Spatial Correlations of Anomalies of Tropospheric Temperature and Water Vapor, Cloud Cover, and OLR with the El Niño Index

Joel Susskind
NASA Goddard Space Flight Center
Code 610, Earth Sciences Division
Greenbelt, MD 20771
Joel.Susskind@nasa.gov

Lena Iredell
Lena.Iredell@nasa.gov

Jae N. Lee
Jae.N.Lee@nasa.gov

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

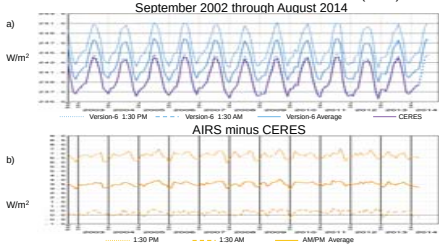
A33A-3161

Background Information

This study uses AIRS Version-6 level-3 products for the 12 year period September 2002 through August 2014 and CERES Edition 2.8 OLR products for the period September 2002 through April 2013, when the CERES data set ends. AIRS1:30 AM and 1:30 PM level-3 products are generated and analyzed separately from each other and each have separate 1°x1° monthly climatologies. AIRS 1°x1° 1:30 AM and 1:30 PM climatologies are based on the average values of parameters for that month for 11 consecutive years, September 2002 through September 2013 (same for October, November, and December) and January 2003 through January 2013 (same for February through August). The CERES climatologies are based on the averages over the same 11 consecutive years as AIRS. The grid point anomaly for a month in a given year is the value of the product for that month minus its climatology. The Average Rate 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 the El Niño Index (**ENI**). The ENI for a given month is the NOAA Niño-4 SST minus its climatology as computed over the same 11 consecutive years.

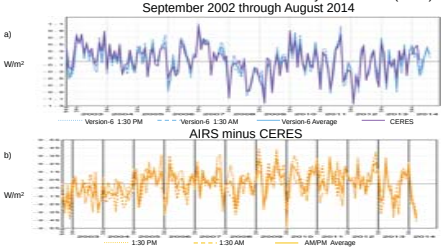
Comparison of Version-6 OLR with CERES Edition 2.8

AIRS and CERES Global Mean OLR Time Series (W/m²)
September 2002 through August 2014



AIRS global mean OLR values at 1:30 AM match those of CERES closely. AIRS values at 1:30 PM are higher than those at 1:30 AM by 7 W/m². This confirms that time of day sampling is important with regard to global mean OLR values.

AIRS and CERES Global Mean OLR Anomaly Time Series (W/m²)
September 2002 through August 2014



AIRS 1:30 AM/PM average anomaly time series matches CERES more closely than do 1:30 AM or 1:30 PM anomaly time series, but they all match well. This agreement validates both the CERES and AIRS OLR data sets from the anomaly perspective.

ARCs of Anomaly Time Series September 2002 through April 2014

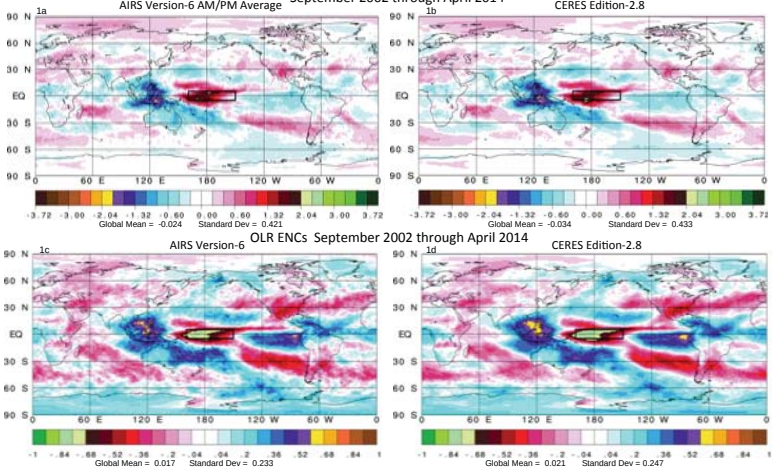
AIRS OLR 1:30 PM W/m²/yr	AIRS OLR 1:30 AM W/m²/yr	AIRS OLR 1:30 AM/PM W/m²/yr	CERES OLR W/m²/yr	ENI K/yr
-0.0264 ±0.0237	-0.0206 ±0.0202	-0.0235 ±0.0215	-0.0335 ±0.0214	-0.0793 ±0.0332

Summary

AIRS Version-6 OLR matches CERES Edition 2.8 OLR very closely globally and on a 1°x1° latitude x longitude scale, both with regard to absolute values, and also with regard to ARCs (anomaly trends) and ENCs of OLR. The largest differences between AIRS and CERES OLR ARCs occur in land areas in which AIRS OLR ARCs differ considerably between 1:30 PM and 1:30 AM. Large contiguous areas contain substantial positive or negative OLR ENCs in the tropics and mid-latitudes, which are of opposite sign to their ARCs because the El Niño Index has decreased over the time period under study. OLR ARCs and ENCs closely follow those of 500 mb specific humidity in the tropics, and follow those of T_{skin} in the extra-tropics. Global mean OLR has decreased over the period September 2002 (El Niño period) through April 2014 (La Niña period) in response to cooling in the Niño-4 area. This result says nothing about global mean OLR changes in the future.

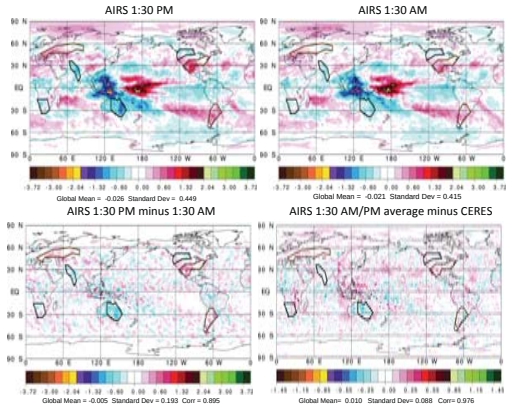
Spatial Relationships of OLR Anomalies with El Niño Activity

AIRS and CERES OLR Anomaly Time Series ARCs (W/m²/yr)
September 2002 through April 2014



Spatially AIRS and CERES OLR ARCs are essentially identical to each other, as are OLR ENCs. Positive OLR ARCs (short term "trends") are shown in red and green, and negative OLR ARCs are shown in blue and orange. OLR ENCs are shown with a reversed color scale compared to ARCs. Patterns of mid-latitude and equatorial OLR ENCs are very similar to those of OLR ARCs, but with opposite signs. This sign reversal occurs because the Niño-4 region has cooled over the period of study. The similarity of OLR ARCs and ENCs in tropical and mid-latitudes regions shows that ARCs in these regions are primarily local responses to El Niño activity. The Niño-4 region is enclosed by a black box in the figures.

OLR ARCs (W/m²/yr)
September 2002 through April 2014



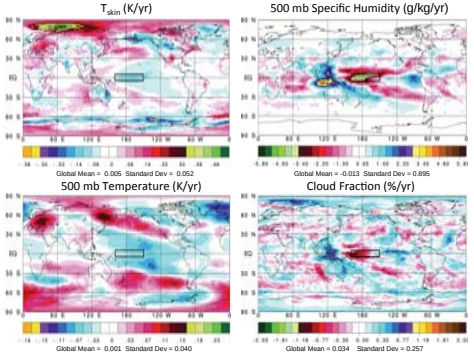
Large **negative** and **positive** AIRS Version-6 OLR ARCs occur in some land areas at 1:30 PM that are reduced considerably at 1:30 AM. A few such areas are indicated in the figures. The difference between global mean 1:30 PM and 1:30 AM OLR ARCs is primarily the result of the large time of day difference in ARCs over Eastern Australia.

AIRS and CERES OLR ARCs agree well both globally and on a 1°x1° spatial scale. The largest differences between AIRS and CERES OLR ARCs occur over Australia, where OLR ARCs are very sensitive to diurnal sampling differences.

Attribution of OLR Variability to those of Component Parts

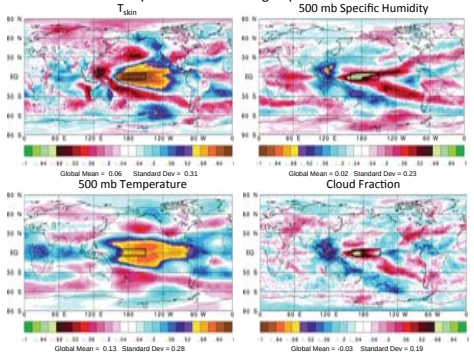
OLR increases with increasing surface skin temperature T_{skin} and atmospheric temperature $T(p)$. OLR decreases with increasing 500 mb specific humidity, especially for very moist cases. OLR also decreases with increasing fractional cloud cover, especially for high clouds. Therefore the color codes of specific humidity and cloud fraction ARCs are reversed compared to those of OLR, T_{skin}, and 500 mb temperature.

AIRS Version-6 ARCs 1:30 AM/PM Average
September 2002 through April 2014



ARCs of 500 mb temperature have generally similar large scale patterns to those of T_{skin}, but are smoother spatially and smaller in magnitude. Tropical OLR ARCs most closely follow those of 500 mb specific humidity. Extra-tropical OLR ARCs most closely follow those of T_{skin}.

AIRS Version-6 ENCs 1:30 AM/PM Average
September 2002 through April 2014



The color codes of ENCs are reversed from those of ARCs. Tropical and mid-latitude anomalies of all parameters are strongly correlated or anti-correlated with El Niño activity. Tropical anomalies of 500 mb temperature are highly positively correlated with the ENI, especially within, and eastward of, the Niño-4 region. These are surrounded, to the north and south, by ENCs of an oscillatory nature. Tropical 500 mb specific humidity ENCs over ocean tend to be in phase with (i.e., have opposite colors compared to) those of T_{skin}. Tropical OLR ENCs primarily follow those of 500 mb specific humidity.