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Estimation of soil hydraulic properties based on time-lapse Ground-Penetrating Radar (GPR) measurements

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Recent developments brought surface-based GPR measurements to a precision that make them useful for estimating soil hydraulic properties.
For this study, we estimate Mualem-Brooks-Corey parameters for a layered subsurface material distribution employing the Levenberg-Marquardt inversion algorithm. The required measurement data were recorded at our artificial test site ASSESS, where we forced the hydraulic system with a fluctuating water table and observed the dynamic deformation of the capillary fringe with time-lapse GPR. Subsequently, these measurements were simulated based on a model comprising (i) the Richards equation describing the temporal evolution of the soil hydraulic system which was solved with MuPhi, (ii) the Complex Refractive Index Model (CRIM) serving as petrophysical relationship which links the soil hydraulic model to (iii) the electrodynamic model consisting of Maxwell's equations which are solved with MEEP. For the objective function of the optimization algorithm, both measured and simulated GPR data were evaluated with a semi-automated wavelet feature detection algorithm allowing to directly compare the travel time and amplitude of the GPR signal.
In this presentation, we discuss the results of the inversion based on the inversion of GPR data and we also discuss how including Time Domain Reflectometry (TDR) measurement data influences the estimated parameters.