  $\delta^{18}\text{O-SO}_4$  values (-9.7 ‰) support microbial iron- sulfur cycling reactions. In combination with evidence for chemodenitrification resulting in iron oxidation, we conclude that coupled abiotic and biotic redox reactions are driving the iron cycle in Lake Vida brine. The results present an outlier in the current state of knowledge and may serve as an analog for icy brines found in other subsurface and subglacial habitats in addition to outer reaches of the solar system.

## ***Pathways to escape: Connecting the subglacial brine reservoir to supraglacial release at Blood Falls, Taylor Glacier, McMurdo Dry Valleys, Antarctica***

**Erin Pettit**<sup>1</sup>, Christina Carr<sup>1</sup>, Jessica Badgeley<sup>2</sup>, Joshua Charmichael<sup>3</sup>, Slawek Tulaczyk<sup>4</sup>, Jill Mikucki<sup>5</sup>, W. Berry Lyons<sup>6</sup>, Bernd Dachwald<sup>7</sup>, MIDGE Team<sup>1,2,3,4,5,6</sup>, EnEx Team<sup>7</sup>

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Blood Falls is the surface release point of microbe- and iron-rich subglacial brine that has been isolated from the atmosphere for over a million years beneath Taylor Glacier, Antarctica. Evolution of the brine microbial ecosystem is an analog for evolution of life in extreme environments due to the microbes' isolation and unique metabolic cycles. In addition to these biological processes, this direct connection to an englacial and subglacial hydrological system provides insight into movement of water beneath and within ice sheets. The brine persists underneath and within cold ice (-17°C) despite ice/brine temperature differences of 10°C, likely maintained by depressed freezing temperatures induced by cryoconcentration of brine salts and latent heat released during partial brine freezing; however, physical and chemical processes leading to episodic brine release are poorly understood. While fluid transport in non-temperate ice often occurs through meltwater delivery from the glacier surface to the bed (hydrofracturing, supraglacial lake drainage), Blood Falls represents the opposite situation: brine moves from a subglacial source to the glacier surface as an episodically flowing artesian well. We show through ground penetrating radar and seismics that an active englacial hydrologic system connects the subglacial brine source to the surface through a basal fracture network that propagates upward to link with surficial cracks. By sampling the englacial brine using Ice Mole, a clean maneuverable ice probe, we confirm that an englacial hydrological system exists 10°C below the ambient ice temperature.

## ***Development and Field Testing VALKYRIE—A prototype cryobot for clean subglacial access and sampling.***

**Victoria Siegel**<sup>1</sup>, Bartholomew Hogan<sup>1</sup>, William C. Stone<sup>1</sup>, Scott Lelievre<sup>1</sup>, Christopher Flesher<sup>1</sup>, Evan Clark<sup>1</sup>, John Harman<sup>2</sup>, Keith Huffstutler<sup>1</sup>

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VALKYRIE is an ice-penetrating robot, also known as a cryobot, developed under a NASA ASTEP grant to test new strategies and technologies for descending through thick ice sheets on the outer-planet icy moons. Technology developed on this project may provide alternative access to deep subglacial lakes on Earth with minimal contamination. The robot can be sterilized and the melt hole allowed to refreeze behind it, minimizing forward contamination. VALKYRIE uses a unique power source: a high-power laser transmits laser light to the robot via glass fiber. Upon reaching the cryobot, the 1070 nm light beam is expanded onto an infrared dispersion mirror, which redirects the light to strike the sidewalls of a cylindrical heat exchanger attached to the vehicle nose cone. The robot can descend either passively, using just the heated nose cone, or via active hot water jetting. The nose cone design incorporates a primary water jet on the centerline and secondary off-center jets that can be activated for turning. In active jetting mode, intake ports in the nose pull water into the heat exchanger and the warmed water is pumped out the nose cone jets. To identify, and thus possibly avoid, obstacles in the ice a novel end-fire Synthetic Aperture Radar was incorporated into the robot design. VALKYRIE carries a science payload consisting of a fluorescence-based multi-channel flow cytometer and water and filter sample collection systems. Autonomous sample collection algorithms were developed which evaluate real-time multichannel flow cytometer data to determine optimal triggering and timing of sampling routines.

The novel laser-over-fiber power transmission concept was first tested in the lab, where 11 kW of power were successfully transmitted over 1,050 m of bare fiber. The cryobot was constructed to use a 5 kW laser source sent over an 85 m process fiber. It was tested over the course of two month-long field seasons on the Matanuska Glacier in Alaska in 2014 and 2015. The initial prototype measured 25 cm in diameter by 2.5 m in length and the first season tested the vehicle's descent speed and turning capability. Using active jetting the robot descended to 30.52 m depth at an average rate of 0.9 m/hr and, using turning jets, achieved a 7-degree diversion angle off dead vertical. Tests were terminated, due to time constraints, with the cryobot fully functioning and all systems go. In the second field season the science payload was integrated into the vehicle. Sample collection algorithms were tested and the cryobot collected filter and water samples for subsequent laboratory analysis. The radar system was tested independently and showed ability to detect, and model for obstacle avoidance behaviors, a 1 m object 80 meters in advance. Successful completion of VALKYRIE has led to the development of advanced cryobot concept designs for the NASA-funded SPINDLE project, which will utilize Antarctic ice sheets as planetary-analog testbeds. Preliminary designs of SPINDLE will be discussed.

## ***Into the deep black sea: The icefin modular AUV for ice-covered ocean exploration***

**Britney Schmidt**<sup>1</sup>, Matthew Meister<sup>1</sup>, Anthony Spears<sup>1</sup>, Michael West<sup>1,2</sup>, Catherine Walker<sup>1</sup>, Jacob Buffo<sup>1</sup>  
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The Icefin autonomous underwater vehicle (AUV) was designed to enable long-range oceanographic exploration of physical and biological ocean environments in ice-covered regions. However, the vehicle is also well suited to work in other subglacial environments such as lakes due to its small footprint and ease of deployment. The vehicle is capable of surveying under-ice bathymetry, ice and ice-ocean interface properties, as well as water column conditions. Icefin was developed with both cryospheric and planetary exploration in mind. The first Icefin prototype was successfully operated in Antarctica in Austral summer 2014 as part of the SIMPLE project. The vehicle was deployed through a borehole in the McMurdo Ice Shelf near Black Island and successfully collected sonar, imaging, video and water column data down to the sea floor at 450 m depth.

Icefin was developed using a modular design to assure mission flexibility and maintain field portability. Each module is designed to perform specific tasks, dependent on the mission objective. Vehicle control and data systems can be stably developed, and power modules added or subtracted for mission flexibility. Multiple sensor bays can be developed in parallel to serve multiple science objectives. This design enables the vehicle to have greater depth capability as well as improved operational simplicity compared to larger vehicles with equivalent capabilities. As opposed to vehicles that require greater logistics and associated costs, Icefin can be deployed through boreholes drilled in the ice. Thus, Icefin satisfies the demands of achieving sub-ice missions while maintaining a small form factor and easy deployment necessary for repeated, low-logistical impact field programs.

The current Icefin prototype is 10.5 inches wide by 10 feet long and weighs 240 pounds. It is comprised of two thruster modules with hovering capabilities, an oceanographic sensing module, main control module and a forward-sensing module for obstacle avoidance. The oceanographic sensing module is fitted with a side scan sonar (SSS), CT sensor, altimetry profiler and Doppler Velocity Log (DVL) with current profiling. Icefin is depth-rated to 1500 m and is equipped with 3.5 km of fiber optic, Kevlar reinforced cable, which provides point-to-point communications as well as a stable recovery platform between missions. Its relatively small size and 5 degree of freedom capability make it ideal for operating in subglacial environments since hovering and variable motion are possible with little environmental disruption, while its modularity offers a chance to increase the sensor capability without having to rebuild the full vehicle.

We will discuss the development of the Icefin vehicle, and opportunities for future partnerships.

SUPPORT: Icefin was designed and built at Georgia Tech, under Dr. Britney Schmidt's startup with effort contributed from Georgia Tech Research Institute (GTRI).

## **S13. Antarctic meteorology and climatology AM1, Meeting Room 406/407, August 22, 2016, 11:30 AM - 1:30 PM**

### ***Evaluation of high-resolution MetUM and AMPS forecasts of near-surface and boundary layer meteorological variables over the Larsen C ice shelf***

**Andrew Orr**<sup>1</sup>, Amelie Kirchgaessner<sup>1</sup>, John King<sup>1</sup>, Mark Weeks<sup>2</sup>, Alan Gadian<sup>3</sup>, Peter Kuipers Munneke<sup>4</sup>, Michiel van den Broeke<sup>4</sup>, Konrad Steffen<sup>5</sup>

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High-resolution weather forecasts are an important tool for understanding the detailed patterns of surface melt on the Larsen C ice shelf (LCIS), Antarctic Peninsula. We investigate the skill of UK Met Office Unified Model (MetUM) and Antarctic Mesoscale Prediction System (AMPS) forecasts with horizontal grid spacing of 4-5 km for a 1 month period during January-February 2011 by comparing near-surface model output to automatic weather station measurements at 5 sites on the LCIS and 3 on the northern Antarctic Peninsula. Forecasts for the range 12-24 hrs showed a fairly homogeneous performance over the LCIS. In particular, both the MetUM and AMPS struggled to represent 2 m temperature, which has a strong relationship to surface melting. The 2 m temperature simulated by AMPS has a correlation with observations of 0.5-0.6 and a systematic cold bias of around -1 °C. By comparison, the MetUM had a higher correlation and was less negatively biased. The skill in forecasting other near-surface meteorological variables is also examined. For example, AMPS yielded better results than the MetUM for 10 m wind speed, being able to capture particularly well synoptically-driven high wind speeds which the MetUM systematically underestimated. Both models showed a general reduction in performance over the northern Antarctic Peninsula compared to the LCIS. Extending the analysis to consider the 12-36 hrs forecast range demonstrated a relatively weak dependence of model skill to the length of the forecast. In an effort to understand the biases in 2 m temperature, the study examines the representation of temperature profiles observed within the boundary layer over the LCIS. Additional model runs focusing on sensitivity to cloud, boundary layer, and surface schemes as well as grid spacing are performed to enable understanding into the important physical mechanisms involved as well as model behaviour.

## ***An evaluation of the performance of Polar Weather Research and Forecasting (WRF) model over West Antarctica***

**Pranab Deb**<sup>1</sup>, Andrew Orr<sup>1</sup>, Scott Hosking<sup>1</sup>, John Turner<sup>1</sup>  
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Despite the recent significant climatic changes observed over West Antarctica, which include large warming in central West Antarctica and accelerated ice loss, adequate validation of regional simulations of meteorological variables are rare for this region. To address this gap, results from a recent version of the Polar Weather Research and Forecasting model (Polar WRF) covering West Antarctica at a high horizontal resolution of 5 km were validated against near-surface meteorological observations. The model employed physics options that included the Mellor-Yamada-Nakanishi-Niino (MYNN) boundary layer scheme, the WRF Single Moment 5-Class cloud microphysics scheme, the new version of the Rapid Radiative Transfer Model for both shortwave and longwave radiation, and the Noah land surface model. Our evaluation finds this model to be a useful tool for realistically capturing the near-surface meteorological conditions. It showed high skill in simulating surface pressure (correlation  $\geq 0.97$ ), good skill for wind speed with better correlation at inland sites (0.7-0.8) compared to coastal sites (0.3-0.6), generally good representation of strong wind events, and good skill for temperature in winter (correlation  $\geq 0.8$ ). The main shortcomings of this configuration of Polar WRF are an occasional failure to properly represent transient cyclones and their influence on coastal winds, an amplified diurnal temperature cycle in summer, and a general tendency to underestimate the wind speed at inland sites in summer. Additional sensitivity studies were performed to quantify the impact of the choice of boundary layer scheme and surface boundary conditions. It is shown that the model is most sensitive to the choice of boundary layer scheme, with the representation of the temperature diurnal cycle in summer significantly improved by selecting the Mellor-Yamada-Janjic boundary layer scheme. By contrast, the model results showed little sensitivity to whether the horizontal resolution was 5 or 15 km.

## ***"Atmospheric measurements by controlled meteorological balloons in coastal areas of Antarctica"***

**Lars Robert Hole**<sup>1</sup>, Paul B. Voss<sup>2</sup>, Alexis Pérez Bello<sup>4</sup>, Tjarda Roberts<sup>3</sup>, Timo Vihma<sup>5</sup>  
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An experiment applying Controlled Meteorological (CMET) Balloons near the coast of Dronning Maud Land, Antarctica, in January 2013 is described. Two balloons were airborne for 60 and 106 hours with trajectory lengths of 885.8 km and 2367.4 km, respectively. The balloons carried out multiple controlled soundings on the atmospheric pressure, temperature and humidity up to the height of 3.3 km. The wind speed and direction were derived from the balloon drift. Observations were compared with radiosonde sounding profiles from the Halley research station, and applied in evaluating simulations carried out with the Weather Research and Forecasting (WRF) mesoscale atmospheric model. The most interesting feature detected by the CMET balloons was a mesoscale anticyclone over the Weddell Sea and the coastal zone, which was reproduced by the WRF experiment, but it was not as intense as the observed one. The modelled wind speed was up to 10 m/s lower and the relative humidity was 20-40% higher than the values observed. In other parts of our study period the WRF results showed a generally much better agreement with the observations. The study suggests that Controlled Meteorological Balloons could be an interesting supplement to Antarctic atmospheric observations, particularly in the free troposphere. In addition, analysis of data from a similar campaign in January/February 2016 will be described with emphasis on challenges in balloon navigation.



## ***A prominent melting event of the Antarctic ice-sheet surface near Syowa station in 2012/13 summer***

**Naohiko Hirasawa**<sup>1</sup>, Hideaki Motoyama<sup>1</sup>, Masahiro Hori<sup>2</sup>

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This paper investigates a prominent melting event of the Antarctic ice-sheet surface near Syowa station occurred in 2012/13 summer. We had seen scattering of many ice-pieces on the way of travel from Syowa station (69°S, 40°E, 22 m a.s.l.) to Dome Fuji station (77.5°S, 40°E, 3810 m a.s.l.). In the 2012/13 summer, we had two extreme events, both of which may generate the ice-pieces scattering. During one of them, rainfall was observed at Syowa station, which was the first time after the previous rainfall nine years ago. During the other, very high surface air temperature (SAT), 8.6°C, was observed at Syowa station, which was the highest SAT after 1979/80 summer. The lower tropospheric warming is mainly due to foehn in down-slope wind which was the circulation around a low system to the northeast of Syowa station. Analyses of the upper air and numerical simulation showed that the latter event is more plausible to form the phenomenon of scattering of ice-pieces (through melting the surface), but we cannot specify the event absolutely from the two candidates because there were no in-situ observation. However, as an effort to know the general mechanism of melting or modification of Antarctic ice-sheet surface from the climatic view, the analyses of the two events occurred in 2012/13 summer are valuable. Thus, this paper demonstrates the two synoptic-scale events with the meteorological elements observed at Syowa station, satellite data, and results obtained from numerical simulation using WRF. This paper also attempts to discuss long-term variation in SAT at Syowa station in connection with the long-term evolution of Ozone Hole.

## ***Observations and modelling of planetary boundary layer over marginal ice zone of Amundsen Sea Embayment, West Antarctica during late summer***

**Pranab Deb**<sup>1</sup>, Andrew Orr<sup>1</sup>, Richard Jones<sup>2</sup>, John Turner<sup>1</sup>, Ian Renfrew<sup>2</sup>

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Observations from 38 radiosonde launches from 1 February 2014 to 4 March 2014 are used to investigate the vertical profile of planetary boundary layer over the marginal ice zone of Amundsen Sea Embayment, West Antarctica during late austral summer. The radiosonde measurements include temperature, wind speed and direction, relative humidity and pressure. A number of distinct vertical structures are observed, including the frequent occurrence of low-level jets, which are associated with strong temperature inversions.

The observed vertical profiles are compared with output from a recent version of the Polar WRF (Weather Research and Forecasting) model with a spatial resolution of 15 km and 30 vertical levels between the surface and the model top at 50 hPa. The model contains optimised physics and boundary conditions, based on a previous evaluation study. It is shown that the model is able to simulate most of the boundary layer features, including the low-level jets, with reasonable accuracy. Output from the model is subsequently used to increase our understanding of the boundary layer processes and their importance within the marginal ice zone.

Sensitivity to vertical resolution and model top was investigated, demonstrating that increasing the number of vertical levels to 70 improved model error statistics, whereas raising the model to 10 hPa had little effect. In a separate run, the model horizontal resolution was increased to 1.67 km, but no significant improvements were apparent.

## ***Regional climate simulations over Antarctica with ACCESS and CCAM models.***

**Siobhan O'Farrell**<sup>1</sup>, Marcus Thatcher<sup>1</sup>, Jack Katzfey<sup>1</sup>, Peter Dobrohotoff<sup>1</sup>  
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CORDEX simulations are underway with ACCESS1.3 model in a global configuration at N320 (~40km) from which the individual CORDEX sub-regions can be separated out, including Antarctica. The CCAM model is also run globally, again the CORDEX sub-regions can be obtained individually and have been run at 50km resolution. The CCAM model also includes an option for interactive sea ice, and an ocean mixed layer which we have been testing high latitudes. To form the boundary conditions the ERA-INT data is nudged in above the atmospheric boundary layer using a filter with a 3000km length scale. Nudging within the ocean is based on SST error on a 500km length scale with no nudging beneath sea ice.

The analysis will focus on the climatology of the model over the continent, surface winds, temperature, accumulation and the role of the sea ice. Comparisons can be made with AMIP runs at the same resolution to examine how realistically the models are capturing the inter-annual variability and also with surface observations from automatic weather stations.

## ***Ozone simulations with the ACCESS model: Response in the stratosphere over Antarctica***

**Siobhan O'Farrell**<sup>1</sup>, Andrew Klekociuk<sup>2</sup>, John French<sup>2</sup>, Calum Knight<sup>3</sup>, Matthew Woodhouse<sup>1</sup>, Gregory Roff<sup>4</sup>  
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We have performed a set of ensemble simulations looking at the ozone response in ACCESS1-0 and ACCESS1-3 models and here summarise several different responses between the ensemble averages.

We tested the ozone response by doing “No-O<sub>3</sub>” perturbation runs where the monthly ozone distribution is held at 1960 levels and the other trace gases and aerosols follow the standard historical scenario. The ozone distribution used is the standard CMIP5 pattern which is zonally averaged above 50hPa and in this UM implementation has been zonally averaged at all levels.

At the surface we found the SAM response was not distinguishable between the historical and the “No-O<sub>3</sub>” case for both ACCESS1-0 and ACCESS1-3 in all seasons. We examined the SAM trends at 500hPa and 50hPa to see which of the two models are better able to represent the impact of ozone change during the SON season and looked at how the SAM evolves during the 21st century using the RCP45/RCP85 simulations.

Our study also examines the quasi stationary Rossby waves in the lower stratosphere and their influence on the ozone distribution. The amplitudes of these waves is biased low compared with reanalysis data. There could be a number of causes for this difference, including the vertical resolution of the simulations, the zonal averaging of the ozone distribution, and the representation of surface roughness over Antarctica in ACCESS1-3 which affects gravity wave drag.

We also have examined runs of ACCESS2 (with 85 vertical levels) where the SST is fixed but the ozone chemistry (within UKCA) is free to evolve and is controlled through the 20th Century and early 21st century by emission levels and the dynamics is nudged in the troposphere by ERA-Interim/ERA-40.

## ***Direct contribution of the stratosphere to recent West Antarctic warming in austral spring***

Julien Nicolas<sup>1</sup>, **David Bromwich**<sup>1,2</sup>

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The causes of the rapid warming of West Antarctica in recent decades are not yet fully understood. Thus far, investigations of the phenomenon have emphasized the role of tropospheric teleconnections originating from the Tropics in austral winter, but have had less success in explaining the strong warming in austral spring (SON). Here, we further explore the mechanisms behind the SON warming by focusing on September, the month during which atmospheric temperature and circulation trends in and around West Antarctica largely account for the 3-month average SON trends. We show that the tropospheric trends toward lower pressures/heights (more cyclonic) over the South Pacific sector of the Southern Ocean previously reported extend vertically well into the stratosphere. In the lower troposphere, these circulation changes, by steering more warm air toward West Antarctica, have likely contributed to the warming of the region. In the stratosphere, we provide evidence that the cyclonic trends are associated with a very prominent stratospheric warming in the Australian sector, believed to be the result of increased tropically-forced planetary wave activity and wave breaking. Through thermal wind balance, this regional stratospheric warming has led to a poleward displacement of the polar-night jet south of Australia, leading to enhanced cyclonic motion and potential vorticity (PV) downwind over the Amundsen Sea region. Finally, we establish, through the PV inversion framework, a causal link between stratospheric and tropospheric changes, whereby large PV anomalies in the stratosphere induce consistent geopotential height anomalies down in the troposphere. Our results highlight not only the important and largely overlooked role played by the stratosphere in recent West Antarctic climate change, but also a new pathway for tropical climate variability to influence Antarctic climate.

## **S20. Observing and mapping the Antarctic continent, Meeting Room 403, August 22, 2016, 11:30 AM - 1:30 PM**

### ***Covering the last major data void of Antarctica with airborne geophysics – first results of the ESA PolarGap project***

**Rene Forsberg**<sup>1</sup>, Arne Olesen<sup>1</sup>, Tom Jordan<sup>2</sup>, Fausto Ferraccioli<sup>2</sup>, Kenichi Matsuoka<sup>3</sup>

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The European Space Agency gravity field mission GOCE 2009-13, which mapped the global gravity field with hitherto unprecedented accuracy left an uncovered polar gap south of latitude 83S. This polar gap was covered in a major airborne geophysics campaign 2015/16 – the “Polar Gap” project, sponsored by ESA. Completing the gravity field coverage of Antarctica has global significance for earth geopotential models (EGM2020), geoid determination and satellite orbits; a true global gravity field coverage of the planet has thus been a “holy grail” for geodesy since more than a century.

The Polar Gap project used a BAS Twin-Otter aircraft equipped with several gravity sensors (spring gravimeter and IMU sensors), magnetometers, ice penetrating radar, and scanning lidar to collect a complete suite of airborne remote sensing data over essentially unmapped regions of the polar gap, along with more detailed flights over the subglacial Recovery Lakes region, to follow up earlier 2013 flights over this region.

The operations took place from two field camps (near Recovery Lakes and Thiel Mountains), as well as from the Amundsen-Scott South Pole station, thanks to a special arrangement with NSF. In addition to the airborne geophysics program, data with an ESA Ku-band radar were also acquired, to investigate anomalous elevation change patterns seen by the ongoing CryoSat mission.

In the talk we outline the Antarctic field operations, and show first results of the campaign, including performance of the gravity sensors, with comparison to limited existing data in the region (e.g., AGAP, IceBridge), as well as initial lidar, magnetics and radar examples. Major new features detected from the geophysical data includes a major subglacial valley system between the Pole and the Filchner-Ronne ice shelf region, as well as extended mountain systems under the ice, both consistent with observed ice stream patterns in the region.

## ***Mapping sub-ice bed topography for Antarctica from imagery***

**Peter Fretwell**<sup>1</sup>, Ted Scambos<sup>2</sup>, Andres Rivera<sup>3</sup>

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The bedrock topography of Antarctica below its ice sheet is a critical parameter for ice sheet models and for understanding the geological history of the continent. Recent compilations of direct measurements using radar and gravity, published as Bedmap (version 2 is current), have improved the coverage, resolution and visualization of the sub-ice-sheet bedrock, but some regions remain poorly mapped. Here we present a new technique that uses continent-wide ice sheet morphology from satellite imagery data (a series of MODIS mosaics), surface topography, and surface ice flow velocity to estimate the elevation of the Antarctic bed. The analysis is based upon an inversion of the driving stress equation with corrections for temperature and plasticity. We test a number of versions of the input data sets at various resolutions to find data and scaling that best replicate well-mapped areas of Bedmap2, or match RES data not incorporated in Bedmap. Results comparing Bedmap2 cells over East Antarctica to a modelled output based upon the MOA mosaic and ice velocity, show a 0.81  $r^2$  correlation with a standard deviation of 898m. The technique works best in areas of moderate flow and thin to moderate ice thickness. In such areas, especially where present RSE data is lacking or sparse, the model provides hitherto unrevealed detail. This data could be used to supplement existing Bedmap models or indicate suitable areas for detailed field survey. The Recovery Glacier region, highlighted below, is an example of such an area.



## ***Airborne ice penetrating radar surveying in Princess Elizabeth Land, East Antarctica***

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During the 32nd Chinese National Antarctic Research Expedition (CHINARE) in 2015/2016, the BT-67 airplane named Snow Eagle was firstly introduced to implement airborne geophysical survey in Antarctica. As a critical instrument, the HiCARS deep ice-penetrating radar was installed on the Snow Eagle to measure the ice sheet in Princess Elizabeth Land (PEL). The largest geophysical data gap still exists in the PEL and the bedrock topography, subglacial conditions and ice thickness is still unknown. The airborne surveying lines were designed to fan shape to achieve extensive coverage in the PEL in the first season with the base of the Zhongshan Station. Finally, about 32 000 kilometers lines were finished in 17 flights, and some flights connected the Zhongshan Station to the Chinese inland Kunlun Station, the Vostok Lake, the Ridge B and the Australian Casey Station. The field data is now being processed and preliminary results of bedrock elevation, ice thickness and subglacial water and lakes will be obtained later. The preliminary will provide the fundamental data for understanding the ice sheet and bedrock geomorphology in the PEL.

## ***Towards a digital dataset of the Antarctic geosphere: The SCAR GeoMap project and progress***

**Simon C. Cox**<sup>1</sup>, Paul Morin<sup>2</sup>, GeoMap Action Group<sup>3</sup>

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There are numerous, hard-copy, regional-scale geological maps of Antarctica that were developed last century. Many have been scanned, some have been georeferenced, but few are more than raster digital information. For the most part they are geologically reliable for defining bedrock geology ('deep time') but unfortunately they contain little representation of glacial geology. The maps have poor spatial reliability in the context of modern science (located by GPS and other satellite sensors), and the maps have not kept pace with the present importance of Antarctica's role in climate change.

The SCAR GeoMap (Geological Mapping Update of Antarctica) action group aims to facilitate an integrated programme to promote the capture of existing geological map data, update its spatial reliability, improve representation of glacial sequences and geomorphology, and enable data delivery via web-feature services. Traditionally national programs and geological surveys have mapped sheets and quadrangles using a 'bottom up' approach. GeoMap instead is taking a 'top down' construction starting from a continent-scale, low density, attribute-poor dataset that is added to and improved through multiple iterations. The top down approach is potentially more attractive to funders as it asks big questions. Glacial deposits and landforms, for example, contain a record of the waxing and waning of Antarctic ice, and help constrain the scale of Antarctica's influence on global climate and its potential contribution to future sea level rise. Studies to date have been mostly localized, and there is a distinct lack of continent-wide digital geological data. Regional-scale maps have very limited depiction of post-Miocene surficial geology and geomorphology. Spatial reliability is also highly variable and a holistic overview is difficult to obtain. GeoMap is capturing the distribution and preservation of surficial geological sequences for comparison between different regions of the continent.

In the first instance the GeoMap focus is to provide a geosphere dataset for other scientists aimed at cross-discipline use, or for continent-wide perspectives, using a mixed chronostratigraphic- and lithostratigraphic-based classification at top-level. The challenge is to collaboratively build a modern geological dataset that classifies and describes the bedrock and surficial geology of Antarctica's rock exposures – classifying and describing around 72,000 distinct polygons that cover 51,000 km<sup>2</sup> - using the international GeoSciML data format standard. Luckily this is <1% of the continent! There has been significant progress to date in the capture of digital geology in Marie Byrd Land, Dronning Maud Land, northern and southern Victoria Land and the Antarctic Peninsula - such that about 20% of Antarctic rock outcrops now have some form of geological representation assigned to them suitable for use at 1:250,000 (or more-regional) scale. Work continues to translate data attributes into a standard format. The GeoMap group welcomes anyone interested in capturing their geological and geomorphological data, or historic data from a particular region.

## ***Antarctic GeoMAP for Marie Byrd Land: A digital map of exposed and subglacial geology and surficial glacial deposits***

**Christine Siddoway**<sup>1</sup>, Samuel Elkind<sup>1</sup>, Simon C. Cox<sup>2</sup>, Belinda Smith Lyttle<sup>2</sup>

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To enable cross-disciplinary access and exploration of bedrock and surficial geology datasets from western Marie Byrd Land, Antarctica, we drew upon published geological maps (e.g. Wade et al., 1977, 1978) and field geological and geophysical data collected between 1998-2012 to create an attribute-rich, queryable GIS database at circa 1: 250 000 scale. This work is a component of the SCAR GeoMap project compilation of ground-based geological map data within a modern digital framework (<http://www.scar.org/geomap>).

Marie Byrd Land supports a major portion of the West Antarctic Ice Sheet and is subject to atmospheric and ocean warming that will contribute to sea-level rise. Marie Byrd Land is tectonically active, as is evident from Late Pleistocene to Holocene eruptive centers, englacial volcanic tephra as young as 2200 years, a site of magma propagation inferred from POLEnet seismic records, and the occurrence of an earthquake cluster of magnitude M4.4 to M5.5 on Edward VII Peninsula in 2012. Geological factors that will come in to play during deglaciation of Marie Byrd Land include subglacial volcanism and associated geothermal flux, faults and zones of alteration/mineralization that influence the position and velocity of outlet glaciers, and characteristics of bedrock units that serve to anchor or accelerate sectors of the ice sheet. Valuable records of lava-ice interaction, subglacial fluvial erosion, and glacial till accumulation during past ice sheet fluctuations exist in this region that borders the Ross Sea and Southern Ocean, but these have yet to be considered within a continent-wide digital geological and geospatial framework.

As a contribution to the continent-scale GeoMap compilation, we developed a chronostratigraphic scheme for classification, with early Paleozoic sedimentary rock and metamorphic derivatives (Swanson Formation); Paleozoic-Mesozoic rocks assigned to intrusive suites (Ford Granodiorite Suite and Byrd Coast Granite); and Cenozoic volcanic rocks, retaining local lithostratigraphic nomenclature. A geomorphic-based classification is being developed for cover sequences of glacial and other surficial deposits (colluvium or till) derived from local glaciers or larger ice sheets. Unit codes, names, descriptions, and ages have been assigned to the rock and moraine Antarctic Digital Datasets (ADD), with the location of polygons adjusted to accord with LIMA satellite imagery, when necessary. Attributes follow the international GeoSciML data format standard, with the addition of bibliographic source files that link to the original published maps. The digital dataset covers 135 000 km<sup>2</sup> of the Antarctic continental margin between 140°E to 160°E, from 75°S to 80°S, at around 1:250 000 scale. It renders 985 geology polygons.

An initial application of the GIS is to the interpretation of sub-ice geology and creation of the first subglacial geotectonic map of this active region, due to its relevance to the first geophysical survey and integrated systems study of the Ross Ice Shelf region (ROSETTA-Ice Project, 2015-18 (<http://www.ideo.columbia.edu/res/pi/rosetta/>)). The next phases of development envisioned for the Marie Byrd Land geodatabase will emphasize environmental domain analysis, ecological studies, and areas of opportunity for future interdisciplinary research.

***"The 2014-15 McMurdo dry valleys baseline; coordinated lidar, air photography and satellite based electro-optical imagery"***

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The McMurdo Dry Valleys are the largest snow free area in Antarctica. In the 2014-15 season the National Center for Airborne Laser Mapping acquired over 3600 km<sup>2</sup> of airborne LiDAR gridded to a 25 cm posting acquired using 133 flight hours over 52 days. All of the major, ice free areas were covered including, Wright, Taylor, Victoria, Beacon, McKelvey and Barwick Valleys. In addition, more than 21,000 air photos with a ground resolution of 4 cm were acquired. Concurrent with this work, the Polar Geospatial Center acquired seamless stereo coverage of 32-42 cm resolution electro-optical imagery. The goal of this project is to provide researchers with a second LiDAR time-step to complement the LiDAR survey in the 2001-2002 season. Distribution of the elevation data is through [opentopography.org](http://opentopography.org). A Dry Valleys Viewer and web services will be available through the Polar Geospatial Center's Website. This section of the Transantarctic Mountains is now one of the most well surveyed areas on the anywhere on earth.

## ***Application of high-resolution satellite imagery for semiautomated mapping of cryospheric vegetation in the Antarctic environment***

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Vegetation mapping based on distribution and density of cryospheric plant communities at fine spatial scales is progressively more supported by remote sensing technology. Mapping and monitoring such changes at the landscape scale is frequently problematical, particularly in remote cryospheric areas, such as Antarctica. Multi-temporal imaging with high spatial resolution satellite sensors provides more detailed seasonal geo-information of vegetation changes frequently. In the present study, multispectral imagery (MSI) and panchromatic imagery (PAN) from very high resolution WorldView-2 (WV-2) have been used for semiautomated extraction of vegetation cover in different forms in the Antarctic environment. This study statistically evaluates supervised and unsupervised classification methods to extract vegetation in Larsemann Hills and Schirmacher oasis, East Antarctica. A range of supervised classification methods were employed on pansharpened WV-2 imagery to classify vegetation cover. Vegetation extraction results were tested using independent ground reference datasets generated by field campaigns and manual digitization. One of the highlight of the present study is that the overall accuracy of vegetation mapping using WV-2 imagery using supervised classification methods ranged from 90% to 92%. Presently, we are carrying out vegetation mapping using object-oriented classification scheme and the preliminary results will be presented and discussed in forthcoming SCAR open science conference.

## ***A new fully automated methodology for differentiating rock and ice in Antarctic from Landsat imagery***

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Differentiating rock outcrop from snow and ice is a particular problem in Antarctica where extensive cloud cover and widespread shaded regions lead to classification errors. The existing rock outcrop dataset has significant georeferencing issues including overestimation and generalisation of rock exposure areas. The existing method for automated rock and snow differentiation, the Normalised Difference Snow Index (NDSI), has difficulty differentiating rock and ice in Antarctica due to misclassification of shaded pixels and cannot differentiate illuminated rock from clouds. This study presents a new method for identifying rock exposures using Landsat 8 data. This is the first fully automated methodology for snow and rock differentiation that excludes areas of snow (both illuminated and shaded), clouds and liquid water whilst identifying both sunlit and shaded rock, achieving higher and more consistent accuracies than alternative data and methods such as the NDSI. The new methodology has been applied to the whole Antarctic continent (north of 82°40' S) using Landsat 8 data to produce a new rock outcrop dataset for Antarctica. The new data (merged with existing data south of 82°40' S) reveals that exposed rock forms 0.18% of the total land area of Antarctica; half of previous estimates.

## **S23. Microbes, diversity, and ecological roles, Meeting Room 401/402, August 22, 2016, 11:30 AM - 1:30 PM**

### ***Convergent microbial ecosystem functions in the McMurdo and Palmer LTERs, two Antarctic aquatic extremes***

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The aquatic environments in the two Antarctic Long Term Ecological Research sites, Palmer (PAL) and the McMurdo Dry Valleys (MCM), represent starkly contrasting polar ecosystems. PAL, a seasonally ice free marine environment, spans from highly productive nearshore waters harboring a rich guild of large predators to less productive waters over the continental slope. MCM covers a range of aquatic and terrestrial environments including several perennially ice covered lakes of marine origin. These lakes are characterized by their isolation, permanent ice-covers, chemical stratification, and few metazoan predators. Despite these differences the PAL and MCM ecosystems are influenced by many of the same environmental factors, including low temperature and changing climate. To explore microbial ecosystem functions that may reflect fundamental differences and similarities between these sites we estimated bacterial metabolic potential from 16S rRNA gene-based analyses of bacterial community structure with the paprica metabolic inference method. For both PAL and MCM likely metabolic functions were structured according to depth and season, with highly specialized low-abundance metabolic pathways accounting for much of the variability between samples. Overall the dissimilarity between PAL and MCM samples was greater in taxonomic than metabolic space, suggesting that microbial functions are more broadly conserved than microbial taxa. Consistent with this finding *Candidatus Pelagibacter ubique* HTCC1062 and *Tropheryma whipplei*, the most closely related genomes to the dominant 16S rRNA phylotypes at PAL and MCM, have considerable functional overlap despite their distant taxonomic relatedness. In addition to the presence of specific metabolic pathways these overlaps include high coding density, small genomes, and the absence of cell motility; all adaptations to low-energy environments. We will describe the predicted genomic features of these divergent microbial ecosystems in greater detail, and discuss a novel classification scheme for exploring how microbial communities change across time and space.

## ***Bacteria from Antarctic macroalgae: A treasure of biodiversity and biotechnological potential***

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The Antarctic marine environment possess a rich biodiversity and high degree of endemism of macroalgal species. Despite this high diversity, few studies to date have explored the diversity, ecological role and biotechnological potential of the microbiota associated with Antarctic algal species.

The aim of this research project was to explore the phylogenetic diversity and biotechnological potential of epiphytic bacteria isolated from Antarctic macroalgae. Specimens of brown (*Adenocystis utricularis*), green (*Monostroma hariotti*) and red algae (*Georgiella confluens*, *Iridaea cordata*, *Pantoneura plocamioides*, *Phycodrys antarctica*, *Pyropia endiviifolia* and *Plocamium cartilagineum*) were collected as attached plants from the intertidal and subtidal zone (5 and 30 m) of King George Island, in January 2014. Surface-associated bacteria were investigated by cultivation-based methods and 16S rRNA gene sequencing. Epibiotic bacteria were screened for antibacterial activity against a panel of medical bacteria and antarctic macroalgae-associated microorganisms. Isolated bacteria were also screened for agarase, lambda- and iota-carrageenase activities on substrate-specific media, and enzymatic activities were quantified by spectrophotometric determination of reducing sugars.

Our results highlight the importance of Antarctic macroalgae as a rich source of Gram-positive bacteria. Analysis of 16S rRNA gene sequences revealed that Gram-positive, epiphytic bacteria were affiliated with 17 genera of Actinobacteria (*Aeromicrobium*, *Agrococcus*, *Amycolatopsis*, *Arthrobacter*, *Brachybacterium*, *Citricoccus*, *Janibacter*, *Kocuria*, *Labeledella*, *Microbacterium*, *Micrococcus*, *Pseudonocardia*, *Rhodococcus*, *Salinibacterium*, *Streptomyces*, *Sanguibacter* and *Tessaracoccus*) and two genera of the Firmicutes (*Staphylococcus* and *Planomicrobium*). Two bacterial phylotypes within Actinobacteria were regarded as potential candidates for new species. Bioactivity was found against *Escherichia coli*, *Mycobacterium smegmatis*, *Listeria monocytogenes* and resident bacteria of macroalgae. The bioactive genera were *Agrococcus*, *Brachybacterium*, *Citricoccus*, *Kocuria*, *Pseudonocardia* and *Streptomyces*. Agarase and carrageenase producers were identified as members of the Gram-negative genera *Cellulophaga* and *Pseudoalteromonas*. Quantitative assays of enzymatic activity in cell-free supernatans showed polysaccharide-degrading activity at low temperature (4°C), which suggest the metabolic adaptation of these epiphytic bacteria to polar environments through the production of cold-active enzymes.

It is concluded that Antarctic macroalgae are an important reservoir of bacterial diversity, and may be a potential source of bacteria producing novel biotechnologically important products.

### **Acknowledgements**

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## ***Microbial community structure in different snow types from King George Island, Antarctica***

Cecilia Chiriac<sup>1</sup>, Corina Itcus<sup>2</sup>, Cristina Purcarea<sup>2,3</sup>, Nicolae Dragos<sup>1</sup>, Knut Rudi<sup>4</sup>, Sorin Marius Avramescu<sup>5</sup>, Irina Fierascu<sup>6</sup>, Lucian Barbu-Tudoran<sup>7</sup>, Iris Tusa<sup>2</sup>, Manuela Elisabeta Sidoroff<sup>2</sup>, **Cristian Coman<sup>1</sup>**

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Snow and ice are extreme habitats that impose specific conditions on microbial life. Even though seasonal snow is an important feature of polar areas, relatively little is known about microbial diversity and life in this environment, especially in Antarctica.

In this study we investigated the microbial diversity in several snow types collected during the ROICE 2015 field trip to NW Antarctica, King George Island: snow with algal blooms, dark and brown snow, clean snow. In order to investigate the bacterial biodiversity associated with each snow types, the samples were thawed and the following analyses were performed: measurement of physical and chemical parameters (pH, conductivity, anion and cation concentration, carbon content etc.), light microscopy for identification and characterization of microalgae, SEM-EDX of the filtered particles, DNA extraction and microbial community metabarcoding by partial sequencing of 16S rRNA genes on an Illumina platform.

To our knowledge, this is the first comparative analysis of microbial diversity in different types of snow on King George Island, Antarctica. The results obtained provide strong evidence that the microbial diversity might be specific to each snow type. Even though at the phylum level the diversity of microorganisms is similar among the samples, with the dominance of Proteobacteria (Alpha-, Beta- and Gamma-), Actinobacteria and Bacteroidetes, at lower levels each snow type has its own taxonomic signature that might be influenced by several factors: the physical and chemical characteristics of the snow type, particle type and abundance, nutrient availability etc.

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## ***Comparative analysis of microbial diversity in soils of maritime Antarctica***

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Geographic and climatic conditions of terrestrial environment in maritime Antarctica contribute to colonization of ice-free areas and development of soil microbial communities. We have studied structure and diversity of bacterial communities from five soil samples collected on Fildes Peninsula (King George Island, Antarctica) by using high-throughput pyrosequencing based on analysis of amplified 16S rRNA genes.

At the phylum level, highly diverse soil microbial communities were represented by 19-21 bacterial phyla: six dominant phyla affiliated with Proteobacteria, Actinobacteria, Acidobacteria, Bacteroidetes, Verrucomicrobia and Gemmatimonadetes; nine phyla consistently present across all samples in lower abundance (Planctomycetes, Chloroflexi, Firmicutes, Cyanobacteria, Nitrospirae, Armatimonadetes, Latescibacteria, candidate divisions WPS-1 and WPS-2), and six phyla with low occurrence detected in few samples (Chlamydiae, Deinococcus-Thermus, Elusimicrobia, Candidatus Saccharibacteria and candidate division BRC1). The most abundant phylotypes at the genus level in all samples were Gaiella, Gemmatimonas, Serratia, Gp4, Gp6, and Gp7 of Acidobacteria, as well as at the class level - Spartobacteria.

The most significant differences at both phylum and genus levels were detected between the soils from the coastal area with thick plant cover and the arid soils from the area distant from the coastline. Soils from the top of the hills with poor vegetation cover showed the greatest bacterial diversity - 851 OTUs at the 3% evolutionary distance, diversity by Shannon's index made 5.93. Proportion of Actinobacteria (23% average) was 2-6 times higher compared to other samples. Also, fifteen unique genera specific only for these samples were detected.

Proteobacteria strongly dominated in the soil microbiomes from the areas distant from the coastline covered with thick moss and lichen, whereby Serratia phylotypes accounted for over 50% of reads.

The lowest bacterial diversity (497 OTUs) and the most equable proportion of dominant phyla were detected in a sample of the coastal soil with thick moss and *D. antarctica* cover. Among all samples, the abundance of Proteobacteria was the lowest (20.4%), but proportions of Acidobacteria (24%) and Verrucomicrobia (16%) were 2.6 – 3.6 times higher compared to the soils from the area distant from the coastline. Coastal soil was the only sample that revealed Gemmatimonadetes as dominant phylum (8.5%), which indicates that the marine environment has significant impact on the formation of the terrestrial microbial communities. At the genus level, Chitinophaga, Bradyrhizobium and Gp4 of Acidobacteria were the most abundant phylotypes of the bacterial community. The following genera were found to be specific only for this sample: Bosea, Inquilinus, Neochlamydia, Nitrobacter, Nitrososphaera, Pedomicrobium and Sideroxydans.

Distance from the coastline and thickness of the plant cover were found to be important biogeographic factors influencing the composition of soil microbial communities. Our findings indicate that the lack of vegetation and harsh environment of arid soils do not facilitate domination of low phylotype number, thus more heterogeneous structure is required for efficient survival of the microbial community.

## ***Wintertime bacterial communities in changing Antarctic sea ice***

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During winter sea-ice bacterial communities resemble those in the parent water from which the ice was derived, remaining nearly unchanged in the upper ice column. Sea ice communities begin to change in spring, following the light-induced onset of algal growth that provides the autochthonous substrate for bacteria. Predominant bacterial classes in spring are the copiotrophic Gammaproteobacteria, Flavobacteriia and Alphaproteobacteria. Most studies on sea-ice bacterial communities studies were, however conducted during spring and summer.

Our knowledge of bacterial diversity in winter sea ice is only based on two earlier studies, both conducted in the Arctic. The diversity of Antarctic bacterial communities in winter is therefore largely unknown. Information on winter bacterial diversity and activity will enable us to understand their biogeochemical role during ice covered periods. It will also facilitate a discussion on the potential consequences of a diminishing sea-ice cover on the biogeochemical cycles and food webs of ice-covered seas.

Samples were collected from both first and second-year sea-ice samples from the Weddell Sea, aboard R/V Polarstern during austral winter (June-July) 2013. Bacterial communities were studied with paired-end sequencing of 16S rRNA genes using Illumina MiSeq coupled with bacterial production (incorporation of 3H-labelled thymidine) and abundance measurements (Flow cytometer).

Sea ice was exceptionally permeable considering the season (Tison et al., in prep.) and chlorophyll-a (chl-a) concentrations in first-year ice were comparable to those in the Arctic during winter/spring transition (range 0-18.1  $\mu\text{g L}^{-1}$ , mean 4.8  $\mu\text{g L}^{-1}$ ). In second-year ice, chl-a concentrations were as high as 113.2  $\mu\text{g L}^{-1}$ . Bacterial communities were dominated by classes of copiotrophic Alphaproteobacteria, Flavobacteriia and Gammaproteobacteria, similar to those found in Spring Arctic sea ice. In addition to first- and second-year ice, rafted ice with high algal biomass trapped inbetween two ice floes was sampled. This ice hosted a distinctly different bacterial community which included anaerobic Deltaproteobacteria.

Bacterial production was equal or higher than that observed in the Arctic during the winter/spring transition (range 0-1, mean 0.3  $\text{pmol L}^{-1} \text{h}^{-1}$ ). Highest bacterial production (6  $\text{pmol L}^{-1} \text{h}^{-1}$ ) and abundance (4.2  $\times 10^6$  cells  $\text{mL}^{-1}$  in bulk ice) were detected in the "old-ice layer" of second-year ice, congruently with highest chl-a concentrations measured. Results indicate that bacterial communities were likely driven by untypically high chl-a concentrations in winter sea ice. The observation on active bacterial communities indicates that the climate warming can potentially alter bacteria-mediated biogeochemical processes such as nutrient cycles during the austral winter.

## ***Microbial dynamics in frontal regimes of the Indian Ocean Sector of Southern Ocean: Role of organic carbon and grazers***

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Seawater samples were collected from 8 depths (0, 10, 30, 50, 75, 100, 120 and 200 m) at 9 stations spread across three different oceanographic frontal regimes during the austral summer, 2012. Based on the oceanographic characteristics, the three fronts were identified as Sub-tropical front (STF), Sub-Antarctic Front (SAF) and Polar Front (PF). The seawater samples were analyzed for a suite of parameters including chlorophyll a (chl a), total bacterial abundance, nutrients (nitrate, nitrite, phosphate and silicate), dissolved oxygen, total organic carbon (TOC) and Particulate organic carbon (%C[POM]). Further, onboard primary production (PP) experiments were also carried out using <sup>14</sup>C-substrates. The column integrated primary productivity showed large variations within STF and ranged from 187.8 mgC m<sup>-2</sup> d<sup>-1</sup> (43°S, 57.5°E) to 905.6 mgC m<sup>-2</sup> d<sup>-1</sup> (43°S, 53.5°E) while in PF it was 695.3 mgC m<sup>-2</sup> d<sup>-1</sup>. Spatially, STF was dominated by flagellates (both mixotrophs and heterotrophs) while SAF and PF were dominated by diatoms. Spatial distribution of surface chl a ranged from 0.12 mg m<sup>-3</sup> (40°S, 53.5°E) to 1.12 mg m<sup>-3</sup> (43°S, 58.5°E) while total bacterial abundance ranged from 7.5 x 10<sup>6</sup> cells ml<sup>-1</sup> (40°S, 58.5°E) to 40 x 10<sup>6</sup> cells ml<sup>-1</sup> (53°S, 57.5°E). Vertical profiles clearly showed the sub-surface chlorophyll maxima was deepest (100 m) at 53°S, 57.5°E shallowest (30 m) at 43°S, 58.5°E. Column integrated bacterial biomass ranged from 331.7 to 8167.4 µg-C m<sup>-2</sup> and did not show any significant correlation with PP and chl a. The high surface bacterial abundance matched with low TOC concentration (PF) while TOC was highest in STF with least bacterial biomass due to predominance of grazers like flagellates. The TOC concentrations showed inverse correlation with primary production but linear correlation with chl a highlighting the varying sources and characteristics of TOC in the study area. Moreover, bacterial biomass showed linear but statistically insignificant trend with TOC but significant correlation ( $r=0.496$ ;  $p<0.001$ ) with %C[POM]. Our study highlights that bacterial biomass across the frontal regimes varied largely due to chemical characteristics of available carbon and grazing pressure.

## ***Characterization of a novel Talaromyces species with strong antimicrobial activities isolated from Deception Island***

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Deception island has been well known for harbouring highly diverse and exceptionally rare microbial species, particularly fungi, due to its unique volcanic environment in Antarctica. This study describes a novel *Talaromyces* species, designated Im33, isolated from Deception island on the basis of morphological, physiological and molecular phylogenetic analyses, as well as the antimicrobial activities against foodborne pathogens. Our findings showed that *Talaromyces* sp. strain Im33 is a psychrotolerant fungus with optimum growth at around 30°C. It appeared as yellow filamentous colonies with orange diffusible pigments on yeast extract-malt extract agar. It was found to possess a variety of enzymes which break down arabinose, fructose, galactose, glucose, inositol, mannitol, mannose, raffinose, sorbitol, sucrose and xylose. Scanning electron microscopic observation and sequence analysis of the internal transcribed spacer regions (ITS-1 and ITS-2) revealed that this strain belonged to the genus *Talaromyces* which clearly diverged from other known species. It was resistant to high cycloheximide concentrations and was capable of inhibiting both Gram positive and Gram negative foodborne pathogens such as *Bacillus cereus*, *Salmonella* spp., *Staphylococcus* spp., *Enterococcus* spp. and so on. Antimicrobial activity of *Talaromyces* strain Im33 was stable at high temperature (100°C/210min) and over a broad pH range (2 - 12). The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of the crude extract against *Escherichia coli* TOP10 were 150 µg/ml and 175 µg/ml. The 72-hr LC50 for the crude extract was 3,863 µg/ml in brine shrimp lethality assay, indicating that the crude extract was non-toxic. We can conclude that this is the first report of a *Talaromyces* species with thermostable antimicrobial compounds from Deception island.

## ***The structure and succession of copper-resistant bacterial communities from the soils of the King George island***

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Abiotic factors are believed to influence the structure of microbial communities in terrestrial Antarctic environments, while trace metals also play important role in shaping the community variation. Copper can be one of such factors since it enters into environments during rock weathering processes and appears to be an abundant anthropogenic pollutant.

Five soil samples were collected on ice-free areas of Fildes Peninsula (King George Island, Antarctica) to discover changes in the microbial communities under the action of copper ions. We studied the formation of the metal-resistant microbial community and its succession in the presence of 200 mg/L Cu(II) ions during 6 days by using 454 pyrosequencing of V4-V8 variable regions of 16S rDNA amplicons.

Metal-resistant communities showed lower heterogeneity of their structure compared to natural diversity of the soil bacterial communities (19-21 phyla) and included 11 phyla (3-8 phyla in each community) - Proteobacteria, Firmicutes, Verrucomicrobia, Actinobacteria, Gemmatimonadetes, Acidobacteria, Bacteroidetes, Cyanobacteria, Planctomycetes, Chloroflexi and Nitrospira.

The dominant part of the Cu-resistant community was bacteria detected in the natural soil samples only as low-abundant or unique sequences – members of the genera *Pseudomonas*, *Ralstonia*, *Microbacterium*, *Caulobacter*, *Methylobacterium*, *Sphingomonas* and *Bacillus*, while genera *Massilia*, *Polaromonas*, *Brevundimonas*, *Rhodococcus* and class *Spartobacteria*, which were abundant in natural communities, accounted for only a smaller proportion.

We have observed 3 different scenarios of succession in Antarctic Cu-resistant bacterial communities: 1) rapid increase in the proportion followed by complete dominance of Gammaproteobacteria; 2) shift of the dominant phylum from Proteobacteria to Firmicutes; 3) gradual increase in the proportion of Actinobacteria during the community incubation.

Diversity of the Cu-resistant community significantly varied and did not depend on the initial diversity of the soil sample. Diversity by Shannon's index in natural communities was in range 4.4-5.9 while for Cu-resistant communities it varied from 1.9 to 0.2. At early stages of the community growth at the 3% evolutionary distance were detected 22-62 OTUs depending on the sampling site (the highest in samples selected on slopes with rich moss and lichen cover). During the growth and succession of the microbial community the tendency to decreasing diversity to 15-40 OTUs was observed. At the same time, at late stages surprisingly high diversity of Cu-resistant anaerobic bacteria that belong to Clostridia class – *Tissierella*, *Clostridium sensu stricto* and *Anaerosporebacter*, was found. Among them, unclassified bacteria of family Ruminococcaceae were the dominant phylotypes that accounted for 30% of total reads.

Three typical strains representing Cu-resistant Antarctic soil bacterial communities were isolated and identified as *Ralstonia pickettii* KG85, *Pseudomonas veronii* KG147 and *Microbacterium laevaniformans* KG138.

The findings of this study contribute to knowledge about the adaptation of highly heterogeneous microbial communities and their changes under pressure of extreme natural and anthropogenic abiotic factors.

## **S24. Physiological adaptations in Antarctic organisms AM1, Meeting Room 404, August 22, 2016, 11:30 AM - 1:30 PM**

### ***Protein structure, function, stability and dynamics in changing environments. Structural constraints and evolution at low temperature***

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Many studies suggest that climate change will be the greatest global threat to biodiversity over the next several decades. The unusual rate of environmental alterations may exceed the capacity of mechanisms that populations have evolved to deal with environmental change. Under changing conditions, species may no longer stay adapted to the new conditions and could therefore fall outside their climatic niche. Of particular concern are “tipping points” where ecosystem thresholds can lead to irreversible shifts. Many ecosystems can undergo sudden jumps in response to changes in the proximity of these thresholds or tipping points. As environmental pressure exceeds the threshold or tipping point, the ecosystem rearranges and falls into an alternative state, leading to an abrupt change that we cannot predict. However the main question in the debate on climate change is whether some species will be able to adapt fast enough to keep up with the rapid pace of changing climate. Whatever the type of adaptive responses, underlying mechanisms are due either to evolution or plasticity. Empirical evidence suggests that physiological plasticity is often more important than genetic contribution in complex, long-living species. Therefore, the critical rate of environmental change is generally lower for species with longer generation times; as a consequence, these species will be at greater extinction risk.

Some of the most striking impacts of global climate change are appearing in polar oceans, where temperature and acidity are changing at more than twice the global average speed. The biological effects of increasing temperature on marine ecosystems are already evident. Temperature governs the rate of chemical reactions and pathways regulating the development and decline of life. Sensitivity to temperature influences the success of organisms in all habitats, and is caused by the susceptibility of biochemical processes, including protein function, to temperature change. Thermodynamic limits to growth rate are dictated by protein thermal stability that in turn governs biological rates. Therefore the thermal stability of proteins is a unifying property in the evolution and adaptation of life on Earth. However, when for instance we consider the primary structure, despite many advances in our understanding of structure–function relationships, we cannot yet predict how the replacement of a particular amino acid residue can affect temperature sensitivity of protein function. Recent studies indicate that only minor structural modifications are needed to change the intrinsic stability of cold-adapted proteins, and that local rather than global flexibility may play an important role.

In this review, we first summarise how cold temperature affects the physiology, then focus on the molecular mechanisms of cold adaptation revealed by recent biophysical, biochemical and genetic studies of a specific group: oxygen-binding proteins. Next, we also discuss the structural and functional features of the cold-adapted globins, in an attempt to put into perspective what has been learnt about these proteins and their role in the biology of cold-adapted species.

# ***Assessing the physiological plasticity of notothenioid fishes using an integrated approach***

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Background: Antarctic fishes of the suborder Notothenioidei have displayed incredibly narrow physiological limits in previous single stressor studies and may be particularly vulnerable to the impacts of global climate change. Given the propensity for both adaptive and potentially mal-adaptive traits found among many species of this suborder, this system provides a unique opportunity to examine physiological trade-offs associated with acclimation to a multi-stressor environment. Here we describe an effort by our research group to combine approaches from the fields of functional genomics and ecological physiology to examine how global climate change may impact the performance of several species of notothenioid fish. By undertaking this comparative approach, we aim to create a framework for predicting population level responses for the suborder as a whole and draw inferences with respect to the stability of hard to study populations under future climatic conditions. This approach may provide critical insight into potential disruptions in food web dynamics of the Southern Ocean as well as the appropriateness of current management principles for an emerging fishery.

Results: We found a significant difference in the overall transcriptomic and physiological response of closely related notothenioid species when acclimated to multiple stressors over a 56d period. *Trematomus bernacchii* demonstrated a strong stress response in the form of metabolic shifts, DNA damage repair, immune system processes, and activation of apoptotic pathways combined with negative regulation of cell proliferation. While the magnitude of this response declined over time, there is some indication *T. bernacchii* is not fully capable of compensating for these environmental perturbations. Similar physiological trends were found in *T. newnesi*; however, the underlying molecular mechanisms employed may differ. On the other-hand, *Pagothenia borchgrevinki* displayed a muted response suggesting a relative insensitivity to the multi-stressor scenario. Despite having an overall muted transcriptional response, we did observe an inducible increase in the molecular chaperone HSP90 in *P. borchgrevinki*, a highly unexpected finding.

Conclusions: To our knowledge, this is the first study to observe elevated expression of any of the major HSPs in an archetypal notothenioid and highlights the importance of using longer-term acclimations in combination with co-variation of multiple stressors in studies assessing the physiological plasticity of polar organisms. Furthermore, while we have evidence that some notothenioid species may lack a level of physiological plasticity necessary to offset rapid environmental changes, it is still unclear how this may affect the fate of these unique fishes in the face of large-scale climate change. It is however quite clear that there are strong species-specific differences in response to environmental perturbation based on physiological and molecular comparisons between closely related notothenioids. As such, future studies and discussions should be cognizant of the possibility that there may not be a generalized pattern of response to stress across Antarctic notothenioids.



## ***Effects of environmental pollutants and changing temperature on the hepatic energy budget of High-Antarctic fish***

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**Objectives:** So far, High-Antarctic waters have been considered a stable environment, unaffected by climate change and chemical pollution. However, due to atmospheric transport and global distillation of persistent organic pollutants, toxic contaminants precipitate and are deposited in the Antarctic environment. As ice acts as a long-term reservoir accumulating organic pollutants, the predicted future seawater-warming and pack-ice melting in the Antarctic may lead to increased pollutant concentrations in remote areas.

The main goal of our study was to elucidate the capacity of cold-stenotherm fish to cope with the challenge of organic pollutants under conditions of increased temperature. Our experiments were aimed to assess how anthropogenic pollutants and acute warming could affect energy metabolism and, as a consequence, physiological costs in response to these global change parameters.

We isolated liver cells of the red-blooded *Trematomus loennbergii* and the white-blooded *Chionodraco hamatus*. Afterwards, we measured cell-respiration during exposure to either benzo(a)pyrene,  $\alpha$ -naphthoflavone or a mixture of both compounds. Cell metabolism was assessed at 0 and 6°C in control and acutely toxicant exposed hepatocytes.

**Results:** Our results revealed that High-Antarctic fish respond to acute toxicant exposure by an increase in hepatocyte metabolism, suggesting an induction of detoxification processes. The red-blooded fish *T. loennbergii* showed a larger increase in hepatocyte metabolism related to toxicant metabolism than the icefish *C. hamatus*. Acute temperature increase had caused a slight depression of liver metabolism in both species, however, this effect was more pronounced in the white-blooded species.

**Conclusions:** Our findings reflect the extreme heat-sensitivity of white-blooded Antarctic fish species compared to red-blooded notothenioids. Furthermore, the icefish appeared more sensitive to combined stressor exposure (warming and toxicants) – than red-blooded High-Antarctic fish. In the end, such species-specific differences in the vulnerability towards global change might strongly influence the fragile ecosystem balance of the Antarctic Ocean in the future.

## ***Cellular versus whole organismal thermal tolerance in Antarctic fishes: Are these animals more sensitive than we thought?***

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The coastal fish fauna of Antarctica is remarkably stenothermal, with upper thermal limits of just 6-8 °C. These animals are known for their numerous adaptations to cold and ice including antifreeze proteins and cold-adapted enzymes and membranes. Despite these evolutionary gains, species of the suborder Notothenioidei have apparently lost the ability to upregulate the production of heat-shock proteins in response to environmental stress. Even without this classical heat shock response, however, certain fishes possess the ability to acclimate to higher temperatures. Researchers are keen to know which molecular mechanisms are still in place that may allow these animals to raise their upper thermal limits. We recently demonstrated the upregulation of C/EBP- $\delta$  in the common Antarctic fish *Trematomus bernacchii*. This transcription factor is associated with exit from the cell cycle as well as the initiation of apoptosis. Flow cytometry and western blotting allowed us to investigate cell fate in hepatocytes isolated from *T. bernacchii*. We found that temperatures as low as 2 °C were sufficient to induce programmed cell death in this system. The disparity between the observed cellular and whole organismal thermal limits raises some important questions. Here I will discuss the possible implications of a cellular-organismal mismatch in these animals' susceptibility to future climate change.

## ***Expression of antioxidants proteins in Antarctic sea urchin during thermal stress.***

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Extreme cold temperatures present in polar environments allow increased oxygen solubility; this situation could produce a high rate of oxidation by formation of reactive oxygen species (ROS) and also affect the stability of proteins in Antarctic marine invertebrates. We evaluated the effect of warming in the antioxidant response of Antarctic sea urchins (*Sterechinus neumayeri*) exposed to thermal stress. During the acute thermal stress and long term thermal stress the transcriptional activity of superoxide dismutase (SOD), catalase (CAT) and metallothionein (MT) was measured by real time RT-PCR. The expression of SOD, CAT and MT during the acute thermal stress at 3°C and 6 °C was measured in short-term cultures of coelomocytes, while the expression a long term was measured in coelomocytes obtained from the coelomic fluid of adult urchin stressed during three weeks at 3°C. During the acute thermal stress the expression of catalase and metallothionein increased significantly at 6°C, whereas the super oxide dismutase decreased at 3°C after 1h and 24h. The heat shock at 3°C during a long period of three weeks did not produce a significant response of superoxide dismutase and catalase in coelomocytes. Sequences obtained by NGS sequencing showed that Cu-Zn SOD and catalase proved highly conservative with respect to amino acid sequence as well as to catalytic sites when compared to others temperate antioxidants enzymes. Apparently, little or no modification of the enzyme molecular structure has occurred in response to evolutionary cold adaptation in sea urchins. Using the sequence information we have produced specific antibodies. We determined that CAT and SOD proteins decrease significantly their expression after thermal stress at 3°C during the week two and three. The genes CAT and MT shown upregulation during acute thermal stress; however, this was produced at higher temperatures than 3°C. During the long period exposition at 3°C we determined that low transcriptional expression for these genes may be correlated by a lesser protein expression. After three weeks, the expression of antioxidant enzymes was not significantly different at 3°C. These data show that under long periods of moderate thermal stress the immune cells of adult *S. neumayeri* seem to maintain their rate expression of antioxidants enzymes, with relatively little measureable effect. Our findings confirm coelomocytes as a sensitive cell for environmental studies and we propose their use for analyses on the effects of warming and ocean acidification.

## ***Allies, cheaters, & thieves: Macroalgal-mesograzer interactions along the western Antarctic peninsula***

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Macroalgae dominate the hard benthos along the Western Antarctic Peninsula to depths of up to 40 m or more. Most of the macroalgae are chemically defended from a variety of macro- and mesograzers but harbor very high densities of amphipod mesograzers. The amphipods benefit from living on the large, chemically-defended macroalgae because they gain refuge from fish which are their primary predators. Most amphipod species do not consume most of the macroalgal species, but are of benefit to the macroalgae by keeping them relatively clean of epiphytic microalgae and filamentous macroalgae. One amphipod species does consume some of the chemically defended red algal species and is able to sequester algal metabolites for its own use as defenses against fish. This is the first known incidence of defensive metabolite sequestration in marine arthropods. Feeding rates of this amphipod on its preferred chemically defended host vary noticeably between experiments with algae from different collection sites. A combined genetic and chemical analysis of the alga from different collection sites revealed that it divides into two closely related phylogroups, not distinct enough to be considered separate species, each of which is further divided into one of five chemogroups. The chemogroups are largely collection-site specific except for differences between individuals of the two phylogroups.

**S29. From the top: Higher trophic predators as ecosystem sentinels D1 AM, Meeting Room 410, August 22, 2016, 11:30 AM - 1:30 PM**

***Sentinels of South: Monitoring vertebrate populations in Larsemann Hills, East Antarctica- Current Status and Opportunities***

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**Aim:** Seabirds have been studied extensively as the indicators of ecosystem change in Southern ocean. This study was initiated to assess abundance, distribution patterns and nesting behaviour of seabirds in the Indian sector of operation of Southern ocean and Antarctica.

**Study area:** Southern Indian Ocean and Larsemann Hills (East Antarctica), located in the Prydz bay region, comprise of several partially ice-free islands spread over an area of 50 Km<sup>2</sup>.

**Methods:** Belt transect method was used to survey sea birds during voyage between Cape Town and the Antarctica. Observations were carried out onboard MV Ivan Papanin and birds seen within 300m either side of the ship were recorded. The pre-determined voyage route represented a non-randomised transect between the two continents. Further, islands of Larsemann hills were visited using helicopters and nesting sites of birds on islands were located using intensive area search method. Nesting sites were marked and characterized for physical parameters.

**Results:** Over 3000 km of voyage route sampled for seabirds revealed the presence of 49 species of seabirds. Analysis showed higher average bird counts at the marginal ice zone near the sea-pack-ice interface in the late summers. Average biomass of pelagic seabirds peaked at south of the sub-tropical convergence and also at sea-pack-ice interface indicating high prey availability. Thirteen islands at Larsemann hills were found to have nesting sites of Snow Petrel, South Polar Skua and Wilson's Storm Petrel. A potential Adélie penguin breeding colony was also located east of Larsemann Hills. The estimated density of Snow Petrel nests was  $0.04 \pm 0.03$  nests/m<sup>2</sup> largely located within slab (59%) and crack (20%) type of rocks. Surface nesting was not observed in any Snow Petrel colony.

**Conclusion:**

Latitudinal distribution patterns of seabirds indicate that fronts and sea ice play key roles in influencing seabird assemblages in Southern ocean. Preliminary results from the nesting data suggest the avoidance of wind and ice accumulation by selecting more sheltered nesting sites. Timing of survey during early austral summers is critical to understand the nest occupancy and survival of breeding seabirds at Larsemann hills.

## ***Identifying areas of ecological importance through marine predator habitat modelling around the Prince Edward Islands, Southern Indian Ocean***

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Marine ecosystems are rapidly changing worldwide and marine predators – as high trophic level species – can be used as bellwethers of such change. However, their trophic level also makes them particularly vulnerable to ecosystem change. Understanding their biogeography is therefore valuable for conservation and management of marine top predators in their own right, as well as for the broader ecosystem. Seabirds, seals and cetaceans have been studied at the Prince Edward Islands, Southern Indian Ocean, since the 1960s, but mainly on a species-by-species basis. By considering multiple species, broader inferences can be made, particularly about community-level habitat use. We use existing data and a multi-species approach to identify important environmental predictors of marine predator distribution around the Prince Edward Islands and to model suitable habitat. We collated data from more than 600 platform transmitter terminal (PTT) as well as global positioning system (GPS) tag deployments on 18 species (five albatrosses, five petrels, four penguins, three seals and one cetacean), resulting in an unprecedented multi-species tracking data set for the Southern Indian Ocean. Remote-sensed environmental variables along real tracks were compared to those along a set of simulated tracks using boosted regression trees and generalised additive models, giving a description of habitat use relative to availability. Transformed prediction maps facilitated comparison among species. We highlight areas of spatial overlap and identify important common environmental drivers of distribution.

## ***The effects of prey variability on resource partitioning by *Pygoscelis* penguins breeding at Palmer Station, Antarctica***

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Pygoscelis penguins along the Western Antarctic Peninsula are undergoing significant population shifts coincident with rapid climate warming. Over the past four decades the number of Adélie penguins breeding near Palmer Station, Anvers Island (64° 46'S, 64° 03'W) has rapidly decreased. Within this same time period gentoo penguins established a founder colony at Palmer and have been increasing in number. These demographic shifts have been attributed to local and large-scale climate shifts, decreased food availability and increased foraging competition. A recent study that tested for foraging competition between Adélie and gentoo penguins near Palmer Station over the course of a single breeding season found that these two species were foraging in separate locations and thus competition was unlikely. Our study builds on this research and tests for foraging competition over a 6-year period that encompasses years of both high and low abundances of Antarctic krill (*Euphausia superba*), the primary prey of both penguin species. In order to examine the effects of variable krill recruitment on the diving behavior and the foraging ranges of Adélie and gentoo penguins, we instrumented birds with satellite and time-depth recording tags and collected diet samples across six breeding seasons (2010-2015). Diet comparisons between species across the entire study period showed no difference in the size of ingested krill. Size-class frequency distributions of krill found in diet samples of both species showed a non-random, forward progression of dominant krill size-classes throughout time, in accordance with previous studies that have found penguin diets to reflect cyclical krill-recruitment patterns. We calculated utilization distributions (UD) of foraging locations using three-dimensional kernel density estimates and found minimal overlap in both the overall (95% UD) and core (50% UD) foraging ranges of both species. Foraging locations were horizontally separated, possibly due to the distance between Adélie and gentoo breeding colonies, while vertical segregation of foraging depths was largely due to species-specific behavior, with gentoo penguins diving deeper than Adélie penguins. The patterns we found were observed across all years of the study period, suggesting that Adélie and gentoo penguins are able to partition a shared prey resource independent of resource variability. These results provide additional evidence indicating that resource limitation is not the primary driver of the population trends of Pygoscelis penguins in this region.

## ***Ticks as potential climate change indicators in the Antarctic Peninsula: effects on the chinstrap penguins***

**Andres Barbosa**<sup>1</sup>, Roger Colominas-Ciuro<sup>1</sup>, Jesus Benzal<sup>2</sup>, Marcelo Bertellotti<sup>3</sup>, Jose Antonio Masero<sup>4</sup>, Estrella Montero<sup>5</sup>, Luis Miguel Gonzalez<sup>5</sup>, Alberto Chaparro<sup>5</sup>, Virginia Vidal<sup>1</sup>  
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Ticks are haematophagous ectoparasites that parasitize a great variety of vertebrates such as reptiles, mammals and birds and are distributed in almost all the ecosystem of the planet, from deserts to Polar Regions. In these last regions the tick species present is *Ixodes uriae* which has a circumpolar distribution and is associated with seabirds. In Antarctica *I. uriae* has been recorded mainly in the Sub-Antarctic region and in the penguin colonies settled in the islands of the Palmer Archipelago. Recently, it has been recorded its presence in a high number of colonies of Adelie, Gentoo and Chinstrap penguins distributed along the Antarctic Peninsula, showing a decrease in their abundance from North to South and showing two distinct genetic populations. The tick effects on Sub-antarctic penguins have been reported affecting mortality in both chicks and adults. Ticks, as ectoparasites, are one of the parasite species candidates to be affected by the increase of temperatures. In fact increase in their numbers has been related to higher temperatures in the Antarctic Peninsula, and they have been proposed as an excellent organism to track climate change in this region. Then, it is expected an indirect effect of climate change on penguin throughout the effects of parasites. However, no information has been published up to now about such effects on penguins in the Antarctic Peninsula. Here, we study for the first time the effects of ticks on the Chinstrap penguin in a colony of Deception Island, South Shetlands. We compare the tick effects in two different areas of the penguin rookery with differences in tick abundance; one area has 20 times more ticks than the other. We measured mortality, chick growth, humoral and cellular immunity, oxidative stress and the prevalence of diseases transmitted by ticks such as Babesiosis produced by *Babesia* infestation and Borreliosis produced by *Borrelia burgdorferi*.

Our results show that penguins settled in the colonies with high tick abundance showed higher mortality and higher immune response than penguins nesting in the colonies with low tick abundance. We report for the first time the presence of *Babesia* sp. and *Borrelia burgdorferi* in Antarctic penguins showing a higher prevalence in the area of high tick abundance. However, we did not find any effect on chick growth or oxidative stress differences between areas with different tick abundance.

We conclude that ticks cause effects on Chinstrap penguins that could affect population numbers in case of a tick increase abundance due to climate change.



# ***Adélie penguin response to environmental conditions challenges accepted wisdom regarding phenological match-mismatch***

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In several systems, evidence of climate change-driven shifts in the timing of biological events (phenology) has raised concerns that interactions between trophic levels are becoming temporally mismatched, resulting in negative consequences for organism fitness. Given the constraints imposed by extreme seasonality at high latitudes and the rapid phenological shifts seen in some polar environments, one would expect Antarctic seabirds to be highly vulnerable to climate change-driven phenological mismatches. We explore here the phenological match-mismatch hypothesis as it pertains to Adélie penguin breeding success, using the largest collection of long-term Antarctic population and breeding phenology time series assembled to date.

Long-term trends in penguin and environmental phenology are modeled using a hierarchical Bayesian approach; quantile regression is used to examine the impact of phenological mismatch, and other environmental variables, on Adélie penguin breeding success. Our analysis shows that a phenological match between penguins and the environment is a 'necessary but not sufficient' condition for high breeding success, but that the existence of multiple constraints largely eliminates the statistical correlation between phenological mismatch and breeding success when using a traditional regression approach. Contrary to previous analyses using shorter time series, we find no evidence of an advance or retreat in Adélie penguin breeding phenology or phytoplankton bloom phenology. Additionally, while the match-mismatch signal is indeed apparent in the Antarctic, neither the magnitude nor frequency of the mismatch is changing over time.

Our conclusions stand in contrast to findings in other systems in which phenological shifts have been examined – regarding both the consequences of the mismatch and the how it propagates through time. We present five, not mutually exclusive, explanations for this phenomenon: 1) the Anna Karenina principle, implying that high breeding success requires several factors to align favorably, while poor breeding success may result from a variety of disparate factors, 2) the importance of breeding synchrony among individual seabirds may outweigh the importance of synchrony with the environment, 3) long-lived prey, such as Antarctic krill, buffer upper trophic level predators from the negative impacts of highly variable environmental phenology, 4) phenological mismatch is the rule rather than the exception in highly variable environments such as the Southern Ocean, and finally, 5) Adélie penguin breeding success is controlled predominantly by density-independent factors, such as local weather conditions.

This work challenges the generality of the match-mismatch hypothesis, and furthers our understanding of the importance of phenology and phenological shifts in the context of Adélie penguin population dynamics. Further implications include providing insights for Antarctic monitoring and management of penguin populations.

## ***Linking ocean productivity with movement and activity patterns of a seabird***

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The productivity of marine ecosystems is variable and heterogeneous on a spatial and temporal scale. On large and meso-scales this productivity is highly predictable and mainly driven by seasonality. Seabirds, on a population and individual level, are known for a remarkable variation in foraging and migration strategies. Linking ocean productivity with the various individual movement and activity patterns is crucial to understand the mechanisms behind seabird distribution. In this study we analysed 47 annual migration tracks (35 with activity data) from 28 Brown Skua (*Catharacta antarctica lonnbergi*) individuals breeding on King George Island. The dataset includes repeated tracks from 16 individuals over two or three consecutive years, which gave us the opportunity to verify if individuals consistently used the same regions at the same time. The results show that Brown Skuas from this population used a large area with heterogeneous levels of productivity. Single individuals however only used portions of the entire area, several of them in a similar way and highly consistent over consecutive years. Individuals which used comparable regions at the same time clustered in four clearly distinguishable distribution strategies. Individuals of two strategies only used one meso-scale region in each case over most of the period, and the other two changed the region. The relocation of the visited regions of those skuas could be linked to seasonal changes in the corresponding ecoregions. At the end of the non-breeding period the spread of the individuals vanished, consequently the migratory connectivity increased, and almost all individuals used the same highly productive area: the Patagonian shelf break front. At this time, in spring, the upwelling of one of the most productive marine regions of the world starts. Brown Skuas from King George Island take advantage from this event. They increase their foraging activity to improve their body condition in this area, before they return to their breeding site in the Antarctic. These annual consistent patterns suggest that the spatio-temporal distribution of Brown Skuas on a large and meso-scale is matching temporarily with highly predictable and productive water masses.

## ***Winter foraging hotspots and habitat use of Weddell seals (*Leptonychotes weddellii*) at the Filchner Outflow System, southern Weddell Sea***

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The marine region off the Filchner Trough in the southern Weddell Sea is characterized by the outflow of very cold, nutrient rich Ice Shelf Water (ISW) originating from the Filchner-Ronne Ice Shelf. The interaction of ISW around the sill of the Filchner Trough with the Warm Deep Water (WDW) of the Weddell Gyre circulation is assumed to convert the Filchner region in a oceanographic “hotspot” that may also show enhanced productivity and corresponding abundances of marine top predators. Model projections predict an increased melting of the Filchner-Ronne Ice Shelf induced by redirected warm water currents. Recent investigations aimed at an integrative food web analysis of the poorly studied Filchner Outflow System (FOS). In this context, Weddell seals (*Leptonychotes weddellii*) are important and abundant top predators, which are known to inhabit the FOS perennially. Since information on movements, habitat use and foraging behaviour of top predators at the FOS is scarce, Weddell seals (n = 7) were tagged with CTD-combined satellite-relayed dive loggers (CTD-SRDs) during the interdisciplinary research expedition PS82 of RV Polarstern in the southern Weddell Sea in 2013/2014. A series of linear mixed effects models was applied in order to investigate effects of environmental factors (e.g. bathymetry, hydrography, light intensities) on the diving behaviour of Weddell seals. This enables an insight into the vertical habitat use and hence also prey preferences and distribution. The horizontal distribution of Weddell seals in relation to known environmental conditions was analysed by implementing a species distribution modeling approach. In this way suitable habitats for Weddell seals were identified, which might be of relevance in the context of a recently proposed marine protected area (MPA) within the Weddell Sea. Overall, this study enhances our understanding of the role of the Weddell seal in the FOS food web, which is already threatened by climatic changes.

## ***Novel movement and dive behaviour of an iconic marine predator: Emperor penguins in the Eastern Ross Sea, Antarctica***

**Kimberly Goetz**<sup>1</sup>, Brigitte McDonald<sup>2</sup>, Stefan Jendersie<sup>3</sup>, Gerald Kooyman<sup>4</sup>

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While there are several marine predators in the southern ocean, emperor penguins (*Aptenodytes forsteri*) are the largest avian species and perhaps the most iconic predator to inhabit Antarctic waters year-round. The development of data-logging technologies has allowed researchers to unlock the mystery of at-sea behaviour during the chick-rearing period. However, the remoteness and lack of information on moulting locations has hindered our ability to understand the migration to and from these areas. The association and reliance on pack ice make emperor penguins an ideal indicator species for climate change. As such, identifying important habitat and foraging areas is critical to address how predicted changes to the oceans climate might impact the survival of this top predator. In this study, we use movement and dive data collected from 21 tagged emperor penguins in the Ross Sea to provide the first-ever qualitative and quantitative description of post-moult behaviour. Tracking data revealed that emperor penguins followed the approximate location and direction of the Ross Sea gyre, traveling east and then north along the shelf break before turning west following the edge of the South-east Pacific Basin before heading south and returning to the tagging location at Cape Colbeck. The average dive depth and duration for all penguins was  $90.2 \pm 77.8$  m and  $4.6 \pm 2.3$  mins, respectively. Significant clusters of deep dives were located both on the shelf and in areas furthest off the shelf while clusters of shallow dives were located in between. Significant clusters of longer dives were located at the furthest extent of travel. Dive rates were significantly higher during the day and twilight hours than at night and penguins showed a preference for foraging within the Antarctic surface waters or circumpolar deep water. During the austral winter, emperor penguins preferred areas that were located closer to ice edge, in shallower depths, closer to the southern boundary of the Antarctic circumpolar current, and over areas with less bathymetric slope than in fall. Overall, our study provides novel information on the ecology of emperor penguins during a stage in their life cycle when they are physically and energetically vulnerable and when they must find breathing holes, avoid predators, and forage to regain body mass before the winter breeding period.

## **S35. Data access and sharing for cutting edge science, Meeting Room 409, August 22, 2016, 11:30 AM - 1:30 PM**

### ***The Polar Rock Repository: a global resource for Antarctic earth science***

**Anne Grunow**<sup>1</sup>

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The National Science Foundation and the United States polar earth science community recognized the need for, and value of, preserving rock samples from Antarctica and hence created the Polar Rock Repository (PRR) at the Byrd Polar and Climate Research Center (BPCRC). Preserving existing polar rock collections at the PRR for future research fulfils an obligation under the Antarctic Treaty (Article III, Section 1c) and the Scientific Committee on Antarctic Research, Antarctic Data Management (2009) directive of providing free, full and open access to metadata and collections.

The PRR collection includes more than 40,000 rock, dredge, terrestrial core and unconsolidated samples (along with associated materials such as field notes, annotated air photos, maps, and thin sections) that are made available for research use. The PRR uses a modern Collection Management System created at the BPCRC that allows for organization of the rock sample database completely via web browser. Repository staff can update and import samples from anywhere in the world and also update sample metadata using a tablet while working in the stacks. The PRR collection system is hosted completely in-house, using open-source, off-the-shelf software. This allows the collection software to be managed by anyone with experience in web and database programming, and allows the software to scale in size and features in the future at a lower cost than commercial museum software. The system also allows for software security and web interface updates to follow modern, industry-standard practices. The collection system operates on standard Linux servers with a PostgreSQL database and NFS file shares. The web app is written in the PHP programming language and uses HTML5 and Javascript supported in all modern web browsers.

On the public-facing website, speed improvements of 10x have been seen with the database search tool after the slow, proprietary database was replaced with a modern solution. Data indexing is utilized on the most important fields in the PRR database, and full-text searches are also available for some fields. Database management functions happen in real-time, which avoids several hours of downtime nightly (when website search functions were completely offline) that were occurring with the previous commercial database used by the PRR. An improved search system allows scientists, researchers, and the public to “drill down” into search results using categories and look-up fields similar to websites like Amazon. Results can be viewed in a table, as thumbnail images, downloaded as a spreadsheet, or plotted on an interactive map that supports display of satellite imagery and bathymetry layers. Researchers can select the samples they wish to study and use the “shopping” cart tool to request samples from the PRR.

The easy discoverability of the PRR samples using the online search and shopping tools helps scientists with research planning particularly given how logistically difficult, financially expensive and the high environmental impact of conducting Antarctic field research.

## ***How does the SCAR policy influence open access in the curation and archiving of personal data?***

**Ria Olivier<sup>1</sup>**

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The Antarctic Treaty (section III.1.c) states, "Scientific observations and results from Antarctica shall be exchanged and made freely available."

"The early researchers did not think that at one time what they were doing would become history, but today we are globalising that history. The opportunity is now there for South African and international academics to discuss and critically evaluate how researchers with Antarctic interests can fruitfully use the growing accessibility of diverse source material to further research," said Lüdecke, a natural scientist at the University of Munich.

In an article in *Science* (Vol. 342, p. 13) Maria McNutt states that even the most brilliant scientific discovery is of little value if not communicated widely and accurately. The Antarctic Legacy of South Africa database consists of thousands of documents, diaries, images and articles as well as references. This information is of immense value to science as well as to our heritage, but if it is not going to be made available widely and accurately it will also be of little value.

When the collection of material started, the aim was to obtain as much information as possible to cover all the years of South Africa's involvement in Antarctica and surrounding islands. Copyright was given to owners of information and the information would only have been made available to researchers, so it was a restricted database. However, it is desirable to make the information more available and we are now making the database openly accessible. The South African National Research Foundation recognises the importance of open access to disseminating the results of research while at the same time appreciating that open access will continue to evolve in response to societal needs, achieving overarching policy harmonisation and new innovative publishing business models.

How does the SCAR data policy influence the decision to make a database of human history openly accessible? Is it possible to make the database open without revealing confidential information?

In a world where digital data is created at an ever-increasing pace, there is the need for a privacy policy which time allows researchers to generate and share data, since even in digital form, research data remains at risk to loss.

## ***Improved tools for easier access to polar data of the IEDA/MGDS data system***

**Frank O. Nitsche**<sup>1</sup>, Vicki Ferrini<sup>1</sup>, Kevin McLain<sup>1</sup>, Suzanne Carbotte<sup>1</sup>, John Morton<sup>1</sup>, Robert Arko<sup>1</sup>, Suzanne O'Hara<sup>1</sup>, William Ryan<sup>1</sup>, Ben Grange<sup>1</sup>, IEDA Team<sup>1</sup>

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Data management, archiving and curation of Polar data is constantly improving and resulting in a rapidly increasing volume of available datasets. Efficient and effective use of these data requires a variety of tools to identify and access these data that will work for a wide range of potential users. The Interdisciplinary Earth Data Alliance (IEDA) is a community-based data facility funded by the US National Science Foundation (NSF) that provides a wide range of data services for observational solid earth data from the Ocean, Earth, and Polar Sciences. The Marine Geoscience Data System, a major IEDA component, is the main curator of marine geophysical and related data collected by vessels of the US Antarctic Program (NB Palmer and L Gould). These data include track navigation, single- and multi-beam bathymetry, seismic and other underway data as well as station data, which are organized by platform and expedition if applicable. In addition, we provide access to derived data products, such as gridded data sets, interpretations or compilations. Besides data curation it is part of the mission of IEDA/MGDS to increase the usability of the data to a broad audience. We have developed and are developing a series of tools, apps and web-interfaces to provide access to the data through various pathways. Here we will present the latest developments of tools for access and use of data from the Polar Regions. These include an improved web-tool for generating and downloading custom basemaps at various resolutions and formats for direct use as maps or in other software package (<http://www.marine-geo.org/tools/GMRTMapTool/>). In addition to our text-based search tools we also developed a new, map-based IEDA data browser that integrates searches of key datasets from various IEDA portals including MGDS cruise tracks, GMRT high-resolution bathymetry and topography, EarthChem, Geochron and SESAR sample data (<http://app.iedadata.org/databrowser/>). This tool provide quick overview and access to available datasets in a user-selected area. In addition to these new tools we upgraded the GMRT basedata and views used for GeoMapApp and other tools.

## ***Bringing data sharers closer together in the Southern Ocean***

**Pip Bricher**<sup>1</sup>, Stephen Diggs<sup>2</sup>, Louise Newman<sup>1</sup>

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The Antarctic and Southern Ocean research communities have long led the way in developing a culture of data sharing, along with the tools to make that possible. The Southern Ocean Observing System (SOOS) is building on these efforts to further streamline data sharing. SOOS efforts include brokering data sharing solutions for researchers and organisations not already affiliated with data centres, developing a metadata portal to aid in data discovery, and developing a field projects database to help coordinate data collection before projects even begin.

There is a clear appetite among oceanic researchers for international conversations about field plans to be started well in advance of going to sea. Such conversations can maximise the amount of data collected on any one voyage, reduce duplication of efforts, and encourage collaboration on data collection methods. Until now though, it has been difficult for those conversations to happen because there's no forum to connect individual researchers across institutions and nations. The design for this database aims to take it beyond existing cruise coordination databases, by including information on individual research projects, in addition to shipping information.

We are coordinating an international effort to design and develop an interoperable spatial database that can share data with existing cruise coordination databases and that allows cruise coordinators and researchers to manually upload their field plans. In this presentation, we will share the lessons learned from our data sharing activities so far, and invite further collaboration.



## ***A Southern Ocean trophic database***

**Anton P. Van de Putte**<sup>1</sup>, Antonio Agüera García<sup>2</sup>, Yves Cherel<sup>3</sup>, Hauke Flores<sup>4</sup>, Luis Huckstadt<sup>5</sup>, Mary-Anne Lea<sup>6</sup>, Julie McInnes<sup>6</sup>, Ben Raymond<sup>7,8,6</sup>, Yan Ropert-Coudert<sup>3</sup>, Fokje L. Schaafsma<sup>9</sup>, Gabriele Stowasser<sup>10</sup>, Rowan Trebilco<sup>8</sup>, Andrea Walters<sup>6,8</sup>

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Understanding the functioning of an ecosystem, such as the Southern Ocean, is important in order to better conserve and manage it. Knowledge on the number and strength of feeding links between organisms is used directly in conservation management and planning activities, and to parameterize and/or evaluate ecosystem models that can be used to explore the effects of human disturbances, such as fisheries, and the effects of environmental change.

There are various ways of determining trophic relationships. Dietary assessments are commonly done directly via composition of gut content or fecal matter, and indirectly by measuring biochemical tracers such as stable isotopes and fatty acids. The energetic content of organisms is also an important source of information in this process as it is the balance between the quantity and energetic content of prey items and the energy requirement of the predator that will determine its survival.

Often such attributes are summarized at the taxon level, despite considerable variation both at inter- and intra-species levels. This intra-specific variation can be due to a variety of reasons including ontogenetic shifts in or geographic variation. Here we present a database that aggregates such trophic traits both at the species and individual level.

Past efforts have focused on published and unpublished data on isotopic data and dietary relationships. Published data are often aggregated (averaged over a number of individuals in a study), which is not ideal for subsequent re-use. With this new database we extended the scope and resolution of trophic trait data. We aim to additionally include fatty acid composition data, proximate composition data and energetic content from published and unpublished sources. Where available the original raw (un-aggregated) data is included in the database.

This database will be of particular relevance to research into Antarctic and Southern Ocean food web analysis and trophic ecology.

## ***Cloud computing infrastructure for polar GNSS e-science applications***

**Luca Pilosu**<sup>1</sup>, Pietro Ruiu<sup>1</sup>, Alberto Scionti<sup>1</sup>, Lucilla Alfonsi<sup>2</sup>, Vincenzo Romano<sup>2</sup>, Rodrigo Romero<sup>3</sup>, Pierre Cilliers<sup>4</sup>, Herman Theron<sup>4</sup>, Emilia Correia<sup>5</sup>, Wagner Sarjob<sup>5</sup>

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The international scientific community involved in Polar research and applications, is increasingly adopting computing infrastructure able to manage and process large sets of data from polar regions. More often the issue is how to structure and deploy an IT infrastructure able to manage data coming from different teams in a multi-user environment considering the computational architecture requires scalability, interoperability, and security features.

Under the SCAR GRAPE (GNSS Research and Application for Polar Environment) expert group, the DemoGRAPE project aims at providing selected case studies of an empirical assessment of the delay and corruption induced by the ionosphere on satellite signals in polar regions. In the framework of the DemoGRAPE project, a system based on a Cloud computing federated infrastructure and integrating three different nodes in Italy, Brazil and South Africa has been implemented. Innovative aspects in terms of management of data and resources for the ionospheric analysis illustrate an important step for creating flexible services to assist GNSS operations at the poles.

The implemented infrastructure adopts the Linux Containers technology (specifically the Docker version) in order to provide a lightweight virtualization system able to run applications in a cloud-federated infrastructure. A centralized management console, coupled with a web-based graphic user interface, allows users to control the execution of applications, and the available resources as well. A distributed storage system is also integrated in the platform, with the aim of providing a scalable and resilient solution to store acquired data. Leveraging the features of Docker containers, the proposed platform can guarantee the intellectual property related of the algorithms used by the applications running on the containers.

This paper reports the details of the implemented infrastructure, introducing an innovative way to manage and share data and tools in polar regions, providing new scenarios from the IT infrastructure perspective, and contributing to the aims of the SCAR Standing Committee on Antarctic Data Management (SCADM).

## ***Quantarctica 3.0: A Cross-Platform, Full-Featured Open GIS for Antarctic Research***

**George Roth**<sup>1</sup>, Kenny Matsuoka<sup>1</sup>, Anders Skoglund<sup>1</sup>, Yngve Melvær<sup>1</sup>, Stein Tronstad<sup>1</sup>  
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The Norwegian Polar Institute has developed the standalone open GIS package “Quantarctica” for Antarctic science and mapping. This geospatial data package is built on the free, open-source, cross-platform QGIS software, and includes a wide range of cartographic basemap layers, geophysical and glaciological datasets, and satellite imagery. Here, we briefly revisit the structure and accomplishments of the first two version releases of Quantarctica since its creation in 2013 and its recognition as an official SCAR data product in 2014, before presenting the vision for version 3.0, to be released in 2016-2017.

Two primary goals exist for Quantarctica 3.0: 1) An increase in the breadth and depth of the included open data from an expanded array of international partners and investigators in Antarctic climatology, biology, oceanography, and atmospheric sciences, and 2) Expanded educational outreach, in the form of online and video tutorials, documentation, and user workshops.

Quantarctica exists as a dynamic compilation of freely-available geospatial data from and for the scientific community. As such, the project welcomes any and all new or updated data contributions, user feedback, and potential collaborations.

## ***The many roles of a National Polar Data Center***

**Taco De Bruin**<sup>1</sup>, Marten Tacoma<sup>1</sup>

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Polar data are extremely valuable, both because of their intrinsic value as unique measurements from a key area of the global (climate) system, as well as because of the high costs associated with collecting the data. Therefore, polar data need to be managed very carefully for the benefit of science and society.

Usually, managing polar data for a National Polar Research Program is the task of a National Polar Data Centre (NPDC). Often, this NPDC is part of an existing, discipline-oriented data center. In some cases, a dedicated NPDC was established. These different models have a series of roles in common, concerning handling the data. The following roles can be distinguished:

- Data from the same or a similar discipline as the data center was originally established for, can easily be handled by the NPDC.
- Data from other disciplines, for which another (inter)national data center exists, could be handled by that other data center. In this case, a steering and coordinating role by the NPDC is required.
- For 'orphan data', for which no logical, discipline-specific host exists, the NPDC should take on the role of a basic data center, providing essential data management support.
- The existence of all data should be made known through discovery metadata infrastructures, which exist both for polar data as well as for data from a growing number of disciplines.
- Finally, access to the data can be provided in different ways. Preferably, there is only one master source for the data, which is accessible via a linked, distributed data infrastructure.

In this presentation, the organization of polar data management within a National Polar Research Program will be discussed. The different roles as mentioned before will be elaborated and special emphasis will be on the cost-effective use of existing (inter)national resources.

## **S13. Antarctic meteorology and climatology PM1, Meeting Room 404, August 22, 2016, 3:30 PM - 6:00 PM**

### ***Assessment of historical and future changes in Antarctic precipitation based on CMIP5 models***

**Malcolm Tang**<sup>1</sup>, Sheeba Nettukandy Chenoli<sup>1</sup>, John Turner<sup>1,2</sup>, Azizan Abu Samah<sup>1</sup>, Ooi See Hai<sup>1</sup>  
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The global climate models of the Coupled Model Intercomparison Project phase 5 (CMIP5), the ERA-Interim Reanalysis, and Global Precipitation Climatology Project (GPCP) satellite data for the period 1979-2005 and 2006-2100 were used to study the variability of Antarctic precipitation. The study of the changes in precipitation in Antarctica has a broad implication in determining the state of health of our climate. It can be extended to verify the study of the global climate and subsequently, the issue of global warming. The precipitation patterns and the trend in the Antarctic generated from the 39 CMIP5 models were compared with those obtained from the ERA-Interim and GPCP. The correlation indices between the models and the ERA-Interim were used as the basis to filter the output from the models which are closely resembled those obtained from the ERA-Interim. In terms of spatial variability of the historical precipitation, we observed that the CMIP5 models could best simulate the spatial pattern of ERA-Interim is the CESM1-CAM5. Moreover, the CMIP5 multimodel mean shows increasing precipitation since 1979, by as much as +0.060 mm/year ( $p > 0.05$ ), while the mean from the ERA-Interim shows a decrease in precipitation over the same period, by -0.40 mm/year ( $p > 0.05$ ). We discussed the role of the Southern Annular Mode (SAM) on the variability of precipitation. We investigated future changes in the precipitation variability for the period 2006-2100 based on the CMIP5 model projections with Representative Concentration Pathways (RCPs) 4.5 and 8.5 using selected models.

## ***CMIP5 wind biases over the Adelie Land sector of the Southern Ocean: the role of resolution and implications for projections***

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Projected changes in the Southern Hemisphere (SH) mid-latitude near-surface westerly winds and associated storm tracks are key influences on Antarctica and the Southern Ocean, with, for example, significant implications for ice sheet stability. Climate model projections from the Coupled Model Intercomparison Project Phase 5 (CMIP5) multi-model ensemble generally exhibit a poleward shift of the SH mid-latitude tropospheric westerly jet under increased greenhouse gas concentrations. However, the largest over-ocean historical near-surface wind strength bias in the CMIP5 models in the Southern Hemisphere appears to be located near the sea ice edge off the Adelie Land sector of East Antarctica (~150°E). Here the CMIP5 mean near-surface westerly wind component exhibits a negative bias of up to 3 m/s. This calls into question the reliability of projections of future wind change in the region and is likely to have significant implications for the polar front storm track, which is associated with a polar front jet (PFJ) in surface winds and extends eastward towards the Antarctic Peninsula from a major cyclogenesis region off Adelie Land.

Here, the factors that lead to the bias in CMIP5 models are investigated. In particular, the role of horizontal grid spacing is evaluated. This is done using the UPSCALE dataset, which comprises a set of atmosphere-only global climate modelling simulations (based on a recent version of the UK Met Office global climate model) at three different grid spacings: 130 km, 60 km and 25 km. The results indicate that approximately half of the Adelie sector CMIP5 wind bias is a consequence of too low atmospheric model resolution. The resolution-related improvement extends equatorward of the steep orography of East Antarctica, therefore indicating that non-orographic processes such as surface forcing or atmospheric eddy momentum fluxes are also better captured at higher resolutions.

It is found that the historical CMIP5 wind biases in the Adelie Land sector have important implications for 21st century projections, particularly in winter when the climatological PFJ is most pronounced. In this season, CMIP5 models with a realistically strong PFJ project wind increases on the poleward side of the jet adjacent to the Antarctic continent (between 60°S and 65°S), whereas models with too weak PFJs exhibit no clear change, even under the high emissions RCP8.5 scenario. Broader implications of these results for the Southern Ocean and Antarctica will be discussed.

## ***A statistical downscaling study on Antarctic Peninsula temperature variability based on Weather Type Classifications***

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Large parts of the Polar Regions are affected by a warming trend associated with substantial changes in the cryosphere. In Antarctica this positive trend pattern is most dominant in the western part of the continent and on the Antarctic Peninsula. An important driving mechanism of temperature variability and trends in this region is the atmospheric circulation. Changes in frequency and intensity of circulation patterns have major implications on temperature characteristics at a certain station or region.

We present results of a statistical downscaling study focused on Antarctic Peninsula temperature variability. This approach is based on weather type classifications and allows quantifying the link between large scale atmospheric circulation patterns and regional climate variables. In our contribution we use daily gridded ECWMF ERA-Interim reanalysis data of six atmospheric pressure levels and daily temperature observations of selected research stations which are provided by the READER data base. An overview on the computation of temperature-conditioned weather type classifications for different classification algorithms, domain sizes and atmospheric height levels will be given. Particular attention is drawn to obtain high explained variances both for the circulation data set and for the temperature data set during the calibration of this statistical modelling approach. The model performance in terms of explained variances varies with the number of classes and the domain sizes.

First results show that weather type classifications are an effective tool for investigating the relationship of large-scale atmospheric circulation patterns and temperature variability. Modelled temperature series and observations show good correlations with coefficients between 0.6 and 0.8 for the selected stations at the Antarctic Peninsula. An analysis of the frequencies of prominent weather types is shown. Furthermore, a new evaluation method for the characterization of circulation pattern intensities is proposed and preliminary results for the temporal development of these pattern intensities are discussed.

Finally, the conclusions focus on the initial question of how the atmospheric circulation has affected temperatures on the Antarctic Peninsula and highlight the benefit of applying weather type classification in Antarctic climate research.

## ***Can temperature extremes in East Antarctica be replicated from ERA Interim reanalysis?***

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Based on daily minimum, maximum and mean surface air temperature (Tmin, Tmax, Tmean) from European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis from 1979 onwards (ERA Interim), the accuracy of daily 2-meter Tmin and Tmax from ERA Interim reanalysis is assessed against in-situ observations from four Automatic Weather Stations (AWS; Zhongshan, EAGLE, LGB69 and Dome A) in East Antarctica for 2005 to 2008. ERA Interim generally shows a warm bias for Tmin and a cool bias for Tmax, with an underestimation of the diurnal temperature range. The reanalysis explains more than 84% of the daily and annual variance, and has annual root mean square errors of 2.4°C, 2.6°C, 3.0°C and 4.3°C for daily Tmin, and 2.2°C, 3.1°C, 3.4°C and 4.9°C for daily Tmax at Zhongshan, LGB69, Eagle and Dome A, respectively. ERA Interim shows little seasonal variability, except at Dome A with better performance in the austral spring and worse in winter and autumn. An analysis spatial distribution of temperature and wind field shows that ERA Interim can replicate the progress of temperature extremes developing, occurring and disappearing. The weather events extracted from ERA Interim occur on the same day as the observation with high cross-correlation coefficient ( $R \geq 0.287$ ,  $N \geq 1131$ ,  $P < 0.001$ ). Both in the daily and annual performance of Tmin and Tmax, and in the ability of prediction, ERA Interim shows the obvious regional differences, with errors tending to increase from the coast to the interior of the East Antarctica ice sheet. ERA Interim is, despite its limitations and deficiencies, a powerful tool for weather and climate studies in the Antarctica region. However, more in situ observations and projections are required for both scientific and recreational purposes.



## ***Climate variability of the Larsen C iceshelf: Past, present, future***

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The Antarctic Peninsula experienced 5 times the global warming since 1945 with a temperature increase of several degrees. Further, the annual melt on the ice shelves has increased by 2 to 3 weeks in just the past 20 years. Several ice shelves have disintegrated in the past decades, including the Larsen A in 1995 and the Larsen B in 2002. We analyzed NCEP surface temperature data from the Antarctic Peninsula for the past three decades and show the seasonal as well as the regional pattern of warming. Analyses of three automatic weather station data on Larsen C ice shelf collected during a recent project since 2008 to present show the sudden increase in surface air temperatures during strong down-slope wind events, caused by the adiabatic warming of air masses crossing the Peninsula in early spring. These Föhn-like storm, dry down-slope winds that descend in the lee of a mountain barrier, are occurring more frequently in the past years, due to the increase in strength of the westerlies winds. The enhanced surface melt on the Larsen C iceshelf close to the grounding line is also visible in radar satellite imagery and are believed to weaken the ice shelf stability increase this process continues.

## ***A long term record of wind direction from aeolian features in Hidden Valley, Antarctica.***

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Within the arid regions of the world, wind abraded geological material is a commonly observed phenomena. Saltating ice and sand grains transported by wind and impacting on rock surfaces ultimately leads to the development of classic ventifaction features such as facets, keels and grooves. The presence of which has long been recognised as a product of a number of variables including wind strength, wind direction, length of exposure and sediment load.

Throughout the McMurdo Dry Valleys such material is commonly observed within Pleistocene to Holocene aged glacial and lacustrine sediments. Typically found in the valley floors, granitic, diorite and basaltic clasts display a range of morphologies in which the geometry and weathering characteristics of wind abraded facets can provide important paleo-environmental information and thus be used in the reconstruction of paleo-wind directions.

Unfortunately, smaller ventifacts (< 0.3 m) sub-aerially exposed in valley floors are prone to post depositional modification, typically clast rotation due to mass loss (via erosion) and exhumation. Therefore their use as a long term paleo-record can be problematic, in stark contrast in-situ bedrock on ridgelines can display similar aeolian features and are immune to many of the issues that affect boulders in valley floors.

At Hidden Valley in the Denton Hills (78.1°S, 163.7°E) large exposures of bedrock displaying extremely well developed facets and fluting are extremely common, not only on ridges, but also proximal to the valley floor. At 96 locations the direction of keel and primary facets were measured in an attempt to understand the long term climatic history of the area, with the spatial distribution of the primary facet direction, allowing a reconstruction of pasts wind within the valley.

Our results suggest that prevailing winds are from the south, pushing into Hidden Valley and north-easterly over the valley ridge, at the same time the southerly airflow reaches into the valley bottom and channels northward into Miers Valley via a prominent gap. These observations differ markedly to the predominant westerly-easterly wind pattern seen in the larger Wright, Taylor and Victoria valleys to the north; therefore a different wind regime must exist to produce the ventifaction seen in Hidden Valley.

High-intensity airflow can penetrate into the valley bottom through several mechanisms such as pressure driven channelling or turbulent erosion of inversion layers from aloft; each having a distinctive flow pattern within the valley system. Regional scale climate modelling and the reconstructed wind direction patterns from our erosion mapping suggests that turbulent erosion is the most likely mechanism in Hidden Valley. This mechanism is most likely prevalent at this location due to the relatively smoother and wider valley cross-section, compared to the larger valleys, and/or significant wave activity in the free atmosphere during intense katabatic outflows.

## ***Measurements of aerosol particle chemical and optical properties in Antarctic station Marambio during three years***

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Human impact on the increase of the greenhouse gas concentrations globally, have resulted in dramatic changes in Antarctic peninsula weather and climate. For example, the annual average temperature has increased by several degrees during the last decades. Further, this has been demonstrated to be crucial for the fragile ecosystems of this region.

Atmospheric aerosol particles are an integral part of the climate, having effects on water-, carbon-, and nutrient cycles, the amount of solar radiation entering the surface and changing the amount of cloudiness and rain, as well as the properties of clouds.

To understand the inter-annual characteristics of the aerosol particles in Antarctic peninsula, their sources and interaction with the Antarctic climate, we studied these particle chemical and optical properties continuously during three consecutive years. Measurements were made using automated instrumentation in Argentinean station Marambio between years 2013 and 2016. Particle chemistry was studied with weekly collection of filter samples using a virtual impactor. Particle optical properties were measured with a 3-wavelength nephelometer (scattering) and a multi-angle absorption photometer (absorption).

In the analysis we focus on the sources of particles, their chemical characteristics and the influence of these factors on particle climatic properties. Also any traces of human influences visible in particle composition will be analysed.

Air masses in Marambio represent most of the year very marine air (calculated using hysplit back-trajectory model). This reflects in particle chemical composition which is mainly sea salt and sulphate, and particles tend to be very acidic. Chemical composition changes between summer and winter seasons, while in summer the particles contain a higher fraction of sulphate and MSA (methanesulphonic acid) and in winter the chemistry is mainly sea salt. A likely cause of this is the lack of sunlight in winter that prohibits any secondary formation processes and therefore affects the particle size. The maximum size of the particles collected was 10 micrometers.

The seasonal variability in particle chemistry and size affects the particle optical properties, and further changes the particle climatic impacts (direct and indirect effects). Large particles with high amounts of sea salt in winter scatter light efficiently, as well as supposedly, they would be very efficient cloud nucleus (not measured here). In summer, particle scattering was elevated more due to the number than the size of the particles, and the average total number concentration was more than a 10-fold (measured using a condensation particle counter).

To our knowledge, this is the first such long-time comprehensive aerosol particle characterization made at the region of Antarctic peninsula. The results explain more specifically which factors are responsible for the aerosol particle climatic impacts year-round in the peninsula region and how these are changing between different years.

## ***Measurements of the spectral albedo at Union Glacier Camp (Antarctica): A case study***

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We report on an intercomparison campaign (in November-December 2015) that involved three instruments suitable for spectral measurements of the snow albedo. The campaign was carried out at a Camp located in the southern Ellsworth Mountains on the broad expanse of Union Glacier (700 m altitude, 79° 46' S; 82° 52'W); about 1,000 km from the South Pole. The three spectral albedometers involved in the campaign were developed based on spectroradiometers that represent different spectral technologies: double monochromator-based, array, and multichannel instruments. The measurements were conducted from the ultraviolet (UV) to the near infrared (IR) and allowed us to weight up the advantages and drawbacks of the tested instruments. We found that the measurements of three albedometers agreed within the uncertainty bounds. The albedo measured at noon was about 0.95 in the UV and the visible part of the spectrum, while it reduces in the IR. Spectral measurements carried out elsewhere as well as satellite-derived estimates of the Lambertian Equivalent Reflectance (LER) were used for further comparisons.

## ***Antarctic wind field research: Trends, topics and future directions***

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Many parts of the coastal zone of Antarctic are subjected to strong, persistent and especially directionally constant near-surface winds, a fact that has been noted since the days of the earliest expeditions to the continent. Recent studies on the surface winds over Antarctic have led to better the greater awareness of its significant role in the climate of the continent and its role in the change of global climate system. Surface winds over Antarctica are possibly the most studied meteorological element. This study provides an overview of the Antarctic wind research spanning the period 1980–2015. The main motivation for this study is to frame the development and current state-of-the-arts of Antarctic wind research based on the publication activity of its community. The analysis covers the distribution of journal selection over time, the most productive researchers, and salient topics inferred from the titles and abstracts of the article. The publication data are sourced from the Thomson ISI Web of Knowledge database. This work would be useful in designing the future research direction on Antarctic wind field to avoid any repetitive work. These literature surveys can assist in identifying the existing knowledge gap in the Antarctic wind field research to point out the future developments needed.

## **S18. Subglacial geology and significant events in the geological evolution of Antarctica, Meeting Room 405, August 22, 2016, 3:30 PM - 6:00 PM**

### ***Subglacial geology and crustal architecture in interior East Antarctica***

**Fausto Ferraccioli**<sup>1</sup>, Robin Bell<sup>2</sup>, Donald Blankenship<sup>3</sup>, Duncan Young<sup>3</sup>, Graeme Eagles<sup>4</sup>, Rene Forsberg<sup>5</sup>, Alexander Golynsky<sup>6</sup>, Alan Aitken<sup>7</sup>, Joachim Jacobs<sup>8</sup>, Carol Finn<sup>9</sup>, Yasmina Martos<sup>1</sup>, Egidio Armadillo<sup>10</sup>, Jorg Ebbing<sup>11</sup>, Wilfried Jokat<sup>4</sup>, Dr Tom Jordan<sup>1</sup>, Ms Antonia Ruppell<sup>12</sup>, Dr Andreas Läufer<sup>12</sup>, Prof. Ian Dalziel<sup>3</sup>  
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East Antarctica is a keystone in the Gondwana, Rodinia and Columbia supercontinental puzzle (e.g. Goodge et al., 2008, Science). Recent aerogeophysical surveys augmented by ongoing gravity (Scheinert et al., 2016- GRL), seismological (An et al., 2015- JGR) and magnetic data compilations (Golynsky et al., 2016 in prep.) are providing tantalising new views into large-scale subglacial geology and crustal architecture in interior East Antarctica.

A mosaic of distinct Precambrian basement provinces has been imaged in interior East Antarctica (Ferraccioli et al., 2011- Nature). A major suture separates the Archean-Neoproterozoic Ruker Province from an inferred Grenvillian-age orogenic Gamburtsev Province with thick crust (up to 60 km thick) and thick lithosphere (over 200 km thick). Whether the proposed suture is linked to Grenvillian-age accretionary processes and the assembly of Rodinia or much later subduction and collision related to the assembly of Gondwana in Pan-African times is controversial (e.g. Ferraccioli et al., 2011 vs An et al., 2015). Further east, magnetic highs delineate the subglacial extent of a Paleo to Mesoproterozoic Nimrod-South Pole igneous province (Goodge and Finn, 2010- JGR) that flanks a composite Mawson Continent- including the Gawler Craton of South Australia (Aitken et al., 2014- GRL).

An over 1,900 km long magnetic and gravity boundary can now be recognised along the western flank of the Wilkes Subglacial Basin. It is the largest feature discovered so far in interior East Antarctica and is currently being interpreted as a lithospheric scale Paleoproterozoic suture zone linked to collisional and transpressional tectonics (Ferraccioli et al., 2016, Nature, in prep.).

Aerogeophysical imaging also reveals an extensive Keweenaw-age (ca 1.1 Ga) large igneous province in the Coats Land Block -isotopically tied with the Mid-Continent Rift System of Laurentia (Loewy et al., 2011- Geology). Grenvillian-age arc terranes are delineated from aeromagnetic images and confirm linkages between the Namaqua-Natal and Maud belts in South Africa and Dronning Maud Land. The aeromagnetically distinct Southeast Dronning Maud Land province (Mieth and Jokat, 2014- Prec. Res.) has been interpreted as a reworked 1000-900 Ma Oceanic Arc Superterrane (Jacobs et al., 2015- Prec. Res.). Imprints of Pan-African age transpression, collision and indentation tectonics can now be recognised in the previously unexplored Recovery Frontier and are interpreted as recording the final amalgamation of Gondwana.

## ***Seeing beneath the ice with satellites - The dynamic Antarctic lithosphere***

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In the GOCE+Antarctica project, part of the Support to Science (STSE) program of the European Space Agency (ESA), we address the thermal and compositional structure of the Antarctic lithosphere by combining gravity (gradients), seismological and petrological models in a forward and inverse manner. Hereby, we discuss both the interplay of the deeper lithospheric architecture with bedrock topography and ice dynamics as its dynamic relation with GIA.

Antarctica is still an underexplored part of the Earth with respect to geophysical data coverage. Despite recent large scale international campaigns, which have for example acquired a wealth of airborne gravity and magnetic datasets, knowledge of the crustal and lithospheric structure of the continent is limited, as the massive ice sheets that cover Antarctica hamper direct sampling and the seismic data coverage is still sparse.

Considerable efforts have been made in recent years to improve the knowledge of the bedrock beneath Antarctica. However, it is estimated that available bedrock compilations have in some regions still uncertainties larger than 1 km. If these uncertainties are present where the bedrock is beneath sea level or bordering the ocean, they can have a large impact on calculations of ice sheet dynamics/stability; this is e.g. the case in interior East Antarctica regions.

We evaluate current seismological upper mantle and crustal models using satellite gravity gradients and discuss the trade-off between the uncertainties of these models and estimates of temperature and composition in the upper mantle. Satellite gravity gradients are due to their characteristic source sensitivity especially well-suited for this kind of analysis and we will present a state-of-the-art lithospheric model for Antarctica.

## ***ADMAP-2: The next-generation Antarctic magnetic anomaly map***

**Alexander Golynsky**<sup>1</sup>, Dmitry Golynsky<sup>1</sup>, Fausto Ferraccioli<sup>2</sup>, Tom Jordan<sup>2</sup>, Detlef Damaske<sup>3</sup>, Don Blankenship<sup>4</sup>, Jack Holt<sup>4</sup>, Duncan Young<sup>4</sup>, Sergey Ivanov<sup>5</sup>, Alexander Kiselev<sup>5</sup>, Valery Masolov<sup>5</sup>, Wilfried Jokat<sup>6</sup>, Matthias Mieth<sup>6</sup>, Karsten Gohl<sup>6</sup>, Graeme Eagles<sup>6</sup>, Robin Bell<sup>7</sup>, Egidio Armadillo<sup>8</sup>, Emanuele Bozzo<sup>8</sup>, Giorgio Caneva<sup>8</sup>, Carol Finn<sup>9</sup>, Rene Forsberg<sup>10</sup>, Alan Aitken<sup>11</sup>, Marta Ghidella<sup>12</sup>, Ralph von Frese<sup>13</sup>, Hyung-Rae Kim<sup>14</sup>, Yoshifumi Nogi<sup>15</sup>, Jongkuk Hong<sup>16</sup>

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The Antarctic Digital Magnetic Anomaly Project compiled the first international magnetic anomaly map of the Antarctic region south of 60°S (ADMAP-1) some six years after its 1995 launch (Golynsky et al., 2001). The international working group produced the ADMAP-1 database from more than 1.5 million line-kilometres of terrestrial, airborne, marine and satellite magnetic observations collected during the IGY 1957-58 through 1999.

Since the publication of the first magnetic anomaly map, the international geomagnetic community has acquired more than 1.9 million line-km of new airborne and marine data. These new data provide important constraints on the geology of the enigmatic Gamburtsev Subglacial Mountains and Prince Charles Mountains, Wilkes Land, Dronning Maud Land, and other largely unexplored Antarctic areas (Ferraccioli et al., 2011, Aitken et al., 2014, Mieth & Jokat, 2014, Golynsky et al., 2013).

The processing of the recently acquired data involved quality assessments by careful statistical analysis of the crossover errors. All magnetic data used in the ADMAP-2 compilation were delivered as profiles, although several of them were in raw form. Some datasets were decimated or upward continued to altitudes of 4 km or higher with the higher frequency geological signals smoothed out. The line data used for the ADMAP-1 compilation were reprocessed for obvious errors and residual corrugations. The new near-surface magnetic data were corrected for the international geomagnetic reference field and diurnal effects, edited for high-frequency errors, and levelled to minimize line-correlated noise.

The magnetic anomaly data collected mainly in the 21-st century clearly cannot be simply stitched together with the previous surveys. Thus, mutual levelling adjustments were required to accommodate overlaps in these surveys. The final compilation merged all the available aeromagnetic and marine grids to create the new composite grid of the Antarctic with minimal mismatch along the boundaries between the datasets. Regional coverage gaps in the composite grid will be filled with anomaly estimates constrained by both the near-surface data and satellite magnetic observations taken mainly from the CHAMP and Swarm missions.

The ADMAP-2 map provides a new geophysical foundation to better understand the geological structure and tectonic history of Antarctica and surrounding marine areas. In particular, it will provide improved constraints on the lithospheric transition of Antarctica to its oceanic basins, and thus enable improved interpretation of the geodynamic evolution of the Antarctic lithosphere that was a key component in the assembly and break-up of the Rodinia and Gondwana supercontinents.

This work was supported by the Korea Polar Research Institute.



## ***Nature and extent of a Tonian Oceanic Arc Super Terrane (TOAST) in eastern Dronning Maud Land: integrating geology and geophysics***

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An extensive Tonian Oceanic Arc Super Terrane (TOAST) has been recognized in a so far poorly studied area in eastern Dronning Maud Land based on integrated geological-geophysical studies. The TOAST is sandwiched in between Kalahari and Rukerland and consists of a characteristic gabbro-trondhjemite-tonalite-granite suite dated at ca. 1000-900 Ma. TOAST samples have normalised trace element patterns typical for subduction-related magmas, have mostly a positive initial epsilon Nd and lack significant inheritance, typical for juvenile crust. The TOAST underwent protracted Late Neoproterozoic/Early Palaeozoic crustal reworking, migmatization and polyphase melt production as a result of accretion-collision tectonics from ca. 650-500 Ma. Airborne geophysics allows us to speculate that the TOAST has a significant southern extent until ca. 76S, where it abuts against a cryptic craton. The western margin of the TOAST probably represents the Forster Magnetic Anomaly in central Dronning Maud Land, whilst the eastern margin is poorly surveyed at present. We have tested the validity of the southern extension of the TOAST with the help of a U-Pb zircon detrital moraine study from the southern side of the Sør Rondane Mts. One-thousand zircons from nine moraine samples from southernmost Sør Rondane, the Nansen ice field and Steingarden, were dated by LA-ICP-MS. The analyses fall into three major age groups at ca. 1080, 950 and 550 Ma; only very few older Palaeoproterozoic zircons were found. Apart from late-tectonic granites, another common lithology in the moraines is a grey gneiss with a U-Pb zircon age of ca. 1080 Ma, similar to the oldest major age peak found. Rocks of this age are not commonly exposed in Sør Rondane. Similar to TOAST samples, the grey gneisses have a subduction signature with negative Nb/Ta anomalies; however, they are more evolved than the proximate juvenile TOAST. Although rocks with ages of ca. 1080 Ma are common in the Maud and Rayner belts to the E and W, the grey gneisses in the moraines differ from the latter two in that they are much more juvenile. The grey gneisses probably represent an early, late Mesoproterozoic phase of the TOAST. A Late Mesoproterozoic/Tonian metamorphic overprint is neither recorded in rocks of the TOAST nor the grey gneisses, indicating that these oceanic arcs probably evolved outboard of Rodinia.

## ***Drilling project at Gamburtsev Subglacial Mountains, East Antarctica: Recent progress and plans for the future***

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The Gamburtsev Subglacial Mountains (GSM), located in the central East Antarctica, have highly dissected Alpine topography reaching maximum elevations of 3000 m and a median elevation of about 1400 m and are completely covered by over 600 m of ice, firn and snow. One of the largest mountain ranges on the Earth has become the subject of great scientific interest because the mechanism driving uplift of the young-shaped GSM in the middle of the old East Antarctic Shield is unknown. The next step of the GSM exploration focuses on the direct observation of ice sheet bed by drilling and recovering geological materials. It is proposed to use cable-suspended drilling technology. All drilling equipment (winch, control desk, drilling fluid station, etc.) is installed inside a movable sledge-mounted warm-keeping and wind-protecting drilling shelter. Mast has two positions: horizontal for transportation and vertical working position. Movable workshop has basically the same design as drilling shelter and serves for keeping two generators, logging service, workshop for repairing and maintaining of drilling equipment, core processing. Drilling shelter and workshop will be transported to the chosen site with crawler tractors together with habitable unit and three sledges with drilling fluid, fuel and auxiliary drilling equipment. All equipment would be ready to start drilling in 2-3 days upon arrival to the site. To drill through ice and bedrock a new, modified version of the cable-suspended Ice and Bedrock Electromechanical Drill IBED was designed and tested. IBED drill is designed to solve three different tasks: (1) dry core drilling with large-diameter auger for drilling of the pilot hole through snow-firn layer; (2) wet core drilling with bottom-fluid reverse circulation for drilling in the unpermeable ice to the base of the ice sheet; (3) bedrock core drilling using teeth diamond bit and standard core barrel from conventional diamond drill string. IBED drill has modulus construction, and different sections of the drill for different tasks are replaced. According to approved schedule, the first field tests are planned to carry out just outside Zhongshan Station near Antarctic coast in season 2016-17. Next season 2017-18 the movable drilling shelter is planned to be transported to the chosen drilling site in the GSM region, and drilling to the bedrock would be finished during two seasons.

## ***Geology of the Lake Vostok area and potential for the lake bottom sampling***

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Lake Vostok is located beneath a thick ice sheet, more than 1000 km inland from the coast. It occupies an extensive NS-trending bedrock depression 250 km long and 50 to 80 km wide. The bottom of the lake averages about 1000 m below sea level and about 1500 m relative to its flanks. The basal (accreted through re-freezing of lake water) layer of the ice sheet above Lake Vostok, studied by the Vostok Station Borehole contains mm-sized, rarely distributed (1-2 per liter of ice) clayey aggregates peppered with micro-grains of minerals (mostly quartz). This material was derived from the shallow south-western lake bottom during formation of the accreted ice and so reflects its composition and also geology of source areas. Some aggregates contain rock clasts representing equigranular quartzose sandstones and siltstones. The biggest 8-mm long siltstone clast was found in the accreted ice layer at a depth of 3607-3608 m which is most abundant with aggregates. Optical and SEM studies showed that this clast is composed of quartz (c. 70 %), feldspar (mostly orthoclase, c. 20 %), cement (chlorite, c. 10 %) and accessories (c. 1%). Its porosity is about 1,5 % and grain density is 2.6 g/cub. cm. Clay minerals from the relatively large aggregate found at a depth of 3607,5 m were studied using X-Ray diffraction and Infrared spectroscopy analyses which showed the presence of illite, chlorite and kaolinite with concentrations of 69%, 24%, 7%, respectively.

Rock clasts found in the accreted ice and identified as sandstones and siltstones suggest sedimentary genesis of the western lake-shore bedrock from where they were eroded and transported to the lake. Petrography and physical properties of these clasts as well as high content of chlorite (24 %) in the aggregate clay fraction suggest that the provenance of bottom sediments consists of well consolidated, diagenetically altered terrigenous rocks. This is also confirmed by refraction seismic data which show seismic velocities of 5.4-5.5 km/s at the bedrock surface of the western lake shore. Age and tectonic setting of sedimentary strata remain uncertain. Zircon grains dated in clasts (Leitchenkov et al., 2016) indicate the youngest ages of 600 Ma and hence original strata are not older than this. Post-600 Ma terrigenous unmetamorphosed sedimentary rocks known in East Antarctica and generally resembling studied rock clasts range from the Neoproterozoic to Early Mesozoic in age but high values of P-wave velocities are rather typical for older (Late Neoproterozoic-Early Paleozoic) assemblages like those developed on the eastern flank of the Denman Glacier where consolidated (2.6 g/cub.cm) sandstones dominate.

A new step and breakthrough in the research of sub-ice geology and environments of central Antarctica can be done by the Lake Vostok bottom sampling. Seismic surveys showed the existence of 100-200 m thick stratified deposits presumably of Oligocene to Pliocene age (Leitchenkov et al., 2016). Technical options for clean access to the lake bottom are currently elaborated and will be presented at the meeting.

## ***Polymetamorphic crust and a Neoproterozoic orogeny in the eastern Wilkes Land inferred from the marine sediments***

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Marine sediments proximal to the east Antarctic Ice Sheet provide a reliable clue to the subice geology. IODP expedition 318 drillsite U1359 is the easternmost of the six boreholes drilled. Sediment supply from the dominantly Palaeozoic and younger terrain from east (Ross Orogen) following East Wind Drift (counter current of the Antarctic Circum Polar Current or ACC) and Archean-Proterozoic shield area from the hinterland has been demonstrated.

Some knowledge of the geology of the eastern source is available and it is also inferred that significant exposures of Ferrar Large Igneous Province exist under a subglacial basin from which Ninnis glacier emanates. However, information on the nature of crust of the shield area is largely lacking.

Using heavy mineral and sedimentological data we show that the shield area comprises of polymetamorphosed terrain. The high grade shield is upper amphibolites to granulite facies and is represented by garnet-amphibole, garnet-orthopyroxene and aluminosilicate bearing pelitic schists and a low grade two-mica schist and possibly chlorite schists.

Chemical geochronology of texturally constrained subhedral monazite in biotite-muscovite schist provides a unimodal age of 799±13 Ma for the low-grade schist. This possibly represents the first report of a definite Neoproterozoic orogeny in the easternmost segment of Wilkes Land and has significant implications for the supercontinent assembly.

## ***The formation and erosion of sedimentary basins in western Wilkes Land.***

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Sedimentary basins are sensitive recorders of both tectonic and surface processes. Here we analyse some of the basins of eastern Wilkes Land (Aurora, Vincennes, Sabrina and Knox Subglacial sedimentary basins) to try to better understand their formation process, and their subsequent erosion. We define several distinct sub-basins each of which has a different inferred style of formation and erosive history. The Aurora and Vincennes Subglacial basins are broad and thick (ca. 4-5 km average preserved thickness), with very-smooth topographic surfaces; The Sabrina Subglacial Basin is broad but thinner (ca. 2 km average preserved thickness), and in general has a rougher surface; The Knox Subglacial Basin is narrow and elongated, and ca. 6 km thick (average preserved thickness), and also has a fairly smooth surface. In addition, our modelling suggests that intra-basin highlands are largely composed of sedimentary rocks. These appear to be little eroded, and allow estimates of erosion to be made: Replacing the eroded material, and accounting for the isostatic effects of the ice sheet and the replaced sedimentary rocks, we generate a model of topography prior to the growth of the East Antarctic Ice Sheet.

## ***Use of a digital subglacial geological map of western Marie Byrd Land to illuminate East Gondwana crustal growth and dispersal***

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The record of East Gondwana crustal growth and dispersal that is evident in rock exposures of the Ford Ranges and Edward VII Peninsula, western Marie Byrd Land, pertains to an extensive subglacial region beneath West Antarctica. We use ground-based geological data, heritage geophysical data, and maps of local extent from journal publications to develop the first digital subglacial geological map for Marie Byrd Land (MBL).

Our point of departure is the new digital geological map at circa 1:250 000 scale that is a component of the new SCAR GeoMap database (<http://www.scar.org/geomap>; Cox & Morin, this volume). GeoMap employs a mixed chronostratigraphic- and lithostratigraphic-based classification to provide a continent-wide geosphere dataset in international GeoSciML data format. For MBL, feature classification was developed using archival US Geological Survey geological maps, data from 1998 to 2007 field investigations, plus blue ice and water features evident in <sup>TM</sup>DigitalGlobe satellite image products. The resulting polygon features include bedrock and surficial geological units, and line features correspond to 7 rankings of crustal- to lithospheric-scale faults. Special care was given to sites of Pliocene and younger volcanism, and zones of inferred mineralization/ geothermal activity, due to their potential consequences for West Antarctic ice sheet stability.

The new GIS is employed for interpretation of the sub-glacial bedrock geology of western Marie Byrd Land, drawing upon archival airborne geophysical data recorded at 10.6 and/or 5.3 km flightline spacing over ca. Edward VII Peninsula (Ferriaccioli et al., 2001) and the Ford Ranges (Luyendyk et al., 2003). Re-examination of these aerogeophysics data is timely due to the new context that has emerged as a result of new geological research (2010-12); availability of integrated geophysical datasets for Antarctica, including those of SCAR ADMAP and Antarctic Seismic Data Library, NASA Icebridge, and POLEnet; and new geophysical exploration via the ROSETTA-Ice Ross Ice Shelf of the U.S. Antarctic program.

The new framework is used to test existing hypotheses about the tectonic and landscape evolution of West Antarctica (Luyendyk et al. 2003; Siddoway, 2008; Sugden et al. 2005). For analysis, the subglacial bedrock geological map is rendered upon BEDMAP2 subglacial topography and adjusted topography following glacial rebound (Wilson et al., 2012). Major outcomes of the MBL subglacial mapping effort include the delimitation of three detachment-bounded gneiss domes (marked by magnetic anomaly maxima, ~600 nT or greater, that are spatially associated with documented and inferred detachment faults), determination of the extent of sub-ice volcanic centers and eruptive products, development of a fault classification hierarchy, and recognition of prospective Permo-Triassic depocenters of small extent. The next phase of investigation addresses the question of bedrock structural controls upon factors that may reduce the stability of the West Antarctic ice sheet.

## **S21. Remote sensing of the Antarctic environment: Multi-disciplinary advances D1, Meeting Room 403, August 22, 2016, 3:30 PM - 6:00 PM**

### ***Timing and regional patterns of snowmelt on Antarctic sea ice from passive microwave satellite observations***

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The better understanding of temporal variability and regional distribution of surface melt on Antarctic sea ice is crucial for the understanding of atmosphere-ocean interactions and the determination of mass and energy budgets of sea ice. Since large regions of Antarctic sea ice are covered with snow during most of the year, observed inter-annual and regional variations of surface melt mainly represents melt processes in the snow. It is therefore important to understand the mechanisms that drive snowmelt, both at different times of the year and in different regions around Antarctica.

In this study we combine two approaches for observing both surface and volume snowmelt by means of passive microwave satellite data. The former is achieved by measuring diurnal differences of the brightness temperature TB at 37 GHz, the latter by analyzing the ratio TB(19GHz)/TB(37GHz). Moreover, we use both melt onset proxies to divide the Antarctic sea ice cover into characteristic surface melt patterns from 1988/89 to 2014/15.

Our results indicate four characteristic melt types. On average, 43% of the ice-covered ocean shows diurnal freeze-thaw cycles in the surface snow layer, resulting in temporary melt (Type A), less than 1% shows continuous snowmelt throughout the snowpack, resulting in strong melt over a period of several days (Type B), 19% shows Type A and B taking place consecutively (Type C), and for 37% no melt is observed at all (Type D). Continuous melt is primarily observed in the outflow of the Weddell Gyre and in the northern Ross Sea, usually 20 days after the onset of temporary melt.

Considering the entire data set, snowmelt processes and onset do not show significant temporal trends. Instead, areas of increasing (decreasing) sea-ice extent have longer (shorter) periods of continuous snowmelt.

## ***Mapping and assessing variability in the Antarctic marginal ice zone, the pack ice and coastal polynyas***

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Sea ice variability within the marginal ice zone (MIZ) and polynyas plays an important role for phytoplankton productivity and krill abundance. Therefore mapping their spatial extent, seasonal and interannual variability is essential for understanding how current and future changes in these biological active regions may impact the Antarctic marine ecosystem. Knowledge of the distribution of different ice types to the total Antarctic sea ice cover may also help to shed light on the factors contributing towards recent expansion of the Antarctic ice cover in some regions and contraction in others. The long-term passive microwave satellite data record provides the longest and most consistent data record for assessing different ice types. However, estimates of the amount of MIZ, consolidated pack ice and polynyas depends strongly on what sea ice algorithm is used. This study uses two popular passive microwave sea ice algorithms, the NASA Team and Bootstrap to evaluate the distribution and variability in the MIZ, the consolidated pack ice and coastal polynyas. Results reveal the NASA Team algorithm has on average twice the MIZ and half the consolidated pack ice area as the Bootstrap algorithm. Polynya area is also larger in the NASA Team algorithm, and the timing of maximum polynya area may differ by as much as 5 months between algorithms. These differences lead to different relationships between sea ice characteristics and biological processes, as illustrated here with the breeding success of an Antarctic seabird.



# ***Model simulation of radar returns for microwave remote sensing of sea ice with computational electromagnetics***

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This paper presents a numerical solution for computational electromagnetics in microwave remote sensing of random discrete medium such as sea ice. In ground truth measurement of sea ice layer found in Antarctica, it shows a wide variety of physical configuration of scatterers such as brine inclusion and air bubbles in the sea ice layer. These scatterers are embedded in the sea ice layer with different distribution, orientation, shape and size. Traditionally, theoretical microwave model has been using an assumption of uniform distribution and orientation of groups of standard scatterers of fixed size and standard shape to represent the overall ensemble of scatterers in the sea ice layer. With the advancement of computer technology and development of computational electromagnetics, it is proposed to utilize this technique for more realistic simulation of scatterers with different size and shape as found in ground truth measurement. In computational electromagnetics, the Equivalence Principle Algorithm (EPA) is applied where it utilizes the concept of equivalent surface to provide a faster and convenient way to compute scattered fields of arbitrary shape of scatterers. This is developed based on our previous work on the Radiative Transfer (RT) theory that was able to compute radar returns which match well with the SAR images in Antarctica where in that model, scatterers were represented with basic shapes of spheres and cylinders. With the new improved theoretical modeling based on numerical solution of EPA, the study can be applied to scatterers of arbitrary shape that can represent better the actual scatterers in sea ice layer of Antarctica. This extends the use of the theoretical modeling to some sea ice areas where previous theoretical modeling cannot be applied to. The results show that the new improved model is able to provide better representation of sea ice layer with the correct calculation of radar returns and analysis of scattering mechanisms involved. This provides a suitable forward scattering model that can be used for the development of inverse model for the retrieval of sea ice parameters such as thickness and the understanding of scattering mechanisms in the sea ice layer will provide the Antarctica user community with better knowledge of radar observation configuration such as frequency, polarization, looking angle for satellite imaging of Antarctica sea ice areas.

## ***A reference elevation model of Antarctica***

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Accurate surface elevation is an essential dataset for glaciology, required for mapping bed topography from ice thickness, measuring ice thickness changes, constraining ice flow and geodynamic models, mapping glacial geomorphology, terrain corrections and filtering of remote sensing observations, and many other science tasks. It is also critical for mapping ice traverse routes, landing sites and other field logistics planning. The polar regions have particularly poor topographic data due to their remoteness and the latitudinal limits of the Shuttle Radar Topography Mission (SRTM) of 60°N and 56°S. For most of Antarctica, continuous grids of surface elevation, termed Digital Elevation Models (DEMs), are limited to spatial resolutions of > 500 m and/or vertical errors reaching 10's of meters or more.

A new collection of sub-meter, electro-optical stereo imagery, public domain photogrammetry software and high-performance computing resources makes a continent-wide elevation model a possibility. We are using the Worldview constellation of three satellites (WV-1,-2,-3) launched in 2007, 2009 and 2014, respectively, with pixel ground resolutions of less than 0.5 m in the panchromatic band. The camera pointing capabilities of these polar orbiting satellites allow them to obtain overlapping images from different look angles, appropriate for stereo-photogrammetric DEM extraction. Using only the Rational Polynomial Coefficients (RPCs) derived from satellite ephemeris, Worldview DEM's may have translational errors (biases) of several meters. These can be reduced with a single ground control point to the point-to-point (relative) error of 20 cm which is comparable to the uncertainty of airborne lidar.

The Antarctic ice sheet is rapidly changing and may contribute substantially to near-future sea level rise, so that changes in its thickness have global consequences. Antarctica remains, however, the most poorly mapped continent on the planet in terms of surface topography. REMA would provide the high-resolution benchmark needed to capture future changes and constrain prognostic models, improving our ability to measure and predicts the ice sheet's contribution to sea level.

## ***Multisensor fusion to reconstruct outlet glacier elevation changes in Antarctica***

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During the last two decades surface elevation data have been gathered over the Greenland and Antarctic Ice Sheet from a variety of different sensors, including spaceborne and airborne laser altimetry (ICESat, ATM and LVIS) and from satellite stereo imaging systems, most notably from SPOT, ASTER and Worldview. The spatio-temporal resolution, the accuracy, and the spatial coverage of all these data differ widely. For example, laser altimetry systems are much more accurate than DEMs derived by correlation from imaging systems. On the other hand, DEMs usually have a superior spatial resolution and extended spatial coverage.

We have originally developed the SERAC system (Surface Elevation Reconstruction And Change detection) for ICESat laser altimetry data with a rigorous solution for crossover areas. It simultaneously determines the ice sheet surface shape and the time series of elevation changes for the crossover areas, size about 1 km by 1 km. We then extended SERAC to include surface patches along ICESat tracks. This solution is rank-deficient due to the dependency of across track slope and elevation change. We fix the problem by introducing knowledge about the across track slope that is derived from adjacent crossover solutions.

Quite often there are elevation data available acquired by other sensors at different times. By incorporating multiple sensor data into SERAC, we achieve time series of elevation changes that are denser and extended in space and time. Moreover, the high accuracy of the laser altimetry observations allows the removal of systematic DEM errors. These abilities make SERAC a true multi-sensor fusion system. After a brief overview the paper explains in detail how different sensor data are treated in SERAC and the significance of spatially and temporally extended time series. This is especially important on rapidly changing outlet glaciers where laser altimetry data might only be available sporadically.

We demonstrate the fusion capabilities of SERAC with several examples from the Sulzberger Ice Shelf, Antarctica. This region is situated around the coast of the West Antarctic Ice Sheet, just south of the Ross Ice Shelf. First we show the density and distribution of ICESat crossover areas and conclude that there are too few points to draw solid conclusions about the regional differences of surface elevation changes. The situation greatly improves when we add along track points but the spatial distribution is far from ideal. Adding corrected ASTER and SPOT DEMs together with ICESat laser altimetry points and computing simultaneously time series of surface elevation changes vividly demonstrates the potential of SERAC.

## ***Development and field testing of ARTEMIS, an AUV designed for sub-ice investigation and mapping***

**Victoria Siegel<sup>1</sup>**, William Stone<sup>1</sup>, Kristof Richmond<sup>1</sup>, Christopher Flesher<sup>1</sup>, Mark Scully<sup>1</sup>, Evan Clark<sup>1</sup>, Peter Kimball<sup>1</sup>, John Harman<sup>1</sup>, Keith Huffstutler<sup>1</sup>, Scott Lelievre<sup>1</sup>, Brian Pease<sup>1</sup>, Peter Doran<sup>2</sup>, Britney Schmidt<sup>3</sup>  
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ARTEMIS is a 6 degree-of-freedom, hovering autonomous underwater vehicle (AUV) designed and built as part of the NASA ASTEP SIMPLE project, which aimed to characterize the underside of the McMurdo Ice Shelf. The AUV is 4.3 m long by 1.2 m wide by 0.8 m high. The physical design was constrained by the need to deploy and retrieve the vehicle through a 1.3 m diameter hole drilled through the sea ice adjacent to the ice shelf. The AUV was outfitted with forward-, downward-, and upward-looking sonar instruments for obstacle avoidance, sea floor bathymetry, and ice ceiling mapping, respectively. Since egress was restricted to a single hole in the sea ice, a precise return-home procedure and docking system were needed to ensure AUV recovery. A docking bar lined with oscillating LED lights was lowered into the water and a machine-vision system on the AUV was used to find, navigate to, and latch onto the bar, which was then winched up through the shaft to recover the vehicle. The AUV incorporated a suite of water chemistry instruments, mostly contained in a sonde package that could be extended above the vehicle for proximity operations near the ice ceiling and to obtain undisturbed water sonde casts. A protein fluorescence spectrometer, designed to look for protein signatures in the ice ceiling, was also housed in the sonde. ARTEMIS carried a RAS100 water sampler and was able to collect 36x100-cc samples per mission. A 1.5 mm diameter data fiber was deployed by the vehicle, linking it to Mission Control on the surface and enabling 1 Gbps data feedback on mission progress and environmental conditions. The vehicle carried a 10 W magnetic field generator that enabled surface tracking of the vehicle through both sea ice and the ice shelf.

The AUV conducted 20 under-ice missions in the Ross Sea, many with complex trajectories aimed at mapping the sea-ice/ice-shelf transition. Maximum mission length was 10.1 km round trip and top speed was 1.05 m/s. Initial problems with high speed pitch instability were resolved by addition of high-surface-area rear fins. Attitude thrust authority was reduced at higher speeds. Many on-board science sensors experienced significant noise input due to the use of switching power supplies. Drag from the data fiber, exacerbated by ocean currents in excess of 0.2 m/s, was significant and became one factor limiting mission range. Hovering proximity operation maneuvers were successfully developed to approach and investigate the ice ceiling. However, platelet ice accumulations on the hard ice surface precluded successful use of the spectrometer. Sonde casts and water sampling were routinely conducted. Ice occasionally formed on the AUV, possibly as a result of transiting from cold seawater to the fresher water adjacent the platelet ice layer. This same platelet ice layer blocked long range, low bandwidth 2 MHz RF communications to the vehicle. Successful experiments were subsequently conducted using 3.75 kHz RF transmission to distances of several kilometers from the vehicle. The AUV successfully completed fully-automated return, rendezvous, and docking procedures.

## ***Mapping patterns of temperature change in the Antarctic***

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Responses of the Antarctic environments to climate change are complex: On one hand, the Antarctic Peninsula is one of the fastest warming areas on Earth, while other areas such as the East Antarctic Ice Sheet experience a cooling trend. This stresses the strong spatial variability in temperature and temperature change. But change is not only characterised by a general trend, but also by alterations in variability and extremes. In order to better understand the spatial patterns of change, we analysed a comprehensive, spatially explicit, gridded dataset of daily land surface temperature (LST) values from 2003 to 2015 made available by the Moderate Resolution Imaging Spectroradiometer (MODIS) programme. The MODIS LST product consists of day-time and night-time measurements at 1 km spatial resolution provided by a sensor mounted on two satellites, Aqua and Terra, which are characterised by differences in overflight times. The complete data from the two satellites Aqua and Terra were downloaded and processed using an open-source processing chain running on a High Performance Computing platform. To minimise data gaps that mostly result from clouds, Aqua and Terra datasets were harmonised and merged. As one of the most comprehensive datasets describing a climate variable and its change over time, it is very valuable to climatic and ecological Antarctic research. We intend to make the dataset available to interested researchers and carried out a case study showing the potential of the data. For each year available, statistical aggregation measures such as average, standard deviation and minimum/maximum values were then calculated. The resulting time series was then standardised and classified to identify areas that show similar patterns of change.

## ***Recognition and mapping of Antarctic lakes using spectral-spatial characteristics of high resolution satellite imagery***

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Mapping and monitoring lakes in remote polar regions using conventional surveying method is a laborious and logistically expensive assignment. A robust method for extracting and monitoring lakes in Antarctic coastal oases has a remarkable geospatial application in polar remote sensing. The present study discusses the design and implementation of semiautomatic approach for extracting lake features from Larsemann Hills, eastern Antarctica, using normalized difference water index (NDWI). NDWIs were developed by incorporating 8 spectral bands of high-resolution WorldView-2 (WV-2) multispectral image (MSI) data. Quantitative assessment of performance of each NDWI was carried out to test the robustness of NDWI approach for mapping lake features in cryospheric environment. Also, we assessed the performance of characteristic 8 spectral bands of WV-2 imagery to compare their performance in mapping lakes in cryospheric environ. Our results suggest that the NDWI approach render significant performance with bias error varying from ~1 to ~34 m<sup>2</sup> (least amount of misclassified pixels). In this study, NDWI based on yellow (585 – 625 nm) and near-infrared 2 (NIR2) band pair performed superior than other band pairs for extraction of frozen lakes, while blue and coastal bands performed superior for open lake extraction. Our research focused on getting a deeper insight into strength and weakness of 8 spectral bands of WV-2 and based on that knowledge designing a brand-new index to accurately delineate lakes from Antarctica, which might be useful for wide geoscientific applications in cryospheric sciences.

## ***Mapping snow patch distribution in the South Shetlands using remote sensing techniques***

**Carla Mora**<sup>1</sup>, Gonçalo Vieira<sup>1</sup>, Juan Javier Jiménez<sup>2</sup>, Pedro Pina<sup>3</sup>, Miguel Ramos<sup>2</sup>, Miguel Angel de Pablo<sup>2</sup>, Lourenço Bandeira<sup>3</sup>, Marc Oliva<sup>1</sup>, Carlos Schaefer<sup>4</sup>, João Branco<sup>1</sup>, Alice Ferreira<sup>1</sup>, Inês Girão<sup>1</sup>, Alexandre Nieuwendam<sup>1</sup>, Ana David<sup>1</sup>

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Pattern and timing of summer snow melt in the ice-free areas of the South Shetlands control numerous environmental processes. The effects of a changing snow cover will influence permafrost and the active layer, surface and subsurface hydrology and the biogeochemical cycle, sediment fluxes, vegetation communities and even local fauna. Therefore, the proper characterization of the changing snow cover and seasonal snow melt is of high priority for understanding the effects of a changing climate in the terrestrial environments of the Antarctic Peninsula. However, monitoring snow melt is very complex, especially when aiming at a high resolution spatial analysis resolving the topography of the small peninsulas of the South Shetlands. Our team has been monitoring snow cover for almost 10 years in detailed study sites in Deception, Livingston and King George Islands and testing various site-based and remote sensing techniques. This presentation discusses the advantages and disadvantages, while showing an overview of the main results obtained with the use of: i. in-situ point monitoring sensors (sonic range sensors, multi-thermometer poles), ii. time-lapse cameras, iii. optical remote sensing imagery (landsat, QuickBird, WorldView, etc.), iv. microwave remote sensing imagery (ENVISAT ASAR, TerraSAR-X) and v. Unmanned Aerial Vehicles.

## ***A novel approach to monitoring the impact of climate change on Antarctic ecosystems***

**Malgorzata Korczak-Abshire**<sup>1</sup>, Anna Zmarz<sup>2</sup>, Stein Rune Karlsen<sup>3</sup>, Mirosław Rodzewicz<sup>4</sup>, Rune Storbvold<sup>3</sup>, Katarzyna Chwedorzewska<sup>1</sup>, Anna Kidawa<sup>1</sup>

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Remotely Piloted Aircraft Systems (RPAS) represent an emerging technology which is increasingly used in environmental research, also in difficult to access Antarctic regions. The main goal of the project was to study the impact of climate change on Antarctic ecosystem and biodiversity. The Western Antarctic Peninsula (WAP) is exhibiting rapid regional climate changes, resulting in changes of the range and abundance of the birds and marine mammals, as well as distribution of vascular plants, which are important ecological bioindicators. This project utilizes three fixed-wing Unmanned Aerial Vehicles (UAVs) to collect baseline geospatial environmental data, which were used to monitor climate change effects on King George Island (South Shetlands), in particular, quantifications of seals and penguins populations, flora distribution, and glacier retreats.

Data collection by UAVs recording data in multiple spectral ranges took place during two Antarctic summer seasons, 2014/15 and 2015/16. The presented study shows successful application of fixed-wing UAVs, which allowed us to obtain geospatial environmental data for the 14.63 km<sup>2</sup> of the investigated area. Small-format aerial photography taken from the altitude of 350 m above ground level makes it possible to obtain large scale images. Analysis of high resolution images (the ground sample distance for the RGB - Red, Green, Blue - camera <5cm) enabled us to locate and count over twenty five thousand occupied nests of three *Pygoscelis* penguin species in five breeding colonies located in Antarctic Specially Protected Areas No 128 and 151 on King George Island. These results coincide with the results of the counts made from the ground. With the UAV data we have developed high resolution vegetation maps and estimated changes in vegetation cover in comparison with previous mappings (summer season 1979). Data processing was based on remote sensing algorithms used on the aerial photogrammetric material, as well as on ground based methods developed by scientists participating in the project. In the future these methods will allow collection of photogrammetric material without the need to conduct additional ground measurements.



## **S23. Microbes, diversity, and ecological roles (A2), Meeting Room 401/402, August 22, 2016, 3:30 PM - 6:00 PM**

### ***Relationship between soil fungal diversity and temperature in the maritime Antarctic***

**David Hopkins**<sup>1</sup>, Kevin Newsham<sup>2</sup>, Steve Rushton<sup>3</sup>, Anthony O'Donnell<sup>4</sup>, Peter Fretwell<sup>2</sup>, Lilia Carvalhais<sup>5</sup>, Paul Dennis<sup>5</sup>

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Soil fungi have pivotal ecological roles as decomposers, pathogens and symbionts. Alterations to their diversity arising from climate change could have substantial effects on ecosystems, and particularly those undergoing rapid warming that contain few species. Here, we report a study using pyrosequencing to assess fungal diversity in 29 soils sampled from a 1,650 km climatic gradient through the maritime Antarctic, the most rapidly-warming region in the southern hemisphere. Using a 'space-for-time' substitution approach, we show that soil fungal diversity is higher in warmer habitats, with increases of 4.7 (observed) and 11.3 (predicted) fungal taxa per degree Celsius rise in surface temperature along the transect. Among 22 predictor variables, air temperature was the most consistent and strongest predictor of diversity. We propose that the current rapid warming in the maritime Antarctic (0.34 °C per decade<sup>6</sup>) will facilitate the colonisation of soil by a wider diversity of fungi than at present, with data from regression models suggesting 20–27% increases in fungal species richness in the southernmost soils by 2100. Such increases in diversity, which provide a sentinel for changes at lower latitudes, are likely to have substantial effects on nutrient cycling and, ultimately, productivity in the species-poor soils of maritime Antarctica.

## ***Bacterial and eukaryotic biodiversity patterns in the Sør Rondane Mountains, Dronning Maud Land, East Antarctica***

**Elie Verleyen**<sup>1</sup>, Bjorn Tytgat<sup>1</sup>, Dagmar Obbels<sup>1</sup>, Maxime Sweetlove<sup>1</sup>, Zorigto Namsaraev<sup>2,3</sup>, Marie-José Mano<sup>2</sup>, Rafael Fernandez-Carazo<sup>2</sup>, Karolien Peeters<sup>1</sup>, Sofie D'Hondt<sup>1</sup>, M. Pia Clercx<sup>1</sup>, Aaike De Wever<sup>1,4</sup>, Damien Ertz<sup>5</sup>, Eric Van Ranst<sup>1</sup>, Stephen Roberts<sup>6</sup>, Koen Sabbe<sup>1</sup>, Annick Wilmotte<sup>2</sup>, Anne Willems<sup>1</sup>, Wim Vyverman<sup>1</sup>

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The microbial biodiversity of inland Antarctic regions and the factors shaping these communities are poorly understood. We used the Illumina MiSeq and the Roche 454 platforms to analyse the bacterial and eukaryotic community structure of a variety of habitats in ice-free regions of the western Sør Rondane Mountains (Dronning Maud Land, East Antarctica), including endolithic communities, cryoconite holes, water lenses where the ice sheet meets bedrock, water samples from melted lake ice, and epiphytic communities on mosses. A particular focus was put on studying the bacterial community structure in soil samples in relation to environmental variability. OTUs belonging to the Rotifera, Chlorophyta, Tardigrada, Ciliophora, Cercozoa, Fungi, Bryophyta, Bacillariophyta, Collembola and Nematoda were present with a relative abundance of at least 0.1% in the eukaryotic communities studied. Cyanobacteria, Proteobacteria, Bacteroidetes, Acidobacteria, FCB, and Actinobacteria were the most abundant bacterial phyla across the different habitats. Multivariate analyses of the 454 pyrosequencing data revealed a lack of differentiation of both eukaryotes and prokaryotes according to habitat type (aquatic versus terrestrial); in the eukaryotes, 46% of the OTUs was shared between both habitats. However, while 33% of the bacterial OTUs occurred in aquatic and terrestrial samples, the bacterial community structure appeared to be significantly different between both habitats. This was partly due to the dominance of the filamentous cyanobacteria *Leptolyngbya* in aquatic environments. In the soils, ordination analyses revealed that total organic carbon content was the most significant variable in structuring prokaryotic communities, followed by pH, electric conductivity, bedrock type and moisture content, while spatial distance was of relatively minor importance. Acidobacteria (*Chloracidobacteria*) and Actinobacteria (*Actinomycetales*) dominated mineral soil samples situated on gneiss derived bedrock, while Proteobacteria (*Sphingomonadaceae*), Cyanobacteria, *Armatimonadetes* and candidate division FCB (OP11) dominated soil samples with a high total organic carbon content mainly on granite derived bedrock. Despite these strong environmental controls, part of the unexplained variation in community structure might be related to unmeasured differences in microclimate conditions that potentially exert large effects on these barren soils. A striking feature in all datasets was the detection of a relatively large amount of sequences new to science, which underscores the need for additional biodiversity assessments in Antarctic inland locations.

## ***Macromolecular composition of Antarctic coastal and sea ice microalgal communities***

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Marine microalgae form the base of the food web, providing the nutrients and energy for higher trophic levels. The surrounding environmental conditions influence the phenotypic traits of microalgae such as, photophysiology and macromolecular composition, consequently impacting on nutrient cycling, grazability and transfer of nutrients and energy to higher trophic levels. Using FTIR spectroscopy we assessed photosynthetic performance and biochemical composition (lipids, carbohydrates and proteins) of microalgal cells sampled from the sea ice and coastal waters of Prydz Bay, Antarctica. The photosynthetic efficiency and photoprotective capacity of the microalgal communities did not differ significantly between locations. However, chl a-specific gross productivity was fourfold greater in the coastal community than the sea ice. For single-cell biochemical analysis, the most dominant species from each location were selected. At the community level, the lipid and carbohydrate content of sea ice algae were almost double that of coastal pelagic algae, while protein content remained relatively similar across both communities. There were also species-specific differences in the macromolecular ratios within each community. These findings emphasise the importance of sea ice assemblages for the Antarctic food web, providing a concentrated source of energy for Antarctic keystone grazers such as krill.

## ***Isolation and preliminary characterisation of psychrotrophic hydrogen producing bacteria from Antarctic soil and seawater***

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Full scale anaerobic bioreactors for biological hydrogen production usually operate under mesophilic or thermophilic conditions. Operation under lower (below 30°C) temperature ranges is still very rare. Bioreactor operations under mesophilic and thermophilic conditions require additional energy to heat it. This means that biohydrogen production under psychrotrophic condition is desirable, from the point of decreasing the bioreactor energy consumption. For this purpose, bacterial strains capable of hydrogen production at lower temperature range first need to be identified. We have successfully isolated several facultative-anaerobic bacteria from soil and seawater samples, from South Victoria Land, and the islands along Danco Coast, Antarctica. The isolated bacteria have been screened for hydrogen producing ability at different fermentation temperatures. Enrichment media were used for the isolation, and fermentation was carried out at 20, 25 and 30°C. Out of all the isolates, six strains have been identified as promising hydrogen producers. Two strains, AB1 and AB11 gave the highest hydrogen production, with H<sub>2</sub> to CO<sub>2</sub> production ratio of 1.53 and 5.84, respectively. These results reveal the presence of psychrotrophic bacteria in the Antarctic environment with potentials to produce hydrogen at temperatures lower than the ones used in most biohydrogen reactors. Currently, these strains are being identified, and optimisation of physicochemical parameters for maximum hydrogen production will be performed. The possibility of using industrial wastes as substrates will also be investigated.

## ***Bacterial community composition in stomach contents, guano and rookery soil samples of Adélie and chinstrap penguins on Signy Island***

**Wen Chyin Yew**<sup>1</sup>, Prof. David Pearce<sup>1,2,3</sup>, Mr. Michael Dunn<sup>2</sup>, Prof. Azizan Abu Samah<sup>1</sup>, Prof. Peter Convey<sup>1,2,3</sup>

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Sympatrically breeding Adélie (*Pygoscelis adeliae*) and chinstrap (*P. antarctica*) penguins on Signy Island, South Orkney Islands share overlapping foraging areas and food sources. We therefore hypothesized that they may share a similar gut microflora. Both penguins make a considerable contribution to nutrient availability in local terrestrial habitats through their guano deposition, and therefore we also predicted some influences from the penguin gut microflora on the soil microbial communities of penguin-influenced terrestrial habitats. The gut microflora of these penguins, and their possible influence on wider terrestrial microbial communities, has not previously been examined. We therefore analysed the bacterial community composition in the stomach contents, guano and local rookery soil samples of these two penguin species using a high throughput sequencing approach. A significant difference in microbial species richness was observed between Adélie and chinstrap penguins in their stomach contents, but not in their guano and rookery soil samples. For both penguin species, associated rookery soils had significantly higher species richness (mean  $\alpha$ -diversity =  $39.16 \pm 11.32$  and  $31.46 \pm 2.17$ , respectively), compared to guano ( $5.79 \pm 4.39$  and  $8.62 \pm 5.21$ ) and stomach ( $2.75 \pm 0.82$  and  $4.07 \pm 0.84$ ) samples. At a 97% confidence threshold, a total of 18 bacterial phyla were identified. Adélie and chinstrap penguins shared the same dominant (>99% in the community) phylum composition in stomach contents (Spearman,  $\rho = 0.947$ ), guano (0.845) and rookery soil (0.799) samples. In both species, there were distinctive but overlapping phylum composition in the bacterial communities of stomach contents, guano and rookery soil samples. A stronger correlation was observed between stomach and guano samples ( $\rho = 0.801$  and  $0.822$ , for the two penguin species), than those between guano and rookery soil samples (0.714 and 0.656), or stomach and rookery soil samples (0.689 and 0.563). Overall, the data indicate that sympatrically breeding Adélie and chinstrap penguins on Signy Island share similar gut microbial community composition. In addition, the overlapping bacterial communities present in stomach contents, guano and rookery soil samples support the existence of links between the penguin gut microflora and the local terrestrial microflora.

## ***Prokaryotic communities within the active layer at Edmonson Point (Northern Victoria Land)***

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Edmonson Point (EP) in the Northern Victoria Land is a volcanic area close to Mt. Melbourne. It is characterized by alluvial sediments and weathered basaltic outcrops with some ponds and not far penguin rookeries. Soils are Aquic Haplorthels overlying continuous permafrost with a relative rich in organic content (0.5-1.6% C org).

Samples of active layer were collected at 35 cm of depth at EP in early January 2014 during the maximum thawing when temperature ranged from 7.4 to 1.8°C.

Samples were examined for bacterial community composition by the Ion Torrent (IT) technique, prokaryotic abundance and cell-shape by microscopic image-analysis (IA), viability by Live/Dead (L/D) stain, respiring cell quantification by 5-Cyano-2,3-ditolyl-tetrazolium chloride (CTC+) stain, potential ectoenzymatic activities rates on proteins, polysaccharides and organic phosphates (by leucine-aminopeptidase,  $\beta$ -glucosidase and alkaline-phosphatase, respectively), physiological profiles by Biolog-Ecoplate™, sub-population assessment by flow-cytometry (FC). Finally, different isolation procedures were adopted to recover aerobic bacteria and a selection of bacterial isolates were identified by the 16S rRNA gene sequencing.

A total of 330 OTUs in 10 bacterial phyla were retrieved by the IT analysis with the predominance of the Proteobacteria and Actinobacteria (34.0 and 19.7%, respectively), followed by the Acidobacteria, Nitrospirae, Chloroflexi, Firmicutes and Bacteroidetes (range 4.9-7.5%). The Gemmatimonadetes, Chlorobi and Cyanobacteria constituted a minor component of the community. Cultivable bacteria were mainly placed within the Actinobacteria (genera *Arthrobacter* and *Cryobacterium*) and Firmicutes (*Bacillus* spp.), followed by Gamma- (*Psychrobacter* spp.) and Betaproteobacteria (*Polaromonas* spp.).

IA, FC, L/D, and CTC+ cell abundances ranged between 0.32 (alive cells by L/D assay) and 3.38 x 10<sup>6</sup> cells/g of wet soil (by FC). Two sub-populations with different apparent DNA content were observed by FC analyses. Viable and dead cells contributed for the 18.14 and 28.81 % of the total IA counts (1.77 x 10<sup>6</sup> cells/g of wet soil), respectively. Respiring cells by CTC+ were 0.72 x 10<sup>6</sup> cells/g (40.56 % of total IA count). Mean cell volume was 0.0885  $\mu$ m<sup>3</sup>. Cell morphologies mainly included rods, cocci and curved rods, and in lower percentages vibrios, coccobacilli and spirillae. Enzymatic activities were on average in the order AP> $\beta$ -GLU>LAP ( 1199.2, 71.7 and 70.1  $\mu$ mol g<sup>-1</sup> h<sup>-1</sup>, respectively). Low substrate utilization rates were determined by Biolog-Ecoplate™, confirming L/D and CTC+ results. A total of 23 substrates were utilized, with carboxylic acids that were generally intensively used, in addition to D-xylose (among carbohydrates), Tween 80 (among polymeric substrates) and L-threonine (among amino acids).

## ***Unveiling diel bacterioplankton structure and activity in the N and C cycle at Antarctic summer coastal waters***

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Antarctic marine microbes guiding biogeochemical processes under HNLC condition are largely unexplored. The structure and functional activity of the bacterioplankton communities (Bacteria and Archaea) inhabiting surface waters of Chile Bay (62° 27' S, 59° 40' W), in the South Shetland Islands, were analyzed on samples collected at day (10:00 am) and night (24:00 pm) time during the summer of 2014 by metagenomics and metatranscriptomics. In situ <sup>15</sup>N<sub>2</sub> fixation and carbon (H<sup>13</sup>CO<sub>3</sub><sup>-</sup>) and nitrogen (<sup>15</sup>NO<sub>3</sub><sup>-</sup> and <sup>15</sup>NH<sub>4</sub><sup>+</sup>) assimilation rates were in parallel measured. The area of study experienced days with long periods of light (~20h) and a typical HNLC condition, up to 1.9 μM HPO<sub>4</sub><sup>-2</sup> and 26.4 μM NO<sub>3</sub><sup>-</sup> + NO<sub>2</sub><sup>-</sup>, with chlorophyll a of ~0.3 - 1 mg C m<sup>-3</sup>. Our results show low N<sub>2</sub> fixation rates (up to 0.5 nmol N L<sup>-1</sup> d<sup>-1</sup>) similar at the community collected during day and night time, while C and N assimilation rates are 3 to 5 times higher at the night community than at the midday community (maximum light period of the day). The later might suggest that the community collected at night prepares for the daily activity before the first hours of daylight. The diversity of the bacterioplankton was similar at both day and night communities, but the activity obtained by metatranscriptomic analysis is significantly higher for the archaea (Thaumarchaeota) at the night community. Metatranscriptomic analysis also demonstrates major abundance and activity of Proteobacteria (Gammaproteobacteria and Alphaproteobacteria), and Flavobacteria compare to the rest of the community at both day and night communities. Interestingly, ammonia-oxidizing archaea belonging to the genus *Nitrosopumilus* (Thaumarchaeota) seems to be totally responsible for the nitrification and possibly for nitrifier denitrification (detoxifying nitrite), with potential contribution to the N<sub>2</sub>O production in the marine Antarctic waters.

## ***Antarctic bacterial regionalisation and functional diversity overlap***

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Understanding how regional and local variability influence diversity is an important step towards clarifying the functioning, sustainability, and services of Antarctic ecosystems. Furthermore, improving knowledge of the spatial scales at which these ecosystems operate provides the basis for the proper conservation planning required in Antarctica. While it is well recognized that the terrestrial ecosystems of Antarctica are dominated by microbes and their processes, current knowledge of Antarctic biodiversity and biogeography is mainly derived from eukaryotic studies. This imbalance is being increasingly addressed, taking advantage of the significant improvements in molecular assessment tools and the slow but steady growth in sampling effort. In this study, we collated information from recent studies on Antarctic terrestrial bacterial communities and distribution in order to review the state of knowledge of Antarctic bacterial diversity patterns. Our synthesis generally supported the presence of regional bacterial distribution patterns analogous to those of Antarctic eukaryotic groups. However, at smaller spatial scales, local physicochemical parameters usually showed stronger correlation with the bacterial community assemblage than did spatial distance. The available data also suggest that “functional redundancy” is present and plays a greater role than previously predicted in these relatively simple Antarctic ecosystems, not least as studies increasingly point to much higher levels of prokaryote diversity than has long been assumed. Integrating evidence for both bacterial regionalisation and functional diversity overlap, we propose a simple conceptual model to explain the mechanisms underlying species-function relationships in Antarctica.



## ***Iron- and sulfur-oxidizing bacteria beneath the east Antarctic ice sheet***

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The main objective was to recover bacterial life beneath the East Antarctic Ice Sheet (EAIS) using the sequencing of bacterial 16S rRNA genes and analyzing the ice samples containing bedrock source mineral inclusions. The samples included the accretion (lake water source) ice of the Vostok ice core (the Russian intra-continental station Vostok) containing small numerous mineral inclusions (ice type I) - three ice samples from the same horizon (3607-3608 m deep; about 16 kyr aged) but obtained from 3 parallel boreholes (5G-1, 5G-2 and 5G-3), and the glacier ice sample containing numerous reddish rather big in size rock sediments of moraine source from East Antarctic coastal area (230 m deep; about 20 kyr aged; D10 ice core, nearby the French station Dumont d'Urville). The samples were strictly decontaminated and treated under 'clean room' conditions (LGGE, CNRS-University Grenoble Alpes).

The comprehensive analyses (constrained by Ancient DNA research criteria) of three Vostok accretion ice samples have revealed three genus-related phylotypes of iron-oxidizing bacteria of Gallionellaceae (closest relatives are *Sideroxydans lithotrophicus* and *Ferriphaselus amnicola*) in two samples (boreholes 5G-2 and 5G-3) along with one phylotype of sulfur-oxidizing Firmicutes - *Tumebacillus* sp. in one sample (5G-2). This provides the evidence that bacterial chemolithoautotrophic communities seem to thrive beneath the EAIS.

As for the D10 ice core sample the 16S rRNA gene sequencing has recovered only two phylotypes both present in Vostok ice cores – one iron-oxidizing bacterium of Gallionellaceae (closest relatives is *Sideroxydans lithotrophicus*) and the same sulfur-oxidizing *Tumebacillus* sp.

Thus, of three phylotypes of aerobic iron-oxidizing beta-proteobacteria (Gallionellaceae) one phylotype (population) has showed the same DNA sequence signature being detected in Vostok 5G-3 and French D10 ice cores. In addition the same phylotype (again population) of sulfur-oxidizing *Tumebacillus* sp. was found in Vostok 5G-2 and French D10 ice cores.

The age of both ice sample types is nearly the same while their origin is evidently different - Vostok accretion (lake water source) ice vs. Dumont d'Urville glacier ice. The storage time periods for ice samples (before to be treated in a laboratory) are quite different (0.5 year for Vostok ice samples vs. 40 years for D10 ice sample) as well as the time frame for the ice treatment (in a range of 1-5 years – D10 ice core sample was treated in a year after the last Vostok 5G-3 ice sample) meaning no cross-contamination happened. Ice coring sites (Vostok and Dumont d'Urville) are far away (more than 1000 km) with no evident hydrological links beneath the EAIS meaning no bacterium 'flow' occurred. How to explain the amazing coincidence in findings? It seems that the presence of bedrock minerals containing Fe(II) and reduced S compounds under similar physical-chemical conditions featured by the existence of unfrozen water might explain the results which prove the existence of bacterial chemolithoautotrophic communities beneath the Antarctic Ice Sheet.

## ***Diversity and distribution of microorganisms in microbial mats of Antarctic lakes***

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The BelSPO project CCAMBIO aims to study the biogeographical distribution of microorganisms in lacustrine microbial mats using a combination of techniques including microscopic observations, strain isolation and genetic characterisation, and molecular diversity assessments using Next Generation Sequencing of environmental DNA. The samples were collected in different Antarctic and sub-Antarctic biogeographical regions.

Preliminary multivariate analysis of >130 samples revealed strong bioregionalisation patterns in microbial eukaryotes, which are in agreement with the classical subdivision of the Antarctic Realm into Maritime Antarctica, Continental Antarctica and the Sub-Antarctic Islands generally observed in plants and animals. The biogeographic structuring was less strong between the continent and Maritime Antarctica in prokaryotes suggesting more regular dispersal events between these two regions. The Sub-Antarctic assemblages harboured more complex foodwebs, with arthropods, nematods, rotifers, flatworms and annelids as main metazoan groups. Lakes on the continent, however, were characterised by fewer metazoan groups and a greater importance of microbial herbivores and secondary consumers, including a relative high diversity of ciliates and tardigrades. In a first analysis of microbial mats from five Antarctic lakes and an aquatic biofilm from the Sub-Antarctic, the majority of the cyanobacterial OTUs retrieved were related to filamentous taxa such as *Leptolyngbya* and *Phormidium*, which are common genera in Antarctic lacustrine microbial mats. However, other phylotypes related to different taxa such as *Geitlerinema*, *Pseudanabaena*, *Synechococcus*, *Chamaesiphon*, *Calothrix* and *Coleodesmium* were also found. Results revealed a higher diversity than what had been reported using traditional methods and also highlighted notable differences between the cyanobacterial communities of the studied lakes. In the coming months, the molecular diversity data will be deposited into the ‘Microbial Antarctic Resource System (MARS)’ presently developed into the webportal [biodiversity.aq](http://biodiversity.aq). Better knowledge of the diversity and distribution of microorganisms will contribute to a better assessment of their resilience and local/regional responses to global change.

**S24. Physiological adaptations in Antarctic organisms PM1,  
Meeting Room 404, August 22, 2016, 3:30 PM - 6:00 PM**

***Adaptation and Exaptation: Coupled evolutionary and physiological responses to freezing and desiccation in *Plectus murrayi****

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Metazoans in the McMurdo Dry Valleys (MCM DV) must cope with multiple environmental stresses including high (and dry) winds, rapid desiccation, and extreme variations in temperature and water availability. A handful of metazoan species not only persist, but also seemingly thrive in these harsh environments. However, we know little of their ecological amplitude or mechanisms by which they can survive multiple, extreme environmental stresses.

To reveal the molecular genetic mechanisms of freezing and anhydrobiotic survival, we explored patterns of gene expression in the desiccation and freeze tolerant Antarctic nematode, *Plectus murrayi* during different types and stages of stress. Interestingly, heat shock and antifreeze proteins are constitutively expressed under normal conditions, but are down-regulated under desiccation stress. The adaptive responses to freezing and desiccation appear to be coupled; temporal analyses of gene expression show that acclimation to mild stress promotes survival of harsher stresses. Putative adaptations to desiccation stress promote enhanced cold tolerance, and slow dehydration enhances the freeze tolerance response. As anhydrobiosis and tolerance to freezing are globally distributed traits, we explore the origin and evolution of these physiological responses, particularly among the Ecdysozoa.

## ***How do lichen algae prepare for anabiosis? A metabolic approach to desiccation tolerance***

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The lichen symbiosis dominates extreme terrestrial environments of continental Antarctica. Understanding the mechanisms of environmental adaptation in lichens and the potentials of the symbiosis' components is therefore crucial for the understanding of Antarctic ecosystem functioning. The lichens' poikilohydric lifestyle is characterized by the ability to fall into a physiologically inactive state, called anabiosis, upon desiccation. Especially in anabiosis, extremes of abiotic environmental factors are tolerated. Rehydration of inactive lichen thalli induces rapid recovery of metabolic activity, enabling the lichens to efficiently use short-term water supply in arid environments such as Antarctic cold deserts. Also the isolated photosynthetic partner of the symbiosis, the photobiont, displays considerable regeneration capacity during rehydration. Nevertheless, desiccation may impose severe, even lethal stress on cells, as cellular structures such as proteins and membranes are disrupted. To avoid such damage, lichen photobionts possess various mechanisms of desiccation tolerance. The effects of desiccation and rehydration on the photosynthetic apparatus of isolated photobionts (genus *Trebouxia*) have been examined by *in vivo* measurement of photosystem I and II energy quenching mechanisms. The isolated photobionts of several different lichen species from continental and marine Antarctic sites have been subjected to metabolite analysis during desiccation and rehydration processes. Especially the role of sugars, sugar alcohols and amino acids has been considered. The concentrations and dynamics of these metabolites reveal adaptations towards water stress. While the detailed strategies of individual strains differ, the metabolite profiles of all photobionts studied reflect the ability to prepare for severe dehydration and for physiological reactivation. It can be concluded that several metabolites' steady-state levels and their dynamics crucially contribute to the symbiosis' extremotolerance in Antarctica.

***Morphology, growth profile and biochemical composition of Pseudanabaena cf. amphigranulata isolated from Svalbard Island, Norway, cultivated under different temperature conditions.***

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Cyanobacteria possess attributes and adaptation to adapt in wide environments, from low temperature in Polar region to more than 80°C in hot spring. In this study, the effects of elevated temperature on the morphological characteristics, growth profile and biochemical composition of *Pseudanabaena cf. amphigranulata* isolated from Svalbard Island, Norway, were examined under three different cultivation temperatures; 4±2°C, 15±2°C and 25±2°C. *P. cf. amphigranulata* cells were cultivated in BG11 media under photoperiod of 12L:12D and light intensity of 28 µmol photon/m<sup>2</sup>/s. At exponential phase, the cells were harvested for the determination of cells ultrastructural and growth characteristics, as well as total lipid and carbohydrate. The widest and longest cells were observed under the temperature of 4±2 °C and 15±2 °C respectively, with doubling time of 0.11 day and 0.18 day. Meanwhile, at 25±2 °C, the cells were the shortest, and the doubling time was the lowest (0.08 day). Growth performance of *P. cf. amphigranulata* showed that it was a psychrotolerant or psychrotrophic species. Cultivating the *P. cf. amphigranulata* under 25±2 °C recorded the lowest total protein and carbohydrate (4.34±0.47 mg/L and 63.32±41.02 mg/L, respectively). The results show that temperature is an important factor influencing the growth and morphology of *P. cf. amphigranulata*. Therefore, response of *P. cf. amphigranulata*, isolated from North Pole, towards elevated temperature regimes can provide as a baseline data to study the effect of global warming on the phototrophic microorganisms.

## ***Stress response in *Chlorella* sp. isolated from snow community in King George Island***

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In coastal areas of West Antarctic Peninsula and adjacent islands, processes occurring in glacier and snowpack dominated ecosystems are closely interrelated with those of the marine realm. Melting of massive snow/ice accumulations and its consequent run-off have strong impact on the physical and biological processes of near-shore pelagic and benthic communities. Snow microalgae have evolutionarily developed different physiological adaptations, such as for example adjustments in the composition of the lipids of the plasmatic membrane, synthesis and accumulation of Astaxanthin, synthesis of antioxidant enzymes, synthesis of Mycosporines like Amino Acids (MAAs). Based on a scenario of extended melt periods in maritime Antarctica with concomitant higher impact of elevated temperature and UV radiation, the examination of stress tolerance mechanisms is essential to understand and predict near-future impacts of climate change especially in polar regions where snowfields and their microalgal communities have an important role on the biogeochemical fluxes. Due to that snow algae inhabit ecosystems highly sensitive and responsive to changes in environmental conditions (e.g. temperature, light and precipitations), they can be regarded as excellent model organisms to examine the impact of climate change. Photosynthetic characteristics in *Chlorella* sp. isolated in February 2015 from a snow microalgal community at King George Island, Maritime Antarctica, submitted to thermal stress and ultraviolet radiation, were studied through chlorophyll fluorescence (rapid light curves and maximum quantum yield) using an amplitude modulation fluorometer (Water PAM, Walz, Effeltrich, Germany). Solar radiation profiles with underwater hyperspectral radiometer (RAMSES-ACC2-UV-Vis, TriOs Optical Sensors, Rastede, Germany) were carried out in the snow column, from the surface up to a depth of 40 cm. The photochemistry of *Chlorella* sp. was affected by UV radiation in a 12-h laboratory exposure under all studied temperatures (5, 10, 15, 20 °C): the algae exposed to PAR + UV-A radiation were inhibited by 5.8 % whilst PAR+UV-A+UV-B radiation decreased Fv/Fm by 15.8 %. In both treatments the 12-h recovery after UV exposure was almost complete (80-100 %). For a sunny day (10 % could cover), the surface irradiance reached values of 1300  $\mu\text{mol m}^{-2} \text{s}^{-1}$  around midday and was attenuated by 70 % at 10 cm (decreasing to less than 350  $\mu\text{mol m}^{-2} \text{s}^{-1}$ ). This value matches the light requirements for saturation of photosynthesis ( $E_k$ ) measured for *Chlorella* sp. The number of hours at which algae remain under saturating irradiance ( $H_{\text{sat}}$ ) at the surface was close to 12-13 h, decreasing with increasing depth. Our findings revealed that *Chlorella* sp. not only shows high photosynthetic efficiency at ambient conditions, but also exhibits tolerance to solar radiation under higher temperatures. Avoiding the highly UV exposed snow surface and possessing a capacity for recovery after inhibition of photosynthesis by UV radiation appear as two important strategies of *Chlorella* sp. in these ecosystem.

The study was supported by the PhD Grant DT\_09-14 from Instituto Antártico Chileno (INACH) and Project ANILLO ART1101, from Conicyt. The support provided by INACH and the staff of Base Julio Escudero Station are greatly acknowledged.

## ***Comparison between the photosynthetic optimal temperatures of Antarctic and temperate mosses***

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Mosses in Antarctica experience much colder air temperatures than their congeners in temperate environments and hence we might expect them to have adapted to have lower optimal temperatures for photosynthesis. However, during the summer growing season the Antarctic moss beds receive high solar radiation and the surface of moss beds can reach 20 to 25 °C—much higher than the ambient air temperature suggests. As moss growth only occurs during these warmer conditions it is possible that the photosynthetic optima may also be higher than expected. We tested the gross photosynthetic optima for three mosses from Casey Station, Antarctic (*Bryum pseudotriquetrum*, *Schistidium antarctici*, *Ceratodon purpureus*) and compared their optima with congeneric species from temperate Australia and King George Island in Maritime Antarctica. We measured electron transport rate using chlorophyll fluorescence technique under laboratory conditions with temperatures varying from 5 to 40 °C and light varying from 0 to 1000  $\mu\text{mol photons m}^{-2}\text{s}^{-1}$ . We found that the optimal temperatures for gross photosynthesis varied from 20 to 30 °C, which was much higher than Antarctic air temperatures, and the Antarctic species had optima within the same range as temperate species. We attribute these results to the fact that Antarctic mosses in full sun are growing under a similar range of temperatures to temperate species in shaded environments, or those that are inactive during the hot, dry summers. While our results for gross photosynthetic optima do not necessarily coincide with the optima for net photosynthesis or other physiological attributes, they highlight that Antarctic and temperate mosses may be more physiological similar than previously believed. This helps us understand the limits to the species potential to adapt to changing environmental conditions.

## ***Influence of temperature on amylase and cellulase activity from polar and tropical soil microfungi***

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Arctic and Antarctic regions present drastic climatic contrasts with the tropics. The polar regions typically experience cold but also highly variable conditions, with mean monthly air temperatures ranging from below -50°C to around +8°C, while tropical temperatures are relatively stable around 30°C all year. While remote from each other, all three regions share similarities in their microbial ecosystems and functions. Extracellular enzymes that are widely produced by soil microfungi are one direct expression of microbial function. The properties and responses of extracellular enzyme production to experimentally imposed stresses may provide important clues to microbial and ecosystem resilience to climatic changes. This study aimed to determine the activity of amylase and cellulase produced by soil microfungi from Arctic, Antarctic and tropical regions, and temperature influence on their production. Crude amylase and cellulase extracts were obtained from flask cultures of fungi from all three regions, and were used to quantify enzyme activity using a dinitrosalicylic acid (DNS) assay. Amylase activity was higher in Antarctic than Arctic fungi, while tropical microfungi exhibited the highest activity. Antarctic fungi showed stronger cellulase activity in comparison with Arctic and tropical fungi, but the differences overall were not significant. Generally, amylase activities of fungi from all three regions were stronger than that of cellulase. Enzyme production varied strongly with temperature in fungi from all three regions, but in a complex manner. The data presented provide a baseline for studies on the effects of temperature on enzyme activity of soil microfungi.



## ***Life history strategy of the endemic tardigrade species, *Acutuncus antarcticus****

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The natural environment in Antarctica is considered the most extreme and variable on Earth in terms of low temperature, limited water availability and short growing season. The harsh environments of Antarctica constrain its terrestrial ecosystems to be relatively simple, comprising a limited flora of bryophytes, lichens, algae and cyanobacteria, and an invertebrate fauna of micro-arthropods, nematodes, tardigrades, rotifers and protozoans. Terrestrial organisms living in these environments are known to demonstrate a variety of physiological and life-history traits that enable them to survive. Nevertheless, knowledge is currently limited mainly to the micro-arthropod groups of mites and springtails, with some information also available on nematodes.

Tardigrades are found in most terrestrial and freshwater Antarctic ecosystems, including some remote nunatak regions where even the otherwise ubiquitous nematodes are absent. In continental lakes and pools, in particular, tardigrades are one of the major community components. *Acutuncus antarcticus* is an endemic tardigrade species known to be widespread and common in both terrestrial and freshwater habitats in Antarctica.

In order to investigate the life history strategy of *A. antarcticus* as part of its adaptation to the Antarctic environment, we observed its survival and reproduction under controlled laboratory conditions. Juvenile *A. antarcticus* hatched within a 24 h period were reared at either 20 °C, 15 °C, 10 °C or 5 °C in darkness on agar plates with Volvic® water and the green alga *Chlorella* sp. Individual tardigrades were inspected daily for 220 d and their survival, egg production and subsequent egg hatching were recorded. Sample sizes were 29 individuals each at 20 °C, 10 °C and 5 °C and 68 individuals at 15 °C. The larger sample size at 15 °C was utilized to investigate in more detail the effect of age on life history traits.

The median life spans of individuals reared at 20 °C, 15 °C, 10 °C or 5 °C were 20 d, 65 d, 65 d and 61 d, respectively. Generation time decreased as the temperature increased. The lifetime reproductive success was substantially greater at 10 °C and 15 °C. These data indicate the optimum temperature range for growth and reproduction in *A. antarcticus* is around 10 °C to 15 °C.

In the more detailed study at 15 °C, weak effects of age were observed on oviposition interval and hatching success, with the former increasing slightly and the latter decreasing slightly with age. The majority of the individuals continued oviposition until shortly before death, with no suggestion of a post-reproductive lifespan. Our observations suggest that any decline in fertility with age in this species of tardigrade is minimal. Prolonged maintenance of reproductive ability gives an advantage in the extended life cycles typical of the natural environment of Antarctica. The minimal reproductive senescence of *A. antarcticus* revealed here may be an important factor contributing to the successful establishment and widespread distribution of this species within the Antarctic region.

## ***Out in the cold: The thermoregulatory role of non-dietary fatty acids in mammals***

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During digestion, mammals deposit the fatty acids (FA) obtained from their prey into their adipose tissues. This has led to the application of FA analysis to foraging ecology studies, as the FA composition of prey and predator is expected to be very similar. Nevertheless, diet is not the only regulator of FAs in mammals. Mammals have the ability to synthesize some FA as a response to their metabolic needs, these are called non-dietary FA.

What is driving non-dietary FA? The adipose tissue of mammals also serves as a thermal insulator; therefore FAs should also reflect the thermoregulatory needs of an animal, and not just its diet. According to their thermal properties, different FA can be more suitable for different climates: monounsaturated FA (MUFA) are good insulators in cold environments, and they maintain the softness of adipose tissues as they freeze only at very low temperatures. Saturated FA (SFA), on the other hand, are poorer insulators and they freeze very easily, which benefits animals living in warmer environments, but not those in cold habitats.

We aim to analyse how FAs in the adipose tissues of mammals change with latitude and type of environment (terrestrial, semi-aquatic or fully-aquatic).

Using a literature search, FA composition data was collated on 44 mammal species inhabiting different latitudes, from the poles to the tropics. Including only non-dietary FAs, a desaturation index, which is a MUFA-to-SFA ratio, was calculated. The higher the desaturation index, the higher the proportion of MUFA in adipose tissues. We tested for correlations between desaturation index and latitude, among mammals living in terrestrial, semi-aquatic and fully-aquatic environments.

Terrestrial mammals displayed lower amounts of MUFAs than semi- and fully-aquatic mammals; but desaturation index did not change with latitude. When skin is kept warm (as it is the case with furry animals) FA do not need to be modified in cold environments.

In semi-aquatic mammals, desaturation index is positively correlated with latitude, thus animals living in Antarctic and Arctic regions display greater amounts of MUFA than those living in warmer latitudes. Semi-aquatic mammals rely on both fur and blubber to retain body heat. But fur is not a good insulator in water, as it increases drag and, when diving, the warm air layer trapped beneath the fur is released due to compression. Therefore, they improve the insulative properties of their blubber by increasing the proportion of MUFA.

Fully-aquatic mammals display higher amounts of MUFA than semi-aquatic and terrestrial mammals, but desaturation index does not correlate with latitude. This was unexpected as they rely solely on blubber to keep warm. Unlike semi-aquatic mammals, fully-aquatic animals can have thicker blubber, so they may not need to increase the amounts of MUFA in their tissues. This may be also due to the water temperature gradient across latitudes is not as great as in air. Furthermore, whale migration makes difficult to interpret the real effect of temperature on FA in this group.

## ***Do Weddell seals “freeze” pregnancy? Intra-specific variation in gestation of a top Antarctic predator***

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Female Weddell seals (*Leptonychotes weddellii*) give birth in October/November each year, nurse their pups for the next 4-6 weeks, and are bred in mid-December shortly after weaning their pups. To cope with large seasonal fluctuations in productivity and prey availability, pinnipeds utilize an embryonic diapause (state of suspended growth) to stretch the reproductive cycle to a full calendar year. This ensures that offspring are born when environmental conditions are most favorable. We used transrectal ultrasonography in Weddell seals during January and February 2014-2016 (equivalent to 69-125 days post-partum) to characterize the reproductive tract, detect early pregnancy, and estimate the length of embryonic diapause. We examined mature multiparous females that had not given birth during the study year (no birth; n=19), and females that gave birth early (October; n=21) or late (November; n=18) in the pupping season. Twelve seals were captured for a second examination to acquire longitudinal measures of embryonic growth. Pregnancy was defined as detection of a fluid-filled embryonic vesicle within the uterus, with or without an embryo proper and heartbeat.

Overall, 78% of no birth, 85% of early birth, and 61% of late birth seals were pregnant in January/February (P=0.141). A corpus luteum was detected in all but one seal in which both ovaries were visualized (i.e., in both pregnant and nonpregnant females) indicating that failure to conceive was not due to failure to ovulate. For those animals that were pregnant, embryonic vesicle measurements were incorporated into growth curves, and mixed model analyses were used to assess the influence of birthing status on embryo development. The size of the embryonic vesicle ranged widely from 0.1 to 47 cm<sup>2</sup>, and was strongly correlated with calendar date and days post-partum (P<0.001). Further, embryonic vesicle size was greater in no birth seals (13.4±2.8cm<sup>2</sup>) compared to early birth (9.4±2.3cm<sup>2</sup>; P=0.015) and late birth seals (4.4±1.2cm<sup>2</sup>; P<0.001), with no effect of maternal age, parity, total body mass, or blubber mass. Birthing records the following season revealed that pregnancy loss was greatest in the late birth females (31%), intermediate in the early birth females (23%) and least in the no birth females (8%; P=0.322). Further, late birth females gave birth later (Nov. 8±2.3 days) the following year than early (Oct. 23±1.4 days; P<0.001) and no birth females (Oct. 25±1.8 days; P<0.001). Pregnancy detection by ultrasound exams in combination with observed birthing dates the following year suggests that Weddell seals have a short (or no) embryonic diapause, and instead have a longer active gestation length of ~10 months. This may serve to spread the energetic costs of gestation across a longer time period while foraging in a polar environment.

**S29. From the top: Higher trophic predators as ecosystem sentinels D1PM, Meeting Room 410, August 22, 2016, 3:30 PM - 6:00 PM**

***Inter-annual breeding and body mass correlates in southern elephant seals***

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Due to the high cost of reproduction, females of the species have to allocate finite resources over the course of their lives to maximize reproduction and survival. Females can alter their breeding behaviour to maximise productivity in response to high reproductive energy demands. More than half of the adult female southern elephant seal (*Mirounga leonina*) population at Marion Island breed intermittently (IBFs) and skip a breeding season at some stage during their reproductive life. Presumably due to either environmental variation and resource acquisition or an alternative reproductive strategy. We photogrammetrically weighed 150 individuals between 2007 and 2013 at the beginning of the annual breeding season ( $n = 93$ ) and at both the beginning and end of the annual moult ( $n = 57$ ). IBFs that skipped reproduction are in superior condition during the following moult than annual breeding females (ABFs). However, the mass advantage disappears by the subsequent breeding season, with ABFs having superior mass to that of IBFs. Despite this mass disadvantage, IBF offspring are similar in mass to ABF, thus conceivably they have similar survival probability. Inferior body mass of intermittent breeding females suggest that they are unable to allocate resources annually and therefore skip a breeding event. Intermittent breeding is a function of environmental variation and resource acquisition rather than reproductive strategy. I argue that females forego reproduction due to lack of reserves as a result of low foraging efficiency in specific seasons or foraging area. As a result, they invest in somatic growth to better their chances of successful reproduction the following season.

## ***Where to Forage? Contrasting behaviour between two populations of an ice-obligate predator in East Antarctica***

Karine Heerah<sup>1,2</sup>, **Mark Hindell**<sup>2,3</sup>, Virginia Andrews-Goff<sup>2</sup>, Iain Field<sup>4</sup>, Clive R. McMahon<sup>5</sup>, Jean-Benoît Charrassin<sup>1</sup>

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Winter is a critical period for capital breeders like Weddell seals that must optimize resource acquisition and storage to provision breeding in spring. However, how Weddell seals interact with their winter environment in winter remains poorly documented.

We equipped adult Weddell seals during winter with satellite relayed data loggers at two sites in East Antarctica: Dumont D'Urville (n = 12, DDU) and Davis (n = 20). Intensive foraging activity (i.e. "hunting" mode) was detected using a tracked-based method that integrates a vertical index enumerating time spent foraging within each dive (i.e. hunting time), thereby integrating the horizontal, vertical and temporal dimensions simultaneously. Environmental variables (i.e. bathymetry, slope, sea-ice) were extracted for each location by taking mean values from 100 simulated tracks to account for ARGOS positioning errors. Finally, we used binomial generalized mixed effect models (GLMM) to investigate Weddell seals' behavioural response (i.e. "hunting" vs. "transit") to their environment.

The tags transmitted positions and dive information from DDU seals over  $183 \pm 13$  days (30319 dives) and from Davis seals over  $158 \pm 7$  days (50170 dives). On average, 50% of the dives occurred at hunting locations and foraging activity was generally concentrated within 5 km of an access breathing hole. Seals likely moved between holes as local food was depleted. There were regional difference in behaviour so that seals at Davis spent more time travelling between holes (three times more) and less time foraging (half the time) than seals at DDU. Despite these differences, hunting dives at both locations were pelagic, centred in areas of high ice concentration and over areas of complex bathymetry. There was also a seasonal shift in diving behaviour from transiting early in winter to more hunting and foraging during winter.

Taken together our observations suggest that Weddell seal foraging behaviour is plastic and hence seals are able to respond behaviourally to changes in their environment to maximise food acquisition and storage. Such plasticity is a hallmark of animals that live in unpredictable environments such as the high Antarctic where resources are unpredictable and locally unpredictable. The methods developed in this study can be applied to a broad range of species and we provide here new insights of the environmental forcing that drive sea-ice obligate species' foraging decisions.

## ***Foraging behavior and diet of seabirds in a changing Antarctic marine environment: can they adapt successfully?***

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The Southern Ocean is currently showing signs of unusually rapid warming, and the resulting habitat alteration may affect species at every trophic level. A complex network of food web interactions determines the resilience, and hence response, of Antarctic marine ecosystems to change. Here, we review the foraging behavior and diet of two upper trophic-level predators, grey-headed albatrosses *Thalassarche chrysostoma* and gentoo penguins *Pygoscelis papua*, under extreme environmental conditions.

In an austral summer when oceanographic conditions close to South Georgia were abnormal (unusually high sea surface temperature), chick-rearing grey-headed albatrosses at Bird Island foraged mainly in Antarctic waters (predominantly shelf waters of the South Shetland Islands and Antarctic Peninsula, and also in oceanic waters around South Georgia), feeding mainly on krill (*Euphausia superba*; 77% by mass). This is in contrast with the chick-rearing periods in normal years when grey-headed albatrosses feed mainly around the APF (Antarctic Polar Front), targeting the ommastrephid squid *Martialia hyadesi*, and rarely in Antarctic waters. Foraging trips lasted 13.3 days on average (range: 5–26 days) in the poor-food year, far longer than the 1–3 days found in previous studies, and breeding success was very low.

The feeding ecology of gentoo penguins during their non-breeding season was examined under abnormal environmental conditions in the austral winter, (unusually high sea surface temperature). Diet assessment through conventional (stomach contents) methods, and stable isotope analyses of red blood cells, plasma and feathers, showed significant differences between males and females; males fed mainly on fish (54% by mass) whereas females fed mainly on crustaceans (89 % by mass). Of the crustacean component, *Themisto gaudichaudii* was the most important prey for both males (64% by mass; 82% by number; 53% by frequency of occurrence) and females (63 % by mass; 77% by number; 89% by frequency of occurrence), contrasting with all previous studies, in which the dominant item was Antarctic krill *Euphausia superba*. A higher number of females than males were found dead on the beach, apparently because of starvation. The significant differences in  $\delta^{13}\text{C}$  values between males and females in both plasma and red blood cells, suggesting that each sex had been feeding in the previous few weeks in different habitats, with females exploiting more pelagic waters, while males fed benthically and closer to the coast.

These studies highlight the consequences of abnormal environmental conditions for two species of seabirds with contrasting foraging ecology. There were clear responses in terms of distribution, habitat use, diet and demographic traits (breeding success or survival). These results have implications for population dynamics of these and other higher predators in the region, particularly in light of major, ongoing climatic change.

## ***Influence of climate variability and krill (*Euphausia superba*) density on southern right whale (*Eubalaena australis*) reproductive success***

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Climate variability is known to influence trophic webs in all oceans through the generation of sea surface anomalies. Nearby South Georgia, lower sea surface temperatures are related to increases in the availability of krill (*Euphausia superba*), a key component in that ecosystem and the main food resource for the southern right whale (*Eubalaena australis*). A population of this species concentrates off the southern Brazilian coast during the breeding season, from July to November. Its reproduction supposedly depends on body condition and, therefore, foraging success. This, in turn, might be affected by productivity on the feeding grounds, which is affected by climate. Events such as El Niño, by an anomalous heat of equatorial Pacific waters, reduce krill biomass and thus compromise reproductive success and survival of krill consumers. Understanding the influence of climate anomalies and variation of food supply on right whale reproductive success may be important for species conservation strategies as they can support decisions about protective measures taken place both in its breeding area off Brazil and in its feeding ground in the Southern Ocean. In addition, krill is an important fishing resource in the south Atlantic sector of the Southern Ocean and has the potential to become one of the major global fisheries. Data on annual southern right whale number of calves were obtained from aerial surveys carried out between 1997 and 2013. These values were related to krill densities near South Georgia, climate indices (Oceanic Niño Index – ONI and Antarctic Oscillation - AAO), sea surface temperatures around South Georgia and sea ice area anomalies for Antarctic in general and for the Weddell Sea area considered separately using cross correlation. Number of calves varied from 7 to 43 ( $\bar{x} = 21.11 \pm 11.88$ ). Significant correlations were found with krill densities ( $r=0.69$ ,  $p=0.002$ ), ONI ( $r=-0.65$ ,  $p=0.03$ ), AAO ( $r=0.76$ ,  $p=0.01$ ) and Antarctic sea ice area ( $r=-0.68$ ,  $p=0.002$ ). Our results suggest that global climate indices influence southern right whale breeding success in southern Brazil by determining variation in food (krill) availability for the species. Therefore, increased frequency of poor krill years due to global warming is likely to lower population's rate of recovery. In addition, they raise the possibility of using southern right whales in Brazil as a monitoring species to detect changes in krill populations in their foraging areas, a role more typically associated with the land-based predators that occur in the monitored region. This also emphasizes the importance of considering the forecasts of climate anomalies to determine krill fishing quotas in the Southern Ocean in conservation plans.

## ***Demography and pregnancy rates of humpback whales along the western Antarctic Peninsula: links to a changing ecosystem***

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Humpback whale populations in Antarctica are recovering after intense commercial whaling in the 20th century. Along the Western Antarctic Peninsula (WAP) this recovery is occurring in an environment that is experiencing the fastest warming of any region on the planet. To begin to understand the dynamics of this recovery under such dramatic climate change, we are studying the demography of these whales. To date, we have collected 241 biopsy samples from 132 males and 117 females during the austral feeding season from 2009-2015. The overall sex ratio of our sample population is 1.13 M:F, supporting early observations that sexes mix randomly on the feeding grounds. Genetic sex was determined via multiplexed PCRs that amplified the sex specific markers (males SRY and SFY/SFX of females). We examined the progesterone levels of a sub-sample of female whales (n=100) along the WAP; to our knowledge, this is the first non-lethal estimation of pregnancy rates in Antarctic whales. We conducted progesterone assays on blubber biopsy samples and extracted hormones following published methods. Our results were verified with assays of humpbacks of known pregnant status (n=4) from the northwestern Atlantic (142.97±57.82 ng/g). Mean progesterone level for pregnant humpback whales in the WAP was 332.0/g ± 41.68 (mean ± SE; n = 62). The mean value for non-pregnant females was 2.03 ng/g± 0.18 (n = 34). We detected an increase in apparent pregnancy rate from 62.5% to 70.83 % from summer to autumn across all years. We also documented an increase in apparent pregnancy rate from 46% to 84% from 2013-2014, although these values have not been corrected for the proportion of immature whales in the sample. The application of these techniques provides a valuable baseline to document variation in demography of this population on the feeding grounds. When combined with other demographic (e.g. genetic mixed-stock analysis) and behavioral (e.g. telemetry-based patterns of movement and timing of migration) analyses, this approach will allow us to better understand recovery trends and the effects of broad-scale climate changes on Antarctic humpback whale populations.



## ***Corresponding exploitation of oceanographic features by an albatross community.***

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The breeding and non-breeding distribution of the four albatross species that breed on Macquarie Island (Wandering, WA; Light-mantled, LMA; Black-browed, BBA; and Grey-headed albatross, GHA) were determined using historical tracking data to identify habitat preference across a large spatial range. Knowledge of community distributions are rare, but valuable for identifying biologically productive regions and assessing species vulnerability to negative environmental change, especially for globally declining species such as albatrosses. With increasing evidence that albatrosses have reduced flexibility in habitat use and are repetitively using the same foraging areas throughout their life, it is imperative that important regions used by individual breeding colonies and populations are identified.

Using light-level geolocators (GLS) and platform terminal transmitters (PTT), individuals were tracked between 1998 and 2009 (n=45). To determine GLS locations a new method of analysis was undertaken using custom built R packages, SGAT and GLStag. This software determines the most likely location by employing a Bayesian framework to initial locations acquired by the twilight threshold method and allows occurrences to be estimated where the tag light sensor has been artificially shaded (eg. by feathers or nesting behaviour). The extracted PTT locations were filtered using R package trip. Using gridded time spent as a foraging metric and response variable, General Additive Models were used to test its relationship with a range oceanographic features including eddy kinetic energy, chlorophyll-a, sea surface temperature gradient, bathymetric gradient, wind strength and sea surface height.

During the breeding period all species spent increased time spent in areas along the Macquarie Ridge and within the Tasman Basin. Significant exploitation of the Antarctic ice edge was limited to LMA and WA. The furthest southerly and northerly excursions were carried out by LMA and WA respectively. During the non-breeding period the Southwest Pacific Basin to the east of New Zealand was utilized by all four species. Species overlap in isolated regions of high time spent was only observed in waters off the southern coast of Chile and along the Polar Frontal Zone. A positive correlation with CHL<sub>a</sub> density and time spent was detected for WA and breeding BBA. Time spent by breeding BBA and nonbreeding LMA and WA was correlated with areas of higher eddy kinetic energy, highlighting their use of the Polar Front and associated eddies. Breeding BBA and GHA and non-breeding GHA and WA showed preference for a strong bathymetric gradient, indicative of foraging along the productive Macquarie Ridge and the edges of the Campbell Plateau. Areas of higher average wind speeds did not appear linked to increased time spent for breeding BBA and WA, whereas moderate wind speeds appeared preferential for nonbreeding BBA, LMA and WA foraging.

Differences detected in key foraging areas highlight variation in the functional traits of each species and their capacity to exploit oceanographic features that are associated with high primary productivity. These findings also highlight important regions for the four species from Macquarie Island that require monitoring and management of fisheries to mediate and mitigate any negative interactions.

## ***Horizontal niche partitioning of humpback and fin whales around the WAP – evidence from a concurrent whale and krill survey***

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During Expedition ANT29-3 of R/V Polarstern in the austral summer 2012/13, a dedicated aerial cetacean survey was conducted at the same time as a standardized net trawl survey for krill around the West Antarctic Peninsula (WAP). Distance sampling data on cetacean occurrence were used to produce density surface models for humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*) over two strata, Bransfield Strait (BS) and Drake Passage (DP). Krill biomass data were used together with CTD data from the same expedition, bathymetric parameters and satellite data on chlorophyll-a and ice concentration to model distribution of *Euphausia superba*, *Euphausia crystallorophias* and *Thysanoessa macrura*. Krill and cetacean distribution patterns were then compared. Results show distinct distribution patterns for humpback and fin whales, with fin whales aggregating at the shelf edge of the South Shetland Islands in DP and humpback whales concentrating in BS. Density of fin whales was predicted at 0.117 (95% CI 0.053 – 0.181) individuals/km<sup>2</sup> in DP and 0.002 (95% CI 0 – 0.004) individuals/km<sup>2</sup> in BS. Humpback whale density for DP was predicted at 0.022 (95% CI 0.006 – 0.038) individuals/km<sup>2</sup> in DP and 0.056 (95% CI 0.017-0.094) individuals/km<sup>2</sup> in BS. Modelled krill biomass showed *E. superba* to be the most widely distributed and dominant species on the shelf, *E. crystallorophias* occurring in smaller aggregations near the coast and *T. macrura* almost restricted to waters beyond the shelf edge. Comparisons of the predicted distributions of both whale species with the predicted krill biomass distributions suggest a complex relationship rather than a straight forward correlation between krill and whales. However, results indicate that fin whales were feeding in an area dominated by *T. macrura*, while humpback whales were found in areas of higher *E. superba* biomass. Our results provide abundance estimates for humpback whales and for the first time for fin whales in the WAP. They contribute important information on habitat use of these two species in the Southern Ocean and provide first evidence for horizontal niche segregation of humpback and fin whales in the WAP.

## ***Scouring the depths – The foraging explorations of elephant seals on the Campbell Plateau***

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Southern elephant seals (*Mirounga leonina*) at sub-Antarctic Campbell Island (NZ) are at the northern extent of their Pacific Ocean range. Here, records of small numbers of pups and moulting individuals are common yet their habitat use and migratory movements in the surrounding oceans are not understood. The Campbell Plateau sustains important fisheries (hoki, scampi, southern blue whiting, ling and Arrow squid) and is considered a frontier basin for oil exploration. The Campbell Plateau is a large topographic barrier naturally delimiting the northern extent of the Antarctic Circumpolar Current. It is characterized by a sluggish circulation of Sub-Antarctic water, sharply separated from the Polar zone by the swift Sub-Antarctic Front which closely follows the Plateau's southern edge. As human activity within the region evolves, understanding the habitat use of benthic specialists such as southern elephant seals is necessary to establish functional ecosystem models for this relatively little studied region as human activity within the region evolves. High resolution satellite CTD tags were deployed on 23 adult male, female and juvenile southern elephant seals between February 2012 and July 2014. We recorded foraging activity for 16 of these individuals for a total of 2200 days. Most seals (88%) spent the majority of their time on the Campbell Plateau. The age classes for these individuals were: adult males (19%), sub-adult males (19%) juveniles (31%, 5 of 7), and weaners (13%) with only one adult female (6%). That animal spent the majority of her time foraging along the southeast coast of the South Island. Sub-adult males commonly focussed their primarily benthic foraging activity within small areas on the Campbell Plateau, while the juveniles and weaners ranged much further afield, including down to the ice edge and to Macquarie Island, 600 km to the south west. This study has highlighted the resident foraging behaviour of southern elephant seals in the Campbell Plateau region indicating that benthic habitats within this region are well utilised by this species. This raises questions regarding the preferred prey species of southern elephant seals in this area and has provided quantitative information on the potential for habitat overlap with fisheries near Campbell Island and on the Plateau.

## ***Changes in the ecology of the Weddell seal after a century of human presence in the Ross Sea***

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The arrival of the first explorers to the Ross Sea, Antarctica, roughly 100 years ago, marked the beginning of a slow, but constant, process of human colonization of one of the most remote and pristine marine ecosystems in the world. Today, human activities in this area range from scientific exploration to commercial exploitation of different high-trophic level fish species, such as the Antarctic toothfish. The consequences of such activities have yet to be determined. As a year-round resident of the fast ice and a top predator of fishes, the Weddell seal *Leptonychotes weddelli* can serve as a sentinel of ecosystem-wide changes in the Ross Sea. We analyzed stable isotopes of fur (bulk tissue and amino acids) from samples collected 100 years ago (early Antarctic expeditions,  $n = 34$ ) and recent years (2010-2012,  $n = 32$ ) to investigate if (1) the ecology of the Weddell seals has changed during the last 100 years and (2) if the Ross Sea has experienced an ecosystem regime shift. Bulk-tissue samples revealed differences in both  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , with  $\delta^{13}\text{C}$  being significantly depleted in samples from 100 years ago ( $\delta^{13}\text{C}_{100\text{years}} = -24.38\text{‰}$ ) compared with present day samples ( $\delta^{13}\text{C}_{\text{Present}} = -23.55\text{‰}$ ), whereas  $\delta^{15}\text{N}$  was significantly higher in samples from 100 years ago ( $\delta^{15}\text{N}_{100\text{years}} = 13.94\text{‰}$ ), compared with present day Weddell seals ( $\delta^{15}\text{N}_{\text{Present}} = 12.99\text{‰}$ ). Further, our data showed a reduction in the isotopic niche width (estimated based on the Convex Hull method): the Weddell seals today occupy a niche that corresponds to only 32.36% of the niche that the species occupied 100 years ago, and there is little overlap in isotopic niche 8.69% of the original 100 year old isotopic niche; 26.86% of today's isotopic niche). Preliminary isotopic analysis of amino acids confirms that the shift in the ecology of Weddell seals is due to a reduction in their trophic level.

## ***Long-term niche fidelity in southern elephant seals: Do individuals display unique foraging strategies?***

**Trevor McIntyre**<sup>1</sup>, Horst Bornemann<sup>2</sup>, Nico de Bruyn<sup>1</sup>, Cheryl Tosh<sup>1</sup>, Marthan Bester<sup>1</sup>

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Fidelity to foraging sites and foraging strategies is potentially beneficial to individuals using habitats with patchily distributed resources, as in a number of marine mammal species. We assessed inter-annual and long term (up to eight year) patterns in the spatial distribution and diving strategies used by southern elephant seals (*Mirounga leonina*) from sub-Antarctic Marion Island, instrumented with satellite-relay data loggers over multiple foraging migrations. We calculated inter-annual three-dimensional (3D) kernel density (KD) range overlaps for seals tracked over at least two post-moult foraging migrations in order to assess overlap for both the water depths and temperatures targeted during foraging migrations. We used intra-class correlation coefficients from linear mixed effects models to calculate intra- and inter-individual variance for a series of track and dive metrics. A repeatability index was ultimately derived for individual metrics, where higher values (between 0.5 and 1) indicate individually unique consistent behaviours, since greater variance occurs between, and not within, individual behaviours. Individual seals displayed high levels of fidelity to vertical depth layers where mean overlap for 95% 3D KD homerange estimates were 52.6% (inter-annual) and 34.3% (multi-year). Similarly, high levels of fidelity to temperature zones were evident where mean overlap for 95% 3D KD homerange estimates were 48% (inter-annual) and 35% (multi-year). Repeatability index values ranged between 0.38 and 0.57 for all metrics tested, indicating that the variance between individuals tested was generally not substantially more than within individuals. This study is the first to show that southern elephant seals display high levels of foraging niche fidelity in terms of spatial areas used, vertical depth layers targeted, as well as preferred in situ thermal conditions. Such observed inter-migration stability in habitat use patterns likely confers long-term energetic advantages to individual seals, despite little evidence for individually unique behaviours between these seals. While previous studies suggested likely inter-sex and inter-age-class avoidance of intra-specific competition in southern elephant seals, the apparent lack of individually unique foraging strategies reported here indicates that there is little individual level avoidance of intra-specific competition.

## **S36. Antarctic education, outreach and training, Meeting Room 408, August 22, 2016, 3:30 PM - 6:00 PM**

### ***Women in Antarctica - Enhancing secondary school students' awareness through interactive forum***

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This paper presents the preliminary results of questionnaire survey carried out during the educational and awareness activities initiated by Yayasan Penyelidikan Antartika Sultan Mizan (YPASM) in conjunction with its MOSTI Social Innovation (MSI) – Malaysia's Journey to the Ice: Women in Antarctica program. YPASM was set up as an agency under the Ministry of Science, Technology and Innovation of Malaysia (MOSTI) in 2012, aiming at helping to raise funds towards supporting Polar research through the Malaysian Antarctic Research Programme (MARP). One of the key objectives of the foundation is to promote Antarctic science in the education system and to disseminate Polar scientific information. The MSI - Malaysia's Journey to the Ice: Women in Antarctica program is among the recent-on going initiatives by YPASM to meet this objective. Specifically, the program aims to increase the secondary school students knowledge about climate change especially the impacts in the Antarctica and the Arctic, to raise the students' interest in exploring the science disciplines particularly the Polar science and to take this as a platform for the Malaysian women Polar region scientists to share the experiences, linking scientific work at the societal level. An interactive session in the form of forum and classroom activities was conducted in a total of 9 secondary schools where 150 samples were collected from each school. The questionnaire consists of a total of 8 questions determining the awareness of the respondents before and after the interactive forum session. The program is ending in March 2016.

## ***Involving educators in expeditions to disseminate polar research: outcomes of an outreach project about the XXX Italian Antarctica expedition 2014/15.***

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Connections between Polar Sciences and the Italian Science Curriculum are abundant, but little attention is paid this topic in science books used in classrooms, resulting in the cryosphere receiving limited attention in the Earth Science in Italian Schools. In this study, we carried out research involving Italian science teachers. A sample of teachers was selected, representative of different grades of school (primary, middle and secondary) and locations within Italy (northern, central, and southern). Some teachers within the sample voluntarily participated in an outreach project offered by the Italian Antarctic Program (Fabulous Antarctica Project, Expedition 2014/15). The project provided for one selected teacher the opportunity to join the Italian Antarctica Expedition with the aim of disseminating Italian Antarctic Research to schools before, during, and after the expedition. This sort of "Education through Expedition," in which teachers are embedded with researchers in the field, is not common in Italy, and PNRA (Italian Antarctic Program) has been a pioneer, among Italian Research Programs, sending 5 teachers to Antarctica since 2006. In this study, we are assessing the effectiveness of the outreach project of expedition 2014/15. The results of this study show 1) that knowledge, among science teachers, of Polar Sciences, especially of Antarctica, is limited, 2) that there is a need for teachers to have a stronger connection with researchers, 3) that outreach projects can be the starting point for creating a new generation of teachers more expert in Polar Sciences. The team hopes that improvements will ensure students are not frozen out of understanding the cryosphere.

## ***Sustaining Malaysia's interest in Antarctica: Education and outreach programme***

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Malaysia's interest in Polar research began in 1985 when the former Science Advisor to the Prime Minister proposed for Malaysia to embark on Antarctic research. Then the first team of scientific expedition involving four Malaysian scientists went to Antarctica in 1999 and a Taskforce on Malaysian Antarctic Research Programme (MARF) was formed under the Academy of Sciences Malaysia in the same year. The setting up of the Sultan Mizan Antarctic Research Foundation (SMARF) as an agency under the Ministry of Science, Technology and Innovation of Malaysia (MOSTI) in 2012 with the mission to promote and develop national and international collaboration in research and conservation of the polar regions, further boosted Malaysia involvement in the Polar regions especially in the Antarctic continent. To achieve this mission, understanding and support from the public is of critical importance; especially for a non-traditional polar country such as Malaysia. The public has to understand the reasons and importance of Malaysia participating in Antarctic research. In this case, communication, education and public awareness programmes are critical to achieving this understanding and inspiring support from the public. This is also crucial to inculcate interest among the youth to choose science as their career path. To fulfil these, SMARF undertook a number of initiatives through partnership with local and international organisations such as sending students and teachers to participate in Arctic Educational Expedition in 2015, Sustainable Antarctic Contest, Antarctica Days Flag Activities, bringing Polar Scientists to schools and organise talk and participation in exhibition regarding Polar throughout the country.



## ***Frozen in time and space? Antarctica in the tertiary curriculum***

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Stimulated by an increase in research activity in the Antarctic in the last decade, the breadth and number of workshops, courses or programmes with an Antarctic-related focus held at tertiary institutions across the globe appears to have grown. Nonetheless, compared to other regions in the world, Antarctica continues to sit at the margins of regional studies or geographical course offerings, undoubtedly at least in part as a result of its physical and cultural remoteness, its lack of permanent human habitation, and its relatively young human history. Such marginalisation is contrasted by the central role Antarctic plays in contemporary climate-change research and by the Antarctic research community's efforts to strengthen Antarctic-related education and outreach and to emphasise multi-, inter-, and trans-disciplinary approaches to inquiry. The latter are central to advancing our understanding of complex phenomena faced by contemporary societies and should play a greater role in tertiary curricula. Why then do we not more readily integrate lessons from Antarctica and Antarctic research in tertiary education?

This paper assesses the ways in which 'Antarctica' is currently embedded in the curricula at tertiary institutions around the world. The objectives and pedagogical approaches of workshops, courses or degree programmes that focus on Antarctica as a place, a human space or a concept will be discussed. A main distinction will be made between course offerings that incorporate trips to, or fieldwork in, Antarctica and those that have to rely on merely virtual presentations or conceptual explorations of Antarctica. It will be argued that more traditional classroom-based teaching and learning represents an important first step in getting students interested in Antarctica, but that experiential learning or more hands-on student-led learning is necessary to deepen an initial interest in Antarctica to commitment and to ensure that the students, or learners, themselves become involved in further Antarctic-related education and outreach initiatives.

## ***Connecting high school students and teachers with the South Pole ice cube neutrino observatory: three approaches that work.***

**Jim Madsen**<sup>1,2</sup>, Silvia Bravo Gallart<sup>2</sup>, Megan Madsen<sup>2</sup>, Jean Demerit<sup>2</sup>, Ellen Bechtol<sup>2</sup>, The IceCube Collaboration<sup>3</sup>  
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The IceCube Neutrino Observatory at the South Pole consists of a cubic kilometer of instrumented ice starting 1450 meters below its square kilometer surface array, IceTop. The science of the project is multifaceted, using neutrinos and cosmic rays as messengers to explore the cosmos and discover new physics phenomena rather than the more common method of detecting light in various energy ranges. The allure of the South Pole, the exotic locale of the IceCube Neutrino Observatory, is often the initial hook that draws people's interest. Three successful efforts that allow high school teachers and students to get a deeper understanding of the science will be described: a one day masterclass for highly motivated high school students and teachers; field deployments for teachers to the South Pole in conjunction with the NSF-funded PolarTREC program; and a narrative arc approach for incorporating IceCube science into a summer science and math enrichment program for the federally funded University of Wisconsin-River Falls Upward Bound program.

## ***Path walked by Antarctic Legacy of South Africa to create awareness of Antarctica amongst all cultures of South Africa***

**Ria Olivier**<sup>1</sup>

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The Antarctic Legacy of South Africa project (ALSA) has been funded by the National Research Foundation to preserve and promote South Africa's involvement in the Antarctic region. Until recently, the history of South African involvement in the Antarctic region (here defined to include the African Sector of the Southern Ocean and the Prince Edward and Gough Islands) was poorly documented and as a consequence was little known and studied.

–The growth and sustainability of a democracy is dependent upon equitable access to information and knowledge” (Library and Information Association of South Africa)

Since 2009 the main aim of ALSA has been to preserve South Africa's Antarctic heritage by creating a comprehensive database. Since 2015 ALSA has commenced an outreach programme to promote South Africa's Antarctic legacy. We have studied educational material produced by Antarctic governmental entities of other countries to see what can be used and implemented in the South African situation.

This presentation will give a brief outline of the educational materials that is used by ALSA and will demonstrate some of its presentations given, other scientists and researchers involved in South Africa's National Antarctic Programme. There remains a lack of awareness and a shortage of educational materials about Antarctica in South African primary and secondary schools. ALSA aims to contribute to addressing this, working mainly in the Western Cape, home of Cape Town, the only Gateway City to Antarctica on the African Continent.

## ***Antarctic education: recent advances and future challenges***

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The Antarctic is famously associated with extreme temperatures, ice, snow, legendary explorers, penguins and other impressive fauna and flora. The past decades have witnessed a revolution in the amount of data collected in the Antarctic, with considerable advances in the knowledge of numerous areas. Educationally, the Antarctic can be the perfect vehicle to transfer educational concepts, but unfortunately, the evaluation of the impact of educational activities related to Antarctic is scarce. This presentation aims to address how to best evaluate educational activities while providing a general review of the importance of the Antarctic educationally, give examples of major advances and discuss how different organizations and programs have been acknowledging the role of Antarctic education and Outreach in Antarctic affairs. The Polar Educators International (PEI), the Association of Polar Early Career Scientists (APECS) and the Scientific Committee on Antarctic Research (SCAR; SCAR Capacity Building, Education and Training advisory group, along with their science research programs (e.g.: SCAR AnT-ERA, SCAR EGBAMM)) have been active, particularly in organizing and supporting workshops and formal/informal educational initiatives, (e.g. PEI master Class, APECS Webinars) along with scholarships for early career scientists. From an Antarctic Treaty System (ATS) perspective, Parties have recognized the relevance of education and outreach by the establishment of an Interseasonal Contact Group on Education and Outreach. Under such level, this presentation will also aim to report the most recent developments at ATS and identify links with the various stakeholders interested in Antarctic education and Outreach.

## ***"Education, outreach and communication (EOC) strategy in strengthening Malaysia's interest towards science of Polar Regions"***

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In the 21st century, the roles of Polar Regions in global sustainability deserve to be acknowledged by all mankind, especially its interconnection with Earth's climate system. Notably, science knowledge dissemination and awareness rising through education, as well as outreach, and effective communication as a part of key areas in working towards environmental conservation and sustainability on the Polar Regions. The aim of this study to explore Malaysia's strategies in Polar Regions in the context of Education, Outreach and Communication (EOC). Since the establishment of Malaysian Antarctic Research Programme (MARP) and Sultan Mizan Antarctic Research Foundation (YPASM), Malaysia is actively engaged with EOC programmes in order to increase awareness and develop national interest on Polar Regions especially for young citizens. As a way forward, a synergy framework of EOC is needed for a national polar program to strengthen and sustain the public's awareness and interest regards to Polar Regions and consequently, it will coordinate stakeholders and funds for EOC initiatives during the Year of Polar Prediction (YOPP).

## ***Penguin CALLS: A model for high-level long-term engagement with school classrooms***

**Gary Wesche**<sup>1,2</sup>, Maureen Lynch<sup>3</sup>, Heather Lynch<sup>3</sup>

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Education and outreach is a vital component of science in the research world. Researchers can be found visiting school classes worldwide, in person or virtually. The challenge facing educators and researchers is how to engage audiences on a higher level of scientific thought without placing unrealistic pressure on limited resources of time, money and equipment.

Here, we present a model utilized to engage researchers with high school students at the highest levels with reasonable commitment from researchers and educators. The presenters will share reproducible methods that worked successfully and methods that proved to be ineffective.

The Penguin CALLS' project has been a three year collaboration between Dr. Heather J. Lynch and graduate student Maureen A. Lynch of Stony Brook University, working on a research project "Acoustic evolution and its role in gentoo penguin colony formations" and Gary Wesche, Penguin Education Coordinator of the Kansas City Zoo. Penguin CALLS' integrated together the conservation mission goals of the Association of Zoos & Aquariums, standards for literacy in science and technical subjects, standards for life sciences and engineering design, and education and outreach goals of Stony Brook University.

Through this partnership high school students have opportunities to interact with field researchers utilizing multiple distance learning platforms. Students participate in team discussions, become versed on current research, and learn to collect, analyse, and draw conclusions from real data. To facilitate science literacy, students are exposed to a variety of written and multimedia resources with pedagogical reading strategies integrated into the project's curriculum. Concepts in the fields of biological science, physical science, Earth science and mathematics are interwoven. Gathered for educators are resources related to these concepts and issues. Over the three years of this project, the team utilized and evaluated various methods of interaction, communication and data sharing with educators and students.

The researchers from Stony Brook University provided access to newly collected data. Their research study is dependent on some very new and unique methods of data collection. Engineering of collection devices is evolving, and new approaches to obtaining detailed and reliable data are emerging. Understanding data needs better informs individuals who will potentially design new forms of data collection. Additionally, analysis of collected data allows students to envision future steps in the research process. To this end students have access to multiple data sets provided by the university.

Dissemination of science knowledge, research, and discoveries enables the general public to improve their science literacy. The Kansas City Zoo hosts yearly science conferences where high school student researchers submit abstracts and are selected to present work in poster sessions, oral sessions, or as featured keynote speakers. High school students have been recognized locally, nationally and internationally for their research.

## ***Drilling Back to the Future: Using ice core science to bridge the gap between researchers and non-technical audiences***

**Louise Huffman**<sup>1</sup>

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Changing ice has urgent implications for people around the world. The Ice Drilling Program Office (IDPO) provides scientific leadership and oversight of ice coring and drilling activities funded by the US National Science Foundation. One of its goals is to enhance communication and information exchange related to ice coring and drilling science and technology. Many education and outreach activities are instrumental in fulfilling this goal.

The IDPO Education and Outreach office works to create programs through partnerships that bridge the gap between science research and a variety of audiences including educators, students, college professors, graduate students, and community members. The IDPO leads face-to-face workshops for educators, highlights ice coring science to a wide variety of audiences through webinars, provides information and media for news and television outlets, and trains college professors in ice coring science among other things. This presentation will share some of those successes and lessons learned as we continually evolve our work toward more effective science education and communication highlighting ice drilling scientists and the results of their research.

## **S41. Evidence based conservation and environmental management in Antarctica, Meeting Room 409, August 22, 2016, 3:30 PM - 6:00 PM**

### ***Environmental monitoring in Antarctic stations: a tool for decision-making and improvement environmental performance. Experience in four Antarctic stations.***

**Claudio Gómez-Fuentes<sup>1</sup>**, Nancy Calisto-Ulloa<sup>1</sup>  
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The environmental monitoring programs are an effective tool for the adoption of mitigation measures in the Antarctic, however the implementation of regular programs is complicated because of the logistical difficulties and techniques.

Chile has incorporated into its National Antarctic Program the project Antarctic Center for Research and Environmental Monitoring, CIMAA, which runs under the Department of Chemical Engineering in the University of Magallanes, UMAG. The project has been working with the leading Chileans logistics players to verify the compliance with environmental commitments, using the existing capabilities in Antarctica, and in coordination with laboratories in Punta Arenas.

The CIMAA, supported by INACH, has been for four years monitoring four Antarctic Stations wastewater discharges in King George Island (2), and at Cape Legoupil, Antarctic Peninsula (2).

The four monitored stations have different technologies for wastewater treatment. The stations are equipped with activated sludge biological systems, electrolysis treatment, biofilters with worms and activated sludge with ultrafiltration membranes. All of them discharge their effluents to the sea in front of the stations. None of them has a specialized spilled system at the pipeline end to facilitate pollutants dispersion.

Faecal coliforms turned out to be the best environmental quality control parameter of the effluent and its impact on the environment. Other physicochemical parameters, as nitrogen and phosphorous compounds, organic matter, suspended solids, dissolved oxygen, turbidity and temperature, have also been tested.

Monitoring indicated that all treatment plants have operational problems of some kind: Variations in the number of people working at the stations, measurement of parameters not suitable for microbiological quality control, lack of maintenance, Insufficient knowledge of how systems work and staff turnover.

Both stations at Cape Legoupil managed to improve quality of discharges when Staff training, proper maintenance of both treatment systems and regular effluents and environment monitoring were implemented. It is important improve quality effluents and environment monitoring using suitable parameters that clearly illustrate the impact of the discharges to the environment. Additionally, wastewater treatment plants maintenance and operation staff should get proper training, enhancing their skills and expertise. Should be promoted the exchange of information on best available technologies for wastewater treatment in Antarctica, and operational care requirements.



## ***Inviolable areas to protect reference sites for future microbiology research in Antarctica***

**Annick Wilmotte**<sup>1</sup>, Anne Willems<sup>2</sup>, Elie Verleyen<sup>3</sup>, Wim Vyverman<sup>3</sup>, David Velazquez<sup>4</sup>, Antonio Quesada<sup>4</sup>, Dail Haywood Laughinghouse<sup>5</sup>, Julia Kleinteich<sup>6</sup>, David A Pearce<sup>7,9</sup>, Josef Elster<sup>8</sup>, Kevin Hughes<sup>9</sup>  
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Antarctica is a continent dominated by microbes. A surprisingly large biodiversity of microorganisms inhabit virtually all habitats, including ice-free regions, ice sheets and subglacial habitats. Recent studies have shown that Antarctic microbiomes may have unique compositions and functions, exhibit biogeographic patterns, and include endemic taxa that have survived in refugia since the formation of the continental ice sheet.

Microbial habitats are under constant pressure due to anthropogenic activities which may introduce non-indigenous microorganisms, via human bodies, clothing, food, cargo, or construction material. New entry points for microbial contamination are a consequence of the increase and diversification of tourism and research stations. Climatic changes might increase the probability of the successful establishment of non-native taxa. The impacts of such introductions are still unknown, but might lead to a loss of the native microbial biodiversity, or its modification.

Recent technical progresses in molecular methodologies have generated very sensitive high-throughput analyses. They have the potential to describe the microbial communities with unprecedented detail. However, due to the anthropogenic pressure described above, we may be losing the pristine Antarctic areas that would enable scientists to study the native microbial flora, its functions and properties.

The Protocol on Environmental Protection of the Antarctic Treaty foresees the designation of Antarctic Specially Protected Areas (ASPAs) to protect "outstanding environmental, scientific, historic, aesthetic, or wilderness values, any combination of those values, or on-going or planned scientific research" ([http://www.ats.aq/e/ep\\_protected.htm](http://www.ats.aq/e/ep_protected.htm)). However, the designation of ASPAs has not followed a systematic planning, and often focused on the conservation of large mammals, birds and/or vegetation. Terrestrial habitats are protected in 55 out of the 72 existing ASPAs (in total less than 700 km<sup>2</sup>). Microalgae are protected in 16 ASPAs, cyanobacteria in 7 and snow microalgae in 3. Only 8 ASPAs mention 'Microbial habitats', 'microbial communities' or 'soil and lake microflora'.

One tool of the Protocol that could be specifically used to protect microbial habitats is the creation of inviolable areas (inside ASPAs, for example) where a special entry permit is required and quarantine equipment should be worn. These zones could be set aside for future research and become extremely valuable. After a few decades, they would be unique examples of pristine habitats, representative of the native microbial diversity and processes. Examples of this are ASPA 126, Byers Peninsula, and ASPA 172, Lower Taylor Glacier and Blood Falls.

Such an option would require discussions and a consensus with scientists of other disciplines than microbiology to select these regions, and develop careful management protocols of the sites and their vicinity. In addition, gaps in knowledge should be addressed, like the extent of transportation of microorganisms by natural means (winds, birds...), and the probability of subsequent colonization of new areas by microorganisms coming from other Antarctic regions or from outside Antarctica.

We hope that the dialogue between scientists and policy makers will improve the conservation of Antarctic microbial diversity and safeguard the possibility to study these unique communities in the future by the next generation of scientists, with the most advanced techniques of the time.

## ***Can rocks really fly? Observations from Antarctica's Dry Valleys and a wind tunnel and implications for wind erosion***

**Jayne Belnap**<sup>1</sup>, Charles Lee<sup>2</sup>, Ian McDonald<sup>2</sup>, Greg Okin<sup>3</sup>, S. Craig Cary<sup>2</sup>

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In January, 2015, during a visit to the Dry Valleys of Antarctica, it was observed that very large (2-20mm, with a few even larger) rocks were driven into cracks in rocks up to 15cm off the ground (although none were found in higher cracks). These rocks were of mixed parent material and shapes. As no overland water movement is present in this setting, the deposits necessarily had to result from wind movement. Accordingly, buckets with backstops facing up and down valley (the direction of the strongest winds) were buried in 6 different surface types to collect a sample of these larger particles over the January 2015-January 2016 period. Immediately after installation, one windy period of several hours moved several larger clasts into the buckets, thus clearly indicating these rocks are being mobilized by wind. Samples from the buckets were collected in January 2016 and large clasts were found. In addition, in 2015, a haphazard sampling of surface rocks was brought back to the U.S. and placed in a wind tunnel for testing. Large clasts (2-20mm) were, indeed, found to move the entire length of the 3m tunnel at surprisingly low wind speeds. Because soils on most of the geomorphic types in the Dry Valleys are entirely covered by larger rocks, it would seem that these soils are completely protected from wind erosion. However, most of these clasts are not embedded into the soil, likely due to cryoturbation, and if they are fairly easily blown (as was observed), this rock cover actually provides little protection to underlying soils from wind erosion. As this is contrary to our understanding of how to predict site vulnerability to wind erosion, understanding how such large clasts are being moved by the wind is critical to understanding aeolian transport in the Dry Valleys. In addition, this understanding is necessary to aid in conservation planning.

## ***35 years of Adélie penguin monitoring in the Ross Sea***

**Fiona Shanhun**<sup>1</sup>, Nicole Stahlmann<sup>1</sup>, Kerry Barton<sup>2</sup>, Phil Lyver<sup>3</sup>

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Since the early 1980s, New Zealand has conducted an annual census of Adélie penguins (*Pygoscelis adeliae*) in the Ross Sea region. Adélie penguins are an indicator species used both by the science community and by policy and management specialists to detect and monitor the effects of environmental change on Antarctic marine ecosystems. Population health is monitored directly by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) through census data submitted to its Ecosystem Monitoring Programme (CEMP).

In the New Zealand monitoring programme, the number of breeding pairs is determined through aerial photography of known colonies, and subsequent image processing and penguin counting using semi-autonomous software. Current use of data generated from the annual census includes both managing ecosystem effects of fishing in the Ross Sea region and assessing the conservation value of the proposed Ross Sea Marine Protected Area. Annual changes in the number of breeding pairs can also be considered in relation to sea ice extent, iceberg activity and other climate parameters in order to distinguish between responses due to natural events and those induced by commercial exploitation. The long-term data set is also important for characterising Ross Sea ecosystems, developing models of ecosystem resilience under changing environmental conditions, investigating the impacts of fishing and invasive species, and identifying indicators of ecosystem function.

This presentation will discuss the trends in the census data over the past 35 years as well as the census methods, process, and challenges associated with this long-term monitoring programme.

## ***Evolution of environmental management in the Ross Sea Region of Antarctica – celebrating 25 years of the Madrid Protocol***

**Tanya O'Neill<sup>1</sup>**, Megan Balks<sup>1</sup>

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2016 marks the 25th anniversary of the Protocol on Environmental Protection to the Antarctic Treaty (The Protocol) whereby parties committed themselves to "...protection of the Antarctic environment and its dependant and associated ecosystems, including its wilderness and aesthetic values...". The Protocol was signed in 1991, and entered into force in 1998. In this paper we discuss the evolution of environmental management in the Ross Sea Region (RSR).

The first explorers/whalers/sealers (late 1800s-early 1900s) focused solely on survival and left environmental impacts, from huts, to whaling stations. US-led "Operation Deep Freeze" in the mid-1950s and the International Geophysical Year (1957/1958, IGY) brought an upsurge in scientific activities. The US McMurdo Station and NZ's Scott Base on Ross Island, and the Italian Terra Nova station were established. Since the first IGY research programmes have expanded with approximately 4000 personnel working in Antarctica each year. Tourism in the RSR commenced in 1968 however long voyages, difficult sea ice conditions, expense, and limited wildlife, keep RSR tourist numbers to about 500 landing passengers per season (summer 2014/2015).

Environmental legacies of the last 60 years of human occupation are scattered across the RSR. Many are remnants of the 1950s-1980s when environmental protection was a lower priority than today. Greenpeace played an important role in the change of attitudes towards environmental stewardship and brought Antarctica to the world's attention in the summer of 1986/1987 when they established World Park Base at Cape Evans. Greenpeace wanted to demonstrate that a base could exist in Antarctica with minimal impact to the environment. Sophisticated communication systems provided interviews, and video footage to the world thus increasing public awareness of environmental management in Antarctica.

The Protocol requires that all activities planned in Antarctica must undergo an Environmental Impact Assessment and commits parties to clear up past waste disposal sites and abandoned equipment. Prior to The Protocol it was common practise to leave waste behind, create landfills, or incinerate rubbish. Many former bases and campsites have now been cleaned up with large amounts of abandoned material removed, for example camps at Marble Point, Lake Vanda, Cape Hallett and the Greenpeace base at Cape Evans. The former station sites of Greenpeace and Vanda Station were visited during the summers of 2008-2010 and clean up practises were noted to be of a high standard with most past disturbance indiscernible to the casual observer.

The Protocol catalysed an important shift from a resource view to an environmental view of Antarctica. This along with the changing attitude of personnel on the ground had a remarkable effect. The Protocol brought with it more accountability for actions in Antarctica and requirements for national programs to develop contingency plans for environmental emergencies, such as fuel spills. Current challenges include; a need to assess the cumulative impacts of activities, issues with compliance by some nations, and a need to address liability for environmental damage and subsequent remediation.

## ***Facilitating Ex Situ Antarctic conservation: The establishment of an international Antarctic Genetic Archive (AGAr).***

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A significant change in climate throughout the Antarctic continent is now predicted to occur within the next 50-100 years. A change in biodiversity is certain to progress with this event, most likely resulting in a shift in biological community composition and structure and eventual loss in unique diversity – especially in the microbial flora. It is imperative that quick action be taken to preserve the Antarctica's unique genetic diversity. Newly developed molecular genetic tools, borrowed from the human forensic sciences, now allow us to acquire and indefinitely maintain samples of DNA at extremely low cost. Hundreds of thousands of samples of DNA can be archived at room temperature with a minimal cost and footprint. Newly developed DNA methods now allow us to comprehensively copy and amplify a small sample of DNA repeatedly producing virtually an unlimited supply when needed.

Through initial support from Antarctica New Zealand and the New Zealand Antarctic Research Institute (NZARI) an international archive of Antarctic genetic diversity has been established at the University of Waikato, New Zealand. The Antarctic Genetic Archive (AGAr) has the ability to receive DNA from all types of environmental samples (soil, filtered water, tissue, plant etc.) and store and manage these samples using available barcoded archive technologies. A centralized database has been designed to capture critical meta-data that will be searchable online in the near future.

Our intention is now to open this new repository to all international programs working on aspects of Antarctic environmental research thereby centralizing the archiving, protection, and distribution of Antarctic biodiversity and genetic complexity in perpetuity. We propose that the archive also be mirrored in at least two geographic locations for complete protection. It is hoped that the two facilities would provide full coverage of the continent and research programs underway. We have also developed simple sampling kits designed to capture “samples of opportunity” from expeditions to remote regions where biologists are not present. Field researchers would be provided with preservation kits and instructions prior to going into the field. On return from the ice the kits will be sent directly to the archive for processing. Selected samples would be extracted, amplified and archived by the facility with split samples shipped to the sister facility for replication. Researchers currently with major collections are also encouraged to deposit selected samples for archiving. The archive has been designed specifically to make available unique DNA samples from remote areas of the continent to any Antarctic researchers thereby facilitating extremely difficult comparative studies and reducing the direct and indirect impacts need to revisit already sampled sites.

## ***Mapping the resistance and resilience to human trampling in the Antarctic Dry Valleys***

**Jayne Belnap**<sup>1</sup>, Charles Lee<sup>2</sup>, Kurt Joy<sup>3</sup>, David Chandler<sup>4</sup>, Greg Okin<sup>5</sup>, Craig Cary<sup>2</sup>

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Consistent human use of the Dry Valleys has been occurring since 1957 and the cumulative impact of this use is of increasing concern. However, only a few studies have addressed this issue and they have been limited to a very few study areas in the Dry Valleys. Many studies in other environments have shown that different geomorphic units vary in their resistance and resilience to human trampling. In this on-going study, we are characterizing the vulnerability and recoverability of different soil characteristics and ecosystem processes to human trampling across a wide array of different soil surfaces. We will use these data to address the following questions: 1) What are the impacts of trampling on soil structure and selected ecosystem processes? 2) What are the recovery timelines on different geomorphic surfaces? 3) Are there simple indicators of the more complex processes that are impacted by trampling, so that future assessments can be made more rapidly and efficiently? and 4) Are there easily measured site factors (e.g., soil, surface type, climate characteristics) that predict the vulnerability and recoverability of various geomorphic so that the resistance and resilience to trampling can be mapped using remote sensing throughout the Dry Valleys? In 2015, we visited a variety of geomorphic surfaces and measured both undisturbed and trampled (20 passes) areas, and found trampling reduced water infiltration; removed most, if not all, of the rock cover that protects soils from wind erosion; reduced surface roughness, further facilitating wind erosion; and left trails that varied in depth, but with some deep enough to likely persist well into the future. In 2016, we visited 40 additional geomorphic surfaces in different locations to add to our data. This paper will report the results of both our 2015 and 2016 seasons on how footprints and trails on different geomorphic surfaces impact soils and ecosystems and any preliminary conclusions we can draw on how soil surface characteristics might predict these impacts.

## ***Quantifying human movement to inform conservation planning***

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In Antarctica people travel in and around stations and they also travel to remote field camps and field huts. We attempted to quantify these human movements within the Australian Antarctic Territory to determine the footprint, in particular, scientific footprint. We collated data from a variety of sources. Travel information was extracted from archived travel reports and other sources spanning a period from 1957 to 2013. In addition, we consulted with Antarctic experts, enabling us to determined human movements for a national Antarctic program.

While the data was patchy over time and came in many different forms were constructed a comprehensive map of where people go. We were able to develop a human footprint for the region, and identify spatial and temporal trends on the number of people travelling, mode of transport used, purpose of travel and visitation rates to specific locations, particularly ice free areas. We identified 360 travel routes over the 56 years of data, with, with over 5,000 people movement events. We showed that human footprint is expanding over time in the region to many "isolated" ice-free areas.

We explore how this data on human movements within a region can inform conservation planning for the region, in particular protected area design.

## ***High resolution mapping of human tracking in the McMurdo Dry Valleys from SfM-MVS photogrammetry.***

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The McMurdo Dry Valleys (MDV) are considered one of the most unique environments within the Ross Sea region, and while the impact of human activities in the MDVs have been mitigated by the creation of specialty managed and protected areas (ASMAs and ASPAs), decades of scientific and tourist visitation has undoubtedly left a mark.

One important but underestimated impact is that of human movement within the MDVs. The glacial and lacustrine sediments found within the valley floors are typically associated with well-developed lag gravels and desert pavements. As footprints and walking tracks disrupt and break these protective surfaces, the underlying fine grained material is exposed and becomes susceptible to aeolian erosion and transport. Therefore, the method in which field parties' travel across these surfaces is directly related to the long term impact that may be observed. Unfortunately, much debate surrounds the topic; should field parties walk in single file and keep spatial impact to a minimum? Or should they walk side by side and therefore minimise cumulative impact? Even Ben Kenobi from Star Wars had an opinion ---"Sandpeople always ride single file to hide their numbers".

To quantify such disturbances, we apply structure from motion / multiview stereo photogrammetry (SfM-MVS) to map surficial impacts. SfM-MVS is a computation technique that analyses a group of overlapping input images, reconstructs their relative camera positions and then creates a 3D point cloud, similar to those produced from scanning laser systems (i.e. aerial and terrestrial LiDAR). Combined with accurately measured ground control points, SfM-MVS allows high resolution, low error 3D models to be created at a 1:1 scale. Although the technique is well suited to kilometre scale mapping using unmanned aerial vehicles, the use of SfM in microtopographic and patch (<1 m<sup>2</sup>) scale erosion studies has not yet been fully exploited as a tool to understand important geomorphological processes.

During the 2016 Antarctic field season, 45 sites within the Victoria and Miers valleys were visited to assess the impact of walking and tracking. Transects of single and multipass disturbances in a range of substrates, were fully photo-documented for SfM-MVS processing in addition to a number of traditional soil disturbance metrics (i.e. soil density, depth of footprints & tension infiltrometry).

Our initial SfM-MVS results show that extremely high resolution digital terrain models (DTMs) of human impacts can be produced, from SfM-MVS derived clouds of up to 120 million points per square metre, using simple methodologies and equipment. The production of such DTMs at the sub-millimetre vertical scale can provide a wealth of information about the distribution of surface clasts and post disturbance morphology.



## ***Mechanisms of enforcement in the Antarctic treaty system: Good governance or rubber stamp***

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The Protocol on Environmental Protection to the Antarctic Treaty (The Protocol), having entered into force nearly twenty years ago, brought a new inspection mechanism to the Antarctic Treaty System (ATS). Article 14 of the Protocol stipulates that parties “shall arrange [...] for inspections.” The central question in this paper is whether the treaty inspections provided for in Article VII of the Antarctic Treaty (AT) and Article 14 of the Protocol are examples of Good Governance.

This paper examines the main enforcement mechanisms of the ATS, treaty inspections, through the lens of Good Governance. The concepts of Good Governance have been promoted and applied by organizations such as the World Bank, the IMF, and other major international institutions. However, these concepts are yet to receive much attention in the context of Antarctic governance. Antarctica has characteristics such as the absence of a voting constituency, which are unique in the world. Consequently, certain applicable Good Governance concepts were reduced to a core question as follows: Transparency - Are materials on Antarctic Treaty inspections easily available? Rule of Law - Did inspectors find compliance or noncompliance? Accountability - Did inspections alter the behavior of the states/stations? Was the intention achieved for all stations to be inspected and all consultative parties to conduct inspections? This paper applies the concepts of Good Governance to an examination of the AT Secretariat’s website and 27 AT inspection reports, and draws on peer-reviewed literature. The analysis of the treaty inspection reports were conducted for nine different Antarctic stations. Six on the Peninsula: Artigas, Bellingshausen, Esperanza, Great Wall, Palmer, Rothera; two in East Antarctica, Maitri and Syowa, and Scott Base, located in the Ross Sea Area.

The study showed that while there was full compliance with the AT, compliance with the Protocol was less robust. It appeared that language was clear in cases of compliance and vague in cases of non-compliance. The authors noted trends towards increased transparency and better quality of information; greater compliance; inspection reports are more standardized; and increased collaboration on inspection teams. The authors conclude that the inspections do overall encourage greater compliance. Treaty inspections, especially for environmental compliance, are the only mechanism provided for in the AT and the Protocol by which the system is self-scrutinizing and to compromise its transparency or rule of law would be to compromise the legitimacy of the ATS. Through the lens of good governance, the ATS can be assessed for strengths and weaknesses within the system itself.

**Mini Symposium : SCAR and COMNAP Fellows, August 23, 2016,  
9:30 AM - 11:00 AM**

***New models for understanding the role of mesopelagic fishes and squid in  
Southern Ocean ecosystems***

**Rowan Trebilco**<sup>1</sup>, Jessica Melbourne-Thomas<sup>1,2</sup>, Mark Hindell<sup>1,3</sup>, Julia Blanchard<sup>3</sup>, Andrew Constable<sup>1,2</sup>  
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Mesopelagic fishes and squid play a key role transferring energy from zooplankton to higher predators in Southern Ocean ecosystems. Suitable representations of these groups for ecosystem models are needed in order to make reliable predictions of future dynamics and change in Southern Ocean food webs, but are currently lacking. We are developing new models to improve this capability. Specifically, we are developing trait-based and multi-species dynamical size spectrum models for the Kerguelen Plateau region in the Indian Sector of the Southern Ocean, and engaging with collaborators to develop an implementation of the SEAPODYM modeling framework for the same region. For model fitting and evaluation, we are drawing together existing data for mesopelagic fish and squid biomass, size distributions, life history traits, and stable isotope and fatty acid signatures. In addition, we are undertaking extensive targeted sampling on a voyage to the southern Kerguelen plateau in early 2016. We will use these models to assess (individually and together) the food-web effects of finfish fisheries and climate change in the region. In particular, we aim to use the models to identify and evaluate potential indicators of change, and to understand the implications of change for higher trophic levels (marine mammals, penguins and other seabirds). Here we provide an overview of this program of research and preliminary results.

## ***Assessing the impact of climate change on microbial diversity across environmental gradients in the southern ocean***

**Camila Signori**<sup>1,2</sup>, Vivian Pellizari<sup>1</sup>, Stefan Sievert<sup>2</sup>

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The Southern Ocean is characterized by a complex interplay of environmental variables that may influence the composition of the microbial communities. It is expected that microbes, which are the main drivers of the biogeochemical cycles and essential for ecosystems functioning, will be affected by climate change and anthropogenic impact. An increased understanding of the factors that drive the diversity of microbes is paramount to predict responses of this important biome to future changes. The polar regions are the most sensitive areas to climate change on Earth, and the Western Antarctic Peninsula is experiencing one of the fastest rates of warming, in contrast to regions in the Eastern Antarctic Peninsula (influenced by the Weddell Sea). So, the current conditions and future scenarios represent an unique opportunity to study the interactions between the climate change and the responses of the microbial communities in the Antarctic marine ecosystem. The main goals of this research were to: 1) Determine the composition, relative abundance and distribution of the microbial communities in different regions of the Southern Ocean: a) Along depth profiles, b) From coastal waters to the open ocean, c) Comparing different years; and 2) Identify the environmental parameters driving the microbial community structure. For the spatial approach we sampled the following areas: Bransfield and Gerlache Straits and the area influenced by the Bellingshausen Sea in the Western Antarctic Peninsula, and the Weddell Sea in the Eastern Antarctic Peninsula. We also sampled areas in front of glaciers melting and near the sea ice edge. Sampling depths were selected according to the CTD profiles. For the temporal approach, ten monitoring stations were selected in order to compare the microbial distribution annually (2013, 2014, 2015, 2016) and seasonally (contrasting the beginning and the end of the austral summers). We filtered 2 liters of seawater onto 0.2 µm Sterivex filters from which DNA was extracted and we used the Illumina sequencing-based profiling of archaeal and bacterial 16S rRNA genes to analyze the composition of the microbial community. We combined these results with environmental data such as temperature, salinity, dissolved oxygen, inorganic nutrients and chlorophyll-a. We used different softwares (QIIME, Cytoscape, ItoI and Ocean Data View) for statistical analyses and plotting for the data. In general, Flavobacteriia and Alphaproteobacteria were very abundant in surface waters, depending on the geographic location on the sampling stations. In waters below 300 m, Alphaproteobacteria and Gammaproteobacteria were the most dominant groups, summing up more than 50%, followed by Thaumarchaeota with 15% of total abundance. Betaproteobacteria were especially prevalent near the sea ice edge, with 10% of relative abundance. A combination of oceanographic factors drive the microbial community composition. The results will be an invaluable contribution to understanding how the dynamic seascape of the Southern Ocean shapes the microbial community composition, considering both spatial and temporal approaches, in light of climate change. This research was made possible by a SCAR fellowship.

## ***Demographic responses of an albatross community to environmental change.***

**Jaimie Cleeland**<sup>1</sup>, Deborah Pardo<sup>2</sup>, Rachael Alderman<sup>3</sup>, Mary-Anne Lea<sup>1</sup>, Clive McMahon<sup>4</sup>, Richard Phillips<sup>2</sup>, Ben Raymond<sup>5</sup>, Aleks Terauds<sup>5</sup>, Geoff Tuck<sup>6</sup>, Mark Hindell<sup>1</sup>

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Using 22 years of mark-recapture data (1993-2015) the influence of fisheries, climate and breeding habitat change on the demographic rates of four albatross species (Wandering; Light-mantled, Black-browed, and Grey-headed albatross) from sub-Antarctic Macquarie Island was assessed. For seabirds, the influence of environmental change on demographic rates can be experienced both at sea and/or at the breeding colony through mechanisms such as increased mortality by fisheries, oceanographic changes influencing food availability or breeding habitat loss. For example, over the past four decades, fluctuations in the population of introduced rabbit (*Oryctolagus cuniculus*) have caused dramatic changes in vegetation cover and land stability, impacting on the quality and availability of nesting habitat for seabirds on the island.

A multi-event framework was used to model demographic parameters of survival, breeding probability and breeding success. Environmental covariates included large-scale climate indices, remotely-sensed oceanographic data, fisheries effort, local weather conditions and rabbit population abundance (as a proxy for habitat quality). Data from 45 tracked individuals (1998-2009) were used to set the spatial bounds for oceanographic and fisheries covariates used in the at-sea habitat analyses. The strength of relationship between covariates and demographic rates were assessed using E-surge, a powerful analytical tool in mark-recapture multi-event modelling; and ANODEV.

Across the four species observed trends in survival could be linked to a range of drivers. Increasing meridional wind and negative Southern Oscillation Index values significantly decreased black-browed albatross ( $R_2 = 0.22$ ) and light-mantled albatross ( $R_2 = 0.11$ ) survival respectively. Breeding probability for all escarpment-nesting species was significantly influenced by rabbit density (BBA  $R_2=0.54$ , GHA  $R_2=0.12$ , LMA  $R_2=0.17$ ). Additionally, increasing sea surface temperature significantly increased light-mantled albatross breeding probability ( $R_2=0.12$ ). Local climate variables (e.g. rainfall and wind;  $R_2=0.18$  and  $R_2=0.18$ ) and rabbit density ( $R_2=0.29$ ), were the strongest drivers of black-browed albatross breeding success. Due to the low numbers of breeding wandering albatross, relationships with environmental covariates could not be tested. A high degree of synchronicity in trends was observed across all the demographic parameters tested for all species.

These findings indicate that albatross may have less capacity to buffer their own survival against climate effects than previously credited. Furthermore, habitat quality at the colony strongly influenced reproductive output. Identifying past demographic drivers of this albatross community will enable the prediction of future population trends given varying climate, fisheries and habitat scenarios and give rise to effective ecosystem-based management decisions benefitting multiple species.

# ***One historian, one hundred logbooks and an historic weather data rescue: a new approach in cutting edge science***

**Ursula Rack**<sup>1</sup>

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The project started with two aims: gathering and analysing logbooks, diaries and reports to make the material accessible for climate scientists, and analysing diaries in view of weather and climate conditions and how it influenced the interaction, social behaviour and wellbeing of early polar expedition members.

This paper will show how the project aims developed and also changed during the life of the research project. It will also demonstrate which opportunities helped my own development as researcher in this cutting edge field between humanities, social science and science.

The results of the research show that diaries of early Antarctic explorer are a valuable source on weather information but are also challenging in extracting the data. These are personal accounts in the first place and not meant to be standardised surveys on weather records. However, the results have shown that it is possible to establish a valuable comparison how expedition members perceived weather phenomena and in some cases how it influenced the interaction within a group or even decision making.

Many presentations (5 research presentations, 6 conference presentations, 3 public talks, and 3 poster presentations at conferences) and 4 publications in peer reviewed papers are the outcome of that research on historic weather data. It even opened for me the opportunity to establish myself as expert in the field of 'cutting edge climate data rescue' which resulted in two convener positions at the SCAR OSC (2014 and 2016).

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Rack, U; „Blizzard blowing again and considerable discomfort on board as usual— Personal accounts of weather as scientific data, and the weather's influence on expedition members during the Heroic Age, In: The Polar Journal 5:1, No 1 pp113-127  
<http://dx.doi.org/10.1080/2154896X.2015.1030159>

## ***Reconstructing the glacial history of western dronning Maud land, Antarctica, using high-resolution numerical ice sheet modeling and geomorphological mapping***

**Jennifer Newall**<sup>1,2,3</sup>, Jorge Bernales<sup>4</sup>, Freya Then<sup>4</sup>, Irina Rogozhina<sup>4,5</sup>, Ola Fredin<sup>6,7</sup>, Neil Glasser<sup>8</sup>, Clas Hättestrand<sup>2,3</sup>, Arjen Stroeven<sup>2,3</sup>, Derek Fabel<sup>10</sup>, Jon Harbor<sup>1,2,3</sup>, Nathaniel Lifton<sup>1,9</sup>, Olaf Eisen<sup>5,11</sup>

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Given current concern about the stability of ice sheets, and potential sea level rise, it is imperative that we are able to reconstruct and predict the response of ice sheets to climate change. The Intergovernmental Panel on Climate Change (IPCC), amongst others, have highlighted that our current ability to do so is limited. Numerical ice sheet models are a central component of the work to address this challenge. An unresolved key issue in this work concerns the volume and rate of ice mass loss needed to explain the large difference between late glacial and interglacial global sea levels. Some 20% of observed sea level rise since the Last Glacial Maximum (LGM) cannot be attributed to any known former ice mass, indicating that this inconsistency arises from the deficiencies in modelled reconstructions of ice sheet volumes and postglacial rebound. Ice sheet models are tested and refined by comparing model predictions of past ice geometries with field-based reconstructions from geological, geomorphological and ice core data. However, on the East Antarctic Ice sheet, Dronning Maud Land (DML) presents a critical gap in the empirical data required to reconstruct changes in ice sheet geometry. In addition, there is poor control on regional climate histories of ice sheet margins, because ice core locations, where detailed reconstructions of climate history exist, are located on high inland domes. This leaves numerical models of regional glaciation history largely unconstrained.

MAGIC-DML is a Swedish-US-Norwegian-German-UK collaboration with a focus on filling the critical data gaps that exist in our knowledge of the timing and pattern of ice surface changes on the western Dronning Maud Land margin. Here we describe a series of high-resolution modelling experiments to help identify those areas across western Dronning Maud Land that are the most sensitive to uncertainties in the regional climate history and the choice of model parameters. For this we employ a wide range of climate and ocean histories combining published outputs of 18 general circulation models for the LGM and mid-Holocene with ice core records. The modelling results together with remote sensing mapping of glacial landforms is informing and guiding cosmogenic nuclide sampling campaigns in western Dronning Maud Land starting 2016/17. Successful integration of numerical modelling and field investigations in an iterative manner is key to achieving the anticipated outcome of the MAGIC-DML project, a reconstruction of the long-term pattern and timing of vertical changes in ice surface elevation since the mid-Pliocene warm period, which will provide the missing empirical data required to constrain numerical ice sheet models.

## **S08. Solid earth responses and influences on cryospheric evolution, Meeting Room 409, August 23, 2016, 3:30 PM - 6:00 PM**

### ***The Influence of 3D Earth structure on a coupled ice sheet-sea level model of the Antarctic Ice Sheet***

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Earth structure beneath the Antarctic Ice Sheet is characterized by significant lateral variability. A stable, thick craton exists in the east, while the west is underlain by a large continental rift system and a relatively thin lithosphere. Moreover, high resolution seismic tomography indicates slow wave speeds in the shallow mantle below WAIS, suggesting a hot, low viscosity asthenosphere. Variations in viscoelastic Earth structure can impact predictions of relative sea-level change and crustal deformation rates by: 1) altering the timing and geometry of load-induced Earth deformation; and 2) perturbing, via a sea-level feedback (Gomez et al., EPSL, 2013, 2015), the timing and extent of the ice-sheet retreat. In this presentation, we use a coupled ice sheet – sea level model to explore the sensitivity of predictions of sea level change, solid Earth deformation and ice-sheet evolution in the Antarctic region to variations in Earth model parameters. We begin with a suite of simulations in which 1-D (depth dependent) viscosity structure that capture depth profiles inferred beneath the West and East Antarctic to explore the sensitivity of coupled system to changes in Earth structure. We then present simulations that incorporate 3-D variations in lithospheric thickness and mantle viscosity.

## ***Investigating the upper mantle seismic structure beneath the northern transantarctic mountains***

**Gregory Brenn**<sup>1</sup>, Samantha Hansen<sup>1</sup>, Yongcheol Park<sup>2</sup>

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The Transantarctic Mountains (TAMs) are the longest non-collisional mountain belt in the world and represent a tectonic boundary between the East Antarctic (EA) craton and the West Antarctic Rift System. Multiple geologic models have been proposed to explain the uplift and high elevations of the TAMs, and the geodynamic origin of these mountains has important implications for understanding the tectonic and climatic evolution of Antarctica. While body wave tomography studies can help constrain the upper mantle velocity structure, and therefore the TAMs uplift mechanism, such studies have only been performed along the central portion of the mountain range. In this study, P- and S-wave travel-times from >600 teleseismic events recorded by the Transantarctic Mountain Northern Network as well as by five stations operated by the Korea Polar Research Institute are being used to tomographically image the upper mantle structure beneath a previously unexplored portion of the northern TAMs. To expand the coverage of our model and to tie our results to previous work, >300 events recorded by the previously deployed Transantarctic Mountain Seismic Experiment and the David Glacier seismic network are also incorporated. Body wave travel-time residuals have been computed and inverted to determine the upper mantle P- and S-wave velocity structure, down to ~400 km depth. Our preliminary models show distinct low-velocity anomalies ( $\delta V_p = -2\%$ ,  $\delta V_s = -3$  to  $-3.5\%$ ) beneath Ross Island and Terra Nova Bay, extending laterally inland beneath the TAMs front. These are in sharp contrast to the fast upper mantle seismic velocities seen further inland beneath the EA craton. The slow velocity anomalies are consistent with warm upper mantle that likely provides a source of thermal buoyancy to support the TAMs uplift, as has been suggested by some previous studies. Further tests will determine whether the slow anomalies observed beneath Ross Island and Terra Nova Bay are continuous and connected at depth, along-strike of the Terror Rift, or if these anomalous features are separate from one another. This structure is important to assess the potentially variable thermal buoyancy contribution along the TAMs.



## ***Ongoing deformation of Antarctica following recent Great Earthquakes***

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The secular motion of Antarctica is thought to be almost everywhere governed by horizontal rigid plate rotation plus three-dimensional deformations due to past and present changes in ice-ocean loading, known as glacial isostatic adjustment (GIA). We use geodetic data to investigate deformation following the 1998 magnitude ~8.1 Antarctic intra-plate Earthquake, and show sustained three-dimensional deformation along East Antarctica's coastline, 600 km from the rupture location. We also suggest that the deformation pattern may have changed again after the 2004 Macquarie Ridge Earthquake 1800+km distant. Using a model of viscoelastic deformation with one dimensional Earth rheology we are able to match observed northward velocity changes, and either east or height, but not all three directions simultaneously. We perform preliminary tests on the effects of lateral variation in Earth structure and show this is important to consider.

Our preliminary modelling predicts much of Antarctica may still be deforming at a level commensurate with the magnitude of model predictions of horizontal GIA.

This previously unconsidered mode of Antarctic deformation affects geodetic estimates of plate motion and GIA and may be large enough to be an important direct bias to ice-sheet mass balance from GRACE. Furthermore, its viscous nature raises the prospect of further present-day deformation due to earlier Great Earthquakes.

## ***Antarctic GIA models for use in the ice mass balance inter-comparison exercise: current strategies and debates***

**Erik Ivins**<sup>1</sup>, Pippa Whitehouse<sup>2</sup>, Andrew Shepherd<sup>3</sup>, Isabella Velicogna<sup>1,4</sup>

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Reconstruction of the Last Glacial Maximum (LGM) and global sea-level during the past 100,000 years is one of the grand challenges in Earth sciences. What is required of contemporary models is consideration of all processes that are capable for both building and collapsing continental bound ice mass. Glacial isostatic adjustment is the process by which the solid Earth and ocean respond to cryosphere and ocean mass changes associated with LGM. Construction of any ‘near-perfect’ forward ice model would require understanding (or constraining) surface mass balance processes, ice stream flux, calving dynamics and grounding line migration over a 100 thousand year time scale. Should such a grand numerical problem be capable of computation, it would usher in a new era of better models that could provide realistic forecasts of future sea-level rise from ice sheet demise/growth in a warming world. However, this seems something that currently we are far away from (Bindschadler et al., 2013; Pattyn et al., 2016). Consequently, all hind-casting ice models used for Antarctic evolution require clever use of glacio-geological information and ice core data. State-of-the art models are facing new challenges as they incorporate ever more sophisticated use of ice core  $\delta^{18}O$  data and other SMB-related model forcing (e.g., Maris et al., 2015), for the Antarctic ice sheet continues to grow in most simulations – and there is a need to better capture the physics of the interaction of fast moving ice streams, water transport, and ice shelf interaction with ocean circulation (e.g., Pattyn et al., 2016).

Inter-comparison of ice sheet mass balance for Antarctica was shown to be tractable when the reported time-series of results are compared over the same time period and the same basins (Shepherd et al., 2012). The results of the first formal inter-comparison exercise (IMBIE-1) used 24 different assessments for Antarctica employing altimetry (laser and radar), input minus output method (IOM) and space gravimetry (Shepherd et al., 2012). While the fully reconciled (time and space coincident) mass balance revealed Antarctica to be in a negative mass balance state (-40 to -105 Gt/yr), the total spread of results between IOM and altimetry was large (+ 20 to -150 Gt/yr) and the focus, therefore, of the second Ice Mass Balance Inter-comparison Exercise will continue to isolate differences in results from the contrasting techniques with a longer over-lap period. Here I discuss the major issues confronting the question of improving the robustness of the surface mass trend for Antarctica in the 14-year-long Gravity Recovery and Climate Experiment (GRACE) time series. This later time series has an advantage in that it directly measures mass changes, but it suffers from a large correction due to rather discrepant GIA models.

Bindschadler, R.A., et al., 2013. *J. Glaciol.*, 59, No. 214, doi:10.3189/2013JoG12J125.

Maris, M.N.A., et al., 2015. *Climate Dyn.*, 45, 837–851, doi:10.1007/s00382-014-2317-z.

Pattyn F., et al., 2016. *Phil. Trans. R. Soc. A* 374, doi: 10.1098/rsta.2014.0296.

Shepherd, A., et al., 2012. A reconciled estimate of ice sheet mass balance, *Science*, 338, 1183-1189.

## ***Testing hypotheses of the LGM ice cap over South Georgia, sub-Antarctic, using glacio-isostatic adjustment modelling of raised marine features.***

**Mike Bentley**<sup>1</sup>, Natasha Barlow<sup>1</sup>, Georgio Spada<sup>2</sup>, Martin Brader<sup>1</sup>, David Evans<sup>1</sup>  
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There are at least two alternate hypotheses as to the size of the ice cap over South Georgia during the Last Glacial Maximum. The first of these suggests that the ice cap was extensive, with ice grounded well out on the continental shelf around South Georgia including in various cross-shelf troughs. This view of ice cap extent has been developed largely from marine geological and geophysical data. A second, contrasting hypothesis, is that the ice cap was much more restricted and that the ice margin remained in the inner fjords along the north coast of the island. The restricted hypothesis is based largely on terrestrial evidence of geomorphology supported by cosmogenic surface exposure dating and radiocarbon dating of lake sediments. Here we use glacio-isostatic adjustment (GIA) modelling constrained by raised marine features (beaches, rock platforms etc) to test between these two widely contrasting hypotheses. Because raised marine features record the GIA following deglaciation they can be sensitive to former ice sheet extent and thickness, and thus have the potential to distinguish between the extensive and restricted ice cap hypotheses.

We report new data on raised marine features from a range of sites along the north coast of South Georgia, and integrate these with previously published reports of raised marine features to develop a relative sea level database. We use a GIA model to explore several ice cap extent scenarios where each scenario provides predicted relative sea level histories that can be tested against the database. We discuss the utility of such modelling for distinguishing between the two ice cap hypotheses.

## ***Geologic controls on ice rise formation***

**J. Paul Winberry**<sup>1</sup>, Howard Conway<sup>2</sup>, Michelle Koutnik<sup>2</sup>, Carlos Martin, Richard Hindmarsh<sup>3</sup>

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Results from numerical models show that ice rises and rumples exert strong control on grounding-line dynamics, but in situ measurements needed to constrain the models are sparse, partly because travel on many of them is hampered by crevassing and rifting. To help provide these needed constraints, during November and December of 2015, we carried out an extensive ground-based geophysical survey on Crary Ice Rise (CIR), just downstream from Whillans Ice Stream in the Ross Sea Embayment. As part of this project, we collected 20 km of high-resolution seismic reflection data to constrain both subglacial conditions as well as the geologic setting of the CIR. These data reveal a complex geologic structure beneath the ice rise. First, several hundred meters of distinct sedimentary packages separated by angular unconformities are imaged. Second, at the base of the sedimentary units are folded structures. In this presentation, we will discuss the possible interpretations of these geologic structures. However, irrespective of interpretation, these results indicate that the topographic high essential for the existence of the ice rise is the product of the tectonic history of the region.

## ***GNSS measurements in the region of West Antarctica and the Antarctic Peninsula constrain solid earth deformation***

**Mirko Scheinert**<sup>1</sup>, Peter Busch<sup>1</sup>, Martin Horwath<sup>1</sup>, Christoph Knöfel<sup>1</sup>, Joanne Johnson<sup>2</sup>, Lutz Eberlein<sup>1</sup>,  
Andres Zakrajsek<sup>3</sup>, Lautaro Simontacchi<sup>4</sup>, Andreas Groh<sup>1</sup>, Reinhard Dietrich<sup>1</sup>, Andreas Richter<sup>1,4</sup>  
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Campaign and continuous geodetic GNSS measurements provide unique in-situ observations of solid earth deformation in Antarctica. Despite a lot of past and recent activities in various regions of Antarctica there remain many areas void of data.

We started to conduct GNSS measurements as early as in the 1995/1996 Antarctic season, in the form of a comprehensive German Antarctic project spanning the period until 1997/1998 (Dietrich et al., 1998). GNSS measurements were concentrated on sites in the region of the northern Antarctic Peninsula and South Shetland Islands. In the recent season some of these sites have been re-observed which enables us to infer coordinate changes over a duration of almost 20 years. In the Amundsen Sea embayment, West Antarctica, GNSS measurements were carried out in early 2006 and 2010. With additional measurements collected from the 2015/2016 season, we aim to extend the time span to almost 10 years for at least one site.

The results of preliminary analyses will be presented. We will focus on the interpretation of inferred vertical deformation regarding GIA, which is expected to give a signal in the cm-level in the Amundsen Sea Embayment (Groh et al., 2012), and of horizontal deformation regarding plate kinematics, especially the tectonic activity in the Bransfield Strait (Rülke et al., 2015). We will address issues such as the proper realization of the terrestrial reference frame with its densification in Antarctica, the separation between plate kinematics and GIA (King et al., 2016), and the impact of our current knowledge of GIA on Antarctic ice sheet mass balance estimates using satellite gravimetry.

These ongoing studies form a contribution to the goals both of the SCAR Expert Group on Geodetic Infrastructure in Antarctica (GIANT) and the SCAR Scientific Program SERCE.

## ***Full waveform adjoint seismic tomography of the Antarctic mantle***

**Andrew Lloyd**<sup>1</sup>, Douglas A. Wiens<sup>1</sup>, Hejun Zhu<sup>2</sup>, Jeroen Tromp<sup>3</sup>, Andrew A. Nyblade<sup>4</sup>, Sridhar Anandakrishnan<sup>4</sup>, Richard C. Aster<sup>5</sup>, Audrey D. Huerta<sup>6</sup>, J. Paul Winberry<sup>6</sup>, Terry Wilson<sup>7</sup>, Ian W. D. Dalziel<sup>8</sup>, Samantha E. Hansen<sup>9</sup>, Patrick J. Shore<sup>1</sup>

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At the turn of the millennium, the Antarctic continent hosted less than ten broadband seismic stations that were restricted to coastal regions or major science bases. Regional deployments of broadband seismic stations have since become a common occurrence within the harsh Antarctic interior and include USAP-lead projects such as ANUBIS (1998-2001), TAMSEIS (2000-2003), GAMSEIS (2007-2012), POLENET/A-NET (2007-present), TAMNNET (2012-2015), and RIS (2014-present). Other countries (e.g., Australia, Argentina, China, etc.) have also contributed to the seismic instrumentation of Antarctica, increasing the number of unique broadband seismic stations that have operated on the continent to over 200. The opportunity now exists for integrating these new data to create an improved plate-scale high-resolution seismic model of the mantle beneath the Antarctic continent and the southern oceans. In this study we are utilizing supercomputing facilities (i.e., TACC – Stampede) and adjoint waveform inversion techniques to develop a high-resolution transverse isotropic shear wave velocity model of the upper mantle and transition zone. This model is being constructed from 250 magnitude (M<sub>w</sub>) 5.5-6.5 earthquakes occurring south of 45°S, which are first relocated within a 3-D global reference earth model (s362ani). This initial phase of the project, which minimizes the mapping of source errors into Earth structure, is computationally expensive; requiring ~1 million CPU-hours. The structural inversion requires just two numerical wave simulations for each earthquake per iteration: one calculation for the current model and a second, ‘adjoint’ calculation that uses time-reversed seismic signals at the receivers as simultaneous, fictitious sources, thereby providing an efficient method for a full waveform inversion. The results of these simulations are used with previously established adjoint inversion techniques to generate sensitivity kernels. We then iteratively improve the 3D earth model by minimizing the misfit of observed and synthetic 3-component seismograms. Similar studies in Europe and China suggest that our model will require ~25 iterations (which in turn will require ~2 million CPU-hours) and that the minimum resolved period at which seismic observations may be modeled and utilized in the inversion is 12-15 s. This new high-resolution model should provide valuable insights into the tectonic structure and processes affecting the Antarctic continent and plate, and allow better estimation of geothermal heat flow beneath the Antarctic ice sheet, which is important for coupled climate-ice sheet models. In addition, because the results extend deeper into the mantle and over a wider geographic region than existing Antarctic seismic models, the new model will provide important constraints on mantle viscosity variations required for accurate modeling of glacial isostatic adjustment.

## ***The gravity trend at Aboa, Dronning Maud Land***

**Jaakko Mäkinen**<sup>1</sup>, Jyri Näränen<sup>1</sup>, Hannu Koivula<sup>1</sup>, Joel Ahola<sup>1</sup>, Markku Poutanen<sup>1</sup>  
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The Finnish Geospatial Research Institute (former name Finnish Geodetic Institute) FGI maintains a time series of absolute gravity (AG) measurements in Western and Central Dronning Maud Land. The purpose is to detect the variation in gravity due to the Glacial Isostatic Adjustment GIA and to the contemporary changes in regional glacier mass balance. The stations also serve as references for gravity surveys. AG measurements were performed at Aboa (in the field seasons 1993, 2000, 2003, 2005, and 2011), Sanae IV (2003, 2005), Novolazarevskaya (2003, 2005, 2011), Maitri (2011) and Troll (2011, 2014). Here we concentrate on the results at Aboa. We have previously demonstrated that the variation in the attraction by near field snow and ice appreciably influences the gravity results and the gravity trends that are determined from them. We have also determined corrections to the AG measurements of 2011 and 2005 relative to the snow situation in 2003 which is when we started the systematic monitoring of the snow heights in the close field. Now we extend the corrections to the AG measurements of 1993 and 2000, using auxiliary data like a nearby snow stake line, photographs, and re-measured heights of legacy relative gravity stations on the near glacier. We then determine a new gravity trend and compare it with the trend in the vertical coordinate at the co-located continuous GNSS station ABOA. We discuss the implications for the determination of GIA trends in gravity and in coordinates. The work is part of the Finnish Antarctic Research Program FINNARP and of the POLENET.

## ***Using 3D Glacial Isostatic Adjustment models to determine the regional sensitivity of the solid Earth to past ice mass change***

**Pippa Whitehouse**<sup>1</sup>, Wouter van der Wal<sup>2</sup>

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The geodetic signature of present-day ice mass change across Antarctica is overprinted by a signal associated with past ice mass change. This signal, known as Glacial Isostatic Adjustment (GIA), depends on temporal variations in surface loading by both ice and water, and also the rheology of the solid Earth. In particular, the decay time for the relaxation of the solid Earth in response to past ice mass change depends on the rheological properties of the mantle.

Traditionally, GIA models for Antarctica have adopted a radially-varying 'Earth model', in which lithospheric thickness and mantle viscosity at a specific depth are assumed to be globally uniform. This assumption means that, within such models, the sensitivity of the solid Earth to past load changes is uniform across Antarctica. However, emerging information on seismic velocity perturbations suggests that there are large variations in relaxation time across Antarctica.

In this study we use seismic velocity perturbations to define the 3D temperature structure of the mantle. This information is combined with estimates of mantle grain size and water content to define a non-linear flow law that describes the response of the solid Earth to changes in surface loading. We produce a map of spatial variations in the characteristic decay time of the upper mantle across Antarctica, which allows us to estimate how far back in time it is necessary to determine past ice load change in different regions in order to produce an accurate estimate of the contemporary GIA signal. In regions where the upper mantle viscosity is high, such as East Antarctica, ice load changes prior to the Holocene will still have an impact on the present-day GIA signal. However, in areas with a low upper mantle viscosity, such as some regions of West Antarctica, the solid Earth response to pre-Holocene ice load change will have largely decayed, and the contemporary GIA signal will strongly depend on the details of ice load change during the last few thousand or even few hundred years. Improving our understanding of recent (mid-to-late Holocene) ice load change across West Antarctica is therefore crucial for accurately determining the present-day GIA signal, and hence constraining the rate of present-day ice mass change via the interpretation of geodetic data.



## **S17. Astronomy and astrophysics from Antarctica, Meeting Room 405, August 23, 2016, 3:30 PM - 6:00 PM**

### ***Scientific results from the 2012 Antarctic BLASTPol flight and the current status of the BLAST-TNG instrument.***

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Polarized thermal emission from interstellar dust grains can be used to map magnetic fields in star forming molecular clouds and the diffuse ISM. The Balloon-borne Large Aperture Submillimeter Telescope for Polarimetry (BLASTPol) flew from Antarctica in 2010 and 2012 and has produced degree scale polarization maps of several nearby molecular clouds with arcminute resolution. Results from the 2012 flight have recently been published and offer new insights into trends with polarization in molecular clouds as well as exciting new information on the dust polarization spectra. The success of BLASTPol has motivated a next-generation instrument, BLAST-TNG, which will use ~3000 linear polarization sensitive Microwave Kinetic Inductance Detectors (MKIDs) combined with a 2.5 m diameter carbon fiber primary mirror to make diffraction limited observations at 250, 350, and 500 microns. With 16 times the mapping speed of BLASTPol, sub-arcminute resolution, and a longer flight time, BLAST-TNG will be able to examine nearby molecular clouds and the diffuse galactic dust polarization spectrum in unprecedented detail. Progress on BLAST-TNG offers insight into the effectiveness of kilopixel MKID arrays for application in submillimeter astronomy. BLAST-TNG is scheduled to fly from Antarctica in December 2016 for 28 days and will be the first balloon-borne telescope to offer a quarter of the flight for "shared risk" observing by the community.

## ***Analysis of four-winter photometric lightcurves obtained by ASTEP South at Dome C***

**Nicolas Crouzet**<sup>1</sup>, Djamel Mékarnia<sup>2</sup>, Tristan Guillot<sup>2</sup>, Lyu Abe<sup>2</sup>, Abdelkrim Agabi<sup>2</sup>, Yan Fanteï-Caujolle<sup>2</sup>, Daniel D. R. Bayliss<sup>3</sup>, George Zhou<sup>4</sup>, Jean-Pierre Rivet<sup>2</sup>, François-Xavier Schmider<sup>2</sup>, Ivan Gonçalves<sup>2</sup>, Jean-Baptiste Daban<sup>2</sup>, Carole Gouvret<sup>2</sup>, Eric Aristidi<sup>2</sup>, Thomas Fruth<sup>5</sup>, Judit Szulagyi<sup>10</sup>, Anders Erikson<sup>5</sup>, Heike Rauer<sup>5</sup>, Erick Bondoux<sup>2</sup>, Zalpha Challita<sup>6</sup>, Cyprien Pouzenc<sup>7</sup>, François Fressin<sup>4</sup>, Franck Valbousquet<sup>8</sup>, Alain Blazit<sup>2</sup>, Serge Bonhomme<sup>2</sup>, François Bouchy<sup>6</sup>, Jérôme Gerakis<sup>2</sup>, Guillaume Bouchez<sup>9</sup>

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ASTEP South is part of the ASTEP project that aims to determine the quality of Dome C for photometry in the visible and to discover and characterize extrasolar planets. ASTEP South consists of a front-illuminated 4k x 4k CCD camera, a 10 cm refractor, and a simple mount in a thermalized enclosure observing a 4x4 square degree field of view centered on the celestial South pole. ASTEP South has been observing nearly continuously for 4 winters, collecting about 30 TB of science data. We present the full analysis of these data. The observing mode of ASTEP South, with stars moving around the CCD with a 1-sidereal day period, make the data reduction particularly challenging. We describe the procedures that we specifically developed for these data as well as the corrections of various effects that affect the photometry. We extract the lightcurves for 6000 stars over 4 winters. Using this unique data base, we infer the quality of Dome C for photometry from the lightcurves themselves, and we search for periodic signals. Comparisons with similar instruments located at temperate sites show the advantage of the continuous phase coverage that can be achieved from Dome C. In particular, we detect long period transit signals that could hardly be detected from temperate sites. As an example, we present the detection of a long-period eclipsing binary system and the follow-up observations of this object, which will allow us to constrain the evolution models of low-mass stars. These results are very encouraging for time-series photometry from Dome C.

## ***The G300-G307 Sector of Our Galaxy in Atomic and Molecular Gas***

**Elida Lailiya Istiqomah**<sup>1,2</sup>, Michael Graham Burton<sup>1</sup>, Catherine Braiding<sup>1</sup>, David Rebolledo<sup>1,3</sup>, Michael Ashley<sup>1</sup>, Craig Kulesa<sup>4</sup>, Gavin Peter Rowell<sup>5</sup>

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We present observations from the first seven degrees of longitude in the Mopra carbon monoxide (CO) survey of the southern Galactic plane, being mapped over the Galactic longitude  $l = 300\text{-}307^\circ$  and latitude  $b = \pm 0.5^\circ$ . These data have been taken at 35 arcsec spatial resolution and 0.1 km s<sup>-1</sup> spectral resolution. The CO and HI data sets, respectively, come from the Mopra and Parkes/ATCA telescopes. The [C I] data comes from the High Elevation Antarctic Terahertz (HEAT) telescope, on the summit of the Antarctic plateau where the precipitable water vapour falls into the lowest values found on the surface of the Earth.

We describe the motivation of the survey, the instrumentation and observing techniques being applied, and the data reduction and analysis methodology. We present some results from the region surveyed, including column densities, line fluxes, molecular masses, and optical depths. From some emission lines, we suggest that it may represent star formation.

## ***Current status of Astronomical instruments at Dome A***

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Several astronomical instruments have been installed at Dome A by Chinese Antarctic Expedition team since 2007 and some of them operated successfully. This year the second AST3 has been maintained for upcoming Antarctic night. At the same time, Chinese Antarctic Kunlun Observatory, mainly including two telescope, a 2.5 meter optic telescope and a 5 meter terahertz telescope, is still on its pre-research stage but made breakthroughs in some key technology.

## ***Update on the Neutron Monitors at McMurdo, Jang Bogo, and South Pole Stations.***

Paul Evenson<sup>2</sup>, Samuel Gardner<sup>3</sup>, **Jim Madsen**<sup>1</sup>, Laura Parmeter<sup>1</sup>, Surujhdeo Seunarine<sup>1</sup>, Robert Zill<sup>4</sup>  
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Efforts in Antarctica to measure neutrons from cosmic ray interactions in the Earth's Atmosphere go back to international geophysical year in 1957. Data has been continuously collected at the McMurdo site since the early 1960s, and nearly as long although not continuously at the South Pole. Neutron monitors are used to investigate the high energy particles produced during solar storms, and the long-term influence of solar magnetic activity on cosmic ray fluxes and radiation input to the Earth's atmosphere. We report on the progress of the project to relocate the neutron monitors at McMurdo Station to the Korean Jang Bogo Station, and describe the contributions undergraduates are making to the Antarctic neutron monitor projects.

## ***Next steps in neutrino astronomy with ice cube***

**John Kelley**<sup>1</sup>, The IceCube Collaboration<sup>2</sup>

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The IceCube Neutrino Observatory is a cubic-kilometer-scale neutrino detector built into the ice sheet at the geographic South Pole. IceCube's discovery of a diffuse flux of high-energy astrophysical neutrinos has vitalized the emerging field of neutrino astronomy, but many questions remain unanswered. We present IceCube's most recent results on these particles, including their energy spectrum and angular distribution. Furthermore, we present strategies for identifying their source(s), including ongoing analyses, new near-real-time multi-messenger campaigns with other observatories, and plans for a next-generation neutrino detector, IceCube–Gen2.

## ***Scientific goals of the LAGO collaboration and its Antarctic node***

**Adriana Maria Gulisano**<sup>1,2,3,4</sup>, Jimmy Joel Masías-Meza<sup>5</sup>, Hernán Asorey<sup>6,7</sup>, Sergio Dasso<sup>3,4,8</sup>, Viviana López<sup>9</sup>, for the LAGO collaboration [lagoproject.org](http://lagoproject.org), see the full list of members and institutions at [lagoproject.org/collab.html](http://lagoproject.org/collab.html)<sup>10</sup>

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The LAGO Collaboration (Latin American Giant Observatory) is operating a network of water Cherenkov detectors (WCDs) across nine Latin American countries (Argentina, Bolivia, Colombia, Ecuador, Guatemala, Mexico, Peru, Venezuela, and Brazil). The LAGO network is recording the energy spectrum and the integrated flux of atmospheric particles at several sites with different altitudes and geomagnetic rigidity cut-offs.

Since the Antarctic continent has the advantage of combining low rigidity cut-offs values and infrastructure to support the operation of WCD, the LAGO collaboration is installing a new node at the Marambio base, in the Antarctic Peninsula. The low rigidity cut-off at this location will extend the space weather observations of the LAGO project. Even more, this site could open a new window to the exploration of possible gamma rays sources at the southern sky.

Numerical simulations have been conducted using the CORSIKA code to assess the development of secondary particles cascades at the chosen location. Asymptotic arrival directions, taking into account the magnetic field influence, have also been studied.

The temperature and pressure height profiles at Marambio (from ground level up to 35km height) have been characterized using extensive balloon soundings (from 1998 up to 2014). They have been also compared with GDAS (Global Data Assimilation System) data in order to improve the atmosphere profile for the numerical simulations. Both have been compared to the MODTRAN subarctic models provided by CORSIKA. In the present work we will present these results for the Marambio site along with the scientific and academic objectives of the LAGO collaboration.

## ***EVA, Evryscopes for the Arctic and Antarctic***

**Andrea Richichi**<sup>1</sup>, Nicholas Law<sup>2</sup>, Octavi Fors<sup>2</sup>, Raymond Carlberg<sup>3</sup>, Peter Tuthill<sup>4</sup>, Michael Ashley<sup>5</sup>,  
Boonrucksar Soonthornthum<sup>1</sup>

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We are planning to construct Evryscopes for the Arctic and Antarctic (EVA), the first ultra-wide-field synoptic sky survey to be conducted from both Poles. The system is based on the successful Evryscope concept, already installed and operating since 2015 at Cerro Tololo in Chile with the following characteristics: robotic operation, ~8,000 square degrees simultaneous sky coverage, 2-minute cadence, milli-mag level photometric accuracy, pipelined data processing for real-time analysis and full data storage for off-line analysis.

The locations proposed for EVA are the PEARL station on Ellesmere island through a collaboration with the University of Toronto, and later the Amundsen-Scott station at the South Pole, pending approval by the NSF.

The science goals enabled by this unique combination of almost full-sky coverage and high temporal cadence are numerous, and include among others ground-breaking forays in the fields of exoplanets, stellar variability, asteroseismology, supernovae and other transient events. The EVA polar locations will enable unprecedented time coverage during the polar night, with uninterrupted observations lasting in principle over weeks and months depending on the weather conditions. Periods of continuously dark photometric conditions lasting over a month have been observed by our prototype instruments at the PEARL Arctic site. When two EVAs will be operational, we will be able to run the observations year-round. EVA will be fully robotic.

We will discuss the EVA science drivers and expected results, and present the logistics and the outline of the project which is expected to have first light in the winter for 2017-18. We will also describe the cost envelope, which can be kept very competitive thanks to R&D already employed for the CTIO Evryscope, to our experience with both Arctic and Antarctic locations, and to the use of off-the-shelf components.



# ***Measuring the K-band infrared sky background from the high Antarctic plateau***

**Matthew Freeman**<sup>1</sup>, Michael Ashley, Nic Bingham, Jon Lawrence, Lifan Wang  
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The central regions of Antarctica have very dark skies in the infrared. Measurements from the South Pole in K-dark (2.35 microns) have shown sky brightness levels as low as  $100 \mu\text{Jy arcsec}^{-2}$ , superior to established infrared sites such as Mauna Kea and the Atacama. The high Antarctic plateau is colder and drier than the South Pole, so is expected to have even better conditions for infrared astronomy. However, no measurements have been taken away from the South Pole.

We report here on the first measurements of the infrared sky background from the Antarctic high plateau, using the robotic NISM instrument near Dome A. This instrument was installed in January 2015, and operated over the winter season. NISM observes the sky in the 2.35 micron Kdark band, which lies in a gap between airglow and thermal emission, and hence has a very low atmospheric background.

A sufficiently low infrared sky background could open up the high plateau of Antarctica for ground-based infrared telescopes, allowing long duration measurements of infrared sources to be made.

## ***Unveiling the dynamic infrared sky with Gattini-IR***

**Anna Moore**<sup>1</sup>, Mansi Kasliwal<sup>2</sup>, Christopher Gelino<sup>3</sup>, Jacob Jencson<sup>2</sup>, Davy Kirkpatrick<sup>3</sup>, Ryan Lau<sup>4</sup>, Roger Smith<sup>1</sup>, Eric Steinbring<sup>5</sup>, Lin Yan<sup>3</sup>

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Optical and radio transient surveys are undergoing a renaissance this decade, however, the infrared sky remains virtually unexplored. The fundamental roadblocks in studying the infrared time-domain have been the overwhelmingly bright sky background, limiting the attainable depth per unit time, and the narrow field-of-view of infrared cameras. To address these challenges and opportunities, we present Gattini-IR, a dual hemisphere, infrared-optimized, ultra-wide field high cadence machine. To take advantage of the low sky background at 2.5  $\mu\text{m}$ , two identical systems will be located at the polar sites of the South Pole, Antarctica and near Eureka on Ellesmere Island, Canada. Gattini-IR will survey 15,000 sq. degrees to a depth of 20AB, the same depth of the VISTA VHS survey, every 4 hours with a survey efficiency of 97%. Gattini-IR will enable transformative science in areas such as the detection of stellar mergers, core collapse supernovae, binary neutron star mergers, variability of and planetary transit detections around Brown Dwarfs and long term monitoring of dust production from Wolf Rayet Carbon (WC) stars.

## **S21. Remote sensing of the Antarctic environment: Multi-disciplinary advances D2, Meeting Room 403, August 23, 2016, 3:30 PM - 6:00 PM**

### ***Mapping vegetation with multi-temporal satellite remote sensing data for indicator of climate change effects in Antarctica peninsula***

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Satellite remotely sensed data with its synoptic viewing and repeatability of data acquisition over the specific target-of-interest offers best source of data for monitoring remote and isolated areas such as in Antarctic Peninsula. Recent development has seen the British Antarctic Survey and United States Polar Studies use remote sensing techniques to produce large-scale topographic mapping series. In addition, spectral transformations of both red and infrared bands with selected vegetation index (VI) for mapping of vegetation-related elements in Antarctica regions also have been reported. Specific spectral transforms derived using satellite data have been used for various indicator of various biophysical parameters ranging from vegetation and forest studies, geologic mineral explorations, environmental air pollutions, and even could be used as indicator submerged seagrass, seaweed and other features in shallow coastal areas. In this article, we report on the refinement of selected VI for detecting and mapping of Antarctica's vegetation (snow algae, lichen and moss) using multi-temporal Landsat Thematic Mapper (TM), archived from early 80's to the recent Landsat-8 Operational Land Imager (OLI). In-situ spectral radiometry samples during UTM-Antarctica summer 2015 expedition were used in air-to-ground correlation of the corresponding satellite data sets, later yield to retrieve occurrences of snow algae, lichen and moss in 2009-2015 summers. Multi-temporal analysis of the vegetation growth extents extracted was then compared to against the climate-change effects of the corresponding area in Antarctic Peninsula. Hence, the indicator for snow-algae growth as effects of the climate-change could be inferred. Results indicated good agreement ( $r^2=0.85$ ,  $p < 0.01$ ) between vegetation growth extents with effects of temperature changes reported for the area. Recent in-situ verification of the selected sites in the region confirmed the agreements.

## ***Mapping vigour of Eastern Antarctic coastal moss beds with a hyperspectral unmanned aircraft system***

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Physiological responses of Antarctic moss ecosystems exposed to multiple environmental stress factors can serve as early indicators of the impacts of climate change in Antarctica. Traditional moss bed monitoring is, however, spatially and temporally constrained by limited human access and the short ice-free season. We have developed a quantitative imaging spectroscopy method capable of capturing and assessing vigour of an entire moss bed during a single visit. Dedicated laboratory experiments and ground-based/airborne spectroscopy measurements were conducted during the 2012-2013 season at Casey station and two near-by research sites in the Windmill Islands, East Antarctica. Spectral measurements of light reflected from the moss canopy under various hydration treatments were related to two stress indicating canopy traits: moss chlorophyll content and effective leaf density. Machine-learning routines called support vector regressions (SVR) were trained and successfully validated to estimate chlorophyll content from reflectance functions between 650 and 715 nm and to retrieve effective leaf density using reflectance between 710 and 780 nm. The best performing SVR algorithms were then applied to imaging hyperspectral data acquired with a Micro-Hyperspec visible-near infrared imaging spectroradiometer. The Micro-Hyperspec was either operated from the ground, mounted on a geodetic tripod and rotated by a computer-controlled platform about 2.5 m above the moss canopy, or from the air, i.e. flown as a hyperspectral unmanned aircraft system (UAS) onboard a small multi-rotor helicopter approximately 10 m above the ground. From these we produced moss chlorophyll and leaf density maps at sub-centimetre resolution for ground based measurements and 4-5 cm spatial resolution for airborne observations. A single relative measure was also computed from these to produce maps of relative moss vigour. Validation of these airborne maps was performed via statistical comparison with independent qualitative assessments of moss health conducted at both study sites during the same season as part of Australian Antarctic State of the Environment Indicator 72.<sup>1</sup> Relative abundance of unstressed, stressed and photosynthetically inactive (moribund) moss exhibited statistically significant linear relationships with chlorophyll, leaf density and moss vigour values obtained at the same locations from the UAS data. Further deployment of this UAS method could provide moss vigour maps of other areas along the Antarctic coastline and contribute to an Antarctic terrestrial and near-shore observing network (ANTOS).

<sup>1</sup>Australian Antarctic State of the Environment Indicator 72 - Windmill Islands terrestrial vegetation dynamics ([https://data.aad.gov.au/aadc/soe/display\\_indicator.cfm?soe\\_id=72](https://data.aad.gov.au/aadc/soe/display_indicator.cfm?soe_id=72))

# ***Direct abundance measurements of wandering albatross from satellite images***

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The newly launched WorldView 3 satellite provides imagery data at 30cm per-pixel on-the-ground resolution in the panchromatic band and 1m multispectral resolution. We acquired an image of Bird Island, South Georgia taken on 10th January 2015 to test the possibility of distinguishing and counting wandering albatross in the imagery. Bird Island has a long term monitoring programme on wandering albatross and all nest locations are recorded every year with records of nest failure and abandonment providing an ideal ground comparison dataset. Wandering albatross breed on gently sloping, tussocky areas and, with a body size of 107 – 135 cm, should be clearly visible on the imagery.

In the WorldView 3 image wandering albatross show up as distinct white dots and could be easily distinguished from the surrounding environment. We tested the accuracy and variance of manual and automated counting methods compared to known number of nesting sites from GPS nest records of every nest on the island. The automated methodology combined a rule-based detection algorithm refined by a habitat model based on vegetation, slope and altitude – three parameters known to be important to wanderers' nesting locations.

Both Automated and manual count results were consistently greater than the number of recorded nest sites, with the mean manual count of 867 birds (5 counters, Standard deviation 85) against 754 nests estimated from GPS records at this time of year. The total number of birds counted by the automated algorithm was similar to that of manual counters, but its accuracy at defining individual birds was poorer and errors of commission more common.

The overestimate in counting is assumed to reflect the presence of none breeding birds (partners, juveniles, and birds in transit) additional to nesting adults. This overestimate is geographically consistent across the island. Analysis of oblique ground photography against known nest sites suggested that the number of additional birds is around 11% greater than the number of known nest, a figure similar to the overestimate from the satellite counts.

The close match of the results to the control data suggest that this methodology could be simply and cost efficiently used in many remote areas to count wandering albatross or other great albatross species across the Southern Ocean.

## ***The impact of a micro UAV on penguins***

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In recent years, the usage of unmanned aerial vehicles (UAVs or drones) has rapidly increased, even in Antarctic regions. While there are guidelines for the operation of manned aircraft near concentrations of birds in Antarctica as well as rules for people how to behave near Antarctic wildlife, the possible environmental impacts of UAVs on bird and mammal populations remain quite unknown.

Due to their potential to cause negative impacts on wildlife and particularly considering the amount of scientific, commercial or private use, it is important that international agreed guidelines for UAV usage in the Antarctic will be developed. Our study aims to contribute to the scientific basis for such guidelines.

Studies were conducted from November 2014 to February 2015 on King George Island, South Shetland Islands, Antarctica. To quantify the impact of drones on penguins we overflew different focal species with a micro UAV (Octocopter MK ARF Okto XL (HiSystems)) while video recording the focal animals from the ground. We focused on the two most common penguin species in the area, the Adélie penguin (*Pygoscelis adeliae*) and the gentoo penguin (*Pygoscelis papua*). We visited several breeding groups regularly during their breeding period and overflew them in different altitudes and directions. We analyzed the recorded material by noting the behavior of the individuals for every second during the trials. For statistical analysis, the data on behavior were grouped into 5 distinct subsets, being comfort, resting, vigilance, agonistic behavior and escaping. The first 2 represent undisturbed behavior, the latter 3 stand for disturbed behavior of different stages.

The analysis for the Adélie penguins reveals a clear change in the behavior caused by the UAV. We detected an increase in the number of individuals showing disturbed behavior with decreasing flight altitude, regardless of the flight direction. A reaction to the drone was already detectable in moderate altitudes (50 m a.g.l.). The disturbance was particularly high at altitudes below 20 m a.g.l., with 80 - 90% of the individuals being disturbed. At these altitudes we also detected differences between the flight directions: an UAV lowering vertically caused higher disturbance than one crossing horizontally. We also found that already the take-off at a remote distance had a significant impact on the penguins on a similar level to overflights at high altitudes. These results show that Adélie penguins are sensitive to UAV flights even in higher altitudes, although a strong reaction was only observed in lower altitudes.

Analysis of the observations of gentoo penguins and comparisons with disturbances caused directly by humans, i.e. tourists and scientists, is still ongoing and will also be presented and discussed at the conference.

## ***A satellite time-machine: Three decades of continent-wide Adélie penguin distribution and abundance from Landsat imagery***

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Profound changes are occurring in the Southern Ocean ecosystem in response to biogeophysical processes that operate over long time and spatial scales. Such changes are now observable in a continent-wide, multi-decadal retrieval of Adélie penguin distribution and abundance from Landsat imagery. The retrieval results are derived from the Landsat Thematic Mapper (TM) series of imaging radiometers which, starting in 1984, provide products with 30 meter pixel resolution in spectral bands covering the visible, near-infrared and short wave infrared portions of the solar spectrum. A physically-based retrieval algorithm developed specifically for this purpose mined through the full suite of Landsat-4, -5, -7, and -8 imagery over Antarctica (Landsat-6 failed to reach orbit and earlier satellites did not manifest the TM instrument). Validation with ground surveys and high-resolution satellite imagery characterize the retrieval algorithm as having low errors of commission and omission, with a detection threshold for colonies having a population of ~2000 nests. A strong linear correlation between satellite retrieval of colony area and ground counts of colony nests ( $r^2=0.89$  on a linear scale and  $r^2=0.78$  on a log scale) indicate that the changes in colony area retrieved from the Landsat data record are also expressed as concomitant changes in Adélie population over this period of record. Retrieval results show that there has been a steady increase in colony area over most of Antarctica during the period of record with the exception of the western Antarctic Peninsula (AP), where Adélie penguin colony area has steadily decreased over time. The Landsat results also find that colony area in the Danger Islands at the northern tip of the Joinville Peninsula initially increased from 1990 to 2000 but more recently decreased, suggesting that the biophysical processes that are affecting penguin populations on the west side of the AP may be starting to influence populations farther to the east. The most dramatic changes in Adélie colony area were observed in the Pine Island Bay area of Marie Byrd Land, which is near the Pine Island Glacier, the fastest moving glacier in Antarctica. The satellite retrievals indicate that colony area in this region increased by >10x in the period from 1989 to 2003 but colony area has since decreased by about one half following that peak. The retrievals observed 161 unique Adélie colonies over the entire continent, including several that were previously undiscovered. Because many sites were imaged 2 or 3 times, the results add 370 new observations of Adélie presence during the 31 year Landsat data record. The results thus fill many gaps in the knowledge of continent wide Adélie penguin distribution and abundance, particularly in the many remote and inaccessible regions of Antarctica.

## ***Real-time streaming of penguin abundance and distribution: Automated workflows for satellite imagery interpretation, analysis, and visualization***

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The rapid influx of very high spatial resolution (VHSR) satellite imagery, as well as the continued availability of medium-resolution sensors such as Landsat, now enables us to map the presence and absence of Antarctic penguins reliably over unprecedented spatial extents (continent-wide). Fully developed and automated, these technologies will allow us to overcome the high-cost and logistical challenges of mapping out the distribution and abundance of Antarctic wildlife. Despite considerable progress over the last decade, several challenges remain before we can automate the workflows associated with the remote detection of Antarctic wildlife. In this study, we explored the potential of geographic object-based analysis (GEOBIA) to classify guano stains, indicative of penguin breeding areas, from VHSR satellite imagery and closely examined the transferability of knowledge-based GEOBIA rules across different study sites. We tasked a controlled experiment to systematically gauge the quality of image segmentation, classification accuracy, and the reproducibility of the 'fuzzy rules' used to attach semantic labels to image segments. The master ruleset was developed based on an image scene encompassing Hope Bay, Antarctic Peninsula and it was re-tasked 'without adaptation' and 'with adaptation' on candidate image scenes comprising guano stains from six different study sites around Antarctica. Our findings suggest that the object-based methods are capable of successful detection of guano stains because they incorporate the spectral, textural, spatial and contextual characteristics available from very high spatial resolution imagery. Reapplication of the master ruleset on candidate scenes without modifications produced inferior classification results, while adapted rules produced comparable or superior results compared to the reference image. A systematic categorization and documentation of individual changes in fuzzy membership functions and a summary of overall changes in the reference ruleset make the workflow more transparent and provides rich opportunities to (1) identify the most critical aspects of the ruleset, (2) interpret possible reasons for deviations in the ruleset among scenes, and (3) make necessary changes to the ruleset design.

Our talk will then briefly introduce how automated guano detection may be used in concert with modeling to provide data relevant to Antarctic decision support. The Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) is a newly developed online searchable database specifically designed to support conservation-focused decision making in Antarctica. When fully developed, MAPPPD will automatically download and interpret satellite imagery for Antarctic penguin colonies, will seamlessly integrate presence/absence records from citizen scientists or other sources, and will provide a transparent permanent record of Antarctic seabird biogeography in support of environmental assessments, conservation planning, and environmentally-sensitive tourism.

Remote sensing has already provided a new understanding of Antarctic biogeography. Linking these scientific developments to Antarctic management will require greater automation and carefully-designed tools for policy-relevant data delivery. Our work provides a road map to an operational 'image-to-assessment pipeline' that will eventually make penguin population census as routine as other Earth observation data streams.



## ***Detecting diet of Adélie penguins using high-resolution satellite imagery***

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Ecosystem-based management of the Southern Ocean via CCAMLR monitoring programs is crucial to maintaining the integrity of the ecosystem and ensuring rational use of resources. Currently, monitoring programs focus on a few populations of krill predators, such as fur seals and Adélie penguins, to determine the relative health of these predators as proxies for abundance and distribution of krill in the Southern Ocean. However, a more direct method of detecting diet across broad landscape would be desirable. To address this issue, we hypothesized that the diet of Adélie penguins could be determined from analysis of the reflectance of guano stains at penguin colonies on high-resolution satellite images. In 2012-2013, we gathered reflectance curves with a spectrometer for guano comprised primarily (>75% composition) of 1) krill, and 2) fish from two penguin colonies at Cape Royds and Cape Crozier on Ross Island, Antarctica. We analyzed 23 reflectance curves (krill=13; fish=10) and created an index to detect differences in the spectral signatures, and thus the diet of Adélie penguins. We found significant differences in the blue spectrum (450-520nm) between guano composed primarily of fish vs. krill, indicating that greater reflectance in the blue band suggest a greater proportion of fish being consumed. We compared these data to diet observations from the ground during the same time and applied our index to high-resolution satellite images (e.g., Quickbird-2 and WorldView-2, DigitalGlobe, Inc.). Our results suggest proportion of krill vs. fish in the diet of Adélie penguins can be differentiated using our reflectance index when applied to satellite images. The implications for this research includes applications across the continent, where little is understood about changes in diet through time, and more informed conservation and management of Southern Ocean resources.

## ***Intraseasonal dynamic of guano cover in *Pygoscelis penguin* colonies derived from satellite images***

Christian Pfeifer<sup>1</sup>, Jan Esefeld<sup>2</sup>, Hannes Grämer<sup>2</sup>, Jakob Maercker<sup>1</sup>, Hans-Ulrich Peter<sup>2</sup>, Daniel Prowaznik<sup>2</sup>, Marie-Charlott Rümmler<sup>2</sup>, Martin Senf<sup>2</sup>, **Osama Mustafa<sup>1</sup>**

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An Antarctic-wide monitoring could provide important information on alterations of penguin populations serving as indicator for changes in ecosystems. Due to the often difficult accessibility of penguin colonies and their large number a spatially consistent monitoring can only be carried out by using satellite based remote sensing techniques.

Owing to frequent cloud coverage particularly of the Maritime Antarctic, satellite images often have to be acquired at non-optimal dates in the course of the breeding season. For example, this could be early in the season when the colony is not yet fully occupied or late in the season when the chicks already left nests and form crèches. This study investigates if or by which degree those images from non-optimal dates can be used for abundance estimations of penguin colonies.

Therefore, a multi-temporal analysis using several very high resolution satellite images from breeding seasons 2014/15 and 2015/16 was performed for Ardley Island penguin colony in the vicinity of King George Island. Furthermore, multiple intraseasonal medium resolution Landsat images from the seasons 2013/14, 2014/15 and 2015/16 of the Adelié penguin colonies at Cape Bird and Pointe Géologie Archipelago were analyzed. As the spatial resolution of satellite images is too low for detecting penguin individuals, the area covered by guano stains was mapped instead and compared with breeding pair numbers based on different ground based-mapping methods at Ardley Island. The results of the satellite-based surveys at Ardley Island were compared with frequently conducted phenological surveys of more than hundred Gentoo penguin nests. This survey shows a clear distinction between different breeding stages like the incubating stage, the hatching stage and the crèche stage. The analysis reveals that the guano covered area, detected by satellite, changes strongly over the course of a season. This leads to the conclusion that the sizes of guano covered areas derived from satellite images taken at hatching phase or crèche phase need to be corrected to be used for abundance calculations. The definition of such a correction method increases the time span for acquiring images that can be used for abundance estimations in frequently overclouded regions like Maritime Antarctic and thus improves the continent-wide coverage of penguin monitoring.

***Novel use of low altitude remote sensing from unmanned aerial vehicles (UAVs) for improved environmental impact assessment in ASPAs.***

**Barbara Bollard Breen**<sup>1</sup>, Ashray Doshi<sup>1</sup>, Rebecca Jarvis<sup>1</sup>, Neil Gilbert<sup>2</sup>, Len Gillman<sup>1</sup>, Steve Pointing<sup>1</sup>, Mark Orams<sup>1</sup>

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Conservation outcomes in the Ross Sea Region are limited by resources for monitoring past and cumulative effects of human impacts on vulnerable ecosystems. Our team are leaders in the development of novel 'zero-harm' remote survey tools for conservation solutions. The low altitude remote sensing project we conducted at three Antarctic Specially Protected Areas (ASPAs) provided high resolution spatial maps of vulnerable habitats obtained from unmanned aerial vehicles (UAV) and spatial analysis software developed specifically for use in Antarctic environments. We interfaced these data with site specific visitor values to understand human interactions with Antarctic sites, thus providing solution-focused outcomes to conserve Antarctic landforms at risk from human impacts.

## ***Australia's next-generation autonomous underwater vehicle for Antarctic research***

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The Antarctic Gateway Partnership has been funded to advance the Australian capacity to undertake Antarctic science and is both improving the understanding of the physical and ecological environment and is building the facilities for the next-generation of Antarctic research. A crucial component of the Partnership is the development of a high-specification, multi-sensor polar Autonomous Underwater Vehicle. A key finding of SCAR's recent Horizon Scanning exercise was the prominent role that Autonomous Underwater Vehicles (AUV) will play in answering the big questions facing Antarctic science.

These big questions, including the mechanics of sea-ice formation, water column processes and ecosystem dynamics, drive the engineering and scientific focus of the AUV's development. Multiple sensor suites, such as a current profiler, side-scan sonar and hyper-spectral camera will complement the collection of physical samples using a sediment corer and a water sampler. Making manifold, simultaneous and diverse observations from a platform that can travel through the water column, to the seabed or under ice has the potential to support a wide array of important multidisciplinary Antarctic research.

We will present our vision for this new facility along with an update on its development and will lay out the deployment options for the vehicle and how it will enable researchers to investigate processes that have to date been too difficult to access or to sample over wide temporal and spatial scales. We will discuss sensor readiness, future missions and the benefit that the international community can gain from Australia's next-generation polar AUV.

## **S23. Microbes, diversity, and ecological roles (D2-PM), Meeting Room 401/402, August 23, 2016, 3:30 PM - 6:00 PM**

### ***Microbial community dynamics governed by mixed layer depth during an austral summer in Ryder Bay, Antarctica.***

**Patrick Rozema**<sup>1</sup>, Tristan Biggs<sup>2</sup>, Pim Sprong<sup>1</sup>, Anita Buma<sup>1</sup>, Hugh Venables<sup>3</sup>, Claire Evans<sup>4</sup>, Michael Meredith<sup>3</sup>, Henk Bolhuis<sup>2</sup>

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The Western Antarctic Peninsula is warming. As a result, summertime salinity stratification may occur more frequently due to enhanced glacial melt water input. The resulting changes in environmental conditions could affect the seasonal dynamics of phytoplankton and Bacteria. The aim of the present study was to examine the environmental characteristics that drive coastal Antarctic microbial community dynamics. Sampling was done at 15 m depth during the austral summer of 2010-2011 at the Rothera oceanographic and biological Time Series site (RaTS) in northern Marguerite bay, Antarctica. Environmental variables included salinity, temperature, density, irradiance, wind speed, major nutrients and  $\delta^{18}\text{O}$ , the latter indicative of fresh water origin. Phytoplankton biomass and group specific composition were followed using size fractionated Chl a and HPLC-CHEMTAX. Four different primer sets were used to study community changes using DGGE analysis: eukaryotes, diatoms, dinoflagellates and Bacteria. Salinity decrease during summer coincided with increased meteoric water input indicative of a glacial origin. Maximum Chl a values of 35  $\mu\text{g l}^{-1}$  were found during midsummer, mainly consisting of diatoms. Analysis of DGGE patterns revealed four distinctly different periods in eukaryotic succession during the season. The Bacteria showed a delayed response to the phytoplankton community. Non-metric multidimensional scaling analysis showed that phytoplankton community dynamics were mainly directed by temperature, mixed layer depth and wind speed. The bacterioplankton community composition was mainly governed by Chl a, suggesting a link to phytoplankton community changes. Sequencing (MiSeq) results for eukaryotes and Bacteria showed a high similarity between January and February. Eukaryotic sequences were dominated by pennate diatoms in December follow by polar centric diatoms in January and February. Our results imply that the reduction of the mixed layer depth during summer, caused by melt water related surface stratification promotes a succession in diatoms rather than (nano)phytoflagellates in Ryder Bay, which may favour higher trophic levels.

## ***Everything is not everywhere: Antarctica Dry Valleys as an extreme counterexample***

**Catarina Magalhães**<sup>1</sup>, Charles Lee<sup>2</sup>, Maria Monteiro<sup>1,2</sup>, Luís Torgo<sup>3</sup>, S. Craig Cary<sup>2,4</sup>

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Understanding the mechanisms that determine the spatio-temporal structuring of microbial communities and how these respond to environmental change are major challenges in microbial ecology, however there is still debate as to whether microorganisms exhibit any biogeographic patterns. Microbial communities from Antarctica Dry Valleys, with a long isolation history, are an ideal subject of study to examine the mechanisms that maintain genetic heterogeneity as well as functional resilience among microbial communities. In this study, we design an experiment to test how the same disturbance applied to different microbial communities, living in extreme habitat conditions, drive diversity and functional relationships. Given the fact that water and availability of Carbon (C) and Nitrogen (N) are major limiting factors to the existence of life in Antarctica Dry Valleys, we subjected soils from the Miers and Beacon Valleys to a drastic disturbance by adding water, N and C. We hypothesized that the microbial communities native to the two Dry Valleys initially be unique, but would converge on a microbial community with similar structure and function, as a result of the same disturbance being applied. Although, our results demonstrated that when communities from different Antarctica Dry Valleys (Miers and Beacon) are subject to the same experimental disturbance the overall community and even rare biosphere members (for 16S rDNA and 16S rRNA data) diverge with time, when were exposed to the same highly selective pressure. Results from this study revealed that microbial abundance and diversity distributions, including the rare biosphere, varies greatly within the same ecosystem (Antarctica Dry Valleys), reinforcing the rejection of the so-called hypothesis for microbial taxa “everything is everywhere, but the environment selects”.

Interestingly, the drastic divergence in community composition, at both 16S rDNA and 16S rRNA levels, was not clearly reflected in a functional survey. Rather, our results suggested a conversion in the predicted functional capabilities, based on PICRUSt analysis of 16S rRNA transcripts, in both Miers and Beacon communities, at the level of predicted genes involved in specific metabolisms (an example for N metabolism is given). Our findings strongly support the occurrence of microbial functional persistence and resilience and represent an actual evidence as to the importance of microbial seed banks in maintaining the diverse functional capabilities of a microbial community.

## ***Diversity of culturable microorganisms and metagenomics of Antarctic Soil from Greenwich Island***

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Antarctic soils have fascinated microbiologists throughout the last century as it was being isolated from anthropogenic activities as the Antarctic continent separated from the supercontinent Gondwana back in 25 million years ago. Being said that, ancient bacteria and other living organisms were frozen and buried deep under the thick layers of ice and glaciers. To date, our current understanding of the Antarctic soil were all derived from culturing on selective media, biodiversity studies based on clone library construction and analysis, quantitative PCR amplification of specific gene sequences and the application of generic microarrays for microbial community analysis. The emergence of metagenomics will enable us to have a better understanding on the microbial community present in these ancient soil.

Here, we investigated the diversity of culturable microorganisms and metagenomics profile of a soil community at Greenwich Island at the following GPS coordinates (S62 ° 27'02.1", W59 ° 44'12.1"). The soil and air temperature were recorded as well. We accessed the culturable microorganism from the Antarctic soil via double enrichment method whereby we used 14 different types of agar to carry out the bacteria isolation. DNA of the isolated bacteria were extracted and the 16s rRNA region were amplified using PCR. The PCR product were sequenced and the bacteria were identified using EzTaxon database. On the other hand, metagenomics will be carried out total soil DNA extraction were performed using GF-1 Nucleic Acid Extraction kit. The extracted DNA were subjected to next generation sequencing by deep sequencing using the marker gene of choice, the 16s rRNA gene. Pyrosequencing on the V1-V3 region of the 16s rRNA gene were performed using the Roche 454 GS FLX+ to offer accurate phylogenetic identification and increased confidence in the taxonomic assignment. Taxonomic classification were assigned to each read at the species level using the EzTaxon database.

There were a few isolates obtained from the isolation culturable microorganism. One of the bacteria was isolated using CHROMagar listeria and confirmed as *Bacillus oceanisediminis* with a similarity index of 99.71%. The remaining few were still being investigated at the time being. On the other hand, there were a total of 1,994,045 reads from the metagenomics analysis. The top kingdom classification were dominated by bacteria which occupied over 99.12% (1,976,580 reads) of the total reads. *Chthoniobacter* and *Arthrobacter* were the dominant genus in the soil. The report of the metagenomics analyses have also indicated that over 197,243 reads (9.89% of total reads) were identified as *Chthoniobacter flavus*. The other remaining top species identified were *Arthrobacter psychrochitiniphilus* and *Desulfovibrio psychrotolerans*.

Taken all together, these results demonstrated the soil microbial community and structure from the study site. Last but not least, from the metagenome analyses, there were a large number of unclassified reads indicated that there were more unknown new bacteria have yet to be discovered from the Antarctic soil.

## ***Molecular insight into bacterial cleavage of oceanic dimethylsulfoniopropionate into dimethyl sulfide***

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The microbial cleavage of dimethylsulfoniopropionate (DMSP) generates volatile dimethyl sulfide (DMS) and is an important step in global sulfur and carbon cycles. DddP is a DMSP lyase in marine bacteria and the deduced dddP gene product is abundant in marine metagenomic data sets. However, DddP belongs to the M24 peptidase family according to sequence alignment. Peptidases hydrolyze C-N bonds but DddP is deduced to cleave C-S bonds. Mechanisms responsible for this striking functional shift are currently unknown. We determined the structures of DMSP lyase RIDddP (the DddP from *Ruegeria lacuscaerulensis* ITI\_1157) bound to inhibitory 2-(N-morpholino) ethanesulfonic acid or  $\text{PO}_4^{3-}$  and of two mutants of RIDddP bound to acrylate. Based on structural, mutational and biochemical analyses, we characterized a new ion-shift catalytic mechanism of RIDddP for DMSP cleavage. Further, we suggested the structural mechanism leading to the loss of peptidase activity and the subsequent development of DMSP lyase activity in DddP. This study sheds light on the catalytic mechanism and the divergent evolution of DddP, leading to a better understanding of marine bacterial DMSP catabolism and global DMS production.



## ***Diversity and community structure of bacterioplankton at the northern tip of the Antarctic Peninsula***

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Global climate change is influencing Antarctic marine ecology, but little attention has been paid to the microbial ecology, such as microbial diversity and community structure, at the northern tip of the Antarctic Peninsula. During December 2011 - January 2012, bacterial diversity and community structure in the upper waters of these area were investigated using pyrosequencing technology. A notable aspect of our study showed that the upper waters became homogeneous in summer and competitive relationships existed among bacteria with similar ecological functions, indicated by ANOVA and Spearman analysis. The results showed that significant co-relationships were observed among dominant bacterial genera with similar ecology functions. In contrast, the bacterial diversity and community structure were minimally influenced by either nutrients or environmental factors such as temperature and salinity. Also, the data revealed that the orders Rickettsiales and Rhodobacterales (Alphaproteobacteria), Oceanospirillales and Alteromonadales (Gammaproteobacteria), and Flavobacteriales (Bacteroidetes) were dominant bacterial communities, as previously observed in other parts of the Southern Ocean. Cyanobacteria were also detected as >1% of the operational taxonomic units (OTUs). Further work based on different geographical scales, time scales and microorganisms ranges is needed to better understand bacterioplankton-associated ecological processes in the Southern Ocean.

## ***Habitat sharing and geographical migration of fungal species in Antarctic environment***

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Fungal diversity of Antarctic environments was analyzed from 1,700,000 LSU rRNA gene sequence reads obtained by amplicon sequencing from terrestrial soil, marine sediment, rock, fresh water, sea water, biofilm in marine environments, plant, and lichen samples. Clustering sequences altogether with 99% similarity cutoff resulted in 26,000 OTUs. The highest fungal diversity was observed from terrestrial soil samples and followed by marine sediments and plant samples. Large proportion of fungal OTUs recovered from fresh water, plant and marine sediments were unique to each habitat. Instead fungal OTUs in lichen samples were frequently found in terrestrial soil, and marine sediment. Many of rock inhabiting fungi were also found in terrestrial soil and lichen samples. The majority of fungi were included in Ascomycota and Basidiomycota, and especially in classes Dothideomycetes, Eurotiomycetes, Lecanoromycetes, Leotiomycetes, Saccharomycetes, and Sordariomycetes in Ascomycota and in classes Agaricomycetes, Pucciniomycetes, Tremellomycetes and Rhodotorula related phylogenetic lineages in Basidiomycota. Many of the fungal OTUs were still unclassified by sequence similarity searches, implying that there are a lot of uncovered fungal species in the Antarctic environments. Habitat sharing and geographical migration of fungal species will be presented.

## ***The soil microbial communities of the vegetation quadrats on the Fildes Peninsula, Antarctic***

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In order to monitor the long-term vegetation variation and its response to global climate change on the Fildes Peninsula, Antarctic, thirteen 1 m×1.5 m vegetation quadrats were established in the Chinese National Antarctic Research Expedition during 2013-2015. In each plot, included Antarctic hair grass, lichen and moss, we investigated the plant (mainly *Deschampsia antarctica*) species, individual number, and their frequency, density. Also, the soil characterization and microbial communities' structure of soil samples in the quadrats were analyzed.

By using high-throughput sequencing, 33 bacterial phyla mainly Proteobacteria, Acidobacteria, Verrucomicrobia, Actinobacteria, Bacteroidetes and 5 fungal phyla Ascomycota, Basidiomycota, Chytridiomycota, Glomeromycota, Zygomycota were detected in the soil samples. However, unique dominant microorganisms were detected at these plots, and the microbial communities that colonized in western coast and eastern coast could be separated by using PCoA (Principal coordinates analysis). It is conjectured that the different environment in eastern and western coasts have a major impact on soil microbial communities of the vegetation quadrats.

## ***Photosynthetic-Irradiance Response Curves revealed active sympagic communities in the Weddell Sea Winter 2013***

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Pack ice that occurs over pelagic waters typically contains discontinuous ice assemblages due to its' various ice types, ages and thicknesses. Therefore it is containing a great diversity of microenvironments inhabited by microalgae and protists. These sympagic communities of auto- and heterotrophic algae and protists were studied from 10 different locations in the Weddell Sea during Austral midwinter (June-July 2013). The abundances of encountered sympagic microbial assemblages was examined with light microscopy showing both their horizontal and vertical distribution. In addition we investigated the similarities of the encountered taxa using molecular ecological tools, sequencing of the 18S rRNA gene with Illumina MiSeq. These results reveal the presence of unidentified organisms, potential new species that cannot be found in GenBank.

The autotrophic activity was investigated as Photosynthetic-Irradiance responses from melted sea ice in laboratory conditions using 9 increasing light levels and two dark controls. There is only one earlier study from the Antarctic Winter showing similar results from two different ice stations. Therefore this will substantially broaden our understanding of the photosynthetic capacity of the sympagic communities during the austral winter.

These sympagic communities studied herein had photosynthesis-irradiance responses showing similar saturation curves to the earlier Antarctic winter study from Weddell-Scotia Sea in 1988 (Lizotte & Sullivan 1991). Yet, unlike Lizotte & Sullivan (1991), whom had highest (P<sub>bm</sub>) values in the surface or near surface 0-20 cm, 0-29cm or 29-49cm during this Polarstern Antarctic winter expedition June-July 2013 we never found the surface community to be the most active. Instead the highest activities were encountered from the middle or lower intermediate ice sections at depths 75-105cm to 105-135cm. This demonstrates the importance of biological investigations through the sea ice column, instead of just focusing in the bottommost layer, which is most commonly done.

There is also a possibility that these kind of laboratory incubations maybe prone to overestimations compared to in situ incubations as the temperature in the ice is lower than that of the melted sea ice:+4C. Furthermore the melting may cause light starvation in the cells as explained in Rintala et al 2014. Yet according to our best current understanding this provides evidence that the sea ice microbial assemblages maintain active even during the coldest and darkest winter months in the Antarctica. These vast sea ice covered areas are far from being icy deserts. Even during the darkest winter months, they form active mosaics that withhold a vertically as well as horizontally diverse and unique microbial assemblages with active processes that involve gas exchange in between the sea ice and atmosphere.

## ***Characterization of the fungal community in soils of Antarctica***

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Microorganisms play a dominant role in ecosystems, yet little is known about fungal diversity in remote and relatively pristine areas like the Antarctic continent. This study focused on the molecular identification of culturable and non-culturable fungal communities from soils of South Shetland Island located in the Antarctic Peninsula.

Soil and sediment samples were collected in the Antarctic summer between the years 2010-2013. Samples were processed by culture-based and molecular techniques including 454 pyrosequencing. Soil samples were first plated onto different broad spectrum culture media including PDA, TSA, and yeast extract. Then, isolates were identified by PCR amplification and sequencing of the ITS1, 5.8S, and ITS2 regions; pyrosequencing was also carried out on amplicons of the same region and results were analyzed using the Quantitative Insights Into Microbial Ecology QIIME software and sequences were compared to the UNITE version 7 database. Richness and Shannon diversity indexes were calculated using the pyrosequencing data.

A total of 126 isolates were obtained and their identity was determined using NCBI's BLAST. The most abundant isolates were of the genera *Pseudogymnoascus*, *Mortierella*, *Antarctomyces*, *Thelebolus*, *Varicosporium*, *Penicillium*, *Cadophora*, *Pseudeurotium*, *Verticillium*, *Paecilomyces*, *Pythium*, *Cladosporium*, *Thelebolus*, *Cryptococcus*, *Candida*, *Rhodotorula*, *Mrkia*, *Debaryomyces*, *Glaciozym*, *Pseudeurotium* among others.

The OTUs obtained by pyrosequencing were assigned to the most representative genera: *Pseudogymnoascus* (14.6%); *Mortierella* (4.8%); *Candida* (4.5%); *Verrucaria* (2.9%); *Oedogoniomyces* (2.0%); *Moniliophthora* (0.7%); *Psoroma* (0.5%); *Hymenoscyphus*, *Hemimycena* (0.4%); *Cryptococcus*, *Bulleribasidium* (0.3%), and 4.3% were not assigned to any taxonomic group. Data showed richness of 71 and Shannon-Weiner index 0.62.

The results of this study are consistent with previous studies where other techniques combining DGGE and traditional culturing were used. This research combining fungal isolation with 454 pyrosequencing emphasizes the importance of the use of molecular methods of detection in addition to traditional culturing methods to obtain a more accurate description of the diversity of the fungal communities present in Antarctica. The diversity of fungal genera in the Antarctic continent is still low, but this is relative knowledge, because a number of unknown genera that were detected may eventually will represent more fungal diversity in the region.

## **S27. Impacts of environmental changes on Antarctic ecosystems and biota, Meeting Room 406/407, August 23, 2016, 3:30 PM - 6:00 PM**

### ***Glacier retreat and its consequences to coastal benthic ecosystems.***

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The Antarctic Peninsula (PA) has lost almost 24 000 km<sup>2</sup> of sea bed ice coverage in the last decades due to its rapid warming. This process can produce two-fold effects, on one side driving hydrological modifications on coastal regimes that could affect established communities and on the other hand opening new areas available for primary production and benthic colonization. These in turn can produce positive and negative feed-backs on climatic change by enhancing or reducing the change rate. Coastal benthic ecosystems along the PA are characterized by high diversities, abundances and biomasses, which can therefore play an important role in Carbon sequestration. Thus, when benthic assemblages are affected positive feedback could be expected and when favored increased Carbon sink could drive to negative feedback. Potter Cove (PC), South Shetland Islands, offered an excellent opportunity to assess both effects due to the retreat of the glacier that surrounds the cove and a long term monitoring program that allowed the establishment of baselines against which to compare changes. We recently reported a sudden shift in benthic communities structure related to increased sedimentation rates driven by the glacier retreat. This highlighted the potential role of sedimentation in driving major changes in coastal communities, especially in fjords systems, and also suggested the possibility of thresholds in environmental factors. This could be important in communities dynamics since gradual changes in environmental variables could not drive responses until the threshold is surpassed and trigger major shifts that could also be difficult to reverse. In this case sedimentation can affect benthic functioning and biomass reducing the potential Carbon sequestration of the system. On the other hand the glacier retirement also opened newly ice-free areas, including a new island. We could sample benthic communities after around six years of being free of ice and found a surprising assemblage characterized by high diversity, species richness, abundances, biomasses and a complex three dimensional structure. Ash-free dry mass was almost 850 g m<sup>2</sup> more than an order of magnitude of the estimated mean in Antarctic shelves and even more than that expected in early successional stages. The finding of such developed assemblage in a new island, challenge the current prevailing image of slow colonization of Antarctic benthos and also opens the question of whether these assemblages could develop under glaciers in ice refuges. But also suggest that the negative feedback to climatic change in newly ice free areas could be more important than previously thought. These processes, i.e. environmental shifts that threaten coastal ecosystems and the opening of new areas available for colonization that could take place at previously unthought velocity could be especially intense in fjords along the AP. Since almost 90 % of the glaciers in the AP are in retreat these results acquire a high relevance.

## ***Marine ecosystem assessment for the Southern Ocean: What, why & how***

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Managing the ecosystem effects of climate change and human activities in the Southern Ocean requires regular assessments of ecosystem status and trends, together with robust assessments of the likelihood of different future ecosystem states under plausible future scenarios. Key questions for research and management are: What essential variables need to be routinely measured in the Southern Ocean for estimating status and trends in key indicators? What is the optimal approach for taking these measurements given available operational support and resources? How do we meaningfully summarise indicators into measures of ecosystem status now and for future projections? And how can results be communicated in a form that is meaningful for policy and decision makers?

In this presentation we will give an overview of current work through the Antarctic Climate & Ecosystems Cooperative Research Centre and the Australian Antarctic Division to: (i) develop a quantitative framework for assessing change in Southern Ocean ecosystems (habitats, species and foodwebs); (ii) undertake the first assessment using that framework; and (iii) use assessments to inform the design of a cost-effective sustained observing program that will be able to detect long-term trends in these ecosystems in the future. With a focus on the Indian Sector of the Southern Ocean, we are developing an assessment toolbox that includes methods for generating data summaries, statistical modeling, and dynamical ecosystem models. We are particularly interested to seek feedback on approaches to visualisation that succinctly capture variability and trends, and that coincide with scales of decision-making. This work is leading towards an international conference in Hobart in 2018 on Marine Ecosystem Assessment for the Southern Ocean ([www.measo2018.aq](http://www.measo2018.aq)), which aims to consolidate results from various groups into a circumpolar ecosystem assessment and to help set the stage for ecosystem research priorities from 2020 to 2025.

## ***Habitat heterogeneity as a driver of benthic diversity on the Sabrina Coast continental shelf, East Antarctica***

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In early 2014 the RVIB Nathaniel B. Palmer conducted the first multidisciplinary study of the Sabrina Coast continental shelf. This area is remote and generally inaccessible, but biological significance is recognised by its initial inclusion within the proposed East Antarctic representative system of Marine Protected Areas. The datasets collected during this voyage allow analysis of the physical habitat parameters and benthic biota through interpretation of bottom camera images, high-resolution multibeam bathymetry, sediment properties, and oceanographic measurements; satellite observations of sea ice also provide important environmental context.

The suite of environmental and biological datasets provides evidence for a diverse, relatively high biomass continental shelf community that is strongly structured by the physical environment. The distribution of benthic taxa is most closely related ( $\rho = 0.592$ ) to seafloor bathymetry, substrate type, latitude and the occurrence of phytodetritus. Phytodetritus accumulation is associated with muddy/sandy substrates, suggesting long-term sediment focussing in these areas, consistent with evidence of bottom water recirculation features. Softer substrates contain relatively high abundances of mobile holothurians and amphipods. Scattered occurrence of dropstones creates habitat heterogeneity at fine-scales. Harder substrates have high abundances of brachiopods, bryozoans, polychaete tubeworms, a range of massive and encrusting sponges, and sea whips. Several taxa are found only on hard substrates, yet have a broad distribution across the sites, indicating that the density of dropstones is sufficient for most sessile invertebrates to disperse across the region. The occurrence of dropstones is associated with significant increases in taxa diversity, abundance and percent biological cover, enhancing the overall diversity and biomass of this ecosystem.

This research confirms that multidisciplinary studies inform understanding of the drivers of benthic ecosystems, provide important constraints for generating realistic ecosystem models, and contribute to improving understanding of the sensitivity of this community to environmental change.



## ***Mixing and phytoplankton dynamics in Antarctica's coastal seas***

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There is a high spatial and temporal variability in the biophysical processes regulating primary productivity in submarine canyons in Antarctica's coastal seas, with Amundsen Sea, Ross Sea and West Antarctic Peninsula canyons being reported as important features for regional primary production. Canyon heads in the West Antarctic Peninsula (WAP) are considered biological "hotspots" by providing predictable food resource and driving penguin foraging locations, however the physiology and composition of the phytoplankton blooms and the physical mechanisms driving them aren't well understood.

Using autonomous underwater gliders equipped with CTD, chlorophyll and backscatter pucks, over 30,000 water column profiles in Antarctica's coastal seas have been analyzed with the goal of characterizing physically and biologically the upper 100 m of the water column. The mixed layer depth (MLD), determined by the maximum of the buoyancy frequency criteria, was found to be the MLD definition with the highest ecological relevance.

The strongest signal found was the seasonal cycle. The shoaling of the MLD in early January results in increased chlorophyll a concentrations and as MLD deepens in mid season due to wind forcing, phytoplankton concentrations decrease, likely due to decreased light availability. A consistent secondary peak in chlorophyll matches a shoaling in MLD later in the growth season. A steady warming and increase in salinity of the MLD is seen throughout the season.

To further evaluate the biological responses to physical forcing, the glider was equipped with a PAR sensor and integrated with a prototype Fluorescence induction and Relaxation (FIRE) sensor. This allowed the continuous and high resolution mapping in depth of the phytoplankton physiological responses to light stress using fluorescence kinetics, as no nutrient limitation was observed. Diel cycles collected show a clear daily cycle dependent on the magnitude of incident radiation, with both  $F_m$  (proxy for chlorophyll) and  $F_v/F_m$  (indicator of photosynthetic efficiency) showing reduced values only in the upper 15 meters at the highest daily irradiance.

With decreasing sea ice trends reported for some Antarctica's coastal regions, especially the WAP, the increased phytoplankton exposure to increased irradiance may result in significant ecological and biogeochemical implications, such as the decrease efficiency of atmospheric carbon sequestration.

## ***Organic carbon and biogenic silica distribution in marine sediments across a climatic gradient in the vicinities of the Antarctic Peninsula***

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Organic carbon (OC) and biogenic silica (bSi) were measured in 17, 5-cm long sediment cores recovered within a climatic gradient from the northwestern Weddell Sea (WS) to the Drake Passage (DP) across the Bransfield Strait (BS). Climate settings in the study area vary from dry and cold (polar) conditions with seasonal sea ice coverage in the WS to a more humid and warm (oceanic) environment where no seasonal sea ice develops in the DP, with the BS as transitional zone undergoing seasonal sea ice coverage. Regional averages were significantly lower for OC in DP samples and higher for bSi in the BS. These results suggested relatively high bSi export to the seabed in the BS, higher degradation for OC in the DP and lower bSi export from the euphotic zone in the WS. The observations made evident that the biogenic matter contents in the sediment not necessarily replicate their production characteristics at the upper ocean even across strong climatic gradients. The results may provide a useful baseline for paleoreconstructions in a rapidly changing environment.

## ***Functional classification and spatial distribution variability of the macrozoobenthos in the Mackellar Inlet, King George Island: what does it reveal?***

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The Antarctic Peninsula is one of the regions that has registered recent rapid regional warming in the last half century. Within the northernmost tip of this region the Admiralty Bay (King George Island) is one of the most sampled sites for its macrozoobenthic communities have been subjected to several studies. Throughout part of the last decade (2007, 08, 10, 12, 13 and 2015) the Peruvian Antarctic Program has been surveying the above mentioned assemblages in fixed sampling stations in the Mackellar Inlet during the austral summers. The community structure had usually been evaluated under the taxonomic approach; yet, this scope doesn't always reveal the processes that can be occurring in the area under study. Instead, the use of a functional groups classification (by trophic functions: (a) Feeding mode (b) food source (c) food type; and distribution functions: (d) Motility (e) life style or habit) can provide the suitable means to associate them with the environmental parameters and their dynamics.

Surface deposit feeders were the most abundant along the timeline, except on 2015 when motile detritus feeders were dominant followed by predator–scavengers and filter feeders. Few sessile organisms (<5%) were counted and this may be due to the shallow bathymetry of the area, the inter–functional competition and the sediment grain size. The sampling stations were grouped similarly to the a priori classification based on the inlet section (Inner, middle and outer). The functional grouping revealed the potential indirect influence of the Domeyk glacier through a marked  $\alpha$ –diversity gradient. It also revealed the influence of water currents (speed and direction) which enter this glaciomarine fjord through the eastern margin of the outer coastline where higher functional diversity was observed.

Overall, there's been a slightly and progressive reduction on the abundance of organisms, nevertheless the same can't be said regarding functional diversity which has shown the opposite pattern. The present surveys' compilation shows that the use of a functional approach is very useful when applying it to different spatiotemporal scales studies, allowing a better understanding on how the communities might change due to variations of the environmental parameters. However, a more incisive abiotic resolution is required in order to directly assess the potential effects of cryosphere dynamics (ice scouring, sediment resuspension and sedimentation, salinity gradients, internal waves, etc.) on the above mentioned trends. The Peruvian Antarctic campaigns (ANTAR) are organized by the ministry of Foreign Affairs.

## ***Benthic-pelagic coupling trophic guilds in the Larsen area (Antarctic Peninsula): integrative tools to detect potential climate change shifts***

**Francyne Elias-Piera**<sup>1</sup>, Julian Gutt<sup>2</sup>, Enrique Isla<sup>3</sup>, Sergio Rossi<sup>4</sup>

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Sudden ice-sheet collapses change physical, chemical and biological features in Antarctic Peninsula areas. This was the case of Larsen area, in which there was a drastic transformation in the trophic conditions, influencing processes like primary productivity, sedimentation rates, fauna distribution and food availability, after its collapse began in 1995. The new conditions presented opportunities for new benthic colonizers to become established, following the increase of phytoplankton blooms that started fuel pelagic and benthic communities after the ice retreat. The question proposed in this study is how the change in these environmental conditions due to the effects of fast climate shifts affects the trophic ecology of several benthic organisms in Larsen area. To achieve this target, representative organisms of benthic communities of Larsen A, B and C sub-areas and King George Island (*Ophiura carinifera*, *Ophioperla koehleri*, *Ophionotus victoriae*, *Pyura bouvetensis*, *Cnemidocarpa verrucosa*, *Primnoisis* sp., *Protelpidia murrayi*, *Bathyploetes fuscivinculum* and *Molpadia musculus*) were analysed using different trophic markers (stable isotopes, free fatty acids and the protein-carbohydrate-lipid balance). The main idea is using a latitudinal gradient in which food resources were potentially different because of the different degrees of ice collapse, look the trophic connections with the primary productivity and the capability of the organisms to store energy. The  $\delta^{13}\text{C}$  stable isotope analysis of sediment ( $\delta^{13}\text{C}$  from -25.3 to -23.8‰) fit with phytoplankton, phytodetritus and microzooplankton values of Western Antarctic Peninsula, but Larsen stations showed  $\delta^{15}\text{N}$  values of sediment between 2 and 4‰, suggesting that sediment has a great amount of non-fresh (reworked) organic matter. The  $\delta^{13}\text{C}$  values observed in the organisms indicate pelagic and benthic food sources (between -24 and -17‰). These results suggest that in Larsen area, some species seem to not be directly linked with fresh material of primary production of the surface. The organisms showed an omnivore diet and some of them present a typical carnivorous diet ( $\delta^{15}\text{N}$  values - 7 and 10‰ approximately), based on non-fresh (reworked) material in Larsen areas studied. This may indicate that the system is in a potential successional process. Interestingly, the sediment free fatty acids values showed clear preponderance of Saturated Fatty Acids (SAFA, 14:0, 16:0 e 18:0), being the Poly Unsaturated Fatty Acids (PUFA) very low represented due to reworked material in the sediments. The sedimented material was potentially part of the diet, but there was not a direct relationship between sediment and organisms on stable isotopes or fatty acids values. On the other hand, depending on the feeding and life style strategy, there were considerable differences in the ability to store reserves in the lipids form, being the vagile species those that apparently accumulate less energy storage reserves. The study indicated that the trophic guilds in the benthic communities of the Antarctic Peninsula are affected by ice dynamics and climate change, transforming the food composition and availability, since the dominance of certain organisms may have a faster or slower transition in the macrobenthic assemblages depending on their trophic strategies and ecological niches.

## ***Simulated environmental change effects on multiple life history stages of *Laternula elliptica*: What we know and what it might mean***

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The bivalve *Laternula elliptica* is a functionally important species in Antarctic coastal benthic ecosystems. It has a circum-Antarctic distribution, represents a considerable proportion of coastal benthic biomass and contributes significantly to benthic-pelagic coupling. As a calcifier and a stenotherm in a high CO<sub>2</sub> world, ocean acidification and warming are potential and very real threats to its existence. A previous laboratory experiment compared physiological and metabolic responses of adults at existing pH levels, with those predicted to occur in the following decades. This found an overall negative impact on a variety of functions (including shell synthesis, metabolism and stress) over relatively short terms (weeks to months). However, data were lacking on the combined effects of warming and acidification on adults, and early life history stages. The latter are, in bivalves, known to be most vulnerable to ocean acidification. Could negative effects of acidification potentially be mitigated by warming? We addressed these knowledge gaps through a series of experiments using temperatures ranging from -0.5 to +1.5°C and pH from 7.80 to 7.65, separately and in combination. Our assessments on early life history stages examined impacts on fertilisation, larval development timing and growth rates. Additionally, the crucial shell forming D-larvae stage was examined to quantify effects on size, morphology, metabolic rates and energy store utilisation. In this talk we will summarise and synthesise the key findings of the multiple experiments, and discuss the potential implications of impending environmental change to this sentinel species.

# ***Potential effects of environmental conditions on the distribution and acoustic behaviour of Antarctic blue whales***

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Harvested to perilously low numbers by commercial whaling in the past century, the response and sensitivity of Antarctic blue whales (*Balaenoptera musculus intermedia*) to environmental variabilities is poorly understood. This study utilises acoustic data collected from 586 sonobuoys deployed in the summer of 1997 through 2009, south of 38°S, coupled with visual observations of blue whales as part of line transect surveys. The characteristic Z-call and the feeding produced D-call of blue whales were detected using an automated template detection function and a manual verification method. Using generalised boosted regression tree and random forest models, we predicted the environmental preferences, spatial occurrence and acoustic behaviour of Antarctic blue whales. Whales were observed to be more vocal active during the day than at night across all acoustic stations. Latitude, longitude, and distance from the nearest Antarctic shores were the main positional predictor of blue whale occurrence. Satellite-derived sea surface temperature, chlorophyll-a and wind speed were the most important environmental predictors of blue whale occurrence. Vocalisation rates of both blue whale call types were majorly predicted by latitude, longitude, number of whales and whale groups in an area, and distance from the nearest Antarctic shore. Satellite-derived chlorophyll-a, wind stress, wind direction, depth, sea surface temperatures, sea surface height and wind speed were the important environmental predictors of blue whale call rates in the Southern Ocean. Blue whales also responded to the significant interannual variabilities of those environmental predictors. This paper presents one of the first quantitative predictions of the potential vulnerability of Antarctic blue whales to interannual variabilities in environmental conditions and predicts suitable habitats for this poorly known blue whale population. Such emerging knowledge about the acoustic behaviour, environmental and habitat preferences of blue whales is critically important in improving the management and conservation of this heavily depleted whale species.

## ***Oil yield data from historical whaling records link energy stores of humpback whales to environmental conditions in the Antarctic***

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Humpback whales are capital breeders that satisfy their annual energy demands by accumulating energy stores in highly productive polar feeding grounds during summer. This energy is stored as lipid in various depots in the body including the blubber, muscle, viscera and bone. The humpback whales from breeding stock D that migrate along the Western Australia coast accumulate their energy stores in the Southern Ocean. This is a dynamic environment that experiences large seasonal and inter-annual fluctuations that affect biological communities. Understanding the relationships between these fluctuations and biological responses will help us predict the biological effects of current and future environmental change. We used oil yield records from historic catch data for 7921 humpback whales collected along the Western Australia coast between 1950 and 1963 as a measure of total body lipid. We related body lipid as a function of length to a selection of climatic variables that integrated (i) large-scale climate conditions (Southern Oscillation Index), (ii) those more specific to Antarctica (Southern Annular Mode) and (iii) those that represent conditions along the migration path (Fremantle Sea Level). Initial results showed a negative relationship between the Southern Annular Mode (SAM) and humpback whale body lipid. Thus in years where the SAM was positive, lipid stores of humpback whales were relatively low. This demonstrates a linkage between environmental conditions in the Antarctic and energy stores of humpback whales, most likely mediated through climate induced variation in their prey, Antarctic krill. As these whales feed almost exclusively in the Antarctic and have limited feeding opportunities en route, any reduction in energy reserves accumulated in the Antarctic will affect their ability to complete their annual migration and to breed successfully. Understanding relationships such as these are particularly important in this era of rapid climate change.

**S31. Ocean acidification, Meeting Room 410, August 23, 2016, 3:30 PM - 6:00 PM**

***Ocean acidification effects on under-ice algal productivity assessed in situ in an Antarctic coastal ecosystem***

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Coastal marine ecosystems in the Ross Sea are dynamic and diverse, with distinct zones of primary production and secondary consumption. In spring, when the water column beneath sea ice contains very little phytoplankton, highly concentrated diatom films can be observed on the underside of the ice. Productivity by under-ice algae is critical to the local marine food web and supports numerous iconic Antarctic species, yet information on the responses of under-ice algae to ocean acidification and other aspects of climate change is lacking. To address this, we deployed sixteen 140 litre flow-through incubation chambers to the underside of coastal Antarctic sea ice, and applied four distinct pH treatments using a dynamic seawater control system, allowing us to monitor the algal productivity response continuously for 2 weeks in situ. We observed marked daily periodicity in net primary productivity (NPP) in all treatments, and an insignificant to slightly positive effect of reduced pH on NPP. Partial pressures of CO<sub>2</sub> (pCO<sub>2</sub>) declined in the chambers signalling uptake of CO<sub>2</sub> by algae. Moreover, rates of pCO<sub>2</sub> change within the chambers (i.e., CO<sub>2</sub> uptake rates) increased with increasing additions of CO<sub>2</sub>, providing further evidence of a stimulatory effect. Finally, algal biomass was highest in the treatment with the greatest addition of CO<sub>2</sub> (the lowest pH), although this result was not statistically significant. All of the results were consistent in suggesting a slight positive effect of ocean acidification on under-ice algal productivity. These findings provide important insights into potential responses to impending environmental change.



## ***Coccolithophore fluxes and species composition in a sediment trap in the Polar Frontal Zone of the Southern Ocean.***

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Sediment trap moorings were deployed from September 1997 through July 2007 at several locations South of Australia. For this study a total of 146 samples from the Polar Frontal Zone (54°S) of the Australian sector of the Southern Ocean, with traps at 800 and 1500 m have been analyzed.

The coccolith assemblages were largely dominated by *Emiliana huxleyi*, with relative abundances at both depths of more than 98% in most of samples. *E. huxleyi* < 4µm is the most abundant, and the type > 4µm also appears in higher quantities than other taxa. Other taxa like *Gephyrocapsa oceanica*, *Calcidiscus leptoporus*, *Gephyrocapsa* <3 µm, *Coccolithus pelagicus*, *Umbilicosphaera* spp., *Neosphaera coccolithomorpha*, *Oolithothus* spp., *Syracosphaera* spp. , *Helicosphaera carteri* and *Pontosphaera* spp. also appear but in less proportions.

The total coccolith calcite flux has been calculated with a new technique, measuring directly the calcite from several images obtained under circularly polarized light and processed with a customized program named C-Calcita. As the total area corresponding to each image is known and the technique used for preparing the samples creates a homogeneous distribution, the total coccolith calcite flux can be estimated by measuring the grey level of each image pixel and turning it into thickness. This methodology allows discriminate coccolith calcite from other non-coccolith calcite, obtaining coherent results.

The temporal flux pattern reflects the variations in surface oceanographic conditions and primary productivity, showing strong annual seasonality. Highest coccolith fluxes always occurred during the summer, while minima were observed during winter. These fluxes have been compared with other physical parameters such as Sea Surface Temperature, Chlorophyll-a or Photosynthetically Active Radiation, finding a delayed relationship between them.

More than eight thousand *Emiliana huxleyi* coccoliths have been isolated and measured from images taken under circularly polarized light using the C-Calcita program. The relationship between the size and the thickness with physical parameters such as pH, has been studied finding a small correlation of the thickness and pH.

## ***Ocean acidification effects on productivity in a coastal Antarctic marine microbial community***

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The oceans have absorbed approximately 30% of anthropogenic CO<sub>2</sub> released to the atmosphere, of which approximately 40% of this CO<sub>2</sub> has been absorbed by the Southern Ocean. Marine microbes (phytoplankton, protozoa and bacteria) are the base of the Antarctic food chain and critical determinants of the fixation and fate of carbon in the oceans. While influencing global climate they are also affected by climate change. Few studies on ocean acidification have been performed in Antarctic waters and its effects on marine microbes in this region are poorly understood. Six 650 L minicosm tanks were used to expose a natural community of Antarctic marine microbes from near-shore waters off Davis Station, Antarctica, to different CO<sub>2</sub> concentrations ranging from ambient to 1500 ppm. Primary and bacterial productivity was measured through the uptake of radioisotope labelled <sup>14</sup>C-bicarbonate and <sup>14</sup>C-Leucine, respectively, and normalised to cell abundance. Results showed that rates of primary production decreased markedly with increasing CO<sub>2</sub> concentration mainly due to the lower growth in these treatments. No marked difference was observed in rates of bacterial production amongst CO<sub>2</sub> treatments. This research will help determine critical thresholds of pCO<sub>2</sub> that elicit changes in microbial production in Antarctic waters and predict the future effects of anthropogenic CO<sub>2</sub> on the Antarctic ecosystem.

# ***Transcriptomic response of Antarctic sea urchin larvae to present and future pH seascapes***

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The transcriptional response of the Antarctic sea urchin, *Sterechinus neumayeri*, to current and projected future ocean acidification conditions was measured using Illumina sequencing. To our knowledge, this is the first study to characterize broad-scale differential gene expression in this species. Furthermore, the first continuous time-series pH data from Antarctica was used to frame the experimental ocean acidification treatments, underscoring the impact that including environmental variability in experimental design can have on the gene expression of *S. neumayeri*.

## ***CO<sub>2</sub> fluxes in the Gerlache Strait (Antarctica) during austral summer 2015***

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Measurements of total alkalinity (AT) and total dissolved inorganic carbon (CT) were made in the Gerlache Strait in February 2015 (austral summer) in order to characterize the carbonate system in the area. Here we focus on the characterization of the net CO<sub>2</sub> fluxes (FCO<sub>2</sub>) at the ocean-atmosphere interface. Partial CO<sub>2</sub> pressure in seawater (pCO<sub>2sw</sub>) was indirectly determined from AT, CT, temperature and salinity data using the CO<sub>2</sub>calc program, whereas the atmospheric pCO<sub>2</sub> (pCO<sub>2atm</sub>) was obtained from discrete data collected in the Palmer Station. The CO<sub>2</sub> flux was calculated using six distinct references for gas transfer coefficient, with the proposal of Wanninkhof & McGillis (1999) indicated to be the most suitable for the study area. We also estimated the CO<sub>2</sub> fluxes through both in situ and ECMWF-NOAA wind speed data. The pCO<sub>2sw</sub> values range between 310 and 560  $\mu$ atm, with the lowest values observed in the southwest region—a more protected area influenced by meltwater, continental input and sea ice. The pCO<sub>2atm</sub> was estimated of 395.7  $\mu$ atm. A large variability in the ocean-atmosphere CO<sub>2</sub> fluxes was observed in the Gerlache Strait associated with different responses in the strength of the biological and physical processes. In general, the study area behaved as a weak source of CO<sub>2</sub> to the atmosphere (FCO<sub>2</sub> = 0.38 mmol m<sup>-2</sup> d<sup>-1</sup>) in February 2015. However, the region can be split in two distinct areas, where the southern region acted an average as a zone of CO<sub>2</sub> absorption (FCO<sub>2</sub> = -0.39 mmol m<sup>-2</sup> d<sup>-1</sup>), whereas the northern region acted as a source of CO<sub>2</sub> to the atmosphere (FCO<sub>2</sub> = 1.14 mmol m<sup>-2</sup> d<sup>-1</sup>).

## **S32. Human biology and medicine, Meeting Room 404, August 23, 2016, 3:30 PM - 6:00 PM**

### ***Winterover to Mars: Use of a spaceflight simulator for investigations on piloting skill maintenance in long-term isolation and confinement.***

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The time constant of degradation for piloting skills has been an ongoing operational issue for aviation, because of the necessary trade-off between economic interests (both flying hours and simulator hours) and safety issues, resulting in the question: What is the minimum requirement for a pilot to keep his qualifications current? This issue is also relevant for long-duration spaceflight. Furthermore, the European Space Agency (ESA) has stated that monitoring of mental performance is an absolute requirement to long-duration missions. Also the need for instruments to validly and reliably detect such decrements is specifically acknowledged and ranked as a research priority.

Despite no experimental data to support the hypothesis, one can expect long-term confinement in isolation to have different effects on pilot performance than solely the effect of time. Indeed, the sensory deprivation, modified group dynamics, and psychophysiological adaptation could all have a severe influence on the piloting skill persistence during future long-duration missions. An Antarctic winterover crew offers the ideal analogue environment to investigate this hypothesis. Indeed, although there is no microgravity present, the extreme temperatures, remoteness and isolation confer a similar degree of hostility to the environment. Furthermore, the high latitudes cause large variations in photoperiod: from the constant illumination of the polar summer, to the constant night of the polar winter. Considering the hostility of the environment, habitats are therefore limited spaces of “viable” environment, relying on a life support system to supply energy, and thus heat and light. As for the social situation, with regard to winter-over crews, this mimics quite closely what would be the case in a long duration exploration flight: being isolated and confined within a small group of people, with reduced or absent communications and no, or very limited, possibility of emergency evacuation.

The present project investigated the evolution of piloting skills in a Soyuz spacecraft simulator during the 2015 winterover at Halley VI. 12 participants carried out the training according to a standardized curriculum to achieve a defined level of proficiency by the end of the summer season. The task being trained and investigated was the docking of the Soyuz to the International Space Station. After their check flight, based on their flight performance, they were divided in a frequent - training every month- and an infrequent -training every 3 months- training group. Every training session on the simulator was coupled to a detailed investigation of psychomotor and cognitive performance through several test batteries.

As data analysis is still ongoing, the following results will be presented:

- Evolution of flight performance throughout winter for both frequent and infrequent training group
- Evolution of cognitive performance throughout winter.
- Link between the experimental approach to cognitive performance, the flight performance on the simulator, and mood and general adaptation of participants.

## ***Person-environment fit: Selection and motivation***

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Despite Antarctica's reputation as a fierce and unforgiving physical environment, studies have shown that such features are not, collectively, the major challenge winter-over crews face. Rather, the social environment may present much more of a challenge. Because of this, those polar personnel whose primary motivation is to test themselves against the polar elements might be disappointed when confronted with the monotonous but relatively comfortable daily life of the dark winter; Worse, they may be ill-prepared for the experience of living in isolation with a small group of people for an extended time. On the other hand, others may thrive in a polar station exactly because it is just this sort of environment. This suggests that screening procedures by national programmes should increase the emphasis on selecting-in and -out for social motivations and skills in order to enhance person-environment fit in these remote and isolated settings.

## ***Different adaptations of Chinese winter-over expeditioners during prolonged Antarctic and sub-Antarctic residence***

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Prolonged residence in Antarctica is characterized by exposure to isolated, confined, and extreme (ICE) environment. Winter-over expeditioners at research stations often exhibit a complex of psycho physiological symptoms, which varied by stations and sociocultural backgrounds. To understand the different patterns of psychophysiological responses provoked by environmental stress, we conducted a longitudinal assessment of mood and endocrine function in two groups of Chinese expeditioners who were deployed to sub-Antarctic (Great Wall Station, 62°S, N=12) and Antarctic (Zhongshan Station, 66°S, N=16) from December 2003 to 2005. Measures of mood, thyroid function, the levels of plasma catecholamine, and circulating interleukins were obtained at departure from China, mid-winter (Antarctica), end of winter (Antarctica), and return to China, respectively. The Zhongshan Station crew experienced significant increases in fatigue, anger, tension, confusion, and decrease in free thyroxine (FT4), norepinephrine (NE), and epinephrine (E) during the winter, increase in thyrotropin (TSH) and total triiodothyronine (TT3) when returning, whereas their counterparts at Great Wall Station only experienced increased TT3 after deployment. Moreover, compared with the Great Wall Station crew, the Zhongshan Station crew exhibited greater increase in anger, greater decrease in FT4, total thyroxine (TT4), NE and E over the winter, and greater increase in TSH when returning. Chinese expeditioners who lived and worked at the Antarctic station and the sub-Antarctic station for over a year showed different change patterns in mood and endocrine hormones. Negative mood and endocrine dysfunction were positively associated with the severity of environment. The study is a supplement to scientific knowledge on psychophysiological variation under ICE environment, which has certain applied value for the development of preventive countermeasures or interventions.

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## ***Circadian misalignment and sleep disruption during the Antarctica winter***

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The Antarctic environment presents extreme seasonal variation in the natural light-dark cycle with overwintering expeditioners exposed to minimal natural sunlight. Ocular light exposure is the primary environmental time cue for synchronising the circadian pacemaker and rhythms of sleep-wake, alertness and performance. Differences in exposure to light can cause variability in the alignment of the circadian pacemaker with the timing of sleep and may result in sleep disruption, and impaired performance and safety. The aim of this study was to assess sleep, circadian phase, cognitive functioning and psychological health in expeditioners overwintering in Antarctica. Fifty-one expeditioners (10F, aged  $45.6 \pm 11.9$  years) stationed at three Australian Antarctic bases (Davis, Mawson and Casey) completed data collection during a six-month winter season from March to September, over two winters. Participants completed daily sleep diaries and monthly computer-based performance tests and questionnaires examining psychological health and wellbeing. They also completed 48-hour urine sample collections each month for assessment of the melatonin metabolite 6-sulphatoxymelatonin (aMT6s) rhythm as a marker of circadian phase. While the average subjective sleep duration was  $7.2 \pm 1.5$  hours ( $n = 6469$  sleep episodes), expeditioners obtained less than 7 hours of sleep on 41.2% of nights and less than 6 hours sleep on 19.1% of nights. Considerable variability in circadian phase was evident with the peak (acrophase) of the rhythm of aMT6s ranging from 10.7 hours prior to wake time to up to 8.4 hours after wake time ( $n = 2009$  days). Thirty four expeditioners had some of their sleep episodes occur at an abnormal circadian phase, accounting for 18.8% (295/1565) of sleep episodes. When sleep occurred out of phase, expeditioners obtained significantly less sleep on average ( $6.36 \pm 1.19$  h sleep), compared to sleeping in phase ( $7.17 \pm 0.95$  h) ( $t(33) = 4.151$ ,  $p < 0.0001$ ). This research highlights the prevalence of misalignment between the timing of sleep and the circadian pacemaker in expeditioners during an Antarctic winter. The results demonstrate that sleep is more impaired when misaligned with the circadian pacemaker and Antarctic expeditioners are obtaining 1-2 hours less sleep than the recommended duration. The study confirms laboratory-based research demonstrating the importance of circadian phase and demonstrates a need to provide appropriate interventions to promote circadian alignment in long-duration missions.

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## ***Behavioural health and performance in extreme environments: thinking beyond the individual before we think beyond the planet***

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Purpose: Existing research regarding human adaptation and performance within Antarctica has primarily focused on individual-level factors, with acknowledgement of the influence of interpersonal dynamics on station. Although acknowledged anecdotally, the influence of interactions with individuals outside the polar environment has not been extensively documented. Similarly, the period of deployment has dominated investigations of human adaptation and performance largely to the exclusion of other phases of the employment experience. To remedy these issues, the current study examined the interrelationships between individual, relationship, and organisational-level factors that influence human adaptation to the Antarctic environment from pre-departure through post-return. Results: Expeditioner adaptation was influenced most by experiences within the pre-departure and post-return phases of the employment experience, which spanned individual, interpersonal, and organisational domains. Conclusion: Human behavioural health and performance in Antarctica is influenced by individual, relationship and organisational factors across all phases of their employment experience. All of these need to be considered in facilitating optimal adaptation to extreme environments, and have implications for manning of space missions.

# ***Psychological adaptation of Indians during prolonged residence in Antarctica***

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Psychological adaptation of Indians during prolonged residence in Antarctica

## **Abstract**

**Background:** Antarctica is considered to be a natural laboratory to study the psychological and physiological adaptation of human beings in extreme conditions of prolonged isolation and extreme environmental conditions, where it is almost impossible for an ill-equipped individual to survive. In view of the growing human activities in Antarctica and increasing exposure of humans to prolonged isolation under extreme conditions, like space travel and deep sea diving, it is necessary to study the psychological adaptation to such an environment. The current study aims to study the psychological adaptation of Indian expeditioners to prolonged residence in Antarctica.

**Methods:** Twenty four winter team members of 27th Indian Science Expedition to Antarctica were administered seven instruments five times over a period of one year during the expedition. The instruments measured cognition and memory, general psychological health and tobacco and alcohol consumption. Informed consent was taken from each member of the expedition, and confidentiality of responses was ensured. The expedition members were all volunteers selected by an interview followed by detailed medical and psychological examination and comprised of scientific and logistics staff. The study was carried out on board the expedition vessel, MV Emerald Sea and at the Indian Antarctic station, Maitri. Maitri is located at 70°45'S, 11°44'E on a 17 X 3 sq km area of exposed rock called Schirmacher Oasis about 100 km inland from the Princess Astrid coast of East Antarctica at an altitude of about 100m above sea level.

**Results:** Alcohol consumption was maximum during the initial days of arrival on the continent and decreased thereafter, with another spike during the peak of the winter season. Externalized psychological reactions peaked during the mid winter period. Anxiety and insomnia peaked during the coldest period, whereas depressive symptoms did not change throughout the expedition. Cognition was at its worst during the final phase of Antarctic residence.

**Conclusion:** Each phase of Antarctic residence could be equated with a particular stage in psychological adaptation. Third quarter phenomenon was not noted in the current study.

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## ***A meta-analytic examination of the third-quarter phenomenon***

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Antarctica is considered one of the most extreme and isolated environments on earth and recognized as placing those who inhabit it outside the optimal physical, social and psychological parameters for survival (Norris, Paton & Ayton, 2010). Existing research and expedition reports have acknowledged the impact of stressors experienced during deployment as contributing to a psychological response known as the third-quarter phenomenon. The third-quarter phenomenon is characterised by seasonal fluctuations in mood and psychosomatic complaints, as well as cognitive and physical deficits and interpersonal tension. Although a majority of personnel only experience mild symptoms associated with the third quarter phenomenon, approximately 5% of winter over personnel experiencing symptoms meeting diagnostic criteria according to the DSM and warranting clinical intervention (Palinkas et al., 1995). Any identified psychological symptoms, irrespective of severity, should be considered noteworthy due to the Antarctica's extreme and isolated conditions. Despite symptoms associated with the third quarter phenomenon being consistently documented in almost all polar expeditions since the early 1900's, there is substantial and unequivocal debate surrounding the parameters and impact of the third quarter phenomenon. To date no research has investigated the third quarter phenomenon across pre-existing empirical evidence in attempt to reach a consensus. Accordingly, the aim of the present study is to elucidate the parameters surrounding the third quarter phenomenon utilising a meta-analysis to summarise qualitative and quantitative empirical evidence. This research will broaden the understanding of the psychological effects individuals employed in Antarctica experience. Furthermore, it will assist personnel management to predict when employees will most likely experience difficulties in coping and to assist in the mitigation of the adverse impacts associated with the third quarter phenomenon.

## ***Sleep on ice: How can we improve "polar insomnia"? Results of bright light exposure and melatonin supplementation.***

**Nathalie Pattyn**<sup>1,2</sup>, Xavier Neyt<sup>1</sup>, Helio Fernandez-Tellez<sup>1,2</sup>, Emilie Dessy<sup>1,3</sup>, Martine Van Puyvelde<sup>1</sup>, Bart Roelands<sup>2</sup>, Romain Meeusen<sup>2</sup>, Eoin MacDonald-Nethercott<sup>1</sup>, Greig Lawson<sup>6</sup>, Igor Mekjavic<sup>4</sup>, Aisha Cortoos<sup>1,5</sup>, Olivier Mairesse<sup>1,3,7</sup>

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Sleep complaints are consistently cited as the most prominent health problem in Arctic and Antarctic expeditions. Whereas the precise mechanisms underlying these disturbances are still not elucidated, several areas of research have pointed in the direction of possible causes. Firstly, chronobiology studies suggest disturbances in melatonin secretion, that might be associated with sleep disturbances. Secondly, mood disturbances are known to interact with sleep problems, both as cause and effect. With regard to Antarctic sojourns, several clusters of symptoms have been suggested to have an association with sleep disorders, such as a) the polar T3 syndrome, which mimics subclinical hypothyroidism; b) the winter-over syndrome, a term coined to describe the association of mood and sleep disturbances; or, c) a sub-syndromal seasonal affective disorder. Lastly, the lack of physical activity and the sensory deprivation due to long-duration isolation and confinement have been hypothesized to be a potential detrimental influence to sleep.

As the fundamental research into these sleep mechanisms is still a work in progress, more applied investigations are necessary to attempt to increase health and well-being of deployed personnel. The current presentation will summarize the findings of our experiments investigating potential interventions with regard to improving sleep quality. The choice of interventions was guided by the existing hypotheses with regard to sleep disturbances. We ran several experiments testing the effect of:

- A regular exercise schedule tailored to individual preferences.
- Melatonin (slow release, 2 mg, nightly) supplementation during the summer season (hence the period of constant daylight).
- Standardized bright light exposure with wearable devices (1 hour exposure after getting up, standard wavelength) during the winter season (hence the period of constant darkness).

The experiments were conducted at Concordia station and Halley VI station, both at 75°S, and thus experiencing the same duration of constant daylight in summer and constant darkness in winter. Sleep was assessed through polysomnography, and parallel evaluations of mood, physical activity and circadian hormones (melatonin and cortisol) were conducted.

Analysis of results is still ongoing, for the melatonin and the bright light exposure, however, results of the effect of regular exercise showed:

- A strong correlation between sleep efficiency and the quantification of physical activity.
- A detrimental effect of exercise on sleep when at altitude (Concordia station), where the exercise load enhanced the sleep disturbing effects of chronic hypobaric hypoxia in terms of respiration.

The results of the three interventions will be presented and discussed, as well as the potential operational implications for personnel deployment.

## ***Tracking long-term team dynamics in the Antarctic***

**Daisy Chang**<sup>1</sup>, Steve Kozlowski<sup>1</sup>, Jessica Santoro<sup>1</sup>, Jeffrey Olenick<sup>1</sup>, Aurora Dixon<sup>1</sup>, Jeff Ayton<sup>2</sup>  
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### OVERVIEW

In our continued research on teams living in isolated, confined, and extreme (ICE) environments, we collected data from teams of scientists and technicians operating at remote stations in the Antarctic. Our data collection focused on benchmarking team processes and understanding how these team processes fluctuate on a day-to-day basis in order to inform long-duration space flight crews on the importance of team processes in influencing healthy team functioning. The Antarctic is an optimal environment in which to study team processes in ICE conditions as station members are exposed to harsh weather conditions and must live in the same location for months at a time with many of the same station members. Here, participants engage in a variety of tasks including science research, extra-vehicular activities on the ice, and maintaining living quarters.

### METHOD AND RESULTS

Participants were asked to fill out a daily report survey at the end of each day of their Antarctic deployment. The daily report survey asked questions about team performance, cohesion, conflict, conflict management, and negative and positive affect. In addition, station members provided open-ended responses which provided evidence that fluctuations in these variables were often tied to daily events.

After three years of collecting information on how team processes fluctuate over time, responses from each year of data collection were averaged across stations to create five graphs depicting season changes in team processes. The team process variables examined were: performance, cohesion, social conflict, task conflict, and conflict management. In addition to averaging over responses from all stations in a given data collection year, the year of data collection was removed from the graphs below to ensure anonymity.

Across all three years of data collection, responses show that performance is the most consistent team process variable. Perceptions of performance fall near the end of a season, but overall, participants feel that performance is generally high on average. Perceptions of team cohesion differ across seasons, particularly for one season which showed substantially lower levels of team cohesion than the other two seasons. Social and task conflict trends provide more information about the reasons as to why perceptions of team cohesion differ across the seasons. In a similar vein, participants began to engage in conflict management more often after the first month of being in the Antarctic. After this first month, participants across all three years report managing conflict about the same on average with some variability occurring approximately 75% of the way through the season.

### CONCLUSIONS

The comparisons of team processes over time show that many of the differences in team processes across seasons occur in cohesion, conflict, and conflict management. Thus, the presentation will discuss the implications of fluctuations in team processes for teams in ICE environments, explanations as to why differences were seen across seasons, and possible interventions to positively impact team functioning in the future.

## **S36. Antarctic education, outreach and training D2, Meeting Room 408, August 23, 2016, 3:30 PM - 6:00 PM**

### ***#SCAR2014 - What happens at the SCAR OSC doesn't stay at the SCAR OSC!***

**Renuka Badhe**<sup>1</sup>

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Clear and near-live communication of science has never been more important. Researchers now widely use social media platforms to engage with each other and with the public. Effective use of such available social media options ensures increased interaction both within the community and with a wider audience. The 2014 Open Science Conference (OSC) at Auckland, saw the first concerted use of social media within the SCAR OSCs. Presented here is the first analysis of the social media outreach from the 2014 OSC. Metrics will be presented mainly using the hashtag #SCAR2014, from several social media platforms. Social media is sometimes considered superfluous, something that distracts from real-time events, discussions, and "real science". Presenting metrics and helping recognise social media's success in communicating near-realtime scientific discussions can help alleviate such feelings. With the total number of impressions just over 700,000, and organic reach of over 150,000 the #SCAR2014 social media campaign can certainly be considered successful. That success came with several months of planning and co-ordination, and over the period of the OSC, issues dealt with and lessons learnt in real time. The social media tools available and most favoured by the general public can change in the fast paced interconnected world, however, the advice contained herein should remain useful for those interested in developing social media strategies for conferences and workshops.

## ***Science communication at the bottom of the world: Adventures in the Ross Sea, Antarctica***

**Cassandra Brooks<sup>1</sup>**

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My Antarctic research experiences are a great privilege and I've always felt compelled to share them with the world. What started as long, descriptive emails to my family and friends has turned into blogging for education and conservation non-profits and most recently for National Geographic. Despite years of writing, photographing and publishing multi-media, I failed to capture the essence of Antarctica in all its austere beauty, until perhaps my 2013 trip to the Ross Sea. During the 52 days I was at sea, in between long hours of sampling, I would race to the bridge at the top of the ship. I would brace myself for the extreme wind and cold, then step outside and scale the narrow and icy railing to affix my camera to the front of the vessel. In the end, I condensed more than 30 hours of footage into a five-minute timelapse, added narration and music and released it into the world. The video went viral overnight, and reached every corner of the world by the end of the week. In the news coverage that followed, a CNN feature stressed that, "Many scientists now believe the Ross Sea is the last untouched marine ecosystem in the world. If Brooks' stunning video is anything to go by, it's also one worth protecting."

My talk will explore the various methods I've utilized in communicating Antarctic science to the public, elaborating on those, like the time-lapse, that I found to be the most powerful and effective. I'll share tips and tools regarding gear and software as well as how to connect with media outlets to publish finished work. I'll discuss how to frame a story for a particular audience. I'll also pose greater questions of the risk, rewards and responsibilities of science communication.

## ***Chromatic biodiversity: engaging through Information Design***

**Skye Moret**<sup>1</sup>, Paul North<sup>2</sup>

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How do we explore new and creative ways of portraying complex marine ecosystems, particularly regarding places that most people will never see? In an effort to engage a broad audience with this theme and create energy and synergy in fields beyond the Antarctic context, we exploited opportunities inherent in visual information design: color, contrast, and motion.

To capture the diversity of life above and below the sea surface, we used iconic photographs to extract and compare color pixels from each image in a vertical bar. Given an array of 100 bars, the juxtaposition of color and intensity exposes our assumptions of a 'colorless' Antarctica and reveals a surprising realm below, one that tends to be neglected in popular dialogue about a quickly warming Antarctic Peninsula. This visualization of biodiversity was produced in both static and interactive forms for use in a variety of didactic and aesthetic contexts.

By simplifying and identifying a visualization method that anyone can relate to, we can inspire curiosity about and access to a diversity of scientific concepts. A cultural consistency of these 'bridge objects' encourages further intrigue and even stimulates a latent sense of Antarctic stewardship. We assessed the efficacy and influence of the chromatic biodiversity piece both through its proliferation in social media and honor of a scientific visualization award, and with a qualitative approach that illuminated visual and cognitive aspects to consider for future projects.

Visual literacy increases daily. On every continent there is need for design that challenges traditional knowledge models and encourages human engagement and transdisciplinary dialogue with relevant scientific ideas. Encouraging and expanding Information Design within the Antarctic context will incite broader cultural cognizance, keeping discourse about the continent afloat amidst the current barrage of media. New modes of Antarctic dialogue and engagement, particularly those that harness data-driven design and storytelling, will only increase in scientific, cultural, and political value within the context of rising socio-environmental concerns about polar regions.



## ***Digital outreach: Crossing borders online with the Association of Polar Early Career Scientists (APECS)***

**Hanne Nielsen**<sup>1,2</sup>, Alexander Thornton<sup>2,4</sup>, Gerlis Fugmann<sup>2,3</sup>

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When used effectively, online media can be a powerful tool for stimulating STEAM (Science, Technology, Engineering, Art, and Mathematics) communication and knowledge transfer. This is especially true when the target demographic are “digital natives.” For many present-day Early Career Researchers (ECRs), the digital environment of the Internet is as familiar as the physical world in which they have grown up. This creates opportunities for easier dissemination of ideas, and for valuable interdisciplinary team building and outreach across geographical borders. Education and outreach are key strands of the Association of Polar Early Career Scientists (APECS). APECS seeks to promote and coordinate effective communication across various spheres: between members; between polar researchers in various disciplines and career stages; and between researchers and the wider public. In recent years, much of this communication has been facilitated by effective use of digital technologies.

APECS coordinates a range of online-based polar outreach activities. This paper outlines the tools available for such outreach, such as Twitter, Facebook, video-based webinars, Reddit question-and-answer forums, online conferences, and website platforms. Case studies of APECS’ online outreach activities highlight the strengths of digital outreach in a real-world context. Collating and analysing details about elements such as content, message reach, and interactions amongst participants provides valuable information. Such analysis can reveal both the sorts of questions being asked of polar researchers today (i.e. major areas of public interest), and what this tells us about greater comprehension of STEAM concepts (e.g. common misconceptions). It can also indicate the most effective forms of engagement with the current generation of “digital natives.” We provide advice to other researchers, communicators, and educators on how to best incorporate online and digital elements into their own outreach programmes, and offer suggestions for maximising participation in future online events for all involved.

# ***'Effectively communicating Antarctic science to a global audience'***

**Nicholas O'Flaherty<sup>1</sup>**

<sup>1</sup>*The Antarctic Report, Auckland, New Zealand*

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## Introduction:

We built and launched The Antarctic Report in 2015 (AntarticReport.com), a news and information portal on Antarctica and the Southern Ocean, as a result of our involvement with Antarctic science at the SCAR OSC in 2014. We were appointed, as a digital communications agency by the Royal Society of New Zealand to project manage the communications for the SCAR Open Science Conference and the ICSU General Assembly in Auckland 2014. It was from this that the idea came about for The Antarctic Report.

In late 2015, we began outreach on social media channels, starting with Twitter (@AntarcticReport), reaching 1,800 followers within eight weeks. Twitter has allowed us to interact with many scientists and operations personnel communicating from the ice this summer, sharing content and extending their reach. We have also attracted a wide group of followers among Antarctic science-related universities and media outlets around the world.

## Purpose of paper

Showcase some of the more outstanding examples of science communicators on social media from Antarctica this summer, as well as those communicating their research findings on social media from around the world.

## Results

The results are mixed: some scientists use best practice in social media communications, while others could benefit from including appropriate digital imagery, knowing their audience, explaining importance and relevance of research, identifying their respective institutions

## Conclusions

Provide a set of guidelines and case studies that highlight:

- ¥ Best practice for scientists on attracting and engaging readers on social media channel
- ¥ The dos and don'ts' of tweeting snackable' content
- ¥ Know your audience; meet their expectations for a professional science communicator
- ¥ Writing digestible content about seemingly complicated science
- ¥ Profiling the top 20 communicators on social media from Antarctica this summer; Twitter, Facebook and blogs
- ¥ Best use of digital imagery
- ¥ Top 20 science topics related to Antarctica and the Southern Ocean; where the interest lies
- ¥ Gaining insights from Google Analytics and traffic data
- ¥ Incorporating effective search strategies into content creation
- ¥ Building your audience; engaging with influencers and advocates

## ***Antarctica Online: Engaging learners in an interdisciplinary online conversation about Antarctica***

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In 2015, Victoria University of Wellington (VUW), with the support of Antarctica New Zealand, launched a fully online, interactive, interdisciplinary, six-week course about Antarctica. The not-for-credit course cost NZ\$120 (US\$80) and was offered to interested “lifelong learners” around the world. The first pilot offering was advertised by email and social media and attracted 57 students from New Zealand, Australia, Germany, Brazil, UK, South Africa, Spain, USA and Canada. These students had a wide range of experience, from school students to retired people, science lecturers to directors of companies, and included several people who had either been to, or will be going to, Antarctica, or had other Antarctic connections.

Antarctica Online featured innovative, field-based video lectures from Antarctica and the SCAR Open Science Conference (2014). These were supported by online readings and a vast array of supplementary online resources. In 2016, the course was expanded to 12-weeks (with modules on history, geology & paleoclimate, climate change, policy, arts and communication), and was offered to both lifelong learners and to third-year undergraduate students for credit.

Antarctica Online is hosted by Antarctic experts from VUW and features guest lectures from artists, policymakers and scientists, offering a truly interdisciplinary teaching programme. Given the severely limited opportunities to take students to Antarctica, the inclusion of lectures filmed on the ice gives students an authentic, yet remote, experience and insight into this unique environment. Inclusion of interviews with SCAR OSC 2014 delegates illustrates the diversity of Antarctic scholarship and breadth of activity internationally that supports Antarctic research.

In Antarctica Online, learners are encouraged to think about the wider scientific, historical, political, social and cultural context of Antarctic field research and to examine the different ways that scientists, policymakers, programme operators, journalists and artists engage with Antarctic science and the Antarctic continent. Using Open Education, an open learning platform designed to provide an accessible and flexible learning environment, students communicate with each other (and the teaching staff) through blogs and a discussion board, which provide the opportunity for ongoing interaction and stimulating conversations. Student feedback for the first offering of the course was overwhelmingly positive, specifically focusing on the immersive experience of “being in Antarctica” with us.

This presentation will include excerpts from video lectures filmed in Antarctica during the 2014/15 field season and discussion of the course development. We invite colleagues from the Antarctic community to discuss the possibility of partnering with us by offering online teaching modules on their specialist area of expertise and helping to create an international, interdisciplinary, teaching tool accessible to students in formal education and lifelong learners from around the world.

## ***Antarctica Day: A platform for schools' participation in polar science***

**David Walton**<sup>1</sup>, Julia Berkman<sup>2</sup>, Allen Pope<sup>3</sup>, Tun Yan Young<sup>4</sup>

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After the Antarctic Treaty Summit in 2009, a new charity– Our Spaces – was established in the UK to develop its educational legacy. Using the designation of the 1 December anniversary of the Treaty's signing as –Antarctica Day,” Our Spaces has established a focus for educators who wish to include aspects of Antarctica in their schools' curricula.

The initial activity aimed to reach students in schools around the world. This was accomplished through outreach networks of Association of Polar Early Career Scientists (APECS), PolarTREC, International Polar Foundation, and Polar Educators International, as well as colleagues in the Antarctic and educational communities. The key for uptake was to provide a simple downloadable 'power point' and one-page exercise (translated into multiple languages) that teachers could present without previous knowledge of Antarctica and complete in a single class. Soliciting the students to produce innovative Antarctic flag designs allowed Our Spaces to organise the despatch of their work to Antarctica with the benefits of photos of them displayed and a certificate. All of this added to the students awareness of Antarctica, the research stations and the scientific work.

Antarctica Day has built increasing interest and participation amongst primary schools from over 30 countries in understanding the key elements of the Antarctic Treaty, including polar science, peace, and co-operation – which students have illustrated through flag designs, books, and exhibits. Our Spaces has recently provided (with the assistance of APECS) a web-based booklet in 15 languages for teachers to use. The Antarctic flag-making activity has connected students ages 5-16 with the researchers who have displayed their flags in Antarctica. The schools have had a chance to liaise with their paired researcher and learn more about their research within the broader context of polar science. The presentation will look at how this approach could be expanded in the future to carry an increasing and expanded STEM content.

## ***From a water drop to the global oceanic circulation - From teaching to creativity***

**Emmanuelle Sultan**<sup>1</sup>

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In the framework of the IPY the MNHN has conducted an ambitious Education and outreach program "Mers Australes" . Teachers and scientists were able to work together on this project with the mediation of devoted teacher settled at the MNHN for a couple of years. In this paper only the education and outreach work regarding the global circulation will be presented. This work was based on a research focus on the dense water formation around Antarctica and its cascade. Between 2007 and 2008 some educational materials had been realised and deployed at different level in schools and high schools. After this intense periode those activities had been conducted for a larger public. This paper will present the evolution of those activities during the years pointing out the success and the failures. This work has inspired a new way of transmitting science that involve many other type of intelligence.

## ***Mixing Music with Antarctic Science: How DJ Spooky communicates scientific messages from the far south to audiences around the globe***

**Carolyn Philpott<sup>1</sup>**

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The purpose of this paper is to explore the projection of scientific ideas and information in the Antarctic-inspired music and performances of Paul D. Miller (also known as DJ Spooky that Subliminal Kid). Based in New York City, Miller is an internationally renowned composer, writer and experimental hip-hop musician. His music draws on a range of influences, including from the visual arts and the natural environment, and he travels extensively in order to perform and to draw creative inspiration for his compositions. He has visited both Antarctica (2007/2008) and the Arctic (2014) and has created a range of musical and multimedia works in response to his experiences of the ice and encounters with scientists working in these regions. In 2014, he was named one of National Geographic's Emerging Explorers in recognition of his role as a leader in raising global awareness of pressing environmental and social concerns to a variety of audiences.

When performing his Antarctic-inspired compositions, Miller typically combines samples of field recordings from the ice with electronic sounds based on patterns derived from scientific data to create listening experiences for audiences that are accessible, engaging and loaded with extra-musical meaning. For example, his seventy-minute multimedia performance work 'Terra Nova: Sinfonia Antarctica' (2008) combines scientific, historical and geographical visual material with music he composed for string quartet based on algorithms of Antarctica's weather and temperature patterns. Over the top of the string quartet music, he layers data-driven electronic sounds and samples of field recordings of ice to provide audiences with an acoustic portrait of the frozen continent. Through such works, he aims to prompt listeners to think deeply about the environmental changes taking place in Antarctica and how these changes have affected, and are continuing to affect, the rest of the world. Miller disseminates his music and ideas through a range of media, from CDs to concerts and from hardcopy books to the internet. In doing so, he is able to reach a very large and broad audience, and challenge listeners around the world to engage with Antarctic science and in debates relating to climate change.

The new research to be presented in this paper draws upon musicological approaches – including score and sound-recording analyses and interviews with the composer – to examine how Miller communicates scientific messages from Antarctica to audiences worldwide. In particular, it will focus on 'Terra Nova: Sinfonia Antarctica', exploring how Miller's performances of this work can inform and educate audiences about important environmental issues affecting and/or influenced by Antarctica. This research will enable greater understanding of Miller's Antarctic-related and ecologically informed work, and will also contribute to the broader discourse on innovative methods for conveying scientific ideas and information to diverse audiences.

**Mini Symposium : Connecting the biological and the physical:  
Environmental drivers of biodiversity in Antarctica, Ballroom 1,  
August 25, 2016, 9:00 AM - 11:00 AM**

***Biodiversity promoted by geothermal processes in Antarctica: Life in volcanic ice caves and on warm soils***

**Ceridwen Fraser<sup>1</sup>**

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Geothermal regions are hypothesised to have supported diverse life in Antarctica throughout past glacial periods. The hypothesis has received support from initial investigations; for example, a recent continent-wide spatial analysis of species richness patterns showed that, for plants and fungi, diversity was highest closest to geothermal areas, and decreased with distance, suggesting populations near geothermal areas were older than those further away. By which mechanisms do geothermal areas promote relatively high levels of biodiversity in Antarctica? For example, do species survive on exposed, warm volcanic soils, or under the ice in geothermal caves? I will present findings from two new studies on volcanic sites. In the first, metabarcoding DNA analysis of soil samples from Mount Erebus was used to assess whether eukaryotic plants and animals occur in subglacial caves formed by volcanic steam. In the second, population genetic analyses were used to assess whether genetic diversity within terrestrial species is higher on warmer versus cooler soils of volcanic Deception Island, in the South Shetland Island group. The exciting results of both studies shed light on the ways in which volcanoes help structure biodiversity in Antarctica, and how they might have provided refugia for terrestrial organisms through past ice ages.

## ***A coastal ecosystem on the move: 25 years of multidisciplinary studies in Potter Cove***

**Irene Schloss**<sup>1</sup>, Doris Abele<sup>4</sup>

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Over 25 years of continuous climatological, hydrographic and ecological studies in Potter Cove (PC), a coastal fjord of King George/25 de Mayo Island (South Shetlands Islands) in the highly dynamic Northern WAP region are revealing a major ecosystem shift. Marine coastal ecosystem observations started in the early 90s and are continuing within consecutive multidisciplinary projects, involving participation of multinational science teams from Argentina, Germany and other European and American countries. Central observation packages include changes of sea ice and glacial mass balance, continuous oceanographic recordings, and timeline observations of pelagic and benthic community composition. Recently experimental studies and spatial system analysis have been intensified, to understand the impact of glacial melting and surface water warming in different sectors of the cove. Southern ocean climate cycles (ENSO, SAM) influence the pelagic and benthic ecosystems of the fjord by changing regional climatic conditions (air temperature, wind speed, wind direction) and the meltwater volume released by the rapidly receding Fourcade glacier during each summer season. The pelagic system has undergone a shift from a bottom up control of light and stratification (climate) to top down control by differential micro- and mesozooplankton grazing on bloom forming microalgae under fluctuating conditions (climate and glacial melt impact). Several of these factors are directly related to the regional and local (PC) trends in sea ice coverage. Uncoupling from grazing leads to intense phytoplankton blooms observed since 2010. On the seafloor, macroalgae are colonizing newly ice free areas forming new habitats for epiphytic species and increasing the detritus formation. Enhanced macroalgal and phytoplankton deposition on the seafloor affects organic matter turnover in surface sediments and alter infauna community composition in the inner cove. Epibenthic macrofauna communities are in transition from filter feeder dominated to mixed communities in the glacier proximal zone, with sediment deposition from glacial erosion acting as a major shaping factor. Ascidians, molluscs, pennatulids and sea urchins are dominant in glacial proximal areas. Spatial modeling is employed to integrate benthic community structure with glacial retreat history, i.e. bathymetric structures, sediment composition and biogeochemical characteristics of the seafloor. A general and several partial (provincial) food webs have been established for PC. These indicate a stable community with high connectivity and short food chains (highest (weighted) trophic level of 4.2). Notothenioids and amphipods are the main mobile species and most highly connected within the web, without being key species, as several alternative pathways coexist. Timeline observations of multilevel changes and interactions in PC allow for modeling the transition from the past to the present system status, and to make ecological forecasting of future change scenarios. Furthermore, our studies contribute to the understanding of the links between the coastal systems of the WAP and surrounding areas of the Southern Ocean.



## ***Surface productivity influences Antarctic seafloor biodiversity***

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Most seafloor communities below 200m water depth rely on food that sinks through the water-column. However, the nature and strength of coupling between surface and seafloor, termed benthic-pelagic coupling, and its influence on the structure and diversity of seafloor communities remains unclear, especially in Antarctica where ecological data are sparse. Here we show that the strength of benthic-pelagic coupling in East Antarctica depends on physical processes and especially the types of benthic organisms considered.

In a novel approach, we used a particle tracking model, informed by remotely sensed surface productivity and combined with a regional oceanographic model to quantify the flux of food to the seafloor in the George V shelf area in East Antarctica. We optimised the particle tracking model-parameters by the statistical fit of the resulting particle distribution to data from sediment cores. The prevailing currents have only little influence in changing the spatial patterns food-abundance during the fast (200m/day) sinking to the seafloor. However, fluctuating seabed currents inhibit particles from permanently settling in certain areas on the banks while other areas in the basins experience increased sedimentation rates.

Analysing data from towed still cameras we found the abundance and diversity of benthic filter feeders, but not other benthic groups, correlates strongly with the estimate of horizontal flux of food particles above the seafloor, enabling spatial predictions of seafloor biodiversity over vast regions of Antarctica.

## ***Antarctic Entomology***

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The Antarctic region comprises the continent, the maritime Antarctic, the sub-Antarctic islands, and the southern cold temperate islands. Continental Antarctica is devoid of insects, but elsewhere diversity varies from two to more than 200 species, of which flies and beetles constitute the majority. Much is known about the drivers of this diversity at local and regional scales, with current climate and glacial history playing important roles. Investigations of responses to low temperatures, dry conditions and varying salinity have spanned the ecological to the genomic, revealing new insights about how insects respond to stressful conditions. Biological invasions are common across much of the region and are expected to increase as climates become warmer. The drivers of invasion likelihood are reasonably well understood, though less is known about the realized impacts of invasion. Antarctic entomology has advanced considerably over the past 50 years, but key drivers, such as interspecific interactions, remain underexplored.

## ***Macrobenthic assemblages and their drivers along steep gradients in the natural environment and in climate change at the Antarctic Peninsula***

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It is generally a challenge to identify ecological drivers of Southern Ocean macrobenthic communities. Reasons are a lack of a unifying concept, the complexity of ecological relationships and the biological diversity. A catch-based macrobenthos study and a sea-bed imaging survey on ascidians were carried out off the tip of the Antarctic Peninsula, an area with above-average steep gradients in the natural environment and in climate-induced changes. The multidisciplinary analyses showed faunistic large-scale differences between the sub-areas in the Drake Passage, Bransfield Strait and western Weddell Sea. They can partially be explained by differences in sea-ice, primary production, water depth, water masses and bottom rugosity. No correlation was found between the benthic communities, as well as ascidians, and their habitats defined by bottom topography, such as bank, slope and canyon. A possible reason might be high between-station heterogeneity. High small-scale variability in ascidian composition analysed along photographic transects indicate that maybe unknown biological factors might mask existing intermediate-scale physical and chemical drivers.

## ***Decadal variability phytoplankton community composition in the coastal waters of a warming West Antarctic Peninsula***

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The coastal waters of the West Antarctic Peninsula (WAP) are associated with large phytoplankton blooms dominated by large (>20 microns) diatoms however, nanoplankton (<20 microns) are also an important component in the phytoplankton community. The dominant nanoflagellate in the WAP appear to be cryptomonad algae. Using a twenty-year time series collected by the Palmer Long Term Ecological Research (Pal LTER) program at the United States Palmer Research Station, we assessed long-term patterns and stability in the coastal phytoplankton communities in the WAP. There was significant interannual variability in the integrated water column chlorophyll a (chl-a) concentrations, which varied by a factor of 5 over the 20-year time series. Within the time series the dominant phytoplankton taxa were diatoms, with the second most abundant phytoplankton taxa present being cryptophytes. Peak biomass was observed in summer months mirroring declines in the seasonal monthly average wind speed. Cryptophytes were most abundant in the summer months of December and January after the seasonal retreat of sea ice. While diatoms were observed over the full range of observed salinities (34.5 to 32) as well as over the full range of in situ temperatures (-1.5 to 2.5° C), the cryptophyte populations were observed in lower salinity (33.75 to 32.5) and colder water (-1 to 1° C). Time series showed that during years when environmental factors favor water column stability, there are larger summer diatom blooms that resulted in high krill recruitment, consistent with the classic Antarctic paradigm of a short diatom-krill-top predator food chain. In lower phytoplankton biomass summers a larger proportion of the overall chl-a was associated with cryptophytes. Consistent with modeling studies this has significant ecological and biogeochemical implications, especially for the West Antarctic Peninsula, which is the experiencing the most rapid winter warming on Earth over the last fifty years.

## ***Evolution and environmental change in the transantarctic mountains***

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The ice-free features of the Transantarctic Mountains (TAM) are ideal for addressing questions about the evolution and ecology of TAM terrestrial ecosystems and how they have responded (in terms of biodiversity and ecosystem functioning) to glacial recession since the LGM: 1) They provide an excellent, accessible archive of geological legacies and past and current climate variability at local to regional scales. 2) They provide an incredible natural experiment for testing hypotheses about how terrestrial ecosystems have evolved since the LGM. 3) Substantial evidence indicates that the community structure and functioning of the ice-free soils of the TAM are correlated almost exclusively with geophysical parameters, and are not obscured by complex biological interactions. 4) These are among the least human-modified terrestrial ecosystems on earth, enabling accurate interpretation of patterns of genetic diversification or dispersal. 5) These simple terrestrial ecosystems allow soil communities to be surveyed in unprecedented detail, to an extent not feasible in more species-rich ecosystems. 6) Lastly, there is a sense of urgency: Antarctic terrestrial ecosystems have changed very little since the LGM, but it is anticipated that this stability will not last much longer and warming is expected to accelerate with the amelioration of the ozone hole.

To understand how ecological communities respond to climate change it is important to understand how they responded during and after the LGM. We have initiated a research program that utilizes the attributes of the TAM outlined above to ask fundamental questions about the ecology and evolution of soil ecosystems in the TAM, including: Could high elevation soil ecosystems have served as refugia for soil biota through the Pleistocene? How have Antarctica's terrestrial biota responded to climate-driven changes since the Last Glacial Maximum (LGM)? As the outlet glaciers of the TAM receded, how were contemporary terrestrial ecosystems restructured? What biotic and abiotic drivers were responsible for observed differences in contemporary biodiversity, ecosystem structure, and functioning?

## **S01. Antarctica in a global system - drivers and responses, Meeting Room 408, August 25, 2016, 11:30 AM - 1:30 PM**

### ***An atmospheric origin of the multi-decadal bipolar seesaw***

**Zhaomin Wang**<sup>1</sup>, Xiangdong Zhang<sup>2</sup>, Zhaoyong Guan<sup>1</sup>, Bo Sun<sup>3</sup>, Xin Yang<sup>4</sup>, Chengyan Liu<sup>1</sup>  
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A prominent feature of recent climatic change is the strong Arctic surface warming that is contemporaneous with broad cooling over much of Antarctica and the Southern Ocean. Longer global surface temperature observations suggest that this contrasting pole-to-pole change could be a manifestation of a multi-decadal interhemispheric or bipolar seesaw pattern, which is well correlated with the North Atlantic sea surface temperature variability, and thus generally hypothesized to originate from Atlantic meridional overturning circulation oscillations. Here, we show that there is an atmospheric origin for this seesaw pattern. The results indicate that the Southern Ocean surface cooling (warming) associated with the seesaw pattern is attributable to the strengthening (weakening) of the Southern Hemisphere westerlies, which can be traced to Northern Hemisphere and tropical tropospheric warming (cooling). Antarctic ozone depletion has been suggested to be an important driving force behind the recently observed increase in the Southern Hemisphere's summer westerly winds; our results imply that Northern Hemisphere and tropical warming may have played a triggering role at a stage earlier than the first detectable Antarctic ozone depletion, and enhanced Antarctic ozone depletion through decreasing the lower stratospheric temperature.

## ***Extended comparison of the connection between Australian drought and snow accumulation at Law Dome***

**Tas van Ommen**<sup>1,2</sup>, Jason Roberts<sup>1,2</sup>, Tessa Vance<sup>2</sup>, Andrew Moy<sup>1,2</sup>, Christopher Plummer<sup>2,3</sup>, Mark Curran<sup>1,2</sup>, Sam Poynter<sup>2</sup>

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Comparison of meteorological records and ice core snowfall data from Law Dome, Antarctica, have previously revealed a teleconnection with drought in southwest Western Australia (van Ommen and Morgan, 2010). Here we extend the comparison period using more recent ice core data (Roberts et al., 2015) that provides a significantly longer overlap with meteorological reanalysis data, bringing the record to AD2012. While the longer comparison confirms the earlier findings, the most recent portion of the record shows a weakened teleconnection that points to the existence of other drivers. This extended analysis also indicates that the recent multi-decadal anomaly, which commenced in 1970 (and which corresponds with a drought period in Western Australia) is the third largest such event in two millennia.

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## ***Antarctic sea ice and southern hemisphere meteorological field climatic forecast***

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Since 2001, we have been forecasting the climatic fields of the Antarctic sea ice (SI) fields and surface air temperature, surface pressure and precipitation anomalies for the Southern Hemisphere at the Meteorological Department of the Argentine Naval Hydrographic Service. Sea Ice forecast are used principally to prepare Navy Summer campaigns to Antarctica but the atmospheric forecasts are used to make the monthly forecast three months ahead. Forecast is based on the results of S-Mode Principal Components Analysis applied on SI series that gives patterns of temporal series with validity areas. These series are important to determine which areas in Antarctica will have positive or negative SI anomalies based on what happen in the atmosphere. On the other hand, T-Mode Principal Components Analysis applied on SI fields gives us the form of the SI fields anomalies based on a classification of 16 patterns. Each pattern has unique atmospheric fields associated to them. Therefore, it is possible to forecast whichever atmosphere variable we decide for the Southern Hemisphere. When the forecast is obtained, each pattern has a probability of occurrence and sometimes it is necessary to compose more than one of them to obtain the final result. S-Mode and T-Mode are monthly updated with new data, for that reason the forecasts improved with the increase of cases since 2001. We used the Monthly Polar Gridded Sea Ice Concentrations database derived from satellite information generated by NASA Team algorithm provided monthly by the National Snow and Ice Data Center of USA that begins in November 1978.

Recently, we have been experimenting with multilayer Perceptron (neuronal network) with supervised learning and a back-propagation algorithm to improve the forecast. The Perceptron is the most common Artificial Neural Network topology dedicated to image pattern recognition. It was implemented through the use of temperature and pressure anomalies field images that were associated with a group of sea ice anomaly patterns. The variables analyzed included only composites of surface air temperature and pressure anomalies to simplify the density of input data and avoid a non-converging solution. The obtained results are encouraging.



## ***Sensitivity of the Amundsen Sea low and associated regional sea ice trends to atmospheric forcing in the AO-UMUKCA model***

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The Amundsen Sea Low (ASL) is a quasi-stationary area of climatological low pressure that exists over the South Pacific sector of the Southern Ocean between the Antarctic Peninsula and the Ross Sea.

The ASL variability has been linked to the out of phase relationship between Sea Ice Extent (SIE) trends in the Ross sea (increasing) and the Bellingshausen sea (decreasing).

Some studies have shown that teleconnections from the tropical Atlantic SSTs caused strengthening of the ASL, while other studies linked it to the tropical Pacific. Studies also previously suggested the deepening was a response to stratospheric ozone depletion.

Here we use a version of the fully coupled AO-UKCA model with interactive stratospheric chemistry to understand the Amundsen Sea Low variability under two different atmospheric forcing scenarios and subsequently sea ice trends in the Amundsen-Bellingshausen seas. We use output from two simulations, a Pre-Industrial (PI) control integration forced with 1850s climate, and a time slice integration forced with 2000s climate (TS2000).

The TS2000 simulation shows a similar annual cycle in SIE compared to that of the PI, but with reduced year to year variability. No net significant trend in Sea ice Concentration (SIC) is observed over the 100 year TS2000 simulation, but there is a decadal variability with contrasting regional trends connected to atmospheric circulation patterns such as the SAM, PSA, and ZW3. The ASL correlation with SIC is closely matched to the ZW3 correlation pattern particularly in TS2000.

We also show that changes in MSLP are linked to variability in both the Atlantic and Pacific Ocean, however, the correlation with the Atlantic Ocean becomes significant only under the 2000 climate scenario.

## ***The effect of exopolymeric substances on iron limited phytoplankton assemblages from the Southern Ocean***

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Exopolymeric substances (EPS) were shown to enhance iron solubility and its bioavailability to Southern Ocean phytoplankton cultures. However, the response of iron-limited natural assemblages has never been tested. Here, we will present results from two sea-going expeditions where the impact of bacterial EPS was investigated on phytoplankton growth and biodiversity following a 4-5 day incubation. Iron bioavailability and chemistry was determined from 24hincubation. . Data showed similar impacts of bacterial EPS observed in both the laboratory and in natural assemblages from the Sub-Antarctic Zone east of Australia, suggesting that EPS are critical for enhancing iron bioavailability and supporting phytoplankton growth in iron-limited areas. To verify the widespread importance of EPS with respect to Fe limitation, this hypothesis will also be tested during an expedition in early 2016 in the Drake Passage as well as the West Antarctic Peninsula. Our results will be discussed in the framework of iron limitation across the Southern Ocean and its consequences for carbon fixation and export.

## ***Seasonal impacts of ozone depletion on Antarctic Sea Ice***

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We study the impact of ozone depletion on the climate of the Antarctic and Southern Ocean using an ensemble of simulations with a coupled GCM, in which the ozone climatology is abruptly switched on day 1 from pre-industrial to late 20th century values.

The model reproduces the usual poleward jet shift in during summer (DJF). The annual-mean sea ice response shows an increase during the first years, followed by a decreasing trend. In addition, there is a strong seasonal signal, with an increase of sea-ice extent in the growing season (fall), but a decrease in spring. There are also some regional differences.

These results are interpreted by considering two competing mechanisms for the impact of the anomalous summer westerlies on the oceanic circulation : the surface cooling by heat fluxes and Ekman transport, and the sub-surface warming by upwelling of deeper water. These mechanisms can have different time-scales, and seem also active at different times of the year.

## **S03. Sustained efforts for observing, mapping and understanding the Southern Ocean and its role in current and future climate, Meeting Room 404, August 25, 2016, 11:30 AM - 1:30 PM**

### ***Implementing the southern ocean observing system***

**Oscar Schofield**<sup>1</sup>, Louise Newman<sup>2</sup>, Anna Wahlin<sup>3</sup>, Andrew Constable<sup>4</sup>, Sebastiaan Swart<sup>5</sup>, Phillippa Bricher<sup>6</sup>

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The Southern Ocean is fundamental to the operation of the Earth system, as it plays a central role in global climate and planetary-scale biogeochemical cycles. The Southern Ocean is changing rapidly, and the critical need to observe and understand the Southern Ocean is well established; however, the harsh conditions and remote location have led to it being the most under-sampled region of the world. Sustained observations are required to detect, interpret, and respond to the physical, chemical, and biological changes that are, and will continue to be measured. The Southern Ocean Observing System (SOOS) is an international initiative with the mission to integrate the global assets and efforts of the international community to enhance data collection, provide access to datasets, and guide the development of strategic-sustained-multidisciplinary science in the Southern Ocean. This presentation will provide an update on SOOS implementation activities, key products and tools, and data management efforts.

## ***Polynya control of ocean exchange at the front of an ice shelf***

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Observations from a mooring deployed 7 km from the front of the Ross Ice Shelf on its western side have found seasonal reversals in the ocean current that ventilate the cavity under the ice shelf. The five year mooring record observed southward flow near Ross Island into the cavity under the Ross Ice Shelf in summer. In winter the flow is northwest out of the Ross Ice Shelf cavity, the same direction as the annual mean flow. In a Regional Ocean Modeling System (ROMS) climatological simulation of the Ross Sea we find the same behaviour in the ocean currents in the broad region of the Ross Ice Shelf Front where mass exchange occurs between the continental shelf and the ice shelf cavity. Further investigation of the ROMS simulation shows the seasonal current reversals are driven by the air-sea fluxes in the Ross Sea Polynya through changes in the water column structure. Salt rejection from winter ice formation in the polynya leads to the formation of a column of dense High Salinity Shelf Water, associated with which is a local depression in the sea surface height. This depression drives a strong cyclonic barotropic mode in the ocean that dominates the local currents. In summer, warming and melting sea ice increase the stratification in the water column and raise the sea surface height, thus reducing the influence of the barotropic ocean mode. The stratification in the water column drives a baroclinic mode which in front of the Ross Ice Shelf reverses the current direction. This is the first reported dependence on a polynya for the seasonal ventilation of an ice shelf cavity, and we expand our analysis to discuss this possibility for other ice shelves, so we can determine if this is a Ross Sea specific mechanism, or if polynyas have a wider role in seasonally controlling the cross ice front exchange.

## ***Southern Ocean deep convection in climate models: a driver for variability of sub-polar gyres and Drake transport on decadal timescales***

**Erik Behrens**<sup>1</sup>, Graham Rickard<sup>1</sup>, Olaf Morgenstern<sup>1</sup>, Torge Martin<sup>2</sup>, Annette Osprey<sup>3</sup>, Manoj Joshi<sup>4,5</sup>  
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We investigate decadal variability and co-variability of Southern Ocean state variables such as the strength of Ross and Weddell Gyres, Drake Passage transport, and sea-ice area using the National Institute of Water and Atmospheric Research UK Chemistry and Aerosols (NIWA-UKCA) model and CMIP5 model output. Additional variability in these variables is stimulated by strong deep reaching convective events in the Southern Ocean. The deep convection results in the formation of a dense water mass in the models which is comparable to Antarctic Bottom Water and its variability. Thus, deep convection affects the large-scale meridional density structure in the Southern Ocean. An increase in the (near) surface stratification, due to freshwater perturbations, can be a pre-condition for subsequent strong convection activity. Enhanced gyre driven sea-ice export and sub surface heat accumulation, leads to a phase shift in freshwater and heat content, and weaken the stratification such that the subsurface heat can be released to the atmosphere by sudden strong mixing events. We find that strong convection reduces the sea-ice cover, weakens the subpolar gyres, increases the meridional density gradient, and subsequently results in a positive Drake Passage transport anomaly. Results of CMIP5 models confirm that variability in sea-ice, Drake Passage transport and, the Weddell Gyre is enhanced if models show strong open ocean convective events. Connections between convection, sea-ice and Drake Passage transport variability are independent if models host open-ocean convection. They are dependent for relations between convection and the strength of Ross and Weddell Gyre.

## ***What does the sea level budget of the Campbell Plateau tell us about the Southern Ocean?***

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Using Campbell Plateau as a case study we examine why changes in Sea Surface Height (SSH) can only be explained by both understanding the thermal expansion and ocean mass contributions to sea level rise. A scenario that contrasts with the global approach of neglecting ocean mass changes because thermal expansion usually dominates changes in global sea level. Campbell Plateau is an extension of the New Zealand continental shelf that intrudes ~1000 km into the Southern Ocean and is mostly shallower than 1000m. It is a natural barrier to the Antarctic Circumpolar Current (ACC) and its geographical configuration makes the ocean on Campbell Plateau a key area to investigate the interaction between subpolar and subtropical waters. In the last two decades the SSH on Campbell Plateau has shown an increase in sea level of 5.2 cm decade<sup>-1</sup>. However seasonal cycles of SSH, steric height and ocean mass on Campbell Plateau show that both steric height and ocean mass are needed to compute a sea level budget that is consistent with SSH observations. Analysis of seasonal variability suggests that this behaviour is also expected in the long term trends. Here will use Campbell Plateau to explain the contribution of the different components to the sea level changes, the potential forcing mechanisms of the SSH trend and the relationship of the ocean on Campbell Plateau with the surrounding open ocean. With this understanding of the interplay of steric height changes and ocean mass in the SSH trend we assess if this is a local phenomenon or it has a role in understanding SSH changes in other parts of the Southern Ocean.

## ***Twisted Transformation - Circulation and interaction of water masses in the Weddell Sea***

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The Antarctic Bottom Water (AABW), which ventilates most of the deepest basins of the world ocean, has shown widespread warming in recent decades that contributes inter alia to the global thermohaline sea level rise. More than half of the AABW is supplied by outflow from the Weddell Sea where it attains its characteristics, in particular its high density, by heat loss of its source water masses to the atmosphere and to the fringing ice shelves and by influx of locally formed water masses such as the high-salinity shelf water shaped by brine release from freezing sea ice. Dense shelf waters cascade down the continental slope along the southern and western rim of the Weddell Sea, mix with the modified source waters and thus replenish the Weddell Sea Bottom (WSBW) and Deep Water (WSDW), precursor of the AABW. The major source water mass, hence conduit of heat for the interior Weddell Sea, is the Circumpolar Deep Water (CDW) advected from the Antarctic Circumpolar Current (ACC) with the southward oriented eastern limb of the Weddell Gyre. During its advection, the CDW is sucked upward by divergence in the large-scale mean wind-field to about 200 m in the central Weddell Sea, where it is termed Warm Deep Water (WDW).

Progress in the understanding of this twisted transformation of water masses is obtained from a combination of three different observational approaches. First, a gridded data set of upper-ocean hydrographic properties in the Weddell Gyre derived by objective mapping of under-ice Argo float profiles; this data set reveals for instance the WDW inflow, its transport with the Weddell Gyre, and the erosion of its core thermohaline properties during circulation. Second, multi-annual time series obtained from repeat deep CTD stations, which demonstrate a significant, approximate linear warming trend in the Weddell Sea deep water masses below 700 m depth of roughly 2 mK per annum during the past 25 years. Third, long-term mooring records of velocity and temperature in the Weddell outflow regime on the northwestern continental slope, which reveal sizable intra-seasonal and seasonal fluctuations in the WSBW plume, and a hardly significant multi-annual trend which indicates rather a cooling than a warming and therefore differs from the significant warming seen in the deep waters of the Weddell interior.



## ***Effects of bathymetry and sea ice on heat content on west Antarctic Peninsula shelf and Rothera Time Series***

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Four seasons of ocean glider deployments across the west Antarctic Peninsula shelf have revealed significant overflows across bathymetric sills (over three hundred metre vertical displacement) on the route modified Circumpolar Deep Water (mCDW) takes across the shelf towards our time series site at Rothera. These overflows cause mixing and entrainment extending well above the sill, to depths less than 200m. This is therefore a route for deep heat to mix upwards and surface variability driven by sea ice changes to propagate downwards, as well as blocking the densest water completely.

Deep mixing and heat loss, exceeding 1°C in winter between 100m and 175m, are repeatedly observed in the upper 200m in the Rothera Time Series (RaTS; Ryder Bay, off Adelaide Island, 67° 36' S, 500m deep) in low sea ice winters (especially 1998 and 2007). The propagation of surface-driven changes to deep water can affect the heat available to melt ice at a wide range of depths.

Persistence of the reduced stratification into the following summer leads to both cooling and warming at RaTS between 40m and 90m. The cooling is in winter as a direct response to being in contact with the ice-free surface due to increased wind-driven mixing. The warming is in summer as the reduced stratification from the winter mixing persists and preconditions the system to a greater extent of vertical mixing, for the same wind stress. Surface warming is therefore mixed down further, with the increased heat uptake exceeding the wintertime heat loss, leading to a warming relative to high ice years and a positive feedback for reduced ice cover. At shallower depths there is a warming through the year, significant in late summer/early autumn.

As well as observing significant overflows across sills the glider data has also revealed two deep enclosed depressions south of Adelaide Island filled with cold thermocline water as mCDW is blocked. One of these was well mapped by swath data while the other was found by chance and appears to have two sections. By contrast Palmer Deep is flooded by temperature maximum water from mCDW and is thus warmer at depth than its source water. These areas provide qualitatively different benthic environments, important for current biogeographical studies as well as understanding of past conditions and interpretation of benthic paleo records. In a glacially carved environment, sills and enclosed depressions are a common feature of the shelf and it is clear they can have significant physical and biological effects.

## ***Access of warm Southern Ocean water along the East Antarctic Margin – results from the NBP1503 cruise***

**Frank O. Nitsche**<sup>1</sup>, Raul Guerrero<sup>2</sup>, Guy Williams<sup>3,5</sup>, David Porter<sup>1</sup>, Eva Cougnon<sup>3,5</sup>, Alexander D. Fraser<sup>3,5</sup>, Ricardo Correia<sup>4</sup>, Dominique Richardson<sup>6</sup>

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The future of the Antarctic Ice Sheet is one of the critical questions in assessing the effects of climate change. The East Antarctic Ice Sheet (EAIS), long regarded as relatively stable in mass balance, has recently become the subject of a series of studies to determine if it might be susceptible to warm ocean melting. We are presenting new oceanographic and bathymetry observations from the East Antarctic continental margin between 115° E and 135° E that have been collected as part of the scientific cruise NBP1503 onboard the NB Palmer in early 2015. We collected detailed multibeam bathymetry and Conductivity-Temperature-Depth (CTD) data from the continental slope, rise and the outer shelf north of the Dibble Glacier, Frost Glacier, Dalton Iceberg Tongue and Totten Glacier. An oceanographic section of 19 CTD stations on the continental slope parallel to the margin shows that modified Circumpolar Deep Water (mCDW) with higher salinity and temperatures is present near the shelf break over large sections of the investigated margin, but is absent in other sections. The shelf break depth varies significantly along the margin with values between ~300 and ~500 m. The shallower depths are potentially an obstacle for access of mCDW to the shelf. As a result, a ~100 m thick layer of mCDW resides on the ~500 m deep outer shelf north of the Totten Glacier, but there is no indication of mCDW in the Dibble Polynya because the shelf break is shallower. The access and presence of warmer mCDW water, especially north of Totten Glacier and the Moscow University Ice Shelf, has important implications in understanding the observed thinning of these ice shelves and streams.

## **S09. Status and trends in Antarctic sea ice and ice shelves (Sec 1), Meeting Room 405, August 25, 2016, 11:30 AM - 1:30 PM**

### ***Long-term observing system for the oceanic regime of Antarctic Ice Shelves - the Filchner-Ronne Ice Shelf***

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Long term observations of the flow of dense waters from their area of formation to the abyss of the World Ocean, and the return flow of warm waters, are central to climate research. For the Weddell Sea an important component of such a system entails monitoring the formation of High Salinity Shelf Water (HSSW) on the continental shelf north of Ronne Ice Front, the transformation to Ice Shelf Water (ISW) beneath the floating Filchner-Ronne ice shelf, and the flux of ISW overflowing the shelf break to the deep Weddell Sea. Equally important is the return flow of warm water toward the Filchner-Ronne Ice Shelf system.

We operate a number of monitoring stations in the southern Weddell Sea. The systems build upon techniques and methods developed over several decades and have a proven record of high data return. Here we present plans for extending, integrating and operating the existing long term observatories to increase our knowledge of the natural variability of the ocean-ice shelf system, and to allow early identification of possible changes of regional or global importance.

The S2 observatory at the Filchner sill was established in 1977 and continues to deliver the longest existing marine time series from Antarctica. As a key site for monitoring the ISW overflow. The existing S2 observatory consists of sub-surface mooring carrying sensors for current velocity, temperature, salinity and dissolved oxygen measurements.

Site 5 at the Ronne Ice Shelf was first established in 1999 and in 2014/15 austral summer the site was reoccupied and three instrumented moorings for long term monitoring of the circulation beneath Ronne Ice Shelf were deployed. In addition, three phase sensitive radars (ApRES) were deployed at the snow surface to monitor the melting/freezing rate at the ice shelf base. Some of the systems transmit in real-time and are designed to operate for more than 10 years. In 2015/16 we extend the observing network by deploying observatories on Filchner Ice Shelf.

The Filchner-Ronne Ice Shelf and S2 observatories will provide the first ever concurrent observations from the ice-shelf cavity where ISW is formed, and the sill where it starts its descent towards the deep Weddell Sea, and will provide a unique dataset allowing us to link processes and variability within the cavity directly to overflow properties and deep water formation.

## ***Basal ice and ice-ocean exchange under the McMurdo Ice Shelf***

**Britney Schmidt**<sup>1</sup>, Catherine Walker<sup>1</sup>, Luke Winslow<sup>2</sup>, Justin Lawrence<sup>1</sup>, Peter Doran<sup>3</sup>, Jacob Buffo<sup>1</sup>, Stacy Kim<sup>4</sup>, Mark Skidmore<sup>5</sup>, William Stone<sup>7</sup>, Krista Soderlund<sup>6</sup>, Jamin Greenbaum<sup>6</sup>, Donald Blankenship<sup>6</sup>, Nathan Bramall<sup>8</sup>, Frank Rack<sup>9</sup>, Andrew Johnson<sup>10</sup>, The The SIMPLE Field Team<sup>1</sup>

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Over the 2012, 2014 and 2015 austral summer Antarctic field seasons, the NASA-funded SIMPLE project (Sub-Ice Marine and Planetary-analog Ecosystems), spent a total of 8 months characterizing ice and ocean exchange processes below the McMurdo Ice Shelf (MIS), a small portion of the larger Ross Ice Shelf easily accessible from USAP's McMurdo Station. The program supported the development of the Deep-SCINI and ARTEMIS vehicles, and used two other vehicles, SCINI and Icefin as well. We have collected imaging and sonar data of the ice, conductivity and temperature profiles of the water column, water samples at the interface for geochemical and biological characterization, and several other complementary in situ measurements. In 2012 the team explored at a single location 5 km back from the front of the ice shelf using the small ROV SCINI (Moss Landing). Here we observed ablation of the ice and a heterogeneous water column, consistent with melting by fast-moving currents. Both imaging data and the CTD profiles are consistent with this conclusion. In 2014, SIMPLE utilized SCINI and a new AUV/ROV vehicle, Icefin (Georgia Tech), to characterize five hot-water-drilled sites below the MIS. These locations ranged between 10 and 20 km from the shelf front. At each site, we observed very different ice conditions from that in 2012. Uniformly, large amounts of platelet ice were observed, regardless of ice-shelf thickness. The layer of platelets was between 1 and several meters thick depending on the site, and ranged between uniform in character to regions with large platelet spears and columns. At a site near Black Island, we observed the possible formation of a solid layer of platelet ice, physically separated from the bottom of the shelf by a thin water lens, at the base of which was newer forming platelet ice. We observed homogeneous water column below the ice, consistent with the formation of platelet ice. We also observed a complex community of organisms at the sea floor under this permanent ice cover. During 2015, the team used the ARTEMIS (SAS) vehicle developed under the project to perform ~1km transects under the shelf from a camp located on multi-year ice at the sea ice-ice shelf transition almost due North of Pegasus field and one of the 2014 sites. Here, we observed a thin layer of platelets across the shelf, and observed nearly four meters of platelet ice growth under the multi-year ice over the course of August through November. We collected high-resolution data of the sea ice-ice shelf transition as well as nearly daily CTD casts over November and early December to pair with the vehicle data. We will describe the project and results, including imaging, CTD and preliminary mapping of the basal ice below the MIS and its relationship with ocean conditions.

## ***Ice core reconstruction of sea ice change in the Amundsen-Ross Seas since 1702 AD***

**Elizabeth Thomas**<sup>1</sup>, Nerilie Abram<sup>2</sup>

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Antarctic Sea ice has been increasing in recent decades but there are strong regional differences. Declining sea ice extent in the Bellingshausen Sea since 1979 has been linked to the observed warming on the Antarctic Peninsula, while the Ross Sea sector has seen a marked increase in sea ice extent during this period. Here we present a 308-year record of methansulphonic acid (MSA) from the Ferrigno ice core in a coastal West Antarctica. MSA at this site is demonstrated to be a robust proxy for winter sea ice extent (SIE) in the Amundsen-Ross Sea. We demonstrate that the recent increase in sea ice in this region is part of a longer trend, with an estimated  $\sim 1^\circ$  northward expansion in SIE during the 20th century and a total expansion of  $\sim 1.3^\circ$  since 1702. The greatest SIE (inferred from MSA) occurred during the mid-1990s, with five of the past 30 years considered exceptional in the context of the past 300 years.

## ***Snow depth on Antarctic sea ice derived from autonomous measurements***

**Marcel Nicolaus**<sup>1</sup>, Stefanie Arndt<sup>1</sup>, Stefan Hendricks<sup>1</sup>, Georg Heygster<sup>2</sup>, Mario Hoppmann<sup>1</sup>, Marcus Huntemann<sup>1,2</sup>, Christian Katlein<sup>1</sup>, Danielle Langevin<sup>3</sup>, Leonard Rossmann<sup>1</sup>, Sandra Schwegmann<sup>1</sup>  
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The snow cover on sea ice received more and more attention in recent sea ice studies and model simulations, because its physical properties dominate many sea ice and upper ocean processes. In particular; the temporal and spatial distribution of snow depth is of crucial importance for the energy and mass budgets of sea ice, as well as for the interaction with the atmosphere and the oceanic freshwater budget. Snow depth is also a crucial parameter for sea ice thickness retrieval algorithms from satellite altimetry data. Recent time series of Arctic sea ice volume only use monthly snow depth climatology, which cannot take into account annual changes of the snow depth and its properties. For Antarctic sea ice, no such climatology is available. With a few exceptions, snow depth on sea ice is determined from manual in-situ measurements with very limited coverage of space and time. Hence the need for more consistent observational data sets of snow depth on sea ice is frequently highlighted.

Here, we present time series measurements of snow depths on Antarctic sea ice, recorded by an innovative and affordable platform. This Snow Buoy is optimized to autonomously monitor the evolution of snow depth on sea ice and will allow new insights into its seasonality. In addition, the instruments report air temperature and atmospheric pressure directly into different international networks, e.g. the Global Telecommunication System (GTS). We introduce the Snow Buoy concept together with technical specifications and results on data quality, reliability, and performance of the units. We highlight the findings from four buoys, which simultaneously drifted through the Weddell Sea for more than 1.5 years, revealing unique information on characteristic regional and seasonal differences.

## ***Enhanced calculations of ocean surface buoyancy flux in Antarctic polynyas.***

**Igor Appel<sup>1</sup>**

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The meridional overturning circulation (MOC) – a system of so-called conveyor belts of currents in the global ocean - transfers energy between latitudinal zones and different depths including surface, deep, and bottom flows. The formation of deep and bottom water takes place in high latitudes: the Labrador and Nordic Seas in the Northern Hemisphere and around Antarctica.

Formation of the Antarctic Bottom Water flowing northward at large depth presents an important component of the global thermohaline circulation and is to a large degree a direct result of the wintertime sea ice production in Antarctic polynyas. Strong cold winds from Antarctica move newly formed ice northward creating leads and consistently exposing open water to sea ice production. Salt rejected from ice increases salinity of sea water making it denser. This dense water descends to deep ocean layers forming the Antarctic Bottom Water.

Sea ice growth in polynyas leading to the formation of the abyssal deep waters modifies ocean properties, influences global ocean circulation and therefore needs to be reliably estimated for both ocean and cryosphere studies. The development of an improved theoretical model to calculate thin ice growth is critically important to estimate heat exchange between ocean and the atmosphere and the formation of deep water.

The proposed model includes two novel principal modifications showing significant promise to better quality of calculations. Surface temperature is defined as an internal model parameter maintaining the consistency between processes of the atmosphere-ice thermodynamic interaction and ice growth. The snow depth on ice is defined as a function of a local snowfall rate. Because snow accumulation on ice influences the temperature of upper snow surface it works as a negative feedback modifying surface temperature and suppressing the influence of uncertainty in snow depth on the quality of modeled ice thickness for the period of ice growth.

The applicability of enhanced methodology to retrieve ice thickness and buoyancy flux from satellite observations is also included into consideration. The improved account for the influence of surface temperature and snow depth increases the accuracy of ice thickness and buoyancy flux calculations and is used to develop analytical Snow Depth / Ice Thickness Look Up Table for infrared satellite observations.

Developed analytical solution of the equation determining growth of thin sea ice simplifies the task of integrating ice production and ocean surface buoyancy flux across the polynyas eliminating the need of gridded calculations, interpolation and other additional data handlings.

The salinity of newly formed ice depends on the thickness of growing ice and on the rate of thickness increase because ice salinity is formed by the combination of two opposite processes: trapping and release of brine during ice growth processes. Currently further efforts are focused on a better account for ice salinity and conductivity as well as specific heat of ice formation, the factors significantly influencing estimates of ocean surface buoyancy flux.

## ***Long-term coastal-polynya dynamics in the southern Weddell Sea from MODIS thermal-infrared imagery***

Stephan Paul<sup>1,2</sup>, Sascha Willmes<sup>1</sup>, **Günther Heinemann**<sup>1</sup>

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Accurate determination of Antarctic polynya characteristics, especially the amount of sea ice that is produced in coastal polynyas is of high research interest. Coastal-polynyas in the Antarctic Weddell Sea are important hot spots for new-ice and deep-water formation as well as for the release of heat and moisture into the atmosphere. Based upon MODIS thermal-infrared satellite imagery in combination with ERA-Interim atmospheric reanalysis data, long-term polynya characteristics (2002-2014; 1 April to 30 September) in the Antarctic southern Weddell Sea were derived. The advanced capabilities of MODIS by means of spatial resolution to resolve even very narrow coastal polynyas is a major advantage over established passive-microwave approaches. The main disadvantage of MODIS, the sensors' inability to retrieve surface information through cloud cover and the deficiencies of the MODIS cloud mask during polar nighttime are circumvented by a new gap-filling approach. This approach uses the temporal and spatial persistence of polynyas in contrast to mobile cloud patterns to derive information on cloud-covered areas based on information of the surrounding clear-sky days, weighted in proportion to their temporal proximity to the center day. Of the six investigated subregions, the results of average wintertime polynya area and accumulated wintertime ice production reveal the sea-ice areas in front of the Ronne Ice Shelf and the Brunt Ice Shelf to be the most active with an average wintertime polynya area of  $3018 \pm 1298 \text{ km}^2$  and  $3516 \pm 1420 \text{ km}^2$ , as well as an accumulated wintertime volume ice production of  $31 \pm 13 \text{ km}^3$  and  $31 \pm 12 \text{ km}^3$ , respectively. In case of the other four regions, estimates amount to  $421 \pm 294 \text{ km}^2$  and  $4 \pm 3 \text{ km}^3$  (Antarctic Peninsula),  $1148 \pm 432 \text{ km}^2$  and  $12 \pm 5 \text{ km}^3$  (Iceberg A23A),  $901 \pm 703 \text{ km}^2$  and  $10 \pm 8 \text{ km}^3$  (Filchner Ice Shelf) as well as  $499 \pm 277 \text{ km}^2$  and  $5 \pm 2 \text{ km}^3$  (Coats Land). However, these results also indicate that the less active regions, in terms of their total contribution to sea-ice production and deep-water formation, should not be neglected.



## ***Sea-level response to abrupt ocean warming of Antarctic ice shelves***

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Antarctica's contribution to global sea-level rise increases steadily. A fundamental question remains whether the ice discharge will lead to marine ice sheet instability (MISI) and collapse of certain sectors of the ice sheet or whether ice loss will increase linearly with the warming trends. Therefore, we employ a newly developed ice sheet model of the Antarctic ice sheet, called f.ETISh (fast Elementary Thermomechanical Ice Sheet model) to simulate ice sheet response to abrupt perturbations in ocean and atmospheric temperature.

The f.ETISh model is a vertically integrated hybrid (SSA/SIA) ice sheet model including ice shelves. Although vertically integrated, thermomechanical coupling is ensured through a simplified representation of ice sheet thermodynamics based on an analytical solution of the vertical temperature profile, including strain heating and horizontal advection. The marine boundary is represented by a flux condition either coherent with power-law basal sliding (Pollard & Deconto (2012) based on Schoof (2007)) or according to Coulomb basal friction (Tsai et al., 2015), both taking into account ice-shelf buttressing. Model initialization is based on optimization of the basal friction field. Besides the traditional MISIP tests, new tests with respect to MISI in plan-view models have been devised.

The model is forced with stepwise ocean and atmosphere temperature perturbations. The former is based on a parametrised sub-shelf melt (limited to ice shelves), while the latter is based on present-day mass balance/surface temperature and corrected for elevation changes. Surface melting is introduced using a PDD model. Results show a general linear response in mass loss to ocean warming. Nonlinear response due to MISI occurs under specific conditions and is highly sensitive to the basal conditions near the grounding line, governed by both the initial conditions and the basal sliding/deformation model. The Coulomb friction model leads to significantly higher sensitivity compared to power-law sliding. On longer time scales, West-antarctic inter-basin connections favour nonlinear response.

# ***A data set on Snow Depth on Antarctic Sea Ice 2002-2015: Climatology and Comparison with Reference Data Sets***

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The high albedo and low heat conductivity (about one magnitude smaller than that of sea ice [Massom et al., 2001]) of snow on sea ice strongly influence polar radiative processes and heat transfer. Consequently snow properties are an important input parameter to correctly quantify heat (and also water) transfer in the ocean-sea ice-atmosphere interaction in climate studies and in data assimilation in global climate and numerical weather prediction models. Furthermore, accurate snow depth data are required to retrieve sea ice thickness from altimeter freeboard measurements. Because Antarctic in-situ measurements are only sparsely available and clouds and missing daylight limit usage of optical and infrared satellite sensors, passive microwave sensors on satellites offer the only possibility to continuously retrieve snow depth on Antarctic scale. However, in the Antarctic specific processes (flooding, melting and refreezing) cause highly variable snow properties. These together with ice ridges make snow depth retrieval particularly difficult and as a consequence often the accuracy of the retrieved snow depth is not known.

The first algorithm for large scale retrieval of snow depth on sea ice was introduced by Markus and Cavalieri in 1998 for SSM/I (Special Sensor Microwave Imager) and later adapted to AMSR-E (Advanced Microwave Scanning Radiometer for EOS) data by conversion of AMSR-E brightness temperatures to SSM/I equivalent brightness temperatures [Comiso et al., 2003, Brucker and Markus, 2013]. Here we report on a further modification of this empirical snow-depth retrieval algorithm which was carried out in the frame of the ESA Sea Ice Climate Change Initiative (SICCI) project. The most important aspects of the modification are the derivation of the empirical equations used in the algorithm directly from AMSR-E brightness temperatures and the computation of snow depth retrieval uncertainties.

To improve this situation, in the frame of the ESA Sea Ice Climate Change Initiative SICCI project, the existing snow depth products from the standard NSIDC AMSR-E [Cavalieri et al., 2014] and Cryosphere Science Research Portal SSM/I [Cryosphere Science Research Portal] retrieval are compared with visual ship-based observations from an extended ASPeCt data set [Worby and Allison, 1999, Worby et al., 2008] on a monthly basis and by Antarctic sectors. By comparing the AMSR-E vertically polarised brightness temperature gradient ratio of the 18.7 and 36.5 GHz channels with ASPeCt snow depth observations, the algorithm is re-evaluated and adapted to be directly applicable to AMSR-E and AMSR2 brightness temperatures. In addition, for the first time an uncertainty estimation based on Gaussian error propagation is included, allowing to distinguish uncertainties resulting from those in the input parameters and those arising from the limitations of the algorithm itself. Emphasis will be put on the validation with independent reference data sets such as buoy and in-situ measurements. A data set for the years 2002-2015 is presented together with a physical analysis of monthly average snow depths.

## **S15. Solar-terrestrial physics in the polar regions, Meeting Room 410, August 25, 2016, 11:30 AM - 1:30 PM**

### ***Gravity waves observations at Ferraz station during 2014 and 2015***

José Valentin Bageston<sup>1</sup>, Cristiano Max Wrasse<sup>2</sup>, Delano Gobbi<sup>2</sup>, Hisao Takahashi<sup>2</sup>, **Takuji Nakamura**<sup>3</sup>  
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Mesospheric gravity waves were observed at Ferraz Antarctic Station (62.1°S, 58.4°W) in the last two years (2014-2015) by optical techniques at the Mesosphere layer. Mesospheric winds at these seasons were not available at the same site and for now, the intrinsic wave parameters were not determined. So, we will present the observed airglow data, its statistics of observations, examples of image data and the observed parameters for all the observed waves. The observed waves parameters for small scale waves fits with previous observations, that is, horizontal wavelength between 20 and 40 km, period mainly between 10 and 20 minutes and observed velocities running from tens m/s up to about 100 m/s. Besides these results, we will present few results for middle scale gravity waves by using the keogram analysis technique. Also, photographic data of sky's horizon until about 55° off zenith were obtained by a popular photographic camera in order to try to see noctilucent clouds (NLCs) at this latitude since than previous sporadic data revealed the occurrence of this phenomena. Data of the last southern hemisphere summer are under analysis and we will present the preliminary results by using photographic camera data to identify gravity waves signatures in the visible noctilucent clouds.

## ***Space weather and polar surface temperature variability - an atmospheric interconnection with energetic particle processes in the magnetosphere.***

**Mark Clilverd**<sup>1</sup>, Annika Seppala<sup>3</sup>, Craig Rodger<sup>2</sup>, Pekka Verronen<sup>3</sup>, Monika Andersson<sup>3</sup>

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In this talk I will present results from a UK-Finland-New Zealand collaboration to examine tropospheric polar temperature variations during years with different levels of geomagnetic activity. Previous modelling work has suggested that Odd Nitrogen (NO<sub>x</sub>) produced at high latitudes by energetic particle precipitation can eventually lead to detectable changes in surface air temperatures (SATs). Using operational surface level air temperature data sets from 1957 to 2006 it has been shown that during winter months, polar SATs in years with high geomagnetic activity are different than in years with low geomagnetic activity; the differences are statistically significant at the 2-sigma level and range up to about +4.5 K depending on location. The temperature differences are larger when years with wintertime Sudden Stratospheric Warmings (SSW) are excluded than when the SSWs occurrence years are included in the analysis. The vertical coupling between the high altitude chemical changes and surface temperature variability is driven by energetic particle precipitation as a result of wave-particle interactions taking place in the Earth's Van Allen radiation belts. Work is continuing to understand a) the space weather processes taking place, b) the resultant energy input into the atmosphere, c) the implications for chemical changes at altitudes of 50-100 km, and d) how high altitude perturbations occurring in the polar atmosphere can link to climate variability in the troposphere. Progress in each of these areas will be discussed.

## ***Hemispheric asymmetries in the global aurora***

**Karl M. Laundal**<sup>1</sup>, Nikolai Østgaard<sup>1</sup>, Jone P. Reistad<sup>1</sup>, Paul Tenfjord<sup>1</sup>, Kristian Snekvik<sup>1</sup>  
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Global satellite images of the UV aurora in the two hemispheres show that substorms can appear significantly differently in the two hemispheres. Observations of substorm onsets, the localized brightening signaling the start of the expansion phase, can appear shifted in magnetic local time. This shift depends strongly on the orientation of the IMF and the dipole tilt angle, and implies that there is an induced magnetic field component in the GSM y direction in the magnetosphere. During the expansion phase, the auroral ovals contract as magnetic flux closes. While the same amount of flux closes in the two hemispheres, the contraction can appear at different places in the two hemispheres, leading to large differences in the morphology of the polar caps. Simultaneously, large differences in the intensity of the aurora can appear. While observations of such events are sparse, it seems that the asymmetries are linked to differences in ionospheric conductivity due to sunlight, and to the orientation of the IMF. The differences related to sunlight can be explained as differences in the ionospheric response to the rapid changes in magnetospheric geometry. Since the ionospheric response feeds back to the magnetosphere, it implicitly affects the opposite hemisphere.

## ***Rethinking the Polar Cap: ULF asymmetry at the highest geomagnetic latitudes***

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Using a unique high-latitude magnetometer network configuration in Antarctica, the day-to-day, longer-term, and statistical features of broadband Pc5-6 ULF activity at polar cap latitudes is presented. Over a 63-day relatively quiet interval in early 2001, it is shown that there is both a day-to-day and a statistical asymmetry between two ground sites (AGO5 and AGO6) at about 86=deg corrected geomagnetic [CGM] latitude, separated 12 hours in magnetic local time [MLT]. Comparing the near-CGM-pole ULF activity from the two sites with concurrent activity at cusp and sub-cusp sites in the network, it is found that hydromagnetic activity at AGO6 is strikingly similar to a cusp-latitude site. However, the observations at AGO5 stand out as truly unique. The results suggest that ULF studies at high CGM latitudes cannot freely be used to infer the ULF activity at other sites of similar CGM latitude, but separated in MLT. This also implies that meridional chains at high CGM latitudes cannot be used to construct CGMLat/MLT statistical ULF maps that are directly applicable to any other meridional chain but the one used to construct the map. The utility of CGM coordinates in the polar cap is questioned. We suggest that the AGO5 location is a better representation of a central point in the polar cap than the CGM pole.

## ***Optical and SuperDARN observations of the shock aurora***

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Interplanetary shock and a sudden solar wind dynamic pressure enhancement can greatly disturb the geospace electromagnetic environment. One noticeable large-scale transient auroral emission is referred as shock aurora. Generally, just after the shock/pressure pulse arrives to the magnetosphere, the shock aurora brightens initially around the magnetic local noon cusp region. After that, within a few or several minutes the shock aurora propagates longitudinally to dawn and dusk sectors and eventually terminates the night sector. Here, using ground-based high temporal and spatial optical and HF radar measurements, we present shock aurora events to illustrate the direct responses of the fine structure auroral emission and localized ionospheric plasma convection. In local noon ionosphere, we observed an intensified red aurora manifesting as a discrete emission band at higher latitude and prompt poleward expanding green diffuse aurora. While SuperDARN monitored two reversed flow cells nested in the noon sector of the polar cap. In post or duskside ionosphere, the optical feature of shock aurora indicated gradual intensification and instant ionospheric plasma flow reversal. Direct observations suggest that the prompt shock compression intensified the wave-particle interaction in the inner magnetosphere and enhanced the lobe magnetic reconnection rate at magnetospheric high latitude, which are responsible for the auroral and ionospheric convection observations at MLT noon. While the field-aligned current (FAC) system associated with the SC triggered by the shock compression plays key role in postnoon ionospheric phenomenon.

## ***Study of the propagation characteristics of Very Low Frequency Signal as observed from Indian Permanent stations Maitri and Bharati***

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Propagation of Very Low Frequency (VLF) radio signal through the Earth-Ionosphere waveguide strongly depends on the plasma properties of the ionospheric D layer. Solar extreme ultraviolet radiation plays the central role in controlling physical and chemical properties of the lower ionospheric layers and hence determining the quality and propagation characteristics of a VLF signal. The nature of interference among different propagating modes varies widely with the length of the propagation path. For a very long path, exposure of solar radiation and thus the degree of ionization vary by a large amount along the path. Study of radio signal characteristics in the Antarctic region during summer period in the Southern Hemisphere gives us a unique opportunity to explore such an inimitable possibility. In addition, there is an extra feature in this path—the presence of solar radiation and hence the D region for the whole day during summer in at least some sections of the path. We present long-distance propagation characteristics of VLF signals transmitted from VTX (18.2 kHz) and NWC (19.8 kHz) from India and Australia respectively recorded simultaneously at Indian permanent stations Maitri (Lat. 70°45'S, Long. 11°40'E) and Bharati (Lat. 69°24'S, Long. 76°10'E). The signal has been recorded individually with both magnetic cross loop and electric field whip antenna/receiver systems having both the broadband and narrowband information. A very stable diurnal variation of the signal (both amplitude and phase) has been obtained with no signature of nighttime fluctuation due the presence of 24 h of sunlight for both the stations. A similar instrument records the same transmitting signals from Kolkata, India to distinguish the whole day and no night situation as obtained from Antarctica. We present the attenuation rate of the dominant waveguide modes corresponding to those propagation conditions where the effects of the Antarctic polar ice on the attenuation of different propagating waveguide modes are visible. The attenuation is higher in Maitri station due to the presence of long ice shelf in the propagation of NWC-Maitri path which validates the observation. We reproduce the signal amplitude variation by calculating ionization rate, using a D-region ion chemistry model and Long Wave Propagation Capability (LWPC) code. The rate of ionization is calculated using the prescription of Chapman. We use satellite data for the solar flux at different altitudes of the lower ionosphere. The rate of ionization thus obtained is fed into sufficient satisfactory Glukhov-Pasko-Inan (GPI) ion chemistry model. We calculate the electron density profile at different heights for the entire day. Also electron density variation is being calculated for different distances from transmitter to receiver locations to reproduce the temporal and spatial distribution of electron density profile. Using this profile in the LWPC code, we reproduce the temporal and spatial amplitude variation of VLF signal. The signal amplitude and phase suffers from a number of different classes of solar flares. We reproduce the perturbed signal amplitude by these solar flares using the Ion-chemistry model. We also present the variation of cosmic rays in polar region.



# ***Gravity wave propagations over the Antarctic mesosphere observed by Antarctic Gravity Wave Imaging/Instrument Network (ANGWIN), using a new spectral analysis***

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ANGWIN (Antarctic Gravity Wave Imaging/Instrument Network) is an international airglow imager/instrument network in the Antarctic. It seeks to reveal characteristics of mesospheric gravity waves, and to study sources, propagation, breaking of the gravity waves over the Antarctic and the effects on general circulation and upper atmosphere. We have compared distributions of horizontal phase velocity of the gravity waves at around 90 km altitude observed in the mesospheric airglow imaging over different locations using our new statistical analysis method of 3-D Fourier transform, developed by Matsuda et al. (2014). Results from the airglow imagers at four stations at Syowa (69S, 40E), Halley (76S, 27W), Davis (69S, 78E) and McMurdo (78S, 156E) out of the ANGWIN imagers have been compared, for the observation period in April and May in 2013. In addition to the horizontal distribution of propagation and phase speed, gravity wave energies have been quantitatively compared, indicating a smaller gravity wave activity in higher latitudes. We further investigated frequency dependence of gravity wave propagation direction, as well as nightly variation of the gravity wave direction and correlation with the background wind variations. We found that variation of propagation direction is partly caused by the effect of background wind in the middle atmosphere through the vertical propagation process, but variation of wave sources could play important role as well. Secondary wave generation is also needed to explain the observed results. These results has brought important information in order to improve the gravity wave parameterization in the general circulation models and climate models.

## **S27. Impacts of environmental changes on Antarctic ecosystems and biota ( Sec 1), Meeting Room 401/402, August 25, 2016, 11:30 AM - 1:30 PM**

### ***Towards monitoring of primary production in Antarctic phytoplankton***

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The Western Antarctic Peninsula is experiencing rapid warming with an increase of 3 °C in the annual mean atmospheric temperature in the past century. The subsequent reduction in sea ice may stimulate and/or reduce marine primary production or may have no significant effect at all. To verify the effects of warming on marine phytoplankton in the Western Antarctic Peninsula, field based primary production measurements are essential. Yet, the common <sup>13</sup>C, <sup>14</sup>C, and/or <sup>12</sup>O techniques are unsuitable for measurements at high temporal and spatial scales due to limitations in methods and health & safety regulations. Our perception of the impact of climate change would therefore benefit from the development of a new, non-intrusive technique to measure marine primary production. Fast Repetition Rate fluorometry is an increasingly used method to estimate primary production of marine phytoplankton in the Antarctic. However, research is needed to accurately convert fluorometry derived electron transport rates into carbon fixation rates. To this end, electron transport rates, carbon fixation, and species composition were assessed in natural phytoplankton communities from Ryder Bay in the West Antarctic Peninsula. In addition, laboratory experiments were performed with four key diatom species isolated from Ryder Bay. *Fragilariopsis minimum*, *Pseudonitzschia subcurvata*, *Thalassiosira antarctica* and *Proboscia alata* were cultured at three different light intensities to assess photophysiology, electron transport rates, carbon fixation and cell growth. Results showed primary production rates between 0.3-7.1 µg C µg Chl-a-1 h<sup>-1</sup> in natural phytoplankton communities from Ryder Bay. Similar rates were found in the isolated phytoplankton species under laboratory conditions, with *Fragilariopsis minimum* showing highest primary production rates at increasing light intensities. Furthermore, the laboratory experiments showed species specific effects of high irradiance intensities on the relationship between electron transport rates and carbon fixation. Further comparison of electron transport and carbon fixation rates and their relation to environmental conditions will strongly advance our understanding of factors that regulate primary production of marine phytoplankton in one of the most rapidly warming regions of the world.

## ***The role of mixing and silicate in regulating phytoplankton community structure in the iron-limited Antarctic Polar Front***

**Wee Cheah**<sup>1</sup>, Mariana A. Soppa<sup>2</sup>, Sonja Wiegmann<sup>2</sup>, Sharyn Ossebaar<sup>3</sup>, Luis Laglera<sup>4</sup>, Volker H. Strass<sup>2</sup>, Juan Santos-Echeandía<sup>5</sup>, Mario Hoppema<sup>2</sup>, Dieter Wolf-Gladrow<sup>2</sup>, Astrid Bracher<sup>2,6</sup>

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Using a combination of physicochemical and biological measurements (e.g. HPLC, CHEMTAX) from the ANT-XXVIII/3 Eddy-Pump cruise conducted in austral summer 2012, we delineate the respective physiological responses of phytoplankton communities under varying nutrient and light regimes in the Antarctic Polar Front (APF) between 45° S to 55° S in the Atlantic sector of the Southern Ocean. Our results show that under iron-limited conditions, high total chlorophyll-a (TChl-a) concentrations can be observed at stations with deep mixed layer across the APF. In contrast, at stations with shallower mixed layer light was excessive and phytoplankton were producing higher amounts of photoprotective pigment at the expense of TChl-a. North of the APF, significantly lower silicic acid (Si(OH)<sub>4</sub>) concentrations lead to the domination of nanophytoplankton, which produced higher ratios of photoprotective pigment under relatively low irradiance conditions. The Si(OH)<sub>4</sub> replete region south of the APF, on the contrary, was dominated by microphytoplankton with lower ratios of photoprotective pigment, despite having been exposed to higher levels of irradiance. The significant correlation between nanophytoplankton and photoprotective pigment indicates that differences in taxon-specific response to light are also influencing TChl-a concentration in the APF during summer. Our results reveal that provided mixing is deep and Si(OH)<sub>4</sub> is replete, high TChl-a concentrations are achievable in the iron-limited APF waters during summer.

## ***Hypercarbia enhances metabolic thermotolerance of the cold temperate nototheniid *Notothenia angustata****

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**Objectives:** Many Antarctic nototheniid fish are considered losers of global change, due to their low thermal tolerance and lack of regulative mechanisms that enhance physiological plasticity. The Austral nototheniid congener *Notothenia angustata* provides an alternative model to explore the effects of ocean acidification and warming, as it inhabits cold temperate to subpolar waters. It is a eurythermal species, with greater capacities for thermal acclimation relative to Antarctic congeners, and therefore presents a useful model against which Antarctic notothenioids can be contrasted.

We investigated the long-term effects of hypercarbic acclimation on whole animal and cardiac mitochondrial function for the Austral nototheniid *N. angustata*. Fish were acclimated under hypercarbic (0.2 kPa CO<sub>2</sub>, 15 days, n=6) and normocarbic conditions (control 0.04 kPa CO<sub>2</sub>, n=10). Routine metabolic rates (RMR) were determined with acute increases in temperature (3°C/d) under normocarbic and hypercarbic conditions. Mitochondrial function was then tested within permeabilised cardiac muscle fibres, and assays conducted in normocarbic (0.04 kPa CO<sub>2</sub>) and hypercarbic (3.0 kPa CO<sub>2</sub>) media at 9, 15 and 21°C. Metabolic profiles were determined in red skeletal muscle.

**Results:** Whole animal critical temperature thresholds occurred beyond 19°C for normocarbic exposed fish, while acutely hypercarbic exposed fish maintained routine metabolic rates up to 21°C. Overall mitochondria mirrored the responses of acutely exposed whole animals, with an increased mitochondrial performance in fish acclimated to chronic hypercarbia. Chronically hypercarbic exposed animals also exhibited altered metabolomes of red muscle, but not liver with apparent increases in metabolites consistent with enhanced anaerobic metabolism and elevated contents of histidine and tryptophan that may contribute to acid-base buffering.

**Conclusions:** Overall enhanced cardiac mitochondrial capacities coincide with increasing hypercarbic and elevated temperature tolerance. This response suggests sufficient metabolic plasticity for Austral nototheniids to acclimate to a warming and acidifying ocean, which has not been observed to that extent in Antarctic notothenioids.

## ***Dynamic Energy Budget (DEB) as a tool to predict Antarctic organisms performance under global environmental changes***

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Marine organisms in Antarctica are adapted to an extreme ecosystem including extremely stable temperatures and strong seasonality due to changes in day length. It is now largely accepted that Southern Ocean organisms are particularly vulnerable to global warming with some regions already being challenged by a rapid increase of temperature. Climate change affects both the physical and biotic components of marine ecosystems and will have an impact on the distribution and population dynamics of Antarctic marine organisms. To predict and assess the effect of climate change on marine ecosystems a more comprehensive knowledge of the life history and physiology of key species is urgently needed. In this study we estimate the Dynamic Energy Budget (DEB) model parameters for key benthic Antarctic species the sea star *Odontaster validus* using available information from literature and experiments. The DEB theory is unique in capturing the metabolic processes of an organism through its entire life cycle as a function of temperature and food availability. The DEB model allows for the inclusion of the different life history stages, and thus, becomes a tool that can be used to model lifetime feeding, growth, reproduction, and their responses to changes in biotic and abiotic conditions. The DEB model developed here for *O. validus* allowed us to increase our knowledge on the ecophysiology of this species, providing new insights on the role of food availability and temperature on its life cycle and reproduction strategy.

This model is then used to create mechanistic trait distribution models to identify the potential impact of global environmental changes (warming, ocean acidification, food availability, shifts in ice regimes) into the future distribution of these organisms.

## ***Comparing the structure and function of the Antarctic and Tropic benthic communities following environmental changes***

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A comparative study was carried out to determine the impacts of environmental changes on the diversity of benthic communities in polar and tropical regions. Study in polar region was carried out by mean of impact of glacier melting on benthic communities in Marian Cove, West Antarctic Peninsula. Sampling were done at stations representing different distances from glacier melting. Benthic organisms were hand-picked and photo-recorded by SCUBA diving. Study in tropical region was done to determine the impacts of rainy season on the benthic diversity in Bidong Island, Malaysia. Hand core (with the aid of SCUBA diving) was used to collect sediment samples containing benthic organisms. For both areas, the comparison of the benthic communities was done by means of their structure (i.e. species richness), taxonomy (i.e. Taxonomic Distinctness index, TD) and function (i.e. Functional Diversity index, FD). Environmental features such as water physico-chemical characteristics and sediment composition were also measured.

The species was less diverse at the site with more impact of glacial melting. Similarly, this also evident in terms of functional diversity where the FD value was low at site closer to glacial impact. The glacial melting seemed to have no impact on the taxonomic aspect of the communities where the TD values were similar among the sites. The similar trend was also recorded in the tropical study, where both species number and functions were low at sites with low environmental impacts, as it showed that both species richness and FD values were low during post-monsoon season compared to pre-monsoon season.

This study showed that the environmental variability had an effect on benthic communities both structurally and functionally. Although widely spatially separated, the responses of different benthic communities towards environmental changes were similar; in particular these were influenced by the sediment composition.

## ***Atmospheric methane-oxidizing bacteria in Antarctic cryosols***

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The diverse and endemic soil microorganisms that have adapted to the hostile environments in Antarctica are facing the challenges due to climate change. The seasonally thawed active layer may exhibit a greater daily and/or seasonal temperature variations and a different soil moisture regime, which would cause compositional shifts in these microbial communities. Our preliminary data showed that Antarctic cryosols are capable of oxidizing methane at atmospheric concentration (~2 ppm) at significantly higher rates than the acidic mineral cryosols from the high Canadian Arctic (N 79°) [The ISME J (2015) 9: 1880-1891]. Understanding of this understudied behavior of these active layer soils is important for determining the potential methane feedback responses in the Antarctic Region. We aimed to investigate the biodiversity and genome-wide adaptation of the responsible atmospheric methane-oxidizing bacteria (atmMOB) in Antarctic cryosol. Six cryosol samples from two polygons in the Taylor Dry Valley, Antarctica (S 77°39', E 163°05') were incubated at 4 and 10°C in triplicate. Methane consumption was monitored over a period of four weeks. Two cryosol samples that oxidized methane at both temperatures were selected for molecular analyses. Polymerase chain reaction, cloning and sequencing of *pmoA* (particulate methane monooxygenase subunit A), the marker gene of methane oxidation, revealed that the alkaline Antarctic cryosols are comprised of atmMOB phylotypes closely related to Upland Soil Cluster  $\gamma$  (USC $\gamma$ ), whereas the high Canadian Arctic cryosols contains predominantly atmMOB USC $\alpha$ -like phylotypes. Four metagenomic libraries were prepared from total DNA and then sequenced (2x100bp, Illumina). Quality-filtered reads (av. 20 M reads per library) were de novo assembled and annotated. A *pmoA* gene cluster was successfully assembled and the *pmoA* gene is closely related to our USC $\gamma$  clone sequences. Putative contigs of the USC $\gamma$  Antarctic strain will be identified for genome construction to inform its metabolic capacity. This study provides the first genetic basis for a possible role of Antarctica as a current and future methane sink.

## ***Functional response of *Blechnum penna marina* to desiccation in tundra environments***

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The climate on the sub-Antarctic Marion Island appears to be changing, providing an important indication of climate trends in the southern Ocean. Over the past forty years, temperature and average wind speed have increased, while rainfall and the number of overcast and windy days have decreased. The impact of these changes on plant physiology has hardly been studied in these isolated floras. The aim of this study is to test how the photosynthetic activity of *Blechnum penna-marina* changes with a decrease in leaf water content, indicative of desiccation that is expected to increase with the observed climate change. *Blechnum penna-marina* is one of the key species on Marion Island as it is one of the most dominant species in terms of cover and biomass, and can be found in most of the habitats below 600m above sea level. I propose using this species as an indicator to help predict how ferns on sub Antarctic islands may respond to changing climatic conditions. *Blechnum penna-marina* samples were collected from closed fernbrake slope habitat, placed in two litre containers with saturating water levels. Samples were acclimated at either 6 or 11 °C for at least 3 days. After acclimation, CO<sub>2</sub> response (50 to 1500 micromol CO<sub>2</sub> mol<sup>-1</sup>) was tested with a LICOR 6400XT allowing simultaneous measurement of gas exchange and chlorophyll fluorescence. Additionally; three leaves from each sample were collected to calculate leaf water content. Samples were then desiccated over time at their respective acclimation temperature. CO<sub>2</sub> response curves were determined at two day intervals during desiccation. Relationships between leaf water content and various photosynthetic parameters were investigated using the following approach: The CO<sub>2</sub> response parameters apparent Rubisco activity (V<sub>cmax</sub>), maximum electrontransport (J<sub>max</sub>), triose-phosphate utilisation (TPU), daytime respiration (R<sub>d</sub>) and mesophyll conductance (G<sub>m</sub>), were response variables, acclimation temperature was a categorical variable, and leaf water content was the independent variable. Factor analysis was also conducted. Plants acclimatized at 6°C had a significantly higher V<sub>cmax</sub>, J<sub>max</sub> and R<sub>d</sub> than plants acclimatized at 11°C degrees. The only value that decreased significantly with leaf water content was the mesophyll conductance of plants acclimated at 11°C. In the factor analysis, TPU, V<sub>cmax</sub>, J<sub>max</sub> and R<sub>d</sub> comprised one factor while leaf water and G<sub>m</sub> comprised another. These results suggest that warming on the island would tend to lower fern productivity, except in areas where low temperature limits the species. The range of the species has been expanding in the past decades, but there has not been a contraction in its major habitats. Other environmental drivers are being currently tested, like wind, soil water, irradiance and temperature. I will attempt to build a mechanistic model that will help to understand how this species could react to global climate change.



## ***Ecosystem carbon fluxes and plant communities distribution at anchorage island, marguerite bay: connections and climatic feedbacks in an Antarctic environment***

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The Antarctic Peninsula is one of the regions of the Southern Hemisphere where warming has been fastest over the last 50 years and exerted significant impacts on the terrestrial ecosystems, with special reference to vegetation and active layer thickness. Climate-driven future changes of vegetation composition and distribution may affect the carbon cycle and, in particular, the CO<sub>2</sub> fluxes, promoting feedbacks to climate. Despite the key ecological role of vegetation and permafrost in determining CO<sub>2</sub> ecosystem flux, there are still few available data concerning in situ measurements of carbon fluxes performed in Antarctica.

At Anchorage Island (67°36'S; 68°11'W, Marguerite Bay) we performed in situ measurements of the CO<sub>2</sub> fluxes during the austral summer 2010/2011. We aimed to: (1) assess the spatial variability of ecosystem CO<sub>2</sub> fluxes under different vegetation types, (2) map the spatial distribution of t vegetation across the island and (3) scale-up CO<sub>2</sub> values from the single plot to the whole island to assess whether it acts as a CO<sub>2</sub> sink or source during the summer season.

We measured Net Ecosystem Exchange (NEE;  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ ) and Ecosystem Respiration (ER;  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ ) at the plot scale across 7 different ecosystem types representative of the island vegetation, and ranging from the bare ground (1 plot), to the vascular Antarctic tundra dominated by *Deschampsia antarctica* (1), including also different types of cryptogam dominated tundra (mesic-hydric moss *Sanionia uncinata*, xeric moss *Andreaea regularis*, algae *Prasiola crista*) as well as co-dominance communities (*Deschampsia-Sanionia* and *Prasiola-Sanionia*). CO<sub>2</sub> exchange rates were measured at least twice a week (17 January – 9 March) using a portable automated CO<sub>2</sub> exchange station containing an infrared gas analyzer (IRGA). Moreover, we recorded also soil temperature, soil moisture and PAR for all our measurements. During the Antarctic summer season 2013/2014, the vegetation occurring across the whole island was mapped in detail (1:2000 scale), recording physiognomy, total coverage, growth form, species composition and abundance. From these data, we elaborated a vegetation map that we used to extrapolate the NEE measurements from the single plots to the entire island, in order to identify distribution and relevance of “sink” and “source” ecosystems.

At inter-community level, magnitude and direction of CO<sub>2</sub> fluxes was influenced by vegetation type, with sink strength (obtained by mean NEE values) decreasing as follow: *Deschampsia* (-0.64), *Prasiola-Sanionia* (-0.64), *Deschampsia-Sanionia* (-0.60), *Prasiola* (-0.38), *Sanionia* (-0.36), *Andreaea* (-0.04), bare ground (-0.04). Mean ER decreased almost with the same order, with the most active vegetation having higher ER too. Despite this, the negative values of NEE highlight how all the ecosystem selected act as sink during the summer season, with just *Andreaea* and bare ground having no effect.

Among these ecosystem types, bare ground was the most widespread condition on the whole island (60%), followed by *Prasiola* (13%), *Deschampsia* (8%) and *Prasiola-Sanionia* (9%). We can therefore hypothesize that in a climate change context a potential further increase of herbs and mesic mosses could likely imply negative feedbacks to the C cycle strengthening their sink effect during the summer season.

**S28. Diversity and distribution of life in Antarctica D6 Sec2,  
Meeting Room 406/407, August 25, 2016, 11:30 AM - 1:30 PM**

***Two contrasting production regimes drive benthic processes and biodiversity  
in the Filchner-Rønne Outflow System in the southern Weddell Sea***

**Dieter Piepenburg**<sup>1</sup>, Santiago Pineda<sup>1</sup>, Enriquei Isla<sup>2</sup>, Dieter Gerdes<sup>1</sup>

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The Filchner-Rønne Outflow System (FROS) in the southernmost Weddell Sea is unique, as sea ice persists longer there than in any other region in the Southern Ocean (SO), strongly determining the ecological processes in the water column and on the seabed. It consists of the deep Filchner Trough (> 1000 m in depth), which conducts water into and from the Filchner-Rønne Ice Shelf and separates two high-Antarctic shelf regions east and west of it. As the system is situated in a remote high-latitude area rather difficult to access, which greatly hampers scientific studies in the region, the knowledge about ecological processes in the FROS was scarce. However, during two cruises of R/V Polarstern in 2013/14 and 2015/16 field campaigns were performed, which united a multidisciplinary community of scientists intensely collaborating with a common overarching approach to study the FROS.

Novel data was gathered by means of corers (multi-corer and multi-grab) and seabed imagery to investigate both infaunal and epifaunal seabed assemblages. First analyses indicated that the macro- and megabenthos on the shelf west of the Filchner Trough was clearly poorer in both abundance and diversity than that at eastern stations. Based on this evidence, we hypothesize that the western and eastern Filchner shelf regions are contrasting ecological systems, characterized by pronouncedly different environmental conditions and distinct benthic communities. We hypothesize further that this difference is primarily due to the contrasting sea-ice regimes, with almost permanent ice cover in the western region vs. the formation of a recurrent summer polynya in the east. As a result, the western system lacks the typical high-Antarctic summer conditions, such as occurrence of wide open-water areas, enhanced light regime, upper water-column stratification triggering phytoplankton blooms, high primary production and particle fluxes, and, hence, strong pelagic-benthic coupling and enhanced food supply to the benthos. In addition, this east-west contrast in the general environmental setting is sustained by the isolating effect of the regional oceanographic current pattern, impeding advective exchange processes (organic matter, larvae, propagules) between the two shelf regions across the trough. As there was evidence from bathymetric as well as seabed imaging data that iceberg scouring likewise impacts both the eastern and western shelf, we further hypothesize that this process, which is generally of high ecological significance for SO shelf benthic systems, does not explain the striking difference in epibenthic community structures. However, as the available evidence is based on admittedly rather few point-type and snapshot-like data, further samples are required to rigorously test those hypotheses.

## ***Reproductive strategy as a piece of the biogeographic puzzle: A case study using Antarctic sea stars (Echinodermata, Asteroidea)***

**Camille Moreau**<sup>1,2</sup>, Quentin Jossart<sup>1</sup>, Antonio Agüera<sup>1</sup>, Arnaud Brayard<sup>2</sup>, Thomas Saucède<sup>2</sup>, Bruno Danis<sup>1</sup>  
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Amongst the life-history specificities of Southern Ocean sea stars, the diversity of developmental mode strategies seems to be a predominant driver in explaining the observed biogeographic patterns. An important proportion of asteroid species use direct development and brood their young, which is thought to lead to poor dispersal capabilities, while others have indirect development with planktonic larvae, enabling propagules to be dispersed over larger distances.

In the framework of this study, we mobilize large amounts of occurrences data from information networks such as biodiversity.aq, OBIS and GBIF and augment them with data from legacy literature, and various collections. The resulting dataset is used to delineate the origin and structure of asteroid biogeographic patterns in the SO.

Using two complementary analytical methods (Joined Bootstrapped Spanning Network (BSN) and hierarchical clustering procedures) we show that the variable capacity of asteroids to disperse (viz. short-range for brooders and long-range for broadcasters) induces contrasting biogeographic patterns and connectivities. Our results suggest that life-history traits such as the dispersal modes should be taken into account for biogeographic studies as a pre-requisite to disentangle the origins of emerging biogeographic patterns. We also propose taking such life history traits into account in the framework of predictive biogeographic using modelisation approaches such as SDMs or TDMs (Species or Trait Distribution Models).

## ***First circumpolar insights into the biodiversity and biogeography of the Antarctic & sub-Antarctic intertidal***

**Cath Waller**<sup>1</sup>, Huw Griffiths<sup>2</sup>

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With the Antarctic Peninsula being one of the fastest warming places on Earth, it comes as little surprise that one of the 80 key questions raised by the first Scientific Committee on Antarctic Research (SCAR) Antarctic and Southern Ocean Science Horizon Scan was: “How will increases in the ice-free Antarctic intertidal zone impact biodiversity and the likelihood of biological invasions?”

This study directly addresses these issues including what little is known about intertidal/ marine invasive species in the Southern Ocean intertidal ecosystems. We consider the potential vectors of transmission of non-native species and the probability of their establishment.

With 87% of marine glacier fronts currently in retreat on the Antarctic Peninsula the Antarctic intertidal environment is undergoing dramatic changes with the potential to expose ever increasing areas of rocky or sedimentary intertidal habitat. This study is the first to include all published and new records of high southern latitude intertidal organisms.

We believe that these findings are significant because the Antarctic intertidal has long been seen as a lifeless desert but we have found, to our surprise, that it has have higher levels of biodiversity than the intertidal of southern South America and the Sub-Antarctic islands. In cool temperate regions the intertidal zone is often seen as the marine “canary in the coal mine” with observed changes in species ranges due to climate change and establishment of invasive species being observed here first.

# ***Bryozoan community of the fjordic environment: their biodiversity, distribution, mineralogy and geochemistry (Admiralty Bay, King George Island, South Shetland, Antarctica).***

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The analysis of the bryozoan community of the Antarctic glacial fjord of Admiralty Bay is based on the large set of qualitative samples collected with the beam trawl from the 15 to 280 meters depth during the 12th Polish Antarctic Expedition of 1988. The analysed 11 samples selected from 80 collected, have proved the presence of rich cheilostomes dominated by ascophoran umbunulomorphs and lepraliomorphs, 4 cyclostomes and one ctenostome, accompanying by rich communities of polychaetes, sponges, amphipods, ophiuroideans, crinoids, foraminifers and algae. The taxonomical and distribution data were analysed together with the previous studies carried out in the same region (Pabis et al. 2014).

Undoubtedly, four assemblages have been discerned. The shallow-water, sublittoral of the central basin bryozoan assemblage of 15–60 m depth, is characterized by the domination of the epibenthic umbunulomorph of *Inversiula* and *Arachnopusia* as well as bugulids. The second assemblage, from the shallow sublittoral of the inner fjords of MacKeller and Martel inlets, from the depth of 60-120 m includes 14 species, which mostly settle the muddy bottom, with the share of the stones are composed of the rooted adeoniform of umbunulomorphs and lepraliomorphs as well as buguliform and flustriform colonies. The third distinctive assemblage of 27 bryozoan species shows the richest biodiversity and biomass and occurs in the depth range of 120-200 m in the central part of the basin on the muddy bottom with some stones. The dominant colony form is adeoniform represented by 12 species which, form erect, bilamellar plates, frondose or folded sheets, branched or lobate zoaria accompanied by numerous erect bugulids, attached by bundles of chitinous rhizoids. The fourth assemblage at the depth of 240-280 m, is represented by a scarce lepraliomorphs of *Lekythoporidae* and *Smittinidae* bryozoans settled on the muddy bottom.

The spatial variability of the bryozoan community structure, species richness and biomass are strongly associated with factors such as substrate type, water depth, location within the basin, and physical factors: influence of the suspended matter inflow or glacial disturbance.

Mineralogically, the bryozoan skeletons from the Admiralty Bay are cheilostomes composed of intermediate magnesian calcite (IMC) where the Mg content ranges from ca. 4.3 to 6.5 wt% MgCo<sub>3</sub>. The bryozoans skeletons exhibit  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  values typical of cool marine waters. Their  $\delta^{18}\text{O}$  ranges from ca. 2.25 to 4.3‰ PDB, with most data clustering between 3 and 4 ‰ PDB. The  $\delta^{13}\text{C}$  varies from ca. -1 to +1.5‰ PDB with most data plotted between +0.5 and +1.5‰ PDB (Hara et al. 2010).

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## ***Chemosynthetic ecosystems in the southern ocean: current knowledge on their biology***

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The existence of hydrothermal and chemosynthetic ecosystems does not come surprising given the tectonic history of Antarctica, the presence of active volcanoes, mid ocean ridges and back-arc basins, and abundance of marine mammals. In the last two decades a variety of active chemosynthetic ecosystems have been discovered in the Southern Ocean, including hydrothermal vents, cold seeps and whalefalls. Here a summary of the data from the known chemosynthetic communities will be presented with a comparison of the faunas from the venting sites in the Bransfield Strait with those of the East Scotia Ridge (ESR) and the South Sandwich Arc, an assessment of the faunas of the Larsen B and South Georgia seepage sites and a discussion of the fauna on Antarctic whale falls. To date the faunal assemblages of the ESR vents are the most detailed studied, therefore this talk focusses on the diversity and composition of the ESR macrofaunal assemblages, their foodweb structure and microdistributions in relation to fluid chemistry and microbiology, as well as the phylogenetic and biogeographic relationships.

The Southern Ocean is driving the global ocean conveyor belt, is suggested as the centre of origin for the global deep-sea fauna and a region of high deep-sea species diversity. It is proposed as a gateway connecting the global hydrothermal vent and seep systems. The mostly endemic species of the Southern Ocean vent macrofauna show links to either one or more oceans (Atlantic, Indian and Pacific) and give evidence also for circum-Antarctic connection. The ESR species *Gigantopelta chessoia*, *Kiwa tyleri* and *Vulcanolepas scotiaensis* have their closest known relatives in the South-west Indian Ridge Longqi vent field, while *Lepetdrilus* sp. and a vesicomyid clam are linked with species in the Atlantic vent fields. The stichasterid *Paulasterias tyleri* and the anthozoan *Relicanthus daphneae* have phylogenetic links with North-eastern Pacific vent fields. *Paulasterias tyleri*, with distribution records from the South Sandwich Islands and Ross Sea, is the only species discovered so far outside the ESR and AAR vent fields and its presence on those locations could indicate further hydrothermal active sites associated with chemosynthetic ecosystems.

## ***Marine landscape mapping at sub-Antarctic South Georgia provides a protocol for underpinning large-scale marine protected areas***

**Oliver T. Hogg**<sup>1,2,3</sup>, Veerle Huvenne<sup>2</sup>, Jonathan Copley<sup>3</sup>, Huw Griffiths<sup>1</sup>, Katrin Linse<sup>1</sup>

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Global biodiversity is in decline. Anthropogenic activities act as drivers of this decline, with the marine environment experiencing significant and increasing pressure from extractive industries such as fishing, rare earth mining, and oil and gas extraction, activities, which are increasingly proliferating into deep-sea environments. Under financial, political and social constraints however, one of the key questions that precede any conservation strategy, is how and where to prioritise limited resources and effort to maximise conservation payoff in an increasingly exploited, yet still poorly understood marine environment. Over the past decade, marine protected areas (MPAs) have increasingly been adopted as the flagship approach to marine conservation, many covering enormous areas of over one million km<sup>2</sup>. At present however, the lack of scientific biological sampling makes understanding and prioritising which regions of the ocean to protect, especially over large spatial scales particularly problematic.

Here, we present an interdisciplinary approach to marine landscape mapping at the sub-Antarctic island of South Georgia, as an effective protocol for underpinning large-scale MPA designations. South Georgia forms part of one of the largest MPAs in the world and supports a highly biodiverse benthic fauna. We developed a new high-resolution (100m) digital elevation model (DEM) of the region and integrate this DEM with bathymetry derived parameters (e.g. rugosity, slope gradient), modelled oceanographic data (e.g. seabed temperature, salinity and currents) and satellite net primary productivity data. These interdisciplinary datasets were used to apply an objective statistical approach to hierarchically partitioning and mapping the benthic environment into distinct ecologically-relevant physical habitats. Using this benthic marine landscape map and overlaying it with a regional biological dataset we aim to assess the application of physical habitat classifications as proxies for biological structuring and as such the application of the landscape mapping protocol for informing on marine spatial planning.

## ***Maximization of sampling efficiency in benthic surveys at high latitudes: sampling gear constraints vs species inventory completeness***

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Sampling activities in extreme environments, such as polar benthic ecosystems, represent an authentic challenge for researchers, showing a variety of logistical difficulties related to the inaccessibility of these areas. In these hostile circumstances, the choice of the gears to deploy is a crucial step, contributing substantially to the maximization of the sampling effort.

In this contribution we focus on Mollusca, one of the most extensively studied groups in Antarctica and hence one of most useful ones to assess our degree of knowledge on the completeness of the species inventory in respect to the sampling effort done. To this aim, we have assembled, for the Ross Sea area, a large data set by merging historical data, available through SOMBASE (the Southern Ocean Mollusc Database; Griffiths et al., 2003), data from recent expeditions done in 2004 (R/V Tangaroa –Bioross” voyage and R/V Italica –Latitudinal Gradient Program”) and 2008 (Tangaroa –PY-CAML” voyage).

For each one of the recorded sampling events occurred in the Ross Sea, we have tried to trace back information about sampling gears used by exploring published literature as well as original data logs of the expeditions. For 582 stations, out of the 710 present in the global database, it was possible to reconstruct the gear used to sample. This large data set (i.e. SOMBASE plus recent expeditions), completed with this previously unrecorded information, can now be viewed as a natural large-scale and multi-gear survey embracing all available data from 1899 to 2008 and, as such, it provides an unique opportunity of evaluating benthic sampling gear performances in terms of contribution to the Ross Sea mollusc species inventory completeness.

By analysing these incidence data under a collector’s curve perspective, we observed that at each grab or dredge deployment the total richness just increased of one unit per time. This number increases to two when trawl data are considered but goes up to 9 species added at each sampling event when fine-mesh sampling gears such as Brenke sled or Rauchert dredge are used. All the above data, analysed through rarefaction and extrapolation techniques in a rigorous statistical framework give useful insights to the sampling strategy that can be adopted at high latitudes when the task is species inventory. In fact, using Brenke sledge and Rauschert dredge, it is possible to obtain more than 50% of the total sample coverage with just few sampling events, while other gears (grab, trawl and dredge) have much lower performances. If the number of stations that need to be performed to reach the expected number of species under the Chao2 estimator is evaluated through Turing’s equations, the greater sampling efficiency of fine-mesh is even more appreciated.



## ***Genetic investigations into cryptic diversity, biogeography and the trophic traits of deep-sea Antarctic polychaetes***

Madeleine Brasier<sup>1</sup>, Rachel Jeffreys<sup>1</sup>, Adrian Glover<sup>2</sup>, Katrin Linse<sup>3</sup>, Helena Wiklund<sup>2</sup>, Lenka Neal<sup>2</sup>, **Huw Griffiths<sup>4</sup>**

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Our knowledge of Antarctic biodiversity and biogeography has improved greatly with the increased use of DNA barcoding. The comparison of sequence data from multiple individuals has revealed that many accepted morphological species actually consist of several genetically distinct cryptic clades. If these sequences are obtained over a large biogeographic area they can also be used to genetically test current biogeographic classifications. Phylogenetic analysis of mitochondrial DNA collected from 15 polychaete species within the Scotia, Amundsen, Bellingshausen and Weddell Seas revealed evidence of cryptic diversity in more than 50% of the morphospecies. The construction of georeferenced haplotype networks showed that the majority of these cryptic species exist allopatrically exhibiting circum-Antarctic distributions. These results suggest a strong role of recent dispersal and high levels of connectivity across the west Antarctic region. To further our understanding of the ecological role of species diversity I will be using compound specific stable isotope analysis to define the trophic level of these genetically identified polychaete species. By combining high-resolution genetic and biochemical data we will gain an insight into the relationship between species and functional diversity within Antarctic polychaetes, their contribution to ecosystem function and speculate the potential impact of species loss with climate change.

**S33. The role of humanities and social sciences in Antarctic studies  
D5 Sec 1, Meeting Room 403, August 25, 2016, 11:30 AM - 1:30 PM**

***Contemporary environmental politics and discourse analysis in Antarctica***

**Lize-Marié Van Der Watt<sup>1</sup>**

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Environments are produced through the shifting relationships between humans and nature, a relationship that changes over time. Antarctica is a continent for environmental discourse. For most of modern history, the idea of Antarctica existed only in human imagination, a place that had to exist because it made sense that it did. In the first section of this presentation, I provide a brief overview of contemporary discourse analysis as applied to environmental politics, focussing not so much on the different theoretical approaches, but on how discourse analysis can contribute to our understanding of environmental politics. In the second section, I discuss three interrelated yet distinct environmental issues in Antarctica that could be seen as illustrative of contemporary environmental discourses: climate change; biosecurity and the direct impacts of human activity on the Antarctic environment. The presentation uses these three environmental issues to illustrate how environmental discourse has emerged as a privileged arena in Antarctic politics, a space where controlling and establishing the discourse becomes crucial to having an effective voice over what can and cannot be done in Antarctica. While science has long dominated as a site for politics and diplomacy in Antarctica, I show that speaking for, defining and controlling the Antarctic environment has become a site through which power constellations between different entities in the Antarctic are negotiated.

## ***Climate Change Governance in the Antarctic Context***

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Despite the ample evidence of the effects of human-induced climate change, there is no consensus on its understanding and further action to combat it. Climate change governance has posed significant challenges for contemporary political and administrative systems, especially due to “institutional inertia” that stymies the progress in designing appropriate and timely response. (The World Bank, 2009) Climate change governance architecture grows in its complexity with the need to design solutions for areas that are particularly vulnerable to the effects of climate change. One of such regions is the Antarctic, a barometer of monitoring climate pattern alterations in an increasingly warming world. The Antarctic is held in a unique position of the Global Commons. Thus, there is no straight, unequivocal answer to who governs the Antarctic climate and where the boundary between global and the Antarctic climate is set.

This research aims to contribute to the existing scientific knowledge from the perspective of the Chilean state and other key agents in relation to their response to climate change, and investigates the integration of Chilean strategy in the global Antarctic governance system. Being in closest proximity to the Antarctic continent (850 km away), Chile is one of the most crucial stakeholders in the Antarctic-related decision-making process; therefore its role in shaping governance cannot be underestimated.

As evidenced by previous research on the topic of climate change governance, a single universal model of governance is a utopia. (Knieling et al, 2013) Moreover, the current model, shaped by the Antarctic Treaty and subsequent agreements, has been denounced as inadequate and unable to respond to the growing challenge of climate change (Berkman et al, 2009) Instead, we encounter a multifaceted web of approaches and solutions that limits the ability to implement constructive regulations and measures for change. Therefore, climate change management policy in the Antarctic will be viewed through the lens of multi-level governance, with a number of actors interacting on different levels, attempting to build foundations for climate change mitigation while simultaneously leaving room to pursue their own interests.

The main question is to evaluate strategies that the governance system of the Antarctic continent designs to address climate change.

The research takes into account measures introduced by the Chilean government, emphasizing the inertia of state actors in addressing the problem constructively. It also considers the position of national scientific community on this controversial issue, with scientists indicating the necessity of setting a cap for emissions in the Antarctic and introducing environmental measures more compatible with the unique Antarctic environment. Finally, the research investigates the approach the national tourism industry adopts to tackle climate change. The environmental impact created by this commercial activity is global while the governance is more localized, and we witness an overwhelming need to bridge the gap between these two phenomena.

## *The anthropology of climate change and Antarctic science*

**Richard Vokes<sup>1</sup>**

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Antarctica has always been good to think with. From the time that Aristotle first postulated the existence of a great Southern Land onwards, the continent has been used to support all manner of theories and ideas regarding the state of the planet, and the course of its potential futures. It is not surprising, then, that in recent years, Antarctica, or more precisely, the results of scientific research carried out in and on Antarctica, have come to be seen – both within the scientific community, and among the general public – as perhaps the key barometer of anthropogenic climate change, and of its likely effects. Conversely, the continent, and the research that is done there, have also come to occupy a central position within some of the main arguments forwarded by climate change sceptics.

This paper, which is part of a wider anthropological project on Antarctica's cultures of science, traces how and why the southern continent has come to occupy such a central role within our understanding of anthropogenic climate change: how it has come to be seen both as a primary laboratory for climate change research, and as a key battleground for climate change skepticism. It also looks at what effects this has had upon the organization and practice of contemporary scientific activities in and on Antarctica. In particular, it looks at how the new context has not only stimulated new forms of inter-disciplinarity within Antarctica science, but also quickened end of Antarctic exceptionalism (by which scientific practice on the continent was for long regarded as essentially different to all forms of science done elsewhere on the planet). Finally, the new context has also stimulated a growing interest among Antarctic scientists in exposing their activities to scrutiny by social scientists, including by anthropologists.

## ***An international lawyer in Japanese Antarctic research expedition: the role of social sciences in Antarctic field research***

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For the first time in its 60 years of history, the Japanese Antarctic Research Expedition (JARE) 2016-17 will include a professor of international law, who will examine international legal and policy implications of Antarctic scientific and logistical activities, working side by side with natural scientists, foreign exchange scientists, and logistical personnel at Showa Station and onboard Shirase, an icebreaker owned and operated by Japan Maritime Self-Defense Force. What academic significance can one find for an international lawyer to participate in Antarctic field research, which heretofore has been considered a proprietary of natural scientists? This question was posed again and again in the process of opening up the JARE's fields of research to include social sciences and humanities from its IXth Six-year Research Plan beginning 2016. This paper examines the discussions and processes leading to the expanded IXth Research Plan and, consequently, to the acceptance of a research project proposed by international law professor for JARE 2016-17. This examination will highlight the emerging recognition globally of the important role social sciences should play in polar studies in both the Antarctica and the Arctic.

The paper begins with a historical examination of Antarctic research dominated by natural sciences, the practice that has a legal pedigree. The term "scientific investigation/observations" in Articles II and III of 1959 Antarctic Treaty meant physical and biological scientific research. 1991 Madrid Protocol on Antarctic Environmental Protection uses a more neutral term "scientific research" throughout its texts, and recognizes that human activities in Antarctica, including scientific activities, can have adverse impacts on the Antarctic environment. The fourth International Polar Year (IPY-4) had a significant component on social sciences, especially in the Arctic research. The Antarctic and Southern Ocean Science Horizon Scan, adopted by SCAR in 2014, was a breakthrough in recognizing the importance of social science studies in the overall Antarctic scientific research. At the same time, the Antarctic Horizon Scan poses a challenge how to situate and possibly integrate Antarctic social sciences within a still predominantly natural science endeavour in the Antarctic.

The expansion of JARE's fields of research to include social sciences can be seen as a response to such international trend. From 2010, when a bigger new icebreaker Shirase-II was introduced, a new category of projects called "Open-Use Research" was established, outside of the main governmental part of JARE, to promote non-traditional research projects and outreach programmes. During the discussion on the IXth Research Plan in an expert committee, in which one of the authors was a member, there emerged a consensus to accept new fields of research, including social sciences, in the "Exploratory" category of the main part of JARE. Now, a proposal to dispatch an international lawyer to Antarctica in JARE's next expedition starting late November 2016 is under examination by the JARE's Headquarters. This paper examines these processes to see what role is expected from social sciences in Antarctic field research.

## ***The establishment of marine protected areas in Antarctica: Science, politics or law?***

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The establishment of marine protected areas (MPAs) in Antarctica has been debated over 5 years within the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). This presentation introduces three MPA proposals: The US/New Zealand Ross Sea MPA; EU/France/Australia East Antarctic Representative System of Marine Protected Areas; and the United Kingdom's proposal on protecting areas when ice shelves collapse in the Antarctic Peninsula region. The presentation then focuses on the major contentious issues within these proposals. Some concerns are scientific, for example, EU/France/Australia's proposal is targeting at so called data-poor area; others are political, such as Russia's concern about using MPAs to strengthen Antarctic claims. Furthermore, the legal interpretation of the "rational use of resources" is a particular challenge for the establishment of Ross Sea MPAs because of fishing interests of countries such as China. The presentation concludes that Antarctic MPAs would need to be based on an ecosystem approach and that further research is necessary to gain a better understanding of the changes of the marine Antarctic ecosystem.

## ***Integration of foreign affair, science and environmental policy in strengthening Malaysia's interest on Antarctica and southern ocean***

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Malaysia's public policy towards Antarctica and Southern Ocean has evolved from diplomacy to science diplomacy since 1982 and extended its scientific research on Arctic region since 2006. Malaysia hopes that the polar science initiatives will accelerate the knowledge-based economy in the context of research and development (R&D). Nonetheless, Malaysia lacks of solid approach in national's polar policy system that may turn out its involvement in this region to be a challenging task. Therefore, Malaysia's agendas on Antarctica and Southern Ocean require strategic policy integration in ensuring a long-term political commitment, a sustain resource of investment and a strengthen dynamic participation of multi-stakeholders. To move forward, Malaysia needs a solid polar policy framework to mobilise and guide government agencies, industries, communities as well as other stakeholders and major groups in addressing the role and importance of polar regions (Antarctic and Arctic) in a holistic manner.

## ***AFoPS: A twelve years old actor in the Antarctic theatre***

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Established in May 2004, the Asian Forum of Polar Sciences (AFoPS) is the most important Asian bloc operating in Polar Regions and consists of five members – India, Japan, Malaysia, the People's Republic of China and the Republic of Korea - and four observers - Indonesia, the Philippines, Thailand and Vietnam.

AFoPS intends to promote the highest level of cooperation between Asian countries in polar issues, to enlarge the activities of non-traditional polar countries in Antarctica and to increase the numbers of Asian states that become Antarctic Treaty Consultative Parties (ATCP). The Philippines, Thailand and Vietnam that nowadays have an observer role in the AFoPS are countries without a strong polar background.

After twelve years of operation, the role of AFoPS within the wider Antarctic geopolitical framework has not yet been studied from a scholarly perspective.

In order to understand the impact of AFoPS on Antarctic geopolitics and operations, it is important to assess the perspectives and roles of all the countries that are currently, or will be in the future, AFoPS members. I will focus on two principal pathways of inquiry that are the connection with other international actors operating in Antarctica, and the analysis of the relations and cooperation within AFoPS.

Understanding Asian countries current and planned Antarctic activities is fundamental in order to comprehend and analyse how their presence in Antarctica is evolving and how this might shape the future of human engagement with the continent, with special consideration given to the priorities these countries set for their Antarctic activities as well as their level of international relations within and beyond the Antarctic Treaty System - around 10% of the ATS members are Asian countries.

In addition, considering the reach AFoPS could have in Asia, it is important to investigate which Asian countries that are not currently Antarctic players or have not a strong polar background would have the potential to undertake Antarctic expeditions and commence Antarctic research programmes and how their presence could change the balance of power on the ice.

Looking into the future, the potential for the Protocol on Environmental Protection to the Antarctic Treaty to be reviewed in 2048 by anyone of the original signatories – there are 4 in AFoPS - could open new opportunities for states, and especially for those Asian states that are interested in exploiting Antarctica's resources. It is possible that many nations are now conducting Antarctic research with the principal aim to be ready to act in the changed world from 2048, and we need to understand the potential role that AFoPS may play in this context.

The research proposed here attempts to address this gap of knowledge and aims at analysing how the growing importance and impact of Asian countries, through AFoPS cooperation, could modify the balance of power in, and with regard to, Antarctica.



## **S39. Antarctic research and the media, Meeting Room 409, August 25, 2016, 11:30 AM - 1:30 PM**

### ***'Between tweets and Hashtags': The use of Social Media platforms by National Antarctic Programmes***

**Gabriela Roldan<sup>1</sup>**

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In the era of globalization, alternative online media platforms have become a common and acceptable source for news and information. Newsworthy and breaking news stories published online are progressively becoming the primary source of information for members of the public in most western Countries. Online media platforms reach a wider audience in real time where remote places and events are accessed from distant locations. Information and misinformation get updated and spread rapidly to and by the online audience.

The rise and popularity of Social Media platforms has been well documented. Social Media users are active members of an imagined community where they share information and express emotional connections with the topic of discussion.

Media, in its traditional and emerging online platforms, have assisted Antarctic States to inform the public on events, scientific advances and current topics concerning Antarctica. Moreover, images of polar landscapes, compelling fauna and the perils of performing scientific research in a hostile environment contributes to create and re-create a desire image of Antarctica to the public.

This paper analyses the use of Facebook and Twitter by two Antarctic National Programmes from Antarctic claimant states: Chile and New Zealand. The discussion centres on the extent to which these mediums are used to inform, educate and disseminate Antarctic information relevant to their nationals. A cluster of Facebook posts, Twitter messages and hashtags are being compared to create topic ranking, original production, repetition and redundancy of the information provided in Social Media by the two case studies.

## ***How can we tell a good story ? Challenges and opportunities to communicate science***

**Taina De Luccas**<sup>1</sup>

<sup>1</sup>*University of Campinas, , Brazil*

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How can we tell a good story about the scientific issues? How can we bring up attractively a research to the public? How can we spread a scientific breakthrough in order to make people aware ? These questions have always persued our work and research of science communication and continue to be a major challenge. As science communicators, we are concerned about transmitting scientific knowledge clearly and easily, taking part of the people and society's lives. Therefore, in our work, we have been looking for breaking out scientific topics from cliches and stereotypes. What has been attributed to scientists who live in their labs and study complex formulas; showing the scientists as a truthly explorers and adventurers, who cross llimits among extreme environments, searching for the discovery of new knowledge and loving science. In our projects of science communication, we aim to bring media elements and entertainment in order to create and develop more compelling stories to the public, without, however, being far from data and generation of qualified scientific information. One of our current projects is the creation of an audiovisual serie to show the scientific research conducted in places of difficult access. We choose to place one of the episodes in a brazilian glaciological research conducted in Antarctica, particularly in the study of ice cores (which cross Antarctica until the geographic South Pole, collecting data in order to discover the history of atmospheric composition of the planet stored on ice for thousand years). Then, how can we tell a good visual story about these studies? Therefore, we make a scientific and creative writting around the communication strategies that can bring new elements to develop a narrative taking into account the aesthetic features of Antarctica and the research's content. We plan to consulte communication studies for the script, lift the elements for giving strength to the story, besides approach studies about aesthetics (such as the importance of understanding the images while sensations blocks. Deleuze, 2009), to the interference of the scene colors, among others. These actual studies integrate my doctoral research, in progress at the University of Campinas (Unicamp, Brazil) and it is also part of some science communication activities in Antarctica, in which I have been taking part for more than 10 years as a journalist and communicator.

## ***Seven Worlds – The Next BBC Landmark Series***

**Michael Becker**<sup>1,2</sup>, Crowley T<sup>1</sup>, Devas F<sup>1</sup>

<sup>1</sup>*British Broadcasting Corporation (BBC); Natural History Unit, , United Kingdom* , <sup>2</sup>*Center for Macroecology, Evolution, and Climate; University of Copenhagen, , Denmark*

(Email: michael.becker@bbc.co.uk)

The creators of films such as Planet Earth and Frozen Planet are pleased to announce a new, ambitious BBC Natural History Unit landmark series called Seven Worlds. Set to air on UK's BBC1 in 2019, and globally in 2020, Seven Worlds will be a stunning science-based series about the seven continents.

We will feature seven 1-hour episodes with each episode focusing on the unique geography and wildlife of each continent. We'll view each continent through their greatest natural wonders: the Congo, the Amazon, the Sahara, the Himalayas, the Trans-Antarctic Mountains and more. These remarkable landscapes have given rise to spectacular animal behaviour and earth system processes. This gives each a distinct character that has a fundamental consequence for life on each of our seven "worlds". By focusing on the dramatic wildlife stories in these iconic landscapes, we'll discover what makes each of our seven continents unique and we'll show that where you live makes all the difference.

In our talk today, we will focus on what is being planned for the Antarctic episode of our series – the ways in which Antarctica is being looked at, what subjects are currently being considered for film, avenues of scientific research that we are interested in developing sequences for, and the message we hope to convey through our series.

Additionally, we would like to invite all interested conference participants to contact us (during the conference or after) about any novel, neglected, or groundbreaking Antarctic science they would like to see on our next series.

## **S19. Antarctic volcanism, Meeting Room 410, August 25, 2016, 3:30 PM - 4:45 PM**

### ***Contrasting glacial and interglacial Early Miocene palaeoenvironments deduced from the two southernmost volcanoes in the world***

**John Smellie**<sup>1</sup>, Kurt Panter<sup>2</sup>, Jenna Reindel<sup>2</sup>

<sup>1</sup>University of Leicester, Leicester, United Kingdom, <sup>2</sup>Bowling Green State University, Bowling Green, USA

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The two southernmost volcanoes in the world are situated at 87°S and 2500 m a.s.l. at the head of Scott Glacier, Transantarctic Mountains. They have Early Miocene published ages (c. 19 and 16 Ma). Both volcanoes were originally interpreted as glaciovolcanic at a time when glaciovolcanism was poorly understood. Initial results of a reinvestigation of both sites in 2015 has determined that only one is unequivocally glaciovolcanic. It shows evidence for eruption beneath an ice sheet that had a palaeo-surface about 500 m higher than the modern Scott Glacier and was thus capable of overtopping the surrounding Transantarctic Mountains. Such a scenario is consistent with published speculative interpretations of  $\delta^{18}\text{O}$  values of benthic foraminifera and Early Miocene clast distributions in AND-2A drillcore but the new results, reflecting inland ice conditions at a high-elevation location, comprise the first unambiguous evidence for a thicker-than-modern East Antarctic Ice Sheet determined directly on the Early Miocene ice sheet itself. The second outcrop overlies a highly uneven granitoid surface eroded by wet-based ice but the volcanic sequence cannot easily be explained as glaciovolcanic. Instead it is a small monogenetic subaerial basaltic shield with a gently sloping surface profile constructed around a tuff cone core. The overall morphological and lithofacies characteristics more closely resemble a volcanic edifice unconfined by coeval ice and constructed in a surface lake, an interpretation that is currently being further investigated. Our results for both outcrops illustrate once again how powerful investigations of volcanic rocks can be in determining palaeoenvironmental conditions in Antarctica (and elsewhere).

## ***Late Pleistocene-Holocene volcanic activity in northern Victoria Land recorded in Ross Sea (Antarctica) marine sediments***

**Paola Del Carlo**<sup>1</sup>, Alessio Di Roberto<sup>1</sup>, Gianfranco Di Vincenzo<sup>2</sup>, Antonella Bertagnini<sup>1</sup>, Patrizia Landi<sup>1</sup>, Massimo Pompilio<sup>1</sup>, Ester Colizza<sup>3</sup>, Guido Giordano<sup>4</sup>

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Eight pyroclastic fall deposits have been identified in cores of Late Pleistocene-Holocene marine sediments from the Ross Sea (Antarctica), and their components, granulometry and clast morphologies were analysed. Sedimentological, petrographic and geochemical analysis of clasts, with <sup>40</sup>Ar-<sup>39</sup>Ar dating of alkali feldspar grains, indicate that during this period at least five explosive eruptions of mid to high intensity (plinian to subplinian) occurred, and that three of these eruptions took place from Mount Melbourne volcanic complex, between 137.1±3.4 and 12 ka.

Geochemical comparison of the studied tephra with micro- and crypto-tephra recovered from deep Antarctic ice cores and from nearby englacial tephra at Frontier Mountain indicates that eruptive activity in the Melbourne Volcanic Province of northern Victoria Land was intense during the Late Pleistocene-Holocene, but only a general area of provenance for the majority of the identified tephra can be identified.

## ***The Mount Erebus (Ross Dependency – Antarctica) magmatic system from surface to source: insights from magnetotelluric measurements***

**Graham Hill**<sup>1,2,3</sup>, Phil Wannamaker<sup>4</sup>, Erin Wallin<sup>1</sup>, Martyn Unsworth<sup>5</sup>, John Stodt<sup>6</sup>, Virginie Maris<sup>4</sup>, Michal Kordy<sup>4</sup>, Daniel Uhlmann<sup>7</sup>, Yasuo Ogawa<sup>8</sup>

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Erebus volcano, Antarctica, in New Zealand's Ross Dependency, offers a unique opportunity to understand the internal works of a volcano, the origin of alkalic magmas, and crustal rifting within West Antarctica. Erebus has the world's only active phonolite lava lakes in its summit crater, and this provides a unique window into the heart of an active degassing volcano's magma chamber. Phonolite magmas such as those at Erebus have been responsible for devastating eruptions (e.g. Pompeii 79 AD; Tambora 1815). We are using magnetotelluric (MT) methods, developed by our team for use in Antarctica, to image the volcano and its underlying magmatic system. In addition we are mapping the rifted crustal structure and examining the mantle source of the magma and the role that the Terror Rift system plays in the active volcanism. Petrologic models suggest that Erebus is undergoing fractional crystallisation of deep mantle derived parental basanite magma in crustal magma chambers. We have just completed our second successful field season, and have now completed measurements at 95 of 134 planned measurement locations on Mount Erebus and the greater Ross Island region. The data collection utilised a pool of 11 Phoenix Geophysics V5 systems belonging to the Tokyo Institute of Technology, the University of Alberta, and Missouri State University; coupled with Numeric Resources high impedance preamplifiers belonging to the University of Utah. Preliminary modelling suggests that we are able to resolve the crustal residence zones and the path taken by the magma as it ascends from mantle depths to the surface. Our work provides new insight into the formation of phonolite magma; our findings have implications for understanding the magmatic process occurring in rift systems globally. It provides the opportunity to compare the processes associated with volcanism in both compressional and extensional tectonics settings.

## ***Volcanism on Heard Island, the southern Indian Ocean.***

**Jodi M Fox**<sup>1</sup>, Rebecca J Carey<sup>1</sup>, Jocelyn McPhie<sup>1</sup>, Fred Jourdan<sup>2</sup>

<sup>1</sup>*Discipline of Earth Sciences, School of Physical Sciences, University of Tasmania, Hobart, Australia,* <sup>2</sup>*Western Australian Argon Isotope Facility, Department of Applied Geology & JdL Centre, Curtin University of Technology, Perth, Australia*

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Heard Island is a sub-Antarctic volcanic island in the southern Indian Ocean, and includes Australia's only active volcano. Mawson Peak, atop of Big Ben, is the current centre of eruptive activity. Located on the Central Kerguelen Plateau, Heard Island is the southernmost subaerial exposure of the plateau. The Kerguelen Plateau is a large igneous province formed as a result of the activity of the Kerguelen Plume over the last 130 Ma (Coffin et al 2002). The Kerguelen Plume is understood to be driving the intraplate volcanic activity at Heard, McDonald and Kerguelen Islands (Weis et al 2002).

Heard Island is heavily glaciated and subject to high winds, snow, and wet conditions. There is no permanent station on the island. Monitoring of volcanic activity on Heard Island is restricted to intermittently collected satellite data and observations made from infrequent passing ships or even less frequent landing parties. The most recent observed eruption was viewed from the RV Investigator during the January 2016 Institute for Marine and Antarctic Studies research voyage to the Heard and McDonald Islands region.

Due to its isolation there is no published map of Heard Island and a limited understanding of the volcanic history of Heard Island. In order to unravel the volcanic history of Heard Island, we have located and reviewed published and unpublished data and reports, modern satellite images, and personal and public rock collections. This information is the basis of a new geological map of Heard Island. The geological map has defined geological spatial relationships on Heard Island and will serve as the foundation for future field-based geological research.

Big Ben is the largest volcano on Heard Island (2813 m high, 18 km diameter). Exposed lavas are dominated by basanite, basalt, and trachybasalt compositions (Stephenson et al. 2006). Historic eruptions have produced relatively small (500 m-8 km), lavas from Mawson Peak. The production of these lavas has seen the summit height increase by 65 metres over the last 30 years. Laurens Peninsula lies to the west of Big Ben and consists of three volcanic peaks. The tallest is Mt Dixon (775 m), a volcanic dome of unknown age. Laurens Peninsula lavas are mainly trachyte and basanite (Quilty & Wheller 2000).

We have dated selected basanite and trachyte lavas from Laurens Peninsula using <sup>39</sup>Ar/<sup>40</sup>Ar technique. Observations in the field led to the interpretation that trachyte lavas on Laurens Peninsula were erupted prior to the development of Mt Dixon as an eruption centre after which time mainly basanite lavas were erupted (Barling 1990). Our age results for the basanites ( $76.6 \pm 5.5$  ka and  $12.6 \pm 1.7$  ka) and trachytes ( $14.2 \pm 1.9$  ka,  $14.4 \pm 1.2$  ka) reveal that the eruption of basanites has occurred both before and after the eruption of trachytes.

The new isotopic age results and geological map form the beginnings of a modern interpretation of volcanism on Heard Island.

## ***Melt origin across a rifted continental edge: $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology, geochemistry and Sr-Nd-O isotope systematics of alkaline basalts, northwestern Ross Sea***

**Kurt Panter**<sup>1</sup>, Pat Castillo<sup>2</sup>, Susan Krans<sup>3</sup>, William McIntosh<sup>4</sup>

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Alkaline magmatism in the northwestern Ross Sea (NWRS) has been recently expanded to include numerous seamounts on the continental shelf and hundreds more located within the oceanic Adare Basin. The seamounts are Pliocene-Pleistocene in age and petrogenetically akin to the mostly mid-late Miocene volcanism on adjacent land in the West Antarctic rift system as well as to a much broader region of long-lived diffuse alkaline volcanism that altogether encompasses West Antarctica, Zealandia and eastern Australia. All of these regions were contiguous prior to the breakup of Gondwanaland at about 100 Ma, suggesting that the magmatism has a common mantle source. However, the origin of this source and the cause of melting remains controversial. The NWRS offers a unique perspective in which to evaluate melt origin by providing geochemical and isotopic data from basalts erupted across the transition from oceanic lithosphere to thinned continental lithosphere adjacent to the thick East Antarctic craton. Major and trace element concentrations as well as isotopes of strontium, neodymium and oxygen in mafic NWRS lavas (> 7 wt.% MgO) vary systematically across the boundary from land to sea, suggesting a gradational change in the composition of their mantle source. Their low volume and geochemical characteristics indicate low mantle potential temperatures (i.e. no hotspot or plume) and edge driven buoyant flow between young thin and old thicker lithosphere is the likely trigger for melting. The pattern of volcanism in the NWRS is controlled by rift related structures, including steep normal faults formed during the youngest phase (Pliocene to present) of tectonic activity in the Adare Basin.



## **S14. Antarctic climate variability during the past two millennia, Meeting Room 410, August 25, 2016, 5:00 PM - 6:00 PM**

### ***A 125-year record of climate and chemistry variability on the Pine Glacier ice divide, Antarctica***

Franciele Schwanck<sup>1</sup>, **Jefferson Simoes<sup>1</sup>**, Michael Handley<sup>2</sup>, Mayewski Paul<sup>2</sup>, Jeffrey Auger<sup>2</sup>, Ronaldo Bernardo<sup>1</sup>, Francisco Aquino<sup>1</sup>

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The Mount Johns ice core (79°55'S; 94°23'W; 2,100 m a.s.l., 15 m temperature = -33°C) was collected near the Pine Island glacier ice divide in the West Antarctica ice sheet during the 2008–2009 austral summer, reaching 92.26 m. The upper 45 m of the record covers approximately 125 years (1883–2008) and shows marked seasonal variability. The trace elements concentrations in 2,137 samples were determined using inductively coupled plasma mass spectrometry (ICP-SFMS). Natural contributions from dust, mainly derived from the arid areas of Australia, New Zealand, and Patagonia, are important sources for aluminum, magnesium, and titanium. Marine aerosols from sea ice are important sources of sodium, strontium, potassium, sulfur, and calcium. Barium, iron, and manganese show considerable contributions of continental dust and marine aerosols. The backward trajectory models show a clear seasonal signal, summer/fall and winter/spring, with strong transport from the west all year round, and secondary transport to the southwest in the summer/fall. The trace elements concentrations in the Mount Johns core, in the 1979–2008 period, are correlated to the transport of marine aerosols from the tropical Pacific and the sea ice cover in the Amundsen/Bellingshausen seas area, they are strongly influenced by climate conditions, such as sea surface temperature anomalies and circulation changes. Our results also show significant enrichment in arsenic concentrations due to human activities. Before 1900 the mean concentration was approximately 1.92 pg g<sup>-1</sup>, rising to 7.94 pg g<sup>-1</sup> in 1950. This enrichment is directly related to mining emissions and casting of non-ferrous metals in South America, mainly in Chile. The decrease in the arsenic concentration, observed in the twenty-first century (mean concentration of 1.94 pg g<sup>-1</sup> after 1999) is interpreted as a consequence of the introduction of environmental laws (in 1994) to reduce emissions of this element during the copper mining and smelting in Chile.

## ***Reconstructing southern hemisphere westerly winds from sub Antarctic Marion Island***

**Bianca B Perren**<sup>1</sup>, Dominic A Hodgson<sup>1</sup>, Stephen J Roberts<sup>1</sup>, Louise C Sime<sup>1</sup>, Claire S Allen<sup>1</sup>, Wim van Nieuwenhuyze<sup>2</sup>, Elie Verleyen<sup>2</sup>, Wim Vyverman<sup>2</sup>, Krystyna Saunders<sup>3</sup>

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Changes in the strength of the Southern Hemisphere westerly winds (SHW) influence Southern Ocean circulation and have the potential to alter its effectiveness as a global CO<sub>2</sub> sink. Despite a recent increase in the strength of the SHW, little is known about their long-term dynamics and influence on the carbon cycle. In this project, we track the variability of the SHW over the late Holocene, using diatom-salinity reconstructions and geochemical data from lake sediments on subantarctic islands Marion, Macquarie, and Hermite.

Here, we present three multiproxy lake sediment records from the western flank of Marion Island, which span the last ~2 ka BP. On Marion Island, SHW dominate the regional climate (>100 days with gale force winds year<sup>-1</sup>, ~2000 mm precipitation year<sup>-1</sup>) and terrestrial environments on the western side of the island have elevated salinity from wind-driven sea spray, compared with the more protected leeward side. This elevated salinity forms the basis of a diatom-based conductivity transfer function with which we track salinity and wind strength back through time. ITRAX-based geochemistry, %C, %N, δ<sup>13</sup>C, hyperspectrally-inferred chlorophyll, and diatoms all track the evolution of these lakes and their response to changing wind regimes over the last few thousand years. Proxies in the cores from each of the lakes document a marked shift towards greater influence of the SHW beginning c. 500 yr BP, with increased moisture availability, increased diatom-inferred conductivity, elevated carbon and chl-a values, enriched δ<sup>13</sup>C, and decreased minerogenic matter. While each of the lakes has a different response to changing wind regimes, the lake records document a coherent island-wide paleoclimate signal.

## ***Late Holocene climate shifts inferred from peat records in coastal region of the western Antarctic Peninsula***

**Zicheng Yu**<sup>1</sup>, Julie Loisel<sup>2</sup>, David Beilman<sup>3</sup>

<sup>1</sup>Lehigh University, Bethlehem, United States, <sup>2</sup>Texas A&M University, College Station, United States,

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The western Antarctic Peninsula (WAP) is one of three regions on Earth that have experienced the greatest warming over recent decades. Here we used paleo records from fossil mosses and peats on the WAP to explore a new paleoclimate archive that links climate, cryosphere and ecosystem dynamics for reconstructing climate change in recent millennia. Continuing retreat of ice and permanent snow has recently exposed numerous entombed mosses and intact peatbank ecosystems along the WAP around 65°S latitude that have been buried under ice and snow during the cold “Little Ice Age” (LIA). Radiocarbon dating analysis indicates ages of 850-600 cal yr BP of re-exposed moss samples from retreating ice and of 100 cal yr BP from shrinking snow. This age difference suggests that initial climate cooling and subsequent ice advance overran peatbanks immediately below the ice margin at the onset of the LIA, followed by permanent snow expansion often from low elevation upslope at the end of the LIA. Furthermore, detailed macrofossil and pollen analysis of a peat core from a moss peatbank on nearby mainland Antarctic Peninsula (Cape Rasmussen) show dramatic shifts from a waterlogged peatland dominated by pure stands of Antarctic hairgrass (*Deschampsia antarctica*) before the LIA at 2400-800 cal yr BP to an aerobic peatbank dominated by erect mosses *Polytrichum strictum* and *Chorisodontium aciphyllum* or *Pohlia* in the last 50 years. At present the nearest known occurrence of *Deschampsia* “bog peats” is in South Georgia, about 1900 km north at 54°S, a location having a mean annual temperature 6°C higher than the study region on the WAP. If we use this modern spatial relationship as an analogue, then this suggests that the climate a few centuries ago was much warmer (up to 6°C) than today, supporting very different ecosystems on the WAP. Our results show that these re-exposed sub-fossil mosses and peats are potentially very useful for the reconstructions of coastal low-elevation terrestrial climates. These records will not only complement climate histories as we learn mostly from marine and ice core records but also provide more relevant environmental information for understanding animal and ecosystem dynamics on the WAP.

## ***High-resolution Holocene climate records from Discussion Lake of Larsemann Hills, East Antarctica: organic geochemistry and diatoms as proxy***

**Mahesh Badanal**<sup>1</sup>, Anish kumar Warriar<sup>1</sup>, Abhilash Nair<sup>1</sup>, Rahul Mohan<sup>1</sup>, Manish Tiwari<sup>1</sup>  
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Pristine freshwater lakes of Antarctic ice-free regions are excellent source of past-climate records. The sediments in these pristine lakes are natural archives of past-climate variations. The lake sediments are source to many physico-chemical and -biological proxies which are extensively used in the recent to reconstruct the natural variability of climate in Antarctica by using these paleolimnological records. High-resolution sediment records are rather rare which are limited to ice-cores. However, here we present a high-resolution lake sedimentary records based on elemental (C%, N% and C/N), isotopic ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ ) variations of organic carbon and diatom variation and abundance for the last 2000 years from a 65 cm radiocarbon dated sediment core retrieved from Discussion Lake, a near-coastal lake of Larsemann Hills, East Antarctica. Through these records, we try to understand the local climate of Larsemann Hills and the influence of region climate over the region. The contents of the sedimentary organic matter (OM) proxies (Corg  $\sim 7 \pm 0.2\%$ , C/N ratios  $\sim 12 \pm 5$  and  $\delta^{13}\text{C}_{\text{COM}} \sim -18 \pm 6\text{‰}$ ) indicate that the OM in this lake sediment is a product of mixing of terrestrial and lacustrine biomass. The organic proxies indicate the dominance of autonomous productivity in the lake with contribution from the organic matter from the catchment area. The most abundant diatom species for the last 2000 years is *Stauriforma inermis* (freshwater specie) followed by *Pinnularia microstauron* (littoral specie) and *Amphora veneta* (brackish water specie). The presence of well developed algal mat and high abundance of diatom taxa *S. inermis* throughout the sediment core indicates that discussion lake was free of permanent ice cover. The near absence or lower abundance of brackish water species *A. veneta* probably suggest a decreased meltwater inputs from catchment regions and quasi constant lake levels.

**S03. Sustained efforts for observing, mapping and understanding the Southern Ocean and its role in current and future climate D4, Meeting Room 404, August 25, 2016, 3:30 PM - 6:00 PM**

***Benchmarking Antarctic and Southern Ocean marine ecosystems in 2022 for assessing change: advancing the Census of Antarctic Marine Life.***

**Andrew Constable**, Oscar Schofield, Anna Wahlin, Sebastian Swart, Louise Newman

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A great challenge for Southern Ocean ecosystem science is to assess the overall status and trends of Southern Ocean marine ecosystems, providing a baseline against which change in ecosystem structure and function can be unambiguously assessed in the future. A range of management and policy bodies require baseline data and assessments, both regionally and globally, such as for setting catch limits and conservation actions in the Commission for the Conservation of Antarctic Marine Living Resources and for assessing long term implications of change by the Intergovernmental Panel on Climate Change. The Southern Ocean Observing System is developing sustained observations of physics, chemistry and biology of the Southern Ocean to underpin estimates of change in the region. This presentation will detail an initiative of the Southern Ocean Observing System to benchmark the ecological status of Southern Ocean ecosystems, which aims to provide the foundation for circum-Antarctic assessments of change in the future. It will build on the comprehensive assessment of the marine biogeography of the region by the Census of Antarctic Marine Life. It will use observations from satellites, ships (physics, chemistry, biology), land-based observations of predators, and remote platforms such as gliders and moorings, to develop an integrated view of the state of the ecosystem from protists to whales. The design of the core activities are intended to help link time-series of observations from the past with a co-ordinated set of observations to be made in the future. Products are intended to further advance the SCAR Biogeographic Atlas of the Southern Ocean, support an updated assessment of the state of the ecosystem, and support the use of ecosystem models for assessing ecosystem scenarios for the future.

## ***Coupling biophysical processes at fine-scale: Development of a specific tool for identifying marine hot-spots in the face of climate change***

**Malcolm O'Toole**<sup>1</sup>, Cedric Cotte<sup>2</sup>, Mark Hindell<sup>3</sup>, Francesco d'Ovidio<sup>1</sup>

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Compared to the terrestrial environment the open ocean is seemingly homogeneous, though in reality the marine biophysical environment is highly dynamic on both spatial and temporal scales. Remote sensing promotes a better understanding of physical mechanisms shaping the marine environment, and addresses major challenges with protecting and monitoring these inaccessible regions. From an ecological perspective, marine physics is important because lower-trophic-level resources (i.e. plankton) are strongly structured by nutrient-rich oceanographic features such as fronts, eddies and filaments. These features are also likely to be ideal foraging habitat for upper-trophic level groups, such as top marine predators searching for prey. However, we cannot interpret satellite-derived maps in terms of resources, habitat vulnerability, and climate change if we do not incorporate biological data.

Marine predators are sensitive to natural and anthropogenic-induced environmental change, making them useful sentinel species of the ecosystem. Consequently, the resilience and response of top predator populations to resource variability is an ongoing question in marine ecology. Recently, SCAR's Expert Group on Birds and Marine Mammals (EG-BAMM) established the Retrospective Analysis of Antarctic Tracking Data (RAATD) project, which compiled telemetry tracks of Antarctic predators, including over 2000 individuals from 10 species (includes seals, penguins and flying seabirds). These species are particularly useful because they interact with important frontal features of the open ocean while carrying multiple sensors that record an individual's location, behaviour and surrounding environment (e.g. temperature and salinity). An important goal of EG-BAMM is to make use of these data to identify areas of ecological significance (AES) in the Southern Ocean. We saw an opportunity to apply new analytical techniques, developed at Laboratoire d'Océanographie et du Climat: Expérimentation et Approches Numériques (LOCEAN) in Paris, to these data to understand the impacts of complex fine-scale physical ocean dynamics on these AES. This comes at a time when signs of important changes are being observed in the Southern Ocean, and when concerns about the conservation of the region are increasing (e.g. managing future fisheries; Constable et al., 2014).

The RAATD data collected from the Kerguelen Plateau region – including marine predator tracks, their dive profiles and surrounding in situ environmental conditions (temperature, salinity and fluorescence) – were used to construct multi-species habitat models to identify AES. We have used contemporary diagnostic tools for altimetry satellite data to identify key fine-scale oceanographic features encountered by focal marine predators. This information has been used to validate and extrapolate multi-species habitat models to understand underlying physical mechanisms and predict future ecological trends in the context of climate change. Here, I will present analyses of key marine habitat for multiple species feeding east of the Kerguelen Plateau, and discuss diagnostic tools used to understand physical mechanisms influencing AES.

Studies at these resolutions are critical for improving global circulation models and making ecological predictions in the face of future climate change impact. Added benefits include fostering innovation, generating new research directions in both disciplines and the development of new satellite remote sensing products.

## ***Southern Annular Mode and ENSO on chlorophyll anomalies in the Antarctic zone of Indian sector of Southern Ocean during summer***

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### **Abstract**

The Southern Annular Mode (SAM) and El Nino-Southern Oscillation (ENSO) are independent climate modes, which frequently co-occur, influencing the Antarctic sea-ice and driving significant changes in the Southern Ocean (SO) at interannual time scale. The Antarctic Zone (AZ), south of the Polar Front, of the SO is generally considered as a high nutrient low-chlorophyll region, and iron (Fe) availability is considered to be the major constraint for limiting chlorophyll production in this area. Also, the chlorophyll variability in this zone is predominantly driven by the sea-ice melt water which provides an additional source of Fe and enhancing the chlorophyll. In the present study, we have used 20-years (1995-2014) of satellite derived chlorophyll, sea surface temperature (SST), winds, merged Sea Level Anomaly (SLA), ocean surface currents and sea-ice data to study the chlorophyll anomalies associated with these two climate modes in the AZ. Large chlorophyll anomalies were noticed in the AZ during the periods 1999-2000 and 2011 and these years are found to be coinciding with intense La Nina and positive SAM events. Southward shift of westerlies, intense colder SST and air temperature anomalies, anomalous Ekman transport, large sea-ice coverage were also noticed in the AZ in association with these events. Our results suggest that SAM and ENSO cause significant variability in chlorophyll of the AZ through their influence on hydrography as well as its sea-ice teleconnection. Resolving the effects of these events on chlorophyll may help us to improve our understanding on the implications of these chlorophyll anomalies on CO<sub>2</sub> sequestration in the AZ.

## ***Long-term monitoring of the Antarctic coastal benthos with non-destructive techniques: the ICE-LAPSE project at Terra Nova Bay (Ross Sea, Antarctica)***

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The PNRA (Italian National Antarctic Research Program) project ICE-LAPSE (PNRA 2013/AZ1.16) aimed at creating a network of permanent monitoring stations for the study of Antarctic benthos at Terra Nova Bay (TNB, Ross Sea) by using novel technologies and non-destructive methods. The collected data will be of fundamental importance in establishing a reference base line for this area to measure future changes and study the dynamics in the benthos in the short and long-term.

All sampling activities of the project took place in November-December 2015 and, in the specific, these were:

- 1) HD video recording along fixed transect in order to start a monitoring program of TNB macrobenthos
- 2) Short-term study (24-48h) of benthos dynamics by using time-lapse video recording
- 3) Placement of a long-term, time-lapse video recording system to study the benthos dynamics for one year
- 4) Placement of ARMS (Autonomous Reef Monitoring Systems) structures to study settlement
- 5) Placement of probes for environmental parameters (T, salinity, light intensity)

The elaboration of preliminary data from the video transects demonstrated the possibility of obtaining 3D models of the bottom through photogrammetric techniques. The details of the images easily enable the count of invertebrates and also the evaluation of the shape and volume of large invertebrates such as sponges with an unprecedented level of detail. Long-term videorecording will end with the next Antarctic expedition (November-December 2016) and no data are available at the moment. Short-term videorecording instead showed a clear and unexpected circadian light regime.

The technology developed in this monitoring program, due to its non-destructive nature and relatively low costs, can be of wider application to other Antarctic areas. As such, it was proposed to the SCAR ANTOS working group as an effective monitoring tool of the Antarctic coastal benthos.



## ***The seasonal distribution and controls of bioactive trace elements cadmium and cobalt in the southern ocean, Atlantic sector.***

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This study reports on the meridional and seasonal variation of trace metals in the Southern Ocean where a high-nutrient low-chlorophyll (HNLC) paradox subsists. The seawater collection method – an adaptation of the GEOTRACES method – facilitated the collection of uncontaminated seawater samples during the austral summer and winter (2015). A SeaFAST™ system coupled with ICP-MS, allowed the accurate and precise quantification of up to 10 trace elements (Al, Zn, Cu, Fe, Mn, V, Cd, Co, Pb and Ni) simultaneously. Here we report on the distribution and controls of Co and Cd in different water masses in the Atlantic Sector of the Southern Ocean – located proximal to the SAF (46°S), the AAZ (54°S) and south-eastern Weddell Gyre (65°S). The depletion of dissolved Co (DCo) and Cd (DCd) in the sub-surface euphotic layer can be attributed to biological uptake by marine phytoplankton. DCd exhibits a typical nutrient-like profile, with biological uptake in the sub-surface and conservative behaviour thereafter. The concentrations ranged from  $125 \pm 3.8$  pmol/kg to  $836 \pm 6.1$  pmol/kg. The Cd/P surface correlation ( $R^2 = 0.94$ ) in the Weddell Gyre exemplified that biological utilization was proportional to phosphate. Conversely DCo demonstrated a typical hybrid-type vertical distribution – nutrient uptake and remineralization in the sub-surface succeeded by scavenging due to an affinity for organic complexation. The concentrations ranged from  $9.46 \pm 0.12$  pmol/kg to  $38.4 \pm 1.4$  pmol/kg. High surface DCo concentrations and a poor but significant DCo/salinity correlation ( $R^2 \leq 0.301$ ) suggest atmospheric input as a source for DCo. Further, an inter-calibration station was performed at 54°S. The locale at 46, 50 and 54°S will form the centre of a seasonal comparative effort aimed at establishing the role of marine phytoplankton on trace metal cycling and vice versa. Ultimately the study will report the interpreted data from 10 stations in the Southern Ocean, Atlantic Sector. Additionally, particulate samples (pTM) – collected during the austral summer using McLane pumps – will be analysed. The pTM sample stations coincide with the dissolved fraction stations enabling the evaluation of the interactions between the particulate fraction and the dissolved fraction. The elucidation of these interactions will advance the understanding of trace metal cycling and source regions in the Southern Ocean. The geochemistry of the pTM samples will be established by coupling acid digestion – HF, H<sub>2</sub>SO<sub>4</sub>, HCl and HNO<sub>3</sub> – with ICP-MS analysis. Further, the study will report on the geomorphology of the nanoparticles and establish to what extent this controls the behavioural characteristics of particles in the ocean.

## ***Surface and intermediate water oxygen isotope ratio variations in the southern ocean: Implications to hydrography of the region***

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Oxygen isotope ratio and its relationship with salinity can play a significant role in understanding the hydrography of a region. In the Indian Ocean sector of the Southern Ocean, very few studies have been carried out that have measured oxygen isotope ratios, especially from the intermediate depths, resulting in a major knowledge gap in the area. In this regard, over the last few years, we have collected and analysed water samples from the surface as well as the intermediate water depths (till 1000 m) of the Southern Ocean. The oxygen isotope analyses have been carried out at the Marine Stable Isotope Lab of NCAOR, Goa, India. We identify five distinct water masses based on oxygen isotope ratio and salinity data of the surface water collected from the Indian Ocean and the Southern Ocean. We obtain more representative oxygen isotope-salinity relationship as we have separated the data pertaining to different water masses. Additionally, to account for temporal variability in oxygen isotope-salinity relationship, we have plotted our data along with that of the previous studies corresponding to the water masses identified in the present study. We observed the presence of Subtropical Front and Polar Front at 44°S and 56°S respectively. Additionally, water samples from depths till 1000 m were collected at six stations from discrete depths across various fronts of the Southern Ocean. We observed signatures of a warm-core eddy extended from 40 to 44 °S and 56 to 59.5 °E. It consisted of Subtropical Surface Water (STSW). Other water masses identified were the Antarctic Surface Water (AASW), Antarctic Intermediate Water (AAIW), and Upper Circumpolar Deep Water (UCDW) based on the salinity, temperature and oxygen isotopic ratios. The slope of the oxygen isotope-salinity relationship indicates that the water in the warm-core eddy was derived from a region dominated by evaporation/precipitation while the water surrounding the eddy came from a region dominated by melting/freezing. The shoaling of AAIW up to water depth of 500 m was observed along the transect. The present dataset offers to bridge the existing gap in the present global grid of the oxygen isotope data set. The oxygen isotope-salinity relationships thus obtained can be used to reconstruct paleo-salinity in the study region as it provides a more accurate relation.

## ***Mid-20th century intrusion of Circumpolar Deep Water on Ross Sea and Wilkes Land continental margins evidenced by stylaster-coral isotopic signals***

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Cold water, stylasterid coral communities are observed throughout the Southern Ocean on outer edges and upper slopes of continental shelves. Such locations are typically situated at frontal boundaries between shelf waters and upwelling water masses, thus resident corals are ideal archives for recording high resolution variability of local circulation over their lifespans. Densely populated coral hard grounds were located on both the outer shelf (~700 m) and upper slope (~1500 m) of the Ross Sea continental margin, East Antarctica. The local hydrography at this site consists of a portion of Modified Circumpolar Deep Water that upwells onto the shelf where it mixes with High Salinity Shelf Water, and flows back over the shelf break as higher density bottom water. Live corals of predominantly *Errina* sp. were collected via large box dredge at a depth range of ~500-1700 m aboard cruise NBP-07-01. Two *Errina* specimens (one from the outer shelf and another from the upper slope) were analyzed for stable carbon ( $\delta^{13}\text{C}$ ) and oxygen ( $\delta^{18}\text{O}$ ) isotopes and revealed high magnitude shifts in stable isotopic values; magnitudes much too large to reflect a temperature change, suggesting these trends reflect a forcing related to water mass presence. A subsequent radiocarbon analysis revealed the specimens becoming anomalously older towards the tips. These trends are notable as the anticipated trend was to become younger and reflect a "bomb spike" of young radiocarbon. These shifts to an older reservoir age suggest an increased intrusion of Circumpolar Deep Water (CDW), which retains a radiocarbon age of roughly 1400 yr. Additionally, growth rates of these specimens (~0.25 mm/yr) suggest that the intrusion event occurred within the last 100 yr. A later cruise, NBP-14-02, located stylasterid coral hard grounds on the upper shelf slope of Wilkes Land, Eastern Antarctica, where the local hydrography is similar to that of the Ross Sea shelf. Live corals were also collected via large box dredge from a depth range of 616-669 m, and a similar series of analyses were performed. Notably, the stable isotopic trends exhibit a shift in both  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  at a magnitude comparable to the Ross Sea corals. In addition, the radiocarbon analysis shows a trend of anomalously older ages towards the tip of the coral, supporting an increased intrusion of Circumpolar Deep Water at Wilkes Land around the same time as the Ross Sea intrusion. With the exception of corals from deeper sites (closer to the CDW source), an intrusion like this has been unprecedented in the last ~400 yr. Together, these coral specimens support a CDW intrusion over a wide geographical range, as evidenced in the Southern Annular Mode intensity index.

## ***The General Bathymetric Chart of the Oceans – a look at the world from an ocean’s perspective***

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The aim of the General Bathymetric Chart of the Oceans (GEBCO) is nothing less than to provide the most up-to -date, authoritative, publicly-available bathymetry data sets for the world’s oceans. Under the joint auspices of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, experts from around the world contribute time and effort to continuously update and improve GEBCO. Initiated in 1903 by an international group of geographers and oceanographers, under the leadership of Prince Albert I of Monaco, GEBCO has moved from a series of maps describing the shape of the ocean floor to digital maps and digital bathymetric models to be used in geographical information systems. The latest GEBCO product is a global gridded raster data set with a resolution of 30 arc seconds (GEBCO\_2014 Grid). These days, GEBCO is an important data set for ocean sciences providing key base data for e.g. ocean modeling and ecosystem studies.

GEBCO’s gridded bathymetric data can be downloaded from the British Oceanographic Data Centre (BODC) <http://www.bodc.ac.uk/projects/international/gebco/>

## ***How reliable are recent global atmospheric reanalyses over the Southern Ocean?***

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Thanks to their ability to synthesize a wide variety of meteorological data and “produce data where there are none”, nowhere are global atmospheric reanalyses more needed than over Antarctica and the Southern Ocean, where long-term records are few and far between. At the same time, because of the reduced observational constraint, nowhere else do reanalyses face more challenges, which can significantly reduce the reliability of their products. Most notably, the transition into the modern satellite era in 1979 greatly affected the skill of the NCEP-NCAR and ERA-40 reanalyses and explains why most reanalysis-based investigations of Antarctic climate change have since focused on the post-1979 period. The most recent generation of reanalyses has benefited from advances in numerical weather prediction, data rescue/quality-control and lessons learned from previous projects, all of which have improved their overall quality in the southern polar region. Alongside comprehensive reanalyses, recent data assimilation experiments using only surface or conventional observations have tried to overcome the “1979 barrier”, but other problems have become apparent, including the necessity to specify realistic ocean boundary conditions (sea ice, SST) around Antarctica prior to 1979. The presentation will provide an up-to-date assessment of the latest generation of global reanalyses over the Southern Ocean. The datasets covered will include ERA-Interim, CFSR, JRA-55, MERRA-2 (released in early 2016), and ERA5 (scheduled to be released by mid-2016) as well as recent century-long efforts (20CR and ERA-20C). Of course, the paucity of observations makes it inherently difficult to carry out a proper evaluation over the Southern Ocean. But the growing reanalysis ensemble, through its spread, can help get a sense of how confident we can be about reanalysis products.

## ***Trace elements distribution and inter-annual variability in the Ross Sea***

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The spatial and temporal distribution of trace metals (TE) in the Ross Sea are assessed by a multi-years study of seawater sample composition collected during four oceanographic campaigns in the Ross Sea from 2000 to 2012. Eighteen depth profiles have been collected in the Ross Sea and two profiles on the convergence area between New Zealand and Antarctica.

High Salinity Shelf Water (HSSW), Ice Shelf Water (ISW) are the typical new formation waters that characterize the Ross Sea, together with Antarctic Surface Water (AASW), Antarctic Bottom Water (AABW) and the Modified Circumpolar Water (CDW) constitute the principal water masses of the Ross Sea and they play a fundamental role in oceanic circulation and ventilation. TE determinations were performed in order to better understand the interaction between the different water masses and their variability along 12 years of observation. New formation waters were discriminated from the oldest on the base of physical and chemical parameters who indicate the evolution of water masses in terms of space and time and results are related to the TE concentration. In particular we recognized waters of new-formation and oldest on the base of the oxygen concentration which showed a negative correlation with concentration values of elements like molybdenum and antimony whom maximum occurs within the oxygen depleted zone [1]. We also discriminate surficial samples from depth ones on the base of their salinity and potential temperature and their content of elements like manganese, iron and cobalt; these latter present an increasing concentration with depth, we can therefore hypothesize that for Mn, Fe and other elements correlate to them, the increase of concentration can derive both from iron and manganese reduction, in ipo-oxygenated water, and input from re-suspension as some studies hypothesized before [2-3]. To assess variations as a function of the time, we have applied the PCA analysis on reduced data sets of samples collected at the same sampling station in different years. The first principal component emphasizes an inter-annual variability on trace element concentration indicating a seasonal effect on the chemical composition of the Ross Sea waters during the twelve years investigated.

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## **S12. Snow and ice in Antarctica D4, Meeting Room 409, August 25, 2016, 3:30 PM - 6:00 PM**

### ***Modelling aeolian transport of snow at a coastal location of East Antarctica using a temperature-dependent parameterization for surface roughness***

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About 75 % of the Antarctic surface mass gain occurs over areas below 2,000 m asl, which cover 40 % of the grounded ice-sheet. This region presents a complex topography and significant slopes with important impact on the production of katabatic winds and on the generation of drifting snow. The regional surface mass balance highly relies on the resulting erosion/deposition processes. Based on data from a meteorological mast set up in the coastal region of Adélie Land and from direct observations performed during austral summers, we analyzed neutral stability 10-m air-snow drag coefficient computed from wind speed profiles collected from December 2012 to November 2013. Combined with an analysis of meteorological conditions, of snow accumulation, of threshold friction velocities and of aeolian snow mass fluxes, we have described the important influence of sintering on changes in surface roughness. We have observed significant seasonal contrasts between high monthly drag coefficients in summer (December to February) and lower values in winter (March to November) that we related to the temperature-dependence of the snow surface erodibility which governs the ability of the sastrugi to orient themselves to the prevalent wind direction. As a consequence, the assumption of a constant drag coefficient which generally used in atmospheric models is inaccurate and lead to incorrect representation of surface wind fields and estimations of the aeolian snow transport contribution to the Antarctic surface mass balance. Here we perform a sensitivity study of the aeolian transport of snow simulated by the regional atmospheric model MAR to the representation of the interactions between surface roughness and aeolian erosion in a low elevation coastal region. The model is run over Adélie Land and compared to meteorological observations collected from December 2012 to November 2013. The integrative domain covers an area of about 450 km x 450 km with a 5 km horizontal resolution. This domain was chosen so as to include the katabatic wind system that develops over the slopes of Adélie Land starting at the break in slope roughly 250 km inland.

## ***Light absorbing particulates on snow: The spectral and chemical measurement of pollutant impacts on snow near South Pole, Antarctica***

**Kimberly Casey**<sup>1</sup>, Susan Kaspari<sup>2</sup>, Karl Kreutz<sup>3</sup>, Michael Handley<sup>3</sup>

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Pure snow in the clean air sector of the South Pole in Antarctica is one of the most clean, reflective surfaces on Earth. Yet, areas near South Pole station are subject to intense fossil fuel emissions where black carbon and other light absorbing impurities (LAI) become deposited on the snow. We present the results of in situ spectral reflectance and analytical chemistry measurements of fossil fuel emission deposition on snow during the austral summer 2014-2015 season at the South Pole, Antarctica. Field spectra (350-2500 nm) of clean snow and increasing levels of polluted snow were collected in December 2014 and January 2015 at seven sites near South Pole station. Snow samples were analyzed for black carbon concentration via a Single Particle Soot Photometer and for trace elements via an inductively coupled plasma mass spectrometer. Snow impurity concentrations ranged from 0.14 – 7000 µg/L BC, 0.0044 – 6.2 µg/L Pb, 0.0028 – 6.1 µg/L Cd, 0.013 – 1.9 µg/L Cr, 0.20 – 660 µg/L Fe, 0.13–120 µg/L Cu, 0.63 – 6.3 µg/L Zn, 0.062–22 µg/L Ba and 9.5 – 1200 µg/L S. Comparing field spectra with black carbon and heavy metal concentrations, we show that black carbon and trace metal concentrations of part per million reduce surface reflectance of snow, and thus increase the radiative absorption of energy. Quantifying the presence of impurities on ice, and measuring the radiative impact of light absorbing impurities on ice is of great interest in understanding global cryospheric radiative balance. This study presents one of the first measurements of heavy concentrations of LAI on ice and snow.



## ***A new look at the stable water isotope signal in firn from the view of depositional processes and snow metamorphism***

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Stable water isotopes conserve a unique climatic signal in ice cores. In general, the isotopic composition is assumed to be correlated with the local temperature and conditions during evaporation at the origin. Enhanced isotopic modification of the snow at the surface, delayed fixation of the snow in the stratigraphic column and advection ("wind pumping") in the upper few meters of the firn complicate this picture in low accumulation areas. We measured isotopic content in three areas with different accumulation rates, namely in an orographically sheltered snow patch in the Allan Hills (accumulation below 0.01 m / y SWE), Point Barnola () and Kohnen (). In addition, we performed controlled laboratory measurements where water vapor with a low d18O ratio was advected through the snow of higher d18O. Our interpretation of the results is that the isotopic composition of the snow is most affected by atmospheric exchange until it is fixed in the stratigraphic column. The time for fixation varies between days and probably several years. Advection of isotopically different water vapor than the snow leads to significant change in the bulk composition. The laboratory experiments showed that this effect is rapidly decreasing with depth; measurements in Kohnen confirm this interpretation, where a seasonal signal across stratigraphic units of different metamorphic evolution shows up. We conclude that the isotopic composition of the snow is a combined signal of the original atmospheric snow and the weather-dependent following modification by advection and re-deposition. The stratigraphic interpretation of the high-resolution profiles shows that the time of fixation in the stratigraphic column of the snow is very variable. The isotopic signal at Kohnen was indicative of the threshold where a seasonal signal was conserved, at Point Barnola most probably a signal of a few years is typical and in the Allan Hills a decadal signal was observed. Accumulation and advection determine by how much the original atmospheric snow precipitation signal was reduced. The interpretation of isotopically highly resolved firn and ice cores should take into account the impact of the local depositional processes, as revealed by high-resolution snow stratigraphy.

## ***Decrease of the snow density near the surface at Dome C between 2002 and 2011***

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The knowledge of the snow density near the surface is crucial to derive the surface mass balance of ice sheets, either from in situ measurements, remote sensing observations and regional climate modeling. This variable is also important to study the surface energy budget, through its influence on albedo and thermal diffusion, the firn densification, especially for ice-core interpretation, and the air–snow exchanges. The “surface snow density” is mainly influenced by the local meteorological conditions such as snowfall, wind and temperature, and evolves with snow metamorphism.

Despite its importance, no method exists to derive the density very close to the surface – the first 10 centimeters – at Antarctic spatial scale with a fine temporal resolution. To accomplish this goal, we use passive microwave observations from AMSR-E satellite, which allow a daily global cover of Antarctica ice sheet, and an inverse modeling approach which uses the Dense Medium Radiative Transfer – Multi-Layer model (DMRT-ML) to simulate brightness temperatures. Our method is tested at Dome C location on the East Antarctica Plateau. Basically, the difference in surface reflection between horizontal and vertical polarization of the emerging brightness temperature, that mainly comes from the dielectric contrast between air and snow, is used to infer the snow density close to the surface. The passive microwave polarization ratio is used to emphasize the differentially polarized surface reflection. The DMRT-ML model is used to show the main influence of the “surface snow density” on the microwave polarization ratio and to derive the relationship between polarization ratio and surface density.

The retrieved snow density is compared to in situ observations and active microwave observations. All observations converge together and validate our method to derive the “surface snow density” from passive microwave data. Results show a large decrease of the “surface snow density” of about 10 kg m<sup>-3</sup> y<sup>-1</sup> between 2002 and 2011 at Dome C, associated with seasonal and very quick (daily to weekly) density variations. The same decrease is observed over a large area around Dome C extending up to Vostok station.

Assumptions required by the method, as well as errors and uncertainties, are then analyzed and discussed. We conclude that hypothesis and errors are not sufficient to explain the observed trend. The decrease of “surface snow density” is consequently unambiguous. No specific meteorological changes have been identified to explain this 10-year density decrease. Temperature, wind speed, radiation and precipitation remain nearly constant during the period according to ERA-Interim reanalysis and AWS data. Nevertheless, a slightly increase of the wind intensity (0.05 m.s<sup>-1</sup> per year) was found when only the directions perpendicular to the prevailing wind direction (South – South East) are selected. The increase of wind speed opposite to the main wind direction can leads to the erosion of the dense and hard snow structures (called “whale back”) often observed in the plateau and then to a decrease in the “surface snow density”. Regional climate modeling (MAR, RACMO) is needed to understand the physical processes responsible of the “surface snow density” decrease.

## ***Metamorphism of layered firn at Dome Fuji, Antarctica: Evolution of relations between Near-infrared reflectivity and the other textural/chemical properties***

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Evolution of polar firn was investigated at sites at Dome Fuji, to better understand signals of deep ice cores. Using samples from a 4-m-deep pit and a 122-m-deep core, relations between major textural and chemical properties, such as Near-infrared light reflectivity  $R$ , density  $\rho$ , microwave dielectric anisotropy  $\delta\epsilon$ , and concentration of major ions, were investigated at a depth range of 0 – 122 m, with high spatial resolutions. At the near-surface depths, we found: (i) Fluctuations of  $R$ ,  $\rho$ , and  $\delta\epsilon$  are positively correlated; (ii)  $\delta\epsilon$  ranges 0.03 – 0.07 immediately below the snow surface at ~0.1 m depth; (iii) These properties of  $R$ ,  $\rho$ , and  $\delta\epsilon$  are not correlated to major ions. With increasing depths during reported phenomena of density crossover, the positive correlation of  $R$  to  $\delta\epsilon$  persistently remains with a slight decrease. Besides,  $R$  becomes weakly negatively correlated to concentration of  $\text{Na}^+$  which is the sea salt marker. These facts suggest that textural features of the near-surface depths are preserved in both  $R$  and  $\delta\epsilon$  at a depth range immediately below bubble-close-off, being weakly affected by reported softening of ice by  $\text{Cl}^-$  ions. We therefore suggest that optically layered features in ice cores are directly linked to the metamorphism.

## ***Using Antarctic snow for satellite visible channel calibration***

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Retrieval of high quality data, especially for the purpose of studying long-term climate changes, requires reliable calibration. Vicarious calibration using different types of land surface and deep convective clouds is considered as a mode to monitor the sensor performance. Snow cover as the brightest and in many cases spatially uniform surface has a significant potential as a calibration target.

It has been previously demonstrated that snow cover at high elevations in Antarctica is characterized by stable climate values of reflectivities, first of all, for close to nadir satellite observations, which is used as a principal basis for calibrations. The analysis in this presentation is limited by the areas of dry snow characteristic for high parts of Antarctica not undergoing summer melting.

Different theoretical approaches -- two-stream theory, Mie discrete scattering, and geometric optics -- were expediently compared to assess their ability to calculate diffusive radiation from snow cover at a visible wavelength for the snow conditions at high elevations in Antarctica. Various descriptions of absorption, transmission, reflectance, and multiple scattering were taken into consideration. It has been demonstrated that only the means of geometric optics could describe angular dependencies related to bidirectional snow reflectance, and a simple asymptotic analytical model could be used to calculate theoretically bidirectional reflectance.

For visible wavelengths, typical grain sizes for conditions under consideration belong to the regime of geometric optics and Mie description could be replaced by the results from geometric optics when optical properties approach to asymptotic values.

The techniques of geometric optic is used to develop the asymptotic analytical equation to describe snow BRDF, which significantly simplifies the calculations without using any assumptions about the distribution of radiation intensities within snow and demonstrates obvious advantages even in calculating integrated characteristic of radiation transfer.

The quality of the analytical BRDF model was estimated on the basis of comparison with the Moderate Resolution Imaging Spectroradiometer (MODIS) observations used as a standard of radiative measurements. The model robustly simulates MODIS directional reflectance fraction measurements. The use of the analytical model shows advantages in comparison with other methods of calibration and works reliably for large zenith angles. In particular, the analytical model of snow BRDF simplifies a combination of data from different instruments to form long-term uniform series of data, theoretically transforming various observations to a single standard without using traditional cross-calibration techniques.

Potential applications of the analytical BRDF model go far beyond means of calibration. The model could be used to calculate snow albedo including large zenith solar and viewing angles (the analysis of the model sensitivities demonstrates a high accuracy of simulation for the cases with large solar or viewing angles). The analytical model of BRDF in combination with a specific scattering phase functions is able to describe a wider variety of snow conditions than best-fit semi-empirical models of BRDF based on decomposition of the reflectance factor into a number of geometric kernel functions and characterized by large errors for low solar elevations.

## ***Observation and modeling of the seasonal evolution of superficial snow specific surface area at Dome C in Antarctica***

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The specific surface area (SSA) of snow at the surface is the main driver of the albedo in the near infrared range where most of the solar energy is absorbed. Surface SSA and in turn albedo evolve due a complex combination of snowfall, wind driven particle redistribution, and metamorphism. Understanding the relative contribution of these intricate processes operating at hourly to seasonal time-scales is a prerequisite to estimate the strength and sign of feedback loops influencing the Antarctic climate on longer terms.

Here, we use ground-based observations, remote sensing data and numerical simulations to explore the variations of superficial snow at Dome C on the East Antarctic Plateau from daily to yearly time-scales. In particular, we present a new time-series of superficial snow SSA retrieved from in-situ automatic spectral albedo measurements acquired nearly continuously over the last 4 years. This time-series confirms the overall decrease of SSA that takes place from December to January and that has already been inferred from optical and microwave remote sensing observations. It also reveals in details the influence of precipitation events which tend to increase the SSA for short periods of time. The inter-annual variability is found to be relatively small during the time-series compared to remote sensing data available over a dozen years.

To further investigate the role of precipitation, we conduct simulations with the snowpack model Crocus adapted to the specific Antarctic conditions and forced by atmospheric reanalyses. We show the relatively good skills of Crocus at daily to seasonal time scales, except for a few cases when snowfalls are not present in the meteorological forcing. It means that the metamorphism laws initially developed for Alpine-like environment do apply to the colder conditions of the Antarctic. Nevertheless, several improvements are still necessary to further improve the skill of the model, they concerns the "initial" SSA of fresh snow and the horizontal redistribution processes that play a great importance in Antarctica.

## ***Ammonium in coastal Antarctic Snow: Role of Penguin emissions***

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Ammonium ( $\text{NH}_4^+$ ) is one of the dominant alkaline species present in the aerosols as well as in surface snow of Polar Regions, controlling the neutralization of the acidic species and thereby affecting the heterogeneous reactions at the air-snow interface. Very few polar studies are focussed on the source apportionment and implications of  $\text{NH}_4^+$  which plays a critical role in driving many chemical processes in the polar ecosystems. Thus, to investigate into the sources and implications of  $\text{NH}_4^+$  in surface snow, 45 time-series surface snow samples were collected from Larsemann Hill region (near third Indian research station, Bharati), East Antarctica. Sampling was carried out during January- February 2014, when sea ice conditions prevailed. The collected samples were preserved in  $-20^\circ\text{C}$  freezers until analysis to prevent volatilization of any ionic species. The major ions ( $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{K}^+$ ,  $\text{NH}_4^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ) was studied through ion chromatography. The snow samples were filtered through quartz fibre filter papers and were analyzed for black carbon (BC) using optical Transmissometer.  $\text{NH}_4^+$  was found to be the second dominant ion in surface snow after sea salt, with an average concentration of 83 ng/g. Sea salt formed 80% of the ionic load and the remaining 20% of the ionic composition was dominated by  $\text{NH}_4^+$ , followed by  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{SO}_4^{2-}$ . The surface snow was nitrate depleted. Moreover the average neutralization ratio (NR) was  $> 10$  which suggests that excess of  $\text{NH}_4^+$  was present in the surface snow, rendering the snow alkaline because the  $\text{NH}_4^+$  was abundant enough to completely neutralize the acidic ions  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$  forming ammonium sulphate and ammonium nitrate. To elucidate the high  $\text{NH}_4^+$  concentration in surface snow, trajectory analysis was carried out. It was observed that all the trajectories passed over the coastal Antarctica and frozen sea. Sea ice conditions were encountered during the entire sampling period hence the open ocean emission of  $\text{NH}_3$  as a source of  $\text{NH}_4^+$  in surface snow can be excluded. The good correlation of  $\text{NH}_4^+$  and nssK<sup>+</sup> ( $r = 0.8$ ,  $p = 0.05$ ) and nssCa ( $r = 0.7$ ,  $p = 0.05$ ) and a poor correlation of nssK<sup>+</sup> with BC ( $r = 0.2$ ,  $p = 0.05$ ) suggested that ornithogenic soils enriched with bacterial decomposition of uric acid (source of ammonium, potassium and calcium) are forming the major contributor to the  $\text{NH}_3$  in Antarctic summer atmosphere. The extreme closeness of the sampling site with the breeding spots and rookeries in East Antarctica and no open ocean source during the sampling time suggests that the primary  $\text{NH}_3$  emission from ornithogenic soils is surpassing any possibility of oceanic  $\text{NH}_3$  emissions, which gets deposited over the surface snow.

It is suggested that such complete neutralization of snow could also affect the availability of  $\text{NO}_3^-$  ion for photolysis and hence also limit the HONO emissions from surface snow. Further studies are needed to study the  $\text{NH}_4^+$  emissions from penguin colonies and their climatic implications arising due to the change in aerosol and snow acidity.

# ***Weakening of ice during creep by development of a network of easy slip grains***

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Understanding the flow of ice in glaciers and ice sheets is important for predicting the response of ice to climate change (Bamber et al., 2007; Pollard and DeConto, 2009). Ice flow generates strong crystallographic preferred orientations (CPO) that significantly influence the mechanical behaviour of ice (Azuma, 1995; Duval et al., 2010), generally weakening the ice for compaction and flow of ice sheets and glaciers. While the weakening of ice after very small strains (the transition from secondary to tertiary creep) is well known and is broadly related to CPO development (Cuffey and Paterson, 2010; Faria et al., 2014b; Hudleston, 2015; Wilson et al., 2014), a mechanism that explains the details of this weakening does not currently exist. We show that significant mechanical weakening, initiated at ~3% axial shortening, corresponds to the development of an interconnected network of easy-slip ice grains in the very early stages of CPO development. The network develops through selective growth, by strain induced grain boundary migration, of ice grains that are well oriented for easy slip. This weakening mechanism is applicable to the early stages of deformation of isotropic ice and also to the transitions in ice CPO that will occur when deformation kinematics change. The experimental results presented here represent an important step towards understanding how ice CPO and mechanics will respond to the kinematic changes that occur in an ice sheet (Bamber et al., 2000; Hulbe and Fahnestock, 2004; Rignot et al., 2011; Winsborrow et al., 2010). Our laboratory measurements show that the CPO changes can be tracked using sound wave velocity anisotropy, enabling laboratory observations to be up scaled to seismic experiments that map the CPO and mechanical properties through the entire thickness of terrestrial ice sheets.

## ***Complex massive englacial structures in West Antarctica determine ice-sheet rheology and ice-flow***

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Complex structures identified within both the East Antarctic and Greenland ice sheets are thought to be generated by the action of basal water freezing to the ice-sheet base, evolving under ice flow. Here, we use ice-penetrating radar to image an extensive series of similarly complex basal ice facies in West Antarctica, revealing a thick (>500 m) tectonised unit in an area dominated by cold-based and relatively slow-flowing ice. We show that major folding and overturning of the unit perpendicular to ice flow elevates deep, warm ice into the mid ice-sheet column, and is then advected into an ice stream shear margin and trunk. In the absence of basal water either now or in full-glacial times, the formation of the unit must have been solely through the deformation of meteoric ice. Radar englacial-layer reflectivities are consistently greater along the fold axes compared with the perpendicular direction, revealing ice-sheet crystal anisotropy is associated with the folding. By linking layers to the Byrd ice-core site, we show the basal ice dates to at least the last glacial cycle, and is likely to be as old as the last interglacial. Deformation of deep ice in this sector of the West Antarctic ice sheet, and potentially elsewhere in Antarctica, may be caused by differential shearing at interglacial-glacial boundaries, in a process analogous to that proposed for interior Greenland. The scale and heterogeneity of the englacial structures, and their subsequent impact on ice sheet rheology, means that the nature of ice flow across the bulk of West Antarctica must be far more complex than is currently accounted for by any numerical ice-sheet model.



## **S16. Global navigation satellite system research and applications, Meeting Room 405, August 25, 2016, 3:30 PM - 6:00 PM**

### ***Ground based water vapor retrieval in Antarctic coastal areas***

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The atmospheric water vapor is an important indicator of the Earth's climate state and evolution. A quantification of the abundance and variability of atmospheric water vapor still requires longer and consistent time series of data, possibly recorded by different and independent sensors to overcome technique-specific systematic errors and obtain accurate results.

Although representing a few percentages of the total atmospheric content, Antarctic water vapor variations impact local temperature variations and play an important role in snowfall accumulation and surface mass balance. Thus, accurate long time series of water vapor content in Antarctica are crucial to better understand the current climate variations and to assess the reliability of global climate models predictions.

We aimed at estimating the content and long-term variation of the precipitable water vapor (PW) at five coastal Antarctic stations, i.e., Casey, Davis, Mawson, McMurdo, and Mario Zucchelli. The GPS station selection was driven by the presence of radiosounding (RS) data locally performed using Barocap, Thermocap and Humicap-A sensors mounted on Vaisala radiosondes

We processed the 12-year time series of GPS and radiosounding observations acquired at those stations, with the purpose of ensuring the utmost accuracy of the results adopting homogeneous, consistent, and up-to-date processing strategies for both data sets.

Using the two fully independent techniques, rather consistent contents and seasonal variations of precipitable water were detected. At each site, high correlation coefficients were found between the GPS and RS time series, with no clear indication regarding the possible dry or wet biases of one technique with respect to the other. Although extremely small, the linear trends of the series are not always consistent in sign. In accordance with the major climate models, the RS linear trends are mostly positive, whereas depending on the site, GPS exhibits a (very small) decrease or increase in water vapor.

To fully exploit the capability of GNSS to provide reliable PW, whenever radiosounding observations are not available, a regional model of the mean Temperature has been computed.

## ***Faster tracking of a Software GPS based receiver using sub sampling technique***

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Software-defined radio (SDR) is a radio communication technology that is based on software defined wireless communication protocols instead of hardwired implementations popular in military and other civil applications. The Software based GPS receiver provides the ultimate receiver implementation. The front end hardware would be minimized, the design should be able to process the multiple transmissions, and most importantly, it would provide a platform to evaluate and test various signal processing algorithms. Tracking is most important process and a challenge task of getting the fine values of carrier frequency and code phase from visible satellite. Ionospheric scintillation cause the GPS tracking error severely affecting the accuracy of GPS positioning. The main purpose of tracking sub-system is to refine these values, keep track, and demodulate the navigation data from the specific. To track a GNSS signal, two tracking loops (phase and delay) are required. This work presents a novel, new, simple, efficient and faster GPS tracking (L1 signal) via sub-sampling for software-defined GPS receiver design. Our algorithm reduces the number of computations, simplifies the hardware implementation, and decreases the tracking time correspondingly. Thus, faster tracking for software based GPS receiver is the goal of this research. The real time implementation of the proposed method in an FPGA provides very fast processing of incoming GNSS signals.

## ***DemoGRAPE: A demonstrator of e-science potential in Antarctica***

**Luca Pilosu**<sup>1</sup>, Pietro Ruiu<sup>1</sup>, Alberto Scionti<sup>1</sup>, Lucilla Alfonsi<sup>2</sup>, Luca Spogli<sup>2</sup>, Vincenzo Romano<sup>2</sup>, Fabio DAVIS<sup>3</sup>, Nicola Linty<sup>3</sup>, Pierre Cilliers<sup>4</sup>, Padraig Riley<sup>4</sup>, Jonathan Ward<sup>4</sup>, Emilia Correia<sup>5</sup>, Jose Henrique<sup>5</sup>, Michele Bavaro<sup>6</sup>, James T. Curran<sup>6</sup>, Joaquim Fortuny<sup>6</sup>

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The Earth's upper atmosphere presents a region particularly rich of ions and free electrons: the ionosphere. Such high concentration of free electrons makes the ionosphere the major natural contributor to the degraded quality of GNSS signals received at ground level. In polar regions, such as in Antarctica, this degradation can be stronger, creating serious problems in using GNSS devices for logistic and scientific purposes. In this context, the DemoGRAPE project developed a Cloud computing federated infrastructure to manage GNSS data and "ad hoc" applications coming from different teams in a multi-user environment. The proposed DemoGRAPE infrastructure shows its potential usefulness in several application scenarios, such as satellite navigation and space weather, as well as to support the investigation of polar cap dynamics, solid Earth and cryosphere evolution. In particular, data coming from two ionosphere monitoring stations (based on a GNSS signal acquisition system and on a software radio receiver and installed in two research stations in Antarctica) have been made available at the South African and Brazilian nodes of the IT infrastructure. Two data analysis tools have been fully integrated on virtualized machines in the Cloud computing infrastructure. The first is based on the well known GBSC (Ground Bases Scintillation Climatology) technique, while the second one use an innovative analysis method for the Software radio receiver data.

The proposed Cloud computing infrastructure leverages on the Docker technology and on a distributed storage system to allow data and tools to be shared within the federated environment. Docker provides a lightweight virtualization system which provides the substrate to efficiently run the "ad-hoc" applications, while the distributed storage system guarantees the availability of the data against failures. The entire infrastructure is managed by means of an ad-hoc console, which also exports a web-based graphic user interface.

Finally a demonstrator has been developed in order to validate and test the proposed architecture and show how it constitutes an opportunity to pioneer new potential services based on the GRAPE and international collaboration.

This paper shows the features and potential of the implemented infrastructure by means of the DemoGRAPE demonstrator.

## ***DemoGRAPE: First phase scintillations on GNSS signals from Galileo satellites as observed from SANAE and EACF***

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The accuracy of satellite navigation in Antarctica is of paramount importance since there is always the danger that people and vehicles can fall into a crevasse during a snowstorm, when visibility is limited and travel is restricted to following well-demarcated routes using satellite navigation systems. SANSA and INPE are key collaborators on an international project to improve satellite navigation in Antarctica. In 2013 SANSA and INPE agreed to support the DemoGRAPE proposal led by Istituto Nazionale di Geofisica e Vulcanologia, in partnership with Politecnico di Torino and Istituto Superiore Mario Boella in Italy. The project is funded by PNRA (the Italian National Program for Antarctic Research). The proposal was to build a demonstrator of cutting edge technology for the empirical assessment of the ionospheric delay and ionospheric scintillations in the polar regions which affect the accuracy of satellite navigation. The demonstrator will include new monitoring equipment to be installed at the South African and Brazilian bases in Antarctica, and the exchange of data via the Cloud computing infrastructure.

A reliable assessment of the ionospheric delay and of the ionospheric perturbations on trans-ionospheric signals at high latitudes is of great interest also for scientific/technological objectives aiming to improve the reliability and accuracy of GPS navigation in polar regions where overland travel is often solely dependent on GPS navigation during hazardous weather conditions. SANSA and INPE manage ionospheric scintillation receivers and GPS receivers at SANAE and EACF in Antarctica (since 2006). Between November and December 2015 SANSA and INPE assisted INGV and the DemoGRAPE team with the installation at SANAE and EACF of two pairs of GNSS receivers. Each Antarctic station is now equipped with a Septentrio PolaRxS receiver and a new-concept of data acquisition system exploiting GNSS software receivers, which provide access to ionospheric delay and related measurements from not only the GPS (US) system of navigation satellites, but also to the Russian GLONASS and European Galileo satellites. The deployment of the new-concept of GNSS data acquisition is also supported by the Joint Research Centre of the European Commission (JRC). The first data recorded during two moderate geomagnetic storms occurred on January 2016 is now available to give evidence of the advantages of the new instrumentation.

The new instruments will provide new research opportunities at international level in Antarctica, and will further global partnerships in Space Research.

## ***On the redistribution of plasma over the northern low-mid latitude and southern polar ionosphere during a positive ionospheric storm.***

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The relative contributions of the composition disturbances and the disturbance electric fields in the redistribution of ionospheric plasma is investigated in detail by taking the case of a long duration positive ionospheric storm that occurred during 18-21 February 2014. GPS total electron content (TEC) data from the Indian Antarctic station, Bharti which is a high latitude station (69.4 °S, 76.2 °E Geographic), the northern mid-latitude station Hanle (32.8 °N, 78.9 °E Geographic), the northern low latitude station in the vicinity of the crest of the Equatorial Ionization Anomaly, Ahmedabad (23.04 °N, 72.54 °E Geographic, dip latitude 17 °N) and the geomagnetic dip equatorial station Trivandrum (8.5 °N, 76.9 °E Geographic, dip latitude 0.6 °N) are used in this study. These are the first simultaneous observations of TEC from Bharti and Hanle during a space weather event. The impact of the intense geomagnetic storm ( $Dst > -130nT$ ) on the southern hemisphere high latitude station was a drastic reduction in TEC (negative ionospheric storm) starting from around 0330 IST on 19 February which continued till 21 February. The maximum amplitude of the reduction in TEC at Bharti on 19 February is ~35 TECU. In the northern hemisphere mid latitude and equatorial stations, a positive ionospheric storm occurred on 19 February and lasted for 3 days. The maximum enhancement in TEC at Hanle is ~25 TECU on 19 February while over Trivandrum it is ~10 TECU. The latitude dependent long duration positive ionospheric storm that prevailed during 18-21 February 2014 provided an opportunity to assess the relative contributions of disturbance electric fields and composition changes in modulating the response of the ionosphere-thermosphere system. The negative ionospheric storm over Bharti and the positive ionospheric storm over Hanle are the result of the changes in the global wind system due to the increase in energy input into the high latitude ionosphere. At the equatorial latitudes, the positive ionospheric storm was due to the interplay of prompt penetration electric field and the disturbance dynamo electric field.

## ***Ionosphere response at high latitudes to the geomagnetic storm occurred on September 26-29, 2011***

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The ionosphere response at high latitudes to a moderate geomagnetic storm occurred on 26 September 2011 was investigated using GPS, ionosonde and riometer observations at different latitude and longitude over Antarctic Continent. The results showed that during the geomagnetic storm main phase the ionosphere presented a strong positive phase during daytime at midlatitude stations, with intensification due to the dusk effect, showing an expansion of the auroral oval to midlatitudes. The daytime positive phase was interpreted by equatorward plasma flow due to the meridional winds generated by joule-heating at auroral oval produced by particle precipitation, as suggested by positive phase observed simultaneously at polar cap stations during local nighttime in close association with ionospheric absorptions. During the geomagnetic recovering phase, the ionosphere showed predominantly a negative phase that was attributed to decreases in the O/N<sub>2</sub> ratio, as well as a weak positive phase during daytime at midlatitude stations, which was attributed to electrodinamical mechanism that survived due minimum effects of auroral currents. The results showed that even during moderate geomagnetic storm the ionosphere at high latitudes can be strongly disturbed, and its effects can propagate in equator direction reaching lower latitudes.

# ***GPS phase scintillation during geomagnetic storms of March 17, 2013 and 2015: Interhemispheric comparison and the relation to auroral electrojets***

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Coronal mass ejections compounded by high-speed plasma streams from coronal holes resulted in strong geomagnetic storms on March 17, 2013 and 2015, the latter being the strongest for the current solar cycle. Phase scintillation was observed at northern and southern high latitudes by arrays of high-rate GNSS Ionospheric Scintillation and TEC Monitors (GISTMs) and geodetic-quality GPS receivers sampling at 1 Hz. The high-latitude ionosphere dynamics is studied using arrays of ground-based instruments including GNSS receivers, HF radars, ionosondes, riometers and magnetometers. In the context of solar wind coupling to the magnetosphere-ionosphere system, the GNSS phase scintillation is primarily enhanced in the cusp, tongue of ionization (TOI) broken into patches drawn into the polar cap from the dayside storm-enhanced plasma density (SED) and in the auroral oval during energetic particle precipitation events, substorms and pseudo-breakups in particular. In this paper, we focus on the relation to auroral electrojet currents observed by arrays of ground-based magnetometers and energetic particle precipitation observed by DMSP satellites. Equivalent ionospheric currents (EICs) are obtained from ground magnetometer data using the spherical elementary currents systems (SECS) technique developed by Amm and Viljanen (Earth Planets Space, 51, 431–440, 1999) that has been applied over the entire North American ground magnetometer network by Weygand et al. (J. Geophys. Res., 116, A03305, 2011). For interhemispheric comparison, EICs are also inverted from magnetometer chains in Europe and Antarctica.

## ***Characteristics of GPS TEC variations in the polar cap ionosphere***

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This study examines the occurrence rate, amplitude, and frequency of total electron content (TEC) variations arising from mesoscale (10s – 100s of kms) structuring of the polar cap ionosphere. In total, six years of TEC measurements were collected from five high-data-rate Global Positioning System (GPS) receivers of the Canadian High Arctic Ionospheric Network (CHAIN). Magnetic latitude and local time maps of TEC variation characteristics were examined as a function of season, solar wind-magnetosphere coupling rate, and orientation of the interplanetary magnetic field (IMF). Occurrence rate of TEC variations was highest in localized dayside regions, with exact local time and latitude of peak occurrence depending primarily on solar wind-magnetosphere coupling rate and IMF orientation in the Y-Z plane. Occurrence of TEC variations throughout the polar cap increased with solar wind-magnetosphere coupling rate, and increasingly non-zero IMF BX, BY, or BZ. This solar wind dependence largely reflects the location and rate of dayside magnetic reconnection, and subsequent polar cap convection and particle precipitation. Amplitudes of TEC variations were largest around noon, and primarily increased with solar wind-magnetosphere coupling rate. Seasonal statistics showed highest occurrence and amplitude of TEC variations in the winter, and lowest in the summer. A surprising result in the frequency distributions of TEC variations was discrete, “preferential” frequencies of around 2 and 4 mHz, which originated from regions corresponding to the plasma mantle, poleward of the cusp region. These statistical trends provide insight into the source and generation mechanisms of mesoscale ionization structures in the polar regions.



## ***The ionospheric structure of the Weddell Sea Anomaly investigated by ground-based GPS, OSTM/Jason-2 and FORMOSAT-3/COSMIC***

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Weddell Sea Anomaly (WSA), appeared mainly in West Antarctica, is a prominent feature of the summer southern ionosphere. For better understanding of WSA, multi-source observations, such as ground-based GPS data, OSTM/Jason-2 data and FORMOSAT-3/COSMIC radio occultation data, are used to extract Total Electron Content (TEC) distributions and the Electron Density (ED) profiles. Ground-based GPS can provide consecutive TEC time series over the stations, and OSTM/Jason-2 can provide TEC over the oceans, which are complementary to depict the large scale characteristics of WSA. Radio occultation can provide the ionospheric electron density profile from the ground to the height of LEO orbit, which play an important role in the research of topside ionosphere. From the spatial distribution, WSA appeared not only in the Weddell Sea but also in the Bellingshausen Sea, and even in the land areas north of 80°S. From the temporal changes, WSA lasts from Oct. to Mar. next year, with the characteristics of low electron density in daytime but high in nighttime. And the ionospheric anomaly become larger in high solar activity. From the vertical structure, WSA is mainly characterized by the electron density enhancement at the top and the electron density reduction at the bottom, which is detected by means of electron density profiles. In all, these three kinds of observations are very useful tools to deepen the study of the ionospheric structure of WSA.

# ***Identification of ionisation structures originating from auroral optical emissions through co-located GPS, riometers, and all-sky camera observations***

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Optical emissions from an all-sky camera at 557.7 nm and riometer images were compared with co-located GPS scintillation measurements in the case of events showing stable arc-like optical structures as well as saturating emissions affecting almost the entire field of view.

Co-located GPS scintillation measurements (1-min scintillation indices as well as 50-Hz sampling of signals intensity and phase) were compared to the optical emissions, assuming an emission altitude of 120 km that the satellite motion was also mapped to. Weak scattering was assumed as a model for the scintillation observations to a good approximation owing to very low levels of measured intensity scintillation.

The method described allowed for the identification of large-scale ionisation structures forming in conjunction with optical emissions following particle precipitation through the analysis of spectral modifications on GPS signals (sampled at 50 Hz). These spectral modifications were interpreted on the basis of a weak scattering approach, justified by very low intensity scintillation. The analysis of spectral modifications of GPS signals has the potential to provide a novel and cost-effective technique for indirect detection of ionisation structures originating from particle precipitation which could be used to complement all-sky camera and riometers measurements.

The comparison of co-located measurements showed that the optical emissions and associated ionisation gradients introduced longer temporal fluctuation periods (i.e. from spatial scales larger than the Fresnel scale) on the GPS carrier phase (from phase PSD), while the Fresnel frequency maintained a constant value throughout the events (from intensity PSD). A constant Fresnel frequency and the relative velocity associated with it did not seem consistent with a phase changing screen in the E region, while they could be plausible with one at the F region.

**S27. Impacts of environmental changes on Antarctic ecosystems and biota ( Sec 2), Meeting Room 401/402, August 25, 2016, 3:30 PM - 6:00 PM**

***First spatial mapping of the human footprint in Antarctica***

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Human footprint maps allow visualization of human spatial pressure across the globe. Up until now, Antarctica has been excluded from global footprint maps, due possibly to the lack of a permanent human population and poor accessibility to necessary datasets. Yet Antarctic ecosystems face increasing cumulative impacts from tourism and national Antarctic operator activities, the management of which could be improved with footprint assessment tools. Moreover, Antarctic ecosystem dynamics could be modelled to incorporate human drivers. Here we present the first map of estimated human footprint across predominantly ice-free areas of Antarctica. The map was created using methodologies applied elsewhere to facilitate integration into global models. To this end, land use, density and accessibility features were incorporated. Results showed that human pressure is primarily clustered in the Antarctic Peninsula, southern Victoria Land and several areas of East Antarctica. It is hoped that use of this tool may help Antarctic Treaty Consultative Meeting policy makers in their decision making concerning issues such as cumulative impacts, non-native species and areas protection.

## ***Consequences of altered freeze-thaw cycle frequency on the dominant soil invertebrate in the McMurdo Dry Valleys***

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The frequency and magnitude of temperature fluctuations in Antarctica are increasing under climate change. We investigated the impact of freeze-thaw cycles on the population density and population structure (age, gender and body size) of the soil nematode *Scottinema lindsayae*, the dominant terrestrial invertebrate in the McMurdo Dry Valleys.

Multi-year field observations on nematode populations and temperature variation in Taylor Valley show a negative effect of freeze-thaw events on *S. lindsayae* populations. To unravel mechanisms behind this effect, a controlled laboratory experiment was performed over 8 weeks on nematodes from soil samples collected in Taylor Valley. Five temperature treatments were compared: three constant temperatures (-4°C, 4°C, 10°C), and two spanning a 10°C diurnal variation with freeze-thaw cycling (-5 to 5°C) or without (0 to 10°C). Before, during and at the end of the experiment, living and dead specimens were counted and assigned to life stage (juveniles or adults, with the latter also partitioned by sex). Microphotographs were taken and individual body size was measured.

The experiment revealed a negative effect of freeze-thaw cycling and temperatures held consistently below freezing on *S. lindsayae* abundance. The proportion of adult vs juvenile density and average individual body size were not significantly affected by any treatment, but regressions of nematode abundance against body size, and analysis of variance of community-weighted mean body size both revealed a shift towards higher abundance of larger individuals under freeze-thaw cycling. A greater proportion of dead nematodes under freeze-thaw cycling also indicated higher mortality. Therefore, it appears that freeze-thaw cycling leads to a selective loss of juveniles and small-sized adult individuals of *S. lindsayae*. Taken together with the field-based observations, our findings indicate slower development and higher mortality of *S. lindsayae* under frequent freeze-thaw cycling, and suggest a reduced abundance of this dominant animal in the Dry Valley soils. Given the long life cycle of this species and the short active season in the Dry Valleys, an increase in the frequency and magnitude of freeze-thaw events as predicted by global climate models may have cascading effects on ecosystem processes regulated by *S. lindsayae*, for instance C turnover rates.

## ***Long-term experimental manipulation of a McMurdo dry valley soil ecosystem***

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The McMurdo Dry Valleys are predicted to experience significant long-term change in climate with increases in summer temperature, solar energy inputs, snow, and permafrost thaw and subsequent lake level rises. These increases will affect soil moisture and other biogeochemical properties with potential effects on the biodiversity and distribution of biotic communities. The soil ecosystem in Taylor Valley, one of the McMurdo Dry Valleys, occupies approximately 95% of the surface area (105km<sup>2</sup>), compared to aquatic habitats of lakes (4.7km<sup>2</sup>) and streams (0.2km<sup>2</sup>) and thus soil biota are significant part of the biodiversity in the Dry Valleys.

We explored the response of soil communities to climate change (temperature and moisture) and soil resource availability (carbon sources) in a long-term (> 15 year, 1993- 2005) manipulation experiment in Taylor Valley, Antarctica, followed by an untreated period (2005 – present) to determine whether the soil invertebrate response differed from untreated controls. To allow for comparison to high elevation systems (Arctic and alpine) ecosystems, we designed a full factorial manipulation experiment using standard ITEX chambers (International Tundra Experiment) to warm the soil. We added liquid water and two sources of carbon in solution (sucrose or mannitol) to determine how the soil communities responded to these factors. We hypothesized that combinations of warming, water and carbon would enhance suitable habitats for nematodes and increase abundance, biomass and diversity of species compared to single treatments. We also predicted that the biogeochemical changes to the soil habitat would persist through subsequent years following treatment, sustaining the increases in nematode abundance, biomass and diversity rather than return to previous levels. Results showed significant inter-annual effects that varied by year throughout the duration of the experimental and recovery periods. ITEX chambers warmed the soils, but also lead to habitat degradation and drought by decreasing soil moisture. Interannual climate variability had a larger effect than moisture additions on total invertebrates. Nematode populations grew with increased soil moisture although *Scottinema lindsayae* population increase was less than *Eudorylaimus* spp.. Soil biogeochemistry (conductivity, pH, chlorophyll a) was variable over time. Treatment additions of soil carbon solutions showed increases in nematodes, but there were high annual variations. These results will be contrasted with more diverse Arctic systems and indicate that polar responses of soil biota to warming and moisture and carbon inputs contrast from the Arctic to Antarctic and are related to different species interactions and levels of change in temperature, moisture and soil carbon.

## ***The signature of heterotrophic respiration in Antarctic Dry Valley soils***

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Soil CO<sub>2</sub> fluxes have been adopted as a means of quantifying Antarctic soil ecosystem activity and carbon turnover times. However, recent research has shown that surface soil CO<sub>2</sub> fluxes comprise a significant abiotic component. This component is associated with CO<sub>2</sub> dissolution and exsolution according to Henry's Law.

In this paper, we present data collected during the 2009/10 austral summer from two contrasting sites in eastern Taylor Valley: a lakeside site which has an annual carbon input from wind-blown algae, and a low-carbon site distal from any contemporary carbon sources. Empirical data from the very low carbon site and a mechanistic model capturing purely abiotic soil processes have characterised an abiotic soil CO<sub>2</sub> dynamic. We compare subsurface soil CO<sub>2</sub> concentration and its isotopic composition and surface flux data from the lakeside (relatively high carbon) site with the abiotic behaviour to isolate pulses of heterotrophic respiration. The pulses were identified by higher CO<sub>2</sub> concentrations and more depleted subsoil δ<sup>13</sup>CO<sub>2</sub> than were demonstrated in the empirical field data from the low-carbon site or the abiotic model. Unexpectedly, the pulses we identify do not occur during the warmest part of the day as is commonly assumed, and appear to originate from the subsoil. The timing, magnitude and depth of the pulses varied on a diel basis.

Our findings demonstrate that through a combination of modelling and field measurement, heterotrophic respiration can be isolated. However, continuous field monitoring over multiple diel cycles may be necessary at times of the year when readily metabolisable carbon is available. Surprisingly, monitoring at the same site in the summer of 2013/14 revealed apparently purely abiotic behaviour. This suggests that annual lake carbon inputs may become exhausted at different times, and together, these results suggest that long-term monitoring of selected sites will be necessary to establish a reliable time-series for assessing ecosystem response to environmental change.

## ***Comparing the ecophysiology and biochemistry of mosses from opposite sides of the continent***

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Major Antarctic climate changes in temperature, stratospheric ozone levels, wind speed and precipitation has strong implications on the bryophyte-dominated terrestrial vegetation. The dissimilarity between the rapid regional warming across the Antarctic Peninsula and nearby islands on the continent's west and the opposing cooling trend over East Antarctica is highly influenced by stratospheric ozone depletion. The reduction in ozone also substantially impacts wind and precipitation weather patterns in addition to the widely-known significant increase in ultraviolet-B (280-315 nm) radiation. As events of precipitation and snow/ice melt are critical to plant survival during the short summer growing seasons when ultraviolet-B light levels are high, environmental changes consequently have the potential to dramatically shift species and ecosystem dynamics. This includes altering the hydrology of terrestrial ecosystems that include several poikilohydric moss species. These small non-vascular plants are important biotic components to terrestrial Antarctic ecosystems and have unique abilities to show rapid and long-term changes in response to their surrounding environment. These responses include their physiology, hormones, chlorophyll pigments, sugars, stable isotopes ( $\delta^{13}\text{C}$ ) and secondary metabolites. In some East Antarctic moss species,  $\delta^{13}\text{C}$  signatures in cellulose has been shown as an accurate and preserved way to detect past water environments. However, this response range is species specific and there is currently little evidence if West Antarctic mosses behave in a similar way or whether moss hormonal signals also shift. Temperature differences across the continent is especially important to moss productivity considering moss surface temperatures can exceed 30 °C on sunny days in the field. However, it is unknown if species continental location affects their temperature optima for productivity. Therefore, we aimed to compare the biochemistry and ecophysiology of moss species from opposite sides of the Antarctic continent. We measured various photosynthetic, metabolic and  $\delta^{13}\text{C}$  responses within a selection of moss species from East and West Antarctic that underwent a range of water, light and temperature stresses in the laboratory. Using plant extraction and analytical techniques, we uncover and describe interesting findings on the changes in the concentrations of numerous metabolites from both laboratory and field samples. Our results indicate that the mosses tested showed different responses to water submergence, which seems to be dependent on their natural water environmental niches. We show that the seven moss species sampled utilise different protective strategies against ultraviolet radiation, including the investment in cell wall-bound sunscreens. We explain that it is important to consider this long-term investment in plants as a way to assess their ability of survival under elevated ultraviolet radiation especially during periods of water stress. In addition, these cell wall sunscreen and  $\delta^{13}\text{C}$  signatures can provide long-term records within ancient moss shoots that have been dated using the radiocarbon bomb-pulse method. The lives of 20-450 year old Antarctic moss shoots and their use as biological paleoproxies will be discussed. Monitoring the short and long-term biochemical and physiological responses of these unique plant species is vital to predict their future productivity and survival in East and West Antarctica during a time of changing climate.

## ***Lichens show the complexity of climate change in the maritime Antarctic***

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The Antarctic Peninsula has been reported to be one of the areas on Earth that has registered the most intense warming in the last decades of the past century. This has had a dramatic effect in the ice balance and glacier extent in this area driving a massive loss of ice and retreat of glacier fronts. One result has been extensive areas of newly exposed ice-free surfaces that are in process of colonization and, because of their particular ecological factors and ages, allow comparisons to be made of vegetation dynamics in different places of the maritime Antarctic. On Livingston Island (South Shetland Islands) lichen colonization on young moraines has been investigated for 24 years. Such pioneering lichen communities on new rock surfaces allow long term measurements to be made of thallus growth whilst avoiding most of the interferences due to competition and coalescent thalli. The relative low diversity of this system also offers the opportunity to determine the growth rate of each species and to discern the species-specific response to environmental changes. In our measurements made in 1991 and 2002 evidence of high and increasing annual growth rates for six selected species was clearly detected. We anticipated a similar trend in our last check in 2015 but, contrary to this expectation, we found a clear disruption in the colonization process. Most of species showed a dramatic slowing down in their annual growth rate and many lichen thalli had completely disappeared. Over the same period, since 2002, there has been a break in the trend to longer melt seasons in this area, in agreement with the increase in snow fall forecast for the whole Antarctica. In this paper we relate our data about lichen colonization to the above trends in air and soil temperature and also to changes in ice balance, snow accumulation and energy balance of the soil. Possible drivers for the dramatic disruption observed in lichen growth are discussed as well as implications for Antarctic vegetation.



## ***Passive warming reduces stress and shifts reproductive effort in an Antarctic moss system: implications for higher-level interactions.***

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The Western Antarctic Peninsula is one of the most rapidly warming regions on Earth, and many biotic communities inhabiting this dynamic region are responding to these well-documented climatic shifts. In this research we investigated the impacts of passive warming by Open Top Chambers (OTCs) in moss-dominated ecosystems on Fildes Peninsula, King George Island, Antarctica. We tested the effects of experimental passive warming on the morphology, sexual reproductive effort, and stress physiology on a common dioecious moss, *Polytrichastrum alpinum*, in order to gain the first species-specific mechanistic insight into moss responses to climatic warming in the Antarctic. We found distinct micro-morphological and physiological shifts in *P. alpinum* under passive warming compared to those without warming: warmed mosses reduced investment in cellular stress defenses, but invested more towards primary productivity and gametangia development. These early results suggest that warming will substantially change the reproductive output of moss dominated systems. We are combining this research with explorations of the species-specific volatile organic compounds (VOCs) emitted by these mosses, which we expect to change with differences in reproductive output, and with exploration of changes in microbial community diversity, as correlated to changes in moss reproductive and VOC patterns. Taken together, results from this novel functional biology study of mosses under passive warming imply that in ice-free moss-dominated regions, climate warming will likely have profound impacts on moss ecosystems.

## ***Plant communities distribution and biodiversity assessment for environmental change detection at Rothera Point, Adelaide Island, Antarctic Peninsula***

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The Antarctic Peninsula has experienced a strong climate warming trend over the last 50 years. Antarctic terrestrial ecosystems are extremely sensitive to climate forcing, due to the closeness to plants physiological limits. Several studies have implemented the understanding of species composition and structure of plant communities in ice-free areas of maritime Antarctic. Less is known about spatial distribution of such communities, although a robust quantitative baseline assessment is required to monitor future changes.

The main objective of this research is to first characterize and fine-scale map the plant communities of Rothera Peninsula, close to Rothera Research Station, Adelaide Island (67°37'S 68°07'E), in order to assess future changes in plant distribution due to environmental drivers. Moreover, as in the study area exist ASPA n.129, to assess the impact of activities undertaken at the Station on species richness and biodiversity, using ASPA as a control area.

During 2010/2011 austral summer, was carried out a detailed mapping and characterization of the plant communities of Rothera Point. Using topographic map (scale 1:2000) and GPS ( $\pm 3$  m), areas with different plant composition were delimited, assessing physiognomy and location. Within each polygon a phytosociological survey of 1 m<sup>2</sup> was undertaken (ASPAs: n=26; Non ASPAs: n = 76); total coverage, species number and abundance were recorded for each survey and some biodiversity indices were carried out.

In an area of approx. 24.7 ha (ASPAs: 3.7 ha, 15.1%; Non-ASPAs: 21 ha, 84.9%), we found only cryptogamic plant communities, covering approximately 34.4% (8.5 ha) of the study area. The remaining 65.6% were non-vegetated ice-free areas (25.4%, 6.3 ha) or snowpatches (40.2%, 9.9 ha). Within ASPAs, plant communities, bare grounds and snowpatches cover, respectively, 46%, 22.7% and 31.3%; whereas outside ASPAs they cover 32.3%, 25.9% and 41.8% (8.8 ha). We mapped four different plant sub-formations (Smith, 1996): crustose and foliose lichen, fruticose and foliose lichen, short moss cushion and turf, tall moss turf formation. Except for the latter, all the preceding communities are present both in and out of ASPAs, with fruticose and crustose lichen subformation as the most common one (ASPAs: 40.7%; Non ASPAs: 17.4 %).

Overall, were detected 65 species: 54 lichens, 10 mosses and 1 terrestrial algae. The most important species are *Lecanora physciella*, *Umbilicaria decussata*, *Usnea antarctica* and *Pseudophebe pubescens*, whereas the most important moss is *Sanionia uncinata*, followed by *Bryum pseudotriquetrum*. The number of species recorded within ASPAs is less than outside (43 vs 57 sp). However, the species density (n. of species/ice-free area ratio) is four time higher within the protected area (16.7 vs 4.7 sp\*ha<sup>-1</sup>), with the rare species (frequency < 0.01) reaching six time difference (6.6 vs 1.1 rare sp\*ha<sup>-1</sup>).

Our work produced the first map of plant communities of Rothera Point, useful for comparison with future surveys in an environmental change scenario. Despite the smaller surface and number of surveys, the positive effect of ASPA n. 129 on biodiversity conservation was confirmed, stressing how protected area could be able to preserve biodiversity to future environmental change.

## ***Does experimental warming shift the relationship between vascular plants and mosses in Antarctica?***

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In Antarctica adverse environmental conditions restrict terrestrial plants' capacity to acquire resources; hence, biotic or abiotic amelioration of these conditions or the provisions of favorable microsites should be beneficial for growth and reproduction. On the western coast of the Antarctic Peninsula and on the Shetland Islands Archipelago, vascular plants distribution is limited to sites with high nutrient and water availability on the few ice-free terrestrial areas. Recently, we have shown that vascular plant populations are expanding throughout the western part of the Antarctic Peninsula as a consequence of warming climate conditions and we found evidence that growth of Antarctic vascular plants were facilitated by moss carpets. However, we were interested to understand how plant-moss interactions may change under scenarios of local warming and climate change. Here we examine the effects of warming on moss-plant interactions using two native vascular plants *Deschampsia antarctica* and *Colobanthus quitensis*. We carried out a plant survival study at Fildes Peninsula on King George Island and Byers Peninsula on Livingston Island during 2013-2015. We performed an experiment planting tillers of *D. antarctica* and plantlets of *C. quitensis* into two naturally occurring substrates: moss carpets and cushions (dominated by *Sanionia uncinata* and *Polytrichastrum alpinum*) and bare ground and we measured vascular plant survival under passive warming using open top chambers (OTC). We found that vascular plant survival was increased with OTC manipulation, with survival varying with plant species and being dependent on study location and substrate. Under ambient conditions, plants survival was slightly higher when planted into moss carpets then into bare ground. However with OTC, vascular plant survival only increased when planted into bare ground, with no observed benefit when planted into moss carpets. Results from this study suggest that warming shifts the relationship and reduces positive interactions between mosses and vascular plants in Antarctic communities. FONDECYT 1120895

## ***Direct and indirect effects of warming explain the expansion of vascular plants populations in Maritime Antarctica***

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The Antarctic Peninsula has experienced the second fastest warming on Earth in the last century. Concomitantly with warming, vascular plant populations (*Deschampsia antarctica* and *Colobanthus quitensis*) have expanded in the Maritime Antarctica. Several hypotheses have been raised trying to explain the biological bases of these plant expansion, such as those suggesting direct effects of temperature on carbon gain and hence increases of growth and reproduction of these species and also hypothesis related to indirect effects of the increase in temperature on soil nutrient cycling and availability for plant growth. These hypotheses have been contrasted by a combination of field and laboratory studies of plant responses to temperature and in situ warming experiments using open top chambers (OTC) in King George Island, near H. Arctowski Station. Plant respiration, photosynthetic activity, growth, soil nutrient availability and micro environmental characterization of OTC and open space (OS), have been monitored during two consecutive seasons in the field. Our results showed that OTC had significant effects on plant growth. However, the response to temperature depended on site nutrient availability (mainly N) and species. Soil respiratory activity increased inside OTC concomitantly with the availability of organic matter and nitrogen. Consistently, laboratory studies indicated that growth of both vascular species responded to nitrogen fertilization. The increase in metabolic activity (photosynthetic activity and respiration at leaf level) observed in OTC was not enough to explain plant growth. An integrated photosynthetic canopy activity of the whole growing season is currently performed to fill this gap. Our results suggest that expansion of vascular species is associated to direct and indirect effects of warming. The relative importance of the implicated factors will be discussed.

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## **S28. Diversity and distribution of life in Antarctica Sec 2, Meeting Room 406/407, August 25, 2016, 3:30 PM - 6:00 PM**

### ***Mapping the distribution of sub-Antarctic demersal fish assemblages***

**Nicole Hill**<sup>1</sup>, Scott Foster<sup>2</sup>, Guy Duhamel<sup>3</sup>, Philippe Koubbi<sup>4</sup>, Dirk Welsford<sup>5</sup>, Craig Johnson<sup>1</sup>  
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Demersal fish form an important component of sub-Antarctic ecosystems. While understanding the distribution of key commercial species is the subject of much current research, patterns in the distribution of benthic fish assemblages as a whole and associated diversity has received less attention. Here we combine Australian and French demersal fish datasets with synoptic environmental data to quantify and predict the distribution of fish assemblages across the Kerguelen Plateau. We achieve this by applying a recently developed method, called Regions of Common Profile (RCP), which quantifies distinct environmental regions containing a similar profile of species. The RCP method directly models species simultaneously (rather than dissimilarities or single species at a time) and offers advantages over previous methods in the areas of model diagnostics, the interpretability of model outputs, and providing estimates of uncertainty. We define the spatial extent of several assemblages across the plateau. We find a distinction between shallow assemblages on the northern and southern sections of the plateau, while deeper assemblages are represented across the entire plateau. Some species characterise many assemblages (e.g. *Dissostichus eleginoides*), while others are more restricted (e.g. *Antimora rostrata*). As is common, depth was highly influential in determining the distribution and composition of assemblages. Proxies for primary productivity were also influential. We discuss our results in the context of the biogeography of the region and potential applications to conservation.

## ***Using fishery data to model predictions of circumpolar habitat suitability for Antarctic toothfish (*Dissostichus mawsoni*)***

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Using habitat suitability models to understand and predict the geographic distribution of commercially targeted species is becoming increasingly important in fisheries science and management as well as identifying potential impacts of future climate change. However, the development of accurate and realistic habitat suitability models can be compromised by biased sampling effort. The Antarctic toothfish *Dissostichus mawsoni* is known to have a circumpolar distribution at depths in excess of 1000m and almost all of the available distribution data comes from commercial fishing operations. This study assessed and corrected the biases in sampling effort, that arise as from a combination of spatial management and fishermen targeting specific habitats, to develop habitat suitability models using fisheries catch data. Georeferenced fishing data from the Antarctic were used with a suit of environmental predictors in the habitat suitability model Maxent. The influence of sampling bias and its potential correction were tested using two methods of background data selection: (1) a random-background sampling approach and; (2) a target-group background sampling approach that aims to correct biased sampling effort. The two approaches provided differing insights into the primary drivers of Antarctic toothfish habitat suitability and a novel post-processing method was developed to produce the most accurate and plausible geographical distribution of habitat suitability for this species. The results are consistent with those from smaller-scale studies and highlight area of habitat suitability transition zones that provide a geographic focus for studies of future distribution changes. This study highlights the utility of fishery-derived data in understanding the circumpolar distribution of key species in the Antarctic marine environment, especially those taxa that are not amenable to traditional scientific sampling approaches.

# ***Bryozoan assemblages (Eocene, La Meseta Formation, Seymour Island, Antarctic Peninsula) and their significance for the climatic events***

**Urszula Hara<sup>1</sup>**

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The bryozoan diversity through time reveals two phases of cladogenesis (Late Cretaceous and Eocene), connected with the substantial evolutionary Paleocene-Eocene turnover, where the cheilostome replaced cyclostomes as a dominant order.

The Early Eocene lowermost part of the La Meseta Formation (Telm1) on Seymour Island includes loosely encrusting (membraniporiform) or unizoidal flexible articulated or rooted colonies (catenelliform) from the base of LMF, which are either taxonomically and morphologically different from the overlying fauna from the lower part of the LMF. This biota composed of bryozoans, benthic foraminifers and ostracods occurs at the very base of the sandy, transgressive series in the lowermost part of Telm1. At the present day such bryozoans are widely distributed in the tropical-warm temperate latitudes and interpreted as deposited in the shallow-water settings (Hara 2015).

The late Early Eocene bryozoans in the lower part of the La Meseta Formation (Telm1), Seymour Island, shows the spectacular diversification, composed mostly by massive, multilamellar colony forms, of higher taxonomical levels (20 families and 30 genera), enhanced by a great radiation of a new taxa. The most significant bryozoans are cerioporine cyclostomes - reminiscent of the Cretaceous in the Northern Hemisphere, and cheilostomes considered to have originated during the Early Eocene (Hara 2001), and then becoming widespread through Neogene to the Recent.

The presence of distinct, lunulitiform, free-living bryozoans, which develop disc-shaped colonies is characteristic for the middle part of the La Meseta Formation (Telm4-5). Environmentally, lunulitids are known to occur in warm, shallow-shelf conditions in temperature of 10-29°C, on coarse, sandy to muddy bottom, with a low to moderate deposition, in fairly high velocity, and they are absent when the temperature of the bottom sediments are lower than 10-12°C.

The bryozoans from the upper part of the LMF (Telm6-7) is scarce. In the Telm6 it was recognized in the fine-grained sandstone, where the colonies form a biostome layer up to 5 cm thick in the life position. A few poorly-preserved sole bryozoan colonies in the Telm7 are associated with vertebrates such as penguins and fish remains. This distinct decline in the Telm7 marks the proximity of the Eocene-Oligocene boundary, when a severe decrease in temperatures occurred in the southern oceans.

The changes in the biotic composition of the bryozoan assemblages in the stratigraphical column of the La Meseta Formation (Telm1-Telm7), should be referred to the climatic events of the Early Eocene (EECO), Middle Eocene (MECO) and to well-marked EOT (Eocene-Oligocene Transition) in the upper part.

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## ***Early phytoplankton bloom and large seafloor productivity footprint in Andvord Bay fjord, Antarctica: results from the first FjordEco cruise***

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The West Antarctic Peninsula (WAP) has an extensive, rapidly warming system of sub-polar fjords with tidewater glaciers. These fjords appear to be hotspots of biomass and biodiversity, with sustained phytoplankton blooms, massive aggregations of krill and humpback whales, and high abundance and species richness of megabenthos. This spectacular marine life attracts >20,000 tourists to individual WAP fjords each summer. Nonetheless, drivers of high fjord productivity/biodiversity, as well as the sensitivity of WAP fjord ecosystems to climate warming, are very poorly understood. Within the FjordEco Project, we are conducting an integrated field and modeling program to evaluate physical oceanographic processes, glacial inputs, plankton dynamics, and benthic community structure and function in Andvord Bay, a sub-polar WAP fjord, to address two overarching questions: (1) What physical, glaciological, biological and chemical processes interact to enhance fjord productivity and biodiversity? (2) How sensitive are these fjord processes to increased glacial meltwater and sediment inputs expected from climate warming? Our field program will test mechanistic hypotheses concerning oceanographic/glaciological forcing and phytoplankton and benthic community responses, and includes: (1) Deployments of moorings (physical oceanographic, sediment traps, seafloor time-lapse camera), weather stations, and glacial and sea-ice time-lapse cameras to obtain an integrated view of ecosystem processes in the fjord and adjacent Gerlache Strait over 15 months; and (2) spring and fall process cruises using shipboard CTD, towed Acrobat system, AUV glider, and intensive studies of phytoplankton and benthic species composition and production/respiration to elucidate fjord ecosystem structure and function during different seasons. We will then use a coupled physical/biological modeling approach (ROMS/NEMURO) to evaluate drivers of biogeochemical cycles in WAP fjords and to explore their potential sensitivity to enhanced meltwater and sediment inputs.

Here we present results from our spring cruise to Andvord Bay in Nov-Dec 2015 to deploy instruments and evaluate ecosystem processes. The fjord proved physically dynamic, with glacial+sea ice filling/emptying the fjord within days due to tides and katabatic winds. Tabular icebergs with 30-m freeboard roved throughout the fjord, potentially stirring waters to >200 m. The spring phytoplankton bloom was well underway in the fjord by late November while it had not yet begin on the open shelf; the fjord bloom was unexpectedly dominated by cryptomonads which may be favored by meltwater conditions. Primary production was highest over sills in the outer fjord, and the fjord appeared to be exporting meltwater, phytoplankton and nutrients into the Gerlache Strait. Benthic megafaunal abundance was dramatically elevated throughout the fjord relative to Gerlache Strait, with extraordinary abundances occurring <1 km from rapidly flowing (>5 m/d) glacial termini. Sediment community respiration was also 4-fold higher in the fjord than on the open shelf, with the highest rates underlying the zone of high pelagic primary production. Our initial results confirm that Andvord Bay is productive early in the season, especially in the outer fjord, with the benthic footprint of this enhanced productivity extending into the fjord's innermost recesses.



## ***Polar benthic and sea surface microalgal assemblages from Antarctic peninsular***

**Muhamad Hilal Mohd Zainudin**<sup>1</sup>, Nur Aqilah Muhamad Darif<sup>2</sup>, Mahadi Mohammad<sup>2</sup>, Sazlina Md. Salleh<sup>3</sup>,  
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The distribution and composition and polar benthic and sea surface microalgal assemblages were studied from the Antarctic Peninsula during the YPASM 2016 expedition (13th January to 14th February 2016). In this study, we also investigated the maximum quantum yield of both benthic and sea surface microalgal. A total of 8 stations were sampled during the expedition along the transect from King George Island 62° S down to Darboux Island 65°S. Environment temperature ranging from 10.5°C to -1.2°C were recorded. While pH range recorded was from 7.98 to 8.34. General aspects of the diversity and distribution of these microalgae in each habitat were discussed, and the composition and ecology of the most common microalgal assemblages in these environments were described in detail.

## ***Long-term ecology: using historic records and the metacommunity concept to understand present day diatom biodiversity in the McMurdo Sound region***

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At the beginning of the 20th century, a small scientific team from Shackleton's Nimrod expedition collected and preserved diatoms from a series of ponds at Cape Royds on Ross Island. These preserved samples collected in 1908 can provide modern-day ecologists with invaluable insight about the stability of Antarctic ecosystems in the face of a changing world. In a recent survey of diatom biodiversity during the 2013-2014 austral summer, we collected and characterized diatom communities in microbial mats from 25 ponds in the McMurdo Dry Valleys and Ross Island, including some of the same ponds sampled during Shackleton's expedition in 1909. We also collected pond physical and chemical characteristics, which are often closely linked to diatom species composition. Here we report on how we are using historic and contemporary data along with metacommunity modeling to understand diatom biodiversity in the McMurdo Sound region of Antarctica.

We used Moran Eigenvector Mapping (MEM) to model spatial variation in pond diatom communities. We used MEMs in variation partitioning analysis to determine the scale at which community turnover corresponded with among-pond variation in environmental factors, such as water chemistry. Spatial patterns in contemporary Diatom biodiversity showed significant spatial structuring over a spatial gradient of ~ 100 km, distinguishing among Ross Island and the McMurdo Dry Valleys. We also detected significant heterogeneity at scales of 100-1000 m, which modeled a spatial gradient describing autocorrelation among ponds at Cape Royds, on Ross Island. In this study, diatom community composition was better predicted by neighboring ponds than biologically meaningful environmental factors, such as pH and nutrient availability. Among-pond variation in diatom assemblages was correlated with bromide and chloride concentrations in pond water, but these ions are not biologically important to diatoms and we interpreted these solutes as tracers of proximity to the coast. When comparing historical and contemporary samples, we found diatom community composition was largely similar between samples collected in 1908 and 2013. However, one of the four ponds sampled in 1908 did show a significant change in its most dominant taxon between in 2013.

The observed contemporary biodiversity patterns interpreted in a metacommunity framework appear to indicate that biogeographic history (e.g. colonization histories and priority effects) influences diatom biodiversity at a broad spatial scale, and mass effects (i.e., significant dispersal of diatoms among neighboring ponds) influence diatom diversity at smaller scales (e.g., among ponds located at Cape Royds). However, we do not know if these mechanisms alone can explain turnover in the most dominant taxon in one of the four ponds at Cape Royds for which we have historical data. Therefore, we ask: is the occurrence of this turnover event over a 100 year timespan significant? To address this question, we modified a metacommunity simulation platform for R (MCSim) to test if this turnover event was extraordinary given our interpretation of the metacommunity dynamics organizing biodiversity patterns in the McMurdo Sound region and at Cape Royds on Ross Island.

## ***Picophytoplankton abundance and distribution in the Prydz Bay of East Antarctica during austral summer***

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Picophytoplankton is sensitive to the environmental variation, and few have been studied in the Southern Ocean. In austral summer 2009 and 2011, during the 25th and 27th Chinese Antarctic Research Expeditions, picophytoplankton abundance and distribution were investigated at Prydz Bay, East Antarctica. Results showed that Pico-eukaryotes (Euk) and *Synechococcus* (Syn) comprised the pico-phytoplankton community. The abundances of Euk ranged from 0.09 to 6.54 cells  $\mu\text{l}^{-1}$  and from 0.01 to 3.33 cells  $\mu\text{l}^{-1}$ , respectively in 2009 and 2011; meanwhile, abundances of Syn ranged from 0.00 to 15.61 cells  $\mu\text{l}^{-1}$  and from 0.00 to 2.45 cells  $\mu\text{l}^{-1}$ , respectively. Euk distributed mainly at Antarctic Summer Surface Water (ASSW) and Syn was observed mainly in front of the Amery Ice Shelf. The correlation analysis showed that picophytoplankton had significant correlation with both hydrophysical and nutrient variables. The sea ice coverage was significant in controlling the annual distribution and variation of picophytoplankton abundance and distribution in this area.

## ***Southern Ocean superhighways and backwaters: Modelling transport and retention of biological particles***

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Many marine species have planktonic forms either at the larval stage of their lifecycle or through whole of their lifecycle. Movement of larvae, in particular the effects of ocean current, is an important component of the lifecycle that influences population structure and successful recruitment. Understanding this behaviour is essential for sustainable fisheries management and development of knowledge of the food-web structure.

In this presentation I will assess spatial patterns and processes affecting the retention time of biological particles in the Southern Ocean, at both regional and circumpolar scale, and using a newly-developed “half-life analysis” method as a measure of retention time. These results use remotely sensed altimetry during the summer season (from December to March) through 22 years (1993-2015). My analyses reveal a surprising level of consistency between spatial patterns in retention time and what is known about the distribution of krill as well as key habitats for top predators in the region. Further work uses ocean model output in place of satellite altimetry-derived velocities. This allows us to compare the patterns for retention time between surface observations and model output, and thus evaluate the performance of the model in simulating observed retention zones. This comparison allows us to have confidence in the results from the model output at depth and under ice (where altimetry is not viable).

Next steps for this work include considering patterns of retention under climate change scenarios, and biological parameters (such as larval survival rates) in my models.

## ***Cephalopod fauna of Antarctic waters: combining new information from predators, nets and habitat suitability prediction models***

**Jose Xavier**<sup>1,2</sup>, Ben Raymond<sup>3,4,5</sup>, Huw Griffiths<sup>2</sup>, Dan Jones<sup>2</sup>, David Thompson<sup>6</sup>, Yves Cherel<sup>7</sup>  
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Cephalopods play an important ecological role in the Southern Ocean, being the main prey group of numerous top predators. However, their basic ecology and biogeography is still poorly known. We assessed the habitats and distributions of Southern Ocean cephalopods, using net-catch data and predators diets to develop habitat suitability models for 15 of the commonest pelagic squid in the Southern Ocean. The individual habitat suitability models were overlaid to generate a “hotspot” index of species richness. The “hotspot” regions in the distribution of cephalopods from the Southern Ocean are related to oceanic waters, across various oceanic fronts. Complementary to this work, we provide new information on Antarctic cephalopods, using Antipodean and Gibson’s albatrosses (*Diomedea antipodensis antipodensis* and *D. antipodensis gibsoni*, respectively) as biological samplers, known to cover huge areas of the Southern Ocean. A total of 9111 cephalopod beaks, from 41 cephalopod taxa, were identified from their diets, with the families Histioteuthidae and Onychoteuthidae, as the most important cephalopods numerically and by reconstructed mass, respectively. Combining both datasets (i.e. habitat suitability precaution models and predator diets), we provide evidence from predators of the circumpolar distribution of numerous key cephalopod species in the Southern Ocean, and provide new information on poorly known cephalopods. Our work emphasize a need for future work to focus on projecting these distributions under scenarios of climate change and their effects on the distributions of Antarctic squid from the Southern Ocean, using habitat suitability prediction models.

## **S33. The role of humanities and social sciences in Antarctic studies D5 Sec 2, Meeting Room 403, August 25, 2016, 3:30 PM - 6:00 PM**

### ***The effect of third states' presence in the Antarctic law and security***

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Ever since the Antarctic began to glitter in the eyes of international community and was brought into the center of attention for various purposes by a few states, and later the Antarctic Treaty System (ATS) came into existence, the entire international regime of the Antarctic has experienced significant changes through all those years. Moreover, The position of the Antarctic in international politics and law evolved ever since namely through participation of a wider international community. In recent years, it is observed that a significant rise in the number of third states, i.e. states that were neither an original signatory nor acceded thereto until recently, willing to explore the so called “7th Continent” and participate in activities therein is occurring. This includes a tangible number of Asian states which in recent decades expressed their willingness and intention to involve in Antarctic science and research through namely affiliation in the ATS or Antarctic related scientific entities. This evolution calls for a re-examination and comprehensive investigation into the possible legal and security effects of such globally rising participation in various activities in Antarctica as to what extent the presence of third states in the Antarctic could influence the existing legal regime and security. This paper will answer the questions pertaining to the effects and influences on the Antarctic law and security through presence of the third States, and to whether or not such effects call for a re-visit of the existing legal and security regime of the Antarctic. Such outcomes could increase understanding of how and why signified effects may occur and how may be responded.

## ***Influential opportunities: Implications of collaborative network structures in polar psychology***

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It can be argued that several features of the polar regions promote collaborations amongst polar psychological researchers. Amongst these features are the expense and logistical difficulties of conducting studies in remote areas, the number of small to moderately sized national programmes, and the comparatively small funding base for polar behavioural science research. It is a postulate of social network theory that such groups have properties that may facilitate or hinder the influence of individual researchers beyond their published research. This study examines the authorship networks drawn from 339 journal articles, books, and book chapters in areas of polar psychology published between 1960 and 2014. Analyses of centrality and key players indicate that a modest number of researchers have had potentially important bridging roles in information flow. As well, analyses of five-year epochs suggest that there have been distinct changes in the structures of collaborations, as well as the links between groups; specifically, there has been a growth in the size, density, and international diversity of collaborations, as well as the number and connectedness of groups within the overall network for the epoch. This longitudinal analysis yields promise for the wider exchange of information in the future, although the number and nodal characteristics of central players may be a limiting structural factor for this exchange.

## ***Compliance with the Antarctica Treaty 1959 and its Protocol before Any Incorporation in a State Environmental Policy***

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The study of compliance with environmental treaty has gained momentum over the recent years. This Article examines international environmental treaty from the perspective of compliance. The failure to understand the decision of compliance is troubling the policy makers because compliance is one of the most central questions of any environmental treaty. The theory of compliance must come to terms with the fact that any international law has virtually had no enforcement mechanism. When a state violates the international treaty, there are two main formal procedures through which other countries can invoke sanctions. Firstly, following the breach of an international obligation, other states may choose to impose some form of sanction such as refusing to enter into future agreements, or demand greater concessions when entering into such agreements, or they lose faith in the strength of existing agreements, all together. Secondly, the cost of violating an international obligation is reputational. A failure to honor that commitment will tarnish a state's reputation because it signals that it is prepared to breach its international commitments. Indeed, the absence of an explanation for why states obey international law in some instances and not in others threatens to undermine the very foundations of international law. If international law matters, it must be the case that it alters state behavior in some circumstances. Without an understanding of this connection between international environmental treaty and state actions, to comply, the policy advisor cannot hope to provide useful policy advice on the transformation of the international treaty into State policy. Without a theory of compliance, State cannot examine the role of treaties, customary international law, or other agreements. Nor can the Government consider how to improve the functioning of the international legal system, to be incorporated in the State policy or develop a workable theory of international legal and regulatory cooperation in implementing the international treaty. The Treaty is recognised, since entering into force on 23 June 1961, as one of the most successful international agreements, contributing to the protection of the global environment through a peaceful cooperation and commitment of the Treaty parties. Malaysia became one of the members when The Malaysian Cabinets decided to accede to the Treaty, in 2011, a move which is expected to boost the country's current scientific research efforts on the continent to a whole new level. Paramount importance to Malaysia as a tropical country vis-a-vis global warming. Especially when the Antarctic environment and climate had a direct link with, and impact on the global environment and climate change. In the conclusion, the Article will suggest the suitable Theory Of Compliance, to pave open the way for State to take into consideration several important factors from the Antarctica Treaty 1959 and the Protocol 1991 to either incorporate them into the present Environmental Policy or the new Environmental Protection Policy or the National Climate Change Policy.



## ***Eternal and ephemeral, ascetic and aesthetic: the difficulties of assigning values to Antarctic landscapes***

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The relationship between humans and landscapes has received much scholarly attention over the last five decades, both from quantitative and qualitative angles. Much of the former was devoted to (a) understanding the effects humans have on landscapes, with humans being viewed agents of physical and biological change to the landscapes, or (b) attempting to evaluate the character and significance of a landscape against a set of pre-defined criteria. A myriad of qualitative approaches were developed to examine what importance humans attach to different landscapes and landscape features, or in other words to find a way of understanding landscape values. Seminal work undertaken by, e.g., McHarg (1969) or Zube et al. (1982) considerably advanced our understanding of the connection between humans and landscapes in an experiential and transactional sense, but their body of work, along with all other substantial studies on landscape values commissioned by think tanks and governments, or spearheaded by individual scholars and tertiary institutions, largely focus on permanently inhabited spaces in North America and Europe and now increasingly also in Asia, Australasia, and South America. So far, aside from Summerson's (2013) doctoral project on Antarctic wilderness values, no substantial scholarly work has been devoted to landscape values in the Antarctic. This paper presents first results from a study currently underway that aims at critically assessing landscape values in the McMurdo Dry Valleys, an Antarctic Specially Managed Area (ASMA) in Victoria Land, Antarctica. This paper firstly discusses the applicability of evaluations of landscape value carried out elsewhere to the Antarctic, with a particular focus on the McMurdo Dry Valleys, and secondly presents the results of a document analysis of policy papers presented at ATCMs and regulatory mechanisms adopted by the Antarctic Treaty Consultative Parties, to identify the social, or political, value the Parties attribute to various Antarctic landscapes. The Parties' precautionary but reasonably prescriptive approach to maintaining landscape character and diversity are contrasted with their hesitant and tenuous attempts at addressing matters related to landscape values. The willingness to protect landscape value, which the Parties hint at, e.g. by emphasising the need to consider and protect the Antarctic environment "...and the intrinsic value of Antarctica, including its wilderness and aesthetic values ..." (Art. 3, Protocol on Environmental Protection to the Antarctic Treaty), is contrasted with an inability to agree on what landscape values to protect, which is at least partially due to a lack of information on what these values are.

## ***Perceptions of Antarctic values in Malaysia***

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Malaysians have been actively involved in Antarctic research since the late 1990s. The involvement covers not only the scientific expeditions by enthusiastic researchers but also the outreach programs carried out by the universities, National Antarctic Research Center, Ministry of Science, technology and Innovation (MOSTI) as well as Yayasan Penyelidikan Antarctic Sultan Mizan (YPASM). These outreach programs aim to inform general public about the research activities involved Malaysian scientists in the South Pole and to raise the public awareness about the importance of Antarctica. This paper presents the preliminary results of a study aimed at mapping the public perceptions of Antarctic throughout the country. The Antarctic values are measured in the categories of scientific, economic, historical/cultural, political/strategic, tourism, environmental, wildlife and sceneries (land and seascapes). Questionnaire survey is employed to carry out this study. A total of 100 random samples are collected from each of the 13 state capitals. The study outcome is expected to serve as a point of reference to measure the outreach programs conducted so far. It aims to identify the gaps to be filled in the future outreach programs, apart from understanding the current perceptions of Antarctic values among the Malaysians.

## ***'Tune in for Antarctic Radio': Strengthening national identity through a regular radio broadcast from Antarctica***

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The reproduction of everyday banal nationalism is common practice in current Antarctic geopolitics. The notion of 'Nation' as a cohesive group is a socially constructed concept that requires continual practice. Antarctic Nations produce expressions of nationalism to strengthen their Polar Agenda.

In many countries, National Radio broadcasting is used to construct and maintain a national identity by spreading national culture, sharing artistic expressions, and providing a platform for community discourse. The audiences for these radio broadcasts are perceived as imagined communities, united by the medium they share across the presumed geographical space that constitutes the Nation. Public Media is used to engage audiences with Antarctica.

In 1979, Argentina set up a radio station in Antarctica. The aim was to provide local information and to create a sense of community in the winter-over families at Esperanza Station, Hope Bay (Antarctic Peninsula). In the last thirty-seven years, LRA 36 Radio Archangel San Gabriel has grown to be part of Argentina's National Radio Broadcasting system, producing a daily programme from Antarctica that can be listened to anywhere in the world. Listeners from outside Antarctica are encouraged to participate and engage with the people at Esperanza Station, forging an integration of the communities of the imagined country.

## ***Information Science can create a platform to link disciplines in a global earth system***

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This presentation will show how information science as a tool can create a well-designed archive of human involvement in Antarctica to interlink disciplines.

As a founder Antarctic Treaty nation South Africa has been involved in the Antarctic region for more than five decades. A slow and steady stream of explorers and scientists continues to study and work on the world's coldest continent and on the surrounding islands in the Southern Ocean. It is a harsh, desolate and extreme region but also fragile and vulnerable. South Africa is proud to be part of the protection of this wilderness.

Many South Africans have been engaged in this mission. It has become apparent in the last few years that a number of new disciplines outside the world of the natural sciences have been involved.

The question therefore is whether it is possible that the use of information to create a research database involving humans can cross disciplines and engage new disciplines in the study of the Antarctic?

This presentation will outline the old as well as the new structure of the Antarctic Legacy Database of South Africa to accommodate a wider field of research. A brief description of how the evaluation and assessment of the database led to the newer structure and metadata. In the demonstration of the database a set of parameters will identify the cross-disciplinary engagement by scholars in the Antarctic research community.

A short travel through the online database during the presentation will show the various fields of research that can be undertaken with the data available in this archive. The importance of keeping the database up-to-date will emphasize that South Africa continues to have a vital and substantial role in the future of the global earth system. In conclusion the demonstration of the Antarctic Legacy database will show that South Africa has played a large role in Antarctica since the Heroic Age.

## ***Heroes wanted: Evolution of the Antarctic hero in advertising media***

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The history of Antarctic advertising is almost as long as the history of human exploration of the continent, thanks both to early sponsorship deals and the concurrent development of the modern day media landscape. The theme of heroism in such advertisements dates back just as far. Many early print examples called upon Heroic Era figures for endorsements of a particular product, such as Bovril beef extract (Shackleton), Yalumba wine (Mawson) or Huntley and Palmers biscuits (Scott). The trope of the Antarctic hero continues to be recycled today, with products re-released, narratives re-purposed, and myths revisited. In light of such cultural changes, this paper asks: to what extent is the Heroic myth of Antarctica still culturally viable? Advertisements provide an ideal litmus test for such an investigation, as they recycle ideas that are already in common cultural circulation. By analysing a series of Antarctic-related advertisements from the past 100 years, I trace the evolution and various manifestations of the theme of heroism.

Centenary celebrations for the Heroic Era expeditions of Scott and Shackleton have occasioned the rerelease of products, such as food and clothing, which were used by the explorers. In such cases, contemporary advertisers often use ironic distance to encourage the would-be consumer to appreciate the cultural history that comes with the shorthand of the Antarctic hero, without accepting the traditional received version of the narrative wholesale. Examining the promotional material around such rereleases reveals the ways the original narratives have been repurposed. This, in turn, indicates both the cultural and commercial currency carried the Antarctic hero-figure at various times.

In other advertisements, specific narratives have been overtaken by the generic concept of the Antarctic hero. The figures depicted in such advertisements are de-identified, and the Antarctic hero becomes a mythical figure, upon which viewers can project their own associations. Rather than being tied to a particular figure, the Antarctic hero now also manifests as an archetypal myth, making the theme far more versatile for advertising purposes.

A century on, the Heroic Era itself may have been relegated to sepia tones in the popular cultural memory, but famed images of men fighting against the blizzard continue to evoke an immediate response. Although it has evolved from straight endorsements, through to ironic distancing and de-identification, the myth of the Heroic explorer still shapes the idea of Antarctica in the public imagination.

## ***IAATO Guidelines on Antarctic Tourism: What's Next?***

**Nuraisyah Chua Abdullah**<sup>1</sup>, Rohani Mohd Shah<sup>1</sup>, Zaliha Hj Husin<sup>1</sup>, Hamisah Abd. Rahman<sup>1</sup>  
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During the last two decades, the Consultative Parties (CPs) to the Antarctic Treaty adopted several instruments to regulate Antarctic tourism. The governmental system of the Antarctic Treaty System (ATS) is paralleled by a comprehensive self-regulation system, developed by the International Association of Antarctica Tour Operators (IAATO), an industry association founded in 1991. These include guidelines on numbers ashore, wildlife watching, small boat and helicopter operations, activity reporting, passenger, crew and staff briefings; contingency and emergency medical evacuation plans; and communication procedures to coordinate site visits. IAATO provides guidance for its members on environmental impact assessment and supports a site inventory programme to monitor impacts at commonly visited sites. Site-specific guidelines were introduced for the 2003/04 and are being further developed. However, the self-regulation by the IAATO was criticised for being ineffective. According to Antarctic and Southern Ocean Coalition (ASOC), the problems resulting from mass tourism is experienced in Antarctica. The absence of outside pressure to ensure compliance with the guidelines is regarded as one of the setbacks of the IAATO's self-regulatory framework. Although the IAATO's self-regulatory guidelines are helpful, they are unable to close the gaps in the policy framework. While IAATO as an industry group has resolved to set the highest possible tourism operating standards in its effort to protect Antarctica and its by-laws are compliant with the Treaty and ATS instruments, members who breach the treaty or instrument can only be subject to reprimand or change in membership status e.g. probation or expulsion, after review by the Membership and Executive Committees. Additionally, tour operators' membership to IAATO is not compulsory thus the guidelines could not be imposed to non-IAATO members. To overcome this limitation, it is suggested that IAATO's self-regulatory framework should co-exist with State's legislative move as it remains the responsibilities of the state parties to establish the regulatory basis for the tourism industry. Given the sensitivity and importance of the Antarctic environment and the potential dangers associated with tourist activity in the region, it can be argued that there remains scope for additional measures to be adopted in order to ensure that the regime can be classified as truly precautionary and sustainable. In order to strengthen the role of IAATO in regulating tourism industry in Antarctica, it is suggested that membership to IAATO should be made mandatory for all operators conducting tourism programmes in Antarctica. The inclusion of IAATO under the Antarctic Treaty System (ATS) is also suggested as this will facilitate the organisation to effectively monitor tourism in Antarctica. Its inclusion under the ATS is also helpful to guarantee IAATO's independence as the organisation will be under direct supervision of the Antarctic Treaty Consultative Meeting (ATCM).

## ***Polar scientists, polar tourists: A foraging analogy***

**Ricardo Roura<sup>1</sup>**

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Science and tourism are two of the main forms of human engagement with the Antarctic region. To a lesser degree the same applies to the Arctic, where the dominant activities emerge from permanent habitation and natural resource extraction. Some scientists, tour operators and even tourists visit both regions. What are the similarities and differences in the behavior of these two groups? To address this question, behavioral observations were conducted during the Spitsbergen Scientific Expedition Edgeøya ([www.SEES.nl](http://www.SEES.nl)) in August 2015, as part of the activities of the Netherlands Polar Program. During the SEES expedition the behavior of scientists and tourists was studied by means of direct observations and photographic and video documentation of behavior and visible evidence of behavior, with a focus on activities ashore.

The SEEs expedition combined a multidisciplinary group of scientists and a group of tourists in approximately equal numbers (about 50 each). The expedition planning and conduct catered to both groups and tried to maximize the number of sites visited, and access to features of interest to a broad range of scientific disciplines and to tourists.

Both groups behaved in distinct ways according to their programs, however in some instances scientists displayed a similar behavior as tourists and vice-versa. Both groups were systematic and opportunistic in terms of how they searched for, found, and "captured" features of interest - such as samples, data, images - while moving through the landscape. Their behavior was systematic in that experienced participants looked for specific targets (e.g. sample sites, sights) in specific places. Behavior was opportunistic in that participants took advantage of chance encounters or findings that had scientific and/or tourism interest. In this regard, a hunter-gatherer analogy can be used to examine the behavior of polar scientists and tourists.

Whilst the analogy is responds only partially to foraging theory, some aspects are relevant including with respect target selection, patch choice, time allocation, and foraging group size. Observed behavior optimized the use of space and time; and also adapted to restrictions imposed by e.g. sea ice, weather, polar bear risk, and a hierarchy of actors and activities inherent to the expedition.

This research took place in the Arctic, but its findings have implications to the conceptual the understanding of human behavior in the Polar Regions, and also for the management of these activities and of the particular polar sites where they take place.

## **S38. Scientific advice for policy, Meeting Room 408, August 25, 2016, 3:30 PM - 6:00 PM**

### ***A strategic vision for NSF investments in Antarctic and southern ocean research: recommendations from the U.S. national academy of sciences***

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We will present a recent example of how the scientific community has helped shape “policy for science” at the national level—through a U.S. National Academies of Sciences study that recommended a strategic vision for the coming decade of National Science Foundation (NSF) investments in Antarctic and Southern Ocean research. This study built upon ideas from almost 500 scientists across the research community.

The study committee recommended that NSF continue to invest in a broad portfolio of research across the disciplinary spectrum, as an effective way to foster innovation and discovery. But they also recommended this be balanced with a few larger-scale, more directed efforts that focus a critical mass of resources toward key research goals. Based on a specific set of evaluation criteria, the committee recommended the following as priority large-scale initiatives: [1] How fast and how far will sea level rise? The Changing Antarctic Ice Sheets Initiative; [2] How do Antarctic biota evolve and adapt to the changing environment? An initiative for decoding the genomic and transcriptomic bases of biological adaptation and response across Antarctic organisms and ecosystems; and [3] How did our Universe begin and what are the underlying physical laws that govern its ultimate fate? A next generation cosmic microwave background program.

We will discuss the key elements of these proposed initiatives; the types of infrastructure, logistical support, data management, and other critical foundations most critical for enabling the proposed research; and the ways in which this national-level guidance relates to the international-level guidance of the SCAR Horizon Scan.



## ***Evaluation of non-native species policy development and implementation within the Antarctic Treaty area***

**Kevin Hughes**<sup>1</sup>, Luis Pertierra<sup>2</sup>, Javier Benayas<sup>3</sup>

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Antarctic non-native species legislation is contained within the Protocol on Environmental Protection to the Antarctic Treaty, with 2016 marking the 25th anniversary of its adoption. We take this opportunity to evaluate the Antarctic Treaty signatory Parties' collective development and implementation of non-native species policy. In general, scientific and policy outputs relating to the issue of non-native species have increased in the past decade. However, data detailing Parties' current implementation of biosecurity practices is not readily available. Policy and guidelines to reduce anthropogenic transfer of indigenous Antarctic species between biogeographic regions, prevent microbial contamination of pristine areas and limit introduction of marine species have yet to be developed fully. Little widespread, internationally coordinated or systematic monitoring of non-native species establishment has occurred, but available data suggest establishment of non-native micro-invertebrates may be greatly underestimated. Several recent small-scale plant eradications have been successful, although larger-scale eradications present a greater challenge due to seed bank formation. Invertebrate establishment synanthropically in research station buildings presents an increasing problem, with mixed eradication success to date. Notable achievements in policy development include the 'CEP Non-native Species Manual' which provides a single point of reference for advice on Antarctic non-native species issues. The opportunity now exists to build on earlier successes, including towards the development of a comprehensive response strategy. To help facilitate this, we identify areas requiring further research and policy development.

## ***Competing values and political complexity in the Southern Ocean: CCAMLR and the challenge of marine protected areas***

**Cassandra Brooks**<sup>1</sup>, Lisa Curran<sup>1</sup>, Larry Crowder<sup>1</sup>  
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The Commission responsible for managing Antarctic marine living resources, CCAMLR, has been lauded as a leader in high seas conservation and science-based management. Exemplary of this leadership, CCAMLR committed to designating a representative network of Southern Ocean marine protected areas (MPAs). However, after adopting the world's first high seas MPA in 2009, progress towards this goal has stalled, despite extensive MPA proposals for the East Antarctic and the Ross Sea. To evaluate the barriers and facilitators of the CCAMLR MPA process, I completed an in-depth case study, that included participant observations of five CCAMLR meetings from 2012-2015, interviews with CCAMLR diplomats and scientists from the 24 Member States, and compiling a diverse suite of other documents and secondary sources. Results indicate that economic interests, geopolitics, and lack of a defined policy process have created institutional inertia within CCAMLR and thus, inhibited CCAMLR's ability to establish MPAs. Worldwide, the Antarctic harbors some of the last regions of unexploited marine living resources, including krill and lucrative toothfish. The MPAs proposed would displace some fishing access, limit potential future access to Southern Ocean resources and set a major precedent for global management in the Antarctic and high seas. Tense international relations (e.g., Crimea) can stall the entire process, as occurred during the 2014 CCAMLR meeting. Moreover, the motivations behind the MPAs are not clear to all participating States, nor is the scientific basis for the location of MPA boundaries. This lack of clarity and the potential disruption of CCAMLR institutional norms may impart distrust among some members, thus, stalling this negotiation process. While CCAMLR member States have collectively agreed to adopt MPAs in the Southern Ocean, the process of implementation has become increasingly entangled in politics. As a consensus-based management body, even a single Member State can block adoption of conservation measures. The way forward may depend on building trust through enhanced transparency, greater collaboration and clearer rules around the MPAs plans and process. Adoption of CCAMLR MPAs may further require a shift in international relationships among participatory States.

## ***Protection of geological heritage within the Antarctic Protected Areas system***

**Jerónimo Lopez-Martínez**, Hughes K<sup>2</sup>, Carcavilla L<sup>3</sup>, Durán J<sup>3</sup>

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Some Antarctic geological and geomorphological features and deposits contain important and relevant scientific information. In some cases, there are particular features or locations that can be key for reconstructing geological history, detecting past climates or revealing the evolution of life on Earth. Some geological features are rare or unique, or are difficult or impossible to observe in other locations, which facilitate our understanding of earth history or show exceptional geological processes. Consequently, these sites having an outstanding scientific value. Increasing pressure from visitors and the construction of infrastructure, can impact upon features that form part of Antarctica's geological heritage. In some cases, key geological features and elements could be inadvertently damaged or destroyed. For these reasons, it is important to identify and protect the most important features and elements that contribute to the geological heritage of Antarctica. Some important geological and geomorphological features are located in places designated as Antarctic Specially Protected Areas (ASPAs). One of the reasons for designation of an area as an ASPA is that it contains outstanding geological, glaciological or geomorphological features. However, in only a few cases have these geological features been the main reason for the protection of the area. More generally, geological features are not considered from the point of view of their protection, and there are many geological features of outstanding value that are not included in the ASPA system. In this work we examine how effectively geological heritage is protected by the current Antarctic Protected Areas system and also how well Antarctic geodiversity is represented. An evaluation of the current situation helps highlight possible ways to advance the protection of the continent's geological heritage. An improved understanding of existing Antarctic geological heritage would provide a useful baseline for the future development of conservation policies and measure to protect Antarctica's scientifically valuable geological and geomorphological features.

This presentation aims to contribute to the ongoing work of the SCAR Action Group on Geological Heritage and Geoconservation, which aims to develop knowledge useful in policy maker's considerations regarding the protection of geological features in Antarctica.

## ***What is the spatial scale of a research event in ice-free Antarctica?***

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With increasing human activity in Antarctica and growing interest in the concept of human footprint and wilderness from policy makers in the context of environmental impact assessments, there is a need to understand the spatial scale of human activity on the continent.

For the 15/16 field season, 22 individuals across two science events were observed to capture data on their activity in an ice-free Antarctic landscape. This provided insight into: the spatial scale of an Antarctic field event; how individuals moved through the landscape; and how differences in the individuals shaped their movement. Utilising this data, we are able ascertain the factors constraining human activity, the amount of area that is impacted, as well as the landscape features which contain recurrent activity.

This research begins quantify the scale of the human footprint in Antarctica. The data will also be used, along with records of the activities of national programmes, to develop a validated model to capture and visualise the historic, current, and future scale of human activity within the Ross Sea region. This will enable us to understand how changes in accessibility and movement can shape the footprint, and the location of areas susceptible to cumulative impacts in ice-free regions. Utilising this information, we hope to provide policy-ready insight into the spatial scale of the human footprint in the ice-free regions of Antarctica.

## ***Antarctic policy, environmental protection and science: Interdependent, or distant cousins?***

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The Antarctic Treaty provides for 'freedom of scientific investigation and cooperation toward that end' in Antarctica. The Antarctic Treaty System's Committee for Environmental Protection (CEP) is charged with reporting back to Treaty Parties (53 Governments) on (among other matters) the state of the Antarctic Environment; the need for scientific research related to environmental protection, the effectiveness of the protected area system; minimising or mitigating environmental impacts in the Treaty Area, the need for strengthened or additional environmental protection mechanisms, and the need for scientific research related to environmental protection. The effectiveness of the CEP to fulfil these responsibilities depends on an accessible and dynamic knowledge base, and a strong connection to the research community. In turn, maintaining Antarctica as a continent devoted to science depends on effective management and governance, and a two way flow of information between scientists and policy makers.

Mechanisms are in place for linking Antarctic science and policy, including through SCAR's role as an official Observer to the Antarctic Treaty, and its Standing Committee on the Antarctic Treaty System (SCATS), which is tasked with facilitating SCAR's scientific advice to the Antarctic Treaty System. The Antarctic Environments Portal ([environments.aq](http://environments.aq)) promotes the link between Antarctic science and policy by making science-based information on current and emerging issues available to the CEP and Antarctic Treaty Parties.

We have an Antarctic governance structure that is committed to science and environmental protection, and through SCATS and the Portal, solid platforms to support closer links between the two. However, information needs, to support comprehensive environmental protection, and a dynamic Treaty System are growing as a result of rapidly changing Antarctic Environments. And policy responses appear to be slowing. We present a critical appraisal of the current science – policy connection to support Antarctic Environmental Protection 25 years after the Protocol was agreed, and consider what Antarctic Environmental Protection could look like in 25 years' time by testing the strength of the connection in light of contemporary and anticipated challenges.

## ***25 Years of the Environmental Protocol***

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2016 marks the 25th anniversary of the signing of the Environmental Protocol to the Antarctic Treaty. The Protocol represents a decisive shift towards making environmental protection a primary goal of Antarctic governance. Therefore, this is an ideal occasion to examine how key articles and Annexes to the Protocol have been implemented over the past decades, and whether this has resulted in improved protection of the Antarctic environment. We will also examine how activities such as tourism and scientific research have changed since 1991, and the challenges these developments present in adhering to the Protocol. In the past 25 years climate change has emerged as a major issue with direct and indirect consequences for Antarctica. In this context, how can science inform a better implementation of the Protocol, and more effective policy making with respect to environmental protection? Tourism in particular has expanded and diversified, and although Antarctic Treaty Parties have agreed that they should take a proactive, precautionary approach to managing tourism, they have not yet done so. Scientific bases and other infrastructure continue to be developed, even when the scientific justification of such bases is not always clear. Possible solutions to managing these challenges include strengthening the Environmental Impact Assessment (EIA) process, improving the assessment of cumulative impacts, and engaging in systematic planning for Antarctic Specially Protected Areas (ASPAs). Science can contribute to improving these and other processes aiming to a better protection of the environment. This in turn will ensure that Antarctica remains, in the words of the Protocol, "a natural reserve devoted to peace and science." In an era marked by climate change and increasing human pressure on the Antarctic environment and ecosystems, Antarctic Treaty Parties must enter a new phase of enhanced Protocol implementation for the next 25 years. In turn, the Antarctic scientific community should aim to turn scientific assessment into action.

## ***Out of balance? Conservation, rational use, and the implementation of the Convention on the Conservation of Antarctic Marine Living Resources***

**Claire Christian**<sup>1</sup>, Ricardo Roura<sup>1</sup>, Jennifer Jacquet<sup>3</sup>, Cassandra Brooks<sup>4</sup>, David Ainley<sup>2</sup>

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The Southern Ocean comprises roughly 10% of the global oceans, managed under the Convention for the Conservation of Antarctic Marine Living Resources (CAMLR Convention). Article II of the CAMLR Convention establishes that conservation is the Convention's primary aim, where "conservation includes rational use", and any harvesting or associated activities shall be guided by three principles of conservation delineated in the article and by the provisions of the Convention. These principles outline a precautionary, ecosystem based approach to fisheries management, rather than a single-species approach. It follows that although fishing can occur, it is secondary to preserving ecological relationships and minimizing the risk to Antarctic marine ecosystems. Due to its ecosystem-based mandate, the CAMLR Convention has been internationally acclaimed as perhaps the leading example for high seas conservation and fisheries management. Despite their legal mandate, in recent years, some countries that are party to the Convention have indicated that they believe Article II gives them a right to fish, or that fishing and conservation must be "balanced". This presentation will explore the evolution of the interpretation of the term "rational use" (which is not defined in Art. II or elsewhere in the Convention), starting from initial negotiations and continuing through the present. We will also examine the implementation of Article II by the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR), the body that implements the Convention, and whether current management practices are being conducted according to Article II's principles. Finally, we will make recommendations for how CCAMLR management could improve its implementation of Article II and thus ensure that "rational use" is indeed consistent with the intent and meaning of the Convention, so that CCAMLR can maintain its status as a leader in precautionary, science-based management and conservation.

## ***Polar science for Europe - Opportunities for planning and communicating European polar science to policymakers***

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The European Polar Board (EPB) is an independent voice of European polar research with the principal role of facilitating cooperation in all fields of polar science across Europe and representing European polar research in the global context. The EPB identifies and promotes scientific priorities of common interest for its members in a foresight process and through specific working groups. It provides policy makers with strategic information, develops multilateral cooperation and implements joint projects in collaboration with relevant scientific polar international organisations. The EPB's mission is to coordinate European polar research by optimizing the use of European research infrastructure and fostering multilateral collaboration between European national funding agencies, national polar institutes and research. EPB provided the platform which brought together 22 European polar organisations to create a successfully funded project - EU-PolarNet. EU-PolarNet provides a specific venue for policy advice, and is described in detail through another presentation in this session by Biebow et al. We will detail the process of planning such an ambitious project and how it was put into practice, including the lessons learnt. The unique aspect of this project is the prior planning for its legacy by the EPB, which will ensure that the products created from this project are used and kept live and updated well beyond the project's life.



## ***Developing an integrated State of the Antarctic reporting system.***

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There has been extensive discussion within the Antarctic Treaty System, including CEP and SC-CAMLR, on the desirability of a 'State of the Antarctic' reporting system in which a range of key data are used to provide headline indicators to policy makers and managers. These indicators would provide managers with a warning of when conservation/management action is required as well as metrics to measure the efficacy of existing measures (in the absence of any metrics of performance is impossible to determine if those actions have been successful – just imagine Apple launching a new iPhone and not collecting any sales data!). It is axiomatic that the design of a 'State of the Antarctic' reporting system requires engagement between scientists and policy makers. Effective engagement is essential to avoid an unrealistic expectation from managers of what the programme is seeking to provide; it will likely also need to reflect an acknowledgement that not all elements of science will be viewed equally in their role in delivering to such a system. Much of the data required for a 'State of the Antarctic' are likely to be available from existing sources, indeed many different groups have commented that they already produce these type of reports, however, they are not collated and analysed in a coordinated way that makes them amenable for delivery into policy and management fora. Developing a consortium of interested parties, both as contributors and consumers, to lead the development of an Antarctic-wide status reporting system is tractable, necessary and, compared to AMAP in the Arctic, overdue.

## **Mini Symposium: The Antarctic Ice Sheet From Past 2 Future, Ballroom 1, August 26, 2016, 9:00 AM - 11:00 AM**

### ***Can models of the past help predict the future?***

**Nick Golledge**<sup>1,2</sup>

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Future environmental change will most likely necessitate costly impact mitigation strategies whose design will depend on both the magnitude and rate of anticipated change. Ice-sheets have the potential to alter global sea-level by accumulating or losing mass in response to environmental perturbations, but the rate at which ice sheets change is also governed by internal processes. Simulations that robustly capture all known aspects of ice-sheet physics are, however, so computationally expensive that their implementation is currently limited to restricted spatial domains or short temporal integrations. Useful projections of sea-level for coming centuries therefore require models that can predict continental-scale changes over centuries to millennia, but such models employ simplified physics to achieve this and so may introduce uncertainties. One way to approach this problem then is to use large-scale models that incorporate parameterisations that mimic the effects of the fine-scale processes of purely physical models. However, the veracity of results from such an approach can only be gauged by comparison to known outcomes, which means that, for reliable large-scale future ice-sheet projections it is necessary to employ modelling approaches that accurately reproduce past ice-sheet transitions as recorded in palaeoenvironmental archives. Here we present simulations of past Antarctic ice-sheet extents under warmer-than-present conditions, as well as through the last glacial-to-interglacial transition, and assess the associated rates and magnitudes of sea-level-equivalent volume changes. We then explore the dominant environmental and glaciological processes involved in these ice-sheet fluctuations and consider these in the context of currently observed Antarctic trends and future predictions.

# ***Past geometry of the Antarctic ice sheet and isostatic response: Corrupting space altimetry and gravimetry inference of present-day mass imbalance***

**Erik Ivins**<sup>1</sup>

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The past geometry and volume change history of the landed ice that contributed to post-Last Glacial Maximum sea-level rise has a direct impact on the interpretation of space-era observational data that pertain to the Antarctic ice sheet contribution to sea-level over the past 25 years. The problem of determining the pattern and amplitude of the secular crustal uplift and geoid rates of change suffers from a number of obstacles; the most prominent being that ice covered regions cannot be directly measured by GNSS monuments that record crustal uplift rates. Altimetry may have to deal with corrections over the vast area of the interior of the East Antarctic Ice Sheet where the ice height change signal is relatively small. Inferences from gravimetry may be directly affected by the fact that the viscoelastic response of the solid Earth to past load changes also has a mass signal that is associated with it. This potential was first pointed out by James and Ivins (1995), and also by Wahr et al. (1995), with a pair of articles on the Antarctic ice sheet appearing in the April 15th issue of *Geophysical Research Letters*. In these 1995 articles, it was pointed out that the separation of ice mass balance and GIA signals required data combination methods.

Today researchers are beginning to tease out such separability using a variety of data types. Here I sketch out some of the requirements that must be in place for such separation using multiple data sets and how any results should be tempered with our knowledge of past mass evolution that is the driver of the viscoelastic deformation field. An additional spatial field that has a substantial impact on the interpretations of mapping present-day GIA signal is the large variations of mantle viscosity that have a strong 3-D character. End-member corruptions in the trends retrieved from Gravity Experiment and Climate Experiment (GRACE) Ice, Cloud, and land Elevation Satellite (ICE-Sat) and Cryo-Sat-2 data are important to consider in either data combinations or in isolated mass balance solutions.

## ***Totten Glacier catchment bed erosion indicates repeated transitions between a modern-scale and a retreated ice sheet***

**Alan Aitken**<sup>1</sup>, Jason Roberts<sup>2,3</sup>, Tas van Ommen<sup>2,3</sup>, Duncan Young<sup>4</sup>, Nick Golledge<sup>5,6</sup>, Jamin Greenbaum<sup>4</sup>, Donald Blankenship<sup>4</sup>, Martin Siegert<sup>7</sup>

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The Totten Glacier is the outlet for one of the most voluminous catchments in East Antarctica, and shows signs of vulnerability to change. The upstream portions of this catchment include the topographic lows of the Sabrina Subglacial Basin (SSB) and the Aurora Subglacial Basin (ASB), which are surrounded by highland regions. The SSB and ASB each are susceptible to marine instabilities. Here we analyse the subglacial topography of the SSB and the thickness of the underlying sedimentary basin to understand the erosive history of the SSB as a proxy for past ice sheet dynamics. We show that the history of this catchment involves long periods with the ice sheet margin located close to today's, and similarly long periods with the ice sheet margin located hundreds of kilometres further inland. The intervening region is less eroded, suggesting erosion through several repeated transitions between these states, but without prolonged residence. Using numerical ice sheet models, we constrain the likely sea-level contribution of these ice-sheet states. In a retreat from modern scenario, up to 150 km of retreat ( 90cm of sea level rise) can be accommodated within the modern-scale state. Further retreat involves marine ice sheet instabilities that drive the ice-sheet extent to the retreated state (2-3 m of sea level rise). Ongoing retreat involves collapse into the ASB, associated with sea level rise in excess of 4m.

## ***Simultaneous disintegration of outlet glaciers in the Porpoise Bay region of East Antarctica, driven by sea ice break-up.***

**Bertie Miles**<sup>1</sup>, Chris Stokes<sup>1</sup>, Stewart Jamieson<sup>1</sup>

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Iceberg calving is an important process accounting for around 50% of total mass loss to the ocean in Antarctica. Moreover, dynamic feedbacks associated with retreat in buttressing ice shelves or floating glacier tongues can result in an increased discharge of ice into the ocean. Therefore, improving our understanding of the mechanisms driving glacier calving and how glacier calving cycles have responded to recent changes in climate is important in the context of future sea level predictions. In this study, we analyse the calving rates of several glaciers in the Porpoise Bay region of East Antarctica using Envisat ASAR imagery at approximately monthly intervals between November 2002 and March 2012. We observe a large simultaneous calving event in January – April, 2007 where a total of ~2,500 km<sup>2</sup> of ice calved from multiple glaciers in the region. We link this calving event to a break out of the landfast sea ice which usually occupies the bay. In the absence of regular satellite imagery prior to 2002, we use sea ice concentrations in Porpoise Bay as a proxy for iceberg calving. This infers a potential speed up in the rate of calving for Holmes glacier, the largest in Porpoise Bay.

## **S28. Diversity and distribution of life in Antarctica D7 Sec 1, Meeting Room 406/407, August 26, 2016, 9:00 AM - 11:00 AM**

### ***Crozet marine ecosystem based approach***

**Philippe Koubbi**<sup>1</sup>, Chloé Mignard<sup>1</sup>, Ophélie Da Silva<sup>3</sup>, Claire Lo Monaco<sup>3</sup>, Cédric Cotté<sup>3</sup>, Francesco D'Ovidio<sup>3</sup>, Charles André Bost<sup>2</sup>, Karine Delord<sup>2</sup>, Alexis Martin<sup>1</sup>, Cédric Marteau<sup>4</sup>  
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This project is related to the CCAMLR objectives to establish a representative network of MPAs in the Southern Ocean and the willing of France to extend the protection within its EEZ. In 2012, a first CCAMLR working group was held at the headquarters of TAAF (French Southern and Antarctic Territories) in La Réunion Island. Several research axes were discussed to improve the marine conservation of the CCAMLR Planning Domain 5. The conclusions of the working group was well evaluated by the CCAMLR Scientific Committee which encouraged to continue further researches to propose MPAs. Moreover, the ecological synthesis which was realized led to propose Marion-Prince Edward Islands, Del Cano and Crozet as EBSA (Ecologically and Biologically Significant Areas) to the Convention on Biological Diversity. Recently, South Africa has declared an MPA in the Marion and Prince Edward EEZ. Our researches on Crozet has the main objective to give scientific advices to extend the actual nature reserve. Indeed, the French Southern Territories nature marine reserves should increase from 22 500km<sup>2</sup> to several hundred thousands of square kilometers within few years.

Our approach is based on the eco-regionalization of the marine environment which consists of combining geographic information layers on biodiversity and the abiotic environment. This will lead to determine ecoregions with that are slightly different in terms of species assemblages or oceanographic features which are very complex in this area. The Crozet islands are located in a meander of the Subantarctic Front and hundreds of nautical miles North of the Antarctic Polar Front. There are important seabirds and marine mammals populations which are influenced by the oceanographic features such as plankton surveyed by the Continuous Plankton Recorder. This area is also harvested by toothfish fisheries with systematic scientific observations.

The complexity of this study is relative to the unequal level of information concerning benthos, plankton, fishes, marine mammals or seabirds. As a first step, it is necessary to clarify the species list of known and potential species in the area and to establish faunal gradients per ecoregions. Geostatistics and habitat modelling will be used to estimate faunal gradients in unsampled areas. The second step will be to establish biodiversity conservation targets and to identify actual and potential pressures on the marine ecosystem. The third step will be to used Systematic Conservation Planning procedures to help determining scenarios that could be used to extent the actual marine nature reserve which is currently limited to 12 nautical miles around some of the islands of the Crozet archipelago.

This will be an important contribution to the conversation of the Subantarctic marine ecosystems, one of the most threatened by climate change.

## ***How many barcodes are enough? Increased local sampling allows recognition of larger distributions and two new species in *Antarctomysis****

**Christoph Held<sup>1</sup>**, Shobhit Agrawal<sup>1</sup>

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Molecular barcoding has improved our knowledge about species inventories dramatically over the last decade but the optimal sampling strategy to balance cost and species discoverability is still a matter of dispute. Due to financial and logistic constraints, large-scale barcoding campaigns typically use pre-sorting to morphotypes and barcode a small number of them (often between two and ten specimens per morphotype).

Using the Southern Ocean endemic mysid genus *Antarctomysis* Coutière 1906 collected by the CEAMARC campaign off Terre Adélie, East Antarctica, five distinct genetic clusters were identified in 143 COI sequences. These genetic groups were classified as species based on, a) various species delimitation methods (distance-based, coalescent-based and phylogenetic tree-based), b) distinct bathymetric distributions and c) morphological analyses.

Using larger than usual sample sizes in a box not exceeding 100km along the edges, we detected all nominal *Antarctomysis* species significantly extending their known ranges and recorded two more species new to science.

Simulations show that for a set of sympatric species, 40% of the species diversity would go undetected if only 10 individuals were sampled. In all simulated scenarios, species were falsely detected to be exclusively present in one region using commonly accepted sample sizes in barcoding studies.

Rare species of a high-abundance taxon will be frequently overlooked in large-scale biodiversity surveys. Inferring patterns of species distribution based on barcoding data can be positively misleading as false patterns of high endemism will be frequently observed.

## ***Pleuragramma antarcticum distribution in the Ross Sea: patterns of early life history and evidence of a new nursery ground***

**Cassandra Brooks**<sup>1</sup>, Jilda Caccavo<sup>2</sup>, Kim Goetz<sup>3</sup>, Lorenzo Zane<sup>2</sup>, Julian Ashford<sup>4</sup>, Mario La Mesa<sup>5</sup>  
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Research into the early life stages of *Pleuragramma antarctica* is essential to understanding how oceanographic changes will impact population distributions over time. During the last decade, scientists have revealed much about the early life history of *P. antarctica*, including confirmation of the first known nursery ground under fast ice in Terra Nova Bay. However, there is still much unknown about larval fish distribution in the Ross Sea, Antarctica. During a United States National Science Foundation research cruise in the late austral summer 2013 (February-March), we opportunistically sampled the ichthyoplankton community at 17 locations in the western Ross Sea (WRS) as well as one location in the central Ross Sea and one location in the far south of the eastern Ross Sea (ERS) in the Bay of Whales. Larval *P. antarctica*, identified based on morphological characteristics, made up more than 99% of the ichthyoplankton in the WRS. Although most of these fish had hatched during the peak summer season (December-January), a unique tow in the Bay of Whales unexpectedly revealed recently (mid March) hatched larvae. To discount species misidentification as a possible explanation, we extracted genomic DNA and amplified 16S rDNA and the D-Loop region using fish universal primers. Despite DNA degradation likely due to issues with freezing and transport of the larvae, sequencing was successful in a fraction of samples from both the WRS and ERS. These sequences were aligned with known GenBank sequences from *P. antarctica* compared to several related notothenioids, definitively confirming species identity. This is a novel use of mitochondrial DNA for species identification in *P. antarctica*, which is also pertinent to samples of any species that may have suffered DNA degradation. Length data from the larval *P. antarctica* obtained from the WRS over the course of the cruise supported growth rates and hatching times consistent with hatching events reported from Terra Nova Bay. The most numerous abundances (3400+ in each tow) were found along the ice margin, suggesting the importance of sea ice distribution to this species following dispersal from spawning areas. By contrast, recently hatched larvae in the Bay of Whales suggested a spawning area in the eastern Ross Sea, with late hatching that may be explained by regional differences in latitude, climate and oceanography.



## ***Under-ice habitat for juvenile krill under climate change: Could less mean more, and how can we tell? Insight from GCMs***

**Stuart Corney**<sup>1</sup>, Jessica Melbourne-Thomas<sup>1,2</sup>, Rowan Trebilco<sup>1</sup>, Michael Sumner<sup>1,2</sup>, Andrew Constable<sup>1,2</sup>  
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Over-wintering of larvae underneath Antarctic pack ice is a critical stage in the lifecycle of Antarctic krill. However, there are no circumpolar assessments of available habitat for krill, making it difficult to evaluate how climate change may impact on this life stage. We define a set of simple assumptions regarding key habitat features for juvenile krill in order to allow us to identify possible regions of larval krill habitat around Antarctica during winter. We then assess the suitability of different model output with regards to identifying potential krill habitat both in the present and under climate change scenarios.

Initially we use a circumpolar sea-ice model to define current and future total habitat area. Results indicate that, while total areal sea ice extent decreases, there is a consistently larger area of potential larval krill habitat under warm conditions.

There are now more than 60 global climate models with output available through the CMIP5 archive that can be used for investigating questions regarding the impacts of climate change. Each of these models has a combination of prescribed variables and optional variables that vary from model to model. Crucially the variables we use to define krill habitat are not essential in CMIP5 models and thus are only available in a small subset of GCMs. We show that for GCMs that have all necessary variables the direction of change for krill habitat is opposite to that of sea ice extent, which is consistent with our finding using a dedicated sea ice model.

These findings highlight that decreases in sea-ice extent may not necessarily be detrimental for krill populations and underline the complexity of predicting future trajectories for this key species in the Antarctic ecosystem. Furthermore, in order to resolve critical ecosystem questions such as future extent of suitable krill habitat, we must identify relevant variables and ensure that they are incorporated as standard requirements into future CMIP experiments.

## ***Feeding ecology of Antarctic krill in the Antarctic Peninsula in the autumn-winter using stable isotope analysis***

**Qi Song**<sup>1</sup>, Guoping Zhu, Xiaoyan Zhu  
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The impacts of global climate change on vulnerable Antarctic ecosystem was increasingly occurred, it's very helpful to understand the change of Antarctic marine ecosystem structure based on the feeding habit of Antarctic krill (*Euphausia superba*). Feeding ecology of Antarctic krill collected off the Antarctic Peninsula was analyzed using stable isotope analysis. The results indicated the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values in the tissue of Antarctic krill ranged from  $-29.65\text{‰}$  to  $-21.43\text{‰}$ , and  $3.05\text{‰}$  to  $8.12\text{‰}$  respectively. The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of krill tissue from the two survey areas were not related to the standard length. The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of the individuals in the Bransfield Strait and the  $\delta^{13}\text{C}$  values of individuals off the South Shetland Islands increased gradually from April to June. However, similar result cannot be found for the  $\delta^{15}\text{N}$  values of individuals off the South Shetland Islands. The  $\delta^{13}\text{C}$  value of krill off the South Shetland Islands was larger than that of krill in the Bransfield Strait in autumn-winter ( May-June). However, the trend of  $\delta^{15}\text{N}$  value was different from the  $\delta^{13}\text{C}$  value . In May, the  $\delta^{15}\text{N}$  value of krill off the South Shetland Islands was larger than that of krill in the Bransfield Strait; but in June, the opposite result occurred. Stable isotope analysis will provide better evidence of material source of the ecosystem, and will be helpful to get insight into ecosystem structure and will provide some references for feeding studies of Antarctic krill.

## ***Hierarchical Bayesian modeling of continental-scale Adélie penguin occupancy and abundance***

**Christian Che-Castaldo**<sup>1</sup>, Heather J. Lynch<sup>1</sup>, Stephanie Jenouvrier<sup>2</sup>, Mathew R. Schwaller<sup>3</sup>  
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We present a hierarchical Bayesian model of Adélie penguin abundance and distribution at all 277 known Adélie penguin colonies. This model incorporates both presence-absence data and abundance estimates, collected from all known publically accessible data on Adélie penguin abundance and distribution, including nest and chick data derived from ground counts, aerial surveys, satellite imagery, and citizen science efforts. Our model provides abundance estimates for each population in each year since the 1979/80 season, including years for which no data are available, and allows us to both estimate trends at each Adélie penguin breeding site and understand how sites co-vary in their interannual dynamics. Our model provides the best global-scale model for Adélie penguin population dynamics, and provides a means by which to assess the impact of climate change, fishing, and other hypothesized drivers of population change.

## ***Status of Marine Mammals in the Indian Ocean, and along the Princess Astrid Coast and Larsemann Hills in Antarctica***

Anant Pande<sup>1</sup>, Sivakumar Kuppusamy<sup>1</sup>, **Sathyakumar Sambandam<sup>1</sup>**, Yash Veer Bhatnagar<sup>2</sup>, Vinod Behari Mathur<sup>1</sup>

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Information on marine mammals in Indian and Southern Oceans is scanty due to less accessibility and extreme environment. We reviewed published data on status of marine mammals from Indian Antarctic Expeditions since 1981 along with data generated in the seven expeditions (1994 to 2016) through systematic studies. The study area spans from Larsemann hills, Prydz Bay in east to shelf area of Princess Astrid coast, Haakon VII Sea. Indian research station Bharati is located at Larsemann Hills while Maitri is located at Schirmacher Oasis, Princess Astrid Coast. Data from Princess Astrid Coast is available for five years (1994-95, 1995-96, 2009-10, 2013-14, 2014-15 and 2016) for Larsemann hills data is available since 2009.

Systematic sightings surveys were conducted during voyage between Goa in the west coast of India to Princess Astrid Coast (1994-1996) and between Cape Town, South Africa to the Indian research bases in Antarctica (since 2009) on board Indian Antarctic Expedition Vessel. Over 11600 nautical miles of track line was surveyed six times (1994-95, 1995-96, 2009-10, 2013-14, 2014-15 and 2016) during austral summers. The pre-determined voyage route represented a non-randomised transect between Goa and India Bay (1994-96) and between the two Indian stations (2009-2016). Aerial surveys for assessing spatial distribution patterns of pack-ice seals were conducted during the years 1994-95, 1995-96, 2009-10, 2013-14 and 2016 around Princess Astrid Coast and Larsemann hills.

Sightings of marine mammals were lesser as per the earlier reports and opportunistic records. The sightings increased from a maximum of 5 species reported during the early expeditions to 12 species with recent data. Humpback whale dominated with over 50% sightings during the voyage surveys. Aerial surveys covered an area of approx. 200-250 square kilometres around both station areas. Weddell Seal's encounter rates were estimated to be highest in comparison with other species due to higher survey effort in fast ice areas. The seal populations around Larsemann hills were observed shifting towards east with sea ice persistent even in peak summer whereas in Princess Astrid coast, the western shelf area with higher ice cover supported more individuals of Weddell Seals. Seal densities varied significantly with distance from the coasts around ice-free islands of Larsemann hills towards the pack ice margin.

Past surveys for marine mammals show high variations in the animal numbers caused mainly by low sample size and the dynamic habitat. Moreover, the methods employed for estimating seal numbers also varied with observers and available logistics. However, these data provide a systematic snapshot of summertime distribution and abundance of marine mammals in the East Antarctic region where few studies have been undertaken. Continuation of the long-term monitoring of marine mammals in the Southern Ocean and around the Indian Stations in Antarctica is emphasised.

## **S05. Past Antarctic climate and ice sheet dynamics: integrating models and observations from the deep ice to the deep sea (Sec 1), Meeting Room 409, August 26, 2016, 11:30 AM - 1:30 PM**

### ***Antarctic contribution to global sea level in a high CO<sub>2</sub> world***

**Nick Golledge**<sup>1,2</sup>, Richard Levy<sup>2</sup>, Tim Naish<sup>1,2</sup>, Rob McKay<sup>1</sup>, Ed Gasson<sup>3</sup>, Doug Kowalewski<sup>4</sup>, Chris Fogwill<sup>5</sup>  
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In 2014 atmospheric CO<sub>2</sub> levels exceeded 400 ppm for the first time since the early Pliocene (3.5-5 Ma). Although the rise in global mean surface temperatures that will accompany continued increases in CO<sub>2</sub> is hard to predict, proxy evidence from the early Pliocene suggests that these CO<sub>2</sub> concentrations, together with higher-than-present summer insolation, were associated with circum-Antarctic seas 2-4°C warmer than present and air temperatures 6-10°C warmer. Large sectors of the present-day Antarctic ice sheet rest on bedrock below sea level, and as such these areas are more sensitive to environmental forcings than ice grounded above sea level because the geometry of their submarine beds allows for runaway retreat in response to relatively small initial perturbations (Thomas & Bentley, 1978; Mengel & Levermann, 2014). Here we present an ice-sheet model ensemble that explores the consequences of a range of air and ocean warming scenarios representative of a higher-than-present CO<sub>2</sub> world. Using circum-Antarctic palaeoenvironmental proxy data to constrain the range of likely conditions adjacent to the continent we calculate probability densities of likely sea-level equivalent ice-sheet volume changes relative to present, together with their associated uncertainties, for a range of timeframes. We find that multi-metre sea-level contributions are likely within centuries, increasing to over ten metres within subsequent millennia. Our results are consistent with empirically-based sea-level reconstructions for the Pliocene, and in addition offer new insights into basin-specific responses within the Antarctic continent.

## ***Glacial cooling and the demise of Southern Ocean carbonate during the late Miocene***

**Rob Mckay**<sup>1</sup>, Rosemary Cody<sup>1</sup>, Lionel Carter<sup>1</sup>, Richard Levy<sup>2</sup>, Tim Naish<sup>1</sup>

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Drill cores collected as part of the ANtarctic DRILLing program (ANDRILL) have provided fundamental new insights about the past variability in Antarctic Ice Sheet extent, glacial thermal regime, and coastal sea ice extent in the Ross Embayment since the Early Miocene. Here, we correlate changes from ANDRILL and other continental margin records from the Antarctic to past changes in the Antarctic Circumpolar Current (ACC) and Pacific deep western boundary current (PDWBC) in the SW Pacific Ocean, the gateway for the largest inflow of deep water into the global ocean. We have developed a standardized lithofacies scheme developed for 34 Circum-Antarctic Southern Ocean Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) drill cores is placed within an internally consistent chronostratigraphic framework using quantitative biostratigraphic correlation techniques (CONstrained OPTimisation - CONOP). This facilitates identification of a linkage between Antarctic glacial development and the sedimentation of the surrounding Southern Ocean, including major shifts in biogenic deposition and the development of regional hiatuses in the Southern Ocean that may be linked to variations in ACC/PDWBC flow. Although variable, particularly at orbital timescales, Antarctic glacial cooling is largely progressive throughout the Neogene, and this is reflecting by declining sedimentation rates in the proximal Antarctic continental rise and abyssal plain, as well as shifts in biofacies in more distal Southern Ocean localities. Regional hiatus with the path of the ACC are common during large transient glacial events, particularly during the well-documented cooling at ~14 Ma. The wholesale shift from biogenic carbonate to biogenic siliceous deposition between 8-6 Ma is coincident with another Southern Ocean hiatus. This event coincides with cooling and expansion of the Antarctic Ice Sheets, as determined by terrigenous sediment starvation on the Antarctic continental shelf, suggesting this carbonate/opal switch was potentially driven by nutrient shifts under a wind-intensified Southern Ocean circulation. The results presented here demonstrate the important physical and biological feedbacks that operate between the Antarctic cryosphere and the surrounding ocean.

# ***A new model of the Antarctic Ice Sheet's behavior over the last 5 million years***

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Previous, time-continuous modeling of the Antarctic Ice Sheet (AIS) from the Pliocene to the present day (Pollard and DeConto, 2009) illustrated the orbital pacing of West Antarctic Ice Sheet (WAIS) retreats and readvances, with general agreement between simulated WAIS behavior and geological records recovered from the Ross Sea by ANDRILL (Naish et al., 2009). The geological data and models compared favorably in terms of the long-term trend in maximum ice volume/extent during Pliocene-Pleistocene glacials. Some specific WAIS retreat events recognized in the ANDRILL record, including a major retreat coinciding with Marine Isotope Stage (MIS) 31 ~1.1Ma, were also captured by the model. However, previous model simulations failed to simulate both the expected magnitude of East Antarctic Ice Sheet (EAIS) retreat during Pliocene interglacials, and 2) substantial WAIS retreats during some specific Late Pleistocene interglacials including MIS-11 and MIS-5e.

Here, we present a revised, five million-year model simulation of AIS behavior, with new model treatments of meltwater-enhanced calving (hydrofracturing) and marine terminating ice-cliff dynamics. The new model simulates the evolution of AIS behavior from the overall warmth of the mid-Pliocene, when the expansion of surface meltwater during interglacials played a key role in AIS retreats- to the Late Pleistocene, when changes in circum-Antarctic ocean temperatures began to play the dominant role in ice sheet variability. The new simulation is in better agreement with proxy sea-level records, captures some Pleistocene retreat events, and provides a new benchmark for comparisons with ice proximal and far-field records of past ice sheet behavior.

## ***Seafloor geomorphology of the Windmill Islands, Wilkes Land, East Antarctica***

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Studies utilising high-resolution multibeam bathymetry datasets to understand the glacial evolution of the previously glaciated Antarctic continental margin are limited, and are particularly meagre for the East Antarctic continental shelf. Here we present an interpretation of the seafloor geomorphology based on a new swath bathymetry dataset from the shallow-water marine environment of the Windmill Islands, adjacent to the Australian Antarctic research station, Casey. A total of 34 km<sup>2</sup> was surveyed over the 2013/14 and 2014/15 summer seasons, to a maximum depth of 170 m. This high resolution data (1 m resolution) permits visualisation of geomorphological features preserved on the seafloor in unprecedented detail. The seafloor is characterised by an assemblage of bedrock, glacial and post-glacial features, providing new insight into the behaviour of the ice-sheet in the region during past glacial episodes and its subsequent retreat to present-day conditions.

Interpretation of the multibeam bathymetry reveals six dominant geomorphic features: (1) basement fault systems, (2) bedrock 'highs', (2) meltwater channels, (3) streamlined sub-glacial landforms, (4) moraine ridges and (5) isolated basins.

Distinctive NW trending linear features that represent bedrock fault systems are clearly evident. These sub-parallel basement bedrock faults have been preferentially eroded and widened by glacial action to form narrow channels and preserve typical 'U-shaped' profiles. The general orientation of the coastline and channels in the region suggests these linear features fundamentally control the regional coastal and seafloor geomorphology.

Regions of bedrock highs, comprised of submarine outcrops of crystalline metamorphic basement, are characterised by complex, rugged and variable topography, forming steep knolls and small banks and reefs.

Numerous channel networks have been incised into bedrock highs and their meandering form, orientation and geometry are consistent with formation by subglacial flow under considerable hydrostatic pressure. They likely formed during a period when the ice-sheet was expanded and grounded over the areas of offshore bedrock, possibly during the late Pleistocene Glacial Maximum (LGM).

Glacial lineations characterised by subdued sub-parallel linear ridges are preserved in basins and appear to have formed from moulding of unconsolidated sediments by overriding ice. The orientation of the lineations is consistent with formation during westward expansion of the Law Dome ice-sheet onto the continental shelf during the LGM.

Regular and closely-spaced arcuate moraine ridge sets are preserved mostly within the prominent NW-trending U-shaped channels. These features appear to be a sequence of recessional moraines or push moraine banks recording slow or episodic retreat of channelized valley glaciers or outlet ice-streams which appear strongly controlled by the local bathymetry.

There are several enclosed basins and shallow depressions between bedrock highs with evidence of post-glacial sedimentary infill. There is little evidence of reworking of sediments by currents and as a result, the glacial features in this dataset are well preserved.

Interpretation of submarine glacial landforms using high-resolution swath bathymetry, integrated with existing information of local ice-sheet evolution from terrestrial studies, allows us to enhance our understanding of the ice-sheet dynamics in the Windmill Islands region.



## ***Testing the ice-ocean feedback mechanism: Reliable extraction of proxy data from surface sediments on the East Antarctic margin.***

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The uncertain response of the Antarctic ice shelves to warming of the surrounding ocean severely limits the reliability of future sea level estimates. Sedimentary records provide an opportunity to test mechanisms regulating the melting of ice shelves that drive ice sheet retreat. A reduction in Southern Ocean overturning circulation is one hypothesis suggested to explain the abrupt rise in global sea level around 14.5 thousand years ago (Golledge et al. 2014). The reduction in Antarctic Bottom Water (AABW) results in subsurface warming on the Antarctic shelf, which melts the base of the ice shelf, driving a feedback that results in accelerated ice sheet retreat.

Reliable extraction of proxy data from sediments on the Antarctic margin are required to test this hypothesis. We present data on surface sediments from George V Shelf, East Antarctica to reconstruct the water mass properties surrounding the ice shelf. Water mass proxies including Nd isotopes and redox sensitive metals (e.g. U, Re) are used to track the presence of AABW, while TEX86 an organic paleothermometer is used to reconstruct subsurface water temperature. We compare these proxy methods with modern oceanographic observations from nearby stations.

[Golledge, N.R., Menviel, L., Carter, L., Fogwill, C.J., England, M.H., Cortese, G., Levy, R.H., 2014. Antarctic contribution to meltwater pulse1A from reduced Southern Ocean overturning. *Nat Comms* 5, 1–10. doi:10.1038/ncomms6107]

## ***High-resolution subglacial hydrology of a potential old ice target near Dome C, Antarctica***

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ICECAP II is a US/Australia/French/Italian collaboration focused on extending coverage of East Antarctic grounding zones and ice shelves as well as searching for sites of million year old ice in the interior of the East Antarctic ice sheet. In January 2016, the ICECAP II project conducted four high resolution survey flights over a region 40 km x 100 km region 50 km to the south of Dome C. Line spacing of 2 km was achieved over much of the target, decreasing to 1 km in locations of most interest. The primary goal was collection of ice penetrating radar data to evaluate the likelihood of stratigraphically intact ice greater than 1 million years in age. In addition, laser altimetry and potential fields data were gathered. ICECAP II data reveals the presence of a dissected bedrock plateau underlying the primary modeled 'old ice' candidate, cut by structurally controlled valleys.

An important constraint on the age of the basal ice is geothermal heat flux, one expression of which is the presence of basal water. Using focused radar data and attenuation independent methods of evaluating the specularity of the basal interface, we map out an extensive population of subglacial lakes occupying the valleys within the old ice target region. We evaluate this population in the context of the subglacial hydrological gradients, englacial attenuation and its implications for the temperature structure of the lower ice column.

## ***What can we learn from the stable water isotope content of the oldest meteoric ice at Vostok?***

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The Vostok climate record, covering the past 420,000 years, was the longest ice-core climate series before the 800,000-year EPICA-DC record was obtained. The age of 420,000 years was reached in the Vostok core at a depth of 3310 m. Below 3539 m, the core consists of accreted Lake Vostok ice that does not contain climatic information. The interval 3310-3539 m is composed of atmospheric ice deposits that should be older than 420,000 years. Recent investigations carried out as part of the VOICE (Vostok Oldest Ice Challenge) initiative suggest that the deepest layers of this ice may be older than 1 Ma, although this assertion has yet to be confirmed.

In this study we present new high-resolution (10 cm) isotopic records obtained from two replicate 5G-1 and 5G-3 cores, which cover the deepest section of the meteoric ice at Vostok. Using the extrapolated glaciological timescale, as well as the data on the ice crystal size, we attempt to match the extended Vostok isotopic record to the well-dated 800,000-year EPICA record. We note that the amplitude of the isotope content variations in the deep Vostok ice is considerably attenuated, reflecting the cumulative effect of ice mixing and diffusive smoothing. We attempt to reconstruct the undisturbed Vostok time series using a back-diffusion model.

Finally, we discuss the possibility to obtain the undisturbed oldest isotopic record from an ice core that would be drilled at Ridge B ice divide upstream from Vostok Station.

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## ***Deglacial history of Pensacola Mountains, Antarctica from glacial geomorphology and cosmogenic surface exposure dating***

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A new dataset of geomorphological and cosmogenic surface exposure dating from the Pensacola Mountains allows us to make inferences on the glacial history of this region, and in particular the deglacial history of the Foundation Ice Stream. There is evidence of at least two glaciations with an earlier glaciation that was warm-based, and which weathering suggests was relatively old, and a second, more recent glaciation that was cold-based. Maximum thickening in the most recent glaciation was >380m. The precise timing of the onset of deglacial thinning is not well-constrained by these data but was well underway by the Early Holocene and there is evidence of progressive thinning of the Foundation Ice Stream and tributary Academy Glacier through the Holocene. The thinning trajectory is similar at multiple sites, reaching present ice levels by 2.5ka. The thinning history reported here is broadly similar to that reported from the Ellsworth Mountains, and is consistent with, but does not mandate, a recently hypothesised retreat within present margins followed by a Late Holocene readvance in the Weddell Sea. These data provide additional constraints on attempts to infer former ice sheet extent in the Weddell Sea embayment using flow line modelling of the expanded Foundation Ice Stream.

## **S11. Antarctic permafrost, periglacial processes and soil development, Meeting Room 405, August 26, 2016, 11:30 AM - 1:30 PM**

### ***Pressurized brines in Continental Antarctica as possible analog of Mars***

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The interest on the brines in extreme and cold environments recently increased after their findings on Mars. These brines can be potential new subsurface habitats for peculiar ecosystems. In the Dry Valleys of the Antarctic, the best analog for Mars conditions, only a few cases of brines were identified in some perennially frozen lakes, while in only one case an underground brine aquifer has been hypothesized. Here we present the occurrence of pressurized brines in a shallow perennially ice-covered lake south 70°S in a ice-free area of Victoria Land, Antarctica. For the first time, we also imaged by means of ground penetrating radar data the existence of a pingo-like-feature (PLF) formed by brines confirmed also by borehole evidences. These brines are fed by an underground talik external to the lake basin enhancing the possibility to have unexploited ecosystems that could find an analogue in the Martian environments. Moreover, considering the 14C age of the basal layer of the sediments collected below the brines was between 12406 and 12038 yr cal BP and there are no evidences of higher levels of the lake, this small basin could preserve at least all the Holocenic hydrological and climatic changes.

Regarding the age of the PLF and therefore of the possible brine flows we can only hypothesize that this event postdates the sedimentation of the dated layer because all the sediment layers within the ice are truncated by the slope of the PLF but we cannot exclude that this feature can be formed by successive episodes that cut the different sediment layers in different times.

## ***Buried glacial ice in the McMurdo Dry Valleys: Climate archives on the edge of change***

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Buried glacial ice is common throughout the McMurdo Dry Valleys, from Pliocene-aged ice in Beacon Valley to Last Glacial Maximum ice in coastal Garwood Valley. The long-term stability of buried ice predominantly depends on summer conditions, which are presently warm enough at the Ross Sea coast to actively melt buried LGM ice. Conversely, prolonged cold and hyper-arid conditions in Beacon Valley (80 km from the coast, 1200-m elevation) have allowed ice to be preserved for million-year timescales. We investigated four buried ice deposits in Pearse and central Taylor Valleys (40 km from the coast, 400-m elevation), situated geographically and climatically between the two end-members mentioned above.

Our analyses focused on the age, origin and stability of the buried ice using ground-penetrating radar and geochemical analyses from ice cores, ice-cemented sediments, and surface ponds. These data were coupled with optically stimulated luminescence (OSL) and cosmogenic exposure dating of sediments, both within and above the buried ice. The ice deposits are commonly < 20 m thick and are consistently overlain by a protective cover of dry alluvial sands. Sediment concentrations in the ice vary with depth and between sites, but in general ice is clean with intermittent sand-rich layers. Ice fabrics and air bubbles within the ice support a glacial origin. Geochemical and geomorphic results indicate that the ice features were deposited by late-Pleistocene advances of alpine glaciers. However, under present climatic conditions, buried ice at all sites is actively melting, evidenced by thermokarst ponds, stream dissection and groundwater seeps. These data highlight the importance of buried glacial ice deposits in Taylor Valley as 1) archives of past glacial fluctuations, 2) potential sources of meltwater and ions for lake ecosystems and 3) climate-sensitive landforms that could be used to monitor present and future climate change in the region.

## ***Potential rock glacier surface sediment contribution to meltwater geochemistry: A Wright Valley case study***

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Don Juan Pond is the most saline natural water body on the continent. Unlike other Dry Valleys saline lakes, it is rich in CaCl<sub>2</sub> rather than NaCl. Its extreme salinity and year-round ice-free nature provide habitat for a unique microbial ecosystem frequently used as a model in astrobiology. Pond chemistry is strongly influenced by mobilization of deliquescent CaCl<sub>2</sub> salts in water streaks along the steep northern and southern slopes extending into the basin. To the west of the Don Juan Pond basin, gullies in a seven-kilometer long rock glacier supply the primary source of water to the pond. Here, we present geochemical data constraining the potential contributions of the rock glacier to the composition of meltwater entering Don Juan Pond. We use x-ray diffraction analyses to determine the primary minerals, alteration products, and salt deposits in E-W and N-S transects of surface sediments across the rock glacier. Leaching and major ion analyses of these surface sediments will yield soluble salt compositions. Major ion analyses of snow banks, gully ice, and upstream pond ice will aid in the definition of meltwater composition on short time scales. These data will be compared with field observations, geochemical and limnological studies on Don Juan Pond, and previously published petrographic works on the rock glacier itself.

## ***Landscape change in the McMurdo dry valleys, Antarctica: Preliminary results***

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Field observations have documented dramatic changes over the past decade in the McMurdo Dry Valleys of Antarctica (MDV): extreme river incision, significant glacier loss, and the appearance of numerous thermokarst slumps. To date these observations have been sporadic and localized, and have not been able to capture change on a regional scale. To assess topographic changes across the valleys we compared a LiDAR DEM acquired in the 2001-2002 austral summer to a new high resolution LiDAR DEM acquired during the 2014-2015 summer. The new observations were acquired with a novel LiDAR sensor with active lasers at three wavelengths simultaneously, which not only increases the point density of ground-returns, but also provides multispectral signatures for observed terrain features. In addition to the LiDAR data, high resolution (0.05-0.15 m pixels) digital color images were collected. Preliminary results show that over the 13-year period between LiDAR flights, several kinds of large (>1m) landscape change have occurred, including stream channel erosion into buried ice deposits (implying the advection of heat by stream water is an important process locally degrading thermokarst) and slope failures in thermokarst landforms from block failure and insolation-driven retreat. Widespread changes are smaller (<0.5m) and common to north-facing slopes suggesting that weathering caused by summer meltwater processes or freeze-thaw cycling may be more important than previously thought.



## ***Observations on frost mounds in the Jutulsessen, Antarctica***

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Seasonal and perennial frost mounds have been described for a number of locations and form due to the presence of frost processes and ice<sup>1</sup>. Thirty-five frost mounds were investigated in the Vassdalen valley (72°01'S, 02°37'W), Jutulsessen, Antarctica, during the early Austral summer of 2015. Similar mounds were once found in the vicinity of the Norwegian station of Troll and described as pingos<sup>2</sup>. However, these have disappeared since construction commenced of the base in the early 1990s.

Eight thermistors, using an XR5 logger, were wired into a selected mound and logged for app. two days at 30-second intervals. Two sensors were placed at each aspect, one at the near surface and one at a depth of ten centimetres. In addition, 24 sediment samples were taken to determine sediment characteristics and physical measurements of mounds obtained. Mounds appear beyond the toe of a rock glacier located in the southern confines of the valley; some situated on ice, others on substrate. Although they protrude within the continuous permafrost zone research suggests this region to have a variable active layer<sup>3</sup>. Mounds approach symmetry, are cone shaped, range from app. one to five meters in height, have fairly steep slopes (~20°), and are arranged along a predominant east-west orientation. They consist of mixed material with larger stones mixed into the matrix; have ice-cemented centres and low moisture content ( $\theta_g < 0.1$ ), with more moisture present towards the bottom of mounds. Although ice lensing is evident, it is not present in all excavated mounds. Temperature regimes for the North-East and South-West aspect pairings exhibit similarity. Furthermore, surface measurements exhibit statistical difference to subsurface measurements and a thermal damping effect is evident.

The paucity of ice lensing and other characteristics suggest that these are not typical pingos or debris cones, similar to landforms described by French and Guglielmin<sup>4</sup>. However, their characteristics suggest they may be described as a form of frost mound. Research from the region has shown that moisture is rare<sup>4</sup>. Nevertheless, the presence of ice in the area and some lensing in evidence suggests ice as a driving factor and their formation. Mound proximity to the toe of the rock glacier also suggests mounds may be partially driven by ice retreat and loss of interstitial ice of the glacier.

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## ***Characteristics of tafoni formation in Western Dronning Maud Land, Antarctica.***

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Tafoni is a formation that has been described in a multitude of ways and it has many different names and definitions. Along with its variation in geographical and spatial location, it is a contentious topic between scientists. Numerous suggestions have been posed on what processes or systems are behind the formation of tafoni but these range between different sites and scientific studies. Since no single process has been stated as the cause of tafoni, it remains an enigma of sorts in the scientific community. Due to the near pristine nature of Antarctica, it is an important site for unbiased studies regarding past, current and future geomorphological changes. The presence of tafoni in Western Dronning Maud Land (WDML), Antarctica has been noted and documented, however, the processes behind tafoni have not yet been explored. This scientific study was conducted in order to locate and characterize the nature of tafoni within WDML, Antarctica. The data gathered in this study aims to elucidate our understanding of what tafoni are, and builds on increasing our understanding of the formation. Particular focus has been placed on typifying size, positioning, geology and microclimate of the tafoni at different sites. Results indicate that parent rock and micro-lithological properties of the host rock heavily influence the formation of Tafoni. Rock hardness values indicate that softer tafoni caverns are surrounded by a case hardening. Morphological characteristics of tafoni have shown relationships between tafoni caverns and lichen colonization. Thermal monitoring within the caverns, paired with thermal imagery shows differences between the inner caverns compared to the surrounding temperature. Additionally, weather variables such as wind speed, wind direction and snowfall, have been noted as possible influences.

## ***Active layer landforms and environments in the Ahlmannryggen and Jutulsessen areas, western Dronning Maud land, Antarctica***

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Permafrost and active-layer thermal and moisture regimes, together with an inventory of landforms commenced in the Ahlmannryggen and the Jutulsessen areas of Western Dronning Maud Land, Antarctica commenced in the 2006/2007 Austral Summer. Initial investigations comprised exploratory observations on 14 nunataks. Initially three nunataks, which was later expanded to eight in the 2012/2013 Summer, were identified for measuring ground temperature and moisture using ANTPAS protocols. The selection criteria used for these eight sites were: location relative to the SANAE IV and Troll Bases, accessibility, soil characteristics, the presence of periglacial landforms, and logistical constraints. Ground temperature, and ground moisture, have been, and are being measured in shallow boreholes, using automated logging devices at ten locations (two nunataks have two logging stations each). Periglacial landforms, where present, were noted and measured on all 14 nunataks investigated.

Thermal and moisture regimes show seasonal variability common to all locations with strong signals that were synchronous with Southern Ocean seasonal controls. Additional controls on seasonal and annual regimes were the distance of a site from the continental margins, the length of daylight, and altitude. Data indicate that shorter-term intra-seasonal variability was influenced by synoptic-scale weather, boundary layer climate and topographic influences. The Ahlmannryggen clearly operates under different synoptic systems to the Jutulsessen areas. It was possible, solely through visual observations, to separate out diurnal, synoptic-scale and seasonal regimes in the data recorded.

The locations, orientations, and dimensions of thermal contraction polygons, frost cracks, sorted patterns, blockfields, rock glaciers, solifluction terraces, and frost mounds were mapped and recorded as part of an inventory that could be utilised for future periglacial research. The distribution, type and size of landforms was found to be dependent on the underlying geology, local topography, and moisture availability. The research undertaken provides a baseline for long term active-layer and permafrost monitoring as well as the impact of geomorphology on providing a habitat for the colonisation of biodiversity.

## ***Bedload transport as a response of terrestrial environment change in ice-free area of Baranowski Glacier (King George Island, W Antarctica)***

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There is growing evidence that glacial system on the King George Island has rapidly respond to climate warming. On the forefield of Baranowski Glacier (King George Island, W Antarctica), large and fast environmental changes have been observed since 1979. Due to the recession of the glacier, area close to 0.73 km<sup>2</sup> has been uncovered and new relief has been formed during that time. The ice-free surface reflects geomorphological as well as hydrological evolution. For example, the proglacial channels, which flow between bottom moraine hills causes the continuous transformation of the valley. In particular, due to the unconsolidated substrate, changing of the troughs morphology is clearly visible. In this work, we assume that the river bedload transport in this geomorphologically changed area may give information about the rate of the environmental changes. Therefore, to carry out the measurement of the bedload transport in two chosen troughs on ice-free area of Baranowski Glacier is the main goal of this research. The field measurements were conducted in both creeks in 24h intervals during summer season of 2016. The first channel, named Fosa Creek, is supplied mainly from the Ginger Lake, dead ice and several left tributaries from Baranowski Glacier. Measurement site was localized around 250 m from the forehead of the glacier. Maximum water discharge and maximum mean water velocity measured at the 31st of January were 0.719 m<sup>3</sup>/s and 0.714 m/s, respectively. The second channel, the Siodlo Creek flows directly from the glacier with maximum water discharge 0.259 m<sup>3</sup>/s and maximum mean water velocity 1.000 m/s, measured at the same day as in the Fosa. In this case, the measurement site was localized around 15 m from its forehead. In spite of the fact, that both troughs are cut down into the same moraine, the differences in the intensity of the bedload transport as well as in the distribution of grain size were observed. In contrast to the Siodlo Creek, where the bedload transport exists continuously, in the Fosa Creek only one extreme event of intense transport was indicated. Moreover, in Siodlo Creek the maximal boulders caught in the bedload traps weighed above 3 kg while in the Fosa Creek the heaviest stone weighed only 0.3 kg. This preliminary work represents an important step forward in the challenging field of monitoring of sediment transport in proglacial channels, which to the best of our knowledge, was one of the first to be conducted in Antarctica. Specifically, we suggest that the differences in the intensity of the bedload transport between these two creeks may be explained by less rinse and less armored of the Siodlo than the Fosa. Moreover, our research provide additional information on the connection between hydrological and geomorphological conditions in Polar Regions extending the previous results. In particular, we clarify the relationship between bedload transport, the rapid outflow and high water discharge.

## **S25. Molecular ecology and evolution, Meeting Room 408, August 26, 2016, 11:30 AM - 1:30 PM**

### ***Integrative biogeography in Nacella (Patellogastropoda: Nacellidae) across the southern ocean***

**Claudio Gonzalez-Wevar**<sup>1,2</sup>, Nicolas Segovia<sup>2</sup>, Hamish Spencer<sup>3</sup>, Steven Chown<sup>4</sup>, Elie Poulin<sup>2</sup>  
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The biogeography of Southern Ocean biota is the result of the complex interaction between macro-evolutionary forces (tectonics, oceanography, climate change) and biotic elements at different temporal and spatial scales. Through multigene phylogenetic reconstructions, divergence time reconstructions, and an integrative-biogeography approach, we aim to elucidate the underlying processes related to the origin, diversification, and to the current distribution of lineages in the limpet genus *Nacella* along its distribution in different provinces of the Southern Ocean (maritime Antarctica, South America, Subantarctic oceanic islands). The separation of the Nacellidae (*Cellana* and *Nacella*) occurred around 28 Ma, close to the Eocene-Oligocene boundary. Within *Nacella* we recognized two main lineages including (a) maritime Antarctic and Sub-Antarctic Islands species and (b) South American lineages. The diversification of these lineages in different provinces of the Southern Ocean occurred during the late Miocene (9 – 5 Ma), long after the physical separation of the continental landmasses. In this context, the marked levels of genetic divergence recorded between Antarctic and Sub-Antarctic lineages of *Nacella* shows the role of transoceanic historical discontinuities in the genus. Further analyses recorded two pulses of diversification in *Nacella* during the late Miocene and the Pleistocene. Major periods of climatic and oceanographic change strongly affected the biogeography of the genus and clearly show both the long- and short-term influence of the ACC on the distribution of near-shore limpet lineages around the Southern Ocean. Our analyses supported the validity of all recognized *Nacella* species, albeit with considerable corrections to the registered distribution of some taxa, and permitted the identification of a new species. This work constitutes the most detailed molecular-based study of an ecologically important invertebrate genus across the Southern Ocean. Hence, it constitutes an important step to an improved understanding of the rhythms and trends in the diversification of marine benthic fauna around the globally important Southern Ocean.

## ***Moss bipolarity revisited***

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Bryophytes (mosses, liverworts, and hornworts) are the second largest group of land plants and are widely distributed in all terrestrial ecosystems, from the polar regions to the tropics. Several moss species can be considered extremophiles because of their tolerance to extremely cold and dry environments such as the polar regions. In the Arctic, bryophytes are considerably diverse, with about 600–700 species, whereas the Antarctic bryoflora is less diverse and composed almost only of mosses (about 111 species). About 45% of the Antarctic mosses species are actually bipolar, i.e., occurring in both the Arctic and Antarctic. Of these, 18 moss species are strictly bipolar, whereas 32 species also occur at intermediate locations on (high) tropical mountains. We are currently investigating the bipolarity from a phylogenetic perspective based on comparative analyses of DNA sequence data. We compile the most comprehensive molecular dataset available, so far including 11 bipolar moss species (3 from the literature and 8 with new data generated). Preliminary phylogenetic analyses (Bayesian Inference, Maximum Likelihood and Maximum Parsimony) based on nuclear ITS and chloroplast trnL-F sequences confirm the bipolarity for all 11 species, except *Bryum pseudotriquetrum*, of which the Antarctic populations seem to belong to *Bryum knowltonii*, a species yet unreported for Antarctica. However, many taxonomical consequences emerge from our study. For example, the bipolar *Hypnum revolutum* does not belong to the family Hypnaceae but to Pylasiaceae, and is actually a new genus that we are describing. Furthermore, our data shows that the circumscription and taxonomy of Antarctic moss species, as well as their phylogenetic relationships, are still incompletely known. We expect our molecular approach to considerably improve our understanding of the genetic diversity of bryophytes in the Polar Regions, with direct consequences for species distribution patterns and biodiversity conservation.

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## ***Ancient persistence or recent colonisation? The evolutionary history of bryophytes in Antarctica***

**Elisabeth Machteld Biersma**<sup>1,2</sup>, Jennifer Jackson<sup>1</sup>, Katrin Linse<sup>1</sup>, Howard Griffiths<sup>2</sup>, Peter Convey<sup>1</sup>  
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How long has the extant flora been present in the Antarctic? Glaciological reconstructions suggest most areas in Antarctica were covered by thick ice sheets throughout the Last Glacial Maximum (LGM; ~22–18kya) as well as during previous glaciations, suggesting habitats supporting terrestrial life must have been extremely limited during these periods. Recent biogeographic and genetic studies have revealed evidence that most extant groups of Antarctic terrestrial fauna survived past glaciations in situ, and that this survival occurred in all the currently-recognised biogeographic regions of Antarctica (i.e. the 15 recently-proposed Antarctic Conservation Biogeographic regions). Despite this, studies on the origin and age of the Antarctic flora remain sparse. Here, focusing on several species of Antarctic bryophytes (several species of the family Polytrichaceae, the genus *Schistidium*, and the species *Bryum argenteum*, *Ceratodon purpureus* and *Chorisodontium aciphyllum*), and using population genetics combined with Bayesian inference and dating methods, we reveal a mixed pattern of persistence in Antarctica. Although some Antarctic populations are of seemingly recent (post-LGM) arrival, others reveal the first evidence of long-term (multi-million year) survival of plants in Antarctica. This study suggests that, despite the harsh polar climate during glacial periods, some bryophytes have had a much longer presence in Antarctica than previously thought.

## ***Genome evolution in Antarctic notothenioid fish***

**John Postlethwait**<sup>1</sup>, Angel Amores<sup>1</sup>, Thomas Desvignes<sup>1</sup>, Peter Batzel<sup>1</sup>, Jason Sydes<sup>1</sup>, Tom Titus<sup>1</sup>, Catherine Wilson<sup>1</sup>, Yann Guiguen<sup>2</sup>, Hyun Park<sup>3</sup>, Wes Warren<sup>4</sup>, H. William Detrich<sup>5</sup>  
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Secrets of genetic adaptation to sub-zero cold are buried in an avalanche of data from our Antarctic fish genome sequencing. We present the first genome sequence of an Antarctic icefish, the white-blooded, benthic-pelagic osteopenic *Chaenocephalus aceratus* (blackfin icefish) and compare it to the sequenced genome of the red-blooded, benthic, robustly mineralized *Notothenia coriiceps* (bullhead notothen). For both species, we first constructed RAD-tag meiotic linkage maps containing thousands of genetic markers using DNAs extracted from embryos made by single-pair matings. We then sequenced and assembled the blackfin icefish genome and aligned sequenced genomic scaffolds from both species to their respective linkage maps to provide chromosomes (genome assemblies of chromosome length); chromosomes, rather than the thousands of independent scaffolds available for most fish genome sequences, are essential for long-range analyses of genome structure, conserved synteny, and genome evolution. We performed RNA-seq experiments on multiple tissues to aid in annotating protein coding and microRNA genes. In addition, we conducted RAD-tag genome scan analyses of more than 50 wild-caught individuals from each species to obtain population genetic data and to identify loci closely linked to sex phenotype. Results revealed that the several longest scaffolds in the bullhead notothen genome assembly are over-merged, but that most scaffolds aligned to unique places in the genetic map. Blackfin icefish has extensive repetitive elements that complicated scaffold assembly, but comparisons to three-spined stickleback, which occupy along with notothenioids Clade XIII of 14 percomorph clades, revealed the history of chromosome rearrangements in *C. aceratus* (N = 24 chromosomes) compared to the mostly pairwise Robertsonian chromosome fusions that led to the 11 chromosomes of bullhead notothen. Global analyses reveal regions of the genome under selection, identify patterns of gene duplication and gene loss, and illuminate the genetic mechanisms of adaptations to icy waters and a secondary pelagic lifestyle.



# ***Evolution of gene regulation by microRNAs in red-blooded and white-blooded Antarctic Notothenioids***

**Thomas Desvignes**<sup>1</sup>, H. William Detrich III<sup>2</sup>, John H. Postlethwait<sup>1</sup>

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As Antarctic waters chilled, red-blooded benthic notothenioid ancestors with a highly mineralized skeleton adapted to the cold, and subsequently, icefishes evolved to white-blooded weakly mineralized semi-pelagic fish. These changes focus attention on gene content evolution (gene gains and losses), and variations in gene transcription and protein translation. A mechanism for regulating protein translation, but yet underappreciated in Antarctic fish, involves miRNAs, endogenous small molecules modulating translation of targeted messenger RNAs when interacting with the RNA-Induced Silencing Complex (RISC). Gene losses and duplications have been proposed to be a source of adaptation, including cold adaptation. We wondered 1) how did miRNA regulation evolve during the cold adaptation of Antarctic fish, and if some miRNA families receded or expanded? In addition, in temperate fish, miRNAs strongly affect the development and physiology of many organs, including erythropoietic tissues, bones, heart, vascular system, and muscles, all of which evolved morphologically and/or functionally in icefish. A gap in our understanding is 2) how did miRNA repertoire (miRNAome) and expression evolve during the evolutionary remodeling of icefish tissues?

To address these questions, we performed high-throughput Illumina miRNA-sequencing on five tissues (erythropoietic kidney marrow, bone (i.e. pectoral girdle) and muscle (e.g. heart ventricle, skeletal muscle, oxidative muscle)) in the red-blooded benthic bullhead notothen *Notothenia coriiceps* and the white-blooded semi-pelagic blackfin icefish *Chaenocephalus aceratus*. We analyzed results using a novel miRNA data analyzing tool, Prost! along with the recently published genome of the bullhead notothen and the as yet unpublished draft genome of the blackfin icefish.

Analysis annotated the miRNAomes of bullhead notothen and blackfin icefish (281 and 294 miRNA genes respectively) and comparisons to other teleost fish suggest that 1), no extensive gene loss nor family expansions occurred in the notothenioid lineage during cold adaptation. Comparisons of bullhead notothen and blackfin icefish miRNAs showed that 2), the icefish lineage also didn't experience major miRNA gene repertoire changes, and detailed analysis of the vertebrate "erythromiRs" (i.e. microRNAs implicated in erythropoiesis) revealed that all known vertebrate erythromiRs are conserved in the blackfin icefish and thus that the loss of specific microRNA genes didn't cause the loss of red-blood cells. In addition, a comparison of miRNA expression levels between notothen and icefish tissues revealed tissue-specificity for most miRNAs and major expression level changes between species, suggesting a role of miRNA regulation in icefish evolution.

In conclusion, our analysis paves the way for a more general study of gene expression regulation by miRNAs in Antarctic Notothenioids and provides evidence for a role of the miRNA system in the adaptation of icefish to loss of red-blood cells and hemoglobin, reduction in bone density, and changes in muscular function as they adapted to a pelagic life.

## ***Evolutionary and phylogeographic patterns of pycnogonida in the southern ocean***

**Andrew Mahon**<sup>1</sup>

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Over 260 of the greater than 1,300 sea spider (Pycnogonida) species described from around the globe, occur in the Southern Ocean. Approximately half of these are noted to be endemic to the Antarctic the region. Recent studies from our group have revealed varying patterns of genetic connectivity across varying geographic regions using genetic data including some findings of population connectivity across thousands of kilometers in the Western Antarctic. In many cases, our studies have found multiple morphologically cryptic and genetically distinct species that are incompatible with the previously hypothesized circumpolar distributions postulated for these Southern Ocean invertebrates. Molecular evidence is beginning to provide some resolution to relationships within many of these complex evolutionary lineages of organisms. Our work has focused on multiple genera of these organisms in the Antarctic, including Nymphon, Pallenopsis, Colossendeis, and Ammothea. Additionally, we have begun genomic studies to investigate the evolutionary history both within and between groups of sea spiders. Here, we present an overview of the bigger picture evolution and phylogeography of these organisms based on large molecular datasets. Findings of multiple instances of cryptic diversity and potentially new species within the Southern Ocean sea spiders from throughout the Western Antarctic will be discussed. Additionally, novel behaviors and life history characteristics found during our collections that add to our understanding of both this group of organisms, but also to the biology of Southern Ocean invertebrates as a whole will be discussed.

## ***Genetic diversity of two notothenioid fish species elucidated by RAD sequencing***

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The teleost fauna of the Southern Ocean is dominated in terms of both abundance and biomass by fishes of the suborder Notothenioidei. They exemplify one of the rare examples of a marine adaptive radiation. Antifreeze glycoproteins and ancient environmental changes, such as increased ice activity, appear to have promoted the diversification of notothenioids into what now comprises more than 100 extant species. Rising ocean temperatures are threatening especially high Antarctic species, e.g. the mainly bottom-dwelling trematomids, as migration to higher latitudes is virtually impossible. It is unclear whether genetic variation may enable them to adapt to changing abiotic conditions. Resolving spatial genetic population structure and connectivity between Southern Ocean fish populations is furthermore important to help identifying priority targets for protective measures.

The population genetics of several notothenioid species have been described using traditional genetic markers. These, however, rely on comparatively few, presumably neutral loci that are used to estimate parameters like effective population size and F statistics. Current reduced genome representation approaches such as restriction-site associated DNA (RAD) sequencing exploit recent major advances in sequencing technology. Thereby RAD sequencing promises the characterization of many genetic markers on a genome wide level, while still being cost-effective. Screening these loci in turn facilitates the identification of targets of selection versus neutral variation. Thus, even subtle patterns of contemporary population structure or signatures of past demographic expansions or reductions, respectively, can be resolved.

We use RAD sequencing for the – to our knowledge – first time on notothenioid fish and carefully evaluate potentials and caveats of this method in Antarctic non-model species. Loci that passed strict quality filtering are used to describe the genetic diversity of one high and one low Antarctic fish species. We compare large and fine scale patterns of population structuring in time and space to infer driving forces of connectivity. Detailed knowledge of their genomic variability will help to ensure sound management and conservation of vulnerable fish species in light of commercial exploitation and predicted environmental changes.

## ***Biogeographical patterns in southern ocean mollusks with contrasting developmental modes***

**Claudio Gonzalez-Wevar**<sup>1,2</sup>, Angie Diaz<sup>3</sup>, Mathias Hüne<sup>2</sup>, Sebastian Rosenfeld<sup>1,2</sup>, Hamish Spencer<sup>4</sup>, Thomas Saucède<sup>5</sup>, Karin Gerard<sup>1</sup>, Elie Poulin<sup>2</sup>

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The evolution of the Southern Ocean marine benthic fauna and the current bioregionalization are the consequence of major tectonic, oceanographic and climate changes that have been operating in the region since the Mesozoic. Continental drift, major gateway openings, and temperature decrease during the last 35 Ma shaped past and present oceanographic circulation in the region. Here, we present new biogeographical analyses based on nuclear and mitochondrial markers in different groups of near-shore benthic mollusks with contrasting developmental modes that are currently found in different provinces of the Southern Ocean. We used phylogenetic and phylogeographic approaches to further understand the role of historical and contemporary processes in the current patterns of genetic divergence, diversity, and structure across provinces of the Southern Ocean. For this purpose, we include in the analyses direct developers (Neobuccinum, Trophon/Trophonella, Margarella, and Siphonaria) and broadcast-spawners (Nacella, Mytilius, Aulacomya, and Yoldia). We determined uncorrected p-distances, divergence time estimations using strict Molecular Clock Hypothesis (MCH) and we constructed Maximum Parsimony genealogies. As general rule, low levels of genetic diversity characterize the analyzed Antarctic and Subantarctic mollusks. Such results may be explained as a consequence of the Quaternary glacial processes that deeply affected population sizes and the demography of near-shore Antarctic and Subantarctic groups. Similarly, the analyzed groups (Nacella, Neobuccinum, Yoldia, Margarella, and Trophon/Trophonella) exhibited a high degree of genetic divergence between Antarctic and Subantarctic provinces supporting the role of the Polar Front as an effective biogeographic barrier. The effective separation between Antarctic and Subantarctic lineages occurred between 3.7 and 14.5 Ma, long after the physical separation of the continental landmasses or to the initiation of the ACC. In this scheme, the geodynamic evolution of Scotia Arc with the establishment of a full deep ACC during the middle Miocene may represent a key driver in the isolation of the marine Antarctic fauna. Surprisingly, several brooders (Margarella, *S. lateralis*, *S. fuegiensis*) exhibited high levels of connectivity between geographically distant Subantarctic provinces (South America, Kerguelen and Macquarie islands). Such results support the role rafting as an important biogeographic mechanism in the Southern Ocean. In contrast, broadcast-spawners (Nacella and Yoldia) showed marked genetic distinction among geographically distant Subantarctic provinces. In this case, life-history traits constrains prevent long-dispersal through larvae in these groups. Finally, current biogeographical patterns in Southern Ocean mollusks are not related to particular groups but to historical oceanographic/climatic processes, as well as contemporary ones including the likelihood of long-distance dispersal.

## **S26. Effects of sea-ice changes and ocean warming on marine ecosystem structure, functioning and services, Meeting Room 401/402, August 26, 2016, 11:30 AM - 1:30 PM**

### ***Interannual variability in phytoplankton in northern Marguerite Bay (WAP) is governed by both winter sea ice cover and summer stratification.***

**Patrick Rozema**<sup>1</sup>, Hugh Venables<sup>2</sup>, Willem van de Poll<sup>1</sup>, Andrew Clarke<sup>2</sup>, Michael Meredith<sup>2</sup>, Anita Buma<sup>1</sup>  
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The rapid warming of the West Antarctic Peninsula region has led to reduced sea ice cover and enhanced glacial melt water input. This has potential implications for marine ecosystems, notably phytoplankton growth, biomass and composition. Earlier studies suggested declining phytoplankton biomass related to reduced winter sea ice cover. In the present study we aimed to link summer and winter phytoplankton performance to the observed decline. Fifteen years (1997-2012) of year-round size fractionated chlorophyll a (chl a), environmental data, and 7 years of phytoplankton pigment fingerprinting were analyzed at the RaTS monitoring site in northern Marguerite Bay, Antarctica.

Winter phytoplankton biomass was low ( $< 0.25 \mu\text{g}$  chlorophyll a l-1) and consisted on average of 69% diatoms, 5% cryptophytes, and 20% haptophytes. Summers following winters with low ( $< 65$  days) sea ice cover were characterized by decreased stratification strength and relatively low (median  $< 4.4 \mu\text{g}$  chlorophyll a l-1) phytoplankton biomass, as compared to summers preceded by high winter sea ice cover. In addition, the summertime microphytoplankton ( $> 20 \mu\text{m}$ ) fraction was strongly decreased in low biomass years, from 92% to 39%, coinciding with a smaller diatom fraction in favor of nanophytoplankton ( $< 20 \mu\text{m}$ ), represented by cryptophytes and haptophytes. In contrast, diatoms dominated ( $> 95\%$ ) summers with average-to-high biomass.

We advance a conceptual model whereby low winter sea ice cover leads to low phytoplankton biomass and enhanced proportions of nanophytoplankton, when this coincides with reduced stratification during summer. Over the observational period, the onset of spring ice melt, as indicated by a salinity decrease, was delayed 100 days when comparing high and low biomass summers. Thus, increased mixing during the winter combined with a decrease in sea ice will delay stratification further and, as such, decrease total summer phytoplankton productivity. Overall, both summer (January – February) and winter biomass declined significantly, 2.88 and  $0.023 \mu\text{g}$  Chlorophyll a l-1 decade<sup>-1</sup> respectively. These changes are likely to have a strong effect on the marine food web, including krill biomass and distribution. Given the current trends in climate change, our observed trends are not likely to be reverted within the near future.

## ***Late Summer and Autumn Algal Blooms in Newly-forming sea ice in the Ross Sea: Implications for the C cycle***

**Robert Dunbar**<sup>1</sup>, Christina Riesselman<sup>2</sup>, Giacomo DiTullio<sup>3</sup>, Peter Lee<sup>3</sup>, Dennis Hansell<sup>4</sup>, Sarah Bercovici<sup>4</sup>,  
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We observed significant concentrations of new algal biomass in recently formed frazil ice and sea ice “pancakes” in the Ross Sea during mid-to-late March, 2013. Late summer algal productivity has seldom been examined in Antarctica’s marginal seas. Observations suggest the involvement of both Langmuir and Couette’s circulation. Langmuir cells formed at wind speeds greater than 13 m s<sup>-1</sup>. With time, frazil ice in windrows exhibited green to gold colors indicative of algal concentration. With declining air temperatures and wind velocities, frazil ice aggregated to form pancake ice overlying frazil ice layers. Frazil and pancake ice exhibited biogenic particle properties that are generally higher by factors of 5 to 17 over the adjacent seawater. The frazil ice was dominated by *Fragilariopsis* spp., and pancakes by *Chaetoceros* spp. *Phaeocystis* is present but not significant in terms of production. Heterotrophic production appears higher in water than in frazil ice. Elevated δ<sup>13</sup>C and δ<sup>15</sup>N in organic matter from both ice types relative to open water indicates continued (and likely rapid) growth of algal community. Concentrated algal biomass in late summer/early autumn ice results from both frazil ice scavenging under influence of Langmuir and Couette’s circulation as well as from substantial in situ growth. 7) Golden pancake and frazil productivity in late summer and early autumn appears to be a regular part of the seasonal cycle in Antarctica – one that is likely not well captured by satellite methods and appears to be under-appreciated. Taken together, our work suggests that high late summer productivity and fluxes are common in the western Ross Sea – and likely in many other parts of Antarctica. In Terra Nova Bay, a deep mixed layer inhibits early summer production but when T drops and ice forms, Langmuir circulation provides mechanisms to maintain algal cells in the uppermost water column, counteracting deep wind mixing. Couette’s circulation continues to provide a concentrating mechanism and buoyancy after sea ice cover is complete. Both Langmuir and Couette’s Circulation provide mechanisms for bundling senescent or dead organic matter into particles that will sink. As the Southern Ocean warms and seasonal sea ice formation occurs later in the autumn when light levels are lower, this type of enhanced production and vertical flux is expected to decrease, posing additional challenges for the trophic structure.

## ***The changing nature of the planktonic community structure and biomass in coastal waters of Scotia Bay (Laurie Island, South Orkney)***

**Viviana Andrea Alder**<sup>1,2,3</sup>, Claudio A. Franzosi<sup>1</sup>, Héctor F. Olguín Salinas<sup>3</sup>, Flavio E. Papparazzo<sup>4</sup>, Mariela Spinelli<sup>5</sup>, Fabiana Capitanio<sup>5</sup>, Martín Yaya<sup>6</sup>, Iván Hoermann<sup>6</sup>, Luciana Santoferrara<sup>7</sup>

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The understanding of feedbacks between temperature changes due to global warming and biological responses of marine communities in terms of nutrient and carbon cycles and productivity is still at an early stage. Knowing the size structure of planktonic communities and their key species allows to predict their role in the biological carbon pump and how environmental changes will propagate to higher trophic levels. Within this context, the aim of the present study was to analyse, for the first time, the size structure of Scotia Bay's (Laurie Island, South Orkney) planktonic communities ranging from pico- to microplankton, and the size-fractionated chlorophyll (0.7-2, 2-10, >10 µm) and macronutrients during an annual cycle -from summer 2014 to summer 2015. Mesozooplankton was sampled only during summer seasons. The study was conducted with logistic support from the Orcadas Research Station (Argentina). Sites with different environmental features (proximity to glaciers, bird colonies, shoreline and deeper points) were selected and sampled by boating operations or through ice holes. From winter to early spring (July to October), the bay was 100% covered by ice.

Mean values from each season reveal the following trends: Summer 2014 was characterized by a moderate N:P ratio (16) and higher silicate (54 µM) and chlorophyll (5 µChl/L) values, with a distinct contribution of the >10 µm size-fractionated chlorophyll, mostly due to a bloom of the micro-diatom *Odontella weissflogii*; diatoms represented 94% of total biomass (> 200 µC/L). During autumn, winter and spring, the contribution to chlorophyll by the three size fractions was quite even but total chlorophyll reached only 1, < 0.5 and 2.3 µChl/L, respectively. Summer 2015, as compared to summer 2014, presented higher values of subsurface sea water temperature and N:P ratio (18.4) while lower silicates (50 µM) and chlorophyll (2.1 µChl/L). There was a remarkable increase of cryptophytes, prasinophytes, pigmented <5 µm flagellates (four-fold increase), nanoplanktonic diatoms (*Thalassiosira* sp), naked ciliates, and dinoflagellates, while mean biomass values of diatoms and total mesozooplankton decreased in one order of magnitude. Neither planktonic cyanobacteria nor krill larvae were detected in any of these two summer seasons. The structure of the summer planktonic community showed a remarkable interannual fluctuation, with a lineal food web in 2014 -more efficient in terms of carbon pumping- and a microbial food web in 2015 -less efficient but with heterotrophic bacteria playing a more important role. Key species and spatial heterogeneity will be discussed. The results from the present study represent the starting point of the "Scotia Bay Planktonic Observatory", meant to provide the basis to address novel goals at the ecosystem level in areas of relevance, such as high seas Antarctic islands located in the southern branch of the Scotia Arc.

## ***Sea ice variability influences zooplankton distribution and larval fish stomach fullness at a coastal Antarctic site***

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Zooplankton that live at high latitudes are influenced by seasonal cycles in primary productivity, the strength and position of major oceanographic currents and the growth and decay of sea ice. Zooplankton are important prey for fish, especially in sheltered coastal regions that act as nurseries for larvae and juveniles. To describe the influence of sea ice dynamics on the long term distribution of zooplankton and, in turn, their availability as prey for fish, sampling in the fast ice zone near Dumont d'Urville Station, located along the coast of Adélie Land in east Antarctica, has been carried out continually from 2000. In the last fifteen years there have been five annual and ten summer field surveys that have sampled the underice zooplankton and ice-associated fish, focussing on the stomach contents of the fish and abundance and diversity of the zooplankton. The fast ice of the region has been mapped via satellites since 2001. Sampling of the sea ice itself began in 2003, with the ice meiofauna counted and identified from multiple ice cores. The sea ice around Dumont d'Urville Station fluctuates in extent, thickness and timing of breakout and this has flow on effects on the biological communities of the area. Notably, the abundance of zooplankton has varied at least 10-fold between years, producing consequences for the fish species that prey on them: in years of low zooplankton abundance the gut fullness of the fish is correspondingly low. The species of zooplankton recorded for the coastal region are typical of other Antarctic coastal areas and consist of small copepods such as *Oithona* spp., *Oncaea* spp. and *Stephos longipes*, larger copepods such as *Metridia* spp. and *Calanoides acutus*, meroplanktonic larvae, appendicularians and euphausiids. Meiofauna in the fast ice is dominated by copepods, particularly *Drescheriella glacialis*, *Paralabidocera antarctica* and *Stephos longipes*. The reduced predictability of sea ice around Dumont d'Urville has led to variations in the life cycles of these key species, as compared to regions where the ice is more predictable from year to year. As such, the region provides important insights into how key zooplankton species and their fish predators might be affected under future conditions of reduced ice cover.



## ***The effect of increased food supply on benthic functions in the Weddell Sea***

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Little is known, how processes at the seafloor - benthic functions - are affected by changes in ice-cover. Up to now, nothing is known about the role of meio- and macrofaunal benthic size compartments for benthic functions under the influence of ice shelf loss or disturbance linked to ice-retreat. We evaluated the response of benthic ecosystem functioning to ice retreat simulated by experimental food increase at different sites in the Weddell Sea. We used pulse-chase experiments and measured two benthic functions, namely food uptake and remineralisation of inorganic nutrients at four sites in the Southern Weddell Sea in January 2016. Here, we present that remineralisation response (measured as benthic boundary fluxes of nitrate, silicic acid, phosphate, oxygen, ammonia) at the sediment-water interface to an increased food input varies in different habitats around the Filchner Trough area. We present potential environmental drivers for these functioning response differences, and how they may be linked to the role of benthic size compartments. Our results contribute to estimations on future developments of biogeochemical provinces at the seafloor of the Weddell Sea.

## ***A ROV study on the feeding and metabolism of Antarctic hexactinellid sponges***

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On Antarctic shelves, glass sponges (Hexactinellida, Porifera) often dominate the megabenthic epifauna. But in spite of intensive research on epifauna community structure, process studies on the ecophysiology of key species are so far lacking, due to the difficulty of accessing glass sponges in their habitat and keeping them alive for experimental work. Here, we present the results of an in situ study carried out in the Weddell Sea using a remotely operated vehicle (ROV) to measure feeding, respiration, ammonium excretion and silicate uptake in the common glass sponges *Rossella nuda*/ *Anoxycalyx joubini*, *R. racovitzae* and *R. villosa*. A custom-developed ROV-mounted water sampler was successfully deployed. A total of 22 samples from sponge oscula and 21 samples from ambient waters were analyzed for picoplankton, ammonium and dissolved Si concentrations. Optode measurements in the ambient water and inside the sponge osculum revealed a measurable difference of 0.5-4  $\mu\text{M}$  oxygen between ambient and exhalant waters. Together with estimates of the exhalant volume flow from concomitant fluorescein dye experiments, the oxygen and Si uptake as well as the ammonia excretion of individual sponges was estimated. Rates were extrapolated to larger spatial scales using data on sponge abundances and sizes recorded along corresponding 2-km seabed-imagery transects with an Ocean Floor Observation System (OFOS). Our findings will help elucidate the role of hexactinellid sponges in C and Si cycling and contribute to understand future effects of sea-ice and productivity changes on Antarctic ecosystem structure, functioning and services.

## ***Assessing Antarctic marine food webs on the Kerguelen Axis***

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The Southern Ocean is one of the most rapidly changing environments on Earth. Key questions for understanding the consequences of change in the region include: (i) Will southward movement of the ocean fronts, as well as the extent of winter sea ice, give rise to a contraction in the northern range of polar species such as Antarctic krill? (ii) Will the supply of iron be altered, thereby affecting productivity? (iii) What factors might give rise to a shift from a krill-based food web to a food web based on copepods and fish? These questions are central to management of fisheries and conservation in the region. Important to managers is the question of how to most efficiently monitor the ecosystem to determine whether such changes are arising or may arise in the near future. This last question is central to developing biological capability within the Southern Ocean Observing System.

The Kerguelen Plateau and its associated marine food webs, including those near the Antarctic continent, form an axis in the Indian Sector of known high productivity. Unlike many other regions of the Southern Ocean, the Kerguelen Axis is a place where environmental drivers of the ecosystem can be differentiated from one another. In this presentation we will highlight recent coordination to assess the status of the ecosystem in this region. We will also describe the initial outcomes of the 2015-2016 summer activities on Kerguelen Axis where we assessed the relative importance of the different physical drivers. Lastly, we will describe efforts for establishing sustained ecosystem observations in this region to assess long-term change.

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## ***Important foraging areas of chinstrap and gentoo penguins breeding on King George Island, Antarctica***

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Identifying marine features that support high foraging performance of predators is useful to determine areas of ecological importance. Especially in the Antarctic Peninsula Region where seasonal sea ice is decreasing rapidly in these decades, insights into important foraging areas are key to understand mechanism of top predator's response to local environmental changes. This study aimed to identify marine features that are important for foraging of chinstrap (*Pygoscelis antarcticus*) and gentoo (*P. papua*) penguins, abundant congeneric upper-trophic level predators in the Antarctic Peninsula region. We investigated the foraging locations of penguins breeding on King George Island using GPS-depth loggers. The areas within penguin foraging range were classified into five zones based on bathymetry: 1) King George Island shelf zone, defined by bottom depth  $\leq 200$  m along the King George Island coast; 2) Nelson Island shelf zone, defined by bottom depth  $\leq 200$  m along the Nelson Island coast; 3) Maxwell Bay zone, defined by bottom depth  $> 200$  m and within 10 km from the colony; 4) Bransfield Strait slope zone, defined by bottom depth  $> 200$  m and  $> 10$  km from the colony, excluding the Seamount zone; and 5) Seamount zone, defined as the area within 10 km from the center of the Orca Seamount. Tracking data from 18 chinstrap (4,232 dives) and 14 gentoo (2,580 dives), 11 chinstrap (2,095 dives) and 11 gentoo (1,929 dives), and 19 chinstrap (3,947 dives) and 17 gentoo (2,966 dives) were obtained in 2007, 2010, and 2015, respectively. In all three years, chinstrap penguins frequently used the seamount zone. The percentage of dives (27.8% in 2007, 36.1% in 2010, and 19.1% in 2015) and depth wiggles (27.1% in 2007, 37.2% in 2010, and 22.3% in 2015) performed in this zone was higher than that predicted from the size of the zone. On the other hand, gentoo penguins frequently used the Nelson Island shelf zone. The percentage of dives (30.2% in 2007, 24.7% in 2010, and 25.2% in 2015) and depth wiggles (35.0% in 2007, 25.0% in 2010, and 28.3% in 2015) performed in this zone was higher than that predicted from the size of the zone. In this zone, gentoo penguins frequently performed benthic dives (28 to 46% of dives). Stomach content analysis showed that both species fed mainly on Antarctic krill ( $> 95\%$  in wet mass) in each year. These results suggest that off-shelf marine features such as seamount provided favorable foraging habitat for breeding chinstrap penguins possibly related to upwelling, whereas shallow areas near islands provided favorable foraging habitat for breeding gentoo penguins possibly related to local accumulation of krill by tidal advection. We suggest that annual food availability in these marine features are key to understand response of chinstrap and gentoo penguins to environmental changes in the Antarctic Peninsula Region.

## **S28. Diversity and distribution of life in Antarctica D6, Meeting Room 406/407, August 26, 2016, 11:30 AM - 1:30 PM**

### ***Mount Howe the Southern most soil on the planet, and the limit of life in Antarctica***

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Mount Howe soil represents the Southern most soil on the planet, being the closest ice free site to the South Pole. Geochemical analysis of the soil showed a moisture content of 1.09% w/w, pH of 6.3, and conductivity of 2395  $\mu\text{S/m}$ . Total carbon and nitrogen contents were both 0.04%. Pyrosequencing showed that the Mt Howe soil community was heavily dominated (70-95%) by members of the Proteobacteria, normally only a small proportion of the bacterial community in similar Antarctic soil habitats. The dominance of Proteobacteria, combined with the relative lack of taxa tolerant of extreme conditions, suggested that Mount Howe may represent a soil habitat unable to support bacterial life, likely due to extreme climatic conditions rather than soil properties. A significant component of the recovered DNA may simply represent the low frequency deposition of aerially transported bacterial cells, continually preserved under the local extreme conditions of constant low temperatures and low humidity. Infact over 25% of Mount Howe OTUs0.03, and almost 40% of sequences, were also present in air samples in the Miers Valley, significantly greater than seen in Miers Valley soils.

## ***Biogeography and diversity of maritime Antarctic soil fauna***

Uffe Nielsen<sup>1</sup>, David J. Van Horn<sup>2</sup>, Peter Convey<sup>3</sup>, **Becky A. Ball<sup>4</sup>**

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The biodiversity and distribution of soil invertebrates in terrestrial ecosystems in Antarctica is poorly described compared with that of most other terrestrial ecosystems. However, ongoing efforts to mine existing datasets and large sampling campaigns using standardized techniques are providing new insights into Antarctic soil communities. Here we give an overview of biogeographical patterns of soil invertebrates focusing on microarthropods (mites, springtails) and nematodes of maritime Antarctica based on current literature and data collected at 10 sites along the Antarctic Peninsula and Scotia Arc (~60-75°S) over the past two field seasons. The sampling was designed to elucidate the distribution of soil organisms in maritime Antarctica and to quantify the influence of climate on aboveground-belowground linkages. The specific goals were to identify biodiversity hotspots including sites of high conservation value, describe biogeographical patterns, and assess linkages between vegetation type and belowground communities. During the 2014-15 and 2015-16 austral summer seasons at each site we collected soil samples beneath five habitat types (moss, grass, lichen, algae, bare ground) in order to describe soil properties and chemistry, soil microbial community composition and the soil fauna. We observed a significant decrease in soil organic matter and an increase in pH towards the southern parts of the Antarctic Peninsula but also significant variation in edaphic variables within sites. Associated with soil chemistry trends we observed a concurrent change in belowground community composition and a decrease in species diversity and abundances. However, we also observed significant differences in community composition and abundances between habitat types within sites. Ultimately, such knowledge will contribute to a better understanding of potential future belowground responses to global changes in maritime Antarctica.

## ***Identifying soil foodwebs' carbon sources in the McMurdo Dry Valleys, Antarctica***

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Two typical soil foodwebs exist in the McMurdo Dry Valleys, Antarctica. These are: wet and dry. The –wet” soil foodwebs are associated with moss and algae mats in stream or lake margins (<5% of area) and have relatively high faunal diversity, which can include several genera of nematodes, tardigrades, rotifers, and microarthropods. The –dry” foodweb (~95% of area) has low faunal diversity (often just one nematode species, *Scottinema lindsayae*). Various combinations of fauna communities exist depending on habitat, resources, and location, but questions remain about organic carbon (C) sources that fuel these foodwebs' energetics. Soil organic C is extremely low. While it includes minor contemporary-C of algal, moss, or cyanobacterial sources, the majority of soil organic C is legacy-C derived from late Pleistocene era lake algal deposits. We asked: How are foodwebs related to C source, habitat, and elevation? We hypothesized: 1) –dry” foodwebs at low elevation use lacustrine legacy-C while –dry” foodwebs at high elevation (above historic lake levels) use wind-deposited marine, ornithological, or contemporary-C sources; 2) –wet” foodwebs use contemporary-C at all elevations. In a field study, we sampled wet and dry soil at both high and low elevations at three sites from valley mouth to end. We identified distinct legacy-C sources (lacustrine, marine, ornithological) and contemporary-C sources (algae, moss) based on unique 13C and 15N signatures. Next, we identified trophic position of nematodes, tardigrades, and rotifers using natural abundances of 13C and 15N. Results showed: 1) C sources identifiable with unique isotopic signatures, 2) three distinct trophic levels, 3) different isotope signatures for C source and fauna in wet vs. dry habitats and high vs. low elevations, and 3) differing foodweb structure among C sources. Wet soil C and fauna were associated with algal sources, while low elevation dry soil C and fauna were linked to lacustrine legacy C sources. The high elevation dry soil foodwebs had isotopic signatures outside the range of lacustrine legacy-C, and used either marine or contemporary-C sources. Several fauna groups were only or predominantly found associated with contemporary-C, while *S. lindsayae* was primarily in dry areas of legacy-C. This research reveals that Antarctic Dry Valley soil foodwebs take advantage of multiple C sources across the landscape, knowledge key to understanding how these ecosystems function.

## ***Processes that Shape and Maintain the Microbial Biogeography of Antarctica***

**Charles Lee**<sup>1,2</sup>, Ian McDonald<sup>1,2</sup>, Stephen Pointing<sup>3</sup>, Craig Cary<sup>1,2</sup>

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Microorganisms (i.e., Bacteria and Archaea) drive ecosystem function and productivity at the most fundamental level, and structural heterogeneities of microbial communities across spatial and environmental gradients (i.e., microbial biogeography) reveal the diversity and interconnectivity of ecosystems at the landscape scale. For terrestrial Antarctica, the significance of microbial biogeography and function is particularly acute due to the absence of vascular plants and comparatively limited presence of eukaryotic photoautotrophs. A holistic understanding of the physicochemical and ecological processes that shape and maintain microbial biogeography can explain current biodiversity patterns in terrestrial Antarctica, and informed projections of these processes under climate change scenarios will reveal the fragility and resilience of ecosystems in ice-free areas of Antarctica.

A complex network of processes relevant to microbial biogeography has emerged from recent applications of advanced molecular genetic tools to and development of ecological models for terrestrial Antarctic habitats. Many of the identified processes represent overwhelming selective pressures at local and regional scales, yet evidence also indicates persistent and substantial intra- and inter-continental redistribution of microorganisms, challenging longstanding conventional wisdom. A synthesis of divergent views on ecosystem organisation for terrestrial Antarctica has revealed potentially important roles of aeolian transport and redistribution at multiple spatial scales, and efforts are ongoing to describe and quantify these processes at local and regional scales. Requirements for an international and interdisciplinary research framework to investigate these aeolian processes at intra- and inter-continental scales will also be discussed.



## ***Year-round autonomous sampling of bacterial communities from the depth of maximum primary productivity of Lake Bonney, Antarctica***

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Antarctic lake research is typically restricted to the austral spring and summer when logistical support permits human access. While spring and summer studies provide a wealth of information about the water column microbial communities, little is known about these microbes in late summer, fall, or the long dark winter. We deployed autonomous samplers at the depth of maximum primary productivity in Lake Bonney's east and west lobes to collect and preserve filtrate approximately every 19 days during two years (2013-2015). Microbial community structure and ecosystem function dynamics were assayed using a combination of small-subunit rRNA and RuBisCO genes. Results will be discussed in relation to simultaneous physico-chemical and biological measurements, including photosynthetically active radiation, dissolved oxygen, and chlorophyll.

Preliminary 16S rRNA gene sequencing results show a dominance of four bacterial phyla (Bacteroidetes, Proteobacteria, Cyanobacteria, and Actinobacteria) throughout all time points. An increase in phototrophic communities was measured during winter months, which is surprising given that photosynthetically active radiation only penetrates the lake ice cover from late-September through late-March. As phototrophs increased abundance, heterotrophic Bacteroidetes decreased. The roles of sinking and mixotrophy in this system will be considered to explain these trends and how annual succession and functional changes contribute to annual lake productivity.

## ***Plant-soil environment and microbial communities across a latitudinal gradient in Antarctica***

**Becky Ball**<sup>1</sup>, Uffe Nielsen<sup>2</sup>, David J. Van Horn<sup>3</sup>, Pete Convey<sup>4</sup>

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The Antarctic Peninsula is experiencing rapid environmental changes, making it susceptible to alterations in species diversity and distribution, both above- and belowground. However, we lack a firm understanding of soil biodiversity, including linkages with the aboveground community and relationships to changing environmental parameters. This strongly limits our ability to predict the consequences of environmental change for soil communities. To begin determining the nature and strength of aboveground-belowground linkages in influencing soil community biogeography and diversity over a latitudinal gradient of environmental and climatic conditions, we sampled the soil microbial (bacteria, archaea, fungi) and invertebrate communities at 10 sites along the Antarctic Peninsula and Scotia Arc (from c. 60-75°S), beneath key aboveground habitats (moss, grass, lichen, algae, and bare soil). Soil chemistry and microclimatic conditions were measured to determine the relationships between soil communities and physical and chemical properties. In this presentation, we consider only soil chemical and microbial results. Soils at the northern end of the sampled region were more acidic and higher in organic matter content, as compared to the neutral, low organic matter content soils found farther south. This reflects the greater biotic influences on the soils in maritime Antarctica as compared to the sandy soils of continental Antarctica to the south. However, it is notable that one of the southern sites with continental soil characteristics hosted a bacterial biomass comparable to the more maritime Antarctic Peninsula sites, despite the less hospitable environmental characteristics. Within individual sites, the type of vegetation cover significantly altered soil chemical and physical properties, with significant site-vegetation interactions for many soil properties. However, the influence of vegetation on habitat characteristics did not always translate to significant differences in microbial biomass.

## ***Environmental limits to terrestrial invertebrate distribution in the Prince Charles Mountains (East Antarctica): exploring high throughput sequencing derived biodiversity capability***

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Knowledge of the relationship between terrestrial Antarctic biodiversity and environmental constraints is necessary for successful conservation management. The potential impact of environmental change on ecosystems can be revealed by comparisons of biodiversity patterns across large-scale gradients. However, studies to date have been limited by the cryptic nature of many terrestrial Antarctic taxa and the time-consuming nature of morphology-based studies. We used high throughput sequencing (HTS) derived biodiversity information to elucidate the relationship between soil properties and invertebrate biodiversity in the Prince Charles Mountains, East Antarctica.

Analysing data obtained from 103 soil samples collected across Mount Menzies, Mawson Escarpment, and Lake Terrasovoje, we found invertebrate distribution in the Prince Charles Mountains significantly influenced by electrical conductivity and/or sulphur content and, to a lesser extent, slope and elevation. Classes Enoplea (Nematoda), Bdelloidea (Rotifera), and phyla Tardigrada and Arachnida only occurred in low salinity substrates with abundant nutrients, but Chromadorea (Nematoda) and Monogonata (Rotifera) were less influenced by salinity and showed broader distributions. Positive correlation between soil salt concentration and time since deglaciation indicated that terrain age might indirectly influence Antarctic terrestrial biodiversity. We demonstrate the value of metataxonomic HTS approaches to investigate environmental constraints on the distribution of invertebrates across large distances.

## ***Linking springtail (Collembola) diversity in the Ross Sea Region with collapse of the Western Antarctic Ice Sheet (WAIS)***

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We used mitochondrial DNA (COI) sequences to examine levels of genetic variability within and among populations of five endemic springtail species (Arthropoda: Collembola), collected from southern Victoria Land and the Queen Maud Mountains. High levels of sequence divergence were found at both small (<15km) and large (>100km) spatial scales for four of the five species. The widespread *Gomphiocephalus hodgsoni*, showed 8% sequence divergence among sites in the vicinity of the Mackay Glacier (77oS) and >8% relative to sites near the Beardmore Glacier (84oS). High levels of sequence divergence were also found for more range-restricted species in southern Victoria Land (*Cryptopygus nivicolus* >5% and *Antarctcinella monoculata* >11%) and in the Queen Maud Mountains (*Antarctophorus subpolaris* >11%). Based on molecular clock estimates, these divergent populations were last connected around 3.5 to 6 MYA. This corresponds to when the Western Antarctic Ice Sheet (WAIS) was thought to have completely collapsed and when meltwater streams and open seaways would have provided ideal dispersal opportunities for springtails. Subsequent glaciations during the Pliocene and throughout the Pleistocene (2 Mya - 10 Kya) are likely to have then isolated these populations in small refugial habitats. We suggest that patterns of glaciation within the Ross Dependency are likely to have promoted and maintained the levels of diversity observed for springtails. The high levels of sequence divergence are also likely to reflect the presence of previously unknown (cryptic) species. Conservation strategies should be directed towards preserving the biotic integrity of fragmented landscapes within the Ross Dependency.

## **S33. The role of humanities and social sciences in Antarctic studies D6, Meeting Room 403, August 26, 2016, 11:30 AM - 1:30 PM**

### ***The spatial distribution of Antarctica's protected areas: A product of pragmatism, geopolitics or conservation need?***

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Globally, few protected areas exist in areas beyond national jurisdiction; however, the Antarctic Protected Areas system operates through multi-national agreement by consensus and 2016 marks the 50th anniversary of the designation of the first Antarctic protected area. In this work, we examined the Antarctic Treaty system to provide an insight on how protected area designation under a multi-party framework may evolve. Antarctic terrestrial and marine environments are under increasing threat from global environmental impacts and increasing human activity in the region. However, the protected area system, now legislated through the Protocol on Environmental Protection to the Antarctic Treaty and the Convention on the Conservation of Antarctic Marine Living Resources, remains largely unsystematic and underdeveloped. Since the entry into force of the Antarctic Treaty in 1961, the original signatory Parties - and Parties with territorial claims in particular - have dominated the work leading to protected area designation in the region. The distribution of protected areas proposed by individual Parties has largely reflected the locations of their research stations, which in turn are largely determined by scientific, operational and national geopolitical criteria. Recently non-claimant Parties have become more involved in area protection, with a concurrent increase in areas proposed for protection collaboratively by more than one Party. In a continent where governance and decision making is carried out through consensus, the early engagement of Parties in collective area protection is likely to strength the protected areas system and help safe-guard the continent's values for the future. The Antarctic Protected Area system's evolution and the degree of engagement by Treaty Parties may hold valuable insights for area protection in regions, such as the high seas or outer space, which are not under national jurisdiction.

## ***Bringing psychology to the Antarctic archives: the 'case' of Sidney Jeffryes***

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In this interdisciplinary paper we combine archival, historical, cultural and psychological perspectives to investigate an intriguing event in Antarctic history: the psychotic breakdown suffered by radio operator Sidney Jeffryes during the second winter of the Australasian Antarctic Expedition (AAE, 1911-14). The only new member of a team of seven men who overwintered in a small hut in Commonwealth Bay in 1913, Jeffryes became paranoid, believing that his companions were plotting to murder him, and sending radio messages relaying this information to the outside world. Attempting suicide during the expedition's return journey, Jeffryes went missing soon after he arrived in Australia, and was found wandering in the Victorian bush. He was institutionalized in a nearby asylum, where he lived the remainder of his life. We will analyse and contextualize Jeffryes' AAE experience, relate it to the social dynamics of the wintering team (in which relations could be very tense, even putting aside Jeffryes' contribution), and examine the ways in which this unheroic episode was represented (or not) in contemporary accounts of this important Heroic-Era expedition, such as the official expedition narrative, 'The Home of the Blizzard' (1915).

The recent centenary of the AAE produced a re-evaluation of this expedition. While historian David Day's revisionist account 'Flaws in the Ice' controversially took aim at the expedition's leader, Douglas Mawson, others focussed on raising the profile of the men he led, publishing their diaries and emphasizing their distinct contributions. In all of this activity, however, Jeffryes has been strangely overlooked. Historians such as Day, Beau Riffenburgh, and Tom Griffiths discuss Jeffryes' breakdown as an intriguing and disturbing episode in the expedition's second winter, but none focuses particularly on him. And while polar psychology is a flourishing field, and sometimes incorporates historical examples, Jeffryes tends to be considered here in passing, given a paragraph or half a page (e.g. Guly; Palinkas and Suedfeld). Accounts in the popular media usually gloss Jeffryes as an advanced case of cabin fever. While the Australian Government implicitly acknowledged Jeffryes' contribution to Australian history by naming a glacier after him in 2010, his experiences go largely undocumented.

This paper thus represents the first detailed examination of Jeffryes' case. With implications for the cultural history of mental illness as well as Australian Antarctic history, our research demonstrates the fruitfulness of collaborations across the humanities and sciences.

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## ***The role of visualization in ‘constructing a continent’***

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What is the role of visualization in stimulating engagement with the Antarctic experience? In the last few years, Information Design as a formal discipline has increasingly become recognized as an indispensable tool in the context of integrating cross-disciplinary knowledge, awareness, and education. Here, I explain how, within the framework of Antarctic studies, information design can be used for participatory design, facilitating conversation, geographical and disciplinary place-making, and as a means of visual storytelling.

With an approach to involve end users—or knowledge consumers—in the design process, I handed out more than 200 questionnaires that simply asked, “When you hear the word ‘Antarctica’ what are you most curious about?” Analysis of the 1100+ answers both surprised me and revealed that, above all else, people are interested in people. I used the participatory results to form a compendium of visualization projects that aimed to ‘humanize’ Antarctica for a broad audience. For example, a data-encoded necklace acts as both a bridge object and conversation facilitator, an interactive map of the continent elucidates how many people live where and offers a glimpse into their daily activities, and a narrative graphic about what to eat in Antarctica seeds further anthropographic questions.

The often oppositional notions of popular imagination and the everyday Antarctic experience cultivate the cultural incognizance that persists today—one where published communications from the continent are weighted toward scientific findings. We now have the opportunity, in a tech-advancing 21st century, to engage in a more pragmatic approach to Antarctic knowledge dissemination—one that sees the value of contextualizing the Antarctic experience through the lens of human engagement both on and off the continent. These visual information design experiments demonstrate how interdisciplinary and experiential media may engender a richer cultural consciousness and connection to the continent.

## ***Adaptation in an Antarctic station***

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Because all Antarctic science is a human endeavour, it can be argued that a large part of its success depends on individual characteristics and how well those characteristics interact with features of the sociophysical context. This interaction is generally known in environmental psychology as “person-environment fit”. Sending a scientist or support person to the Ice is both time-consuming (e.g., long screening processes, training) and expensive (e.g., the cost of logistics for traveling, maintaining a habitable station). It is thus essential that these personnel are wisely selected, especially those who will be sent for extended durations. This talk will provide a brief overview of theoretical aspects of person-environment fit and how they pertain to human adaptation in Antarctic settings. It will also be shown that this contextualist approach to adaptation has broader implications for all human activity on the Ice.



# ***Representations of Antarctica in the literatures of the polar gateways. From idyllic space to monster's den. A PhD Project***

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This paper outlines my PhD project, the aim of which is to analyse representations of Antarctica in a series of works of literature from Argentina, Chile, Australia and New Zealand. This project will identify the salient features of these representations, trace links between them, and contextualize them historically.

Although some important studies on representations of Antarctica in English literature has been done (Leane, 2012□; Nielsen, 2013□; Chaplow, 2011)□, alongside work on more general representations of a southern continent (Stallard, 2010)□; there are almost no analyses of the imagined versions of Antarctica in Spanish literature. Nor is there any comparative study of how different cultures with strong links to Antarctica represent the South Polar regions.

My PhD project asks: how have representations of Antarctica in the national literatures mentioned above changed as a consequence of historical and scientific developments? Have these representations been affected by the presence of national ties and territorial claims? Do issues such as international collaboration – or lack thereof – in Antarctica affect the ways in which the White Continent is represented in literature?

Although my research is still in its early stages, I report on preliminary findings, focussing particularly on the representations of Antarctica in Argentine literature, and the links between those representations and changes in Argentine society.

My research will contribute to a better understanding of the differences and similarities between representations of the Antarctic region produced in these four countries. This understanding is particularly important given the unusual political status of Antarctica, where a culturally diverse group of countries govern by common consent.

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## ***The beauty and the beast. The reception of Antarctica in contemporary British literature.***

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Nature is perhaps the most complex word in the language” claims Raymond Williams in the beginning of his essay “Nature”. What is nature? Where does it begin and where does it end? Every culture constructs a prism through which we perceive our surroundings and every human being has its own ideas of what constitutes nature. Which descriptions do authors use for the most complex word of our language, according to Williams, and how do nature and humans interact in these texts? My paper aims to investigate the perception of Antarctica, one of the last large-scale ecosystems of our planet, in recent literary examples. The continent is a place bereft of indigenous inhabitants and their corresponding creation myths. It has no own legends, language and culture. Antarctica, in short, is a blank space on which humans paint their ideas, fears, desires and dreams on. With the help of contemporary British literature dealing with the continent, I will explore how the gap between terrain and self and between human and nature is depicted. Literature can thereby evoke the idea of Antarctica as the best place on earth and the worst; a place that embodies a sleeping ice beauty and a monstrous south simultaneously. Travelling to Antarctica, however, does not only entail a journey downwards in a geographical sense, but also a journey inwards. Both texts project inner psychological processes on the icy exterior landscapes and vice versa. The frozen continent therefore confronts humans both with their deepest fears and their hidden, forbidden desires. Sensory deprivation, questions of gender studies and myth-making as well as notions of biocentrism and anthropocentrism, therefore play an internal role in the literature dealing with Antarctica. Ultimately, meeting Antarctica is not only waking a sleeping ice beauty or fighting a monstrous south, but also coping with a place where humans have to re-define themselves in relation to their natural surroundings.

# ***The South Pole dome: An architect's perspective***

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In recent years, architects have become increasingly involved with the design of new stations and the restructuring of existing stations in Antarctica. Researchers, however, have been far slower to look at Antarctic architecture and spatiality more generally. This paper contributes to an emerging understanding of the role of architecture in Antarctica by focussing on one of its most iconic structures: the South Pole Dome.

In 1975 the Dome replaced the first South Pole station, a Navy Camp which established US presence in 1956. Due to heavy snow accumulation, the Navy Camp was replaced by the new geodesic structure. The Dome was patented by architect Buckminster Fuller (1895 – 1983), engineered by the company Temcor and built by the Navy's Construction Battalion (CB-201). The construction of the Dome marked the transition of US military presence to an US civilian occupancy at the South Pole. In 2008 the Dome was dismantled and removed due to snow accumulation and increasing demands for accommodation. In the meantime, a third South Pole station (the current one) had been built, adding to the recent building "boom" in Antarctica. However, the former South Pole Dome still remains actively and widely present in narratives, shared experiences and imagery.

The multiple meanings of the South Pole Dome are the focus of my research. My approach is multi-layered, combining architectural analysis with an investigation of theoretical writings of Buckminster Fuller, Banham and Rawes(1) . My research is informed by interpretive studies of written and visual sources, including maps, photographs, field notes and diaries. All of these sources provide insight into the complex cultural, social, material and ecological interactions that composed the Dome at this remote and geopolitically contested place.

My research on the Dome thus ranges from the micro-scale of individual to the macro-scale of geopolitics. These scales are also part of the futuristic visions of Buckminster Fuller. His Dymaxion World Map (1940) resolved not only the cartographical distortions of Antarctica in the Mercator projection, but also offered new perspectives on environmental and geopolitical issues. The same mathematical principles used for the map formed the foundation for the structural design of geodesic domes. The Dymaxion World Map and the domed structures supported Buckminster Fuller's vision that an environmental disaster due to rapid expansion of human population and increasing energy need could only be prevented by technological solutions.

The South Pole Dome is therefore more than just a shelter for humans, but also accommodates cultural, social and ecological significance. This paper investigates these meanings from an architectural perspective.

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## **S40. Environmental contamination in Antarctica, Meeting Room 404, August 26, 2016, 11:30 AM - 1:30 PM**

### ***Impacts of fuel contamination on Antarctic and sub-Antarctic flora***

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Fuel spills have occurred in Antarctic and sub-Antarctic regions, and comprehensive remediation strategies have recently been established to clean-up fuel spills at Australia's Casey Station and Macquarie Island. However, there are currently no environmental quality guidelines specific for Antarctic soils and the sensitivity of Antarctic flora and fauna to petroleum hydrocarbons is unknown. This research developed routine toxicity test procedures with native Antarctic terrestrial flora to guide remediation activities, with a view to establish remediation target concentrations for hydrocarbons using local flora, and for subsequent use in environmental risk assessments.

The sensitivity and response of various native plant species to soil contaminated with Special Antarctic Blend (SAB) fuel was investigated using three Antarctic mosses, one Antarctic terrestrial alga, and seven Macquarie island grass and shrubs. Artificial soils with high and low organic carbon content were spiked with SAB fuel and used either immediately to represent a fresh fuel spill, or after two weeks to simulate an aged spill. Toxicity tests were performed for 21-28 days under controlled conditions (15°C; 16/8 hours photoperiod) to simulate growth conditions during Antarctic summer months. Several endpoints were investigated: photosynthetic efficiency, pigment content and visual health used for slower growing mosses and algae, and germination and root and shoot length investigated for faster growing grasses and shrubs.

The early life stages of grasses and shrub identified that germination, and root and shoot length varied in response to fuel-contaminated soil, with root and shoot length exhibiting greater sensitivity than germination. Thus moss and algae may be under limited threat from present hydrocarbon contamination, however, future contamination from fresh spills are more problematic, particularly if the Antarctic climate continues to get drier. In general, fresh fuel was more toxic than aged fuel, with moss and algal communities eliciting tolerance to exposures up to 25,500 mgSAB/kg.

## ***Spatial covariance of soil contaminants at McMurdo Station, Antarctica***

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Petroleum hydrocarbons and lead are among the two most common anthropogenic contaminants found in soils near scientific stations operated by national Antarctic programs. McMurdo Station, operated by the United States Antarctic Program (USAP), is no exception. Over 3500 soil samples have been collected across the Station between 1999 and 2012 and have enabled detailed mapping of the concentrations of TPH, Pb and other selected trace metals (Al, Fe, Mg, Mn, As, Ba, Be, Cd, Co, Cr, Cu, Hg, Ni, V and Zn). Total Petroleum Hydrocarbons (TPH) and lead (Pb) have been found to be the two most common soil contaminants at the station. Areas of elevated concentrations of contaminants are typically found in areas of historic or ongoing station operations or in areas of historic waste disposal. This analysis examines the spatial co-occurrence or covariance of soil containments at McMurdo Station, focusing on TPH and Pb, the two most common contaminants. For the station as a whole, the Pearson Correlation Coefficient for the log-normalized concentrations of TPH and Lead is 0.469 and is statistically significant at the 95% level. This indicates some relationship in concentrations between these two common contaminants. To investigate their spatial covariance, two statistical approaches, a locally adaptive Pearson's Correlation Coefficient and Geographically Weighted Regression (GWR), were employed and varying spatial scales were considered. At most locations at the station, TPH and Pb concentrations were found to be positively correlated. As fuel and lead-based paint from buildings are possible sources of anthropogenic lead, GWR analysis was then used to examine the spatial relationship of these two contaminants in greater detail to better understand the possible sources of elevated lead for different areas within the station.

## ***Human impact on the McMurdo Dry Valley soils of Antarctica: extending the limits of forensic DNA detection.***

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Human impact on the McMurdo Dry Valley soils of Antarctica: extending the limits of forensic DNA detection.

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Human presence is ever-increasing in the Antarctic, primarily in forms of tourism and science-driven activities. Under the Antarctic Treaty of 1959, all activities are required to keep the environment in a pristine state. However, the current definition of pristine focuses on disturbance of physical (to the landscape and visible biota) and chemical (i.e., release of material) nature. The release of human genetic material and human-associated microorganisms through routine human activities is not understood, much less quantified. Direct experimentation has demonstrated that microbial communities have the capacity to respond and change to altered environmental conditions. The effects of releasing human DNA and associated microbiota have not been investigated in an MDV environment, for instance, whether microbial community composition and functionality is altered and whether there is a change in overall phylogenetic signal. Given the extremely low biomass in most of terrestrial Antarctica, the presence of these materials can act as a reliable indicator of human presence and activities to allow auditing of reported visitations and the detection of unpermitted landings and unauthorised entry into restricted areas.

As part of New Zealand's effort to carry out evidence-based risk assessment of the McMurdo Dry Valley ecosystem (DryVER project), this research will quantify human impact, in the form of human DNA and human-associated microbiota, across temporal and spatial scales. Areas of human activity, including camps and stations, were selected as sampling sites in the McMurdo Dry Valleys (MDV), from which soil samples were collected. Human-specific genetic markers in conjunction with digital PCR were used to detect human presence at the lowest possible limit. A DNA longevity experiment was established in situ in Miers Valley to elucidate factors that promote DNA preservation in MDV soil. The data generated from a MDV setting will be used to create metric tools for detecting human genetic and microbiological footprints. The direct outcome of this research will be a review of the environmental management systems in place, namely the McMurdo Dry Valleys Antarctic Specially Managed Area (ASMA) Management Plan. Better management will safeguard the unique MDV ecosystems by using the best practice to minimize anthropomorphic impact.

## ***Advanced wastewater bioremediation in Antarctic stations using an Antarctic chlorella strain***

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For decades, microalgae have received a lot of attention because of their capability of using inorganic carbon (carbon dioxide, CO<sub>2</sub>) as carbon source and wastewater components as nutrients while producing biomass. On the other hand, disposal of wastewater often results in high nutrient loading into aquatic environments, which may lead to favorable conditions for undesirable phytoplankton blooms. Microalgae are efficient in removing nitrogen, phosphorus, and toxic metals from wastewater under controlled environments.

During the Antarctic summer, the population in Antarctic stations tend to increase significantly, causing high stress on wastewater treatment systems. Usually, these systems are not designed for the removal of nutrients and therefore low-quality effluent are obtained. Because of this, the use of algae obtained from Antarctic becomes an interesting alternative to supplement the wastewater treatment. This alternative does not introduce species in antarctic environmental and it in summer could complement existing treatment systems. Also problems, such as resistance to long periods of low temperatures and high solar light, could be minimized.

This research worked with *Chlorella* sp isolated from Fildes Bay on King George Island, archipelago of the South Shetland Islands. The reasons C: N: P ideals for the growth of algae were determined in synthetic media under controlled laboratory conditions. In addition, experiments with raw wastewater (pretreated) and synthetic wastewater were performed (simulating an effluent of a secondary treatment with and without disinfection). Testing wastewater were developed in two conditions of temperature and light: 15 ° C and light periods of 12 hours and uncontrolled environmental conditions, corresponding to the city of Punta Arenas in Chilean Patagonia, variable temperature between 7 and 20 ° C and exposure to typical summer light (about 16 hours). Wastewater trials were performed in one-liter reactors of methacrylate, agitated by injecting air. Samples were taken every two days for measuring total nitrogen, organic matter (COD) and phosphorus. The pH was monitored daily.

Results of growth rate assay, using synthetic medium with different N:P ratios, revealed that higher values of growth rate was obtained on N:P (6:1) ratio that is similar to those found in urban wastewater. Preliminary results from tests on three types of wastewater (raw wastewater and synthetic secondary effluent with and without disinfection), showed that the system is able to maintain an approximately constant pH for 15 days. The maximum removal efficiencies of nitrogen were observed in raw wastewater under uncontrolled conditions, reaching an elimination of 55% and 85% on day 8 and 13 respectively. For the same conditions, the removal of organic matter (measured as COD filtered) peaked at 87% (8th). Phosphorus removal was not significant in all tests performed.

The results show that the inclusion of Antarctic algae in wastewaters treatments represent an opportunity to improve the quality of effluent and the possible valorization of them.

## ***Environmental contamination and the legacy of human activity: mitigation and remediation in the Antarctic***

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The impacts of pollution in Antarctica are multi-faceted and significant. Atmospheric, marine and terrestrial contaminants are having adverse effects on the Antarctic environment and pose significant management challenges. The current framework for managing human activities in the Antarctic is increasingly complex with considerable differences in the operationalisation and interpretation of both the Antarctic Treaty and the Madrid Protocol between Antarctic operators. Many current practices are incongruent with the principles outlined within the Treaty and the Protocol. Attempts to rectify these practices have so far failed to elicit unanimous positive environmental outcomes. Effective mitigation strategies are necessary to prevent further contamination and provide best practice environmental management with the increasing pressures of human activity in Antarctica. Managing legacy and liability issues is an important stage in remediating past environmental contamination. A more effective governance regime and increased political will by all is required to achieve compliance with the environmental standards set within the Protocol in order to achieve comprehensive protection of Antarctica and Antarctic values.



# ***Environmental considerations of ice core-drilling technology in Antarctica***

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Many of the scientific questions can only be addressed by a deep ice core-drilling. Ice core data have become central to our understanding of past climate change, and to assessments of possible future climate change. For the first time the deep ice core-drilling in Antarctica was carried out by USA CRREL at Byrd Station in 1967 – 1968. During fifty years after this event, more than 30 intermediate and deep fluid-filled boreholes were drilled in Antarctic ice sheet. However, drilling technology is still very harmful for Antarctic environment. Among the sources of environmental impact that are associated with drilling projects like construction of subsurface trenches, diesel power station operation, erection of electrification equipment, etc., drilling fluids have the most significant environmental pollution effect.

Drilling fluids are introduced into an open borehole for three main purposes. First, the presence of a density balanced fluid in the hole prevents it from closure through viscoplastic deformation. Second, a circulating fluid in the borehole provides a mechanism for sweeping chips away from the drill bit. Third, presence of a fluid in the hole can avoid the ice cores from developing brittleness. Drilling fluids for oil and gas well drilling are not suitable for deep ice core-drilling due to their high viscosity, complex performance and other technical issues. Therefore, the various special low-temperature drilling fluids were used for coring in ice: (1) two-component kerosene-based fluids with density additives, (2) alcohol compounds and (3) ester compounds. It was also proposed to use the low-molecular dimethylsiloxane oils as drilling fluid.

The effects of drilling fluids on the natural environment are analyzed from the following points of view: (1) occupational safety and health; (2) ozone depletion and global warming; (3) chemical pollution; and (4) biological pollution. Not all recent low-temperature drilling fluids qualify as intelligent choices from these standpoints. They can contaminate air, surface and near-surface snow-firn layers, ice cuttings, subglacial water resources and most of them cause severe health problems when drillers inhale or absorb harmful chemicals from drilling fluids through mouth or nose, or via skin contact. Interactions of the drilling at inland on the Antarctic ice sheet with surface or air biota are unlikely, but the possibility of impacts to subglacial water biota from drilling fluid can occur almost at any inland drilling site. Effects of drilling fluids are particularly important if fluid is to be left in the hole. Because of the movement of the ice, fluid in the borehole will eventually reach the sea after a period of many thousands of years.

It is proposed to reduce environmental impact of drilling fluid by the following practice: (1) development of the drilling fluid and waste utilization safety protocol; (2) further searching for the new environmental-friendly compositions of low-temperature drilling fluids; (3) safe isolation of permeable snow-firn layer; (4) full recycling of drilling fluid from ice chips and drill string/drill cable; (5) removing of drilling fluid from the borehole after drilling completion; (6) ecological monitoring of air, snow and firn on the drill site.

## ***Recent increase of perchlorate in Antarctic snow tied to anthropogenic CFC emissions***

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Perchlorate ( $\text{ClO}_4^-$ ) is a potentially harmful trace contaminant that has received increasing attention due to its widespread occurrence in the environment and its adverse health effects on humans. Perchlorate in the Antarctic is likely produced in the atmosphere from ozone-mediated oxidative reactions of chlorine oxide species and deposited with precipitation. There is little information on perchlorate produced in the atmosphere and if this production has varied over time; a long-term record of perchlorate in the Antarctic would provide such information.

We have measured perchlorate throughout a 15 m South Pole ice core that has been dated to cover the time period from 1920 to 2004. Perchlorate concentrations began to increase in the mid-1970s and the increase accelerated starting in the mid-1980s. The pattern of increasing perchlorate in more recent times at the South Pole parallels the increasing trend of chlorine in the stratosphere. Correlational analysis between stratospheric chlorine and perchlorate at the South Pole suggests a strong positive relationship, indicating that the increase in perchlorate may be caused by the increase in stratospheric chlorine. It may be that anthropogenic emissions of chlorine compounds (CFCs) have caused perchlorate production over the Antarctic to increase tenfold.

**S05. Past Antarctic climate and ice sheet dynamics: integrating models and observations from the deep ice to the deep sea (Sec 2), Meeting Room 409, August 26, 2016, 2:30 PM - 4:30 PM**

***A high resolution record of trans-Antarctic peninsula ice stream retreat and a comparison of potential forcing mechanisms***

**Eugene Domack**<sup>1</sup>, Amelia Shevenell<sup>1</sup>, Katherine Smith<sup>1</sup>, Brad Rosenheim<sup>1</sup>, Scott Ishman<sup>2</sup>, Amy Leventer<sup>3</sup>, Cristina Subt<sup>1</sup>, Dylan Peck<sup>4</sup>, Ho-Il Yoon<sup>5</sup>, Kyu-Cheul Yoo<sup>5</sup>, Julia Wellner<sup>6</sup>, Yeong Bae Seong<sup>7</sup>, Jeffrey Evans<sup>8</sup>, Andrew Christ<sup>9</sup>, Ara Jeong<sup>7</sup>

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We compare cross-Peninsula reconstructions of paleo Ice streams as they likely existed during the Last Glacial Maximum and present an extensive ensemble of sediment cores, all with well constrained radiocarbon chronologies. We do this for the western side of the Antarctic Peninsula (WAP) by including the Hugo-Anvers Island Palmer Deep (HAPD) system and the Gerlache-Boyd Strait (GBS) system. For the eastern side of the (EAP), we include the Hektoria-Jason Peninsula (HJP) system and the Greenpeace-Robertson Trough (GRT) system. Further we link all four systems into a common, calibrated chronology by using accurate reservoir corrections developed independently for the western versus eastern sides as well as for vital effects between different organisms. We also express our age models with probability functions thus allowing for assessment of uncertainty in the resulting deglacial model and hence a more accurate evaluation of potential forcing mechanisms. This analysis indicates significant variation in the timing of glacial recession both between individual ice streams and more importantly between the WAP and the EAP. We then evaluate the role of paleoceanographic, physiographic, and geologic boundary conditions that may have forced or regulated the retreat patterns that are now observed for the first time in a common space-time configuration.

## ***Drilling in the Amundsen Sea Embayment: Development and sensitivity of the West Antarctic Ice Sheet at its heart***

**Karsten Gohl**<sup>1</sup>, Julia Wellner<sup>2</sup>, Claus-Dieter Hillenbrand<sup>3</sup>, Hoon-II Yoon<sup>4</sup>, John Anderson<sup>5</sup>, Werner Ehrmann<sup>6</sup>, Ulrich Salzmann<sup>7</sup>, Gabriele Uenzelmann-Neben<sup>1</sup>, Gerhard Kuhn<sup>1</sup>, Reed Scherer<sup>8</sup>, Jonathan Warnock<sup>8</sup>, Frank Nitsche<sup>9</sup>, Torsten Bickert<sup>10</sup>

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The West Antarctic Ice Sheet (WAIS) is largely marine-based and, thus, highly sensitive to climatic and oceanographic changes. It probably had a very dynamic history over the last several million years. A complete collapse of the WAIS would result in a global sea-level rise of 3.3-4.3 m, yet, the world's scientific community is not able to predict its future behavior. Moreover, knowledge about the past dynamics of the WAIS is poor, in particular during geological times with climatic conditions similar to those expected for the near and distant future. Reconstructions and quantifications of partial or complete WAIS collapses in the past are urgently needed for constraining and testing ice sheet models that aim to predict future WAIS behavior and the potential contribution of the WAIS to global sea-level rise. Large uncertainties exist regarding the chronology, extent, rates, and spatial and temporal variability of past advances and retreats of the WAIS across the continental shelves. These uncertainties mainly result from the fundamental lack of data from drill cores recovered proximal to the WAIS. The continental shelf and rise of the Amundsen Sea are prime targets for drilling, because the records are expected to yield archives of pure WAIS dynamics unaffected by other ice sheets, and the WAIS sector draining into the Amundsen Sea Embayment (ASE) currently experiences the largest ice loss in Antarctica. A series of drill sites are planned for the ASE shelf where seismic data reveal oceanward dipping sedimentary sequences that span the time from the pre-glacial depositional phase to the youngest glacial periods. Our strategy is to drill transects from the oldest sequences close to the bedrock-basin boundary at the middle-inner shelf transition to the youngest sequences on the outer shelf in both the western and the eastern ASE. These transects will provide a detailed history of the glacial cycles in the Amundsen Sea region and allow comparison to the WAIS history known from the Ross Sea sector. In addition, deep-water sites on the continental rise of the Amundsen Sea are selected for recovering continuous records of glacially transported sediments and detailed archives of climatic and oceanographic changes throughout glacial-interglacial cycles. We will apply a broad suite of analytical techniques, including multi-proxy analyses, to address our objectives of reconstructing the onset of glaciation in the greenhouse to icehouse transition and processes of dynamic ice sheet behavior during the Neogene and Quaternary.

## ***Timing and drivers of the deglaciation in the Ross sea region***

**Nancy Bertler**<sup>1,2</sup>, Howard Conway<sup>3</sup>, Dorthe Dahl-Jensen<sup>4</sup>, Giovanni Baccolo<sup>6</sup>, Troy Baisden<sup>2</sup>, Thomas Blunier<sup>4</sup>, Hannah Brightley<sup>1,2</sup>, Edward Brook<sup>5</sup>, Christo Buizert<sup>5</sup>, Lionel Carter<sup>1</sup>, Gabriela Ciobanu<sup>4</sup>, Ruzica Dadic<sup>1</sup>, Barbara Delmonte<sup>6</sup>, Zhang Dongqi<sup>7</sup>, Ross Edwards<sup>8</sup>, Aja Ellis<sup>8</sup>, Daniel Emanuelsson<sup>1,2</sup>, T.J. Fudge<sup>3</sup>, Nicolas Golledge<sup>1,2</sup>, Richard Hindmarsh<sup>9</sup>, Robert Hawley<sup>10</sup>, Yung Jiao<sup>7</sup>, Liz Keller<sup>2</sup>, Jonathan Kingslake<sup>9</sup>, Sepp Kipfstuhl<sup>11</sup>, Helle Kjær<sup>4</sup>, Elena Korokikh<sup>12</sup>, Andrei Kurbatov<sup>12</sup>, James Lee<sup>5</sup>, Paul Mayewski<sup>12</sup>, Timothy Naish<sup>1,2</sup>, Peter Neff<sup>13</sup>, Reed Scherer<sup>14</sup>, Spruce Schoeneman<sup>3</sup>, Jeffrey Severinghaus<sup>15</sup>, Marius Simonsen<sup>4</sup>, Eric Steig<sup>3</sup>, Paul Vallelonga<sup>4</sup>, Edwin Waddington<sup>2</sup>, Holly Winton<sup>8</sup>

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Geological evidence and modelling experiments suggest that the removal of ice shelves from marine based ice sheets can lead to catastrophic collapse. Roosevelt and Ross Islands are thought to be stabilization anchors for the Ross Ice Shelf and thus the West Antarctic Ice Sheet.

As part of the Roosevelt Island Climate Evolution (RICE) project, a 763m deep ice core was recovered during 2011-2013 from Roosevelt Island, at the northern edge of the Ross Ice Shelf. The ice at Roosevelt Island is grounded 210 m below sea level and accumulates in situ, with the Ross Ice Shelf flowing around the rise. High resolution radar surveys show a well developed Raymond Bump at the divide of the ice dome. The RICE age model is developed using high resolution methane data tied to the WAIS Divide ice core record, supported with annual layer count, tephra ages and a glacial flow model.

Here we show data spanning the past 30ka and discuss reconstructions of sea surface and air temperature, sea ice extent, atmospheric circulation patterns, and ice shelf grounding line retreat. An ensemble of sensitivity modelling experiments is used to determine thresholds for the removal of ice on Roosevelt Island and correlated grounding line and ice volume changes of the Ross Ice Shelf and the West Antarctic Ice Sheet.

Our data suggest that the delayed onset of the Ross Ice Shelf grounding line retreat during the deglaciation was driven at least in part by the early onset of deglaciation in West Antarctica as recorded in the WAIS ice core. The Ross Ice Shelf grounding line started to retreat rapidly with the initiation of an ice shelf cavity.

## ***Searching for the most detailed, continuous, late Miocene to Quaternary records of Antarctic Peninsula and West Antarctic Ice Sheet dynamics***

**Robert D. Larter**<sup>1</sup>, Claus-Dieter Hillenbrand<sup>1</sup>, Alastair G.C. Graham<sup>2</sup>, James E.T. Channell<sup>3</sup>, Javier Hernández-Molina<sup>4</sup>, David A. Hodell<sup>5</sup>, Kelly A. Hogan<sup>1</sup>, Chuang Xuan<sup>6</sup>, Karsten Gohl<sup>7</sup>, Michele Rebesco<sup>8</sup>, Gabriele Uenzelmann-Neben<sup>7</sup>, Simon Crowhurst<sup>5</sup>, Maria C. Williams<sup>1</sup>, JR298 Shipboard Party  
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Changes observed in the West Antarctic Ice Sheet (WAIS) and Antarctic Peninsula Ice Sheet (APIS) over recent decades include thinning and break up of ice shelves, glacier flow acceleration and grounding line retreat. How rapidly and how far these ice sheets will retreat in a warmer climate, however, remains uncertain. For example, it remains unclear whether or not the marine-based WAIS “collapsed” during Quaternary interglacial periods, including the last one, contributing more than 3 m to global sea-level rise. Continuous long-term records of ice sheet change with precise chronology are needed in order to answer these questions. On the Antarctic continental shelf, sedimentary records are interrupted by numerous unconformities resulting from glacial erosion, good core recovery has only been achieved from platforms sited on sea ice or ice shelves, and establishing reliable chronologies has proved challenging. In contrast, sediment drifts on the upper continental rise around Antarctica contain expanded, continuous successions dominated by muddy lithologies from which good recovery can be achieved using standard scientific ocean drilling methods. Ocean Drilling Program (ODP) Leg 178 demonstrated that sediment drifts west of the Antarctic Peninsula contain a rich high-resolution archive of Southern Ocean paleoceanography and APIS history that extends back to at least the late Miocene. The potential of existing ODP cores from the drifts is, however, compromised by incomplete composite sections and lack of precise chronological control. An International Ocean Discovery Program proposal (732-Full2) for future drilling on these drifts has been scientifically approved and is with the JOIDES Resolution Facilities Board for scheduling. The main aims of the proposal are to obtain continuous, high-resolution records from sites on sediment drifts off both the Antarctic Peninsula and West Antarctica (southern Bellingshausen Sea). The challenges will then be achieving good chronological control using a range of established and novel techniques and interpreting what facies variations indicate in terms of changes in the ice sheets. During a 2015 research cruise on RRS James Clark Ross (JR298) we obtained additional site survey data around the proposed sites including high-resolution multichannel seismic reflection data, piston cores and box cores. We will present results from this cruise and interpret them in terms of sedimentary processes that operated during the development of the drifts, and links between depositional systems on the continental rise, paleo-ice-sheet dynamics and paleoceanographic processes.

## ***New environmental magnetic and organic geochemical insights into the Pliocene warm period from Taylor Valley, Southern Victoria Land.***

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We present a record from the Taylor Valley, DVDP-11 drill core, which paints a new picture of the Pliocene period in Southern Victoria Land, Antarctica. Paleomagnetic data provide robust age control of the successions and indicate that below 200 m the successions is of early Pliocene to latest Miocene age and the upper portion dates from the mid Pleistocene to modern times. Sediments comprise thin mudstones and massive to stratified diamictites. Sedimentary and paleoecological evidence indicates that during the latest Miocene - early Pliocene, wet based glaciers filled the Taylor fiord and that glaciers retreated during the Pliocene warm period leaving open marine conditions and a deep fiord (>300 m).

We conducted environmental magnetic and organic geochemical analyses to characterize the terrestrial environment and determine sea surface temperatures of the ancient fiord. Magnetic analyses revealed oxidized magnetic minerals, which indicate that soils likely formed at the edges of the fiord. Soil formation requires warm and wet conditions and a significant increase in the number of above-freezing days compared with today. In order to further test the hypothesis of Pliocene soil development we conducted geochemical analyses in which we identify significant concentrations of n-alkanes and fatty alcohols indicative of higher order, vascular plants. Pollen analyses of the same samples yielded only a handful of recognizable palynomorphs possibly because sediments were winnowed, therefore pollen data do not provide supporting evidence of a Pliocene plant community. However, the concentrations and composition of organic biomarkers exclude advection from low latitude landmasses or from an older, local source, suggesting the presence of local plant community. We determined sea surface temperatures using the long chain diol index which indicate temperatures of up to  $5.6 \pm 2^\circ\text{C}$  during the early Pliocene.

We suggest that conditions were significantly different during the Pliocene warm period and possibly warm enough to support higher order plants. Such a setting would require a significant reduction in Antarctic ice volume in line with recently published results from IODP Expedition 318, the ANDRILL MIS core and computer simulations which suggest East Antarctic ice volume was probably much lower than previously thought.

# ***Reconstructing winds in the Amundsen-Bellingshausen Sea over the past 300 years***

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Extensive thinning of fast flowing glaciers, has made the Amundsen Sea coast region one of the largest Antarctic contributors to sea-level rise. The dominant patterns of both basal and surface melting and the collapse of Antarctic ice shelves in the Amundsen and Bellingshausen Seas could be explained by wind forcing. However, long records of past wind strength and atmospheric circulation are needed to assess the significance of these recent changes and their impact on Antarctic mass balance. Here we present a novel proxy for past wind strength in the Amundsen-Bellingshausen Sea, based on diatoms entrained in ice cores. The diatom abundance, species assemblages and total particulate content vary from year to year and are believed to be related to the local/regional wind strength and circulation patterns that influence the onshore northerly winds. We present data from ice cores drilled in the southern Antarctic Peninsula and Ellsworth Land to investigate past wind strength and circulation over the past 300 years and its relationship with snow accumulation and surface temperature on the Amundsen Sea coast.



## ***Testing the “swinging-gate” hypothesis of deglaciation in the Ross Sea using multibeam bathymetry***

**Jae Il Lee**<sup>1</sup>, Rob McKay<sup>2</sup>, Nick Golledge<sup>2</sup>, Ho Il Yoon<sup>1</sup>, Kyu Cheul Yoo<sup>1</sup>, Hyung Joon Kim<sup>1</sup>, Jong Kuk Hong<sup>1</sup>  
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A “swinging-gate” type of deglaciation has been suggested by Conway et al. (1999) by which the grounding line in the Ross Sea receded in a uniform north-to-south pattern during the Holocene in the Western Ross Sea. An implication of this hypothesis is that geological evidence from the western Ross Sea have been used to interpret retreat histories of the West Antarctic Ice Sheet across the wider Ross Sea embayment. Sediment provenance studies, however, indicate an East Antarctic source for the western Ross Sea sediment during the LGM, and emphasize an active role of the East Antarctic Ice Sheet (EAIS) feeding the marine based ice sheets in the Ross Sea at LGM. Multibeam swath bathymetry is very useful in reconstructing paleo-ice flow and retreat history, and some subglacial geomorphic features in the southwestern Ross Sea do indicate eastward flow. However, large parts of the southwestern Ross Sea have not been mapped, and the limited amount of multibeam data made it difficult to understand the retreat pattern in a broader perspective.

Here we present a new multibeam swath bathymetry data from the southwestern Ross Sea obtained during the R/V Araon cruise in January 2015. We identify well-preserved glacial features that suggest thick (>700m) ice derived from the EAIS existed over 100 km from coast in the southwestern Ross Sea. Subglacial geomorphic features indicate that ice coming out of present outlet glacier valleys (Mawson Glacier and Granite Harbor) flowed southeastward, turned counterclockwise around Crary Bank, and proceeded northeastward to the JOIDES Trough. Southeastward flow direction identified between Mawson Glacier and north of Beaufort Island implies an absence of major northward ice flow from south, and effectively rules out the “swinging-gate” pattern of deglaciation in the Ross Sea. This multibeam-based interpretation is consistent with model-based interpretations of an earlier retreat of the WAIS in the central Ross Sea. The extended presence of the large EAIS-derived piedmont lobes in the western Ross Sea anticipates that retreat age along the Victoria Coast would generally get younger toward west, but not a continuous southward decrease in deglacial ages.

# ***Deep-keeled iceberg ploughmarks in Pine Island Bay, West Antarctica, and their implications for past ice dynamics***

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High-resolution multi-beam swath bathymetry of the mid-shelf region of Pine Island Trough and the adjacent banks reveal an abundance of linear-curvilinear depressions. These features, interpreted as relict iceberg ploughmarks, indicate the importance and ubiquity of iceberg ploughing within the late Quaternary marine-geomorphic record of Pine Island Trough since ice retreat from the outer- and mid-Pine Island Bay shelf before ~12.3 k cal. a B.P. Through detailed quantification of the cross-sectional and planform dimensions and morphologies of these iceberg ploughmarks, the iceberg source region is identified. The glacial dynamics at the time of iceberg formation are also inferred, based on the first-order control exerted by the shape and dimensions of an iceberg keel on the shape and morphology of an iceberg ploughmark, and, the observed linear relationship between each. Observed over a contemporary water depth range of 506 m to 848 m, analysis of ploughmark width, incision depth and cross-sectional shape indicates an absence of bathymetric and water-depth control, suggesting little variance in glacial ice dynamic behaviour during the period of ploughmark formation. This has maintained the iceberg population morphology during deglaciation, despite changes in relative sea-level and glacial thicknesses. Relatively small ploughmark widths ( $x = 115$  m) and incision depths ( $x = 2.76$  m), a dominant v-shaped cross-sectional shape ( $x = 1.13$ ), and, a lack of parallelism between adjacent features, does not support the grounding and ploughing of large tabular icebergs which infrequently calve from Pine Island Glacier today. A population of smaller, more irregular, pinnacle-shaped icebergs is instead preferred, having likely formed from the fragmentation of larger icebergs, and, from the direct production of icebergs at the calving margin. This mode of calving, attributed to fast-flowing ice fronts and intense patterns of crevassing and rifting, thus compares favourably to that observed at ice streams including Pine Island and Thwaites Glaciers. Based on a high stand relative sea level, at most, 20 m above present ~12 k cal. a B.P., iceberg keel-depths on average 160 m above those of the modern Pine Island Glacier are indicated (656 m), presenting an average ice-margin thickness of ~734 m, inclusive of a variable density firn layer. The absence of topographic or bathymetric constraint on the layout of Pine Island Bay, and, comparisons of this ice thickness with that of modern ice margins, indicates that icebergs have calved from a fast-flowing ice-stream, similar to the modern Pine Island Glacier. Variable reversible orientations and ice-core proxy analysis, suggest an open ocean environment, free of sea-ice, ice mélange or an iceberg armada at the time of iceberg ploughmark formation.

## **S11. Antarctic permafrost, periglacial processes and soil development D7, Meeting Room 405, August 26, 2016, 2:30 PM - 4:30 PM**

### ***Ground surface temperature and active layer thickness along a latitudinal gradient in continental Antarctica***

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Recently in Continental Antarctica a strong active layer thickening was documented in the Terra Nova Bay area despite the absence of any air warming since 1996 showing an opposite trend respect the Antarctic Peninsula and other sectors of the continent. This active layer thickening was mainly attributed to the increase of incoming radiation. Moreover, ground surface temperature (GST) and thus active layer can experience a large variability due to snow cover distribution and vegetation buffering effect.

Since 2009 GST was monitored along a latitudinal gradient (73°31' - 75°51'S) in Northern Victoria Land, Continental Antarctica. GST was measured through thermistors (Hobo Microstation, resolution 0.01°C, accuracy 0.1°C) installed at depth of 2 cm. For each of the 8 plots covering different types of ground surface like mosses, lichens, bare ground two thermistors were installed. The plots were located at 3 different sites: Apostrophe Island (73°31'S; bare ground, lichenized mosses), Edmonson Point (74°19'S; bare ground, mesic mosses, hydric mosses), Prior Island (75°51', bare ground, mosses, lichens). At the same sites, at least one Photosynthetic Active Radiation (PAR) sensor for each site was also installed at the ground surface. More recently, (November 2014) we performed a new borehole 1 m deep instrumented with 4 thermistors at 4 different depths in all this plots (except for the lichens plot in Prior Island), in order to monitor the active layer thickness (ALT) defined as the depth of the 0°C isotherm. We analysed the trend of GST, comparing inter-site variability (latitudinal effect) and intra-site as well as inter-soil cover variability (soil coverage effect) considering also other thermal indices (e.g. TDD, FDD, Annual Maximum etc.). The intra-site comparison showed as in 2 of the three sites bare grounds sites are warmer followed by mosses and lichens. The northernmost site did not show any significant difference, maybe due to the effect of late melting snow in the bare ground plot.

Latitude apparently did not exert any effect on the GST whereas the different surface coverage influence the GST, but only during the summer season, with bare ground and lichens being respectively the warmest and the coldest ( $F=10.8$ ,  $p<0.01$ ). Moreover MAGST is highly correlated with the ALT of the same year ( $r=-0.73$ ,  $p<0.01$ ).

Soil cover is thus regulating the temperature evolution in these soils, overwhelming the latitude effect, and regulating as well the ALT thickness. Different vegetation type can exert different effect on GST, thus emphasizing the spatial variation of ground temperature, even at intra-site level.

# ***Spatial variability of Active Layer Thickness under different soil and vegetation conditions at Anchorage Island, Marguerite Bay, Maritime Antarctica***

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Maritime Antarctica has been recognized as a key region for monitoring climate change and its impacts on the abiotic and biotic components of ecosystems such as active layer thickness (ALT), soil, carbon cycle, vegetation coverage and compositions. The warming of ground surface temperature and the consequent thickening of active layer could lead to further positive feedback on climate forcing on these fragile ecosystems, underlining how interactions between climate forcing, vegetation and soil need to be better investigated.

This paper describes the spatial distribution of ALT under different soil and vegetation conditions at Anchorage Island (67°36'S; 68°11'W, Marguerite Bay). Anchorage is an island 2.5 km long and 500 m wide, partly covered by semi-permanent snow patches and ice fields; it includes several rocky ridges and reaches a maximum height of 57 m asl.

During the Antarctic summer season 2013/2014, a geomorphological and soil map was carried out at 1:2000 scale. In each different geomorphological unit and for each different main vegetation coverage several soil trenches down to 0.54 m were excavated to describe the soil profile, measure the thermal profile and collect soil samples in each horizon. A total of 155 soil trenches were described and sampled. For each sampling sites were recorded GPS position, altitude, slope, aspect, soil surface texture and total vegetation coverage. In each trench, the soil was described identifying the different horizons recording the soil texture, the soil structure and the color (with Munsell Chart). The thermal profile was measured recording the ground temperature at different depths (2, 10, 20, 30, 40, 50 and bottom) and for comparison the air temperature (160 cm). ALT was calculated as the maximum 0 °C depth by extrapolating the thermal gradient from the two deepest temperature available. The presence of ice and/or water seepage restricted the sampling depth to a maximum of 0.54 m. Water content, grain size through dry sieving, pH and Organic carbon content (through loss-on-ignition, LOI method) were determined for each sample. Soil classification followed the US Soil Taxonomy (2014).

Soils are generally shallow, classified as Gelisols, belonging to Histels (n=25), Turbels (20), Orthels (110) suborder, with maximum depth of 36, 48 and 54 cm respectively. Vegetation cover occurs in 87 on 155 surveys, with mean coverage of 36% and *Prasiola crispa* as most common growth form (especially close to the shore), followed by mosses, herbs and terricolous lichens. The soils have a pH ranging between 2.8 and 8.4 with an average of 4.7 while LOI between 0.6 and 84.2 with an average of 19.1%. Between soil types, pH values don't show any significant differences, whereas LOI values are higher in Histels (mean = 42.1%) than in Turbels (9.9%) and Orthels (15.6%). With reference to coverage, bare grounds have less acidic soil, whereas mosses and herbs soils have higher LOI values (33.5 and 31.3%, respectively).

Overall, the ALT ranged between 27 and 150 cm; within soil types, maximum depth is found in Histels soils (54 cm) whereas between soil coverage underneath algae dominated communities (150 cm).

## ***Spatial variability of soil CO<sub>2</sub>-C exchange in the main terrestrial ecosystems of Maritime Antarctica***

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Soils and vegetation have an important role in terrestrial carbon exchanges in Maritime Antarctica. The objective of the present study was to investigate (i) the soil development in relation to (ii) spatial variability of ecosystem respiration (ER), net ecosystem CO<sub>2</sub> exchange (NEE), gross primary production (GPP), soil temperature (ST) and soil moisture (SM) under four distinct vegetation patches and a bare soil in Keller Peninsula, King George Island, Maritime Antarctica. Five sites were selected in February 2015, as follow: site 1: moss-turf communities; site 2: moss-carpet communities; site 3: phanerogamic antarctic communities; site 4: moss-carpet communitie (predominantly colonized by *Sanionia uncinata*); site 5: bare soil. Soils were sampled at different layers and a regular grid (5x8 m) with 40-point. A minimum separation distance of 1m was installed at each site to quantify the spatial variability of carbon exchange, soil moisture and temperature. Vegetation characteristics showed close relationship with soil development in the studied sites. ER reached 2.26  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$  in site 3, where ST was higher (7.53°C). Greater carbon sink effect was observed in site 4 (net uptake of 1.54  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ ) associated with elevated SM (0.32  $\text{m}^3 \text{ m}^{-3}$ ). Spherical models were fitted to describe all experimental semivariograms. Overall, results indicate that ST and SM are directly related to the spatial variability of CO<sub>2</sub> exchange. Heterogeneous vegetation patches showed smaller range values. The poorly drained terrestrial ecosystems are the major CO<sub>2</sub> sink. In well drained sites, ER is more pronounced and associated with intense soil mineralization. The formation of new ice-free areas (well and poorly drained), have an important effect on CO<sub>2</sub> exchange. With increasing warming and melting under periglacial condition, the likely increase of poorly drained areas, increasing CO<sub>2</sub> sink strength in terrestrial ecosystems of Maritime Antarctica is expected.

## ***Evolution of permafrost and active layer temperatures in the South Shetlands since 2000***

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The Western Antarctic Peninsula has been one of the Earth's regions showing a faster warming rate since the 1950's, with an increase of over +2.5 °C in mean annual air temperatures since 1950. The South Shetland Islands, located some 100 km off its northwestern coast are near the climate limit of permafrost. Changing permafrost will influence the terrestrial ecosystems by modifications in the active layer thickness, ground freezing regime, hydrology, geomorphodynamics and possibly, by changes in biogeochemical fluxes. Boreholes installed in Deception Island, Livingston island and King George Island aim at identifying regional controls on permafrost and the active layer, but also local and site-specific influences. For the former, we maintain 4 to 25 m depth boreholes with continuous logging of temperatures, as well as associated meteorological stations. For the later, we a number of very shallow boreholes with 0.8 to 2 m depth was installed at diverse settings in the vicinity of the main boreholes. The network is integrated in the Global Network for Permafrost (IPAWMO/GCOS).

Permafrost temperatures across the South Shetlands are warm, between slightly below 0 and -2.0 °C and the ground thermal regime shows a strong dependence from varying snow conditions, as well as thermophysical properties and ice-content of the ground. Active layer thickness varies from 0.4 in the volcanic deposits of Deception Island, to several meters in high diffusivity bedrock. Active layer data since 2000 shows a large interannual variability in mean ground temperatures without any significant climatic trend. However, since 2008 active layer thickness has been decreasing and a general cooling has been observed at the South Shetlands sites, which are the only ones providing longer term data. The reasons for this ground cooling are related to a longer lasting snow cover during spring and summer, inhibiting ground heat gain.

# ***Seasonal and diurnal frost environments in western Dronning Maud Land: Preliminary observations***

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Permafrost and active-layer conditions have been monitored in the vicinity of the South African research station of SANAE IV, Antarctica at eight sites. Ground thermal environments have been measured at three sites, Flårjuven Bluff 1, Vesleskarvet (SANAE Base), and Troll Station 1, for eight, seven and nine years respectively [1]. During the Austral summer of 2012, seven new shallow boreholes were drilled at five new sites (Grunehogna Peaks, Robertsollen, Slettfjell, Schumacherfjellet, and Valterkulten), as well as two new shallow boreholes at two existing sites (Flårjuven Bluff 2 and Troll Station 2). At these sites sensors log thermal data at hourly intervals at various depths in the ground (near surface, 15 cm, 30 cm, 45 cm, 60 cm), as well as ambient air temperature. The exceptions to this are the Troll Station sites, which log to a depth of two meters (near surface, 50 cm, 100 cm, 150 cm, 200 cm). Sites span a variety of altitudes, from 1416 m.a.s.l. on Slettfjell, to 284 m.a.s.l. at Robertsollen. All sites are located on dioritic and doleritic dykes and sills [2], with the exception of Troll, which is characterised by granitic gneisses and orthogneisses [3]. Slettfjell is the southern- and westernmost site (72°08'S, 03°19'W), while Robertsollen, the closest to the ice shelf (coast), is the northernmost location monitored (71°25'S). Troll Station was located further to the east (02°32'E) than any of the other monitored sites.

This paper presents preliminary results on the thermal regime from the younger boreholes, focusing on the annual, seasonal and diurnal environments. Robertsollen had the deepest active layer (57.0 cm), with Slettfjell the shallowest at 11.5 cm. The 2013/14 Austral summer recorded the deepest active layer observed. Inter-annual variation of active layer depth is presented and shows that all monitored sites exhibit synchronous temperature changes. No thaw events were recorded at any of the sites in winter and active-layers were found present during summer. All sites also provided evidence of the ground thawing during the spring of 2013. Valterkulten and Flårjuven Bluff 2 were found to be the most dynamic of the sites in respect of thawing events. The data and analysis presented provide an ideal foundation for understanding the permafrost and active-layer environments for part of Dronning Maud Land.

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## ***Ecosystems services of the Antarctic soils***

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Over the last past 50 years, the ecosystems of Polar Regions have undergone increasingly rapid and extensive anthropogenic changes. Increased human impact through intensive intentional or unintentional modification of terrestrial, freshwater, or marine environments, and predicted climatic changes are likely to result in a substantial and largely irreversible loss of Antarctic environments. Terrestrial ecosystems are complex formations that comprise biota, soils, water, gas, and other environmental components interacting together as a coherent whole. Investigations of soil functioning in polar environments are crucial for the development of strategies for sustainable environmental management in the locations of national polar stations in Antarctic. Nowadays, anthropogenic influences have changed interrelation of all environmental components related to ecosystem development and evolution. Recently, the effectiveness of ecosystem functioning has been assessed in terms of ecological functions, but at the current stage of the biosphere and antroposphere evolution, the terminology of ecosystems services is more appropriate for describing and analyzing the mutual interrelations between ecosystems and human beings. Ecosystems services are the benefits that people obtain from an ecosystem based on its functioning. Ecological functions of permafrost-affected Antarctic soils and their ecosystem services in the rapidly changing polar environments are poorly studied. The following ecosystem services of Antarctic soils are considered as most important for maintaining the sustainable development of polar regions: (1) sequestration and storage of carbon and other bio-active elements in the extensive permafrost-affected areas, (2) stabilization of organic matter and regulation of green house gases cycles; (3) pollutant immobilization and degradation potentials of soils, which act as a filter and buffer that prevents further penetration of organic and inorganic pollutants into other environmental components of arctic landscapes; (4) regulation of water movement and water quality in the landscape and catchment basins; (5) regulation of microbial biodiversity in the pedosphere of Antarctic ecosystems, and (6) regulation of the storage of genetic information as soil metagenome. Soil ecosystems services on examples of Antarctic antropogenically affected and pristine landscapes will be discussed in presentation in details. Indexes and parameters of soil ecosystems services evaluation will be discussed as well. Aspects of the soil protection management will be considered in terms Antarctic Treaty for the selected plots of the Antarctic.



## ***Antarctic soils: Biogeochemical drivers of soil ecosystems***

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The investigation of Antarctic soils dates back to 1916, with samples collected in the McMurdo area during the British Antarctic Expedition of 1907-1909. The International Geophysical Year in 1958 led to an upsurge in scientific exploration. Most Antarctic studies to date have focused on the underlying geology, with fewer on the major nutrient sources and cycles, and in particular on the relationship between microbes and the soils. The variability in physical environmental factors, together with the generally suboptimal and often extremely low levels of nutrients required for biological activity, severely restrict microbial communities in polar environments. In Antarctic habitats, microbes play important roles as mediators of biogeochemical cycles, especially through their involvement in the carbon, nitrogen and phosphorus cycles. Recently, it has been recognised that climate and environmental changes are likely to affect the ecological strategies of soil bacteria. Synthesising existing research on soil ecosystems, it is clear that the linkages between microbes and biogeochemical processes are fundamentally important yet remain poorly understood, and are the most urgent areas for research attention.

## ***The influence of the natural environment on habitat preference for lichens in Western Dronning Maud Land, Antarctica.***

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The biogeography of lichens in part of Western Dronning Maud Antarctica was used to elucidate Biology-Geomorphological interactions. Two continental nunataks, Vesleskarvet and Robertskollen, were selected to characterise climatic, topographical and geomorphological variables and their impact on lichen colonisation at a fine resolution. Small-scale (sub-metre) topographical features were identified and classified together with the specific lichen species that colonised them. The methodology employed included the use of structure from motion techniques to create three-dimensional models for the display of the habitat preference on specific clasts. Small-scale topographical features provide sheltered locations that serve as microhabitats that support lichen colonisation. Moist and sheltered microhabitats are the most suitable for colonisation, with habitat preferences being noted to be specific to a particular lichen species. The predominant species, *Usnea sphacelata* and *Umbilicaria decussata*, colonised sheltered depressions in the topography, specifically beneath overhangs. Finer topographical features such as cracks, pitting and tafoni were found to be colonised by other lichen species. This study shows preferential colonisation strategies of lichens in Antarctica and, thus, these habitats are a suitable proxy for monitoring environmental changes.

## **S25. Molecular ecology and evolution D7, Meeting Room 408, August 26, 2016, 2:30 PM - 4:30 PM**

### ***Differential gene expression by red- and white-blooded Antarctic notothenioids: implications of the loss of erythropoiesis by icefishes***

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Antarctic notothenioid fishes comprise a unique evolutionary radiation that occurred as the cooling Southern Ocean (SO) caused most other fish taxa to become locally extinct. Cold-adapted and extremely stenothermal today, these fishes are now threatened by rapid warming of the SO over periods measured in a few centuries. Key to understanding both the adaptation of notothenioids to the cold and their potential resilience to future warming are studies that examine the evolvability of notothenioid genomes and the extent of phenotypic plasticity in various taxa at multiple levels of biological organization.

To contribute to this effort, we have sequenced and analyzed the transcriptomes of multiple tissues from four Antarctic notothenioids – two red-blooded species, the spiny plunderfish *Harpagifer antarcticus* (Harpagiferidae) and the dragonfish *Parachaenichthys charcoti* (Bathypagrusidae), and two white-blooded icefish, *Neopagetopsis ionah* and *Pseudochaenichthys georgianus* (Channichthyidae). RNA for Illumina sequencing was purified from 58 tissue samples obtained from 1-4 specimens of each species. Multiple-tissue transcriptomes were assembled for each species with Trinity. 18,781 orthologous protein-coding genes were identified in notothenioid species using OMA stand-alone (v.0.99t) and reciprocal blast criteria supported 15,606 of these orthologous comparisons. 9,566 genes were identified that correspond to a pair of orthologs in zebrafish and stickleback.

To identify genes that are differentially expressed by white- and red-blooded notothenioids, we performed an in silico screen to compare transcript levels of genes in the tissue transcriptomes of the icefish, *P. georgianus*, and the closely related dragonfish, *P. charcoti*. Differential expression analysis was carried out with edgeR v3.10.2 to normalize and detect significant differences (Pvalue 1E-05) between read counts in each tissue with 2-3 biological replicates per sample. Significantly differentially expressed transcripts were identified in brain, head kidney (HK), liver, ovary, spleen, trunk kidney, pectoral muscle, white muscle, and ventricle.

The most obvious phenotype that differentiates the icefishes from the other seven families of notothenioids is their lack of red blood cells and hemoglobin. Using hierarchical clustering of TPM normalized expression values, we identified a tissue-specific gene network of weakly expressed genes in icefish (*P. georgianus*) HK (site of erythropoiesis in teleost fishes) that are linked to myeloerythroid differentiation and which may include novel regulators of erythropoiesis. Consistent with our prior results [Near et al. (2006) Mol. Biol. Evol. 23, 2008],  $\beta$ -globin mRNA was not detectable in the icefish transcriptome. Transcript levels of major erythroid differentiation genes [erythropoietin (epo), the epo receptor (epor), transferrin receptor, gata1, fog1, klf1,  $\beta$ -spectrin, band3, band4.1, alas2, fech, etc.) were significantly decreased in *P. georgianus* HK. In agreement with the results of Xu et al. [(2015) Mol. Ecol. 24, 4664], we observed increased levels of mRNAs for TGF- $\beta$  signaling components in icefish HK, a condition known to suppress human erythropoiesis. Thus, the icefishes are excellent models for human dyserythropoiesis.

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## ***Resolving phylogeography of endemic circumpolar Southern Ocean brittle star *Ophionotus victoriae****

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The Southern Ocean is characterized by a highly endemic benthic fauna. Brittle stars, or ophiuroids, in particular are an abundant and conspicuous member of the benthic assemblage, and often dominate at many localities. Among Southern Ocean ophiuroids, *Ophionotus victoriae* is a highly abundant endemic brittle star. It has a planktotrophic life stage and is thought to possess a circumpolar distribution. As a conspicuous member of the benthic fauna, *O. victoriae* is an ideal candidate to exam gene flow and identify possible barriers to dispersal. Previous population genetic work revealed genetic structure through the geographic range of the Antarctic Peninsula. Our sampling greatly expands on this work in geographic distance and numeric abundance of samples. This data set included 88 sampling localities with 419 specimens that span the Ross, Amundsen, Bellingshausen, Antarctic Peninsula, Weddell Seas and subantarctic islands, or a geographic distance of > 7,000 km. Whereas two mitochondrial markers, 16S & COI, were employed to allow comparison to earlier work, a whole genome Single Nucleotide Polymorphism (SNP) approach based on 2b-RAD tags allowed sampling of loci across the genome. For 2b-RAD analyses, a subset of 89 samples spanning 15 sampling localities from the Ross Sea through the Western Weddell Seas were examined. Although mtDNA data of 419 individuals suggest 3 major lineages, 2b-RAD data provided greater resolution and identified four distinct genetic lineages from 1,999 biallelic SNP loci from a reduced geographic range of the Ross Sea into the western Weddell Sea. *O. victoriae* genetic lineages were geographically distinct and included a Ross Sea/western Antarctic Peninsula lineage, an Amundsen/Bellingshausen Seas lineage and two Weddell Sea lineages. Both 2b-RAD and mtDNA samples recovered strong connections between the Ross Sea and Western Antarctic Peninsula, a distance of over 5,000 km, bypassing the Bellingshausen and Amundsen Seas. A subsequent benefit of our study was the ability to compare traditional mtDNA markers and a high resolution whole genome SNP based approach such as 2b-RAD. Although general phylogeographic structure of large scale SO regions was able to be ascertained through mtDNA, the genetic break between the two Weddell Sea populations would have gone unrecognized if we had not employed the 2b-RAD analyses. In ecosystems such as the Southern Ocean where barriers to dispersal can often be unclear, high resolution based approaches show promise to help clarify the boundaries and connections of a species range.

## ***Antarctic meiofaunal composition revealed by high-throughput molecular metabarcoding.***

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Marine meiofauna, animals that live between sediment grains, have not been well studied in the Antarctic. Traditional approaches to examining this size class of animals rely on considerable microscopy time and taxonomic expertise. As a result, processing of samples often focuses on select taxa (e.g., nematodes, copepods, etc.). The advent of high-throughput molecular sequencing has enabled metabarcoding approaches that permit holistic examination of communities in a much faster manner than previously possible. Metabarcoding methods, however, are limited by the quality and extent of properly identified taxa in available databases. During two research cruises in 2013, sediment cores were obtained, from across Western Antarctica (including the northwestern Weddell Sea, Antarctic Peninsula, Bellingshausen, Amundsen and Ross Seas) to study the composition and distribution of meiofauna across Antarctic shelf regions. Using an Illumina amplicon approach, we surveyed the 0-2cm fraction of these cores for meiofaunal organisms. Alpha and beta diversity metrics were calculated for the regions examined. With these data, we found high proportions of annelid and nematode taxa in the sediment. A number of hemichordate taxa were discovered that were not known prior to this work. As to be expected, small arthropods were present, but somewhat limited in numbers. Although available databases lack information on Antarctic species for which molecular data has been morphologically identified (i.e. ground truthing), the metabarcoding approach allowed identification at the family level which offered hitherto unprecedented resolution of Antarctic meiofaunal communities. Diversity measures revealed that the Antarctic Peninsula was somewhat unique compared to other regions. Additionally, we compare this work to recently published metabarcoding analyses of microbial communities. Given the remote nature of the Antarctic, the challenge to undertake fieldwork, and limited taxonomic knowledge, high throughput metabarcoding approaches such as the one used here have the possibility of rapidly advancing our understanding of meiofaunal communities. Such communities are especially important in energy coupling of pelagic and benthic environments. Rapid assessment of these communities may also allow insight as to how changes in ice cover and climate may influence benthic systems.

## ***The Antarctic Circumpolar Current isolates and connects: Circumpolarity in the sea star *Glabraster antarctica****

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The Antarctic Circumpolar Current (ACC) connects benthic populations by transporting larvae around the continent, but also isolates faunas north and south of the Antarctic Convergence. We test circumpolar panmixia, and dispersal across the Antarctic Convergence barrier in the benthic sea star *Glabraster antarctica*. We undertook comprehensive sampling in the Southern Ocean and south Atlantic Ocean, including the Falkland Islands, Scotia Arc, Antarctic Peninsula, Ross Sea and East Antarctica. We sequenced COI (n = 285) and corroborated mitochondrial patterns with data from the internal transcribed spacer region 2 (ITS2; n = 33). We calculated haplotype networks for each genetic marker and estimated population connectivity using  $\Phi_{ST}$  for COI data. Migration rates and population size estimates around the Antarctic and across the Antarctic Convergence were calculated in MIGRATE-N for  $\Phi_{ST}$ -pooled samples. Our study shows that *G. antarctica* is a single circum-Antarctic species with instances of gene flow between distant locations. Despite the homogenising potential of the ACC, population structure is high ( $\Phi_{ST} = 0.5236$ ), and some subpopulations have infrequent immigration. Genetic breaks in the Magellanic region do not match the Antarctic Convergence, in contrast with prior studies. Connectivity patterns in East Antarctic sites are not uniform, with some regional isolation and some surprising affinity to the distant Scotia Arc. Gene flow estimates suggest a pattern of strong, multidirectional connectivity among most subpopulations.

## ***Biodiversity, distribution and larval development in the ascidian-feeding Antarctic genus *Marseniopsis* (Mollusca, Gastropoda, Velutinidae)***

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*Marseniopsis* Bergh, 1886 is a genus of marine benthic gastropods (Velutinidae), including nine described species, eight of which endemic to the Southern Ocean. Species of this genus feed on ascidians and lay eggs in their tunics. This genus is characterized by a peculiar planktotrophic larva, the "limacosphaera", having a potentially long pelagic life, an unusual developmental strategy for Antarctic gastropods. In the framework of recent scientific expeditions held in the Ross Sea, at the tip of the Antarctic Peninsula and in Weddell sector, a special effort was done in documenting with digital pictures the colour pattern of the different species routinely encountered during sampling activities. Thanks to this live-collected new material, several different colour patterns, within and amongst presumed conspecific samples, were documented, suggesting the existence of an hitherto unnoticed cryptic diversity.

We produced a dataset of COI, 16S and 28S genes of 104 samples of *Marseniopsis* from 41 Antarctic sampling sites. Through genetic distances and Automatic Barcode Gap Discovery (ABGD) we identified 14 MOTUs, 9 of which exclusively from the Weddell Sea-Antarctic Peninsula. These MOTUs resulted also basal to MOTUs from the Ross Sea in the phylogenetic reconstruction. The isolation-by-distance analysis did not show any significant correlation between genetic and geographic distances among populations of each clade and the spatial-PCA analysis did not evidence a significant global structure in the genetic spatial distribution of them. Protoconchs dimension and sculpture divided the dataset in two main clades, consistently with spatial distribution. In Weddell Sea-Antarctic Peninsula endemic MOTUs, we observed bigger protoconch, without a longitudinal sculpture peculiar of the Ross Sea ones.

These results suggest the presence of a hidden biodiversity of Antarctic *Marseniopsis*. Mantel colour turned out not to be always a diagnostic character and probably due to the alimentary homochromy of *Marseniopsis* with ascidians. The absence of correlation between geographic distance and genetic diversity and the presence of some MOTUs in all sampling areas are congruent with the long pelagic life of the *Marseniopsis* larva. However, some MOTUs distribution restricted to Weddell Sea-Antarctic Peninsula with a smaller protoconch lets hypothesize the existence of a second type of larva, with a limited dispersion capacity.

## ***Population genetic structure of *Pleuragramma antarctica* across the Weddell Sea***

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*Pleuragramma antarctica* is a keystone notothenioid species in the Southern Ocean, dominating the mid-water fish biomass and providing an essential link between higher and lower trophic levels. *P. antarctica* is particularly susceptible to impacts related to climate change, as their larvae develop within the platelet ice layer underneath sea ice. This dependence on sea ice early in life may structure spatial distributions based on available habitats. Evidence of population structuring amongst notothenioids in the Southern Ocean has been mixed, given that strong circumpolar currents promote gene flow, resulting in relative panmixia in some species. However, recent evidence for genetic differentiation along the Antarctic peninsula has been shown in *P. antarctica*, despite its largely pelagic life history. In an effort to expand the scope of previous work on population connectivity in *P. antarctica*, the present study investigates population genetic structure across the entirety of the Weddell Sea, from the Antarctic peninsula in the west to Atka Bay in the east. Furthermore, the fish used in this study were collected over 25 years in an effort to understand both temporal and geographic differentiation. Established microsatellites markers were used to genotype individuals collected at 27 different locations across the Weddell Sea, Antarctic Peninsula, Ross Sea and Orkney Islands, during 12 different collection years spanning from 1989 to 2014. While changes were not seen over time, population structuring was evidenced by significant differences detected between multiple locations. These promising preliminary results will likely reveal further structuring when age cohorts are taken into account based on otolith growth rings, as was seen in previous work in the Antarctic peninsula where genetic differentiation was found between different length cohorts. Understanding the population genetic structure of *P. antarctica* over time and across regions can provide valuable insights into the distribution of this important species, on which the impact of environmental changes can be gauged.



## ***How to survive in Antarctica: Ecological activities of marine natural products from benthic macroorganisms***

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Antarctic benthic communities are regulated by abundant interactions of different types among organisms, such as predation, competition, etc. Predators are usually sea stars, with omnivorous habits, as well as other invertebrates. Against this strong predation pressure, many organisms have developed all sorts of defensive strategies, including chemical defenses. Natural products are thus quite common in Antarctic organisms with an important ecological and pharmacological potential. The chemical defenses of the Antarctic organisms studied during the ECOQUIM and ACTIQUIM projects, as well as their pharmacological potential, are reviewed here. For the ecological defenses, predation against the sea star *Odontaster validus* is analyzed and evaluated along depth gradients and considering the life-style of the organisms. For the pharmacological activity, the antitumoral, antiinflammatory and antibacterial activities tested are considered here. Even if the sampling efforts are not uniform along depth, most ecologically active organisms are found between 200 and 500 m depth. Also, from the samples studied, sessile organisms possess about four times more chemical defenses against the sea star than the vagile ones. Pharmacological activity has not been tested uniformly in all groups, but the results show that relevant activity is found in different phyla, especially in Porifera, Cnidaria, Bryozoa and Tunicata. No relationship between depth and pharmacological activity can be established with the samples tested. Indeed, more studies are needed in order to better understand the ecological relationships among Antarctic invertebrates mediated by natural products and to fully explore their pharmacological potential.

## ***The Relationship between Ecological Specialization and Response to Pleistocene Climate Change***

Anton P. Van de Putte<sup>1,2</sup>, **Anton P. Van de Putte**<sup>3,4</sup>, Craig Marshall<sup>5</sup>, Karel Janko<sup>1,2,6,7</sup>

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Major climatic changes in the Pleistocene had significant effects on marine organisms and the environments in which they lived. The presence of divergent patterns of demographic history even among phylogenetically closely-related species sharing climatic changes raises questions as to the respective influence of species-specific traits on population structure. In this work we tested whether the lifestyle of Antarctic notothenioid benthic and pelagic fish species from the Southern Ocean influenced the concerted population response to Pleistocene climatic fluctuations. This was done by a comparative analysis of sequence variation at the *cyt b* and *S7* loci in nine newly sequenced and four re-analysed species. We found that all species underwent more or less intensive changes in population size but we also found consistent differences between demographic histories of pelagic and benthic species. Contemporary pelagic populations are significantly more genetically diverse and bear traces of older demographic expansions than less diverse benthic species that show evidence of more recent population expansions. Our findings suggest that the lifestyles of different species have strong influences on their responses to the same environmental events. Our data, in conjunction with previous studies showing a constant diversification tempo of these species during the Pleistocene, support the hypothesis that Pleistocene glaciations had a smaller effect on pelagic species than on benthic species whose survival may have relied upon ephemeral refugia in shallow shelf waters. These findings suggest that the interaction between lifestyle and environmental changes should be considered in genetic analyses.

## **S28. Diversity and distribution of life in Antarctica D7, Meeting Room 406/407, August 26, 2016, 2:30 PM - 4:30 PM**

### ***A Gondwanan origin of lacustrine eukaryotic microbiomes in the high latitudes of the southern hemisphere?***

**Elie Verleyen**<sup>1</sup>, Wim Vyverman<sup>1</sup>, Bart Van de Vijver<sup>2</sup>, M. Maxime Sweetlove<sup>1</sup>, M. Eveline Pinseel<sup>1</sup>, M. Bjorn Tytgat<sup>1</sup>, Koen Sabbe<sup>1</sup>, CCAMBIO consortium<sup>1</sup>  
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Understanding the processes shaping spatio-temporal dynamics in microbiome composition of Antarctic terrestrial habitats is of key importance to predict future changes in their ecosystem structure and function, as well as to assist conservation planning. Our large-scale inventories of high-latitude lacustrine eukaryotes based on high-throughput sequencing of environmental DNA, standard microscopy and culture-based approaches, revealed strong biogeographical and macroecological patterns in the Southern Hemisphere for microbial eukaryotic phyla and the food webs they are part of. The patterns are remarkably congruent between microscopic eukaryotes and multicellular organisms, and suggest a shared evolutionary history on the southern hemisphere landmasses. For well-studied taxa such as diatoms, evidence indicates that lakes in the Antarctic Realm share few species with those from environmentally similar lake districts in the (sub)-Arctic. This suggests a high level of endemism as well as other key features of canonical island biota, including a marked taxonomic imbalance and adaptive radiation. Comparison with Miocene freshwater diatom deposits shows the loss of a more temperate flora with a distinct Gondwana signature in the Antarctic, resulting from strong climatic sorting since the onset of the Miocene cooling event. Furthermore, both fossil evidence and phylogeographic studies in focal taxa indicate a strong species turnover since the Mid-Miocene, due to in situ adaptation and speciation of native taxa as well as from multiple colonization events. These observations form compelling evidence for the combined role of historical and contemporary processes in shaping eukaryotic microbiomes in aquatic Antarctic habitats. Our results also call for increased attention to prevent human introductions of microorganisms and the subsequent homogenization of the microbiomes in these relatively pristine ecosystems.

## ***An investigation of the effects of decadal scale environmental change on the diversity of terrestrial algae and other microflora on Signy Island, South Orkney Islands***

**Faradina Merican**<sup>1</sup>, Peter Convey<sup>2</sup>, Paul Broady<sup>3</sup>, Japareng Lalung<sup>1</sup>, Wan Maznah Wan Omar<sup>1</sup>, Latiffah Zakaria<sup>1</sup>

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Antarctic terrestrial ecosystems are sensitive to small fluctuations in various change drivers, and may have limited resilience when the ecological balance is disturbed. To elucidate the effects of environmental and ecological changes to the terrestrial microflora of these ecosystems, this study was conducted on the climatically and ecologically sensitive Signy Island, South Orkney Islands. This small isolated maritime Antarctic island (lat. 60° 43'S), a paradigmatic example of Antarctic terrestrial ecosystems, has experienced some of the largest and most significant changes in climate in the Antarctic over recent decades, leading to relatively rapid ecological change. We have re-examined in detail the diversity of the terrestrial microalgae at locations on Signy Island whose baseline algal biodiversity was previously studied and documented in the late 1970s. Comparisons are made with the diversity previously recorded from 122 sites, including the two Signy Island Reference Sites. A polyphasic approach combining phenotypic descriptions of field collected specimens and cultures via light microscopy, ecological distribution data and molecular 16S rDNA are being used to fully characterise and reliably identify morphospecies present. These data provide valuable insights into the impacts on the terrestrial microflora of the various change drivers experienced on Signy Island.

## ***Hypnum revolutum (Mitt.) Lindb. a case study of bipolarity***

**Paulo Camara**<sup>1</sup>, Micheline Carvalho-Silva<sup>1</sup>, Michael Stech<sup>2</sup>, Diego Knopp Henriques<sup>1</sup>

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Bryophytes (mosses, liverworts, and hornworts) are the second largest group of land plants and are widely distributed in all terrestrial ecosystems, from the polar regions to the tropics. Several moss species can be considered extremophiles because of their tolerance to extremely cold and dry environments such as the Polar Regions. The Antarctic bryoflora is composed almost only of mosses (about 111 species). About 45% of the Antarctic mosses species are actually bipolar, i.e., occurring in both the Arctic and Antarctic. Of these, 18 moss species are strictly bipolar, whereas 32 species also occur at intermediate locations on (high) tropical mountains. We are currently undergoing a major investigation on bipolar moss species from a phylogenetic perspective based on comparative analyses of DNA sequence data. Preliminary phylogenetic analyses (Bayesian Inference, Maximum Likelihood and Maximum Parsimony) based on nuclear ITS and chloroplast trnL-F sequences on one of our target species *Hypnum revolutum* (bipolar strict) has posed a taxonomic problem as none of the names available for this species can be used (*Stereodon revolutus*, *Drepanium revolutum*, *Rhaphidostichum revolutum*). Contrary to current belief this species does not belong into family Hypnaceae but in Pylaisiaceae (a family previously unreported to Antarctica), a new genus is proposed by us to accommodate this species. Now that the taxonomy is being resolved we are moving towards the understanding of its origin and the relationships among populations. Preliminary data suggests that populations in the South Shetlands hold more genetic affinity with populations of Norway than with much closer ones in James Ross Island.

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## ***The importance of facilitative interactions on the growth and survival of *Colobanthus quitensis* in an Antarctic tundra.***

**Lohengrin Cavieres**<sup>1</sup>, Mercedes Vivas<sup>1</sup>, Maritza Mihoc<sup>1</sup>, Ana Karen Sanhueza<sup>1</sup>, Leon Bravo<sup>2</sup>  
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According to the Stress Gradient Hypothesis (SGH), Antarctic habitats are expected to be prone to facilitative interactions among plant species. Although the presence of facilitative interactions among Antarctic plants has been reported to occur between *Deschampsia antarctica* and mosses, little is known about the other Antarctic vascular plant species: *Colobanthus quitensis*. In this study we estimated the sign of the spatial association of *C. quitensis* with *D. antarctica*, and through a removal experiment in the field assessed the importance of neighbors for the survival, growth and photosynthetic performance of *C. quitensis* individuals. In addition, laboratory experiments where we grew both vascular species either alone or in association were carried out at two different temperatures. The vegetation sampling and the removal experiments were carried out in the vicinity of the H. Arctowsky Polish Antarctic Station in a typical Antarctic tundra dominated by lichens and mosses. The analyses of vegetation distribution indicated that it was more frequent to find *C. quitensis* individuals growing associated with *D. antarctica* than alone, and that those individuals growing associated with *D. antarctica* were bigger than those growing alone. The growth, survival and photosynthetic performance of *C. quitensis* with neighbors were higher than in individuals where the neighbors were removed. Finally, lab experiments also indicated that *C. quitensis* individuals growing side by side with *D. antarctica* individuals had higher biomass than those growing alone. All in all, our results clearly indicate that as expected according to the SGH positive interactions are present and are important for the growth and survival of *C. quitensis* in the Antarctic tundra.

## **S34. Footprints in Antarctica, and Antarctica's footprint: perspectives from history, Meeting Room 403, August 26, 2016, 2:30 PM - 4:30 PM**

### ***Antarctic cultural heritage: Geopolitics and management***

**Ricardo Roura**<sup>1</sup>

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The material remains of past Antarctic activities reflect nearly two hundred years of exploration, exploitation and settlement of the region. These remains are echoes of the cultures and behavioural practices prevalent at the time in which some events took place. Examples include sealers' shelters, explorers' huts, vestiges of industrial whaling, expedition remains such as sledges, campsites, and cairns, as well as abandoned or unused stations, waste dumps, and evidence of fuel spills. Commemorative monuments of various kinds add to this list.

Contemporary management practices reflect the value assigned to those remains in more recent times. Following proposals by some Parties, some of these remains have been designated by the the Antarctic Treaty Consultative Meeting as Historic Sites and Monuments, which are legally protected cultural heritage because of their recognized historic value.

Plainly the Antarctic is a site with geopolitical significance, with seven claimant states and a number of non-claimants. In recent decades new state actors have become active in the Antarctic, adding to the original countries active in Antarctica including the twelve original signatories of the 1959 Antarctic Treaty. Each state active in Antarctica strives to promote national interests in the context of an international regime focused on scientific research, the maintenance of international peace, and environmental protection, and where territorial claims are "frozen" under Art. IV of the Antarctic Treaty.

This presentation reviews Antarctic history as illustrated in the list of Historic Sites and Monuments and examines the geopolitical uses of the Antarctic material cultural heritage.

## ***Missing footprints in German Antarctic research***

**Cornelia Lüdecke<sup>1</sup>**

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How important are footprints for polar history? Some remains of the heroic age like houses and their interior, as well as various items deposited in its surroundings are well protected historic sites today. Referring to Scott's hut or Shackleton's hut, they demonstrate a long tradition in Antarctic exploration. In contrast, Germany left only a single unimportant footprint although three expeditions went south until World War II.

During the first German South Polar Expedition (1901-1903) Erich von Drygalski's ship "Gauss" was trapped by ice at 90°E close to the Polar Circle 80 km off the inland ice. Just by chance they discovered the extinct volcano called "Gaussberg" of about 330 m height in their waste neighbourhood of snow and ice. Here they started some land based investigations. The only footprint left on Antarctica was a cairn at the foot hill of Gaussberg with information about their expedition.

The following German expeditions - Wilhelm Filchner on "Deutschland" (1911-1912) and Alfred Ritscher on "Schwabenland" (1938/39) - performed extensive research and without leaving nothing behind which would be according the demand of today. "Deutschland" was trapped by sea ice and drifted through the Weddell Sea until it came free after a year, while all remains of the expedition disappeared in the deep sea, when the surrounding ice melted. Ritscher's expedition was designed as summer campaign with two Dornier Wal aircraft starting from a catapult ship, but without any buildings on land. A map of Neuschwabenland was produced from photogrammetric pictures taken from the air. However, it was not correct, because ground control points were missing, because they did not put a foot on the continent.

After World War II, the legacy of the first German Antarctic exploration was given to the next generation. Karl Maria Herrligkoffer, a German physician and well-known as leader of the successful expedition to Nanga Parbat, wanted to re-establish German presence in Antarctica during the International Geophysical Year (1957-1958). Among other investigations he planned to produce the missing ground control points for Ritscher's map. Being an outsider of the community geographers did not support Herrligkoffer's extensive plan and due to their resistance he could not finance his ideas. However it is interesting to note that he planned to establish his main station at Atka Bay (east entrance of Weddell Sea), where just by chance the Georg-von-Neumayer-Station of the Federal Republic of Germany was established in 1980/81.

Researchers from the German Democratic Republic already started to work on Russian stations in Antarctica since 1960. After 30 Years of existence the Georg Forster Station of the close to the Russian station Nowolazarewskaya was taken away completely, leaving only a metal place commemorating its former existence from 1976-1996.

The paper will demonstrate how Antarctic research was treated in Germany at different times referring to existing and/or not existing footprints



## ***Hoofprints in Antarctica: The significance of Byrd's polar dairy***

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The historical transport of live animals to and from the Antarctic has attracted increasing attention from researchers recently [1]. While relocations of this kind had many motivations – commercial, logistical, scientific, nutritional, promotional and personal – they also had symbolic significance. In this paper, we examine the multiple meanings attached to three cows taken south by a US expedition in the 1930s, focussing particularly on their ability to evoke a sense of national settlement on the ice.

In 1933 Admiral Richard E. Byrd's second expedition set sail for Antarctica, ready to make "dairy history" [2]. Byrd took with him three Golden Guernseys, "the first cows ever to venture into the frozen wastes of the South Pole Region"[3]; a surge milking machine; ten tons of Larro Dairy Feed; and the curiosity of the American public. The cows, known as "Klondike Gay Nira", "Deerfoot Guernsey Maid," and "Foremost Southern Girl," were "expected to take care of the milk problem for the expedition" and "build up the men for the hardships of the Antarctic" [4]. However, the cows' function in the expedition went well beyond this proclaimed nutritional role.

This was not first time domestic animals had been taken south; dogs, ponies, donkeys, goats, pigs, cats, rabbits, mice and rats had visited Antarctica before. Unlike these antecedents, however, the Guernseys were the subject of an intense media campaign. With the cows came the opportunity to claim another 'first,' and Byrd's experience flying in both polar regions had taught him that firsts meant media coverage. The birth of a calf en route – celebrated back in the US with commemorative pins dedicated to the beast born "the farthest south of any dairy animal" – also ensured ongoing media attention for the expedition, raising the leader's profile. In the process, the cows themselves briefly became national celebrities, to the delight of the farms who had loaned them to the expedition and the companies that had sponsored their feed and milking equipment.

The case of Byrd's cows highlights the degree to which Antarctic expeditions of the time were dependent on media publicity. Yet the Guernseys' symbolic value exceeded their status as a quirky "first." The presence of livestock at the base reinforced Byrd's desire to stake a claim in Antarctica for his homeland, giving "Little America II" something of the feel of a ranch. More than just a whimsical hoofnote in Antarctic history, these cows were a means through which ideologies of colonialism and nationalism operated in the far south.

[1] See e.g. Peder Roberts, "Enriching Polar Environments through Animals: The Curious History of Bipolar Animal Transfers," Lewander Lecture, SCAR History, Humanities and Social Sciences Meeting, Fort Collins/Boulder, Colorado, 20-23 May 2015; Robert Headland, "History of Exotic Terrestrial Animals in the Antarctic Regions," *Polar Record* 48 (2012): 123-44.

[2] Admiral Byrd takes Larro to the South Pole. Larro Milling Company: Detroit, Michigan. 1934, p.2

[3] *Ibid.*

[4] *Ibid.*

## ***Changing patterns of human activity in the McMurdo dry valleys since the 1950s Lewander Lecture***

**Adrian Howkins**<sup>1</sup>

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Since the International Geophysical Year of 1957-58, the McMurdo Dry Valleys have been an important location for Antarctic science. Research conducted in the region has made important contributions to numerous fields including geology, geomorphology, and ecology. Long-term monitoring has created important data sets that provide valuable information about environmental change over time. However, scientific research has also left a human footprint in the region in the form of field camps, experimental sites, footpaths, and other impacts. Utilizing environmental history research conducted as part of the McMurdo Dry Valleys Long Term Ecological Research project, this paper will investigate the ways in which human activity has changed over time in this unique region of Antarctica. It will pay particular attention to the growing realization that scientific research could have a detrimental impact on fragile ecosystems and geological features, and think about how scientists contributed to the development of environmental management plans to protect the environment. Building on this case study, the paper will argue that historical research has much to contribute to our thinking about the human footprint in Antarctica, and calls for more collaborations between historians and scientists to think about environmental change over time.

## ***Dispatches from Continent Seven: The presence – or absence – of scientists' voices in Antarctic anthologies***

**Rebecca Priestley<sup>1</sup>**

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"Dispatches from Continent Seven" is an anthology of Antarctic science, compiled and edited by Rebecca Priestley, published in March 2016 by Awa Press in New Zealand. In contrast to many previous Antarctic anthologies this volume focuses on narrative accounts by Antarctic field scientists, including palaeontologists, glaciologists, sedimentologists, marine biologists, astrophysicists, and more, and includes passages by contemporary Antarctic scientists such as Robin Bell, Rob Dunbar and Nancy Bertler. Complementary narratives by explorers such as James Cook and Thaddeus von Bellingshausen cover early geographic exploration and poets such as Bill Manhire offer a different perspective on topics covered in scientists' narratives.

In this presentation, I talk about the process of selecting pieces for the anthology, which come from books, blogs, journals and reports from 1773 to 2015, the decision to include poetry, and the distinctive and changing themes that are apparent in scientists' narratives at different times in history. Throughout the book scientists do more than describe and reflect on their fieldwork and scientific discipline; they explore how Antarctica has changed their perspective – on everything from their scientific discipline to major issues facing humanity – and reflect on the impact human activity is having on Antarctica. In the last section of the chronologically arranged book, "Global Barometer", which includes narratives from 1985 to 2015, scientists comment on climate change, pollution, invasive species, ocean acidification, the future of Antarctica and what this means for the rest of the planet.

But where does this book fit in the plethora of Antarctic anthologies already published? In previous Antarctic anthologies, scientists' voices have been the exception rather than the norm: passages by explorers, journalists and fiction writers have taken precedent over scientists' narratives. In this presentation I challenge this norm and argue that scientists – who have been privileged with access to the continent for almost 60 years now – produce some of the the best and most diverse writing about Antarctica.

## ***Uncovering forgotten history: Shipwrecks, fatalities and female pioneers at sub-Antarctic Marion Island***

**John Cooper<sup>1</sup>**

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Since South Africa annexed Marion and Prince Edward Islands in 1948 South African researchers have been making regular expeditions “down south”. The Antarctic Legacy of South Africa (ALSA) project of Stellenbosch University aims to preserve the rich human history of these expeditions and South Africa’s presence in the Southern Ocean over the last 70 years.

Aside from the results of biological and physical research, these expeditions have produced a wealth of photographs, videos, and written and oral accounts. This historical record also includes maps, journals, logbooks, newspaper articles, and artworks. The Antarctic Legacy of South Africa collates, digitises and archives these records, along with out-of-print South African research articles and unpublished papers residing in governmental archives, departments and museums, and makes them accessible to the public. ALSA’s website ([www.antarcticlegacy.org](http://www.antarcticlegacy.org)) serves as a public portal to provide access to this information, which currently stands at over 5000 records.

With the passage of years, events and happenings, well known at the time, can become “lost to history” and delving into dusty files, fading photo albums and uncertain memories is required to resurrect past them for posterity. To illustrate this fading from consciousness three aspects of the human history of Marion Island have been chosen.

In 1908 a Norwegian sealing vessel, the *Solglimt* run aground on Marion, with its crew stranded on the island for several months. With the help of Norwegian colleagues searches in their country’s archives and museums have yielded a wealth of written material, hitherto completely unknown in South Africa. Translations allow the “inside story” of the *Solglimt*’s voyage to be told: of recalcitrant sailors, a threatened mutiny and an enquiry which let the Captain off lightly.

Since 1948 three members of the South African National Antarctic Programme (*sensu lato*) have lost their lives at Marion Island from small-boat capsizes. The drowning of Petty Officer John Bold in 1956 is recounted, with discovered film and still photographs of the event and aftermath. It has been confirmed that a blank cross on the island, for which no past or current SANAP member interviewed knew of its origin, was erected in his memory. His military record has poignantly revealed that he failed a navy swim test a few years before his death in rough and cold sub-Antarctic waters.

For many years, SANAP members overwintering on Marion Island were all male. The first woman ever known to have gone ashore was in 1959 – and only for an hour or so. It was not until 1979 that the first female researcher visited the island during a short relief and not until 1986 that woman were allowed to overwinter. Since then woman have occupied nearly all the team positions on the island: from Leader, Medical Orderly to Field Scientists studying seals and seabirds. Research has identified such “gender milestones” as the first woman to summit Marion via the ice plateau, the first to complete a “round-island” trip, and the first to do so (over 70 km of rough terrain) in less than a day.

## ***Our conception of Antarctica today through the lives of early explorers***

**Ursula Rack<sup>1</sup>**

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For a long period of exploration the human impact on the Antarctic was hardly visible. However, the Antarctic influence on human beings, especially in the early days of Antarctic exploration, can be clearly grasped from their diaries and in some cases even later from their biographies. Some early pioneers had never the opportunity to go back or intended to do so. However, some were so affected by their experience down on the ice that they never got a foothold back in a normal civic life and tried to go back as soon as a chance was in sight; Ernest Shackleton's life is a prime example for this. Some others were confronted with traumatic experiences and never wanted to go back but could also not give up on adventures for the rest of their lives as is the case of Wilhelm Filchner. After his difficult episode as leader of the Second German Antarctic Expedition in 1911-1912 in the Antarctic, he went on to explore Asia in several expeditions, as he did before his polar endeavours.

Many circumstances could shape the way how expedition members experienced this exceptional place. Weather phenomena, social interactions, character, dangerous events, or death of a fellow member could have an impact on a person and consequently on the group as a whole.

This paper will explore three examples of the Heroic Age expeditions, how weather phenomena, living conditions, hierarchal position and disposition could influence a person's life on the ice and also during the life story after experiencing the Antarctic. This had, however, also an impact on the imagination of the people back home about this unique place.

## ***The life and work of HT Ferrar***

**Susanna Ferrar**<sup>1</sup>

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The purpose of my presentation is to tell the story of my grandfather, Hartley Travers Ferrar, and how he survived more than two years in Antarctica on board "Discovery", 1901-4, then active service in the army in WW1, only to die at the age of 53, for want of a medical technique which appears to be routine these days. I would also like to show how the way in which his life was saved, in 1902, by a young seaman called William Heald, fed into Shackleton's rescue of the 22 men he had left on Elephant Island in 1916.

H T Ferrar was the youngest officer on "Discovery" on which both Scott and Shackleton made their first journeys to Antarctica in 1901. He stepped in at the last minute to take on the role of Geologist which had become vacant. Ferrar had only just finished at Cambridge and this was his first real job. He was something of an outsider, not being either a Naval Officer or an established scientist. His laboratory and cabin were amidships, off the galley, so he was quite isolated both from the Officers and from the "men", and he walked a delicate line. His diary records moments of frustration and humiliation when he was indignant at the way he was treated, yet he acquitted himself sufficiently well to have a glacier named after him, and to be invited on the later "Terra Nova" expedition, which he declined, quite possibly because his family life outweighed other considerations at that point. The "Terra Nova" sailed from Cardiff on the 15th of June 1910 and his first child Evelyn was born in Cambridge on September 19th 1910.

I have spent some time in the SPRI archives with H T Ferrar's original papers, with the result that I'm beginning to feel that I know him fairly well, at least, the young man he was when he was the first person up Observation Hill in 1902, and built the cairn.

After WW1 H T Ferrar tried teaching for a short while, then joined the New Zealand Soil Survey. He was very interested in water courses as well as the underlying rocks, and was able to improve both irrigation systems and the quality of the topsoil in parts of New Zealand. It was for this work he was awarded an honorary doctorate by the University of New Zealand (as it was then) in February 1932. Sadly he didn't have long to enjoy this distinction before he died in April of that same year.

A short while later permission was sought to name a mountain after him in New Zealand, and so one peak in the Cloudy Peak Range is known as "Ferrar Peak".

My conclusion is that this modest, hard-working man deserved better at his ship-mates' hands in Antarctica. He made valuable contributions both scientifically and practically but did not pursue honours for himself and was rather overlooked.

## **S40. Environmental contamination in Antarctica D7, Meeting Room 404, August 26, 2016, 2:30 PM - 4:30 PM**

### ***Origin and availability of mercury in Deception Island, Antarctica***

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Mercury (Hg) is identified as pollutant of great concern, however in contrast with the established long-term research programs in the Arctic, little is known about mercury biogeochemistry in Antarctica. Comparatively to other locations in Antarctica, environmental studies in Deception Island (South Shetlands Archipelago) are scarce and are of great interest since it has potential source of Hg, to the volcanic activity. Previous results from the Portuguese team showed the presence of relatively higher Hg and methylmercury (MeHg) in Port Foster waters. Our study in this volcanic island aimed to better understand the Hg cycle in Deception ecosystem particularly, fluxes, speciation and bioavailability of mercury.

Field campaigns took place in Deception Island in 2015 and 2016. Sediment and water samples were processed and analysed for total mercury, methylmercury (MeHg) and other interpretative physico-chemical parameters. In the laboratory trace element bioavailability tests were also performed. Some samples were also incubated using Hg stable isotope techniques. Stable Hg isotope ratios were also measured to confirm the origin of the volcanic mercury source. Finally, a three-dimensional hydrodynamic model was also implemented using Mohid water modelling system. Hg data was applied on the model to better understand the Hg circulation in the Bay.

Mercury levels in water and sediments sampled at two fumaroles were up to 10000 times higher than in the other sampling sites. Moreover, the concentrations obtained in Port Foster waters are considerably higher than the ones found in open waters of the Atlantic or the Southern Ocean. MeHg proportion (MeHg/HgT) was surprisingly high in saline waters of Port Foster (13 – 33 %), suggesting exceptional conditions for Hg methylation processes in the water column of Port Foster.

Additionally, the high residence time of water (ca. 1.7 yr) in the Bay may also contribute to create an inner pool of mercury and MeHg available for aquatic organisms. Moreover, the low capacity of sediments for Hg adsorption, (low carbon content and low superficial area (Si/Al>4)), may also contribute to keep mercury in solution and therefore increase its bioavailability. This bioavailability hypothesis was then supported by the bioavailability tests performed using Port Foster waters.

A first approach to the circulation of Hg and MeHg was done using Lagrangian tracers, allowing visualizing their movement in the aquatic environment and concluding that the tidal currents have almost no impact in the elements dispersion.

Results obtained in this work pointed to a continuous input of Hg to the Deception ecosystem due to volcanic emissions. This input and the special biogeochemical conditions in Port Foster Bay water promotes Hg methylation and the presence of more bioavailable Hg species that can, in fact, be uptake by aquatic organisms

## ***Occurrence of benthic marine microplastic at the Mackellar Inlet, King George Island, Antarctica***

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Anthropogenic pollution causes the accumulation of contaminants along marine ecosystems. Plastics and other synthetic materials are the most abundant and widespread contaminants, from the equator to the poles, and even in remote areas such as the Antarctica. Global plastic production is considerably increasing nowadays, a production of 299 million tons was estimated in 2013. Plastics and synthetic particles are highly persistent contaminants, which are difficult to biodegrade, but a gradual break-down to smaller pieces due to mechanical action is possible. These pieces or fragments caused by the partial degradation are known as micro, meso and macroparticles according to size: <5mm; <5–25mm>; >25mm respectively. Despite the Peruvian expeditions ANTAR XXI (2013) and XXIII (2015) in Mackellar Inlet, King George Island - Antarctica did not have the aim to study microplastics and synthetic particles, a total of 167 synthetic particles were found as part of the benthos samples (BS1 and BS2) and algae samples (AS) samples. Eleven (E1-E11) and six (E1, E2, E4, E5-AS, E7, E9 y E11) stations were sampled during the ANTAR XXI and XXIII respectively. From the 17 stations, only 4 were free of microplastics and synthetic particles. The benthic sample BS1 contained 9 synthetic particles in ANTAR XXI, while BS2 contained 124 synthetic particles in ANTAR XXIII. The AS were associated to 34 synthetic particles in the ANTAR XXIII. From the 167 examined synthetic particles (0-23 mm), 139 were identified as synthetic microparticles (< 5mm) and 72 as microplastics (< 5mm). Out of the total synthetic particles (by weight), up to 54.31% were identified as paint chips, 17.56% as rust particles, 17.11% as fragments, 8.30% as knotted filaments and 2.73 as filaments. Microplastics exhibited around 8 different colors: light blue, blue and "multicolor" were the most common. The total weight (mg) of synthetic particles was about 4 (BS1), 305 (BS2) and 146.1 (AS). The origin of these particles is still unknown as they might have drifted from ocean gyres or from human activities at nearby research stations. The importance of good waste management practices is highlighted as well as the consequences of human pollution to this pristine environment. ANTAR expeditions are founded by the Peruvian Ministry of Foreign Affairs.



## ***Occurrence of microalgae on Signy Island, maritime Antarctica: Pristine versus heavy metals-impacted sites***

**Dang Nguk-Ling**<sup>1</sup>, Chu Wan-Loy<sup>2</sup>, Kok Yih-Yih<sup>3</sup>, Chan Kok-Keong<sup>4</sup>, Yap Kok-Seng, Ivan<sup>5</sup>, Phang Siew-Moi<sup>6</sup>, Peter Convey<sup>7</sup>

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Antarctica is generally regarded as the last pristine continent on Earth. However, there are human and animal impacted sites in Antarctica that are contaminated with heavy metals. The aim of the present study was to investigate the occurrence of microalgae on Signy Island, South Orkney Islands, maritime Antarctica, with emphasis on sites that are pristine versus those with high levels of heavy metals, especially copper (Cu) and lead (Pb). During the recent expedition to Signy Island (18 January – 14 April 2015), a total of 175 soils samples were collected from pristine and impacted sites on the island, namely Berntsen Point, Gourlay Peninsula, Pumphouse Lake, Jane Col and North Point. Microalgae from the samples were identified based on the cultures that developed after inoculation into enriched medium (Bold's Basal Medium). A range of heavy metals (Cu, Pb, As, Al, Cd, Cr, Hg, Mn, Ni and Zn) of the soils were determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Results showed that high levels of Pb ( $81.6 \pm 20.3 \mu\text{g/g}$ ) were detected in soils from Berntsen Point, the site where the research station is located. In comparison, samples from Gourlay Peninsula (penguin rookery) contained high levels of Cu ( $188.7 \pm 41.5 \mu\text{g/g}$ ). Samples from the pristine site Jane Cole contained low levels of both metals (Pb =  $3.8 \pm 0.2 \mu\text{g/g}$ ; Cu =  $31.3 \pm 8.9 \mu\text{g/g}$ ). The dominant microalgae recorded from Berntsen Point include *Botrydiopsis callosa* (xanthophyte) and *Klebsormidium* sp. (chlorophyte) while the samples from Gourlay Peninsula contained mainly *Oscillatoria princeps* (cyanobacteria). In comparison, the soils from Jane Col contained mainly *Gloeobotrys* sp. (xanthophyte). The algal cultures established will be useful for our ongoing studies on toxicity of heavy metals in Antarctic microalgae.

# ***Quantification of marine pollution near Antarctic station in King George Island***

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In Antarctic stations during the summer season the human population increases significantly in a short time, this can cause stress in the wastewater treatment system and changes in coast seawater quality due to increased production of wastewater.

In this study in order to evaluate the effect of wastewater discharges in the vicinity of the Antarctic stations the spatial distribution of physical, chemical and microbiological parameters were determined. The measurement was done in seven permanent stations on King George Island, archipelago of the South Shetland Islands. Each of these Antarctic stations has different sewage treatment system. Five stations discharge their treated wastewater directly into the sea (Frei, Carlini, Great Wall, King Sejong and Escudero with Chilean Navy Station), one of the stations, Bellinhausen, discharges its treated wastewater to a small river flowing into sea and finally, the Artigas station stores its wastewater for transport out of the Antarctic continent.

The samples were collected during January of the years 2014 and 2015 in Carlini, Great Wall, King Sejon and Artigas Stations. The samples next to Bellinhausen, Frei and Escudero Stations were collected between the year 2009 and 2015.

All seawater samples were collected from sites evenly distributed around the sewage outfalls of the stations. Control samples were collected from pristine sites.

Physical and chemical parameters (temperature, dissolved oxygen, pH, total phosphorus, total nitrogen and chemical oxygen demand) showed values not clearly related to the distance from the discharge point. Oils and fats only showed significant differences between the two sampling campaigns, due to a fuel spill occurred in December 2009 on Fildes Bay.

The distribution of Fecal Coliforms in seawater exhibits a clear pattern associated with wastewater discharged. High densities of fecal coliforms (maximum 31000 CFU/100 ml) were found in seawater surrounding the sewage outfalls. However, the bacterial counts decreased rapidly with increasing distance from the outfall. In all samples collected further than 150 m from the outfall, the bacterial indicators were absent. Fecal coliforms were not detected at the pristine sites.

Multivariate analysis revealed relationships between the variables that originally could not be observed, allowing the reduction of the dimensionality of the system.

The human activities could change the water quality of the Antarctica environment in specific sites. This study has shown that contamination is limited to the immediate vicinity of the sewage outfall. Faecal coliforms turned out to be the best environmental quality control parameter of the effluent and its impact on the environment.

## ***Toxicity of metal contaminants to Antarctic marine algae and implications for the development of water quality guidelines.***

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Over one hundred years of anthropogenic activity in Antarctica has resulted in areas of contamination in near-shore marine ecosystems. Such contamination has been shown to adversely affect community structure and the diversity of algae in these environments. To better manage impacts and to facilitate the remediation of this unique environment, a robust framework of site-specific water quality guidelines are required for Antarctica. Current protocols for toxicological assessment generally investigate single contaminant exposures; however, contaminants rarely exist singularly in nature and the response of organisms to contaminant mixtures are not always predictable from single contaminant exposures. Thus, both the toxicity of individual metals and of metal mixtures needs to be better understood to inform the development of environmental guidelines for Antarctica.

This research has developed an environmentally relevant test protocol for Antarctic marine unicellular microalgae that best reflects the summer field conditions in Antarctic marine environments. Test conditions were a 24 d exposure using algae at low initial cell densities ( $1-3 \times 10^3$  cells/mL) in filtered seawater with minimal dissolved organic carbon ( $1.4 \pm 0.3$  mg/L) and supplemented nutrients (1.5 mg NO<sub>3</sub>-/L and 0.15 mg PO<sub>4</sub><sup>3-</sup>/L). Tests were maintained at a temperature of  $1 \pm 1^\circ\text{C}$  exposed to 150-200  $\mu\text{mol}/\text{m}^2/\text{s}$  of light on a 20:4 h light:dark cycle. Five metals commonly reported as contaminants in Antarctic marine systems (Cd, Cu, Ni, Pb, and Zn) were investigated. Single metal exposures used a gradient of increasing metal concentrations to derive modelled concentrations that inhibited population growth rates by 10% (IC<sub>10</sub> values). Metal mixtures tested included an equitoxic mixture of metals at their IC<sub>10</sub> concentrations, and mixtures based on the field-reported ratio of metal concentrations from a contaminated bay in Antarctica. In line with current best ecotoxicological practice, population growth rate and sub-cellular physiological parameters were measured by flow cytometry, and metal concentration exposures were measured by ICP-OES.

In single metal exposures, IC<sub>10</sub> values (95% confidence intervals) derived from dose-response curves were: Cu 19 (15-22)  $\mu\text{g}/\text{L}$ , Pb 84 (36-134)  $\mu\text{g}/\text{L}$ , Cd 480 (25-935)  $\mu\text{g}/\text{L}$ , Zn 824 (287-1362)  $\mu\text{g}/\text{L}$ , and Ni 1187 (1064-1310)  $\mu\text{g}/\text{L}$ . In metal mixture exposures the results showed antagonistic toxicity to the population growth rate, and synergistic toxicity to other physiological parameters. This research highlights the complexity in predicting effects of contaminant mixtures on Antarctic biota, and the need for more comprehensive assessments to develop site-specific water quality guidelines to better manage contaminated sites in Antarctica.

## ***Localized anthropogenic effects on the marine environment at palmer station, Antarctica***

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Palmer Station is a small US research base (15-40 people) north of the Antarctic circle (64.8°S). In 1989, the Argentine supply vessel Bahia Paraiso ran aground and eventually sunk, leaking an estimated half a million liters of diesel and other hydrocarbons. Subsequent impact monitoring from 1989 to 1992 determined that some marine sediments were contaminated, along with bioaccumulation in, and mortality of, intertidal limpets. However, an assessment of local anthropogenic effects on the marine environment had not been conducted since 1992. In 2014 and 2015, marine sediments were collected to quantify the extent and effects of any potential contamination on deep (18 to 24 m), soft-sediment benthic macrofauna from both the Bahia Paraiso, and from Palmer Station itself. Intertidal and subtidal limpet tissues were also sampled to determine any potential contamination effects in shallow areas (<10 m) where hard substrate dominates. The current status of human impacts, and comparisons with the 1989 to 1992 assessments will be presented.

## ***Oxidative damage and antioxidant defence parameters in the Antarctic bivalve *Laternula elliptica* as biomarkers for pollution impacts.***

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The Antarctic continent is increasingly vulnerable to anthropogenic pollution, however assessments of the impacts that chemical pollutants have on cold-adapted marine organisms are limited. Oxidative stress occurs when the rate of reactive oxygen species generation exceeds the scavenging capacity of an organism's antioxidant system and is an important unifying feature underlying the toxicity of many chemical contaminants in aquatic organisms. The Antarctic bivalve *Laternula elliptica* is a widely distributed, infaunal filter-feeding organism. We analysed antioxidant enzyme activities, levels of the molecular antioxidant glutathione, protein carbonylation and lipid peroxidation as oxidative stress biomarkers in *L. elliptica* from contaminant-impacted sites near McMurdo Station and the relatively pristine Cape Evans. The objective was to evaluate the effectiveness of these biomarkers for detecting contaminant stress in this cold-adapted marine invertebrate. The concentrations of total polycyclic aromatic hydrocarbons (PAHs) were quantified as a proxy for contamination and found to be elevated in gonad and muscle tissues from *L. elliptica* dwelling in contaminated sites. These individuals exhibited a greater degree of oxidative stress than those from the reference site, evidenced by increases in oxidative lipid and protein damage, as well as an upregulation of antioxidant defences. Coincidentally, *L. elliptica* from the contaminated sites were significantly smaller in shell length (1.3-fold) than those from the reference site. Oxidative biomarkers proved to be useful indicators of contamination exposure in the present study and were used to document ongoing biological impacts from historic and current pollution in McMurdo Sound.

## ***Long-term changes in macrobenthic communities in contaminated sediments and epifauna bioaccumulation adjacent to McMurdo Station, Antarctica***

**Terry Palmer**<sup>1</sup>, Paul Montagna<sup>1</sup>, Larry Hyde<sup>1</sup>, Stephen Sweet<sup>2</sup>, Andrew Klein<sup>2</sup>, Jose Sericano<sup>2</sup>, Terry Wade<sup>2</sup>, Sara Smith<sup>1</sup>, Mahlon Kennicutt<sup>2</sup>

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Marine sediment in the immediate vicinity of McMurdo Station contains some of the most contaminated sediment in Antarctica. Localized contaminated sediments contain high concentrations of PCBs, lead, DDT, petroleum hydrocarbons, organic carbon, and several trace metals. Cold temperatures and stable hydrology mean that the breakdown of these contaminants is slow. Our team have been monitoring the changes in contamination in the marine environment and effects of this contamination on the benthic communities over three depths (12, 24, 36 m) annually since 2000. Historic contamination has caused substantial changes to the macrofaunal community composition and these legacy effects remain, despite small recent changes in community composition. Our research has calculated a variety of biotic indicators to distinguish changes in natural and anthropogenic stresses and have used the best ones to determine if any changes in macrofauna communities are likely to be the result of the small changes in contamination. Some contaminants (e.g. PCBs, lead, polycyclic aromatic hydrocarbons) have been bioaccumulated in some larger epifaunal taxa found in contaminated areas, with PCBs being elevated above the US Food and Drug Administration advisory level for organisms consumed by humans. The occurrence of bioaccumulation in some epifauna gives suspicion of potential impacts further up the food chain, which is of particular concern given that some of these epifauna are mobile (e.g. the fish *Trematomus* sp.).

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## SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH: BIENNIAL MEETINGS & OPEN SCIENCE CONFERENCE 2016

ANTARCTICA IN THE GLOBAL EARTH SYSTEM:  
FROM THE POLES TO THE TROPICS

Abstract Book - *Poster*



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# Mini Symposium: Tropical Antarctic Teleconnections

## *Assessment of recent trends in southern hemisphere subtropical jet and future projections based on CMIP5 models*

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Jet streams are important because its position signifies the existence of baroclinicity and they play a major role in the formation and development of middle-latitudes cyclones, and storm tracks follows the jet axis. Therefore changes in jet stream location, intensity, or altitude can have important consequences for the Southern Hemispheric climate. The main aim of this study is to investigate the projected changes in the speed and meridional location of the subtropical jet (STJ) during winter using output of the Coupled Model Intercomparison Project Phase 5 (CMIP5) models.

We use ERA-Interim reanalysis dataset to evaluate the historical simulations of the STJ by 18 of the CMIP5 models for the period 1979-2012. Based on the climatology of the STJ from ERA-Interim, we selected the area of study as 70°E - 290°E and 40°S - 20°S, which is over the Indian and Southern Pacific Oceans, and 300 hPa to 100 hPa to reduce altitude related bias. In order to assess the changes and future projections of the jet streams in terms of strength, latitude and the shift in the location, we performed a three dimensional analysis on CMIP5 model output instead of normal static 200 hPa to eliminate altitude bias.

Analysis of historical trends of the STJ in ERA-Interim shows a poleward shift of 0.09°decade<sup>-1</sup> with a decrease in speed of 0.18 ms<sup>-1</sup> decade<sup>-1</sup> during winter since 1979. The historical simulations of the CMIP5 models show a wide range of trends in meridional movement and jet strength, with a multi-model mean of 0.03°decade<sup>-1</sup> equatorward and 0.5 ms<sup>-1</sup>decade<sup>-1</sup> respectively. Majority (94%) of the CMIP5 models selected for this study show a strengthening of the jet in the historical runs. During El Niño events there is strengthening of the STJ and weakening of the PFJ. It is evident from the standardised anomalies of average zonal wind that during El Niño and La Niña events, the STJ and PFJ show an oscillation in the strength over the Pacific Ocean. The STJ is stronger with a maximum wind standardised anomaly of 0.8 and shifts eastward in the Pacific Ocean during El Niño. It is weaker during La Niña with a negative standardised anomaly of 0.8. Results show that 47% of the CMIP5 models used in this study were able to simulate ENSO impacts realistically. Furthermore, it is more difficult for the models to reproduce the observed intensity of ENSO impacts than the pattern. It is also clear that there are differences in the responses of the models in simulating the impacts of El Niño and La Niña on STJ.

Representative Concentration Pathways (RCPs) 4.5 and 8.5 were used for analysis of changes of the STJ for the period 2011-2099. Based on the RCP 4.5 (RCP 8.5) scenario the multi-model mean trend of the 18 CMIP5 models project a statistically significant (5% level) increase in jet strength by 0.26 ms<sup>-1</sup>decade<sup>-1</sup> (0.55 ms<sup>-1</sup>decade<sup>-1</sup>). Also, the mean jet meridional location is projected to shift poleward by 0.005°decade<sup>-1</sup> (0.039° decade<sup>-1</sup>) by 2099 during winter.

## ***Composite analysis of ENSO impacts on Antarctica***

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Previous investigations of the relationship between the El Niño Southern Oscillation (ENSO) and Antarctic climate have focused on regions which are impacted by both El Niño and La Niña, which favors analysis over the Amundsen and Bellingshausen Seas (ABS). Here, 35 years (1979-2013) of European Centre for Medium-range Weather Forecasts Reanalysis-Interim (ERA-Interim) data are analyzed to investigate the relationship between ENSO and Antarctica for each season using a compositing method which includes 9 El Niño and 9 La Niña periods. Composites of 2 m temperature (T2 m), sea level pressure (SLP), 500 hPa height, sea surface temperatures (SST) and 300 hPa height were calculated separately for El Niño minus neutral and La Niña minus neutral conditions, to provide an analysis of features associated with each phase of ENSO. These anomaly patterns can differ in important ways from El Niño minus La Niña composites, which may be expected from the geographical shift in tropical deep convection and associated pattern of planetary wave propagation into the Southern Hemisphere. The primary new result is the robust signal, during La Niña, of cooling over East Antarctica. This cooling is found from December through August. The link between the Southern Annular Mode (SAM) and this cooling is explored. Both El Niño and La Niña experience the weakest signal during austral autumn. The peak signal for La Niña occurs during austral summer, while El Niño is found to peak during austral spring. This presentation is based on work of the same name published in the Journal of Climate special issue on polar to tropical connections.

## ***Environmental variations over the southern subtropical coast of Brazil associated with the precipitation anomalies related to the SAM and ENSO***

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This work analyze the influence of the Southern Annular Mode (SAM) and the El Niño - Southern Oscillation (ENSO) variability in precipitation (PP) of the Coastal Plain of Rio Grande do Sul (PCRGs), subtropical region of southern Brazil. Were analyzed the behavior of the precipitation anomalies for the entire PCRGs and its three sectors individually: south, central and north. Also will be analyzed hydro variations in coastal geoindicators, related to periods of anomalous precipitation associated with SAM and ENSO in 16 years of data (1998 – 2013). To analyze the correlation between anomalous precipitations (Tropical Rainfall Measurement Mission – TRMM), SAM index (<http://ljp.gcess.cn/dct/page/65609>) and Multivariate ENSO Index (MEI), contingency tables were employed and the t test was applied. The results show a significant positive correlation between anomalous precipitation in PCRGs and south coast with MEI and negative SAM ( $\alpha < 0,05$ ). The central coast has negative significance to the SAM ( $\alpha < 0,05$ ) and has no correlation with MEI, while the north coast is not related to any of the two indexes. Series of continuous data were visual interpreted in where 28 events consecutive months precipitation above (PP+) and down (PP-) of the medium associated with the positive and negative phases of the SAM and MEI were identified. Of these events, 22 (78%) were characterized by PP- associated with SAM+ and MEI-, while the remaining 6 events indicate PP+ with SAM- and MEI+. The events were related to coastal geoindicators, observed in Landsat Thematic Mapper images, in the three different sectors of PCRGs. In the south coast, in the Hermenegildo Beach's field dune, a set of washovers showed variations in their water flow, and an PP+ event and a PP-, as was observed in a giant washover ( $\approx 100 \text{ km}^2$ ), located in the Torres's dunes field on the north coast of PCRGs. In the central coast the geoindicator used was the Peixe Lagoon, situated in a national park, which showed the greatest hydro variation between PP + events and PP-, full and completely dry, respectively. The variability of the SAM and the ENSO statistically influences the precipitation throughout PCRGs, but it is not homogeneous in its three sectors. When observed events and selected geoindicators on the individually three sectors it is possible to identify long dry periods of up to one year that it can be generated by the combination of the SAM+ and MEI-. The tendency to SAM+ in recent decades, intensified by climate change, possibly will increase the frequency of droughts in PCRGs, also increasing the aeolian erosion overdue the dry sediments impacting the susceptible ecosystem balance as the Peixe Lagoon.



## ***Evolution of the eastward shift in the quasi-stationary minimum of Antarctic total column ozone***

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The distribution of ozone over Antarctic spring is determined by the polar stratospheric vortex disturbed by large-scale planetary waves. Inner regions of the polar vortex are ozone-poor that results in the phenomenon known as "ozone hole". Quasi-stationary pattern of the ozone hole is predominantly created by planetary wave with zonal number 1 which has a minimum in the Atlantic longitudinal sector and a maximum in the Australian one. In this paper, characteristics of the quasi-stationary structures in the Antarctic ozone spring distribution are analysed with use of the 1979–2013 satellite data. It was determined the cessation of the earlier described quasi-stationary ozone minimum's eastward movement took place in the early or mid-2000s. A similar tendency is noted in the dynamics of Fourier harmonics of zonal wave number 1. In contrast the position of the quasi-stationary wave maximum in ozone distribution did not shifted significantly. The changes in the movement direction of the quasi-stationary ozone minimum may be a part of processes connected with the modelled ozone recovery process over the Antarctica. Eastward drift in the quasi-stationary wave minimum's position was revealed in earlier papers by analysis of the Antarctic spring ozone distribution. This phenomenon is supposed to be connected with significant ozone depletion during several decades. Observations of a stabilization in ozone hole parameters require new estimations for the eastward minimum's drift. An attempt to the estimation is done in the presented report. Satellite total ozone data for the latitudinal range 50–80°S have been used. Long-term tendencies were considered by means of polynomial fitting of degree 1–6. All polynomials with degree higher than 1 exhibit a cessation of the eastward drift using September–November total ozone data. Time moment of the cessation is determined as the early or mid-2000s. The analogous pattern exists for extremes of the quasi-stationary Fourier harmonics with zonal number 1. Maximum of the quasi-stationary distribution has not exhibited any significant tendency.

# ***From the tropics to Antarctica: Intraseasonal variability of Antarctic atmosphere and cryosphere driven by tropical convection***

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The leading mode of tropical atmospheric variability on the intraseasonal time scale is the Madden-Julian Oscillation (MJO). The envelope of anomalous convection associated with an eastward-propagating MJO event has been shown to excite poleward-propagating Rossby waves that interact with and modulate the extratropical environment. To date, most of the MJO-extratropical research has focused mid-latitude weather in both hemispheres and polar conditions in the Northern Hemisphere. The MJO's potential influence in the Southern Hemisphere remains understudied.

In this project, the MJO's modulation of the Antarctic atmosphere and cryosphere was explored. Amplitude and phase of the MJO were characterized using cutting-edge indices developed in the past three years, specifically the OLR- and circulation-based indices of Ventrice et al. (2013) and Kiladis et al. (2014). Daily values of atmospheric heights, temperatures, and circulation observations from the ERA-interim reanalysis, along with daily sea ice extent, area, and concentration maintained by NASA and NSIDC, were composited by binning each day from 1980 to 2015 by MJO phase and amplitude. Mean daily anomalies for each MJO phase and amplitude were then calculated by subtracting the long-term monthly mean from the mean of each MJO phase. Atmospheric anomalies were then used to establish physical reasons for observed sea ice anomalies for each phase. Because of seasonality in the latitudinal center of MJO convection, each month was examined separately.

## ***Gradient change of cyanobacterial diversity in the natural environment revealed by assessment of DNA barcoding gene***

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### Abstract

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Cyanobacteria are able to survive under diverse environmental conditions due to their ability to adapt even in harsh environments such as the polar region. This study was carried out to determine the gradient change of cyanobacteria population from three different regions; tropics, temperate and polar. The genetic diversity of cyanobacteria from all three regions was determined based on the combination of both metagenomic and phylogenetic analysis. For tropical samples, analysis was performed on sediment samples collected from Pinang River Basin tributaries. Genomic DNA of the collected sediments were extracted using PowerSoil DNA isolation Kit (MOBIO), but with some modifications, due to the presence of humic acid in the samples. Metagenomic approach of 16S rRNA amplicon was used to target the 16S rRNA gene in the samples. Taxonomic abundance of cyanobacteria was generated using an open source web application, MG-RAST (Metagenomic Rapid Annotations using Subsystems Technology). Results obtained indicated that the cyanobacterial diversity ranged from 0.5% to 24% of the general bacterial diversity in the respective rivers. Oscillatoria, Lyngbya, Synechococcus, Pleurocapsa, Phormidium, Dolichospermum and Microcoleus were abundant genus recorded from all five rivers. Whereas, the dominant species in all five rivers were Oscillatoria acuminata, Lyngbya bouilloni, Synechococcus sp. NAN, Pleurocapsa sp. PCC 719, Phormidium mucicola, Dolichospermum flos-aquae. The samples from Arctic were collected from four sites; Kvartsittsletta (North, East: 77.02775, 15.17011), Revdalen (North, East: 77.03122, 15.35875), Hansbreen (North, East: 77.01492, 15.59994), and Fugleberget (North, East: 77.01453, 15.58708) and these sites were located in Spitsbergen Island. DNA extraction of Polar samples from Arctic (Svalbard), collected during summer 2011 is currently under progress. This study demonstrates that metagenomic is an important tool to build a predictive understanding of how cyanobacterial diversity and function vary across the continents.

# ***Ice core evidence of tropical Antarctic teleconnections over the past 300 years***

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A number of studies have demonstrated the teleconnection between climate variability in West Antarctica and the tropical Pacific region. However, the instrumental records in both regions are short and sparse making it hard to understand the mechanisms involved. Here we present ice core evidence of a close relationship between snow accumulation and surface temperatures (stable isotopes) in the Antarctic Peninsula and Ellsworth Land, with sea surface temperatures and sea surface pressure anomalies in the tropical Pacific. The teleconnection is a persistent feature throughout the 20th century, with proxy records linking the two regions back to 1700.

## ***Influence of ENSO, ENSO MODOKI and the Indian Ocean Dipole on southern high latitude climate.***

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Tropical SST variability is an important part of global climate system. The SST variability of the tropics influence various regions and processes on earth. This is mostly achieved by modulation of atmospheric general circulation. These changes in the atmospheric circulation pattern has distinct influence on the high latitude as well. The imprints of tropical SST variability can be found in sea – ice, high latitude precipitation, air temperature, etc. Present study tries to understand the Indo – Pacific SST variability and its influence on southern high latitudes. Of all the processes ENSO dominates the tropical – high latitude teleconnection. During ENSO a high pressure anomaly is generated west of the Antarctic peninsula, resulting in changes in air temperature, sea – ice and SSTs. ENSO Modoki also generates a high pressure anomaly west of the Antarctic peninsula, however its location is slightly to the west of the high pressure cell generated by the ENSO. The Indian ocean also has its own modes of SST variability, prominent is the Indian Ocean Dipole mode (IOD). The response to IOD in the southern high latitude, unlike ENSO and ENSO Modoki, is characterised by a negative pressure anomaly near the Ross sea. During an IOD the low pressure system near the Ross sea. This drives warm air to the west of the Antarctic peninsula by southward(warm) atmospheric transport, the northward (cold) heat transport associated with IOD was located west of the Ross sea, . However the influence of IOD is mostly limited to the western hemisphere. But in the most recent decade influence of IOD can be seen in the western hemisphere also. One possible reason for this could be the reduction in IOD – ENSO correlation during the last decade.

## ***Modulation of the Antarctic Circumpolar Wave and its relationship to large scale modes of variability***

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The Southern Annular Mode (SAM), El Niño-Southern Oscillation (ENSO) and Zonal Wavenumber-3 (ZW3) signals are dominant factors on Southern Ocean climate variability on a wide range of timescales ranging from daily to interdecadal. Theoretical and observational considerations suggest that these patterns modulate the interdecadal variations affecting the Antarctic Circumpolar Wave (ACW) across the mid-latitudes and sub-Antarctic. In this paper a composite dataset and various climate indices spanning 1871-2012 have been used to diagnose interactions among the SAM, ENSO and ZW3 circulation patterns on interannual and sub-decadal scales. We show that SAM and ENSO patterns interact with each other modulating ACW anomalies in the western and central south Pacific Ocean on interannual scale. ENSO sets the scales of appearance of ACWs, whose oscillations are realized only when the SAM signal shows lower amplitudes compared to those of ENSO, its superimposed counterpart. This is because the SAM pattern seems to have a more important role in damping ACW phases or in interrupting any existing eastward propagating waves. As a consequence, the times of occurrence of the SAM, ENSO and ZW3 interactions as well as trends experienced by these three phenomena have a key role in influencing ACW anomalies and their interdecadal changes. Results have also shown that the ozone depletion tends to reduce the ACWs, and we suggest it modulates the upward trend of the SAM pattern. Moreover, a ZW3-ozone relationship should be taken into account together with the already known SAM-ozone interaction, since these two patterns are intrinsically linked.

## ***The role of the tropical pacific in the recent expansion of Antarctic sea ice coverage***

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Sea ice in the Arctic has been decreasing since ~1979 and it is widely believed that the dominant cause is anthropogenic global warming. At the same time, however, the area covered by sea ice in the Antarctic has been increasing. Most climate models, when forced by observations for recent decades, reproduce the observed reduction of Arctic sea ice, but they do not reproduce the observed increase in Antarctic sea ice. Recent work (e.g., Ding et al., 2011, 2012; Ding and Steig, 2013) suggests that interannual to multidecadal variability in the tropical Pacific is an important source of variability in Antarctic climate. What fraction of the observed climate change (e.g., temperature, precipitation, circulation and sea ice extent) in the high latitude SH over the past 60–100 years is due to variability in the tropical Pacific and what fraction is due to human activity? Do the climate models used by the International Panel on Climate Change (IPCC) to assess and attribute the causes of climate change adequately capture the observed tropical variability and the teleconnections that link the tropical Pacific to the high latitude SH? We will answer these questions in this talk. Based on our result, we conclude that a substantial portion of the SH high-latitude circulation variability originates from the tropics, and this circulation variability has an important role in modulating Antarctic sea ice change over the past 60–100 years.

Most climate models predict a decrease of Antarctic sea ice in the face of climate warming. But reality seems to tell a different story and a slight expansion of sea ice has been observed. This discrepancy has been seized upon by some to call into doubt the credibility of climate models to make projections about future climate. Understanding this mismatch has important scientific and social implications. Inevitably, projections of Antarctic sea ice change hinge on climate models, and we must assure that these models capture both natural and anthropogenic drivers of Antarctic climate change. The knowledge gained in this study can improve our ability to forecast Antarctic sea ice.

## ***The temporal distribution of Antarctic Peninsula vegetation based on observation of a tropical ecologist***

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After working for more than 30 years on various aspects of ecologies ranging from rivers, lakes, wetlands, coastal areas, islands, montane forests and deserts, I was intrigued when confronted with Antarctic vegetation. The species are relatively unique particularly they could stand the extremely cold winter weather. It is interesting to note that their adaptability to this cold ambient Antarctic condition, provide a good comparatively study especially when compare to the warm weather in the tropics. The five Argentinian stations visited were Marambio, Esperanza, Camara, Deception Island and Jubany. Perhaps these research stations were relatively milder compare to other stations. At Esperanza station, the Mount Flora formation, plant fossils particularly from the species *Nothofagus* was part of an interesting paleo botany study. I observed the living genus of *Nothofagus* in Tasmania, Cape Town and Tiera del Fuego. The Strait of Magellan is not only one the rich marine diversities however the landscape view of surrounding Tiera del Fuego forests are beautiful landscapes which are high in endemic vegetation. For example, *Nothofagus nervosa* wild populations are one of the common species widely distributed in these temperate forests of southern South America. In addition to fossil plants, there are about 100 species of mosses including 25 liverworts, lichens and snow alga. Although, the eco region is lack of trees and shrubs, however Antarctica hair grass (*Deschampsia antarctica*) and Antarctica pearlwort (*Colobanthus quitensis*) are widly found in Antarctic Peninsula. An invasive grass, *Poa annua* populations are colonizing the warmer habitats. The evolution of higher plants can be evidently proved by comparatively study between the tropics and the polar region. The study is a crucial finding in learning more about the pertinent global problems such as global warning and loss of diversity. Perhaps it still can provide a lot of basic information on plant distribution and evolution globally.



## ***Variations in cyclone density during extreme Antarctic sea ice retraction and expansion***

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Extratropical cyclones are transient systems that affect weather conditions through rain formation, intense winds, and sudden changes in temperature. Because the boundary of Antarctic sea ice is located in a sensitive region under the Antarctic Polar Front, there is a great potential for sea ice variability to affect the position and intensity of baroclinic systems and the atmospheric circulation. The main objective of this study is to investigate if there are variations in cyclone density during extreme Antarctic sea ice retraction and expansion in austral winter between 1979 and 2013. The results show that during extreme sea ice retraction (expansion) events in the Weddell Sea and Bellingshausen-Amundsen Sea sectors (Ross Sea sector), there is a strengthening of the polar jet. At the same time, there is a strengthening of the circumpolar low pressure belt as well as the ascending branch of the regional Ferrel cell over the Southeastern Pacific from 50° to 60°S. Thus, there is an increase in cyclone density. There is a corresponding weakening of the ascending branch of the regional Ferrel cell around 40°S via conservation of mass, indicating a southward shift of the cell. There is also a strengthening of the descending branch of the regional Hadley cell over the tropics, suggesting a strengthening of the South Pacific subtropical high. Thus, there is a decrease in cyclone density in the latitudes between 30° and 50°S, and the propagation of air masses toward lower latitudes is limited. We observed the opposite pattern during extreme sea ice expansion (retraction) events in the Weddell Sea and Bellingshausen-Amundsen Sea sectors (Ross Sea sector).

## **S02. Evolution of the physical and biological environment of Antarctica and the Southern Ocean over the 21st and 22nd centuries**

### ***Biogeographic distribution of extant Coccolithophores in the Indian Sector of the Southern Ocean***

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Nine vertical profiles down to 110 m water depth were sampled along north-south transect (between 39°S and 65.49°S, ~57.3°E) were sampled to study the biogeographic distribution patterns of extant coccolithophores during the 4th Indian Southern Ocean Expedition (between 31st January and 18th February, 2010). Both coccospheres and coccoliths were counted separately using a Scanning Electron Microscope (SEM) for obtaining information on coccolithophore abundance and distribution across oceanic frontal regions of the Indian sector of the Southern Ocean (SO). A total of 39 species (including morphotypes, types and subspecies) were recorded as intact coccospheres with cell abundance reaching up to 745x10<sup>3</sup> coccospheres/l at Subantarctic Front (SAF). *Emiliana huxleyi* was recognized as the most abundant, accounting for more than 86% of the total coccolithophore assemblage at each station. The elevated coccolithophore abundance and diversity was observed to be associated with the major oceanic frontal regions (ARF= Agulhas Retroflexion Front, SSTF = Southern Boundary of Subtropical Front, SAF = Subantarctic Front and PF = Polar Front), however, abundance decreased southward and monospecific assemblage of *E. huxleyi* was recorded at and south of the PF region. Two coccolithophore assemblages were recognized based on coccolithophore abundance and diversity (ARF-SSTF assemblage and SAF-PF assemblage). The ARF-SSTF assemblage consists of high coccolithophore diversity (39 species) which can be linked with the warm, high saline and oligotrophic waters. The SAF-PF assemblage is characterized by reduced number of species (about 13 species) observed at the SAF and monospecific assemblage of *E. huxleyi* (preferentially morphotype C and B/C) was observed at and south of the PF region. Multivariate statistics showed that temperature, salinity, silicate, phosphate and nitrate were the most influencing parameters for coccolithophore diversity and distribution in the Indian Sector of the Southern Ocean. Monospecific occurrence of *E. huxleyi* at south of the PF confirms its ability to thrive in cold, nutrient rich waters, whereas the occurrence of a large number of detached coccoliths (of 85 species- including varieties, morphotypes) in the present study demands explanation for understanding of their transport by currents and residence time of their detached coccoliths in the water column. Coccolithophore assemblage and its distribution in relation to frontal dynamics recorded in this study will be helpful in reconstructions of the past climate in the Indian Sector of the Southern Ocean.

# ***Evaluation of the growth of polymicrobial biofilms developed from soil samples of Signy Island, Antarctica***

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Having a cold environment as a habitat definitely pose a great threat and interference to any microbial species including psychrophiles. As a result of this, psychrophiles have the ability to produce extracellular polymeric substances which are the construction material of polar biofilm. Polar biofilms enable the psychrophiles to attach to the surface for easy access of nutrients and also protection. Various factors such as different temperatures and media influence the growth of different psychrophiles species which lead to the formation of polymicrobial biofilm of distinctive morphology. Here, we present a pilot study to evaluate the growth of biofilms using different media and at different temperatures. The ultimate aim is to develop microbial biofilm cultures for the testing of heavy metals. Soil samples collected from Signy Island, Antarctica were cultured in 24 well cell culture plates using six different media at three different temperatures which are 4 °C, 10 °C and 15 °C. Two defined and four complex media were used. The defined media contained sodium chloride, disodium hydrogen phosphate, ammonium chloride and sugars while the latter consisted of varying types of salts, peptone, enrichment broth, yeast extract and carbon sources. Based on the data collected, we were able to identify that media containing enrichment, salts and carbon sources provide ideal condition for culturing gram positive psychrophiles, whereas media supplemented with enrichment broth provide the ideal condition growth for gram negative psychrophiles. Complex media at 15°C served as the ideal conditions for polar polymicrobial biofilms formation as compared to defined media and lower temperatures. Through this, we were able to estimate the growth of polymicrobial biofilm of Antarctica origin in different media. The biofilms produced by the microbes were estimated by crystal violet staining method. Most of the media supported biofilms, saline used as negative control. The biofilms produced will be useful for our ongoing studies on assessing the toxicity of heavy metals in Antarctic microbes.

## ***Spatial variations of particulate organic carbon and its isotope distribution in surface waters during summer in Prydz Bay, Antarctica***

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Based on the measurement results of particulate organic carbon (POC) and its stable isotope ( $\delta^{13}\text{C}_{\text{POC}}$ ) in surface suspension particulate collected from 61 stations in the Prydz Bay by the 29th China Antarctic scientific expedition, in combination with the data of sea surface temperature (SST), Chlorophyll-a concentration, and sea ice coverage in the research region obtained from the satellite remote-sensing interpretation, the distribution of the sea-surface suspended POC in the Prydz Bay was investigated. Furthermore, the influencing factors of POC distribution, sources and transport processes were studied. The results show that the POC concentration in the sea surface water in Prydz Bay was 0.28-0.84 mg·L<sup>-1</sup>, with an average concentration of 0.48 mg·L<sup>-1</sup>, and the  $\delta^{13}\text{C}_{\text{POC}}$  value ranged from -29.68‰ to -26.30‰, with an average of -28.01‰. The surface suspended POC showed a distribution pattern in which the concentration was higher in the near-shore areas than in the far-shore areas and higher in the western portion than in the eastern portion of the Prydz Bay. POC content has good correlation with chlorophyll a concentration and sea ice coverage, suggesting that POC was mainly from the phytoplankton production in the local water columns, while the growth of phytoplankton was obviously affected by sea ice. The  $\delta^{13}\text{C}_{\text{POC}}$  value of the suspended particles in the outer Prydz Bay gradually decreases, while from the shore to the sea  $\delta^{13}\text{C}_{\text{POC}}$  value gradually become more negative in the eastern survey area, suggesting that  $\delta^{13}\text{C}_{\text{POC}}$  was mainly influenced by the phytoplankton fixation CO<sub>2</sub> rate outside Prydz Bay waters. The  $\delta^{13}\text{C}_{\text{POC}}$  value of the suspended particles near Zhongshan Station was significantly more negative, possibly due to the effects imposed by the input of terrigenous organic matter and the change in phytoplankton species composition in the offshore area.

## S06. Glaciers and ice sheet mass balance

### *Estimating the errors involved in glacier ice-volume computation from ground penetrating radar data*

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Computing glacier volume from ice-thickness data is fundamental for glacier mass-balance projections. It provides an estimate of the potential mass losses and hence information regarding for how long can a given rate of projected losses be sustained. Ground penetrating radar (GPR) is the most widespread geophysical method to measure ice-thickness, and digital elevation models (DEM) of glacier-ice thickness are used to calculate the glacier volume. To estimate the error of this volume calculation, we need to know the error of the thickness values at the grid points of the DEM.

Our error calculation procedure consists of three steps. First, the estimate of the data errors. Second, the estimate of the errors at the grid points of the DEM, which involves both data errors and interpolation errors. Finally, the estimate of the errors associated to the volume computation from the DEM.

In the estimate of the accuracy of GPR-retrieved ice-thickness data, we take into account the errors in radio-wave velocity and the errors in timing. The accuracy of the boundary delineation of the glacier is also taken into account, as well as the error in positioning of the data.

An interpolation error would be produced even for hypothetically error-free data, but we additionally analyse the propagation of the data error to the grid points of the ice-thickness DEM through the interpolation algorithm. To estimate this error we use a function relating the error at a given grid point with the distance to the closest GPR profile.

We also provide a method to evaluate the degrees of freedom of the data, derived from their variogram, which we use for calculating the error in glacier volume by combining the errors in volume at the grid-cell level.

## ***Gravimetric mass balance products for the Antarctic ice sheet***

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Within the framework of ESA's Climate Change Initiative (CCI) mass balance products for both the Antarctic Ice Sheet (AIS) and the Greenland Ice Sheet (GIS) have been developed by the AIS\_cci and the GIS\_cci project. These Gravimetric Mass Balance (GMB) products are derived from satellite gravimetry data acquired by GRACE (Gravity Recovery and Climate Experiment), which is the only sensor directly sensitive to changes in mass. Using monthly GRACE gravity field solutions covering the period from 2002 until present two different GMB products are derived: (a) time series of monthly mass changes for the entire ice sheet and for individual drainage basins, and (b) gridded mass changes covering the entire ice sheet. The gridded product depicts spatial patterns of mass changes at a formal resolution of about 50 km, although the effective resolution provided by GRACE is about 200-500km.

We present the first release of the ESA CCI GMB products for the Antarctic Ice Sheet. They are derived from GRACE monthly gravity field solutions by a refinement of the regional integration approach which directly tailors sensitivity kernels by a formal optimization procedure to minimize the sum of propagated GRACE solution errors and leakage errors. This approach involves the incorporation of information on the structure of GRACE errors and the structure of those mass change signals that are most relevant for leakage errors. Based on our products we discuss the latest mass balance estimates. The GMB products are freely accessible through an AIS\_cci data portal.

## ***Mass balance and velocities of the glaciers in vicinity of Bulgarian Antarctic base, Livingston I. Antarctica***

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The Bulgarian Antarctic Base "St. Kliment Ohridski" (BAB, 62° 38'29"S and 60°21'53"W) is located on Livingston Island, South Shetland Islands, Antarctic Peninsula.

The base has been active during the austral summers since 1993. The glaciers in the neighbourhood of the base have undergone visible changes in the period 1993-2015. The first observations were performed in the austral summer of 1994-1995 in a region with total area of about 60 km<sup>2</sup>, including parts of the glaciers Balkan, Johnsons, Huntress and Contell.

In the next few years different methods have been applied in order to estimate the density, temperatures, velocities, accumulation, ablation and equilibrium line of the glaciers. Firstly, we have deployed and observed the positions of about 30 wooden stakes, and then we have carried out ice drillings at 13 locations in different zones of the glaciers. The field work included measuring of temperature in the drilling hole, describing the ice-carrots, cutting them into fragments, then weighing, melting, acidifying and filtering them through ion-exchange resins. The samples (filters) were analysed in the Laboratoire de Glaciologie et Géophysique de l'Environnement, CNRS, Grenoble. The goal was to estimate deposited radionuclides (<sup>7</sup>Be and <sup>137</sup>Cs) and the depth of the layer from 1965, when nuclear tests were performed in the Southern Hemisphere. The filters were analysed by gamma spectrometry using a specially designed low-background scintillation detector.

Traces of <sup>137</sup>Cs have been found in samples from 4 ice drilling sites, and have not been found in the remaining 9 drillings. This might be due to percolation effects, transporting <sup>137</sup>Cs to deeper layers of the glaciers.

For this reason, drilling in 5 supplementary points on the glaciers has been carried out and the collected samples have been analysed for Tritium activity concentrations in the laboratories of the Nuclear Physics Institute of the Czech Academy of Sciences. A liquid scintillation spectrometer Quantulus 1220 with scintillation cocktail UltimaGold LLT has been used. This analysis has allowed to estimate more precisely the equilibrium line.

For dating ice layers we have carried out also analysis of tephra layers, looking at traces of Deception volcano eruptions from 1969 and 1970.

Our studies have shown that the glaciers in the vicinity of the Bulgarian Antarctic Base "St. Kliment Ohridski" consist of firn and ice. The temperature from their surface up to their bottom is 0°C, confirming that these glaciers are warm. The equilibrium line on the western slopes of the glaciers is located at about 206 m a. s. l. The mean mass balance in the accumulation area for the period 1999-2002 is about +0.36 meters water equivalent per year and the mass balance in the ablation area for the same period is about -0.51 meters water equivalent per year.

# ***Surface mass balance of the Ross Ice Shelf: Dating snow layers from radar by using stable isotope analysis***

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Ice sheet surface mass balance (SMB) is a major topic that is studied with respect to global change and sea level rise, however remains poorly understood in Antarctica due to spatial and temporal variability, and logistical constraints. Of particular importance in a changing climate are the Antarctic Ice Shelves, stabilising the grounded ice sheets. The Ross Ice Shelf (RIS) is the largest, and provides a tremendous backpressure that maintains stability of the marine based West Antarctic Ice Sheet (WAIS). The existence of the RIS is governed by inflow of ice from the grounded ice sheet, basal freezing and the SMB. SMB studies on the RIS are scarce; there have been no comprehensive SMB studies since the late 1970's. Here, stable isotope ratios ( $\delta^{18}\text{O}$  &  $\delta\text{D}$ ) are analysed in a 16m firn core to determine annual accumulation rates, acting as a ground truth for ground penetrating radar (GPR) measurements across larger area. The aim of this study was to interpret GPR data to analyse the spatial and temporal variability of snow accumulation and compare it with historical observations and climate models. These measurements are required for validating and calibrating atmospheric and surface mass balance models that can be used to simulate the future behaviour and stability of the RIS in a warming globe.



## ***The French ITASE Contribution - Recent results***

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How will the surface mass balance varies over Antarctica in the future? In spite of decades of studies, an international effort is still necessary to reduce the important remaining uncertainties. Because large regions of Antarctica are still unexplored, important scientific traverses have been designed in the framework of SCAR-ITASE program (International Trans-Antarctic Scientific Expeditions) to collect invaluable samples and observations in the field. The goal of this presentation is to present recent results obtained by the French ITASE community, and to describe its strategy for future research performed in Antarctica. During the 2009-10, 2011-2012 and 2013-14 summers, scientific traverses have been performed over large distances on the plateau. Results show that the coast-to-plateau transition zone had been largely ignored, while this is where most of future changes are expected to occur. This is where a new traverse is planned for summer 2016-17. We will collect information on snow physical properties to analyze the processes responsible for their spatial and temporal variations. Local accumulation data obtained from firn cores will be interpolated with ground penetration radar data along the traverse. A special attention will be paid on the way to use remote sensing data to infer the physical characteristics of snow with a peculiar attention to the temporal and spatial variations of the surface roughness length. This knowledge is expected to allow the interpretation of remote sensing signal in terms of surface mass balance. Getting information on how the origin and transport of moisture affect chemical and isotopic signals stored in firn and ice will also be improved. Initial analyses have already been performed on a set of 6 shallow firn cores drilled at the close to the coast to verify the robustness of our approach. This knowledge will help us to validate climate and surface mass balance models, which are the indispensable tools for future surface mass balance forecasts. First results from remote sensing data analysis, from firn cores and regional circulation models will be described in this presentation.

## S10. Subglacial aquatic environments

### *Liquid water beneath cold glaciers - Anomalously warm ice found in the vicinity of blood falls, Taylor Glacier, Antarctica*

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Thin margins of the Antarctic ice sheet are generally assumed to be frozen to the bed and have no active subglacial hydrology. Yet, Blood Falls, an intermittent discharge of subglacial hypersaline brine at the snout of Taylor Glacier, has been observed since the earliest scientific investigations in Antarctica a century ago. More recently, similar subglacial brine has been found leaking directly from beneath Taylor Glacier into Lake Bonney (Dr. P. Doran, personal communication). Both of these discharges may be sourced from the regionally extensive layer of brine-saturated sediments imaged beneath this glacier by helicopter-borne, time-domain electromagnetic survey (Mikucki et al., 2015; Foley et al., 2016). The high solute concentration of this Taylor Glacier brine helps it stay liquid down to at least -6 degrees C. We will present evidence from englacial temperature measurements in Taylor Glacier showing that freezing of the brine provides large source of heat that exceeds geothermal flux by about an order of magnitude. Combination of high salinity and latent heat release may keep basal temperatures at the freezing point of brine allowing existence of extensive hydrological systems beneath those parts of the Antarctic ice sheet that have been previously assumed to be frozen dry. Such areas will represent an extensive subglacial aquatic environment with high salinity brines which may sustain microbial ecosystems different than the ones characterizing subglacial freshwater environments.

## ***Potential subglacial lakes derived from a new DEM from Cryosat-2 and satellite optical image in the David Glacier, Antarctica***

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The potential subglacial lake locations and melt water path ways can be simply determined from the hydraulic potential surface. The hydraulic potential is usually calculated using ice thickness and bedrock topography. However, the current data sets of ice thickness and bedrock topography (e.g. BEDMAP2) are not accurate enough to predict correct subglacial lake locations in the David Glacier, Antarctica. In order to improve the quality of hydraulic potential estimates, we constructed a new high-resolution digital elevation model (DEM) by means of combining the Cryosat-2 measurements and the satellite optical images geostatistically. The Cryosat-2 has a disadvantage that the ground tracks are quite irregular over an area with rough topography so that the radar altimetry often fails to measure the elevations in topographic hollows. To overcome this limitation, we generate a relative elevation distribution from a single satellite optical image and a method called as “shape from shading” and combine it with the Cryosat-2 measurements using the simple Kriging with local mean. The new DEM model corresponds well with the ICESat measurements. Based on the new DEM, we estimate the bedrock topography using a shape optimization algorithm in the assumption of shallow ice approximation. The improved DEM and bedrock topography is used to map the hydraulic potential. As a result, the active subglacial lake David 1 (D1), already discovered by the ICESat measurements, has several hydraulic sinks indicating that the lake D1 is not a single lake. The GPS measurements for more than 5 months at two sites in the lake D1 also support this result.

# ***Power supply considerations for environmental friendly exploration of Antarctic subglacial lakes using autonomous sonde RECAS***

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Antarctic subglacial aquatic system is a particular extreme environment with high water pressure, low temperature, total darkness, low nutrient, which isolates from atmosphere for a long time. In-situ investigations of Antarctic subglacial aquatic system are recognized as one of the most important means of learning environment beneath Antarctic Ice Sheet and exploring presumable peculiar life forms. Penetration with RECoverable Autonomous Sonde (RECAS) can be considered as particularly environmentally friendly technology for accessing of ice sheet base by means of hot-point melting and subglacial water sampling. The RECAS can run automatically without manual operation. Generally, the ice sheet depth of exploration site will be more likely several kilometers, it will cost rather long working time (might be several months) to finish the investigation. Additionally, the main operation locations would be designated in inland of Antarctica where people can work only during short summer seasons. Therefore, it was decided to equip self-acting power supply system for the RECAS equipment, in order to provide electricity for electrically heated melting tips (EHMT) to penetrate and return, coil winch to lower and lift the sonde, testing system and sampling unit to measure and sample. Antarctic environment is granted exceptional advantages of renewable energy sources. The relevant power supply methods of renewable have been applied in kinds of power systems of Antarctic scientific investigation equipment as well. For instance, solar photovoltaic panels and wind turbine have been adopted to supply the power for a good deal of automatic weather stations, ice sheet dynamic monitoring stations, and magnetic monitoring stations located in Antarctica. However, by reason of lack of sunshine for several months in Antarctica, and different katabatic wind velocity in various areas, the generating efficiencies are distinct, the renewable generating methods cannot satisfy the power requirement while explore in specific time and location. Therefore, extra automatically controlled diesel engines should be equipped for continuous power supply. In this case, three types of power supply for long-term automatic operation of RECAS are considered: (1) solar power supply and storage for batteries, (2) wind generator, (3) auto diesel engine. Accounting solar radiation time and angle, and katabatic wind velocity, the rational power output of renewable sources are estimated. Then an optimal power supply scheme including suggested three types of power sources are given depending on RECAS energy demands, required working time (ice sheet depth intended to drill), location of drilling site, time-of-year, logistical potential.

## ***Prokaryotic abundance, biomass and metabolism in the brines of an Antarctic perennially frozen lake (Tarn Flat, Northern Victoria Land)***

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The recent discovery on Mars of seasonal brines has increased interest in analogous environments on Earth. In fact, the ice cap of several Antarctic lakes encapsulates sometimes brine pools characterized by a unique combination of extreme conditions. Moreover, the study of these cryoecosystems allows insights on geochemical processes affecting microbial life and on how the latter can be supported in similar terrestrial environments and in other icy worlds of the universe.

In order to find new extreme ecological niches of life, within the Italian National Research Programme in Antarctica (PNRA), in October-November 2014 a screening of several frozen lakes in the Northern Victoria Land through the ground probing radar (GPR) investigation was made. Two hypersaline brines found at two different depths (B1-3.90 m; B2-4.50 m) in a perennially frozen Tarn Flat lake were studied. The two pockets of liquid brines were separated from an ice layer of 12 cm and had a different salinity (84-92 and 74-75 psu, respectively) and pH (7.22 and 6.74, respectively).

Brines were sampled under sterile conditions and analysed by microscopic image-analysis to assess abundance, cell-shape, viable (Live/Dead) and respiring cells (5-Cyano-2,3-ditolyl-tetrazolium chloride stain). Moreover, the physiological profiles by Biolog-Ecoplate™ were determined as well as the potential ectoenzymatic activities rates (leucine-aminopeptidase, LAP;  $\beta$ -glucosidase,  $\beta$ -GLU; alkaline-phosphatase, AP).

Prokaryotic abundances were in the order of 10<sup>9</sup> cells L<sup>-1</sup> and viable/respiring cells were comprised between 1 and 74 % of the total abundance. In the deepest brine higher cell volumes (0.11  $\mu$ m<sup>3</sup>) as well as a higher percentage of respiring cells were found. Three main cell morphologies - coccobacilli, cocci and rods - were recognized. However in B2 curved rods with the highest cell volumes (0.21  $\mu$ m<sup>3</sup>) were also present. Microbial biomass modulated by cell volumes was 3.6 times lower in B1 (67  $\mu$ g C L<sup>-1</sup>) than in B2. The physiological profiles described wide metabolic potentials by the prokaryotic community and revealed differences in the quality of used substrates. The high values of LAP (~ 6 nmol L<sup>-1</sup> h<sup>-1</sup>) with respect to AP (~ 3 nmol L<sup>-1</sup> h<sup>-1</sup>) suggested that prokaryotic cells were able to decompose proteins rather than organic phosphates in both samples.  $\beta$ -glucosidase activity on polysaccharides was negligible in B2 (0.4 nmol L<sup>-1</sup> h<sup>-1</sup>) and high in B1 (7.6 nmol L<sup>-1</sup> h<sup>-1</sup>).

In conclusion, this first screening of prokaryotic assemblages in the brines of an unexplored Antarctic perennially frozen lake fills some gaps on the knowledge of these peculiar ecological niches.

## ***Subsurface hypersaline brine discharge from Taylor Glacier in to Lake Bonney at depth***

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Hypersaline subglacial brine exists beneath Taylor Glacier in the McMurdo Dry Valleys and is well characterized by the presence of Blood Falls, a surface discharge feature that flows from the northern terminus of Taylor Glacier directly on to the west lobe of proglacial Lake Bonney. The Blood Falls discharge is rich in iron and sulfate and is a major geochemical influence on West Lobe Bonney (WLB). Discharge events at Blood Falls are episodic and the mechanism is poorly understood, but recent data from an airborne survey have suggested that Blood Falls is just a minor surface impression of a much larger subglacial system, and that brine discharges from beneath Taylor Glacier all along its contact with WLB. Previous temperature measurements made in WLB by an autonomous underwater vehicle suggested the presence of a saline intrusion emanating from the submerged glacier face of Taylor Glacier between 20-25 m water depth. To further capture this inflow, two high resolution thermistor strings were deployed from 12-25 m in the lake between the glacier and the deepest point of WLB where regular CTD measurements have been made for over 20 years. An Ice Tethered Profiler (ITP) was also deployed near the deep spot and has provided daily CTD data year-round between ca. 13-20 m depth. Because the contribution of the salinity gradient is so much more important than temperature in determining density, temperature anomalies in the water column can be used as tracers for the movement of cold, saline intrusions emanating from the glacier face and flowing horizontally along their density gradient. At 22 m depth during the austral winter of 2015, the thermistor string nearest to the glacier experienced temperature anomalies up to 1.2°C colder than the typical temperature for that depth. Three discrete week-long events in mid-August, late August, and early November where the water column at 22 m fell below -2°C, relative to -1.3°C which is typical for this depth, were also identified. The speed of movement of the brine intrusions can be determined with the second thermistor string. Identifying temperature anomalies with such high resolution makes it possible to characterize brine intrusions emanating from the submerged glacier face and track their fate through the water column of WLB. The subglacial discharge of brine into WLB could be an important source of nutrients and microbes. Identifying and monitoring direct brine intrusions from the submerged glacier face to the deep waters of Lake Bonney beneath the chemocline could have important implications for the geochemistry and biology of this unique proglacial lake.

## ***The behavior of the drilling fluid in the borehole after the first unsealing of subglacial Lake Vostok***

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Drilling fluid (DF) is one of the main sources of chemical and biological contamination of deep ice cores and lake water samples in the exploration of Subglacial Antarctic Lake Environments. In our study, we investigate the contamination of ice cores that represent the first sample of refrozen lake water obtained one year after the unsealing of Lake Vostok in 2012. We show that these samples contain inclusions of the DF with a concentration of at least 16.7 mg/L. This makes it extremely difficult to obtain reliable data on the real chemical composition of the lake water. The focus of our study is the organic components of the DF, which built up in the secondary ice while the water was freezing in the borehole. Of all the possible organic compounds of the DF, only phenol congeners and hydrochlorofluorocarbon HCFC- 141b, a DF densifier, were found in the central channel, which was the last part of the core to freeze in the borehole. We conclude that the phenol compounds emerge due to physical processes, namely fractionation, during freezing, rather than any chemical reaction between the DF and the lake water. Possible mechanisms of samples contamination will be discussed.

## ***The future of Chinese studies on subglacial lakes in Princess Elizabeth Land, Antarctic***

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The biggest canyon on the earth has been found in Princess Elizabeth Land recently, the ice radar data show that, the length of the canyon is more than 1000 km, the depth is more than 1500m, which larger than the Grand Canyon of the Colorado. Most important finds are the subglacial lakes under the ice sheet in Princess Elizabeth Land, so many subglacial lakes and connected with each other, subglacial wetlands formed in this area. The ice radar results also show that, the geothermal flux is much higher of Princess Elizabeth Land than other places, which should be important clue for the study of subglacial lakes formation. In the future, the characteristics of the subglacial lakes should be depicted based on ice radar data and GRACE (Gravity Recovery and Climate Experiment) satellite data, especially for their connection routines and discharge channels to the deep sea; geothermal evidences should be given more investigation works, which would be the key factor for the subglacial lakes formation; ice-water interface variation and their impact on the material flux during frozen and melt processes also been interesting and important issues, indoor experiments and simulation works should be done in the future study of subglacial lakes study in Antarctic.



## ***The major element, nutrient and isotopic geochemistry of the Taylor glacier sub glacial brine***

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Blood Falls is a hypersaline, iron-rich discharge from the snout of the Taylor Glacier in the McMurdo Dry Valleys. In November 2014, the brine within the glacier was penetrated and sampled using clean entry techniques and the IceMole melting probe. The brine sample was filtered through a 0.4 $\mu$  filter and analyzed for filterable total iron (fFe), major cations and anions (Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>), nutrients (NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>, PO<sub>4</sub><sup>3-</sup>, H<sub>4</sub>SiO<sub>4</sub>), organic carbon and perchlorate. In addition, aliquots were analyzed for a suite of isotopic measurements including  $\delta$ D and  $\delta$ 18O of water,  $\delta$ 34S and  $\delta$ 18O of sulfate, 234U, 238U,  $\delta$ 11B, 224 and 226Ra, 87Sr/86Sr and  $\delta$ 81Br. These measurements were made in order to: (1) help determine the source and geochemical evolution of the brine, and (2) compare the chemistry of the brine to that of nearby hypersaline lake waters. The subglacial brine had higher Cl<sup>-</sup> and fFe concentrations than the Blood Falls end-member discharge, however other constituents were similar. The isotope data indicate the water in the brine is derived from glacier melt, as was previously noted in the discharge. The H<sub>4</sub>SiO<sub>4</sub>, U and Sr isotope concentrations suggest a very high degree of chemical weathering products in the brine. The brine has a low N:P ratio of ~6, with most of the DIN in the form of NH<sub>4</sub><sup>+</sup>. The DOC concentrations are similar to the end-member discharge values. The isotope data, when compared to the end-member discharge, and the hypersaline lake water of nearby Lake Bonney, suggest a more complex hydrological relationship between the different brine types. Based on all these measurements, we speculate on the initial origin of the solutes in these brines.

# ***The source of sediment organic matter and their Petroleum Geology Significance in northeast waters to Antarctic Peninsula***

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Biomarkers, like paleo-fossils, can help to discuss organic geochemical history of hydrocarbon in a molecular level, and provide information on organic sources, sedimentary environments, maturity, hydrocarbon migration and biodegradation for hydrocarbon prospecting in the evolution of sedimentary organic matter and sedimentary deposits (especially oil and gas). Aiming to illuminate the formation, development degree of high-quality organic sediments and their hydrocarbon-generation potential in northeast waters to Antarctic Peninsula, the chromatography - mass spectrometry of soluble extracts from organic sediment source in surface sediment, short core sediment ANT28/D5-06 and sediment core ANT28/D4-09 and ANT30/D1-07 allow investigations on molecular biomarkers (n-alkanes, isoprenoid, steroid terpane), organic carbon and isotope, forming environment, organic maturity, hydrocarbon-generation potential and hydrocarbon migration of these sediment. The results show that, n-alkanes show a unimodal distribution, with peak carbons of nC16, nC17 and nC18, and weak high-carbon peak group; the organic matter type is sapropel, with  $(\sum C_{21}-/\sum C_{22+})$  and  $(C_{21}+C_{22})/(C_{28}+C_{29})$  ratios greater than 1.0, indicative of the derivation of organic matter chiefly from a marine environment; the organic sediment is abundant with tricyclic terpanes and pentacyclic triterpane, with a high content of gammacerane and a distribution dominance of C29 sterol and C27 sterol, further suggesting the organic matter is dominated by input of lower organisms; isotopes of organic carbon ( $\delta^{13}C$ ) lie between -25.30‰ and -25.91‰, implying a characteristic of marine aquatic organisms; Pr/Ph ratios range from 0.41 to 0.97, indicating a strong reducing environment;  $C_{29\alpha\alpha\alpha}20S/C_{29\alpha\alpha\alpha}(20S+20R)$  ratios are mostly between 0.32 and 0.48;  $C_{29\alpha\beta\beta}/C_{29(\alpha\alpha\alpha+\alpha\beta\beta)}$  ratios lie in a range of 0.31-0.54;  $C_{32}22S/C_{32}(22S+22R)$  ratios range from 0.56 to 0.62;  $Ts/(Tm+Ts)$  ratios lie between 0.33 and 0.51; all these indices for discrimination of mature oil illustrate that, the organic sediment have an overall high maturity, close to high-quality organic sediment source, possessing favorable hydrocarbon-generation conditions, and some organic sediment source horizons have reached hydrocarbon-generation peak, which indicate a great prospecting potential for this region.

Keywords: Biomarker, organic matter source, hydrocarbon generation, Antarctic Peninsula Acknowledgments Heartfelt thanks to the research staff and the crew on the "Xuelong" icebreaker during the 29th Chinese Antarctic scientific expedition. And thanks to the support by Chinese Polar Environment comprehensive Investigation & Assessment Programmes (CHINARE2012-01-02, CHINRE2013-01-02, CHINARE2014-01-02, CHINARE2015-01-02, CHINARE2013-04-01, CHINARE2014-04-01, CHINARE2015-04-01).

## **S13. Antarctic meteorology and climatology**

### ***Characteristics of surface meteorology at Lindsey Island, Amundsen Sea, West Antarctica from 2008 to 2014***

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Research on warming in West Antarctica is important to prognoses and diagnose mass balance change of the ice sheet over the region, which is directly connected to global sea level. A lack of ground based measurements of meteorology across West Antarctica, however, have limited better understanding of how the large area has been influenced by the warming through atmospheric processes and how fast the warming has progressed on the region. An automatic weather station (i.e. AWS) was setup at the Lindsey Island, Amundsen Sea close to the coastal area of West Antarctica in 2008 and has been operated for about seven years. To identify meteorological characteristics near the coastal area, we analyzed the measured temperature, pressure and wind speed, which showed high inter-annual variability, particularly in winter season. The variations in monthly averaged temperature, wind speed and pressured agreed well with near and far inland five AWS sites, particularly better with those at Bear Peninsula. Semi annual oscillation (SAO) was dominant in the annual cycle of pressure, but no significant change in temperature due to SAO for pressure was found. There were no significant trends in seasonal averaged temperature with year over last seven years. The area was characterized with persistent influence of katabatic wind from the continent, but Amundsen-Bellingshausen Seas Low depending on its longitudinal location influenced surface wind regime and resulted in temperature change in winter at the site.

# ***Climate of the Antarctic Peninsula, regional atmospheric circulation and teleconnections***

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The main purpose of our research was to demonstrate latest climate changes on the Antarctic Peninsula (AP) region and to specify atmospheric circulation mechanisms. A period of distinct growth in the near-surface air temperatures (SAT) in the late 20th century was followed a decade of weak SAT variability in the on the AP stations, with some indicators of seasonal cooling on individual stations, accompanying with frequent anomalies in precipitation, winds, seasonal sea surface temperatures (SST), and sea ice. Spatial and temporal characteristics of regional climate are described, with significant seasonal and topography-dependent SAT variability.

Long-term dynamics of the main meteorological parameters on AP stations is juxtaposed against main climatic modes; predominant atmospheric circulation patterns are distinguished for different climate periods. It is detected that on decadal timescale regional climate is governed by El Niño-Southern Oscillation. The most accelerated warming in the AP region has been observed from mid-1980s, and is related to warmer Pacific SST. Eastward displacement of the large-scale synoptic centres of action in the West Antarctic sector (WAS) occurred during the recent warming phase coherently with their Northern Hemisphere counterparts (Aleutian depression, NAO) emphasizing global teleconnections. Current transition to some new regional climate regime is attributed to colder, LaNina conditions. Signal propagation time from El Niño area through extratropics is studied, atmospheric mechanism is shown, and prognostic potential for seasonal SAT predictions at AP stations is presented.

Classification of the predominant regional atmospheric circulation patterns has been made showing how significantly they have been changing between coldest and warmest periods. High sensitivity of AP weather to migrating synoptic patterns has been found. Recent warming episode is related to the intensification of westerlies and intensification of cyclonicity in WAS; regional warming is also enhanced by local weather modifications. Current tropospheric circulation is associated with greater time residence of prevailing synoptic patterns in SE Pacific and South Atlantic, including like-blocking events determining persistent seasonal weather anomalies in the AP region.

Latest climate variability in the Antarctic Peninsula region is studied; atmospheric mechanisms are shown along with accompanying weather anomalies, and prognostic potential for seasonal SAT on AP stations is shown.

## ***Continuous observations of atmospheric concentrations of carbon dioxide and methane at Base Marambio, Antarctica***

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Atmospheric concentrations of greenhouse gases have variations and trends as a result of their anthropogenic and natural sources and sinks. Anthropogenic emissions take place mostly in the northern hemisphere of the globe. From the northern hemisphere and tropical regions elevated concentrations are advected by winds to the Antarctica. During the transport they experience mainly natural processes. Concerning carbon dioxide (CO<sub>2</sub>), the most important process is air-sea exchange, the Southern Ocean acting as a net sink. The direction and strength of the flux varies seasonally. Methane (CH<sub>4</sub>) has only very minor sources in the Southern Ocean and around Antarctica, the primary variation being seasonal cycle of atmospheric concentration by solar radiation induced photochemical reactions.

To study global background concentrations of the two most important greenhouse gases, carbon dioxide and methane, Finnish Meteorological Institute, in collaboration with Meteorological Service of Argentina (SMN), monitored concentrations of these gases at Base Marambio, near the tip of Antarctic Peninsula (64.2433° S, 56.631° W, 198 m a.s.l.). The laboratory provided by the Finnish Meteorological Institute, include instrumentation to observe additionally aerosol scattering and absorption (black carbon) and aerosol size distribution, wind, global and ultraviolet radiation, air temperature, humidity and pressure. Concentrations of CO<sub>2</sub> and CH<sub>4</sub> were measured continuously by G2301 laser spectrometer (Picarro, Inc.). To ensure compatibility of our calibration scale to the global greenhouse gas measurement networks, we used three calibration gases and one target gas traceable to the scale maintained by Central Calibration Laboratory (in NOAA, U.S.A.) of the World Meteorological Organization. This presentation shows results from the period February 2013-February 2016.

On the average, CO<sub>2</sub> concentrations increased 2.3 ppm per year reaching 598.5 ppm in the end of 2015. Seasonal cycle of CO<sub>2</sub> concentration was less pronounced compared to the northern hemisphere because there is less seasonally active terrestrial vegetation in the southern hemisphere. During austral summer we observed a seasonal concentration minimum of the order of 1 ppm in February. In more detail, CO<sub>2</sub> concentrations were at Base Marambio about 0.3ppm lower than at the South Pole station operated by NOAA. Lower concentrations at Base Marambio suggest that in austral summer oceans around the Antarctic Peninsula acted as a sink of CO<sub>2</sub>.

During our observation period, methane concentrations increased 10.6ppb per year in accordance with global observations showing new growth since 2007. Methane concentrations had pronounced seasonal cycle following solar cycle. Minimum was in late austral summer, in the end of February-beginning of March and maximum in September.

# ***Mesocyclone activity over the Southern Ocean from satellite infrared mosaics for winter 2004***

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Satellite based estimations of cloud shapes and mesocyclones produce realistic picture of mesocyclone activity however they suffer from consumption that characterise manual tracking of mesocyclones from satellite images. To fill the gap in realistic picture of mesocyclone activity in Southern Hemisphere we present the new unique database of mesoscale vortexes (<1000 km in diameter) activity for one winter 2004 over the Southern Ocean.

Mesocyclones were derived from AMSL satellite infrared mosaics (<https://amrc.ssec.wisc.edu/>) that cover SH polar regions inside 35 s.h. with 3-hourly time resolution. We manually tracked all mesocyclones from their signature in cloud structures, keeping notes on their diameter, cloud shapes and synoptic situation at the moment of mesoscale cyclogenesis. Based on this data we demonstrate statistics of mesocyclones' lifecycle (such as lifetime, diameter, migration speed, and distance) and spatial distribution of genesis/lysis points and tracks was analysed.

We also focus on phenomena known as polar lows and show that more than 50% of all mesocyclones during winter of 2004 satisfy criteria (10 meter wind speed > 15 m/s) and can be considered as polar lows.

This database provides unique source of validation material for new tracking algorithms for designed especially for mesocyclones.

We also provide an assessment of the representation of mesocyclones in global 3rd generation of reanalyses (NCEP CFSR, ERA INTERIM, MERRA2 and JRA55) and high resolution WRF ARW hindcast that we made for investigated region. Based on this modeling data we revealed different types of large-scale circulation in which mesoscale cyclones are likely to develop.

# ***Reconstructions of atmospheric circulation over the Southern Hemisphere and Antarctica***

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The global climatic regime change always appears from the transformation of large-scale atmospheric circulation. The transformation of this circulation in time leads to the regional circulation change resulted in a regional climate change. For the analysis of the climatic regime changes in the area of the South Polar Region it is necessary to examine the transformation of the atmospheric circulation from decade to decade since the beginning of period of global warming in this region. However, archive of the observations of the sea level pressure and geopotential fields over South Hemisphere exists for this region only from the second half of the 20th century. Therefore, the main objective of this study is the reconstruction of sea level pressure fields of South Hemisphere (SH) and Antarctica using the atmospheric circulation regularities in the Northern Hemisphere because archive of observations of atmospheric circulation over the North hemisphere (NH) exists from end of the 19th century. We found that the period of oscillation of large-scale atmospheric circulation over NH is about 50-60 years. It corresponds to a shift of circulation to the west-east  $\pm$  20 degrees. The direction of displacement of circulation over the NH is governed by rule: shift to the east corresponds to the warming as it was at the end of the 20th century; shift to the west corresponds to the cooling as it was in the middle of the 20th century. The study of the atmospheric circulation over SH showed shift to the west from decade to decade from middle to end 20 th century similarly to the NH. Comparative assessment of reconstructed and actual pressure fields over the South Hemisphere confirmed results of reconstruction for the last decades of the 20th century.

# ***The response of lightning occurrence during extreme precipitation over the Antarctic Peninsula***

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Antarctica is always regarded as a desert due to low precipitation. However, the regions near the coastal, the ocean stores heat and thus create milder temperatures and increases the chance of higher precipitation. The high precipitation may produce thunderstorm events and this is a very important parameter to improve weather forecasting. This paper aims to study the response of lightning occurrence during extreme precipitation events over the Antarctic Peninsula in 2013. Days with the total daily precipitation rate of more than 1.5 mm/hr was selected as a case study; Case 1 (March 13th and March 14th), Case 2 (March 31st to April 2nd) and Case 3 (August 31st), where each case has different circumstances. The effect of extreme precipitation towards lightning response was investigated by observing the lightning occurrences, precipitations rate, and events. Results showed that March has the highest daily precipitation rate followed by April and August where Case 1 has the highest rate of 2.007 mm/hr while Case 3 has the lowest rate. Lightning was recorded in Case 2 and two to three days before and after the onset days in Case 2 and Case 3. However, lightning was not detected in Case 1 although the precipitation rate is high which shows more snow, rain, and fog. Case 1 and Case 2 occurs during the early year and had a lot of precipitation due to the season. From the three cases, lightning is recorded to occur after the precipitation events such as snowfall. Although lightning has been detected, the thunderstorm event was not recorded in each case. This possibly due to the lightning detected are near the range of the detector though it occurred over the ocean. To further understand the lightning response during the extreme precipitation, more data needs to be analyzed for further research.



# ***Updated analysis of the near-surface air temperature at King George Island, Antarctic Peninsula***

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Daily weather observations carry out at the Chilean Eduardo Frei station allow a detailed analysis of the behavior of meteorological variables at different timescales. In this occasion, near-surface extreme (minimum and maximum) air temperatures data are analyzed from 1970 to 2015. An overall warming is observed in the annual mean temperature, mainly during the eighties and nineties and a cooling during the last fifteen years. The minimum temperature shows a positive trend until around 2000 and a slight negative trend afterward, while the maximum air temperature shows a slight warming until early eighties and a cooling afterward. The average diurnal temperature range (DTR) shows an overall negative trend during the 1970-2015 period. The daily data allow estimating the starting and ending freezing period (defined as days when the maximum air temperature is below zero degree). Results show no significant change in the starting freezing period during the analyzed period, which occur around mid-April; while, the ending freezing period shows a significant change of about one month, from the late October to late November. This implies that the number of freezing (non-freezing) days has increased (decreased) mainly during the last 15 year.

## ***Using a simple model to improve understanding of the interactions between three phases of water in the climate system***

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General circulation models (GCMs) are currently the most common tools to predict changes in the energy balance of the climate system. However, the high complexity of GCMs often makes it difficult to understand the underlying causes of observed model behaviour. Since the 1960s, as a complementary tool to more complex GCMs, a group of simple climate models, referred to as energy balance models (EBMs), have been used to gain a fundamental understanding of the climate system. In particular, the effects of heat transport and the ice-albedo feedback have been studied. These simple models provide an elegant illustration of the ice-albedo feedback and have been useful in understanding a range of other climate feedbacks.

It is well known that clouds and water vapour play a critical role in the energy balance of the Earth's climate system. Unfortunately, they are some of the least well understood elements of the global climate system. In this project, an extension of a simple EBM has been developed to include feedback not only from ice-albedo, but also from the other two phases of water in the Earth's climate: clouds and water vapour. The extended EBM is used to explore the behaviour and interrelationships between the nonlinear climatic feedbacks caused by ice caps, water vapour and liquid water in clouds. We use this model to examine interactions between these feedbacks in this simple framework and also in an attempt to understand how these feedbacks might interact to change polar amplification.

# ***Wind lidar measurements of the atmospheric boundary layer in the Weddell Sea***

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The representation of the atmospheric boundary layer (ABL) in the Antarctic is a major challenge for numerical weather forecast models and regional climate models. Reference data sets are rare, particularly over the ocean areas. During a cruise of the research vessel Polarstern from December 2015 to February 2016, wind lidar measurements of the atmospheric boundary layer were performed in the eastern and southern Weddell Sea. The fully programmable scanning Halo-Photonics Streamline-wind lidar was used to obtain a data set of high-resolution vertical profiles of wind, aerosols and turbulence at a high temporal resolution. For special observation periods, cross-sections and horizontal scans were performed. Wind profiles are compared to radiosondes launched from the research vessel.

## ***World Meteorological Organisations (WMO) Interest in Antarctica***

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At the 4 yearly WMO congress meeting in Geneva in June last year the seven priorities for 2016-2019 were decided. One of these was Polar and High Mountain regions where the WMO says it want to “improve operational meteorological and hydrological monitoring, prediction and services in polar, and high mountain regions, where the scale of environmental change has significant implications on weather and climate patterns worldwide”

This poster will look at the areas of interest that the WMO has in Antarctica and look at the Global Cryosphere Watch (GCW), the activities of the Antarctic Task Team (ATT) within the WMO's Panel of Experts on Polar and High Mountain Observations, Research and Services (EC-PHORS) and the work being done for the Year Of Polar Prediction (YOPP).

## **S18. Subglacial geology and significant events in the geological evolution of Antarctica**

### ***"South Georgia microcontinent: Preliminary results of RVIB Nathaniel B. Palmer cruise 1408"***

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South Georgia, a rugged, mountainous island, is the emergent part of a microcontinent ca. 375 km long and 175 km wide located near the eastern end of the North Scotia Ridge. It is over 1500 km east of Isla de los Estados, the termination of the Andean Cordillera at the southeasternmost tip of South America. Comprising Lower Cretaceous turbidites, including a formation with dominantly siliceous detritus, an ophiolitic complex, Mesozoic granitic plutons and calc-alkaline arc volcanics, it is clearly not a typical oceanic island. Prior to plate tectonics it was an enigma in the same sense as the crustal blocks of West Antarctica and the Falkland/Malvinas Islands block. During the 1970's, through mapping on the island as well as in southernmost South America, it was determined that the geology of South Georgia exactly matches that of the Andean hinterland to the south of the Beagle Channel in Tierra del Fuego. Moreover, it was noted that with the South Georgia microcontinent restored to the embayment in the South American continental margin immediately east of Cape Horn there is an obvious source, the Upper Jurassic rhyolitic Tobifera Formation, for the siliceous detritus in the Lower Cretaceous turbidites of the Sandebugten Formation on the northeastern coast of the island. A source is conspicuously absent at its present day location. An alternative was proposed in 2010, namely the southeastern corner of the Falkland/Malvinas Plateau to the NNE of the islands present location, but recent U-Pb detrital zircon studies have confirmed the status of the microcontinent as formerly a part of the Andean Cordillera in Tierra del Fuego.

In other senses, however, the island and its surrounding microcontinent remain enigmatic. How did it reach its present location over 1500 km east of the tip of the Andes in eastern Tierra del Fuego, and when? How did it reach its present height of ca. 3 km, which is three times as high as the mountains in Tierra del Fuego from which it was separated? What role did the island and subjacent microcontinent play in the onset and development of the Antarctic Circumpolar Current? Cruise 1408 of the United States National Science Foundation's RVIB Nathaniel B. Palmer, 22 September – 22 October 2014, was planned with these questions in mind. They will be addressed in the presentation which will include preliminary interpretation of the first multi-channel seismic lines obtained across the margins of the microcontinent.

# ***A long-lived, composite and migrating accretionary orogen revealed from geophysical imaging in Northern Victoria Land, East Antarctica***

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Accretionary orogens typically include supra-subduction zone forearc, magmatic arc and back-arc segments. Retreating accretionary orogens undergo long-term extension that facilitate back-arc and intra-arc basin development, while advancing orogens often comprise fold and thrust belts.

Here we focus on the Northern Victoria Land (NVL) segment of the Cambro-Ordovician Ross Orogen in East Antarctica, where considerable debate centres on postulated terrane accretion processes linked to long-lived subduction along the paleo-Pacific margin of Gondwana. New aeromagnetic and gravity data compilations are used here as a tool to investigate subglacial geology and the deeper crustal architecture hidden beneath the exposed parts of this accretionary orogen.

Prominent aeromagnetic anomalies characterise the eastern edge of the Wilkes Subglacial Basin (WSB) and reveal a major tectonic boundary separating it from the western Wilson Terrane (WT). A largely unexposed early-Ross arc terrane that may have docked against the WT has been proposed as a source for these anomalies (Ferraccioli et al., 2009- Tectonophysics). Zircon U–Pb dating over exposures of gabbro-diorites within the Prince Albert Mountains broadly supports the hypothesis for a ca 530 Ma early-Ross age arc in the region. However, based on our comparisons with the Curnamona Craton in Australia, the longer-wavelength anomalies may additionally relate to hitherto unrecognised buried Paleo to Mesoproterozoic basement. In this scenario, early-Ross arc magmatism may have intruded into a pre-existing basement high. This may in turn have formed a backstop for the late-Ross fold and thrust fault belt typical of the WT, which does not appear to extend within the WSB.

Magnetic segments of the Ross-age arc are also identified ca 150 km further to the east. We propose that these arc segments were originally closer to each other. Intra-arc and back-arc transtensional processes may have separated the western and eastern arc segments of the WT in an overall retreating Early Cambrian accretionary setting. This hypothesis is attractive, as it also creates the required accommodation space for the development of thick Cambrian sedimentary basins. Basin inversion and the development of a major thrusts and pop-up structures within the WT is attributed here to a later intraplate transpressional stage (ca 490–460 Ma) during an advancing orogenic stage.

Enhanced magnetic images and 3D inversions reveal un-suspected linkages between the Exiles Thrust within the western WT and the Lanterman Fault, a contested suture between the WT and the Bowers Terrane (BT). Rather than a far-travelled intra-oceanic island arc origin for the BT, the WT-BT regions could have formed part of an evolving arc, forearc, back-arc segment of an accretionary system, which was in part dismembered by strike-slip motion, as typical in oblique subduction settings.

Overall, our new geophysical interpretation indicates that NVL hosts the remnants of a long-lived, composite and evolving accretionary orogen, which likely migrated in response to changes in the geometry and dynamics of the subduction system and included back-arc, arc and forearc components as well as rifted-off Precambrian basement ribbons.

# ***Bathymetric features in west Antarctic Peninsula fjords, implications for glacial ice behavior***

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Submarine glacial geomorphic features have been found in the inner shelf and in fjords in the western Antarctic Peninsula. Similar features have been mapped in other glaciated environments and in the Antarctic continental shelf giving insight into the glacial history of each region. We present multibeam swath bathymetry data collected in several fjords in the Antarctic Peninsula; from the South Shetland Islands, Maxwell Bay and Admiralty Bay, to Anvers Island, Lapeyriere Bay and Fournier Bay, and along the western side of the Antarctic Peninsula, Charlotte Bay, Andvord Bay, Flandres Bay, and Beascochea Bay. We also include a comparison between the geomorphology and bay geometry, glacier catchment areas, lithology, and recent ice front velocities. We map the geomorphic features in fjords and compare the submarine geomorphology to fjord characteristics. Our ultimate goal is to understand the controls of ice flow behavior in each location. Multibeam soundings were collected using a Simrad EM120 12 kHz swath profiler, consisting of 191 beams. The survey data were corrected for anomalous readings and edited to create relief maps with a resolution of 20 meters. The bathymetric features found include grounding zone wedges, drumlins, glacial lineations, and meltwater channels. These landforms differ in size and distribution from those found in the Antarctic continental shelf, possibly resulting from varying bay geometries and rugged seafloor. Geomorphic features present also differ between fjords. Maxwell Bay and Admiralty Bay, the northernmost study areas, are characterized by a relatively flatter seafloor than other fjords at more southern latitudes. In the northern fjords, there is a high probability that the submarine landforms have been buried by post-glacial sediment deposition. The distribution of landforms in bays is complex and does not follow consistent patterns, suggesting that each fjord has a different glacial retreat history. Multiple grounding zones were found in fjords implying episodic retreat and possibly glacier readvances. The location of grounding zone wedges correlates to narrow and/or shallow areas of fjords, demonstrating the control of fjord geometry on ice retreat. The drumlins found have low elongation ratios and were not found in large assemblages, and glacial lineations are shorter in average than those found in the continental shelf. Meltwater channels are only present in the southern fjords indicating the occurrence of subglacial meltwater, although no indication of modern meltwater erosion was observed.

## ***Cenozoic geodynamic evolution of Tierra del Fuego (Northwestern Scotia Arc) from fracture population analysis***

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Tierra del Fuego represents the northwestern branch of the Scotia Arc and its largest emerged sector. It comprises the southernmost segment of the Andean Cordillera that forms a regional orogenic reentrant arc with a NW-SE to E-W trend commonly referred to as the Patagonian orocline. The main objectives of this research are: (i) Characterizing the different Cenozoic palaeostress fields in Tierra del Fuego region and (ii) Establishing the relationship between the evolution of major tectonic structures and the orientation of the stress fields. To do that, 1496 faults, joints, tension gashes and clastic dikes were measured at 87 sites located in Upper Jurassic to Quaternary rocks. A total of 124 palaeostress tensors were obtained using the Right Dihedra, the y-R diagram, the Etchecopar's and the Search Grid Inversion Palaeostress determination methods. Although the tectonic analysis was primarily based on palaeostress reconstructions using fault-slip data, the orientation of tensional joints, gashes and clastic dikes have also been used to establish maximum and minimum horizontal stress trends.

From the stress axes directions, a dominant NE-SW  $\zeta 1$  (maximum compression) direction as well as NW-SE and N-S secondary  $\zeta 1$  stress directions are observed. The  $\zeta 3$  (minimum compression) orientation shows two main modes trending ENE-WSW and NW-SE, and three secondary  $\zeta 3$  stress directions (NE-SW, E-W and NNW-SSE). The R relationship of the NE-SW  $\zeta 1$  mainly indicates an axial compression to wrench regime. The NW-SE and N-S horizontal main stress directions have an R relationship ranging from axial compression to tensional regime

Obtained stress evolution is consistent with the regional NE-SW compressive stress field active in the area since Lower Cretaceous.

The NE-SW subduction of the Phoenix Plate under Antarctica and South America plates at the end of the Lower Cretaceous is related with a major episode of crustal shortening, which led a widespread folding and faulting to the Tierra del Fuego basement with a structural trend N-S to NW-SE. During the Upper Cretaceous started the closure of the Rocas Verdes back arc basin, developed in the Middle-Upper Jurassic in relationship with the Gondwana fragmentation, linked to the progression of the contractional deformation with NE-SW direction. This closure could have produced a maximum regional counterclockwise rotation of 30° that developed the Patagonian orocline, and arranged the NW-SE structures to an E-W direction. The final structural curvature may have been acquired due to the interaction of the orogenic wedge with the Río Chico promontory during Upper Cretaceous-Oligocene. The promontory indentation caused a variation in the trend of the compressive stress axis along the Tierra del Fuego, showing NE-SW direction in the western part and N-S to NW-SE in the eastern sector. Finally, since late Miocene, the activity of the North Scotia Ridge provokes strike-slip faulting in Tierra del Fuego that deflects the NE-SW stress trajectories changing to E-W direction near of the major Magallanes-Fagnano Fault System.



# ***Coexisting mylonite and pseudotachylyte-pulsating change in rate of strain: Evidence from the Veteheia nunatak, CDML, East Antarctica***

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The spatial association of pseudotachylytes with mylonites, though apparently incompatible, is reported from some ductile shear zones. In some cases it is interpreted that the pseudotachylytes are formed at a late stage where mylonites are brought at a higher crustal level by erosion or upliftment that facilitates brittle deformation. Pseudotachylytes are also reported to have developed simultaneously along with mylonites during progressive ductile deformation.

The enderbitic gneisses on the western flank of Veteheia nunatak (in close proximity to Schirmacher Oasis) exhibit shear deformation. A 3-4 meter wide subvertical discrete shear zone (N20°W-S20°E trending) is located within the enderbitic gneisses. This shear zone cuts across the dominant D<sub>2</sub> Schirmacher shear plane (N60°E-S60°W) which may attribute to the retrogressive event represented by amphibolite facies (M<sub>2</sub>) condition. The kinematic indicators indicate a predominant sinistral sense of strike-slip movement along this discrete shear zone. The enderbitic gneisses are affected by the shear with varying intensity resulting in different textures, micro-structures and grain size refinement. Enderbitic gneisses are converted to mylonites as a result of crystal-plastic deformation in the shear zone. In contrast, there are localized zones of brittle failure with frictional heat generation exemplified by the development of thin but conspicuous bands and veins of pseudotachylytes, which are emplaced mostly sub-parallel with or at times transgressing the C-planes of the mylonites. Synchronous development of mylonite-pseudotachylyte during progressive ductile deformation or a two stage model for their development is a subject of discussion. The geometry and kinematics of this discrete shear zone indicate that this could be the last major deformational event in this area. This is significant in the quest for the cause of formation of the mylonite and pseudotachylyte.

Some authors suggested gradual tectonic upliftment along the shear zone to be the cause of simultaneous development of mylonite and pseudotachylytes in certain areas. But, the dominantly strike slip nature of movement in this discrete shear zone of Veteheia nunatak rules out such a possibility. It can be concluded that near synchronous development of these two deformational features occurred more or less at the same crustal depth and perhaps at the same P-T condition. Whereas, the cataclasis of the host mylonitic rock could have been take place after reactivation indicate reactivation of the shear zone during a later tectonic event.

The prominent influencing factor appears to be the variation in strain rate along the movement planes (C-planes) as a result of increasing differential stress. The occurrence of pseudotachylytes mostly along the C-planes also corroborates the idea of localized higher strain rates.

Thus, in the discrete shear zone in Veteheia nunatak in comparison to Schirmacher shear plane, pulsating change in the rate of strain in this dominant ductile deformation regime can be the cause for the development of two otherwise mutually exclusive phenomena i.e. mylonites and pseudotachylytes. Such presence of pseudotachylyte is first time reported from the Schirmacher Oasis area of central Dronning Maud Land, East Antarctica.

# ***Effective elastic thickness over the Transantarctic Mountains and Ross Sea and its implications for lithospheric structure***

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The effective elastic thickness ( $T_e$ ) is a proxy for lithospheric strength and primarily depends on its thermal gradient and composition. Accordingly, the spatial variations of  $T_e$  reflect lithospheric properties and further help us to understand its structure and deformation. In this paper, we investigate the Transantarctic Mountains and Ross Sea in terms of  $T_e$  by using gravity and topography data based on fan wavelet transform technique. The results reveal that relatively high- $T_e$  values dominate in the Victoria Land and Ross Sea while the  $T_e$  values are very low in the Transantarctic Mountains Front and deep ocean basin, in which the lowest  $T_e$  value occurs in the Ross Island, Iselin Bank and onshore Northern Victoria Land. In addition, we find the spatial variations of  $T_e$  correlate well with lithospheric structure at regional scale. By combining with published seismic and heat flow data, we suggest that the anomalously low and coast-parallel  $T_e$  values reflect the lithosphere beneath the Transantarctic Mountains Front becomes extremely weak due to volcanism and rifting in late Cenozoic and possible modern activity. The  $T_e$  values increase monotonously from Transantarctic Mountains Front (7 km) to its landward side (>80 km) which indicates the continental lithosphere underlying Victoria Land belongs to be the classic Gondwana craton. The gradual transition in  $T_e$  reflects Transantarctic Mountains Front appears to mark the free boundary between East and West Antarctica. The  $T_e$  values in the continental shelf of Ross Sea change subtly, averaging about 35 km. We interpret the relatively high  $T_e$  values in the continental shelf to indicate the lithosphere becomes cooler at the time of sediment filling in late Eocene-Neogene than late Cretaceous extension.

## ***Erosion-driven uplift in the Gamburtsev Subglacial Mountains of East Antarctica***

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The relative roles of climate and tectonics in mountain building have been widely debated. Central to this debate is the process of isostasy, and in particular flexural uplift in response to valley incision. Here we quantify the amount of erosion-driven peak uplift in the Gamburtsev Subglacial Mountains of Antarctica. Previous studies indicate that rifting and strike-slip tectonics may have provided a key trigger for the initial uplift of the modern Gamburtsevs at ca. 250 Ma and 100–70 Ma respectively (Ferraccioli et al., 2011 Nature), but the 3D effects of more recent valley incision remain to be quantified. Inverse spectral (free-air admittance and Bouguer coherence) methods indicate that, unusually for continents, the coherence between free-air gravity anomalies and bedrock topography is high ( $>0.5$ ) and that the elastic thickness ( $T_e$ ) of the Precambrian lithosphere of interior East Antarctica is anomalously low ( $<20$  km). The low  $T_e$  values we find contrast with previously reported values of up to 70 km for the Gamburtsev Province that were derived from other methods of  $T_e$  estimation, which include seismic constraints on Moho depth and lower crustal loads (Ferraccioli et al., 2011 Nature). The isostatic effects of two different styles of erosion are quantified: dendritic fluvial incision overprinted by Alpine-style glacial erosion in the Gamburtsevs and outlet glacier-type selective linear erosion in the Lambert Rift, part of the East Antarctic Rift System. 3D Flexural models indicate that valley incision has contributed ca. 500 m of peak uplift in the Gamburtsevs and up to 1.2 km in the Lambert Rift, which is consistent with the present-day elevation of Oligocene–Miocene glaciomarine sediments (Hambrey & McKelvey, 2000 Geology). Our models show that the magnitude of estimated peak uplift in the Gamburtsevs is not very sensitive to  $T_e$ . Overall, we find that 17–25% of Gamburtsev peak uplift can be explained by erosional unloading. These relatively low values are typical of temperate mountain ranges, suggesting that most of the valley incision in the Gamburtsevs occurred prior to widespread glaciation at 34 Ma. The pre-incision topography of the Gamburtsevs lies at 2–2.5 km above sea-level, confirming that they were a key inception point for the development of the East Antarctic Ice Sheet. Tectonic and/or dynamic topography (O'Donnell & Nyblade, 2014 EPSL) processes were responsible for ca. 80% of the modern Gamburtsev Subglacial Mountains' elevation.

## ***Geophysical survey progress with AWI aircraft since 2014***

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Polar 5 and Polar 6, the Alfred Wegener Institute's two multi-purpose polar research aircraft, were configured for and completed geophysical surveys in widespread Antarctic locations in the seasons 2013/14, 2014/15 and 2015/16. Two flights in late 2013 form the start of a survey over the eastern Enderby Basin off Prydz Bay. The magnetic data confirm the presence of M-Series anomaly isochrons in the basin. A larger programme of nearly 30 flights at 10 km spacing completed in the second part of the 2013/14 season and throughout the 2014/15 season concentrated on the regions around and to the east and south of eastern Sør Rondane. The magnetic anomaly data have been interpreted in terms of the accretion and amalgamation of Tonian-aged arc terranes to form the interior of Gondwana in late Proterozoic and early Phanerozoic times. Gravity data collected with a LaCoste and Romberg AirSea gravimeter in 2013/14 and AWI's new Gravimetric Technologies GT2A gravimeter in 2014/15 reveal the topographic variability of the sub-ice surface in greater detail than the existing 20 km-spaced Russian radar and gravity data collected in the early 1990s. A broad subglacial channel separates eastern Sør Rondane from the Yamato Belgica Mountains, whereas further south the data reveal a dendritic pattern of subglacial valleys that converge towards the SW. Initial processing of new radar data from the 2013-15 surveys is underway and will complement the gravity data with accurate depth information about the sub-ice surface, enabling the computation of further anomalies to highlight crustal structure and enable tectonic interpretations. In 2015/16, Polar 5 operated out of Neumayer base, collecting around 50 hours of new magnetic data that begin the task of tightening the spacing of existing survey data over the Forster Magnetic Anomaly, suggested in the literature to represent a suture between the Grunehogna craton and the Tonian aged arc terranes in the east, from 10 km to 5 km. Two further flights concentrated on a high-resolution (2 km spacing) survey of the Ekström ice shelf to the west and south of Neumayer base, primarily intended to generate a gravity anomaly data set that will be used to model the underlying bathymetry.

## ***Intraplate earthquakes in East Antarctica outline potential 'rifts' adjacent to the Gamburtsev Subglacial Mountains***

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East Antarctica is largely composed of a stable craton and therefore undergoes limited deformation as indicated by geodetic data. Although it has long been thought that East Antarctica does not experience significant seismicity, a few relatively small teleseismic events have been detected over the past 25 years. The AGAP/GAMSEIS project, a temporary seismic network of 26 broadband seismographs operated for the entire year of 2009, document 27 well-constrained seismic events (Mw 1.70-3.44). Event depths indicate that the majority of these events occur well within the crust, and are thus tectonic in origin. More than 20 of the 27 events located in East Antarctica occur below subglacial topographic depressions that flank the Gamburtsev Subglacial Mountains (GSM). The most striking examples are events that correlate with subglacial basins between the GSM and Vostok Subglacial Highlands (VSH) that form a linear feature connecting the Polar Subglacial Basin with the Lambert Graben. This is one of the features termed 'rifts' by Ferraccioli et al. (2011). This area also represents a line of demarcation in gravity anomalies, with Bouguer anomalies are high in the 'rift' compared to the GSM and VSH whereas free air anomalies show the opposite pattern (Ferraccioli et al., 2011). Mantle velocities are also distinct between the two regions with 'rift' areas characterized by slow mantle velocities compared to the faster velocities beneath the GSM and VSH (Heeszel et al., 2013; Lloyd et al., 2013). This topographic feature is possibly a terrain boundary between the Mawson Craton and the Crohn Craton (Boger, 2011). However, the seismicity we observe is also reminiscent of that observed in failed continental rift settings such as the Mississippi Embayment. With only the earthquakes recorded in the course of one year it is impossible to state empirically whether the recorded seismic events outline an ancient continental rift (which connects to the known Lambert Rift), a terrain boundary, or perhaps an example of Phanerozoic rifting coinciding with an ancient terrain boundary suture. In order to better constrain the most likely tectonic situation we calculate first motion double couple focal mechanisms for events with impulsive body wave arrivals and adequate azimuthal station coverage. Preliminary results indicate fault plane solutions are primarily oriented parallel or subparallel to the strike of the linear feature connecting the Polar Subglacial Basin to the Lambert Graben. The majority of focal mechanisms indicate extensional faulting along the 'rift' features. With the limited current data we are unable to fully constrain the tectonic model but propose these events are intraplate earthquakes occurring along zones of weakness associated with a failed continental rifting episode during the Carboniferous through the Cretaceous, likely along an ancient terrain boundary suture.

## ***Late Miocene littoral microfossils from the Fisher Massif, Prince Charles Mountains, East Antarctica***

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Glaciomarine sediments of the Fisher Bench Formation in the Prince Charles Mts. yielded discontinuous record of Miocene diatoms and rare horizons of shell hash (Gogorev & Pushina 2014). During the 53rd Russian Antarctic Expedition in 2008, two penguin bones and a single shell of a pectenoid bivalve were found by a Russian-Polish team in one horizon in the lower part of the formation. The shell was  $^{87}\text{Sr}/^{86}\text{Sr}$  dated at 10.2 Ma indicating an early Late Miocene age (Jadwiszczak et al. 2013). A small piece of sandy sediment matrix attached to the shell was found to be rich in calcareous and siliceous microfossils, including abundant diatoms and foraminifera associated with juvenile pectenoids, fragmented echinoids, ostracods, gastropods, as well as a fish tooth. Diatom assemblage is composed predominantly of *Achnanthes*, *Amphora*, *Cocconeis*, *Hyalodiscus*, *Odontella* sensu lato; occasional resting spores of *Chaetoceros* also occur. However, the most abundant diatom genus is *Saeptifera*, represented by five species that are endemic for the Antarctic. Their type locality is the Fisher Massif (Gogorev & Pushina 2014). The foraminiferal assemblage is strongly dominated by *Rosalina*, associated with much less numerous *Nonionella*, *Ammoelphidiella*, *Buccella*, and only single individuals of other foraminifera. They are the only Miocene foraminifera reported from East Antarctica. Diatom and foraminiferal assemblage taxonomic composition and population structure indicate shallow-water, littoral paleoenvironment.

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## ***Linking subice geology and geophysics- preliminary observations from a segment of Princess Elizabeth Land***

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Rocks underneath East Antarctic Ice Sheet (EAIS) possess concealed geological history which can be traced back to Archaen. Princess Elizabeth Land (PEL) is one portion of this amalgamated East Antarctica, whose affinity and resemblance to any other continent is not well defined. Rock exposures are available only along small parts of the coast and some isolated nunataks.

Lambert Graben, a ~100km wide rift, defines its western limit. The rift infill Permian-Triassic rocks of the Lambert Bay itself are thought to be continuous with either the Mahanadi-Gondwana basin or the Godavari Valley-Gondwana basin of India. However, matching ground geology with either of these fits requires knowledge of geology on either side of the Lambert Bay near the coast which is under permanent ice cover.

The Lambert Bay cross-cut three distinct terranes, viz., the Archean-Mesoproterozoic terrane, the Grenvillean terrane and the Pan-African terrane, each linked with a global orogenic cycle. The boundaries of these terranes and their continuation below continental ice shelf are debatable and remain conjectural.

The eastern part of the PEL is occupied by Late Archean Vestfold Hills and the Rauer Group. Vestfold Hills do not have rocks older than 2.6 Ga. Again, Rauer Group has only very limited known exposure of Late Archean rock and is strongly affected by Grenvillean and Pan-African metamorphism.

The area in between the Lambert Bay and Rauer Group exposes an ensemble of orthogneiss and paragneiss for about 200 km along the coast till the Rauer Islands and Vestfold hills in the NE. This ensemble of orthogneiss and paragneiss bear evidence of at least two granulite facies metamorphic events, one Late Mesoproterozoic-Early Neoproterozoic or Grenvillean and the other Late Neoproterozoic-Early Cambrian or Pan-African. It is debatable whether the orthogneiss and the paragneiss represent a basement-cover relationship or a cover intruded by later magmatism. Each of these granulite facies events has been modeled by various workers to be related to past collisional events related to formation of either Rodenia or Gondwana. Both these models remain speculative in nature because of absence of supporting geological features. Also, these collision models do not portray reliable continuation of orogenic belts beyond the PEL.

Recent studies indicate high geothermal flow in coastal rock exposures in PEL attributed to high percentages of U, Th and K in Cambrian-aged granites and pegmatites. Similar high heat production values have been reported in Mahanadi Graben in India. Several questions are still unanswered about this anomalously high heat values and radioactivity. The variable heat flow of the subice lithology and its interpretation in terms of subglacial geology has a bearing on long-term ice sheet behaviour.

ICECAP-2 (International Collaborative Exploration of Central East Antarctica through Airborne geophysical Profiling) provides an opportunity to obtain the missing link of sub-ice geology through geophysical signals to provide corroborating data to test these models. Field and petrological data from a segment of area covered by airborne geophysical survey will be discussed in the present work in this context.

## ***Neoproterozoic (~900Ma) to late Cambrian (~490Ma) crustal evolution of Fisher Island, Larsemann Hills, Prydz Bay: Implications on collisional orogeny-East Gondwana assembly.***

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The whole package of rocks belongs to a 935-486 Ma deep crustal section exposed in the Fisher island, Larsemann Hills, Prydz Bay, East Antarctica. The rocks of Fisher Island have experienced three phases of metamorphism namely M<sub>1</sub> - M<sub>2</sub> (prograde) and M<sub>3</sub> (retrograde). The M<sub>1</sub> phase is constrained by the texture such as development of ilmenite along biotite thus suggesting a near isobaric heating event in the garnetiferous gneiss. The peak metamorphism is characterised by the stability of the mineral assemblage: garnet+sillimanite+quartz+ cordierite+ ilmenite+spinel with K-feldspar and plagioclase in metapelite which clearly indicates a high temperature granulite facies condition. The imprints of retrograde metamorphism are strongly depicted by the inclusion assemblages, corona and symplectitic intergrowth of mineral phases. The peak metamorphic (M<sub>2</sub>) P-T in pyroxene granulites and enderbite are 870°C at 6.2 Kb and 865°C at 6.5 Kb respectively.

The retrograde path is defined by the isothermal decompression due to exhumation (uplift) after reaching the peak (granulite facies) followed by isobaric cooling to lower amphibolite facies metamorphic conditions. The post peak retrograde phase represented by the isothermal decompression commenced at the late stage of 550 Ma and continued till ~486 Ma to isobaric cooling phases.

U-Pb-Th chemical dating of monazite grains reveal that the prograde isobaric heating event might have been triggered at the end of Grenvillian Orogeny (~850-900Ma) where heat budget was supplied by the process of crustal thinning and continued up to 583 Ma to reach the peak stage whereas the high P-T condition might have been sustained by the crustal rejuvenation through collision tectonics during Pan-African Orogeny.

The crustal evolution of Fisher island might have commenced through less fertile protolith of metabasite granulite just at the end of Grenvillian Orogeny (~900Ma). The rejuvenation of the crust by the Pan-African event (during 600-500Ma) might have influenced the supply of the new material for crust formation. It can be inferred that the segregated melt (I or S -type granitoids) generated at different crustal levels from the metabasite/metapelite sources could have given rise to the garnetiferous gneiss and sillimanite-cordierite gneiss (metapelite) of the Fisher island.

The shape of the P-T-t-d path provides an indication of the tectonic processes involved in the formation and evolution of the granulites in the study area. The relatively high peak P-T conditions followed by decompression of 2-3 kbar inferred from the granulites in the Fisher Island indicate a considerable crustal thickening subsequently followed by tectonic uplift and unroofing during the Cambrian orogeny. This scenario is consistent with the widespread development of contemporaneous compressional and subsequent extensional deformation in the Prydz Bay. The intrusion of voluminous syn to post orogenic granitoids (Progress Granite) in the belt, particularly the widespread distribution of garnetiferous-granite-granodiorite gneiss and pegmatites in the Fisher Island suggests that lithospheric delamination and asthenospheric upwelling could have occurred during post-collisional extension. Coupled with the evidences of field observations as well as analytical data, we favour the suggestion that the Prydz Bay represents a collisional orogen that resulted from the assembly of Gondwana during Cambrian times.



## ***New aerogeophysical data - Additional evidences of riftogenic crust in eastern princess Elizabeth land, east Antarctica***

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Analysis of radio-echosounding and RADARSAT mosaic data reveals at least 500 km long structure called the Gaussberg rift over the eastern part of Princess Elizabeth Land, East Antarctica. New Russian ice penetrating radar data shows that the floor of the central depression placed more than 1000 m below sea level. Horsts and grabens are heavily dissected by N-S running transverse lineaments that were discovered by analysis of ice surface satellite imagery.

High-quality aeromagnetic data show that outstanding changes of the magnetic anomaly patterns observed in vicinity, along strike and over shoulders of the inferred Gaussberg rift are thought to have the tectonic origin. Abrupt disappearance of the long-wavelength high-intensity magnetic anomaly belt with a number of short-wavelength anomalies associated with eastern boundary of the Vestfold-Rauer cratonic block in vicinity of western depression can't be explained simply by subglacial erosion. In our interpretation, these changes of magnetic anomaly pattern apparently associated with development of regional fault zones during initial stages of rifting.

The Mount Brown horst is clearly evident in magnetic data as an area of concentration of high-intensity anomalies with amplitude up to 1575 nT. The observed trends are in agreement with the strike of the metamorphic rocks in Mount Brown, which experienced c. 980–920 Ma high-grade metamorphism. This suggests that this area experienced the Rayner Orogeny, distinguished in Kemp Land and the northern Prince Charles Mountains and may represent suspect suture of the Mesoproterozoic age, as evidenced by new date for Mount Brown mafic rocks at c. 1480 Ma.

Depth-estimates of magnetic anomaly sources indicate that the central depression of the rift is likely underlain by a 3-5 km thick sedimentary basin, thereby supporting our idea of existence of riftogenic structure in the eastern part of Princess Elizabeth Land. Crustal two-dimensional modelling by using gravity data also shows over 4 km deep sedimentary basins beneath central depression of the rift.

Linear short-wavelength anomalies of low amplitude developed over horsts and grabens are interpreted to be responsible for the Pan-African mega-scale shear zone system of Princess Elizabeth Land. The distinguished length of this curvilinear feature exceeds 900 km, while it might be extended up to the Leopold and Astrid Coast, where similar linear anomalies with NE-SW trend are recognised. The early Paleozoic shear zone with NE-SW trend is collinear with orientation of the Gaussberg rift thereby contradicts to the idea that ca 500 Ma event is concentrated along coastal regions and attenuated inland. This idea based on extensive indications of a ca 500 Ma event in coastal areas (granitoid intrusions in Mirny Oasis and inherited zircons found in Gaussberg volcano), together with the lack of indications of this age in Mount Brown. The mega-scale Princess Elizabeth Land shear zone has fundamental implications in terms of tectonic inheritance and intraplate strain localization for later reactivation linked to development of the Lambert and Gaussberg rifts and rifting and intraplate strike-slip motion in interior of East Antarctica before and during Gondwana break-up.

## ***New aerogeophysical survey explores the South Pole Frontier***

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Despite recent advancements in airborne geophysical research over Antarctica, the South Pole region has remained one of the largest “poles of ignorance” of the entire continent, as very little data have been acquired here since pioneering reconnaissance surveys performed in the 1970’s (Drewry, 1983). A modern aerogeophysical survey was flown by the University of Texas in the late 1990’s and provided a unique glimpse into subglacial geology inland of the Transantarctic Mountains in particular over the South Pole subglacial basin region (Studinger et al., 2006 EPSL).

The South Pole area is currently receiving heightened attention in the geosciences community in light of potential future efforts to drill in the region to try and recover > 1.2 Ma old ice and if feasible drill to the bedrock to help constrain the currently largely unknown subglacial geology of the composite East Antarctic craton in the region.

During the 2015-2016 Antarctic campaign a major aerogeophysical survey comprising new radio echo sounding, laser altimetry, airborne gravity and aeromagnetic data collection was flown over the South Pole region as part of our PolarGAP project, supported by the European Space Agency. The main aim of the survey was to provide key missing airborne gravity datasets required to fill in the major data void in GOCE (Gravity Field and Steady-State Ocean Circulation Explorer) satellite gravity data coverage south of ca 83.3°S to augment global gravity modelling.

Here we present the first products derived from this survey, including preliminary ice thickness, bedrock topography, and gravity and magnetic anomaly images for the region. We focus in particular on some of the major open geological questions that the new datasets will help address, such as: 1) what is the extent and origin of the Pensacola/Pole subglacial basins that lie in the hinterland of the Ellsworth/Whitmore and Transantarctic Mountains region?; are these basins merely the result of Cenozoic lithospheric flexure linked to the uplift of these ranges along the flank of the West Antarctic Rift System, or are these basins linked to major tectonic features related e.g. to the Jurassic basins of the Weddell Sea Rift System and major Jurassic strike-fault systems recently proposed at the edge of East Antarctica (Jordan et al., 2013- Tectonophysics)?; 2) is there evidence for a continuation of the recently proposed Paleo to Mesoproterozoic South Pole igneous province inferred from satellite magnetic imaging and neighbouring AGAP aerogeophysical data (Ferraccioli et al., 2011- Nature) in the region? and, if so, where are and what is the nature of its boundaries with the Recovery Province?; 3) are there major fault-controlled sedimentary basins in the region? and, if these basins do exist, do these exert significant geological controls on enhanced ice sheet flow observed far in the interior of East Antarctica in the South Pole frontier (e.g. Bingham et al., 2007- JGR)?

## ***New magnetic and gravity compilations help trace East Antarctic crustal provinces from the Shackleton Range to Dronning Maud Land***

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The sector of East Antarctica between the Shackleton Range and Dronning Maud Land is key for geological reconstructions of Antarctica and for establishing its linkages with Rodinia and Gondwana supercontinental evolution. In the Shackleton Range ~500 Ma ophiolites (Talarico et al., 1999- Terra Antarctica), high-P metamorphism, including a rare occurrence of eclogite facies rocks (Schmädicke and Will, 2006- Geology), and thrust faults suggests that a major suture zone separates the Coats Land Block (Loewy et al., 2011- Geology) from the proposed northernmost edge of the Mawson Continent (Will et al., 2010- Prec. Res.).

The ca 1130 to 1040 Ga Maud Belt lies in between the Coats Land Block and the Grunehogna Craton and these in turn link with the Namaqua-Natal and Kalahari craton of South Africa respectively. The 650-500 Ma East African-Antarctic Orogen was a major event that reworked several older crustal domains identified in Dronning Maud Land and is also generally thought to be linked to processes of collision between East and West Gondwana.

Here we combine extensive aeromagnetic (e.g. Mieth and Jokat, 2014- Prec. Res.) and airborne gravity datasets collected over the Dronning Maud region including the latest surveys performed in 2013 and 2014 to the south over the largely ice-covered Recovery and Slessor glacier catchments to provide new geophysical perspectives on this part of East Antarctica.

Aeromagnetic anomaly patterns enable us to trace the extent of Grenvillian-age arc terranes in the interior of East Antarctica. They also reveal the subglacial extent of widespread rift-related Keweenawan-age igneous rocks from their small exposures in Coats Land, and that have been interpreted as possible remnants of the Mid-Continent Rift System of Laurentia (Loewy et al., 2011).

The combination of enhanced aeromagnetic and gravity images reveals that the Shackleton Range suture extends at least 500 km into the interior of East Antarctica and suggests that it may change orientation from E-W to ca N-S in the Recovery Lakes region. Aerogeophysical data coverage is poor further in the interior but satellite gravity data suggest that a major lithospheric boundary separates much thicker crust underlying the recently proposed Tonian Oceanic Arc Superterrane of eastern Dronning Maud Land (Jacobs et al., 2015- Prec. Res.) from the thinner crust of the Recovery block (Ferraccioli et al., 2011- Nature).

Our interpretation maps derived from enhanced potential field imaging suggest the occurrence of complex anastomosing crustal-scale shear zones similar for example to major Pan-African-age shear zones like the Anza Shear Zone in Africa. The picture that is emerging is that this part of East Antarctica is a collage of crustal provinces criss-crossed by crustal-scale shear zones, which were imposed upon pre-existing block/terrane boundaries. It is therefore likely that both weaker and stronger crustal blocks exist in interior East Antarctica and that these responded differently to the effects of Pan-African-age collision and transpression, much like what is observed in several modern collisional systems (e.g. Jacobs and Thomas, 2004- Geology).

## ***Oldest record of nothofagus leaves in Nelson Island, South Shetland Islands, Antarctica: Implications for biogeography***

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Fieldwork in a Campanian locality at Rip Point, Stansbury Peninsula, Nelson Island resulted in the discovery of plant-bearing units contained Nothofagus leaf imprints, associated with ferns and angiosperm remains. The presence of Nothofagus, key genus of the modern sub Antarctic forests of New Caledonia, Queensland, New Zealand, Chile and Argentina, is the oldest record of well preserved and complete leaves in the world. The average size of the leaves is over 15 cm long, represented in at least three species. Previous work have been pointed a Lower Campanian age, that could explain the existence of megathermal leaves under a greenhouse interval. This new findings could be considered good evidence to discuss the center of origin and diversification of the group.

## ***Re-interpretation of geological evolution of Larsemann Hills, Prydz Bay in the context of supercontinent reconstructions***

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The geology of the Larsemann Hills in the Prydz Bay is in the focus of debates on whether it represents an orogenic belt related to ~1.0 Ga Rodinian or ~0.5 Ga Gondwanadian supercontinent. Paragneiss and orthogneiss present in the area both bear imprints one (high) medium pressure granulite event at ~1.0 Ga and the other low-pressure granulite event at ~0.5 Ga. Our new field observations, particularly in locations where geochronological data by earlier workers are available, are summarized below:

i. Mafic granulite/foliated amphibolites represent original mafic tuff/ volcanic and intrusive rocks.

They occur interlayered with laminated quartzite and felsic metavolcanics in scales of few millimeters to few tens of centimeters. We name it CMA unit (Chert-Mafic-Acid volcanic association)

and interpret it to have deposited in an oceanic setting. Comparing the locations of samples dated by early workers (Wang et al., 2008, Grew et al., 2012), the depositional age of this sequence is constrained at ~1.1 Ga.

ii. Protolith of the paragneiss includes greywacke, lithic arenite, ferruginous pelites and calcareous sediments that likely represent volcanogenic turbidites. They occur in close association and interlayered with the CMA unit and are thus cobasinal in origin.

iii. CMA unit and other metasediments show outcrop scale early isoclinal folds accompanied with intrusion of syntectonic leuco-granites (G2 Granites). These granites are described earlier as Grovness Orthogneiss, Blundell Orthogneiss, and Zhongshan Gneiss etc. Field evidences indicate that there is more than one phase of G2 granites. G2 granites are placed at ~1.0 Ga old with possible younger components at ~0.8 Ga (Wang et al., 2008, Grew et al., 2012). The ~1.0 Ga age is also recorded as the new zircon growth in mafic granulites of the CMA unit.

iv. The Paleozoic tectonothermal event is represented by SW vergent open to tight folds and pervasive intrusion of weakly foliated to non-foliated K-feldspar rich granites (G3 granites). The G3 granites occur as small plutons (like Progress Granite). Thus, the Prydz Bay area started with a (deep) oceanic basin at ~1.1 Ga in which cherts, mafic volcanic rocks and minor acid volcanic rocks deposited as inter-layered sequence. This oceanic basin also received volcanogenic turbidites. The volcano-sedimentary units suffered high to medium pressure granulite facies tectonothermal event at ~1.0 Ga. Further thermal event was at ~0.8 Ga though its effect is not much discernable. The Paleozoic (~0.5 Ga) tectonothermal event is represented by SW vergent open to tight folds, low-pressure granulites metamorphism and intrusion of massive granites. This event is likely caused by uplift and decompression of the whole sequence. The Prydz Bay area thus represents an accretionary basin of late Mesoproterozoic time that suffered high- to medium pressure granulite event during Grenvillian orogeny. Since the Paleozoic event is represented only west vergent folds, low-pressure granulites and decompression related granitic melts, the area unlikely represents portion of Gondwanadian suturing.

## ***Ross Ice Shelf seismic survey: Bathymetry, sediments and deeper structures***

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As one of three main gateways through which change in the ocean and atmosphere can be propagated into the interior of West Antarctica, it is important to understand the processes and process interactions that define how the Ross Ice Shelf (RIS) responds to change. Improved knowledge of the geological units underneath the RIS is required if that goal is to be met. Ice sheet models and the geological record point to widespread retreat under past warm climates. However, there is limited data available inland of the continental shelf on when and how quickly the ice retreated at the end of the last glaciation and on the current oceanographic setting. In November 2015, we conducted a seismic survey on the Ross Ice Shelf to aid in the positioning of a proposed hot water drilling site at which future expeditions will collect sediment cores and deploy an oceanographic mooring.

The active-source seismic survey, comprising four multi-channel seismic lines, was collected on the Ross Ice Shelf, approximately 300 km south of Ross Island. Over 45 km of data were collected using a purpose built, ski mounted 250-kg weight-drop seismic source and a 96-channel snow streamer. The main objective was to image seafloor sediments and resolve bathymetric details underneath a proposed hot water drilling site. The seismic survey was undertaken as part of Aotearoa New Zealand Ross Ice Shelf Programme funded by the New Zealand Antarctic Research Institute (NZARI).

Our seismic survey revealed that the seafloor in the target region is relatively smooth. Up to 100 m of layered sediments containing slight undulations are imaged beneath the seafloor. Underlying these units, there is evidence of more complex geological structures. Hot water drilling at this site will collect seafloor sediments during future field seasons. This seismic survey is the first conducted in this area, and provides a first glimpse of the seafloor geology at this location. Future sedimentary and geophysical studies will help to constrain geological interpretations in this poorly understood area of ice-covered continental shelf.

# ***Tectonic evolution of the Lanterman-Mariner Suture Zone, northern Victoria Land, Antarctica: insights from the structural and petrographic features***

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In northern Victoria Land, rocks and structures of the Ross Orogeny are well exposed; here the boundary between the Wilson and the Bowers terranes (i.e. two major lithotectonic domains) is known as the Lanterman-Mariner Suture Zone. Such suture encompasses discontinuous slices of rocks of varied provenance, that display different metamorphic evolution, from medium-P amphibolite facies to ultrahigh-P eclogite facies, with a late retrograde imprint at the transition amphibolite-greenschist facies. Therefore, the Lanterman-Mariner Suture Zone represents a tectonic melange, resulting from the accretion of an arc/back-arc system to the paleo-Pacific continental margin of Gondwana during the Ross Orogeny.

The focus of this work is on the Black Spider Greenschist and on the Sledger Group (Molar and Glasgow formations), occurring at the southern end of the Lanterman-Mariner Suture zone. The base of data are new structural observations, collected during the XIX (2003-04), XXI (2005-06), XXX (2014-15) Italian Antarctic Expeditions and the XXI (2015-16) Ganovex expedition and subsequent microstructural and petrographic investigations on the sampled rocks.

Rocks were sampled along a SW-NE transect, from the medium-P amphibolite facies rocks of the Dessent Ridge Unit, to the intervening Black Spider Greenschist and to the very-low grade rocks of the Molar Formation.

The Black Spider Greenschist are a higher strain and higher metamorphism equivalent of the adjacent Sledger Group. From a structural point of view, they display a more complex polyphase deformation history, with widespread strain partitioning, so that slices of low-strain undeformed gabbro and basalt are enclosed in high-strain mylonitic zones. Similarly, the metamorphism is heterogeneously distributed, with metavolcanics showing both syntectonic albite-chlorite-actinolite-epidote assemblage (greenschist facies) and oligoclase-hornblende assemblage, which are typical of the transition from greenschist to amphibolite facies. The metasediments show the quartz-chlorite-muscovite-Mg-biotite (+graphite) assemblage, indicating greenschist facies metamorphism with  $T > 350^\circ \text{C}$ . The assessment of metamorphic conditions took advantage also from pseudosection calculations.

The tectonic evolution of the Lanterman - Mariner Suture Zone is derived from such structural and metamorphic features; this approach can lead to a more general understanding of the tectonics of the intra-arc/back-arc suture zones.

## ***The Gamburtsev Province as part of a major ca 1000 Ma accretionary belt in interior East Antarctica?***

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The Gamburtsev Subglacial Mountains in interior East Antarctica are underlain by 50-60 km thick crust imaged by gravity and seismic models (Ferraccioli et al., 2011 -Nature; An et al., 2015- JGR). In contrast, the composite Archean to Mesoproterozoic Mawson craton that occupies the Wilkes and Terre Adelie sector of East Antarctica typically features only 40-45 km thick crust (Aitken et al., 2014- GRL).

Over 200 km thick and seismically fast lithosphere underlies the Gamburtsev Province, as typically observed over Precambrian lithosphere that has not been substantially reworked during Phanerozoic subduction or collision. Satellite and airborne magnetic data indicate that the Gamburtsev Province is sandwiched in between distinct Precambrian lithospheric blocks including the Ruker, Princess Elizabeth Land, Vostok, Nimrod (Goode and Finn, 2010 -JGR), South Pole and Recovery provinces.

Ferraccioli et al., (2011) proposed that a segment of a stalled orogen (i.e. an orogen where widespread orogenic collapse and root delamination has not occurred) is preserved in the Gamburtsev Province and further hypothesised that its origin relates to widespread accretionary and collisional events linked to the assembly of the Rodinia supercontinent. However, recent passive seismic interpretations (An et al., 2015) indicate that crustal thickening may relate instead to Pan-African age subduction and the assembly of Greater India, East Antarctica and Australia within Gondwana.

Here we present a set of new enhanced magnetic and gravity images, depth to magnetic and gravity sources and preliminary 2D and 3D forward and inverse models in order to characterise the crustal architecture of the Gamburtsev Province. We use 3D flexural models to compute gravity signatures arising from Moho depth variations across interior East Antarctica and then derive residual intra-crustal gravity anomalies that are easier to interpret together with aeromagnetic signatures. We then contrast our new geophysical interpretations with previous geophysical and geological work in the Prince Charles Mountains (McLean et al., 2009- JGR), the Sør Rondane region (Mieth et al., 2014- Prec. Res.; Ruppel et al., 2015- Tectonics) and the eastern Dronning Maud Land province (Mieth and Jokat, 2014- Prec. Res.).

We conclude by hypothesising that the Gamburtsev Province may be part or related to a widespread 1000–900 Ma? accretionary belt in interior East Antarctica linked to the recently inferred Tonian Oceanic Arc Superterrane province, which was at least partially overprinted by 630-500 Ma metamorphism and granitoid magmatism (Jacobs et al., 2015- Prec. Res.). If this hypothesis holds true, then the Gamburtsev Province may perhaps not have been an integral part of the Rodinia supercontinent and may also have been affected by “Pan-African” age processes responsible for juxtaposing Greater India and a collage of distinct crustal blocks and terranes that make up interior East Antarctica.



## **S20. Observing and Mapping the Antarctic Continent**

### ***A new seamless digital geological 1:250 000 scale map of Dronning Maud Land: progress report***

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Geological mapping and investigation of the mountain chain in Dronning Maud Land (DML) has been carried out by a number of geologists from South Africa, Japan, India, Germany, Russia and Norway over the last 40-50 years. A total of approximately 80 geological traditional paper map sheets have been gathered, as well as geological map data from scientific publications. All source maps are scanned, georeferenced and digitalized in ArcGIS. The goal is to integrate the existing paper maps into a new seamless, digital data product with one common, homogenous legend. The new overview map of DML is being compiled at the scale of 1:250 000.

There are several challenges related to the compilation of the existing map data. The major challenge relates to geological harmonization. The original source maps all have their own way of presenting the geology, which depends on the map compilers and the individual mapping geologists. The maps vary greatly in detail and the scale of the existing maps varies from 1:5 000 to 1:500 000. The maps show quite different standards and norms for classification of rocks units. An additional issue is that the understanding of the geology of an area may change with time. Maps of different age might also reflect change in mapping philosophy.

The digital topographic basemap dataset from DML is from the Antarctic Digital Database, which provide the best currently available data in Antarctica. The resolution of the data varies widely. The data from central DML is based on relatively old topographic maps from the 1960s. There is a significant discrepancy between the topographic dataset and the more recent Landsat images. To ensure that the new GIS database matches the real topography, geological maps are georeferenced to recent Landsat imagery.

Building a new descriptive legend for the overview map is one of the core tasks of the project. Each polygon on the map will have code which is translated into a color and a descriptive text by the GIS program. The legend will be organized by age with superficial deposits at the top and Precambrian rocks at the bottom. The geological units will also be organized by region. The rock units that belong to a supergroup, igneous province or metamorphic complexes will be grouped together even if they cover more than one time period. Where the nomenclature of the source map is not suitable or appropriate for international use, we will adopt modern nomenclature and follow the principles based on international standards (IUGS recommendations).

# ***Calculation of gravity terrain and isostatic corrections based on BEDMAP2 and their applications in Antarctica***

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Using BEDMAP2 (Fretwell et al., 2013) and JGP95E (a global digital terrain model, Arabelos, 1999), we have calculated the global terrain effects and the Airy isostatic effects on the gravity field of the Antarctic continent and its surroundings. In order to gain a tradeoff between computational accuracy and speed, the global relief needs to be divided into near zones and far zones by the outer limit of the Hayford-Bowie zone O (1°29'58" or 166.7 km) (Heiskanen and Moritz, 1967) surrounding each computation point, which is constrained by 1 nautical mile by 1 nautical mile grid of rectangular coordinates of the polar azimuth projection. The BEDMAP2 is fully used for the near-zone calculation. JGP95E south of 60°S is replaced by BEDMAP2, and this reconstructed JGP95E is used for the far-zone calculation. Gravity effects of both the near zone and the far zone are computed by the same formula for the gravity effect due to a truncated spherical shell in a spherical coordinate system (Lei, 1984; Gao and Jin, 2003; Mikuška et al., 2006). BEDMAP2 and the reconstructed JGP95E are rearranged into rings around each computation point. We have obtained Bouguer and isostatic gravity anomalies in the Antarctica and its surroundings by subtracting gravity terrain and isostatic effects from the DTU10 free-air gravity anomaly (Andersen, 2010), with land filled by EGM2008. This also serves a way to check the accuracy and reliability of our gravity terrain and isostatic calculations.

Bouguer gravity anomalies mainly reflect the effects of the isostatic compensation root, i.e., the Moho which is deep under land (especially the core of East Antarctica, but not so deep in Wilkes land) and shallow under sea (especially the Atlantic and southeastern Pacific Oceans, but not so shallow in Scotia sea, seaward of Ross Sea and off Wilkes Land). Isostatic gravity anomalies imply that the Antarctic continent and its surroundings are generally in an isostatic equilibrium status. Though not valid for the entire Antarctica (especially in Scotia sea and along the East Antarctic continental margin on the side of the Atlantic), the local Airy isostatic compensation seems suitable for seaward of Ross Sea and off Wilkes Land.

## **Acknowledgements**

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## ***Comparison of Sr and Nd isotope data from the Namuno Terrane of Mozambique with data from Dronning Maud Land, Antarctica.***

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A mega-nappe model for the amalgamation of Gondwana between Mozambique and Antarctica during the Neoproterozoic–Cambrian-age Kuunga Orogeny involves collision between N. and S. Gondwana. S.Gondwana is inferred to have comprised the Kalahari Craton of southern Africa and parts of adjacent metamorphic belts including the Barue and Nampula complexes of the Mozambique Belt, the Grunehogna Craton of western Dronning Maud Land (WDML), Antarctica, along with the Maud Belt, Antarctica and Sri Lanka (consisting of the Vijayan Complex). N. Gondwana is inferred to have comprised parts of south central Africa, Sri Lanka, Madagascar and India (consisting of the Tanzanian Craton and parts of adjacent metamorphic belts including the Namuno Terrane of northern Mozambique, the Highlands and Wannai Complexes of Sri Lanka and the Central Dronning Maud Land, Sor Rondane areas and Lutzow-Holm-Bukta areas of Antarctica.

Geochronological data from the metamorphic belts of the various areas are fundamental to defining the various components of the mega-nappe model and facilitate definition of different crustal blocks. Comparison of published and unpublished Sr and Nd radiogenic isotope data, calculated at 500Ma from the various basement gneisses crustal blocks of the mega-nappe component areas, show broad differences between the different areas from N and S Gondwana.

Neoproterozoic to Cambrian-age granitoids which intrude the various crustal blocks mostly mirror their host country rocks suggesting localised anatexis without significant juvenile input. Sr and Nd isotope data from some of the granitoids suggest that they were sourced in the footwall but intrude the hanging wall components of the mega-nappe. The Sr-Nd data from the N. Gondwana correlated areas dominantly show marginally negative, less evolved  $\epsilon_{Nd}$  characteristics but similar, positive, wide ranged  $\epsilon_{Sr}$  characteristics compared to the S. Gondwana correlated areas.

Comparison of the Sr-Nd isotopic provinces show broad similarities with various geophysical domains defined by recently published aeromagnetic and gravity data sets from Antarctica.

The data are evaluated in terms of their implications for the mega-nappe model for the Kuunga Orogeny. The data also provide suggestions of extensions of cratonic areas at depth beneath some areas of the metamorphic belts. Most crustal blocks comprising the mega-nappe model share similar isotopic characteristics suggesting that these blocks may be correlated in support of the proposed model.

# ***Comparison of SSMIS and AMSR2 sea ice concentration in the Amundsen Sea, West Antarctica, with KOMPSAT-5 SAR images***

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Sea ice in the Arctic and Antarctic Ocean plays a role of an indicator of climate changes. Since 1970s, passive microwave sensors have been widely used to study the Arctic and Antarctic sea ice because they have observed the whole polar oceans at least once in every two days, regardless of weather conditions and sun altitudes. The Special Sensor Microwave Imager/Sounder (SSMIS) and the Advanced Microwave Scanning Radiometer 2 (AMSR2), the successor to the Special Sensor Microwave Imager (SSM/I) and the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E), respectively, are the representative passive microwave sensors, producing sea ice concentration since 2008 and 2012, respectively. As sea ice concentration products derived from SSMIS and AMSR2 are universally used in various research fields, it is very important to evaluate accuracies of the products, especially in sea ice melting season. Synthetic Aperture Radar (SAR) is very useful tool for observing sea ice because it is all-weather and day-and-night imaging system. In this study, SSMIS and AMSR2 sea ice concentration was evaluated by using Korea Multi-Purpose SATellite-5 (KOMPSAT-5) SAR, South Korea's first satellite SAR, images obtained in the Amundsen Sea in the West Antarctica during January-February 2016. All KOMPSAT-5 SAR images were obtained in HH-polarization at Enhanced Wide (EW) swath mode with spatial resolution of 6.25 m. Sea ice, icebergs and open water were classified from the SAR images based on Random Forest, a rule-based machine learning approach, in which texture features derived from gray level co-occurrence matrix were used as input variables. Then sea ice concentration was computed from the SAR images and compared with the passive microwave sea ice concentration. The comparisons showed that both SSMIS and AMSR2 sea ice concentrations were underestimated. This would be probably caused by melting of ice surface which is regarded as open water in sea ice algorithms of the passive microwave sensors. Particularly, SSMIS and AMSR2 sea ice concentration were very low over icebergs due to different microwave radiation characteristics between sea ice and glacial ice.

## ***First digital geological map dataset of Marie Byrd Land: A product of the SCAR GeoMap project***

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Bedrock exposures are relatively sparse in Marie Byrd Land (MBL), due to the presence of extensive sheet, but they provide important constraints on the geological evolution and glacial history of West Antarctica. The most extensive area of outcrops is found in the Ford Ranges and Edward VII Peninsula, bordering the Ross Sea and Ice Shelf. We used ground-based geological observations to develop the first digital geological map for Marie Byrd Land, as a component of the new SCAR GeoMap project (<http://www.scar.org/geomap>). Feature classification and description uses the international GeoSciML data format standard. The map covers an on-continent coastal area of 135 000 km<sup>2</sup> between 140°E to 160°E, from 75°S to 80°S, at around 1:250 000 scale. Exposed rock is delimited by 911 polygons, occupying 250 km<sup>2</sup> that comprises 0.2% of the total area. Supraglacial features and glacial till, together with seasonal water and blue ice, also are distinguished within the digital map, due to their relevance to ice sheet history and dynamics. There are 119 mapped till deposit polygons (11.2 km<sup>2</sup>), 58 supraglacial tills (5.7 km<sup>2</sup>) and 69 seasonal water features (21.5 km<sup>2</sup>) that provide a baseline for past and future glaciological change. Rendered in geographic information system software Esri© ArcMap, the GIS will be made publicly available as an ArcGIS map service and Google Earth files.

Using the new GIS, an interpretive map of sub-glacial bedrock geology has been generated for the region, drawing upon archival airborne geophysical data (magnetics, gravity, ice thickness, and sub-ice topography) recorded at 5.3 and 10.6 km line spacing over the Ford Ranges (Luyendyk et al., 2003), augmented by marine bathymetry (e.g. Luyendyk et al., 2001; Sorlien et al., 2006). Polygon features correspond to geological formations, and line features to inferred crustal faults at regional scale. Six fault classifications reflect the strength of the basis for the inference of the subglacial structure, based on criteria including active seismicity, topographic or ice surface lineament, and steep gravity or magnetic gradients. Pliocene and younger volcanism, zones of inferred mineralization/ geothermal activity, and glacial deposits were mapped with extreme care due to their potential consequences for ice sheet stability. The current configuration is rendered upon BEDMAP2 subglacial topography and an alternative view is projected onto adjusted topography following glacial rebound (after Wilson et al. 2012). The re-examination of archival data is timely within ongoing geophysical exploration and dataset compilation for Antarctica, such as SCAR ADMAP, NASA Icebridge, and POLEnet. The new subglacial framework and deeper understanding of bedrock structure in MBL is used to test existing hypotheses about the tectonic evolution and identify factors that may affect ice sheet stability. It provides a geological context for the eastern boundary of the Ross Ice Shelf region being mapped by the 2015-2018 USAP ROSETTA-Ice airborne geophysical investigation.

## ***First digital geological map dataset of northern Victoria Land: a product of the SCAR GeoMap project***

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There are relatively extensive exposures bedrock and cover sequences in the Transantarctic Mountains of northern Victoria Land. A program of geological mapping by German and Italian geological teams called GIGAMAP (German Italian Geological Antarctic Map Program), led to the publication of several 1:250,000 geological sheets between 1997 and 2014, which cover much of northern Victoria Land. Information from geological maps has now been captured in digital format as part of the SCAR GeoMap project – an international effort to compile unified geological and geomorphological datasets describing Antarctica's exposed geosphere. The goal is to generate a spatially precise and geologically accurate GIS dataset that can act as a fundamental layer for ecological, glacial dynamic, climate change and hard-rock geology studies.

Efforts in northern Victoria Land have been devoted to achieving a smooth integration of GIGAMAP sheets with the continent-scale GeoMap compilation. Unit codes, names, descriptions and ages have been assigned to the rock00 and moraine00 Antarctic Digital Datasets (ADD) between 158 and 172°, from -69 to -76°. Rock and moraine polygon positions have been updated using the latest LIMA satellite imagery and attributed following the best-practice, international GeoSciML scheme. A bibliographic source file clearly links each polygon classification back to its original published map so that all original work can be appropriately referenced. Classification at the highest level follows a chronostratigraphic scheme, with Paleozoic-Ordovician rocks linked to terranes (Wilson, Bowers, Robertson Bay) and suture zones; Mesozoic rocks assigned to intrusive suites (Admiralty Intrusives and Gallipoli Volcanics) or Supergroups (Beacon and Ferrar); and Cenozoic volcanics and intrusives retaining local lithostratigraphic nomenclature. Cover sequences of glacial and other surficial deposits, whose area totals 9% of exposures, are presently assigned to geomorphic-based classification of colluvium or tills, derived either from local glaciers or larger ice sheets, but this working classification may be modified. Beneath the first order classification is a wealth of descriptions and secondary variables. The entire dataset covers 6135 km<sup>2</sup> of exposed Antarctic geology with 11,100 polygons, suitable for use at around 1:250,000 (or more-regional) scale, focused on data attributes for interrogation of rock-outcrop exposures. It does not yet provide any interpreted sub-ice geology, being focused in the first instance towards describing the exposed geosphere for ecological studies, environmental domain analysis, or regional geological needs.

## ***Geochemistry of sediments in Crepin point: Towards environmental base line in Machu Picchu Peruvian Antarctic station. King George Island.***

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Since 1989, the Antarctic scientific station has been used and visited by scientists and base personnel during the austral summers. Peru does not have a permanent scientific station, unlike Brazil or Poland, the nearest stations. However, only human presence, although sporadic, has an impact on this fragile ecosystem.

Birkenmajer (1980) release the first reconnaissance and mapping of geological units and subsequent work helps to define regional geochemical characteristics (Kraus et al., 2010). Locally, the first reconnaissance work in the Peruvian area was conducted by Palacios (1988) in the Antar II expedition; geomorphological and stratigraphic units present were defined. Subsequent works performed in Crepin Point were aimed to establishing the geotechnical (Fidel, 1991; Guzman, 1999; Pari & Zavala, 2000), mineralogical (Quispesivana, 1995; Aranda, 1997) and paleontological characteristics (Romero 2000; Morales 2002).

In Crepin Point, the oldest geological units are a Paleocene andesitic and dacitic lavas and pyroclastics flows outcrop was intruded by an Eocene granitic-granodioritic stock. In the contact area a small argillic alteration was developed with quartz-chlorite veins. Both units were intruded by a several dykes with EW and NS orientation. This geology is reflect in the composition of the sediments, and therefore in geochemical distribution of these.

Studies in sediments in Admiralty Bay and around the permanent scientific stations (Santos et al., 2005; Santos et al., 2007; Ribeiro et al, 2011; Sun et al, 2003) show concentration of As, Cd, Cr, Cu, Ni, Pb and Zn; which are associated, probably permanent human activity in these sectors. However the Antarctic Scientific Machu Picchu station is occupied temporarily, which significantly reduces the influence of human beings on the environment

Since Antar XXII Expedition (2013-2014) INGEMMET release a new cartography of lithological and structural units at the Crepin Point. And also take samples for delineate a geochemical database. Preliminary reports geochemical values of copper, manganese, arsenic, lead and zinc at the contact between volcanic and intrusive rocks. Also sediments samples around the Machu Picchu Station were human activities are common were examined for heavy metal content. The redistribution of lead, zinc, arsenic and copper arising from point sources of these metals was demonstrated. The levels are a geochemical and environmental baseline for futures human activities in Punta Crepin area.

## ***GeoMap progress towards a digital dataset of the Antarctic rock exposures***

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The SCAR GeoMap (Geological Mapping Update of Antarctica) action group aims to facilitate an integrated programme to capture existing geological map data, update its spatial reliability, improve representation of glacial sequences and geomorphology, and enable data delivery via web-feature services. The team is collaboratively developing a digital dataset in which rock exposures are assigned with geological information using the international GeoSciML data format standard. Aimed towards continent-wide perspectives and for cross-discipline use, work involves classifying and describing around 72,000 distinct polygons that cover 51,000 km<sup>2</sup>. This describes known geology of rock exposures, at least in the first instance, rather than interpreted sub-ice features. An important focus are glacial deposits and landform features, as these potentially contain records of the waxing and waning of ice of relevance for understanding Antarctica's role in climate change.

In this continent-scale overview poster we highlight: (1) The large number of hard-copy geological maps and data sources, which range in scale and quality, and geological classification schemes. It is hoped conference participants will offer information about publications or datasets that may have been missed or overlooked. (2) Capture of digital geology in Marie Byrd Land, Dronning Maud Land, northern and southern Victoria Land and the Antarctic Peninsula. About 20% of Antarctic rock outcrops now have some form of geological representation assigned to them in GeoSciML suitable for use at 1:250,000 (or more-regional) scale. (3) Progress towards a unified classification scheme using a mixed chronostratigraphic- and lithostratigraphic-based classification at top-levels, with provision of a bibliographic link enabling each polygon to be referenced back to authors of key original work. (4) Potential for the dataset to provide fresh perspectives, for example, through combined geological legends and interrogation of continent-wide time-space plots.

The GeoMap group welcomes anyone interested in contributing their geological and geomorphological data, or capturing historic data from a particular region.



## ***Glacial geomorphological mapping of western dronning Maud land, Antarctica***

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Given current concern about the stability of ice sheets, and potential sea level rise, it is imperative that we are able to reconstruct and predict the response of ice sheets to climate change. The Intergovernmental Panel on Climate Change (IPCC), amongst others, have highlighted that our current ability to do so is limited and presents a major weakness in climate science. Numerical ice sheet models are a central component of the work to address this challenge. These models are tested and improved by comparing model predictions of past ice thickness and extents with field-based reconstructions from geological and geomorphological data. However, on the East Antarctic Ice sheet, Dronning Maud Land (DML) presents a critical gap in the empirical data required to reconstruct changes in ice elevation. In addition, there are significant uncertainties in regional climate history along the ice sheet margin due to remoteness of these areas from ice core locations where detailed reconstructions of climate history have been performed. This leaves numerical models of regional glaciation history poorly constrained.

MAGIC-DML is a Swedish-UK-US-Norwegian-German collaboration with a focus on filling the critical data gaps that exist in our knowledge of the timing and pattern of ice surface changes on the western Dronning Maud Land margin of the East Antarctic Ice Sheet. A combination of geomorphological mapping using remote sensing data, field investigations, surface exposure dating, and numerical ice-sheet modelling are being used in an iterative manner to produce a comprehensive reconstruction of the glacial history of western Dronning Maud Land. Here we present the results from the first phase of this project which involves mapping of the field area using historic and recent aerial imagery together with a range of satellite multispectral data. Ice-surface features such as flow-lines, nunataks and blue-ice areas illustrate present-day ice configuration and flow dynamics. Past configurations and characteristics of the ice are interpreted from marginal moraines, surface veneers, and trim-lines on nunataks. The high spatial resolution of the WorldView satellites has enabled us to map in great detail the glacial geomorphology on individual nunataks in western Dronning Maud Land and distinguish different drift generations. This mapping, together with ice sheet modelling experiments, are being used to guide the field component of the MAGIC-DML project in which we will sample for surface exposure dating.

## ***Heat flow of Scotia Sea from magnetic anomaly data***

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The opening of the Drake Passage, situated between South America and Antarctica, represents the final stage of the fragmentation of Gondwana supercontinent. It led to the Scotia Arc formation, bordering the Scotia Sea, which is surrounded by fragments of the former continental connection. It is currently composed of Scotia and Sandwich Plates.

The Shackleton Fracture Zone constitutes a sinistral transpressive fault zone in the western Scotia Sea and it is a key structure that accommodates former Phoenix and Scotia Plates's differential movement. The formation of the Drake Passage and the Scotia Sea is considered of great importance to ocean circulation, as it allows the establishment of the Antarctic Circumpolar Current that isolated the Antarctic continent, with strong implications for climate and global changes.

Thermal structure of the Earth's crust is one of the main parameters controlling geodynamic processes. There is few information regarding heat flow values on Scotia arc. These values are mainly located in its westernmost, southern and easternmost part, which are not enough to extract conclusions regarding lithospheric thickness variations and asthenospheric flow. Taking advantage of the World Digital Magnetic Anomaly Map Project's compilation we have extracted magnetic anomaly data, which fall inside the Scotia Arc and surrounding areas. This magnetic anomaly picture provides the best representation of magnetic properties to date. We have used spectral methods on this regional magnetic compilation to obtain depth to the bottom of magnetic sources (DTBMS) as a proxy to infer Curie depth and heat flow distribution in the Scotia Sea.

Results show a complex DTBMS picture, where Curie's depth varies less than 10 km from deepest to shallowest values. Although scarce information regarding heat flow values is available in the area, they are in good agreement with our results. Besides we compare DBTMS wherever possible with Moho depth values. Our DTBMS are always deeper. As a by-product we present a 2D heat flow map of this remote area which complements the scarce heat flow information available and we discussed these results with previous seismic tomography and gravity data of the area.

# ***Remote Geologic Mapping of the Antarctic using Orbital Multispectral Imagery***

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Remote geologic mapping of ice-free regions throughout the Antarctic has recently been made possible through significant advancements in imaging capabilities and the calibration and validation of observed spectral signatures. We present the latest improvements to these techniques, which have been made possible through close collaborations with the Polar Geospatial Center (PGC) and the Polar Rock Repository (PRR) in the United States. To date, more than 600 geologic samples from the PRR have been spectrally characterized at visible and near-infrared wavelengths. These laboratory data provide the necessary “ground truthing” to link orbital observations to materials on the surface. We have also made significant improvements to the remote characterization of atmospheric path radiance, which must be removed from the orbital data before the observed spectra can be compared to laboratory measurements. Together, these advancements have revolutionized our ability to remotely study geologic exposures and ecological communities remotely before the need for tedious and costly field work.

Our work is unique in its ability to link atomic-level chemical and physical properties to orbital-scale surface observations. This presentation will highlight targeted studies throughout the Antarctic that fully span these scales of research. These studies include:

- (1) The identification of primary compositional variability within the Ferrar Dolerite, one of the most widespread igneous units in Antarctica. Cryptic compositional variability has been used to study the magmatic evolution of this complex igneous intrusion. Significant advancements have been made through the identification and mapping of these variations from orbit, over scales and landscapes that are impossible to characterize from the ground.
- (2) The mapping of fossiliferous sedimentary units on James Ross Island in the Antarctic Peninsula. Pre-field mapping and geologic characterization are extremely advantageous by helping to pinpoint targets and locations of interest. Our pre-field efforts are highlighted in this particular study, which is focused on targeted sedimentary lithologies that can be readily differentiated from other nearby geologic units.
- (3) The characterization of surface oxidation and weathering as related to surface exposure ages. Glacial moraine deposits throughout the Transantarctic Mountains show a unique spectral trend of increasing ferric iron oxidation signatures with increasing distance from the current glacial toe. These signatures suggest that oxidative weathering, which occurs in cold, dry, and stable environments throughout the Antarctic, is directly related to glacial retreat. Studies to quantify this relationship are ongoing.
- (4) The mapping of photosynthetic algal communities within the McMurdo Dry Valleys has been shown to be possible over the course of a single field season. The distribution and spectral strength of these signatures can be used to more effectively understand the spatial and temporal evolution of these complex ecosystems that have traditionally required in situ analyses.

## ***Scan basin seafloor spreading magnetic anomalies: New insights on the central scotia sea geodynamic evolution***

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The Scotia Sea is surrounded by the Scotia Arc formed by the eastward asthenospheric flows from the Pacific to the Atlantic that determines the fragmentation and widespread of the continental connection between Antarctica and South America. Several small sized oceanic basins are developed in the southern Scotia Sea since the Oligocene, from W to E: Ona, Protector, Dove and Scan basins surrounded by continental fragments. Scan basin is located between the westwards Bruce Bank and the eastward Discovery Bank. It is an elongated roughly triangular basin, whose axis change in direction from N-S in the northern part to NE-SW toward the southern narrower part. This basin was formed by rifting processes and subsequent spreading accretion from the Oligocene to the Miocene, based on morpho-structural and seismo-stratigraphic analyses of the available multichannel seismic reflection profiles. The magnetic anomaly profiles orthogonal to the continental margins acquired during several cruises on board of the R/V Hesperides contribute to constrain the oceanic spreading. Scan basin is divided in three main regions: a northern region with N-S linear magnetic anomalies, a central disturbed area with wide intense magnetic anomaly minima in the western side and the southern characterized by NE-SW linear magnetic anomalies. Although due to the short oceanic spreading magnetic anomaly profiles cannot uniquely support a single correspondence, the best attribution is comprised between anomaly C8n (25.5 Ma) and C7n.1r (24 Ma), with faster spreading rates in the northern part (up to 11 cm/yr) than in the southern (5.8 mm/yr). Moreover, oceanic spreading was asymmetrical with faster western than eastern rates. Although magnetic anomalies have a clear linear character typical of oceanic spreading, due to the short length of the profiles, other alternative older ages models may fit the data. A tectonic model is proposed for the opening of the SCAN basin with continental block rotation and an aborted triple junction.

# ***Supraglacial debris and stream extraction by synergetic usage of spectral-spatial-textural information in high-resolution satellite imagery***

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The supraglacial environment is attributed by several geospatial features that are present on the surface of the ice or glacier. The semiautomatic mapping of geographical features from supraglacial environment is quite challenging using pixel-based image analysis. Therefore, mapping of the supraglacial debris and streams in the Schirmacher Oasis and environ, east Antarctica, was carried out by using high resolution optical remote sensing data. We used 8-band calibrated hyper-spherical color sharpened (HCS) and atmospherically corrected WorldView-2 (WV-2) imagery. High resolution satellite data provide high spatial, spectral and contextual information. Utilization of spatial and contextual information of image objects is highly required to extract the information from high resolution satellite data. Supraglacial debris and streams were manually digitized from the satellite imagery to generate the ground reference data. Several trials were performed using few existing traditional pixel-based classification techniques and color-texture based object-oriented classification methods to extract supraglacial debris and streams over a small domain of the study area. Our results indicate that object-oriented approach (overall accuracy = 93%) performed better than all the traditional pixel-based methods (overall accuracy = 80 - 85%) for extracting supraglacial debris and streams. Presently, we are attempting similar more trials for supraglacial stream extraction and then we will attempt to develop new techniques for debris and supraglacial stream extraction, which would be based on object-based image analysis (OBIA) and spectral index ratio (SIR) approaches. Preliminary results will be discussed in the forthcoming SCAR open science conference.

## ***Terrestrial Data Analysis for the Ross Sea region***

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The explosion of data over the last 15 years has had a massive impact on science. Disciplines have moved from data-poor to data-rich and Antarctic terrestrial science is no exception. Utilising the inherent value of Antarctic data is imperative because of the unique nature and importance of the region, also because collecting data in Antarctica is difficult and expensive. This research has begun to collate, analyse, and enhance the spatiotemporal resolutions of existing environmental (climate, soil, geological and water), human activity, and biological data to provide the framework to complete a regional-scale impact assessment for the Ross Sea region. At the two year mark of the four year programme, the initial Tier 1 data products have been developed and we invite collaboration to utilise these products.

Utilising this collated data, the research now focuses on analysing the interlinked pressures on the environment and the terrestrial ecosystem. Aspects proposed in this stage of the research are: dynamical downscaling of climate change impacts to a regional scale; spatial wetness modelling linked to climate; digital soil and geological analysis; bioregionalisation that accounts for climate change; agent based modelling to enhance human movement and impact databases; and complex systems theory to explore and mine the collated data for new insights.

We aim that both the summarised data and these synthesised analyses will provide science context for policy advice and development by the Antarctic policy community to ensure the well-informed reporting, monitoring and management of the region. This poster will highlight the programme, the available Tier 1 data products, expected policy outputs, and invite collaboration.

## ***The SCAR Antarctic Digital Database - Freely available topographic data for mapping, science and operations planning***

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Scientific work in Antarctica and its operational support depends on a reliable, consistent geographic framework. The SCAR Antarctic Digital Database (ADD) <http://www.add.scar.org/home/add7> aims to provide this resource for the Antarctic community.

The ADD is a seamless compilation of topographic data for the continent to 60°S, merging data from international organisations active in mapping Antarctica. It includes data layers for coastline, ice-shelf grounding line, rock outcrop, contours and human-presence features such as Research Station locations. Some areas have specific data for glacier catchments and historic coastal change. The topographic data can be viewed in context with the Landsat Image Mosaic of Antarctica (LIMA) and surface and bed DEMs from BEDMAP2. All the data have metadata about the original source material.

All topographic data are provided at the original source and as generalised data suitable for smaller map scales of 1:1 million and 1:10 million. The data are available for download through the ADD website in a range of formats including CSV, ESRI shapefiles, Geotiff and KML, or can be linked to a GIS through an OGC WMTS feed.

The ADD is available free of charge for all uses, but users must accept the disclaimer.

It is managed by British Antarctic Survey on behalf of the copyright holder, the Scientific Committee on Antarctic Research.

This poster aims to highlight the SCAR ADD and encourage its use as a consistent, managed, easy to use source of topographic data for Antarctic mapping, science and operations planning.

# ***Variations in glacier fronts positions and ice-free areas at the northern tip of the Antarctica Peninsula between 1988 and 2015***

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This paper conducted a survey of variations of ice fronts in glaciers on the northern tip of the Trinity Peninsula by using remote sensing techniques. Advances and retreats of glaciers were mapped, as well as ice-free areas in the 27-year period between 1988-2015, and the results were complemented with air temperature data for the region. The database used eight satellite images from Landsat 5, 7 and 8. In addition, it was used the Antarctica Digital Database (ADD) data, the Landsat Image Mosaic of Antarctica (LIMA), and the digital elevation model Antarctic Peninsula 100 m Digital Elevation Model (APGDEM). The temperature data used come from the Antarctic station Esperanza (ARG), acquired through READER. The glaciers ice fronts positions were obtained through automatic and manual methods. Unsupervised and supervised classifications were performed in the acquisition of these, turning them into vectors and uniting them with the delimitation of glacial drainage basins provided by ADD, thus forming the set of glaciers with its front position for each year of images (1988, 2000, 2006, 2011 and 2015). The ice-free areas were obtained by supervised classification. The classifications were validated through the Kappa index, obtaining satisfactory results. The total study area is approximately 1,450 square kilometers and has 32 glacial drainage basins, these, three are named glacier (Arena, Depot and Mondor), all three tidewater glaciers. In the period of analysis, since 1988, there has been a loss of mass of ice area of approximately 50 square kilometers, whereas the total gain was only  $\pm 10$  square kilometers, resulting in an overall decrease of approximately  $\pm 40$  square kilometers (i.e.  $\pm 2,7\%$  of the total area). Between 1988-2000 (the wider range of investigations), the area lost  $\pm 25.1$  square kilometers of ice on its fronts, from 2000 to 2006 there was a decrease of  $\pm 12.2$  km<sup>2</sup>, and between 2006 to 2011 others  $\pm 5.0$  km<sup>2</sup>; the 2011-2015 interval was the only one to show advances greater than retreats with a  $\pm 2.5$  sq km increase in the area ( $\pm 0.16\%$ ). The Depot and Mondor glaciers showed retreat behavior, and Depot did not show any advance within the periods, the Arena glacier showed advances and retreats in all intervals, remaining virtually unchanged. The ice-free area increased by approximately 18 square kilometers, that is, a  $\pm 114\%$  increase over the 1988 snow/ice free area. The largest increases were given in the years 1988-2000, in 1988 the area represented  $\pm 15.91$  km<sup>2</sup>, reaching  $\pm 37.54$  km<sup>2</sup> in 2000 and  $\pm 37.90$  km in 2006, in 2011 there was a decrease, with an area of  $\pm 28.32$  square kilometers, and in 2015 the area returned to its previous values,  $\pm 34.09$  km<sup>2</sup>. The air temperature evaluation in Esperanza observed in 1964-2014 years show an increase of 1.45°C



## S24. Physiological Adaptations In Antarctic Organisms

### *Are Antarctic plants more tolerant to stress than others? A world-wide comparison.*

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Important climatic shifts are reported for Maritime Antarctica as well as for other regions world-wide which may affect phenology, distribution and abundance of plant species. Plants native to extreme environments such as Antarctica, should have higher stress tolerance than other from moderate climates. Therefore, studies describing the tolerance of these species to stress become essential to improve our understanding of the possible effects of global warming into the different plant communities. In this work, we aim to compare the stress tolerance of several antarctic species in Maritime Antarctica to that of other species from different environments and climates of the Earth (alpine, mediterranean, hot deserts, oceanic temperate areas, etc.) by applying a handy method for dehydration and viability assessment of the photosynthetic tissues.

This method performs a semiquantitative assessment of desiccation-tolerance based in the "Austin protocol", but improving its portability and sensitivity. Desiccation extent of photosynthetic tissues was monitored by measuring their relative water content (RWC) and their viability was assessed by chlorophyll a fluorescence techniques, measuring the maximum photochemical efficiency (Fv/Fm). Measurements were performed (i) at initial turgor state, (ii) after a 48-h exposition to different drying conditions (80%, 50% and 10 % relative humidities (RH)) and finally (iii) the recovery assessment after 48 h of rehydration to assess recovery. This methodology allows large-scale multi-species comparisons and the establishment of correlative relationships between morpho-physiological traits and ecological attributes. Moreover, as it has minimal instrumental requirements it can be applied in remote locations.

The comparison of the Antarctic species with species from other regions and climates helps us deep on the understanding of the resilience of Antarctic and other regions plant communities to climate change.

## ***Chemical defenses of Antarctic sponges***

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Marine sponges are exposed to predation as well as to a wide array of harmful microorganisms, and therefore they often show chemical activity against them. It is known that some chemical defenses from sponges are effective avoiding microbial colonization or infections as well as protecting from feeding deterrence. In this study, the antibacterial activity of 18 species of Antarctic sponges was tested against four Antarctic bacteria and four human pathogenic bacteria from culture collections. Moreover, all these extracts were tested for feeding repellence against the seastar *Odontaster validus*, one of the most important predator in these habitats. Samples were collected in the coastal area of Deception Island, in the South Shetland Islands and the O'Higgins station, in the Antarctic Peninsula. Samples were extracted with organic solvents and separated in two fractions, the most hydrophilic compounds and the lipophilic ones. With a remarkable difference, the hydrophilic fractions showed a much weaker antibacterial activity, while the lipophilic fractions displayed a broader incidence, as well as a stronger activity. Also, the antibacterial effect was stronger against sympatric bacterial strains, respect to the pathogenic ones. In contrast, the feeding deterrence was low, with similar activities in both hydrophilic and lipophilic fractions. All the sponge species tested showed antibacterial activity against at least one sympatric bacterial strain, although not all were active against pathogenic bacteria. Some extracts displayed a broad activity against the different bacteria, while others displayed selective activity. Only four sponges among those tested here presented anti-predatory chemical defenses. Therefore, we conclude that chemical antimicrobial defenses are common in Antarctic sponges, and in fact, the sponges tested here seem to be better protected against microbes than against predators.

## ***Design and structural characterisation of antifreeze peptides from type I shorthorn sculpin, myoxocephalus scorpius***

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Antifreeze proteins (AFPs) are synthesized by various cold-adapted organisms to enable them to survive in subzero environment. Exotic functions of AFPs have recently been attracted with much interest to develop them as commercial products. Hence, AFPs require a more detailed and rapid structural characterisation of AFPs to determine the relationship between structure and antifreeze activity. In this work, we have studied the antifreeze activity of three short helical protein fragments (peptides) isolated from different regions of type I shorthorn sculpin, *Myoxocephalus scorpius*. We have demonstrated that short peptide segments derived from yeast AFP possess antifreeze activity and result in modification of the ice crystals growth rates and habits. Spectroscopic results reveal all designed peptide has  $\alpha$ -helical regions and concordant with the information obtained from circular dichroism (CD) data. This strategy has enabled the preparation of short AFP with high antifreeze activity in large amount of quantities at a low cost further opens the chance of developing the commercial potentials of AFPs.

# ***Diffusive and biochemical limitations to photosynthesis in Antarctic plants from two populations in Antarctica***

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Due to advances in photosynthesis modeling, a deeper understanding of the mechanisms controlling photosynthetic responses to temperatures has been accrued. However, these approaches have not been applied in field studies including antarctic species. These analyses provide useful information to develop predictive models of CO<sub>2</sub> assimilation and the effects of climate change, incorporating two key aspects of the photosynthetic limitations: the mesophyll conductance of CO<sub>2</sub> (g<sub>m</sub>) and the biochemical limitation related with the Rubisco performance. In this study we evaluated in situ photosynthesis and photosynthetic limitations in two populations of *Colobanthus quitensis* and *Deschampsia antarctica*: King George Island (KGI) and Lagotellerie Island (LAG). We modeled AN-Ci response using biochemical Rubisco parameters determined in this study for each species. Extremely low values for g<sub>m</sub> were estimated in both, being the highest value 0.13 mol CO<sub>2</sub> m<sup>-2</sup> s<sup>-1</sup> for *D. antarctica* LAG at 15°C. This fact provokes that the total leaf conductance (g<sub>tot</sub>) was low and mainly determined by g<sub>m</sub>. The relationship between net photosynthesis (AN) and g<sub>tot</sub> was highly significant, indicative that AN in the antarctic plants under field conditions are limited by diffusional components. Regarding the biochemical determinants, the maximum rate of Rubisco carboxylation (V<sub>cmax</sub>) tended to increase with the increase in the temperature, and *D. antarctica* showed higher values than *C. quitensis*. A high Rubisco specificity factor (S<sub>c/o</sub>) was determined in both species. So in these species, as in many xeric species, photosynthetic rates are limited by the capacity to mobilize CO<sub>2</sub> into the leaf, and the mechanism to compensate this limitation, is to develop a Rubisco highly specific to CO<sub>2</sub>.

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## ***Effect of temperature on the growth and photosynthetic performance of Antarctic and tropical *Chlorella* species.***

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Elevated temperatures as a consequence of global warming have significant impacts on the adaptation and survival of microalgae which are important primary producers in the ecosystems. Those living close to their thermal tolerances face an imminent risk of localized extinction, others may resort to shifts in distribution or evolutionary adaptation. The impact of abiotic factors such as temperature on the photosynthesis of microalgae is of great interest as the primary production of algal biomass is strongly dependent on the photosynthetic rates in a dynamic environment. The aim of the present study was to examine the effects of elevated temperature on similar taxa of *Chlorella* originating from different latitudes. In this study, four *Chlorella* strains were used i.e. two each from the Antarctic and the tropics, with marine and freshwater origins for each latitudinal group. The polar and tropical strains were grown at a specific temperature ranging from 4 to 38 °C and 28 to 45°C, respectively. A pulse-amplitude modulated (PAM) fluorometer was used to assess the photosynthetic responses of the microalgae. Parameters such as maximum quantum efficiency (Fv/Fm), the relative electron transport rate (rETR), and light harvesting efficiency ( $\alpha$ ) were determined from the rapid light curves (RLCs). The specific growth rate ( $\mu$ ) of the marine Antarctic strain increased with temperature up to 28°C. Further increment in temperature up to 35°C resulted in suppressed growth and cell division was completely inhibited above 35°C. The  $\mu$  of the freshwater Antarctic strain peaked at 20°C which then decreased with increasing temperatures until 33°C, beyond which, growth was inhibited. As for the marine tropical strain, best growth was attained at its ambient temperature of 28°C with declining growth observed as temperature increased until growth was inhibited at 40°C. The freshwater tropical strain displayed the highest  $\mu$  at 30°C with an upper growth limit at 43°C. In general, the tropical strains displayed a reduction in photosynthetic activity after several days of exposure to 35°C and 38°C, while photosynthetic activity was rapidly inhibited upon exposure to 40°C. The photosynthetic activity of the marine Antarctic strain was not affected by rising temperatures up to 35°C; however, it was severely inhibited at 38°C. The results suggested that Antarctic and tropical strains portrayed different trends in their response to elevated temperatures and the effects of temperature on the growth and photosynthetic performance of microalgae are latitude-dependent.

## ***Effects of different silica levels on the growth rate and photosynthesis of polar diatom *Chaetoceros neglectus****

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### **Abstract**

Sea-ice algae make up about 5% annual primary productivity in the Southern Ocean. However, their ecological importance in the food web is often underestimated. One of the important nutrients for diatoms to survive in harsh condition of the Southern Ocean is silica. Thus, this study was aimed to investigate effects of silica on the growth rate and photosynthesis of polar diatom culture, *Chaetoceros neglectus* under a controlled laboratory experiment. The treatment cultures were grown in 26 L carboys of f/2 medium without silica for five days. Then, they were transferred as triplicate batch cultures in conical flasks at five silica levels ranging from 0 - 107  $\mu\text{mol/L}$ . No silica treatment was added for control cultures. For every five days, the growth rate of *C. neglectus* was recorded. It was observed the growth rate of *C. neglectus* was the highest at 107  $\mu\text{mol/L}$  silica concentration. Meanwhile, *C. neglectus* experienced a negative growth rate during the exponential stage at silica concentration of 2  $\mu\text{mol/L}$ . Photosynthesis rate was measured using chl a fluorescence by looking at maximum quantum yield of Photosystem (PS) II, Fv/Fm value. Specific growth rate, Fv/Fm for control was the highest ( $0.671 \pm 0.023$ ) at the end of day 10 followed by 2  $\mu\text{mol/L}$  silica concentration ( $0.628 \pm 0.023$ ). This result indicates this diatom did not require high silica concentration for good growth.

## ***Energetic adaptations of the Antarctic silverfish *Pleuragramma antarcticum****

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The Antarctic silverfish *Pleuragramma antarcticum* is one of the few truly pelagic fish species in the Southern Ocean and it is a dominant component of the fish fauna in the high-Antarctic Weddell Sea. As all notothenioids *P. antarcticum* lacks a swim bladder and has developed various morphological and biochemical adaptations to obtain neutral buoyancy and thus save locomotory energy. One typical life history trait involves the ontogenetic accumulation of lipids, mainly triacylglycerols (TAG). This neutral lipid provides uplift and may also serve as energy deposit. In our study total lipid levels of *P. antarcticum* specimens were largely determined by the developmental stage and size, with lower lipid levels (<20% of dry mass, DM) found in the larvae (10-16 mm) and intermediate concentrations in the younger juveniles, which increased strongly to maximum amounts of lipid (40-55%DM) in the older juveniles (>55-105 mm). Lipid class composition was clearly related to total lipid levels, with neutral lipids (TAG) comprising <20% of total lipid (%TL) in the younger lipid-poor specimens and >65%TL in the older lipid-rich fishes. Principal fatty acids were 14:0, 16:0, 18:1(n-9), 18:1(n-7), 20:5(n-3) and 22:6(n-3). High concentrations of the long-chain monounsaturated trophic marker fatty acids, 20:1 and 22:1, in the lipid-rich specimens suggest the ingestion of two dominant calanoid copepod species, the wax ester-rich *Calanoides acutus* and the triacylglycerol-rich *Calanus propinquus*. Apparently, wax ester moieties (fatty acids and alcohols) ingested with prey, e.g. copepods, are converted to triacylglycerols via fatty acids or metabolized by *P. antarcticum*. We discuss the function of these low-density and high-energy lipid compounds as buoyancy aid and/or energy reserve in this fish species, which thrives in the pelagic Antarctic Ocean without a swimbladder.

## ***Extreme phenotypic plasticity in metabolic physiology of Antarctic demosponges***

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Seasonal measurements of the metabolic physiology of four Antarctic demosponges and their associated assemblages, maintained in a flow through aquarium facility, demonstrated one of the largest differences in seasonal strategies between species and their associated sponge communities. The sponge oxygen consumption measured here exhibited both the lowest and highest seasonal changes for any Antarctic species; metabolic rates varied from a 25% decrease to a 5.8 fold increase from winter to summer, a range which was greater than all 17 Antarctic marine species (encompassing 8 phyla) previously investigated and amongst the highest recorded for any marine environment. The differences in nitrogen excretion, metabolic substrate utilisation and tissue composition between species were, overall, greater than seasonal changes. The largest seasonal difference in tissue composition was an increase in CHN (Carbon, Hydrogen and Nitrogen) content in *Homaxinella balfourensis*, a pioneer species in ice-scour regions, which changed growth form to a twig-like morph in winter. The considerable flexibility in seasonal and metabolic physiology across the Demospongiae likely enables these species to respond to rapid environmental change such as ice-scour, reductions in sea ice cover and ice-shelf collapse in the polar regions, shifting the paradigm that polar sponges always live “life in the slow lane”. Great phenotypic plasticity in physiology has been linked to differences in symbiotic community composition, and this is likely to be a key factor in the global success of sponges in all marine environments and their dominant role in many climax communities.



## ***Growth and extracellular enzyme production in marine fungi from different latitudes in response to varying temperature***

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The potential growth and extracellular enzyme production in response to warming climates of marine fungi has received little research attention to date. This study aims to determine growth characteristics (biomass) and extracellular hydrolase production of selected marine fungal strains obtained from different latitudes between tropical and polar regions in response to varying temperature around their natural ambient values. Strains of three fungi, *Fusarium equiseti*, *Trichocladium constrictum* and *Geomyces* sp., originally isolated from coastal areas of Malaysia (tropical), Taiwan (subtropical), and King George Island, Antarctica (polar), respectively, were incubated in 25 mL liquid-state cultures (Potato Dextrose Broth, 3% salt, 0.1% chloramphenicol) at temperatures of 4, 10, 15, 20, 25, 30, 35, and 40°C. Two mycelial discs (diameter 4 mm) from master culture plates were inoculated into each liquid culture flask across all eight temperature treatments. The positions of all culture flasks were randomised as they were placed in a shaking incubator (120 rpm). Fungal biomass from three random flasks in each temperature treatment were sampled every 24 h during the course of a 10 d culture run. This was filtered using a vacuum pump through Whatman No. 1 filter paper, stored at -80°C, and subsequently freeze-dried overnight. Dry biomass measures were used to obtain growth curves and growth profiles of each fungal strain across the full experimental temperature range. These data were used to identify standard growth phases, namely, the lag, the log, transition, stationary and autolytic phases. Split-plot analysis of covariance (SPANCOVA), with pH value and temperature anomaly as covariances, was applied to determine correlations between fungal growth and temperature. Amylase, cellulase and protease activities were screened in solid-state enzyme assays (Reasoner's 2A Agar, 3% salt, 0.1% chloramphenicol) augmented with soluble starch (0.4% w/v), carboxymethylcellulase and trypan blue (0.4% and 0.01% w/v respectively), or skim milk (0.4% w/v), respectively, at 4 and 25°C. One mycelial disc (diameter 4 mm) was plugged into every assay plate and relative enzyme activities of each fungal strain were recorded for 10 d. Enzymes and strains of interest will be selected for further study of the relationship between fungal growth and extracellular hydrolase production patterns across temperatures.

## ***Heat shock protein expression in immune cells of Antarctic sea urchin by stress inductors.***

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The Antarctic sea urchin *Stereochinus neumayeri* has evolved under a cold and thermally stable environment for million years, as most of the Antarctic coastal benthic organisms. Antarctic sea urchins have a low metabolic rate; however the activation of the immune response is possible at low temperatures. Those responsible for initiating the immune response are the coelomocytes. These cells are capable to mediate immune response by mechanism recognition, phagocytosis, encapsulation of foreign particles, in conjunction with the release of antimicrobial molecules. These cells are part of coelomic fluid, which can be considered similar to seawater, for this reason these cells could be considered as sentinels of environmental stress. The transcriptome analysis done by RNA-seq produced a several sequences related to stress response, like heat shock proteins (Hsps). In previous work we demonstrated that adult sea urchins exposed to elevated temperatures triggers the synthesis of Hsps which help protect cells against high temperatures and a variety of other potentially toxic agents. As an alternative to whole animal tests that require a large number of animals, the in vitro study was conducted to evaluated the chaperones expression of short-term primary cells culture of coelomocytes exposing to proteasome inhibitor (MG-132), Cadmium (10 and 100  $\mu$ M) and heat stress (3°C and 6°C). Four chaperones (Hsc70, Hsp90, Grp 78 and Grp120) were chosen for qPCR analysis and their expression levels were measured relative to housekeeping genes (18S and Gapdh). The chemical inducer MG-132 result in a significant increase expression of Hsp90 after exposure to 24 h at 100  $\mu$ M, however the expression of other Hsps was not induced. When coelomocytes were incubated at different cadmium concentration, the Hsps expression did not show a significant increase in their levels. Finally, when cells were exposed to heat stress, it caused an increase in the Hsp90, Grp78 and Grp120 levels after 24 h at 6°C, however the expression of Hsc70 it was not changed respect to the control levels.

The primary cells culture of *S. neumayeri* are capable of overexpressing stress proteins as a result of stress inductors, however, this response is delayed and to a lesser degree compared to other Antarctic or temperate species. Antarctic sea urchin coelomocytes could be a sensitive cell culture system for environmental studies and it is possible their use for the analysis on the effects of increased temperature and ocean acidification.

## ***How efficient and thermally flexible is the toxicant metabolism of Antarctic notothenioid fish?***

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**Objectives:** Current trends point to increasing chemical contamination of the Antarctic environment due to the appearance of emerging contaminants. The physiology of fish living in the Southern Ocean is evolutionary highly adapted to their extremely cold and stable environment. These adaptations involve a very limited or even absent capability to deal with environmental changes. It is known that Antarctic fish accumulate organic pollutants, however, no knowledge is available on the capability of Antarctic fishes to cope with these chemicals.

**Methods:** In order to determine the potential toxicity of HAHs for Antarctic fish, we analyzed species differing in trophic position and physiology (red-blooded: *Notothenia rossii*, *Gobionotothen gibberifrons*, white-blooded: *Chaenocephalus aceratus* & *Champscephalus gunnari*), and compared them to rainbow trout (*Oncorhynchus mykiss*). We measured activities of biotransformation enzymes (e.g. EROD, GST) from 0 to 12°C, as well as actual rates of xenobiotic metabolism in vitro in liver S9 fractions.

**Results:** Our data revealed that the enzymatic biotransformation capacities of Antarctic fish are only half as efficient as in temperate fish. Therefore, bioaccumulation factors for metabolizable lipophilic contaminants may be higher in Antarctic than in temperate fish. Likewise, the thermal adaptive capacities and flexibilities of the EROD and GST activities in Antarctic fish were significantly lower than in trout.

**Conclusions:** As a consequence, increasing water temperatures in the Southern Ocean will additionally compromise the already low detoxification capacities of Antarctic fish. Overall, the findings of our study suggest that the evolutionary adaptation of Antarctic fish makes them more susceptible to the effects of anthropogenic pollution than temperate fish, with the white-blooded icefish being the most vulnerable species among the notothenioids investigated.

## ***Impact of diurnal freeze - Thaw cycling on Antarctic Tardigrade mortality***

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Dramatic changes to global climate not only results in higher temperatures, but can also greatly affect climate variability. In cold regions, such as Antarctica, global climate changes have caused shifts in the duration and occurrence of soil freeze/thaw cycles and moisture levels in the soil. These changes can have profound physiological impacts on Antarctic wildlife, especially within the communities of microscopic, poikilothermic animals with little mobility. To assess the impact of climate variability on Antarctic soil ecosystems, we evaluated how the tardigrade *Acutuncus antarcticus* survives under different soil conditions and how they respond changes in the number of freeze-thaw cycles. We cultured individuals collected from the McMurdo Dry Valleys and exposed them to several freeze-thaw cycles under different soil moisture levels. We conclude that tardigrades going through wet freeze-thaw cycles have much higher mortality than tardigrades that are allowed to desiccate. Because tardigrades play an important role in McMurdo Dry Valley ecosystems, our findings suggest that ecosystem functioning could be significantly altered in response to climate variation that produces increased moisture and freeze-thaw cycles.

## ***Major transcriptional shifts in the Antarctic yeast *Rhodotorula* sp. USM-psy62 in response to temperature stress***

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Antarctic yeasts exhibit great abilities to endure and survive extreme cold environment. They can serve as good model organisms to uncover important molecular mechanisms involved in cold adaptation. Their response towards changes in environmental temperature can provide indications on how Antarctic microorganisms adapt to global climate change. *Rhodotorula* sp. USM-PSY62 is a basidiomycetous yeast isolated from sea ice and has an optimum growth temperature of 15 °C. A transcriptomic approach using RNA-seq was employed to determine its cold shock (15 °C to 5 °C; 5 °C to 0 °C) and heat shock (15 °C to 21 °C) responses. A total of 286 transcripts were differentially expressed by at least four fold and 72 of these were successfully functionally annotated. These were divided into three main functional groups based on the Cluster of Orthologous Groups (COGs) system: 38 transcripts (metabolism), 17 transcripts (cellular processes and signalling) and 17 transcripts (information storage and processing). The major cold shock responses of *Rhodotorula* sp. USM-PSY62 observed were an up-regulation of magnesium (*corA*) and carbohydrate (*BglX*) transport and metabolism genes; up-regulation of cell wall biogenesis related proteins (murein lipoprotein) and intracellular trafficking proteins (PX domain). Genes associated with the transcription-related HepA proteins were up-regulated in both cold and heat shock treatments. In summary, the sea ice yeast *Rhodotorula* sp. USM-PSY62 has a wide range of responses to protect its cells to survive varying temperature stress.

## ***Photosynthetic performance in Antarctic plants: Effects of in situ warming***

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Low temperature, water availability, and short growing season are the major constraints for plant performance in the Antarctica. *Deschampsia antarctica* and *Colobanthus quitensis*, the only two vascular plants that grow naturally in Antarctica, are able to maintain their growth by maximizing photosynthesis during the growing season. In the face of warming, we ask whether the in-field photosynthetic mechanisms developed by these species, and their ability to survive in extreme conditions, will be sufficient to respond to the climate change. We conducted a climate-manipulation experiment in King George Island (62° 09' S, 58° 28' W) over three growing seasons, using passive warming systems (OTC), and the effect of warming on photosynthesis, the diffusive and biochemical limitations, and the relationship among these and plant growth was tested during the last growing season (Dec 2014-Feb 2015). Both species responded differently to the warming in most of the parameters evaluated. The relative growth (%RG) and dry mass per area (LMA) of *D. antarctica* were not affected by warming. On the contrary, in *C. quitensis*, the influence of warming led to a significant greater %RG and lower LMA. Despite *D. antarctica* presented higher net photosynthesis (AN) than *C. quitensis*, only in the latter, AN was positively affected by warming. No differences in mitochondrial respiration at darkness were found, suggesting possible differences in other determinants of the photosynthetic process. The leaf mesophyll conductance (gm) displayed trends similar to AN. Thus, the diffusion limitations were more evident in *C. quitensis* compared to *D. antarctica*. The increase of gm in *C. quitensis* growing under warming increased significantly the CO<sub>2</sub> concentration at the Rubisco carboxylation site (Cc), favoring the maximum rate of Rubisco carboxylation (V<sub>cmax</sub>). On the contrary, no differences were found in *D. antarctica*. Thus, only *C. quitensis* seems to respond positively to the warming, promoting higher rates of net photosynthesis and, therefore, more growth under a climate change scenario.

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# ***Physiological and molecular stress response in *Nothothenia rossii*: modulation of in vivo and in vitro HPI sensitivity by environmental challenges***

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The Antarctic Peninsula is exposed to the fastest climate change rate in the planet, up to ten times higher than the global average. To which extent can coastal notothenioid fish adjust to the warming conditions forecasted by the models of climate change, possibly leading to ice melting and freshening of shallow waters in enclosed areas?

The ~30 million-year evolution in extreme stenothermal isolation was a strong selective pressure for the development of a highly endemic fish fauna, with likely structural and functional constraints and several molecular mechanisms of the stress axis of Antarctic fish seem less reactive than in temperate species. However there is reduced information on the endocrine response to chronic and acute stress. Here we looked at the HPI sensitivity by evaluating cortisol secretion and the gene expression in in vivo and in vitro experiments upon thermal, osmotic and handling challenges.

Experiments were performed in Arctowski (PL) and Great Wall (CN) stations in King George Island, in summers of 2012, 2013 and 2016. *Nothothenia rossii* were collected by boat at 5-25 meter deep using fishing poles and were transferred to experimental tanks in cold-rooms acclimated to natural temperatures (0-2°C). Fish were exposed to rapid/gradual changes in water temperature (to 4-6-8°C using thermostat-controlled heaters) and water salinity (to 20-10‰ by addition of freshwater to recirculating tanks) over a period of up to 10 days. In a second experiment the HPI axis was manipulated by injecting known blockers/ agonists of cortisol release and its receptors prior to the environmental acclimation. Subsets of fish at each temperature were subjected to additional handling stress and air exposure for 2 minutes. Time-course of the stress response was followed over 24 hours.

Fish were deeply anesthetized in tanks and upon blood collection, sacrifices by spinal section. Tissue samples were collected for gene expression and enzymatic analysis. The interrenal tissue was used in in vitro superfusion experiments to assess changes in sensitivity to an ACTH spike.

Exposure to altered conditions had no effect in immediate mortality. Increased temperature reduced overall activity and behavioral response to stimuli, although it had no clear effect on mobilization of energetic substrates. Fish responded to HPI manipulation in a way similar to temperate species. Both cortisol and gene expression of metabolic-related proteins and glucocorticoid- and mineralocorticoid receptors were modified after heat shock, but the cortisol response to handling appeared to be reduced, indicating loss of sensitivity. Still, samples from 2016 are still under analysis. The rise in temperature induced a dependent decrease in plasma osmolality while increasing branchial and renal Na<sup>+</sup>/K<sup>+</sup>-ATPase activity, thus decreasing osmoregulatory efficiency. In conclusion, Antarctic fish are reactive to environmental change, but that their ability to accommodate rapid or adaptive responses may be compromised.

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## ***Physiological response of *Chlorella* and *Chlamydomonas* species from different latitudes towards ultraviolet radiation (UVR)***

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The continuous destruction of the ozone layer has led to an increase in ultraviolet radiation (UVR) reaching the earth's surface. Besides forming the basis of the food web, microalgae are important for life on earth as producers of half of the atmospheric oxygen and helping in CO<sub>2</sub> sequestration. Thus, it is of great significance to investigate the physiological response of some green microalgae specifically *Chlorella* spp. and *Chlamydomonas* spp. originating from different geographical origins, to UVR. Three *Chlorella* and three *Chlamydomonas* strains from different geographical origins i.e. Antarctic, temperate and tropical were selected for this study. The microalgae were exposed to either a) photosynthetic active radiation (PAR) for 48 hours with a 12:12h light-dark regime, b) PAR + UVA or c) PAR + UVA + UVB for six hours during the light period of a 12:12 h light-dark cycle followed by recovery with PAR only for 42 hours, at their respective ambient temperatures. Analyses of their growth (chlorophyll-a content and optical density at 620 nm), photosynthetic performance and biochemical composition (total carbohydrate, total protein, total lipid and fatty acid composition) were then conducted. The changes in their growth and biochemical composition were only detectable during the recovery period, while the photosynthetic performance was affected after six hours of UVR exposure. The PAR + UVA treatment showed no significant effects on the growth and biochemical composition of all strains as compared to cultures exposed to PAR only (control). In contrast, growth was adversely affected by UVB radiation due to the destruction of chlorophyll structure and inhibition of chlorophyll biosynthesis. There were no signs of recovery during the 42 hours after exposure to UVB. The effects of UVB radiation on the biochemical composition of microalgae were species-specific and showed no consistent trends. Pulse amplitude modulated (PAM) fluorometry was used to assess the effects of UVR on photosynthesis. During the six hours of UVA exposure, a slight reduction was recorded in the photosynthetic parameters (Fv/Fm, rETRmax, Alpha, Ek, and NPQ) of the temperate and Antarctic strains with a full recovery observed at the end of the recovery process (42 hours) while the tropical strain was not affected. On the other hand, UVB radiation resulted in drastic reductions in the photosynthetic parameters of all six strains. The tolerance of microalgae to UVB can be related to their geographical origin. In general, the extent of recovery from UVB as assessed based on Fv/Fm values were the highest in tropical strains followed by the temperate and lastly, the Antarctic strains.



## ***Production of omega-3 long chain polyunsaturated fatty acids and characterization of natural compounds from Glaciozyma Antarctica***

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*Glaciozyma antarctica* is a psychrophilic yeast that survives at a growth temperature as below as 15°C. This research is designed to determine the lipid profile, especially the fatty acid and chemical components produced by the yeast at various growth temperatures of 12°C, 0°C, and -18°C in order to elucidate the temperature adaptation response. The lipid extraction from the *G. antarctica* pellet was conducted using the solvent chloroform:methanol. The total amount of lipid produced at growth temperature -18°C is 0.80 g which is lower than the amount produced at the temperature 0°C , 1.20 g , and 12°C , 2.30 g. On the other hand, liquid-liquid extraction was performed on the *G. antarctica* supernatant using the solvent ethyl acetate. A non-polar compound, designated as G.a-01 np, were isolated from the ethyl acetate extract of the supernatant of *G. antarctica* culture grown at the temperature -18°C. The structure of isolated molecule were established by spectroscopic techniques (HPLC, LCMS, FTIR, NMR). The presences of fatty acids in the lipid extract of *G. antarctica* pellet were identified using gas chromatography-flame induced detector (GC-FID). The major expected fatty acids from *G. antarctica* pellets are oleic acid (C18:1n9), linoleic acid (C18:2n6) and α-linoleic acid (C18:3n3). Most of the expected fatty acids are unsaturated.

## ***Shedding light on the dominance of cryptophytes in Antarctic coastal waters: A case study in Gerlache Strait***

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Changes in phytoplankton composition from large diatoms to small cryptophytes and their implications to the food web have been previously associated with rapid warming of surface waters in the western Antarctic Peninsula (WAP). This work aimed to investigate natural phytoplankton assemblages during two late summer cruises (2013 and 2014) in the Gerlache Strait, WAP. In addition, incubation experiments were conducted with natural populations to study the physiological and community responses to high irradiance. Cryptophytes were an important phytoplankton component in the region (on average ~ 50% of biomass in both years) and were mainly distributed above the pycnocline in shallow mixed layers and stratified conditions. Experimental results showed important photoprotective mechanisms, allowing for recovery and maintenance of photosynthetic function after extreme light exposure, sustaining growth of cryptophytes along with small diatoms (*Fragilariopsis* spp.) previously shown to be well adapted to high irradiance. This work suggests that the prevalence of cryptophytes in WAP coastal waters can be, to a great extent, a result of the ability of those small flagellates to successfully grow in highly illuminated conditions in shallow upper mixed layers.

## ***Use of oxidative stress enzymes as a biomarker for assessment of environmental stress on sea ice algae from Peninsula Antarctic***

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Environmental conditions affect many aspects of cellular metabolism. In recent years, growing attention has been devoted to the damage induced by oxygen radicals to cells under stress conditions. In biological system, reactive oxygen species (ROS) such as singlet oxygen ( $^1O_2$ ), hydrogen peroxide ( $H_2O_2$ ), superoxide anion radical ( $O_2^{\bullet-}$ ) and hydroxyl radical ( $\bullet OH$ ) are produced in normal metabolic pathways, as well as due to the exposure of different environmental stress. Organisms protect against these oxygen centred molecules, to some extent by developing antioxidant defence systems, which constitute both enzymatic and non enzymatic biomolecules, such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX), glutathione S-transferase (GST), reduced glutathione (GSH) and ascorbic acid (AsA). Algae are notable bioindicator species in environmental pollution studies. In view of this, efforts are made to investigate the use of oxidative stress enzymes (OSE) as a biomarker for environmental stress on sea ice algae. Levels of these OSE in sea ice algae from Graham Coast, Peninsula Antarctic collected during the Malaysian Antarctic Expedition 2016 will allow the establishment of baseline data that will be used for developing a monitoring programme. The findings of the present study may contribute to the understanding of how the Antarctic algae respond to environmental stress, and to use oxidative stress enzymes levels to monitor the impact of climate change and increased contamination of the polar habitats.

## **S29. From The Top: Higher Trophic Predators As Ecosystem Sentinels**

### ***Antarctic pack ice seals and oceanographic features at the Filchner Outflow System, southern Weddell Sea***

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The Filchner Outflow System (FOS) in the southern Weddell Sea is one of the most important areas for deep water formation. Here the outflow of Ice Shelf Water (ISW) of the Filchner Ronne Ice Shelf interacts with Warm Deep Water (WDW) of the Weddell Gyre circulation, resulting in Weddell Sea Deep and Bottom Water production (WSDW, WSBW). The interaction around the sill of the Filchner Trough is thought to result in a physical oceanography "hotspot" that may also aggregate primary and secondary producers, leading to increased abundance of top predators. However, data on top predator abundance for the FOS are scarce. Two aerial surveys over ice-covered sea were carried out to estimate density gradients and the regional abundance of pack ice seals in the FOS. A digital imaging survey with fixed wing research aircraft Polar 6 in November 2013 preceded a helicopter survey from aboard RV Polarstern during January 2014. The Polar 6 survey comprised 11 transects summing to a survey effort of 1,148.44 km. 265 seals were counted on transect lines with a higher encounter rate on transects located further to the west. The helicopter survey allowed seal species to be identified. Twenty-five transects (1,367.61 km) were flown in the FOS region and another six transects (425.54 km) further south within the Filchner Trough. Only two seal species, the crabeater seal (*Lobodon carcinophaga*) (n = 754) and the Weddell seal (*Leptonychotes weddellii*) (n = 217), were observed. Distance sampling analysis suggested that the density of seals differed strongly between the two survey regions, with very few seals encountered on transects located in the more southerly Filchner Trough region. A longitudinal density gradient increasing from east to west within the FOS region during January 2014 supported the results obtained from the Polar 6 survey, but failed to support the idea of a top predator hotspot at the sill of the Filchner Trough at least for seals.

## ***Current knowledge of Antarctic wildlife pathogens: Identification of gaps and opportunities for research***

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Pathogens, including microbes and parasites are active players in the regulation of host populations. The most evident pathogen effect on host populations is mortality causing a mass mortality event in a short period of time. However, other pathogens effects different from catastrophic events such as sublethal and subtle effects affecting for instance life history traits like reproduction phenology, clutch size, brood size could also affect host populations at long term. Moreover, pathogens can also increase the vulnerability to toxins, opportunistic pathogens and parasites, or reduce the ability of animals to manage extreme environmental changes. In spite of their geographical isolation of Antarctic continent its wildlife is not beyond of such effects. Information about the health status of birds and marine mammals in Antarctica is crucial to assess the risk of disease outbreaks and likely population crashes. There have been very few mass mortality events of birds or marine mammals reported in the Antarctic continent but the increase of human activity and ongoing environmental changes during the last years is likely to increase the risk of disease epidemics. Moreover, migratory species can contribute to the spread of pathogenic organisms in Antarctica. Therefore, baseline information about what pathogens and parasites are present in Antarctica, their prevalence and infection intensity is needed. This information is up to now scarce and fragmented in spite of some recent reviews. As such, efforts should be directed towards increasing knowledge about not only the presence/absence of diseases or parasites within Antarctic wildlife but on their potential to cause clinical disease and mortality. Here, we review all the published information about pathogens and diseases in Antarctic wildlife and provide an overview of current knowledge of disease and pathogen occurrence in Antarctic fauna. We also analyse the spatial and temporal distribution of studies by host, pathogen and analysis method, and analyse the gaps of knowledge on this issue and future research opportunities.

• This is a contribution of the Working Group of Health Monitoring of Birds and Marine Mammals of the SCAR EGBAMM.

## ***Distribution, habitat and trophic ecology of Antarctic squid *Kondakovia longimana* and *Moroteuthis knipovitchi*: inferences from predators and stable isotopes***

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Cephalopods have an important role in the marine environment though knowledge of their distribution and trophic ecology is limited by a lack of observations. This is particularly true for Antarctic species. Toothfish species are key predators of cephalopods and may be viewed as ideal biological samplers of these species. A total of 256 cephalopod lower beaks were identified from the stomachs of Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*Dissostichus mawsoni*), captured in fisheries of South Georgia and the South Sandwich Islands in the South Atlantic. Long-armed octopus squid (*Kondakovia longimana*) and smooth-hooked squid (*Moroteuthis knipovitchi*) were the main cephalopod prey and both were predated upon wherever toothfish were captured, though this cephalopod species appear to inhabit deeper waters at the South Sandwich Islands than at South Georgia. Measurements of  $\delta^{13}\text{C}$  from beak material indicated a clear segregation of habitat use comparing adult and sub-adult sized *K. longimana*. Variation in  $\delta^{15}\text{N}$  with size indicated an ontogenetic shift in the diet of cephalopods and also suggested some trophic plasticity among years. This study provides new insights in to the life of some elusive Antarctic cephalopods in an underexplored region of the South Atlantic.

## ***Movements and diving of satellite-monitored fin whales off the Antarctic Peninsula***

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Waters surrounding the Antarctic Peninsula region are a known feeding ground for Southern Hemisphere fin whales, *Balaenoptera physalus*. Here we present preliminary results on local movements and diving of fin whales instrumented with satellite tags in this region. One satellite tag was deployed on 19 February 2014 in the western Weddell Sea and three others were deployed on 18-19 February 2015 in the Bransfield Strait. The individual in The Weddell Sea was tracked for 12 days, during which period it moved about 990 km, based on provided Argos locations. Whales tagged in Bransfield Strait stayed in the area during the whole tracking period, of 28 and 37 days, during which they moved about 2,836 and 3,012 km, respectively. Dive data included 2,882 dives recorded in the Weddell Sea and about 41,580 dives in the Bransfield Strait, with most dives occurring at depths shallower than 60 m and lasting less than 3 minutes. Maximum dive depths and duration were in the range of 300-500 m and 15-20 min, respectively. Ongoing analyses using state space models to estimate locations and behavioral modes and generalized additive mixed models to investigate their relationship to environmental variables will provide further insights into the species' habitat use. These data represent the first telemetry study of fin whales in the Southern Ocean, and show individuals occupying an area inside Bransfield Strait waters where the occurrence of the species was relatively uncommon.

## ***Re-evaluating the role of seals in the trophic webs of the western Antarctic Peninsula***

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The use of stable isotopes analysis (SIA) in ecology has proved a powerful technique to study the structure and fluxes of energy of trophic webs. New advances in SIA allow us to make use of the specificity of biological molecules (e.g. amino acids) to define and characterize the base of the trophic web (carbon fingerprinting), as well as to more accurately describe the trophic position of consumers and make comparisons across different trophic webs. We used SIA combined with compound-specific SIA (CSIA) of amino acids to investigate the trophic ecology of two species of Antarctic phocids along the western Antarctica Peninsula: the southern elephant (Mirounga leonina) and crabeater seal (Lobodon carcinophaga). Our objectives were (1) to evaluate what trophic webs of the western Antarctica Peninsula are impacted by these species, and (2) to accurately define the trophic position (TP) of both species. Samples of seal vibrissae were collected in 2007 at Livingston Island (nelephant seals = 10) and around Marguerite Bay (ncrabeater seals = 10) and analyzed for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of bulk tissue and CSIA of amino acids. Bulk tissue data showed differences between species, with crabeater seals consistently having significant lower values for both  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  than elephant seals. Despite their more restricted spatial ranges, crabeater seals showed larger variability in their isotopic values, likely a result of seasonal shifts in the composition of the coastal phytoplankton community. Using amino acids that do not undergo changes through the trophic web (i.e. conserve the signal from the primary producers) we were able to discriminate between at least three food webs that are impacted by crabeater and elephant seals: a coastal, intermediate and oceanic food web. As predicted, most crabeater seals occupy a coastal trophic web, whereas the vast majority of the elephant seals form part of the oceanic one, yet there is an intermediate trophic web that is being used by both species. Most individuals occupy similar TPs when comparing values within species (TP crabeater seal coastal = 2.12, TP elephant seal oceanic = 3.21), however, the TPs of both species of seals is similar for those individuals in the intermediate trophic web (TP crabeater seal intermediate = 2.96, TP elephant seal intermediate = 3.29). Further research should be directed towards identifying the trophic links and structure of this potential third trophic pathway.



# ***Temporal shift in the isotopic niche of female Antarctic fur seals from Bouvetøya***

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Altered trophic interactions can affect population dynamics of both prey and predator species. Investigating the trophic ecology of marine predators can help identifying changes that have occurred at lower levels within their food web. The Antarctic fur seal *Arctocephalus gazella* is a key marine predator in the Southern Ocean, a region that has recently started to show changes as a result of global climate change. Here, carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) stable isotope analyses (SIA) on whole blood and plasma samples were used to examine the isotopic niche of lactating Antarctic fur seal females at two temporal scales (interannually and seasonally). At an interannual scale, a significant increase in  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  was found between 1997 and 2015; change occurred at an average rate of 0.067‰ ( $\delta^{13}\text{C}$ ) and 0.072‰ ( $\delta^{15}\text{N}$ ) per year over this period. This shows that over this period of a decade and a half an isotopic niche shift occurred, which likely corresponds to a shift in diet towards higher-trophic level prey, such as fish (replacing krill). At a seasonal scale, an average decrease of -0.7‰ per month (95% CI = [-0.9; -0.6]) in  $\delta^{13}\text{C}$  occurred while there was an average increase of 1.1‰ per month in  $\delta^{15}\text{N}$ . These results match observations at other breeding Antarctic fur seal colonies that have shown a stronger reliance on higher-trophic level prey, and more offshore foraging grounds, as the breeding season progresses. Our results constitute the first isotopic assessment for females Antarctic fur seals from Bouvetøya and can provide a baseline for the use of this predator species as a sentinel of the marine trophic system in one of the least studied areas within the species distributional range.

## ***Vibrissae of juvenile southern elephant seals *Mirounga leonina* as matrix for obtaining fine-scale, time-based dietary information***

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Combining satellite-linked telemetry and stable isotope analysis provides a powerful, indirect approach to assess the trophic ecology of individuals on a spatial and temporally integrated basis. However, this approach requires accurate species-specific quantification of the period of biomolecule deposition in the sampled tissue. Sequentially sampled vibrissae (whiskers) provide a chronology of biogeochemical data; but, the vibrissal growth rate and history are required for temporally integrated data interpretations. The purpose of this study was to a) quantify the vibrissal growth parameters of southern elephant seals (SES) *Mirounga leonina*, and b) use serially sampled vibrissal regrowths with a known growth history to obtain a fine-scale, temporally related dietary reconstruction of the sampled individuals. Contrary to the previously described asynchronous vibrissal shedding pattern of southern elephant seals (SES) *Mirounga leonina* during the annual pelage moult, 71.1 % (n = 140 individuals) displayed vibrissal shedding at Marion Island, southern Indian Ocean. Irregular vibrissal shedding, however, impedes the ability to draw general assumptions regarding the growth history of any unknown vibrissa collected, irrespective of having a detailed vibrissal growth rate model. To account for the unknown onset of biomolecule deposition in the vibrissae, vibrissal regrowths with known (mark-recapture data) growth histories were sampled. The von Bertalanffy growth function indicated that the vibrissal growth rate of known-aged SES decreases as the asymptotic length is approached. The resolution of the dietary data obtainable from a single 2 mm vibrissal segment ranged from a maximum of 3.5 days, but decreased to > 40 days as the growth rate decreased near the base of the regrowth. Nevertheless, the temporal resolution obtained spanned an entire year, demonstrating that fine-scale, long-term, temporally integrated dietary information can be obtained. Secondly, the vibrissa regrowths of underyearling SES (n = 14) (aged < 1.3 yo) were sequentially sampled along the length of each vibrissa and produced fine-scale intra- and inter-individual dietary information during their first year at sea. The depleted  $\delta^{15}\text{N}$  ( $8.5 \pm 0.6\text{‰}$ , mean  $\pm$  SD) measured during the post-weaning foraging confirmed that underyearling SES of both sexes predated lower trophic level (TL) prey (TL = 2.7) within the Antarctic Polar Front (APF) and Polar Frontal Zone (PFZ). The Bayesian isotopic mixing model approach indicated that the underyearling SES diet consisted predominantly of Subantarctic krill species (52%), such as *Euphausia vallentini*. Lower TL crustacean feeding cephalopods contributed 26%, whilst myctophid fish and larger cephalopods contributed 12%. The initial krill-based diet of underyearling SES shifted to myctophid fish in older age-classes and underyearling SES utilized a unique trophic niche within the guild of marine top predators at Marion Island, suggesting low levels of intra- and inter-specific competition. This study represents the first utilization of vibrissa regrowths to increase the resolution of dietary information obtainable through SI analysis.

## ***Video-loggers reveal the significance of jellyfish as food for Adélie penguins***

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Concern of pelagic gelatinous organisms taking over perturbed marine ecosystems has led to a recent increase in research into this group. However, quantifying the significance of this group as prey remains challenging, and hence gelatinous consumers are often depicted incorrectly as dead ends of pelagic food webs. In the Southern Ocean, where a shift in trophic webs may favour gelatinous animals, we video-monitored prey intake of a key predator. Twenty-eight chick-rearing Adélie penguins *Pygoscelis adeliae* from Dumont d'Urville station (66°40'S, 140°01'E) were instrumented with miniaturized video-loggers in 2014-2015. Among other items (krill, fish), 101 gelatinous organisms (n=79 jellyfish, 6 salps and 16 unidentified) were observed on 13 of 21 exploitable video footages (total: 59 h). Importantly, 65.3% of gelatinous organisms were attacked, but within them, salps were never attacked. Attacks on jellyfish were significantly associated with the visible presence of the jellyfish's gonad. Jellyfish were encountered at an average depth of  $26.2 \pm 10.4$  m, significantly shallower than the depths at which krill was found. Attacks occurred mostly during bottom, but also descent or ascent dive phases. Concomitant GPS location for four birds revealed that attacks on jellyfish occurred above the shelf, 35 km north from the colony, where sea-ice concentration reached 88%. These results indicate that Adélie penguins occasionally feed on jellyfish, even though other prey types are also available. Refining our perception of scyphozoans' niche may thus help anticipating the functional response of predators to the extensive changes witnessed in the Antarctic environment.

## **S35. Data Access And Sharing For Cutting Edge Science**

### ***Antarctic data and information for Canada: The polar data catalogue***

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Since its online launch in 2007, the Polar Data Catalogue (PDC, <https://polardata.ca>) has become Canada's primary on-line source for data and information on research in the polar regions. The PDC is home to hundreds of research and monitoring datasets, thousands of descriptive metadata records, and tens of thousands of satellite images from a variety of Canadian and international programs, including Polar Knowledge Canada (POLAR), the country's adhering body to the Scientific Committee on Antarctic Research (SCAR). With the recent application to become Canada's National Antarctic Data Centre (NADC), the PDC is poised to be the official repository for data and information from the growing Antarctic research community in Canada. Related activities are as follows:

Through our partnership with the Canadian Space Agency, the 1997 and 2000 RADARSAT continental mosaics of Antarctica and the component tile products are being made available for free download from the PDC. This satellite imagery was originally provided in formats which are difficult to use, so we have transformed the data into formats which are accessible to a much wider variety of users. When used with the 2008 Antarctic RADARSAT-2 satellite mosaic (also available on the PDC), the 1997 and 2000 snapshots provide historic information on changing ice conditions in Antarctica.

Along with numerous hosts including SCAR, the Standing Committee on Antarctic Data Management (SC-ADM), and the ICSU World Data System, PDC/CCIN co-hosted Polar Data Forum II: International Collaboration for Advancing Polar Data Access and Preservation (PDF II) in Waterloo, Canada in October 2015. Over 110 Arctic and Antarctic data managers, researchers, students and early career researchers, Arctic residents, policy and funding agency representatives, and others from 18 countries participated to collaborate on improving access to polar data and information. Following the success of Polar Data Forum I held in Tokyo in 2013, PDF II has resulted in closer collaboration between the Antarctic and Arctic data communities, including formal linkage between SC-ADM and the Arctic Data Committee of the International Arctic Science Committee and Sustaining Arctic Observing Networks. PDC participation in both SC-ADM and the Arctic Data Committee helps link the two communities, informing each one of the work taking place at the other pole and enhancing and improving data management from a bi-polar perspective.

To ensure compliance with the requirements of being Canada's NADC, we have begun sending the PDC's Antarctic metadata records to the Global Change Master Directory (GCMD), for inclusion in the Antarctic Master Directory. The PDC metadata are provided natively in the North American Profile of ISO 19115:2003 and FGDC-STD-001-1998 standard formats, so we are translating our metadata records to the Directory Interchange Format (DIF) standard used at GCMD.

We expect the PDC's involvement in Antarctic data management to continue growing with expansion of Antarctic research activities and interest in Canada, providing a focus and home within the country for progress in data stewardship for both polar regions.

## ***Arca Arctic present climatic change and past extreme events***

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Understanding the mechanism behind the release of large volumes of cold and fresh water from melting of ice caps is critical for climate studies. The project ARCA (Arctic present Climatic change and pAst extreme events) aims to study this complex system from the point of view of paleoclimatic and of present-day air-sea-ice interaction processes. Activities of ARCA project include (a) support to an international scientific drilling campaign (CORIBAR, <https://sites.google.com/site/ipynicestreams/coribar>) and analyses of resulting data, (b) intensive campaigns aimed to study the energy balance at the surface interaction processes and air-sea-ice (along the edge of the tidewater glaciers that overlook the Kongsfjorden), (c) the acquisition / data sharing for monitoring the dynamics of large outlet glaciers of Greenland, and d) realization of a distributed structure based on the concepts of brokering approach, with nodes managed by the various participants and the central infrastructure implemented at CNR.

The work of analysis and synthesis of data allow to correlate the main events of past meltwaters climatic conditions. The possible anthropogenic influence on these processes have been investigated by reconstructing the recent history of the last 150 years through the analysis of sediments and ice cores collected in the area of Kongsfjorden.

Furthermore, present-day hydrological and dynamic properties of seawater in the Svalbard and Fram strait region areas have been studied using underwater instruments as part of a marine observatory that consists of moored instruments and interoperable open access database. Land-based and atmospheric measurements are also considered.

ARCA activities and the state of the art are here shown. Arca is supported by Italian Ministry of Education, University and Research.

## ***BCO-DMO: Southern ocean marine ecosystem data and more***

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The diverse and unique marine ecosystems found in the Southern Ocean are being exposed to rapid environmental changes. Access to research data from the region is critical to gain new insights and support greater understanding of the changes taking place in the region and their impact. Data from decades of U.S. National Science Foundation funded Southern Ocean research programs are available from the Biological and Chemical Oceanography Data Management Office (BCO-DMO). Individual researchers, small research teams and large coordinated programs have contributed data including the full range of in situ measurements, experimental laboratory results, synthesis products and model output. Data from the US Joint Global Ocean Flux Study (JGOFS) and the Southern Ocean GLOBal Ocean ECosystems Dynamics (GLOBEC) program are available along with results from in situ iron fertilization studies and more recently funded studies of productivity, biogeochemical cycling and marine food webs. The data are openly available and accompanied by sufficient documentation to support re-use.

## ***Italian Polar Data and Metadata Infrastructure (IPDMI) A digital infrastructure to collect, manage, publish and share polar research results***

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The CNR coordinates the research activities in the Antarctica and in the Arctic and is in charge of managing the data and disseminate the scientific results of the activities carried out in those areas. The data collected mainly refer to projects carried out at Antarctic stations of Concordia (Dome C), Mario Zucchelli (Terra Nova Bay) and at Arctic station Dirigibile Italia in Ny - Alesund ( Svalbard Islands). Many of these data sets are not yet interoperable and accessible because they do not accomplish to international standard formats. An organized and distributed information system becomes necessary to manage the continuously increasing amount of data. Moreover historical catalog must be updated to the international standards and federated in the same system.

CNR is establishing the digital infrastructure (IPDMI) to provide to the polar scientific community, to easily manage real-time data and metadata. The infrastructure will ensure transparent data discovery through the interconnection of the system with the most common ones for discovery and broker access to environmental data, integration with the global environmental observation network of GEOSS, and contribute to increase the entire GEO community. The IPDMI system is conceived to support the scientist through simple and intuitive interfaces to create a customized work environment. The infrastructure will also be provided with SOS service to allow real time updates on data and metadata directly from remote sensors.

The architecture that applies the "System of Systems" principles will increment the existing systems by supplementing but not supplanting their mandates and governance arrangements. This allows to keep the existing capacities as autonomous as possible. This infrastructure implements multi-disciplinary interoperability following a Brokering approach, supporting SCAR data policy and in accordance with European and international standards, including GEO/GEOSS, INSPIRE. The functionality of the infrastructure has been validated using the data acquired by different type of measurement and sensors at Italian Arctic Station in Ny Alesund – Svalbard and the full operability will be applied to all data referring to polar regions.

# ***Marine mammals in the Southern Ocean – How WebGIS technology and GIS infrastructure supports data visualization, publication and sharing***

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Long-distance tracking of marine mammals in the Southern Ocean by satellite relies on the ARGOS system. ARGOS satellite transmitters for marine mammal applications are designed to provide at-sea locations for the animals and transmit this data to polar-orbiting satellites when the seals surface. Some instruments transmit logging data about each dive (i.e, dive depth, dive duration, post-dive surface interval) and others have the capacity to process and transmit in-situ measurements on hydrographic features (i.e, water temperature and conductivity) for the entire migration path of tracked individuals. However, location-specific transmitters and dive loggers rely on a post-hoc reconciliation of the animals' position with oceanographic data, and even those units that measure certain hydrographic features rely on post-processing with bathymetric data. Here, we present a Geographic Information Systems (GIS)-based approach to visualize the cumulative data sets of our ARGOS locations over a 20-year period of tracking of Antarctic seals, in conjunction with the respective environmental features.

The ARGOS data received was aggregated into files with each file representing one deployment of a satellite tag on a seal. The data was archived by the Data Publisher for Earth and Environmental Science PANGAEA as plain tables and, hence, each data set was citable via its digital object identifier (doi). In total, more than 350,000 individual locations have been archived. GIS-based web services (WebGIS service) are excellent tools to visualize, publish or share data. AWI has established a comprehensive and highly scalable GIS infrastructure to provide these functionalities to AWI scientists within an easy-to-use, widely accessible GIS environment.

The data download for marine mammals was operated using PANGAEA's data warehouse functionalities and transferred to the AWI GIS database, a PostgreSQL (9.3) database management system. This database was prepared to store and operate spatial data by installing ArcSDE (Spatial Database Engine), subsequently accessible via desktop or server GIS applications. GIS services were created and designed using ArcGIS for Desktop (10.3) and finally published as a Web Map Service (WMS), an internationally standardized format (Open Geospatial Consortium (OGC)), using ArcGIS for Server (10.3). The project specific marine mammal WMS, as well as an Antarctic background map WMS were embedded into a GIS viewer application based on Leaflet, an open-source JavaScript library. WMS queries were edited by a specific GIS viewer editing unit. All open accessible AWI WebGIS projects can be found at maps@awi (maps.awi.de).



## ***Online sea ice data platform: [www.seaiceportal.de](http://www.seaiceportal.de)***

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There is an increasing public interest in sea ice information from both Polar Regions, which requires up-to-date background information and data sets at different levels for various target groups. In order to serve this interest and need, [seaiceportal.de](http://seaiceportal.de) (originally: [meereisportal.de](http://meereisportal.de)) was developed as a comprehensive German knowledge platform on sea ice and its snow cover in the Arctic and Antarctic. It was launched in April 2013. Since then, the content and selection of data sets increased and the data portal received increasing attention, also from the international science community. Meanwhile, we are providing near-real time and archive data of many key parameters of sea ice and its snow cover. The data sets result from measurements acquired by various platforms as well as numerical simulations. Satellite observations of sea ice concentration, freeboard, thickness and drift are available as gridded data sets. Sea ice and snow temperatures and thickness as well as atmospheric parameters are available from autonomous platforms (buoys). Additional ship observations, ice station measurements, and mooring time series are compiled as data collections over the last decade. In parallel, we are continuously extending our meta-data and uncertainty information for all data sets. In addition to the data portal, [seaiceportal.de](http://seaiceportal.de) provides general comprehensive background information on sea ice and snow as well as expert statements on recent observations and developments. This content is mostly in German in order to complement the various existing international sites for the German speaking public. We will present the portal, its content and function, but we are also asking for direct user feedback.

## ***Sea stars field guides: A proof of concept for opening more data***

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Ten years after the creation of the Register of Antarctic Marine Species (RAMS), in the framework of the Census of Antarctic Marine Life and the International Polar Year, we have focused on trying to create a field guide dedicated to Southern Ocean sea stars identification, using tools available under the biodiversity.aq information system.

When working on specific taxa, it becomes evident that the synergy between historical and modern data is a must. Whether to perform the fundamental process of identification or to accomplish any research purpose requiring good knowledge of the studied organism, basal information can prove itself hard or nearly impossible to find.

In this poster we present a new, open access, collaborative platform for identifying Antarctic sea stars in the field, using a set of tools developed under the auspices of the biodiversity.aq initiative. Using the Antarctic Field Guides platform ([afg.biodiversity.aq](http://afg.biodiversity.aq)), and enriching data from RAMS with legacy literature and high-resolution pictures, we present a new online resource.

The AstAPor (Asteroid Antarctic Portal) allows user to search, visualize and download a field guide in PDF format, which aggregates information from a wide variety of authoritative sources. Up to now, we have completed available information with more than 14,000 occurrence records, many scanned literature resources (including legacy cruise reports and/or original descriptions), hundreds of high resolution pictures of specimens, and hotlinks to genetics data, filling a large number of pending gaps in Antarctic biodiversity information.

## ***South African data portal for polar and high latitude polar research data***

**Katherine Niemantinga**<sup>1</sup>, Pierre Cilliers<sup>1</sup>, Gert Lamprecht<sup>1</sup>  
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SCAR Open Science Conference, Kuala Lumpur, Malaysia, 22-26 August 2016

Abstract

SANDIMS: A new South African data portal for polar and high latitude polar research data from the South African Antarctic base, Marion Island and Gough Island.

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<sup>1</sup>South African National Space Agency, Hermanus, South Africa

The archiving and dissemination of geophysical research data collected at the South African Antarctic research base (SANAE IV) and at the South African high latitude observatories on Marion Island and Gough Island, which fall under the South African National Antarctic Programme (SANAP) has until recently been fragmented and inaccessible to international researchers.

At the Space Science Directorate of the South African National Space Agency (SANSA) in Hermanus we are in the process of implementing a scientific data portal called the South African National Data and Information Management System (SANDIMS) which will for the first time make the geophysical data collected and used by SANSA available through a single data portal. The SANDIMS data portal will be based on a Hadoop cluster that will not only be an active storage facility for all of our data as well as international complimentary data but also enable our researchers to process and analysis their data faster at a few clicks of a button. This will allow our agency to control and manage our data for research and application purposes.

The system will meet national and international obligations and expectations, as well as raise the standard of South African research. The system's unique database will contain high-quality data from areas in space that, potentially, could supply information for unanswered scientific questions and enhance scientific development.

The paper will present the design philosophy and various aspects of the implementation of the SANDIMS data portal.

## ***Spatial database development based on metadata and GIS software: applications for Terrantar Center***

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The Terrantar Center, the Federal University of Viçosa and member of the National Institute of Science and Technology of the Cryosphere, produced several studies on soil and environmental monitoring in Antarctica region in the last 13 years. This period was gathered a large volume of data in the form of maps, theses, articles, images and analytical results. The objective of this work was to manufacture spatial database to gather all the material generated by Terrantar team and make them available through a Geoportail, composed of the catalog metadata and GIS software. The methodology was developed in five stages: collection of data; grouping the data by geographic location; standardization of geographical information; metadata generation according to the ISO 19139 (Metadata Implementation Specification), held in ArcCatalog 10.2 software; and availability of data on the internet using the GeoServer and GeoNode systems for vector and raster files and Geonetwork systems for metadata, with option to download the data. Approximately 177 Gb of data has been recovered, in which the search can be performed by keyword or the geographical position through the advanced search on the map base. It is noteworthy that this is a dynamic process that always needs to be enriched with new information generated not only by Terrantar team, but also by contributions from researchers from other institutions. Access can be done by URL: <http://terrantar.ufv.br>.

## ***The Antarctic data management system, making scientific research in Antarctica discoverable***

**Anton P. Van de Putte**<sup>1</sup>, all other SCADM members

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Data and information are valuable and irreplaceable resources. Proper management of data and information is not an “add-on” or an additional task; it is a fundamental aspect of modern science. In the pursuit of various scientific objectives, it is often necessary to use data and information collected by scientists from many countries. SCAR recognizes the critical and essential importance of the stewardship of data and information within national and international programmes and its accessibility to all.

SCAR has adopted a Data and Information Management Strategy (DIMS), developed by the SCAR Standing Committee on Antarctic Data Management (SCADM), to ensure that the scientific user community has adequate access to data and information.

National Antarctic Data Centres and thematic initiatives such as the Southern Ocean Observation System and the Antarctic Biodiversity Portal make meta data on various topics available through the Antarctic Master Directory.

Here we provide more information on the how meta data is contributed to the AMD and how researcher can retrieve it.

## ***The EU-PolarNet/COMNAP/INTERACT Polar infrastructure database cooperation: facilitating the management of Polar logistics and promoting science access***

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EU-PolarNet is the European consortium in expertise and infrastructures for polar research, involving 22 organisations and several international partners, aiming at developing an Integrated European Polar Research Programme, co-designed with all relevant stakeholders. In order to facilitate this objective, a new database on European Polar facilities, vessels, aircraft and key observatories has been prepared. The database structure was developed in close cooperation with the Council of Managers of National Antarctic Programs (COMNAP) and the International Network for Terrestrial Research and Monitoring in the Arctic (INTERACT), allowing the database to be designed following the requirements of the three organisations. The common database structure is available for each organization to archive and manage its own data, facilitating the development of specific products, such as catalogues or websites. The three databases are easily updatable and transferrable and will facilitate the development of a number of products targeting at maximising the efficiency of infrastructure management, utilization and access by scientists. On the European side, the European Polar Board, a partner of EU-PolarNet will manage the European Polar infrastructure database and a webGIS platform will allow for easy access and dissemination. EU-PolarNet is funded by the European Commission's Horizon 2020 programme.

## ***The U.S. Antarctic Program Data Center (USAP-DC): Recent results and new developments***

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The U.S. Antarctic Program Data Center (USAP-DC) supports investigators funded by the U.S. National Science Foundation (NSF) in documenting, preserving, and disseminating their research results. USAP-DC registers datasets in the Antarctic Master Directory (AMD) to comply with Antarctic Treaty requirements under Article III; facilitates submission of datasets to long-term national archives; and represents the United States in the Scientific Committee on Antarctic Research (SCAR) Standing Committee on Antarctic Data Management (SC-ADM).

USAP-DC publishes a Directory Interchange Format (DIF) record in the Antarctic Master Directory for each NSF-supported project. The DIF record is indexed to the NSF Antarctic funding program (Astrophysics and Geospace Sciences, Earth Sciences, Glaciology, Integrated System Science, Ocean and Atmospheric Sciences, Organisms and Ecosystems) and award number, and contains dataset download link(s) where available. In the case where no recognized national archive exists, a dataset may be uploaded directly to USAP-DC, which will publish a Digital Object Identifier (DOI) and deposit the dataset to the Academic Preservation Trust (APTrust) archive. USAP-DC has archived 305,685 files (7.1 TB) to date, for datasets ranging from snowmobile radar traverses to volcano observatory video. Beginning in 2016, USAP-DC will host the Antarctic Glaciological Data Center (AGDC), serving glaciological and cryospheric data collected by the U.S Antarctic Program with supporting documentation and links to related datasets.

USAP-DC is a member of the Interdisciplinary Earth Data Alliance (IEDA) and a partner in the Antarctic and Arctic Data Consortium (A2DC).

## **S41. Evidence Based Conservation And Environmental Management In Antarctica**

### ***Antarctic environmental challenges: the effectiveness of the protocol on environmental protection to the Antarctic treaty***

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The Protocol on Environmental Protection to the Antarctic Treaty (the Protocol), which aspires to protect the Antarctic environment, including its dependent and associated ecosystems (ATS, 2016), was adopted in 1991 and entered into force in 1998. Over the last two decades since the adoption of the Protocol, the parameters around human activities in the Antarctic and around Antarctic politics have changed dramatically. Scholars such as Shaw et al. (2014) and Hughes et al. (2015) argue that the changing parameters of human engagement with the Antarctic might erode the foundations of the Antarctic Treaty System and put the Protocol to the test. The latter has not undergone an in-depth scholarly assessment since Stokke & Vidas' (1996) work on the effectiveness of the Protocol. This paper reports on the first part of a research project aiming to analyse the effectiveness of the Protocol in light of the increased level of human activities in the Antarctic and the changing character of political engagement with the Antarctic. After positioning the Protocol as a global environmental regime, this paper explores different schools of thought with regard to assessing the effectiveness of multi-lateral environmental regimes. Findings of a literature analysis indicate that the more explicit the rules and norms of a multi-lateral environmental regime the greater its effectiveness. Firstly, ambiguous norms and rules can lead to confusion and different interpretations by Parties. Currently, the procedures introduced by the Protocol on environmental impact assessments are not clearly defined, which can reduce the success of the regime in achieving its objectives it set out to achieve, in consequence, reducing regime effectiveness. Secondly, the behavior of actors within the regime and their responses to requests made by central institutions within the regime, such as the Antarctic Treaty Secretariat, has a bearing on the effectiveness of the regime. The influence of the Antarctic Treaty Secretariat is limited, as is evidenced by the generally poor reporting culture by Antarctic Treaty Parties; similarly, authority held by the Committee for Environmental Protection is limited to an advisory role without any legislative or executive powers over the Parties. This paper will explore these aforementioned and other, matters related to the effectiveness of the environmental regimes in general, and the Protocol in particular, drawing preliminary conclusions on the effectiveness of the Protocol.



## ***Everything as usual at Fildes Peninsula? Ongoing environmental shortcomings in environmental management***

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The Fildes Peninsula in the south-west of King George Island, South Shetland Islands, Antarctic (62°08' – 62°14'S, 59°02' – 58°51'W) represents one of the largest ice-free areas in the maritime Antarctic and is characterized by a high biodiversity. At the same time, the Fildes Peninsula hosts six Antarctic stations and an airstrip turning the area into a superregional logistical hub. Therefore, the area is characterized by variety of human activities including research, logistic and tourism, which resulted in significant negative impact on the local natural values. Since the adoption of the Madrid Protocol in 1991 a multitude of legally binding and non-binding provisions have been developed in order to minimize human pressure on the Antarctic ecosystem. Many, if not most, of these provisions have relevance on Fildes Peninsula due the unique concentration of different human activities. Sadly, Fildes Peninsula and Ardley Island serve as a paradigm for inadequate implementation of these well-intentioned provisions and for insufficient compliance with existing regulations.

A long-term monitoring of the environmental situation (2003/04 – 2015/16) revealed some improvement in the implementation of some aspects of the Madrid Protocol by the resident national Antarctic programs (e.g. fuel or waste management, sewage treatment, dissemination of information). Nevertheless, widespread and continuing breaches of environmental protection standards have still been recorded. For example, this included the incineration of waste without any control and reduction of harmful emissions. Many incidences of minor hydrocarbon contaminations were noted along the existing road network and within the boundaries of almost all stations on Fildes Peninsula. Mitigation measures after a recent oil spill appeared to be largely inadequate and failed to prevent chronic and widespread pollution of the local marine environment close to a penguin colony. Pungent smell and high turbidity of discharged water at some sewage outfalls indicated a partly ineffective sewage treatment. The banned practice of actively feeding skuas with human food and food remains can still be observed at all stations. Continuing construction activities produced significant damage on vegetation. Furthermore, station personnel, film teams or national delegations regularly caused disturbance of birds and seals. We noted considerable differences regarding breeding pair numbers and breeding success of southern giant petrels in adjacent colonies, which were only attributable to the differing level of visitation of station personnel in their leisure time. The increase of some tourism forms (e.g. yacht tourism) provokes additional disturbance.

These observations illustrate the need for action to reduce current impacts and to minimize further environmental risks. Based on our area of expertise, we are expecting a further growth of human activities and further anthropogenic influences affecting Fildes Peninsula on different scales. Therefore, the immediate implementation of an effective management is required with the highest priority of strict compliance of the provisions set out in the Madrid Protocol's Annexes I to V regarding the management of waste, oil and sewage at the stations in order to safeguard the scientific and environmental values of the area.

## ***Measuring the environmental cost of science in Antarctica***

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So much of the science that occurs in Antarctica relates back to the state of global climate change, however, due to its remoteness and extreme environment, the environmental cost of this environmental science is significant.

Using data from Antarctica New Zealand's Scott Base on Ross Island, this presentation estimates the environmental costs of running a science support base, landing and housing a scientist in Antarctica and determines the success of cost reduction initiatives in both financial and environmental terms. It also estimated benefits gained by the logistics share arrangement with the United States Antarctic Program (USAP).

While so much of the science is world leading, is the execution of that science and science support leading the world?

The privilege of awareness that comes with our knowledge brings a un-detachable responsibility to ask "How are WE doing?", "Can we do better and if so, how?"

# **S08. Solid Earth Responses And Influences On Cryospheric Evolution**

## ***A set of vertical Antarctic GPS velocities***

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GPS data is used to provide observations of solid earth deformation caused by e.g. glacial isostatic adjustment (GIA) and hydrologic loading. The vertical velocities estimated from the GPS data may be assimilated into GIA models or used for comparison purposes.

While state-of-the art global GPS analysis has previously been performed for many Antarctic sites, errors in the resulting site velocities are typically obtained from noise analysis of the time series, which is challenging for shorter or incomplete time series. Here we present a consistently processed set of vertical GPS velocities and associated state-of-the-art errors for available Antarctic GPS data (1995 -2013.7), including estimation of orbits using global networks, manual evaluation of time series, and error propagation of noise characteristics from long time series to shorter ones.

## ***Antarctic crustal thickness and bedrock elevation***

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Bedrock elevation is generally observed to increase with crustal thickness, but notable differences have been observed between different seismo-tectonic regimes that have been linked to the underlying thermal and convectional structure of the mantle (e.g., Hyndman, 2010). For example, in North America the western Cordillera lie anomalously high relative to its crustal thickness and this may be related to high asthenospheric temperatures. An analysis of bedrock elevation and crustal thickness was carried out for six regions in Antarctica: Antarctic Peninsula, Ellsworth Land, Marie Byrd Land, West Antarctic Rift System, Transantarctic Mountains, and East Antarctica. Continent-wide compilations of crustal thickness (CRUST 2.0; Bassin et al., 2010) and bedrock elevation (BEDMAP; Lythe and Vaughan, 2001) were utilized for the analysis. Marie Byrd Land lies close to the hot mantle trend, but results are mixed for other regions and may reflect interpolation between sparse observations necessary for some regions of Antarctica. In contrast, consideration of a limited number of seismic studies that directly determine crustal thickness at specified locations yields more coherent results. East Antarctic results lie on or close to the cold mantle trend, while West Antarctic results (which are largely from the Marie Byrd Land region) are clustered closer to the hot mantle trend. The results are thus broadly consistent with previous findings suggesting that Marie Byrd Land is region of domal uplift lying above a mantle plume with high asthenospheric temperatures and low viscosities. The trends in inferred mantle temperatures have implications for glacial isostatic adjustment.

## ***Application of satellite remote sensing data for geological mapping in Antarctic Peninsula***

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Remote sensing imagery is capable to provide a solution to overcome the difficulties associated with field mapping in the Antarctic. Recent generation of high resolution multi-platform satellite sensors with various spectra-spatial imagery in shortwave infrared to long wavelength thermal and radar regions of the electromagnetic spectrum could be investigated to extract geological information for Antarctic environments. The Antarctic Peninsula (AP) contains a variety of well-exposed lithologies and areas that have not been mapped. The different geological history and environmental conditions suggest that Antarctic Peninsula (AP) is one of the more likely places in Antarctica for significant base-metal deposits and possible associated gold and silver due to analogy with the Andes Mountain Range of South America. In this scientific research, the Antarctic Peninsula (AP) was selected to conduct satellite remote sensing investigations. Landsat-8 Thematic Mapper (TM), the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) data were used to extract the information in different regions of the electromagnetic spectrum. The improvised image processing algorithms and systematic GIS techniques were implemented to detect structural elements and geological features for producing detailed geological maps of the Antarctic Peninsula. The outcomes of the investigation demonstrated that new revisions of geological maps with high accuracy of the Antarctic Peninsula could be produced using recent remote sensing satellite data. The results could be extended to map coverage of non-investigated regions further east and validated previously inferred geological observations concerning other rocks and mineral deposits throughout the Antarctica.

# ***Characteristic seismic tremors with harmonic overtones in the Lützow-Holm Bay, East Antarctica: 2014-2015***

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At the International Polar Year (IPY2007-2008), the Polar Earth Observing Network (POLENET) was the largest contributions in establishing seismic network in the Antarctic. Several kinds of seismic signals associated with environmental variations within the atmosphere - ocean - cryosphere - solid earth system had been detected in continental margins and surrounding Southern Ocean. Ice-related seismic motions for small magnitude events are generally named ice-quakes (ice-shocks) and can be generated by glacially related dynamics. Such kinds of cryoseismic sources are classified into several kinds; movements of ice sheets, sea-ice, oceanic tide-cracks, oceanic gravity waves, icebergs and the calving fronts of ice caps. Hypocenters of these local events nearby Syowa Station were identified as their location along the coast and edges of the fast-ice in the Lützow-Holm Bay (LHB) region.

In this study, characteristic features of seismic tremors observed around LHB are demonstrated, by taking into consideration a relationship between surface environmental changes in vicinity of the area. 121 seismic tremors are recognized in both the three-component short-period seismographs (HES) and broadband seismographs (STS-1) deploying at Syowa Station, during the period from October 2014 to April 2015. Many of the tremors hold characteristics of strong harmonic overtones, in their frequency content over the 1 Hz, representing nonlinear features (upward and/or downward frequency contents) with duration times from few minutes till few hours. These tremors occur independently with the arrivals of teleseismic phases, as well as are recorded by both the type of sensors (HES and STS-1) simultaneously. The harmonic overtones can be explained by a repetitive source (Powell and Neuberg, 2003), suggesting existence of several inter-glacial asperities which generate the characteristic tremors. It implies the tremor signals might be involved in the local origins, presumably the cryosphere dynamics; discharge of fast-ice from the Bay, collision of icebergs and fast-ices, calving of glaciers.

In the austral winter in 1997, actually, a few tens of hours duration tremor of harmonic overtones were strikingly observed involving the discharge of a large volume of sea-ice (fast-ice) from LHB (Kanao et al., 2012). The similar nonlinear harmonic tremors associated with the glacial earthquakes have been reported at Whillans Ice Stream, West Antarctica (Winberry et al., 2011, 2013), with the colliding icebergs in the Ross Sea (MacAyeal et al., 2008) and nearby the Neumayer Station of Dronning Maud Land (Eckstaller et al., 2007), respectively. In contrast, relatively small tremor signals are estimated to have very local origins, such as ice-shocks in relation to the sea-ice level changes in relation to oceanic tide variation in LHB. It is noticed that the laming signals by an ice-breaker ship "Shirase" are clearly identified around 11-13 January 2015, when the ship approach nearby Syowa Station. The laming signals hold frequency contents over few Hz with 10-15 min. intervals.

In summary, seismic tremors in terms of cryosphere dynamics are likely to be involved with variations in surface environments, and continuous monitoring of their time-space variability provides indirect evidence of climate change in the Antarctic.

## ***Crustal motion measurements from the POLENET Antarctic Network: comparisons with glacial isostatic adjustment models***

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Crustal motions measured by GPS provide a unique proxy record of ice mass change, due to the elastic and viscoelastic response of the earth to removal of ice loads. The ANET/POLENET array of bedrock GPS sites spans much of the Antarctic interior, encompassing regions where glacial isostatic adjustment (GIA) models predict large crustal displacements due to ice loss since the Last Glacial Maximum (LGM) and the sector of coastal West Antarctica where major modern ice mass loss is documented. The GPS-derived crustal motion patterns across the ANET array are spatially complex and differ significantly in magnitude from model predictions for many sectors of Antarctica.

In the Weddell Embayment region, where modern ice mass change is minimal, measured vertical velocities are commonly lower than uplift predicted by GIA models. An intriguing exception occurs at sites in the southernmost Transantarctic Mountains and the Whitmore Mountains, where measured uplift significantly exceeds GIA model predictions.

Within the Amundsen Sea Embayment, sites with extremely high upward displacements are flanked by subsiding regions. Seismic results in the Amundsen region document thin crust and low mantle viscosity, suggesting that these observed crustal motions can't be ascribed to an LGM ice loss signal, which would have already relaxed. Both the vertical and horizontal crustal motion patterns can be modeled by combining an elastic response to modern ice mass change with a viscoelastic response to ice loss on decadal-centennial time scales.

We present a systematic comparison of measured and predicted velocities within different sectors of Antarctica, in order to examine spatial patterns relative to modern ice mass changes, ice history model uncertainties, and lateral variations in earth properties.

## ***Crustal velocity solutions in polar environments: GPS position errors caused by ice in antennas***

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Continuously operating GPS sites in Antarctica provide a valuable data set utilized by a wide range of disciplines. For studies of glacial isostatic adjustment, the solid earth response to ice sheet mass changes, where displacements are on the order of millimeters per year, establishing robust crustal velocity solutions is essential and sources of positioning error must be minimized. Much like other cold-weather GPS networks, GPS sites in the Antarctic Network (ANET) of the Polar Earth Observing Network (POLENET) project utilize Dorne-Margolin-style choke ring antennas covered with SCIGN radomes. It has long been understood that accumulation of snow and ice outside of GPS antennas and radomes causes data scatter and errors in positioning. Here we present a relatively overlooked issue related to accumulation of snow and ice inside the choke rings, beneath the radome. While replacing a faulty antenna at an ANET GPS site during the 2014 – 2015 austral summer field season, thick rings of ice were discovered inside the choke rings. During the 2015-2016 austral summer field season, all visited ANET GPS sites were checked for internal snow and ice accumulation, and nearly one third of sites were found to have ice inside the antenna rings. Based on years of field experience and observations of wind and snow behavior in extreme polar environments, we suggest that blowing spindrift snow entering the antenna drain holes and spaces between the antenna and radome is causing the observed accumulation. An experiment was conducted at Ohio State University to test for position offsets due to internal accumulation in choke ring antennas. Scenarios of air, snow, water, and ice were all tested. Results show easting, northing, and height position components all impacted, with offsets of up to 7 cm. Icing occurrences are widespread in polar GPS time series as well as other high-latitude and high-elevation stations. It should no longer be assumed that these issues are the result of external ice accumulation alone. Given the observations and results presented here, the polar and high-elevation GPS community should begin considering equipment modifications or alternative antenna and radome combinations and should derive methods to identify and remove data outliers caused by internal ice accumulation to improve positioning and crustal motion solutions.



## ***GEOICE- A Next Generation Polar Seismic Observatory: Field tests of sensor and power systems***

**Audrey Huerta**<sup>1</sup>, J. Paul Winberry<sup>1</sup>, Bruce Bruce Beaudoin<sup>2</sup>, Paul Carpenter<sup>2</sup>, Jason Hebert<sup>2</sup>, Phillip Chung<sup>2</sup>, Kent Anderson<sup>2</sup>, Susan Bilek<sup>3</sup>

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We report on the development and field testing of a new U.S. NSF supported community seismic observatory for studies in ice-covered regions- the Geophysical Earth Observatory for ice Covered Environs (GEOICE). This project is motivated by the need for systems that are polar-rated, are light and small, have low power usage, and deploy quickly. The envisioned ~100 seismic sensor GEOICE observatory will nearly double the current polar inventory.

Ongoing field-testing of the prototype instruments and power systems includes a late-summer installation on the Taku glacier, with extreme conditions of rapid ablation and water-saturated ice. Sensors were installed in drill holes ~1.5 meters deep, and many were completely melted out in <28 days. High tilt-tolerance ( $\pm 5^\circ$ ) extended the data-gathering period to an average of 7 days. Winter testing via direct-burial on the Taku outwash plain provided longer-term (>4 months) testing of the sensors and power systems. These newly developed power systems include primary (non-rechargeable) and secondary (rechargeable) banks of lithium (optimized for weight) alkaline batteries (optimized for ease of purchase), rechargeable lithiums (weight and cost), and air-cell batteries (weight and cost).

## ***GNSS observations on outcrop areas around Syowa Station, East Antarctica***

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Campaign Global Navigation Satellite System (GNSS) observations have been carried out at five sites on bedrock outcrops along Soya Coast including a site at Syowa Station since 1998 to investigate motion of Antarctic plate and displacements due to Glacial Isostatic Adjustment (GIA) (Ozono et al., 2006). In Ozono et al. (2006), horizontal displacement of about 1.3–4.9 mm/year and uplift of about 1.3–7.0 mm/year were obtained.

Recently, we established two new permanent observation sites in the southern part of Soya Coast. The system of the sites consists of a GNSS receiver of power saving type and lithium-ion battery with solar panel. Iterative 24 hours observations of one-month interval are carried out automatically by the system. We are in the process of introducing the new unmanned observation system at the established sites.

In the previous study (Ozono et al., 2006), we reported the analysis result of the campaign GNSS observation data until 2003. In this presentation, we will show the recent the results obtained from the data after 2003 as well as the newly introduced observation system.

## ***Ice mass loading and deformation structures under grounded ice sheets: Examples from the and-1b and and-2a cores***

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Deformation of substrate beneath flowing, grounded ice sheets is a common manifestation of cryosphere-solid earth interactions. Here we investigate whether abundant mineralized fractures and clastic intrusions in two sedimentary rock cores recovered from the Victoria Land Basin of Antarctica by the ANDRILL project formed due to subglacial deformation. Horizons interpreted to represent 'glacial surfaces of erosion' marking grounded ice over the drillsite locations are commonly recognized based on internal fabrics within diamictites and features such as boxwork veining and clastic intrusions. If mineralized fractures and clastic intrusions formed during subglacial deformation, the expectation is that they (1) would be present and abundant in strata immediately above and below the interpreted glacial surfaces of erosion; (2) would be most abundant where the most numerous grounded ice intervals have been interpreted from the stratigraphic record; (3) could show high abundance in stratigraphic intervals coeval with glacial thermal regimes associated with abundant meltwater; (4) would conform to the Riedel fracture model for horizontal shear at the base of the ice and (5) would have a geometry consistent with the sense of shearing associated with the direction of ice flow. The abundance and distribution of mineralized fractures and clastic intrusions from the AND-1A and AND-2B cores show inconsistent spatial relations with respect to inferred depths of 'glacial surfaces of erosion'; increased abundance does not correlate with stratigraphic intervals in which grounded ice is interpreted to have repeatedly been present. The geometry and orientation of mineralized fractures in the sedimentary cores does not conform to a geometric fracture pattern defined by the Riedel shear model expected of brittle subglacial deformation or the shear direction imparted by the direction of ice flow over the substrate. Vein abundance and volume has been compared to the inferred glacial thermal regime (i.e., polar, polythermal, and wet-based glaciers) and the prediction of a larger abundance and overall volume of mineralized fractures within intervals where large volumes of subglacial meltwater are present is not supported. Origin of the mineralized fractures and clastic intrusions by the direct influence of shear deformation beneath flowing grounded ice appears to be precluded. However, overcompaction, dewatering and changing stress regimes due to mass loading by grounded ice sheets are all considered important factors in developing fracture sets in Victoria Land Basin strata.

# ***Incomplete separability of Antarctic plate rotation from glacial isostatic adjustment deformation within geodetic observations***

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Geodetic measurements of Antarctic solid Earth deformation include signals from plate rotation and glacial isostatic adjustment (GIA). Through simulation, we investigate the degree to which these signals are separable within horizontal GPS site velocities that commonly define plate rotation estimates and that promise new constraints on models of GIA. Using a suite of GIA model predictions which incorporate both one-dimensional and three-dimensional Earth rheologies, we show that, given the present location of GPS sites within East Antarctica, unmodelled or mismodelled GIA signal within GPS velocities produces biased estimates of plate rotation. When biased plate rotation is removed from the GPS velocities, errors as large as 0.8 mm/yr are introduced; a value commonly larger than the predicted GIA signal magnitude. In the absence of reliable forward models of plate rotation or GIA then Antarctic geodetic velocities cannot totally and unambiguously constrain either process, especially GIA.

## ***Investigating the tectonic and erosional evolution of the Shackleton Range region in East Antarctica***

**Guy Paxman**<sup>1</sup>, Stewart Jamieson<sup>1</sup>, Fausto Ferraccioli<sup>2</sup>, Rene Forsberg<sup>3</sup>, Mike Bentley<sup>1</sup>, Neil Ross<sup>4</sup>, Anthony Watts<sup>5</sup>, Tom Jordan<sup>2</sup>, Kenichi Matsuoka<sup>6</sup>, Arne Olsen<sup>3</sup>, Marta Ghidella<sup>7</sup>

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The evolution of Antarctic bedrock topography is a key control on ice sheet behaviour. Evolution of the subglacial landscape over geological timescales is controlled by tectonics, erosion, and deposition, as well as the solid Earth response to these processes. Here we aim to quantify these processes to better constrain the palaeotopographic evolution of the Shackleton Range in the previously largely unexplored Recovery Province of East Antarctica. The effective elastic thickness of the lithosphere is determined by modelling recently acquired bedrock topography and airborne gravity data over the region. Estimates of the effective elastic thickness of the lithosphere and effective viscosity of the upper mantle are then used in 2D and 3D flexural models to quantify the magnitude and rates of the elastic and viscoelastic responses of the solid Earth to several end-member scenarios for glacial incision in the Slessor, Recovery and Thiel Troughs over the last 34 Ma. We also examine the effect of fluvial incision over longer timescales. Geological constraints on the amount of erosion and uplift in the Shackleton Range include the observed tilt of the sub-Beacon Peneplain and apatite fission track and (U–Th)/He thermochronology datasets. The effect of tectonics is examined by modelling the uplift of the Shackleton Range on the flank of the Filchner Rift. Our models will help to quantify the relative contributions of tectonics and erosion (and climate) in shaping the topography of the Shackleton Range region, and better comprehend the linkages between the evolution of palaeotopography and the behaviour of the Antarctic ice sheet since the Early Oligocene.

## ***Problem of glacial isostasy during Quaternary***

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Recently more and more publications review the problem of integumentary Quaternary glaciations of Eurasia and North America and glacial isostasy concept connected with them. As an indirect confirmation of this concept the results of gravity measurements in North America have been taken. They exposed the violations of isostatic equilibrium in the Earth's crust. This fact is accounted for removing of the cover glaciation's load because of its degradation during Holocene. But there are no any reasonable comparative calculations, the correction in the direction of thickness increasing of supposed Laurentian glacier, estimated viscosity of the upper mantle, and others.

Some researchers convincingly argue that these regions in the Quaternary were undergone the glaciation of the mountain type only. The gravitational field primarily reflects the actually existing heterogeneous character of the distribution of masses in the Earth's bowel. It is known that the facts are stubborn things, but one can interpret them in different ways, and it is really that if these professionals have not heard about glacial expansion, they would give a different explanation for their observations.

Now the problems of isostatic and the response of the crust to exogenous stress are developed still weakly. The examples to the above are so far unexplained occurrences of mismatch of the Moho surface's relief and the outlines of areas of postglacial uplift with adequate sign of the gravity anomaly, the not all-round asthenosphere and others. Often the vertical motions of the Earth's surface take place in the direction opposite to one which should be in accordance with the principle of isostasy. Thus, the Caspian basin sinks, but it would have to rise; in some mountain the mass excess are marked (Central Asia).

The followers of the concept of thick ice cover's existence in these regions do not give a reasonable explanation of the geologically rapid (during the first thousand years) melting of estimated volumes of Late Pleistocene ice sheets (the temperature would be as in the modern Sahara!), of comparable speed of raising of geological similar off-glacier regions during Late Holocene (for example, the Brazilian shield rises at the same rate as the Laurentian one and the Ukrainian as the Baltic one), of the finds of synchronous relict and endemic flora and fauna in the areas of suspected ice sheets and others. The pattern of glacial isostasy ICE-4G which is applied by some researchers is based only on the theoretical concepts of the mantle viscosity and its possible reaction to the magnitude and duration of exogenous load on the crust. Such patterns cannot be the basis of concerned problem. In conclusion, it should be noted that often the pattern of natural scenarios are created completely or to a considerable extent on speculative assumptions and in future are perceived as something real. This also applies to the problem of Quaternary glaciation and glacial isostasy. Acknowledgments. This work was supported by the State Contract (theme 0149-2014-0035).

## ***Seismic investigations of the Northern Transantarctic Mountains: The TAMNNET deployment***

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The Transantarctic Mountains (TAMs) are the largest non-compressional mountain range in the world, and their structure plays a key role in the climatic and tectonic development of Antarctica. While numerous uplift mechanisms for the TAMs have been proposed, there is little consensus on their origin, partially because most seismic investigations of the TAMs have been focused on a central portion of the mountain range, near Ross Island. Therefore, there is little along-strike constraint of any structural variability. Over the past three years, we have operated the Transantarctic Mountains Northern Network (TAMNNET), an array of 15 broadband seismic stations, within a previously unexplored portion of the TAMs. Using data collected by this network, numerous studies have been undertaken to further assess the crustal and lithospheric structure along the mountain range and to differentiate between competing origin models. This presentation will highlight the most recent TAMNNET findings. Specifically, receiver functions indicate crustal thickening inland from the Ross Sea coast but comparable crustal thickness beneath the TAMs and the East Antarctic plateau, indicating little evidence for a substantial crustal root beneath the mountain range. Body and surface wave analyses show a pronounced low-velocity anomaly beneath Terror Rift, adjacent to the TAMs, and extending beneath Victoria Land in the upper mantle. Together, these findings support a thermally-buoyant source of uplift for the northern TAMs and broad flexure of the East Antarctic lithosphere.

## ***VLNDEF: An integrated geodetic project and its latest results***

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GPS measurements are the core of the Italian geodetic activity in Antarctica. A large network devoted to the detection and monitoring of crustal deformations in the Northern Victoria Land (NVL) was established during 1999-2000 expedition. Nowadays, 28 markers are monumented on rocky outcrops and form the VLNDEF (Victoria Land Network for DEformation Control) network, which extends over 500 km North-South and 300 km East-West, and its markers can be accessed by means of helicopter from Mario Zucchelli Station (MZS) or planning remote camps in the North and or South of NVL.

A full repetition of the whole network have been performed during the 2014/2015 expedition, while during the latest expedition an essential change on the permanent station (TNB1), working since 1998 at MZS and supported since 2008 by an additional permanent GPS station (TNB2), was made. A new LEICA GR25/LEIAT504GG system was installed and the near real time downloading of the data was arranged.

Since the end of 2014, three VLNDEF markers host 3 POLENET permanent stations, giving us a further opportunity for joint scientific activities with US research institutions.

Since its establishment, VLNDEF has been surveyed more than ten times, of which four are complete surveys. The remarkable amount of GPS data collected so far can be used to highlight the ongoing crustal deformations, their pattern and the presence of any neo-tectonic activity. We present the results of the network obtained using the Bernese GNSS Software, adopting the most up-to-date analysis strategy, models and parameters. The solutions, expressed into ITRF2008, of the VL appear to be rather consistent with a general motion toward South-West with mean velocity of 16 mm/a.

Subtracting the estimated plate rotation Pole, we found very small residual horizontal velocities. The tectonic model of active faulting proposed in Dubbini et al (2010) is mostly confirmed by the new results for the period (1998-2015). Although a general decrease of the residual velocities, the relative motions along most of the monitored regional faults can be confirmed.

These news vertical and horizontal velocities will be used to refine the neotectonic model and will be compared with the most up-to-date GIA models.

Other geodetic activities are performed in MZS and NVL. In 2002 a new activity started, acquiring more than 100 gravity data with the aim to evaluate an high accuracy local geoid for all NVL. A second campaign was carried out in 2012 in the northern part of MZS, extending the measurements until the Rennick glacier. In 2014/2015 gravimetric measurements have been performed to complete the geoid definition of the whole NVL. The new model will be presented.

In 2006 a tide gauge Aandaraa WRL7 has been installed at a depth of 27 meters under the sea surface overlooking MZS. Local measurements have been performed for the co-location with GPS systems, by means of GNSS observations. The data are stored into an internal memory module and downloaded every year. Tsoft and T\_Tide have been used to perform the data analysis and to compute the main tide components.



## **S17. Astronomy And Astrophysics From Antarctica**

### ***AST3 Survey in 2016***

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The second Antarctic Survey Telescope AST3-2 has been serviced during the 32nd CHINARE by the traverse team to Dome A in early 2016. Both the telescope and the Control, Operation and Data System have been upgraded. Engineering tests started shortly after the servicing and scientific operation is expected to start in March. Based on experiences gained from remote/robotic operation and lessons learned in previous years, we expect AST3-2 to perform more stably and produce more scientific data for supernova survey, exo-planet search and time-domain astronomy. We plan to report the progress and results from AST3 survey up to the OSC meeting in 2016.

# ***Correlating dark matter simulations to SPT clusters & other extragalactic surveys***

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This study investigates properties of the large-scale structure of the universe using both dark matter simulations (provided with courtesy of ICRAR and the Magneticum team) and current galaxy catalogues. A fractal analysis approach to examining voids is utilized due to 2 order of magnitude difference between WDM and CDM. The South Pole Telescope (SPT) identified hundreds of new galaxy clusters in 2500 square degrees and the high sensitivity made this survey a good candidate for simulation comparisons. Along with 4 additional observational datasets, we plan to discuss the power laws that are derived from the fractal analysis and how they relate to simulations and observations.

## ***Future power systems for remote astronomical observatories in Antarctica***

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For almost a decade now we have had reliable power systems (the PLATO observatories) able to provide 1 kW of power at remote sites on the high plateau of Antarctica for a year without servicing.

The coming generations of astronomical instruments will need multi-kW power supplies, and this poses some difficult challenges beyond a simple scaling-up of the existing designs.

A mix of solar, wind, and diesel, appears to be a good choice. This paper will give an update on the latest ideas being trialled, which include custom wind turbines designed to operate at the extreme temperatures and low air pressures and wind speeds on the plateau. There is also an emphasis on modularity, to allow power to be added in increments as needed. For the medium term, diesel power will still be necessary, and there are a number of challenges involved in running engines throughout the year with no people on site.

The nature of remote power systems also has an impact on the telescope/instrument designer.

## ***Meteorological data from KLAWS-2G for astronomical site survey at dome A, Antarctica***

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We built the second generation Kunlun Automated Weather Station (KLAWS-2G) for monitoring astronomical site conditions at Dome A as well as for operation support of AST3 telescope. KLAWS-2G has 11 temperature sensors and 7 anemometers in different elevations, 1 humidity sensor and 1 barometer, which are mounted on a 15-meter-tall mast. It was installed by the traverse team to Dome A in early 2015 during the 31st CHINARE. From then on, it survived the extremely cold polar winter and continuously worked for an entire year. KLAWS-2G has been maintained by the transverse team of the 32nd CHINARE, and is now working properly. By analyzing the data from KLAWS-2G, we find that a strong temperature inversion and stable atmosphere existed at all heights for most of the time in 2015, confirming our finding for 2011 data and suggesting that Dome A should be an excellent site for astronomical observations. All the data from KLAWS-2G can be viewed in realtime on <http://aag.bao.ac.cn/klaws/>.

## ***PAIX the first robotic Antarctic mission: Towards an understanding the stellar pulsation and evolution.***

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The first robotic Antarctic mission PAIX -Photometer Antarcctica eXtinction- gives new insight to cope with unresolved stellar enigma and stellar oscillation challenges and offers a great opportunity to benefit from an access to one of the best astronomical site on Earth –Dome Charlie– where the seeing reaches a median value of 1 arcsec during the polar night. PAIX is a multiband photometer attached to the Cassegrain focus of a 40-cm Ritchey-Chrétien optical telescope, with a F/D ratio of 10, located at Dome C in the open field, without any shelter, installed at ice level. PAIX challenges space telescopes and even has more advantages than CoRoT and KEPLER in observing in UBVRI bands and then collecting multicolor light curves simultaneously of several targets within the same 12.4 x 8.3 arcmin field of view with long uninterrupted and continuous observations over 150 days. PAIX has been antarctized to run under extreme weather conditions with temperatures as low as -80 deg.C, and has been robotized, designed and built by PaixTeam whose operating headquarters are located at Universié de Nice Sophia–Antipolis and Observatoire de la Côte d'Azur.

In this talk, we describe PAIX and how is automatically operated without any human on-site intervention. We present the first long time series of multicolor photometric polar observations from the heart of Antarctica - Dome Charlie- and we discuss the first outcome of stellar pulsation from the polar sky, especially the impact of PAIX on the connection between temporal hydrodynamic phenomena and cyclic modulations in the pulsating stars.

## ***The G332 molecular cloud ring - A terahertz tale from Antarctica***

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The major part of the ISM exists in form of ionised gas which envelopes the denser Giant Molecular Clouds (GMCs) complexes, mainly composed by H<sub>2</sub> gas. Within these, in the colder denser cores, the earliest stages of star formation occur. The origin of the protostellar dense cores depends on the morphology and dynamics of the GMC in which they are, thus, a precise characterisation of the molecular clouds is required to investigate the conditions under which the dense cores form.

The Carbon Monoxide (CO) is a well known tracer for the diffuse molecular hydrogen in the Galaxy and it enables to map the colder ISM fraction. Nevertheless the CO surveys miss a H<sub>2</sub> fraction because the carbon monoxide is presents in detectable quantities deeper inside the molecular clouds than the molecular hydrogen. The ionised carbon and the atomic carbon, whose principal lines fall in the THz frequencies, are present in the external layers of the clouds, making them a good tracer for the missing H<sub>2</sub> gas.

Observing the THz spectrum from the Earth is not easy because of the large water vapour optical thickness at this frequencies. A dry site with a very stable atmosphere is required in order to open the terahertz window in the atmosphere.

The Antarctic plateau, with its extreme cold and dry conditions, has been found to be the best place on Earth for such observations. In particular at Ridge A, almost 140 km from Dome A in the high antarctic plateau, the High Elevation Antarctic Terahertz (HEAT) telescope is observing the Galaxy in the THz band.

Combining the data coming from the MopraCO survey and the HEAT telescope it is possible to characterise more accurately the morphology and dynamics of the molecular clouds in the Galaxy.

In particular, in the G332 region, a new GMC reveals its peculiar morphology in many CO and CI transitions lines. This Giant Molecular Cloud hosts many phenomena at different energy scales and offers a wide view on the early stages of the star formation process.

## ***THz solar photometers on a stratospheric trans-Antarctic balloon flight***

Pierre Kaufmann<sup>1,10</sup>, André Abrantes<sup>2</sup>, Emilio C. Bortolucci<sup>10</sup>, Amir Caspi<sup>3</sup>, **Emilia Correia**<sup>1,11</sup>, Luis Olavo T. Fernandes<sup>1</sup>, Amauri S. Kudaka<sup>1</sup>, Glenn Laurent<sup>3</sup>, Nelson Machado<sup>2</sup>, Adolfo Marun<sup>4</sup>, Rogério Marcon<sup>5,6</sup>, Valery Nicolae<sup>7</sup>, Ray Fernando H. Ramirez<sup>1</sup>, Pascal Saint-Hilaire<sup>8</sup>, Claudemir M. Silva<sup>9</sup>, Alexander Timofeevsky<sup>7</sup>

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Sub-THz and 30 THz solar burst observations revealed a new spectral component, with fluxes increasing towards THz frequencies, simultaneously with the well known component peaking at microwaves, bringing challenging constraints for interpretation. THz flare spectrum can be completed with measurements made from space. A new system of two photometers has been developed to observe solar flares, one at 3 and 7 THz named SOLAR-T. An innovative optical setup allows observations of the full solar disk with high sensitivity to detect small burst with time resolution of less than one second. The SOLAR-T uses two Golay cell detectors at the foci of 7.6 cm Cassegrain telescopes. The incoming radiation undergoes low-pass filters made of rough surface primary mirrors and membranes, 3 and 7 THz band-pass filters, and choppers. The system has been integrated to data acquisition and Iridium short-burst data services telemetry modules for this application. SOLAR-T has been flown coupled to U.C. Berkeley solar hard X-ray and gamma-ray imaging spectropolarimeter GRIPS experiment launched on a NASA CSBF stratospheric balloon from U.S. McMurdo base on January 18, 2016, on a trans-Antarctic flight. The mission terminated on January 30. The payload landed in the Argentina Mountain Range, nearly 2100 km from McMurdo. The SOLAR-T mission was accomplished with success, with full space qualification instrumentation. Solar events occurred in the period are being examined. These activities were partially supported by Brazilian agencies FAPESP, CNPq and Mackpesquisa, U.S. AFOSR and NASA, and Argentine's Conicet.

## **S21. Remote Sensing Of The Antarctic Environment: Multi-Disciplinary Advances**

### ***An algorithm for automated identification of Adélie penguin colony area from satellite imagery***

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The theoretical basis for an algorithm that automates detection of Adélie penguin colonies from satellite imagery is described in detail. The algorithm is based on a physical model that accounts for changing solar elevation, azimuth, sun-Earth distance, colony surface slope and aspect relative to the sun and spacecraft, as well as calibration differences among different imaging radiometers on the Landsat series of satellites. Because surface reflectance characteristics of penguin colonies are essentially uncharacterized and unknown, the algorithm relies on a training dataset collected from known colonies, rock outcrops, and other surfaces. Training data are employed to cross calibrate imagery from different satellite imaging radiometers. The algorithm then uses the training data to define a region of spectral space that minimizes classification errors of omission and commission by applying an optimization method designed specifically for this purpose. The result of the optimization is a 6x6 transition matrix which, when multiplied by Landsat pixels, yields a simple yes/no result for determining whether the pixel belongs to an Adélie colony class. Algorithm validation using ground surveys and high-resolution satellite imagery found that the retrieval errors of omission and commission are very low, on the order of 1-2%. The algorithm was originally developed for Landsat-7 but has recently been used to mine the full set of Landsat 4, 5, 7 and 8 data dating back to 1984, yielding a long term dataset of Adélie colony distribution and spatial extent. It should be possible to use the algorithm for future continent-wide surveys of Adélie colony distribution and extent at intervals separated by no more than two years.



# ***An improved remote sensing backscattering model for the identification of scattering mechanisms in sea ice and snow layers***

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There have been many research works on studying earth terrain in Antarctica, as this region has a direct impact on global environment. Research on remote sensing has been done for several decades as it is an important earth observation technique in Antarctic studies. In remote sensing study, developing a reliable theoretical model is essential to study and understand the interaction and scattering mechanisms between electromagnetic waves and snow and sea ice. In this paper, we study the effect of incorporating the advanced integral equation model (AIEM) to a backscattering model for an electrically dense medium such as sea ice and snow layer. The dense medium was modelled as a layer embedded with randomly distributed dielectric spherical scatterers, and covered on top and bottom by irregular rough surfaces, characterized by roughness spectrum of exponential correlation function. The close spacing effects of the scatterers were taken into account by considering the modified phase matrix for Mie scatterers based on the dense medium phase and amplitude correction theory (DM-PACT). Previously, the surface scattering on top and bottom rough surface was modelled using the original integral equation model (IEM) accounting for both single and multiple surface scattering. In this paper, a newer version of IEM which is the AIEM is proposed to be used in the model for the surface scattering calculation to improve the total backscattering coefficient, since AIEM provides more accurate prediction in surface scattering. The backscattering coefficient of this medium was calculated by applying the radiative transfer theory which was solved iteratively up to the second order. The three major scattering mechanisms in the model are direct surface scattering, surface-volume scattering up to the second order and volume scattering. Comparisons are to be made between theories to study the effect of incorporating AIEM for like and cross-polarized return. Its effect on each scattering mechanism will also be investigated and the analysis will be presented. Comparisons will also be made with field measurement results in polar regions to validate the backscattering model. Preliminary studies show that the model proposed here may be able to improve the total backscattering coefficient calculation of sea ice and snow layers.

## ***DNA analysis of surfactant associated bacteria in the sea surface microlayer in application to satellite oceanography***

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The sea surface microlayer (SML) covers more than 70% of the Earth, links the hydrosphere with the atmosphere and is critical in Earth's processes, especially air-sea gas exchange and the cycling of organic material (Carlson et al. 1988; Cunliffe et al. 2013, Liss and Duce 2005). The SML and the near subsurface water is known to contain surface-active materials (surfactants), which alter surface tension forces. The main focus of this work is surfactant-associated bacteria, which serves as an indicator for presence of slicks on the sea surface. Sources of surfactants also include deposition from the atmosphere, terrestrial runoff, phytoplankton and, perhaps, marine animals. The slicks can be seen by synthetic aperture radar satellites (SAR).

We are studying the bacterial content of the sea surface microlayer and surfactant-associated bacteria using DNA analysis. We have implemented a new approach, which has significantly reduced potential contamination of microlayer samples during collection, handling and processing at the lab (Kurata et al. 2015; Hamilton et al. 2015). Microlayer sampling has been done in the Straits of Florida and the Gulf of Mexico during TerraSAR-X and Radarsat 2 overpasses.

More recently, as a part of the Gulf of Mexico Research Initiative (CARTHE), over 100 samples (SML and subsurface combined) have been collected during a research cruise between February 6 and February 12, 2016 in the Gulf of Mexico near De Soto Canyon. Some of them were reasonably close to the time of a TerraSAR-X satellite overpass.

We will discuss these experiments and future plans for expanding the observational sites to several locations in the World Ocean. The marginal ice zones in the Arctic and Antarctic are of particular interest due to rich microbial environment during some seasons.

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## ***Empirical modelling of bathymetry of Antarctic lakes using high-resolution multispectral imagery***

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Empirical bathymetric modeling of 36 lakes around Larsemann Hills and Schirmacher oasis, east Antarctica, was performed by using very high resolution pansharpened images from WorldView-2 (WV-2). At first, all lake features from both the study areas were manually digitized. In order to model the bathymetry from WV-2 imagery, we used three different models: (a) Stumpf model and (b) Lyzenga model, and (c) Jupp's model. Multiband image combinations of 8 spectral bands of WV-2 were used to improve the results of bathymetric modeling. The modelled depths were cross-verified against the in-situ depth values and root mean square error (RMSE) was computed. Our results indicate a significant correlation ( $R = 0.6\sim 0.8$ ) between modelled depth and in-situ depth values (RMSE = 0.1 to 1.3 m). Our bathymetric modeling suggests that the coastal blue band of WV-2 imagery played a significant role in modeling accurate bathymetry of Antarctic lakes compared to other spectral bands. It is also observed that very shallow lakes provided better correlation ( $\approx 0.8$ ) compared to shallow ( $\approx 0.6$ ) and deep lakes ( $\approx 0.4$ ) for bathymetry modeling. In case of bathymetric modeling based on size of lakes, large lakes yielded better correlation in comparison to medium and small lakes. This study proves the tremendous potential of very high resolution optical remote sensing imagery for effective empirical modeling of bathymetry in cryospheric environment.

## ***High resolution DEM generation using UAV images in Barton Peninsula, King George Island, Antarctica***

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Topographic map is a basic data in establishing field work plans and an essential data for analyzing land cover changes in Antarctica. Topographic information including topographic map and digital elevation model (DEM) has been obtained from multi-view satellite and aerial images or conventional surveying as a spatial resolution of a few tens of meters of a few meters, whereas unmanned aerial vehicle (UAV) and structure from motion (SfM) technique can be used to generate high resolution, i.e. a spatial resolution of less than 10 centimeters, in local scale within a short period of time. In this study, a fixed-wing UAV was used to obtain high-resolution images with a spatial resolution of less than 10 centimeters and enough overlaps between images for investigation on the relationships between distribution patterns of vegetation and influencing environmental factors in Barton Peninsula, King George Island, Antarctica. The UAV flight missions were conducted during January 2016 and a DEM was generated from the obtained images using SfM software. The DEM was used to extract environmental factors such as slope and aspect of topography, local solar radiation energy and surface water flow direction and accumulation. The DEM also can be used to model microclimates such local wind direction, wind speed, temperature and humidity.

## ***High resolution digital elevation model of an ice-free area of Maritime Antarctica obtained by laser scanner***

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The digital elevation model (DEM) represents a numerical representation of the landform and terrain relief, and is major source of digital environmental data for various research applications. Currently there are several ways to obtain an DEM, especially the SRTM (Shuttle Radar Topography Mission) and Aster-GDEM (Global Digital Elevation Map), both with 30 m spatial resolution, which limits its application to more detailed maps. However, new are tools are available to the generation of DEM with high spatial resolution, such as terrestrial laser scanner. The objective of this work was to produce a DEM of Keller Peninsula, on King George Island, Maritime Antarctic, with the use of a terrestrial laser scanner (Riegel VZ-1000 model with configuration Panorama 60) with a range of up to 1400 m. The scanning took 138 scan points to cover 540 hectares of the peninsula. The cloud of points was processed using the Riscan PRO 1.8.1 software. It was necessary to reduce the amount of points to converge all the readings taken, generating a final cloud of over 500 million points. The station coordinates were obtained using GNSS Leica GS08 Plus model receiver, and data processing by the Leica Geo Office 6.0 software. The points were converted to the Dataset LAS format and imported into Arcgis 10.2 software, which was converted to a raster file with spatial resolution of 1 meter. With the generated DEM, different attributes (slope, aspect, terrain roughness index, moisture content index, and 16 others) were derived in the SAGA Gis software, allowing a detailed understanding of the geomorphology and terrain attributes of Keller Peninsula, useful for different applications.

## ***High resolution radar data used to detect human-induced features on Ardley Island and part of Fildes Peninsula, South Shetland Islands***

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Human activities in the past decades have been intensifying in the South Shetland Islands due to research activities and commercial tourism. This archipelago is the closest terrestrial area of Antarctica accessible from Patagonia and therefore, there is a concentration of visitors that come to the islands either as tourists or for research purposes. This is the area of Antarctica with the highest concentration of research stations, and that receives the greatest number of tourists. Therefore, it is particularly interesting to detect and monitor the effects of human activities resulting in modifications and impacts to the environment and related ecosystems. The objective of this work is to characterize and determine the spatial distribution of a series of impacts due to human activities in the terrain surface on Fildes Peninsula and Ardley Island using high-resolution Synthetic Aperture Radar (SAR) images. A TerraSAR-X Staring Spotlight polarimetric SAR image as single look complex data in vertical polarized mode (emission and reception), with a ground resolution of 0.17 x 0.56 m (azimuth x ground range) and covering an area of 14.8 km<sup>2</sup> was acquired on the 10th of March 2015. The area covered includes 4 of the 5 permanent stations (Chile's Frei and Escudero bases, China's Great Wall Station and Russia's Bellingshausen Station) on Fildes Peninsula, that are open all year round. Pre-processing of the image included radiometric correction, using a speckle filter, terrain and geometric corrections. Texture analyses of the images based on co-occurrence matrix method was carried out combined with detailed field observations that are used as reference to extract the information related with the human-induced activities.

Different impacts caused by human activities have been identified within and surrounding the stations using the high-resolution TerraSAR-X data. These include buildings and structures, aerodrome, walking paths and unpaved roads, landfills, fuel deposits and areas with instrumentation for experiments. In some cases, soil surface alterations can be distinguished from the natural causes due to their often linear appearance as well as the context in which the disturbances are related with the different stations. The characterization and monitoring of these impacts in this and in other areas of the region is regarded as important as the stations are normally within ice-free areas which often support ecosystems that are highly sensitive to natural and human-induced changes. It is to point out that within the area of the image there are two Antarctic Specially Protected Areas (ASPANo. 125a on Fildes Peninsula, and ASPANo. 150 on Ardley Island). This type of SAR data is considered suitable for monitoring changes that occur as a result of human-induced activities.

## ***Mapping penguins by Drone – How to count breeding pair numbers from orthophotomosaics***

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Drones have become increasingly used for wildlife monitoring. In the Antarctic penguin colonies turned out to be mapped easily and extensively by application of this technology. Particularly the quality of breeding pair censuses of large and remote colonies could be improved by drone mapping.

Hundreds or thousands of single images are taken during such a flight campaign. Their processing to large orthophotomosaics is almost a standard procedure today, but how can these data be analyzed reasonably and efficiently?

Previous experiences show that individual penguins are easily identifiable in the orthophotomosaics obtained from drone flights. However, in many cases it is difficult to distinguish breeding penguins sitting on their nests from other individuals like their mates or resting non breeders. Recognizability can be improved by higher camera performance or by lower flight altitude. Though low flight altitudes do not allow covering large areas during a flight campaign, particularly in regions with unstable weather conditions or at sites with timely limited access. Moreover too low flight altitudes cause disturbance to penguins. The help of better cameras is limited too, as heavier and larger payload reduces flight time. Furthermore the visibility of nest structures from above depends very much on topography, availability and color of substrate and weather conditions. Hence, the decision which penguin represents a nest in the orthophotomosaic always remains subjective and the whole process time consuming. Aim of this study was to find a robust, objective and reproducible method to count breeding pair numbers from drone orthophotomosaics.

We used a octocopter micro drone for mapping three colonies of Pygoscelid penguins in the vicinity of southwestern King George Island during the 2013/14 and 2014/15 breeding season.

We compared the breeding pair numbers obtained by traditional ground mapping campaigns with drone mappings. Different species were included as well as different breeding stages. The total number of adult individuals identifiable within defined breeding groups was found to be in a stable ratio to the number of nests obtained by ground mapping. At the end of the breeding season when adult and juvenile individuals are difficult to distinguish from high above, the method is not applicable.

By use of the found ratio it was possible to quantify the penguin population of a before uncounted colony for the first time.

## ***Phytoplankton dynamics in Lake Bonney through the polar night measured by an autonomous in situ profiler***

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The perennially ice-covered lakes of the McMurdo Dry Valleys, Antarctica, have been the focus of intense ecological research for greater than 20 years. Logistical constraints prevent sampling of these lakes during the austral winter (April-September). Consequently, little is known about how the microbial communities which inhabit these lakes respond to the long periods of total darkness. Phytoplankton are responsible for the majority of the organic carbon production in these lake systems. Measuring their dynamics during the polar night is critical to understanding carbon cycling within the lakes. We made daily in-situ measurements between 2013 and 2015 of total chlorophyll-a concentration and the chlorophyll-a contribution of four phytoplankton groups (chlorophytes, haptophytes, cyanobacteria, and cryptophytes) using a submersible spectrofluorometer attached to an ice-tethered profiler in both lobes (east and west) of Lake Bonney. These data show that chlorophyll-a in the shallow (5-15m) waters increased for four months (February-May) following the onset of darkness whereas deep (15-22m) water chlorophyll remained relatively constant (east lobe) or increased (west lobe) until late winter (August), when average chlorophyll-a decreased at rates of 0.02 and 0.11 mg chlorophyll-a m<sup>3</sup> d<sup>-1</sup>, respectively. These late winter loss rates were balanced by rapid phytoplankton growth (0.05 and 0.09 mg chlorophyll-a m<sup>3</sup> d<sup>-1</sup> for the east and west lobes, respectively) in mid-October as solar radiation increased in the water column. Chlorophytes, which dominated the water column during summer, were replaced by haptophytes during winter at both depth ranges in the lakes. The persistence of high chlorophyll concentration during the polar night indicates that some phytoplankton (haptophytes) in this lake persist in winter by alternative modes of metabolism while others (chlorophytes) may retain their photosynthetic apparatus long after solar radiation has disappeared.



## ***Support of research vessels in the Antarctic with NRT radar information: an innovative service at DLR's Antarctic station GARS O'Higgins***

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On their journeys through areas with large layers of sea ice even vessels of high ice class or icebreakers could get into trouble. Reliable information from earth orbiting satellites could therefore be highly desirable. The German satellites TerraSAR-X (TSX) and TanDEM-X (TDX) are capable to deliver precise information about the ice cover, independent of the time of day and cloud coverage.

The German Antarctic Receiving Station GARS O'Higgins of the German Aerospace Center (DLR) is now equipped with near-real time (NRT) processing capability for the TSX/TDX data. Thus, the overall TSX/TDX ground segment provides navigation guidance in NRT to research vessels in the Antarctic.

By providing information products from synthetic aperture radar (SAR) acquisitions, DLR supports a crew to safely navigate through ice. For this purpose, the TSX/TDX data is received at the GARS O'Higgins station directly after the acquisition and is locally processed in near-real time. Subsequently, just one hour after the raw data is acquired from the satellite, the TSX/TDX information product is transferred via email from GARS O'Higgins to the ship. Such a product is generated up to twice a day.

NRT processing at GARS O'Higgins for the Antarctic has been routinely carried out since the beginning of the year. First test campaigns in January/February 2016 were performed successfully.

The German research vessel Polarstern of the Alfred Wegener Institute Helmholtz Centre for polar and marine research (AWI) was supported by DLR during its Expedition PS 96 to the Weddell Sea, Antarctica. The main objective of the planned extensive support of SAR images of sea ice was to support Polarstern navigating through the heavy ice fields in the Weddell Sea, and thus give the possibility for an improved route planning throughout the expedition. In addition, the data were used by different working groups on board to plan the exact position of biological, geological and oceanographic stations dependent on the current ice situation.

## ***Surface characterization using a photon counting Lidar in East Antarctica***

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Swath lidar data has applications for determining ice sheet surface roughness and elevation change (including corrections for surface slope), as well as many uses for operational site characterization. The University of Texas Institute for Geophysics's ALAMO (Airborne Laser Altimeter with Mapping Optics) instrument combines a single beam nadir Riegl laser with a scanning Sigma Space Photon Counting Lidar (PCL). The ALAMO sensor configuration generates a 300m wide, 3D surface swath when flying at a nominal 600 meter altitude. This instrument has been deployed in 5 field campaigns, primarily in East Antarctica. We have surveyed surfaces including open water, sea ice, rock, man-made buildings, crevasse fields, snow and blue ice, and in this paper we present data over targets including Totten, the Vestfold Hills, Law Dome, and George V Coast.

Interpreting data from a PCL has two main complications. First, solar photons reflected from the surface add significant background noise that must be filtered out. They also contribute to ALAMO's high data rate of ~2 M points/second, which requires efficient approaches to data processing. Second, the detected ranges are probabilistic: while a detection is very accurately timed (equivalent to ~1.4 cm in range), it is not possible to know where in the outgoing pulse it originated (~30 cm).

Previous usage of the ALAMO sensor has relied on a median filter to address these noise sources, which provides excellent elevation precision on larger scales, but discards significant information about the shape of the surface. This work provides the first demonstration of photon-level surface filtering from the ALAMO instrument.

Rather than attempting to georeference photons and then perform filtering calculations in 3D space, we work in a 2D space where the axes are laser pulse number and photon travel time. We find that applying a series of simple filtering operations allows us to reliably separate signal photons from noise. This is based on the observation that the internal sensor noise source creates dense returns within a single pulse that are not continuous across pulses, while solar noise is uniformly low density on both axes.

We demonstrate successful filtering on a variety of surfaces, and compare the resulting estimates to aerial and satellite imagery. Additionally, we explore the fundamental theoretical and practical limits of vertical resolution for a PCL-derived surface estimate as a function of reflectivity and desired horizontal resolution.

ALAMO has already been used to improve dh/dt records in East Antarctica. Additionally, we expect that the filtering approach and the characterization of PCL performance in various Antarctic environments described in this paper will have applications to the future ICESat2 mission, for which this sensor is a prototype.

## ***The time-space variability of pCO<sub>2</sub> in the Southern Ocean during the 26th CHINARE cruise in 2009***

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The Southern Ocean is an important sink of atmospheric CO<sub>2</sub> despite the scarcity of in-situ observations due to its remote and rough waters. Meanwhile, the time-space distribution of partial pressure of carbon dioxide (pCO<sub>2</sub>) is uncertain due to various processes, including eddy mixing, ice formation, and biological processes. Empirical relationships were deduced based on the in-situ pCO<sub>2</sub> in surface seawater and its main controls including Chlorophyll a (Chl-a) and Sea Surface Temperature (SST) obtained during the 26th CHINARE cruise in late spring (November) and early summer (December), 2009. An extrapolation method based on multiple linear regressions was set up for combining the empirical relationship with satellite data to compute the spatiotemporal distribution of pCO<sub>2</sub> in the Southern Ocean (south of 50°S). The empirical relationships are validated with independent measurements from SOCATv2 database. The mean standard deviation differences (Std) between extrapolated and measured pCO<sub>2</sub> from SOCATv2 database (13.8 to 18.1 μatm) are consistent with the precision of our regressions (13.6 to 21.3 μatm). From the distribution of extrapolated pCO<sub>2sw</sub>, we found that biological activities were the dominant controlling factor when Chl-a value is above a given threshold in the marine ice zone in the Southern Ocean in warm season. Additionally, the precision of remotely sensed Chl-a is the key factor to determine the precision of extrapolated pCO<sub>2sw</sub>.

## ***Ultra-high resolution baseline vegetation map of the forefield of the Sphinx glacier, Admiralty Bay area, King Gorge Island***

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The most spectacular vegetation changes due to local climate warming are observed in the forefields of retreating glaciers in the maritime Antarctic. When glacier retreats, new lands are exposed, which change the albedo properties depending on which plants that are established in the forefields. The main aim of this study is to develop an ultra-high resolution baseline map for plant succession studies in the forefields of the Sphinx glacier, located on the west coast of Admiralty Bay area (ASPAN No. 128) on King George Island. This glacier has retreated about 500m the last 37 years. We use the Crywing Scout, a twin engine fully electric Unmanned Aerial Systems (UAS) with a wingspan of 2.5 m and maximum flying time of 90 minutes. The UAS is hand launched and well suited to be operated in the field with no need of a runway. For this particular experiment the UAS was equipped with a NDVI camera and a on square kilometre large area in the forefield was mapped with a spatial resolution of 7 cm. The preliminary results shows that about 480m from the glacier front a 250 square meter large moss-bed have been developed in a mesic area and that moss-patches of less than 10cm can easily be mapped, but not on species level. In dryer areas the vascular plants *Deschampsia antarctica* and *Colobanthus quitensis* occurs frequently, however only the largest individuals (> ca 7 cm) of these can be mapped.

## ***Vegetation mapping on King George Island using Unmanned Aerial Systems (UAS)***

Stein-Rune Karlsen<sup>2</sup>, **Katarzyna Chwedorzewska**<sup>1</sup>, Agnar Sivertsen<sup>2</sup>, Anna Zmarz<sup>3</sup>, Małgorzata Korczak-Abshire<sup>1</sup>, Rune Storvold<sup>2</sup>

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The vegetation cover in maritime Antarctica is scattered and often dominated by mosses and lichen. In the few places where continuous vegetation occurs, the plant communities change from meter to meter. For a sensible mapping of such scattered or patchy vegetation ultra-high resolution is needed. The aim of this study is to map the Arctowski area on western part of the Admiralty Bay area on King George Island, a total area of about 1.5 square kilometer. We use the Cryowing Scout, a twin engine fully electric Unmanned Aerial Systems (UAS) with a wingspan of 2.5 m and maximum flying time of 90 minutes. The UAS is hand launched and well suited to be operated in the field with no need of a runway. For this particular experiment the UAS was equipped with two sensors, a NDVI camera providing spatial resolution on 5 cm, and a hyperspectral camera (Rikola) with spatial resolution of about 30cm. First we use the NDVI data to create a mask for vegetated areas, and then we classify the hyperspectral data for the vegetated areas. The preliminary results indicate that three variants of grass (*Deschampsia antarctica*) dominated vegetation types can be mapped, four forms of moss-dominated vegetation, where two of them are dominated by *Sanonia uncinata*, and one lichen (*Usnea antarctica*) plant community.

## S23. Microbes, Diversity, And Ecological Roles

### *A polyphasic strategy incorporating genomic data for the taxonomic description of two species of Pseudanabaena from Arctic and tropics*

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Microscopic cyanobacteria species, including those related to water blooms have been ignored because of difficulties in isolation and observation due to their relatively small cell/filament sizes. Pseudanabaena is a group of microscopic cyanobacteria characterized by the presence of trichomes, apical cell and uniseriate row of connected cylindrical cells. In this study, two strains of Pseudanabaena from Arctic (Svalbard Island) and tropics (Tasik Harapan, USM, Malaysia) were isolated and inspected taxonomically and phylogenetically. Polar strain was identified as Pseudanabaena amphigranulata, whereas tropical strain matched with the species description of Pseudanabaena mucicola. We combined morphological identification and phylogenetic characterization using primers that targets 16s rRNA to identify this genera at species level. Cell dimensions, thylakoid arrangement and apical cell shape of these two strains fit the Pseudanabaena genus description. The cellular ultrastructures revealed parietal arrangement of 3-5 of peripheral thylakoids and granules of polyphosphate and phycocyanin. Phylogenetic results based on 16S rRNA gene sequences showed that the Pseudanabaena strains used in this study including sequences from GenBank, assembled into one large cluster that represents the core of the genus Pseudanabaena. In this study, we described the morphology and phylogeny of Pseudanabaena species from two different regions (Arctic and tropics), contributing new intuition into the taxonomy of the genera Pseudanabaena.

## ***A review on sea-ice micro-algae for modeling purposes: Linking functional traits to production parameters.***

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Climate change is most profound in the polar regions, where a decrease in sea-ice cover is apparent. The consequences of the decline in sea-ice for climate-feedback processes are poorly understood. Sea-ice biogeochemical models need more process understanding in order to improve confidence levels in parameterizations. One of the largest unknowns is sea-ice biological productivity and its impact on global biogeochemical cycles. We will present here a review on sea-ice microalgae: functional algal groups are defined and related to production parameters. This study couples different types and the various layers in sea-ice with the composition of its inhabitants. These data are meant to advice sea-ice modelers so as to improve sea-ice biogeochemistry models.

## ***Agarolytic and carrageenolytic activities of fungi associated with macroalgae from Antarctica***

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We surveyed the detection of agarolytic and carrageenolytic activities of fungi associated with seven different macroalgae species from Antarctica. After a selective isolating process, 44 fungal isolates were recovered, which were identified using molecular methods as belonging to genera *Antarctomyces*, *Cladosporium*, *Coprinellus*, *Doratomyces*, *Leucosporidiella*, *Metschnikowia*, *Penicillium* and *Pseudogymnoascus*. Eleven fungi displayed agarolytic and/or carrageenolytic activities. The Rhodophyta macroalgae species shelter the fungi with the best potential to produce agarolytic and carrageenolytic activities. *Penicillium chrysogenum* UFMGCB 10066, recovered from the thalli of *Iridaea cordata*, and *P. chrysogenum* UFMGCB 10053, recovered from the thalli of *Ascoseira mirabilis*, displayed the best carrageenolytic and agarolytic activities, respectively. Our results indicate that the endemic and cold-adapted Antarctic macroalgae can shelter specific fungal taxa able to produce enzymes with important role in the marine mineral cycling in Antarctica. Additionally, these agarolytic and/or carrageenolytic fungi may be useful in biotechnological processes involving the use of algal biomass waste to recover agar and carrageenan for industrial use.



## ***Antarctic rocks: An unexpected microhabitat of potential innate virulent fungi “trapped” and/or hidden in a polar desert of continental Antarctica***

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We assessed the diversity of cultivable fungi living in the rocks of continental Antarctica to evaluate their physiological virulence potential. The seventy fungal isolates obtained were identified as nine species of *Acremonium*, *Byssochlamys*, *Cladosporium*, *Debaryomyces*, *Penicillium* and *Rhodotorula*. *Penicillium chrysogenum*, *Penicillium tardochrysogenum* and *Cladosporium halotolerans* were the most frequent species and were found at the highest densities. The fungi were recovered from quartzite and phyllite rocks. These rocks were weathered beyond what would be expected from the cold and dry conditions of the region, showing chemical alteration processes and biogenic weathering, similar to those caused by fungal activity. *Acremonium* sp., *D. hansenii*, *P. chrysogenum*, *P. citrinum*, *P. tardochrysogenum* and *Rh. mucilaginoso* were able to grow at 35 °C; in addition, *B. spectabilis* displayed a high level of growth at 35 and 45 °C. Thirty-one isolates of *P. chrysogenum*, *P. citrinum* and *P. tardochrysogenum* were able to produce partial haemolysis on blood agar at 35 °C. *Acremonium* sp., *P. citrinum* and *P. tardochrysogenum* showed spore sizes ranging from 2.81 to 5.13 µm diameters at 35 °C. Of these, *P. chrysogenum* and *P. tardochrysogenum* displayed morphological dimorphism. Our results suggest that these fungi may represent pristine models, which may possess genomes that allow the study of the evolutionary origins of virulence in fungi compared with their pathogenic and/or mycotoxigenic relatives. Additionally, the presence of different fungal isolates within the rocks of the ultra-extreme cold and dry environment of the Ellsworth, coupled with the observed chemical alteration processes, suggests that endolithic domains represent a favourable microhabitat with the capacity to support microbial life better than the extreme conditions of the outside environment.

## ***Antibiotic resistance profiles of bacteria from King George Island and Deception Island***

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Multiple-antibiotic-resistant bacteria are commonly found in terrestrial samples. However, it is not known whether multiple-antibiotic-resistant strains of bacteria are also common in terrestrial samples from the Antarctica. Hence, this study was conducted to examine the prevalence of antibiotic-resistant strains among Antarctic bacteria from sediment and soils samples. Forty five bacterial strains from Estrellas lake (EL) of King George Island and Crater lake (CL) of Deception Island, Antarctica were exposed to 30 different antibiotics. Forty out of the forty five bacterial strains were affiliated to twelve genera, Aeromicrobium, Arthrobacter, Bacillus, Brevundimonas, Cryobacterium, Dyadobacter, Flavobacterium, Methylibium, Pedobacter, Pseudomonas, Rhodococcus and Sphingomonas. Among the bacteria, forty three strains were resistant to at least 3 antibiotics, and twenty six strains were resistant to 10 or more different antibiotics. Pseudomonas spp. and four unknown Microbacteriaceae bacteria were found to be resistant to majority of the antibiotics tested. Two bacteria, each from Estrellas and Crater lakes, were sensitive to all the antibiotics tested. These results indicated that Antarctic bacteria are resistant to multiple antibiotics.

## ***Antimicrobial properties and the influence of temperature on secondary metabolite production in cold environment soil fungi***

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Microbes in the polar environments are often subjected to unique combinations of extreme environmental stresses. The current study investigated the antimicrobial properties of forty cold-adapted soil fungi from King George Island, maritime Antarctic and Hornsund, Svalbard, High Arctic and identified the changes in the secreted secondary metabolite profile in response to temperature variation. Results from this study showed, 45% of tested fungal cultures expressed antimicrobial activity towards at least one of five human pathogenic bacteria tested (*B. subtilis*, *B. cereus*, *P. aeruginosa*, *E. faecalis* and *E. coli*). *Geomyces pannorum*, *Penicillium* sp., and *Atradiomyces muscivora* are fungal isolates that showed stronger antimicrobial activity. Temperature influence towards the production of secondary metabolites and antagonistic ability of these fungal isolates was also investigated. We report that when these fungal isolates were incubated at temperatures away from optimal culture conditions, the biological activity of extracted crude differed, confirming an influence of environmental conditions such as temperature on the production of secondary metabolites

## ***Characterization of Antarctic Flavobacterium strain with agarase and alginate lyase activities***

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The geographical isolation of Antarctic continent as well as extreme environmental conditions (e.g., low temperatures, dry cold weather, high UV radiation, terrain snow-capped most of the time,) have imposed a selective pressures to all forms of lifes. Environmental constraints and geographical isolation are responsible for the emergence of different types of microorganisms (mainly, bacteria, fungi, actinomycete) with unique metabolic pathways and highly adapted to Antarctic environments. In Antarctic marine ecosystems, bacterial community play critical ecological roles in recycling process of nutrients and organic matter. Target species of bacteria can be found in marine environments displaying a wide range of enzymatic activities, such as polysaccharide hydrolases, able to break down complex molecular structures. The specificity of polysaccharide hydrolases varies among target bacteria species and also under environmental conditions. The ability to display a wide range of enzymatic machinery adapted to different environmental conditions and also different substrates could be a competitive advantage in extreme environments important to understand. However, despite of all efforts, still remains some gaps of fundamental knowledge related with the characterization of target species of bacteria and its enzymatic activities. This type of information is important to understand not only the role of bacterial communities in ecosystem process in Antarctica but also to guide bioprospection efforts in the near future. being

The aim of this study was characterize an Antarctic Flavobacterium strain (INACH0011.6), using a polyphasic approach and evaluated the ability of the culture cell-free supernatant to hydrolyze phycocolloids at different temperatures under controlled conditions.

The strain INACH0011.6, isolated from algae wrack, in King George Island, Antarctica, was identified as member of the genus Flavobacterium through 16S rDNA gene analysis. The phylogenetic analysis using related sequences of the genus Flavobacterium, clustered strain INACH0011.6, *F. faecale* and *F. algicola* into a well-supported subclade which was distinguishable from other phylogenetically-related sequences. In agreement with previous report, the morphological characteristics of INACH0011.6, typically rod-shaped cells and yellow-pigmented colonies were similar to Flavobacterium strains isolated from a variety of Antarctic habitats. According to growing parameters, optimum temperature (17 °C) and maximal temperature (20 °C) of growth, INACH0011.6 strain was characterized as psychrotrophic microorganism. Agarase and alginate-lyase displayed enzymatic activities within a range of 10 °C to 50 °C, with differences in the optimal temperature to hydrolyze agar (50 °C), agarose (50 °C) and alginate (30 °C) during the first 30 min.

Flavobacterium are recognized for their role in remineralization processes in the ocean due to their ability to decompose dissolved complexes and particulate organic matters, which gives them the versatility to colonize substrates containing different polysaccharides. Some species in the genus Flavobacterium have been previously reported to be able to hydrolyze agar or alginate and recently an Antarctic Flavobacterium was reported as an agarase-producing strain. Strain INACH0011.6 exhibited a higher degree of identity (99.8 %) to *F. faecale*, however both strains have different carbon source (agar and alginate) utilization patterns.

## ***Characterization of Leptolyngbya and Phormidium diversity in Antarctic biotopes***

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In Antarctica, cyanobacteria are the key primary producers and drivers of the carbon and food webs in freshwater ecosystems forming conspicuous benthic microbial mat communities. In these mats, thin filamentous cyanobacteria (*Leptolyngbya*, *Phormidium*) are common and form a matrix that supports other microorganisms. These genera, previously described by botanical criteria, are polyphyletic and thus, in need of detailed taxonomic revisions. Characterization of strains is the first step for an assessment of the real diversity of these taxa and to better understand their role in the environment.

A polyphasic approach was used. We have performed a molecular analysis of Antarctic strains of *Leptolyngbya antarctica*, *Leptolyngbya cf fragilis*, *L. glacialis* and *Phormidium priestleyi* using different taxonomic markers (16S rRNA, ITS and *rpoC1*). Cultures at different stages were observed by light and epifluorescence microscopy. Pigments were extracted and analyzed by HPLC. Nitrogen fixation ability was identified by PCR amplification of the *nifH* gene. The presence of secondary metabolite sequences was performed using whole genome sequencing of selected strains. Finally, we investigated their distribution in Antarctica using 454 pyrosequencing targeting the 16S rRNA gene in 15 microbial mat samples.

The strains appear distributed into four lineages. Phylogenetic trees support the distribution of *P. priestleyi* strains into at least two potentially new lineages. The first lineage includes nine *P. priestleyi* strains isolated from samples collected in 3 different regions (Dronning Maud Land, East Antarctica, and Transantarctic Mountains). This lineage appears to be cosmopolitan and include two European strains (Greece, Czech Republic). On the basis of morphological observations of 1-year-old cultures, we confirmed the features observed by our Greek colleagues.

Some *L. antarctica* clearly belong to the newly described cosmopolitan genus *Nodosilinea*. Strikingly, this lineage was the most abundant in the majority of samples (13/15). The genus *Nodosilinea* is known as a nitrogen-fixer clade, however, we were not able to detect the gene encoding for the nitrogenase in Antarctic strains.

The second lineage of *L. antarctica* strains possesses the *nifH* gene and seems to grow normally in N-depleted medium. This lineage seems endemic to Antarctica and only shares 91-91.2% 16S rRNA gene sequence similarities with its closest relative *Leptolyngbya* sp. ULC023.

The last group of strains forms a cosmopolitan lineage composed by strains that were identified under different names. However, the Antarctic strains of this cluster shared 96.3% to 100% 16S rRNA similarity, a value that often define the same genus.

Genome analyses revealed the presence of sequences related to the production of secondary metabolites into strains from two of these lineages. Secondary metabolites are often known for their antimicrobial activities. Such properties would partly explain how cyanobacterial mats survive to predation and degradation by other bacteria. In addition, HPLC analyses revealed the presence of UV-protective compounds (e.g. scytonemin).

This work provides the first building block to the understanding of survival strategies developed by mat-forming cyanobacteria in Antarctica and how they succeeded as the most abundant phototrophs on the continent.

## ***Characterization of psychrotroph Streptomyces sp. strain with antimicrobial and anticancer activities isolated from Fildes Peninsula.***

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Members of the actinobacteria phyla are widely distributed in a multiplicity of natural environments: terrestrial, aquatic and extreme environments from tropical to polar regions. They play significant roles in several processes that contribute to soil fertility, such as nutrient cycling, decomposition of various compounds like complex biopolymers, and formation of beneficial soil humus. Actinobacteria comprise several different genera, the *Streptomyces* genus has attracted great interest due to its well known ability to synthesize many different bioactive secondary metabolites, including more than 80% of known antibiotics, antitumor compounds and growth effectors. Antarctic microorganisms, especially the psychrophiles and psychrotrophs, develop novel metabolic pathways as a result of the evolutionary selection to survive and grow under these extreme conditions.

The aim of this study was to phylogenetically and physiologically characterize an Antarctic *Streptomyces* strain and test the activity of bioactive compounds against foodborne pathogens and MCF-7 (breast cancer), PC-3 (prostate cancer) and HT-29 (colon cancer) cell lines.

The taxonomic status of the isolate was established using a polyphasic approach. The strain was identified as belonging to the genus *Streptomyces* based on the scanning electron microscopic observation and partial 16S rRNA gene sequence analysis. The phylogenetic tree analysis revealed that *Streptomyces* strain fell into the same subclade with *S. fildesensis* and *S. purpureus*. The similarity analysis showed that it is closely related to *Streptomyces fildesensis* (99.8%), *Streptomyces purpureus* (97.2%) and *Streptomyces beijiangensis* (98.1%). This *Streptomyces* strain was observed to be psychrotolerant according to growing parameters, optimum temperature (30 °C,  $\mu=0,762$ ) and maximal temperature (37°C,  $\mu=0.0336$ ) of growth, slightly halotolerant (up to 5% of NaCl) and tolerant to a wide pH range of 5.0–12.0.

The bioactive compounds production was higher at 12°C than at 28°C. Bioactive compounds are capable of inhibiting the growth of 7 foodborne pathogens and showed significant activity against cancer cell lines. The LC 50 value of bioactive compounds recovered for the Control OKF6-TERT2, Control Colon cell, MCF-7, PC-3 and HT-29 cell lines were 73.46, 28.02, 19.54, 18.16, and 6.618 µg/ml, respectively.

In conclusion, the Antarctic Peninsula, even though some areas are occupied by human, remains as a largely unexploited source of cold-adapted microorganisms capable of producing valuable bioactive compounds. The current study described a promising psychrotolerant Antarctic *Streptomyces* that might be a potential source of genes encoding for antimicrobial compounds and enzymes with medical applications.

## ***Cold adaptation of a family I.3 lipase isolated from an Antarctic Pseudomonas***

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Psychrophilic enzyme is an interesting subject to study due to its special ability to adapt to low temperatures, unlike typical enzymes. Previously, a gene encoding a family I.3 lipase was isolated from an Antarctic *Pseudomonas* sp. The enzyme was successfully expressed in prokaryotic expression system and purified to homogeneity. The structure and function of the cold active lipase was predicted utilizing computational and biophysical approaches. The enzyme was subjected to molecular simulation at varying temperatures for 3D structural analysis. The predicted model of the lipase displayed some features suitable for cold adaptation including the increase of flexible conformation. Structural changes were observed during the temperature simulation using the predicted 3D structure of lipase. This finding was also supported by the lipase biochemical and biophysical characteristics. The analysis of the structure and function of cold active lipase provides new insights into the structural adaptation of protein at low temperatures. The information obtained could be useful for low temperature organic synthesis and molecular engineering purposes, in the near future.

## ***Cold-active extracellular amylase production in Cassava starch from novel Antarctic bacteria***

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Cold-active enzyme present high catalytic efficiency in condition of low temperature and offer various economical and ecological benefits. Investigation related in bioprospecting of extremophiles microorganisms and the biotechnological use of their thermos-stable biomolecules in industrial process are rising in nowadays. Amylase is a hydrolytic enzyme that degrade starch in a simples saccharide compounds. The continuous development of food, textile, bakery, pharmaceutical and detergent industries are forced in the search more thermo-stable and efficient enzymes for these process. Cassava starch is becoming increasingly important modern industrial use a reduced level or amylose, in the nanotechnology, the granular size of the starch and their shapes are very important properties at the moment of deciding the type to be used. Around 137 isolates are obtained from Antarctic soil sample in the Pedro Vicente Maldonado (Ecuador Antarctic station). Only 17 of the tested isolates have amylase activity when was grown in mineral agar containing cassava starch, as carbon source. The strain C-27 has the best activity evaluate on starch media. The production of amylase activity, starts at 72 hours after inoculation at 18°C and pH 6.5. The molecular weight of extracellular amylase is upper 50kD. The extract should stability in cold conservation (4C°) and lost this activity when was frozen (- 20°C). The induction of this activity with Cassava starch, good activity a low temperature and rapid production of this enzyme, it makes it promising to be studied in depth and incorporate into biotechnological processes.



## ***Corrosion in aluminum alloy mediated by microorganisms found in the corrosion product of an aircraft operating in Antarctica***

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Several environmental factors may facilitate or accelerate corrosion of metal alloys, one of which is the presence of microorganisms. These are found in all environments and through the formation of a biofilm are able to adhere to surfaces and to modify the physical and chemical conditions in the metal / environment interface, through the production of extracellular metabolites and by generating differential aeration cells. Addition it has been found in aircraft operating in Antarctica present a more accelerated corrosion compared with these operating in other areas of Chile, It should be aware that low temperatures decrease the corrosion. In order to study this effect in an aluminum alloy, corrosion product samples of a Twin Otter aircraft operating in the Chilean Antarctic base were taken, and contained many microorganisms producing the enzyme catalase. It described the effect of this enzyme as an accelerator of the oxygen reduction reaction, and therefore increases the overall corrosion process. The identification of microorganisms was performed by sequencing of 16S ribosomal DNA (rDNA) and allowed to distinguish bacteria belonging to the genera Staphylococcus and Kocuria among others. Studies of electrochemical impedance spectroscopy (EIS) performed to determine the material's resistance against bacterial consortium and the isolated bacteria, indicate that microorganisms initially protect the metal surface and as time progresses some begin to adversely affect, ie resistance aluminum alloy under study (AA2024) begins in reducing overall, favoring the corrosion process.

## ***Cyanobacterial diversity in soil crusts in the Sör Rondane Mountains***

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The cyanobacterial diversity in soil crust samples from four nunataks and ridges (Utsteinen, Pingvinane, Teltet, Tanngarden) in the Sör Rondane Mountains (Dronning Maud Land) has been studied. These sites serve as control areas for Open Top Chambers that were installed in 2010. The average annual air temperature in the studied area fluctuated from -23 to -15 oC. However, the mean air temperature in the summer, when water is available for metabolic activity, may vary between -2 to -8 oC.

Measurement of cyanobacterial biovolumes using light and epifluorescence microscopy revealed the differences between the studied sites. The highest cyanobacterial abundance was recorded in soil crusts from Pingvinane and Tanngarden, with a dominance of heterocystous and filamentous cyanobacteria. This might be linked to a high water content in these localities, which is an important factor for cyanobacterial growth and development. However, in soil crusts from Utsteinen, where the total cyanobacterial biovolume decreased, unicellular cyanobacteria were dominant. Moreover, soil crusts from this area had a high water content, but low pH.

Soil crusts from Teltet exhibited a low water content and high pH, and they had the lowest cyanobacterial abundance. As a consequence, the DNA extraction for pyrosequencing was not possible.

The cyanobacterial diversity in the soil crusts from three sites (Utsteinen, Pingvinane, Tanngarden) was characterized using 454 pyrosequencing of the V3-V4 variable region of the 16S rRNA gene. After data processing, 17 cyanobacterial OTUs corresponding to the orders Oscillatoriales, Nostocales and Chroococcales have been obtained. The dominant OTUs belonged to the cyanobacterial genera Phormidium, Leptolyngbya, Nostoc and Synechococcus.

## ***Cytotoxicity of active compounds isolated from *barrientosiimonas humi* towards human colon cancer cell line***

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Colorectal cancer is one of the most common cancers worldwide and its incidence tends to increase year by year. The search for novel drug candidates is a priority goal for cancer therapy and natural products are often used as valuable leads. *Barrientosiimonas humi* (*B. humi*) is a novel actinobacterium of family Dermacoccaceae which was isolated from the Antarctic soil. Actinomycetes isolated from unusual environments have been known as potential producers of novel secondary metabolites. In previous study, the organic crude extracts of *B. humi* that were extracted using ethyl acetate showed significant anticancer effect. Therefore, the fractionation of the organic extracts provides great potential in isolating novel bioactive compounds that exhibit promising anticancer activities. In the present study, we investigated the cytotoxicity of bioactive compounds produced by *B. humi* against colon cancer cell lines. The cell-free culture supernatant of *B. humi* was extracted using ethyl acetate and the extracts obtained were subjected to bioassay-guided fractionation. Fractions (F1, F2, F3, F4 and F5) were collected through radial chromatography method and they were subjected to real time cell viability monitoring assay against human colon cancer cell line, HT-29. Doxorubicin was served as positive control and DMSO as solvent control. F1 and F5 resulted in a decline of cell index of HT-29 in a dose-dependent manner at a minimum concentration of 0.02µg/ml. Based on the result, nine sub-fractions were isolated and were again evaluated by using real time assay. 3 out of 9 fractions (F4, F6 and F8) were showed to be effective against HT-29 at a minimum concentration of 0.04µg/ml. As a result, pure compound, Bh-03, was being isolated from F4 and was found to be effective at minimum concentration of 320µg/ml. In this study, toxicity of the compounds was investigated by using normal human embryonic kidney cell line, HEK293. Normal cell growth of HEK293 were not affected by all of the bioactive compounds tested, indicating the non-toxicity of compounds. From the result present here, the bioactive compounds isolated from *B. humi* exhibited cytotoxicity properties and could be highly potential in contributing to the drug leads development in the future.

## ***Cytotoxicity of extracts from a marine strain isolated from Antarctic on Staphylococcus aureus, Candida albicans and human cancer cell lines***

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In recent decades, research into finding new sources of secondary metabolites from marine ecosystems has been important. This interest is due to the natural products of marine origin to be structurally very diverse and complex, in many cases serve as a model and / or scaffold to manufacture new synthetic compounds (Newman and Cragg 2004, Koehn & Carter. 2005, Cragg & Newman 2013)

In this study the cytotoxic effect of ethanol extracts and ethyl acetate, from the cell-free culture of a marine strain, isolated from the Antarctic marine sediments was assessed. This strain is in process of sequencing. The sample was obtained from Punta Suffield (62 ° 12' S, 58 ° 55 'W) at 30m deep, and the cytotoxic effect was evaluated against Staphylococcus aureus, Candida albicans and human cancer cell lines. On S. aureus and C. albicans the minimum inhibitory concentration (MIC) was determined. On human tumor lines the median effective concentration (EC<sub>50</sub>) for cellular viability was analysed using sulforhodamine B assay. Cell lines used were MCF-7 (breast cancer), PC-3 (prostate cancer), HT-29 (colon cancer) and CON (human colon epithelial cells), as a non-tumoral cell line control. Finally the selectivity index of each extract, corresponding ratio of the EC<sub>50</sub> of non-tumor line (CON) with EC<sub>50</sub> of tumor cell line (MCF-7 cells, PC-3, HT-29) was calculated. If the ratio is equal to or greater than 3, the extract, fraction or compound is considered selective.

The ethanol extract had no greater effect against human pathogens used, with the minimum inhibitory concentration greater than 2.5 mg ml<sup>-1</sup> for both microorganisms. The effect of ethyl acetate extract on C. albicans was similar because the MIC was greater than 2.5 mg ml<sup>-1</sup>. However, on S. aureus, the MIC was 500 µg ml<sup>-1</sup>.

In the four human cell lines both extracts were cytotoxic. Ethyl acetate extract was shown to be more effective, since the EC<sub>50</sub> into cells CON, MCF-7, PC-3, HT-29 were 61.03 µg ml<sup>-1</sup>, 20.65 µg ml<sup>-1</sup>, 61.29 µg ml<sup>-1</sup> and 24.67 µg ml<sup>-1</sup> respectively. The EC<sub>50</sub> of ethanol extracts in the cells CON, MCF-7, PC-3 and HT-29 were 230.09 µg ml<sup>-1</sup>, 174.58 µg ml<sup>-1</sup>, 107.09 µg ml<sup>-1</sup> and 187.01 µg ml<sup>-1</sup> respectively.

Regarding the selectivity index, both extracts are not selective in their action against tumor cells. The ethyl acetate extract was more selective than the ethanol extract as in MCF-7 (2.96) and HT-29 (2.47) cells observed values close to 3. The ethanol extract presented a selectivity index less than 2 in the three tumor cell lines.

In conclusion, interesting cytotoxicity values were obtained, however it is necessary to isolate and identify bioactive metabolites to know the potential cytotoxicity of compound present in the extracts of the strain isolated from marine sediment of Antarctica.

## ***Distribution of prokaryotic communities and nifH gene diversity in the extreme Darwin Mountains, Antarctica***

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Approximately 99.7% of continental Antarctica is permanently covered by the Antarctic Ice sheet and the few remaining ice-free areas are patchily distributed across the continent. The existing environmental conditions have shaped soil ecosystems of low diversity and simple trophic structure in which soil microorganisms face severe conditions. In these areas, the diversity of microorganisms involved in key biogeochemical processes such as the nitrogen (N) cycle is still largely unknown. The Darwin Mountains represent the second largest ice free region in the Transantarctic Mountains and the Darwin-Hatherton region is an important outflow glacier system that connected the East and West Antarctic ice sheets during previous glacial maximum. Little is still known about its glacial history, geomorphology and biodiversity of the region. In a previous study we examined biodiversity at different multi-trophic levels across the abiotic spatial heterogeneity and geological history to understand environmental constraints influencing community composition and structure in Darwin Mountains. In this study, we aim to deeply characterize the distribution patterns of the prokaryotic communities that inhabit the remote Darwin-Hatherton using not only high-throughput sequencing methodologies (amplification of the prokaryotic 16s rRNA gene), but also a functional approach targeting the *nifH*, a gene which encodes a sub-unit of the nitrogenase enzyme, responsible for nitrogen fixation. Next Generation Sequence (NGS) meta-analysis revealed the occurrence of a significant spatial heterogeneity in the prokaryotic communities across the sampling area with high ranges of species diversity (Shannon index between 3.96 and 9.47) between the different sampling sites. Archaeal phyla represented between 0.1% and 1.5% of the sequences in each location with a dominance of members of genus *Nitrososphaera*. Dominant bacterial phyla were Actinobacteria (13.1% - 58%), Bacteroidetes (1.5% - 47.65%) and Proteobacteria (0.6% - 35.6 %). Frequencies of occurrence of Cyanobacteria varied between 0.2% and 2.9% with the exception of one location where they represented 36.7% of the sequences and the dominant phyla present. NGS results have also confirmed the presence of taxonomically different N fixers, which is supported by variability at the level of the *nifH* gene sequences. Future work will consist of establishing relationships between the prokaryotic diversity data generated and the intrinsic environmental features that characterize the Darwin Mountains.

## ***Diversity and community structures of prokaryotes and eukaryotic microbes in Antarctic freshwater glacial lake***

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Previous Antarctic studies have revealed significant microbial diversity, particular among bacteria. However, many studies of microbial community structures in Antarctica have focused on prokaryotes in saline lakes, and only limited information is available regarding eukaryotic microbes. In the present study, we attempted to elucidate the whole microbial community structures of Antarctic freshwater glacial lake Yukidori-Ike using SSU rRNA gene clone analysis.

Lake Yukidori-Ike is located in the mid Langhovde region on the east coast of Lutzow-Holm Bay, Antarctica. The water sample was collected from the lake on December 26, 2012 during the 54th Japanese Antarctic Research Expedition. The water temperature was 5.4°C and the pH 7.5 during sampling. Bacterial and Archaeal 16S rDNA and Eukaryotic 18S rDNA clone libraries were constructed using metagenomic DNA extracted from the sample. The clones were randomly chosen, sequenced, and identified using EzTaxon and BLASTN. Shannon diversity index and Chao1 richness were also calculated.

Concentrations of NO<sub>3</sub>, NO<sub>2</sub>, SiO<sub>2</sub> and NH<sub>4</sub> of the lake-water were 5.2 μM, 0.13 μM, 25.6 μM and 1.3 μM, respectively. PO<sub>4</sub> concentration was below detection limits. Bacterial 198 clones were taxonomically identified and grouped into 128 phylotypes in species level. These phylotypes were further classified into 11 phyla. Proteobacteria was the most dominant phylum (50%) in Lake Yukidori-Ike and was composed of α-, β-, δ-, and γ-Proteobacteria. β-Proteobacteria was the most dominant class, accounted for 59% of Proteobacteria. The second dominant phylum was Cyanobacteria (15%) consisting of two orders Nostocales and Oscillatoriales. Shannon and Chao1 values of the bacterial community were 4.6 and 310, respectively. These results indicated that bacterial diversity of Lake Yukidori-Ike was remarkably high.

In contrast to the bacterial diversity, archaeal diversity was quite low. A total of 72 clones were classified into only two phylotypes. One of the phylotype that accounted for 97% of archaeal community showed 98.5% sequence similarity with *Methanosarcina spelaei*. The other phylotype contributed to 3% archaeal community and showed 96.0% sequence similarity with *Methanosaeta concilii*.

Eukaryotic 91 clones were grouped into 19 phylotypes consisting of five phyla. The most dominant phylum was Tardigrada, which comprised 55% of eukaryotic clones and grouped into two phylotypes. One of these phylotypes showed 98.3% of 18S rDNA sequence similarity with *Diphascos pingue*. The second and third dominant eukaryotic phyla were Ciliophora (17%) and Chloophyta (8%), respectively. Shannon index of eukaryotic microbes of Lake Yukidori-Ike was 2.6.

Although the archaeal diversity was very low, overall microbial diversity of the lake was remarkably high as well as the aquatic environments in the temperate and tropical regions. The lake's nutrient profile indicated that Lake Yukidori-Ike is classified as an oligotrophic lake. However, several thousands of Snow petrels (*Pagodroma nivea*) inhabited along with Yukidori-Valley and provide their excrements that might be important source of nutrients for the microbes especially chemolithotrophs and phototrophs.

In the phylogenetic trees of bacteria and eukaryotic microbes, there are several clusters consisted of only cryospheric clones. These microbes might adapt to and evolved in the cold environments.

## ***Diversity of bacteria of the Fildes Peninsula: Baseline survey for future monitoring of diversity shifts under simulated warming***

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The impacts of global warming are increasingly evident in marine and terrestrial environments over the past century. It is projected that global temperatures would rise by about 0.2 °C per decade on average for the next two decades depending on the concentrations of greenhouse gases. Temperature rise is expected to contribute changes to soil microbial communities in affected regions. There is also increasing concern of the possible surge in pathogenic bacteria. Temperature increase by about 1 °C in the Baltic Sea is reported to coincide with a two-fold increase of *Vibrio* cases. At the moment it is not clear how warming of the terrestrial environment will affect the diversity of bacteria. In conjunction with this, we have conducted a baseline survey on the diversity of bacteria on soil samples from ten sites at the Fildes Peninsula of King George Island using the Denaturing Gradient Gel Electrophoresis (DGGE) and Next Generation Sequencer (NGS). All the soil samples have different profiles of predominant bands on the DGGE. Intense DNA bands in the DGGE gel from ten locations, namely Antarctic Lake, GFZ Lake, Estrellas Lake, Playa Elefantos, Minas River, Collins Glacier, Kitiash Lake, Belem Lake, Geografos Lake and sea front were excised from the DGGE gel and sequenced. The results of the analysis provided an overview of the predominant groups of bacteria and the diversity of the bacterial communities. The most abundant phyla of bacteria in Fildes Peninsula were Bacteroidetes, Proteobacteria, Acidobacteria, Gemmatimonadetes, Nitrospira, Firmicutes, Actinobacteria, Chloroflexi, Cyanobacteria, Spirochaetes, Deinococcus-Thermus, WS3 and BRC1. NGS data captured two additional phyla that were not captured using the DGGE analysis. There were the Verrucomicrobia and Planctomycetes. Additionally, it showed the presence of *Legionella* spp., a genera which consisted potential pathogens and *Mycobacterium pinnipedii*, a member of the *Mycobacterium tuberculosis* complex which primarily infects seals. In the future, one or two of the above sites will be used for long term monitoring to determine whether there will be a diversity shift when there is a rise in temperature by 1 to 2 °C.

## ***Diversity of polar soil fungi***

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Fungi inhabit diverse niches across the globe, including those in the extreme environments of the Earth's poles. Polar microbial communities continue to lack comprehensive characterization or functional studies that link community composition with ecosystem function. Microbial processes are crucial to the soil ecosystem, and soil fungi constitute a significant and important proportion of soil microbial diversity and biomass. Here, we provide a synthesis of current knowledge of the diversity and distribution of polar soil fungi, and their functional biology, specifically focusing on the continental and maritime Antarctic regions, along with the High Arctic, which experience broadly overlapping environmental parameters. Most fungal diversity studies in the Arctic and Antarctic have relied on observations and therefore, focused on lichens and fungi with visible sporocarps. However, as part of their survival strategy in the extreme polar environmental conditions, many fungi remain permanently in the anamorphic stage and lack visible reproductive structures. As a result, microfungal diversity, including the majority of soil flora, has largely been overlooked. In order to develop a consolidated overview of fungi that have been isolated and reported in High Arctic and Antarctic soils, we compiled data from 26 studies published in 1999-2013. While clearly not fully representative of the true diversity of soil fungi found in these regions, it provides a benchmark for the current state of knowledge, and highlights factors such as the over-representation of certain subgroups introduced by methodology and sampling bias. Sub-phyla are grouped according to region and soil habitat, showing an overlap of phyla and sub-phyla found in both the Antarctic and Arctic. To understand the diversity and distribution of polar soil fungi, it is imperative to understand the properties of soils in the Arctic and Antarctic and fungal relationships to them. Soil formation in the polar regions is influenced by climate, parent material, biotic elements, relief and time. Major environmental variables that may act as stressors in the extreme environments in these regions include solar radiation, temperature, soil moisture, osmotic pressure, pH and freeze-thaw activity. The lack of available data on polar soil fungi, both in terms of diversity and function, continues to challenge the study of their ecology, diversity, and potential responses to change.



## ***Diversity, thermal characteristics and hydrolase enzyme from polar soil fungi***

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We compared diversity and hydrolase enzyme activity in soil fungi isolated from locations in the Antarctic (Fildes Peninsula, King George Island) during the austral summer seasons of 2006/07 (February 2007) and Arctic (Hornsund, Spitsbergen) in August 2010. We assessed culturable soil microfungal diversity in various habitats using potato dextrose agar (PDA) medium. Identifications were based on morphological characteristics and intergenic spacer regions of morphotypes were sequenced. Thermal growth classification of the fungi obtained was determined by incubation at 4°C and 25°C, permitting separation of those with psychrophilic, psychrotolerant and mesophilic characteristics. Psychrophilic and psychrotolerant isolates from Hornsund and King George Island were screened for activity of extracellular hydrolase enzymes (Hornsund – keratinase; King George Island – amylase and cellulase) using screening plate method. Enzyme activity was classified based on relative enzyme activity (RA) with the significant activity was determined by >1.0 RA value. A total of sixty-four fungal taxa were obtained from both study sites consisting of twenty-nine genera, three yeasts, a sterile mycelium and two unidentified species. Thirty-three morphotypes were classified as psychrophilic, seven psychrotolerant and twenty-four mesophilic. Of these, twenty-five fungal taxa were isolated from Hornsund while forty-one taxa from King George Island. Four genera were observed to occur from both Polar Regions – *Geomyces* spp., *Mortierella* spp., *Phialophora* spp. and *Penicillium* spp. The most frequent isolated taxa from Hornsund and King George Island were *Phialophora lagerbergii* and *Geomyces pannorum*, respectively. The best amylase and cellulase producer were isolates from King George Island; *G. pannorum* and *Mrakia frigida*, respectively while isolates from Hornsund, *G. pannorum* showed a significant activity on keratinase. The studies also revealed that bipolar soil fungi, *G. pannorum* produced cold-active extracellular hydrolase enzyme as a survival strategy in cold habitats. The knowledge generated will further improve baseline understanding of soil fungal diversity and ecological role across the different habitats of the Polar region.

## ***Effectiveness of a bacterial consortium isolated in the Antarctic Peruvian Base "Machu Picchu" on the bioremediation of hydrocarbons contaminated soils in terrarium level***

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The use of petroleum fuels as a source of energy could bring about pollution of soil in the surrounding areas to the stations and settlements in Antarctic continent. At our laboratory There were isolated psychrophilic and psychrotolerant bacterial strains that have biodegradative activity on several kinds of petroleum hydrocarbon at low temperatures, so the aim of this research was to evaluate the efficacy of psychrotolerant bacterial strains isolated from Peruvian Base "Machu Picchu" in Antarctic on the soil contaminated with oil, under laboratory conditions. We used a psychrotolerant bacterial consortium integrated by *Pseudomonas putida* (63Bb, 9Ab, 60Bf, 39Bfa), *Pseudomonas* sp. (9Aa), *Pseudomonas aeruginosa* (63Ba), *Aeromonas* sp. (39Bfb), *Stenotrophomonas rhizophila* (116B), and *Paenibacillus lautus* (95Fa, 95Fb). Three terrarium (23 cm x 12 cm x 8 cm) were conditioned with 1.3 Kg of soil contaminated with petroleum (5% w/w); the first one was inoculated with the psychrotolerant bacterial consortium, the second one, with a positive control consortium: *Pseudomonas aeruginosa* (68P and 202P) and *Bacillus subtilis* (202G); isolated from the north of Peru and the third one was the abiotic control. Treatment was performed for 180 days at a 4-5° C. The oil biodegradation was measured by gravimetric method (SOXHLET), the bacterial count and the screening of the physical and chemical parameters of each terrarium was carried out each 30 days. The results showed that bacterial growth was exponential in 120 days, with a maximum value of 2.18x10<sup>5</sup> CFU/g and the hydrocarbonoclastic psychrotolerant bacterial count reached 4.3x10<sup>4</sup> NMP/g, which coincides with the 57.88% of reduction of hydrocarbons in 120 days. Finally, after 180 days, in positive control and abiotic terrarium was observed, 37.30% and 11.96% of reduction of hydrocarbons, respectively. In conclusion, psychrotolerant terrarium reached a significant reduction of 58.41% (p<=0.001) so the consortium could be used for bioremediation of soils contaminated with petroleum hydrocarbons in low temperature environments, controlling moisture and pH conditions.

## ***Fungal communities present in ornithogenic soils of Antarctic Peninsula: diversity, distribution and potential innate virulence***

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We surveyed diversity, distribution and physiological virulence potential of fungi present in ornithogenic soils around the nest of the birds *Macronectes giganteus*, *Phalacrocorax atriceps*, *Pygoscelis antarcticus* and *Pygoscelis papua* in Antarctic Peninsula. Four hundred eight-one fungal isolates were recovered (368 filamentous fungi and 113 yeasts), which were submitted to capability to grow at 37 °C. Fifty fungal isolates (33 filamentous fungi and 17 yeasts) grew at 37 °C and were identified as species of the genera *Aspergillus*, *Byssoschlamys*, *Cryptococcus*, *Chrysosporium*, *Debaryomyces*, *Eutypella*, *Penicillium*, *Peniophora*, *Phanerochaete*, *Phlebia*, *Psathyrella*, *Rhizopus*, *Rhodotorula* and *Trametes*. *Penicillium chrysogenum* associated present in soil next to nest of *P. antarcticus* and *P. atriceps*, and *Aspergillus fumigatus*, associated with soil next to nest of *M. giganteus*, were the taxa dominantly recovered. *Aspergillus fumigatus*, *Byssoschlamys spectabilis*, *Rhizopus oryzae* and *Cryptococcus laurentii* displayed capabilities to grow at 40 °C. Different isolates of *Cr. laurentii*, *P. chrysogenum* and *Peniophora* sp. produced complete hemolysis on blood agar medium. Isolates of *Cr. laurentii*, *Eutypella* sp., *Rh. oryzae* and *Trametes* cf. *polyzona* were able to produce phospholipase. *Aspergillus fumigatus*, *P. chrysogenum* and *Rh. oryzae* showed spore sizes  $\leq 3$   $\mu\text{m}$  diameter at 35 °C. *Cryptococcus laurentii*, *P. chrysogenum* and *Rh. oryzae* displayed resistance to antifungal drug amphotericin B. Our results suggest that ornithogenic soils of Antarctica shelter rich and diverse fungal communities, which include taxa with physiological characteristics similar of the pathogenic fungi.

## ***Genetic diversity of psychrophilic microorganisms and their ability to make microbial consortia***

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The study describes the genetic diversity of microorganisms from polar glaciers and their ability to make microbial consortia on rock particles. The first step was to develop the appropriate media that would provide the optimal culture conditions. Then analyzed genetic material obtained using a variety of biochemical methods and techniques of molecular biology. It was detected that studied polar fungi are psychrophilic and oligotrophic microorganisms, including two species of fungi: *Mrakia frigida* and *Glaciozyma antarctica*. In samples were also present *Polaromonas* sp. bacteria. Further analysis showed differences in the variety of microorganisms from various glaciers and from different parts of glacier. Within the glacier, the greatest biodiversity of microbiota is observed in the old ice, and the smallest occurring on the dome of the glacier. Further research is required into the impact of "contamination" of air, eg. the presence of nesting colonies of birds, to the diversity of ice microbiota.

Presumably fungi species *M. frigida* and *G. antarctica* may be associated with inorganic particles via bacteria of the *Polaromonas* genus. To check the possibility of a rapid selection of microorganisms that have the ability to bind to a suspension of uncoated particles of inorganic paramagnetic beads (having a diameter of approx. 100 microns) trials were incubated with stationary cultures of bacteria of *Polaromonas* and unicellular fungi *M. frigida* and *G. antarctica*. This allowed for quick selecting microorganisms associated to beads without sedimentation, which theoretically exclude false results due to sedimentation together microbes and inorganic particles.

Previous studies have shown that glacier microorganisms are mainly found on the surface of rock dust what can be especially seen in the case of cryoconites. This may be the result of sedimentation together microbes and particles of rock or active implantable on the rock material. It can be assumed that under extremely oligotrophic conditions, capacity for adhesion and formation of consortia on the surface of rock particles is an adaptation that allows the survival of not only the microbial relationships dependent on photoautotroph, but also the consortia in which the key role is played by chemotroph.

## ***Growth inhibition of Phoma spp. fungi by bacteria B2Y4 from Antarctic soils***

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Background: Fungi constitute a highly versatile group of eukaryotic heterotrophic organisms that have successfully occupied most natural habitats, including plants. The association of fungi and plants is ancient and involves many different fungi. Fungi are also an important group of plant pathogens, causing most plant diseases, and considerable annual crop yield losses, economic and societal impacts. *Phoma* spp. are amongst the most common fungal plant pathogens infesting crops such as potato, alfalfa, oilseed rape and cereals. Currently available fungicides are not very effective in managing such fungal plant pathogens, as many fungal pathogens have developed chemoresistance against fungicides. Therefore, research to discover alternative antifungal agents is urgent. To our knowledge, no antifungal agent has been isolated from Antarctic bacteria that is capable of targeting fungal plant pathogens.

Methodology: Isolation of bacteria from Antarctic soils was performed by serial dilution using the dilution plate technique. The plates were incubated at 4°C and pure cultures of each colony were isolated onto sterile Luria broth (LB) agar plates. Bacterial isolates were co-cultured with natural occurring fungi and *Phoma* spp. which had been isolated previously from Antarctica soils.

Results and Discussion: Twenty-eight bacterial isolates were isolated from the Antarctic soil samples. Bacteria B2Y4 selectively inhibited the growth of *Phoma* spp. for up to 28 d after inoculation. Other bacterial isolates inhibited the growth of fungi for 7-14 d but growth then recovered by day 28. This is an important observation: the antifungal effect of the bacteria (or their bioactive compounds) is selective against fungal plant pathogens but there is no effect on other naturally occurring fungi.

Conclusion: Bacterial isolates from Antarctic soils have potential application in the management of fungal plant pathogens such as *Phoma* spp. Further study is required to characterise B2Y4 and to identify the potential anti-fungal agent(s) it produces.

## ***Growth performance, total protein and carbohydrate of Arctic and Tropical Pseudanabaenaceae during different growth phases of a batch culture experiment***

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Cyanobacteria are able to grow under diverse environmental conditions, and their biochemical composition during different growth stages is varied due to nutrient depletion related to culture age. Arctic cyanobacteria, *Pseudanabaena* cf. *amphigranulata* was isolated from Revdalen, Svalbard Island, Norway while Tropical cyanobacteria, *Pseudanabaena mucicola* was isolated from Harapan Lake, Universiti Sains Malaysia, Penang, Malaysia. Both species was maintained in BG11 media and light intensity of 50  $\mu\text{mol m}^{-2} \text{s}^{-1}$ , under 15°C for *P. amphigranulata* cf. and 25°C for *P. mucicola*. The cyanobacteria were harvested by centrifugation and filtration at lag (Day 4), logarithmic (Day 14) and stationary phases (Day 21) for the determination of growth rate, cell division rate, total protein, total carbohydrate and chlorophyll a concentration. The growth rate recorded for Arctic cyanobacteria, *P. amphigranulata* cf. was 1.667 cell/ml/day with the doubling time of 2.405 day<sup>-1</sup>, while Tropical cyanobacteria, *P. mucicola* recorded 1.575 cell/ml/day and 2.722 day<sup>-1</sup> of growth rate and doubling time, respectively. Chlorophyll a concentration increased with increasing growth stages, but measured biochemical composition during different growth stages between both species was varied. For example, total carbohydrate for *P. mucicola* was higher in lag phase but lower in logarithmic phase. Furthermore, *P. amphigranulata* cf. recorded higher total protein than *P. mucicola* at lag and stationary phases but slightly lower during logarithmic phase. *P. amphigranulata* cf. have greater growth rate than tropical *P. mucicola*, and our results showed that total protein and carbohydrate of both species varied with growth stages.

## ***Investigating cyanotoxin production from three decades deep freeze Antarctic cyanobacterial mats***

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### Investigating Cyanotoxin Production by Antarctic Cyanobacterial Mats

Cyanobacteria have been known to produce toxic secondary metabolites since as early as 1898. Cyanotoxins were commonly thought to be produced in warm, high light exposure, slow moving and eutrophic water bodies in temperate and tropical regions. However, the discovery of the first cyanotoxin production in Antarctica 16 years ago changed this paradigm, with the confirmation of the production of nodularin and microcystin-LR in the extreme cold environment. Here, we examined cyanotoxin production in 31 deep freeze cyanobacterial mats samples which were collected from Cape Royds, Ross Island, Antarctica in 1986-7. Polyphasic assessment was used for morphospecies identification, including thorough descriptions of morphospecies by light microscopy of field-collected samples and cultured isolates, 16S rDNA phylogenies and internal transcribed spacer (ITS) compositions. The presence of toxin-encoding genes will be examined using specific primers on genes encoding for microcystin, anatoxin-a, saxitoxin, cylindrospermopsin and nodularin.

## ***Isolation and biochemical characterisation of bacteria isolated from soil samples from Signy islands using defined and complex media***

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Psychrophilic bacteria are cold-loving bacteria inhabiting the cold polar region categorised as extremophiles. Continued and coordinated efforts to understand bacterial community structure and function in Antarctic soils will be necessary to monitor and predict ecological responses in these changing environments. The primary aim of this study was to characterise the bacteria isolated from soil samples collected from Signy Island, Antarctica, as part of a bigger project to assess the toxicity of heavy metals in polar microbes. The bacteria were grown in different media and at different temperatures. The Antarctic soil samples were primarily suspended in saline medium and centrifuged at 1500g, and the supernatant was used for inoculation as soil saline suspension. The suspension was seeded into different broths and incubated at 4°C, 10°C and 15°C. In this study several defined media and complex media was used. The defined media consisted of salts and sugars including dextrose, sucrose, glucose, sodium chloride and di sodium phosphate as carbon and energy sources. For the complex media, more complex components like peptone, gelatin, brain heart infusion, yeast extract, tryptone with salts and sugars were used. The different broths (1 mL) were added into different wells, and in some wells, the contents were enriched with heat killed bacterium. A total of 57 soil samples were screened by inoculating them into various defined and complex media, with/without salts, sugar and enrichments in 24-well micro well plates and incubated for three weeks. Different kinds of poly microbial bacteria were isolated from different media. The culture positive broths were plated on agar medium, and single colonies of bacteria were transferred to fresh medium. The bacterial isolates from the agar plates were characterised by gram-staining, oxidase test and catalase test. Various forms of bacteria were isolated, including gram positive and gram negative cocci, spore forming bacteria and bacilli of different shapes and size.



## ***Isolation of cold-active protease - Producing microbes from Antarctic freshwater lakes***

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Proteases are ubiquitous enzymes that hydrolyze peptide bonds of other proteins. These enzymes have been used for various industrial applications. Cold-active protease may have potentials for food processing or organic wastewater treatment at low temperature, and also as research materials for studies of cold-adapted enzymes. In this paper, we report the results of isolation and identification of microbes that secrete cold-active protease from Antarctic freshwater lakes.

The water samples including surface sediments were collected from three lakes: Yukidori-Ike, Hotoke-Ike, and Skallen-Oike located in the coastal region of Lutzow-Holm Bay, East Antarctica during December 2012 through January 2013 in the 54th Japanese Antarctic Research Expedition. The water temperatures were 5.4-6.1°C and pH at around 7.5. The 0.1 mL of the water samples were spread onto LB- or MBSY-agar plates supplemented with 30 g/L skim milk and incubated at 4°C. The colonies appeared with clear zones, indicating proteolytic activity, were selected and purified by repeated single colony isolation. The purified strains were identified by partial nucleotide sequences of SSU-rDNA. To examine proteolytic activity of the isolates, the 1 µL of culture of each strain was inoculated onto MBSY-agar-skim milk plates and incubated at 4 and 25°C. The proteolytic activity of each strain was evaluated based on the ratio of the diameter of colony to the radius of clear zone.

Total 71 strains were isolated as cold-active protease-producing microbes, and they were grouped into bacteria (63 isolates) and eukaryote (8 isolates). Bacterial isolates were classified in genera *Flavobacterium* (28 isolates), *Pseudomonas* (14 isolates), *Arthrobacter* (10 isolates), *Psychrobacter* (7 isolates), *Cryobacterium* (2 isolates), *Hymenobacter* (1 isolate) and *Polaromonas* (1 isolate). All eukaryotic isolates were identified as yeast *Leucosporidium antarcticum*. Bacterial 43 isolates and all eukaryotic isolates showed higher proteolytic activity at 4°C in comparison with that at 25°C. Also, bacterial 24 isolates and all eukaryotic isolates were not able to grow at 25°C indicating that they were proteolytic psychrophiles. Bacterial strain ANS4-1 identified as *Pseudomonas prosekii* showed the highest proteolytic activity at both 4 and 25°C among all the isolates. *Cryobacterium psychrophilum* strain ANH4-27 showed the highest proteolytic activity among the psychrophilic isolates. Interestingly, *Flavobacterium psychrolimnae* strain ANY4-14 showed much higher proteolytic activity at 4°C in comparison with that at 25°C even though this strain better grew at 25°C than 4°C.

These results expanded our knowledge about microbial diversity in Antarctic fresh water lakes and provide additional sources for cold-active proteases. Further study is needed in order to reveal the detailed characteristics of the isolates and their proteases.

## ***Kinetic profiles of molybdate-reducing enzyme from an Antarctic microbial isolate***

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An Antarctic bacterium capable of converting sodium molybdate to molybdenum blue has been isolated. The molybdate-reducing enzyme was partially purified using ion exchange and gel filtration chromatography. The optimal pH and temperature for activity are 6.0 and 20°C, respectively. Molybdate-reducing activities were up to 95% inhibited by metal ions such as cadmium, chromium, copper, silver, lead and mercury. In this work, kinetic profiles of the molybdate-reducing enzyme were studied. Initial rates against electron donor (NADH) substrate concentrations at 15mM phosphomolybdate were plotted and modelled. The Michaelis Menten's parameters ( $R^2 = 0.9927$ ),  $K_m$  and  $V_{max}$  of NADH are 0.4838 mM and 21.51 units/mg enzyme, respectively. The Hill's parameters ( $R^2 = 0.9927$ ) are 0.477 mM<sup>n</sup>, 21.44 units/mg enzyme and 1.008 for  $K$ ,  $V_{max}$  and  $n$ , respectively. Initial rates were also plotted and modelled against phosphomolybdate as the electron acceptor at 3mM NADH. The Michaelis Menten's parameters ( $R^2 = 0.9728$ ) are 5.347 mM and 64.04 units/mg enzyme for  $K_m$  and  $V_{max}$  values, respectively. The Hill's parameters ( $R^2 = 0.9919$ ) are 43.26 mM<sup>n</sup>, 53.72 units/mg enzyme and 2.341 for  $K$ ,  $V_{max}$  and  $n$  values, respectively. This suggests that the model shows atypical kinetic profiles, which possibly due to the simultaneous binding of multiple molecules within the active site of the enzyme.

## ***Malaysian expedition to the Antarctic Peninsula for the collection of algae***

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The Antarctic Peninsula is the only part of the Antarctic continent that extends outside the Antarctic Circle, stretching to approximately 2000 km long, from 75°S to 63°S. The Malaysian Scientific Expedition to Antarctica 2016 organized by the Sultan Mizan Antarctic Research Foundation (YPASM) has taken place from the 25th till 31st January 2016. The first author joined the expedition with the main aim of collecting samples for the isolation of algae. Soil samples were collected along the Antarctic Peninsula, starting from King George Island (62°S, 59°W) all the way down to Darboux Island (65°S, 64°W). The samples were collected at eight different latitudes along the Antarctic Peninsula, including Deception Island, a volcanic island. The collection sites include the coastline regions, exposed rocks, snow banks and moist soil. GPS coordination, temperature, PAR, UVA and UVB level were recorded at each site. A checklist of algal species will be compiled and presented. The algae collection will be useful for our ongoing research on the physiological and genomic responses of microalgae to climate changes across a global gradient.

## ***Metallomics of Psychrophilic Yeast *Glaciozyma Antarctica****

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Metal-ions are essential for life and therefore, systematic metal-homeostasis is important for cell to ensure sustainability while avoiding toxicity due to over-accumulation. With the rapid advancements in the genome sequencing techniques, development of bioinformatics tools have provided a prominent way for thorough genome study. This shed light for illustrating the metal-protein partnership that may not be observed during in vitro but are physiologically relevant. *Glaciozyma antarctica* PI12, a psychrophilic yeast (contains 7857 predicted genes) that isolated near Casey Station, Antarctica is our focus in this project. Using the query-ensembles collected from publicly available databases, general sequence-based predictive approaches were implied for preliminary identification of putative metal-binding proteins in the genome. Subsequently, functional domain screening and Gene Ontology (GO) terms assignment were performed for functional inferences of the protein sequences particularly related to metal-binding ability. Subcellular compartment location of the selected putative metal-binding proteins was predicted to locate their distribution in cell. We found that 26% of the proteins were putatively metal-bounded, with zinc-binding proteins were the most prevalence metal-type. Higher preferences for transition metals to be selected were noticed, while presence of metal-binding proteins was found spanning in almost all the cell compartments, as a consequence of their vast participation in the cellular system. This study is hope to assist the understanding on the partnership between environment and the cell's physiological system, especially for life in Antarctica that frequently reported to be exposed to severe threats from pollution associated with increase of human activity.

## ***Microbial oceanography of the different southern ocean water masses***

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The Southern Ocean plays an essential role in controlling atmospheric carbon dioxide level, capable of sequestering up to 40% of the global anthropogenic carbon dioxide via its biological carbon and solubility pumps. However, it is also particularly sensitive to climate change and the physical oceanic changes (i.e. shifting of the Antarctic Circumpolar Current) driven by global warming is likely to disturb the function of the biological pump and carbon dioxide uptake.

More importantly, marine microbes are key players of the biological nutrient pump, and form the base of marine food webs. The marine microbiome varies across the different water masses of the Southern Ocean, as separated not only latitudinally by the Southern Ocean circumpolar fronts but longitudinally as well. These water masses form regions with variable physicochemical characteristics such as temperature, density, salinity and nutrient content. The response of the Southern Ocean microbiome to any environmental shifts is thus likely to differ regionally. Much is still unknown about what regulates the microbial community structure, composition and their environmental role, of the vast Southern Ocean. Thus far there have been very few studies aimed towards understanding the microbial composition and dynamics due to harsh environmental conditions. There is a critical need for improved sampling resolution, geographical coverage and a better understanding of this to more accurately predict how the Earth's changing climate will alter the ocean microbiome and future carbon cycle.

Our study significantly expands the Southern Ocean microbial diversity database through metagenomic surveys targeting bacteria, archaea and eukaryotes sampled from 48 sites strategically situated to cover every degree south from Australia to Antarctica, and spanning all major Southern Ocean fronts and masses. This research will generate an extensive database of microbial diversity using high throughput tag sequencing of 16S rDNA bacterial, archaeal and 18S eukaryotic gene sequences. An established MOTHRU pipeline will be used correspondingly to establish the identity of the bacteria community and their relationship within the site of study. By combining molecular data analysis on microbial diversity and abundance in correlation with the physicochemical environmental analysis and satellite data, the key environmental parameters leading to any changes in the microbial community can be elucidated using statistical and visualization software. This will enable us to identify potential triggers for microbial community shifts and improve our knowledge of the microbial dynamics within the Southern Ocean. Identifying the main microbial lineages in the different Southern Ocean water masses and their relationships to the environmental variables influencing them will improve predictions of biological responses and carbon uptake towards future climate change in addition to paving the way for future research development directions.

## ***Novel actinobacterium strain S63 isolated from Signy, Antarctica***

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Signy Island, in the maritime Antarctic South Orkney Islands archipelago, provides a paradigmatic example of the region's terrestrial ecosystems. Recent studies of Antarctic soils using both culture-dependent and culture-independent approaches have shown that microbial life thrives despite the apparently extreme environmental pressures, hosting a far wider range of microbial, and especially prokaryotic, diversity than previously widely assumed. Culture-independent studies of various Antarctic microbial communities have shown a large proportion of their bacteria are previously unknown and are undescribed. Studies of soils obtained in recent years from Signy Island have yielded a number of novel bacteria, one of which is Actinobacterium strain S63. This was isolated from a soil sample obtained at Spindrift Col, and is a Gram-positive bacterium with a high G+C content (approx. 69.3%). 16S rRNA gene sequence analysis of this strain identified 97% similarity with Humibacillus xanthopallidus, the only described species of its genus. Here we describe and characterise strain S63 and provide a high quality draft of its genome sequence. The genome size was approximately 5.0 Mbp. The draft genome consists of 135 contigs and 125 scaffolds. Preliminary analysis has revealed the presence of genes coding for antifreeze proteins, consistent with adaptation to its harsh polar environment.

## ***Phylogenetic analysis and implications of microbial communities in deliquescent wet patches within Taylor valley, Antarctica***

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Ephemeral briny wet patches in Taylor Valley, Antarctica, created by deliquescence, offer dynamic and challenging environments for the bacteria and archaea that inhabit them. Deliquescence creates temporary briny wet patches by absorbing atmospheric moisture into highly saline soils beyond saturation. The high soil salinity also prevents the water from freezing. Deliquescence is largely believed to be responsible for wet patches also observed in certain Martian slopes and is commonly referred to as Recurring slope lineae (RSL). We performed targeted amplicon sequencing of environmental DNA recovered from soil samples taken from ephemeral wet patches in Taylor Valley, Antarctica. These microbial communities are composed of hundreds of genera of Bacteria and a few genera of Archaea. A significant proportion of the most enriched taxa in these temporary briny tracks are members of just a few genera in the bacterial Family Flavobacteriaceae, which are thought to be of marine origin. A preliminary phylogenetic analysis of the Family reveals that the taxa found in the wet patches are paraphyletic relative to other members of their clade. We hypothesize that their presence in these desert hillsides may reflect the legacy of marine inundation of Taylor Valley during sea level rise, followed by adaptations that facilitate survival in the extreme water track environment.

## ***Production of cold adapted hydrolytic enzyme from a polar microorganism***

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Industrial enzymes market is projected to grow at a very rapid rate. The rise in application scopes due to escalating innovation works is expected to increase enzymes demand and bring in more revenues. When the hydrolytic enzyme like lipase is found to have the ability to hydrolyse triacylglycerols and will be beneficial to various biotechnological approaches, the demands spike worldwide. In addition, a versatile enzyme that can work well in low temperature is also of massive interest. A psychrophilic microorganism isolated from Arctic soil tested positive as a lipase producer was studied. DNA extraction was conducted by modified CTAB method and 16S rRNA sequencing revealed its identity to be in close resemblance with *Pseudomonas* sp. The microorganism was found to be a psychrotolerant with growth temperature ranging from 4°C to 25+2°C. Lipase activity was detected using sensitive and specific plate assay using olive oil as substrate. Lipase gene was amplified by PCR method using specific set of primers that was designed to target the gene of interest. The amplified gene was cloned into *E.coli* JM109 and was found to be highly similar to the lipase gene of *Pseudomonas fluorescens* by sequencing. The lipase gene was sub-cloned into pCold I expression system for massive production of lipase for further purification and characterisation studies.



## ***Quantification of cold adapted lipase genes from Signy station, Antarctica via QPCR***

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Human activities in the polar regions utilize petroleum hydrocarbons as the main energy source for a large majority of operations. As a result of accidental spills and past disposal practices, petroleum contamination has occurred especially around settlements, including scientific bases on the Antarctic continent. The objective of the study was to obtain and characterize cold-adapted enzymes from Antarctic soil microbial isolates which are able to degrade such hydrocarbons. Quantitative real-time PCR was selected for the rapid and reliable quantification of cold-adapted lipase genes in positive hydrocarbon degrading soil bacteria obtained from Signy station (South Orkney Islands, maritime Antarctic). The study addresses questions including how widespread are the distributions of particular lipase genes, and their uniqueness to the Antarctic environment or other cold regions. The quantitative approach used enables prediction of the amounts of targeted lipase genes by comparison with recognized standards qPCR carried out after incubation of microbial cultures at 4°C identified every 12 hrs interval time. The standard curve produced was supported by a high value of 0.9999, confirming that minimal error occurred during the pipetting, dilution and reading of the plates. Quantification of the lipase gene based on the standard curve was in between the concentration of 6.92 RFU; recording a high amount at the first 12hrs. The qPCR study managed to prove the existence of a large number of bioremediative lipase genes exist in Signy isolate, where they occurred in high frequency

## ***Spatial diversity of glacier ice bacteria from King George Island (NW Antarctica)***

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The impact of glaciers retreat on the bacterial communities was investigated on various locations of King George Island (NW Antarctica). Sixteen ice samples were collected from glacier transects of Barton Peninsula, Weaver Peninsula and Potter Cove areas during ROICE 2015 field trip (February 2015) to KOPRI (South Korea) King Sejong Station. Melted ice samples were cultivated on 1 x R2B and 1:50 diluted media at 4°C and 15°C under stirring conditions showing variations of growth parameters. Inoculation of R2A medium with the resulted cultures led to isolation of 102 bacterial colonies. Scanning Electron Microscopy analysis of both microbial communities and isolated colonies showed different type of dominant bacteria for the edge and medial sectors of the glacier. Glacier.

Physicochemical geochemical parameters of melted ice samples were determined, indicating an extremely low mineral content, with average TDS values of about 15 mg L<sup>-1</sup>, and slightly alkaline pH values. As expected, the glacier ice is rather homogenous, belonging to Na-HCO<sub>3</sub> type, with higher calcium content in the vicinity of subglacier streams. All samples were characterized by a low organic carbon content. A general absence of nitrates and a high content of Cl<sup>-</sup> were observed, in addition to a relatively high trace elements content for the ice in contact with stream water at the edge of the glacier.

Genomic DNA was isolated in triplicate from all 18 ice samples, and the bacterial diversity screening by 16S rRNA partial gene sequencing using a MiSeq Illumina platform is currently under way for further correlation of the and analyzed in correlation with the physicochemical parameters and geochemistry of the glacier samples along the analyzed transects.

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## ***Stable Isotope Probing sheds light on the McMurdo Dry Valley soil food web***

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The soils of the McMurdo Dry Valleys (MDV), located in Southern Victoria Land, Antarctica, are a harsh terrestrial environment that is inhospitable to all but the hardiest of organisms. However, despite high pH, extremely low moisture, high salinity, minimal carbon sources and freezing temperatures there is a thriving microbial soil community. An unexpected diversity of microorganisms inhabits the soils - including viruses, archaea, and protists - although bacteria and microscopic metazoans have received the most attention. The metazoan diversity consists of a few species of nematodes, tardigrades and rotifers, and in highly productive areas (e.g. high moisture and organic carbon) mites and springtails. Currently, food web interactions are thought to be limited primarily to metazoan grazing of bacteria, though limited evidence suggests that under certain circumstances there may be horizontal predation at the higher (metazoan) trophic level. Recent work has begun to explore the diversity of protozoa in these valleys, organisms that play crucial roles in mobilization of nutrients and regulation of bacterial populations in virtually all ecosystems where they are found. Protozoa are microscopic eukaryotes that are almost always unicellular and mobile. In most ecosystems, they are the primary grazers of bacteria and serve as an important food source for meiofauna (e.g. nematodes). In this way, they form an important bridge between bacteria and metazoan grazers. However, their ecological role and position in the food web in the MDV is still largely a mystery. The sensitivity of polar regions, including the MDV, to predicted changes in global climate foreshadows major changes in soil community interactions. To better understand how sensitive the MDV soil food webs are to large scale disturbances like climate change, we need to first establish the system's food web dynamics. To investigate the role of protozoa in the MDV soil food webs, we incubated soil samples during the summer season of 2014-15 with the stable radioisotope Carbon-13. Preliminary results indicate that protozoa may be playing important roles in the dry valley system and that the food web there is potentially more complex than presumed. This complexity would have implications for community sensitivity and resilience, and would provide a foundation for important ecological investigations into how microbial trophic relationships respond as a whole to ecosystem-level disturbances.

# ***Taxonomic characterization and bio-potentials of bacteria and yeasts isolated from Nella Lake sediments, East Antarctica***

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Lake Nella is an ultra-oligotrophic lake located in the Broknes peninsula, Larsemann Hills region, East Antarctica. Bacterial and Yeast isolates were obtained from the sediment core samples cored up to a depth of 90 cm. The isolates were orange, yellow, cream and white in colour. Culturable bacterial and yeast diversity was studied using different sub-samples of sediment core. A total of 170 bacterial strains were isolated and based on 16S rRNA gene sequence analyses, the isolates could be categorised in to groups which representing different taxa belonging to Actinobacteria, Bacilli, Flavobacteria and Proteobacteria. Yeasts were grouped based on their cultural characteristics and carbon source utilization abilities. Sequence analysis of the ITS and D1/D2 domains identified the species as *Cryptococcus albidus*, *Cryptococcus antarcticus* and *Rhodotorula* sp.. The three *Rhodotorula* strains (Y-23, Y-36 and Y-37) have closest similarity with *Rhodotorula* sp. YSAR15 (GenBank: AM922292).

Physiological tests such as effect of temperature, pH and salinity (NaCl) on growth of the isolates were studied. All isolates grew at 4 to 22°C and good growth between pH 4 to 9. Carbon sources such as D-glucose, Sucrose, Raffinose, Dgluconate, D-ribose, DL-Lactate, Myoinositol, Maltose, Cellobiose, Mannitol, D galactose, L-rhamnose and L-arabinose were utilized by all the strains. D-xylose, Melezitose and D-glucuronate were utilized by all isolates except *Cryptococcus albidus* Y-34 while D-arabinose and Lactose were utilized by all except *Cryptococcus antarcticus* Y-33. Amongst the different isolates, the four *Cryptococcus* strains utilized about 18 to 20 while *Rhodotorula* utilized 21 to 24 of the total 25 carbon sources tested. Assimilation of the other carbon sources by the strains varied. All the cultures showed varying degree of growth in the presence of the different nitrogen sources tested.

Enzymatic screening of the isolates showed their ability to degrade complex macromolecules such as proteins, carbohydrates and lipids, indicating their probable ecological role. Esterase activity was observed in 7 strains while protease was observed in all. Urease activity was seen in all strains of *Rhodotorula* but in none of the strains of *Cryptococcus*. Only one isolate (*Cryptococcus albidus* Y-32) exhibited phosphatase activity.

The isolates were also subjected to antibiotic susceptibility testing using antifungal agents. Two clinically important classes of antimycotic drugs, the polyenes and the azoles were tested for their effect against the isolated Antarctic yeast strains. All isolates tested were sensitive to Amphotericin B and Nystatin antibiotics. Overall, the test demonstrates that the polyene class of antifungal antibiotics can more effectively control the growth of Antarctic yeast strains as compared to the azole class.

With best of our knowledge this is a first documentation of bacterial and yeast in the sediment cores of lake from the Broknes peninsula, Larsemann Hills region, East Antarctica.

# ***The study of anticancer properties of bioactive fractions produced by a novel Antarctica actinobacteria, barrientosiimonas humi***

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**Background:** Barrientosiimonas humi (B. humi) is a novel actinobacteria, which was discovered from the Antarctica soil (62° 24' 26.0" S 59° 44' 49.1" W), a poorly explored region on Earth. Novel actinobacteria are associated with high potency in producing novel bioactive compounds to treat various diseases. Most of the commercially available chemotherapeutic drugs such as bleomycin, daunorubicin and doxorubicin are isolated from soil Actinobacteria. Currently, searching for new and effective chemotherapeutic agents is an urgent medical need due to the problems of systemic toxicity and multidrug resistance in cancer. In previous study, the preliminary screening of the crude extracts of B. humi showed significant anticancer activities. Therefore, the fractionation of the active crude extract could pave a way for the isolation of active compounds with significant anticancer properties.

**Objective:** The aim of this study is to evaluate the anticancer effects of potential bioactive compounds produced by a novel actinobacteria, B. humi.

**Methodology:** The active crude ethyl acetate extract was first fractionated using radial chromatography which yielded 9 fractions. Each fraction was tested against human breast cancer cell line (MCF-7) and human prostate cancer cell line (PC-3) using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay with concentrations ranged from 0.04 mg/ml to 0.48 mg/ml. The cytotoxicity activity of each fraction was further confirmed using a Real Time Cellular Analysis (RTCA) system, a label-free assay which enables real time monitoring of cell viability. Toxicity assessment of the fractions was conducted using human embryonic kidney normal cell line (HEK-293). Doxorubicin was used as positive control and DMSO as solvent control. The inhibition concentration (IC<sub>50</sub>) which inhibits cell proliferation by 50% was calculated graphically using GraphPad Prism 5.0. All the data were analysed by one-way ANOVA, at significance level p<0.05.

**Results:** All the fractions inhibited cell growth of both cancer cell lines in a dose-dependent manners. Both MTT and Real Time Cellular Analysis assays showed comparable results. Three out of nine fractions exhibited significant (p<0.05) anticancer activities against MCF-7 (Fractions 4 and 5) and PC-3 (Fractions 5 and 6) cancer cell lines. Based on the result of toxicity assessment, all fractions were found to be non-toxic to the normal cell line.

**Conclusion:** The results suggest that this is the first report of the anticancer activities exhibited by the members of family Dermacoccaceae. Fractions 4, 5 and 6 were selected as the most promising active fractions for downstream applications.

## **S27. Impacts Of Environmental Changes On Antarctic Ecosystems And Biota**

### ***A conspicuous massive growth of benthic diatoms on benthic megafauna in Marian Cove, an Antarctic fjord on King George Island***

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We report a conspicuous benthic diatom bloom on an Antarctic fjord shallow seafloor, which has not been reported elsewhere in Antarctica. A thick and massive growth of benthic diatoms was covering or being entangled with a variety of common benthic megafauna such as stalked ascidians, sponges, tube-dwelling polychaetes, gastropods, bryozoans, and others. This finding is an outcome of recent investigations on benthic communities in Marian Cove, King George Island, where glacier retreat has been proceeding quickly for the past several decades. Dominance of benthic diatoms during the austral summer has been frequently reported in shallow Antarctic nearshore waters, which in turn indicates their potential as a primary food item for secondary producers living in this harsh environment. However, previous blooming records of the benthic diatoms were primarily based on data from water column samples. In this study, for the first time, we provide photographic images of the massive benthic diatom bloom on the shallow seafloor, including their megafaunal associations in Marian Cove. No reasonable explanation for this phenomenon has been postulated in the current literature, and we provide some perspective for this phenomenon in the context of climate-induced processes, such as glacier melting. Ongoing warming and consequent glacier melting are expected to proceed over the next decades or longer, particularly in the Antarctic Peninsula Region. Future studies are necessary to elucidate whether blooming of these benthic diatoms is attributable mainly to meltwater processes and if so, what the consequences of these blooms may be to the Antarctic fjord ecosystem. In addition, the tight association of the massive diatom bloom with the common megabenthic fauna, mostly filter feeders strongly indicates that benthic diatoms are of prime importance as the primary food source in the Antarctic fjord benthic food web. This speculation should be substantiated by analytical studies using trophic tracer (e.g., carbon and nitrogen stable isotopes or fatty acids) techniques. A preliminary analysis revealed that the massive blooms are likely mainly due to the chain-forming centric diatom *Paralia sulcata*. Knowledge on the diatom composition and the relative abundance should also be improved with refined taxonomy and quantitative analysis.

## ***Across the Antarctic Peninsula to the continent- microclimate characterisation of habitats of the lichen species *Usnea antarctica* and *U. lambii****

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The habitats of lichens can be described as micro niches. The colonisation sites of lichens are characterised by the environmental parameters of the microclimate. Because lichens are poikilohydric organisms water availability is the crucial parameter followed by air and substrate temperature as well as the parameters air humidity, light intensity and wind speed. The success of colonisation depends on the combination and range of sizes of these parameters. Conspicuously, several lichen species are able to establish at terrestrial habitats in a transect across the Antarctic Peninsula and a few even to the continent. Extensive microclimate measurements with a variety of lichen species have been carried out in the northern maritime Antarctic on Livingston Island, at Rothera and adjacent islands in the southern maritime Antarctic, at the southernmost maritime Antarctic in the south of Alexander Island and in North Victoria Land, continent. All environmental parameters mentioned above have been measured at the respective study sites. The study presented is limited to the two lichen species *Usnea antarctica* and *U. lambii* because of the enormous dataset concerning the additional investigated lichen species. The data clearly show the wide range how the respective sites – micro niches – of the lichen species are characterized by the environmental parameters. Additionally, the data give indications on adaptation strategies of the lichen species as well as the adaptive potential considering the respective environmental conditions. The knowledge will provide and support a baseline for the recognition and interpretation of the consequences of global change in future times.

## ***Assessing the relationship between sponge assemblages and canopy-forming algae in shallow-water rocky reefs in the Western Antarctic Peninsula***

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Sponges play important roles in community dynamics, as microhabitat providers and also positively influencing diversity and composition of Antarctic benthic communities. Recent evidence suggests their diversity and abundance in algae-dominated rocky reefs in the Western Antarctic Peninsula has been underestimated. This highlights that the existing knowledge on the diversity, abundance and distribution patterns of shallow-water sponges in vast zones of the Western Antarctic Peninsula is still incomplete. The long-term goal of this work is to evaluate the utility of sponge species as indicators environmental perturbation with Antarctic benthic communities. The objectives of this proposal, which are a step towards attaining the long-term goal, are to generate baseline data on the distribution of Antarctic sponge species and their microbial communities against which future temperature-induced changes can be assessed, and to undertake initial evaluations of the effect of temperature increases on the ecophysiological performance of Antarctic sponges. Permanent transects were placed at 4 sites around Doumer Island (64°52'24"S; 63°36'00"W), Palmer Archipelago, Antarctic Peninsula. A 30 m long transect was placed parallel to the shore at 10 and 20 m depth. Along each transect ten 0.25 m<sup>2</sup> photoquadrats were established and photographed during the austral summer. Species richness and percent cover of sponges and other organisms were estimated. In addition, the percent cover of settled sediment and bare rock and other variables including canopy cover, presence of predators and substrate type were also recorded. Water temperature and light intensity levels were recorded in situ by HOBO pendant temperature/light data loggers deployed in the proximity of the transects. Preliminary results confirms previous evidence suggesting the presence of diverse sponge assemblages in zones with higher coverage of canopy-forming algae (e.g. *Himantothallus grandifolius*), which suggest canopy-formers may play an important role facilitating sponge assemblages in shallow rocky reefs in the Western Antarctic Peninsula. It is possible algae may help maintain sponge diversity in highly disturbed areas; however, further studies are required to confirm this situation. Loss of species and shifts in dominance and community structure are signs of change in ecosystem behavior and identity; hence, it is important to improve our knowledge of current spatial and temporal patterns in shallow-water sponge assemblages and the factors affecting them. This type of knowledge will help our understanding of current patterns, which is essential for informing our ability to detect future changes in these communities resulting from increasing temperatures.



## ***Biogeochemical characteristics of hydrologically connected and isolated cryoconite holes in coastal Antarctica***

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Cryoconite holes in coastal ice sheets and glaciers play a significant role in the bio-geochemical cycles. Cryoconite hole systems may occur either in isolation or connected to hydrological systems. Ionic concentrations and microbial community of cryoconite samples from Larsemann Hills (LHS), central Dronning Maud Land (cDML) and Amery Ice Shelf (AIS) were studied. Since seasonal cycles of refreezing and melting do not affect the Cl<sup>-</sup> concentration as long as a cryoconite hole is hydrologically isolated, Cl<sup>-</sup> is considered as the conservative proxy that accumulates in the hole as the glacier melts. Cl<sup>-</sup> in the cryoconite holes at LHS (92.82 µgL<sup>-1</sup>), cDML (270.18 µgL<sup>-1</sup>) and AIS (1236.28 µgL<sup>-1</sup>) suggest that the cryoconite holes in LHS and cDML are hydrologically connected whereas they are hydrologically isolated in AIS. In all the three locations, they are influenced by the hills surrounding the cryoconite sites. Unlike AIS, cryoconite holes at LHS are located near the sea coast and at cDML, they are formed on blue ice region. Organic carbon is of great significance to global carbon dynamics. Carboxylate ions are significant contributors to Total Organic Carbon (TOC) and also contribute to the bio-geochemistry of the supra-glacial environment. In LHS and AIS surface snow, carboxylate ion like Acetate (Ac<sup>-</sup>), Formate (Fo<sup>-</sup>) and Oxalate (Oxy<sup>-</sup>) contribute between 1 and 19 % to the TOC. In the present study, carboxylate ion concentrations in the cryoconite holes in LHS (Ac<sup>-</sup> = 4.6µgL<sup>-1</sup> and Fo<sup>-</sup> = 2.2µgL<sup>-1</sup>) and cDML (Ac<sup>-</sup> = 9.7µgL<sup>-1</sup> and Fo<sup>-</sup> = 3.0µgL<sup>-1</sup>) were lower than their concentrations in surface snow. In contrast, at AIS, carboxylate ion concentrations in cryoconite holes (Ac<sup>-</sup> = 23.4µgL<sup>-1</sup> and Fo<sup>-</sup> = 25.9µgL<sup>-1</sup>) were found to be much higher than their values in surface snow. Similar trend was observed for major inorganic ions in the cryoconite holes and surface snow of these regions. However, microbial community was also found to be different in these hydrologically differentiated cryoconite holes. Hence, the biogeochemistry of these hydrologically differentiated cryoconite hole systems maybe different from each other but needs to be studied further.

## ***Biogeography of phytoplankton pigments around the tip of the Antarctic Peninsula***

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The ocean around the Antarctic Peninsula (AP) region is characterized by large spatial and seasonal/interannual variability in physical and chemical processes, which affect primary producers supporting aquatic food webs. However, the environmental drivers of changes in phytoplankton biomass and composition remain uncertain, especially when collinear variables are addressed. Hydrological profiles, dissolved nutrients and phytoplankton pigments were measured around the tip of the AP in late summer during five years (February/March 2008, 2009, 2010, 2013 and 2014), and analyzed using multivariate methods to assess the causative mechanisms controlling phytoplankton dynamics. Chlorophyll a (Chl a) and other phytoplankton pigments were determined by high performance liquid chromatography (HPLC). Since some carotenoids and chlorophylls can be used as taxonomic indicators of phytoplankton groups, HPLC pigment analysis allows the study of phytoplankton assemblage composition and structure. In addition, variations in the relative concentration of those pigments may be used as indicators of the physiological state of phytoplankton communities. A great spatial variability in Chl a was observed in the study area: highest levels in the vicinity of the James Ross Island (exceeding 7 mg m<sup>-3</sup> in 2009), intermediate values (0.5 to 2 mg m<sup>-3</sup>) in the Bransfield Strait, and low concentrations in the Weddell Sea and Drake Passage (below 0.5 mg m<sup>-3</sup>). Generally, water column structure was the most important environmental factor determining phytoplankton communities' biomass and distribution. This study highlights the usefulness of HPLC pigments as biotic indicators of phytoplankton changes in relation to environmental conditions in an overlooked region of the Southern Ocean, highly susceptible to global climate change.

# ***Changes in the composition, abundance and distribution of the vascular herbaceous vegetation of the Sierra de los Cuchumatanes, that already exists in the Antarctic and possible relation to climate change***

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This study was carried out in the highlands of the Cuchumatanes mountain range and in the Antarctic (King George Island and Robert Island). The objective of the same was to determine whether the composition, abundance and distribution of herbaceous vegetation from both ecosystems have been modified by potential climate effects. The design suggested by Cumes (1995) and Torres et al. (2011) was used; in addition, data on climate conditions shown in each region of the study was analyzed. For the Cuchumatanes mountain range, during the 1992-2012 period, it was determined that the average temperature increased by +1.16°C and that the average rainfall was reduced by 1.47%, compared with the 1971-1991 period. The species composition reported a significant difference ( $p = 0.036$ ). The average coverage for 2012 was of 9.47%, while the distribution determined that *Oreomyrrhis daucifolia*, *Cirsium* sp, *Alchemilla vulcanica*, *Helenium integrifolium*, *Werneria nubigena*, *Gnaphalium standleyi*, and *Helenia alata* remained within the normal distribution range, but its frequency has changed. For the Antarctic, during the 1992-2013 period, it was determined that there was an increase in the average temperature of +0.4°C and an increase in the availability of melt water, compared with the 1969-1991 period. The species composition has not changed; however, the average coverage has increased for *Deschampsia antarctica* by 1.32%, while for *Colobanthus quitensis*, in 2013, was 3%. In addition, five sites where the expansion pattern can be studied in the future were identified through the distribution. Finally, this study suggests that there have been changes in the vegetable producing communities due to climate changes; therefore, it is recommended to monitor the same to prove the hypothesis.

## ***Combined effects of temperature and ultraviolet radiation on the growth, pigmentation and oxidative stress response of polar and tropical Chlorella***

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Global climate warming and increased penetration of ultraviolet radiation (UVR) resulting from the thinning of ozone layers in the Antarctic has been shown to have an adverse impact on microalgae. The objective of the present study was to investigate the response of the green microalga *Chlorella*, isolated from the Antarctic and tropical regions, to the combined effects of temperature and UVR stress. Two tropical *Chlorella* (UMACC 001 and CHSS 26-2) and two polar *Chlorella* (UMACC 237 and UMACC 263) were grown at different temperatures and exposed to three light treatments, PAR+UVA, PAR+UVA+UVB and PAR alone for 4 days. The polar *Chlorella* were grown at 4, 14 and 20 °C while the tropical *Chlorella* were exposed to 28, 32 and 36°C. Growth response, photosynthetic pigment contents (chl-a, chl-b and carotenoids), reactive oxygen species (ROS) and lipid peroxidation levels of *Chlorella* isolates were assessed. Results showed that no marked effect of UVA in all the *Chlorella* isolates at different temperatures. However, the polar and tropical *Chlorella* showed different trends in terms of photosynthetic pigments and oxidative stress response when subjected to the combined effects of UVB and temperature stress. At 36°C, the tropical *Chlorella* CHSS 26-2 produced more chl-a under UVB treatment as compared to PAR alone, indicating that the algal is adapted to higher temperature with UVB stress. The ROS and lipid peroxidation levels in the polar *Chlorella* were higher than tropical *Chlorella* when subjected to UVB at high temperatures.

## ***Continuous Measurement of CO<sub>2</sub> Flux from Dry Valley Soils: Determining Its Source and Environmental Controls***

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Soils within the McMurdo Dry Valleys are known to exhibit carbon dioxide (CO<sub>2</sub>) flux, but the extent to which biological activities contribute to this flux is increasingly questioned, and its observed temporal variability does not appear to conform to expectations based on any single biotic or abiotic mechanism. As a result, little is known regarding how seasonal and environmental drivers exert influence on the temporal dynamics of CO<sub>2</sub> flux in Dry Valley soils.

Building on a continuous CO<sub>2</sub> monitoring station that had collected flux records over three full annual cycles, our research team deployed a fully automated CO<sub>2</sub> surface flux and depth concentration monitoring system near Spaulding Pond in Taylor Valley. From the data it collected, we observed marked diel variability in CO<sub>2</sub> concentrations within the soil profile (~100 ppm CO<sub>2</sub> above or below atmospheric). The concentration pattern observed at multiple depths suggested an alternating daily transition from source to sink correlated with temperature-driven changes in the solubility of CO<sub>2</sub> in water films. The temperature dependence and magnitude of CO<sub>2</sub> flux into and out of soil water films was confirmed by a controlled laboratory experiment. These results confirm a CO<sub>2</sub> solution storage flux previously proposed by our research team.

Disentangling biotic from abiotic sources of CO<sub>2</sub> in Dry Valley soils may be achieved using stable isotope tracers (<sup>13</sup>C vs <sup>12</sup>C), and characterization of isotopic signals of CO<sub>2</sub> dissolution and exsolution has been carried out to distinguish fluxes derived from these geochemical processes from heterotrophic respiration. The results reveal potential cryptic processors or sources at play that greatly complicates the application of soil CO<sub>2</sub> flux as a proxy for microbial biomass in Dry Valley soils.

## ***Diatom distributions delineated by lipid, genomic and microscopic observations: the imprint of past summer sea ice extent.***

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In 2014 the RVIB Nathaniel B. Palmer was used to undertake a US-led voyage focused on a geological and oceanographic survey of the George V and Sabrina coastlines with respect to the history of the East Antarctic glacial ice drainage basins (NBP14-02). During this voyage biological survey work was undertaken to broaden methodological applications of the phytoplankton community beyond microscopic observations in an attempt to help with providing ground-truth data for both modern biological distributions and palaeo-oceanographic interpretations. Surface water, sampled and concentrated from the ship's intake line, was filtered for algal lipid (isoprenoid) and genomic analysis. Preliminary results from all three applications are presented and considered across the sampling locations ranging from the permanently open ocean zone (POOZ) with no seasonal sea-ice cover, the near-shore summer sea ice zone (SIZ), where sea ice remains long into the summer melt season, and the marginal ice zone (MIZ), located between the POOZ and the SIZ, and with a highly variable latitudinal sea-ice edge throughout the season.

Highly branched isoprenoids and fatty acids were identified in the surface waters with concentrations varying in some cases distinctly across the survey transect in relation to winter and summer sea ice extents of the preceding season. Microscopic and genomic analyses of the diatom (18S rDNA) communities indicate that similarly variable community distributions occur in tandem to the lipid analyses. This on-going research under-pins the hypothesis that specific diatoms are suspected of producing different lipids (specifically trienes and dienes), associated with diatoms growing in/under sea ice or associated with diatoms growing in Antarctic waters when sea ice clears. The implications of ground-truthing the diatom to lipid associations in this study will mean that HBI biomarkers will be the first reliable proxy for Antarctic summer sea-ice coverage going back 1,000s to 1,000,000s of years.

## ***Ecological research of James Ross Island. Ecosystem components-based approach to study structure and function of Antarctic vegetation oases.***

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Long-term research of structure and function of Antarctic terrestrial ecosystems has been carried out on northern part of James Ross Island (JRI) by Czech scientists since 2007. In this contribution, results of both long-term studies and latest achievements of 2016 Czech Antarctic Expeditions are presented. Long-term ecological projects focus Climatology, Glaciers and permafrost, Hydrology and limnology, Terrestrial Biology, Environmental Science, and Medical Science. Main results are related to changes in climate characteristics on a local scale and their reflection in glacier mass dynamics and active layer of permafrost variation. Measurements of permafrost depth along a 6-km-long profile and on permanent research plots was done repeatedly using a probe approach. Soil samples in vertical profile of some probes were taken for analyses of grain structure and mass/volume soil characteristics. Recently a 6-m-deep drill was done into a permafrost to install temperature sensors for a long-term monitoring of temperature profile. Since JRI has a large deglaciated area, a great variety of biotops exhibiting, thank to different water availability during vegetation season, different stages of colonization are available for detailed biological studies. From samples collected within last several years, a great number of autotrophs (diatoms, algae, cyanobacteria) are reported as well as some heterotrophs, including new-for-science bacteria *Pseudomonas prosekii*, *P. gregormendelii*. Recently, a great attention is devoted to seal carcasses found at JRI (altitude up to 200 m a.s.l.) in great numbers. They serve as nutrient sources available for growth and development of several communities. Colonization of seal carcasses by lichens, mosses and other autotrophic organisms was studied as a species richness appearing in a close neighborhood of the carcasses. It was found that species richness is dependent on liquid water availability and stage of disintegration of seal remnants. The study still continues since many of organisms isolated from the samples and cultivated on agars recently should be determined and analysed using biochemical and molecular biological tools. Special stress-physiology studies are performed under laboratory conditions in order to address a range of tolerance of selected organisms (*Xanthoria elegans*, *Usnea antarctica*, *Nostoc commune*, *Zygnema* sp.) to individual stress factors. In Jan-Feb 2016, vegetation cover and microclimate in 12 open to chambers, located in 3 contrasting localities of JRI, were investigated. Photosynthesis performance of *Bryum* sp. was evaluated by effective quantum yield of PS II using field installations of fluorometers. Similar ecophysiological approach was applied to small-area freshwater ponds. Using a field system comprising of oxygen electrodes, thermocouples, PAR sensors, and data loggers, in situ long-term monitoring of dissolved oxygen concentration (DOC) was carried out in 2 selected ponds. Since 2012, heavy metal contents, mercury in particular, have been studied using the samples collected from different JRI ecosystems. In Jan-Feb 2016, a great number of samples from lakes, ponds, streams, soils, sediments, and lichens were collected. They comprised samples of soil, mosses and microbiological mats, seepages, wet rock walls, cryoconites. They were taken to the laboratories in Brno so that biodiversity of Antarctic terrestrial diatoms, algae, cyanobacteria, and soil nematodes of JRI could be estimated.

## ***Effects of ultraviolet irradiation in pteropods, chaetognaths and salps in Admiralty bay, King George island, Antarctica (summer 2009/2010)***

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The objective of this study was to evaluate the influence of the ultraviolet irradiation on the zooplankton density in shallow Antarctic waters of Admiralty Bay, King George Island. During the summer of 2009/2010 seven samples were effected (4 in December/2009 and 3 in February/2010) in 5 points: Comandante Ferraz (CF: 62°05'13,0"S; 058°23'10,5"W), Botany Point (BP: 62°05'45,9"S; 058°20'09,5"W), Machu Picchu (MP: 62°05'31,5"S; 058°27'44,8"W), Thomas Point (PT: 62°09'14,8"S; 058°29'06,3"W), Arctowski (AR: 62°09'16,3"S; 058°27'37,9"W). In each point three 5 minutes oblique tows from the bottom (15-30 m) to the water surface were made with a conical net (mesh size 150 µm), equipped with a flowmeter. For this analysis monthly values of the intensities of radiation Lyman-alpha (121.6 nm) as proxy to evaluate the intensity of the radiation UV-B (290-320 nm) that reaches the Earth was considered. The data of air temperature and of the pressure at sea level (SLP) were obtained from the National Institute of Space Researches (Instituto Nacional de Pesquisas Espaciais - INPE). One hundred and five samples were collected and a total of 20 pteropods, 51 chaetognaths and 132 salps were sorted, with mean density of 0.29 (± 0.83), 1.49 (± 3.27) and 15.42 (± 120.39) individuals.100m<sup>-3</sup>, respectively. Significant differences (p<0.50) were observed between December/2009 and February/2010 for pteropods densities (p=0.02) and salps (p=0.43). The air mean temperature decreased from 0.9°C in December/2009 to 0.2°C in February/2010, in the same way the mean density of salps (21.46 individuals.100m<sup>-3</sup> in December/2009 to 4.35 individuals.100m<sup>-3</sup> in February/2010) and chaetognaths (1.75 to 1.02 individuals.100m<sup>-3</sup>). For SLP was observed an increase of the average of 990.0 hPA in December/2009 to 993.5 hPA in February/2010. Similar to the increase observed for UV-B irradiation (3.57x10<sup>11</sup>fotons.cm<sup>-2</sup>.s<sup>-1</sup> in December/2009 and 3.71x10<sup>11</sup>fotons.cm<sup>-2</sup>.s<sup>-1</sup> in February/2010) and increased in the mean density of pteropods (0.17 to 0.50 individuals.100m<sup>-3</sup>) was observed in the same period. These data can indicate the influence of the meteorological parameters evaluated with the variation of holoplanktonic organisms from the water surface to 30m depth.

Key words: UV-B, holoplanktonic, meteorological parameters, South Shetland Islands.



# ***From pole to pole: The potential for the Arctic seastar *Asterias amurensis* to invade a warming Southern Ocean***

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Due to climatic warming, *Asterias amurensis*, a keystone boreal predatory seastar that has established extensive invasive populations in southern Australia, is a potential high-risk invader of the sub-Antarctic and Antarctic. To assess the potential range expansion of *A. amurensis* to the Southern Ocean as it warms, we investigated the bioclimatic envelope of the adult and larval life stages. We analysed the distribution of adult *A. amurensis* with respect to present day and future climate scenarios using habitat temperature data to construct species distribution models (SDM). To integrate the physiological response of the dispersive phase we determined the thermal envelope of larval development to assess their performance in present day and future thermal regimes and the potential for success of *A. amurensis* in poleward latitudes. The SDM indicated that the thermal 'niche' of the adult stage correlates with a 0-17 °C and 1-22.5 °C range, in winter and summer, respectively. As the ocean warms the range of *A. amurensis* in Australia will contract, while more southern latitudes will have conditions favorable for range expansion. Successful fertilisation occurred from 3-23.8 °C. By day 12, development to the early larval stage was successful from 5.5-18 °C. Although embryos were able to reach the blastula stage at 2 °C, they had arrested development and high mortality. The optimal thermal range for survival of pelagic stages was 3.5-19.2 °C with a lower and upper critical limit of 2.6 °C and 20.3 °C, respectively. Our data predict that *A. amurensis* faces demise in its current invasive range while more favourable conditions at higher latitudes would facilitate invasion of both larval and adult stages to the Southern Ocean. Our results show that vigilance is needed to reduce the risk that this ecologically important Arctic carnivore may invade the Southern Ocean and Antarctica.

## ***Glacier retreat and its consequences to coastal benthic ecosystems.***

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The Antarctic Peninsula (PA) has lost almost 24 000 km<sup>2</sup> of sea bed ice coverage in the last decades due to its rapid warming. This process can produce two-fold effects, on one side driving hydrological modifications on coastal regimes that could affect established communities and on the other hand opening new areas available for primary production and benthic colonization. These in turn can produce positive and negative feed-backs on climatic change by enhancing or reducing the change rate. Coastal benthic ecosystems along the PA are characterized by high diversities, abundances and biomasses, which can therefore play an important role in Carbon sequestration. Thus, when benthic assemblages are affected positive feedback could be expected and when favored increased Carbon sink could drive to negative feedback. Potter Cove (PC), South Shetland Islands, offered an excellent opportunity to asses both effects due to the retreat of the glacier that surrounds the cove and a long term monitoring program that allowed the establishment of baselines against which to compare changes. We recently reported a sudden shift in benthic communities structure related to increased sedimentation rates driven by the glacier retreat. This highlighted the potential role of sedimentation in driving major changes in coastal communities, especially in fjords systems, and also suggested the possibility of thresholds in environmental factors. This could be important in communities dynamics since gradual changes in environmental variables could not drive responses until the threshold is surpassed and trigger major shifts that could also be difficult to reverse. In this case sedimentation can affect benthic functioning and biomass reducing the potential Carbon sequestration of the system. On the other hand the glacier retirement also opened newly ice-free areas, including a new island. We could sample benthic communities after around six years of being free of ice and found a surprising assemblage characterized by high diversity, species richness, abundances, biomasses and a complex three dimensional structure. Ash-free dry mass was almost 850 g m<sup>2</sup> more than an order of magnitude of the estimated mean in Antarctic shelves and even more than that expected in early successional stages. The finding of such developed assemblage in a new island, challenge the current prevailing image of slow colonization of Antarctic benthos and also opens the question of whether these assemblages could develop under glaciers in ice refuges. But also suggest that the negative feedback to climatic change in newly ice free areas could be more important than previously thought. These processes, i.e. environmental shifts that threaten coastal ecosystems and the opening of new areas available for colonization that could take place at previously unthought velocity could be especially intense in fjords along the AP. Since almost 90 % of the glaciers in the AP are in retreat these results acquire a high relevance.

## ***Implementing species distribution models for exotic springtail species in Antarctica: an unexplored tool to assess invasion risk***

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Invasive species are one of the most important threats to Antarctic terrestrial biodiversity. At least four exotic species of springtails (Collembola) have been found in this continent, but their spatial distributions, potential geographical expansion and effects on native species remain largely unknown. While Species Distribution Models (SDMs) are a useful tool to assess the suitability of non-occupied areas to invasive species, they have been rarely applied in Antarctica. Perhaps one of the major challenges to produce SDMs in this continent is the paucity (or lack) of environmental layers to parameterize the models. We have overcome this limitation by generating a set of 19 bioclimatic variables from global temperature and specific humidity MERRA-based satellite data at different spatial resolutions (30 seconds, 2.5 minutes, 5 minutes and 10 minutes). Using global occurrence data for those springtail species that have been recorded as exotic in Antarctica, we implemented nine presence-only (and pseudo-absence) modelling algorithms to better understand their geographic distributions and range dynamics in this continent. Our results show that only small areas of maritime Antarctica offer similar climatic conditions to those found in other parts of the world where these invasive springtails occur. Despite minor differences between algorithms, SDMs provide spatially congruent responses on the location of areas with the highest risk for the establishment and geographical spread of these invasive species.

## ***Microalgae diversity along an Antarctic glacier forefield***

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Glacier retreat due to global warming has been observed in all the cryosphere, systematically exposing new terrestrial ecosystems that had previously been covered by ice. Primary succession, i.e. the assembly of microbiological communities on newly exposed habitats, can be studied along glacier forefields, where distance from the glacier terminus is used as a proxy for time since deglaciation. The study of microbial succession is still at its infancy, but understanding the relationships between microbial communities and soil development will provide us with crucial knowledge on how they influence and respond to changes in environmental conditions. In the present study, we investigated the structure of microalgal communities along a deglaciation gradient in the forefield of Collins Glacier (Fildes Peninsula, King George Island, Maritime Antarctica). A total of 12 surface soil samples have been analyzed so far, covering a time period of ca. 8000 years of glacier retreat. Plastid and cyanobacterial 16S rRNA gene sequences were obtained by 454 pyrosequencing and photosynthetic/photoprotective pigments were assessed by HPLC. A total of 103,346 16S rRNA gene sequences were obtained for the 12 samples, which were clustered into 199 OTUs at 97.5% similarity. From these, 58 OTUs (29.1%) belonged to plastid sequences of green algae (Chlorophyta), heterokonts (Stramenopiles) as well as Streptophyta. The remaining 141 OTUs (70.9%) were assigned to cyanobacteria from the orders Nostocales, Chroococcales, Oscillatoriales, Pseudanabaenales and Synechococcales. Pigment analysis of the microalgal communities by HPLC are being currently carried out. Further multivariate analysis of the molecular and pigment data will allow us to assess the major microbial drivers of soil development along the deglaciation chronosequence. The study of microbial succession in high-latitudes ecosystems is of special interest, where the effect of global warming on microbial processes is expected to be the highest.

## ***Miming global warming. A transcriptomic study to explore how *Colobanthus quitensis* (Kunth) Bartl. defend itself from heat stress***

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Over the past 50 years, the west coast of the Antarctic Peninsula has been one of the most rapidly warming parts of the planet with significant impact on its physical and living environment. In particular, since its biota lives often at the physiological limits, also a small climate change may induce relevant alterations in the physiology, productivity and growth of the living organisms. Studying the effect of climate change on Antarctic biota is important because it enables scientists to predict more accurately future climate change monitoring specific molecular biomarkers of global warming. To date the maritime Antarctic ecosystems host two species of flowering plants: the Antarctic hairgrass *Deschampsia antarctica* Desv. (Poaceae) and the Antarctic pearlwort *Colobanthus quitensis* (Kunth) Bartl. (Caryophyllaceae). In this work, *C. quitensis* was chosen as a model plant to assess the molecular basis of adaptation to low temperatures as well as its ability to respond to climate warming. In a field experiment, carried out near Arctowski Polish station (King George Island - Antarctica Marittima 62° 14'S, 58° 48'W), several *C. quitensis* individuals were grown for one year inside small greenhouses open on the top, namely Open Top Chambers (OTCs), which determine an increase of about 4 °C in the internal temperature during midday, miming the effect of global warming. Samples of plants grown both under heat stress (inside OTCs) or natural conditions (outside OTCs) were subjected to transcriptome analysis, to get a complete overview of the physiological traits altered by heating. The RNA sequencing led to the de novo assembly of 165508 coding sequences which were aligned to the NCBI Viridiplantae Database using the BLASTn tool. This analysis led to the identification of 96163 (58.1%) genes and about 33% of them could be assigned with a best score to the sequences from *Ricinus communis*. Differential gene expression between the plant samples grown inside and outside OTCs was quantified using the RPKM (Reads Per Kilobase per Million mapped reads) values. Interestingly, 78775 out of 96163 identified genes were found to be under-expressed and only 17388 over-expressed in the samples grown inside OTCs with respect to those grown outside, highlighting that higher temperatures induce a general repression of gene expression.

To identify functional categories, all the best BLAST hits were analysed with the Gene Ontology (GO) Software Blast2GO. In total, 48448 (50.4%) genes could be assigned to gene ontology classes. The most represented GO groups were metabolic process and cellular process in the Biological Process category, and catalytic activity and binding in the Metabolic Function category. To further gain insights into the biological functions and interactions of our genes, a pathway based analysis was performed in the Kyoto Encyclopedia of Genes and Genomes (KEGG) Pathway database leading to mapping about 28000 (29%) genes in 138 KEGG pathways.

## ***Modelling abiotic Antarctic soil CO<sub>2</sub> fluxes***

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Fluxes of CO<sub>2</sub> from Antarctic soils have been used to infer rates of heterotrophic respiration and biological activity. However, recent work has shown that fluxes likely comprise a significant abiotic component due to temperature-related changes in CO<sub>2</sub> solubility in alkaline soil solution. Discriminating biotic and abiotic components remains an important challenge if soil respiration is to fulfil its potential for monitoring soil microbial activity and soil carbon dynamics in a changing Antarctic terrestrial environment. We compare results from a mechanistic model of Antarctic abiotic soil CO<sub>2</sub> dynamics with empirical data from an in situ subsoil and surface respiration monitoring programme carried out in Taylor Valley in the summer of 2013/14. The model also predicts changes in the isotopic composition of subsoil CO<sub>2</sub> and surface CO<sub>2</sub> flux.

The model, when driven by sinusoidally varying surface and subsurface temperatures similar to that observed at the study site, produces CO<sub>2</sub> flux and subsurface concentrations qualitatively and quantitatively similar to the empirical data. At least over the period of monitoring, it is impossible on the basis of comparison, to unequivocally identify a source of CO<sub>2</sub> related to heterotrophic respiration. Model results for C isotopic composition of the surface flux demonstrate extreme variations of δ<sup>13</sup>C that are unrelated to CO<sub>2</sub> source signatures; rather, these extreme shifts are due to dynamic fractionation effects arising from shifting soil CO<sub>2</sub> concentration gradients and contrasting diffusivities of the <sup>13</sup>CO<sub>2</sub> and <sup>12</sup>CO<sub>2</sub> isotopologues.

The model provides an envelope of soil behaviour with respect to concentration and δ<sup>13</sup>CO<sub>2</sub> of subsurface soil CO<sub>2</sub> and surface fluxes that can be used, with simple parameterisation, to identify fluxes of likely biological origin. The model assumes equilibrium isotopic fractionation between CO<sub>2</sub> in the soil atmosphere and soil solution. We also present results from an experiment aimed at testing this assumption in light of reports of kinetic fractionation affecting CO<sub>2</sub> dissolution in alkaline solutions.

## ***Monitoring lichen and moss activity at subzero temperatures using chlorophyll fluorescence.***

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Lichens and mosses are poikilohydric meaning that they are only active when hydrated. It is known that environmental conditions when these organisms are active can be very different from the general climate that is reported in standard meteorological data. It is important if one is to look at potential adaptation and/or acclimation in lichens and mosses to know when, and under what conditions, these organisms are active. Chlorophyll fluorometers are the instrument of choice to make this assessment and versions are being developed that can monitor sample activity semi-continuously together with concurrent light and temperature. We report here about a MoniDA system that was installed outside Scott Base in January 2016 and has been reporting fluorescence and environmental data by satellite communication since then. This short data set has revealed several potential problems in interpreting chlorophyll fluorescence from lichens and mosses at sub-zero temperatures. Most important is a clear down-regulation of both basal and maximal fluorescence at temperatures below about 0°C. The underlying mechanism for this is not known. This phenomenon together with the falling basal fluorescence signal should be taken into account when interpreting the recorded data. The lichens and mosses appear to be active for long periods at sub-zero temperatures and this contrasts with published results from the Dry Valleys. It is known that soil becomes the preferred habitat for lichens in extreme habitats such as the Darwin area and the monitoring data suggests that the habitat water status is much better than the more normal rock surface habitats. The results confirm that the fluorescence systems can successfully operate under these extreme conditions.

## ***Non-Antarctic notothenioids: Past phylogenetic history and contemporary phylogeographic implications in the face of environmental changes***

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The non-Antarctic Notothenioidei families, Bovichtidae, Pseudaphritidae and Eleginopsidae, diverged early from the main notothenioid lineage. They are important in clarifying the early evolutionary processes that triggered notothenioid evolution in the Antarctic. The early-diverged group represents 8% of all notothenioid species and never established themselves on the Antarctic shelf. Most attention has been paid to the Antarctic notothenioids and their limited physiological tolerance to climate change and increased temperatures. In this review, we discuss key life history traits that are characteristic of the non-Antarctic early-diverged notothenioid taxa as well as the genetic resources and population differentiation information available for this group. We emphasise the population fitness and dynamics of these species and indicate how resource management and conservation of the group can be strengthened through an integrative approach. Both Antarctic waters and the non-Antarctic regions face rapid temperature rises combined with strong anthropogenic exploitation. While it is expected that early-diverged notothenioid species may have physiological advantages over high Antarctic species, it is difficult to predict how climate changes might alter the geographic range, behaviour, phenology and ultimately genetic variability of these species. It is possible, however, that their high degree of endemism and dependence on local environmental specificities to complete their life cycles might enhance their vulnerability.



## ***Photosynthetic performance and genomic response of Chlorella species from different origins, to ultraviolet radiation (UVR)***

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Changes in photosynthetic efficiency and heat dissipation can be used as early stress indicators in phototrophs. The primary objective of the study was to investigate the photosynthetic and genomic responses of *Chlorella* sp. isolated from different geographical regions (Antarctic *Chlorella* UMACC 237, Arctic *Chlorella* UMACC 263, temperate *Chlorella* UMACC 248, tropical *Chlorella* UMACC 001) to ultraviolet radiation (UVR) stress.

Three light treatments were used in a continuous six hour duration: (i) PAR (control), (ii) PAR+UVA (UVA stress) and (iii) PAR+UVA+UVB (UVB stress). Chlorophyll fluorescence measured by Pulse-Amplitude Modulation Fluorometer (PAM) was used to determine the photosynthetic performance of *Chlorella* sp. Parameters such as maximum quantum yield ( $F_v/F_m$ ), photosynthetic efficiency ( $\alpha$ ), relative maximum electron transport rate (rETR<sub>m</sub>) and photoadaptive index ( $E_k$ ) were determined from rapid light curves. UVB radiation caused significant stress as compared to the UVA-treated and the controlled samples.

DNA mutation can be assessed via the Random Amplified Polymorphic DNA (RAPD) analysis which detects genetic variation ranging from changes in a single nucleotide to complex chromosomal rearrangements, by comparing the amplification products generated from the control (untreated sample) and treated samples. For the genomic response study, RAPD was conducted in this study to identify the change in nucleotide sequence between the controlled sample and the samples subjected to UVB and UVA treatments. RAPD analysis revealed DNA mutation caused by both UVA and UVB treatments in all strains.

## ***Photosynthetic response of sea ice microalgae (*Navicula directa* and *Navicula glaciei*) to changes in CO<sub>2</sub>.***

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Sea-ice algae, occupying the bottom and in sea ice and brine channels provide notably to the primary production in ice-covered polar areas and provide a substantial carbon source to higher trophic levels. Here we aim to compare photosynthetic response toward changes in CO<sub>2</sub> and pH of two sea ice microalgae, *Navicula directa* and *Navicula glaciei*. To investigate how elevated CO<sub>2</sub> levels affects the photosynthetic activities; the Pulse Amplitude Modulation (PAM) were used. The ability of sea ice algae to grow and photosynthesis within physio-chemical gradient in the sea ice suggests that both algae are well adapted to cope with changes in pCO<sub>2</sub> concentrations. Lower pH and higher pCO<sub>2</sub> resulted in higher biomass till day seven especially for *Navicula directa* and by comparison to the controlled samples. However, decline in photosynthetic capacity were seen for both species, especially Maximum relative electron transport rate (rETR<sub>max</sub>) values (highest value 11.375±0.163: control sample and 8.322±1.282: Treatment) however, *Navicula glaciei* showed significant effects on its photosynthetic response by comparison to *Navicula directa* when exposed to elevated CO<sub>2</sub>. Changes in CO<sub>2</sub> and pH may therefore not affect the diatom as such, but may lead to changes in the photosynthetic activities in some species.

## ***Predictions of macroalgae habitat shifts due to climate change impact in an Antarctic Peninsula fjord***

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Macroalgae are (among) the major primary producers in West Antarctic coastal environments and respond highly sensitive to environmental factors such as light conditions. In Potter Cove, King George Island (Isla 25 de Mayo), Antarctica, suspended particulate matter (SPM) from glacial melting leads to shading of photosynthetic light during the summer growth season, with predictable effects on macroalgal bed extension on newly ice-free areas inside the cove. The R-package `biomod2` includes 10 different species distribution models (SDM) and 10 different evaluation methods to predict species or community occurrence based on statistical relationships with environmental conditions. In this study, we applied `biomod2` to macroalgae presence and absence data to test the suitability of SDMs and to assess the environmental response of macroalgae to glacial retreat. Four different scenarios of distribution shifts were modeled assuming different SPM conditions for varying climate change scenarios. According to the averaged evaluation scores of relative operating characteristics (ROC) and true scale statistics (TSS) by the models applied, those methods based on a multitude of decision trees such as Random Forest and Classification Tree Analysis, reached the highest predictive ability followed by generalized boosted models (GBM) and maximum-entropy approaches (MAXENT). The final ensemble model (EM) used 135 of 200 calculated models (TSS > 0.7) and identified hard substrate and SPM as the best predictors explaining more than 60 % of the distribution. These variables were followed by distance to glacier, total organic carbon (TOC), bathymetry and slope. The modeled present status of macroalgae spatial distribution in this study results in only 18.25 % of visually estimated areas colonized by macroalgae in Potter Cove. We coupled the EM with changing SPM conditions representing an increase of melt water input to model the light condition niche of macroalgae in Potter Cove and its potential response to projected climate change. Under the climate change scenario of 25% increasing SPM the suitability for macroalgae may decrease up to 38%. Reduction in light condition suitability will be most severe in biodiversity hotspots such as polar shelf areas. Our results identify hotspots for macroalgae under climate change. The change in their habitats and accompanying biodiversity also could serve for posing challenges to conservation actions.

## ***Research initiative of Kopri on ecosystem responses to climate change in the northern Victoria Land Coast***

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Korea Polar Research Institute (KOPRI) is planning a research project to promote scientific investigation on the Ecosystem Responses to Climate Change in the Northern Victoria Land Coast (NBLC). Although some ecological studies were carried out in this area for a past few decades, there are few implementing comprehensive long-term ecological monitoring program owing to the inaccessibility. In 2014, Korean Antarctic Research Station 'Jangbogo' opened in the middle of the Victoria Land coast. KOPRI is constructing the research infrastructure based on Jangbogo Station and icebreaking research vessel ARAON to conduct a comprehensive monitoring in the NBLC. Our research project will be focused on the interactions among ecosystem components, climate change and environmental factors. We are planning the studies of the spatial distribution of marine organisms and biological diversity by using ARAON in the Ross Sea. To provide information about the effects of environmental change on ecosystem we will investigate the breeding biology and population dynamics of the Adelie penguin which is one of the krill-dependent species.

# ***Response of megafaunal and macrofaunal benthos to collapse of the Larsen A Ice Shelf along the Antarctic Peninsula***

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Regional climate warming has led to the disintegration of the Larsen A Ice Shelf in the Weddell Sea, with a series of breakup events over several decades culminating with a final ice-shelf collapse in 1995. The extreme marine ecological change from an ice-shelf-covered, oligotrophic pelagic ecosystem to a seasonal sea-ice zone with annual phytoplankton blooms is expected to have caused dramatic changes in export flux to the seafloor, altering benthic community structure and function on the underlying deep continental shelf. The sequential breakout of large chunks of the Larsen A Ice Shelf over decadal time scales has allowed us to study Antarctic benthic community response to ice-shelf loss over different time scales, specifically by evaluating the benthic ecosystem at sites exposed for 15, 17, 44, 60 and >170 years since ice-shelf breakout. As part of the LARISSA Project, we are studying benthic ecosystem response to ice-shelf loss along this temporal shelf-collapse gradient by evaluating megafaunal and macrofaunal abundance, community structure, species diversity, and food-web structure, based on yoyo-camera surveys, trawl sampling, megacore sampling and stable-isotope analyses. We find substantial differences in mega- and macrofaunal species richness, evenness and community structure along the transect, with megafaunal richness and evenness higher at the stations ice-free for longer periods of time. Furthermore, these stations had relatively higher abundance of sessile forms, while stations exposed more recently were dominated by mobile benthos. In contrast, no monotonic trends were observed along this temporal breakout gradient in either total mega- or macrofaunal abundance. Our results suggest that certain benthic community parameters, such as mega- and macrofaunal abundance, may respond relatively rapidly (<15 yr) to ice-shelf collapse and establishment of overlying phytoplankton production, whereas other community parameters including biodiversity and functional-group structure may require decades to fully develop.

## ***Spatial-temporal variation in trophic relationships of a drifting species in the vicinity of the Prince Edward Islands***

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Invertebrate drifting species represent an important link for the dispersal of benthic marine species that colonise islands. These species are sensitive to changes in food availability and ocean circulation, with consequences for the success of the population's abundance and distribution. Shifts in water masses (i.e. speed, direction), play a fundamental role in determining food availability for benthic populations, which form the base of the trophic food chain. Recent studies suggest that due to climate change, the Sub-Antarctic Front (SAF) of the Antarctic Circumpolar Current (ACC) is shifting southwards, resulting in changes in food availability for benthic organisms living in close proximity to Sub Antarctic Islands. This study investigates the impact that changing oceanographic conditions have on the diet of a kelp-drifting species at select stations around the Prince Edward Islands (PEIs), an archipelago comprising Marion and Prince Edward Island. Furthermore, as part of this study, we compared these diet signatures with historical data collected in 1999. Specifically, we investigated the dietary signatures of the mussel *Gaimardia trapesina* using fatty acid (FA) and stable isotope (SI) analyses, which integrate diet signatures over a few weeks and months respectively. Samples of *G. trapesina*, kelp and suspended particulate matter (SPM) were collected at six stations in April 2015. Oceanographic data suggests that in the months prior to specimen collection, the southern branch of the SAF had deflected southwards bringing Antarctic cold water into the island archipelago; while in April the SAF lay further south of the islands, suggesting that sub-Antarctic water masses now dominated the inter-island region. The highest abundances of *G. trapesina* were found on the north-east sides of both islands, while this species was not present on the west side of either island. SI indicated that *G. trapesina* feed predominantly on SPM, as was shown for samples from 1999, a pattern that was confirmed by the FA analyses. However, while the SI signatures of *G. trapesina* did not differ among stations, FA showed significant differences with specimens from Marion Island being characterized by dinoflagellate trophic markers while those from Prince Edward Island did not show any specific trophic marker. This spatial variability is seen in the short-term FA signatures but appears to be absent over a longer time frame suggesting that this high variability may be associated to the position of the SAF prior to biological sampling and impacting the food availability for these species. This also indicates that *G. trapesina* is capable of utilizing these changing food resources.

## ***Species on the move in East Antarctic terrestrial communities***

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Antarctica has experienced major changes in temperature, wind speed and stratospheric ozone levels over the last 50 years. Whilst West Antarctica and the peninsula have shown rapid warming and consequent ecosystem change, East Antarctica appeared to be little impacted by climate warming, thus biological changes were predicted to be relatively slow. Detecting the ecological effects of Antarctic climate change has been hindered by the paucity of long-term data sets, particularly for organisms that have been exposed to these changes throughout their lives. We have shown that radiocarbon signals preserved along shoots of the dominant Antarctic moss flora can be used to determine accurate growth rates over a period of several decades, allowing us to explore the influence of environmental variables on growth and providing a dramatic demonstration of the effects of recent climate change. This work has revealed evidence of a drying trend in several of the extensive moss beds in the Windmill Islands region of East Antarctica. Following a pilot study in 2000, long-term monitoring of vegetation communities along moisture gradients at two sites commenced in 2003 using three complementary sampling regimes; turf water content, digitally determined broad-scale percent cover of vegetation and finer scale relative abundance of species.<sup>1</sup> These methods indicate that species are on the move even in those regions where it is hard to detect evidence of climate change. These findings highlight the importance of developing a robust Antarctic terrestrial and near-shore observing network (ANTOS) and considering the efficacy of the current protected areas across the Antarctic continent to adequately protect biodiversity.

<sup>1</sup>Australian Antarctic State of the Environment Indicator 72 - Windmill Islands terrestrial vegetation dynamics ([https://data.aad.gov.au/aadc/soe/display\\_indicator.cfm?soe\\_id=72](https://data.aad.gov.au/aadc/soe/display_indicator.cfm?soe_id=72))

## ***The impact of environmental changes on microbial nitrifiers in the McMurdo dry valleys***

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The McMurdo Dry Valleys (MDV) of Antarctica are vast ice-free areas considered to be one of the most extreme terrestrial environments on Earth. The freezing temperatures, oligotrophy, low water availability and strong UV radiation impose limits on the development of complex biological communities. Meanwhile, the apparent simplicity of this ecosystem masks an unexpectedly diverse and heterogeneous microbiome, which appears to be driven by physicochemical gradients. Recent, microbiological surveys have focused mostly on resolving biogeographical patterns and community composition, while information concerning the functional attributes of the communities is still sparse. Nitrogen (N) is a crucial element for life, but N content in MDV soils can be highly variable and often below our detection limits. Several recent metagenomic surveys have identified the presence of taxa and functional genes involved in N pathways, such as N fixation and nitrification across the MDV. It has also been proposed that specific environmental gradients (e.g. copper, conductivity and water availability) influence the distribution and abundance of different groups of nitrifying organisms, which can in turn influence the nitrification process and N recycling in the MDV. In order to study the effect of specific environmental conditions in the nitrification process, bulk soils from two physicochemically distinct Dry Valleys (Beacon and Miers Valleys) were subjected to five different treatments. The soils were incubated for 68 days, mimicking low and high concentrations of ammonia, high conductivity and high concentrations of organic matter and copper. Samples were taken after 24 hours, 28 days, and 68 days for analysis of 16S rDNA and rRNA amplicons, ammonia oxidizing genes expression, nutrients, and rates of nitrification. In comparison to Beacon soils, Miers samples exhibited a greater abundance of nitrifying organisms, suggesting a higher potential for nitrification. Copper and organic carbon augmentations were correlated with an increased proportion of ammonia-oxidizing archaea over ammonia-oxidizing bacteria. This potentially indicates the presence of mixotrophic metabolism in archaeal ammonia oxidizing communities from the MDV. In Beacon Valley soils, increased conductivity was correlated with an increase in the relative abundance of ammonia-oxidizing archaea, reflecting what has been described in situ and indicates better adaptation of this group to stronger environmental stressors.

Interestingly, there was an accumulation of nitrate (final product of nitrification pathway) in Miers Valley soils during the course of the incubation, whereas nitrates concentrations in Beacon Valley soils remained stable. However we recognize that the increase of nitrate content in Miers Valley soils cannot be explained by the observed nitrifying groups and further investigation is required to understand the biological processes underpinning the change in geochemical stoichiometry in these soils.



## ***The influence of global warming on *Colobanthus quitensis* reproduction***

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The rising in average temperatures on Earth is one of the main consequences of the increase of atmospheric greenhouse gases. This phenomenon appears especially severe and best documented in Antarctica, where climate change is having the most visible and significant impacts. This provides a unique opportunity to study the genetic and molecular traits of the local plants to assess the impact of climate change on their growth and reproduction.

Only two vascular species are native to Antarctica: the hairgrass *Deschampsia antarctica* Desv. (Poaceae) and the pearlwort *Colobanthus quitensis* (Kunth) Bartl. (Caryophyllaceae). In this work, a field experiment was carried out near Arctowski Polish station (King George Island - Antarctica Marittima 62° 14'S, 58° 48'W) where small greenhouses open on the top (Open Top Chambers, OTCs) were placed on the ground surrounding several *C. quitensis* individuals whose growth temperature was around 4°C higher than that of external plants around midday. After one year samples were collected inside and outside OTCs, and qPCR analysis were carried out to compare the expression level of specific genes involved in floral development. Interestingly, even if higher temperatures were found to enhance floral development in several model plants, such as *Arabidopsis*, we observed an under-expression of some genes known to act as floral inducers (FLT, *Apetala*, *Leafy*, *Constans*, *Suppressor of overexpression of Constans 1*), leading to the hypothesis that higher temperatures cause a delay in floral development extending vegetative growth. This result was supported by phenological observations according to which plants subjected to heat increase had grown more than control plants.

## ***The influence of the natural environment on habitat preference for lichens in Western Dronning Maud Land, Antarctica.***

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The biogeography of lichens in part of Western Dronning Maud Antarctica was used to elucidate Biology-Geomorphological interactions. Two continental nunataks, Vesleskarvet and Robertskollen, were selected to characterise climatic, topographical and geomorphological variables and their impact on lichen colonisation at a fine resolution. Small-scale (sub-metre) topographical features were identified and classified together with the specific lichen species that colonised them. The methodology employed included the use of structure from motion techniques to create three-dimensional models for the display of the habitat preference on specific clasts. Small-scale topographical features provide sheltered locations that serve as microhabitats that support lichen colonisation. Moist and sheltered microhabitats are the most suitable for colonisation, with habitat preferences being noted to be specific to a particular lichen species. The predominant species, *Usnea sphacelata* and *Umbilicaria decussata*, colonised sheltered depressions in the topography, specifically beneath overhangs. Finer topographical features such as cracks, pitting and tafoni were found to be colonised by other lichen species. This study shows preferential colonisation strategies of lichens in Antarctica and, thus, these habitats are a suitable proxy for monitoring environmental changes.

## ***The temperature sensitivity of two contrasting Antarctic soils in response to climate change: preliminary results***

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The temperature sensitivity of soil microbial respiration was compared across a transect of ornithogenic and non-ornithogenic soil of contrasting nutrient content. Soil samples were investigated from an ultra-eutrophic (nutrient rich/moisture abundant) site within the active penguin rookery at Cape Adare; to a transition zone, and to an oligotrophic (nutrient poor/moisture limited) site at the top of an unoccupied ridge. This research is the first test of macromolecular rate theory (MMRT) (Schipper et al. 2014) on soils of extremely cold environments and it was hypothesized that MMRT would better predict the temperature sensitivity of respiration than existing models and could alter estimates of C cycling in the high latitudes during a warming climate.

There is evidence to suggest that some high latitude regions are warming up to two times faster than the global average and that these cold ecosystems are particularly susceptible because biochemical processes are more temperature-sensitive in colder environments. Past studies have indicated penguin rookeries are significant sources for atmospheric CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub> and have shown increased greenhouse gas emissions during freeze-thaw cycles (FTCs). In coastal Antarctica FTC frequency is considerably higher during the summer and unstable weather conditions and it remains unclear whether climate change will amplify effects. Furthermore, the number of rookeries is potentially large and therefore any climate-induced changes to the annual fluxes of greenhouse gases from these hotspots is critical to identify.

Cape Adare, northern Victoria-Land, comprises one of the largest Adélie penguin rookeries in Antarctica, an estimated 250,000 breeding pairs, and consequently vast deposits of penguin guano and ornithogenic soils. Soil organic C and total N concentrations varied across the transect with highest levels within the active rookery and lowest levels at the drier ridge site.

In the laboratory ambient temperature was manipulated to replicate the direct and indirect effects of expected climate change on soil ecosystems. Recent soil samples were incubated in a temperature-gradient block comprising a temperature range of -2 °C to 30 °C for a total of 24 hours. Soil respiration was measured after 1, 6, and 24 hours. MMRT was applied to the observed temperature response curves generated to constrain the temperature optimum and predict the maximum temperature sensitivity of respiration.

Given the central role of microbes in nutrient cycling, an advanced understanding of the temperature sensitivity of these cold region soils is crucial for predicting the trajectory of Antarctic terrestrial environments in response to climate change.

## ***Unreported N<sub>2</sub>O sink in marine (sub-) polar systems***

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The increasing concentration of heat-trapping gases in the troposphere, such as CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> is already increasing global temperatures. It is the case of nitrous oxide (N<sub>2</sub>O) playing a major role in the Earth's radiative balance, since its greenhouse and ozone-depleting effects. Most of the oceans are supersaturated in N<sub>2</sub>O (<100% saturation), where is mainly produced by microbial processes as nitrification or/and denitrification, if oxygen level is low enough, which is not the case for Arctic and Antarctic regions.

This is a report of N<sub>2</sub>O distribution, cycling and fixation, in (sub-) polar waters: central Arctic Ocean, Antarctic Peninsula and Kerguelen Islands. They represent regions with antecedents of rapid freshening and warming changes. Arctic waters were sampled during Lomrog III cruise in summer of 2012, covering the Amundsen and Nansen basins (82.19°N to 88.15°N) up to 4300 m depth. In the Antarctic Peninsula time series studies were conducted in Chile Bay (62° 27' S, 59° 40' W) at the South Shetland Islands during the austral summer (February-March) of 2014, 2015 and 2016, whereas the Kerguelen Islands (42–47°S) area (Indian sector of the Southern Ocean) was sampled in Spring 2011 during the KEOPS II cruise. In these three different areas, physical mechanisms associated with an increased gas solubility under low-temperature and biological production by nitrifying (i.e., oxygenated and cold water should accumulate and produce N<sub>2</sub>O), are expected to yield N<sub>2</sub>O supersaturated condition.

Unexpectedly, the three sampled areas revealed conditions of N<sub>2</sub>O under-saturation or in equilibrium with the atmosphere, suggesting that consumption or depletion of N<sub>2</sub>O occurs at surface and intermediate waters. Chile Bay shows under-saturated waters or in slightly equilibrium with the atmosphere around 60-100 %, coincident with N<sub>2</sub>O consumption rates up to 4.9 nmol L<sup>-1</sup> d<sup>-1</sup>. The central Arctic Ocean reveals sub- to slightly saturation of N<sub>2</sub>O (50 to 111 %). N<sub>2</sub>O fixation in ice-brine and sea-water Arctic stations were detected using <sup>15</sup>N-N<sub>2</sub>O isotopically labeled, with daily rates of 22.9 and 162.6 nmol L<sup>-1</sup> d<sup>-1</sup>, suggesting that this consumption may sustain the low N<sub>2</sub>O saturation found in the waters. In addition, Ocean Kerguelen sub-polar waters have also N<sub>2</sub>O levels as low as 70%.

At the three sites investigated, physical mechanisms seem to be not responsible for these under-saturated conditions; despite cold high latitudes waters allow high gas solubility. If changes in temperature and salinity are faster than the required times for allowing an equilibrium of gases with the atmosphere, they drive to a non-equilibrium condition. When potential changes (heating, cooling or refreshing), were assumed in the (sub) polar systems studied, under-saturated gas conditions should not be reproduced. Since high surface O<sub>2</sub> concentrations preclude N<sub>2</sub>O consumption by denitrification, the most plausible mechanisms explaining low N<sub>2</sub>O levels could be biological nitrogen fixation by diazotrophic activity, detected in these systems. Thus, our analysis point to biological processes as main mechanisms to produce N<sub>2</sub>O under-saturation in these different marine regions of the ocean.

## S31. Ocean Acidification

### *Distribution of anthropogenic carbon in the Bransfield and Gerlache Straits (Antarctic) waters during austral summer 2015*

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Measurements of total alkalinity (AT) and total dissolved inorganic carbon (CT) were made in Bransfield and Gerlache Straits in February 2015 (austral summer) in order to characterize the carbonate system in the area. Here we focus on the quantification and distribution of the anthropogenic carbon (Cant) in the waters of the study area. Measurements of AT and CT were made simultaneously by potentiometric titrations in a closed cell, using the method described by Dickson et al. (2007). Regular quality control was performed through Certified Reference Material analysis (batch 96), enabling AT and CT precisions of 3.3  $\mu\text{mol kg}^{-1}$  and 5.9  $\mu\text{mol kg}^{-1}$ , respectively. Cant concentration was determined through TrOCA method. AT values were higher in Gerlache Strait ( $2378.32 \pm 17.71 \mu\text{mol kg}^{-1}$ ) than in Bransfield Strait ( $2339.80 \pm 26.06 \mu\text{mol kg}^{-1}$ ), whereas CT presented the opposite pattern ( $2266.64 \pm 19.30 \mu\text{mol kg}^{-1}$  and  $2295 \pm 27.69 \mu\text{mol kg}^{-1}$ , respectively). The results showed higher Cant absorption in the Bransfield Strait than in the Gerlache Strait, with an average for the whole water (excluding surface mixed layer data) of  $73.64 \pm 35.54 \mu\text{mol kg}^{-1}$  and  $19.73 \pm 13.19 \mu\text{mol kg}^{-1}$ , respectively. The central basin of the Bransfield strait was observed to be the most affected region by the large amount of Cant penetration, achieving values higher than  $100 \mu\text{mol kg}^{-1}$ , whereas the highest values for the Gerlache Strait ( $\sim 50 \mu\text{mol kg}^{-1}$ ) were observed at shallow depths  $\sim 100$  m only in the eastern side of Brabant Island, close to the Antarctic Peninsula and influenced by shelf water masses flowing from the Bransfield Strait and Weddell Sea. In summary, both Bransfield and Gerlache Straits are affected by Cant absorption for the entire water column.

## ***Lipid use in the lecithotrophic larvae of *Laternula elliptica* under pH and temperature stress***

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Ocean change may impact larval development due to the increased energetic costs of acid-base regulation under ocean acidification and the maintenance of higher metabolic rates. This may strain energetic reserves, which are limited in lecithotrophic larvae, reducing larval response capacity or diverting energy from somatic growth or calcification. The lecithotrophic larvae of the Antarctic bivalve, *Laternula elliptica* were raised under elevated temperature (-0.5, 0.5 and 1.5°C) and reduced pH conditions (pH 7.65). Primary lipid classes were identified and quantified in the larvae using a Thin Layer Chromatography/Flame Ionization Detection system. The use of lipids during development and under stress was determined by measuring the concentrations of different lipid classes and total lipids in newly fertilised and late stage larvae. Effects of temperature and pH conditions on D-larval metabolic rates were determined from oxygen consumption measurements. The primary lipid classes in *L. elliptica* larvae were triacylglycerols and phospholipids, comprising over 85% of the total lipid content. Despite considerable depletion of both of these lipid classes during development, significant reserves remained for metamorphosis. However, lipid utilisation was not significantly different between treatments. In contrast, metabolic rates significantly increased in elevated temperature treatments, but were not affected at reduced pH. Larvae of *L. elliptica* are well provisioned for development to the D-larval stage, with significant lipid reserves remaining for metamorphosis even under end of century temperature and pH projections. The lack of significant treatment effects on lipid depletion was surprising given the increased metabolic rates. Furthermore, a companion study shows negative effects on larval growth, suggesting diversion of energetic resources away from larval development. However, increased energetic costs to maintaining acid-base balance may be met by sources other than lipids. Examination of the impacts of stressors on protein reserves is pending and those results will also be presented.

## ***Mesoscale variability in the carbonate system chemistry and CO<sub>2</sub> air–sea fluxes of the Ross Sea (Antarctica) shelf area.***

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The Ross Sea is an important region in the global carbon cycle, however little is known about the effects of surface mesoscale processes (on spatial scale of 10 km and temporal ranges from hours to days) on the carbonate system chemistry and CO<sub>2</sub> air–sea fluxes.

To this purpose, the Ross Sea Mesoscale Experiment (RoME) project during the austral summer 2013-14 used a combination of remote sensing and high resolution ship measurements to investigate the importance of mesoscale circulation in the distribution of the biogeochemical properties of the surface waters in the shelf area.

Sampling was performed in selected areas, characterized by different distances from the coast and different hydrodynamic structures. RoME 1 area was located at approximately 170E and 75S, whereas RoME 3 in the southwestern Ross Sea, NE of Ross Island, at 168E and 76.5S.

Total alkalinity, pH, O<sub>2</sub>, nutrients, phytoplankton pigments and composition were investigated in combination with measurements of temperature, salinity and current speed. Total inorganic carbon, sea water CO<sub>2</sub> partial pressure and the saturation state ( $\Omega$ ) for calcite and aragonite were calculated from the measured parameters. In addition, continuous measurements of atmospheric CO<sub>2</sub> concentration were completed. Our results document substantial spatial heterogeneity and complexity in carbonate system properties and the magnitude of the CO<sub>2</sub> flux at a horizontal length scale of about 10 km, emphasizing the importance of mesoscale events to regional biogeochemistry. The distribution of the carbonate system was controlled primarily by phytoplankton activity rather than physical forcing, which, on the other hand, created the favorable conditions for the growth in the upper layer of the water column.

## S32. Human Biology And Medicine

### ***An association analysis between psychophysical characteristics and genome-wide gene expression changes in human adaptation to the Antarctic Dome Argus***

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Genome-wide gene expression measurements have enabled comprehensive studies that integrate the changes of gene expression and phenotypic information to uncover their novel associations. Here we reported the association analysis between psychophysical phenotypes and genome-wide gene expression changes in human adaptation to one of the most extreme climates on Earth, the Antarctic Dome Argus. Dome A is the highest ice feature in Antarctica, and may be the coldest, driest and windiest location on earth. It is considered unapproachable due to its hostile environment. In 2007, a Chinese team of 17 male explorers made the expedition to Dome A for scientific investigation. Overall, 133 psychophysical phenotypes were recorded, and genome-wide gene expression profiles from the blood samples of the explorers were measured before their departure and upon their arrival at Dome A. We found that mood disturbances, including tension (anxiety), depression, anger and fatigue, had a strong, positive, linear relationship with the level of a male sex hormone, testosterone, using the Pearson correlation coefficient (PCC) analysis. We also demonstrated that significantly lowest-level Gene Ontology groups in changes of gene expression in blood cells with erythrocyte removal were consistent with the adaptation of the psychophysical characteristics. Interestingly, we discovered a list of genes that were strongly related to significant phenotypes using phenotype and gene expression PCC analysis. Importantly, among the 70 genes that were identified, most were significantly related to mood disturbances, where 42 genes have been reported in the literature mining, suggesting that the other 28 genes were likely novel genes involved in the mood disturbance mechanism. Taken together, our association analysis provides a reliable method to uncover novel genes and mechanisms related to phenotypes, although further studies are needed.

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Xu C, Ju X, Song D, Huang F contributed equally to this work.

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## ***Association between urinary status and psychological mood states at Syowa Station, Antarctica***

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A number of factors are reportedly associated with urinary status. Among them, involvement of psychological mood states has also been suggested. This study aimed to elucidate the association between urinary status and psychological mood states by analyzing data from the following researches, which were conducted in members of the Japanese wintering party at Syowa Station, Antarctica: 1) an investigation on urinary status and sleep quality and 2) a research on psychological mood states.

We used questionnaires (International Prostate Symptom Score [IPSS], Overactive Bladder Symptom Score [OABSS], and daily voiding dairies [3 consecutive days]) to assess urinary status. We used the Pittsburgh Sleep Quality Index (PSQI) to measure sleep quality and the Profile of Mood States (POMS) to measure psychological mood states.

The subjects were 11 members of the expedition party who had participated in both researches. Analyses were conducted using their data collected at seven time points: before departure in Japan, at the beginning of the wintering period, during the polar night, at polar daybreak, in springtime, at the starting of the midnight sun, and on the returning ship.

In a group of subjects whose IPSS increased after departure, their Tension-Anxiety score decreased from 55 before departure to 42 and their Total Mood Disturbance (TMD) score decreased from 208 to 175 during the wintering period in Antarctica. In a group of subjects whose OABSS increased after departure, their Tension-Anxiety score decreased from 55 to 42. The group also had a low vigor score. In a group of subjects whose PSQI increased after departure, their Anger-Hostility score increased from 45 to 53 and their TMD score increased from 193 to 223 during springtime and midnight sun. The group also had a low vigor score.

Although these data were within healthy ranges, subjects with deterioration of urination had decreased tension/anxiety during the wintering period in Antarctica and subjects with deterioration of sleep quality had increased anger/hostility during the third-quarter. These results indicate that psychological stresses during the wintering period in Antarctica were manifested as physical symptoms. Specifically, this raises the possibility that the more aware a person is of his/her own physical symptoms, the better the person's psychological mood state may become. On the other hand, the study also showed that deterioration of sleep quality is associated with an increase in anger/hostility.

# ***Behavioural health in extreme environments: normal reactions to an abnormal environment***

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It is well recognised that the challenges of extreme environments such as Antarctica pose unique challenges to human adaptation and performance. It is also well understood that this can manifest in fluctuations in mood and well-being. Despite acceptance that these constitute normal reactions to abnormal environments, we continue to use standard population norms to define distress in this population. This presentation considers the development of psychiatric norms relevant to extreme environments, which may reduce the risk of unnecessary and inappropriate pathologising and thereby allow for more appropriate responses to variations in well-being observed in these populations.

## ***Influence of ecological conditions from Antarctica on human erythrocytes viability. Preliminary report.***

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The aim of this study was to analyze the influence of environmental conditions on the viability of human erythrocytes in Antarctica , as a haematological adaptation. We considered that the red blood cells can be excellent models for studies on environmental adaptations. These adaptations can be on morphological, physiological or molecular level.

Human red blood cells (RBCs) or erythrocytes have a definite life span of 120 days and these are specialized in the transport of respiratory gases in blood. Human erythrocytes lack a cell nucleus and most organelles, in order to accommodate maximum space for hemoglobin. Erythrocyte senescence is associated with cell shrinkage, plasma membrane microvesiculation, a progressive shape change from discocyte to spherocyte, cytoskeleton alterations associated with protein (spectrin) degradation, and loss of plasma membrane phospholipid asymmetry leading to the externalization of phosphatidylserine, that may represent one of the signals allowing macrophages to ingest the senescent erythrocytes (erythroptosis also called eryptosis)

Recently we devised a new, rapid and simple flow cytometric assay for the measurement of viability and ageing of human RBCs using calcein-AM. Analyses revealed two regions could be clearly and unambiguously defined: i) the region of fluorescent RBCs with intact membranes which is related to the intracellular esterase activity and strongly correlated with the number of living cells, including ageing or dying cells; ii) the region of non-fluorescent dead cells with damaged cell membranes. We also found that loss of calcein fluorescence is associated with a decrease in the amount of ATP which is classically considered as an indicator of viability for RBCs. The loss of esterase activity is an early event which occurs prior to the phosphatidylserine exposure.

Our preliminary results obtained by comparing the data collected from 3 persons, before and after 3 weeks of staying in Antarctica , demonstrates a clear influence on the viability of erythrocytes by its decreasing, which can mean a faster aging of erythrocytes. It is difficult to say which of climatic factors caused the viability changes. There weren't any morphological changes.

## ***Neutrofin-3 as a support marker in evaluating the haemoleucogram changes in Romanian polar expeditioners***

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Our previous investigations suggested that neutrophin-3 (NT-3) is an efficient marker for Antarctic expeditioners selection and their health state monitoring on Antarctic continent (SCAR-OSC 2014). In this paper, we further discuss this conclusion by evaluating the haemoleucogram changes in relation to NT-3 dynamics in Romanian expeditioners in Polar Regions.

Our study included expeditioners in Antarctica [January-February 2006 (n=3), February-March 2007 (n=1)], Greenland [March-April 2008 (n=4)], Svalbard [July 2008 (N=2)], Sweden Lapland [February 2011 (n=1)] and cold-exposed voluntaries in Romanian Bucegi Mountains, 2257m [February 2005 (n=5)]. The mean age (years) was  $52.8 \pm 11.6$  (26-63) for expeditioners and  $40.9 \pm 12.5$  (25-58) for voluntaries. Environmental parameters are specified. Haemoleucograms have been performed before (PI) and after the expeditionary activity (PII). Serum concentrations of NT-3, ceruloplasmin (CP) [protein involved in iron metabolism], and cortisol (CO) [stress hormone], have been determined at the same moments.

Results (PII vs PI). Significant haemoleucogram changes in polar expeditionaries were found: a decrease by 5.8% of the red blood cell number [RBC ( $\times 10^3/\mu\text{L}$ ):  $4688 \pm 522$  vs  $4975 \pm 517$ ,  $p=0.0005$ ] accompanied by an increase by 4.5% of the mean corpuscular haemoglobin [MCH (pg):  $30.48 \pm 2.33$  vs  $29.16 \pm 1.57$ ,  $p=0.0057$ ]. Variations of RBC and MCH were insignificant in voluntaries. The characteristic common for the expeditioners and voluntaries was a significant increase of the mean corpuscular volume [MCV (fL):  $89.66 \pm 4.82$  vs  $88.04 \pm 5.33$ ,  $p=0.006$ ; respectively  $89.14 \pm 5.43$  vs  $87.60 \pm 5.76$ ,  $p=0.0007$ ]. One expeditioner, that successfully passed the cold test in Bucegi Mountains, shown an adaptation incapacity to Antarctic environment associated with a normal number of RBC [ $5100 \times 10^3/\mu\text{L}$ ] but of sub-normal sizes [MCV=77.5 fL] and levels too low of MCH [25.3 fL] and serum Fe [39  $\mu\text{g/dl}$ ]. The CP dysfunction anemia evidenced by the severe decrease of serum CP level on the Antarctic continent [20.3 mg%] and the concentrations exacerbated of NT-3 [2000-3000 pg/mL] is discussed.

Six expeditioners shown a significant decrease of white blood cell, and neutrophil numbers, respectively [WBC/ $\mu\text{L}$ :  $7090 \pm 1970$  vs  $8340 \pm 1564$ ,  $p=0.0153$ ; NEU/ $\mu\text{L}$ :  $4388 \pm 1514$  vs  $5606 \pm 1540$ ,  $p=0.0059$ ; NEU%:  $60.8 \pm 7$  vs  $66.7 \pm 7.7$ ,  $p=0.05$ ] associated with low levels of NT-3 [pg/mL:  $\leq 7.3$  vs  $\leq 4.9$ ]. Contrary, the other 5 expeditioners presented significant increases of WBC, neutrophils, lymphocytes and monocytes, respectively [WBC/ $\mu\text{L}$ :  $8910 \pm 2220$  vs  $6352 \pm 1789$ ,  $p=0.0133$ ; NEU/ $\mu\text{L}$ :  $5662 \pm 1923$  vs  $3885 \pm 1430$ ,  $p=0.0209$ ; LYM/ $\mu\text{L}$ :  $2317 \pm 905$  vs  $1920 \pm 760$ ,  $p=0.0289$ ; MONO/ $\mu\text{L}$ :  $794 \pm 95$  vs  $461 \pm 172$ ,  $p=0.0042$ ] associated with higher levels of NT-3 [pg/mL:  $16.93$  vs  $24.95$  (n=4), 2000 vs 3000 (n=1)].

Four voluntaries with the haemoleucogram characterized by a decrease in the WBC number, statistically significant for lymphocytes and eosinophils [LYM/ $\mu\text{L}$ :  $2370 \pm 352$  vs  $2595 \pm 352$ ,  $p=0.0085$ ; EOS/ $\mu\text{L}$ :  $68 \pm 44$  vs  $107 \pm 65$ ,  $p=0.0343$ ], shown low CO levels [ $\mu\text{g/dL}$ :  $8.25 \pm 1.3$  vs  $12.74 \pm 4.7$ ]. Contrary, one voluntary with a higher CO level [ $\mu\text{g/dL}$  17.8] shown a WBC number increase [NEU, LYM, MONO].

Conclusion: The haemoleucogram changes found in the polar expeditioners and the cold-exposed voluntaries are induced both by the environmental and individual factors. NT-3 could be used in support of the differentiation between these two effects.

## ***Relationship between mood states and ego states experienced by a Japanese wintering party in Antarctica***

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Successive Japanese wintering parties were placed in an isolated environment in Antarctica for about one year. They received few visitors because no other permanent research stations were nearby. The main purposes of our research were to investigate how mood states of wintering members changed over time and to clarify the relationships between mood states and ego states and between mood states and coping with stress in a long term isolated environment.

Questionnaires were conducted seven times and completed by 29 people in a Japanese wintering party. Questionnaires included the Profile of Mood States (POMS), the inventory of coping strategies (COPE), and Egograms which measures ego states.

The results were that Depression-Dejection and Anger-Hostility correlated positively with Adapted Child but negatively with Critical Parent and Nurturing Parent. Tension-Anxiety, Depression-Dejection, Anger-Hostility, and Confusion positively correlated with mental disengagement and focus on & venting of emotions.

These results indicated that there was a cooperative but obedient ego state behind their depression and anger. These results also indicated that the ego states of persisting in one's beliefs and of being generous could have helped to suppress depression and anger. Moreover, these results indicated that cooperative but obedient wintering members could suffer from heavier mental burdens in long-term isolated environments

## ***Telemedicine in Indian scientific expeditions to Antarctica***

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**Objectives:** To describe the Indian experience with telemedicine at its Antarctic stations and to emphasize the potential for telemedicine in Antarctica

**Background:** Telemedicine has been revolutionized in Antarctica with the rapidly improving satellite communications. Though telemedicine has been practiced in Antarctica since satellite phones came into use on the continent, institutionalized telemedicine facilities remain the need of the hour for emergent and non-emergent consultations for a population with no access to specialized health care facilities. The Indian experience with telemedicine is largely undocumented. The authors present their experience with telemedicine on the continent.

**Methods:** Three Indian expeditions (22nd, 27th and 28th Indian Scientific Expeditions to Antarctica (ISEA) and the First Indian Expedition to the South Pole) were included in the study. Firsthand accounts of the authors as the team members of the concerned expeditions were considered. Medical reports of other expeditions were consulted, but no documented instances of use of telecommunication facilities could be found.

**Results:**

In the 22nd and 27th ISEA, only rudimentary internet facilities were available at Maitri. However, in the 28th ISEA, full internet connectivity was available. The 1st Indian Expedition to South Pole did not have any internet connectivity. However, satellite phones were available.

During the 22nd ISEA, a case of crush injury thumb was managed conservatively. Though telephonic advice was sought from the Russian Antarctic Station, Novolazarevskaya for darkening of the skin, it was not followed and the patient recovered uneventfully. Telephonic advice was also sought for a case of acute appendicitis from a general surgeon who was a personal contact of the author before undertaking the operative procedure.

During 27th ISEA, advice through email was sought for treatment of a case of lumbar disc prolapse not responding to bed rest from an orthopaedic surgeon, who was the personal contact of the presenting author. Psychiatric advice was also sought from a personal contact for one patient who appeared to be malingering.

During 28th ISEA, the station meteorologist died of massive acute myocardial infarction. This incidence caused concerns of psychological disorders in the team members. Multiple sessions of psychological consultations were given to the team members in following period over the recently commissioned videoconferencing facility.

The 1st Indian expedition to the South Pole lasted for about two months. Only satellite telephony was available. Telemedicine services were not required during this expedition.

**Conclusion:** Institutionalized telemedicine services for Antarctic populations would provide much needed specialist consultations to the team members, and also give a fillip to health related discussions and talks with specialists in India. First aid courses could also be run online for all team members.

# ***The other "forgotten" population in extreme environments: Psychological experiences and well-being of non-deployed staff***

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The impacts of extreme environments on the health and well-being of deployed personnel is an ongoing focus of research attention, in terms of adaptation to both routine and critical incidents. However, to date limited research attention has been directed towards the well-being and experiences of non-deployed personnel (i.e. those who work at the host organisation) who have responsibilities associated with employees "on the ice". This is potentially problematic considering that these individuals are often impacted by events that occur in Antarctica, either personally or professionally, yet often intervention efforts are oriented towards those "on the ice" rather than those peripherally impacted. The current study aims to examine the psychological well-being of non-deployed staff and determine the extent to which they experience psychological fluctuations, the cause of such fluctuations, and what (if any) interventions may be of benefit in supporting these largely "forgotten" populations. This research has implications for the occupational health and safety policies of all national Antarctic programs, as well as within space analogue environments.

## ***The third-quarter phenomenon in Antarctica: The relationship between mood, job, and personality***

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Antarctica is an isolated and confined environment. Psychological states and health conditions are known to change as a result of long periods of stay in Antarctica. These changes are collectively called winter-over syndrome (Strange et al., 1973). The "third-quarter phenomenon" hypothesis (Bechtel and Berning, 1991) suggests that these changes in condition occur in the latter half of long stays. According to Steel (2001), the phenomenon does not always occur. The conditions in which they occur are not clear.

The aim of this research is to analyze the relationship between mood, job, and personality in order to recognize the conditions for occurrence of the third-quarter phenomenon.

A total of 304 members of the Japanese Antarctic Research Expedition (JARE) at Syowa Station participated in this research. The testing was conducted before departure (#1), at the beginning of the wintering period (#2), in the middle of the wintering period (#3), in the summer / third-quarter (#4), and on the return ship (#5).

Their moods were measured by the Positive and Negative Affect Schedule [PANAS] and the Profile of Mood States [POMS]. The wintering members were divided into two groups, an observation group and a logistic group. Their personalities were measured by the Two-Sided Personality Scale [TSPS] (Kuwabara, 1991) and the Big Five Scale (Wada, 1996).

The following findings became clear as a result of the investigation. 1) The tiredness of the observation group was relatively high. 2) Changes over time were not dependent on job type. 3) Positive moods and negative moods did not change over time in accordance with personalities. 4) Neuroticism on the Big Five Scale was related with a negative mood. 5) 'Vigor' was related with neuroticism, extraversion, and agreeableness. 6) The group of high 'Openness to experiences' score had high 'Tension-Anxiety' score before departure and during the stay in Antarctica. However, in the group of low 'Openness to experiences' score, 'Tension-Anxiety' score decreased at the beginning of the wintering period and the tendency continued until the return ship.



## S36. Antarctic Education, Outreach And Training

### *"Advances in polar science's call for papers--Advances in polar science is changing and improving"*

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Advances in Polar Science (APS) has been published since 1990 as a peer-reviewed English-language journal dedicated to the presentation of multi-disciplinary achievements in Arctic and Antarctic expeditions and research (until 2011 it was known as the Chinese Journal of Polar Science [English Edition]). Now, commencing with Vol. 26, No. 3 in 2015, we are moving to make APS more truly international, with two new Co-Editors-in Chief (Huigen Yang, Director General, Polar Research Institute of China; Ian Allison, Honorary Research Associate, Antarctic Climate and Ecosystems CRC), and a new expert team of disciplinary Editors from China and many other nations involved in polar research (see <http://www.aps-polar.org> ).

Our broad goals for the journal in the near future are to improve the quality of contributions and to attract more involvement and contributions from outside China. Specific objectives will include using APS as a platform to raise international awareness of Chinese polar research and to facilitate collaboration between China and other nations in polar science, and to build both inter-disciplinary and bi-polar links within our research community.

Manuscript submissions on relevant polar research topics will be accepted from scientists of any nation and subject to peer review by at least two expert referees, at least one of whom will be from outside China. The review process will be managed by one of the expert disciplinary Editors, working in collaboration with the international Editorial Board. Authors will usually be informed of decisions within six weeks of submission and, once accepted, a paper will normally be published in the next issue of the journal. APS will continue as a true open-access, quarterly scientific journal. Publishing in APS is free of charge thanks to generous funding from the Polar Research Institute of China, and free access is provided to all articles as soon as they are accepted (at <http://www.aps-polar.org> ).

We also propose to publish one or two "Special Issues" of APS each year on polar research projects, disciplinary topics or polar geographical regions of current interest. In particular "Special Issues" will focus on those polar themes which have strong internationally collaborative links. Special issue topics currently under consideration are editions on "Ice-ocean interaction in Prydz Bay, Antarctica" and "A decade of scientific research at Dome A, Antarctica".

We welcome your continuing involvement in the journal Advances in Polar Science. We look forward to the submission of new manuscripts (which can be made online at <http://mc03.manuscriptcentral.com/apsci>) and for any suggestions of future "Special Issues" (which can be made via email to the editorial office at [journal@pric.org.cn](mailto:journal@pric.org.cn) ).

## ***Biological adaptations to environmental change in Antarctica - An advanced training program for early career scientists***

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The biological impacts of global climate change (e.g., responses to warming temperatures, ozone depletion, ocean acidification) and the potential to adapt to rapid change in the cold biosphere are central themes in the study of Antarctic organisms and ecosystems. Antarctica is, however, a difficult place to do science and this is especially true for field access for new investigators starting careers in polar biology. Few early-career scientists (PhD students and postdoctoral-level investigators) have the opportunity to work on-site in Antarctica, unless they are directly associated with an established scientist who has a funded project. Since 1994 the United States National Science Foundation (NSF) has supported a series of international, advanced-level training courses for early-career scientists to study the biology of marine organisms in Antarctica. These courses, held at McMurdo Station, served to introduce early-career scientists from a wide range of disciplinary backgrounds to key issues in polar science. A special focus of these programs was to provide the opportunity for early-career scientists to gain hands-on experience in Antarctic field activities. In total, there have been over 240 participants from 126 institutions representing 24 countries. These programs have proven to be effective in enhancing the professional careers of the participants and increasing international collaboration. Course alumni have leveraged their Antarctic course experience to develop new research directions, incorporate polar science into curricula at their home institutions, and enhance public outreach activities.

During July 2016 the NSF Antarctic Biology Course will be continued for a 10th session at Palmer Station on the Antarctic Peninsula, and in January 2018 the course will again be held at McMurdo Station on the Ross Sea. The major expectations from continuing to offer these advanced training courses in Antarctica are to 1) introduce new researchers to the unique features of biological processes in an extreme cold environment, 2) place that understanding of Antarctic biology in the context of environmental change in polar regions, 3) train course participants in modern field and research methods used to study the mechanisms that are unique to biology in Antarctica, 4) foster an appreciation for the importance of the physical and biological components of the Antarctic ecosystem on global processes, and 5) prepare early career scientists for success in developing their own independent research programs in polar regions, while fostering the next generation of polar scientists.

## ***Challenges for the video classes production for the popularization of the Brazilian Antarctic research***

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Among the challenges of video classes production, that meet the goals of popularizing the polar sciences, included: forming a multidisciplinary video production team, set video production processes which can be quickly disseminated and appropriated by teachers and researchers, to prepare them to work in video recording situations.

These described challenges, for example, by Gerbase (2006) to analyze the feeling of fear among teachers (we could also extend it to researchers), when they are asked to go beyond the comfortable verbal boundary in an audiovisual recording experience can manifest the fear of self-extinction, the loss of autonomy and detachment with the student (or pairs). According to Gerbase, these feelings are common when the professionals come enjoined (or intimidated?) by the cameras.

In other words, feel unimportant because of the referentiality space loss (I'm no longer the center) and the content (Will I be replaced by all sorts of images, words, sounds?), be unsure as to a supposed displacement of function (I'm not an actor!), and live with the feeling of not being in dialogue directly with other human beings are obstacles to be overcome by teachers and researchers for video recording and video classes.

To these discomforts, described by Gerbase, sum up one more: the difficulty of jointly conceive a language that expresses the authenticity, accuracy, and creativity of research and scientific knowledge in general.

In our experience of video classes production for the distance learning course Antarctic or Antarctica?, which aim is to offer teacher training for Antarctic insertion in the Brazilian basic school curriculum, we work with six researchers, directly involved in the production and dissemination of research and scientific knowledge on the Antarctic continent.

The main challenge was to reconcile the creative and aesthetic interests of video professionals (producer, screenwriter, editor) with the expectations of the image itself and the reliability of the information. The adaptation of a word, an association between non-causal images or the insistence by a silence after a pause are examples of the form of questions that often give rise to disagreements between the discourses that should make up the work: it is necessary to find a way to work in which the creativity of research meets the creative expression of the video makers.

As a result, 25 video classes were done, that present the research carried out by each of the six researchers, using their records from Antarctic (photos and videos) helping to demystify the figure of the scientist.

The video classes experience a diversity of audiovisual languages, bypassing the traditional and boring recording classes. We understand the video classes as an hybrid genre, since its audiovisual expression is formed from language references to other genres such as the journalism (interview, story, etc.) the documentary (testimonials, stories, etc ...) video art (collages, overlays, etc.). In this perspective, the video lesson, even not leaving behind their educational goals, deviates from its stigma of "recorded class."

## ***Challenges in educational game development on polar science***

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This research aims to investigate the process of developing an educational adventure game (Novak, 2010), which pretends to contribute to the popularization of science in Antarctica. The game tells the story of two young scientists on the continent which during their journey witness some incidents and decides to go deeper in their investigations. In the course the adventure they discover a network of illegal exploration of natural resources and disarm to preserve the environment and animals' integrity.

The scientific discoveries' popularization to non-specialized public is the motivating aspect of this study, mainly when dealing with the live and almost untouchable laboratory which is Antarctica, thus, the digital games configures itself as prominent element to transformations on science knowledge dissemination.

Kenski (1998, p.29) observes which the contemporary digital life includes not only the new equipments usage as computers, smartphones and videogames to production and apprehension of knowledge, but, also, "new behaviors of learning, new rationalities and new perceptual stimulus".

In this sense, the videogame's potential needs to be explored in the divulgation process of the scientific wisdom, because the games reaches great part of the young and adults, and can be important contextualization tools, in formal and non-formal education, curricular and scientific contents, in our case about the Antarctica.

The game was developed using the INTERA methodology for creation of Learning objects (Wiley, 2000), in this methodology we comprehend, with base in studies and research conducted (BRAGA et al., 2014, p. 124), which the motivation is consider one of the reasons to use games as Learning Objects, but emerges the concern that these games doesn't treat the teaching and learning as a simple transmission of contents, but, instead, being enablers tools of the process of knowledge construction which the player is an active member of his learning being a protagonist in the act of have fun.

During the development the multidisciplinary team faced obstacles to comprehend and apply the guidelines and rules of Antarctic land with the goal to avoid conceptual mistakes in game design, but without lose the entertainment/fun, player's main motivators.

The challenges found were since difficulties on a multidisciplinary approach, game design, technologies and time management. In the most part of the time we are keeping in mind to align concept with gameplay to maintain not only a good video game experience but a good learning experience.

Our methods to solve these challenges were based on understanding where the Antarctic knowledge would influence the game design and try to set what would be passed as knowledge to the player. Align with a series of concept validation to make a development based on a step-by-step approved by concept team.

## ***Communicating Antarctic scientific and environmental information to the scientific community and decision factors***

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Romania developed the last ten years educational and outreach programs on Antarctic issues. Various activities were organized and achieved (2005-2010) by the Romanian Polar Research Institute and Romanian Antarctic Foundation, with 15 research institutes and universities, in the project "Polar Research and Protection – a Priority" to raise awareness of scientists, decision makers and general public of the impact of anthropic activities and climate changes on polar regions. These activities produced papers, abstract volumes, three international polar research symposia (2006-2008), conferences at: Romanian Academy (RA), Romanian Research and Education Ministry, universities in Romania/abroad, research institutes; radio/TV broadcasts on IPY, Polar Week; You Tube videos, and two books by Dr. Teodor Negoita (2005, 2007) describing Romania cooperation with Australia, China and Russian Federation in Antarctica (all reported to IPY and SCAR). Institute of Biology of RA Bucharest organized a postgraduate course (2008) and an international symposium (2009) on extremophiles. Romanian National Commission for Antarctic Research (NCAR) of RA, the current Romanian Antarctic Operator, developed and performed (2012-2016) an intense program meant to inform the scientific community and decision factors on the Antarctic issues/policies, considering the Antarctic research and protection while observing the Antarctic Treaty System regulations. Research fields included genomic, physical and biological/medical sciences. Communications addressed to professors and students in Romanian universities in Bucharest, Iasi, Cluj, Timisoara, Galati, Constanta, Arad; Ecological University Bucharest (EUB). Scientific events (conferences, workshops) within RA (NCAR and Romanian Committee of Science and Technique History and Philosophy) referred to Antarctic science development and necessary policies/programs. Romanian (Bucharest) research institutes (of RA: Institute of Virology; Astronomical Institute; Institute of Speleology and Institute of Biology; and R&D Institute of Biological Sciences; National Administration of Meteorology) benefitted by this information. Romanian Ministries (of National Education and Scientific Research; of Environment, Water and Forests; of External Affairs) and RA, as decision factors, conducted inter-institutional discussions on Antarctic issues. All a.m. institutions were involved in organizing/contributing to those events. Scientific/professional associations (CRIOSPHERA, Romanian Plasmapheresis Association) were informed on Antarctic issues. Education and outreach activities resulted in progress in Romanian Antarctic research and training. New Master and PhD programs (temperate/polar regions comparison; life in extreme environments) are initiated in universities (EUB, Galati and Cluj universities), possibly in cooperation. Polar microorganism research led to patent applications (Galati University). A Department of Antarctic and Arctic Research within R&D Institute of Biological Sciences was established following discussions of AR-NCAR and the a.m. ministries, which organized two Antarctic expeditions (2015, 2016) in cooperation with Korea. Domestic and international scientific cooperation extended. The number of papers (in journals and submitted to SCAR (OSC) 2008, 2010, 2013; APECS), and books (Fendrihan, S., 2011; Manea, P., 2015) increased. Cooperation of universities with ECO-Clubs (ECOING of EUB, -T. Negoita" ECO-Club Bacau), when teachers, pupils and students are volunteers in protected areas (Danube Delta, Bistrita) support environmental protection. Increased interest for polar issues attracted sponsors for Antarctic research, supporting university programs or Antarctic expeditions.  
[http://www.academiaromana.ro/comisiiAR/Comisia-CNCA/comisii\\_CNCA\\_even.htm](http://www.academiaromana.ro/comisiiAR/Comisia-CNCA/comisii_CNCA_even.htm)  
<http://www.bokus.com/bok/9783211996904/adaption-of-microbial-life-to-environmental-extremes/>  
[columna.crifst.ro/sites/columna.crifst.ro/files/.../columna\\_2015\\_7\\_01.pdf](http://columna.crifst.ro/sites/columna.crifst.ro/files/.../columna_2015_7_01.pdf)

## ***Education and outreach activities of the United States Antarctic Program***

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The United States Antarctic Program (USAP) has long supported education and outreach activities with an increased effort associated with the International Polar Year, 2007-2009 (IPY). Following IPY, the USAP has continued to support a variety of endeavors, both directly and in partnership with other organizations. The United States has also actively participated in and supported SCAR and COMNAP education and outreach efforts including fellowships and student exchange programs. A number of USAP programs and projects are well-established, with a long history of support, while many were of shorter duration in association with discrete outreach events and funded research projects. The following are a few examples of the many successful polar education and outreach programs supported by the U.S. National Science Foundation (NSF) and the USAP.

For more than three decades, the NSF Antarctic Artists & Writers Program has provided opportunities and logistical support for more than 90 scholars in the humanities (painting, photography, documentary films writing, history, and other liberal arts) to conduct fieldwork in Antarctica and on the Southern Ocean.

For almost ten years, NSF has supported the participation of U.S. high school students in the Joint Science Education Project (JSEP). JSEP was established by the Joint Committee of the Greenlandic, Danish and American governments as a collaborative diplomatic effort during the IPY to educate and inspire the next generation of polar scientists and to build strong networks of students and teachers among the three countries by taking students to Greenland to observe polar science in action. More recently, in a new internationally collaborative program with similarities to JSEP, U.S. high school students and teachers traveled to Antarctica with the winning teams of students and teachers of the long-running Chilean Feria Antártica Escolar. This Joint Antarctic School Expedition provides participants with hands-on experience with Antarctic environments and ecosystems research with the support of the Chilean National Antarctic Institute (INACH) and the USAP.

NSF funds Long Term Ecological Research (LTER) projects at two sites in Antarctica – the McMurdo Dry Valleys and the Palmer Station area. Both LTER projects support a variety of education and outreach efforts that are mainly aimed at K-12 students and include websites, children's books, and bringing educators into the field.

Polar-ICE is a new, NSF-funded program that creates partnerships between teachers and polar researchers for the purposes of helping polar scientists communicate with diverse audiences; creating opportunities for educators and students to virtually get involved in polar research; and sharing our broader understanding of science education practices.

Future directions for NSF and USAP education and outreach include efforts to bring scientific data from the polar regions directly into the classroom and to develop international collaborations for scientists at an early stage in their careers.

## ***Educational outreaches of the CzechPolar project and associated activities within the Czech Antarctic Programme***

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Within last two decades, education of undergraduate and postgraduate students at the Masaryk University (Brno), an institution responsible for running the Czech Antarctic station J.G.Mendel and education of a new generation of Czech specialists in a variety of disciplines in Antarctic science, has been carried out in regular courses: (1) Polar Ecology, and (2) Polar Plant Biology. The two core courses have annual attendance of about 20 students each and focus a variety of topics related to Antarctic science. The course Polar Ecology covers the theoretical part of geoscientific disciplines focused on Polar regions. It includes information covering polar research in the following scientific branches: geology, geomorphology, meteorology, climatology, glaciology, hydrology and limnology. The Polar Plant Biology includes Plants in the Arctic and Antarctica, vegetation of coastal and continental Antarctica, vascular plants in polar regions, diversity of algae and cyanobacteria, mosses and lichens • physiology of plant acclimation and adaptation, and plant stress physiology. The aim of the two courses is to provide information on principles of structure and function of polar ecosystems, critical environmental factors in polar regions, acclimation and adaptation strategies of plants to extreme polar environments, basics of field work in polar regions, including polar expedition scheduling and organization. Last but not least case studies analysis approach is applied in the two courses. Just recently, some new courses have been introduced to attract international students coming to the Masaryk university mainly within ERASMUS- or bilateral agreement-based framework. The new courses (given in English) are: (a) Past, Present and Future Changes of the Cryosphere, and (b) Experimental Plant Biology. Within the first course, students work on a special project processing data from Antarctica. Within the latter course, students are provided a chance to work experimentally with Antarctic samples in a specialized laboratory (Extreme Environments Life laboratory, MU, Brno). Result of students project could be published. Students are offered an opportunity to submit a manuscript to an international peer-reviewed SCOPUS-indexed journal Czech Polar Reports which has a policy to encourage young and early-career polar scientists to publish short communication or methodological note. Apart of regular teaching, there is a practical training of students in specialized university-based laboratories or CzechPolar infrastructure. Within last five years, 43 students (including international students) of Master and Bachelor study programmes were trained directly at the CzechPolar (Masaryk University) Infrastructure (J.G. Mendel Czech Antarctic Station and EEL Laboratory). The number of postgraduate students trained at the Infrastructure reached 17 within last 5 years. Five PhD students connected to the infrastructure successfully defended their PhD theses during the entire CzechPolar project run. The results and outputs of the Infrastructure were implemented into 15 taught modules for more than 500 students of three different Czech Universities (Masaryk University Brno, Charles University Prague, University of South Bohemia České Budějovice). Approximately 2000 students could get acquainted with the results of the infrastructure during the CzechPolar project run. Academicians associated with CzechPolar project have also given more than 100 other lectures within other courses or lectures for secondary school students.

## ***E-learning course on the Antarctic environment: An interdisciplinary and collaborative production***

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Citizens all over the world ignore major aspects related to the Antarctic environment. The geographic distance from the frozen continent and the apparent absence of linked climatic and ecological characteristics are some of the major reasons of this phenomenon, which is reflected in the formal education and informal knowledge basis. In formal educational courses the Antarctic related subjects are clearly underestimated by teachers. This mainly occurs because teachers themselves are not adequately informed – and formed - and there is virtually no in deep literature on the theme. In order to fulfil this gap we idealized and produced a Portuguese-based e-learning course focused on the Antarctic environment, covering its physical, chemical, biological and ecological aspects. The course is basically composed of video classes presented by six Brazilian polar researchers working in different universities and with diverse expertises. All researchers are current members of the APECS-Brazil council. To support teachers during the e-course we also produced additional literature and practical activities to be used during their classes. This course was only possible because an extremely wealthy environment has been constructed between the INTERA (Inteligência em Tecnologia Educacional e Recursos Acessíveis – Educational Technology Intelligence and Accessible Resources) Research Group (Federal University of ABC, Santo André municipality, SP, Brazil) and the APECS-Brazil, a successful case of multidisciplinary and collaborative research work. The project was implemented following these steps: 1) meetings to address subjects for each researcher, 2) preparation of the content to be included in the videos, 3) script preparation and approval, 4) searching and selection of images and videos to be used in each class, 5) selection of each location (studio, outside, online set), 6) record in the Federal University of ABC, 9) edition of all videos by professionals, 10) revision of each lecture by the entire team until they are made available for the audience. Researchers contributed technically and scientifically within all Antarctic themes and presented lectures themselves, whereas the INTERA team offered the expertise in-video production and in-distance e-learning course. The major challenge to the researchers was to face the camera and act as “actors” using a clear and entertaining language, without losing focus of conveying information accurately. This was because all activities that involve producing videos, from writing scripts to interpretation, were unusual and really new to all researches engaged in this production. After some takes, however, it became a pleasure for both researchers and video-producers. This was a wonderful experience to researchers as well as an action to really reach different stakeholders. The e-learning course is produced by communication specialists and presents technical and esthetical high quality aiming to disseminate the Antarctic-related knowledge to a wider and diverse audience.



## ***Expedition to the South Pole: a role play for pupils***

**Lucilla Alfonsi**<sup>1</sup>, Claudio Cesaroni<sup>1</sup>, Massimo Crescimbene<sup>1</sup>, Federica La Longa<sup>1</sup>, Vincenzo Romano<sup>1</sup>  
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The idea to communicate and to share the experience of the scientific research in Antarctica with the public and with the school is a challenge that a team of INGV researchers, engaged for many years in scientific missions in Antarctica, carries on with great enthusiasm within the several outreach activities of the Italian National Program for Antarctic Research (PNRA).

The present work reports the experience of the outreach laboratory "Expedition to the South Pole", realized in the frame of events organized by INGV and dedicated to the primary school (8-11 years).

The educational themes developed within the laboratory concern the research in Antarctica, with particular focus on the human aspects, the geophysics and the progress of new technologies. The innovative aspect of the laboratory stands in the strategy to deal with Antarctica with an educational aim, proposing Antarctica as a natural laboratory, not only from a scientific point of view, but also as a laboratory of human experiences sharing.

The laboratory is realized by role playing methodology. Kids play the roles with the goal to acquire the knowledge on Antarctica, to explore its characteristics, to experiment an emotional education through individual and team experiences. A video of the laboratory was played to demonstrate the positive response of the pupils to the proposed activities. The video is structured as a tutorial for teachers that want to include the Antarctic themes in their lessons through an original approach. The presentation will illustrate the laboratory, also by means of the video excerpts, to show the outcome of the proposed experiences and to propose the role play technique to educate the new generations on the several meanings of the scientific activities in Antarctica.

## ***Ice Flows: A Game-based Learning approach to Science Communication.***

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Game-based learning allows people to become immersed in an environment, and learn how the system functions and responds to change through playing a game. Science and gaming share a similar characteristic: they both involve learning and understanding the rules of the environment you are in, in order to achieve your objective.

We will demonstrate and promote the educational game “Ice Flows” which tasks the player with getting a penguin to its destination, through controlling the size of the ice sheet via ocean temperature and snowfall. The game aims to educate the user about the controls on the behaviour of the ice sheet, including the configuration of the basal topography.

The game is funded by a NERC Large Grant entitled “Ice shelves in a warming world: Filchner Ice Shelf system, Antarctica”, so will use data from Weddell Sea sector of the West Antarctic Ice Sheet to generate unique levels. The game will be easily expandable to other regions of Antarctica and beyond, with the ultimate aim of giving a full understanding to the user of different ice flow regimes across the planet.

## ***Lost information on a new continent: What do newspapers tell us about Antarctica?***

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Some newspapers are published daily and can be valuable sources of information and knowledge for the general public. Additionally, newspapers may also be considered source of historical records, keeping hard copy and digital archives of their issues. This archive can provide historical data over time that are useful for researchers across subjects. Newspapers publish news about science at the global level every day, and society is increasingly interested in news about science and technology, in particular about scientific discoveries and also about anthropogenic impacts in the Planet. Newspapers publish information sourced from all areas of the planet, including the remote Antarctic continent. The aim of this study was to delineate the profile of the diffusion of science related to Antarctica and climate change published in two Brazilian newspapers with mass circulation: "O Globo" and "Folha de S. Paulo". Both newspapers have all published materials available digitally. Published material was examined over the period from 1980 to 2014, and includes the period immediately prior to the initiation of Brazilian research activities in Antarctica (1982/1983). All newspapers articles including reference to Antarctica were classified under the subject headings of: Science, Culture, Brazil in Antarctica, World, Politics, Sports, Opinion, Advertising, Tourism, Brazil, Education, Economy, People or Others. Our study presents novel and original information on the dissemination of polar information in Brazil since the setting up of the Brazilian Antarctic Program. Over the period considered we found 3,511 articles published in "O Globo" and 2,776 published in "Folha de S. Paulo". About 29% (1,020) of the "O Globo" articles and 27% (833) of those in "Folha de S. Paulo" were classified as Science. These articles addressed recent research and scientific discoveries, generally using scientific journals as a source. As the general public has little or no access to academic journals, these newspapers are clearly playing a role in bringing science to the public. In terms of specific scientific subjects, "Climate Change" was the most addressed. We found 422 articles in "O Globo" and 308 articles in "Folha de S. Paulo" including at least one of the following keywords: "Global-warming", "Ozone-layer", "Melting-Ice" "Greenhouse-effect" "Climate-Change". The keyword "Global Warming", was the most frequently used, appearing in 193 articles classified as science. The number of articles about Antarctica and climatic changes published by Brazilian newspapers has increased considerably in the last 10 years. Brazilian media interest in Antarctica theme has increased year-on-year since Brazil started national research activities on the continent. Our data also indicate that climate change is an issue of great public interest, underlying the increased attention given by newspapers to the subject.

## ***Outreach programs on polar science by NIPR, Japan***

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To reach out mainly to young students, “Antarctic and Arctic science contest” and “Antarctic teacher program” have been carried out by National Institute of Polar Research (NIPR), Japan. The video conference system is used as the key technology to connect the relay between bipolar field and the classroom in Japan.

“Antarctic and Arctic science contest” had been launched in 2004, and the 13th contest will be held in this year. This program invites the design of observation, research or experiment in Antarctic or Arctic from junior high school and high school students. The first-prize proposal is implemented by Antarctic or Arctic expeditioners and the result is reported directly from polar stations by using video conference system. Every year, several hundred proposals are carried to the public relations office in NIPR and staffs are alternating between joy and embarrassment on the selection.

In 2009, NIPR and Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched another project, “Antarctic Teacher Program”. Every year, two teachers from the elementary, junior high, or high schools had been selected by competition on syllabus planning, and sent to Syowa station in Antarctica as companions of Japanese Antarctic Research Expedition (JARE) team. In austral summer, they give the live lectures from Antarctic to their working schools and some other venues, by using video conference system. Also after back from Antarctic, the teachers have many chance to talk their experience to children and/or general citizen. In total, 14 teachers had been sent to Antarctic until the 2015-2016 season and the network of the returned teachers were organized.

## ***Portugal Education And Outreach: bringing polar science to wider audiences***

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Continuing the successful education, outreach and communication work developed in the last 10 years, most recently through the projects “Profession Polar Scientist” and “Education Propolar”, coordinated by polar educators and polar scientists in collaboration with the Association of Polar Early Career Scientists (APECS), Polar Educators International (PEI) and the Portuguese Polar Program PROPOLAR, Portugal have been developed initiatives to bring polar science to a wide range of audiences.

In this presentation, we wish to review our national activities in a wider international context, providing examples of taking polar science until the classroom, the development of a close collaboration between scientists and teachers/educators in SCAR, ATCM, APECS and PEI and promote activities of a greater interest and involvement of younger generations in science, creating deeper roots and strong for the dialog between science and society and promoting a participation and contribution based on global challenges that the World faces today.

This has been achieved both nationally and internationally. Nationally, we produced educational materials relevant to educational institutions: short movies (aka frostbytes) about a specific Antarctic theme – in Portuguese and English, an itinerant photo exhibition about Polar Regions that has been all over the country (in schools, universities and public places) and organizing POLAR WEEKS, taking polar scientists into schools (to give presentations) or via skype from the polar regions. This latter initiative occurs twice a year in collaboration with APECS, PEI and PROPOLAR. Finally, national polar science education workshops, organized every 2 years directed to polar educators (Mamarrosa 2014 and Lisbon 2016), aims to boost the network of polar educators while addressing the major gaps of knowledge and needs of this community. Internationally, Portugal has been highly active at the Antarctic Treaty Consultative Meetings, particularly on the Intersessional Contact Group on Education and Outreach (ATCM ICG E & O) to promote a network of information exchange and collaborations of Parties on Education and Outreach, being active on the SCAR Education and Outreach subcommittee, Polar scientists and educators have co-organized the International Polar Science Education Workshop (Hannover, 2015) organized by PEI, and Polar scientists and educators actively participated in the international master class in collaboration with Polar Educators International. Various papers on the issue have started to be published (e.g. Xavier et al. in press; May et al 2014, Walton et al 2013, Zicus et al. 2011, Baeseman et al. 2011). In conclusion, Portuguese polar community (Polar scientists and educators) has carried out a wide range of education and outreach activities, with an international network (connecting SCAR, APECS and PEI, and numerous countries worldwide), that has produced useful tools and materials that can be applied by other countries.

## ***Texts production for a distance learning course on Antarctica - dialogic training for basic education teachers***

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The polar science popularization is a practicable way to present to society the importance of the frozen continent to the life on Earth. Thus, spread the Brazilian scientific research in Antarctica allows us to understand how such a remote place interacts with the context in which we live.

In Brazil, the visibility of Antarctic sciences could achieve better levels if they were integrated into education. However, several issues related to this field still does not include the minimum curriculum for basic education and, for this reason, teachers rarely have the knowledge or equipment to work in the classroom.

This paper presents the production process of written teaching materials for a distance learning course that is based on a dialogical conception of learning, whose goal is to prepare basic education teachers to insert various topics of Antarctic Sciences in the school context.

In the dialogical learning (Dotta, 2009), the methodology agrees with an interdiscursive condition of the language in which each discourse composes itself from another speech, creating multiple voices. The voices are appropriated from the reality in which the subject is inserted in a social and discursively context and presents itself in several texts revealing ideas, experiences, opinions, points of views, ideological positions (Bakhtin, 2009). In this sense, dialogicity opens ways for subjects to interact, learn, grow in diversity and before the various discourses on educational practice, gradually reveal the inquisitive curiosity and problematizing that promotes the search for the significance of meanings (Freire, 1987).

The course is divided into six independent modules (Compass, Convergence, Life, Ice, Environment, and Destination) and is distributed within twelve weeks. Its composition is based on a structured tripod by materials (video lessons, texts, tutorials), activities (discussion forum, project, social network) and communication (educational support, technical support, and group discussion forum) in which proposals agree with a dialogical and problematizing approach responsible for the continuous interaction between the attendees and others offered contexts.

Our choice for the dialogic textual composition is the result of a research project in distance learning, which finds in this methodology a timely linguistic tool, allowing us to "translate" the Antarctic knowledge to an accessible language.

We hope to encourage the progressive training of multipliers of Antarctic knowledge so that the differential of the dialogic proposal is an enabler of cognitive apprehension and an exciting way to develop critical and reflective postures about the future of the planet.

## ***The marine fauna and flora of Terra Nova Bay (Ross Sea): a book for the recognition of Antarctic coastal species***

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Despite more than one century of Antarctic research, a large body of literature potentially available and the existence of online tools, such as the Antarctic Field Guide initiative ([www. http://afg.biodiversity.aq](http://afg.biodiversity.aq)), most Antarctic species still cannot be easily recognized in the field by non-experts. In general, there is lack of field-guides showing species colour patterns, their living habitus and the skeletal elements necessary to their classification.

In the book “The marine fauna and flora of Terra Nova Bay (Ross Sea)” we try to fill this gap by producing the first global census of the species occurring in the area, from diatoms and forams up to whales, and a pictorial guide for most of these.

In fact, thanks to a massive effort done in the past years to document species by high-quality digital photography, jointly with a detailed research of images already published in several papers, we’ve tried to reach the ambitious target to give an image to each species. We have also placed a special effort in adding those features (such as spicules, ossicles, sclerites) that are routinely omitted in field guides when sponges, holothuroids and octocorals species are figured. These skeletal elements have been photographed at the scanning electron microscope and, thanks to the availability of this supplementary information, species can reasonably well recognized in the field also by not-experienced young Antarctic researchers.

Several other peculiarities distinguish this book from the other already existing guides. In fact, most determinations of the figured species have been validated through barcoding and most of the figured species are from museum vouchers permanently stored at the Italian National Antarctic Museum (Section of Genoa). As such, these vouchers will remain permanently available to the scientific community for further studies and crosschecks. Distributional records of the species have also been validated and will progressively be published in form of data papers on Zookeys, becoming therefore accessible through GBIF. At the end of the guide, a collection of ROV images done in the course of several ROV explorations in the area is also offered to the reader, completing the photographic documentation of the species done in the lab with in situ images of untouched species.

All chapters of the book result from a collaborative effort of Italian and foreign expert of the different groups that joined this project with enthusiasm. Despite the apparently limited geographical scope of this field guide, it will potentially result useful also for other Antarctic areas, since several species have broad distributions. In any case, this book, by encompassing all marine groups, automatically represent a valid textbook of zoology also for education, outreach and training purposes.

## ***Valorization of national and international polar education and outreach programs to disseminate Antarctic information***

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Romanian polar research institutions (1994-2010), i.e. former Romanian Polar Research Institute and Romanian Antarctic Foundation, since 2005 developed/performed, involving universities/research institutes, schools, the media, a program of polar education&outreach within the Project "Polar Research and Protection—a Priority", enabling scientists, students and pupils, decision factors, media and general public to be informed on Antarctic values/challenges and the necessity of Antarctic research and protection. The program included: conferences [Romanian Academy (RA), Ministries], school-classes, pupil contests/drawings, photographic exhibitions, public library lectures, educational journals (Terra Magazine), information by the media: interviews, press-releases, Radio/TV broadcasts, YouTube videos, important Romanian journals; two books (expedition diaries) by Dr. Teodor Negoita on Romanian cooperation with Australia, China, Russian Federation in Antarctica: "With Chinese People in Antarctica" (2005); "Romanian Embassy in Antarctica. Law-Racovita Station" (2007); a photo-album/CD in English, Romanian, Danish: "Ways to Greenland" by Andrei Iordache (2008 Romanian expedition). National Commission for Antarctic Research (NCAR) of RA, since 2012 the current national Antarctic Operator, continued this program to raise awareness of scientists, educators, decision makers, general public of anthropic activities, climate change impact on polar regions, and efforts to preserve biodiversity/polar ecosystems. Programs "Discover life in Antarctica with polar researchers" and "Know and protect Antarctica!" were implemented, including lectures, school-classes, books/CDs (Pompiliu Manea "Emil Racovita and his successors", 2015), interviews, Radio/TV broadcasts; reports on web-sites (RA; "Memorandum"; Romanian Embassy in Australia on Romanian-Australian cooperation; Romanian Embassy in Brussels on ATCM 2013, "Belgica" Expedition, "The Explorer" documentary film on Emil Racovita). Romanian educational system includes environmental protection classes at all pre-university levels. University/school partnerships with ecological agencies/clubs are meant to develop responsibility for areas unique in the World, Antarctica included. Voluntary participation of students, teachers, pupils in ecological activities encourage participants to use knowledge to protect nature [ECOIND of Ecological University Bucharest; "T.Gh.Negoita" ECO-Club and "D.Mangeron" Technical College Bacau; Circle of Studies "The Danube Delta and Law-Racovita Antarctic Station" at C.A.Rosetti School with 7 satellite-schools in Danube Delta Natural (Biosphere) Reserve (UNESCO). Student-pupil-teacher-ecologist cooperation supports environmental protection in neighbouring protected areas (Danube Delta; Bacau Bistrita); comparison with Antarctic protected areas is inspiring. National educational mean "Another kind of School" involving pupil visits to institutioes (Astronomical Institute, 2014-2015) or in-school optional activities [South Pole Exploration Centenary Symposium at "E.Nicolau" Technical School (six Focsani-County institutions)] proved efficient. National Museum of Natural History Bucharest organizes periodical/holiday non-conventional classes of biology/ecology and funny lessons to ecologically make educational/arts products. NCAR actively valorized the international polar education&outreach programs: Polar Week (2008-2010, 2014), Poles Day, Antarctica Day (2010-2015). Romania is the only state celebrating its National Day on Antarctica Day (December 1th) [e.g. Focsani Arts Highschool celebrated 25 years since Madrid Protocol: "Visual arts as a tool revealing the importance of Antarctic environment protection", 2015]. Young researchers participated in CRIOSPERA 2013-2015, APECS (2010; 2013-2015). These programs enhanced public interest on Antarctica, the number of participating institutions/people, inter-institutional cooperation; diversified educational methods/means; contributed to the capacity-building efforts.



<http://memorandum.ro/statia-law-racovita-negoita-din-antarctica-un-vis-implinit-in-lumea-aisbergurilor/>  
<http://www.antipa.ro/ro/categories/58/page>  
<http://vranceamedia.ro/antarctica-day-2015-la-liceul-de-arta-din-focsani/>

## **Mini Symposium : Connecting the biological and the physical: Environmental drivers of biodiversity in Antarctica**

### ***An environmental role in assembling cyanobacterial mat communities in ponds of the McMurdo Sound region, Antarctica***

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The variety of microbial ecosystems that exist in Antarctica represents an extraordinary opportunity for research on microbial ecology, diversity and evolution and particularly of cyanobacteria which are frequently the dominant autotrophs. Here we focus on the role of environment in controlling cyanobacterial mat assembly, and begin by describing the cyanobacterial diversity of mats in ponds from four distinct geographic sites: McMurdo Ice Shelf, Ross Island and Upper and Lower Wright Valley. We then investigated whether cyanobacteria composition of mats is related to environmental conditions, geographic position or a mixture of both by relating physical and chemical properties to the distribution of cyanobacterial morphospecies in 25 ponds. Twenty-nine morphospecies were identified and described. Four were assigned to the order Chroococcales, three to Nostocales and 22 to Oscillatoriales. Based on multivariate analysis of habitat variables, Ross Island, McMurdo Ice Shelf and Upper and Lower Wright Valley ponds tended to cluster by site, though with considerable overlap, and with the two Wright Valley and two coastal sites (Ice Shelf and Ross Island) tending to be more similar to each other. This pattern was reproduced in analysis of biomass and species composition data, though we were able to identify taxa that were broadly spread across the region and others that were more restricted by site. Although our data revealed that there is a clear gradient from coastal ponds (nitrogen-depleted and high phosphorus concentration) to inland ponds (high nitrogen concentration, high electrical conductivity and low phosphorus concentrations) the geographic effects make it difficult to isolate environmental variables that specifically correspond to mat composition and how. In conclusion, our findings suggest that within the area bounded by our study sites, a metapopulation of cyanobacteria appears to exist, most of which are well dispersed, probably by wind. On the other hand, the association of some taxa with a specific site suggests that a deterministic mode might be acting on local cyanobacteria community composition. The presence of local taxa across a range of pond conductivities within each site may reflect efficient short-distance dispersal within sites that may create more local specificity than across the whole McMurdo Sound region. While this pattern remains to be confirmed by a broader study, the present study provides an increased knowledge of the ecology of Antarctic cyanobacteria, as well as suggesting the importance of keeping these areas in pristine condition in order to protect biodiversity of regional Antarctic ecosystems.

## ***Bacterial population profiles of inland nunataks in Dronning Maud Land, Antarctica.***

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The Antarctic is considered to be the last remaining pristine continent left on Earth. Most of the continent is covered by ice, with only approximately 0.3 % of the terrestrial habitat being ice-free. It is these ice-free areas where the soil ecology almost entirely comprises of microorganisms. To date, little to no characterisation of microbial populations in Dronning Maud Land (eastern Antarctica) have been done. In this area, exposed soil is limited to nunataks which are isolated from one another by large ice-sheets. In this study, soil bacterial populations from nine nunataks were surveyed to determine if each isolated nunataks harbours unique microbes or if wind dispersal mechanisms result in ubiquitous distribution patterns. Microbial biodiversity was investigated using next generation sequencing of the 16S rRNA genes amplified from environmental DNA. The physical and chemical parameters of the soil were also measured for each nunataks surveyed. Despite the oligotrophic nature of the soils, the majority of the microbial communities at these nunataks were represented by Actinobacteria. Furthermore, unlike the microbial populations found at maritime sites (Antarctic Peninsula) or continental cold desert soils of the Dry Valleys in Victoria Land (Western Antarctica), representation of the phylum Proteobacteria was limited at these inland nunataks. In some instances, the bacterial community diversity profiles observed at different nunataks showed commonality whilst at others, limited species overlap was observed. Generally, differences in community profiles could be attributed to distance between nunataks and physico-chemical variances with minimal species distribution patterns attributable to aeolian processes.

## ***Cape Adare – A sentinel for change in Antarctica***

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Cape Adare stretches some 40km beyond the Antarctic Continent across the Continental Shelf. It is flanked to the east by the northern Ross Sea and to the West by Robertson Bay. The following characteristics make it an ideal monitoring and observation point to understand the impact of warm ocean and climate propagating into Antarctica from the Southern Ocean:

- 1) Robertson Bay is some 500m deep and has the potential to record deep water inflow which is predicted as climate warms and is also indicated as the biggest risk for melting Antarctic ice shelves.
- 2) Cape Adare also lies between the Antarctic continental high pressure and the Southern Ocean low pressure
- 3) Ridley Beach at the tip of the Peninsula is home to Antarctica's largest Adelie Penguin Colony

In November 2015 we conducted a pilot survey of the marine and terrestrial ecology and physical setting, with a view to determining what opportunities exist for developing a long term monitoring system. Cape Adare and the Ridley Beach Penguin Colony also offers the advantage of being on the edge of the proposed Ross Sea marine protected area and may represent an opportunity to monitor the associated ecosystem. Our goal is to find a long-term ecological research and monitoring site that:

- 1) integrates across a range of marine and terrestrial environments,
- 2) integrates across a range of timescales,
- 3) allows a time-series to be developed that attributes change in order to inform policy and managements goals,
- 4) can decipher trend and variability without aliasing the signal, and
- 5) acts as a sentinel for wider scale processes and connections.

In our recent visit, we were able to begin a penguin monitoring programme through nest monitoring and attaching splash tags to adult birds, collect a range of soil samples across Ridley Beach and Adare Ridge (for nutrient, DNA, isotope, TOC and elemental analysis), install the first ANTOS (Antarctic Nearshore and Terrestrial Observing System) station (two met stations, soil monitoring sensors and a camera). We were also able to identify benthic habitats and communities using a drop camera from the Robertson Bay Sea Ice, conduct plankton tows and sea ice algae, and conduct a series of CTD casts to define the Robertson Bay water column.

Preliminary analysis indicates that Robertson Bay has a stratified water column that is a direct extension of the Southern Ocean and the benthos is indicative of an environment more connected to the southern Ocean than sites further south in the Ross Embayment. The site is also exposed to the regular and strong cyclonic storms that circulate around the Southern Ocean.

## ***Detection of toxin-encoding genes from terrestrial cyanobacteria isolated from Signy Island, South Orkney Islands, maritime Antarctic***

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Some cyanobacteria are known to produce toxins, which can be fatal to vertebrates such as humans, dogs and fish. These toxins may be part of a strategy to avoid predation. Although maritime Antarctic food webs are, even today, poorly characterised, cyanobacteria clearly may form part of the diet of various native terrestrial invertebrates, such as mites, springtails, nematodes, tardigrades and rotifers. We collected terrestrial cyanobacterial samples from 72 sites on Signy Island between December 2015 and February 2016 in order to determine their ability to produce various toxins. This ability is assessed by detecting the presence of toxin-encoding genes, targetting genes that encode the most common cyanobacterial toxins such as such as microcystin, anatoxin-a, clyndropermopsin, nodularin and saxitoxin. Cyanobacterial strains are also being isolated, purified and identified using both morphological and molecular 16S Ribosomal RNA) methodologies.

## ***Dial changes in community structure and function in coastal waters of the Southern Ocean during austral summer***

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Taxonomical composition and functional activity of the whole community inhabiting the surface waters of the Chile Bay (Greenwich Island, Antarctica) were analyzed during 2014 austral summer using metagenomics and metatranscriptomics techniques. Furthermore, in situ nitrogen and carbon fixation, together with nitrate and ammonium assimilation isotopes experiments were also examined on samples collected during day and night in the same sampling site.

We found differences in the abundances and activity among taxonomic groups of Bacteria, Archaea, and Eukarya.

The most relevant example was in the Archaea division, which were very low represented during the night but, nevertheless, it was the period where they showed the higher activity.

On the other hand, microcosms experiments revealed that nitrogen fixation rates were low, but they were greater in the light. Nitrate uptake was always much higher than that of ammonia and in both cases, assimilation rates were higher during the night. Metatranscriptomics also revealed that Thaumarchaeota were very active at night and they could have been involved in nitrification and denitrification processes, the more represented nitrogen metabolism in our samples.

More samples have to be analyzed and new experiments have to be done to really understand the role of Thaumarchaeota in the Antarctic surface waters but our preliminary findings reveal an important role in the Antarctic nitrogen cycle.

## ***Did stepping-stone dispersal along the Scotia Arc cause the faunal similarity between Antarctica and South-America? A molecular case study***

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Of all continents around Antarctica, South America is the one sharing more species with shelf-depth habitats in the Southern Ocean than any other (Australia/New Zealand, South Africa). This large-scale pattern holds true across many different taxa and has been explained by inferring a facilitated inter-continental dispersal thanks to the presence of the Scotia Arc. This series of intermediate islands provide suitable intermediate shallow-water habitats to break a successful dispersal across an open-water barrier into a series of shorter, more likely ones along the linear dispersal route.

Here, we use mitochondrial sequence and 10 unlinked nuclear microsatellite data from *Glyptonotus* sp., a giant Antarctic crustacean, collected from Rothera in the South all along the hypothesized Scotia Arc dispersal pathway up until South Georgia in the North to test predictions of the stepping stone dispersal hypothesis in a statistical framework. Our results indicate that the stepping-stone hypothesis is an oversimplified view and that the evolutionary past of *Glyptonotus* and likely other shallow-water fauna can be reconstructed as a complex mixture of short- and large-scale dispersal events at various temporal scales.

While the presence of islands in the Scotia Arc as such may have influenced the dispersal on a continental scale over evolutionary times, our data clearly indicate that the framework of stepping stone dispersal does not enhance our understanding of the underlying processes and underpin the importance of current oceanography and glacial past instead.

## ***Distribution patterns of seabirds in Southern Ocean and Antarctica with reference to climate change***

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Seabirds have been studied extensively as the indicators of ecosystem change in Southern ocean. A study aimed to assess abundance, distribution patterns and nesting behaviour of seabirds in the Indian sector of operation of Southern ocean and Antarctica was initiated in 2013-14. Southern Indian Ocean and in Antarctica at Larsemann Hills (East Antarctica), located in the Prydz bay region, comprise of several partially ice-free islands spread over an area of 50 Km<sup>2</sup>.

Variable width belt transect method was used to survey sea birds during voyage between Cape Town and the Antarctica. Observations were carried out onboard MV Ivan Papanin and recorded all birds seen within 300m either side of the ship. The pre-determined voyage route represented a non-randomised transect between the two continents. Further, islands of Larsemann hills were visited using helicopters and nesting sites of birds on islands were located using area search method. Nesting sites were marked and characterized for physical parameters such as location, slope, aspect, rock type, chamber volume, orientation, substrate type etc.

Over 3000 km of voyage route sampled for seabirds revealed the presence of minimum 49 species of seabirds. Analysis showed higher average bird counts at the marginal ice zone near the sea-pack-ice interface in the late summers. Although, the number of bird species recorded in the different latitudinal zones were more or less similar ( $R^2=0.003$ ), higher number of oceanic birds were recorded between 60°S and 70°S. Average biomass of pelagic seabirds peaked at south of the Sub-tropical convergence shows that the sea-pack-ice interface seems to be better habitat for high prey species abundances. Thirteen islands at Larsemann hills were found to have nesting sites of Snow Petrel, South Polar Skua and Wilson's Storm Petrel. A potential Adélie penguin breeding colony was also located east of Larsmann Hills. The estimated density of snow petrel nests was  $0.04 \pm 0.03$  nests/m<sup>2</sup> at Larsemann Hills and largely located at slab (59%) and crack (20%) type of rocks. Surface nesting was not observed in any snow petrel colony.

Latitudinal distribution patterns of birds indicates that fronts and sea ice play key roles in influencing seabird assemblages in Southern ocean. Further, preliminary results from the nesting data suggest the avoidance of wind and ice accumulation by selecting more sheltered nesting sites. Survey during the early summer is found to be critical to better understand the nest occupancy and survival breeding seabirds of Larsemann hills. Range extension of Cory's Shearwater, Antarctica skua, Cape Petrel, White-capped albatross, Grey-headed albatross, Blue petrel, Sooty albatross, Kerguelen petrel and Great winged petrel towards Antarctica might be due to increase in temperature because of global climate change is worrisome as it will affect the overall species composition of biodiversity in polar region.

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## ***Diurnal activity of Antarctic soil arthropods relative to environmental conditions and genomic characteristics: Implications for a changing climate***

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Arthropod communities within the McMurdo Dry Valleys of southern Victoria Land consist of only three species: the springtail *Gomphiocephalus hodgsoni*, and mites *Stereotydeus mollis* and *Nanorchestes antarcticus*. However, the majority of studies have focussed on *G. hodgsoni*, a species which is metabolically active when soil temperatures are above 0 °C and harbours high genetic diversity (allozyme variability, mitochondrial DNA haplotypes). To assess how projected temperature increases may influence genetic diversity and gene flow among both springtail and mite populations, we focussed on monitoring the activity of both taxa relative to local environmental conditions.

Most animals collected in pitfall traps in Miers Valley (16-24 January, 2016) were *N. antarcticus* (91%), with *G. hodgsoni* comprising only 5% and *S. mollis* 3% of the captured individuals. This suggests that *N. antarcticus* is more numerous and is also more active than the other arthropod taxa in Miers Valley. Based on 24 hour daylight sampling of “-morning” (9 am to 1 pm), “-afternoon” (1 pm to 5 pm), “-evening” (5 to 9 pm) and “-night” (9 pm to 9 am) collections, average subsurface soil temperature was lowest during the “-night” (average 3.7°C; max. 11.2°C). Evening sampling (max. 15.6°C) harboured the lowest activity overall at only 12% of the total captured population, whereas morning (max. 19.2°C) and afternoon (max. 16.5°C) collection periods were highly similar with 29% and 28% of the activity occurring during these periods, respectively.

Previous assessment of soil arthropod activity at a Taylor Valley location revealed differential responses relative to air temperature between two genetic (mitochondrial COI haplotype) groups of *G. hodgsoni*. Genetic data from the current season will also be aligned with arthropod activity data and microhabitat environmental measurements to ascertain any correlations between haplotype activity and environmental variables in Miers Valley.

Arthropod activity and genetic mutations vary considerably between different locations within the Dry Valleys of southern Victoria Land, Antarctica. Genomic characteristics of populations are likely to be particularly informative to monitor as they are highly variable, whereas only a handful of morphological species are present. This will provide a suitable and subtle measure by which to detect the effects of gradual climate changes on biological communities and allow predictions to be made on how populations are likely to respond to climate changes.

## ***Effects of freeze thaw cycles on bacterial diversity in polar and tropical soils***

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Freeze thaw stress has been known to alter the soil bacterial community structure. The primary objective of this study was to investigate the effects of freeze thaw cycles on the polar and tropical bacterial soil community. Bacterial diversity responses to repeated freeze–thaw conditions were studied in two complementary experiments. Soil samples collected from the Arctic, Antarctic and Peninsular Malaysia were subjected to gradual freeze–thaw cycles (from 4 to 2, 0, –2 and –5 °C) and abrupt freeze–thaw cycles (from –20 to 10 °C). 16S rRNA gene-based denaturing gradient gel electrophoresis profiles revealed persistence of the dominant bacterial taxa under gradual freeze–thaw cycles, whereas bacterial diversity decreased markedly under abrupt freeze–thaw cycles, particularly of the tropical soil sample.

## ***Feeding ecology of Antarctic krill (*Euphausia superba*) in the Antarctic Peninsula in the autumn-winter using stable isotope analysis***

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The impacts of global climate change on vulnerable Antarctic ecosystem was increasingly occurred, it's very helpful to understand the change of Antarctic marine ecosystem structure based on the feeding habit of Antarctic krill (*Euphausia superba*). Feeding ecology of Antarctic krill off the Antarctic Peninsula was analyzed using stable isotope analysis. The results indicated the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values in the of Antarctic krill ranged from  $-29.65\text{‰}$  to  $-21.43\text{‰}$ , and  $3.05\text{‰}$  to  $8.12\text{‰}$  respectively. The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of krill tissue from the two survey areas (off South Shetland Islands and in the Bransfield Strait) were not related to the standard length. The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of the individuals in the Bransfield Strait and the  $\delta^{13}\text{C}$  values of individuals off the South Shetland Islands increased gradually from April to June. However, similar result cannot be found for the  $\delta^{15}\text{N}$  values of individuals off the South Shetland Islands. The  $\delta^{13}\text{C}$  value of krill off the South Shetland Islands was larger than that of krill in the Bransfield Strait in autumn-winter (May-June). However, the trend of  $\delta^{15}\text{N}$  value was different from the  $\delta^{13}\text{C}$  value. In May, the  $\delta^{15}\text{N}$  value of krill off the South Shetland Islands was larger than that of krill in the Bransfield Strait; but in June, the opposite result occurred. The results showed that the food source of krill was stable when entering into the winter season. Stable isotope analysis will provide better evidence of material source of the ecosystem, and will be helpful to get insight into ecosystem structure and will provide some references for feeding studies of Antarctic krill.

## ***Genetic diversity of the Antarctic pearlwort colobanthus quitensis (Caryophyllaceae)***

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With the exception of the recently human-introduced *Poa annua* (Poaceae), the flora of the Maritime Antarctic includes only two species of vascular plants: *Colobanthus quitensis* and *Deschampsia antarctica*. *Colobanthus quitensis* is a small size perennial herb that forms aggregation of shoots in dense cushions (5-30 cm diameter). Interestingly, this species is within the vascular plants with the more extended range of distribution worldwide growing from México (17°N) to the Antarctic Peninsula (68°S). While some authors have suggested the Tertiary relict status of these Antarctic plants, others have claimed that it is a recent Holocene immigration. Although there is no concluding evidence (fossil record) supporting the Tertiary relict status of this species in Antarctica, molecular data could shed light on this enigma. In this study we used AFLP (Amplified Fragment Length Polymorphism) markers to examine the patterns of within- and among-population genetic diversity of eight South American (high Andean and Patagonian) and five Antarctic populations of *C. quitensis*. Four selective primer combinations produced 730 polymorphic bands. These data were used to estimate the following indices of within-population genetic diversity: mean unbiased expected heterozygosity (HE), percentage of polymorphic loci (PPL), and Shannon information index (I). In addition, among-population genetic differentiation was evaluated using the analysis of molecular variance (AMOVA). Overall, within population genetic diversity was moderate (HE= 0.121; PPL= 42%, I = 0.181). Within population genetic diversity did not decrease with latitude. AMOVA analysis showed that of the total genetic diversity detected, 16% was maintained among populations, 10% contained among regions, and 74% resided within populations. In contrast to *D. antarctica*, we did not find evidence for a reduction in genetic diversity with latitude in *C. quitensis*. Our results do not provide evidence for a recent stepping-stone model of colonization of Antarctic populations of *C. quitensis*.

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## ***Hydrographic characteristics in the Gerlache strait during summer 2016***

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Gerlache Strait (GS) is located in the western area of Antarctic Peninsula, a region of high biological productivity which is currently being affected by climate change. The south-western end of this strait is characterized by the cold surface of Antarctic Surface Water (AASW) above the Lower Circumpolar Deep Water (LCDW) present in Bellinshausen Sea (BS), less warm and less saline (García et al. 2002). The waters in the north-eastern region of GS can be divided into well stratified, relatively warm dominated by typical characteristics of BS; and cooler waters, more saline and relatively stratified dominated by Weddell Sea (WS) characteristics. García et al (1994) referred these waters as Transitional Water with BS influence (TBW) and Transitional Water with WS influence (TWW), respectively.

During summer 2016, 16 oceanographic stations were made on board of MOV Dr. Bernardo Houssay in GS and passages that communicate with adjacent waters. It was used a SBE 911 plus CTD profiler with oxygen sensor SBE 43 and fluorometer WET Labs ECO-FL-NTU, connected to SBE 32 rosette with 5L Niskin bottles. Observations were made in a section between Amberes and Bravante islands, and from there, in a leg to Bransfield Strait (north leg) and other to Orleans channel (south leg). Water samples were obtained from several depths in order to determine chlorophyll-a concentration.

The objective of this study, is to characterize physical-chemical parameters and water masses in the GS.

## ***Oceanographic characteristics of Bahía Paraíso during summer 2016***

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The aim of this work is to make a preliminary analysis of the oceanographic data collected during the Antarctic Summer Campaign 2016, on board of the MOV Dr. Bernardo Houssay.

Seven stations were made in Bahía Paraíso, in the western area of the Antarctic Peninsula. This bay is connected with the Gerlache Strait by the southern branch of the Canal Argentino, where water originated in the Bellingshausen Sea enters the bay; and the Pasaje Marinero and the northern branch of Canal Argentino, where waters that flow back to the strait generate an anticyclonic circulation around Bryde Island (Roese & Speroni, 1994).

The weather of the study area, the characteristics of its coasts and the irregularities of its seabed are strong determinants of the marine dynamics of the area.

The profiles of temperature and salinity were obtained with a SBE 911 CTD, which also count with a SBE 43 oxygen sensor and a WET Labs ECO-AFL/FL Fluorometer, and the samples of water were taken with Niskin bottles in order to make an in situ Cl-a determination.

In the northern branch of the Canal Argentino and in the Pasaje Marinero, warmer and saltier surface water, with average values of 0.9°C in temperature and a salinity of 33.9 psu were found, while the bottom values have reached -0.5°C and 34.5 psu. The highest values of Fluorescence and Oxygen were recorded in this branch, with a maximum of 29.33 mg/m<sup>3</sup> and 9.98 ml/l respectively. For stations located in the southern branch, the average values of temperature and salinity were 0.8 °C and 33.7 psu in the surface, and -0.02°C and 34.4 psu in the bottom. Maximum fluorescence and oxygen values were 22.48 mg/m<sup>3</sup> and 8.79 ml/l, respectively.

The maximums in fluorescence and oxygen into the outflow from Bahía Paraíso, are associated to an increased biological activity in the area.

## ***Semi-automated Antarctic vegetation monitoring using digital photography***

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Continental Antarctic vegetation forms sparse, isolated communities on small patches of ice-free land, predominantly on coastal outcrops, larger islands and some inland nunataks. These communities are good baseline environments for research into human impacts, as they have a relatively simple trophic structure, few biotic interactions and have been largely unaffected by direct human influences or invasive species. Long term studies are required to determine anthropogenic impacts such as climate change, however these communities exist in extremely harsh environmental conditions, and accessing these communities for scientific research can be challenging. Weather conditions can change quickly and time spent in the field can be short, so developing methodologies that minimise the time required in the field is vital to ensure the continuity of any long term vegetation study on the continent. Non destructive methods are preferable given the very slow growth and regenerative capacity of the vegetation. Digital photography allows very fast collection of ultra high spatial resolution data in the field, and all analyses can subsequently be completed in a warm, dry laboratory. This sampling method also complies with the Antarctic Treaty System principle of minimal destructive sampling.

A planned 25 year long term vegetation study was established, and the first three sampling periods completed, along a moisture gradient at two sites in the Windmill Islands, East Antarctica, forming the Australian Antarctic State of the Environment indicator 72 terrestrial vegetation monitoring program<sup>1</sup>. Digital photographs were taken in the 2003, 2008, 2012 and 2013 field seasons at each of 60 permanent 25 x 25 cm quadrat locations. Following preprocessing, object based image analysis (OBIA) was used for automated classification of the vegetation in the images using rules based on red, green and blue band digital values. The vegetation in each image was separated into classes of healthy, stressed and moribund moss, in addition to other ground cover classes such as rock and lichens. The relative percent cover of each class was calculated per quadrat.

The relative percent cover estimates were found to be within the range of estimates from experts, and are a comparatively non-subjective method of vegetation cover estimation. Relative percent cover estimates from object based image analysis show both rapid and reversible change, and longer lasting stress, over a decade of Antarctic vegetation monitoring in the Windmill Islands. Digital photography and object based image analysis is a useful technique for fast, repeatable and non-destructive analysis of vegetation percent cover, particularly in field sites with extreme climates.

<sup>1</sup>Australian Antarctic State of the Environment Indicator 72 - Windmill Islands terrestrial vegetation dynamics ([https://data.aad.gov.au/aadc/soe/display\\_indicator.cfm?soe\\_id=72](https://data.aad.gov.au/aadc/soe/display_indicator.cfm?soe_id=72))

## ***Solar heating, microclimate, and the formation of peat-accumulating ecosystems in Antarctica***

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Waterlogged peatlands and aerobic moss peatbanks are carbon-rich peat-forming ecosystems. Understanding their environmental controls is important for projecting their future dynamics and trajectories in a changing climate. While peatlands are widely distributed in the boreal and sub-Arctic regions as well as in the tropical and southern-hemisphere temperate regions, peatbanks only occur in the Maritime Antarctic region, on some sub-Antarctic islands, and in the High Arctic. Here we use microclimate measurements, including solar radiation, air temperature, air humidity, soil temperature and moisture content, at several peat sites in the Antarctic Peninsula and Patagonia to evaluate the key differences between peatbanks and peatlands in terms of their microclimate response to regional climate. Our results show that temperatures of moss surfaces in aerobic peatbanks of the Antarctic Peninsula can be 20°C higher than air temperature, in response to direct solar radiation heating. In these systems, high temperatures likely increase primary production and may strongly affect the rate of biomass accumulation during very short growing seasons. On the other hand, moss surfaces in waterlogged peatlands are much cooler during daytime and warmer at night than air temperature due to the influence of waterlogging on heat capacity and latent heat effects. This suggests that current cold climate in the Antarctic may limit the development of waterlogged peatlands, but support aerobic peatbanks and their expansion into hostile environments on the Antarctic Peninsula.



## ***The Antarctic Marginal Sea Ice Zone: A physical characterization and the link to biology***

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The marginal sea ice zone is a highly dynamic area due to the interaction of winds, waves and currents. In addition, the marginal sea ice zone is biologically important because of its brief, but intense spring primary production, which is an important carbon source for the marine food web from zooplankton, to fishes, to larger marine mammals. The strong variability in time and space, together with its exposure and vulnerability to weather changes, makes it hard to sample and characterize. In this work we present data collected in December 2014 and January 2015 (late spring and early summer) in the Antarctic marginal sea ice zone during a ship based expedition to the Eastern Weddell Sea. Sea ice surveys were conducted with a Surface and Under Ice Trawl (SUIT). The SUIT is equipped with a sensor array to characterize the environmental properties of the ice and under ice habitats such as: surface salinity, temperature, chl-a, spectral radiation, ice thickness, ice floe distribution, ice roughness and sea-ice algae content. The SUIT is also equipped with a net that enables the sampling and characterization of the under ice fauna. These observations in combination with biomass estimates from an echo-sounder allow us to investigate the link of sea-ice physical properties with the pelagic and under-ice community. The integration of satellite data and airborne sea-ice thickness and sea-ice surface properties allows a link and comparison between the SUIT spatial scale (~2 km) and a larger spatial scale (>10 km). Results highlight common features of the marginal ice zone but also strong differences due to temporal and dynamic changes. In particular, during late spring the marginal ice zone still extended to lower latitudes and it consisted of larger floes (>100 m) and less ridges. During early summer, the marginal ice zone was a relatively small belt surrounding the ice edge and consisted of mainly small floes with higher ridge density. These differences cannot be assessed based on remote sensing data. Moreover, such differences result in a diverse pattern of the under ice light regime with a subsequent impact on sea-ice algae content and the under ice population.

## ***The fauna of the hydrothermally active Kemp Caldera (South Sandwich Arc, Antarctica): Biodiversity and biogeography***

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In 2009, multibeam surveys in the vicinity of the Vysokaya Bank, southern South Sandwich Island volcanic arc, revealed a caldera to the west of the Kemp Seamount (59°42'S 28°20'W). This previously unseen feature measures a E-W rim-to-rim width of 8300 m and a N-S width of 6500 m. The sill depth is at 900 m while the inner caldera floor depth is ~1600 m. The topography of inner caldera floor is virtually flat apart from the presence of a resurgent cone, rising 250 m from the caldera floor, and a neighbouring bank on the western side. On the SE base of resurgent cone and on the NE flank of the bank hydrothermally active areas including venting chimneys and diffuse flow sites have been discovered. In 2010 the Kemp Caldera was further studied during JC42, as part of the NERC ChEsSo consortium science.

The fauna inside the Kemp Caldera was studied by analysing UW imagery and ROV suction sampler collections and specific faunal assemblages and their habitats described. The studies focussed on the benthic fauna and on the identified hydrothermally active areas while an overview given on the observed benthic and pelagic fauna from the non-venting environments. The video analyses define eight assemblage types (biotopes), under the influence of hydrothermal activities based either on the dominating macrofauna or on the type of substrate.

In total 26 benthic species were reported from the chemosynthetic biotopes in the Kemp Caldera, of which ten species are known from the benthic fauna in the Southern Ocean of non-chemosynthetic environments and 16 species are so far reported only from hydrothermally active areas.

## ***The role of sea-ice associated fauna for ecosystem functions in the Weddell Sea, Southern Ocean***

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In large parts of the Southern Ocean, sea-ice habitats are deteriorating rapidly. Sea ice offers an attractive substrate for numerous sea-ice-associated species known as sea-ice fauna. Sea-ice fauna performs important ecosystem functions, e.g., carbon cycling. Ecosystem functions in turn are often enhanced by biodiversity. The decline of the sea ice can alter the composition and biodiversity of the sea ice fauna. Thus, understanding the relationship of the biodiversity of sea-ice fauna with ecosystem functions is important for predicting consequences of climate change in polar ecosystems.

During the Sea-Ice Physics and Ecology Study (SIPES) of Polarstern in the Weddell Sea (PS89, 12/2014 2/2015) we sampled under ice and in ice biota. Biodiversity and community structure of sea-ice fauna was analyzed by using morphological taxonomy as well as latest DNA sequencing techniques. The relationship between biodiversity and ecosystem functions was investigated by using size spectra and carbon budgets. The results of this project will yield a comparative analysis of key ecosystem functions in relation to biodiversity in this polar region. Such insight is highly warranted for the resource and conservation management of polar sea-ice ecosystems.

## **S03. Sustained efforts for observing, mapping and understanding the Southern Ocean and its role in current and future climate**

### ***Aerosol trace metal concentration and dissolution from known dust sources in Southern Africa***

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Understanding different physical characteristics and trace elemental of dust compositions is crucial in determining the possible bioavailability of trace elements to phytoplankton communities. Surface sediment samples were collected from four known dust plume sources in Southern Africa namely: Etosha Pan, Kuiseb and Omaruru River in Namibia and the Makgadikgadi Pan in Botswana. The sedimentological characteristics of the sediments were determined. HYSPLIT modelling software was used to determine when most of the dust travels towards the Southern Oceans. Modelling trajectories showed high variability, although the months between April and September, showed dust pathways which travelled to the southern oceans with a few circulating around Antarctica. Based on the modelling, the Southern African dust travels most towards the Indian Ocean and Australian continent. Only a small fraction of dust from Southern Africa gets dispersed towards Antarctica. However, modelling the dust pathways showed high variability with changes in modeled parameters which illustrates the level of heterogeneity in dust trajectories. Complete digestion of different sediment types was performed to determine the overall trace metal composition. Experiments were conducted to leach iron from aerosol samples from the four dust plume sources. Several types of aerosols and leaching solutions were tested. Iron solubility was determined from these experiments to determine which dust is most suitable as a fertilizer for southern oceans. Dissolution kinetics of the selected trace metals was additionally determined (under the guidelines of the Geotraces community). The general geochemistry of the different dust samples was analysed to determine the speciation of the different trace metals.

## ***Assessing the role of iron and light on phytoplankton production and air-sea CO<sub>2</sub> fluxes in the changing western Antarctic Peninsula.***

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Our understanding of biophysical processes in the ocean, and in particular in the changing western Antarctic Peninsula, has been limited by a lack of observations, and an earlier generation of idealised numerical models. This project uses an intense 3-year period of shipboard, combined with sophisticated data assimilating ocean models, to analyse and simulate physical, optical and biological processes in the Bransfield Strait region. This is significantly improving our understanding of the physical forcing of biological processes such as primary production at the scale of the Bransfield Strait, and comes at a time when the scientific and broader community is urgently seeking quantification of the regional impacts of a warming ocean.

## ***Austral summer N<sub>2</sub>O sink and source characteristics and their impact factors in Prydz Bay, Antarctica***

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The ocean, particularly the Southern Ocean, is considered a significant source of atmospheric N<sub>2</sub>O, which is an ozone-depleting greenhouse gas. However, there are limited data available supporting this conclusion. Thus, this study sampled and analyzed the oceanic N<sub>2</sub>O in Prydz Bay. The results demonstrated that the distribution of N<sub>2</sub>O in this embayment differed between the north and south sides of the Antarctic Slope Front (ASF), corresponding to the different hydrographic characteristics on each side. Although the air-sea N<sub>2</sub>O flux north of the shelf break is  $\sim -1.20 \pm 0.44 \mu\text{mol m}^{-2} \text{d}^{-1}$ , the source sink characteristics need to be further constrained because the Circumpolar Deep Water (CDW) may occasionally outcrop over the surface layer. The water masses over the continental shelf south of the shelf break may be a temporary or even a permanent N<sub>2</sub>O sink when sea ice is absent. The air-sea flux south of the shelf break is  $\sim -3.65 \pm 0.95 \mu\text{mol m}^{-2} \text{d}^{-1}$ , and the water column is undersaturated with N<sub>2</sub>O, which may result from the deep convection of N<sub>2</sub>O-undersaturated surface water during the winter. Evidence also suggests that the formation of Antarctic Bottom Water (AABW) may provide a pathway for N<sub>2</sub>O removal from the upper layer at high latitudes.

## ***Bathymetry and geological setting of the Drake Passage: The new map***

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The Drake Passage is an oceanic gateway of about 850 km width located between South America and the Antarctic Peninsula that connects the southeastern Pacific and the southwestern Atlantic oceans and is an important gateway for mantle flow, oceanographic water masses, and migrations of biota. This gateway developed within the framework of geological evolution of the Scotia Arc. This tectonic arc encloses most of the Scotia and Sandwich plates, which are bounded to the north by the North Scotia Ridge, to the south by the South Scotia Ridge, to the west by the Shackleton Fracture Zone, and to the east by the South Sandwich Trench. The Scotia Sea contains several active and extinct spreading ridges that formed during the opening of the Drake Passage, which involved complex geological process such as continental fragmentation, development of oceanic basins and rifting of continental blocks. As a consequence of this and subsequent submarine processes, this region shows a varied physiography.

We present a new detailed map, with a 200 m cell resolution of the seafloor in Drake Passage that permits identification of the main seafloor features. The map is mainly based on a compilation of precise multibeam bathymetric data obtained on cruises between 1992 and 2014 in the Drake Passage region, and covers the area between parallels 52°S and 63°S and meridians 70°W and 50°W. This first version of the compilation constitutes an international cooperative effort coordinated by the Spanish Geological Survey (IGME), the British Antarctic Survey (BAS), the Alfred Wegener Institute (AWI) and the Korean Polar Research Institute (KOPRI), together with USA data available from the Lamont-Doherty Earth Observatory (LDEO). The GEBCO14 dataset, including IBCSO v1.0, was used in order to fill gaps in the coverage.

The map's main cartographic characteristics are: a scale of 1: 1 500 000, Mercator projection in WGS84 ellipsoid, a DTM with a 200 m cell resolution displayed as a color image using a color table ranging from - 6000 to 2500 m. Additionally, other useful geological information shown includes: seafloor magnetic lineations, historical seismicity (depth and magnitude), relative plate motion according TLP2003 model and main tectonic structures, together a brief geological setting description including the main scientific and cartographic references.

Seafloor digital elevation models are very important in geosciences, physical sciences and life sciences. The seafloor topography in the Drake Passage region is an important boundary condition for high-resolution ocean circulation models and also provides constraints on geodynamic models for the initiation and development of Drake Passage opening.

This initiative is part of IBCSO (International Bathymetric Chart of the Southern Ocean), under the SCAR umbrella, which recognises the importance of regional data compilations and mapping programs in areas of particular scientific interest around Antarctica, such as the Ross Sea, Drake Passage and the southern margin of the Weddell Sea.

## ***CDW intrusion onto the Prydz Bay shelf***

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The intrusion of Circumpolar Deep Water onto the Prydz Bay shelf is studied based on CTD data and mooring data. It gives us some more important imaging about the water exchange in the Prydz Bay region. The CDW intrusion shows significantly annual and seasonal variability. The CDW can easily go up onto the continent shelf during austral summer. But this is not obvious during the austral winter. The change of the seasonal mixed layer depth is a key impact factor in this physical process.



## ***Characteristics of suspended particulate organic matter in Subtropical Front of the Indian sector of Southern Ocean: Influence of eddies.***

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This study investigates the influence of a cyclonic eddy & an anticyclonic eddy on particulate organic matter in the Subtropical Front (STF) of the Indian Ocean sector of the Southern Ocean. Seawater samples were collected at 3 stations across the two eddies for the analysis of stable isotopic ratio of carbon and nitrogen along with its elemental composition of suspended particulate organic matter (POM) and other physico-chemical variables to understand the biogeochemical changes of POM due to the two eddies (cyclonic and anticyclonic) encountered during austral summer of 2012 & 2013, respectively. During 2012, cyclonic eddy was observed at 40°S, 56.30°E and in 2013 an anti-cyclonic eddy was at 41°S, 57.30°E. During 2012 austral summer,  $\delta^{13}\text{C}(\text{POM})$  and  $\delta^{15}\text{N}(\text{POM})$  values ranged from -27.99‰ to -21.40 ‰ and -0.13‰ to 4.39 ‰, respectively for the 3 stations sampled along 40°S. An enrichment of >1.5‰ was observed in  $\delta^{13}\text{C}(\text{POM})$  at the station influenced by cyclonic eddy, which was persistent in the entire euphotic depth (120m) and coincided with higher %C and %N. The enrichment at the core of the eddy was supported by elevated nutrient concentrations due to upwelling, especially nitrate that ranged from 2.29-15.64 $\mu\text{M}$  in the upper 120m and was ~10 fold higher at the surface than neighbouring non-eddy stations (0.09-6.90 $\mu\text{M}$ ). During austral summer of 2013,  $\delta^{13}\text{C}(\text{POM})$  and  $\delta^{15}\text{N}(\text{POM})$  values ranged from -26.60‰ to -22.50‰ and -5.81‰ to 5.46 ‰ respectively for 3 stations along 57.30°E, with an enrichment of ~1.5‰ in the upper 50m at the anticyclonic eddy station. However, this station was marked with lower nitrate (0.78-8.67 $\mu\text{M}$ ) in the upper 120m compared to the ambient waters that ranged from 11.51-30.94 $\mu\text{M}$ .

Overall it was observed that the enrichment at the core of the cyclonic eddy was more compared to that at the anticyclonic eddy. This can be attributed to the physical characteristics of the two eddies as these features influence the physico-chemical conditions of the two regions. Also, the age of eddies and its origin may influence the characteristics of POM and its isotopic signatures, impacting the biological community structure and biological processes which control the diagenetic state of POM and its isotopic signature.

## ***GPS RO sensing of Boundary Layer Height in the Southern Ocean***

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The COSMIC constellation of GPS RO satellites has been used extensively over the previous few years to generate climatologies of boundary layer height (BLH). These satellites use high precision clocks to measure the time it takes for a signal to be transmitted through the atmosphere. From the time measurements, the bending angle of the signal can be calculated and then used in turn to calculate atmospheric refractivity. Boundary layer heights can then be determined by identifying sharp gradients in the refractivity profile. The results of this approach have been compared with radiosonde data and show a high level of agreement. By using this technique, we also generated a BLH climatology which was then used to analyze how the height of the boundary layer varies within the specific meteorological context of Southern Ocean cyclones.

Analysis of the BLH behaviour over cyclones was primarily based upon generating cyclone composites. This is done by averaging together measurements in a cyclone relative framework to generate a representative cyclone. This technique allows a direct examination of the mean state, however it is also valuable for further analysis such as splitting the composite into regions and analyzing the distribution of values over each of these sub-regions.

We also investigated the relationship between boundary layer height and surface variables in the Southern Ocean. There is a particularly strong negative relationship between sea ice concentration and boundary layer height. The reasons for this phenomena are not entirely clear, but appears to be at least partially related to changes in the surface sensible heat flux. The effects of other surface variables such as air temperature, sea surface temperature and wind speeds were relatively minor.

## ***IBCSO – Collaborative bathymetric base data for Antarctic science***

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The International Bathymetric Chart of the Southern Ocean (IBCSO) project aims to create comprehensive and reliable digital bathymetric models (DBM) for the Circum-Antarctic waters. Due to the size, remoteness and inaccessibility of this region, the success of the project depends on international efforts and collaboration. For this reason, IBCSO is well connected to internationally operating scientific and hydrographic organizations. IBCSO is an expert group of SCAR since 2004. Furthermore, it is a regional mapping project of the General Bathymetric Chart of the Ocean (GEBCO) under the joint auspices of the Intergovernmental Oceanographic Commission (IOC) (of UNESCO) and the International Hydrographic Organization (IHO).

In 2013, the first version of IBCSO became available to the scientific community, accompanied by a publication in *Geophysical Research Letters* (Arndt et al., 2013). For this version, more than 30 institutions from 15 countries contributed data and knowledge. The DBM covers the area south of 60° S with a cell resolution of 500 m. The data can be downloaded in various formats from the project website, as well as a chart and cartographic background data ([www.ibcso.org](http://www.ibcso.org)).

Even though all available data had been compiled for IBCSO V1.0, approximately 83 % of the area remained not directly constrained by data obtained by ship. In the meantime the amount of available data has increased significantly and will do so in the future. Accordingly a possible IBCSO version 2.0 has been discussed during the SCAR 2014 meeting in Auckland, NZ. Here it was agreed, that besides an improved DBM of the current projects extent, a second version of the IBCSO should be extended north to 50°S. With this extent IBCSO V2.0 will include the main oceanic gateways of the Antarctic Circumpolar Current. To achieve these goals, a first data exchange of new data will take place during the Arctic-Antarctic Mapping Meeting in June 2016 at the IHO in Monaco and further data exchange is also envisaged to take place during the SCAR 2016 meeting in Malaysia.

We will present the IBCSO data sets that have become available in the last years. Furthermore, we will provide an update on the current stage of the project and we will give an outlook on its future development.

## ***L'Astrolabe for Science an initiative to get an alternative boost to Antarctic and southern ocean observations.***

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In the Antarctic Treaty's spirit of peace and cooperation, the L'Astrolabe for Science initiative intends to embark on two circumnavigations of the continent, on a voyage to gather more information on the Southern Ocean's role in current and future climate. An international team of scientists has been developing a new approach to transform the icebreaker L'Astrolabe into an efficient, multidisciplinary, and cost-effective scientific research platform.

L'Astrolabe for Science intends to engage in a 10 year sustained observation system complementing national efforts and exploring the gaps in the Antarctic continental shelf environment.

This presentation will first describe the scientific objectives and capabilities that will make up the basis of the two-year long circumnavigations. The use of such a platform in the continental shelf area and the sea ice zones has the potential to benefit the scientific research community by addressing a number of key science questions across various disciplines. The outcomes of the multi-year voyage will assist in the enduring questions of global changes in the climate. It is intended the scientific information will be communicated during the voyages in such a way as to assist policy-makers to make informed decisions about the value of scientific research, innovation, and the international community's response to climate change.

The presentation will also describe the logistical endeavors of the team's acquisition, transformation and use of the L'Astrolabe icebreaker. This will include evaluations of seasonal voyage plans, the relation to National Antarctic Programs, non-governmental organization and philanthropic focus, and how to best reflect the cooperative and peaceful principles of the Antarctic Treaty for the benefit of all humankind. We'll present the project and all the science objective and capabilities that can be built up. A 2 years initial plan with 2 circumnavigations within the Antarctic continental shelf / sea ice zone can create or strengthen baseline information for long term monitoring and benefit to a large number of key science questions and a wide range of scientific topics.

Key questions L'Astrolabe for Science intends to contribute to include:

- \* How is the Antarctic ocean changing?
- \* How vulnerable is the Antarctic Ice Sheet to changes in the surrounding ocean?
- \* Why is Antarctic sea ice slowly expanding, while Arctic sea ice is rapidly shrinking?
- \* How sensitive are Antarctic ecosystems to environmental change, including warming, changes in sea ice, and ocean acidification?
- \* What controls the productivity of Antarctic waters, and what is the impact of human activities on ecosystems?

## ***Microbial lipids for Southern Ocean paleo-thermometry***

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Archaea are single celled microbes that are found throughout the ocean. These microbes have the ability to adjust the structure of their membrane lipids in order to survive in a wide range of temperatures. The lipids are fairly resistant against degradation and can be detected in sediment records. They are thus used to reconstruct past temperature changes. The lipids targeted in this study are the glycerol dialkyl glycerol tetraether (GDGTs) and more specifically the isoprenoidal GDGTs. Some GDGTs, such as crenarchaeol are specific markers for Thaumarchaeota, while a range of other isoprenoidal GDGTs are used for paleothermometry. All proxies need to be calibrated and in this study we targeted a recently discovered type of GDGTs, the hydroxylated GDGTs that had been proposed to be especially suitable for temperature reconstructions in cold, polar waters. We present indices derived from the hydroxylated GDGTs and their potential for past sea surface reconstructions in the Southern Ocean. Understanding of the changes in the past helps constraining the natural variability of the modern and future Southern Ocean.

## ***Monitoring from Antarctic coastal embayment; underutilized opportunity to link with Southern Ocean observation***

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Antarctic coastal embayment is an environment where multiple systems interact to elicit responses reflecting overall Antarctic and Southern Ocean changes. These locations are often more easily accessible by established research stations or instrument installations. Atmospheric, oceanographic, sea ice and glacier changes can be more systematically observed in multidisciplinary fashion with corresponding alterations in ecosystem structures and dynamics. These potentials will be enhanced when networked around the Antarctic and integrated with more open water Southern Ocean measurements. In this contribution, a case for King George Island situated in the rapidly changing Antarctic Peninsula region is made with a proposal for partnership and data base that can complete the Antarctic Peninsula gradient.

## ***Physical control on the summer chlorophyll - A distribution in the Indian sector of Southern Ocean***

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Role of physical processes on the chlorophyll a (chl) distribution in the Indian sector of the Southern Ocean (ISSO) has been studied using in situ data collected during the austral summers of 2009, 2010 and 2011. It has been noted that the ISSO fronts are not always chl productive. In the subtropical frontal (STF) region the chl variability is mainly governed by the mesoscale eddy activity associated with the Agulhas Return Current. ISSO region south of STF is high nutrient- low chl (HNLC) region mainly because of the low iron input owing to the deep bottom topography. The Subantarctic Frontal (SAF) and Polar frontal (PF) region is noted to be silica limited. It has also been observed that presence of extended sea ice during winter has a positive effect on chl concentration in the seasonal sea ice zone in the consecutive summer. Furthermore the advected sea ice from eastern Weddell gyre may have higher iron concentration and such an event resulted in increased chl concentration in ISSO during summer of 2011.

## ***Position of main ACC fronts south of New Zealand from satellite altimetry and XBT data in the period 1994-2015***

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A long time series of XBT data collected during Austral summers and satellite altimetry data south of New Zealand are used to identify the positions of the main Antarctic Circumpolar Current (ACC) fronts and their branches from 1994 to 2015. The study area has been investigated since 1994 in the framework of the Climatic Long-term Interaction for the Mass balance in Antarctica (CLIMA), the Southern Ocean Chokepoints Italian Contribution (SOChIC) and the Marine Observatory in the Ross Sea (MORSEA) projects of the Italian National Research Program in Antarctica (PNRA). During these projects, in situ temperature sections of the surface layer (0-800 m) of the Southern Ocean along the track New Zealand-Ross Sea have been occupied almost every summer season by means of XBT.

The flow of the ACC is well known to be concentrated in several jets associated with fronts, or regions of strong horizontal gradients in water mass properties and sea surface height. These fronts are linked to particular water mass features, allowing simple criteria based on temperature and salinity to be used to locate them. In this study regional thermal criteria have been used for the detection of ACC fronts from in situ XBT data. The positions of ACC fronts from in situ XBT data agree with existing literature even if a slight increase in the standard deviation during last years is found and the indication of a southward trend in the positions of fronts is shown.

Moreover, satellite altimetry data provided by AVISO have been used to identify the positions of the fronts on the basis of specific dynamic height values usually associated to each front as well as through the location on the maximum Absolute Dynamic Topography gradient within a predetermined frontal region. Both altimetry-based methods allowed us to partially fill the gap between consecutive in situ measurements and offered different results. These positions have been compared with those determined from in situ data and finally results from the three identification methods are discussed.



## ***Response of Southern Ocean phytoplankton to iron and light limitation***

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Iron and light are essential factors driving phytoplankton growth and photosynthesis (i.e. CO<sub>2</sub> uptake) in the Southern Ocean. Here we conducted 10 shipboard incubation experiments in summer, late summer and winter conditions in the subantarctic zone, the polar frontal zone and the antarctic zone. The response of Southern Ocean phytoplankton varies with the water masses and it appears that the response to higher light is in most experiments much stronger than the response to iron addition. We discuss photophysiological adaptation strategies, other potential co-limitation factors based on in-situ macro- and micronutrient concentrations, as well as the potential impact of microbial and phytoplankton community composition based on chemotaxonomic and genomic analysis.

# ***Seasonal variations of Shelf Water and their connection with the atmosphere in Prydz Bay, East Antarctica***

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The hydrographic surveys from 1981 to 2015, instrumented seal data from 2004 to 2014, the mooring data from 2014 to 2016 and the reanalysis atmosphere data are used to reveal the seasonal variations of Shelf Water (SW) and the connection between SW and the atmosphere in Prydz Bay. Significant seasonal variations of SW are determined and the effect of the atmospheric forcing are investigated in Prydz Bay. There are different type of water mass in different shelf regions and they have distinct seasonal changes. A high salinity SW ( $S > 34.6$ ) is observed in the central and northern part of the Amery Basin in summer, which is non-existent in the winter. The water is like to be caused by the Circumpolar Deep Water (CDW) intrusion in summer and there could be less CDW intrusion in winter because of the ice cover. Another high salinity SW is observed by the seal near the Mackenzie polynya in the eastern Prydz Bay in winter, which is caused by brine rejection in ice production process and has strong relationship with the wind forcing. The water is salty and dense enough and may have contribution to the Antarctic Bottom Water formation. But it does not exist in the summer and there is lack of the direct observation of the denser SW overflow. The change process in the region remains unclear and requires further study. The shelf water in the western Prydz Bay is relative less salty, but a continuous salinity increasing trend of 0.1 is found from July to December in 2015 based on the mooring data. The salinity increasing trend happens in all the water column and the wind forcing could have the primary impact to the salinity increasing, suggesting the water change process is a response to the atmospheric forcing.

## ***Temporal variability of the Circumpolar Deep Water inflow onto the Ross Sea continental shelf***

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The intrusion of Circumpolar Deep Water (CDW) onto the Antarctic continental shelves is the primary source of heat, salt and nutrients, playing a major role on the shelf physical and biological processes.

Different studies have analyzed the processes responsible for the transport of CDW across the Ross Sea shelf break, but until now, there are no continuous observations that investigate the timing of the intrusions. Besides, few works focused on the effect of the tide that controls the intrusion itself.

We use hydrographic observations and moored time series acquired in the western Ross Sea (Drygalski Trough - DT) to characterize the spatial and temporal variability of the CDW inflow onto the shelf. Our data span from 2004 to the beginning of 2014.

In the DT the CDW enters as a thick layer of about 150 m between 250 - 400 m moving upward towards south. At the mooring location, about 50 Km from the shelf break, two main CDW cores can be observed: one on the east side of the trough spreading along the west slope of Mawson Bank from about 200 m to the bottom and the other one in the central-west side from 200 m to about 350 m depth.

A signature of this lighter and relatively warm water is detected by the instruments on the mooring at bottom of the DT. The intermittent CDW intrusion at the bottom of the trough is strictly related to the diurnal and spring/neap tidal cycles, but a strong seasonal and interannual variability of the CDW is also clear.

A strong inflow of CDW is observed every year at the end of December, while the CDW inflow is at its seasonal minimum during the end of the austral summer.

## ***The distribution and controls of bioactive trace elements (Cu and Zn) in the Atlantic Sector of the Southern Ocean.***

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An improved method for the contamination free collection of seawater and subsequent trace element analysis is presented. A vertical profile sampling method was employed for the collection of seawater samples along the Bonus Goodhope Line (BGL) during the 2014/2015 austral summer. Validation through intercalibration with the University of Plymouth (UK) proved the implementation of this technique successful. Samples from two locations, 46°S, Polar Frontal Zone (PFZ) and 65°S, Weddell Gyre (WG), were analysed for their total and dissolved fractions in a land based trace clean laboratory approximately 6 months later. An offline preconcentration step was successfully employed to extract the trace elements from their seawater matrix and ensure quantitative recovery by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This method allowed the simultaneous quantification of 10 trace elements (Al, V, Mn, Fe, Ni, Cu, Zn, Mo, Co, Cd, Pb). Validation of the offline preconcentration and ICP-MS analysis was performed by analysis of external SAFE standards as well as internally by analysis of Multi-Element Standards (MES). Furthermore this study reports on the distribution and controls of dissolved copper (DCu) and dissolved zinc (DZn) in the Southern Ocean. In the PFZ, DCu and DZn displayed typical nutrient like behaviour with concentrations increasing with depth. This is consistent with surface water trace element uptake by marine phytoplankton and remineralization of organic biomass by bacteria in the deeper waters. DCu and DZn had similar surface concentrations of  $1.00 \pm 0.04$  nmol/kg and  $1.46 \pm 0.61$  nmol/kg respectively while at the greatest depth sampled (4300 m), DZn exhibited a higher maximum concentration of  $6.96 \pm 0.35$  nmol/kg compared to  $3.15 \pm 0.01$  nmol/kg for DCu. In the WG, both DCu and DZn showed higher surface concentrations compared to the PFZ, most likely the result of ice melt. DZn concentrations decreased rapidly from  $5.78 \pm 0.01$  nmol/kg at 100 metres depth to  $1.02 \pm 0.03$  nmol/kg at the surface and similarly from  $1.89 \pm 0.09$  nmol/kg to  $1.29 \pm 0.01$  nmol/kg for DCu. This rapid depletion in the WG can be attributed to increased biological uptake by marine phytoplankton compared to the PFZ which is in agreement with chl-a data collected during occupation of the sample stations. Deepwater (>1000m) DZn and DCu concentrations remained relatively constant at approximately 5.5 nmol/kg and 2.4 nmol/kg respectively. This suggests that the cold deepwaters in the WG, characterised by Weddell Sea Deep Water (WSDW), inhibited the bacteria's ability to remineralize sinking organic matter. Analysis of macronutrient data revealed that the Antarctic Polar Front (APF) exerted an important control whereby macronutrients were limiting primary productivity North of the APF and trace elements were limiting primary productivity to the South. Currently we are analysing the rest of the Austral Summer seawater samples as well as samples collected during the 2015 Austral Winter. We hope to make conclusions on the seasonal cycling of trace elements based on three overlapping stations at 46°S, 50°S and 54°S.

## ***The integrated mathematical modeling and visualization of southern ocean movement based on navier-stokes, heat and salinity equations***

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Approximately 97% of the water in the world was found in the ocean reported by the National Oceanic and Atmospheric Administration (NOAA). The ocean is always moving and exposed the complex pattern of the movement. Even though, the change in ocean's climate is relatively slow, it is important in governing the global climate system even if the ocean is not moving. The interplay of atmosphere and ocean decided on the time scales for the most of the climate varies from a few hours to millennia. In this paper, the integrated mathematical modeling of two dimensional time dependent has been used to observe the Southern Ocean movement and visual the changes. Navier-Stokes equation, heat equation and salinity equation are focused with the specific parameter changing. The Navier - Stokes equation is used to present the ocean movement while the heat equation for investigating the distribution of heat transfers of the ocean movement. Also, salinity equation is describing the concentration of salinity in the ocean that can identify the sources of ocean water masses and ocean movement patterns. The integrated modeling is considered as a potential technique to identify the oceanographic parameters such as velocity, temperature behavior and salinity of the Southern Ocean movement and visualization. Besides that, the model is related to the climatic variables that enable the projecting of the future global climate change. Then, the process of discretization by using a five-point finite difference method is an important step to govern the linear system of equation before implementing some numerical method such as Jacobi and Gauss-Seidel method. The computation platform supports the big data simulation with the implementation on C programming and Comsol Multiphysics is used as a tool for visualizing the temperature behaviour. The numerical analysis is presented in terms of time execution, number of iterations, maximum error and root mean square error. The process of data validation will obtain the comparison between the numerical results and NIRW data sources. Based on the numerical results, visualization proven and data validation, the paper agreed that the Southern ocean movement is bounded directly to the global sea level rise with the increasing of ocean temperatures and the effects of the Antarctic Ice Sheet melted drastically. As a conclusion, the mathematical modeling and discretization and simulation have a high potential to predict the ocean movement by estimating some parameters accurately, approximating the range of value changes of the dependent variable, visualizing the movement and validating the numerical results via NIRW data sources.

## **S09. Status and trends in Antarctic sea ice and ice shelves**

### ***Antarctic ice thickness variation and safety of ship hull for different ice classes***

**Pentti Kujala**<sup>1</sup>, Mikko Suominen<sup>1</sup>, Mikko Lensu<sup>2</sup>, Petteri Uotila<sup>2</sup>, Eero Rinne<sup>2</sup>, Keith Soul<sup>3</sup>  
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The selecting an appropriate ice class for the future ships for Antarctic operations is of high importance both from a safety as well as an economical perspective, but the process is still based merely on accumulated experience and traditions within the areas of operations. The increased exploitation of the Polar waters as well as the introduction of new international design standards, reduces the relevancy of existing experience as basis and new methods and knowledge have to be developed.

To gather experience of the load levels experienced by the ships navigating in Antarctic waters, the research vessel of Agulhass II built in Finland for South African Ministry of Environment was instrumented during 2012 for hull and propulsion ice loads measurements. In addition an advanced new stereo camera system was developed to monitor the ice conditions and a shipborne EM system was used to measure ice thickness. During four full scale voyages from Cape Town to Antarctica on 2012-2016, detail data of the ice conditions and encountered ice induced loads and vibrations onboard the vessel have been gathered. The shipborne datasets are complemented by modelling and satellite altimetry. A global implementation of NEMO/LIM3 ice-ocean model with Southern Ocean emphasis was made to provide understanding on the interannual ice variations in the transected sea areas and to extrapolate the load levels to Antarctic seas. The altimeter data from Cryosat-2 satellite have been compared to modelled and EM thickness and to ship load data. The agreement is generally good and is expected to improve still as Cryosat-2 Baseline-C data product will be made available by ESA.

The paper will summarise the main findings during the measured period. Great variation on both the ice conditions and operation principles of the vessel has been observed causing high scatter on the measured ice load and vibration level onboard the vessel. Recurrent zones of different degree of navigational difficulty could be recognised in the load and ice thickness records. The gathered data base gives good background to determine the statistical estimates for the long term loads experienced by the ship hull, which can form sound basis for the design of future safe ship hulls and engine power requirements for these operations. In addition, based on the full scale measurements of ice loads during summers 2013-2014 in the Antarctica, the structural strength of the South African research vessel S.A. Agulhas II has been evaluated to assess the suitability of the chosen ice class of the vessel. The new polar code (Mandatory for all operations in Polar waters from 1.1.2017) and especially the new Polar Operational Limit Assessment Risk Indexing System (POLARIS) is applied on this vessel to evaluate the suitable ice class. It is found the PC 3 is the most suitable ice class for ships navigating in harsh Antarctic ice conditions.

## ***Atmospheric forcing of sea ice concentration and velocity anomalies in the Ross Sea Polynya region***

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Despite warming trends in global temperatures, sea ice extent in the southern hemisphere has shown an increasing trend over recent decades. Wind-driven sea ice export from coastal polynyas is an important source of sea ice production. Areas of major polynyas in the Ross Sea, the region with largest increase in sea ice extent, have been suggested to produce the vast amount of the sea ice in the region. We investigate the impacts of strong wind events on polynyas and the subsequent sea ice production.

We utilize Bootstrap sea ice concentration (SIC) measurements derived from satellite based, Special Sensor Microwave Imager (SSM/I) brightness temperature images. These are compared with surface wind measurements made by automatic weather stations of the University of Wisconsin-Madison Antarctic Meteorology Program. Our analysis focusses on the winter period defined as 1st April to 1st November in this study. Wind data was used to classify each day into characteristic regimes based on the change of wind speed. For each regime, a composite of SIC anomaly was formed for the Ross Sea region. We found that persistent weak winds near the edge of the Ross Ice Shelf are generally associated with positive SIC anomalies in the Ross Sea polynya area (RSP). Conversely we found negative SIC anomalies in this area during persistent strong winds. By analyzing sea ice motion vectors derived from SSM/I brightness temperatures, we find significant sea ice motion anomalies throughout the Ross Sea during strong wind events. These anomalies persist for several days after the strong wind event.

Strong, negative correlations are found between SIC within the RSP and wind speed indicating that strong winds cause significant advection of sea ice in the RSP. This rapid decrease in SIC is followed by a more gradual recovery in SIC. This increase occurs on a time scale greater than the average persistence of strong wind events and the resulting Sea ice motion anomalies, highlighting the production of new sea ice through thermodynamic processes.

## ***Confirmation of Ice Pump that spans the Ross Ice Shelf: Heat and nutrient exchange between open ocean and grounding zone***

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Grounding zones, the transitions between ice sheets and ice shelves, are the primary gateways through which the Antarctic Ice Sheet loses mass. In these environments, ice, ocean, meltwater and sediment meet and interact, influencing both the ice sheet and ocean circulation beneath the ice shelf. Yet, despite their importance to ice sheet mass balance, grounding zones are difficult to access and are poorly understood. Much of our current understanding derives from theory, geological inferences from older deposits, and remote observations. Though these have provided essential insight into fundamental processes, many hypotheses still lack direct confirmation. As these are unexplored systems many processes and details also remain unknown. Here, we report on conditions near the grounding zone of the Whillans Ice Stream, one of the principle tributaries supplying ice to the Ross Ice Shelf. Cameras and instruments were lowered through an ice borehole in order to observe and sample the environment in the ocean cavity beneath the ice shelf. The data that were collected suggest an active exchange of heat and nutrients between the grounding zone and the open ocean, despite being separated by over 600km. Thus life found near the grounding line appears not to be an isolated oasis, but may instead be part of a much broader ecosystem that spans the ice shelf. This exchange also has implications for melting beneath the ice shelf. Currently, the grounding zone is bathed in cold water formed from sea ice production in the Ross Sea. This processes maintains ocean temperatures throughout most of the Ross Sea near the surface freezing point and is thought to buffer many larger ice shelves from warming in the Southern Ocean. However, sea ice production may drop drastically within the century. If it does, even grounding zones behind large ice shelves could warm quickly to drive grounding line retreat.



## ***Cycling of organic sulphur and carbon in Antarctic sea ice and surrounding waters***

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Changes in temperature and weather patterns are reducing the sea ice extent along the West Antarctic Peninsula, and subsequently the nutrient availability. These changes can significantly alter the growth patterns of marine microbial communities growing within sea ice and the water column below. These communities have been identified as significant producers of organic sulphur compounds, likely as an osmoprotectant within the often rapidly changing salinity, temperature and nutrient environment of sea ice: changes to the sea-ice community can subsequently affect the cycling of organic sulphur within the microbial food web. Through reduced production of the volatile organic sulphur compound dimethylsulphide (DMS) by these algae, the flux of sulphur to the atmosphere will also be affected. This study presents the results from the first years of a five year time-series (2012-2017) studying seawater concentrations of DMS, dimethylsulphoniopropionate (DMSP) and dimethylsulphoxide (DMSO) along with the phytoplankton community dynamics alongside the Rothera oceanographic and biological Time Series (RaTS) measurements by the British Antarctic Survey, and assessed the changes in terms of community composition and physico-chemical properties of the region.

During each season, a number of significant bloom events were detected between November to April, with Chl-a reaching concentrations over 25 µg L<sup>-1</sup>. Assessment of phytoplankton community structure using CHEMTAX analysis showed succession of the community: from cryptophytes, prasinophytes and Phaeocystis haptophytes in the early summer, to large diatom species dominating later in the season as the water column increasingly stratified. Concentrations of particulate DMSP were often correlated to Chl-a, and showed concentrations at times exceeding 300 nmol L<sup>-1</sup> when haptophytes and dinoflagellates were abundant; DMS and DMSO concentrations were regularly identified as being uncoupled to DMSP and Chl-a, with concentrations exceeding 50 nmol L<sup>-1</sup>. High concentrations of these compounds were, however, related to melting sea ice, and were associated with release from the ice-algal community. As the first DMS results measured as part of the RaTS dataset, these measurements give a baseline on which to establish the relationships between DMS, primary production and sea ice melt, which can be expanded in future southern summer seasons.

## ***Dominant signals in the Southern Ocean and Antarctic sea ice modulation during last three decades***

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In this paper, a composite dataset (comprising of sea level pressure, geopotential height, sea surface temperature, zonal and meridional surface winds, precipitation, cloud cover, surface air temperature, latent plus sensible heat flux, sea ice concentration) has been investigated with the aim to reveal the dominant timescales of variability in the data series from 1982 to 2013. Three covarying climate signals promoting variations in the sea ice distribution around Antarctica have been detected through the application of the Multiple-Taper Method with Singular Value Decomposition (MTM-SVD). Features of already know patterns of variation over the Southern Hemisphere (SH) extratropics have been identified in each of these three climate signals in form of coupled or individual oscillations. The climate patterns considered in this study includes the Southern Annular Mode (SAM), the Pacific-South America (PSA) teleconnection, the Semi-Annual Oscillation (SAO) and the Zonal Wavenumber-3 (ZW3) mode. Results have shown that most of the sea ice variance concentrates on the quasi-biennial scale resulting from the constructive superposition between the PSA and ZW3 patterns. In addition we can see that the combination between the SAM and SAO patterns is found to promote the interannual sea ice variations underlying a general change in the Southern Ocean atmospheric and oceanic circulation. These variabilities are found in agreement with the upward summer (DJF) trends shown by the SAM and SAO patterns. In addition, the occurrence of positive SAM and SAO phases detected during DJF could have favored the cooling of the sub-Antarctic over time, implying important changes in the Antarctic sea ice distribution since 2000.

## ***Estimation of Antarctic land-fast sea ice algal biomass from under-ice spectra: the effects of proximity of an ice shelf***

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Land-fast sea ice (fast ice) is stationary sea ice that is “fastened” to the coastline or held in place by grounded icebergs. In such locations, the ice generally grows in thickness due to loss of thermal energy to the atmosphere. However, in Antarctic regions where it directly abuts an ice shelf, fast ice may also thicken through platelet ice formation related to cold water emergence from deep in the ice shelf cavity. The dependence of fast ice upon these purely thermodynamic processes means that its maximum thickness is likely to be a sensitive indicator of climate change. Fast ice is also an important structural component of Antarctic coastal ecosystems, providing a habitat for diverse microbial communities. Ice algal biomass in platelet ice is generally more abundant than in other ice types found further from an ice shelf.

In this work, we examine the relationship between the normalised difference index (NDI) and sea ice algal biomass, using paired measurements of chl a concentrations and hyperspectral-transmitted under ice spectra acquired as part of a joint New Zealand-Australia experimental programme in Antarctica. Although this technique has previously been used to assess biomass in both Arctic fast ice and Antarctic pack ice, it has never been tested before in Antarctic fast ice.

Here, we analyse measurements of sea ice physical properties and under-ice transmitted radiance and irradiance along transect lines at two contrasting fast ice sites i.e., offshore from Scott Base, Ross Sea and Davis Station, Prydz Bay, near and distant from an ice shelf, respectively. Snow and ice thickness, and ice salinity, temperature and density measurements underpin our in situ optical and biological paired measurements, as a function of sea ice type. Ultimately, our aim is to develop an observation-based algorithm for estimating fast-ice algal biomass from underwater sensors, in order to map Antarctic sea-ice algal distribution at regional scales using remotely-operated or autonomous underwater vehicles.

## ***Fast ice dynamics in McMurdo sound***

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Seasonal sea ice has a major influence on the ecology of Antarctic marine systems. While large scale sea ice patterns have been modeled, smaller scale patterns of nearshore fast ice have rarely been examined. Nevertheless, the advance, retreat, and thickness of nearshore fast ice can strongly influence under-ice primary production, with ramifications through food webs. Climate change is altering sea ice patterns in polar seas, and in the Ross Sea, Antarctica, the sea ice has been increasing in extent, contrary to patterns elsewhere. Climate change is a global human impact that is changing sea ice parameters through indirect anthropogenic effects, however, direct impacts such as the icebreaker channel that is annually cut into McMurdo Sound may also be important in altering fast ice characteristics. We present fine scale records of the seasonal extents of fast ice in McMurdo Sound, Antarctica, since 1979, along with direct measurements of fast ice thickness and temperature. These data sets, along with wind velocity records, are used to test the effects of direct human influence, via the channel annually cut in the ice by an icebreaker, on fast ice stability. We determined that the icebreaker channel is linked to fast ice stability, less strongly than wind velocity and ice temperature, but more strongly than ice thickness. We could not eliminate the possible autocorrelation introduced by icebreaker scheduling to coincide with low sea ice extent, however, the icebreaker apparently contributes to the breakup of fast ice though not necessarily to the timing of the seasonal low extent of the fast ice. Fast ice temperature was unexpectedly important in the models of ice retreat date, and might be considered as an additional factor in future predictive models. We observed that the fast ice on the west side of McMurdo Sound has been retreating further in recent years, and this historically ice-covered, stable, oligotrophic region may thus be exposed to more light, productivity, and water motion. The changes in fast ice distribution are likely impacting local marine communities, which have been previously noted as deep-sea analogues because of the lack of food and disturbance. The indication that the anthropogenic activity of the annual icebreaker channel plays a role in fast ice dynamics in McMurdo Sound should encourage us to consider the wider ramifications of our activities in this system with few direct human impacts.

## ***Photosynthetically Active Radiation, chlorophyll-a and other biogeochemical changes along a 5 km transect under the sea ice of McMurdo Sound***

**Peter Doran**<sup>1</sup>, Luke Winslow<sup>2</sup>, Britney Schmidt<sup>4</sup>, Mark Skidmore<sup>3</sup>, Don Blankenship<sup>5</sup>, Bill Stone<sup>6</sup>, Stacy Kim<sup>7</sup>, Frank Rack<sup>8</sup>, Andrew Johnson<sup>9</sup>, Nathan Bramall<sup>10</sup>, Evan Clark<sup>6</sup>

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The SIMPLE (Sub-Ice Marine and Planetary-analog Ecosystems) project designed and constructed an autonomous underwater vehicle (AUV) specifically for investigating the ice/water interface of the McMurdo Ice Shelf. The vehicle was equipped with instruments for measuring CTD (Conductivity Temperature and Depth), pH, redox, PAR (Photosynthetically active radiation), chlorophyll-a, turbidity, DOM (Dissolved Organic Matter), DO (dissolved oxygen) and the under-ice topography above the robot (including ice thickness estimates). An on-board water sampler was capable of collecting 36 discrete water samples from every mission. Here we present the variability in observed PAR, physical parameters and sample results at high spatial resolution for a 5 km transect under the McMurdo Sound sea ice at a relatively constant standoff distance of 12 m. Our results showed among other things that PAR was highly variable at short spatial scales (~100 m) and temperature, salinity and dissolved oxygen varied systematically at the full-transect scale (~5 km).

## ***Ross ice shelf Polynya – Contribution to Antarctic sea ice variability***

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The complexity of the Antarctic sea ice system is contributed to by the numerous sea ice generating polynyas which occur around the continental coast. The Ross Ice Shelf Polynya (RISP) is the largest by far and has the highest ice production rates. It is commonly assumed that the relationship between the size of the open water area and sea ice generation is positive. This study uses NASA Team sea ice concentration (SIC) and a new dataset of daily RISP area to examine the contribution of the sea ice generated within the RISP to sea ice variability in the Ross Sea. The dataset spans the period 1987 – 2009 and represents the longest timeseries of this polynya to date. Initial analyses show that areal variability of the RISP influences SIC in the Ross Sea. The relationship varies in sign and strength depending on the time of year. During the warm season, the relationship is strongly negative suggesting that a larger polynya is associated with lower SIC. During the cold season, the relationship is positive and stronger in some months than others. This study sheds new light on the way in which the RISP interacts with SIC in the Ross Sea.

## ***Simulations of ice flux through Totten Glacier as ice shelf calving changes***

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Totten glacier is one of the fastest thinning ice streams in East Antarctic ice sheet. The glacier flow into the ocean close to the Antarctic circle and experience very high ocean-driven melt rates under the ice shelf in front of the glacier, and the ice shelf seems to suffer from extensive basal melt-induced calving. The ice shelf is underlain by a relatively narrow and convoluted cavity, which recent resurveying suggests maybe substantially different from Bedmap2 geometry. Here we use the BISICLES ice flow model to simulate present day ice dynamics. We then use a discrete particle model so simulate the ice shelf fracturing pattern based on the present day to estimate the buttressing force. The new ice shelf geometry is then used with the continuum model to asses ice flux through the region 50 years into the future. The results suggest considerable changes in glacier-ice shelf configuration, but which are sensitive to ice shelf pinning points and sub-shelf cavity geometry.

# ***Simultaneous disintegration of outlet glaciers in the Porpoise Bay region of East Antarctica, driven by sea ice break-up.***

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Iceberg calving is an important process accounting for around 50% of total mass loss to the ocean in Antarctica. Moreover, dynamic feedbacks associated with retreat in buttressing ice shelves or floating glacier tongues can result in an increased discharge of ice into the ocean. Therefore, improving our understanding of the mechanisms driving glacier calving and how glacier calving cycles have responded to recent changes in climate is important in the context of future sea level predictions. In this study, we analyse the calving rates of several glaciers in the Porpoise Bay region of East Antarctica using Envisat ASAR imagery at approximately monthly intervals between November 2002 and March 2012. We observe a large simultaneous calving event in January – April, 2007 where a total of ~2,500 km<sup>2</sup> of ice calved from multiple glaciers in the region. We link this calving event to a break out of the landfast sea ice which usually occupies the bay. In the absence of regular satellite imagery prior to 2002, we use sea ice concentrations in Porpoise Bay as a proxy for iceberg calving. This infers a potential speed up in the rate of calving for Holmes glacier, the largest in Porpoise Bay.



## ***Slush fund: Investigating the impact of multiphase physics in icy shells***

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Ice shelf-ocean interactions and exchange are important processes that drive the evolution of ice shelves. In turn, these processes observed on Earth are likely relevant to the evolution of the ice shells of the ocean moons of the outer solar system. Models of ice accretion and formation at the base of ice shelves have lagged behind similar model development for sea ice, and for the ocean moons, relatively little has been done to understand these processes. Here, we describe efforts to construct a realistic model of ice-ocean interactions that considers how platelet and marine ice form on the underside of ice shelves. This model will also be extrapolated to the ocean moons.

We model ice-ocean interaction by treating basal ice as a porous media, and consider its possible implications on the formation of biological niches. Treating ice as a porous media drastically affects the thermodynamic properties it exhibits. Thus inclusion of this phenomenon is critical in accurately representing the dynamics and evolution of all ice-ocean environments. This model begins from equations that describe the dynamics of sea ice when it is treated as a porous media (Hunke et al. 2011), and is coupled with a basal melt and accretion model (Holland and Jenkins 1999). Combining these two models, we hope to be capable of resolving variations within the ice due to environmental pressures. We include profiles of temperature, salinity, solid fraction, and Darcy velocity, as well as temporally and spatially varying melt and accretion rates. Thus, we are working towards understanding marine ice formation rates under a host of different environmental conditions. Observations gathered by programs like the SIMPLE project (Schmidt et al, this meeting) and earlier work on the McMurdo (e.g. Robinson et al 2014) Amery (e.g. Craven et al 2009) ice shelves provide ground truth for our modeling efforts.

As terrestrial ice shelves provide a close analog to planetary ice-ocean environments, we truth test the models validity against observations of ice shelves, and then extrapolate to Europa, the innermost icy moon of Jupiter. A porous medium is an ideal place for the coalescence of nutrients and the formation of energy gradients, key controllers of biological activity. Understanding the physics that influence ice-ocean exchange is thus essential in assessing the habitability of Europa.

We describe our initial results and future directions for including further multiphase physics into models of the evolution of ice shelves and ice shells.

## ***The area changes of Terra Nova Bay Polynia from 2009 to 2014 based on the estimation of sea ice distribution***

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The distribution of sea ice in Terra Nova Bay will have direct effects on the area changes of the polynia (Terra Nova Bay Polynia, TNBP). As we all know, when the ice free time is coming, there is open water and the polynia appears. The study of TNBP has great importance in both mass circulation and sea transportation. First, the circulation between ocean and atmospheric will be strengthened during the ice free time. The exchange between upper water and lower water will be more frequent. Second, If we keep on sensing the sea ice distribution of TNB and estimating the open water time, we can give reasonable advices on sea transportation.

In the research, we estimate the area of TNBP from 2009 to 2014 by using the MODIS data. There shows a decreasing area of TNBP from January to March and the increasing area is from November to December. The area of TNBP does not show significant changes compared with different years. The maximum area is about 5300 km<sup>2</sup> which appears in January and December every year and the minimum area is around 800 km<sup>2</sup> which appears in the late March and the early November every year. Also, we can see some mutations in area changes especially in the stage of area increasing and decreasing time. This is mainly because of the strong katabatic wind from the surrounding glaciers.

From the results, the area changes of TNBP and the sea ice distribution have a distinct seasonal nature and there are 3 affecting factors. First, the strong katabatic wind from the glaciers will blow the sea ice away from TNB and this is in favor of the polynya forming. There are some glaciers surrounded, such as Larsen glacier, Reeves glacier and Campbell glacier. Second, the Drygalski tongue located in the south of TNB helps block the sea ice flow into the bay. Third, the new sea ice will generate in the low temperature and this happens in the early February. In the research, we analysis the relationship between area changes of TNBP and meteorological environment by using the data from the Italy Eneide atmosphere weather station, such as temperature, wind speed and direction data. Specially, the study of TNBP from April to October is still ongoing because of polar night and poorly data. We suppose to use infrared and SAR images to monitor the sea ice distribution to supplement the study.

## **S25: Molecular Ecology and Evolution**

### ***A pharmaceutical composition for treating cancer through nanoemulsions***

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A pharmaceutical composition to suppress the multiplication of cells for the treatment of cancer using nanoemulsions of Rosuvastatin Calcium (RST) and Ketorolac Tromethamine (KT) along with oil, a surfactant, a co-surfactant and water added in drops while continuously stirring the preparation is disclosed. The method of preparing the composition comprises mixing of the composition by using a high speed homogenizer followed by an ultrasonication. After preparing the composition the undissolved drug is removed by filtration using a filtering membrane. The concentration of drug in the filtrate was measured using a HPLC and the prepared emulsions were diluted by adding a suitable quantity of water to determine anticancer activity. The pharmaceutical composition is effective in suppressing the multiplication of cells for treating cancer cells without effecting the cells and organs and improving the bioavailability of drugs

## ***Barcoding Southern Ocean lanternfish, myctophidae and othe mesopelagic fish***

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While myctophids are among the most abundant mesopelagic fish in the world's ocean, little is know about their ecology not only globally, but also in the Southern Ocean. Over the last decade DNA barcoding has increasingly been used for molecular specimen identification in the Southern Ocean. While not without limitations COI DNA barcoding provides a clear and unified framework for biodiversity analysis. Here we present a comprehensive COI DNA barcode library of myctophid fish and other mesopelagic fish taxa found in the Southern Ocean. We combined information from various published and unpublished sources of barcoding data, including the Census of Antarctic Marine Life data available through Barcoding of Life Database. Where possible the COI gene was complemented by D-loop and the nuclear rhodopsin retrogene. Where morphological identification was verified using pictures or contacting the original investigator. By comparing morphological and molecular results we were able add numerous well-identified specimens from different life stages and sequences.

This study will contribute to improve the identification of different species and life stages of Antarctic mesopelagic fish as well as our understanding of between and within species geographic genetic variability.

## ***Genetic diversity among shallow-water benthic foraminifera across the Drake Passage***

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Genetic diversity among shallow-water benthic foraminifera across the Drake Passage

Aneta Majda<sup>1</sup>, Wojciech Majewski<sup>1</sup>, Michał Grabowski<sup>2</sup>, Tomasz Mamos<sup>2</sup>, Maria Angélica Godoi<sup>3</sup>, Jan Pawlowski<sup>4</sup>

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Benthic foraminifera are among the most studied part of meiobenthos. They are widely distributed in Antarctic and Patagonian waters. Presence of morphologically similar foraminiferal species in South Shetlands and Patagonia was noted by some foraminiferal specialists, thus our goal was to verify these links using molecular data. We compared genetically eight benthic foraminiferal morphospecies from different areas of West Antarctica (South Shetlands, Ross Sea, and Rothera) and southern Patagonia. Our molecular data allow to propose dispersal scenarios that stay behind current biogeographic distribution of analysed taxa.

We obtained 99 small subunit (SSU) rDNA sequences of eight foraminiferal genera from West Antarctica and southern Patagonia and combined them with 216 Antarctic sequences from Majewski et al. (2015). The analysis of SSU sequences along with haplotype networking show variable biogeographic patterns for different benthic foraminifera. High molecular diversity in six taxa was expressed by the presence of multiple Molecular Operational Taxonomic Units (MOTUs) within each morphospecies. The distribution of different MOTUs was restricted to either sides of the Drake Passage indicating restricted gene flow between Antarctica and Patagonia, and suggesting that these MOTUs could be considered as distinct species. The remaining two morphospecies expressed low genetic dissimilarities and were represented by single MOTUs, suggesting Recent gene flow between West Antarctica and Patagonia. The spatial and demographic aspects of the eight foraminiferal taxa were also analysed. To confirm expansion scenario for MOTUs with star-like topologies identified in haplotype networking, groupings were tested using mismatch distribution analysis and Tajima's D and Fu's neutrality tests. Restricted gene flow among some shallow-water benthic foraminifera could be associated with their bathymetrical distribution in relation with circulation patterns.

### References:

Majewski W., Bowser S.S., Pawlowski J. 2015. Widespread intra-specific genetic homogeneity of coastal Antarctic benthic foraminifera. *Polar Biology* 38: 2047-2058.

## ***Genome of Antarctic-endemic copepod and evolutionary adaptation to extreme environments***

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The Antarctic intertidal zone is continuously subject to extreme fluctuations in biotic and abiotic stressors, and the West Antarctic Peninsula is the most rapidly warming region on earth. Organisms living in Antarctic intertidal pools are therefore of great interest for research on topics such as evolutionary adaptation to extreme environments and the effects of climate change. Here, we report the whole-genome sequence of the endemic Harpacticoid copepod, *Tigriopus kingsejongensis*, from tide pools in the West Antarctic Peninsula. Genome sequencing and comparative genome analysis with other arthropod species revealed that *T. kingsejongensis* specific genes are enriched in transport and metabolism processes. Furthermore, rapidly evolving genes related to energy metabolism showed signatures of positive selection. Evolutionary adaptation to cold 25 temperatures has led to the distinct feature that transmembrane transport genes (TkTret) in functional categories are highly induced at low temperatures in *T. kingsejongensis*. The TkTret gene family is regulated at low temperatures by specific transcription factors, these have been reported to be involved in the transport of trehalose, which provides a cryo- or anhydroprotectant nutrient source that helps protect against environmental stresses. Interestingly, this phenomenon is not observed in the temperate genome of *Tigriopus* spp. The genome of *T. kingsejongensis* therefore provides an interesting example of an evolutionary strategy for Antarctic cold adaptation, and offers new genetic insights into Antarctic intertidal biota.

## ***How connected are populations of Snow Petrels (*Pagodroma nivea*) in East-Antarctica?***

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Despite their high vagility, several mechanisms can drive population divergence in seabirds. While the presence of effective barriers to seabird movement seems to be rare, historical climate fluctuations, complex life history traits and local adaptation can play an important role promoting population divergence of seabird species. Understanding the dispersal capabilities of a species, and the extent to which migration occurs among populations, is essential for effective management plans, helping to delimit protected areas that are crucial for the conservation of biodiversity. Recently, genetic studies have shed light on the population structure and evolutionary history of non-flying Antarctic seabirds, e.g. Emperor and Adélie penguins, however such studies are scarce for flying seabirds in Antarctica. Gene flow among populations occurs when migrants contribute genes to subsequent generations. We use mitochondrial and nuclear DNA markers to assess population connectivity of Snow Petrel populations among three regions in East Antarctica. Samples were obtained from 4 sites located near Mawson station (N=34), 3 sites located near Davis station (N=8), and 2 sites near Casey station (N=15). Genomic DNA was extracted from muscle tissue and a total of 4,754bp were sequenced, which correspond to two mitochondrial markers: Cyt b (865bp) and ND2 (893), and to four nuclear loci: P1 (675bp), P5 (715bp), and P7 (742bp), that are anonymous loci and one nuclear intron (864bp). No evidence of genetic structure among populations from the three different regions was found in our preliminary analysis (AMOVA,  $p > 0.05$ ; TCS haplotype networks). This lack of divergence observed among populations can be explained by historic migration (e.g. during re-colonization after Pleistocene climate fluctuations) and low current migration, or by ongoing high migration rates. To discern between these two possibilities we will present results from Kinship analysis. Finally, we used these data to estimate changes in effective population size, i.e. population expansions or declines, and link them to known climate perturbations that occurred during glaciation and inter-glaciation periods. Such inferences will also be presented, which can help us understand how this species was affected by climate change in the past, and its vulnerability to future climate change.

## ***Life history evolution in Antarctica: Elemental stoichiometry and the growth rate hypothesis***

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Elemental stoichiometry is a powerful integrator of biological and geochemical evolution, provides a useful framework for understanding sources and controls of nutrient availability, and has been widely applied in the study of different ecosystems, including the Antarctic Dry Valleys. Prior in situ research on natural populations of the Antarctic soil nematode *Plectus murrayi* revealed a link between cellular phosphorus (P) and organismal development as postulated by the growth rate hypothesis (GRH). This hypothesis infers that high biomass P-content reflects an increased allocation to P-rich ribosomal RNA, and is needed to meet the protein synthesis demands of development. In accordance with the GRH, we hypothesize that in a P-limited environment, animals will grow more slowly but achieve a larger body size at maturity. We also predict that in a P-deficient environment we will find lower cellular RNA concentrations and that natural selection will reduce the number of copies of RNA genes in the genome, and subsequently lower rates of overall gene expression. To test the GRH in *P. murrayi* under laboratory conditions, we manipulated the amount of available P to see if we could replicate in the laboratory the pattern previously identified in Dry Valley field conditions, and to see if we could identify some of the specific mechanisms connecting elemental constraints and ontogeny. Because even under the best conditions field and laboratory-reared populations of *P. murrayi* are relatively slow growing, we replicated our experiments with the more rapidly growing nematode, *Caenorhabditis elegans*. Our experimental evolution results for *C. elegans* are consistent with resource availability and the GRH. We found that the number of copies of the 18S ribosomal DNA tandem array in *C. elegans* cultured in a P-limited environment is 13 times less than populations reared in a P-enriched environment. Under similar conditions, *P. murrayi* also evolved a decrease in rDNA gene copy number, although not as dramatic (0.24 fold reduction). Additionally, the adult body size of both *C. elegans* and *P. murrayi* reared in excess P was significantly smaller than those reared in P-limited conditions. Our findings underscore the important relationship between the evolution of life history traits and genome organization, as well as the role of elemental stoichiometry in shaping the organization of trophic interactions and, ultimately, ecosystem structure and functioning.



## ***Phylogeographic patterns of the bipolar lichens *Polycauliona candelaria* (Teloschistaceae) and *Sphaerophorus globosus* (Sphaerophoraceae)***

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Lichens with bipolar distribution occur in both Polar Regions and in high mountains of tropical and temperate areas. About 40% of Antarctic lichen species are described as bipolar. The recurrence of this pattern in different species was already explained as vicariance, replacing of old species by new ones and long-distance dispersal. Currently, most of the studies on the evolution of bipolar species of lichens point to a probable Holarctic origin and colonization of the southern regions through dispersion. Lichens present exceptional dispersion abilities. Exclusively fungal structures appear to be more effective over long distances, but this form of dispersion requires the contact with the photobiont to re-establish the symbiotic relationship and complete de process. Vegetative propagules contain both symbiotic partners, however, the distances reached by these structures are limited by their larger volume and weight. In the literature, water, wind and animals are reported as the main dispersers of lichens. The purpose of this study is to examine the phylogeographic patterns of two species of bipolar lichens commonly found in Antarctica: *Polycauliona candelaria* (Teloschistaceae) and *Sphaerophorus globosus* (Sphaerophoraceae). The samples were obtained directly in the field (Brazilian Antarctic Program) and from herbaria specimens along the known geographic distribution of the species. After the DNA extraction, different regions of the nuclear and mitochondrial genomes were amplified and sequenced (ITS, IGS, SSU, RPB1, LSU, beta-tubulin). The sequences were assembled and aligned using the Geneious 8.1.6 program. Phylogenetic trees were estimated using a Bayesian approach with the software BEAST v1.8.2. The relationships between haplotypes from the southern and northern hemispheres were also estimated with the NETWORK 5 program using the Median-Joining method. Basic sequence statistics, such as haplotype (h) and nucleotide (p) diversities, as well as the analysis of molecular variance (AMOVA) were obtained with Arlequin ver. 3.5.2.1. Mantel's test, as implemented in the program Alleles in Space v. 1.0, was used to examine the correlation between genetic and geographic distances among populations. Preliminary data from both species revealed unique haplotypes of populations of Antarctic and haplotype sharing among specimens from both hemispheres. The absence of association between the geographic structure and genetic diversity and the low genetic divergence found suggest recent dispersion events and corroborate the description of these species as bipolar. The next stages of this study include: (1) coalescence analyses to estimate the time of the dispersal events and migratory rates; (2) demographic analyses; and (3) morphological evaluation of the dispersal structures.

## ***The genetic diversity and distribution of diaspores at an Antarctic inland site - future perspectives by global change?***

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Antarctic nunataka are characterised by limited ecosystem complexity. For colonisation, diaspores of different taxa will be able to reach the habitat and the environmental conditions must be appropriate. Recently, only very scarce knowledge is available on the diversity of diaspores at Antarctic terrestrial habitats in general. The only more extensive research has been done in the northern maritime Antarctic mainly on Signy Island, South Orkney Islands more than 20 years ago. The results presented in this study are the first of an Antarctic inland site of the southernmost maritime Antarctic. The site, Coal Nunatak, is situated in the south of Alexander Island (72° 03`S 68° 31`W). The Nunatak is characterised by a striking scarce colonisation by lichens and mosses. We studied the diversity of diaspores which have been transported into the site by wind or even by snow in the time span of two years. Numerous samples have been taken after 3 weeks, 6 weeks and two times after one year, respectively. The identification of the diaspores has been carried out by using molecular approach of the cultured organisms as well as TGGE directly from the diaspore filters. Organisms from numerous taxa could be identified (bacteria, cyanobacteria, chlorophyta, bryophyta, basidiomycetes, ascomycetes) mostly on species level. The highest number of diaspores has been discovered in the group of ascomycetes. Despite the high number of diaspores of different taxa identified only exceptionally these organisms colonise the habitat at Coal Nunatak which might primarily depend on the recent severe environmental conditions. The results and the achieved knowledge will provide and support a baseline for the recognition and interpretation of the consequences of global change in future times.

## **S28. Diversity and distribution of life in Antarctica**

### ***A new land mammal locality from the Eocene of Seymour Island, Antarctica***

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In the last summer Antarctic fieldtrip during January and February of 2016, within the activities of the "Vertebrate Paleontology of the James Ross Basin, Antarctic Peninsula" project of the Instituto Antártico Argentino (IAA), new remains of fossil terrestrial mammals were found in Seymour Island, NE of Antarctic Peninsula. The new locality IAA 2/16 is placed near the López de Bertodano Bay coast where crop out the Eocene (Ypresian) levels of Campamento and Cucullaea I Allomember of the La Meseta Formation. The fossil remains came from the lower coquina bed of Cucullaea I, which in contrast to the upper naticid bank of the same allomember, were reworked from the lower Campamento level. The surface was prospected seeking for fossils to the naked eye and also, a lot of sediment were sieved, concentrating around 400 kg for future search of small remains, by "picking" under loupe magnification. The faunistic association was dominated by invertebrates, mainly bivalves and a few gastropods. The more abundant vertebrates were sharks teeth, followed by chimaerid tooth plates and teleostean teeth. Isolated bones of Aves, particularly penguins were also present but not so rich, like those from the upper naticid bank which outcrop in other classic Antarctic localities.

In this context, three mammalian teeth fragment were found, two of them belong to the same tooth. The first is a broken portion of enamel which seems to be part of a labial cusp, with a very strong basal cingulid or cingulum. This basal structure is almost straight and bends pointing to the enamel at one of its ends. The other teeth, which match together, are part of a single lower left molariform, preliminary assigned to a p4 or m1 of *Notiolofos arquinotensis* (Litopterna, Sparnotheriodontidae) due to trigonid and talonid sizes. Several features not previously identified in *N. arquinotensis*, are clearly observed due to the scarce wear over the enamel of this tooth. Among them, the identification of the of the protocone outline, the presence of a small mesoconid on the cristid obliqua, and, the clear separation of the hypoconulid "lobe" from the entoconid and hypoconid, which resembles what is expected for an m3 of an ungulate. These are important phylogenetic features in order to improve the knowledge about the relation between Antarctic and South American sparotheriodontids during the Paleogene, and also to test paleobiogeographic hypothesis.

Taken in to account, the proportionally few working time spent in IAA 2/16 and the above mentioned discoveries, this locality rise as promising for the finding of other Paleogene terrestrial mammals. This will be partially evaluated by "picking" work at lab using the sieved sediment collected in the field.

## ***A population of 'giant' Dollo's plunderfish *Dolloidraco longedorsalis* in the Banana Trench, West-Antarctic Peninsula***

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Most major fjords, deeps, and trenches around Antarctica are well studied and many enjoy extensive regular ecological surveys. In contrast, smaller continental shelf trenches have received far less attention. The "Banana Trench" is a small deep located in the Crystal Sound on the east side of Lavoisier Island on the West-Antarctic Peninsula. The steep depression, flat at the bottom, is approximately 20 km long and two km wide at a depth of about 900 meters, 600 meters deeper than the surrounding area.

To investigate the fish populations present in such small isolated trenches, we performed six successive trawls at the bottom of the Banana Trench in May 2014 on board the RV Laurence M Gould. Among the catch, trawls contained 18 specimens of the monotypic Dollo's Plunderfish *Dolloidraco longedorsalis*, which we analyzed to assess the morphological and reproductive characters of this seemingly isolated population and compared them to other circum-Antarctic populations.

Morphologically, individuals captured in the Banana Trench correspond to the largest specimens ever reported for the species, with 14 of 18 specimens being longer than the previously reported maximum size of 13.7cm total length. The longest specimen measured 15.3cm, and the smallest was 13.0cm for weights ranging from 19g to 30.5g.

Among collected individuals, the sex ratio was strongly biased towards females (two males and 15 females, 1:7.5) (one fish wasn't sexed) and appears very different from the 1:1.3 sex ratio reported in the Ross Sea. We do not know, however, whether this skewed sex ratio reflects the general plunderfish population of the Banana trench or whether it resulted from selective catch due to either sex-specific behaviors or chance. Gonadal histology revealed that the two males, while of different sizes, were both sexually mature, and that females were at various levels of sexual maturity with about half in pre-vitellogenesis, a quarter in vitellogenesis, and a quarter gravid. The gonado-somatic index (GSI) was low and averaged 1.03% in males, and 2.74% in females with variation related to oocyte developmental stage: GSI was 2.11% in fish with pre-vitellogenic ovaries and 4.54% in gravid females. The low GSI value suggests a small reproductive effort of the species; total fecundity should be studied in greater detail.

In addition, we studied three morphologically different mental barbels and described elements of the skeleton with a focus on the characteristic hooked opercle and posteriorly extended sub-opercle complex, the fins, and the craniofacial sensory canals.

Together, this work provides a broader perspective on the understudied small continental shelf deeps and their benthic fish populations. In the previously undescribed "Banana Trench", a population of Dollo's plunderfish consists of giants among the species and collections were strongly sex biased. Future studies on this species of Artedidraconidae, which is the most rapidly evolving group of Notothenioids, will inform the impact of a small trench on genetic isolation and morphological evolution.

# ***Abundance and distribution of echinoderms in coastal soft-bottom habitats at Deception Island (South Shetland Islands, Antarctica): dominance of opportunistic sediment-feeders***

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Deception Island is an active volcano with high sedimentation rates, which greatly affect the soft-bottom communities. Echinoderms are usually the dominant organisms in these shallow areas. During the summer of 2012-2013, an exhaustive survey of the shallow water soft-bottom communities of Deception Island was carried out. This study examined the patterns of abundance, distribution, and size structure of the three dominant benthic echinoderms (*Ophionotus victoriae*, *Sterechinus neumayeri*, and *Odontaster validus*) in these areas. Eight locations, and two depths were selected to evaluate the spatial distribution within Port Foster. The megafaunal community here seems to be recovered from the post-eruption conditions, with the return in high numbers of the three 'key echinoderm species'. Patterns of density for the three studied echinoderms differed between depths, and were inconsistent from site to site. These results do not support the initial hypothesis that invertebrate communities from sites closer to the open sea will show higher abundances for the three species studied. Soft-bottom altogether with high ash sedimentation rates were suggested to explain the scarce filter-feeding megafaunal communities at Port Foster, resulting in a total dominance of sediment-feeders, sheltered about coastal soft-bottom ecosystems. Moreover, high sedimentation rates combined with low ice-related disturbance could be the reason behind the high densities of the opportunistic echinoderms hold up by the highest densities of Antarctic macrofauna found in these waters.

# ***Atmospheric linkages and the potential for dispersal of bryophytes in the Antarctic Peninsula region and South Atlantic***

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Antarctic terrestrial habitats are typically 'island like', isolated on various physical scales from metres to hundreds of kilometres. Along the Antarctic Peninsula and Scotia Arc, some terrestrial biota are widely distributed. As the majority, although not all, of these 'islands' probably became exposed from ice during post-Pleistocene glacial retreat, it is clear that successful dispersal events must be reasonably frequent, although few biological studies have addressed this directly. In contrast, other biota have very restricted distributions, a particularly striking example of this being given by the bryophytes specifically associated with geothermal ecosystems of the South Sandwich Islands and Deception Island (South Shetland Islands), where some species may be restricted to a single fumarole system. Bryophytes are well known to produce different dispersing propagules, and spores in particular are thought to be amenable to passive dispersal in the air column. However, very few studies have addressed the basic aerobiological questions of how frequently such transfer events occur in the Antarctic and across the Southern Ocean. Here, we provide an overview of the importance of spore production in Antarctic and Southern Ocean Island bryophytes. Further, we demonstrate approaches, principally based on atmospheric physical modelling of air flow trajectories, to quantifying the potential aerobiological connectedness between different locations within the Antarctic Peninsula, the remote South Atlantic islands, and lower latitudes.

## ***Bartramia patens* Brid : Aan endemic moss from Antarctica?**

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The genus *Bartramia* is a member of the Bartramiaceae, also known as “apple mosses”. The traditional concept of *Bartramia* has proved to be polyphyletic. The genus is widespread all over the world and many of its species show a broad morphological plasticity, making difficult to establish boundaries among them. *Bartramia patens* is a well known taxa that occurs in South America temperate zones and Antarctica. It is considered morphologically identical to *Bartramia ithyphylla* which shows a bipolar distribution. Some authors consider the first just a subspecies of the latter. The current work is investigating the relation between *B. patens* and *B. ithyphylla* using phylogenetic approach based in molecular data. DNA sequences were obtained from fresh material and, when available, from online molecular data banks (Genbank and European Nucleotide Archive). The phylogenetic analyses (Bayesian, Maximum Likelihood and Maximum Parsimony) based on nuclear ITS sequences have shown that specimens of *B. patens* from Antarctica form a separate clade from those of *B. ithyphylla*. These results suggest that *B. patens* is, in fact, a distinct species and is endemic with its distribution restricted to Antarctica and Subantarctic region. *Bartramia patens* may integrate the endemic moss species list of Antarctica Flora to contribute to future conservational measures regarding the continent’s territory and it’s surrounding, which are facing severe environmental and climate changes that are affecting both fauna and flora. Next steps include obtaining more sequences from fresh material collected in Antarctica and the use of a plastidial marker to enhance the analysis. After investigating the phylogenetic relation between those two taxa, further studies will also aim to establish morphological boundaries between them by comparing their morphology. Financial support: project 64/2013 - MCTI/CNPq – PROANTAR, Marinha do Brasil and CNPq Ciências sem fronteiras.

## ***Biogeographic review of carnivorous sponges in the Southern Ocean***

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Carnivorous sponges are unique in the filter-feeding sponge phylum, as they have developed the ability to trap and digest prey. This is the first biogeographic review of this rare and unusual sponge family in the Southern Ocean. Our study analyses all known records of carnivorous sponges in the Southern Ocean, including the description of eight new species, to understand their diversity and distribution patterns.

In the last 20 years the numbers of carnivorous sponge records from the Southern Ocean have tripled with the continued exploration of new environments, regions and depths. Globally, the Southern Ocean is found to be an important region for carnivorous sponge richness and endemism, with over 20% of all species found there. The Cladorhizidae family are found to be highly endemic and are now found to be the second most species-rich Demospongiae family in the Southern Ocean.

Carnivorous sponges are found at all depths, and in a variety of environments including under ice-shelves, shallow rock overhangs, and on the abyssal plain of the Southern Ocean. Our study highlights the importance of seamount habitats for supporting a rich and endemic carnivorous sponge fauna in the Southern Ocean, and the potential reasons for this are discussed. The sub-Antarctic region is also highlighted as an important region for richness and endemism of carnivorous sponges in the Southern Ocean.

There have been significant advances in carnivorous sponge taxonomy, with new advances in the integration of taxonomy with molecular biology. However, in the Southern Ocean, 45% of carnivorous sponge specimens have not been identified to species-level. In the future, the increased utilisation of molecular techniques coupled with morphological taxonomy in the Southern Ocean would continue to improve our biogeographic understanding of this species-rich family.



## ***Chemical ecology in the Antarctic nudibranch *Charcotia granulosa* (Gastropoda: Heterobranchia: Charcotiidae)***

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The loss of the shell in nudibranch gastropods has been related to the acquisition of chemical defensive strategies during evolution, such as the use of natural products to deter predation. In the present study we investigated the origin, location, and putative role of granulocide (1), a new homosesterterpene lactone isolated from the Antarctic nudibranch *Charcotia granulosa* Vayssière, 1906. Several adults, egg masses, and its bryozoan prey, *Beania erecta* Waters, 1904, were chemically analyzed by chromatographic and spectroscopic techniques. Light- (LM) and transmission electron microscopy (TEM) of the mantle revealed complex glandular structures, which might be associated with the storage of defensive compounds in analogy to mantle dermal formations (MDFs) described in other nudibranchs. Although preliminary in situ repellence bioassays with live specimens of the nudibranch showed avoidance against the Antarctic generalist sea star predator *Odontaster validus*, the specific role of the terpene granulocide requires further investigation. The egg masses do not present granulocide and the glandular structures are absent in the trochophore larvae. Our results suggest that *C. granulosa* synthesizes granulocide de novo in early stages of its ontogeny, instead of obtaining it from the prey. Considering the wide geographic area inhabited by this slug, this may be advantageous, because natural products produced will not be affected by food availability. Overall, the Antarctic sea slug *C. granulosa* seems to possess defensive strategies that are similar to nudibranchs from other regions of the world, being one of the few cladobranchs investigated so far that presents de novo biosynthesis of its defensive compounds.

## ***Development an analytical method of RGB data for vegetation survey of terrestrial ecosystem on Antarctica***

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The quadrat method has been widely used in vegetation monitoring. The method is performed to set some quadrats in a field and survey plants in the quadrat with investigator's naked eyes then the method need monetary cost and human resources. Recently, an approaches analyzing photographs of the investigation object taken by compact digital camera as one of the remote sensing techniques is increasingly attempt to diminish the costs of vegetation monitoring (Richardson 2007, Sakamoto et al. 2011). However the method is never applied to communities constructed by extremely small plants such as mosses, cyanobacteria and lichens. These plants cannot investigate using satellite remote sensing because the plants communities are distributed in micro habitat such as interspace of stones or rocks and are extremely small to survey using satellite remote sensing that has finest resolution of 50 cm. Remote sensing survey for vegetation of these plants require data at resolution of a few centimeters.

We attempt to develop an analytical method of RGB data of photographs by digital video camera for vegetation survey. The analyzed photographs are of permanent quadrat for vegetation survey near Showa station on the north east Antarctica. The permanent quadrat for vegetation survey has been set and kept since 1984 in the Antarctic Specially Protected Area No. 141 and taken photographs using compact digital camera each quadrats by Japanese Antarctic Research Expedition since 1988. The quadrat is chosen places growing mosses, cyanobacteria and lichens in the area. The RGB data ware derived from these photographs and analyze using discriminant analysis to detect the cover degree of whole plant community and each taxonomic groups. And raw RGB value, brightness, relative RGB value to brightness and 2G\_RG index (Richardson 2007) ware chosen as variables and examined availability of the variables to discriminate the cover degree of vegetation and separate a vegetation to the each taxonomic groups. It was obtained as a result that raw RGB values had a least error rate when the teacher data and target data are from same pictures. The error rate differed depending on the pictures. And we discuss about the applicability of the derived criteria from the analysis to plants community lived in micro habitat on the other climate zones.

***Distribution of short-finned squid *Illex argentinus* (Cephalopoda: Ommastrephidae) inferred from the diets of Southern Ocean albatrosses using stable isotope analyses***

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Climate change can affect species distributions leading to poleward range shifts and invasion of new habitats. The diets of marine predators are a potential source of information about range shifts in their prey. For example, the short-finned squid *Illex argentinus*, a species which is commercially fished on the Patagonian Shelf in the South Atlantic, has been reported in the diet of grey-headed, *Thalassarche chrysostoma*; black-browed, *T. melanophrys*; and wandering, *Diomedea exulans*, albatrosses breeding at Bird Island, South Georgia (54°S 28°W) in the Southern Ocean. Tracking data suggests that these birds may feed on *I. argentinus* while foraging in Southern Ocean waters during their breeding season. This led to the hypothesis that *I. argentinus* may occur south the Antarctic Polar Front. To test this hypothesis, we used stable isotope analyses to assess the origin of *I. argentinus*. We compared *I. argentinus* beaks from the diets of the three albatross species with beaks of cephalopod species endemic to the Patagonian Shelf and others from the Southern Ocean. Our results show that *I. argentinus* beaks from the diet of albatrosses at Bird Island have  $\delta^{13}\text{C}$  values in the range -18.77 to -15.28 ‰. This is consistent with  $\delta^{13}\text{C}$  values for *Octopus tehuelchus*, a typical species from the Patagonian Shelf. In contrast, *Alluroteuthis antarcticus*, a Southern Ocean squid, has typically Antarctic  $\delta^{13}\text{C}$  values in the range -25.46 to -18.61. This suggests that *I. argentinus* originated from warmer waters of the Patagonian Shelf region. It is more likely that the albatross species obtained *I. argentinus* by foraging in the Patagonian Shelf region than that *I. argentinus* naturally occurs south of the Antarctic Polar Front.

## ***Distribution of zooplankton groups by simultaneous acoustic-biological sampling around San Pedro Island, South Georgias Is., during autumn, 2013.***

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The South Georgia region is characterised by high productivity of phytoplankton and associated high biomass of zooplankton and numerous predator species. In this study, we present preliminary results of a research survey carried out in this area during April/May, 2013 in austral autumn. Acoustic data was recorded at frequencies of 38 and 200 kHz along transects. Biological samples were obtained from 26 oblique tows with a 1m<sup>2</sup> RMT plankton net from a maximum depth of 250 m. Principal zooplankton components found in the catches were identified and quantified including amphipods, euphausiids, mysids, chaetognaths and copepods. Macrozooplankton in net catches consisted mostly of euphausiids, represented by the species *Thysanoessa* spp., *Euphausia frigida*, *E. vallentini*, *E. triacantha* and *E. superba* (krill), this last one in a relative low abundance. Among the hyperiid amphipods *Themisto gaudichaudii* was the main species caught. The comparison of the horizontal distribution of the acoustic records at 200 kHz with that of the most conspicuous macrozooplanktonic species showed a general agreement, with several areas of high abundance at both the northern and southern waters.

## ***Diversity of the aerobic anoxygenic phototrophy gene pufM in Arctic and Antarctic coastal seawaters***

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Aerobic anoxygenic phototrophic (AAP) bacteria serve important functions in marine carbon and energy cycling because of their capability to utilize dissolved organic substrates and harvest light energy. AAP bacteria are widely distributed in marine environments, and their diversity has been examined in marine habitats. However, information about AAP bacteria at high latitudes remains insufficient to date. Therefore, this study determined the summer AAP bacterial diversity in Arctic Kongsfjorden and in the Antarctic coastal seawater of King George Island on the basis of pufM, a gene that encodes a pigment-binding protein subunit of the reaction center complex. Four pufM clone libraries were constructed, and 674 positive clones were obtained from four investigated stations (two in Kongsfjorden and two in the Antarctic Maxwell Bay). Arctic clones were clustered within the Alphaproteobacteria, whereas Antarctic clones were classified into the Alphaproteobacteria and Betaproteobacteria classes. Rhodobacteraceae-like pufM genes dominated in all samples. In addition, sequences closely related to pufM encoded on a plasmid in *Sulfitobacter guttiformis* were predominant in both Arctic and Antarctic samples. This result indicates the transpolar or even global distribution of pufM genes in marine environments. Meanwhile, differences between the Arctic and Antarctic sequences may prove polar endemism. These results indicate the important role of Rhodobacteraceae as AAP bacteria in bipolar coastal waters.

## ***Environmental connotations of diatom and benthic foraminiferal assemblages from coastal West Antarctica***

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Despite increasing interest in fjord sediments as valuable archives of paleoenvironmental histories, up to recently, studies on coastal Antarctic microfossils were sparse and limited geographically. Our analysis of phytoplankton and foraminiferal communities within a broad geographical and environmental context aims to fill this gap and provide a basis for paleo-environmental studies. We examine 33 surface samples collected along a 2500 km transect. The samples come from coastal settings along the northwestern Antarctic Peninsula as well as the Pine Island Bay area, water depths ranging between 20 and 1257 m, latitudes between 62° and 73°S, and bottom water temperatures from -1.5 to 1.2 °C. Assemblages' variability was analyzed along with their environmental affinities that were interpreted in a context of a wide array of ecological conditions, including CTD data.

Four diatom assemblages were identified: three pelagic assemblages related to different sea-ice duration, SST, and other conditions affecting primary production, and one benthic and epiphytic- dominated assemblage typical of near-shore, shallow-water habitats. *Chaetoceros* resting spores are an important component of diatom assemblages. Their high concentrations may reflect increasing primary production and are associated with low total assemblage diversities. In the same study area, benthic foraminiferal communities are more variable. Six foraminiferal assemblages are dominated by calcareous taxa. Among other factors, they correspond to variable food supply, terrigenous sedimentation, and water mass properties. Another two assemblages are dominated by agglutinated foraminifera and reflect conditions corrosive to carbonate.

Diatoms are the key primary producers while benthic foraminifera are important consumers, thus links between these two important groups are through the food web. Intense primary production, exhibited by abundant *Chaetoceros* and lower diatom diversities, affects benthic foraminiferal living assemblages and their preservation in fossil record.

## ***Environmental drivers of spatial changes in marine productivity in the Gerlache Strait (Antarctica) during January 2015.***

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Factors that regulate Phytoplankton production in polar oceans include those that control cell growth (temperature and nutrients) and those that control cell accumulation rates and hence population growth (water-column stability, advection and grazing). Furthermore, biological productivity in the Southern Ocean may be limited by a general lack of iron or its availability in the euphotic zone. With the aim of studying both horizontal and vertical spatial changes in pigments concentration, as a tracer of marine productivity in the Gerlache Strait (Antarctic Peninsula), current measurements were performed using an acoustic profiler type ADCP of 300 KHz, profiles of fluorescence, temperature, salinity, and oxygen using a CTDO SBE 19 + V2, in 20 stations with depths between 189 and 1200 m approximately, surface sediment samples were collected at 3 stations for analysis of metals and organic matter. Further, measurements of wind speed and direction were made. This oceanographic survey was conducted during the first scientific Colombian expedition to Antarctica in January 2015.

The results show a large spatial variability in pigment concentrations, with high values (4.6 mg m<sup>-3</sup>) on surface in most of the south area, as well in some stations in the central and northern zone. Another maximum (8.06 mg m<sup>-3</sup>) was detected in the intermediate and bottom waters from the north to central area of the strait. Such distribution could be associated with 3 different environmental conditions: (1) Influence of Marginal sea-ice zone (MIZ) from the Bellingshausen Sea, which explains the high values in the south, (2) upper Deep Circumpolar Water (uCDW) brought up to surface by upwelling, which explains high values on surface stations in the central and northern zone, and (3) lower Circumpolar Deep Water (ICDW), brings macronutrients and dissolved inorganic Carbon onto the region. These mechanisms are also associated with input of trace metals such as iron (trapped in the ice and accumulated in intermediate waters, respectively) which promotes productivity. NW and NE winds measured during the cruise are related with SAM, but differ from the average values reported by NCEP (1948-2015), NE winds promotes the arrival of water masses from the Weddell Sea. Additionally, in some places the lower concentrations might be associated with grazing by the krill inferred by the location of largest aggregations of marine mammals. The high pigment concentration values recorded in the area during the study period suggest a response of productivity to the influence of a positive Southern Annular Mode (SAM), this has been documented by other authors, also coinciding with the end of La Niña phase and the beginning of El Niño. A comparison of this study with others suggest interannual variability in both oceanographic features and marine productivity in the study area.

## ***Eocene whales from the La Meseta Formation, Antarctica: Clues on the radiation of Pelagiceti in the Southern Hemisphere.***

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Eocene cetacean records, mainly from the northern hemisphere, documented one of the most outstanding processes of mammalian evolution such as the shift from terrestrial to an aquatic lifestyle. On the other hand, Eocene Southern Hemisphere records are significant in documenting the other critical episode in cetacean evolution: the radiation of fully aquatic whales (i.e. Pelagiceti). Pelagiceti, spread into temperate latitudes far from the Tethys Sea, and include the Basilosauridae and Neoceti the group comprising the modern lineages Mysticeti and Odontoceti. The most significant Pelagiceti records from the Southern Hemisphere were recovered from Eocene beds of the La Meseta Formation (Marambio = Seymour Island, Antarctica), and consists in fragmentary basilosaurid materials and a single specimen of the earliest member of Mysticeti, the holotype of *Llanocetus denticrenatus*.

During the last five years, fieldwork conducted in the Marambio (=Seymour) Island by the Dirección Nacional del Antártico – Instituto Antártico Argentino and Museo de La Plata, resulted in the collection of new cetacean material which increased our knowledge of the Antarctic cetaceans. Here we report new significant remains including one of the most complete skeleton of a Pelagiceti indet.(in study), a complete cheek tooth of *Llanocetus* as well as new remains of archaeocete basilosaurids. All these specimens were exhumed from upper levels of the Submeseta Formation (Submeseta II Allomember, level 39). The Pelagiceti indet. corresponds to a large and juvenile specimen represented by associated cervical and thoracic vertebrae, ribs and forelimb elements. The cheek tooth is completely preserved and the accessory cups of the crown form a characteristic broad palmate which allow confidentially referred it to *Llanocetus*. Finally, the archaeocete material includes one specimen represented by teeth, skull bone fragments including part of a periotic. Preliminary observations of the periotic bone show a similar anatomical configuration of the cochlear region with the basilosaurid *Zygorhiza*.

Eocene Antarctic basilosaurids are relevant because they are represented by small-medium sized forms with morphology closer to New Zealand than to Peruvian basilosaurids, suggesting that at least two clades radiated into the Southern Hemisphere. Its records also suggest a rapid spread of these whales into high latitudes, documenting an early global dispersal of the group at least as early middle Eocene. Finally, future studies of the juvenile specimen of Pelagiceti indet. could provide insights into the taxic diversity and paleoecological aspects of these whales during the Paleogene in these latitudes.



## ***Exploring the heterogeneity of Antarctic biodiversity data in space and time***

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Classically, biogeographic studies of the Southern Ocean make use of two alternative approaches: (i) the comparative analysis of the composition and the distribution of taxa across bioregions and (ii) ecoregionalisation, which is the joint-analysis of biotic and abiotic parameters of the environment. Understanding the patterns of species distribution and the driving factors that control them is crucial to conservation purposes in the current context of climate change and direct anthropogenetic disturbances (e.g. exploitation of marine resources, pollution, ...). Based on available scenarios of environment change the ecoregionalisation approach provides the means to identify regions in which Antarctic marine life might be particularly at risk considering the amplitude of the predicted changes and the potential increase of various disturbance sources, natural and anthropogenetic.

Significant environmental changes have already been observed over the last century in certain parts of the Southern Ocean, mainly along the Antarctic Peninsula, and the evolution of several abiotic parameters (e.g. sea water temperature and salinity) have been documented in detail over the last half century. Some datasets combine marine species distribution data from disparate sources based on samples collected during various oceanographic campaigns, among which certain cruises that were undertaken at the end of the nineteenth and beginning of the twentieth centuries when oceanographic conditions were slightly different from those prevailing nowadays. Prior to analyzing the link between combined species distribution datasets and present-day oceanographic parameters, we decided to explore the heterogeneity of species distribution data in space and time with regards to past environmental changes.

We worked on an Antarctic echinoid (sea urchins) database that includes more than 7,100 georeferenced occurrence records from samples collected in the Southern Ocean sensu lato (south of the Subtropical Front that is, south of 45°S latitude) during cruises spanning over 143 years between 1872 and 2015. Sea urchins are common in the Southern Ocean benthic communities. A total of 80 species are represented that display contrasted depth ranges and distribution patterns across austral provinces and bioregions, and show various ecological traits including nutrition and reproductive strategies. This potentially precludes various responses of species to environmental changes, past and future. Environmental data were gathered from datasets of the World Ocean Atlas 2013 and from those used for the Biogeographic Atlas of the Southern Ocean published in 2014. Abiotic parameters selection was based on their significance for echinoid ecology and on their spatial resolution. Data were formatted to the same grid resolution using R and incorporated in a GIS. We checked for autocorrelation between variables and different modeling procedures were performed based on different algorithms and approaches.

## ***Feeding selectivity in *Notothenia coriiceps* and *N. rossii* (Pisces, Nototheniidae) on amphipod species at Potter Cove, South Shetland Islands, Antarctica***

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In inshore waters of the western Antarctic Peninsula and the South Shetland Islands, among the organisms of the benthic community ingested by fish (e.g. amphipods, polychaetes, bivalves, gastropods, cephalopods, chitons, isopods, echinoids), amphipods of the Suborder Gammaridea are the energy-richest taxa of the benthos. Furthermore, these organisms constitute the main food during most of the year for fish of the Suborder Notothenioidei, including the black rockcod *Notothenia coriiceps* (NOC) and the marbled rockcod *Notothenia rossii* (NOR). In contrast, other benthic components of very low energetic value (e.g. algae, sponges, corals, asteroids, ophiuroids, ascidians) are much less important fish prey. Despite their ecological resemblances and in line with their distinct body shape and morphology, NOC is more demersal and sedentary feeding mainly on a wider range of benthic organisms, whereas NOR is more semipelagic and migratory, feeding more regularly than NOC on water column prey. There is a high occurrence of amphipods (up to 85% of the total macrobenthos) in macrobenthic communities along the western Antarctic Peninsula. In this area of the southern Scotia Arc, including Potter Cove, King George Island/Isla 25 de Mayo, macroalgae colonized the sublittoral rocky shores and are extremely abundant in terms of biomass. They constitute natural habitat for amphipods and other invertebrates, being brown algae species with large bushy blades (e.g. of Order Desmarestiales) a suitable refuge from predation and/or environmental stress. Likewise, numerous mobile invertebrates, including amphipods, feed on small benthic diatoms among the macroalgae. In Potter Cove from the last three decades, due mainly to the effects of climate change, the retreat of the Fourcade Glacier has created newly ice-free areas available for benthic colonization. At the same time these areas have been exposed to high loads of sediment input from subglacial waters. Nevertheless, it was revealed that these new ice free areas are indeed a suitable site for macroalgal colonization. Thus, the community of macroalgae and associated fauna could have been expanded at Potter Cove ecosystem according to new hard substrate available for colonization. Due to the importance of gammarideans as prey of several fishes, it has been indicated that food competition would seem to be high in Potter Cove. However, different fish species may feed on different gammaridean species resulting in a low food overlap; for example, amphipods among macroalgae and epibenthic gammarideans. In the South Shetland Islands and western Antarctic Peninsula area only a few studies have been conducted on feeding selectivity by notothenioids in relation to food availability in the wild. Using samples obtained in Potter Cove, close to the scientific station Carlini (62° 14'S, 58° 40'W) in February-March of 2016, we carried out a comparative analysis of the benthic amphipods found in the fish diets with those collected along a depth gradient in rocky bottom with macroalgae. This allowed us to determine the degree of feeding selectivity 1) on different amphipod species; 2) between two morphological distinct notothenioid species.

## ***First results of the SO-AntEco expedition***

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The South Orkney Islands is a small archipelago located in the Southern Ocean, 375 miles north-east of the tip of the Antarctic Peninsula. The seafloor around the South Orkney Islands has been shown to be an area with exceptionally high biodiversity. The marine animals there represent approximately one fifth of all species recorded for the entire Southern Ocean.

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) closed all finfish fisheries around the South Orkney Islands in 1989, and in 2009 they established the South Orkney Islands Southern Shelf Marine Protected Area (SOISS MPA), the first MPA located entirely within the High Seas anywhere on the planet.

SO-AntEco is a British Antarctic Survey (BAS) led expedition undertaken in conjunction with an international team of scientists from the Scientific Committee for Antarctic Research (SCAR) AntEco research programme. The team includes participants from 9 different countries and 16 institutes.

The SO-AntEco expedition will investigate the diversity of life both inside and outside of the SOISS MPA region in order to better understand the distribution and composition of the seafloor communities around islands. We will undertake a research cruise that will explore the different seafloor habitats to investigate if different environments support different communities of animals. Understanding where animals that are vulnerable to fishing and other human impacts (such as corals and sponges) live will help us to manage the region's natural resources in the future.

Here we present the initial findings of this expedition and their likely implications for conservation and management in the region.

## ***First step to eradication of *Poa annua* L. from Arctowski Oasis (King George Island, South Shetlands, Antarctica)***

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*Poa annua* is the only flowering plant species that has established a breeding population in the maritime Antarctic, through repeated anthropogenic introduction. Annual bluegrass inhabits mainly anthropogenic sites, but recently has entered tundra communities. The functioning of *P. annua* in the Antarctic could not have been possible without adaptations that enable the plants to persist in the specific climatic conditions typical for this zone. *Poa annua* is highly adaptable to environmental stress and unstable habitats: huge phenotypic and genotypic variability, small size, plastic life cycle (life-history types ranging from annual to perennial forms). The spreading of *P. annua* in the Antarctic Peninsula region is a classic example of the expansion process following anthropogenic introduction of an invasive species, and illustrates the dangers to Antarctic terrestrial ecosystems that are associated with increasing human traffic.

We report the first steps to eradicate the species after all the necessary initial research has been conducted. After detailed mapping a part of the "Arctowski" population closest to a valuable moss carpet formation has been removed. We removed altogether 314 out of 1439 tussocks growing in the vicinity of Station buildings and all of the 49 tussocks growing in the forefield of Ecology Glacier. In subsequent years we will continue the eradication process and monitor the eradicated sites. This will provide valuable information on procedures concerning removal of alien species in the maritime Antarctic and will help making future informed decisions for other invasions in the region.

# ***Functional response of *Blechnum penna-marina* to desiccation in tundra environments***

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The climate on the sub-Antarctic Marion Island appears to be changing, providing an important indication of climate trends in the southern Ocean. Over the past forty years, temperature and average wind speed have increased, while rainfall and the number of overcast and windy days have decreased. The impact of these changes on plant physiology has hardly been studied in these isolated floras. The aim of this study is to test how the photosynthetic activity of *Blechnum penna-marina* changes with a decrease in leaf water content, indicative of desiccation that is expected to increase with the observed climate change. *Blechnum penna-marina* is one of the key species on Marion Island as it is one of the most dominant species in terms of cover and biomass, and can be found in most of the habitats below 600m above sea level. I propose using this species as an indicator to help predict how ferns on sub Antarctic islands may respond to changing climatic conditions. *Blechnum penna-marina* samples were collected from closed fernbrake slope habitat, placed in two liter containers with saturating water levels. Samples were acclimated at either 6 or 11 °C for at least 3 days. After acclimation, CO<sub>2</sub> response (50 to 1500 micromol CO<sub>2</sub> mol<sup>-1</sup>) was tested with a LICOR 6400XT allowing simultaneous measurement of gas exchange and chlorophyll fluorescence. Additionally; three leaves from each sample were collected to calculate leaf water content. Samples were then desiccated over time at their respective acclimation temperature. CO<sub>2</sub> response curves were determined at two day intervals during desiccation. Relationships between leaf water content and various photosynthetic parameters were investigated using the following approach: The CO<sub>2</sub> response parameters apparent Rubisco activity (V<sub>cmax</sub>), maximum electrontransport (J<sub>max</sub>), triose-phosphate utilisation (TPU), daytime respiration (R<sub>d</sub>) and mesophyll conductance (G<sub>m</sub>), were response variables, acclimation temperature was a categorical variable, and leaf water content was the independent variable. Factor analysis was also conducted. Plants acclimatized at 6°C had a significantly higher V<sub>cmax</sub>, J<sub>max</sub> and R<sub>d</sub> than plants acclimatized at 11°C degrees. The only value that decreased significantly with leaf water content was the mesophyll conductance of plants acclimated at 11°C. In the factor analysis, TPU, V<sub>cmax</sub>, J<sub>max</sub> and R<sub>d</sub> comprised one factor while leaf water and G<sub>m</sub> comprised another. These results suggest that warming on the island would tend to lower fern productivity, except in areas where low temperature limits the species. The range of the species has been expanding in the past decades, but there has not been a contraction in its major habitats. Other environmental drivers are being currently tested, like wind, soil water, irradiance and temperature. I will attempt to build a mechanistic model that will help to understand how this species could react to global climate change.

# ***Glacial dropstones enhance megabenthic habitat diversity and species richness in west Antarctic Peninsula fjords***

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The west Antarctic Peninsula (WAP) margin is composed of a network of deep (>400 m) sub-polar fjords containing numerous fast-flowing tidewater glaciers; This region has sustained substantial climate warming over recent decades. Glacial calving within fjords delivers ice-rafted debris (e.g. dropstones) which can provide habitat for many benthic organisms. Because most of the Antarctic shelf, including fjord seafloors, consists of fine-grained sediments, dropstones may increase beta diversity by providing new substrate for both obligate and facultative hard-substrate fauna. We are evaluating the influence of dropstones on fjord benthic biodiversity, testing predictions derived from island biogeographic theory. Seafloor images from yoyo-camera surveys are being analyzed using ImageJ software to evaluate the abundance and size distributions of dropstones, as well associated megafaunal abundance, biodiversity and community structure, in multiple sediment-floored basins of three WAP fjords: Andvord, Flandres, and Barilari Bays. Fjord dropstone and megafaunal distribution patterns are being contrasted with those at similar depths on the open continental shelf > 100 km from glacial termini. Results for Andvord Bay indicate that the fjord dropstones cover a small percentage (~1%) of the seafloor area and have small mean size (220 cm<sup>2</sup>) but still are much abundant than on the open shelf, especially within middle fjord basins. Bray-Curtis similarity analyses reveal that dropstone community composition differs between inner, middle and outer basins of Andvord Bay. These differences may result from down-fjord differences in mean dropstone size and/or burial disturbance of hard-substrate fauna. We find at least nine morphotypes of obligate hard-substrate fauna on dropstones in Andvord Bay, and species richness estimators (e.g., Chao 1) predict a total of >40 species on dropstones in the deep fjord basins. Thus, although dropstones represent only ~1% of the available substrate in Andvord Bay, we find that they significantly enhance beta and gamma diversity at the fjord floor, providing further evidence that fjords may contribute substantially to regional diversity at shelf depths (400-600 m) along the WAP.

# ***Glacial Refugia as a Means of Nematode Survival during the Last Glacial Maximum***

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During the last glacial maximum Antarctica was thought to have been completely blanketed by a thick sheet of ice. Ice-free areas that currently support terrestrial communities would have been completely uninhabitable by terrestrial organisms. However, recent molecular and geological research indicates that Antarctic nematode species probably survived in situ for millions of years. To do so, the extant biota in these ice-free areas would have had to either recolonize Antarctica from other ice-free areas in the southern hemisphere with each successive glacial recession, or somehow persist on nunataks or geothermally warmed soils. While nematodes are the most abundant metazoans of Victoria Land soils, their evolutionary history still remains unclear. Using soil samples collected from different locations in Victoria Land, we compared mtDNA and rDNA haplotype variation of the nematode *Eudorylaimus* to test hypotheses of speciation, and that these nematodes survived repeated glaciations in Antarctica in high elevation refugia, such as nunataks. Putative refugia include high elevation features near the Mckay Glacier in southern Victoria Land. We hypothesized that populations from putative refugia would have greater amounts of genetic variation than populations from surrounding, lower elevation sites. As soil habitats are altered in response to climate change, understanding how nematodes previously evolved and adapted to environmental change will be key to developing conservation and management efforts needed to ensure the stability of Antarctic ecosystems.

## ***Glass sponge distribution in relation to abiotic factors and predators – a large-scale regional study in the Weddell Sea, Antarctica***

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Glass sponges (Porifera, Hexactinellida) are important structuring components of the benthos in Antarctic shelf regions. These sessile filter feeders can grow up to 2 m in height and form extensive sponge beds in some areas, dominating the benthic biomass and providing habitat for a variety of other animals. However, much of their ecology is still unknown to date, including the factors determining their distribution and abundance. In the current study, we investigated glass sponge distribution and abundance in the south-eastern Weddell Sea in relation to environmental factors (water mass characteristics, currents, ice cover), as well as food availability and abundance of predators. During two recent expeditions with RV Polarstern, we collected photos and videos of the ocean floor by using different gear equipped with HD cameras: a multi grab (MG), an Ocean Floor Observation System (OFOS) and a Remotely Operated Vehicle (ROV). For each of 30 stations, 30 images were randomly selected and analyzed for abundance and species composition of glass sponges and their predators, as well as substrate characteristics. In addition to that, we measured temperature, salinity, dissolved silicate, particulate silicate and bacterial cell numbers. Currents and ice cover were modelled using the FESOM model. Glass sponge abundance was related to the environmental data and predator abundance in order to identify the factors determining glass sponge abundance and distribution in the south-eastern Weddell Sea. Our findings provide an important baseline to assess how glass sponge communities might change in a changing Antarctic environment.



## ***High abundance of the epibenthic trachymedusa *Ptychogastria polaris* in subpolar fjords along the West Antarctic Peninsula***

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Improvements in the design and use of underwater sampling technologies for visual surveys and specimen collection have recently clarified the high abundance and diversity of gelatinous zooplankton in deep-sea benthic boundary layers. Little is known however about the medusae that can be conspicuous members of seafloor communities, particularly those taxa that exist in polar seas. The epibenthic trachymedusa *Ptychogastria polaris* Allman, 1878 (Trachylida, Hydroidea) has been reported at high latitudes in both the northern and southern hemispheres, with a circumpolar distribution in the sub- to high Arctic, and disjunct reports of a few individuals from east Antarctica and the South Shetland Islands. These studies have focused on taxonomy, with little investigation of the ecology and population structure of this trachymedusa. We conducted seafloor photosurveys and megacoring at 436-725 m depths in three subpolar fjords along the Danco-Graham Coast of the West Antarctic Peninsula (WAP); Andvord, Flandres and Barilari Bays. Based on morphological characteristics and DNA barcoding, *P. polaris* was a common epifaunal component in Andvord and Flandres Bays, attaining mean densities in fjord basins ranging from 0.06 to 4.2 ind/m<sup>2</sup>. The medusa, however, was absent from the epifauna of Barilari Bay. These densities are 2 to 400-fold higher than reported for *P. polaris* in the Arctic. The trachymedusae ranged in size from 15-25 mm bell diameter, and size-frequency distributions suggest that recruitment is limited to a single event per year in the fjord populations. A similar benthopelagic medusa, likely *P. polaris*, was also noted in all three fjords. This benthopelagic form attained abundances up to 7 ind/m<sup>2</sup>, however, most *P. polaris* were observed on or just above soft sediments and classified as epibenthic (~ 80%), with less than 1.5% associated with dropstones. Our findings extend the known distribution of *P. polaris* to include Antarctic Peninsula waters, and indicate that fjords provide a habitat for dense populations, likely because of high and varied food inputs. Because *P. polaris* can spend time in the water column and at the seafloor, large *P. polaris* populations may contribute to pelagic-benthic coupling in west WAP fjord ecosystems.

## ***Highest diversity of cyanobacteria on granite substrates in the Sør Rondane Mountains***

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Cyanobacteria are common in the terrestrial environment throughout the ice-free regions of Antarctica. These ice-free regions represent only about 0.3% of the continent and are scattered all over the continent. In the Sør Rondane Mountains (Dronning Maud Land), the cyanobacteria are mainly present as biofilms or crusts in sheltered spots of the rocky biotopes, probably thanks to microtopographic and microclimatic conditions that allow their survival.

To study the cyanobacterial diversity, samples were collected on granite (5) and gneiss (5) substrates in the vicinity of the Belgian Station Princess Elisabeth and included gravel, biofilms and crusts. In total, 10 sites were sampled.

The cyanobacterial diversity was observed by light microscopy in 126 samples collected in 2009 and 2010. A selection of 27 samples was further studied by DGGE based on the 16S rRNA gene. As some taxa have large polysaccharidic sheaths, a new DNA extraction protocol was designed and tested.

The morphological observations showed the presence of cyanobacteria like *Aphanocapsa* sp., *Coleodesmium* sp. or *Nostoc* sp. with yellow, red, brown or dark-blue pigmented and thick sheaths. Heterocystous cyanobacteria were present in all the 28 cyanobacterial crust samples, but more sporadically in the other samples types. They are able to fix atmospheric nitrogen and could favor the colonization and growth of microbial communities in the oligotrophic terrestrial habitats of Antarctica.

Based on microscopy, the richest sample types were crusts followed by gravels. Furthermore, we observe that the development of cyanobacterial biofilms or crusts seems to be linked to the rock type. Indeed, the most diverse communities were found on the granitic rocks. This could be explained by higher stability of underlying rock and its ability to keep water on the surface, thus creating favorable conditions for development of cyanobacterial communities.

On the basis of DGGE, the 55 obtained sequences and the 27 sequences from Fernandez et al. (2012) were grouped into 28 OTUs sharing at least 97.5% of 16S rRNA similarity. The OTUs' richness assessed by DGGE varied between 1 and 5 per sample. For most of the samples studied by both approaches (18 of 27), the number of morphotypes was higher than the number of OTUs, with 1 to 7 more morphotypes than OTUs. The most frequently observed OTU (9 samples in 7 sites) was affiliated to *Phormidium/Microcoleus*. Ten of the 28 OTUs were only found in one sample. There was no OTU common to all the 10 studied sites. Similarly to the morphological diversity, the richest sampling sites were the Utsteinen Ridge, Utsteinen Nunatak and the Pingvinane Nunataks. The latter two sites shared six OTUs, probably due to similar environmental conditions and local dissemination by winds.

As the Pingvinane Nunataks are more distant from the station, they would be good candidates to create a protected area (ASPA) to preserve the diversity of cyanobacterial communities in this type of rocky environment.

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## ***Is Bryum pseudotriquetrum a bipolar moss species?***

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Bipolar species occur in the polar regions of both hemispheres, either without or with intermediate occurrences on (high) tropical mountains (strict or intermediate bipolar species, respectively). Although the Arctic and Antarctic share a polar climate, the diversity and vegetation composition of bryophytes in both polar regions is quite different. In the Arctic, bryophytes are considerably diverse, with about 600–700 species, whereas the Antarctic bryoflora is less diverse and composed almost only of mosses (about 111 species). About 50 of the Antarctic moss species are bipolar, either strictly bipolar (18 species) or with intermediate occurrences (32 species).

*Bryum* is one of the largest genera of mosses including about 400 species worldwide. In Antarctica, seven species are reported. *Bryum pseudotriquetrum* is considering the most common *Bryum* species of Antarctica, growing in all Antarctic regions, often abundantly and in a wide range of habitats. According to the literature, *B. pseudotriquetrum* is considered a bipolar species with intermediate populations occurring at high elevations in the Neotropics and tropical Africa. Using a molecular approach, we tested if *B. pseudotriquetrum* is monophyletic and indeed represents a bipolar species. Phylogenetic analyses based on nuclear and plastid DNA markers of *B. pseudotriquetrum* specimens from both polar regions and intermediate samples of American mountains showed that *B. pseudotriquetrum* from Antarctica falls into a different clade than *B. pseudotriquetrum* from the Arctic and intermediate regions, suggesting that Antarctic *B. pseudotriquetrum* belongs to another species, *Bryum knowltonii*. The latter species so far has been considered to be of Northern Hemisphere distribution and has not yet been recorded from Antarctica. A re-investigation of morphological characters supports the identity of Antarctic *B. pseudotriquetrum* specimens as belonging to *B. knowltonii*, which consequently, should be considered a (strict) bipolar species. Financial support: project 64/2013 MCTI/CNPq – PROANTAR, Marinha do Brasil and CNPq Ciências sem Fronteiras, NWO ALW-NPP 851.30.027, EU ARCFAC-026129-2008-31, EU ARCFAC-026129-2009-123, EU INTERACT Transnational Access C-13-4(12), Royal Dutch Navy, Netherlands Scientific Expedition Edgeøya Spitsbergen 2015 (SEES).

# ***Jurassic marine fishes from longing gap, Antarctic Peninsula: 2016 fieldwork report***

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The expedition to Longing Gap, Antarctic Peninsula during January and February of 2016 was supported by the Argentinian Antarctic Institute (IAA). In that area, the Ameghino (=Nordenskjöld) Formation (Kimmeridgian–Berriasian) crops out. Because Antarctic Late Jurassic fish record is still scarce –represented only by few specimens collected at James Ross Island and Antarctic Peninsula–, the focus of our expedition was collect new Late Jurassic fish material at Longing Gap. As a result, more than 500 specimens were recorded giving rise to the most important –in terms of taxa diversity and preservation quality– marine fish collection of the Jurassic of Antarctica. The greatest part of the specimens was collected in the early Tithonian Longing Member of the Ameghino Formation and only few fragmentary small actinopterygians were recovered from the late Tithonian –Ameghino” Member. Here that new fish material is reported. Also, few marine reptiles (pliosauroids and ichthyosaurs), plants (leaf and wood), and several invertebrates (mainly nautiloids, ammonoids, and bivalves) were recovered in levels of the Ameghino Formation. The fish material found includes semionotiforms, teleostemorphs (aspidorhynchids, pachycormids), and teleosts. We add new information relative to the scales morphologies and fin rays of the enigmatic Ameghinichthys antarcticus. Semionotids are represented by scale patches, fin rays, and one skull roof; being the southernmost record of the group. Among teleostemorphs both, aspidorhynchids and pachycormids were found; aspidorhynchids were previously reported from the Ameghino Formation (i.e., Vinctifer) but the new and outstanding specimens recovered during the 2016 fieldwork shows some differences relative to the scales morphologies and disposition over the body, predentary length, teeth, and skull bones. Among pachycormids only suspension feeders were recovered; this record extends the latitudinal distribution of Pachycormidae to the southernmost part of the Southern Hemisphere. Teleosts are represented by at least two morphotypes, the previously recorded Antarctithrissops and new specimens that are currently under study. The fishes recovered provide new information about the taxonomic and morphological fish diversity of the Ameghino Formation and could be useful for the understanding of actinopterygian paleobiogeography and evolution.

## ***Macroinvertebrates associated with two Antarctic macroalgae, the role of habitat complexity***

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In Admiralty Bay, King George Island, benthic macroalgae cover a significant percentage of the shallow seafloor; forming a complex habitat for invertebrates looking for shelter, protection and feeding grounds. Even though the area has been subjected to intense sampling, there are few studies aimed at the macrofauna associated with Antarctic macroalgae; especially in the area of the Mackellar Inlet. The main objective of this research was to determine the composition of macroinvertebrates associated with *Desmarestia menziesii* and *D. antarctica*, two of the most common macroalgae found at the bay, as well as the factors that may contribute to the difference in diversity of organisms associated with them. From the analysis (to the lowest possible level) of the epiphytic assemblage of 10 samples of macroalgae collected at the Mackellar Inlet (Admiralty Bay, King George Island), between January and February 2015, 18 taxa belonging to 3 phyla were found: Arthropoda, Mollusca and Annelida; where Amphipoda (Arthropoda) was the dominant group (94,32 %) for both macroalgae. However, the densities were not equal for both algae as there was a higher abundance of macroinvertebrates associated with *D. menziesii* than *D. antarctica* (1552 ± 1401,5 individuals belonging to 17 taxa and 56 ± 82,42 individuals belonging to 8 taxa, respectively). Nevertheless, diversity indices (Shannon and Simpson) showed higher values for *D. antarctica* ( $H' = 1,212$ ;  $D = 0,625$ ) than *D. menziesii* ( $H' = 0,779$ ;  $D = 0,513$ ) mostly due to the strong dominance of *Gondogeneia* sp. (Amphipoda). The evenness index showed higher value for *D. antarctica* (0,505 vs 0,245), demonstrating that an equitable distribution among taxa is a key ingredient in the diversity. Studies have shown that morphological aspects of macroalgae are important for epiphytic animal assemblages as the three-dimensional complexity of macroalgae played an important role in its diversity values and macroinvertebrate associated densities. In this case study, it is evident that the numerous branching fronds of *D. menziesii* provides a habitat with greater complexity than sparse foliose fronds of *D. antarctica*. This project was part of the Peruvian Antarctic Expedition ANTAR XXIII.

## ***Modelling tag loss of two species of fur seals at Macquarie Island***

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Understanding the demography of wild populations relies on the long-term identification of individuals based on natural or human created markings. Such mark-recapture studies are based on one of two assumptions; (i) marks are never lost or (ii) the rates of losing marks are estimated. When marks are known to be lost, if loss rate is underestimated the survival rate is biased low, and if loss rate is over estimated survival rate is biased high, and this can have implications on population management and conservation. Ideally, to make informed population survival estimates when using mark-recapture methods, individuals within a population are marked with a form of permanent identification and then doubled-tagged in order to account for tag loss. Here we used a 26 year mark-recapture dataset of two species of fur seal: Antarctic fur seal (*Arctocephalus gazella*), Subantarctic fur seal (*A. tropicalis*), doubled-tagged (one tag in each fore-flipper) and microchipped with an implanted radio frequency identification transponder (RFID). Using a Bayesian approach, tag loss probabilities were found to differ by sex, age, and species. Tag loss rates were then incorporated into population survival probabilities, providing the first survival estimates of the Antarctic and Subantarctic fur seals at Macquarie Island since the monitor program began.

## ***New metatherian mammal from early Eocene levels of the La Meseta Formation, Antarctic Peninsula***

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We describe a new mammal coming from site IAA 1/90, Marambio (Seymour) Island, Antarctic Peninsula. The specimen (MLP 14-I-10-20) is a tiny lower left molar partially worn (total length: 2.24 mm; trigonid length: 0.72 mm; trigonid width: 1.11 mm; talonid width: 1.45 mm), and represents a new taxon for the Antarctic Paleogene mammalian assemblage. It was recovered from early Eocene (Ypresian) levels of the Cucullaea 1 Allomember, La Meseta Formation. Main features of it are its small size, brachydont and bunoid aspect, short trigonid, very wide and long talonid, closely set paraconid and metaconid, low protoconid, very large entoconid, the development of an incipient, bulbous cingulum at the labial base of the crown (between trigonid and talonid), and the persistence of a short posterior cingulum. The new specimen can be confidently referred to the Metatheria (Mammalia), more precisely to the Marsupialia. Within the latter, some features are reminiscent of the Paucituberculata (e.g., appressed para- and metaconid, quite developed and salient hypoconid, large entoconid). However, other features suggest the allocation of this specimen to basal polydolopimorphians, either stem Bonapartheriiformes (e.g., Prepidolopidae) or even to the more generalized Glasbiidae. Glasbids have been regarded as the basalmost clade within the whole order Polydolopimorphia, which is considered as part of the Australidelphia (i.e., Microbiotheria + Australasian marsupials). The discovery of specimen MLP 14-I-10-20 offers new insights on the origins and early diversification of Australidelphian marsupials in southern continents. It also adds significant information to our knowledge of the diversity of Antarctic Paleogene mammals, their evolution and historical biogeography.

## ***Paleontological inheritance of West Antarctica: Preliminary report of the newly found Mesozoic/Cenozoic fossil vertebrates from Antarctic Peninsula***

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During December 2015 / February 2016, within the activities of the "Vertebrate Paleontology of the James Ross Basin, Antarctic Peninsula" project of the Instituto Antártico Argentino, principal fossiliferous localities of Marambio (=Seymour) Island, northeast Antarctic Peninsula (marine late Cretaceous, K-Pg and Paleogene outcrops), and Cape Longing, Antarctic Peninsula (marine Jurassic) were prospected seeking for marine and terrestrial vertebrates. An exceptional latest Cretaceous to Eocene shallow – marginal marine sedimentary sequence (over 2000 m thick) is exposed on Marambio (=Seymour) Island, located then and now at ~65°S. The López de Bertodano Formation (late Cretaceous to early Paleocene) contains the K–Pg boundary (identified using biostratigraphy and an iridium anomaly) and is overlain by the Sobral Formation (Paleocene), the Cross Valley Formation (?late Paleocene), the La Meseta Formation (early-middle Eocene), and the Submeseta Formation (late Eocene).

New extensive collections of vertebrate fossils from Marambio (=Seymour) Island include late Eocene Submeseta Formation cetaceans, sharks, and birds; early-middle Eocene La Meseta Formation teleostean fishes, sharks, birds, terrestrial mammals, early Paleocene Sobral Formation teleostean fishes and sharks, and late Maastrichtian López de Bertodano Formation teleostean fishes, sharks, plesiosaurs, mosasaurs and dinosaurs. The taxonomical, ecological and biostratigraphical information of these fossils will be analyzed and the results will be used for paleoenvironmental reconstruction and identification of the oceanographic changes that occurred prior to the Gondwana break up and after the demise of the connections between Antarctica and South America.

Also we report the discovery of a new marine fossil assemblage from the marine Jurassic sites of Longing Cape, eastern Antarctic Peninsula. It includes fishes, ichthyosaurs and plesiosaurs, and is one of the richest Jurassic marine biotic assemblages found in Antarctica.



## ***Patterns in East Antarctic zooplankton diversity: What can structural and compositional aspects of biodiversity tell us?***

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Zooplankton are an abundant and diverse group that form an integral component of the Southern Ocean ecosystem. Quantifying current zooplankton diversity and distribution patterns and their relationship with environmental variables facilitates a better understanding of this component of the ecosystem and how it may change with future scenarios. However, diversity can be defined in many ways. A broad distinction occurs between metrics that quantify structural aspects (richness, abundance, evenness) of diversity and those that emphasise community composition (where the identity of species is important). Each provides a complementary view of how communities are structured and function with respect to their environment. Here we model and map both structural and compositional aspects of zooplankton diversity across East Antarctica using the Continuous Plankton Recorder (CPR) dataset and synoptic environmental data. We compare and contrast spatial patterns in structural and compositional biodiversity as well as their environmental correlates. We identify regions with distinct and rare combinations of biodiversity and examine congruence with pelagic regionalisations that were derived from environmental variables only. We discuss how combining both aspects of biodiversity enhances our understanding of zooplankton communities and may assist in conservation or monitoring efforts.

## ***Pohlia Hedw. (Bryophyte-Mniaceae) in Antarctic region: diversity and bipolarity.***

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Although the Arctic and the Antarctic regions share the polar climate with extreme variations in temperature, the vegetation composition is quite different. In the Arctic region, vascular plants predominate with 2.218 species, from which 600-700 are bryophytes. In the Antarctic region there are 111 bryophytes with only two are angiosperm. The bryophytes in both regions are predominantly acrocarpous growing in tufts or mats. Bipolar mosses are those which occurs, in both Arctic and Antarctic regions and 45% (50 species) of the bryoflora of Antarctica are bipolar, from those, 18 species occur only into the polar region and others 32 bipolar species occur into the polar regions plus into the mountains in tropical regions. *Pohlia* is a big genus of bryophyte with ca. 150 species and its taxonomy is quite complicated due its complex morphology. In the Antarctic there are five species reported, and recently we found a new occurrence to the region, *Pohlia longicolla* (Hedw.) Lindb. We are also using a phylogenetic approach to check the number of the species of *Pohlia* in Antarctica and its bipolarity. We used nuclear (ITS) and plastid (trnLF) markers and included five species from Antarctica into the currently existing phylogenetic data. The Antarctic species of *Pohlia* belong into at least four different clades within the family Mniaceae. *Pohlia cruda* (Hedw.) Lindb. is a bipolar species and is in a well-supported clade, *P. cruda* basal in the family and is the most genetically different of all others species of *Pohlia*. Our preliminary data also suggests that *Pohlia nutans* (Hedw.) Lindb. is bipolar with high support. *Pohlia drummondii* (Müll. Hal.) A.L. Andrews and *P. longicolla* are apparently polyphyletic and may constitute more than one species. Financial support: project 64/2013 MCTI/CNPq – PROANTAR, CNPq Ciências sem Fronteiras, Marinha do Brasil, NWO ALW-NPP 851.30.027, EU ARCFAC-026129-2008-31, EU ARCFAC-026129-2009-123, EU INTERACT Transnational Access C-13-4(12), Royal Dutch Navy, Netherlands Scientific Expedition Edgeøya Spitsbergen 2015 (SEES).

## ***Prokaryotic communities in brine pockets of three frozen Antarctic lakes (Tarn Flat and Boulder Clay, Northern Victoria Land)***

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Brines occur within talik in Arctic and Antarctic permafrost, remain liquid at temperature below 0°C and can be isolated for a long time. These extreme habitats can harbour halotolerant and cold-tolerant microbial communities which remain metabolically active at near freezing point and represent useful model for studying the survival strategies adopted by microorganisms.

The present work aims to give preliminary information on the microbial communities inhabiting five Antarctic brine samples. Sampling activities were performed under sterile conditions in two frozen Antarctic lakes, Tarn Flat (TF) and Boulder Clay (BC), in the Northern Victoria Land. TF brines, collected from two different depths (B1 and B2 from 3.90 and 4.50 m, respectively), were separated by an ice layer of 12 cm and had different salinity (19.9 and 16.6 mS/cm, respectively) and pH (7.22 and 6.74, respectively). Salinity and pH of BC brines (BC-1, BC-2 and BC-3) collected from three different depths (2.5, 1, and 2 m) ranged between 0.2 and 3.6 mS/cm, and between 7.60 and 8.76, respectively.

Brine aliquots (200 µl) were plated in duplicate on Tryptic Soy Agar (TSA) and R2 Agar (R2A) at different strength, Acid Agar (AA) and Halobacterium medium (HAL). Plates were incubated at 4°C and checked for bacterial growth after one month. Viable counts in TF brines on TSA media ranged between 3.13 x 10<sup>3</sup> and 4.72 x 10<sup>3</sup> CFU/ml in B1 (on TSA1% and TSA50%, respectively), and between 5.3 x 10<sup>3</sup> and 7.24 x 10<sup>3</sup> CFU/ml in B2 (on TSA100% and TSA1%, respectively). In the case of the BC site, viable counts ranged between 17.5 (BC-3 on TSA1%) and 1.6 x 10<sup>4</sup> CFU/ml (BC-1 on TSA1%). Bacterial growth on the remaining media differed among samples with R2A10% that yielded colonies only in TF samples (about 60 CFU/ml), AA only in BC-1 (1.5 x 10<sup>3</sup> CFU/ml), and HAL only in BC-1 (1.16 x 10<sup>3</sup> CFU/ml) and BC-3 (60 CFU/ml).

A total of 223 isolates were obtained from agar plates and tested for NaCl and temperature range for growth. The majority of isolates grew between 30 and 130 g/L of NaCl, and between 4 and 15°C. Few isolates (mainly in B1 from TF) were able to tolerate up to 190 g/L of NaCl or grew in the absence of salt. The 16S rRNA gene sequencing allowed identified bacterial isolates as affiliated to the Proteobacteria (e.g. genera *Psychrobacter* among the Gammaproteobacteria, and *Mycoplana* among the Alphaproteobacteria), Firmicutes (e.g. genus *Sporosarcina*) and CF group of Bacteroidetes (e.g. genus *Flavobacterium*). Finally, total genomic DNA was extracted from brine samples, the V3-V4 region amplified and then analyzed by the Ion Torrent technique to investigate the composition of the prokaryotic communities.

# ***Temporal, spatial, and sampling heterogeneities in species distribution modeling. The case study of the data-poor area of the Kerguelen Plateau.***

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The Kerguelen plateau is an important economical area for fishing activities, concentrating substantial issues of conservation for marine biodiversity. To assess the impacts of global warming and of fishing activities on marine biodiversity, methods of species distribution modeling provide convenient tools. Species distribution models are used to estimate species presence in a given area as a function of environmental factors (Elith et Leathwick, 2009). They are commonly used in biogeography and ecology (Gutt et al., 2012) and can constitute seminal conservation planning tools.

The present work aims at improving the robustness of existing modeling approaches in the case of areas for which only poor and heterogeneous biodiversity data are available, a situation prevailing in most regions of the Southern Ocean. Data compilation from various sources implies temporal heterogeneities that may constitute a critical point when building species distribution models (Aguiar et al., 2015). Spatial and sampling heterogeneities are also likely to introduce biases due to differences in sampling strategies and in the gears used during the various cruises. Our objective is to assess the influence of temporal, spatial, and sampling heterogeneities on species distribution modeling using datasets of echinoid occurrences over the Kerguelen Plateau. Data were compiled from many oceanographic campaigns led over a long period starting with the Challenger Expedition in 1872-76 and ending with the recent PROTEKER campaign in 2015. Environmental data were gathered from datasets of the World Ocean Atlas 2013 and from those used for the Biogeographic Atlas of the Southern Ocean published in 2014.

Data subsets were defined to partition heterogeneity sources and build different models. The models were compared with each other to test the effect of each heterogeneity source. Several modeling procedures (BRT, Maxent, GAM, MARS) were selected to best fit the type of data analysed (discontinuous/continuous, interpolated/parcelled out, categorical/numeric data...).

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## ***Terrestrial diatom communities from Ulu Peninsula (James Ross Island, NE Antarctic Peninsula)***

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Diatoms (Bacillariophyta) are one of the most diverse and abundant algal groups in the Antarctic Region and play a dominant role in almost all freshwater and terrestrial ecosystems. Recent ecological surveys were dealing with the freshwater, semi-aquatic and moss-inhabiting diatom communities of the Ulu Peninsula. Despite the increased diatom research and efforts, the diversity, ecology and taxonomy of the terrestrial diatom flora of James Ross Island remain poorly known and a more thorough ecological and taxonomical survey was highly needed.

The main aim of this study was to define the ecological, taxonomical and biogeographical characterization of terrestrial diatom communities from the ice-free area of Ulu Peninsula, James Ross Island. Diatom samples were collected during January and February 2015 from terrestrial habitats on James Ross Island, a 2,600 km<sup>2</sup> large island, situated in the north-western part of the Weddell Sea, close to the northern tip of the Antarctic Peninsula. A total of 86 diatom taxa (including species, varieties and forms) belonging to 25 genera has been found during the analysis of 54 samples. Species richness per sample ranged from 5 to 35, with an average number of taxa per sample of 17. The most abundant species were *Hantzschia amphioxys* f. *muelleri*, *Luticola muticopsis* and *Pinnularia borealis* s.l. The most species rich genera include *Luticola* (22 species), *Humidophila* (9 species), *Pinnularia*, *Nitzschia* (8 species), *Achnanthes*, *Hantzschia* and *Muelleria* (5 species). Biogeographically, the soil diatom flora of the Ulu Peninsula is composed of cosmopolitan, Antarctic and endemic elements. Canonical Component Analysis was used to classify the samples based on their chemical characteristics, indicating that specific conductivity, moisture and TOC were the main factors dividing the samples into four different groups. The present study is the first focusing on the ecology of terrestrial diatom communities on James Ross Island, revealing the presence of a rather species rich diatom flora and relationships between site-specific environmental parameters and diatom diversity. The authors would like to thank the scientific infrastructure of the J.G. Mendel Czech Antarctic Station and its crew for their support.

## ***The BCCM/ULC collection: a Biological Resource Center to give access to the Antarctic cyanobacterial diversity***

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On the Antarctic continent, cyanobacteria represent key primary producers and important drivers of the food webs in a wide range of aquatic to terrestrial habitats. For example, they build benthic microbial mats in lakes and soil crusts in terrestrial biotopes. They may present interesting features to survive freeze/thaw cycles, sea-sonally contrasted light intensities, high UV radiations, desiccation and other stresses.

The BCCM/ULC public collection funded by the Belgian Science Policy Office since 2011 aims to gather a representative portion of the polar cyanobacterial diversity with different ecological origins (limnetic microbial mats, soil crusts, cryoconites, endoliths, etc.). It makes it available for researchers to study the taxonomy, evolution, adaptations to harsh environmental conditions, and genomic make-up. It presently includes 226 cyanobacterial strains, with 119 being of Antarctic origin (catalogue: <http://bccm.belspo.be/catalogues/ulc-catalogue-search>).

The morphological identification shows that the strains belong to the orders Synechococcales, Oscillatoriales, Pleurocapsales, Chroococciopsidales and Nostocales.

We present here the molecular datasets showing the diversity of the BCCM/ULC strains, studied on the basis of the 16S rRNA gene. A selection of strains was also characterized by sequencing of *rpoC1*, *recA*, and *gyrA* genes after amplification with newly designed primers.

Our results show that the Antarctic strains of BCCM/ULC are situated in 25 OTUs (groups of 16S rRNA sequences with more than 97,5% similarity) and thus represent a large genetic diversity. Moreover, strains identified as members of the genera *Leptolyngbya* or *Phormidium* appear in several lineages. This supports the need to revise the taxonomy of these polyphyletic genera with a simple filamentous morphology. A certain divergence of some Antarctic strains from related strains isolated from other regions can also be observed. It suggests that a portion of the Antarctic cyanobacterial flora may have evolved independently from the cyanobacteria in other continents.

# ***The first record of manta ray (Myliobatiformes, Mobulidae) in the Eocene of Antarctica***

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The modern Antarctic fish fauna is highly endemic and well-adapted to the polar conditions and geographic peculiarities of the Southern Ocean, which is geologically the youngest ocean and forms about 10% of the world's ocean surfaces. Continental ice sheets, cold polar waters delimited by the Antarctic Polar Frontal Zone (45-60°), the Circum Antarctic Current, as well as shelf and upper slopes that are isolated from other shelf areas are characteristics of modern Antarctica.

A diverse elasmobranch fauna, dominated by the shark *Stratiolamia macrota*, was collected from the Eocene (Ypresian) La Meseta Formation in Seymour (Marambio) island, Antarctic Peninsula. So far, 24 species of chondrichthyans belonging to 15 families have been described from these levels. Interestingly, the diversity of the rays in the Eocene of the Southern Ocean before the establishment of the Antarctic Convergence is larger than previously assumed, depicting interesting faunal relationships. At the end of the Eocene, most elasmobranchs disappeared from Antarctic waters resulting in the extremely impoverished elasmobranch fauna of the modern Southern Ocean, which include only few skate taxa. Sharks only invade Southern Ocean occasionally.

Here, we present new material and also new record of a manta ray for Antarctica assigned to the Family Mobulidae enabling a revision and taxonomic assignment of this ray.

The material consists in two teeth, one tooth comes from an anterolateral jaw position, and the other one is central in position. They are rather massive and very small (less than 3 mm wide) with a lingually inclined cusp. The crown is low differentiated in a mesiodistally elongated and rather high base and a low, stout, symmetrical cusp, which approximately equals the height of the crown base. The cutting edges of the main cusp are continuous with those of the lateral heels. The occlusal face of the crown is concave whereas the lingual face is regularly convex. The root is well developed, massive and rather high.

The characteristic of these teeth allow relating them with two basal taxa of the Family Mobulidae: *Burnhamia* Cappetta, 1976 and *Eoplinthicus* Cappetta y Stringer, 2002. These two genera have records only in the Paleogene of the Northern Hemisphere

## ***The macrofauna of the ESR hydrothermal vents: status update on taxonomic descriptions***

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In 2010 the newly discovered hydrothermal vents on the East Scotia Ridge were investigated using the ROV Isis and macrofaunal species present at the vent sites have been collected for taxonomic and ecological studies. Since then the majority of the vent species have been formally described, their microdistributions, ecology and phylogenetic relationships analysed. The chemosynthetic ecosystems hosted by these vents are dominated by the yeti crab *Kiwa tyleri*, the stalked barnacles *Vulcanolepas scotiaensis* and the peltospiroid gastropod *Gigantopelta chessoia* and home to *Paulasterias tyleri*, three new species of Sericosura seaspiders, new species of *Lepetodrilus* and *Provanna* as well as of the anthozoan of unknown order *Relicanthus daphneae*. Here we present a summary of the current taxonomic knowledge from the ESR hydrothermal vents, including published and yet to be published results.



## ***The tiniest penguin (Aves, Sphenisciformes) from the Eocene of Seymour Island, West Antarctica***

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Penguins were and are a successful group of seabirds that conquest different ecological niches occupying marine coast in different cold and temperate environments around the world. Antarctic penguins are mainly represented by large and giant species, although in fact, the high diversity found during the Eocene in Seymour Island includes a wide spectrum of sizes. Fossil species are mostly known through huge specimens, which are abundant during the Eocene, but small-sized penguins also lived in Antarctica at the same time. The finding of a tiny humerus in the upper Bartonian- Priabonian (Submeseta III Allomember, Submeseta Formation) of Seymour Island (West Antarctica) motivates the present study.

Only three species of small-sized genera have been described in Antarctica: *Delphinornis*, *Mesetaornis* and *Marambiornis*, known only through their tarsometatarsi. In addition, penguins equally sized are known also out of Antarctica: *Eretiscus tonni* from the early Miocene of Argentina, the *Hakataramea* penguin nominated by Tatsuro Ando as *Pakudyptes hakataramea* in his unpublished dissertation, from the latest Oligocene-earliest Miocene of New Zealand, and the modern species *Eudyptula minor*, habitant of New Zealand, Australia, Chatham Is., and Tasmania. However, the only similarity among them is size, and the systematic assignment of the MLP 00-I-1-19 to *Eudyptula minor*, *Eretiscus tonni*, and the *Hakataramea* penguin can be easily discarded because their fossa tricipitalis are bipartite whereas it is single in the Antarctic material. The huge difference in size precludes its assignment to any species of *Tonniornis*, *Archaeospheniscus*, *Palaeudyptes*, and *Anthropornis*; that way, comparison will be only worth to make in detail with *Marambiornis*, *Mesetaornis*, and *Delphinornis*. Previous assignments published by Jadwyszczak using statistical approaches indicate a humerus of ca. 91 mm length for these species, whereas the MLP 00-I-1-19 only reaches 48.7 mm length. Some morphological differences can be pointed, for instance, the shaft is narrower proximal to the angulus preaxialis in the new specimen, whereas in *Marambiornis*, *Mesetaornis*, and *Delphinornis* it is constant in width, and the angulus preaxialis is more pronounced in the MLP 00-I-1-19 than in the other species. The textural aging and the ossification degree of the new specimen permit to recognize that this fossil belongs to an adult bird whose tiny size is not ought to an ontogenetic issue. These arguments favor the idea that the MLP 00-I-1-19 belong to a different species respect to the humeri previously assigned to *Marambiornis*, *Mesetaornis*, and *Delphinornis*. Nevertheless, a re-evaluation of the these taxa, considering all the material now available is necessary before the proposal of a new species. The evidence strongly suggests that the MLP 00-I-1-19 belongs to an un-described species.

## S40. Environmental contamination in Antarctica

### *Antibiotic resistance in escherichia coli strains isolated from Antarctic bird stools, wastewater and seawater samples taken in the Antarctic*

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Antibiotic resistance is a problem of global concern and has been frequently associated with human activity. The study of antibiotic resistance in bacteria isolated from pristine environments like Antarctica contributes to the understanding of this fragile ecosystem. Escherichia coli strains, an important bacterial indicator of faecal pollution, were isolated and identified from samples taken from Fildes Peninsula's seawater (area with the highest human influence in Antarctica), Antarctic bird stool and inside one Fildes Peninsula's wastewater treatment plant. The strains were molecularly typed by PFGE to determine the genetic relations between them and submitted to antibiotic disk diffusion tests using the following antibiotic families:  $\beta$ -lactams, quinolones, aminoglycosides, tetracyclines, phenicols and trimethoprim-sulfonamide. The maximum E. coli count for seawater samples was 2400 cfu/100 mL. Genetic relatedness in-between groups, was only found within strains isolated from seawater and the wastewater treatment plant. Strains of both groups showed resistance to  $\beta$ -lactams, aminoglycosides, tetracycline and trimethoprim-sulfonamide. Whereas Antarctic bird stool isolated strains exhibited no antibiotic resistance at all.

The antibiotic resistance profiles found in E. coli isolated from Fildes Peninsula seawater are a cause of concern, with the southern area having the highest in E. coli counts and most multidrug resistance. Comparing antibiotic resistance patterns of strains isolated from Antarctic bird stool, wastewater treatment plant and seawater, it is highly probable that these strains come from the wastewater treatment plant that discharge in the area.

This work contributes to the field of antibiotic resistance of bacterial strains in Antarctica, and further research is needed in order to establish the horizontal gene transfer of resistance determinants to autochthonous Antarctic bacteria.

## ***Chemical composition of *Pygoscelis adeliae* feathers assessed by X-ray fluorescence***

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Seabirds have several characteristics which make them particularly suitable for studying the impact of contaminants on marine ecosystems: they are diurnal, abundant, conspicuous, easily monitored and have long lifespans. There are many approaches to measuring levels of trace metals in seabirds, including using internal organs, blood and feathers. Feathers are considered an excellent tool for monitoring the environment, because they act as archives of the animal's exposure over time. In the Antarctic, penguins can be considered as good sentinels to monitor the local marine environment since they are non-migratory. This study therefore aimed to quantify the elemental composition of penguin feathers by applying X-ray fluorescence, a technique that allows the determination of the levels of different elements present in a samples Individual *Pygoscelis adeliae* (n=14) were sampled at Hennequin Point (King George Island, South Shetland Islands) and about 3 g of feathers were collected. The chemical composition of feathers was measured by X-ray fluorescence inorganic analysis, in the first application of this technique to the analysis of penguin feathers. A total of 19 trace elements were quantified, including toxic trace elements (Ag, Al, Cr, Cu), major essential elements (Ca, Cl, K, Mg, Na, P and S) and other trace elements (Br, F, Fe, Mn, Si, Sr, Ti and Zn). The highest concentration detected was for Fe, but this related to only a single sample. The elements Na, Mg, Al, Si, P, S, Cl, K, Ca and Fe were detected in all samples. S was the most abundant element recorded, representing over 50% of all inorganic elements present. The remaining elements Ag, Cu, Cr, Zn, Mn, Sr, Ti and Br were present at low levels. Our data indicate that, despite variation being present in the composition and abundance of elements between individual samples, X-ray fluorescence is an efficient and useful technique to quantify the elemental composition of feathers.

## ***Dissolved black carbon in Antarctic lakes: Chemical signatures of past and present sources***

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Glaciers control the storage and release of organic carbon to surface waters fed by glacial-melt. Biogeochemical processes occurring in the receiving waters will further influence the persistence of the dissolved black carbon. The perennially ice-covered, closed-basin lakes in the McMurdo Dry Valleys, Antarctica, serve as sentinels for understanding the fate of dissolved black carbon from glacial sources in aquatic ecosystems. Here we show that dissolved black carbon can persist in freshwater and saline surface waters for thousands of years, while preserving the chemical signature of the original particulate material. The ancient brines of the lake bottom waters have retained dissolved black carbon with a woody chemical signature, representing long-range transport of black carbon from wildfires. In contrast, the surface waters are enriched in contemporary black carbon from fossil fuel combustion. Comparison of samples collected 25 years apart from the same lake suggests the enrichment in anthropogenic black carbon is recent. This fossil fuel signature could serve as an indicator of anthropogenic influences in Antarctic environments, which may continue to expand in the future. Differences in the chemical composition of dissolved black carbon among the lakes is likely due to biogeochemical processing such as photolysis and sorption on metal oxides.

## ***Hydrocarbon-contaminated soil bioremediation in Antarctica: Effectiveness of two consecutive year's field assays in Carlini Station***

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Soil contamination in Antarctica requires the development of simple remediation protocols, because availability of machinery and facilities is, in general, scarce. Bioremediation -and biostimulation in particular- provides a simple, low cost and effective tool to mend these soils. In this work, we compare the performance of two consecutive biostimulation field assays using biopiles. Assays were performed during 2013/2014 and 2014/2015 Argentinian Antarctic Expeditions in Carlini Station (25 de Mayo Island, South Shetland Islands). The treated soil – approximately 480kg soil per system- was located on 800 µm polyethylene geomembrane and covered after amendment with Nitrogen and Phosphorus sources (Biostimulated systems, BS) in a previously optimized C:N:P ratio (Martínez Álvarez et al 2015). Similar biopiles without the addition of nutrients were analyzed as well (Control systems, CC). Hydrocarbon removal percentages, biological activity, total and hydrocarbon-degrading bacterial counts, temperature, conductivity and moisture (in and outside the biopiles) were evaluated during the entire experiments, both years. The results showed that the first-year field assay was more efficient in the removal of hydrocarbons from soil. Biostimulated system removed 75.79% of the contaminant in 50 days, while control biopile only 49.54% in this first assay. In the second experiment, BS biopile reached 55.04% of removal, and CC biopile 41.73%. Total bacterial counts and biological activity reached higher values in the first year; while degrading bacterial counts were higher in the second one, but no significant differences were found in these parameters between both years. In any case, when compared with results from the systems in which no biostimulation was performed, nutrient addition proved to enhance microbial activity. Significant differences were found between the temperatures reached inside biopiles between both years. The difference between temperature inside the biopile and surrounding soil climbed up to 1.3°C the first year, while only 0.3°C was the difference in the second year. This fact suggests the possibility that differences in the hydrocarbon removal efficiency in biopiled field assays could be related to differences in the internal temperature of the biopiles, factor that clearly is strongly influenced by environmental temperature and total solar radiation received by the experimental systems.

Martínez Álvarez LM, Lo Balbo A, Mac Cormack WP, Ruberto LAM (2015) Bioremediation of a petroleum hydrocarbon-contaminated Antarctic soil: Optimization of a biostimulation strategy using response-surface methodology (RSM). *Cold Regions Science and Technology* 119: 61-67.  
<http://dx.doi.org/10.1016/j.coldregions.2015.07.005>

## ***Isolation and screening of diesel-degrading Antarctic bacteria for bioremediation purposes***

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Currently, hydrocarbon pollution in Antarctica has caused some environmental concerns as it causes severe toxicity towards human health and environmental conditions. This is due to the increasing industrial activities and technological progress in this region that demanded the drastic use of petroleum hydrocarbons. Intensive efforts to reduce the contamination of these pollutants have been done especially in bioremediation techniques, a biological method that utilises microbial species to degrade hazardous compounds into their less toxic forms. Many microorganisms' especially bacterial species have been introduced to be utilised for contamination clean-up. These studies were conducted to exploit the potential of isolated bacteria from Antarctic soil for the degradation of diesel, which is one of the petroleum hydrocarbons' products. Contaminated soil samples were collected at 43 different sites and analysed for the availability and growth of bacteria on basal media. 12 pure isolates that were successfully isolated were subjected for screening process to observe their diesel-degrading ability. Screening was conducted in two phases that include both primary and secondary screening. Diesel degradation was examined by 2,6-dichlorophenol indophenol (DCPIP) assay using spectrophotometric technique. In the primary screening, isolates were assayed for diesel-degrading ability using 0.1% filter-sterilised diesel in basal media. Four isolates were observed to have greater potential in degrading diesel within 5 days. These isolates then further subjected for secondary screening using 0.5% filter-sterilised diesel in basal media. Isolate 36 showed fastest degradation among the four isolates although the other three isolates shows good potential in degrading diesel. Isolate 36 will then be subjected for identification to study its characteristics in degradation of diesel. The outcomes of this study may offer a useful guideline in evaluating potential hydrocarbon degraders from the polar environment.

## ***Mercury and methylmercury in the Atlantic sector of the Southern Ocean: Results from Eddy Pump - ANTXXVIII/3 cruise***

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Mercury is a global pollutant and is considered one of the most toxic heavy metals to the environment by the United Nations Environmental Program. The oceans constitute one of the most important reservoirs for this metal. While many studies have been published about the Hg cycling in the world's oceans much less attention has been given to the abiotic compartments in the Southern Ocean (SO).

In order to provide a first insight into the concentrations of Hg species in the SO and to understand the processes responsible for their distribution, partitioning and speciation, a sampling campaign was carried out south of the Polar Front (Atlantic sector of the SO).

Water samples taken at discrete depths from the surface down to 300 m at five stations (84, 91, 140, 143, 163 and 174) were analysed for total Hg (HgT), methylmercury (MeHg) and other interpretative parameters (e.g. salinity, temperature, dissolved and particulate organic carbon, etc).

Results showed a high spatial and variability in the concentrations of Hg and MeHg. In general Hg levels were higher in the eastern stations ( $0.93 \pm 0.69$  ng L<sup>-1</sup> in st. 84) decreasing to west. Similar results were observed for MeHg. In some sites a decrease of HgT with depth and a consequently increase in MeHg was observed (e.g. st. 143 and 174) suggesting the occurrence of Hg-methylation processes. At other stations (e.g. 84 and 163) a concurrent decrease or increase, with depth, respectively, of both mercury species was observed. In spite of these difference, in general, positive correlations between HgT and MeHg were observed in all samples, the differences in the vertical profiles of Hg species was attributed to favourable environmental conditions for Hg methylation. In fact, the highest proportion of MeHg (% of the total) was observed in sites with low dissolved oxygen or highest mineralization rates.

The results obtained in this study shows that Hg distribution in the Atlantic sector of the SO are comparable (or in some sites higher) to the ones published for the other oceanic regions, however MeHg species present in this area are more dependent of the environmental conditions than the amount of Hg present in the water.

## ***Organic contaminant concentrations in sub-tidal sediments in the vicinity of Palmer Station 25 years after the Bahia Paraiso spill.***

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Palmer Station, operated by the United States Antarctic Program (USAP) located on Gammage Point, Anvers Island, Antarctica, consists of a small number of small structures. Its Peak capacity is approx. 44 people, generally from October to April, with a smaller presence from May through September. The station is supported by ship from South America and is visited by cruise ships periodically during the summer. The ship activity, small boat operations, sewage and runoff from the Palmer Station represent potential sources of hydrocarbons to the environment. Subtidal sediment samples were taken from sites in vicinity of Palmer Station in 2014 and 2015. The sampling re-occupied a number of sites collected in response to the 1989 Bahia Paraiso spill and included grab samples collected from the Laurence M Gould within a 2 mile radius of the station and diver collected samples closer to Palmer and Old Palmer Stations. Petroleum Hydrocarbon levels from the 2014 and 2015 samplings are compared with data collected from 1989 to 1992 following the Bahia Paraiso spill. The earlier analysis was focused on hydrocarbon contamination; while the 2014-2015 analysis examines a wider range of environmental contaminants including pesticides, PCBs, and trace elements.



## ***Phenol degradation and heavy metals tolerance of Antarctic yeasts***

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In cold environments, biodegradation of organic pollutants and heavy metals bioconversion requires the activity of cold-adapted or cold-tolerant microorganisms, which have adjusted their metabolism to function optimally at low temperature,

In this work, the ability to utilize phenol for growth and tolerate different heavy metals was investigated in 140 culturable cold-adapted yeasts isolated from Antarctica at 15°C. The biodegradation of phenol (2.5 mM) was tested in agitated submerged cultures in YNB medium with (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, whereas heavy metal tolerance was assayed in Petri dishes containing agarized YM medium. The growth at different temperatures (5, 25 and 30°C) was also investigated. After the end of the screening scheme, DNA of the selected yeasts was extracted (using the standard glass-beads method with a lysis buffer) for molecular identification by sequencing of 26S rRNA gene D1/D2 domain and internal transcribed spacers (ITS1-5.8S-ITS2) region.

After the growth temperature assay, 67% of the yeasts could be classified as psicrotolerant as they were able to growth in all the range of temperature tested, while the other 33% could be classified as psicrophilic as they did not growth at 25 or 30°C.

Thirty percent of the yeasts were able to utilize phenol (2.5 mM) as C source. In relation to heavy metals, 82%, 63% and 25% were tolerant to 1 mM of Cu(II), Cd(II) and Cr(VI) respectively, but only 18% tolerate all of them. In addition, 16% could be classified as sensitive, showing no growth after 14 d. Only four yeast were able to grow using phenol and tolerate all metals tested.

All the selected yeasts belong to genera and species previously reported as common for Antarctic soils, and have also been profusely reported in Arctic or near-Arctic regions or associated with Alpine or Andean glaciers; representing well cold adapted yeasts.

The isolates here reported, able to remove phenol and tolerate heavy metals at low temperatures could be valuable as inocula for cold wastewater treatment in extremely cold environments.

## ***Physicochemical characteristics of Antarctic ambient aerosol and sedimentary aerosol***

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As the aerosols influence water and energy budgets of the atmosphere and snowpack by absorption of solar radiation, interactions with clouds, and reduction of surface albedo, light absorbing particles in snow and ice have been identified as one of major factors affecting climate change in the fourth and fifth assessment reports of IPCC, which probably accelerates the speed of snowpack melt. To demonstrate the physicochemical characteristics of Antarctic ambient aerosol and sedimentary aerosol, analysis have been conducted based on the aerosol filter membranes and sedimentary aerosol on snow and ice derived from six sampling spots near the Great Wall Station (62°13' S, 58°58' W) in the 30th Antarctic Scientific Expedition of China. The average concentrations of organic carbon and elemental carbon have been measured using atomic absorption spectrophotometry and optothermal method to reveal the variation of baseline contrasting to previous studies, combined with discussion about optical absorption properties. Moreover, the concentrations and size distributions of water-soluble inorganic aerosols have been analyzed via atomic analyzer, which mainly illustrated that the concentration of Cl<sup>-</sup> was 2.31 times of Na<sup>+</sup> and the concentration of K<sup>+</sup> in quartz filter membrane was 1.79 times of those deposited on the surface of snow and ice. Further analyses aim at separating exogenous ions from baseline through the proportion and chemical reaction of ions to explore the specific influence derived from anthropogenic activities.

## ***Screening and isolation of Antarctic phenol-degrading bacteria***

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Hydrocarbon pollution of Antarctic due to the rapid increase in anthropogenic activities has potentially caused phenol as the major pollutant in the most pristine region on Earth. In recent years, the utilization of indigenous bacteria in the treatment of phenol contaminated sites is well recognized. However, due to the anti-microbial properties of phenol and the severe climate conditions such as low temperature and poor nutrients, phenol bioremediation became a foremost challenge in Antarctic. A study on pure cultures of phenol degrading bacteria isolated from Antarctic soils was conducted. The study encompassed the process of isolating and screening the psychrophilic phenol-degrading bacteria. From three soil samples collected from Antarctic, seventeen pure phenol-degrading colonies were isolated by five cycles of repeated subculturing onto mineral medium agar plates supplemented with 0.5 g/l of phenol and incubated at 4°C. Out of seventeen phenol-degrading isolates, three isolates were found to be capable of degrading 0.5 g/L of phenol in MSM completely within a five-day incubation period in a shaking incubator with 150 rpm at 4°C. Phenol degradation was monitored daily using 4-aminoantipyrine colorimetric assay following the method of the American Public Health Association. Based on the preliminary screening, isolate CHI-11.1 isolated from GPS location: S62° 09' S 7.2° W 58° 11.4' with highest degradation activity was found to be capable of degrading up to 95% of phenol at a concentration of 0.5 g/L within 96 hours of incubation period. This study revealed the potential use of psychrophilic bacteria in the treatment of phenol-contaminated sites, and therefore contributes to the environmental sustainability of Antarctic.

## ***Temporal and spatial distribution of polycyclic aromatic hydrocarbons in terrestrial soils of Antarctica***

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Polycyclic aromatic hydrocarbons (PAHs) are mutagenic and carcinogenic organic compounds of natural or anthropogenic origin that persist photodecomposition, homogeneous/heterogeneous chemical reaction, and biological degradation. They are widely recognized as highly hydrophobic, resulting in bioaccumulation in fatty tissues of living organisms. PAHs can be travelled in the remote area at extremely low contents by movement of water mass either fresh or sea waters. Furthermore, the long-range transboundary air pollution is responsible for both the regional and global distribution of PAHs in various environmental compartments. The atmospheric fate, transport, and transformation of PAHs in the atmosphere are basically controlled by their gas/particle (g/p) partitioning. Both physical and chemical removal processes such as wet/dry deposition, photolysis, and reactions with other pollutants have different influences on gaseous and particulate PAHs. The main purposes of this study are to

(i) Determine the spatial and temporal distribution of terrestrial soils collected at Showa Station, a Japanese research station on East Ongul Island in Queen Maud Land, and Great Wall Station, a Chinese research station on King George Island, Antarctica.

(ii) Evaluate the risk assessment of sediment toxicity based on the total toxic B[a]P equivalent (TEQ<sub>carc</sub>) by using the formula proposed by Nisbet and Lagoy.

(iii) Assess both environmental cancer and non-cancer risks, which were conducted using the equations following the framework proposed by The Agency for Toxic Substances and Disease Registry (ATSDR), which is a federal public health agency of the U.S. Department of Health and Human Services.

(iv) Determine the soil cleanup target levels for carcinogens and non-carcinogens in Antarctic soils by using the equations developed by Florida Department of Environmental Protection (FDEP).

## ***The influence of migratory flyways in the distribution and levels of metals in Antarctic flying seabirds***

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The increasing levels of contaminants in Antarctica is an issue that concerns the scientific community because of the vulnerability of polar regions to high levels of pollutants. Due to the rising human presence in Antarctica, is important to monitor contaminants levels in Antarctic biota. Therefore, is indispensable to include in the analysis those animals that occupies high levels of the food chain, and thus accumulate contaminants, as the seabirds. Metals naturally occurs in Antarctic environment, although some human activities enhance the availability of these metals in the system to be absorbed by the biota. Some of these metals, e.g., Cadmium (Cd), can be very toxic, causing kidney damage even at low concentrations. Other metals in inorganic form are not harmful, however its organic compounds, e.g., Methylmercury and organotins, can bioaccumulate in the organisms and biomagnify through the food chain. The present study aimed to investigate the concentrations of Cadmium (Cd), Mercury (Hg) and Tin (Sn) in feathers of Antarctic seabirds considering their migratory flyways. We expected that long-distance migrants, which can reach the Northern Hemisphere (NH) (*Catharacta maccormicki* and *Oceanites oceanicus*), would present higher levels of the analyzed metals, when compared with species that remain in the Southern Hemisphere (SH) in austral winter (*Larus dominicanus*, *Macronectes giganteus*, *Chionis albus*, *Phalacrocorax atriceps* and *Sterna vittata*). We collected the samples in Admiralty Bay (King George Island, South Shetlands Islands) during the breeding period of 2012/2013 and 2013/2014. In the lab we washed the feathers to remove external contamination and digested the samples in acid solution. We quantified Cd and Sn in a Graphite Furnace Atomic Absorption Spectrometer (GFAAS) and Hg using a Cold Vapor Atomic Absorption Spectrometer (CVAAS). Our results detected that Hg levels for NH migrants were two times higher than the levels of SH migrants ( $U= 72.0$ ;  $p= 0.0022$ ;  $n=43$ ), in accordance with our hypothesis. However, the Cd levels of SH migrants were 13 times higher than the levels of NH migrants ( $U= 15.0$ ;  $p= 0.0003$ ;  $n=25$ ). For Sn there were no significant differences between the groups ( $U= 19.5$ ;  $p= 0.73$ ;  $n=14$ ). Apparently, Sn levels are not influenced by migratory patterns and the levels of this element in pelagic zones probably reflects natural sources. Some studies have described a natural Cd enrichment in Antarctic food webs. This is probably the reason for the higher levels of Cd in species that stay in SH during the winter. The findings for Hg indicate that *C. maccormicki* and *O. oceanicus* were exposed to higher Hg concentrations than the natural levels founded in Antarctic. The source of this Hg incorporated in northern waters, is unknown but it is probably from anthropogenic sources. It is important to emphasize that these species can act as carriers of some contaminants to Antarctica during the breeding period

# **S01. Antarctica In A Global System - Drivers And Responses**

## ***Antarctica in the global earth system: From the poles to the tropics***

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The recently designated southern ocean envelops the continent of Antarctica and is the largest ocean in the world. The ring of water enveloping the continent of Antarctica is located between 60°s latitude and 360°s longitude connected with the Antarctica circumpolar current the southern ocean includes the Amundsen Sea, Drake passage, Ross Sea, Bellingshausen Sea, Weddell Sea and part of the Scotia Sea. The coastline length is 17,968 KM and the area is 20,327,000 KM<sup>2</sup>. Sea temperature vary from about -2 to 10°C (28 to 50°F). Equinox to equinox in line with the seen's seasonal influence, the Antarctica ice park fluctuates from an average minimum of 2.6 million square KM (1.0 \* 10<sup>6</sup> square mi) in September, more than a sevenfold increase in area.

Environmental issues in the southern ocean include concern that the increase of UVB radiation through an ozone hole directly above has reduced the number of phytoplankton, the primary produces in the ocean by 15% and is mutation the DNA of fish.

Due to the lack of human influence, Antarctica is a valuable region for research. Between 1956 and 1957, 12 countries collaborated in the international Geophysical year to establish research stations, communication, rescue efforts and weather reporting. Research stations like the Mcmurdo station built on volcanic rock resemble small cities with 50,000 people from more than 25 countries working on the bases, clean-up effort had to be initiated to take care of the trash accumulation. Now, any country working in Antarctica is responsible for packing their trash out to where it came from.

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## ***Changes in ocean heat content on Antarctica's regional seas from ocean reanalysis***

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This study compares changes in ocean heat content associated with the Southern Ocean regional seas (Ross, Bellingshausen-Amundsen and Weddell) in five ocean reanalysis products between 1980 and 2011 for two layers. Results show that changes of OHC among the regional seas behave differently from each other, and that most OHC trends shift around the early 2000's for both layers. OHC is correlated to changes in sea-ice extent. Although both upper (0-700 m) ocean heat content and sea-ice extent show considerably strong correlations, analysis of the wind and sea surface temperature fields shows that sea ice responds stronger to atmospheric forcing.

## ***Decline of AABW production in the 20th Century***

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Numerical modeling of the oceans has significantly improved during the last decades, however, the representation of specific climate relevant processes, such as the dense water formation in polar regions, still remain a challenge. These water transformation mechanisms play a major role on Earth's heat budget supporting the Meridional Overturning Circulation (MOC). The Antarctic Bottom Water (AABW) is one of the densest water masses in the ocean and makes the link between the warm upper limb of the MOC and the cold deep one. Hence, oscillations on AABW's export from Antarctic margins may directly affect the global ocean ventilation. Applying the Coordinated Ocean–Ice Reference (CORE) interannual forcing we have run a 60-year simulation (1948–2007) using the Regional Ocean Modeling System (ROMS) with sea ice/ice shelf thermodynamics module to investigate the oscillation on AABW's properties. The experiment employed a circumpolar variable resolution ( $1/2^\circ$  to  $1/24^\circ$ ) grid reaching less than 5 km at the southern boundary and 40 sigma levels. Results show that AABW temperature has risen during the simulation period from  $\theta \sim -0.4^\circ\text{C}$  in the 1950s to  $\theta \sim -0.3^\circ\text{C}$  in the 2000s, while salinity has lessened from 34.80 to 34.63, which may be related to the freshening and/or reduced production of AABW. In order to quantify the changes in the production of AABW, we have computed AABW's volume along two  $1^\circ$ -thick meridional sections crossing the Weddell Sea ( $40^\circ\text{W}$ ) and the Ross Sea ( $165^\circ\text{W}$ ), using the neutral density  $\gamma_n = 28.3 \text{ kg.m}^{-3}$  for the upper limit of AABW (usually  $\gamma_n = 28.27 \text{ kg.m}^{-3}$  on observational data), given the model's relatively coarse vertical resolution at the deep and bottom layers.

Our calculations reveal that the volume of AABW exported from the Ross Sea has decreased from  $3.92 \times 10^{-5} \text{ km}^3$  in the 1950s to  $2.61 \times 10^{-5} \text{ km}^3$  in the 2000s, about 33% in 60 years. The Weddell Sea variety of the AABW showed a more pronounced drop during the first three decades of the simulation, from  $10.83 \times 10^{-5} \text{ km}^3$  to  $6.35 \times 10^{-5} \text{ km}^3$  between the '50s and '70s. This drop was followed by a mild recovery of AABW's volume leaving the Weddell Sea during the 1970s. This is explained considering the Weddell Sea Polynya big events. These started in 1972 and helped to pump AABW back to a steady state of  $\sim 7.50 \times 10^{-5} \text{ km}^3$  till the end of the simulation. These results are consistent with observations and other numerical experiments who showed that for the entire Weddell Sea, the deep ocean heat content drastically weakened during the '70s due to the Polynya recurrence. The heat content drop may be associated with AABW recovery, as the heat induced vertical instability controls ocean deep convection.



## ***Distribution of limno-terrestrial rotifers supports need for complex Antarctic conservation biogeography***

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Recent biogeographical classification of Antarctica includes 15 ice-free Antarctic Conservation Biogeographic Regions (ACBRs), with a marked development from the traditional division into continental and maritime Antarctic, sub-Antarctic and southern cold-temperate region. This development was underlain by analysis of a comprehensive and spatially explicit biodiversity database, in which the most represented phyla were ascomycete fungi, mosses, arthropods and green algae. Our biogeographical study augments this analysis, being aimed at the group of abundant and widely distributed Antarctic micrometazoans on which published data are still scarce – the rotifers (mainly of the group Bdelloidea).

The material examined was collected in continental (North and South Victoria Land, NVL and SVL, respectively) and maritime Antarctic – both in the Antarctic Peninsula (AP) and the associated island archipelagoes. Rotifers were extracted from soil, terrestrial mosses and algal mats, morphologically and morphometrically analysed, and processed for DNA sequencing (mtCOX1). Species delimitation was performed both by classical taxonomic methods and the estimation of independently evolving entities from COX1 phylogeny.

Of 87 rotifer species identified both by morphology and molecular analysis (5 belonging to Monogononta and the rest to Bdelloidea), 18 were found in NVL, 38 – in SVL, 9 in AP, 32 in James Ross Island, 28 in the Argentine islands, and 5 in King George Island. At large geographical scale, 25 species (39%) occurred in both maritime and continental Antarctica. However, finer-scale differences in rotifer species composition were found within these large zones. Thus, NVL and SVL shared 22% (10 species) of rotifer diversity within Victoria Land, and only 11% (6/55 species) were shared between North-west and Central-South Antarctic Peninsula regions. Cluster analysis based on morphospecies composition and abundance also showed significant differences in rotifer diversity between these ACBRs.

Other recent studies have proposed that the majority of Antarctic rotifers are endemics, and that even within Antarctica there are substantial differences in local fauna. The present study both provides evidence confirming this, and support for fine-scale biogeographical division, as proposed in the creation of ACBRs. Such complex biogeography provides an urgent challenge to those charged with the conservation and governance of the Antarctic region.

## ***Distribution of NADW and AABW source varieties in the Atlantic Ocean***

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The deep and bottom waters are formed by high latitudes physical processes and are responsible for the transport of heat, gases and nutrients to all ocean basins. The formation and circulation of those water masses are important to the maintenance of the global circulation cell, which in turn is a key driver of climate system. Even though many studies have focused at the water masses distribution and variability in Atlantic Ocean, there is a few which investigate this topic in a global or ocean basin scale. Thus, the distribution of Atlantic deep waters is not yet fully comprehended neither their time variations. Owing to these facts the mixture of Atlantic's deep and bottom water varieties were calculated and their distribution delimited using the historical dataset World Ocean Database 2013. Their temporal variability were investigated in north and south Atlantic basins applying Optimum Multiparameter analysis at data from World Ocean Circulation Experiment repeated transects (A10 and A16). At south Atlantic basin, the upper North Atlantic Deep Water (NADW; 2000 m to 3000 m) is composed of more than 50% of Labrador Sea Water (LSW), which shows a deepening of its core between 25°S-45°S, have a major contribution at western basin and maximum extending until 55°S with just 5% of mixing contribution. The lower NADW (3000 m to 4000 m) is composed of a mixing between LSW, waters from Nordic Sea (Iceland Scotland Overflow Water, ISOW; Denmark Strait Overflow Water, DSOW) and Weddell Sea (Weddell Sea Deep Water, WSDW; Weddell Sea Bottom Water, WSBW), with contributions around 20%, 50% and 30%, respectively. The Nordic Sea waters extend until around 40°S and Weddell Sea waters until 50°N at North Atlantic basin. AABW is observed with higher contributions at eastern than western northern basin. At 50°S WSDW sinks to the bottom of Atlantic basins, WSBW is restricted to higher latitudes, while NADW varieties rise to shallower depths. The contribution of LSW has rising from 1993 to 2013—this is observed at western and eastern south Atlantic basins—, whereas DSOW and ISOW showed the largest variations and an alternate pattern—their contribution change from higher to lower suggesting that they have opposite formation and/or export rate. AABW showed high changes in 1993 with contribution 15% higher than the mean average (80%), however the two following decades (represented by data from 2003 and 2013) showed lower contributions. This study has shown that the NADW varieties reach 40°S to 55°S of latitude, the upper waters have shown a raising contribution and the lower waters higher variability ranging from positive and negative pulses. The southern sourced bottom waters show a decreased contribution from 2003 to 2013, suggesting higher influence of the lower NADW varieties to the composition of the bottom waters.

## ***Dynamic response of the Ross Ice Shelf to environmental forcing***

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Ice shelves are gateways through which climate change can be transmitted from the ocean or atmosphere to the grounded ice sheet. Changes in the flow of glaciers and ice sheets can drive ice shelf change as well. It is thus important to separate patterns of ice shelf change driven internally (from the ice sheet) and patterns driven externally (by the ocean or atmosphere) so that modern observations can be viewed in an appropriate context. Here, we focus on the Ross Ice Shelf (RIS), a major contributor to West Antarctic Ice Sheet stability and a feature known to experience variable ice flux conditions from surrounding glaciers and ice streams (for example, ice stream stagnation and glacier surges).

Transient simulations of ice shelf flow are used to identify distinctive patterns of ice thickness and velocity change associated with perturbations of various boundary conditions. Ice stream and glacier flux changes produce both instantaneous changes to the flow field and longer time scale adjustments in the coupled thickness and flow. The Kamb Ice Stream stagnated 160 years ago. In response, ice thickness in the middle of the RIS is currently adjusting to stagnation of the Kamb Ice Stream at a rate of about 0.1 m/a of dynamic thinning. Ice dynamic patterns are imprinted by the morphology of the coastline and sea floor. For example, Crary Ice Rise limits the rate at which the ice shelf can respond to deceleration of Whillans Ice Stream. Recent satellite-based observations of thickness change on the RIS allow model simulations to be evaluated in a meaningful way.

## ***Linking iron marine chemistry with bioavailability in the Southern Ocean***

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In most of the Southern Ocean sub-nanomolar concentrations of dissolved iron (Fe) are typically reported. However, less than 1% of this appears as free Fe, known as bioavailable to support phytoplankton growth. Most Fe is bound to organic ligands that can either enhance or limit Fe bioavailability. As a result of the changes in Fe concentrations from the ancient to the contemporary ocean, different phytoplankton species have adapted to different Fe requirements and developed specific uptake strategies. As a result, for a given Fe chemistry, Fe bioavailability will differ depending on what species are present. In order to illustrate both the chemical and biological variability, we investigate the link between Fe chemistry on the GEOTRACES - GIPY6 (SR3) line across the Southern Ocean and its bioavailability to keystone iron-limited phytoplankton monoclonal cultures. Here, we chose the bacillariophyceae (*Pseudo-nitzschia subcurvata*) and prymnesiophyceae (*Phaeocystis antarctica*) as they represent two dominant species in the Southern Ocean. Fe bioavailability is derived using bioaccumulation experiments with the radioisotope <sup>55</sup>Fe. First, the ability to acquire different Fe chemical forms is determined using model compounds (siderophores: desferrioxamine B and enterobactin; EDTA and humic substances: Suwannee River fluvic acid) as well as compounds recently recognised for Fe biogeochemistry (saccharides: glucuronic acid and alginate; and a bacterial exopolysaccharide: L6). Then, Fe bioavailability in samples from the SR3 line is determined using 10 picomolar <sup>55</sup>Fe addition in order to not significantly affect in situ Fe chemistry from water samples. In order to compare Fe bioavailability with chemistry, Fe speciation is determined using a competitive ligand exchange adsorptive cathodic stripping voltammetry in presence of salicylaldoxime. Results clearly illustrate the challenge in linking Fe bioavailability to chemistry. Given the widespread of Fe limitation across the Southern Ocean and cascading impact on carbon pump and biodiversity, this work contributes to disentangle the mechanisms ruling Fe limitation.

## ***Miocene major events in tectonic and oceanographic contexts: Example from south Scotia Sea basins (Antarctica)***

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The Scotia Sea is located in the Southern Ocean to the east of the Drake Passage. This mayor gateway opened at Eocene times during the last steps of fragmentation of Gondwana, when the Antarctic and South America plates become apart. The tectonic and oceanographic processes occurred since then have left an imprint in the sedimentary record of the south Scotia Sea basins. The formation and evolution of these basins have also determined major oceanographic changes with major impacts in the Global Thermohaline Circulation system since they are mayor gateways for the Antarctic Circumpolar Current (ACC) and the Antarctic Bottom Water (AABW). The main aim of the present work is to relate the major tectonic and oceanographic changes occurred in the Scotia Sea since its formation and correlate then with mayor changes globally identified.

Morpho-structural and seismo-stratigraphic analyses have been done in the multichannel seismic dataset available along the southern Scotia Sea. Two mayor changes in the stratigraphic record are identified along the southern Scotia Sea basins. The former occurred at an age estimated in early Miocene represent a shift in the regional extensional direction of the Scotia Arc from WNW-ESE to E-W tentatively related to the end of the northwest Weddell Sea subduction. At the same time major remote tectonic events have been identified, as the onset of the India-Asia thrust and the uplift of the Himalaya. These changes occurred during a period when the AABW was restricted to the deepest basins located at the southern most areas of the planet that did not include the Scotia Sea.

A most recent major change has an age estimated in middle Miocene. Traditionally it has been associated with the advance of the ice sheet in southern latitudes and a mayor palaeoceanographic change in the Scotia Sea when the passages of the south opened and allowed the outflow of the AABW, first through the Scotia Sea and later to northern latitudes. However, the middle Miocene change constituted also the onset of an interval of generalised subsidence of the south Scotia Sea basins. Such subsidence have been globally observed and related to an increase in orogenic activity in the main continental cordilleras accompanied by a global decrease in the activity rate of the main spreading centres and a sedimentation rate peak in the three main oceans.

Therefore, early and middle Miocene changes in the sedimentary record are coincident with tectonic events in the Scotia Sea basins, which were coeval with other events globally widespread. These events not only controlled the major changes in the sedimentary stacking pattern but also the main palaeoceanographic changes.

## ***Modelling sea ice formation in the Terra Nova Bay polynya***

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Antarctic sea ice is constantly exported from the shore by strong near surface winds opening leads and large polynyas in the pack ice. The latter, known as wind-driven polynyas, are responsible for significant water mass modifications due to the high salt flux into the ocean associated with enhanced ice growth. The Ross Sea is an oceanographic environment of interest being characterized by the presence of wind-driven polynyas. In particular we are going to focus on the Terra Nova Bay (TNB) polynya. Brine rejected during sea ice formation processes that occur in TBN polynya densifies the water column leading to the formation of the most characteristic water mass of the Ross Sea, the High Salinity Shelf Water (HSSW). This, in turn, takes part to the formation of the Antarctic Bottom Water (AABW), the densest water mass of the Southern Ocean which plays a major role in the global meridional overturning circulation affecting the global climate system. A coupled sea ice – ocean model has been developed to simulate the seasonal cycle of sea ice formation in, and export off, the polynya. The sea ice model accounts for both thermal and mechanical processes. The oceanic circulation is described by a reduced gravity model, one-and-a-half layer. The domain resolution is of 1 km, which is sufficient to represent the salient features of the coastline geometry, notably the Drygalski Ice Tongue. The model is forced by a combination of Era Interim reanalysis and in-situ data from automatic weather stations, and also by climatological oceanic dataset developed through in situ oceanic observations. The sensitivity of the polynya to the atmospheric forcing is well reproduced by the model when merging in situ and reanalysis data, which allows to capture in detail the strength and the spatial distribution of the katabatic winds. The model resolves accurately sea ice drift in TNB and sea ice production rates leading to realistic polynya extent estimates. The model-derived polynya extent has been validated. The comparison between the modelled sea ice concentration and the MODIS high resolution satellite images confirms that the model is able to reasonably reproduce the TNB polynya evolution in terms of both shape and numerical extent.

## ***Sea ice, cloudiness and surface air temperature: Relationships in the Antarctic and Arctic regions from observations and model simulations***

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Changes of sea-ice concentration (SIC), cloudiness characteristics (total cloud fraction – TCF, in particular) and surface air temperature (SAT), as well as their relationships for the Antarctic region (ANT, from 55S to 70S) in the comparison with the Arctic region (ARC, from 70N to 90N) are analyzed. Analysis was performed for different seasons and different datasets. We used satellite observations (ISCCP, PATMOS-x, CM SAF), reanalyses and CMIP5 model simulations (including simulations with CanESM2, CSIRO-MK3, GFDL-CM3, HadGEM2-ES, IPSL-CM5A-MR and MPI-ESM-MR) for historical and RCP scenarios. The cross-wavelet and lagged correlation analyses were performed as well.

The largest changes (trends and variability) from observations were noted in summer in both Hemispheres (July-August-September in ARC and January-February-March in ANT). SIC decreased in ARC and increased in ANT during last decades in all seasons. Analyzed satellite observations show no significant trend of TCF in ARC, and trends of TCF with different sign in ANT. For ANT, negative SIC-TCF correlation is noted from observations, while in ARC the sign of SIC-TCF correlation depends on season and dataset.

According to model simulations for the historical period (1860-2005), the sign of SIC-TCF correlation coefficient in autumn (March in ANT and September in ARC with the SIC minimum) is negative in ARC (not significant for some models) and varies from model to model in ANT. In spring (March in ARC and September in ANT with the SIC maximum), all analyzed models show insignificant SIC-TCF correlation in ARC, while in ANT models show both positive and negative significant SIC-TCF correlation. For projected scenarios for the 21st century (2006-2100), the significance of SIC-TCF, SIC-SAT and TCF-SAT correlations is increasing with the increase of anthropogenic forcing (from RCP2.6 to RCP8.5) in both polar regions. More aggressive anthropogenic scenarios lead to stronger SIC-TCF correlation in autumn in ARC and in spring in ANT.

## **S05. Past Antarctic Climate And Ice Sheet Dynamics: Integrating Models And Observations From The Deep Ice To The Deep Sea**

### ***Abrupt Antarctic ice-sheet collapse – Past reconstruction and future implications***

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The response of the Antarctic Ice Sheet (AIS) to past climate change was previously based on only a few near-field sediment sequences, which limited our understanding of the dominant feedbacks between AIS, ocean, and global sea level. Shallow marine and terrestrial Antarctic sequences cannot be dated adequately because the ice sheet prohibits or disrupts sediment deposition, reveals only the final stage of ice retreat, or resolve only local responses to climate forcing, leaving much room for speculation on both the processes and timing of ice-sheet dynamics on a continental scale.

We investigated far-field records from the slope of the Weddell Sea continental margin and from the deep Scotia Sea, following the continent-to-abys strategy of PAIS (Past Antarctic Ice Sheet dynamics). These records advance our knowledge substantially and revise our current understanding of ice-sheet dynamics. They indicate, for the first time, multiple phases of enhanced iceberg routing during the last deglaciation that commenced abruptly (within a decade!) and lasted from centuries to a millennium. Among them are three that appeared synchronous with Meltwater Pulse (MWP) 19 ka, MWP-1A, and MWP-1b, indicating that AIS deglaciation accelerated at ~17 ka, peaked at Meltwater Pulse 1A around 14.5 ka, and declined thereafter until ~8 ka. This reconstruction differs substantially from previous scenarios of a minor and late AIS retreat that continued into the Late Holocene.

Deciphering past sea-level changes is key to understanding current and future climate change because AIS collapse in a warming world would lead to rapid sea-level rise. We apply for two drilling proposals within the International Ocean Discovery Program (IODP) to address open questions on AIS dynamics and related sea-level changes in a transect from the Weddell Sea to the Scotia Sea on the Atlantic side of the Southern Ocean. IODP proposal 848 (Late Neogene to Quaternary ice-sheet and sea-level history of the Weddell Sea, Antarctica) shall drill several contourite drifts in the southeastern Weddell Sea that contain high-resolution Mio-Pleistocene sections of ice advance and retreat. IODP proposal 847 (Plio-Pleistocene reconstruction of ice-sheet, atmosphere, and ocean dynamics in Iceberg Alley) shall drill two deep-ocean sites in the Scotia Sea farther north. Here, we aim at delivering the first well-dated, high-resolution and spatially integrated record of variability in icebergs flux from the center of Iceberg Alley.



## ***Anvers-Hugo Trough paleo-ice stream, Antarctic Peninsula: Geomorphological evidence for the importance of water availability in facilitating ice stream flow***

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New multibeam swath bathymetry and acoustic sub-bottom profiler data collected in 2014 over the Anvers-Hugo Trough to the west of the Antarctic Peninsula make it now one of the most completely surveyed paleo-ice stream pathways in Antarctica. The new data extend from the inner continental shelf to the shelf break and span the full width of the trough on the middle shelf. The same trough system was an early focus of Antarctic paleo-ice stream studies in the 1980s and 1990s, and extensive multichannel seismic, deep-tow boomer and sidescan sonar data are available from those previous investigations. Multibeam swath bathymetry surveys had been conducted previously further inshore over part of the inner shelf and the southernmost part of the trough close to Hugo Island. On the basis of those previous surveys it had been hypothesized that meltwater evacuated from a subglacial lake in the 1400 m-deep Palmer Deep basin on the inner shelf significantly influenced the dynamic behaviour of the paleo-ice stream in the Anvers-Hugo Trough. The new multibeam data reveal a set of northward shoaling and narrowing canyons along-trough from the proposed overflow from Palmer Deep. The canyons are located directly north of a morphological transition over the southeastern margin of a mid-shelf sedimentary basin mapped from seismic profiles. They extend from a zone on the harder bedrock south of the transition in which anastomosing channels and crescentic scours, features generally interpreted as products of basal meltwater erosion, are observed. Individual canyons are up to 300 m wide. Their location and morphology is consistent with the hypothesis that large fluxes of meltwater derived from the inner shelf flowed into the bed of the ice stream, probably episodically. Further north along the trough (downstream in terms of paleo-ice flow), the new multibeam data reveal details of bedforms over a confluence where a tributary ice stream merged with the Anvers-Hugo one. In this area the lateral limits of the paleo-ice streams are sharply defined by abrupt boundaries to the fields of mega-scale glacial lineations that formed at their bed. Directly juxtaposed against these boundaries, in the area between the converging ice streams, several sharp-sided and flat-bottomed depressions that are up to 1500 m across and 40 m deep are observed. These depressions are very similar to the holes of hill-hole pairs observed in an inter-ice-stream area on the Amundsen Sea continental shelf, and such features are widely regarded as characteristic of cold-based ice. However, no corresponding hills are observed. In view of the proximity of the holes to the paleo-ice stream confluence we consider it likely that the excavated material was dragged by slow ice flow into the streaming ice, which then swept it away. This close juxtaposition of features formed beneath wet-based and cold-based ice, together with the canyons further upstream that we interpret as features carved by basal meltwater, illustrate the importance of water availability in facilitating ice stream flow.

## ***Dating the un-datable: Pushing radiocarbon dating in marginal marine Antarctic sediments to new limits***

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Radiocarbon chronologies have been a valuable tool for examining changes in Antarctic ice sheet retreat and advance during the Late Quaternary. However, these chronologies pose more than a few difficulties in acquisition due to the rarity of microfossils around the Antarctic margins. Bulk acid insoluble organic (AIO) <sup>14</sup>C dating has been used frequently as a result, but works best where high productivity and sedimentation rates reign, and not too well in condensed sequences where high proportions of detritus are present. Moreover, carbonate microfossils suffer from vital effects, which can result in variability of up to 500 years in living organisms. Compound specific dating methods have also been employed, but these may still yield an average age from a mixture of components. Alternate methods of applying a chronology have also been used, such as magnetic intensity dating, or regional correlation with well-dated cores, but these may not always provide the most accurate dates. Here we present progressive improvements of Ramped PyrOx <sup>14</sup>C dating techniques made on typical bulk AIO <sup>14</sup>C dating by utilizing the thermochemical degradation of components within a given sediment sample. These improvements include novel approaches that have been used to date sediments where the proportion of contemporaneously deposited carbon is very small relative to other detrital components, and maximize the accuracy of resulting dates while minimizing costs in precision from utilizing ultra-small fractions of the bulk sample. We have become adept at employing Ramped PyrOx techniques to generate chronologies for cores that would otherwise go undated. Furthermore, these techniques can be used to push the limits of radiocarbon dating not only to regions where accurate core chronologies have been difficult to come by, but also further back in time, into marine sediment horizons deposited at or before the last glacial maximum (LGM), where highly detrital material has precluded radiocarbon dating in the past. It is our hope that wider use of our techniques will enable more coordinated a priori coring efforts to constrain regional glacial responses to rapid warming.

## ***Depositional processes on the eastern Ross Sea slope and rise: Slides, mounds, presence of fluids.***

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### **PURPOSE:**

This project aims to understand the processes affecting the eastern Ross Sea slope and rise and reconstruct its evolution in the Cenozoic. Differently from the shelf, this area has a shortage of data and is less studied. This is an area where oceanic circulation and glacial dynamics interplay; therefore it has a strategic importance in understanding the causes of variation of ice sheet extension and the impact on climate and global oceanographic processes. Another aim of this study is also in terms of geohazard, by estimating slope stability, through the investigation of the fluid occurrence and dynamics in the sediments.

We re-processed and interpreted some seismic sections from Italian, USA, German campaigns (IT88A, L284AN, BGR80), in order to identify and map sedimentary bodies and erosional features, used to infer active or old processes along the slope.

### **PRELIMINARY RESULTS:**

The re-processing of the original data from past campaigns allows to recognize acoustic properties and geometry of seismic facies. The regional mapping of the seismic facies allows to reconstruct depositional elements within the continental slope.

The identified structures relate the sea bottom, some buried features and some structures that leak in several reflectors (and in some cases reach the sea bed).

In effect, analyzing some particular formation in different sections, we could interpret wavy reflectors and features similar to mounds on the sea bottom, like fluids that come out.

Three main zones are identified and described in the examined areas. They show different processes taking place along the slope during the Cenozoic. Today the three zones clearly differ depending on the inclination of the slope, the sediment type and their location respect to the pathways of bottom currents:

1) Seaward of the Glomar Challenger Basin and Hayes bank, slide features (scar and foot) are frequent and well developed, within a glacial prograding shelf margin fan, up to the present day sea floor. They can be caused by repeated glacial sediments accumulation on the slope and collapsing.

2) The Hillary Canyon at the mouth of the Glomar Challenger Basin is characterised by erosional features and little accumulation of sediments on the slope comparing to area 1. Ice sheet, during past phases of maximum advance, dragged sediment up to the shelf edge, that by-passed the canyon and was deposited in deep water in channel-levee systems.

3) On the eastern flank of the Iselin bank, a morphological high of the external continental shelf, where the Cenozoic sedimentary sequence is very thin, the slope is very steep and the sea floor appears relatively flat (no evidence specific of glacial furrow).

Deposits at the base of the slope are much more chaotic than in areas 1 and 2, with discontinuous and deformed reflectors. The chaotic banks characterizing the slope of this area were interpreted as resulting from gravitational processes.

## ***Evolution of a fjord depositional environment: Insights into climate change at the Subantarctic Auckland Islands, New Zealand***

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The Southern Hemisphere westerly winds (SHWW) are an important component of global oceanic and atmospheric circulation and play a primary role in regulating CO<sup>2</sup> flux in the mid to high southern latitudes. Despite their importance, there are few highly resolved Holocene and Late Glacial records of past climate change from New Zealand's subantarctic Auckland Islands (50.5°S) that can reconstruct past SHWW change. The Auckland Islands are in a unique location at the core of the modern SHWW belt. Changes in hydrology, temperature, and vegetation on the islands are driven by the westerlies and these changes should be preserved in fjord sediments accumulating in silled sub-basins. More information on the links between the SHWW, climate changes, and CO<sup>2</sup> flux is needed for our understanding of global atmosphere and ocean circulation systems and to establish future climate trends.

A series of sediment cores were collected in February 2015 and 2016 from Norman Inlet, Auckland Islands, and are being used to reconstruct a high-resolution record of climate change following the Last Glacial Maximum (LGM). Sediment has been preserved in Norman Inlet due to a sill, of probable glacial origin, creating a depositional basin that was protected from the influence of sea-level rise until the early Holocene. Physical property data, ITRAX XRF and visual core descriptions indicate the cores capture several phases of sedimentation. We identify four primary sedimentary facies: 1) a deglacial facies exhibiting mm-scale laminae defined by magnetic susceptibility and density contrasts and high counts of elements associated with terrigenous deposition; 2) a lacustrine facies defined by very low density, high organic carbon concentrations and low counts of terrigenous elements; 3) a marine transgression facies with moderate density, moderate bioturbation, and alternating marine and lacustrine sedimentary components; 4) a marine facies that contains biogenic carbonate. Initial radiocarbon results indicate deglacial sedimentation was underway in the basin by approximately 19,000 cal yr BP. This relatively old age, and the lithologic character of the unit it was obtained from, indicates that minimal ice (perhaps retreating ice) was present in the drainage basin at this time. Three radiocarbon dates between 15,200 to 14,500 cal yr BP were obtained from the base of the interpreted lacustrine interval. We are awaiting results for the timing of the marine transgression, but ages we obtained so far indicate a lake was present in Norman Inlet from 15,200 cal yr BP until marine transgression, which occurred sometime before 9,500 cal yr BP (our youngest radiocarbon date from the marine unit). We will present a bulk organic C and N isotope stratigraphy, accompanied by an n-alkane hydrogen isotope profile, which together will contribute to building a robust record of climate change since the LGM at the Auckland Islands that can be compared to existing records from Tasmania, Southern South America, and Antarctica. Ultimately, our work will provide a broader picture of SHWW change across the Southern Hemisphere.

## ***Foraminiferal radiocarbon dates from the Ross-Bank death assemblage: insights into WAIS decoupling and ice-shelf retreat in Glomar-Challenger-Basin and Pennell-Basin paleo-ice-streams.***

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Many studies have focused on documenting the deflation and retreat of the West Antarctic Ice Sheet (WAIS) since the Last Glacial Maximum. In the marine realm, most studies survey the axes of broad, dip-aligned bathymetric troughs because these basins were backfilled with a transgressive succession of grounding zone wedges (GZWs) each of which marks former locations at which the retreating grounding line paused. Dating WAIS retreat has been challenging because ice-proximal sediment contains very little in situ datable material that cannot be easily isolated from reworked fractions. Moreover, corrosive waters bathe the deep troughs, preventing carbonate preservation.

During expedition NBP1502B, we explored a different strategy to examine WAIS retreat history. Video and several hundred photographs taken over a short transect at the crest of Ross Bank revealed abundant benthic life, including organisms with calcareous shells, covering the bank crest at a depth of 175 m. A box core, NBP1502B BC1, obtained at the site reveals what we interpret to be a death assemblage of foraminifera from the near subsurface sediments. The preservation states of foraminifera range from pristine to poor. We propose that the foraminifera and other fossils present in the death assemblage could only have been established in the time since grounded ice retreated to south of Ross Bank. In our ongoing study, we have isolated foraminifera from the box core sediment. These specimens will be radiocarbon dated. We hypothesize that the oldest radiocarbon dates will provide a minimum time for which grounded ice moved south of Ross Bank transitioning from a sub-ice-shelf to open-water environments at the site.

The radiocarbon results from the Ross-Bank death assemblage will be compared to the chronology developed from a traditional approach to date the deglacial history of the Glomar Challenger Basin, which is a paleo-ice-stream trough to the east of Ross Bank. In Glomar Challenger Basin, a new Kasten Core, NBP1502B KC2, was obtained during NBP1502B on the topset surface of the middle shelf GZW. The core penetrated GZW diamict overlain by sediments representing sub-ice-shelf and open-marine facies. A previous study of Glomar Challenger Basin suggested that the middle-shelf grounding event in Glomar Challenger Basin ended at 26 kyr BP. This chronology is considered suspect because there is as of yet no explanation as to why the WAIS would have retreated prior to the LGM. Moreover, recent radiocarbon dates from the Whales Deep paleo-ice-stream trough indicates post-LGM retreat. The results of this study should help provide additional constraints on the deglacial history of eastern Ross Sea.

## ***Holocene climate change recorded in laminated sediment cores from Moubray Bay, Northern Victoria Land, Antarctica***

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Laminated diatom oozes accumulating in Antarctic coastal basins provide an excellent opportunity to compile high-resolution paleoclimate records that can capture Holocene ocean-atmosphere variability at decadal to multi-millennial timescales. Diatom silica preserved in marine sediments reflects spatial variations in the productivity of the overlying water column. Core-top diatom assemblages have well-documented associations with specific environmental conditions such as presence of sea-ice, light and nutrient availability, sea-surface temperature, and water column stratification. The relationship between sediment geochemistry, diatom assemblages, and related environmental conditions can therefore be utilised to reconstruct a range of climatic conditions at a particular site through time.

Here we present initial results from two new marine sediment cores collected from an isolated basin in Moubray Bay, Northern Victoria Land (72° 04.5'S, 170° 27.4'E) by the R/V Araon during the 2015 ANA05B expedition. Core GC-62 is 2.7m long and core LC-62 is 4.82m long. Both cores are composed of three sedimentary units. Unit 1, 0 - 0.1 metres below sea floor (mbsf) is a dark grey volcanoclastic sand with shell fragments, foraminifera, high magnetic susceptibility, and less than 5% biogenic silica by weight (wt% BSi). Unit 2, which extends from 0.1 - 1.53 mbsf in GC-62 and 0.1 - 2.2 mbsf in LC-62, comprises a laminated diatomaceous ooze with the horizontal layering differentiated by changes in colour (cream, olive, and orange), texture (massive, fluffy) and density. Unit 3 extends from the base of Unit 2 to the base of each core. This unit is composed of disturbed diatom ooze which is characterised by undulating and interweaving layers of the same colours and textures that were observed in Unit 2. Although the style of accumulation differs between units 2 and 3, biogenic silica is high in pilot samples from both diatom ooze units, ranging from 34-42 wt% in Unit 2 and 32-52 wt% in Unit 3. Core top samples contain diverse and well-preserved diatom assemblages characterized by sea-ice associated species including *Fragilariopsis curta*, *F. sublinearis*, *F. obliquecostata*, *Thalassiosira lentiginosa*, *T. antarctica*, and *Stellarima stellaris*. Diatom assemblages from LC-62 section break samples (~1.5m spacing) are dominated by *Corethron pennatum*, which is associated with a shallow mixed layer and rapid export and burial, and by variable abundances of sea-ice associated *Fragilariopsis* species and *Chaetoceros* resting spores. Ongoing work aims to establish a radiocarbon chronology, stable isotope stratigraphy, and a quantitative diatom paleoenvironmental reconstruction.

Existing paleoclimate reconstructions from around Antarctica show that Holocene climate fluctuations are not synchronous, indicating the influence of regional variations in the timing and location of the climate response. These laminated cores will allow high-resolution reconstruction of Holocene climate conditions at Moubray Bay, contributing to the regional picture of climate response in the Ross Sea region. In addition, this record will provide a new point of comparison to high-resolution ice and sediment cores from Antarctica and sediment cores from the mid-latitudes of the Southern Hemisphere, ultimately building a more nuanced understanding of Holocene climate change.

## ***Ice core records from the Amundsen / Bellingshausen Sea Coastal Domes – Scientific Priorities and logistical challenges***

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Increased wind-driven incursions of warmed, modified Circumpolar Deep Water on to the adjacent continental are suggested as the major driver to melt ice shelves and destabilise grounding lines. The over-deepened, reverse slope bathymetry of Antarctica's continental shelves provides an ideal configuration for a runaway retreat with the potential for abrupt collapse and accelerated sea level increase - a process that may be already underway in some regions. With CO<sub>2</sub> concentrations and global temperatures projected to continue to rise, model simulations of the Antarctic-Southern Ocean project for the coming decades an increase in surface warming resulting in reduced sea-ice extent, weakened deep-water formation including Antarctic Bottom Water and Antarctic Deep Water, enhanced CDW upwelling and production of Antarctic Surface Water and Shelf Waters, along with grounding line retreat.

However, observational data from this region are sparse and/or cover only short time periods. Ice core reconstructions from coastal domes could provide important insights in the natural variability, past thresholds and climate sensitivities. Here we report and discuss the outcome of two international workshops held in 2015 to develop a science strategy for the region and to overcome logistics challenges.

The remarkable success and data set of the NASA project - Operation IceBridge has provided the science community with a detailed survey including the coastal regions of West Antarctica. This data set along with recent scientific deployments of the US, British, Korean, and Brazilian national Antarctic programmes to the region provide an exciting opportunity to identify suitable ice core drilling sites. Two different types of ice core drilling methods are needed – a lightweight, fast access drill to the bedrock to determine the last time the bedrock was exposed (i.e. during the Eemian) and an intermediate depth ice core drilling system to obtain a continuous ice core record at least for the past 2,000 years but preferably longer to extend the observational record and assess natural variability. Logistical challenges include the extremely high snow accumulation (up to 2m water equivalent per year), high winds speeds, and remoteness. Overland traverse to the site from either WAIS Divide camp or the Antarctic Peninsula will need to be considered perhaps along with ship and fix wing support. Operational challenges include warm temperatures (ice core storage, melt), high snow precipitation (thus a need for underground operation, living quarters and storage), and the need for multi-year occupation.

Participants of the workshops - Coastal Domes in the Amundsen / Bellingshausen Seas – Science Plan in support of an International Consortium Approach:

10-12 April 2015, Vienna, Austria: Bertler, N., Bentley, M., Blunier, T., Conway, H., Fudge, T.J., Hwang, H., Kang, J., Kawamura, K., Matsuoka, K., Medley, B., Mulvaney, R., Neff, P., Pattyn, F., Ritz, C.

19-20 September 2015, Colorado, USA: Bertler, N. Conway, H., Das, S., Do Hur, S., Johnson, J., Kang, J., Kingslake, J., Kippenhan, M., Koutnik, M., Medley, B., Muto, A., Neff, P., Pyne, A., Scambos, T., Simones, J., Smith, A., Trusel, L., Vaughan, D., Zhang, D., Zhang, T. and representatives of logistics support and funding agencies.

## ***Large-Ensemble modeling of Antarctic Ice Sheet variations with a coupled ice-Earth-sea level model***

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To date, most modeling of the Antarctic Ice Sheet's response to future warming has been calibrated using recent and modern observations. As an alternate approach, we apply a hybrid 3-D ice sheet-shelf model to the last deglacial retreat of Antarctica, making use of geologic data of the last ~20,000 years to test the model against the large-scale variations during this period. The ice model is coupled to a global Earth-sea level model to improve modeling of the bedrock response and to capture ocean-ice gravitational interactions.

Following several recent ice-sheet studies, we use Large Ensemble (LE) statistical methods, performing sets of 625 runs from 30,000 years to present with systematically varying model parameters. Objective scores for each run are calculated using modern data and past reconstructed grounding lines, relative sea level records, cosmogenic elevation-age data and uplift rates. The LE results are analyzed to calibrate 4 particularly uncertain model parameters that concern marginal ice processes and interaction with the ocean.

LE's are extended into the future with climates following RCP scenarios. An additional scoring criterion tests the model's ability to reproduce estimated sea-level high stands in the warm mid-Pliocene, for which drastic retreat mechanisms of hydrofracturing and ice-cliff failure are needed in the model. The LE analysis provides future sea-level-rise envelopes with well-defined parametric uncertainty bounds. Sensitivities of LE results to Pliocene sea-level estimates, coupling to the Earth-sea level model, and vertical profiles of Earth properties, will be presented.



## ***Last Glacial - Holocene Climate Variability in the Southern Ocean Atlantic sector: Implications of West Antarctic Ice Sheet dynamics***

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Cold water extension in the Southern Ocean Atlantic sector is closely related to the Weddell Gyre, which represents an interface between the West Antarctic Ice Sheet (WAIS) and the open ocean South Atlantic. The generation of cold surface and bottom waters in the Weddell Sea is connected to the presence of large sub-ice cavities beneath the shelf ice. Thus, the reconstruction of Weddell Gyre cold water expansion history helps understanding the ice-ocean interaction under past climate conditions. However, most of the sediment beneath the modern Weddell Gyre is deposited at low sedimentation rates and bears only minor biogenic components due to the sea ice cover, thus broadly lacks microfossil assemblages required for paleoceanographic reconstructions.

In this study, we investigated high resolution diatom records from a series of sediment cores from the Atlantic and Western Indian sectors of the Southern Ocean between the modern Polar Front (PF) and the Winter Sea Ice (WSI) edge, an area sensitive to cold water extension from the Weddell Gyre, thus provide implications of WAIS dynamics. Summer sea surface temperature (SSST) and sea ice information spanning the past 30 thousand years were derived from diatom transfer functions and indicators, which provide important environmental boundary conditions for climate simulations understanding the past climate development in the high latitudes Southern Ocean.

Our reconstructions show that the Last Glacial (LG) SSSTs south of the modern PF are 1-3 °C colder than modern conditions, WSI expanded to the modern PF. Deglacial warming was more suppressed towards south, due to continuous ice discharge from Antarctica. A weak cold Weddell Gyre extension during the early Holocene optimum is characterized by SSSTs exceeded modern values and WSI extent probably retreated south of its modern position, suggesting the lack of cavity development beneath the WAIS. The Mid-Late Holocene cooling with WSI re-expanding to the Bouvet Island area, probably related to enhanced cold-water export by the Weddell Gyre from the developing cavity under the WAIS.

## ***Late Neogene sediment properties in the Wilkes Land continental rise (IODP Exp. 318 Hole U1359A), East Antarctica***

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On the basis of the variations of sediment properties such as biogenic opal, grain size, natural gamma ray (NGR), and clay mineralogy, we differentiate two types of Late Neogene marine sediments that record paleoclimate changes associated with the growth and retreat of the EAIS and associated changes in sea ice cover. The first type of sediments are massive muds characterized by high biogenic opal (30~55%), low NGR (15~30 counts per second (cps)), large mean grain size (>8.3  $\mu\text{m}$ ), and low smectite/(illite+chlorite) [S/(I+C)] ratios (<~0.2). We interpret these sediments as the result from deposition by hemipelagic sedimentation during interglacial conditions. In contrast, the second type of sediments are laminated muds characterized by low biogenic opal (5~7%), high NGR (45~67 cps), small mean grain size (<6.3  $\mu\text{m}$ ), and high S/(I+C) ratios (>~0.2). We interpret these sediments as the result from deposition by either turbiditic or contouritic processes during glacial conditions. All these sediment properties indicate that the Wilkes Land continental rise recorded Late Neogene paleoclimatic changes in terms of surface water productivity, sediment provenance and transport pathway, and depositional processes that are related to the growth and retreat of EAIS. In addition, the decreased maxima of biogenic opal content at Hole U1359A highlights the temporal climatic change between the late Pliocene (~2.0 Ma to ~3.7 Ma) and the early Pliocene to late Miocene (~3.7 Ma to ~6.3 Ma), confirming the important role of sea ice to the surface water productivity associated with the global cooling trend in the East Antarctica.

## ***Late Quaternary sedimentation patterns in Ona Basin, southern Scotia Sea, Antarctica: Preliminary results***

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Recent sedimentation patterns of presumed Quaternary age in the Scotia Sea appear to be dominated by contourite drifts generated by the influence of the Antarctic Circumpolar Current (ACC), the Weddell Sea Deep Water (WSDW) and/or the interaction between both water masses. Intercalated between stratified contourite deposits, chaotic lenses interpreted as gravitational deposits are also frequently found in diverse basins along the Scotia Sea [1, 2].

We present the first results about recent sedimentary products in Ona Basin, the westernmost of the southern Scotia Sea basins, located north of the South Scotia Ridge (SSR). This basin is bounded by the Shackleton Fracture Zone (SFZ) to the west, Terror Rise to the east, and the South Shetland Islands Block (SSIB) to the south, whereas it opens to the north into the western Scotia Sea basin plain. Ona Basin, located at the entrance of the present-day Drake-Scotia marine gateway, is crucial for a better understanding of palaeoceanographic changes affecting the strength and distribution of major regional currents (ACC and WSDW). As thus, most of Ona basin is directly influenced by the Circumpolar Deep Water (CDW), which constitutes the main component of the eastward-flowing ACC. However, a branch of the WSDW that flows westward along the SSR affects the southern margin of this basin.

The aim of the study is to reveal: (1) the spatial and temporal variation of contourite depositional systems through the description of depositional and erosive features of contourite origin; and (2) the significance of gravitational processes in proximal basin settings.

This work is based on the analysis of a geophysical database comprising multibeam bathymetric data and very high-resolution seismic profiles acquired using a TOPAS (Topographic Parametric Sonar) PS 18 system. These data were collected onboard the RV Hespérides during the SCAN-2004, 2008 and 2013 cruises. In addition several sediment cores collected with a gravity corer were also collected in the region. For the purposes of this study, we focus on the detailed seismic interpretation of the TOPAS profiles, through the depiction of main seismic reflections and subsequent definition of seismic units.

The high-resolution subsurface seismic record of the southern margin of the basin is characterized by the alternation between stratified and chaotic deposits. Stratified units are laterally continuous, with constant thickness and sub-parallel seismic facies; these units have erosional limits at the margins of the abyssal plain and close to structural highs. Chaotic units show lenticular shapes and tend to disappear toward the abyssal plain. Future work will be conducted toward feasible chronostratigraphic correlations between available sediment cores collected in the central Scotia Sea and the high-resolution datasets interpreted in this study. Our final intention is to improve the regional picture of recent palaeoceanographic changes, in particular the development of both contouritic and gravitational processes under the guiding framework of Pleistocene glaciations.

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## ***Limited glaciation of the New Zealand subantarctic islands during the Last Glacial Maximum***

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The New Zealand subantarctic islands of Auckland and Campbell – situated in the Pacific sector of the Southern Ocean and straddling major ocean fronts – have the potential to provide valuable terrestrial palaeoclimate records in this climatically important region. The islands, though currently experiencing a maritime-temperate climate, show clear evidence of past glaciation and can thus be used to provide insights into the timing and nature of climatic regime shifts across these latitudes during Pleistocene glaciations. Here we present the results of a detailed multidisciplinary survey of the islands combining marine and terrestrial geomorphological mapping and extensive sediment coring and radiocarbon analysis. Our synthesis of analyses demonstrates that, despite extensive early Pleistocene glacial expansion, glacial extent during the Last Glacial Maximum (LGM, 21,000±3000 years ago) was severely restricted, contrary to previous interpretations. Flowline modelling on Campbell Island, in conjunction with field evidence, shows that although the islands experienced a mean annual air temperature depression of approximately 5°C, the combination of high seasonality and substantial precipitation reduction left the islands incapable of sustaining significant glaciation during the LGM. We propose that the northwards expansion of winter sea ice during the LGM and subsequent Antarctic Cold Reversal led to precipitation starvation across the mid to high latitudes of the Southern Ocean, resulting in markedly reduced glaciation of the subantarctic islands in comparison with larger Southern Hemisphere landmasses.

## ***Mid to Late Holocene ice discharge in the Bransfield Strait, Antarctic Peninsula region and its tele-connection with ENSO***

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As one of the most sensitive areas to recent global warming, the Antarctic Peninsula region is experiencing continuous ice discharge from disintegration of the adjacent shelf ice. A Holocene history of ice discharge in this area will provide insights of its past global change. We investigated a sediment core retrieved from the Bransfield Strait during the 28th Chinese Antarctic Expedition to study the ice dynamics in this area for the past 6 ka. The core stratigraphy is established by AMS 14C dating and regional correlations of tephra layers. Ice Rafted Debris (IRD) indicates ice discharge frequently occurred in the past 2.5 ka. The most prominent IRD events centered at ca. 2 ka corresponds to intensified ENSO activity, suggesting instability of ice shelf probably due to enhanced upwelling of upper circum-polar deep water during strong La Niña periods. Sea ice diatoms (*Fragilariopsis curta* and *Fragilariopsis cylindrus*) generally increased since 3.5 ka, indicating a cooling with sea ice expansion. Slight decrease of mean grain size of sortable silt during this period implies a weakened bottom current, indicating a northward shift of the Westerlies.

## ***Optical dust logging for million-year ice***

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The Rapid Access Ice Drill concept combines fast access drilling with optical dust logging as an “Oldest Ice” reconnaissance tool, for discovering 1.5 million year old ice encompassing the Mid-Pleistocene Transition. More than 15 years ago in a partnership between glaciologists and particle physicists, we developed the optical dust logger as a means to quickly date glacial ice without retrieval of a core. We have used this method to match distinct stratigraphic features at centimeter precision, within core depth registration errors, to synchronize both hot-water and drill-fluid boreholes across Antarctica and Greenland. Insoluble particulate deposits originating from continental, volcanic or extraterrestrial sources are quite uniform over Antarctica and do not diffuse or significantly degrade. Synchronization between ice records is trivial and matching dust to dated marine records is straightforward, so the timescale of any site can be determined within hours of a hole being drilled. Optical dust logging can produce a more stratigraphically coherent environmental record than core measurements and reveals such authentic fine structure that the data are regularly used to corroborate core sample measurements. The method does not involve sampling or resonant coupling of a high-finesse cavity, and is insensitive to vibrations or changes in temperature and pressure. During commissioning of IceCube detector strings in refreezing hot-water holes, we obtained high resolution paleoclimate records at meter-per-second logging speeds. Independent projects for surveying old ice are now developing optical dust loggers as well, since it is technically the simplest, most proven and reliable method for rapid determination of age versus depth in ice.

# ***Paleobathymetry of Southern Ocean and its role in paleoclimate and paleo-ice sheet variations: call for a sequence of paleobathymetric grids***

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Paleo-ocean circulation models of the Southern Ocean suffer from missing boundary conditions, which describe accurately the geometries of the seafloor surfaces at their geological epoch and their dynamics over long time-scales. The accurate parameterisation of these models controls the meaning and implications of regional and global paleo-climate models. For instance, the onset and consequences of the deep-water opening of the Southern Ocean gateways – Drake Passage and the Tasmanian Gateway – is only indirectly and vaguely determined by proxy analyses of microfossils. The development and implications for deflections of major deep-sea current systems through structural obstacles such as oceanic plateaus and ridges, but also the extent and morphological shape of the continental shelves, is not described due to lacking reconstructions of their bathymetric development.

Although plate-kinematic reconstructions of the Southern Ocean have reached a state at which the plate circuit can be almost closed with geodynamic constraints of improving certainties, a major obstacle for calculating Southern Ocean paleobathymetric grids has been the missing or insufficiently assessed components of sedimentary deposition/erosion and mantle-driven dynamic topography. Existing paleobathymetric models consider only the top of oceanic basement based on paleo-age models from magnetic sea-floor spreading anomalies and plate-kinematic reconstructions. Others simplify the sedimentary cover using outdated isopach databases. A re-assessment of old seismic data as well as recently collected new seismic lines reveal that the sedimentary cover has been greatly underestimated in almost all conjugate continental margins and in some of the deep Southern Ocean basins. Incorporating sedimentary processes in paleobathymetric reconstruction grids is particularly important in reconstructing the opening of oceanic gateways where the question of shallow to deep-water exchange determines the accuracy of paleo-ocean circulation and paleo-climate models. The dynamics of ocean currents in proximity of the continental margins is also controlled by the development of the regional morphology of the conjugate continental shelves, slopes and rises.

The ultimate aim of such paleobathymetric grids is to generate Cenozoic climate reconstructions using a variety of Earth system models designed to evaluate the effect of ocean gateways and basins on paleo-circulation patterns, the global carbon cycle and the nature of Antarctic ice sheet development. These experiments will include sensitivity runs incorporating the new paleobathymetric reconstructions. The results are compared with other model simulations, which include different forcing factors such as atmospheric greenhouse gasses and mountain uplift to determine the relative importance of paleo-geography on the evolution of global climates over long geological timescales.

## ***Paleoclimate implications during LGM from cores collected off Coulman High, western Ross Sea, Antarctica***

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Here we present preliminary results from a multi-proxy study of different cores from Coulman High area in the western Ross Sea, Antarctica.

Seventeen cores have been sampled at the Antarctic Marine Geology Research Facility (AMRF), Florida State University in order to reconstruct the depositional setting and related climate implications in a peculiar ice-proximal marine setting during LGM time. Coulman High area is located along the Antarctic continental margin where different Ice Shelves (WAIS EIAS and RossIS) have played a significant role on marine sedimentation. Sedimentological observations, REEs compositional analysis and evaluation about their source areas have been performed on sediments from both a Northern and a Southern transects off Coulman High to better constrain the LGM record. The LGM definition is difficult due to a lack of biostratigraphic control, in the present study LGM sediments have been defined on the basis of their stratigraphic position, and the discrimination of ice-proximal vs marine/glacimarine sediments.

LGM sediments from the Southern cores mainly consist of dark greenish diatomaceous sandy mud containing abundant crumbled diatoms. Diatom-bearing ooze are uncommon and sub-centimetric dropstones are rarely present. Sediments from different cores show a similar bulk composition, sedimentation might be related to subglacial conditions during ice-sheet retreat.

Sedimentation along the Northern transect shows a wider variability, diatomaceous sandy muds have been poorly recorded. The sedimentary record consists mainly of fine-grained sediments containing mostly biogenic carbonate remains, as foraminifera, bivalves, echinoids. These facies are interpreted as related to marine/glacimarine setting.

Extensive characterizations of the biogenic vs non/biogenic components, and REE from Coulman High cores, to be integrated with REE provenance data from several sites in the western Ross Sea, will allow to better define the sedimentary processes, to understand the evolution of the ice-proximal marine setting and to evaluate the related extent of the ice-sheets in the Coulman High area during LGM time.



## ***Postglacial records of southern hemisphere westerly wind variability from the New Zealand Sub-Antarctic Auckland Islands***

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The strength and latitudinal position of the Southern Hemisphere westerly winds (SHWW) play a fundamental role in influencing mid-latitude climate and carbon dioxide exchange between the Southern Ocean and the atmosphere. Despite their importance, our understanding of past changes in the SHWW is limited by the small number of paleoclimate records from the modern wind maximum, which are often not in agreement. The New Zealand subantarctic Auckland Islands are located within the core of the modern wind belt (50°S), a key latitude where ocean-atmospheric linkages between the Antarctic and middle latitudes are strong. In contrast to other subantarctic islands on the Campbell Plateau, the Auckland Islands have protected fjord sub-basins, deep lakes, and peatlands that are advantageous for the development of high-resolution paleoclimate records.

We will present ongoing work towards the establishment of multi-proxy and multi-site reconstructions of past SHWW variability from the Auckland Islands. Modern process and paleoclimate results from research cruises during the last three austral summers suggest that in lacustrine and fjord settings, the degree of water column mixing, the stable isotopic composition of n-alkanes and benthic foraminifera, the influx of terrestrial organic matter are good indicators of wind-induced mixing of the water column or precipitation-driven erosion within catchments. In ombrotrophic peatlands, hydrogen isotope ratios of specific organic molecules allow reconstructions of the hydrogen isotope ratios of precipitation, which is related to precipitation source area and the latitudinal position of the SHWW. Using abundances of leaf wax biomarkers, supported by terrestrial macrophyte assemblage data, we are able to estimate moisture balance at peatland coring sites. Our initial results indicate an overall strengthening of the SHWW at the Auckland Islands through the Holocene. We will discuss these results within the context of complimentary records developed from New Zealand and southern South America to ultimately obtain a Pacific basin view of Holocene SHWW.

## ***Post-LGM calving-front and grounding-line migration within the Whales Deep paleo-ice-stream trough, eastern Ross Sea***

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New geological and geophysical data from the eastern Ross Sea continental shelf were acquired during expedition NBP1502B. These regional data provide an opportunity to investigate the post-LGM ice-sheet and ice-shelf evacuation of the Whales Deep paleo-ice-stream trough. Piston- and Kasten-core sedimentology indicate upcore transitions from grounding-zone-wedge (GZW) to sub-ice-shelf and open-marine paleo-environments. We are conducting an ongoing integration of diatom and foraminiferal assemblage data with core sedimentology and former grounding-line positions as revealed from the new multibeam bathymetry. Thus far, the syntheses of these data suggest that grounded ice retreated from the shelf edge to the middle shelf in a stepped manner. During this time of initial grounding-line retreat, an ice shelf was established but its calving front remained in the vicinity of the shelf edge. Ice-shelf collapse then occurred and shortly thereafter, grounded ice experienced a major retreat from the middle shelf. The grounding line may have re-established at the latitude of the modern Roosevelt-Island ice rise. A larger ice shelf was re-established in the area between the former grounding line on the middle shelf and the new (?) grounding line location at Roosevelt Island. Core sites south of the middle shelf grounding line position show that the calving front stabilized near 77°S. In the calving front zone, the upcore transitions from sub-ice-shelf to open-marine facies show an alternation between modern diatom assemblages and mixed (i.e., modern+ pre-modern) assemblages. The co-occurrence of planktonic and relatively-high abundances of benthic foraminifera in throughout this sub-ice-shelf facies is also consistent with a calving front near 77°S. Conversely, a core located closer to the Roosevelt Island grounding line (i.e., far south of the paleo-calving front) is devoid of modern diatom and benthic foraminifera assemblages. The calving front of this large paleo ice shelf then experienced a single abrupt retreat of at least 100 km south to the modern Ross Ice Shelf calving front location. Identification of grounding line and calving front migration and behavior within the eastern Ross Sea will have far reaching implications for ice sheet modeling and understanding the mechanisms for WAIS retreat.

## ***Pre-glacial to full glacial sedimentation along the Pacific margin of West Antarctica: Record of shifting pattern of supply and transport***

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The seismic sediment record of the Amundsen Sea continental rise provides insight into the sedimentation processes from pre-glacial to glacial times, variations in ocean-bottom circulation, early ice sheet growth, and intensification towards the present icehouse regime. Seismic reflection data acquired during the 2010 RV *Polarstern* and the 2006 RV *Tangaroa* expeditions, created a 2000 km long continuous Amundsen Sea to Ross Sea seismic transect. Pre-existing lines linked to this transect, connect key seismic stratigraphy horizons from the Ross Sea shelf to the rise and farther along the West Antarctic margin, up to the Amundsen Sea Embayment. Seismic units AS-1 to AS-3 constitute the Cretaceous to Eocene pre-glacial (PG) sequence, units AS-4 to AS-6 the Eocene to mid-Miocene transitional (T) sequence, and units AS-7 to AS-11 the mid-Miocene to Quaternary full glacial (FG) sequence. The top PG sequence boundary horizon AS-u3/uPG-T links to unconformity RSU6 of the Ross Sea shelf and to the base of Unit II of the eastern Amundsen Sea, and is interpreted as the first arrival of grounded ice on the shelf. The top T sequence boundary AS-u6/uT-FG, links to RSU4 and the base of Unit III, and is interpreted as the onset of the FG regime with intensified ice sheet advances onto the outer shelves. The constructed pre-glacial sediment thickness grid depicts 1.3-4.0 km thick depocenters on the continental rise, relatively evenly distributed along the margin. The depocenters change markedly in the transitional phase at or after the Eocene/Oligocene boundary when first major ice sheets reached the shelf. Full glacial sequences, starting in the middle Miocene, indicate new depocenter formation in front of the Amundsen Sea Embayment and a localized eastward shift in the Bellingshausen Sea and Antarctic Peninsula basins. Using present-day drainage paths and source areas on the continent, we calculated volumes of eroded sediment for the pre-glacial, transitional and full glacial stages. In total, an estimated volume of about  $10.2 \times 10^6 \text{ km}^3$  was eroded from West Antarctica and transported into the Pacific since separation of New Zealand in the Late Cretaceous.

## ***Radar isochronic dating for the deep ice core site of Kunlun Station, Antarctica***

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The Chinese First Deep Ice-Core Drilling Project has started at Kunlun station in the Dome A region, East Antarctica. Internal isochronic layers from deep-penetrating radar data collected during the 2004/2005 Chinese National Research Expedition (CHINARE) and the Dome Connection East Antarctica (DoCo) project of the Alfred Wegener Institut (AWI) were linked to compare the new deep ice coring site of Kunlun station and the Vostok ice core site. Six visible layers, upon the depth greater than half the ice thickness at the Kunlun station ice core site, were dated based on the Vostok ice core chronology. At 1640 m depth, an age of ~160,400 yr corresponding to a bright layer at the Kunlun station ice core site was revealed. The age-depth relationship of the ice would be used to correlate the dating of the deep ice core at Kunlun station.

## ***Record of Holocene paleoclimate change in outer Bigo Bay, West Antarctic Peninsula***

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A 5.62 m-long core WAP13-GC47 (65°06'N, 64°07'W, 673 m deep) was retrieved from outer Bigo Bay in the West Antarctic Peninsula by the R/V Araon in 2013. Core WAP13-GC47 is generally composed of diatomaceous greenish-light olive grey mud, with a turbidite layer composed of sand and diatomaceous greenish grey mud between 2.16 m and 2.30 m. Magnetic susceptibility (MS), concentrations of total organic carbon (TOC), biogenic opal, and CaCO<sub>3</sub>, and grain size were measured at 2 – 4 cm intervals. <sup>14</sup>C dates were obtained from 6 horizons using bulk sediment and from 2 horizons using shell fragments. Co-variation pattern between biogenic opal and TOC concentrations indicates that export production is primarily controlled by diatom production. An interval of 3.3 – 5.4 m (~4200 – 7000 corrected <sup>14</sup>C yr BP) is characterized by high surface productivity and low MS values, which is deposited under seasonally open marine conditions during the mid-Holocene warm period. Bulk sediment age at 3.06 m was calculated as 8820±40 corrected <sup>14</sup>C yr BP, which may be influenced by old carbon input. However, chronological consistency of the bulk sediment age with corrected <sup>14</sup>C ages using shells from adjacent horizons (2.82 m and 3.09 m) suggests that sediments and shells are contemporaneous. A large part of sediments in the chronologically reversed layer is thought to be transported from shallower-water depth inner-mid Bigo Bay by meltwater plumes, resulting in high sedimentation rate. The turbidite layer marked by increases in mean grain size and MS and high sand concentration was deposited probably under ice-proximal conditions. The reversed ages of shell fragments and bulk sediment during the Neoglacial period indicate that mid-inner Bigo Bay was deglaciated at least 9000 corrected <sup>14</sup>C yr BP, which is consistent with other study results from Palmer Deep, Barilari Bay, and Lallemand Fjord in the West Antarctic Peninsula.

***Record of late neogene and quaternary paleoenvironmental and paleoclimatic conditions in southwest pacific sector of the southern ocean: Preliminary results***

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A 14.9 m-long core RS15-LC48 (68°54'S, 171°10'E) was retrieved on the lower continental rise in 3167 meters of water, lies about 270 km north of Cape Adare, in close proximity to the Ross Sea shelf in January, 2015, from the R/VIB Araon. The core is generally composed of alternating massive light gray sandy mud and laminated greenish gray diatomaceous mud. Intermittent existence of IRDs on the whole core indicates that ice rafting contributed substantially to sediment deposition. Overall sediments include the traces of bioturbation. They contain diatoms and foraminifera, although diatoms are by far the dominant fossil present. Although study site is located near the late Cenozoic volcanic centers of Adare Peninsula and the Balleny islands, there is little evidence of volcanic contribution to the sediment. Some glass shards are present, but they are small in volume. The chronology was roughly constructed based on paleomagnetism data by comparing with marine magnetic anomalies. Assuming the constant sedimentation rate (0.05~0.06 mm/yr), the core sediment is supposed to cover about 2.6 million years. Magnetic susceptibility (MS), concentrations of total organic carbon (TOC), biogenic opal, and CaCO<sub>3</sub>, and grain size were measured at 1 – 4 cm intervals. Here we present initial results from this core sediments.

## ***Recoverable autonomous thermal sonde for in-situ dating of glacier ice***

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The proposed recoverable autonomous thermal sonde will allow to measure the geochemical composition of ice in situ and is able to acquire new field data needed to locate the most suitable drilling sites for retrieving oldest ice core records in Antarctica. The sonde is equipped with two electrically heated melting tips, one on the bottom and one on the top of a cylindrical probe. When one of the tips is powered, the sonde moves up or down similarly to a hot-point thermal electric drill. The electric power and signal cable is coiled inside the probe on an electric-motor-powered coil. When the lower tip is powered, the probe advances downwards by gravity. The melted water is not recovered from the hole and it refreezes behind the sonde. The power and signal line is released from the coil inside the sonde. In order to move the probe up, power is applied to the upper heated tip and the coil motor pulls the cable, moving the probe upwards and melting the borehole above the probe. About 10% of the melted water is pumped through sampling analytical devices and expelled to the water-filled borehole. The water inlet is located just above the lower tip. The gas dissolved in this water is separated in the membrane and analyzed by an embedded laser spectrometer. Coded data from the sonde are transmitted to a computer on the surface. A conventional internal combustion engine electric generator on the glacier surface provides 9–10 kW of power to the sonde via an umbilical cable stored in the probe. Electric power enables a penetration rate of 2.4–2.9 m/h, and thus 4–5 months will be required to reach a depth of 3500 m and return to the surface.

## ***Sea ice and seasonality on the East Antarctic margin: A high-resolution Holocene diatom and geochemical reconstruction from the Adélie Drift***

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Photosynthetic products are efficiently exported in regions of deep water formation, such as the coastal polynyas of the Wilkes Land margin, effectively sequestering carbon and nutrients in the deep ocean. On geologic timescales, enhanced primary production in such regions may increase the efficiency of the biological pump in drawing down atmospheric CO<sub>2</sub>. Here, we present a new reconstruction from a high resolution Holocene marine sedimentary succession collected in Adélie Basin, on the Wilkes Land margin of the East Antarctic continental shelf. At Site U1357, IODP Exp. 318 recovered ~185 meters of diatom ooze in regularly alternating light/dark couplets, underlain by glacial diamict. Individual couplets range in thickness from 1.5 to 3.5 cm, and the basal diatom ooze age of ~11,800 calendar years, provided by a reservoir-corrected radiocarbon chronology from bulk sedimentary (acid insoluble) organic matter, suggests annual to near-annual lamination with accumulation rates comparable to coastal ice cores. Discrete sampling of the light and dark members of each couplet, respectively interpreted to preserve spring and summer/autumn diatom bloom and export, allows us to examine the influence of seasonality on primary production throughout the Holocene.

Wt % BSi in paired light and dark samples from Adélie Drift is a reflection of fossil diatom accumulation, relative to other sedimentary constituents. This parameter is high (mean = 48%) throughout the 11,800-year record, however the light member of each lamina couplet is consistently characterized by a silica concentration that is between 3 and 10% higher than the dark member. This result is consistent with an interpretation in which each light member represents a "clean" and nearly instantaneous export of the spring bloom into the sediments, while each dark member represents continued diatom growth throughout the summer and fall, allowing more time for the incorporation of wind- and ice-blown terrigenous material.

Bulk sedimentary  $\delta^{13}\text{C}$  is interpreted using a model wherein more positive values reflect the continual replenishment of dissolved organic carbon (DIC) from deeper waters into the surface ocean (a well-mixed water column), while more negative values reflect the progressive utilization of DIC in a water column stratified by sea-ice melt or other processes. The  $\delta^{13}\text{C}$  of Adélie Drift sediments is more negative in older sediments and becomes more positive up-core, suggesting that stratification became more pronounced through the Holocene. Furthermore, comparison of  $\delta^{13}\text{C}$  from light and dark members of lamina couplets clearly shows three phases in this progression: an interval with great seasonal differences in primary production and/or stratification between 11,800 years and ~7,000 years ago, an interval with minimal seasonal differences from ~7,000 to ~4,800 years ago, and a final interval from ~4,800 years ago to the top of the core (roughly modern) during which seasonal differences are again substantial in an environment with greater stratification overall. Diatom assemblages from the upper portion of the record indicate an overall shift from a more open-ocean flora towards a flora dominated by sea ice around 4,800 years ago, concurrent with the shift from low to high seasonality inferred from carbon isotope results.



## ***Sedimentological evidences of enhanced bottom-currents developed across the Tasman Gateway from the Late Eocene to Oligocene-Miocene Transition.***

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The opening and closing of the Tasman Gateway drastically affected sedimentation, global ocean and atmospheric circulation, climate, and the Antarctic ice sheet. Previous work suggests deepening of the seaway at ~35.5 Ma, allowing through flow of deep (3000 m) water masses [1]. Bathyal depths were reached before 32 Ma, yet marine geological and paleoceanographic based estimates suggest wide range of ACC onset age, extending from the Late Eocene to the Early Miocene [2].

Sediment cores collected during Deep Sea Drilling (DSDP) Leg 28 at Sites: 267, 269 and 274, and Integrated Ocean Drilling Program (IODP) Expedition 318 at Site U1356 in the Southern Ocean were selected to provide for a latitudinal transect across the Polar Front as well as for a comparison of the Indian and Pacific sides of the Tasman Gateway. We have described and sampled the cores focusing in the interval extending from the Latest Eocene to the Early Miocene. This interval encompasses two major transitions in Earth's climate: the Eocene-Oligocene (EOT) Transition and the Oligocene-Miocene Transition (OMT) that resulted in two major expansions of the Antarctic ice sheets (Oi-1 and the Mi-1 events, respectively).

Our results are based on the study of facies and facies associations in the cores, which record deposition in a deep-water setting dominated by bottom currents reworking hemipelagic sediments. As we conduct additional improvements in the age model and isotopic analysis to potentially characterize water masses, we provide preliminary insights into the relationship between sedimentary and oceanographic processes across the Tasman Gateway.

### References

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## ***Subglacial and glacimarine bedforms on the continental shelf of the SE Weddell Sea: New findings from RV "Polarstern" expedition PS96***

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The glacial history of the continental shelf in the southern Weddell Sea, Antarctica, is poorly known. Sparse multibeam data collected on previous expeditions from the outer, middle and inner shelf parts of Filchner Trough and along the Filchner-Ronne Ice Shelf front revealed the presence of subglacial bedforms in the Filchner, Ronne and Hughes bathymetric troughs, while highly consolidated diamictons recovered in cores elsewhere from the Weddell Sea

shelf were classified as subglacial tills. These findings were interpreted as evidence for the widespread presence of grounded ice both in the troughs and on shallower shelf banks during the younger geological past, probably at the Last Glacial Maximum (LGM; ca. 19-23 ka BP). In contrast, cosmogenic surface exposure ages of erratics collected from nunataks in the hinterland of the Weddell Sea embayment indicated that the LGM ice sheet could not have been thick enough to cause its grounding in the deeper parts of the Filchner and Ronne palaeo-ice stream troughs. Resolving these contradicting reconstructions is crucial, however, for a correct estimation of the ice volume stored in Antarctica during the LGM and or deciphering whether the Antarctic Ice Sheet was the main contributor for the rapid, drastic global sea-level rise of meltwater pulse 1A (MWP-1a; ca. 14.5 ka BP) during the last deglaciation.

In order to solve this problem multibeam swath bathymetry data (ATLAS Hydrosweep DS3), acoustic subbottom profiles (ATLAS Parasound P-70) and marine sediment cores were collected from the East and West Antarctic continental shelves in the southern Weddell Sea during RV "Polarstern" expedition PS96 in Dec 2015-Feb 2016. Despite severe sea-ice conditions that hampered multibeam surveys and coring operations a previously unknown grounding zone wedge (GZW) within the outer shelf part of Filchner Trough could be

mapped and sampled with two gravity cores. Morphology and acoustic stratigraphy of the GZW suggest that this feature marks the maximum extent of the Filchner palaeo-ice stream at the LGM rather than the position of a grounding-line stillstand during ice stream retreat from the shelf edge. In addition, hydroacoustic data and seabed images (Ocean Floor Observation System) acquired from other areas of the continental shelf reveal the strong control of seabed

substrate and tidal currents on the orientation and shape of iceberg furrows. Here we present a collection of the new geomorphological and geological data and discuss their significance for bedform genesis and Antarctic Ice Sheet history.

## ***The Sabrina Coast Flora: A new, unique floristic assemblage from East Antarctica***

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Two organic-rich sediment cores collected from an eroded trough on the inner shelf of the Sabrina Coast contain abundant palynomorphs, providing a glimpse into the terrestrial environment of East Antarctica before the onset of long-term glaciation. The sedimentology, seismic stratigraphy and palynology suggest a complex paratropical deltaic environment on the Sabrina Coast. This interpretation is complicated by the presence in one core of abundant angular cobbles and gravel that are assumed to be ice-rafted.

One of the cores contains a large gastropod and a large spherical concretion formed around a presumed fossilized flower bud or a monocot leaf stem. The sediment matrix yielded abundant palynomorphs that evidence a warm terrestrial paleoenvironment. The palynological assemblage is dominated by *Gambierina rudata* and *G.edwardsii* complexes. Proteaceae are also abundant and diverse and include *P. tenuixinus*, along with previously undescribed species. This angiosperm-dominated assemblage also includes *Battenipollis sectilis*, *Forcipites* spp. and *Nothofagidites* spp. (mostly belonging to the *N. cf. rocaensis*-*cf. flemingii* complex), along with a few fern spores such as *Laevigatosporites ovatus*, and moderate presence of conifers such as *Phyllocladites mawsonii* and *Microalaticites paleogenicus*.

Dating the sequence based on this assemblage is not simple as this is a previously undescribed Antarctic flora. Based on some key biostratigraphic data and the most abundant species (such as the *Gambierina* spp.), this interval could fit within the latest Paleocene upper *Lygistepollenites balmei* Zone to Early Eocene *Malvacipollis diversus* Zone. Most of the pollen recovered are pristine, suggesting that most of these represent the penecontemporaneous vegetation. *Battenipollis sectilis* and *Forcipites* spp. could possibly be reworked from Cretaceous/early Paleocene unless they were able to survive longer in this part of Antarctica. Truswell and Macphail (2009) suggested that *Gambierina* spp. could have survived to the Middle to Late Eocene near Prydz Bay, but many typical Late Eocene flora are missing or rare (i.e. abundant *Podocarpidites* spp. and *Nothofagidites lachlaniae*). Also notably absent are palm pollen commonly recorded from Early Eocene intervals in close proximity to our site from eastern Wilkes Land (Contreras et al., 2013).

The presence of *Proteacidites* spp. and small numbers of *Nothofagidites* spp. (in contrast with their dominance in Late Eocene and ice-house Antarctic sections) suggest a warm Late Paleocene/Early to Middle Eocene climate. The dominant in situ *Gambierina* species are of unknown paleobotanical affinity, so little can be inferred yet on the type of environment that would have allowed these plants to thrive on the Sabrina Coast. The absence of palm pollen recently documented from this same margin would suggest either a significant paleoenvironmental gradient from east to west along the East Antarctic margin and/or restriction to a middle Eocene age for the assemblage we describe herein. This later interpretation is more consistent with suggestions of small ice sheets in East Antarctica, commencing in the middle Eocene (Villa et al, 2014), but requires a reassessment of regional palynostratigraphy.

## ***West Antarctic Ice Sheet retreat in the eastern Ross Sea – A post-LGM deglacial chronology from foraminiferal radiocarbon dates***

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Two recent studies presented radiocarbon dates from eastern Ross Sea, which suggest that the West Antarctic Ice Sheet (WAIS) retreated from outer continental shelf prior to the Last Glacial Maximum (LGM). To date, no mechanisms have been proposed to explain a pre-LGM WAIS retreat. Moreover, this interpretation is at odds with post-LGM deglacial chronologies from most other Antarctic margins. One key objective of expedition NBP1502B was to test the pre-LGM retreat hypothesis. A suite of 15 Kasten and 6 Jumbo Piston cores were obtained along the axis of the Whales Deep paleo-ice-stream trough. The core sites were selected on the basis of a new large-area multibeam survey and regional seismic stratigraphy. These geophysical data show a backstepping succession of grounding zone wedges (GZWs), which show the former grounding-line positions occupied by the WAIS as it vacated the outer- and middle-shelf sectors of the paleo-ice-stream trough and moved southward to the modern grounding line. Here we present thirteen radiocarbon dates from in situ foraminifera that were isolated from sediment facies corresponding to three distinct paleo-environments identified in core: 1) a GZW marine foreset, 2) a sub-ice-shelf setting, and 3) an open-marine setting. The dates are fully consistent with a newly developed regional-scale synthesis of sedimentology, stratigraphy and seafloor geomorphology. The synthesis suggests that the WAIS had advanced to the shelf edge sometime after  $46.7 \pm 0.5$  cal kyr BP and remained grounded throughout the LGM. At least a short-distance grounding-line retreat from the shelf edge had begun by  $14.7 \pm 0.5$  cal kyr BP. A relatively-small ice shelf was concomitantly established over the part of the outer shelf that was formerly covered by grounded ice. Over the next 3200 years, an overall 50-km retreat of grounded ice to the middle shelf was interrupted at least five times. These interruptions were sufficient to construct five discrete back-stepped GZWs detected from multibeam bathymetry and seismic stratigraphy. The small ice-shelf broke up prior to the end of the fifth grounding event at  $12.2 \pm 0.4$  cal kyr BP but the grounding line remained stable on the middle shelf for nearly a millennia until grounded ice retreated at  $11.5 \pm 0.3$  cal kyr BP. This chronology requires a post-LGM retreat of the WAIS from the Whales Deep paleo-ice-stream trough. The previously published WAIS chronologies indicating a pre-LGM retreat in eastern Ross Sea should be considered suspect.

## ***What do McMurdo Dry Valleys paleolake deltas really tell us about grounding line position? New Insights from Garwood Valley***

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Lacustrine and perched delta deposits in the McMurdo Dry Valleys (MDV) of Antarctica are widely considered to be evidence of valley-filling lakes dammed by the grounded Ross Sea Ice Sheet during the last glacial maximum (LGM). We used luminescence dating to determine the age of paleolake deltas and glacial tills in Garwood Valley, a coastal valley that opens to the Ross Sea. Samples were collected from delta topsets and from associated tills and alluvium. Luminescence results are stratigraphically consistent with radiocarbon results from algal mats within the same delta deposits and are geomorphically consistent based on topographic and cross-cutting relationships (i.e., delta topsets are younger for deltas that onlap onto pre-existing deltas). Results suggest that delta deposition into paleolake Howard in Garwood Valley persisted until ~3 ka. This date is significantly younger than when grounded ice is thought to have retreated southward past McMurdo Sound and the MDV, suggesting that locally stranded ice intrusions, rather than regional ice sheet dynamics, may control lake levels for some MDV paleolakes. Modern examples of such ice-bounded lakes are common in the MDV. We show that such lakes have the potential to provide a novel climate record for the MDV region extending into the mid- to late-Holocene.

## **S11. Antarctic permafrost, periglacial processes and soil development**

### ***Active layer hydrologic controls on the geochemistry of Lake Vanda, Antarctica***

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Lake Vanda is the deepest and warmest lake in the McMurdo Dry Valleys, and is fed by the largest river on the continent of Antarctica. The hypersaline bottom water of Lake Vanda is unique in comparison to other Dry Valley lakes, being dominated by calcium chloride rather than sodium chloride. Existing hypotheses on the origin of the hypersaline bottom water of the lake include cryoconcentration during lake ice formation, surface evaporation during periods of lake level decline, and the potential influence of groundwater. To further explore the role of active layer and deep groundwater brines in controlling the geochemistry of Lake Vanda, a geophysical survey of below-ground resistivity was carried out in central Wright Valley using a helicopter mounted airborne electromagnetic (AEM) sensor in December 2011. Our AEM survey collected 31 km of resistivity data above and surrounding Lake Vanda to a maximum penetration depth of 100 to 600 meters depending on the substrate. In this polar-desert environment, high resistivity values (>1000 ohm-m) are interpreted as ice, bedrock, or permafrost, whereas low resistivity values (<10 ohm-m) indicate the presence of liquid water.

The AEM survey revealed resistivities <1 ohm-m in and beneath the bottom of Lake Vanda and near the inflow of the Onyx River. A distinct low resistivity region at the eastern edge of the lake basin suggests that high conductivity brines may flow from the thaw zone of the Onyx River through unconsolidated lake sediments to the bottom of Lake Vanda. Given the size of the Onyx River, freeze thaw cycles in the active layer are a possible mechanism for brine production, which may control the geochemical signature of the lake. In addition, the extremely warm temperature of the bottom waters (> 20°C) maintains an open talik beneath Lake Vanda, preventing the underlying sediments from freezing. This further contributes to the extent and connectivity of the groundwater system. This is the first geophysical survey to provide evidence of subsurface flow through Lake Vanda sediments and provides a new outlook on our understanding of active layer hydrology in cold environments.

## ***Active layer thermal and moisture regime of Keller Peninsula, Maritime Antarctica: a case study***

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The soil thermal regime, the presence of permafrost and active layer are related to various environmental attributes that may indicate regional climate changes in Maritime Antarctica region. We evaluated the thermal and moisture regime, air and soil temperature between the 2011 and 2014, aiming at understanding the active layer and permafrost dynamics at four representative sites located in Keller Peninsula, King George Island, Maritime Antarctica. Site 1 to 4 represents: (1) Leptosol gelic, (2) Criossol Skeletic, (3) Regosol skeletal-gelic. (4) Patterned ground. There is a great variability of active layer thermal regime between the four-years monitoring period. The highest mean annual air temperature during the period at the four sites studied was -1.7 °C on site II, and the lowest annual average temperature was -4.8 °C at site III. The highest mean monthly soil temperature was 5.0 °C ( $\pm 3.9$ ), and the lowest minimum daily temperature was -8.5 °C ( $\pm 4.2$ ), both at 10 cm depth in site II. The longest thawing period of the active layer was January 2012 for site I, and January 2012, 2013 and 2014 for site II, with 31 days of thawing at all depths studied. The largest sum of thawing degree days of 154.6 °C in site II, at 10 cm, in January 2012. The soil remained frozen at all sites, during the period between August and September during the entire monitoring period. The lowest sum of Freezing degree days was 263.3 °C in July 2011 at site II. Simple linear regression analysis for all sites showed a mean daily temperature below 0 °C. In sites I, II and III the thickness of the active layer was 1.39 m, 1.50 m and 1.08 m respectively, so that permafrost was absent down to 100cm, one of the requirements for classifying Cryosols. At the patterned ground (site III), the thermal regime reached the permafrost layer at 77 cm depth at the edge of the polygon, and 70 cm at the center, indicating active cryoturbation and convection. There was correlation between AAO x Air Temperature (Ta) and SOI X Air Temperature (Ta), with a 19 and 13 months delay between phases, respectively. This result was consistent with active layer regime of site II, where the phase delay between the above-mentioned series was 14 months and 13 months respectively.

## ***An environmental magnetic approach to understand pedogenesis in Larsemann Hills, East Antarctica***

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Pedogenesis is one of the key processes on the Earth's surface. In the cold desert of Antarctica, soil formation is mainly attributed to physical weathering rather than chemical weathering. However, in the Antarctic Peninsula (which is the warmest and wettest area in Antarctica), chemical weathering is prominent, leading to the transformation of primary minerals into secondary minerals. According to Jenny (1941), five factors control the formation of soils: lithology, topography, organic matter, climate and time. Whereas a lot has been researched on the textural characteristics of soils and their mode of formation in the Antarctic Peninsula, such studies are rare in the East Antarctica region. Environmental magnetic techniques offer tremendous potential in establishing the role of soil formation. These techniques are rapid, non-destructive, inexpensive and sensitive. Several studies using environmental magnetic methods have been carried out on tropical and temperate soils but not on soils of polar regions. In this study, we have investigated the rock magnetic properties of soil samples from seven locations in the Larsemann Hills - a 50 sq. km. ice-free region located on the Ingrid Christensen Coast of Princess Elizabeth Land, East Antarctica and comprise of two main peninsulas, i.e., the Broknes and the Stornes. The area is surrounded by small islands. The lithology of Larsemann Hills is dominated by low-pressure granulite facies, meta-sedimentary gneisses and partial melt bodies. Sixty seven surface soil samples were collected from the catchment of seven lakes in the Larsemann Hills during the 33rd Indian Scientific Expedition to Antarctica. A range of environmental magnetic measurements were made following standard procedures (Walden et al., 1999) and inter-parametric ratios calculated.

The samples from Bharati station (AK), Murkwater Lake (MWL) and Reid Lake (RL) have high magnetic susceptibility ( $\chi_{lf}$ ) values, suggesting a high concentration of magnetic minerals. The samples from Mochou Lake (ML) exhibit moderate  $\chi_{lf}$  values whereas those from Discussion Lake (DL), LH-73 Lake (LH-73) and Stepped Lake (SL) show low  $\chi_{lf}$  values. The magnetic susceptibility signal in all the samples is primarily controlled by magnetic grains in the multi-domain (MD) and pseudo-single domain (PSD) size range; besides, a negligible amount of superparamagnetic (SP) grains is present, which is evident from the  $\chi_{fd}$  % values of < 2 % for all the samples. Therefore, the intensity of pedogenesis is remarkably low, the magnetic minerals being derived primarily from parent rocks in the lake catchment areas. It is well known that magnetic grain size is in the MD and PSD range when magnetic minerals are derived from parent rocks. The magnetic mineralogy is magnetite or titanomagnetite as evident from the high S-ratio values and the isothermal remanence acquisition curves. The preliminary environmental magnetic results obtained indicate that physical weathering is dominant in the Larsemann Hills and the role of chemical weathering is insignificant.



## ***Austral winter imaging of Don Juan Pond: Polar desert brine flow at -40°C***

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Don Juan Pond (DJP) [1], in Wright Valley, is the most saline body of water on Earth. Summer observations indicate that lake level is controlled by deliquescence-derived brine [2], snowmelt, and potential input from a deeper aquifer [3]. With a eutectic temperature of -51.8°C [4], it is unlikely that the CaCl<sub>2</sub> brine in DJP ever freezes. Documentation of the behavior of DJP in winter, however, has not occurred. Here, we describe the full-year behavior of DJP by using the first time-lapse imaging during winter, when temperatures (~-30°C - ~-40°C) restrict freshwater processes.

DJP remains unfrozen during austral winter. Surprisingly, changes in lake level and shoreline position occur throughout the winter, indicating that discharge into the basin occurs year-round. In fall, discharge is focused in the east, where seepage of CaCl<sub>2</sub>-rich active layer liquids has been documented [12]. Ponding in this zone recedes such that it is disconnected from DJP by the end of April. Standing water is also observed within the southwestern region of the basin.

In mid-winter, reflected light from the gibbous moon reveals discharge and ponding occurring in the western portion of the basin. Channels emerging from the toe of the lobe west of DJP are liquid-filled in the winter. Standing water in the east varies in extent during the winter, at times existing only as a small pool disconnected from DJP, and never expanding beyond its fall and spring extents.

From September through October, pond levels drop to near summertime levels. Surface temperatures do not reach 0°C until early November. Activity in the east in October increases with expansion of ponded fluids, further in extent than had been observed during austral summer.

These initial observations suggest that discharge into DJP occurs from multiple sources. Seepage from the east is a perennial phenomenon. Non-summer Discharge and ponding in the west is limited to mid-winter. The proximity of this discharge to the debris lobe could be coincidental, but the lobe may serve as (1) a potential reservoir for brines or (2) an aquiclude for a groundwater source. Fluids could become pressurized and discharged as a result of freezing and expansion within the lobe or beneath it.

Our results indicate that, unlike fresh-water sourced ice-covered lakes in the Dry Valleys, DJP experiences increased pond level during austral winter and net evaporation during austral summer.

[1] Meyer, G. H. et al. (1962) *Science*, 1103-1104. [2] Dickson, J. L. et al. (2013) *Scientific Reports*, 10.1038/srep01166. [3] Harris, H. J. H. and K. Cartwright (1981) *DVDP, Ant. Res. Ser.* 33, 161-184. [4] Marion, G. M. (1997) *Antarctic Sci.* 9, 92-99.

## ***Chronosequence of ornithogenic, volcanic soils on olivine basalts from Barrientos Island, maritime Antarctica***

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Great amounts of organic matter deposited by marine birds, especially penguins, are accumulated on ice-free areas of Maritime Antarctica during the short austral summer. The well-known ornithogenic soils of this region are unique to Antarctica, and represent important sites where phosphatization is the main soil-forming process. Most studies were conducted on andesite and acid parent materials, and no reports are available of ornithogenic soils on mafic volcanics from Antarctica. This study reports the main chemical, physical and mineralogical characteristics of a topo-chronosequence of ornithogenic soils of Barrientos, an island totally covered by vegetation, evaluating the effects of altitude, sea proximity and bird species. Five soils in a topo-chronosequence were selected. No permafrost was detected down to 100 cm and thermal profiles to this depth indicates its absence down to 200cm. Hence, soils were classified as Entisols or Inceptisols by Soil Taxonomy (SSS, 2010) or Leptosols and Cambisols by the WRB/FAO. Soils are comparatively deep, with coarse textured, with a predominance of sand>silt.. High amounts of Na in all soils across the island indicate the general influence of salt-sprays due to the constant wind. Extractable P was high, but less marked in Petrels nest, compared with penguins, although the later was younger in age. The amounts of exchangeable Ca and Mg were very high, due to olivine basalt composition of the parent material and low leaching of bases. Clay mineralogy is basically composed by smectites, vermiculite, plagioclases, apatite and strengite. The amount of bioavailable P of Barrientos island is comparatively lower to other ornithogenic soils under penguin, suggesting an old age of Barrientos soils and lower presente-day penguin activity. This suggest that P levels can be used as proxies for estimating penguin populations in future studies involving larger soil databases.

## ***Dust distribution in the SW Ross Sea, Antarctica***

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Dust derived from ice-free areas around the Antarctic coast is an important but poorly-constrained source of sediment and micro-nutrients including iron into the Ross Sea. Previous studies in southern McMurdo Sound suggest most dust originates from a relatively small area of unconsolidated debris on the McMurdo Ice shelf and is blown northward and offshore by the dominant southerly airflow forming a plume that decreases in mass and particle size away from source. Further north, in the Terra Nova Bay area, katabatic airflow channels dust from several local sources directly offshore into Terra Nova Bay polynya. In these locations, the distinctive particle size distributions of windblown sediment have been recognised in sea floor grab samples 10's of km offshore. Moreover, reanalysis of regional wind field data and numerical modelling suggest the dust may actually be distributed much farther (hundreds km) offshore overlapping with the Ross Sea polynya where vast phytoplankton blooms occur each summer.

We present new dust composition data from a network of samples from potential source areas along the Victoria Land coast between McMurdo Sound and Terra Nova Bay, as well as samples from extensive areas sea ice and ice shelves fringing the coast and also from sea floor grab samples from across the SW Ross Sea. Preliminary X-ray fluorescence analysis of major elements suggests dust on sea ice can be matched to various source areas and different geological terranes. We plan to combine XRF analyses of sea floor sediment with additional numerical modelling of dust flux to trace dust from onshore sources to offshore Ross Sea sink. This will contribute to an improved understanding of the impact of dust on primary productivity, biogeochemical cycling and sedimentation in the region.

## ***Fractal dimension to evaluate the spatial variability of soil attributes in a typical periglacial area of Maritime Antarctica***

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Terrestrial ecosystems of Maritime Antarctica are very heterogeneous under periglacial conditions, but spatial variability structure of soil attributes is yet unknown. The objective of this study was to characterize, by means of a fractal dimension, the spatial variability structure of soil attributes in a typical periglacial area in Keller Peninsula, King George Island, Maritime Antarctica. A typical ice-free area was selected in February 2015 for surveying and sampling, and soil general attributes and total organic carbon were determined. A principal component analysis (PCA) was performed to select the most important soil attributes, according to their contribution to the

total variance in the selected area. The spatial variability structure characterization was performed by deriving fractal dimension values (FD) from experimental semivariograms calculated at angles of 0, 45, 90 and 135° in a 133 point grid (50x50 m), with a minimum separation distance of 0.5 m. Scales of 0.5/5; 1/10; 2/20; 3/30; 4/40 and 5/50 m (separation distance/range) were considered in this study. The most important soil attributes retained by PCA were: exchangeable Al, total acidity (H+Al), bases sum (BS), C content (% C), extractable Fe and % Sand. Topologically significant DF values (FD < 3) were obtained for all calculated scales in average, indicating significant spatial variability structure for most soil attributes determined. Mean FD values were significantly lower ( $p < 0.05$ ) at a small scale (5 m) and large scales (40 and 50 m) in the 90° direction, which tended to present anisotropic pattern, especially for C and Al. These attributes (C and Al) presented spatial similarity based on the observed

fractogram, and corroborated by significant correlation. Results indicate that factors like guano input, colonization by mosses and lichens, and soil drainage, significantly affected the spatial variability structure of soil attributes, highlighting zones where soil is more or less heterogeneous. The FD approach provided a meaningful way to look at the pattern of pedogenesis and its spatial variation under periglacial conditions.

## ***High-resolution imagery acquisition with an UAV for mapping the ice-free areas of Barton Peninsula (King George Island, Antarctica)***

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The Antarctic Peninsula is one of the Earth's regions that have shown strongest warming on the last six decades. Some of the ice-free areas in this continent are located in this region assuming particular relevance to understand the present changes in the cryosphere. Between 2014 and 2016 three campaigns, were conducted in Barton Peninsula, located in King George Island, part of the South Shetland Islands, with the purpose of acquiring high-resolution remote sensing images using a light UAV – eBee.

Environmental concerns for flying UAV's in Antarctica imposed the use of specific procedures when preparing and conducting the flights. We obtained georeferenced images with a spatial resolution of <4cm on two sets of composite images: Red, Green and Blue (RGB) and Near Infrared (NIR). A total of eighteen flights generated RGB images, and twelve flights, NIR images, covering over two thirds of the area of Barton Peninsula.

An integrated software package based on Structure from Motion (SfM) technics was used to process the individual images and generating mosaics of the surveyed areas. This process generates an ortophotomap and a Digital Surface Model (DSM) for the areas flown. Ground Control Points (GCP) obtained by use of a differential GPS were inserted to the mosaics increasing the geolocation accuracy of the ortophotomaps. High resolution contours with 50 cm equidistance and the extraction of derivate information originate a high quality tool for detailed geomorphological and terrain analysis making small periglacial structures like stone circles becoming observable. Vegetation enhanced by the NIR images are also visible allowing classification and delimitation of communities.

## ***Hydrochemistry of groundwater suprapermafrost in the Machu Picchu aquifer***

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Machu Picchu Peruvian station is located on King George Island, South Shetland Islands, Antarctic Peninsula. Hydrogeology research were conducted during the austral summer 2015, we took groundwater samples in 7 piezometers for analysis of major and minor components, and dissolved metals.

Machu Picchu aquifer is a detrital aquifer and it is composed of glacial, alluvial, marine, fluvial, alluvial fluvial and alluvial glacial deposits. Lithological data in piezometers show that about 3 meters deep, there are 3 horizons (Ng et al., 2015): Horizon H1 (more superficial, permeable and porous soil), Horizon 2 (intermediate, semi-permeable to impermeable) and Horizon 3 (depper horizon, permeable and porous ground where groundwater is stored). Groundwater flow is from South to North.

Electrical conductivity in the piezometers are low: 92.45 (PZ-08), 126.1 (PZ-07), 218.0 (PZ-04), 219.2 (PZ-03), 219.6 (PZ-06), 324.4 (PZ-09) and 512.5 uS/cm (PZ-05). Watertypes are mixing: Na-Ca-Cl-SO<sub>4</sub> (PZ-08), Ca-Na-SO<sub>4</sub>-HCO<sub>3</sub>-Cl (PZ-07), Ca-Na-SO<sub>4</sub> (PZ-04), Na-Ca-Mg-SO<sub>4</sub>-Cl (PZ-03), Ca-Na-SO<sub>4</sub>-Cl-HCO<sub>3</sub> (PZ-06), Na-Ca-Mg-SO<sub>4</sub>-Cl (PZ-09) and Ca-SO<sub>4</sub> (PZ-05). Na and Cl values are related to local recharge by thawing snow. Groundwater has low values of Al, Cu, Sr, He, Li, Mn, Ni and Zn; while values of Sb, As, Be, Bi, Cd, Cr, Sn, Hg, Mo, Ag, Pb, Se, Ti, U y V were below the detection limit.

# ***Impact of periglacial processes on rocky coast geomorphology in Admiralty Bay, King George Island, Antarctic***

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In contrast to mid and low latitude coasts, relatively little is known regarding the potential impacts of climate and sea-level change on polar coastal margins. Indeed, many of the existing intellectual paradigms regarding the functioning of polar coasts are now out-dated, based on descriptive geomorphology and a limited process-based understanding.

Our work aims to address this deficiency in understanding by quantifying the processes controlling the evolution and behaviour of rock coasts in polar climates, based on representative examples from South Shetland Islands (Antarctic).

The pristine coasts of Admiralty Bay, King George Island provide a superb opportunity to quantify how sub-Antarctic rock coasts are responding to sea-level changes and intensification of periglacial and paraglacial processes associated with climate warming. The selected coastline forms part of the South Shetlands strandflat, which is characterized by diverse range of coastal landforms. The rock cliffs and shore platforms in selected area are formed in volcanic rocks (Birkenmajer 1980). To our knowledge, a paper by Marsz (1996) is the only study to have considered any aspects of the rock coast geomorphology within Admiralty Bay (King George Island, South Shetlands), presenting a descriptive study of so-called weathered shores, assumed to form through frost shattering of rockwalls under a cold and wet sub-Antarctic climate.

In our project we utilise a rigorous, coherent and novel suite of techniques to analyse the spatially and temporally diverse range of processes and responses controlling the polar rock coast environments:

- Schmidt Hammer and Equotip tests of rock surface resistance
- micro-erosion meter measurements of rock surface downwearing rates
- observations of seasonal changes in the state of permafrost developed in solid rocks using electrical resistivity tomography (ERT)
- monitoring of thermal state of the rocky cliffs and platforms using network of thermistors
- photogrammetric analysis of digital images of scanned cliffs and platforms and GIS processing of obtained data

In this paper we present the results of the first field campaign of the project carried out in austral summer 2016 in Admiralty Bay that focused on:

- pilot survey of rock resistance using Schmidt Hammer Rock Tests (SHRT) and Equotip (EQ) across the modern and uplifted shore platforms formed in various volcanic rocks
- pilot measurements of shore platform downwearing using the Traverse Micro-Erosion Meter (TMEM)
- mapping coastal permafrost distribution using ERT

SHRT, EQ and TMEM surveys along several morphologically different coast types demonstrated broad variety of interrelations between rock surface resistance and distance from present-day shoreline as well as thickness of sediment and snow covers. The results of ERT survey suggest that most of the rocky capes and platforms are free of continuous permafrost and frozen ground conditions develop further inland along mountain slopes and plateaux.

This paper is a contribution to the National Science Centre in Poland OPUS project UMO2013/11/B/ST10/00283:

POROCO – Mechanisms controlling the evolution and geomorphology of rock coasts in polar climates’.

## ***Is rock varnish from the McMurdo Dry Valleys the result of the interplay between dust accretion and biogeochemical weathering?***

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Rock varnish is a glossy, yellowish to dark brown coating that in arid lands covers geomorphically stable, aerially exposed rock surfaces and landforms. In warm deserts, rock varnish consists of clay minerals and Mn-Fe oxides/hydroxides, occasionally containing sulphates, carbonates, phosphates, and organic particles. In Antarctica, rock varnish has been described being mostly formed of Si, Al, Fe, and sulphates; whereas Mn/Fe-rich coatings were rarely observed. Moreover, the development of rock varnish is often related to the physiographic unit where it grows, and therefore, in a same area, distinct geomorphological features (e.g., horizontal or vertical rock surfaces, fractures, weathering pits...) may display different degrees of varnishing or a specific stratigraphy and chemical composition of varnish microlayers. For that reason, we collected samples of rock coatings developed on sandstones outcropping at different localities of the Dry Valleys of Antarctica; samples belong to horizontal rock surfaces and weathering pits. In the most of samples from rock surfaces, the varnishing is extremely complex and multi-layered. Optical microscope evidenced the occurrence of highly birefringent material, occasionally thinly laminated, which is enriched in Si and Al. Few micron-thick, dark lenses and continuous strata interlayer this coating. The dark features are well evident under the scanning electron microscope and chemical analysis (EDS microprobe) confirmed that they consist of different kinds of sulphates, mostly belonging to the jarosite-alunite series; moreover, gypsum crystals were also found, interspersed in the Si and Al-bearing varnish. Fe-rich crusts and coatings were also detected, sometimes preserving the shape of the hyphae they have replaced. The samples collected from the bottom of weathering pits evidenced some differences: they are thinner and rarely display a tinny Si/Al-bearing rock varnish. On the contrary, these samples generally show a yellowish brown rind around the external quartz grains, which are often coated or cemented by an amorphous, dark Mn/Fe-rich rock varnish. Preliminary data suggest that the formation of rock varnish in the Dry Valleys of Antarctica was a complex process, requiring the accretion of airborne dust of variable composition and subsequent precipitation and recrystallization of some constituent, including the enrichment of elements leached from the rock substrate. Microorganisms possibly drove the processes of precipitation and recrystallization. On the contrary, the formation of Mn-rich varnish in weathering pits should be related to the occurrence of higher environmental humidity within these features. As evident, rock varnish in the Dry Valleys represents a potential tool to reconstruct past oscillations in environmental humidity, changes in the aeolian fallout, and more in general to reconstruct the surface processes occurred in the region.



## ***Mapping of periglacial and other surface features using polarimetric RADARSAT-2 data in Cape Lamb, Vega Island, northern Antarctic Peninsula region***

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The ice-free areas of the northern Antarctic Peninsula region show a diversity of geomorphological processes and landforms. Climate change influences surface processes and to an increasing extent conditions for vegetation and soil formation. Therefore, changes are occurring within an area where periglacial processes have a dominant presence within the ice-free areas. In this case, remotely sensed radar techniques using Synthetic Aperture Radar (SAR) data are ideal for determining the surface geomorphology within these regions as the SAR sensors provide the capacity to obtain information even in the harsh weather conditions found in this part of Antarctica.

The objective of this work is to map the geomorphological landforms within Cape Lamb on Vega Island using fully polarimetric SAR RADARSAT-2 data. Periglacial features are dominant and are accompanied by landforms and deposits of glacial, fluvial and coastal origin. A quad-pol fine wide image as Single Look Complex data was acquired through the Canadian Space Agency within the framework of the Science and Operational Applications Research Program (Project SOAR-5169) on the 7th of March 2015. Pre-processing of the RADARSAT-2 data includes radiometric correction, using a bilateral polarimetric speckle filter, terrain and geometric correction. Thereafter, polarimetric parameters are extracted and related to the different surface covers according to the backscattering characteristics received by the sensor. A supervised classification is carried out using Random Forest (RF), a decision tree-based classifier. Detailed field observations are used as reference for the classifier where the importance of each polarimetric parameter is determined in characterizing a particular surface cover.

The results obtained show that individual scattering mechanisms are well identified with the polarimetric RADARSAT-2 data and can be associated to different geomorphological landforms and surface cover features that are closely related to their physical properties and the influence of topography. Using RF, a variable ranking of the polarimetric parameters for individual terrain classes can be obtained. This is useful when trying to distinguish different classes that bear resemblance to each other such as pattern grounds, pavements and stone fields. The final mapping is therefore based using important variables obtained from the polarimetric data.

## ***Microbial assemblage and metabolism in the brines of two Antarctic frozen lakes (Boulder Clay, Northern Victoria Land)***

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Frozen lakes are a prominent structure in the ice-free regions of Antarctica and such perennial glacial lakes sometimes encapsulate lenses of brines, representing an extreme cryogenic ecosystem. The study of these unique environments allows insights on the geochemical processes affecting the microbial life in analogues terrestrial cryoecosystems and increases our perceptions on possible traces of life that must be sought beyond Earth.

In order to find new extreme refugia for microbial life, in October-November 2014 a screening of several frozen lakes in the Northern Victoria Land through the ground probing radar (GPR) investigation was made. Two lenses of liquid brines were found at different depths in two adjacent frozen Boulder Clay lakes (Lake-1: 2.5 m; Lake-2: 2.0) and had a different salinity (0.2 and 3.6 mS/cm, respectively) and pH (8.17 and 8.76, respectively).

Brines were sampled under sterile conditions and analysed by microscopic image-analysis to assess prokaryotic abundance, cell-shape, and respiring cells (CTC+) and by flow-cytometry to determine virus abundance. Moreover, the physiological profiles by Biolog-Ecoplate™ were determined as well as the potential ectoenzymatic activities rates (leucine-aminopeptidase, LAP;  $\beta$ -glucosidase,  $\beta$ -GLU; alkaline-phosphatase, AP).

Prokaryotic abundances in the brines of the two lakes were in the order of 10<sup>8</sup>-10<sup>9</sup> cells L<sup>-1</sup> (Lake-1>Lake-2) and respiring cells were comprised between 0.2 and 1 % (Lake-1>Lake-2) of the total abundance. Viral numbers exceeded prokaryotic numbers by two orders of magnitude in both brine lakes (Lake-1>Lake-2). Mean cell volumes ranged between 0.138 (Lake-2) and 0.242  $\mu$ m<sup>3</sup> (Lake-1). The different shapes of the cells in the brine of the two lakes were ascribable to six morphotypes, as follows: vibrios, coccobacilli, cocci, rods, curved rods and filamentous forms. In Lake 2 only coccobacilli and rods were detected. The prokaryotic biomass varied widely between the two lakes and was surprisingly high in Lake 1 (567  $\mu$ g C L<sup>-1</sup>).

The physiological profiles revealed differences in the quality of used substrates in the two lakes. In the brine of Lake-1 higher values of LAP (2.0 nmol L<sup>-1</sup> h<sup>-1</sup>) and AP (3.9 nmol L<sup>-1</sup> h<sup>-1</sup>) were detected than in Lake-2, suggesting the presence of cells more able to decompose proteins and organic phosphates; the  $\beta$ -glucosidase activity on polysaccharides was negligible in Lake-1 and high in Lake-2 (0.1 and 1.6 nmol L<sup>-1</sup> h<sup>-1</sup>, respectively).

This first screening of prokaryotic assemblages in the brines of these two Antarctic frozen lake has highlighted a different habitability of these cryoenvironments.

## ***Projecting Potential Distribution Model of *Sanionia uncinata* (Hedw.) Loeske for two Holocene periods in the Fildes Peninsula, King George Island.***

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In Antarctica, specifically in the South Shetland Islands, warmer conditions that occurred after the last glacial maximum prompted the phasing out of the ice with the consequently exposure of ice-free areas, favourable to colonizer species. The geomorphology of these ice-free areas shows processes such as glacier fluctuations, isostatic rebounds and marine transgressions, suggesting that the current ice-free areas have undergone a number of changes from the Last Glacial Maximum. However, the evolution and spatial extent of those areas suitable for vegetation colonization is still unknown.

In general, a specific combination of ice-free soil and abiotic factors creates suitable conditions for some species to colonize new areas and develop. Among colonizing species adapted to extreme environmental conditions, the moss *Sanionia uncinata* Hedw. Loeske is the most widely distributed throughout the South Shetland Islands. However, at the moment there are no records about its past distribution and population dynamics (mostly related to glacier fluctuation), which resulted in its current distribution.

The aim of this study is to reconstruct the potential distribution of *S. uncinata* in the Fildes Peninsula, King George Island, for the past 15,000 years, using an ecological niche model. This entails: defining the spatial configuration of *S. uncinata* for given time periods during of the last 15 kyr; build and validate a model of its potential distribution and then project the potential distribution for the last 15 kyr.

MAXENT platform was selected to create and project the potential distribution model. In addition, a geographic information system supported the extraction of abiotic variables and the spatial analysis of the results. The selection of ice-free time periods as well as the reconstruction of corresponding temperatures were based on literature.

Finally, combining topographic variables (elevation, slope and exposure) and temperature, the model of potential distribution of *S. uncinata* was built, and then projected for the years 11,000 BP and 6,000 BP. The weight of each variable was evaluated by model calibration and comparison with the Normalized Difference Vegetation Index (NDVI).

The resulting potential distribution was validated against the current extent of *S. uncinata*, using a NDVI map. The results of the distribution model successfully identified the ranges of abiotic variables that increase the likelihood of presence of *S. uncinata* in the study area.

## ***Prokaryotes in Antarctic permafrost: abundances and metabolism in the Northern Victoria Land and Upper Victoria Valley.***

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Our contribution is devoted to test the hypothesis that Continental Antarctic permafrost harboured prokaryotic communities rich in viable cells and metabolic potentials. With this aim, three permafrost cores collected in Boulder Clay (Northern Victoria Land) were examined for the prokaryotic abundance, viability, and potential metabolism using culture-independent methods. Samples were analysed by microscopic image-analysis to assess abundance and cell-shape determinations, and by flow-cytometry to recognise sub-populations according to nucleic acid contents. The quantification of viable and respiring cells was performed by image analysis using the Live/Dead and 5-Cyano-2,3-ditolyl-tetrazolium chloride stains, respectively. The potential ectoenzymatic activities rates on proteinaceous (leucine-aminopeptidase) and glucidic ( $\beta$ -glucosidase) organic matter and on organic phosphates (alkaline-phosphatase) were determined as well as the physiological profiles by Biolog-Ecoplate™. In comparison, another permafrost sample, collected from the Dry Valleys (Upper Victoria Valley), was analysed by the same methods.

Cell counts ranged in the order of 10<sup>5</sup>-10<sup>6</sup> cells g<sup>-1</sup> of permafrost. Viable/respiring cells were comprised between 11 and 86% of the total abundance and increased with increasing depth. The high values of LAP and  $\beta$ -GLU suggested the presence of cells particularly able to decompose proteins and polysaccharides. However, the decreasing vertical pattern of LAP activity inside the Boulder Clay stations reflected a progressive decomposition of labile organic matter.

The physiological profiles described that the prokaryotic community expressed wide metabolic potentials and revealed differences in the quality of substrates used at different depths.

Finally, the cluster analysis carried out on all the data revealed some differences and similarities among the Boulder Clay and Dry Valleys samples. These findings could be attributed to the intrinsic sample characteristics, like as to the exchange with external input of liquid water, exchanges with atmosphere, sources of underground liquid waters and daily/yearly temperature variations.

In conclusion, our contribution fills some gaps in the knowledge of the permafrost prokaryotic assemblage using culture-independent techniques, confirming that permafrost of Victoria Land - in depth levels less than 550 cm - hosts a community rich in viable cells, in terms of both cells with intact membranes and respiring. They possess large metabolic potential and intense levels of functionality. This first screening of prokaryotic assemblages in the Victoria Land shows the biocomplexity of prokaryotic community in relation to intrinsic sample characteristics.

## ***Sediment transport history of marine sediment from microtextural analysis, Vestfold Hills, East Antarctica***

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Analysis of microscopic textural features of quartz grains was undertaken to infer transport processes of sediments in shallow marine and near-shore terrestrial environments near Davis station, Vestfold Hills, East Antarctica. The results presented here are part of a study at Geoscience Australia testing new methods for characterising marine sediment transport processes in nearshore environments. The Vestfold Hills are a 400 km<sup>2</sup> ice and snow free area located on the eastern shore of Prydz Bay, and thought to have remained exposed since at least the Last Glacial Maximum. Detailed observations and imaging of sand grains were acquired with a scanning electron microscope (SEM) and compared with published catalogues of textural features. Marine samples were taken from six grab samples in water up to 40 m deep. Terrestrial samples were derived from unconsolidated sediments from two excavation pits.

Quartz is an ideal mineral for microtextural analysis because of its hardness, resistance to weathering, and ubiquity in crustal rocks. Sedimentary transport processes can impart distinctive microscopic surface features as grains collide with each other. In near-shore shallow marine environments, however, there is added complexity from sediments derived from multiple sources and a variety of transport mechanisms. This study focussed on the dominant physical and chemical weathering features, rather than attempting to discriminate particular environments. Textural features that are considered characteristic of physical or mechanical weathering include conchoidal fractures (shell-like fracture shape), sharp or rounded grain edges, and irregular gouges on grain faces. Features considered typical of chemical weathering environments include irregular solution pits, oriented etch pits, precipitation of secondary silica, and scaling on the grain surfaces.

Samples from both environments had abundant conchoidal fractures, created by the impact of grains against each other in high energy environments. Grain edges were slightly rounded, indicating reworking in a lower energy environment. Oriented etch pits were observed on the marine samples, indicative of subaqueous transport. Evidence of chemical weathering was observed in samples from both settings. Grain faces were chemically eroded and small areas had secondary silica precipitated on the surface. Given the low solubility of silica in the near-surface and the cold, dry terrestrial environment of Antarctica, this finding was unexpected.

The textural results suggest these sediments have not been extensively transported by wind. Evidence of recent glacial entrainment was also not observed. The sediments have undergone at least two phases of transport, in a high energy environment followed by a lower energy, probably subaqueous, environment. This is consistent with the interpreted recent landscape evolution of the study area, with no recent glaciation. Future studies of terrestrial and marine geomorphology and sediment transport could be augmented with an investigation of sediment transport processes. Such studies enhance understanding of the dominant processes contributing to sediment flux in the water column and the nature of benthic substrates in near shore Antarctic environments to inform environment change monitoring and anthropogenic disturbance to habitats.

## ***Soil and geomorphology interactions in the Edson Hills glacial valley, Ellsworth Mountains, Continental Antarctica***

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The main relief units from the Edson Hills glacial valley from Ellsworth Mountains, with emphasis on the analysis of the geomorphologic interactions were identified. The soils were analyzed according to their morphological, physical and chemical properties; their salinity, surface boulder frequency, soil classification and soil weathering stages. Slightly creeping debris-mantled slopes, steep debris-mantled slopes, steep slopes, glacial cirques, talus deposits, supraglacial moraine, hummocky moraine, patterned ground, thawing lakes, frozen puddles, termokarst and aretes were the identified units. The debris-mantled were the most abundant units, indicating the importance of the paraglacial processes for the definition of the local relief. Glacial features such as the morainic systems demonstrate the current glacial action. Although they possibly not in phase, features produced by periglacial processes were identified in the fields of patterned grounds, termokarst, thawing lakes and frozen puddles. The soils from the glacial valley are very little pedogenetically evolved; however, it is remarkable the higher developments from the soils formed in the patterned grounds and in the moraine systems. All the soils have desert pavement due to the action of severe eolic erosion. The soils accumulate salt depending on the conditions of local draining. The most abundant soil classes among the sampled soils were Typic Haploturbel and Typic Anhyorthel, due to the trended presence of ice cemented permafrost on the lower portions of the landscape, particularly in the patterned grounds and in the hummocky moraine; and the presence of dry permafrost in relief units in higher positions of the landscape such as in debris-mantled slopes and talus deposits. Thus, we observed a close relationship among the soils characteristics from the glacial valley from Edson Hills and the relief unit where it develops. Furthermore, the relief units identified in the area suggest a great relationship with glacial, paraglacial and periglacial processes to its formation.

***Spatial database development based on metadata and GIS software:  
Applications for the Brazilian National Institute of the Cryosphere (INCT-  
Criosfera - Terrantar Center)***

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The Terrantar Center, based at the Federal University of Viçosa and member of the Brazilian National Institute of the Cryosphere, has been continuously conducting research on soil, permafrost and environmental monitoring in Antarctica and Andean high mountains in the last 14 years. During this period, a large volume of data was gathered, in the form of maps, theses, articles, images and analytical results. The objective of this work was to compile, organize and create an spatial database tailored to gather all the information of scientific interest, generated by the Terrantar team, and make them available through a Geoportal, composed by the metadata catalog and GIS software. The methodology was developed in a five steps approach: collection of data; grouping the data by geographic location; standardization of geographical information; metadata generation according to the ISO 19139 (Metadata Implementation Specification), held in ArcCatalog 10.2 software; and availability of data on the internet using the GeoServer and GeoNode systems for vector and raster files and Geonetwork systems for metadata, with option to download the data. Approximately 177 Gb of data has been recovered, in which the search can be performed by keyword or the geographical position through the advanced search on the map base. It is noteworthy that This is a dynamic process that always needs to be uploaded with new information, generated not only by Terrantar team, but also by contributions from researchers from other institutions. Access can be done by URL: <http://terrantar.ufv.br>.

## ***Study of depositional feature dynamic in periglacial environment***

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The dynamics of depositional features of a representative rock glacier of a periglacial area in Keller Peninsula, Maritime Antarctica, was studied by GPS monitoring of 12 points along the rock glacier surface, determining their velocities, amplitudes and directions. The experiment was installed in 2011, and measurements carried out to

2015, with a dual frequency GPS receiver, and post-processing based the RBMC installed at the neighboring Ferraz Station. We calculated the annual linear distance offset for all points from the UTM coordinates. The annual linear differences, the UTM latitudinal amplitude and longitudinal range were calculated at each point. The largest offset distance observed was 0.311 m, representing an average speed of 0.104 m.year<sup>-1</sup>. The shortest distance shift was 0.007 m, but the annual average speed over the entire period was 0.082 m.year<sup>-1</sup>. Considering the altitude, almost all points showed reduced heights, as well as soil displacement. Data between 2014 and 2015 suggest the occurrence of solifluction phenomenon at the rock glacier surface.



## ***The deglaciation of the ice-free areas in the South Shetland Islands. Examples from Byers (Livingston) and Barton (King George)***

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The process of deglaciation the present-day ice-free environments in the Maritime Antarctica has profound geomorphological and ecological implications. However, the timing of glacier retreat is still poorly understood. This is the case of some deglaciated areas existing in the South Shetland Islands, such as Byers (Livingston Island) and Barton peninsulas (King George Island). The dating of the basal sediments collected from different lakes from in these two peninsulas allows to infer the age of formation of each lake. The integration of these ages enables the reconstruction of the spatial and temporal pattern of deglaciation of these spaces. The chronological framework has been established using two complementary techniques: radiocarbon dating and thermoluminescence. In both peninsulas the deglaciation started during the Early Holocene, around 8 ka cal BP. The areas located far away from the current ice domes and the highest peaks in the two peninsulas (nunataks) were the first areas to become ice-free. During the mid-Holocene (5-6 ka cal BP) the central part of these peninsulas was progressively deglaciated. Finally, during the Late Holocene glacier fronts remained confined to the current position defined by the present frontal moraines, with minor advances and retreats.

## ***The spatial variability of thermal state of active-layer in Fildes Peninsula, maritime Antarctica***

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The Active Layer Thermal regime (ALTR) has been recently investigated in different parts of Maritime Antarctica, where there is a clear trend of warming recorded in the last three decades. Its present knowledge is mostly based on single sites representing varying locations, vegetation covers, and topographic positions, but little knowledge is available with regard to its spatial variability at a local scale. To address this gap, we set up an experiment with 10 points across a 200 meters transect, on a flat upper Cryoplanated platform at Fildes Peninsula, under periglacial conditions and patterned ground. The two extremes of this transect represent a typical moisture gradient, ranging from a well-drained site, with an Usnea/mixed lichen mosses cover (P10) to a site under hydromorphic conditions, and water saturation at the summer season, and a moss (Sanionia) field. The thermal regime is comparable between the two extreme sites (P1 and P10), at 5 and 35 cm deep, but there are consistent differences along the transect. At the moist, hydromorphic soil site (P1), the TDD sum is almost twice the TDD value of the well-drained site (P10) at the surface, and nearly ten times higher at 35 cm. This indicates a much more pronounced effect of cryoturbation, despite a similar predominance of a frozen regime in both sites. With less moisture, the TDD sharply decreased from 5 to 35 cm (TDD: 39-5), compared with a much smaller difference at the same depths of P1. Regarding the FDD, results are higher at the surface for the moist site, with a trend of lower values down to 35 cm. Apparently, the freezing front at the moist site moves upwards the soil at a faster rate compared with the well-drained site. The overall results indicate that great differences of the ALTR occur at local scales, hence preventing a generalization of the ACTR determined at single sites. Also, large differences in ALTR can be expected when soil moisture conditions vary, temporally and spatially, a common feature across the entire periglacial zone of Maritime Antarctica.

# ***The use of proxy data to determine patterns of rock exposure on a nunatak in western Dronning Maud Land, Antarctica***

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It is widely accepted that climate change will have far-ranging consequences globally, with the greatest impacts potentially being felt in the polar regions of the planet. In particular, Antarctic permafrost and vegetation are sensitive to a changing climate. To evaluate such change it is important to establish baseline conditions for the various Antarctic environments and landforms, their current state and how they have developed. Determining the sequence of deglaciation and exposure of surfaces aids in how landforms may further be affected by a changing climate. This paper focuses on establishing the sequence of deglaciation of the autochthonous blockfield on the Northern Buttress of the Vesleskarvet nunatak, western Dronning Maud Land, Antarctica using proxy data. Furthermore, the paper aims to contribute toward the SCAR Horizon Scan question #39.

The early successional stage of colonisation of lichens and bryophytes occurs within a few decades of deglaciation (Favero-Longo et al., 2012), and their distribution is, thus, useful to provide relative ages of exposure. Another means to determining relative ages of deglaciation may be achieved by using rock hardness as a proxy for exposure time (Sumner et al., 2002; Matthews and Owen, 2008; Shakesby et al., 2011). Between 2009 and 2014, lichen abundance and distribution were mapped together with rock hardness measurements. Additional observations of weathering forms, such as pitting and tafoni, as well as the extent of annual snow cover were recorded. Lichens were found to be most abundant and prolific at the northern end of the blockfield, where the only evidence of tafoni on the nunatak was found. While sediment and gravel-sized clasts are rare, pockets of such material do exist on the western edge of the blockfield. Findings suggest that the northernmost (and most elevated) point of the nunatak deglaciated first, with a deglaciation pattern towards the east in evidence. Rock hardness proxies supported this observation, with the softest rock found where lichen was most abundant. Relative harder rock surfaces and less dense lichen distribution is argued to represent later deglaciation and, hence, exposure at the south and eastern edges of the blockfield.

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## ***Time series analysis applied to active layer thermal regime monitoring at Maritime Antarctica***

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Time series analysis is an important tool for the understanding of climate variability. In this work, a five-years temporal series showed differences in thermal regimes in terms of soil temperature (Ts) at different landscapes of Maritime Antarctica (Keller Peninsula, King George Island) and its monthly variability in the period from 01/2011 to 12/2014. The description of the series was conducted by evaluating the most relevant characteristics and possible relations with the AAO (Antarctic Oscillation Index), SOI (Southern Oscillation Index) and the MEI (Multivariate ENSO Index). The Box-Pierce Augmented Dickey Fuller test confirmed both the stationary and the independent distribution of the series, respectively. The harmonic analysis allowed to describe the frequency domain that is repeated at regular time intervals. It was verified by this analysis that there was a cyclic period of approximately 7.7 months in air temperature (Ta) and the Ts, at the sites I, II and IV, that corresponded to the same harmonic period (sum of the three harmonics) of the AAO and the the SOI. This pattern was explained by the scatter plot, in which the coefficient of determination ( $r^2$ ) was greater than 60% for site I, >30% for the site II and > 50% for site IV. For Site III a cyclic period of 7.2 months was observed in all layers, with > 70% explained by the sum of the three largest power spectrum harmonics in the series. When we plotted the most dominant harmonic indices AAO and the SOI with Tar, it was possible to observe that they are in phase. We conclude that the climate variability influencing the Tar in these active layer sites of Maritime Antarctica were basically the AAO and the SOI indexes. Similarly, when plotted the Tar harmonics with the Ts it was possible to observe a four-month period with a negative phase and a four-month positive phase, alternating along the studied period. This period is divided into positive (mean soil temperatures above 0°C), negative (with mean soil temperatures below 0°C) and the isothermal or transition (temperature between -0.5 °C and 0.5 °C) phases.

## S12. Snow and ice in Antarctica

### *Accelerated redox chemical processes of inorganic compounds in frozen state and its impact on polar environment*

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In general, most chemical reactions are slowed down when temperature decreases. However, several chemical processes can be enhanced in frozen state. The bioavailability, mobility, toxicity, and environmental fate of metals or inorganic elements are controlled by their redox speciation. Although the chemical processes in ice play a critical role on various environmental system, they have rarely studied. Firstly, we investigated the dissolution of bioavailable trace elements (Fe(II)aq and Mn(II)aq) from their oxide particles in water and ice. The dissolution of metal (iron and manganese) oxides particles in ice phase was significantly enhanced compared to those in aqueous solution both in the presence and absence of light although the dissolution rate was enhanced under UV irradiation. The dissolution rate depends on crystallinity, BET surface areas, kinds of present organics or inorganics, pH, light sources, presence of oxygen, and etc. We also investigated the reduction of Cr(VI) in the presence of organic/inorganic compounds and the simultaneous transformation of Cr(VI) and As(III) in ice in comparison with those in aqueous solution. The reduction of Cr(VI) by various organic acids (electron donors) or H<sub>2</sub>O<sub>2</sub> was negligible in ambient aqueous solution but was significantly accelerated in ice. The reduction of Cr(VI) in the presence of H<sub>2</sub>O<sub>2</sub> in ice shows different reaction pathway compared to those in aqueous solution. The simultaneous reduction of Cr(VI) and oxidation of As(III) in ice phase proceeded stoichiometrically, whereas their mutual conversion was insignificant in aqueous solution. The enhanced redox transformation in ice phase is ascribed to the freeze concentration effect (when solution is solidified the existed organic and inorganic compounds are highly concentrated in unfrozen liquid-like regions) in ice crystal grain boundaries. These results imply that understanding the redox conversion of various inorganic/organic compounds in ice phase may provide newer views and insights on the environmental chemical processes in the icy environments (e.g., upper troposphere, permafrost, polar/high latitude environment and mid-latitudes during winter season) where the freeze-thaw cycles repeat. We also found that the oxidation of iodide to form I<sub>3</sub><sup>-</sup> and I<sub>2</sub> is greatly accelerated in frozen solution, which is even more enhanced under natural solar irradiation. The release of gaseous I<sub>2</sub> upon thawing the irradiated ice was detected by using cavity ring down spectroscopy. The ice-enhanced generation of I<sub>3</sub><sup>-</sup> and I<sub>2</sub> is ascribed to the freeze concentration of iodide and dissolved O<sub>2</sub> trapped in polycrystalline ice grain boundaries. This finding proposes a previously unrecognized source of gaseous I<sub>2</sub> through abiotic process in polar region. Here, we introduce our previous studies on intrinsic chemical processes of inorganic species in ice phase and its environmental implications.

## ***Calcium nitrate in East Antarctic snow: Formation processes and its implications***

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An understanding of spatial and seasonal characteristics of chemical composition of Antarctic snow is necessary in order to strengthen the interpretation of past signatures from ice cores. A snow coring program was undertaken along two geographically distinct regions (>2000 km apart) across East Antarctica during the austral summer of 2008-2009 with focus on glaciochemical studies. A total of 41 snow cores (~1 m long) were collected along two transects from coastal-inland regions of Princess Elizabeth Land (PEL) and central Dronning Maud Land (cDML) covering a total distance of 380 km and an elevation up to 3000 m a.s.l.

Glaciochemical distribution along with correlation statistics, ionic balance and principal component analysis (PCA) revealed that the major sea-spray derived ions (Na, Cl, K, and Mg) in both PEL and cDML did not undergo any reaction during their transport and deposition in snow. The ions representing biogenic activities (nssSO<sub>4</sub> and MSA) were found to be strongly associated with each other and also with H, indicating the atmospheric H<sub>2</sub>SO<sub>4</sub> formation, especially during the summer. The results also revealed a very strong and consistent association between nssCa and NO<sub>3</sub> (at 99 % significance) at both near-coastal (PEL, r = 0.74; cDML, r = 0.82) and the inland regions (PEL, r = 0.73; cDML, r = 0.84). This association is interesting mainly due to the fact that both nssCa and NO<sub>3</sub> have entirely different sources. Such associations have been known to be existed when the atmosphere was dusty during the dry glacial periods, revealed by the ice core records. However, there are very few aerosol and snowpack studies that show such strong association between nssCa and NO<sub>3</sub>. The nssCa in the Antarctic continent is mainly derived from long-range transported dust particles and from locally exposed mountains and land areas. Nitrate in Antarctica is derived from the upper stratospheric and transport from mid-tropospheric sources.

Results from forward and back trajectory analyses using HYSPLIT revealed Southern South America as an important dust source to the study region, aided by the Westerlies. The results from PCA and trajectory analyses strongly show that the nssCa - NO<sub>3</sub> association possibly occurred during the long-range transport rather than the local neutralization processes. Also, samples from the mountainous section in cDML and coastal section in PEL showed comparatively weaker association, indicating that the local sources of nssCa could mask such association. Our study shows that a significant amount of NO<sub>3</sub> (~70-75 % in the coast and ~50-55 % in the inland) is associated with the nssCa. Also, such reactions are of importance to the Antarctic snow chemistry as well as the interpretation of ice core records.

## ***Electric field meter responses for the blizzards and snow falls over Antarctica***

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Variation of atmospheric electrical parameters during snow fall and Blizzards are presented in this work. The measurements have been conducted at Maitri (70 45' S, 11 44' E) Antarctic research station more than a decade. Time series analysis of ground based atmospheric electrical parameters during weather hazards (snow fall and Blizzard) is thought to characteristic such events. Usually they carry charges (positive/negative) in the form of ice or snow which is then convected by the strong surface wind. It can be sensed in the vicinity range of Electric Field sensors (EFM-100). It is inferred that EFM-100 has significant response during pre and post occurrences of blizzards; however, the variation depends on the strength of blizzard and its associated weather parameters. The new findings will be presented in the conference.

## ***Preliminary results of stable water isotope analysis of shallow firn cores from the union glacier region***

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Union Glacier (UG) is located within the Ellsworth Mountains region, being a major tributary to Filchner Ice Shelf. Models suggest that this is a transition region between the warming West Antarctic Ice Sheet (WAIS) and the neutral region of the East Antarctic Ice Sheet (EAIS).

Since 2014 a new Chilean scientific camp has been running in UG (79°46'10"S, 82°54'26"W), where we have been collecting shallow cores in a transect from the Filchner Ice Shelf to the Antarctic Plateau. The cores shown in this work were extracted from two ice rises: Dott (79°17'37.80"S, 81°43'53.70"W) and Fletcher (78°40'7.76"S, 79°21'3.86"W), a point nearby the camp (79°46'30"S/82°54'26"W) and at the local divide of the glacier Schanz and Schneider (79°36'25.48"S, 83°54'53.38"W). All cores were weighed for density determination and later sub-sampling (5cm) for stable water isotope analysis. Preliminary data from the Schanz-Schneider dived core show a clear seasonality of deuterium (oxygen) ratios, with highly depleted values (mean value of -273‰ for deuterium with respect to VMSOW), which reflects the low temperatures of the region (mean annual air temperature of -22°C at UG camp). On the other hand the core from the UG camp show no clear seasonality probably reflecting a strong snow drift, due to its location propitious for strong katabatic winds. Also no clear altitudinal effect is observed between both locations, re-enforcing the previous assumption of strong mixing from precipitations coming from higher altitudes at UG. The accumulation rates, as derived from the density profiles and isotope annual layer counting, exhibit a clear negative trend on the accumulation from 400 kg / m<sup>2</sup> a at the end of the 1980's to 200 kg / m<sup>2</sup> a during the last years. This is observation has been yet not corroborated with the other cores, but it is by itself an unexpected result. On the other hand no trends are observed from the oxygen (deuterium) values, indicating stable air temperature trends for almost four decades. This confirms that UG region represent a key region to understand the current warming phenomenon of the WAIS and stability of EAIS. Geophysical survey carried out previously in this region show an ice thickness larger than 900 m, likely storing precipitation (climate proxy) of the last millennium or even beyond.



## ***Snow depth on Antarctic sea ice: Advancing its satellite remote sensing***

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Snow on Antarctic sea ice plays a key role for sea ice formation and melt as well as for in- and under-ice biota. It is further a geophysical parameter which influences satellite remote sensing of sea ice. It has the potential to create substantial biases in the, e.g., sea ice area fraction computed from satellite microwave radiometry. The snow depth on sea ice itself is required, by present day approaches, to estimate the Antarctic sea ice thickness distribution from satellite altimetry.

Satellite-based retrieval of snow depth on Antarctic sea ice is currently done by passive microwave sensors using brightness temperature observations. These enable weather- and daylight independent daily retrieval of the snow depth. However, the obtained snow depth is usually under-estimated over deformed sea ice. In addition, elevated snow moisture / wetness caused either by surface melting or by ice-snow interface flooding can lead to an under-estimation of the snow depth retrieved.

One way to improve snow depth retrieval from satellite microwave radiometry would be to combine the microwave brightness temperatures with additional information about sea ice and surface properties such as its roughness and temperature. Only one to two previous studies have demonstrated the potential to do so. Within the EU-funded project SPICES, one of the goals is to improve retrieval of Antarctic snow depth on sea ice by means of combined usage of satellite active and passive microwave data.

In this contribution, we focus on the effect of surface roughness. We will present first results of an inter-comparison of in-situ and ASPeCt ship-based observations of snow depth and other relevant environmental parameters such as ice thickness co-located with available snow depth on sea ice products, with brightness temperature (passive microwave) and with radar backscatter (active microwave) data. In addition we will present results of an inter-comparison of measures of the surface roughness as obtained from airborne: Operation Ice Bridge and space-borne: ICESat-1 sensors co-located with the same set of satellite-based observations. The results of these inter-comparison studies will be one element for a modified snow depth on Antarctic sea ice retrieval using satellite microwave radiometry.

# ***Spatial and temporal variability of accumulation rate and chemistry of surface snow at East Antarctic ice sheet***

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Snow stakes along the traverse routes have been observed for long term monitoring program 'the variation of ice sheet surface mass balance' from the 1960's by the Japanese Antarctic Research Expedition in Shirase glacier drainage basin, East Antarctica. During the traverse route between coastal S16 point (69 02'S, 40 03'E, 580m a.s.l.) to inland Dome Fuji (77 22'S, 39 42'E, 3,810m a.s.l.), the snow stake observations every 2 km have been carried out from 1992. Yearly net snow accumulations from S16 to Dome Fuji were calculated. They were different in way accumulating spatial pattern depending on places. The yearly accumulation rates were compared with seasonal change of AAO-index (SAM). As a result, yearly accumulation rate and AAO-index showed the positive correlation.

Surface snow samplings were conducted every 10km along the traverse route. Generally, the snow surface features are classified into three regions.

- (1) the coastal region: smooth surface, high snow accumulation
- (2) the katabatic slope region: rough sastrugi surface and smooth glazed surface
- (3) the high plateau region: smooth surface, little snow accumulation

The chemistry of surface snow changes from the coast to inland. Furthermore, the chemical properties of snow are different for each surface at the same area. We can classify the surface snow with fresh drifting snow, deposited drift snow, soft and hard surface snow, sastrugi, surface hoar and so on. The value of each isotope ration and ion concentration greatly varied. Sometimes, snow might deposit thick equally. But the deposited snow was redistributed by the wind. When the snowstorm occurred, the blowing snow started to deposit in a certain opportunity. As for it, the area was not the uniform. It is necessary to discuss inhomogeneity of the depositional condition quantitatively.

Snow pit observations of 2m depth were conducted at coastal, katabatic and inland areas. How did an inconsistent characteristic colonize at the snow surface?

We also report a result of the JARE glaciological observation (ice coring, firn air sampling, AWS setup, etc.) in 2015-2016 austral summer season.

## ***Spatial variability of carboxylate ions in Amery Ice Shelf and Princess Elizabeth Land, East Antarctica and their possible sources***

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Carboxylate ions are one of the dominant classes of organic compounds found in the troposphere. It is an important contributor to the acidity of atmospheric deposition in remote areas like Antarctica. Carboxylate ions constituting Acetate (Ac<sup>-</sup>), Formate (Fo<sup>-</sup>) and Oxalate (Oxy<sup>-</sup>) were studied in surface snow from Amery Ice Shelf (AIS) and Princess Elizabeth Land (PEL). Surface snow sampling was carried out at an interval of 10 km over coastal – inland transects of 120 km at AIS and 180 km at PEL. A total of 13 samples from AIS and 18 samples from PEL were used for the study. In the present study, carboxylate ions constituted between 1 and 19 % to the Total Organic Carbon (TOC) and 4 % to the total anion concentration. Carboxylate ion concentrations ranged below detection limit (DL) to  $21.54 \pm 0.31 \mu\text{g L}^{-1}$  at AIS and below DL to  $42.93 \pm 0.00 \mu\text{g L}^{-1}$  at PEL. Sea-salt Na<sup>+</sup> results show that sea spray has a uniform influence over the sampling transect at AIS whereas significant decrease of its influence was observed at PEL with the increasing distance and elevation. A weak correlation of carboxylate ions with the distance and ssNa<sup>+</sup> at AIS and PEL suggests that the contribution of sea spray to carboxylate ion deposition might be very small. Apart from atmospheric sources in remote areas like Antarctica, carboxylic acids can also be formed in snow pack from Dissolved Organic Matter (DOM) through OH<sup>-</sup> initiated reactions. Major source of OH<sup>-</sup> in snow pack is the photochemical reactions involving NO<sub>3</sub><sup>-</sup>. In this study, significant amount of NO<sub>3</sub><sup>-</sup> was found in the snowpack. Furthermore, significant correlations of Ac<sup>-</sup> ( $r = 0.711$ ,  $p < 0.01$ ) and Oxy<sup>-</sup> ( $r = -0.387$ ,  $p < 0.05$ ) with the NO<sub>3</sub><sup>-</sup> suggest that their origin could be due to photochemical activity. However, TOC constituting significant amount (1 to 19 %) of carboxylate ions is also significantly correlated to NO<sub>3</sub><sup>-</sup> which suggests that carboxylate ions might have been produced from the DOM present in the snowpack. Also, the presence of variety of bacteria, fungi and microalgae in the snow samples indicate the possible contribution of microbial activity in the formation of the carboxylic acids.

## ***Spatio-temporal variability of snow surface albedo and grain size derived from airborne and ground-based observations in Antarctica***

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Surface albedo is one of the most important factors determining near-surface energy fluxes and is therefore a key parameter in regional and global climate models. In case of snow surfaces, the high albedo multiplies the impact of the surface on the radiative energy budget. However, the snow surface albedo can show high temporal and spatial variability that cause local changes of the radiative energy budget. These changes are driven by differences in snow grain size or atmospheric parameters such as cloud cover. Therefore, it is of great interest to incorporate a reliable measurement-based surface albedo scheme into numerical climate models. However, past measurements were either limited to short timescales or single observation sites.

During the austral summer season 2013/14 a field campaign dedicated to snow surface properties was conducted at Kohnen Station (75°00'S, 0°04'E) on the East Antarctic Plateau. The project combined long-term observations at Kohnen with airborne measurements (60 flight hours) over Dronning Maud Land. Simultaneous measurements of spectral and broadband surface albedo and of Specific Surface Area (SSA) of snow by means of ICE-Cube System by A2 Photonic Sensors allow for a direct validation of snow properties derived from remote sensing.

It is found that both low-level clouds and changes in SSA (grain size) can modify surface albedo by the same magnitude. Overcast conditions, defined by 8/8 cloud cover in the lowest cloud layer, result in a broadband albedo increase of about 3%. A similar broadband albedo increase is provoked when SSA increases by 18 m<sup>2</sup>/kg as observed regularly after precipitation events. Cloud abundance results in an abrupt, short-term increase of surface albedo. Changes in SSA provoke a sudden increase, too, but are followed by a long-term cascading decrease that results from snow metamorphic processes leading to an increase in snow grain size. SSA is therefore considered to alter the basic seasonal albedo pattern, whereas clouds overprint the seasonal trend only for the period of their abundance.

In addition, snow grain size was retrieved from airborne measurements of spectral surface albedo using the Spectral Modular Airborne Radiation measurement sysTem (SMART)-Albedometer on board of the research aircraft Polar 6. The airborne observations covered a large area of Dronning Maud Land and indicate a significant horizontal variability of snow albedo and snow grain size. Collocated airborne and ground-based observations at Kohnen Station were performed during each single flight. Grain sizes retrieved by SMART in the Kohnen area were in good agreement with in situ measurements. This agreement will allow to put the local grain size observations of high temporal resolution into context with the large-scale variability in Dronning Maud Land.

## **S14. Antarctic climate variability during the past two millennia**

### ***Holocene paleolimnological changes of coastal freshwater lakes in Soya Coast, East Antarctica using fossil diatom assemblages***

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The East Antarctic Ice Sheet (EAIS) is the largest glacial system on Earth, and documenting its changes is important to understand and estimate its future behavior. Antarctic coastal lakes are invaluable archives of paleoclimate and paleoenvironment changes caused by the retreat of Antarctic Ice Sheet. In Soya Kaigan (Coast) of Lutzow-Holm Bay region, many coastal lakes are located in ice-free areas. Some coastal lakes located below 20m ASL are marine relict lakes resulted from the recession of glaciers and subsequent isostatic uplift (Igarashi et al., 1995, Miura et al., 1998). This study discussed the environmental change inferred from microscopic observation of fossil diatom assemblages in a sediment cores from such coastal freshwater lakes, Lake Oyako-ike, Lake Maruwanminami-ike and Lake Maruwan-Oike, in Soya Coast along with sedimentary facies and AMS <sup>14</sup>C dating.

Diatoms are one of the most common phytoplankton (Class: Bacillariophyceae), and it is used as powerful and reliable environmental indicators (Cholnoky, 1968; Lowe, 1974) which can be attributed to their high abundance and species diversity. Also, they are distributed among most aquatic environment. Additionally, their cell wall is made of silica (hydrated silicon dioxide) called as frustule, so that their remains are highly durable and well preserved in accumulated sediments as fossils (Smol & Stoermer, 2010). In this study, Diatom analysis was conducted in order to understand past water quality such as salinity when they live on.

The Ok4C-01 core (length 135 cm) from Lake Oyako-ike was divided in 5 zones according to the diatom assemblage changes. This lake has changed from coastal marine to freshwater lake at ca. 1100 cal yr BP (core depth 60 cm). The MwS4C-01 core (length 147 cm) from Lake Maruwanminami-ike was also divided in 4 zones. This lake has changed from coastal marine to freshwater lake at ca. 2400 cal yr BP (core depth 65 cm). The Mw4C-01 core (length 226 cm) from Lake Maruwan-Oike was divided in 4 zones as well. This lake has changed from coastal marine to freshwater lake at ca. 2800 cal yr BP (core depth 22 cm). Diatom assemblage changes in these sediment cores show similar pattern with other results such as sediment facies and elemental analyses (TC, TS, TN contents). However, to compare the environmental changes between these lakes, we need more consideration about the age models.

## ***Mid-Holocene transition from an Antarctic to North Atlantic climate pattern on sub-Antarctic South Georgia***

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Asynchronous changes in polar temperatures during the last glacial period and the Holocene are partly defined by the position of the Antarctic Polar Frontal Zone (PFZ), which separates the climate changes between the high latitudes of the Southern Hemisphere from those of the rest of the planet. Sub-Antarctic South Georgia's location within the PFZ makes it ideal for studying past shifts in the PFZ from palaeoenvironmental records. We carried out a high resolution multi-proxy study of lake sediment records from two contrasting sites in order to separate local effects from common externally forced palaeoenvironmental and palaeoclimate signals. These included a c. 7800 cal. yr BP record from Fan Lake (54°29'0"S, 37°5'0"W) on Annenkov Island off the south coast of South Georgia, and a 7200 cal. yr BP record from Lake POH1 (54°04,369'S; 37°08.033'W) in Prince Olav Harbour on the northwest coast. Results show that local glaciers had receded to mid-upper valley positions 7800-7200 cal. yr BP, but persisted through the mid Holocene maintaining a low nutrient/low productivity environment in the lakes until c. 4700 cal. yr BP (Lake POH1), and c. 4300 cal. yr BP (Fan Lake). Primary production peaked during the regional Mid-Late Holocene Hypsithermal (Lake POH1: 4700-2000 cal. yr BP; Fan Lake: 4300-2500 cal. yr BP), a feature seen in most lake records from the Antarctic Peninsula and Scotia Arc, and likely driven by increasingly warmer and/or extended Austral summers. Similar to other Antarctic Peninsula lake, ice core and (some) marine records a major ('neoglacial') downshift in productivity occurred after c. 2000 cal. yr BP. Following this, the climate at South Georgia displays more similarities with North Atlantic climate patterns. In particular, we identify a prominent warm period between c. 1000-500 cal. yr BP, that coincided with the globally-defined 'Medieval Climate Anomaly' and generally colder conditions between 500 and 100 cal. yr BP during the Northern Hemisphere-defined 'Little Ice Age'. We attribute these patterns to a southward shift in the PFZ after sometime between 2000 and 1000 cal. yr BP. In the last 50 years an increase in lake productivity is consistent with the recent rapid warming trend observed on South Georgia since c. 1950 A.D. This is seen in other terrestrial and oceanographic records from the Atlantic sector of the SH and the Antarctic Peninsula, and also in the northern high latitudes in response to anthropogenic forcing.

## ***Oxygen and Hydrogen stable isotopes as climate tracers in the Laclavere Plateau, Antarctic Peninsula***

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Oxygen and Hydrogen stable isotopes as climate tracers in the Laclavere Plateau, Antarctic Peninsula  
In the last decades the western side of the Antarctic Peninsula has presented the highest temperature increase of the southern hemisphere. The lack of instrumental meteorological records in this region has hindered the study of regional climatic trends. In this context the study of ice cores has become a powerful source of information because they contain records of greater temporal extension and from areas where meteorological information hasn't been retrieved. Ice cores from high-accumulation regions can significantly contribute to understand the undergoing climate variability and expand short meteorological time-series to the past.

Laclavere Plateau (63°27'15"S / 57°41'53"W / 1130 m.a.s.l.) is situated in the northern tip of the Antarctic Peninsula and is the northern area in the Peninsula which has a height above 1000 m.a.s.l. The climatological regime in the north of the Peninsula presents a complex interaction between the different elements that form the climatic system. Meteorological conditions in this area are strongly controlled by the variation in the sea ice extension, the position of the Antarctic Circumpolar Current and the differences in the lapse rate throughout the year.

The air parcels that precipitate over the Laclavere Plateau are strongly related with the conditions that prevail on the Southern Seas at the west of the Antarctic Peninsula and in particular with the conditions present near coastal areas of the Bellingshausen Sea. Since 2008, we have studied the northern part of the Antarctic Peninsula, where several surface firn cores (<20m depth) have been collected from sea level to the divide between west and east coast at the Plateau Laclavere. The isotope signature of the cores shows a complicated signal to interpret. No clear seasonality is observed from  $\delta^{18}\text{O}$  ( $\delta\text{D}$ ). Here we show the statistical treatment that allow us to conclude that the deuterium excess ( $\text{dexcess} = \delta\text{D} - 8 \delta^{18}\text{O}$ ), oxygen and deuterium ratios can be potentially used as a seasonal marker. We propose that variations observed in the stable isotope signal and in meteorological conditions are related with the development of an inversion layer in the lower troposphere (below 1000 m.a.s.l.) during the winter because of the formation of sea ice in the western coast of the Peninsula.

We estimate that the Laclavere Plateau present appropriate conditions for the conservation of the isotopic signal recorded in the snow that accumulates on its surface (mean value of 1,700 kg m<sup>2</sup> a<sup>-1</sup>). Therefore, we conclude that isotopic signal recovered from Laclavere's Plateau ice show that ice is a strong indicator of actual meteorological parameters, which make them capable of being proxy of local variability in atmospheric circulation, snow accumulation and temperatures above surface. The well preserved isotope signal, along with the thick ice cover over the Laclavere Plateau (surveyed by geophysical methods), project this place as a favorable spot to recover a medium depth ice core (>250m), from which it could be developed a paleoclimatic reconstruction covering at least half century at a high temporal resolution.

## ***Reconstructing the Little Ice Age Conditions in the eastern Ross Sea as captured in the RICE Ice Core***

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The Little Ice Age (LIA) (1400-1850) represents one of the most significant climatic shifts over the past 5000 years. Previously recorded ice core and borehole measurements from Antarctica have portrayed generally cooler and stormier conditions during this time period, except for the Siple Dome ice core record, obtained from the eastern Ross Sea region, which records a warming signal. Here we present data from a new record– the Roosevelt Island Climate Evolution (RICE) ice core. Preliminary stable isotope measurements from the RICE ice core suggest relatively stable climate conditions over the last 2000 years. This raises the question, whether the lack of cooling at the nearby Siple Dome and Roosevelt Island cores represents a true temperature anomaly or whether the atmospheric circulation pattern caused an isotopic enrichment that masks an underlying cooling. We analyse seven major ions (Na<sup>+</sup>, Mg<sup>2+</sup>, Ca<sup>2+</sup>, MS<sup>-</sup>, Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>) in order to reconstruct the atmospheric circulation pattern, sea ice extent, Ross Sea polynya activity and marine primary productivity. This provides an opportunity to distinguish regional warming in the eastern Ross Sea or changes in the isotopic fractionation pathways.



## ***Spectral analysis of time series in marine laminated sediments of the eastern basin of Bransfield Strait (Antarctic Peninsula)***

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One marine sediment core GC00-13 (1,400 m water depth) collected in the eastern basin of Bransfield Strait (Antarctic Peninsula) is 907 cm core length of the whole laminated diatom ooze sediments. This sediment appears with continuous alternating monospecific diatom ooze and terrigenous laminae indicative of annual cyclicities illustrated from back-scattered electron imaging technique. Well-defined chronology from AMS <sup>14</sup>C ages of marine shells indicates the sedimentation rate is about 0.501 yr/cm and the age of core bottom is about 1,800 yrs. It provide a reference for climatic/oceanographic variations in the northern Antarctic Peninsula to study the paleoenvironmental time-series data by means of spectral analysis. The interest of this work is the use of the sediment as one of palaeo-climatic indicators. The spectral analysis of time series from marine laminated sediments is a powerful tool for the study of climatic information stored in high-resolution marine sediments. Physical, geochemical and paleontological data recovered two climatic episodes, Little Ice Age and Medieval Warm Period in the Holocene. Periodicities obtained from spectral analysis could be related to natural phenomena like sunspot cycles and ENSO that are capable of modulating the climate in this frequency band with annual variations. Periodical variability according to climatic episodes suggests that climatic change with the cyclicities could drive regional depositional process and ecosystem with sea-ice variations.

## S15. Solar-terrestrial physics in the polar regions

### *Antarctic gravity wave imaging / Instrument network (ANGWIN)*

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Recent observational and modeling studies of gravity waves have significantly improved our understanding of their important role for transporting energy and momentum within the middle atmosphere and the coupled thermosphere/ionosphere system. However, gravity wave fluxes and dynamical contributions at polar latitudes are not well understood, primarily due to insufficient measurements. ANGWIN (ANTarctic Gravity Wave Imaging/Instrument Network) is a highly successful "grass roots" program initiated in 2011 that utilizes a network of instrumentation at several international research stations around Antarctica under international cooperation among USA, UK,, Australia, Brazil, and Japan. The research goal is to qualify and understand the dominant sources, propagation and impact of a broad spectrum of gravity waves on a continental-wide scale. The cooperation is not limited to the collaborative research and data/software sharing, but the education of young scientists is included. In this paper, present status of collaborations, and research results/findings will be presented.

## ***Exploration and characterization of earth's electromagnetism and conductivity due to space weather perturbation at polar and equatorial regions***

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Space weather is related to the solar perturbations that emitted from the Sun and travelling its surrounding area including the Earth. It has its cycle with solar activity rising and falling over ~11 years solar cycle. Currently we are in the declining phase of solar cycle 24. Space weather includes Travelling Ionospheric Disturbance (TID), Sudden Ionospheric Disturbance (SID) and geomagnetic storm in which at certain conditions will penetrate into the Earth's ionosphere through polar region and cause higher variations in the Earth's magnetic field. To date, several geomagnetic arrays such as A Global Ground-Based Magnetometer Initiative (SuperMAG), International Real-Time Magnetic Observatory Network (INTERMAGNET) and Magnetic Data Acquisition System (MAGDAS) have been established mainly to monitor the secular variation of Earth's electromagnetism. Theoretically, electromagnetic perturbations from space also affecting underground conductivity [Jusoh et. al, 2012; Duma & Ruzhin, 2003]. However, simultaneous measurement of both geomagnetic field and underground conductivity is not well explored yet due to lack of equipment synchronization and research collaboration in both fields.

Therefore, to empirically investigate possible coupling between space weather, geomagnetic activities and underground conductivity, an experiment and observation of Earth's electromagnetism and underground conductivity has been designed to be carried out at both polar and equatorial regions. For polar region, King Sejong Station which is located at King George Island, Antarctic has been chosen for observation encompassing several periods of observations during Malaysian Antarctic Scientific Expedition 2016. This location was chosen due to accessible to utilities which are power and internet connection, security and availability of manpower. The experiment also conducted at low latitude (equatorial) region for characterization purposes. For this scientific expedition, three equipment were used to obtain the geomagnetic and Earth's conductivity data - Wireless Magnetometer (Wimag - our own developed magnetometer), Magnetotester and Earth and Resistivity Tester. In this analysis, electromagnetic perturbation data from extraterrestrial (solar wind) were retrieved from the ACE Science Center, NASA via ACE Browse Data Explorer.

From this investigation, we observed significant result that possibly correlates between the geomagnetic activities and underground conductivity at polar (Antarctic) and equatorial regions during space weather perturbation. Further result and analysis will be discussed during the presentation session.

## ***Investigation of gravity wave source regions near the south pole***

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Gravity waves have been observed with all-sky imagers over South Pole Station for a number of years. However, their sourcing location(s) and mechanism(s) remain undetermined. In this study we analyze all-sky imager data taken from a multi-wavelength all-sky imager system located at the South Pole Station for the presence of gravity waves. Using images taken during three months of the 2003 and 2004 austral winters, we determine the spatial and temporal characteristics of a large number of observed waves. Using these wave parameters, and a background atmosphere constructed from European Center for Medium-range Weather Forecasts (ECMWF) Reanalysis, the NRLMSISE-00 empirical model, and the Horizontal Wind Model (HWM), we model wave propagation from the polar mesosphere to each wave's source using the FOREGRATS ray-tracing model. Results indicate a significant portion of observed wave are launched in several discrete layers in the tropopause and stratosphere, and further analysis of ECMWF geopotentials and temperatures demonstrate wave formation is a result of baroclinic instability processes in the stratosphere and interaction of planetary waves with the background wind fields in the tropopause.

## ***On the geomagnetic measurements from Antarctica in the satellite era: The magnetic pole location by ground and space recordings***

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The systematic observations of the Earth's magnetic field, older than those of meteorology and seismology, allowed Gauss since mid of nineteenth century to recognize that the main contribution to the field comes from its dipolar component. The quality of the analytic model has been improved along the decades with the growing number of observatories spread around the world but the most important significance has to be ascribed to the observations collected from the remote and inaccessible areas of the planet, like those from the Antarctic continent. Here the field is stronger than in any other place and its geometric dipolar pattern shows here high space gradients, boundary conditions for any reconstruction of the field. Moreover, the magnetic poles, the point where the horizontal component of the field vanishes, are also located in polar areas, far away from the geomagnetic poles and the poles of rotation of the Earth.

We take the advantage of using Swarm ESA's constellation of satellites dataset for determining the current position of the South Magnetic Pole (SMP). We also analyze the SMP spatial shift during magnetic quiet and disturbed days in comparison to the determination made by means of ground observatories, in the same time interval and in recent historical times for tracking its migration path over the surface of the Earth.

## ***Polar ionosphere status during radial Interplanetary Magnetic Field: a statistical study.***

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The orientation of the interplanetary magnetic field has an important role in the dynamics of the solar wind - magnetosphere - ionosphere system. When the interplanetary magnetic field is nearly aligned with the solar wind velocity, a quasi-parallel shock develops in front of the magnetosphere together with strong turbulent fluctuations both in the upstream and downstream regions. Here we investigate on the status of the polar ionosphere during prolonged periods of almost radial interplanetary magnetic field by means of a statistical study of HF radars and magnetometers observations.

## ***Solar flare effects on the geomagnetic field in the South American sector***

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Here we analyze geomagnetic field changes in the South American sector produced by a solar flare effect (SFE), which is also known as magnetic crochet. This study evaluate the association of geomagnetic field with the ionosphere response detected by GNSS VTEC, ionosonde and VLF observations at stations from low to mid-latitude over Brazilian territory and at Brazilian Antarctic Station Comandante Ferraz. The ionization increase in the D and E layers of ionosphere produced by this kind of solar flares changes their properties, particularly the conductivity, which changes the electric currents and affects the Earth's magnetic field. The SFE analyzed here was produced by a solar event classified as X1.0/2B that occurred at 17:48 UTC on 29 March 2014 in an active region located at N10W32. The geomagnetic effect on horizontal (H) component of the geomagnetic field was present from equatorial region till middle latitudes in the South of Brazil and Argentine. The results will be discussed in terms of ionosphere response as a function of latitude, and its association with the surface geomagnetic field components.

## ***The madrigal distributed database system: Services and features for Antarctic data providers***

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The Madrigal distributed database system is an open source, web based distributed database system created and maintained at MIT Haystack Observatory under support from NSF Geospace Facilities. Madrigal acts as a repository and data interface for a wide variety of geospace observational research instruments with high visibility to the scientific community. Madrigal system capabilities provide data storage, retrieval, search, and visualization tools through defined user application programming interfaces (APIs) and a user-friendly web interface, accessible to anyone in the community through a standard web browser. Full online documentation is maintained at the OpenMadrigal project website located at <http://www.openmadrigal.org>. The CEDAR upper atmospheric community uses the Madrigal system as its central archival and data access provider.

Madrigal capabilities are well suited to storage, access, and visualization needs for both historic and emerging Antarctic data sets. Existing instrument types in Madrigal include incoherent scatter radar, GNSS TEC from the world wide GNSS network, GPS scintillation parameters from individual receivers, meteor radar, ionosonde, Fabry-Perot interferometer, and major geophysical indices. In Antarctica, Madrigal currently hosts data from the Mawson, Davis, Rothera, and Scott Base MF radars, the South Pole, Palmer Station, Arrival Heights, and Halley Fabry-Perot interferometers, the Czerny-Turner OH Grating Spectrometer, the South Pole Michelson Interferometer, and GPS scintillation parameters from individual GNSS receivers at the South Pole and McMurdo stations. MIT Haystack works collaboratively with the community to upload new instrument data sets to Madrigal in a mode allowing users to provide their data in their chosen format. This feature allows easy upload and maintenance of high data availability to the broad scientific community with very minimal burden on data providers. Typically less than a week is required to develop a fully automated upload process.

Madrigal services provide access to summary plots and plotting tools for a large segment of its data. These tools are developed at MIT Haystack jointly using an open source model with the community and data providers. For example, Madrigal allows direct access to plotting tools that overlay SuperDARN southern hemisphere radar observations and products onto GPS TEC maps. For GPS scintillation parameters, Madrigal web services provide access to pre-defined survey plots with background GPS TEC data overlays at 20 minute cadence where data is available. New plotting products are currently being developed to directly overlay GPS scintillation data onto the all-sky camera images produced by the all sky imagers at the South Pole site (<http://www.southpole-aurora.org/>).



## **S16. Global navigation satellite system research and applications**

### ***A morphological study of the variation of Total Electron Content (TEC) of ionosphere over the Indian Antarctic base, Bharti***

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A set of dual frequency GPS receiver has been installed at the Indian Antarctic station Bharti under the aegis of the SPL's Science Program "Energetic coupling between Sun-Earth System" (EcSES). The station is located at Larsemann Hills (76 Deg. S Magnetic latitude), which remains mostly inside the auroral oval and hence is exposed to the direct impact of the solar wind. However, since the polar cap is a highly dynamic region, the position of Bharti changes quickly from being poleward of the auroral oval to the auroral region or even equatorward of the auroral oval in response to varying IMF Bz conditions. This makes Bharti an ideal location to monitor the impact of the solar wind on the terrestrial coupled ionospheric-magnetospheric system. The GPS receiver system is in operation at Bharti since February 2013 and since then it is recording ionospheric parameters like the TEC and ionospheric scintillations regularly.

The TEC of the ionosphere over Bharti, as estimated by the onsite GPS Receiver, shows a consistent seasonal variation with minimum being in June (the local winter month) and maximum in December (the local summer). Morphological comparison between the IRI 2012 model and the GPS TEC shows a qualitative agreement. However, there are significant seasonal differences in the magnitude of the model-derived TEC and GPS-observed TEC. During June, when the solar zenith angle at Bharti is consistently more than 90 degree (i.e. there is no direct solar radiation producing photo-ions), both the GPS observed TEC and model derived TEC agreed well. However there was a three fold magnitude difference in the observed and modeled TEC during December (a summer month which had consistently high solar zenith angle throughout the day). The in-house developed quasi-two dimensional model, where only ion-chemistry was used, also shows the magnitude of the TEC at Bharti location, produced solely due to photochemistry, comparatively less than that observed by the GPS. In addition, a comparison of the TEC at measured at Bharti was made with the outputs from the models like the Parameterized Ionospheric Model (PIM) and International Reference Ionosphere model (IRI-2012). While the TEC measured during austral winter matches well with the model output, the same observed during summer has extreme differences. It only goes to show that the dynamic nature of the location of Bharti with respect to the position of polar cap plays an important role on the control of plasma density at the polar region, an aspect which has not been clear so far. Observations of the TEC from the GPS receiver at Bharti adds a new dimension to our understanding about the control of solar dynamics on the plasma density in the Earth's ionosphere.

## ***Characterization of atmospheric lightning with GPS TEC over the Antarctic Peninsula***

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One cause of the enhancement of total electron content (TEC) in the upper atmosphere is infiltration of energy dissipated by the lightning discharge in the troposphere into the hemisphere. Lightning discharges signify a change in atmospheric convection which is caused by heating during the day through solar radiation or at night due to the mixing of different densities of air masses. This paper characterizes the lightning occurrence with TEC disturbance over the Antarctic Peninsula during the year 2013. The effect of TEC towards lightning response was investigated by observing the lightning occurrence and TEC value. TEC is obtained from GPS measurements while lightning data was taken from World Wide Lightning Location Network (WWLLN). Three locations were selected for the case study, which are Palmer (PALM), O'Higgins (OHI3), and Rothera (ROTH). Four cases of lightning discharge are investigated which covers rms energy of less than 1 million (Case 1: February and March), rms energy between 1 million to 7 million (Case 2: May and September), Case 3 is between 8-100 million rms energy (January and December), and Case 4 is between 100-450 million rms energy (April and October). Results showed that TEC value is higher in January, November and December which occur during the summer. This increment was due to the very active of the Sun. TEC value then gradually decreases in February and there is a sudden increase in March until early of May. The lightning occurrence has appeared in Case 1 and 2 within 1-7 days with increased the TEC value of 6.3 TECU while in Case 3 and Case 4 the TEC is increased only 2.0 TECU. Significant enhancement of TEC in Case 1 is possibly due to the heating during summer season while for Case 4 it needs to be investigated further whether due to solar activity or lightning. The interaction between atmospheric lightning and TEC is important for studying the coupling process between the lower and upper atmospheres.

## ***From solar cycle 23 to solar cycle 24: Twelve years of ionospheric scintillations measurements at Ny-Ålesund (Svalbard Island)***

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INGV is operating a network of GNSS (GPS, GLONASS, Galileo) receivers, especially modified to monitor the perturbations of the high latitudes upper atmosphere. In particular, the first GPS receiver was installed in 2003 at Ny-Ålesund (Svalbard Island, 78°55'30"N 11°55'20"E). The combined analysis of the scintillations parameters (S4 and  $\sigma_{\square}$ ) measured by INGV receiver, together with the calibrated TEC derived from IGS stations installed at the Svalbard Islands since 1993, gives the opportunity to study the behaviour of the high latitudes ionosphere during the different phase of a solar cycle. With the aim to derive the long-term trend of the behaviour of the ionospheric irregularities driving L-band scintillation and to study on different time scales the external forcing effects on the ionosphere, non-linear data analysis method, the so-called Hilbert-Huang transform (HHT), is applied. HHT is an adaptive technique based on the Empirical Mode Decomposition (EMD) and on the Hilbert Spectral Analysis (HSA), capable to produce physically meaningful representations of data related to non-stationary processes as the fluctuations of the GNSS signals caused by small-scale ionospheric irregularities. Differently from other spectral techniques, such as Fourier transform, HHT is able to provide both the amplitude and the frequency of each component as functions of time. In this paper, the application of EMD on both TEC and scintillations long time series is presented with the scope to infer the relationship between the physical processes ruling the morphology of the high latitudes ionosphere and the amplitude and phase scintillations on GNSS signals.

## ***Investigation of MSTIDs at midlatitude by GNSS and ionosonde***

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In these work we are focuses on both horizontal and vertical structure of MSTIDs. For MSTIDs latitude and longitude dynamics, two dimensional perturbation TEC (first usage by A. Saito and S. Fukao, 1998) maps (TEC maps) observed by GNSS reviewer network are used. Our ground GNSS (GPS and GLONASS) network consists of nearly 150 reviewers. For MSTIDs investigation we use only 60 reviewers with distance between them ~30 km. The TEC maps resolution was increased due to the inclusion of GLONASS data. Some features of the GLONASS system were taken into account in construction of TEC maps. Their spatial resolution is 0.15 latitude x 0.15 longitude and temporal resolution is 30 seconds. The vertical structure of MSTIDs observed by ionosonde «Cyclon» with 1 minute temporal resolution and height resolution ~300 m. The minute temporal resolution of ionosonde allows us to watch on MSTIDs height dynamics. The GNSS and ionosonde coordinated observations are needed to clarifying the characteristics of MSTIDs and correct interpretation of occurrence reasons.

## ***The software defined radio approach to ionosphere monitoring using GNSS: multiple receivers at the price of one***

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Professional and commercial hardware GNSS receivers have been successfully exploited for ionosphere monitoring since years. In particular, Ionospheric Scintillation Monitoring Receivers (ISMRS) are commercial devices specifically designed for monitoring ionospheric events affecting GNSS signals. Nevertheless, recent trends in GNSS receivers implementation also consider Software Defined Radio (SDR) as a valuable technology.

SDR refers to an ensemble of hardware and software technologies that enable re-configurable radio communication architectures. Dedicated hardware components are realized in software, either on programmable platforms (high-performance general purpose processors) or on re-configurable hardware, like FPGA, DSP, microprocessors or ASIP).

With respect to commercial hardware tools, SDR receivers allow to access intermediate and low level signal processing; therefore, they offer to the user a larger subset of observables. This fact yields higher flexibility and re-configurability and, in turn, enables the possibility to design and implement innovative ionosphere monitoring techniques.

The most common architecture of a GNSS SDR receiver can be split in two blocks:

- A GNSS antenna and a Radio Frequency (RF) front-end, which acts as a data grabber; the GNSS signal is received, pre-conditioned, analog-to-digital converted, and finally raw GNSS samples are stored on mass memories for further processing.

- A signal processing stage, which can process the stored data, either in real time or in a post-processing phase. This is the actual stage of the receiver which is SDR implemented.

The implementation by means of the SDR approach adds flexibility to the implementation of the whole monitoring station. In fact, when using commercial GNSS receivers, only the storage of post-processed data is possible, such as ionospheric data and outputs of the correlation stages. By means of the SDR implementation, the two different blocks can operate independently during monitoring operations. Raw signal samples collected on site can be transferred exploiting external memories and then post-processed, either by using different configurations and architectures of the receivers (e.g. loops bandwidth or order), or by implementing techniques and innovative algorithms tailored to ionosphere monitoring.

This feature makes the approach equivalent to a plethora of receivers, the performance of which can be replicated changing the configuration of the software architecture.

Last but not least, even considering the hardware cost for the front-end section, the solution is cost effective, especially when considering the possibility to mimic the behavior of different receiver architectures and the possibility to replay scenarios for significant atmospheric events by means of advanced signal processing algorithms (for example for multipath and interference removal).

The effectiveness of the architecture has been proved in several installations at equatorial regions, and lately by the installation of two data collection systems designed and realized for the purposes of the DemoGRAPE project in two Antarctica research stations: the Brazilian station Estação Antártica Comandante Ferraz (EACF), and the South African Antarctic base SANAE IV.

During the first months of operation, significant events have been observed, and the software processing has been able to provide values for the scintillation indexes S4 and  $\phi_{i60}$  with the quality of a Septentrio PolARxS PRO ISMR.

## **S19. Antarctic volcanism in space & time – magmatic, tectonic and palaeoenvironmental aspects & linkages**

### ***An evaluation of geothermal flux along a subglacial volcanic construct in the Executive Committee Range***

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Marie Byrd Land (MBL) is an area of active volcanism and elevated topography within the West Antarctic rift system (WARS), a Cretaceous through Cenozoic area of continental extension characterized by thin crust mostly below sea level. The landward sloping topography of WARS makes the West Antarctic Ice Sheet (WAIS) that lies within it, susceptible to marine instability and potential collapse, which models hypothesize to have occurred repeatedly in the past.

Elevated geothermal flux represents a critical yet poorly constrained boundary condition and potential threat to the stability of WAIS. Anomalously high geothermal flux has been reported at the WAIS Divide ice core drilling site and Subglacial Lake Whillans, which is consistent with estimates in the Thwaites Glacier catchment from airborne radar based techniques. New receiver function model results have also revealed a significant thermal anomaly along the Bentley Subglacial Trench and a second anomaly extending to 200 km depth centered beneath Mount Sidney in the Executive Committee Range (ECR) in MBL. Together, these observations suggest that elevated geothermal flux characterizes large sectors of WARS.

Subglacial volcanic activity has been recently documented along the ECR, where a swarm of deep long-period earthquakes was registered in 2010 and 2011 by the POLENET seismic network. DLPs occur beneath active volcanoes due to deep magmatic activity and therefore provide strong evidence of ongoing volcanic activity along the southward end of the Executive Committee mountain range, consistently with the Range north-south activity progression in the Miocene through Holocene epochs.

The swarm of DLP events were sourced ~25 km below a subglacial topographic and magnetic high, as shown by an airborne profile collected during the first season of the Geophysical Investigation of Marie Byrd Land (GIMBLE I) project, located ~ 5 km to the east of the swarm center. MBL was further surveyed as part of the second season of GIMBLE (GIMBLE II, 2014-2015), during which airborne profiles were flown directly above the DLP swarm center to collect airborne data over the hypothesized subglacial volcanic edifice.

Although MBL is topographically above sea level, subglacial volcanic activity and elevated geothermal flux in the region can still play a role in the stability of the WAIS by providing melt water to the surrounding low lands, lubricate the base of the ice sheet, and affect flow. Here we use the GIMBLE II airborne radar data and apply a newly developed radar technique that uses radar basal echo strength and a subglacial water routing model, to evaluate geothermal flux over the ECR subglacial volcano. This technique has already been adopted over Thwaites Glacier catchment and is adapted here for application in MBL. Ultimately our results will provide much needed basal heat flux constraint to ice models currently used for predictions of ice sheet response to climate change and contribution to sea level change.

## ***Evidence of an active shallow volcanic source at Mt Melbourne Volcano (Northern Victoria Land) and future perspectives for its monitoring***

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Physical volcanology researches aimed at studying Mt Melbourne's internal dynamics began in 1988 within the framework of the Italian PNRA (National Program of Research in Antarctica). A tilt network of 5 permanent continuously recording stations was installed in 1988-89 and a seismic network in 1990. Tilt signals have been recorded on Mt. Melbourne Volcano since early 1989 and up to 2004 by a permanent shallow borehole tiltmeter network. We focused our observations on long-term tilt trends that at the end of 1997 showed coherent changes at the three highest altitude stations, thus suggesting the presence of a ground deformation source whose effects are restricted to the summit area of Mt. Melbourne. We inverted these data using a finite spherical body source thereby obtaining a shallow deflation volume source located under summit area. Ground deformation observed corroborate the hypothesis that Mt. Melbourne volcanic edifice has an active dynamics, suggesting the desirable development of multidisciplinary monitoring.

In the light of it, recently ICE-VOLC (multiparametric Experiment at antarctica VOLCanoes: data from volcano and cryosphere-ocean-atmosphere dynamics) project has been approved in the PNRA framework. The main aim of this project, involving 26 researchers and technicians from Istituto Nazionale di Geofisica e Vulcanologia of Catania and Palermo, and from University of Perugia, is to assess the state of health at first of Melbourne and secondly of Rittmann, and the investigation of their dynamics by acquisition, analysis and integration of multiparametric geophysical, geochemical and thermal data. Complementary objectives include (a) investigation of the relationship between seismo-acoustic activity recorded in Antarctica and cryosphere-ocean-atmosphere dynamics, (b) evaluation of the impact of volcanic gas in atmosphere, and finally (c) dissemination of the project outcomes.

Monitoring,

## ***Local seismicity in the vicinity of Mt. Melbourne in Terra Nova Bay, Antarctica***

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The first Korean seismic network, KPSN@TNB, consisting of four broadband seismic stations, was installed during the Comprehensive Environmental Evaluation of Jang Bogo Station, Antarctica, in January 2011. Continuous data were retrieved from 2011 through 2013, although abnormally high sensor currents were observed in the data from stations KP02 in 2011 and KP03 between 2011 and 2013. From the continuous data from 2012-13, over 100 seismic events were detected inside of the KPSN@TNB, and the events were divided into two groups by their locations; one is on Campbell Glacier (Group1) and the other is around the summit of Mt. Melbourne (Group2). The Group1 events have occurred on where the glacial speed is over 250 m/yr. We found low frequency volcanic events from the Group2. This is preliminary result and we will complete this study by adding the newly acquired continuous data during 2015-16 summer Antarctic field work.



## ***Petrogenetic overview of Mount Morning eruptive centre and the Erebus volcanic province, Antarctica***

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Half a century of study reveals a complex petrogenesis to Cenozoic volcanic rocks of the Erebus volcanic province (EVP), Antarctica. The EVP rocks are part of the geographically wide-spread McMurdo Volcanic Group that stretches from at least Northern Victoria Land, south to Mount Early (c. 85° south). Eruptive centres at Ross Island, White Island, Mount Morning and in the foothills of the Transantarctic Mountains (e.g. Foster Crater) are particularly well studied. At Mount Morning, two volcanic lineages are identified, an older (at least 18.7-11.4 Ma), mildly alkalic nepheline- or quartz-normative 'Mason Spur Lineage' and a younger (at least 6-0.02 Ma) nepheline normative, strongly alkalic 'Riviera Ridge Lineage'. Both lineages evolved by fractional crystallization from nominally anhydrous parental magmas. This is distinct from volcanic lineages evolved from a hydrous mantle and where kuersutite is present on the liquid line of descent, as seen, for example, at Mount Erebus.

Trace element and Sr-Nd-Pb isotopic ratios from volcanic centres across the region are also distinct, suggesting a deca-kilometre-scale mantle H<sub>2</sub>O, trace element and Sr-Nd-Pb isotopic heterogeneity. Refertilisation and metasomatism processes have affected the lithosphere across the province. Carbonatite, N-MORB and alkalic melts have been proposed and Mount Erebus lavas record an end-member HIMU mantle component on U/Th and <sup>230</sup>Th/<sup>232</sup>Th versus Pb isotope plots.

Primitive lava isotopic ratios tend to lie along a mixing trajectory between mantle end-member components DMM and HIMU. An enriched mantle component is evident at White Island and Mount Morning (EMI and EMII) and some pyroxenites at Mount Morning share trace element and isotopic characteristics with eclogite. Despite this complex regional history, oxygen fugacity  $\Delta\log fO_2$  values averaging -1 FMQ at Mount Morning (from Mössbauer spectroscopic measurements), overlap with the global median in rifted settings (-0.9 FMQ).

The younger basanites in the province (equivalent to the Riviera Ridge Lineage at Mount Morning) contain numerous mantle and crustal xenoliths. The peridotite types include spinel lherzolites, harzburgites and rare dunites, and rare plagioclase-bearing spinel lherzolites, which are thought to have formed via metamorphic reaction and refertilisation processes. Pyroxenite and crustal xenoliths are also found throughout the province and geothermometry on these rocks show an atypically hot geotherm of 50-100 °C/km in the EVP, which may be caused by advective heat transfer from melt refertilisation over the past 24 Ma or more. Study of McMurdo Volcanic Group rocks from Northern Victoria Land has traditionally been well advanced compared to the work published on the EVP. The major advancements in the understanding of the petrogenesis of the EVP means that, perhaps for the first time, it is possible to consider the petrogenesis of the McMurdo Volcanic Group as a whole.

## ***Preliminary results of regional volcano - Tectonic activity from hydroacoustic monitoring installed near Balleny Islands***

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Ocean hydrophones can often detect smaller and more numerous deep-ocean earthquakes than land-based seismic networks and generally provides well constrained event locations because of the optimized hydrophone array geometry relative to oceanic plate boundaries. A joint KOPRI and NOAA/PMEL scientific expedition was conducted to identify seismicity in the vicinity of the Balleny Islands. One goal of this project is to detect acoustic signals (earthquakes and volcanic tremor) associated with submarine volcanic activity in the Balleny Islands because the Balleny Islands are a series of subaerial and submarine stratovolcanoes that have been erupting, intermittently, since they were first discovered by whalers in 1839. Also the Balleny Islands appear to lie on the offshore extension of the West Antarctic Rift System.

Five hydrophones were moored neighboring the Balleny Islands during the R/V Aaron cruise of KOPRI in January 2015. Recovery of the hydrophones was conducted in March 2016. Recovered data contain over one year records of seismic events. We are presenting preliminary results of distribution of earthquakes recorded in the hydroacoustic mooring systems.

## ***Volcanic structures and flexure of the lithosphere in the West and Central Scotia Sea***

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The seafloor is characterized by a large number of seamounts, most of them are volcanic. These structures are useful for studying the flexure of the lithosphere and help to describe the regional oceanic evolution. This work focus on the study of volcanic structures (VS) located in the Scotia Sea, between South America and Antarctica, providing new insights into the geodynamic of the area. Many volcanic structures have been found in this region and most of them are located in the West Scotia Sea towards its boundaries. The main objectives of this research are to characterize the upper structure of the lithosphere, determining the flexure based on elastic plate model and to calculate the elastic thickness of the lithosphere ( $T_e$ ). For that, we have combined multibeam bathymetry data, multichannel seismic data, gravity and magnetics. The gravity models show that the lithosphere is deformed by the VS following a pattern of continuous plate flexural model. The maximum deflection of the base of the lithosphere is 14 km beneath the VS.  $T_e$  values, obtained from the different models, are low (between 1 and 4 km) for the age of the oceanic crust (around 22 Ma) at the time of loading according to equation  $(2.7 \pm 0.15) \sqrt{t}$  or 450 °C isotherm, but consistent with the size of the load and the flexural parameter. Additionally we found that the VS are located overlying the recently proposed asthenospheric channels in the Scotia Sea. Finally, the results of elastic thickness and magnetic anomaly studies allowed us to estimate the origin of VS associated with the eastward Pacific upper mantle outflow in the Scotia Sea. Also, the VS behave as barriers for the deep water masses of the Antarctic Circumpolar Current, which control the sedimentary processes of the region.

## **S26. Effects of sea-ice changes and ocean warming on marine ecosystem structure, functioning and services**

### ***Dinoflagellate dynamics in Potter Cove, King George Island, Antarctica, over a 14 months period.***

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The diverse and ubiquitous group of dinoflagellates is often ignored in studies addressing climate change impacts on coastal Antarctic protists. Our study focused on the dynamics of dinoflagellate as well as overall eukaryote community structure in surface waters of Potter Cove, King George Island, West-Antarctic Peninsula. This cove is strongly affected by glacial meltwater input during late spring, summer and early autumn. Samples were collected and environmental parameters quantified between November 2007 and February 2009 on a weekly to monthly basis, at three locations that differed in their distance to the Fourcade Glacier. Samples were analyzed using 18S rRNA PCR amplification, Denaturing Gradient Gel Electrophoresis (DGGE), clone libraries and genetic sequencing. Locations near the glacier showed a higher (variability in) suspended particulate matter influx, lower phytoplankton biomass [measured as chlorophyll-a (chl-a) concentration] and distinct eukaryote and dinoflagellate communities. The dominant factor in determining community composition variance was 'Location' for the eukaryote and 'Season' for the dinoflagellate community. Diversity peaked during spring and summer in the eukaryote community (preceding the [chl-a] peak) and during summer and autumn in the dinoflagellate community (coinciding with a [chl-a] peak). The dinoflagellate community differed between spring/summer and autumn/winter. Whereas athecate species were abundant throughout the year, relative thecate species abundance showed a distinct peak during autumn.

## ***Dynamics of landfast sea ice of Atka Bay (East Antarctica) and its relevance to an emperor penguin colony***

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Due to climate change the landfast sea ice of Antarctica undergoes regional differentiated alterations. Emperor penguins (*Aptenodytes forsteri*) that breed on Antarctic landfast sea ice might be affected by this process. To assess possible effects on an emperor penguin colony in Atka Bay (East Antarctica), local extent changes of landfast sea ice have been studied for the period 1973/74 - 2015/16 aided by satellite images.

Landfast sea-ice extent was measured for each month from September to April in the above study period. For the period 2000/01 – 2015/16 the record is complete, while there are data gaps in the previous seasons due to the lack of suitable satellite images. In the study area ice breaks up from December to January, reaching its minimum in February and March while the Atka bay freezes again in April. No significant year-to-year ice-coverage trend was recorded by the available data until season 2010/11. Thereafter a distinct increase of ice coverage was recorded. Observations of future seasons will show whether this increase is an indication of changing climatological conditions or a singularity e.g. caused by a large grounded iceberg that blocked the northern part of the bay from August 2012 to July 2013.

Analysis of the spatio-temporal pattern revealed the existence of a robust ice zone in the southwestern part of Atka Bay. In robust zone, landfast sea ice breaks up later in the season and forms again earlier. This prolongates the time span of solid ice cover in this part of the bay. By delineating the area used by the penguins as breeding site since 1984 it was found that the colony predominantly uses the robust zone even if the whole bay is frozen. Available database evidence does not support short-term threat to emperor penguin colony of Atka Bay due to changing dynamics of landfast sea ice.

## ***Food availability and energy storage in Antarctic benthic communities: integration of processes through the trophic markers in the Weddell sea***

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Food availability is an important parameter to understand the distribution and population structure of benthic organisms, their capability to store energy as well as carbon fluxes to the benthic realm. In the Antarctic Ocean, a complex three-dimensional structure composed by suspension feeders depends on a strong seasonality. Part of the vertical flux of organic matter remains fresh for several months after the spring-summer phytoplankton blooms forming food banks on the sea floor. In order to understand how climate change might influence carbon fluxes and potential changes of benthic communities on larger scales it is helpful to study the available food sources and effects on the benthos using integrative tools allowing spatial and temporal comparisons. Combining trophic markers (e.g. stable isotopes, free fatty acids, protein-lipid-carbohydrate balance, C/N ratios, etc.) may be considered an excellent tool to understand such processes and the potential changes that may continue due to the rapid shift of the climate change induced physical and chemical conditions. These markers may be used to analyse seston availability in the water column and in near bottom water layers, the sedimented particulate organic matter quality and quantity, and, in the organisms of the benthic communities, their relationship of energy storage with reproductive or growth periods. The combination of all these approaches may give some cues to understand the above-mentioned fast changes in the composition of the seascape, as well as the changes in the dominance of key organisms. The aim of this presentation is to show in different areas of the Weddell Sea (Antarctic Peninsula with King George Island, Bransfield Strait and Larsen A, B, C embayments, the Eastern Weddell Sea Shelf, Bouvet Island) and in different seasons how the trophic markers may help to understand trophic ecology and carbon fluxes in the Southern Ocean. Such comparisons of latitudinal, longitudinal and seasonal patterns of the trophic markers allow to understand the impact on the energy storage capability of benthic organisms depending on their trophic strategy and how the organisms will adapt to the fast changes posed by climate change.

## ***Physiological effects of iron limitation on diatom-dominated phytoplankton assemblages in the Antarctic Peninsula region***

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The Southern Ocean is generally a high-nutrient and low-chlorophyll (HNLC) area, primarily due to the limitation of micronutrients, such as iron. Nevertheless, microphytoplankton may bloom if iron is available and if light and mixing conditions are appropriate. To investigate the effects of iron limitation and high irradiance on the physiological and ecological adaptations of phytoplankton assemblages, a 6-day deck incubation experiment was conducted during the austral summer of 2013, using phytoplankton populations from the upper mixed layer of the waters within the Bransfield Strait. After sampling the water (iron clean protocol), experimental units were maintained in on-deck incubation in triplicates for 6 days with 3 treatments (natural sea water, Fe-repleted and Fe-limited). Fe-repleted treatment samples were inoculated with FeCl<sub>2</sub> (1nM) while Fe-limitation was simulated with an iron-binding agent (desferrioxamine) that reduces iron availability ten-fold. The values of chlorophyll a, biovolume, PSII maximum quantum efficiency (Fv/Fm) and relative electron transport rate (rETR) were measured in all treatments. After six days, chlorophyll a in the Fe-limited treatment increased with a lower proportion (6.4 mg m<sup>-3</sup>, compared with the Fe-repleted treatment which increased 10.2 mg m<sup>-3</sup>) and presented Fv/Fm values of 0.55 ±0.02 (compared with the Fe-repleted treatment which presented 0.62 ±0.02). Microscopic analysis showed the preponderance of larger diatoms in the Fe-repleted treatment, while smaller diatoms dominated in the Fe-limited, in particular *Pseudonitzschia* species. Although desferrioxamine inhibited biogenic iron uptake in the Fe-limited treatment, phytoplankton continued to grow, but with lower responses of the measured physiological parameters, indicating the first signs of iron limitation. Expressive phytoplankton growth in all three treatments indicates that the waters of the study region in the Bransfield Strait were not limited by the micro-element iron.

# ***Spatial variability in photophysiology, primary production rates and phytoplankton community across the western Antarctic Peninsula in 2013 late summer***

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Primary production records of Southern Ocean present rising signs, mainly observed at Antarctic Peninsula, where the most pronunciation of sea/air warming has been noticed. During late summer of 2013, a cruise was conducted in the Bransfield Strait (BS) and Gerlache Strait (GS) in the western Antarctic Peninsula (wAP) to access primary production levels. The sampled area was subdivided into 3 sub-regions: the Transitional Bellingshausen Water (TBW-dominated sub-region), Transitional Water with Weddell influence (TWW-dominated sub-region), both occupying the Bransfield Strait (BS), and a mixture of both water masses in Gerlache Strait (Gerlache sub-region). Comparisons between sub-regions have shown, on average, that chlorophyll a (Chl a) concentration ( $0.65 \text{ mg m}^{-3}$ ) was lower and upper mixed layer depth (ZUMLD =  $52.62 \text{ m}$ ) was deeper in TWW-dominated waters, whereas intermediate Chl a ( $1.22 \text{ mg m}^{-3}$ ) and lower ZUMLD ( $22.33 \text{ m}$ ) values were found in the TBW-dominated sub-region and moderate ZUMLD ( $36.46 \text{ m}$ ) and higher Chl a values ( $1.58 \text{ mg m}^{-3}$ ) were found in Gerlache sub-region. A Canonical Correspondence Analysis highlighted the dominance of diatoms coupled with higher photosynthetic carotenoids per total pigments ratio (especially fucoxanthin) in TBW-dominated sub-region. On the other hand, higher photoprotective carotenoids per total pigments (particularly alloxanthin of cryptophytes) and lower ZUMLD in Gerlache. Primary production rates derived from PAM (Pulse Amplitude Modulate) fluorometric technique agreed very well with  $^{14}\text{C}$  measurements. Higher specific chlorophyll a primary production rate was found in the TWW sub-region ( $1.91 \pm 1.22 \text{ mgC}\cdot\text{mg Chl a}^{-1} \text{ h}^{-1}$ ). There were no considerable differences in photosynthetic efficiency (Fv/Fm) between the sub-regions. In short, a large spatial variability of physical features in water column was observed that significantly affected the late summer phytoplankton dynamics and, consequently, their photophysiological resilience in the wAP.



## ***Wintertime sea ice controls on summer stratification and productivity at the Rothera Time Series, western Antarctic Peninsula***

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Strong links are found between phytoplankton bloom strength and sea ice cover the previous winter at the Rothera Time Series (RaTS) on the west Antarctic Peninsula (Ryder Bay, off Adelaide Island, 67° 36' S). The strength of the bloom has varied considerably (summer median 2-12 mg m<sup>-3</sup>) with the low years being closely associated with a reduction in summer stratification (but not an increase in summer mixed layer depth) following deep mixed layer depth formation during periods of low sea ice the preceding winter. Winter sampling shows deep mixed layer depths associated with wind-driven mixing of the exposed sea surface, rather than brine rejection, as deep salinities decrease strongly with mixing. This reduction in stratification in the following spring and summer preconditions the upper 100m to increased mixing. Changes in surface heat uptake confirm that there is indeed significantly more vertical mixing after low ice winters.

The pattern is repeatable through the time series but isn't driven directly by a reduced average light availability. Due to reduced self shading there is more light in low chlorophyll years, though with greater variability due to increased vertical mixing. This variability in conditions, together with dilution events, is likely a key driver in the decline in bloom strength. Though it is not possible to infer the precise mechanisms from the time series data, further intensive sampling is under way investigating various controls, including iron, viruses and light variability.

## **S33. The role of humanities and social sciences in Antarctic studies**

### ***"The role of universities in strengthening Malaysia's interest in Antarctica and southern ocean"***

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Governance mechanism of the national Antarctic program is variable depending on the national interest and capability to undertake Antarctic research activities. Therefore, the country has kept an open mind about the best approach to structure and institutional its Antarctic programme which involves management and financial resources. Notably, university is a part of institutional stakeholders that play significant roles in strengthening the national interest in the Antarctic region since research, teaching and community engagement are its core business. The aim of this study is to identify Malaysia's governance mechanism in strengthening national interests on Antarctica and Southern Ocean. Malaysia's local universities and its researchers have played crucial roles in strengthening the development of Malaysia Antarctic Research Programme (MARP), even it works with limited logistic and facilities with a minimal amount of research funds. To move forward, Malaysia needs to strengthen the Quadruple Helix Model (Academia-driven Living Lab) cooperation in order to ensure equitable participation by a wide range of universities and other institutions, relevant government agencies and industries as well as the corporate sectors. The strategic cooperation will strengthen the national interest and investment towards Antarctic science and consequently, will accelerate the polar science initiatives as a key research contributor of Knowledge-Based Economy for Malaysia.

## ***A new governance: International environmental protection policy incorporating science diplomacy from Antarctica***

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The main influence of globalization processes the world community, into a single holistic system and this is a good approach to dealing with rampant environmental issues around the globe. At the same time, there are no one single governance mechanisms adequate to deal with this holism approach. Global governance cannot emerge spontaneously to deal with the global issue of environmental protection. We need to rethinking globalization processes and focus on subjectivity and pay attention as to avoid the "Tragedy of the Commons". Through globalization, science diplomacy is our available foundation tools to secure a sustainable future, the best lesson is from Antarctica, and the best treaty representing successful global cooperation on science interfaced with environmental policy is through the Antarctica Treaty 1959 and its 1991 Protocol. In Antarctica, each official governmental mission is dual: to promote science and peace, which means, in this case, avoiding weapons or military proliferation and ensuring international cooperation and consensus. Therefore, the purpose of this paper is to examine whether science diplomacy from Antarctica that promoting several principle on environmental protection incorporating them into the new generation of International Environmental Protection Policy. In the past century, many environmental regimes and action plan negotiated, the prominent gaps in one global international environmental policy framework remain open. The existing framework available are just a collection of numerous treaties, each addressing relatively discrete global or regional environmental issues. The influence of scientists on environmental policymaking put the scientists' role as the neutral advisor which changes over the three phases of the policymaking process. The first phase is the agenda-setting, the second is the legislation phases, and the implementation phases. In the first phases, the scientists face more pressure to uphold the ideal of objectivity engage in advocacy and persuasion. In the later phases, scientists play the role of neutral advisor. Regardless of their accuracy, scientific facts cannot conceal the complexity of decisions that must include other issues and take into account State own interest and priority agendas. One must acknowledge the fact that in the world community, through their laws and policy targeting, first of all, their profits and self-interests welfare. Each State Governments must then, bring a new toughness to international environmental law and make serious efforts to address the underlying drivers of environmental deterioration and improve the overall economic and political context that determines whether the legal regimes works or fails. The new generation policy on environmental protection, of course, will need an institution to govern it. There have been lots of proposed schemes and solutions to the global environmental governance "problem." These range from the reform of UNEP to the creation of a World or Global Environmental Organization or "clustering" the secretariats by specialty under one organization. In the conclusion, it is recommended that with The New International Environmental Protection Policy, the governing institution may remain with the State government.

# ***Antarctica as Science, Art and Politics Laboratory for humanity's balancing act***

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## **Purpose:**

The Antarctic Treaty of 1959 devotes the continent as a reserve for peace and science. A study of Antarctic science, history and culture reveals it as a physical and metaphoric place for nations to explore and create models of inquiry, innovation and cooperation. Antarctica is an inspiration and a harbinger.

Ptolemy imagined Antarctica in 150AD certain there had to be a counterpoint southern continent to the northern land mass. Antarctica wasn't sighted perhaps until 1821.

With no indigenous population but an introduced species of humans some 100 years ago, Antarctica is the location of significant earth and physical studies as well as a human laboratory where people weave unique geopolitical relationships and activities.

Antarctica's stakeholders must balance national interests and common interests. How they do it is instructive for social scientists to understand human behaviour and potential for increased equilibrium in ecosystem and human security.

## **Results:**

Early polar explorers sought personal gain and national interests but also modelled the pursuit of scientific studies and collaboration in challenging circumstances.

Scientists sample the planet's past climate in Antarctica's ancient ice core archives and tell us about human impact on its geology and ecosystems.

Antarctica's short history tells us how scientific inquiry has also had a positive impact on global activities.

The Antarctic Treaty that followed the International Geophysical Year (1957-8) became the basis for a body of international law exemplifying common interests and peaceful use of international space beyond national jurisdiction (Paul Berkman).

At Halley Station scientists discovered depletion of the earth's ozone in 1985. Scientific and political action resulted in the 1987 Montreal Protocol controlling ozone depleting chemicals.

Arctic explorer Fridtjof Nansen contributed to modern oceanography, shared his learnings from the Inuit on polar survival and was an honoured humanitarian. He helped create the League of Nations and created the Nansen Passport in 1922 that was issued to 450,000 stateless people.

A recent art project mimics, perhaps unconsciously, Nansen's passport. Lucy and Jorge Orta's Antarctic World Passport calls people to jointly tackle concerns defining the 21st century such as biodiversity and climate change through obtaining a symbolic Antarctic citizenship.

One of artist Anne Noble's maps is an image of a board game produced by Shell Oil commemorating the Hillary/Fuchs Antarctic 1958-9 expedition. It's an ominous message about past and future designs on Antarctic resources.

## **Conclusions**

Antarctic humanities and social sciences include examples of how humankind can cooperate and problem-solve as well as falter. Science and art are a tool of diplomacy.

Antarctica's cultural history of 'constructed' heroics at the 'last frontier' is now a 'mediated location where humans test the limits of biopolitical management of population and place.' (Elena Glasberg)

The continent's current 'borderless' political framework illustrates how "humanity is so marginal and vulnerable that narrow nationalism appears both comic and inept." (Tom Griffiths). We have yet to discover how to behave better in urbanized, increasingly 'walled' and crowded places.

While we continue to study Antarctica, it behooves us to remember Antarctica's first recorded manifestation - a place of balance.

## ***Picturing Antarctica – Contrasting visions of the state of an environment***

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More often than not, camera users capture Antarctica as pristine wilderness – a view from which the tourism industry benefits and to which others are attached, perhaps no more so than in the year that Antarctic Treaty Parties commemorate the 25th anniversary of the Madrid Protocol.

Against this backdrop, is there room for a less than picture-perfect vision of conservation success?

Experiential evidence suggests that plastic and other debris is so ubiquitous at some Antarctic locales that those venturing south are becoming ambivalent to its presence. How best can social scientists and other researchers working in the humanities engage on this change?

## ***Visual representations of Antarctica in contemporary fine art: Conveyed values and societal impacts.***

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Over the past century Antarctica has been a fertile source of inspiration for explorers, scientists, writers and artists who have endeavoured to define and describe this vast white continent. The last 50 years have particularly seen an increasing interest in Antarctica as a playground for contemporary art practice, through artists' independent projects, but also the establishment of residency programs, governmental-related initiatives, etc.... Antarctica fascinates, plays with imagination and reality, and is a growing source of inspiration for many artists.

My research is a critical review of contemporary art as a mechanism to communicate/express values in relation to Antarctica.

In most cases, fine art production conveys, consciously or not, values intimately linked to artists' emotions, mindset and sensitiveness. Photography, video, painting, sculpture, installation through figurative, conceptual or participative forms of art have indeed contributed to express values (human, economical, political,...) that can be assessed as per the following categories:

- Aesthetics;
- Wilderness;
- Scientific and technical developments;
- Supranationalism, peace and human rights;
- Historical memory;
- Imagination and creativity.

Some more hidden values, bearing some more controversial connotations, can also be identified, such as political propaganda for example.

My research is also an attempt to understand the mechanism behind the increasingly relevant role of contemporary art in creating greater awareness about issues related to human activities in and engagement with Antarctica.

How these values conveyed by Antarctic-related fine art initiatives can provide insights contributing to arise awareness about societal issues ? Through which key fundamental process such values will initiate a change in many different areas of our organized societies ?

The study tries to assess the direct and/or indirect impacts of Antarctic-related fine art artistic production with respect to environmental, economical, social and cultural contemporary issues, such as preservation of the environment, consciousness of global climate change, defence of the last territory preserved from conflicts or mineral resource exploitation,....

## ***Well-tempered listening: Historical and creative interpretations of Antarctic experience***

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As the grand-daughter of someone who has been called "The father of Antarctic Geology", H T Ferrar, I am seeking to find out about the continent and his place in it by studying and researching, although I am by no means a natural or conventional academic.

My BA degree is in Social Anthropology and I am a qualified Maths teacher, yet I have spent most of my working life teaching the violin to small children in schools. The bridging of disciplines seems to be my calling. I have a six-minute film, made by a fellow-student on the PCAS course, showing me playing my violin in the "Discovery" hut at McMurdo. This would introduce the discipline of musical free improvisation to the delegates. Just as we all have our own "Antarctica", so we have our own antennae - our means of exploration of inner and outer worlds and the liminal states where these worlds interact.

The other day a rocket scientist friend described to me a state I'd often experienced but never heard anyone else speak of. He said he'd been in a lecture and begun to drift, as he was tired, and the content of the lecture began to address the story he'd been reading. There are moments when the inter-connectedness of everything becomes apparent. This is what makes it possible for me to commune with the long-departed crew of "Discovery" through playing my violin in their hut a hundred years later, for example, and in general, what makes any form of artistic interpretation relevant, appealing or even possible.

Some more tangible results arrive from the putting together of previously un-joined stories: a seaman called William Heald saved HT Ferrar's life in 1902, and the way he did it fed into Shackleton's famous crossing of South Georgia, which in turn allowed the rescue of the 22 men stranded on Elephant Island. I discovered this in the course of my continuing researches at the Scott Polar Research Institute in Cambridge.

I am transcribing my grandfather's archive so that it can be available online. Just about one afternoon a week I immerse myself in 1901-4. From this immersion, over several years, I'm beginning to experience a wealth of familiarity which is allowing artistic interpretations, stories and dreams to emerge.

My purpose in presenting my work is to demonstrate the validity of artistic interpretations and connections. Hopefully the result would be a greater awareness of the roundedness of our humanity and the conclusion, that exploration is possible, both inner and outer, by whatever means we have at our disposal.



## **S34. Footprints in Antarctica, and Antarctica's footprint: perspectives from history**

### ***Human history coincides with science: launching a series of publications by the Antarctic Legacy of South Africa.***

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South Africa, as a founding member of the Antarctic Treaty, has a long-term track record of and commitment to undertaking oceanic, terrestrial and atmospheric research in Antarctica and the Southern Ocean. The South African Government has indicated its commitment to continued research through major financial investments in new state-of-the-art platforms, including new bases on Marion Island and in Antarctica, and an advanced research and supply vessel, the S.A. Agulhas II. These endeavours have helped to keep South African scientific research at the forefront of international research in Antarctica and the Southern Ocean..

The Antarctic Legacy of South Africa project (ALSA) commenced in 2009. ALSA is a NRF (National Research Foundation)-funded project that forms part of the South African National Antarctic Programme (SANAP), based in the Department of Botany and Zoology at Stellenbosch University. ALSA's primary role is to archive electronically historical information relating to South Africa's involvement in the Antarctic region the sub-Antarctic Islands (primarily Marion and Prince Edward Group and Gough) and at sea in the African Sector of the Southern Ocean. The period of interest extends from the heroic age of Antarctic exploration until the present day. The main aim is to create a legacy for all South Africans and the rest of the World.

The collection and curation of these materials have given the project the advantage of making contact with past and present overwintering teams at Gough, Marion and Antarctica (and their descendants) and others who have been or are involved with SANAP.

One key commitment of the project is to publish books to ensure that South Africa's Antarctic Legacy will not be lost for research. This presentation will show the importance of taking one step closer to preserving the footprints made by many South Africans –down south". The first book in the planned ALSA series is the diary of Brian Huntley, the botanist on the First Biological and Geological Expedition to Marion Island over 1965/66.

## ***Paw prints in human Antarctic history***

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Paw Prints in Human Antarctic History

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### Abstract

This paper explores the history of humans' employment of canines in scientific research and exploration in Antarctica, and the imprint this has left on both the frozen continent and the humans themselves.

In the beginning, there was a furious "dogfight" amongst scientists and explorers regarding bringing dogs to Antarctica to help in the humans' work and discovery of the unknown continent. Some, such as Robert Falcon Scott and Clements Markham, abhorred the idea of yoking the dog to do man's work, whereas others like Fridtjof Nansen and Roald Amundsen, championed the method of loading the sledge dog with the task of pulling sled loads and guiding the men to their ultimate goals. The Norwegian Carsten Borchgrevink made a trailblazing crossing over Antarctic land with sledge dogs in 1899. But many Brits, including Ernest Shackleton, would not see it so. The two camps intellectually battled over this argument, and then put their theories into practice, with Scott dismissing his dogs and employing ponies and ultimately pulling his own loads, and Amundsen putting his entire expedition's success on his dogs' canine shoulders. The dogs led him to the South Pole.

Australian, German, Swedish, Argentine, and other expeditions have also employed dogs, benefiting not only from their tireless work but also their companionship. Many diaries from expeditions during the heroic age of exploration reflect the necessity of the friendship of these dogs, and how their presence enabled the men to carry on in their work and living conditions within a harsh and isolated environment. The men carried away from Antarctica impressions of the Polar experience which included interaction with Polar dogs. Some even adopted these dogs to take back with them, bringing the Antarctic experience home through their canine companions.

Most sledge dogs were killed or lost during these Antarctic expeditions of over a century ago. Some became culinary fodder for men and dogs alike. Countless canines were swallowed by the ice – some canine skeletons perhaps are still preserved in the crevasses into which they fell during many a sledge tour.

The Madrid Protocol in 1991 brought an end to canine presence in Antarctica, limiting the alien species allowed to invade the native land to humans only. While technology and evolved thought have eased some of the burdens of humans working in Antarctica, replacing the sled dogs with modern vehicles and machinery, the companionship and partnership of dogs have not been replaced. Their imprint, only a memory now, is a significant one, and a lesson to be learned regarding the use of animals for human purposes.

## **S38. Scientific advice for policy**

### ***Development of the Antarctic protected areas: Mathematical forecast for 2020***

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This paper discusses the growing dynamics of the increasing of the amount and especially the Antarctic Specially Protected Areas (ASPAs) and the Antarctic Specially Managed Areas (ASMA). This dynamics is a reflection of the sustainable environmental imperative in the national interests of the Antarctic Treaty Parties. This dynamics is analyzed using the Richardson's model, which was used by Thomas L. Saaty for the analysis of the arms race dynamics in the twentieth century. Using this model made it possible to estimate the expected of the ASPA and ASMA amount and areas in the near future. So in 2020 it is expected to increase the total areas of ASPA and ASMA up to 103,700 km<sup>2</sup> (which is comparable to the Iceland area). The question of the accuracy increasing of the used model and the accuracy of the quantitative characteristics is discussed. The obtained quantitative characteristics will provide the policy makers and national Antarctic program managers by the additional arguments for decision-making on the further management of the human activities and nature conservation in the Antarctic. Among the general public obtained characteristics will contribute to the better understanding of the development trends of the international legal regime of the Antarctic.

## ***Eu-PolarNet: Opportunities for Antarctic research***

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Polar issues have been rising up the political agenda across Europe over the past decade since the rapid changes occurring in the Polar Regions are significantly influencing global climate with consequences for global society. As a result, the European Union and its executive body, the European Commission (EC), attribute an increasing importance to science and innovation in the high latitudes for a variety of reasons. As a first step in this direction, EC has launched a five-year coordination and support action –EU-PolarNet – Connecting Science with Society” which will work in close cooperation with the EC in the upcoming five years in shaping Europe’s polar research and policy agenda.

EU-PolarNet will establish an ongoing dialogue between policymakers, business and industry leaders, local communities and scientists to increase mutual understanding and identify new ways of working that will deliver economic and societal benefits. The results of this dialogue will be brought together in a plan for an Integrated European Research Programme for the Antarctic and the Arctic that will be co-designed with all relevant stakeholders and coordinated with the activities of many other polar research nations beyond Europe, including Canada and the United States, with which consortium partners already have productive links. Additionally, EU-PolarNet will closely cooperate with the European Commission by providing support and advice on all issues related to the Polar Regions.

## ***Network efficiency of Antarctic research stations***

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The network efficiency of Antarctic research stations reflects the actual operating efficiency and radiation area of a country's built facilities in Antarctica. The quantitative evaluation of the network efficiency is required to perfect national Antarctic strategic planning and improve the sustainable development of Antarctic scientific research. In this study, based on Multi-Criteria Decision-Making Methods (MCDM) and Network Graph Theory, the network efficiency model system was developed to quantify the station efficiency, line efficiency and then the efficiency of the whole network with aid from geographic information systems (GIS). Analytical hierarchy analysis (AHP) and TOPSIS, as two typical MCMD, were combined to quantitative evaluate the relative importance of stations and connections between stations. In AHP, through considering scientific investigation, logistic support capability and strategic layout, 15 and 6 factors (corresponding to stations and lines) were used as multiple evaluation sub-criteria to calculate their weights for stations or lines efficiency evaluation. TOPSIS gave out the rank order and relative efficiency of all the stations or lines after the index weighting. Comparisons were made between the AHP-TOPSIS results and other MCMD to demonstrate fitness-of-use of this combination. Integrating station and line efficiency, the proportion of the actual radiation area in the total network area was utilized to assess the network efficiency. By using this system, the network efficiency of Chinese, American and Russian current Antarctic research stations turn out to be 20.6%, 40.5% and 25.6% respectively, which indicates that there is not a positive connection between the number of stations and their network efficiency. This model offers a comprehensive quantitative evaluation system for decision-makers in the assessment of current facilities and subsequent layout of Antarctic facilities.

## ***Terrestrial geothermal environments: Science informing policy***

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Terrestrial geothermal environments in Antarctica are of high scientific value to a wide range of disciplines, including for example geologists, glaciologists, botanists, microbiologists, and atmospheric scientists, amongst others. Recent evidence suggests that terrestrial geothermal environments in Antarctica support unique and diverse biological communities, and have played an important role as biological refugia. This environment type has been identified as rare and relatively small in extent in Antarctica, and vulnerable to disturbance. These environments, particularly those that have not yet been visited, are at risk from introduced species, ground disturbance, or other damage by human activity if appropriate mitigation measures are not followed.

There are more than 40 known volcanoes in Antarctica. Of these, there are four known active volcanoes with geothermal habitats south of 60 degrees; Mount Erebus (including the Erebus Ice Caves), Mount Melbourne and Mount Rittmann in the Ross Sea and Deception Island, South Shetland Islands on the Antarctic Peninsula. Activities at these sites include science, media, station operations, as well as tourism, and not all sites are afforded the same level of protection.

Management tools used at geothermal sites currently include two Antarctic Specially Protected Areas (ASPAs) with site-specific protection measures, one Antarctic Specially Managed Area (ASMA 4 Deception Island) with associated general Codes of Conduct and Biosecurity Guidelines, and an interim Code of Conduct specifically applying to the geothermal ice caves on Mount Erebus. Some areas have no formal protection (e.g. other parts of Mount Erebus) and at present generally accepted guidelines have yet to be adopted for activities in terrestrial geothermal environments, including at sites not yet discovered or visited.

Recognising the need to manage activities within these environments, a stakeholder workshop was held (scientists from multiple disciplines and policy makers) to determine what form of management might be most useful to protect these environments. From this consultation and with advice from the Scientific Committee on Antarctic Research (SCAR), a Code of Conduct for Activities within Terrestrial Geothermal Environments in Antarctica was developed to establish principles and to provide practical guidance on field procedures and protocols to help maintain the unique environmental and scientific values of terrestrial geothermal sites across the continent. The draft Code of Conduct includes guidance on matters such as access to and movement within geothermal environments, camps, handling of food, waste management, fuel and energy supplies, materials and chemicals, installations and equipment, sampling and experimental sites, and reporting on activities.

The draft Code of Conduct has been distributed for the consideration by Antarctic Treaty Parties, the Committee for Environmental Protection, SCAR and the scientific community, the Council of Managers of National Antarctic Programs (COMNAP) and others before acceptance and endorsement by relevant bodies, which it is hoped will be achieved in 2016.

## ***The evolution of SCAR reports to the Antarctic Treaty on marine acoustic technology and its impacts.***

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SCAR became involved in understanding the impacts of anthropogenic noise in the marine environment in 2000 when some jurisdictions introduced severe restrictions on seismic surveys in Antarctic waters. These restrictions were a surprise to the Antarctic geophysical community because the issue arose from adverse effects caused by military sonars in low latitudes. SCAR formed a joint group between Biology, Geology and Geophysics Working Groups at SCAR XIX. The group's terms of reference were to identify the scientific issues and come up with recommendations on how to manage acoustic surveys in the Antarctic and to progress the scientific basis for management in Antarctica. The ad hoc/action group held workshops in 2001, 2004 and 2006 which produced Working and Information Papers for the ATCM. Since 2006, the amount of research going on low latitudes had reached the point whereby SCAR workshops were no longer an effective method for reviewing the field and the Action Group opted for reviews of peer-reviewed literature, the latest of which was presented by SCATS to the CEP in 2011. The SCAR Acoustics Group, while being peripheral to the main acoustics research community, has made useful contributions to the field by identifying and filling gaps in the discussion. The 2001 workshop recognised significant ignorance of basic acoustics, cross-disciplinary ignorance, whereby members of different disciplines had no understanding of each other's issues, and a lack of Antarctic-specific information. The 2002 paper addressed some of these problems. The following workshops developed a qualitative risk assessment matrix that could be used by non-specialists and that allowed identification of low and higher risk activities and tried to place the risks posed by scientific instruments in the context of other human activities such as shipping. The most recent literature review has tapped into a large body of research, most of which could not be carried out in the Antarctic, and has refined but not substantially altered the original recommendations. These recommendations can be summarised as: aim to minimise the ecological footprint of research. The field is a difficult one where hard data are few and conjecture common. Progress is likely to be through well-funded research in low latitudes but it will be slow. Also, Antarctica is different, with low levels of ship traffic and geophysical surveys but very high levels of natural noise from sea ice and icebergs. Hence, SCAR will continue to have a role in translating and filtering research for the Antarctic Treaty System.

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Two King penguins are standing on a sandy beach. They have black heads and backs with a distinctive yellow patch on their necks. Their wings are slightly out to the sides. The background is a soft-focus view of the ocean and a distant shoreline under a clear sky.

**We thank you for your valuable participation!**