TECHNICAL PRESENTATION 2:

"Where to Find Permafrost and What Happens When It Degrades?"

Lukas Arenson, BGC Engineering

Dr.Lukas Arenson

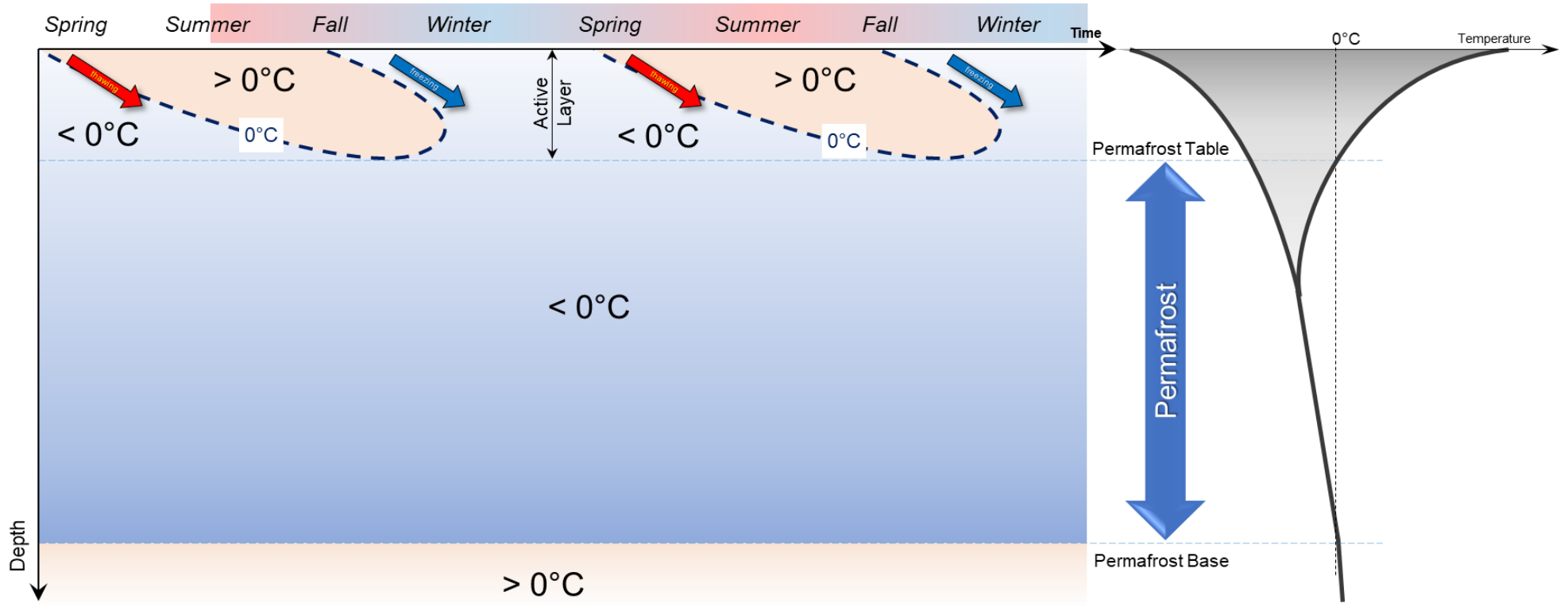
BGC Engineering, ADB Consultant

Dr. Lukas Arenson, Ph.D., P.Eng. (BC, YK, NU, NT) is a Principal Geotechnical Engineer whose main area of expertise is geotechnical, mountain permafrost engineering with specialization in frozen soil mechanics and geothermal modelling. He is a renowned expert in the dynamics of ice-rich frozen slopes in particular rock glaciers. He has expert knowledge in in-situ testing and monitoring of mountain permafrost in North America, the European Alps and the dry Andes of South America. He has further developed analytical solutions to analyze rock glacier stability and a permafrost distribution model to estimate the spatial probability of permafrost occurrence in the mountainous terrain of the Andes, Alaska and the Hindukush Himalaya. During his research, Dr. Arenson also concentrated on the thermo-mechanical processes of frozen and freezing soils on a microstructural level to better understand the hydraulic, strength and deformation properties of frozen soils with changing stress, temperature and salinity. Dr. Arenson has been involved in work related to preventing permafrost degradation, re-establishing pre-construction thermal regimes after constructions, and accelerating the consolidation of mine waste tailings or cold climate heap leaching.

Dr. Arenson is Adjunct Professor at the University of Manitoba and Polytechnique Montreal, and currently serves as VP for the International Permafrost Association.

What is Permafrost?

Soil or rock, with or without included water, that has remained at or below 0°C for 2 or more years. *Muller, 1947*



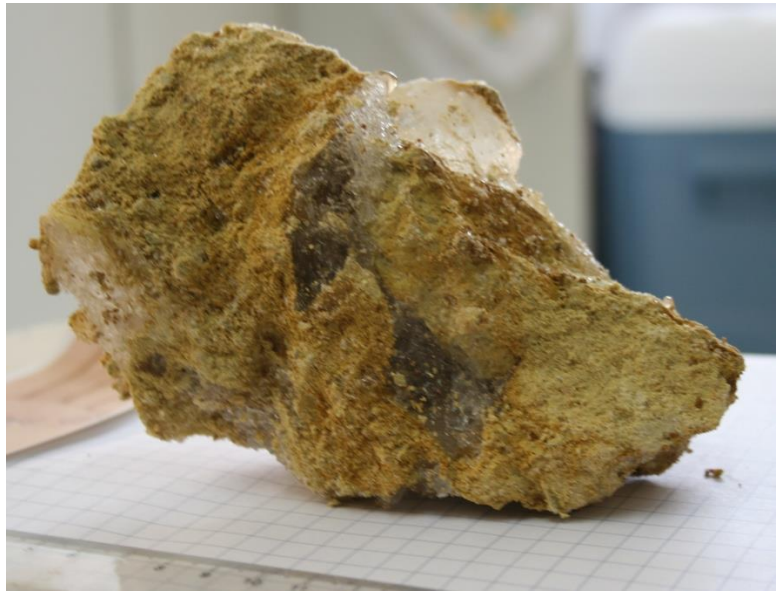
What is Permafrost and Ground Ice?

Source: B. O'Neill

How much Energy is in it?

Change in 1°C: 2.05 MJ/m^3

Thawing: 327 MJ/m^3

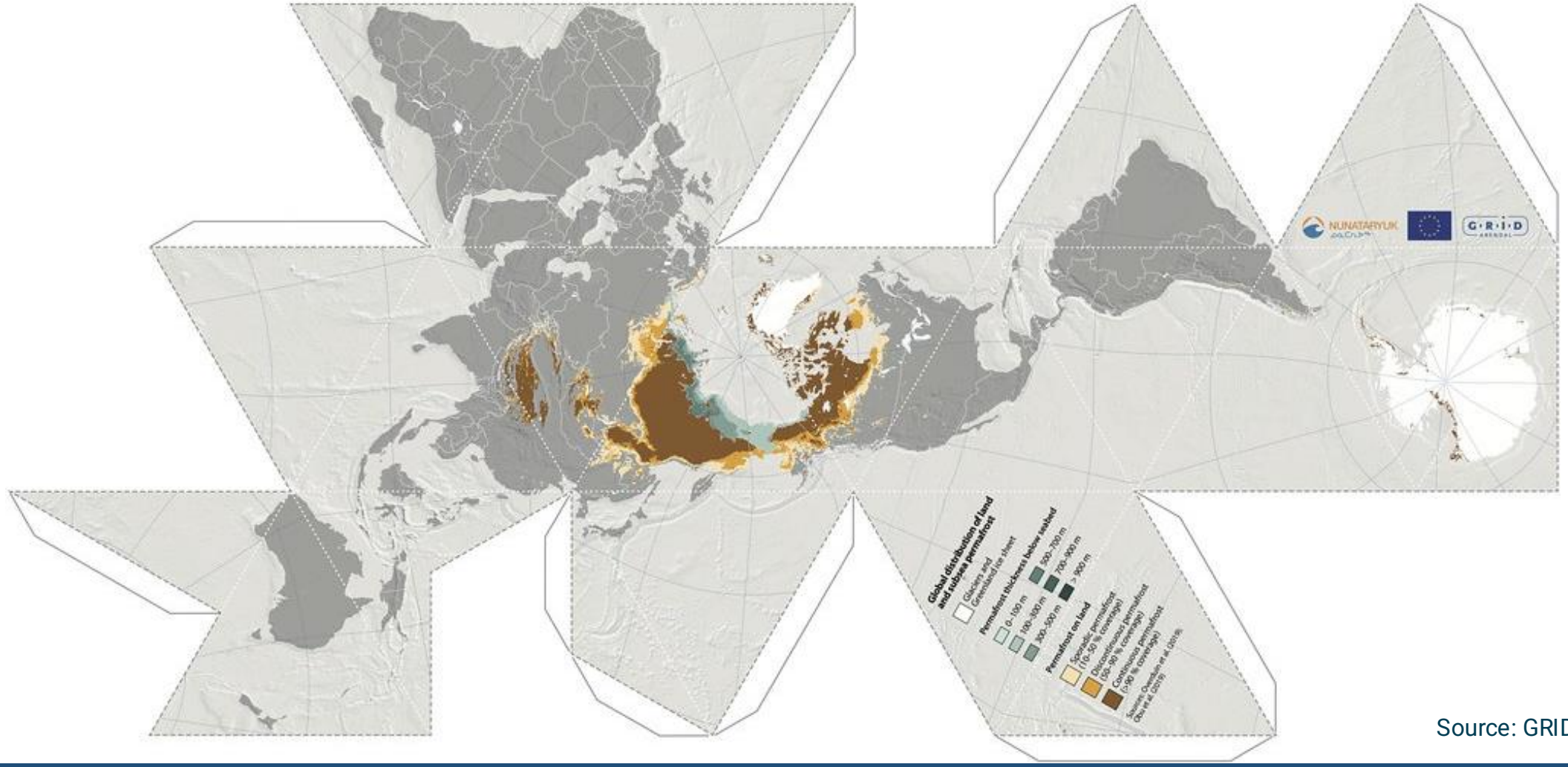


Change in 1°C: 3 MJ/m^3

Thawing: 250 MJ/m^3

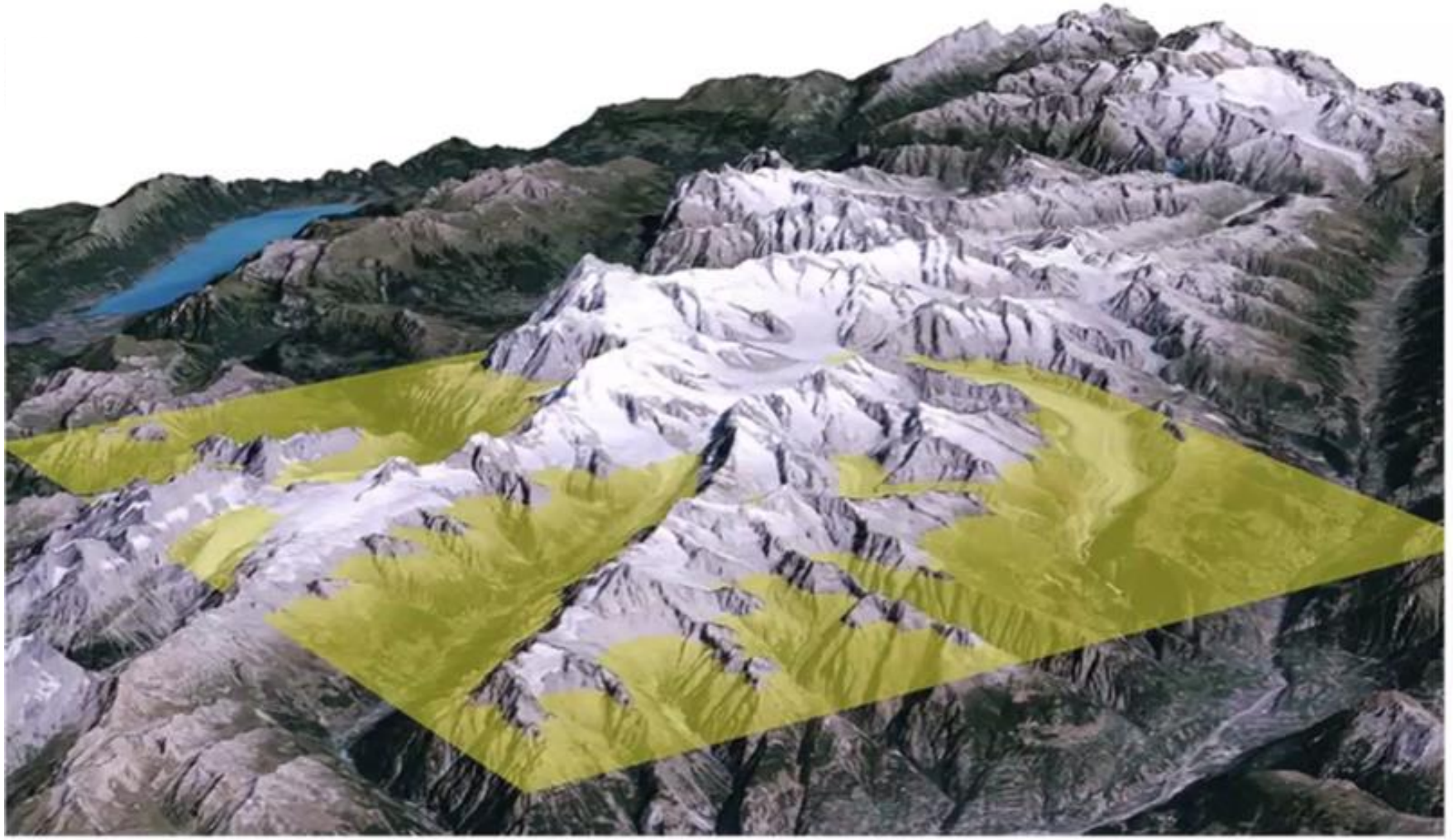
***f*(ice content)**

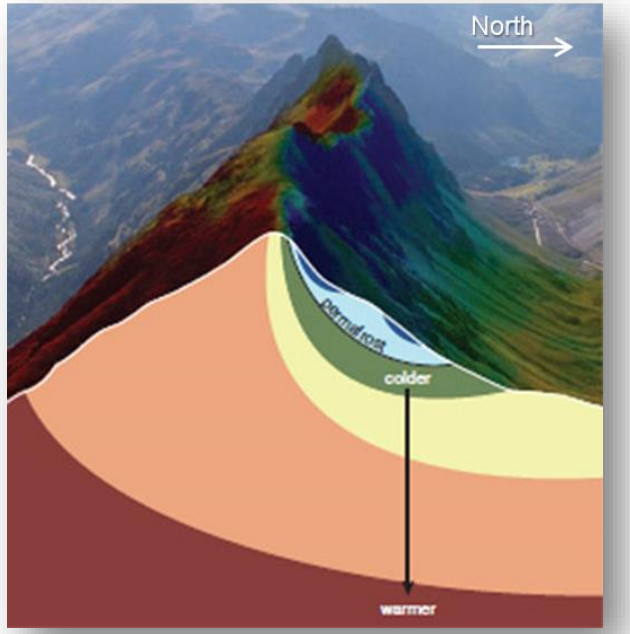
Where do we find permafrost?



Source: GRID-Arendal

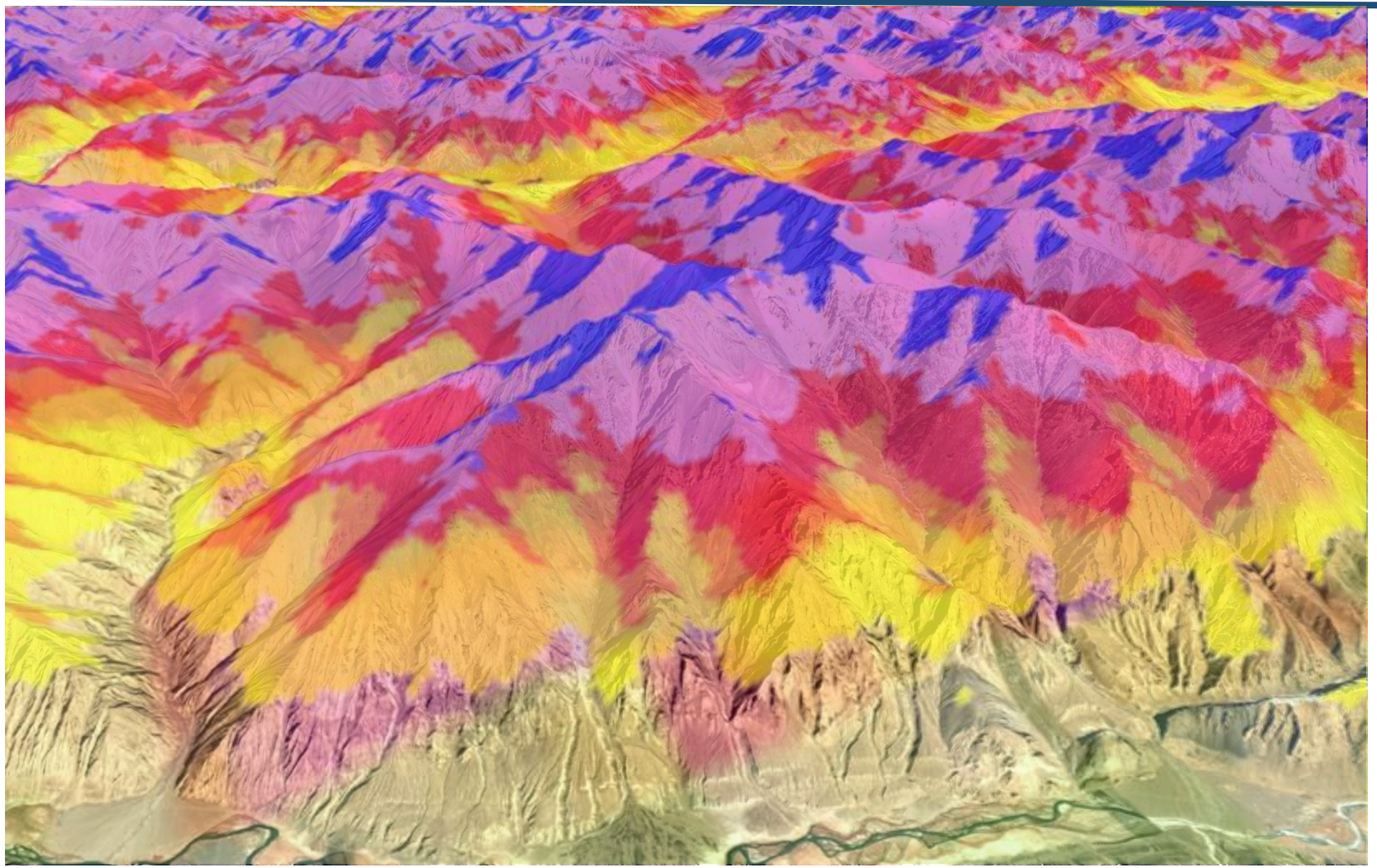
Scale





Source: S. Gruber

Mid- to High Resolution Permafrost Model



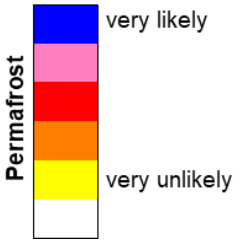
Permafrost Zonation

Blue: Permafrost in nearly all conditions (cold, deep)

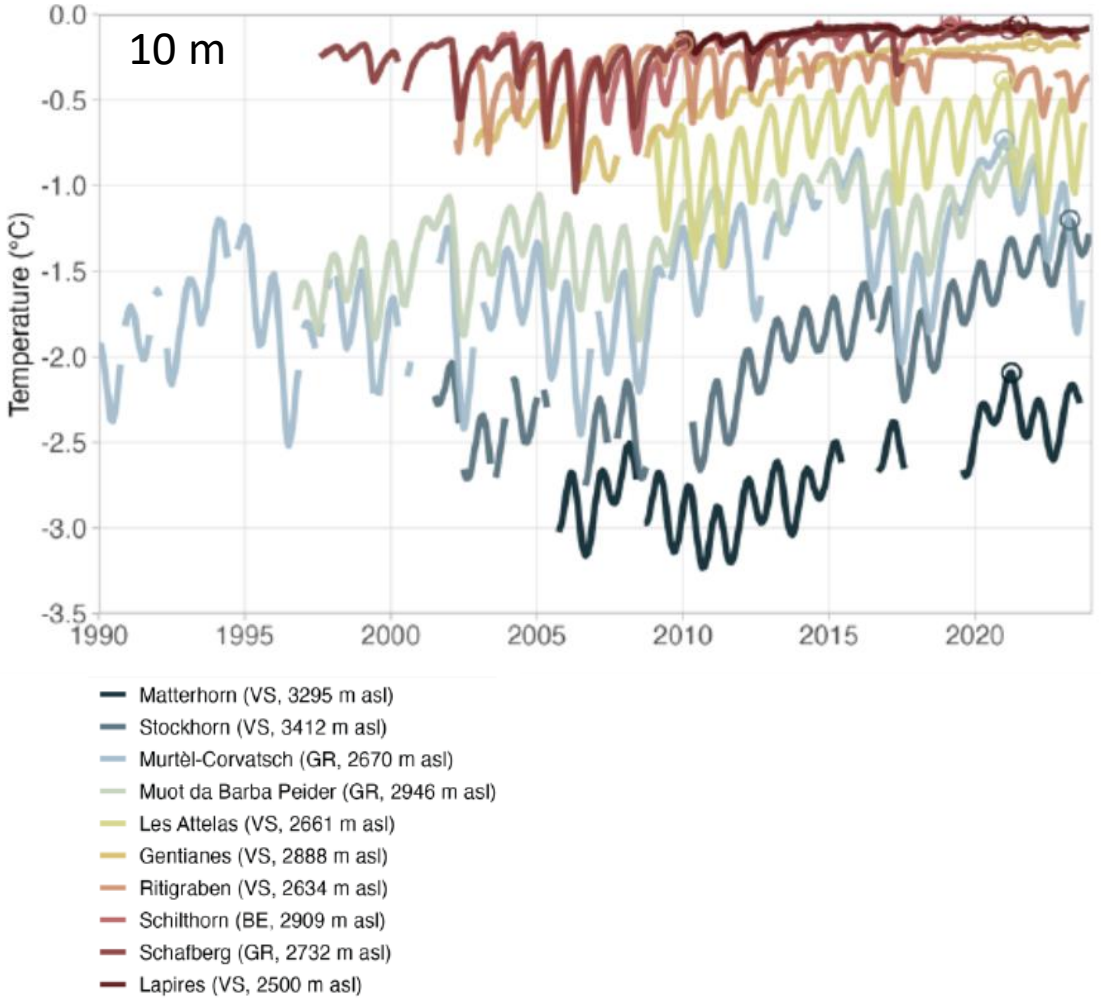
Yellow: Permafrost only in very favorable conditions (warm, shallow)

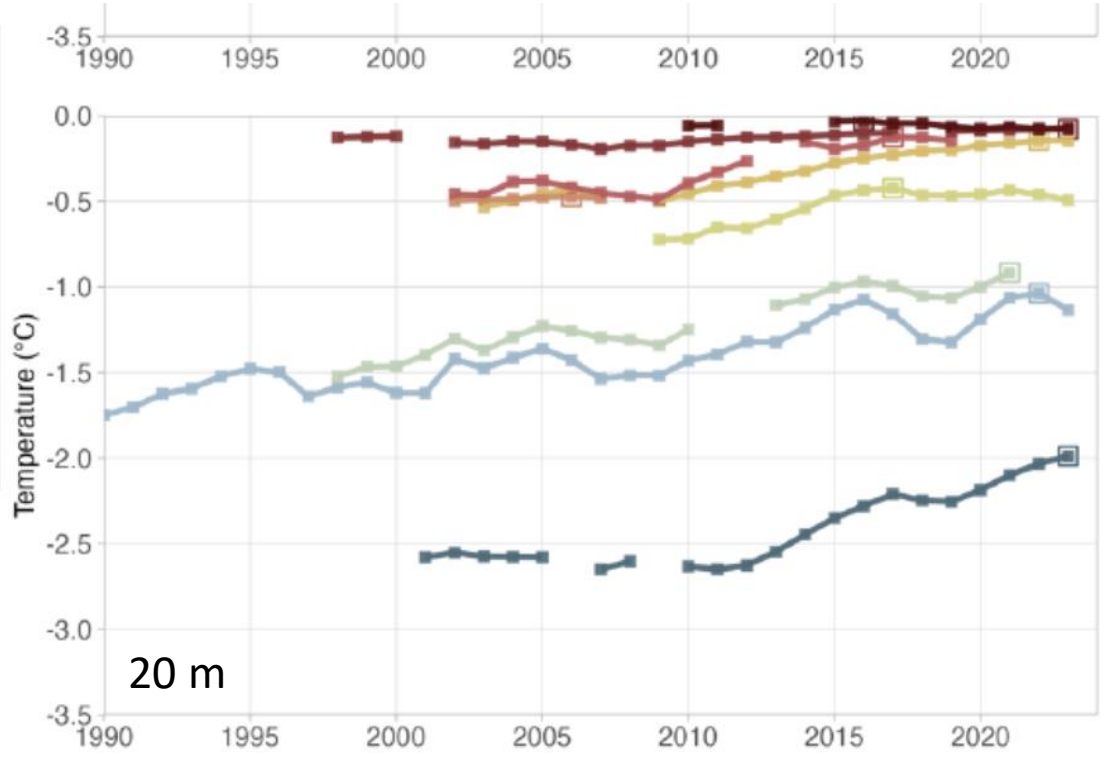
Glaciers are not shown and not masked

University of Zurich



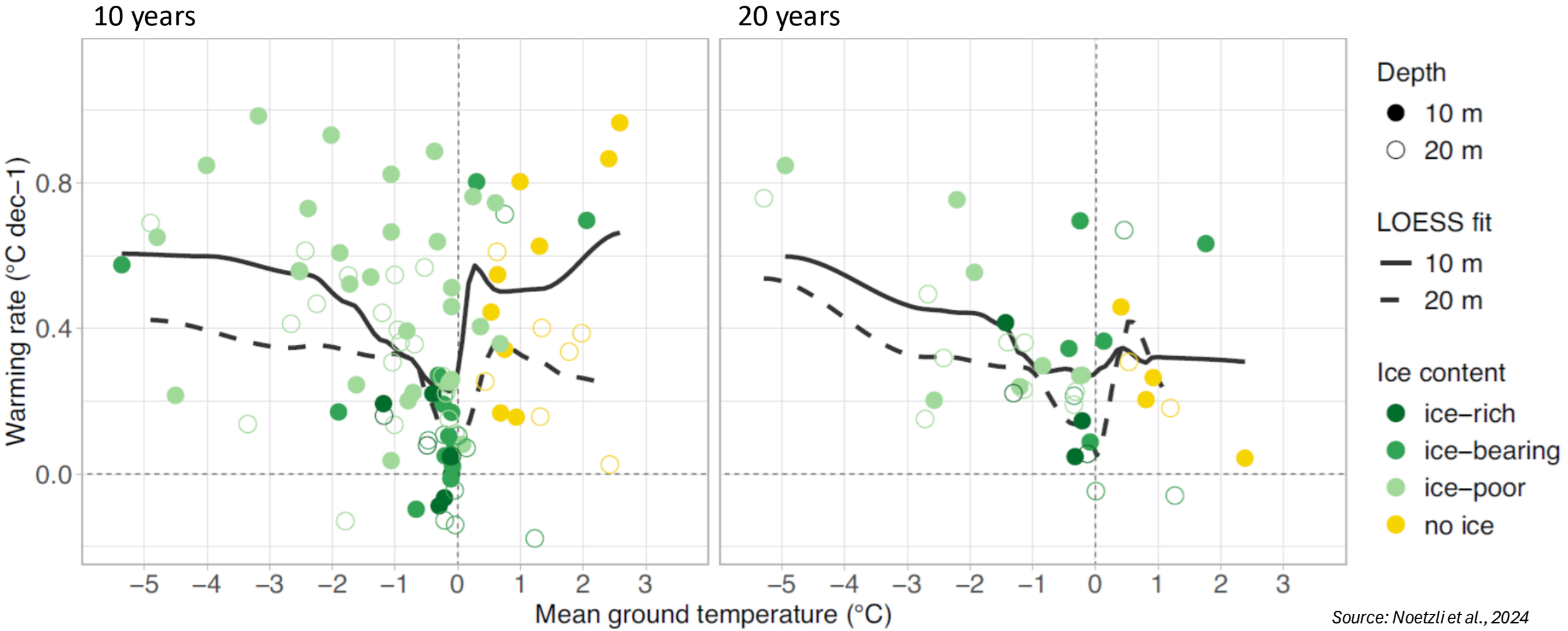
Permafrost and Climate Change





Source: Smith et al., 2022

Permafrost and Climate Change



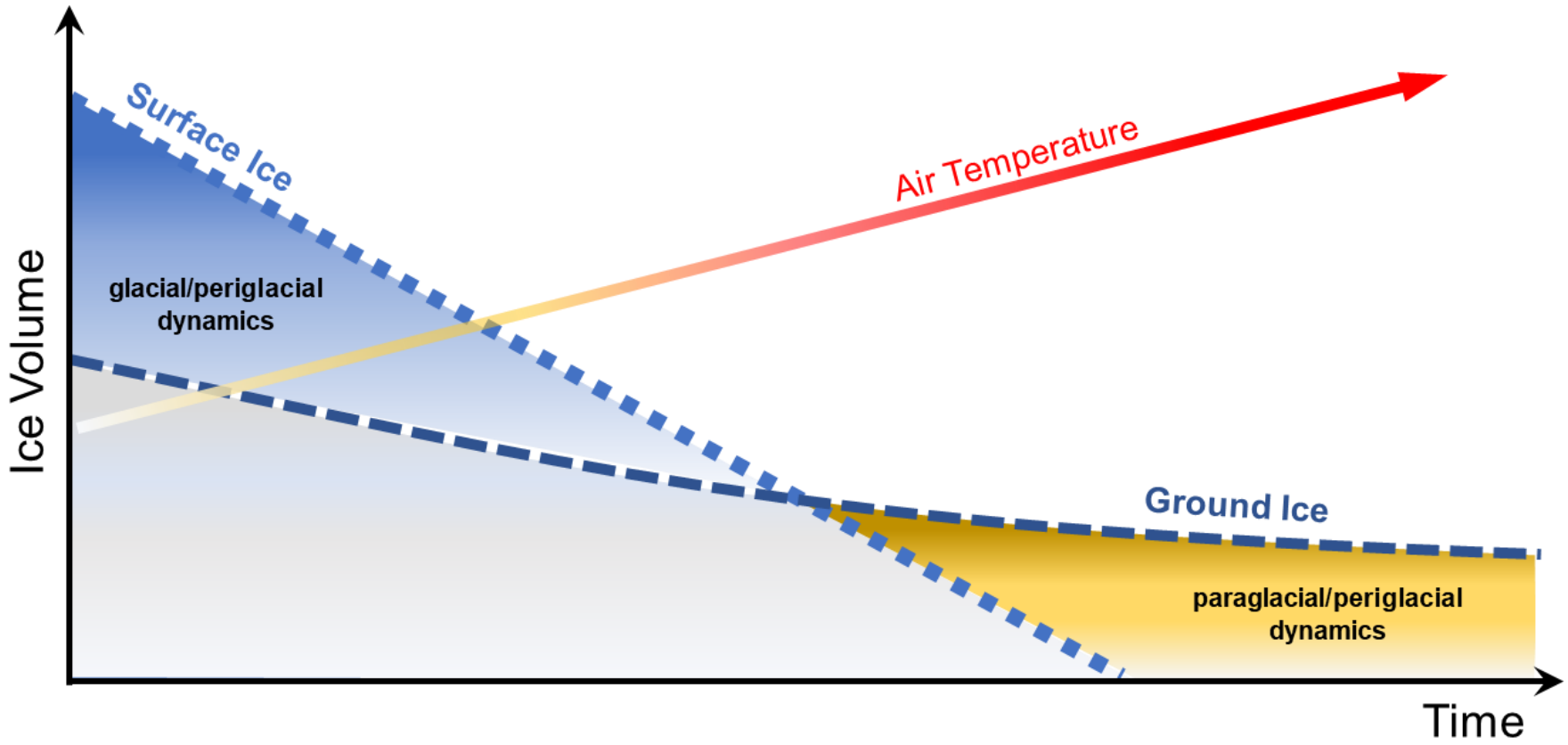
Source: Noetzli et al., 2024

What are the consequences?

Source: B. O'Neill

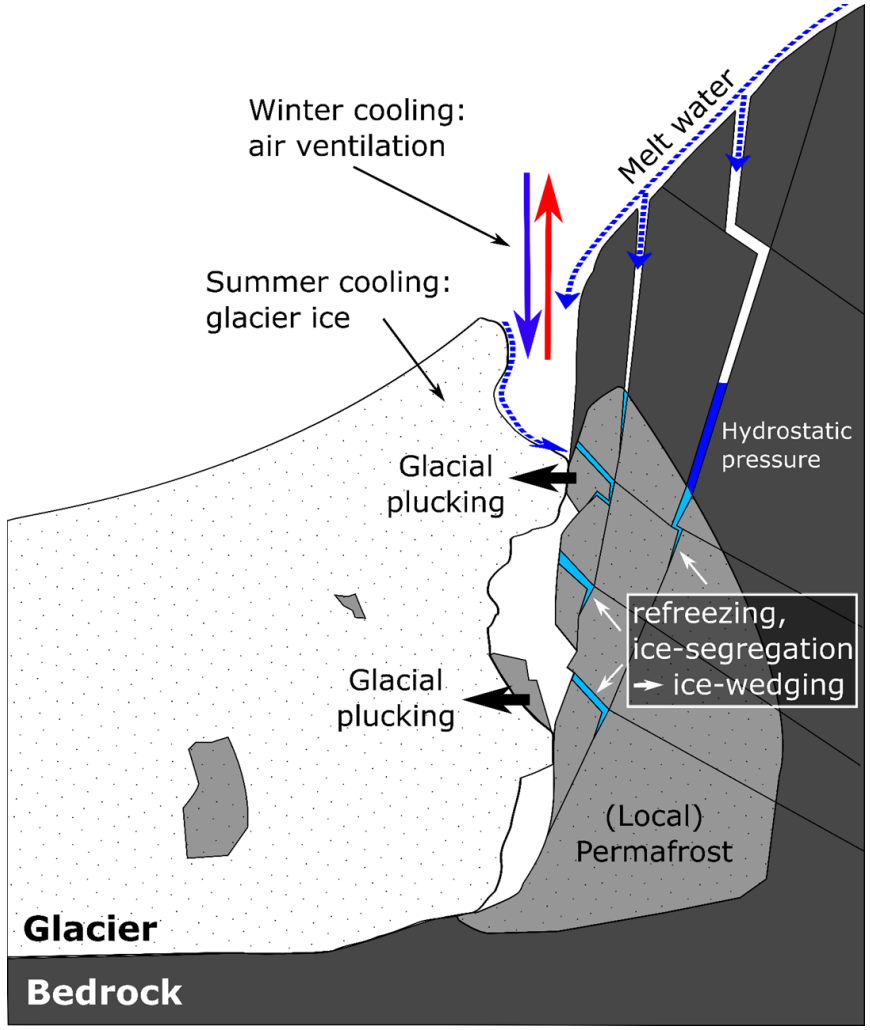
Source: S. Gallup / Getty Images

Surface Ice vs. Ground Ice (Permafrost)



Source: L. Arenson / W. Haeberli

Rapid Rock Wall Erosion

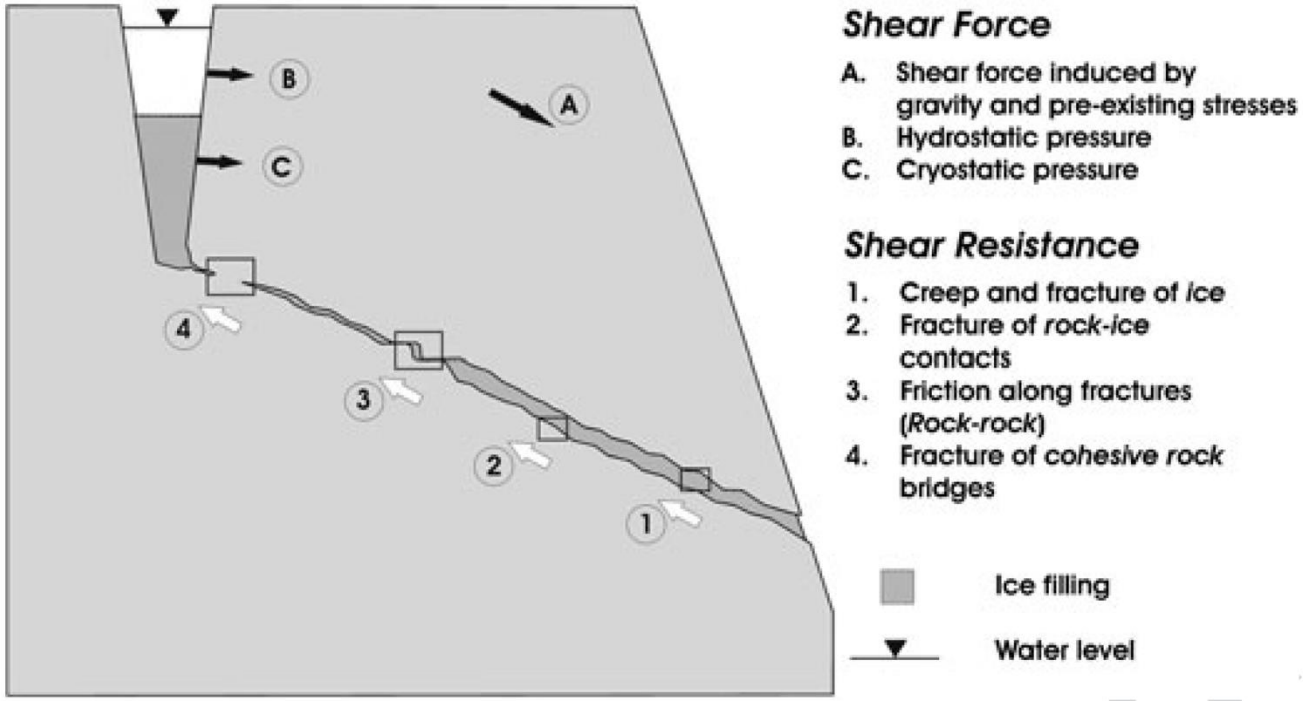


Schematic sketch, illustrating the processes causing rapid rock wall erosion in a bergschrund.

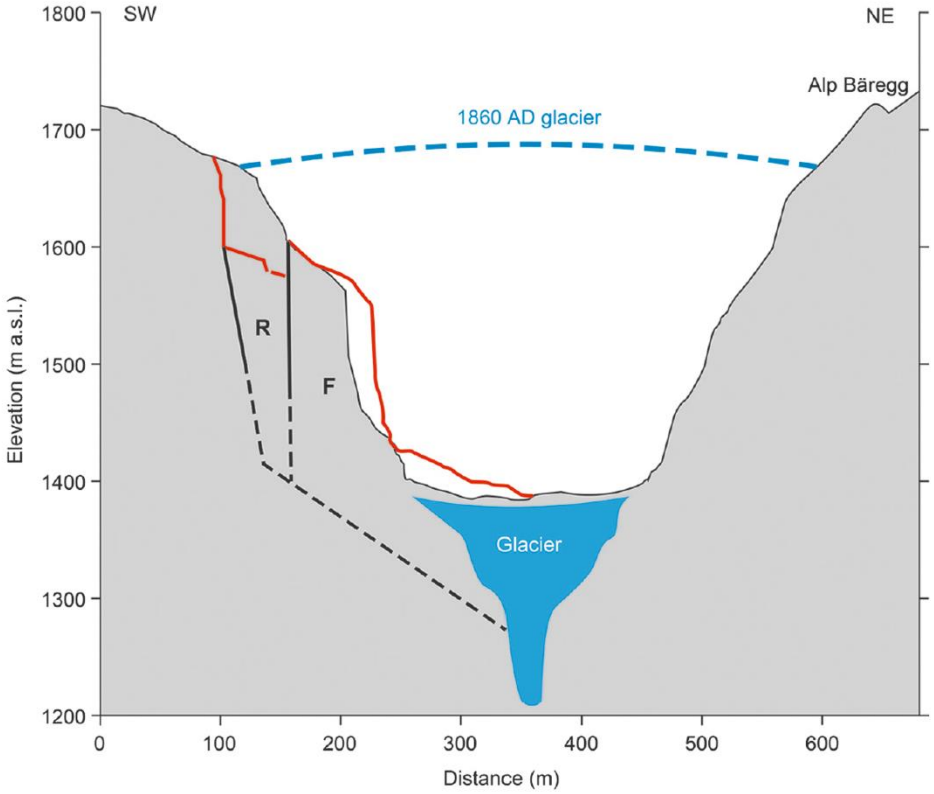
Source: M. Kraublatter

Slope instabilities

Pore pressure and ice pressure buildup

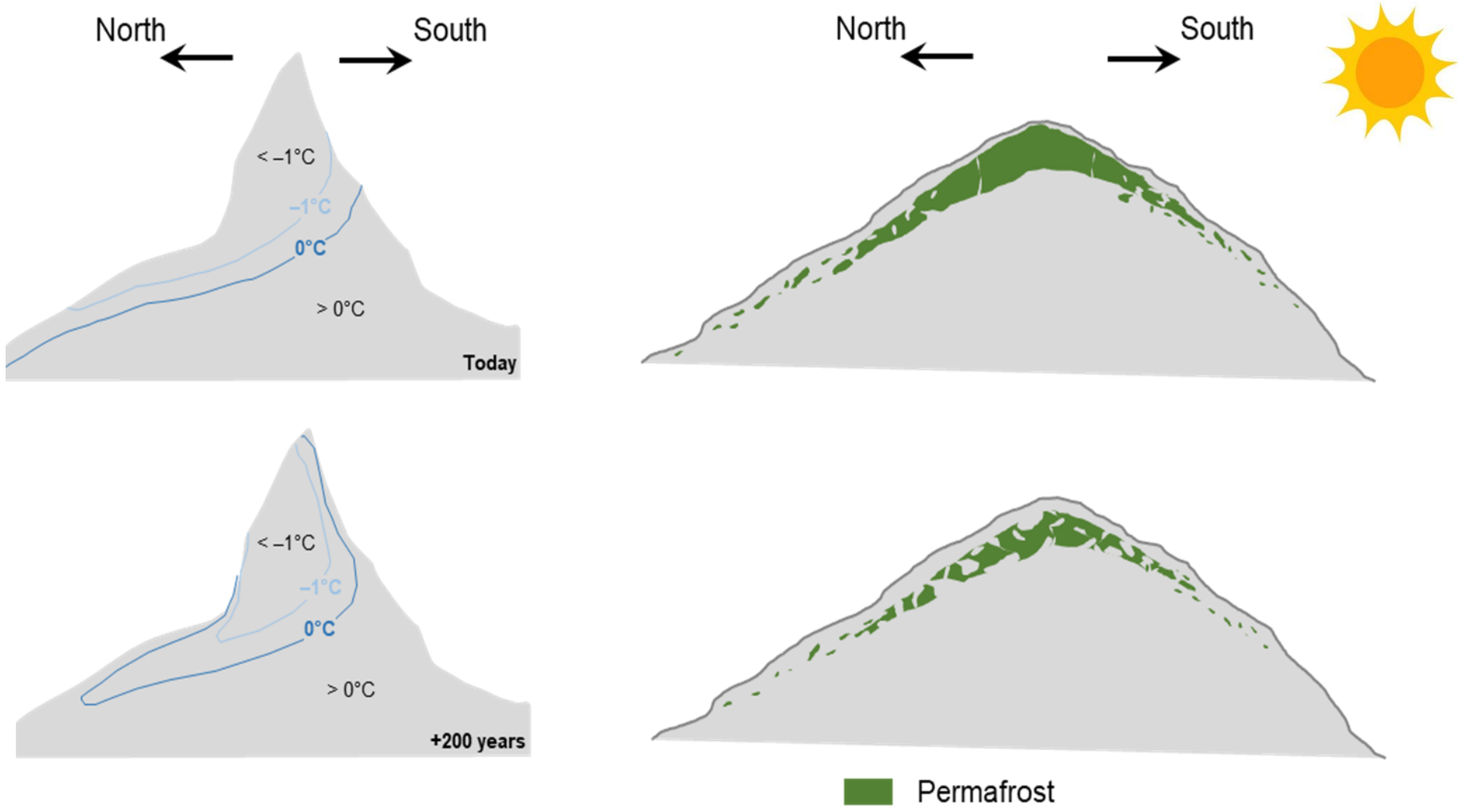


Debuttressing



Source: M. Krautblatter

Topography driven degradation



Conclusions

- Permafrost is warming and degrading
- The spatial distribution of permafrost is complex
- Ground ice is controlling the presence and the degradation
- Permafrost degradation is slower than deglaciation
- Permafrost degradation leads to instabilities
  ("Permafrost is the glue that holds the mountain together")
- Permafrost degradation influences surface runoff and groundwater recharge