Global Distribution and Variability of Surface Skin and Surface Air Temperatures as Depicted in the AIRS Version-6 Data Set

Joel Susskind
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Joel.Susskind@nasa.gov

For questions or comments during AGU poster session call
Joel Susskind (240) 793-6398
GC51D-0446

Background Information

The AIRS Science Team AIRS/AMSU Version-6 Data Set

AIRS is the advanced IR Sounder flying on EOS Aqua accompanied by AMSU, an advanced microwave sounder. There are 9 AIRS 15 km x 15 km Fields of View (FOVs) within a single AMSU A 45 km x 45 km Field of Regard (FOR). AIRS products include land/ocean/surface skin temperature \( T_{skin} \), atmospheric temperature profile \( T(p) \), water vapor profile \( q(p) \), and trace gas profiles; fractional surface skin temperature \( \epsilon_{skin} \) and shortwave spectral bi-directional reflectance \( \alpha_{sw} \), and shortwave spectral surface bi-directional reflectance \( \alpha_{sw} \), and shortwave spectral surface bi-directional reflectance \( \alpha_{sw} \), and shortwave spectral surface bi-directional reflectance \( \alpha_{sw} \), and shortwave spectral surface bi-directional reflectance \( \alpha_{sw} \). AIRS soundings are generated in up to 90% fractional cloud cover. Level-3 products are gridded separately for 1:30 AM orbits and 1:30 PM orbits on a global 1° x 1° spatial grid on a daily, eight day, and monthly mean basis.

Improved AIRS Version-6 Surface Skin Parameters

AIRS Version-6 products are significantly improved over those obtained previously, especially with respect to surface skin temperature \( T_{skin} \) and surface air temperature \( T_{ps} \). These improvements led to the ability to conduct meaningful studies of the global distribution of the difference between surface skin temperature and surface air temperature, as observed by AIRS both 1:30 PM and 1:30 AM local time. We refer to this surface skin/air temperature difference as \( \Delta T_{s,a} \) and it is a very important parameter with regard to the understanding of the sensible heat flux between the Earth’s surface skin and its atmosphere.

Data Sets Used in This Study

This study used the AIRS Science Team Version-6 monthly mean level-3 data for surface skin temperature and surface air temperature, each gridded separately for 1:30 AM and 1:30 PM. Values of \( \Delta T_{s,a} \) are not contained in the Version-6 data set. Data products used extend from September 2002 (the start of the data set) to August 2014. Twelve-month monthly mean climatologies were generated for each 1° x 1° grid box by averaging monthly mean data for all Januarys, Februarys, etc. Similarly, we generated seasonal climatologies for each season. Separate climatologies were generated for 1:30 PM and 1:30 AM. The monthly anomaly for each grid box is the difference of the value for that month from that month’s climatology, and the seasonal anomaly is the difference of the values for that season from its climatology. AIRS level-2 (retrieval by retrieval) and level-3 1° x 1° gridded products can be obtained at the Goddard DISC http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings

Version-6 Generation of \( T_{skin} \) and \( T_{ps} \)

AIRS radiances are very sensitive to changes in \( T_{ps} \) very near the surface. \( T_{ps} \) retrievals are generated by adding vertical component \( \Delta T_{0} \) to the surface temperature profile fine structure \( \Delta T_{0} \). AIRS Version-6 generates for the first time reasonable values of \( T_{ps} \) because the Version-6 Neural-Net first guess \( T_{ps} \) contains very accurate fine level temperature profile fine structure. This was not the case in Version-5, which used a regression guess for \( T_{ps} \).

Summary

We computed level-3 values of surface skin minus surface air temperature, \( \Delta T_{s,a} \) by subtracting level-3 values of \( T_{ps} \) from level-3 values of \( T_{skin} \). Level-3 values of \( \Delta T_{s,a} \) appear to be of high quality with regard to both their climatology and interannual variability. We encourage researchers to study the characteristics of \( \Delta T_{s,a} \) to evaluate if it is currently accurate enough for their research purposes.

Interannual Variability of Surface Skin and Surface Air Temperature Difference \( \Delta T_{s,a} \)

The figures in the panel to the right show the variability of \( \Delta T_{s,a} \) in terms of the behavior of its anomaly time series, as depicted by ARCs and ENCs. The Average Rule of Change (ARC) of a product is the slope of the linear least squares fit to the anomaly time series. The El Niño Correlation (ENC) is the correlation of the anomaly time series with that of the El Niño Index (ENI), which is given by the NOAA Niño-4 SST minus its climatology as computed over the same 12 consecutive years. Results shown are for the average of the 1:30 AM/PM observations, as computed over the period September 2002 through August 2014.

Interannual Variability of Surface Skin and Surface Air Temperature Difference (\( \Delta T_{s,a} \))

ARCs of surface skin and surface air temperatures each show pronounced large scale spatial patterns which are highly correlated with each other. ARCs of surface skin temperature \( T_{skin} \) are generally larger than those of surface air temperature. Surface skin temperatures over the Nino 4 region, which is surrounded by a black rectangle, have cooled over the last 12 years, which started with an El Niño and ended with a La Niña. There has been considerable warming over this period of both surface skin and surface air temperatures at high northern latitudes, but cooling over Greenland. Global mean surface skin and surface air temperature have both warmed at a rate of +0.05 Kyr over this time period.

Anomaly time series of surface skin and surface air temperatures are for the most part each locally highly correlated (or anti-correlated) with the El Niño Index (ENI). ENCs of surface skin temperature are similar to those of surface air temperature, but larger in magnitude. These correlations are the main cause for the patterns of ARCs computed over the time period under study. Regions with positive El Niño Correlations cooled, while regions with negative El Niño Correlations warmed. Surface skin and surface air temperature anomalies in oceanic regions are not highly correlated with El Niño activity. ENCs of surface skin minus surface air temperature are in general small, but they exhibit a strong oscillation centered over Indonesia.

Data Sets Used in This Study

This study used the AIRS Science Team Version-6 monthly mean level-3 data for surface skin temperature and surface air temperature, each gridded separately for 1:30 AM and 1:30 PM. Values of \( \Delta T_{s,a} \) are not contained in the Version-6 data set. Data products used extend from September 2002 (the start of the data set) to August 2014. Twelve-month monthly mean climatologies were generated for each 1° x 1° grid box by averaging monthly mean data for all Januarys, Februarys, etc. Similarly, we generated seasonal climatologies for each season. Separate climatologies were generated for 1:30 PM and 1:30 AM. The monthly anomaly for each grid box is the difference of the value for that month from that month’s climatology, and the seasonal anomaly is the difference of the values for that season from its climatology. AIRS level-2 (retrieval by retrieval) and level-3 1° x 1° gridded products can be obtained at the Goddard DISC http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings

Version-6 Generation of \( T_{skin} \) and \( T_{ps} \)

AIRS radiances are very sensitive to changes in \( T_{ps} \) very near the surface. \( T_{ps} \) retrievals are generated by adding vertical component \( \Delta T_{0} \) to the surface temperature profile fine structure \( \Delta T_{0} \). AIRS Version-6 generates for the first time reasonable values of \( T_{ps} \) because the Version-6 Neural-Net first guess \( T_{ps} \) contains very accurate fine level temperature profile fine structure. This was not the case in Version-5, which used a regression guess for \( T_{ps} \).

Summary

We computed level-3 values of surface skin minus surface air temperature, \( \Delta T_{s,a} \) by subtracting level-3 values of \( T_{ps} \) from level-3 values of \( T_{skin} \). Level-3 values of \( \Delta T_{s,a} \) appear to be of high quality with regard to both their climatology and interannual variability. We encourage researchers to study the characteristics of \( \Delta T_{s,a} \) to evaluate if it is currently accurate enough for their research purposes.