SIMULTANEOUS ESTIMATION OF SOIL HYDRAULIC AND ROOT DISTRIBUTION PARAMETERS FROM LYSIMETER DATA BY INVERSE MODELING

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SUMMARY

Weighable lysimeters are powerful measurement systems for identifying soil hydraulic processes and properties, because the boundary fluxes (precipitation, actual evapotranspiration, and seepage across the bottom) can be determined very precisely. However, root water uptake by plants and the soil water flux are interrelated. Thus, the simultaneous estimation of root water uptake parameters and soil hydraulic parameters from macroscopic state observations is a challenge. In this study we investigate the possibility of simultaneously estimating root water uptake and soil hydraulic parameters by inverse simulation of soil water flow in monolithic lysimeters under atmospheric boundary conditions. We use the Richards equation and a macroscopic root water uptake model to simulate the processes. We analyze the amount of information needed for the unique identification of parameters and investigated the magnitude of their uncertainties. To check the principal feasibility of our approach, we first examine synthetic data sets for different scenarios and instrumentation campaigns that differ in their information content and complexity of soil properties.

The investigations of synthetic data show that for homogeneous profiles, cumulative outflow and profile-averaged water content data contain enough system information to allow the simultaneous estimation of soil hydraulic properties and root-distribution parameters. In contrast, for soil profiles consisting of two layers, unique soil hydraulic parameters and the correct rooting depth can only be estimated if matric potential measurements from both layers are included in the objective function.

To test the procedure with real data, soil hydraulic properties of the grass-reference lysimeter at Wagna (Austria) were estimated using actual measurements. Water dynamics in the lysimeter could be described well by an effective parameterization assuming a homogeneous soil profile. Furthermore, the system behavior under different boundary conditions could be predicted adequately with the estimated parameters (Fig. 1). This demonstrates the usefulness of the identified system properties for predictive modeling.
Fig. 1: Fitted and predicted data for the grass-reference lysimeter in Wagna for the period 2008-2009. Top: Measured and simulated cumulative outflow. Bottom: Profile-averaged water content data and the corresponding residuals. Inverse modeling was performed using data from 2008, prediction was done for 2009. We used an effective free-form parameterization for the simultaneous estimation of two layers.