Geophysical Research Abstracts
Vol. 14, EGU2012-11684, 2012
EGU General Assembly 2012
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Discontinuity of mountain permafrost: examples from the western Swiss Alps

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In comparison with lowland permafrost, mountain permafrost is largely discontinuous. This is due to many factors, whose main are: 1) mean annual air temperature and especially mean air temperature of the snow free period, 2) solar radiation, 3) snow cover characteristics, 4) ground (sub-)surface characteristics and 5) topographical location (the lower parts of steep sedimentary deposits are often overcooled and, on the contrary, the upper parts are warmed due to air advection processes). These factors may vary rapidly over very short distance and often influence each other. In particular, the snow and the ground characteristics cause strong thermal offsets, which are crucial factors for the occurrence of permafrost.

In the context of the current climate warming, changes in the temperature and the ice content of frozen sediments may affect the stability of the slopes, which may be a significant concern in inhabited mountain regions. Thus, it is important to increase the knowledge on mountain permafrost characteristics and distribution, as well as precisely understand the temporal evolution of permafrost and its implications. The numerical simulation of the strong discontinuity of mountain permafrost is also a challenging task.

During the last ten years, we carried out several studies on various alpine sedimentary deposits in order to map and characterize the permafrost at the local scale, with the help of geophysical surveys (electrical resistivity tomography, seismic refraction) coupled with ground temperature measurements at the surface and in boreholes. The results confirm the extreme discontinuity of mountain permafrost, which is frequently absent despite favourable topoclimatical conditions, as for instance at the roots of the Tsaté-Moiry rock glacier (46°06'36" N / 7°33'13" E) at 2900 m a.s.l. (MAAT 2007-2011 : 2.3°C) in north-east aspect, where resistivities lower than 500 Ohm·m were measured. Such low values clearly indicate that permafrost is absent. Conversely, permafrost is often present in much less favourable topoclimatical conditions (lower altitudes, intense solar radiation), either in the lower parts of talus slopes, or in active rock glaciers, which can export permafrost at relatively low altitudes.

This presentation will show different examples illustrating the discontinuity of mountain permafrost in sedimentary deposits (rock glaciers, moraine deposits, talus slopes, complex slopes).