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Model appraisal and resolution analysis of geoelectric imaging results for frozen ground investigations

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Knowledge of the vertical extent and location of permafrost are important for construction and other geotechnical and land-management activities in mountainous areas. Geoelectric imaging is a practical tool for efficiently mapping and characterizing permafrost occurrences. Multi-electrode devices are used to collect the data and the generally poor electrical contacts in the active layer are overcome by coupling the electrodes to the ground via sponges soaked in salt water. The data are then processed and inverted in terms of resistivity models of the subsurface. A challenging aspect in geoelectric imaging of permafrost is the very large resistivity contrast between frozen and unfrozen material. Such a contrast makes inversion and interpretation difficult. To assess whether features at depth are required by the data or are artifacts of the inversion process, the reliability of models needs to be evaluated.

Different approaches were used to assess the reliability of resistivity images in permafrost investigations: (i) depth of investigation based techniques (DOI) and (ii) resolution matrix based techniques. To compute DOI indices, two (or more) inversions of the same data set using quite different reference resistivity models are carried out. At

locations where the resistivity is well constrained by the data, the inversions yield the same results. At other locations, the inversions yield different values that are controlled by the reference models. The resolution matrix, which is based on the sensitivity matrix calculated during the inversion, quantifies the degree to which each resistivity cell in the model can be resolved by the data. Different parameters can be obtained from the computation of the resolution matrix.

Application of these two approaches to field data acquired in the Swiss Alps and Jura Mountains suggests that it is very difficult to obtain dependable ground resistivity information beneath occurrences of resistive bodies (massive ice or highly porous medium). The reliability tests, which tell us to what depth the resistivity images are trustworthy, help us explain erratic and non-geologic features in the inversion models. The DOI and resolution matrix techniques do not provide exactly the same information about model reliability. Instead, a combination of the two approaches prevents over-interpretations or misinterpretations of inversion results.