

WCRP REPORT

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Summary Report

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of the Climate and Cryosphere Project
Scientific Steering Group

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Submitted by Jenny Baeseman (CliC Director) and Vladimir Ryabinin



Left to Right: C. Duguay, W. Meier, A. Rinke, V. Rachold, M. Raphael, V. Romanovsky, A. Klepikov, G. Cassassa, M. Drinkwater, J. Stähelin, J. Baeseman, C. Feirz, V. Ryabinin, G. Kaser, M. Sparrow, N. Koç, S. Gerland, H. Rott, T. Ohata, G. Asrar, and K. Steffen.

Opening, CliC status and goals of the session

The meeting was opened by SSG Chair, Konrad Steffen, at 13:30 on Monday 12 March 2012. Helmut Rott, a CliC SSG member and the host of the session, welcomed participants on behalf of the Research Center for Climate and Cryosphere of the University of Innsbruck. The session took place at the Department for Natural Hazards and Alpine Timberline of the Austrian Federal Research and Training Centre for Forests, Natural Hazards and Landscape based at the Innsbruck Hofburg. Its representative, Karl Kleemayr warmly welcomed the participants to the Institute and Innsbruck.

In the introductory talk Konrad Steffen reminded the participants of the goals of the CliC project and analysed its current state. The important issues highlighted in the talk and the ensuing discussions were as follows:

- The need to organise better reporting and follow-up from CliC-sponsored workshops, which may require monitoring and a template to be used for the reporting
- The importance of developing an efficient CliC outreach program
- The need to consider how the knowledge on cryosphere and related observations, modelling and prediction can help the development of emerging climate services
- Need to attract leading scientists to guide and develop CliC activities such as
 - ice sheet research for sea-level assessments
 - ice shelf modelling
 - the CliC fresh water initiative
 - the cryospheric and polar dimension of major modelling and data assimilation experiments such as CMIP5 and CORDEX, the Arctic System Reanalysis, etc.
- Future of CliC initiatives such as ARCHIMEDES, SOPHOCLES, an intercomparison of passive microwave algorithms for sea-ice cover and related initiatives such as the WCRP polar climate predictability initiative, research on permafrost and carbon, etc.

- The need to facilitate the accelerated development of sea-ice and snow modelling and data assimilation and its pick-up into climate models and prediction schemes
- The need to move ahead on prediction of changes in the mountain cryosphere and its role in future water resources
- Overall progress and coordination of sea-level research addressing the role of ice sheets and their dynamics, warming ocean effect of accelerated melting, etc.
- Representation of CliC and its liaison with WCRP constituencies such as WCRP Modelling and Data Advisory Councils, Working Group on Coupled Modelling and Working Group on Seasonal to Inter-annual Prediction
- CliC's role in the new WCRP Grand Challenges
- The need of overall strengthening of CliC contributions to all relevant aspects of climate model development and climate prediction at a wide spectrum of time and space scales
- New membership of CliC SSG and working bodies
- Considerations if CliC has to adjust the title of the project to better reflect new requirements of the project

1. Stakeholders update

Updates were provided by the International Association for Cryospheric Sciences (IACS, represented by Charles Fierz), the International Arctic Science Committee (IASC, represented by Volker Rachold), and the Scientific Committee on Antarctic Research (SCAR, represented by Michael Sparrow).

The IACS division on Cryosphere, Atmosphere and Climate, which is led by Valérie Masson Delmotte, is the closest to the scope of CliC activities. Among other activities, IACS plans are to concentrate on research of glaciers and seasonal snow. For the former the priorities are better glacier inventories that can be developed in cooperation with the Global Terrestrial Network for Glaciers (GTN-G) and other relevant partners and improved parameterizations of the regional response of glaciers to changing climate. This priority is definitely shared by WCRP and CliC. Other potentially important issues for IACS include permafrost and methane release and mid-latitude snow and ice hydrology. Many CliC-affiliated scientists will take part in the joint IAMAS-IACS Davos Atmosphere and Cryosphere Assembly on 8-13 July 2013 (www.daca-13.org), and several sessions of prime interest to CliC will be organized at that meeting, which offers an opportunity to determine common activities with CliC. The desire for the development of a memorandum of understanding between CliC and IACS was discussed, in addition to CliC joining the 'Cryosphere organizations' MoU signed by other partners last October.

There are very significant common interests between CliC and IASC Working Groups and activities, especially the groups on cryosphere, atmosphere, and marine; and there is large cross-representation of researchers on the groups and in CliC activities. The most recent SWIPA assessment was a project in which both IASC and CliC actively contributed. Many of IASC-affiliated networks are of significant interest to WCRP and CliC. Therefore, optimization and prioritization may be recommended, potentially based on an analysis of the current activities and their relevance for the core common goals of CliC and IASC. Communication and coordination are key, and an agreement on who acts as a leader and who is a contributor may be instrumental for specific activities. Such considerations may help the WCRP and CliC contribution to the potential 3rd International Conference on Arctic Research Planning (ICARP); however, it is equally essential to efficiently implement ideas expressed at the ICARP-2 in Copenhagen in 2005. IASC research activities of main interest to CliC are related to carbon and permafrost, improving the global inventory of glaciers and ice caps, compiling a current assessment of glacier and ice cap loss rates, improving existing loss rate projection methods, studying and modelling polar atmosphere and its interactions with sea ice, and understanding and predicting rapid changes to the Arctic Ocean system and the role of sea ice in them. As one of the sponsors of the Sustaining Arctic Observing Networks (SAON), IASC welcomes WCRP and CliC contributions to establishing observations in the Arctic region. For the Integrated Arctic Ocean Observation System (iAOOS), the plan involves designing an intensive international multidisciplinary research effort initially with its focus

on the Greater Canada Basin and its marginal ice zone. Polar Climate Predictability is an issue of growing interest particularly as it becomes clear that Arctic amplification has an impact on lower latitudes. IASC, together with WCRP and CliC can play a leading role in bringing the international community together to address issues related to decadal and multi-decadal prediction. IASC together with SCAR and WCRP have a MoU on co-sponsorship of CliC that is in effect until July 2013. Discussions should be started on the next phase of the partnership.

There is well-developed cooperation between WCRP and SCAR. The Open Science Conference of SCAR in July 2012 in Portland, USA, will be a milestone in initiating a number of WCRP-relevant initiatives and projects and summarising important existing activities, such as the Antarctic Climate Change and the Environment (ACCE), Southern Ocean Observing System (SOOS), Ice Sheet Mass Balance (ISMASS), Antarctic Sea-ice Processes and Climate (ASPeCt), the CLIVAR/CliC/SCAR Southern Ocean panel, and the WCRP-SCAR International Programme for Antarctic Buoys (IPAB). SCAR data management efforts, such as the REference Antarctic Data for Environmental Research (READER) can be of significant interest for WCRP and CliC. As in the case of IASC, coordination and efficient representation of various initiatives was considered essential, particularly while SCAR is moving ahead with the establishment of several new large-scale programs such as the Antarctic Climate in the 21st Century (AntClim21). The fundamental outcome of this program will be improved predictions of the future role and response of Antarctica to global change. The Programme “Past Antarctic Ice Sheet Dynamics” (PAIS) will be of central interest for sea-level research.

The following potential issues and activities were indicated in the discussions on CliC interaction with stakeholders:

- There is a need to review existing memorandums of understanding of CliC reflecting current goals, ideas and availability to resources to achieve the project objectives. CliC IPO is well positioned to offer liaison to many research organizations with cryospheric interest. A database of funded cryospheric projects may be of interest for planning purposes and gaps analysis. This might be an instrument of informing funders of polar and cryospheric research as well as aiding researchers in the development of new collaborations and initiatives.
- The issues considered revealed the necessity of close coordination of the CliC work with IASC and SCAR, which involve in their work, in many cases, the same people. The closest links should be with the IASC WGs on cryosphere and atmosphere and the leading scientists of the new SCAR research programmes. One of these initiatives is Ice Sheets and Mass Balance (ISMASS), in which WCRP is a cosponsor of the forthcoming workshop on 14 July 2012. Edward Hanna is representing CliC on ISMASS.

2. Update on WCRP and its projects

The update on WCRP was provided in talks by Tony Busalacchi (by Skype) and Ghasem Asrar. Representatives of all WCRP core projects addressed the CliC SSG speaking on their existing and desirable cooperation with CliC. Johannes Staehelin spoke on behalf of SPARC. Talks on GEWEX by Kevin Trenberth and CLIVAR by Martin Visbeck were given via Skype.

Future planning of the WCRP activities has been strongly stimulated by a very successful and well-attended Open Science Conference in Denver, USA, in October 2011, which identified a strong need in actionable climate science. The development of the Global Framework of Climate Services is dependent on focussed input of climate research with respect of global and regional climate issues. In that connection CliC has a lot to offer to climate services, particularly for the Arctic. The real needs will have to be formulated in a dialog between users and scientists. Another development in the arena of global change research is the formation of the “Future Earth“ initiative, which will subsume IGBP, IHDP and Diversitas’ structures at the programme level. WCRP has very recently established two advisory councils, on modelling and data, and they will coordinate modelling, observation and data management

aspects across WCRP, also addressing the development of reanalyses. The councils will make an attempt of identifying efforts in the WCRP core projects that can use coordination support.

Polar processes are probably the area of the strongest joint interest of SPARC and CliC. SPARC unites research on atmospheric dynamics and chemistry, and one of its foci, which is particularly prominent in the polar regions, is the stratospheric ozone. SPARC has been successful in developing quantitative metrics for Climate-Chemistry Models and this helped the project to make a seminal contribution to the WMO/UNEP Scientific Assessment of Ozone Depletion, particularly in 2010. Potential avenues of joint activities with GEWEX could include, among other issues, a global snow cover assessment. Some GEWEX regional hydroclimate projects, such as NEESPI, have a strong bearing on CliC. Research on hydrological processes in high latitudes is still very much limited and needs to be enhanced. Polar and cryospheric aspects of research that are conducted by CLIVAR make CliC an important potential contributor to almost all CLIVAR imperatives. CliC is expected to help with the sea-ice component of the CHFP project, aimed at studying seasonal predictability. There are similar requirements for research on the decadal time scale. Cryospheric input is awaited for CMIP simulations and some other CLIVAR activities such as Coordinated ocean-ice reference experiments (CORE) of the Working Group in Ocean Model Development. CliC and CLIVAR are the two main projects that are in position and are also expected to lead on almost all aspects of the research on regional sea level and its extremes. Still pending is the issue how to address coordination of the Arctic climate research within WCRP and organization of effective partnerships with the relevant organizations such as IASC. The needs for research activities in the Southern Ocean are covered by the joint CLIVAR/CliC/SCAR Southern Ocean Panel, which also contributes to the development of the Southern Ocean Observing System.

3. Interaction with polar (prediction) initiatives

This theme was introduced by Vladimir Ryabinin. Based on recommendations from a dedicated workshop on the International Polar Decade (IPD) initiative (St. Petersburg, Russian Federation, April 2011), a steering group is reviewing approaches to formulating a Concept of a new initiative that would preserve the legacy of the International Polar Year 2007-2008 (IPY). The concept is supposed to be first unveiled to the wider audience at the IPY 2012 Conference “From Knowledge to Action” (Montreal, Canada, April 2012) and various side meetings at the conference. The Steering Group proposes a novel cooperation framework provisionally entitled “International Polar Initiative” (IPI). Based on input from the various communities, it seeks to design a common implementation plan for the development of observing systems, research, services, related education and outreach, and practical applications of scientific knowledge in the Polar Regions that would optimize the use of existing resources and identify areas where new investments in polar activities are necessary for environmental protection, sustainable development of the regions, and addressing existing and emerging societal needs. Climate is a focus for IPI. The SSG noted the development of IPI and agreed that while its concept is being developed, this should not stop or delay any polar activities of interest to WCRP.

Under the WMO Expert Team on Polar Observations, Research and Services (EC-PORS), there is a proposal to develop a Global Integrated Polar Prediction System (GIPPS) that is going to provide experimental and, later, operational predictions on three time scales, from hours to a season, from seasons to decades, and for time scales of relevance to sea-level rise aspects. The World Weather Research Programme is developing the Polar Prediction Project (PPP) as a legacy of the International Polar Year 2007-2008 (IPY) polar weather prediction research. It is focusing on the GIPPS time scales from weather nowcasting to a season. The project is chaired by Dr Thomas Jung of AWI, Germany. It has an established steering group and their implementation plan is almost complete.

Based on the recommendations from the WCRP workshop in Bergen in October 2010, a group of scientists chaired by Ted Shepherd is working on the implementation considerations for a WCRP polar climate predictability initiative. Several people in this group are also affiliated with other research entities such as the International Arctic Science Committee (IASC), and particularly the IASC Working

Group on Atmosphere. For that reason this activity enjoys the interest and support of IASC. The objective of the WCRP/IASC workshop in Toronto on 2-4 April 2012 was to discuss an implementation strategy for the initiative. This draft strategy will be presented to the WCRP JSC-33 in Beijing July 2012.

There is close working contact between the scientists and coordinators developing the WCRP Polar Climate Predictability Initiative and the PPP project. There is also very significant common interest between the groups, including sharing knowledge on aspects of polar ocean, atmosphere, snow and sea-ice modelling and data assimilation. Early cooperation between groups focusing on the interaction of time scales is useful for exploiting possible “seamlessness” of future polar prediction.

WCRP intends to develop its polar initiative as a part of the identified Grand Challenge on provision of regional climate information. In the WCRP traditions, the initiative will address critical issues in our understanding of polar climate predictability. It will have activities focussing on the Arctic, the Southern Ocean and Antarctic. Existence of scientific interest and the ability to achieve progress in key aspects of the scientific issue will be taken into account in developing the programme.

The implementation mechanisms include workshops, temporary working groups, cooperation with developers of reanalyses, numerical experiments, etc. A Year of Polar Prediction (YOPP), tentatively planned for 2016-2018, will be taken into account in the planning. The PPP and WCRP Polar Climate Predictability initiative will be a WCRP contribution to the emerging International Polar Initiative.

3.1 Enabling Antarctic climate prediction

This agenda item and the sub-items under it were introduced by Vladimir Ryabinin, Alexander Klepikov, Michael Sparrow and Marilyn Raphael. Enabling Antarctic climate prediction and providing for this the necessary cryospheric knowledge and expertise is one of the long-term objectives of CliC. The main WCRP-affiliated means of achieving progress in this domain will be the emerging WCRP Polar Climate Predictability Initiative and its part for the Antarctic and Southern Ocean. The CLIVAR/CliC/SCAR Southern Ocean Panel (SOP), the Antarctic Observing Network (AntON), the Southern Ocean Observing System (SOOS), the Antarctic Sea-Ice Processes and Climate (ASPeCt), and the International Programme for Antarctic Buoys (IPAB) will be the main building blocks for these initiatives in the Southern Hemisphere. There exist many issues of their joint interest. Many new SCAR programmes as outlined in the introductory talk by Michael Sparrow under agenda item 2 will be focussed on various aspects of Antarctic climate prediction. Many IPY projects such as CASO and SASSI can be used as a platform for future advances. The strong coupling between polar oceans, sea ice, troposphere, and stratosphere calls for an interdisciplinary approach to research on this regional climate system, and the main focus of this research should be the improved understanding of the workings of the climate system and identification of the main drivers of change, which likely include the alterations in the stratospheric ozone layer, interaction of the ocean with ice sheets and ice shelves, the greenhouse effect, the role of the Southern Ocean in the global carbon balance.

3.2 Enabling Arctic climate prediction

This agenda item and the sub-items under it were introduced by Vladimir Ryabinin, Walt Meier, Vladimir Romanovsky, and Volker Rachold. The main focus for the Arctic should be on the role of snow and sea-ice in climate predictability and prediction, and the greatest challenge is to investigate the explanations for the inability of CMIP3 models, and also likely CMIP5 models, to reproduce the observed reduction in sea-ice cover at the beginning of this century. The CliC Arctic Sea-Ice Working Group is expanding and refocusing its activities to involve more modelling and process studies, in cooperation with related initiatives as the Sea-Ice Outlook of U.S. SEARCH. Seasonal prediction of sea ice cover or extent, particularly of its September minimal value, remains the area of most significant interest. Intercomparison of ice extent algorithms and their generalization, so that they are able to satisfy

the interest of users in having access to the least uncertain and uncontroversial sea-ice extent data, will remain high-priority activities for CliC.

There is a need to address the multitude of issues related to the role of the Arctic Ocean in climate and the corresponding engagement of the Arctic oceanographic community. Joint work with the IASC Marine group (formerly AOSB) may cover some of the needs but at present there is no solution that is capable of ensuring that Arctic Ocean data requirements for climate research and prediction are met. Relations with the Pacific Action Group (PAG) of IASC would also be valuable in this context.

Together with the International Permafrost Association (IPA) and the Global Carbon Project, in 2004 CliC started to promote the research on the role of thawing permafrost in the carbon cycle. The IPY Permafrost and Carbon (PEACE) and, later, CAPER, projects were the next steps in this research. At present many groups work in this area of research and there is a need for their coordination. This work has to involve IASC Working Groups. There is a need to have balanced activities both in Europe and North America and there is a need to have adequate involvement of Russian researchers. Several studies indicate a possibility of Arctic turning into a carbon source in not so distant perspective. CliC may also consider expanding support to the research on release of methane in from sub-sea permafrost. These issues can be included in the Memorandum of Understanding with IPA that needs to be renewed.

4. Cryosphere observations and data services

Based on the presentation on the WMO Global Cryosphere Watch made by Barry Goodison (by Skype), CliC SSG discussed necessary contribution of the CliC community to the development of the CRYOS, The Cryosphere Observing System, proposed in the CliC-supported IGOS Theme on Cryosphere. CliC can formulate research requirements for the development of cryospheric supersites. The development of new observing methods and data processing techniques for satellite observations is required. CliC regional activities may provide a platform for corresponding regional development of GCW. A clear priority would be the development of snow products including for snow on sea ice. Walter Meier was asked to be a liaison between CliC and GCW.

Mark Drinkwater reported that the cryosphere is a strong focus of ESA and CliC is a “champion user” of many ESA activities including its Climate Change Initiative, Data User Element, and Support to Science Element. This involves such projects like GlobSnow, GlobIce, GlobGlacier, and the ESA permafrost project. CliC has agreed to organise, together with ESA and EGU, an ESA/CliC/EGU Conference on Earth Observations for Cryosphere. It will be held in Frascati, in November 2012 (See <http://www.eo4cryosphere.info/> for more details).

5. Cryospheric and cold climate modelling

Annette Rinke reviewed main directions of cryosphere and cold climate region model development. Usually, forcing of cryospheric models requires very high-resolution atmospheric data. This in turn requires systematic work to promote the development of high-resolution regional climate models (RCMs) and corresponding downscaling techniques. The following directions of modelling research are therefore of primary importance to CliC:

- improving representation of cryospheric processes in models and better understanding of physical processes/feedbacks through which cryosphere interacts within the climate system,
- research on high latitude atmospheric and cryospheric processes as well as atmosphere-cryosphere interactions using RCMs,
- improving parameterizations of the key processes in the atmosphere (boundary layer, clouds/aerosol), land surface (hydrology, permafrost, wetlands), snow (aging, black carbon, redistribution), sea ice (albedo, melt ponds), and

- development of regional Earth System modes with a focus on the Greenland ice sheet, dynamic vegetation models, and river routing schemes.

The models ability to simulate the realistic summer sea-ice extent depends on both the reproduction of the atmospheric circulation during summer and the reasonable ice thickness distribution in spring, which in turn depends on the preconditioning during previous years. This requires realism of representation of the inner-Arctic feedback processes and the initial state of the climate system. Two types of international coordination activities can help CliC to provide useful input in to this work. CliC should promote

- improved linkages between the cryosphere/atmosphere observation and process study communities and the global and regional modelling community and
- cross-disciplinary work (as many model shortcomings in cryosphere aspects derive from errors not in the cryosphere components themselves, but rather from the coupling with the atmosphere or ocean).

Joint work of CliC-affiliated researchers and the IASC Working Group on Atmosphere is very promising, especially with respect to the large-scale field experiment that is being planned in the Arctic. CliC should stimulate climate prediction and projection experiments for the high latitudes including ones at high resolution. Participation of several modelling groups in the Arctic and Antarctic CORDEX looks very promising. CliC should promote this work and its subsequent analysis.

6. Sea-level and terrestrial cryosphere

The work on addressing shortcomings, uncertainties and resolving differences in estimates of cryospheric contributions to sea-level rise is accelerating as the final stage of preparation of the IPCC Fifth Assessment Report is approaching. There has been a concern in IPCC circles that progress will not be sufficient because there is still a rather poor agreement between estimates of ice sheet mass balance (and the consequent global sea level contribution) as determined using the three satellite geodetic techniques of altimetry, interferometry (mass budget), and gravimetry. To address this issue, ESA and NASA have stimulated a one year- August 2011- 2012 Ice sheet Mass Balance Inter-comparison Exercise (IMBIE) to reconcile the current differences in geodetic estimates of ice sheet mass balance. The idea was to investigate the causes for differences and refine current methodologies. Several CliC-affiliated scientists take active part in this project. In addition, there is very significant research underway on all factors contributing to sea-level changes. There are now new estimates of ground-water contribution to sea level that were not available several years ago. Konrad Steffen, the CliC SSG Chair, is going to change jobs and is stepping down from leading CliC activities including the work of the CliC's theme on cryospheric contribution to sea-level rise. There is also a need to keep providing leadership and support to the WCRP-IOC Task Group on Sea-level variability and change.

The EU Ice2Sea project provides an excellent platform for moving ahead on the cryospheric contribution to sea-level rise. As stated above, modelling of the changes in glaciers and ice sheets requires high-resolution forcing from atmospheric models. The regional analysis for Patagonia, the area exhibiting large mass turnover and high sensitivity to climate change, has shown a possibility to qualitatively well downscale reanalysis and GCM for using a mass balance model of glaciers that reproduce mass balance changes observed in the past. After correction of temperature and precipitation biases in the model, there is a possibility to undertake experimental projections of the regional mass balance for the future. One requirement for such estimates is a complete inventory of glacier outlines and related hypsometry. The existing models will make it possible to derive, with sufficient accuracy, the present day glacier volumes and use the existing models for reconstruction and projection of the future volumes.

7. Northern Hydrology

The overall goal of the Northern Hydrology initiative is to support the international efforts coordinated by the CliC project of the WCRP to exploit the use of EO technology, models and in situ data to improve the characterization of river and lake ice processes and their contribution to the Northern Hydrology system. It aims to develop a portfolio of novel multi-mission geo-information products (maximizing the use of ESA data), improving the current characterization of river and lakes ice dynamics to enhance NWP and modelling of key hydrological processes at northern latitudes. The work will start with consolidation of scientific requirements for the project, in collaboration with the CliC community, modellers and national authorities, and defining the characteristics of the target products, the models and the experimental dataset to be developed. The main phase will concern the development, implementation and validation of the target products and adaptation of the models. This shall be supported by a verification analysis justifying the implementation choices. The tools developed will be used to generate the experimental dataset and experimental model outputs. A CliC workshop may be required to brainstorm on freshwater hydrology and fluxes. This can be a contribution to the Arctic HYDRA project and probably needs to be done in cooperation with the group managing the project.

8. Regional Activities

The highlights of the CliC regional activities are the continuing development of the Asia-CliC and emerging activities in South America. Several important CliC-related meetings have taken place in China including

- the International Conference “Cryospheric Issues in Regional Sustainable Development” (Lijiang, China, August 12-14, 2010),
- 50th Anniversary of Tianshan Glaciological Station & Symposium on Science and Monitoring of Glaciers (August 8-12, 2011), and
- the International Symposium on Changing Cryosphere, Water Availability and Sustainable Development in Central Asia (Urumqi, China, October 8-10, 2011).

The major event for 2012 will be the “International Conference on Cryosphere: Changes, Impacts, and Adaptation” (Sanya City, China, November 10-12, 2012).

In Japan a major initiative is the Cryosphere Data Archive Partnership (CrDAP), which acts as a basis for archiving the available Asian cryosphere data. The Japan Society of Snow and Ice and committees related to cryosphere in the Science Council of Japan agreed to coordinate their activities in the domain of the cryosphere. The Second International Symposium on Arctic Research (ISAR-2) was held in December 7-9, 2010 in Tokyo. Cryospheric research comprises an essential part of the new research program “Rapid Change of the Arctic Climate System and its Global Influences” to be implemented in 2011-2016. Its strategic research targets are:

- understanding the mechanism of warming amplification in the Arctic,
- understanding the role of Arctic in global climate and its future change,
- evaluation of the effects of Arctic change on weather in Japan, marine ecosystems and fisheries, and
- prediction of sea-ice distribution and effects upon Arctic sea routes.

A Japan Consortium for Arctic Environmental Research was formed to implement the program. The Third International Symposium on the Arctic Research (ISAR-3) will take place in Tokyo, Japan, 15-17 January, 2013.

In order to strengthen the interaction between Asian countries in the area of cryospheric research and increase the communication between them, there is a need for a platform for cooperation. In addition to the Asia-CliC Project, the Global Cryosphere Watch may be instrumental in this respect.

In South America, effective collaboration may be achieved with the UNESCO International Hydrological Program. A proposal was made to organize a capacity building event for early career scientists from several regions whereby South American and Asian could benefit from participation in the a major glaciological workshop and subsequent field practice on a standardized glacier survey. This can be done through the Asia CliC project, with regional links to be provided by Gino Casassa, and with involvement of APECS.

9. CliC IPO development

With the selection and appointment of Jenny Baeseman as the CliC IPO Director, announcement of the position of an administrative officer, availability of some travel budget, and assurances of Nalan Koç, the NPI Research Director, that NPI has long-term interest in maintaining the CliC office presence in the Institute, the conditions for successful continuation of the IPO operation were considered very promising. There should be further steps to generate adequate resources for office operation, such as submitting a proposal to the Research Council of Norway, development of the project website, restart of publishing the CliC Newsletter “Ice and Climate“, and other actions. The CliC IPO should also explore ways to help coordinate overall cryosphere organization activities.

Support from other interested centres, with a possibility of having an office, which has distributed work force, consideration of a possibility of having a visiting scientist position at the office, hosting science and coordination meetings in Tromsø, stepping up the office outreach efforts were indicated as useful means of strengthening the CliC IPO. The office visibility at NPI is most important. A written agreement between NPI and WCRP-SCAR-IASC/CliC should be developed that outlines the specific relationship between the project and the host. The IPO will also need to update the mailing list for the project, the website, and develop a plan for the way forward.

10. CliC directions, structure, and liaisons to various activities

The four main CliC themes and related scientific questions are:

- Ice Masses and Sea Level (IMSL)
 - *contribution of glaciers, ice caps and ice sheets to sea level rise*
 - *how will ice shelves respond to changes in ocean and atmosphere*
 - The Marine Cryosphere and Climate (MarC)
 - *impacts and feedbacks of a reduction in sea ice cover*
 - *nature of hemispheric differences between the two polar regions*
 - Terrestrial Cryosphere and Hydroclimatology of Cold Regions (TCHM)
 - *role of terrestrial processes in water, energy, carbon cycles of cold regions*
 - *interactions and feedbacks between terrestrial and other elements of cryosphere/climate*
- Global Predictions and the Cryosphere (GPC)
- *impacts of changes on ocean and atmosphere circulation*
 - *likelihood of abrupt climate changes*

These themes will remain to guide project activities. CliC needs to determine means of efficiently contributing to the WCRP research on polar climate predictability and to improvement of climate projections. Involvement of paleoclimate research is desirable as it strongly involves cryosphere. Also, there is a very important requirement to contribute to the development of regional climate products, which for CliC involves the both polar regions and also the regions where climate and water reserves depend on the cryosphere.

The sea-ice research in CliC is developing very successfully. There is a need to continue to support these efforts, in both hemispheres, using CASIWG and ASPeCt, and to involve sea-ice modellers and experts in data assimilation. Cryospheric research (both on sea ice and snow) needs to be a strong contributor to studies of climate predictability, prediction and projection. For the time scales of order of a season, there must be an effort to improve the determination of the initial state for climate prediction. Joint efforts with the U.S. SEARCH Sea Ice Outlook may be productive. Confronting model and observation work to improve both would be the main way forward.

The research on role of carbon and permafrost in the climate system is progressing. Many groups that are active in the Arctic are going to work on these topics as well and this will require strengthening coordination of activities between North America and in Eurasia. There is a need to more actively involve Russian scientists in this work and have a means of translating the advances in survey of carbon pools in the permafrost affected soils into solid modelling experiments that would take into account all necessary geomorphologic and biogeochemical processes. The issue of subsea permafrost and carbon release needs to be considered together with IASC and IPA to outline first steps forward.

In the work on glaciers and their monitoring and prediction progress depends on the availability of adequate digital glacier inventories and downscaled climate predictions and projections with very high resolution. There is a possibility to assemble a high-resolution dataset on the change in hypsography of Patagonian glaciers. CliC has to support the development of this dataset. Helmut Rott and Gino Casassa have agreed to lead preparation of a short white paper with correct partners to make the existing dataset available for glacier mass balance assessment. Continuation of this work requires a working group with corresponding partners to make sure that the requirements for data and model validation are followed through. This issue will be further discussed at the Earth Observation and Cryosphere Science Conference in Frascati, Italy, in November 2012.

The work on river and lake ice and northern hydrology in general is of significant interest for both GEWEX and CliC and needs to be supported stronger than in the past. One very significant requirement for CliC is address the need of climate observation, information and modelling in datasets, parameterizations and modules of snow in climate models. A small task group on requirements in this area of research should be established by CliC to outline the way forward. This direction of research has strong links to the proposed assessment of the Arctic Freshwater Flux. There is a need for leaders and contributors to the group of initiatives.

The research, observations, and model development with respect to ice sheets and estimation of their mass balance will be organized via ISMASS. Adequate involvement of satellite agencies, coordination with the IMBIE project, and cooperation with SCAR and IASC are important for its successful development. SCAR, IASC, CliC, APECS and IACS have won an ICSU grant for an ISMASS workshop that is going to take place in Portland, USA, on 14 July 2012. Edward Hanna will represent CliC at the workshop and, depending on the meeting outcomes, further CliC actions in relation to the ice sheet observations and modelling will be determined. CliC may consider establishing an ice sheet / ice shelf working group.

CliC has to have a role in addressing the WCRP Grand Challenges that will be discussed by the WCRP JSC at its 33rd session in Beijing in July 2012, and especially, with respect of the cryospheric challenge. Based on the JSC discussions and identified priorities, CliC will then need to prioritize cryospheric research issues in the CliC themes and develop a plan of actions for the several years to come. This plan would include updated goals, initiatives, and crosscutting activities with other WCRP projects and programs.

CliC SSG then discussed representation of the project on various groups. Identified scientists will be asked to consider their possible nomination to the groups and various functions.

11. CliC meetings in 2012 and 2013

The following meetings were discussed and endorsed as (co-)sponsored by CliC:

- 1) The ESA/CliC Conference "Earth Observation and Cryosphere Science" (Frascati, Italy, 13 - 16 November 2012)
- 2) A Workshop on the carbon and permafrost research (venue and dates TBD)
- 3) A meeting of the ASPeCt group (venue and dates TBD)
- 4) Arctic Sea Ice Working Group (venue and dates TBD)
- 5) ISMASS Workshop (Portland, USA, 14 July 2012)
- 6) A CliC regional meeting in South America (venue and dates TBD)
- 7) Asia-South America capacity building event (venue and dates TBD)
- 8) Ice at the Interface: Atmosphere-Ice-Ocean Boundary Layer Processes and Their Role in Polar Change (Boulder, USA, 25-27 June 2012)
- 9) ISAR-3 (Tokyo, Japan, 14-17 January 2013)

The venue and dates for the 9th Session of the CliC SSG will be decided later. The SSG warmly thanked Tetsuo Ohata for a kind offer to host it in Tokyo in conjunction with the ISAR-3 and Volker Rachold for stating that CliC is always welcome to have a meeting of its SSG in Potsdam, Germany, on the premises of IASC and AWI.

12. Meeting Closure

Konrad Steffen closed the SSG meeting at 12:30 on 15 March 2012. He thanked the SSG members and other participants including invited experts for fruitful and productive discussions. He deeply thanked Helmut Rott, for hosting the session with outstanding hospitality and for the excellent local support to the meeting.

13. Science Session

On Wednesday, 14 March 2012, a joint Science day was held with Austrian scientists involved in research on cryosphere and climate. The program included introductory talks on the main programs and a number of well presented and received science talks. The agenda of the Science day is included in Annex 2 of this Report. After the Science Day and a reception, the participants in the Science Day enjoyed very much a visit to the Alpine Club Museum in the Innsbruck Hofburg. This museum was identified as "excellent" in the course of awarding the Tyrolean and Austrian Museum Prizes for 2009 and was nominated for the European Museum Prize in 2010.

Annex 1: List of Participants

SSG Members

Casassa, Gino (Vice-Chair)
Centro de Estudios Científicos
Arturo Prat 514, Valdivia
Chile
gc@cecs.cl

Gerland, Sebastian
Norwegian Polar Institute
Polar Environmental Centre
NO-9296 Tromsø
Norway
sebastian.gerland@npolar.no

Klepikov, Alexander
Arctic and Antarctic Research Institute
38 Bering Street, St. Petersburg, 199397 Russian
Federation
klep@aari.nw.ru

Rinke, Annette
Alfred Wegener Institute
Telegrafenberg A43
D-14473 Potsdam
Germany
Annette.Rinke@awi.de

Romanovsky, Vladimir
Geophysical Institute
University of Alaska, Fairbanks
P.O. Box 10 04 65
903 Koyukuk Drive
Fairbanks, AK 99775-7320
United States of America
veromanovsky@alaska.edu

Rott, Helmut
Institute for Meteorology and Geophysics
University of Innsbruck
Innrain 52
AT-6020 Innsbruck
Austria
Helmut.Rott@uibk.ac.at

Steffen, Konrad (Chair)
CIRES
CIRES Ekeley Building, S264
Boulder, CO, 80309-0216
USA
konrad.steffen@colorado.edu

WCRP representatives

Busalacchi, Antonio
(JSC Chair, participating by Skype)
Earth System Science Interdisciplinary Center
Suite 4001, M Square Office Building, #950
5825 University Research Court
University of Maryland
College Park, MD 20740
USA
Email: tonyb@essic.umd.edu

Stähelin, Johannes
(Director, SPARC International Project Office)
ETHZ
Institut f. Atmosphäre und Klima
CHN P 11, Universitätstrasse 16
8092 Zürich
johannes.staehelin@env.ethz.ch

Trenberth, Kevin
(Chair, GEWEX SSG, participating by Skype)
Climate Analysis Section
NCAR
P.O. Box 3000
Boulder, CO 80307
USA
trenbert@ucar.edu

Visbeck, Martin
(Co-chair, CLIVAR SSG, participating by Skype)
Leibniz-Institute of Marine Sciences
Duesternbrooker Weg 20
D-24105 Kiel
Germany
mvisbeck@ifm-geomar.de

Invitees

Drinkwater, Mark
Mission Science Division
European Space Agency ESTEC
2200 AG Noordwijk
The Netherlands
Mark.Drinkwater@esa.int

Duguay, Claude
Interdisciplinary Centre on Climate Change
Department of Geography and Environmental
Management
University of Waterloo
200 University Avenue West
Waterloo ON N2L 3G1
Canada
crduuguay@uwaterloo.ca

Fierz, Charles
Institute for Snow and Avalanche Research
Flüelastrasse 11
CH-7260 Davos Dorf
Switzerland
fierz@slf.ch

Goodison, Barry (by Skype)
World Meteorological Organization
7bis, avenue de la Paix
Case Postale 2300
CH-1211 Geneva 2
Switzerland
bgoodison@wmo.int

Kaser, Georg
Institute of Meteorology and Geophysics
Innrain 52
A - 6020 Innsbruck
Austria
georg.kaser@uibk.ac.at

Koç, Nalan
Norwegian Polar Institute
Framsenteret
9296 Tromsø
Norway
Nalan.koc@npolar.no

Meier, Walt
National Snow and Ice Data Centre
University of Colorado
Campus Box 449
Boulder, CO 80309
USA
walt@nsidc.org

Ohata, Tetsuo
IORGC-JAMSTEC
2-15 Natsushima-cho
Yokosuka 237-0016
Japan
ohatat@jamstec.go.jp

Rachold, Volker
IASC Secretariat
Telegrafenberg A43
14473 Potsdam
Germany
Volker.Rachold@iasc.info

Raphael, Marilyn
Department of Geography
1255 Bunche Hall
Los Angeles, CA 90095-1524
USA
Raphael@geog.ucla.edu

Sparrow, Michael
Scientific Committee on Antarctic Research
Scott Polar Research Institute
Lensfield Road
Cambridge
CB2 1ER
United Kingdom
mds68@cam.ac.uk

CliC IPO and WCRP JPS

Baeseman, Jenny
CliC International Project Office
c/o Norwegian Polar Institute
Framsenteret
9296 Tromsø
Norway
jbaeseman@gmail.com

Asrar, Ghassem
GAsrar@wmo.int

and

Ryabinin, Vladimir
VRyabinin@wmo.int

World Climate Research Programme
c/o World Meteorological Organization
7 bis, avenue de la Paix
Case Postale 2300
CH-1211 Geneva 2
Switzerland

Annex 2: Agenda

1. Opening

- a. Welcome from the University of Innsbruck H. Rott
- b. Welcome from the BFW K. Kleemayr
- c. Round of self-introductions All
- d. Approval of agenda V. Ryabinin
- e. CliC status and goals of the meeting K. Steffen

2. Sponsors and stakeholder's update

- a. IASC: Plans, Priorities, & Way Forward V. Rachold
- b. SCAR: Plans, Priorities, & Way Forward M. Sparrow
- c. WCRP: Plans, Priorities, & Way Forward T. Busalacchi by Skype
- d. IACS: Plans, Priorities, & Way Forward C. Fierz

3. WCRP update

- a. SPARC J. Staehelin
- b. GEWEX K. Trenberth by Skype
- c. CLIVAR M. Visbeck by Skype
- d. WCRP coordination of data, modelling, & regional activities, role in GFCS G. Asrar

4. Discussion on existing activities and way forward

5. Current polar (prediction) initiatives

V. Ryabinin

6. Enabling Antarctic climate prediction (AACP)

- a. Emerging WCRP Polar Climate Predictability Initiative for Antarctic and Southern Ocean V. Ryabinin
- b. CLIVAR/CliC/SCAR Southern Ocean Implementation Panel (update) A. Klepikov
- c. AntON A. Klepikov
- d. SOOS M. Sparrow
- e. ASPeCt M. Raphael
- f. How WCRP/CliC & SCAR can help enabling AACP, a discussion All, lead: M. Sparrow

7. Enabling Arctic Climate Prediction (ACP)

- a. WCRP Polar Climate Predictability Initiative for Arctic V. Ryabinin
- a. CliC Arctic Sea-Ice WG, update, plans and ideas S. Gerland
- b. Arctic Ocean sea-ice cover W. Meier
- c. Carbon and Permafrost V. Romanovsky
- d. How WCRP/CliC & IASC can help enabling ACP, a discussion All, lead: V. Rachold

8. Cryosphere observations and data services

- b. GCW + CryOS, role of CliC B. Goodison by skype
- c. ESA Climate Change Initiative, Data User Element, Support to Science Element and CliC M. Drinkwater

9. Cryospheric and cold climate modelling

A. Rinke

10. Sea-level variability and change (SLVC) and issues related to terrestrial cryosphere

- a. Cryospheric contribution to sea level including ISMASS and IMBIE
- b. WCRP – IOC Task Group on SLVC
- c. Prediction of mountain cryosphere
- d. Northern Hydrology initiatives

K. Steffen / H. Rott
K. Steffen
G.Casassa / H.Rott / G.Kaser
C.Duguay / H.Rott / T.Ohata

11. Regional activities

- a. South American activities
- b. Asia - CliC

G. Casassa
T. Ohata

12. CliC IPO development

K. Steffen, N. Koç, G. Asrar + All

13. New CliC: directions, structure liaisons to various activities, action items, meetings

- a. Action Items
- b. Meetings 2012, heads up for 2013
- c. Dates and venue for CliC SSG-9

J. Baeseman
V. Ryabinin
All

14. Closure of Open Session

Joint Science Day with Cryosphere Group of Uni Innsbruck

Opening	H. Rott
Introduction to WCRP	G. Asrar
Polar Science Priorities	V. Rachold et al.
Cryospheric Research at University of Innsbruck	G. Kaser
Natural hazards and climate change	K. Kleemayr
Midlatitude Atmospheric Circulation and Antarctic Climate variability	M. Raphael
Mid-latitude glaciers: status and impacts	G. Casasa
Glaciers in the low latitude climate	G. Kaser
Paleoclimate from glaciers - the Alps during Termination 1	H. Kerschner
Reconstructing and projecting the mass balances of unsampled glaciers: global and regional applications	B. Marzeion
Recent changes in permafrost in Alaska and Russia and their impact on environment and infrastructure	V. Romanovsky

Annex 3: SSG-8 Action List

No.	Action	Responsible	Deadline
1.	Review and if required renew existing Memorandums of Understanding with IPA, SCAR and IASC	D/CIPO	2012
2.	Develop a MoU with IACS	D/CIPO	2012
3.	Develop a plan for CliC activities for 2012-2014	Chair SSG with help of SSG and D/CIPO and JPS Contact	2012
4.	Update CliC website	CliC IPO	2012
5.	Restart production of the Ice and Climate Newsletter and develop social media presence	D/CIPO	2012
6.	Establish CliC working groups focussing on: <ul style="list-style-type: none"> • Modelling of surface processes in cold climate regions including snow • Modelling and data aspects of ice sheet and regional sea-level research • Northern Hydrology and Fresh Water Balance of Polar Oceans Develop their ToRs and membership		
7.	Discuss possible modalities of continuation of the Arctic and Southern Ocean Fresh Water Balance Assessment initiative	D/CIPO	2012
8.	Prepare a letter or a white paper on high resolution 3-D satellite imagery data set for use in glacier inventories	Helmut Rott, Gino Casassa	August 2012
9.	Prepare proposals on SSG membership of representation of CliC On pan-WCRP working bodies	D/CIPO and JPS Contact	June 2012
10.	Assign <ul style="list-style-type: none"> • Alexander Klepikov as CliC liaison to the Southern Ocean Panel • Edward Hanna as CliC liaison to ISMASS 		

Annex 4: Acronyms

ACCE	Antarctic Climate Change and the Environment
AntON	Antarctic Observing Network
ARCHIMEDES	Arctic Hindcast and Model Diagnostic Experiments
AntCim21	Antarctic Climate in the 21st Century
APECS	Association for Polar Early Career Scientists
ASPeCt	Antarctic Sea Ice Processes and Climate
CASIWG	CliC Arctic Sea-Ice Working Group
CHFP	Climate-system Historical Forecasting Project
CliC	Climate and Cryosphere
CLIVAR	Climate Variability and Predictability
CMIP	Coupled Model Intercomparison Project
CORDEX	Coordinated Regional Climate Downscaling Experiment
CORE	Coordinated Ocean-ice Reference Experiments
EC	European Commission
ENSO	El Nino Southern Oscillation
EO	Earth Observation
ESA	European Space Agency
EU	European Union
GCW	Global Cryosphere Watch
GEWEX	Global Energy and Water Cycle Experiment
GFCS	Global Framework for Climate Services
GIPPS	Global Integrated Polar Prediction System
GPC	Global Predictions and the Cryosphere
GTN-G	Global Terrestrial Network for Glaciers
IACS	International Association for Cryospheric Sciences
IAMAS	International Association for Meteorology and Atmospheric Sciences
iAOOS	International Arctic Ocean Observation System
IASC	International Arctic Science Committee
ICARP	International Conference on Arctic Research Planning
ICSU	International Council for Science
IHDP	International Human Dimensions Programme of Global Change Research
IGBP	International Geosphere-Biosphere Programme
IGOS	Integrated Global Observing Strategy
IMSL	Ice Masses and Sea Level
IOC	Intergovernmental Oceanographic Commission
IPA	International Permafrost Association
IPAB	International Programme for Antarctic Buoys
IPCC	Intergovernmental Panel on Climate Change
IPD	International Polar Decade
IPI	International Polar Initiative
IPO	International Project Office
IPY	International Polar Year 2007-2008
ISAR	International Symposium on Arctic Research
ISMASS	Ice Sheet MASs balance and Sea level

JPS	Joint Planning Staff
JSC	Joint Scientific Committee
MarC	The Marine Cryosphere and Climate
NASA	National Aeronautics and Space Administration
NEESPI	North Eurasian Earth System Partnership Initiative
NOAA	National Oceanic and Atmospheric Administration
NPI	Norwegian Polar Institute
NWP	Numerical Weather Prediction
PAIS	Past Antarctic Ice Sheet Dynamics
PPP	Polar Prediction Project
RCM	Regional Climate Model
READER	REference Antarctic Data for Environmental Research
SAON	Sustaining Arctic Observing Networks
SCAR	Scientific Committee on Antarctic Research
SEARCH	Study of Environmental Arctic Change
SOOS	Southern Ocean Observing System
SOP	Southern Ocean Panel
SOPHOCLES	Southern Ocean Physical Oceanography and Cryosphere Linkages
SPARC	Stratospheric Processes and their Role in Climate
SSG	Scientific Steering Group
TCHM	Terrestrial Cryosphere and Hydroclimatology of Cold Regions
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Science, and Cultural Organization
WCRP	World Climate Research Programme
WMAC	WCRP Modelling Advisory Council
WDAC	WCRP Data Advisory Council
WG	Working Group
WGCM	Working Group on Coupled Modelling
WGRC	Working Group on Regional Climate Science and Information
WGSIP	Working Group on Seasonal to Inter-annual Prediction
WMO	World Meteorological Organization
WWRP	World Weather Research Programme
YOPP	Year of Polar Prediction