REPORT No. 4
2014

WORLD METEOROLOGICAL ORGANIZATION
GLOBAL CRYOSPHERE WATCH

Final Report of the CryoNet Team Meeting

First Session

Reykjavik, Iceland
20-22 January 2014

World Meteorological Organization
Weather • Climate • Water

GCW Global Cryosphere Watch

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1. ORGANIZATION OF THE MEETING

1.1. Welcome and Opening of the session

1.1.1 The First CryoNet Team Meeting of the Global Cryosphere Watch (GCW) was held at the Icelandic Meteorological Office in Reykjavik, Iceland from January 20-22, 2014. A. Snorrason as Chair welcomed the attendees and appreciated everyone's presence despite restrictions in some institutions on travel.

1.2. Adoption of the Agenda

1.2.1 A. Snorrason explained the logic of the agenda which was subsequently approved (Annex 1), and stressed the main objectives of this meeting:

- Create a final draft of CryoNet site requirements and site types (baseline, reference, integrated)
- Revise the site questionnaire
- Formulate the way forward for best practices.
- Agree on the first CryoNet sites
- Define a draft for the data policy within CryoNet
- Create a CryoNet work plan (action items with names and dates)
- Finalize CryoNet Team Terms of Reference
- Update the list of CryoNet Team members.

1.2.2 All documents and presentations prepared for, or given at, the meeting are available online at:
http://www.wmo.int/pages/prog/www/OSY/Meetings/GCW-CNT1/CryoNet_Reykjavik_DocPlan.html.

1.3. Participant introductions

1.3.1 Participants (Annex 1) briefly introduced themselves and identified their interests and background relevant to GCW and CryoNet (see also Annex 6).

2. REPORT OF THE CRYONET TEAM

2.1. Overview on activities and current status of CryoNet (W. Schöner)

2.1.1 One of the immediate priorities in GCW development and implementation is to establish the core network of GCW surface measurement sites – CryoNet. CryoNet is one part of the whole GCW observing system, which is, in turn, a component observing system of the WMO Integrated Global Observing System (WIGOS).

2.1.2 Wolfgang Schöner provided an overview on the CryoNet activities showing a list of the former activities (Questionnaires, Cryosphere Station inventory, Guide to GCW CryoNet (draft)) since the first CryoNet meeting (Nov. 2012, Vienna, Austria). He focused on the First Asia CryoNet Workshop held in December 2013 in Beijing, China, which revealed some key points:

- Strong activity of China (e.g. book describing their cryospheric monitoring activities)

- Idea of Regional Working Groups for CryoNet or even GCW in general (need for potential other regional meetings)
- List of CryoNet candidate sites for Asia high mountains
- Considerable interest for glacier monitoring and the need for guideline/standard

2.1.3 W. Schöner stated that the criteria that would make CryoNet successful depends first on WMO but is also highly dependent on groups of researchers/promoters through providing the theoretical background relying on the strengths of WMO support (intercomparison studies, providing guidelines, networking, promotion, etc.) and not its weaknesses. WMO will not give any direct funding to a CryoNet station but can motivate its partners e.g. the World Bank to do so via programs.

2.2. Report from Asia CryoNet Meeting

2.2.1 Raymond Le Bris reported on the main results of the First Asia CryoNet Workshop. The meeting was hosted by the Chinese Academy of Sciences (CAS) at the China Meteorology Administration (CMA) in Beijing, China from 3 to 5 December 2013. Forty-seven experts from China and from fourteen other countries attended the meeting. Main topics addressed in the sessions were related to the objectives and benefits of Asia CryoNet and on potential GCW stations at both high elevations and over high latitudes of Asia. Further discussions focused on observations, measurements and data.

2.2.2 More than thirty stations in China were proposed for inclusion in CryoNet as well as eighteen others from several countries in Asia (Kyrgyzstan, Kazakhstan, Russia, Japan, Nepal, Mongolia, Tajikistan and Pakistan).

2.2.3 The first draft report of the workshop is accessible here:
www.wmo.int/pages/prog/www/OSY/Meetings/GCW-CNT1/Doc_212_CryoNet_Asia_Report_v1.doc

2.2.4 The participants agreed on developing a work plan encompassing specific actions with deadlines and responsible persons (Annex 8).

2.3. Status of CryoNet Guide

2.3.1 Wolfgang Schöner first posed the question of how to proceed with the documentation table of CryoNet candidate stations available in the CryoNet document. Discussions led to an agreement to rename the document to “Primer” instead of “Guide” with a title as follow: *Primer to the Global Cryosphere Watch Surface-Based Observational Network – CryoNet*. It was also proposed to divide the document into two parts: (i) a technical document and (ii) the status of CryoNet. However, this proposition was not retained.

2.3.2 Major modifications were made to the document based on the outcomes from the First Asia CryoNet Workshop. The attendees agreed on the content and topics of the Primer to CryoNet document:

- Requirements for Site Inclusion
- Design, planning and evolution
- Instrumentation and Methods of Observation
- Operations
- Observational Metadata
- Quality Management

3. CRYONET BACKGROUND

3.1. CryoNet within GCW Implementation Plan

3.1.1 Jeff Key provided an overview on the CryoNet background within the GCW Implementation Plan (GCW IP) with a clear GCW timeline (see Figure 1).

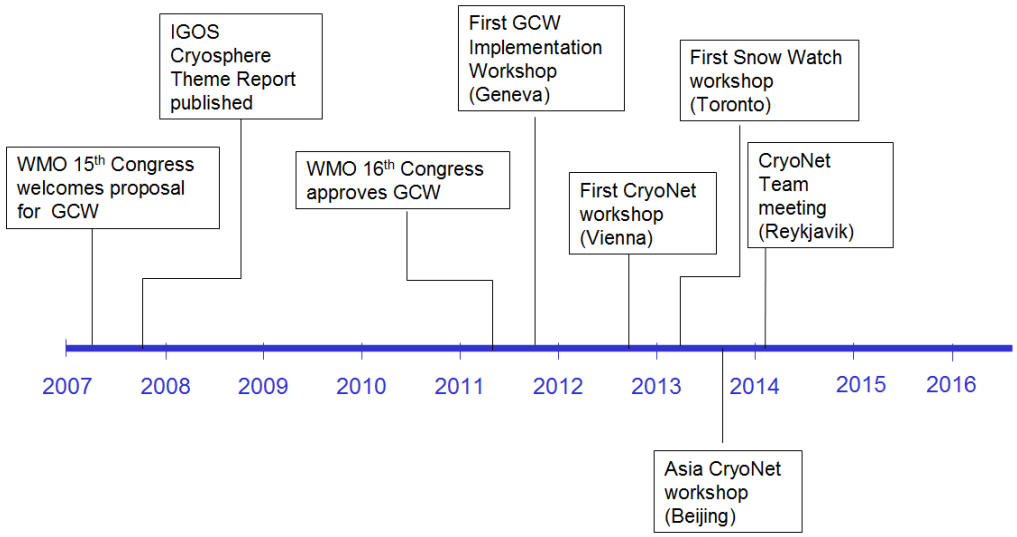

Figure 1: GCW Timeline

He also reaffirmed the main tasks of GCW:

- developing a network of surface observations which builds on existing networks;
- developing measurement guidelines and best practices;
- refining observational requirements for the WMO Rolling Review of Requirements;
- engaging in and providing support for intercomparison of products;
- contributing to WMO's space-based capabilities database (with PSTG);
- assessing snow cover products through the GCW Snow Watch project;
- creating unique products, e.g., the SWE Tracker, in collaboration with partners;
- engaging in historical data rescue (e.g., snow depth);
- building a snow and ice glossary;
- developing international training and outreach materials;

3.1.2 Discussions that followed addressed several topics regarding the glossary compiled in the GCW website as well as the CryoNet structure. It was noticed that the compilation of a cryospheric glossary is a huge task and that the terminology is extremely important especially when it is translated into different languages. Even institutions within same country may use different glossaries. Therefore, a precise description of what terms mean within a particular community is required. This point should be also included in the Primer to CryoNet document. The importance of connecting with modelers and remote sensing communities was also reaffirmed to make sure the same terminology is used. To avoid redundancies in activities, a close relation between the Infrastructures and Practices Team and the CryoNet Team is needed.

3.2. Report from the Snow Watch workshop

3.2.1 Barry Goodison reported the main outcomes from the *Snow Watch* workshop. The First workshop on implementing a *Snow Watch* component of GCW was hosted by Environment Canada at Toronto, Canada from January 28-30, 2013. The aims were to determine the current state of global snow monitoring, to identify critical issues affecting the ability to provide authoritative information on the current state of snow cover, and to initiate GCW *Snow Watch* projects to address priority areas. Principal action items required are listed here:

- Identify mutual interests and actions between CryoNet and Snow Watch requiring further action.
- Recommend issues for which CryoNet could/should take the lead for implementing, and those where CryoNet would partner with Snow Watch on implementation.
- Identify interested experts to contribute to all Snow Watch recommendations.

3.2.2 B. Goodison provided a summary of the recommended actions from the GCW Snow Watch workshop and the current status of these actions. He also invited those who have snow and ice measurement methodologies to share their documents.

3.3. Status of cryospheric observations in South America

3.3.1 Gino Casassa provided a summary on the status of cryospheric observations in South America. He described an active community in Latin America that addresses cryosphere related issues. Several national agencies and research institutions studied non-debris covered glaciers, glacier outburst floods (GLOFs, jökulhlaups), and other glacier hazard issues like ice avalanches. Permafrost and rock glaciers are mainly surveyed by mining companies with an emerging interest from national agencies especially in connection with recently introduced legislation in certain countries. Snow hydrology and snow avalanches are also monitored by water and hydroelectric companies as well as national agencies and research institutions. However, lake and river ice do not constitute an area of active research or monitoring.

3.3.2 The southern hemisphere represents an important target for CryoNet and the network would gain in including stations/sites both from New Zealand and from South America. At the moment only Antarctica (Dome C) is part of the preliminary list for the Southern Hemisphere. It was noticed that even for this founding phase it is important to have some Southern Hemisphere stations.

4. STANDARDS AND GUIDELINES FOR CRYONET

4.1. The WMO concept of standards and guidelines

4.1.1 Miroslav Ondras presented an informative summary of the importance of standardization within WMO and its relevance to GCW. He briefly explained the WMO structure and raised some key points from the WMO Convention:

- To facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology;
- To promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics;

4.1.2 M. Ondras also provided important recommendations for standardization in CryoNet:

- Review of existing agreed practices (list of CryoNet relevant practices already established by CryoNet Team)
- Define standard (shall) and recommended (should) practices to be included in the WMO Technical Regulations (TR)
- Define standard (shall) and recommended (should) practices to be included in the Manual on WIGOS (Annex to WMO TRs)
- Define detailed procedure and practices, implementation guidelines, explanations, examples, good practice to be included in the GCW Guide
- Develop a work plan, members' responsibilities, deadlines
- Develop a roadmap (respect deadlines for Cg-17):
  WMO TR final version in May/June 2014
  WIGOS Manual final version in May/June 2014
  GCW Guide before CryoNet is operational

4.2. Overview of existing Cryosphere guidelines

4.2.1 W. Schöner stated that GCW standards and best practices for cryospheric measurements are currently being compiled. GCW is drawing on existing measurement methods where possible and where a scientific consensus has been or can be reached. An initial inventory of existing documents describing measurement practices is available on the GCW website (http://globalcryospherewatch.org/cryonet/methods.html).

4.2.2 Attendees agreed to change the names "Guidelines" and "Standards" to "Agreed Practices". The notions of accuracy and precision should as well be replaced to "documented quality".

4.3. Evaluation of the Tiered Network Strategy

4.3.1 The main objective of a network such as CryoNet is to capture the state of the cryosphere worldwide. Terrestrial observations at both high latitudes and high altitudes are crucial. Those observations shall include two-way interactions: (i) between observers and modelers and (ii) between surface-based observations and the remote sensing scientists. CryoNet is a purpose-oriented network with three classes of stations (see below). The term 'tier' used in earlier documents is replaced by "class". Basic requirements for a successful network should define best practices for cryospheric observations, improved training in particular at the international level and insure a commitment of station owners to run stations "continuously" according to requirements.

4.3.2 C. Fierz explained that all CryoNet stations/sites should allow (near) real-time (whenever possible) access to observations and should make them available publicly and without cost. In some specific cases however, up to 2 years delay should be allowed for both quality control of data and submission to archives (e.g. glacier mass balance data or observations in Antarctica).

4.3.3 Terminology is also seen as an important characteristic when establishing a network. As the cryosphere is part of other spheres of the Earth, it is important to adapt clear and consistent methods to observe the cryospheric components (e.g. solid precipitation) and to develop and agree on a common glossary.

4.4. Definition of criteria for inclusion of existing stations in CryoNet

4.4.1 W. Schöner provided the participants with a draft list of criteria for site inclusion. This list served to initiate a discussion on defining clear criteria for assigning existing and new stations/sites to the single classes of the network. Such criteria have to guarantee (e.g. for a data user) that well-described levels of data quality and measurement best practices have been met. This criteria catalogue will be developed as a separate GCW CryoNet document covering the three classes of sites (baseline sites, reference sites and integrated sites). See Figure 2 for an updated graphic on basic requirements according to sites classes.

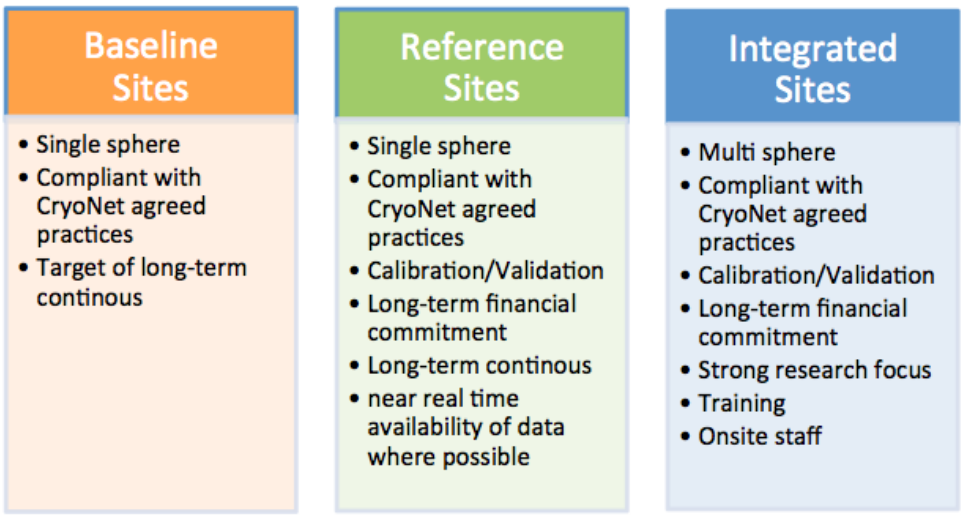

Figure 2: Basic requirements defined for the different sites classes within CryoNet.

4.4.2 This presentation led to a long and constructive discussion regarding site classification. First, it was agreed to change the term "Tiered" to "Class" to describe the CryoNet structure. Differentiation between site and station was also evoked mentioning that a site could have one or several stations. The scale of a given site could also influence the classification. Free public access to data has also been recognized as fundamental criterion that in turn would be a strong filter to many research sites and institutions to be included in CryoNet.

4.4.3 Referring to point 1 of "Requirements for Site Inclusion" (Annex 3), it was agreed that a general reference for any given station's "representativeness" should be expressed in this form: "it is spatially/temporally representative for measuring one or several components of the cryosphere". When applying for each site/station joining CryoNet, providing a substantiated statement of representativeness is mandatory for the applicant.

4.4.4 For some specific sites/stations (AWS, drifting buoys, (moored or mobile)) which could be considered as integrated sites (multi-sphere), further discussions remained necessary regarding their inclusion and classification in CryoNet. This topic will be addressed by the CryoNet Team and the GCW Steering Group.

4.4.5 All the revised and agreed criteria for site inclusion are listed in Annex 3.

4.5. Formal procedure of station inclusion

4.5.1 Sandy Starkweather presented a formal procedure and consideration of station inclusion. She stressed the fact that a procedure should focus on capturing as much documentation about the station as possible (e.g. institutional (POC's maintenance plans, etc.); Infrastructure

(facilities/platform, coordinates, station history, etc.) and inventories (instruments, data sets, products, etc.). It should also involve some type of expert/peer review evidence for inclusion evaluated against criteria; identify calibration/validation collaborators and ask for evidence of partnership; site visits by Regional Teams. Eventually, a procedure should consider recurring meetings for improved participation (Regional Teams).

4.5.2 This presentation engendered a discussion on the suitability of creating a sub-group to test the site classification by selecting a few stations and trying to apply the defined requirements.

4.6. Discussion on implementation of CryoNet Guidelines

4.6.1 It was agreed that the Infrastructure and Practices Team should take the responsibility for establishing the Best Practices document by creating a subgroup. A first preliminary subgroup (C. Fierz, M. Citterio, B. Goodison) was formed during the meeting. The document is expected early 2015.

5. ESTABLISHMENT OF CRYONET

5.1. Summary of the CryoNet Sites Questionnaire

5.1.1 W. Schöner gave a comprehensive review on the questionnaire that was sent to all participants in preparation for both the Vienna and the Beijing meetings. The synthesis of the questionnaire responses showed that participants were mainly concerned about the following key points:

- Implementation of a tiered network
- High need for standards and guidelines in cryospheric observations (many counts)
- Serve science and practitioners
- Cooperate with existing networks
- Fill gaps in existing networks
- Data policy and data provision

5.1.2 After the presentation the discussion focussed more on the update of the questionnaire to be used to gather detailed information about the initial CryoNet stations. The GCW questionnaire was revised based in part on the questions posed in the Global Atmosphere Watch (GAW) site application. Sandy Starkweather suggested that the template used for IASOA stations might provide additional insight.

5.1.3 It was also proposed to work in close collaboration with several people who manage stations in order to develop (or revise) the CryoNet Questionnaire.

5.2. Principles for a design of CryoNet

5.2.1 Hironori Yabuki presented the GEOSS “Asia Water Cycle Initiative (AWCI)” involving 20 countries. This project is a big step ahead of CryoNet and features an impressive capacity for integrating and analysing data, including calibration and validation of data sets.

5.2.2 Some recommendations for the development of CryoNet were provided. For instance, an observation network should be composed not only of operational observation sites but also include experimental observation sites with specific information on the experiment conducted. To encourage the participation of such experimental sites, a clear data policy should be established

with also a clarification of the advantages to the data contributor. Regional Working Groups (e.g. Asia CryoNet Workshop, South-America CryoNet Workshop) might stimulate regional community to work jointly.

5.2.3 The presentation led to a discussion about the GCW data portal and the format behind the metadata (see below section 7 on Data Policy). IASOA works with an ISO-standard but the participants noted that the prime requirement would be interoperability with WMO-WIS, which is also applicable to (near)-real time data in order to process them through the GTS/WIS system.

5.2.4 A CryoNet design has to be developed in order to define all specific elements of the network (e.g. a site should be defined by a polygon which could include either a baseline or an integrated station; density of stations; spatial distribution (X, Y and Z) etc.). Those specifications should be identified and compiled in a technical document (e.g. Principles of Design for CryoNet).

5.2.5 Data policy should also be included in the site inclusion requirements. It was stated that a design feature for reference and integrated sites should be developed to allow calibration and validation studies.

5.2.6 The presentation ended with three points from Professor Toshio Koike, University of Tokyo, to be considered when establishing CryoNet:

1. Agree to data policy at an early stage, and write it down, and let all participants know and understand about it.
2. Establish cooperation with advanced IT technical people, and develop a system that can easily be used (applied) by observation people for quality management and meta-data registration.
3. Identify a data researcher, independent from field scientists and model scientists, or find an organization that has this ability. This needs to be done at the design stage of the project.

5.3. Review of potential sites

5.3.1 In this session attendees reviewed the list of potential stations/sites to be considered in CryoNet. In a first approach, W. Schöner stated that one of the first things to think about when selecting a station or a site is the spatial distribution and the heterogeneity of the site (type, location, cryospheric component being measured at the place, science representativeness etc.). He also asked how we should deal with the preliminary list resulting from the Asia CryoNet Workshop. Collaboration between sites/stations should be assessed as well according to the aims of CryoNet.

5.3.2 The selection process done during this meeting constitutes a demonstration phase. Official invitation to be part of CryoNet and other administrative issues will be addressed later on by the GCW Steering Group. Having around six to eight sites in a short preliminary list was a goal for this meeting. Eventually, fourteen stations were selected in the preliminary list. This list is given in Annex 7.

5.3.3 In order to make an efficient classification, it was suggested to ask (through the questionnaire) the manager or responsible person for any given station to describe and explain in which class the station should be included. The final decision would be made by the GCW

Steering Group. It is recognized that data policy will play an important role in the selection process.

5.4. Selection of sites for CryoNet

5.4.1 Surface stations that are part of CryoNet are listed in a table in Annex 7. Detailed information is available for each site on the GCW website (http://globalcryospherewatch.org/cryonet/stations.php). This is the initial list of fourteen potential CryoNet sites that are expected to be confirmed in early 2014. Following this demonstration phase many more stations will be added through an application process in the near future.

5.4.2 The Global Atmosphere Watch (GAW) was mentioned as a good example on how a given candidate station is evaluated prior to its inclusion in the network. This scheme could be followed in CryoNet.

5.4.3 A formal invitation has to be sent to potential stations/site providers to explicitly ask them if they wish their stations/sites to become part of CryoNet. If they do, then they will be asked to complete the version of the Site Questionnaire that will be online by mid-2014.

5.5. Interaction with other networks: CryoNet-IASOA-INTERACT

5.5.1 The session ended with a short summary of a side meeting held at the AGU Fall Meeting 2013. Sandy Starkweather and Wolfgang Schöner initiated the meeting with the intention in identifying common interests of GCW/CryoNet, IASOA, and InterAct (Artic terrestrial ecology network). Many ecologists attended the meeting but only few meteorologists showed up. In summary, Sandy noted that the goals of the three initiatives are not well aligned except maybe for data management. Nevertheless, measurement practices could be shared and the presence of Campbell Scientific representatives, to address cold-weather modifications to relevant instruments, underlines it.

6. CRYONET TEAM

6.1. Review of Terms of Reference

6.1.1 The purpose of the document 6.1.1 was to provide a draft for a discussion on the Terms of Reference (TOR) for the CryoNet Team based on information provided in the draft GCW Implementation Plan.

6.1.2 Some participants raise a concern with time required by the process of updating the list of stations/sites. In fact, any changes or updates would only require formal approval from EC-PORS. This design will make CryoNet more flexible.

6.1.3 Agreement on a revised version of the TOR of CryoNet Team was made and submitted to the GCW Steering Group for consideration. The Terms of Reference for the CryoNet Team are given in Annex 4.

6.2. Development of the Work Plan

6.2.1 One of the main outcomes from this meeting is the establishment of a CryoNet Team work plan that defines actions, responsible persons and deadlines for the agreed tasks. This work plan is given in Annex 5.

6.3. CryoNet Team membership

6.3.1 A first attempt to compose the CryoNet Team was made during this session with the idea that the team should represent the variety of cryospheric observations and linkages to networks. This was recognized as one of the main priorities. Modelers should also be involved in the development of the data policy document in order to understand and consider their needs, and should be part of the CryoNet Team.

6.3.2 The preliminary list of team members is: Wolfgang Schöner (Chair), Matthias Bernhardt, Michele Citterio, Charles Fierz, Christophe Genthon, Vasily Smolyanitsky, Þorsteinn Þorsteinsson, Gino Casassa, Kaji Luojus, Sandy Starkweather, Hironori Yabuki and Xiao Cunde. Jeff Key and Barry Goodison serve as ex-officio participants. Sub-groups can be established to address particular issues as required. More details on the CryoNet Team members (e.g. affiliation, expertises) are given in Annex 6.

7. CRYONET DATA POLICY

7.1. Data vs. meta-data

7.1.1 The WMO Information System (WIS) enables systematic access, retrieval, and dissemination and exchange of data and information of a variety of the WMO and related international Programmes. The GCW Portal is now WIS compliant but data should be compliant too. In this regard, it was suggested that the WMO Global Telecommunication System (GTS) develops a specific buffer for cryospheric data ingestion into the GCW Portal with however, some constrains because the WMO system recognizes only binary data and uses algorithms to automatically decode data. An identification of the type of data that should be shared in real time is a prerequisite to developing a formal common template for submission.

7.1.2 Participants recognized that the most important issue at present is that the GCW Portal provides metadata for users with links to the data whenever possible. In the meantime, data should be submitted to a publicly accessible data center that is inter-compatible with the GCW Portal (e.g. WGMS/GTN-G for glaciers, GTN-P for permafrost) and meet the submission requirements. Information on the data uncertainty is also mandatory. If no data centre exists for a specific type of data, GCW could co-fund or help to develop one.

7.1.3 Downloading data from the GTS system requires a login and a formal request. It was agreed that CryoNet should be more flexible but further discussions are needed to address this issue.

7.2. Potential CryoNet data policy/IASOA experiences

7.2.1 S. Starkweather suggested some recommendations for developing an open data policy through the example of the International Arctic Systems for Observing the Atmosphere (IASOA). The mission of IASOA is to advance coordinated research objectives from independent pan-Arctic atmospheric observatories through (1) strategically developing comprehensive observational capacity, (2) facilitating data access and usability through a single gateway, and (3) mobilizing contributions to synergistic science and socially-relevant services derived from IASOA assets and expertise.

7.2.2 IASOA's recommendations are listed here:

- Document all datasets using metadata that is compliant with international data management procedures,

- Use machine readable interfaces for metadata (e.g. xml),
- Use flexible and domain generated vocabularies to describe datasets, reference a "thesaurus", support crosswalks in the background,
- Follow recommended standards for file formats (date formats, etc.),
- Wherever possible facilitate machine interfaces to datasets, enabling higher order services to be built on data other relevant bodies,
- Consider a compliance period?
- If the data isn't accessible, we don't (want to) include it (red/yellow/green rating),
- Harvest as much as possible even if it doesn't meet our standards; lobby for it to meet our standards (e.g. BSRN, GAW),
- Support giving credit, citations, looking to build in DOI capability.

7.2.3 The meeting raised some concerns on potential commercial uses of data available through the GCW Portal. A non-commercial clause could reduce the distribution of data. The International Polar Year (IPY) data policy provides an example on how to handle this issue and should be consulted.

7.2.4 There is a resolution under the Global Framework for Climate Services (GFCS) mentioning that data should be made freely available for cryospheric observations. The GCW CryoNet Team which has the responsibility to contribute to the draft of the Data Policy could refer to it. A sub group could be defined to address this issue. The Global Atmospheric Watch (GAW) Data Policy is also an excellent example to look at. The document will be considered by EC-PORS.

8. GCW WEBSITE, CRYONET SERVICE AND CAPACITY BUILDING

8.1. Web platform to demonstrate the development of CryoNet

8.1.1 The GCW website (http://globalcryospherewatch.org) differs from the METNO GCW data portal in that it contains more dynamic information (news, state of the cryosphere plots, highlights, calendar), as well as background, higher-level information, GCW documents, and outreach material. It links to the METNO data portal.

8.1.2 The website and the portal should remain separate from each other though linked and complementary. The website should serve as back up for all documents related to stations/sites (e.g. questionnaire responses). Metadata of stations could be available through the website by developing a compatible and dynamic ingestion process as well as a possibility to update the site questionnaire and metadata by the station manager directly online. This, however, represents a significant amount of work and would require dedicated staff to make it efficient.

8.2. How to better include the sea-ice community

8.2.1 Vasily Smolyanitsky presented a comprehensive overview of the areas of the sea ice and icebergs monitoring, existing terminology, standards, data sources, data dissemination and collection, managing bodies and potential interactions that could be developed between GCW CryoNet and the sea-ice community (see Figure 3 below). He noted that the WMO Sea-Ice Nomenclature (WMO-No.259) includes terminology for all principal kinds of 'floating ice' including the sea, lake, river and glacier ice and the same services and standards are or can be used for observations and data management, though pragmatically it would be useful to consider two ice groups: sea ice, ice sheets, icebergs and river, lake ice. Several gaps that have to be addressed:

- International standard for distributing buoys information on the GTS (drift, mass-balance, ULS),
- Extension of ice buoys networks (IABP, IPAB),
- Specifications for ice information (observations and products) for WIS,
- WMO-approved manual for ice observations (manual for ice observers is still a draft),
- Data policy (on-line / delayed mode / access to scientific data / data from applied research),
- Closer linkages with the NWP and scientific community,
- Perhaps consider two categories of “floating ice” (sea ice & ice shelves & icebergs / river & lake).

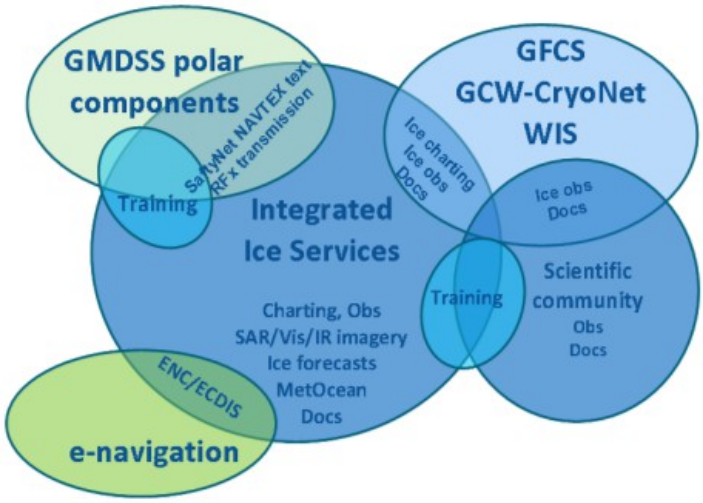

Figure 3: Concept of linkages of integrated ice services - national practices – scientific community – CryoNet - GCW

8.3. Experience from capacity building within IASOA

8.3.1 In the last year, IASOA has begun to form thematic expert groups to develop new knowledge and data products from its long and broad collection of atmospheric observations at IASOA observatories (all of which are strong candidates for CryoNet sites). The mission of these groups is to identify critical observing gaps or performance issues at participating observatories; to identify robust and well-documented processes for quality control and assessment; to identify error correction schemes and consistent definitions of uncertainty; to pool resources for the execution of analysis; to educate each other about observational best practices; and draw broad regional conclusions from comparisons of data sets. All of the activities point to type of capacity building that IASOA and similar networks like CryoNet can facilitate.

8.3.2 Two groups, the Net Radiation Working Group and the Equivalent Black Carbon Working Group were initiated last year. The IASOA Steering Committee was careful to only form groups that are non-duplicating with other efforts and that had clear leadership, resources and readiness to accomplish something useful. The U.S. led annual Arctic Report Card publication was chosen as an outlet for science analysis; the groups will also work towards multi-authored publications in traditional journals.

8.3.3 The lessons learned from this initial year of development were:

- Choose low friction, ready-to-go starting points: Starting where there was logical leadership, resources for analysis and a readiness of data rather than creating a top-down vision of working group structure that is comprehensive.
- Aim for quick results that will leave a legacy of lasting value. The analysis for the Arctic Report Card gave the team quick results. The legacy of lasting value is that more than a dozen datasets were QA'd, processes in a consistent way and are being archives in World Data Centres.

8.3.4 IASOA reported on a third working group that they are starting to build. This one is much more ambitious and broad, related to atmospheric-surface coupling and flux measurements. It is the most important group for connecting IASOA with GCW because of the linkages between atmospheric and cryospheric processes. IASOA also tried to involve the European group INTERACT because of their strong ties with both the Arctic and the Terrestrial flux measurement community. Moving forward, because the topic is so broad and interdisciplinary, it will be crucial to get very focused on specific areas of highest importance. It will also be important to align objectives among IASOA, GCW and INTERACT and other emerging partners so each group is highly motivated and clear on how they can contribute.

8.4. Discussion on CryoNet services

8.4.1 Christophe Genthon presented research conducted in Antarctica including at the Dome C station, Antarctica, reminding the audience of the specificities of Antarctica regarding its particular environment (which implies singular logistical and technical issues) and its geopolitical characteristics. Antarctica is $15x10^6$ km^2 with most of the stations operated in the vicinity of the coastline and only a few year-round permanent stations in the interior (i.e. Amundsen–Scott South Pole, Dome C and Vostok stations). Meteorological data gathered in Antarctica mainly result from Automatic Weather Stations (AWS). They are made freely available via the Antarctic Meterological Research Center (AMRC, University of Wisconsin) in compliance with the article 3.3 of the Madrid protocol ratified in1991, which stipulates that: "Scientific observations and results from Antarctica shall be exchanged and made freely available".

8.4.2 The practice formally agreed upon by French and Italian polar institutes at Dome C is that data are freely available (no price tag, no co-authorship required, but acknowledgement needed) in all possible manners two years after they are obtained. This two-year delay is required because most of the observations are made and funded in research projects which imply an exclusive time to adequately produce project deliverables including publications. All metadata (data type, method, site, sampling, period...) are immediately publicly available from the Antarctic Master Directory:

http://gcmd.gsfc.nasa.gov/KeywordSearch/Home.do?Portal=amd&MetadataType=0

8.4.3 Participants underlined the importance for GCW to consider Antarctica's issues since Antarctica brings some exceptional challenges for observation methods compared to other locations.

8.4.4 C. Genthon raised concerns regarding what GCW and in particular CryoNet can do for the particular example of cryospheric observations in Antarctica. Can GCW or CryoNet help to develop data access or make available the GTS over Antarctica (besides existing routine surface

and upper-atmosphere meteorology)? What about satellite data (essential over Antarctica) and elaborated data (models), both using in situ observation for calibration / validation?

8.4.5 He recalled that the WMO Solid Precipitation Inter-comparison Experiment (SPICE) will marginally help due to the fact that snowfall is too different than elsewhere. Therefore, a major breakthrough for precipitation studies could be achieved by implementing an Antarctica-SPICE.

9. THE WAY FORWARD FOR CRYONET

9.1. Discussion on:

Further building of CryoNet

9.1.1 It was noticed that Dome C (Antarctica) represents a really interesting case to test the CryoNet classification scheme because the site could fit in the three classes.

9.1.2 V. Smolyanitsky mentioned that more stations from the Russian Federation and other nations can be proposed for inclusion in CryoNet and also asked how to consider networks of ice buoys and the ice charting (which represents both observations and services/products) within CryoNet.

Management of CryoNet

9.1.3 The meeting suggested that a formal nomination of new CryoNet Team members should be proposed by the GCW Steering Group to EC-PORS for approval.

9.2. Need for a South American CryoNet Workshop

9.2.1 The meeting recognizes the necessity to organize a workshop in the South America in order to fill the gap in the CryoNet representation (spatial distribution of stations in Southern Hemisphere). Gino Casassa suggested the possibility of hosting a meeting in Santiago, Chile, at the Chilean Water Agency offices or at the Met office. This would possibly bring together the South American community involved in CryoNet.

9.2.2 October-November 2014 could be the ideal period of the year for this meeting. The meeting language could be either English or Spanish with some interpreters. The core of the meeting could be as follows: 2 days for a general meeting - 2 days for specific workshops. G. Casassa proposed to send a note within the month with potential names and information on the venue.

9.3. Recommendations to the GCW Steering Team and EC-PORS 5, including CryoNet establishment & CryoNet Team membership

9.3.1 GCW Steering Group is requested to consider the preliminary CryoNet Team structure including the leadership and membership as suggested by the participants (Annex 6)

9.3.2 GCW Steering Group is requested to consider the revised version of the Terms of Reference for the CryoNet Team (Annex 4).

9.3.3 GCW Steering Group is requested to consider the first selection of CryoNet sites (Annex 7) and to develop a formal application for candidate stations/sites as well as an evaluation process prior to inclusion in the network.

9.3.4 GCW Steering Group is requested to approve the site requirements for inclusion in CryoNet revised by the participants (Annex 3).

9.3.5 GCW Steering Group is requested to consider the work plan (action items with names and dates) defined by the meeting (Annex 5).

9.4. All other business

9.4.1 The meeting recognized the need to organize a CryoNet Portal Team meeting in the coming month to address the data and metadata accessibility issues and all other questions regarding the Portal development. It was suggested to hold this meeting in Davos, Switzerland around June 2014.

9.4.2 The participants agreed that the full list of candidate sites (more than 100) should not be on the GCW website at this time..

9.4.3 The meeting encouraged persons who might have contacts either in institutions or agencies related to all cryosphere issues in South America to instigate links in a view of potential collaborations/contributions to CryoNet.

ANNEX 1: MEETING AGENDA

Monday, January 20 (0930-1745)

1 ORGANIZATION OF THE MEETING

1.1 Welcome and Opening of the session
1.2 Adoption of the Agenda
1.3 Working Arrangements
1.4 Participant introductions

2 REPORT OF THE CRYONET TEAM

2.1 Overview on activities and current status of CryoNet (W. Schöner)
2.2 Report from Asia CryoNet Meeting (R. Le Bris)
2.3 Status of CryoNet Guide (W. Schöner)

3 CRYONET BACKGROUND

3.1 CryoNet within GCW Implementation Plan (J. Key)
3.2 Role of satellite data within GCW observations and linkages to CryoNet (J. Key)
3.3 Report from the Snow Watch workshop (B. Goodison)
3.4 Status of cryospheric observations in South America (G. Casassa)

4 STANDARDS AND GUIDELINES FOR CRYONET

4.1 The WMO concept of standards and guidelines (M. Ondras)
4.2 Overview on existing Cryosphere guidelines (W. Schöner)
4.3 Evaluation of the Tiered Network Strategy (C. Fierz)
4.4 Definition of criteria for inclusion of existing stations in CryoNet (W. Schöner)
4.5 Formal procedure of station inclusion (S. Starkweather)
4.6 Discussion on implementation of Guideline Working Group (All)

END OF DAY (1745)

19:00 GROUP DINNER (own expense, place to be determined)

Tuesday, January 21 (0930-1745)

5 ESTABLISHEMENT OF CRYONET

5.1 Summary of the CryoNet Sites Questionnaire (W. Schöner)
5.2 Principles for a design of CryoNet (T. Ohata)
5.3 Review of potential sites (W. Schöner)
5.4 Break-out session on establishment of CryoNet (Chair: A. Snorrason)
5.5 Report and Summary of Break-out session
5.6 Selection of sites for CryoNet (W. Schöner)
5.7 Interaction with other networks: CryoNet-IASOA-INTERACT (S. Starkweather)

6 CRYONET TEAM

6.1 Review of Terms of Reference (J. Key)
6.2 Development of the Work Plan (W. Schöner)
6.3 CryoNet Team membership

END OF DAY (1745)

Wednesday, January 22 (0930-1745)

7 CRYONET DATA POLICY

7.1 Data vs. meta-data (W. Schöner)
7.2 Potential CryoNet data policy/IASOA experiences (S. Starkweather)
7.3 Breakout Session (C. Fierz)
7.4 Report and Summary of Break-out session

8 GCW WEBSITE, CRYONET SERVICE AND CAPACITY BUILDING

8.1 Web platform to demonstrate the development of CryoNet (J. Key)
8.2 How to better include sea-ice community (V. Smolyanitzky)
8.3 Experience from capacity building within IASOA (S. Starkweather)
8.4 Discussion on CryoNet services (C. Genthon)

9 THE WAY FORWARD FOR CRYONET

9.1 Discussion on:
    9.1.1 Further building of CryoNet (W. Schöner)
    9.1.2 Management of CryoNet (W. Schöner)
9.2 Need for a South American CryoNet Workshop (G. Casassa, W. Schöner)
9.3 Recommendations to GCW Advisory Team and EC-PORS 5, including CryoNet establishment & CryoNet Team membership (J. Key)
9.4 All other business

10 CLOSURE OF MEETING

ANNEX 2: LIST OF PARTICIPANTS

N°	NAME	INSTITUTION	E-MAIL
1	Arni Snorrason	International Activities Office	arni.snorrason@vedur.is
2	Charles Fierz	WSL Institute for Snow and Avalanche Research SLF, and International Association of Cryospheric Sciences (IACS), Davos, Switzerland	fierz@slf.ch
3	Christophe Genthon	LGGE, Grenoble, France	genthon@lgge.obs.ujf-grenoble.fr
4	Gino Casassa	Centro de Estudios Científicos, Chile, Vice-chair of CliC Scientific Steering Group (SSG)	gcasassa@cecs.cl
5	Jeff Key	NOAA, Madison, USA	jkey@ssec.wisc.edu
6	Michele Citterio	GEUS - Geological Survey of Denmark and Greenland, Copenhagen, Denmark	mcit@geus.dk
7	Sandy Starkweather	University of Colorado, Boulder, Colorado, USA	Sandy.Starkweather@noaa.gov
8	Tetsuo Ohata	Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan	ohatat@jamstec.go.jp
9	Hironori Yabuki	Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan	yabuki@jamstec.go.jp
10	Þorsteinn Þorsteinsson	Icelandic Meteorological Office, Reykjavík, Iceland	thor@vedur.is
11	Vasily Smolyanitsky	Arctic and Antarctic Research Institute, St. Petersburg, Russian Federation	vms@aari.aq
12	Tomas Johannesson	Icelandic Meteorological Office, Reykjavík, Iceland	tj@vedur.is
13	Wolfgang Schoener	Central Institute for Meteorology and Geodynamics, Vienna, Austria	wolfgang.schoener@zamg.ac.at
14	Miroslav Ondras	WMO, Geneva, Switzerland (Secretariat)	mondras@wmo.int
15	Barry Goodison	Kanata, Ontario, Canada	barrygo@rogers.com
16	Raymond Le Bris	WMO, Geneva, Switzerland (Secretariat)	rlebris@wmo.int

ANNEX 3: SITE REQUIREMENTS FOR INCLUSION IN CRYONET

1. The site location is chosen such that, for the variables measured, it is spatially/temporally representative for measuring one or several components of the cryosphere.
2. User needs have been considered in the observation design process.
3. CryoNet sites have to be active and perform sustained observations according to CryoNet agreed practices.
4. Technical personnel are trained in the operation and maintenance of the equipment.
5. For all CryoNet sites, there is an intent by the responsible agencies to sustain long-term observations of at least one of the CryoNet variables. Reference sites have a continuous record of at least 10 years of cryospheric observations (using CryoNet agreed practices). Integrated sites measure at least three components of the cryosphere as well as their interactions with other Earth spheres.
6. The relevant CryoNet observations are of documented quality. The measurements are made and quality controlled according to CryoNet agreed practices.
7. Associated standard meteorological in situ observations, when necessary for the accurate determination and interpretation of the GCW variables, are made with documented quality.
8. A station logbook for observations and activities that may affect observations is maintained and used in the data validation process.
9. The data and metadata including changes in instrumentation, traceability and observation procedures are submitted in a timely manner to a data centre that is interoperable with the GCW portal.
10. The station characteristics and observational programme information are kept up-to-date in the GCW station information database. Station metadata are also provided to the WMO Operational Information Resource (WIR) and maintained regularly.

ANNEX 4: TERMS OF REFERENCE OF THE GCW CRYONET TEAM

Under the general guidance of the GCW Steering Group (GSG), the *CryoNet Team* will be responsible for the establishment and subsequent operations of the core surface-based observational network called CryoNet. Especially, it will:

1) Develop practices for CryoNet design and evolution;
2) Identify, in coordination with the GCW focal points of WMO Members and those of partners, suitable observing sites for CryoNet surface-based observational network;
3) Submit the initial list of stations of CryoNet for consideration by GCW Steering Group (GSG) and EC-PORS;
4) Regularly review and update the list of CryoNet stations;
5) Review available observing practices currently used in cryospheric measurement;
6) Propose and/or develop best practices for CryoNet stations for consideration by GSG and EC-PORS;
7) Develop relevant CryoNet sections to be included in the WMO Technical Regulations and in the WIGOS Manual;
8) Develop data policy and identify data management practices, including archiving, data sharing and data exchange and interoperability arrangements, for consideration by GSG and EC-PORS;
9) Liaise with managers of CryoNet stations on aspects related to the CryoNet work programme at their stations;
10) Organize implementation and training workshops to supervise the development of CryoNet;
11) Report annually to GSG, including recommendations for CryoNet operation and development;
12) Provide annual reports to all stakeholders, as appropriate thorough GCW website and/or Newsletter.

ANNEX 5: GCW CRYONET TEAM WORK PLAN

N°	Task	Deliverable / Activity	Due	Responsible	Status	Comment
1	Primer to CryoNet	Technical report	April 2014	W. Schöner, C. Genthon, V. Smolyanitsky	Draft version	
2	Text for WIGOS section for WMO TR 49	Document	May 2014	W. Schöner, J. Key, B. Goodison		
3	Chapter 6 for WIGOS Manual	Document	May 2014	W. Schöner, J. Key, B. Goodison		
4	Minimum requirements for site inclusion in CryoNet	Document	Feb. 2014	W. Schöner	Draft version	
5	Site questionnaire (metadata information)	Document	Feb. 2014	J. Key, S. Starkweather	Draft version	In scoop with Portal Team
6	TOR for CryoNet	Document	Jan. 2014	B. Goodison	Done	
7	List of CryoNet candidate sites (including metadata)	Document	Jan. 2014	J. Key		
8	List of initial CryoNet sites	Document	Jan. 2014	J. Key		
9	Draft CryoNet Data Policies	Document	Feb. 2014	W. Schöner, T. Johannesson, T. Thorsteinsson		
10	South America CryoNet Meeting	Workshop	Oct. 2014	G. Casassa		Resources required
11	Design Principles of CryoNet	Document	May 2014	M. Citterio, V. Smolyanisky, T. Ohata		
12	CryoNet Portal Team Meeting (including data management)	Meeting	June 2014	J. Key, C. Fierz		Resources required
13	Review of Best Practices	Document	2015	C. Fierz, M. Citterio, B. Goodison		

ANNEX 6: CRYONET TEAM MEMBERSHIP

Name	**Affiliation**	**Expertise**	**Expertise for cryospheric component(s)** (Glacier, sea-ice, snow...)
Wolfgang Schöner (Chair)	ZAMG	Field observations, data homogenisation	Mountain glaciers, snow cover
Matthias Bernhardt	LMU		
Michele Citterio	GEUS	Automated field observations, satellite telemetry	Greenland ice sheet, ice caps
Charles Fierz	WSL / SLF	Field observation, atmospheric modeling	Mountain snow cover, Avalanches
Christophe Genthon	LGGE	Field observation, atmospheric modeling	Antarctic ice sheet
Barry Goodison			Precipitation, snow
Gino Casassa	Geostudios		Mountain glaciers
Kaji Luojus	FMI	Remote sensing	Tundra snow cover
Jeff Key (GCW)	NOAA	Remote sensing	
Sandy Starkweather	NOAA	Network management	
Vasily Smolyanitsky	AARI	Field observations, data management	Sea ice
Hironori Yabuki	JAMSTEC	Data and Metadata Management	
Þorsteinn Þorsteinsson	IMO		Glaciers, glacier hydrology
Cunde Xiao	CMA		
Permafrost	??? - IPA		
Cryospheric modelling			
Remote sensing			

ANNEX 7: INITIAL CRYONET SITES

ID	**Station**	Elevation (m)	Country	Region	Type
1	Sodankylä	180	Finland	Europe	Integrated
2	Zackenberg	0-1500	Greenland/Denmark	Europe	Integrated
3	Sonnblick	3105	Austria	Europe	Integrated
4	Weissfluhjoch/Davos	2540	Switzerland	Europe	Integrated
5	SIGMA-A	1490	Greenland/Denmark	Europe	Baseline
6	PROMICE (20+ stations across Greenland)	270-1850	Greenland/Denmark	Europe	Baseline
7	Eureka	610	Canada	North America	Reference
8	Barrow	11	USA	North America	Reference
9	Tiksi	n/a	Russian Federation	Asia	Integrated
10	Cape Baranova	30	Russian Federation	Asia	Baseline
11	Tianshan	2130	China	Asia	Integrated
12	Mt. Everest	5210	China	Asia	Baseline
13	Yakutsk	220	Russian Federation	Asia	Integrated
14	Dome C	3222	n/a	Antarctica	Reference

ANNEX 8: ASIA CRYONET WORK PLAN

N°	Action	By	Deadline	Comments/Status
CryoNet structure				
1	Establish Regional Working Groups (GCW-R-WG) (according to WMO Regions), i.e., membership, work plans, etc.	Jeff Key & Arni Snorrason (with help from Secretariat)	Jun.2014	Should GCW be organized by WMO regions?
2	Within GCW-R-WG in RA II, establish a Working Group on Practices, i.e., membership, work plan.	Cunde Xiao (with help from Secretariat)	Jun.2014	
3	Define a formal procedure to nominate experts to GCW-R-WG	Cunde Xiao & Barry Goodison (with help from Secretariat)	Mar.2014	
4	Compile information on proposed stations of CryoNet Asia.	Secretariat	Mar.2014	
5	Write a letter to countries' Permanent Representative for WMO to reaffirm the GCW focal point and to seek support for GCW and CryoNet.	Secretariat	Mar.2014	
6	Include AWS in the CryoNet Asia.	Members of GCW-R-WG	Sep.2014	Are we all agreed that AWSs should be part of CryoNet?
7	Update GCW-IP to better define role of the Third Pole in GCW	Jeff Key	Jan.2014	These are at least partly done in the latest IP version. More discussions on that point are required.
8	Update GCW-IP to include Himalaya, Pamir and Tien Shan in the Third Pole definition of CryoNet Asia (wider than it is now).	Jeff Key	Jan.2014	
9	Update GCW-IP to include a mechanism within GCW to coordinate work of GCW Working Groups and GCW-R-WGs.	Jeff Key	Jan.2014	
10	Update GCW-IP by replacing the term "Supersite" by "Integrated Site".	Jeff Key	Jan.2014	
N°	**Action**	**By**	**Deadline**	**Comments/Status**
Data policy				
11	Develop data policy for Baseline, Reference and Integrated sites.	GCW-R-WGs	Dec.2014	
12	Provide metadata for Baseline, Reference and Integrated sites.	Site operators	Dec.2014	
13	Provide recommendations on data sharing principles to the Draft Resolution under discussions for GFCS.	GCW-R-WGs	Sep.2014	
14	Define data quality requirements within CryoNet-Asia.	GCW-R-WG	Sep.2014	

15	Encourage free data exchange.	GCW-R-WG	ongoing	
16	Clearly cite the data provider when including data in GCW products (who's the provider, data originator, publication reference…).	GCW community	ongoing	
N°	**Action**	**By**	**Deadline**	**Comments/Status**
Other issues				
17	Strengthen the collaboration between observing network operators, observers and modellers to create an integrated network.	GCW-R-WG	ongoing	
18	Create a link to the main research publications on the GCW website.	Jeff Key	Mar.2014	Possible only if a journal has an RSS feed.
19	Organise the next meeting of GCW-R-WG-RA-II in 2014.	Cunde Xiao (with help from Secretariat)	Oct/Nov. 2015	