PermaNET • Permafrost long-term monitoring network

New rock glaciers inventory of Aosta Valley, Italy

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Abstract: A new rock glaciers inventory of Aosta Valley region is presented. After a preliminary localization of the rock glaciers, the manually bounding in a GIS environment is made crossing the visual information coming from stereoscopic vision of IRFC coupled images, orthophotos and hillshade effect derived from DTM. Main geomorphic parameters are automatically calculated by means of GIS tools and all rock glaciers characteristics are inserted in a database. As two operators work on the inventory examining different areas, a test has been done in order to assess which parameters are most reliable and can be used in future analysis and to produce a final database as uniform as possible,.

1. Introduction

Some data of Aosta Valley rock glaciers already exist in the *Rock Glacier Inventory of the Italian Alps* (data collection of the Italian Glaciological Committee, edited by Smiraglia and Guglielmin, 1997), but a census based on the new cartographic products available has been performed for the entire region. Realized in the frame of the project *PermaNET – Longterm Permafrost Monitoring Network* (Alpine Space program), the new inventory is part of the Permafrost Evidences Database of the work package 5 (*WP5 - Permafrost and Climate Change*) as rock glaciers are considered an indirect evidence of permafrost. The evidences collected by the project partners are used for the construction and for the validation of a permafrost distribution map, common for the whole Alpine Space.

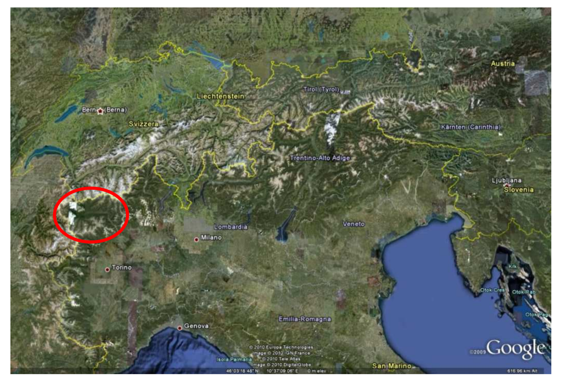


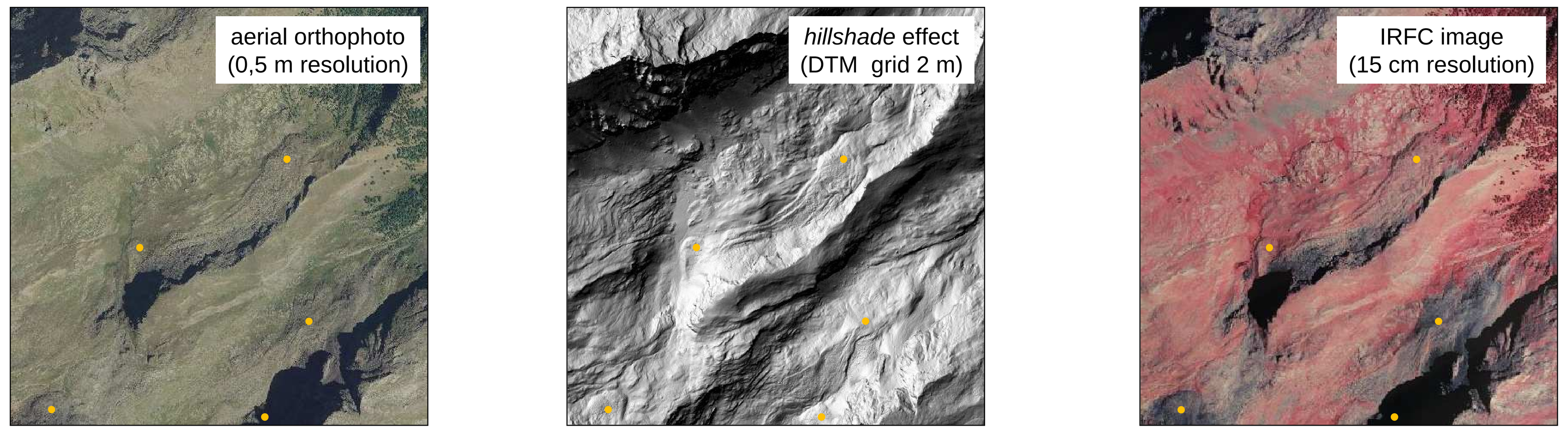
Fig 1. Study area. The Aosta Valley is a small alpine region in the Alps in the North West of Italy, at the corner with France and Switzerland. Its surface (about 3300 km²) is prevalently mountainous with more than 50% of the territory above 2000 m asl and about 5% of glaciated areas.

2. Methodology

Each rock glacier is identified (**STEP 1**) and manually bounded (**STEP 2**) inside a GIS environment crossing the visual information coming from the stereoscopic vision of IRFC images, hillshade effect derived from DTM and ortophotos. For each deposit the main geomorphic parameters (area, length, width, slope, aspect, elevation of the front, elevation of the upper part and altitude of the relief from which they originate) are mapped and quantified by the DTM. For each rock glacier a detailed table is filled and stored in the inventory database, constructed following the example of existing rock glacier inventories (Seppi et al. 2005; Guglielmin & Smiraglia 1997) (**STEP 3**). At the same time the fields required for rock glaciers in *PermaNET* Permafrost Evidences Database are filled. Some new fields were added, such as quality of the information which includes the certainty in the deposit boundaries, the definition of the state of activity and the detection of morphological features is evaluated. In addition possible interferences with human structures (e.g. cableways, roads, ski tracks, huts, etc) are mentioned for the analysis of risks deriving from permafrost degradation. Also potentially dangerous positions of the deposits in relation to the inhabited valley floors are pointed out, considering the possibility of loose material release from rock glaciers. Furthermore surveying or monitoring activities are specified in dedicated fields. (See yellow fields in **STEP 3** table).

STEP 1

Preliminary localization points

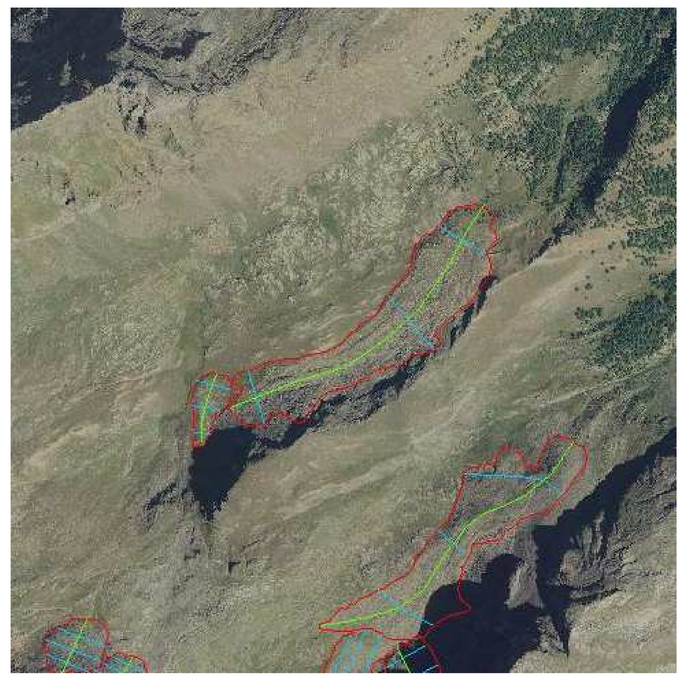


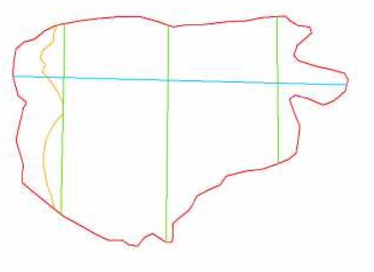
STEP 3

Table of rock glaciers characteristics

	FIELD NAME	POSSIBLE CHOICES	EXPLANATION
GENERAL	RG_ID		Progressive number
	NAME		Name of the most significant place close to the RG (e.g.: lake, peak, ...)
	X		Coordinates given by ArcGIS for the centroid in UTM ED50
	Y		
	MAP		Number of the CTR (Regional Cartography) map
	LAT		Coordinates X,Y converted to geographics WGS84
	LON		
MORPHOMETRY	Max elevation	Derived from ArcGIS calculation functions based on DTM	Maximum elevation of the polygon perimeter
	Min elevation		Minimum elevation of the polygon perimeter
	Max elevation of the scarp		Maximum elevation of the upper part of the front scarp (if evident)
	Max elevation of the relief		Maximum elevation of the peak/ridge above the RG
	Lenght		Calculated from the polyline shape
	Width		Mean of 3 different segments (in a polyline shape); the first is the lower one, in the frontal part
	Area		Derived from the polygon shape
	Aspect		Mean aspect of the polygon
	Slope		Mean slope of the polygon
ROCK GLACIER CHARACTERISTICS	Degree of activity	A/I	Intact (Active/inactive)
		REL	Relict
	Geometry	TS	Tongue shaped
		LO	Lobate
		EQ	Equidimensional
	Form	SI	Simple
		CO (*)	Complex
	Complexity (*)	MP	Multipart
		ML	Multilobe
		MU	Multiunit
		MR	Multiroot
	Alimentation	MOD	Morainic-derived
		TAD	Talus-derived
	Location	CI	Circle
		SL	On slope
		FS	Foot of slope
		VB	Valley bottom
	Relation with glacial form	GL	Glacier
		GLR	Glacieret
		SNB	Snowbank
	Relation with vegetation limits	AB	Above vegetation limits
		BCM	Below the continuous meadow limit
		BTL	Below the tree limit
	Morphological features	LRF	Longitudinal ridges
		TRF	Transverse ridges
		SWB	Swollen body
		HLB	Hollow body
		CP	Presence of conical pits
OTHER INFORMATION	Possibles interferences		Actual and future possible interferences with infrastructures (e.g:tracks, ski tracks or pillar of cable way, rock glacier directly above tha valley bottom, possibly dangerous for debris flows)
	Notes		
	Notes 2		Annotations related to field surveys and subsequent changes in the RG characteristics identification
	Aerial photographs		Aerial photographs characteristics
	Other cartographic data		
	Other available material		Historical iconography, other pictures
	Monitoring or study activities		
DEGREE OF QUALITY	Degree of Quality	DC	Perimeter delimitation certain
		DIF	Uncertain perimeter delimitation in the frontal part
		DIM	Uncertain perimeter delimitation in the upper part
		GAC	Degree of activity certain
		GAI	Degree of activity uncertain
		CMC	Morphological features certain
		CMI	Morphological features uncertain
		SHA	Shade in the ortophotos

STEP 2 **Rock glacier bounding**





4 shape files are created:

- Rock glacier perimeter (polygon shape file)
- Rock glacier lenght (polyline shape file)
- Rock glacier width (polyline shape file)
- Rock glacier upper front scarp (polyline shape file)

3. Methodology test

Two different operators worked on different areas of Aosta Valley (**Fig 2**). In order to assess which parameters are most reliable and can be used in future statistical analysis for the whole dataset, the upper Valgrisenche Valley has been used as test area: the two operators separately bounded the rock glaciers and filled the table. Resulting data and features were compared.

An almost perfect correspondence exists in 9 cases in features bounding (**Fig 3**); in these cases also main rock glacier characteristics, such as degree of activity, geometry and elevation of the front, correspond. In 4 cases preliminary points match, while in 9 cases there is no agreement. In 6 cases one operator bounds the feature while the other only puts a preliminary localization point: in particular, one of them tends more to bound the shapes while the other seems to be more cautious with doubtful cases and it puts only preliminary points to be controlled in a second moment.

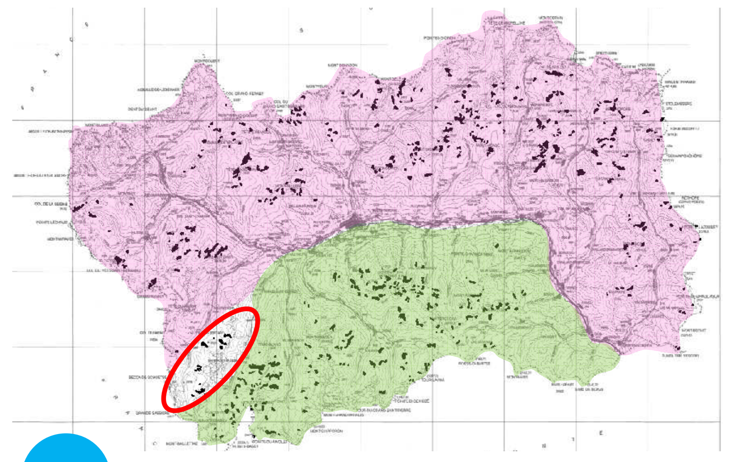


Fig 2. The different colours indicate areas analysed by two different operators; the red circle indicates the test area, upper Valgrisenche Valley. About 750 rock glaciers have been bounded on the whole region.

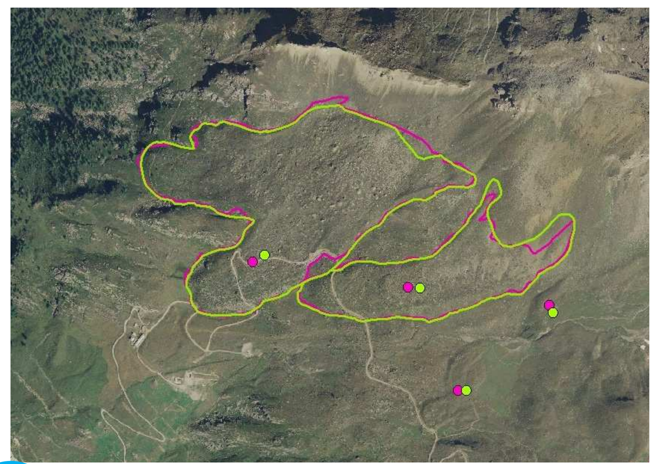
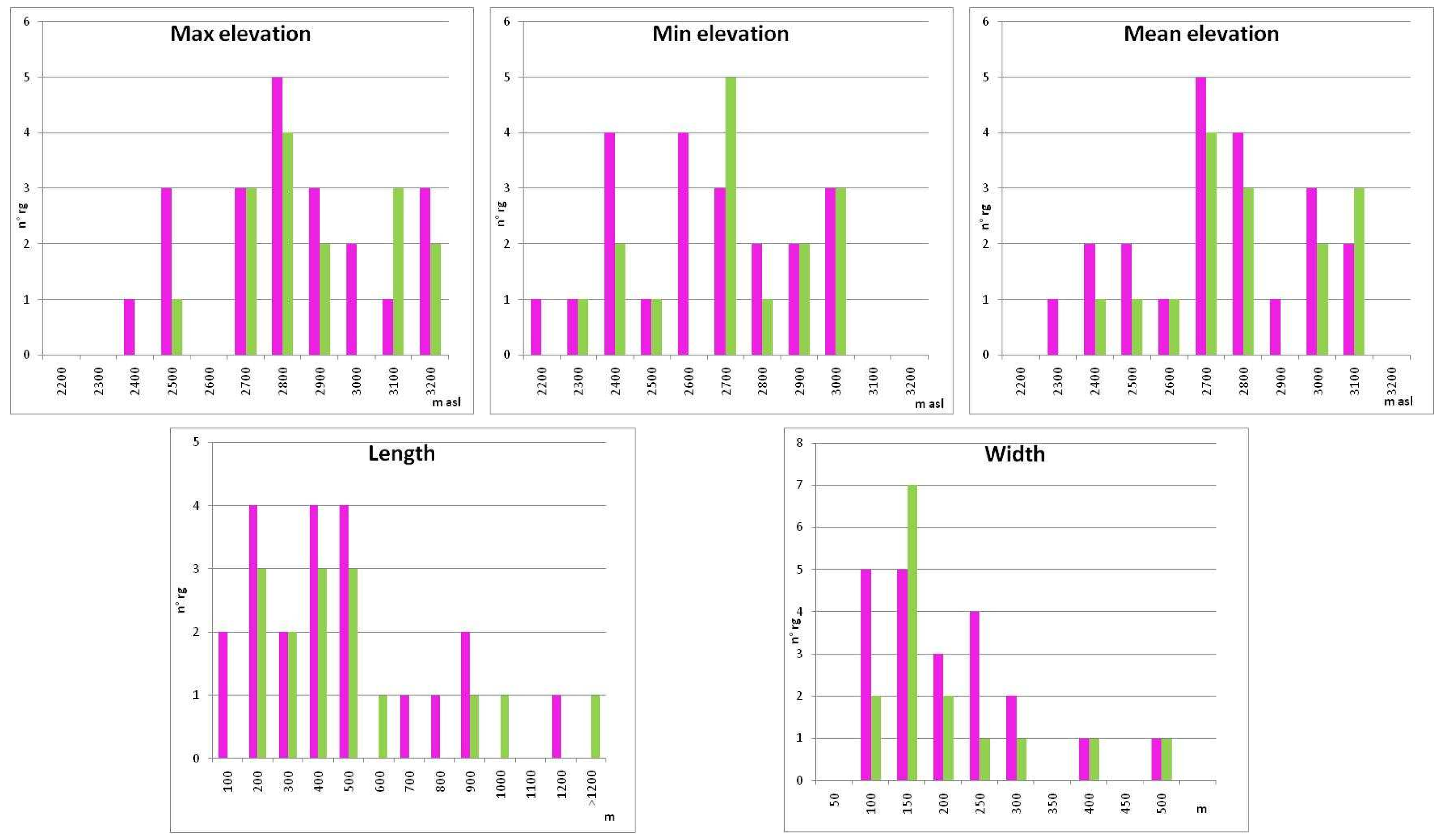


Fig 3. An example of good agreement in rock glacier bounding.



	Mean elevation [m asl]	Max elevation [m asl]	Min elevation [m asl]	Elevation of the closet relief [m asl]	Length [m]	Width [m]	Area [m²]	Aspect [°]	Slope [°]
OPERATOR 1	2752	2844	2663	3154	465	179	91760	260	25
OPERATOR 2	2686	2781	2605	3112	420	183	91374	246	24

Charts, tab 1. Distributions and mean values of main geomorphological parameters found by the two operators considering all the rock glaciers they identified and bounded in the test area (operator 1: 15 rock glaciers; operator 2: 21 rock glaciers).

Differences between operators' values

Mean elevation [m]	Max elevation [m]	Min front elevation [m]	Length [m]	Width [m]	Area [m²]	Aspect [°]	Slope [°]
3	2	0	40	1	5002	9	1
48	50	1	197	35	32060	8	1
1	25	0	94	28	618	1	0
3	2	2	13	1	567	5	0
4	1	3	40	12	440	6	0
1	13	0	69	16	1556	3	0
17	8	0	30	91	67539	6	0
7	5	0	215	7	10001	2	1
3	1	0	125	190	1053	0	0

Tab 2. Difference between operator 1 and 2 for main geomorphological parameters for the 9 common rock glaciers: a very good agreement exists for the minimum elevation of the front. Highlighted data indicate data for which one operator points out an uncertainty.

From the analysis (on a small dataset and area) some conclusions can be pointed out:

- a high degree of subjectivity affects rock glaciers definition (localization, bounding, characteristics);
- operators act in a different way in doubtful cases even if the methodology has been fixed before;
- the uncertainty concerns rock glaciers with a poorly evident shape while for sharply-defined ones a good agreement between the operators can be observed (**Fig 3; Tab 2, 3**);
- some parameters are more reliable (i.e. they are defined with a better agreement) such as minimum elevation of the front, degree of activity, geometry (**Tab 3**);
- despite of differences in single records, mean values for the whole dataset match quite well (**Tab 1**).

Differences between operators for rock glaciers characteristics

		Degree of quality - Uncertainty of the data
Degree of activity	no difference	3 uncertain data
Geometry	no difference	
Form (simple/complex)	1 difference	
Alimentation (morain, talus, both)	6 differences	
Localisation (circle, slope, ...)	6 differences	
Relation with glacial forms	4 differences	
Relation with vegetation limits	2 differences	
Morphological features	5 cases with differences	7 uncertain data
Max elevation	3 cases with differences>10m (see Table 2)	3 uncertain data, not matching with max differences (see Table 2)
Min elevation of the front	3 differences, all <3m (see Table 2)	2 uncertain data, not matching with max differences (see Table 2)

Tab 3. Summary table resulting from data analysis for the 9 common rock glaciers.

4. Open questions and perspectives

- Only few and most reliable parameters should be used for the analysis?
- How to deal with uncertain data (rock glaciers with uncertain shape)?
- How to merge datasets from different operators taking in account the subjectivity of operators themselves?

The data of the whole region will be verified and geostatistical analysis will be performed on the final dataset.
Specific fields survey are planned for Summer 2010.

References
Seppi, R., Carton, A., Baroni, C. 2005, Proposta di una nuova scheda per il censimento dei rock glaciers da fotografie aeree: applicazione sull'Alta Val d'Ultimo (Gruppo Ortles-Cevedale), *Geogr. Fis. Dinam. Quat. Suppl.VII*
Guglielmin, M., Smiraglia, C. (eds.) 1997, Rock glacier inventory of the italian alps, *Arch. Comit. Glaciol.*, GNGFG., 3, Torino

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