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Freeze-thaw cycles in the rocks of the Bessanese experimental site (Western Alps, Italy)

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INTRODUCTION

Freeze-thaw action induces both rock weathering and mass wasting, destabilizing rock and debris slopes in high mountain regions.
Matsuoka, in 1990, defines an **Effective Freeze-Thaw Cycle** (**EFTC**) as a fall below -2 °C of the rock surface temperature followed by a rise above +2 °C.
Rock temperatures in alpine environments are strongly influenced by slope inclination, slope aspect, local topoclimatic conditions (including seasonal snow cover), and thermal properties of the rock.

OBJECTIVES

Our **main objectives** are: to investigate rock and air temperature variability in an instrumented site at high elevation in the Western Alps of Italy, to identify rockfall events occurred in the monitoring period, and finally to search for possible links between rock and air temperature and rockfall occurrence.

METHODS

Calculation of EFTCs in rocks and air

Rock and air temperature data have been collected by:
- 7 MicroTemp Dataloggers (**MTs**) with known measurement uncertainty, placed in 2016 at 10 cm depth
- Automated Weather Station (**AWS**) of ARPA Piemonte installed since 1988

MTs number	Site	Topographic position	Geology *	Elevation (m a.s.l.)	Aspect (class)	Slope (°)	Data series (DDMMYY)
1	A-Gastaldi Hut	Rock outcrop	C	2667	W	75	200716-160718
2	A-Gastaldi Hut	Rock outcrop	C	2666	NE	85	200716-160718
3	B-Lake	Rock boulder	P	2594	E	30	200716-150818
4	B-Lake	Rock boulder	P	2586	NE	80	200716-150818
5	B-Lake	Rock boulder	P	2586	SW	80	200716-150819
6	C-Glacier front	Rock outcrop	PCI	2772	SE	80	170817-150818
7	C-Glacier front	Rock outcrop	PCI	2790	S	80	170816-150818

* P=prasinite; C=calcschist; PCI=prasinite with calcschist intercalations

Rockfall events identification

Different data sources have been analysed in order to identify rockfall events:
- reports of the annual glaciological survey published by the Italian Glaciological Committee since 1927 containing valuable source of information about glacial environment and the surroundings;
- aerial photos by the Italian Military Geographic Institute and on the Italian and French geoportals;
- personal communications from the Rifugio Gastaldi keeper;
- field surveys.

Finally, the images captured by a **Livecam PANOMAX** (https://bessanese.panomax.com/) supported the visual monitoring of the study area and the interpretation of the acquired temperature data.

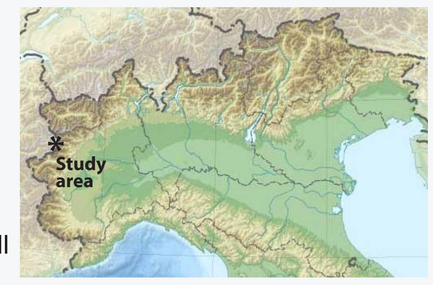
STUDY AREA

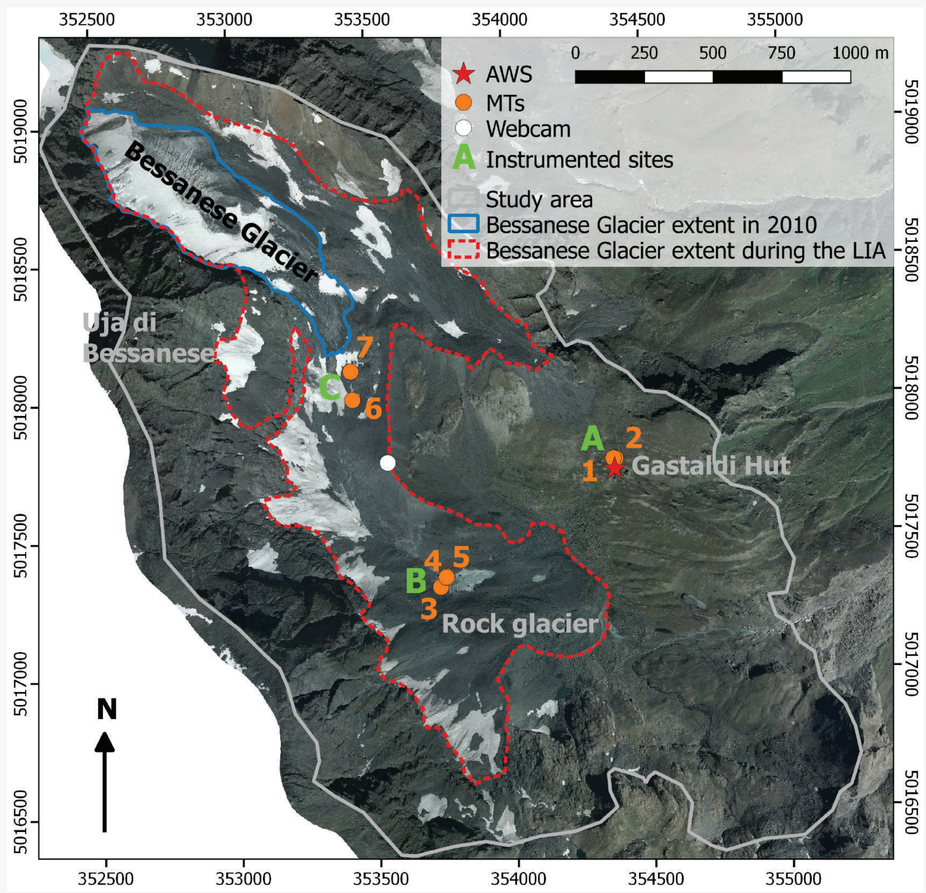
Location of the study area: Western Italian Alps, Graian Alps, Val d'Ala, Bessanese glacial basin

Elevation range: from 2586 to 3620 m a.s.l.

Geomorphological elements: **Bessanese Glacier**, Huge left LIA lateral moraine, Crot del Ciaussinet **rock glacier**, **Uja di Bessanese** 1000 m rock wall cut by several incisions

Geology: three main lithologies: calcschists (C), prasinites (P) and prasinites with calcschists intercalations (PCI).

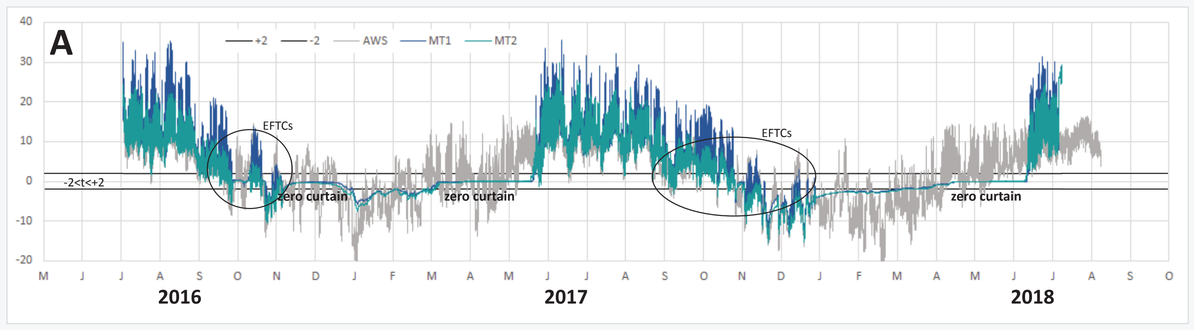


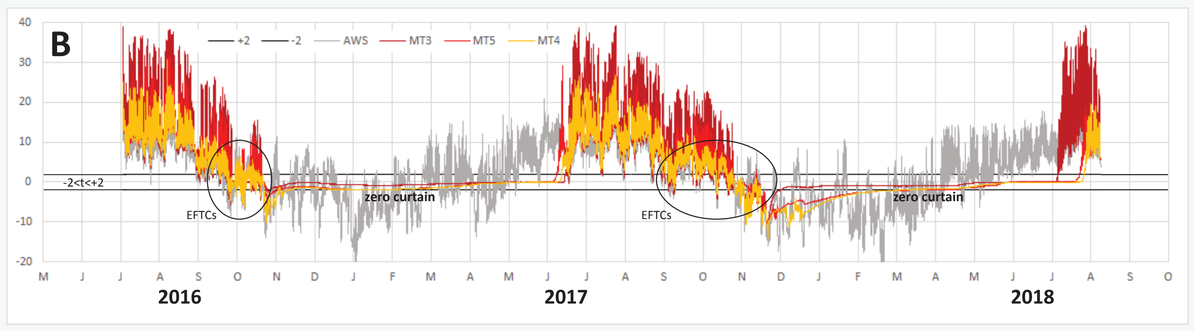


Base map: Piemonte Region 2010 orthophoto; Reference system: WGS84 / UTM 32N

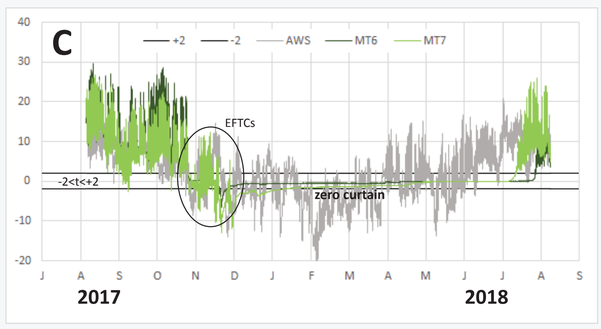
PRELIMINARY RESULTS

EFTCs in rock and air





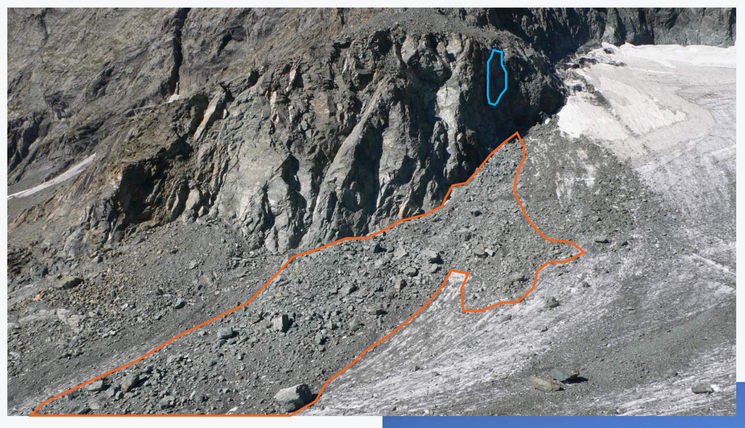
Analysing rock temperature trend in the measurement period some observation can be done:
- the insulating effect of the snow cover in winter and spring ("zero curtain", i.e. nearly constant temperature close to the freezing point) is well visible for all the 7 MTs;
- the aspect of the rock surface is a fundamental parameter influencing rock temperature;
- EFTCs in the air start in autumn and continue until spring;
- EFTCs in the rocks can be identified only during autumn-early winter (see black ovals), before the first snow fall;
- EFTCs in rock are in general less than in the air, with few exceptions.



Rockfall events

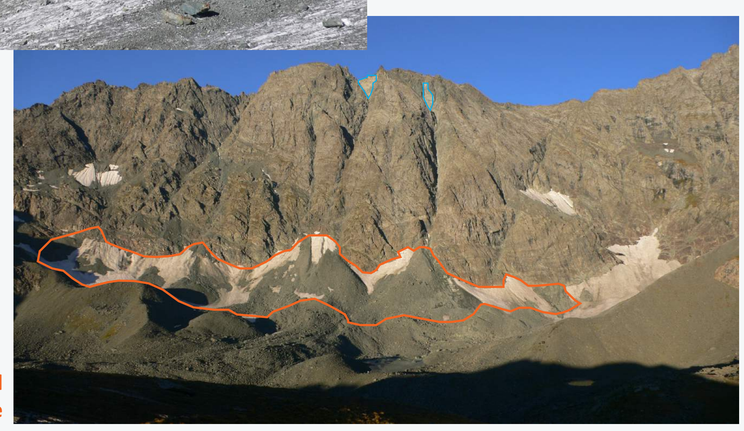
Date	Detachment location	Data source	Additional informations
27 august 2017	At the base of the NE ridge of the Uja di Bessanese	Gastaldi Hut keeper	At about 10:55 A.M.
30 september 2016	Channel in the Bessanese rockwall above the rock glacier	Gastaldi Hut keeper	A cloud of dust was visible after the rockfall
Summer 2003	At the base of the NE ridge of the Uja di Bessanese	Report of the glaciological survey	Debris mass deposited on the southern tongue of the glacier at 3000 m a.s.l. During a period of enhanced rockfalls activity.
1958	Continuous rockfalls from the incisions in the Bessanese rockwall	Report of the glaciological survey	Debris material on the right fan at the end of the Bessanese rockwall channels
1956		Report of the glaciological survey	Huge rockfall deposit on the glacier front

Thanks to the analysis of different data sources, 5 rockfall events have been identified in the study area. The events are concentrated in the summer months and occurred mainly from the NE ridge of the Uja di Bessanese and from the channels cutting the Bessanese rockwall.



27 august 2017 rockfall from the NE ridge of the Uja di Bessanese

The two photos represent rockfalls detachment and accumulation zones.



Incisions in the Bessanese rockwall and debris fans at the base

CONCLUDING REMARKS AND PERSPECTIVES

- The adopted methodology (data collected by MTs with known measurement uncertainty and AWS, rockfall information and near-real time images of the study area) has proven to be valid for the objectives of the project.
- MTs location was useful for a preliminary investigation of rock temperature trend during the year in the instrumented basin. Recorded data were strongly influenced by snow cover and are thus not completely representative of rockwall temperature in winter and spring.
- Based on the above considerations, in summer 2018, MTs location was changed in order to reduce snow cover effect. 20 MTs were installed at different depths (10, 30, 50 cm) in four sites in order to investigate thermal conductivity. Results will be available in summer 2019.
- The documented rockfall events occurred in summer/early autumn: for these events we can infer that EFTCs have not been a triggering factor. Further analyses will be carried out in order to investigate their potential role as preparing factor.
- This instrumented site can become a reference site in which to develop and share new methodological approaches for cryosphere studies. Collaborations are welcome.

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Fondazione CRT

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