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Electrical and seismic mixing rules for detecting changes in ground ice content in permafrost studies

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Geophysical methods are now widely used in permafrost research to detect and monitor frozen ground and potentially quantify the ground ice content in the soil. Hereby, often a combination of different methods is used to reduce the ambiguities inherent with the indirect nature of geophysical surveys.

Geophysical mixing rules and petrophysical relationships originally developed by exploration industry may help to quantitatively relate geophysical variables such as the electrical resistivity or the seismic P-wave velocity to the physical properties of the subsurface. Two of these mixing rules were combined by Hauck et al. (2011) in a so-called 4-phase model to attempt to quantify the ground ice, air- and water content and their changes with time in permafrost environments (e.g. Pellet et al. 2016). However, these mixing rules are often either empirically derived (making use of a large number of borehole samples) or based on a simplified mixing model, i.e. an equal weighting of each phase component (ice, water, soil/rock, air) depending on the actual fractional content of each phase. There is thus no obvious 'best choice' model from the available geophysical approaches.

Stimulated by recent theoretical work by Glover (2010), who analysed the relationships between the empirical and theory-derived mixing models, this contribution aims to analyse the applicability of various mixing models for electrical and seismic data sets in the context of detecting and monitoring permafrost degradation. Input data stem from various geophysical surveys around the world and ground truth data for validation is available from corresponding permafrost boreholes from the PERMOS and GTN-P data bases.

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