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Assimilation of various types of SMOS observations into the GEOS-5 Catchment Land Surface Model, and the effect on turbulent fluxes and runoff

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Three different data products from the Soil Moisture Ocean Salinity (SMOS) mission are assimilated separately into the Goddard Earth Observing System Model, version 5 (GEOS-5) to improve estimates of surface and root-zone soil moisture. The first product consists of multi-angle, dual-polarization brightness temperature (Tb) observations at the bottom of the atmosphere extracted from Level 1 data. The second product is a derived SMOS Tb product that mimics the data at a 40o incidence angle from the Soil Moisture Active Passive (SMAP) mission. The third product is the operational SMOS Level 2 surface soil moisture (SM) retrieval product. The assimilation system uses a spatially distributed ensemble Kalman filter with seasonally varying climatological bias mitigation for Tb assimilation, whereas a time-invariant cumulative density function matching is used for SM retrieval assimilation. All assimilation experiments improve the soil moisture estimates compared to model-only simulations averaged across 187 sites in the US. However, the various assimilation experiments result in large differences in skill locally, and the data assimilation diagnostics reveal large differences in how the observations add value in the Tb and SM retrieval assimilation systems. The assimilation of SMOS Tb observations further reveals that the effect of Tb assimilation reaches beyond that of improving soil moisture, and has a profound impact on soil temperature, turbulent surface fluxes and runoff.