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# Recent Advances of Soil Pedotransfer Functions and Multimodel Ensemble Estimates of Soil Hydraulic Parameters with Global Coverage

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A correct quantification of mass and energy exchange processes among Earth's land surface, groundwater and atmosphere requires an accurate parameterization of soil hydraulic properties. Pedotransfer functions (PTFs) are useful in this regard because they estimate these otherwise difficult to obtain characteristics using texture and other ubiquitous soils data. In this presentation, we first present our recent work that improved a widely used Rosetta PTF model (Rosetta3) that unifies the water retention and saturated hydraulic conductivity (Ks) submodels into one and utilizes parameter uncertainty of the fit of the water retention curve to the original retention data in the calibration procedure. Most PTFs estimate parameters of empirical hydraulic functions with modest accuracy. We developed a PTF that estimates the parameters of the Kosugi functions (Kosugi 1994, 1996), which explicitly assume a lognormal pore size distribution and apply the Young-Laplace equation to derive a corresponding pressure head distribution. Using a combination of machine learning and bootstrapping, we developed five hierarchical models that allow for estimates under practical data-poor to data-rich conditions. Using an independent global dataset containing nearly 50,000 samples (118,000 retention points) we demonstrated that the new PTF outperformed two van Genuchten-based PTFs calibrated on the same data. The PTF was applied to a $1\times1$ km2 map of texture and bulk density, thus producing maps of the parameters, field capacity, wilting point, plant available water, and associated uncertainties. Finally, 13 widely used PTFs were grouped according to input data requirements and evaluated against independent global dataset. Weighted ensembles were shown to have improved performance over individual PTFs in terms of root mean square error and other model selection criteria. Global maps of soil water retention data from the ensemble models as well as their uncertainty were provided. Our full 13-member ensemble model provides more accurate estimates than PTFs that are currently being used in earth system models.