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Coupled hydrogeophysical inversion of time-lapse off-ground GPR and hydrological data

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We present a coupled hydrogeophysical inversion approach that uses time-lapse off-ground ground-penetrating radar (GPR) data and other hydrological data for estimating soil hydraulic parameters, and apply it to data sets collected in a field experiment. Off-ground GPR data are mainly related to the near-surface water content profile and time variations thereof, and are thus only indirectly related to soil hydraulic parameters, such as the permeability and the parameters of the relative permeability and capillary pressure functions. However, in our approach the GPR model is coupled to a hydrodynamic model, such that the electromagnetic parameters (dielectric constant and electrical conductivity) that serve as input to the GPR model become a function of hydrodynamic model output (i.e., water content), thereby enabling estimation of the soil hydraulic properties with GPR data (together with other data sets) in an inverse modelling framework (iTOUGH2). The hydrodynamic model used in this work is based on a one-dimensional solution of non-isothermal multiphase flow. The GPR model involves a full-waveform frequency-domain solution of Maxwell's equations for wave propagation in three-dimensional multilayered media. The data sets we consider were collected in a field experiment at the Selhausen test site of Forschungszentrum Juelich, Germany, in summer 2009 over a 30-day period in which three major precipitation events occurred. To monitor the dynamics of the soil, time-lapse TDR, temperature, and GPR measurements were performed repeatedly. The probes used for the TDR and temperature measurements were installed at four depths near the footprint of the GPR antennae. Preliminary results suggest that improved estimates of soil hydraulic parameters are obtained when both GPR and hydrological measurements are used for inversion, compared to using either data set alone.