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GLOBAL CRYOSPHERE WATCH

FINAL REPORT OF THE GCW STEERING GROUP FOURTH SESSION GSG-4

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Executive Summary

The fourth session of the Global Cryosphere Watch (GCW) Steering Group (GSG) took place from 16 to 19 January, 2017, being hosted by the British Antarctic Survey (BAS), in Cambridge, United Kingdom.

The session was chaired by the GSG Chair, Dr Árni Snorrason (Iceland) and the co-Chair, Dr Barry Goodison (Canada). This was an excellent opportunity for an active interaction with the BAS experts, and for exploring enhancing the collaboration of GCW with BAS.

The meeting was well attended by representatives of organizations represented on GSG. Their engaged contribution positively to the outcomes of this meeting demonstrated, once again, the value of the active and systematic engagement.

The meeting reviewed the progress on the implementation of GCW, and towards its operationalization by 2020. Reports of progress since the 3rd session of the Steering Group, GSG-3, in December 2015, were presented by the Working Group Chairs and Team Leads. The participants examined the interaction with partners and identified actions for furthering these engagements in a more structured manner, and in the context of the WMO Integrated Global Observing System (WIGOS) framework.

Among the results achieved in 2016 are, the definition of the minimum observing program for the GCW surface observing network, the assessment of over 130 stations for inclusion in the GCW observing network, improvements to the real time reporting and exchange of snow depths, availability of satellite snow product intercomparison, availability of snow trackers, the evolution of the GCW website, advancing the interoperability of the GCW Data Portal with relevant Data Centres, the growth of the GCW Glossary.

The meeting identified the GCW priorities for the following 1-2 years, among them being expanding the GCW observing network, in particular in data sparse areas, the completion of the Best Practices Guide and Manual, continuing the development of interoperability of GCW Data Portal with contributing Data Centers, the development of WIGOS Metadata vocabulary, the development of solutions for data exchange, developing a GCW integrated products strategy, including in the context of the engagement with the Arctic Polar Regional Climate Centres (Arctic PRCC) and in collaboration with all partners, including the Polar Satellite Task Group (PSTG) of WMO, continuing with the planned regional activities and taking a user needs perspective.

The GCW experts agreed to conduct the assessment of GCW applications and product development in the context of the WMO Rolling Review of Requirements (RRR), and identify (i) those already covered (or potentially covered) by existing WMO Application Areas (AAs) whereby GCW could provide additional input, and (ii) those which should be regarded as independent from existing AAs and for which new AAs could be proposed.

The meeting reviewed the role of the GCW Steering Group and the working structure of GCW, to ensure a focused approach to high priority tasks for the next 2 years. Relevant items were prepared for the 7th session of the Executive Council Panel of Experts on Polar and High Mountain Observations, Research, and Services, (EC PHORS-7), and for approval by the Executive Council (EC-69).

It was agreed that the strategic evolution of GCW must be supported by an effective Communication and Outreach Plan and by relevant performance indicators. The participants agreed to develop these before the 5th session of GSG.

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MEETING REPORT

1. ORGANIZATION OF THE MEETING

1.1 Welcome and Opening of the meeting

The fourth session of the Global Cryosphere Watch (GCW) Steering Group (GSG) opened at 09:00 hours on Monday, 16 January 2017, being hosted by the British Antarctic Survey (BAS), in Cambridge, United Kingdom.

The GSG Chair, Dr Árni Snorrason (Iceland) and the co-Chair, Dr Barry Goodison (Canada), welcomed the participants and wished for a successful meeting. Prof. David Vaughan, the Director of Science of BAS, also welcomed the participants highlighting the importance of cryosphere observations, research and services, and the opportunity for further collaboration with GCW.

Mr Etienne Charpentier, on behalf of the Secretary General of WMO, Dr Petteri Taalas, thanked BAS for hosting the meeting, and for the collaboration with GCW. He reminded the participants of the seven WMO strategic priorities from the WMO Strategic Plan 2016-2019, most of which relate to the work of GCW, and in particular (i) Polar and High Mountain regions, (ii) WMO Integrated Global Observing System (WIGOS), (iii) Global Framework for Climate Services (GFCS), (iv) Disaster Risk Reduction, and (v) Capacity Development.

1.2 Adoption of the Agenda

The Provisional Agenda, as provided in Annex 1 was adopted by the meeting.

1.3 Working Arrangements

The work of the meeting was conducted as a committee of the whole. The session and documentation were in English only. The Team agreed on its working hours and adopted a tentative time table for consideration of the various agenda items.

The Secretariat introduced the documentation plan of the meeting, available at http://www.wmo.int/pages/prog/www/OSY/Meetings/GCW_Meetings/GSGDocumentPlan.html . The Chair thanked all those who contributed to the documentation plan.

1.4 Introductions of participants

The list of participants is provided in Annex 2. The chair of GSG invited the participants to introduce themselves.

1.5 Meeting priorities

The GSG Chair outlined the meeting priorities, to take stock of the progress made by each of the GCW working groups (WG) since GSG-3, December 2015, to examine the potential related to the interaction with partners, to define priorities for 2017-2018, as well as reviewing the role of GSG and the working structure of GCW, with the view of its operationalization by 2020. The Chair requested that items which require the EC PHORS

endorsement and approval by the Executive Council (EC-69), be addressed with high priority.

S Barrell recommended that GSG develops a GCW communication plan, as well as key performance/success indicators.

During the meeting, the Secretariat urged the GCW experts to conduct the assessment of GCW applications and product development in direct correlation with the WMO Rolling Review of Requirements (RRR), and identify (i) those already covered (or potentially covered) by existing WMO Application Areas (AAs) (e.g. for marine transportation in the polar regions) whereby GCW could provide additional input, and (ii) those which should be regarded as independent from existing AAs and for which new AAs could be proposed.

2. GCW WORKING GROUPS PROGRESS AND RESULTS

2.1 Definition of the GCW Observing Network (re-confirmation)

The participants recalled the definition of the GCW surface observing network. At the proposal of the Co-Chair, GSG agreed that existing operational networks providing observations of cryosphere components, e.g. synoptic, climate, agrometeorological networks, with data already exchanged via the GTS, should be included in the GCW Surface Observing Network, as affiliated networks[1]. The definition endorsed at GSG-3, states that the *"GCW surface observing network" is comprised of CryoNet and contributing stations, as a tiered network".* B Goodison asked the Steering Group to further update the definition of the GCW surface observing system to include the affiliated networks and reflect its space component. [**GSG members, GSG-5]**

The Group noted that the components of the GCW Observing system[2] are defined in the Manual on the WMO Integrated Global Observing System (WIGOS) Annex VIII to the Technical Regulations, Chapter 8. Attributes Specific to the Observing Component of the Global Cryosphere Watch, updated in 2016. The GCW manuals and other regulatory material are subject to the approval process applicable for the WIGOS regulatory materials. This was re-confirmed at the recent Inter-Commission Coordination Group of the WMO Integrated Observing System (ICG-WIGOS) meeting, January 12-14, 2017.

2.2 Observations Working Group Progress and Results

The progress of the CryoNet Team, since GSG-3 was summarized by the Team Lead, W Schöner and covered several key activities of the Team, as outlined below.

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1 The terms "affiliated" and "contributing" were discussed. The matter was refered to EC PHORS-7 (March, 2017), for decision. EC PHORS endorsed the term "affiliated networks" for those networks which are interested in a formal engagement with GCW.

2 (8.3) A GCW Contributing station shall measure at least one variable of at least one cryosphere component. (8.4) A GCW Contributing station shall be a station that provides useful measurements of the cryosphere but does not meet minimum requirements for a CryoNet station, or in some other way does not provide the quality and/or consistency of data required by CryoNet stations.

2.2.1 Minimum Observing Requirements for the CryoNet Program

2.2.2.1 At the request of W Schöner, GSG approved that the minimum observing programme for CryoNet stations/sites, and for each cryosphere component, consists of recommended, desired, and required variables, including the respective time resolution of measurements. This was recommended at the 5th session of the CryoNet Team (CryoNet-5, Sept. 2016).

GSG also approved the variables proposed at CryoNet-5 for snow/solid precipitation, sea ice, glaciers and ice caps, ice sheets, ice shelves, icebergs, permafrost, seasonally frozen ground, and surface meteorology, as recommended at the conclusion of the GSG-4 meeting. The list of approved variables is provided in Annex 13.

The participants endorsed combining the lake ice and river ice variables lists into one, for simplicity, recommending that the consolidated lists be further discussed with experts outside GCW. The participants recommended the engagement of the following experts: Tom Graziano, NOAA, Claude Duguay (Canada) and Terry Prowse (Canada), Matti Leppäranta (Finland) **[Secretariat, 06.2017].**

The GSG Chair requested that the CryoNet Team consults more broadly on the recommended variables to gather additional support**. [W Schöner, 06.2017]**

2.2.1.2 W Schöner clarified that the requirement for specific meteorological variables reported from CryoNet stations (air temperature, humidity, wind speed and direction) was introduced to support the derivation of advanced products, e.g. energy balances. He also clarified that measurements and observations are done on GCW stations, only, and not on sites. CryoNet sites are aggregates of minimum two stations, of which, at least one being a CryoNet station.

2.2.1.4 B Goodison noted that the atmospheric pressure could be a significant contribution from the GCW observing network for other applications, NWP in particular, and for stations reporting from data sparse regions. GSG agreed to include “atmospheric pressure” as a (highly) recommended meteorological variable and requested it be included on the approved variables, in Annex 13. **[W Schöner, end of meeting]** The Group agreed that, while the precipitation type identification is still a challenge, it’s important to capture the requirement, and monitor the evolution of technology which could make its reporting more feasible in the future.

2.2.1.5 It was agreed that information regarding specific aspects of the CryoNet observing program should be included in the Best Practices Guide. The Co-Leads of the Best Practices Team were asked to ensure that the following aspects are captured in the Guide [**Co-Leads, Best Practices, GSG-5**]:

- Include recommendations on reporting the precipitation type;
- Provide clarification on “Frequency of measurement” and “Frequency of reporting”, noting that near real time reporting is recommended, where possible;
- where data are reported daily, the time of reporting should be recommended**;**
- For permafrost variables, include, at the minimum, the daily measurement of ground temperature. For mountain permafrost, recommend hourly measurements of ground temperature.

2.2.2 Consolidation of CRYONET variable terminology for OSCAR Surface

2.2.2.1 In the context of the work plan of the Commission for Basic Systems (CBS) Inter Programme Expert Team on Observing System Design and Evolution (IPET OSDE), M Citterio compiled and updated a comparative list of cryosphere variables reflecting the recommended minimum observing program (Annex 13). The list shows whether these variables were captured in the Integrated Global Observing System-Cryosphere Theme (IGOS, 2007), and whether they are already available in OSCAR Surface. There are over 170 variables, and only less than 10% of those are in OSCAR Surface, at the time of GSG-4.

M Citterio emphasized the need to populate OSCAR Surface, to reflect the needs of the GCW minimum observing program. The OSCAR update could take place only once these variables are associated with applications supported by the respective variables (existing among the fourteen AAs already defined, or new), e.g. cryosphere monitoring and applications/services. The participants agreed that this is work on the critical path and it needs to be completed as a matter of priority in the context of the RRR efforts of WMO, as noted in 1.5.3.

W Schöner and M Citterio agreed to coordinate with the other WG Chairs to ensure consistency of terminology, recognizing that from a practical point of view the scientific and operational communities could have different perspectives on the same terminalogy. Ø Godøy requested that the Observations WG also works on harmonizing the terminology and definitions for variable metadata, and their cross reference with OSCAR, in conjunction with the current work of the WIGOS Metadata Task Team. See also 2.4.1. **[Observations WG Chairs; 09.2017].**

It was noted that IGOS was developed in 2007, prior to WIGOS, and it reflects primarily satellite observational capabilities and requirements of the time. The document remains a key reference, however differences between the surface observing program of GCW and the recommendations from IGOS are to be expected.

2.2.2.2 As already mentioned in 1.5.3, the observational user requirements recorded in OSCAR are technology free for the fourteen Application Areas (AA), already defined, their goal is not to address how realistically the stated used requirements can be met using space-based and surface-based observing systems. By comparing the user requirements (from the AA) with the observing systems capabilities, at a given time, by using impact studies and expert assessments, the AA Points of Contact and IPET-OSDE are able to identify gaps which are captured in application specific Statements of Guidance. These provide guidance to Members on how the gaps can be addressed, taking into account long-term vision, WMO and their respective priorities, and the cost-effectiveness of specific observing systems.

GSG agreed that GCW needs to identify sub-applications for which independent sets of user requirements could be developed**.** Once new GCW AAs are defined, GCW needs to nominate a focal point for each of those. The Focal Point will coordinate with the respective user communities for developing sets of observational user requirements, which will be recorded in OSCAR/Requirements, and conducting gap analyses leading to Statements of Guidance. **[Observations WG Chairs, GSG-5]**.

S Barrell committed to support the work of GCW experts in cooperation with IPET OSDE, by bringing to the attention of the WIGOS management group new application areas identified in this process, for approval.

2.2.3 Assessment of new submissions for the GCW observing network

2.2.3.1 W Schöner provided an overview of the 130 submissions received in 2016, for the GCW observing network (as contributing stations, CryoNet stations and CryoNet sites). The assessment process was fine-tuned in 2016, including at the 5th session of the CryoNet Team. The assessment of these submissions will be completed by mid-February, 2017. Once approved by the GSG Chair and Co-Chair, the list will be submitted to EC-PHORS-7 and then for approval by the Executive Council, EC-69, in May 2017, of establishing the GCW surface observing network. **[W Schöner, Secretariat, 02.2017]**.

2.2.3.2 As recommended by the 5th session of the CryoNet Team, the GSG approved two changes on the assessment process and asked J Key to ensure the changes are accepted by EC PHORS-7. Also, J Key was asked to update the GCW website **[J Key, 03.2017].** The revised evaluation process is provided in Annex 4 of this report:

- The requirement for an agreement between the proponent organization and the National Hydro-Meteorological Services (NHMSs) of the respective country was removed.
- A station included in the GCW surface observing network must be endorsed by the PR of the country where the station is operational needs. When an organization operates a station in a country other than its country of origin, the PR of the country of origin should also endorse the station. For stations in Antarctica, the stations should be endorsed by the PR of the country of the organization proposing the station.

2.2.3.4 The participants agreed that being part of the GCW observing network gives a station increased visibility, stronger arguments for funding proposals, increases the exposure of their data and research goals to a broader community. J Key also reminded the participants that the process requires a yearly review of the compliance to the GCW criteria.

2.2.3.5 The participants agreed that station metadata should be archived and asked J Key to explore the potential for archiving the site/station historical information. **[J Key, GSG-5]**

2.2.3.6 The participants agreed that more needs to be done to address the current gaps in the CryoNet network, with a focus on North America, over oceans, Antarctica, and the marine environment.

2.2.3.7 Dr Schöner indicated that several submissions received in 2016 are for contributing stations operating on mobile/ship platforms, which may operate intermittently and that their location may not fixed. For CryoNet stations *"The responsible agencies shall be committed, to the extent reasonable, to sustaining long-term observations of at least one cryosphere component. There shall be a commitment to continue measurements for a minimum of four (4) years."* The participants agreed that the GCW observing network must include ocean/sea observations. The participants noted that buoys and ship based observing systems are WIGOS stations and provide critical observations over oceans, a data sparse area. It was noted that CryoNet provides a framework for engaging Members and partner organizations and that such an opportunity should not be missed with too stringent requirements for mobile stations

(e.g. ships may be operated on a sustained basis in a given region and with strong commitment from a Member).

The participants noted that a decision relevant to the exchange of data from mobile platforms, internationally, must be linked to the input/feedback that GCW needs to provide to the Task Team on WIGOS Metadata. V Smolyanitsky was asked to contribute to the task identified in 2.2.2.1.

GSG tasked V Smolyanitsky and the CryoNet Team to develop recommendations regarding the evaluation of observing systems on ships and buoys (mobile platforms), considering the sustainability and the continuity of observations, and present it for approval by GSG and information to EC PHORS. **[V Smolyanitsky, CryoNet Team, 09.2017]**

2.2.3.8 W Schöner noted that in 2015 Vuriloches, approved on a trial basis as a CryoNet station, was closed because of precarious conditions. GSG approved that the site is maintained in the GCW database as a GCW contributing station.

2.2.3.9 It was requested that future submissions should be reviewed first for completeness, by the Secretariat, before inviting the CryoNet Team experts to assess the compliance to CryoNet criteria. **[Secretariat, on-going]**

2.2.3.10 The work plan for the Observations WG is included in Section 7.1.1 of this report.

2.2.4 GCW Station ID

2.2.4.1 S Barrell clarified that the WIGOS metadata and the station ID are associated with a station, and not with a CryoNet site. The station ID is a means of linking observations with metadata. The GCW concept of a cluster of stations, named sites, is not represented in the structure of WIGOS metadata database (OSCAR). The WIGOS station IDs could only be allocated to stations and not to sites.

2.2.4.2 At the same time, S Barrell noted that the new WIGOS station IDs are not referring to any program for which the data is used. As the GCW stations are often operated by organizations other than the National Meteorological and Hydrological Services (NMHSs), these require the national support in obtaining the required WIGOS ID. The Permanent Representatives (PR) allocate WIGOS IDs for stations within their territory; in cases where a PR is unable to issue an identifier, the WMO Secretary General (SG) may do so. The GSG Chair asked the Secretariat to provide details to GCW Experts on the definition and use of WIGOS ID for GCW stations, for inclusion in the GCW Best Practices Guide. **[Secretariat, 09.2017].**

2.2.4.3 The CryoNet Team Lead recommended that EC PHORS requests Members, through EC-69, to provide support to their national organizations on contributing to the GCW observing network with the implementation of recommended formatting of data and metadata, to allow their distribution in [near] real time, though GTS/WIS (for data), and to OSCAR Surface (for instrument/platform metadata) **[Secretariat, 09.2017]**.

2.2.5 Best Practices Progress Report

2.2.5.1 The progress and work plans of the Best Practices Team since GSG-3 were presented by the Team Co-Leads, C Fierz and Þ Þorsteinsson, and focused on the

development of the GCW Best practices Manual and Guide. C Fierz noted that a detailed assessment of the progress and the work plan were to be addressed during the working meeting organized on January 20, 2017.

2.2.5.1 C Fierz noted that following the 1st session of the Best Practices Team, the progress was slower than planned, noting challenges in engaging experts. He highlighted the positive development with the engagement of Mr Craig Smith from Environment and Climate Change Canada (ECCC) who will work on the development of the Snow chapter for the GCW Best Practices Guide and Manual. Mr Smith will collaborate with the COST Action HarmoSnow and CIMO, bringing together the existing guidelines.

2.2.5.3 Þ Þorsteinsson informed on the potential engagement of Liss Marie Andreassen (Norway) for the chapter on Glaciers. He also reported the plan of the Islandic Meteorological Office (IMO) to hire a student to support the development of the Glaciers chapter for the GCW Best Practices Guide.

2.2.5.3 It was noted that the availability of an interactive platform for input (e.g. Wiki) could help collect input from multiple experts without significant overhead.

2.2.5.4 The Co-Leads of the Best Practices Team indicated their commitment to lead the development of the GCW Best Practices Guide to its conclusion, in 2017, for approval by EC-70**. [Best Practices Team co-leads, GSG-5**]

2.3 Integrated Products Working Group

2.3.1 Snow Watch Team

2.3.1.1 The results and work plans of the Snow Watch Team were presented by the Team Co-Leads, R Brown and K Luojus. A summary is included in Annex 5.

2.3.1.2 A Second Session of the Snow Watch Team was held in June 2016 at the Byrd Polar and Climate Research Center in Columbus, Ohio. The 2017-2018 work plan is summarised in section 7.1.2.1 and detailed in Annex 5.

The Snow Watch Team reported on the improvements made on the real time reporting of snow depth, satellite snow product intercomparison, multi-dataset analysis for snow cover monitoring and trends, participation in SnowPEx, a strong team with committed invited experts especially for the remote sensing of snow. On recommendations from the Snow Watch team, ESA initiated, funded, and conducted a Satellite Snow Products intercomparison and evaluation Exercise – ESA SnowPEx (from 06/2014 to 12/2016), with the final workshop (ISSPI-3) to be held in 2017. The results will be published in 3-4 scientific papers.

2.3.1.3 R Brown thanked CMA for providing to the GCW snow data inventory a historical dataset of daily snow depth from 212 stations. J Wang was invited to work with the Snow Watch Team to identify if additional snow depth data from China could be made available**. [R Brown, J Wang, GSG-5]**

2.3.1.4 R Brown emphasized the goal to include the reporting of snow depth in OSCAR and to investigate the RT exchange of snow on ground and snow water equivalent data on WIS, committing to work with the Observations WG to complete this task (see also2.2.2.1). **[R Brown, K Luojus, 09.2017]**

2.3.1.5 The need for new products was discussed, in particular in the context of PRCC sea ice trackers (e.g. September sea ice extent), SWE, snow cover extent, which could

contribute to the proposed Global Climate Observing System (GCOS) climate indicators. The success of currently available snow anomaly trackers produced by the FMI and ECCC was noted. It was recommended to work towards including additional real time data sources into the existing and other tracking products, which is consistent with the SnowPEx recommendations to move to multi-dataset snow cover monitoring. G Balsamo recommended including outliers in the product displayed. B Goodison noted the need for polar stereographic projections. **[R Brown, K Luojus, GSG-5]** These activities are linked to those in section 3.3.

2.3.1.6 M. Drinkwater noted that the ESA-funded project "Snow Product Intercomparison Exercise" (SnowPEx: http://snowpex.enveo.at/) has met its objectives to intercompare and evaluate (pre-)operational global / hemispheric snow products (snow extent and water equivalent) derived from different Earth Observation sensors, and to evaluate and inter-compare temporal trends of seasonal snow parameters from the various products. The SnowPEx project has been extremely valuable in bringing the international community together on establishing standards and protocols (QA4EO: https://earth.esa.int/web/sppa/activities/qa4eo/snowpex), which allow the intercomparison of the respective snow algorithms. This effort has both, benefitted the validation of satellite based snow algorithms with reference to independent station data and reference datasets, and identified weaknesses in snow algorithms, which lead in differences between the products.

GSG asked the GCW experts to find means to store the documentation from the SnowPEx study and make the results available to the wider community. These could be used as basis for Best Practices for satellite observations, including the feedback about the quality of the results obtained from this project. **[R Brown, K Luojus, M Drinkwater, GSG-5]**

2.3.1.7 Noting the success of the SnowPex project, B Goodison invited the participants to consider which future missions would further the cryosphere science needs, and invited the Snow Watch Team to include this in their work plan. R Brown noted that many refinements can be made to existing algorithms used on existing single satellite data or with developments in multi-sensor or synergistic snow products (i.e. space + in-situ), and that an important gap is the accurate monitoring capability for snow water equivalent (SWE) at the appropriate spatial scale. Current passive microwave and SAR data are insufficiently accurate and this is recognised as a key area for development for the satellite agencies. **[WG Chairs]**

2.3.1.8 M Drinkwater noted that ESA is progressively transferring snow algorithms from R&D environment to the EUMETSAT operational domain, e.g. the EUMETSAT hydrology SAF will be responsible for Snow Water Equivalent in addition to snow extent in the future, for which the algorithms have their heritage in the GlobSnow R&D activity led by FMI. M Drinkwater invited the GCW experts to identify the criteria for a CryoNet station to be used for satellite validation, and recommended the engagement of GCW teams are with the Polar Space Task Group (PSTG) to develop the observing requirements for validation. [**J Key, PSTG-7**]

2.3.1.9 M Drinkwater also recommended to GCW to consider the preparation of a paper for a high profile journal such as *Nature*, as the only way to elevate the attention and call for a new set of satellite-borne snow water equivalent capabilities **[Secretariat to coordinate]**

2.4 Information and Services Working Group

2.4.1 Data Portal Team

2.4.1.1 The progress and results of the GCW Data Portal Team since GSG-3 were presented by the Data Portal Team Lead, Ø Godøy.

2.4.1.2 Interoperability was established with SLF-Davos, Pangea, and the Canadian Cryosphere Information Network (CCIN). For the latter, some manual supervision for harvesting metadata is still needed. Once CCIN adopts the GCW recommended vocabulary, the process will improve. Work is under way with other data centres, e.g. the Data Centre of Environment and Climate Change Canada (ECCC) and the Global Terrestrial Network on Permafrost (GTN-P).

2.4.1.3 Ø Godøy noted the need to take into account the differences between research and operational communities regarding data policies, data management practices and infrastructure, platforms for collaboration, resources. He noted that the metadata exchange is working quite well, the availability of consistent terminology for all variables expected is a step on the critical path for achieving the full interoperability. The data exchange is more challenging. As demonstrated during the test with Davos CryoNet site, the proponent organizations need to invest in making changes to their data and file formats, to prepare them for data exchange. This is a challenge that requires that GCW finds a sustainable solution for data exchange. The application from Davos CryoNet, with additional development, could be made portable for other CryoNet stations. [**Ø Godøy, Secretariat, 06.2017]**

2.4.1.4 Ø Godøy represented GCW at the meeting of the Task Team on WIGOS Metadata (TT-WMD), in December 2016. In collaboration with TT-WMD, GCW could develop the metadata vocabulary to reflect its observing program. TT-WMD plans to wrap up current consultations by March 2017, in preparation of their submission to EC-69. Changes made past this data will be implemented in 2018. Hence, the review of the WIGOS Metadata vocabulary is a priority for the Observations WG. *(Action in conjunction with actions defined on 2.2.2.1)*

S Barrell requested that GCW nominate a representative on TT-WMD. **[W Schöner, Ø Godøy, 09.2017]**

2.4.1.5 While WMO exchanges data in BUFR format, the research communities in GCW are not familiar with it and alternative data exchange formats need to be accepted. NetCDF/CF and OpeNDAP are feasible alternatives, with some BUFR thinking behind. G Balsamo indicated that NetCDF is widely used for data ingested by ECMWF and that ECMWF has applications that convert NetCDF format into BUFR. He offered to connect the ECMWF expert developing this application with Ø Godøy. **[Ø Godøy, G Balsamo, 09.2017]**

2.4.1.6 Ø Godøy recommended the traceability of data using Digital Object Identifier (DOI) through GCW, as this enables the citation for the use of data (e.g. GTN-P through PANGEA), and this is captured in the GCW Data Policy.

2.4.1.7 There was full agreement that the metadata for stations in the GCW observing network be harvested directly from questionnaires, as much as possible, to avoid the duplication of work **[J Key, Ø Godøy, GSG-5]**. S Colwell supported the goal of having all metadata in OSCAR as a useful tool when fully implemented, although OSCAR

is not, currently, common among researchers. S Barrell noted that the Surface component of OSCAR will be improved and is critical that a GCW expert is part of the team working on OSCAR development. [**Secretariat, 06.2017,** ensure representation from GCW]

2.4.1.8 Ø Godøy noted the significant level of effort required for developing the interoperability with Data Centres. Currently 5 people support the Data Portal development supporting several projects, GCW included at the Norwegian Meteorological Institute (MetNo). He recommended that increased coordination is needed to avoid duplication and repetition. He recommended a meeting of the GCW Data Portal team is recommended, focusing on coordinated further development. **[Ø Godøy, Secretariat, 09.2017]**

2.4.1.9 J Baeseman recommended that GCW Data Portal becomes interoperable with the data centre of the Australian Antarctic Division, which will provide a link to the Antarctic data. She also noted that the Antarctic Master Directory, held as part of NASA's Global Change Master Directory, is not currently linked to the GCW Portal and it should be. **[Ø Godøy, j Baeseman, GSG-5]**

2.4.2 GCW Website and Outreach Team

2.4.2.1 The progress and results of the GCW Website and Outreach Team since GSG-3 was presented by the Team Lead, J Key. He highlighted the significant modifications made to the station/site questionnaire and database, and the improvements to the dynamic pages displaying station/site information. The CryoNet recommended and desired variables are now posted, as well as the 2015 assessments for all cryosphere components and the atmosphere, together with new sea ice trackers from JAXA and NOAA/CIMSS, covering ice extent, ice thickness, surface temperature, and surface albedo, and also new products such as Cryosat and SMOS ice thickness plots (not trackers), and regional sea ice products for Alaska.

2.4.2.2 All GCW handouts have been updated and are available on the GCW website (http://globalcryospherewatch.org/outreach/materials.html). These could be used for future events, e.g. EC-PHORS, a side event at EC-69. J Key recommended that the Secretariat engage the WMO Media Department to revise and improve the GCW handouts and other outreach material. **[Secretariat, 06.2017]**

2.4.2.8 G Balsamo noted the remarkable evolution of the GCW website and recommended that a video is used as the opening to give a first overview of what is GCW, and what one can find by accessing the website. **[J Key, GSG-5]**

2.4.2.9 S Barrell and A Snorrason recommended that GCW promotes its goals and results at EC-69, CG-18 and other key events, in particular where the PRs and other decision makers are present, to show why it's important for them to invest in contributions to GCW, including expert and technical resources. **[GSG, Secretariat]**

2.4.3 Terminology Team

2.4.3.1 The progress of the GCW Terminology Team were summarised by J Key. He noted that additional sources were added, as suggested by GSG-3. There are, currently, more than 2900 entries from 20 sources, and over 1600 of those are unique.

2.4.3.2 In December 2016 a 3-month contract was issued to Clément Hutin, a former WMO intern. As a result of this contract, a large number of terms from several well-known resources will be added to the GCW on-line Glossary, at http://globalcryospherewatch.org/reference/glossary.php :

New sources added:

- Swisseduc - Photo glossary of glaciological terms.
- Illustrated Glossary of Snow and Ice (1973).
- American Meteorological Society, Glossary of Meteorology.

2.4.3.3 B Goodison reminded the participants that the goal is, for each physical parameter, to compile and recommend one or more GCW definitions based on the definitions captured in the GCW glossary. It was recognized that this is a formidable task, and it needs significant resources; WMO tried it in the past, with mixed results. As suggested by C Fierz, GSG agreed to conduct this work in collaboration with the partner communities, to get their buy on. [**Terminology Team, 2018]**.

2.4.3.4 H Lantuit commended the efforts to date, noting that the GCW Glossary is a useful tool. He urged GCW to actively promote this resource, and recommended that the site gets a DOI to be citable, as it has become a resource in itself. **[J Key, Secretariat, GSG-5]**

2.4.3.5 J Key was encouraged to use google analytics to monitor the access to the GCW website. This could be an indicator of its utility, and could be used to tailor future development based on the external interest. [**J Key, GSG-5]**.

2.4.3.6 C Xiao shared the Glossary of Cryosphere Science and English-Chinese dictionary of cryosphere science (Chinese and English) published in print, in China. J Key and J Wang will work together for linking the electronic versions to the GCW website. **[J Wang, J Key, 09.2017]**

2.5 GCW Observing System: Data Exchange

2.5.1 GCW Data Policy[3]

2.5.1.1 Þ Þorsteinsson presented the draft of the GCW Data Policy, developed in consultation with the other GCW experts to provide clarity regarding the responsibilities and the opportunities regarding the GCW data exchange, including giving appropriate recognition to data providers. The proposed protocol draws upon data policies of other organizations. The participants provided feedback, which will be integrated in the final version. Most relevant:

(a) Include the use of Digital Object Identifiers (DOIs) for the data sets available from GCW stations, which will allow attributing the ownership of data;
(b) Include a standard statement for acknowledging the source of data and require that this is used by anyone using the data;

3 *After reviewing the submission from GCW, the 7th session of EC PHORS (March 2017) recommended the term, "GCW Data Protocol" instead of "GCW Data Policy", and ensure its alignment with the WIGOS Data protocols and partnership criteria, recognizing that GCW observing network is an integral part of WIGOS. The final document will be published as "GCW Data Protocol";*

(c) Include additional guidance on the validity of data that are not exchanged in (near) real-time, e.g. the data provider could hold it for up to two years before being released for open access, (e.g. for preparing specific publications). When the data are not released past the agreed term, the association with GCW could be terminated.

The final version of the GCW Data Policy will be presented at EC-PHORS-7, for endorsement, as included in Annex 6 (see footnote #3). **[Þ Þorsteinsson Secretariat, EC-PHORS-7]**

3. GCW DATA AND PRODUCTS

3.1 CBS-16 decisions regarding the reporting of snow

3.1.1 **Issue:** GCW submitted to CBS-16 a recommendation requesting the amendment of the Manual on the Global Observing System (WMO No. 544), regarding the specifics of the International Exchange of Snow Data. The recommendation was drafted as binding (using "shall") for all Members to report snow cover and snow depth from all stations where snow is experienced, four times a day, and to report values of zero snow depth (0 cm) from these stations when snow is not present, for the period during which snow can be expected.

Following interventions from several Members, the recommendation was adopted as non-binding, "shall" being replaced with "should", i.e. the Members would make their best efforts to comply.

The feedback received after CBS-16 suggests that Members were willing to report snow depth four times a day, but not all have the capabilities to do so, at all sites; this was confirmed with by Samantha Pullen, of the Snow Watch Team, who spoke with representatives of Members who expressed concerns at CBS-16. The potential differentiation between manual and automatic measurements was discussed, but not pursued. There was no indication of Members having issues with reporting zero snow depth; however, there, as well, "shall" was replaced with "should".

3.1.2 GSG agreed to pursue the revision of the text of Recommendation 41, as adopted by CBS-16. The revised wording is closer to the initial proposal. GSG agreed to ask EC PHORS, as its governing entity and a Panel of EC, to support it at EC-69. In preparation of the submission to EC PHORS, at its 7th session, in March 2017, S. Pullen of the Snow Watch Team was asked to prepare an amendment to Recommendation 41, based on consultations with other members of the Snow Watch team, and with the representatives of those Members who expressed concerns regarding the feasibility of the request, at CBS-16 S Barrell kindly offered to present the revised wording to EC PHORS and on to the EC-69.**[S Pullen, Secretariat, 03.2017]**

3.1.3 B Goodison noted that the current regulations don't include a requirement for snow depth reporting at global level. He requested the Secretariat to present the recommendations of CBS-16 at the Regional Association meetings (RA-II, RA-IV, RA-VI, in 2017), stressing regional requirements and capabilities, and requesting the RAs to work with their Members to define the Member specific period "when snow is expected", as required in the above mentioned recommendation. **[Secretariat, 2017]**.

3.1.4 S Barrell recommended that, for the future, an expert should attend meetings or sessions where specific requirements are proposed, to provide timely and accurate

information supporting the decisions made. This would remove the need for mitigating actions following the initial decision.

3.2 Data Quality and Monitoring

3.2.1 General aspects

B Goodison noted the need for monitoring the performance of stations and of the availability and the quality of data, as an important benefit for the contributing organizations. Dr Xiao recommended that GCW adopts an approach similar to that currently used by World Glacier Monitoring Services (WGMS) which outputs an annual report of the status of its stations. This would ensure the visibility of GCW participating stations and their organizations, as is currently the case in China. J Wang also provided an overview of the system used by CMA for monitoring station data availability.

S Barrell informed the participants about the development of the WIGOS data monitoring system (WDQMS), which will involve regional centres responsible for the quality monitoring of affiliated stations. A trial is underway and, once this is finalized, similar systems will be used in all regions. She encouraged GCW to be actively involved in the development of WDQMS.

GSG agreed that the operationalization of GCW must address the quality monitoring of CryoNet stations, and requested that a strategy is defined in collaboration with WIGOS, e.g. in the context of the WIGOS Data Quality Management Systems, WDMQS and presented at GSG-5 (2018) **[W Schöner, GSG-5]**. Additionally, GSG asked the Secretariat (E. Charpentier) to liaise with WIGOS Project Office on the role that these centres could play with regard to the monitoring of cryospheric data, and report back to GCW. **[Secretariat, GSG-5]**

3.2.2 BAS Data Quality and Monitoring System

B Goodison noted the importance of the BAS interface, and that the goal is for CryoNet to provide monitoring and data quality control support, especially for those (research) stations which do not have capabilities to do so.

Peter Kirsch, Senior Data and Science Information Manager, provided a summary of BAS data monitoring and quality control assessment for meteorological observations Hi role includes overseeing the electronic management of scientific data and information within the Polar Data Centre of BAS. He noted that reports are generated on the percentage of available observations, with plots of critical parameters in the background. A colour coded dashboard, gives a qualitative assessment of data availability. The system is used to notify operators about problems, e.g. data not being available on GTS (https://legacy.bas.ac.uk/met/jds/met/climat_2017.html).

The BAS resources currently supporting the monitoring function is approximately 10-15% of a person, and the tools are fully functional. Mr. Kirsch noted that the switching to BUFR is still causing some problems.

Ø Godøy obtained information on harvesting information from the BAS system. P Kirsch also noted that, currently, the monitoring of GCW stations is not built in the GCW Data Portal, but it could be done, given clarity of objectives and resources.

P Kirsch informed participants about the availability of ice core data. Currently, the IceREADER is a metadata portal for ice cores, but provides no access to data; the design of the data interface is underway. He asked the GCW experts and GSG members for input on the preferred access to the ice core data (e.g. web service), its expected use, noting that the datasets will be DOI'd. The database will potentially be interoperable to allow for coordination at international level (e.g. GCW Data Portal). CliC, IASC, SCAR could coordinate the identification of other potential interested parties. **[J Key, 2017]**

3.3 Development of GCW products

3.3.1 J Key highlighted the need for developing assessments on key cryosphere variables, at least annually, and publishing them on the GCW website, thereby addressing the mission statement of GCW to providing authoritative information on the state of the cryosphere. These are critical in demonstrating the value of GCW.

To date, J Key supported a young scientist who prepared short assessments of glaciers, ice sheets, permafrost, and sea ice, but these need to be sustainable. The range of products and outreach depend on the visibility desired, e.g. should media go through the GCW website to access other products? The GCW assessments can be important contributions to WMO's climate assessments, if done robustly. M Drinkwater noted that the GCW website should be the access point for authoritative products, developed by GCW and its partner organizations, including ECMWF, with appropriate attribution [**J Key, WG Integrated Products Co-Chairs, GSG-5)**.

3.3.2 R Brown recommended that key climate and cryospheric indicator time series such as spring/fall air temperatures, September sea ice extent, spring snow cover extent and Greenland ice volume be presented together on a GCW dashboard to provide a diagnostic chart on the state of the global cryosphere. V Smolyanitsky recommended the development of regional trackers as products for the GCW website. R Brown expressed concerns regarding the current connection with users and how the products and trackers developed could be used more effectively, e.g. trackers are effective in identifying anomalies. More needs to be done to build engagement. **[see 3.3.1]**

3.3.3 The participants agreed on the value of using a unified system for representing the results on the website, to facilitate their integrated understanding and use. The representatives of partners were asked to identify how they see their contribution with products, trackers, and they were invited to provide input to Secretariat. C Xiao recommended that periodically these products be compiled in a published paper or WMO report, to give more visibility for GCW. **[see 3.3.1]**

3.3.4 J Baeseman recommended that GCW should consider joint products with joint identity. She urged GCW to carefully decide its strategy on products and outreach, to ensure that the time and energy are used wisely, and avoid over commitment. She noted that other portals are already displaying related products (e.g. SCAR's, Antarctic Environmental Portal), which are currently used by policy makers, and these could be linked to the GCW website **[see 3.3.1]**

M Drinkwater noted that ESA has a portal for its Climate Change Initiative (http://cci.esa.int/) which publishes essential climate variable (ECV) products and includes a toolbox to facilitate combining and analyzing of products and includes a visualization tool. The products available include glaciers, Antarctic Ice Sheet, Greenland

Ice Sheet, land cover, sea ice, among others. He encouraged GCW experts to build on and integrate the information available there. **[GSG, PSTG, partners, GSG-5**]

3.4 GCW and the Polar Regional Climate Centres (PRCCs)

3.4.1 A Snorrason provided an overview of the initiative of EC-PHORS, the Services Task Team (STT), on developing and implementing an Arctic Polar Regional Climate Centre (Arctic PRCC) Network. The Arctic PRCC implementation plan was developed following its meeting in November 2016. GCW was represented by A Snorrason. A demonstration phase of the Arctic PRCC-Network will commence by the end of 2017. GCW is a key contributor to PRCC and its contribution would include:

- Measurements from the GCW surface network support of the RCC Mandatory and Highly Recommended Functions; these could be used for product validation;
- GCW products, such as snow trackers, Snow Watch intercomparisons, snow assessments, and additional new products identified of common interest (e.g. permafrost products/tracker);
- The GCW metadata archive could be linked to the PRCC-Network metadata archive. Norway houses the WIS compliant GCW data portal, and will likely also house the WIS compliant Arctic PRCC data portal;
- GCW could serve as an excellent resource for technical expertise in matters related to the cryosphere, and could support the validation of user needs;
- GCW will contribute to the review and assessment of the PRCC cryosphere specific products, e.g. forecast verification, model initialization, and assist with the interpretation of long range forecasting products for Polar Climate Outlook Forums.

3.4.2 GCW would benefit from PRCC and the WMO Regional Associations promoting improved exchange of snow data and other cryospheric data elements. The PRCC implementation plan noted that the breakdown of total precipitation to rainfall and snowfall is very important in areas where solid precipitation occurs. This is a topic relevant to the work plan on solid precipitation products, of the Snow Watch Team (see 6.1.1).

3.4.3 A Snorrason requested that the GCW is engaged in the development of the Arctic PRCC and that the GCW proposed product strategy takes into account the Arctic PRCC goals (e.g. 3.4.2, above) . He requested that GCW Implementation Plan is aligned with the PRCC Implementation Plan to contribute to the PRCC goals of EC PHORS. **[WG Chairs and Co-chairs, GSG-5]**

3.4.4 C Xiao attended the first WMO Workshop on Operational Climate Prediction, in 2016, in Jaipur, India, and noted that China is interested in hosting a workshop on RCC with a focus on high elevation cryosphere related impacts, e.g. floods. J Wang proposed that a Third Pole RCC for high mountain regions to be developed linked to the RCC Beijing, focusing on the Asian high mountains. A proposal in this sense will be submitted for EC PHORS-7. **[J Wang, 03.2017].**

4. GCW IN THE ANTARCTIC

4.1 Overview of British Antarctic Survey activities

Prof David Vaughan, Director of Science of BAS, presented a summary of BAS activities with relevance to GCW, focusing on BAS strategy questions on polar science for the next 5 years, (1) How will the changing cryosphere affect our planet? (2) How can we preserve species and ecosystems, whilst benefitting from natural resources? (3) How can we unlock the history of life, climate and the Earth itself to inform our predictions of the future? (4) How do the oceans and atmosphere affect regional and global climate change? (5) How can we minimise risk of extreme space weather events?

BAS is primarily focused on Antarctic research, where it operates 6 stations. More recently, the focus has expanded to include overseas development (ODA), in Iran and the Himalaya region. The goal is to deploy instruments developed in Antarctica, e.g. for thickness of glaciers, to project water availability. BAS experts have been working for the past two seasons in the Himalaya, developing measurement options; they will continue the tests in 2017, and deploy in 2018. The technology will be shared with partners, including GCW. The point of contact for the project is Andrew Orr, anmcr@bas.ac.uk. (**action in 6.2.1**)

The GSG Chair and Co-Chair thanked Prof Vaughan for the presentation, the range of opportunities presented, highlighting the importance of the potential opportunities for collaboration.

4.2 Overview of the Polar View consortium

Andrew Fleming, Manager of Polar View activities in Antarctica, which develops and delivers near-real-time sea ice information for users operating in both Polar Regions, provided an overview of their activities and products. These include satellite-based information, data services (sea ice, icebergs, lake and river ice, snow, glaciers) related to resource development, safety of operations, environmental protection and sustainable economic growth in geographic areas affected by ice and snow, both in Arctic and Antarctic regions, high resolution, up-to-date images of the sea ice coverage (www.polarview.aq), e.g. sea ice thickness service from CryoSat 2 (http://www.cpom.ucl.ac.uk/csopr/seaice.html).

A Fleming presented the ice products available. GSG noted that GCW is interested in being a facilitator on the distribution of products from Polar View, via the GCW website, and noted the need for closer collaboration with PSTG. M Drinkwater, V Smolyanitsky and J Key were asked to work with A Fleming to develop a plan for enhancing the collaboration, identify additional products, potentially distributed via the GCW website, and to identify new products as more satellite data become available. A Fleming shared Polar View goals of increasing the visibility of their products and reaching a broader range of users. Some options were considered, e.g. the integration of the bipolar sea ice monitoring service, PolarIce.eu, into Copernicus, and making the products available for assimilation into the ECMWF models. [**M Drinkwater, V Smolyanitsky and J Key, 2017, linked to Section 3.3 on GCW Product Strategy]**

Ø Godøy noted that MetNo already has a hub for Sentinel data, and M Drinkwater noted that the alpine regions are covered by Sentinel. (CryoLand: http://cryoportal.enveo.at/.

4.3 GCW in the context of SCAR activities

4.3.1 Dr Jenny Baeseman, the Executive Director of the Science Committee for Antarctic Research (SCAR), presented a short overview of SCAR activities, in the context of its current strategic plan, 2017-2022. SCAR's mission is science leadership, by coordinating high quality scientific research in the Antarctic and Southern Ocean regions, and scientific advice, by providing independent scientific advice to the Antarctic Treaty system and other bodies, such as IPCC. Over the next several years, SCAR will work to develop the scientific capacity of its Members, including students and early career scientists, supporting countries with small Antarctic programs, and helping in developing new research foci. She also noted that the role of social sciences is rapidly growing, which is demonstrated by the merger of the International Council for Science (ICSU) with the International Social Science Council (ISSC). The socio-economic impacts are increasingly seen as critical drivers for scientific activities.

4.3.2 J Baeseman outlined several activities of SCAR with great potential for GCW (Annex 7). She indicated her strong preference for a closer, active collaboration SCAR-GCW-CliC, and asked to formalise this in an agreement with defined projects and achievable results. **[J Baeseman, Secretariat, 09.2017]**

Some examples of SCAR's activities relevant to GCW are:

- Standing Committee on Antarctic Data Management (SCADM): facilitate co-operation between scientists and nations with regard to scientific data;
- Standing Committee on Antarctic Geographic Information (SCAGI): manages and enhances the geographic framework for Antarctic scientific research, operations, environmental management, and tourism.

4.3.3 J Baeseman recommended that GCW and SCAR collaborate on:

- GCW, SCAR and CliC co-organize an Antarctic Observing Activities Workshop for exploring opportunities to enhance available observations by building on existing platforms. **[J Baeseman, L Hislop, Obs WG, 2017];**
- Seek to influence the new generation of Icebreakers, by recommending standardized observing equipment and observing requirements for the newly built ships to ensure that required data are available. **[J Baeseman, V Smolyanitsky, Secretariat, 2017];**
- Further develop AntON through engagements with COMNAP/EU-PolarNet. **[J Baeseman, S Colwell, Obs WG, 2017];**
- Explore the collaboration with the Scientific Committee on Ocean Research, SCOR, measuring essential climate variables in sea ice methodological intercalibration experiments in sea ice to obtain reliable measurements of basic variables. **[J Baeseman, V Smolyanitsky, Obs WG, 2017].**

4.3.4 M Drinkwater noted that the Southern Ocean satellite data requirements have been published as a consequence of the Scientific User Requirement survey undertaken by SCAR/SOOS/CliC, based on an original request by PSTG and EC-PHORS (https://doi.org/10.1017/S0954102016000390). These requirements will serve as guidance for the space agencies for future planning.

4.4 GCW in the context of JCOMM

4.4.1 GSG agreed to pursue a formal relationship with the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) by coordinating the activities of GCW Sea Ice Team and the Expert Team on Sea Ice (ETSI) of JCOMM.

Additionally, coordination with the International Ice Charting Working Group (IICWG) is strongly desired, to ensure better governance and the realization of common goals.

B Goodison, the GSG Vice-Chair, requested through the JCOMM co-President, Johan Stander, and the JCOMM Management Committee that JCOMM re-establishes at JCOMM-5 (2017) ETSI, as a joint team of JCOMM and GCW, in consideration of better realizing the synergies between the two communities with regard to sea ice matters. The request was received positively. V Smolyanitsky, the current ETSI chair, and the co-chair of the GCW Integrated Products WG was asked to prepare a proposal for the joint team, to be presented at JCOMM-7 and GSG-5. **[V Smolyanitsky, 06.2017].**

4.4.2 The participants agreed that GCW should actively work with JCOMM for recruiting observing platforms for the GCW observing network, which would address a significant gap in the current network. [**Obs WG Chair & Co-Chair]**.

4.5 Collaboration of GCW with WCRP and Climate and Cryosphere (CliC)

4.5.1 M Sparrow and L Hislop presented a short overview of the World Climate Research program (WCRP) and the Climate and Cryosphere (CliC). CliC is a project of WCRP, together with CLIVAR (Ocean-Atmosphere), GEWEX (Land-Atmosphere), SPARC (Troposphere-Stratosphere) and CORDEX (Regional Climate Downscaling).

CliC focuses on enhancing the understanding of the changing cryosphere and its climate connections, improving the ability to make quantitative predictions and projections of the cryosphere in a changing climate, and linking observations and modelling communities. Its domains are sea ice, ice sheets, glaciers, permafrost, snow cover, freshwater.

4.5.2 CliC has several projects with potential for collaboration with GCW, e.g. sea ice observations and research, Central Asia activities. Their user communities are interested in the GCW Data Portal as a window for accessing metadata and data. Among those, are:

- SIMIP – Sea Ice Model Intercomparison Project;
- CASIWG – CliC Arctic Sea Ice Working Group;
- ASPeCt – Antarctic Sea Ice Processes and Climate;
- HICAP – Himalayan Climate Change Adaptation Programme (2012-2017), funded by the Ministry of Foreign Affairs of Norway, and in collaboration with ICIMOD, with activities in Nepal, India, Pakistan, China.

4.5.3 CliC and GCW have already recognized the opportunities for collaboration and a semi-formal agreement was established in May 2016. GSG agreed with the engagement of GCW and CliC and asked for specific activities for collaboration to be identified. **[L Hislop, GCW WG Leads, 06.2017]**

5. GCW INTERACTIONS AND LINKAGES

5.1 Development of Partnerships

5.1.1 The participants acknowledged the partnership criteria defined in the GCW Implementation Plan. It was agreed that partnership agreements are beneficial for both parties, and need to be simple, identifying mutual benefits, with specific results. An example of benefits for partners is the use of the GCW Data Portal to access to the data infrastructure.

It was noted that partnerships are critical for WIGOS goals, which is in process of developing its own partnership criteria. As a component of WIGOS, GCW partnership criteria should be aligned with those of WIGOS, and the Secretariat was asked to work with the WIGOS Project Office the activities related to the partnership criteria. **[Secretariat, 2017].**

5.1.2 The meeting acknowledged that WMO has Memorandums of Understanding (MoU) with many organizations, which have activities relevant to GCW (e.g. MoU with IUGG for IACS). The Secretariat was asked to summarize the existing agreements and identify the opportunities to amend and expand existing agreements with partner organizations. [**Secretariat, 09.2017].**

5.1.3 The participants appreciated the wide range of opportunities for collaboration identified by the participating partners. In particular, the agreement GCW- CliC, the planned agreement with SCAR, and the planned joint team GCW-JCOMM/ETSI, GSG requested that the mapping of sea ice activities, research and operational, is conducted, jointly, as a matter of priority, to identify opportunities and gaps. This would support the need to develop agreed upon best practices, recommended standards, and explore opportunities for integrated products, as part of the planned GCW products strategy. **[Observations & Integrated Products WG Chair & Co-Chairs, 09.2017].**

5.1.4 The participants recommended stronger engagements with the partners represented on GSG, as well as with ICIMOD, UNESCO, WMO Commission for Instruments and Methods of Observations (CIMO), Commission for Hydrology, COST Action HarmoSnow, International Network for Alpine Catchment Hydrology (INARCH), the Mountain Research Initiative (MRI), GEO Cold Region Initiative (GEOCRI), SAON, the European Polar Board (EPB), and the International Network for Terrestrial Research and Monitoring in the Arctic (INTERACT) http://www.eu-interact.org/, International Arctic Observations System (INTAROS) by engaging them in specific areas of interest according to their mandate and activities and the GCW priorities. **[GCW WG Chairs& Co-Chairs, GSG-5].**

5.2 GCW in the context of GTN-P

5.2.1 H Lantuit presented a summary of the Global Terrestrial Network – Permafrost (GTN-P) activities (www.gtnpdatabase.org), highlighting opportunities for collaboration with GCW. A detailed summary on GTN-P is available in Annex 9 and an account of the International Permafrost Association is available in Annex 10.

5.2.2 H Lantuit noted that GTN-P has now its own governance structure, and it has remained affiliated with IPA. It has redefined its focus and strategy, identified user needs and benefits, defined a data policy including authorship, and, most importantly, defined what they will NOT do. He noted that the redesigned database could be made interoperable with GCW Data Portal and asked the GCW Data Portal Team for continuing the collaboration under way [**Ø Godøy, H Lantuit, GSG-5]** He also noted the lack of a metadata vocabulary for permafrost variables, which makes the data exchange difficult, and the potential for collaboration with GCW, to develop it. **[Obs WG Chair&Co-Chair, H Lantuit, 09.2017]**

5.2.3 B Goodison recommended promoting operationalizing the existing borehole sites with NMHSs in the respective countries, as a way to ensure longer term sustainability and easier data exchange**.**

5.2.4 H Lantuit asked the GCW Best Practices Team for collaboration on developing the standard of measurement for permafrost and seasonally frozen ground, which is critical to GTN-P for promoting increase of standardization at its stations, e.g. recommended depths of measurement for temperature. This should include defining what means to run an operational network, potentially connecting to existing AWS. H Lantuit asked the Best Practices Team to recommend how GTN-P could be involved in this work **[Best Practices Team Leads, H Lantuit, 2017].**

5.2.5 H Lantuit committed to nominated someone from GTN-P, directly involved with the network should be invited **[H Lantuit, 06.2017].**

5.3 ECMWF contribution to GCW

5.3.1 G Balsamo provided a summary of opportunities for enhancing the collaboration between GCW and ECMWF (Annex 11). ECMWF recommended an active engagement of GCW with the modelling community during YOPP core-phase campaigns, and encourage the production of multi-source cryospheric datasets. These activities will support data uptake and usage, expand the knowledge achieved in the GCW teams and reinforce the connection across modelling and observations communities. A larger use of meteorological and cryosphere data will provide a more comprehensive understanding of cryospheric changes. ECMWF will continue its high level of commitment to polar research, which started with a joint ECMWF-WWRP workshop on polar prediction in 2013.

5.4 GCW collaboration with SAON

5.4.1 Mr Jan Rene Larsen from the Arctic Monitoring and Assessment Program (AMAP) Secretariat presented an overview of the collaboration with GCW, in particular in the context of Sustained Arctic Observing Networks (SAON) initiative. The SWIPA report (Snow, Water, Ice, Permafrost in the Arctic) recently revised and to be published in 2017, is a reference document, which was developed with the contribution of experts active in GCW.

J Larsen noted that SAON is interested in the collaboration with GCW on the WMO Rolling Review of Requirements regarding the Arctic and cryosphere related applications, the development of the Best Practice guidelines for observations, in terms of configuration, monitoring, and sustainability of observations, and the data and metadata exchange.

5.4.2 SAON's goal is to broker the availability of observational data, and includes representatives from arctic and non-arctic nations. SAON has two committees, the Arctic Data Committee (ADC) and the Committee of Observing Networks (CON). GCW as a WMO program is represented on both, as well as on the SAON Board. Following the recent meeting of the ADC in Frascati (Italy) it was agreed that stronger linkages with WMO would be beneficial. To realise these, the next meeting of ADC is proposed to be organized at WMO, in Geneva, in late 2017. This will give members of ADC the opportunity to learn more about the WIGOS, WIS systems, critical to open data exchange. This proposal was received positively by GSG and the details will be discussed at a later date. **[Ø Godøy, 09.2017]**

5.4.3 As a member of SAON Board, WMO participated in the organization of the Arctic Observing Framework Workshop, January 2017, in Washington, an action from the

White House Arctic Science Ministerial Meeting in September 2016, aiming at developing guidance for optimum arctic observing systems based on societal benefit areas.

5.4.4 J Larsen noted that SAON will organize the Arctic Observing Summit (AOS2018), in Davos, in 2018, as a joint event with Antarctic observing communities, and in the context of the Polar2018 conference. GCW/WMO is encouraged to be involved. The participants welcomed the opportunity. **[Secretariat, 03.2017]**

5.4.5 A Snorrason thanked J Larsen for his participation and asked the WMO Secretariat to follow up on the potential for strengthening the collaboration between GCW and SAON, including by developing a more formal agreement between GCW and SAON.

5.5 UNESCO

5.5.1 The Secretariat noted that GSG-3 recommended increasing the co-operation with UNESCO, the Intergovernmental Oceanographic Commission (IOC) and the Division of Water Sciences, International Hydrology Program (IHP). Given its important presence in South America, GCW (and WMO) can work more effectively with UNESCO IHP on alpine/glacier initiatives. UNESCO IHP has established a Central Asian Regional Glaciological Centre in Almaty, Kazakhstan.

5.5.2 C Fierz had an informal meeting with representative of UNESCO-IHP (Anil Mishra) in June 2015, exploring a possible collaboration with, both, IACS & GCW on education outreach. A meeting between the GCW Secretariat and UNESCO IHP, Paris office, is planned in 2017. [**Secretariat, 06.2017]**

5.5.3 The Secretariat has been in contact with UNESCO Asia/Almaty office, planning a stronger collaboration in the context of GCW regional activities in Asia. There is an offer from the UNESCO Almaty office to provide support for the organization of the planned GCW workshop, in the region. [**Secretariat, 2017]**

5.5.4 A proposal for GCW contributing to the UNESCO led workshop/training session in Latin America, was made in 2016, but this has not materialized yet. Re-connection with UNESCO-IHP is needed to assess the current need and options for the future. [**G Casassa, 2017]**

5.6 ICIMOD

5.6.1 On the engagement with ICIMOD, the Secretariat noted that WMO has a MoU with ICIMOD dated 2002, focusing on hydrology related activities. While a Letter of Intent was initiated between GCW and ICIMOD, in 2016, the recommendation from GSG was to amend the existing MoU. **[Secretariat, 2017]**

5.6.2 ICIMOD is coordinating the Hindu Kush Himalayan Monitoring and Assessment Programme (HIMAP) to produce a Comprehensive Assessment of the Hindu Kush Himalayan (HKH) Region. This assessment will identify critical data gaps and increase the understanding of drivers of change in the region, and their impacts, including the cryosphere.

5.7 GCW in the context of GEO Cold Regions Initiative (GEOCRI)

5.7.1 J Key, who is engaged in the GEO Cold Regions Initiative (GEOCRI), provided a summary of the GEOCRI activities, relevant to GCW. WMO endorsed the ten key WMO-GEO collaboration principles, defined jointly, at Executive Council, EC-68, in 2016. One of these is the collaboration on Cryosphere activities as exemplified by GEO Cold Region Activities and the WMO Polar and High Mountain Regions activities, including the Global Cryosphere Watch, the Year of Polar Predictions, etc. The activities of the GEOCRI Implementation Plan and relevant to GCW are summarized in Annex 8.

5.7.2 J Key informed that the work plan of GEOCRI includes six tasks, and he is involved on all six. These are Infrastructure, Monitoring Network and Data, Integrating in-situ and Remote Sensing Observations, User Engagement and Communication, Capacity Building and Knowledge Transfer, and Management and Monitoring. Teleconferences for all six tasks were held in the last two months.

5.7.3 S Barrell recommended that, as a founding member of GEO, WMO should use every possible opportunity to demonstrate the contribution of WMO programs with data, information and results. WMO, as a member of the executive committee, must be much more specific about its contribution**. [J Key, Secretariat, 2017]**

6. GCW WORKING STRUCTURE AND NEW AND REGIONAL ACTIVITIES

6.1 New activities:

6.1.1 Solid Precipitation Products

The Secretariat noted that GSG-3 approved the GCW working structure with a Team on Solid Precipitation included in the Observations WG. After examining the potential for continuing the collaboration with CIMO, in the context of the Solid Precipitation Intercomparison Experiment (SPICE), led by CIMO, it was proposed that the Solid Precipitation Team goals are refocused on solid precipitation data products. It was agreed to include the activities related to solid precipitation data products in the Terms of Reference of the Snow Watch Team. GSG asked K Luojus and R Brown to propose amended ToR for the Snow Watch Team, propose experts to contribute to these goals, and recommend next steps. [**K Luojus and R Brown, 06.2017]**

GSG reiterated its commitment for continuing the collaboration with CIMO for achieving these goals.

6.1.2 Sea Ice Integrated Products

V Smolyanitsky presented a summary of proposed activities on Sea Ice products. He noted the opportunity for GCW coordinating these activities with those of IICWG, of ETSI of JCOMM, of PSTG, of Polar View, and of relevant groups from SCAR and CliC. **[See 4.4]**

M Drinkwater reiterated the need to continue developing integrated sea ice products, with clear labelling of which data are used in the products. Such integrated products help strengthen the case for continuity and additional coverage in satellite observations. Linking of products between different satellites helps identifying the gaps and weaknesses in current observations, identify specific product requirements which would anchor required satellite observations. He noted that the biggest challenges remain in the Southern Ocean, where the spatial and temporal sampling remains the poorest. The

PSTG meeting will likely take place in September 2017, and is a good opportunity to discuss the requirements from IISWG and the Southern Ocean community. GSG will monitor the results of this meeting. **[V Smolyanitsky, J Key, GSG-5]**

6.2 Regional groups and activities

6.2.1 GCW Asia High Mountain Activities

6.2.1.1 The Secretariat summarized the GCW activities in Asia, in particular, the High Mountain regions of Asia and the proposed Asia High Elevation Cryosphere Observations (AHECO) project. To date, two GCW CryoNet Asia meetings were held (Beijing, 2013 and Salekhard, 2016). In 2016, the AHECO proposal was developed for 10-15 new stations at high elevation, primarily for glacier monitoring. At the Salekhard meeting, thirty sites were proposed by NMHSs in the region as potential contributors to the GCW observing network, for different climate regimes, their status needs to be reconfirmed. **[Secretariat, 06.2017]**

6.2.1.2 The participants agreed that the most significant challenge in the region is the lack of standardization of observations; many international organization established observing stations, with minimum or no coordination. One of the most impactful contributions of GCW would be the active dissemination of the GCW Best Practices guide, to support achieving data availability and continuity with local capacity (local experts and station operators).

Another area of contribution for GCW is mapping the international initiatives on cryosphere observations in the region, and building upon them. For example, currently, the World Bank has projects in Nepal and Bhutan, and the Secretariat has been discussing options for coordination.

A Snorrason noted that the development of the GCW activities in central Asia were planned to follow the AntON concept for high mountain observations, and asked the Observations WG to ensure that the intent has remained the same**.**

B Goodison noted that capacity building must remain a key deliverable of GCW, as this is one of the seven current priorities of WMO. Given WMO's activities in Central Asia, e.g. hydrological observations and flood forecasting, B Goodison requested that GCW links with CHy, PSTG, GCOS, and WMO resource mobilization activities. The satellite observations available in the regions must be included, e.g. ENVEO, CryoLand (http://www.cryoland.eu/). S Barrell recommended that the GCW efforts in Central Asia take into account the experience of GCOS, which has voluntary cooperation engagements with local organizations to support the expansion of GCOS network.

The Secretariat informed about initiating conversations with Dr Kristine Tovmasyan from UNESCO, Almaty office. UNESCO held in Nov 2016 in Bishkek, Kyrgyzstan, a 2-day workshop on the impact of melting glaciers on water resources, with 60 participants from all five Central Asia countries and Afghanistan, representing national research institutions, government agencies in charge of water and climate change adaptation, as well as other partners, donors, and some experts from Russia. A follow up workshop is planned for 2017. GCW could organize the planned workshop in conjunction with UNESCO activities.

The participants reiterated their support for the GCW activities in the High Mountain regions of Central Asia and requested the Observations WG to revise the AHECO project

proposal. This should include the regional known initiatives with similar objectives, e.g. other WMO programmes, CliC, BAS (see Section 4.1), SCAR, UNESCO Almaty office, World Bank, ICIMOD, UN Environment Central Asia Sub-Regional Office, GCOS, and other known projects. Investments from Swiss Development Agency, Finnish Environmental Institute, World Bank, USAid, are already known. L Hislop (CliC) worked in the region, on projects funded by the Government of Norway, and committed to connect GCW with ICIMOD. The revised proposal will inform on the next steps on timing, scope, invitations, benefits, impacts, for the 3rd workshop.

V Smolyanitsky noted that the Russian Academy of Science (RAS) is willing to facilitate the engagement of the Central Asia countries, given the wide use of the Russian language. The Secretariat will work with V Smolyanitsky and the RAS contacts. **[Observations WG, Secretariat, V Smolyanitsky, 09.2017**].

6.2.2 Tropical Cryosphere Activities

6.2.2.1 The Secretariat presented a summary of the proposed workshop on tropical cryosphere. The participants agreed that the workshop must focus on all relevant components of the cryosphere, i.e. glaciers, snow and snow cover related to glaciers, and relating them to the socio benefits expected (take a user perspective), e.g. tourism industry, water resource management, etc.

It was agreed to include countries from Latin America, Africa, as well as Indonesia, by initiating the conversations with the national meteorological and hydrological services. Other international organizations with similar interests in these regions should be consulted, IPA, UNEP (UN Environment) offices in Africa and Latin America and the Caribbean Office, potentially their Asia and Pacific offices (for Indonesia). The agreed name is “GCW Tropical Cryosphere Workshop”. **[Secretariat, Observations WG, 03.2017]**

6.2.2.2 GSG members were asked to provide names of experts who could be involved in the workshop by mid-February. Several experts were suggested, e.g. Rainer Prinz (University of Graz, Austria), Ian Allison (Australia), Lonnie Thompson (Ohio State University, USA), Andrew Klein (Texas A&M University, USA), Bryan Mark (Ohio State University), Georg Kaser (University of Innsbruck, Austria), Thomas Mölg (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany). **[GSG, 02.2017]**

6.2.2.3 The Secretariat was asked to coordinate with the GCW experts the nomination of a Rapporteur and the definition of workshop objectives. **[GSG, Secretariat, 04.2017]**

6. 3 GCW Work Structure

6.3.1 Amendments to Current Work Structure

Given recent feedback from the WMO Secretary General regarding the high number of teams in GCW, and following discussions with the GCW Chair and Co-Chair, the Secretariat presented a proposal for organizing the work within the existing GCW Working Groups and streamlines the delivery of results in Task Teams, a delivery model widely used by other Technical Commissions of WMO. The Group expressed support for the implementation of this proposal, pending the EC PHORS endorsement. [**WG Chairs, Secretariat, 03.2017**]

Currently, GCW works through its three Working Groups on Observations, Integrated Products, and Information and Services, and two Regional Groups, led by Chairs. Each WG is organized in teams, led by one or more Leads, and conducts tasks addressing GCW deliverables. Several teams have not been active, yet (Solid Precipitation, Sea Ice and Glacier Products).

The current proposal would bring the following updates:

- Working Groups are maintained as already defined;
- The deliverables of each WG will be carried out as project by Task Teams, which will function as long as a project/task is under development;
- Each Task Team will be led by a Lead/Co-Lead, agreed upon by the WG Chair;
- Task Team members will be selected based on their specific contribution to project goals;
- An expert could be engaged in multiple Task Teams;
- All GCW nominated experts will remain associated with one or more WG, and a TT Lead would draw from the available pool of experts.

Advantages:

- Enable a more focused approach to priority activities;
- Engage experts based on their expertise and interest;
- Provide more flexibility on the organization of results, meetings (agenda, participation, expected outcomes).

Disadvantages:

- Risk of not involving some experts, especially in meetings, leading to dissatisfaction;
- Need to balance results oriented approaches with other objectives (regional representation, etc.).

The Regional Groups are organized as projects and are organized asTask Teams.

6.3.2 Nomination of experts

6.3.2.1 The Secretariat informed that since GSG-3, additional experts were nominated either by existing GCW experts or WMO Members. The participants agreed that in the future, the selection of new GCW experts will reviewed based on the candidate's experience and expertise, and their potential for contribution to specific priority activities. It was agreed that:

- When changes in membership take place between meetings, the Secretariat will seek approval from GCW Chair and Co-Chair via email, based on proposals from WG Chairs;
- A letter of endorsement from the PR of the respective country is required. For experts working for organizations other than a National Hydro-Meteorological Service (e.g. IACS(IUGG), WGMS(IACS), IASC, SCAR, CliC, as well as national organizations), the endorsement of the senior management of their organization should be obtained, and the notification of the country's PR remains required.

6.3.2.2 H Lantuit recommended the engagement of young scientists through the Association of Early Career Scientists (APECS) stream, who could undertake work under the guidance of experts. This would address the need for results, mitigating the over commitment of experts. It will give young scientists mentoring opportunities and the potential for participation in activities of high priority (e.g. meetings). Opportunities could be advertised on CRYOLIST (http://cryolist.org/about.html).[**WG Chairs, 2017]**

6.3.3 Approval of New Members and other membership changes

6.3.3.1 The Secretariat presented the list of experts nominated since its 3rd session. These nominations, listed in Annex 12, were approved by GSG, as presented. The Secretariat was asked to circulate periodically the list of members, as a reminder of the available resources. [**Secretariat, GSG-5**]

6.3.3.2 C Xiao noted that he has changed positions recently and he is no longer able to contribute to GCW. Together with J Wang of CMA, they will provide names of experts from China to replace C Xiao and augment the Chinese contribution to GCW. These proposals will be considered using the email approval process. The GSG Chair thanked C Xiao for his active engagement and contribution to GCW. **[J Wang, 03.2017]**

6.4 Role and Structure of the GCW Steering Group

6.4.1 S Barrell noted that the GCW Steering Group has a good balance of expertise and organizational oversight and there is a good understanding of needed linkages and engagements, relative to the strategic goals of GCW. There was general consensus on the balance of expertise, leadership and representation from key partner organizations, people who are facilitating the connection of GCW with communities of interest outside the traditional WMO communities. The participants agreed that no changes in the GSG structure and membership, are needed, at this time.

6.4.2 It was noted that the Steering Group must develop a strategy for when GCW becomes a fully operational program. The participants were invited to provide recommendations on the organization and leadership model of GCW, as it will need to evolve over the next 2-3 years**. [GSG Chair, Secretariat, in preparation of GSG-5]**

6.4.3 GSG agreed to convene an executive committee, mandated to decide on tactical matters of GCW between meetings, and this should include the GSG Chair and Co-Chair and the WG Chairs and Team Leads. **[Secretariat, 2017]**

6.5 Engagement of GCW Focal Points

The participants reviewed and reconfirmed the terms of reference for the Focal Points as published in the GCW Implementation Plan. The participants agreed that more active engagement of the Focal Points was needed, for example by holding regular webinars with the Focal Points, and invite experts to present updates and opportunities for further contribution. It was proposed to ask the Focal Points about the potential for them to be engaged to address well-defined topics, and under the guidance of a GCW expert. **[WG Chairs, 2017]**

7. ACTION PLAN AND FUTURE ACTIVITIES

7.1 GCW Work Plan 2017/2018

7.1.1 Observations WG

The following activities were identified as high priority deliverables for the Observations WG, in 2017:

- Completion of the GCW regulatory material for approval in 2018, e.g. Best Practices Guide, GCW Primer, addressing all cryosphere components; [GSG-5]
- Completion of the evaluation of 2016 proposed stations, for submission to EC PHORS-7, and complete assessment of new submissions;[EC-PHORS7; GSG-5]
- Finalise the minimum observing program for all cryosphere components as soon as possible;[06.2017]
- Development of the Metadata vocabulary, ensure consistency of terminology used for the minimum observing program for the GCW observing network (with OSCAR);[09.2017]
- Publish GCW Data Policy;[EC PHORS-7]
- Finalise the procedure for data exchange, including data formats (for example NetCDF/CF) and recommend updates to BUFR; [09.2017]
- Further develop the exchange of metadata and data from CryoNet stations using the GCW Data Portal in cooperation with the Data Portal Team. [09.2017]

7.1.2 Integrated Products WG

7.1.2.1 Snow Watch Team

- Update the Snow Watch Team Terms of Reference to include additional goals regarding solid precipitation products;[06.2017]
- Develop mechanism to link with Polar Regional Climate Centres (PRCCs) and address the need for products, e.g. multi-dataset regional snow cover and SWE trackers. Link with the PRCC implementation plan;[GSG-5]
- Establish a set of global reference stations with long-term, consistent snow depth observations for monitoring global snow cover change and those suitable for model and/or satellite validation/evaluation. Describe what we mean with the subcategory “cal/val” for CryoNet stations in the case of snow. So should be done in cooperation with Observations WG; [GSG-5]
- Assist in the development of GCW regulatory material;[GSG-5]
- Continue efforts to promote the real-time reporting and exchange of snow data, including in real time;[EC-69, GSG-5]
- Continue to develop the historical global SWE archive maintained at FMI. [GSG-5]

7.1.2.2 Sea Ice Products Team

- Develop a strategy for integrated work planning with ETSI; [06.2017, for submission to JCOMM-7]
- Contribute to the development of the GCW Integrated Products strategy by develop summary of products that could be made available via GCW and in collaboration with relevant groups.[GSG-5]

7.1.3 Information and Outreach WG

Terminology Team[GSG-5]

- Include additional sources; assess existing definitions for the same or similar variables to propose, where possible, integrated definitions. This would require dedicated resources, and is possible as funds become available.

Website Team [GSG-5]

- develop a GCW Wikipedia entry, to create an archive for Cryosphere in the News articles, storing assessments and interesting events pages in a database;
- minor updates to the questionnaires;
- improve the website for use on mobile devices;
- develop a resource database with CliC, the GCW Newsletter, recreating global cryosphere maps;
- add a quality assurance CryoNet webpage, similar to that used by the GAW (http://www.wmo.int/pages/prog/arep/gaw/qassurance.html).

Data Portal

Key activities to support the further development of the GCW Data Portal are:

- Manage the further development of the WIGOS Metadata vocabularies, to fulfill the requirements of GCW, in collaboration with Observations WG [09.2017];
- Develop the GCW-OSCAR interfaces [GSG-5];
- Develop new software components to advance the data and metadata harvesting, and establish interoperability with other Data Centres. For some of these activities additional resources would be required. [GSG-5].

7.2 Development of GCW Performance Indicators

S Barrell recommended that GCW develops practical and measurable success indicators (SMART), to drive its strategic development, and be used for measuring and communicating progress, including with the communities contributing to GCW. Practical indicators could be very effective in identifying impact and will provide insight on adjustments needed to remain relevant.

S Barrell agreed to lead this effort, on behalf of GSG and asked the WG Leads to contribute with proposals for performance indicators, e.g. the number of partners, benefits, impact: website, Google Analytics (how many visits, which products). **[S Barrell, Secretariat for coordination, GSG-5]**

7.3 GCW Communication and Outreach Strategy

7.3.1 GSG recognized the priority of developing a "*GCW Communication and Outreach Strategy*". This will identify the GCW audience, goals, benefits to its partners and to community, enabling "brand recognition". It will have to draw boundaries, i.e. what will not be done. S Barrell noted that GCW is an international mechanism, and recommended to GSG to consider whether representing it as an intergovernmental mechanism would be more impactful.

It was recommended that GCW uses WIGOS and the Global Atmosphere Watch (GAW) communication plans as examples, and uses WMO resources to develop this strategy, focusing on audience, messages, and target products.

Synergies with GAW should be pursued more actively, as they went through a similar development process; e.g. on their communication plan, arguments used for funding stations and on the contribution to public policy, impacts, etc.

B Goodison remarked the need to equally address the primary audience, WMO Members, as well as the scientific community engaged in monitoring the cryosphere. GCW needs to make Members aware of issues and where they could improve their services, including data availability and quality. He noted the need for the active engagement of the WMO commissions, Regional Associations, and other programs.

H Lantuit recommended that decisions on GCW strategy on products, as well as the outreach strategy must be planned within a coordinated, overall, longer term perspective, e.g. 5 years, to remain pragmatic on what is possible. The products made available need to be a service of value to the target audience. This strategy must articulate with clarity which priorities are most important and will be done well and what will not be done.

The partners members of GSG strongly encouraged GCW to do a better job in articulating its identify and promoting its contribution, including by communicating to potential partners more clearly the benefits from joining the GCW observing network. J Baeseman recommended that the communication strategy defines clearly who the target audience is, and most importantly who is not the audience, and use professional services to develop this strategy.

7.3.2 H Lantuit recommended that GCW works to make itself more visible, including via publications, e.g. a paper on the GCW Data Portal, similar to that published on the new database of GTN-P, or papers on the state of the cryosphere. Publicizing the GCW results will help in securing additional funding for its contributors and as a whole, to support further development, in a similar manner as GTN-P, which has secured funding from multiple sources. [**GCW WG Chairs& Co-Chairs]**

There was consensus that cryosphere research, observations, services are of great interest and that there are many organizations and initiatives in these areas. GCW can become a recognized key player only with a very clear and focused message on the uniqueness of its contribution, and why others should become engaged. The GCW communication strategy is critical for GCW to make itself known either directly or through partners, especially where there is still doubt about its usefulness; as noted "*where the competitors go, GCW needs to go*".

The Data Portal is the best "candy" that GCW brings, especially for research communities. It was agreed that demonstrations on how to use WIS to access data from CryoNet stations and how the data and metadata are made available via GCW Data

Portal, and very effective means to demonstrate the value of GCW. **[Data Portal Team, GSG-5]**

7.3.3 The partners requested to receive one slide that would define GCW and the opportunities that it brings to the table, and be informative and appealing. The Secretariat was asked to coordinate the preparation, in conjunction with the Communication office of WMO. **[J Key, Secretariat, 04.2017]**

7.3.4 M Sparrow noted that a paper on GCW will be presented at the Antarctic Treaty Consultative Meeting (ATCM), in May, and this should include information on the website and its value to the community**. [Secretariat, 04.2017]**

7.3.5 The Chair and Co-Chair requested that GCW is actively represented at the GCOS Terrestrial Observations Panel on Climate (TOPC). **[GSG, 04.2017]**

8. REPORT TO EC-PHORS

GSG recommended the following topics to be brought forward to EC-PHORS-7 **[J Key, Secretariat, EC PHORS-5]:**

- Stations recommended for inclusion in the GCW Observing Network;
- Request Members to provide support to their national organizations for contributing to GCW, in particular regarding the implementation of WIS and WIGOS formatting of data and metadata, and allow their distribution in [near] real time, though GTS/WIS (for data), and to OSCAR Surface (for instrument/platform metadata);
- Changes to the approved CBS Recommendation on snow data exchange, for submission to EC-59
- Data Policy;
- Information on regional activities;
- Proposed amendments to the working structure of GCW.

9. ANY OTHER BUSINESS

9.1 Next GSG Session

EC-70, in 2018, is critical, as it will be preparing all submissions for Cg-18, 2019. This means that every resolution for Cg-18 must be drafted for EC-70, in May 2018. For this reason the GSG meeting in 2018 is a significant milestone in the development of GCW as an operational program. The participants agreed that the 5th session of GSG must take place in January 2018, prior to EC-PHORS-8 (March 2018).

One potential location for the GSG meeting is Tokyo, Japan, in parallel with the International Symposium on Arctic Research, 5th conference. **[Secretariat to coordinate, 06.2017]**

The participants considered organizing yearly meetings involving all GCW experts and members of the Steering Group, where to hold a plenary session and side meetings to address priority activities. This may be a more efficient use of available funding. GSG recommended that the option has merits and should to be further explored.

The participants agreed that the future GSG meetings should be include meetings on deliverables of Task Teams (engaging those contributing to specific results) and an

executive session, engaging representatives of partners. The exact format will be further refined in conjunction with the revised working structure.

9.2 Other GCW meetings in 2017

The following meetings and activities were proposed:

- GCW Tropical Cryosphere, Tanzania, July 3-6, 2017;
- GCW Asia High Mountain Cryosphere workshop (fall 2017);
- A face to face meeting of the CryoNet Team is not needed in 2017;
- Best Practices Team: potentially meet in Q4 2017, for the final review of the first version of the GCW Best Practices Guide, with targeted working expert sessions for content development;
- Snow Watch would consider a meeting focusing on Solid Precipitation. A full meeting regarding Snow Watch activities will be organized in 2018;
- The SnowPex project will meet in 2017 and it might make sense to enable the participation of key GCW Snow Watch experts;
- Sea Ice Integrated Products will explore meeting in conjunction with other related activities, for example, prior to the IICWG meeting in Sept 2017;
- GCW Data Portal Team will seek the organization of targeted working sessions that will further develop the interoperability of new data centres with the GCW Data Portal.

10. CLOSURE OF MEETING

The Chair thanked the participants and the Secretariat for contributing to the successful outcome of the meeting.

The meeting closed at 17.00 hours on Thursday, 19 January 2017.

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ANNEX 1: AGENDA

(GCW Steering Group 4th Session)

VENUE: British Antarctic Survey, Cambridge, United Kingdom

DATE/TIME: 16 January 2017, 09.00 to 19 January 2017 17.00

1. **ORGANIZATION OF THE MEETING**

1.1 Welcome (David Vaughan, Director of Science, BAS)

1.2 Opening of the meeting and adoption of the Agenda (Chair, GSG)

1.3 Working Arrangements (Chair, GSG; Steve Colwell, BAS)

1.4 Introductions of participants (participants)

1.5 Overview of meeting goals: Chair

2. **GCW WORKING GROUP REPORTS (WG AND TEAM LEADS)**:

(Progress, gaps, challenges; work plans, recommendations for EC-PHORS)

2.1 **Observations Working Group (W Schöner, C Fierz, Þ Þorsteinsson)**

- CryoNet-5 decisions: variables, updates to the assessment process;
- CryoNet submissions and assessment results;
- Best Practices Guide and Manual - progress, challenges, and plans;
- GCW observing system: CryoNet, contributing stations, synoptic stations, other cryosphere networks (e.g. GTN-P, GTN-G, etc.);
- GCW Website: Aligning with amendments to the CryoNet assessment process; development of CryoNet station "product trackers".

Visit British Antarctic Service facilities: ice core testing facility, cold water aquarium, Antarctic clothing store and the meteorology lab, etc. (Steve Colwell)

2.2 **Report of Integrated Products WG:**

Snow Watch: progress, challenges, work plan (R Brown, K Luojus);

2.3 **Report of Information and Services WG** (J Key, Ø Godøy, G Casassa);

- Website and Outreach Team: progress, challenges, work plan; discussion on authoritative information and the media;
- Terminology Team: progress, challenges, work plan;
- Data Portal Team: progress, challenges, work plan;

2.4 **GCW Observing System: Data Exchange**

- GCW Data Policy
- Interfacing CryoNet stations/sites and data exchange: application of WIGOS metadata/data; integration with WIS; use of GCW ID.

3. GCW DATA AND PRODUCTS

3.1 **CBS-16 decisions**: impact and strategies for the future;

3.2 **Data quality monitoring and assessment**; Explore opportunities with BAS (e.g. support as for AntON monitoring);

3.3 **Additional GCW products** (snow trackers, satellite products, sea ice, e.g. Copernicus);

3.4 **GCW and the Polar Regional Climate Centres (PRCCs):** A Snorrason, V Smolyanitsky.

4. GCW IN THE ANTARCTIC

4.1 GCW in the context of **BAS activities (**D Vaughan);

4.2 GCW in the context of **SCAR activities (**J Baeseman);

4.3 GCW in the context of **JCOMM:** data buoys, sea ice, IICWG (V Smolyanitsky);

4.4 **GCW Observing System in the Antarctic:** CryoNet, contributing stations, AntON, buoys, cryosphere research networks (W. Schöner).

5. OTHER GCW INTERACTIONS AND LINKAGES (GSG CHAIR, CO-CHAIR)

5.1 GCW Implementation: Current and future collaboration (with input from the organizations represented on GSG): mutual benefits and engagements;

5.2 GCW's Partnership Criteria; Recommended actions relative to TC, RA.

GCW STRUCTURE:

6.1 GCW **Structure**; GCW in 2040;

GCW **Membership;** Teams as functional themes;

6.2 Consideration of **newer activities/teams:**

i. Solid precipitation products
ii. Sea Ice Team
iii. Glaciers Team
iv. Permafrost
v. Regional groups and activities

6.3 GSG Role and Structure;

6.4 Engagement of GCW Focal Points.

7. ACTION PLAN AND FUTURE ACTIVITIES

Draft list of CryoNet stations/sites for EC-PHORS-7 and EC-69;

Actions plan 2017/2018;

Next meetings and workshops;

Outreach plan.

8. REPORT TO EC-PHORS

8.1 Draft Resolutions to EC-69.

9. ANY OTHER BUSINESS

9.1 Next GSG meeting.

10. CLOSURE OF MEETING (18:00)

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ANNEX 2: LIST OF PARTICIPANTS

(GCW Steering Group 4th Session, Cambridge, UK, 16-19 January 2017)

No.	Name	Institution / Affiliation	e-mail
1	Árni Snorrason Chair, GCW Steering Group	Icelandic Meteorological Office, Reykjavik, Iceland	arni.snorrason@vedur.is
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ANNEX 3: Action Items from GSG-4

No.	*Ref.*	*Action items*	*By whom*	*Deadline*
1	2.1	Update the definition of the GCW observing system to reflect its space component and affiliated networks.	W Schöner	GSG-5
2	2.2.1	Finalise the list of variables for river ice and lake ice for inclusion in the GCW minimum observing program by consulting additional experts.	Secretariat	06.2017
3	2.2.1	Consult more broadly on the recommended list of variables to gather broader support	Observations WG Chairs	06.2017
4	2.2.1.4	Include the observation of atmospheric pressure as a (highly) recommended variable	Observations WG Chairs	01.2017
5	2.2.1.5; also: 5.2.4; 5.2.5	Include in the final Best practices Guide: • recommendations on reporting precipitation type • "Frequency of measurement", "Frequency of reporting", include near real time reporting. • For daily data indicate the required time of reporting • Permafrost: include, at the minimum, daily measurements of ground temperature. For mountain permafrost, hourly measurements of ground temperature are recommended. • develop a standard of measurement for permafrost and seasonally frozen ground (see details 5.2.4); define requirements for engaging the GTN-P community • H Lantuit to nominate contributing experts.	Best Practices Team Leads; H Lantuit	GSG-5
6	2.2.2.1; 2.4.1.4 5.2.2	Develop/recommend WIGOS Metadata vocabulary for all GCW variables. Develop input to OSCAR Surface (see next action, also); Harmonize the terminology and definitions, and cross reference with OSCAR. Ensure consistency of terminology on the definition of variables recommended as part of the GCW minimum observing program. Nominate a GCW Expert for the WIGOS Metadata Task Team Engage GTN-P for the development of Metadata vocabulary for Permafrost.	CryoNet Lead, Terminology Lead; Data Portal Lead H Lantuit	09.2017
7	2.2.2.2	Identify sub-applications for which independent sets of user requirements could be developed. to - nominate a focal point for each AA, for coordinating with the respective user communities for developing sets of observational user requirements to be recorded in OSCAR/Requirements, and conducting gap analysis (i.e. Statements of Guidance). Actions in coordination with 2.2.2.1	Observations WG Chairs	GSG-5
8	2.2.3.1	Complete the assessment of 2016 submissions for the GCW Surface Observing Network, and prepare submissions to EC-PHORS and EC-69, once approved by Chair and Co-Chair of GSG.	Observations WG, Secretariat	02.2017
9	2.2.3.2	Inform EC PHORS of changes to the assessment process; post approved changes on GCW website	J Key	03.2017
10	2.2.3.5	Archive station metadata and explore archiving the historical site/station information.	J Key	GSG-5

No.	*Ref.*	*Action items*	*By whom*	*Deadline*
11	2.2.3.7	Develop specific criteria for the assessment of mobile platforms applying for inclusion in the GCW observing network as CryoNet stations.	V Smolyanitsky, CryoNet Team,	09.2017
12	2.2.3.9	Secretariat to act as the first reviewer for new submissions, to ensure completeness of information, before referring then to the CryoNet Team.	Secretariat	On-going
13	2.2.4.2	Provide details to GCW Experts on the definition and use of WIGOS ID for GCW stations, for the GCW Best Practices Guide.	Secretariat	09.2017
14	2.2.4.3	Prepare recommendation for EC PHORS (for EC-69) to request support from Members for their national organizations contributing to GCW, regarding the implementation of WMO data and metadata formats (WIS, OSCAR)	Secretariat	03.2017
15	2.2.5	Finalise the Best Practices Guide, version 1, for GSG-5	Best Practices Team Co-Leads	GSG-5
16	2.3.1.3	Snow Watch Team to work with J Wang (CMA) to identify additional snow datasets that could be made available.	Snow Watch Co-Leads, J Wang	GSG-5
17	2.3.1.4	Include the reporting of snow depth in OSCAR and the need to investigate the RT exchange of SoG SWE data on WIS *(see also 2.2.2.1)*	Snow Watch Co-Leads	09.2017
18	2.3.1.5 (also 3.3 actions)	Further develop snow trackers to include additional real time data sources, and produce multi-dataset snow cover info. Consider including outliers in the product display and explore polar stereographic projections. *To be considered as part of GCW product strategy, section 3.3.*	Snow Watch Co-Leads	GSG-5
19	2.3.1.6	Identify location for storing the documentation from SnowPEx and make the results available to the wider community. These could be used as basis for Best Practices for satellite observations. In conjunction with 3.3 actions.	Snow Watch Co-Leads, M. Drinkwater	GSG-5
20	2.3.1.7	Identify requirements for future missions to further the cryosphere science needs, and invited the Snow Watch Team to include this in their work plan *(coordinate with actions from 3.3).*	Snow Watch Co-Leads, M. Drinkwater	GSG-5
21	2.3.1.8	Identify station criteria for stations which could be used for satellite validation, in cooperation with PSTG	J Key, M Drinkwater	PSTG-7
22	6.1.1	Propose amended ToR for the Snow Watch Team and propose experts to contribute to the goals on solid precipitation products, and continue the collaboration with CIMO	K Luojus and R Brown	06.2017
23	2.4.1.3; 2.3.1.6	Further development of the Davos CryoNet data exchange application to evolve it into an application portable to other stations (including contracting the work)	Ø Godøy, C Fierz, Secretariat	06.2017
24	2.4.1.5	Collaborate with G Balsamo regarding the use of the ECMWF applications for converting NetCDF into BUFR, as needed.	Ø Godøy, G Balsamo	2017
25	2.4.1.7	Develop applications to harvest metadata for the stations in the GCW observing network directly from questionnaires, as much as possible, to avoid the duplication of work	J Key, Ø Godøy,	GSG-5

No.	*Ref.*	*Action items*	*By whom*	*Deadline*
26	2.4.1.8	Organize a GCW Data Portal meeting, tentatively Sept 2017	Ø Godøy, Secretariat	09.2017
27	2.4.1.9; 5.2.2	Establish interoperability with other Data Centres, as new stations are added to the GCW network, e.g. Australian Antarctic Division data centre, GTN-P database	Ø Godøy	GSG-5
28	2.4.2.9	Organize GCW events at EC-69, EC-70, Cg-18, and other high level events	GSG, Secretariat	EC-69, etc
29	2.4.3.3	For each physical parameter, compile and recommend GCW definition(s) based on existing definitions captured in the GCW glossary. Involve partner communities. This will support the Metadata definition, as well.	Terminology Team Lead	GSG-5
30	2.4.3.4	Obtain a DOI for the GCW Glossary	J Key	GSG-5
31	2.4.3.5	Use google analytics to monitor the accessing of GCW Website, in general, and specific pages, e.g. the GCW Glossary to show its utility, and report results to GSG-5	J Key	GSG-5
32	2.4.2.6	Integrate the English version of the Glossary of Cryosphere Science and English-Chinese dictionary of cryosphere science, into the GCW Glossary	J Wang, J Key	09.2017
33	2.5.1	Present the final version of the GCW Data Policy at EC-PHORS-7, for endorsement, followed by publication	Þ Þorsteinsson Secretariat	03.2017
34	3.1.2	Prepare an amendment to CBS-16 Recommendation 41, on Snow Depth reporting, to be reviewed at EC PHORS-7, and submitted to EC-69 for final approval.	S Pullen, Secretariat	03.2017
35	3.1.3	Present the recommendations of CBS-16 at the Regional Association meetings (RA-II, RA-IV, RA-VI, in 2017). Request RAs to work with their Members to define Member specific period “when snow is expected”, as required	Secretariat	2017
36	3.2.2	Provide input to Peter Kirsch (BAS) on the preferred access to the ice core data (e.g. web service), its expected use, noting that the datasets will be DOI’d	J Baeseman, L Hislop	2017
37	3.2.1	Develop a strategy for providing support to CryoNet stations regarding the monitoring of data availability and quality (e.g. in the context of the WIGOS Data Quality Management Systems, WDMQS); Secretariat (E. Charpentier) to liaise with WIGOS Project Office on the role of WDQMS could play on the monitoring of cryospheric data, and report back to GCW	Observations WG Chair/Co-Chair; Secretariat	GSG-5
38	3.3. (1, 2, 3, 4) 4.2.2	Develop a GCW integrated products plan (strategy) to identify assessments and products to be developed, distributed, and published on the GCW website. Engage partners regarding their potential contribution to GCW products Identify products from partner organizations and PSTG which could be included (with appropriate attribution). (Include information identified throughout the report, relevant to this topic.	J Key, Integrated Products WG Co-Chairs, PSTG, partners	GSG-5
39	3.4.2;	Provide support for the development of the Arctic PRCC taking into account the Arctic PRCC goals.	WG Chairs and	Report at

No.	*Ref.*	*Action items*	*By whom*	*Deadline*
	3.4.3	Align the GCW Implementation Plan and product strategy with the PRCC Implementation Plan, as needed.	Co-chairs	GSG-5
40	3.4.4	Provide proposal for a Third Pole RCC for high mountain regions, linked with RCC Beijing, focusing on the Asian High Mountains	J Wang	EC PHORS-7
41	4.3.2	Formalize a collaborative agreement between GCW and SCAR (see next 4 actions, as examples for collaborative work)	WMO Secretariat, J Baeseman	GSG-5
42	4.3.3, 4.5.3	GCW, SCAR and CliC co-organize an Antarctic Observing Activities Workshop for exploring opportunities to enhance available observations by building on existing platforms.	J Baeseman, L Hislop, Obs WG Chair & Co-Chair	2017
43	4.3.3	Seek to influence the new generation of Icebreakers, by recommending standardized observing equipment and observing requirements for the newly built ships to ensure that required data are available.	J Baeseman, V Smolyanitsky, Secretariat	2017
44	4.3.3	Facilitate the further develop AntON through engagements with COMNAP/EU-PolarNet.	J Baeseman, S Colwell, Obs WG Chair & Co-Chair	2017
45	4.4.2 6.1.2 4.3.3	Prepare a proposal for a joint team JCOMM – ETSI and GCW-Sea Ice, for JCOMM-7 and GSG-5. Coordinate activities of GCW with those of IICWG, of ETS-JCOMM, of PSTG, Polar View, and of relevant groups from SCAR and CliC regarding the availability of sea ice products (see also actions from Section 3.3.) Explore the collaboration with Scientific Committee on Ocean Research, SCOR	V Smolyanitsky J Baeseman, Obs WG Chair & Co-Chair	09.2017
46	5.1.4	Map sea ice activities, research and operational, jointly with SCAR, CliC, and ETSI (and others, as needed) to identify opportunities and gaps and contribute to the development of best practices, recommended standards and opportunities for integrated products.	V Smolyanitsky, J Baeseman, L Hislop	09.2017
47	6.1.2	Monitor the results of the PSTG meeting, September 2017, on the requirements from IISWG and the Southern Ocean community. Report to GSG the results of this meeting.	V Smolyanitsky, J Key, GSG-5	GSG-5
48	4.4.2;	Work with JCOMM for recruiting observing platforms for the GCW observing network	Obs WG Chair & Co-Chair	GSG-5
49	5.1.1	Coordinate the evolution of GCW partnership criteria with those developed for WIGOS	Secretariat, GCW WG Leads	2017
50	5.1.2	Summarize existing WMO agreements and identify opportunities to amend and expand the collaboration of GCW with relevant organizations	Secretariat	GSG-5
51	5.1.4; 5.6.1	Pursue stronger engagements with WMO CIMO, WMO CHy, ICIMOD, UNESCO, INARCH, COST Action HarmoSnow, INTERACT, INTAROS, Mountain Research Initiative (MRI), European Polar	GSG	GSG-5

No.	*Ref.*	*Action items*	*By whom*	*Deadline*
		Board.		
52	5.4.2	Explore the potential for organizing the Arctic Data Committee meeting at WMO, in late 2017, and present WIGOS and WIS systems	Ø Godøy	09.2017
53	5.4.4	Participate in the organization of the Arctic Observing Summit AOS2018 (with SAON)	Secretariat	04.2017
54	5.5.2; 5.5.3;	GCW Secretariat and UNESCO IHP to follow up on opportunities for collaboration (Paris and Almaty offices)	Secretariat	06.2017
55	5.5.4	Follow up on the potential for collaboration with UNESCO for organizing the glacier training /workshop in South and Central America	Secretariat; G Casassa	09.2017
56	5.7.3	WMO, GCW in particular, to actively use every opportunity to demonstrate the effective contribution of its programs to GEOCRI with data, information and results.	J Key, Secretariat, Ø Godøy (through ADC)	GSG-5
	6.2	**GCW Regional Activities**		
57	6.2.1.1	Obtain updates on the status of proposals received in Salekhard for the GCW observing network.	Secretariat	09.2017
58	6.2.1.2; 5; 6; 7.	Develop the next version of the GCW plan for engagements in Asia High Mountain regions: build on the AntON model, involve PSTG, include other WMO programs active in the region (CHy, capacity building, GCOS), other potential partners in the region (World Bank, BAS, CliC, Swiss Development Agency, Finnish Environmental Institute, USAid, Research Council of Norway, ICIMOD) Compile an up-to-date list of projects in the region for a clear understanding of options for engagement (e.g. observations, services) Follow up with the UNESCO Office in Almaty regarding future workshops on cryosphere related matters, with which GCW could coordinate for its future meetings in Asia.	Observations WG	**09.2017**
59	6.2.1.8	Engage representatives of the Russian Academy of Science for the GCW activities in Central Asia	V Smolyanitsky	09.2017
60	6.2.2.1	Organize the Tropical Cryosphere Workshop in Arusha, Tanzania, 4-6 July, 2017; invite all Members in tropical and subtropical regions that experience cryosphere and are affected by it.	Observations WG	06.2017
61	6.2.2.2	Propose experts who could be engaged in the Tropical Cryosphere Workshop	GSG participants	02.2017
62	6.2.2.3	Nominate a Rapporteur for the Tropical Cryosphere Workshop	GSG	04.2017
	6.3	**GCW Working Structure**		
63	6.3.1	Organize the deliverables of GCW Working Groups as projects delivered by Task Teams. GSG asked that the proposal be presented to EC PHORS for endorsement, following EC PHORS endorsement of this concept	WG Chairs, Secretariat	03.2017
64	6.3.2.2	Develop collaboration with the Association of Early Career Scientists (APECS) stream, by engaging young scientists on work under the guidance of experienced experts, within the scope of GCW	WG Chairs	09.2017

No.	*Ref.*	*Action items*	*By whom*	*Deadline*
		priority activities		
65	6.3.3.1	Circulate updated list of GCW experts, regularly.	Secretariat	yearly
66	6.3.3.2	New experts to be proposed from China; Secretariat to seek approval from Chair and Co-Chair, at the recommendation of WG Chairs.	J Wang	03.2017
67	6.4.2	Develop strategy for a fully operational GCW program, including on program meetings that are programmatically effective and financially efficient. GSG members to provide recommendations on the organization and leadership model of GCW to Secretariat.	GSG Chair, Secretariat, GSG members	GSG-5
68	6.4.3	Engage Chair, Co-Chair, WG Chairs and Team Leads as an executive committee, as a first level of decision of GCW.	Secretariat	2017
69	6.5	Engage Focal Points in addressing well-defined topics, and under the guidance of a GCW expert. Organize regular webinars with the Focal Points to disseminate information on GCW	WG Chairs	2017
70	7.2	Develop practicable and measurable success indicators to drive the strategic development of GCW	S Barrell	GSG-5
71	7.3.1; 2.4.2.7	Develop a “GCW Communication and Outreach Strategy” in consultation with WIGOS, GAW, partners; to identify the audience, goals, the “GCW brand” and its benefits to the audience. Link it to the Products strategy.	Chair, Co-Chair, Services and Outreach WG	GSG-5
72	7.3.2	Seek opportunities to demonstrate GCW tools, e.g. The Data Portal, how to use WIS to access data from CryoNet stations and how the data and metadata are made available via GCW Data Portal.	Services and Outreach WG	2017
73	2.3.1.8 7.3.2	Prepare a paper on GCW, in *Nature* or other relevant journals	WG Leads	GSG-5
74	7.3.3;	Prepare one standard slide to be shared with partners to promote the benefits of engagement with GCW	Services and Outreach WG	05.2017
75	2.4.2.2	Engage WMO Media Department for revise and improve the GCW handouts and media materials	Secretariat	06.2017
76	7.3.4	Prepare paper on GCW for the Antarctic Treaty Consultative Meeting (ATCM)	Secretariat, Obs WG	04.2017
77	7.3.5	Participate to the GCOS-TOPC meeting	GSG	04.2017
78	8	Prepare report on GCW to EC PHORS	J Key	03.2017
79	9	Identify location for the next Steering Group meeting	Chair, Co-chair; Secretariat	06.2017

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ANNEX 4: GCW Observing Network: Application Process

GCW welcomes the contribution of any station that makes measurements of the cryosphere. Its goal is to design a network that advances WMO's scientific and operational objectives. The process of evaluating a station or a site for inclusion in the GCW surface network is described below. It is the same for stations and sites, core (CryoNet) and contributing, unless indicated otherwise.

1. A representative of the station or site (hereafter, the "applicant" and the "station") completes and submits the station questionnaire (the "application") on the GCW website (globalcryospherewatch.org/CryoNet/questionnaire).
    - It is recommended, though not required, that the applicant present the station at a GCW meeting before beginning the application process.
    - By submitting the application for a core station, the applicant is implicitly agreeing that the station meets the CryoNet Minimum Requirements. A commitment to longevity, data quality, and data distribution is particularly important.
2. In addition to the online questionnaire, a letter of endorsement is required before the station/site receives final approval. It is recommended that it be provided as early as possible in the process. For all proposed stations, either operated by the WMO Member's national meteorological or hydrological service (NMHS) or another entity, the WMO Permanent Representative (PR) of the station's operating country must provide a letter of endorsement to WMO. (template) For stations that are located in a country other than that of the proposing organization, the agreement to operate in that country and to share data as per GCW requirements must be provided. The PR of the country in which the station is located must be informed that the station could become part of CryoNet. For stations operating in Antarctica, the stations should be endorsed by the PR of the country of the proposing organization. For mobile platforms operating in international waters, or by an international consortium, endorsement is done by the designated PR of the concerned countries with concurrence by the chair of the relevant consortium.
3. The application is examined by the WMO Secretariat for completeness.
4. The GCW CryoNet Team, in consultation with relevant experts, evaluates the application[4]. This is normally done annually, but may be expedited in some situations. There are no site visits.
5. If the Team recommends that the station is not be included in the GCW surface network, feedback is provided to the applicant on the results of the assessment. The application can be modified and resubmitted at any time.
6. If the Team recommends that the station be included in the network, the GCW Steering Group (GSG) makes its determination. This is normally done at GSG annual meetings. If GSG recommends that the station not be included in the GCW surface network, feedback is provided to the applicant.

4 To ensure a unique, high-quality network of surface observations, stations and sites are evaluated for inclusion in CryoNet based on several factors. Fulfilling the minimum requirements does not in itself guarantee acceptance as a CryoNet station. Other criteria that are considered by the CryoNet Team when evaluating applications include (1) the number of recommended variables that are measured (see the lists), (2) the continuity and length of the data record, (3) the extent to which data are available and accessible, (4) sustainability of the station, (5) conformity to GCW best practices, and (6) the location and representativeness of the proposed station relative to the geographic distribution of existing CryoNet stations.

7. If GSG recommends the station for inclusion in the network, the station is conditionally accepted and enters a one-year trial period. The station shall operate according to the Minimum Requirements, including the submission of data and metadata.
8. GSG informs the EC-PHORS at EC-PHORS regular meetings, regarding the selection of stations for the CryoNet network. EC-PHORS meets every 12-15 months.
9. EC-PHORS, upon recommendation from GSG, approves and submits the list of selected stations for approval by the WMO Executive Council (EC). EC meets annually.
10. The approval process following the GSG decision takes place in parallel with the one-year trial period.

Additional Information:

- Each CryoNet station will be evaluated annually to ensure that it continues to meet the Minimum Requirements. If it does not, a timeline for correcting deficiencies will be mutually agreed upon by the Team and the station representatives. If no agreement can be reached, the station will be removed from the CryoNet network or, by mutual agreement, will become a contributing station.
- A change in the station type, core or contributing, requires reapplication. This entails a modification to the original application, resubmission, and re-evaluation by the Team and GSG. It does not require approval by EC.
- Stations may be withdrawn at any time from the GCW surface network by request, in writing, of the station owners/operators.
- When an application is submitted via the online questionnaire process, the station is listed on the GCW website as “candidate”. It is not yet part of the GCW surface network. When the GCW Steering Group recommends stations for inclusion in the surface network, for all practical purposes they are part of the GCW network and will be listed on the website accordingly. They are not, however, officially part of the network until approved by EC.

LETTER OF ENDORSEMENT (TEMPLATE)

To WMO Secretary General:

In view of the WMO priority to increase the availability of cryosphere data and information from polar and high mountain areas, I’m pleased to endorse the station/site … (station name)…, located at (address), and operated by … (name of the proponent organization)…, for inclusion in the GCW Observing Network.

The contact person for the station/site is …. (name, email, address, phone). For any additional information please contact Mr/Ms…

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ANNEX 5: SNOW WATCH TEAM PROGRESS REPORT AND WORK PLAN

The recommended priority action items identified at “First” GCW Snow Watch Session, Toronto 2013, formed the basis for 2014-2016 work plan

1. Improve real time flow and access to in situ snow measurements (e.g. non-reporting of snow depths by some countries; encourage zero snow depth reporting)
2. Initiate a satellite snow products evaluation/intercomparison activity
3. Develop hemispheric "snow anomaly trackers" for SCE and SWE for GCW website
4. Develop an inventory of existing snow datasets and products
5. Initiate a PI self-assessment of snow products
6. Initiate activities to standardize snow-related nomenclature, and promote standards and best practices as a contribution to CryoNet

Improve real-time flow of snow depth observations

- Additional real-time snow depth data obtained from 6 national networks: Sweden, Romania, The Netherlands, Denmark, Hungary, Norway, (plus Switzerland who now reports as these additional data as SYNOP).
- Still have gaps in USA, China and Southern Hemisphere
- US gap linked to lack of BUFR coding – has more than 20,000 stations with NRT snow depth data
- Major improvement over China in the past two years regarding the amount of global snow depth data exchanged in real-time
- Collaboration and coordination of efforts by COST action HarmoSnow, NAEDEX (North America Europe Data Exchange), and Snow Watch are needed to ensure the more global acceptance of the new ECMWF BUFR template

Initiatives relevant to address the availability of snow observations on the GTS

- GCW Snow Watch
- COST action on Snow: Harmosnow;
- NAEDEX (North America-Europe data exchange)
- WMO OSCAR: with a new section for in-situ surface data. Would be relevant to use it to monitor snow depth data availability but it needs to be populated with snow data.

Zero snow depth reporting

- Transition to use of BUFR encoding enables the use of a distinct code for zero cm snow, as opposed to missing report
- Regional Reporting Practices – Manual on Codes Volume II states for Europe (Region VI) that snow depth and state of ground “shall be included only if snow or ice cover is observed on the ground”
- Regional guidelines differ - reporting of snow depth is not consistent from region to region… need consistent regular reporting of snow depths regardless of the state of the ground
- CBS-16 recommendation 5.8(2)/2 submitted to report snow depth four times a day and to report zero snow depths over the period which snow is expected (*to be discussed under agenda item 3.1*)

ESA SnowPex

- Following Snow Watch recommendation, ESA initiated (and funded) a Satellite Snow Products intercomparison and evaluation Exercise – ESA SnowPEx (06/2014 -> 12/2016)
- Two international workshops (ISSPI-1 and 2) held in College Park 07/2014 and Boulder 09/2015
- ESA publications developed on: guidelines, protocols and procedures for satellite snow product validation, best practices for quality assessment and uncertainty estimates
- Intercomparison of datasets
- trend analysis of snow extent and snow mass
- Final workshop (ISSPI-3) to be held in Europe in spring 2017 to wrap-up final results and prepare outlines for 3-4 scientific papers

GCW Snow Anomaly trackers

- Near real-time tracking of NH SWE from GlobSnow (FMI) and the CMC daily snow depth analysis (ECCC) in place since 2014
- CMC operational snow depth analysis to transition to new land system data assimilation system in 2018; procedures in place to maintain tracker

Snow Data set inventory

- 2016 addition of 212 station Chinese daily snow depth dataset with data covering 1951-2014
- Ongoing effort required to update inventory as new datasets come on stream. Also need feedback from users/literature on new datasets.
- Note: I have not received any feedback from visitors to the inventory since it was put online in March 2015… is it being consulted?
- The activity to include PI self-assessment of snow products in the inventory has been dropped (not objective; is being done to some extent through SnowPEx activities)

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ANNEX 6: GCW Data Policy (final draft)

FINAL DRAFT version 5 – February 5 2017

Introduction

The World Meteorological Organization's Global Cryosphere Watch (GCW – see www.globalcryospherewatch.org) is an international mechanism for supporting observations of all components of the Earth´s cryosphere, including snow cover, glaciers, ice caps, ice sheets, sea ice, lake and river ice, permafrost, seasonally frozen ground, and solid precipitation. GCW aims to provide authoritative, clear, and useable data, information, and analyses on the past, current and future state of the cryosphere. Improving access to data and products is a fundamental objective of GCW.

The core of the GCW surface observing network is called *CryoNet*. This network is comprised of *stations* and *sites* which meet certain requirements. The GCW surface network 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 Observations System of Systems (GEOSS).

The principles enshrined in this GCW Data Policy must be applied to qualified data from each station and site operated under the auspices of GCW, including submission of metadata and data per an agreed timetable. The GCW CryoNet Team is responsible for the Data Policy. Questions about the policy and its implementation should be directed to the CryoNet Team lead.

Objectives

The purpose of the GCW Data Policy is to support the objectives of the Global Cryosphere Watch, which include the development of CryoNet, data and information delivery on the state of the cryosphere, and the creation of a data portal. The objective of GCW data management is to ensure the security, integrity, accessibility and free exchange of relevant data that support current research and future use of the data. The GCW Data Policy provides initial guidance for meeting this objective. More detailed guidance is provided in separate GCW documents.

Data definition

As used here, “GCW data” includes data from stations and sites operated by the core GCW surface observing network, CryoNet, and data from contributing stations that are not part of CryoNet. All CryoNet data are produced in accordance with the minimum requirements set out for CryoNet stations and sites (see http://globalcryospherewatch.org/cryonet/requirements.html), and with the procedures laid out in the *GCW Best Practices Manual* and *GCW Best Practices Guide*. Contributing stations may not necessarily meet the CryoNet station requirements and may not be

compliant with GCW best practices. This data policy applies to both CryoNet and contributing station data that are available through the GCW Data Portal. All stations are expected to meet GCW requirements by the beginning of the operational phase on 1 January 2020.

Metadata

Metadata are essential to the discovery, access, and effective use of data. Metadata may be defined as all the information necessary for data to be independently understood by users and for ensuring proper stewardship of the data. All GCW observational data and products must be accompanied by metadata that document and describe the data. The metadata must be in a “machine readable” (i.e. digital) form. Regardless of any data access restrictions or delays in delivery of the data itself, operators of GCW CryoNet stations and sites should promptly provide basic descriptive metadata for datasets (WIS metadata) and observations facilities (WIGOS metadata) in an internationally recognized, standard format to the GCW Data Portal. When submitting data to the Data Portal, contributors should adhere to GCW’s best practices for data, as detailed in the following documents:

Guidelines for Data Centres Contributing to GCW

Operational Manual for Data Centres Contributing to GCW

Data availability and exchange

The Global Cryosphere Watch aims to make observational data and ancillary data freely available through its Data Portal, and whenever possible in near real-time. The data management is based on the FAIR Data Principles (Wilkinson et al. (2016). The GCW Data Portal is a web interface that contains information about datasets (metadata), but not the data themselves. Instead, it links to datasets that are stored at partner data centres. It is compatible with the WMO Information Service (WIS). Linkages between the GCW Portal and data partners/providers are illustrated at http://globalcryospherewatch.org/data/data.html

At its Seventeenth Congress in 2015 (Cg-17), WMO agreed on Resolution 60 concerning the WMO policy for the international exchange of data and products to support the Global Framework for Climate Services (GFCS). Resolution 60 noted a number of other resolutions, including Resolution 40 (Cg-XII) on the policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities, and Resolution 25 (Cg-XIII) for the exchange of hydrological data. Resolution 40 adopts the following policy:

As a fundamental principle of the World Meteorological Organization (WMO), and in consonance with the expanding requirements for its scientific and technical expertise, WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products.

The GCW Data Policy will adhere to the above-mentioned resolutions and to the following open-access resolutions passed by international scientific organizations in the past 20 years:

- ICSU 1996 General Assembly Resolution
- ICSU Assessment on Scientific Data and Information
- Article III-1c from the Antarctic Treaty
- Intergovernmental Oceanographic Commission Data Exchange Policy

"Full and open access" is defined by ICSU (2004) as equitable, non-discriminatory access to all data preferably free of cost, but some reasonable cost-recovery is acceptable. WMO Resolution 40 uses the terms "free and unrestricted" and defines these terms as meaning "non discriminatory" and without charge". "Without charge" in the context of this resolution means at no more than the cost of reproduction and delivery without charge for the data and products themselves.

Data preservation

Recognizing that the true value of scientific data is often realized long after they have been collected, it is essential to ensure long-term preservation and sustained access to GCW data. All GCW data must be archived in their simplest, useful form and be accompanied by a complete metadata description (including export of discovery metadata to the GCW Portal). Given that the GCW Data Portal does not store data, long-term preservation of GCW datasets is generally the responsibility of the data providers.

Data acknowledgment/attribution

To recognize the valuable role of data providers (those who collect, prepare, and provide the data) and to facilitate repeatability of experiments in keeping with the scientific method, users of GCW data must formally acknowledge data authors (contributors) and sources. Where possible, this acknowledgment should take the form of a formal citation, such as when citing a book or journal article. GCW encourages data citation according to the principles outlined by DataCite (https://www.datacite.org/), and recommends the form:

Creator (PublicationYear)
Title
Version
Publisher
ResourceType
Identifier
Example:
Doe. J. (2016).
Arctic Sea Ice Extent 1900-2016. Version 1.

My Institute/My Data Centre.

Dataset.

http://www.data.int/mydata-1900-2016.html

[Accessed 2016-11-25]

To simplify this process, GCW recommends that all datasets have a digital object identifier (DOI).

Acknowledgments

Data policy documents created by SCAR, IPY, SVALI, IASC and the ICSU WDS data sharing principles were consulted during preparation of this document (see reference list).

Appendix

To create a framework for sustained in-situ and satellite-based observations of snow, ice and permafrost, GCW has formed partnerships with several international organizations that coordinate monitoring of individual components of Earth´s cryosphere, and with major data centres and distribution networks. Data partners include (in alphabetical order):

AARI	Arctic and Antarctic Research Institute, St. Petersburg, Russia
BAS	British Antarctic Survey, Cambridge, UK
ESA	European Space Agency
CCIN	Canadian Cryosphere Information Network
CryoClim	Norwegian Space Centre (NSC), Oslo, Norway
IASC	International Arctic Science Committee
ICSU	International Council for Science
IPY	International Polar Year
NSIDC	National Snow and Ice Data Center, Boulder, Colorado, USA
SCAR	Scientific Committee on Antarctic Research
SVALI	Stability and Variations of Arctic Land Ice
WDS	World Data System

ANNEX 7: SCAR ACTIVITIES OF INTEREST FOR GCW

Dr Baeseman outlined in her presentation a number of activities of SCAR, which could represent opportunities for engagement for GCW, for accessing additional expertise to contribute to the development of the GCW products, best practices guides.

- Southern Ocean Observing System, soos.aq (SOOS). This program has potential for being included in GCW. SCAR, GCW and CliC published in 2016 a paper on requirements for satellite observations for the Southern Oceans.
- Antarctic Permafrost and Soils (ANTPAS), which is part of GTN-P.
- Snow in Antarctica (SnowAnt), including SnowREADER (Reference Antarctic Data for Environmental Research database) documenting disturbed areas, historic snow profiles, accumulation data from AWS, stake farms, surface radar profiles, shallow firn – snow cores.
- Operational Meteorology in the Antarctic (OpMet), engaged with AntON, and Reference Antarctic Data for Environmental Research (READER).
- Remote Sensing, merging of snow and ice studies with climate research, ice-ocean interaction, and bird/animal monitoring via remote sensing.
- Geodetic Infrastructure of Antarctica (GIANT), overseeing the development of geodetic infrastructure across the Antarctic.
- Antarctic Climate Change and the Environment (ACCE), coordinating research results across SCAR on past and potential future climate change over the Antarctic continent and in the Southern Ocean and is submitted to the Antarctic Treaty Consultative Meetings yearly. There could be opportunity to work together on these and a State of the Cryosphere Summary.
- Antarctic Near-shore and Terrestrial Observing System (ANTOS), establishing an integrated, coordinated transcontinental and trans- regional observations system to track variability and change, both in biota and their environments, establishing Automatic Weather Stations, sample collection, etc with data hosted by KOPRI.
- Co-sponsored SCAR/CliC Antarctic Sea-ice Processes and Climate (ASPeCt), developing Specification of a standard ice observing protocol for sea ice thickness, observations made aboard ships in the Antarctic pack ice; it could contribute significantly to the development of the GCW Best Practices Guide.
- SCAR/IASC/CliC Ice Sheet Mass Balance and Sea Level (ISMASS), promoting research on the estimation of the mass balance of ice sheets and its contribution to sea level;
- Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII), linking modellers and field scientists studying sea-ice biogeochemistry, it includes data inventories, standardized protocols and databases;
- Forum for Research into Ice Shelf Processes (FRISP), focusing on the glaciological, oceanic and atmospheric processes governing the behaviour of ice shelves that are key to the ice sheet contribution to sea level change;
- International Partnership in Ice Core Sciences (IPICS), promoting the maintenance, enhancement and sharing of expertise and capability in ice core drilling, curation, analysis and other technical areas needed to carry out the priority projects.

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ANNEX 8: GEO Cold Region Initiative (GEOCRI)

The GEOCRI Implementation Plan has several tasks relevant to GCW:

- Activity 1.1 Identify and document needs and requirements for cold region Earth observations data and information for all users, both within and outside of cold regions. Make regular updates as needs and requirements change and emerge. Coordinate user requirements with WMO and its Rolling Review of Requirements (RRR) mechanism.
- Activity 1.6 Support GCW in the development and expansion of CryoNet, identifying best practices for observations, sharing open data principles and capacity development activities. Allow for discovery of CryoNet through GCW Data Portal.
- Activity 2.1 Create dialogue between infrastructure networks for collaboration and more efficient use of infrastructures
- 2.2 Advocate and support incorporation of different research infrastructure catalogues on cold regions (e.g. INTERACT, Eu-PolarNet, UArctic).
- 4.6 Promote and advocate the use of coordinated, comprehensive and sustained cold region Earth observations to inform decisions and actions by policy makers, industry, local communities, researchers and others.
- Activity 6.1 Develop and maintain an inventory of existing cold region Earth observations initiatives including organizations, programs, projects, networks and systems, particularly those which are active or have impact internationally and regionally.
- Activity 6.1 Develop and maintain an inventory of existing cold region Earth observations initiatives including organizations, programs, projects, networks and systems, particularly those which are active or have impact internationally and regionally.
- 6.7 Engage with existing observing networks in cold regions, such as GTN-P, GLISN, GLMS, GCW, SIOS, etc. and emerging cold region regional observing networks to contribute to GEOCRI. Promote incorporation of data from these networks to GCI.

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ANNEX 9: Global Terrestrial Network for Permafrost: GTN-P

Boris K. Biskaborn and Hugues Lantuit

1. Background
    a. Context AWI

The Global Terrestrial Network for Permafrost (GTN-P, gtnp.org) is part of the Global Climate Observing System (GCOS) and the World Meteorological Organization (WMO). It was established in 1999 by the International Permafrost Association (IPA) aiming for systematic and long-term documentation of the distribution, variability and trends of permafrost. Permafrost has been identified as an Essential Climate Variable (ECV) by GCOS and GTN-P defined permafrost temperature and active layer thickness as main indicators and developed a Data Management System for these two variables. Funded and coordinated by AWI, the EU project PAGE21 and ESKP, the GTN-P Database was launched in September 2015. The database currently includes about 1300 permafrost temperature boreholes and 250 active layer sites from the terrestrial Arctic, Antarctic and mountain areas (Fig. 1).

Ongoing permafrost degradation associated with rising air temperatures are considered to amplify warming of the atmosphere through the conversion of soil organic carbon that has been frozen for thousands of years, into greenhouse gases (Schuur et al., 2015). The GTN-P scientific community assesses the impact of warming permafrost to the global climate system. Therefore, GTN-P data products are of very high relevance for a broad range of stakeholders from scientific, public and economical sectors.

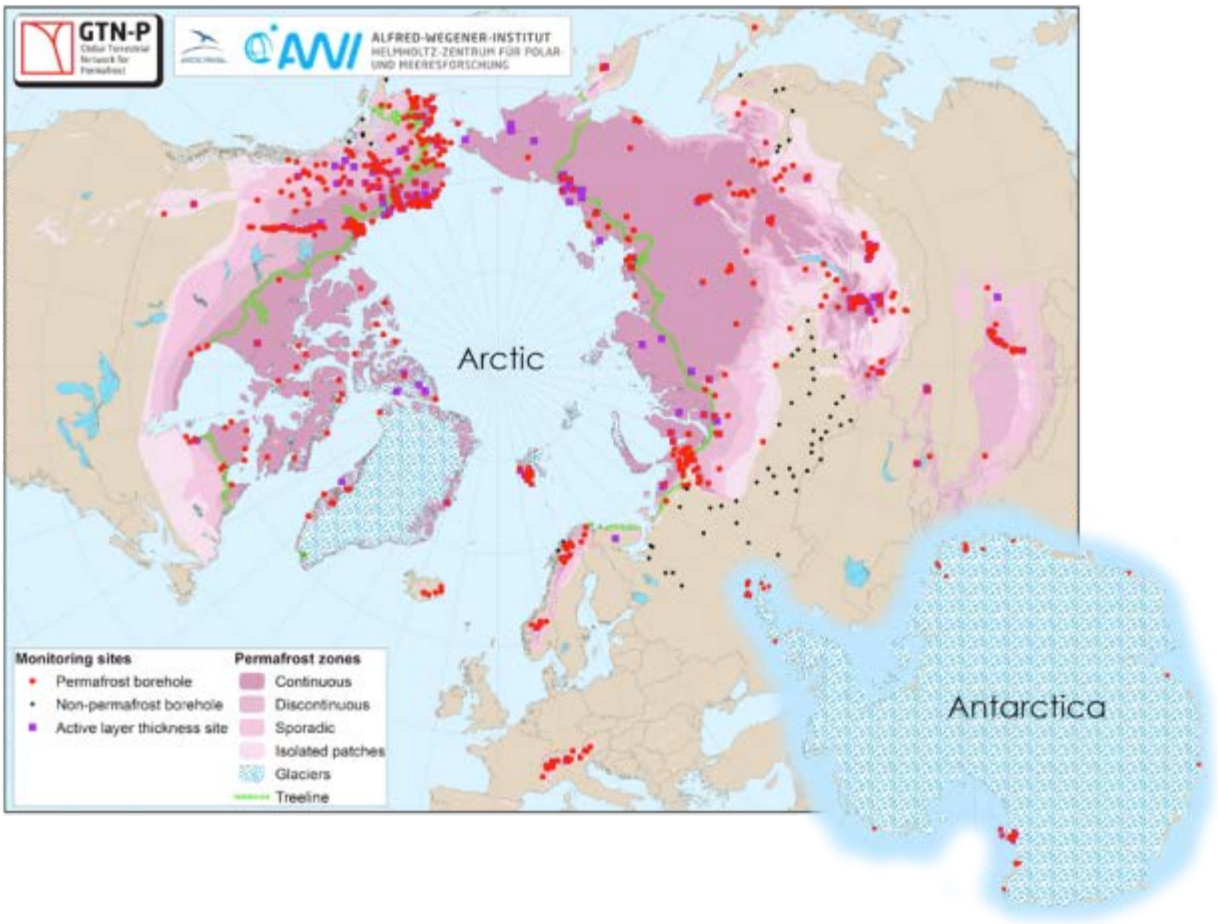

Figure 1. Distribution of boreholes and active layer thickness sites in the GTN-P Database

2. Scope and Motivation

a. Leadership

The GTN-P Secretariat and its executive director are located at the AWI in Potsdam, Germany.

b. Relevant Stakeholders/Target Audience

Hosted by the Arctic Portal, the GTN-P DMS provides a critical link between the researchers involved in field data collection and various end-users, from hard-core climate modelers, to policy makers, to the general public interested in permafrost. Main stakeholders are scientists, public audience, universities, schools and environmental agencies.

3. Material and Methods

a. Project Set-up

The GTN-P Database (GTN-P, 2015) was developed by AWI and the Arctic Portal and is accessible online at the URL http://gtnpdatabase.org or through the GTN-P website at http://gtnp.org. The general framework of the GTN-P Database is based on open source technologies following an object-oriented data model implemented with CakePHP and the spatial version of PostgreSQL. The database structure distinguishes between permafrost temperatures and annual thaw depths. The DMS allows for data-queries, visualization, and the ability to download data in various formats. To ensure interoperability and enable inter-database search, metadata field names are based on a controlled vocabulary registry (gtnp.org, ISSN 2410-2385). GTN-P follows an open-access policy in line with the IPY data policy and the GEO (Group on Earth Observations) data sharing principles.

b. Knowledge Transfer Methods/Formats

The GTN-P products are developed and released by the GTN-P secretariat, and are freely available in harmonized formats (CSV, XML, KML, GIS shapefiles) as well as in network Common Data Form (NetCDF) to facilitate implementation in global models.

4. Activities

The 2nd GTN-P National Correspondents Workshop, supported by AWI, IASC, GCW and the IPA, was visited by 30 participants representing 16 countries, involved either in the GTN-P Steering Committee, the Secretariat, Advisory Board, as National Correspondent or as invited external collaborator (e.g. IASC, IPA, NSIDC and NORDICANA-D). During the workshop the new governance structure and terms of reference were approved. Several keynote talks were given on GTN-P in the modern scientific society. National Correspondents (NC) gave short talks on the state and availability of boreholes and active layer sites in their countries and the needs necessary to facilitate data management for data flow toward GTN-P were identified. The Permafrost Young Research Network (PYRN) was involved to establish “Young National Correspondents” of GTN-P, which actively support data management and participate in scientific reports, meetings, and workshops. GTN-P Database and metadata statistics were published in the journal ESSD (Biskaborn et al., 2015). The policy for the report on permafrost temperature development was planned to establish a mirror of the GTN-P database at research institutes, i.e. in Russia, to facilitate data transfer on national level. The next major GTN-P meeting organized by AWI before the ICOP2016 in Potsdam brought together 50 participants from 20 countries; they discussed the contribution of the GTN-P community to the GCOS Implementation Plan and development of a GTN-P Strategy and Implementation Plan 2020 (SiP2020), outlining network milestones and priorities for the next four years. The conference session “Results from GTN-P: TSP, CALM, and related

environmental datasets and models" was the largest at the conference (with 60 abstracts), highlighting the important role of GTN-P within the international permafrost community.

5. Outlook

GTN-P is preparing the first report on global permafrost temperature change (Fig. 3). Datasets will be provided in standardized and quality checked format to the modeling community. GTN-P is drafting the new GTN-P Strategy and Implementation Plan (2016-2020) including a funding concept to involve stationary data on climate observations and to establish mirrors of the Database at selected research institutes, i.e. in Germany and in Russia for facilitating data management and data input on national level.

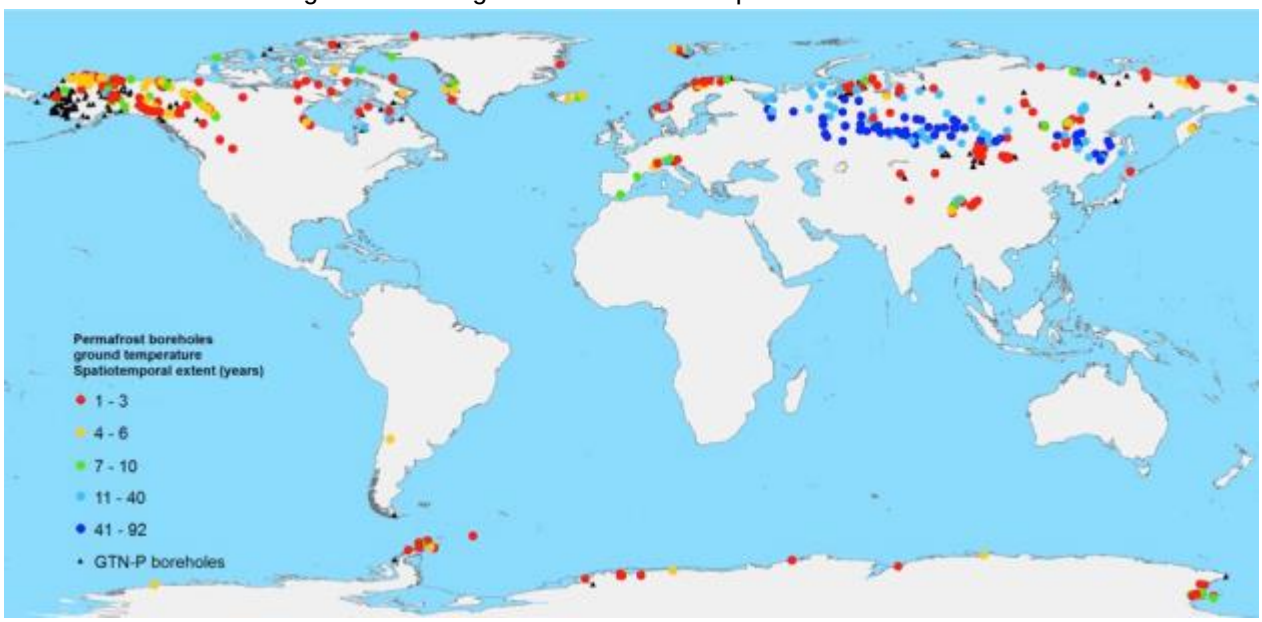

Figure 3. Visualization of the temporal extent of data sets with mean annual ground temperature values in the GTN-P Database. These datasets are currently being quality checked and processed to report on the global temperature change in permafrost.

6. Acknowledgements

GCW, IASC, CAREERI, GCOS, PAGE21, ONR Global, the NSIDC and ESKP Germany were instrumental in supporting the development of GTN-P. We also thank Jean-Pierre Lanckman, Malek Kaderi and Anseok Joo (Arctic Portal), and Almut Dressler and Saskia Bacher (AWI) for data management.

7. References

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ANNEX 10: International Permafrost Association (IPA) updates

The International Permafrost Association (IPA), founded in 1983, has as its objectives to foster the dissemination of knowledge concerning permafrost and to promote cooperation among persons and national or international organizations engaged in scientific investigation and engineering work on permafrost.

Activities in 2016

The 11th International Conference on Permafrost (ICOP 2016) was held 20-24 June 2016 in Potsdam, Germany, with the theme "Exploring Permafrost in a Future Earth." The conference featured 306 oral presentations and 532 accepted posters. The conference was preceded by a workshop organized by the Permafrost Young Researchers Network (PYRN), and was followed by three extended post-conference field trips. ICOP 2016 was one of the largest and most international permafrost conferences in history, building on a strong legacy of previous ICOPs.

The IPA supported four Action Groups in 2016:

- The Yedoma Region – they will produce a map showing the circum-Arctic distribution and thickness of Yedoma deposits. They have already published Yedoma thickness and photo databases online;
- The InterFrost Evaluation Platform – Over 20 participants participated in a comparison of 13 coupled thermo-hydrological codes in order to better match codes to the complex natural systems encountered in cold regions. The first phase of this project has been completed, which included determining the convergence of existing codes and setting baselines for future work in this area.
- Arctic Coastal Web Implementation – This group met at ICOP 2016 and continues to develop their website, which includes the Arctic Coastal Dynamics (ACD) GIS.
- A Frozen-Ground Cartoon – This project aims to present permafrost field research to a broad audience by using thematic comic strips. Two illustrators were selected from 49 applicants to produce the final comic strips; these cartoons were just finished in December 2016 and will be distributed in the coming year.

The Education and Outreach Standing Committee of the IPA has been promoting the use of frost tubes to teach K-12 students about frozen ground, in addition to producing other classroom materials. This committee continues to develop graduate curriculum and coordinate field courses pertaining to permafrost. Outreach efforts are also dedicated to northern and indigenous communities where monitoring systems have been developed.

Major Plans for 2017

The IPA will support two new Action Groups in 2017: The next generation of IPA global permafrost mapping product and service, and Arctic Permafrost Transects. Three previously existing Action Groups will continue their efforts in 2017: Permafrost and Culture, The InterFrost Evaluation Platform, and A Frozen-Ground Cartoon.

The IPA looks forward to the 2nd Asian Conference on Permafrost, Sapporo, Japan, 2-6 July 2017. This meeting will include presentations, day trips, and extended field trips.

Members of the IPA will also be significantly involved in other conferences throughout the year, including Arctic Science Summit Week in April 2017

ANNEX 11: ECMWF statement to GCW/GSG-4

ECMWF will continue its high level of commitment to polar research, which has been initiated with a joint ECMWF-WWRP workshop on polar prediction in 2013:

http://www.ecmwf.int/en/learning/workshops-and-seminars/pastworkshops/ecmwf-wwrp/thorpex-workshop-polar-prediction

(and a QJRMS special issue, Bauer et al. 2014). WWRP's Polar Prediction Project (PPP, http://www.polarprediction.net) has gained significant momentum since then. ECMWF's commitment continues throughout the preparation phase of the Year Of Polar Prediction (YOPP), which will enter its core-phase mid-2017 to mid-2019 and represents one of key deliverables of PPP (Jung et al. 2016).

The research performed in PPP aims at strengthening the European role in monitoring and predicting the state of the cryosphere and its influence on weather and climate at all latitudes. These objectives appear prominently in the newly released ECMWF ten-year strategy 2016-2025 http://www.ecmwf.int/en/about/what-we-do/strategy.

Model, data assimilation and observational representation of the cryosphere have been significantly enhanced operationally in 2016 at ECMWF, through the addition of a dynamic sea-ice model. This upgrade is part of the ensemble forecasting system extending into the monthly forecast range up to day 46 (also contributing to the subseasonal-to-seasonal activities (S2S in WWRP): http://www.ecmwf.int/en/about/media-centre/news/2016/model-upgradebrings-sea-ice-coupling-and-higher-ocean-resolution.

It complements a number of improvements in cryospheric data acquisition, processing, assimilation, and initialization that aim at enhanced consistency and skill of ECMWF forecasts.

ECMWF recommends an active engagement with the modelling community during the YOPP core-phase campaigns to encourage the production of multi-source cryospheric dataset (as recommended already within the SnowWATCH) and the colocation of meteorological data output from the global and regional modelling and analysis systems with the CryoNet sites and stations.

These activities will support data uptake and usage, expand the knowledge achieved in the GCW teams and reinforce the connection across modelling and observations communities. A larger use of meteorological and cryosphere data will provide a more comprehensive understanding of cryospheric changes. The year 2016 has been an extreme example in this context with the annual-mean global surface temperature reaching a warming level of 1.3°C above pre-industrial times as highlighted by the Copernicus Climate Change Services press-release of 5th January 2017.

Similarly, an exceptional reduction in global sea-ice extent has been observed in 2016, encompassing both Arctic and Antarctic, and for this the European Copernicus programme will provide dedicated monitoring via Sentinel satellites:

https://sentinel.esa.int/web/sentinel/thematic-areas/marine-monitoringcontent/-/article/sentinel-1-data-advance-sea-ice-monitoring

Recent sea-ice studies and datasets highlight the robustness of the trends of the marine cryosphere (e.g. Tonboe et al. 2016).

In the period 2017-2020, a European project is being funded in the Horizon-2020 funding framework of the European Commission (APPLICATE, coordinated by AWI).

The project aims at advancing the understanding of the fast-changing cryosphere and its impact on weather and climate, by making use of satellite-based and surface observations to enhance the quality of predictive models http://www.awi.de/nc/en/about-us/service/press/press-release/eu-horizon-2020-project-applicate-kicks-off.html

http://applicate.eu

These research advances are beginning to benefit reanalyses for climate reconstructions (Dee et al. 2014), that will more consistently monitor the state of climate (close to real time), starting with the new ERA5 reanalysis, currently in production and that will be released in stages starting in 2017.

Full engagement of the ECMWF's Member and Cooperating States, via the National Meteorological and Hydrological Services, and of the collaborating Agencies and Institutes will give full support to these ambitious plans, building on a shared knowledge base that has allowed a steady pace of improvement in past decades (e.g. Bauer et al. 2015).

References:

Bauer, P., A. Thorpe, and G. Brunet. 2015: The quiet revolution of numerical weather prediction. Nature 525(7567):47-55.

Bauer, P. and T. Jung, 2014: Editorial for the Quarterly Journal's special issue on Polar Prediction. Quart. J. Roy. Meteor. Soc., 142, 537–538.

Dee, D., M. Balmaseda, G. Balsamo, R. Engelen, A. Simmons, and J. Thépaut, 2014: Toward a Consistent Reanalysis of the Climate System. Bull. Amer. Meteor. Soc., 95, 1235–1248, doi: 10.1175/BAMS-D-13-00043.1.

Jung, T., N. Gordon, P. Bauer, D. Bromwich, M. Chevallier, J. Day, J. Dawson, F. Doblas-Reyes, C. Fairall, H. Goessling, M. Holland, J. Inoue, T. Iversen, S. Klebe, P. Lemke, M.

Losch, A. Makshtas, B. Mills, P. Nurmi, D. Perovich, P. Reid, I. Renfrew, G. Smith, G.Svensson, M. Tolstykh, and Q. Yang, 2016: Advancing Polar Prediction Capabilities on Daily to Seasonal Time Scales. Bull. Amer. Meteor. Soc., 97, 1631–1647, doi: 10.1175/BAMS-D-14-00246.1.

Tonboe, R. T., Eastwood, S., Lavergne, T., Sørensen, A. M., Rathmann, N., Dybkjær, G., Pedersen, L. T., Høyer, J. L., and Kern, S.: The EUMETSAT sea ice concentration climate data record, The Cryosphere, 10, 2275-2290, doi:10.5194/tc-10-2275-2016, 2016.

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ANNEX 12: NEW GCW EXPERTS

GCW EXPERTS APPROVED AT THE 4TH SESSION, GCW STEERING GROUP

WG Observations

- Dr. Annett Bartsch (Austria) proposed by the PR of Austria (expertise: permafrost, remote sensing) for the CryoNet Team
- Dr. Petra Heil (Australia): expertise sea-ice processes; Dr Heil is currently a member of the Best Practices Team, and approved as a member of the CryoNet Team, as proposed by the WG Chair.
- Mr Craig Smith (Canada) as a member of the Best Practices Team

Dr Rainer Prinz proposed by the WG Chair was not endorsed by the PR of Austria. Given his expertise in tropical glaciology, GSG decided to invite him as an expert, in support of the Tropical Climate Cryosphere workshop in Tanzania, in July 2017.

Sea Ice Team

V Smolyanitsky, proposed two new members for the Sea Ice products Team. GSG agreed witht the proposals, pending endorsement by the PR of their countries. These are:

- Nick Hughes, (Norway)
- Petra Heil, (Australia)

Portal Team

In the pre-meeting review of membership, It was noted that Lynn Yarmey, proposed at the 4th session of the CryoNet Team as a member of the Portal Team has changed positions and is no longer member of the Team.

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ANNEX 13: CRYONET Minimum Observing Program

SNOW/SOLID PRECIPITATION	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Snow on the ground (According to WMO code 0975: State of ground with snow or measurable ice cover.)		**M**(S)						
Snow depth (including stake farms and snow courses)	**A**(S, G, SI, LRI)	**M**(S)		**M**(SI, LRI)			**M**(G, IS)	
Snow depth (including stake farms and snow courses)	**A**(IS, P)	**M**(P)		**M**(S)				
Snow water equivalent	**A**(S)			**M**(S)			**M**(G, IS)	
Solid precipitation (Requires both amount and type of precipitation to be measured)	**A**(S)							
Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature)				**M**(S)			**M**(IS)	
Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature)				**M**(SI, LRI)				
Depth of snowfall		**M**(S)						
Water equivalent of snowfall		**M**(S)						

Snow cover extent	**A**(SI, LRI)			**M**(SI, LRI)				
Snow chemistry				**M**(S, IS)				
Snow surface temperature	**A**(S, SI)			**M**(SI)				
Snow temperature	**A**(S)							
Drifting snow	**A**(S)	**M**(S)						
Specific surface area				**M**(S)			**M**(IS)	

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

S: snow, G: glaciers, IS: ice sheets, ISV: ice shelves, P: permafrost, SFG: seasonally frozen ground, SI: sea ice, LRI: lake and river ice

GLACIERS and ICE CAPS	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	seasonal	yearly	multi-year
Surface accumulation (point)	**A**					**M**		
Surface ablation (point)	**A**						**M**	
Surface mass balance (glacier wide)							**M**	
Surface mass balance (point)	**A**						**M**	
Glacier area (glacier wide)								**M**
Surface accumulation (glacier wide)							**M**	

Surface ablation (glacier wide)							**M**	
Basal Ablation (point)	**A**						**M**	
Surface mass balance (glacier wide)							**M**	
Glacier thickness (point)								**M**
Glacier volume (glacier wide)								**M**
Glacial runoff	**A**							
Calving flux (point)							**A / M**	
Ice velocity (point)		**A**					**M**	
Ice/firn temperature profile (point)	**A**							

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

ICE SHEETS	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	seasonal	yearly	multi-year
Surface accumulation (point)		**A**						
Surface ablation (point)		**A**						
Surface mass balance (point)		**A**					**M**	
Ice sheet thickness (point)								**M**
Ice velocity (point)					**A**			

Ice/firn temperature profile (point)	**A**							

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

ICE SHELVES	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	seasonal	yearly	multi-year
Basal Ablation							**A / M**	
Ice velocity		**A**					**M**	

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

ICEBERGS	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Iceberg position			**M**					
Iceberg form, size			**M**					
Concentration (distance) of icebergs			**M**					

Iceberg motion		**A,M**						
Iceberg height (above the sea)		**A,M**						
Iceberg width, length (at waterline)		**A,M**						
Iceberg draft				**A**				
Underwater 3-D form				**A**				

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

PERMAFROST	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Ground temperature	**A**							
Active layer thickness		**A**					**M**	
Rock glacier creep velocity						**M**		
Rock glacier discharge	**M**							
Rock glacier spring temperature	**M**							
seasonal frost heath/subsidence							**M**	
surface elevation change								**M**
ground ice volume							**M**	
coastal retreat							**M**	

soil moisture		**A**			**M**			

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

SEASONALLY FROZEN GROUND	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Ground temperature	**A**							

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

SEA ICE	Recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Sea ice thickness	**A**			**M**				
Sea ice freeboard	**A**			**M**				
Sea ice concentration		**A, M**						
Sea ice class (pack, fast ice)		**M**						

Sea ice type (level/rafted/ridged & floe descriptor)		**M**						
Form of ice (floe size)			**M**					
Stage of ice development			**M**					
Sea ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up)			**A / M**				**M**	
Sea ice stage of melting		**M**						
Sea ice openings (leads, polynyas, cracks)		**A**						
Sea ice velocity	**A**	**M**						
Sea ice deformation (divergence/convergence)	**A**	**M**						
Sea ice ridge height	**A**	**M**						
Sea ice ridge cover (concentration of ice ridges)	**A**	**M**						
Sea ice draft				**M**				
Sea ice salinity profile (vertical)				**M**				
Sea ice stratigraphy				**M**				
Surface temperature (surface-air interface)	**A**							
Sea ice temperature profile (vertical)	**A**			**M**				

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

LAKE ICE	Recommended minimum frequency of observations at CryoNet stations
Variable	**Timescale**

	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Ice thickness	**A**			**M**				
Ice concentration		**A, M**						
Ice class (pack, fast ice)		**M**						
Ice type (level/rafted/ridged & floe descriptor)		**M**						
Form of ice (floe size, fast ice width)			**M**					
Stage of ice development			**M**					
Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up)			**A / M**				**M**	
Ice stage of melting		**M**						
Areal extent of floating/grounded ice			**M**					
Ice surface temperature	**A**							
Ice openings (leads, polynyas, cracks)		**A**						
Ice velocity	**A**	**M**						
Ice deformation (divergence/convergence)	**A**	**M**						
Ice ridge height	**A**	**M**						
Ice ridge cover (concentration of ice ridges)	**A**	**M**						
Ice stratigraphy				**M**				
Ice temperature profile (vertical)	**A**			**M**				

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

RIVER ICE	Recommended minimum frequency of observations at CryoNet stations							
Variable	**Timescale**							
	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Ice thickness	**A**			**M**				
Ice concentration		**A, M**						
Ice class (pack, fast ice)		**M**						
Ice type (level/rafted/ridged & floe descriptor)		**M**						
Form of ice (floe size, fast ice width)			**M**					
Stage of ice development			**M**					
Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up)			**A/M**				**M**	
Ice stage of melting		**M**						
River ice jams and dams		**M**						
Flooding extent caused by jams and dams		**M**						
River icings (aufeis)		**M**						
Maximum level		**M**						
Areal extent of floating/grounded ice			**M**					
Ice surface temperature	**A**							
Ice openings (leads, polynyas, cracks)		**A**						
Ice deformation (divergence/convergence)	**A**	**M**						
Ice ridge height	**A**	**M**						
Ice ridge cover (concentration of ice ridges)	**A**	**M**						

Ice stratigraphy				**M**				
Ice temperature profile (vertical)	**A**			**M**				

Blue shading/fill indicates recommended measurements for CryoNet stations

Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

SURFACE METEOROLOGY	Required/recommended minimum frequency of observations at CryoNet stations							
	Timescale							
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	yearly	multi-year
Air temperature	**A**							
Air humidity	**A**							
Wind speed	**A**							
Wind direction	**A**							
Air pressure	**A**							
Incoming shortwave radiation	**A**							
Reflected shortwave radiation	**A**							
Incoming longwave radiation	**A**							
Outgoing longwave radiation	**A**							
Precipitation	**A**							

Yellow shading/fill indicates required measurements for CryoNet stations

Blue shading/fill indicates recommended measurements for CryoNet stations
Green shading/fill indicates desired measurements for CryoNet stations

A: automatic, M: manual

ANNEX 14: List of acronyms

AA	Application Area
ADC	Arctic Data Committee (SAON)
AHECO	Asia High Elevation Cryosphere Observations project
AMAP	Arctic Monitoring and Assessment Programme
AntON	Antarctic Observing Network
AOS2018	Arctic Observing Summit, 2018
APECS	Association of Polar Early Career Scientists
ASPECT	Antarctic Sea ice Processes and Climate
ATCM	Antarctic Treaty Consultative Meeting
BAS	British Antarctic Survey
BUFR	Binary Universal Form for the Representation of Meteorological Data
CBS	Commission for Basic Systems (WMO)
CCIN	Canadian Cryosphere Information Network
Cg	Congress
CHy	Commission for Hydrology (WMO)
CIMO	Commission for Instruments and Methods of Observation (WMO)
CliC	Climate and Cryosphere project
CMA	China Meteorological Administration
CON	Committee on Observing Networks (SAON)
CONMAP	Continental Margin Mapping
CryoNet	GCW core observing network
DOI	Digital Object Identifier
ECCC	Environment and Climate Change Canada
EC	Executive Council
EC-69	Sixty-Ninth Session of the Executive Council
EC-PHORS	WMO Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services (formerly EC-PORS)
ECMWF	European Centre for Medium-Range Weatehr Forecast
ECV	Essential Climate Variables
EPB	European Polar Board
ESA	European Space Agency
ETSI	Expert Team on Sea Ice (JCOMM)
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FMI	Finnish Meteorological Institute
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System (WMO-IOC-UNEP-ICSU)
GCW	Global Cryosphere Watch
GEO	Group on Earth Observations
GEOCRI	GEO Cold Regions Initiative
GEWEX	Global Energy and Water Cycle Exchanges Project
GOS	Global Observing System
GSG	GCW Steering Group
GTN-P	Global Terrestrial Network - Permafrost
GTS	Global Telecommunications System
HICAP	Himalayan Climate Change Adaptation Programme
HIMAP	Hindu Kush Himalayan Monitoring and Assessment Programme
HKH	Hindu Kush Himalayan region
HYCOS	Hydrological Cycle Observing System
IACS	International Association of Cryospheric Sciences
IASC	International Arctic Science Committee
ICG-WIGOS	Inter-Commission Coordination Group on WIGOS
ICIMOD	International Centre for Integrated Mountain Development
ICSU	International Council for Science
IGOS	Integrated Global Observing System-Cryosphere Theme
IHP	International Hydrological Program (of UNESCO)

IICWG	International Ice Charting Working Group
INARCH	International Network for Alpine Research Catchment Hydrology
INTAROS	International Arctic Observation System
INTERACT	International Network for Terrestrial Research and Monitoring in the Arctic
IOC	Intergovernmental Oceanographic Commission (UNESCO)
IOS	Integrated Observing Systems
IPA	International Permafrost Association
IPET OSDE	Inter Programme Expert Team on Observing System Design and Evolution
ISSC	International Social Science Council
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
MetNo	Norwegian Meteorological Institute
MRI	Mountain Research Initiative
NASA	National Aeronautics and Space Administration
NetDCF	Set of software libraries and self-describing, machine independent data formats
NMHS(s)	National Meteorological and Hydrological Service(s)
NOAA	National Oceanographic and Atmospheric Administration
NWP	Numerical Weather Prediction
OpeNDAP	Framework that simplifies all aspects of scientific data networking
OSCAR	Observing System Capability Analysis and Review tool
PCOFs	Polar Regional Outlook Forums
PR	Permanent Representative (of Country with WMO)
PRCC(s)	Polar Regional Climate Centre(s)
PSTG	Polar Space Task Group
RA	Regional Association
RAS	Russian Academy of Science
RRR	Rolling Review of Requirements
SAON	Sustained Arctic Observing Network
SAR	Synthetic Aperture Radar
SCADM	Standing Committee on Antarctic Data Management
SCAGI	Standing Committee on Antarctic Geographic Information
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Ocean Research
SnowPEX	Snow Product Intercomparison Exercise
SOOS	Southern Ocean Observing System
SPICE	Solid Precipitation Intercomparison Experiment
SWIPA	Snow, Water, Ice, Permafrost in the Arctic
ToR	Terms of Reference
TT-WMD	Task Team on WIGOS Metadata
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCRP	World Climate Research Programme (WMO-IOC-ICSU)
WGMS	World Glacier Monitoring Service
WIGOS	WMO Integrated Global Observing System
WDQMS	WIGOS Data Quality Management System
WIS	WMO Information System
WMO	World Meteorological Organization
WWRP	World Weather Research Programme (WMO)
WWW	World Weather Watch
YOPP	Year of Polar Prediction