

1. Abstract

Errors in soil moisture adversely impact the modeling of land-atmosphere water and energy fluxes and, consequently, near-surface atmospheric conditions in atmospheric data assimilation systems (ADAS).

To mitigate such errors, this study assimilates L-band brightness temperature (Tb) observations from the Soil Moisture Active Passive (SMAP) mission during boreal summer (JJA) 2017 (Reichle et al. 2021).

The SMAP Tb analysis is weakly coupled with the Goddard Earth Observing System (GEOS) ADAS and improves the correlation of surface and root-zone soil moisture vs. in situ measurements by ~0.1-0.26 over that of estimates without the SMAP Tb analysis.

Regionally, the RMSE vs. in situ measurements of screen-level specific humidity (q2m) and daily maximum temperature (T2m_{max}) is improved by up to 0.4 g/kg and 0.3 K, resp. Improvements in specific humidity extend into the lower troposphere (below ~700 mb), with 15-25% relative improvement in bias.

2. Soil Moisture

The SMAP Tb analysis significantly improves the correlation skill of surface (0-5 cm) soil moisture. Improvements are also seen in the unbiased RMSE and in root-zone (0-100 cm) soil moisture.

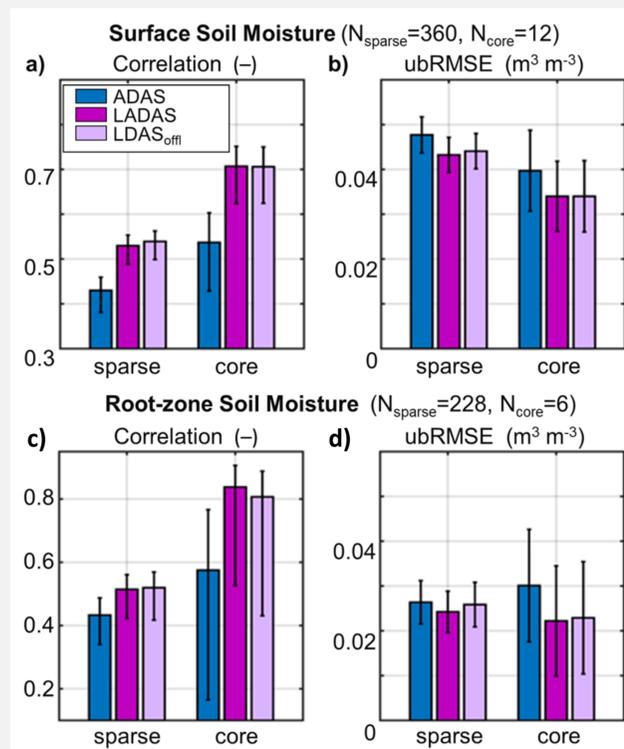


Figure 2. (a,c) Correlation and (b,d) unbiased RMSE (or std-dev of the error) for (a,b) surface and (c,d) root-zone soil moisture from the ADAS (no SMAP analysis) and LADAS (with SMAP analysis). Also shown are results for a land-only (LDAS_{off}) experiment with SMAP assimilation. Metrics are computed vs. in situ measurements from sparse soil moisture networks (first group of bars) and SMAP core validation sites (second group of bars) for JJA 2017. N_{sparse} and N_{core} indicate the number of sites used to compute the metrics. Error bars indicate 95% confidence intervals.

3. Screen-Level Variables

The SMAP Tb analysis improves the RMSE of q2m and T2m_{max}, in some regions by up to 0.4 g/kg and 0.3 K, respectively.

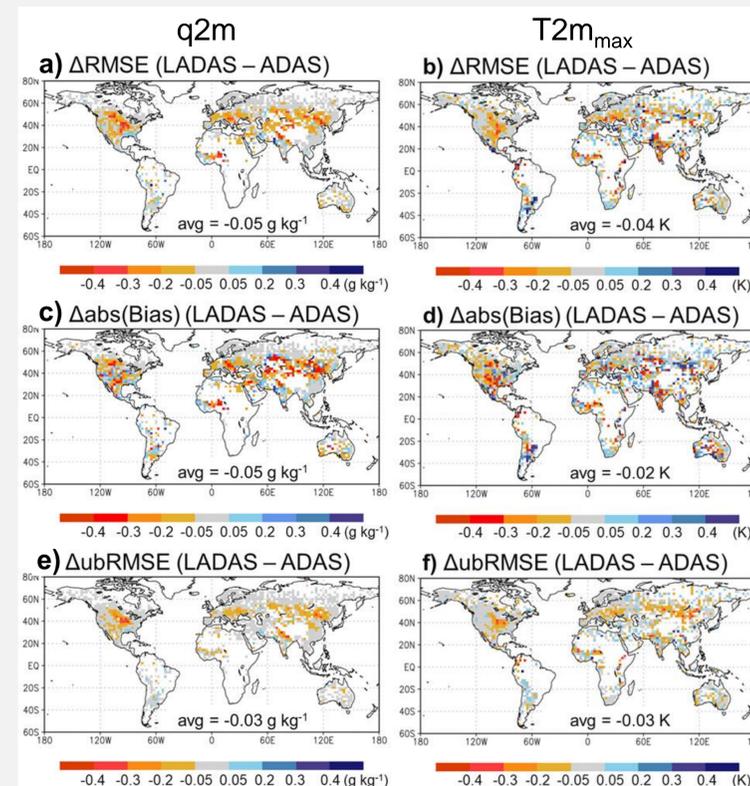


Figure 3. Difference in (a,b) RMSE, (c,d) absolute bias, and (e,f) unbiased RMSE between LADAS (with SMAP assimilation) and ADAS (no SMAP assimilation) for (a,c,e) q2m and (b,d,f) T2m_{max}. Metrics computed vs. in situ measurements. Red colors indicate that SMAP assimilation improves the skill. All statistics are calculated for JJA 2017.

4. Atmospheric Profiles

Improvements in specific humidity (q) extend into the lower troposphere (below ~700 mb), with 15-25% relative improvement in absolute bias. A slight relative degradation of <5% is seen for temperature (T).

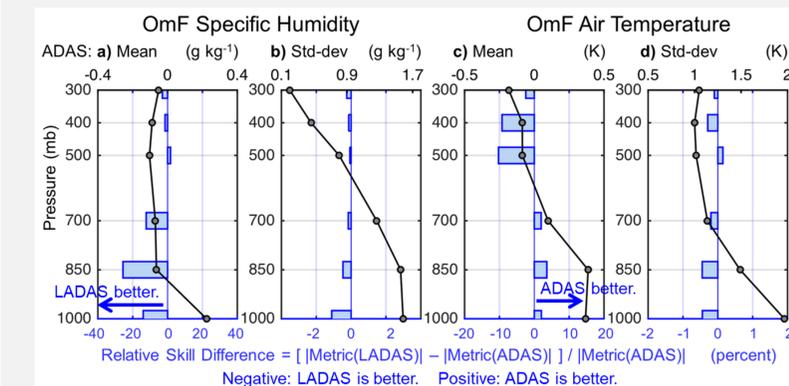


Figure 4. Black dots show atmospheric profiles of the (a,c) mean and (b,d) std-dev of observation-minus-forecast (OmF) residuals from the ADAS experiment (without SMAP assimilation) for (a,b) q and (c,d) T across global continental land for JJA 2017. OmF residuals are computed using radiosonde observations. Blue bars indicate corresponding relative skill difference (LADAS vs. ADAS) in OmF (a,c) absolute mean and (b,d) standard deviation in units of percent. Blue bars with negative (positive) percentage values indicate better (worse) performance of LADAS compared to ADAS.

5. Summary and Next Steps

SMAP assimilation in the GEOS LADAS improved estimates of humidity and temperature near the surface (q2m, T2m_{max}) and specific humidity in the lower troposphere.

Next steps include:

- Integrate SMAP assimilation into the latest GEOS 4D-Hybrid-EnVar ADAS (in progress).
- Connect the ADAS and LDAS ensembles.
- Investigate the skill of surface turbulent fluxes and medium-range forecasts.

References

- Draper & Reichle (2019), Assimilation of Satellite Soil Moisture for Improved Atmospheric Reanalyses, *Monthly Weather Review*, 147, 2163–2188, doi:[10.1175/MWR-D-18-0393.1](https://doi.org/10.1175/MWR-D-18-0393.1).
- Reichle et al. (2019), Version 4 of the SMAP Level-4 Soil Moisture Algorithm and Data Product, *Journal of Advances in Modeling Earth Systems*, 11, 3106-3130, doi:[10.1029/2019MS001729](https://doi.org/10.1029/2019MS001729).
- Reichle et al. (2021), Assimilation of SMAP Brightness Temperature Observations in the GEOS Land-Atmosphere Data Assimilation System, *IEEE JSTARS*, conditionally accepted.