Title

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Joint inversion of ground-penetrating radar and thermal-hydrological measurements: overview and recent progress

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We review recent progress made in the development and application of a method for jointly inverting time-lapse ground-penetrating radar (GPR) travel times and hydrological data to estimate field-scale soil hydraulic parameters. Our approach takes advantage of a wide range of cross-borehole GPR data acquisition configurations and hydrological measurement types, and accommodates uncertainty in the petrophysical function, which relates soil porosity, water saturation, and temperature to the effective dielectric constant. Through synthetic examples, we observe that realistic errors in the petrophysical function result in substantial errors in soil hydraulic parameter estimates, but such errors are minimized through simultaneous estimation of petrophysical parameters. We also discuss application of the method to large-scale field experiments involving the injection of water and heat. These examples demonstrate that the complimentary information contained in geophysical and hydrological data can be successfully extracted in a joint inversion approach. Moreover, since the generation of tomograms is not required, the amount of GPR data required for analyses is relatively low, and difficulties inherent to tomography methods are alleviated. Finally, the approach provides a means to capture the properties and system state of heterogeneous soil, both of which are crucial for assessing and predicting subsurface flow and contaminant transport. This work was supported in part by the U.S. Dept. of Energy under Contract No. DE-AC03-76SF00098.

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