



## **Monitoring of rapid ground ice degradation in an alpine talus slope at Flüela Pass, Swiss Alps with geophysical surveys and borehole temperature measurements**

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The occurrence of permafrost at the base of an alpine talus slope at Flüela Pass (Eastern Swiss Alps) was first detected in the 1970s (Haeberli 1975) using geophysical soundings. The presence of ground ice was confirmed by drilling in 2002 (Luetsch et al. 2004). Site-specific processes, such as an intra-talus air circulation system and thermal protection through long-lasting avalanche snow at the foot of the slope in summer, influence the subsurface thermal regime and allowed the conservation of permafrost at the relatively low elevation of 2394 m ASL. However, in recent years the ground ice has undergone surprisingly rapid degradation from its base upwards. (Phillips et al. 2009).

Borehole temperature measurements showed significant increases of 0.1°C/year at 6 m depth and a decrease of thickness of the ice-rich permafrost body from 7 m to 2 m since 2004. The active layer thickness (3 m) remained constant, confirming a permafrost degradation from below. Due to the proximity of a lake at the foot of the talus slope, it was hypothesised that the lake water acts as an additional heat source, responsible for the observed melt rates.

In this contribution we present additional confirmation of this rapid thawing phenomenon through repeated Electrical Resistivity Tomography and Refraction Seismic Tomography surveys in the summers 2009 and 2010. The results were combined using the so-called 4-phase model to give quantitative estimates of the changes in ice and liquid water content. The results are compared with the melt rates estimated from the borehole temperatures, and the possible reasons for the rapid degradation are discussed. The combination of direct but 'pin-prick' borehole measurements with long geophysical profiles allows calibrating the geophysical measurements and gives an overview of the evolution of the entire permafrost body.

### References:

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