

2023 WCRP Climate and Cryosphere (CliC) Annual Report



Photo credit: Rakesh Rao / NCPOR

About CliC

CliC Mission

To advance understanding of climate-driven changes in the frozen parts of our planet and to support efforts to mitigate and adapt to their impacts on ecosystems and human society.

Who we are

CliC is a Core Project of the World Climate Research Program. We are a global community of scientists investigating the cryosphere and its interactions with the climate system. Our expertise includes modelling, observations, cross-disciplinary work, and stakeholder engagement.

What we do

CliC identifies key research priorities pertaining to climate and the cryosphere and coordinates international activities to address them. We highlight emerging issues, facilitate scientific exchanges, cooperate with stakeholders, and promote early career researcher development. We also communicate cryosphere-related science to policymakers, funding agencies, and the general public.

How we work

CliC brings together scientists and stakeholders from all over the world to plan and implement activities targeting scientific and societal priorities. A Scientific Steering Group has overall responsibility for planning and guiding our work. Our International Project Office is the main point of contact for CliC.

This Annual Report was edited by Meghan Taylor and Katie Quigley (IPO) with contributions from: *Amy Lovecraft, Edward Hanna, Martin Vancoppenolle, Patricia Derepentigny, François Massonnet, Ariaan Purich, Amy Solomon, Carolina Dufour, Torge Martin, Benjamin Rabe, Sophie Nowicki, Ben Marzeion, Tony Payne, Heiko Goelzer, Regine Hock, Melinda Webster, Jan de Rydt, Nicolas Jourdain, Ted Schuur, Harry Zekollari, Marilyn Raphael, Petra Heil, Jacqueline Stefels, Letizia Tedesco, Annette Rinke, Andrew Orr, James Overland, John Cassano, and Christoph Kittel*

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Executive Summary

The year 2023 was one of renewal for CliC. We established an International Project Office (IPO) at the University of Massachusetts via five-year National Science Foundation and National Aeronautics and Space Administration Grants. For several years previously we had been without an IPO or full-time staff. The new office welcomed Keith Alverson as Executive Director, Meghan Taylor as Executive Officer, and Katherine Quigley as Communications and Outreach Manager. In addition, we welcomed the climate change and cryosphere expertise of Drs. Raymond Bradley and Rob De Conto from UMass on board as IPO Host Institution Scientists and ex officio members of the Science Steering Group (SSG). This team met in person in September 2023 along with the Co-Chairs Edward Hanna and Amy Lauren Lovecraft for an intense and positive approach to update CliC for the coming decade. After a four year hiatus (which was largely due to COVID-related travel restrictions during 2020-2022), we held the first in-person CliC meeting with IPO and SSG in December at the AGU meeting in San Francisco where we renewed our ties and addressed the pending WCRP Joint Science Committee (JSC) Review of CliC that took place in 2023-2024.

As the cryosphere continues to diminish across the globe, CliC's role as a connector of modelling groups, funder of projects and early career scientists, and storehouse of science and event news becomes ever more important. In order to catch up with the activities of the other core WCRP groups, we fostered an ambitious suite of activities in 2023 to bring the cryosphere and its elements - permafrost, snow, glaciers, ice sheets and shelves and icebergs, sea ice - to the forefront of scientific research and public imagination.

Funding

CliC supported a dozen separate in-person/hybrid meetings and workshops for CliC co-sponsored activities at multiple international conferences and venues. This included support for early career researchers travelling to these events. Many high-level research papers have come out during 2022-2024 as a result of these activities' meetings (see list of references at the end of this report).

CliC administered grants to early career researchers for field work in crucial cryospheric systems to 1) investigate the effect of permafrost thaw in the Khentii Mountains of Mongolia on water availability 2) socio-economic factors affecting water storage and availability in the Chilean Andes, and 3) novel instrumentation development to improve satellite-based sea ice thickness estimates.

CliC provided funds for a mini-documentary highlighting permafrost carbon science and synthesis work for the Permafrost Carbon Network, due out in Summer, 2024.



The CliC SSG held its first in-person meeting since 2019 at AGU in 2023.

Communications and Outreach

The CliC website has a new design with improved functionality and resources: see climate-cryosphere.org. This new version of the website now has a user-friendly interface allowing users to quickly access information including CliC's organisational structure, working groups, upcoming events and resources. The improved website now serves as a two-way tool to facilitate outreach and data collection by way of forms, including one to collect upcoming events from the community. The front page of CliC's redesigned website also features a news section wherein the IPO shares all the latest announcements and opportunities with the community.

CliC also developed a set of webinars by leading subject experts to the wider community, to be held weekly for a series of months in early 2024. We plan to have a similar offering annually. Webinars will be recorded and uploaded to CliC's Youtube Channel ([@CliC_WCRP](https://www.youtube.com/@CliC_WCRP)).

As of late 2023, CliC's most active social media platform is Twitter, where we have 3,862 followers. There were ~17k impressions and 69 new followers since June. Social media related goals for 2024 include reinstating our Facebook page and exploring Instagram. We have a Communications Intern coming on board in early 2024 who will assist with the expansion of our social media presence.

Projects and Publications

Based on lengthy discussions the co-chairs had with the different CliC affiliate groups in early 2023, we moved forward an idea to enhance visibility of the Antarctic with a reporting mechanism that would be similar to the “Arctic Report Card.”

ASIWG members have a leading role in writing the Arctic sea ice sections of the Bulletin of the American Society’s State of the Climate Report (2023 in press) and the [NOAA Arctic Report Card](#). There is also a joint press release between the Arctic Sea Ice Working Group and Antarctic Sea Ice Properties & Climate groups for a call of action was [published here](#). Further bipolar work is evident in the cooperation between PolarCORDEX, which published Policy-relevant science highlights from the Antarctic CORDEX project in the World Meteorological Organisation Antarctic Treaty Paper, highlighting modelling insights about Antarctic Ice Sheet surface mass balance results and policy recommendations.

Co-chair Edward Hanna contributed to a BBC Natural History Unit/INTERACT “Arctic Climate Magnification” video on the jet stream and Arctic/midlatitude climate linkages, that was published in October 2023 (from 7min25): www.youtube.com/watch?v=xCqofgFN7CA.

Edward also led the publication of a review article for Nature Reviews Earth & Environment based on a 2022 ISMASS workshop: Hanna, E. et al. Short- and long-term variability of the Antarctic and Greenland ice sheets. Nat Rev Earth Environ (2024). <https://doi.org/10.1038/s43017-023-00509-7>

Additionally, ISMIP7 started a series of expert community workshops leading towards the forthcoming IPCC AR7 cycle.

Another cooperative venture, joint with the International Arctic Science Committee, has been the study of Arctic-midlatitude climate linkages via the CliC/IASC workshop on the “Influence of the lower stratospheric polar vortex on cold-air outbreaks under climate warming”, which was held at University of Lincoln, UK, in September 2023 (led by E. Hanna and J. Overland), with an invited scientific paper submitted summarising the results.

In summary, 2023 was a year of gathering momentum for CliC, and we look forward to growing new CliC working groups and projects in 2024 and into the future.

– *Edward Hanna and Amy Lovecraft, CliC co-chairs*

Leadership 2023

Scientific Steering Group

Co-chairs

Amy L. Lovecraft, University of Alaska, Fairbanks, US

Edward Hanna, Lincoln University, UK

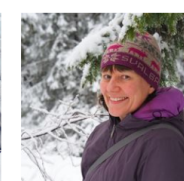
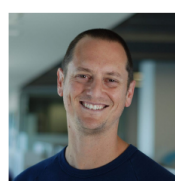
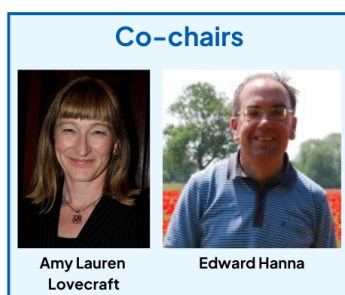
Term

1/2023-12/2026

1/2022-12/2025

Members

Juan Höfer, Pontificia Universidad Católica, Chile	1/2022-12/2025
Camille Lique, IFREMER LOPS, France	1/2020-12/2023
Thamban Meloth, National Centre for Polar and Ocean Research, India	1/2022-12/2025
Ramiro Saurral, Universidad Buenos Aires, Argentina	1/2022-12/2025
Sandra Berreira, Naval Hydrographic Services, Argentina	1/2023-12/2026
Shin Sugiyama, Hokkaido University, Japan	1/2020-12/2023
Lauren Vargo, Victoria University Wellington, New Zealand	1/2022-12/2025
Ben Galton-Fenzi, Australian Antarctic Division, Australia	1/2023-12/2026
Martin Vancoppenolle, Institut Pierre-Simon Laplace, France	1/2019-12/2023
Hanne H. Christiansen, University Centre in Svalbard, Norway	1/2020-12/2023



WCRP Support

JSC liaison



Tim Naish

Antarctic Research Centre at
 Victoria University of
 Wellington, New Zealand

JSC liaison



Krishnan Raghavan

Centre for Climate Change
 Research, Indian Institute of
 Tropical Meteorology, India

Secretariat



Narelle van der Wel

WMO, Switzerland

The International Project Office (IPO)

The CliC International Project Office moved to the University of Massachusetts, Amherst in the United States in June, 2023 through the efforts of host scientists Ray Bradley and Rob DeConto and the support of the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). This represented a major upgrade in support capacity compared with the previous IPO. A Director, Keith Alverson, was hired, as well as an Executive Officer, Meghan Taylor, and a Communications and Outreach Manager, Katie Quigley.

CliC IPO Staff



Keith Alverson



Meghan Taylor



Katie Quigley

UMass Support

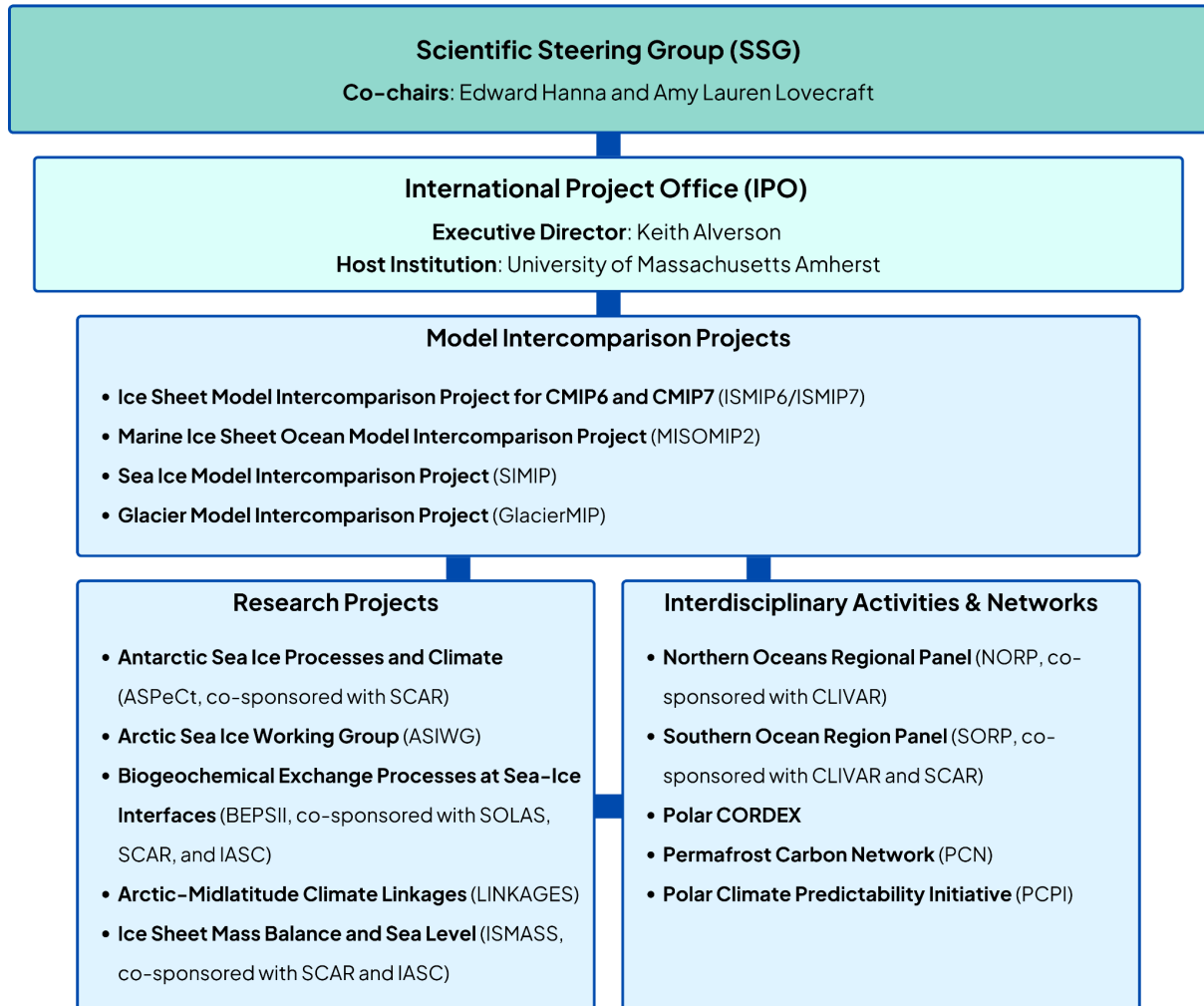


Raymond Bradley



Rob DeConto

CLiC Organisational Chart



CliC Working Groups

Ice Sheet Model Intercomparison Project for CMIP6 and CMIP7 (ISMIP6/ISMIP7)

The Ice Sheet Model Intercomparison for CMIP6 (ISMIP6), and its follow-on activity ISMIP7, 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). As uncertainties in future sea level arise due to both the climate forcing and the response of the ice sheets, a primary focus for ISMIP6 was to become better integrated in the CMIP6 initiative. ISMIP6 became an endorsed activity of CMIP6 in 2015 allowing for the first time in CMIP for ice sheets to be considered as a component of the Earth system. ISMIP6 experimental protocol explores the uncertainty in sea level projections due to ice sheet model initialization and ice sheet models, climate scenario uncertainty and uncertainty in the representation of ice-ocean interactions on centennial timescale. ISMIP6 was designed to deliver projections for use in the IPCC 6th Assessment report. ISMIP7 is a MIP of CMIP7 which will target the IPCC 7th Assessment report.

Science Highlights

Our primary activities in 2023 were the continued analysis of the ISMIP6 Antarctica 2100 projections (Seroussi et al., 2023), the ISMIP6 Antarctica Projections to 2300 (Seroussi et al., in prep), the launch of ISMIP7, understanding CMIP7 timescales and preliminary protocol design for ISMIP7. Results for ISMIP6 Antarctica projections to 2100 and 2300, as well as preliminary protocols for ISMIP7, were presented at IUGG, SCAR-INSTANT, Fall AGU and many other meetings.

The latest analysis of ISMIP6 Antarctica 2100 model ensemble explores the vulnerability of Antarctic glaciers and associated uncertainty (Figure 1). The study of Seroussi et al. (2023) shows that in addition to Thwaites and Pine Island glaciers in West Antarctica, Totten and Moscow University glaciers in East Antarctica present comparable future dynamic mass loss and high sensitivity to ice shelf basal melt. The uncertainty associated with the choice of climate model increases over time and reaches 13 % of the uncertainty by 2100 for the Antarctic Ice Sheet but varies between 4 % for Thwaites Glacier and 53 % for Whillans Ice Stream. The uncertainty associated with the ice–climate interaction, which captures

different treatments of oceanic forcings such as the choice of melt parameterization, its calibration, and simulated ice shelf geometries, accounts for 22 % of the uncertainty at the ice sheet scale but reaches 36 % and 39 % for Institute Ice Stream and Thwaites Glacier, respectively, by 2100.

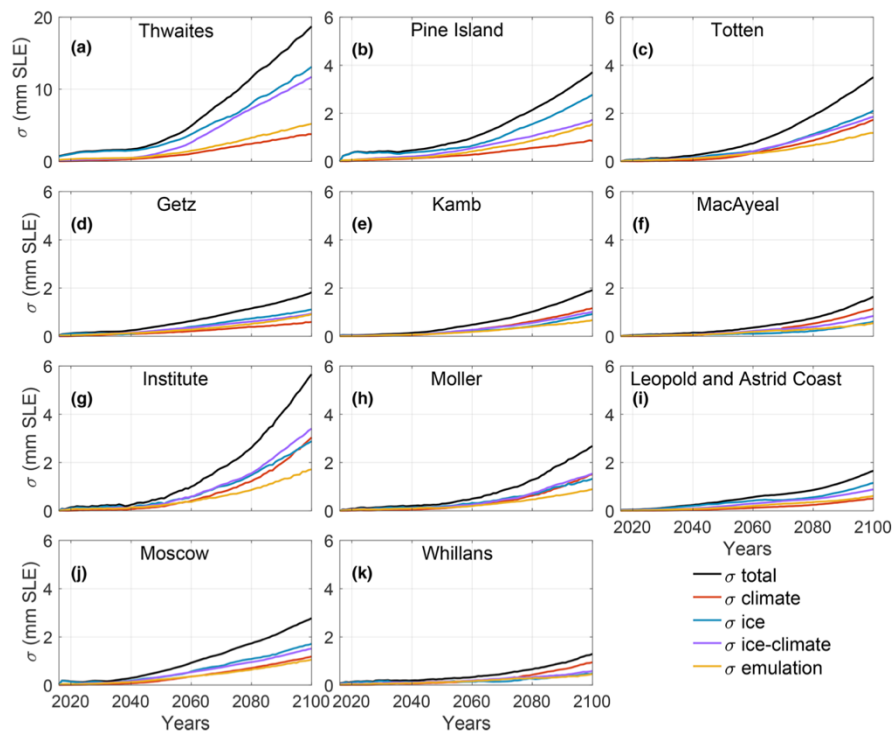


Figure 1: Total uncertainty and different sources of uncertainty for the 11 glaciers contributing most to sea level rise: (a) Thwaites, (b) Pine Island, (c) Totten, (d) Getz, (e) Kamb, (f) MacAyeal, (g) Institute, (h) Möller, (i) Leopold and Astrid Coast, (j) Moscow, and (k) Whillans. Note that the scale is similar for all glaciers except for Thwaites Glacier (a). Source: Seroussi et al. (2023).

Sixteen ice sheet modelling groups took part in the simulations for Antarctica to 2300, an increase in participation from our 2100 activities. The protocol considers 5 climate models (NorESM1-M, CCSM4, HadGEM2, CESM2, UKESM) under low emission scenarios (RCP2.6, ssp1-26) and high emission scenarios (RCP8.5 and ssp5-85). A series of experiments also focus on the impact of ice shelf collapse under high emission scenarios. Key findings in Seroussi et al. (in prep) are that Antarctic mass loss and associated uncertainty increases sharply after 2100 (see Figure 2), and that on multi-centennial timescales, uncertainty in mass loss is dominated by the choice of ice flow model, followed by the climate forcing.

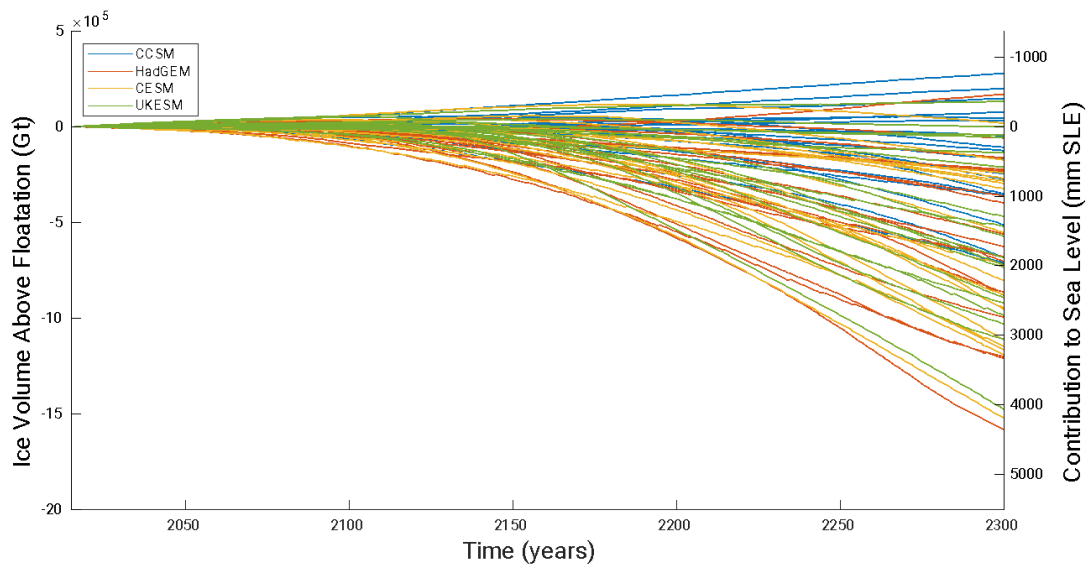


Figure 2: Evolution of ice volume above flotation converted into mass (in Gt and m SLE) for experiments with high emission and forcing simulated until 2300. Source: Seroussi et al. (in prep)

In 2023, ISMIP6/7 hosted a series of workshops to collect community feedback and input for revised protocols for follow activities with standalone ice sheet models and dynamic ice sheets coupled to climate models. These workshops are key for community building and consensus of project direction. Aspects that were identified as crucial areas that needed improvement for CMIP7 were simulations over the historical and last decades. This focus requires interdisciplinary collaborations and the development of a new framework. ISMIP7 launched 6 focus groups tasked to revisit every aspect of ISMIP6 protocol. To increase community input, these focus groups are led by non-ISMIP7 steering committee members. The current set of focus groups and leaders are:

1. Surface mass balance and atmospheric forcing - Nicole Schlegel (USA) and Brice Noel (BE)
2. Greenland calving and frontal marine melt – Donald Slater (UK) and Denis Felikson (USA)
3. Antarctic marine melt – Nicolas Jourdain (FR) and Ronja Reese (UK)
4. Antarctic surface meltwater and fracture - Luke Trusel (USA) and Catherine Walker (USA)
5. Observation – Leigh Sterns (USA) and Ines Ootosaka (UK)
6. Glacial isostatic adjustment and conversion to SLR – Natalya Gomez (CA) and Matt Hoffman (USA)

We are also establishing working groups, which have a broader remit than focus groups:

1. Ice sheets in climate model – lead by Robin Smith (UK)

2. Uncertainty, emulation, and experimental design – steering committee with help of community

ISMIP7 continued community building in the climate modeling community that is coupling dynamic ice sheets to climate models. The project facilitated these interactions with a series of virtual meetings where groups can share their coupling strategies as well as challenges that arise when coupling dynamic ice sheets to climate models. This working group formulated a protocol for CMIP7 that will be finalized when CMIP7 simulations are decided.

Annual Meetings, Workshops, and Conferences



Workshop during IUGG conference in Berlin, DE (July 2023) was attended by 15 in person and 10 remote participants. Objective was to revisit the lessons learned from ISMIP6 and design a strawman protocol for ISMIP7. The event was co-sponsored by the University at Buffalo.



Workshop during SCAR INSTANT conference in Trieste, IT (September 2023) was attended by 30 participants. Objective was to get feedback strawman protocol and agree on focus group themes. The event was co-sponsored by SCAR.



PreAGU workshop in San Francisco, USA (December 2023) was attended by 30 participants. Objective was to launch the new focus groups and work on strawman protocol. The event was co-sponsored by the University at Buffalo.

Future Plans

As ISMIP7 plans its follow-on activities, we will continue to interact with other activities from which we can either contribute to or benefit from such as other MIPs (e.g., MISOMIP,

TIPMIP) or initiatives (e.g., GRISO, PROTECT, ISMASS, SCAR INSTANT), as well as CMIP (e.g., FastTrack, PMIP, WhatifMIP, and possible new Freshwater input for CMIP). We are also working with GlacierMIP and the glacier community to coordinate experimental protocols where possible. Our primary focus for community building in the near term will continue to be with the climate modeling community that is coupling dynamic ice sheets to climate models, and with researchers interested in helping identify the CMIP7 protocol for standalone simulations. The project is facilitating these interactions with our focus groups and working groups, that meet virtually or in person when possible. We are organizing in person meetings at EGU (Vienna, April 2024), a weeklong workshop sponsored by the Heising Simons Foundation (Washington DC, late spring 2024), a day workshop linked with IGS (Northumbria, August 2024), and our annual pre-AGU meeting (Washington DC, December 2024) to review progress, get community feedback and discuss next steps in these activities.

Peer Review Publications (also those *in press*)

Group publications:

H. Seroussi, V. Verjans, S. Nowicki, A. Payne, H. Goelzer, W. Lipscomb, A. Abe Ouchi, C. Agosta, T. Albrecht, X. Asay-Davis, A. Barthel, R. Calov, R. Cullather, C. Dumas, B. Galton-Fenzi, R. Gladstone, N. Golledge, J. Gregory, R. Greve, T. Hatterman, M. Hoffman, A. Humbert, P. Huybrechts, N. Jourdain, T. Kleiner, E. Larour, G. Leguy, D. Lowry, C. Little, M. Morlighem, F. Pattyn, T. Pelle, S. Price, A. Quiquet, R. Reese, N. Schlegel, A. Shepherd, E. Simon, R. Smith, F. Straneo, S. Sun, L. Trusel, J. Van Breedam, P. Van Katwyk, R. van de Wal, R. Winkelmann, C. Zhao, T. Zhang, and T. Zwinger, 2023. Insights into the vulnerability of Antarctic glaciers from the ISMIP6 ice sheet model ensemble and associated uncertainty, 17, 5197-5217, *The Cryosphere*, <https://doi.org/10.5194/tc-170-5197-2023>

Publications that requested an ISMIP6 publication number:

Greve, R., Chambers, C., Obase, T., Saito, F., and Abe-Ouchi, A., 2023: Future Projections for the Antarctic ice sheet until the year 2300 with a climate index method. *Journal of Glaciology*, 1-11. <https://doi.org/10.1017/jog.2023.41>

Roffman J., Gomez N., Yousefi M., Han H.K., and Nowicki, S., 2023: Spatial and temporal variability of 21st century sea level changes. *Geophysical Journal International*, 235, 1, 342–352, <https://doi.org/10.1093/gji/ggad170>

Van Katwyk, P., B. Fox-Kemper, H. Seroussi, S. Nowicki, and K. Bergen, 2023. A variational LSTM emulator of sea level contribution from the Antarctic ice sheet. Journal of Advances in Modeling Earth Systems, 15, 12, e2023MS003899, <https://doi.org/10.1029/2023MS003899>

Contact Information

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Tony Payne, University of Liverpool, UK, A.J.Payne@liverpool.ac.uk

Steering committee: Helene Seroussi, Heiko Goelzer, William Lipscomb, Ayako Abe-Ouchi, Xylar Asay-Davis, Beata Csatho, Robin Smith

Homepage address: <https://thehub.org/groups/ismip6/wiki>

Marine Ice Sheet Ocean Model Intercomparison Project (MISOMIP2)

Science Highlights

The [MISOMIP2 protocol](#) has now been finalized and submitted for review to the EGUSphere.

Annual Meetings, Workshops, and Conferences

We organised a [Splinter meeting at EGU2023](#) to discuss the MISOMIP2 protocol. About 30 participants attended in person and online. The outcomes of the meeting were implemented in the MISOMIP2 protocol paper, which is now available as a preprint on the EGUSphere discussion forum. A [poster on the MISOMIP2 protocol](#) was presented at EGU2023.

Peer Review Publications (also those *in press*)

Protocol in review (see above)

Future Plans

The MISOMIP2 protocol paper will be published once the open discussion and review process has ended. At this time, we will send out a call for contributions through our email list and Cryolist, with submission deadline TBC but likely sometime in 2025.

We will contribute to a Splinter meeting at EGU2024 on coupled ice-ocean-atmosphere modelling.

Contact Information

Co-Chairs:

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Homepage address: <https://misomip.github.io/>

Glacier Model Intercomparison Project (GlacierMIP)

Science Highlights

In 2023, the GlacierMIP activities have mainly focused on the third phase of GlacierMIP (GlacierMIP3), which projects the long-term (millennial scale) equilibration of glaciers under a wide range of climatic conditions. More specifically, GlacierMIP3 focuses on two policy-relevant questions:

- (1) *“How much glacier ice will be left if global air temperatures were to stabilize?”*: For this, we analyse the steady state of glaciers if global mean temperatures were to stabilize at present-day levels and at different temperature levels (e.g. in +1.5/+2°C world). Additionally, we evaluate regional differences in committed mass losses (i.e. losses to occur without additional warming) and the sensitivity of mass change to changing climatic conditions.
- (2) *“How fast will the glaciers melt?”*: How much time would the glaciers need to reach, for instance, 80% of the total change. Which regions are the fastest/slowest and why?

In 2023, the (final) submissions from GlacierMIP3 participants were obtained. In total, eight groups participated to GlacierMIP3, with a very diverse geographic distribution (groups from Austria, Belgium, Japan, Netherlands, Switzerland, UK, USA (x2)). Half of the submissions were global (i.e. for all 19 glacier regions as defined by the Randolph Glacier Inventory), while the other half were submitted for selected regions (varying between 1 and 11 regions).

The submissions were analysed by the GlacierMIP3 core team (Regine Hock, Ben Marzeion, Fabien Maussion, Lilian Schuster, Harry Zekollari), and discussed elaborately with the consortium members during an open workshop that took place during the 28th *IUGG* General Assembly (detailed below). The results are now being summarized in a publication with a strong policy-relevant emphasis.

Annual Meetings, Workshops, and Conferences

A GlacierMIP workshop took place during the 28th *IUGG* General Assembly (11-20 July 2023) in Berlin (hybrid, with online attendance). The workshop consisted of two parts, with one part focusing on GlacierMIP3 (detailed above), and another part in which future plans for GlacierMIP were discussed. Whereas the first part (on Tuesday, July 11) was mainly focused

towards GlacierMIP3 participants (8 participants), the second part (the Annual Business Meeting, on Wednesday, July 12) was widely attended by a broader audience of glacier scientists (more than 30 participants on-site), allowing for new perspectives and ideas to be included when discussing future plans.



GlacierMIP workshop at IUGG Berlin. Here, during the meeting on Tuesday (July 11), with an emphasis on GlacierMIP3.

Peer Review Publications (also those *in press*):

We plan to submit a publication summarising GlacierMIP3 results in the coming months.

Future Plans

In the first half of 2024, our efforts will focus on finalizing a manuscript summarizing GlacierMIP3 findings. Whereas the emphasis of this publication will be on the policy-relevant results, we also plan to, in a second step, work on a more technical publication that will mainly focus on evaluation the differences between models' results and their causes. Aside from this GlacierMIP3 work, our efforts will increasingly shift towards shaping future GlacierMIP efforts (first ideas were discussed during workshop in Berlin), which may include (i) focusing on past glacier evolution (with focus on attribution of glacier changes to anthropogenic climate change) and (ii) the evolution of glaciers under CMIP6/7 scenarios (in direct contact with CMIP7 and ISMIP7 efforts to coordinate this).

Contact Information

Co-chairs:

- Regine Hock, rehock@alaska.edu
- Ben Marzeion, ben.marzeion@uni-bremen.de
- Harry Zekollari, harry.zekollari@vub.be

Members of the steering committee or working group (* = early career, PhD researcher or PhD obtained within last 7 years):

- Brian Anderson, University of Wellington, New Zealand
- Nicolas Champollion, University Grenoble Alpes, France
- Loris Compagno*, ETH Zurich, Switzerland
- Matthias Huss, ETH Zurich, Switzerland
- Koji Fujita, Nagoya University, Japan
- Walter Immerzeel, Utrecht University, The Netherlands
- Megan James*, King's College London, United Kingdom
- Philip Kraaijenbrink*, Utrecht University, The Netherlands
- Gunter Leguy, National Center for Atmospheric Research, USA
- William Lipscomb, National Center for Atmospheric Research, USA
- Samar Minallah*, National Center for Atmospheric Research, USA
- Hamid Mojtabavi*, University of Bremen, Germany
- Fabien Maussion, University of Bristol, UK
- David Rounce*, Carnegie Mellon University, USA
- Akiko Sakai, Nagoya University, Japan
- Lillian Schuster*, University of Innsbruck, Austria
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- Harry Zekollari*, Vrije Universiteit Brussel, Belgium

Sea Ice Model Intercomparison Project (SIMIP)

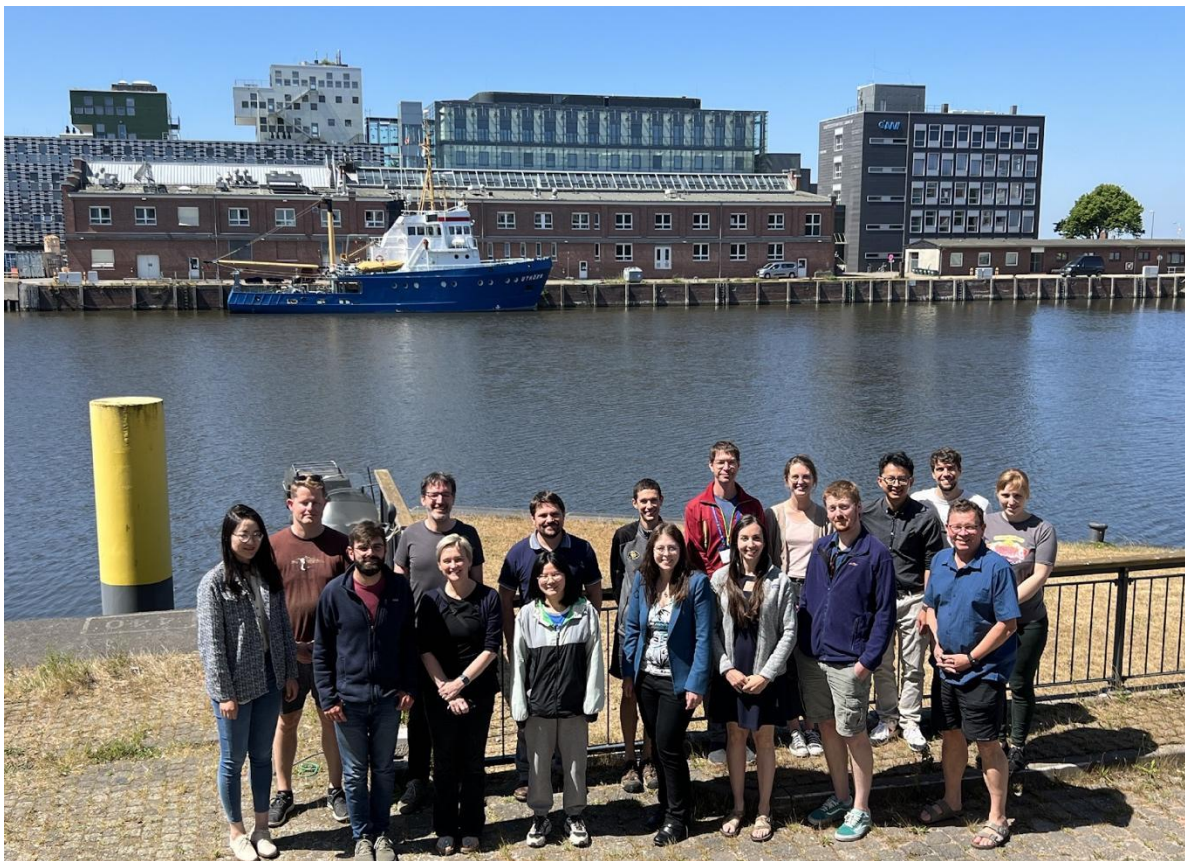
Science Highlights

SIMIP coordinates the sea ice component of climate simulation activities used in the framework of the IPCC report. Groups outside of the SIMIP group are using SIMIP results. SIMIP now has new scientific leadership composition since September 2023.

The composition of steering committee is currently under revision. Previous SSG had 8 members. There will be some overlap with the new SSG as 50% of the members will rotate off. About 10 members from diverse geographic origin and with a diversity of expertise will be gathered. The composition of the SSG will be settled in spring 2024.

Annual Meetings, Workshops, and Conferences

Final CMIP6 meeting in June in Bremerhaven (report on the [website](#))



CLiC funded the attendance of 10 early career scientists at the SIMIP workshop by providing one day per diem to extend their stay past the IGS meeting.

Peer Review Publications (also those *in press*):

Rieke, O., Årthun, M., and Dörr, J. S.: Rapid sea ice changes in the future Barents Sea, *The Cryosphere*, 17, 1445–1456, <https://doi.org/10.5194/tc-17-1445-2023>, 2023.

Future Plans

SIMIP will finalize composition of the SSG. SIMIP plans to define a scientific strategy for CMIP7, including reformulating science questions if needed, revising data request protocols, and writing a MIP description paper. An online meeting will be organized in 2024 to establish this revised strategy.

Contact Information

Co-Chairs:

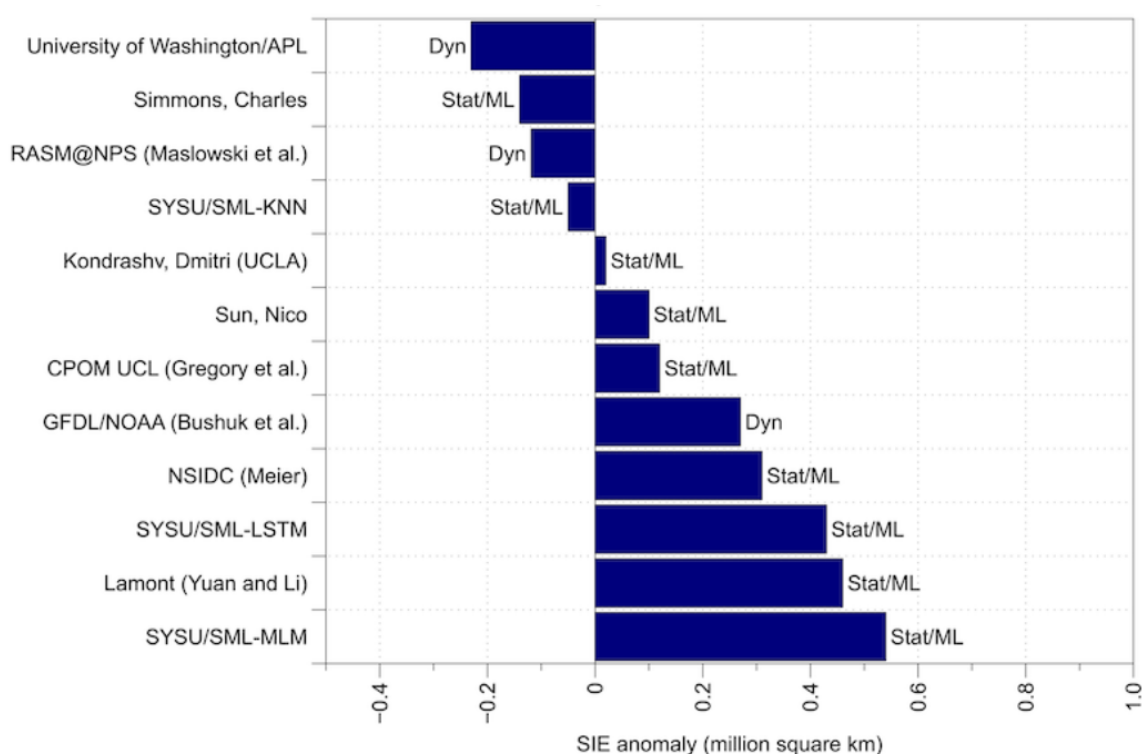
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- Martin Vancoppenolle, martin.vancoppenolle@locean.ipsl.fr

Homepage address: <https://climate-cryosphere.org/simip-about/>

Arctic Sea Ice Working Group (ASIWG)

Science Highlights

As part of the Sea Ice Prediction Network, the annual Sea Ice Outlook (SIO) initiative provides an open process for those interested in Arctic sea ice to share ideas about the September minimum sea ice extent. SIO produces reports in June, July, and August containing a variety of perspectives on Arctic sea ice—from observations of current conditions to advanced numerical models, to qualitative perspectives from citizen scientists. The ASIWG is actively seeking to establish linkages with other working groups to optimize the usefulness of the SIO activity: <https://www.arcus.org/sign/sea-ice-outlook>.



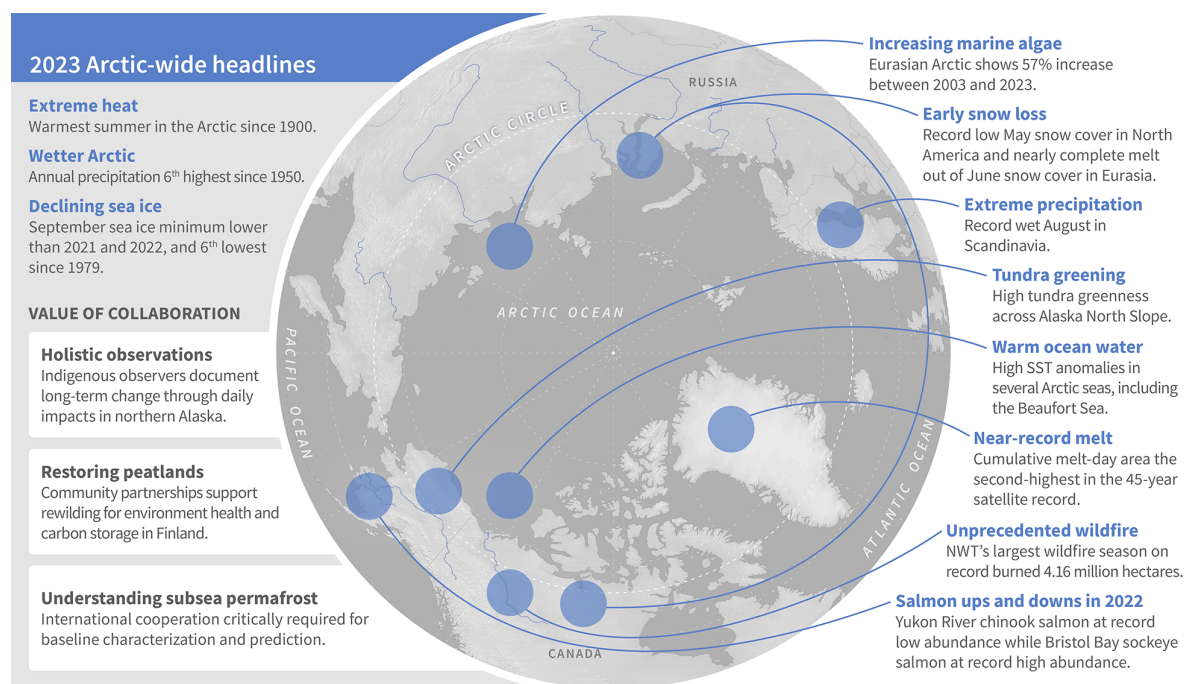
The Sea Ice Outlook forecasts for 2023 September sea-ice extent anomaly in millions of square kilometers. These forecasts have been a valuable means for pinpointing sources of deficiencies in models and pathways for improvement. From the post-season Sea Ice Outlook report (2023).

ASIWG continues to work with citizen scientists using ASSIST ice watch software to record sea ice conditions from ships.

Peer Review Publications (also those *in press*):

ASIWG members have a leading role in writing the Arctic sea ice sections of the [Bulletin of the American Society's State of the Climate Report \(2023\)](#)

[NOAA Arctic Report Card](#)



Results of the executive summary from NOAA's 2023 Arctic Report Card.

Several articles led by ASIWG members were published in 2022 in The Oceanography Society's special issue on The New Arctic Ocean, a series of multidisciplinary articles centred on the Arctic sea-ice system: <https://tos.org/oceanography/issue/volume-35-issue-3-4>

Annual Meetings, Workshops, and Conferences

The Arctic Sea Ice Working Group (ASIWG) held their first open meeting since 2019. The meeting was held in Bremerhaven, Germany on 4 June 2023 with over 40 attendees. >30% of the attendees were Early Career Researchers (ECR), and more than 25% of the presentations were given by ECRs. The morning session was dedicated to ASIWG activities, while the afternoon session was jointly coordinated with the SCAR/CLiC Antarctic Sea Ice Processes & Climate (ASPeCt) working group. Numerous initiatives and working groups were represented. To highlight a few: International Arctic Science Committee (IASC), Sea-Ice Model Intercomparison (SIMIP) project, Biogeochemical Exchanges at the Sea Ice Interfaces (BEPSII), Association of Polar Early Career Scientists (APECS), & the Sustaining Arctic

Observing Networks (SAON).

Outcomes:

A joint press release between the ASIWG and ASPeCt groups for a call of action was [published here](#).

Through discussion sessions during the meeting, 3 issues arose that will help guide future ASIWG activities:

- Numerous working groups/initiatives have the same goals. There is a strong need for coordination across groups to reduce redundancy and optimize complementary activities.
- There are ongoing needs for inter-comparison studies to elucidate uncertainties, biases, & appropriateness of different observation products for use for different applications.
- There is a need to reconcile differences in nomenclature across communities and update the use of sea ice characteristics as a reliable metric of sea-ice conditions given the state change of Arctic sea ice.



The ASIWG meeting was held on 4 June 2023 in Bremerhaven, Germany. It brought a diverse group of sea-ice researchers together with the goals of: (1) Developing, standardizing, and implementing measurement protocols for Arctic sea ice; (2) Integrating surface-based

observations with remote sensing and modelling efforts; and (3) Establishing & fostering connections between international groups involved in sea ice observations, modelling, remote sensing, & data assimilation.

Future Plans

- Update ASIWG website.
- Bring on board new ASIWG members, with an emphasis on geographic diversity and early career stage. We are aiming to increase the working group size to 8-9 members in total. We plan for four-year terms with the opportunity for renewal. We aim to overlap members rotating off with those rotating on to facilitate mentorship and consistency of ASIWG objectives.
- Coordinate with Alice Bradley (SAON) to facilitate a virtual workshop that brings chairs of various groups and initiatives together to promote coordination and reduce redundancy across Arctic sea ice activities. The ASIWG would like to engage with APECS to create opportunities for ECRs to be exposed to different groups and initiatives.
- Coordinate with Jari Haapala and explore the Arctic-ROOS initiative to dovetail its aims into existing Arctic sea-ice research activities and groups.
- The ASIWG is tentatively planning a meeting alongside the Arctic Science Summit Week in Boulder, Colorado in March 2025. We anticipate 40-50 participants. We are currently discussing themes that include but are not limited to: the Sea Ice Prediction Network, artificial intelligence, geoengineering in the Arctic, and others.
- The ASIWG is tentatively planning a meeting alongside the International Glaciological Society's Sea Ice Symposium in Hobart, Tasmania in 2027. We anticipate 40-50 participants, and 70-80 during a joint session with the ASPeCt working group. Themes are to be determined.

Contact Information

Chair: Melinda Webster, mwebster3@alaska.edu

Steering Committee Members:

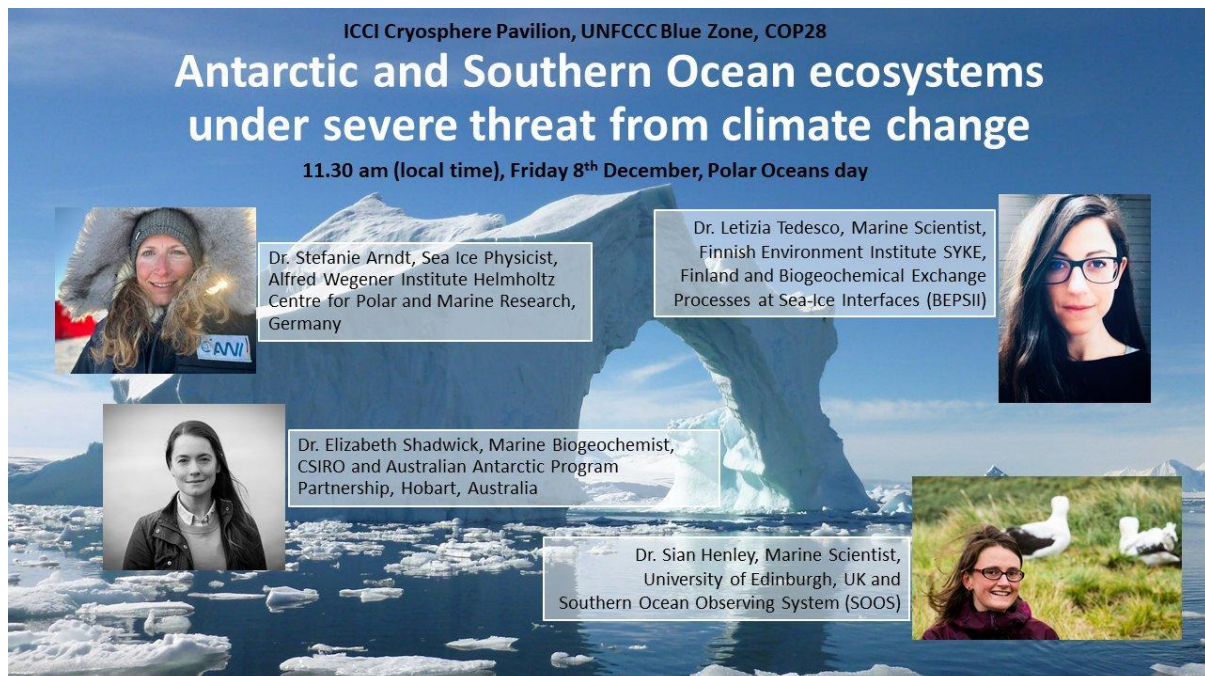
- Sebastian Gerland
- Walt Meier
- Rotating in: Ioanna Merkouriadi
- Rotating off: Don Perovich, Jenny Hutchings

Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII)

Science Highlights

BEPSII organised a side event at the COP28 Cryosphere pavilion on The role of sea-ice biogeochemistry and ice-associated ecosystems in the Earth system. Letizia Tedesco led the session and, together with BEPSII member Sian Henley, attended. Presentations during the event were:

- The future of Arctic sea-ice biogeochemistry and ice-associated ecosystems: a complex tale of winners and losers, Delphine Lannuzel
- Antarctic sea ice as a living and life-sustaining system, Sian Henley
- Climate change impacts on sea-ice ecosystem services, Nadja Steiner
- Arctic sea-ice restoration as a climate intervention strategy: how and what if?, Lisa Miller
- Protecting sea-ice ecosystems in Antarctica: Building resilience and safeguarding global values, Cassandra Brooks



ICCI Cryosphere Pavilion, UNFCCC Blue Zone, COP28

Antarctic and Southern Ocean ecosystems under severe threat from climate change

11.30 am (local time), Friday 8th December, Polar Oceans day

Dr. Stefanie Arndt, Sea Ice Physicist, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Germany

Dr. Letizia Tedesco, Marine Scientist, Finnish Environment Institute SYKE, Finland and Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII)

Dr. Elizabeth Shadwick, Marine Biogeochemist, CSIRO and Australian Antarctic Program Partnership, Hobart, Australia

Dr. Sian Henley, Marine Scientist, University of Edinburgh, UK and Southern Ocean Observing System (SOOS)

Presentations are available: <https://www.youtube.com/watch?v=Os7Oob2wsNw>

ECV-ice (SCOR WG152): Successfully completed with a final meeting in March 2023. During the project period, 7 intercomparison experiments were performed, 6 papers were written and several more to come.

Annual Meeting, Workshops, Conferences

On March 12-14, 2023, BEPSII's annual meeting was organized at La Jolla Scripps Institution of Oceanography, California, following the GRC in Polar Marine Sciences 2023. This was the first in-person (hybrid) meeting after 4 years of online meetings. A report can be found on [the SOLAS website](#). BEPSII co-sponsored a side event at EGU, April 2022, Vienna, which led to an IPY- planning activity. BEPSII session at the International Glaciological Society Sea-Ice Symposium, 4-9 June 2023, Bremerhaven (30 abstracts, 14 orals, 1 plenary). The 2nd Clce2Clouds meeting was held in Grenoble, 9-10 September, in conjunction with the General Assembly of the EU project CRiceS.

Peer Review Publications (also those in press)

Antarctic fast ice nutrients: Macronutrient biogeochemistry in Antarctic land-fast sea ice: Insights from a circumpolar data compilation, Sian F. Henley, S Cozzi, F Fripiat, et al (2023) Marine Chemistry, 257,104324, <https://doi.org/10.1016/j.marchem.2023.104324>.

SOLAS Review, Polar Ocean and Sea Ice in a changing climate, Willis, Lannuzel, Else et al (2023) Elementa Science of the Anthropocene 11 (1): 00056. <https://doi.org/10.1525/elementa.2023.00056>

Arctic Optical measurements: Light Under Arctic Sea Ice in Observations and Earth System Models M. Lebrun, M. Vancoppenolle, G. Madec et al. (2023) JGR Oceans 128, <https://doi.org/10.1029/2021JC018161>

Melting procedure impacts on microbial community structure: E. Chamberlain et al, 2022, Elementa Science of the Anthropocene, 10 (1) <https://doi.org/10.1525/elementa.2022.00017>

Outreach Activities

BEPSII emphasises the inclusion of Early Career Scientists in BEPSII research projects and encourages ECR leadership and training.

Examples:

- The BEPSII SSC includes 2 ECS (2 years assignments). Currently: Eeva Eronen-Rasimus (Finland) and Pat Wongpang (Australia). In 2024, they will rotate off and be replaced by Emilia Chamberlain (USA) and Laura Dalman (Australia).
- Pat Wongpang is coordinator of the Antarctica and the Southern Ocean Collection in *Frontiers of Young Minds - Science* journal for kids (20 of 24 articles are published of which 4 written by BEPSII members).

<https://kids.frontiersin.org/collections/37947/antarctica-and-the-southern-ocean>

Other outreach activities:

- Leaflets, 1-slide summaries, presentations, poster => available on BEPSII website "Documentation"
- Mailing list (through SCAR), usual contents: upcoming meetings, job announcements, relevant events.
- Funding/connections: SOLAS, CLIC, SCAR, IASC, SCOR (WG163: Clce2Clouds) – CATCH, MOSAIC, SOOS, ASPeCt
- Youtube channel created – contains videos from school, to be expanded (compiled by Yann Ilunga)
- Google drive for internal and external use

Future Plans

Finalizing a position analysis for the Antarctic. (Meiners et al.). Once completed, BEPSII is planning a Policy brief for the Antarctic highlighting the position analysis and the Antarctic component of the sea-ice ecosystem services paper (Steiner et al., 2022). Our 2nd Special Feature in *Elementa Science of the Anthropocene* is finishing up. There are plans for a new special feature for Clce2Clouds, which will focus on BEPSII, CATCH and predominantly joint papers (to be initiated by N. Steiner and M. Willis). The BEPSII annual meeting 2024 will be online and will focus on developing a revised science plan. In 2022, BEPSII started with its Early Career Scientist Exchange Program, in which ECRs are fully or partially funded to spend time in another institute to work on BEPSII collaborative projects. In 2021 the program was funded through SOLAS, CLIC & SCAR. In 2024, a 2nd call is out, for which SOLAS and SCAR have confirmed support. We also seek support from IASC and CLiC. The SCOR working group Clce2Clouds connects BEPSII and CATCH (the Cryosphere & Atmospheric Chemistry, cosponsored by SOLAS and IGAC) and is well on its way of producing a tutorial paper on ocean-ice-atmosphere interactions in the polar oceans and synthesis papers for each main topic: the sulfur cycle, primary aerosols, and the nitrogen cycle in sea-ice areas. Ice Algae Model Intercomparison Project (IAMIP2) inviting participants (Info: IAMIP2 website and

Hayashida et al. 2021, GMD) – model runs, analysis and discussions among participants in progress. Next BEPSII field school is planned for 2026 in Saroma-ko lagoon, Japan.

Contact Information

Co-chairs:

- Letizia Tedesco (Finland), Letizia.Tedesco@environment.fi
- Jacqueline Stefels (The Netherlands), j.stefels@rug.nl

Members of the steering committee:

- Nadja Steiner (Canada)
- Lisa Miller (Canada)
- Martin Vancoppenolle (France)
- Bruno Delille (Belgium)
- Klaus Meiners (Australia)
- Delphine Lannuzel (Australia)
- Sebastien Moreau (Norway)

ECVice/Task group 1 chairs:

- Francois Fripiat (Belgium; rotating off)
- Daiki Nomura (Japan)
- Brent Else (Canada)

ECR members (will rotate off in 2024):

- Eeva Eronen-Rasimus (Finland)
- Pat Wongpan (Australia)

Antarctic Sea Ice Processes and Climate (ASPeCt)

Science Highlights

ASPeCt held its first in person meeting since 2018, at the IGS Sea ice Symposium in Bremerhaven on June 4th, 2023. Six ECRs were supported to participate in this meeting. One important outcome was a press release "Polar scientists call for urgent action in view of rapid Arctic and Antarctic change" (which was released by the WMO on 16 June 2023 and picked up widely by organisations, [including SCAR](#), and the media.



Annual Meeting, Workshops, Conferences

ASPeCt held its first in person meeting since 2018, at the IGS Sea ice Symposium in Bremerhaven on June 4th, 2023. There were 23 in person participants (see group photo below) and several online. The workshop was all day. In the morning ASPeCt scientists shared progress from their national programs (Japan – Kay Ohshima , New Zealand – Inga Smith Australia – Petra Heil, Switzerland – Ruzica Dadic UK – Jeremy Wilkinson (Webex) Germany – Stefanie Arndt, France/Belgium - Martin Vancoppenolle). This was followed by a discussion of observing initiatives (ISPOLD2, IPAB and IABP, DEFIANT and KOPRI). Potential ideas for Polar Year 2032 were also discussed. A first draft of the press release was also

created and there were science presentations on the loss of fast ice in 2023 as well as the 2022 and 2023 sea ice extent minima within the context of capturing recent observations and need for future focus.

Participants in the ASPeCt Workshop in Bremerhaven, June 4th, 2023. In the afternoon ASPeCt held a joint session with ASWIG where we discussed the standardization of observations and the global Cryosphere Watch (GCW) in particular, Sea-ice Nomenclature, Sea-Ice Best Practices, Observational methods and Data & metadata. Additionally, ASPeCt Leadership Group held several meetings (every ~3 months) in 2023.

Peer Review Publications (also those in press)

Polona Itkin, Stefan Hendricks, Melinda Webster, Luisa von Albedyll, Stefanie Arndt, Dmitry Divine, Matthias Jaggi, Marc Oggier, Ian Raphael, Robert Ricker, Jan Rohde, Martin Schneebeli, Glen E. Liston; Sea ice and snow characteristics from year-long transects at the MOSAiC Central Observatory. *Elementa: Science of the Anthropocene* 5 January 2023; 11 (1): 00048. doi: <https://doi.org/10.1525/elementa.2022.00048>

Tian R. Tian, Alexander D. Fraser, Thomas Lavergne, Sonya L. Fiddes, Chen Zhao, Petra Heil. Linking timescale-dependent Antarctic sea ice kinematic observations to ice thickness. *Remote Sensing of Environment*, Volume 298, 2023, 113813, ISSN 0034-4257, <https://doi.org/10.1016/j.rse.2023.113813>

These are just two publications. There are many more.

Future Plans

- Renewed enlistment of cruises going into the sea ice zone using DUE SOUTH as a tool to access information on upcoming cruises, i.e., 2023/24 season.
- Continuing development of the ASPeCt ship-based observation system and database for sea ice measurements taken by remote vessels (airborne and under ice), ship-based instruments and surface-based instruments and sampling.
- ASPeCt plans to hold a virtual meeting in May 2024 and to participate in the SCAR 2024 OSC in Pucon, Chile.
- ASPeCt is in the process of making a major overhaul of its website.

Outreach Activities

ASPeCt has a mailing list of more than 60 members. This mailing list is housed at the Los Alamos Lab and administered by Elizabeth Hunke as well as the ASPeCt leadership. The mailing list is used frequently to inform the group, to foster discussion about ASPeCt activities and to collect information about the results of ASPeCt-related activities. The mailing list is quite diverse in terms of gender and nationality and continues to grow.

Contact Information

Chair and leadership:

- Marilyn Raphael (Chair), Raphael@geog.ucla.edu, University of California, Los Angeles
- Stephen Ackley (Immediate Past Chair), University of Texas at San Antonio
- Petra Heil (Data and Communications Executive)
- Stefanie Arndt (Junior Officer, ECS)

Members of the steering committee or working group:

- Sharon Stammerjohn (USA)
- Ted Maksym (USA)
- Gunther Heinemann (Germany)
- Rob Massom (Australia)
- Kay Ohshima (Japan)
- Burcu Orszoy (Turkey)
- Elizabeth Hunke (USA)
- Jean-Louis Tison (Belgium)

Arctic-Midlatitude Climate Linkages (LINKAGES)

Science Highlights

An international LINKAGES workshop was held at University of Lincoln, UK, during 11-13 Sept. 2023 – please see details below.

Peer Review Publications (also those in press)

We have submitted a proposal for a synthesis/review manuscript on this topic to the Chief Editor at NATURE REVIEWS EARTH & ENVIRONMENT.

We have an extensive track record of publications emerging from our previous CliC-/IASC-sponsored LINKAGES workshops, including:

- Overland et al. (2015) The melting Arctic and midlatitude weather patterns: Are they connected? J. Clim. 28, 7917-7932.
- Overland et al. (2016) Nonlinear response of mid-latitude weather to the changing Arctic. Nature Clim. Change 6, 992-999.
- Hanna et al. (2017) Can Arctic warming influence UK extreme weather? Weather 72, 346-352.
- Vihma et al. (2019) Effects of the tropospheric large-scale circulation on European winter temperatures during the period of amplified Arctic warming. Environ. Res. Lett. 40, 509-529.
- Overland et al. (2020) The polar vortex and extreme weather: the Beast from the East in winter 2018. Atmosphere 11(6), 664, doi.org/10.3390/atmos11060664.
- Overland et al. (2021) How do intermittency and simultaneous processes obfuscate the Arctic influence on midlatitude winter extreme weather events? Environ. Res. Lett. 16, 043002.

Annual Meeting, Workshops, Conferences

IASC/CliC workshop on “The influence of the lower stratospheric polar vortex on cold air outbreaks under climate warming”, held at the University of Lincoln, Lincoln, UK, 11-13 September 2023.

Even now with warmer winter average midlatitude temperatures, there are still major winter cold events affecting the lives and economics of millions of people in eastern North American and Asia and Europe. The connection between Arctic change and midlatitude weather events is a scientific challenge as events appear local, intermittent, and do not occur every year. This has led to ongoing controversy in the atmospheric community. We hypothesize that movement of the lower stratospheric polar vortex to over the North American or Eurasia continents provides a mechanism for enhancing regional cold air outbreaks. This small (19-person) workshop, including a diverse range of participants from research institutes in the UK, Finland, Germany, USA, China, Korea and Japan, involved focused presentation from established subject experts and promising Early Career Scientists as well as intensive discussion to advance the understanding of this meteorological connection.

Presentations were on the following topics: Overview of polar vortex studies; The twisted and tortured path of Arctic influence on mid latitude extreme weather; The polar vortex response to sea-ice loss and its state dependence; Greenland Blocking as a conduit of stratosphere-troposphere coupling and Stratospheric Polar Vortex (SPV) impacts; Factors influencing predictability of Northern European cold spells; Drivers of extreme cold events in Europe; Arctic-east Asia teleconnection via troposphere and stratosphere; North American extreme winter weather and the polar vortex; Extreme cold events in North America and Eurasia in November-December 2022: a potential vorticity gradient perspective; Tropical role in the Arctic-midlatitude linkage; The potential vorticity theory of atmospheric blocking in the nonlinear multi-scale interaction model: an application to the Arctic-midlatitude linkage; A new approach to identifying stratospheric polar vortex configurations and connections; Stratosphere-troposphere oscillation and its contribution to cold air outbreaks; The varied surface impacts associated with sudden stratospheric warming in observations and CMIP6; Internal variability increased Arctic amplification during 1980-2022; Investigating pathways connecting tropospheric precursors to stratospheric extreme events; The impact of sea-ice concentration and sea-surface temperature boundary forcing in different experimental settings with ECHAM6 on the polar stratosphere.

During break-out discussions the following themes were identified as key priorities for further research in this area:

1. Improving weather/climate predictions: improving our ability to predict and understand Arctic-Midlatitude linkages in global climate and Numerical Weather Prediction models for more accurate extreme weather, seasonal to sub-seasonal (S2S) and climate projections.
2. Stratosphere-troposphere coupling: developing a comprehensive framework for stratosphere-troposphere coupling events beyond just Sudden Stratospheric

Warming (SSW), including asymmetric structures of the SPV, the role of large-scale circulation, and more detailed spatio-temporal analysis of SPV.

3. Impact on extreme weather: investigating the influence of stratospheric forcing and blocking on extreme weather events, such as temperature and precipitation extremes and identifying precursors in the troposphere.
4. Climate change and Linkages: Examining the impact of climate change on Arctic Amplification and Arctic-Midlatitude linkages, particularly in relation to the Quasi-Biennial Oscillation (QBO) and other tropical drivers, and the changing jet stream. Detection and attribution studies of Arctic influence, using AI methods.
5. Model improvements: addressing challenges in numerical models, including their ability to capture Arctic-Midlatitude linkages, blocking, SPV interactions with the jet stream, and the need for better representation of Arctic Amplification (AA) in simulations while considering the trade-offs between significance and ensemble size.
6. Clarify terminology (e.g. weak SPV & prolonged structure of SPV, locations of SPV centre).
7. Cross-timescale interaction.
8. Nonlinearity: assumption of linearity in many current analyses - more non-linear tests are needed.

The workshop organisers are currently working on a review/synthesis paper(s) for a high-profile peer-reviewed journal. The accompanying photos show University of Lincoln Minerva Building (inside and outside the meeting room), in the Georgian Town Hall ballroom and in front of the Norman castle at Newark-on-Trent, Nottinghamshire, UK - a day excursion to Edward Hanna's home town near Lincoln. The workshop was deemed by participants to have been highly successful and enjoyable. We thank the co-sponsors: IASC, WCRP CLiC and the University of Lincoln.

Outreach Activities

Edward Hanna contributed to a BBC Natural History Unit/INTERACT "Arctic Climate Magnification" video on the jet stream and Arctic/midlatitude climate linkages, that was published in October 2023 (from 7min25):

<https://www.youtube.com/watch?v=xCqofgFN7CA>

Future Plans

To be determined in mid-2024 once we've submitted a synthesis review paper based on the workshop outcomes. Overland and Hanna plan to present new findings on this topic, including a summary of the 2023 Lincoln workshop findings, at the Asia Oceania

Geosciences Society 2024 conference in Pyeongchang, Gangwon-do, South Korea during 23-28 June: <https://www.asiaoceania.org/aogs2024/public.asp?page=home.asp>.

Our working group member M. Wang will convene a relevant session there.

Contact Information

Co-chairs: James E. Overland (james.e.overland@noaa.gov) and Edward Hanna (EHanna@lincoln.ac.uk)

Members of the steering committee or working group:

- Jennifer Francis (Woodwell Climate Research Center)
- Timo Vihma (Finnish Meteorological Institute)
- Muyin Wang (NOAA PMEL)

Ice Sheet Mass Balance and Sea Level (ISMASS)

Science highlights

Workshop “ice sheet modelling across timescales” in Trieste (see below)

Review Article based on a ISMASS workshop (see below)

Annual Meeting, Workshops, Conferences

Workshop “ice sheet modelling across timescales”

13 September 2023, Trieste (Italy)

The workshop discussed strategies and design of ice sheet model simulations that span multiple timescales in past, present and future (Agenda).

Part of SCAR-INSTANT conference; ~30 participants.

Co-sponsored by SCAR and CliC

Peer Review Publications (also those in press)

Review Article for Nature Reviews Earth & Environment based on a 2022 ISMASS workshop
Hanna, E. et al. Short- and long-term variability of the Antarctic and Greenland ice sheets.

Nat Rev Earth Environ (2024). <https://doi.org/10.1038/s43017-023-00509-7>

Future Plans

Model intercomparisons and ISMIP7. H. Goelzer is leading the Greenland ice sheet intercomparison and is member of the scientific steering committee of ISMIP7. F. Pattyn is leading the CalvingMIP project, which is part of EU-project PROTECT. ISMASS is contributing to SCAR-INSTANT by leading a working group on “Inter ice-sheet models simulation design” bridging the gap between past and present/future modelling. H. Goelzer is member of the scientific steering committee of INSTANT.

Contact Information

Co-chair: Heiko Goelzer (heig@norceresearch.no) – NORWAY

Members of the steering committee or working group:

- Edward Hanna (ehanna@lincoln.ac.uk) – UK (CliC representative)
- Frank Pattyn (fpattyn@ulb.be) – BELGIUM (SCAR representative)
- Shawn Marshall (marshals@ucalgary.ca) - CANADA (IASC representative)
- Catherine Ritz (catherine.ritz@univ-grenoble-alpes.fr) – FRANCE (outgoing chair)

Homepage address: <https://climate-cryosphere.org/ismass/>

Southern Ocean Region Panel (SORP)

Science Highlights

The Southern Ocean Freshwater Input from Antarctica (SOFIA) Initiative is now an official CLIVAR task team, and an experimental design protocol paper has been published (Swart et al. 2023; see below). SOFIA continues to expand, and now includes 23 members representing 11 different participating models; 10 modelling groups have finished Tier 1 experiments and uploaded model output to an internally shared ftp site hosted by Environment and Climate Change Canada. These Tier 1 experiments aim at understanding model uncertainty in freshwater-release experiments of 0.1 Sv from Antarctica under pre-industrial climate. Tier 2 experiments will then cover the historical period and future scenarios. Scientific analysis started in mid/late 2022 and is ongoing, with the first scientific paper resulting from SOFIA simulations being published in 2023 (Chen et al. 2023; see below). SOFIA has also been registered as an official Community MIP with CMIP (SOFIAMIP) and SOFIA members are engaging in discussions with the broader freshwater and CMIP communities.

Contributions for a CLIVAR Exchange issue have been collected and are currently undergoing an internal review by SORP panel members. These seven contributions will form a special issue highlighting emerging Southern Ocean and Antarctic programs and feature in particular programs developed in the Global South.

Antarctica InSync was endorsed as an Ocean Decade Action and announced at the Polar Summit in Paris. SORP member Alexander Haumann is one of the Antarctica InSync coordinators and has also joined the SOOS SSG.

Planning for a joint activity comprising a summer school on polar climate and a workshop on sea ice role and variability in the climate system together with NORP and ICTP in Trieste, Italy, in July 2024 is underway, with a NORP-SORP task team meeting fortnightly. For this activity we would appreciate financial support by CLiC (see Appendix A).

SORP has instigated a quarterly seminar series, PROS4SORP, to build a more coherent community and raise awareness of SORP activities. The first seminar was held in October, with Sharon Stammerjohn presenting on Antarctic Sea ice changes. The seminar was attended by 70 people, and an online recording has been made available. The next seminar is planned for late January 2024.

Annual Meeting, Workshops, Conferences

SORP convened sessions at the EGU General Assembly 2023: “OS1.8 - The Southern Ocean in a changing climate: open-ocean physical and biogeochemical processes”; and “OS1.9 Under cover: The Southern Ocean’s connection to sea ice and ice shelves”.



SORP held its 15th business meeting (SORP-15) in July 2023 in-person in Potsdam and Berlin and with a hybrid option available, from which reorganized and reinvigorated task teams emerged. Part of the 2-day meeting was held together with NORP for continued collaboration and a session involving OMDP was organised to discuss polar model development and joint experiments.

Strong SORP and SOFIA presence at the IUGG General Assembly in Berlin, including participation in session JP03a - Physical and Biogeochemical Ocean and Ice Processes in the Southern Ocean: Observations, State Estimation and Modeling (IAPSO, IACS), and in P03/JP04 breakout panel discussion on OCEAN:ICE interactions - Ice sheet impacts on ocean circulation and climate feedbacks, in July 2023.

Workshop on Antarctic InSync initiative at SOOS Symposium, Hobart, Australia, August 2023.

Monthly SOFIA meetings are growing to become a notable exchange platform for ocean and climate modellers including discussions of ice-ocean interaction, in particular ocean-driven melt of the Antarctic Ice Sheet.

Peer Review Publications (also those in press)

Rabe, B., T. Martin, A. Solomon, K. M. Assmann, L. C. Biddle, T. Haine, T. Hattermann, F. A. Haumann, A. Jahn, T. Karpouzoglou, G. Laukert, A. Naveira Garabato, E. Rosenblum, E. Sikes, L. Yin, and X. Zhang, 2023: Polar Fresh Water in a Changing Global Climate: Linking Arctic and Southern Ocean Processes. *Bull. Amer. Meteor. Soc.*, 104, E970–E979, <https://doi.org/10.1175/BAMS-D-23-0046.1>, available at: <https://journals.ametsoc.org/view/journals/bams/104/5/BAMS-D-23-0046.1.xml>

Swart, N., T. Martin, R. Beadling, J.-J. Chen, C. Danek, M. H. England, R. Farneti, S. M. Griffies, T. Hatterman, J. Hauck, F. A. Haumann, A. Jüling, Q. Li, J. Marshall, M. Muilwijk, A. G. Pauling, A. Purich, I. J. Smith and M. Thomas, 2023, The Southern Ocean Freshwater Input from Antarctica (SOFIA) Initiative: scientific objectives and experimental design, *Geoscientific Model Development*, 16, 7289–7309, <https://doi.org/10.5194/gmd-16-7289-2023>, available at: <https://gmd.copernicus.org/articles/16/7289/2023/>

Chen, J.-J., N. C. Swart, R. Beadling, X. Cheng, T. Hattermann, A. Jüling, Q. Li, J. Marshall, T. Martin, M. Muilwijk, A. G. Pauling, A. Purich, I. J. Smith, and M. Thomas (2023), Reduced Deep Convection and Bottom Water Formation Due to Antarctic Meltwater in a Multi-Model Ensemble, *Geophysical Research Letters*, 50, e2023GL106492. <https://doi.org/10.1029/2023GL106492>, available at: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2023GL106492>

Future Plans

Continued work on SOFIA, including submitting analysis papers based on Tier 1 experiments, running higher tier experiments, and investigating submitting SOFIA output as a formal model intercomparison (MIP) as part of the Coupled Model Intercomparison Project phase 6 (CMIP6). Another branch of SOFIA includes investigating possible contributions to CMIP7 as so-called Community MIP.

Editing and publishing the CLIVAR Exchange issue on highlighting emerging Antarctic and Southern Ocean programs.

Continued planning and running the ICTP-NORP-SORP summer school on Polar Climates: Theoretical, Observational and Modelling Advances, and the

ICTP-NORP-SORP workshop on the Role of Sea Ice and Variability in the Climate System in July 2024, Trieste, Italy.

2024 is an important implementation year for Antarctica InSync, with work underway for a website, a structure plan by theme, national and disciplines.

Outreach activities

SORP outreach activities include the CLIVAR Exchange issue, the ICTP-NORP-SORP summer school and the PROS4SORP seminar series, all described above.

Contact Information

Co-chairs:

- Ariaan Purich (ariaan.purich@monash.edu)
- Torge Martin (tomartin@geomar.de) rotated off 12/2023
- Carolina Dufour (Carolina.dufour@mcgill.ca) started on 01/2024

Members of the steering committee or working group:

New members (early 2023)

- Carolina Dufour (McGill University, Canada)
- Alvaro Scardilli (Servicio de Hidrografía Naval, Argentina)
- Elin Darelus (University of Bergen and the Bjerknes Centre for Climate Research, Norway)
- Ted Scambos (University of Colorado Boulder, USA)

Ongoing members

- Torge Martin (GEOMAR, German)
- Ariaan Purich (Monash University, Australia)
- Natalie Robinson (NIWA, New Zealand)
- Clive McMahon (Sydney Institute of Marine Sciences, Australia)
- Alexander Haumann (AWI, German)
- Tore Hattermann (Norwegian Polar Institute, Norway)

- Luciano Pezzi (Ex-officio; INPE, Brazil)

Members rotating off (end of 2023)

- Michiyo Yamamoto-Kawai (Tokyo University of Marine Science and Technology, Japan)
- Ronald Souza (INPE, Brazil)
- Neil Swart (Environment and Climate Change Canada)

Northern Oceans Regional Panel (NORP)

NORP aims to strategically coordinate efforts in science of the Arctic Ocean and subarctic seas in the global climate system by involving researchers on an international level. Aspects cover process understanding, evaluation of state-of-the-art as well as predictability. The panel has been revisiting its Terms of References, currently in draft form:

1. Facilitate progress in the development of tools and methods to monitor and assess climate variability and change, and evaluate climate predictability of the ocean-atmosphere-ice system in the Arctic and Subarctic Ocean.
2. Connect to other international efforts, programmes and panels by members liaising themselves or via contacts
3. Monitor and evaluate progress in Arctic Ocean research, and identify gaps / make recommendations.
4. Coordinate and feedback on Arctic data sets and data archiving, e.g. by meeting up with data center reps.

The terms of reference will be discussed at one of the regular online meetings of NORP in early 2024 and a final version for the CLIVAR website provided.

Science Highlights

NORP and SORP jointly organized an online workshop “NORP-SORP workshop on polar fresh water: Sources, Pathways and Impacts of fresh water in northern and southern Polar oceans and seas (SPICE UP)”, held online in September 2022 with CLIVAR support (see also <https://www.clivar.org/events/norp-sorp-workshop-polar-fresh-water-sources-pathways-and-impacts-fresh-water-northern-and>). The workshop was co-sponsored by the World Climate Research Programme (WCRP), World Meteorological Organization (WMO), Climate and Ocean: Variability, Predictability, and Change (CLIVAR), Climate and Cryosphere (CLiC), Scientific Committee on Antarctic Research (SCAR), Global Ocean Observing System (GOOS), and Global Climate Observing System (GCOS). The Zoom license was provided by our co-sponsor International Arctic Science Committee (IASC). One of the outputs was a report from this online workshop, published in the Bulletin of the American Meteorological Society (Rabe et al., 2023) and a CLIVAR report describing organizational aspects and the unprocessed outcome of the discussion sessions (CLIVAR, 2023). See <https://doi.org/10.36071/clivar.rp.2.2023> for images of the highlights of the workshop. Capacity building has been ongoing, including links to other CLIVAR and WCRP panels; in particular, OMDP (Dorotea Iovino) and OOPC (Benjamin Rabe).

Arctic Processes CMIP6 bootcamp

Learn how to work with climate model (CMIP6) data, from the modellers who produced them.

Use these data in conjunction with other datasets to answer crucial science questions about the past, present or future Arctic climate system, under the guidance of experts in the field.

Contribute to the publications resulting from the bootcamp.

Organised by the
CLIVAR/CLIC Northern Oceans Region Panel:
Céline Heuzé – Amy Solomon – Ruth Mottram – Benjamin Rabe – Patrick Heimbach – Dorotea Iovino – Laurent Bertino – Tor Eldevik – Sheldon Bacon – Xiangdong Zhang – Arild Sundfjord – Vladimir Ivanov – Qi Shu

11-21 October 2022
Søminestationen, Denmark*

Apply here:
https://sunet.artologik.net/gu/NORP_CMIP6bootcamp
The deadline is 29th April 23.59 CEST.
More information: cmip6bootcamp@gmail.com

* The summer school will be subject to COVID-development by autumn 2022










The Polar Prediction Project (PPP) **GÖTEBORGS UNIVERSITET**

Annual Meeting, Workshops, Conferences

After a break from in-person meetings in 2022, due to COVID, the 2023 panel meeting was held in hybrid format, partly together with the southern ocean panel. NORP and SORP met in-person in Potsdam and Berlin in advance of the IUGG conference with online participation by some of the members ([see here](#)). The meeting consisted of NORP-only and joint NORP-SORP sessions. In addition, members of the Ocean Model Development Panel (OMDP) were invited to join for part of the NORP sessions.



The Arctic Processes in CMIP6 Bootcamp was an activity designed for young scientists and PhD students, and was very successful.

Peer Review Publications (also those in press)

CLIVAR, 2023: Final report on the NORP-SORP workshop on polar fresh water: Sources, Pathways and Impacts of fresh water in northern and southern Polar oceans and seas (SPICE UP). CLIVAR Report 02/2023, 35 pp., <https://doi.org/10.36071/clivar.rp.2.2023>.

Rabe, B., and Coauthors, 2023: Polar Fresh Water in a Changing Global Climate: Linking Arctic and Southern Ocean Processes. *Bull. Amer. Meteor. Soc.*, 104, E970–E979, <https://doi.org/10.1175/BAMS-D-23-0046.1>.

Outreach Activities

The CMIP6 summer school and the workshop on polar fresh water, described above, also furthered outreach to the wider science community and to early career researchers.

Future Plans

NORP plans to orient its future activities around the new terms of reference, including meeting with representatives of Arctic data centers, comparing Arctic Ocean reanalysis products with respect to specific science questions and engage with northern (local) communities. An online Arctic heat budget workshop (and follow-on review papers) is planned, likely to be scheduled late 2024 or early 2025. An organising committee will be formed early 2024. Together with SORP, the panel intends to organize freshwater forcing model experiments and joint sessions at international conferences. The panels aim to keep in touch through bi-annual telecons. NORP and OMDP aim to explore potential collaboration on Arctic water mass analysis and processes in OMIP runs, and engage with respect to CMIP7.

NORP decided to have the next in-person meeting in 2025 and meet online in 2024. The cooperation with SORP is ongoing and will involve joint online meetings in the future, as well as the connection to other panels (e.g. OMDP).

NORP is organising a workshop at ICTP, together with SORP, 22 to 31 July 2024: “School and Workshop on Polar Climates: Theoretical, Observational and Modelling Advances”, organized by NORP and SORP; at ICTP, Italy. See also <https://indico.ictp.it/event/10498/> and CLiC news

item. NORP and SORP are jointly requesting 5 kEUR funding from CLiC for this event – see separate email correspondence (CLiC already granted the money).

Contact Information

Co-chairs:

- Benjamin Rabe, benjamin.rabe@awi.de
- Amy Solomon (until end 2023), amy.solomon@noaa.gov
- Petteri Uotila (new in 2024), petteri.uotila@helsinki.fi

Members of the steering committee or working group

The following members joined beginning of 2023:

- Lorenz Meire
- Alexandra Jahn
- Stephanie Waterman
- Letizia Tedesco (as full member)
- Julianne Stroeve (as ex-officio)

The following members rotated off as full members end 2023:

- Amy Solomon
- Patrick Heimbach
- Vladimir Ivanov
- Tor Eldevik

The following members became ex-officio in 2024:

- Amy Solomon
- Patrick Heimbach

The following members joined in 2024

- Lars Smedsrud
- Petteri Uotila
- Milena Veneziani
- Hannah Zanowski

Homepage address: <https://www.clivar.org/clivar-panels/northern>

Polar Coordinated Regional Downscaling Experiment – Arctic and Antarctic Domains (Polar CORDEX)

Science highlights

In the Arctic, new coordinated multi-model research activities were started. One of those activities is an evaluation of Arctic atmospheric boundary layer stability regimes, their frequency and radiative and mechanical forcing using observations from the year-long MOSAiC expedition. The approach is based on Jozef et al. (2023). A total of 12 modeling groups have indicated an interest in participating in this model intercomparison. According to output from the different RCMs has been provided, results of a first model (CAFS) have been presented by Jozef and Cassano (2023), and first multi-model analysis results are expected next spring. Another activity is the process-oriented investigation of a warm air intrusion event during mid-April 2020 that was observed during MOSAiC (Kirbus et al., 2023; Svensson et al., 2023). This study has its focus on the atmospheric boundary layer, air mass transformation, surface energy budget, and aerosol-cloud-radiation interactions. This multi-model activity is a joint effort of Polar CORDEX and the EU-funded project [PolarRES](#).

To quantify possible climate change effects, wind energy potentials from a multi-RCM ensemble of Arctic-CORDEX were calculated for future scenarios (Akperov et al., 2023). The seasonal wind power density over the Arctic is estimated to increase in the 21st century under a high emission scenario (RCP8.5). Surface roughness through sea-ice and vegetation changes may significantly impact on the variability of future wind energy potentials in the Arctic.

In the Antarctic, to determine which ice shelves are vulnerable to melt-induced hydrofracture, Orr et al. (2023) used near-surface temperature output from 1979/80 to 2018/19 from two Antarctic CORDEX simulations (MetUM and HIRHAM5) to calculate a regional surface “melt potential” index (MPI) over Antarctic ice shelves that describes the frequency (MPI-freq, %) and intensity (MPI-int, K) of daily maximum summer temperatures exceeding a melt threshold of 273.15 (0°C), which is the melting point of snow/ice. Results are based on output from two models to enable model-dependence and consistency to be assessed. Hansen et al. (2023) examined the representation of an extensive melt event that occurred over the Ross Ice Shelf during January 2016 by the MetUM and HIRHAM5 Antarctic CORDEX simulations, as well as a physically-based, multi-layer, offline coupled firn model forced by both HIRHAM5 and MetUM output. The results show that both the HIRHAM5 and

MetUM simulations considerably underestimated the number of melt days that occurred during the event, which is likely due to both limitations in their own ice/snow surface schemes and an absence of spin-up. However, using HIRHAM5 and MetUM output to force the offline coupled firn model resulted in a considerable improvement in modelled melt. However, despite its sophistication, the offline coupled firn model was unable to realistically represent the complete melt pattern over the RIS, which they suggest is due to deficiencies in the representation of cloud phase partitioning in models.

Peer Review Publications (also those in press)

Title, journal and link to publication	Author/-s	Date
An Overview of the Vertical Structure of the Atmospheric Boundary Layer in the Central Arctic during MOSAiC, <i>Atmos. Chem. Phys.</i> , 24, https://doi.org/10.5194/acp-24-1429-2024	Jozef et al.	2024
Thermodynamic and kinematic drivers of atmospheric boundary layer stability in the central Arctic during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC). <i>Atmos. Chem. Phys.</i> , 23, https://doi.org/10.5194/acp-23-13087-2023 .	Jozef et al.	2023
Surface impacts and associated mechanisms of a moisture intrusion into the Arctic observed in mid-April 2020 during MOSAiC, <i>Front. Earth Sci.</i> , https://doi.org/10.3389/feart.2023.1147848	Kirbus et al.	2023
Warm air intrusions reaching the MOSAiC expedition in April 2020—The YOPP targeted observing period (TOP). <i>Elementa: Science of the Anthropocene</i> , https://doi.org/10.1525/elementa.2023.00016	Svensson et al.	2023
Future projections of wind energy potentials in the Arctic for the 21st century under the RCP8.5 scenario from regional climate models (Arctic-CORDEX), <i>Anthropocene</i> , https://doi.org/10.1016/j.ancene.2023.100402	Akperov et al.	2023
Policy-relevant science highlights from the Antarctic CORDEX project, <i>World Meteorological Organisation Antarctic Treaty Paper</i> , https://www.ats.aq/devAS/Meetings/Documents/95	Orr	2023
Characteristics of surface melt potential over Antarctic ice shelves based on regional atmospheric model	Orr et al.	2023

simulations of summer air temperature extremes from 1979/80 to 2018/19, <i>J. Clim.</i> , https://doi.org/10.1175/JCLI-D-22-0386.1		
Variable temperature thresholds of melt pond formation on Antarctic ice shelves. <i>Nature Climate Change</i> , https://doi.org/10.1038/s41558-022-01577-1	van Wessem et al.	2023
Higher Antarctic ice sheet accumulation and surface melt rates revealed at 2 km resolution. <i>Nature Communications</i> , https://doi.org/10.1038/s41467-023-43584-6	Noël et al.	2023
Deep learning regional climate model emulators: A comparison of two downscaling training frameworks. <i>J. Adv. Modeling Earth Systems</i> , https://doi.org/10.1029/2022MS003593	van der Meer et al.	2023
The importance of cloud phase when assessing surface melting in an offline coupled firn model over Ross Ice shelf, West Antarctica, <i>The Cryosphere Discuss.</i> , https://doi.org/10.5194/tc-2023-145	Hansen et al.	2023

Annual Meeting, Workshops, Conferences

Annual Polar Cordex meeting 4-6 October 2023, Utrecht University, Netherlands, in-person + online, Report	A. Rinke, J. Cassano, A. Orr, W. J. van de Berg	Cordex, CLiC
D2 session on “Regional Climate Modelling in the Polar Regions: Applications and the road ahead” at ICRC-CORDEX 2023 25-29 September 2023, Trieste, Italy, in-person + online, https://icrc-cordex2023.cordex.org/	P.A. Mooney, A. Rinke, J. Cassano	
Session M15 on “Polar Modelling” at IUGG, Berlin, Germany, 11-20 July 2023, in-person, https://www.iugg2023berlin.org/	J. Cassano, A. Rinke, A. Orr	

Outreach Activities

Policy-relevant science highlights from the Antarctic CORDEX project, World Meteorological Organisation Antarctic Treaty Paper, <https://www.ats.aq/devAS/Meetings/Documents/95> (A. Orr)

Future Plans

Annual Polar Cordex meeting, autumn 2024, Potsdam, Germany

Contact Information

Co-chairs:

- John Cassano, cassano@colorado.edu
- Annette Rinke, annette.rinke@awi.de
- Andrew Orr, anmcr@bas.ac.uk
- Christoph Kittel, ckittel@uliege.be

Permafrost Carbon Network (PCN)

The Permafrost Carbon Network produces new knowledge through research synthesis to quantify the role of permafrost carbon in driving future climate change. This is achieved by network building and organizing workshops.

Peer Review Publications (also those in press)

These peer-reviewed synthesis publications (published and in review/revision) were initiated in part through activities by the Permafrost Carbon Network or through contributions from PCN scientists. In many cases, support was also derived from other projects and brought together by the PCN.

Oehri, J., Schaepman-Strub, G., Kin, J., Grysko, R., Kropp, H., Grunberg, I., Zemlianskii, V., Sonnentag, O., Euskirchen, E.S., Chacko, M.R., Muscari, G., Blanken, P.D., Dean, J.F., Di Sarra, A., Harding, R.J., Sobota, I., Kutzbach, L., Plenkhanovia, E., Riihela, A., Boike, J., Miller, N.B., Beringer, J., Lopez-Blankoc, E., Stoy, P.C., Sullivan, R.C., Kejna, M., Parmentier, F.W., Gamon, J.A., Mastepanov, M., Willie, C., Jackowicz-Korczynski, M., CKarger, D.N., Quinton, W.L., Putkonen, J., Van As, D., Christensen, T.O.R., Hakuba, M.Z., Stone, R.S., Metzger, S., Vandecrux, B., Frost, G.V., Wild, M., Hansen, B., Meloni, D., Domine, F., Te Beest, M., Sachs, T., Kalhori, A., Rocha, A.V., Williamson, S.N., Morris, S., Atchley, A.L., Essery, R., Runkley, B.R.K., Holl, D., Riihimäki, L.D., Iwata, H., Schuur, E.A.G., Cox, C.J., Grachev, A.A., McFadden, J.P., Fausto, R.S., Gockede, M., Ueyama, M., Pirk, N., De Boer, G., Bret-Harte, M.S., Lepparanta, M., Steffen, K., Friborg, T., Ohmura, A., Edgar, C.W., Olofsson, J., and Chambers, S.D. 2022. Vegetation type is an important predictor of the arctic summer albedo and surface energy budget. *Nature Communications*. 13 (1), 6379.
<https://doi.org/10.1038/s41467-022-34049-3>

Ramage, J.L., Kuhn, M., Virkkala, A.M., Voigt, C., Marushchak, M.E., Bastos, A., Biasi, C., Canadell, J.G., Ciais, P., Lopez-Blanco, E., Natali, S.M., Olefeldt, D., Potter, S., Poulter, B., Rogers, B., EAG Schuur et al. The net GHG balance and budget of the permafrost region (2000-2020) from ecosystem flux upscaling. 2023. ESS Open Archive
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Maes, SL, Dietrich, J, Midolo, G, Schwieger, S, Kummu, M, Vandvik, V, Aerts, R, Althuizen, I.H.J, Biasi, C, Björk, RGB, Böhner, H, Carbognani, M, Chiari, G, Christiansen, CT, Clemmensen, KE, Cooper, EJ, Michelsen, A, Cornelissen, JH, Elberling, B, Faubert, P, Fetcher, N, Forte, TGW, Gaudard, J, Gavazov, K, Guan, Z-H, Gumundsson J, Gya, R, Hallin, S, Hansen, BB, Haugum, SV, He, J-S, Hicks Pries, C, Hovenden, MJ, Jalava, M, Jónsdóttir, IS, Juhanson, J, Jung, JY, Kaarlejärvi, E, Kwon, MJ, Lamprecht, RE, Le Moullec, M, Lee, H, Marushchak, ME, Munir, TM, Myrsky, E, Nielsen, CS, Nyberg, M, Olofsson, J, Óskarsson, H, Parker, TC, Pedersen, EP, Petit Bon, M, Petraglia, A, Raundrup, K, Ravn, NMR, Rinnan, R, Rodenhizer, H, Ryde, I, Schmidt, NM, Schuur, EAG, Sjogersten, S, Stark, S, Strack, M, Tang, J, Tolvanen, A, Töpper, JP, Väisänen, MK, van Logtestijn, RS, Voigt, C, Walz, J, Weedon, JT, Yang, Y, Yläne, H, Björkman, MP, Sarneel, JM, Dorrepaal E. 2024. Environmental drivers of increased ecosystem respiration with warming in tundra. *Nature*, in press.

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Anna-Maria Virkkala, Brendan M. Rogers, Jennifer D. Watts, Kyle A. Arndt, Stefano Potter, Isabel Wargowsky, Edward A. G. Schuur, Craig See, Marguerite Mauritz, Julia Boike, Syndonia M. Bret-Harte, Eleanor J. Burke, Arden Burrell, Namyi Chae, Abhishek Chatterjee, Frederic Chevallier, Torben R. Christensen, Roisin Commane, Han Dolman, Bo Elberling, Craig A. Emmerton, Eugenie S. Euskirchen, Liang Feng, Mathias Goeckede, Achim Grelle, Manuel Helbig, David Holl, Järvi Järveoja, Hideki Kobayashi, Lars Kutzbach, Junjie Liu, Ingrid Liujkx, Efrén López-Blanco, Kyle Lunneberg, Ivan Mammarella, Maija E. Marushchak, Mikhail Mastepanov, Yojiro Matsuura, Trofim Maximov, Lutz Merbold, Gesa Meyer, Mats B. Nilsson, Yosuke Niwa, Walter Oechel, Sang-Jong Park, Frans-Jan W. Parmentier, Matthias Peichl, Wouter Peters, Roman Petrov, William Quinton, Christian Rödenbeck, Torsten Sachs, Christopher Schulze, Oliver Sonnentag, Vincent St.Louis, Eeva-Stiina Tuittila, Masahito Ueyama, Andrej Varlagin, Donatella Zona, and Susan M. Natali. 2024. An increasing Arctic-Boreal CO₂ sink despite strong regional sources. *Nature Climate Change*, in review.

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Goeckede, Achim Grelle, Juha Hatakka, Liam Heffernan, Manuel Helbig, David Holl, Elyn Humphreys, Hiroki Iwata, Järvi Järveoja, Hideki Kobayashi, John Kochendorfer, Pasi Kolari, Ayumi Kotani, Lars Kutzbach, Min Jung Kwon, Emma R. Lathrop, Tuomas Laurila, Annalea Lohila, Efrén López-Blanco, Ivan Mammarella, Maija E. Marushchak, Mikhail Mastepanov, Yojiro Matsuura, Lutz Merbold, Gesa Meyer, Christina Minions, Mats B. Nilsson, Julia Nojeim, Steven F. Oberbauer, David Olefeldt, Sang-Jong Park, Frans-Jan W. Parmentier, Matthias Peichl, Darcy Peter, Roman Petrov, Rafael Poyatos, Anatoly S. Prokushkin, William Quinton, Heidi Rodenhizer, Torsten Sachs, Kathleen Savage, Christopher Schulze, Sofie Sjögersten, Oliver Sonnentag, Vincent L. St. Louis, Margaret Torn, Eeva-Stiina Tuittila, Juha-Pekka Tuovinen, Masahito Ueyama, Andrej Varlagin, Carolina Voigt, Jennifer D. Watts, Donatella Zona, Viacheslav I. Zyryanov, and Edward A. G. Schuur. 2024. Decadal increases in carbon uptake offset by respiratory losses across northern permafrost ecosystems. *Nature Climate Change*, in press.

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Annual meeting, Workshops, Conferences

We hosted an in-person Permafrost Carbon Network workshop May 3-5, 2023 in Flagstaff, AZ for 38 participants, with a significant representation of early career scientists. We based the agenda on feedback we received from the steering committee, polls of the community and discussions over the past year. The first day, we had two focused discussions on the topics of Carbon Flux Synthesis and Permafrost Carbon Modeling. Each period started with a short set of connected speaker presentations about the state of synthesis followed by targeted breakout discussions in smaller groups so that all participants could contribute their voices. These two topics form the key focal science areas of our grant. The second day, we focused on Science Communication and Emerging Syntheses. These also featured either a panel discussion or presentations followed by additional breakout discussions. All sessions comprised permafrost experts across axes of diversity including: gender, career stage, nationality, scientific discipline among others. Meeting participants were actively engaged using breakout discussions and interactive poll questions where results were viewed in real-time. We used the third day to focus on permafrost carbon in the policy world and had two breakout activities that focused on congressional resolutions and a review of EPA

Greenhouse Gas reporting. Breakouts were introduced and lead by Permafrost Carbon Network steering committee members and other Network members and focused on active discussion with participants. The in-person workshop was timely after several years online, and all participants reported the need to intersperse online and in-person workshops in the future to maintain momentum producing new knowledge and direction for the network.

The Permafrost Carbon Network organized oral and poster sessions at the 2023 American Geophysical Union meeting in San Francisco. Vulnerability of Permafrost Carbon to Climate Change; Focus groups: Biogeosciences, Cryosphere, Global Change. This is also a training experience as we combine senior and junior career scientists when organizing and leading the session. Products: See AGU program for abstracts. The Permafrost Carbon Network also hosted an in-person gathering of the steering committee members for those who attended AGU San Francisco.

Outreach Activities

Multiple presentations were given to various audiences based on the permafrost carbon science synthesis paper listed above.

Development of a Permafrost Carbon Network mini-documentary to highlight permafrost carbon science and science synthesis of the network. This mini-documentary is still under final review but should be completed Spring 2024.

Future Plans

Organized oral and poster sessions at the 2024 International Conference on Permafrost (ICOP) meeting in Whitehorse, Canada. This session was co-organized with Elchin Javarov (Woodwell Climate Research Center) and Jing Tao (Department of Energy, Berkeley Laboratory)

We plan to hold a 1-day, in person all-scientist Permafrost Carbon Network workshop in advance of the 2024 AGU meeting in Washington, DC.

Contact Information

Chair: Ted Schuur (Northern Arizona University, ted.schuur@nau.edu)

Members of the steering committee or working group:

- Ben Abbott (Brigham Young University, USA)
- Jessica Ernakovich (University of New Hampshire, USA)
- Guido Grosse (Alfred Wegener Institute, Germany)
- Gustaf Hugelius (Stockholm University, Sweden)
- Charles Koven (Lawrence Berkeley National Lab, USA)
- Dave Lawrence (National Center for Atmospheric Research, USA)
- Michael Loranty (Colgate University, USA)
- Sue Natali (Woodwell Climate Research Center)
- David Olefeldt (University of Alberta, Canada)
- Verity Salmon (Oak Ridge National Laboratory)
- Claire Treat (Alfred Wegener Institute, Germany)
- Merritt Turetsky (University of Colorado Boulder, USA)
- Anna Virkkala (Woodwell Climate Research Center) (new addition)

Homepage address: www.permafrostcarbon.org

CliC Grants and Fellowships 2023

Background

The second open call for CliC grants and fellowships was launched in November 2022. The goal of the awards was to increase the engagement of Early Career Scientist (ECR) in CliC activities as well as to promote participation of scientists from regions currently underrepresented in CliC, i.e., South America, Asia and Africa.

Evaluation and selection

An evaluation committee composed of a sub-set of the SSG selected two applications for grants and two for fellowships according to the following criteria: quality of the research, how the project target CliC strategic areas, career stage, geographical distribution, and gender of the applicants.

Two out of four projects were completed, whilst two were delayed and will be carried out during 2024.

1. *PI:* **Lautaro Clavero**, University of Buenos Aires - IANIGLA CONICET, Mendoza City, Argentina

Project title: Glacier related hazards in the Northern Patagonian Andes of Argentina.

2. *PI:* **Gansukh Yadamsuren**, Mongolian University of Life Sciences, Darkhan-Uul, Mongolia

Project title: Permafrost degradation and its impact on water supply in Mongolia

3. *PI:* **Robbie Mallett**, University of Manitoba, Winnipeg, Canada

Project title: A new generation of low-cost, handheld radars for sea ice research and teaching

– *Delayed, will start in 2024*

4. *PI:* **Ellie Fox**, University of Exeter, Exeter, U.K.

Project title: Investigating the relationships between mountain cryosphere changes and water availability and access for communities in the semi-arid Chilean Andes

– *Delayed, will start in 2024*