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Investigating local controls on soil moisture temporal stability using an inverse modeling approach

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A better understanding of the temporal stability of soil moisture and its relation to local and nonlocal controls is a major challenge in modern hydrology. Both local controls, such as soil and vegetation properties, and non-local controls, such as topography and climate variability, affect soil moisture dynamics. Wireless sensor networks are becoming more readily available, which opens up opportunities to investigate spatial and temporal variability of soil moisture with unprecedented resolution. In this study, we employed the wireless sensor network SoilNet developed by the Forschungszentrum Jülich to investigate soil moisture variability of a grassland headwater catchment in Western Germany within the framework of the TERENO initiative. In particular, we investigated the effect of soil hydraulic parameters on the temporal stability of soil moisture. For this, the HYDRUS-1D code coupled with a global optimizer (DREAM) was used to inversely estimate Mualem-van Genuchten parameters from soil moisture observations at three depths under natural (transient) boundary conditions for 83 locations in the headwater catchment. On the basis of the optimized parameter sets, we then evaluated to which extent the variability in soil hydraulic conductivity, pore size distribution, air entry suction and soil depth between these 83 locations controlled the temporal stability of soil moisture, which was independently determined from the observed soil moisture data. It was found that the saturated hydraulic conductivity (Ks) was the most significant attribute to explain temporal stability of soil moisture as expressed by the mean relative difference (MRD).