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Using remotely-sensed estimates of soil moisture to infer soil texture and hydraulic properties across a semi-arid watershed

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Near-surface soil moisture is a critical component of land surface energy and water balance models, but its accurate simulation is often hampered by soil texture and hydraulic property information that is difficult to obtain. This study approaches the problem of parameterizing soil properties in land surface models from a unique perspective based on components originally developed for operational estimation of soil moisture as a determinant of soil strength. Estimates of near-surface soil moisture derived from passive airborne (L-band; during 1990) and, for the first time, active satellite (C-band; during 2003) microwave remote sensing were acquired during the summer monsoon season in southeastern Arizona, and used to calibrate hydraulic properties in an offline land surface model. Specifically, a robust parameter estimation tool was used to calibrate the Noah land surface model at very high spatial resolution across the Walnut Gulch Experimental Watershed. Errors in simulated versus observed soil moisture were minimized by adjusting the soil texture, which in turn controls the hydraulic properties through the use of pedotransfer functions. By estimating within a continuous range of widely applicable soil properties such as sand, silt, and clay percentages rather than applying rigid soil texture classes, lookup tables, or large parameter sets as in previous studies, the physical accuracy and consistency of the estimated soil properties could then be assessed against in situ measurements

In addition, the sensitivity of this calibration method to the number and timing of microwave retrievals is determined in relation to temporal patterns in soil drying. The impact of precipitation uncertainty on the accuracy and retrievability of estimated soil texture and hydraulic properties is also quantified by systematically varying precipitation forcing from a dense, interpolated gauge network to a continental-scale reanalysis product. It is shown that the quality and resolution of precipitation data are critical determinants of whether successive remotely sensed soil moisture images may be used in this approach, and that the importance of microwave retrieval and precipitation data availability can be modulated by other parameters in the Noah land surface model that impact the soil hydraulics. Overall, this study presents a methodology to gain physically meaningful soils information using simple parameter estimation with few but appropriately timed remote sensing retrievals, and a potential pathway to exploit future global, high-resolution monitoring of soil moisture such as that which will be available from the Soil Moisture and Ocean Salinity (SMOS) mission.