The Matterhorn Cryosphere Observatory CH/ITA

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[© Google Earth]

Permafrost Is Steadily Warming

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Increasing surface velocities are observed in the mountain cryosphere

Grabengufer rock glacier, Randa VS

[© PermaSense Project]

Large Landslides are Seemingly on the Rise

Kleines Nesthorn
Birchgletscher, Blatten, CH
5 Mio m³ rock + 3-4 Mio m³ ice + erosion
300+ people evacuated – 1 missing
[© Martin Proksch, Ct. Valais]

In contrast to lowlands

Permafrost (change) is **occurring above our heads**

[W. Häberli]

[© Ludovic Ravanel, Chamonix]

The Matterhorn
Our online lab since 2008

The Matterhorn
Our online lab since 2008

Why have a laboratory on the mountain?

[© PermaSense Project]

2003 Matterhorn Hörnliridge Rockfall

July 15, 2003 – 1500-2500 m^3 – 84 alpinists evacuated

[© Bruno Jelk, Zermatt]

[Bondo – Piz Cengalo rockfall, August 21, 2017, youtube.com]

Goals:

Process Studies

Understanding Root Causes of Catastrophes

Climate Impacts on the Mountain Cryosphere

Thermistors and Electrodes

Permanent GNSS + Meteo

South Side

GST @Summit
Boreholes @Carrel hut
North Summit
South Summit

North Borehole
South Boreholes

The clefts move in distinct patterns

[**A. Hasler, S. Gruber and J. Beutel: *Kinematics of steep bedrock permafrost*. J. Geophys. Res., 117, F01016.**
Weber, S., Beutel, J., Faillettaz, J., Hasler, A., Krautblatter, M., and Vieli, A.: *Quantifying irreversible movement in steep, fractured bedrock permafrost on Matterhorn (CH)*, The Cryosphere, 11, 567-583.]

Large-scale kinematics captured using D-GNSS and Inclinometers

[Weber et al: *A decade of detailed observations (2008-2018) in steep bedrock permafrost at the Matterhorn Hörnligrat (Zermatt, CH)*. Earth Syst. Sci. Data, 11, 1203–1237, 2019. Impact Factor 10.951]

Patterns of Freeze-Thaw Across Scales

Warming Degrades Stability of Frozen Rocks

Matterhorn rock block topple
01 June 2023 - 14 June 2023

[Weber, S., etal.: Progressive destabilization of a freestanding rock pillar in permafrost on the Matterhorn (Swiss Alps): Field observations, laboratory experiments and mechanical modeling, Earth Surface Dynamics, 2025.]

Ambient Resonance as Means to Assess Stability

Phase I: summer **Phase II:** freezing **Phase III:** winter **Phase IV:** melt onset

[S. Weber, D. Fäh, J. Beutel, J. Faillettaz, S. Gruber, A. Vieli: *Ambient seismic vibrations in steep bedrock permafrost used to infer variations of ice-fill in fractures.* Earth and Planetary Science Letters, Volume 501, 2018.]

High-altitude extension to Solvay 4003 m asl Kettensatz 4300 m asl

- Meteo Station
- Ground Surface Temperature
- Broadband Seismic

nanometrics

Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service

Topographic Amplification of Resonant Modes

[© PermaSense Project]

Topographic Amplification of Resonant Modes

[© PermaSense Project]

[S. Weber, J. Beutel, M. Häusler, P.R. Geimer, D. Fäh, and J.R. Moore: *Spectral amplification of ground motion linked to resonance of large-scale mountain landforms.* Earth and Planetary Science Letters, Volume 578, 2022.]

Regular media outreach

Currently in cinemas

[© PermaSense Project]

After 18+ years…

universität innsbruck

ARPA Valle d'Aosta

PERMOS

SLF

Universität Zürich[UZH]

- Unique long-term, quality controlled, curated datasets
- Updated annually

https://doi.org/10.5194/essd-11-1203-2019 (Data description paper)
https://doi.pangaea.de/10.1594/PANGAEA.983718 (In-situ Dataset)

https://doi.org/10.12686/sed/networks/1i (Seismic Dataset)

http://data.permasense.ch (Online data portal)

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