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Time-lapse Ground-Penetrating Radar for Deriving Soil Hydraulic Properties

Patrick Klenk, Stefan Jaumann, and Kurt Roth

Heidelberg University, Institute of Environmental Physics, Heidelberg, Germany (patrick.klenk@iup.uni-heidelberg.de, +49 6221 54-6405)

A profound understanding of subsurface hydrological processes demands a detailed description of hydraulic parameter distributions at the pertinent scale of interest. However, characterizing soil hydraulic properties remains a challenge, especially for field scale studies. Accurate high-resolution GPR measurements of soil water dynamics have shown promise to alleviate this challenge.

In recent years, ASSESS-GPR, a field scale test site for advancing Ground-Penetrating Radar methods has been successfully established in Heidelberg (e.g., Buchner et al, 2012 or Klenk, 2012). Permanently installed TDR sensor profiles allow for an independent, corroborating dataset which can serve as basis for hydrologic modeling. In such a well-controlled experimental setup, we can achieve a very high relative precision for non-invasively monitoring soil water dynamics with GPR (Klenk, 2012). We can furthermore study the dynamics of the capillary fringe in different materials through time-lapse GPR measurements during pumping experiments. For example, as Dagenbach et al (2013) have shown, information can be gained about the appropriate form of a hydraulic parameterization.

We here expand on these previous works by presenting a set of experiments, where the water table has been raised and subsequently lowered in a multi-step fashion over the course of several days. We discuss the non-invasive, high-resolution monitoring of the corresponding subsurface water dynamics by time-lapse GPR and thoroughly assess potentials for deriving hydraulic parameters for the different materials through electromagnetic modeling of the GPR response for said materials under the measured forcing.