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**GCW STEERING GROUP**

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**Group Photo**

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# Executive Summary

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# meeting Report

**1. ORGANIZATION OF THE MEETING**

**1.1 Welcome and Opening of the meeting**

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

1.1.2 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, BAS, also welcomed the participants highlighting the importance of cryosphere observation, research and services.

1.1.3 Mr Etienne Charpentier, on behalf of the Secretary General of WMO, Dr Petteri Taalas, thanking 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.

The list of participants is provided in [Annex 2](#Annex2).

**1.2 Adoption of the Agenda**

The Provisional Agenda, as provided in [Annex 1](#Annex1) was adopted by the meeting.

**1.3 Working Arrangements**

1.3.1 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 have contributed to the documentation plan.

**1.4 Introductions of participants**

The chair of the GCW Steering Group (GSG) invited the participants to introduce themselves.

**1.5 Meeting priorities**

1.5.1 The GSG Chair outlined the meeting priorities, focusing on the results of the GCW working groups since the 3rd session of the Steering Group GSG meeting, December 2015, the interaction with partners, the definition of priorities for 2017, as well as a review of the role of the GSG and the structure of the GCW, with the view of facilitating the operationalization of the GCW by 2020. The Chair requested the participants to identify those items that require the review and endorsement of the EC-PHORS, and submission to the Executive Council, for decision.

1.5.2 During the proceeding S Barrell recommended that the GSG develops of a GCW communication plan, as well as key performance/success indicators to measure the results and impact of GCW, given the GCW engagements with organizations outside WMO. The meeting addressed these proposals with appropriate actions, as recorded in this report.

1.5.3 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)

2.1.1 The participants recalled the definition of the GCW surface observing network. At the proposal of the GSG Co-Chair, the GSG agreed that existing operational networks that are providing observations of various cryosphere components, e.g. synoptic, climate, agrometeorological networks, with data already exchanged via the GTS, to be included in the GCW Surface Observing Network, as contributing networks. This reflects the definition endorsed at the 3rd session of the GSG, that *“GCW surface observing network”, is comprised of CryoNet and contributing stations, as a tiered network.*

Dr Goodison asked the Steering Group to consider further updating the definition of the GCW observing system to reflect its space component of the in the definition. [**Action]**

2.1.2 The participants noted that the Manual on the WMO Integrated GlobalObserving System, Annex VIII to the Technical Regulations, Chapter 8. ATTRIBUTES SPECIFIC TO THE OBSERVING COMPONENT OF THE GLOBAL CRYOSPHERIC WATCH, as updated in 2016, includes the definitions of the elements of the GCW Observing system**[[1]](#footnote-1)**.

**2.2 Observations Working Group Progress and Results**

The progress, results, and work plans relevant to the activities of the CryoNet Team, since the 3rd session of the GSG was summarized by the Team Lead, W Schöner.

**2.2.1 Minimum Observing Requirements for the CryoNet Program**

2.2.1.1. W Schöner requested the approval of the GCW Steering Group on the recommendations of the CryoNet team (Annex 13), following its 5th meeting, Graz, Austria on the minimum observing program for CryoNet stations/sites. This consists of recommended, desired, and required variables for each cryosphere component. It was agreed that the lists are not exclusive and would evolve, as new applications and requirements are identified and incorporated (e.g. for sea ice: the break up events, ice sheet front, ice stresses in the ice shelf, surface melting, currently measured by satellite). The minimum observation programme for the CryoNet was approved by the GSG and is provided in Annex 13.  **[decision]**

2.2.1.2 The GCW Steering Group approved the lists of variables 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 Chair, A Snorrason, requested that the CryoNet Team consult more broadly on the recommended list of variables to gather broader support, while recognizing that the risk of divergent feedback**. [decision, action]**

2.2.1.3 The participants endorsed the combining of the river ice and lake ice recommended variables lists. One area of further clarification is whether the lake size needs to be tracked, and whether there is a threshold for monitoring. Currently there are no stations proposed for CryoNet covering rives and lake ice observations, and further review will not impact network decisions.

2.2.1.4 C Scott recommended separating shore sea ice and fast sea ice. The GSG recognized the value of separating the sea ice variables by location, however, it decided to maintain a simple approach, and not to pursue the proposal. Dr Badhe recommended the monitoring of white ice, as a future consideration.

2.2.1.5 The variables for river and lake ice, as consolidated during the meeting will be further discussed with experts, as recommended by GSG. Experts to be involved are Tom Graziano, Director of the Office of Water Prediction (OWP), NOAA, from Canada Claude Duguay (lake ice) and Terry Prowse (river ice) and from Russia (names to be provided by V Smolyanitsky). **[action]**

2.2.1.6 The recommended variables are included in Annex 13 of this report.

As recommended by the CryoNet Team at its 5th session, measurements and observations are done at stations, only, not sites. CryoNet sites are aggregates of minimum two stations, with at least one is a CryoNet station.

2.2.1.7 W Schöner noted that the requirement for specific meteorological variables reported from the CryoNet stations (air temperature, humidity, wind speed and direction) was introduced to support the derivation of advanced products, e.g. energy balances.

2.2.1.8 B Goodison noted that the observation of atmospheric pressure is currently affordable and could be a significant contribution from the GCW observing network for other applications, and NWP in particular for stations reporting from data sparse regions. He proposed that the variable “atmospheric pressure” be deemed as a (highly) recommended meteorological variable. The GSG fully supported the proposal and the change is reflected in the list of variables included in this report. **[action]** The participants agreed that, while the precipitation type identification is still a challenge, it’s important to retain the requirement, as it could drive the vision of WIGOS in the future, for example the evolution of technology could make it possible in the future.

2.2.1.9 G Balsamo suggested to the CryoNet team actively encourage the stations included in the GCW observing network to install, where possible, additional observations which could support other products and applications, e.g. time series of observations.

2.2.1.10 The discussions on the recommended observing program for the CryoNet stations highlighted the need for further clarification and it was agreed that this will be best provided in the Best Practices Guide. The Co-Leads of the Best Practices Team were asked to include in the Guide additional clarification on:

* recommendations on how to achieve the goal of reporting precipitation type [**action**].
* clarification on whether Frequency refers to “Frequency of measurement” or “Frequency of reporting”, noting that near real time reporting is recommended, where possible, being important if used for satellite validation [**action**].
* where the data is reported daily, the time of reporting should be specified in the Best Practices guide [**action].**
* For permafrost variables, include recommendations on daily measurement of ground temperature, at the minimum. **[action]** For mountain permafrost, the frequency of measurements is needed hourly.

2.2.1.11 It was agreed that the discussion on variables is relevant in the context of the RRR efforts of the WMO. The list of variables will be used for developing the requirements, being relevant for the data/metadata exchange. W Schöner agreed to coordinate with the Terminology Team to ensure consistency, while recognizing that from a practical point of view the scientific and operational communities could have different perspectives on the same terms. **[action**]

2.2.1.12 Ø Godøy noted the need for the harmonization of the terminology and definitions, including from the perspective of the data exchange, thus the variables proposed must be cross referenced with OSCAR.

**2.2.2 Consolidation of variable terminology OSCAR - CRYONET**

2.2.2.1 In the context of the Commission for Basic Systems (CBS) Inter Programme Expert Team on Observing System Design and Evolution (IPET OSDE) the GCW experts compiled and updated the comparative list of cryosphere variables from OSCAR, the Integrated Global Observing System-Cryosphere Theme (IGOS), and the minimum observing program for the CryoNet stations. M Citterio updated the compilation and noted several differences. He highlighted the need to update OSCAR, to reflect the minimum observing program defined for the CryoNet Stations. The group agreed that the reconciliation of variables is done with high priority and updates are requested in OSCAR. **[action].** Additionally, he indicated that the update of OSCAR could take place only once applications supported by the additional variables are identified, including their respective requirements, e.g. cryosphere monitoring and applications/services. **[action]**

2.2.2.3 It was noted that the IGOS was developed in 2007, prior to WIGOS, and it primarily reflects satellite observational capabilities and requirements at the time. It was recognized that the document remains a key reference, however differences between the surface observing program of GCW and the recommendations of the IGOS are to be expected. To enable data exchange, OSCAR and CryoNet observing program variables need to be aligned, acknowledging the differences from IGOS. It was also noted that the observational user requirements recorded in OSCAR are technology free for the fourteen Application Areas, and do not therefore address how realistically these can be met using space-based and surface-based observing systems. It is by comparing the technology free user requirements with the observing systems capabilities, and by mean of impact studies and expert assessment that the Application Areas Points of Contact and the IPET-OSDE are able to identify gaps (Statements of Guidance) and to provide guidance to Members with regard to how the gaps can be addressed, taking into account long-term vision, WMO priorities, and cost-effectiveness of specific observing systems. Independent sets of observational user requirements are also recorded in OSCAR for each of the 14 Application Areas. GCW is therefore invited to identify the sub-applications for which independent sets of user requirements could be developed **[action]**.

2.2.2.3 S Barrell committed to support the work of GCW experts in cooperation with the IPET OSDE, by bringing to the management group meeting new application areas identified in this process, and request approval. It is important that GCW makes the case for new applications and the associated independent requirements to support them. **[action]**

**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, as contributions to the GCW observing network. The assessment has been slower as the process was fine-tuned in 2016, including at the 5th session of the CryoNet Team, in September. This required additional interactions with the proponents for providing clarification and for obtaining additional information, e.g. clarifying the differences between stations and sites, obtaining information on the availability of meteorological observations.

2.2.3.2 Given the challenges encountered, the assessment of submissions received in 2016 will be completed by mid-February 2017, for submission to EC-PHORS, in the view of being recommended for approval by the Executive Council, EC-69, in May 2017. The GSG agreed with the proposed time table and has asked W Schöner to ensure that the submission to EC-PHORS is fully reviewed and accepted by the GSG. W Schöner and the Secretariat will acquire the outstanding information, as needed. Should information not be available to complete the evaluation by the set date, the proposals will be retained as pending, and the evaluation will be completed during 2017.

2.2.3.3 As recommended by the CryoNet Team following its 5th session, the GSG was asked to approve two changes to the assessment process.

* First, the process was amended to remove the requirement for an agreement between the proponent organization and the National Hydro-meteorological Services (NHMS) of the respective country.
* The second change restated that each station needs to be endorsed by the PR of the country where the station is operated. When a proponent 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 operating in Antarctica, the stations should be endorsed by the PR of the country of the organization proposing the station.

2.2.3.4 The GSG approved the proposed changes and asked J Key to update the GCW website to reflect the revised procedure **[decision; action].**  The revised evaluation process is provided in Annex 4 of this report.

2.2.3.5 The participants agreed that being part of the GCW observing network gives increased visibility, stronger arguments for funding proposals, broader accessibility to the station data. Dr Key also noted that the process requires a yearly review of the compliance to the GCW criteria.

2.2.3.6 The need for monitoring the performance of stations and the availability and the quality of data was reiterated by B Goodison. 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 increased visibility for the participants to the GCW observing network, as is currently the case in China. This is to be considered in the development of GCW products **[action].**

2.2.3.7 The participants agreed the stations information, as it evolves over time has value and should be tracked. Dr Key was asked to explore the potential for implementation of an archive function of the submission database, to ensure the archival of information over time. **[action]**

2.2.3.8 The participants agreed that more needs to be done to address the currently available gaps in the CryoNet network, with a focus on North America, Antarctica, and the marine environment. **[action]**

2.2.3.9 Dr Schöner indicated that several submissions received in 2016 are for mobile/ship based platforms. Their assessment is currently on hold until a specific assessment procedure is developed. Recognizing that 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.”,* additional guidance must be developed on how to assess the mobile observing platforms, recognizing that there could operate intermittently and that their location is not fixed. At the same time, the participants agreed that the GCW Observing Network must include ocean/sea observations. The group 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 and opportunity for Members and partner organizations to commit to GCW requirements, and that such an opportunity should not be missed because of too stringent requirements that could be enforced for mobile stations (e.g. ships do not make continuous measurements but may be operated on a sustained basis in a given region and with strong commitment from a Member).

The GSG tasked Dr Smolyanitsky and the CryoNet Team to develop a policy regarding the evaluation of the observing systems on ships and buoys (mobile platforms), considering the issues of sustainability and continuity of observations, and present it for approval by the EC PHORS. **[action]**

2.2.3.10 Dr Schöner noted that in 2015 one of the stations approved on a trial basis as a CryoNet station, Vuriloches, was closed because of precarious conditions, and he proposed that the site is maintained in the GCW database as a GCW contributing station. The GSG approved the proposal **[decision].**

In the context of the evolution of station configuration, Dr Goodison requested that the CryoNet Team develops an approach for approving and tracking of changes to stations included in the GCW observing network. **[action]**

2.2.3.11 As the GCW surface observing network is one of the four components of WIGOS, which reports to CBS and CIMO, and CBS approves the regulatory material, the process applicable for the WIGOS regulatory material needs to be applied for the GCW materials. This was also discussed and agreed at the recent ICG-WIGOS meeting, Jan 12-14, 2017 (Inter-Commission Coordination Group of the WMO Integrated Observing System).

2.2.3.12 GCW was strongly encouraged by H Lantuit to explore ties with the International Network for Terrestrial Research and Monitoring in the Arctic (INTERACT) <http://www.eu-interact.org/>. He noted that INTERACT promotes a culture of innovation and there is an opportunity to aligning the data management, the development and use of observing standards and best practices. Dr Badhe noted that the European Polar Board [EPB] is working with INTERACT, for developing a database of Antarctic facilities similar to the inventory of Arctic facilities. **[action]**

2.2.3.13 It was noted that in the current assessment procedure, new applications should be examined first by the WMO Secretariat for completeness. With the strengthening of capacity supporting the GCW, the participants agreed that future submissions should be reviewed by the Secretariat first, ensuring the availability of all information needed for evaluation, consistently, before inviting the CryoNet Team experts to assess the compliance to CryoNet criteria. **[action]**

**2.2.4 GCW Station ID**

2.2.4.1 S Barrell clarified that a station is the WIGOS unit associated with the metadata. Station ID and station metadata are the most critical to WIGOS. The GCW cluster of stations, named sites, are outside the WIGOS structure and that the newly proposed WIGOS stations IDs could only be allocated to stations and not for sites. As the observing component of GCW is part of WIGOS, the GCW ID requirements will need to be aligned with the WIGOS ID strategies.

At the same time, Dr Barrell noted that the new WIGOS station IDs will allow for any stations to be associated with one or more networks or programs. Given the fact that the GCW stations are often operated by other organizations, these organizations require the GCW support in obtaining the required WIGOS ID.

2.2.4.2 The procedure for the allocation of WIGOS IDs is under development, currently a station ID is allocation by a country’s Permanent Representative (PR), the WMO Secretary General (SG).

The GSG Chair asked the Secretariat to follow-up and provide details to the GCW Experts on the definition and use of WIGOS ID for GCW stations, for inclusion in the GCW Best Practices Guide. **[action**]

2.2.4.3 It was noted that the majority of proponents of stations for the CryoNet network are not Met Services. The CryoNet Team Lead requested that a resolution is proposed to ask NMHSs to provide support to their national organizations in contributing to the GCW Observing Network, with the implementation of recommended formatting of data and metadata, and allow their distribution in [near] real time, though the GTS/WIS (for data), and to OSCAR/Surface (for instrument/platform metadata).

**2.2.5 Best Practices Progress Report**

2.2.5.1 The progress, results, and work plans relevant to the activities of the Best Practices Team, since the 3rd session of the GSG was reviewed based on the information provided by the Co-Leads of the Team, C Fierz and Þ Þorsteinsson, specifically 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 specific session organized on January 20, 2017, following the conclusion of the GSG meeting.

2.2.5.1 C Fierz noted that following the 1st session of the Best Practices Team the progress has been slower than planned, noting the difficulties in engage experts who could dedicate time for developing contributions for the Guide and the Manual. He noted the positive development with the engagement of Mr Craig Smith from Environment and Climate Change Canada who will contribute to the development of the Snow chapter for the GCW Best Practices Guide and Manual. As agreed, Mr Smith will collaborate with the HarmoSnow and CIMO, also focusing on bringing together the existing guidelines on the measurements of snow.

2.2.5.3 T Thorsteinsson noted the potential engagement of Liss Marie Andreassen who could contribute to the development of the chapter on Glaciers. He also noted the plan of the Islandic Meteorological Office (IMO) to hire a student to support the development 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.

**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. The summary is available in Annex 5.

2.3.1.2 The Snow Watch Team highlights include improving the real time reporting of snow depths, 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 remote sensing of snow. Following Snow Watch recommendation, ESA initiated (and funded) 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 Some of the planned activities are the recommendations regarding the development of the GCW website content (assessments, authoritative information), involvement of experts from outside North America and Europe, the development of stronger linkages with the other GCW activities such as CryoNet. It was also noted that the visibility of the GCW Snow Watch activities and interactions could be strengthened at national levels. Of these, the contribution to the development of GCW website content on Snow products was seen as a priority, and the need for resources was highlighted.

2.3.1.4 R Brown thanked CMA for providing 212 additional snow datasets for the snow data inventory of GCW. J Wang was invited to work with the Snow Watch Team to identify whether more data is possible to be made available**. [action]**

2.3.1.5 R Brown highlighted the need to include the reporting of snow depth in OSCAR and the need to investigate the RT exchange of SoG SWE data on WIS. **[action]**

2.3.1.6 In the WMO Rolling Review of Requirements framework, the Secretariat invited the GCW to consider identifying GCW Application Areas for which sets of observational user requirements independent (defined quantitatively in terms of space and time resolution, uncertainty, timeliness and stability) from the other existing Applications Areas could be defined **[action]**. Once/if new GCW Application Areas are defined, the GCW shall then work at nominating a focal point for each of those, responsible for coordinating with his/her user community for developing sets of observational user requirements to be recorded in OSCAR/Requirements, and conducting gap analysis (i.e. Statements of Guidance) **[action]**.

2.3.1.7 The need for new products was emphasised, in particular in the context of the engagement with PRCC are sea ice trackers (e.g. September sea ice), SWE, snow cover extent. These could be indicators that GCW would propose as GCOS climate indicators. The success of the snow anomaly trackers produced by the FMI and ECCC, was noted. Currently, these are produced from archived data. It was recommended that similar products using real time data would be beneficial. Dr Balsamo recommended that the outliers are included in the product display. B Goodison noted the need for polar stereographic projections.

2.3.1.8 The participants agreed that the GCW Best Practices Guide needs to work with the Snow Watch Team to include guidance on the products made available by GCW (taking an end to end approach**). [action]**

2.3.1.9 M. Drinkwater pointed out 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 activity has been extremely valuable in bringing the international community together to establish standards and protocols (QA4EO:<https://earth.esa.int/web/sppa/activities/qa4eo/snowpex>) such that the respective snow algorithms could be intercompared. 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 result in differences between the products.

The GSG agreed with the proposal from M Drinkwater that GCW maintains or links to the documentation from the SnowPEx study, so that the results may be exposed to the wider GCW community on how such a product intercomparison can be made, and they will be used as basis for Best Practices for satellite observations, including the feedback about the quality of the results obtained from this project.

2.3.1.10 Noting the success of the SnowPex project, B Goodison invited the participants to consider which future missions would further the cryosphere science needs. These are questions from the satellite community, e.g. EUMETSAT, and invited the Snow Watch Team to include this in their work plan **[action]**

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.

2.3.1.11 R Brown noted that whilst there are many refinements that can be made to the various algorithms used on existing single satellite data or with developments in multi-sensor or synergistic snow products (i.e. space + in-situ), from a requirements perspective the snow community recognises an important gap in an 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.

2.3.1.12 M Drinkwater invited the participants to consider the criteria that would qualify a CryoNet station as a station for satellite validation., and recommended that the GCW teams are engaged with the Polar Space Task Group (PSTG) to develop the observing requirements for validation. He also recommended that GCW considers the preparation of a paper for the journal *Nature* as the only way to elevate the call for a new set of capabilities**. [action]**

**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 the 3rd session of the GSG was reviewed based on the summary provided by the Team Lead, Ø Godøy.

2.4.1.2 Ø Godøy noted several areas of progress. Specifically, the successful interoperability development with SLF-Davos, a new link was established with the Canadian Cryosphere Information Network (CCIN), although manual supervision of harvested data still needed, which is a challenge. CCIN does not have resources to implement the recommended WIGOS vocabulary. Support to CCIN to adopt the GCW recommended vocabulary would greatly improve the efficiency of the exchange. Also, work is under way to link with the Data Center of the Environment and Climate Change Canada (ECCC) and Pangea, which has archived data. A dialog will be initiated with the Global Terrestrial Network on Permafrost (GTN-P), which has metadata and data available.

2.4.1.3 Ø Godøy informed that the development of the interoperability guidelines are progressing, after being modified following discussions with research stations. A key goal is restricting the number of interfaces. He noted the differences between the research and operational communities regarding data policies, enforcement versus pragmatism, platforms for collaboration, resources.

2.4.1.4 Ø Godøy noted that the metadata exchange is working quite well, with the exception of the consistent use of terminology. The data exchange is more challenging; there are protocols, but the formats, semantics, and data models are still a challenge. As demonstrated during the test on data exchange from Davos CryoNet site, the proponent organizations need to invest in changes to their data and file formats. This is a challenge that needs to be addressed, if data is expected to be exchanged. The Davos solution may be released for other CryoNet stations.

2.4.1.5 The WIS metadata is supported by the GCW Data Portal; it complies with the recommendations of the Federal Geographic Data Committee (FGDC) for digital geospatial metadata and the provisions of the ISO 19115, which defines the schema required for describing geographic information and services by means of metadata. The Data Portal is also looking at Open Search.

Currently, the WIGOS metadata is not supported in the GCW Data Portal, but editor, version controlled repository functionality and OAI-PMH for exchange is available and configurable for WMDS. Efforts are being made to integrate WIGOS metadata and the GCW data portal.

2.4.1.6 Of high priority is the need for WIS/WIGOS interaction, GCW participating in the Task Team on WIGOS Metadata (TT-WMD), testing the transformation of CryoNet information to WDMS XML, discussion the exchange of information, the review of vocabulary, and assess how to create a cost-efficient system/approach. The WIGOS Metadata Task Team plans to wrap up the consultations by March 2017, after which further changes will be very difficult to implement. For that reason, the review of the WIGOS Metadata vocabulary is conducted as a matter of priority by the Observation WG, and feedback is provided to the TT-WMD. **[action]** This needs to includethe variable which are relevant to GCW but not available, currently, in the WIGOS vocabulary.

2.4.1.7 While WMO uses the BUFR format for data exchange, the research communities in GCW, not familiar with BUFR and do not have the means or the interest to adopt BUFR. Alternative means for data exchange are needed, which would have a broader use and acceptance. Ø Godøy suggested the use of NetCDF/CF and OpeNDAP where possible, which allow for computer readable data exchange. He also noted that ideally it should be NetCDF with some BUFR thinking behind.

2.4.1.8 G Balsamo indicated that the NetCDF is widely used for the 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 Dr Godøy. **[action]**

2.4.1.9 Ø Godøy recommended the traceability of data using Digital Object Identifier (DOI) through the GCW, this enables the citation for the use of the data (e.g. GTN-P through PANGEA).

2.4.1.10 Ø Godøy requested that the GSG considers how the review of the controlled vocabulary will be conducted at national level, for the organizations outside the NMHSs, as the NMHSs will likely not provide the GCW focused needs. **[action]**

2.4.1.11 With the development of the GCW Data Portal, a decision will be required on the potential interfaces GCW-OSCAR, i.e. GCW to harvest OSCAR, OSCAR to harvest GCW, or a combination. S Colwell noted the advantage of having all data in OSCAR. There is a web interface readily available, and could implement interface to harvest metadata from OSCAR. Dr Fierz noted that the use of OSCAR is nor common among researchers and agreed with Ø Godøy that the metadata should be harvested from questionnaires, as much as possible, to avoid the duplication of work. **[action]**

S Barrell note that the Surface component of OSCAR surface will be improved and is critical that a GCW expert is part of the team working on OSCAR development. **[action]**

2.4.1.12 Ø Godøy noted the significant level of effort required for developing the interoperability with the Data Centers. Currently at the Norwegian Meteorological Institute (MetNo) there are 5 people who support the Data Portal development supporting several projects, GCW included. He recommended that increased coordination would be needed to ensure that work is not duplicated or repeated. A meeting of the GCW Data Portal team is recommended, at least as a working meeting focusing on coordinated development. **[action]**

2.4.1.13 Dr Baeseman strongly recommended the linking of the data center of the Australian Antarctic Division with the GCW Data Portal, and will provide a link to the Antarctic data. **[action]**

**2.4.2 GCW Website and Outreach Team**

2.4.2.1 The progress and results of the GCW Website and Outreach Team since the 3rd session of the GSG was reviewed by the Team Lead, J Key, noting significant modifications to the station/site questionnaire and database, improvements to the dynamic pages that display station/site information, the addition of assessments for all cryosphere components and the atmosphere for 2015, posting of CryoNet recommended variables lists, the development of new sea ice trackers from JAXA and NOAA/CIMSS, including ice extent, ice thickness, surface temperature, and surface albedo, and the addition of new products such as Cryosat and SMOS ice thickness plots (not trackers), as well as 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)](http://globalcryospherewatch.org/outreach/materials.html%29). These would need to be used for future events, e.g. EC-PHORS, a side event at the EC-69. **[action]** It was recommended that the Secretariat engage the WMO Media Department to revise and improve the GCW handouts and other outreach material.

2.4.2.3 J Key noted the need for developing and publishing website assessments on the various components of the cryosphere at least annually, thereby addressing the mission statement of GCW to provide authoritative information on the state of the cryosphere. These are critical in demonstrating the value of GCW. A list of assessments should be identified and appropriate resources need to be engaged for development (dedicated, resources, through partners). To date, J Key supported a young scientist who wrote short assessments of glaciers, ice sheets, permafrost, and sea ice, but more needs to be done. 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 assessment if done robustly. M Drinkwater noted that the GCW website should be the access point for authoritative products, from GCW and other organizations, with appropriate attribution.

2.4.2.4 For examples of additional products possible, R Brown recommended that individual assessments are made available and published together on a GCW dashboard. The products developed for SWIPA are good examples to follow, where there are two cryosphere components plotted together, thus telling a more comprehensive story. Dr Smolyanitsky recommended the development of regional trackers as products for the GCW website. **[action]**

2.4.2.5 In was recommended that the Global Atmosphere Watch is used as an example for the GCW outreach, noting that GAW published every December the ozone report card. Synergies with GAW should be pursued as they went through a similar development process; learn from them about their communication plan, arguments used for funding stations and on the contribution to public policy, impacts, etc. The Secretariat will connect with the GAW Secretariat and report back to GSG. **[action]**

2.4.2.6 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. **[action]**

2.4.2.7 M Sparrow noted that a paper on GCW will be presented at the Antarctic Treaty Management Committee, in May, and this should include information on the website and its value to the community**. [action]**

2.4.2.8 S Barrell and A Snorrason recommended that GCW aims at using the opportunity of EC-69 and CG-19 to promote and educate the PRs and participants of why is important to invest in the contribution to GCW. They recommended the use of pamphlets and the organization of a side event. Also use other events to distribute information on the GCW progress and benefits. **[action]**

2.4.2.9 The participants were asked to identify how to contribute to the website with products, trackers, and provide input to Secretariat. They agreed that it’s important to use a unified system for representing the results, for easier understanding and use. **[action]**

2.4.2.10 C Xiao recommended that periodically these products are compiled in a published paper or WMO reports, to give more visibility for GCW. **[action]**

2.4.2.11 M Drinkwater noted that ESA has a portal of Climate Change Initiative (<http://cci.esa.int/>) which publishes ECV products and a toolbox to facilitate the combining and analysis of the products and a visualization tool supporting research. The products available include glaciers, Antarctic Ice sheet, ice sheets Greenland, land cover, sea ice, among overs. He recommended building on the information available there.

**2.4.3 Terminology Team**

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

2.4.3.2 In December 2016 a contract was issued to Clemént Hutin, a former WMO intern, for adding new terms from eight additional sources. He included all relevant terms (160) from Swisseduc - Photo glossary of glaciological terms. He digitized and added 148 terms from the Illustrated Glossary of Snow and Ice (1973), and currently working on the American Meteorological Society, Glossary of Meteorology, to be finished by mid/late January. These additions will be available on line following review.

2.4.3.3 B Goodison clarified that the GCW glossary needs to integrate multiple definitions available and develop a GCW definition for each physical parameter, reducing the number of variations for the same parameter. It was recognized that this is a formidable task, and it needs significant resources; WMO tried it in the past. C Fierz noted that the partner communities need to be involved, to get their buy on, to ensure success.

2.4.3.4 H Lantuit commended the efforts to date, noting that the GCW Glossary is a useful tool. He noted that people need to be made aware of it. He also recommended that the site gets a DOI to be citable. Although a compilation of many resources, it has become a resource in itself. **[action]** J Key was encouraged to monitor the access, to show its utility. **[action]**

2.4.3.5 C Xiao shared with the participants the Glossary of Cryosphere Science and English-Chinese dictionary of cryosphere science (Chinese and English) published in print, in China. J Key asked if there were electronic versions that could be linked to the GCW website. C Xiao will provide feedback if approved and when they can be posted. **[action]**

**2.5 GCW Observing System: Data Exchange**

**2.5.1** **GCW Data Policy**

2.5.1.1 T Thorsteinsson presented the proposed GCW Data Policy, developed in consultation with the GCW experts. It will enable the data exchange, giving appropriate recognition to data providers. The proposed policy draws upon existing data policies of other organizations. The participants provided t feedback. Most relevant:

1. the use of Digital Object Identifiers (DOIs) for the data sets available from GCW stations, allowing for the attribution of data ownership.
2. Inclusion of a recommended standard statement to be used as acknowledgement.
3. Inclusion of guidance on the data that is not exchanges in (near) real-time, e.g. allow it to be held for up to two years before being released for open access, (e.g. preparing specific publications). When the data is not released past the agreed term, the association with GCW would be terminated.

The updated version of the GCW Data Policy is included in Annex 6.

**3 GCW DATA AND PRODUCTS**

**3.1 CBS-16 decisions regarding the reporting of snow**

3.1.1 Issue: GCW submitted to CBS-16 the Recommendation 5.8(2)/2 for amending the Manual on the Global Observing System on the International Exchange of Snow Data. By using the verb “shall”, the recommendation was drafted as mandatory for Members to report snow cover and snow depth from all stations where snow is experienced, four times a day, namely 00, 06, 12 and 18 UTC, and to report values of zero snow depth (0 cm) from the above stations when snow is not present, for the entire period during which snow can be expected.

Following interventions from several Members during the session, the recommendation was adopted with the “shall” being replaced with “should”, i.e. the Members would make best efforts to comply, but the requirements are no longer mandatory. The feedback received suggests that Members were willing to report snow depth four times a day, but not all have the capability to do so at all sites; this was confirmed by additional information collected by S Pullen of the Snow Watch Team. The differentiation between manual and automatic measurements was discussed, but not pursued.

There was no indication of Members having any issues with reporting of zero snow depth, however, the change from “shall” to “should” was applied on this recommendation, as well.

3.1.2 As a lesson learned, S Barrell recommended that, in the future, an expert should attend a CBS meeting and Session when 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.

3.1.3 S Pullen of the Snow Watch Team was asked to prepare an amendment in consultation with the other members of the Snow Watch team. [**Action]**

3.1.4 The participants at the meeting assessed the options for amending the text approved by CBS-16, to ensure a broader availability of snow depth/snow cover data. The Chair requested that the draft be presented at EC-PHORS, for support. S Barrell kindly offered to present the revised wording to EC PHORS and on to the EC-69.**[action]**

3.1.5 Dr Goodison noted that the current regulations don’t have snow depth as a requirement or a recommendation at global level. He encouraged the Snow Watch Team to include it as a “should”, which would be, already, a significant step forward. **[action]** He also requested the Secretariat to present the recommendations of CBS-16 at the Regional Association meetings, while stressing on regional requirements and taking into account regional capabilities, as their Members needs to prepare for its implementation, including by 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. **[action]**.

 **3.2 Data Quality and Monitoring**

* + 1. **BAS Data Quality and Monitoring System**

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

3.2.1.2 The level of resources currently at BAS supporting the monitoring function is approximately 10-15% of a person as the tools have been developed and fully functional. Mr Kirsch noted that the switching to BUFR is still causing some problems.

3.2.1.3 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. S Barrell informed the participants about the development of the WIGOS data monitoring system, which will involve regional centers 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.

3.2.1.4 Ø Godøy requested information on harvesting information from the BAS system, and he followed up with P Kirsch during the meeting, on this topic. He also noted that, currently, the monitoring of GCW station is not built in in the GCW Data Portal, but it could be done, given clarity of objectives and resources.

3.2.1.4 The GSG agreed that the operationalization of the GCW must address the quality monitoring of the CryoNet stations, and requested that a strategy is defined in collaboration with WIGOS and presented at the next Steering Group meeting **[action]**. Additionally, the GSG asked the Secretariat (E. Charpentier) to liaise with WIGOS Project Office on the regional WIGOS centers and the role such centres could play with regard to the monitoring of cryospheric data, and report back to GCW. **[action]**

3.2.1.5 J Wang provide an overview of the system used by CMA for monitoring station data availability.

3.2.1.6 P Kirsch informed the participants about the availability of ice core data. Currently, the IceREADER is metadata portal for ice cores, but 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. **[action]**

**3.3 Additional GCW products**

3.3.1 Throughout the meeting discussions, the topic of additional products was explored in the context of the evolution of the Terms of Reference of the Snow Watch Team and the Sea Ice Team, the workplan of the Website and Outreach Team, and during the discussions on the collaboration with partners. Proposals made are included in the respective sections of this report.

3.3.2 H Lantuit recommended that decisions on GCW products and the outreach strategy must be planned within a coordinated, overall, longer term, e.g. 5 years, communication strategy, to remain pragmatic on what is possible. This should articulate with clarity which priorities are most important and will be done well, how much effort could be devoted to which goals, and what will not be done. The products made available need to be of value. GCW should also consider joint products with joint identity.

He also recommended that GCW measures its impact using analytics to track access to its website.

3.3.3 J Baeseman recommended that decisions on products and outreach are carefully taken to ensure that the time and energy are used wisely, to avoid over commitment. She noted other portals displaying related products (e.g. SCAR’s, Antarctic Environmental Portal), used by policy makers, and could be linked to the GCW website.

**3.4 GCW and the Polar Regional Climate Centres (PRCCs)**

3.4.1 A Snorrason provided an overview of initiative of WMO Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services (EC-PHORS) Services Task Team (STT), towards the implementation of an Arctic Polar Regional Climate Centre (PRCC) Network. A meeting in November 2016 led to development of the implementation plan. GCW was represented by A Snorrason. A demonstration phase of the Arctic PRCC-Network will be initiated by the end of 2017. GCW is a key contributor and can facilitate for PRCC the contact with providers and users of cryosphere information and services. The potential GCW contribution would include:

* Measurements from the GCW surface network to the RCC Mandatory and Highly Recommended Functions and useful 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 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 to help review and assess PRCC products relevant to the cryosphere including forecast verification and on initial conditions, and assist on 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, or 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, which aligns with the plan to add solid precipitation products to the Snow Watch Team.

3.4.3 R Brown expressed concerns regarding the current connection with the users, and how the products/trackers developed could be used more effectively, e.g. trackers are effective in identifying anomalies. More needs to be done to build engagement.

3.4.4 C Xiao attended the first WMO Workshop on Operational Climate Prediction, in 2015, in India and noted that China is interested in hosting a workshop on RCC, to further develop the concept of RCC with a focus on cryosphere, e.g. floods. J Wang proposed that a PRCC for high mountain regions to be developed in the context of the RCC Beijing. It will focus on the Asia High Mountain. **[action]**

3.4.5 A Snorrason requested that the GCW Implementation Plan is reviewed to ensure the consistency with the PRCC Implementation Plan **[action]** and asked that each team aligns its work plan to provide support to PRCC goals. **[action]**

**4. GCW IN THE ANTARCTIC**

**4.1 Overview of British Antarctic Survey activities**

4.1.1 Prof David Vaughan, the Director of Science of BAS, presented a summary of BAS activities with relevance to GCW, focusing on the BAS strategy questions for the next 5 years, on polar science for planet earth 2017. These are (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?

4.1.2 BAS is primarily focused on Antarctic research, where it operates 6 stations. More recently, the focus has expanded to include interest on 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. The point of contact for the project is Andrew Orr, anmcr@bas.ac.uk .

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

**4.2 Overview of the Polar View consortium**

4.2.1 Andrew Fleming, Manager of Polar View activities in the Antarctic, which develops and delivers near-real-time sea ice information to users operating in both polar regions, provided an overview of the activities and products of Polar View. 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 Arctic and Antarctic regions. For example mariners need high resolution, up-to-date images of the sea ice coverage ([www.polarview.aq/polar](http://www.polarview.aq/polar)), e.g. sea ice thickness service from Cryosat 2.

4.2.2 A Fleming provided an overview of short term ice products available. It was noted that GCW is interested in being a facilitator on the distribution of products made available by 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 becomes available. [**Action]**

4.2.3 Ø Godøy noted that MetNo already has a hub for Sentinel data, and M Drinkwater noted that all high alpine regions are covered by Sentinel. (CryoLand).

4.2.4 Mr Fleming noted their intent to increase the visibility of PolarView products to a broader range of users. Some options considered are the integration of the PolarIce.eu into Copernicus, and the products being available for assimilation into the ECMWF. Real time planning of future satellite missions be achieved with the engagement of communities.

**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 mission is science leadership, by initiating, developing, and coordinating high quality scientific research in the Antarctic and Southern Ocean region, and scientific advice, by providing objective and independent scientific advice to the Antarctic treaty System and other bodies, such the IPCC. One of key goals of SCAR is the development of scientific capacity in its Members, including students and early career scientists, and supporting countries with small Antarctic program, as the role of social sciences in rapidly growing, which is demonstrated by the planned merger between International Council for Science (ICSU) and the International Social Science Council (ISSC).

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

Examples of SCAR’s projects 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 in the following ways:

* GCW, SCAR and CliC co-organize an Antarctic Observing Activities Workshop for exploring opportunities to enhance available observations by building on existing platforms.
* Seek to influence the new generation of Icebreakers, by providing standardized observing equipment and observing requirements for the newly built ships to ensure that required data is available.
* Further develop AntON through engagements with COMNAP/EU-PolarNet.
* SCAR Group Measuring Essential Climate Variables in Sea Ice methodological intercalibration experiments in sea ice to obtain reliable measurements of basic variables.

4.3.4 M Drinkwater noted that the Southern Ocean requirements have been published and these could be used to communicate needs to ship builders.

**4.4 GCW in the context of JCOMM**

4.4.1 The GSG agreed to pursue a formal relationship with JCOMM by coordinating the activities of GCW Sea Ice Team and the Expert Team on Sea Ice (ETSI) of JCOMM (Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology). Additionally, coordination with the International Ice Charting Working Group (IICWG), is strongly recommended. This will ensure a better governance and the realization of common goals.

4.4.2. B Goodison, the GSG Vice-Chair, requested through the JCOMM co-President, Johan Stander, and the JCOMM Management Committee that the JCOMM re-establishes at JCOMM-5 (2017) the ETSI, as a joint team between 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. Dr 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 EC-PHORS. **[action]**

4.4.3 The group 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 prepare a proposal to be included in the submission to the Task Team meeting scheduled for March 2017**. [action]**

4.4.4 The group agreed that GCW should actively work with JCOMM for recruiting observing platforms for the GCW observing network, to address a significant gap in the current network.

**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 Climate and Cryosphere (CliC). CliC is a project of the 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 the observation and modelling communities. Its domains are sea ice, ice sheets, glaciers, permafrost, snow cover, freshwater.

4.5.2 CliC has several projects offering opportunities for collaboration with GCW, related to sea ice observations and research, and in Central Asia. Their user communities are interested in the GCW Data Portal as a window to 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. The GSG recommended that specific activities for collaboration are identified. **[action]**

4.5.4 L Hislop recommended that GCW develops a standard slide to be provided to all partners for synthesizing its goals and the potential benefits for the community. **[action]**

4.5.5 Recognizing the GCW priority activities in high mountain regions of Central Asia, L Hislop offered to link with ICIMOD and contribute to the GCW activities in the region. **[action]**

4.5.6 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.

**4.6 GCW in the context of GEOCRI**

4.6.1 J Key, who represents GCW on the GEO Cold Regions Initiative, provided a summary of GEOCRI activities, relevant to GCW. WMO decided to endorse 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, relevant to GCW are summarized in Annex 8.

4.6.2 J Key informed that the work plan of GEOCRI is concentrated around six tasks, and he represents GCW 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.

4.6.3 S Barrell recommended that, as a foundation member of GEO, WMO should use every possible opportunity to demonstrate the effective 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**. [action]**

4.6.4 H Lantuit expressed concerns about the absence of permafrost in the GEOCRI plan. He recommended that within the context of a targeted communication plan, GCW should organize a joint session with GEOCRI, for better understanding of the opportunities. **[action]**

**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 which could drive each party in entering in such agreement, with specific results expected in the near term. An example of benefits for partners is the access to the data infrastructure, via OSCAR and WIGOS metadata.

5.1.2 It was noted that WIGOS is also about building partnerships, and is in process of developing its own partnership criteria. As a component of WIGOS, GCW and WIGOS partnership criteria must be similar, and the Secretariat was asked to work with the WIGOS Project Office towards it. **[action]**

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

5.1.4 J Baeseman recommended that GCW provides to potential partners more clarity on the benefits of joining the GCW observing network. **[action]**

5.1.5 The participants appreciated the wide range of opportunities for collaboration identified during the discussions and committed to follow up on them. In particular, as a result of the initiated agreements GCW-SCAR-CliC, and the planned collaboration GCW-JCOMM/ETSI, as a matter of priority, the GSG requested that the mapping of sea ice activities, research and operational, is conducted, jointly, to identify opportunities and gaps. This would support the need to develop agreed upon best practices, recommended standards and opportunities for integrated products. **[action]**

5.1.6 The participants also recommended a stronger engagement with the partners represented on the GCW Steering Group, as well as with ICIMOD, UNESCO, WMO Commission for Instruments and Methods of Observation (CIMO), HARMOSNOW Initiative, and the Mountain Research Initiative (MRI) and the European Polar Board. **[action]**

**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](http://www.gtnpdatabase.org)), highlighting the 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 separated from IPA, and has redefined its focus and strategy, the user needs and benefits, data policy, authorship and aims, 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. **[action]** 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.**[action]**

5.2.3 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, as that published by GTN-P on the state of the permafrost temp in 2016. Publicizing the results of the GCW will help in securing additional funding for its contributors and as a whole, to support further development, in a similar manner as the GTN-P, which has secured funding from multiple sources PALMOD, INTERACT II, GTN-P, HGF-RSF (2018-2020)

5.2.4 B Goodison recommended the consideration about promoting operationalizing the existing borehole sites with the Meteorological Services in the respective countries, as a way to ensure longer term sustainability and easier data exchange **[action]**

5.2.5 H Lantuit asked GCW Best Practices Team to focus 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 expressed a keen interest in contributing to the development of the Best Practices guide, the section on permafrost, and has asked the Best Practices Team for the definition of the requirements **[action].**

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

**5.3 ECMWF contribution to GCW**

5.3.1 G Balsamo provided a summary of opportunities for enhancing the collaboration between GCW and ECMWF, available in Annex 11. ECMWF recommendsan active engagement of GCW with the modelling community during the YOPP core-phase campaigns to encourage the production of multi-source cryospheric dataset (as recommended already within the Snow WATCH) and the colocation of meteorological data output from the global and regional modelling and analysis systems with the Cryonet sites and stations.

5.3.2 These activities will support data uptake and usage, expand the knowledge achieved in the GCW teams and reinforce the connection across modelling and observation 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 has been initiated with a joint ECMWF-WWRP workshop on polar prediction in 2013.

5.3.3 Given the observed reduction in global sea-ice extent, encompassing both Arctic and Antarctic, the European Copernicus programme will provide dedicated monitoring via Sentinel satellites.

5.3.4 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.

5.3.5 The GSG requested that a specific list of potential products that could be distributed via the GCW Website is identified **[action]**

**5.4 GCW in the context of SAON**

5.4.1 Mr Jan Rene Larsen from the Arctic Monitoring and Assessment Program (AMAP) Secretariat presented an overview of the potential for collaboration with GCW, which is important for AMAP, in particular in the context of Sustained Arctic Observing Networks (SAON) initiative. An example of successful collaboration is the development of the SWIPA (Snow, Water, Ice, Permafrost in the Arctic) report, recently revised, with the contribution of experts also active in GCW, and is due for publication in 2017. He 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 observation guidelines, in terms of configuration, monitoring, and sustainability of observations, and the data and metadata exchange. **[action]**

5.4.2 SAON’s goal is to make observation data readily available 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), and 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 held at WMO, in Geneva, in late 2017, to give the ADC members the opportunity to learn more about the WIGOS, WIS systems, critical to open data exchange. This proposal was received positively by the GCW Steering Group, the details of the meeting arrangements to be established at a later date. **[action]**

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 JR Larsen noted that SAON will organize the Arctic Observing Summit, 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 GCW Steering Group welcomed the opportunity, with details to be defined later. **[action]**

5.4.5 A Snorrason thanked JR Larson and asked the WMO Secretariat to follow up on the potential for strengthening the collaboration, including by developing a more formal agreement between GCW and SAON. **[action]**

**5.5 UNESCO**

5.5.1 On the collaboration with UNESCO, the Secretariat noted that the GSG at its 3rd session, recommended an increased co-operation with UNESCO, the Intergovernmental Oceanographic Commission (IOC) and 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 Kazakhstan.

5.5.2 C Fierz had an informal meeting with representative of UNESCO-IHP (Anil Mishra) on June 2015 on possible collaboration in terms of education outreach, with both IACS & GCW. A meeting between the GCW Secretariat and UNESCO IHP, Paris office, is planned in Q1 2017.

5.5.3 The Secretariat has connected with UNESCO Asia/Almaty office, planning stronger collaboration re. Asia GCW activities (AHECO).There is an offer from the UNESCO Almaty office to provide support for the organization of AHECO workshop.

5.5.4 The planning for proposed workshop/training session in Latin America, led by UNESCO, with potential participation from GCW, has not advanced, at this time.

**5.6 ICIMOD**

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

5.6.2 It was also noted that ICIMOD is currently 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 address critical data gaps and increase the understanding of various drivers of change and their impacts, including the cryosphere.

5.6.3 Given the standing collaboration between CliC and ICIMOD, L Hislop indicated his willingness to facilitate a closer engagement between GCW and ICIMOD. **[action]**

**6. GCW WORKING STRUCTURE**

**6. 1 GCW Work Structure**

**6.1.1 Amendments to Current Work Structure**

6.1.1.1 Given recent feedback from the Secretary General regarding the 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, to streamline the delivery of results, reduce duplication, and ensure flexibility in addressing priorities.

6.1.1.2 Currently, GCW works through its three Working Groups on Observations, Integrated Products, and Information and Services, and two Regional Groups, led by Chairs. Each is organized in teams, led by one or more Leads, and conduct specific tasks addressing major GCW deliverables. Several proposed teams have not been active, yet (Solid Precipitation, Sea Ice and Glacier Products). It has been also noted that the same experts are members in several teams.

The proposal presented consists in:

* Working Groups are maintained as already defined;
* Each WG will include key “Themes”, linked to the Implementation Plan, and an evolution of the Team’s Terms of Reference;
* Each Theme will be led by a Lead/Co-Lead;
* The revised ToRs of Themes would be focused-activities, targeting defined results (e.g. if continuous activities, define yearly results);
* Focused activities will be conducted by time-bound Task-focused Teams (TT), led by a TT Lead, nominated by the WG Chair and the Theme Lead.
* An expert could be engaged in multiple targeted-activities, based on their expertise and interest in contributing.
* All GCW nominated experts will be associated with a WG, and a TT Lead would draw from the pool of experts, those who would contribute to an identified task.

Advantages:

* Enable a more focused approach to priority activities;
* Allow for the engagement of experts based on their expertise and interest and not only based on their association with a team;
* Provide more flexibility on the organization of meeting (agenda, participation, expected outcomes).

Disadvantages:

* Initial effort required in defining focused activities.
* Risk of not involving all experts, especially in meetings, causing dissatisfaction.
* Need to balance results oriented approaches with other objectives (regional representation, etc)

The Regional Groups are organized as projects, and are similar to the Task Teams.

6.1.1.3 The Group considered the option of organizing yearly meetings involving all GCW experts and the members of the Steering Group, and having side meetings to address priority activities. This could allow for a more efficient use of the available funding, increased focus on implementing the program. It was noted that the Steering Group must start thinking into the future, also, and develop a different strategy for when the program is fully operational. Different models will be required for when the GCW will be operational, comparative to the implementation phase.

6.1.1.4 The GSG recommended that the option has merits and needs to be submitted to EC-PHORS for consideration **[action]**

**6.1.2 Nomination of experts**

6.1.2.1 The Secretariat summarised that since the 3rd session of the GSG, additional experts have been nominated either by existing GCW experts or WMO Members. The approval process demonstrated that more clarification is needed for achieving consistency. The participants agreed that in the future, the selection of new GCW experts will be based on the candidate's experience and expertise, and their potential for contribution to specific priority activities. A proposed expert will have to provide a summary of the relevant expertize.

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.
* When new members are proposed by the GSG, these are invited to participate and a letter of endorsement is required.
* GCW membership requires the endorsement of the PR of the home country. The PR endorses the expert for participation in GCW, not for participation in a specific GCW Working Group, team, or activity. For experts working for organizations other than a National Hydro-Meteorological Service, the endorsement of the senior management of their organization will be sufficient, and the notification of the country’s PR is strongly encouraged.
* It was noted that many experts would come from organizations already partnering with GCW.

6.1.2.2 H Lantuit recommended that GCW brings in young scientists, as members and junior officers, through the Early Career Scientist stream, who could undertake a significant part of the development work under the guidance of experienced experts. This would address the need for progress, mitigating the over commitment of experts. The reward for young scientists; mentoring, attendance of meetings. One option for advertising is to post a broad invitation on CRYOLIST (<http://cryolist.org/about.html>).

6.1.2.2 T Thorsteinsson indicated the Islandic Meteorological Organization will seek the engagement of a student to contribute to the development of the GCW Best practices Guide, the section on Glaciers.

6.1.2.3 The participants agreed that it’s worthwhile 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.

**6.1.3 Approval of New Members and other membership changes**

6.1.3.1 The Secretariat requested the GSG to approve the experts nominated since its 3rd session. All nominations were approved by GSG as presented. The list is included in Annex 12.

6.1.3.2 C Xiao noted that he has changed positions recently and his ability to contribute to the GCW results is greatly diminished. 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 processed using the email approval process. **[action]**

**6.2 New activities: Solid Precipitation products; Sea Ice**

**6.2.1 Solid Precipitation Products**

6.2.1.1 The Secretariat noted that the GSG-3 approved the GCW working structure with a Team on Solid Precipitation as part of the Observation Working Group. After examining the potential for continuing the collaboration with the Commission for Instruments and Methods of Observation, in the context of the project on the Solid Precipitation Intercomparison Experiment (SPICE), led by CIMO, due to publish its report in 2017, it was proposed that the Solid Precipitation Team goals are redefined to focus on solid precipitation data products.

6.2.1.2 Given the close linkages with the goals of Snow Watch Team, it was agreed that the solid precipitation data products activities are included in the Terms of Reference of the Snow Watch Team. The GSG asked K Luojus and R Brown to propose amended ToR for the Snow Watch Team and propose experts to contribute to these goals. **[action]**

6.2.1.3 The GSG stressed the need for close collaboration with CIMO in achieving these goals.

**6.2.2 Sea Ice Integrated Products**

6.2.2.1 V Smolyanitsky presented a summary of proposed activities contributing to the goal of improving the availability of Sea Ice products through GCW. This would include sustained analyses of sea ice and icebergs, e.g. supporting marine transportation. The activities would be coordinated between GCW, the International Ice Charting Working Group (IICWG), and the Expert Team of Sea Ice (ETSI) of JCOMM (Joint technical Commission for Oceanography and Marine Meteorology), and, as discussed earlier, with Polar View and PSTG.

6.2.2.2 M Drinkwater recommended that integrated sea ice products should be developed jointly by GCW and PSTG, which would strengthen the case for new satellite observations, driving the focus towards what is fundamental, and enable the linking of products between different satellites, as satellite missions must be anchored on the specific products to be developed to meet specific needs. He noted that the biggest challenges are in the Southern oceans. The PSTG meeting will take place in September and is a good opportunity to bring the requirements from IISWG. **[action]**

**6.3 Regional groups and activities**

**6.3.1 GCW Asia High Mountain Activities**

6.3.1.1 The Secretariat introduced a summary of the GCW focus in Asia, in particular, the High Mountain regions of Asia and the proposed Asia High Elevation Cryosphere Observations (AHECO) project. AHECO is intended to address the WMO priority on improving the observations in high mountain regions. To date, two GCW CryoNet Asia meetings have been held (Beijing, 2013 and Salekhard, 2016).

6.3.1.2 In 2016, the AHECO proposal was developed for installing 10-15 new stations at high elevation, primarily glacier monitoring. Additionally, other 30 sites were proposed for different climate regimes, by the NMHSs in the region, with potential for contribution to the GCW observing network; their availability needs to be reconfirmed. The Secretariat was asked to contact all proponents of sites, listed in the GCW Salekhard report (report #12), reconfirm their interest to contribute to the GCW observing network, and ask for the missing information in the questionnaires submitted. **[action]**

6.3.1.3 The GSG agreed that the most important challenge in the region is the lack of standardization of observations, as numerous international organization have established observing stations, primarily automatic weather stations. As a result, one of the most impactful contributions of GCW would be the active dissemination of the GCW Best Practices guide, to support achieving data availability with local capacity, applying recommended procedures for supporting the operation of stations (local experts and station operators).

6.3.1.4 Expansion of observations must be complemented with knowledge. Currently, the local capacity is weak, and varies greatly from country to country. Without knowledge and support, the AWSs risk of lasting for only a very short time.

6.3.1.5 It was agreed that a second contribution from GCW is the mapping of the numerous initiatives already active in the region, and building on them. Investments from Swiss Development Agency, Finnish Environmental Institute, World Bank, USAid, and other organizations are known. L Hislop (CliC) worked in the region, on projects funded by the Government of Norway, and noted the existing engagement of CliC and ICIMOD. **[action].** S Colwell recommended that mapping of available observations, is a necessary step towards identifying where GCW could have most impact. He also reiterated that BAS is interested in working with GCW, supporting the expansion of observations in the Himalayan region. **[action]**

6.3.1.6 It was noted that ICIMOD is currently coordinating the Hindu Kush Himalayan Monitoring and Assessment Programme (HIMAP) to produce a Comprehensive Assessment of the Hindu Kush Himalayan (HKH) Region, to be published in 2017. [The report will include chapters on the Status and change of the cryosphere and a chapter on Water availability and use (water security).] CliC and Secretariat will further explore and document the engagement options, including the relationship with ICIMOD. **[action**]

Currently, the World Bank has projects in Nepal and Bhutan, and the Secretariat has been discussing with Wolfgang Grabs (WB) options for coordination. GCW glacier experts may be invited to a potential glacier observations workshop organized by the World Bank for its employees. [**action]** Secretariat will follow up with W Grabs and inform GSG about progress and options for collaboration (March 2017).

6.3.1.7 A Snorrason noted that the development of the GCW activities in central Asia were planned to follow the AntON concept for high mountain observations, especially as most of the existing observations are obtained from stations which are not operated by the national hydro meteorological services, and asked the Asia WG ensures that the intent has remained the same**. [action]**

6.3.1.8 B Goodison noted that WMO already has numerous engagements in the Central Asia, through its hydrology program, and GCW must link with these. Also, capacity building must be a key deliverable of GCW engagement in the region, as one of the seven current priorities of WMO. **[action]** When developing the overall view of the observing plans, the satellite observations available in the regions must to included, e.g. ENVEO, CryoLand ([http://www.cryoland.eu/)](http://www.cryoland.eu/%29). [**action]**

6.3.1.9 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, and recommended that the Secretariat consults with GCOS on this. **[action]**

6.3.1.10 C Xiao and J Wang invited the GSG to consider the organization of a workshop in conjunction with the proposed high mountain PRCC, which would explore the end to end engagement of GCW in the high mountain regions of Asia, from observations to services.

6.3.1.11 The Secretariat informed about the initiation of collaboration with the UNESCO Almaty office, Dr Kristine Tovmasyan. 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, climate change adaptation, as well as 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. **[action]**

6.3.1.12 The GSG reiterated its support for activities in the High Mountain regions of Central Asia and requested the Asia WG and the Secretariat to revise the AHECO project proposal. This should include mapping of existing known initiatives in the regions with similar objectives, including other WMO programmes, CliC, BAS, SCAR, UNESCO Almaty office, World Bank, ICIMOD, UN Environment Central Asia Sub-Regional Office, GCOS, and other known projects. A revised proposal should inform on the next steps on timing, scope, invitations, benefits, impacts, for the 3rd workshop. **[action]**

6.1.3.13 V Smolyanitsky informed the GSG 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 Dr Smolyanitsky and the RAS contacts as part of the preparation of future activities in this region.

**6.3.2 Tropical Cryosphere Activities**

6.3.2.1 The Secretariat presented a summary of the proposed workshop related to tropical climate cryosphere. The participants agreed that the workshop must focus on all relevant components of the cryosphere, not only glaciers, by adding snow and snow cover related to glaciers, identify the socio benefits expected (take a user perspective), e.g. tourism industry, etc.

6.3.2.2 The suggested name is “GCW Tropical Climate Cryosphere Workshop”. Regarding the geographical scope, the GSG recommended to include a sample of Latin America and most Africa, as well as Indonesia.

6.3.2.3 Regarding engagement, the NMHSs of the countries in the region must be engaged from the onset, as well as the IPA, SCAR, CliC other international organizations with activities in these regions, e.g. UNEP (UN Environment) offices in Africa and Latin America and the Caribbean Office, potentially the Asia and the Pacific office (for Indonesia). H Lantuit, J Baeseman, L Hislop to provide names representing the the respective perspectives. **[action]**

6.3.2.4 The GSG members were asked to provide names of experts who could be involved in the workshop by mid-February. **[action]** Several experts were suggested, e.g. Rainer Prinz (Austria), Ian Allison (Australia), Lonnie Thompson (Ohio State University, USA), Andrew Klein Texas A&M University, USA), Bryan Mark (Ohio State University), Georg Kaser, Thomas Mölg from University of Innsbruck It was recommended to contact known experts already involved in WMO activities, e.g. from Morocco, e.g. Rabia Merrouchi. The Secretariat will discuss engagement with the representative of Morocco on EC-PHORS. **[action]**

6.3.2.5 Participants identify the need to nominate a Rapporteur for this workshop, but a name was not agreed upon, before the end of the meeting. **[action]**

6.3.2.6 The Secretariat was asked to coordinate with the GCW experts the identification of the workshop objectives and goals, align with the implementation of GCW. **[action]**

**6.4 Role and Structure of the GCW Steering Group**

6.4.1 S Barrell noted that the Steering Group of GCW has a good balance between expertize and organizational oversight and there is a good understanding of needed linkages and dynamics.

The general consensus was that the current structure of the GSG offers a good balance of expertize, leadership and representation from key partner organizations, people who are connecting with different communities, understand the dynamics of organizations, and no changes are needed, at this time.

6.4.2 The participants were invited to consider how the organization and leadership model of GCW will need to evolve once it becomes operational.

6.4.3 GSG agreed with the setup of an executive committee, to decide on tactical topics, between meetings, recommending to include the Chair, Co-Chair, WG Chairs.

**6.5 Engagement of GCW Focal Points**

6.5.1 The participants reviewed and reconfirmed the terms of reference for the Focal Points as published in the GCW Implementation Plan.

6.5.2 The Group agreed that more active engagement of the Focal Points was needed, for example by holding regular webinars for the Focal Points, and invite representatives of different projects to present updates and opportunities for further contribution.  **[action]**

**7. ACTION PLAN AND FUTURE ACTIVITIES**

**7.1 GCW Actions plan 2017/2018**

**7.1.1 Work plan of the Observations WG**

The following activities were identified as the 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.
* Completion of the evaluation of 2016 proposed stations, for submission to EC PHORS-7, and complete assessment of new submissions.
* Finalise the minimum observing program for all cryosphere components as soon as possible.
* Development of the Metadata vocabulary, ensure consistency of terminology used for the minimum observing program for the GCW observing network.
* Publish the GCW Data Policy.
* Finalise the procedure for data exchange, including data formats and the need to update BUFR

**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.
* 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.
* 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.
* Assist in the development of GCW regulatory material.
* Continue efforts to promote the real-time reporting and exchange of snow data, including in real time.
* Continue to develop the historical global SWE archive maintained at FMI

7.1.2.2 Sea Ice Products Team

* Develop a strategy for integrated work planning with the ETSI.
* Develop summary of additional products that could be made available via GCW.

**7.1.3 Information and Outreach WG**

7.1.3.1 Terminology Team

The activities will be focused on the inclusion of additional sources, and assessment of definitions for the same or similar variables to explore opportunities for streamlining the terminology, for a broader audience. This would require dedicated resources, and is possible as funds become available.

7.1.3.2 Website Team

Future plans include the development of a GCW Wikipedia entry, creating an archive for Cryosphere in the News articles, storing assessments and interesting events pages in a database, making minor updates to the questionnaires, and improving the website for use on mobile devices. Other possibilities are the development of a resource database with CliC, the GCW Newsletter, recreating global cryosphere maps, developing a GCW mobile app, and adding quality assurance CryoNet webpage, similar to that used by the Global Atmosphere Watch (<http://www.wmo.int/pages/prog/arep/gaw/qassurance.html>).

7.1.3.2 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.
* Develop the GCW-OSCAR interfaces
* Develop new software components to advance the metadata harvesting, interoperability with other Data Centers

**7.2 Development of GCW Performance Indicators**

7.2.1 S Barrell recommended to the Chair and Co-Chair of GCW to lead the development of practical and measurable success indicators (SMART) for GCW, to drive the strategic development, which would be used for measuring and communicating progress, as well as a means of communicating with the outside communities on their contribution of GCW to key initiatives, projects.

7.2.2 S Barrell agreed to lead this effort, and the WG Leads were asked to provide proposals for performance indicators to the Secretariat, for synthesis and further development, e.g. the number of partners, benefits, impact: website, Google Analytics (how many visits, which products).  **[action]**

Practical Indicators could be very effective to identify which activities have impact and which do not have, and will provide insight on adjustments needed to remain relevant.

**7.3 Development of a GCW Communication Strategy**

7.3.1 GSG recognized that GCW needs to develop, as a matter of priority, a communication strategy to serve as the basis for engagement outside the traditional WMO base, as well as an internal communication strategy to support the primary WMO audience, the NMHSs, and to engage with other WMO commissions, Regional Associations and programs.

7.3.2 The communication strategy needs to identify the GCW audience, goals, and draw the boundaries, i.e. what will not be done. H Lantuit strongly recommended that GCW takes additional steps to present the benefits that it brings to the community, to ensure the recognition and to engage more users. He recommended as a strategy, the release of a range of products at the same time to show the value of the dataset. He also recommended that GCW measures its impact using analytics to track access to its website.

The partners attending the GSG meeting recommended that, overall, GCW must do a better job articulating its identify and promote its contributions.

7.3.3 J Baeseman recommended that the strategy defines clearly who is the target audience, and most importantly who is not the audience, and GCW should use a professional for this. B Goodison remarked that the first audience is the WMO members, and that GCW needs to make them aware of issues and where they could improve their services, including data availability, quality.

7.3.4 S Barrell recommended that GCW uses the WIGOS communication plan as an example, and develops its own communication plan with WMO resources focusing on audience, messages, and target products.**[action]**

**7.4 GCW Outreach Plan**

7.4.1 There was consensus that cryosphere research, observations, service are of great interest to multiple communities and there are many organizations active in these areas. For GCW to become a key player it must define very clearly what it brings to the table, the gaps it addresses and the benefit for engagement. The planned communication strategy is critical to achieve this. GCW must 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 to the community, especially for the research community. A recommended practical goal is to develop, by mid-2018, demonstrations on how to use WIS to access data; for example, select several CryoNet stations which to be added to WIS and show how the metadata is made available via GCW Data Portal. **[action]**

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

7.4.3 SCAR and CliC invited GCW to make a short presentation (5 min) on its benefits to cryosphere science at the Arctic Science Summit, in Prague, April 2017. **[action]**

7.4.4 M Sparrow will represent WMO at the upcoming Antarctic Treaty Management Committee (ATMC) meeting, and he will work with the GCW Secretariat to prepare a presentation on GCW for this meeting **[action].**

7.4.5 The Chair and Co-Chair requested that GCW is actively represented at the GCOS Terrestrial Observation Panel on Climate (TOPC). **[action]**

**8. REPORT TO EC-PHORS**

8.1 Draft Resolutions

The GSG recommended the following topics to be brought forward to EC-PHORS-7:

* Final list of stations recommended for inclusion in the GCW Observing Network
* Recommendation the National Hydrometeorological Services to provide support to their national organizations in contributing to the GCW Observing Network, with the implementation of recommended formatting of data and metadata, and allow their distribution in [near] real time, though the GTS/WIS (for data), and to OSCAR/Surface (for instrument/platform metadata)
* Recommended changes to the approved CBS Recommendation on snow data exchange.
* Information on regional activities;
* Proposed amendments to the working structure of GCW

**9. ANY OTHER BUSINESS**

**9.1 Next GSG Session**

Given the importance of the EC-70, in 2018, preceding the GC-19, 2019, it was agreed that the GSG must meet in January 2018, prior to EC-PHORS-8 (date and place TDB, probably March 2018), to prepare its submissions that will require the approval and decision of the EC. The opportunity of meeting in Japan was discussed, in the context of the International Symposium on Arctic Research, 5th conference.

The participants agreed that the future GCW meetings should be organized as theme driven sessions (engaging the contributors to the specific results) and an executive session, engaging representatives of partners, could be organized in parallel.

**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 will seek the organization of targeted working sessions that will further develop the interoperability of new data centers with the GCW Data Portal.

**10. CLOSURE OF MEETING (17h00)**

The Chair thanked the participants and the Secretariat for contributing to the successful outcome of the meeting. The participants agreed that this has been a very productive 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 Kingdon

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

**Monday, 16 January, 2017 (9:00 – 18:00)**

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, T Thorsteinsson)**

* + - 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”.

 NOTE: breakout groups may be organized, as needed.

**Tuesday, 17 January, 2017 (8:30 – 17:00)**

**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;

*17:00 End of the Day*

GROUP DINNER (own expense, <http://www.galleriacambridge.co.uk> )

**Wednesday, 18 January, 2016 (8:30 – 18:00)**

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 (**S Colwell);

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.

1. **GCW STRUCTURE:**
	1. GCW **Structure**; GCW in 2040;

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

* 1. Consideration of **newer activities/teams:**
1. Solid precipitation products
2. Sea Ice Team
3. Glaciers Team
4. Permafrost
5. Regional groups and activities
	1. GSG Role and Structure;
	2. Engagement of GCW Focal Points.

**Thursday, 19 January, 2017 (8:30 – 18:00)**

**cont 6…**

1. **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.

1. **REPORT TO EC-PHORS**
	1. Draft Resolutions to EC-69.
2. **ANY OTHER BUSINESS**
	1. Next GSG meeting.

1. **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 SnorrasonChair, GCW Steering Group | Icelandic Meteorological Office, Reykjavik, Iceland | arni.snorrason@vedur.is |
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| 4 | Jeff Key | National Oceanic and Atmospheric Administration (NOAA)Madison WI, USA | jkey@ssec.wisc.edu |
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| 9 | Vasily Smolyanitsky | Arctic and Antarctic Research Institute, St. Petersburg, Russian Federation | vms@aari.aq |
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| 13 | Cunde Xiao | State Key Laboratory of Cryospheric Sciences, Institute of Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), Chinese Academy of Sciences (CAS), Lanzhou, China | cdxiao@lzb.ac.cn |
| 14 | Jenny Baeseman | Executive Director, Scientific Committee on Antarctic Researchc/o Scott Polar Research InstituteCambridgeUnited Kingdom | jenny@scar.org |
| 15 | Renuka Badhe | Executive SecretaryEuropean Polar BoardThe Hague, The Netherlands | r.badhe@nwo.nl |
| 16 | Gianpaolo Balsamo | Research Earth System Modelling Section, Coupled Processes GroupEuropean Centre for Medium-Range Weather Forecasts (ECMWF) | Gianpaolo.balsamo@ecmwf.int  |
| 17 | Steve Colwell | British Antarctic Survey,CAMBRIDGEUnited Kingdom | src@bas.ac.uk  |
| 18 | Mark Drinkwater | Mission Science Division (EOP-SM), European Space Agency (ESA), ESTEC, Noordwijk, The Netherlands | mark.drinkwater@esa.int |
| 19 | Lawrence Hislop  | Executive Director of the WCRP/CliC International Project Office | lawrence@climate-cryosphere.org  |
| 20 | Hugues Lantuit | Alfred Wegener InstitutePotsdam, Germany | Hugues.Lantuit@awi.de  |
| 21 | Jan Rene Larsen | SAON SecretaryOsloNorway | jan.rene.larsen@amap.no |
| 22 | Carven Scott | Director, Alaska RegionNational Weather Service NOAA, Anchorage, AK, USA | Carven.scott@noaa.gov  |
| 23 | Jiankai Wang | Division of the observational networks design and management,Department of integrated of observations, China Meteorology AdministrationChina | wjkaoc@cma.gov.cn  |
| 24 | Michael Sparrow, WCRP Scientific Officer | World Meteorological OrganizationGeneva,Switzerland | msparrow@wmo.int  |
| 25 | David Vaughan | Director of Science, British Antarctic SurveyCambridge, UK | dgv@bas.ac.uk  |
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| 29 | Rodica NituGCW Project Manager | WMO Secretariat, Geneva,Switzerland | rnitu@wmo.int |

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# Annex 3: LIST OF ACTION ITEMS ARISING FROM THE MEETING

**1. Action items from the meeting**

| ***No.*** | ***Ref.*** | ***Action item*** | ***By whom*** | ***Deadline*** |
| --- | --- | --- | --- | --- |
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# Annex 4: GCW OBSERVING NETWORK, APPLICATION PROCESS DESCRIPTION

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)](#endorsment)  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[[2]](#footnote-2). 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.
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

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

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

# 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 expertize 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 to collaborate on a satellite ocean requirements paper.
* 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 across SCAR on past and potential future climate change over the Antarctic continent and in the Southern Ocean and State of the Cryosphere Summaries, being liked to the Antarctic Treaty, and could be an area to work together to develop assessment.
* Antarctic Near-shore and Terrestrial Observing System (ANTOS), establishing an integrated, coordinated transcontinental and trans- regional observation 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 observation protocol for sea ice thickness, observations made aboard ships in the Antarctic pack ice; data is hosted by the Australian Antarctic Division; it could contribute significantly to the development fo 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 observation 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 observation 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
	1. 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

1. Scope and Motivation
	1. Leadership

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

* 1. 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.

1. Material and Methods
	1. 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.

* 1. 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.

1. 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, 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.

1. Outlook

GTN-P is preparing the first report on global permafrost temperature change (Fig. 3). The dataset 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 observation 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 extend of data sets with mean annual ground temperature values in the GTN-P Database. This data set is currently being quality checked and processed to report on the global temperature change in permafrost.

1. 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.

1. 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 observation 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).

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# Annex 12: GCW EXPERTS APPROVED AT THE 4TH SESSION, GCW STEERING GROUP

1. **WG OBSERVATIONS:**
* Dr. Annett Bartsch (Austria) proposed by the PR of Austria (expertize: permafrost, remote sensing) for the CryoNet Team
* Dr. Petra Heil (Australia): expertize 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
1. Dr Rainer Prinz proposed by the WG Chair was not endorsed by the PR of Austria. Given his expertise in tropical glaciology, the GSG decided to invite him as an expert, in support of the Tropical Climate Cryosphere workshop in Tanzania, in July 2017.
2. **Sea Ice Team**

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

* Nick Hughes, (Norway)
* Petra Heil, (Australia)
1. **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: MINIMUM OBSERVATION PROGRAM CRYONET NETWORK

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1. (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. [↑](#footnote-ref-1)
2. 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. [↑](#footnote-ref-2)