A Comparison of Clear-Sky Land Skin Temperature from GEOS-5 and from Geostationary Satellite Retrievals

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Atmospheric models rely on accurate initial radiometric and surface conditions for better short-term meteorological forecasts and improved evaluation of global climate models. Remote sensing of the Earth's energy budget, particularly with instruments flown on geostationary satellites, allows for near-real-time evaluation of cloud and surface radiation properties. The persistence and coverage of geostationary remote sensing instruments grant the frequent retrieval of quasi-global skin temperature. Among other cloud and clear-sky retrieval parameters, NASA Langley Research Center (LaRC) provides a non-polar, high-resolution, near-real-time land surface skin temperature dataset from the Geostationary Operational Environmental Satellite (GOES) series. This study characterizes the diurnal and seasonal biases and root-mean-square differences (RMSDs) between the satellite retrievals and modeled land surface temperature (LST) values from the NASA Goddard Earth Observing System Version 5.7.2 (GEOS-5) at 0.25º by 0.3125º resolution in preparation for assimilation of the retrievals into GEOS-5.

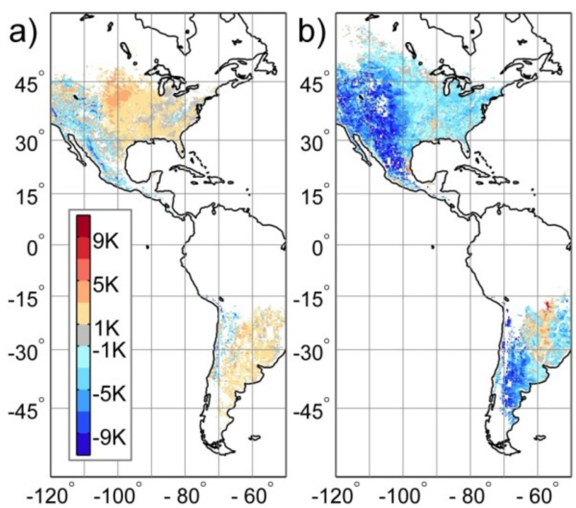

Figure 1: Mean difference (K) between GEOS-5 land surface temperature and GOES-13 HRTP for clear-sky conditions at (a) 06:00 UTC (nighttime) and (b) 18:00 UTC (daytime), averaged over 1 August 2011 to 31 July 2012. Areas in white indicate that metrics were not computed due to insufficient data.

Figure 1 shows the nighttime (06:00 UTC) and daytime (18:00 UTC) mean differences between the model and satellite estimates (GEOS-5 minus GOES-13) for the 12-month period from 1 August 2011 to 31 July 2012. The mean differences during the night are typically within ±3 K (Figure 1a). During the day, the mean differences are considerably larger (Figure 1b). In the western US, western Mexico, and western Argentina GEOS-5 LSTs are cooler than the GOES-13 retrievals by up to 10 K. Such large daytime differences, however, can be expected. While the satellite retrievals describe a true "skin" temperature, the GEOS-5 LST estimates are for a prognostic model surface layer with a small but non-zero heat capacity. The peak daytime model temperatures are therefore considerably lower than the satellite-retrieved skin temperatures. The situation is different in east-central Argentina, where GEOS-5 LSTs exceed the GOES-13 retrievals by as much as 9 K. An analysis of GEOS-5 cloud optical depth estimates suggests that these counter-intuitive differences are most likely caused by errors in the GEOS-5 moist physics and cloud parameterizations, which lead to strongly biased model temperatures that adversely impact model skin temperature estimates even during clear days (not shown).

Figure 2 shows daytime (18:00 UTC) seasonal RMSD values (excluding seasonal mean differences) between GEOS-5 LST and GOES-13 retrievals. The RMSD values are usually between 1 and 4 K, except during summer. The RMSD values exceed 4 K during JJA in much of the north-central US and during DJF in portions of Argentina and Uruguay. The lowest RMSD values of 1-2 K are found during cooler conditions (e.g., in the eastern and central US during DJF, in the southern US during SON, and in eastern Argentina and Uruguay during JJA). As can be expected, the nighttime (06:00 UTC) RMSD values are considerably lower and are typically 1-3 K across the domain and throughout the year (not shown).

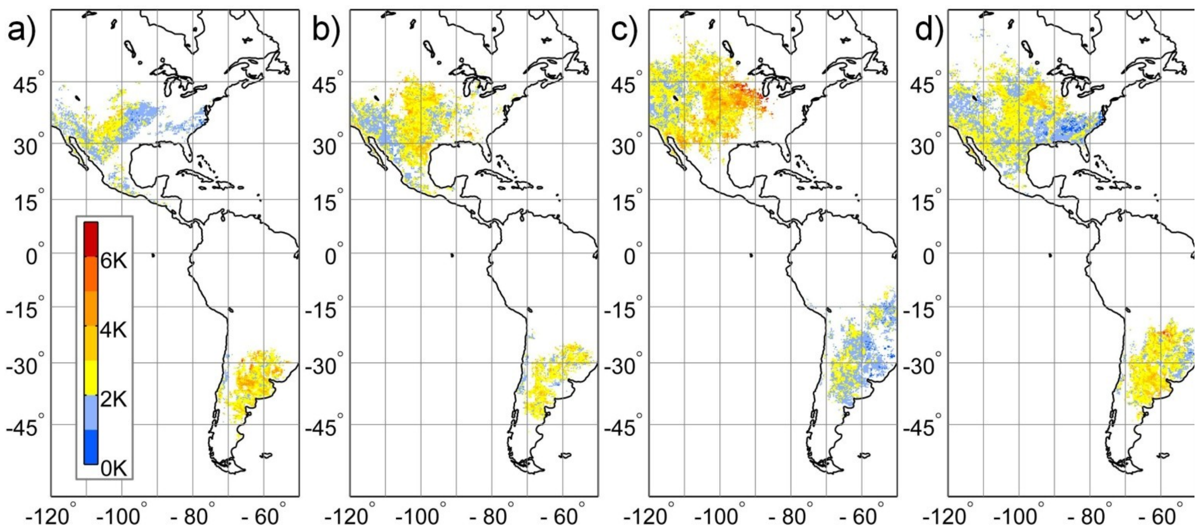

Figure 2: Daytime (18:00 UTC) seasonal RMSD (excluding seasonal mean difference) in Kelvin between GEOS-5 land surface temperature and GOES-13 HRTP for clear-sky conditions for (a) DJF (Dec 2011-Feb 2012), (b) MAM (Mar-May 2012), (c) JJA (Aug 2011, Jun-Jul 2012), and (d) SON (Sep-Nov 2011).

The area-average diurnal cycles of the annual bias and RMSDs (excluding annual mean differences) are shown in Figure 3. The domain-averaged bias is typically below 1 K during the night (00:00 UTC to 09:00 UTC) and is considerably larger during the day (up to -4 K at 18:00 UTC). Similarly, the RMSD values are typically below 2 K during nighttime, including early morning and evening (00:00 UTC to 12:00 UTC). During the daytime (15:00 UTC to 21:00 UTC), however, the RMSD values exceed 2 K, with a maximum of 3 K at 18:00 UTC.

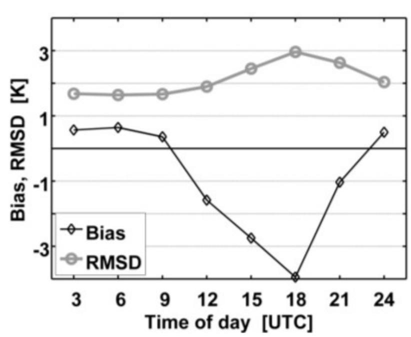

Figure 3: Bias and RMSD (excluding annual mean differences) in Kelvins between GEOS-5 land surface temperature and GOES-13 skin temperature for clear-sky conditions, averaged over 1 August 2011 to 31 July 2012 and the areas in North, Central, and South America shown in Figures 1 and 2.

Looking forward, the comparison of the GOES-13 skin temperature retrievals with LST estimates from the GEOS-5 atmospheric analysis system is a necessary step towards the assimilation of the geostationary retrievals into the GEOS-5 system. The spatial and temporal variations of the biases shown in Figures 1 and 3 must be addressed as part of the assimilation system, which can be accomplished using a bias estimation and correction approach. Furthermore, the seasonal variations of the RMSD values (Figure 2) should be reflected in the model and observation error covariances that are required for the assimilation of the satellite observations into GEOS-5. Our analysis also reveals serious issues with cloud modeling in the GEOS-5 atmospheric model during summer over portions of Argentina. These issues manifest themselves in large and counter-intuitive mean differences between the GEOS-5 land surface temperatures and the GOES-13 satellite retrievals, but can only be fully resolved through improvements in the GEOS-5 atmospheric model.

Publication:

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