The contributions of precipitation and soil moisture observations to the skill of soil moisture estimates in a land data assimilation system

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Overview: 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 enhanced 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.

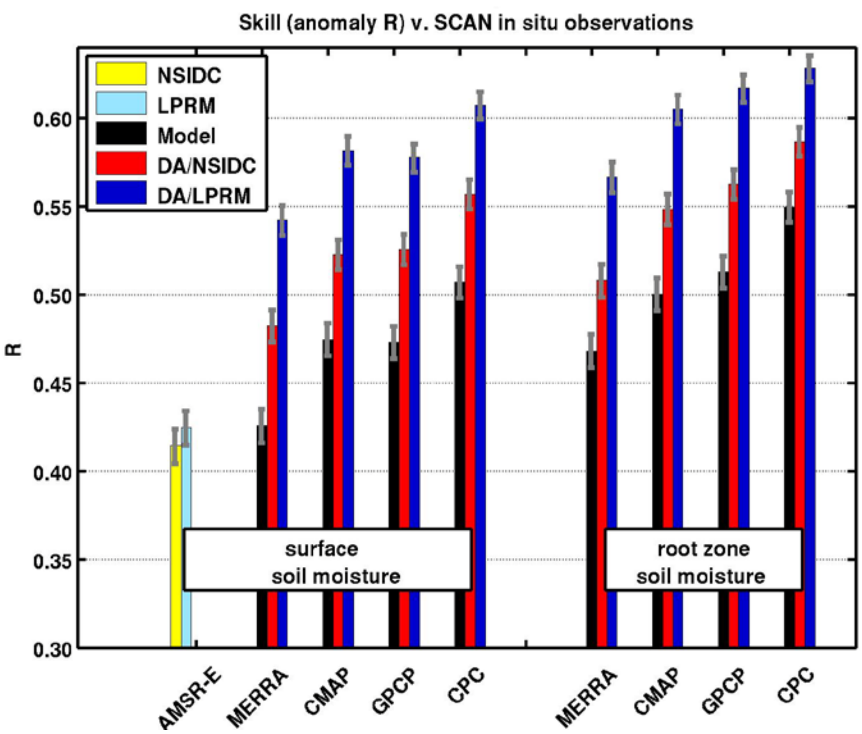

Figure 1: Average time series correlation coefficient R with SCAN in situ surface and root zone soil moisture anomalies for estimates from two AMSR-E retrieval datasets (NSIDC and LPRM), the Catchment model forced with four different precipitation datasets (MERRA, CMAP, GPCP, and CPC), and the corresponding data assimilation integrations (red bars: DA/NSIDC and blue bars: DA/LPRM). Average is based on 37 SCAN sites for surface and 35 SCAN sites for root zone soil moisture. Error bars indicate approximate 95% confidence

Results: 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).

Three precipitation products were used to correct the MERRA precipitation towards gauge- and satellite-based observations. Specifically, we used the NOAA Climate Prediction Center Merged Analysis of Precipitation (CMAP) pentad product ("standard" version), the Global Precipitation Climatology Project (GPCP) version 2.1 pentad product, and the NOAA Climate Prediction Center (CPC) daily unified precipitation analysis over the United States.

Two different surface soil moisture retrieval products were assimilated into the Catchment model: (i) the operational NASA Level-2B AMSR-E "AE-Land" product (version V09) archived at the National Snow and ice Data Center (NSIDC) and (ii) the AMSR-E Land Parameter Retrieval Model (hereinafter LPRM) product (EASE grid version 03) developed at the VU Amsterdam.

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. Skill is assessed in terms of the anomaly time series correlation coefficient R.

Figure 1 shows that the average skill of the AMSR-E and MERRA surface soil moisture estimates is comparable. Adding information from precipitation observations increases soil moisture skills for surface *and* root zone soil moisture. Assimilating satellite estimates of *surface* soil moisture also increases soil moisture skills, again for surface *and* root zone soil moisture. Adding information from both sources (precipitation and soil moisture observations) 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.

We repeated our skill analysis against measurements from 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. 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 (not shown). The relative skill contributions by precipitation corrections and soil moisture retrieval assimilation, however, remain unchanged (not shown). This corroborates the results shown in Figure 1 which were obtained with a larger network of single-profile sensors.

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