Title: **The contributions of precipitation and soil moisture observations to the skill of soil moisture estimates in a land data assimilation system, *Journal of Hydrometeorology* (American Meteorological Society)**

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Abstract:

The contributions of precipitation and soil moisture observations to soil moisture skill in a land data assimilation system are assessed. Relative to baseline estimates from the Modern Era Retrospective-analysis for Research and Applications (MERRA), the study investigates soil moisture skill derived from (i) model forcing corrections based on large-scale, gauge- and satellite-based precipitation observations and (ii) assimilation of surface soil moisture retrievals from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E). Soil moisture skill (defined as the anomaly time series correlation coefficient R) is assessed using in situ observations in the continental United States at 37 single-profile sites within the Soil Climate Analysis Network (SCAN) for which skillful AMSR-E retrievals are available and at four USDA Agricultural Research Service ("CalVal") watersheds with high-quality distributed sensor networks that measure soil moisture at the scale of land model and satellite estimates. The average skill of AMSR-E retrievals is R=0.42 versus SCAN and R=0.55 versus CalVal measurements. The skill of MERRA surface and root-zone soil moisture is R=0.43 and R=0.47, respectively, versus SCAN measurements. MERRA surface moisture skill is R=0.55 versus CalVal measurements. Adding information from precipitation observations increases (surface and root zone) soil moisture skills by $\Delta R \sim 0.06$. Assimilating AMSR-E retrievals increases soil moisture skills by $\Delta R \sim 0.08$. Adding information from both sources increases soil moisture skills by $\Delta R \sim 0.13$, which demonstrates that precipitation corrections and assimilation of satellite soil moisture retrievals contribute important and largely independent amounts of information.

Popular Summary:

Knowledge of the amount of moisture stored in the soil is important for many applications related to the water, energy and carbon transfers between land and atmosphere, including the assessment and prediction of floods and droughts. But global observations of soil moisture have not been available at the spatial and temporal resolution and with the accuracy necessary to meet applications requirements. Enhanced

estimates of soil moisture conditions can be obtained by merging satellite observations of soil moisture with soil moisture estimates from a numerical model of land surface processes that is forced with observation-based precipitation data. This process is also known as land data assimilation. The resulting optimal soil moisture estimates are thus based on two sources of information: (i) direct observations of soil moisture from satellite and (ii) observations of the precipitation forcing that drives soil moisture dynamics. The present paper investigates these contributions in a land data assimilation system. Relative to baseline soil moisture estimates from the Modern Era Retrospective-analysis for Research and Applications (MERRA), the study investigates soil moisture skill derived from (i) land model forcing corrections based on large-scale, gauge- and satellite-based precipitation observations and (ii) assimilation of surface soil moisture retrievals from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E). Soil moisture skill is assessed using in situ observations in the continental United States at 37 single-profile sites within the Soil Climate Analysis Network (SCAN) for which skillful AMSR-E retrievals are available and at four USDA Agricultural Research Service ("CalVal") watersheds with high-quality distributed sensor networks that measure soil moisture at the scale of land model and satellite estimates. The average skill of AMSR-E and MERRA estimates is comparable. As expected, the skill of the satellite, model, and assimilation estimates is higher when assessed against the multi-sensor CalVal observations than when skill is assessed against single-profile SCAN measurements. Adding information from precipitation observations increases (surface and root zone) soil moisture skills. Assimilating satellite estimates of surface soil moisture also increases soil moisture skills. Adding information from both sources increases soil moisture skills by almost the sum of the individual skill contributions, which demonstrates that precipitation corrections and assimilation of satellite soil moisture retrievals contribute important and largely independent amounts of information.