Evaluating the sensitivity of LSM surface soil moisture dynamics to soil profile layering schemes

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1. Abstract

We utilize a number of soil profile layering schemes within the Noah and Noah-MP land surface models to quantify their influence on simulated surface soil moisture dynamics. Experiments are carried out over the continental U.S. with the model's top soil layer thickness set to: 10 cm (default), 5 cm, and 2 cm. Continent-wide, the simulated surface soil moistures are compared with SMAP retrievals, which are nominally sensitive to moisture between the surface and a depth of 5 cm. At seven USDA watersheds, the simulated soil moistures are also compared to basin-wide averages from in-situ probes placed at 5 cm.

The three layering schemes exhibit differences in their dynamic ranges: shallower layers have lower means and higher standard deviations. Agreement between models, SMAP observations, and in-situ probes depends on region, reflecting differences in hydrologic regimes and suggesting differences in effective SMAP sensing depth. Insights from this work will aid efforts to enhance the observability (i.e. consistency with in-situ estimates) of simulated soil moisture from models, which is necessary for improving the efficiency of soil moisture data assimilation environments.

2. Motivation

Improve simulated soil moisture observability for SMAP data assimilation applications.

- SMAP sensing depth: 5 cm or less
- Default model surface layer: 10 cm

Model drying behavior is affected by surface layer thickness

3. Experiments

Model setup

- Noah-MP 3.6
- Dynamic vegetation
- 1/8 degree resolution
- CONUS domain
- NLDAS-2 forcings
- 4/1/2015 – 4/1/2018

3 Layering schemes

Model layer thicknesses (cm)	Experiment label
10, 30, 60, 100	10_30
5, 5, 30, 60, 100	05_05
2, 3, 6, 9, 15, 24, 40, 100	02_03

4. Results (time)

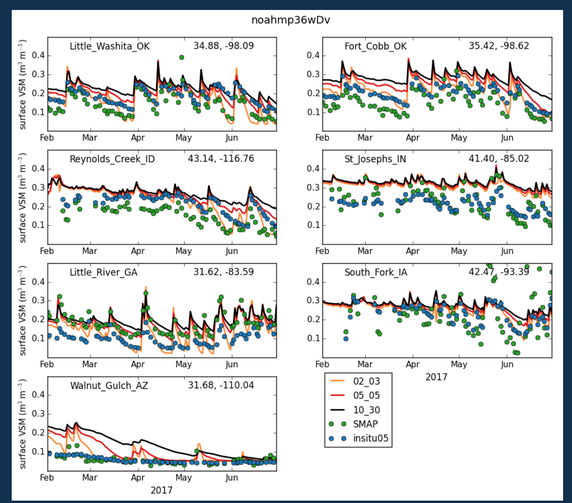


Figure 1 (above): Locations of USDA sites with basin-averaged *in situ* data. Soil moisture probes are placed at 5 cm.

Figure 2 (left): Sample time series of simulations, observations, and SMAP retrievals

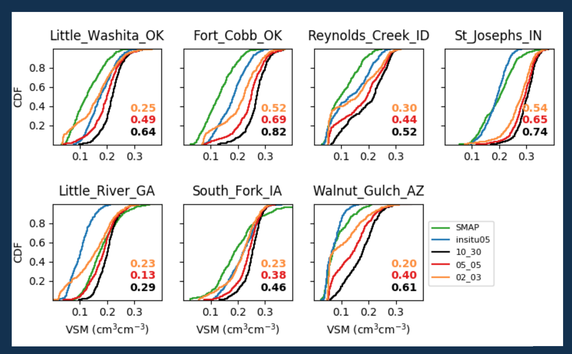
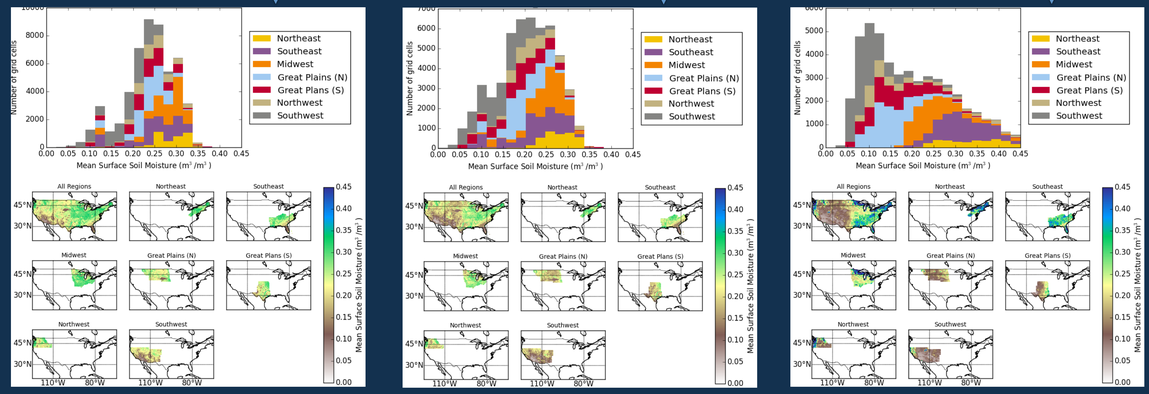


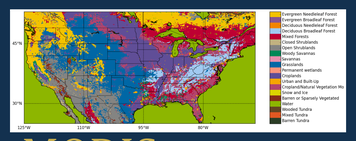
Figure 3 (left): Soil moisture CDFs using all 3 years of data. Inset values are Kolmogorov-Smirnov test results between simulations (indicated by color) and SMAP retrievals.

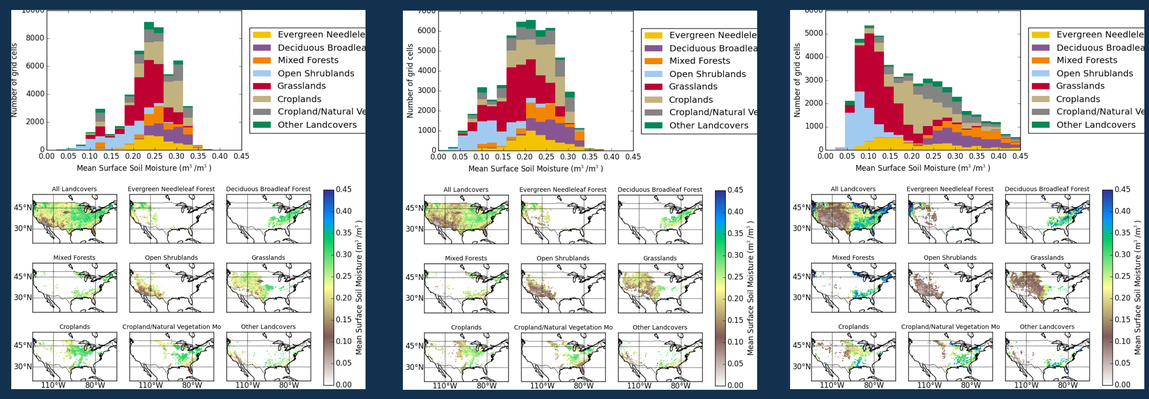
5. Results (space)

10_30 → 02_03 → SMAP

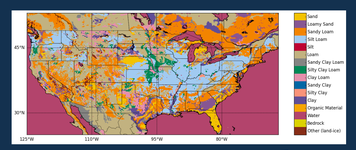


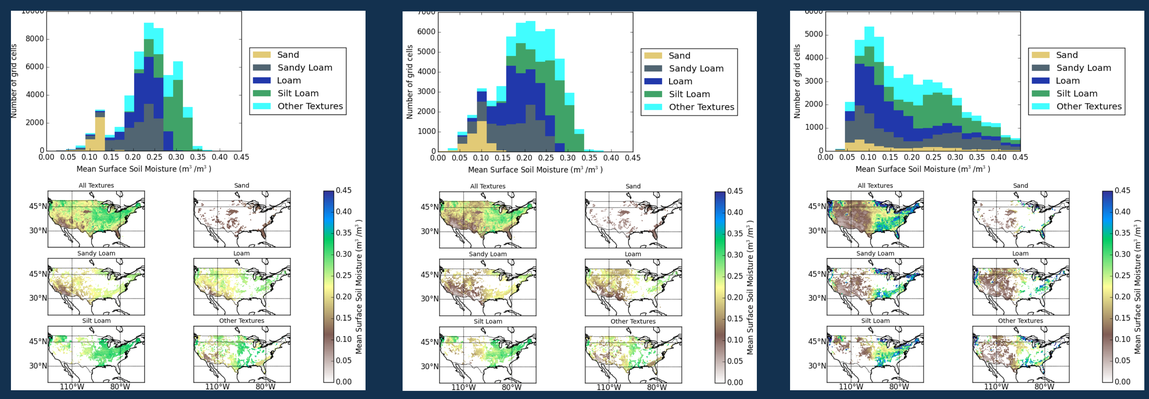
Figures 4-6 (right): Mean surface soil moisture values from models and SMAP, grouped by National Climate Assessment Region.





Figures 7-9 (right): As in Figs 4-6, but grouped by landcover type.





Figures 10-12 (right): As in Figs 4-6, but grouped by soil texture class

6. Conclusions

Shallower surface layering results in simulations with drier, more dynamic, and more diverse surface soil moisture in time and space