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Inverse modelling of water flow in lysimeters

Henrike Schelle (1), Sascha C. Iden (1), Johann Fank (2), and Wolfgang Durner (1)

(1) Institut für Geoökologie, Technische Universität Braunschweig, Braunschweig, Germany (h.schelle@tu-bs.de), (2) RESOURCES - Water Resources Management, Joanneum Research, Graz, Austria

The simulation of water flow and solute transport in unsaturated soils and the prediction of water and heat transfer in the soil-vegetation-atmosphere-system requires knowledge of appropriate soil hydraulic properties. These properties can be estimated from field observations under atmospheric boundary conditions by inverse modelling techniques. However, incomplete or erroneous information about boundary fluxes (precipitation, actual evapotranspiration, deep percolation) makes the inverse problem ill-posed. Weighable precision lysimeters overcome this limitation and, if equipped with additional sensors for water content and matric potential, are powerful test systems to validate our model concepts about hydraulic processes and functions, but also to determine effective hydraulic properties. In planted soils, the action of plant roots poses an additional challenge. The aim of this work was to identify effective soil hydraulic functions and root parameters by inverse simulation of soil water flow in monolithic lysimeters under atmospheric boundary conditions using the Richards equation. Questions comprise the existence of effective soil hydraulic functions, the magnitude of their uncertainties, and the propagation of these uncertainties into uncertainties of the model predictions. To check whether simultaneously estimating soil hydraulic properties and root water uptake parameters by inverse modelling is at all a well-posed inverse problem, we first analysed synthetic data for different scenarios, using atmospheric boundary conditions as measured in Wagna, Austria. The information content of the synthetic data was varied by changing the number of data types included in the objective function. Then, we determined effective soil hydraulic properties of the lysimeter monoliths, based on long-time measurements of water flow and soil water state variables in the Wagna lysimeters. The results show that the simultaneous estimation of soil hydraulic properties and root-distribution parameters works very well for homogeneous profiles. The same holds for soil profiles consisting of two layers if soil hydraulic parameters are estimated for both layers.