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Inverse dual-permeability simulations: sensitivity analysis

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Reliable prediction of water flow in natural porous systems depends to a large extent on an appropriate description of unsaturated hydraulic properties. Estimation of the soil hydraulic parameters is affected by adequacy and usability of a parametric model, its sensitivity and mutual dependence of parameters. The determination of hydraulic parameters for a dual-permeability medium by inverse modeling is an uneasy task. Beside the fact that the inversion of the Richards' equation is quite difficult in itself, the dual system introduces additional level of complexity. In our study, the dual-permeability forward simulator (S1D Dual code) was optimized by non-linear weighted least-squares routine based on the Levenberg-Marquardt algorithm. The optimization procedure was used to minimize the discrepancies between the simulated and the measured values. The objective function formation follows identical logic as in single permeability systems. On the basis of the laboratory infiltration-outflow experiment data and the field monitoring of soil-water dynamics, some specific solutions are presented for the dual-permeability model. Various approaches to estimation of the volumetric proportion of the preferential flow domain and its permeability are demonstrated. In addition, numerical analysis of the effect of different interpretation of tensiometric measurements, in the context of the dual-permeability model, is presented. The uniqueness of the inverse problem and the sensitivity of the hydraulic parameters are analyzed.