Geophysical Research Abstracts
Vol. 21, EGU2019-4195, 2019
EGU General Assembly 2019

Geophysical monitoring techniques to observe Alpine permafrost degradation – a 20-years perspective

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The application of geophysical techniques has a long tradition in permafrost research, however, the use of standard techniques such as geoelectrics or seismics for operational monitoring purposes in permafrost terrain started much more recently. The longest time series available reach now almost two decades, which makes them suitable for analysis of spatio-temporal changes and corresponding processes in a climate related context. Within this time period, significant changes in the permafrost characteristics, such as active layer deepening and ground ice loss, have been observed in several European mountain permafrost environments. From the variety of geophysical techniques, especially electrical methods such as Electrical Resistivity Tomography (ERT) are cost-effective and logistically feasible for application in high mountain terrain, because a fixed installation of electrodes is cheap, robust and ensures an exact repetition of measurement geometry over several years. Besides, it poses no danger to the environment, nor does it affect the surface and subsurface characteristics. However, geophysical monitoring data require different filtering and inversion algorithms than data from individual surveys. Furthermore, the resulting electrical resistivities (or P-wave velocities in the case of seismic monitoring) have to be related to physical properties such as ice/water content or temperature in a consistent way for the whole time series and their spatial distribution in the tomogram. In this contribution, several of the existing approaches will be reviewed by showing some examples from the longest geophysical time series available in European mountains. The results highlight not only the feasibility of long-term geophysical monitoring in permafrost terrain, but also the clear degradation trend of permafrost occurrences during the past two decades.