Guide to the Global Cryosphere Watch Surface-Based Observational Network - CryoNet

Wolfgang Schöner[1], Eric Brun, Michele Citterio, Charles Fierz, Barry Goodsion, Jeff Key, Tetsuo Ohata, Þorsteinn Þorsteinsson, …

[1]Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Vienna, Austria
[2] Meteo France, Paris, France
[3] Geological Survey of Greenland, Copenhagen, Danmark
[4] Institute for Snow and Avalanche Research SLF, Davos, Switzerland
[5] Environmental Canada, , Canada
[6] NOAA, , USA
[7] , , Japan
[8] Institute for Snow and Avalanche Research SLF, Davos, Switzerland
9 Icelandic Meteorological Office, Reyclavik, Iceland

Version 0.2, 15 June 2013

Document Version

Version	Authors	Date	Description
0.1	**W. Schöner**	**Jan. 2013**	**Initial draft**
0.2	**W. Schöner**	**Jun. 2013**	**Major modification based on feedback from CryoNet team**
0.3			

The CryoNet Working Group:

Jeff Key	Jeff.Key@noaa.gov
Barry Goodison	barrygo@rogers.com
Wolfgang Schöner	wolfgang.schoener@zamg.ac.at
Eric Brun	eric.brun@meteo.fr
Christian Genthon	genthon@lgge.obs.ujf-grenoble.fr
Charles Fierz	fierz@slf.ch
Tetsuo Ohata	ohatat@jamstec.go.jp
Þorsteinn Þorsteinsson	thor@vedur.is
Michele Citterio	mcit@geus.dk
Sandy Starkweather	sandy.starkweather @noaa.gov
Matthias Bernhardt	m.bernhardt@iggf.geo.uni-muenchen.de
Hugues Lantuit	Hugues.Lantuit@awi.de
Xiao Cunde	cdxiao@lzb.ac.cn
Vasily Smolyanitsky	vms@aari.aq
Juan Manuel Hörler	jhorler@smn.gov.ar
Kari Luojus	kari.luojus@fmi.fi

Table of Contents

1. Introduction

The cryosphere collectively describes elements of the Earth System containing water in its frozen state. It includes solid precipitation, snow cover, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost, and seasonally frozen ground. The cryosphere is global, existing not just in the Arctic, Antarctic and mountain regions, but at all latitudes and in approximately one hundred countries. The cryosphere provides some of the most useful indicators of climate change, yet is one the most under-sampled domains of the Earth System. Improved cryospheric monitoring and integration of that monitoring is essential to fully assess, predict, and adapt to climate variability and change.

The cryosphere, its changes, and its impacts have received increased attention in recent years. Today, it receives constant coverage by the media, creating an unparalleled demand for authoritative information on the past, present and future state of the world's snow and ice resources on a multitude of time and space scales, reaching from polar ice to tropical glaciers.

The cryosphere is a key element of the Earth system that is particularly relevant for

- understanding climate change through its feedback mechanisms,
- societal impacts as a major water resource and source for hydropower
- business economics such as tourism (snow) or transport business (sea-ice)
- weather forecasting (e.g. snow cover data for data assimilation for NWP)

WMO, with the co-operation of other national and international bodies and organizations, and using its global observing and telecommunication capability, is in a position to provide an integrated, authoritative, continuing assessment of the cryosphere – a Global Cryosphere Watch (GCW).

GCW will initiate a comprehensive surface-based cryosphere observing network called "CryoNet", a network of reference sites or "supersites" in cold climate regions, on land or sea, operating a sustained, standardized programme for observing and monitoring as many cryospheric components as possible. The general goals of GCW were described in LINK and the implementation of GCW is outlined in LINK. The conceptual framework of GCW is described by Figure 1, with the major activity "CryoNet" covering the observation part of GCW. Initially, CryoNet will build on existing cryosphere observing programmes or add standardized cryospheric observations to existing facilities to create a tiered network from simple sites to supersite environmental observatories.

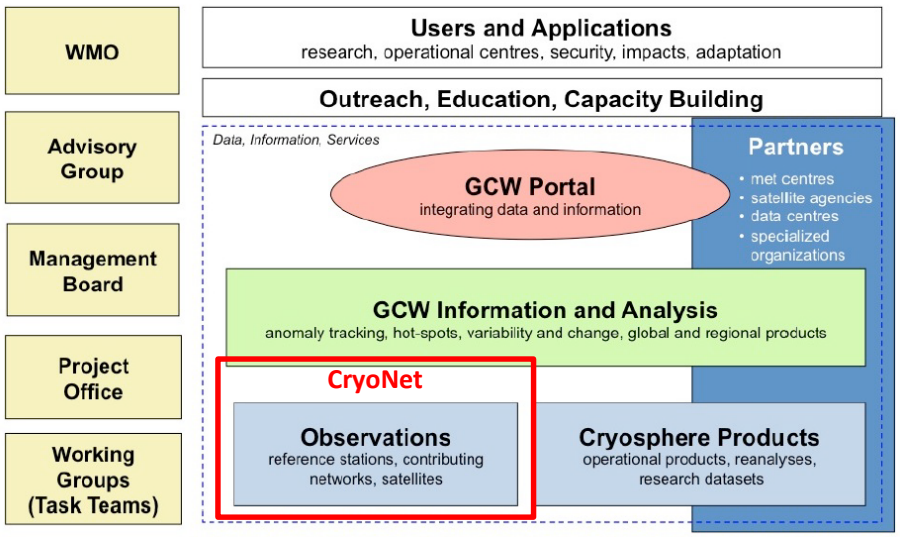


Figure 1: The conceptual framework of Global Cryosphere Watch (GCW) and its CryoNet part (red box)

The purpose of this document is to describe the implementation of CryoNet. It will identify linkages to existing networks, provide a detailed site type structure, list the required observations, and establish criteria for inclusion in CryoNet.

CryoNet covers all components of the cryosphere (glaciers, ice shelves, ice sheets, snow, permafrost, sea-ice, river/lake ice) through an extensive approach of in-situ observations. Whereas some of these cryospheric components are already measured through existing component networks (such as GTN-P for permafrost or GTN-G for glaciers), other components are not represented by similar networks (e.g. sea ice) or partly covered by existing networks (e.g. snow). The present situation of singular cryospheric monitoring networks is described by Figure 1. In several cases these networks are performing measurements on the same cryospheric quantity (e.g. snow water equivalent) using different guidelines or procedures. Consequently, an improved and integrating global cryospheric network of surface observations is of utmost relevance for assessing the state of the cryosphere. The following gaps have been identified by the community of researchers and practitioners with respect to cryospheric observations and monitoring:

- lack of harmonization in cryospheric observations
- lack of network-hosts for several cryospheric observations (e.g. glacier flow measurements, automatic weather stations on glaciers)
- lack of guidelines for some of the cryospheric observations
- need for improved training in particular at the international level

- access to cryospheric observational data

GCW-CryoNet aims to fully support the existing networks and gain added value from a series of across-network-boundaries and new activities. WMO already coordinates worldwide monitoring of one of the "spheres" mentioned in the GCW document (the atmosphere); and thus can build on extensive experience and knowhow in building up a new monitoring system for the cryosphere

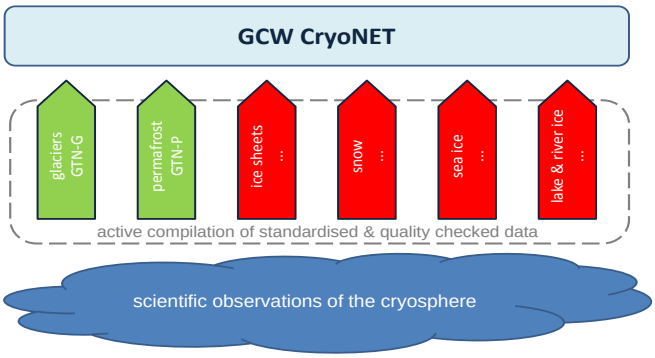


Figure 2: The current structure of cryospheric monitoring and the need for a Global Cryosphere Watch and CryoNet

Linkage to GCOS:

GCW is considered as the cryospheric component of the Global Climate Observing System (GCOS).

The GCOS implementation strategy envisaged five observation network types for climate:

(a) Comprehensive global observing networks, including regional and national in situ sites as well as satellites;

(b) Baseline global observing networks, a limited number of observations at selected locations that are globally distributed and provide long-term, high-quality data records of key variables;

(c) Reference networks that provide highly detailed and accurate observations at a few locations for calibration purposes;

(d) Research networks that can provide estimates of the local variability of key variables; and

(e) Ecosystem networks, where a number of different variables are measured at several locations within a specific ecosystem.

GCW-CryoNet will contribute to all of the above GCOS topics as the relevant network for the cryosphere.

Linkage to GEO/GEOSS……

2. GCW CryoNet objectives

The main long-term objectives of GCW-CryoNet are in line with the WMO Strategic Plan 2011-20?? and identical with those expressed in further documents……. [????, 2011]. The overall objective of CryoNet is to provide a comprehensive network of cryospheric in-situ observations using standardized procedures as well as enabling a related framework of network-services according to user needs. With respect to the first GCW Implementation Plan (200?-20??) [WMO, 20??], the CryoNet aims for the following main developments:

Link different cryospheric observational networks to achieve its comprehensive potential through

Extensive monitoring of cryosphere through harmonized measurements

Providing cryospheric-data for improved process understanding and modelling

Providing calibration and validation data for satellite data

Linking cryospheric ground truth observations to cryospheric models

Training for cryospheric observations

Standardized guidelines for cryospheric observations

- ***Extensive monitoring of cryosphere through harmonized measurements***

Currently observations of the cryosphere are done by a series of independent networks. Each network structure is based on its own objectives and preferences. Adjustment of differences and inconsistencies among different measurements, procedures and methods, will make them uniform and mutually compatible. Filling gaps from missing observations could be easier achieved in a comprehensive monitoring program based on high number of users. Extensive monitoring covering several cryospheric variables will initiate new research fields. A standardized terminology/vocabulary for the cryosphere will facilitate communication between specialists speaking different languages.

- ***Providing cryospheric-data for improved process understanding and modelling***

Cryospheric observations are essential input data for earth system modelling, in particular for past and future climate simulations in order to understand and predict climate change.

- ***Providing calibration and validation data for satellite data***

Today satellite data and products offer an indispensable source for Earth observation and input for model studies. However, satellite data are needed to be calibrated and validated against observations (ground truth data). In particular global coverage of calibration/validation data is important for satellite data and derived products. GCW-CryoNet will clearly improve the access to calibration/validation data for satellite data.

- ***Linking cryospheric ground truth observations to cryospheric models***

Similar as satellite data cryospheric models (also as part of more complex climate models or earth system models) are highly dependent on high quality as well as spatially and temporally dense observation data. They are needed for both as driving data as well as for model calibration/validation. Cryospheric models are highly relevant for short-term forecast purposes (e.g. snow cover models, sea-ice models) on the time scale of hours to days or for scenario generation (e.g. ice-sheet models, permafrost models) on the time scales of decades to centuries.

- ***Training for cryospheric observations***

Training is essential for high quality measurements relevant for spatial analysis (inter-site comparison), as model input or calibration/validation of satellite data. Training of observers based on standardized guidelines and protocols (see below) is a WMO activity done at a regular base both at national as well as international level. Thus GCW can provide highly practical and user-relevant trainings for cryospheric observations. This will be done in cooperation with cooperating cryospheric networks.

- ***Standardized guidelines for cryospheric observations***

A critical component in the development of CryoNet is the effort to establish best practices, guidelines and standards for cryospheric measurements. This would include consideration of data homogeneity, interoperability, and compatibility of observations from all GCW constituent observing and monitoring systems and derived cryospheric products. The first step in the process is to determine what is currently being measured, how it is being measured and which best practices, guidelines or standards are being followed and who are conducting or co-ordinating the measurements. Once this compilation is available, then the different practices, methods, standards could be compiled and compared as a first step in ultimately preparing a comprehensive manual on the topic.

3. Observations of Global Cryosphere Watch focal areas

3.1. Snowcover

Current status

Goals

3.2. Glaciers

Current status

Goals

3.3. Ice sheets

Current status

Goals

3.4. Sea ice

Current status

Goals

3.5. Lake ice

Current status

Goals

3.6. Permafrost

Current status

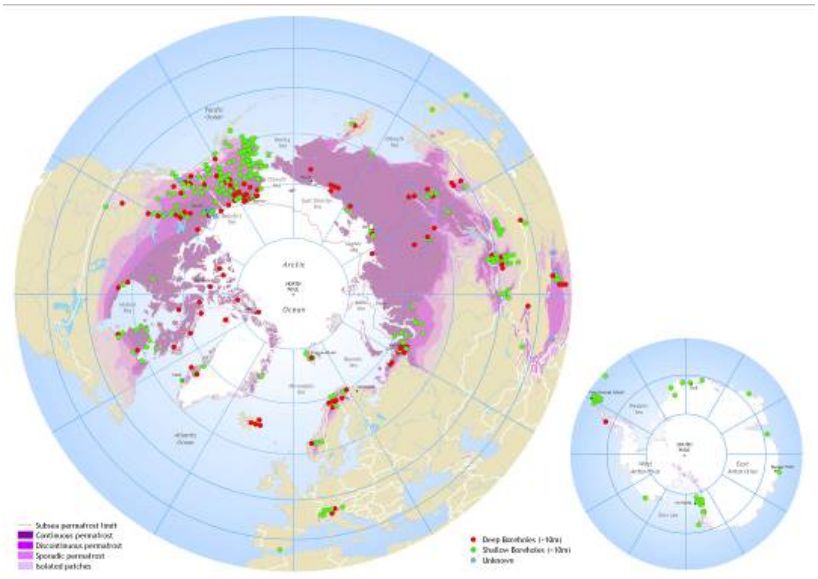


Figure X: Location of long-term monitoring sites of the Thermal State of Permafrost (TSP) in GTN-P (source: .

Goals

4. Structure of CryoNet

Based on its general objectives, three highly interlinked core tasks of activity are relevant for CryoNet which are:

- *Observation*
  Providing essential cryospheric variables from existing cryospheric observational networks (such as GTN-P or GTN-P) and potential new networks in standardized and traceable format for the GCW data portal which will be the link to the various users of CryoNet data
- *Coordination and capacity building*
  Cooperation and communication with existing cryospheric networks and with national WMO representatives in order to provide a common and sustainable CryoNet of cryospheric observations. Financial coverage of costs for monitoring networks is a key issue generally relevant for all networks. Though GCW through WMO is not able to directly fund monitoring activities, it has a high potential for promoting the relevance of cryospheric monitoring through its existing international networks.
- *Service*

To support the CryoNet community with relevant observational guidelines, training, harmonisation activities, standardization documents and technical know-how in order to provide cryospheric observations at the highest level of quality possible.

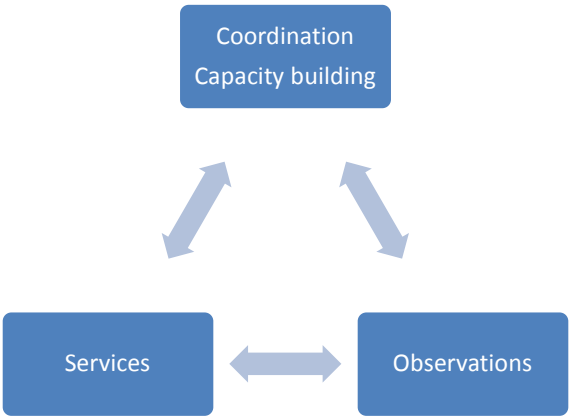


Figure 3: The three core tasks of GCW CryoNet

4.1. Observations

CryoNet covers all components of the cryosphere (glaciers, ice shelves, ice sheets, snow, permafrost, sea-ice, river/lake ice) through an extensive approach of in-situ observations. Whereas some of these cryospheric components are already measured through component networks (e.g. GTN-P for permafrost or GTN-G for glaciers), other components are not integrated into equivalent networks (e.g. sea ice) or part of several networks (e.g. snow). CryoNet

In order to meet different user-needs and because of the spatially distributed nature of different components of the cryosphere, the CryoNet network of in-situ observations is structured into three different classes of sites (Figure 3):

- Baseline sites
- Reference sites
- Integrated sites

Baseline sites

Baseline sites make measurements of at least one element of the cryosphere; e.g. snow, permafrost, sea ice, or glaciers. The cryosphere is one “sphere” of the climate system. Other spheres are atmosphere, biosphere, and lithosphere. Therefore, baseline sites are “single

sphere". Baseline, reference, and integrated sites all make measurements according to standardized methods and best practices.

Reference sites

Commented [WS1]: Comment from Thorstein:
Would it be an idea to use the term "Reference and process study sites" instead of "Reference sites" – for the 2nd layer stations? The structure outlined in the draft document seems to place research focus mainly on the Integrated sites, which are supposed to be staffed stations. But one could also think of locations that could not be manned year round but would nevertheless be very valuable sites for specific research projects.

Reference sites are the key sites of CryoNet with respect to the assessment of long term changes of the cryosphere as well as for the validation and calibration of satellite data and cryospheric models. In order to be accepted as a reference site for a single cryospheric component (either by GCW-CryoNet or by the relevant component network) the site/station has to accept relevant standards and has to provide continuous measurements since at least 10 years. Ideally, reference sites are sites fully in operation but could be closed stations in case of highly relevance of the data. Similar to Integrated Sites Reference Sites could also have a research oriented focus, but for a specific cryospheric component.

Integrated sites

The mission of Integrated sites is to promote, through worldwide scientific collaboration, progress in the scientific understanding of the physical processes generating changes of the cryosphere. These sites integrate in-situ and space-based observations at high level of extensiveness and create platforms of cryospheric observatories.

Monitoring at integrated sites covers several components of the cryosphere with a highly process orientated approach. Thus these sites are ideal places for understanding the interaction between the atmosphere and the various cryospheric components including feedback mechanisms. Integrated sites could either be a single station or a larger region covering several stations or field sites. Integrated sites are suitable sites for defining standards of cryospheric observations and making trainings on measurements. Because of the high level of measurements on-site technical staff is obligatory at integrated sites. In general these sites are supported by long-term financial commitments running standard monitoring programs of the cryosphere. Whereas for some cryospheric components integrated sites are also reference sites, for other cryospheric components they are not.

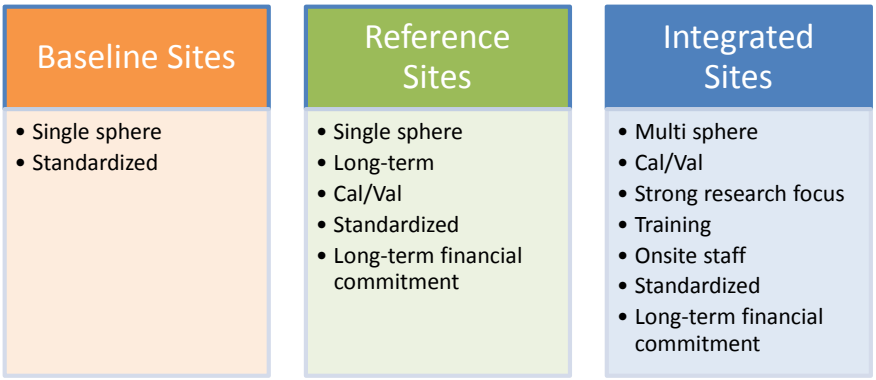


Figure 4: The structure of CryoNet

4.2. Cooperation and capacity building

Cooperation between existing cryospheric networks is a major mission of GCW and is an obvious need to be concluded from the CryoNet questionnaire shown in the appendix. Primary existing networks already cooperating with GCW for CryoNet are:

IASC (International Association of Cryospheric Sciences)
WGMS (World Glacier Monitoring Service)
NSIDC (National Snow and Ice Data Centre)
GTN-P (Global Terrestrial Network – Permafrost)
IPA (International Permafrost Association)
GTN-G (Global Terrestrial Network- Glaciers)
……

Funding of a sustainable long-term monitoring of the cryosphere is a major objective and challenge for GCW CryoNet. Though GCW is not able to provide direct funds for the cryospheric observations in the participating countries, GCW is able, through its WMO background, to support and push the relevance of an extensive and coordinated cryospheric monitoring using its international network and via national WMO representatives. The GAW (Global Atmosphere Watch) program of WMO could serve as a good example of a powerful network successfully hosted by WMO.

4.3. Services

GCW-CryoNet, through its WMO roots, has a high potential for supporting cryospheric observational network with relevant services. Based on the experience from other WMO networks CryoNet can provide the following relevant services to network operators and data users:

+ Intercomparison experiments on sensors, measurement procedures, ….

+ Guidelines for cryospheric measurements

+ Training of observers and students

5. Criteria for Site Inclusion into CryoNet

A tiered observational network need clear criteria for assigning existing and new stations/sites to the single classes of the network. Such criteria has to guarantee (e.g. for a data user) that well-described levels of data quality, measurement standards and guidelines have been met

Currently, Cryonet neither do have such criteria nor can easily adopt existing criteria from cryospheric component networks. However, there is high potential from some of these component networks and GCW, in strong cooperation with these networks, will establish such criteria catalogue. This will be done as a separate GCW-Cryonet document covering the 3 classes of sites (baseline sites, reference sites and integrated sites)

Essential characteristics of a GCW-CryoNet Station/Site

1. The station/site location is chosen such that, for the variables measured, it is regionally representative.
2. There are adequate power, communication and building facilities to sustain long term observations with greater than 90% data capture (i.e. <10% missing data).
3. The technical support provided is trained in the operation of the equipment.
4. There is a commitment by the responsible agency to long term observations of at least one of the GCW variables in the GCW focal areas.
5. The GCW observation made is of known quality and linked to the GCW Standard.

6. The data and associated metadata are submitted to one of the international cryospheric data centres (such as GTN-P, WGMS, GCOS etc.) no later than one year after the observation is made. Changes of metadata including instrumentation, traceability, observation procedures, are reported to the responsible WDC in a timely manner.

7. If required, data are submitted to a designated data distribution system in near-real-time.

8. Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GCW variables, are made with known accuracy and precision.

9. The station characteristics and observational programme are updated in the GCW Station Information System (GCWSIS) on a regular basis.

10. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.

6. Measurement Standards and Best Practices

To ensure high quality, consistent observations, measurements of snow and ice properties at CryoNet sites will be made according to accepted standards. Many measurement standards have been compiled by WMO or other networks, though the compilation is not exhaustive for snow and ice measurements. Some existing cryosphere networks have their own standards. However, similar to item 4 from above “criteria for site inclusion”, there is no GCW-CryoNet measurement standard available or could be easily extracted from existing measurement standards or guidelines from single cryosphere component networks. In fact it will be a major effort of GCW-CryoNet to establish such standard in agreement with the standards and guidelines existing (and routinely used) for observations of single cryospheric components. Thus CryoNet measurement standards will draw on existing standards and add new standards, as necessary. They will be reviewed by the scientific community, modified as necessary, and maintained in the *GCW Manual*.

As a first step towards a GCW measurement standard/guideline GCW-CryoNet made a survey of existing measurement standards and practices which is listed with some details in Table 1. The GCW-CryoNet measurement standard/guideline will be reworked as a separate document within the implementation phase of CryoNet. Existing manuals such the Manual on the Global Observing System and the Guide to Meteorological Instruments and Methods of Observation (CIMO Guide) could serve as an important base for a “GCW-Manual”. Establishing best practices, guidelines and standards for cryospheric measurements will include consideration of data homogeneity, interoperability, and compatibility of observations from all GCW constituent observing and monitoring systems and derived cryospheric products.

Additionally, intercomparisons campaigns of instruments will be conducted in order to determine and intercompare performance characteristics of instruments under field or laboratory conditions and to link readings of different instruments – data compatibility & homogeneity. The current WMO Solid Precipitation Intercomparison (SPICE), including snowfall & snow depth, is of direct relevance to GCW, and is considered as a contribution to GCW. Potential GCW reference sites might be suitable sites for inclusion in this intercomparison.

The following objectives are part of the CryoNet implementation with respect to measurement standards and best practices:

- Standardization of Practices (networks, observations, instruments, data exchange & policy, products):
- Review existing GCW practices and develop an inventory; identify differences and inconsistencies
- Identify a need for new standard/best practices, identify priorities and develop new standard/best practices
- Develop a Cryospheric Vocabulary
- Identify standard/practices that may be promoted to ISO standards?
- Develop "GCW Manual"; provide input to WIGOS Manual, CIMO Guide
- Register cryospheric user requirements in WMO Rolling Review of Requirements (RRR) data base (propose a new application area – Cryosphere, identify focal points for Cryo different application areas and observing system capabilities, verify existing variables and add new (key) cryospheric variables in RRR database)
- Establish Centres of Excellence from among GCW Reference sites e.g., Instrument Centres and Testbeds responsible for maintaining a set of standard instruments, calibration, intercomparison, traceability, compatibility, integration of RS and in-situ observations

Table 1: List of existing cryospheric guidelines

Organisation	Guideline (authors and title)	Year published	Cryospheric component
IACS, UNESCO	Fierz, C., Armstrong, R.L., Durand, Y., Etchevers, P., Greene, E., McClung, D.M., Nishimura, K., Satyawali, P.K. and Sokratov, S.A. 2009. The International Classification for Seasonal Snow on the Ground. IHP-VII Technical Documents in Hydrology No. 83, UNESCO-IHP, Paris. 90 pp.	2009	Snow
IACS	Cogley, J.G., Hock, R., Rasmussen, L.A., Arendt, A.A., Bauder, A., Braithwaite, R.J., Jansson, P., Kaser, G., Möller, M., Nicholson, L. and Zemp, M., 2010,	2010	Glaciers

	Glossary of Glacier Mass Balance and Related Terms. IHP-VII Technical Documents in Hydrology No. 86, IACS Contribution No. 2, UNESCO-IHP, Paris. 114 pp.		
UNESCO	Kaser, G., Fountain, A., and Jansson, P., 2003. A Manual For Monitoring the Mass Balance of Mountain Glaciers. IHP-VI Technical Documents in Hydrology No. 59, UNESCO-IHP, Paris.	2003	Glaciers
WMO	Goodison B.E., P.Y.T. Louie, D. Yang, 1998, WMO Solid Precipitation Measurement Intercomparison- Final Report, WMO/TD - No. 872	1998	Snow
WMO	Nitu R. and Wong K., 2010, CIMO Survey on National Summaries of Methods and Instruments for Solid Precipitation Measurements at Automatic Weather Stations	2010	Snow
WMO	World Meteorological Organization (WMO) 2008. Guide to meteorological instruments and methods of observation. WMO-8 8 1-681	2008	Snow
UNESCO, IAHS, WMO	UNESCO, IASH, WMO, 1970. Seasonal snow cover, a guide for measurement compilation and assemblage of data. Technical papers in hydrology, a contribution to the International Hydrological Decade, published by the United Nations Educational, Scientific and Cultural Organisation, Place de Fontenoy, 75 Paris-7e, 37 pages.	1970	Snow
National Hydrology Research Institute Canada	Östrem G. and M. Brugmann, 1991, Glacier Mass Balance Measurements. A manual for field and office work. National Hydrology Research Institute (Canada), Science Report No. 4	1991	Glaciers
CEN	CEN/TR 15996:2010, Hydrometry - Measurement of snow water equivalent using snow mass registration devices	2010	Snow
UNESCO, IAHS	UNESCO, IAHS, 1970, Combined Heat, Ice and Water Balances at Selected Glacier Basins. A Guide to Measurement and Data Compilation. Technical Papers in Hydrology No. 5, UNESCO, Paris	1970	Glaciers
Environment Canada	Manual of Climatological Observations, 3rd Edition	1992	Precipitation, snowfall
Environment Canada	MANOBS, Manual of Surface Weather Observations, 7th Edition	1977, 2011	Precipitation, snow
WMO	WMO Sea-Ice Nomenclature, WMO-No.259. Volume I – Terminology, Volume II – Illustrated Glossary, Volume III – International system of sea-ice symbols. Electronic version is available at http://www.aari.ru/gdsidb/XML/wmo_259.php	2004	Sea Ice
WMO	Sea-Ice Information Services in the World, WMO-No.574. "Sea Ice Information Services in the World" is intended to provide to mariners and other users the latest snapshot of the sea ice services available world-wide, effectively extending the WMO publication No. 9, Volume D - information for Shipping.	2010 edition	Sea Ice

WMO-IOC JCOMM	Electronic Chart Systems Ice Objects Catalogue, version 5.1	2012	Ice (sea, lake)
WMO	SIGRID-3: A vector archive format for sea ice charts, JCOMM-TR-23, WMO/TD-NO.1214	2010 edition	Ice (sea, lake and river)
WMO	Ice Chart Colour Code Standard, JCOMM-TR-23, WMO/TD-NO.1214	2004	Ice (sea, lake and river)
National Research Council Canada	Johnston, M.E, Timco, G. W. Understanding and Identifying Old Ice in Summer. National Research Council Canada, Canadian Hydraulics Centre, 2008	2008	Sea Ice
Arctic and Antarctic Research Institute Russia	Manual for ice experts – ice observers	2007	Sea ice
Meteorological Service of Canada	Manual of standard procedures for observing and reporting ice conditions	2005	Sea ice
Canadian Avalanche Association	CAA, 2007. Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches. Canadian Avalanche Association, Revelstoke, BC, Canada. Updated 2008.	2007	Snow, Weather, Avalanches
American Avalanche Association;	Greene, E., Atkins, E.D., Birkeland, K., Elder, K., Landry, C., Lazar, B., McCammon, I., Moore, M., Sharaf, D., Sternenz, C., Tremper, B., and Williams, K., 2010. Snow, Weather, and Avalanches: Observational Guidelines for Avalanche Programs in the United States. American Avalanche Association, Pagosa Springs, CO.	2010	Snow, Weather, Avalanches
WGMS	General Guidelines for Data Submission and Notes on the Completion of Data Sheets. World Glacier Monitoring Service, Zurich, Switzerland:	2011	Glaciers
UNESCO, GTN-G	Perennial ice and snow masses – a guide for compilation and assemblage of data for the World Glacier Inventory. Technical Papers in Hydrology No. 1	1970	Glaciers
ESA	Guidelines for the compilation of glacier inventory data from digital sources, 23 pp. Online at: http://www.globglacier.ch/docs/guidelines_inventory.pdf	2010	Glaciers
GTOS	ECV T6 Glaciers and ice caps (GTOS Report), link:	2009	Glaciers
WMO	IGOS Cryosphere Theme Report, WMO TD-No. 1405, (http://igos-cryosphere.org/docs/cryos_theme_report.pdf)	2007	All
IPA	Global Terrestrial Network on Permafrost Strategy and Implementation Plan, 2012-2016	2012	Permafrost

7. Appendix

7.1. Results from the GCW-CryoNet Questionnaire for the Vienna meeting, 20-22 November 2012

One of the top priorities of the Global Cryosphere Watch (GCW) is the initiation of CryoNet, the surface-based observational network. Engagement of participants in advance of the meeting is essential so that background information can be shared before the meeting itself. This first implementation workshop for CryoNet will define the types of surface sites, such as supersites, reference sites, and/or tiered sites in cold climate regions, on land or sea, operating a sustained, standardized programme for observing and monitoring as many cryospheric variables as possible. We will also initiate the development of formal procedures for establishing the GCW network, evaluate potential supersites, discuss measurement standards, and explore data availability and exchange.

To start the GCW-CryoNet discussion prior to the meeting and to share participants' thoughts on the purpose and benefits, structure and scope of the network, participants were asked to answer a few questions about contributions to, and benefits from, CryoNet. A second questionnaire sought information on potential sites for CryoNet (see agenda item 3.2). Additional information on the different types of sites is provided below.

Background Questions

1. How could GCW-CryoNet help meet your national, regional or global interests?

2. What could you or your organization contribute to the implementation of GCW-CryoNet?

3. What do you see as the benefits of CryoNet: (e.g. for operational and research network operators, scientific and decision/policy making community, environmental monitoring and modelling, scientists, satellite data providers, etc.)?

4. What do you see as existing gaps in cryospheric observations (e.g. thematic, spatial, temporal, availability, exchange, data policy, etc.) and how might CryoNet address these?

5. Please prioritize CryoNet activities according your personal view (indicate HIGH/MEDIUM/LOW):

Establishment of CryoNet tier#1-tier#4 network:

Establishment of supersite network:

Harmonisation of cryospheric network:

Standards, guidelines and training for observations:

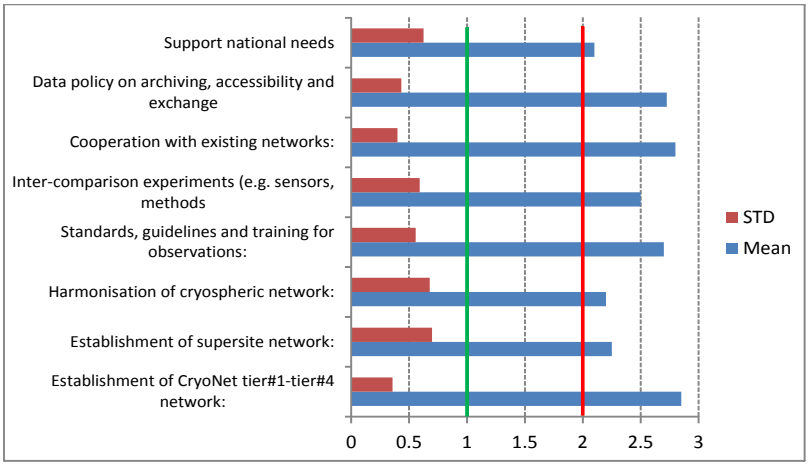
Inter-comparison experiments (e.g. sensors, methods):

Cooperation with existing networks:

Data policy on archiving, accessibility and exchange:

Support national needs:

Resuts of 5 (prioritization of CryoNet activities according to personal view of the workshop-participants (indicate HIGH/MEDIUM/LOW)): CryoNet questionnaire: General statements on CryoNet



Conclusions from the feedback to questions:

- High interest from participants to establish CryoNet
- Existing cryo-networks are highly interested in cooperation
- There is high potential for harmonisation and standardization in cryospheric observations
- Establishment of CryoNet network was ranked at the highest priority
- ……..

a) Station inventory