The Climate and Cryosphere (CliC) Project of the World Climate Research Programme (WCRP)

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Summary

The World Climate Research Programme’s *Climate and Cryosphere (CliC)* project is a global community of researchers with expertise and knowledge of the cryosphere (polar seas, permafrost, snow-covered land and glaciated regions, including ice sheets and mountainous areas) and its interactions with the climate system. Activities span observations, modelling, process understanding, predictions and projections and cross-cutting activities. Climate change is affecting Antarctica, and in return Antarctic change is impacting our planet. Here we present CliC endorsed activities in Antarctica and the Southern Ocean, a better understanding of: (i) changes to the Antarctic outlet glaciers and ice sheets that have a direct impact on global sea level rise and (ii) changes in sea-ice extent that may accelerate surface warming, destabilising ice shelves leading to rapid and potentially unstoppable loss of up to one third of the Antarctica’s ice sheets. Moreover sea-ice loss weakens ocean circulation impacting global heat distribution, and together with changes in marine biogeochemistry, reduce nutrient supplies that currently support 75% of global ocean productivity and the ability of the southern ocean to store atmospheric CO2.

CliC is working closely with its partners to improve knowledge of these critical Antarctic climate change and ecosystem processes and related impacts, which are outlined in the new [CliC strategic plan](https://climate-cryosphere.org/wp-content/uploads/2022/01/CliC_StrategicPlan_2022-2031.pdf). This work also directly addresses SCAR’s 2022 ACCE Decadal Synopsis Report which includes policy and research recommendations that were presented in ATCMXLIV WP30 rev.1 and ATCMXLIV WP31 rev.1 and recognised in ATCM XLIV Resolution 4 (2022). CliC plans to work with SCAR to provide regular information and updates to support the Parties in taking action on mitigation and adaptation.

**Introduction**

The Climate and Cryosphere (CliC) Core Project of the World Climate Research Programme (WCRP) co-sponsored by WMO, is a global community of researchers with expertise and knowledge of the cryosphere and its interactions with the climate system. CliC identifies key research questions, priorities, gaps, and challenges pertaining to the cryosphere and its interaction with the global climate system and coordinates international activities to promote activities that address these matters. CliC highlights emerging issues, facilitates exchanges amongst scientists and relevant external stakeholders, and promotes international cooperation. The project also communicates cryosphere-related science to policymakers, funding agencies, and the general public. To ensure that we are preparing for the future, CliC also promotes the career development of Early Career Researchers, through the provision of (normally annual) research grants.

A picture containing text, outdoor, snow, ice

Description automatically generatedFor the upcoming decade CliC has broadened its vision and mission to include research that is co-designed and executed with relevant stakeholders and user communities, while continuing to support fundamental science research on climate/cryosphere processes. The [CliC Strategic Plan 2022-2031](https://climate-cryosphere.org/wp-content/uploads/2022/01/CliC_StrategicPlan_2022-2031.pdf) is a response to an improved understanding of the cryosphere. It reflects an increased awareness of the large impact that human activities are having on the planet and how these changes, in turn, are affecting human and natural systems. In the cryosphere, the rate of loss of land ice, sea ice, and permafrost, has rapidly increased over the last few decades and continues to do so, representing arguably the clearest planetary-wide response to human-induced global warming.

CliC strives to support a systematic understanding of the cryosphere and its services by encouraging co-designed research projects between natural and social scientists, stakeholders and affected communities. CliC´s new decadal strategy aligns with the vision of the [WCRP Strategic Plan 2019-2028,](https://www.wcrp-climate.org/wcrp-sp) for “…*sound, relevant, and timely climate science to ensure a more resilient present and sustainable future for humankind”,* and directly addresses the strategic objective of *“bridging climate science and society.*” A key factor in implementing the strategy will be developing strong partnerships with other organisations (e.g. SCAR) with aligned priorities.

Below, we describe CliC endorsed activities in Antarctica and the Southern Ocean that also deliver key information for IPCC projections

Modelling

The *Ice Sheet Model Intercomparison for CMIP6 (ISMIP6)* has the key objective of improving projections of ice mass contribution from the Greenland and Antarctic ice sheets to sea level. 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, ice sheets to be considered as a component of the Earth system. ISMIP, with its partner SCAR-INSTANT, is also interested in reducing uncertainty through a better understanding of “low-confidence” processes that may promote instability of the Antarctic Ice sheet. *Contact*: Sophie Nowicki, University at Buffalo, USA ([sophien@buffalo.edu](mailto:sophien@buffalo.edu)).

The aim of the *Marine Ice Sheet Ocean Model Intercomparison Project (MISOMIP*) is to address the uncertain role of ocean forcing on marine-based sectors of both the Greenland and Antarctic Ice Sheets. These regions have potential for rapid and irreversible threshold behaviour. This is achieved through nurturing strong relationships between the ocean and ice-sheet modelling communities and to further investigate the robustness and biases of ocean and/or ice-sheet models in a range of Antarctic environments. Phase 2 of MISOMIP will provide a platform to assess the ability of ocean models to simulate melt rates for different realistic forcings and variable cavity geometries and assess the sensitivity of ice dynamics to various perturbations in a realistic environment. *Contacts*: Jan De Rydt, Northumbria University, UK ([jan.rydt@northumbria.ac.uk](mailto:jan.rydt@northumbria.ac.uk)); Nicolas Jourdain, U. Grenoble, France ([nicolas.jourdain@univ-grenoble-alpes.fr](mailto:nicolas.jourdain@univ-grenoble-alpes.fr))

The *Land Surface, Snow and Soil Moisture Intercomparison Project (LS3MIP)* is an endorsed subproject of CMIP6. The *ESM Snow Model Intercomparison (ESM-SnowMIP*) is an extension to LS3MIP focusing on the evaluation of the representation of snow in global and dedicated process models. In addition to global land surface and coupled simulations like LS3MIP, ESM-SnowMIP also includes site-scale simulations designed to evaluate model performance at local scales. *Contact*: Gerhard Krinner, Institut des Géosciences de l´Environment, France ([gerhard.krinner](mailto:gerhard.krinner)[@cnrs.fr](http://www.ige-grenoble.fr/-gerhard-krinner-))

The *Global Scale Glacier Intercomparison Model Project (GlacierMIP*) is a model intercomparison project focusing on all glaciers in the world outside the ice sheets. It provides a framework for a coordinated intercomparison of global-scale glacier evolution models, to foster model improvements and reduce uncertainties in global glacier projections and related sea-level projections. *Contacts*: Regine Hock, University of Oslo, Norway ([regine.hock@geo.uio.no](mailto:regine.hock@geo.uio.no)); Ben Marzeion, University of Bremen, Germany ([ben.marzeion@uni-bremen.de](mailto:ben.marzeion@uni-bremen.de))

The *Diagnostic Sea Ice Intercomparison Model Project (SIMIP)* contributes to a better understanding of the role of sea ice in the changing climate of our planet. They coordinate large-scale model simulations and facilitate the exchange of ideas between modelers and observers through joint workshops. As part of this effort, the Diagnostic Sea Ice Model Intercomparison Project (SIMIP) facilitates process-based model analysis of sea ice in CMIP6, through an updated variable request, community coordination, and workshops. SIMIP is an endorsed diagnostic MIP for CMIP6 that defines a list of variables to understand the evolution of sea ice in any experiment using the sea ice model as part of CMIP6. *Contacts*: Alexandra Jahn, University of Colorado, Boulder, USA ([*Alexandra.Jahn@Colorado.edu*](mailto:Alexandra.Jahn@Colorado.edu)*);* Dirk Notz, MPI/University of Hamburg, Germany ([dirk.notz@mpimet.mpg.de](mailto:dirk.notz@mpimet.mpg.de))

The *Polar Climate Predictability Initiative (PCPI*) is an initiative of WCRP, whose goal is to improve the understanding of the predictability of climate and the effect of human activities on climate. The PCPI focuses on polar regions and their role in the global climate system and aims to improve predictability of climate on all time scales by improving our understanding of the underlying physical mechanisms and their representation in climate models. The PCPI is supported by both CliC and the WCRP [Stratosphere-troposphere Processes And their Role in Climate Project (SPARC)](http://www.sparc-climate.org/) Core Project*. Contacts*: Marilyn Raphael, UCLA, USA ([raphael@geog.ucla.edu](mailto:raphael@geog.ucla.edu)), Julie Jones, University of Sheffield, UK ([julie.jones@sheffield.ac.uk](mailto:julie.jones@sheffield.ac.uk))

Observations, process understanding and cross-disciplinary activities

The SCAR/CliC *Antarctic Sea Ice Processes and Climate (ASPeCt*) is an expert group on multi-disciplinary Antarctic sea ice zone research with the key objective of improving our understanding of the Antarctic sea ice zone and its response to climate change. This is achieved through focused field programs, the systematic monitoring of the ice cover, and the analysis of remote sensing and numerical modelling tools. *Contacts*: Marilyn Raphael, UCLA, USA ([Raphael@geog.ucla.edu](mailto:Raphael@geog.ucla.edu)); Petra Heil, Antarctic Climate and Ecosystems Cooperative Research Centre, Australia ([petra.heil@utas.edu.au](mailto:petra.heil@utas.edu.au))

The goal of the *Ice Sheet Mass Balance and Sea Level (ISMASS*) project is to promote research on the estimation of the mass balance of ice sheets and its contribution to sea level, to facilitate coordination 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 scientific knowledge and the main achievements in this field of science. *Contact*: Heiko Goelzer, NORCE and Bjerknes Centre for Climate Research, Norway ([heig@norceresearch.no](mailto:heig@norceresearch.no))

The CliC/CLIVAR (Climate and Ocean – Variability, Predictability, and Change Core Project of WCRP) /SCAR *Southern Ocean Regional Panel* (SORP) serves as a forum for the discussion and communication of scientific advances on the understanding of climate variability and change in the Southern Ocean. It also advises CLIVAR, CliC, and SCAR on progress, achievements, new opportunities, and impediments in internationally coordinated Southern Ocean research. *Contacts*: Torge Martin, GEOMAR, Germany ([tomartin@geomar.de](mailto:tomartin@geomar.de)), Ariann Purich, Monash U, Australia ([ariaan.purich@monash.edu](mailto:ariaan.purich@monash.edu))

Polar CORDEX is a CliC/CORDEX endorsed activity that aims at improving the understanding of polar processes and the generation of regional climate change projections in the Arctic and Antarctica. *Contact*: Andrew Orr, British Antarctic Survey, UK ([anmcr@bas.ac.uk](mailto:anmcr@bas.ac.uk)). See accompanying IP.

The *Biogeochemical Exchange Processes at Sea Ice Interface (BEPSII)* is an endorsed SOLAS-CliC forum as well as a SCAR Action Group. BEPSII coordinates community activities linked to the biogeochemistry of sea ice-influenced environments, involving about 120 scientists. *Contact*: Jackeline Stefens, University of Groningen, The Netherlands ([j.stefels@rug.nl](mailto:j.stefels@rug.nl)); Nadja Steiner, Fisheries and Oceans Canada ([Nadja.Steiner@dfo-mpo.gc.ca](mailto:Nadja.Steiner@dfo-mpo.gc.ca))

**Governance**

CliC activities are overseen by a Scientific Steering Group (SSG) which has the overall responsibility for planning and guiding the work of the Core Project. The SSG is composed of international experts spanning all cryosphere research fields, with a balance in the representation of gender, career stage and geographical distribution. An International Project Office (currently moving to the University of Massachusetts Amherst in the US) supports the SSG and the wider CliC community in their work and is the main point of contact for CliC.

**Recommendations**

WCRP-CliC supports SCAR in its efforts to encourage CEP Members and Antarctic Treaty Parties (as outlined in ATCMXLIV WP042) to:

1. continue to implement the 2022 ACCE Decadal Synopsis recommendations with urgency (particularly in communicating internationally the critical importance of meeting and exceeding targets for the reduction of greenhouse gas emissions, and the need for resources to address research priorities to understand global impacts, as well as impacts on Antarctica (IP 95 *Understanding Future Sea-level Change Around Antarctica*)
2. continue to engage with the research community to deepen understanding of the key messages emerging from research as well as to determine what science and what types of information will best support the development of robust policies and actions;
3. consider how to provide regular assessments of progress against the recommendations and priority actions identified by the 2022 ACCE Decadal Synopsis and the 2023 joint CEP/ATCM session on climate change.

**Further details**

Contact: International Project Office at [info@climate-cryosphere.org](mailto:info@climate-cryosphere.org)

Web: [www.climate-cryosphere.org](http://www.climate-cryosphere.org)