Early warning approach for permafrost degradation and related process chains

(WP 6, task 6.6: pilot site Switzerland)

P. Mani[1], **J. Rempfer**[1], **C. Berger**[1], **N. Hählen**[2], **M. Stoffel**[3]

[1]geo7 AG, Neufeldstrasse 5-9, 3012 Bern, Switzerland (GEO7); [2]Amt für Wald KAWA, Abteilung Naturgefahren, Schloss 2, 3800 (VOLBE); [3]Institute for Environmental Sciences, University of Geneva, 66 Bvd Carl Vogt, 1205 Geneva, Switzerland (UNIGE)

www.geo7.ch

Peter Mani
peter.mani@geo7.ch

Abteilung Naturgefahren

Amt für Wald des Kantons Bern

ANYWHERE

UNIVERSITÉ DE GENÈVE

ANYWHERE 2nd meeting and workshop | 20-21 September 2017 | Helsinki, Finland

Permafrost

Permafrost is made up by rock and soil (permafrost temperature is defined to be at or below freezing point of water for more than 1 consecutive years). Its temperature is affected by meteorological conditions such as air temperature, precipitation, radiation as well as snow cover depth and duration. Anthropogenic climate change will lead to an increase in air temperature and thus to permafrost degradation. Due to its role in the stabilisation of, e.g., rock walls and unconsolidated material, the degradation of permafrost will affect the occurrence of rock falls and avalanches as well as of debris flows.

Process chains induced by permafrost degradation

(1) destabilisation of rock walls and unconsolidated material (e.g., moraines, talus slopes) results from permafrost degradation
(2) destabilised rock walls/unconsolidated material act as starting points of rock avalanches and rock falls
(3) deposits represent reservoirs and starting points for debris flows which increase sediment transport to receiving channels (Figure 1)
(4) increased sediment transport may lead to an aggradation of channel beds and as a consequence may reduce flood safety (Figures 2,3)

Workflow, goals

(1) Simulation of permafrost characteristics for different rock and sediment types (fine grained and coarse sediments, solid and fractured rock) with the snowpack model based on observed meteorological conditions (Figure 4)
(2) Simulation of permafrost scenarios with the snowpack model based on ECMWF midrange ensemble forecast (Figure 5)
(3) Derive the disposition for natural hazards from permafrost characteristics and meteorological parameters

First results and next steps

- We defined boundary conditions for exemplary sites where no observations are available.
- We realised a first long term simulation (> 20 years) for such a site. Resulting ground surface temperatures reflect well-known characteristics of permafrost bodies (Figure 6)

We now aim to

- define boundary conditions and examine simulations for different sediment and rock types (fine grained and coarse sediments, solid and fractured rock)
- implement a model to deduce disposition for natural hazards from simulated permafrost characteristics (e.g., temperature, active layer depth, water and ice content)
- set up an automatic system for a regular (e.g., weekly) calculation of physical conditions in permafrost bodies and the resulting disposition for natural hazards (such as debris flows and rock falls) at different sites.

Figure 1: Sediment input from debris flows into the river Kander

Figure 2: Channel aggradation at the river Aare induced by large sediment input from Spreitgrabe

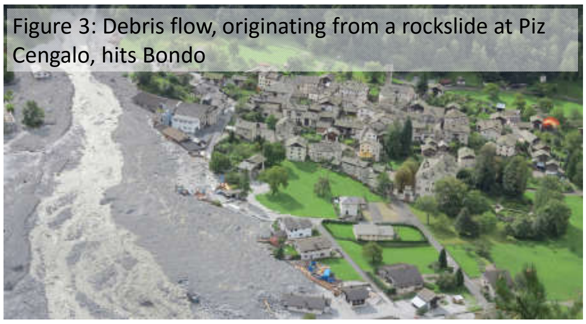

Figure 3: Debris flow, originating from a rockslide at Piz Cengalo, hits Bondo

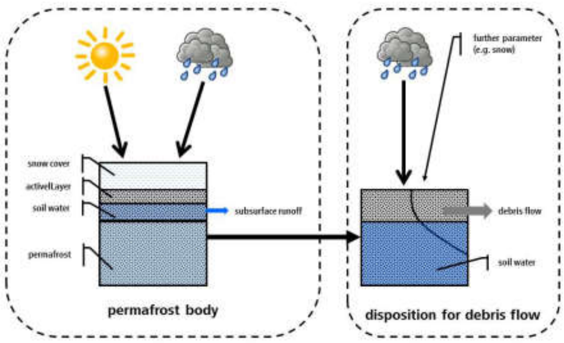

Figure 4: Parameters affecting permafrost degradation

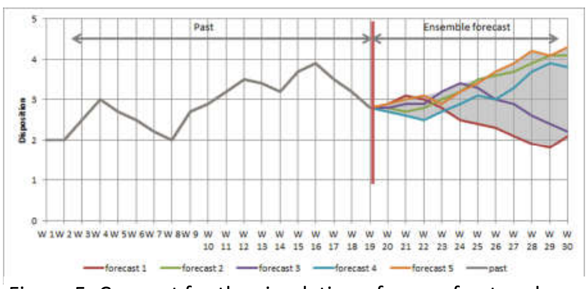

Figure 5: Concept for the simulation of permafrost under (1) observed and (2) future conditions.

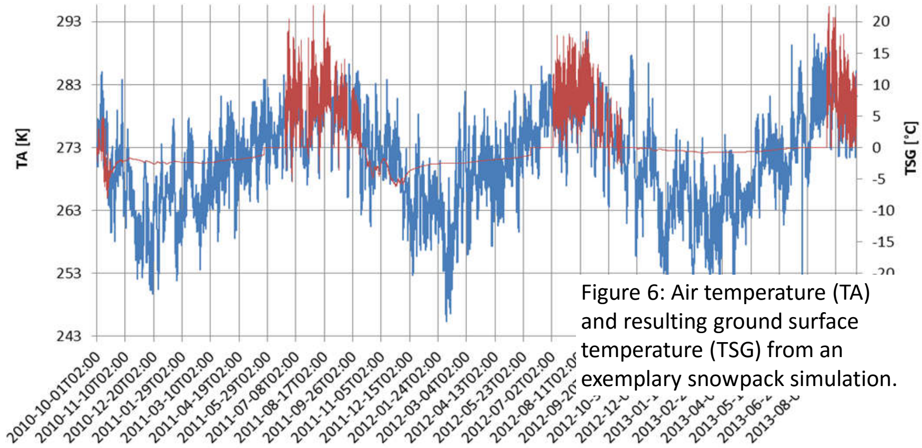

Figure 6: Air temperature (TA) and resulting ground surface temperature (TSG) from an exemplary snowpack simulation.