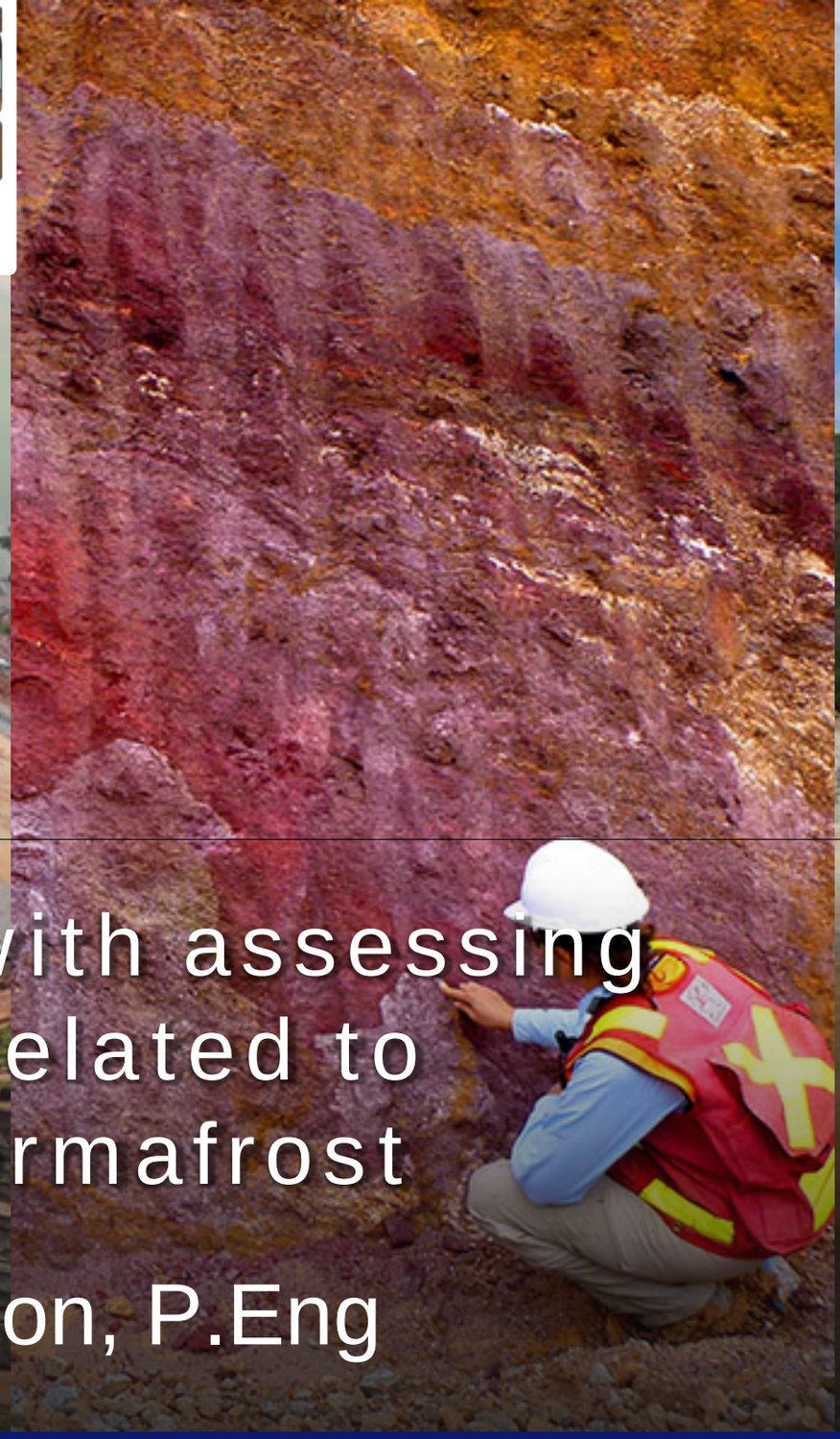
GSA 2014

19-22 October | Vancouver, BC, Canada



Challenges with assessing geohazards related to degrading permafrost

Dr. Lukas Arenson, P.Eng

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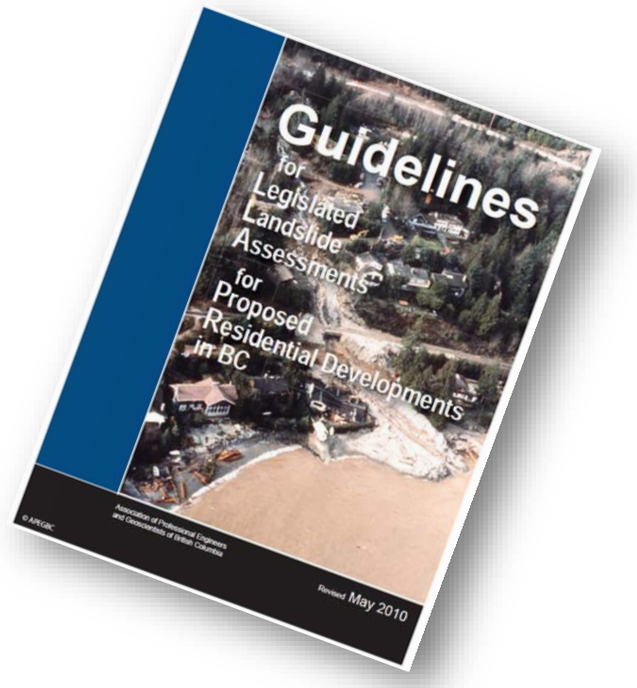
Objectives

- Assessing risks from an environment that is likely changing at an unprecedented rate and historic events may not be representative for future behaviour

Why?



- Best practice guidelines
- Risk based design
- Climate change -> rapid changes, unprecedented
- Projects in “extreme” locations

Content

- Introduction
- A Changing Environment
- A Systematic Approach
- Summary and Conclusions

SRF, 2014

Adolph, 2007

Brideau et al., 2006

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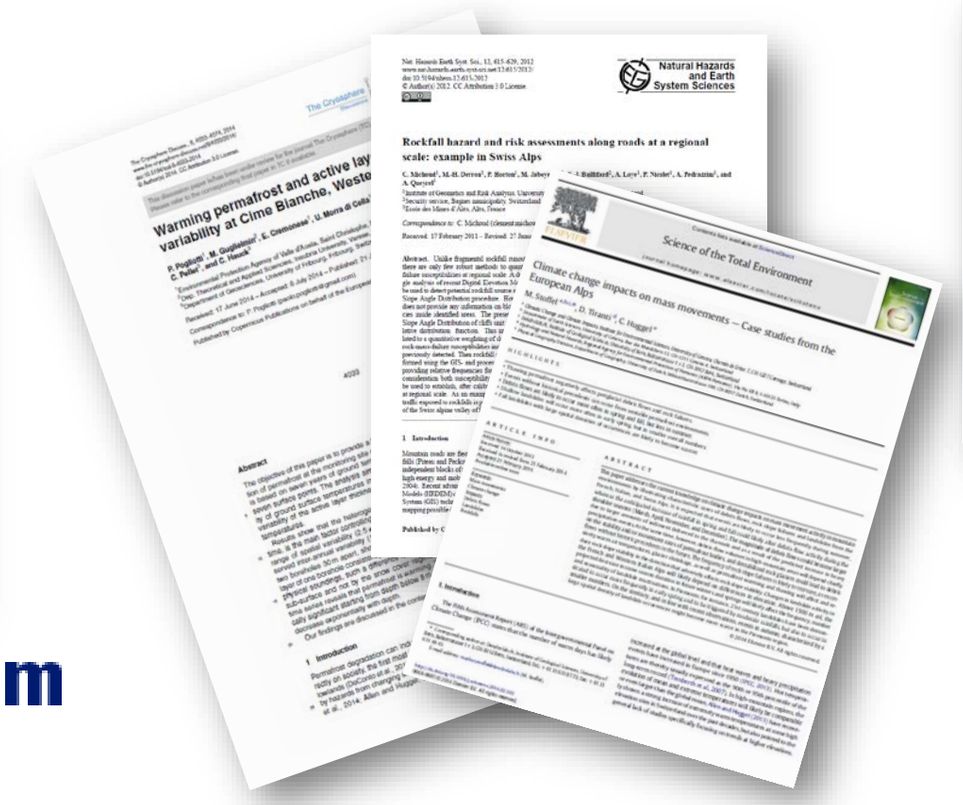
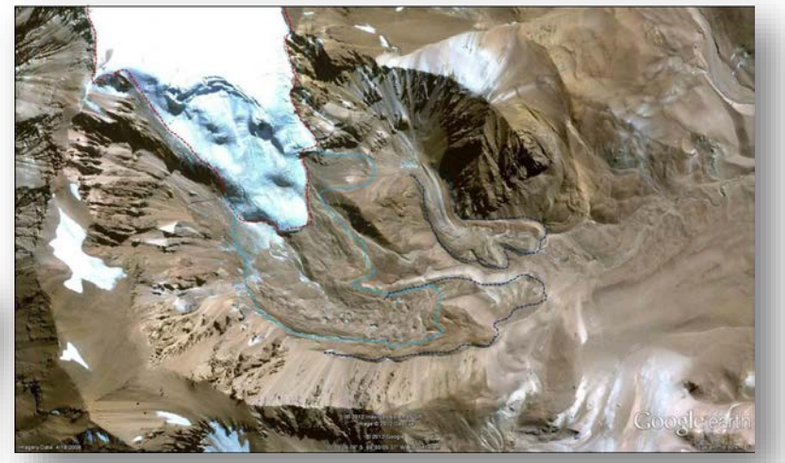
Periglacial Environment

- Affected by cold temperatures, glaciers and snow, i.e. strongly dependent on the climate
- Dynamic environment
- Lots of publications indicate changes in the geohazards from the periglacial environment





GoogleEarth

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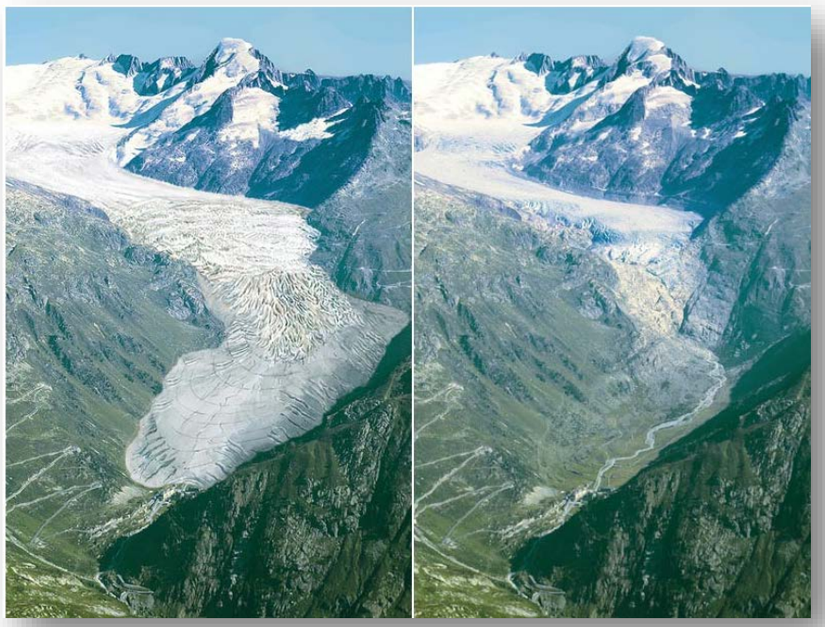
Environmental Changes?

- Rapid glacier retreat
- Permafrost degradation
- Frost action
- Pre-glacial lake (GLOF)



ETH, 2010

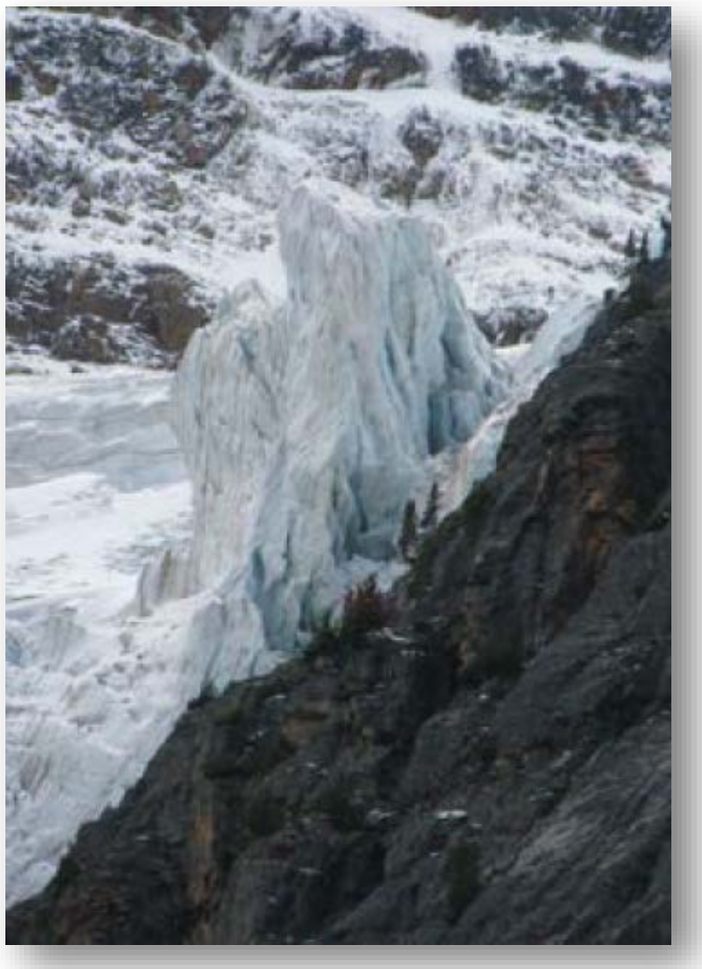
BGC, 2014

Risk

Hazard x Consequence

Constant ?

Geobrugg



Quinn et al., 2014

Parks Canada

SRF, 2014

Frequency

Magnitude

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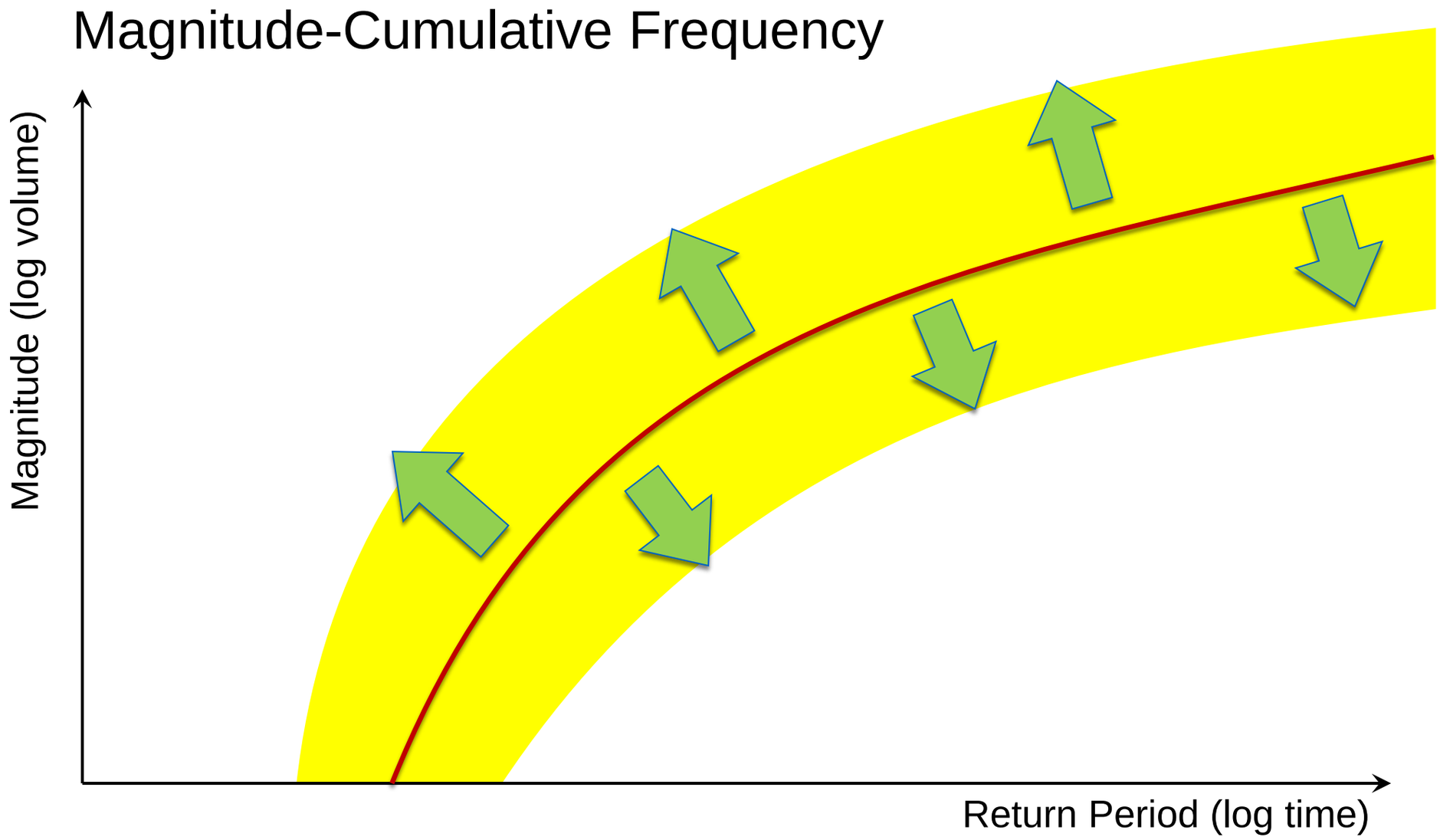
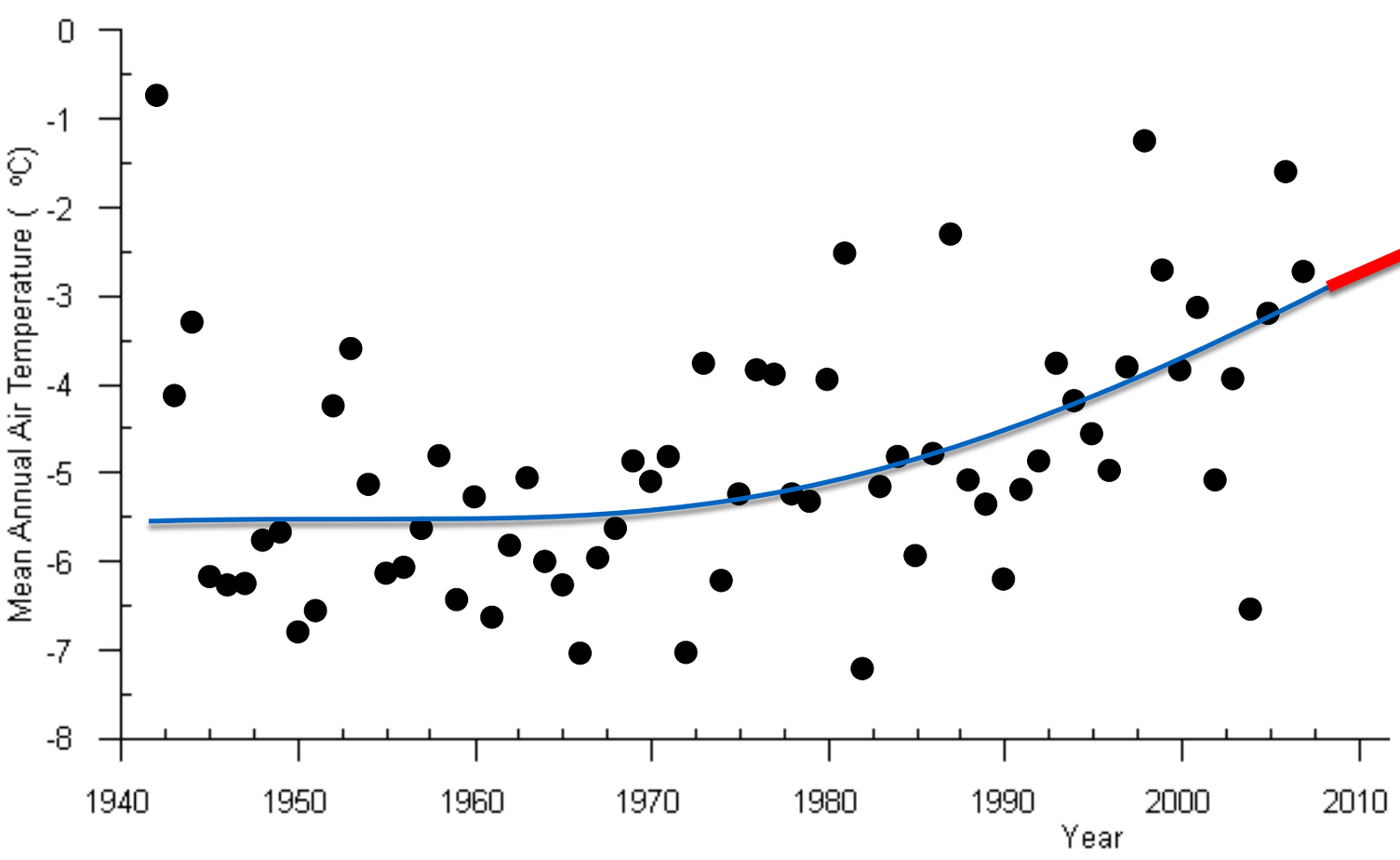
Frequency - Magnitude



Systematic Approach

- FCM curves that are based on historic events may no longer be applicable
- Need to assess the changes in the frequency and the magnitude of certain events
- Use numerical models for parameter studies
- Use advanced statistics to assess changes in environmental input parameters
- Evaluate which (if at all) climate change rates can be used

E.g. Change in Air Temperature



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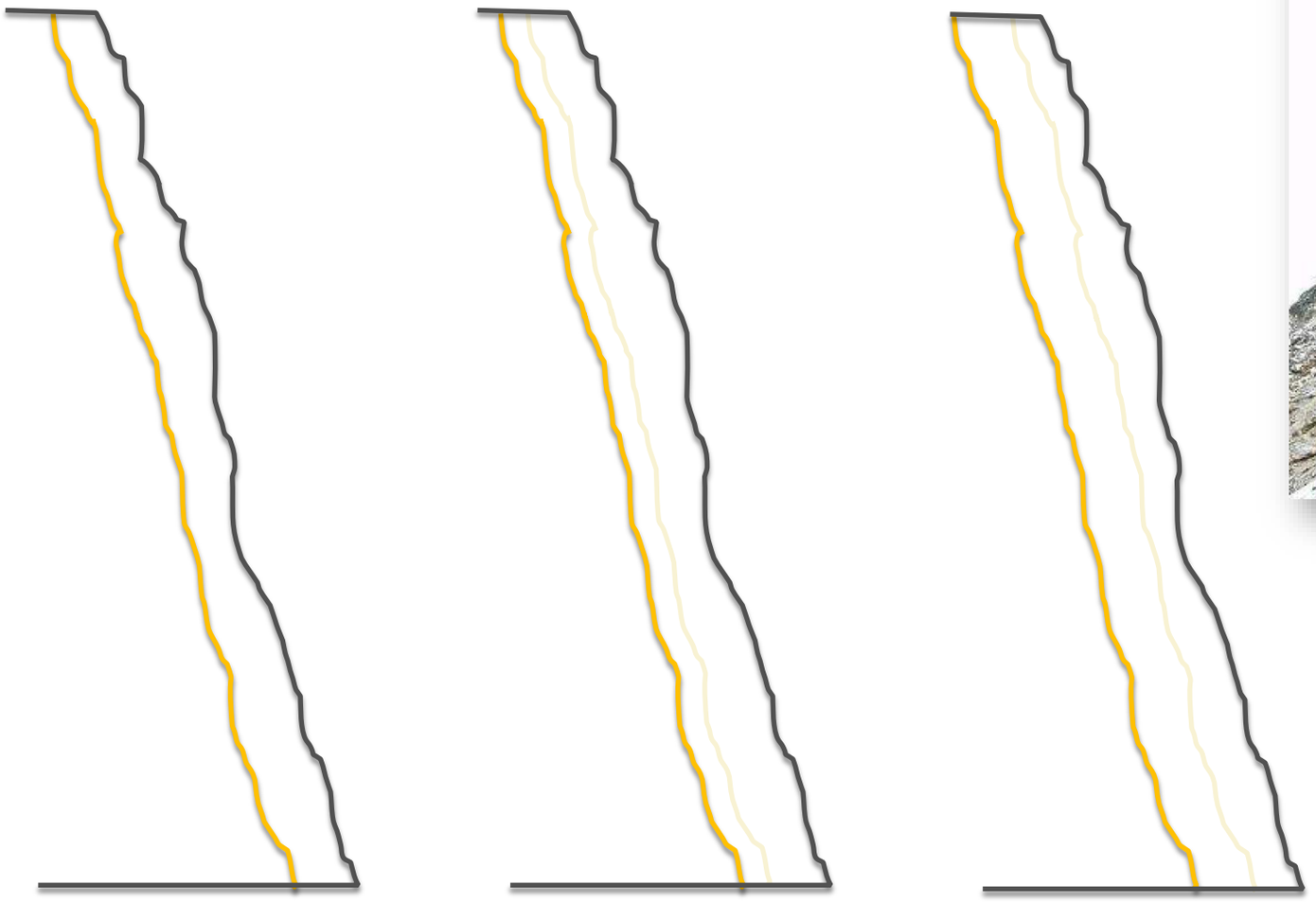
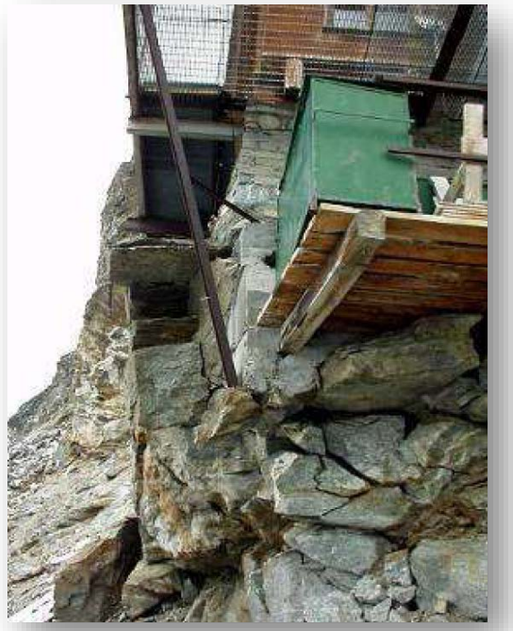
Change in Active Layer - Rockfall



t_0 t_{+20} t_{+40}



Schoeneich et al. - 2011

Michoud et al. - 2012

Michoud et al. - 2012

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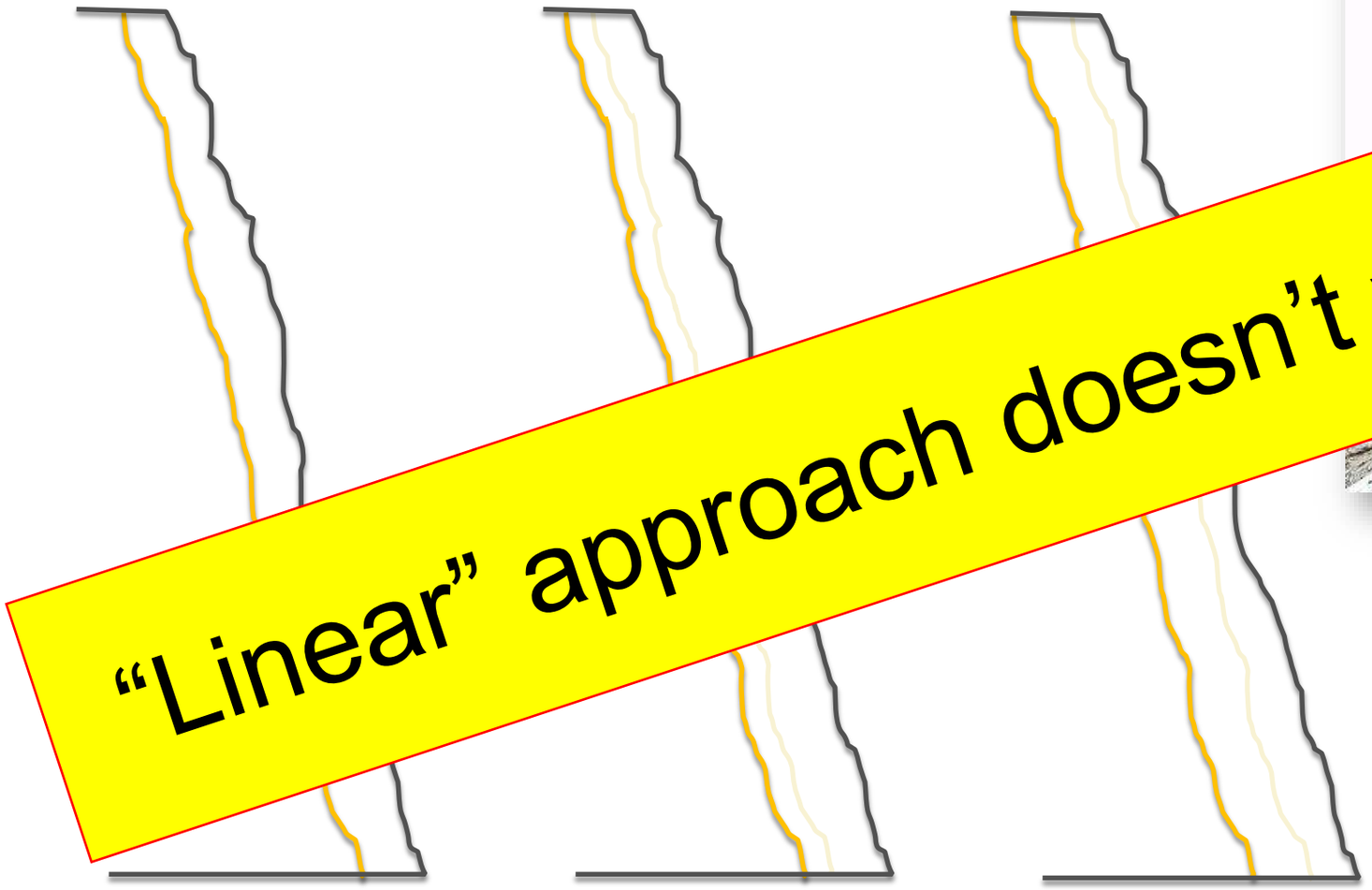
Change in Active Layer - Rockfall



Schoeneich et al. - 2011

Michoud et al. - 2012

Michoud et al. - 2012

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What should one do then?

- Use a probabilistic approach
- What are the trends in thawing indices?
- What are the trends in the extremes?
- What is the change in annual probability of active layer reaching a certain depth?

Proposed Steps

1. Evaluation of current risk (quantitative)
2. Determination of changes in key climate parameters and delineation of design values
3. Calculation of potential changes using sensitivity analyses
4. Evaluation of the new hazard potential
5. Calculation of new hazard probability, magnitude and any potential changes in consequences
6. Identifying new hazards and risks

Summary and Conclusions (1)

- Quantitative risk assessments are becoming more frequent tools for making engineering decisions
- The periglacial environment is changing rapidly due to rapid changes in climate and new hazards emerge
- Historic events are no longer representative for the future, i.e. first principle is not applicable
- A systematic approach is introduced that may improve the assessment of geohazard risks occurring within the periglacial belt
- Applying a systematic methodology that incorporates changes in the physical environment is better suited for quantitative risk assessments than qualitative estimates

Summary and Conclusions (2)

- Proper analysis of historic and projected climate data is the key for a good hazard assessment, e.g. importance of extremes
- Numerical tools should be used carefully to carry out sensitivity analysis for assessing potential changes in future geohazard
- Evaluation of new geohazards and additional consequences must be performed
- Additional research is needed to reduce the uncertainties in projecting physical changes and associated risks in mountainous permafrost environments around the world

Summary and Conclusions (2)

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A proper assessment helps in making informed decisions

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