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Effective hydraulic behaviour of lysimeters with layered soils

W. Durner(1), U. Jansen(1), and S.C. Iden(1)

(1) Institut für Geoökologie, Technische Universität Carolo-Wilhelmina zu Braunschweig, Langer Kamp 19c, 38106 Braunschweig, Germany (w.durner@tu-bs.de)

Soil water movement in a lysimeter is the best possible approximation to one-dimensional vertical water movement in the field. We wanted to investigate whether the water fluxes at the atmospheric surface and at the lower end of a 2 m long profile be approximated with numerical simulations under the assumption of internal homogeneity, even if the true soil profiles are layered. Specific questions of interest were the existence and uniqueness of effective hydraulic properties for lysimeters that are internally heterogeneous. To answer these questions, synthetic measurements of water contents, pressure heads, and fluxes across the system boundaries were generated by forward modelling of water flow, based on the Richards equation, for a variety of homogeneous and layered soils and under varying types of boundary conditions (multi-step outflow, evaporation, transient atmospheric). We evaluated the measurements by inverse modelling assuming a homogeneous system. For the weakly heterogeneous layered soils, the soil water dynamics could be well described with effective homogeneous properties. For highly heterogeneous, layered soils, it was still possible to match the boundary fluxes for all types of experiments. Internal system states could not be matched. For these soils no effective soil hydraulic properties exist. We found that for strongly layered soils the simultaneous determination of the hydraulic properties of multiple soil layers by inverse modelling is a practicable alternative to the description with effective parameters.