Global Cryosphere Watch (GCW)
Mission, Objectives, Expected Outcomes, Implementation

GCW First Implementation Meeting
November 21-25, 2011
Geneva, Switzerland

Barry Goodison
World Meteorological Organization, Geneva, Switzerland

http://www.wmo.int/pages/prog/www/polar/index_en.html
Countries where cryosphere occurs

sea ice, lake and river ice, snow cover, solid precipitation, glaciers, ice caps, ice sheets, ice shelves, permafrost and seasonally frozen ground.

~ 100 countries identified with cryospheric components

Cryosphere truly is global
Sea level rise threatens vital infrastructure.

Changes in sea-ice affect access to the polar oceans and resources, tourism, and security. Declining summer sea-ice affects ocean circulation and weather patterns.

Natural hazards such as icebergs, avalanches and glacier outburst floods create risks.

Permafrost thawing impacts infrastructure and is potentially a major source of methane, a greenhouse gas.

Changes in the cryosphere impact water supply, food production, freshwater ecosystems, hydropower production, and the risk of floods and droughts.

Retreating sea ice results in a loss of habitat for mammals such as polar bears and seals.
Global Cryosphere Watch - A WMO Initiative

“The 15th WMO Congress (May 2007) welcomed the proposal of Canada that WMO will create a Global Cryosphere Watch which would be an important component of the IPY legacy. Congress requested the WMO Inter-commission Task Group on IPY to establish an ad-hoc expert group to explore the possibility of creation of such global system and prepare recommendations for its development.”

Considerations

• **IPY 2007-2008** identified Shrinking Snow and Ice: Rapid Changes in Polar Regions as the first of four key issues requiring urgent attention
• **IPCC WG 1 and 2** reports highlighted for first time importance of the cryosphere, observed changes of some elements of global cryosphere and potential impacts on societies and countries;
• **ACIA, ICARPII, (and now SWIPA and SCAR’s Antarctic Climate Change and the Environment reports)** identified the cryosphere as a critical element in monitoring and understanding changes in the our polar systems;
• the development of the conceptual framework for the Cryosphere Observing System (CryOS)
• cryosphere is an integrative element within climate system and **indicator of climate change**
To monitor the cryosphere we need to measure a broad spectrum of snow and ice properties

**Snow**
- snow water equivalent (SWE), depth, extent, density, snowfall, albedo
- in-situ climate & synoptic (manual, auto), weather radar, remote sensing

**Solid Precipitation**
- in-situ climate & synoptic (manual, auto), remote sensing (challenging)

**Lake and River Ice**
- freezeup/breakup, thickness, snow on ice
- in-situ (shore based), remote sensing

**Sea Ice**
- extent, concentration, type (age), thickness, motion, icebergs, snow on ice
- landfast (manual), ship-based & aerial reconnaissance, satellite & airborne reconnaissance

**Glaciers, Ice Caps, Ice sheets**
- mass balance (accumulation/ablation), thickness, area, length (geometry), firn temperature, snowline/equilibrium line, snow on ice
- ground-based (in-situ), remote sensing

**Frozen Ground/Permafrost**
- soil temperature/thermal state, active layer thickness, borehole temperature, extent, snow cover
  - in-situ (manual, auto), remote sensing (new)

Green: mature capability; Blue: moderate/developing capability; Red: little or no capability
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But, the responsibility for these measurements is scattered: snow in terrestrial programs, sea ice in oceans, and then there is WMO, GCOS, GTOS, GOOS, CEOS, IPA, WCRP, research institutes etc. etc.

...... Needed over the entire range of time and space scales for weather, climate, water and environmental matters

*These are the basis for GCOS Essential Climate Variables (ECV’s)*

Green: mature capability; Blue: moderate/developing capability; Red: little or no capability
The IGOS Cryosphere Theme was developed primarily to:

• create a framework for improved coordination of cryospheric observations

• assess current capabilities and requirements for cryospheric observations

Over 100 recommendations provide the basis for subsequent actions. But who will take action?

Global Cryosphere Watch
**Mission:** GCW will 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. GCW will:

- implement the IGOS Cryosphere Theme (CryOS);
- support reliable, comprehensive **observations** through an integrated observing approach in collaboration with relevant national and international programmes and agencies;
- provide the scientific community with the means to **predict** the future state of the cryosphere;
- facilitate the **assessment of changes** in the cryosphere and their impact; support decision making and environmental policy development;
- provide authoritative information on the current state and projected fate of the cryosphere for use by the scientific community, media, public, decision and policy makers – **meet user needs**
GCW Linkages/Partnerships

- GCW will **contribute to** WIGOS and WIS and to GCOS and will strengthen the WMO contribution to the GFCS

- The strong community desire to establish a **network of stations** (reference or supersites), **CryoNET** will require partnering

- GCW will provide leadership in the effort to establish best practices, **guidelines and standards** for cryospheric measurements by Members, Partners and scientific community and for **cryosphere terminology**.

- GCW will **work with, and build on**, existing programs such as GCOS (including GTOS (GTN-G, GTN-P, GTN-H), and work with partners such as WMO Technical Commissions, Regional Associations and its co-sponsored programs (WCRP), space agencies, World Data Centers, scientific associations, other national and international bodies and institutes, etc.

- GCW will **contribute to** GEOSS through WIGOS and the implementation of **CryOS**

- GCW will **need a one-stop portal** for authoritative up-to-date cryosphere data and products/information (prototype at met.no). GCW is **not seen to be** a data archive, but would link to associated data centres.
Partnerships

Considering all of the above, it is essential to understand that:

**GCW is not assuming the mandate of any of the Partners/Collaborators**

instead

**GCW enables Partners/Collaborators to exercise their mandate effectively**
The 16th WMO Congress (2011) agreed that WMO needs to have a focus on global cryosphere issues to be able to provide authoritative information to meet Members’ responsibilities on regional and global weather, climate, water and related environmental matters, and decided to embark on the development of the Global Cryosphere Watch (GCW), as an IPY Legacy, with a view of an operational GCW.

**Key Tasks**

- Implement recommendations of CryOS;
- Initiate pilot and demonstration projects;
- Establish cryosphere reference sites;
- Develop an inventory of satellite products for GCW;
- Develop a web portal and interoperability for cryosphere users and providers;
- Capacity building;
- Communication and outreach;
- Monitor scientific progress.

**EC-PORS will guide GCW Development**
Direct contact with WMO Members:
GCW Focal Points/Contacts

Region I: Ethiopia, Kenya, Morocco, Niger, United Republic of Tanzania, Zambia (South Africa is a member of EC-PORS)

Region II: China, Islamic Republic of Iran, India (TBC), Japan, Kazakhstan, Maldives, Thailand, Tajikistan, Uzbekistan

Region III: Argentina, Colombia, Peru (Chile is a member of EC-PORS)

Region IV: Canada, United States of America

Region V: Australia, Malaysia, New Zealand

Regions VI: Austria, Belgium, Finland, France, Iceland, Netherlands (the), Norway, Russian Federation, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland (Germany is a member of EC-PORS)
Issue: Perspective and Scale

- Point
- 100s of meters
- 10s of km
- Arctic-wide and Global

Remote Sensing

Modeling

Field Measurements

= Calibration/Validation Scales

From Waleed Abdalati ICARPII
Observing the Cryosphere

The cryosphere observing system includes satellites…
..... in situ, marine, and aircraft measurements ...
A conceptual model of Inuit ice terminology is being developed for incorporation into the floe ice edge monitoring product.
Challenges: Identifying Reference Sites

Arctic Atmosphere Observing Network A Basis for CryoNET?
Distribution of Himalayas Cryospheric Observation Network (HIMALCON)

Courtesy, Xiao Cunde, CMA/CAS
Distribution of Tanggula Cryospheric Observing Network (TCON)

Observation items | Method | Frequency | Accuracy |
--- | --- | --- | --- |
Cryospheric components | Mass balance | Stake/Snowpit | 1 Month | 0.03 m |
 | | Area | RTK-GPS/Remote sensing | 2-3 Year | 2 % |
 | | Thickness | Ice Radar | 3-5 year | 2-5 m |
 | | Terminal position | RTK-GPS, etc | 1 Year | 1 % |
 | | Surface velocity | RTK-GPS/InSAR | 1 Year | 1 % |
 | | Ice temperature | Heat-sensitive sensor | 1 week | 0.1K |
 | | ELA/snowline | Glaciological Means | 1 year | 10 m |
 | Others (debris) | | 1 Year | --- |

Courtesy, Xiao Cunde, CMA/CAS
Standards, Guidelines, Metadata

- Churchill RCT1 (top) Dec 2000: Huge rocks create deep drifts, dry patches
- RCT2 (bottom) Mar 2003: Open tundra with small obstacles creates 20-30 cm drifts
- Flagging of trees points away from Hudson’s Bay
- Need for community agreed guidelines, best practices, standards and metadata – applies to all cryospheric components
- All part of dialogue between users (e.g. modellers) and network operations
- All are needed for reference and super sites
Quantification of Cold Region Precipitation – Demonstration Project

- development of data sets, adjusted for known systematic errors, suitable for meteorological, hydrological and climate modelling
- through GCW and with others (CIMO, WIGOS, GCOS), update observing procedures and standards for cryospheric variables
- Development and assessment of new technologies for precipitation measurement in cold climate regions is essential – IPWG, CIMO
- WMO/CIMO/GCW focus on Precip in Cold Regions – strong link with GPCC
- GPM - Ground Validation in high latitudes
- What do modellers need to validate precipitation in cold climates?
- What can we do for determining precipitation in data sparse regions, such as polar and alpine?
- What do we do in Antarctica?

Impact of automation

![Impact of automation graph]
Trends in Permafrost Temperature across the Canadian Arctic

**Western Arctic**

- Fort Simpson 10m
- Northern Alberta 10m
- Wrigley 12m
- Norman Wells 10m

Mackenzie Valley

- 0.3° C per decade

**High Arctic**

- Alert BH5 15m

**Eastern Arctic**

- Iqaluit Monthly ground temperatures at 5 m depth
- Trend 1993-2000 +0.4° C per year
Warming Impact at Eureka, 2011

Landslide changes terrain

Soft Runway

Temperatures averaged around 10°C with a new daily maximum record of 17.6°C set on Tuesday, August 2nd [2011] beating the old record of 14.9°C set back in 2009 on that day.

The warm, sunny weather .... has really affected the surrounding area. I have never seen so many mudslides, slumps and sink holes .... since I have been coming here 13 years ago. It’s scary to see the permafrost melting so far and so quickly this year.

Rai le Cotey

Need for Real-time Data to address daily operations??
Need to operationalize permafrost temperature measurements?
GCW portal functionality

• It should support both
  - Data producers
  - Data consumers

• Data discovery has first priority

• Higher order functionality should be enabled wherever possible
  - Visualisation
  - Transformation
Distributed data management
The GCW web portal will make GCW data and information available to WMO Members, their partners, and users while providing the ability to exchange data and information among a distributed network of providers of data and products. The portal, as a part of WIS, will allow for rapid exchange of data, metadata, information, and analyses.
Initial Expected Outcomes for GCW Near-Term Tasks

- **Begin** implementation of IGOS Cryosphere Theme recommendations.
- **Determine** pilot projects and regional/national demonstration projects.
- **Establish** cryosphere reference sites, co-ordinate development of guidelines, best practices and standards and cryosphere terminology.
- **Develop** an inventory of satellite products for GCW.
- **Establish** GCW partnerships i.e. National and international operational and research agencies, institutes and scientific bodies involved in the generation and use of cryospheric data and information, from *in-situ*, space based and modelled sources (*NSIDC, IPA, WGMS*).
- **Implement** an operational GCW web portal.
- **Identify** needs for capacity building, communication and outreach, and identify potential funding sources.
- **PLUS IDEAS FROM THE FIRST GCW IMPLEMENTATION WORKSHOP**

*GCW can only be successful through collaboration, partnership, action*
Conceptual Framework for GCW Operation

- **WMO, Co-sponsors, Partners**
- **GCW Advisory Committee**
- **GCW Expert, Technical, & Regional Teams**

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**Users & Applications**
- research, operational centres, security, impacts, adaptation

**Outreach, Education, Capacity Building**

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**Data and Information**

**Mission**
- Provide authoritative, clear, 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.

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**GCW Portal**

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**GCW Information and Analysis**
- anomaly tracking, hot-spots, variability and change (past, present, future), global and regional products, reference station data

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**Observations**
- GCW stations, contributing networks, satellites

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**Cryosphere Products**
- operational products, reanalyses, research datasets
# GCW Tasks and Timelines

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<td>Develop web portal and interoperability with cryo info providers</td>
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### Work done to date
- Work planned or underway
- Work part of normal operations and not part of project
- Not needed
GCW can only be successful through collaboration and partnership

WMO Initiative:
Global Cryosphere Watch