WCRP REPORT

World Climate Research Programme

WORLD CLIMATE RESEARCH PROGRAMME (WCRP)
SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH (SCAR)
INTERNATIONAL ARCTIC SCIENCE COMMITTEE (IASC)

Climate and Cryosphere (CliC) Project

Report of the fifth session of the
CliC Scientific Steering Group (SSG-V)

(Geneva, Switzerland, 8-11 December 2008)

January 2010

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Introduction

On December 8 through 11, 2008, the fifth meeting of the CliC Scientific Steering Group (SSG-V) was held at the *World Meteorological Organization* building in Geneva, Switzerland. The goals of this session were to: 1) Evaluate CliC current status and progress; and, 2) Focus CliC on achieving a number of high-impact outcomes contributing to WCRP's Coordinated Observation and Prediction of the Earth System (COPES) Strategic Framework 2005-2015 (http://wcrp.wmo.int/pdf/WCRP_strategimple_LowRes.pdf).

The anticipated results were: 1) CliC's contribution to the WCRP Implementation Plan 2009-2013 and to its Accomplishments document; 2) Future activities such as conferences and workshops; 3) Proposed names for new Steering Group members, taking into consideration members who would contribute optimally to the project; 4) Promote CliC in the WMO Secretariat, and inform and make participants aware of WMO and its development, and to establish contacts with relevant WMO staff.

Summary

The meeting evaluated CliC progress during the year and discussed future activities and directions. National, regional, and thematic activities were presented and reviewed. Considerable time was spent discussing initiatives to be pursued under the WCRP intermediate-term implementation plan as CliC's contributions to COPES. Closer interactions and collaboration with other major international earth science programs – including operational and space agencies – were also discussed. In addition, the need to address how CliC research and products can better serve WCRP project requirements and the broader user communities, policy makers and the general public was brought up, and several suggested solutions were presented. At the end of the meeting, a rough draft of CliC contributions to the 2009 JSC meeting was ready for review and refinement, and a proposed list of future meeting activities and action items were presented and agreed upon.

1.0 Opening

Before the meeting began, Vladimir Ryabinin led the group in a one-minute silence in honor of Dr *Victor Savtchenko*, a Senior Scientific Officer of the WCRP, during the ACSYS period, who died of cancer in August 2008.

Barry Goodison, CliC SSG Chair, welcomed the participants and noted that five members - himself included - would be leaving the SSG this year, with chairmanship shared between Koni Steffen and Tony Worby starting 2009. The agenda was approved and adopted, based on the understanding that minor adjustments may become necessary as the meeting progressed.

Prof. YAN Hong, **Deputy-Secretary General** of WMO, welcomed everyone and briefly described CliC's past and future role in WCRP.
He thanked Dr. Barry Goodison for his leadership role in the last 6 years, and ended by wishing all participants a successful meeting.

2.0 WCRP Update

The WCRP leadership and management were well represented at the meeting, with Ghassem Asrar (WCRP director) and Vladimir Ryabinin (Sr. Scientific Officer, Joint Planning Staff) attending the entire meeting. Toni Busalacchi (Chair, WCRP Joint Scientific Committee), and Ed Sarukhanian (Special Advisor to the WMO Secretary-General on IPY matters) also participated.

2.1-2.3 WCRP and CliC Future

Ghassem Asrar and *Antonio Busalacchi* presented updates on current WCRP activities, whose sponsors have formally acknowledged the value of WCRP contributions to the IPCC. They noted that the future challenge to climate change science is to develop a fully integrated view of the Earth system that takes into account its physical, biogeochemical and human dimensions. WCRP is in a good position to lead an Earth system modelling effort that will ultimately deliver tangible benefits to society.

During the past year, an independent review[1] of WCRP was carried out as commissioned by its sponsors, and a draft report was distributed to the WCRP core projects and associated panels and working groups, seeking their input to the WCRP response. In addition, and as a result of the 2008 JSC in Arcachon, France, the WCRP is in the process of developing a new *Implementation Pla*n that looks to the future of climate change in the next decade and beyond. Issues raised by the WCRP review panel must also be considered when developing the new implementation plan. The CliC SSG meeting provided a good opportunity for its participants to help formulate a response to the review of WCRP, as well as to give input to the new implementation plan.

The JSC has recommended that in the near term, crosscuts should be fully integrated into the projects' work, and that all aspects of WCRP's work should be evaluated against their contribution to the COPES strategy. In this context, all core projects, including CliC, have been asked to assess and identify which activities needed further emphasis and which could be de-emphasized in the intermediate term, including:

- What are the accomplishments to date
- What are the key issues to address
- What are the unifying themes of modelling, observation, climate system analysis
- Implementing WCRP cross cuts
- Ensuring societal needs are met (informing the public)

Break-out groups on Day 3 worked on the *WCRP Implementation Plan 2009-2015* and on the *CliC Accomplishments Document.* Plenary discussions of the break-out groups' output followed immediately afterwards. The aim was to complete the first drafts of both in time for the April 2009 Joint Science Committee meeting.

Summary of plenary discussions - WCRP-project relation and future planning:

WCRP wants to identify gaps in the core projects and to carry out research of cross-cut themes, such as the SLR and monsoon study across the projects. WCRP wants to bring the issues of gaps and cross cut and questions to a higher level among WCRP projects. WCRP wants to build partnerships among the core projects, i.e. more cross-fertilization among the projects and working closely together on the key topics.

The issue of current and future WCRP funds for workshops and meetings was discussed. WCRP is making changes in project promotion and supporting activities. WCRP wants to get

[1] The review was conducted by a panel appointed by the International Council for Science, World Meteorological Organization and the Intergovernmental Oceanographic Commission of UNESCO, together with the International Group of Funding Agencies for Global Change Research. This was undertaken in parallel with a review of the International Geosphere-Biosphere Programme (IGBP).

the info and request from the core projects and sees how much funds WCRP can support. WCRP will work with the project office and project's leaders to discuss the necessary activities. JSC approves and supports this new approach. One thing important to note is the trajectory of WCRP funds is going down over the last 5 years. But 2008 budget is much better; there are more funds for the future 1-2 years. We expect a healthy budget for 2009. We WCRP can give projects first offer for the planned activities in the next 12-24 months. The funds are almost twice much relative to 2008. It was suggested that the project offices collect and recommend necessary meetings before hand, so we can bring the meeting plans to the JSC level. Possible funds from other sources, such as from the users were also discussed. It is the project's decision on how to engage users; as users can range from participation to partnerships and support. There is a need to define the partnership; the decision is up to the project as far as how to decide contribution and partnerships. Future fund in the bad economy conditions was a concern. The impacts slowing economy was seen in EU and US, but not yet on the basic research funds. There is no sign of bad budget for next year yet. We all need to communicate with our national and regional funding agencies about the need of climate change research. We have been in tough time before. We need to identify and priority future projects and directions. We must support the project offices.

Near the end of the discussion, the issue of uncertainty in SLR prediction due to lack of ice sheet dynamic in models was brought up. This affects society in many ways, where insurance was one example. A key question is how to reduce the uncertainty in SLR prediction. We need good predictions with small uncertainly.

3.0 IPY – Activities and Emerging Legacy

In his presentation, *Ed Sarukhanian* noted that 63 countries participated actively in IPY activities, and that an estimated USD 1.2 billion in new science investments would be made during the period. He reviewed the various IPY phases (initial, atmosphere, oceans, hydrology, permafrost, space activities, etc.), and emphasized the importance of a continuing IPY legacy. To help secure this legacy, two new coordination bodies had been established:

1) The *WMO EC Panel of Experts on Polar Observations, Research, and Services* to coordinate the observing system legacy in the areas of polar meteorology, hydrology and glaciology; and,
2) the *IASC/SCAR Joint Bipolar Action Group* to advice its EC Committees on the development of mechanisms to nurture the IPY legacy, with special focus on IASC and SCAR roles.

Finally, the CliC SSG was invited to note and endorse the major pan-Arctic observing initiatives aimed at securing the IPY legacy; to identify areas of cooperation and coordination between CliC and the WMO EC Panel of Experts on Polar Observations, Research, and Services; and to explore and support the idea of an International Polar Decade as a means of securing the IPY legacy.

4.0 Global Cryosphere Watch (GCW)

At the 15th WMO Congress in May 2007 the delegation of Canada proposed to create a Global Cryosphere Watch (GCW). The Congress welcomed that proposal. It requested the WMO Inter-commission Task Group on IPY to explore the feasibility of creating such a global system as an important contribution to the IPY legacy and prepare recommendations for its development. The idea is to establish an *ad hoc* expert group on GCW, which will ensure that consultations on it will be widespread, reaching across all relevant WMO Programmes and Technical Commissions, engaging other organizations and agencies, and the

cryosphere scientific community as well. An expert meeting was hold before the SSG meeting at WMO, which is an important part of scheduled consultations.

Dr. Barry Goodison gave a talk on the Global Cryosphere Watch (GCW), focusing on the background, status, concept, and required actions. Following is a briefly summary of his presentation.

The International Polar Year 2007-2008 (IPY) has provided a unique opportunity to help close this gap in global observations by developing our polar observing systems further. WCRP's Climate and Cryosphere project (CliC) led the development of the conceptual framework for the Cryosphere Observing System <http://igos-cryosphere.org/documents.html>, for a sustained, robust observing system for the cryosphere and a crucial element of the future multidisciplinary observing system. But, there is an urgent need to ensure a real legacy for cryosphere observing and monitoring, not only in polar regions, but also globally.

The cryosphere, its changes, and its impacts, not only have received increased scientific scrutiny in recent years, but now receive constant coverage by the media, creating an unparalleled demand for authoritative information on past, present and future changes of our global snow and ice resources. WMO, with the co-operation of its 188 Member countries and territories, its co-sponsored programmes, and other National and International Bodies and organizations and using its global observing and telecommunication capability, is able to provide an integrated, authoritative, ongoing assessment of the cryosphere – a Global Cryosphere Watch.

The Initial Concept of GCW involves research, monitoring, assessment, product development and prediction. The mission of GCW would be to:
Initiate implementation the IGOS Cryosphere Theme (CryOS);
make reliable, comprehensive observations of the elements of the cryosphere through an integrated observing approach on global and regional scales, in collaboration with other international programmes and agencies;

- provide the scientific community with the means to predict the future state of the cryosphere; provide quality assured global and regional products of the cryosphere for use in climate, hydrological and numerical weather prediction over a range of time and space scales;
- facilitate assessment of changes in the cryosphere and their impacts, and use of this information to aid the detection of climate change;
- organize assessments of changes in regional and global components of the cryosphere to support decision making and policy development in support of formulating environmental policy;
- provide authoritative information on the current state and projected fate of the cryosphere for use by the media, public, decision and policy makers.

Main discussion points include IPY funds, observation vs. information as final products, and CliC-GCW relationship. There are funds available from IPY programs for research and how to use the limited funds to sustain the networks after the IPY. National funds and contributions are important to sustain the sites set up during the IPY. IPY is short, and there was a proposal to arrange an International Polar decade. It is a general, but important, question about what to produce as the final products. Public wants information not research results, so there is a great need from the WCRP sponsors and the society to have useful info for decision-making rather than products directly from observations. CliC needs to consider

what to focus on for the next decade and beyond. CliC needs to provide info for future, not observations along. Research should produce useful info in future. GCW can also produce info. CliC is very closely related with GCW, GWC evolved from CliC. On the other hand, CliC covers very broad areas; it needs integrations maybe via GCW.

5.0 CliC Theme Progress Reports

Presentations were given showing the progress within the four CliC themes during the past year. Except for Theme 4, reports included CliC's contributions to the Arctic Council's cryosphere project *Snow, Water, Ice, and Permafrost in the Arctic* (SWIPA[2]).

5.1 Theme 2: Ice Masses and Sea Level (IMSL), including SWIPA

5.1.1 WCRP Sea-level Rise Cross-cuts, Status, Plans and Required Actions

Koni Steffen presented an update of the IMSL theme. A brief summary is given below

- SLR is caused by (1) change in terrestrial water storage, extraction of ground water, building of reservoirs, change in runoff, and seepage into aquifers; (2) subsidence in river delta region, land movements, and tectonic displacement, (3) surface and deep ocean circulation changes, storm surges, (4) thermal expansions the ocean warms, and (5) exchange of water stored on land by glaciers and ice sheets with ocean water.
- Potential sea level change contributions are (1) thermal expansion of 0.10 m per 1 °C SST rise, (2) 0.55 m from all glaciers and small ice caps, (3) 7 m from Greenland, (4) 60 m from Antarctica, and (5) < 0.5 m from land storage.
- Future sea level predictions are uncertain because of uncertainties in the contributions of Greenland and Antarctica. Current language in the IPCC 4th report is conservative - 0.28 - 0.58 m of sea level rise by 2100. A recent study suggests a range of 0.4 - 1.4 m by 2100.
- Even if greenhouse gases were stabilized now, substantial sea level rise would continue for several centuries because of inertia in the climate system (at about 0.1 - 0.25 m/century depending on whether concentrations or emissions are stabilized).
- Several workshops and meetings were organized and co-sponsored by CliC on the sea level rise topic; (1) A Need for More Realistic Ice Sheet Models, SCAR & ICSU report No. 30, Nov. 2007, co-sponsored by CliC, (2) Improving Ice Sheet Models, Workshop (SCAR meeting St. Petersburg, Russia, 5-7 July, 2008), (3) Climate Change – Global Risk, Challenges & Decisions, Copenhagen, 9-12 March 2009:Cryosphere and Sea Level session, (4) Summer School: Ice sheet models for the 21st century, Portland State University, in Portland, Oregon, USA, on 3-14 August 2009
- New WCRP/IOC Task Group on Sea-Level Variability and Change. The group will primarily work via email, telephone hook-ups and face-to-face meetings during (or immediately adjacent to) other conferences/meetings. The group may convene broader community workshops. The TG is expected to report to IOC in 2011. CliC, through the SSG co-chair K. Steffen, will be actively involved in this task force representing WCRP, and J. Church will be representing IOC.

[2] SWIPA is coordinated through the Arctic Monitoring and Assessment Programme (AMAP) in Oslo, Norway and cosponsored by CliC and IASC.

Comments on the presentation included welcoming the formation of the WCRP team on the SLR, and the need to work out a review paper on model predictions of SLR. CliC is ready to lead this group within the WCRP.

6.1 Theme 3: Marine Cryosphere and Climate (MarC), Including SWIPA

Tony Worby presented an update for the MarC theme. A brief summery is given below

A list of science questions was presented for this theme, one of them being the sea ice prediction from models. Recent activities include *Antarctic* sea ice workshop, snow depth comparison between *in-situ* and the ARSER–E data. Observational networks; i.e., SOOS, were also reviewed. Future activities include an Arctic sea ice workshop to be held in Tromsø, Norway in early 2009, where strategies for improving consistency of surface-based observations would be discussed.

Currently under review is a 400pp sea-ice field handbook by a group of sea ice researchers which will form the basis for field training for student. Many CliC scientists are involved in the review. CliC was invited to endorse the product and otherwise provide support in the way of funding part of the publication costs.

Future challenges for this theme are: developing a capability for regional ice and snow mapping; dataset development for validations of model and remote sensing products; developing and implementing sustained networks of ice observations; improved regional models, and ice shelf models.

Future recommendations include:

- Need to focus the CliC themes on a few key activities that are manageable within the confines of budget and volunteers involved
- Theme areas need to be organized around these activities, and be nimble in their organisational structure. Small working group preferred.
- CliC website is a tool for building capacity, highlighting the theme areas and communicating program results to users – needs updating
- Is it possible for CliC to produce annual or bi-annual "position statement" on the state of the cryosphere? Cooperation across themes, engaging CliC specialists and the SSG
- Series of CliC reports from sponsored-workshops

Sebastian Gerland's talk on marine cryosphere in the Arctic included the issue of changing Arctic sea-ice extent. September records for the period 1979-2008 show a decreasing trend of 11.7% per decade. Models suggest a soot-induced snow albedo reduction, but validation is lacking. Improvement of climate model and snow-property data over the Arctic Ocean is necessary. Increased shipping activities near the sea ice could raise the importance of climate forcing from soot in snow.

Sebastian also noted that at least 19 IPY projects were related to sea ice - ranging from Inuit voices and reindeer herding to sophisticated data from satellite observations.

The kick-off meeting of *SWIPA* Sea-Ice component was held in Tromsø in August 2008, where a core group of experts revised and defined the sea-ice chapter of the SWIP report.

Selection of contributing authors of the various chapters is ongoing. See the AMAP website http://www.amap.no/ for additional information.

This session also reviewed the SOOS, JCOMM and iAOOS activities. Questions and comments focused on the modelling aspect of the MarC theme and the need to produce an end-to-end approach of observations, analysis and assessment common to many international projects. Sea ice model and simulation are challenging, and CliC sees the need to enhance modelling of sea ice in the future. NCAR is planning AR5 runs, and the Hardly Center is updating its sea ice model. It is also important to develop standards and ask others to sign up and agree to follow the same standards. Operational agencies should produce quality-controlled sea ice maps and similar products by an adopted standard. Error analysis and defined characteristics are useful for all products. The new GCW is attempting to address some of these issues.

7.1 Theme 4: Global Cryosphere Predictions (GCP)

Annette Rinke presented a view on the Global Prediction of the Cryosphere theme and what needs to be worked on over the next couple of years.

Regional climate models (RCM) are being run across both polar regions with atmosphere-only, ocean-only and coupled atmosphere-ice-ocean models being under development. Atmosphere-only models have been used to investigate high latitude atmospheric processes, and as part of high-horizontal weather forecasting systems. But, since sea ice must be specified within these models, their output cannot help to predict sea ice, however, they can help to investigate the impacts of sea ice on the atmosphere. Many regional ice/ocean models are assimilating sea-ice data, but how much is thrown away? If model and observation disagree by more than a certain amount, the data does not get assimilated.

CliC could contribute to improved prediction of the cryosphere by aiding the development of polar RCMs. The Arctic Regional Climate Model Intercomparison Project (ARCMIP) and the Arctic Ocean Model Intercomparison Project (AOMIP) are already providing a high degree of coordination of RCMs in the Arctic, but there is no comparable initiative for the Antarctic, and none specifically aimed at the cryosphere.

To address the issue, a workshop on “Prediction of the cryosphere using Regional Climate Models” was suggested. The workshop would bring together the cryospheric and RCM communities to look at the capability to predict the various elements of the cryosphere using Regional Climate Models.

7.2 CAPER (Carbon and PERmafrost) Proposal: a Joint WCRP-CliC and IGBP-AMES initiative

Vladimir Kattsov, together with *Kathy Hibbard*, proposed a joint CliC and AIMES initiative to promote complementary approaches to understand and quantify carbon cycle and permafrost dynamics across scales of observations, measurements and models for regional to global analyses. The goal is to develop a coordinated modelling framework for the NHL to quantify key vulnerabilities and thresholds of the coupled carbon-climate system.

Two focused workshops were suggested for 2009/2010: 1) to develop coordinated strategies for translating process understanding to model parameterization and initialization; and, 2) to provide feedback from model experiments from regional to global context for NHL interactions with the climate system.

The proposal was discussed at length see Appendix 6 for further details.

8.1 Main Outcome from the Working Groups on Numerical Experimentation (WGNE) and Coupled Modelling (WGCM) Sessions, Including CMIP5

Diana Verseghy and Vladimir Kattsov updated the participants on the Working Groups on Numerical Experimentation (WGNE) and the Working Group on Coupled Modelling (WGCM). The main question is: What are the main WCRP/climate requirements in modelling, and what can CliC contribute to meet them? Until recently, there was not much interest in the cold / cryo processes, bit this has changes. The time is now right for CliC to work on the model, such as putting RCM and process model results into operational models to bridge the gap. WGNE is working on model development, validation, and on improving key processes, radiation, energy balance and cold-region precipitation. CliC needs to work with them.

8.2 ESA – CliC Collaboration

A presentation by *Mark Drinkwater* (ESA) highlighted ESA's ongoing contributions to meeting CliC strategic goals, and outlines a new Programme framework for a new ESA-CliC Science Partnership. The background and goals of the Support to Science Element (STSE) of ESA's Earth Observation programme were described, and a number of potential thematic areas identified within which ESA encouraged CliC to propose potential ideas. On the basis of a requested *Science Requirements document* (Appendix 10) and its alignment with CliC and ESA scientific challenges, a thematic User Workshop will be convened in 2009 with the intent of initiating a new ESA funded Project.

In the presentation, ESA suggested some topics for consideration of future collaboration. This includes snow accumulation on ice sheets and its impact on mass balance variations, river and lake ice monitoring over the northern regions, and snow radiance. Given the importance and potential of this collaboration, it was decided by the SSG a small group be formed to engage others interested and to work with CIPO on this effort. CIPO has drafted a scientific requirement document for this effort. This draft needs to be refined, in order to specify research topics for each theme (see Appendix 5).

8.3 IPY Legacy Satellite Data

Mark Drinkwater (ESA) gave a summary of the Global Interagency IPY Polar Snapshot Year (GIIPSY) IPY Project (#91) contribution to the IPY Data Legacy. Science requirements based IPY goals were developed by GIIPSY and the IPY JCOMM mandated Task Group had the role of coordinating 13 Space Agencies to address these goals. Results of this coordination were shown, with examples indicating the success of this project in addressing a number of key scientific firsts.

New data and products include new SAR – X band data of sea ice extent, INSAR ice stream velocity information, river and lake ice monitoring, Ozone map, IPY ICE logistical support portal, etc. It was noted that these new data and products have not been used by the users. There is a need to provide them to the broader user communities, although the impact to have these data and products is very clear to the global community.

8.4 CLIVAR

Howard Cattle presented an overview of CLIVAR, its role in the WCRP cross-cutting topics in the context of the WCRP Strategic Plan 2005-25, and potential areas where CLIVAR and CliC might interact to make contributions to these. Such areas include study of cryospheric aspects of the major WCRP cross cutting climate modelling experiments on seasonal to decadal timescale predictions, the role of the cryosphere for monsoon variability and the nature of climate extremes associated with cryospheric processes. Because of its responsibility in WCRP for the role of the oceans in climate there are also clear areas where CLIVAR might contribute to the sea level cross cut managed under CliC. CLIVAR is helping to organize the upcoming OceanObs'09 symposium (Venice, September 2009) for which input on the high latitude oceans and sea ice is an important factor. Finally, the SSG were reminded of the activities of the joint CLIVAR/CliC/SCAR Southern Ocean Panel which will meet next in Sydney, Australia in February 2009.

9.1 Theme 1: Terrestrial Cryosphere and Hydrometeorology of Cold Regions (TCHM) - Including SWIPA and FreshNor

Terry Prowse talked for this theme, below are the main points from his talk

- Theme 1 in general is too large, recent activities include ICARP II, Arctic Ocean freshwater budget (proposal), IP3 – review and update, and the FreshNor- over the Nordic sea, including Greenland.
- HP special issue – review of cryospheric change and its impact on hydrology - CliC paid for the cover and its logo on it.
- SWIPA – river and lake ice as a part – may produce CliC product, plan to have a meeting in UViC, i.e., a writers' workshop, could CliC support it?
- FreshNor part of theme 1, need to engage them more in the future.
- Theme 1 Future workshops:
    - Lake and river ice, SWIPA, 2011
    - Methodology of coupling GCM/RCM in the cold regions, GEWEX and CliC
    - Arctic fresh water budget – think-tank assessment

D-WCRP comment: This is consistent with the model discussions in the WCRP, need to form a team to discusses the co-ordinations, need products and deliverables

Solid Precipitation

Cold region precipitation is an urgent issue that CliC can lead and contribute to in many ways. There is a precipitation issue paper by Daqing Yang and others for the 08 SSG meeting. We need to work on this ASAP together with the GCW and other WCRP Projects, and data centers.

9.3 Coordinated Energy and Water Cycle Observation Project - Cold Region and High Elevation (CEOP-HE) Initiative

Gianni Tartari, Chair, CEOP-HE gave a short talk on the CEOP High elevations initiative (a GEWEX project). The initiative will help spread knowledge on physical and dynamical processes in high-elevation areas, which regulate and affect the water and energy cycles, and contribute to global hydro-climate studies. In this context, the cryosphere is an intrinsic part of the global energy and water cycle, impacting weather, water and energy. Glaciers, snow

cover, permafrost and the periglacial zone are important components of the high-elevation cryosphere and are critical reserves for water supply. Therefore, a better understanding of the water cycle and its variability, particularly in high altitude regions, is important. The CliC project may benefit from collaboration with the CEOP-HE initiative.

Through promoting development of a coordinated terrestrial monitoring network of high elevation observatories with a global coverage and high quality data products, CEOP-HE seeks to contribute to the study of interaction between land-surfaces and atmosphere at high altitude and their feedback on climate and atmosphere circulation, and to improve regional and global energy balance/atmosphere circulation models.

Acquisition of new information on high altitude areas may also contribute to the study of alpine hydrology and to asses the fresh water resources more precisely, particularly in those regions where the demand for water is projected to rise continuously, but where seasonal variability of snow cover, glaciers and permafrost are strongly affected by global warming and rapid changing climate.

10.0 Meeting with Representatives of WMO Departments and Programs

- WMO and its structure – V. Ryabinin
- Short overview of CliC and GCW for WMO information - B. Goodison
- Meteorological services and cryosphere - ??
- Climate and water, - including WCC-3 and PCOF – Kumar Kolli
- ARE, seamless prediction, research department – cryospheric interests – Len Barrie
- GCOS – Stephan Bojinski
- WIS and WIGOS – Igor Zahumensky & David Thomas
- WMO space programme – Jeff Key
- Discussion on CliC, WMO, CryOS, GCW: What WMO would expect from WCRP in the area of cryosphere (including cryospheric observations)

WMO Res director / Len Barrie

- Global precip chemistry project under GAW…. related with CliC
- IPCC black carbon in snow in the polar regions when the haze are prominent – regional prospective, not included in the GCM. One of the things in common.
- Snow albedo should be in the ECV
- Aerosol in the polar regions
- Key gaps in res, cryo is one of them…

11.0 CryOS

Jeff Key (NOAA) presented a status report on the Integrated Global Observing Strategy (IGOS) Cryosphere Theme. By mutual decision of the Partners and the Group on Earth Observations, the IGOS themes will effectively be merged into the Global Earth Observation System of Systems (GEOSS). The IGOS Partnership was therefore dissolved at its last meeting in late May 2008. The IGOS Cryosphere Theme is expected to be implemented largely through the WMO Global Cryosphere Watch. The Theme team will continue to work with and within GEOSS to the extent that it is beneficial to both. The Theme will also continue to contribute to, and draw from, other activities such as the IPY Sustaining Arctic Observing Networks (SAON) effort and the WMO Space Task Group for IPY. The Theme is currently working with the Committee on Earth Observation Satellite (CEOS) on a cryosphere gap analysis.

10-11 Discussions on CliC, WMO, CryOS, GCW

What would WMO expect from WCRP in the area of cryosphere, including cryospheric observations?

12.1 WCRP Implementation Plan - Structure

Participants were divided into two groups led by Koni Steffen and Toni Worby. Together with Vladimir Ryabinin and Daqing Yang, the groups discussed the structure of the WCRP implementation plan 2009-2013 and the WCRP accomplishment document and what is expected of CliC, its various activities and initiatives. The next day, plenary discussions of the break-out groups' output were held, where directors and representatives of WMO departments were invited to partake.

13.0 IASC, SCAR, IACS, IPA updates / Memorandum of Understanding (MoU)

13.2 International Arctic Science Committee (IASC)

IASC update includes office move to Germany (Alfred Wegener Institute), change of structure, partnerships with SCAR, CliC and ASPEC, and a new element of cryo system (Martin Sharp, chair). This is closely related with CliC and they look forward for CliC contribution. Arctic summit week will be in Bergen in spring 2009. There will be science sessions and they welcome CliC to attend. Budget for IASC does not support projects, it has seed money to initiate projects, total budget 250K EU per yr.

CliC questions and comments include how the International SEARCH fits in the cryosphere community, we need to complement, not duplicate each other. WCRP polar initiative will consult IASC. CliC may consider inviting Martin Sharp for future CliC meetings.

13.3 Scientific Committee on Antarctic Research (SCAR)

Tony Worby spoke for SCAR. He gave a program updates which included a list of new projects. Observing system and data include SOOS, SAON, Pantos, polar info commons. He also presented a meetings list, including a summer school in Stockholm in 2010. There is a need for CliC to talk with SCAR for future conferences, although scar meetings are very costly to have sessions.

13.1 International Association of Cryospheric Sciences (IACS)

Georg Kaser represented IACS and talked about the history and structure of the organization, where SK was the rep for CliC. He mentioned a case of mountain regions and glacier mass balance data were not long enough and have breaks in the records, 1987-2006. The results for mass balance vary among the glaciers –there is a need to improve the glacier data collections in the Himalayan regions. Standard for mass balance monitoring is necessary, CliC comments include relationships among the IGS, IASH, ICSA are important, we have similar interest, it is easy to communicate among us.

13.4 International Permafrost Association (IPA)

Vladimir Romanovsky showed a list of IPA projects, four of which were IPY projects. The *Thermal state of permafrost is* a new project funded by NSF. They reactivated more than ground temp 100 sites in FSU. The Calm network has 25-150 sites in the NH, with records up to 050 years. Other project is on carbon pool, 650-1024 gt of carbon in permafrost, including peatlands. There are data issues: in CAPS 3 CD, 2009-2010. Permafrost watch a new idea in

GCW? Comments were made from CliC on how can CliC contribute to IPA activities. IPY needs CliC to promote its projects, to use this info, and synthesize the results.

14. CliC and WCRP Data Management

- We should have a regular/permanent contact at WGNE and WGCM to report back on
- Links between modellers and satellite agencies to determine metrics for satellite products
- Products do not have error bars
- Proliferation of products that have discrepancies, require standardizing etc.
- Coordinate with producers of data products (GCOS, CEOS come in here)
- A HUGE job and HUGE efforts required

15. CliC Regional Projects:

Discussions on CliC regional and national activities in Asia CliC, South American perspectives

15.1 Asia CliC

Asia-CliC is a successful example of regional projects that deal with regional and national issues in cryosphere.

Dr. Zhou Datong participated on behalf of Dr. Qin who could not participate due to a medical condition. Zhou updated the group on China CliC activities and future plans. Major activities in 2008 include research projects in China on frozen soil change along Tibet highway, analysis of snow-cover changes over China, hydrology studies in the cold regions, and see-ice and river- ice observations. Meetings include the Asia-CliC conference in 2007, and the IGS glacier inventory workshop held in the fall of 2008. Future meetings include the China National CliC annual meeting in late February 2009, the International conference on cryosphere change and its impacts in summer 2010, and the 2nd Glacier inventory workshop, also in 2010.

Daqing Yang showed Tetsuo Ohata's presentation on the CliC collaboration with GEWEX/CEOP. Among other topics, cold region precipitation and modelling are the key issues.

15.2 CliC from a South-American Perspective

Gino Casassa talked about meetings and activities in South America. There is an active IASH Working Group on Snow and Ice (mostly glaciers) in Chile, as well as a Frozen Ground initiative, both of which CliC was invited to co-sponsor. He agreed to contribute to the CliC Newsletter, also perhaps hosting the SSG in Chile in 2010. There is an active snow and ice working group under IASH, with links to international projects and publications, as well as a frozen ground initiative. CliC was also invited to co-sponsor these. A large international conference on ice and climate change takes place in Valdivia, Chile in early 2010. CliC representatives were encouraged to attend.

15.3 Russia-CliC Update

T. Khromova summarized Russian IPY activities funded through ROSHYDROMET and the Russian Academy of Sciences. Approximately 90 institutions and organizations are involved in IPY activities. These activities provided, among others, the opportunity to complete a wide scope of Arctic basin measurements, including: drift-ice thickness using ship-based video

monitoring, measurements of water and ice characteristics in melt-water pools, etc. New sea-ice information resources were created, and old ones updated. Field studies in Antarctica included glacio-geophysic studies of Lake Vostok.

Russia-CliC proposed to arrange a CliC Open Science Conference in Russia in 2011 where IACS should be invited as co-sponsor.

16.1-18 Break-out group discussions

The following subjects were discussed at length. Discussions were to continue on-line after the meeting, aiming for final publication in early 2009:

16.1 Break-out groups work on the WCRP Implementation Plan 2009-2013 and Accomplishment document
17.0 Reports on CliC's contributions to the WCRP Implementation Plan 2009-2013 and accomplishment document and their discussion, along with a presentation on CliC potential contribution to WMO activities
18.0 What will CliC need to do to achieve their contributions to WCRP? Breaking out into groups to discuss various CliC activities and initiatives

19.0 Meeting proposals (2009-2010), etc.

This is to set up the priorities for meetings and workshop in the near future, 2009 and 2010. It is also necessary to estimate the cost for meeting, so WCRP and CliC can plan future activities.

A table was made after the SSG meeting, (See a table for summary). This table is not completed due to lack of interest in filling the meeting info form before and during the SSG meeting. After some general discussion on how to rank the meeting and info, it was agreed that the CIPO will compile all info in about two weeks, and the CliC executives will rank them and determine the funds for meetings and workshops in 2009.

20.0 CliC IPO Report

Daqing Yang, director of the project office, gave a summary talk for the office. He mainly focused the talk on the activities since fall of 2008. He emphasized that goal of the project office is to serve WCRP/JSC, SSG, and its panels. The functions of the office include maintaining and updating the CliC website, publication of the News letter (2 issues per year), organizing meetings and workshops, and productions of reports, such as workshop reports for regional activities, annual report for WCRP/JSC and other sponsors, i.e. SCAR/IASC/NRC. He also proposed actions at the CIPO, including news update and improvement of communication between the SSG and working groups.

21.0 Proposed 2009-2010 CliC meetings

More than 30 workshop and meeting proposals were submitted. Among them were: Prediction of the cryosphere using Regional Climate Models; an Ice Sheet Modelling Summer School addressing key science gaps for sea-level rise; a Kick-off meeting for CliC/AIMES, and Changing river and lake ice around the circumpolar.north (assessment and contribution to SWIPA). See the final list in Appendix 4.

22.0 Final discussions on CliC contribution to the WCRP implementation plan 2009-2013 and the accomplishments document

T-Team: Report and discussions brought up the issues of serving the users. It is recognized hat the user group is huge. For instance, models need snow and ice info for predictions, dam regulations for hold water from spring snowmelt to summer season, need knowledge in seasonality changes – this info is needed for many users.

K- team set two time steps: for the near term, CliC need to focus on the feedback processes. Solid precipitation in the northern regions is one thing CliC can lead and do well. In addition, feedback also include ice sheet and ice shelf in the GCM, processes into future GCM. Social and economic impact of cryosphere changes is also important and should be the new direction for activities. In the long term beyond 2013, CliC can work on decadal forecast and impacts, reduce uncertainty in cryosphere predictions, and energy interest and info requirement

In the end, the group agrees that it is critical to set up the focus groups. To do so, we need to reach out and engage other WCRP Projects and research groups. CliC and GCW both work on and deal with solid precipitation issues, this will provide a strong science support to the GCW.

The WCRP director comments: CliC is not far away from what you need to be done. CliC needs to synthesis and analysis of the key issues in the cryosphere system. CliC may need to consider adjusting its organization, structure, and process in order to do a better job in global cryosphere research. CliC needs to focus on a few critical issues, to get the community to accept its research focus. CliC can build on the past foundations; and move forward to present itself in a way with a better visibility and importance. In doing son, we must maintain and take advance of the networks that CliC already established over the last years. CliC needs to showcase the accomplishments via review papers in journals to highlight the accomplishments over past years.

CliC response: The SSG believes that CliC can work better with other projects. CliC has done good work for a young project, we need to find out what to do in near term and long range, We are ready for integration, such as via ongoing projects in Asian regions, or through new initiatives and assessment activities, such as the ICARP II, SAON, and SWIPA. CliC is ready to work on the draft report: of 5-10 gapes with boxes when possible.

23.0 CliC project structure, Working Groups, Experts, and Rapporteurs

The structure of CliC was discussed at the meeting. One suggestion is to replace the themes with new existing and new working groups. Most at the meeting agree that themes are necessary and working group should expand to fit the new needs and developments of CliC. It was decided not to make major and drastic changes in the CliC structure. There is a need to work on this more via emails and telecons and maybe at next SSG meeting.

24.0 Action items for 2009 and beyond

A list of new action items were reviewed and recorded (see Appendix 10)

25.0 CliC SSG-VI session, location and dates

Not much discussion at the meeting due to time limitation. At one dinner during the meeting, Japan was suggested among other options. Koni Steffen suggested contacting Tetsuo Ohata for a possible SSG meeting in Tokyo, Japan. We also agree to explore other options.

26.0 Closed session

CliC SSG, CIPO and JSC staff discussed SSG membership, preparations for WCRP Joint Science Committee meeting (JSC-30) at the University of Maryland, as well as representation of CliC on WGCM, WMP, and WOAP.

APPENDICES

1. Agenda
2. List of participants
3. Template for meeting proposals
4. List of proposed 2009 meetings and workshops
5. Global cryosphere research and the CliC project (draft 1)
6. CAPER (Carbon and PERmafrost) – proposed new WCRP-IGBP initiative
7. A data processing strategy for satellite data collection during IPY
8. Global prediction of the cryosphere – thoughts for 2009-2010
9. Action items
10. Scientific requirement document for global cryosphere research and CliC Project (Draft 1)

?? What else???

Appendix 1

Agenda (V7, 8 Dec.)
CliC SSG-V, Geneva, 8-11 Dec 2008

Day 1, 8 December 2008, meeting room C2, basement, level "-1"

Item	begin	end	duration	topic	speaker / resp.
	8:30	9:00	0:30	Registration	Staff
1				**Opening**	
1,1	9:00	9:05	0:05	Opening	Barry Goodison
1,2	9:05	9:15	0:10	Round of self-introductions	All
1,3	9:15	9:30	0:15	Welcome by WMO	WMO Deputy Secretary-General or his nominee
1,4	9:15	9:20	0:05	Adoption of agenda	Barry Goodison
1,5	9:20	9:25	0:05	Practical information	Vladimir Ryabinin
2				**WCRP Update**	
2,1	9:25	10:00	0:35	WCRP and CliC Future	Tony Busalacchi & Ghassem Asrar
	10:00	10:30	0:30	**Coffee**	
2,2	10:30	11:00	0:30	Discussion on the WCRP Update (2.1)	All
3	11:00	11:30	0:30	IPY, activities and emerging legacy; WMO EC Panel on Polar Observations, Research and Services, SAON	Ed Sarukhanian
4	11:30	12:00	0:30	GCW, status, concept, required actions	Barry Goodison
3+4	12:00	12:15	0:15	Discussion of IPY and GCW	All
	12:15	13:30	1:15	**Lunch**	
5,1	13:30	14:15	0:45	WCRP Sea-Level Rise Crosscut, status, plans, required actions and CliC Theme 2: Ice Masses and Sea-Level Rise (including SWIPA)	Koni Steffen
5,2	14:15	14:45	0:30	CliC Theme 2 discussion	All
6,1	14:45	15:15	0:30	CliC Theme 3: Marine Cryosphere including SWIPA	Tony Worby/Sebastian Gerland
6,2	15:15	15:35	0:20	SOOS and iAOOS	Vladimir Ryabinin
	15:35	16:00		**Coffee**	
6,3	16:00	16:10	0:10	JCOMM	Vladimir Ryabinin
6,4	16:10	16:40	0:30	CliC Theme 3 discussion	All
7,1	16:40	17:10	0:30	CliC Theme 4: Global Cryospheric Predictions	Annette Rinke
7,2	17:10	17:35	0:25	Carbon - permafrost initiative	Vladimir Kattsov / Kathy Hibbard
7,3	17:35	17:55	0:20	Discussion of CliC Theme 4 and the initiative	All

End of Day 1 - no host dinner

Appendix 1

Day 2, 9 December 2008, meeting room C2, basement, level "-1"

Item	begin	end	duration	topic	speaker / resp.
8,1	8:45	9:15	0:30	Main outcomes from WGNE and WGCM sessions including CMIP5. What are main WCRP/climate research requirements in modelling and what can CliC contribute to meet them?	discussion led by Vladimir Kattsov
8,2	9:15	9:35	0:20	ESA - CliC collaboration	Mark Drinkwater / F87D. Yang
8,3	9:35	9:45		IPY legacy sateliite data	Mark Drinkwater
8,4	9:45	10:00		Updates from CLIVAR including on WCRP crosscuts that are led by them, with focus on cryospheric requirements	Howard Cattle
	10:00	10:30	0:30	**Coffee**	
9,1	10:30	11:00	0:30	CliC Theme 1: Terrestrial Cryosphere + Climate of Cold Regions including SWIPA and FreshNor	Terry Prowse
9,2	11:00	11:15	0:15	Solid precipitation	Daqing Yang
9,3	11:15	11:30	0:15	CEOP, cold region + High Elevation	Tetsuo Ohata / Gianni Tartari
9,4	11:30	12:00	0:30	CliC Theme 1 discussion	All
	12:00	13:15	1:15	**Lunch**	
10				Meeting with representatives of WMO Departments and Programs	
10,1	13:15	13:30	0:15	WMO and its structure	Vladimir Ryabinin
10,2	13:30	13:50	0:20	Short overview of CliC and GCW for WMO people	Barry Goodison
10,3					
10,4	13:50	14:10	0:20	Meteorological services and cryosphere	TBF
10,5	14:10	14:40	0:30	Climate and water including WCC-3 and PCOF	Kumar Kolli
	14:40	15:10	0:30	**Coffee**	
10,6	15:10	15:30	0:20	ARE, seamless prediction, Research Department - cryospheric interests	Len Barrie
10,7	15:30	15:50	0:20	GCOS	Stephan Bojinski
10,8	15:50	16:10	0:20	WIS and WIGOS	Igor Zahumensky & David Thomas
10,9	16:10	16:30	0:20	WMO Space Programme	Brian O'Donnel
11	16:30	16:50	0:20	CryOS	Jeff Key
10,11	16:50	17:10	0:20	Discussion on CliC, WMO, CryOS, GCW: what WMO would expect from WCRP in the area of cryosphere including cryospheric observations	
12,1	17:10	17:50	0:40	Structure of the WCRP Implementation Plan 2009-2013 and the accomplishment document and what is expected from CliC. Break-out to groups input to write CliC's contributions to the document	discussion led by Koni Steffen and Tony Worby with Vladimir Ryabinin and Daqing Yang
	18:00			Reception at the WMO Secretariat (finger food, drinks)	

Appendix 1

End of Day 2

Day 3, 10 December 2008, meeting room C2, basement, level "-1" and breakout rooms

Item	begin	end	duration	topic	speaker / resp.
13,1	8:45	9:00	0:15	Update from IASC, MoU	Volker Rachold's rep
13,1	9:00	9:15	0:15	Update from SCAR	Tony Worby
13,1	9:15	9:30	0:15	Update from IACS	Georg Kaser
13,1	9:30	9:45	0:15	Update from IPA	Vladimir Romanovsky
14	9:45	10:15	0:30	CliC and WRCP data management	discussion led by Barry Goodison, Howard Cattle and CIPO
	10:15	10:45	0:30	**Coffee**	
15,1	10:45	11:30	0:45	CliC Regional Projects: Asia CliC, South American perspectives	Dahe Qin, Tetsuo Ohata, Gino Casassa
15,1	11:30	12:15	0:45	Voluntary updates on national activities, discussion on CliC regional and national activities	All
	12:15	13:30	1:15	**Lunch**	
16,1	13:30	14:45	1:15	Break-out groups work on the WCRP Implementation Plan 2009-2013 and the accomplishment document	
16,2	14:45	15:30	0:45	Plenary discussion of the breakout groups output	led by Koni Steffen, Tony Worby, Daqing Yang
	15:30	16:00	0:30	**Coffee**	
17	16:00	17:00	1:00	Reports on the CliC's contributions to the WCRP Implementation Plan 2009-2013 and accomplishment document and their discussion, along with a presentation on CliC potential contribution to WMO activities	Koni Steffen/Tony Worbyand with invitation of Directors and/or representatives of WMO Departments
18	17:00	17:20	0:20	What will CliCkers need to do to achieve their contrributions to WCRP? Breaking out into groups to discuss various CliC activities and initiatives	All
19,1	17:20	18:00	0:40	Breakout groups to discuss activities they would like to pursue, organize, what they would need (meetings, MIPs, what else)...	All, by breakout groups

End of Day 3

Appendix 1

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Day 4, 11 December 2008, meeting room C2, basement, level "-1" and breakout rooms

Item	begin	end	duration	topic	speaker / resp.
19,2	8:45	9:15	0:30	Presentations by various groups and people on their initiatives, proposed meetings, requirements for support, etc.	All
20	9:15	9:35	0:20	CliC IPO, report	CIPO
21	9:35	10:00	0:25	List of CliC meetings for 2009 and 2010, their priority and cost estimation	Daqing Yang
	10:00	10:30	0:30	**Coffee**	
22	10:30	11:30	1:00	Final discussion on CliC contribution to the WCRP Implementation Plan 2009-2013 and the accomplishment document	All, led by Koni Steffen, Tony Worby
23	11:30	12:15	0:45	CliC Project structure, working groups, experts, rapporteurs required	Koni Steffen, Tony Worby, Daqing Yang
	12:15	13:30	1:15	**Lunch**	
24	13:30	14:00	0:30	Action items for 2009 and beyond	Daqing Yang
25	14:00	14:10	0:10	CliC SSG-6 Session, location and dates	Daqing Yang
26	14:10	15:00	0:50	Closed session of CliC SSG, focussing on membership, preparations for WCRP JSC -30, and representation of CliC on WGCM, WMP, WOAP, etc. (If required, the session may continue longer and then the CliC Executive Session will start later)	All SSG members
	15:00	15:30	0:30	**Coffee**	
	15:30	17:00	1:30	CliC Executive	

End of CliC SSG-5

12 December 2008

Meeting of CliC IPO staff and JPS

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Appendix 3

TEMPLATE

CliC and CliC-related meeting proposal/plan for 2009 and 2010

Information should be sent to D/CIPO (daqing@npolar.no) with a copy to JPS WCRP (vryabinin@wmo.int) with the following details (when possible):

Who proposes the meeting and in which capacity (e.g. CliC Theme leader, etc.)

Title of meeting or workshop

Proposed venue

Proposed dates

Proposed attendees, including likely number

Rationale and relevance to CliC themes and future activities

Specific objectives and key agenda items

Anticipated outcomes (deliverables)

Science Organizing Committee (if any or relevant)

Local Organizing Committee (if any or relevant)

Proposed funding sources and anticipated funding request from WCRP

Additional comment and information, web link etc.

Appendix 4

Proposed CliC Workshops & Meetings 2009

No.	Theme of Workshop	Date	Site	Contact	Approximate number of participants	Priority	Contribution to COPES
1	Prediction of the cryosphere using regional climate models	Late 2009 or 2010/TBD	Toronto, Canada	Turner, John A. Rinke	up to 10-15	highest	addressing key sci. gap in science for SLR, see Sydney Workshop recommendations
2	Ice Sheet Modelling Summer School	summer 2009	TBD	WCRP/CliC, Steffen, Ryabinin	50	highest	key gap, as above
3	CliC Workshop on Arctic surface-based sea ice observations: Integrated protocols & coordinated data acquisition	2009, Jan 26-27,	Tromsø, Norway	Sebastian Gerland, Donald K. Perovich Hajo Eicken	30	high, approved by SSG in 2007	key for the Arctic sea-ice climatology
4	WMO/GEO/WCRP Workshop on contributions of IPY to GCW and GEOSS	April – May 2009, TBC ASAP	Geneva	B. Goodison	40 to 60	high	our IPY Legacy commitment
5	Cryospheric controls of the Freshwater Budget of the Arctic	approximately August 2009	Victoria BC, Canada;	Terry Prowse	12 to 15	high	key for addressing isses related to abrupt climate change and THC circulation, integration of knowledge
6	Carbon pools in permafrost regions (CAPP)	2009, June 3-5	Stockholm University	V. Kattsov, K. Hibbard, V. Romanovsky	40	high	key uncertaintly and hot spot in climate system, data gathering
7	Kick-off meeting for CliC/AIMES “CAPER” (carbon and permafrost)	2009, June 3-6	Stockholm University	V. Kattsov, CliC SSG	10	highest	addressing a key uncertainty in carbon-cycle models
8	CliC SSG Meeting	Late in 2009	Japan	CliC SSG	30	high	key for planning and coordination

Appendix 4

No.	Theme of Workshop	Date	Site	Contact	Approximate number of participants	Priority	Contribution to COPES
9	CliC's participation and representation at most important meetings outside of WCRP	Jan 2009, Mar 2009	Iceland, Bergen	CliC Executive	2 to 4	high	key for planning and coordination
10	Changing River and Lake Ice around the Circumpolar North	Mar.09	Victoria BC, Canada;	Terry Prowse		important	assessment, contribution to SWIPA
11	Participation in costs of publication costs of "Handbook on field techniques in sea ice research"	first half 2009	Univ. Alaska Press.	A. Worby, S. Gerland	N/A	important	key publication for sea-ice research, related to the sea-ice issue
12	Black Carbon sampling, albedo effects and climate impact	2009, 2 days, Aug	TBD	S. Gerland, CliC SSG/Co-lead Arctic Sea-Ice WG	30, mostly by invitation	important but not 100% directly for CliC	key for ACC
13	Northern Res Basin (NRB)	Summer 09	In Canadian arctic	K. Young, D. Yang	40 to 50	useful	cooperation, partnership
14	Hydroclimatology of Asian Cryosphere, snow cover data-set and products	2009, Mar	Japan	T. Ohata	up to 20 by invitation	need clarifi-cation	key regioanl issue for water balance, potential contribution to CEOP
15	2008/2009 Annual meeting of CNC-CliC	2009, late Feb	Beijing, China	CNC-CliC (China), D Qin	???	need clarifi-cation	need clarification

Appendix 5

Global Cryosphere Research and the CliC Project
Scientific Requirement Document

(Draft 1)

Daqing Yang

1. Cryosphere impacts and challenges

The term "cryosphere" collectively describes the portions of the Earth's surface where water is in a solid form and includes sea-, lake-, and river-ice, snow cover, glaciers, ice caps and ice sheets, and frozen ground (including permafrost). The cryosphere is an integral part of the global climate system with important linkages and feedbacks through its influence on surface energy, carbon and moisture fluxes, clouds, precipitation, hydrological conditions, and atmospheric and oceanic circulation. The cryosphere plays a significant role in global climate, in climate model response to global change, and as an indicator of change in the climate system. However, the impact and response of the entire cryosphere in the global climate system, and the use of cryospheric indicators for climate change detection, have not been fully understood. There are notable gaps in present studies of cryospheric elements and in the accurate and appropriate treatment of cryospheric processes in climate models:

a. Interactions between the atmosphere snow/ice and land

Better understanding of the interactions and feedback of the land/cryosphere system and their adequate parameterization within climate and hydrological models are needed. Specific issues include the interactions and feedback of terrestrial snow and ice in the current climate and their variability; in land surface processes; and in the hydrological cycle. Improved knowledge is required of the amount, distribution, and variability of solid precipitation on a regional and global scale, and its response to a changing climate. Seasonally-frozen ground and permafrost modulate water and energy fluxes, and the exchange of carbon, between the land and the atmosphere.

b. Interactions between land ice and sea level

The primary issue regarding the role of the cryosphere on sea level is the past, present and future contribution of land ice to sea level change. We need to know how much of the sea level rise over the last 100 years can be explained by changes in land ice volume. In order to understand past sea level change and predict future change, it is essential to measure via ground- and space-based observations and explain the current state of balance of glaciers, ice caps and ice sheets, and especially to resolve the large uncertainties in the mass budgets of the Greenland and Antarctic ice sheets.

c. Interactions between sea ice, oceans, and the atmosphere

Over a considerable fraction of the high-latitude global ocean, sea ice forms a boundary between the atmosphere and the ocean, and considerably influences their interaction. The details and consequences of the role of sea ice in the global climate system are still poorly known. Improved knowledge is needed of the broad-scale time-varying distributions of the physical characteristics of sea ice, particularly ice thickness and the overlying snow-cover thickness, in both hemispheres, and the dominant processes of ice formation, modification, decay and transport which influence and determine ice thickness, composition and

distribution. We do not know how accurate present model predictions of the sea ice responses to climate change are, since the representation of much of the physics is incomplete in many models, and it will be necessary to improve coupled models considerably to provide this predictive capability.

d. Cryospheric interactions with the atmosphere and the ocean on a global scale
Key issues on the global scale understand the direct interactions between the cryosphere and atmosphere, correctly parameterizing the processes involved in models, and providing improved data sets to support these activities. In particular, improved interactive modelling of the atmosphere-cryosphere surface energy budget and surface hydrology, including fresh-water runoff, is required. A key question, given the impact this has on the high sensitivity of the polar regions to climate change, is how the atmosphere responds to and helps determine systematic changes in the ice and snow cover, and how these will influence the response to global warming.

2. CliC scientific strategy

The scientific strategy for the CliC project is similar in each of the areas of interaction: a combination of measurement, observation, monitoring and analysis, field process studies and modelling at a range of time and space scales. The CliC modelling strategy focuses on improved parameterization in models of the direct interactions between all components of the cryosphere, the atmosphere, and the ocean. It will need to do this at a variety of scales from the regional to global; and with a hierarchy of models ranging from those of individual processes to fully coupled climate models. It is also essential to provide the improved data sets necessary for validation of models and parameterization schemes.

A broad observational framework for CliC is provided by the World Meteorological Organization
(WMO) meteorological and hydrological networks, and other regional and global observation networks and systems, such as the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS) and the Global Ocean Observing System (GOOS) relating to the cryosphere; CliC recognizes that satellite remote sensing methods are particularly important. They provide invaluable and often unique observational data for a range of climate and cryosphere studies, including: process studies; analyses of variability at regional to global scales; monitoring climate change; and validation and/or assimilation data for numerical models. Numerous satellite cryospheric data sets or products have already been developed, and more are under development from present and near-future sensor systems, including the European Space Agency (ESA) CryoSat. These new systems will complement the current and future systems including Special Sensor Microwave Imager (SSM/I), Advanced Microwave Scanning Radiometer (AMSR) and Synthetic Aperture Radar (SAR), which provide valuable information on snow and ice resources.

3. CliC–ESA collaboration and benefit

CliC project encourages and promotes research into the cryosphere and its interactions with the global climate system. CliC was on the ICARP II Scientific Steering Committee and organized the development of two ICARP science plans. CliC generated strong input from

the climate research community to the International Polar Year and will lead in establishing a Global Cryosphere Watch (a WMO initiative) as an IPY legacy. CliC also currently collaborates as members of the Initiating Group of SAON, Sustaining Arctic Observing Networks.

CliC has a leading role in coordinating and promoting cryospheric research worldwide. With strong support from many space agencies, including ESA, CliC led the development of a Cryosphere Observing System concept (CryOS): a sustained, robust observing system for the cryosphere. The Integrated Global Observing Strategy (IGOS) published this Theme Report in 2007; the report articulates the requirements in cryospheric observations, data and products, and recommends on their development and maintenance. The implementation of the Theme largely depends on the involvement of major satellite operators like CSA, ESA, JAXA, NASA, and NOAA. CliC is ready to work closely with operational and space agencies to implement some of the important recommendations made in the IGOS-Cryo report.

CliC has directly collaborated in the past with ESA missions. CliC has been involved in the supporting of CryoSat-1 mission and has continuing interest in future missions, such as Cryosat-2 and the concept of COld Regions Hydrology High-Resolution Observatory (CoReH2O), as these missions will fill data gaps and provide critical products for global cryosphere investigations. Furthermore, ESA EO existing data and products are valuable for all four CliC themes (*Terrestrial Cryosphere and Hydroclimatology of Cold Regions; Ice Masses and Sea Level; Marine Cryosphere and Climate; Global Prediction of the Cryosphere*).

The newly established “Support to Science Element (STSE)” under the ESA's Earth Observation Programs provides an exciting opportunity for global earth science research, including cryosphere. CliC project will participate and contribute to this new program to the full extent possible. CliC interacts with many national and international organizations. Its worldwide scientific focus makes it a valuable partner for organis*ations with regional and global interests. CliC strongly believes that partnership with ESA Earth Observation Programs can directly contribute and benefit its objective - to improve understanding and prediction of the changing global cryosphere, and to provide the essential science for sound decision making and policy development. This partnership also benefits ESA Earth Observation Programs. It will stimulate research to address the major science challenges outlined in the “Changing Planet”. It will establish an important communication and feedback mechanism between ESA and earth science research community, and, enhance the exploration and application of existing and new ESA EO data and products for CliC regional and global research activities over various cold regions around the globe. CliC will be very pleased to increase its collaboration with the ESA Earth Observation Programs through its participation in the STSE ITT, STSE projects, and Data User Element (DUE).

Appendix 6

CAPER (CArbon and PERmafrost): towards discussion of a new joint WCRP-CliC and IGBP-AIMES initiative

V.Kattsov and Kathy Hibbard

The IPCC WG-1 Fourth Assessment Report (2007) highlighted the cryosphere as a major source of global climate projection uncertainties. Significant knowledge gaps related to cryosphere include the impact of thawing permafrost on the global carbon cycle in the warming climate. The magnitude of the positive feedback between the warming climate and additional emission of greenhouse gases into the atmosphere from natural sources and particularly from thawing permafrost is unknown. Some scientists believe the effect may be catastrophic, while others are skeptical about the significance of the effect. The picture is complicated by insufficient understanding of the interactions between terrestrial cryosphere, hydrology and vegetation in the northern high latitudes (NHL) in the warming climate.

The current generation Earth system models (ESM) do not include processes that account for regional dynamics, but rather, include carbon cycle models from first principles that, for example, do not account for functional attributes of organic or peatland soils. Because there has been limited progress in regional modelling efforts about how the carbon cycle of the NHL will respond to climate change, it is not surprising that coupled carbon-climate models do not represent processes that are thought to be important in the arctic carbon cycle. Some ESMs have developed globally coupled biogeochemistry and dynamic vegetation components, but these results are limited to a few groups. Others have also implemented physical and/or hydrologic dynamics of NHL into global climate models (e.g., Lawrence and Slater, 2005), but they do not account for the biogeochemistry of the coupled hydrology and carbon cycle-permafrost dynamics.

McGuire et al., (submitted) suggest that key processes in the NHL carbon cycle can be tested with regional terrestrial ecosystem models providing insight into the importance of understanding the context of regional NHL carbon cycle and permafrost dynamics for global model development. Testable hypothesis include tradeoffs between CO_2 and increased methane emissions with warming, wildfire and CO_2 emissions and decomposition processes. Improved regional understanding can be attained through an iterative communication between the observing, measuring and modelling communities that transmit process understanding to model development and parameterization, incorporating the understanding gained from integrated studies into both uncoupled and fully coupled carbon-climate modelling efforts. Model results can then be used to test hypotheses about carbon cycle dynamics that are not observable or measureable, improving experimental designs for field campaigns and individual process studies.

We propose a joint CLiC and AIMES activity that will promote complementary approaches for understanding and quantifying carbon cycle and permafrost dynamics across scales of observations, measurements and models for regional to global analyses. The goal is to develop a coordinated modelling framework for the NHL to quantify key vulnerabilities and thresholds of the coupled carbon-climate system. An implementation strategy includes collaboration with existing international coordinated bodies, for instance, from the observation and measurement perspective, NEESPI and from the

global climate perspective the C^{4}MIP communities. A CliC-AIMES NHL-focused activity will aim to improve the representation of key NHL processes in regional and Earth System models drawing on studies from local and regional observational, experimental and modelling communities through an iterative process to facilitate analyses of feedbacks between biogeochemistry and climate across scales with an emphasis on the coupled permafrost-carbon and hydrologic system.

We suggest that two focused workshops occur in 2009/2010 to develop coordinated strategies for translating process understanding to model parameterization and initialization and to providing feedback from model experiments from regional to global context for NHL interactions with the climate system.

Appendix 7

A Data Processing Strategy for Satellite Data Collected during the IPY
Prepared by GIIPSY
Submitted to the IPY Space Task Group, November 20, 2008

DRAFT 1.0

The International Polar Year Space Task Group (IPY STG) is organized through the World Meteorological Organization to acquire bipolar, legacy data sets using spaceborne, earth observing systems. STG membership includes representatives from most of the world's space agencies, who together are engaged in a coordinated effort to support the IPY. Scientific guidance is provided by the IPY-approved GIIPSY project which has developed a set of detailed scientific goals and observational requirements (http://bprc.osu.edu/rsl/GIIPSY/).

After two years of dedicated effort, the STG can point to major accomplishments in fulfillment of GIIPSY observational requirements. These include PALSAR coverage of Antarctica and parts of the Arctic basin, the completion of Radarsat 2 polarimetric imaging of Antarctica, the start of Radarsat-2, ERS-2 and TerraSAR X interferometric observations over Antarctica, coverage of the western arctic basin with Envisat and R1/2, the start of a new ERS-2 InSAR campaign over the arctic and the work using SPOT to create DEMs over selected regions (SPIRIT Project).

The original aim of GIIPSY and the STG was to acquire legacy data sets - that is to make sure data were acquired while deferring complex issues associated with processing the data. Indeed, learning how to do coordinated acquisitions proved a challenge. Now, and given the successes mentioned above, members of the STG and GIIPSY are confident the first step has been taken and it seems prudent to begin thinking about data processing. To that end, the Canadian Space Agency representative to the STG, who is also the chair of the STG SAR Subgroup, called on GIIPSY and the broader science community to develop a data processing strategy.

In the spirit of the IPY data acquisition phase, we present here a data processing strategy wherein the shared resources of the international space agencies can be used to effectively and economically process the voluminous and diverse data set. We believe this can be accomplished if the agencies can focus on specific and well defined themes specified by the science community. Our objective is to identify the most important and unique data products that could be created from the IPY data set. Selection criteria include that the products have high scientific value, be applicable for use by policy makers and be generally exciting to the public. For example in the tables below, we recommend a pole to coast velocity map of Antarctica. Completion will require collaboration between CSA, DLR, ESA, JAXA, and ASI who can provide SAR data and NASA, JAXA and CNES who can provide topographic data through their SPOT, PRISM, ASTER and ICEsat instrument data streams. We can envision that by working together, the agencies could distribute the processing load between different tasks and over different geographical sectors of the Antarctic while still assembling a seamless velocity product. Digital elevation models from high resolution optical and laser data are important integrative data sets in their own right. MODIS and MERIS visible and infra-red data may present additional data synthesis opportunities for products such as maps of seasonal snow cover.

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This approach we are recommending is different from the conventional, single investigator driven processing activity. It has several potential advantages. First, it can help resolve some of the issues associated with releasing 'raw' data that might have commercial licensing restrictions. We believe that concentrating on a select set of higher level data products can avoid that issue. Second, it spreads the financial load across the partners. Third, it immediately focuses on distributing the most important products directly to the user/modelling community. There is risk of course because this level of coordination and cooperation is untried.

There are three elements to the strategy. The first, and the one addressed in detail here, is to identify the key science objectives and the associated data products. This task rightly falls to the science community and is well understood. The second element is to seek concurrence on the plan from the STG members who will be responsible for securing resources for processing their contributed data sets. Each agency will have to work through its particular and prescribed approaches for seeking resources. The final element is data fusion into seamless products and will involve both the participating agencies and the science community. This last element is the least well defined and will require development of data fusion protocols and procedures for assuring data product quality.

Turning to the first element of the strategy, the complete set of GIIPSY science and observational requirements can be found at:
http://bprc.osu.edu/rsl/GIIPSY/index_files/GIIPSYScienceRequirements.htm.

Science objectives span a range of polar processes from river ice formation to motion of the Antarctic sea ice pack. Observational requirements are similarly wide ranging. These include moderate resolution optical and infra-red images to high resolution SAR and InSAR data sets. The science objectives and requirements were adopted by the STG as a long range goal. To better direct their work, the STG early on identified a subset of objectives intended to leave an IPY legacy of bipolar snapshots, based on satellite data, comprising a series of scientific firsts. These are:

- For the first time, pole to coast multi-frequency InSAR measurements of ice-sheet surface velocity.
- For the first time, repeat fine-resolution SAR mapping of the entire Southern Ocean sea-ice cover for sea ice motion.
- For the first time, one complete high resolution visible and thermal IR (Vis/IR) snapshot of circumpolar permafrost.
- For the first time, pan-Arctic high and moderate resolution Vis/IR snapshots of freshwater (lake and river) freeze-up and break-up.

Subsequent to meetings at CSA and DLR, the SAR subgroup further specified this set of observational objectives:

- C-Band coverage (3-day snapshots) for the Arctic Ocean during the remainder of IPY (background missions, operation data acquisitions, etc.).
- Winter pole to coast InSAR coverage of the Antarctic in high-resolution mode (3-4 consecutive cycles in ascending and descending).

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- Greenland and major Canadian Icefields InSAR acquisition over 3-4 consecutive cycles of high-resolution in winter.
- Supersites for multi-polarization and frequency data collection.

Based on these observational objectives and the selection criteria discussed above, we have prepared two tables which list the data products that can be created from the expected acquisition suite and which address the GIIPSY science requirements. In general, the algorithms and methods for creating these products are well known and there is a wealth of expertise from which to draw lessons on the processing details.

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Table 1: Science Products Supported with SAR

Data Product	Product Specification	Satellite System
1 winter C band SAR image of the Antarctic	25 m grid, orthorectified, radiometrically seamless polarimetric data set; subsets provided at 100 and 200 m grid spacing, polar stereographic project, -71 S	Radarsat-2
1 winter and 1 summer L,C and X band image of viewable Antarctica, Greenland and the Arctic Ice Caps	25 m grid, orthorectified, radiometrically seamless polarimetric data set; subsets provided at 100 and 200 m grid spacing, polar stereographic project, -71 S	Combination of ASAR, COSMOS-SKYMED, TerraSAR-X, Radarsat-2, ERS-2, PALSAR
1 pole-to-coast surface velocity map of the Greenland and Antarctic Ice Sheets	500 m post spacing, x,y,z components of velocity vector (ascending/descending; InSAR/speckle), geocoded	Combination of ASAR, COSMOS-SKYMED, TerraSAR-X, Radarsat-2, ERS-2, PALSAR(DEM requirements fulfilled by optical and laser data - see table 2)
1 complete surface velocity map of the major Canadian Icefields	500 m post spacing, x,y,z components of velocity vector (ascending/descending; InSAR/speckle), geocoded	Combination of ASAR, COSMOS-SKYMED, TerraSAR-X, Radarsat-2, ERS-2, PALSAR (DEM requirements fulfilled by optical and laser data - see table 2)
Arctic Sea Ice Motion Fields	1km spacing x,y components of sea-ice velocity	ASAR GMM and WSM mode swath and mosaic-derived products

Table 2: Science Products Supported by Optical and Laser System

Data Product	Product Specification	Satellite System
Digital Elevation Models of the Coastal Regions of the Polar Ice Sheets	See SPIRIT PROJECT TBD	SPOT, PRISM, ASTER
Integrated Digital Elevation Models of the Polar Ice sheets and Ice Caps	TBD	SPOT, PRISM, ASTER ICEsat data set, Cryosat
Continent-scale Mosaics	NRCan, 250m (TBC)	MODIS,
Arctic Mosaics	GlobCover, 300m	SPOT, Landsat, MERIS
Snow/Ice Surface Temp.	TBD	MODIS/AATSR

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We believe that creation of these products facilitate major advancements in polar science. It would also demonstrate a new paradigm for data production and dissemination much as the STG data acquisition activity itself has been a ground breaking effort in international cooperation. Nevertheless, it should be noted that the IPY data base will surely contain additional information not yet fully appreciated. Extracting this information will rely on a more traditional research based approach. Addressing the full range of issues presented by individual exploration of the data set will await the outcome of this first effort.

Global Prediction of the Cryosphere: Thoughts for 2009-1010
J. Turner/A. Rinke

To improve prediction of many elements of the cryosphere, we need improve d models. For example; with sea ice there is simply no way that we can make reliable predictions without realistic coupled atmosphere-ocean-sea ice models. However, as was clear with the IPCC AR4 models, it is a major challenge to get all three components right, and small errors in any part of the system can result in large errors in the sea ice. A great deal of work is underway to improve the atmospheric, oceanic and sea-ice elements of global climate models, and CliC is involved with the sea-ice representation via various initiatives. However, complementary to the global models are the regional climate models, which have the long-term potential to deliver better cryospheric predictions as a result of their higher horizontal resolution and improved representation of regional climate processes. Such models are being run across both polar regions with atmosphere-only, ocean-only and coupled-models being under development. Atmosphere-only models have been used to investigate high latitude atmospheric processes and as part of high horizontal weather forecasting systems. But since sea ice must be specified within such models, their output cannot help with prediction of sea ice.

The long-term goal must be to develop fully coupled regional atmosphere-ocean-sea ice models that are embedded within global models and obtain their lateral boundary conditions from the global models. This is a very difficult problem, and there are many issues to be overcome in coupling the different components. However, such high-resolution coupled models offer great potential for aiding research into issues such as how the ice shelves around the Antarctic may change in the future, which is important for understanding the evolution of the ice sheets. Sophisticated models of the ocean flow under the ice shelves are available, but are currently run in isolation and forced by reanalysis fields. In the future it is hoped that the regional climate models will incorporate better representation of the ice shelves, although this is again a major challenge.

Aiding the development of the regional climate models is one way that CliC could contribute to improved prediction of the cryosphere. There is already a high degree of coordination of RCMs in the Arctic via the Arctic Regional Climate Model Intercomparison (ARCMIP) project. Annette Rinke is involved in this effort and will be able to provide details of the project. There is no comparable initiative for the Antarctic, and no effort concerned specifically with the cryosphere. Such models have the potential to improve prediction of a number of elements of the cryosphere besides sea ice, such as permafrost and snow cover, by giving improved high-resolution predictions of precipitation and temperature. Such data would also be valuable as input to ice-sheet models, and via downscaling to river-and lake-ice prediction.

We would initially suggest having a small workshop on a theme such as *Prediction of the cryosphere using Regional Climate Models*. This would be by invitation only and would focus on determining our capability to predict the various elements of the cryosphere using regional climate models, and on proposing future research needs.