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Short-term velocity variations of permafrost slope movements

V. Wirz(1), S. Gruber(2), J. Beutel(3), A. Vieli(1)

(1) University of Zurich, (2) Carleton University, Ottawa (Ca), (3) ETH Zurich

University of Zurich
ETH Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Introduction and aims

- Slope instabilities are a potential risk for infrastructure and human life.
- Processes-understanding important for detection and monitoring of slope movements
- Temporal variability can be used to investigate environmental controls.
- This requires reliable velocity-estimations based on measurements with high temporal resolutions.
- Continuous Global Positioning Systems (GPS) measurements typically have a high noise level.

Aim: Detect & characterize differing slope movements, with the ultimate goal to understand phenomena and processes.

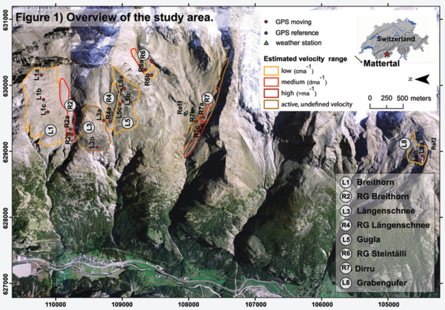

Figure 1) Overview of the study area.

Methods

Continuous GPS and near-surface ground temperature measurements at 18 locations distributed on eight landforms (Fig. 1).

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Velocity estimations using Signal-to-Noise ratio Thresholding (SNRT) with SNR>40.

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Relation of velocity changes to local environmental factors using detailed qualitative analysis and logistic regression models.

Main findings

- Mean annual velocities ranged from 0.004 to > 6 ma^{-1}.
- Reliable velocity estimates based on daily GPS-positions allow to study influence of environmental factors:
  - A seasonal cycle in velocity was observed both for deep-seated landslides and rock glaciers:
    - Acceleration in spring started during snowmelt.
    - Frequently deceleration in winter was smoother than acceleration in spring.
    - Phase lag of velocity fluctuations to changes in GST was longer for landslides.
  - Several short velocity-peaks per year occurred at two steep rock glacier tongues (Mar.–Dec.):
    - At least one velocity-peak during the snowmelt period.
    - Peaks occurred immediately after high water input.
- Made observations and statistical modelling provide support for:
  - -> Amount of deceleration in winter is controlled by winter temperatures.
  - -> Spring acceleration is strongly influenced by snow meltwater infiltration.
  - -> Strong water input from snowmelt (in combination with rain on snow) or heavy precipitation can cause velocity-peaks.
  - -> Short delay between water infiltration and acceleration of rock glacier movement.
  - -> Fast discharge within rock glaciers.

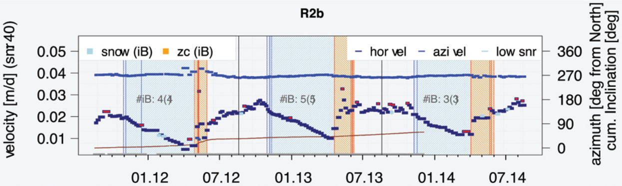

Figure 2) Relative horizontal velocities of all GPS stations and filtered air temperature and GST (running mean over 61 days). Period of insulating snow cover (light blue) and zero curtain (i.e. snowmelt, orange) is shadowed.

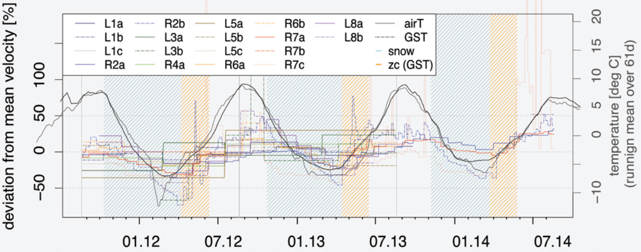

Figure 3) Relative horizontal velocities of all GPS stations and filtered air temperature and GST (running mean over 61 days). Period of insulating snow cover (light blue) and zero curtain (i.e. snowmelt, orange) is shadowed.

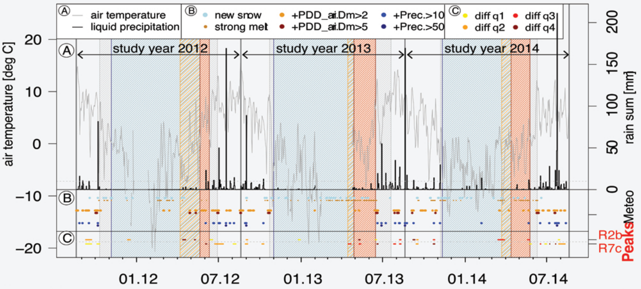

Figure 4) Comparison of velocity peaks at R2b and R7c with meteorological factors. A) Air temperature and liquid precipitation. B) Exceptional values of meteorological factors. C) Occurrence of velocity peaks for R2b (upper bars) and R7c (lower bars). The colors of the peak-periods refer to the strength of the peaks (given as quantiles).

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