



ICSU
International Council for Science



2015

WCRP CLiC Annual Report



Photo courtesy of Lawrence Hislop



About CliC

Who we are...

The Climate and Cryosphere Project (CliC) is one of the four core projects of the WMO/ISCU/IOC World Climate Research Programme (WCRP) (<http://www.wcrp-climate.org>) together with CLIVAR, GEWEX, and SPARC, and was established as such in 2003. The four core projects work closely with the WCRP Joint Planning Staff (JPS) and other working groups of WCRP. The projects organize its work through various initiatives, experiments, and their respective scientific advisory committees and workshops.

What we do...

The Climate and Cryosphere project encourages and promotes research into the cryosphere and its interactions as part of the global climate system. It seeks to focus attention on the most important issues, encourage communication between researchers with common interests in cryospheric and climate science, promote international cooperation, and highlight the importance of this field of science to policy makers, funding agencies, and the general public. CliC also publishes significant findings regarding the role of the cryosphere in climate, and recommends directions for future study.

How we work...

The CliC Scientific Steering Group (SSG) is composed of world-renowned researchers and has the overall responsibility for planning and guiding the CliC project. 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 a 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 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 the CliC activities.

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



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2015 Overview from the Co-Chairs

We are proud to present this 2015 CliC annual report, which provides an overview of the activities that were accomplished under the banner of the Climate and Cryosphere core project of WCRP and the Grand Challenge “Melting Ice and Global Consequences”.

This year has seen significant progress on many fronts. Some of CliC’s new activities include a global glacier modelling initiative as well as contributions to the Permafrost Carbon Network (PCN) and the Year of Polar Prediction (YOPP). The model intercomparison projects are continuing to build momentum, while the Arctic Freshwater Synthesis is soon concluding its work.

CliC’s CMIP6-related model intercomparison projects i.e., ISMIP6, SIMIP and LS3MIP, have now been endorsed by the WGCM’s CMIP panel. Together with several other activities, such as the marine ice sheet – ocean and the mountain glacier intercomparison, these initiatives are the successful result of a strategy aimed at tightening the links between the cryospheric research and global modelling communities.

The focus and content of the Grand Challenge “Melting Ice and Global Consequences” has been further sharpened and developed, now clearly targeting aspects of cryospheric change that have global impacts, as its new name indicates: Permafrost and the global carbon cycle; ice sheets, glaciers and rising sea level; and sea ice and snow interacting with a changing climate.

This research has been carried out in the context of tight WCRP-wide budget constraints that force us to critically review our activities and make difficult choices with respect to funding requests. It is only with the continued enthusiasm and engagement of all of us – all engaged scientists, engineers and students; CliC activity leaders and SSG members; the CliC project office and the WCRP joint planning staff – that we can continue to produce highly visible and relevant research through fruitful international collaboration.

In this context, we particularly stress the crucial role of our CliC project officer Gwénaëlle Hamon who has acted as office director since September 2015 when Jenny Baeseman left the CliC office for SCAR. She has done a fantastic job of keeping the office working smoothly after Jenny’s departure. Thank you so much, Jenny and Gwen, for your past and ongoing work! We are now very happy to welcome the new CliC international project office director, Lawrence Hislop, who will take up his position in February, and we take the opportunity to sincerely thank the Norwegian Polar Institute for their continuing vital support of CliC.

The CliC leadership group, composed of the members of the Scientific Steering Group (SSG) and the leaders of the various CliC activities, now has regular open teleconferences every month, usually with a specific topic related to existing CliC activities or discussions on future research priorities. We think that these regular teleconferences are a very valuable tool that helps maintain momentum for the project as a whole and the coherence between the very diverse CliC-related activities. Importantly, these leadership teleconferences are open. Everybody interested in learning about ongoing CliC activities and engaging in future projects is welcome to join.

We would also like to thank four outgoing members of the CliC SSG for their tireless efforts and hope they will stay engaged in CliC activities: Larry Hinzman, Peter Lemke, Nalân Koç and Tetsuo Ohata. We would also like to extend a warm welcome to our new SSG members: Hiroyuki Enomoto, Stephen Hudson, Dario Trombotto Liaudat and Lars Smedsrud. We would also like to thank Mike Sparrow from the WCRP Joint Planning Staff in Geneva for his strong support and guidance, particularly during the transition to a new project office Director.

Looking ahead, we anticipate significant progress in the planning and implementation of the cryospheric elements of the CMIP6 model intercomparison effort, with finalization of the data requests and experimental design details in the coming year. We also look forward to further progress under the Polar Climate Predictability Initiative (PCPI) and planning for the Year of Polar Prediction (YOPP). Finally, building on the expertise of our new Director, we anticipate further enhancement of our highly-appreciated web site and outreach/communication activities.

Gerhard Krinner and Greg Flato – CliC SSG Co-Chairs

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)

Members

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

Alexandra Jahn, University of Colorado Boulder, USA (1/2014-12/2018)

Margareta Johansson, Lund University, Sweden (1/2015-12/2017)

Shichang Kang, Environmental and Engineering Research Institute, Chinese Academy of Sciences, China (1/2015-12/2017)

Rob Massom, Australian Antarctic Division and Antarctic Climate and Ecosystems Cooperative Research Centre, Australia (1/2013-12/2017)

Sebastian Mernild, Center for Scientific Studies, Chile (1/2014-12/2018)

Tatiana V. Pavlova, Voeikov Main Geophysical Observatory, Russia (1/2015-12/2017)

New Members:

Hiroyuki Enomoto, National Institute of Polar Research (NIPR), Japan (1/2016-12/2018)

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 Members:

Larry Hinzman, International Arctic Research Center, University of Alaska Fairbanks, USA (1/2013-12/2015)

Nalân Koç, Norwegian Polar Institute, Norway (1/2013-12/2015)

Peter Lemke, Alfred Wegener Institute for Polar and Marine Research, Germany (1/2013-12/2015)

Tetsuo Ohata, National Institute of Polar Research, Japan (1/2013-12/2015)

WCRP Joint Science Committee Liaisons

James Renwick, Victoria University of Wellington, New Zealand (2013 -)

Mauricio M. Mata, Federal University of Rio Grande-FURG, Brazil (2014 -)

Flurries in the Project Office

In 2015, the CliC Office helped organize and fund 25 workshops, including support for more than 60 people. This support includes arranging travel, fellowships, website content, and participation on organizing committees. We also helped initiate a number of new targeted activities, connected researchers to potential collaborators, participated in partner organization activities, and organized speaking engagements about CliC at various meetings. We also provide coordination support for various co-sponsored initiatives, several cryosphere community resources (see Outreach section of this report), and act as a contact point for cryosphere research within the WCRP.

We had a turnover in staff again this year. Dr. Jenny Baeseman, CliC International Project Office Director since 2012, became the new director of SCAR. The renewed energy and activity now visible in CliC is largely attributable to her hard work and dedication. The CliC community in general will certainly miss Jenny and all of the enthusiasm and organizational talent she brought to the CliC project. Much progress on our understanding of climate and cryosphere interactions has been made thanks to the numerous initiatives that she has developed over these past three years.

Lawrence Hislop was appointed as the new Executive Director of the CliC International Project Office, starting in February 2016. Lawrence is from Montreal, Canada, has more than ten years of international experience leading United Nations and European Union funded projects, and has co-authored many environmental assessments and related communications products. In addition to his research work, Lawrence also produces documentary photography, films and infographics. We look forward to starting work with Lawrence in 2016!

In 2015, Gwénaëlle Hamon became the CliC Executive Officer after starting working for CliC in 2014 on the Arctic Freshwater Synthesis project. She will remain in her position of Executive Officer in 2016.

We would also like to thank Greg Flato and Gerhard Krinner, our wonderful Co-Chairs, the WCRP Joint Planning Staff (JPS) and in particular our Liaison there, Mike Sparrow, and the Norwegian Polar Institute for their continued support.

2015 Workshops and Meetings

ESA-CliC Earth Observation and Arctic Science Priorities

January 20, 2015, Tromsø, Norway

<http://www.climate-cryosphere.org/meetings/past/2015a/esa-arctic-2015>

11th session of the CliC Scientific Steering Group (SSG)

February 9-12, 2015, Boulder, CO, USA

<http://www.climate-cryosphere.org/meetings/past/2015a/ssg11>

Large-scale Climate Variability in Antarctica and the Southern Ocean over decades to centuries, and links to extra polar climate

March 24-26, 2015, La Jolla, CA, USA

<http://www.climate-cryosphere.org/wcrp/pcpi/meetings/initiative-1-mar2015>

36th Session of the WCRP Joint Scientific Committee

April 8-10, 2015, Geneva, Switzerland

<http://wcrp-climate.org/jsc36-about>

Southern Ocean Satellite Data Requirements

April 17-22, 2015, Tromsø, Norway

<http://www.climate-cryosphere.org/activities/targeted/so-sat-req>

Arctic Science Summit Week (ASSW) & International Conference on Arctic Research Planning (ICARP III) Symposium

April 23-30, 2015, Toyama, Japan

<http://www.assw2015.org/>

Future Earth Norway Meeting

May 7, 2015, Oslo, Norway

Permafrost Carbon Network Working Group Lead/Co-lead

May 11-12, 2015, Flagstaff, AZ, USA

www.permafrostcarbon.org

Arctic Freshwater Synthesis Final Science Meeting

May 12-14, 2015, Victoria, Canada

<http://www.climate-cryosphere.org/activities/targeted/afs/meetings/final-science-meeting>

Constraining Uncertainty in Greenland Ice Sheet Surface Mass Balance Model Output and In Situ Validation

May 19-20, 2015, Sheffield, UK

<http://www.climate-cryosphere.org/activities/groups/ismass/meetings/1270-uncertainty-greenland-ice-sheet-models>

Where Are They Now? Writing Meeting

June 15, 2015, Tromsø, Norway

Intergovernmental Oceanographic Commission of UNESCO Ocean Science Day

June 17, 2015, Paris, France

CliC/IACS Special Session on “Understanding Linkages Between Different Elements of the High-Latitude Cryosphere”

June 25, 2015, 26th IUGG GA, Prague, Czech Republic

GlacierMIP Kick-Off Workshop

June 26-27, 2015, 26th IUGG GA, Prague, Czech Republic

<http://www.climate-cryosphere.org/activities/targeted/glaciernip>

Year Of Polar Prediction (YOPP) Summit

July 13-15, 2015, Geneva, Switzerland

<http://www.polarprediction.net/yopp/yopp-summit.html>

ISMASS Workshop on the Marine Ice Sheet and Ice Shelf-Ocean Model Intercomparison Projects (at the International Symposium on Contemporary Ice-Sheet Dynamics: Ocean interaction, meltwater and non-linear effects)

August 16, 2015, Cambridge, UK

<http://www.climate-cryosphere.org/activities/groups/ismass/meetings/mismips-cambridge>

Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) Data Workshop (at the International Symposium on Contemporary Ice-Sheet Dynamics: Ocean interaction, meltwater and non-linear effects)

August 19, 2015, Cambridge, UK,

<http://www.climate-cryosphere.org/activities/targeted/ismip6/meetings/2015-data-workshop>

Polar Climate Predictability Initiative (PCPI) Theme Leaders' Meeting

September 9-11, 2015, University of Reading, UK

<http://www.climate-cryosphere.org/wcrp/pcpi/meetings/2015-leads>

3rd International Conference on Arctic Research Planning (ICARPIII) and International Polar Partnership Initiative (IPPI) Steering Group Meetings

September 10-11, 2015, Reykjavik, Iceland

SWIPA Follow-up Workshop

October 5-6, 2015, Copenhagen, Denmark

Land Modelling ("LandMIP") Workshop

October 26-28, 2015, Zurich, Switzerland

<http://www.climate-cryosphere.org/activities/targeted/ls3mip/meetings/landmodelling>

Linkage Between Arctic Climate Change and Mid-Latitude Weather Extremes Workshop

November 3-5, 2015, University of Sheffield, UK

<http://www.climate-cryosphere.org/activities/targeted/linkages/linkages->

Pre-AGU Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) Workshop

December 12-13, 2015, San Francisco, USA

<http://www.climate-cryosphere.org/activities/targeted/ismip6/meetings/ismip6-agu>

Pre-AGU Greenland Ice Sheet Ocean Observing System (GrIOOS) Workshop

December 12-13, 2015, San Francisco, USA

In addition to these in person workshops, CliC has been hosting monthly Leadership Online Meetings since the summer of 2015. These calls addressed various topics such as the WCRP Grand Challenges, the various CliC Groups, Targeted Activities, and the Model Intercomparison Projects (MIPs) etc. These monthly calls aim to update the Leadership on the CliC activities and to prepare for the 2016 Scientific Steering Group Meeting.

CliC Activity Report Summaries

Arctic Freshwater Synthesis (AFS)

Terry Prowse, University of Victoria/Environment Canada; Johanna Mård Karlsson, Stockholm University, Sweden; Arvid Bring, University of New Hampshire, USA

Introduction

The Arctic Freshwater Synthesis is an interdisciplinary science integration activity that has produced a circum-Arctic review and synthesis of the Arctic freshwater system, focusing on the storage, fluxes and effects of freshwater. There is increasing scientific recognition that changes to the Arctic freshwater systems have produced, and could produce even greater, changes to the Arctic environment, society and economy. 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.

Achievements for 2015

During 2015, the project participants finalized six synthesis papers, in addition to an introductory and summary manuscript. Final versions of all papers were submitted to the *Journal of Geophysical Research: Biogeosciences* in the summer of 2015, with some papers currently in review and others already accepted and available online. The latter includes the introduction and summary papers, which introduce the AFS and highlight a number of key findings. A presentation was organized at the Arctic Science Summit Week in Toyama, Japan, on April 23-30 2015, with contributions from several of the AFS component teams.

A key outcome from the synthesis is highlighting the need to focus on the role of the near-coastal domain as an important interface between terrestrial hydrology and the ocean. Along the coast, information shortages combine to yield great uncertainty both in surface flows, which are poorly monitored for many smaller rivers, and the interaction between groundwater, surface water, permafrost and seawater. In addition, there is recognition that additional rivers further south than commonly considered in Arctic hydrological studies may need to be included to fully understand and model freshwater circulation in the Arctic Ocean.

Plans for 2016 and beyond

During early 2016, the AFS authors will finish and revise the last AFS journal manuscripts that are still in review. The AFS supporting organizations will also, with input from the AFS lead authors, finalize the production of a layman's report, in shorter and more accessible format, directed towards policymakers and the general public. This document will also highlight recommendations for future research planning and prioritization.

Results from the AFS are currently also being integrated in the work preparing for an update of the Snow, Water, Ice, and Permafrost in the Arctic (SWIPA) report, which will serve as knowledge input to the Adaptation Actions for a Changing Arctic (AACA) process.

Resulting Publications

Introduction (accepted)

Prowse, T.D., Bring, A., Carmack, E., Karlsson, J.M. 2015. The Arctic Freshwater Synthesis: Background and Introduction, *J. Geophys. Res. Biogeosci.*, doi:10.1002/2015JG003127.

Summary (published)

Prowse, T., Bring, A., Mård, J., Carmack, E., Holland, M., Instanes, A., Vihma, T., Wrona, F. J. (2015), Arctic Freshwater Synthesis: Summary of key emerging issues, *J. Geophys. Res. Biogeosci.*, 120, 1887–1893, doi:10.1002/2015JG003128.

Terrestrial Ecology (in acceptance phase)

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. 2015. Transitions in Arctic Ecosystems: Implications of a changing hydrological regime.

Modeling (accepted)

Lique, C., Holland, M.M., Dibike, Y., Lawrence, D.M., Screen, J.A. 2015. Modeling the Arctic Freshwater System and its integration in the global system: Lessons learned and future challenges, *J. Geophys. Res. Biogeosci.*, doi: 10.1002/2015JG003120.

Atmosphere (accepted)

Vihma, T., Screen, J.A., Deser, C., Holland, M., Newton, B., Popova, V., Prowse, T.D., Tjernström, M., Walsh, J., Zhang, X. 2015. The Arctic atmospheric water cycle: processes, past and future changes and their impacts.

Ocean (accepted)

Carmack, E., Yamamoto-Kawai, M., Bacon, S., Bluhm, B., Haine, T., Lique, C., Melling, H., Polyakov, I., Straneo, F., Timmermans, M.L., Williams, W. 2015. 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, *J. Geophys. Res. Biogeosci.*, doi: 10.1002/2015JG003140.

Resources (accepted)

Instanes, A., Kokorev, V., Janowicz, R., Bruland, O., Sand, K., Prowse, T.D. 2015. Changes to freshwater systems affecting Arctic infrastructure and natural resources.

Terrestrial Hydrology (accepted)

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

Webpage

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

Arctic Sea Ice Working Group (ASIWG)

Don Perovich, Engineer Research and Development Center Cold Regions Research and Engineering Laboratory, USA

Introduction

The goals of the Climate and Cryosphere Arctic Sea Ice Working Group are to:

- i) Develop, standardize, and implement observation and 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) Establish and foster connections between international groups involved in sea ice observations, modeling, remote sensing, and data assimilation.

Achievements for 2015

The ASIWG was involved in several activities over the past year. Professor Jenny Hutchings deployed the ASSIST sea ice observation software on seven research vessels operating in the Arctic this past summer. The ASSIST software and all the observations are available at the Geographic Information Network of Alaska (GINA) data center (<http://icewatch.gina.alaska.edu/>). Observations made using ASSIST are also being provided to national ice centers.

The ASSIST software was also used by passengers aboard the Russian Icebreaker *50 Years of Victory* on four round-trip cruises to the North Pole in July - August of 2015. In addition, aerial photographs were taken during sightseeing helicopter flights and in situ measurements of snow depth and melt pond properties were made on the ice at 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 contributed to the planning of large international, interdisciplinary projects, such as the Year of Polar Prediction Summit and MOSAiC – Multidisciplinary drifting observatory for the Study of Arctic Climate.



ASIWG members organized a workshop that included both classroom and field components. The workshop matched an international team of six researchers who primarily made field observations with eight researchers who mainly used sea ice and climate models. This resulted in a better-informed and more coordinated research community that will help to advance the development of improved snow-on-sea-ice treatments within climate models.

Plans for 2016 and beyond

ASIWG will continue to integrate Arctic sea ice related activities into MOSAiC, Year of Polar Prediction, Sea Ice Prediction Network, the CliC Antarctic Sea Ice Processes and Climate, and Sea Ice and Climate Modeling. This coordination is critical since the Year of Polar Prediction program takes place in 2017-2019 and MOSAiC is moving forward towards a field campaign from 2019-2020. ASIWG will continue to provide support for the Arctic sea ice portion of these activities.

There are plans to expand the use of the ASSIST ice watch software to scientific research vessels operating in the Arctic, and to reach out to the tourism industry to acquire sea ice observations.

Planning is underway for an ASIWG workshop in 2016 that will in part discuss ways of facilitating the development of sea-ice/cryospheric flagship observatories in the Arctic. There are several coastal observatories around the Arctic (e.g., Ny Ålesund in Svalbard, Barrow in Alaska, CHARS in Canada, Tiksi and Cape Baranov in Russia and others) with different, as of now uncoordinated sea ice and cryospheric components. The ASIWG will seek ways of standardizing and integrating the sea ice observations at these observatories.

References

Perovich, D., M. Holland, and E. Hunke (2015), Improving representation of snow on sea ice in climate models, *Eos*, 96, doi:10.1029/2015EO039419.

Jeffries, M., and others. The Arctic (in "State of the Climate in 2014"). *Bull. Amer. Meteor. Soc.* 96, 2015.

Webpage

<http://www.climate-cryosphere.org/activities/groups/164-arctic-sea-ice-wg>

Antarctic Sea Ice Processes and Climate (ASPeCt)

Stephen Ackley, University of Texas at San Antonio, USA; Marilyn Raphael, University of California, Los Angeles, USA

Introduction

ASPeCt has the key objective of improving our understanding of the Antarctic sea ice zone through focused and ongoing field programs, remote sensing and numerical modelling. Designed to complement, and contribute to, other international science programs in Antarctica as well as existing and proposed research programs within national Antarctic programs, ASPeCt coordinates the collection, analysis and archiving of in situ sea-ice observations for use in validation/verification of remote-sensing, numerical modelling and other climate studies. ASPeCt also includes a component of data rescue of valuable historical sea ice zone information.

Achievements for 2015

ASPeCt participated in two Council of Managers of National Antarctic Program (COMNAP) workshops in 2015. The Sea Ice Challenges Workshop in Tasmania explored the sea ice challenges our National Antarctic programs are experiencing in some parts of Antarctica right now and especially in recent seasons.

The second meeting was the SCAR/COMNAP workshop in Tromsø which examined the logistics/infrastructure requirements relating to implementation of the 2014 SCAR Horizon Scan initiative. Steve Ackley participated in the workshop, providing the sea ice input around use of icebreakers, autonomous vehicles, buoy networks, satellite observations etc. Two community surveys were conducted online prior to that workshop and a majority of responses supported sea ice as a key discipline and underlined the growing importance of ASPeCt-related science in future undertakings in Antarctic/Southern Ocean research.

ASPeCt scientists at AWI conducted an expedition onboard *R/V Polarstern* to the Weddell Sea with a focus on sea ice thermodynamics and snow cover. They used an ROV for under-ice studies and deployed a suite of buoys. A map and reports on this expedition may be found at <http://www.pangaea.de/PHP/CruiseReports.php?b=Polarstern> under the label

PS89. This cruise also contributed to additional ASPeCT sea ice observations, which are also available from Pangaea.

Continuing work:

ASPeCt data collection and testing of the ship-board sea-ice observation software prototype by the AAD, AWI and CHINARE continues. Additions to the ship observations database (ASPeCt observations) are also being made on a continuing basis.

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

Plans for 2016 and beyond

ASPeCt is involved in planning and participating in the National Academy of Science's Antarctic sea ice variability and trends workshop. ASPeCt is represented by Workshop Committee members Marilyn Raphael and Ted Maksym and participants Steve Ackley and Sharon Stammerjohn. This workshop, scheduled for January 11-12, 2016, will address our current understanding of processes driving Antarctic sea ice changes, whether or not these changes remain within the expected range of natural climate variability, and why climate models continue to fail at simulating observed Antarctic sea ice changes. CliC is providing funding for early-career participants at this Workshop.

ASPeCt will also convene a session on Antarctic sea ice processes and ice shelves status at the SCAR OSC in Kuala Lumpur (August 2016) and hold a workshop under the auspices of that meeting.

References

Drews, R., Brown, J., Matsuoka, K., Witrant, E., Philippe, M., Hubbard, B., and Pattyn, F.: Anomalous dense firn in an ice-shelf channel revealed by wide-angle radar, *The Cryosphere Discuss.*, 9, 5647-5680, doi:10.5194/tcd-9-5647-2015, 2015.

A manuscript discussing the processing of CryoSat-2 sea ice freeboard (and later also thickness) is under review in *The Cryosphere* (Schwegmann et al.): <http://www.the-cryosphere-discuss.net/9/4893/2015/tcd-9-4893-2015.html>

Webpage

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

Technical Committee on Sea Ice Observations

Stephen Ackley, University of Texas at San Antonio, USA; Jennifer Hutching, Oregon State University, USA

Introduction

This technical committee was founded to facilitate conversation between field researchers in the Antarctic and Arctic CliC-sponsored sea ice working groups. It aims to ensure technological transfer between the researchers to avoid duplication of effort.

The forum shares technical expertise regarding the development of autonomous systems for sea ice observation. Such systems will greatly expand the utility of ship sea ice observations, and by developing a standardized system we anticipate it could be run on non-research ships. An example of this technology is the EISCAM being developed by Steve Ackley's group.

Achievements for 2015

In previous years (2013-2014), CliC has sponsored a project led by Petra Heil (Australian Antarctic Division and ACE CRC) to develop a software tool to record ASPeCt sea ice observations on Antarctic research cruises. At the same time, Jenny Hutchings has developed a software tool, ASSIST, to be backward compatible with ASPeCt codes and include observations specific to the Arctic. We are now ensuring that the two software programs continue to develop and provide key data to both Arctic and Antarctic databases. Achievements this year towards this goal are as follows:

1. New ASPeCt observation software was release in March 2015 for beta testing.
2. The Arctic version of ASPeCt sea ice observation software (ASSIST) has been taken up widely this year with seven ships participating and an increase in data reported (icewatch.gina.alaska.edu). The database has been cleaned, updated to the ASSIST format and data is freely available from a web interface that is easy to navigate. Version 3 of ASSIST was released this year.
3. We are working on removing all bugs and inconveniences from the ASSIST and archiving the software. This has been a 3 year project funded by JAXA and NSF, and this year we expect to have a final version released that addresses the needs and concerns of our user base.
4. This summer, there was a successful field trial that expanded the Arctic Ice Watch program to the merchant navy, and ASSIST was used on 4 tourist cruises.
5. ASSIST data have been provided to national ice services, and this summer we beta tested a SIGRID-3 version of the data that will allow easy use for ice charting and forecasting.
6. Petra Heil has provided Jenny Hutchings with information about the ASPeCt CSV data convention, and Hutchings has provided the same to Heil for ASSIST, together with information about differences between ASPeCt and ASSIST.
7. A new version of the EISCAM (earlier versions were previously trialed on the SIMBA and SIPEX-2 cruises in the Antarctic) was constructed and used on the *Sikuliaq* cruise in the Beaufort-Chukchi Seas from October 1-November 4 2015. Near-continuous photography was obtained (night and day) while the vessel was underway in the sea ice and coincident with hourly 24/7 ASSIST/ASPeCt ice observations conducted by bridge-based observers. Two analyses are planned for the camera images in conjunction with the ice observations. The first will be an examination of the images for the twenty minutes centered on the hour when the ice observations were made. These will provide some independent assessment of the identification of ice types, quantification of ice concentration and other parameters made by the observers on the hour. The second analysis will be to obtain a continuous time series of ice concentration from the photos that will then be comparable to remote sensing imagery (passive microwave and radar) obtained over the same region and as input to the continuous boundary layer flux measurements that were made concurrently from the ship's foremast.

Plans for 2016 and beyond

Hutchings software team will convert ASSIST format to ASPeCt, and anticipate a release of this data format in 2016. This will allow ASSIST data, if collected in the Antarctic, to be archived in the AAD ASPeCt database.

In the next year we will develop an ASSIST-lite version for use in the tourist industry and merchant navy. ASSISTv4 will be the final version of ASSIST, with all known bugs and annoyances fixed.

Hutchings will work with Marcel Nicolaus at the Alfred Wegner Institute, to archive Arctic ASSIST observations in the Pandora data archive.

The ASPeCt Ice Observation Software will undergo further development following the outcome of beta testing trials.

References

The Ice Watch database (for Arctic ASSIST data): <http://icewatch.gina.alaska.edu>

Interactions Between High-latitude Cryosphere Elements

Rob Massom, Australian Antarctic Division and Antarctic Climate & Ecosystems CRC
Introduction

Little is known about the inter-relationships between the different component “elements” of the global high-latitude cryosphere – including sea ice, ice sheet/glaciers, icebergs, snow and permafrost (connected by oceanic and atmospheric processes). How does change in one element affect the others, what processes are involved, and how do these interactions contribute to observe change in the cryosphere?

Recent studies suggest that these linkages may be important yet are complex and involve subtle and previously-unconsidered feedbacks. The aim of this CliC Targeted Activity is to: draw together experts and early-career scientists from across cryospheric disciplines (and underpinning fields) to raise awareness of key cross-cryosphere linkages and encourage their inclusion in models (including Earth System); synthesize and integrate existing work to provide new insights and identify critical knowledge gaps; and promote and foster cross-disciplinary & -polar discussion, collaboration and coordination. The underpinning motivation is to provide new information for inclusion into models, to improve the performance of the latter.

Achievements for 2015

Major activities and outcomes this year include: 1) a dedicated and well-attended special session around the targeted activity at a major international symposium; and 2) publication of a study highlighting cross-cryosphere linkages as they affect iceberg calving. The special session on “Understanding Linkages Between Different Elements of the High-Latitude Cryosphere” took place as part of the International Association of Cryospheric Sciences (IACS) Symposium at the 26th General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Prague (22 June to 2 July 2015). This strongly cross-disciplinary session was co-sponsored by CliC and IACS. It covered both polar regions, had strong young-scientist involvement, and generated lively discussion between the observational and modeling communities regarding the practicalities of better representing cross-cryosphere processes in Earth System models. Lead convener was Rob Massom, with co-conveners Ian Allison (president of IACS) and Cristina Surdu, an early-career scientist from Canada (selected in the spirit of CliC). The mini-symposium also entailed a poster session; this included a poster outlining this Targeted Activity, and again generated strong interest and feedback.



Figure 1: CliC/IACS Special Session on “Understanding Linkages Between Different Elements of the High-Latitude Cryosphere” (25 June, 2015), as part of the IACS Symposium at the 26th IUGG GA, in Prague

In the spirit of generating improved cross-cryosphere collaboration to aid climate modeling, Dr Massom also participated in an important new initiative to take modelers into the field – i) for them to learn more about snow on sea ice, how it is measured, how snow and sea ice interact; and ii) for the observationalists to learn about how snow is parameterized in models and the issues involved. This mutually beneficial exercise, which took place in Barrow (Alaska) over a few days in April-May 2015 (led by Drs Don Perovich, Matthew Sturm and Marika Holland, was highly successful on both fronts, and it is hoped that it will continue.

Plans for 2016 and beyond

Work will continue towards a first community-based review paper (in progress) that highlights the current state-of-knowledge (including key gaps) on cross-linkages and feedbacks between different cryospheric elements (underpinned by the atmosphere and ocean), their likely and actual response to (and role in modulating) climate change/variability, and how change in one element can affect other elements. Discussions have also taken place with interested parties regarding subsequent review papers that focus on specific cross-cryosphere linkages e.g., sea ice-ice shelf interactions.

It is planned to promote this targeted activity and gain further support and input from the wider cryospheric community via attendance (funding permitting) at two major International symposia: i) on Interactions of Ice Sheets and Glaciers with the Ocean (10-15 July 2016, La Jolla, USA); and ii) on The Cryosphere in a Changing Climate (12-17 February, 2017, Wellington, New Zealand).

Continued engagement with the various modeling communities (global and regional climate, coupled sea ice-ocean-atmosphere, ice sheet etc.) is also essential and planned. Strong linkage and overlap is noted with Dr David Holland’s CliC Targeted Activity “Marine Ice Sheet-Ocean Model Intercomparison Project (MISOMIP)”, and the CLIVAR Southern Ocean Panel and West Antarctic Ice Sheet (WAIS) programme activities. The Interactions Between Cryospheric Elements Targeted Activity could inform and contribute to these programmes.

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Webpage

Under development. <http://www.climate-cryosphere.org/activities/targeted>

ESM-Snow Model Intercomparison Project (ESM-SnowMIP)

Gerhard Krinner, Laboratoire de Glaciologie et Géophysique de l'Environnement/Université Joseph Fourier, France; Chris Derksen, Climate Research Division, Environment Canada
Steering Committee: Richard Essery, Stefan Hagemann, Alex Hall, Helmut Rott, Andrew Slater, Matthew Sturm

Introduction

Because climate models show divergent responses and representations of snow-related feedbacks, and systematic biases due to simplifications or missing parameterizations of key processes, CliC identified an intercomparison and improvement of snow models within Earth System Models as a priority contribution to the WCRP “Cryosphere in a Changing Climate” Grand Challenge. The overall goal of the Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP) is to improve our knowledge and understanding of the temporal dynamics and physical properties of snow as an active component of the coupled climate system.

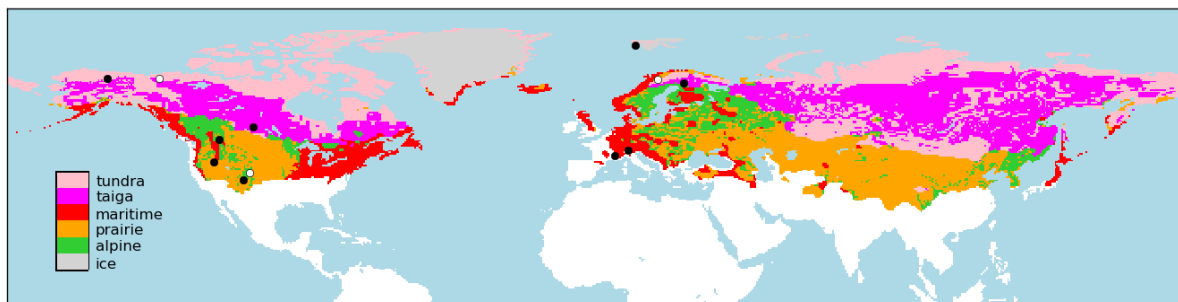
Achievements for 2015

After substantial work on the application for CMIP6 endorsement, LS3MIP was officially endorsed as a CMIP6 sub-project this year. LS3MIP plays an important role in the CMIP6 setup, most notably because it proposes a detailed evaluation of the land surface modules used in the CMIP6 models that is planned to become an “obligatory” exercise in future CMIP editions.

LS3MIP was presented and discussed at the WCRP/CMIP workshop in Dubrovnik this year, and a 2-day workshop with CliC and GEWEX funding was held at ETH Zürich in October.

During the course of this year, the phasing of ESM-SnowMIP and LS3MIP was clarified. In order not to put too much work load on the modeling groups and computer resources during the “hot” CMIP phase, it was decided to postpone ESM-SnowMIP coupled experiments until about 2018, i.e. after the CMIP6 model runs. ESM-SnowMIP global offline and site simulations will be carried out during 2016 and 2017, together with the coupled and offline LS3MIP experiments.

Early 2015 was dedicated to finalizing the ESM-SnowMIP simulation protocol. The Figure below shows the spatial distribution of the sites selected for plot-scale simulations. Following community feedback, some of the proposed experiments will be amended, reformulated or redefined, and some reduction of the proposed tiered experiments will be carried out.



Data provided by NCAR/EOL under sponsorship of the National Science Foundation. <http://data.eol.ucar.edu/>

Figure 2: Reference site locations on a map of seasonal snow classes

Plans for 2016 and beyond

The launch of the global offline simulations, in addition to those that will also be started within the LS3MIP framework, is planned. A 1.5 day workshop focusing on the site and global offline simulations, bringing together the ESM and non-ESM snow modeling communities and observational specialists, both on local and large spatial scales, will be organised to effectively launch the activity.

Concerning LS3MIP, a paper is under preparation for the CMIP6 special volume of Geoscientific Model Development.

First results from the CliC endorsed and European Space Agency funded Satellite Snow Product Intercomparison and Evaluation Experiment (SnowPEX) were presented to the snow remote sensing and land surface modeling community through an international workshop in Boulder, Colorado (September 2015). This analysis will be finalized in 2016 in order to provide quantified uncertainty for gridded snow extent and snow water equivalent products available for model evaluation (and potentially as input to prescribed runs).

WCRP-Project link: the team is considering establishing a more formal link to the GEWEX-GLASS community that has carried out a number of intercomparison exercises of climate model land surface schemes; preliminary discussions show that much interest exists in that community to re-engage on snow-related activities.

References

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Webpage

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

Ice Sheet Mass Balance and Sea-Level (ISMASS)

Catherine Ritz, LGGE, France (chair); Frank Pattyn, Université libre de Bruxelles, Belgium (representing SCAR); Francisco Navarro, Technical University of Madrid, Spain (representing IASC); Edward Hanna, University of Sheffield, UK (representing CliC)

Introduction

The goals of ISMASS are:

- to promote research on the estimation of ice-sheet mass balance and its contribution to sea-level change,

- to facilitate co-ordination among the different international efforts focused on this field of research,
- to propose directions for future research in this area,
- to integrate observations and modelling efforts as well as the distribution and archiving of the corresponding data,
- to attract a new generation of scientists into this field of research, and
- to contribute to the dissemination to society and policymakers of the current knowledge and the main achievements in this field of science.

ISMASS is currently co-sponsored by the Scientific Committee on Antarctic Research (SCAR), the International Arctic Science Committee (IASC), and CliC.

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

<http://www.scar.org/ssg/physical-sciences/ismass>.

Achievements for 2015

A meeting took place from 19-20 May 2015 at the University of Sheffield, UK. The workshop accomplished the following outputs:

1. A new international peer-reviewed publication on SMB model intercomparison that will highlight remaining disparities and uncertainties and the next steps forward; this will be produced for a leading geophysics or cryospheric science journal.
2. It is anticipated that the results of our improved/updated SMB model intercomparison can be directly used to recommend specific spatial areas and parameters for improved in situ data collection for better validating GrIS SMB models to major international (e.g. UK/European and US) funding agencies. This will be the second measurable deliverable/output of the workshop.

Plans for 2016 and beyond

ISMASS proposes to organize a plenary session at the next SCAR OSC meeting in Malaysia, involving SRP AntClim21, PAIS and SERCE and focusing on the interactions between the different groups. All SRP representatives have been involved in this process.

MISOMIP will have its second meeting in May 2016 at the New York University Campus in Abu Dhabi, United Arab Emirates (organized by David Holland). This is a CliC and ISMASS endorsed initiative.

SCAR2016-Malaysia-related activities will include:

(1) A Mini-symposium co-organized by ISMASS and 3 big SCAR programmes (SERCE-PAIS-AntClim21): MS 4. The Antarctic Ice Sheet from past to future.

(2) A session in which ISMASS SC members are heavily involved (S6. Glaciers and ice sheet mass balance)

ISMASS is considering revisiting the *Nature* review paper (Hanna et al. 2013) and start writing an updated review paper on the observational estimates and uncertainties of ice-sheet mass balance at the SCAR 2016 meetings in Malaysia.

References

Edward Hanna is coordinating a group research publication arising from the ISMASS Sheffield (GrIS SMB) workshop in May 2015. This is expected to be submitted for publication to a leading glaciological journal during 2016.

Webpage

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

ISMIP6: Ice Sheet Model Intercomparison Project for CMIP6

Sophie Nowicki, NASA GSFC, USA; Tony Payne, University of Bristol, UK; Eric Larour, NASA JPL, USA

Introduction

The Ice Sheet Model Intercomparison for CMIP6 (ISMIP6) has the key objective of improving projection of sea level from the Greenland and Antarctic ice sheets, and our understanding of the cryosphere in a changing climate. These goals map into both “Melting Ice and Global Consequences” and “Regional Sea-level Change” Grand Challenges relevant to CliC and the World Climate Research Program (WCRP).

Achievements for the year

The main achievement for 2015 was the endorsement of ISMIP6 by the Coupled Model Intercomparison Project – Phase 6 CMIP6. Until now, the sea level projections made by the glaciological community as part of the Intergovernmental Panel on Climate Change (IPCC) process have often been out of phase with the projections considered by the wider CMIP community. The ISMIP6 proposed experiments are tightly coupled to the CMIP6 experiments, allowing for the first time for ice sheet mass budget (hence sea level) to become part of the standard CMIP data stream.

ISMIP6 also initiated its first round of model intercomparison in 2015. The new initMIP project is focused on understanding uncertainty due to the choice of initialization method in ice sheet models.

ISMIP6 has started to form collaborations with other activities, such as PMIP (Paleoclimate Modelling Intercomparison Project), GrIOOS (Greenland Ice Ocean Observing System), MISOMIP (Marine Ice Sheet-Ocean Model Intercomparison Project) and the upcoming IMBIE2 (Ice sheet Mass Balance Intercomparison Exercise, phase 2) – a component of ISMASS (Ice Sheet Mass Balance and Sea level).

ISMIP6 now has a website and a wiki:

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

Wiki: www.climate-cryosphere.org/wiki/index.php?title=ISMIP6_wiki_page

Plans for next year and beyond

ISMIP6 aligns itself with the timelines and deliverables set by CMIP6 (the nominal period for CMIP6 is 2015-2020). As a delay in the CMIP6 model simulations is expected, ISMIP6 will continue to focus on initMIP during 2016. This involves building on the current experiment based on analysis of the first suite of experiments. We also plan to continue building the framework for the ISMIP6 standalone ISM experiment, using the CMIP5 climate models as a trial for the CMIP6 simulations, thereby ensuring that “all the machinery is in place”. Some of this effort will require strengthening our emerging collaborations mentioned above and developing new ones.

A large workshop, in collaboration with ISMASS, is anticipated in the spring / early summer 2017 to evaluate the CMIP6 DECK model simulation of polar climate (both atmosphere and ocean) and therefore the CMIP6 forcing for the standalone ISM simulations.

Linkage Between Arctic Climate Change and Mid-Latitude Weather Extremes

Ed Hanna, University of Sheffield, UK; James Overland, NOAA, USA

Introduction

The assessment for recent Arctic changes to influence broader hemispheric weather (Linkages) is a difficult and controversial topic with considerable scepticism; yet this remains a major pathway to contribute to improved understanding of mid-latitude weather events. There has been some conciliation of ideas in the last year on mechanisms in eastern Asia and eastern North America, and a focus on events rather than seasonal shifts, although still with significant fragmentation between scientists. Little consensus has been reached on problem formulation and methods in the research community.

Achievements for 2015

The main scientific difficulties in Linkages research are the short record length since major Arctic Amplification began, and the large chaotic energy of the atmospheric circulation at mid- and high latitudes.

The Linkage topic was presented at an ASSW/ICARP III/ISAR session in Japan April 2015, convened by Jim Overland. Edward Hanna, representing CliC, was a co-convenor.

A second small International Research Workshop on *Arctic climate change-extreme mid-latitude weather linkages* was held in Sheffield, UK, in early November 2015, organised by Edward Hanna and Richard Hall (University of Sheffield, UK) together with James Overland.

The foci of the Sheffield workshop were:

- Advancing understanding of the connection between Arctic climate forcing and internal atmospheric variability (the latter is essentially chaotic mid-latitude weather changes)
- Whether Arctic climate-mid latitude weather linkages depend on a certain atmospheric circulation pattern – an effect termed “state dependence”
- Presenting information to a broad audience, including non-scientists. The group also discussed plans for further publications.



Figure 3: Participants in the Sheffield Workshop, November 2015

The workshop was co-sponsored by the Climate and Cryosphere (CliC) project of the World Climate Research Programme (WCRP), the International Arctic Science Committee (IASC) and the University of Sheffield.

Linkages will continue to be an important topic moving forward in the next few years to decades, so we anticipate that occasional meetings and author workshops will prove fruitful.

Plans for 2016 and beyond

Results based on several key themes from the recent (November 2015) Sheffield workshop discussions for a further contribution in a leading science journal are being synthesized. A more popular-level review publication on Linkages for a wider science/public audience is also planned.

Project leads will continue to interact and build links with WCRP SPARC.

References

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A CliC Science Feature written by James Overland is based on this paper:
<http://www.climate-cryosphere.org/news/clic-news/1439-linkages>

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Hanna, E., T.E. Cropper, P.D. Jones, A.A. Scaife and R. Allan (2015) Recent seasonal asymmetric changes in the NAO (a marked summer decline and increased winter variability) and associated changes in the AO and Greenland Blocking Index. *International Journal of Climatology* 35, 2540–2554. [doi: 10.1002/joc.4157](https://doi.org/10.1002/joc.4157).

Webpage

<http://www.climate-cryosphere.org/activities/targeted/linkages>

Polar Coordinated Regional Downscaling Experiment (Polar CORDEX)

Annette Rinke, AWI, Germany; John Cassano, Cooperative Institute for Research in Environmental Sciences (CIRES)/ Department of Atmospheric and Oceanic Sciences (ATOC), University of Colorado, Boulder, USA

Introduction

Polar CORDEX is part of the international CORDEX (Coordinated Regional Downscaling Experiment - Arctic and Antarctic Domains) initiative. Its primary goal is to organize an international coordinated framework to produce an improved generation of regional climate change projections for input into impact and adaptation studies. Currently, the core of Polar CORDEX consists of regional climate model (RCM) simulations over the Arctic, with both hindcast and scenario simulations being conducted.

Achievements for 2015

11 atmosphere-only model simulations over the Arctic CORDEX domain at ca. 50 km horizontal resolution forced by the ERA-Interim data have been conducted. Also, a few higher resolution atmosphere-only model simulations at ca. 25 km and ca. 15 km horizontal resolution are finished.

Results from individual models have already been published (Koenigk et al., 2015; Scinocca et al., 2015). The analysis of Zentek et al. (2015) has been discussed by the Arctic CORDEX participants as a potential guide for future evaluation of added value in higher resolution simulations by investigating the spectra of wind, kinetic energy and temperature. Further, an analysis of the ensemble of atmosphere-only model simulations has been started to conduct a multi-model intercomparison.

Five coupled atmosphere-ice-ocean model simulations over the Arctic CORDEX domain at ca. 50 km atmospheric model resolution and ca. 9 to 50 km ocean model resolution, forced by the ERA-Interim data have been conducted. The analysis of these runs has been started by looking into the individual model results (Berg et al., 2015; Roberts et al., 2015; Sein et al., 2015).

The scenario simulations covering 2006-2100 were further advanced. The focus was on the RCP8.5 scenario, although RCP4.5 simulations are also conducted. We agreed to use a set of 4 CMIP5 GCMs (EC-Earth, MPI-ESM, NorESM, CanESM) to drive the RCM simulations. Each of the GCMs will be downscaled by at least 4 RCMs.

An Arctic CORDEX workshop with 15 participants was held in Potsdam on October 24-26, 2015. The objective of the workshop was to present and discuss results from individual model groups, but also first results from multi-model intercomparison studies. Accordingly, we had discussion sessions on downscaling ERA-Interim (validation runs), multi-model intercomparisons, climate extremes, and downscaling CMIP5 GCMs for projections. Further, we discussed the future plans for simulations, and upcoming joint analyses.



Figure 4: Participants at the Arctic CORDEX meeting at AWI Potsdam, Oct. 24-26, 2015

No activity or further progress can be reported from the Antarctic CORDEX, except that new groups (from DMI, LGEE, BAS) expressed their interest to participate in this in future.

Plans for 2016 and beyond

Arctic CORDEX

The hindcast Era-Interim driven runs from 11 atmosphere models and 5 coupled atmosphere-ocean models will be analyzed. The multi-model analysis will include: general performance and uncertainty of temperature and precipitation, temperature and precipitation

extremes, and cyclone activity. We plan to include also more analysis of the coupled runs, which will include the analysis of e.g. the ocean mixed layer, sea ice and atmospheric feedbacks.

The projection runs from 10 atmosphere models (driven by 4 different GCMs; focus on RCP8.5) will be finished and the multi-model ensemble will be started to analyze. The projection runs with the existing coupled atmosphere-ocean models will further advance. Other groups continue their coupled model development.

We will keep the contact to the Arctic Council “Adaptation Actions in a Changing Arctic” (AACCA) project with the aim to include results of Arctic Cordex into the final circum-Arctic AACCA report.

Antarctic CORDEX

Interest for Antarctic simulations has been expressed by different groups (model HIRHAM5 by DMI; model RACMO by Univ. Utrecht/KNMI; model COSMO-CLM from Univ. Leuven; stretched-grid AGCMs (LMDz, Arpège) by CNRS/LGEE; model PolarWRF by BAS).

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Webpage

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

Permafrost Carbon Network

Ted Schuur, Northern Arizona University, USA; A. David McGuire, University of Alaska Fairbanks, USA; Christina Schaedel, Northern Arizona University, USA

Introduction

The Permafrost Carbon Network is a synthesis project whose objectives are to link biological C cycle research with well-developed networks in the physical sciences focused on the

thermal state of permafrost. Over the last five years, the network expanded from a core group of 40 scientists to more than 300 scientists from 121 research institutions located in 22 countries.

The working groups produce new knowledge by synthesizing data that can be assimilated by biospheric and climate models and that will contribute to future global environmental assessments, including the Intergovernmental Panel on Climate Change (IPCC). Since 2014 the Permafrost Carbon Network has become part of the Permafrost Action Team under the umbrella of the Study of Environmental Arctic Research (SEARCH) project, which is a system-scale, cross-disciplinary research program that seeks to connect the science of Arctic change to decisions makers.

Achievements for 2015

In February of 2015, PCN worked with Dr. Gerhard Krinner of CliC to develop the CliC Permafrost Modeling Forum as a collaborative activity between CliC and the Permafrost Carbon Network.

The Permafrost Carbon Model Intercomparison Project (PC-MIP) has achieved the first manuscript that is a retrospective analysis of carbon dynamics of the permafrost zone from 1960-2010 (McGuire et al. in prep). This represents attempts to improve interactions of the modeling community in the permafrost region with both the earth system modeling community outside the permafrost region and with the empirical community in the permafrost region.

In May of 2015, the 5th workshop for synthesis leads and co-leads of the Permafrost Carbon Network was held at Northern Arizona University in Flagstaff, Arizona. For this two-day workshop, CliC supported the participation of six researchers, all of them early career-scientists within 10 years of their final degree.

Plans for 2016 and beyond

The Permafrost Carbon Network will continue beyond 2016 as part of the Permafrost Action Team under the Umbrella of SEARCH. For continued progress and success of the activities it is crucial that half-yearly in person meetings are held where synthesis leads and co-leads can get input from the other leads and discuss progress in the group. In between those in person meetings web-based communication is used. The next synthesis lead and co-lead workshop will be held in conjunction with the XI International Conference on Permafrost (ICOP) in June of 2016 in Potsdam, Germany.

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Figure 5: Group photo of workshop participants, Flagstaff, AZ, May 2015

Webpage

<http://www.permafrostcarbon.org>

Permafrost Research Priorities– A roadmap for the future of permafrost research

Permafrost Research Priorities Core Group:

Hugues Lantuit, AWI, Germany (Chair); Michel Allard, Université Laval, Canada; Mauro Guglielmin, Insubria University, Italy; Margareta Johansson, Lund University, Sweden; Gleb Kraev; Centre for Forest Ecology and Productivity, Russian Federation; Michael Krautblatter, Technical University of Munich, Germany; Gerhard Krinner, LGGE Grenoble, France; Edward A. G. Schuur, Northern Arizona University, USA; Ylva Sjöberg, Stockholm University, Sweden, CliC Fellow; Jenny Baeseman, SCAR, Norway; Karina Schollän, IPA, Ex-Officio, Germany

Introduction

The International Permafrost Association (IPA) and CliC were invited to participate in the Third International Conference on Arctic Research Planning (ICARP III) process, led by the International Arctic Science Committee (IASC). The ICARP III process aims at integrating priorities for forward-looking, collaborative, interdisciplinary Arctic research and observing. The IPA and CliC, acknowledging that no consensus document exists at the international level to identify forward-looking priorities in permafrost research, decided to initiate a process by which such a document, focusing on permafrost research at large (i.e. including Arctic, Mountain, Antarctic and sub-sea permafrost) would be published based on the engagement of the permafrost research community as a contribution to ICARP III. The product stemming from the effort should consist of a high level, but short benchmark publication listing and putting into context research priorities for the next 10 years.

A core group was appointed in January 2014 and consists of the above mentioned individuals. The core group set up an online questionnaire on the IPA and CliC websites for the input of scientific questions. The questionnaire was open from July 15th until September

20, 2014. The announcement was circulated widely to encourage input into the process. A townhall meeting as well as a dedicated “world café” session in the young researchers workshop were held during the Fourth European Conference on Permafrost and has been used as the venue to launch the process and to foster community engagement.

The Permafrost Research Priorities survey received almost 650 questions from more than 300 participants. A list of all the submitted questions and preliminary figures depicting demographic data can be found at the project website.

Achievements for 2015

The PRP process was delayed.

Webpage

<http://www.permafrostpriorities.org>

<http://www.climate-cryosphere.org/activities/targeted/permafrost-research-priorities>

Sea Ice and Climate Modelling Forum

Alexandra Jahn, NCAR, USA; Dirk Notz, Max Planck Institute for Meteorology, Germany

Introduction

The CliC sea ice and climate modelling forum aims at improving the simulations of sea ice in large-scale models facilitating international cooperation on the following research items:

1. Model evaluation: We aim at establishing a standard protocol for sea-ice output from large-scale model simulations that allow for a process-based evaluation of model simulations
2. Model biases: We aim at facilitating the analysis of biases and internal variability in large-scale sea-ice simulations through the coordinated analysis of multi-model ensemble simulations as provided by CMIP and dedicated additional experiments
3. Model development: We aim at improving communication between individual model-development groups and the observational community to foster the most efficient development of the sea-ice component in coupled climate models.

Achievements for 2015

The main achievement of the CliC sea ice and climate modelling forum in 2015 was the endorsement of our CMIP5 Sea-Ice Model Intercomparison Project SIMIP by the CMIP6 panel. SIMIP aims at establishing a new standard for sea-ice related output from coupled climate models which will allow us to understand the evolution of sea ice in large-scale models with a much stronger focus on individual processes than has ever been possible before.

The new protocol was discussed and coordinated with other endorsed CMIP6 MIPs at the CMIP6 workshop in Dubrovnik in September 2015. Throughout the year, we were very closely involved in the establishment of the final CMIP6 data call; in ensuring consistency of all sea-ice related variables across all MIPs, and in ensuring consistency with the CF standard of climate variables.

Plans for 2016 and beyond

In 2016, we will organise a workshop that will bring sea-ice modelling and sea-ice observing expertise together. Through this workshop, we hope that both communities will better be able to understand the needs of the other, and will establish the most efficient pathway for

joining the insights of modelers and observationalists in better understanding the past and future evolution of sea ice.

References

The list of SIMIP variables is available at <http://www.climate-cryosphere.org/activities/targeted/simip>

CLIVAR/CliC/SCAR Southern Ocean Region Panel

Lynne Talley (Co-chair), Scripps Institution of Oceanography, USA

Achievements for 2015

The Co-Chairs of the Southern Ocean Region Panel are Lynne Talley and John Fyfe. Since 2015, CliC appoints SORP SSG members together with CLIVAR which was not the case before. SORP had an online meeting and a face-to-face in meeting in Frascati, in September 2015. Another teleconference will be scheduled before the next SORP-11 meeting being planned for 2016. SORP also participated in the SOOS-WCRP-ESA Air-Sea Fluxes Workshop by co-sponsoring and endorsing it.

SORP has mostly been engaged in commenting on plans, doing surveys and so forth. One of their major activities this summer was their input to the YOPP Planning document. SOOS and SORP were strongly involved in addressing the fact that Antarctica and the Southern Ocean were poorly represented in the YOPP document, and tried to articulate the Southern Atmosphere's interest in YOPP.

Plans for 2016 and beyond

Having an interest in both, the SORP members will attend either the CLIVAR Open Science Conference in Qingdao in September 2016 or the SCAR OSC in Kuala Lumpur in August 2016. SORP will also be involved in the WCRP Sea Level Grand Challenge meeting at NYU in 2017 and the 2017 IGS/IACS/CliC Cryosphere in a Changing Climate Conference in Wellington, NZ. SORP needs to follow up on the 2017 Southern Ocean Colloquium in Liege, Belgium.

SORP is also brainstorming on developing ideas for co-sponsorship of workshops. SORP is also informing the SCAR Science Plan (meeting in Paris in January 2016) and contributing to the SCAR Science Plan. SORP is also continuously working with SOOS and interested in the WCRP MIP structure. There is an informal, loosely defined Southern Ocean MIP which did not make the deadline for a formal MIP.

Webpage

<http://www.clivar.org/panels-and-working-groups/southern>

Southern Ocean Satellite Requirements

Allen Pope, NSIDC, Colorado, USA; Penelope Wagner, Norwegian Ice Service, Norway; Rob Johnson, Bureau of Meteorology, Australia; Louise Newman, SOOS, Australia; Jenny Baeseman, CliC, Norway.

Introduction

Remote sensing of the Southern Ocean is not without significant challenges and much work is needed to enhance cross-calibration and independent validation with *in situ* data, improve

algorithms and geophysical corrections, ensure continuity of time series, and drive development of better sensor technology and global climate prediction models.

Between 12 March and 26 June 2014, SOOS, SCAR and CliC initiated a community survey in order to provide a consolidated user voice from the entire Southern Ocean community, spanning 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.

Achievements for 2015

Over the past year, the full review including recommendations for action regarding Southern Ocean remote sensing has been produced, facilitated by an in-person meeting of 4 of the report's authors and hosted by CliC. In addition, the document has been (over the 2015 northern summer) reviewed by a wide community to ensure completeness and correctness. The resulting edits and suggestions have been incorporated, and the document is currently under peer review for publication (see below).

Plans for 2016 and beyond

Upcoming plans include getting this above publication through review and likely producing a brief recommendations article for submission to Nature Geoscience, Eos, or similar.

References

Pope, A., P. Wagner, R. Johnson, J.D. Shutler, J. Baeseman & L. Newman (*in review*), "Community Review of Southern Ocean Satellite Data Needs," *Antarctic Science*.

Webpage

<http://www.climate-cryosphere.org/activities/targeted/so-sat-req>
<http://www.soos.aq/science/satellite-data>

Submarine Permafrost Mapping Action Group

Paul Overduin, AWI, Germany

Introduction

In Fall 2011, the International Permafrost Association (IPA) voted to support the new IPA Subsea Permafrost Mapping Action Group (SuPerMAG), proposed by the Coastal and Offshore Permafrost Dynamics Interest Group of the IPA. The action group recognized the need to support the development and production of a map or maps of subsea permafrost, based on resolutions met by the Coastal and Offshore Permafrost Dynamics (COPD) Working Group at the 9th International Conference on Permafrost (NICOP) in 2008. In March 2013, the Climate and Cryosphere (CliC) Project endorsed this effort and agreed to support it as one of its Targeted Activities.

Achievements for 2015

Based on the results of the first SuPerMAG workshop on June 18, 2014 at the 4th European Conference on Permafrost (EUCOP4) in Evora, Portugal, modelers and regional experts began writing a review document to assemble the state of the art on submarine permafrost mapping initiatives and to catalogue relevant input, parameterization and validation data for a modelling effort. This effort has begun and has resulted in a preliminary spatial database of historical data, and a literature list of available sources.

A modelling core group assembled in the fall of 2014, and held meetings (Oslo, June 18-20; Potsdam, October 30-31) and teleconferences in 2015. A part-time post-doctoral position was created in the summer of 2015, the purpose of which was to adapt an existing permafrost model, CryoGrid (Gisnås et al., 2013; Westermann et al., 2015) to a submarine permafrost implementation, to identify and assemble necessary input data and to implement this parameterization. This effort was completed in December, and first model outputs, including detailed cross-shelf transects and circumpolar mapping, were achieved by the end of the year. An abstract has been submitted to the 11th International Conference on Permafrost (ICOP2016), which takes place in June 2016 in Potsdam, Germany, to submit result to public scrutiny, in parallel with the peer-review publication process.

Plans for 2016

Plans for 2016 are to submit modelling results for review before ICOP and to present results at the meeting's special session on offshore permafrost. A side meeting at ICOP is not planned, but the session will be used to solicit interest and to re-connect with participants of the inaugural 2014 meeting. One goal of discussions will be to establish the necessity, goals and timing of a next SuPerMAG workshop.

Project Results

To illustrate progress since SuPerMAG's first meeting, Figure 1 shows the first results of permafrost modelling at the circumpolar scale. The figure is meant to demonstrate the modelling domain, the type of results to be expected and the central result of group activity in 2015, which has resulted in a viable model. Until sensitivity tests have been completed, the values shown are neither final nor worthy of being evaluated critically.

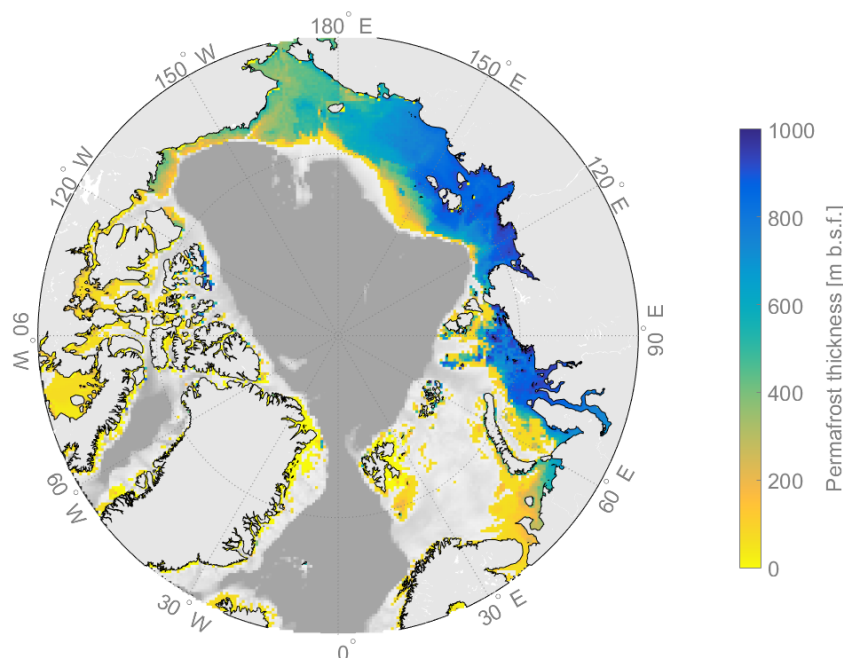


Figure 6: Thermally modelled submarine permafrost thickness (in m below sea floor, m b.s.f.) on the Arctic shelf projected at 25 km resolution on the EASE Grid 2.0, using the International Bathymetric Chart of the Arctic Ocean (IBCAO, Jakobsson et al., 2012, in gray tones) as background and the Global Self-consistent, Hierarchical, High-resolution Shoreline (GSHHS 2.2, Wessel and Smith, 1996) coastline (black line around gray continents). The definition of permafrost common to western literature is adopted for this representation: perennially cryotic earth material ($< 0^{\circ}\text{C}$ for > 2 years). Model results permit cartographic representation of various characteristics of submarine permafrost.

References

- Gisnås, K., Etzelmüller, B., Farbroth, H., Schuler, T. V., and Westermann, S. (2013), CryoGRID 1.0: Permafrost Distribution in Norway estimated by a Spatial Numerical Model. *Permafrost Periglac. Process.*, 24: 2–19. [doi: 10.1002/ppp.1765](https://doi.org/10.1002/ppp.1765).
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- Wessel, P., and Smith, W. H. F., (1996), A global, self-consistent, hierarchical, high-resolution shoreline database, *J. Geophys. Res.*, 101(B4), 8741–8743, [doi:10.1029/96JB00104](https://doi.org/10.1029/96JB00104).
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Marine Ice Sheet Ocean Model Intercomparison Project (MISOMIP)

David M. and Denise Holland, New York University, USA

Introduction

The most uncertain aspect of future sea-level change has to do with marine based ice sheets. Despite the importance of these ice sheets, current generation global climate models are unable to simulate sea-level change arising from glacier-ocean interaction, limiting the discussion on this important topic.

In an effort to improve this situation, a number of international glaciologists and oceanographers with expertise in modelling outlet glaciers and sub-ice shelf cavities were brought together to brain storm a way forward. It was decided that a coupled modeling Intercomparison activity should be started. The experts present noted that there are already two related and relevant inter comparison efforts. First, the Marine Ice Sheet Modeling Intercomparison Project (MISMIP) has made significant progress in uncoupled outlet glacier modeling. Second, the Ice Shelf Ocean Model Intercomparison Project (ISOMIP) has likewise made notable progress in uncoupled sub-ice shelf cavity modeling. The conclusion of the workshop was that these two efforts should continue but, in addition, a coupled activity should be initiated. Accordingly, the Marine Ice Shelf Ocean Modeling Intercomparison Project (MISOMIP) was created. All three projects are now affiliated with one another with each project having two co-chairs. Going forward, the MISOMIP activity will foster not only itself but the MISMIP and ISOMIP allowing for clear communication between these related projects.

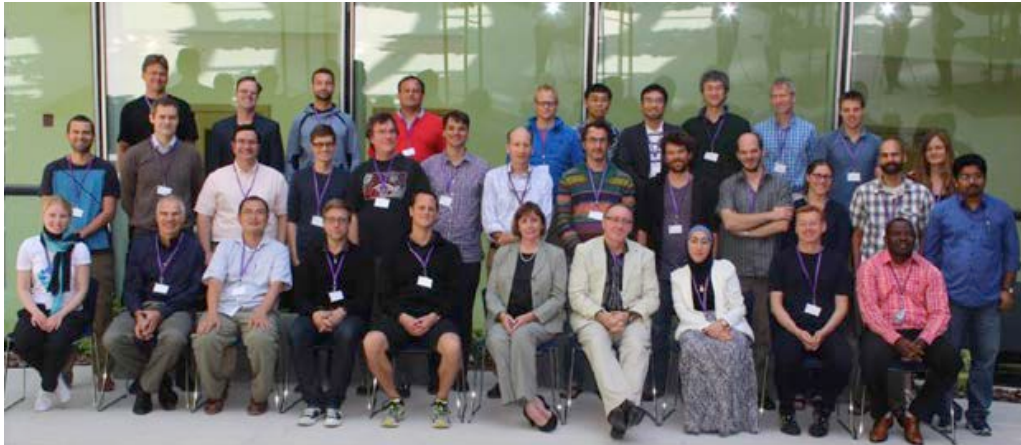


Figure 7. Rising Coastal Seas on a Warming Earth - MISOMIP Kick-Off Meeting. Abu Dhabi, UAE, 27-29 October 2014

Achievements for 2015

The organizers have published a paper in *EOS* (see below), as well as a paper submitted by a participant describing how the modeling will be organized (see below).

Dr. Asay-Davis organized two side meetings of MISOMIP, one at the EGU Spring meeting and the other at the IGS August meeting. These meetings were attended by a large number of people on the MISOMIP email list as well as attracting new members. The MISOMIP group now has 70 members.

Plans for 2016 and beyond

A 2nd workshop will bring together experts in the international modelling community to discuss the advancement of state-of-the-art regional-scale glacier ocean simulations at the NYUAD campus from May 16–18, 2016. Members of the modelling community working with glacier, ocean, and coupled glacier ocean models will report on their progress since the first workshop. Each day of the meeting will be solely devoted to each of these three modelling categories (MISOMIP, MISMIP, ISOMIP), culminating in an overall project directive for the next workshop.

The 2nd workshop is an important next step in improving physically-based estimates of sea-level change coming from the West Antarctica Ice Sheet over the present century and beyond. Such regional-modeling research also lays the groundwork to include glacier-ocean interaction in Intergovernmental Panel on Climate Change (IPCC)-class models in future assessments. This meeting will be held every 18 months.

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Webpage

<http://www.climate-cryosphere.org/activities/targeted/misomip>
<http://nyuad.nyu.edu/en/research/nyuad-institute/institute-research/cscl.html>

Where Are They Now?

A Case Study of International Travel Support for Early Career Researchers

Sanna Majaneva, University of Helsinki, Finland; Gwénaëlle Hamon, CliC, Norway; Gerlis Fugmann, APECS, Norway; Maja Lisowska, Jagiellonian University, Poland; and Jenny Baeseman, SCAR, Norway

Introduction

When establishing priorities for Arctic and Antarctic science for the coming decade, it is essential to prepare and retain early career researchers (ERS) to ensure that research will be continued well into the future. To maintain the continuum of knowledge in polar sciences that was established during the 2nd International Conference on Arctic Research Planning and the International Polar Year, it is of great importance to continue to support the next generation of researchers. Many organizations are working on that allow early career 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 missing.

To aid in assessing how past support has influenced early career researchers and potentially enhanced future opportunities, the APECS and CliC have launched the *Where are they now?* project. It is a case study to assess the value of international travel support for early career researchers.

Achievements for 2015

For the first time, the project is investigating the subsequent career paths of early career Arctic researchers that received travel funding from International Arctic Science Committee since the start of the most recent International Polar Year (2007-2008) until 2013. International Arctic Science Committee has provided travel support for 287 early career researchers during this time.

A survey, with 50 questions concerning demographics, meeting, benefits, Arctic research, IASC, and other questions, was sent to each of these researchers. In addition, 1-2 page summaries of their experiences of the event where they received the funding were analyzed. Specifically, they provided information on: what they expected to get out of the workshop/event; what they in fact got out of the workshop; and how the workshop enhanced their research goals.

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.

The project participants wrote a paper that was submitted to the ICARP III/ISAR 4 Special Issue of Polar Science at the end of November. In Spring 2015, recommendations were made to ICARP III, specifically related to support of ECRs.

Plans for 2016 and beyond

In 2016, the projects leads hope to push for continuing support of ECRs and to work on how to improve their effectiveness.

Webpage

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

CliC Contribution to the Year Of Polar Prediction (YOPP)

Alice Bradley, University of Colorado Boulder, USA; François Massonnet, Barcelona Supercomputing Center, Spain; Gerhard Krinner, Laboratoire de Glaciologie et Géophysique de l'Environnement, France

Introduction

The Year of Polar Prediction is an international effort to “enable a significant improvement in environmental prediction capabilities for the polar regions and beyond, by coordinating a period of intensive observing, modelling, verification, user-engagement and education activities.”

The Year of Polar Prediction (YOPP) is part of the Polar Prediction Project (PPP), an element of the World Weather Research Programme (WWRP). The intensive effort associated with YOPP is scheduled to take place from mid-2017 to mid-2019. This effort will involve coordinated observational and modeling activities in the polar regions. In addition to the research activities, YOPP plans to engage stakeholders and features a strong educational component.

YOPP is currently in the preparation phase (2013-2017), YOPP main activity (mid-2017 - mid-2019), and a consolidation phase (2019-2022).

CliC contributes to YOPP efforts through the activities of the assorted CliC working groups and projects. Two CliC Fellows (Alice Bradley and François Massonnet) are working to facilitate communication between YOPP and CliC and to coordinate and document the CliC contributions to the project.



Achievements for the year

In June 2015, with input from the CliC SSG and the chairs of the various working groups, Alice Bradley and François Massonnet wrote the CliC YOPP contributions document. This report highlighted the areas in the existing plans for the different working groups that dovetail with YOPP goals. The report proposes concrete contributions in four major areas that will be of interest for YOPP: (1) Observations, (2) Model development, (3) Data assimilation and model validation and (4) Outreach and Community building.

The report was presented by Gerhard Krinner at the YOPP planning summit in Geneva (July 2015). François Massonnet and Alice Bradley also attended, and each co-chaired discussion sections (modeling efforts and observational plans, respectively). They helped lead the summary discussion at the end of the meeting and contributed to the meeting report.

Following the July meeting, Alice and François contributed to updating the YOPP implementation plan to the current version 2, which includes the intensive observational period plans developed at the YOPP planning summit.

Resulting publications

Climate and Cryosphere Contributions for the Year of Polar Prediction (YOPP) available at <http://www.climate-cryosphere.org/media-gallery/1521-clic4yopp>

YOPP Implementation Plan Version 2.0 will be available from the YOPP website in early 2016: <http://www.polarprediction.net/yopp.html>

Plans for next year and beyond

The CliC fellows will maintain communication with the PPP and YOPP steering groups and the CliC SSG regarding YOPP planning. This will include a CliC fellow attending the PPP steering group meeting.

CliC fellows will also revisit the contributions report in spring 2016 to make sure that it still reflects the activities of the CliC working groups as well as the priorities of the YOPP community.

WCRP Grand Challenge Contributions

The WCRP Grand Challenges (GCs) represent major foci of scientific research, modelling, analysis and observations over the next decade or so. The WCRP intends to promote these GCs through community organized workshops, conferences and strategic planning meetings to identify high priority and exciting research that require international partnership and coordination, and that yield “actionable information” for decision makers. Currently WCRP has five GCs, with a sixth with a focus on Decadal Climate Variability in the planning stages:

1. Clouds, Circulation & Climate Sensitivity
2. Melting Ice & Global Consequences
3. Climate Extremes
4. Regional Sea-level Change & Coastal Impacts
5. Water Availability

Of these Melting Ice & Global Consequences and Regional Sea-level Change & Coastal Impacts are the most relevant to CliC.

The Melting Ice & Global Consequences Grand Challenge has recently been re-shuffled and is chaired by CliC Co-Chair Greg Flato. This GC is composed of several pieces 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 and Global Consequences Grand Challenge and has several of its activities aligned with the GC. These activities include:

- 1) Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP) (which is part of a broader MIP, LandMIP)
- 2) Ice Sheet Model Intercomparison for CMIP6 (ISMIP6)
- 3) Diagnostic Sea Ice Model Intercomparison Project (SIMIP)

The Marine Ice Sheet-Ocean Model Intercomparison Project (MISOMIP) lead David Holland is strongly involved in the Regional Sea-Level Change and Coastal Changes Grand Challenge. In 2017, a meeting (500 people) focusing on this GC will be organized at New

York University (NYU). A second MISOMIP workshop will also be organized in Abu Dhabi in Spring 2016.

Polar Climate Predictability Initiative

Cecilia Bitz, University of Washington, USA; Marilyn Raphael, University of California Los Angeles, USA

Introduction

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 the stratosphere. PCPI is concerned with the success of modelling and observing the rapid changes seen in the Arctic and the mixed, slow and fast changes occurring in the Antarctic. PCPI is investigating the role of the poles in global climate and prediction. An implementation plan for PCPI arose from a pair of workshops in 2010 and 2012, defining six themes. The WCRP JSC agreed to designate PCPI as a sub-initiative of the “Melting Ice and Global Consequences” Grand Challenge: A cross-cutting Initiative, with especially close ties to CliC and SPARC. Two champions were chosen for each of our six initiatives to comprise a PCPI leadership committee, which began organizing activities in 2013. Half of the PCPI themes are joint with our sister program, the Polar Prediction Project (PPP) of the WWRP, which focuses on similar problems but at sub-seasonal timescales.

Achievements for 2015

Ted Shepherd has stepped down as Co-Chair of PCPI and Marilyn Raphael is replacing him and is now co-chairing the Initiative together with Cecilia Bitz. This became official in September 2015 at the PCPI Leads meeting in Reading, UK, from September 9-11, 2015. The meeting aimed to report on the six initiatives of PCPI, each of them being led by two leading scientists in the area. Participants also discussed the way forward for PCPI.

This year has been fairly active for PCPI. The ‘Large-scale climate variability in Antarctica and the Southern Ocean over decades to centuries, and links to extra-polar climate’ workshop was held on March 24-26, 2015, at the Scripps Institution in La Jolla, CA, USA and was very successful. PCPI is working on a joint paper with the target of Nature and Climate Change and which should be submitted in November.

The Sea Ice Prediction Workshop, organized on April 8-10, 2015, in Reading, UK, brought together a group interested in the predictability of polar sea-ice on seasonal to inter-annual timescales. Contributions included presentations on understanding causes of inter-annual polar climate variability, as well as idealized predictability studies, and operational forecasts. This workshop was a follow-up to the Sea Ice Prediction Workshop held in Boulder in April 2014.

Overlapping interests with the Southern Ocean Region Panel (SORP) were noted and SORP expressed their interest in joining in some of these activities.

Plans for 2016 and beyond

The WWRP/WCRP/Bolin Centre Polar Prediction School will be held from April 5 to 15, 2016, in Abisko, Sweden. That will be followed by a Polar Predictability Workshop at Lamont, NY, USA in May 2015. Sessions will also be convened at AGU and EGU in 2015 and 2016.

Webpage

<http://www.climate-cryosphere.org/wcrp/pcpi>

Emerging Activities

In addition to the many new activities that CliC has started in the past few years, more are developing each year. The main emerging activity for 2016 is the Sea Ice Biogeochemistry Forum, as a follow up to BEPSII.

BEPSII stands for "Biogeochemical Exchange Processes at Sea Ice Interfaces". Behind this great acronym hides a group of researchers in sea-ice biogeochemistry that started in 2009, was formalized as a SCOR working group in 2012, and has since continued to grow. BEPSII serves as a unique forum linking modellers and field scientists studying sea-ice biogeochemistry. As a SCOR working group, BEPSII has been organized around three task groups, focussed on: 1) improving observation methods; 2) building large-scale databases; and 3) upscaling processes within models. The community now recognizes a need to expand beyond the mandate of the SCOR working group, in order to gain more flexibility to establish new task groups and entrain new members.

The idea of a joint SOLAS-CliC forum has emerged as a sound basis for future activities. SOLAS has already demonstrated its support of BEPSII activities through its mid-term strategy on "Sea-ice biogeochemistry and interactions with the atmosphere". CliC's support of cryospheric sciences, in particular sea ice physics in the Earth System, makes CliC an ideal complementary sponsor of BEPSII activities. Links with other programs (such as IMBER, IGAC, YOPP, SOOS, ArcticSTAR, FAMOS) and working groups (i.e., OASIS, AICI) will be maintained and developed. Particular attention will be paid to collaboration and avoiding redundancy in activities. Research themes, based on workshops and activities will be expanded. Relevant connections between BEPSII activities and various stakeholders, including human communities in the Arctic and biodiversity conservation programs in both the Arctic and Antarctic polar regions will be identified.

Links to Other Projects and Groups

2015 has again been a productive year for CliC in working with many of our international partners. Below we list just a few of some of the more developed collaborations and relationships, as well as ideas that are just beginning to develop – in no particular order. We welcome more ideas from the community and other organizations to continue to develop our global efforts on enhancing our understanding of the connections between the cryosphere and climate.

- The CliC-lead and initiated Arctic Freshwater Synthesis is co-sponsored by IASC and AMAP. This was presented to the Arctic Council and is part of ICARP III. It will be launched at the ASSW 2016 in Fairbanks.
- IASC and CliC co-sponsored the Linkage Between Arctic Climate Change and Mid-Latitude Weather Extremes project and are in close cooperation on many other activities and events.
- CliC is a co-sponsor, together with SCAR and IASC, of the ISMASS group.
- SCAR invited CliC to participate in their Horizon Scan activity, which has demonstrated a great deal of interest in new Antarctic research.
- Together with SOOS we worked on a Southern Ocean Satellite Data Requirements report and paper and CliC helped with the logistics for their writing meeting in Tromsø in April.
- In January 2015, ESA and CliC co-sponsored the Earth Observations and Arctic Science Priorities Workshop and planning another conference on Earth Observations and Cryosphere Science in Prague in May 2016 as part of the Living Planet Symposium.

- ICARP III is an international effort to help set priorities for Arctic Research for the next 10 years and CliC is a proud partner for this effort and sits on the steering committee.
- CliC's Director was appointed to the Steering Committee for the Global Cryosphere Watch (GCW) and we hope this will start to bridge some of the gaps between observations and modelling of the cryosphere.
- CliC co-sponsored 2 sessions with IACS at the IUGG 26th Assembly in 2015, and discussions on creating an internationally agreed upon cryosphere glossary are beginning.
- CliC works closely with IASC, IACS, ARCUS, SOOS, SCAR and other groups to maintain the Cryosphere Community Calendar, which brings together all the events happening related to the cryosphere in an automatically updated online calendar.
- Support for early-career researchers is an important component of CliC's activities and part of this is working on various activities with APECS such as the Where Are They Now project, creating FrostBytes, and developing leadership opportunities for enthusiastic early-career cryospheric scientists.
- This year has seen a stronger connection between the CliC project and the WWRP Polar Prediction Project where we have worked together to create a polar prediction mailing list with over 400 subscribers, a joint calendar for polar prediction events, planning of a Polar Prediction two-week school in 2016 (together with APECS and others), helping to plan the YOPP Summit in 2015, and more. This has also helped to strengthen the connection between PCPI as it is an important part of the Cryosphere Grand Challenge, and is co-sponsored by SPARC.
- CliC and GEWEX enhanced collaborations this year through the development of the LS3MIP activity and we hope more joint efforts will continue to come to fruition.
- A renewed effort spurred by CLIVAR to engage CliC in the Southern Ocean Region Panel activities (joint with CLIVAR and SCAR) began, as well as discussions about CliC's contributions to the cryosphere portion of the Sea Level Grand Challenge. Discussions with CLIVAR, particularly lead by US CLIVAR on fostering stronger collaborations on Greenland Ice Sheet – Ocean Interactions are also underway.
- CliC also supports Polar Educators International (PEI), an international organization for polar educators, by providing online tools and website hosting, sharing of new science results and other important outreach activities.
- CliC has active representatives on WCRP's Modelling and Data advisory councils which help to tie together various cross-cutting WCRP efforts.
- We have been working with the WCRP Working Group on Seasonal to Interannual Prediction (WGSIP) concerning potential links between ESM-SnowMIP and SnowGLACE, a WGSIP activity studying the effect of snow on predictability on seasonal time scales.
- The CliC SSC co-chairs are ex-officio members of the WCRP Working Group on Coupled Modelling (WGCM). WGCM is organizing CMIP6, and several CliC-led activities (LS3MIP, ISMIP, SIMIP) were proposed as sub-projects of CMIP6.

Capacity Building, Outreach, and Community Services

CliC has a long history of supporting the career development and providing opportunities for early-career researchers through their support of the Association of Polar Early Career Scientists (APECS). This tradition continued this year by CliC providing travel support to almost 30 early career researchers, including participation in the CliC Scientific Steering

Group meeting. In addition, we have offered opportunities for several young researchers to help lead activities, including the CliC contribution to the Year of Polar Prediction, the Arctic Freshwater Synthesis, and the Southern Ocean Satellite Requirements. CliC has also been working with APECS to develop a CliC Fellows program where early-career researchers are actively involved in supporting the development of our targeted activities and are mentored by some of the most successful cryosphere researchers in the world. Two CliC Fellows, Alice Bradley and François Massonnet, started working on the CliC contribution to YOPP.



CliC has lead the effort to continue to build the APECS' FrostBytes initiative. FrostBytes are 30-60 second sound bites or videos highlighting cryosphere research targeted for a general audience. CliC

has instituted a policy where people receiving travel funding are required to produce a FrostByte with the help of our volunteer technical video editor. To date over 250 FrostBytes have been produced and are featured on the FrostBytes iTunes podcast channel. More information can be found at <http://www.climate-cryosphere.org/activities/outreach/frostbytes>.

A new resource that the CliC office has been helping groups to use is the GoToMeeting and GoToWebinar system. This online meeting tool is easy to use and works well with low bandwidth. Many groups are now using CliC's service including CliC's own activities, and partners such as PEI, PPP, and AMAP. More than 130 online meetings have been held in 2015 on CliC's GoToMeeting platform. Interested parties should contact the IPO if they are interested in using this free service.

In addition to the quarterly newsletter that goes out to over 2000 people, CliC has an active Twitter feed with over 1560 followers including scientists, journalists, policy makers, and members of the general public. The Facebook page has over 1230 likes and helps to keep connected with the community. The CliC office also maintains the Cryosphere Community Calendar, which keeps track of meetings and events from several partner organizations as well as other announcements that come across our desktops. The office also set up a similar system for WCRP to bring together all events and news items to facilitate communication between projects. The CliC website also has comprehensive database of reports from various meetings dating back to the late 1990s, presentations and pdfs from workshops and meetings, and generates a list of all recently published cryosphere literature articles.

We are also in the process of expanding our cryosphere projects catalog to join with Iceplan.org (developed by Jenny Hutchings and CASIWG) to serve as a resource where people can find projects on a variety of topics in the cryosphere, as well as keep track of which groups will be in the field and when, to allow for shared data collection and enhanced collaboration. This year we have also continued to work on our database of resources of interest to the cryosphere community.

Useful Links:

FrostBytes

<http://www.climate-cryosphere.org/activities/outreach/frostbytes>.

Cryosphere Community Calendar

<http://www.climate-cryosphere.org/meetings/community-calendar>

Cryosphere Projects Catalog

<http://www.climate-cryosphere.org/resources/catalog>

IcePlan

<http://www.iceplan.org/>

Reports, powerpoints, and more

<http://www.climate-cryosphere.org/resources/multimedia>

Recent Cryosphere Literature

<http://www.climate-cryosphere.org/resources/literature>

Cryosphere Resources

<http://www.climate-cryosphere.org/resources/resource-database>



Photo Courtesy of Allen Pope



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