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Combination of multiobjective optimization and data depth - chances for the estimation of robust effective soil hydraulic parameters ?

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The estimation of effective soil hydraulic parameters for the characterization of the unsaturated soil hydraulic properties is important for many applications from prediction of solute and pesticide transport to water balance or soil-plant-atmosphere modeling. One option to obtain these parameters is the inference from dynamic experiments and the observation of the state variables. The application of multiobjective optimization algorithms to infer the soil hydraulic properties allows to include more information about the system under study and leads to a pareto optimal set of solutions for the defined problem. Subsequently, different subsets, or single solutions which achieve an acceptable compromise performance have to be selected by the modeler. This is mostly done in the objective function space by either the introduction of threshold values for the objectives or by calculation of distance measures towards the reference point, at which all objectives are perfectly satisfied.
However, recent investigations in the calibration of flood forecasting models suggest to select appropriate parameter sets by a geometrical analysis, based on the concept of data depth, performed in the parameter space rather than the objective function space in order to obtain robust parameter vectors from the pareto optimal sets of solutions. This methodology was applied to an extensive data set gathered during a two-year investigation of the water flow in a lysimeter taken from a gravelly vadose zone. The lysimeter was equipped with overall 48 sensors to allow the observation of pressure heads and water contents in six one-dimensional arrays, consisting of four sensor pairs in four different depths, respectively. The experimental results show a high degree of heterogeneity of the state variables and a distinct preferential flow behavior complicating the estimation of effective soil hydraulic properties.
The existing time series have been divided into different subsets for which the soil hydraulic parameters were estimated using the Hydrus1D model and the AMALGAM optimization algorithm. Subsequent analysis of the estimated parameter sets shows that these estimates depend largely on the system state contained in the data set and therefore on the information content. The results show that the application of the concept of data depth to parameter space leads to a better validation performances for most of the one-dimensional arrays compared to the use of simple threshold or distance measure approaches. The cluster based depth analysis in the parameter space allows furthermore the identification of different groups of system representations indicating the problem of non-uniqueness in the estimation of effective soil hydraulic properties.