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New solution to an old problem: improved parameter estimation of soil hydraulic functions

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The representation of land surface properties in hydrologic and climatic models critically depends on soil hydraulic functions (SHF). Parameters of SHF are routinely identified from soil water retention (SWR) and hydraulic conductivity (HC) data by nonlinear least squares. This is a notoriously difficult task because typically only few measurements are available per sample or plot for estimating the many SHF parameters (up to seven for the van Genuchten-Mualem model). As a consequence, the estimated parameters are often highly uncertain and could yield unrealistic predictions of related physical quantities such as the characteristic length L_c for stage 1 evaporation (Lehmann et al., 2008). We address these limitations by capitalizing on the conditional linearity of some of the SHF parameters. Conditional linear parameters, say $\boldsymbol{\mu}$, can be substituted in the least squares objective by an explicit estimate (Bates & Watts, 1988), leading to an objective that depends only on the remaining nonlinear parameters $\boldsymbol{\nu}$. This step substantially reduces the dimensionality of the SHF estimation and improves the quality of estimated parameters. Additionally, instead of minimizing the least squares objective only with box constraints for $\boldsymbol{\nu}$, we minimize it by nonlinear programming algorithms that allow to physically constrain estimates of $\boldsymbol{\nu}$ by L_c. We have implemented this estimation approach in an R software package capable of processing global SWR and HC data. Using ensemble machine learning algorithms, the novel parameter estimation results will be coupled with auxiliary covariates (vegetation, climate) to create improved global maps of SHF parameters.

References:

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