P2.2 COMPARISON OF LST FROM AIRS AND MODIS FROM THE EOS AQUA PLATFORM

Robert Knuteson*, Jacob Cychosz, Szu Chia Lee, Hank Revercomb, Dave Tobin, and Ken Vinson

Cooperative Institute for Meteorological Satellite Studies (CIMSS)
Space Science and Engineering Center, University of Wisconsin-Madison

A preliminary comparison of Level 3 gridded global land surface products from the EOS Aqua AIRS and MODIS sensors has been made over a 12 month period beginning January 2003. Monthly mean land surface temperature estimates from the Aqua AIRS sensors at 1 degree spatial resolution are compared with the corresponding estimates from the Aqua MODIS sensor averaged over the same spatial domain. Global differences maps in land surface temperature have been produced at 1 degree spatial resolution along with time series plots of the monthly AIRS and MODIS differences for selected geographic regions.

.

1. INTRODUCTION

Global numerical weather prediction (NWP) models assimilate global measurements of atmospheric temperature, water vapor, and winds but use only infrared satellite data not affected by emission from the land surface. This is due to the uncertainty in surface emissivity at the spatial scales needed for atmospheric remote sensing. The accuracy of the land surface temperature derived from satellite infrared observations is dependent on an accurate method for the determination of land surface emissivity. Surface emissivity errors of 1.5 % lead to surface temperature errors of about 1 °C. An improved understanding of land surface infrared emission will address the following two important goals: (1) better utilization of satellite sounding data over land and (2) study of the evolution of land surface characteristics. Observations from the Atmospheric InfraRed Sounder (AIRS) sensor on the EOS Aqua platform provide key information needed to assess the characterization of the land surface at the spatial scales needed for NWP models (Knuteson et al., 2004). A quantitative assessment of the Moderate Resolution Imaging Spectroradiometer (MODIS) operational products has been made by comparing the MODIS MOD11 temperature and emissivity at spatial scales appropriate for comparison to the same products by the AIRS sensor. These comparisons have been applied to selected global observations in order to provide a representative distribution of surface emission characteristics for a range of atmospheric and surface conditions. Level 3 gridded global land surface products from the EOS Aqua AIRS and MODIS sensors are compared over a 12 month period beginning January 2003 at 1 degree spatial resolution. This paper describes the methodology of the comparison of AIRS and MODIS temperature products and provides examples of the comparison for selected months over the Eastern and Western United States.

* *Corresponding author address:* Robert Knuteson, 1225 W. Dayton St., University of Wisconsin-Madison, Madison, WI 53706; robert.knuteson@ssec.wisc.edu

2. INSTRUMENTATION

MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites (King et al., 1995; http://modis.gsfc.nasa.gov). Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths. These data are improving our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS has infrared channels in the 3.5-4 micron and the 8-12 micron windows which are used for determination of the land surface temperature and infrared emissivity at selected narrow bands. The MODIS infrared channels have a spatial resolution of about 1 km at nadir.

The Atmospheric InfraRed Sounder (AIRS) is a research instrument developed by NASA to provide high spectral resolution observations of outgoing infrared emission from the Earth surface and atmosphere for use in the study of weather and climate (Aumann et al., 2003; http://www-airs.jpl.nasa.gov). The AIRS was launched into a sun-synchronous polar orbit aboard the NASA EOS Aqua platform in June 2002. The high spectral resolution AIRS observations are a prelude to similar observations that will be obtained by the CrIS and IASI sensors on the operational NPOESS and METOP platforms. The AIRS uses a grating spectrometer with over 2000 detector elements to obtain a spectral resolving power of about 1200 and a field of view diameter of approximately 15-km at nadir.

The EOS Aqua satellite contains both an AIRS and MODIS instrument on the same platform. The data from these two instruments form the basis of the comparisons shown in this paper. Aqua is in a sun synchronous orbit with a overpass time of approximately 1:30 am (night) and 1:30 pm (day) local time.

3. METHODOLOGY

The AIRS land surface temperature L3 product (version 3.x) was composited on a 1 degree latitude/longitude grid from the standard L2 retrieval products (Susskind et al., 2002). A one degree grid is used because the AIRS standard product is only produced for a 50 km diameter region centered on a 3x3 grid of AIRS pixels. The land surface temperature product is produced from an algorithm that simultaneously retrieved the vertical profile of atmospheric temperature and water vapor. The monthly AIRS composite produced by the AIRS science team was used in this analysis. It should be noted that at the time of writing of this paper, AIRS version 4 processing is underway which will supersede the results shown here. The AIRS version 3 results shown are highly preliminary in nature and may not represent the final AIRS temperature product.

The MODIS land surface temperature L3 product (collection 4 based on MOD11 C1 product; Wan et al., 2004) is produced on a 0.05 degree grid and was reduced to 1 degree grid by averaging. This product makes use of a day/night algorithm to simultaneously retrieve temperature and infrared emissivity under the assumption that the land surface emissivity remains constant over a 5 km grid cell during the time that day and night overpasses are collected. This paper uses the MODIS monthly composite.

The results in this paper are obtained by degrading the MODIS 0.05 degree (about 5 km) surface temperature values to the same 1 degree grid used by the AIRS team in compositing the AIRS land surface temperature with screening using the quality control flags provided. Since the official products are produced independently by the MODIS and AIRS science teams there is no guarantee that a monthly composite will contain coincident measurements in each of the products. The investigation of this and other algorithm specific issues is the subject of further research. The global land surface temperature differences have been produced by month on a 1 degree latitude/longitude grid. Ongoing research is bringing this comparison up to date and incorporating the latest product version releases. In addition detailed investigation of the L1b and L2 swath data is being used on a case study basis.

4. RESULTS

Global gridded comparisons of official AIRS and MODIS land surface temperature products have been generated for the year 2003. Preliminary inspection has shown strong latitudinal and seasonal variations in the product temperature differences that exceed the expectations for product accuracy of either instrument. Figures 1 to 4 are four panel plots showing a comparison of MODIS and AIRS temperature products on a common 1 degree grid for the U.S. during the months of January and July 2003. Figure 5 is a time series of the mean comparison over the eastern U.S. for each month of the year 2003.

5. CONCLUSIONS

Preliminary comparison of the AIRS version 3 and MODIS collection 4 land surface temperature products show significant regional and temporal differences. Maximum differences in regional averages over the U.S. are over 2 degrees Kelvin and show a seasonal dependence. Further investigation will be conducted to identify the source of this discrepancy including inspection of the land surface emissivities associated with these derived temperatures. The differences are not believed to be due to instrument calibration which as been directly validated for MODIS and AIRS window channels. These differences cannot at this time be attributed to either product algorithm but the discrepancies do serve to highlight the value of comparing two well documented data product streams. These studies will provide the clues to a better understanding of the range of conditions when each product is valid. For this reason, the inter-comparison of land surface products from AIRS and MODIS sensors is being conducted under NASA Aqua validation.

ACKNOWLEDGEMENTS

This work was supported by NASA federal grant NNG04GJ46G .

REFERENCES

Aumann, H. H., M. T. Chahine, C. Gautier, M. D. Goldberg, E. Kalnay, L. M. McMillin, H. E. Revercomb, P. W. Rosenkranz, W. L. Smith, D. H. Staelin, L. L. Strow, and J. Susskind, AIRS/AMSU/HSB on the Aqua Mission: Design, Science Objectives, Data Products, and Processing Systems, IEEE Transactions on Geoscience and Remote Sensing, 41, No. 2, pp. 253-264, 2003.

King, M. D., Herring, D. D., & Diner, D. J. (1995). The Earth Observing System (EOS): A space-based program for assessing mankind's impact on the global environment. Optics & Photonics News, 6, 34-39.

Knuteson, R., F. Best, D. DeSlover, B. Osborne, H. Revercomb, and W. Smith, Sr., 2004: Infrared land surface remote sensing using high spectral resolution aircraft observations, Adv. Space Res., Vol. 33, (2004), pp 1114-1119.

Salisbury, J. W., and D'Aria, D. M., “Emissivity of terrestrial materials in the 3-5 μm atmospheric window”, Remote Sensing of Environment, 47, pp. 345-361, 1994.

Susskind, J., C. Barnett, J. Blaisdell, L. Iredell, F. Keita, L. Kouvaris, 2002: Early results from AIRS/AMSU/HSB. Proc. SPIE Earth Observing Systems VIII, San Diego, CA, 5151, 244-251.

Wan, Z., Y. Zhang, Q. Zhang, and Z.-L. Li, (2004,). Quality assessment and validation of the MODIS global land-surface temperature. Int. J. Remote Sens, 25(1), 261-274.

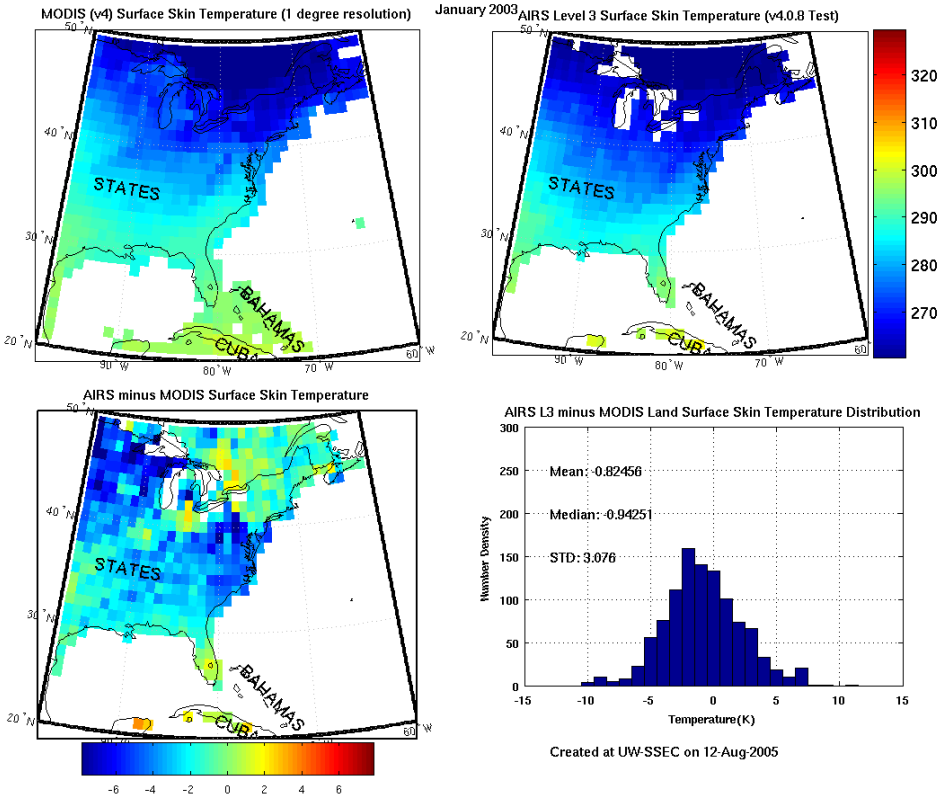

Figure 1. MODIS and AIRS land surface temperature comparison for January 2003 Eastern U.S..

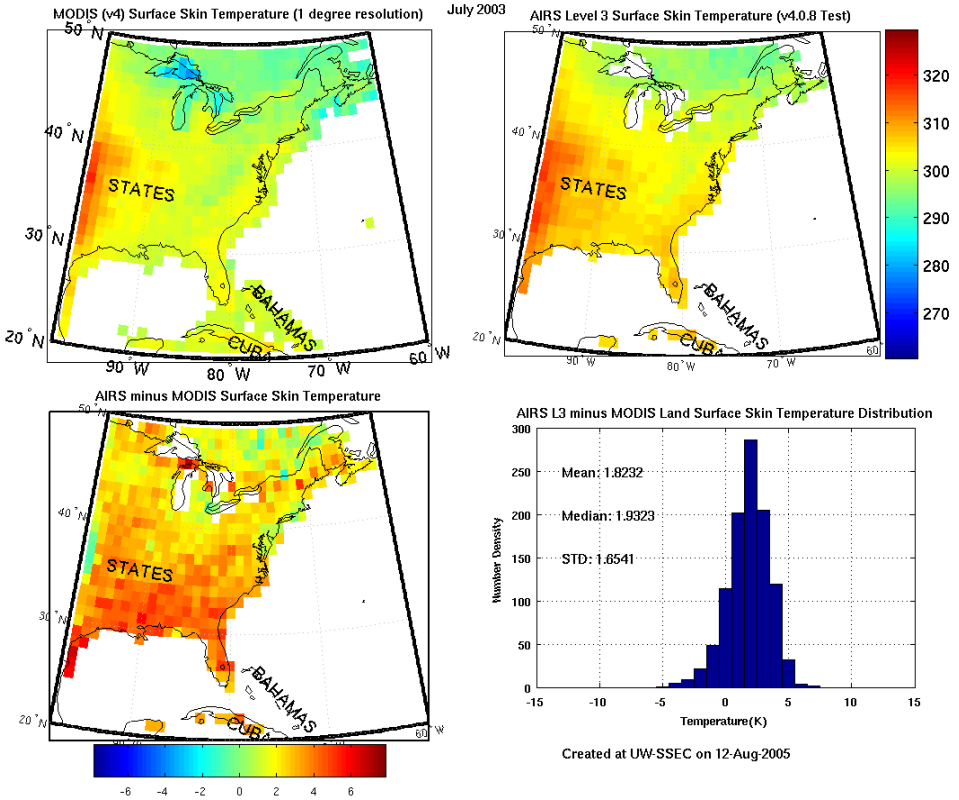

Figure 2. MODIS and AIRS land surface temperature comparison for July 2003 Eastern U.S..

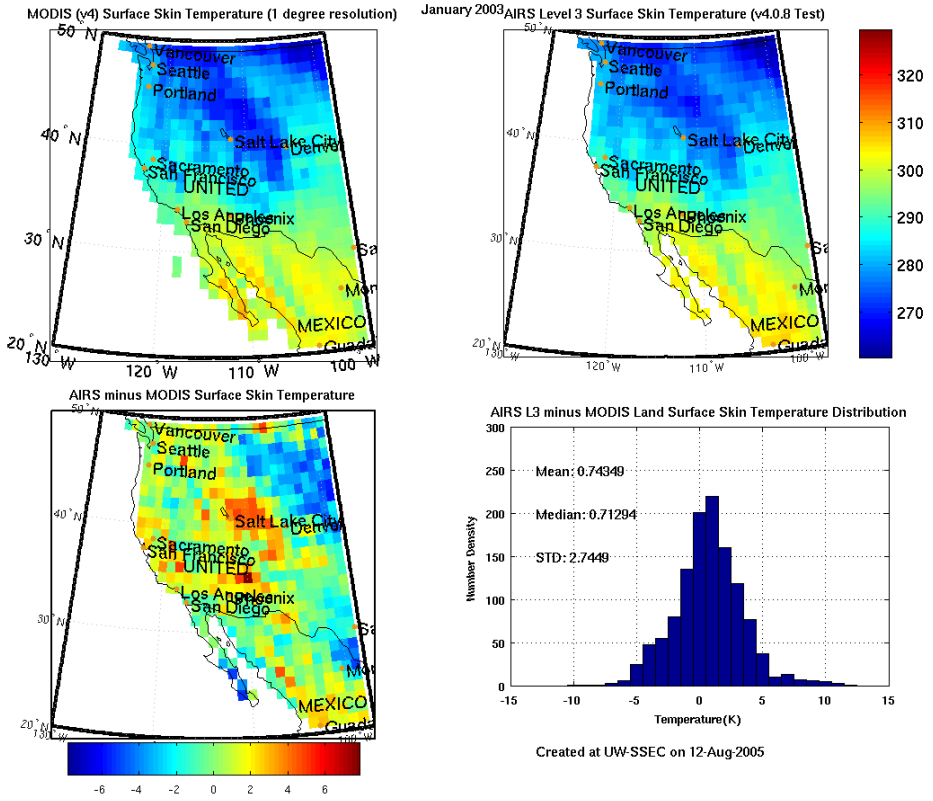

Figure 3. MODIS and AIRS land surface temperature comparison for January 2003 Western U.S..

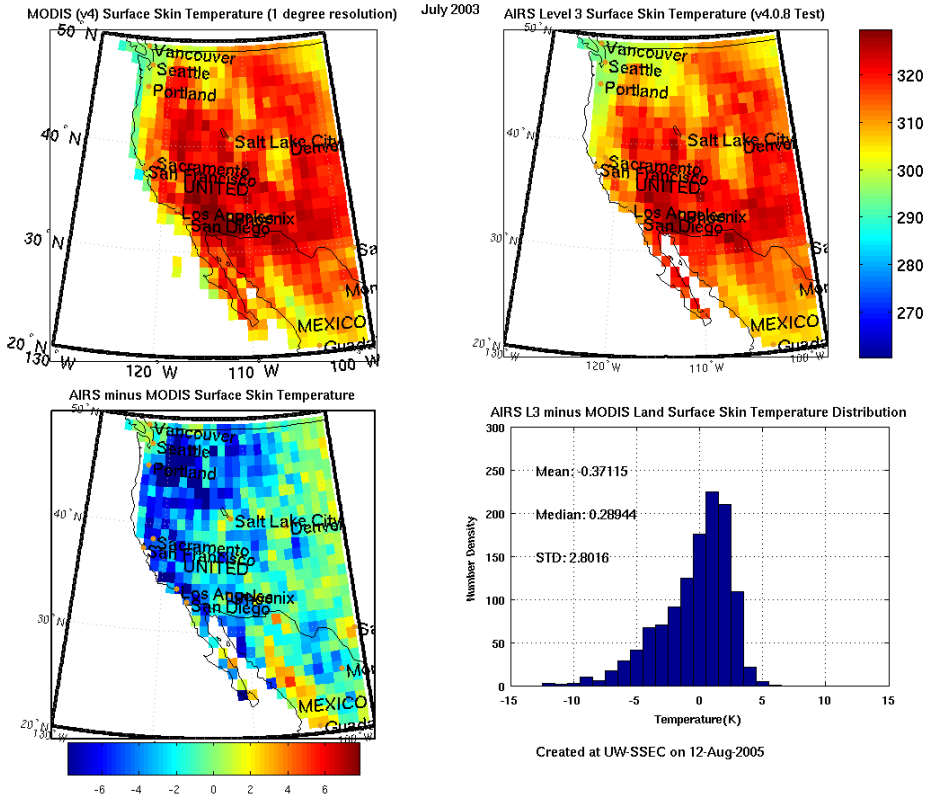

Figure 4. MODIS and AIRS land surface temperature comparison for July 2003 Western U.S..

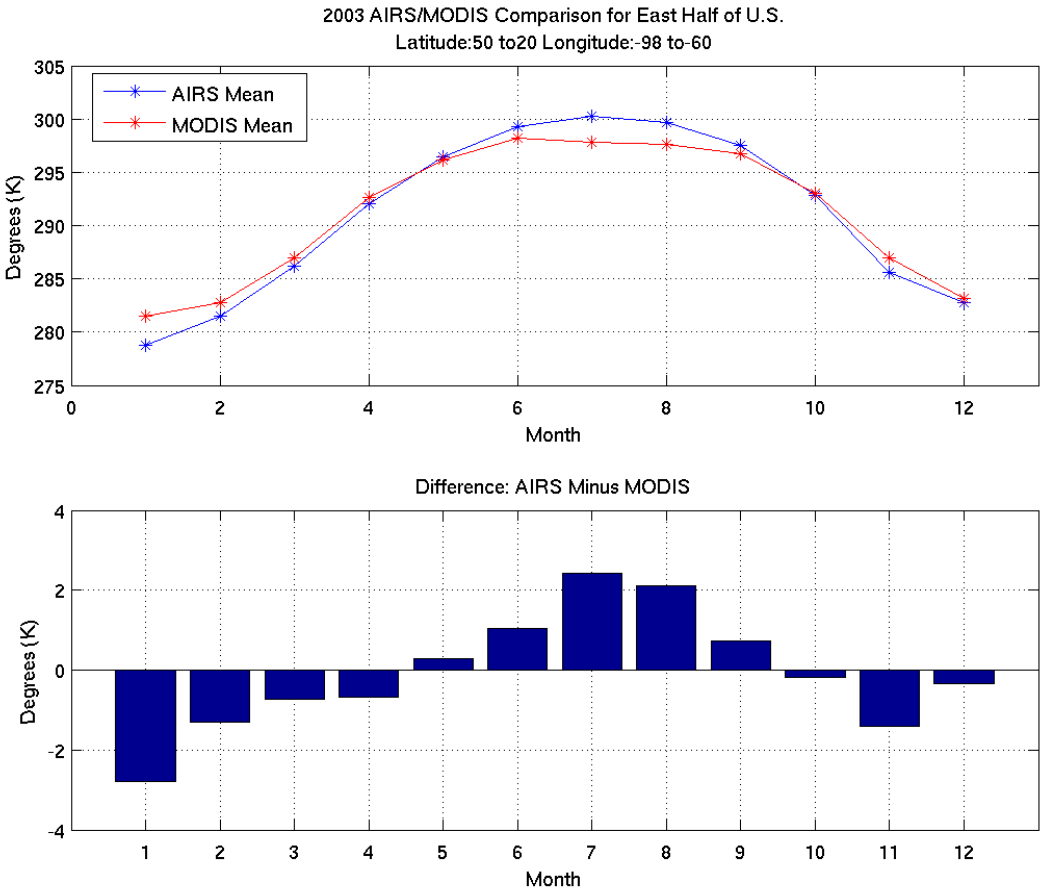

Figure 5. Time series comparison of MODIS (Collection 4) and AIRS (Version 3) land surface temperature for the eastern U.S. for 2003. Results are highly preliminary and will be superseded when AIRS version 4 products become available in late 2005.