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Inverse modeling of rainfall infiltration with a dual permeability approach using different matrix-fracture coupling variants.

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In this contribution we propose implementations of the dual permeability model with different inter-domain exchange descriptions and metaheuristic optimization algorithms for parameter identification and mesh optimization. We compare variants of the coupling term with different numbers of parameters to test if a reduction of parameters is feasible. This can reduce parameter uncertainty in inverse modeling, but also allow for different conceptual models of the domain and matrix coupling. The different variants of the dual permeability model are implemented in the open-source objective library DRUtES written in FORTRAN 2003/2008 in 1D and 2D. For parameter identification we use adaptations of the particle swarm optimization (PSO) and Teaching-learning-based optimization (TLBO), which are population-based metaheuristics with different learning strategies. These are high-level stochastic-based search algorithms that don't require gradient information or a convex search space. Despite increasing computing power and parallel processing, an overly fine mesh is not feasible for parameter identification. This creates the need to find a mesh that optimizes both accuracy and simulation time. We use a bi-objective PSO algorithm to generate a Pareto front of optimal meshes to account for both objectives.

The dual permeability model and the optimization algorithms were tested on virtual data and field TDR sensor readings. The TDR sensor readings showed a very steep increase during rapid rainfall events and a subsequent steep decrease. This was theorized to be an effect of artificial macroporous envelopes surrounding TDR sensors creating an anomalous region with distinct local soil hydraulic properties. One of our objectives is to test how well the dual permeability model can describe this infiltration behavior and what coupling term would be most suitable.