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Comparing two soil hydraulic parameterizations and related uncertainties to simulate catchment-scale distributed water budget with HydroGeoSphere

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Optimal management of water resources at catchment scale depends on the prediction capability of process-based hydrological models. In particular, the Richards-equation-based distributed models require lowering the mismatch between the scale of the process dynamics and that of the variability of input parameters. Therefore, a detailed description of the hydrological processes highly depends on the proper assessment of spatial variability of the soil hydraulic properties (SHPs), namely the soil water retention (WRF) and unsaturated hydraulic conductivity (HCF) functions. Field surveys and sampling campaigns commonly provide sparse local scale measurements of SHPs. The performances of two parameterization approaches are compared to simulate water budget in a small catchment of the Alento Hydrological Observatory by using HydroGeoSphere (HGS) model. The first approach relies on a scaling technique by providing the so-called "aggregated" SHPs over the spatial domain of interest. The second approach, instead, is based on indirect measurement of soil saturation in one representative plot during an infiltration experiment by using electrical-resistivity tomography (ERT). The measured ERT dataset is exploited to estimate the "equivalent" SHPs through an inverse modeling approach that combines HGS and DREAMZS global optimization tool. Within the framework of a functional evaluation, we compare the outputs of HGS simulations in terms of streamflow (as a lumped flux) and near-surface soil moisture patterns (as distributed state variables). Better comparisons between observed and simulated streamflow values are obtained when HGS is run by using the ERT-based "equivalent" SHPs. Conversely, water budget simulations depending on the "aggregated" SHPs are quite close to the observed soil moisture patterns. The two measurement techniques differ because the ERT-based is affected by hydraulic nonequilibrium during transient conditions characterizing the infiltration experiment. This study highlights the pros and cons and potential flaws when choosing two different parameterization techniques in spatially distributed modeling applications.