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Active Layer Thawing and Freeze-Back in Svalbard using DC Resistivity Tomography

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The thawing of the active layer has an important impact on the permafrost below, since the state of the uppermost soil layers determines how large surface temperature fluctuations are translated to deeper ground. Latent heat and combined liquid water and energy transport during the thawing season influence the energy exchange between permafrost and atmosphere.

A first step to a better understanding of these processes is to determine the depth of the active layer and its thermal state the best possible way. Borehole temperatures give a very accurate measure of the ground thermal state but are, like active layer depths from mechanical probing, single point measurements. Geophysical imaging methods, such as DC resistivity tomography, allow for a 2d-image of subsurface soil properties, but should be supplemented with point temperature measurements as the results might be ambiguous.

In spring and late summer 2007 electrode arrays have been permanently installed in three different permafrost landforms in Svalbard (a gently sloping solifluction sheet, a valley bottom loess terrace and a vertical sandstone rockwall) as a part of the IPY-project – 'Permafrost Observatory Project: A Contribution to the Thermal State of Permafrost in Norway and Svalbard' TSP Norway.
With a spacing of 20cm and a total array length of 16m this allows for a maximum measurement depth of about 2.5m. During most parts of IPY measurements were carried on a more or less regular basis - ideally in a two weeks interval. While measurements in the rockwall suffered from permanent loosening of the electrodes in the brittle sandstone, the measurements on the loess terrace and the solifluction slope were only interrupted during the very cold spring conditions as grounding errors occurred. Hence field work focused on the loess terrace and the solifluction sheet – the former consisting of silt and fine clay; the latter characterized by its high water content and a rather heterogeneous grain size distribution with small (and large) rocks found in finer bulk material.
Including a more intense measurement campaign in autumn 2008 about 30 profiles are available for each of these two sites. But not all data is of sufficient quality to allow for a more detailed interpretation due to problems during data acquisition either related to environmental conditions (grounding, noise) or technical issues (cable problems etc.).

The resulting resistivity measurement profiles differ between the sites and through the seasons. Summer results from the solifluction site show an increase of resistivity with depth, in agreement with the expected thaw progression. The resistivity profile from the loess terrace is rather uniform, and cannot resolve the thaw depths recorded in a Circumpolar Active Layer Monitoring (CALM) grid at this site, the UNISCALM grid. This might be related to very low water content. Freezing from the top, however, could be measured at both field sites during autumn. Still the onset of freezing could not be measured very accurately as the electrodes might have been too deep into the ground (about 30cm) to resolve the very top of the ground.
The validation of the profiles with other data is very important as soil resistivity is not only dependent on temperature, but a variety of variables. Close-to-ground air temperatures, borehole temperatures, active layer thaw progression data from mechanical probing and snow depth are additionally available for some of the profiles. An analysis of the resistivity data together with these data will be presented. For future measurements it would be important to intensify the collection of these background data to enable a more quantitative interpretation of permafrost resistivity data.