Dealing with climate-change impacts on glacier and permafrost hazards: adaptation strategies in mountain regions

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Premise

For anticipation, and essentially the management, of natural hazards in the future, we need to know:

- location of events
- magnitude of events
- frequency of events

=> Important basis for future adaptation and mitigation actions

Content

- Effects of climate change, and related understanding and hazards:
    - glaciers
    - permafrost
    - interactions between surface and subsurface ice
- Adaptation strategies
- Mitigation options

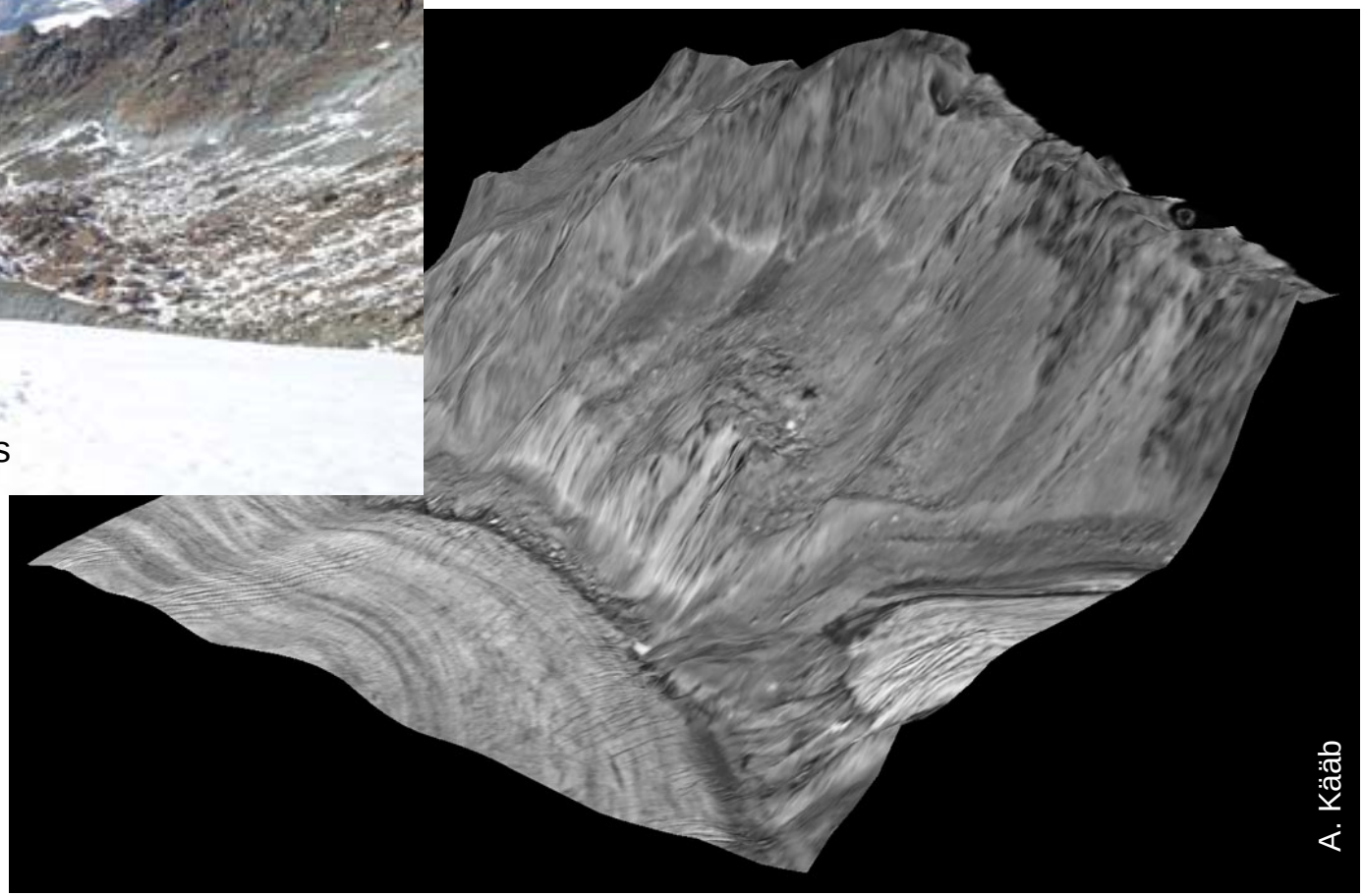
Effects on glaciers

Retreating and decaying glaciers and lake formation and growth
=> Glacial lake outburst and floods

Effects on glaciers

Debuttressing/unloading effect due to glacier retreat
=> rock-/landslides

Findelen Glacier, Valais



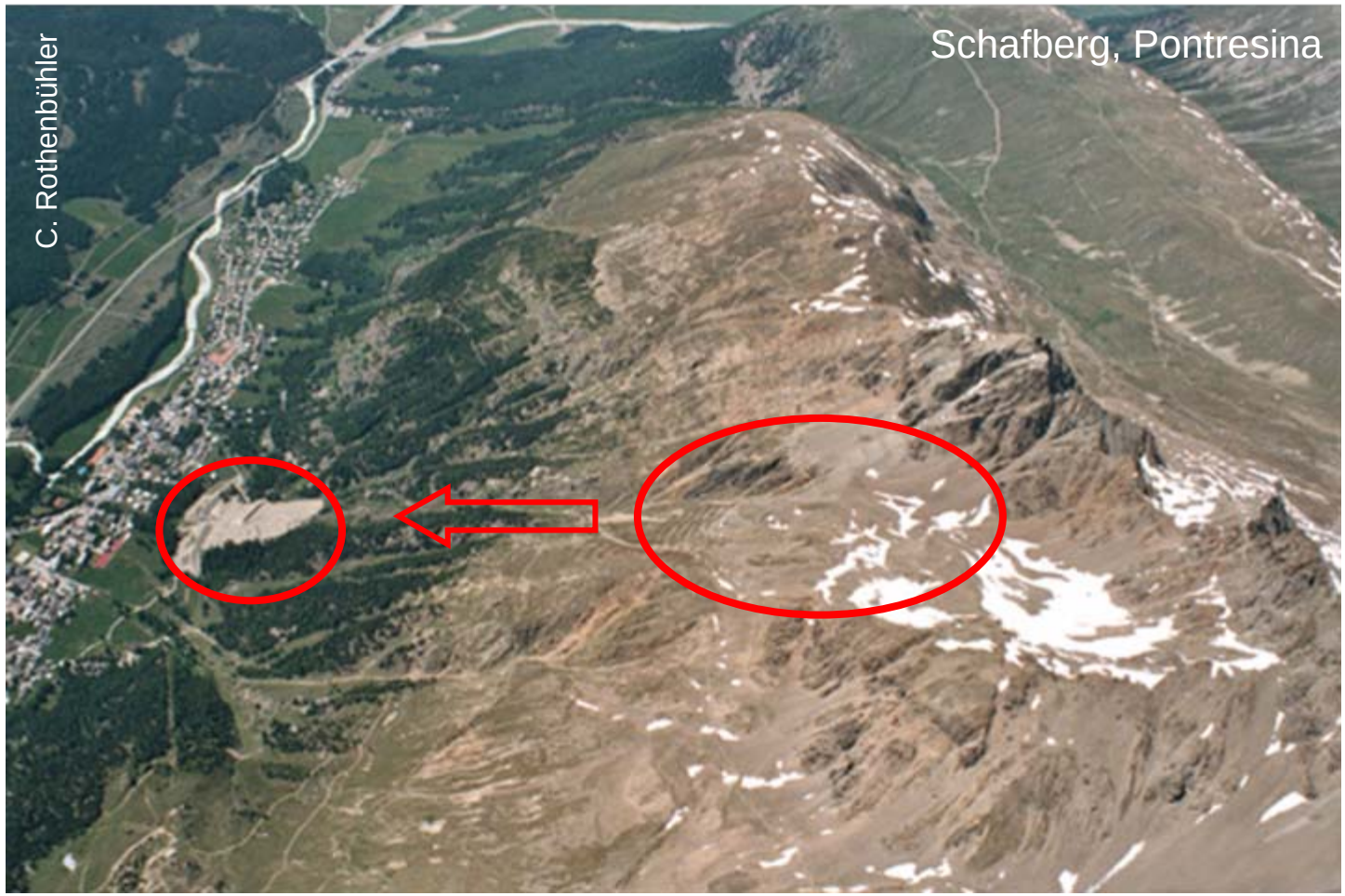
A. Kääb

Effects on glaciers

Retreating glaciers and uncovering of unconsolidated sediment
=> Debris flows

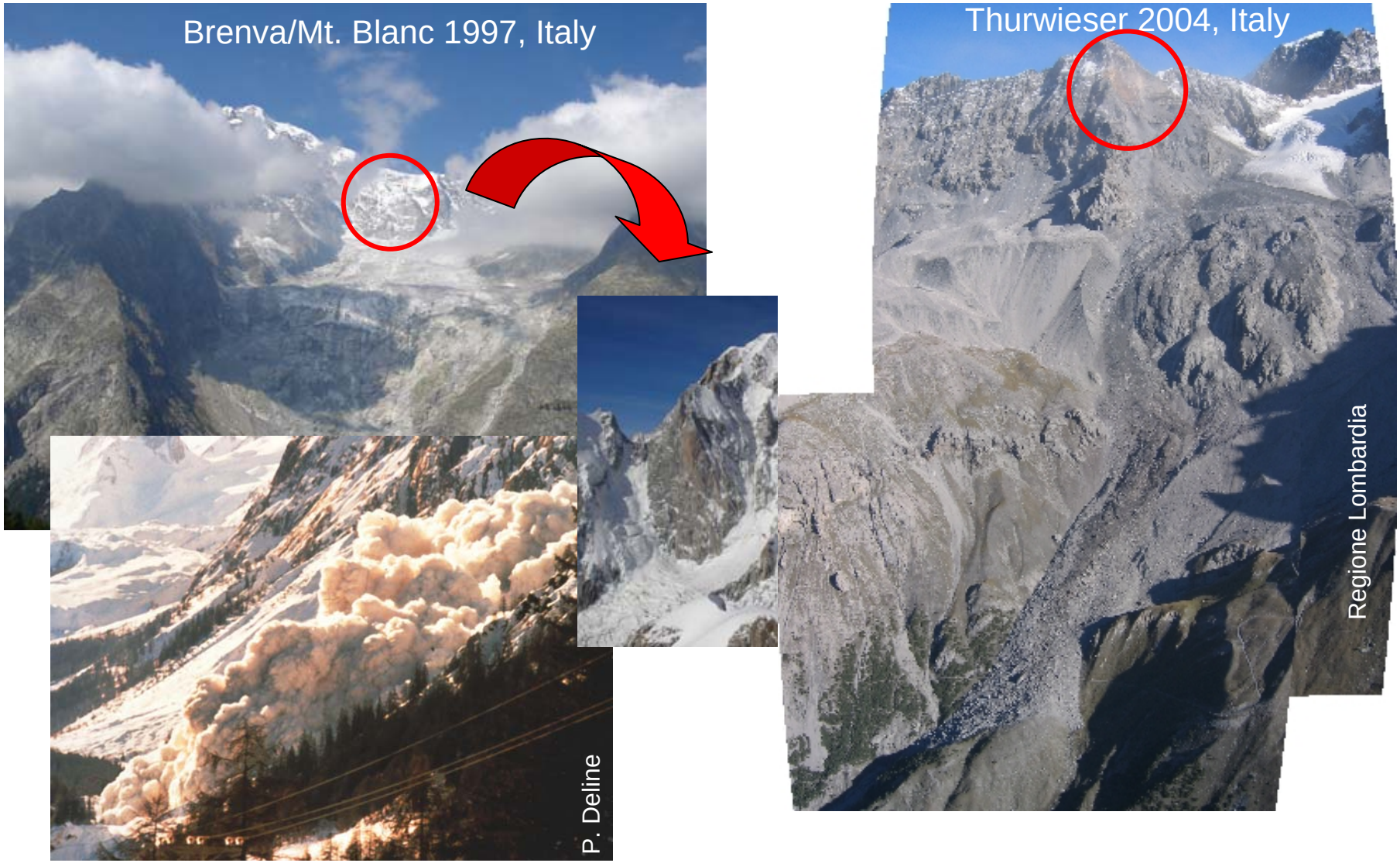
Effects on permafrost

Permafrost degradation and hydro-geologic implications in debris accumulations
=> Changes in debris flow activity



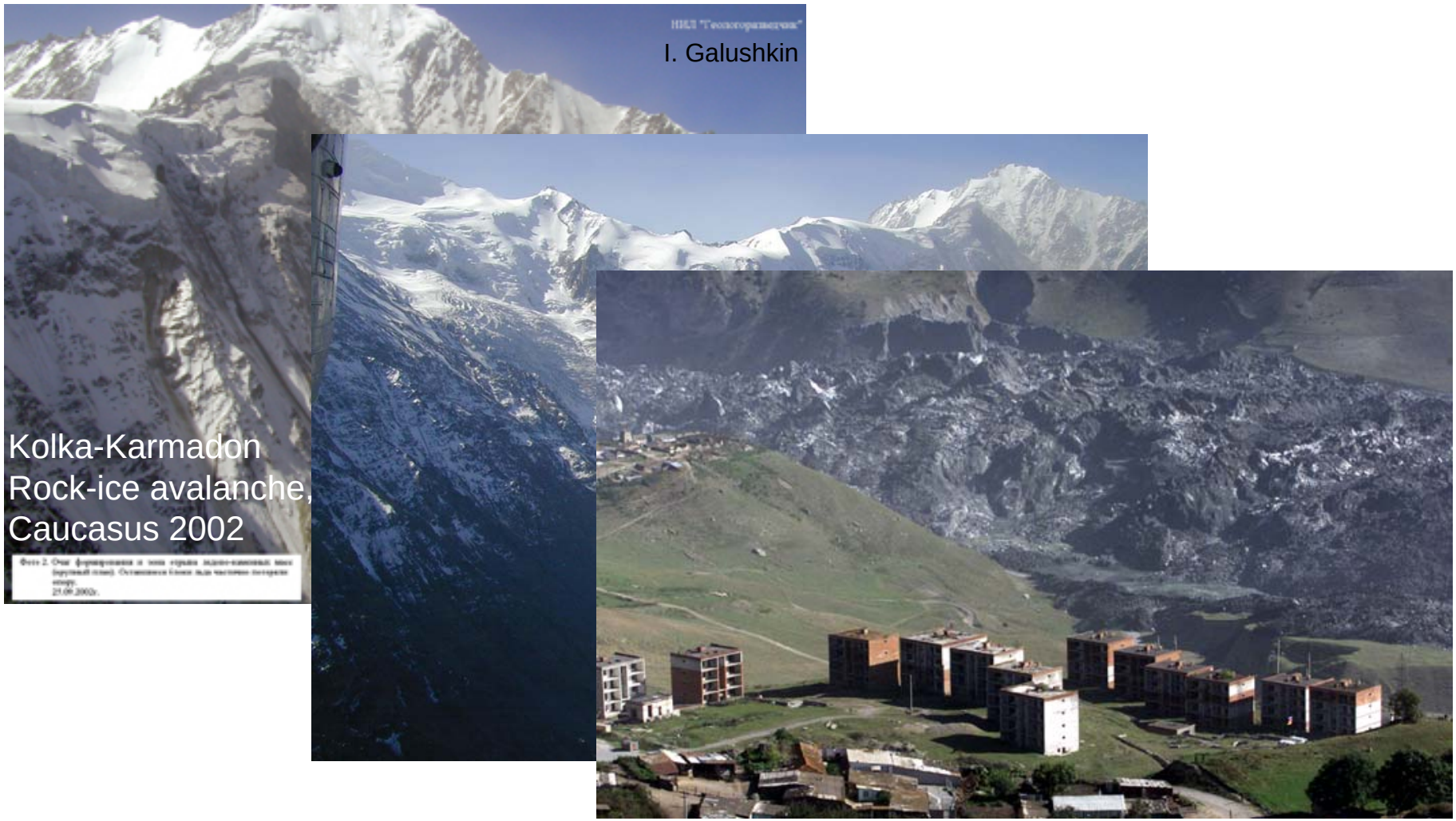
Effects on permafrost

Large rock avalanches from permafrost-affected rock walls: e.g. north-south exposed ridges



Effects on permafrost – glacier interactions

Permafrost and steep glacier interactions: glacierized high-mountain walls => large slope instabilities

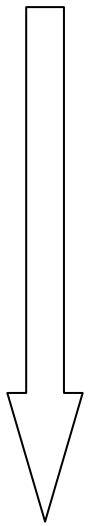


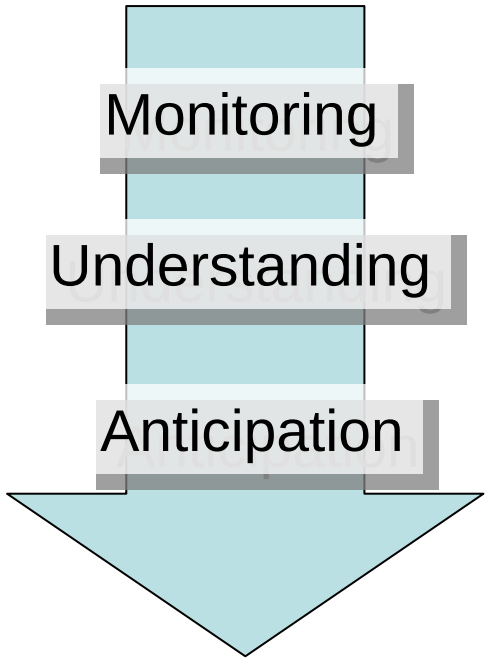
Adaptation strategies

Comparatively well understood processes and developed tools

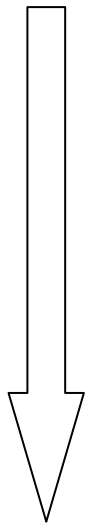
Important gaps and uncertainties

Glacial lakes



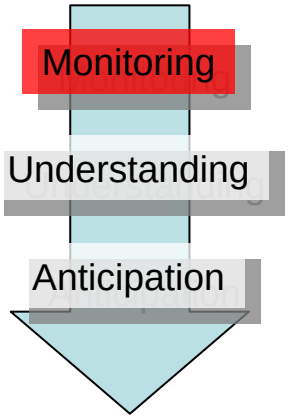


Permafrost-affected rock walls



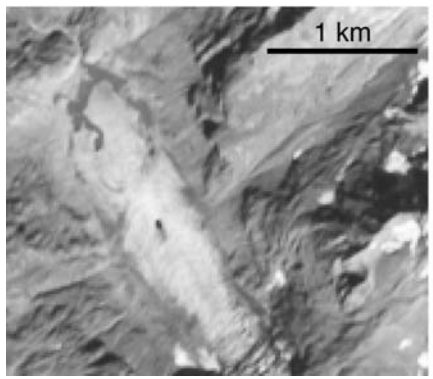
active/passive adaptation and mitigation measures

Adaptation strategies: glacial lakes - science

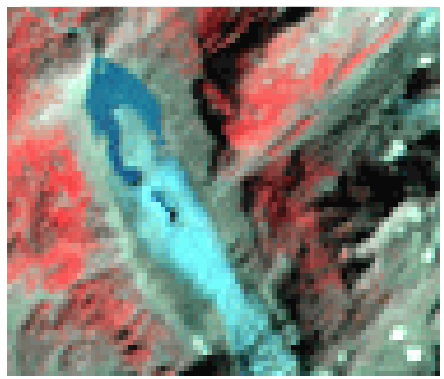


1999

2000

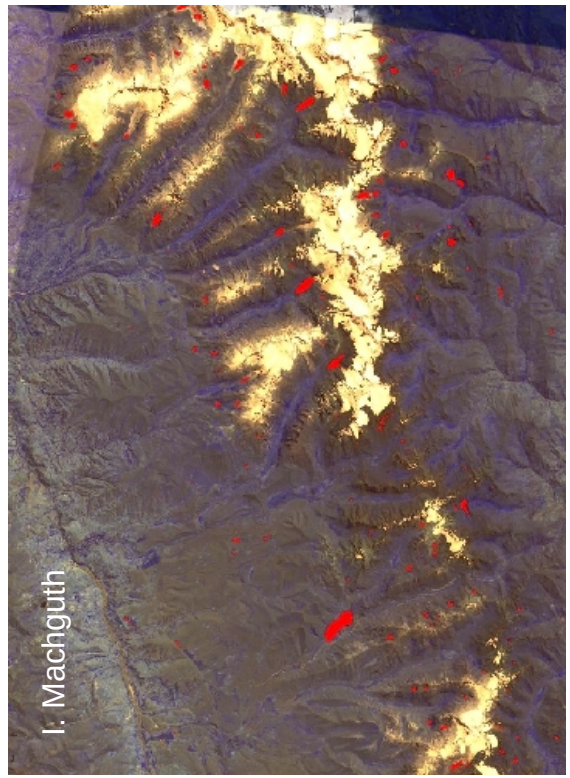


2001



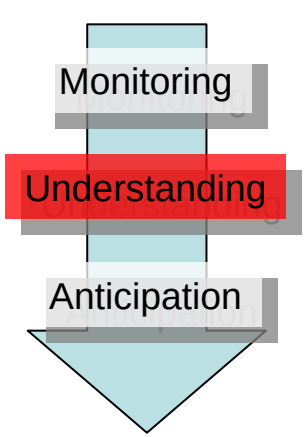
2003

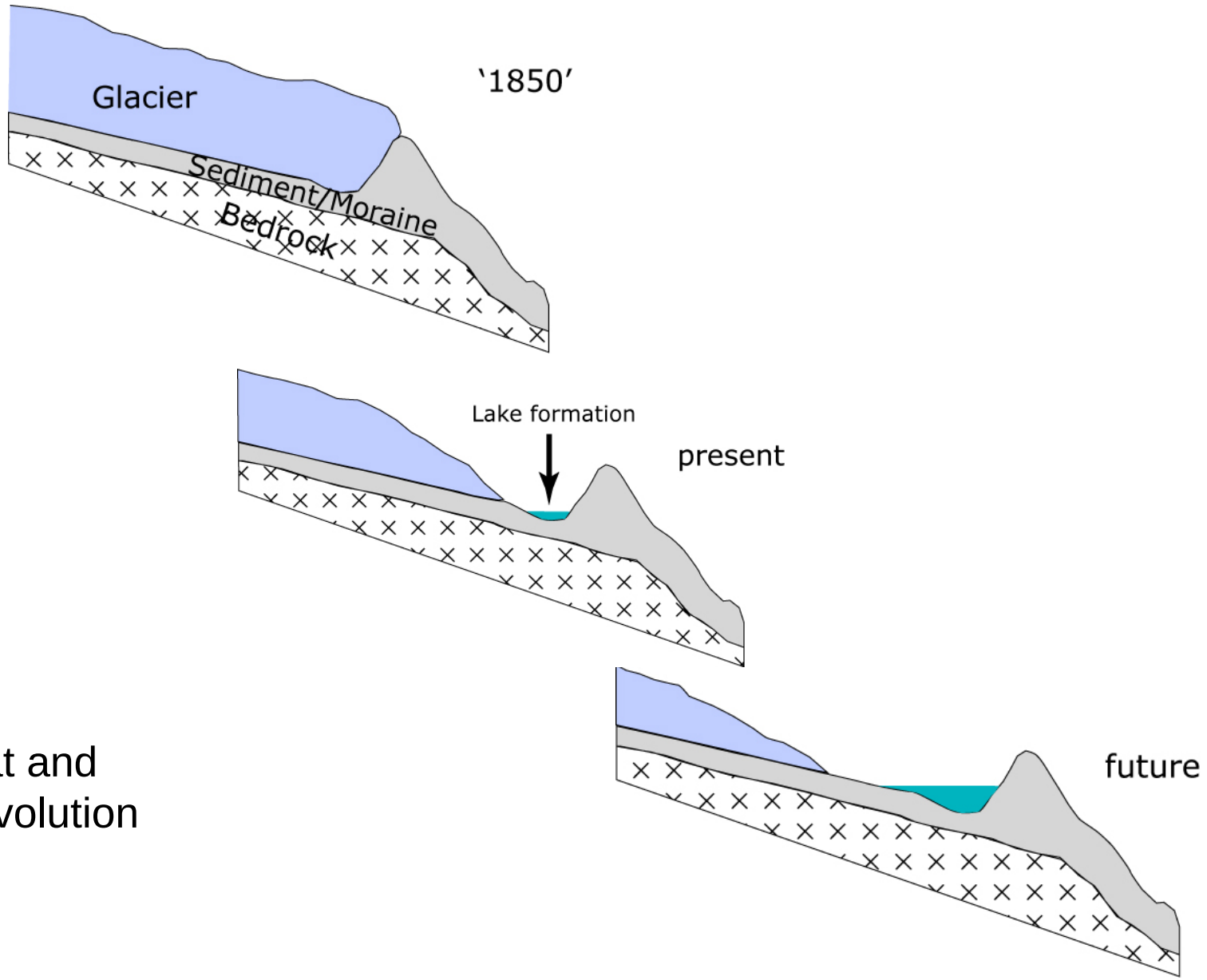
Trift glacier Lake: Satellite remote sensing: Landsat-TM, IKONOS, ASTER



Glacier lake detection, Cordillera Blanca, Peru

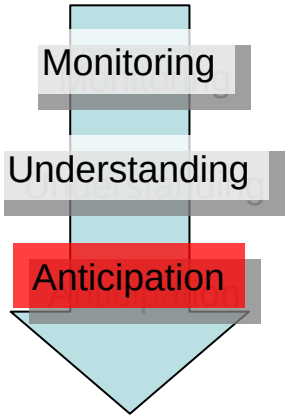
Adaptation strategies: glacial lakes - science





Glacier retreat and
glacial lake evolution

Adaptation strategies: glacial lakes - science



Glacier retreat and lake outburst flood modeling and assessment

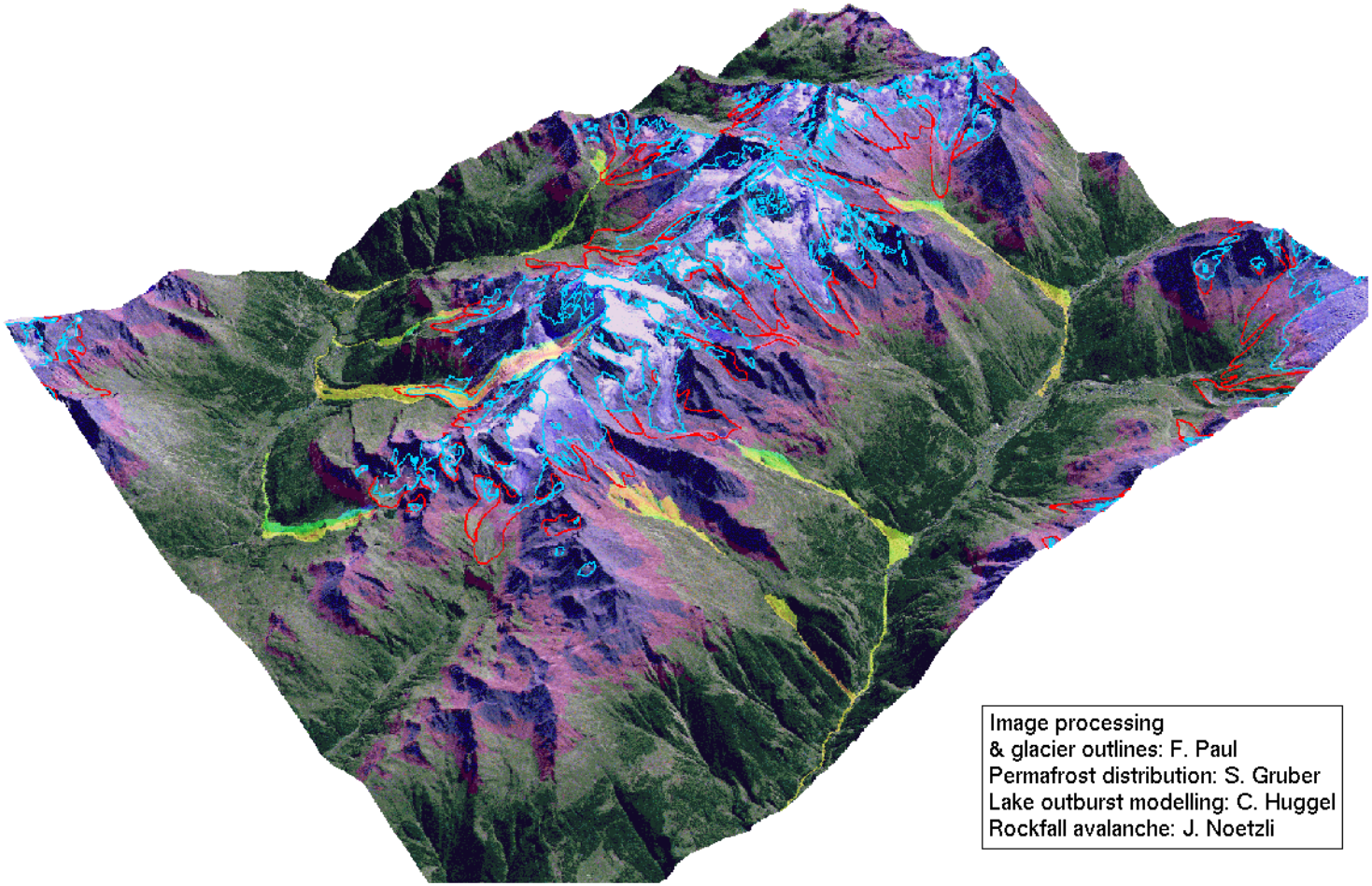


Image processing
& glacier outlines: F. Paul
Permafrost distribution: S. Gruber
Lake outburst modelling: C. Huggel
Rockfall avalanche: J. Noetzli

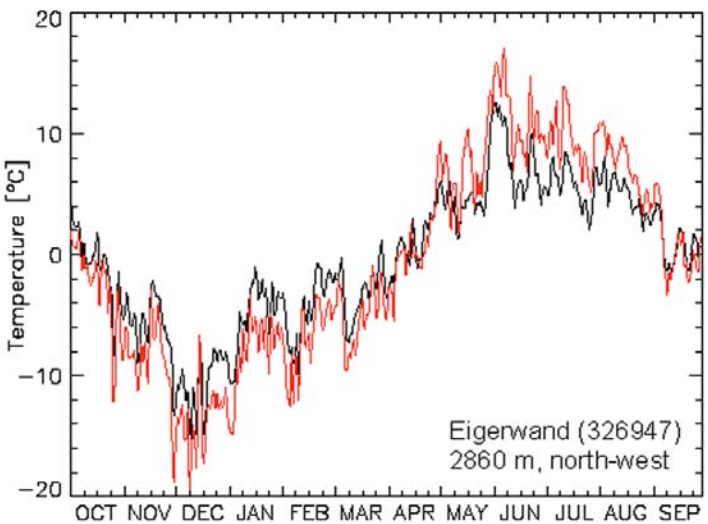
Adaptation strategies: permafrost-affected rock walls - science

Monitoring

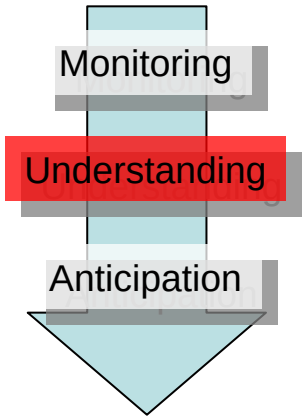
Understanding

Anticipation

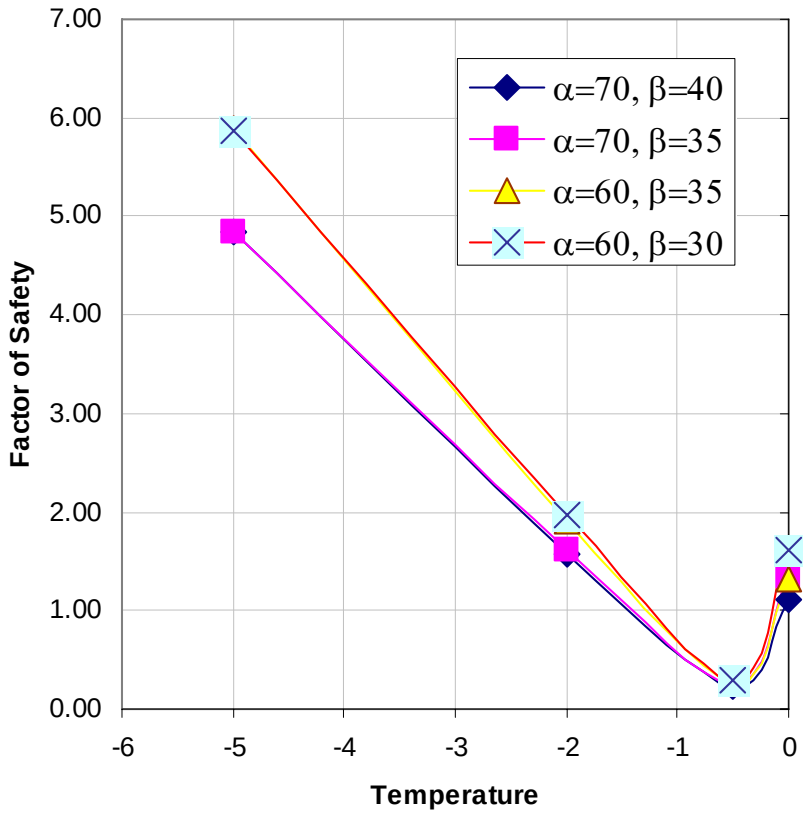
Rock wall temperature measurements



Adaptation strategies: permafrost-affected rock walls - science



Findings from centrifuge modeling on rock failure in permafrost conditions

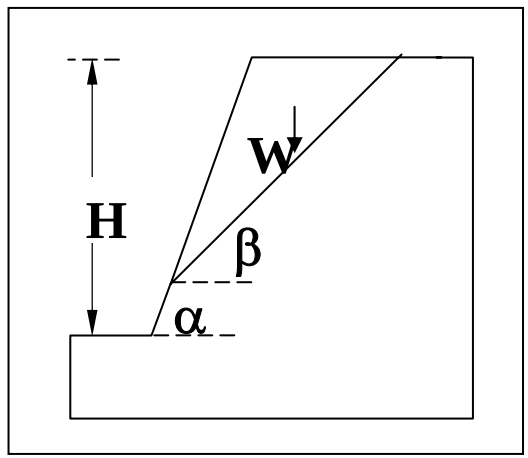


M. Davies, University of Dundee

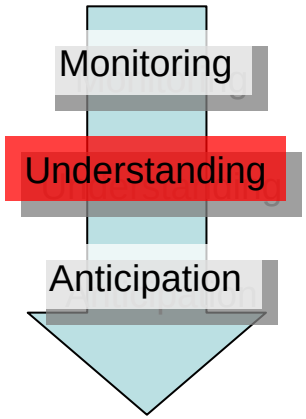
Factor of safety

< 1 with T < 1.5°C

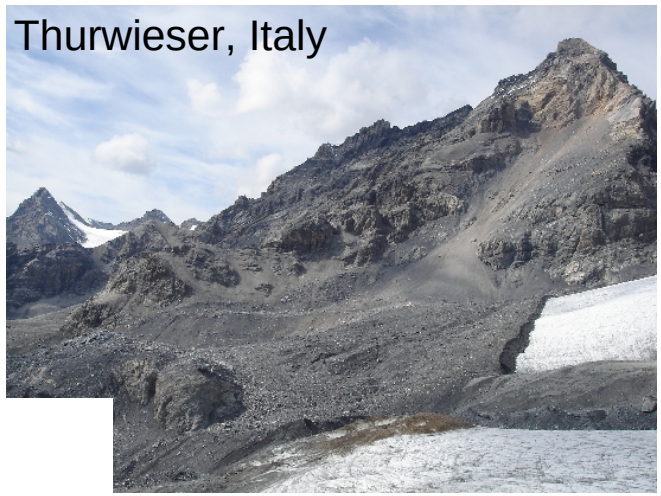
But:
FoS > 1 without ice

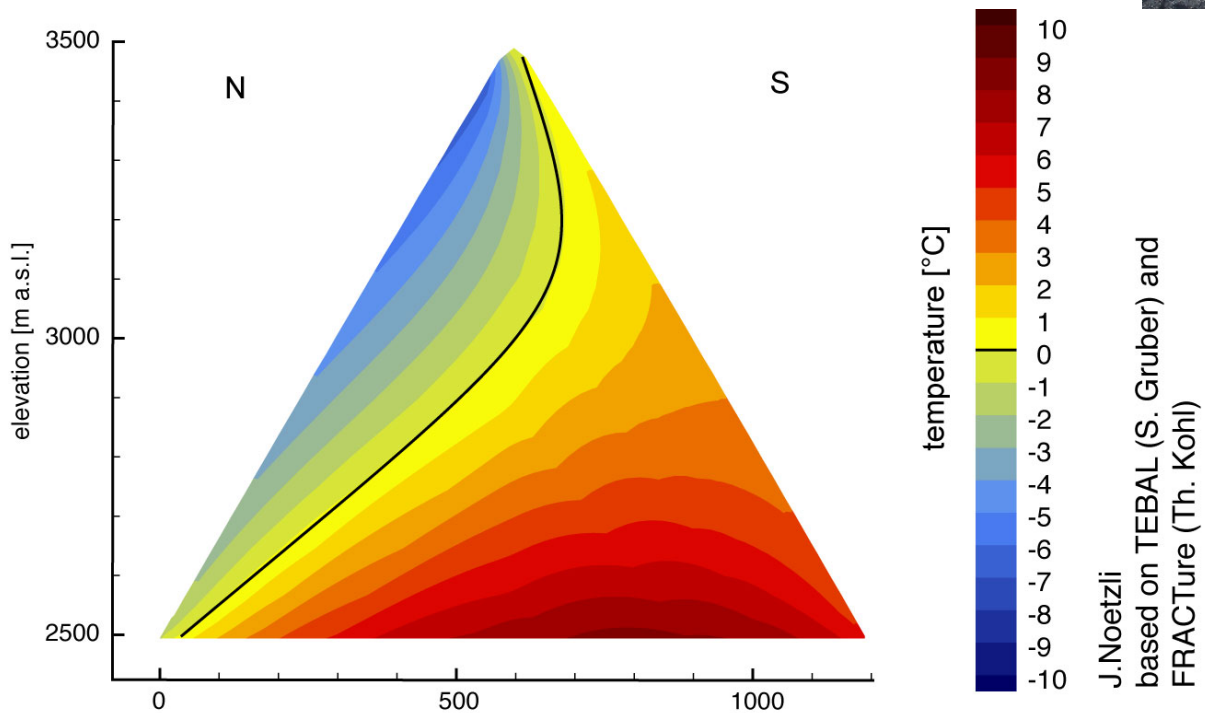


Adaptation strategies: permafrost-affected rock walls - science

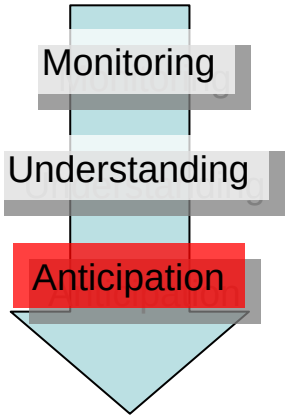


3D temperature distribution modeling for conditions in depth

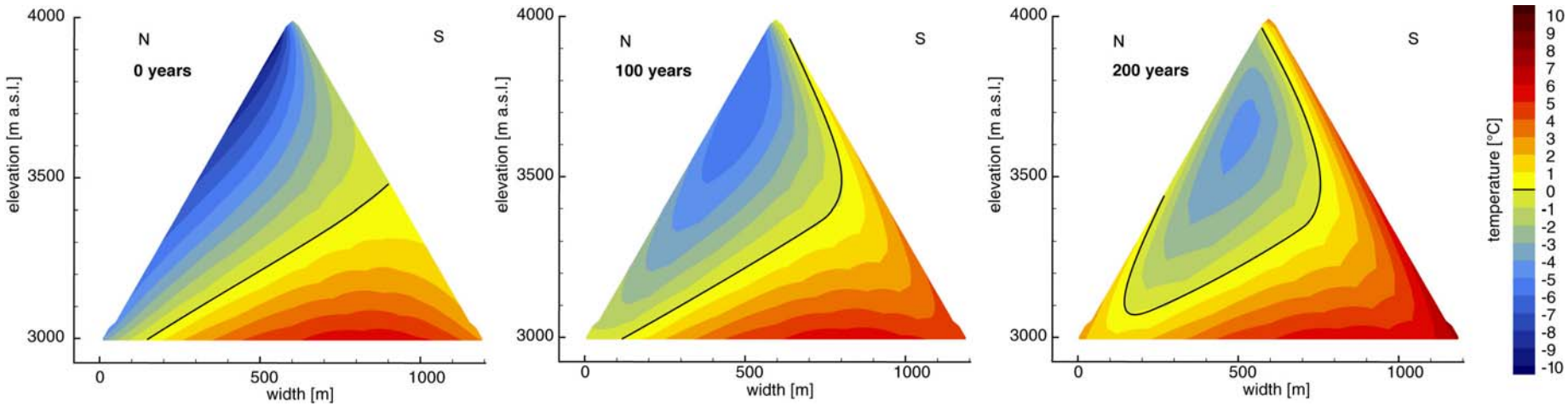




Adaptation strategies: permafrost-affected rock walls - science



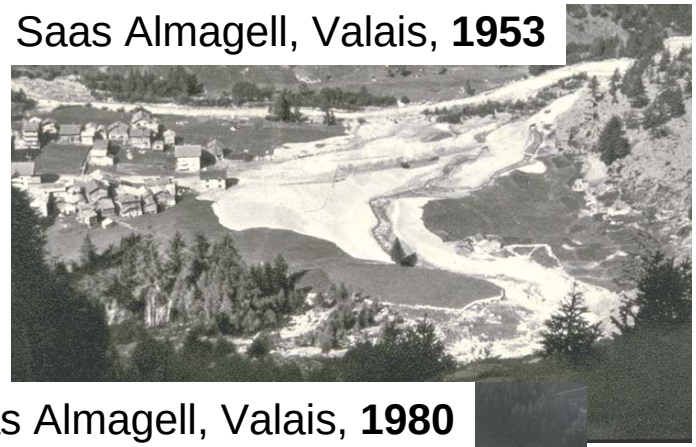
Projected temperature change in depth of a North-South ridge situation
(i.e. similar to Thurwieser, Brenva)



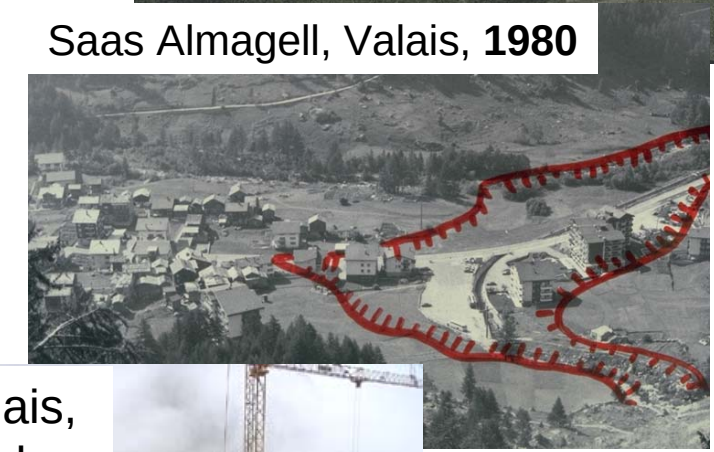
Adaptation and mitigation strategies: decision-makers

- Land-use planning
- Structural protection measures
- Warning systems
- Vulnerability and risk assessments
- Preparedness (emergency plans etc.)
- Relocation

Saas Almagell, Valais, **1953**



Saas Almagell, Valais, **1980**

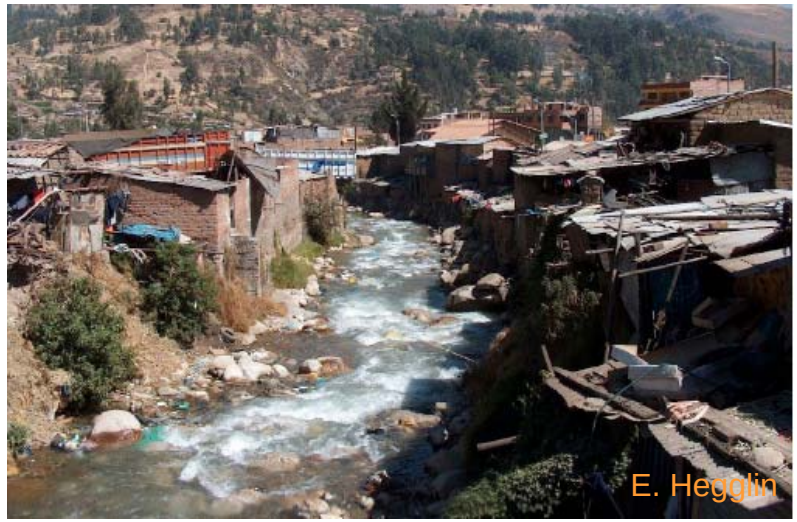


Täsch, Valais, protection dam

Adaptation strategies: decision-makers

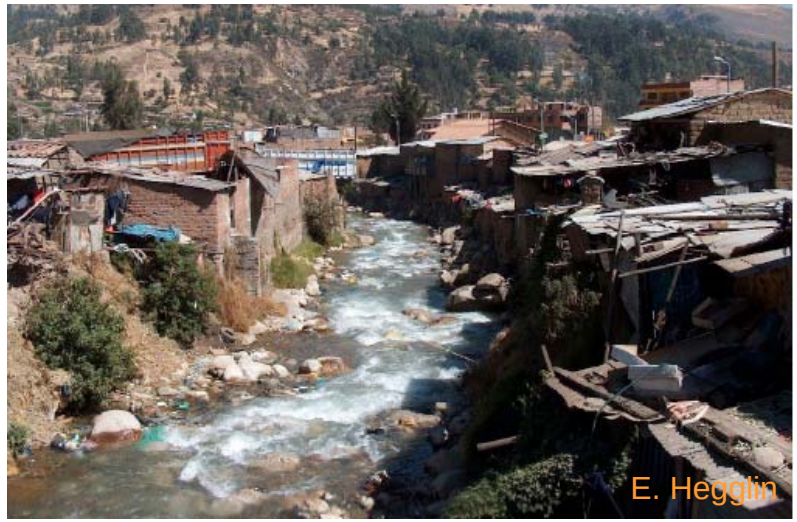
- ~~Land-use planning~~
- ~~Structural protection measures~~
- ~~Warning systems~~
- ~~Vulnerability and risk assessments~~
- ~~Preparedness (emergency plans etc.)~~
- Relocation

Cordillera Blanca, Peru



Adaptation strategies: decision-makers

Cordillera Blanca, Peru



Relocation

Adaptation strategies: decision-makers

Colombia:
Relocation? – Alternatives?

Relocation

Conclusions

• Climate change strongly affects cryospheric systems
on the surface and thus directly observable
in the sub-surface and often only indirectly observable
in coupled systems (glacier-permafrost)
all having potentially severe impacts in terms of hazards.

• Methods and tools for hazard monitoring and assessment have been developed for much longer time in relation with glaciers than with (mountain) permafrost.

• Monitoring, understanding, modeling and anticipation/prediction can be viewed as an integrative part of adaptation efforts, and has to be considered for taking further measures.

• The choice of adaptation and mitigation measures is often limited by economic, social or cultural conditions of a region/country. In general, a shift from high-cost to low-cost measures may be necessary.

Thanks for your attention !

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