2016
WCRP CliC
Annual Report

About CliC

Who we are...

The Climate and Cryosphere Project (CliC) is one of five core projects of the WMO/ISCU/IOC World Climate Research Programme (WCRP) (http://www.wcrp-climate.org) together with CLIVAR, GEWEX, SPARC, and CORDEX. The core projects work closely with the WCRP Joint Planning Staff (JPS) and other working groups of WCRP. The projects organize their work through various focussed initiatives, experiments, scientific advisory committees and panels.

What we do...

The Climate and Cryosphere project encourages and promotes research into the cryosphere and its interactions with the global climate system. It highlights emerging issues, encourages communication between researchers with common interests in cryospheric and climate science, promotes international cooperation, and highlights the importance of this field to policy makers, funding agencies, and the general public. CliC also publishes scientific papers on the role of the cryosphere in the global climate system, and recommends directions for future study.

How we work...

The CliC Scientific Steering Group (SSG) is composed of high calibre researchers and has the overall responsibility for planning and guiding the CliC science plan. SSG members are appointed by the WCRP Joint Scientific Committee (JSC), based on recommendations from the CliC SSG. Initial membership is for three years and, as a rule, two extensions of two years each may be recommended. The SSG usually meets once per year.

The CliC International Project Office (IPO) is hosted at the Norwegian Polar Institute in Tromsø, Norway. The IPO supports the SSG and the CliC community in coordinating and implementing the CliC science projects and tasks. Its functions of international communication and liaison make it the primary point of contact for those wishing to participate in, contribute to, or learn more about CliC activities.

CliC is fortunate to have a large number of leading cryosphere researchers working through regional and national programs, working groups, and expert panels.

Report prepared by Lawrence Hislop and Gwénaëlle Hamon with contributions from Greg Flato, Gerhard Krinner, James Renwick, Mike Sparrow, Sophie Nowicki, Eric Larour, Tony Payne, David and Denise Holland, Chris Derksen, Regine Hock, Ben Marzeion, Alexandra Jahn, Dirk Notz, Christina Schaedel, Ted Schuur, Don Perovich, Marilyn Raphael, Jenny Hutchings, Steve Ackley, Allen Pope, Penny Wagner, Rob Johnson, Jamie Shutler, Jenne Baeseman, Louise Newman, Martin Vancoppenolle, Bruno Delille, Jacqueline Stefels, Lisa Miller, Nadja Steiner, Klaus Meiners, Terry Prowse, Arvid Bring, Johanna Mård Karlsson, Kazuyuki Saito, Dave McGuire, Ed Hanna, Catherine Ritz, Frank Pattyn, Francisco Navarro, Inga Smith, John Fyfe, Annette Rinke, John Cassano, Andrew Orr, Rob Massom, Sanna Majaneva, Gerlis Fugmann, Maja Lisowska, and Cecilia Bitz

Table of Contents

Cover photo courtesy of Lawrence Hislop

Overview from the Co-Chairs

We are happy to share the exciting progress and achievements of the Climate and Cryosphere (CliC) community in this 2016 annual report. The report summarizes the activities and accomplishments of the past year including results from the WCRP Grand Challenge on "Melting Ice and Global Consequences".

This year has seen the completion of some important projects and the start-up of innovative new activities. The Arctic Freshwater Synthesis (AFS) was launched in March in a special issue of JGR Biogeosciences and the results were highlighted on the AGU Editor's Vox blog. Another output focusing on Southern Ocean Satellite Requirements was published in December in Antarctic Science and is intended to help in the planning of future satellite missions. An exciting new initiative on Biogeochemical Exchange Processes at Sea Ice Interfaces (BEPSII) was also launched together with the Surface Ocean - Lower Atmosphere Study (SOLAS).

CliC plays an important role in global cryosphere modelling and supports the sixth iteration of the WCRP Coupled Model Intercomparison Project (CMIP6). CliC is currently sponsoring model intercomparison projects covering snow, ice sheets, glaciers and sea ice (ESM-SnowMIP, ISMIP6, MISOMIP, GlacierMIP, SIMIP). These initiatives are the successful result of a strategy aimed at tightening the links between the cryospheric research and global modelling communities.

The Grand Challenge "Melting Ice and Global Consequences" has been moving forward on its initial focus areas. On the topic of permafrost carbon, a high-profile paper on circumpolar carbon was published in Nature Communications by the Permafrost Carbon Network – a jointly sponsored international effort. On the topic of model intercomparisons, CliC has successfully mobilized the crysopshere community in the intercomparisons projects listed above, with data requests published and analysis plans well established. Looking ahead, we anticipate these efforts will feed directly into the Intergovernmental Panel on Climate Change (IPCC) Special Report on the Oceans and Cryosphere and the full IPCC 6th Assessment Report. It should be noted that several CliC-affiliated scientists were at the Special Report scoping meeting held in Monaco in December, 2016.

Another important link we have in the World Meteorological Organization (WMO) is to the Year of Polar Prediction (YOPP) initiative which will be entering an intensive Polar observation phase from mid-2017 to mid-2019. CliC supports two fellowships that help connect CliC priorities in YOPP. In February 2017 we also look forward to the International Symposium on the Cryosphere in a Changing Climate in Wellington, New Zealand, which CliC is co-sponsoring with the International Glaciological Society (IGS) and the International Association of Cryospheric Sciences (IACS).

The co-chairs are happy to see the close cooperation between the CliC project office, the WCRP joint planning staff and the Norwegian Polar Institute. These links provide vital strategic support for CliC.

Participants in the CliC SSG12, in Copenhagen, February

Scientific Steering Group (SSG) Members

Chairs

Greg Flato, Environment Canada, Canada (Co-Chair, 1/2013-12/2016)
Gerhard Krinner, LGGE, France (Co-Chair, 7/2014-12/2017, member 1/2013-7/2014)
James Renwick, Victoria University of Wellington, New Zealand (1/2017-12/2019)

Members

Alexandra Jahn, University of Colorado Boulder, USA (1/2014-12/2018)
Hiroyuki Enomoto, National Institute of Polar Research (NIPR), Japan (1/2016-12/2018)
Margareta Johansson, Lund University, Sweden (1/2015-12/2017)
Shichang Kang, State Key Laboratory of Cryospheric Sciences, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, China (1/2015-12/2017)
Rob Massom, Australian Antarctic Division, Antarctic Climate and Ecosystems Cooperative Research Centre, Australia (1/2013-12/2017)
Sebastian Mernild, Nansen Center, Bergen, Norway (1/2014-12/2018)
Tatiana V. Pavlova, Voeikov Main Geophysical Observatory, Russia (1/2015-12/2017)
Stephen Hudson, Norwegian Polar Institute, Norway (1/2016-12/2018)
Lars H. Smedsrud, University of Bergen, Norway (1/2016-12/2018)
Dario Trombotto Liaudat, Universidad Nacional de Córdoba, Argentina (1/2016-12/2018)

Outgoing Member

Dorthe Dahl-Jensen, Niels Bohr Institute, University of Copenhagen, Denmark (1/2013 -12/2016)

WCRP Joint Science Committee Liaisons

James Renwick, Victoria University of Wellington, New Zealand (2013 -2016)
Mauricio M. Mata, Federal University of Rio Grande-FURG, Brazil (2014 -)
Jens Hesselbjerg Christensen, Danish Meteorological Institute, Denmark (2016-)

The International Project Office

2016 has been an exciting year for the CliC project office with the start-up of a new project director and the continued development of 20 ongoing projects that help achieve the CliC science plan.

Much of the project office time was spent coordinating and supporting the 17 workshops that were planned throughout the year. More than 430 participants attended these events from 20 countries/organizations globally. The IPO was also fortunate to participate directly in some of these activities including workshops organized by Arctic CORDEX, ISMIP6 and ESM-SnowMIP. Attending such meetings helps the IPO gain better knowledge of the logistics requirements of our projects and allows us to get first hand updates on the science accomplishments of our teams.

Another core function of the IPO is communication and outreach with our host organizations, partners, projects and the general public. The CliC web site continues to expand rapidly in terms of content and viewership and the IPO is looking to refresh the site in 2017 with improved structure and simplified navigation. Our social media feeds on Facebook and Twitter continue to grow (more than 1630 Likes on Facebook and more than 2045 followers on Twitter) and we are regularly looking for opportunities to showcase the scientific outputs from our network. The CliC leadership group, composed of the members of the Scientific Steering Group (SSG) and the leaders of the various CliC activities, also hold quarterly on-line leadership meetings to discuss important strategic issues and update the network on our activities. CliC hosted more than 80 online meetings on its GoToMeeting account in 2016.

Linking with our host organizations, WCRP and the Norwegian Polar Institute (NPI), is important for achieving our annual goals. We hold regular coordination meetings with our co-chairs and Joint Planning Staff as well as participate in the planning meetings of the oceans and sea ice team at NPI. The CliC director also partakes in quarterly WCRP directors meetings to help coordinate activities across the WCRP projects. The director attended international conferences to promote the CliC network and made presentations during the Arctic Science Summit Week, the Arctic Circle, and the American Geophysical Union meetings.

We would like to thank our entire network for a fun and productive year and we look forward to an exciting 2017 and beyond. We would especially like to thank our out-going CliC co-chair Greg Flato for excellent leadership and guidance in implementing our science plan. We also welcome our new incoming Chair, James Renwick, who will be our host for the CliC SSG 13 in Wellington New Zealand in February 2017.

WCRP JPS Liaison Mike Sparrow, CliC Co-Chairs Gerhard Krinner, Greg Flato (former), James Renwick (new), CliC Executive Officer Gwénaëlle Hamon, and CliC Director Lawrence Hislop at the WCRP JSC Meeting in Geneva, April 2016

CliC-sponsored Workshops and Meetings

Antarctic Sea Ice Variability in the Southern Ocean-Climate System

January 11-12, 2016, Boulder, CO, USA
http://dels.nas.edu/Past-Events/Antarctic-Variability/AUTO-7-26-08-D

12th Session of the CliC Scientific Steering Group

February 2-5, 2016, Copenhagen, Denmark
http://www.climate-cryosphere.org/media/com_hwdmediashare/files/dc/31/a9/0a355ff53ffb70d7afda25d07c5bc937.pdf

BEPSII - Biogeochemical exchange processes at Sea Ice Interfaces Meeting

March 16-18 2016, Paris, France
https://sites.google.com/site/bepsiiwg140/meetings

PCPI Polar Prediction Workshop

May 4-6, 2016, Lamont, Palisades, NY, USA
https://www.arcus.org/sipn/meetings/workshops/may-2016

Earth Observation and Cryosphere Science

May 10-13, 2016, Prague, Czech Republic
http://www.eo4cryosphere2016.info/

Rising Coastal Seas on a Warming Earth II Workshop

May 16-18, 2016, Abu Dhabi, United Arab Emirates
http://nyuad.nyu.edu/en/news-events/abu-dhabi-events/2016/05/rising-coastal-seas-on-a-warming-earth-ii.html

PCPI Workshop on feedbacks in polar regions and the way they are represented in climate models

May 17-19, 2016, Louvain-la-Neuve, ; Belgium
http://www.climate-cryosphere.org/wcrp/pcpi/meetings

International Conference on Regional Climate (ICRC)-CORDEX

May 17-20, 2016, Stockholm, Sweden
http://www.icrc-cordex2016.org/

Permaforst Carbon Network Lead/Co-lead meeting at the 11thInternational Conference On Permafrost (ICOPXI)

June 16, 2016, Potsdam, Germany
http://www.permafrostcarbon.org/past%20meetings.html

Technical Committee on Sea Ice Observations Meeting

September 5-9, 2016, Hobart, Australia
http://www.climate-cryosphere.org/news/clic-news/1547-seaicecommittee-september2016meeting

Southern Ocean Region Panel Workshop at the CLIVAR Open Science Conference

December 17-18, 2016, Qingdao, China
http://www.clivar.org/sites/default/files/documents/SORP_11_report_v1_Lei_finalized_Dec7.pdf

International Glaciological Society (IGS) Nordic Branch Meeting

October 26-28, 2016, Tromsø, Norway
http://www.npolar.no/en/events/2016/10-annual-meeting-of-the-nordic-branch-of-the-international-glaciological-society/

CliC-SOLAS Forum on Sea Ice Biogeochemistry (BEPSII) Meeting

October 27-28, 2016, Amsterdam, The Netherlands
https://sites.google.com/site/bepsiiwg140/home

Arctic CORDEX Meeting

November 28-30, 2016
Bergen, Norway
http://www.climate-cryosphere.org/activities/targeted/polar-cordex/meetings/1541-2016arcticcordex

Sea Ice Historical Charts Meeting

November 30-December 1, 2016, Tromsø, Norway

Pre-AGU Ice Sheet Model Intercomparison Project for CMIP6 Meeting

December 10-11, 2016, San Francisco, USA
http://www.climate-cryosphere.org/activities/targeted/ismip6/about

Pre-AGU Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP) Meeting

December 10, 2016, San Francisco, USA
http://www.climate-cryosphere.org/activities/targeted/esm-snowmip

Report Format

The remainder of this report presents the science highlights, publications and future plans of the various projects in the CliC network. Our projects are generally clustered into three activity areas that can be seen in the graphic below. These encompass modelling activities that support the WCRP Grand Challenge on Melting Ice and Global Consequences (contributions to the CMIP6 process), limited lifetime activities that typically have a bounded timespan, and partner projects that CliC co-sponsors with other international organisations. To help present the contributions of these activities we have divided the remainder of this report into the following sections:

- WCRP Grand Challenge - Melting Ice and Global Consequence
- Sea Ice
- Hydrology & Permafrost
- Ice Sheets
- Regional Activities
- Inter-disciplinary Activities
- Social Science
- Emerging Activities and Ideas

Structure of CliC

WCRP Grand Challenge Melting Ice and Global Consequences

The WCRP Grand Challenges (GCs) represent major foci of scientific research, modelling, analysis and observations over the next decade. The WCRP intends to promote these GCs through community-organized workshops, conferences and strategic planning meetings to identify high priority and emerging research that require international partnership and coordination, and that yield "actionable information" for decision makers. Currently WCRP has seven GCs:

- Melting Ice and Global Consequences
- Clouds, Circulation and Climate Sensitivity
- Carbon Feedbacks in the Climate System
- Understanding and Predicting Weather and Climate Extremes
- Water for the Food Baskets of the World
- Regional Sea-Level Change and Coastal Impacts
- Near-term Climate Prediction

The Melting Ice and Global Consequences Grand Challenge has been re-organized and is chaired by former CliC Co-Chair Greg Flato. This GC is composed of several elements coming together to take advantage of the opportunity given by CMIP6, the 6th version of the WCRP Coupled Model Intercomparison Project.

CliC is taking the lead for the implementation of the Melting Ice & Global Consequences Grand Challenge and has several of its activities aligned with the GC. These activities include:

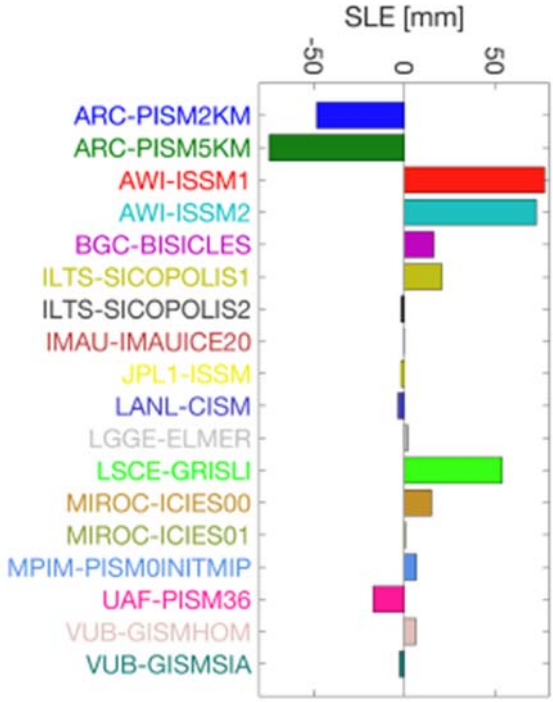
- Ice Sheet Model Intercomparison for CMIP6 (ISMIP6)
- Marine Ice Sheet-Ocean Model Intercomparison Project (MISOMIP)
- Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP) (which is part of a broader MIP, LandMIP)
- Glacier Model Intercomparision Project (GlacierMIP)
- Diagnostic Sea Ice Model Intercomparison Project (SIMIP)
- Permafrost Carbon Network (PCN)

Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6)

Introduction

ISMIP6 has the objectives of improving projections of sea level from the Greenland and Antarctic ice sheets, and increasing our understanding of the cryosphere in a changing climate. It maps into the 'Melting Ice and Global Consequences' and 'Regional Sea-level Change' Grand Challenges of the World Climate Research Program. ISMIP6 is an endorsed activity within CMIP6. For more details please visit the website: www.climate-cryosphere.org/activities/targeted/ismip6

Science Highlight



Centennial sea level background trend in control experiments due to model drift or transient initialization from the initMIP-Greenland models, an effort that investigates uncertainty resulting from the initialization.

2016 Highlights

-The ISMIP6 experiments and data protocols were finalized.
-13 modelling groups participated in initMIP-Greenland.
-Launch of initMIP-Antarctica.
-Three workshops: initMIP-Greenland at EGU, initMIP-Greenland and Antarctica at AGU, and ice-ocean interactions at AGU.
-Presentations at EGU, AGU, N-SLCT, CMIP Analysis and Modelling Workshop,CLiC SSG and Sea Level GC.

2016 Publications

Nowicki, S. M. J., Payne, T., Larour, E., Seroussi, H., Goelzer, H., Lipscomb, W., Gregory, J., Abe-Ouchi, A., and Shepherd, A.: Ice Sheet Model Intercomparison Project (ISMIP6) contribution to CMIP6, Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-105, in review, 2016.

Future activities and developments

-Publication of the initMIP-Greenland results.
-Analysis of the initMIP-Antarctica model simulations.
-Workshops at EGU, and large workshop on evaluation of CMIP6 climate models to derive forcing for ice sheet models.

Participants in the ISMIP6 Workshop at AGU, December 2016, in San Francisco, USA

Contact:

Sophie Nowicki, NASA GSFC, USA, sophie.nowicki@nasa.gov
Tony Payne, University of Bristol, UK, a.j.payne@bristol.ac.uk
Eric Larour, NASA JPL, USA, eric.larour@jpl.nasa.gov

http://www.climate-cryosphere.org/activities/targeted/ismip6

Marine Ice Sheet Ocean Model Intercomparison Project (MISOMIP)

Introduction

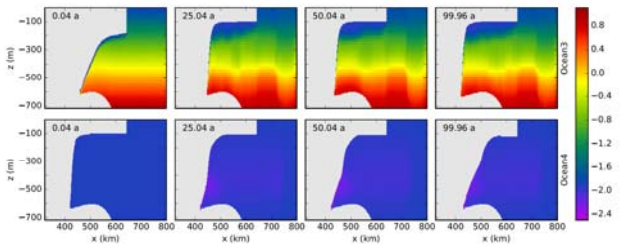
The potential societal impacts of sea-level rise in a warming climate are widely recognized, but rates of future sea-level change are not well constrained. In the coming centuries, one of the largest, but also most uncertain, sources of sea-level rise is likely to be mass loss from the marine-based ice sheets, particularly the West Antarctic Ice Sheet (WAIS). The large uncertainties result, in part, from the lack of ice sheet-ocean coupling in the current generation of global climate models.

As a step toward remedying this situation, MISOMIP has held annual workshops bringing together the international ice sheet-ocean modeling community to plan collaborative research toward fully coupled regional-scale simulations focused on WAIS. To date, this work has yielded a set of idealized experiments to aid in building, testing and further understanding the coupled ice sheet-ocean models and their components. MISOMIP's longer term goal is to produce physically-based estimates of sea-level change from WAIS over the coming centuries. This regional-modeling research will lay the groundwork for including ice sheet-ocean interaction in global scale, IPCC class models.

2016 Highlights

A second workshop brought together experts in the international modeling community to further discuss the advancement of state-of-the-art regional-scale glacier-ocean simulations. One day each was devoted to ice-sheet, ocean and coupled ice-sheet ocean modeling. Participants reported on their progress since the first workshop and discussed potential directions for future collaborative work in each category, culminating in an overall project directive for the next workshop.

Science Highlight



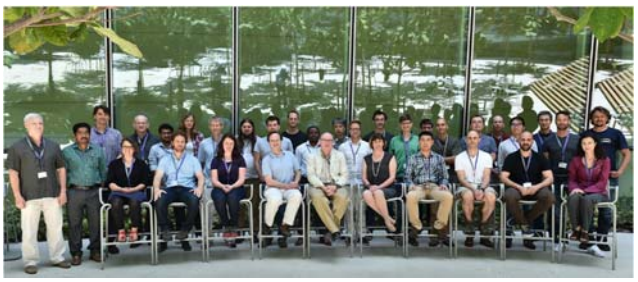
Asay-Davis et al. (2016) describes three interrelated MIPs for marine ice-sheet models and ocean models with sub-ice-shelf cavities. The figure shows cross sections of ocean temperature (colored) and ice topography (gray) evolving in time in one of the MIPs experiments. The results from the first of the three MIPs were received in early October, and analysis has already begun. The results are expected to provide a basis for future model improvements.

2016 Publication

Asay-Davis, X. S., et al.: Experimental design for three interrelated marine ice sheet and ocean model intercomparison projects. Geosci. Model Dev., 9, 2471-2497, 2016.

Future activities and developments

Side-bar MISOMIP meetings will be held at AGU, EGU, IGS and related meetings. Several publications analyzing MIP results are expected in 2017. Planning has begun for the third MISOMIP meeting in spring 2018.



MISOMIP Participants, May 2016 at NYU Abu Dhabi, UAE.

Contacts:

Professor David M. Holland, NYU, dmh4@nyu.edu
Denise Holland, NYU, dh416@nyu.edu

http://www.climate-cryosphere.org/activities/targeted/misomip

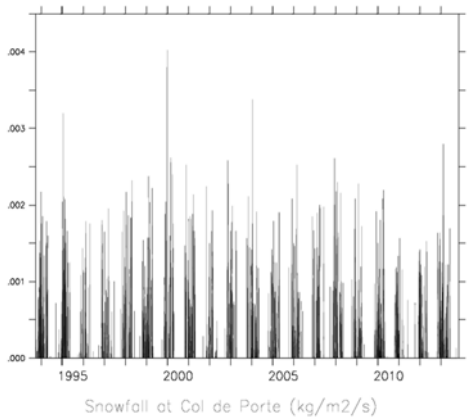
Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP)

Introduction

ESM-SnowMIP is a comprehensive snow model intercomparison project building on the legacy of site-level snow model intercomparisons. ESM-SnowMIP extends the scope to include both specific snow models and the snow modules of Earth System Models taking part in CMIP6. The aim is twofold: 1) improve the representation of snow processes in all classes of snow models; 2) better quantify snow-related feedbacks in the Earth system in the context of future climate change.

ESM-SnowMIP is tightly linked to the Land Surface, Snow and Soil Moisture Intercomparison Project LS3MIP, which is one of the CMIP6 subprojects. LS3MIP pursues very similar goal as ESM-SnowMIP, with a broader scope extending to all land surface processes in CMIP6 Earth System Models and land-related feedbacks.

Science Highlight



Quality-controlled meteorological forcing to be used for site-scale snow simulations in ESM-SnowMIP (here: snowfall rates at Col de Porte, France)

2016 Highlights

Simulation protocols finalized both for LS3MIP (see publication by van den Hurk listed below) and for ESM-SnowMIP.

Meteorological forcing files on global and site scales produced.

LS3MIP and ESM-SnowMIP are transitioning into the simulation production phases.

ESM-SnowMIP held its official kickoff workshop in San Francisco in December 2016. This workshop was the opportunity to discuss first offline site simulations carried out by several groups, refine output analysis strategies and identify leaders for specific analysis axes.

2016 Publications

Van den Hurk, B., Kim, H., Krinner, G., Seneviratne, S. I., Derksen, C., Oki, T., and 19 others: LS3MIP (v1.0) contribution to CMIP6: the Land Surface, Snow and Soil moisture Model Intercomparison Project – aims, setup and expected outcome, Geosci. Model Dev., 9, 2809-2832, doi:10.5194/gmd-9-2809-2016, 2016.

Future activities and developments

CMIP6, and thus LS3MIP, enter production phase in 2017. First results of global land offline simulations from LS3MIP are expected towards the end of 2017. Similarly, ESM-SnowMIP site simulations will be carried out in 2017.

Participants in the ESM-SnowMIP Workshop at AGU, December 2016, San Francisco, USA

Contact:
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Chris Derksen, Environment and Climate Change Canada, chris.derksen@canada.ca

http://www.climate-cryosphere.org/activities/targeted/esm-snowmip

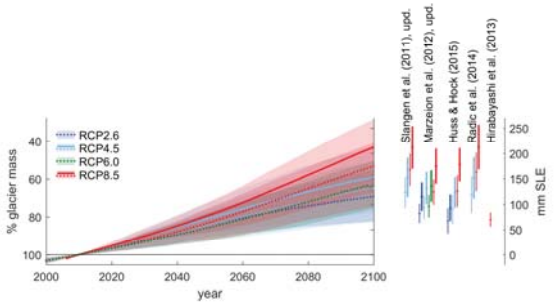
GlacierMIP – A model intercomparison of global-scale glacier models

Introduction

GlacierMIP is a model intercoparison project focusing on all glaciers in the world outside the ice sheets. It provides – for the first time - a framework for a coordinated intercomparison of global-scale glacier mass change models to foster model improvements and reduce uncertainties in global glacier projections. Primary goals are (a) to coordinate a model intercomparison of existing state-of-the-art large-scale glacier models with respect to decadal to century scale glacier mass change projections, and (b) to identify current model deficiencies and data needs, and work towards a new generation of global-scale glacier models that allow more accurate projections.

Science Highlight

The data from six previous studies were submitted to GlacierMIP by the end of September 2015, and preliminary GlacierMIP comparisons have been presented at the AGU fall meeting in December 2015. Each study used 8-15 GCMs to force the projections. Results indicate that globally glaciers will lose between 15 and 55% of their current volume BY 2100 (multi-model mean of runs forced by 8-15 GCM and a variety of emission scenarios). This corresponds to 7 – 22 cm sea-level equivalent.



Transient global glacier projections of two global glacier mass change projections, updated from Slangen et al. (2011, solid) and from Marzeion et al. (2012, dotted). Shading indicates one ensemble standard deviation. Projections by 2100 are compared to 3 other publised studies. Thick lines including, thin lines excluding peripheral glaciers (Slangen et al., 2016).

2016 Highlights

A GlacierMIP meeting was held at AGU 2015. Work towards a joint peer-reviewed publication comparing recent global glacier projections is underway.

2016 Publications

Slangen, A.B.A., Adloff, F., Jevrejeva, S. et al. Sea-Level Projections at Global and Regional Scales. Surv. Geophys. (2016). doi:10.1007/s10712-016-9374-2.

Future activities and developments

A GlacierMIP meeting will be held at the IGS/IACS/CliC conference in Wellington in February 2017.

Participants in the GlacierMIP Workshop at IUGG, June 2015, Prague, Czech Republic

Contact:

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Ben Marzeion, University of Bremen, Germany, ben.marzeion@uni-bremen.de

http://www.climate-cryosphere.org/activities/targeted/glaciermip

Sea Ice and Climate Modeling Forum
Diagnostic Sea Ice Model Intercomparison Project (SIMIP)

Introduction

The CliC Sea ice and climate modeling forum aims to foster activities that improve our understanding of sea ice and its interaction with the climate system of our planet. These aims are achieved through a focus on improving model simulations of sea ice, to facilitate their analysis and to coordinate joint modeling work.

Science Highlight

2. Tendencies of sea-ice mass and area fraction (all negative for decreasing mass)						
siforcetx	tendency_of_sea_ice_area_fraction_due_to_thermodynamics	1	sea ice	1/s	sea-ice area fraction change from thermodynamics	Total change in sea-ice area fraction through thermodynamic processes
siforcedx	tendency_of_sea_ice_area_fraction_due_to_dynamics	1	sea ice	1/s	sea-ice area fraction change from dynamics	Total change in sea-ice area fraction through dynamics-related processes (advection, divergence…)
sidmassth	tendency_of_sea_ice_amount_due_to_thermodynamics	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change from thermodynamics	Total change in sea-ice mass from thermodynamic processes divided by grid-cell area
sidmassdyn	tendency_of_sea_ice_amount_due_to_dynamics	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change from dynamics	Total change in sea-ice mass through dynamics-related processes (advection,…) divided by grid-cell area
sidmassgrowthwat	tendency_of_sea_ice_amount_due_to_freezing_in_open_water	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change through growth in supercooled open water (aka frazil)	The rate of change of sea ice mass due to sea ice formation in supercooled water (often through frazil formations) divided by grid-cell area. Together, sidmassgrowthwat and sidmassgrowthbot should give total ice growth
sidmassgrowthbot	tendency_of_sea_ice_amount_due_to_congelation_ice_accumulation	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change through basal growth	The rate of change of sea ice mass due to vertical growth of existing sea ice at its base divided by grid-cell area.
sidmasssi	tendency_of_sea_ice_amount_due_to_snow_conversion	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change through snow-to-ice conversion	The rate of change of sea ice mass due to transformation of snow to sea ice divided by grid-cell area
sidmassevapsubl	water_evaporation_flux	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change through evaporation and sublimation	The rate of change of sea ice mass through evaporation and sublimation divided by grid-cell
sidmassmelttop	tendency_of_sea_ice_amount_due_to_surface_melting	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change through surface melting	The rate of change of sea ice mass through melting at the ice surface divided by grid-cell area
sidmassmeltbot	tendency_of_sea_ice_amount_due_to_basal_melting	1	sea ice	kg m^{-2} s^{-1}	sea-ice mass change through bottom melting	The rate of change of sea ice mass through melting at the ice bottom divided by grid-cell area
sidmasslat	tendency_of_sea_ice_amount_due_to_lateral_melting	-1	sea ice	kg m^{-2} s^{-1}	Lateral sea ice melt rate	The rate of change of sea ice mass through lateral melting divided by grid-cell area (=sum of if not explicitly calculated thermodynamically)
sndmassmelt	snowfall_flux	1	sea ice	kg m^{-2} s^{-1}	snow mass change through snow fall	mass of solid precipitation falling onto sea ice divided by grid-cell area
sndmassmelt	surface_snow_melt_flux	1	sea ice	kg m^{-2} s^{-1}	snow mass change through melt	the rate of change of snow mass through melt divided by grid-cell area
sndmassevap	surface_snow_sublimation_flux	-1	sea ice	kg m^{-2} s^{-1}	snow mass change through evaporation or sublimation	the rate of change of snow mass through evaporation, sublimation and evaporation divided by grid-cell
sndmassdyn	tendency_of_snow_mass_due_to_sea_ice_dynamics	-1	sea ice	kg m^{-2} s^{-1}	snow mass change through advection by sea-ice dynamics	the rate of change of snow mass through advection with sea ice divided by grid-cell area
sndmasssi	tendency_of_snow_mass_due_to_snow_to_ice_conversion	-1	sea ice	kg m^{-2} s^{-1}	snow mass change through snow-to-ice conversion	the rate of change of snow mass due to transformation of snow to sea ice divided by grid-cell area
sndmasswindrif	tendency_of_snow_mass_due_to_drifting_snow	-1	sea ice	kg m^{-2} s^{-1}	snow mass change through wind drift of snow	the rate of change of snow mass through wind drift of snow divided by grid-cell area
3. Heat and freshwater fluxes (all only for sea-ice fraction of grid cell, downward always positive)						
sifdownsw	surface_downwelling_shortwave_flux_in_air	1	sea ice	W m^{-2}	Downwelling shortwave flux over sea ice	The downwelling shortwave flux over sea ice (always positive by sign convention)
sifupsw	surface_upwelling_shortwave_flux_in_air	1	sea ice	W m^{-2}	Upward shortwave flux over sea ice	the upward shortwave flux over sea ice (always negative)
sifswbot	bottom_downwelling_shortwave_flux_into_ocean	-1	sea ice	W m^{-2}	Downwelling shortwave flux under sea ice	the downwelling shortwave flux underneath sea ice (always positive)
sifdownlw	surface_downwelling_longwave_flux_in_air	1	sea ice	W m^{-2}	Downwelling longwave flux over sea ice	the downwelling longwave flux over sea ice (always positive)
sifupsw	surface_upwelling_longwave_flux_in_air	1	sea ice	W m^{-2}	Upward longwave flux over sea ice	the upward longwave flux over sea ice (always negative)
sifsenstop	surface_upward_sensible_heat_flux	1	sea ice	W m^{-2}	Net sensible heat flux over sea ice	the net sensible heat flux over sea ice
siflatstop	surface_upward_latent_heat_flux	1	sea ice	W m^{-2}	Net latent heat flux over sea ice	the net latent heat flux over sea ice
sifsenstbot	ice_ocean_heat_flux	-1	sea ice	W m^{-2}	Net sensible heat flux under sea ice	the net sensible heat flux under sea ice from the

Snippet of the newly established standard for sea-ice output from large scale model simulations. Full list available from www.climate-cryosphere.org/simip

2016 Highlights

Most of our work in 2016 was focused on finalizing the diagnostic protocol for sea-ice related work within the upcoming Coupled Model Intercomparison Project 6 (CMIP6). To this end, we had substantial communication both with the CMIP6 data panel and with the leading scientists who implement the protocol into the most widely used sea-ice models LIM and CICE.

2016 Publications

Notz, D., Jahn, A., Holland, M., Hunke, E., Massonnet, F., Stroeve, J., Tremblay, B., and Vancoppenolle, M.: The CMIP6 Sea-Ice Model Intercomparison Project (SIMIP): understanding sea ice through climate-model simulations, *Geosci. Model Dev.*, **9**, 3427-3446, 2016.

Future activities and developments

For 2017, we have two main activites planned. First, we will host a workshop of modelers and observationalists to establish the most efficient way of future cooperation between both groups. A particular focus will be on evaluation data sets for the upcoming CMIP6 simulations.

Second, we will coordinate a dedicated analysis of sea-ice simulations regarding the 1.5 °C global warming target of the Paris-agreement.

Deploying a newly developed instrument to measure sea-ice salinity in situ, which informs ongoing modeling activities to better understand the exchange of salt between sea ice and the underlying ocean. Photo: MPI-M

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http://www.climate-cryosphere.org/activities/targeted/simip

Permafrost Carbon Network (PCN)

Introduction

The Permafrost Carbon Network (PCN) is an international scientific effort linking biological carbon cycle research with networks in the physical sciences focused on the thermal state of permafrost.

The network has been successfully running since 2011 with continuous support from CliC and is now part of the Permafrost Action Team under the umbrella of the Study of Environmental Arctic Change (SEARCH).

Science Highlight

One major synthesis published in 2016 using incubation studies shows that drier, aerobic soil conditions released more than three times more carbon than wetter, anaerobic soil conditions. The implications of this study are that the permafrost carbon feedback will be stronger when a larger percentage of the permafrost zone undergoes thaw in a dry and oxygen-rich environment (Figure below). For more details see Schädel et al. 2016.

In thawing Arctic permafrost soils, carbon dioxide is produced by microbes in dry conditions, while both methane and carbon dioxide are produced by microbes in wet conditions. (Image courtesy Victor O. Leshyk)

2016 Highlights

Multiple syntheses as part of PCN activities have been published in high profile journals in 2016. McGuire et al. 2016 presents a retrospective analysis of 15 land surface model simulations including carbon cycle processes and permafrost for 1960-2009. Olefeldt et al. 2016 combines maps and thermokarst landscapes with projections of future climates, which allows scientists to predict future greenhouse gas emissions following permafrost thaw. Wik et al. 2016 describes improved estimates and future redictions of CH4 emissions from northern lakes and ponds. In June of 2016, the PCN held its 6th network lead meeting in Potsdam, Germany. Synthesis leads gave short presentations and updated the group on synthesis progress.

2016 Publications

McGuire et al. (2016) Variability in the sensitivity among model simulations of permafrost and carbon dynamics in the permafrost region between 1960 and 2009. Global Biogeochemical Cycles. doi:10.1002/2016GB005405

Olefeldt et al. (2016) Circumpolar distribution and carbon storage of thermokarst landscapes. Nature Communications, 7, 13043. doi:10.1038/ncomms13043

Schädel et al. (2016) Potential carbon emissions dominated by carbon dioxide from thawed permafrost soils. Nature Clim. Change, 6, 950-953. doi:10.1038/nclimate3054

Wik et al. (2016) Climate-sensitive northern lakes and ponds are critical components of methane release. Nature Geosci, doi:10.1038/ngeo2578

Future activities and developments

The 6th Annual Meeting of the PCN will be held in San Francisco, December 11 2016. Updates on syntheses will be given to the larger science community and new ideas will be discussed in afternoon break out groups.

Lead Meeting of the Permafrost Carbon Network, June 18-19, 2016, Potsdam, Germany

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www.permafrostcarbon.org

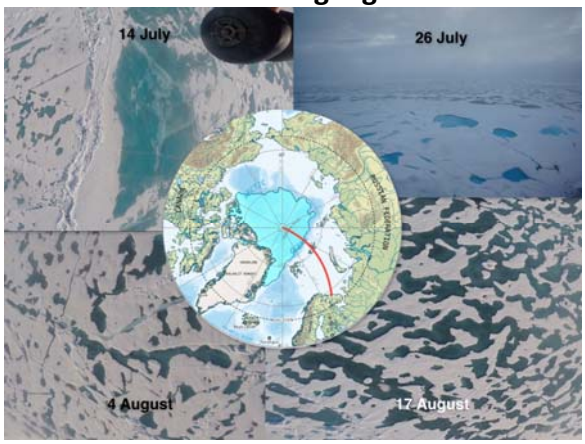
Sea Ice

Arctic Sea Ice Working Group (ASIWG)

Introduction

The goals of the Climate and Cryosphere Arctic Sea Ice Working Group are: i) Develop, standardize, and implement measurement protocols for Arctic sea ice in coastal, seasonal, and perennial ice zones; ii) Integrate surface-based observations with remote sensing and modeling efforts; and iii) Foster connections between international groups involved in sea ice observations, modeling, and remote sensing. The ASIWG has organized workshops and produced documents addressing these goals.

Science Highlight



Aerial photographs showing seasonal evolution of ice conditions near the North Pole from tourist cruises to the North Pole in 2015.

2016 Highlights

ASSIST the sea ice observation software is being used on research cruises and by passengers aboard the Russian Icebreaker 50 Years of Victory on summer cruises to the North Pole. Plans are underway to extend these measurements to other ecotourism ships. ASIWG members have continued to contribute to the Sea Ice Section of the NOAA Arctic Report Card and to the Bulletin of the American Meteorological Society State of the Climate issue. In the past year, the ASIWG participated in the sea ice portion of the planning of the international, interdisciplinary programs of the Year of Polar Prediction and MOSAiC – Multidisciplinary drifting observatory for the Study of Arctic Climate. ASIWG members organized a 25 person field workshop aimed at integrating the sea ice observational and modeling communities.

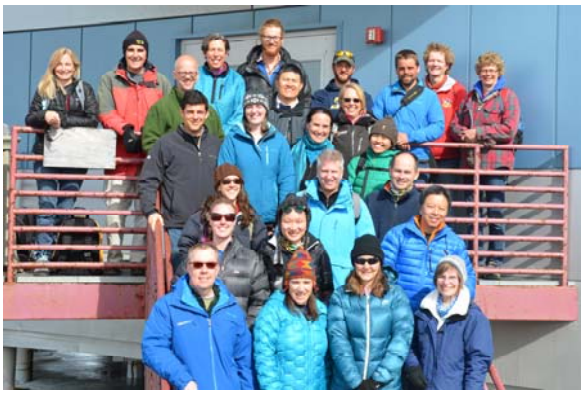
2016 Publications

Farmer, L., A. Cowan, J. Hutchings, and D. Perovich (2016), Citizen scientists train a thousand eyes on the North Pole, *Eos*, 97.

Richter-Menge, and others. The Arctic (in "State of the Climate in 2015"). *Bull. Amer. Meteor. Soc.* 97, 2016.

Future activities and developments

The group will continue to integrate Arctic sea ice related activities into MOSAiC and the Year of Polar Prediction. This coordination is critical since the Year of Polar Prediction is 2017-2019 and the MOSAIC field campaign is from 2019-2020. Efforts will also be coordinated with the CliC groups on Antarctic Sea Ice Processes and Climate and Sea Ice and Climate Modeling. The ASSIST ice watch software will be made available to research vessels and to cruise ships operating in the Arctic. An ASIWG workshop in 2017 is being planned.



Participants in sea ice modeling and observing summer camp in Barrow

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http://www.climate-cryosphere.org/activities/groups/arctic-sea-ice-working-group

Antarctic Sea Ice Processes and Climate (ASPeCt)

Introduction

ASPeCt is an expert group on multi-disciplinary Antarctic sea ice zone research. ASPeCt has the key objective of improving our understanding of the Antarctic sea ice zone and its response to climate change. This understanding is to be achieved through focussed field programs, systematic monitoring of the ice cover, analysis of remote sensing and numerical modelling.

Science Highlight
Drones over Ice

Pilot project on US voyage to continental shelf region of the Totten Glacier. 1st ever approval for ship-based drone project

Williams et al, 2016

2016 Highlights

The ASPeCt digital underway ice observation method, version 2 has been launched. Voyages from October 2015 - March 2016 used this version 2.

Additionally, near-real time upload is implemented, ¨ pending networking from vessel to central server.

Automatic cameras are being implemented on some research cruises to take images that currently supplement ASPeCt visual observations and are being used for quality control and training of ice observers.

The prototype for the AFIN data portal was deployed for testing in austral winter 2016. It is available for testing/use and feedback is welcome.

- Project to work on IceBridge airborne lidar analyses for sea ice thickness continues. Research outcomes in press.

-ASPeCt joined in planning and participated in the USA's National Academy of Science's Antarctic sea ice variability and trends workshop held in January 2016. This workshop addressed our current understanding of processes driving Antarctic sea ice changes. A workshop report will be out later in 2016.

2016 Publications

Wang, X.W., F. Guan, J. Liu, H. Xie, and S. Ackley, 2016. An improved approach of total freeboard retrieval with IceBridge Airborne Topographic Mapper (ATM) elevation and Digital Mapping System (DMS) images. *Remote Sensing of Environment* (accepted).

Future activities and developments

-Development of the ASPeCt ship-based observation system and database for sea ice measurements taken by remote vessels (airborne and under ice), ship-based instruments and surface-based instruments and sampling is ongoing.

-A two-month (April 15-June 15 2017) cruise into the Ross Sea on the US Icebreaker NB Palmer will be conducting an atmosphere-ice-ocean interaction experiment in the polynyas and sea ice regions of the western Ross Sea.

-ASPeCt scientists will participate in a newly funded multi-disciplinary project (PI: K. Leonard, USA/Switzerland) within the Swiss Antarctic Circumpolar Expedition project, to measure snowfall and sea surface salinity (and temperature) around Antarctica.

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Marilyn Raphael, University of California, Los Angeles, Raphael@geog.ucla.edu

http://aspect.antarctica.gov.au/

Technical Committee on Sea Ice Observation

Introduction

This working group is a joint sub-group of the Arctic Sea Ice and The Sea Ice Antarctic Processes and Climate Working Groups. It bridges Arctic and Antarctic interests in developing technical solutions for expanding in-situ observations of sea ice. The working group is focused on standardization of observation procedures and ensuring this is achieved globally. We are also building technical capability to automate ship-based sea ice observations.

Beaufort sea ice flatter, at more advanced stages of melt and smaller floe size in summers 2007-2012 compared to the 1960s-1980s.

Article submitted to the journal Arctic, November 2016.

2016 Highlights

A sub-group of the Sea Ice Technical Working group held a working meeting in Hobart, Australia, September 5-9 2016 to discuss full coordination of Arctic and Antarctic ship bridge-based sea-ice observations. We succeeded in ensuring measurements were compatible between the two Arctic and Antarctic standards. Heil and Hutchings have jointly drafted a manual for bridge based research quality sea ice observations.

2016 Publications

Tanaka, Y. , K. Tateyama, T. Kameda, J.K. Hutchings. Estimation of melt pond fraction using satellite passive microwave data in the Arctic Ocean, J. Geophys. Res. Oceans, accepted [2016].

Hutchings, J.K., N. Hughes, A. R. Orlich, S. MacFarlane, A. Cowen, L. Farmer and M. K. Faber, Ice Watch: Standardizing and expanding Arctic ship based sea ice observations, white paper presented at Arctic Observing Summit, Fairbanks, Alaska, USA, Feb. 2016. Accessible from: http://www.arcticobservingsummit.org/aos-2016-white-papers-and-short-statements-public [2016].

Farmer, L., A. Cowen, J.K. Hutchings, D. K. Perovich. Citizen scientists train a thousand eyes on the pole, EOS, 97, doi:10.1029/2016EO054989, [2016]

Future activities and developments

Ice Watch continues to expand into citizen science programs on tourist cruises. This is happening in the Arctic and the Antarctic, and to facilitate data sharing between Arctic and Antarctic programs Ice Watch is developing capability to provide ASPeCt formatted data to the Australian Antarctic Division data archive.

Citizen scientists participated in Ice Watch. Photo credit Lauren Farmer.

Contact:

Jenny Hutchings, Oregon State University, jhutchings@coas.oregonstate.edu

Steve Ackley, University of Texas San Antonio, Stephen.Ackley@utsa.eduActivity

Biogeochemical Exchange Processes at Sea Ice Interfaces (BEPSII)

Introduction

BEPSII, "Biogeochemical Exchange Processes at Sea-Ice Interfaces" started in 2011 with a focus on sea-ice biogeochemistry. BEPSII was a SCOR working group from 2012 until September 2016, and has since been endorsed as a SOLAS-CliC forum (2016).

BEPSII is now coordinating some community activities linked to the biogeochemistry of sea ice-influenced environments.

Science Highlights

Amongst the wealth of activities, the analysis of sea-ice core historical data illustrates particularly well the strength of community work.

Fripiat et al. (2016) and Lannuzel et al (2016) gathered the first compilations of ice cores for resp. macro-nutrients and iron in Antarctic sea ice.

Because of the increased amount of ice cores used, both works not only confirm some earlier studies, but also feature new findings.

These studies provide development and evaluation opportunities for large-scale sea-ice models.

2016 Highlights

-BEPSII SCOR-WG final meeting, Paris, Mar 16-18, 2016. (>30 participants)
-BEPSII MOSAiC and COST action meeting, Amsterdam, Oct 28-29, 2016 (14 participants)

2016 Publications

BEPSII Special feature of the Elementa Journal (13 accepted contributions so far)

Future activities and developments

We are actively designing our future activities. Just a few examples.

-Complementary SCOR WG ECV-Ice (PIs F. Fripiat, D. Nomura, B. Else) will focus on the design of inter-calibration experiments for sea-ice biogeochemical observation techniques.
-Expert contribution to ongoing discussions on the design of MOSAiC (wrt biogeochemistry and ecosystem).
-Model development and inter-comparison (links to CMIP6, SIMIP and FAMOS).
-New terms of reference & organization are to be finalized in a 5-yr activity plan.

2017 Agenda

-Gordon Research Conference on Polar Marine Ecosystems, Ventura, California, Mar 26-31, 2017.
-BEPSII annual meeting, Scripps, San Diego, California, Apr 2-5, 2017.

Participants in the BEPSII SCOR-WG final meeting, Paris, March, 2016

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https://sites.google.com/site/bepsiiwg140/home

Hydrology
&
Permafrost

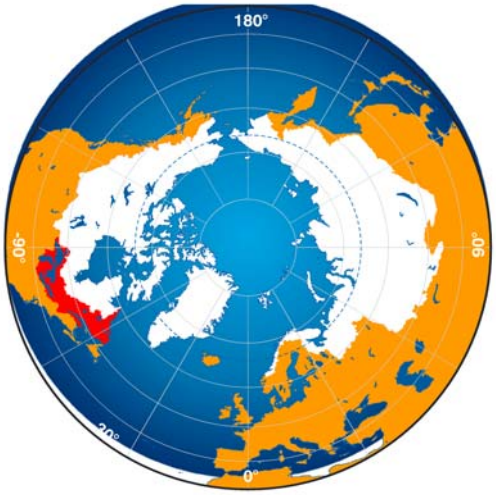
Arctic Freshwater Synthesis

Introduction

The Arctic Freshwater Synthesis (AFS) is a science integration of the Arctic freshwater system that focuses on storage, fluxes and effects. There is increasing scientific recognition that changes to the Arctic freshwater systems produce changes to the Arctic environment, society and economy, with consequences at the global level. AFS activities prior to 2016 include a planning phase during 2013, and several AFS co-leads workshops in 2013, 2014 and 2015. The AFS has been supported by CliC, the International Arctic Science Committee (IASC), the Arctic Monitoring and Assessment Programme (AMAP), the Norwegian Ministry of Environment and the Norwegian Ministry of Foreign Affairs.

Science Highlight

Results from the AFS suggest that the freshwater domain in the Arctic is broader than previously thought.



The Arctic freshwater domain, with new addition of the St Lawrence river basin.

2016 Highlights

In 2016, the AFS special issue was published in *JGR Biogeosciences.* CliC also coordinated an awareness raising campaign in social media, and the AFS results were highlighted on the AGU Editor's Vox blog. During spring, a layman's report highlighting key findings was released.

2016 Publications

Bring, A., Fedorova, I., Dibike, Y., Hinzman, L., Mård, J., Mernild, S.H., Prowse, T.D., Semenova, O., Stuefer, S., Woo, M.-K., 2016. Arctic terrestrial hydrology: A synthesis of processes, regional effects and research challenges. JGR: Biogeosciences 121, doi:10.1002/2015JG003131

Carmack, E.C., Yamamoto-Kawai, M., Haine, T., Bacon, S., Bluhm, B., Lique, C., Melling, H., Polyakov, I., Straneo, F., Timmermans, M.-L., Williams, W., 2016. Fresh water and its role in the Arctic Marine System: sources, disposition, storage, export, and physical and biogeochemical consequences in the Arctic and global oceans. JGR: Biogeosciences 121, doi:10.1002/2015JG003140

Instanes, A., Kokorev, V., Janowicz, R., Bruland, O., Sand, K., Prowse, T.D., 2016. Changes to freshwater systems affecting Arctic infrastructure and natural resources. JGR: Biogeosciences 121, doi:10.1002/2015JG003125

Lique, C., Holland, M.M., Dibike, Y., Lawrence, D.M., Screen, J., 2016. Modeling the Arctic Freshwater System and its integration in the global system: Lessons learned and future challenges. JGR: Biogeosciences 121, doi:10.1002/2015JG003120

Vihma, T., Screen, J., Tjernström, M., Newton, B., Zhang, X., Popova, V., Deser, C., Holland, M., Prowse, T.D., 2016. The atmospheric role in the Arctic water cycle: processes, past and future changes, and their impacts. JGR: Biogeosciences 121, doi:10.1002/2015JG003132

Wrona, F.J., Johansson, M., Culp, J.M., Jenkins, A., Mård, J., Myers-Smith, I.H., Prowse, T.D., Vincent, W.F., Wookey, P.A., 2016. Transitions in Arctic Ecosystems: Ecological Implications of a changing hydrological regime. JGR: Biogeosciences 121, doi:10.1002/2015JG003133

Future activities and developments

Results from the AFS will be integrated in the Snow, Water, Ice, and Permafrost in the Arctic II (SWIPA II) report.

Part of AFS team, Victoria workshop, 2015

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Arvid Bring, Stockholm University, arvid.bring@natgeo.su.se

http://www.climate-cryosphere.org/activities/targeted/afs

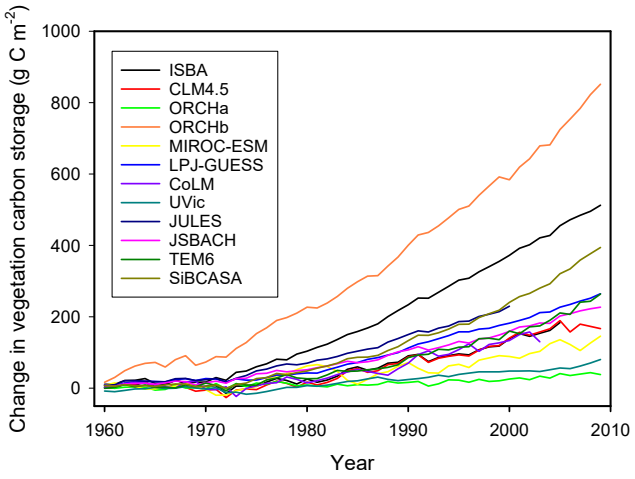
Permafrost Modeling Forum

Introduction

The Permafrost Modeling Forum is an interdisciplinary activity that attempts to represent the modeling of both natural and social related to the goals of the Climate and Cryosphere, with frozen ground dynamics modeling as a primary focus. This forum has close ties with Permafrost Carbon Network (PCN), Next-Generation Ecosystem Experiments-Arctic (NGEE), and other Ground Challenge activities (e.g., biogeochemistry).

Science Highlight

In a retrospective land surface model simulations, the models indicate that changes in vegetation C storage across the permafrost region started to increase in the 1970s and continued to increase through 2009



Simulated changes in vegetation carbon storage between 1960 and 2009 among the models (McGuire et al. 2016. Global Biogeochemical Cycles)

2016 Highlights

- Work on a future model comparison paper (Permafrost-Hydro MIP) has been started in collaboration with PCN and NGEE.
- A model benchmarking activity is underway, with a soil carbon comparison being the first study to be conducted (led by Gustaf Hugelius)

2016 and 2017 Publications

- McGuire, AD, C Koven, DM Lawrence et al.: Glob. Biogeoch. Cycle, 2016,
- Peng, S, P Ciais, G Krinner, et al.: The Cryosphere, 2016.
- Wang, W et al.: The Cryosphere, 2016.
- Wang, W, A Rinke, et al.: The Cryosphere, 2016.
- Xia, J., A.D. McGuire , D. Lawrence , et al.: accepted to JGR, 2017.

Future activities and developments

- Continue work on the Permafrost-Hydro MIP.
- 2nd Asian Conference on Permafrost (ACOP2017. Jul 2-6. Sapporo, Japan) holds sessions on all aspects of frozen ground, including modeling (http://acop2017.arc.hokudai.ac.jp/).
-Synthesis paper on paleo-permafrost reconstructions and modeling; collaborations with young scientists (esp. from Asia), utilizing the ACOP2017 as the venue of discussion. Possible focus is the Tibetan Plateau.
- Arctic Terrestrial Modeling Workshop (Sept 14-15. Oxford, UK).

Contact:

A. David McGuire (UAF, admcguire@ alaska.edu), Kazuyuki Saito (JAMSTEC, ksaito@jamstec.go.jp).

Ice Sheets

SCAR/IASC/CliC Ice Sheet Mass Balance and Sea Level (ISMASS)

Introduction

Since May 2015, The ISMASS Steering Committee and members have:

1- Organized a MISOMIP workshop in Cambridge.

2- Participated in a GIA modelling symposium (see GIA2015 report below)

3- Held a mini symposium during the SCAR open conference in Kuala Lumpur in August 2016 on: "The Antarctic Ice sheet from Past 2future"

4- Held an ISMASS session during the SCAR open conference.

Science Highlight

Glacial Isostatic Adjustment (GIA) modelling (Fairbanks, May_2015).

This three-day symposium drew together scientists working on ice sheet reconstructions, modelling of the viscoelastic response of the solid Earth to surface loading, and comparisons of modelling with sea-level and geodetic observations. Understanding past ice and ocean loading has long been a focus of GIA modelling. Characterizing the rheological properties of the Earth is now a growing field, due to improved constraints on both the details of, and the solid Earth response to, surface mass change. The meeting encompassed both of these aspects. The schedule included time for group discussion following each session, a format that proved popular with the mixed-discipline audience, and the intimate size of the meeting allowed all participants to interact over the course of the four days. The meeting also included a half-day field trip to the Gilmore Creek Tracking station (a major satellite downlink station and also the site of the Fairbanks VLBI and GPS sites), and the Poker Flat Research Range (a rocket launching range operated by the University of Alaska Fairbanks). The final day of the meeting comprised a hands-on workshop using the open source tools SPOTL and REAR to model the high resolution elastic response of the Earth to prescribed surface mass changes.

The symposium was organized by Jeff Freymueller and held in the University of Alaska Fairbanks Geophysical Institute, with additional sponsorship kindly provided by the University of Tasmania, the Technical University of Denmark DTU-Space, and the SERCE Scientific Research Program of SCAR. One of the symposium/workshop organisers, Pippa Whitehouse, represented ISMASS.
See http://www.gia2015.org/ for more details.

Future activities and developments

Most recently, Frank Pattyn and Catherine Ritz are starting to organise a workshop "ice sheets and sea level rise if global warming is limited to 1.5°C. This topic was suggested by CliC. The workshop will be held in Brussels on 11-13 January 2017, and Catherine will report on it during the IGS/IACS/CliC 2017 International Symposium on 'The Cryosphere in a Changing Climate', to be held on 12–17 February 2017, in Wellington, New Zealand.

Contacts:

Chair: Catherine Ritz (catherine.ritz@univ-grenoble-alpes.fr)
Representatives from member organizations are Frank Pattyn (SCAR), Francisco Navarro (IASC) and Edward Hanna (CliC, ehanna@sheffield.ac.uk)

http://www.climate-cryosphere.org/activities/groups/ismass

Regional Activities

SCAR/IASC/CliC Southern Ocean Region Panel (SORP)

Summary of the 11th Session of SORP

The Session was held on 17-18 September 2016 in Qingdao, China and took place in conjunction with the CLIVAR Open Science Conference (OSC, 19-23 September, at the same hotel. Three cross-panel meetings between SORP and other panels were also organized; one with the Atlantic Region Panel (ARP) on the carbon cycle; one on upwelling with the Atlantic Region Panel (ARP), Southern Ocean Region Panel (SORP) and Eastern Boundary Upwelling System Research Foci (EBUS); and one with the Ocean Model Development Panel (OMDP) on modelling initiatives relevant to the Southern Ocean.

Aside from talks from the panel members, Mauricio Mata, member of SOOS (Southern Ocean Observing System) SSC, presented the goals and objectives of SOOS. SOOS is keen to promote two-way communications such as inviting SORP to jointly look at SO EOVs templates, and invite SORP to send an observer to the next SOOS SSC meeting that will likely be at AWI in May 2017. On the specific aspects that SORP may help with SOOS, Mauricio thought SORP provides science insights into what needs to be observed, which help SOOS to develop the observing system. Many suggestions on the closer cooperation between SOOS and SORP were proposed, such as adding an ex-officio member recommended by SOOS to SORP, a joint workshop on capabilities, joint sessions at SCAR OSC 2018, and new capability working groups. Mike Sparrow mentioned that SORP always had one or two SOOS representatives in the past. Lynne Talley suggested the discussion on national representatives between SOOS and SORP needs to be ongoing, and make sure SORP is involved in reviewing SOOS plans as they are available.

SORP aims to have at least one expert/representative for each of the relevant groups on SORP at any given time. The panel co-chairs are trying to appoint new members to fill known gaps, such as SOOS.

Concerning the national representatives, the panel decides to form subcommittee with any others interested to sort out a policy for national representatives: how appointed, term limits, what is required of them and how to keep them in the loop with SORP activities.

The discussion of the cross-panel meeting of the CLIVAR Atlantic Region Panel (ARP), Southern Ocean Region Panel (SORP) and Eastern Boundary Upwelling System Research Foci (EBUS) on the eastern boundary upwelling was concentrated on four possible common themes of interest: "Climate" teleconnections between the SO and EBUs regions; Mesoscale (and sub-mesoscale) "mixing" and restratification processes responsible for the surface effects of wind-driven upwelling; Importance of spatio-temporal variability of wind forcing field and its consequences for the spatio-temporal distribution of upwelling; Model systematic biases and underlying process related to all of the above.

The next session, SORP-12, is planned to occur alongside with YOPP-SH meeting in the late June of 2017. SORP-13 is likely to be at the SCAR/IASC OSC in 2018.

Participants in SORP-11, September 2016, Qingdao, China

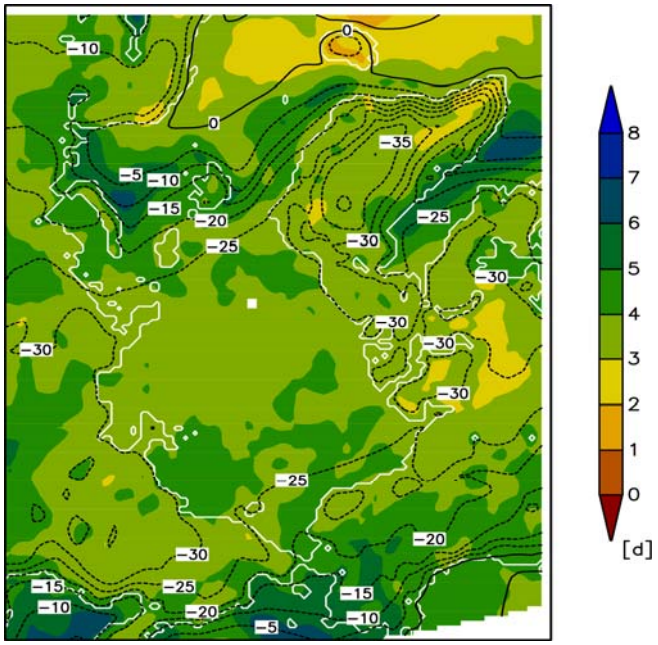
http://www.clivar.org/clivar-panels/southern

Polar CORDEX

Introduction

Polar CORDEX focuses on both Arctic and Antarctic regional climate simulations and is represented by 13 Arctic-focused and ca. 5 Antarctic-focused modeling groups. Details about the participating groups, models, and conducted/planned simulations can be found at www.climate-cryosphere.org/activities/targeted/polar-cordex.

Science Highlight



Ensemble mean from 12 Arctic RCMs of Cold Spell Days (CSDI; shading) and mean 2m air temperature (isolines) for winter (DJF), averaged over 1980-2010. In comparison to ERA-Interim, the ensemble mean captures the mean air temperature very well (pattern correlation coefficient 0.98, mean root mean square error 1.7K). Cold temperature extremes represented here by CSDI are less well reproduced (pattern correlation coefficient 0.64, mean root mean square error 1d), but still, the general pattern and magnitude of the reanalysis data is represented (Matthes et al., in preparation)

2016 Highlights

-Four oral, seven poster presentations, and Polar CORDEX breakout session during the ICRC-CORDEX 2016 conference, Stockholm, May 2016.
-Arctic CORDEX runs from 11 atmosphere and 6 coupled atmosphere-ice-ocean RCMs are available for the Era-interim period.
-Some high-resolution simulations (15 km pan Arctic and 5 km Greenland) are available.
-Multi-model analyses of extreme temperature and cyclones are finished.
-Arctic CORDEX simulations are used to project temperature and precipitation change over Svalbard area.
-The annual Arctic CORDEX meeting was held in Bergen/Norway at UNIS/Bjerkness Centre in Nov. 2016.

2016 resulting publications

-11 papers at ICRC-CORDEX conference (abstracts at www.icrc-cordex2016.org)
-Scinocca et al., 2016: Coordinated global and regional climate modeling. J. Clim., doi:10.1175/JCLI-D-15-0161.1
-Osuch and Wawrzyniak, 2016: Climate projections in the Hornsund area, Southern Spitsbergen. Polish Polar Res., doi:10.1515/popore-2016-0020

Future activities and developments

-Continuation of multi-model analyses for Arctic CORDEX.
-At the moment there are few Antarctic simulations, but the plan is to enable multi-model intercomparison studies.

Participants in the Arctic CORDEX meeting, Bjerkness Centre, November 2016, Bergen, Norway

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http://www.climate-cryosphere.org/activities/targeted/polar-cordex

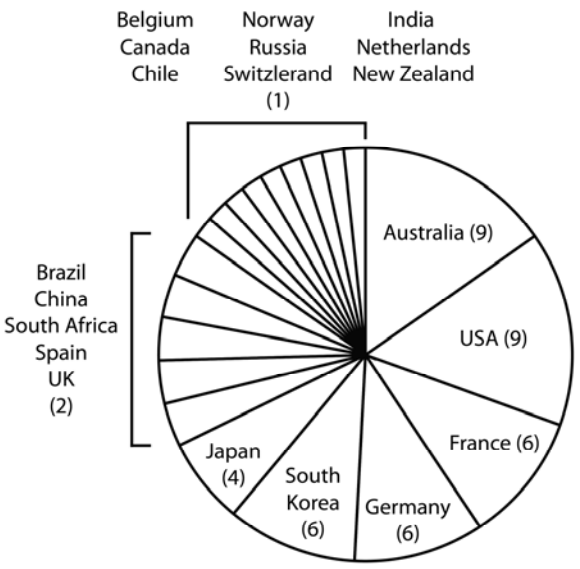
Southern Ocean Satellite Requirement

Introduction

CliC together with Southern Ocean Observing System (SOOS) put together a survey to collect information on satellite data requirements for monitoring changes in the biological, geophysical, and biogeochemical regimes in the Southern Ocean (across all temporal/spatial scales). The key motivation of the survey and report/publication is to provide the Satellite data providers with a strong, consolidated "user voice" on Southern Ocean satellite data requirements for use when planning future satellite missions.

The survey, conducted in 2014, spanned a wide range of research and operational disciplines and goals. The survey received 59 unique responses from 19 countries worldwide. This project worked to bring together the results of this survey, along with further information from the literature and a broad community review, to provide clear recommendations from the project.

Science Highlight



Nationalities of survey respondents.

2016 Highlights

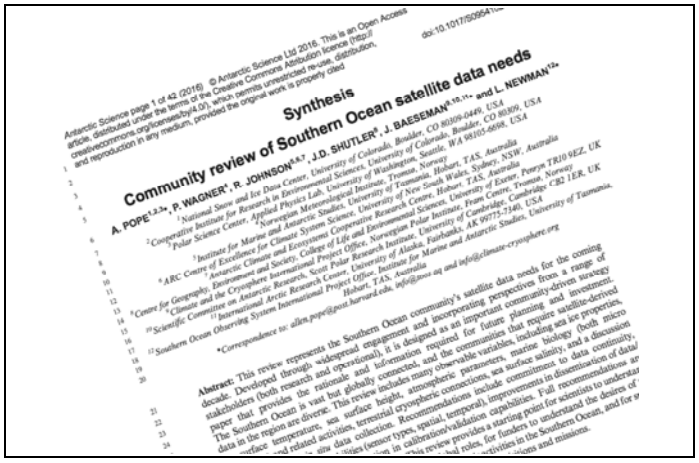
In 2016, the Southern Ocean Satellite Data Needs Report was revised and accepted for publication in Antarctic Science.

2016 Publications

Pope, A., Wagner, P., Johnson, R., Shutler, J.D., Baeseman, J. and Newman, L. (2016) 'Community review of Southern Ocean satellite data needs', Antarctic Science, , pp. 1–42. doi: 10.1017/S0954102016000390.

Future activities and developments

We are working to publish a shortened summary of the report in a broad community platform, for example AGU's Eos. We also aim to have it highlighted in the news section of Science magazine when published. These activities will conclude the work of the CliC Southern Ocean Satellite Requirements Project.


Synthesis

Community review of Southern Ocean satellite data needs

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Rob Johnson, Bureau of Meteorology, Australia
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http://www.climate-cryosphere.org/activities/targeted/so-sat-req

Inter-disciplinary Activities

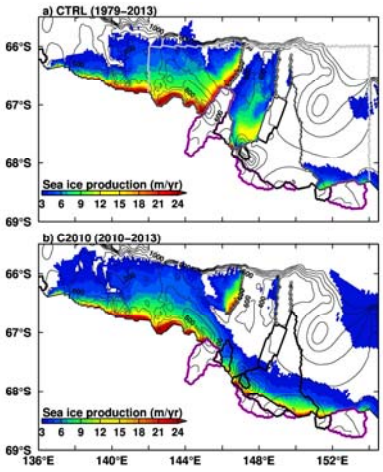
Understanding Interactions Between Cryosphere Element

Introduction

Major change is occurring in both polar cryospheres, yet little is known about the contributing role of interactions between the different component "elements" involved – including ice sheets/glaciers, icebergs, sea ice, snow and permafrost (connected by oceanic and atmospheric processes). The aim of this CliC Targeted Activity is to identify and raise awareness and understanding of key cross-cryosphere interactions; foster and facilitate cross-disciplinary and -polar discussion and collaboration; synthesize and integrate existing work and information from both polar regions; identify gaps; and bridge and connect the polar/hemispheric and climate observational and modeling communities.The ultimate goal is to provide new information towards more realistic parameterization of cross-cryosphere linkages and processes in models (Earth System, coupled regional high-resolution and ice sheet/shelf etc.), to improve model performance.

Science Highlight

A new high-resolution modeling study highlighting the effects of change in Antarctic coastal configuration (large-scale calving of the Mertz Glacier Tongue) on sea ice production, ice-shelf basal melt, fast ice distribution and dense shelf water export.



Maps of mean annual sea ice production (a) before and (b) after the 2010 calving of the Mertz Glacier calving. Observations: purple lines are ice shelf regions; black circles are grounded icebergs that block sea ice advection; and black lines show boundaries of icebergs and fast ice before 2010 (Kusahara et al., in press).

2016 Highlights

- A poster and discussions at the IGS *International Symposium on Interactions of Ice Sheets and Glaciers with the Ocean* (USA, June 2016), highlighting the activity, its aims, recent cross-cryosphere research, and the important role of sea ice in modulating ice sheet margin processes.
- Strong engagement of the international community, and recruitment of key players carrying out cross-cryosphere research.

2016 Publications

Kusahara, K. et al. In press. Modeling ocean-cryosphere interactions off Adélie and George V Land, East Antarctica. *Journal of Climate*.

Heil, P. et al. 2016. SIPEX 2012: Extreme sea-ice and atmospheric conditions off East Antarctica. *Deep-Sea Research II,* DOI:10.1016/j.dsr2.2016.06.015. Includes discussion of iceberg-sea ice interaction.

Toyota, T. et al. 2016. On the extraordinary snow on the sea ice off East Antarctica in late winter, 2012. *Deep-Sea Research II*, doi:10.1016/j.dsr2.2016.02.003i.

Future activities and developments

- Leadership of a series of community-based review papers on the role of important polar cross-cryosphere interactions in climate processes.
- First review paper (in progress) - on current state of knowledge of interactions and feedbacks between sea ice, floating ice sheet margins and icebergs in both polar regions.
- Strong involvement of early-career scientists.
- Development of the project webpage as a "one-stop shop" for relevant information.
- Promotion and engagement at the IGS/CliC/IACS International Symposium on The Cryosphere in a Changing Climate (New Zealand, February 2017).

Attendance of the IGS International Symposium (see above) enabled successful engagement of the community in this project.

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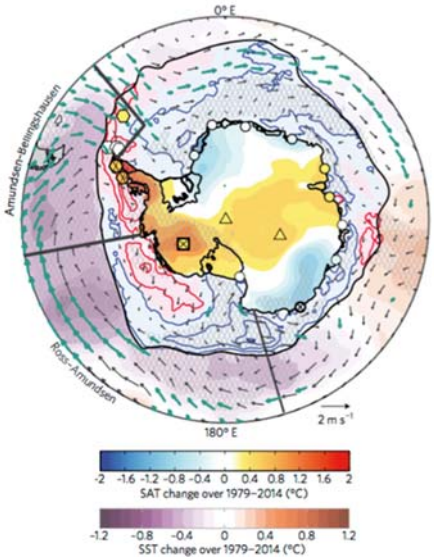
Polar Climate Predictability Initiative (PCPI)

Introduction

The Polar Climate Predictability Initiative (PCPI) aims to advance understanding of the sources of polar climate predictability on timescales ranging from seasonal to multi-decadal. Polar predictability stems from the unique persistence of signals in ice and snow and through exchange with the ocean at all depths and with the stratosphere. PCPI is concerned with the success of modelling and observing the rapid changes seen in the Arctic and the varied changes occurring in the Antarctic. PCPI is investigating the role of the poles in global climate and prediction. We work jointly with the Polar Prediction Project of the WWRP on mutual interests, though our focus tends towards longer timescales.

Science Highlight



Antarctic climate system trends in the instrumental record period. These trends were found to be typical of variability in Antarctic paleoclimate records of the past two centuries, while most climate model simulations are incompatible with these observations.

2016 Highlights

In 2016, we held a Spring School on Polar Prediction for 30 post graduate and early career scientists at the Abisko Field Station in Sweden in collaboration with PPP. We organized three workshops with the topics Polar Prediction (with PPP), Polar Feedbacks and Sea Ice Thickness. We published one review paper on recent trends in the Southern Ocean (Jones et al, 2016) that is an outcome of a workshop we held last year. We published an intercomparison paper on the sensitivity of predictions to initial sea ice thickness (Blanchard-Wrigglesworth et al, 2016). We hosted sessions at AGU and EGU on Polar Prediction and at AGU on Data Assimilation Products.

2016 Publications

Jones, J. M., S. T. Gille, H. Goosse, N. and 22 others, 2016. Assessing recent trends in high-latitude Southern Hemisphere surface climate, Nature Climate Change, 6, 917-926, doi:10.1038/NCLIMATE3103.

Blanchard-Wrigglesworth, E. and 13 others, 2016: Multi-model seasonal forecast of Arctic sea-ice forecast uncertainty at pan-Arctic and regional scales, Climate Dynamics, doi:10.1007/s00382-016-3388-9.

Future activities and developments

A review paper, led by Goosse and Kay, that evolved from

Group photograph from the Workshop on Polar Feedbacks held at Louvain-la-Neuve, Belgium in May 2016.

our workshop last year on climate feedbacks is in final review by the 14 authors. We will hold a joint PCPI-PPP workshop on Polar Prediction in March 2017 at Bremerhaven, Germany. We also have a session at the 2017 EGU.

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Social Science

Where Are They Now? A Case Study of International Travel Support for Early Career Researchers

Introduction

To help maintain the continuum of knowledge in polar sciences that was established during the 2nd International Conference on Arctic Research Planning (ICARP) and the International Polar Year (IPY), it is of great importance to continue to support the next generation of researchers. Many organizations are working on initiatives that allow early career Arctic researchers to discuss their ideas, work together, and exchange information with an international and renowned group of Arctic scientists. Yet, the evaluation of how effective these initiatives are is still lacking.

To aide in assessing how past support has influenced early career Arctic researchers and potentially enhanced future opportunities, the Association of Polar Early Career Scientist (APECS), the Climate and Cryosphere Project (CliC) and International Arctic Science Committee (IASC) are working together to use IASC funding of early career researchers as a case study to assess the value of travel support for early career researchers. As a contribution to ICARP III, the "Where are they now?" Project investigated the subsequent career paths of early career researchers that received travel funding from IASC since the start of the most recent IPY (2007-2008) until 2013.

Survey and Results

IASC provided travel support for 287 early career researchers during this time. A survey was sent to each of these researchers and 132 people responded, a 45.9 % response rate. Results from the survey indicate that 90% of these researchers are still active in Arctic work. Results indicate that travel support was beneficial to both the research and careers of the early career scientists responding. Responses from survey participants provided details on the specific impacts of travel support to various meetings and included suggestions on how funds could be better used in the future.

Results indicate that 90% of these researchers are still active in Arctic work and qualitative results indicate that travel support was beneficial to both the research and careers of the early career scientists responding. Of the 10% that are no longer working with Arctic issues, 29% stated personal reasons influencing their decision to move to other fields. Other reasons were change of topic, related to funding or institutional issues, or taking whatever job was offered. As the biggest challenges in their work with the Arctic issues, they name funding and limited positions. As the most important benefit from the funding, they name networking. Quite a few early-career researchers mentioned that the networking at the event had resulted in new opportunities and new collaborations.

2016 Project Highlights

A peer-reviewed paper was published in the ISAR-4/ ICARPIII, Science Symposium of ASSW2015 Special Issue of the Polar Science journal.

2016 Publications

Majaneva, S., Hamon, G., Fugmann, G., Lisowska, M., Baeseman, J. 2016. Where are they now? A Case Study of the Impact of International Travel Support for Early Career Arctic Researchers, Polar Science (2016), doi:10.1016/j.polar.2016.06.001

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http://www.climate-cryosphere.org/activities/targeted/wherenow

Emerging Activities and Ideas

Historical Ice Charts for Quantification of Climate Change

In 2017, the Norwegian Meteorological Institute (MetNo) and CliC are planning a workshop which will focus on improving the use of ice charts to reconstruct the historical climate, projection of future sea ice conditions, and data assimilation for hindcast and forecasting applications. The goal of the CliC sponsored 3-day paper writing workshop in Tromsø, Norway from November 29 - December 1, 2016 (hosted at Norwegian Polar Institute) was to expand on previous analyses of the sea ice edge variability in the European Arctic, also based on the ACSYS/CliC Historical Ice Chart Archive (1553-2002) (Divine and Dick, 2006, 2007, and Vinje, T., 2001). During the workshop, the participants discussed the production of a publication that will compile current sea ice edge information from ice charts to extend previous archives from the following: ACSYS/CliC (ACSYS, 2003), Global Digital Sea Ice Data Bank (GSIDB) (http://www.aari.ru/gdsidb/gdsidb_2.html), National Snow and Ice Data Center Arctic Sea Ice Charts from the Danish Meteorological Institute (NSIDC DMI)(DMI and NSIDC, 2012), and the Gridded Monthly Sea Ice Extent and Concentration product (Walsh, et al., 2015). Other applicable sources of data will be included (e.g. Ship logs, reconnaissance, and others). With the advance in increased high spatial and temporal resolution satellite data and significant improvements in sea ice charting techniques, this study will allow for the development of better ice edge information for historical reconstruction and data assimilation.

Following the workshop the CliC and Met.no team are planning to organize a workshop to discuss the results of the paper with data providers and users in the community. This will also allow the team to get feedback on how to optimize the use of the results for sea ice model studies. This is particularly relevant given the upcoming Year of Polar Prediction (YOPP).

The main objective of the workshop will be to present satellite and technical improvements in sea ice charts since 2003, results of the paper and discuss the capabilities of sea ice charts in current scientific applications. Key agenda items will focus on the following:

1. Current Historical Sea Ice Chart Archives
2. Development of a metric to quantify sea ice charts for sea ice edge location
3. Use of sea ice charts for data assimilation (Norwegian Ice Service (www.polarview.met.no), Canadian Ice Service (www.ec.gc.ca/glaces-ice/), U.S. National Ice Center (www.natice.noaa.gov), Arctic and Antarctic Research Institute (www.aari.ru)
4. Dissemination of archived sea ice chart information

Exercises will be created to gain input from experts and how sea ice chart information fits within the framework of current scientific approaches. Discussions and suggestions from this function would provide valuable instruction on how we can optimize the use of sea ice operational information.

Though a publication from the CliC sponsored writing workshop will be in progress, from this workshop a report or a white paper will be produced to outline the recommendations for the science and operation community from the expert team comprised in the workshop. This will be used as a baseline document for further improvements to quantify sea ice charts and applied to sea ice edge variability studies for the Antarctic.

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