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10-15 years of GST monitoring over mountain permafrost in Switzerland: Indicators for driving forces for permafrost evolution

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Ground Surface Temperatures (GST) are mainly controlled by atmospheric factors and topographical effects and represent an important standard element within the operational permafrost monitoring network PERMOS in Switzerland. Due to its shape, position and extent the Alpine arc is influenced by prevailing winds from several directions provoking a complex and highly variable pattern of precipitation in different regions of Switzerland with a general trend to a more continental climate in some inner-alpine valleys. The lower boundary for the occurrence of mountain permafrost in the Swiss Alps is located at about 2500 m asl., close to the free atmosphere where air temperatures are almost homogenous in all regions, but precipitation usually shows large regional differences regarding timing and quantity depending on the meteorological conditions.

At the elevation range of mountain permafrost the ground surface remains snow-free only for about 4-5 months (between June and November) with a high temporal and spatial variability, while over the rest of the year it stays well shielded from the atmosphere (due to the high surface albedo and emissivity and low thermal conductivity of snow). Therefore, the influence of the atmosphere at this boundary layer on the ground thermal regime is well reflected by GST measurements on a very local, site-specific scale. Relative values like GST anomalies can serve as indicators describing processes of energy and heat transfer at the ground surface in a semi-quantitative way. This information is used in a signal-response analysis integrating GST with other permafrost monitoring elements that represent the permafrost response to external effects (e.g. relative changes in borehole temperatures, apparent electrical resistivities or rock glacier creep rates).

To identify and quantify the dominant processes and factors controlling the response of Alpine permafrost to external forces, special consideration is devoted to the characteristics of different landform types (e.g. debris mantled terrain, talus slopes, rock glaciers, ice-cored moraines, push moraines), the topographical context (e.g. exposure to wind and solar radiation, remobilization of snow by avalanches) and regional aspects (e.g. precipitation events, timing and duration of the insulating snow cover). GST anomalies, indices and derivatives are analyzed over a large data set ($\sim$15 field sites) provided by the PERMOS network and different institutions within the SNF Sinergia project «The Evolution of Mountain Permafrost in Switzerland» (TEMPS, 2011–2014).

First results show that GST anomalies observed during the past 10 to 15 years show largest disparities for different types of landforms and topographical contexts (because of modified snow cover dynamics). Despite of the complex and highly variable pattern of precipitation in the Swiss Alps, regional differences in GST anomalies remain remarkable small. These findings implicate that future permafrost monitoring based on GST does not necessarily depend on a dense network with a high number of field sites, but should cover at least one suitable spot per region with a variety of different topographical contexts.