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Estimability analysis for optimization of hysteretic soil hydraulic parameters using data of a field irrigation experiment

Viet V. Ngo (1), Horst H. Gerke (2), and Annika Badorreck (3)

(1) Laboratoire d'Hydrologie et de Géochimie de Strasbourg, Université de Strasbourg/EOST, CNRS, 1 rue Blessig, F-67084 Strasbourg Cedex, France , (2) Leibniz-Zentrum für Agrarlandschaftsforschung, Bodenlandschaftsforschung, Müncheberg, Germany (hgerke@zalf.de, +49 33432 82280), (3) Bodenschutz und Rekultivierung, BTU Cottbus-Senftenberg, Germany

The estimability analysis has been proposed to improve the quality of parameter optimization. For field data, wetting and drying processes may complicate optimization of soil hydraulic parameters. The objectives of this study were to apply estimability analysis for improving optimization of soil hydraulic parameters and compare models with and without considering hysteresis. Soil water pressure head data of a field irrigation experiment were used. The one-dimensional vertical water movement in variably-saturated soil was described with the Richards equation using the HYDRUS-1D code. Estimability of the unimodal van Genuchten - Mualem hydraulic model parameters as well as of the hysteretic parameter model of Parker and Lenhard was classified according to a sensitivity coefficient matrix. The matrix was obtained by sequentially calculating effects of initial parameter variations on changes in the simulated pressure head values. Optimization was carried out by means of the Levenberg-Marquardt method as implemented in the HYDRUS-1D code. The parameters α, Ks, θs, and n in the nonhysteretic model were found sensitive and parameter θs and n strongly correlated with parameter n in the nonhysteretic model. When assuming hysteresis, the estimability was highest for αw and decreased with soil depth for Ks and αd, and increased for θs and n. The hysteretic model could approximate the pressure heads in the soil by considering parameters from wetting and drying periods separately as initial estimates. The inverse optimization could be carried out more efficiently with most estimable parameters. Despite the weaknesses of the local optimization algorithm and the inflexibility of the unimodal van Genuchten model, the results suggested that estimability analysis could be considered as a guidance to better define the optimization scenarios and then improved the determination of soil hydraulic parameters.