

WORLD CLIMATE RESEARCH PROGRAMME

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CliC

ANNUAL PROGRESS REPORT

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DELIVERED ADDED VALUE OF ACTIVITY / PROJECT

CliC's ongoing efforts to raise the awareness of the cryosphere have delivered several important contributions to improve our ability to assess and quantify the impacts that climatic variability and change have on components of the cryosphere and the consequences of these impacts for the climate system.

IPCC AR4 WG1: A separate chapter on Snow, Ice and Frozen Ground reviewed major changes in the cryosphere. The follow-up GCOS/WCRP/IGBP Workshop on Lessons Learned from AR4, further raised attention and identified needed research and observations, especially on ice sheets and sea level rise.

International Polar Year (March 2007-2009): CliC generated strong input from the climate research community to IPY. Especially noteworthy is GIIPSY, a polar satellite snapshot to obtain unprecedented coverage of both polar regions with observations. It adds major value to IPY. Initiatives related to IPY are discussed in the accompanying IPY Crosscut Report.

IGOS-Cryosphere Theme: The IGOS-Cryosphere Theme report was approved at the IGOS Partnership meeting in May 2007, and received very high praise. This document is being used by space agencies (CEOS), international programs, such as GCOS, in defining capabilities and needs and defining new space missions and associated science programs.

'Asia-CliC' Regional Group: This group engaged scientists from over a dozen Asian countries to provide a leading role in coordinating cryospheric research in Asia. Through regional workshops and conferences, concrete actions have been initiated to support determination of the state and fate of the Asian cryosphere. Co-operation has begun to create an Asia-Region snow-cover data-archive. This is the first opportunity for scientists from the different countries to come together to learn what each is doing and plan how they can work together to create a cohesive picture for the region.

Global Prediction of the Cryosphere: A GPC workshop identified problems to be overcome for predicting the cryosphere evolution in the 21st century, one of them being high horizontal resolution atmospheric fields to drive cryospheric models.

Terrestrial Cryosphere/Hydrosphere: CliC's theme on terrestrial cryosphere and hydroclimatology of cold regions has now been formulated to advance the goals of the international 10-15 year research plan designed for the Cryosphere/Hydrology component of the International Conference on Arctic Research Planning (ICARPII), and which has now also become the basis for the shorter term Arctic-Hydra project for IPY.

CliC's partnering with Arctic Council AMAP and IASC, its strong contribution to ICARPII, and publication of the IGOS theme report have allowed it to be a founding co-sponsor, and to take a prominent role, in the development of **SAON** (Sustained Arctic Observing Networks) and the engagement of WMO Members in the initiative, and in the development of Arctic Council's Climate and Cryosphere initiative as an update to ACIA.

Global Cryosphere Watch: A new WMO initiative build on efforts of CliC, GCW was accepted by WMO Congress and EC in May 2007.

END USERS OF ACTIVITY / PROJECT OUTCOMES

CliC, as WCRP, has a wide range of users of its activities, ranging from the science, impact and adaptation, forecast and service delivery, policy and decision-making communities to the public and media worldwide. The 15th WMO Congress (May 2007) noted that integration of climate and Earth system science is essential for NMHSs to be able to deliver end-user benefits. CliC develops **observations and science needed to build NMHSs' capacity** to adequately address such crucial socio-economic issues as contributions to sea level rise from melting of ice sheets and glaciers, changes in fresh water supply from glacier and snow melt,

the future of sea-ice cover, especially in the Arctic, permafrost thawing and associated release of greenhouse gases and many other global and regional issues. Its activities contribute to WMO's top-level objectives and its strategic thrusts identified in the WMO Strategic Plan (WMO Doc. 1028).

The **IGOS-Cryo Theme** report is being used by space agencies (CEOS), international programs, including GCOS and SAON, to define capabilities and needs for cryospheric observation and monitoring and to define new space missions and associated science programs. ESA has acknowledged CliC's direct help to add value to the ESA Data User Element studies GlobICE, GlobGlacier and GlobSnow.

Users of CliC developments are scientists and national and international agencies in many regions. The scientific outputs of Asia-CliC have been directed very specifically to agencies, such as those in the western Chinese provinces. In the Antarctic, scientists in many related fields (e.g. terrestrial and marine biology) are using the improved projections of Antarctic climatic change for the next century produced by the Global Prediction of the Cryosphere theme. Agencies participating under the IPY Arctic-Hydra project are both contributors to refining our knowledge about flux of freshwater from the various hydrologic components to the Arctic Ocean as well as end users of the collective information from all countries.

MAJOR ACTIVITIES AND ACHIEVEMENTS IN 2007

CliC focuses its activities through the **themes**: Terrestrial Cryosphere and Hydroclimatology of Cold Regions (TCHM); Ice Masses and Sea Level (IMSL); Marine Cryosphere and Climate (MarC); Global Prediction of the Cryosphere (GPC), and through rapporteurs and working groups on specific issues. Key achievements follow.

IGOS Theme Report on Cryosphere was accepted by IGOS partners and published. It is a major report reflecting worldwide consensus on the development of cryospheric observations for years to come (chair: J. Key, co-chairs: M. Drinkwater and J. Ukita). It creates a framework for improved coordination of observations collected by research, long-term monitoring, and operational programs, achieving better availability and accessibility of cryospheric information for operational services and research, strengthening national and international institutional structures responsible for cryospheric observations, and increasing resources for ensuring the transition of research-based observing projects into sustained observations and practical applications. The report was distributed at the GEO Ministerial Summit in November 2007. The recommendations in it are expected to be taken up in the development of GEOSS. Discussions on this process are underway.

There is an exciting new WMO initiative in which WCRP/CliC had an important role. The 15th WMO Congress supported the proposal of Canada that WMO create a **Global Cryosphere Watch (GCW)**. Congress requested the WMO Inter-commission Task Group on IPY to establish an ad hoc expert group to explore the possibility of creation of such a global system and prepare recommendations for its development. This was approved in January 2008. Consultation will be widespread, engaging across all WMO Programmes and Technical Commissions and engage other organizations and agencies and the cryosphere scientific community. Further information is in the IPY report.

'Asia-CliC' Regional Group took a leading role in coordinating cryospheric research through the Workshop on Large-scale Hydrometeorology of Asian Cryosphere (Yokohama, JAMSTEC) and the 2nd Asia CliC Symposium 'The State and Fate of Asian Cryosphere' (Lanzhou, China). Development of cryosphere datasets – including data rescue – is a high priority; representatives from more than a dozen Asian countries are working collectively to make cryospheric data available for the region in an integrated manner. The Asian cryosphere is at the headwaters of the major rivers flowing into the Pacific, Indian and Arctic oceans. This coordinated effort underlined the societal benefits of cryosphere research for the whole Asian continent, and the need for better predictions; cryosphere has large implications in terms of water supply and natural hazards. An Asia-CliC Committee and SSG are being finalized to oversee the regional program. This model will lead to the formation of other regional groups, such as in South America.

CliC has made special effort to strengthen its modelling capability geared toward **Global Prediction of the Cryosphere**. A workshop on Recent High Latitude Climate Change reviewed current knowledge of the mechanisms behind climatic changes in both polar regions over the last several decades. A report was submitted to EOS. The GPC theme organised a

workshop on Global Prediction of the Cryosphere (Cambridge, October 2007) to bring together experts to review our ability to predict the evolution of the cryosphere over the 21st century at the global scale, identify gaps in our current understanding, and propose research activities in the framework of CliC. CliC participated in the WCRP Seasonal Prediction Workshop in Barcelona; Xiaojun Yuan prepared a report with four concrete recommendations for CliC to improve the cryosphere contribution to seasonal forecasting. Other modeling efforts include co-ordination of ice sheet modeling and modeling of the Arctic (ICARPII) and the Antarctic. GPC theme members published a paper on improved climatic projections for the Antarctic for the 21st Century by weighting AR4 model output according to how they represented observed changes over the last few decades. Southern Hemisphere sea ice is particularly poorly represented in global models. An initiative led by CliC is being organized to compare and improve the sea ice models in the Southern Ocean, and to investigate the representation of ice shelves and glacier melt in these models. CliC continues to work with partners to improve coordination of sea ice research, such as with SCAR, the International Ice Charting Working Group (**Workshop on sea ice modeling and data assimilation**, May 2007) and Arctic Council AMAP (ACIA up-date). CliC established a **new Arctic Sea Ice Observations Group** to coordinate sea ice research activities. This work includes establishing links with ongoing observing networks and preparing a field handbook for sea ice observations.

With IASC, AMAP and NSF, CliC was a founding co-sponsor of a coordinated plan to develop a **Sustained Arctic Observing Network (SAON)**, engaging research and operational entities. This will be a legacy of IPY. At the 1st SAON workshop, CliC organized, chaired and reported on the hydrology/cryosphere working session. This coordination continues for the next two workshops. A similar initiative in the Antarctic, **PAntOS (Pan-Antarctic Observations System)** is also underway.

GOALS AND PLANS FOR MAJOR ACTIVITIES IN 2008 AND INTO 2009

CliC major activities in 2008 and 2009 will include:

- Planning contribution to possible AR5 (using the outcomes of WCRP-GCOS-IGBP Sydney Meeting),
- Continued support to the IPY projects and implementation of the IPY legacy, especially GCW and SAON. As contact on the GEO Task on IPY legacy, CliC will lead a WMO/GEO/WCRP IPY Legacy workshop on Global Cryospheric Observations in December 2008.
- Concerted efforts will be made on developing more realistic ice-sheet models, involving data collection and interpretation, improved process understanding and incorporation into numerical models. A first workshop will be led jointly by SCAR (ISMAS) and IASC (WAG), in partnership with CliC (St. Petersburg, Russia, July, 2008) to consider how best to improve: the physical understanding of ice sheet processes; prognostic numerical models that better incorporate non-linear ice-sheet response to environmental forcings (such as change in surface mass modeling balance, loss of buttressing from floating ice shelves and ice tongues, and rising sea level); incorporation of the physical understanding into the numerical models; and, assimilation of the appropriate data into the models. A summer school on ice-sheet modeling is being planned with several partners.
- Continuing development of the Asia-CliC Regional Group: high-priority involvement to gather higher quality data, improved data management and archiving; establishment of better regional observational networks, possibly through CryOS and GEOSS and application of various models to overcome the spatial/temporal shortcomings; building contacts to add to the implementation of the monsoon cross-cut; contacts with other groups (MAIRS, GEWEX, GCW, CryOs); co-sponsoring/organization of workshops (“Mountain glaciers under global warming”, China Oct 2008; “Snow cover and hydrology”, Japan, 2009); publishing book on “Asian Cryosphere, present state and past changes” (end 2009). The strong momentum created by the 2nd Asia CliC Symposium will also lead to a 3rd Symposium in 2009 or 2010.
- TCHM and GPC themes will hold a workshop on integrating atmospheric and cryospheric-hydrologic models for application in cold-regions basins, involving joint studies of Environment Canada, British Antarctic Survey and AWI’s efforts on ICARPII modeling. GPC also plans a full workshop on generating high horizontal resolution atmospheric fields to drive cryospheric models (late 2008). It intends to produce improved projections (including sea ice) for the Arctic for the 21stC by weighting the IPCC AR4 model output and complete a study

showing that Antarctic sea ice extent is increasing because of anthropogenic factors, and especially the ozone hole.

- Together with the World Climate Programme, CliC is organizing a Climate Information and Prediction Services Workshop (September 2008, St. Petersburg, Russia).
- MarC initiatives on sea ice include: development of a Southern Ocean Observing System (jointly with SCAR, SCOR and other partners); ongoing involvement with development of Arctic Observing Systems; a workshop for young scientists on sea ice field techniques (hosted by University of Alaska); CliC-led sessions on the Marine Cryosphere at major international conferences (especially Fall AGU); ongoing development of the sea ice data portal and data mining activities related to that; and work toward making sea ice a fully interactive part of IPCC-class GCMS.
- Continuing close relationships with other WCRP core project offices. Collaboration with GEWEX includes the development of a joint focus on precipitation in cold climates. Collaboration with CLIVAR includes better communication between Greenland ice specialists of CliC IMSL theme and the CLIVAR Atlantic Panel

INTERACTIONS (ESPECIALLY WITH WCRP'S SPONSORS & PARTNERS)

CliC interacts with many national and international organizations. Its **worldwide scientific focus** makes it a valuable partner for organizations with a more regional interest. CliC's MoU with the **International Permafrost Association** will be renewed in 2008. A new MoU is being finalized with **IASC, making it a co-sponsor of CliC**. IASC and SCAR are ICSU bodies.

CliC sponsors workshops/conferences/meetings with many scientific bodies, such as SCAR, IACS, IAHS, IAMAS, IAPSO, and the new International Association on Cryospheric Sciences. WCRP/CliC is the only cryospheric focus in ESSP. CliC is developing close collaboration with the **Arctic Council** and its Arctic Monitoring and Assessment Program (AMAP). The AMAP-CliC-IASC Arctic Carbon Cycle Assessment Workshop (February 2007) was held in an effort toward the scientific synthesis and assessment of the Arctic system carbon cycle. CliC is providing expertise to the development and preparation of an Arctic Council Project on Climate Change and the Cryosphere (2007-2011), an ACIA update assessment, focused on sea ice, the Greenland ice sheet, terrestrial cryosphere and modeling of the Arctic climate.

CliC continues to engage regional scientific studies. The CliC SSG endorsed the proposal of an affiliation with **IP3** (Improved Processes and Parameterization for Prediction in Cold Regions). IP3 fits into the activities of CliC TCHM Theme. It is primarily a Canadian focused group and CliC encourages IP3 to engage collaborators from other countries.

CHALLENGES AND CONSTRAINTS

The role of the cryosphere in the climate and in Earth System will remain a high priority research topic over the next decade. The cryosphere and its response to a changing climate is now an almost daily discussion topic – be in disappearing sea ice, extreme snowfalls, record snow cover, thawing permafrost, ice sheets and sea level etc. Other organizations are now also interested in the rapidly changing cryosphere, regionally or with a circumpolar focus. IPY has of course been a catalyst to focus on the cryosphere in the polar regions, and CliC has had an active role in formulating and delivering IPY activities. The legacy of IPY beyond 2009 will be a challenge over the long term. Through its involvement in initiatives such as SAON and GCW, CliC is already contributing to its planning, be it observations, data, infrastructure or improved cryospheric prediction. This will be done most effectively by partnering. CliC brings expertise and a global network of investigators. **But, an adequate base level of funding is essential for CliC to deliver its program and to be able to leverage other resources.** Research funds are accessed nationally and regionally, but funding for co-ordination (the glue) is essential for CliC, and hence WCRP, to be a credible research partner.

PUBLICATIONS AND OTHER PRODUCTS

There have been many CliC-related peer reviewed publications by scientists, too numerous to list. Two issues of WCRP/SCAR/CliC newsletter '**Ice and Climate News**' came out in 2007: issue # 8 (January 2007) concentrated on the results of the International Symposium on Cryospheric Indicators of Global Climate Change (Cambridge, UK, August 2006); issue # 9 was dedicated to mountain cryosphere. CliC prepared several workshop/meeting reports: WCRP Inf. Reports No. 4, 14, 18 and CIPO Informal reports No. 3, 4, 5, which are available through the websites. CIPO also produced a glossy flyer entitled '**Antarctic Sea Ice**

Thickness... the way forward', describing the outcomes and recommendations of the CliC-sponsored "Antarctic sea-ice thickness workshop". CliC IPO also produced several posters on the CliC themes to be used at meetings and conferences to promote CliC activities. A special issue (Hydrologic effects of a shrinking cryosphere) of the international journal, Hydrologic Processes, was initiated. T. Prowse (ed.) has arranged for about 12 theme papers to be written on a range of terrestrial cryospheric subjects.

The major CliC publication was the IGOS cryosphere report:

IGOS, 2007. Integrated Global Observing Strategy Cryosphere Theme Report - For the Monitoring of our Environment from Space and from Earth. Geneva: World Meteorological Organization. WMO/TD-No. 1405. 100 pp. (800 copies printed)

A contribution was also made to the IPY special issue of the WMO Bulletin:

B. Goodison, J. Brown, K. Jezek, J. Key, T. Prowse, A. Snorrason, T. Worby, 2007. State and fate of the polar cryosphere, including variability of the Arctic hydrological cycle. *WMO Bulletin*, 56 (4), 284-292.

OUTREACH AND CAPACITY BUILDING ACTIVITIES

CliC established contact with the **Association of Polar Early Career Scientists (APECS)**, an international and interdisciplinary organization providing networking and career development opportunities to young scientists with interest in polar regions and the cryosphere. CliC has been cosponsoring young scientists since 2005 through the Permafrost Young Researcher Networks awards at permafrost conferences (with SCAR and the IPA).

CliC scientists have given many scientific and popular lectures on climate and the cryosphere to agencies, the public and the media. CliC is active at major scientific forums (e.g. IUGG, AGU, EGU), sponsoring sessions and hosting specialist meetings/workshops. E.g., a CliC-sponsored public meeting on sea-ice at the 2007 Fall AGU attracted 65 scientists and provided a forum to discuss opportunities for new collaborative programs, sharing of information about national activities and the need to establish data standards.

During 2007, very significant progress was made on development of a sea ice data portal at the Australian Antarctic Data Centre, including the submission of a large number of data sets from sea ice groups around the world. The establishment of this facility was a recommendation of the 2006 workshop on Antarctic sea ice thickness and it will be available online by mid 2008. Australia has provided significant funding to establish this facility.

CliC took advantage of high profile visits to promote its activities, such as with the **US Arctic Research Commission** and entourage when they visited Tromsø, and with Mr Ban Ki-moon, Secretary General of United Nations when he visited the South Shetland Islands (Antarctica) and Torres del Paine glaciers (Chile).

CliC has established a **cryosphere 'specialist' list** to enhance co-ordination capability and to identify and engage experts for CliC activities. This has increased the involvement of scientists in cryospheric initiatives and has provided contacts for improved coordination.

IPO, PROGRAM ADMINISTRATION AND MANAGEMENT

Victoria Lytle resigned as CliC IPO director (80% position) at the end of 2007. Angélique Prick was part-time Deputy Director (40%) since July 2006. Until a new Director is hired, she will serve as full-time A/Director. A full-time Admin Assistant is provided by NPI. CliC IPO currently operates at reduced capacity compared to 2007. The program will experience further change with appointment of a new chair. CliC IPO and JPS WCRP are dedicated to ensure the continuity and quality of CliC activities in these transitional times.

ADDITIONAL COMMENTS FOR THE JSC

There are some questions, where JSC consideration is requested:

- CliC has built an extensive network of partners. This has proven effective. IASC wishes to co-sponsor CliC along with SCAR and WCRP. JSC concurrence of this is requested.
- Co-ordination of precipitation in cold climate regions in WCRP is needed. At one point a cross-cut was proposed for all precipitation issues. Should there be a WCRP WG on precipitation, or does informal collaboration between core projects suffice.
- JSC guidance on how WCRP and its core projects will operate within the new WMO structure is requested. There is a need to build partnerships within WMO.

