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AGENDA ITEM: 7

WMO GLOBAL CRYOSPHERE WATCH (GCW)
Background, Concept, Status, Next Steps

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Summary and Purpose of Document

The report scopes the rationale, concept, consultation, principles and characteristics and next steps of the strategy to establish a WMO Global Cryosphere Watch (GCW) as part of the International Polar Year (IPY) Legacy.

Scoping of Global Cryosphere Watch: Phase I

1. GCW Phase I

1.1 An *ad-hoc* expert team, established by the Inter-Commission Task Group on IPY on request of the 15th WMO Congress (Cg-XV), and led by Dr. B. Goodison (Appendix I), initiated the scoping of a framework for developing and implementing a GCW within WMO. The initial phase has involved extensive consultation to confirm or establish:

- the rationale, concept, principles and characteristics of GCW,
- engagement of WMO Programmes and Technical Commissions, of key Partners from other existing Centers and organizations, and of the scientific community who could contribute to, and be part of, the development and implementation of GCW;
- a draft conceptual model of the elements of a GCW ;
- the feasibility of pilot projects and regional/national demonstration projects to test the GCW concept of operation over the next 18-24 months; and,
- recommendations to WMO Executive Council (EC-LVI) in June 2009 for developing an implementation strategy to be presented to WMO Congress XVI in 2011.

2. Background

2.1 The cryosphere collectively describes elements of the Earth System containing water in its frozen state and includes solid precipitation, snow cover, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost, and seasonally frozen ground. The presence of frozen water in the atmosphere, on land, and on the ocean surface affects energy, moisture, gas and particle fluxes; clouds; precipitation; hydrological conditions; and, atmospheric and oceanic circulation. Elements of the cryosphere also contain important records of past climate, providing benchmarks for interpreting modern climate change. The cryosphere exists on all latitudes of the Earth and occurs in approximately one hundred countries of the world. While the cryosphere is an integrative element within the climate system and provides one of the most useful indicators of climate change, it is arguably the most under-sampled domain in the climate system.

2.2 The cryosphere, its changes, and its impacts, not only have received increased scientific scrutiny in recent years, but also now receive constant coverage by the media, creating an unparalled demand for authoritative information on past, present and future state of the world's snow and ice resources. WMO, with the co-operation of other national and international bodies and organizations, and using its global observing and telecommunication capability, is able to provide an integrated, authoritative, continuing assessment of the cryosphere – a Global Cryosphere Watch.

2.3 WMO Congress (Cg-XV) in May 2007 welcomed the proposal of Canada to create a Global Cryosphere Watch. Canada seconded Dr. B. Goodison to WMO from September 2008 to March 2009 and provided additional funds to conduct widespread consultations reaching across all relevant WMO Programmes and Technical Commissions, engaging other organizations and agencies, and the cryosphere scientific community and to coordinate development of the initial feasibility assessment. The *ad-hoc* expert team on GCW has actively contributed to the current concept and to the recommended strategy for developing and implementing the GCW within WMO.

3. Rationale

3.1 The proposal for a GCW was based on:

- the "Scope of Science for the IPY 2007-2008" produced by the ICSU/WMO Joint Committee identified "Shrinking Snow and Ice: Rapid Changes in Polar Regions" as a key issue requiring urgent attention;
- the IPCC's special attention to the cryosphere, emphasizing the observed changes of elements of the cryosphere, globally and regionally, and discussing their potential impacts on societies and countries;
- the development and acceptance of the IGOS-P Cryosphere Theme Report, providing the conceptual framework for a Cryosphere Observing System (CryOS), which could provide the basis for a more comprehensive, coordinated, and integrated cryospheric observing system;

- the Arctic Climate Impact Assessment (ACIA) and the 2nd Conference on Arctic Research Planning (ICARPII) which identified the cryosphere as a critical element in monitoring and understanding changes in the Arctic System;
- the collaborative initiative SAON (Sustaining Arctic Observing Networks) that provides an unique opportunity for organizations, agencies and communities to collaborate to sustain and integrate Arctic observing systems and networks over the long term and make data more easily available and accessible; and,
- WMO Congress (CG-XV), which "expressed the view that the IPY projects when implemented would provide a great opportunity for the integrated observations of polar environment, and in this context IPY should be considered as a "pilot project" for the establishment of integrated observing systems over the globe".

4. Concept

4.1. IPY 2007-2008 has provided a unique opportunity to help close the gap in global observations by further developing polar observing systems. WCRP's CliC project, in co-operation with SCAR, led the development of the conceptual framework for CryOS (http://igos-cryosphere.org/documents.html), but there remains an urgent need for a sustained, robust end-to-end cryosphere observing and monitoring system, not only for polar regions, but also globally. Widespread consultation confirmed the need for a GCW and provided valuable suggestions for developing its initial concept.

4.2. The GCW, in its full/comprehensive concept would include observation, monitoring, assessment, product development, prediction, and related research. It should provide authoritative, clear, understandable and useable information on the past, current and future state of the cryosphere for use by the media, public, decision and policy makers.

4.3 GCW should be an international mechanism for supporting all key cryospheric in-situ and remote-sensing observations and for implementing the recommendations of CryOS.. Collaboration, partnership and engagement of various programs would be essential in providing reliable, comprehensive observations of the components of the cryosphere through an integrated observing approach from national to global scale to meet the needs of climate, hydrology, weather and environmental science. GCW should provide the scientific and operational climate community with the means to predict the future state of the cryosphere and provide quality assured global and regional products of the cryosphere. It should organize assessments of the cryosphere and its components on regional to global scale to support climate change science, decision making and formulation of environmental policy. Implementation of GCW would contribute to GEOSS and serve as an IPY Legacy for observation, monitoring and provision of data and information.

4.4 GCW should have direct application to all societal benefit areas, such as those outlined by GEOSS, and others, such as transport. The Polar Regions and the global cryosphere have been shown to play a pivotal role in climate, and improved information

is essential to fully assess, predict, and adapt to climate variability and change. The contribution of the cryosphere to sea level rise in a changing climate is a critical issue for society. The cryosphere, being frozen water, is an intrinsic part of the global water cycle, for example, impacting water, weather, energy and agriculture. Accurate determination of precipitation, including the solid component, is essential to understanding the global water cycle. Snow- and glacier-melt are critical sources of water for agricultural, domestic and industrial water supply and hydropower production, and directly contribute to flood and drought hazard conditions. Lake-, river- and sea-ice directly affect high latitude transportation and ecosystems, including regional and global transportation routes, regional economic development, and the well-being of northern peoples. Other short and long term hazards directly related to the cryosphere include avalanches, glacier lake outburst floods, subsidence due to thawing permafrost, snowstorms, blizzards, icing, coastal erosion, and of course sea level rise. GCW should focus on not just "physical hot-spots" but also on "socio-economic" hot spots. Information provided for use by decision-makers in climate sensitive sectors, for their use in real time and planning decisions related to adaptation to climate variability and change, needs to be relevant to their decision processes and requirements, and over time, information needs to become more 'demand-driven'. Flow of information to, and feedback from the user communities muse be increasingly implemented and effective, for product improvement, enhancement of the observations and associated research, and improved communications.

5. GCW and WMO

5.1 Global Cryosphere Watch would be designed in the context of the WMO Strategic Plan. It will help Members to enhance their capacity to provide cryospheric information as part of their effort to meet society's needs for weather, climate and water and related environmental information and services to manage nature's risks and enhance social and economic benefits. It clearly will contribute to the top-level objectives of WMO and each of its strategic thrusts, namely:

- Science and technology development and implementation to monitor and observe the environment, forecast and warn of significant weather, climate and water conditions, and understand the Earth System: GCW will involve research, observation and monitoring, assessment and prediction;
- Service delivery of weather, climate, water and related environmental information to reach the user in an understandable and usable form and in a timely manner to have maximum impact: GCW must make data and information available to meet the needs of a range of;
- Partnership with international agencies, other organizations, academia, media and the private sector to improve the range and quality of critical environmental information and services: GCW has to partner with key agencies, organizations and the broader scientific community to provide data and information on all the components of the cryosphere over a range of time and space scales, building on accomplishments to date;

- Capacity-building of Members to provide essential environmental service to their societies: GCW will engage Members with "cold climate regions", including developing countries, in the research, observation and production of cryospheric information on a national, regional and global basis;
- Efficient management and good governance to ensure affordable environmental information and services: GCW would use a results-based management and accountability framework, and will add a significant value to existing services.

5.2 GCW would address virtually all of the 11 expected results of the WMO Strategic Plan. It cuts across all the WMO technical departments (Observing and Information Systems, Research, Climate and Water, Weather and Disaster Risk Reduction Services), joint sponsored activities (e.g. WCRP, GCOS) and most of the WMO Technical Commissions (JCOMM, CHy, CCl, CBS, CIMO, CAS, CAgM). GCW will:

- enhance capabilities to produce better climate predictions and assessments, hydrological forecasts and assessments, weather forecasts and warnings,
- co-ordinate cryospheric observations of WMO and other agencies, organizations,
- be part of the WMO Integrated Global Observing and Information Systems (WIGOS and WIS);
- provide the mechanism to integrate the atmospheric, terrestrial and marine cryosphere Essential Climate Variables (ECVs) within GCOS.

6. Consultation

6.1 Since the acceptance of the original GCW proposal by Cg-XV 2007 there has been widespread consultation on the GCW concept within WMO, with NMHS's and with potential partners, organizations, agencies and the scientific community (Annex 3). Response has been very positive, emphasizing the need for an integrated view of the cryosphere, which builds on and integrates what is being done currently. It has also been noted that for GCW to be successful, countries and agencies must demonstrate the importance of the cryosphere to resolution of national and/or regional issues as well as how it will contribute to success of our activities at the global scale.

6.2 Key external organizations engaged in cryospheric observation and data management have responded very positively to the GCW concept and offered to contribute to make GCW comprehensive and integrated (i.e. NSIDC, WGMS, IPA). The WMO-IOC-UNEP-ICSU Steering Committee for GCOS discussed the contribution that GCW could make to GCOS. They endorsed the creation of Global Cryosphere Watch as a mechanism for integrating cryospheric observations. The Steering Committee noted that the GCW would be an important component of GCOS. Interaction with GCOS on how this can be best accomplished is ongoing.

6.3 Likewise, the joint US-Canada GEO Workshop (October 2008) noted that GCW will benefit both the USA and Canada and would benefit from support by critical countries. They recommended that Canada and the US should contribute to the

development of GCW, which will be the primary implementation mechanism for the IGOS Cryosphere Theme. They identified actions for their countries, including development of a coordinated, funded plan to support the implementation of GCW. The plan should focus on a few key issues including a selection of *in-situ* and satellite products as contributions to GCW, an evaluation of the adequacy of existing observational networks for snow, ice, and solid precipitation, and an assessment of the possibilities for additional or enhanced surface-based reference sites/super sites. They identified the importance of the ice centers/services being involved. In addition, the US NSIDC has stated that they "totally support the concept of a Global Cryosphere Watch and will do all that they can, within limitations of available resources, to assure the success of GCW" The support of such organizations will be essential for the ultimate success of GCW.

6.3 Members of the *ad-hoc* expert team and WMO programme representatives met in December 2008 to further develop the GCW concept. The team reviewed the initial rationale and concept, discussed potential contributions from partner organizations and agencies, established initial principles and characteristics for GCW, discussed potential pilot and demonstration projects, reviewed a conceptual framework for its organization and identified near-term actions to demonstrate the viability and utility of WMO GCW.

7. Principles and Characteristics of GCW:

7.1 To develop an effective GCW, there was a need to agree on some basic principles and characteristics for the initiative. The expert team meeting agreed that:

- GCW would be a mechanism for implementing IGOS Cryosphere Theme (CryOS);
- GCW should ensure a comprehensive, coordinated and sustainable system of cryospheric observations and information and access to related information to allow full understanding of the cryosphere and its changes.
- GCW should initiate a comprehensive cryosphere observing network "CryoNet", a network of reference sites in cold climate regions operating a sustained, standard program for observation and monitoring changes in components of the cryosphere for developing and validating models and remote sensing products, and producing valuable long-term records, while covering key areas of the globe with cryospheric observations;
- GCW is based on the premise that agreed-upon standards and recommended practices and procedures will apply to the cryospheric observing systems. Where these do not currently exist, GCW would work with WMO and partners to develop appropriate best practices, guidelines and standards. This should include homogeneity, interoperability, and compatibility of observations from all GCW constituent observing and monitoring systems and derived cryospheric products.
- GCW will include all elements of the cryosphere at national, regional and global scale and appropriate temporal and spatial requirements. It should provide access to data and information on past, present and future cryospheric conditions, drawing

on operational and research-based observation and monitoring (in-situ and space-based monitoring) and modeling.

- Improved monitoring of the cryosphere through the integration of surface- and space-based observations is essential for understanding global climate change, optimizing knowledge of current environmental conditions and exploiting this information for predictive weather, climate and water products and services.
- GCW should provide a mechanism to ensure availability of real, near-real time and non-real time access to cryospheric data and products, ultimately through the WMO Information System (WIS). GCW will respect partnership, ownership and data-sharing policies of all observing components and partner organizations.
- GCW should have an organizational, programmatic, procedural and governance structure that will significantly improve the availability of, and access to, authoritative cryospheric information.
- WIGOS identified three areas of integration, which GCW would logically encompass: standardization of instruments and methods of observation; WIS information infrastructure; and end product quality assurance. Targeted pilot and demonstration projects over the next two years should be implemented as soon as possible to demonstrate the feasibility of GCW.
- Many diverse organizations, agencies and individuals contribute data, information and knowledge on the cryosphere, globally and regionally. GCW is the response to meet the need for integration and will work with, and build on, existing programs such as GCOS, and work with external partners such as space agencies, World Data Centres and external cryospheric observing programs

8. Pilot and Demonstration Projects

8.1 The use of pilot projects to demonstrate operation of GCW was strongly endorsed by the community during consultations. They would be implemented to demonstrate: the range of information that could be provided for cryosphere components, globally, regionally and nationally; how GCW could build on existing efforts by the cryospheric community; identify the time and resources required to create a fully functional integrated cryosphere information system; document standards, guidelines and best practices being used in observing and product development; and, identify challenges/gaps/needs that the GCW could address in a logical manner. Initiating GCW Pilot Projects now allows us to address major issues on the integration process and provide clear evidence of not only the feasibility of GCW but also its sustainability and benefits to a range of users. Discussions have been initiated to identify pilot projects that could be implemented relatively quickly, within available resources, and provide information to address the issues noted above. Some of the pilot projects that have been suggested and could be considered for implementation are given in Appendix II.

8.2 There is also a desire for a limited number of demonstration projects that would focus on regional or national contributions as well as focus on specific tasks to demonstrate standardization, integration and interoperability. There is a very strong

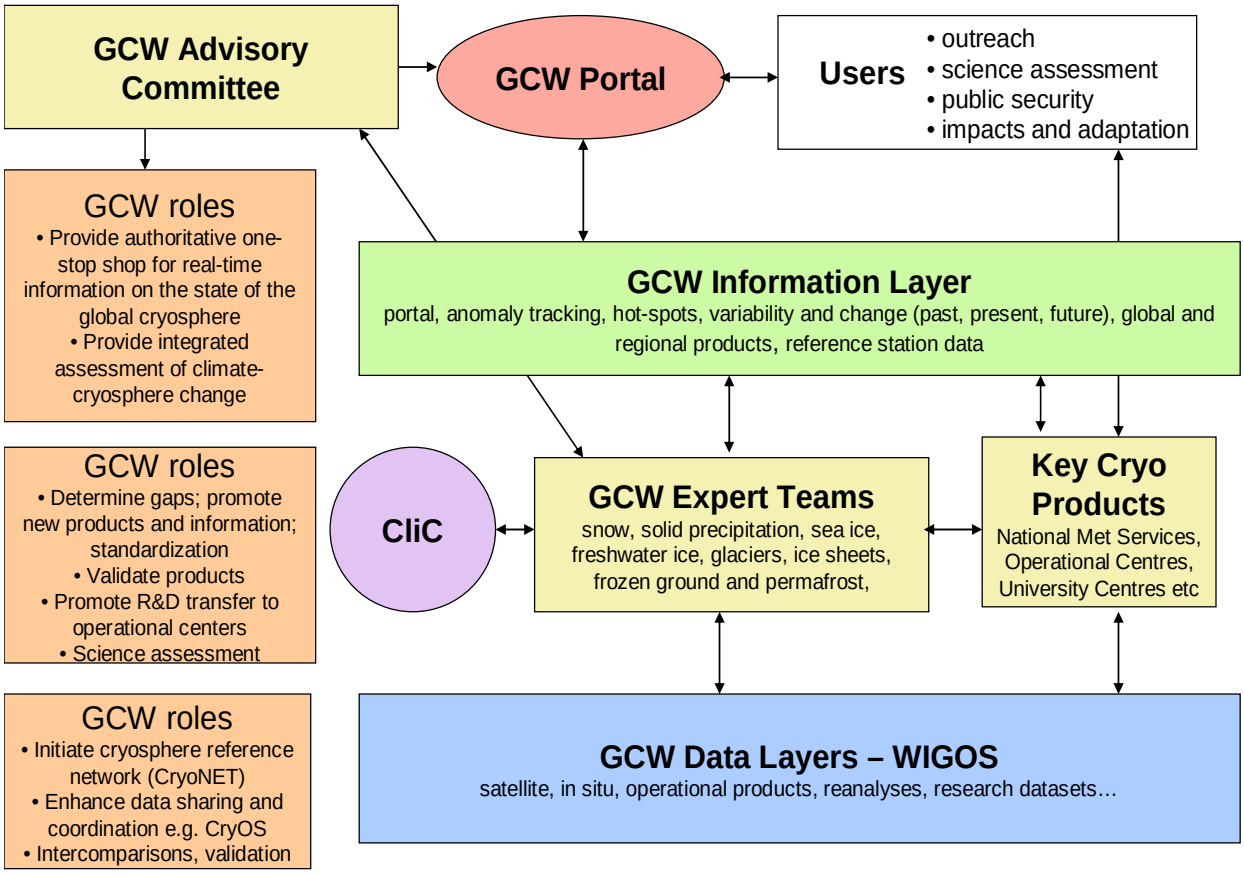
desire to implement a standardized network of cryospheric observatories in cold climate regions. Initially, this would involve a few stations, which would build on existing cryosphere observing programs or add standardized cryosphere observing programs to existing observing facilities to minimize operating costs (e.g. CryoNET).

9. Conceptual Framework for GCW

9.1 A key to the ultimate success of GCW is to have a GCW portal that will serve as the “single-point entry” to access GCW data, information and products. There are several portals now being implemented for other related studies. The concept of the portal and demonstration of its attributes and characteristics need to be defined. The portal must be WIS compliant. The portal will require resources and a country/agency has yet to be identified as a contributor. A pilot project to demonstrate the operational capabilities of a GCW portal and prepare a design document for the portal is one approach without an agency having to commit to long-term operation of the portal.

9.2 An initial framework, or conceptual model, for GCW is presented in Fig. 1. It originated from discussions among some members of the *ad-hoc* team and scientists at the US National Snow and Ice Data Center (NSIDC). It has been updated by the *ad-hoc* expert team. The conceptual model will continue to evolve to reflect GCW development.

Fig. 1: Draft conceptual model of elements of a Global Cryosphere Watch v0.3



9.3 By its nature, cryospheric research, observations, monitoring, assessment, product development, and prediction go beyond the sole responsibility of WMO and an efficiently working GCW will require coordination with research, observing and monitoring, and prediction efforts conducted by other organizations. GCW must engage Members, other agencies and institutions who collect and produce cryospheric data and information (in-situ, satellite and other remote sensors) and scientific programs with a cryospheric responsibility, such as WCRP/CliC. These groups would provide the expertise for the GCW Expert Teams and the GCW Advisory Committee.

Scoping the Way Forward

10. The Next Steps

10.1 Consultations to date (Appendix III) with WMO Members, operators, and the scientific community have clearly shown the need and desire to create the GCW, in fact, sooner rather than later. Based on these consultations, the expert team, in

collaboration with relevant Members and partners, proposes to work with the community to continue development of GCW through 2011, by:

- promoting, negotiating and coordinating the conduct of pilot or demonstration projects to demonstrate the viability of the GCW,
- developing a mechanism to implement the IGOS Cryosphere Theme recommendations within the framework of GCW;
- identifying cryosphere information sources and systems to be part of GCW (existing or new); documenting data, information and products currently made available which could be included in a GCW;
- documenting Members' and other users' needs for cryospheric information, particularly for climate, water, weather and environmental applications and prediction;
- developing resource requirements to support the ongoing operation of a GCW, nationally, regionally and at the WMO Secretariat level;
- conducting a results based management and accountability framework for GCW in the context of the WMO Strategic Plan;
- preparing and presenting a GCW implementation strategy for approval by WMO Congress in 2011.

6.5 It must be noted that Canada's secondment of Dr. Goodison to WMO for six months, and its provision of financial support for initial GCW meetings, has been essential to initiate the GCW process. Follow-on funding from Members for GCW planning, program development and pilot and demonstration projects will be necessary.

10.2 Coordination of this work would need a WMO-based focal point. Initially, the GCW could be considered as an IPY/CliC legacy initiative, with direct links to WIGOS and WIS and reporting to Executive Council through its Panel on Polar Research, Observation and Services.

APPENDIX I

Members, GCW *ad-hoc* Expert Team (Phase I):

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Dr. J. Key (USA)
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Representatives from WMO and related programmes:
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APPENDIX II

Suggestions for Pilot and Demonstration projects:

Pilot Projects would focus on the elements of the cryosphere and identify how they: would contribute to implementing CryOS; meet the GCW principles and characteristics, would contribute to demonstrating integration of cryospheric data and information from research to prediction, and, would provide authoritative cryospheric information. Some suggestions, around which a pilot project could be constituted based on discussions to date, are given below. The nature and scope of potential pilot projects, including participants are part of the ongoing consultations and discussion.

P.1 **Sea ice**: There are many sea ice products currently being produced by operational and research organizations in many countries. There are research products of area, extent and concentration, such as produced by NSIDC and Arctic ROOS. There are operational sea ice products produced by NMHSs, such as the Norwegian Meteorological Institute (met.no) products produced for ECMWF and EUMETSAT. There are operational sea ice products as produced by national ice services with co-ordination through IICWG. Discussions have been initiated to have at least an operational sea ice product, complete with metadata, algorithm description and evaluation procedures, and product verification as a pilot project

P.2: **Snow** (extent, depth, SWE) is a cryospheric element for which a pilot project is essential. Discussions have begun on organizing a pilot on “snow extent”. There are many such products, from in-situ, satellite, and NWP models. Snow extent has been mapped for years, but there are products at different scales, from different sources and it has been found that during melt there can be considerable difference between products. The challenge is then to produce products that are well documented, verified through an independent intercomparison, and will be sustained. A “snow extent pilot” would serve as a test of what it will take to prepare an “authoritative GCW product”. There is also a desire to test a snow water equivalent product, real-time national/regional snow information (e.g. depth), and a test the transfer of snow information from research products to operational products, such as through GlobSnow.

P.3. A **Glacier** element will build on excellent work already being done by partner organizations, notably the World Glacier Monitoring Service (WGMS) supported by Switzerland. It will engage WGMS and what is currently being done for GTN-G of GCOS and link to GLIMS if possible. Discussions on a specific pilot are to be held in the near future.

P.4. A pilot project on **permafrost and frozen ground,** including the active layer, will build on collaborative work being done for GTN-P, largely through the International Permafrost Association. The pilot is yet to be defined, but could build on the IPY project on the Thermal State of Permafrost. Discussions are to be held in the near future. There is also the possibility of a freeze/thaw product through the NSIDC.

P.5. A critical element of the cryosphere is precipitation, and for GCW, **solid precipitation,** or snowfall. There is an ever increasing need for global and regional precipitation products, adjusted for systematic errors of measurement. The GPCC in Germany does produce global, monthly precipitation products, including maps adjusted for systematic errors in measuring solid precipitation. The CliC project has a new initiative to look at improving the ability to define and adjust for systematic errors. A pilot project is being discussed to combine efforts to produce an improved precipitation product globally and regionally, incorporating new knowledge on errors in measurement. This could be further extended to global products that blend in-situ and satellite estimates. Discussions of what is feasible in a pilot project have been initiated.

Demonstration Projects would focus on regional or national contributions as well as focus on specific tasks to demonstrate standardization, integration and interoperability. Some ideas have been discussed and should be developed to demonstrate the broader, integrated aspect of GCW.

D.1. From all consultations, it is clear that the community would like GCW to initiate the CryOS recommendation on establishment of a network of reference sites or "supersites". It would implement a standardized network of cryospheric observatories in cold climate regions, not just polar regions, where as many cryospheric elements would be monitored in a standard manner for the long-term. These sites would augment relevant CEOP reference sites or GTN sites and would also be suitable for validation of satellite and model outputs of cryospheric elements. This is key near-term recommendation in implementing CryOS. A demonstration team will be established to initiate this process.

D.2. Consultations also identified integrated regional cryospheric products as another value-added contribution that GCW could make. Very limited cryospheric information is currently presented in an integrated manner. For example, in alpine regions, are changes in glaciers, snow and permafrost giving the same information? A demonstration project in the Alps is being discussed that would look at the snow and ice in an integrated manner.

D.3. There are several other topics which have been identified as possible demonstration projects, but that have not had full discussion to date. These include:

- transfer of cryosphere remote sensing products from research to operations, e.g. GlobSnow
- Specific regional contributions, such as contributions from Asia-CliC or tropical regions
- Real-time reporting of cryospheric "hot news" from NMHSs and the scientific community
- Modelling: making AR4 cryospheric outputs more easily available (TBD)

D.4 An important region where consultations are yet to be fully completed is Antarctica. Discussions on how to present a more integrated picture of cryospheric change on the continent and in surrounding seas and the development of a possible demonstration

project is yet to be done. Consultation with SCAR, research agencies, such as NSF, NASA, ESA, BAS, AAD and the WMO WG on Antarctic meteorology need to be completed.

APPENDIX III

GCW Consultations

2007

- *Joint Congress of the Canadian Meteorological and Oceanographic Society/American Meteorological Society Polar Meteorology and Eastern Snow Conference, St. John's, Canada (cryosphere scientists from NMHS's, academia and other agencies, including users and providers of cryospheric data and information)*
- *WCRP CLIVAR Scientific Steering Group, Geneva, Switzerland (information and consultation)*
- *WMO Departments and co-sponsored programs: World Climate Research Programme, World Climate Program, Hydrology, World Weather Watch, Atmospheric Research and Environment Program, Global Climate Observing System Secretariat. (All - consultation) and Water Resources Department, Atmospheric Research and Environment Programme,*
- *Arctic Monitoring and Assessment program, Copenhagen, Denmark (consultation)*
- *Asia-CliC 2nd Symposium, Lanzhou, China (presentation and consultation)*
- *IPY Joint Committee, Quebec City, Canada (consultation)*
- *GCOS TOPC, Rome, Italy (presentation and open discussion) – endorsed GCW as the initiative to integrate the cryospheric observations from ocean, terrestrial and atmospheric domains*
- *WCRP CliC Scientific Steering Group, Geneva, Switzerland (presentation and consultation)*
- *International Permafrost Association, Geneva (discussion)*

2008

- *WMO PR for Canada (consultation on Canadian support)*
- *WMO IPY Intercommission Task Group (presentation and open discussion)*
- *EARSel Meeting on "Changing Climate-Changing Cryosphere", Bern, Switzerland (consultation)*
- *Sustaining Arctic Observing Networks Workshops, Edmonton, Canada, St. Petersburg, Russia and Helsinki, Finland (discussion and consultations)*
- *IPY Open Science Conference, St. Petersburg, Russia (discussion and consultation)*
- *US National Snow and Ice Data Center, Boulder, Colorado (presentation and 3-day consultation session with NSIDC and UCAR scientists)*
- *Polar CLIPS Workshop, St. Petersburg, Russia (presentation and discussion)*
- *GCW Briefing to Canadian cryosphere community "CRYSYS", Ottawa, Canada (presentation and open discussion for 1 day)*
- *Western Canadian Cryosphere network meeting, Prince George, Canada (presentation and consultation)*
- *International Ice Charting Working Group, Lulea, Sweden (presentation and consultation)*
- *GCOS Steering Committee, Geneva, Switzerland (presentation, discussion, endorsement)*
- *Briefing to WMO Directors, Geneva*
- *IPY project meeting, Variability and Change in the Canadian Cryosphere, Toronto, Canada (presentation and consultation)*
- *Sub-Group on WIGOS, Geneva, Switzerland (presentation and discussion)*
- *Met.no, Oslo, Norway (consultation with Climate and Observation)*
- *GCW ad-hoc Expert Team Meeting, Geneva, Switzerland (presentation, discussion, consultation, scoping)*
- *WCRP CliC Scientific Steering Committee (presentation, consultation, scoping)*

- *American Geophysical Union Fall meeting, San Francisco, USA (presentation, consultation, scoping)*

2009

- *IPY Space Task Group, Geneva, Switzerland (presentation, consultation, scoping)*
- *MeteoSwiss, GCOS Office, Geneva Switzerland (consultation, discussion of pilot projects)*
- *WMO Space Programme, Geneva, Switzerland (discussion)*
- *IPY Joint Committee (discussion of legacy)*
- *1st Executive Panel Meeting, Regional/Specialized Satellite Centers for Climate Monitoring, Geneva (discussion)*
- *International Experts Meeting, Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges, Monte Carlo, Monaco presentation, discussion, recommendation of support)*

APPENDIX IV

LIST OF ACRONYMS:

AAD	Australian Antarctic Division
ACIA	Arctic Climate Impact Assessment
AGU	American Geophysical Union
Arctic ROOS	Arctic Regional Ocean Observing System
BAS	British Antarctic Survey
CAgM	WMO Commission for Agricultural Meteorology
CAS	WMO Commission for Atmospheric Sciences
CBS	WMO Commission for Basic Systems
CCl	WMO Commission for Climatology
Cg	WMO Congress
CEOP	Coordinated Energy and Water Cycle Observations Project
CHy	WMO Commission for Hydrology
CliC	Climate and Cryosphere Project
CryOS	Cryosphere Observing System
EARSeL	European Association of Remote Sensing Laboratories
ECMWF	European Centre for Medium-Range Weather Forecasts
EC	WMO Executive Council
ECV	Essential Climate Variable
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GCOS	Global Climate Observing System
GCW	Global Cryosphere Watch
GEOSS	Global Earth Observation System of Systems
GLIMS	Global Land Ice Measurements from Space
GOOS	Global Ocean Observing System
GTN-G	Global Terrestrial Network for Glaciers
GTN-H	Global Terrestrial Network for Hydrology
GTN-P	Global Terrestrial Network for Permafrost
ICARPII	2nd International Conference on Arctic Research Planning
ICSU	International Council for Science
IGOS-P	Integrated Global Observing Strategy – Partners
IOC	Intergovernmental Oceanographic Commission
IPA	International Permafrost Association
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year 2007-2008
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
NASA	National Aeronautics and Space Administration (USA)
NMHS	National Meteorological and Hydrological Service
NSF	US National Science Foundation
NSIDC	National Snow and Ice Data Center (USA)
PR	Permanent Representative
SAON	Sustaining Arctic Observing Networks
SCAR	Scientific Committee on Antarctic Research
SWE	Snow Water Equivalent
TOPC	Terrestrial Observing Panel for Climate
UNEP	United Nations Environment programme

WCRP	World Climate Research Programme
WGMS	World Glacier Monitoring Service
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization