



climate change initiative

European Space Agency

User Workshop Report (UWR)



glaciers
cci

Prepared by: Glaciers_cci consortium
Contract: 4000127593/19/I-NB
Name: Glaciers_cci+_Ph2_D5.3_UWR
Version: 0.2
Date: 22.11.2024

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J **GAMMA REMOTE SENSING**



Document status sheet

Version	Date	Changes	Approval
0.1	31.10.2024	Initial draft	
0.2	22.11.2024	Consortium Feedback included	

The work described in this report was done under ESA contract 4000127593/19/I-NB. Responsibility for the contents resides with the authors who prepared it.

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1. Purpose

This is the User Workshop Report (UWR) of the Glaciers_cci+ Phase 2 project. It presents details of a specific scientific session with appended discussion held at the International Union of Geodesy and Geophysics (IUGG) General Assembly 2023 in Berlin.

2. Venue and topic

The 28th General Assembly of the IUGG took place in Berlin from 11.-19.7.2023. Scientific sessions related to the cryosphere (organized by IACS) were scheduled for 12.-16.7.2024. In response to the steadily increasing interest in glacier changes taking place in High Mountain Asia (HMA), a session on this topic was proposed and accepted by IACS for the IUGG. The session was called ‘Glacier Changes in High Mountain Asia and the Karakoram Anomaly: Latest insights from the atmosphere and cryosphere’ and was convened by Frank Paul with co-conveners Emily Collier from Austria, Daniel Farinotti from Switzerland and Pankaj Kumar from India. The description of the related session C02 reads:

‘Snow cover and glacier changes in High Mountain Asia (HMA) have been intensely studied over the past two decades, mostly using satellite data, numerical models, and an increasing number of field observations. The interest in the region is high, as snow and glacier melt are of high importance for the water resources of millions of people living downstream of major mountain ranges. Of similar interest are the still poorly understood reasons for the high spatial variability of cryospheric changes, and amongst these, the so-called ‘Karakoram Anomaly’ is of particular interest. Marking a region with stable or advancing (and often surging) glaciers, balanced mass budgets, and decreasing (summer) temperatures, the glacier evolution in the Karakoram is in stark contrast to the strong retreat and mass loss observed elsewhere in HMA and most other glacierized regions on Earth.

With limited availability of temperature and precipitation observations, an extremely steep and high topography, a strong influence of the monsoon and westerly climate regimes, and nearly absent glacier mass balance measurements, our understanding of the governing processes are still vague. The combination of atmospheric and glaciological modelling with remote sensing observations has a great potential to improve our knowledge, and further progress is required if the future of the cryosphere and the water cycle are to be predicted correctly. For this symposium, we invite contributions reporting on the latest findings on cryospheric and atmospheric changes in HMA. We invite contributions based on remote sensing observations, field surveys or numerical modelling. We envision a special focus on the Karakoram Anomaly, but invite contributions from nearby regions as well. We particularly welcome studies that synergistically combine atmospheric and cryospheric modelling with remote sensing data or studies that investigate possible drivers of observed changes.’

The session attracted 11 abstracts of which 6 were selected as oral presentations and 5 as posters. The session was held on 13.7.2024 with about 50 persons in attendance. As one presentation was not given, we used about 25 minutes for a general discussion with the speakers and audience about research challenges and directions for glaciers in HMA.

3. Agenda

In Table 1 we provide an overview of the oral and poster presentations. We invited Tobias Bolch, who has been working about glaciers in HMA since about 20 years, as a solicited speaker to give an overview and latest update on glacier changes in HMA. The other presentations provided a wide range of topics from meteorological causes of the Karakoram Anomaly to long-term trends at high elevation weather stations, to extreme events in the Pamir Mountains, to glacier elevation and volume changes from regional to local scales. The authors also presented studies related to the modelling of past glacier mass balances, wrong precipitation amounts in re-analysis datasets, the impact of temperature trends on permafrost thaw and of future climate change on run-off as well as an analysis of historic glacier surges using historic images from the Keyhole mission.

Table 1: Overview of the oral (O1-O6) and poster (P1-P5) presentations.

Nr.	Presenter	Country	Title
O1	T. Bolch	Austria	The State and Fate of Glaciers in High Mountain Asia
O2	J. Javed	India	Western Disturbances and their role in sustaining the 'Karakoram Anomaly'
O3	F. Salerno	Italy	Glacier feedback on Himalayan climate under global warming
O4	F. Pellicciotti	Switzerland	The pulse of the Pamirs: How do the warm summers of 2021 and 2022 fit into the bigger picture?
O5	Q. Wang	China	Seasonal cycles of High Mountain Asia glacier surface elevation detected by ICESat-2
O6	P.J. Navinkumar	India	Early 21st century glacier ice volume changes in the Teesta basin Eastern Himalayas
P1	S. Minallah	USA	Modelling the mass balance and ice dynamics of Karakoram glaciers
P2	A. Jouberton	Switzerland	On the representation of precipitation phase and its impact on glacier changes in HMA catchments
P3	N. Guyennon	Italy	Himalayan periglacial environment may be currently preserved from global warming by glacier feedback
P4	S. Fugger	Switzerland	The future of a glacierized Amu Darya headwater catchment
P5	F. Paul	Switzerland	Two glacier surges in the central Karakorum observed from Corona stereo images

4. Discussion

The presentations and subsequent discussion made clear that glaciers and their changes play a vital role for the population dependent on the water from the mountains and despite recent improvements, the available measurements are still not adequate for proper understanding and modelling of climate change impacts. It was emphasized that satellite-based observations (incl. the opening of the Landsat archive and free access to numerous other datasets) and the increasingly automated processing lines (e.g. DEM generation and flow velocities) provide an urgently required overview of glacier changes in HMA over the past decades. In combination with numerical modelling (using satellite-derived datasets for calibration), process understanding increased considerably and major questions about glacier distribution, ice reserves and run-off could be answered. However, it was also stated that ground-based measurements are sparse, very difficult to obtain, often not representative for high-mountain regions and even if performed, are often not shared (e.g. run-off data). In this field improvements are seen due to automated measurements, use of drones and dedicated research projects, but long-term maintenance and coordination (within a country and across countries) is still weak and not up to its potential. Political dispute over national boundaries as well as missing scientific training and adequate (long-term) financial support for engaging the local population in related activities are further challenges for improving the situation. Dedicated research projects are of great help (when data are shared afterwards), but the missing coordination or unclear link to overarching research questions often limits wider uptake or use by the community.

On the other hand, it was also made clear that certain restrictions will remain even if measurements were performed and shared. For example, the difficulties in accurately measuring precipitation in mountain ranges (liquid and solid) are a global problem and obtaining snow and firn density data (e.g. performed as a part of mass balance measurements on glaciers) might be possible, but its representativeness for a larger region is not known. All this is further challenged by special climatic conditions (monsoon climate with highest accumulation and ablation occurring at the same time), special glacier types (e.g. fed by snow avalanches, surging), difficult access and unclear data quality. Hence, a calibration or validation of satellite and/or model-based results with field data is only possible for a few specific sites from which data are shared. It was mentioned that measurement activities have recently increased in the Tibetan Plateau, but also that the entire Karakoram lacks mass balance measurements (maybe apart from ablation measurements over a short period of time on Batura, Baltoro and Siachen glaciers). This results in large gaps for process understanding and related high uncertainties when modelling the future evolution of these glaciers. This is really unfortunate considering the importance of the region for water supply and given that this is one of the regions hosting the most dynamic glaciers in the world. Hence, satellite data combined with numerical modelling will be the key tools to obtain further insights. Luckily, the wealth of currently available satellite data and related progress in mass balance modelling offers ample opportunities for further exploration.

Overall, the discussion revealed that still many knowledge gaps exist and that cryospheric research and monitoring should thus be continued and extended as good as possible in the respective countries. The wealth of now available remote sensing data combined with advances in data processing and numerical modelling will support related efforts.