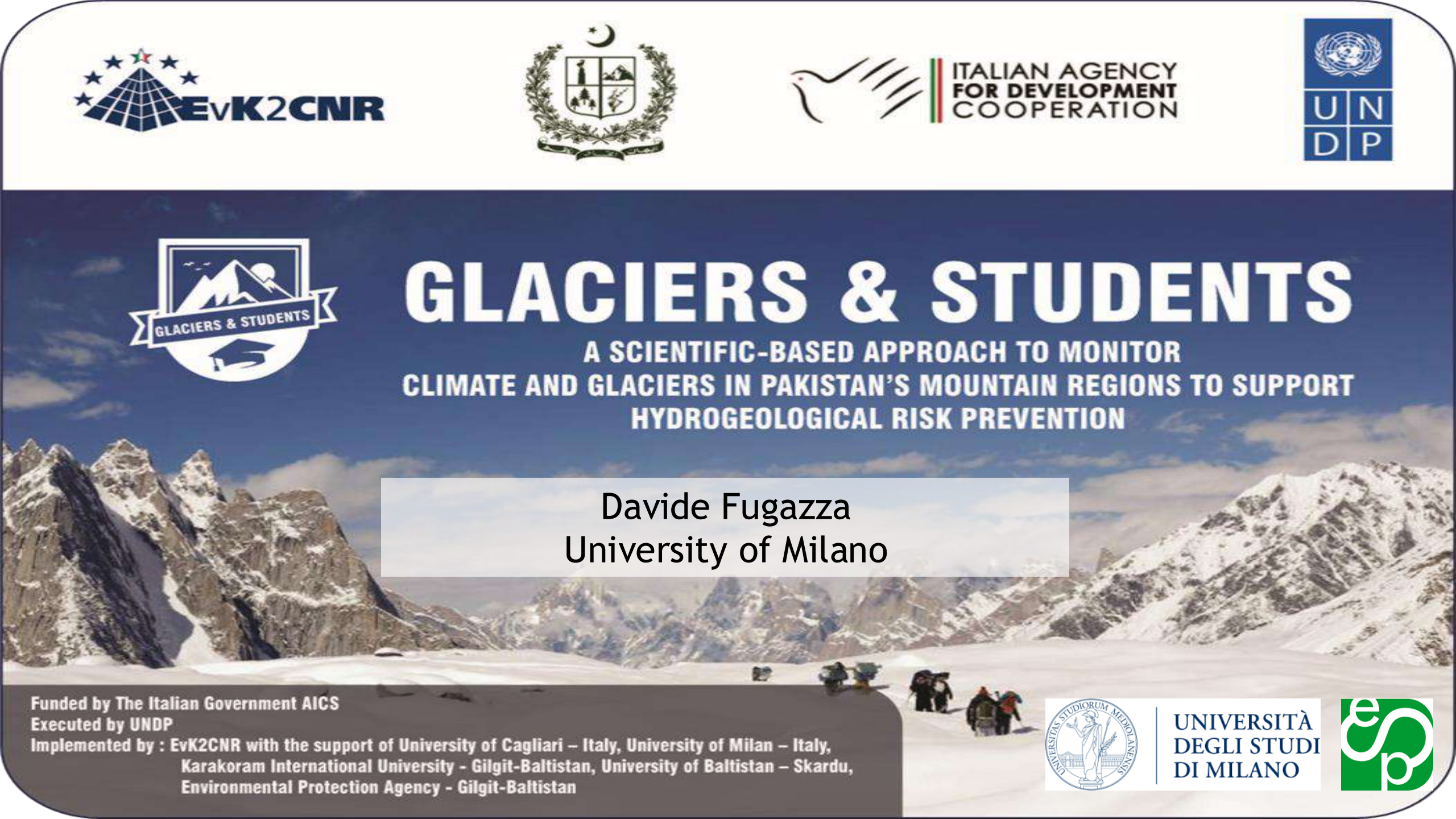
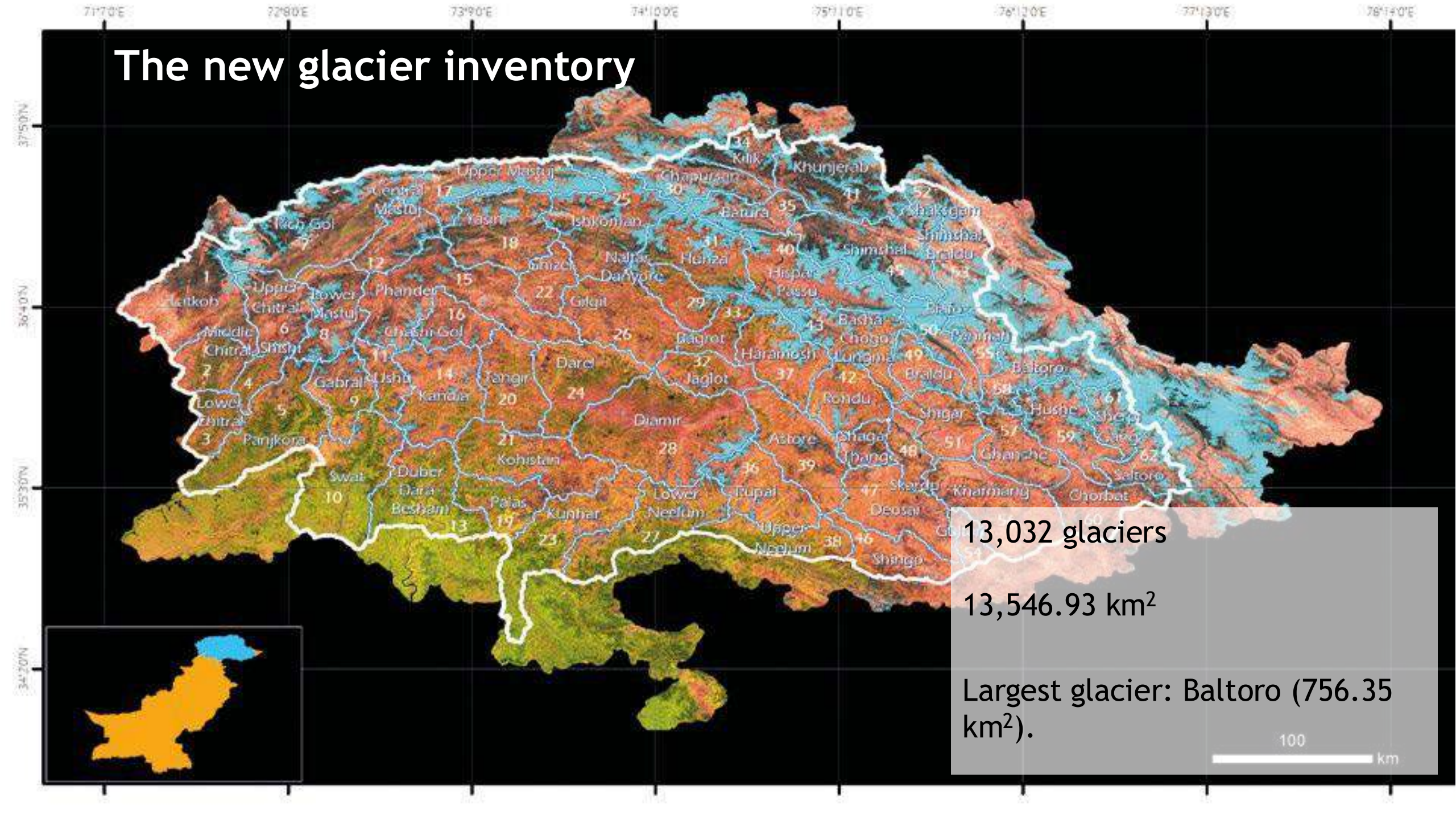

EvK2CNR
ITALIAN AGENCY FOR DEVELOPMENT COOPERATION
UNDP
GLACIERS & STUDENTS
GLACIERS & STUDENTS
A SCIENTIFIC-BASED APPROACH TO MONITOR
CLIMATE AND GLACIERS IN PAKISTAN'S MOUNTAIN REGIONS TO SUPPORT
HYDROGEOLOGICAL RISK PREVENTION
Davide Fugazza
University of Milano
Funded by The Italian Government AICS
Executed by UNDP
Implemented by : EvK2CNR with the support of University of Cagliari – Italy, University of Milan – Italy,
Karakoram International University - Gilgit-Baltistan, University of Baltistan – Skardu,
Environmental Protection Agency - Gilgit-Baltistan
UNIVERSITÀ DEGLI STUDI DI MILANO

The new glacier inventory



13,032 glaciers

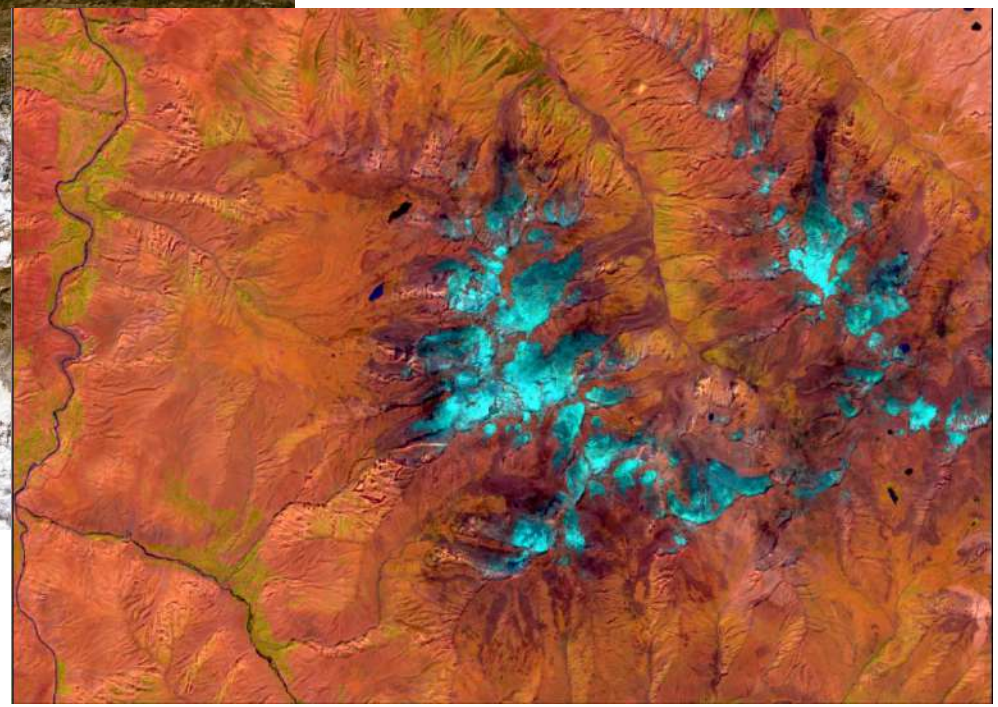
13,546.93 km^2

Largest glacier: Baltoro (756.35 km^2).

100 km

The new glacier inventory

- Sentinel-2 images by ESA
- 10 m resolution
- Acquired over one summer season (2022)



The new glacier inventory - results

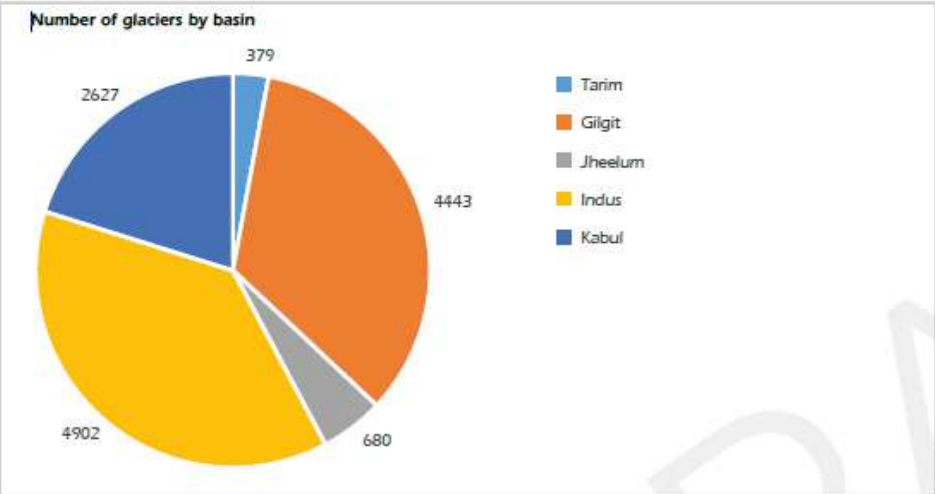


Figure 10: Number of glaciers in each basin of the 1st order.

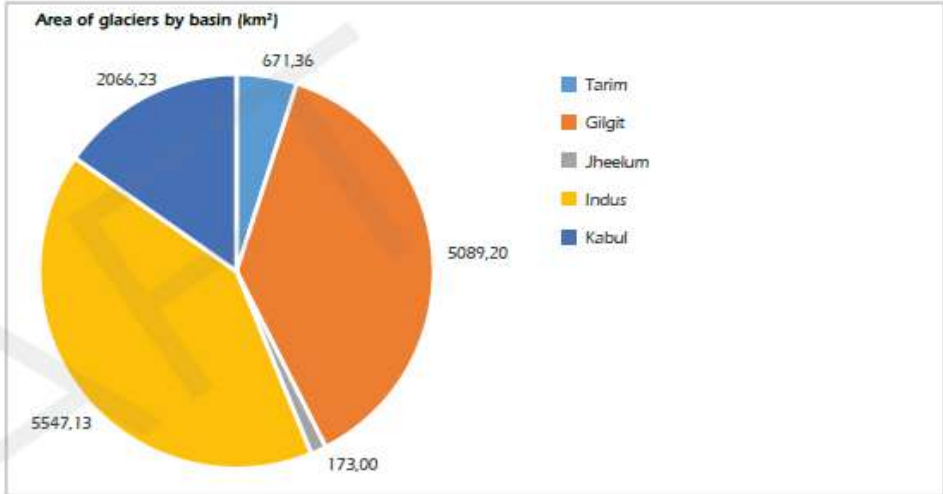


Figure 11: Area of glaciers in each basin of the 1st order.

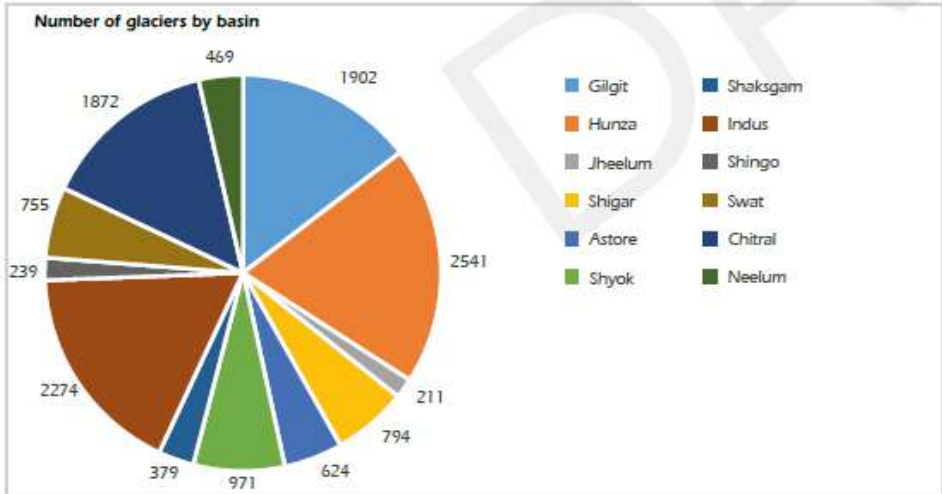


Figure 12: Number of glaciers in each basin of the 2nd order

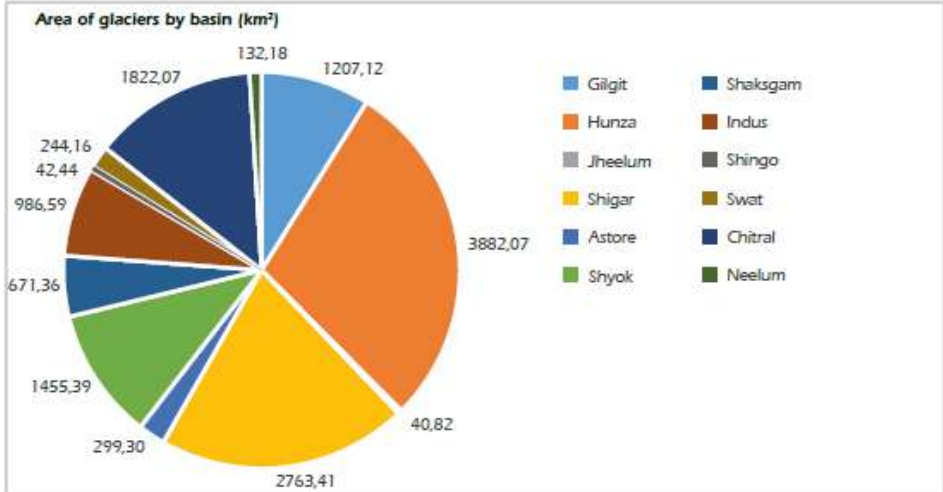


Figure 13: Area of glaciers in each basin of the 2nd order

The new glacier inventory - results

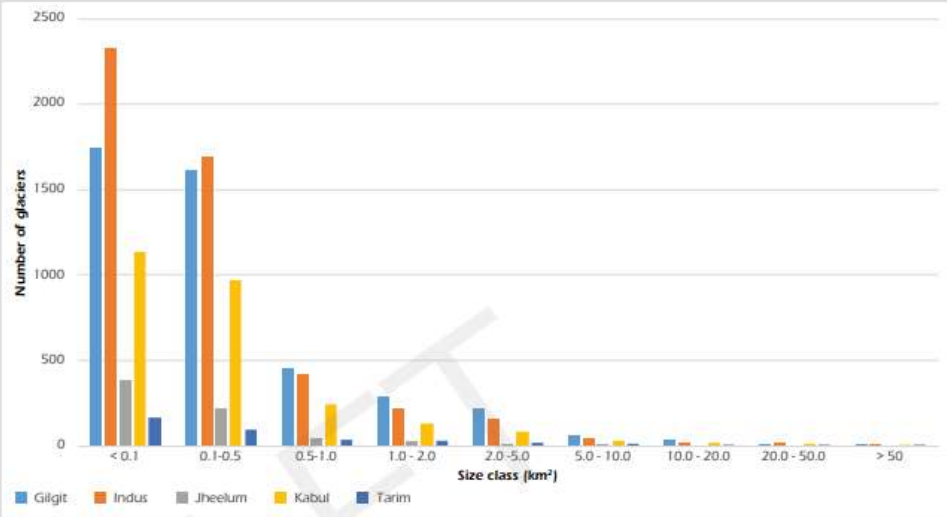


Figure 14: Number of glaciers in each size class for the 5 basins in the 1st order division

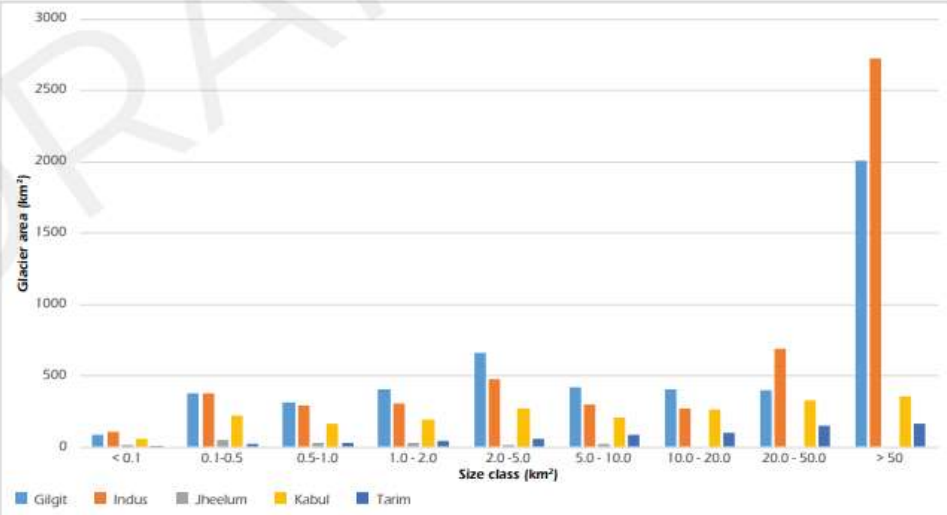
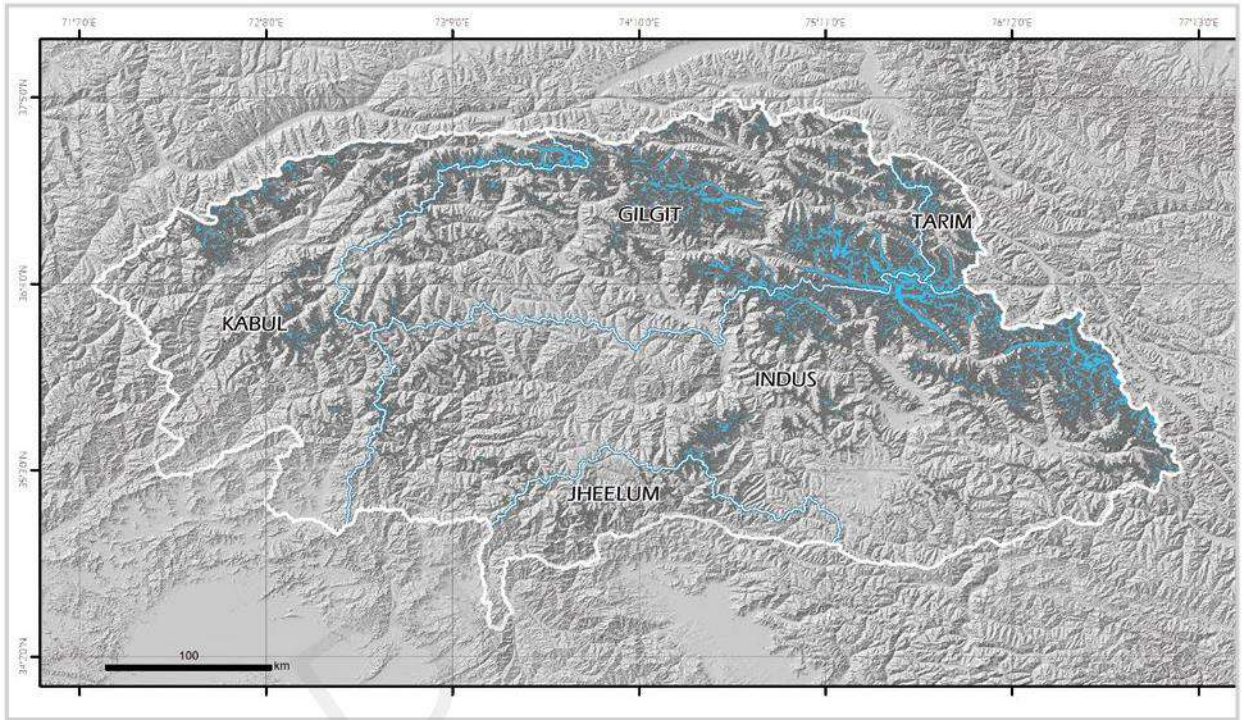


Figure 15: Area of glaciers in each size class for the 5 basins in the 1st order division

A large number of small glaciers

A small number of large glaciers!



The new glacier inventory - elevation

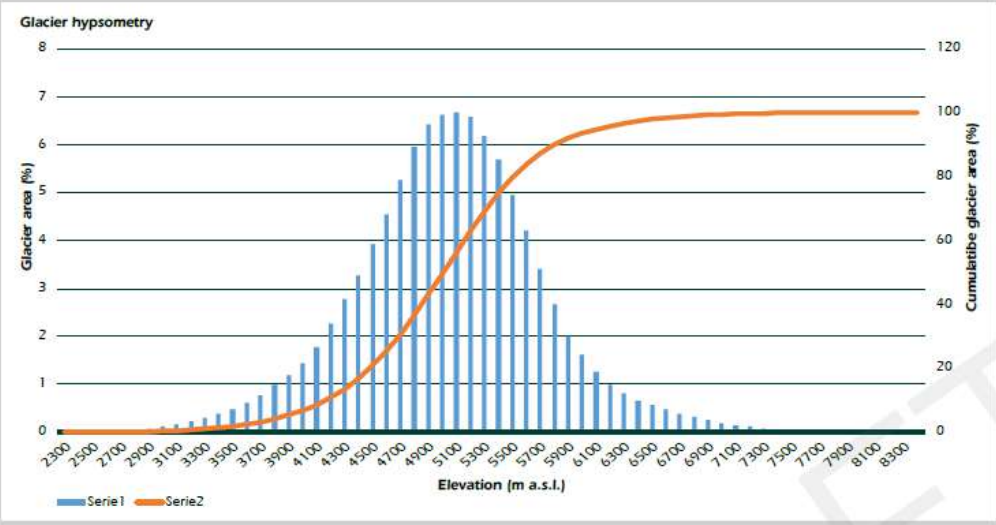


Figure 18: Hypsometric distribution of all glaciers in Pakistan in 100 m elevation bands.

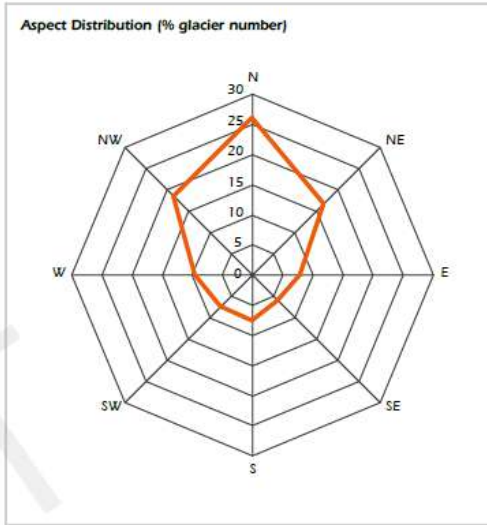


Figure 19: Percentage of glaciers in each aspect class (8 directions).

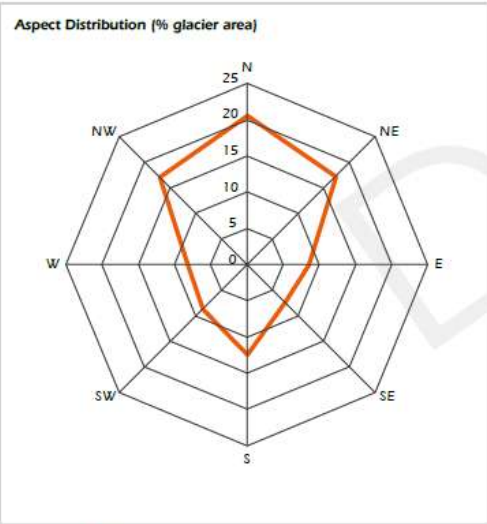


Figure 20: Percentage of glacier area in each aspect class (8 directions)

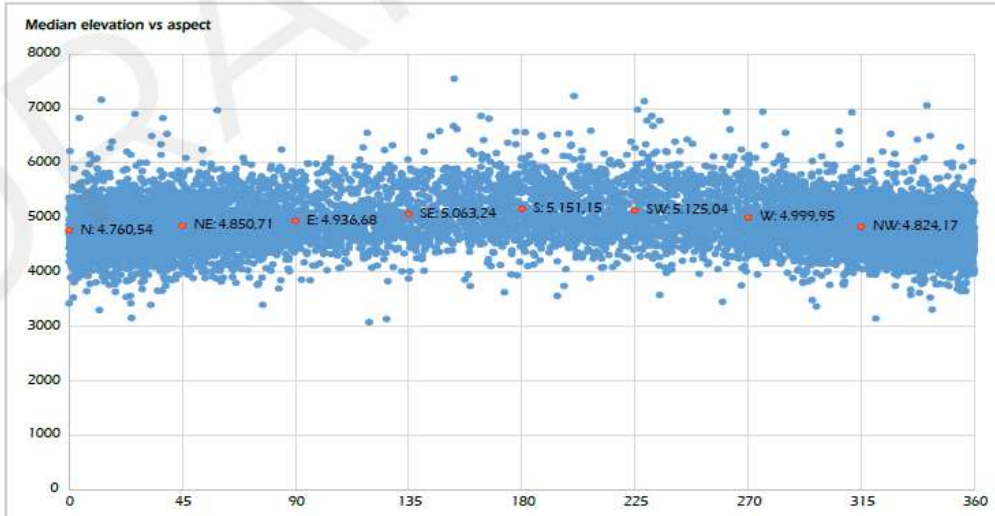
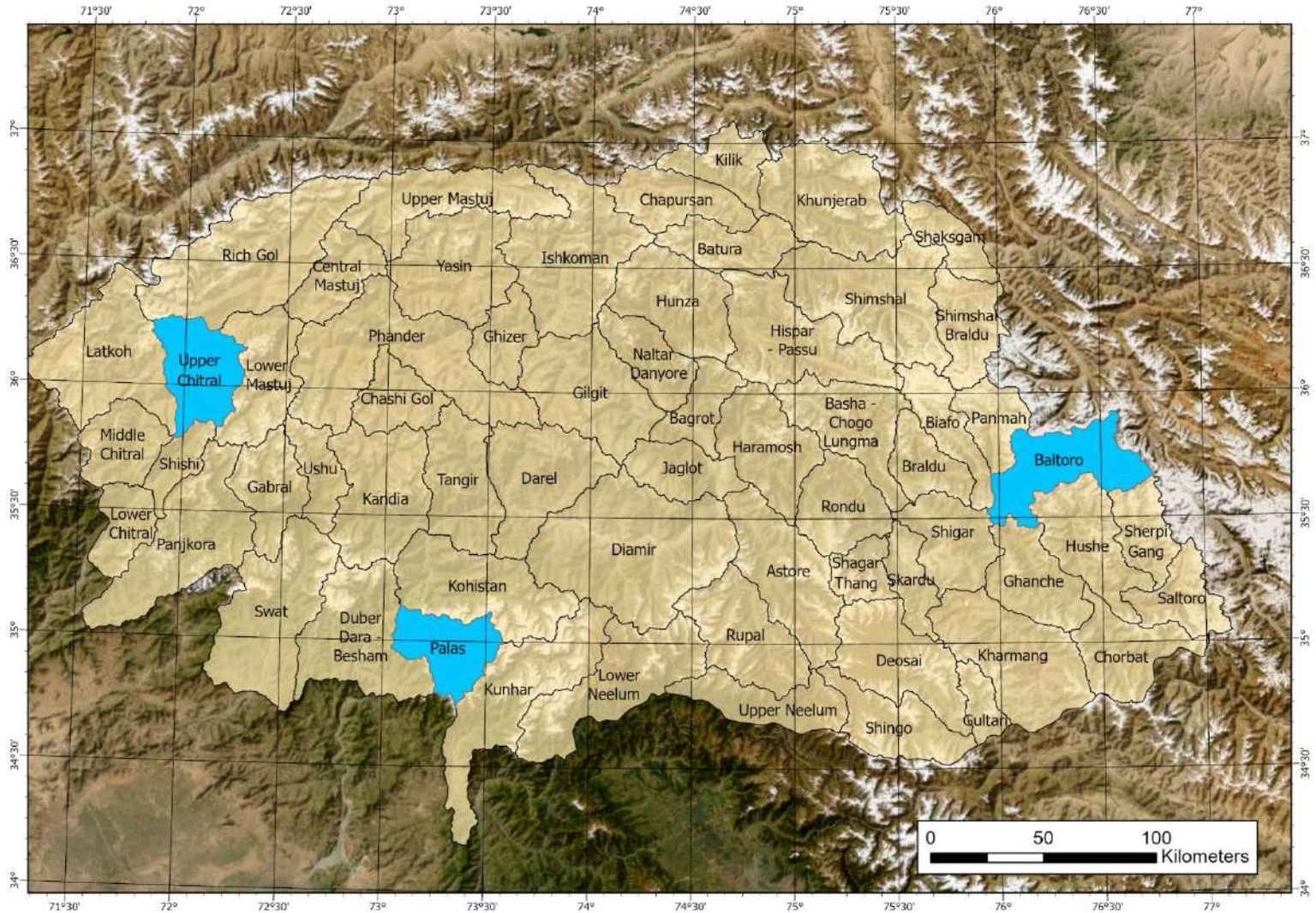


Figure 21: Relationship between glacier median elevation and aspect. Red dots show the average median elevation for each aspect class.

Most glaciers face north (> 25%), and those that do are at lower elevations compared to those facing south (400 m difference)

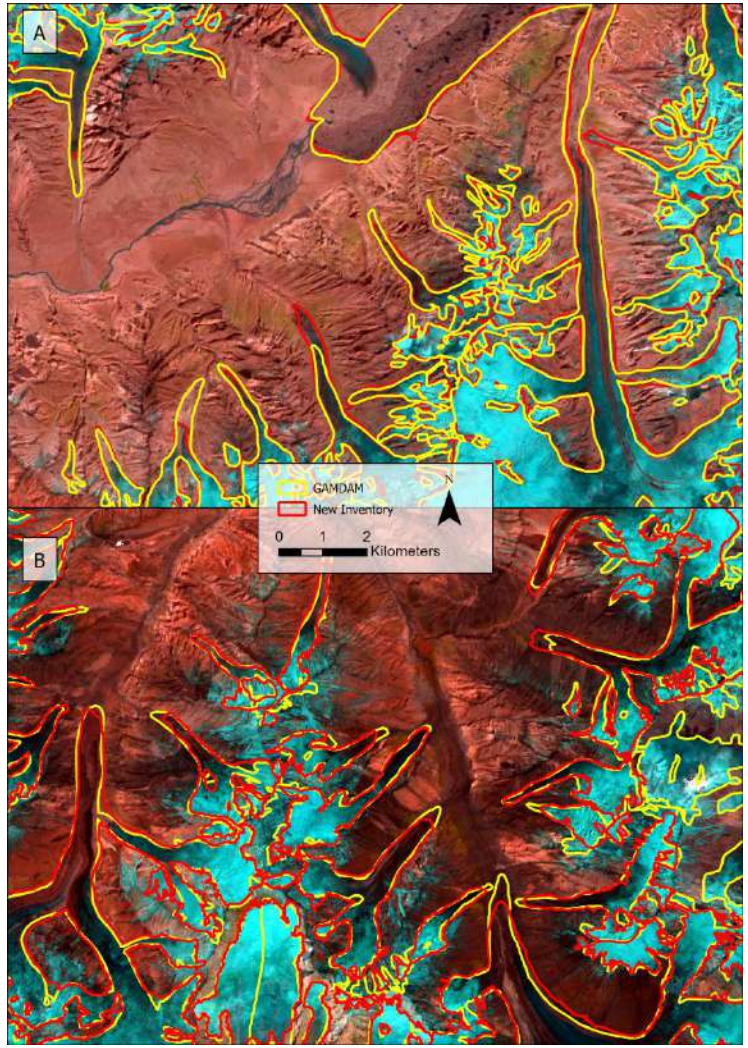
Median glacier elevation is around 5000 m a.s.l.

The new glacier inventory – glacier changes since 2000



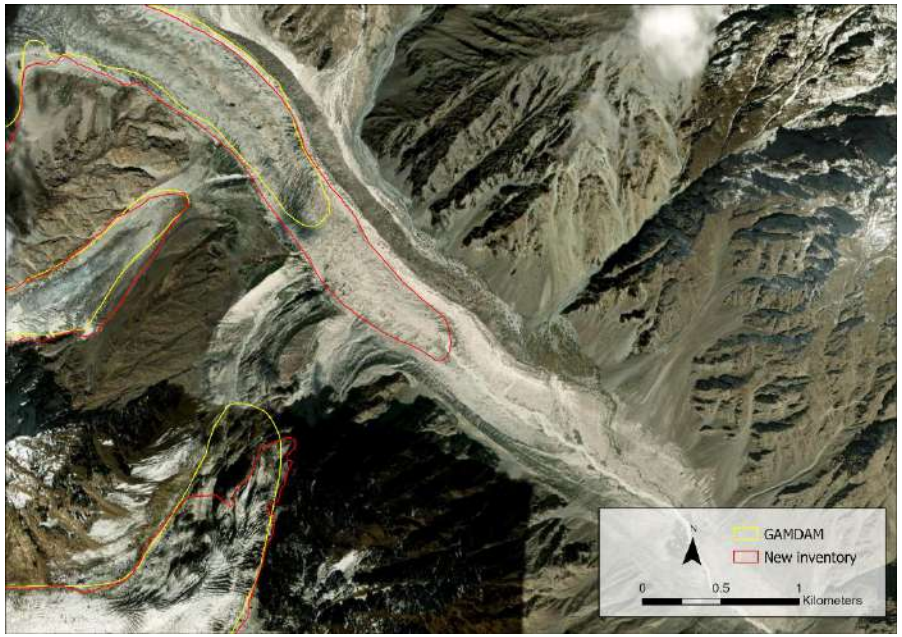
Comparison between the new inventory and GAMDAM glacier inventory (~2000) for Baltoro basin (Karakoram), Palas basin (Himalayas) and Upper Chitral basin (Hindukush)

The new glacier inventory – glacier changes since 2000



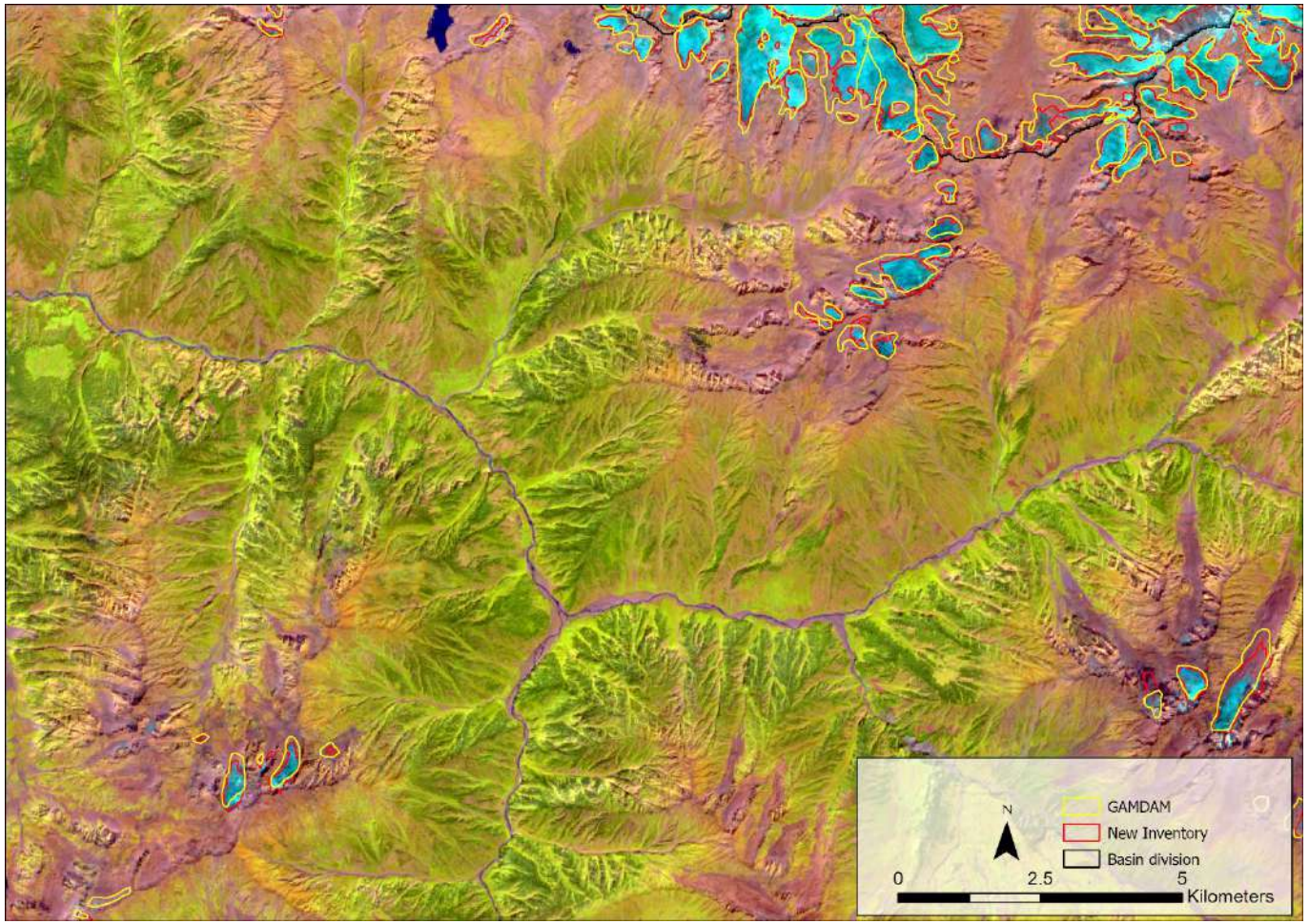
In Baltoro basin (Karakoram), glacier area is stable, and changes are caused by the surging behaviour of glaciers

In Upper Chitral basin (Hindukush), changes are caused by the different interpretation of debris covered glaciers



The methodology needs to be consistent when performing comparisons!

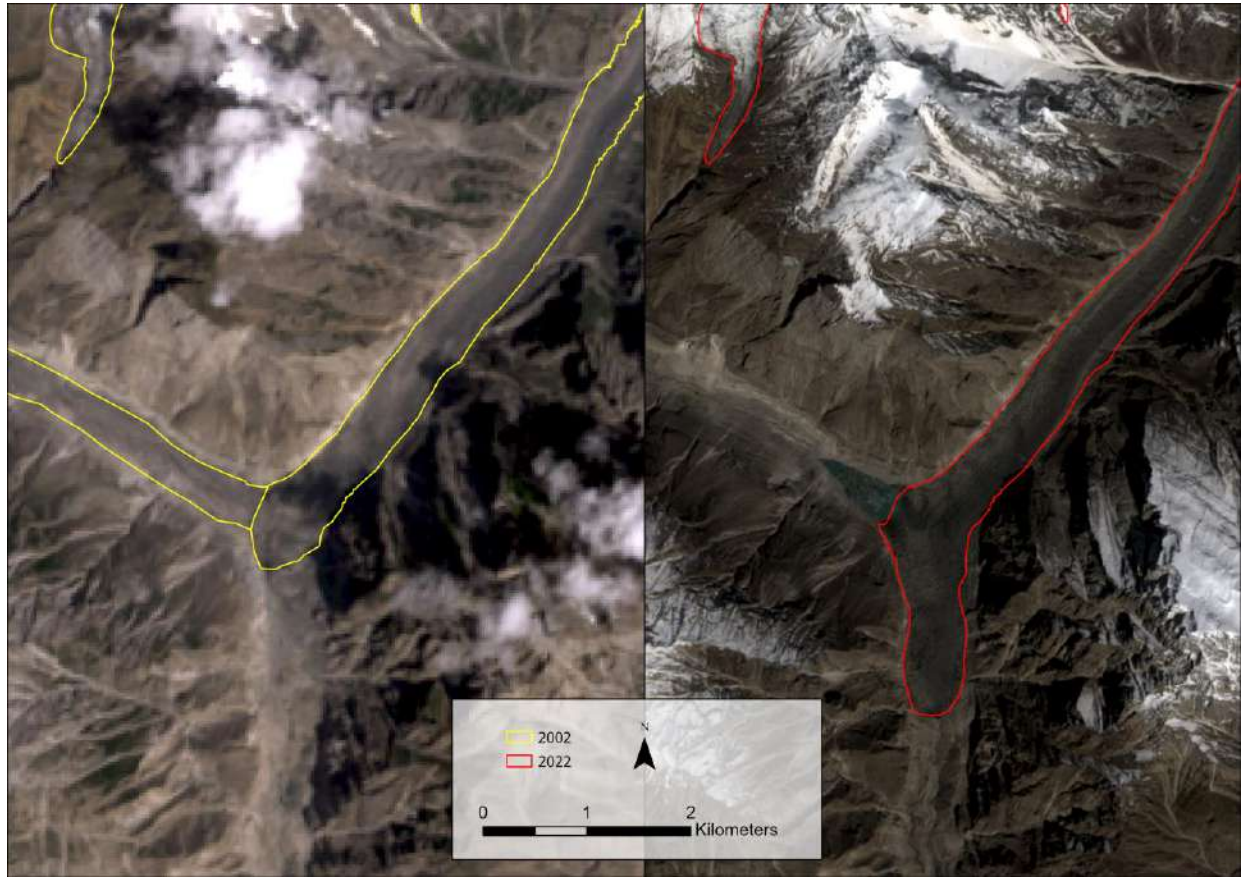
The new glacier inventory – glacier changes since 2000



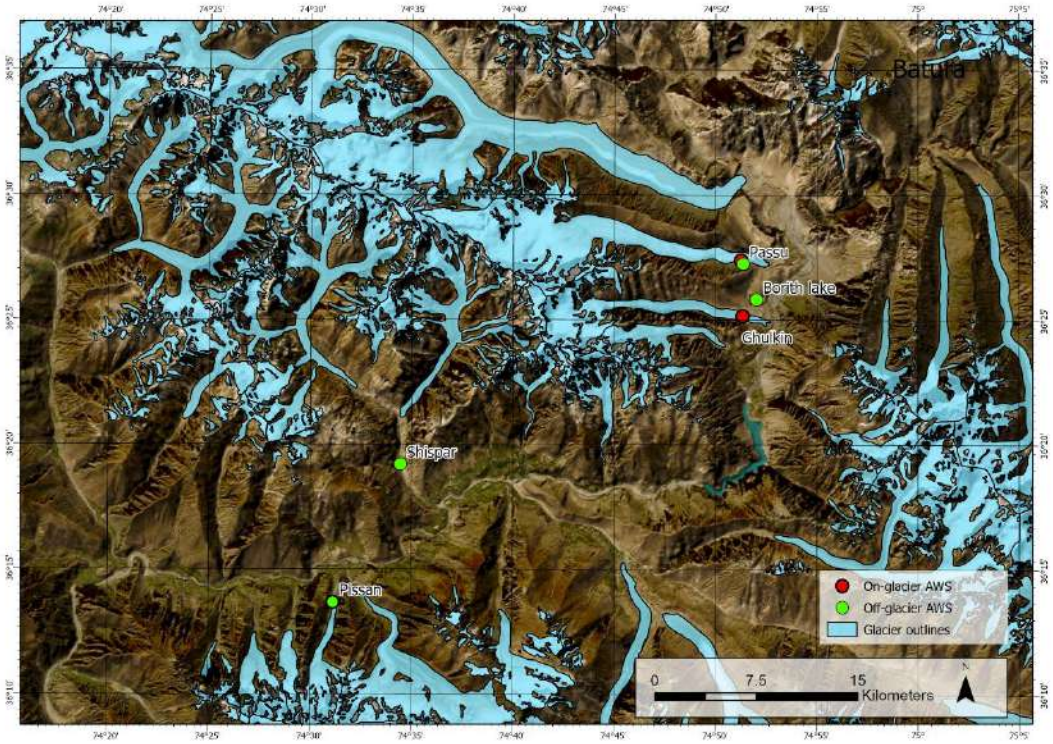
In Palas basin (Himalayas), there is evident retreat (-16% in ~ 20 years)

The new glacier inventory – Surging glaciers

Shishpar/Muchuhar glaciers in 2002 and 2022

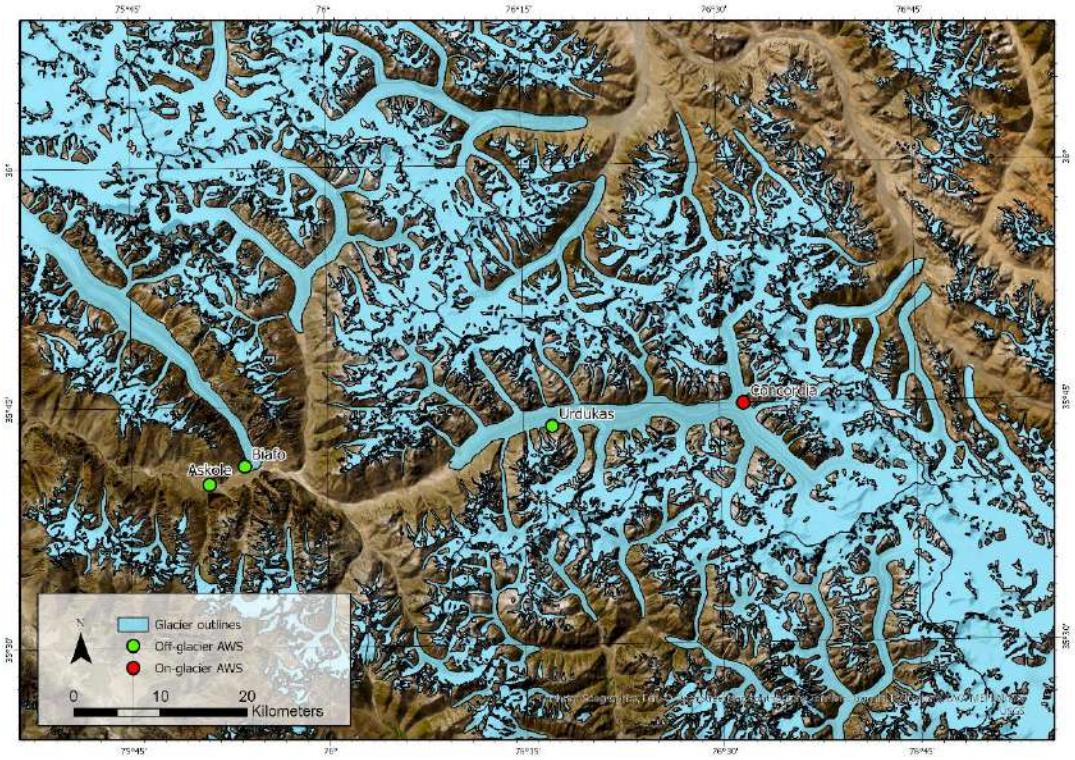


The new Automatic Weather Station network



Hunza basin

- Shispar
- Passu
- Ghulkin
- Pissan

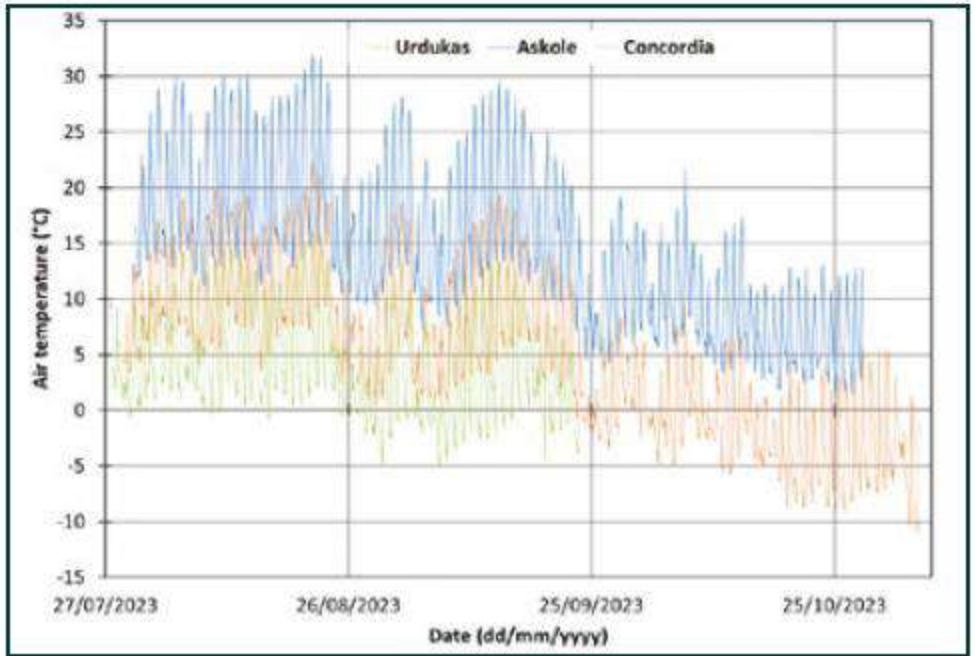


Baltistan

- Baltoro
- Biafo

Automatic Weather Stations

AWS data - Baltoro



August and September 2023 were warmer than previous years on record

Askole	2005	2006	2007	2008	2009	2010	2011	2012	2013
1		-6.14	-5.78	-6.33	-6.97	-4.99	-6.64	-6.57	
2		-1.35	-1.31	-5.45	-4.16	-3.52	-4.33	-3.70	
3		1.14	0.86	3.22	0.32	2.49	0.76	-0.08	
4		5.51	9.86	6.66	5.67	6.36	6.55	6.71	
5		13.37	12.73	12.60	10.50	9.14	12.81	9.38	
6		13.95	15.78	17.63	12.67		16.06	12.20	
7		18.52	17.08	18.22	16.08		16.39	17.27	
8			16.76	17.35	16.88		17.22	17.60	19.12
9			13.09	11.43	12.65		13.13	11.93	15.26
10			6.72	6.65	6.08	8.04	7.27	6.50	8.07
11	0.38			2.60	-0.46	2.77	2.21	1.28	
12	-4.50		-3.68	-3.96	-5.43	-2.67		-4.48	

Table 2: Monthly mean air temperatures (°C) at Askole from 2005 to 2023.

Urdukas	2004	2005	2006	2007	2008	2009	2010	2011	2012	2023
1			-11.49		-13.41	-12.33		-14.57		
2			-7.71		-13.00	-10.46		-10.85		
3			-6.71		-5.15	-6.67		-6.78		
4		-3.21	-2.66		-1.46	-2.18		-1.99		
5		0.10	5.09		4.21	2.16		4.40		
6		6.29	6.20			4.50		8.05		
7	8.66	9.04	11.69			8.26				
8	7.70	8.84	10.12					9.83		10.30
9	5.74	6.28						5.59		6.31
10	-2.84	-1.78						-0.82		-1.85
11	-7.10	-8.05		-5.32				-5.77		
12	-9.07	-11.99		-10.84						

Table 3: Monthly mean air temperatures (°C) at Urdukas from 2004 to 2023.

Monitoring glacier melt

glacier melt was extremely high in 2022 and 2023!

Between September 2022 and July 2023, more than 9 m of ice melted on Passu glacier and Ghulkin glacier at some locations.

The measured ablation will be used to validate a model to estimate freshwater availability from glacier melt

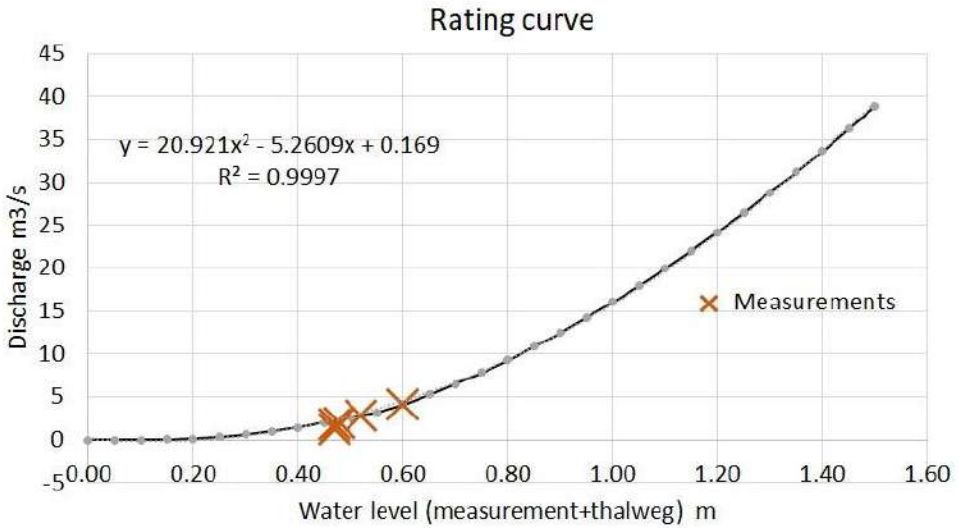
Stake	Length
GH60	9.10 m
GH52	All stakes out
GH50	9.93 m
GH51	8.81 m
GH40	8.15 m
GH22	5.53 m
GH20	8.90 m
GH21	5.53 m
GH15	6.10 m

Glacier research in the W4D project

Starting the glacier inventory carried out in the Glaciers & Students project, we will investigate the glaciers in relation to

- climate change impacts
- seasonal surface runoff trends
- hydrogeological risk phenomena
- availability of freshwater downstream in the present and future

Glacier research in the W4D project



- Installation of new meteorological and hydrometric monitoring stations to study the hydrological behaviour of the project basins
- Determine ice volume and water availability
- Development of local warning protocols by integrating medium-term weather forecasts, ground data and GIS data.


Thank you for your attention