Geophysical Research Abstracts,
Vol. 11, EGU2009-5598-1, 2009
EGU General Assembly 2009

On the potential of time-lapse refraction seismics for the detection of changes in ground ice content in permafrost regions

C. Hilbich (1), C. Hauck (2), and R. Mäusbacher (1)

(1) Department of Geography, University of Jena, Germany (c7hich@uni-jena.de), (2) Department of Geosciences, University of Fribourg, Switzerland

The application of geophysical techniques to permafrost related problems has become a standard approach in recent years and is commonly used for the detection, mapping and characterisation of mountain permafrost. Within the context of global warming not only the assessment of its present state but also the temporal evolution of permafrost is of particular interest. In addition to 1-dimensional (1D) thermal monitoring techniques (e.g. in boreholes), also 2D electrical resistivity tomography monitoring (ERTM) has been proven to be a powerful technique for the observation of possible permafrost degradation.

However, in principle, also other geophysical methods are suitable for monitoring purposes. The requirements for an adequate method to monitor changes in ground ice content comprise a) a pronounced contrast of the measured signal between ground ice, frozen material containing no (or only little) ice, and unfrozen material, and b) the reproducibility of measurement conditions. The latter can best be achieved by permanently installed survey lines, but also fixed positions of transmitters and receivers are possible.

In this study, data from two different test sites in the Swiss Alps served to evaluate the performance of a refraction seismic monitoring approach: a time-lapse data set of roughly one month time instance between two measurements in July and August 2008, respectively, at a) the ventilated talus slope Lapires (Valais), and b) the rock slope Schilthorn (Bernese Oberland).

The approach is based on the assumption that P-wave velocities of the subsurface are affected by seasonal or inter-annual freezing or thawing processes, and that repeated refraction seismic measurements under constant measurement conditions allow the assessment of such temporal changes. The evaluation strategy comprised a) the analysis of the reproducibility of the seismic signal, b) the analysis of time-lapse travel time curves concerning the resolution of shifts in travel times, and c) the comparison of inverted tomograms including the quantification of spatio-temporal velocity changes.

Important results from this study are the generally good reproducibility of the waveforms and the signal strength for subsequent measurements, and systematic temporal changes in the seismic response that revealed insights into lateral and vertical variations of subsurface changes. The models derived from tomographic inversion are largely comparable concerning their overall structure, but exhibit a clear vertical shift in the transition between the low velocity overburden and the refractor underneath indicating the seasonal progression of the thawing front to larger depths.

From the preliminary results of the analysis of time-lapse seismic refraction data it can be concluded, that the approach provides a valuable potential in terms of an independent and complementary monitoring approach for the detection of altered subsurface conditions caused by freezing and thawing processes. Although the effort in data acquisition and processing is much higher than for ERTM, refraction seismic monitoring has the potential to improve the interpretation in a) ambiguous cases, or b) in zones where ERTM provides only low resolution or reliability (e.g. due to artefacts or contamination by conductive infrastructure). The approach was tested for a data set on a small time scale but is believed to work equally well for long-term changes and will be applied to inter-annual time scales at several sites within the following years.