Cryosphere meteorological observations

MA Lijuan

Senior Research Scientist

National Climate Center, China Meteorological Administration

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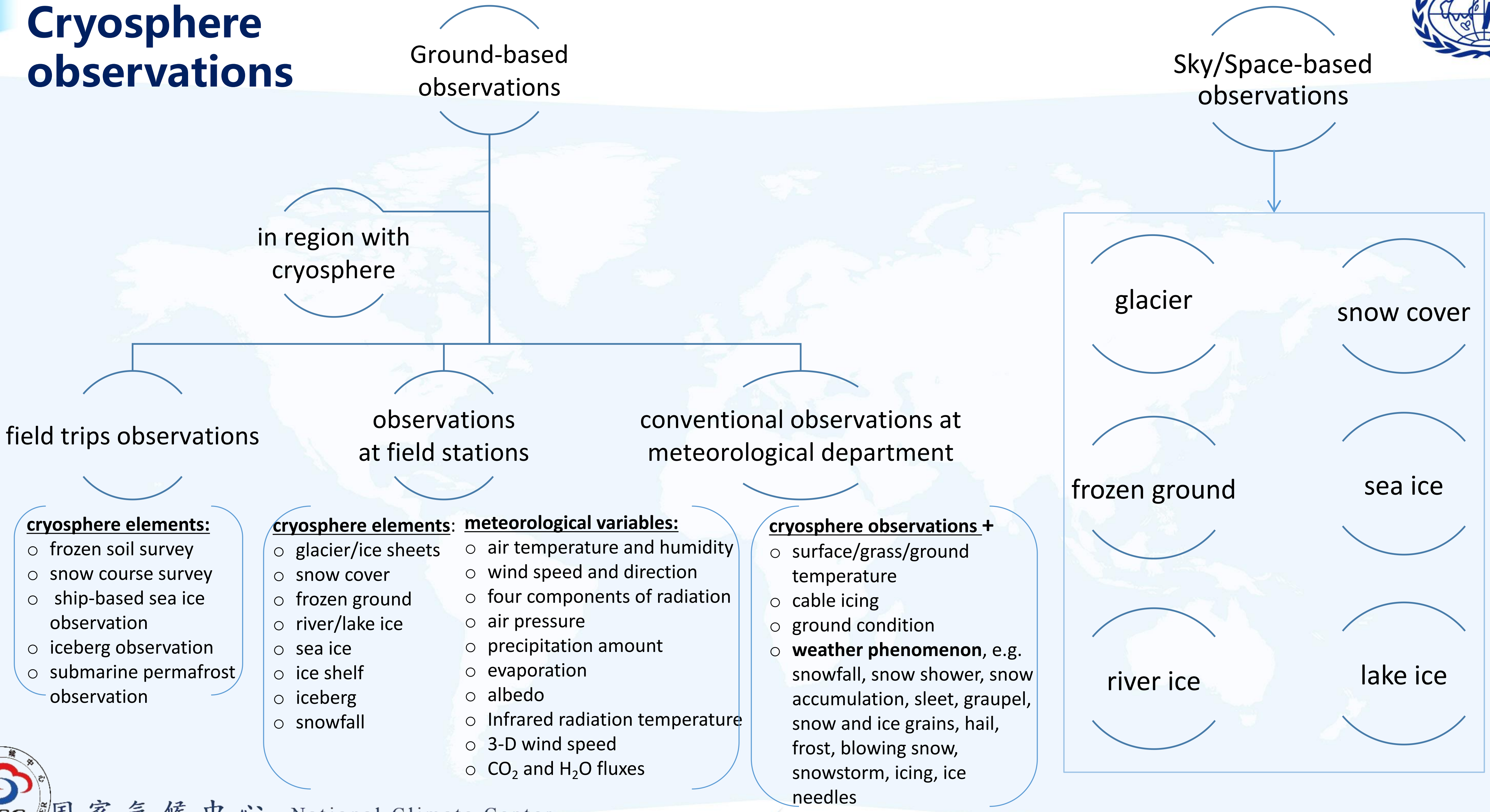
Outline

1 Cryosphere meteorological observations

2 Climatic monitoring application

3 The way of an operational cryosphere

Cryosphere observations



Ground-based observations

in region with cryosphere

field trips observations

cryosphere elements:
- frozen soil survey
- snow course survey
- ship-based sea ice observation
- iceberg observation
- submarine permafrost observation

observations at field stations

cryosphere elements:
- glacier/ice sheets
- snow cover
- frozen ground
- river/lake ice
- sea ice
- ice shelf
- iceberg
- snowfall

meteorological variables:
- air temperature and humidity
- wind speed and direction
- four components of radiation
- air pressure
- precipitation amount
- evaporation
- albedo
- Infrared radiation temperature
- 3-D wind speed
- CO_2 and H_2O fluxes

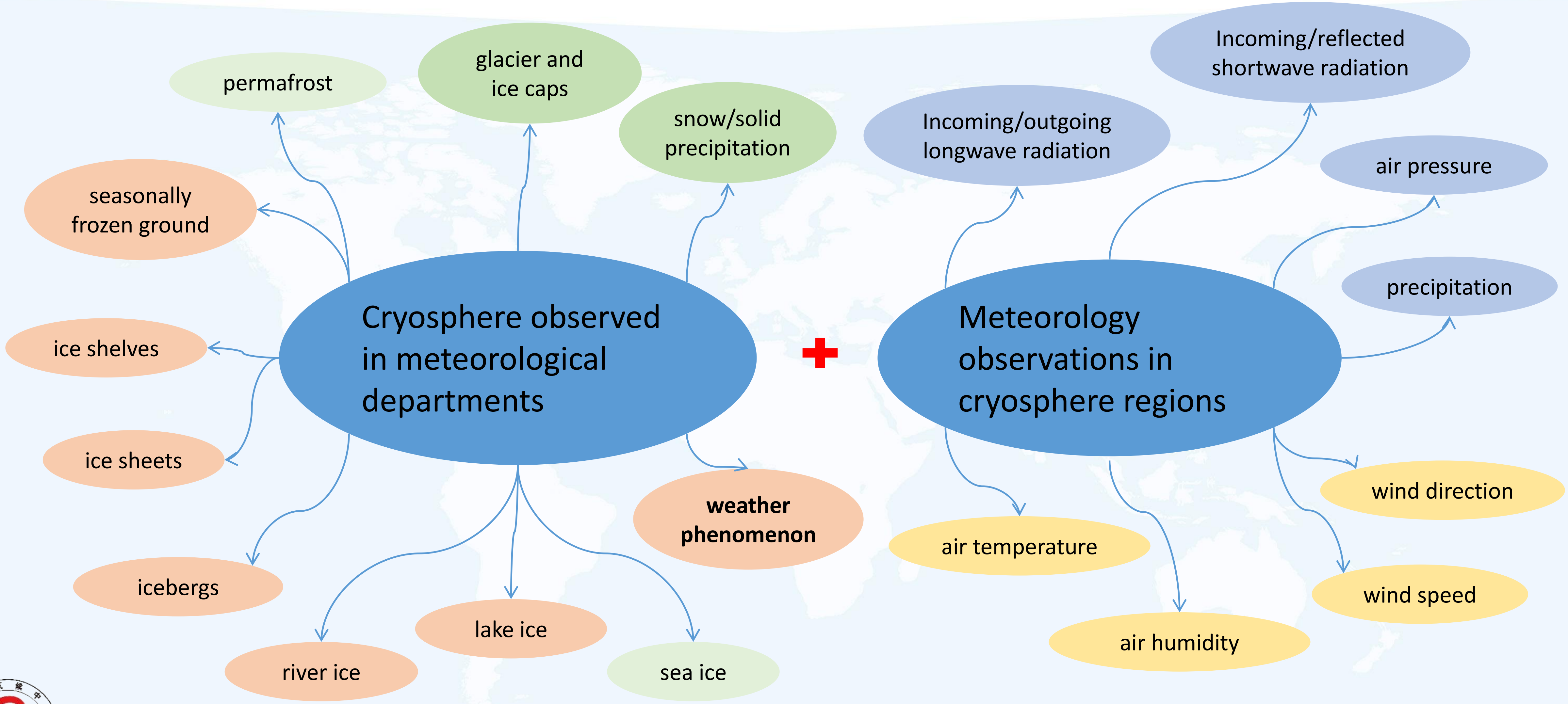
conventional observations at meteorological department

cryosphere observations +
- surface/grass/ground temperature
- cable icing
- ground condition
- **weather phenomenon**, e.g. snowfall, snow shower, snow accumulation, sleet, graupel, snow and ice grains, hail, frost, blowing snow, snowstorm, icing, ice needles

Sky/Space-based observations

- glacier
- snow cover
- frozen ground
- sea ice
- river ice
- lake ice

1. Cryosphere meteorological observations

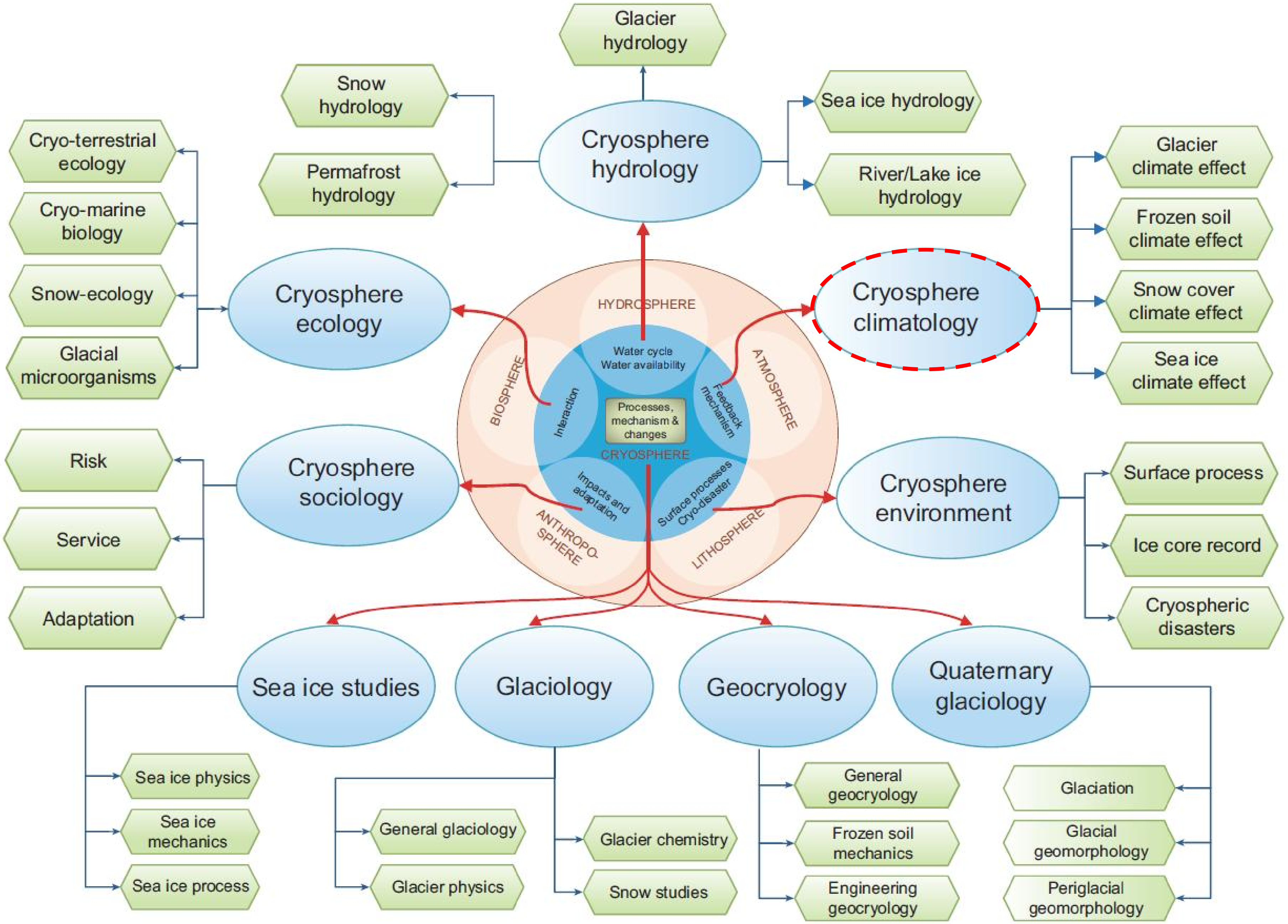


Best practices have been published by WMO.

Ancillary meteo. obs. required desired , as recommended by GCW.

Disciplinary system of Cryospheric Science

Cryosphere climatology is a science that studies the influence and feedback of the cryosphere and its constituent elements on the atmosphere, and serves for the sustainable development of social economy.



Cryosphere hydrology
- Glacier hydrology
- Snow hydrology
- Permafrost hydrology
- Sea ice hydrology
- River/Lake ice hydrology

Cryosphere ecology
- Cryo-terrestrial ecology
- Cryo-marine biology
- Snow-ecology
- Glacial microorganisms

Cryosphere climatology
- Glacier climate effect
- Frozen soil climate effect
- Snow cover climate effect
- Sea ice climate effect

Cryosphere sociology
- Risk
- Service
- Adaptation

Cryosphere environment
- Surface process
- Ice core record
- Cryospheric disasters

Sea ice studies
- Sea ice physics
- Sea ice mechanics
- Sea ice process

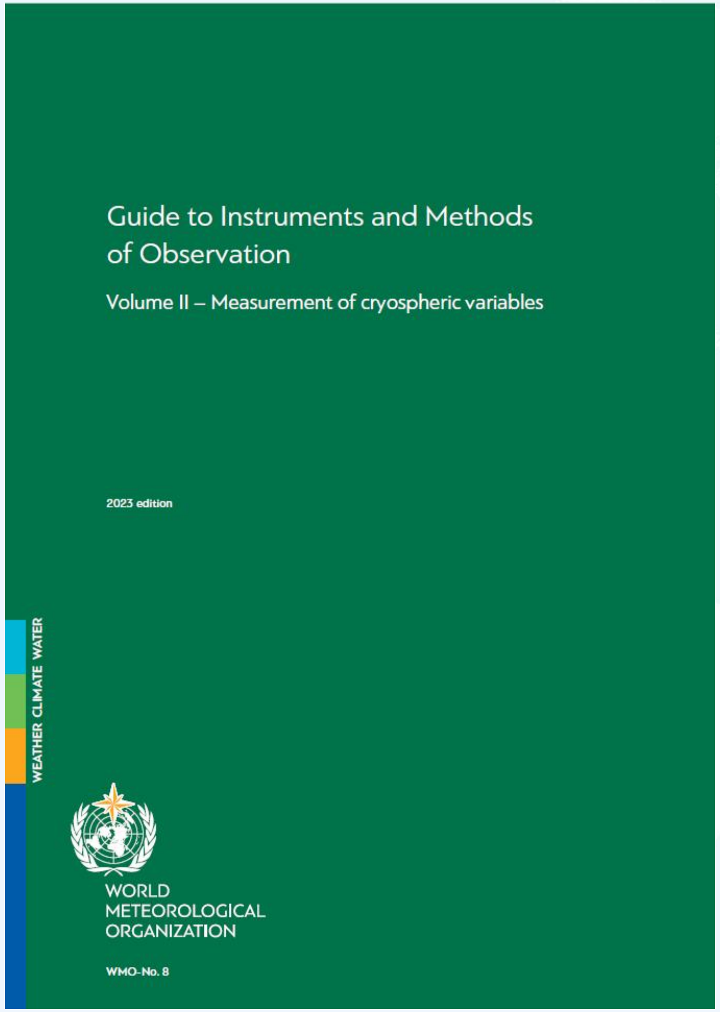
Glaciology
- General glaciology
- Glacier physics
- Glacier chemistry
- Snow studies

Geocryology
- General geocryology
- Frozen soil mechanics
- Engineering geocryology

Quaternary glaciology
- Glaciation
- Glacial geomorphology
- Periglacial geomorphology

Qin et al., 2018

Follow relevant specifications/best practices released by WMO



Guide to Instruments and Methods of Observation

Volume II – Measurement of cryospheric variables

2023 edition

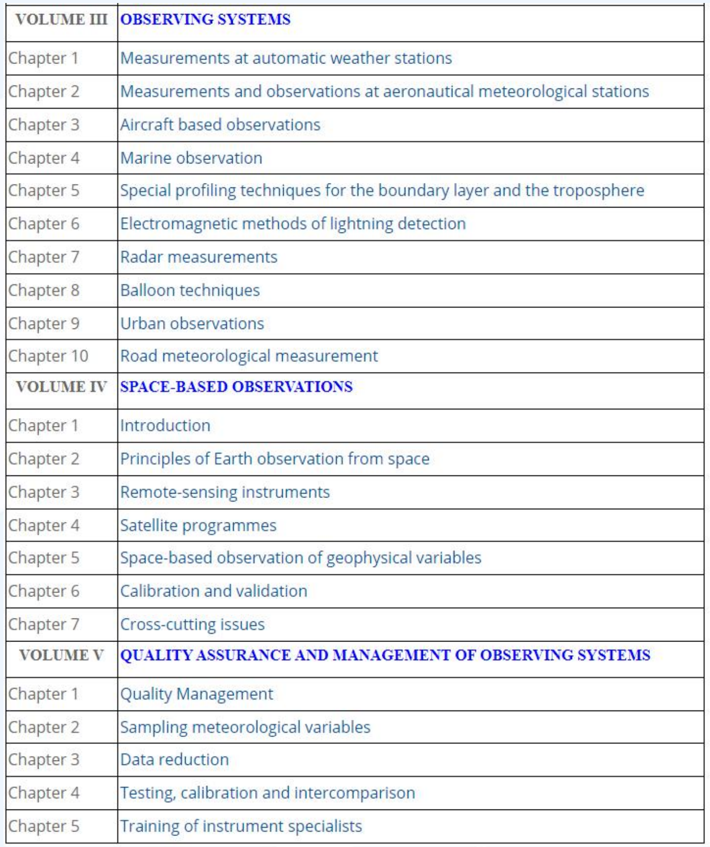
WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION

WMO-No. 8

VOLUME I	MEASUREMENT OF METEOROLOGICAL VARIABLES
Chapter 1	General
Chapter 2	Measurement of temperature
Chapter 3	Measurement of atmospheric pressure
Chapter 4	Measurement of humidity
Chapter 5	Measurement of surface wind
Chapter 6	Measurement of precipitation
Chapter 7	Measurement of radiation
Chapter 8	Measurement of sunshine duration
Chapter 9	Measurement of visibility
Chapter 10	Measurement of evaporation
Chapter 11	Measurement of soil moisture
Chapter 12	Measurement of upper-air pressure, temperature and humidity
Chapter 13	Measurement of upper wind
Chapter 14	Observation of present and past weather; state of the ground
Chapter 15	Observation and measurement of clouds
Chapter 16	Measurement of atmospheric composition
VOLUME II	MEASUREMENT OF CRYOSPHERIC VARIABLES
Chapter 1	General
Chapter 2	Measurement of snow
Chapter 3	Measurement of glaciers

https://library.wmo.int/viewer/68660/download?file=8_II-2023_en.pdf&type=pdf&navigator=1



VOLUME III	OBSERVING SYSTEMS
Chapter 1	Measurements at automatic weather stations
Chapter 2	Measurements and observations at aeronautical meteorological stations
Chapter 3	Aircraft based observations
Chapter 4	Marine observation
Chapter 5	Special profiling techniques for the boundary layer and the troposphere
Chapter 6	Electromagnetic methods of lightning detection
Chapter 7	Radar measurements
Chapter 8	Balloon techniques
Chapter 9	Urban observations
Chapter 10	Road meteorological measurement
VOLUME IV	SPACE-BASED OBSERVATIONS
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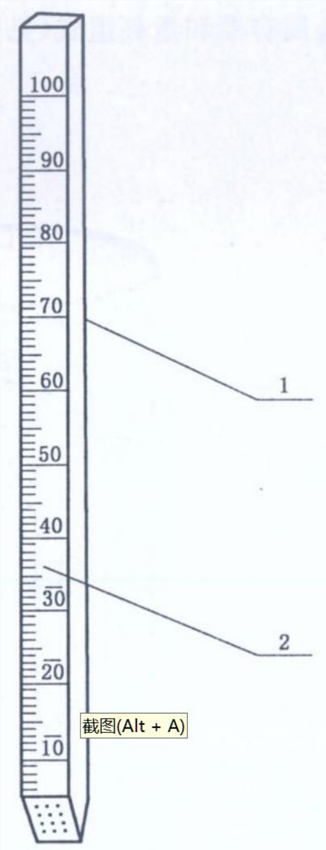
Chapter 2	Principles of Earth observation from space
Chapter 3	Remote-sensing instruments
Chapter 4	Satellite programmes
Chapter 5	Space-based observation of geophysical variables
Chapter 6	Calibration and validation
Chapter 7	Cross-cutting issues
VOLUME V	QUALITY ASSURANCE AND MANAGEMENT OF OBSERVING SYSTEMS
Chapter 1	Quality Management
Chapter 2	Sampling meteorological variables
Chapter 3	Data reduction
Chapter 4	Testing, calibration and intercomparison
Chapter 5	Training of instrument specialists

adapt at national level according to availability, resources, etc. of instruments

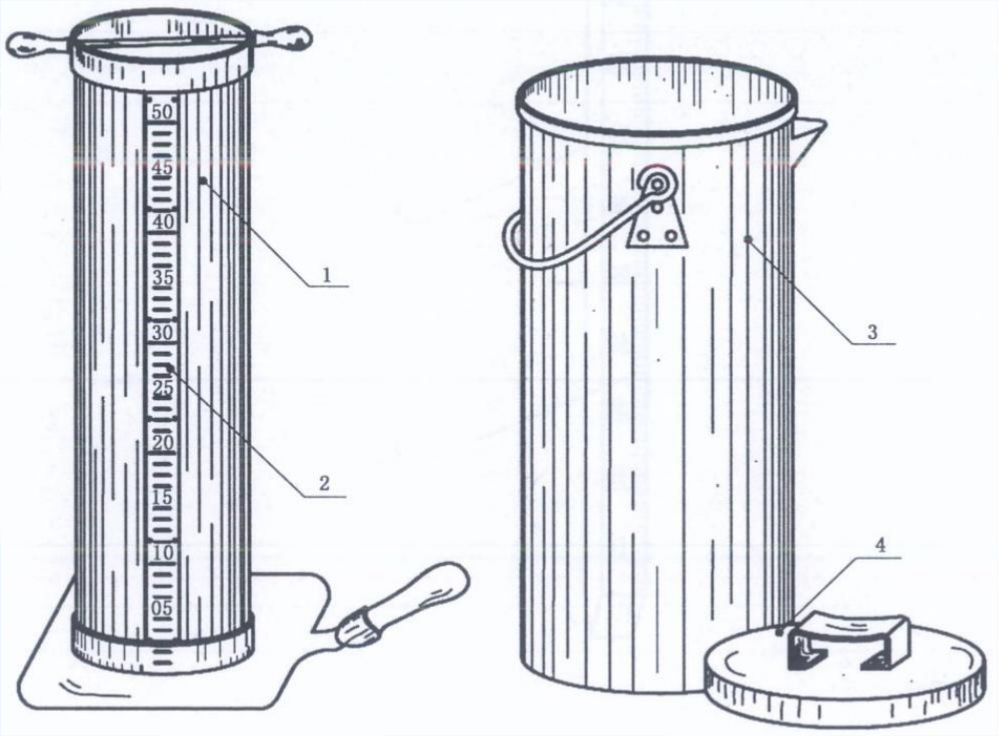
Snow cover – manual observation of snow depth and snow pressure

GB/T 35229—2017



snow stake

snow depth in cm



Volumetric snow gauge

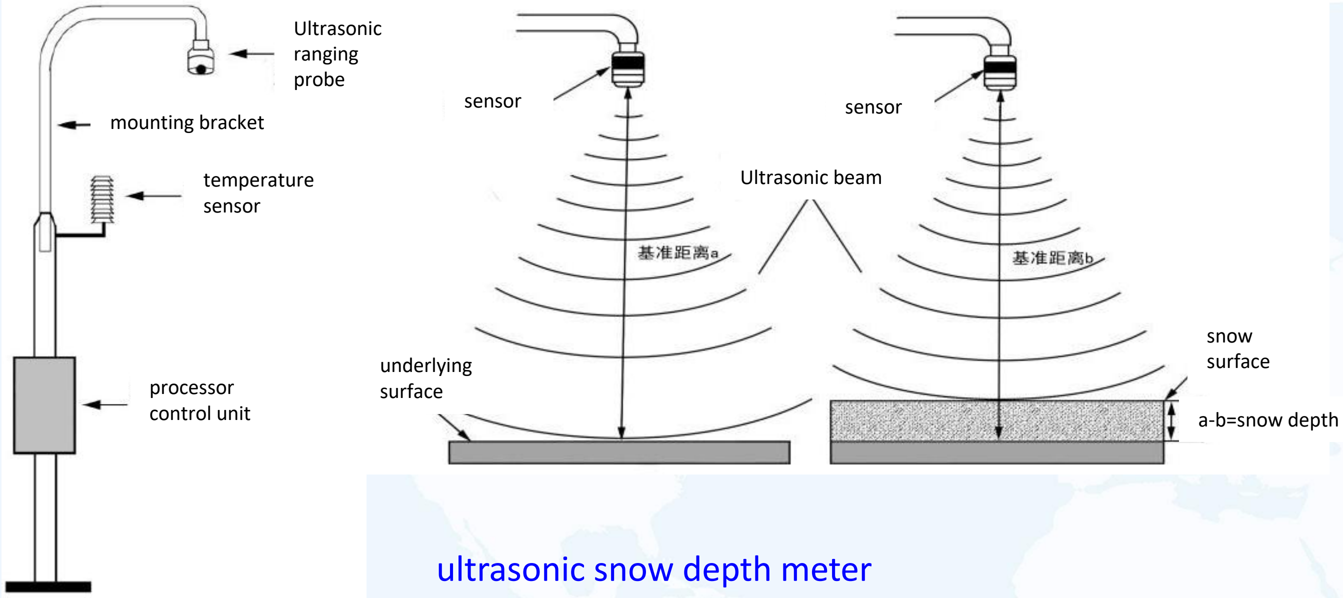
snow pressure (P) in g/cm^2

Snow pressure → SWE (mm):

$$SWE = P / \rho_w * 10$$

$$\rho_w = 1 \text{ g/cm}^3$$

Snow cover – automatic observation of snow depth

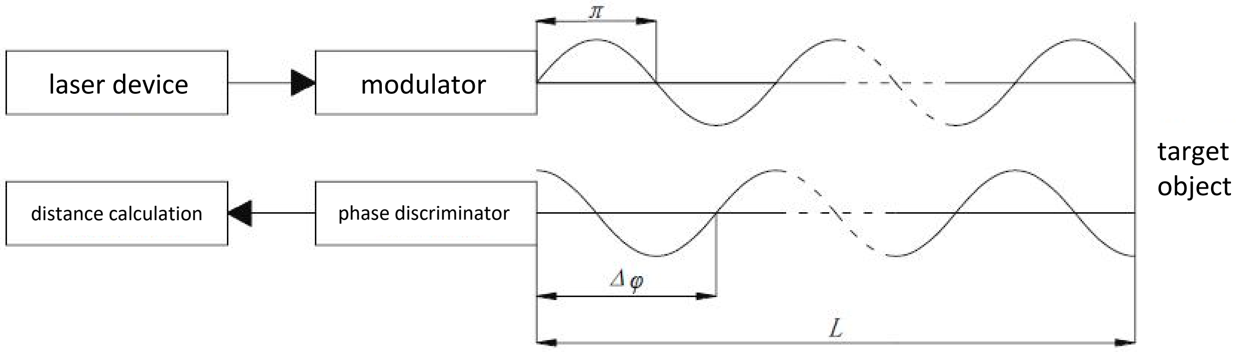


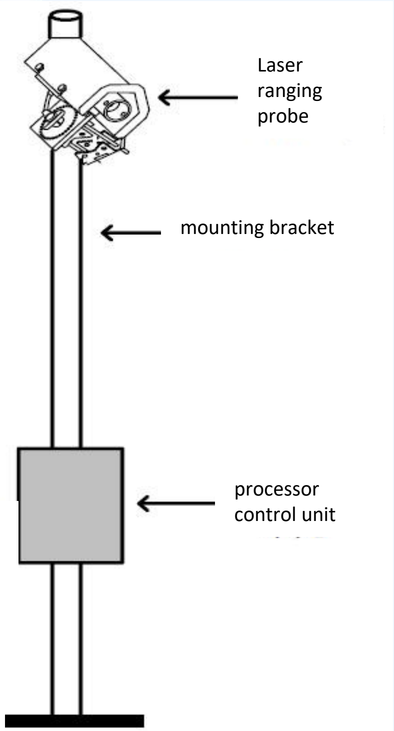
ultrasonic snow depth meter

Ultrasonic snow depth meter **calculates the distance from the ranging probe to the target by measuring the time of the ultrasonic pulse launching and returning**, and realizes the automatic continuous monitoring of the snow depth.

- The laser beam is modulated by the frequency of radio band, and the phase delay generated by the modulation light is measured.
- Then the distance represented by the phase delay is converted according to the wavelength of the modulation light.

Laser snow depth meter



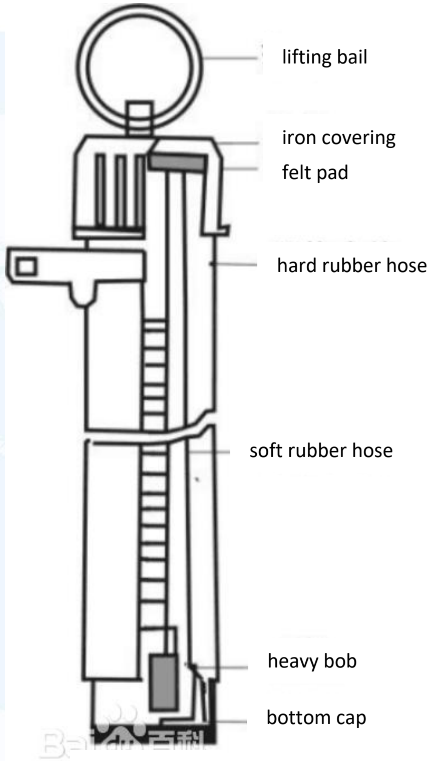


Frozen Ground – manual observation of depth of frozen soil

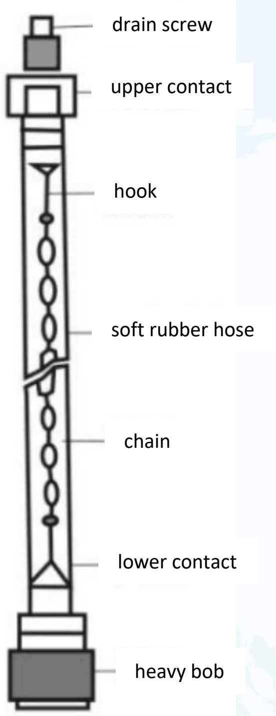
GB/T 35234—2017

frozen soil apparatus

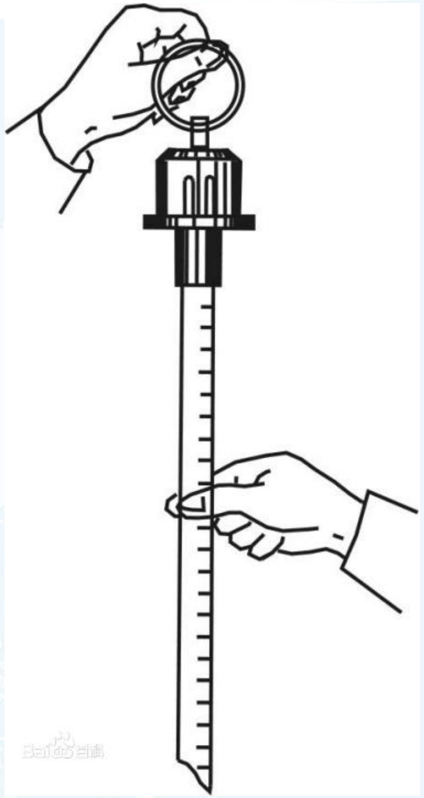
When the ground temperature drops to 0°C or below and the soil begins to freeze, the frozen soil is observed once a day at 8 o'clock until the soil is completely thawed the following year.



Apparatus



Inner tube

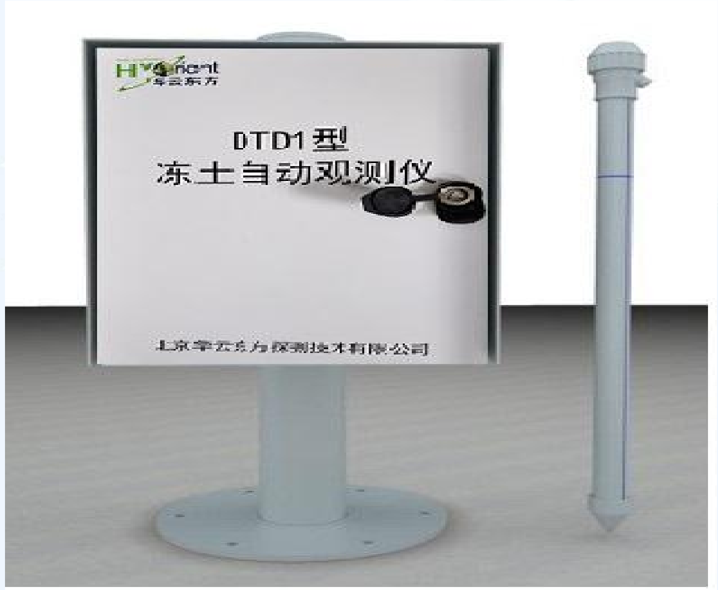


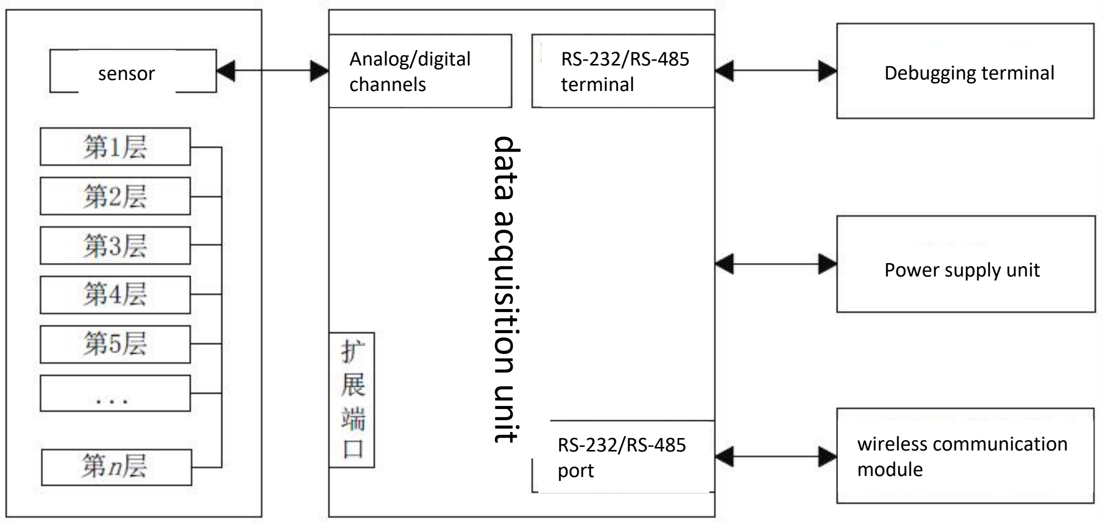
- lift the iron cover and the inner tube with one hand
- use the other hand to touch the position of ice in the inner tube
- read the corresponding scale number at both ends of the ice, representing the upper and lower depth of the frozen layer, respectively
- record the number of depth in the observation book
- reinsert the inner tube and close the cover
- mark both the upper and lower limits as "0“ when the scale number is less than 0.5cm

Frozen Ground – automatic observation of freezing layers and freezing depth (cm)

QX/T 691—2023

According to the **freeze-thaw characteristics of soil containing water**, the automatic observation instrument uses **thresholds** to judge the freezing layers and depth of frozen soil by measuring water phase, soil frequency domain reflection (FDR) or temperature identification.





structure of frozen soil automatic observer

- **frozen-resistance type**

Based on the principle that physical properties of **water volume and resistance will change with the water phase changes**, the freezing level and upper and lower depths of frozen soil are obtained by measuring the relevant physical properties using non-pure water as induction medium.

- **capacitor type**

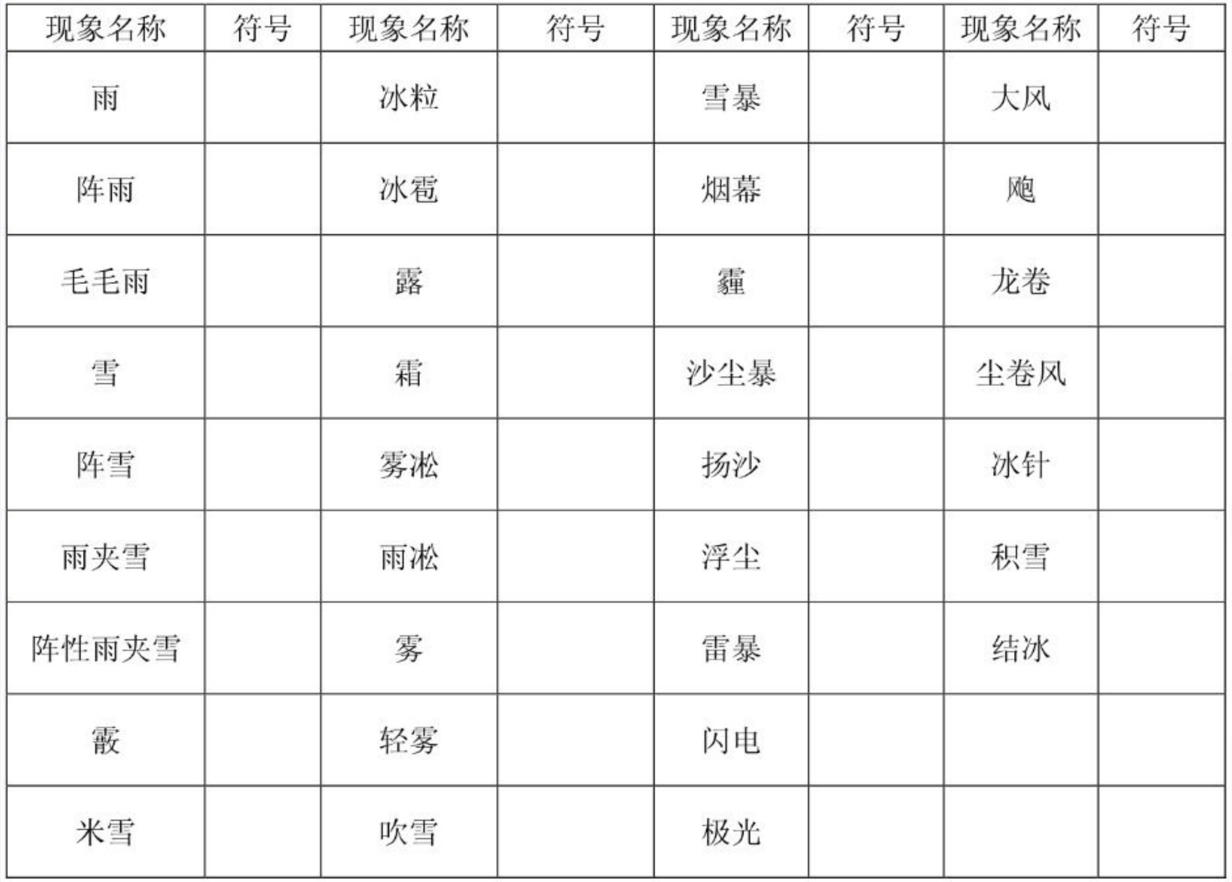
The frequency of LC oscillation circuit responds to **changes in water dielectric constant when there is phase changes of water in soil**. The discriminant model of soil freeze-thaw state was established according to the frequency variation rule and soil temperature, and the freezing level and upper and lower depths are obtained.

- **thermometric type**

The freezing level and upper and lower depths are obtained according to the characteristic of **temperature changes when water condensing into ice or ice melting into water**, combined with the freezing point determination algorithm.

Weather phenomenon – manual observations

GB/T 35224—2017

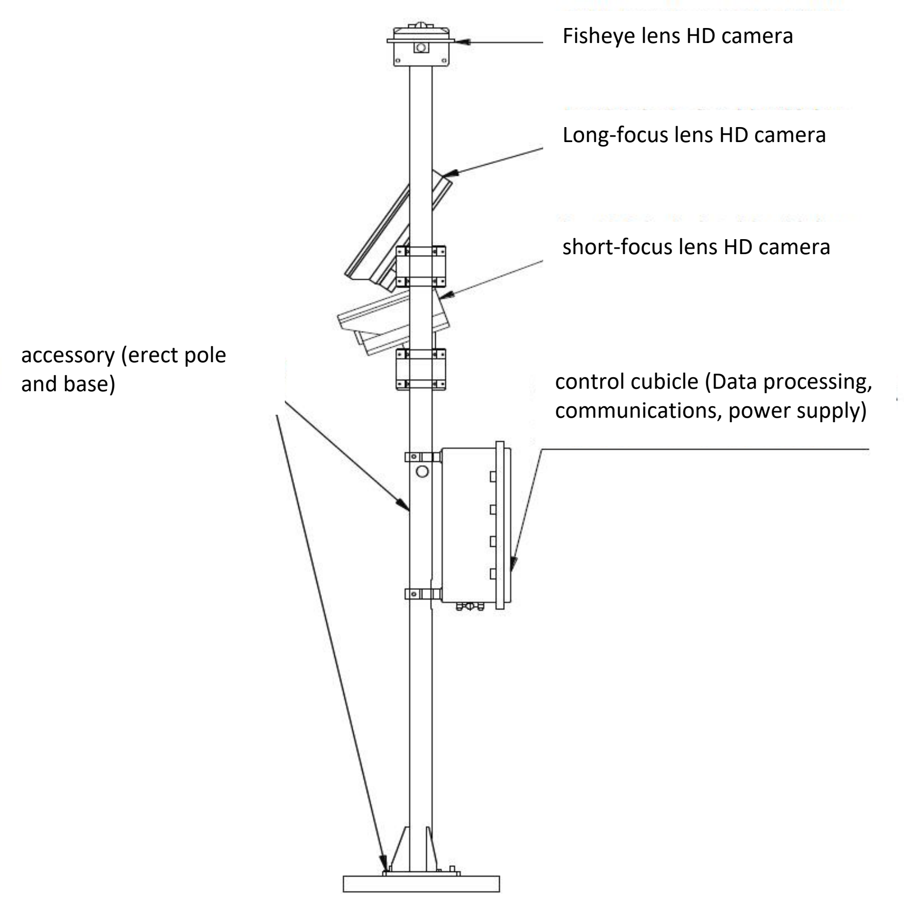


现象名称	符号	现象名称	符号	现象名称	符号	现象名称	符号
雨		冰粒		雪暴		大风	
阵雨		冰雹		烟幕		飑	
毛毛雨		露		霾		龙卷	
雪		霜		沙尘暴		尘卷风	
阵雪		雾凇		扬沙		冰针	
雨夹雪		雨凇		浮尘		积雪	
阵性雨夹雪		雾		雷暴		结冰	
霰		轻雾		闪电			
米雪		吹雪		极光			

Weather phenomena record sheet

- Mark corresponding symbol in the sheet **whenever any** type of weather phenomena occurs in the visual area.
- Some need to record start and end times, e.g. snowfall, snow shower, sleet, glaze, rime, graupel, snowstorm, etc.
- Some do not need to record start and end times, e.g., snow accumulation, frost, icing, ice needles, etc.

Weather phenomenon – automatic observation



Weather phenomena video intelligent observer

- **computer vision principle** (total cloud cover, icing, snow accumulation, etc.): a kind of simulation of biological vision by using computer and related equipment. It can obtain 3D information of corresponding scene by processing collected video or picture.
- **deep learning principle** (cloud shape, ground condensation phenomena – frost, dew, glaze, rime): a kind of algorithm based on artificial neural network for data representation learning.
- **Comprehensive identification** from multi-source observations (cloud cover, **cloud height**, ground condensation phenomenon – dew, frost, glaze, rime, **visual range disturbance phenomenon – fog, light fog, haze, floating dust, sandstorm, blowing sand**, and **thunderstorms**, snow cover, **icing**, snow depth and **snow pressure**, **frozen soil** and etc.): through the rapid update of numerical products from **satellite, sounding, automatic weather station, lightning detection, lightning imaging**, uniformly generated at national level and distributed to provincial level.

Anduo Meteorological Observation Station (a.s.l. 4802 m)

The highest manned meteo. station in the world.

Sejra Pass National Meteorological Observation Station (a.s.l. 4720 m)

-- automatic station

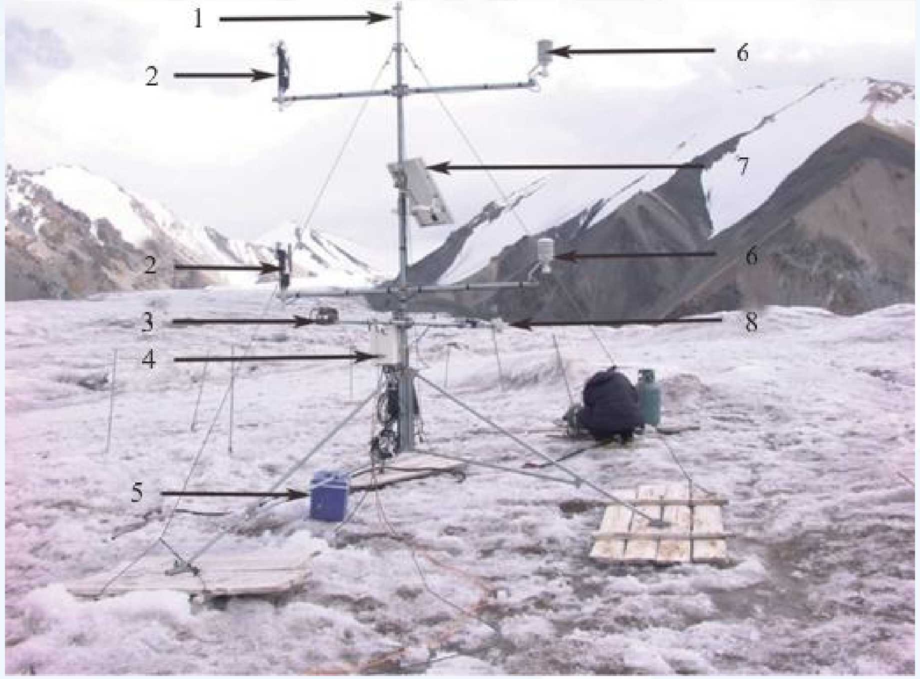
Daxigou Meteorological Observation Station (a.s.l. 3543.8 m)

-- close to Urumqi Glacier No.1, Tianshan Mountains

Automatic weather stations for the cryosphere

☐ The arrangement of observations should be **flexible**, the instruments should be **portable**, and the meteorological parameters should be observed with **unique specifications**.

☐ The sensors for meteorological observation must be characterized by **low temperature resistance**, **a wide measurement range**, **high precision** and **easy maintenance**.



Surface automatic weather site

1. Lightning rod; 2. Wind speed and direction sensor; 3. Snow depth sensors; 4. Data collector; 5. Battery; 6. Temperature and humidity sensors; 7. Solar panels; 8. Four components of radiation

Eddy dynamic system on ice surface

1. Lightning rod; 2. Temperature and humidity sensor; 3.Data logger; 4. Data processor; 5. 3-D ultrasonic wind speed/direction sensor; 6. Batteries

Qin et al., 2021

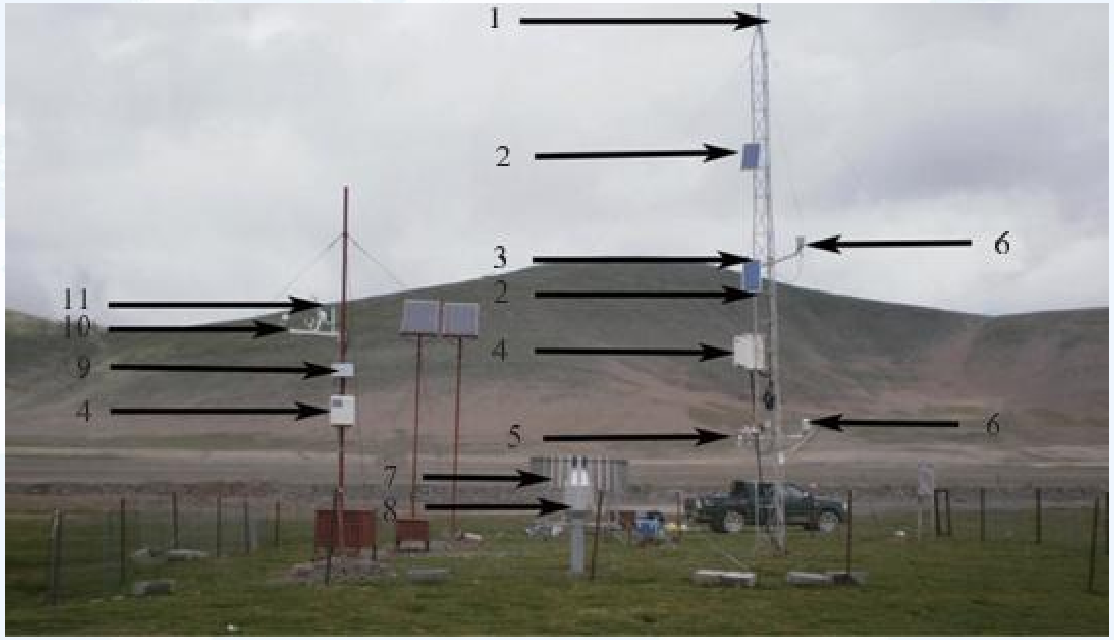
① monitor the **meteorological factors affecting** glaciers, snow cover, permafrost and melt water runoff from snow and ice;

② study the **micro-climatic characteristics** of glaciers, snow cover and permafrost regions;

③ the **energy-mass exchange characteristics** on the surfaces of glaciers and permafrost.

T200B rain gauge

1. Solar panel; 2. Data logger; 3. Rain and snow gauge container;
4. Wind protection fence



meteorological observation field for permafrost

1. Lightning rod; 2. Solar panels; 3. Wind speed and direction sensor;
4. Data logger; 5. Snow depth sensor; 6. Temperature and humidity collector;
7. Windbreak fence; 8. Snow and rain gauge container; 9. Data processor;
10. CO2/H2O analyzer; 11. 3-D ultrasonic wind speed and direction sensor

Qin et al., 2021

WR

- On May 4, 2022, an automatic weather station was built at an altitude of 8,830 m on the north slope of Mount Qomolangma, by the second Comprehensive Scientific Expedition to the Qinghai-Tibet Plateau.
- They also built seven automatic meteorological observation stations along the route from 5,200 m to 8,300 m (a.s.l.), marking the initial completion of China's gradient meteorological observation system for Mount Qomolangma.

Operational process and specification of metadata and raw data collection

Four types of data:

- ○ automatic observation data
- ○ automatic integrated identification data
- ○ status data (running status and information about the device)
- ○ metadata

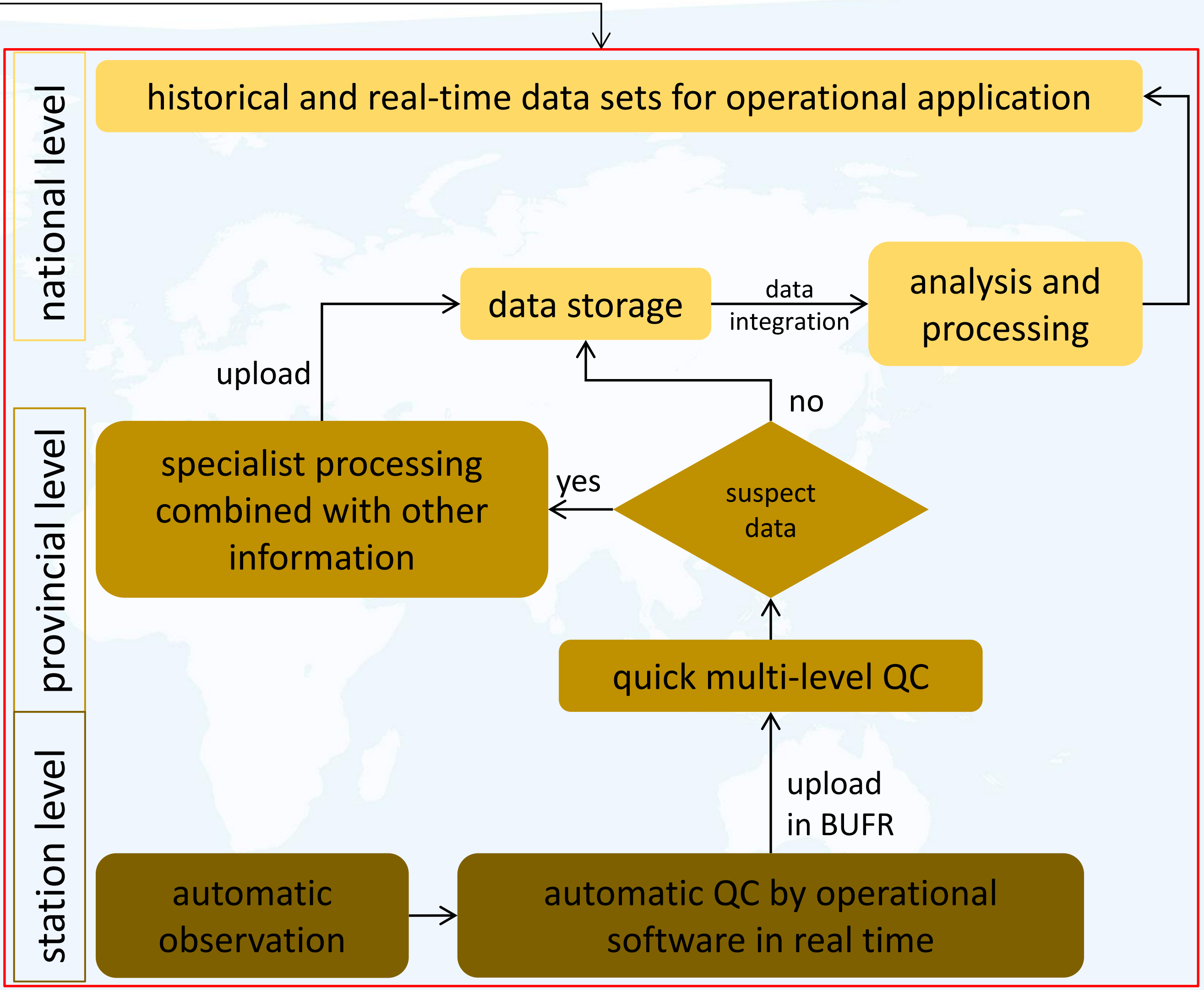
🟥 Data acquisition and transmission process

🟥 Data quality control process

🟦 Operational monitoring process

🟩 Equipment support process

warning/alert: this process monitors the integrity, timeliness and quality of operation status, data transmission, processing and storage.



national level

historical and real-time data sets for operational application

data storage

data integration

analysis and processing

upload

no

provincial level

specialist processing combined with other information

yes

suspect data

quick multi-level QC

upload in BUFR

station level

automatic observation

automatic QC by operational software in real time

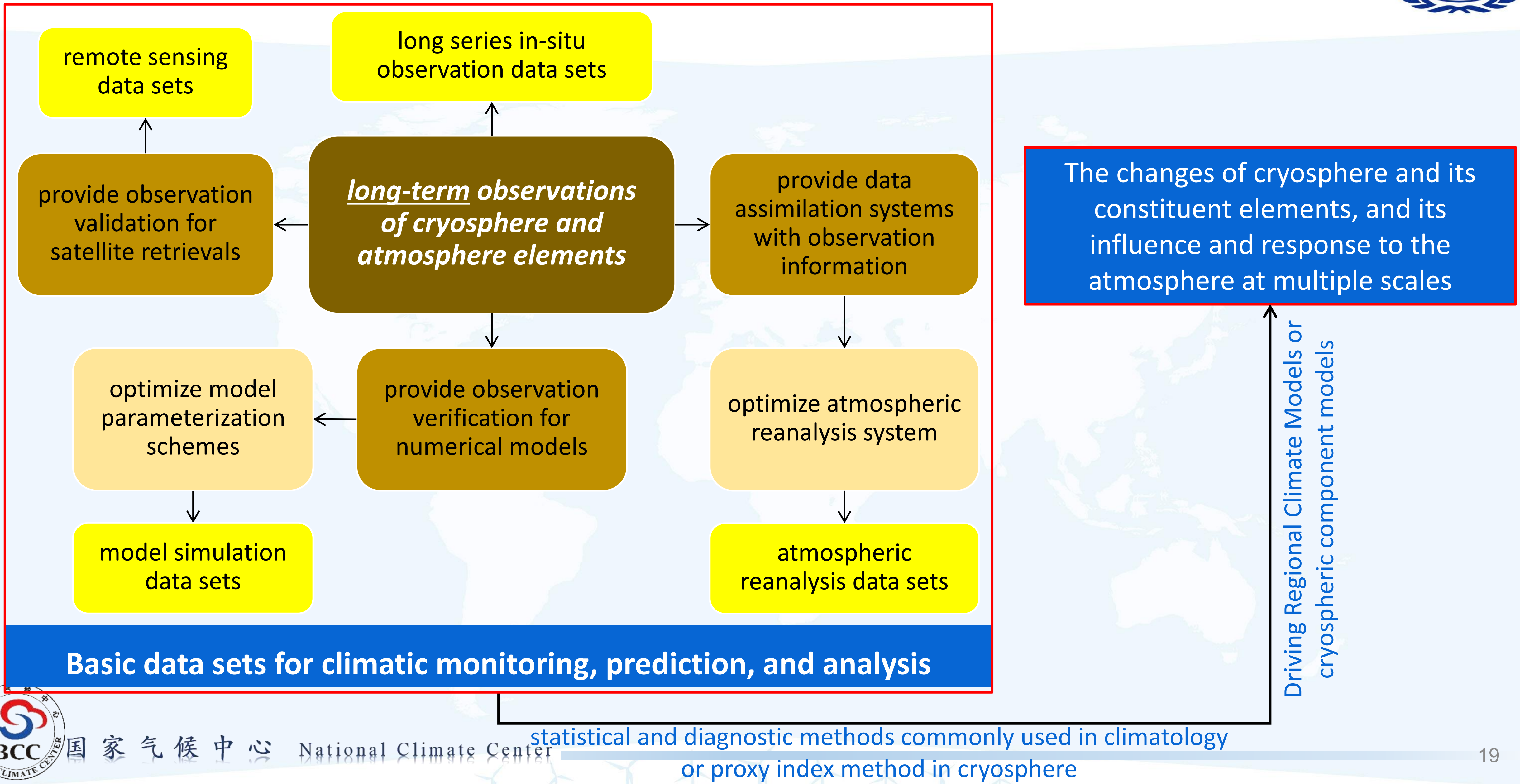
Outline

1 Cryosphere meteorological observations

2 Climatic monitoring application

3 Status of An Operational Cryosphere

General process of applying in-situ observations for cryosphere climatology



remote sensing data sets

long series in-situ observation data sets

provide observation validation for satellite retrievals

<u>long-term</u> observations of cryosphere and atmosphere elements

provide data assimilation systems with observation information

optimize model parameterization schemes

provide observation verification for numerical models

optimize atmospheric reanalysis system

model simulation data sets

atmospheric reanalysis data sets

Basic data sets for climatic monitoring, prediction, and analysis

statistical and diagnostic methods commonly used in climatology or proxy index method in cryosphere

Driving Regional Climate Models or cryospheric component models

The changes of cryosphere and its constituent elements, and its influence and response to the atmosphere at multiple scales

WMO’s effort in building observing networks

Observing Network of WMO

WMO does not observe by itself, but develop observing networks based on users’ needs, in turn to promote improvement of meteo. infrastructure.

WWW: WMO Flagship Programme

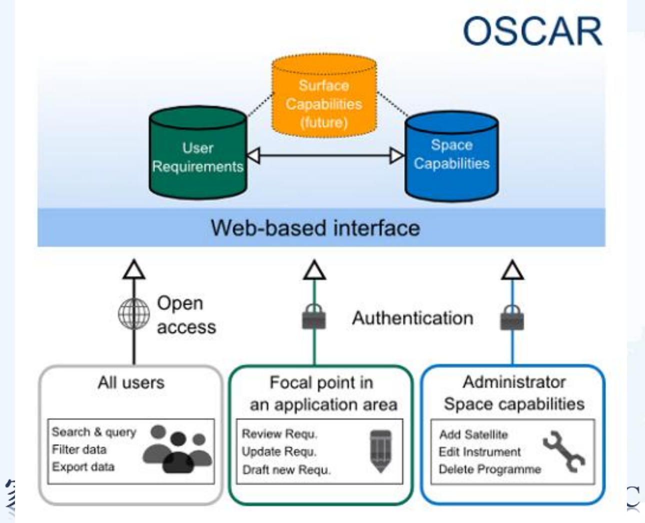
WIGOS: WMO Integrated Global Observing System;

WIS: WMO Information System

WMO Integrated Global Observing System (WIGOS)

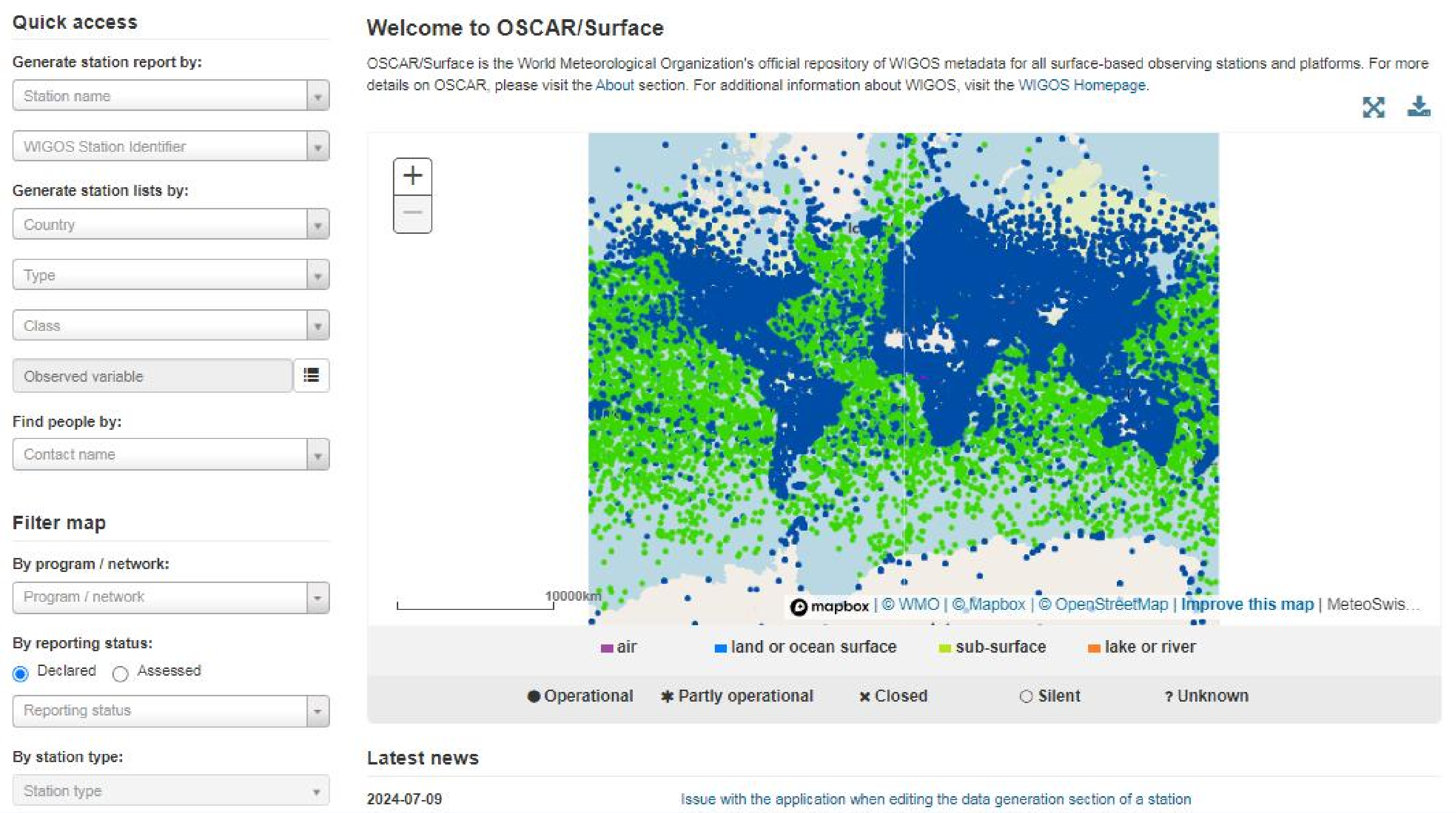
WIGOS Component Systems

- Global Observing System (WWW/**GOS**)
- Observing component of Global Atmospheric Watch (**GAW**)
- WMO Hydrological Observations (including **WHYCOS**)
- Observing component of Global Cryosphere Watch (**GCW**)



OSCAR

Station and Observation metadata:
Observing Systems Capability Analysis and Review Tool (OSCAR)



Quick access

Generate station report by:

Station name

WIGOS Station Identifier

Generate station lists by:

Country

Type

Class

Observed variable

Find people by:

Contact name

Filter map

By program / network:

Program / network

By reporting status:

● Declared ○ Assessed

Reporting status

By station type:

Station type

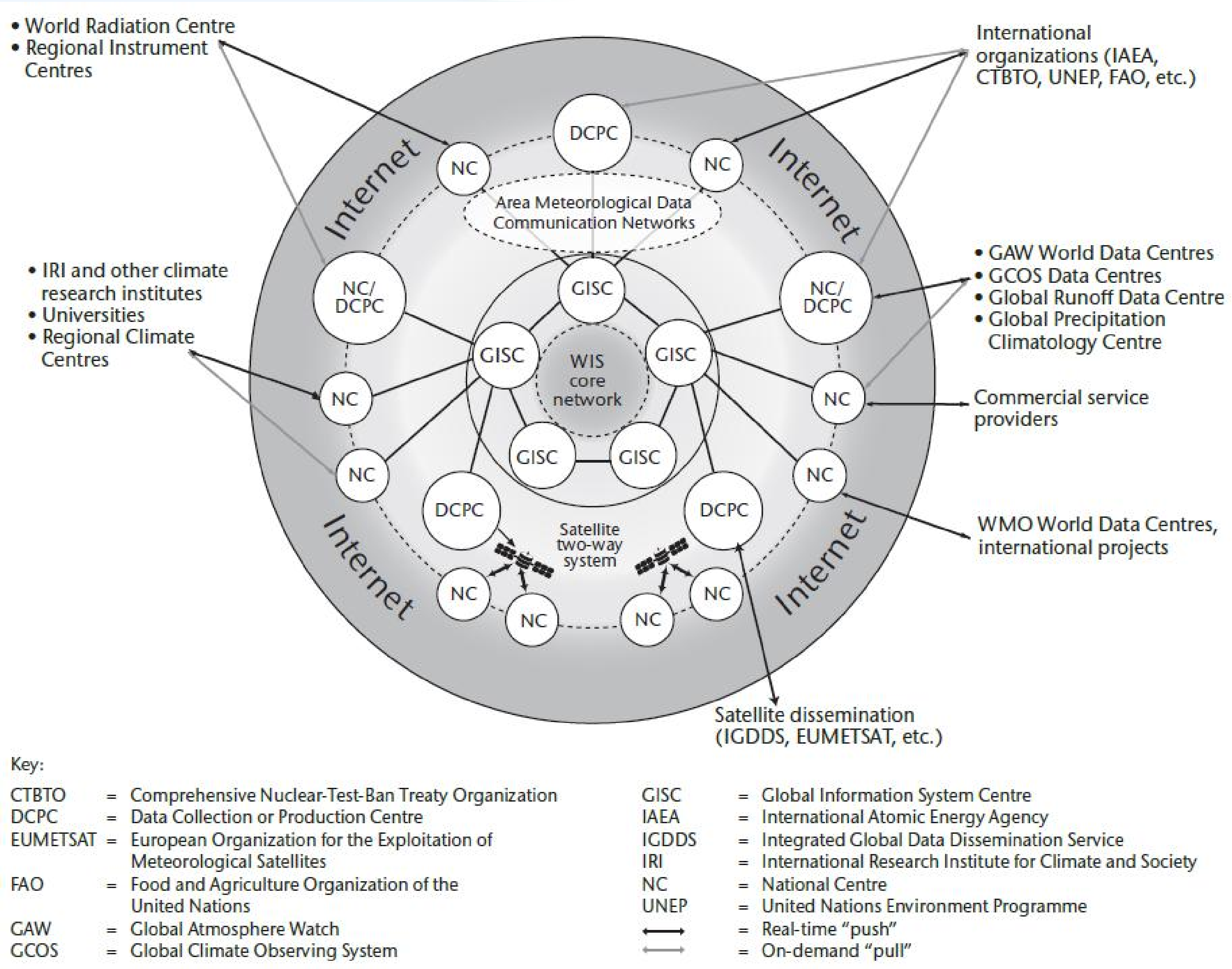
Welcome to OSCAR/Surface

OSCAR/Surface is the World Meteorological Organization's official repository of WIGOS metadata for all surface-based observing stations and platforms. For more details on OSCAR, please visit the About section. For additional information about WIGOS, visit the WIGOS Homepage.

Latest news

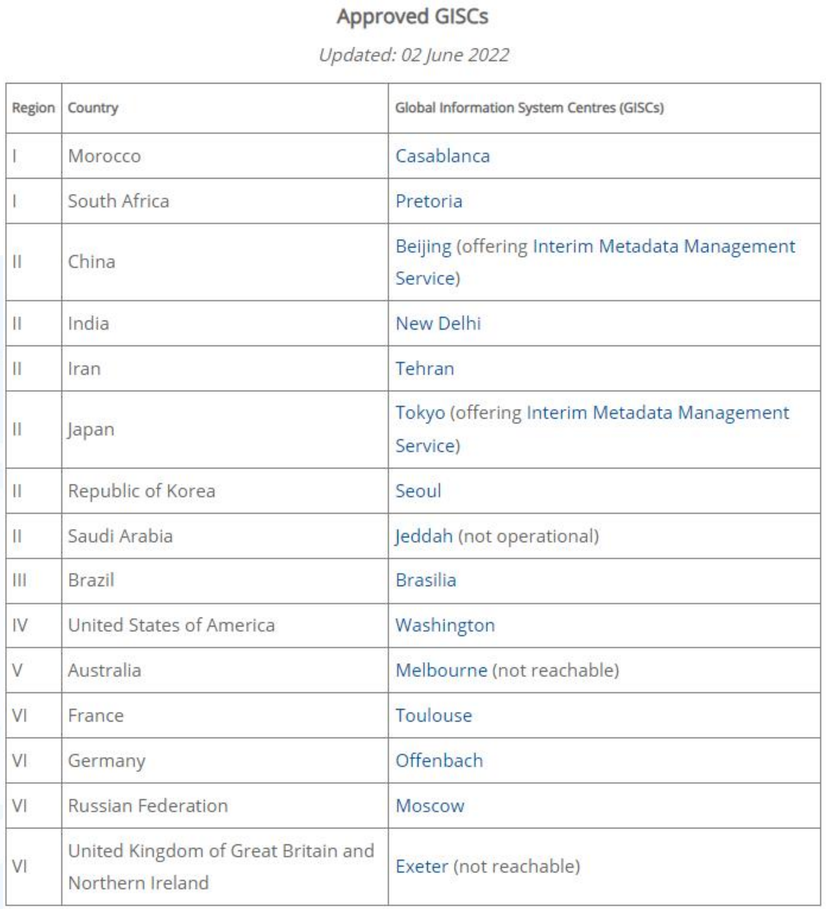
2024-07-09 Issue with the application when editing the data generation section of a station

WMO Information System (WIS)



Key:

CTBTO	= Comprehensive Nuclear-Test-Ban Treaty Organization	GISC	= Global Information System Centre
DCPC	= Data Collection or Production Centre	IAEA	= International Atomic Energy Agency
EUMETSAT	= European Organization for the Exploitation of Meteorological Satellites	IGDDS	= Integrated Global Data Dissemination Service
		IRI	= International Research Institute for Climate and Society
FAO	= Food and Agriculture Organization of the United Nations	NC	= National Centre
		UNEP	= United Nations Environment Programme
GAW	= Global Atmosphere Watch	⟷	= Real-time "push"
GCOS	= Global Climate Observing System	⟷	= On-demand "pull"



Approved GISCs

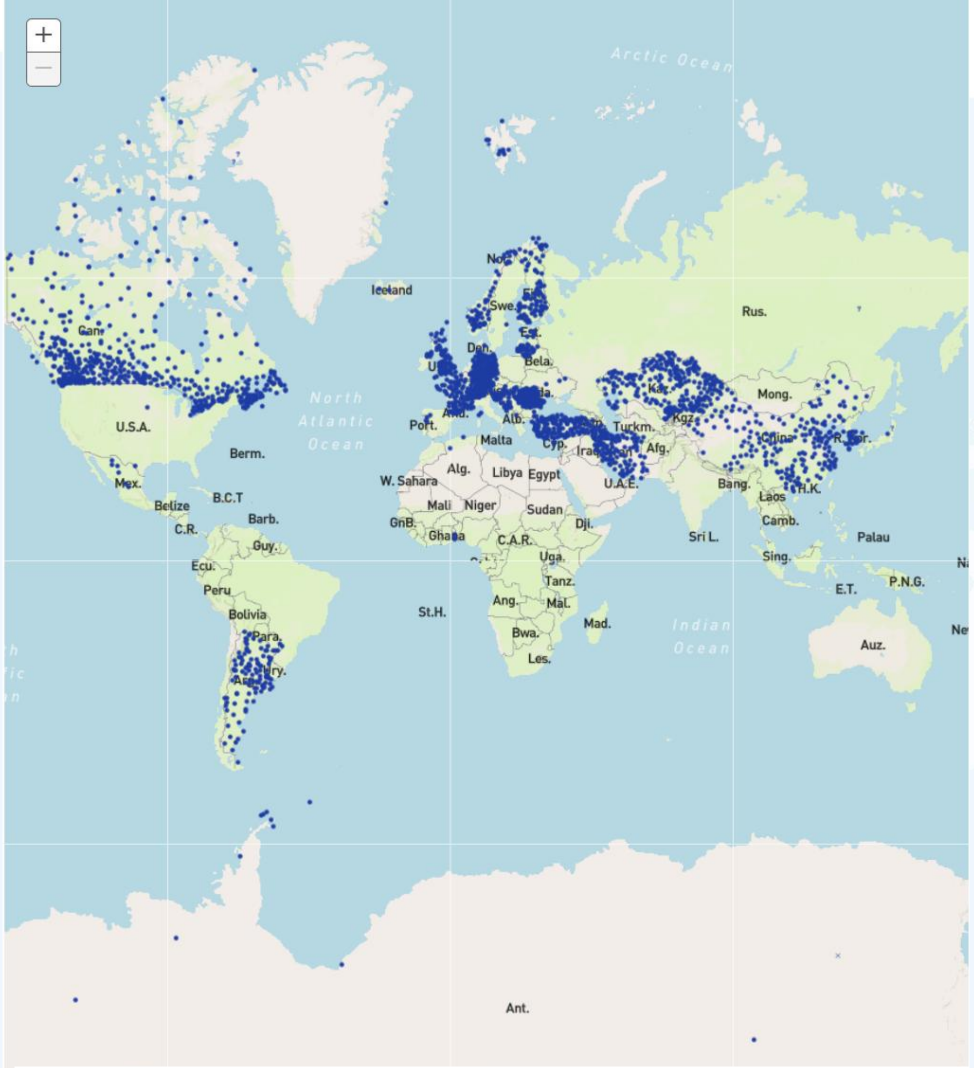
Updated: 02 June 2022

Region	Country	Global Information System Centres (GISCs)
I	Morocco	Casablanca
I	South Africa	Pretoria
II	China	Beijing (offering Interim Metadata Management Service)
II	India	New Delhi
II	Iran	Tehran
II	Japan	Tokyo (offering Interim Metadata Management Service)
II	Republic of Korea	Seoul
II	Saudi Arabia	Jeddah (not operational)
III	Brazil	Brasilia
IV	United States of America	Washington
V	Australia	Melbourne (not reachable)
VI	France	Toulouse
VI	Germany	Offenbach
VI	Russian Federation	Moscow
VI	United Kingdom of Great Britain and Northern Ireland	Exeter (not reachable)

WWW Centres	WIS Centres
NMC	NC
RSMC	DCPC
WMC	DCPC and/or GISC
RTH	DCPC
RTH on MTN	DCPC and/or GISC
Others	NC and/or DCPC

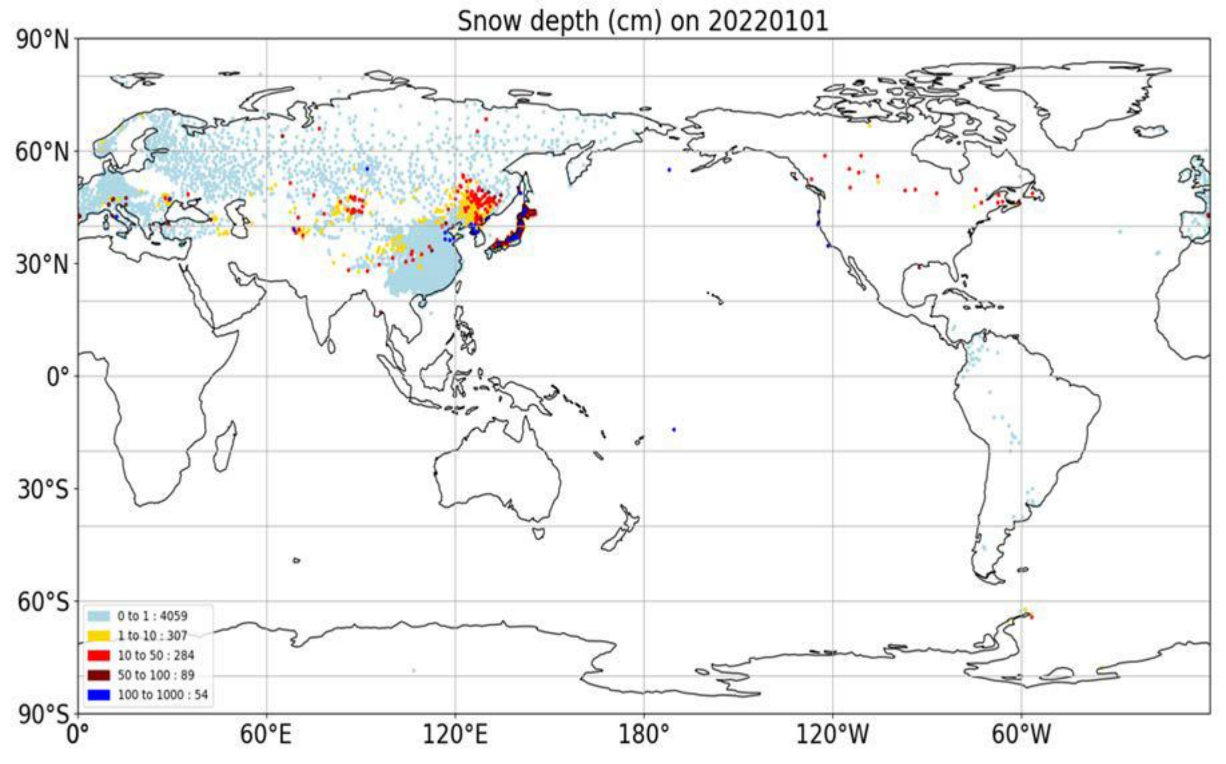
Table - Expected mapping of current WWW Centres into WIS

OSCAR/Surface



2438 stations/platforms are registered with snow depth observations

GTS



Daily snow depth data shared via GTS (January 1, 2022)

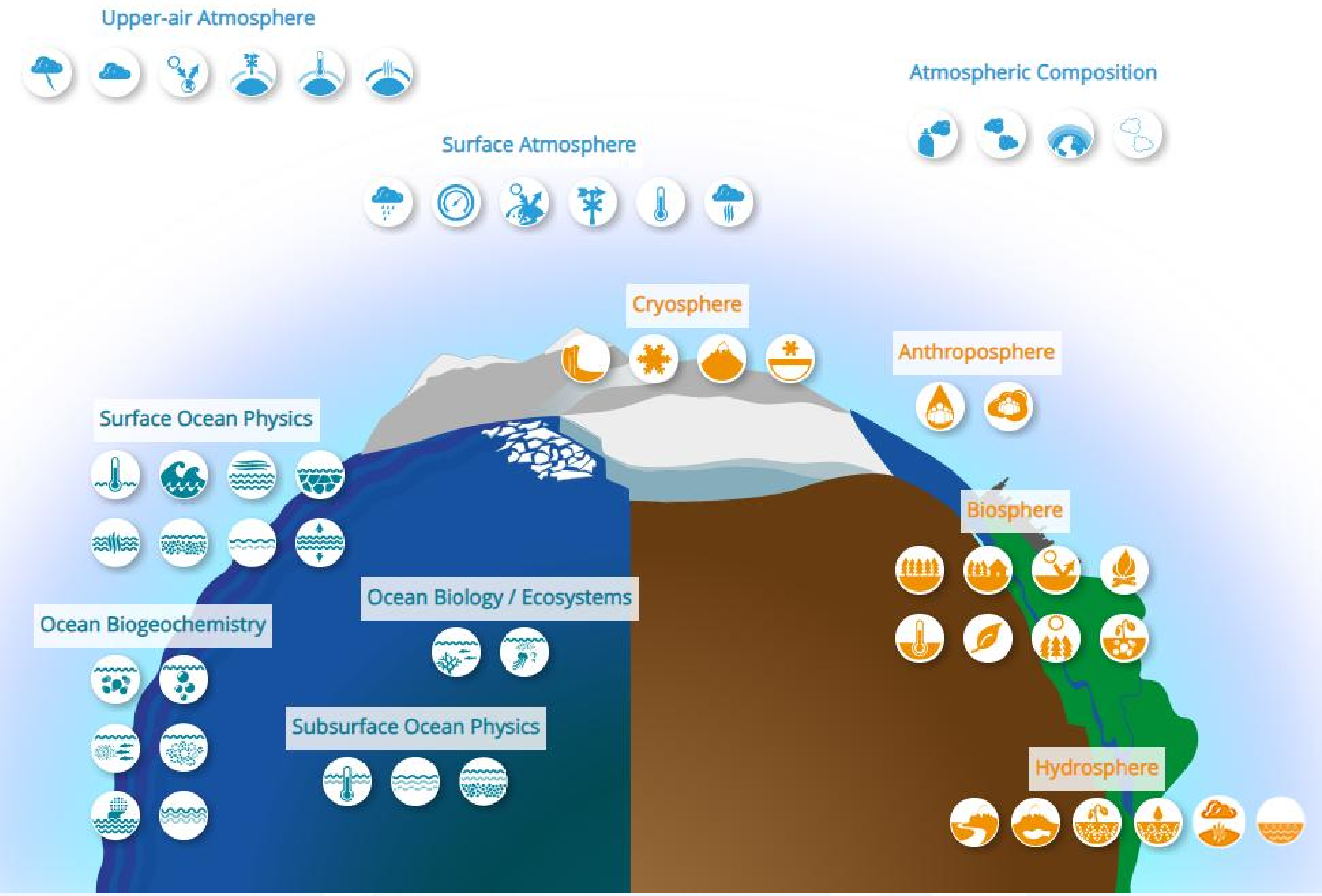
Global Climate Observing System (GCOS)

WMO IOC International Science Council UN environment

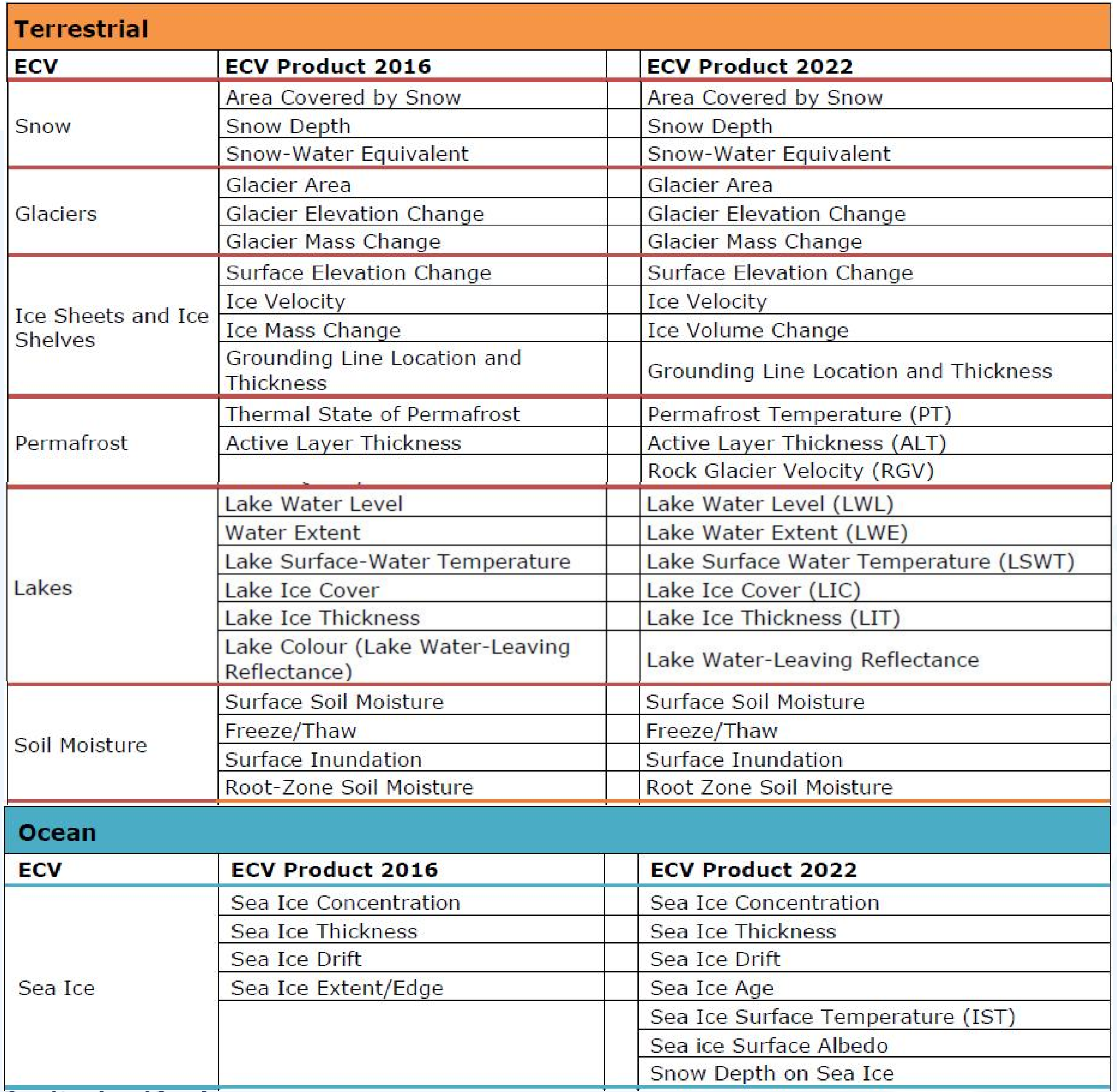
outcome

GLOBAL CLIMATE OBSERVING SYSTEM
KEEPING WATCH OVER OUR CLIMATE

- GCOS was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users.
- GCOS regularly assesses the status of global climate observations and produces guidance for its improvement.
- GCOS works towards a world where climate observations are accurate and sustained, and access to climate data is free and open.



- GCOS currently specifies 55 Essential Climate Variables (ECVs).
- An ECV is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth’ s climate.



Terrestrial

ECV	ECV Product 2016	ECV Product 2022
Snow	Area Covered by Snow	Area Covered by Snow
	Snow Depth	Snow Depth
	Snow-Water Equivalent	Snow-Water Equivalent
Glaciers	Glacier Area	Glacier Area
	Glacier Elevation Change	Glacier Elevation Change
	Glacier Mass Change	Glacier Mass Change
Ice Sheets and Ice Shelves	Surface Elevation Change	Surface Elevation Change
	Ice Velocity	Ice Velocity
	Ice Mass Change	Ice Volume Change
	Grounding Line Location and Thickness	Grounding Line Location and Thickness
Permafrost	Thermal State of Permafrost	Permafrost Temperature (PT)
	Active Layer Thickness	Active Layer Thickness (ALT)
		Rock Glacier Velocity (RGV)
Lakes	Lake Water Level	Lake Water Level (LWL)
	Water Extent	Lake Water Extent (LWE)
	Lake Surface-Water Temperature	Lake Surface Water Temperature (LSWT)
	Lake Ice Cover	Lake Ice Cover (LIC)
	Lake Ice Thickness	Lake Ice Thickness (LIT)
	Lake Colour (Lake Water-Leaving Reflectance)	Lake Water-Leaving Reflectance
Soil Moisture	Surface Soil Moisture	Surface Soil Moisture
	Freeze/Thaw	Freeze/Thaw
	Surface Inundation	Surface Inundation
	Root-Zone Soil Moisture	Root Zone Soil Moisture

Ocean

ECV	ECV Product 2016	ECV Product 2022
Sea Ice	Sea Ice Concentration	Sea Ice Concentration
	Sea Ice Thickness	Sea Ice Thickness
	Sea Ice Drift	Sea Ice Drift
	Sea Ice Extent/Edge	Sea Ice Age
		Sea Ice Surface Temperature (IST)
		Sea ice Surface Albedo
		Snow Depth on Sea Ice

❑ **7/55 ECVs are cryosphere-relevant ECVs.**

❑ ECV are identified based on the following criteria:

- **Relevance**: The variable is critical for characterizing the climate system and its changes.
- **Feasibility**: Observing or deriving the variable on a global scale is technically feasible using proven, scientifically understood methods.
- **Cost effectiveness**: Generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets.

❑ ECV datasets provide the empirical evidence needed to **understand and predict the evolution of climate**, to **guide mitigation and adaptation measures**, to **assess risks and enable attribution of climate events** to underlying causes, and **to underpin climate services**.

GCOS Observation requirements for ECV products -- take snow for example

Name	**Area Covered by Snow**
Definition	Snow cover refers to the % coverage solid surface (ground, ice sea ice, lake ice, glaciers, etc) in open areas and on top of vegetation cover that is present, such as forest canopies covered by snow at a given time. Sometimes called "viewable snow".
Unit	km^2
Note	Area covered by snow is observed in-situ and by satellite (Robinson, 2013; Frei et al., 2012). The visible satellite identifies the snow cover with few millimeters of snow depth. The microwave radiometer can detect at first from few centimeters of snow depth.

Requirements

Item needed	Unit	Metric	[1]	Value	Notes
Horizontal Resolution	m	Size of grid cell	G	50	
			B	500	
			T	1000	
Vertical Resolution			G	-	N/A
			B	-	
			T	-	
Temporal Resolution	h	Frequency of measurement	G	6	
			B	24	
			T	48	
Timeliness	h		G	3	
			B	24	
			T	240	
Required Measurement Uncertainty (2-sigma)	%		G	5	
			B	15	
			T	20	
Stability	%		G	1	
			B	5	
			T	10	

Name	**Snow Depth**
Definition	Snow thickness is the perpendicular distance between snowpack surface and the underlying surface (ground, sea ice, lake ice, ice sheets, on ice shelves, glaciers, etc.).
Unit	m
Note	

Requirements

Item needed	Unit	Metric	[1]	Value	Notes
Horizontal Resolution	km	Size of grid cell	G	0.5	
			B	5	
			T	25	The resoluti coverage in mountain ar
Vertical Resolution			G	-	N/A
			B	-	
			T	-	
Temporal Resolution	d		G	6	
			B	24	
			T	48	
Timeliness	h		G	1	
			B	6	
			T	24	
Required Measurement Uncertainty (2-sigma)	mm		G	10	
			B	25	
			T	50	
Stability	cm		G	1	
			B	2	
			T	5	

Name	**Snow-Water Equivalent**
Definition	Water equivalent of snow cover: the vertical depth of the water that would be obtained if the snow cover melted completely, which equates to the snow-cover mass per unit area.
Unit	mm
Note	

Requirements

Item needed	Unit	Metric	[1]	Value	Notes
Horizontal Resolution	km	Size of grid cell	G	0.5	
			B	5	These horizontal resolutions apply to non-mountain snow covered regions only.
			T	25	
Vertical Resolution			G	-	N/A
			B	-	
			T	-	
Temporal Resolution	h		G	6	
			B	24	
			T	48	
Timeliness	h		G	3	
			B	24	
			T	240	
Required Measurement Uncertainty (2-sigma)	mm		G	1	For mountain areas 20%
			B	5	For mountain areas 30%
			T	10	For mountain areas 40%
Stability	mm		G	5	
			B	8	
			T	10	

G=Goal
B=Breakthrough
T=Threshold

requirements at global level

In WMO framework

https://globalcryospherewatch.org/cryonet/variables/recommended_variables.html

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

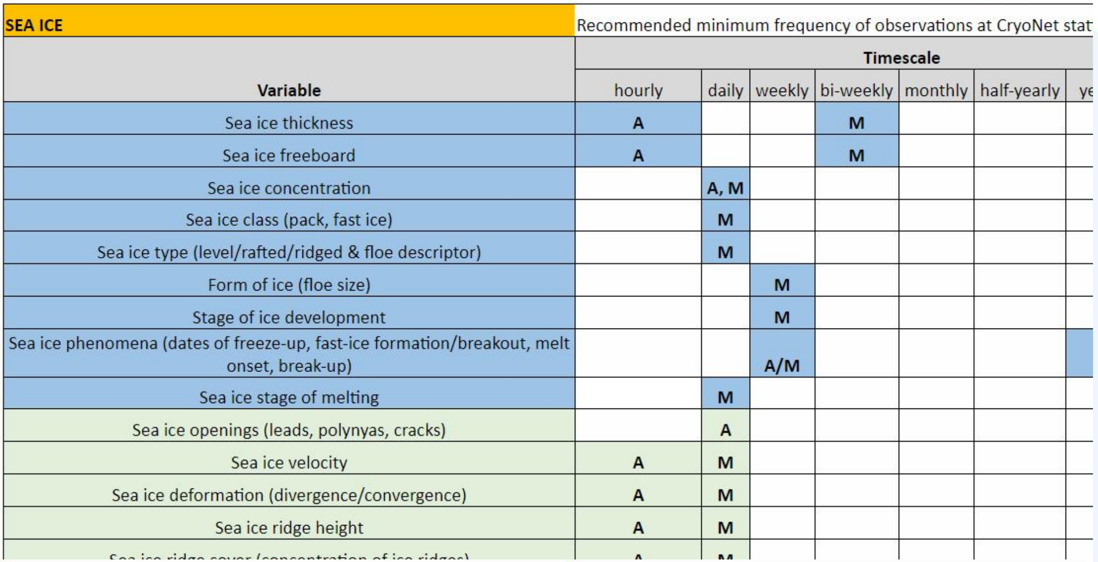
GLACIERS and ICE CAPS	Recommended minimur	
Variable	hourly	daily
Surface accumulation (point)	A	
Surface ablation (point)		
Surface mass balance (glacier wid		
Surface mass balance (point)		
Glacier area (glacier wide)		
Surface accumulation (glacier wid		
Surface ablation (glacier wide)		
Basal Ablation (point)		
Glacier thickness (point)		
Glacier volume (glacier wide)		

ICE SHEETS
Variable
Surface accumulation (point)
Surface ablation (point)
Surface mass balance (point)
Ice sheet thickness (point)
Ice velocity (point)
Ice/firn temperature profile (point

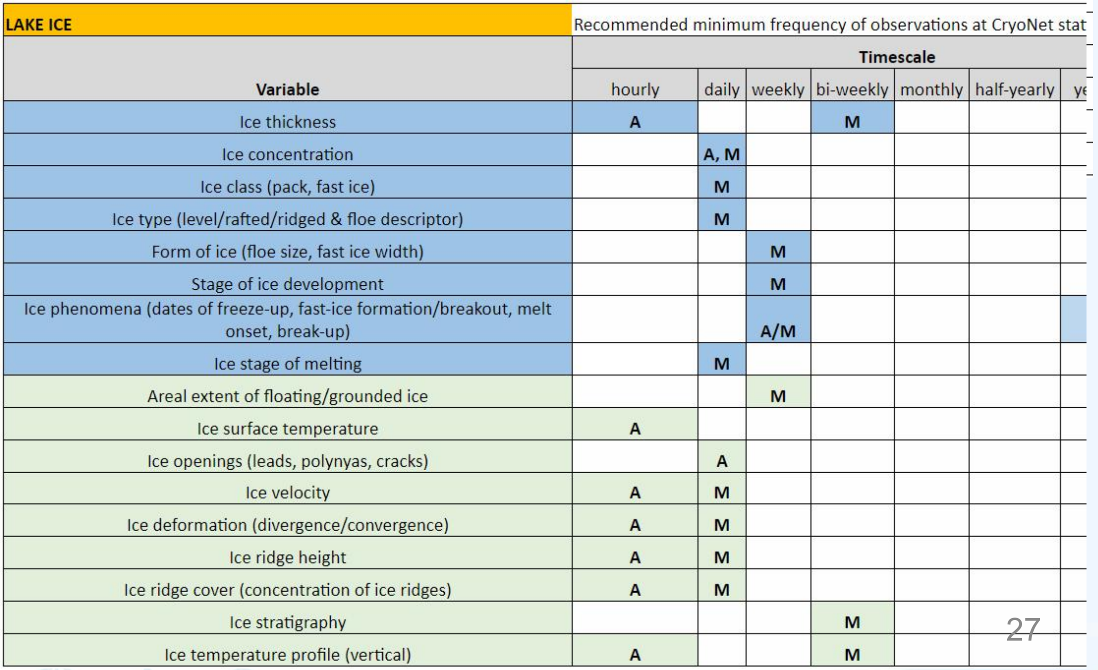
ommended measuremer

PERMAFROST	Recommended minimum frequency of observations at CryoNet static
Variable	
Ground temperature	
Active layer thickness	
Rock glacier creep velocity	
Rock glacier discharge	
Rock glacier spring temperature	
seasonal frost heath/subsidence	
surface elevation change	
ground ice volume	
coastal retreat	
soil moisture	

ICEBERGS	Recommer
Variable	hourl
Iceberg position	
Iceberg form, size	
Concentration (distance) of icebergs	
Iceberg motion	
Iceberg height (above the sea)	
Iceberg width, length (at waterline)	
Iceberg draft	
Underwater 3-D form	



SEA ICE	Recommended minimum frequency of observations at CryoNet stat						
	Timescale						
Variable	hourly	daily	weekly	bi-weekly	monthly	half-yearly	ye
Sea ice thickness	A			M			
Sea ice freeboard	A			M			
Sea ice concentration		A, M					
Sea ice class (pack, fast ice)		M					
Sea ice type (level/rafted/ridged & floe descriptor)		M					
Form of ice (floe size)			M				
Stage of ice development			M				
Sea ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up)			A/M				
Sea ice stage of melting		M					
Sea ice openings (leads, polynyas, cracks)		A					
Sea ice velocity	A	M					
Sea ice deformation (divergence/convergence)	A	M					
Sea ice ridge height	A	M					
Sea ice ridge cover (concentration of ice ridges)	A	M					



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

WMO Rolling Review of Requirement (RRR)

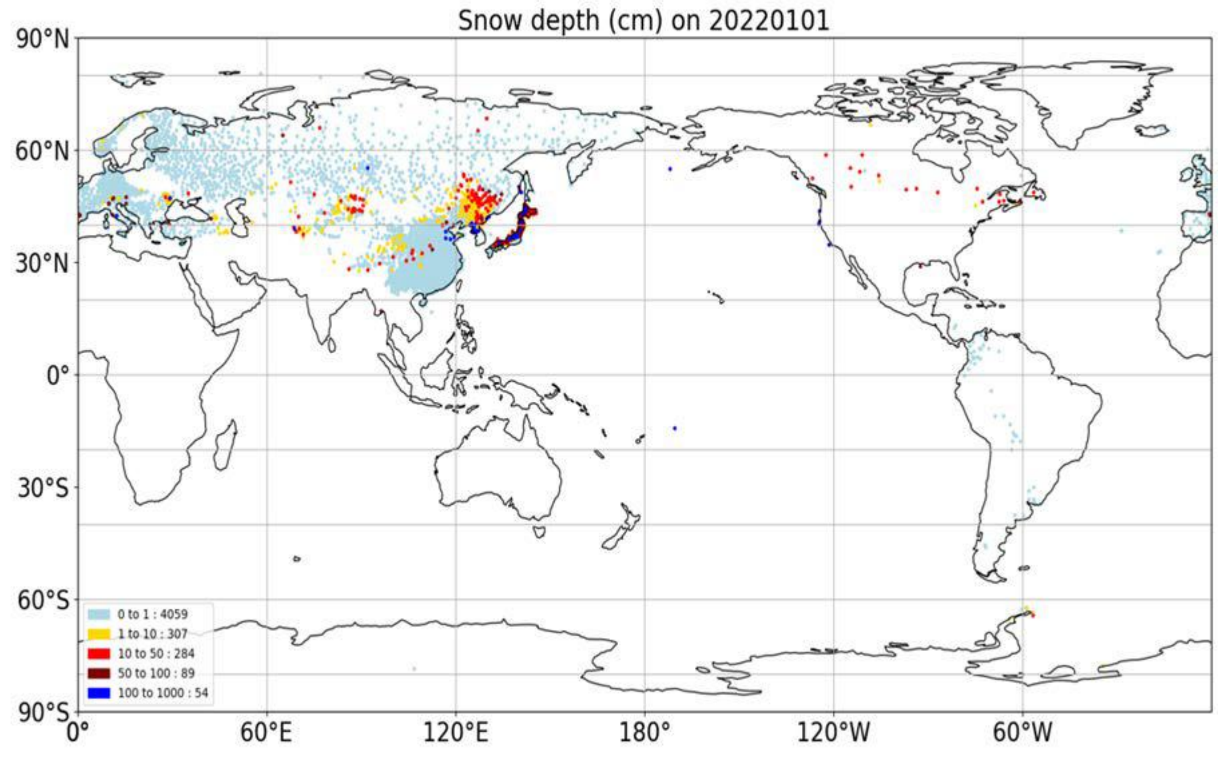
ESAC	Application areas
1. Space Weather Applications	1.1 Sun, Heliosphere and Solar Wind Forecasting and Monitoring 1.2 Energetic Particle and Magnetosphere Forecasting and Monitoring 1.3 Ionosphere, Thermosphere and Geomagnetic Field Forecasting and Monitoring
2. Atmospheric Applications	2.1 Global Numerical Weather Prediction and Real-time Monitoring 2.2 High-Resolution Numerical Weather Prediction 2.3 Nowcasting / Very Short-Range Forecasting 2.8 Aeronautical Meteorology 2.9 Agricultural Meteorology 2.6 Atmospheric Composition Forecasting and Monitoring 2.7 Atmospheric Composition Information Services in Urban and Populated Areas 2.4 Sub-Seasonal to Longer Predictions 2.5 Atmospheric Climate Monitoring
3. Oceanic Applications	3.1 Ocean Forecasting and Real-Time Monitoring 3.2 Coastal Forecasting 3.3 Oceanic Climate Monitoring and Services 3.4 Tsunami Monitoring and Detection 3.5 Marine Environmental Emergency Response 3.6 Maritime Safety (ports to open ocean) 3.7 Ocean Biogeochemical Cycles
4. Hydrological and Terrestrial Applications	4.1 Hydrological Forecasting and Real-time Monitoring 4.2 Hydrological and Terrestrial Climate Monitoring
5. Cryospheric Applications	5.1 Terrestrial Cryosphere Forecasting and Monitoring 5.2 Sea-Ice Forecasting and Monitoring 5.3 Cryospheric Climate Monitoring
6. Integrated Earth System Applications	6.1 Earth System Forecasting and Monitoring 6.2 Understanding Earth System Processes

6 Earth System Application Categories and 26 Application Areas:

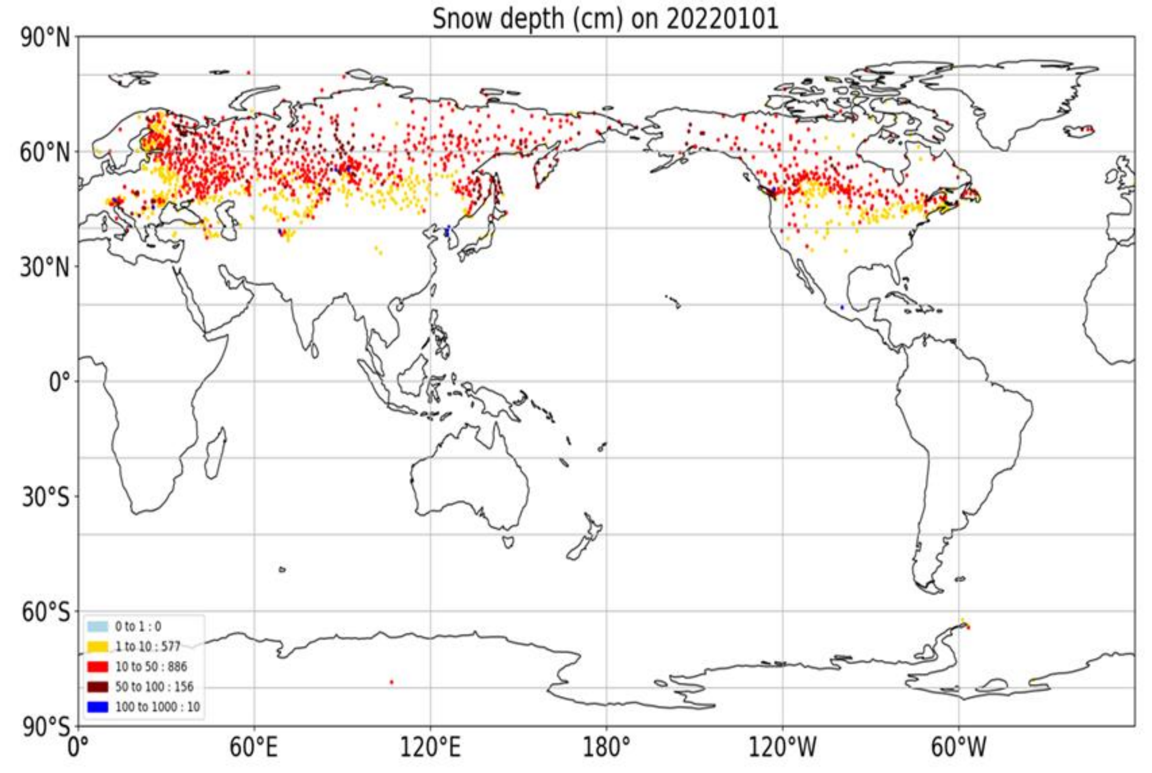
- Category 5: Cryospheric Applications
- Application area 5.1 includes snow, glaciers and permafrost, ice caps, glaciers;
- Climate Monitoring are split into different Categories, e.g. 5.3 Cryosphere Climate Monitoring, 2.5 Atmospheric Climate Monitoring

- **GCW works with GCOS to harmonize the cryosphere variables and ECVs products, and corresponding observing requirements.**

CMA’s effort in producing data sets for climatic application



Daily snow depth data shared via GTS (January 1, 2022)



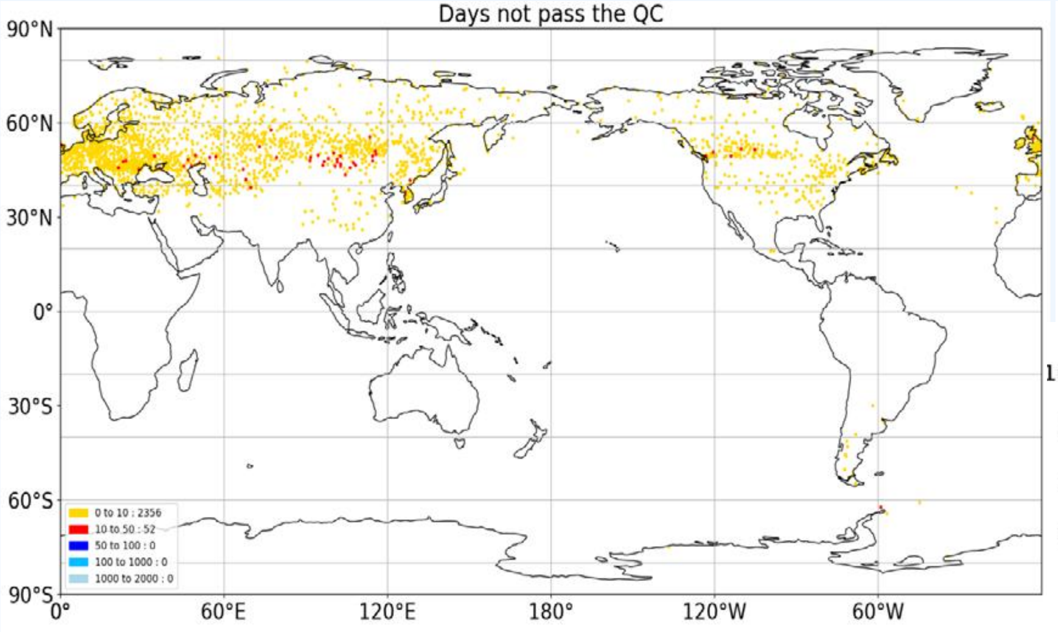
Daily snow depth data based on GSOD for January 1, 2022

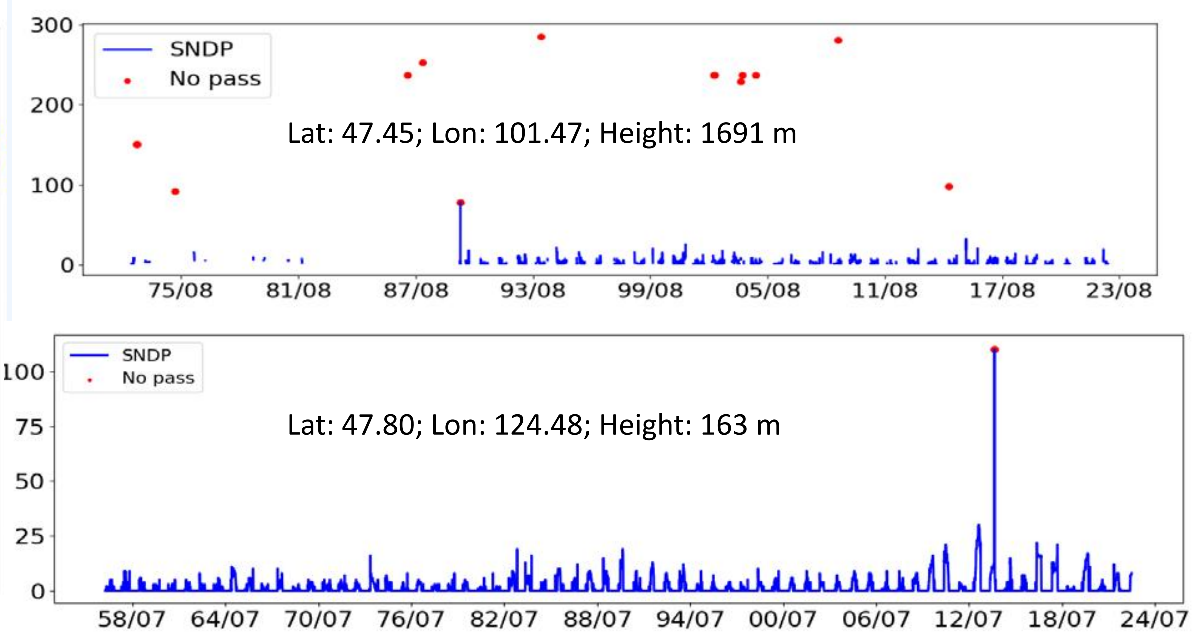
- ☐ GTS snow depth data are sparse in North America.
- ☐ In Eurasia, big differences exist in GTS and GSOD snow depth.

The storage of snow depth data in global BUFR format were inconsistent with those in TAC format, resulting in misalignment of snow depth data in Eurasia.

credit: Dr. Wenhui XU

Climate outlier check for historical snow depth data set



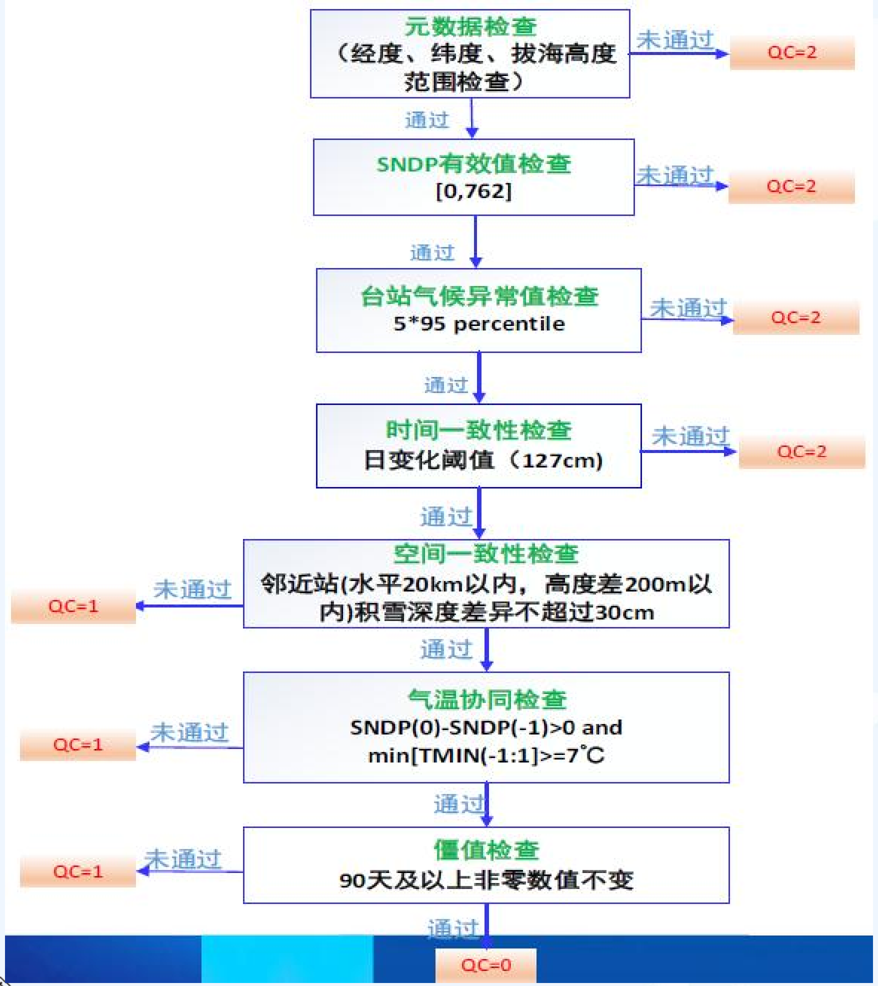


stations with climate outliers that are verified from historical data

- ❑ Threshold value: The 95th percentile of daily snow depth of all stations within the 1-degree grid from January to December was calculated using historical daily snow depth data from 1943 to 2022, and the 5* 95th percentile of snow depth value in each grid point was used as the threshold of climate outliers for all stations within the grid point;
- ❑ A total of 2408 stations had outlier problems, 52 of which contained outliers recorded more than 10 days, and the maximum number of outliers recorded at a single station was 15 days.

credit: Dr. Wenhui XU

Quality control algorithm flow for historical snow depth data set



The number of suspect data records identified by different quality control steps from 1943 to 2022

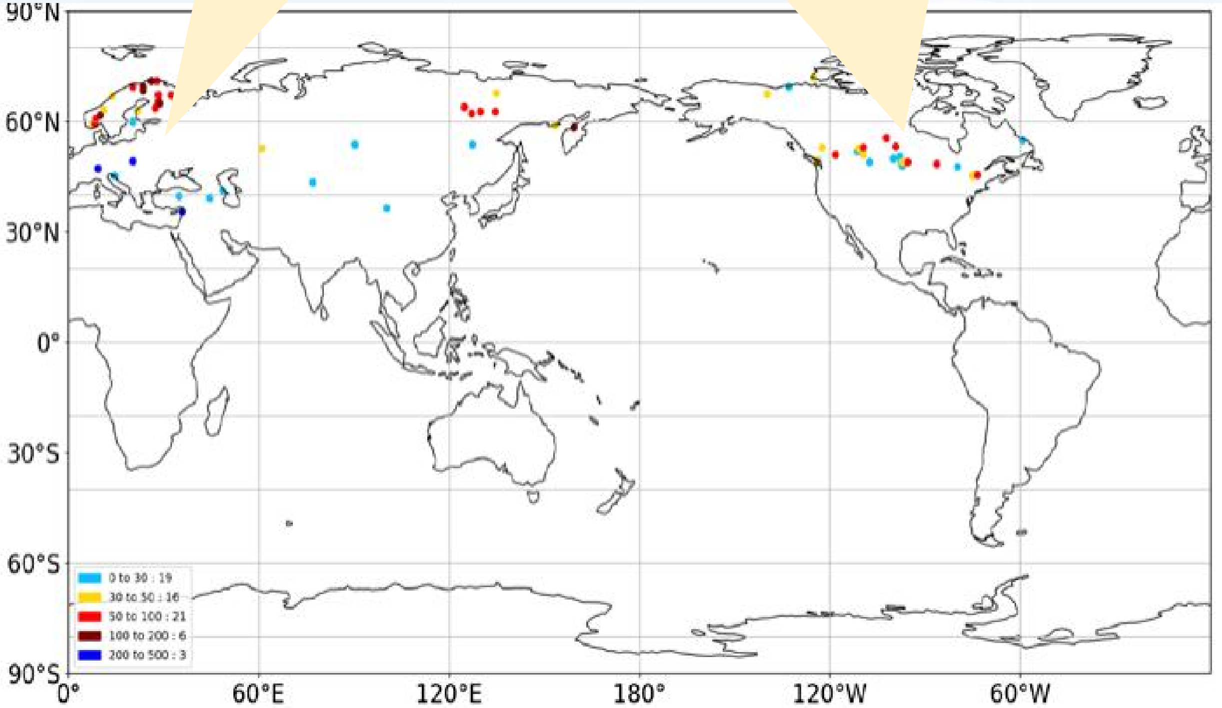
Quality control process code meaning	Number of stations with suspect data	Number of suspect data records (and ratio)
Metadata check	207	17623 (0.03%)
Valid value check	0	0
Climate outlier check	2408	5953 (0.009%)
Time consistency check	358	457 (0.0007%)
Cooperative temperature check	2249	6366 (0.01%)
Spatial consistency check	42	1047 (0.002%)
Duplicate value check	226	66667 (0.1%)

credit: Dr. Wenhui XU

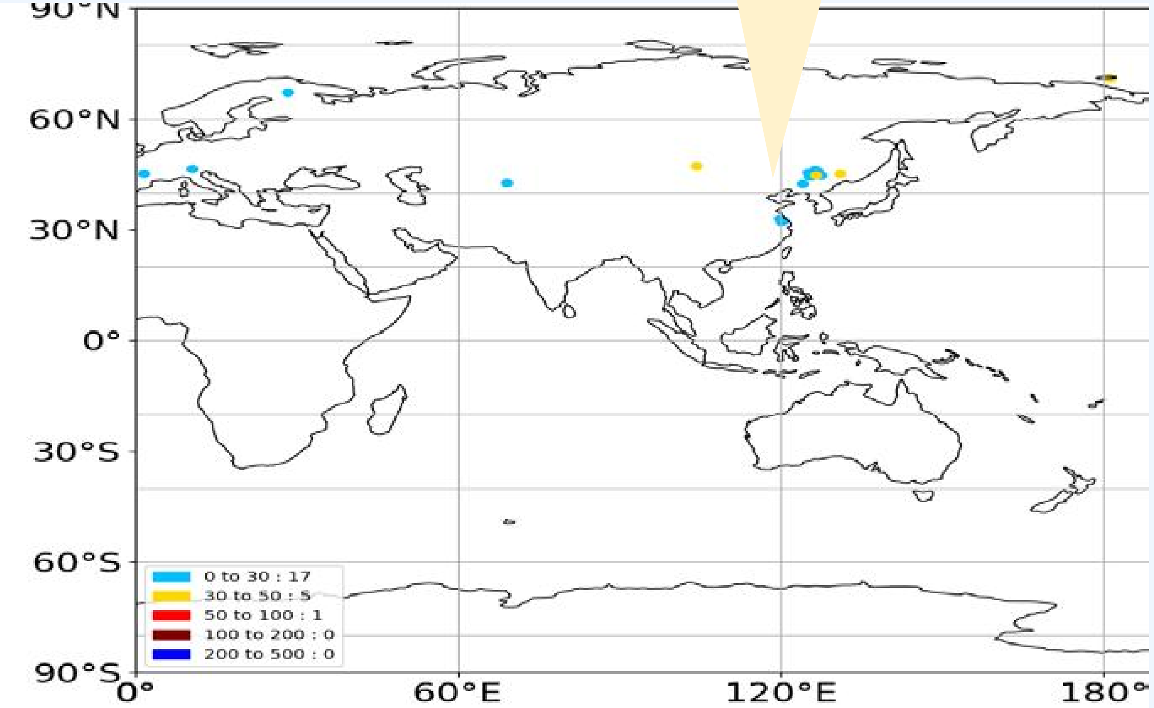
In April, "cold spring", many countries in Europe suffered rare snow.

In early April, an extreme snowstorm process occurred from west to east in Canada and the east-central United States

On November 6, a large area of snow fell in northeast China



On April 1, 2023, stations that exceeded the historical extreme value of the month



On Nov. 6, 2023, stations that exceeded the historical extreme value of the month

- ☐ After QC, it can monitor extreme events quickly and quantitatively.
- ☐ The extreme blizzard events in 2023 were well captured.

Quality control method for snow depth data set

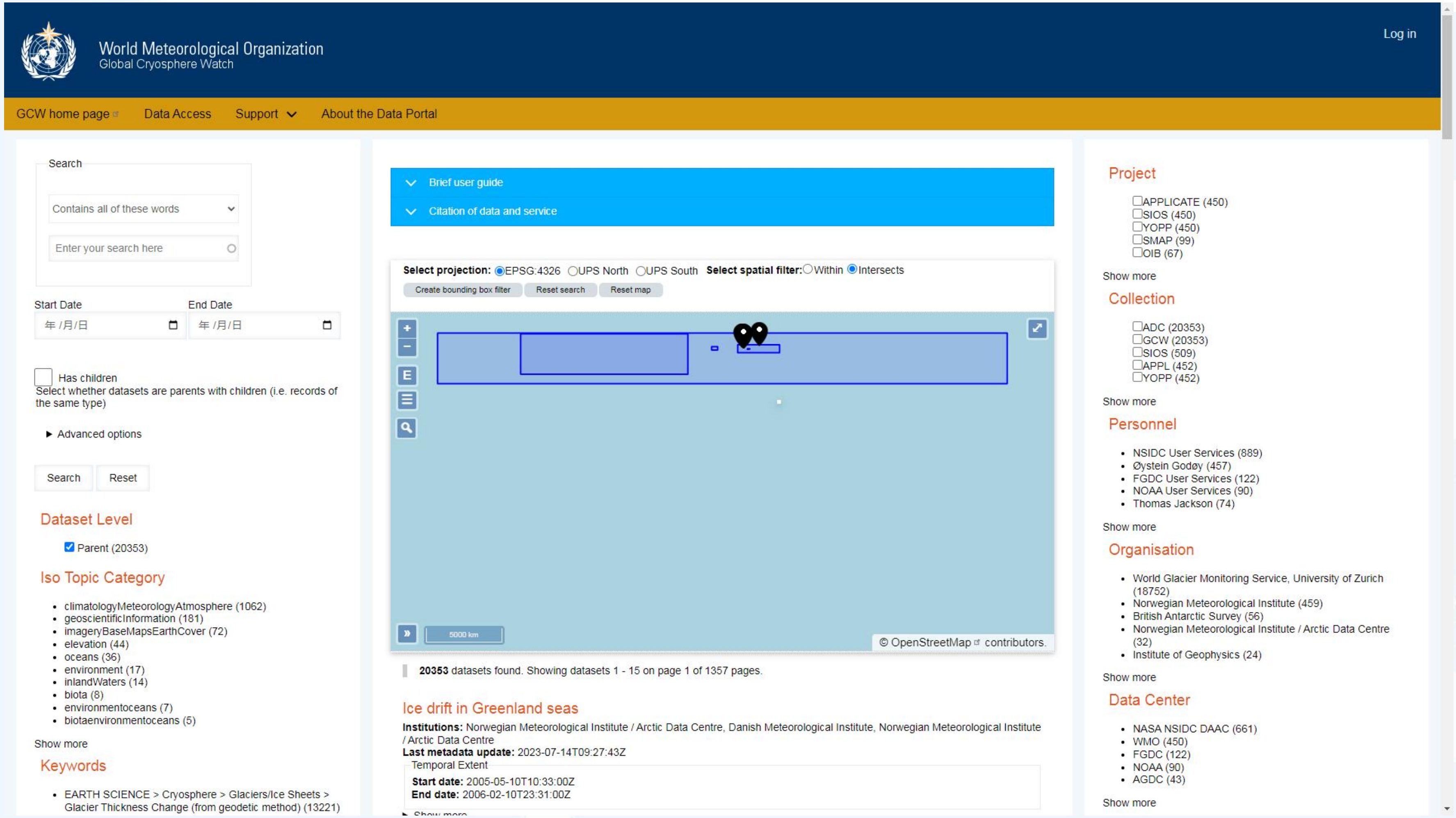
☐ Hourly snow depth quality control algorithm

- USA MADIS: **effective value check** (0-762 cm), **internal consistency check** (maximum snow water equivalent must not exceed the total amount of snow equivalent observed at the same station), **time consistency check** (difference between each observation <127 cm)
- China MDOS: **threshold value check** (0-1000 cm), **internal consistency check** (snow depth >0 cm when there is snow)

☐ Daily snow depth quality control algorithm

- USA GHCN-Daily: **duplicate value check** (90 days and above), **extreme value check** (<1146 cm), **abrupt value check**, and **temperature consistency check** (when the snow depth increases, the minimum value of minimum temperature < 7°C), **the consistency check with snowfall** and **precipitation**, **the spatial consistency check with snowfall and temperature**, **the time consistency check** (daily growth <192.5 cm), **the snow season authenticity check in the northern and southern hemispheres** (SNWD > 0 from May to October, SNWD=0 from November to April) (Durreet al.,2010)
- Canada: **Major range check** (95th percentile), **time consistency check** (change less than 45 cm), **precipitation and temperature coordination check**, **spatial consistency check** (30 cm), QC of daily **snow depth values in different climate zones** (Baronettiet al., 2019)

GCW data portal -- to enable a one-stop search for cryospheric data sets



World Meteorological Organization
Global Cryosphere Watch

Search

Start Date 年 /月/日

End Date 年 /月/日

☐ Has children
Select whether datasets are parents with children (i.e. records of the same type)

Dataset Level

☑ Parent (20353)

Iso Topic Category

- climatologyMeteorologyAtmosphere (1062)
- geoscientificInformation (181)
- imageryBaseMapsEarthCover (72)
- elevation (44)
- oceans (36)
- environment (17)
- inlandWaters (14)
- biota (8)
- environmentoceans (7)
- biotaenvironmentoceans (5)

Show more

Keywords

- EARTH SCIENCE > Cryosphere > Glaciers/Ice Sheets > Glacier Thickness Change (from geodetic method) (13221)

Select projection: ● EPSG:4326 ○ UPS North ○ UPS South **Select spatial filter:** ○ Within ● Intersects

20353 datasets found. Showing datasets 1 - 15 on page 1 of 1357 pages.

Ice drift in Greenland seas

Institutions: Norwegian Meteorological Institute / Arctic Data Centre, Danish Meteorological Institute, Norwegian Meteorological Institute / Arctic Data Centre
Last metadata update: 2023-07-14T09:27:43Z

Temporal Extent
Start date: 2005-05-10T10:33:00Z
End date: 2006-02-10T23:31:00Z

Project

☐ APPLICATE (450)
☐ SIOS (450)
☐ YOPP (450)
☐ SMAP (99)
☐ OIB (67)

Show more

Collection

☐ ADC (20353)
☐ GCW (20353)
☐ SIOS (509)
☐ APPL (452)
☐ YOPP (452)

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Personnel

- NSIDC User Services (889)
- Øystein Godøy (457)
- FGDC User Services (122)
- NOAA User Services (90)
- Thomas Jackson (74)

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Organisation

- World Glacier Monitoring Service, University of Zurich (18752)
- Norwegian Meteorological Institute (459)
- British Antarctic Survey (56)
- Norwegian Meteorological Institute / Arctic Data Centre (32)
- Institute of Geophysics (24)

Show more

Data Center

- NASA NSIDC DAAC (661)
- WMO (450)
- FGDC (122)
- NOAA (90)
- AGDC (43)

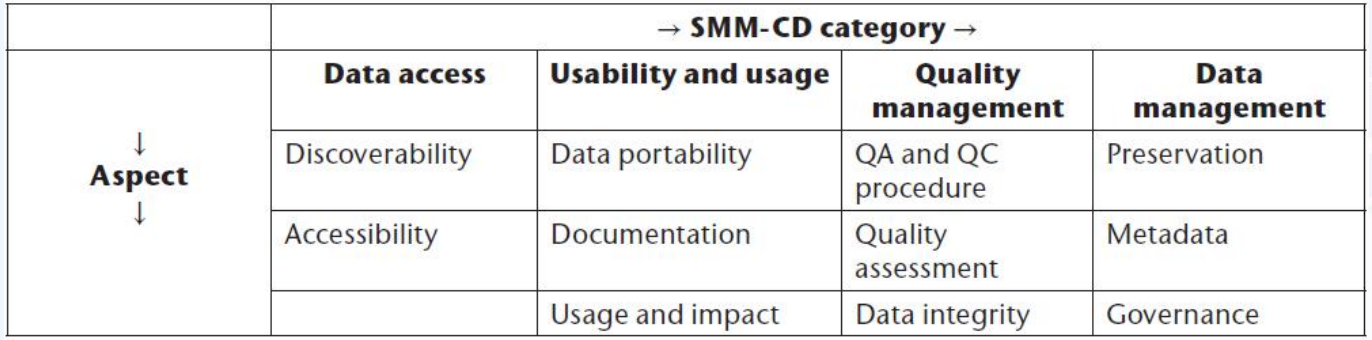
Show more

FAIR principle:

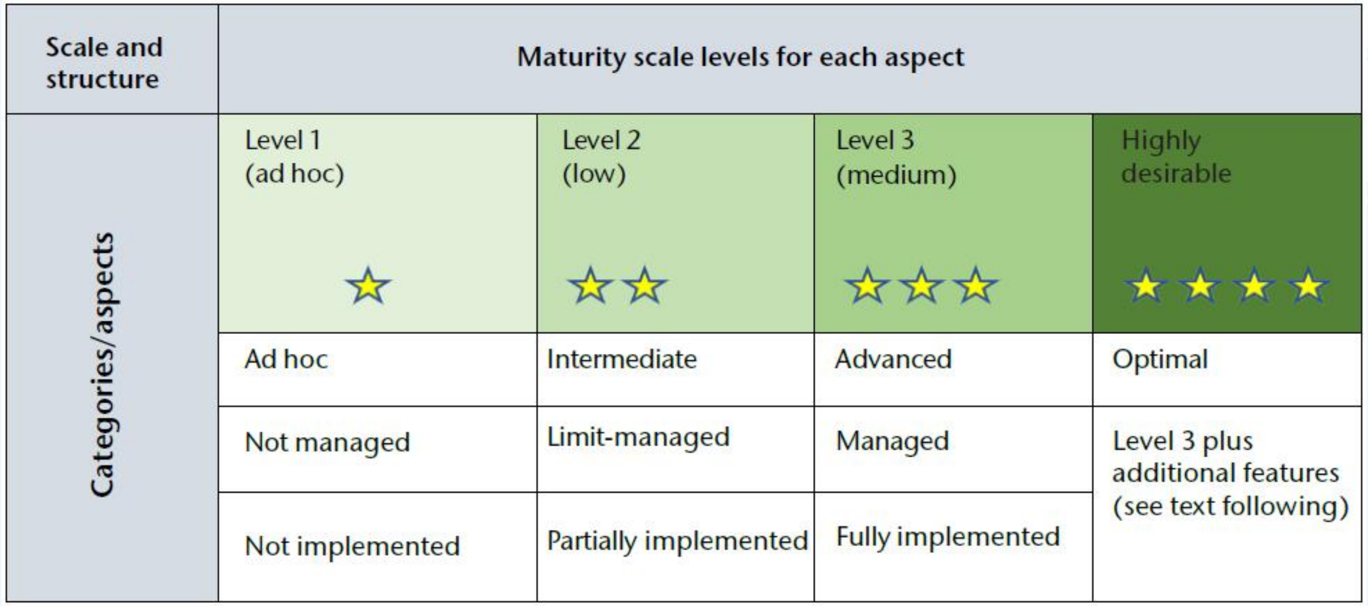
- **Findability**
- **Accessibility**
- **Interoperability**
- **Reuse**

https://gcw.met.no/

WMO Stewardship Maturity Matrix -- for assess data centres that manage climate data sets



	→ SMM-CD category →			
	Data access	**Usability and usage**	**Quality management**	**Data management**
↓ **Aspect** ↓	Discoverability	Data portability	QA and QC procedure	Preservation
	Accessibility	Documentation	Quality assessment	Metadata
		Usage and impact	Data integrity	Governance



Scale and structure	Maturity scale levels for each aspect			
Categories/aspects	Level 1 (ad hoc) ★	Level 2 (low) ★★	Level 3 (medium) ★★★	Highly desirable ★★★★
	Ad hoc	Intermediate	Advanced	Optimal
	Not managed	Limit-managed	Managed	Level 3 plus additional features (see text following)
	Not implemented	Partially implemented	Fully implemented	

useful links:

[The Stewardship Maturity Matrix for Climate Data (SMM-CD)]()
[The SMM-CD for National and Regional Purposes (SMM-CD_NRP) assessment template]()
[Guidance Booklet: WMO Stewardship Maturity Matrix for Climate Data (WMO-No. 1328)]()

WMO Catalogue for Climate Data

Listed Global datasets were assessed using the WMO Stewardship Maturity Matrix for Climate Data (SMM-CD).

Global Land Ice Measurements from Space (GLIMS)

Assessment: WMO-SMM-CD_GLIMS_v03r00_20190319

Data access: GLIMS: Global Land Ice Measurements from Space

Data point of contact: Bruce Raup; braup@nsidc.org; National Snow and Ice Data Center

Assessment point of contact: Bruce Raup; braup@nsidc.org; National Snow and Ice Data Center

Sea Ice Index, version 3

Assessment: Sea-Ice-Index-v3_WMO_SMM-CD_v01r01-20190429

Data access: Sea Ice Index, Version 3 | National Snow and Ice Data Center (nsidc.org)

Dataset point of contact: Florence Fetterer; fetterer@nsidc.org; NSIDC

Assessment point of contact: Florence Fetterer; fetterer@nsidc.org; NSIDC

GLAS/ICESat 500 m Laser Altimetry Digital Elevation Model of Antarctica, Version 1 (NSIDC-0304)

Assessment: GLAS-DEM/WMO-SMM-CD_GLAS-DEM-500m_v01r01_20190318

Data access: Cloud Datasets | PO.DAAC (nasa.gov)

Dataset point of contact: User services; podaac@podaac.jpl.nasa.gov; PODAAC

Assessment point of contact: Amy Steiker; amy.steiker@nsidc.org; NSIDC

Greenland Mass Variability Time Series Version 1 from JPL GRACE Mascon CRI Filtered

Assessment: WMO-SMM-CD_Greenland-GRACE_v02r00-20190131

Data access: Cloud Datasets | PO.DAAC (nasa.gov)

Dataset point of contact: User services; podaac@podaac.jpl.nasa.gov; PODAAC

Assessment point of contact: Amy Steiker; amy.steiker@nsidc.org; NSIDC

Antarctic 1 km Digital Elevation Model (DEM) from Combined ERS-1 Radar and ICESat Laser Satellite Altimetry, Version 1

Assessment: GLAS-DEM/WMO-SMM-CD_GLAS-DEM-1km_v01r01_20190318

Data access: Antarctic 1 km Digital Elevation Model (DEM) from Combined ERS-1 Radar and ICESat Laser Satellite Altimetry, Version 1 | National Snow and Ice Data Center (nsidc.org)

Dataset point of contact: Amy Steiker; amy.steiker@nsidc.org; NSIDC

Assessment point of contact: Amy Steiker; amy.steiker@nsidc.org; NSIDC

Antarctica Mass Variability Time Series Version 1 from JPL GRACE Mascon CRI Filtered

Assessment: WMO-SMM-CD_Antarctica-GRACE_v01r01_20190310

Data access: Cloud Datasets | PO.DAAC (nasa.gov)

Dataset point of contact: User services; podaac@podaac.jpl.nasa.gov; PODAAC

Assessment point of contact: Amy Steiker; amy.steiker@nsidc.org; NSIDC

https://climatedata-catalogue-wmo.org/

Outline

1 Cryosphere meteorological observations

2 Climatic monitoring application

3 **The way of an operational cryosphere**

The way of an operational cryosphere…

1882/83 (12), 1932/33 (40), 1957/58 (67), 2007/08 (63), 2032/33 (…)

inherit the legacy

GCW
Global Cryosphere Watch

Sustaining cryospheric observations and data systems→GCW Data Portal

integrated cryosphere system

WMO STRATEGIC PLAN
2024–2027

Objective 1.5 Accelerate the development of integrated systems and services to address global risks associated with irreversible changes in the cryosphere and downstream impacts on water resources and sea level rise

cryo.data provision for prediction

Roadmap for the integration of cryosphere in WIPPS

Operationalize cryo. products;
Operational centre/pilot project on the cryosphere.

cryosphere service

Joint Expert Team on Cryosphere related Services

Members

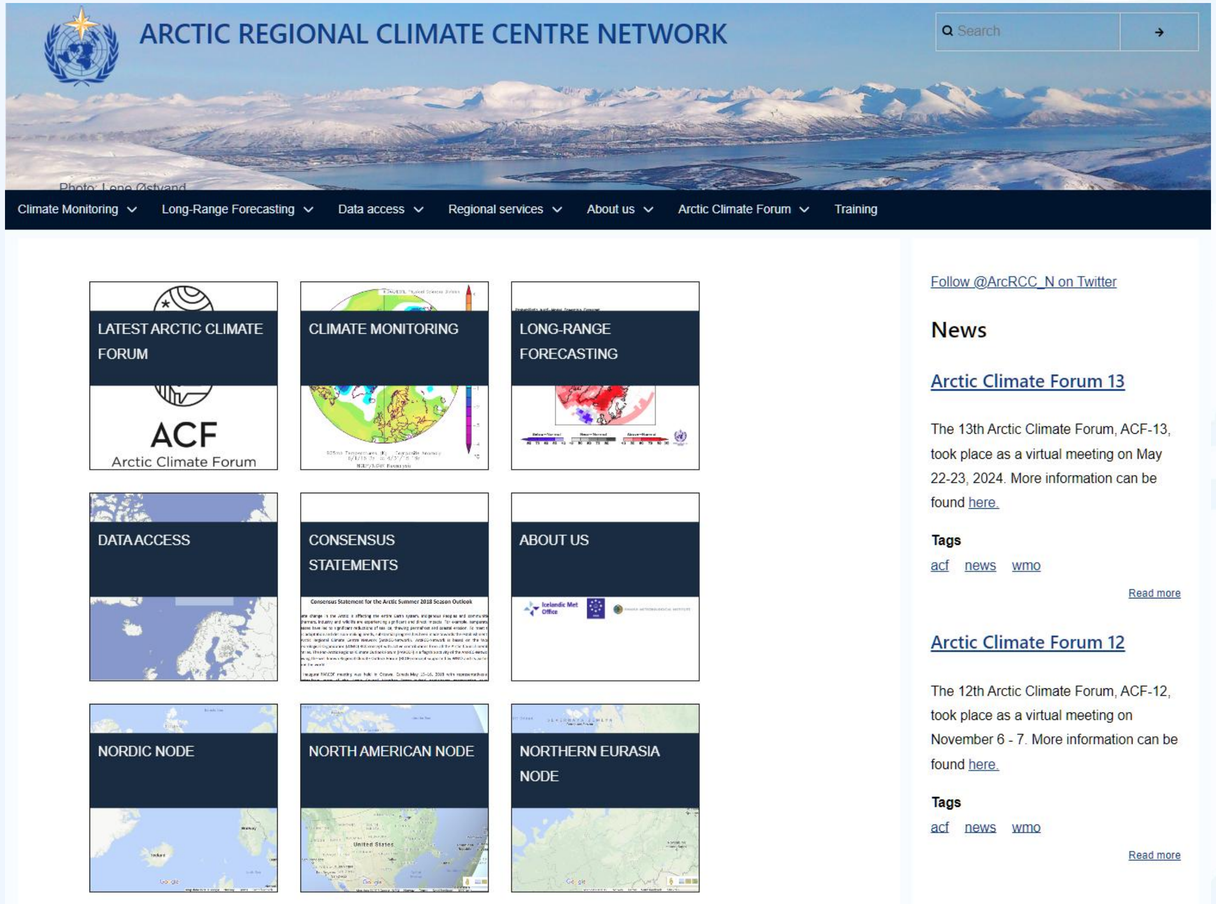
Dr James KIRKHAM - Core member- (United Kingdom of Great Britain and Northern Ireland)
Dr MA, Lijuan - Core member- (China)
Dr Petra Heil - Core member- (Australia)
Dr Rupa Kumar Kolli - Focal point- (India)
Dr Yanina GARCÍA SKABAR (Ms) - Focal point- (Argentina)
Dr Yuri SIMONOV - Focal point- (Russian Federation)
Jonas Mphepya - Core member- (South Africa)
Mr Alexander Klepikov - Core member- (Russian Federation)
Mr Helge Tangen - Co-chair- (Norway)
Ms Natalie Rose Gervasi - Core member- (Canada)

EC-PHORS
Polar and high mountain service

WMO OMM

Arctic RCC-Network
Antarctic RCC-Network
Third Pole RCC-Network

Arctic Regional Climate Centre - Network



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News

Arctic Climate Forum 13

The 13th Arctic Climate Forum, ACF-13, took place as a virtual meeting on May 22-23, 2024. More information can be found here.

Tags
acf news wmo

Read more

Arctic Climate Forum 12

The 12th Arctic Climate Forum, ACF-12, took place as a virtual meeting on November 6 - 7. More information can be found here.

Tags
acf news wmo

Read more

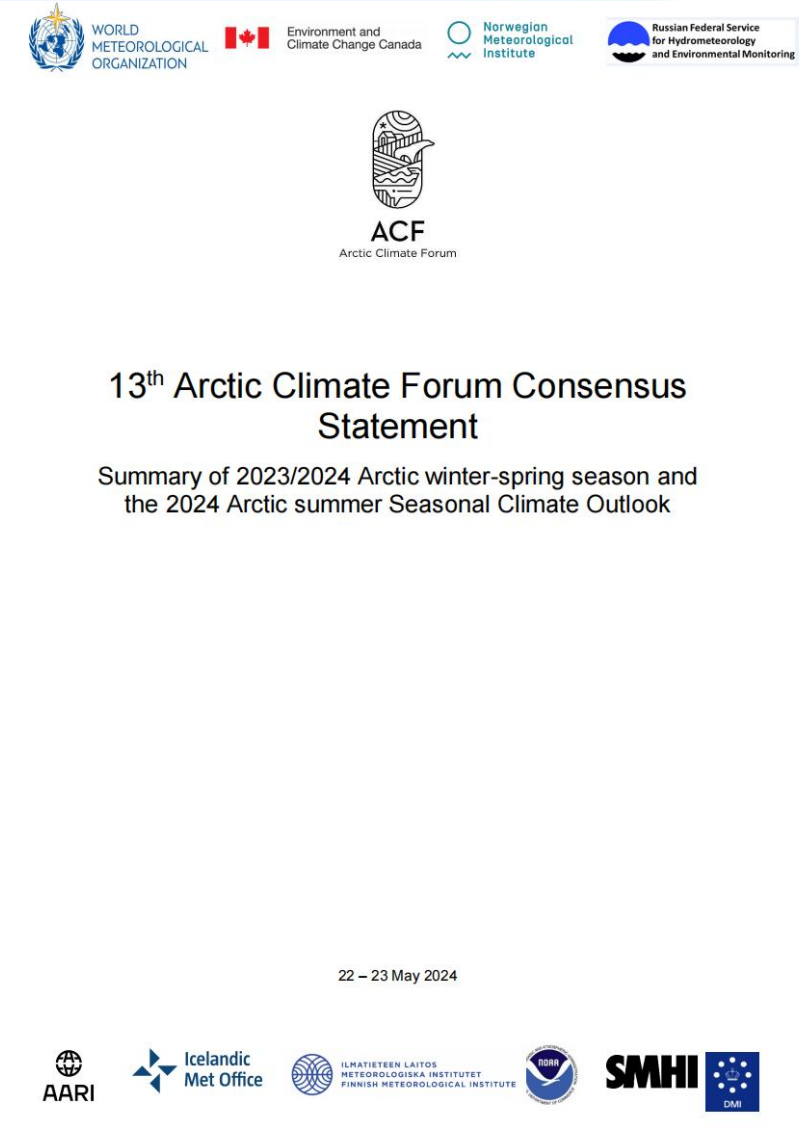
https://arctic-rcc.org/

2008: WMO's Climate Information and Prediction Services (CLIPS) concept was promoted in Polar Regions.

service domain of Arctic RCC

Arctic Climate Forum (since 2018, twice a year)

Consensus Statement



WORLD METEOROLOGICAL ORGANIZATION

Environment and Climate Change Canada

Norwegian Meteorological Institute

Russian Federal Service for Hydrometeorology and Environmental Monitoring

ACF
Arctic Climate Forum

13th Arctic Climate Forum Consensus Statement

Summary of 2023/2024 Arctic winter-spring season and the 2024 Arctic summer Seasonal Climate Outlook

22 – 23 May 2024

AARI

Icelandic Met Office

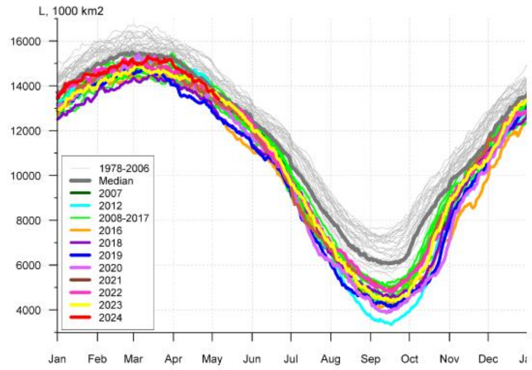
ILMATIETEEN LAITOS METEOROLOGISKA INSTITUTET FINNISH METEOROLOGICAL INSTITUTE

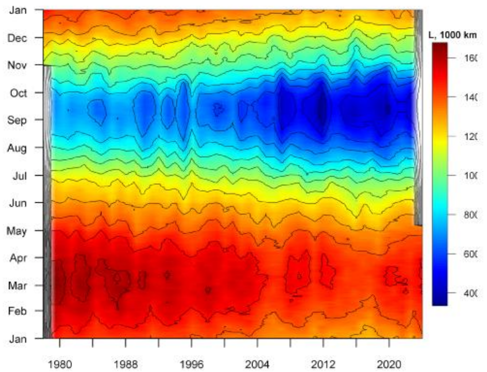
NOAA

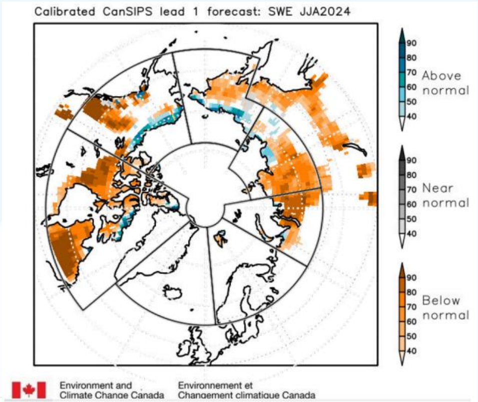
SMHI

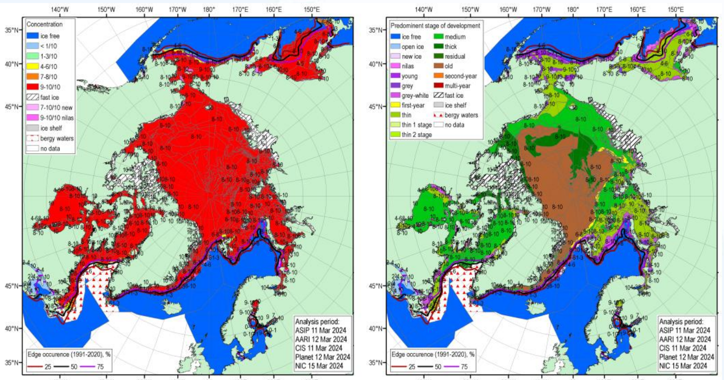
DMI

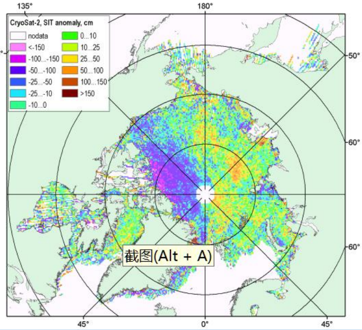
monitoring and prediction of sea ice and SWE

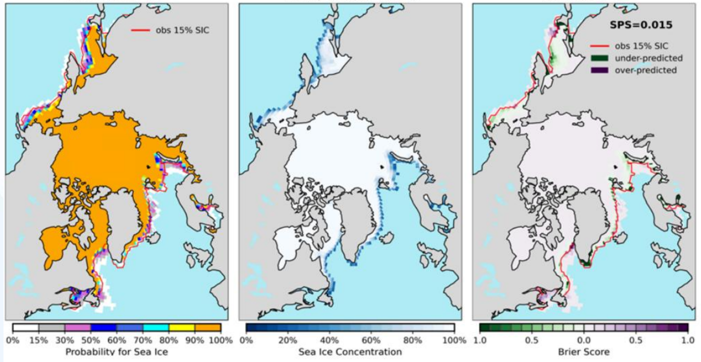


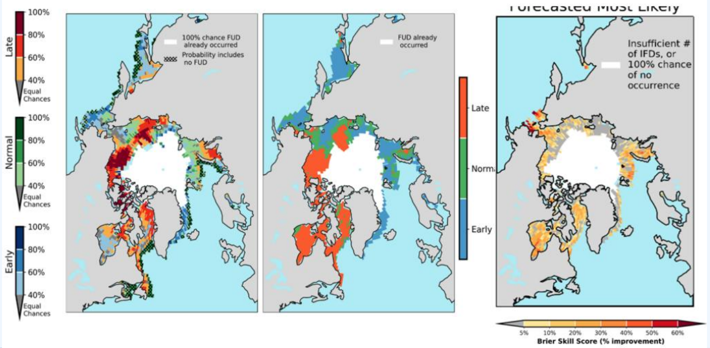






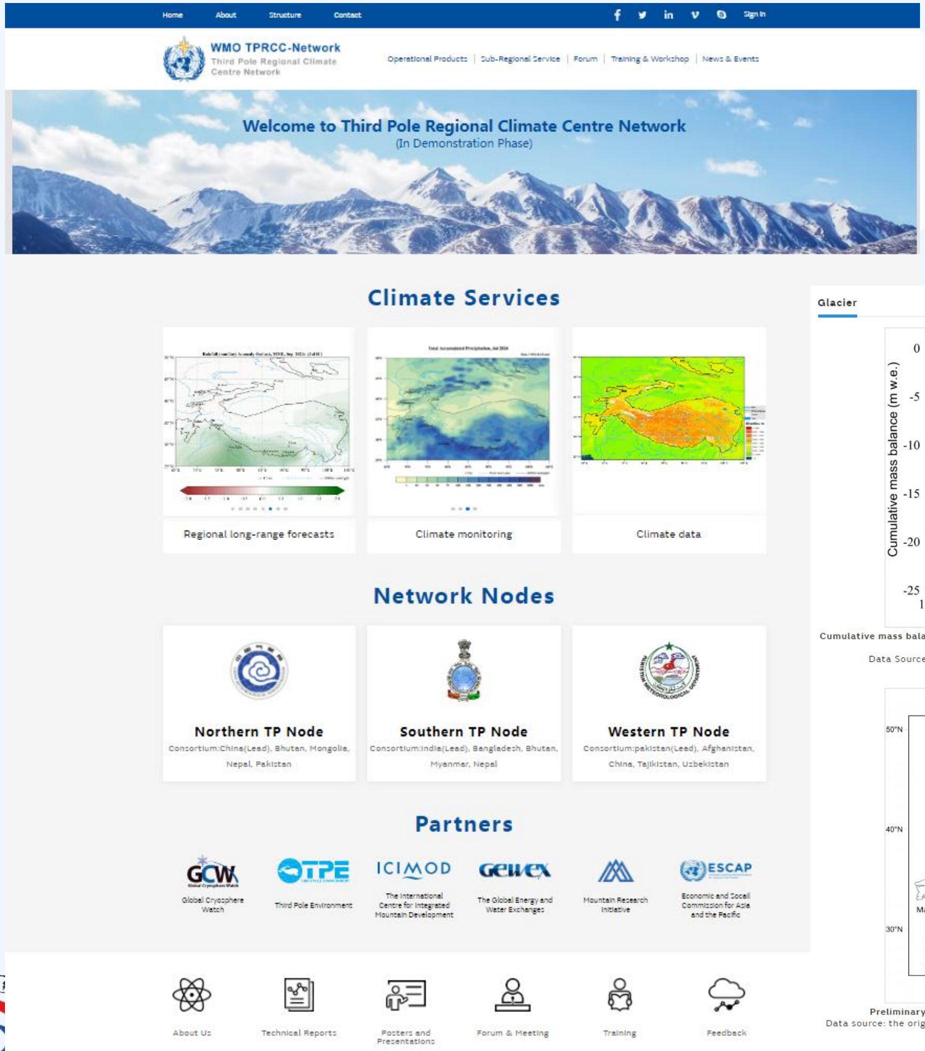






Third Pole Regional Climate Centre - Network

http://www.rccra2.org/tp-rcc/



Welcome to Third Pole Regional Climate Centre Network

(In Demonstration Phase)

Climate Services

Network Nodes

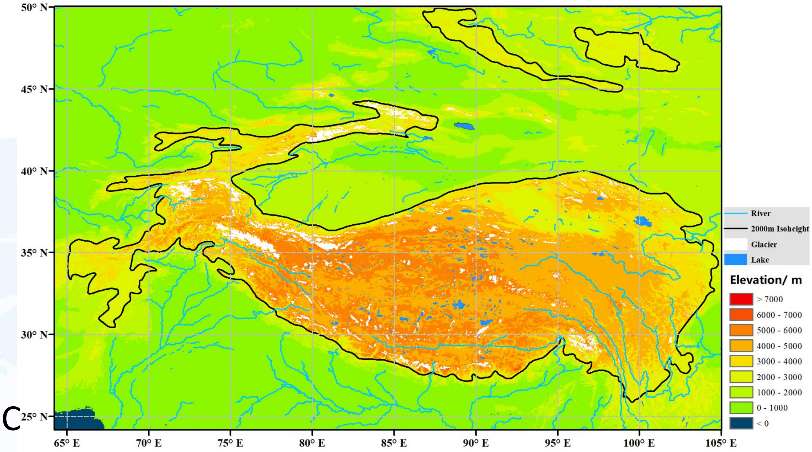
Northern TP Node
Consortium:China(Lead), Bhutan, Mongolia, Nepal, Pakistan

Southern TP Node
Consortium:India(Lead), Bangladesh, Bhutan, Myanmar, Nepal

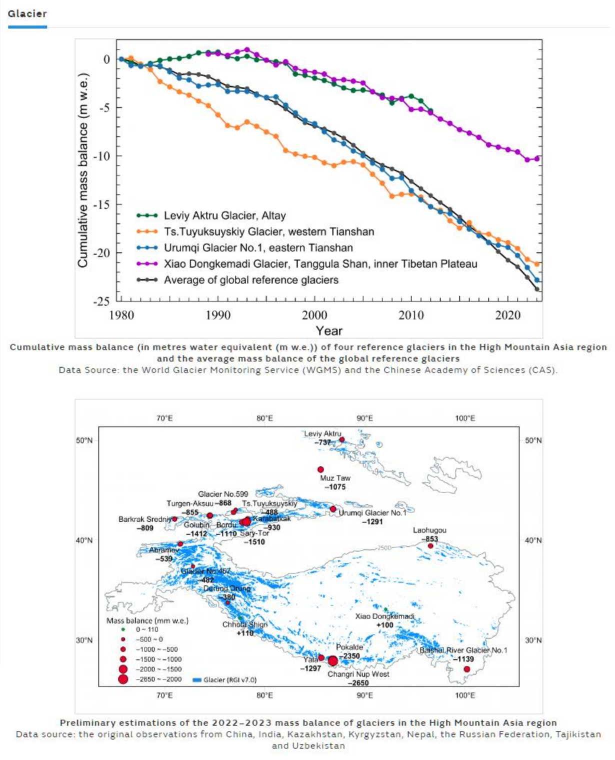
Western TP Node
Consortium:pakistan(Lead), Afghanistan, China, Tajikistan, Uzbekistan

Partners

- initiated in 2017
- currently in demonstration phase



service domain of TPRCC

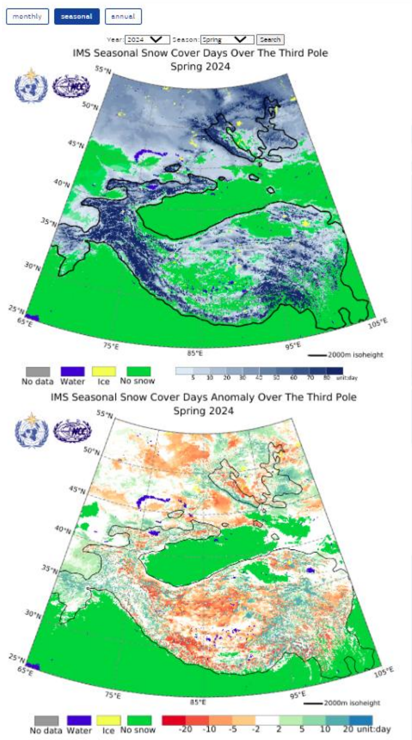


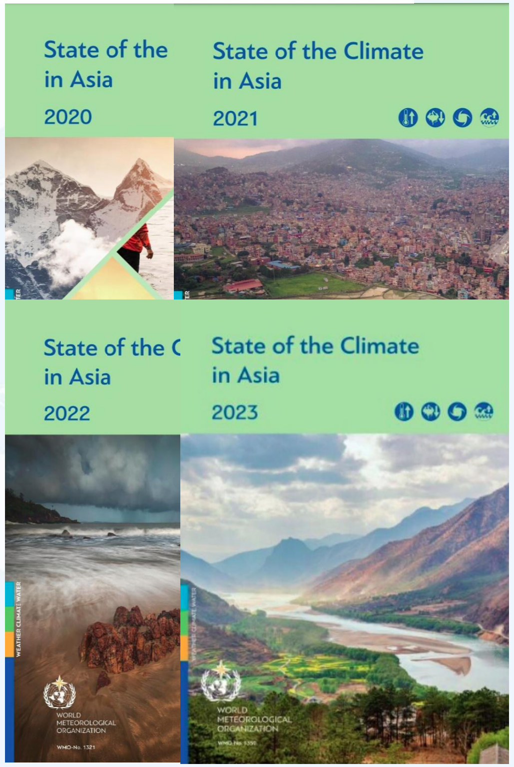
Cumulative mass balance (in metres water equivalent (m w.e.)) of four reference glaciers in the High Mountain Asia region and the average mass balance of the global reference glaciers

Data Source: the World Glacier Monitoring Service (WGMS) and the Chinese Academy of Sciences (CAS).

Preliminary estimations of the 2022–2023 mass balance of glaciers in the High Mountain Asia region

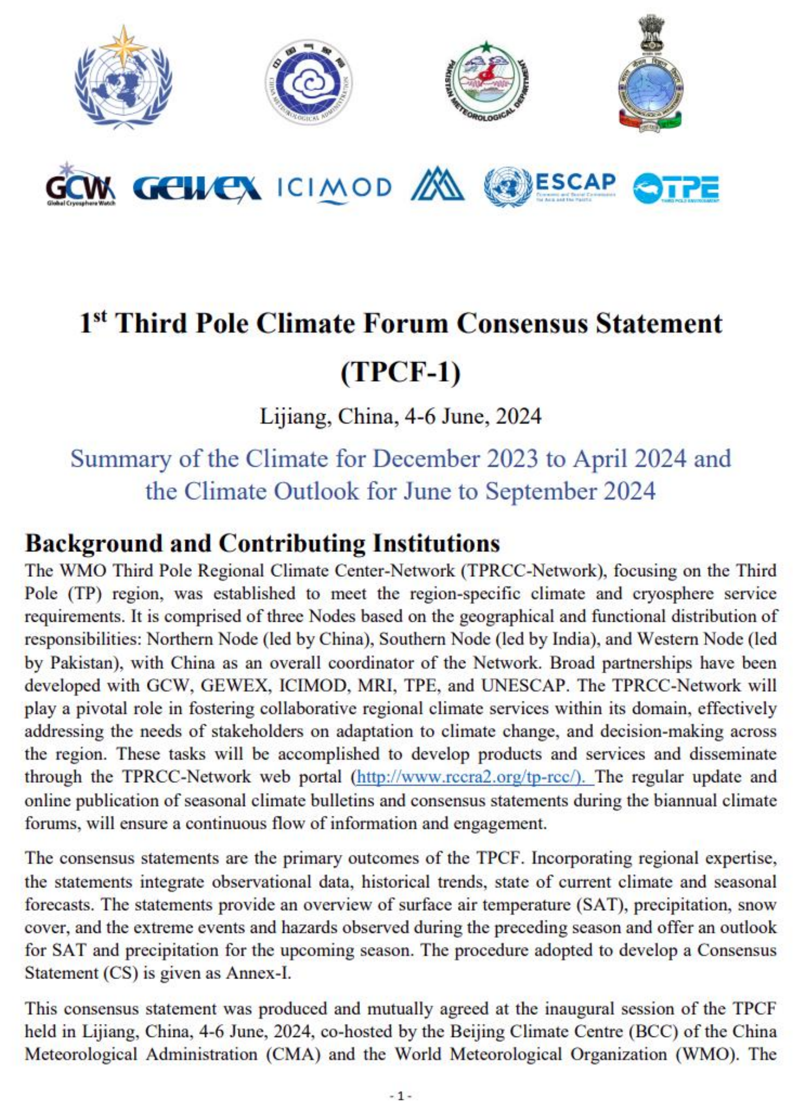
Data source: the original observations from China, India, Kazakhstan, Kyrgyzstan, Nepal, the Russian Federation, Tajikistan and Uzbekistan





Inaugural session of TPCF, Lijiang, China, 4-6 June 2024

1st Consensus Statement



1st Third Pole Climate Forum Consensus Statement (TPCF-1)

Lijiang, China, 4-6 June, 2024

Summary of the Climate for December 2023 to April 2024 and the Climate Outlook for June to September 2024

Background and Contributing Institutions

The WMO Third Pole Regional Climate Center-Network (TPRCC-Network), focusing on the Third Pole (TP) region, was established to meet the region-specific climate and cryosphere service requirements. It is comprised of three Nodes based on the geographical and functional distribution of responsibilities: Northern Node (led by China), Southern Node (led by India), and Western Node (led by Pakistan), with China as an overall coordinator of the Network. Broad partnerships have been developed with GCW, GEWEX, ICIMOD, MRI, TPE, and UNESCAP. The TPRCC-Network will play a pivotal role in fostering collaborative regional climate services within its domain, effectively addressing the needs of stakeholders on adaptation to climate change, and decision-making across the region. These tasks will be accomplished to develop products and services and disseminate through the TPRCC-Network web portal (http://www.rccra2.org/tp-rcc/). The regular update and online publication of seasonal climate bulletins and consensus statements during the biannual climate forums, will ensure a continuous flow of information and engagement.

The consensus statements are the primary outcomes of the TPCF. Incorporating regional expertise, the statements integrate observational data, historical trends, state of current climate and seasonal forecasts. The statements provide an overview of surface air temperature (SAT), precipitation, snow cover, and the extreme events and hazards observed during the preceding season and offer an outlook for SAT and precipitation for the upcoming season. The procedure adopted to develop a Consensus Statement (CS) is given as Annex-I.

This consensus statement was produced and mutually agreed at the inaugural session of the TPCF held in Lijiang, China, 4-6 June, 2024, co-hosted by the Beijing Climate Centre (BCC) of the China Meteorological Administration (CMA) and the World Meteorological Organization (WMO). The

- 1 -

Users’ Needs on Long-Range Forecast

Outcomes of TPCF and scoping meetings

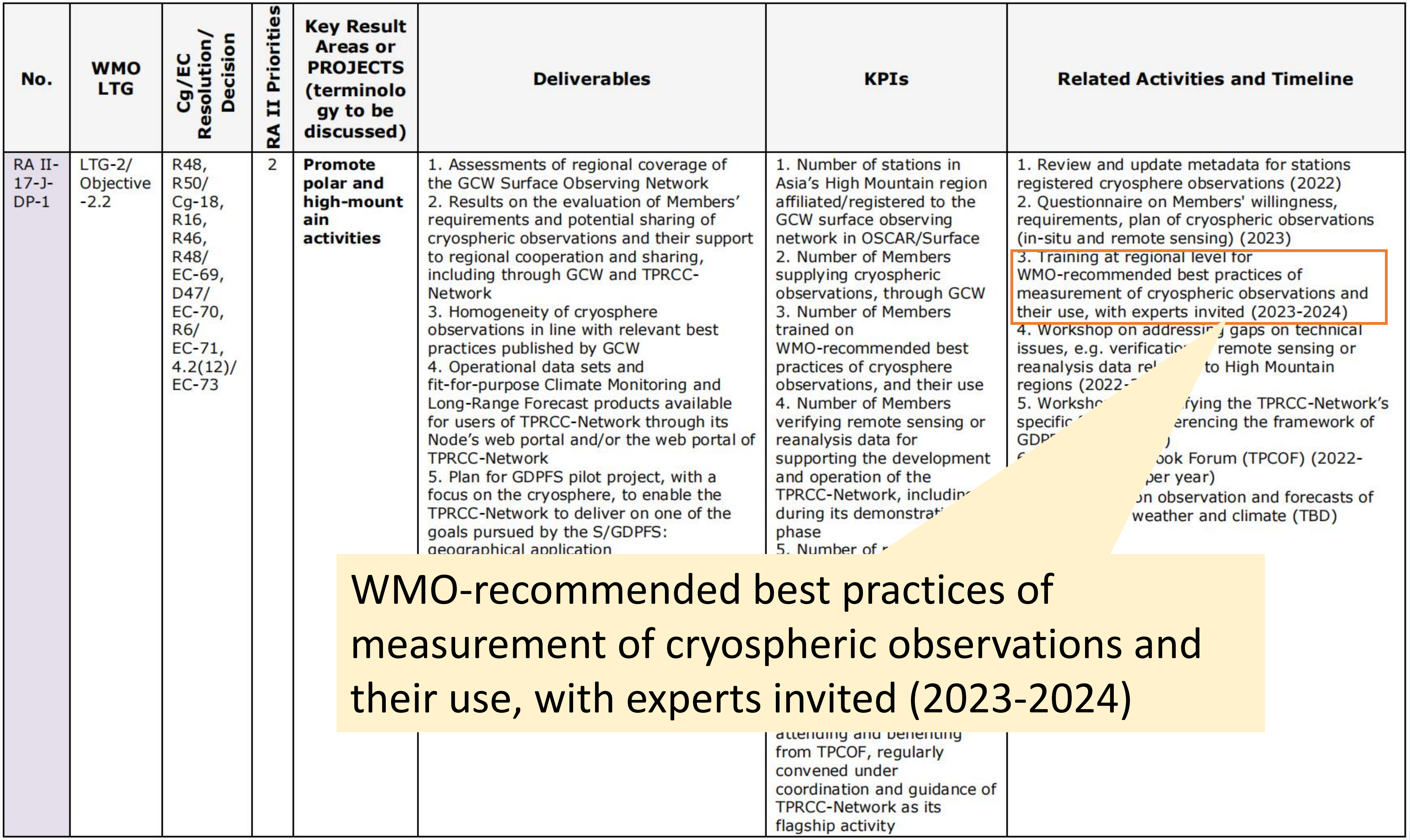
Recommendation	No.	Action
Improve the production of regional outlooks	1	Follow the production of the first regional monitoring / outlook
	2	Explore customized products from the leading centres (e.g. cryosphere-related products) and provide feedback
	3	Diagnostic (satellite) and prediction on snow cover extent; water availability for the predicted season
Seasonal T&P, maximize using of GPC products	4	Use more than one reanalysis (Jonathon Wright) - led by TPRCC; Suggest member and approach to use
	5	Include geographical TPRCC covering domain in LC-LRFMME graphical domain
Consider Impact-Based Forecast	6	Climate Watch products related to **hazards** covered by mandatory function
	7	Provide the customized products (digital products behind the graphics) and elaborated types of variables to support **EW4ALL**
Understanding research needs to improve monitoring and prediction	8	Engage WCRP (coordinate Climate Research Forum, there’s one for South Asia – Mandira link science to society), e.g. CliC fellowships - Kazakhstan (Maria provided information)
Development of climate prediction verification products and related technological documents for multi-users	9	TT-LRF to lead

Most Critical Hazards Identified

1. Floods including GLOF, flash flood
2. Drought including ZUD (long dry spell)
3. Land slide and debris flow
4. Avalanches, land/mountain slides
5. Large scale forest fires (long dry spell)
6. Frost, lightning
7. Increasing temperature, extreme temperature
8. Extreme rainfall in sub-seasonal scale

Outcome of TPCF scoping meeting in Bangkok, Nov. 2023

JDP-TPRCC in WMO RAII Operational Plan 2021-2024



No.	WMO LTG	Cg/EC Resolution/ Decision	RA II Priorities	Key Result Areas or PROJECTS (terminology to be discussed)	Deliverables	KPIs	Related Activities and Timeline
RA II-17-J-DP-1	LTG-2/ Objective -2.2	R48, R50/ Cg-18, R16, R46, R48/ EC-69, D47/ EC-70, R6/ EC-71, 4.2(12)/ EC-73	2	**Promote polar and high-mountain activities**	1. Assessments of regional coverage of the GCW Surface Observing Network 2. Results on the evaluation of Members' requirements and potential sharing of cryospheric observations and their support to regional cooperation and sharing, including through GCW and TPRCC-Network 3. Homogeneity of cryosphere observations in line with relevant best practices published by GCW 4. Operational data sets and fit-for-purpose Climate Monitoring and Long-Range Forecast products available for users of TPRCC-Network through its Node's web portal and/or the web portal of TPRCC-Network 5. Plan for GDPFS pilot project, with a focus on the cryosphere, to enable the TPRCC-Network to deliver on one of the goals pursued by the S/GDPFS: geographical application	1. Number of stations in Asia's High Mountain region affiliated/registered to the GCW surface observing network in OSCAR/Surface 2. Number of Members supplying cryospheric observations, through GCW 3. Number of Members trained on WMO-recommended best practices of cryosphere observations, and their use 4. Number of Members verifying remote sensing or reanalysis data for supporting the development and operation of the TPRCC-Network, includin during its demonstrat phase 5. Number of attending and benefiting from TPCOF, regularly convened under coordination and guidance of TPRCC-Network as its flagship activity	1. Review and update metadata for stations registered cryosphere observations (2022) 2. Questionnaire on Members' willingness, requirements, plan of cryospheric observations (in-situ and remote sensing) (2023) 3. Training at regional level for WMO-recommended best practices of measurement of cryospheric observations and their use, with experts invited (2023-2024) 4. Workshop on addressin gaps on technical issues, e.g. verificatio remote sensing or reanalysis data re to High Mountain regions (2022- 5. Worksho fying the TPRCC-Network's specific erencing the framework of GDP) ook Forum (TPCOF) (2022- per year) on observation and forecasts of weather and climate (TBD)

WMO-recommended best practices of measurement of cryospheric observations and their use, with experts invited (2023-2024)

JDP-TPRCC in WMO RAII Operational Plan 2024-2027

No.	Deliverables	KPIs	Related Activities and Timeline
J-DP-TPRCC	1. Consensus Statements for the Third Pole region;	1. Number of participants attending TPCF;	1. Convene Third Pole Climate Forum, twice a year (2024-2027)
	2. Procedure of producing consensus seasonal outlook;	2. Models recommended for ensemble mean and data set for verification;	2. Technical meetings on Long-Range Forecast (mostly virtual by TT-LRF), under the guidance of JET-TPRCC (2024-2027)
	3. Operational data sets and fit-for-purpose Climate Monitoring and Long-Range Forecast products available for users of TPRCC-Network;	3. Number of products available on web portal and nodes' websites;	3. JET-TPRCC meetings (mostly virtual) to address gaps identified between users' demands and service provisions (2024-2027)
	4. Recommendations on cryosphere observations and data sharing to relevant constituent bodies;	4. Number of recommendations;	4. Analyze Members' feedbacks to questionnaire on terrestrial cryosphere observations and data (2024-2025)
	5. Approach of accessing in-situ and remote sensing data for producing thematic datasets for the third pole region	5. Number of data available for operational use;	5. Data focused workshop with capacity building activities, e.g. observing techniques, data access, etc. (2024)
	6. Training program	6. Number of participants;	6. Combined training on method and instruments of cryosphere observations and state-of-art research, etc. (2024-2025)

Cryosphere ambitions endorsed by WMO EC-78:

- Everyone on the planet is prepared for and resilient to the impacts from changes in the cryosphere.
- The global community works collaboratively to limit and reduce cryosphere loss and its impacts.
- Data, science, and indigenous knowledge are accessible and provide a sound basis for policies and decisions on response, mitigation, and adaptation in the face of future changes.
- The importance of the cryosphere and the consequences of its changes are known, universally understood and inspire actions.

Thanks

国家气候中心 National Climate Center