Proposal for IASC Joint Body on **the status of mountain snow cover (JB-SMSC)**

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Organizations involved: International Association of Cryospheric Sciences (IACS), the Mountain Research Initiative (MRI), and the World Meteorological Organization's Global Cryosphere Watch (GCW (WMO)).

Duration: 4 years (2022-2025)

The proposal was prepared by this core team of scientists currently active in various fields of snow research, data and information. After approval of the joint body, an open call for participation will be sent out through specific networks such as e.g. Cryolist, GCW national focal points, IACS national committees, the MRI and its Global Network on Observations and Information in Mountain Environments (GEO Mountains), among others. The call will specifically encourage the participation of female and early career scientists and aims to increase diversity in snow science with regard to race, color, religion, gender identity or expression, sexual orientation, genetics or disability. Participation in the IACS-MRI-GCW joint body will be open to everybody who is willing to actively contribute to one or several of the objectives listed in the proposal.

1. Background:

Snow is a key feature of mountain regions globally. Snow helps mountain regions to serve as water towers, providing a critical supply of water to downstream areas. Furthermore, water from snow melt is essential for power generation, irrigation, water supply, groundwater recharge and aquatic ecosystems. Besides hydrology, snow plays an important role for mountain ecosystems, natural hazards, and tourism.

Climate change is clearly impacting the amount and distribution of mountain snow cover over space and time, although the relationships between climatic change or more precisely atmospheric variables and snowpack responses are not simple and straightforward. Snow accumulation is the result of complex interactions between precipitation-bearing air masses and mountain orography. Snow on the ground can subsequently be redistributed via numerous mechanisms. Ablation, meanwhile, is a complex process chain of surface-atmosphere interactions that reduces snow deposited on the ground by melt or sublimation. As such, it is apparent that the response of the snowpack to climate change in mountains worldwide is not a simple temperature effect, but depends on (i) the geographic location (climate zone), (ii) the atmospheric characteristics of a mountain region (e.g., interaction with synoptic-scale atmospheric flow), (iii) elevation and (iv) small-scale geographic location (topographic influences).

There are inventories (often called global, though they exclude mountain regions) of snow cover changes available for regions outside mountains (based on satellite data, from Globsnow, ESA-GCW Snow-Watch, etc.), as well as numerous process studies and selected data availability for some

mountain regions. **Despite the high relevance of snow in mountain regions, an inventory for mountain snow-cover at the global scale is missing so far. Even regional inventories are strongly limited to a few well-monitored mountain ranges like the U.S. Rockies and the European Alps**.

2. Objectives:

Beside the idea of highlighting the relevance of the mountain snow cover in general, the study has a multiple motivation:

1. The primary research objective is to provide robust information on mountain snow cover changes at a global scale in the past few decades based on compiling and standardizing existing data (sources) at sufficiently high resolution. The study will include surface observations (from weather and hydro stations as well as from avalanche services), remote sensing products, downscaled reanalysis data and snow model simulations. While station data provide highly temporally resolved and long-term local information, satellite products can significantly increase spatial coverage of snow observations.

2. In addition to compiling and analyzing existing data series by investigating spatial and temporal trends of snow cover properties and derived indicators, this initiative also aims to better understand processes of accumulation and ablation based on existing modelling and observational studies.

3. Another important objective of the initiative is open access to the snow data for the research community, and to contribute to the operational capacity building in terms of understanding mountain snow cover changes and its impacts on and responses to climate, water and environment.

3. Work plan and related deliverables/milestones:

The initiative will start with a kickoff-workshop (e.g. at EGU2022) that will specify the work packages and their tasks in detail and coordinate them with recommendations from the research community. At the same time, the research community will be given the opportunity to get directly involved in the project, make commitments and to contribute. A workshop report will be provided as a cross-cutting deliverable for WPs1-4.

WP 1: Mountain snow data quality control and homogenization for use in climatology and hydrology

WP1 is dedicated to the provision of snow data (from national meteorological and hydrological services, avalanche agencies, …), data quality control and homogenization, and methods of deriving snow information from remote sensing data. The general approach is not to build a new database but to use and link existing database infrastructures (e.g. the "Snow Dataset Inventory" https://globalcryospherewatch.org/reference/snow_inventory.php). Data should include at least snow depth, depth of snowfall, water equivalent of snow cover, density of snow cover and snow cover extent. Analysis of snow data/networks representativeness will provide information on related methods and identify existing spatial data gaps in mountain regions.

Deliverables:

D1-1: Methods of data quality control, homogenization (as open-source tools/scripts), minimum meta data for station observations

D1-2: Methods of remote sensing measuring snow cover extent, water equivalent of snow cover, snow depth (as open-source tools/scripts)

D1-3: Global data set of snow depth, depth of snowfall, water equivalent of snow cover, density of snow cover and snow cover extent from mountain regions following FAIR data principles (including strategy for regular updates). Both station timeseries and remotely sensed data are included.

D1-4: Publish resultant datasets as data paper (e.g. Scientific Data)

D1-5 Publish an inventory of existing observing facilities, networks and programmes, in-situ and space based, including affiliations

D1-6: Report on methods of snow data/networks representativeness and spatial data gaps in mountain regions

D1-7: Reports to GCW and Group on Earth Observation (GEO) via the MRI

D1-8: Presentations at IACS Scientific Assemblies, EGU, and AGU

WP2: Status of snow cover multi-decadal changes in mountain regions of the world

Based on data already available and those provided by WP1, WP2 investigates the change of snow cover in mountain regions worldwide over the last decades. The different data bases in the various mountain regions of the world will allow for a different period of investigation, but where possible, an assessment back to 1950 is generally aimed at. Station data will generally provide good information on temporal changes, remote sensing data will in particular help to better identify spatial patterns. Downscaled reanalysis data and snow model simulations could bridge the gap between station series and remote sensing data and help to understand findings. Snow cover properties should include at least snow depth, depth of snowfall, water equivalent of snow cover and density of snow cover.

Deliverables:

D2-1: Standardized methods for analyzing snow data and derived indicators for temporal and spatial trends/changes (as open-source tools/scripts)

D2-2: Analysis of elevation dependency of changes of snow cover properties

D2-3: Paper on the status of past/recent snow cover changes in mountain regions of the world

D2-4: Maps of mountain snow climatology and snow indicators

D2-5: White paper on environmental impact of mountain snow cover and global picture of relevance of mountain snow cover for humans

D2-6: Process understanding of observed snow cover changes (effects of air temperature changes, precipitation changes, … and how they vary in time and space)

D2-7: Presentations at IACS Scientific Assemblies, EGU, and AGU

WP3: Snow accumulation processes

The results of WP3 should contribute to a better understanding of observed changes in snow cover in mountain regions (e.g. process understanding for elevation dependence of changes in snow cover properties). The focus is on processes of snow precipitation formation and the influence of mountain

orography (e.g. effects on 0°-line, effects on snowfall-line, …) as well as the understanding of wind-driven snow redistribution and gravitational mass transport.

Deliverables:

D3-1: Review of processes affecting snow-precipitation formation and preferential deposition/snow redistribution in mountains regions

D3-2: Data set of snow-precipitation relevant atmospheric variables from model simulations for selected test sites (different mountain regions) running high-resolution terrain-resolving atmospheric models

D3-3: Review paper on snow precipitation processes under climate change, esp. differences in mountain areas from other regions

D3-4: Review paper on current understanding of snow redistribution and research gaps

D3-5: White paper on research gaps in snow precipitation and snow redistribution modelling

D3-6: Presentations at IACS Scientific Assemblies, EGU, and AGU

WP4: Snow ablation processes - research gaps in mountain snow modelling

While WP3 focuses on snow accumulation, WP4 is dedicated to the processes of snow ablation. Effects of mountain orography on the mass and energy balance of the snowpack and the snow ablation resulting from the energy balance are of particular interest and are also where there are research gaps in mountain snow modelling.

Deliverables:

D4-1: Review of processes affecting mass- and energy balance of snow cover and related snow ablation in mountains

D4-2: Inventory of (physical based) snow models used for operational weather forecast and reanalysis simulations

D4-3: White paper on research gaps in mountain snow modelling and coupling with RGCM (in coordination with the WMO Study Group on cryosphere SG-Cryo)

D4-4: Presentations at IACS Scientific Assemblies, EGU, and AGU

Schedule:

Workpackage	2022				2023				2024				2025			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
WP1																
WP2																
WP3																
WP4																

Requested budget:

We ask for a total of 18.000 Euros as a contribution to the coordination of the proposed kick-off workshop and for staff time to compile the data base in WP1. Both MRI and WMO-GCW have already committed a contribution of EUR 6000,- per organization, so we are requesting support of EUR 6000,- from IACS. In view of optimizing the requested budget, and considerations for reducing the carbon footprint associated with this project, most of the communication will be organized in the form of virtual meetings or side events at international conferences (*IACS Scientific Assemblies,* AGU, EGU).