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Identification of effective flow processes and properties from virtual soils using inverse modelling

H. Schelle (1), S.C. Iden (1), S. Schlüter (2), H.-J. Vogel (2), and W. Durner (1)

(1) Technische Universität Braunschweig, Institut für Geoökologie, Braunschweig, Germany (h.schelle@tu-bs.de), (2) Department of Soil Physics, UFZ Helmholtz-Centre for Environmental Research, Leipzig-Halle, Germany

Simulation of water flow and solute transport in unsaturated soils requires accurate knowledge of soil hydraulic properties. This study aims at developing strategies for deriving the flow and transport parameters for effective models at the scale of an agricultural field. Although hydraulic properties can be estimated from field observations under atmospheric boundary conditions by inverse modeling, the spatial heterogeneity of soil hydraulic properties within a field is known to strongly influence both local observations and the average behavior of the system. To assess the impact of individual or combined structural components on the water dynamics within the system, the interdisciplinary research group INVEST performs water flow simulations in complex two- and three-dimensional virtual realities, representing cultivated soils with spatial heterogeneity on multiple scales. Numerical simulations with a high spatiotemporal resolution yield synthetic datasets of internal state variables and fluxes. These data mimic measurements which could be recorded by typical instruments in a field soil. The simulated datasets are used to analyze the influence of the soil structures on the variability of measured data and to develop and test parameter estimation procedures. The central questions being addressed in this contribution are: (i) How big is the lateral variability of the measured data? (ii) How can within-field structures be related to the effective model parameters that are needed to predict average water dynamics at the field scale? (iii) How do the estimated hydraulic properties depend on measurement type and location? And (iv) what is the impact of the variability of the estimated effective hydraulic properties on the assessment of the soil water budget? To answer these questions we evaluate different data sets in terms of information content and usefulness for identifying suitable effective models and effective model parameters. The simulations show that a general idea about the lateral heterogeneity is indispensable to develop an adequate measurement strategy to obtain a representative insight into the hydrological regime.