Geophysical Research Abstracts, Vol. 8, 04181, 2006
SRef-ID: 1607-7962/gra/EGU06-A-04181

Mapping and monitoring mountain permafrost using electrical resistivity tomography

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Geophysical methods are particularly suitable for geomorphological investigations since the knowledge of structure, layering and composition of the subsurface at different scales are key parameters for geomorphological problems. Among the different geophysical methods which are standardly applied, electrical resistivity tomography is considered as the most multifunctional method for research in periglacial environments since a comprehensive characterisation of the subsurface lithology can be obtained, a differentiation between genetic ice types is enabled in many cases and the evolution of subsurface properties can be monitored which can be linked to the triggering processes involved. In this contribution several geoelectrical surveys on different alpine periglacial landforms are presented. Can we use electrical resistivity tomography to confirm general genetic concepts and dynamics in periglacial geomorphology? To what extent can we hereby use the obtained resistivity value ranges for the interpretation? The examples include geoelectrical mapping of the present-day permafrost occurrences as well as geoelectrical monitoring of permafrost on fine and coarse grained loose sediments. For the monitoring of time-dependent processes (so-called time-lapse experiments) changes in the subsurface resistivity are estimated by using changes in the apparent resistivity measurements. In order to study the changes of subsurface resistivity with time, 2D resistivity surveys are repeated over the same survey line at different times. This requires accurate and reproducible results even on rough terrain. For the measurements on a blocky moraine a fixed electrode array was installed with 2m electrode spacing using the Wenner and Wenner-Schlumberger configurations. In consideration of the rugged topography the inversion results are of good quality and reproducible. The data were first inverted independently. This approach has given only limited information on subsurface resistivity changes with time since the inversion

routine tries to minimize the difference between the measured and calculated apparent resistivity values. Thus, differences in the resistivity values are not necessarily related to actual changes in the subsurface resistivity distribution. To overcome this problem a joint inversion technique (time-lapse inversion method within RES2DINV) was applied. Hereby, the model obtained from the inversion of the first measurement is used as a reference model to constrain the inversion of the later time-lapse measurements. The observed decrease of resistivities can most likely be related to a thickening of the active layer due to melting of permafrost at the lower boundary of the active layer towards the underlying ice-rich permafrost. A significant influence of temperature effects on the decrease of the resistivity values or heavy rainfall within this time span can be disregarded. These results show that the spatio-temporal evolution of the active layer thickness can be monitored also on rugged terrain with rough surface conditions using repeated measurements of the subsurface resistivity distribution.