Imaging of hydraulic conductivity from seismic and electrical data in a joint inversion framework

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The hydraulic conductivity (K) is a relevant parameter in soil sciences as it is critical, e.g., for hydrological modeling or the characterization of groundwater flow and atmosphere-soil interactions. Field investigations allow for the direct assessment of K, yet the number and distribution of the sampling points limit the spatial resolution. To assess the spatial variability of K at the field scale, pedotransfer functions (PTFs) have been developed, which estimate K from soil parameters such as soil texture or bulk density. On the other hand, geophysical methods have also revealed their potential to quantify K in laboratory investigations, yet investigations at the field scale are still rare. In this study, we investigate the estimation of K through the simultaneous inversion of seismic and electrical data in an imaging framework. We use an open-source joint inversion framework, and adapt the underlying petrophysical model to take into account the (electrical) surface conductivity during parameter estimation. In particular, we invert resistivity data collected at a low and a high frequency, considering that the associated difference accounts for the (electrical) surface conductivity based on the frequency dependence of the observed electrical response. Accordingly, our joint inversion scheme solves, among other parameters, for water content, cation exchange capacity, polarization and porosity, which we use to quantify K through different models developed from laboratory investigations. Moreover, we investigate the possibility to enhance the quantification of K by adapting the joint inversion scheme to solve directly for the parameters required by the employed models. We illustrate our approach based on data collected at the Hydrological Open Air Laboratory (HOAL), a thoroughly investigated and monitored catchment located in Petzenkirchen (Lower Austria). We use available information about soil properties to calibrate our joint inversion scheme and evaluate the resolved K models based on K values obtained through direct investigations or the use of PTFs, respectively. Our approach contributes to the field-scale estimation of process-relevant subsurface properties at high spatial resolution by means of non-invasive geophysical imaging techniques – a key objective of the hydrogeophysical discipline.