Global Cryosphere Watch Overview

Rodica Nitu, Barry Goodison, Jeff Key, Wolfgang Schöner
Global Cryosphere Watch
World Meteorological Organization
WMO Priorities 2016-2019 include...

- **Polar and High-mountain Regions:**
  - Improve meteorological and hydrological monitoring, prediction and services in polar and high-mountain regions and beyond, by:
  - (i) operationalizing the Global Cryosphere Watch (GCW);
  - (ii) better understanding the implications of changes in these regions on the global weather and climate patterns, and
  - (iii) advancing the polar prediction under the Global Integrated Polar Prediction System

**GCW is a cross-cutting activity dependent on partnerships**

Globalcryospherewatch.org

**GCW Mission:** provide authoritative, understandable, and useable data, information, and analyses on the past, current and future state of the cryosphere to meet the needs of WMO Members and partners in delivering services to users, the media, public, decision and policy makers.
Integrated Global Observing System-Cryosphere Theme
Cryosphere: snow cover*, solid precipitation*, sea ice*, lake and river ice, glaciers*, ice caps*, ice sheets*, ice shelves, icebergs, permafrost* and seasonally frozen ground (*GCOS ECV)

Many of these areas are:
- Remote
- Sparse networks
- Harsh operating conditions
- Expensive to operate
- Very vulnerable to a changing climate
GCW Goals

• promoting *standardization of observations*
• *network of surface observations*, building on existing networks
  – "CryoNet“: standardized, high quality observations
• refining *observational requirements*;
• enabling *access to data and metadata* through GCW portal;
• *intercomparisons of instruments/products*, e.g. satellite snow products (SnowPEx);
• *enhancing* near real-time snow depth observations on the GTS/WIS;
• producing *unique hemispheric products*, e.g., “snow anomaly trackers”;
• contributing to WMO’s space-based capabilities
• engaging in *historical data rescue* (e.g., snow depth);
• building a *glossary of cryospheric terms*;
• Outreach: *up-to-date information on the state of the cryosphere*;
GCW Surface Observing Network, 2017

77 CryoNet Station
43 Contributing Stations
11 CryoNet Sites
Minimum requirements of a CryoNet Station

1. **Measurement Requirements**: at least one variable of one of the cryosphere components (i.e. snow, solid precipitation, lake and river ice, sea ice, glaciers, frozen ground, permafrost).

2. **Compliance with Agreed Regulatory Practice**: observational procedures, instruments and method of observations, quality control practices, etc., should follow GCW endorsed regulations, manuals, guides and recommended best practices.

3. **Commitment of Operational Continuity**: The station must be active and committed to continue measurements for minimum four (4) years.

4. **Station Metadata is Up to Date and Available** on the GCW Portal and compliant with data and metadata standards.

5. **Data and Ancillary Data Freely Available**: and whenever possible in near real-time (meteorological observations)

6. **Competency of Staff**: Personnel must be trained in the operation and maintenance of the station.
part of WMO Information System: WIS;
- Interoperable with a distributed network of Data Centers, a heterogeneous community of data providers (NMHS, universities, research, other organizations) will exchange cryosphere data, metadata, information and analyses;
<table>
<thead>
<tr>
<th>Variable</th>
<th>Timescale</th>
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<tbody>
<tr>
<td>Snow on the ground</td>
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<tr>
<td>(According to WMO code 0975: State of ground with snow or measurable ice cover.)</td>
<td>M(S)</td>
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<tr>
<td>Snow depth (including stake farms and snow courses)</td>
<td>A(S, G, SI, LRI) M(S) M(SI, LRI) M(G, IS)</td>
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<tr>
<td>Snow depth (including stake farms and snow courses)</td>
<td>A(IS, P)  M(P) M(S)</td>
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<td>Snow water equivalent</td>
<td>A(S)      M(S) M(G, IS)</td>
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<td>Solid precipitation (Requires both amount and type of precipitation to be measured)</td>
<td>A(S)</td>
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<td>Snow profiles (density, grain shape &amp; size, hardness, liquid water content, salinity, temperature)</td>
<td>M(S) M(IS)</td>
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<tr>
<td>Snow profiles (density, grain shape &amp; size, hardness, liquid water content, salinity, temperature)</td>
<td>M(SI, LRI)</td>
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<tr>
<td>Depth of snowfall</td>
<td>M(S)</td>
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<td>Water equivalent of snowfall</td>
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<td>Snow cover extent</td>
<td>A(SI, LRI) M(SI, LRI)</td>
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<td>Snow chemistry</td>
<td>M(S, IS)</td>
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<td>Snow surface temperature</td>
<td>A(S, SI)  M(SI)</td>
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<td>Snow temperature</td>
<td>A(S)      M(SI)</td>
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<td>Drifting snow</td>
<td>A(S)      M(S)</td>
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<td>Specific surface area</td>
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Blue shading/fill indicates recommended measurements for CryoNet stations
Green shading/fill indicates desired measurements for CryoNet stations
A: automatic, M: manual
S: snow, G: glaciers, IS: ice sheets, ISV: ice shelves, P: permafrost, SFG: seasonally frozen ground, SI: sea ice, LRI: lake and river ice
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<td>Surface ablation (point)</td>
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<td>Glacier volume (glacier wide)</td>
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<td>Glacial runoff</td>
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<td>Ice velocity (point)</td>
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Evolution of the snow depth observations availability on the GTS
Following GCW/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

- Proposed Snow Workshop
  To establish and agree on the recommendations and actions (programmatic and scientific) to be explore in a near finite horizon (3-5 years)
Estimation of SE from snow depth or SWE is sensitive to the threshold used for snow cover

- Reanalysis products very sensitive to low SWE thresholds
- Climatology and trends sensitive to SWE threshold although 0 mm can be ruled out as a reasonable threshold

L. Mudryk, ECCC/CPS
GCW "snow anomaly trackers"

- Near real-time tracking of NH SWE from GlobSnow (FMI) and the Canadian Meteorological Centre (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

Total water (Gt) stored in seasonal snow cover over NH land areas for 2016/17 season up to Jan 11, 2017

ECCC SWE estimated from CMC daily snow depth analyses
GTN-P network and data management
towards sustained permafrost
temperature monitoring
on global scale
GTN-P network and data management

towards sustained permafrost temperature monitoring on global scale

Boris K. Biskaborn¹, Dmitry Streletsii², Sharon L. Smith³, Vladimir E. Romanovsky⁴, Heidrun Matthes¹, Jeannette Nötzli⁵, Gonçalo Vieira⁶, Philippe Schoeneich⁷, Jean-Pierre F. Lanckman⁸, Hugues Lantuit¹.⁹

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³ Geological Survey of Canada, Natural Resources Canada, Ottawa, Canada
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⁵ WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
⁶ Instituto de Geografia e Ordenamento do Território, University of Lisbon, Lisbon, Portugal
⁷ Institut de Géographie Alpine, Université de Grenoble Alpes, France
⁸ Arctic Portal, Akureyri, Iceland
⁹ University of Potsdam, Potsdam, Germany

www.gtnp.org
Global Terrestrial Network for Permafrost

Primary monitoring network for Essential Climate Variable

Global Terrestrial Network for Permafrost

GTN-P Database

Global standardized time series of ground temperature data

Global standardized time series of active layer thickness data

Essential Climate Variable (ECV): Permafrost

Permafrost temperature

Annual thaw depth

Permafrost Monitoring

TSP (Thermal State of Permafrost)

ALT (Active Layer Thickness, mostly CALM)

www.gtnp.org
Network reformation

1st GTN-P Workshop
Germany
Potsdam 2011

2nd GTN-P Workshop
Canada
Quebec 2015

And GTN-P meetings at EUCOP, ASSW, ICOP, ...
Strategy and Implementation Plan

• Revival of GTN-P via EU project PAGE21 / AWI

• Harmonisation of datasets following international standards for metadata and data ➔ AWI and Arctic Portal

• Develop a Data Management System
  gtnpdatabase.org

• Provide global permafrost temperature and active layer thickness data in model-ready formats
Network Governance

GTN-P

STEERING COMMITTEE
Dmitry Streletsikiy (Chair)  Sharon Smith (Co-Chair)
Jeanette Noetzli (Co-Chair)  Gonçalo Vieira
Philippe Schoeneich  Alexey Maslakov (YNC)

SECRETARIAT
Director: Boris K. Biskaborn, AWI
Technical Director: Jean-Pierre F. Lanckman, AP
Network Coordination: Karina Schollan, IPA
Technical Assistant: William Cable, UAF

GTN-P National Correspondents
36 Representatives of 25 countries with permafrost, responsible for coordinating and sustaining national data upload

GTN-P Young National Correspondents
17 Representatives of 17 countries, support to NC responsibilities

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Paolo Pogliotti
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Global Map with new functions

Have a look at the global map on the webpages of the GTN-P Database. We have been working on improving and implementing new functions on...

Maps and Graphics
Useful Geospatial Layers produced by the Global Terrestrial Network for Permafrost (GTN-P) or related to permafrost studies. We provide the downloads as different file types.

Database tutorials

We have created a range of tutorials to help you start working with the GTN-P Database. All tutorials are
Scientist level, National Correspondents
Metadata and data quality

Automated visualisation

CALM active layer grids

TSP borehole temperatures

TSP trumpet curves
Global Terrestrial Network for Permafrost

1350 boreholes
249 active layer sites
5 Million data points

www.gtnp.org

Data Management System for transferring permafrost temperature and active layer thickness to global models
Metadata publication and database launch

The new database of the Global Terrestrial Network for Permafrost (GTN-P)

B. K. Biskaborn¹, J.-P. Lanckman², H. Lantuit¹, K. Elger³, D. A. Streletska⁴, W. L. Cable⁵, and V. E. Romanovsky⁶,⁷

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⁷Earth Cryosphere Institute, Tyumen, Russia
GTN-P metadata statistics

Total numbers of TSP boreholes (bh) and percentages of the GTN-P depth classes:
- <10 m SU Surface
- 10-25 m SH Shallow
- 25-125 m IB Intermediate borehole
- >125 m DB Deep borehole

Biskaborn et al. (2015), ESSD
Localisation of spatial monitoring gaps

Voronoi Tessellation Analysis

TSP Boreholes

Biskaborn et al. (2015), ESSD
Localisation of spatial monitoring gaps

Voronoi Tessellation Analysis

**CALM active layer sites**

*Biskaborn et al. (2015), ESSD*
15 different global climate models, number of TSP and CALM sites in each zone of projected temperature. Differences of mean annual near surface temperature between 2070–2099 AD and 1970–2000 AD for representative concentration pathways (rcp’s) 4.5 and 8.5: ACCESS1-0, bcc- csm1-1, CanESM2, CCSM4, CNRM-CM5, CSIRO-MK3-6-0, GISS-E2-H, GISS-E2-H, GISS-E2-R, HadGEM2-ES, inmcm4, IPSL-CM5A-LR, MPI-ESM-LR, MRI-CGCM3 and NorESM1-M.
Thank you