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Multiobjective Optimization of Effective Soil Hydraulic Properties on a Lysimeter from a Layered, Gravelly Vadose Zone

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Estimation of effective soil hydraulic parameters for characterization of the vadose zone properties is important for many applications from prediction of solute and pesticide transport to water balance modeling in small catchments. Inverse modeling has become a common approach to infer the parameters of the water retention and hydraulic conductivity functions from dynamic experiments under varying boundary conditions.
To gain further inside into to the water transport behavior of an agricultural field site with a layered, gravelly vadose zone, a lysimeter was taken and equipped with a total of 48 sensors (24 tensiometers and 24 water content probes). The sensors were arranged in 6 vertical arrays consisting of 4 sensor pairs, respectively. Pressure heads and water contents were measured in four depths in each of the arrays allowing for the estimation of the soil hydraulic properties of the three individual soil layers by inverse modeling.
For each of the soil horizons, a separate objective function was defined to fit the model to the observation. We used the global multiobjective multimethod search algorithm AMALGAM (Vrugt et al., 2007) in combination with the water flow and solute transport model Hydrus1D (Šimúnek et al., 2008) to estimate the soil hydraulic properties of the Mualem van Genuchten model (van Genuchten, 1980).
This experimental design served for the investigation of two important questions: a) do effective soil hydraulic properties at the lysimeter scale exist, more specifically: can a single representative parameter set be found which describes the hydraulic behavior in each of the arrays with acceptable performance? And b) which degree of freedom is necessary or required for an accurate description of the one dimensional water flow at each of the arrays?
Effective soil hydraulic parameters were obtained for each of the sensor arrays individually, resulting in good agreement between the model predictions and the observations for the individual soil horizons. However, no general parameter set could be identified to describe the integral water flow over all arrays with acceptable performance due to the high degree of horizontal heterogeneity within the soil horizons. Furthermore it is shown that some of the hydraulic parameters are well defined, while others are associated with high uncertainties, e.g. the saturated hydraulic conductivity and the residual water content.

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