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Assimilation of SMOS Brightness Temperature Observations in the NASA GEOS-5 Land Data Assimilation System

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Multi-angular L-band (1.4 GHz) microwave observations from the Soil Moisture Ocean Salinity (SMOS) mission are assimilated into the Goddard Earth Observing System version 5 (GEOS-5) land surface model using a spatially distributed ensemble Kalman filter. This system will be used for the Soil Moisture Active Passive (SMAP) Level 4 soil moisture product (L4_SM). The assimilation involves a simulation of brightness temperatures (Tb), followed by an inversion of the differences between these Tb forecasts and corresponding observations into updates to the modeled surface soil moisture, root-zone soil moisture, and surface soil temperature. To optimize the filter, spatially and temporally variable Tb error variances are estimated based on a historical record of Tb observations and forecasts.

The Tb assimilation significantly improves the surface and root-zone soil moisture estimates in terms of anomaly correlations versus distributed measurements from select validation watersheds and versus point-scale measurements from sparse networks across the US. With assimilation, the unbiased root-mean-square error is less than the L4_SM target of 0.04 m3/m3 for surface and root-zone soil moisture for the validation watersheds. At the global scale, most of the impact on soil moisture is found in wetter areas, whereas the soil temperature is more affected in drier areas. The soil moisture updates induce changes in energy fluxes and runoff of about 15% relative to their respective seasonal variability.