SuggestedCryoNetObjectives: fordiscussion

GCW-CryoNET:

3 levels: Supersite - reference site – observation sitesare suggested (the classification is indicative and the labels of each class needs to be adjusted considering existing classifications of various cryospheric monitoring networks (WGMS, IACS, GTN_P, ….). It is important not to downgrade the quality rating of existing networks.

1) Tier 1 CryoNET sites (tentative name SUPER-SITE)

SUPER-SITE: = CryoNET station which monitorsthe physical and chemical propertiesof all components (GCW focal areas) of the local cryospherein its full complexity and at the highest quality standards as well as the interaction of local/regionalatmosphere. It has established linkages to satellite observations and to other disciplines such as hydrology, oceanography, ecology etc.). In many cases the stations are supported by more than one research agency, have strong scientific supporting programme and provide facilities for intensive campaigns.Super-sites are stations/observatories with on-site personal for maintaining the monitoring and scientific experiments. Super-site is a "high-level seal" of WMO-GCW for cryospheric observations similar as GAW global station.

Aims:
a) Monitoring of changes of the physical and chemical properties of the cryosphere with respect to changes of the atmosphere (climate) and including interactions between different components of the cryosphere
b) Linkage of ground truth with satellite observations (ground truth, calibration, merge both information …) in order to monitor the global cryosphere at high spatial and temporal scale
c) Estimation of the impact of changes of cryosphere on hydrology, water management, ecology, …
c) Extensive datasets for cryospheric modelling approaches (validation, calibration)
c) Training of personal for cryospheric observations
d) Extensive information to the public

Standards for measurements:
Atmosphere: WMO, GAW, BSRN
Snow: IACS, WMO
Glaciers: IACS, WGMS/NSIDC, GTN-G
Permafrost: GTN-P
Lake/river ice: ????
Sea ice: ????

Data availability: real-time ornear real-time

Monitoring components:
Atmosphere: *SW-, LW-radiation, air pressure, air temperature, humidity, wind speed, wind direction, precipitation, aerosols, trace gases, …*
Snow: *depth, SWE, snow temperature, snow density, stratigraphy, snow chemistry, share of solid*

precipitation
Glacier/Icecap: *winter-, annual mass balance, glacial discharge, surface velocity, ice thickness, stream flow water chemistry, stream flow water temperature, sediment*
Permafrost: *borehole temperature, active layer thickness, water chemistry, discharge*
Lake/river ice:*ice thickness,*
Sea ice:

2) Tier 2CryoNET sites (tentative name REFERENCE-SITE)

REFERENCE-SITE: (=Cryonet station monitoring at least 1 component of the cryosphere at the level of reference site of relevant network organisation as e.g. WGMS for glaciers, GTN-P for permafrost etc.)

Aims:
a) Monitoring of changes of the physical and chemical properties of the cryosphere
b) Extensive datasets for cryospheric modelling approaches
c) Training of personal for cryospheric observations
d) Information to the public

Standards for measurements:
According to the cryospheric parameter the relevant network determines the standard (e.g. IACS for glaciers and snow, GTN-P for permafrost etc.)

Data availability: dependent on cryospheric component, determined by relevant network-organisation

Monitoring components:
dependent on cryospheric component, determined by relevant network-organisation

3) Tier 3CryoNET sites (tentative name OBSERVATION-SITE)

OBSERVATION-SITE: (=Cryonet station monitoring at least 1 component of the cryosphere at the level of accepted GCW standards)

Aims:
a) Monitoring of changes of the physical and chemical properties of the cryosphere
b) Datasets for cryospheric modelling approaches
d) Information to the public

Standards for measurements:
According to the cryospheric parameter the relevant network determines the standard (e.g. IACS for

glaciers and snow, GTN-P for permafrost etc.)

Data availability: dependent on cryospheric component, determined by relevant network-organisation

Monitoring components:
dependent on cryospheric component, determined by relevant network-organisation

ANNEX 8 from protocol of GCW Implementation meeting 1

IDEAS ON MONITORING STATIONS IN CRYONET (FINLAND)

A8.1 Finnish Meteorological Institute (14 Nov. 2011)

The focus here is on seasonally-snow covered, terrestrial (non-mountainous) cryosphere (boreal forest and sub-arctic zones). Regarding the monitoring of snow cover, the network should cover different snow regimes of the world. They are listed in Table 1 following the article: Sturm, M., Holmgren, J., and Liston, G. (1995), A seasonal snow classification system for local to global applications, *Journal of Climate*, 8:1261-1283.

Table 1*: Snow classes to be included (and excluded) in target areas of the Phase 1 of the mission with a 3-day repeat cycle, classes and their description according to Sturm et al. (1995).*

Snow coverclass	*Typicalcharacteristics*	*Indicative range of max. SWE before melt (mm)*
Tundra	A thin, cold and wind blown snow cover; high density	40 - 280
Taiga	Thin/moderate depth cold snow cover with low density, depth hoar typical	80 – 300
Alpine	A deep snowpack with intermediate to cold temperatures, some wind crust and some melt-refreeze effects	200 – 750
Maritime	A warm deep snow cover, melt features very common	250 – 1700
Ephimeral	A thin, very warm snow cover	0 – 150
Prairie	A thin (except in drifts) moderately cold snow cover. Wind effects.	0 – 180
Mountain (specialclass)	Highly variable snowcover	-

A8.1.1 Parameters to be monitored at supersites

Continuous automatic data (distributed observations covering, for example, different ecosystems/soil/land cover types)

- Soilmoistureprofiles (distributed)
- Soil temperature/soil frost profiles (distributed)
- Snow depth and/or SWE (distributed)
- Snow temperatureprofiles (distributed)
- Automatic synoptic weather station observations (including temperature 2 m, temperature ground, dew point temperature, air pressure, air relative humidity, wind

speed, wind direction, precipitation, cloud height, amount of clouds, visibility, snow depth, prevailing weather code)
- Radiation observations (incoming and reflected)
- Distrometerobservations on precipitation
- Atmospheric soundings (troposphere and stratosphere)
- CO2 and/or methane fluxes between the atmosphere and soil-vegetation system (preferably for different ecosystems)
- Watertabledepth on wetlands

Regular manualobservations

- SWE and snow depth on snow pits (forest and bog sites)
- Snowpack layering and snow grain size on snow pits (visible snow grain size observations/photography and/or SSA measurements)
- Soilfrostdepth
- Snow surveys (snow courses with a preferable length of some kilometres)

Optionally

- Specific reference measurements for Earth Observation (EO) instruments (e.g. reference systems of cryosphere monitoring satellite instruments)
- Aerosol opticaldepth
- Energy fluxes (sensible, latent and soil heat), evaporation/transpiration and soil respiration.

A8.1.2 Parameters to be monitored at regular sites

Continuousautomaticdata

- Soilmoistureprofiles
- Soiltemperature/soilfrostprofiles
- Snow depthand SWE
- Snow temperatureprofiles
- Automaticsynopticweatherstationobservations
- Radiation observations (incoming and reflected)

Regular manualobservations

- SWE and snow depth on snow pits (forest and bog sites)
- Snowpack layering and snow grain size on snow pits (visible snow grain size observations)
- Snow surveys (snow courses with a preferable length of some kilometers).

A8.2 China (High Asian Cryosphere)

The State Key Laboratory for Cryospheric Sciences has summarized their ECV measurements for the cryosphere and also identified gaps. Examples are below.

An Example of Observed ECVs and methods Used: Glacier

Component	ECVs	Methods（manual/auto）	accuracy	Standard methodrecommended
Glacier	Massbalance	● stake/snowpit (manual) ● waterbalance (manual/auto) ● Geodetic survey (altimetry, in-situ survey, stereography, DEM) (manual/Aut）	● 5 mm ~ 20 mm ● 10 mm ~ 100 mm ● -	Stake/snowpit
	Surfaceicevelocity	● In-situ survey (theodolite, all-station, RTK-GPS（manual） ● InSAR（auto） ● Sub-pixel methods（auto）	● 1 mm ~ 1 m ● - ● variable	In-situ survey
	Area	● in-situ geodetic（manual） ● stereography（manual） ● remote sensing（auto）	● 1 mm ~ 1 m ● Instrument depends ● variable	in-situ geodetic
	Thickness	● ice-penetrating radar（manual） ● DEM (SAR、in-situ geodetic、stereography, remote sensing）（manual/auto）	● ~ 5m	Ice-penetratingradar
	Icetemperature	20m quartztemperaturesensor（manual/auto）	0.1℃	20m quartztemperaturesensor(auto)
	Meltwaterrunoff	Hydrological section survey (manual/auto）	Instrument depends	Hydrological section survey (manual/aotu)
	Surfaceenergybalance	AWS（auto）	Instrument depends	AWS

An Example of Gaps in ECV Measurements: Freshwater Ice

Applications	Essential Cryospheric Variables（ECV）*
River ice	**Length of frozen river**，**thickness**，**frozen date**，**break-up date**，snow cover on ice，concentration，**types**，roughness，ice volume，**width**，flow velocity
Lake ice	**Frozen date**，**break-up date**，**thickness,** snow cover on ice，concentration，temperature，salinity，surface energy balance

Bold: operated ECVs