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Simple models of soil hydraulic properties in the complete moisture range: Testing the new PDI model system with a comprehensive experimental dataset

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Simulation of water, solute, and energy transport in the vadose zone requires appropriate soil hydraulic properties models. The established models implicitly assume that water storage and water flow occur only in completely filled soil pores, but neglect the so called non-capillary water (i.e. water in films on grain surfaces, and in pore corners). These models are therefore suitable to model water flow and solute transport in the medium to wet moisture range, but likely fail when soils become dry. During the last decade, modelling approaches have been developed that take into account non-capillary water. One of these is the PDI model system developed by Peters (2013, 2014) and Iden and Durner (2014). It is a simple parametric system that extends any basic model of capillary retention and conductivity with a non-capillary counterpart, requiring an additional fitting parameter for the non-capillary liquid conductivity. Despite the simple model structure, the resulting soil hydraulic curves are in close agreement with the more comprehensive physically based film flow conductivity model of Lebeau and Konrad (2010). In this paper, we (i) present a PDI model variant that replaces the additional fitting parameter for non-capillary conductivity with a physically derived parameter, thus eliminating the need for additional fitting parameters compared to the established models, and (ii) conduct a comprehensive model performance test of several established capillary models alone (no PDI) and in combination with the original PDI, and the new PDI variant.

The model performance test is based on highly resolved water retention and conductivity data measured at 500 undisturbed soil samples. Soil water retention and conductivity data in the wet range were obtained in the laboratory by the evaporation method. Retention data in the dry range were obtained by the dew point method. For each data set we estimated the soil hydraulic parameters for nine scenarios, resulting from combinations of three basic models [(i) van Genuchten with m=1-1/n, (ii) van Genuchten with a free parameter m (van Genuchten, 1980), (iii) Fredlund & Xing (1994)] with three considerations of non-capillary water [(i) not considered, (ii) original PDI with additional fitting parameter for non-capillary conductivity, and (iii) the new PDI without additional fitting parameter).

The most flexible basic functions generally yielded the best model fits. Considering non-capillary water by the PDI model system clearly increased the model performance. The description of the measured retention and the conductivity data was improved in the order from original, to PDI without additional fitting parameter, to PDI with fitted non-capillary conductivity parameter. Notably, the new PDI model variant with exactly the same free parameters described data significantly better than the original models.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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