EGU2021 – Session CR 4.7 – April 30th, 2021

Climate change and cryosphere in high mountains:

Updates from the Capanna Margherita hut study case (Punta Gnifetti, Monte Rosa Massif, Pennine Alps)

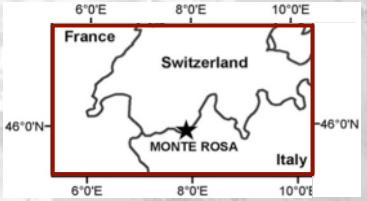
Marco Giardino [1]
Antonio Montani [2]
Andrea Tamburini [3]
Francesco Calvetti [4]
Alessandro Borghi [1]
Fabio Villa [3]
Davide Martelli [3]
Graziano Salvalai [4]
Federico Tognetto [1]
Luigi Perotti [1]

1) University of Torino
Earth Science Dept.
2) CAI (Club Alpino Italiano)
Central Direction Comm.
3) IMAGEO srl
Ex spin-off Univ. Torino
4) Politecnico di Milano,
Dipartimento A.B.C.

CC BY

Photo Arnold Welf

Monte ROSA



European Western Alps
2nd highest mountain
4634 m a.s.l.

Climate change affects landscape dynamics of high mountains, as well as slope stability, erosion/sedimentation, and **hazard/risk** conditions.



East Face, Colle Gnifetti (Fadilla, **1893**). Large hanging glaciers.



East Face (Forumfree, **2016**). Few glaciers, slope instability.

One of the highest periglacial rock faces In the European Alps: the permafrost-affected and partially glacierised **East face of Monte Rosa** (Fisher et al., 2011).

Mountain Huts & Access Routes

Instability phenomena and cascading effects:

- *Glacier retreat*
- *Permafrost Degradation*
- *Rock block fall*
- *Accelerated erosion*
- *Debris flow*
- *Flood*

Margherita Hut

Est. by CAI on **1893**, re-built on **1980** at **Punta Gnifetti 4554 m a.s.l.**
The highest building in Europe, and UniTO scientific laboratory.

Interreg ALCOTRA «Eco innovation en altitude»

CC BY

Margherita Hut



Aims:

1) identify relevant geomechanical features for rock mass stability;

2) verify permafrost related instabilities;

3) reconstruct the ice-covered morphology of the Punta Gnifetti peak;

4) calculate rock-building interactions.

Margherita Hut

- **NW side of the hut:** *Study of ice thickness by means of georadar.*

- **Rocky spur N of the hut:** *Monumentation of a topographical reference point for GPS network*

- **Top pf Punta Gnifetti:** *geological framework by means of petrographic samples and local structural data*

- **SE side of the hut:**
- *Geomechanical characterization of the rock mass by means of TLS*

- **Whole Punta Gnifetti and SE face:** retrospective collection, georeferencing and interpretation of **historical photos** maps and archival reports

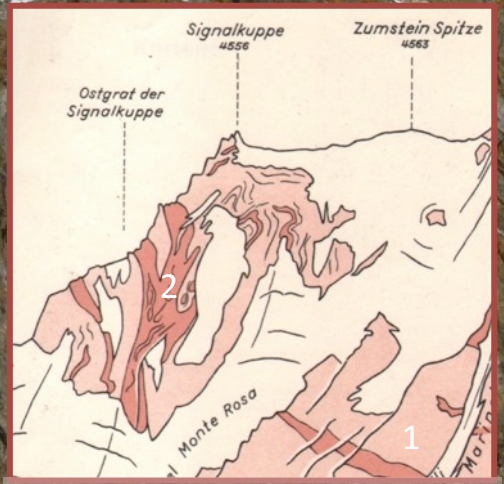




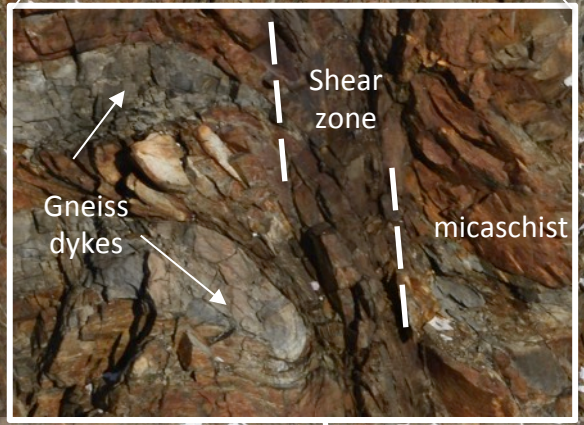
Geological framework

Isoclinal folding

WSW dip of regional main schistisity (dip-slope with respect to the East Face)



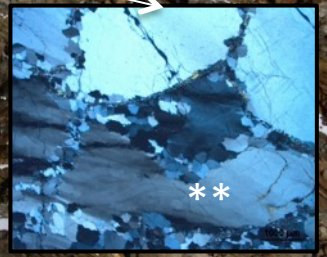
Folded structure with 1) micashists and 2) othogneisses (Bearth, 1953)



Geological contacts and ductile structure: detachment due to the contrast of competence, respect to deformation.

Enhanced instability of fractured micashists and micro-sheared ortogneiss (reduced strenght to ΔT)





A “brittle” Qz for sin-kynematic re-crysrallization and micro-deformation (**cross polarized light)

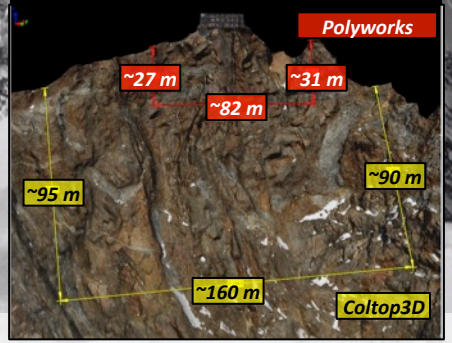
EGU General Assembly CR4.7

Climate change and cryosphere in high mountains: updates from the Capanna Margherita hut (Punta Gnifetti, Monte Rosa, W-Alps, Italy)

IMAGEO

Aims: 1) identify relevant geomechanical features for rock mass stability; 2) verify permafrost related instabilities; 3) reconstruct the ice-covered morphology of the Punta Gnifetti peak; 4) calculate rock-building interactions.

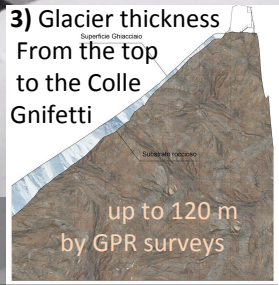
1) 3D model by integrating helicopter-borne photogrammetry with terrestrial laser scanner



Margherita Hut

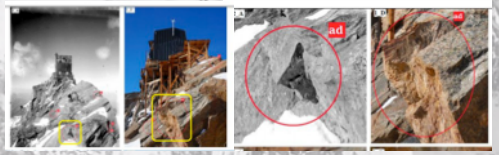
Est. by CAI on 1893, re-built on 1980
at Punta Gnifetti 4554 m a.s.l
The highest building in Europe, and UniTO scientific laboratory

3) Glacier thickness From the top to the Colle Gnifetti



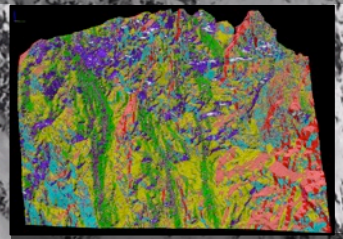
1-4) The geomechanical analysis of the dense point cloud provided by terrestrial laser scanner, integrated with direct field investigations.

2) Comparison of historical pictures for multi-temporal analysis of instabile sectors

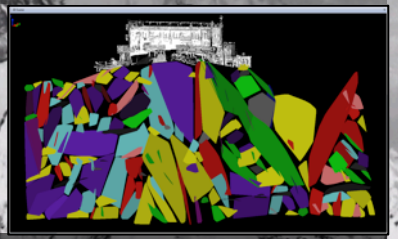


Results on the website
www.geositlab.unito.it/capanna

Coltop3D — Analyses of dip and dip direction of the of the large exposed rock surfaces — Polyworks



	Color	Dip	Dip Direction	Label
User Planes				
1		85	99	A
2		76	43	B
3		82	172	C
4		56	309	D
5		48	160	E
6		81	139	F
7		53	77	G
8		62	120	H



4) 3D numerical modelling for simulating interactions between the hut and the foundation rock.

Marco Giardino [a]
Antonio Montani [b]
Andrea Tamburini [c]
Francesco Calvetti [d]
Davide Martelli [c]
Graziano Salvalai [d]
Federico Tognetto [a]
Luigi Perotti [a]

An Interdidciplinary team, since 2019:

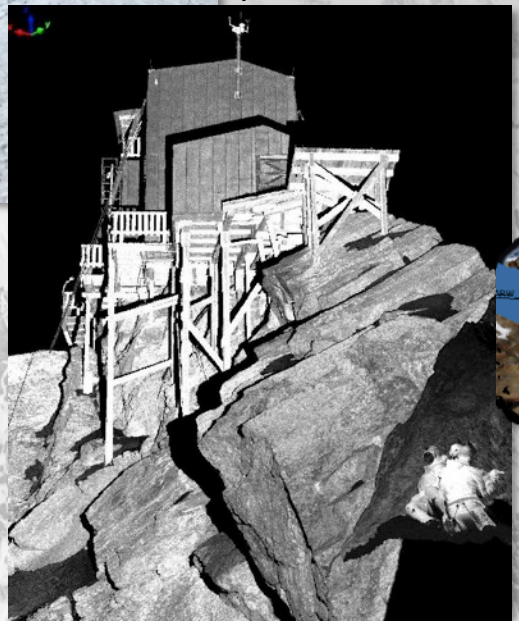
a) University of Torino
Earth Science Dept.
b) CAI (Club Alpino Italiano)
Central Direction Comm.
c) IMAGEO srl
Ex spin-off Univ. Torino
d) Politecnico di Milano,
Dipartimento A.B.C.

CC BY
Photo Arnold Welf

Field activities: 3D modeling



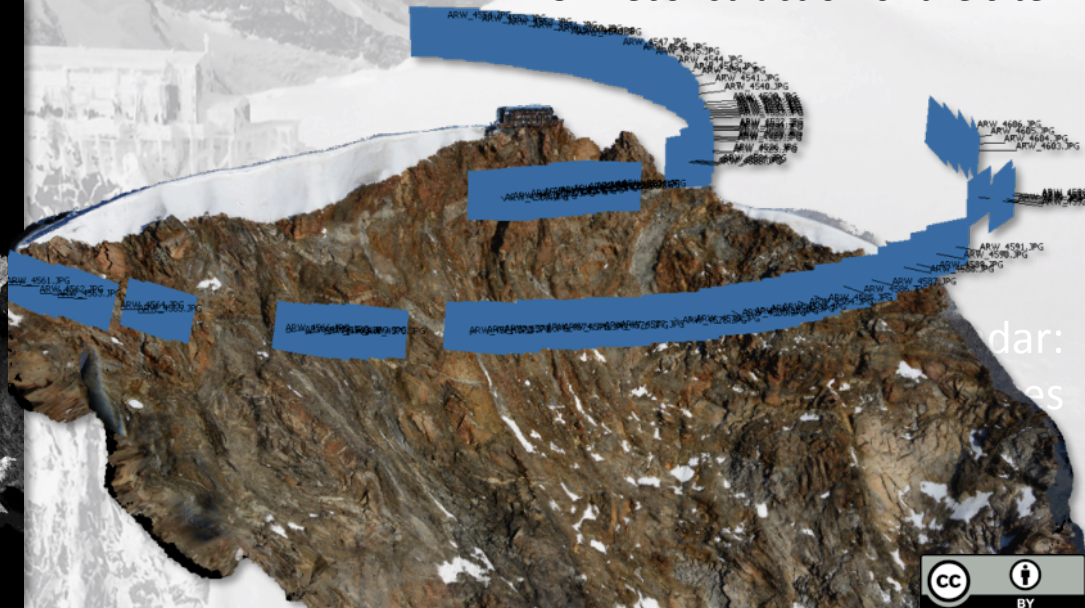
Terrestrial Laser Scanner:
Detailed characterization of the geomechanical structure of the rock mass



9 points of view
Cloud of 128 M points



Heli-photogrammetry:
96 shoots (preliminary flight)
3D reconstruction of the site



dar:
es

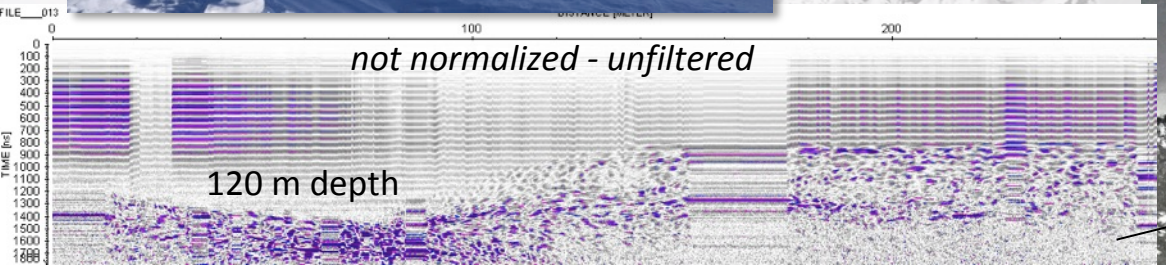
CC BY

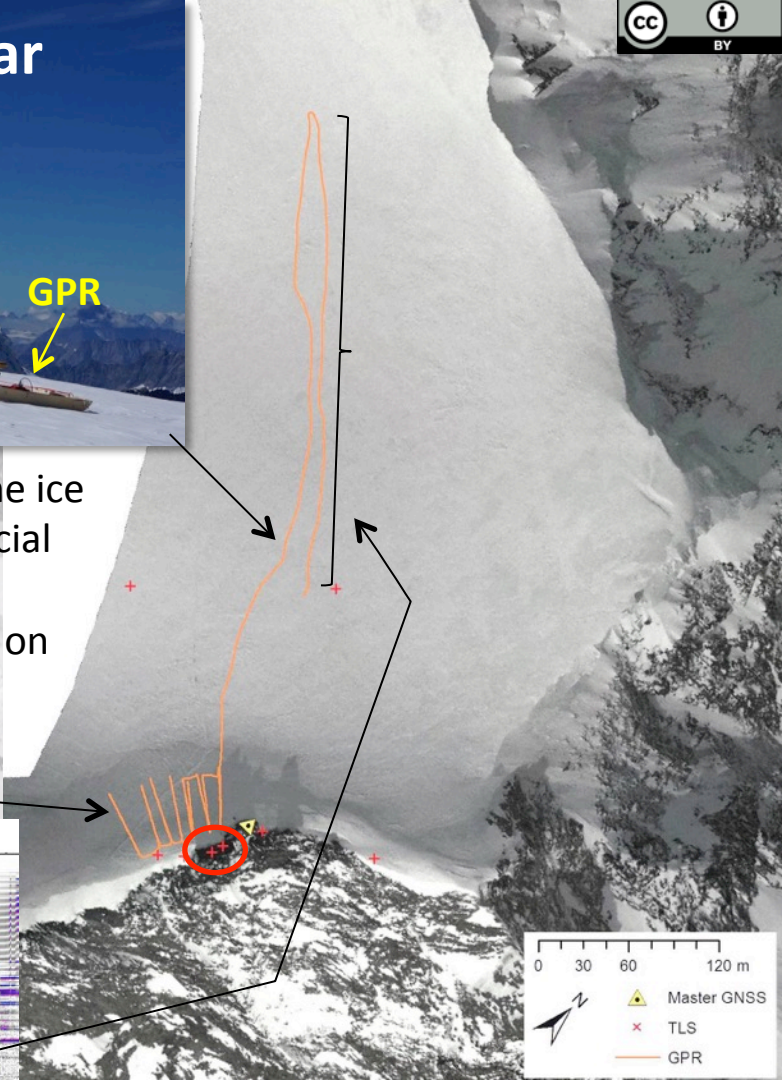
Ground Penetrating Radar



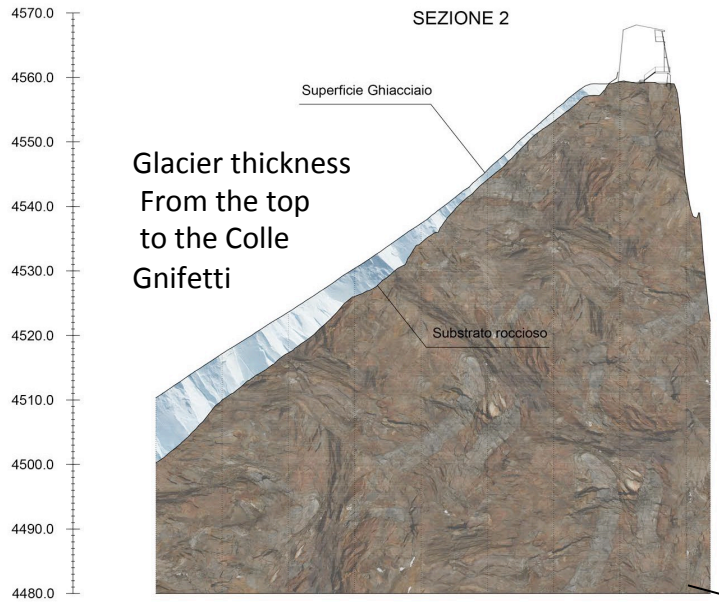


Determination of the ice thickness of the glacial cover, long 1.5 km traces, in particular on the summit ramp.





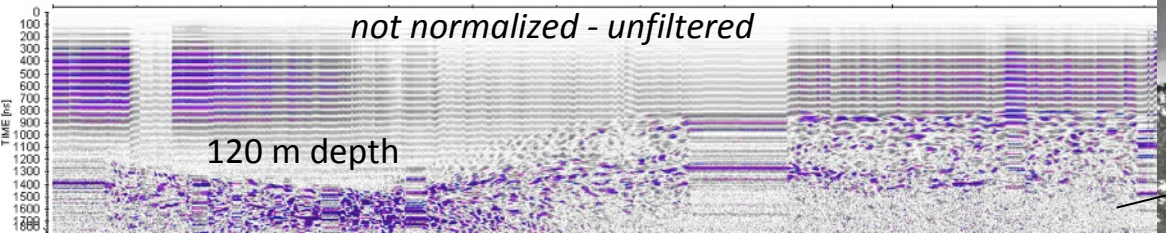
Ground Penetrating Radar

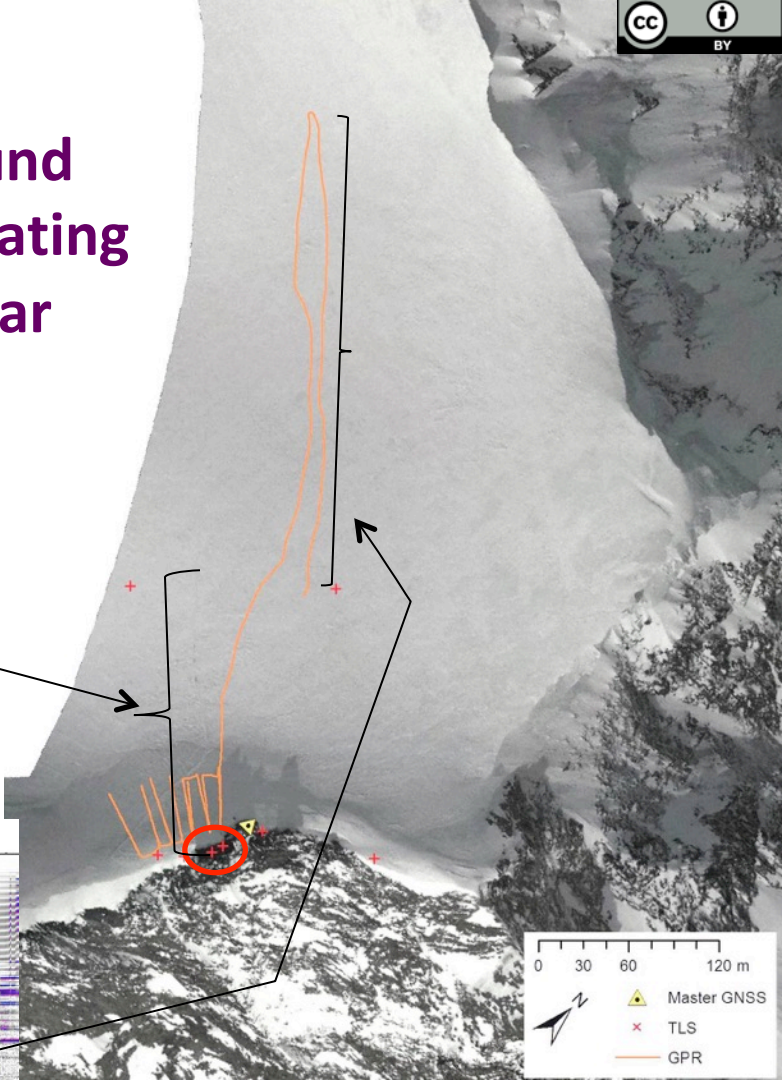


Glacier thickness
From the top
to the Colle
Gnifetti

LEGENDA:
Massa Glaciale
Massa Rocciosa

Quota elevazione Superficie Rocciosa [m]	4500.24	4510.02	4517.32	4526.04	4534.32	4544.13	4553.15	4559.36	4543.59	4522.21
Quota elevazione Superficie Ghiacciaio [m]	4510.33	4517.18	4523.64	4530.41	4537.37	4545.62	4554.76	-	-	-
Spessore massa glaciale [m]	10.09	7.16	6.32	4.37	3.05	1.49	1.61	-	-	-

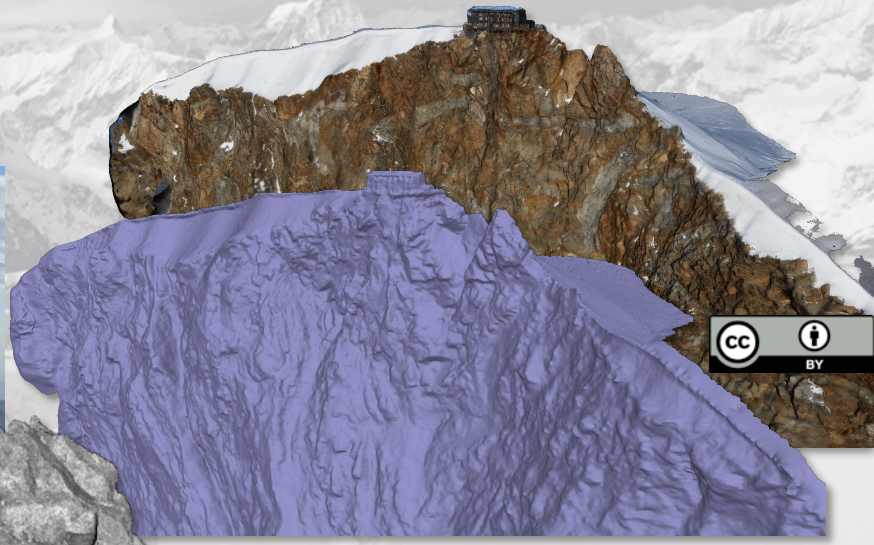


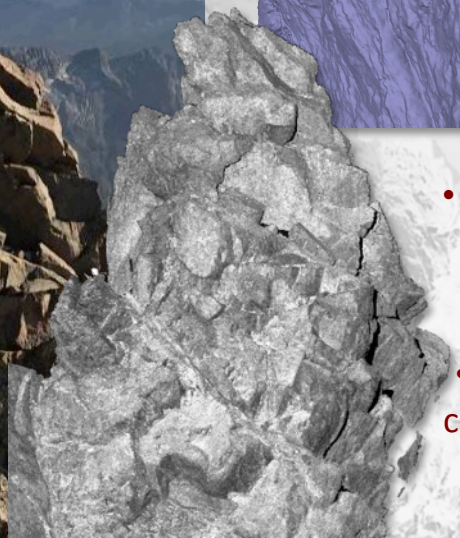


Results (work in progress)

- P.ta Gnifetti 3D model
- Rock-cliff detailed 3D model
- Capanna Margherita detailed 3D model
- Ice-depth map

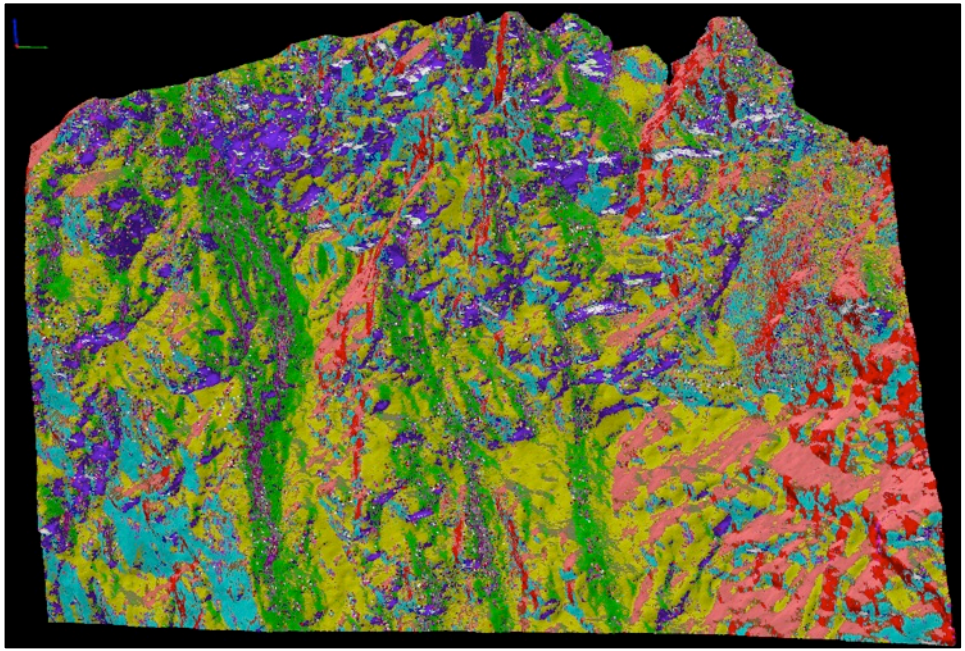


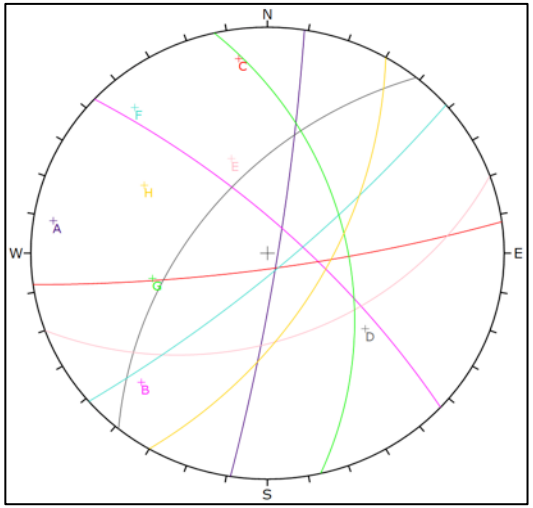




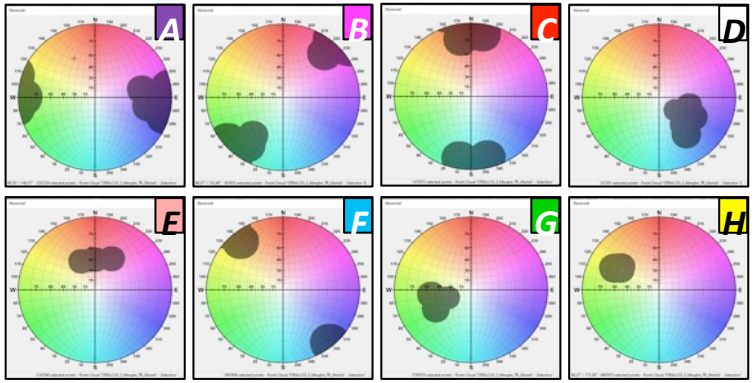
- **geomechanical characterization** of the rock mass (main discontinuity sets) from point cloud processing;
- integration with **on site surveys**;
- **stability analyses** of the rock face compared to past and present changes in the boundary and initial conditions

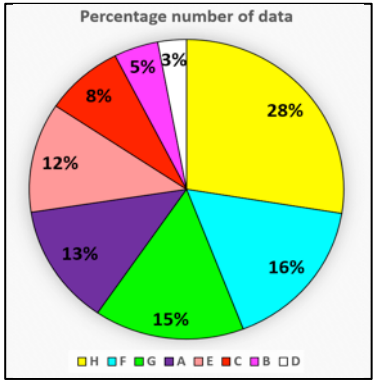
Coltop3D



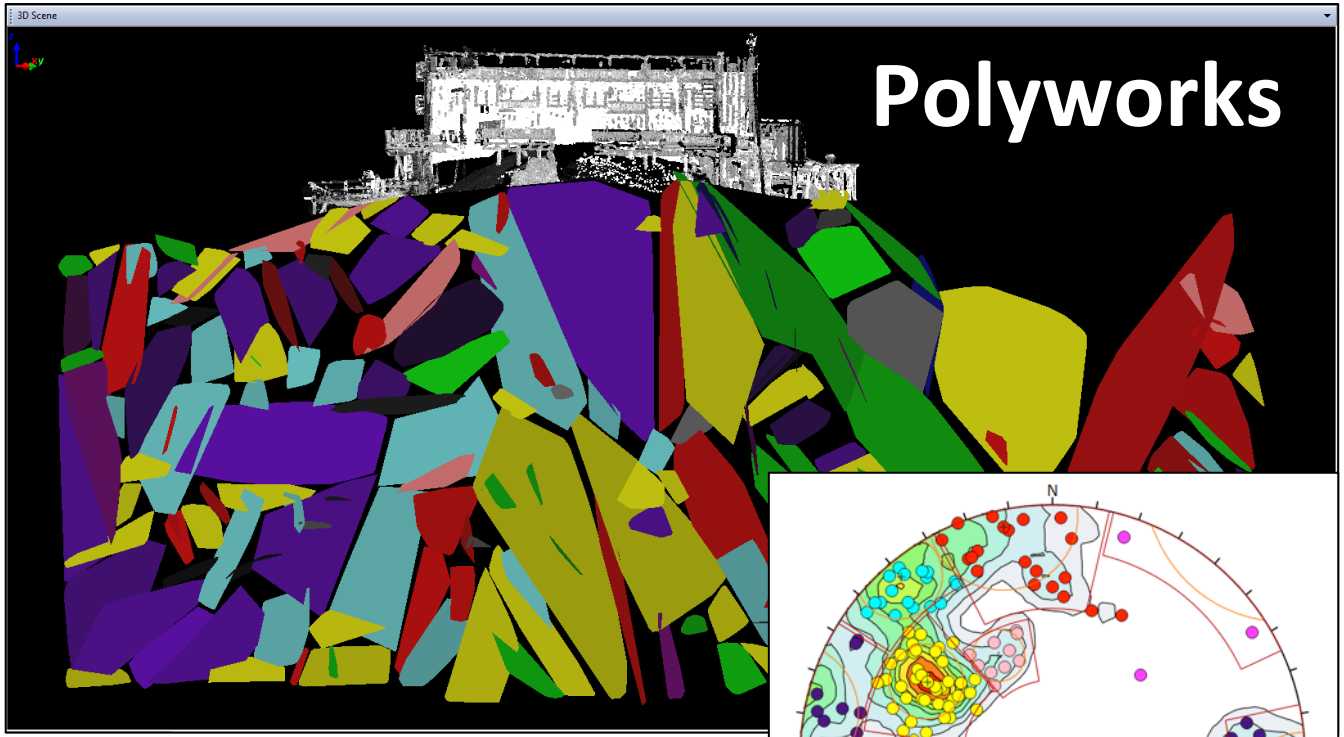


Dip and dip direction of the of the large exposed surfaces





	Color	Dip	Dip Direction	Label
User Planes				
1		85	99	A
2		76	43	B
3		82	172	C
4		56	309	D
5		48	160	E
6		81	139	F
7		53	77	G
8		62	120	H

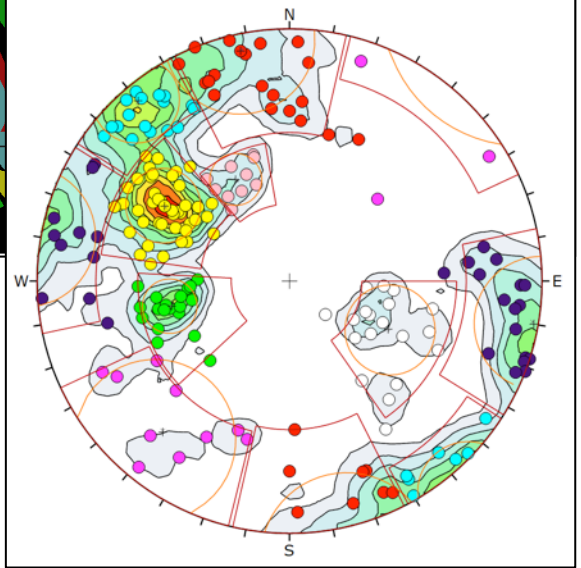


Symbol	SET_PRELIMINARE	Quantity
	A	28
	B	13
	C	28
	D	19
	E	10
	F	24
	G	20
	H	46

Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00
Maximum Density	7.76%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

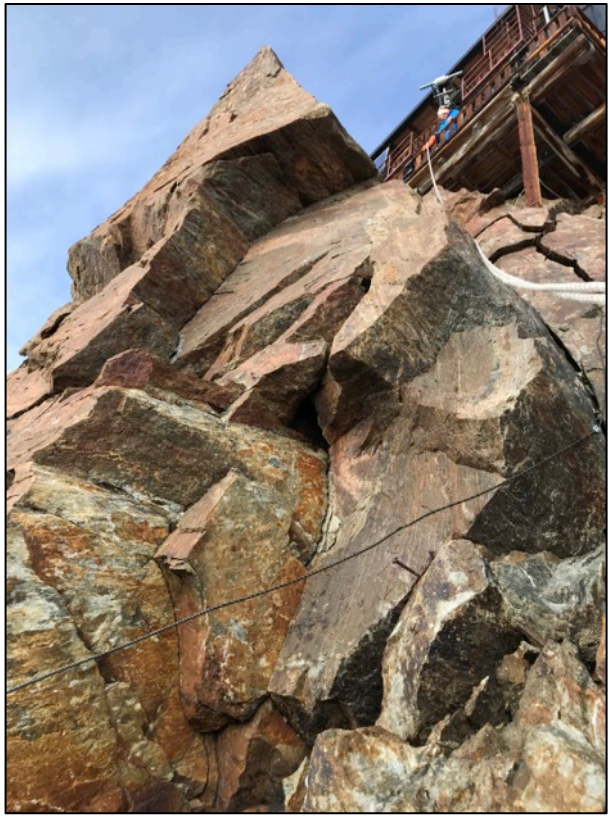
	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		89	280	A
2m		76	40	B
3m		86	168	C
4m		47	296	D
5m		49	152	E
6m		86	140	F
7m		51	78	G
8m		60	121	H

Plot Mode	Pole Vectors
Vector Count	188 (188 Entries)
Hemisphere	Lower
Projection	Equal Angle



Dip and dip direction of the of the large exposed surfaces

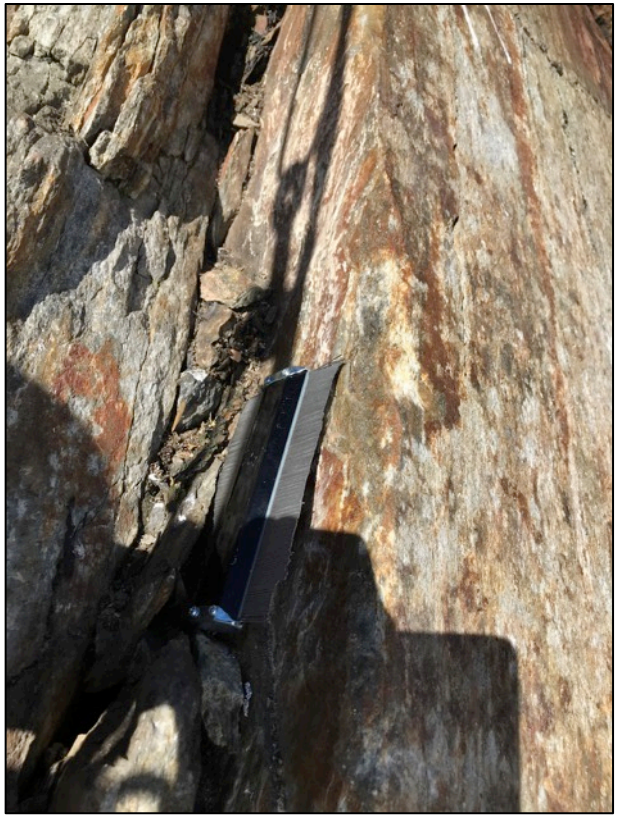
Separation, weathering of walls and gouge



✓ Separation: closed or >> 5 mm



✓ Weathering of walls: slightly to mod. weathered



✓ Gouge: none

2020) Comparison of historical pictures for multi-temporal analysis of instabile sectors



1892
I primi lavori sulla Punta Gnifetti



1899
La Capanna Margherita



inizio '900
Lavori alla Capanna Margherita



1947
Foto aerea della parete Nord



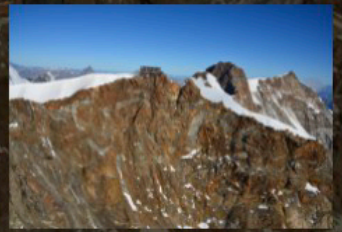
anni '80
La nuova Capanna Margherita dopo il corposo restauro



2018
Vista aerea da Ovest dell'attuale Capanna Margherita



2019
La parete Sud della Punta Gnifetti vista da valle

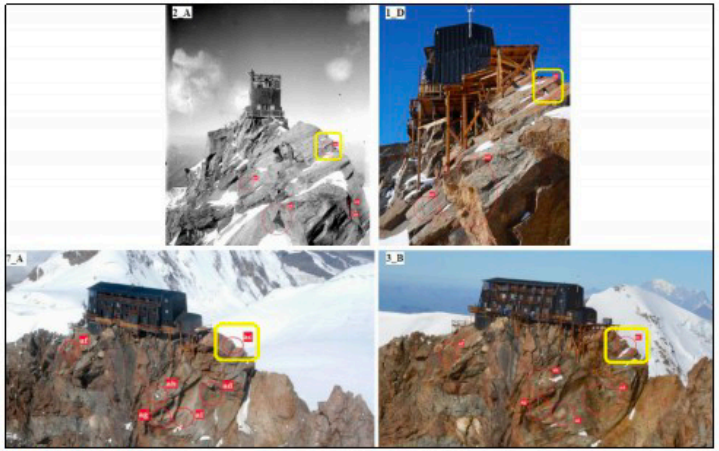


2019
Vista aerea dell'attuale parete S con in cima la Capanna Margherita

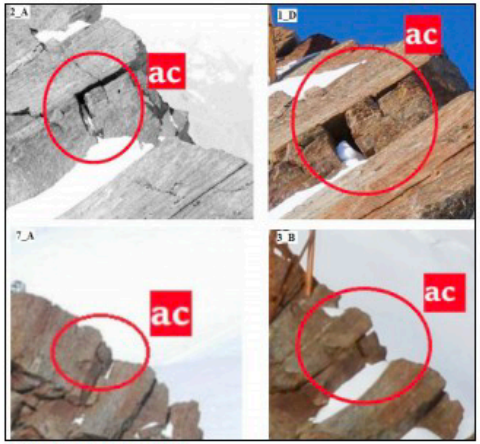
Results on the website www.geositlab.unito.it/capanna



Results on the website www.geositlab.unito.it/capanna



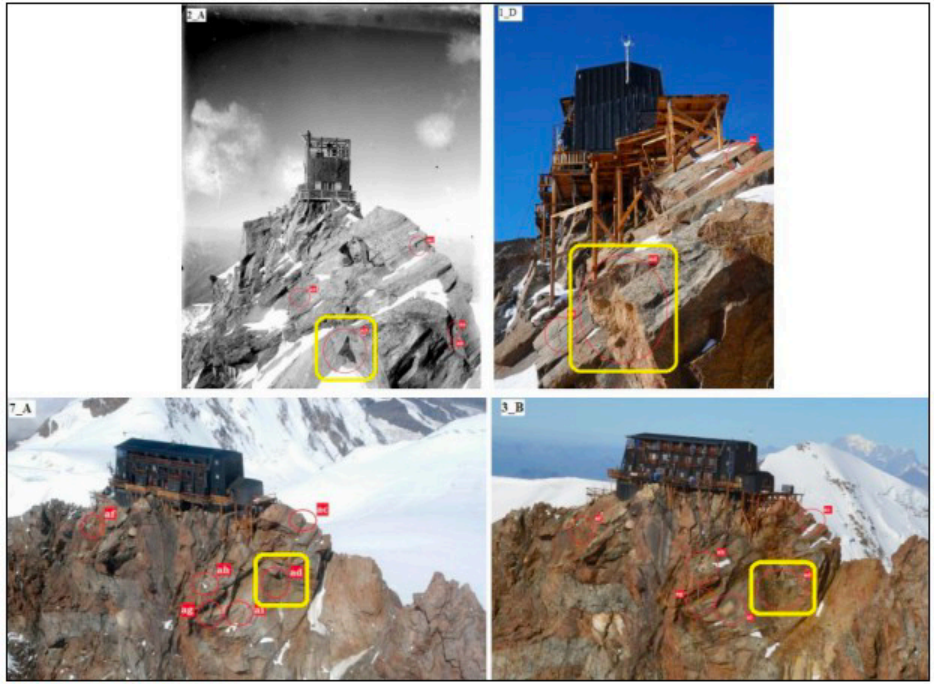
Visione d'insieme



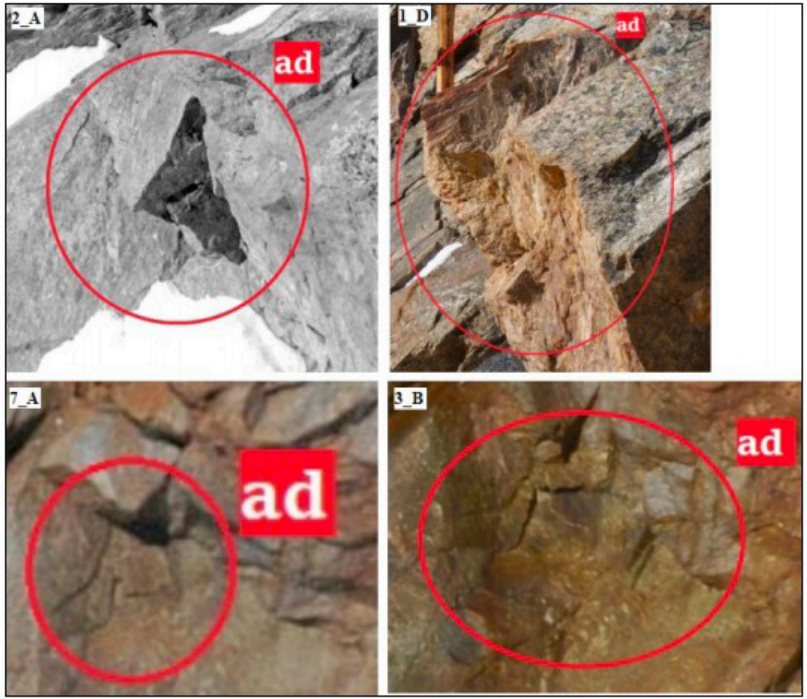
Visione di dettaglio

Corrispondenza fotografica	Vista laterale 2_A / 1_D (anno 2019), vista frontale 7_A / 3_B (anno 2019)
Descrizione	Si può notare un aumento dell'ampiezza delle fessure che caratterizzano la porzione rocciosa evidenziata. La grande cavità indotta dalla frattura sulla sinistra del dettaglio sembrerebbe, nella foto più recente, essere aumentata di volume.
Interpretazione	Il blocco rimasto isolato potrebbe essersi leggermente spostato e aver ruotato di qualche grado, probabilmente per riduzione della forza coesiva data dal ghiaccio nella frattura. Data la vicinanza al palo ligneo di sostegno, assente all'epoca della foto più antica, l'attività antropica potrebbe aver influito. È da considerare anche la possibile percezione distorta data dalla differenza di angolazione al momento dello scatto fotografico.

Results on the website www.geositlab.unito.it/capanna

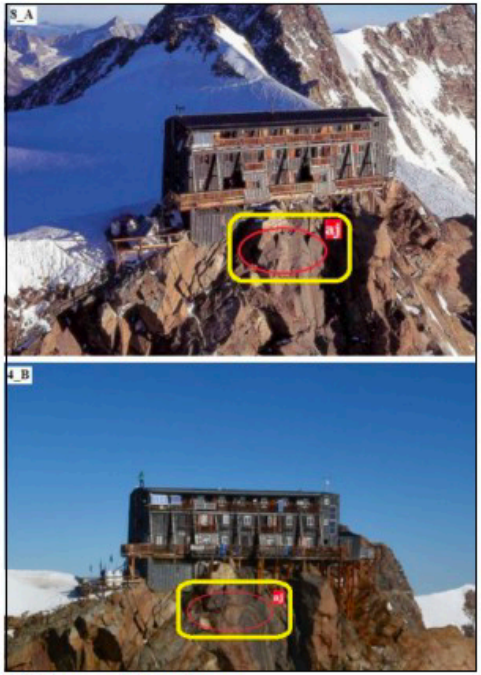


Visione d'insieme

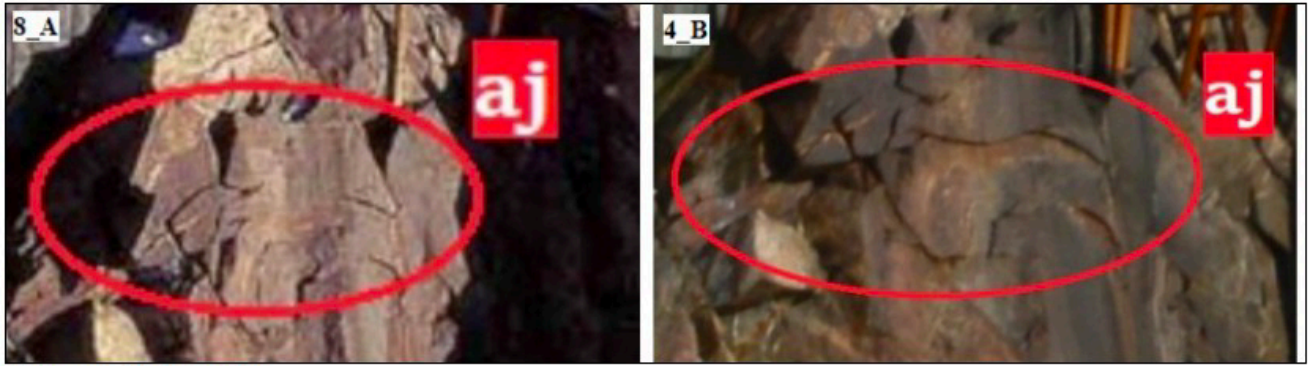


Visione di dettaglio

Results on the website www.geositlab.unito.it/capanna



Visione d'insieme



Visione di dettaglio



Climate change
and cryosphere in high mountains:
Updates from the Capanna Margherita hut study case
(Punta Gnifetti, Monte Rosa Massif, Pennine Alps)

)

Retrospective collection and interpretation of photos, archival news and climate data.

- Creation of a **multi-temporal model of geomorphological settings** of Punta Gnifetti
- Comparison to meteorological historical series for creating a **morphoclimatic "timeline".**

New plan for effective data collection on 2021 (!?), including comparative analyses to:

- identify the relevant geomechanical features for **rock mass stability**;
- verify presence of ice inside fractures forpossible **permafrost degradation**;
- simulating **interactions between the hut and the foundation rock**.

Thank you for your attention…