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Inversion of time dependent geoelectric and seismic data for 2D imaging of ice- and watercontent in the upper subsurface

M. Bach (1), C. Hauck (1)

(1) Institute for Meteorology and Climate Research Forschungszentrum Karlsruhe/University of Karlsruhe (TH) (mathias.bach@imk.fzk.de)

Quantifying and 2-dimensional imaging of the distribution of water and ice in the near subsurface is an important task in a number of environmental and engineering projects, such as the mountain permafrost monitoring study GO4ICE (Geophysical observation and 4-phase modelling of ice content evolution) and the determination of large-scale soil moisture fields for soil-atmosphere transfer models (MoistureNet). The main goal in the co-operation of these two projects is to quantitatively determine the volumetric contents of ice and water in the upper subsurface. This will be investigated in a time dependent analysis considering long-term (ice) and short-term (water) changes for different field data sets. Electrical resistivity and seismic refraction tomography is used to image the subsurface in terms of resistivity and p-wave velocity, respectively. With use of Archie’s Law and the seismic mixing rule by Timur it is possible to develop a "Four-Phase-Model", deriving expressions for three of the four volumetric parts water, ice, air and rock. Input parameters, besides sesimic and geoelectrical data, are the three free parameters in Archie’s Law cementation factor (m), saturation exponent (n) and a fitting parameter (a). To achieve an optimal model adjustment fitting of the usually unknown volumetric rock content is essential as well. These four parameters are varied within a Monte-Carlo approach, limited by maximum and minimum values of each parameter known from literature. In case of time-dependent measurements the rock volume (1-porosity) will remain constant, by this enabling the determination of all four volumetric contents. Results from test studies performed on time independent data from the Swiss Alps yield good matches to ice, air and water distributions known from borehole data. Similarly successful model results have been achieved on ice-rich permafrost occurrences on a test field in the Maritime Antarctica. In this contribution,

first results concerning the model and its time-dependent variant will be presented, and future approaches will be discussed.