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Monitoring active layer thaw and freeze-back in four different periglacial landforms in Svalbard using Electrical Resistivity Tomography (ERT)

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Thawing and freezing of the active layer has an important impact on the underlying permafrost through latent heat effects and changes in effective thermal conductivity and mechanisms of heat transport. Information on the active layer freeze/thaw dynamics is therefore important to understand the permafrost response to climate variability. In addition, active layer deepening may be an early sign of permafrost degradation, making monitoring programs such as the CALM network important. Active layer depths are traditionally measured by mechanical probing in fine-grained sediments or by vertical arrays of ground temperature sensors. The first technique prevents measurements to be made in stony sediments, while the latter technique gives only a point value of the active layer depth.

In this study we have tested Electrical Resistivity Tomography (ERT) as a tool to measure and monitor active layer depth and freeze/thaw dynamics. The electrical resistivity of the ground is largely dependent on the unfrozen water content, making resistivity monitoring a potentially valuable tool to delineate freeze and thaw extent, and patterns in soil moisture. The results presented here are part of the IPY 2007-2009 research project 'Permafrost Observatory Project: A Contribution to the Thermal State of Permafrost in Norway and Svalbard' (TSP NORWAY) and the IPA periglacial working group project on 'High-Resolution Periglacial Climate Indicators'.

Electrode arrays were installed permanently in four different periglacial landforms in the Adventdalen valley area in central Svalbard; a solifluction slope in May 2007, a loess terrace (the UNISCALM site) in September 2007, and a mudboil site and ice-wedge site in June 2009 (Watanabe et al., submitted). The arrays were 16m long, giving maximum profile depths of 2m, and electrodes were installed with 0.2m spacing. Measurements were made with irregular but approximately two- to four-week time intervals, depending on weather conditions and instrument availability. Data are available until autumn 2009 for all sites, and until autumn 2010 for the mudboil and ice-wedge sites. Ground temperature and soil moisture is monitored at all four sites, and mechanical probing of thaw depth progression was performed along with the resistivity measurements for parts of the period.

The apparent resistivity raw data error is low in the summer, but in the wintertime 40 to 50% of the data was excluded in the worst cases. The errors are higher in the dry loess site also in the summer, compared to the other three relatively wet sites. After inverting the raw data to give subsurface models of the specific resistivity, depth of investigation mapping was made to identify model areas that were not well constrained by the data. The models show good reliability except at the model edges, in some cases of steep resistivity gradients and at local resistivity extremes.

Preliminary results of this study have been presented (Juliussen et al 2010, Oswald 2010), but here the aim is to (1) quantify the accuracy of ERT-based thaw depth estimates as compared to the probed depths, and (2) to analyze the resistivity values with respect to soil moisture and temperature data and ground ice content obtained from coring.

References:

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