WCRP Climate and Cryosphere (CliC) Project

2017 – 2021 Action Plan

A working document laying out
CliC science and organization
for the period 2017-2021

Other documents of interest

ACSYS Implementation Plan: 1994
CliC Science and Coordination Plan: 2001
CliC Implementation Plan: 2007
Cryosphere Grand Challenge White Paper: 2012
Melting Ice and Global Consequences; Initial Implementation Plan: 2015

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Background

The term "cryosphere" collectively describes the frozen water in the Earth system and includes sea ice, ice on lakes and rivers, snow, glaciers, ice caps and ice sheets, icebergs and frozen ground including permafrost. Although predominant in the Arctic and Antarctic, the cryosphere has important components in high-elevation areas even at much lower latitudes, notably South America and the 'third pole' region in Asia. As a key part of the global climate system, the cryosphere is involved in a range of important feedbacks that shape the response of the climate system to various forcings (natural and anthropogenic). The cryosphere also plays a role in many socioeconomic issues such as water supply, transportation, food production, built infrastructure, tourism and recreation.

The Climate and Cryosphere (CliC, www.climate-cryosphere.org) project is one of the core projects of the World Climate Research Programme (WCRP, www.wcrp-climate.org), serving as the focal point for climate science related to the cryosphere, its variability and change, and interaction with the broader climate system. The CliC science strategy is aimed at promoting and facilitating new collaborative research related to the cryosphere and climate variations over seasons and longer, making links between cryospheric research and research in other disciplines, and communicating research results to policy- and decision-makers and other non-scientific users. Cryospheric research coordinated by CliC covers the Arctic, Antarctic, high-elevation mountain areas, and broad regions that experience snow, lake and river ice and permafrost. It further informs a range of stakeholders in the relevant socioeconomic domains and contributes to international efforts like the Global Framework for Climate Services (GFCS, http://www.gfcs-climate.org/), which provides a worldwide mechanism for coordinated actions to enhance the quality, quantity and application of climate services.

CliC research spans the entire diversity of the Earth's cryosphere (see above), and a balance between disciplinary specialization and multi-disciplinary collaboration, which allows integration of outcomes of this research as input to assessments and predictions of the cryosphere and climate. The connection between cryospheric observations, process studies and modelling (regional and global) is an increasingly important focus for CliC.

A further influence on CliC science planning is the concept of Grand Challenges (http://www.wcrp-climate.org/grand-challenges), initiated as a result of the WCRP First Open Science Conference (Denver, USA, 2011). The WCRP Grand Challenges are areas of high-priority research, where it is thought that focussing efforts of the science community, over a 5- to 10- year time frame, can result in significant progress on a science problem of societal importance. The role of permafrost thaw in the global carbon balance, the fate of the Arctic summer sea ice, and the contribution of cryosphere to global and regional sea-level rise are examples of such problems and they constitute the substance of the WCRP Grand Challenge, Melting Ice and Global Consequences (http://www.wcrp-climate.org/gc-cryosphere) for which CliC serves as a focal point. As such, CliC has the responsibility for planning and implementation of this Grand Challenge, which includes activities of the WCRP Polar Climate Predictability

Initiative (http://www.climate-cryosphere.org/wcrp/pcpi). CliC also contributes to one of the work packages of the Grand Challenge on Regional Sea Level Rise (https://www.wcrp-climate.org/grand-challenges/gc-sea-level), specifically that related to the contribution of land ice to sea level rise. The fate of permafrost and the related potential release of carbon into the atmosphere is investigated as a common activity of the "Carbon Feedbacks in the Climate System" (https://www.wcrp-climate.org/grand-challenges/gc-carbon-feedbacks) and Melting Ice and Global Consequences (https://www.wcrp-climate.org/grand-challenges/gc-melting-ice-global-consequences) Grand Challenges.

The current document briefly describes the overarching research needs and themes that guide CliC activities, the structure of CliC and its main activities over the next years. It builds upon earlier documents such as the CliC Science and Coordination Plan, published in 2001, when the Arctic Climate System Study (1994-2003), a WCRP regional climate project, was extended globally.

The Science

Overarching research needs that guide CliC activities

The following overarching research needs in the Cryosphere-Climate domain have been identified in various planning meetings over the past few years:

1. Improved understanding and quantification of the role of the cryosphere in the global climate system, its variability and change.
2. Improved utilization of cryospheric observations as indicators of global and regional climate change.
3. Improved understanding of the physical, chemical and other processes that govern behaviour of the cryosphere, and the representation of these processes in Earth System Models.
4. Improved ability to make quantitative predictions and projections of the cryosphere in a changing climate.

Science Themes

Four general CliC Science Themes address the overarching research needs described above. These Themes, described below, provide the broad framework within which CliC activities are developed.

Observing the Cryosphere

Observations of cryospheric components form the basis of all science pursued throughout CliC. Because of the wide range of temporal and spatial scales, response times and feedback processes, and the remote nature of many components of the cryosphere, the state of several key parameters (e.g. global sea ice volume) remains uncertain. Many observations are taken remotely, often from satellites, and are really estimates derived from mathematical models. The aim of observations is to identify the current state of and trends in the cryosphere, and to help understand the balance and exchange of water and energy between the cryosphere and other components of the climate system. Assessing the role of the cryosphere in climate variability on global and regional scales therefore presents a particular challenge, and links directly to other WCRP Grand Challenges, notably those on biogeochemistry, water availability, and sea-level rise.

Central Questions:

- What are the magnitudes, patterns and rates of change in terrestrial cryosphere regimes on seasonal-to-century time-scales? What are the associated changes in the water cycle and carbon cycles?
- What are the present mean states, natural variability, and recent trends in sea-ice mass, seasonality of coverage and other characteristics in both hemispheres? What remote and in-situ techniques are best used to determine sea ice volume?

- How did and do mountain glaciers and permafrost react to recent and ongoing climate change? How far are they out of balance today?
- How, why and where do the major ice sheets vary over time scales from years to millennia? What is the magnitude of current trends in ice sheet mass?
- How much carbon is available in frozen ground and in frozen marine sediments?
- How can the climate modeling community use the available cryospheric observations over a wide range of time and space scales?

Physical Processes and Dynamical Understanding

Key issues here involve improving our understanding of how components of the cryosphere interact with each other and with the rest of the climate system on a broad range of spatial and temporal scales[1], and understanding the associated feedbacks and thresholds. This is advanced through evaluation of enhanced observations, process studies and models. This includes the dynamics and thermodynamics of sea ice and its snow cover, the impact of sea ice on water masses, processes modulating mountain glacier mass balance, mountain permafrost cryodynamics, and the dynamics and thermodynamics of ice sheets and ice shelves and their interaction with the oceans and underlying seabed/bedrock. Ice shelf-ocean interactions are directly implicated in the stability of large ice sheets, and therefore link to the Melting Ice and Global Consequences Grand Challenge. Ice shelves and icebergs also play an important role in the ocean freshwater budget, with effects on ocean thermohaline circulation and large-scale ocean heat transport – issues that the WCRP CLIVAR core project are concerned with. The Melting Ice and Global Consequences and Carbon Feedbacks in the Climate System Grand Challenges aim at an improved understanding of physical and biogeochemical processes in permafrost, and their link with the snow cover above, which is required to reduce the large uncertainties on the vulnerability of the permafrost carbon reservoir.

Central Questions:

- What is the role of terrestrial cryospheric processes in the spatial and temporal variability of the water, energy and carbon cycles of cold climate regions?
- What are the interactions and feedbacks between the terrestrial cryosphere and atmosphere/ocean systems and current climate? How variable are these interactions and how will they change in the future?
- What processes control the emission of carbon in frozen ground and frozen marine sediments, and how rapidly could this be emitted to the atmosphere as the climate warms? What proportion of the emitted carbon will be in the form of carbon dioxide versus methane?
- What are the physical processes and forcings controlling sea ice mass and distribution in both hemispheres? How will changing sea-ice cover affect climate through its interactions with the atmosphere and ocean?

[1] CliC does not formally investigate paleoclimates, but does work with the IGBP PAGES project to inform research on past climates.

- What is the role of the seasonal production of sea ice in the neighbourhood of ice shelves in driving currents beneath the shelves and thereby influencing basal melting and re-freezing?
- How do processes of ice-ocean interaction, including basal melt and marine ice accretion, affect the mass balance and stability of floating ice masses in Greenland and Antarctica?
- How does sea ice and the freshwater input to the polar oceans affect the high-latitude ocean ecosystem and carbon uptake? (Note that the marine ecosystem in the Southern Ocean is a particularly important component of the global carbon cycle.)
- What are the key sensitive regions for rapid changes in ice volume (i.e., ice masses grounded below sea level, over-deepened channels of outlet glaciers) and what are their potential contributions of sea level in a warming climate?
- How stable are ice shelves in Antarctica and Greenland, given recent increases in ocean heat content and circulation?
- What is the distribution and variability of fresh water input to the oceans from ice shelves, icebergs and ice sheet runoff, and what impact does this have on ocean circulation (e.g., maintenance of global thermohaline circulation)?

Modelling the Cryosphere

Climate and Earth System models that include a fully interactive cryosphere are the best tools we have to quantify future changes in a warming world. Many of the processes involving the cryosphere are poorly represented in current climate models, often as a result of oversimplified physical parameterizations and the effect of spatial variability at scales smaller than model grid spacings. There is a need to improve parameterisations of key processes associated with energy and moisture budgets and transports, to include relevant couplings with cryospheric components in Earth System Models. There is also a need to increase the spatial resolution of models to better capture processes on smaller scale, regarding glaciers on land and sea ice in the ocean alike.

Of particular societal interest is improving our ability to make reliable future projections of the mass balance of the Antarctic and Greenland ice sheets and their contribution to sea-level rise. Research in this area is closely linked to the WCRP Grand Challenges on Sea Level and on Water Availability. The ability to model the three-dimensional flow of ice sheets is improving rapidly, and there is progress being made on including ice-sheet processes in global Earth System models. Our ability to simulate changes in sea ice in the future also needs to be improved.

Central Questions:

- How can interactions between terrestrial cryospheric processes and water, energy and carbon cycles of cold climate regions best be parameterized in models, over a range of time and space scales?

- How can the interactions between mountain glaciers and the climate system be better represented in models, and how can estimates of future freshwater availability be improved?
- What is the contribution of glaciers, ice caps and ice sheets to changes in global sea level on decadal-to-century time scales? Are all the relevant processes captured adequately in models?
- How can recent Arctic and Antarctic sea ice trends be better simulated, and how large a role is played by forcing natural climate variability?
- How can permafrost be parameterized in models?

Global and Regional Prediction and Predictability of the Cryosphere

Activities in this broad area serve as the CliC linkage to WCRP activities in global and regional climate modelling, climate prediction and longer term climate change projection. CliC is jointly responsible (with SPARC (http://www.sparc-climate.org/)) for overseeing the Polar Climate Predictability Initiative (PCPI -- http://www.climate-cryosphere.org/wcrp/pcpi) aimed at improving our ability to make quantitative predictions of polar climate on time scales from seasons to decades and longer. The ability to represent cryospheric processes and feedbacks in models is at the centre of this theme, and linkages to the WCRP Working Group on Coupled Modelling (WGCM – http://www.wcrp-climate.org/wgcm/) and the Working Group on Seasonal to Interannual Prediction (WGSIP – http://www.wcrp-climate.org/wgsip/) are exploited to ensure improved sharing of expertise - both in terms of improving the representation of cryospheric processes in climate models and fostering more quantitative evaluation of the cryosphere simulated in such models. An important aspect of this is facilitating better connections between the cryospheric observation community and the model development community. At regional scales, connections to the WCRP's Coordinated Regional Downscaling Experiment (CORDEX, http://www.cordex.org/) are being exploited to focus analysis on the Arctic and Antarctic regional modelling results (Polar CORDEX, http://www.climate-cryosphere.org/activities/targeted/polar-cordex).

Central Questions:

- What are the sources of, and limits to, predictability in components of the cryosphere at seasonal to longer time scales?
- How is the cryosphere involved in feedbacks that affect predictions and projections of global and regional climate change?
- Can we attribute observed changes in the cryosphere to specific causes, be they anthropogenic or otherwise?
- What are the limitations to improving regional climate predictions and projections through the use of high-resolution regional downscaling techniques?
- How will sea ice respond in the future to a changing climate e.g., will the Arctic Ocean be ice free in summer in the 21st Century? How will Antarctic sea ice respond to natural and anthropogenic forcings over the rest of the 21st Century?

The Organization

CliC is a core project of the WCRP and is overseen by a Scientific Steering Group (SSG) responsible for overall direction and planning. The Scientific Steering Group typically meets once per year. The International CliC Project Office (ICPO -- hosted by the Norwegian Polar Institute) serves as the administrative home for the project under the leadership of the CliC Director. The Director and Project Office staff are responsible for the operation of the project.

The CliC Project necessarily functions within the broader WCRP framework and so maintains direct connections with other WCRP core projects and working groups. The WCRP has also initiated several 'Grand Challenges' (http://www.wcrp-climate.org/grand-challenges) whose role is to focus international research on some key climate science topics. One of these Grand Challenges, Melting Ice and Global Consequences, is overseen jointly by CliC and SPARC. This Grand Challenge is outlined in a white paper (http://www.wcrp-climate.org/images/documents/grand_challenges/GC_cryo.pdf), and many of the issues raised in this white paper are very closely aligned with the core science that CliC has been pursuing for some time. As a result, there is considerable overlap between ongoing CliC scientific foci and the specific topics identified in the Grand Challenge. Although the Melting Ice and Global Consequences Grand Challenge will have a separate implementation plan, much of what CliC does contributes directly to, or complements, activities specific to this Grand Challenge.

Finally, CliC operates in an international scientific arena in which other organizations also play particular roles in organizing or coordinating research that involves the cryosphere. In order to avoid duplication and to maximize opportunities for coordinated effort, CliC has memoranda of understanding with two other international bodies whose research interests are particularly well-aligned. These are the Scientific Committee on Antarctic Research (SCAR – http://www.scar.org/) and the International Arctic Science Committee (IASC – http://iasc.info/). Some CliC activities are jointly sponsored by one or both of these partners.

Structure

The current structure is illustrated in the figure below, and is comprised of 'management bodies' (the SSG and ICPO), 'coordination bodies' (the groups, panels, and fora indicated in the light blue box (bottom left of the figure)), and a collection of both WCRP Grand Challenge on Melting Ice and Global Consequences activities (wide blue box at the top) and limited lifetime targeted activities' (listed in the dark blue box (bottom right of the figure). The targeted activities, some of which are overseen by one of the working groups or fora, comprise the primary research activities coordinated by CliC and constitute new research activities that fill an identified need or gap.

Figure 1. CliC organizational structure. The blue box at the top of the figure lists the activities under the Melting Ice and Global Consequences Grand Challenge's umbrella. The light blue box at the bottom-left corner includes the CliC Groups, Panels and Fora. The dark blue box at the bottom-right corner lists the current targeted activities being pursued by CliC. The two boxes at the top of the figure represent the management structure – the SSG and the International CliC Project Office.

Grand Challenge and Targeted Activities

The specific activities that CliC undertakes are intended to address particular scientific issues that have been identified and for which some international coordinated effort could yield tangible progress. These targeted activities are prioritized and approved by the SSG, and are intended to be limited in scope and lifetime (typically on the order of 3 to 5 years). They are led by an individual scientist or group of scientists who are responsible for coordinating the activity and reporting on progress. The CliC project office (ICPO) provides funding for workshops and meetings and provides logistic support (e.g. meeting arrangements, video- and teleconference facilities, web pages, etc.). In some cases these activities are overseen by one of the working groups or fora. Because of the close alignment of the CliC mandate and the WCRP's Cryosphere Grand Challenge (which CliC is tasked with coordinating), some of these current targeted activities constitute a contribution to both, and no attempt has been made to artificially categorize them. As part of the prioritization effort, the SSG has sought to maintain some disciplinary balance across the scientific themes discussed in Section 1.

It should be noted that the Polar Climate Predictability Initiative (PCPI), which is jointly organized by CliC and SPARC, is comprised of a complementary set of targeted activities which are described in more detail in the PCPI implementation strategy

In the following, the current CliC activities (both Grand Challenge and Targeted Activities) are briefly described. A more detailed description is provided on the CliC website.

Arctic Freshwater Synthesis
This activity is a follow-on to previous CliC activities involving surface hydrology and water drainage in the Arctic Basin. The objective is to improve quantification of the various contributors to Arctic freshwater drainage, its variability and change, and the role of this freshwater in the circulation and water-mass properties of the Arctic Ocean. This activity is wrapping up in 2016, having successfully completed a series of peer-reviewed papers appearing in a special issue of JGR Biogeosciences, with an overview article led by Terry Prowse. A plain-language synthesis document was provided to the activity co-sponsor, the Arctic Monitoring and Assessment Programme (AMAP).

Marine Ice-Sheet-Ocean Model Intercomparison
This activity aims to improve understanding of the connections between the Antarctic ice sheet, the ice streams and ice shelves which drain it, and the surrounding Southern Ocean. This activity is particularly relevant to questions about stability of the Antarctic ice sheet in a warming climate, the role of ocean circulation and heat transport in ice-shelf collapse, and the asymmetry in Arctic vs Antarctic warming and sea-ice decline.

ESM Snow Model Intercomparison
This activity is a contribution to the WCRP's Working Group on Coupled Modelling (WGCM) 6th Coupled Model Intercomparison Project (CMIP6) and involves careful evaluation of the snow simulations in contemporary Earth System Models (ESMs). This activity involves specialists in snow processes, local and global snow observations, and climate model developers, and will provide in-depth comparisons of snow properties and processes as simulated in climate models. This activity is part of a broader intercomparison of land surface model components being organized jointly with GEWEX.

Ice Sheet Model Intercomparison
This activity fills a need for international coordination in the evaluation and testing of large-scale ice sheet models and the development of consistently-applied test cases and diagnostics. A specific effort connected to CMIP6 called the Ice Sheet Model Intercomparison Project (ISMIP6) will be undertaken to evaluate the simulation of ice sheets in those ESMs that include an interactive ice sheet component, and to evaluate the surface energy/mass balance terms over ice sheets in those ESMs that do not explicitly include ice sheet dynamics.

Sea ice Model Intercomparison
This activity is a contribution to the WCRP's Working Group on Coupled Modelling (WGCM) 6th Coupled Model Intercomparison Project (CMIP6) and involves evaluation

of the sea ice simulations in CMIP6 models. The Sea ice Model Intercomparison Project (SIMIP) (http://www.climate-cryosphere.org/activities/targeted/simip) compiled a new list of sea ice diagnostics that were requested from CMIP6 model simulations, to allow a detailed budget analysis of the sea ice simulations. The goal of the planned analysis is to better understand the physical processes driving the simulated evaluation of sea ice in the two hemisphere, in order to better understand projection uncertainty due to model biases and model spread.

Polar CORDEX Analysis / Arctic Regional Climate Scenarios
This activity builds upon the WCRP Working Group on Regional Climate (WGRC) and its Coordinated Regional Climate Downscaling Experiment (CORDEX). In particular, this activity mobilizes expertise in high-latitude climate and cryosphere topics to enhance the evaluation of results from the Arctic and Antarctic domain CORDEX runs, thereby improving the integration of the cryosphere science community into regional climate modelling efforts. In addition, this activity will coordinate regional climate information for the Arctic in support of climate impact assessments being undertaken by the Arctic Monitoring and Assessment Programme (AMAP). This activity also constitutes a connection to the Global Framework for Climate Services (GFCS).

Global Glacier Mass Balance Modelling
This activity is aimed at evaluating and improving models developed to simulate past and future changes in mountain glaciers and small ice caps around the world. Such models provide estimates of the meltwater contribution to global sea-level rise and so complement the efforts to improve estimates from the Greenland and Antarctic Ice Sheets. Improving the ability to simulate regional glacier mass balance is particularly important in areas of the world where glaciers constitute a vital source of freshwater for part of the year.

Interactions Between Cryospheric Elements
This activity aims to encourage cross-cryosphere research and explore interactions between different components of the cryosphere. The Antarctic region provides particularly compelling examples of such interactions; for example the connections between sea ice and floating ice sheet margins including ice shelves, and the close association between sea ice and icebergs. This activity provides opportunities to establish linkages and research collaborations between scientists (and programs) concerned with individual cryospheric components, and promises to yield new insights into the way in which cryospheric elements interact and how change in once element may affect others.

Polar Jet Stream Variability and Extremes
This activity is concerned with understanding the role of the polar jet stream in high- and mid-latitude climate variability and extremes. Although this is not directly a cryosphere topic, sea ice and terrestrial snow cover play important roles in modulating the jet stream and so this represents a societally-relevant connection between the cryosphere and atmosphere, particularly as the jet stream is associated with weather and climate impacts that touch a significant fraction of the world’s population.

Improved Greenland Mass Balance Estimation
This activity, overseen by ISMASS, aims at improving our ability to quantify surface mass balance over Greenland using in-situ and remote-sensing observations, along with process models. This activity is clearly aligned with the WCRP Grand Challenge on Sea Level, and will promote coordinated research targeted at reducing uncertainty regarding the contribution of Greenland to sea-level rise now and in the future.

Carbon Cycle Feedbacks in a Changing Arctic Climate
This activity, overseen by the Permafrost Carbon Network, is focused on connections between the cryosphere and the biogeochemical cycles that control sources and sinks of carbon dioxide and methane at high latitudes. This activity represents an important contribution to improved understanding of linked permafrost-carbon processes and will help quantify the amount of carbon available in frozen soils and the potential positive feedback between climate warming and natural greenhouse gas emissions.

Polar Climate Predictability Initiative (PCPI)

Climate model projections consistently illustrate enhanced warming in high latitudes, particularly in the Arctic, and this has implications for global and regional climate change. In addition, as Arctic sea ice declines, shipping and resource extraction activities are likely to expand, requiring improved capabilities for seasonal and longer scale predictions in support of planning and decision-making. In the Antarctic, there are also interesting scientific questions raised by the notable lack of observed sea ice decline overall (although significant change is observed in certain sectors). In both Polar Regions, there is a need to better understand the mechanisms involved in seasonal, interannual and interdecadal variability, and a desire to improve the ability to make quantitative predictions and projections as the climate changes.

The PCPI was established to focus WCRP research in this societally-relevant area, and CliC and SPARC were assigned responsibility to oversee this initiative. An implementation plan has been prepared *(*http://www.climate-cryosphere.org/media-gallery/596-wcrp-polar-nov2012?album_id=43) and a number of sub-activities have been identified, and scientific collaborations have now begun. It should be noted that a closely-related project, the Polar Prediction Project (http://polarprediction.net/), which is focused on hourly to seasonal time scales, is being pursued by the World Weather Research Programme (WWRP). These two initiatives are proceeding in a coordinated fashion, with a joint project office hosted in Germany by the Alfred Wegener Institute (http://www.polarprediction.net/about-ppp/ico.html).

Coordination Bodies

The Groups, Panels, and Fora indicated in the light blue box (bottom left of the figure) in the figure constitute the centres of scientific expertise within CliC and they serve to coordinate international research activities and to foster collaboration with other international bodies. As noted in Figure 1, some of these working groups are co-sponsored by IASC and SCAR.

Sea Ice and Climate Modelling Forum

This Forum is intended to provide a mechanism for promoting communication and coordination amongst researchers responsible for the sea-ice component of global climate models so as to share information and research results, to plan coordinated activities (such as model intercomparison or analysis efforts), and to better link those involved in the development and application of sea-ice/climate models with those involved in detail process studies and observations. Some specific goals include:

- **Model evaluation:** Compile a list of useful variables to be included in coordinated model experiments going forward (like CMIP6), to facilitate model-model comparisons as well as model-data comparisons. Develop a standardized sea ice simulation protocol and identify data needs.
- **Causes of model biases**: Analyze the cause of the biases in sea ice model simulations, through the analysis of existing simulations (CMIP5, CORE-II) and targeted additional experiments when needed. One goal is to determine the role of sea ice model deficiencies versus biases originating from the sea ice model versus the coupled system
- **Model development:** Share experience with sea ice model developments and their impact in climate simulations (e.g., prognostic salinity, sophisticated melt pond schemes, snow cover parameterization, rheology choices, etc.) and identify the best way forward as well as observational data needs for model development
- Out of the activities in the Sea Ice and Climate Modeling Forum, the targeted activity SIMIP was started, to address these goals within the upcoming CMIP6 framework.

Permafrost Carbon Network

An important aspect of permafrost in a changing climate is the potential for various forms of carbon (presently immobilized in frozen ground or sub-sea sediments) to be released to the atmosphere and providing a positive feedback to climate change. This Network is in particular an important part of the cross-disciplinary US SEARCH Project. This aim of this network is to promote data synthesis and model development in its specific scientific domain. Its activities include a series of meetings and working groups designed to synthesize ongoing permafrost carbon research in order to produce new knowledge to quantify the role of permafrost carbon in driving climate change in the 21st century and beyond. See http://www.permafrostcarbon.org for more information.

ISMASS – Ice Sheet Mass Balance and Sea Level Expert Group

This group is co-sponsored by SCAR, IASC and CliC. Its goals are: to promote research on the estimation of the mass balance of ice sheets and its contribution to sea level; to facilitate the coordination among the different international efforts focused on this field of research; to propose directions for future research in this area; to integrate the 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 diffusion, to society and policy makers, of the current scientific knowledge and the main achievements in this field of science.

Ocean Ecosystems, Biogeochemistry and Sea Ice

Many unique processes involving the ocean ecosystem occur at the interface with sea ice, and these processes contribute directly to the global carbon cycle. A working group called “Biogeochemical Exchange Processes at Sea Ice Interfaces” (BEPSII)

was initiated under the auspices of the Scientific Committee on Ocean Research (SCOR). Recognizing the need to evolve beyond their initial mandate, and the need to connect more closely to WCRP's cryospheric research activities, this group approached CliC for endorsement as a joint SOLAS-CliC forum. This was supported in principle by the CliC SSG, and details of the workplan and how this will be integrated into the CliC organizational structure are being discussed.

Management Bodies

The Scientific Steering Group (SSG) and the International CliC Project Office (ICPO) serve as the oversight and administrative bodies for the project. The project office is hosted by the Norwegian Polar Institute in Tromsø. The Scientific Steering Group meets annually and is comprised of cryospheric scientists chosen to represent a broad range of disciplines and geographical regions. In addition, CliC has a more informal 'leadership group', comprised of the SSG plus the leads of all the fora and targeted activities, and this group holds regular teleconferences throughout the year (more or less monthly) on various topics.

As with all WCRP Core Projects, CliC ultimately reports to the WCRP Joint Scientific Committee (JSC), and the Co-Chairs and Director attend the annual JSC meeting to report on progress and receive advice and strategic guidance.