Soil Moisture Initialization Impacts on Weather Prediction

Joseph A. Santanello, Jr.[1] and Patricia Lawston[2,1]
[1]Hydrological Sciences Lab, NASA-GSFC , [2]ESSIC-UMCP

Soil moisture products commonly used to initialize NWP forecasts vary widely in resolution and accuracy.

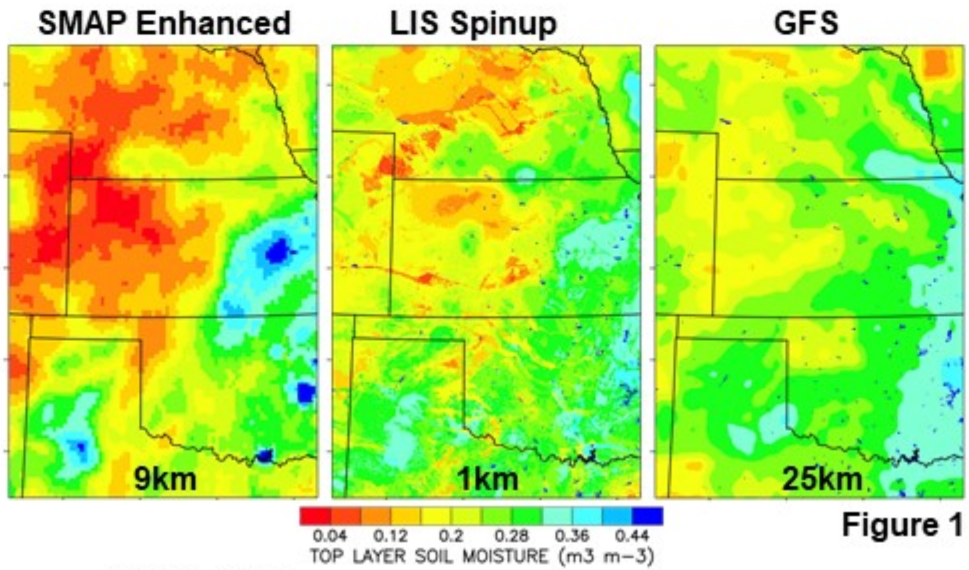

Figure 1

Coupled forecast impacts are sensitive to the choice of soil moisture initialization throughout the domain.

SMAP - GFS

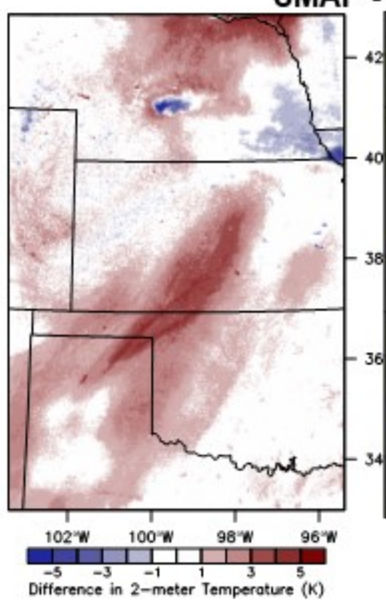

Figure 2

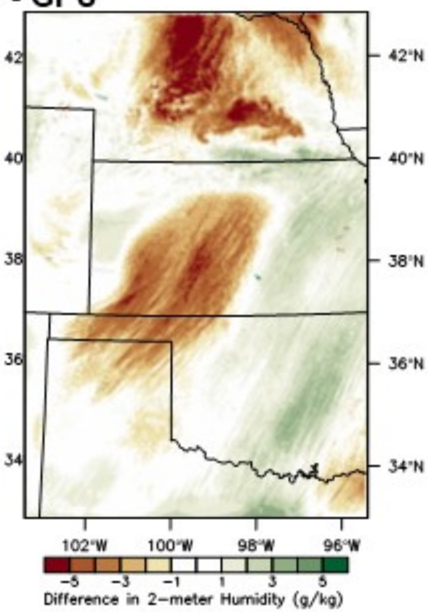

Figure 3

Land surface states (i.e. soil moisture and temperature) in Numerical Weather Prediction models can be initialized in a variety of ways as shown in **Fig. 1**, including from high-resolution land surface model spinup (NASA's Land Information System, satellite (SMAP), global atmospheric models (GFS).

Experiments utilizing LIS and NASA Unified WRF (NU-WRF) model capabilities demonstrate that the choice of initialization approach has unique and significant impacts on coupled weather prediction including air temperature & humidity (**Figs. 2 & 3**), and precipitation.

Name: Joseph Santanello, Jr., Hydrological Sciences Lab, NASA GSFC
E-mail: joseph.a.santanello@nasa.gov
Phone: 301-286-7450

References:

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· Santanello, J. A., S. V. Kumar, C. D. Peters-Lidard, and P. M. Lawston. 2016. "Impact of Soil Moisture Assimilation on Land Surface Model Spinup and Coupled Land-Atmosphere Prediction." Journal of Hydrometeorology 17 517-540 [10.1175/jhm-d-15-0072.1]

Data Sources: NASA Land Information System (LIS) simulations using the Noah v.3.3 land surface model (LSM), NLDAS-2 output using the Noah v2.7.1 LSM, GFS- and NARR- based soil moisture, and SMAP Level 3 Enhanced soil moisture (9km, descending (am) overpass).

Technical Description of Figures: The suite of soil moisture conditions used to initialize the NASA Unified WRF (NU-WRF) model (Fig. 1) demonstrates the diversity in soil moisture conditions that can result from the varying resolution and quality of each product, and shows that SMAP does a reasonable job of representing soil moisture and spatial heterogeneity on this date. The impact of soil moisture initialization on NWP can be seen in the ambient temperature (Fig. 2) and humidity (Fig. 3) of the NU-WRF forecasts on the following day, where the maximum differences due solely to soil moisture initial conditions range from 2-6 K and 2-6 g kg-1, respectively, over most of the domain with larger impacts in regions where precipitation has been impacted (e.g. Nebraska).

Figure 1: Near-surface soil moisture over the Southern Great Plains valid at 12 UTC on 11 July 2015 as derived from a) SMAP 9km Enhanced (0-5cm), b) LIS-Noah simulations (0-10cm), and c) Global Forecast System (GFS), each of which employ the Noah LSM. Each of these was used as soil moisture initial conditions for 24h NU-WRF simulations over this region to determine the impact of the quality and resolution of initialization data on coupled prediction.
Figure 2: Maximum differences in 2-meter temperature from the NU-WRF simulations valid at 18 UTC across the simulations driven by the suite of initialization approaches, indicating the impact of soil moisture on daytime temperature forecasts.
Figure 3: Same as Fig. 2, but for 2-meter humidity.

Scientific significance, societal relevance, and relationships to future missions: The role of the land surface in weather prediction models has been largely overlooked by the atmospheric modeling community, who typically employ default initialization approaches for soil temperature and moisture based on coarse atmospheric model products. We now have the ability to generate high resolution, high quality, long-term spinups of the land surface in systems such as LIS, while incorporating satellite data from SMAP via assimilation and calibration. It is therefore important to assess the impacts of these widely varying initialization approaches that are used across the community, and to compare 'off-the-shelf' products from NLDAS-2, GFS, and NARR to those of LIS and satellite retrievals. As operational centers are focused solely on 2-meter temperature and humidity and precipitation statistics, the community is now demonstrating that the land states and strength of land-atmosphere coupling can play a significant role in the accuracy of ambient weather forecasts. Improving the initial conditions of soil moisture, temperature, and vegetation using NASA satellite observations and assimilation systems therefore becomes even more critical, and the combination of NASA's SMAP, LIS and NU-WRF resources can be used to develop and test these approaches and coupled impacts.