The Global Cryosphere Watch Surface Network in the Arctic and Beyond

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Summary

The cryosphere exists in various forms in about one hundred countries, at all latitudes and altitudes. It is one of the most useful indicators of climate change yet is significantly under-sampled. The World Meteorological Organization (WMO) Global Cryosphere Watch (GCW) is providing service-oriented information for informed decision-making and policy development related to climate, water and weather. It will ensure a comprehensive, coordinated and sustainable system of observations and information that will allow for a full understanding of the cryosphere and its changes.

One of the main objectives of GCW is the development of a surface-based cryosphere observing network with two components: a core component called, CryoNet, and contributing stations. Through the continuing implementation of CryoNet, GCW is leading the effort to establish best practices, guidelines and standards for cryospheric measurement, as well as refining observational requirements for the various elements of the cryosphere. To date, 36 stations distributed globally have been approved for inclusion in CryoNet, with many more to come. Ten of those stations are located in the Arctic; additional stations are needed to fill gaps.

To provide access to data from its surface network and from other sources, GCW is establishing interoperability between data management systems. The GCW Data Portal will make data and information available to users while providing the ability to exchange data and information among a distributed network of providers. Interoperability between the GCW Data Portal and a number of data centers worldwide has been established, though much remains to be done.

1. Introduction

The cryosphere is a component of the Earth System that, at the Earth's surface, includes snow cover, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost, seasonally frozen ground, and solid precipitation at the surface. The cryosphere is global, existing not just in the Arctic, Antarctic and mountain regions, but also in various forms at all latitudes and in approximately one hundred countries. The cryosphere provides some of the most useful indicators of climate variability and change, yet is one the most under-sampled domains of the Earth System. Improved cryospheric monitoring is essential to fully assess, predict, and adapt to variability and change in the Earth's weather, climate and water cycles.

The cryosphere, its changes, and its impacts have received increased attention in recent years. Today it receives constant coverage by the media, creating a demand for authoritative information on the state of the world's snow and ice resources. The World Meteorological Organization (WMO), with the cooperation of other national and international bodies and organizations, and using its global observing and telecommunication capability, is now providing an integrated, authoritative, continuing assessment of the cryosphere – a Global Cryosphere Watch (GCW).

GCW is an international mechanism for supporting all key cryospheric in-situ and remote sensing observations. GCW includes observation, monitoring, assessment, product development, and related research. It will have a positive impact on prediction, thus supporting assessments of the future state of the cryosphere and climate. GCW provides the framework for reliable, comprehensive, sustained observing of the cryosphere through a coordinated and integrated approach on national to global scales to deliver quality-assured global and regional products and services. GCW implementation encompasses:

- Requirements: Meet evolving cryospheric observing requirements of WMO Members, partners, and the scientific community, by contributing to the WMO Rolling Review of Requirements (RRR) process;
- Standardization: Enhance the quality of observational data by improving observing standards and best practices and guidelines for the measurement of essential cryospheric variables;
- Access: Improve exchange of, access to, and utilization of observations and products from WMO observing systems and those of its partners;
- Coordination: Foster research and development activities and coherent planning for future observing systems and global observing network optimization.

The observing network of GCW is a component of the WMO Integrated Global Observing System (WIGOS). Through WIGOS and the WMO Information System (WIS), GCW provides a fundamental contribution to the Global Earth Observation System of Systems (GEOSS). GCW will organize analyses and assessments of the cryosphere to support science, decision-making, environmental policy and services through, inter alia, its foundational support to the Global Framework for Climate Services (GFCS). Collaboration and cooperation with partners are essential to successfully conduct GCW activities at the international, regional, and national levels. Therefore WMO, through its Executive Council Panel of Experts on Polar and High Mountain Observations (EC-PHORS), facilitates engagement of organizations with polar interests in the development of GCW.

In this paper we focus on the GCW surface observing network. Its objectives, structure, and status are described and illustrated. GCW, mainly through its standardization activities and Data Portal, has an ambitious goal of filling the existing gaps in polar and high mountain observations, data compatibility, and data accessibility, thus supporting other Arctic observing initiatives.

2. GCW Surface Network

The GCW surface observing network is comprised of a core component, called **CryoNet**, and contributing stations that are not part of CryoNet. The GCW network builds on existing cryosphere observing programs and promotes the addition of standardized cryospheric observations to existing facilities in order to create more robust environmental observatories. The overall objective of CryoNet is to provide a comprehensive network of cryospheric in situ observations using standardized procedures, as well as to enable a framework of network services according to user needs. CryoNet aims to link different cryospheric observational networks to achieve its comprehensive potential through:

- Extensive monitoring of the cryosphere using harmonized measurements;
- Providing cryospheric data for improved process understanding and modeling;
- Providing calibration and validation data for satellite measurements;
- Linking cryospheric ground truth observations to cryospheric models;
- Training in cryospheric measurement;
- Standardizing practices for cryospheric observations;
- Promoting long-term, sustainable observing and monitoring.

Network Structure

The basic component of the GCW network, including *CryoNet*, is the *station*. A station measures one or more components of the cryosphere and one or more variables of each component, for example depth and snow water equivalent of the component snow. All types of GCW stations need to make their data, metadata, and observation procedures available in a timely manner, preferably to a data centre that is interoperable with the GCW portal. Observations are made and quality controlled according to CryoNet best practices.

A *CryoNet station* must meet the minimum set of requirements, which includes providing ancillary meteorological measurements. Potential attributes of CryoNet stations are given below. All stations will be either Primary or Reference, and may have additional attributes.

- *Primary* - Have a target (intent) of long-term operation and have at least a 4-year initial commitment.
- *Reference* - Have a long-term operational commitment and long-term (more than 10 years) data records.
- *Cal/val* - In addition, the station is being used for calibration and/or validation of satellite products and/or (Earth System) models, or it has been used for such purposes in the past and it still provides the needed facilities.
- *Research* - In addition, the station has a broader research focus related to the cryosphere.

The minimum requirements of CryoNet station are:

1. **Meeting Core CryoNet Measurement Requirements -** The station shall measure at least one of the variables of one of the cryosphere components (i.e. snow, solid precipitation, lake and river ice, sea ice, glaciers and ice caps, ice sheets, frozen ground and permafrost). The station location is chosen such that cryospheric measurements are representative of the surrounding region, and such representativeness needs to be clearly described.
2. **Commitment of Operational Continuity -** The station must be active. The responsible agencies are committed, to the extent reasonable, to sustaining long-term observations of at least one cryosphere component. There must be a commitment to continue measurements for a minimum of four (4) years.
3. **Metadata Up to Date and Availability -** The station metadata, including all metadata describing the station characteristics and observational programme, are kept up-to-date and available in the GCW Portal as the interface to the WIGOS Information Resource (WIR).
4. **Compliance with Agreed Regulatory Practice -** The station observational procedures, the instruments and method of observations, quality control practices, etc., should follow GCW endorsed regulations, manuals, guides and, to the extent possible, the recommended best practices.
5. **Data and Ancillary Data Freely Available -** Data are made freely available, and whenever possible in near real-time. In situ ancillary meteorological observations, as required by CryoNet best practices, should also be available with documented quality.
6. **Competency of Staff -** Personnel must be trained in the operation and maintenance of the station.

A *CryoNet site* generally encompasses an area greater than a conventional observing station and is comprised of two or more active GCW stations with varying capabilities that are operated as a coordinated unit. At least one station has to be a CryoNet station. A site may encompass several micro-climatological regions or extend over larger altitudinal gradients. Thus, further ancillary meteorological stations are part of a site. Different partners may operate the stations, but they are coordinated through one agency or institute. Each CryoNet site has to provide a concept describing the research approach and the site management.

Typically, sites have a broader research focus related to the cryosphere compared to stations.

Whereas simple sites investigate the cryosphere only, integrated sites aim to provide a better understanding of the cryosphere and/or its linkages to other components of the Earth System, for example, the atmosphere, the hydrosphere, the biosphere, the oceans, soil, vegetation, etc. Potential attributes of CryoNet sites are:

- *Basic* - Monitor single or multiple components of the cryosphere.
- *Integrated* - Monitor at least two components of cryosphere or at least one cryosphere component and one other component of the Earth System. Integrated sites are particularly important for the study of feedbacks and complex interactions between these components.

Requirements for CryoNet sites are:

1. A site comprises at least one CryoNet station.
2. Integrated sites have technical supporting staff.
3. Integrated sites have training capability.
4. There is a long-term financial commitment.
5. Data are made freely available, and whenever possible in (near) real-time.

CryoNet station and site characteristics are summarized in Figure 1.

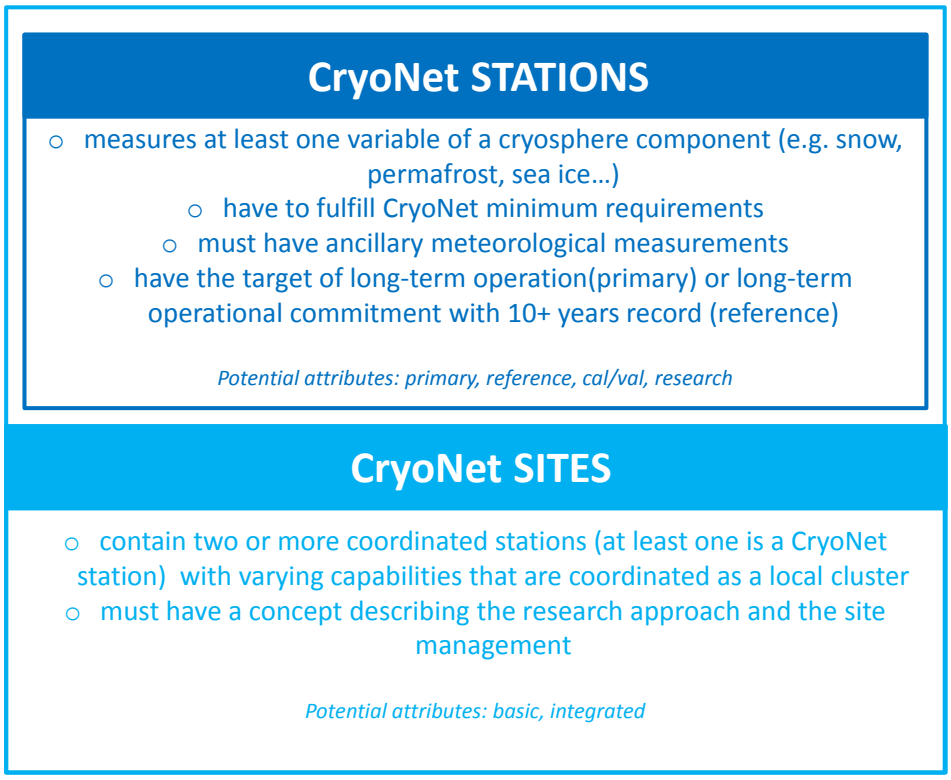

Figure 1: Properties of CryoNet Stations and CryoNet Sites.

A *GCW contributing station* is required to measure at least one variable of at least one cryosphere component (e.g. snow, permafrost, sea ice, etc.). Contributing stations are those that provide useful measurements of the cryosphere but do not fulfill CryoNet minimum requirements, or in some other way do not provide the quality and/or consistency of data required by CryoNet stations; for example, where data records may be short or with large gaps. These stations may be in remote, hard to access regions where cryospheric observations are scarce or in regions where they complement other cryospheric measurements. Mobile platforms such as ships, drifting stations and buoys may also be contributing stations. Contributing stations may have this attribute:

- *Reference* - Have a long-term operational commitment and/or long-term (more than 10 years) data records.

Synoptic/climate stations of the NMHSs measuring cryospheric variables to WMO standards, and providing their metadata and data via WIS and WIGOS, could fulfill the necessary requirements in order to contribute to GCW and to be accepted as stations in the GCW surface network.

As encouraged by GCOS, GCW will facilitate the establishment of high-latitude stations with co-located measurements of key variables, especially permafrost and snow cover, thus enhancing GCOS/GTOS Networks for Permafrost (GTN-P), Glaciers (-G) and Hydrology (-H) and including the measurements of solid precipitation. In addition, aerosol contamination of surface snow (dust, black carbon, heavy metals, etc.) will also be monitored to link with existing atmospheric measurements from the GAW network. GAW stations and WCRP/Coordinated Energy and Water Cycle Observations Project (CEOP) reference sites in cold climates are potential candidates. Community monitoring also offers new network opportunities for GCW.

GCW will drive performance and provide motivation for high quality observations. Being a GCW station or CryoNet site means being part of an international, operational, global observing system and thus providing observations of known quality for research and knowledge beyond a site's local region.

GCW Surface Network Status

The 17th World Meteorological Congress (Cg-17, May-June 2015) decided that Polar and High Mountain Regions would be one of the seven WMO priorities for 2016-2019, including operationalizing GCW. Cg-17 recognized that an immediate priority for GCW is to establish CryoNet. Through extensive collaboration with partners, more than 100 sites have been proposed for CryoNet, of which 36 will be used for a pre-operational testing phase. Most of these sites were proposed as a result of CryoNet workshops in Asia (Beijing, December 2013) and South America (Santiago de Chile, October 2014). They are listed in Table 1 and their geographic locations are shown in Figure 2. The existing gaps will continue to be filled through engagements with partners, including workshops being organized or planned for cold regions in Asia/Eurasia, Latin America, North America and regions with tropical glaciers.

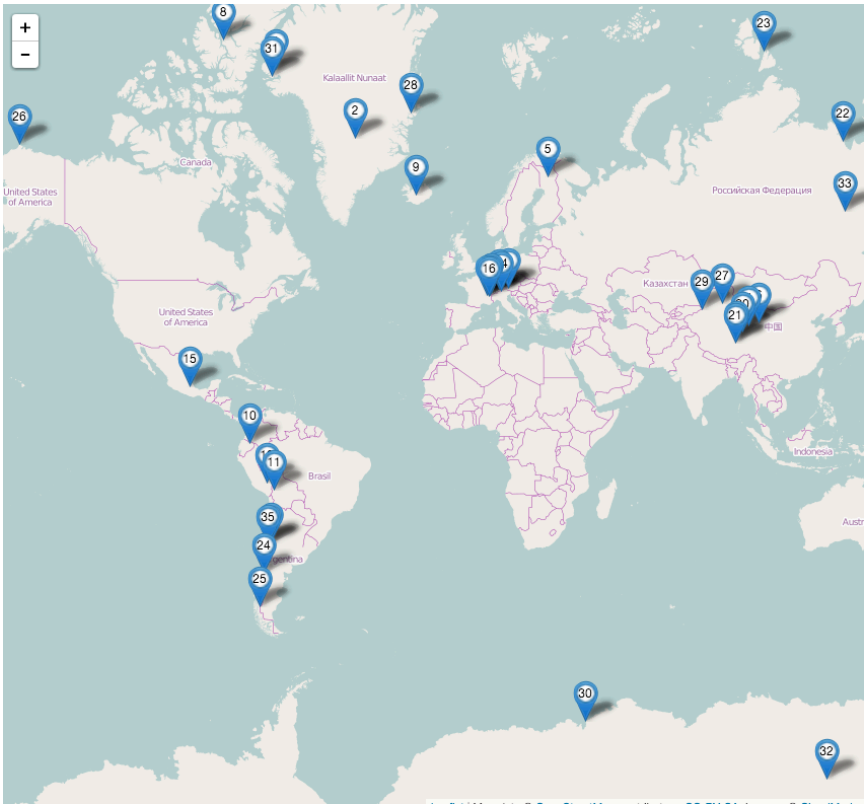

Figure 2: Locations of the 36 pre-operational phase CryoNet stations.

Table 1: The 36 stations approved for the CryoNet pre-operational testing phase.

	Station/Site	Operating Country	Location	Type
1	SIGMA-A	Japan	Greenland	Basic
2	PROMICE Greenland Ice Sheet Monitoring Network	Denmark	Greenland	Basic
3	Sonnblick	Austria	Austria	Integrated
4	Qilianshan Station of Glaciology and Ecologic Environment	China	China	Basic
5	Sodankylä-Pallas	Finland	Finland	Integrated
6	Qilian	China	China	Integrated
7	Tanggula Cryosphere and Environment Observation Station	China	China	Basic
8	Eureka	Canada	Canada	Basic
9	Hofsjökull	Iceland	Iceland	Basic
10	Antisana 15 alfa	Equador	Equador	Basic
11	Zongo Glacier	France	Bolivia	Integrated
12	Morenas Coloradas Rockglacier	Argentina	Argentina	Basic
13	Quelccaya Ice Cap	USA	Peru	Basic
14	Weissfluhjoch - Davos	Switzerland	Switzerland	Integrated
15	Glaciar Norte	Mexico	Mexico	Basic
16	Saint-Sorlin Glacier	France	France	Integrated
17	Argentiere Glacier	France	France	Integrated
18	Mer de Glace Glacier	France	France	Basic
19	Gebroulaz Glacier	France	France	Basic
20	Xidatan	China	China	Integrated
21	Tanggula	China	China	Integrated
22	Tiksi	Russia	Russia	Integrated
23	Ice Base Cape Baranova	Russia	Russia	Integrated
24	Vuriloches	Argentina	Argentina	Basic
25	Aonikenk	Argentina	Argentina	Basic
26	Barrow Baseline Observatory	USA	USA	Integrated
27	Tianshan	China	China	Basic
28	Zackenberg	Denmark	Greenland	Integrated
29	The Koxkar Glacier Camp (KGC)	China	China	Integrated
30	Syowa	Japan	Antarctica	Integrated
31	SIGMA-B	Japan	Greenland	Basic
32	Dome-C	France-Italy	Antarctica	Basic
33	Spasskaya Pad (Yakutsk)	Japan	Russia	Integrated
34	Forni Glacier	Italy	Italy (Europe)	Basic
35	Valle Nevado	Chile	Chile	Basic
36	Col de Porte	France	France	Integrated

3. Measurement Standards, Guidelines, and Best Practices

To ensure high quality and consistent observations, measurements at CryoNet sites will be made according to accepted guidelines, best practices and standards. Many of these have been compiled by WMO, though the compilations are not exhaustive for snow, ice, and permafrost measurements. Some existing cryosphere networks have implemented their own guidelines, best practices and standards. It will be a major effort for GCW to establish best practices that are in agreement with existing guidelines. Thus, CryoNet will draw on existing guidelines and best practices standards and add new ones, as necessary, to ultimately achieve the desired standards. They will be reviewed by the scientific community, modified as necessary, and maintained in the forthcoming *GCW Manual*.

As a first step towards a GCW measurement standard/guideline, GCW's CryoNet Team produced an inventory of existing measurement guidelines, best practices, and standards. Some details of that survey are given in Table 2. Existing manuals such as the WMO Manual on the Global Observing System and the WMO Guide to Meteorological Instruments and Methods of Observation (CIMO Guide) could serve as an important base for the *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 observing and monitoring systems and derived cryospheric products.

Additionally, instrument intercomparison campaigns will be conducted in order to determine and intercompare performance characteristics of instruments under field or laboratory conditions. The WMO Solid Precipitation Intercomparison Experiment (SPICE), which includes snowfall and snow depth, is of direct relevance to GCW and is considered as a contribution to GCW.

Table 2: 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, UNESCO	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, 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.	2010	Glaciers
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, ICSI, 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	Østrem 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, ICSI, 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,	1970	Glaciers

	UNESCO, Paris		
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	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
International Ice Charting Working group	Ice Information Services: Socio-Economic Benefits and Earth Observation Requirements. Electronic version is available at: nsidc.org/noaa/iicwg/docs/IICWG_2007/IICWG_SE_2007_Update_Final_.pdf	2007	Ice (sea, lake and river)

4. Data Access and Interoperability

The main purposes of the GCW Data Portal (or "catalogue"; http://gcw.met.no) are to provide an overview of datasets relevant to GCW, to provide access to datasets wherever possible (e.g. real or near real-time data streams, archive access), and to connect GCW with the WMO Information System (WIS) and WMO Global Telecommunication System (GTS) when real time exchange of data is requested by the GCW community. The intention is to establish the GCW Data Portal as a WIS Data Collection and Production Centre (DCPC) and to rely on WIS and WIGOS efforts for standardizing the metadata that are submitted to WMO. GCW data management follows a metadata-driven approach where datasets are described through metadata that is exchanged between contributing data centers and the GCW catalogue.

GCW itself will produce few low-level datasets, but instead relies on distributed data management technologies and partners to establish the GCW catalogue, which will publish WIS-compliant descriptions of GCW data and products into WMO's Global Information System Centres (GISCs) catalogues. This will create a unified interface to datasets in an otherwise fragmented terrain. No data will be kept in the GCW catalogue without an agreement with the data producer following a request from the user community. GCW will respect partnership, ownership, and data-sharing policies of its partners.

The ingested metadata will be harvested from project specific, national and international catalogues. In addition to harvesting existing catalogues, the data management part of the GCW Data Portal will facilitate forms for submission of metadata on datasets not handled by existing catalogues. Currently only a limited number of catalogues are integrated, but dialogues on integration have been established with a number of other catalogues (Figure 3). Quite frequently this involves some degree of adaptation of systems on either side.

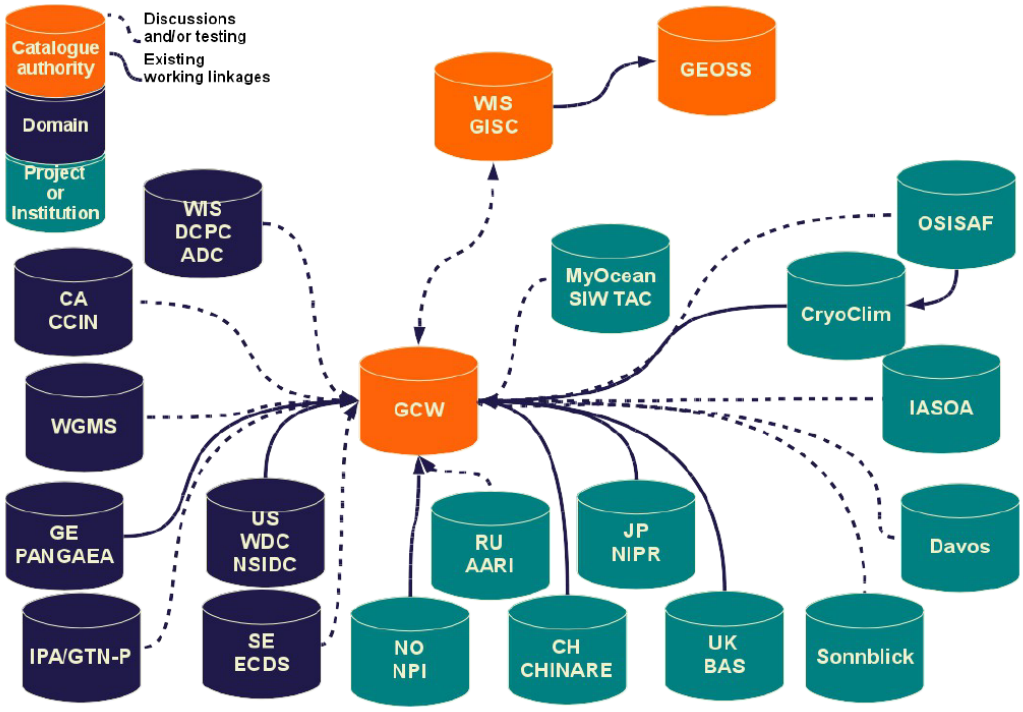

Figure 3: Data centers being addressed within GCW data management currently or in the short term. Solid lines indicate existing linkages; dashed lines indicate ongoing discussions and/or testing. All acronyms are defined at http://globalcryospherewatch.org/reference/acronyms.html.

There are technological considerations for catalogue interoperability, involving harvesting/exporting metadata using standard interoperability interfaces and documentation standards (e.g. Open Archives Initiative - Protocol for Metadata Harvesting (OAI-PMH), Open Geospatial Consortium (OGC) Catalogue Service for the Web (CSW), ISO23950, ISO19115, Global Change Master Directory (GCMD) Data Interchange Format (DIF)). OAI-PMH is the preferred solution for exposure of metadata due to its low cost of implementation. Implementations of OAI-PMH should support at least GCMD DIF or ISO19115 among which ISO19115 following the WMO profile is the preferred solution in the long term. To simplify data brokering, data streams established through Open-source Project for a Network Data Access Protocol (OPeNDAP) interfaces are the preferred solution as these map to the generic data model UNIDATA Common Data Model. There are relevant frameworks for catalogue interoperability including WMO Information System (WIS), ICSU World Data System (WDS), Group on Earth Observation (GEO).

The GCW Data Portal has been developed by the Norwegian Meteorological Institute (METNO), building on their web-based tool for searching data. This approach will facilitate seamless access with national meteorological and hydrological services (primarily utilizing WIS) and external data centers holding relevant cryospheric data and information at the national or global scale.

5. Recommendations

The Arctic observing initiatives and programmes are invited to consider participation in GCW implementation through:

1. Filling the gaps in the GCW Observing network and its core network, CryoNet, across the Arctic region, notably in North America, eastern Europe, western Russia, and over the Arctic Ocean;
2. Participation in the assessment, harmonization, and development of best practices to be applied to crysopheric observations in the Arctic;
3. Participation in the assessment, harmonization, and further development of vocabularies and definitions relevant to crysopheric observations in the Arctic;
4. Building interfaces with the GCW Data Portal; and
5. Community vetting of the observational requirements for cryospheric observations in the Arctic.

All of these aspects of implementation, particularly the first three, will enhance GCW's contribution to the Year of Polar Prediction (YOPP) scheduled to take place from mid-2017 to mid-2019.

More information on CryoNet and GCW is available online at http://globalcryospherewatch.org.