AIRS Water Vapor and Cloud Products Validate and Explain Recent Short Term Decreases in Global and Tropical OLR as Observed by CERES

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A43B-202

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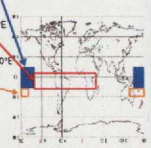
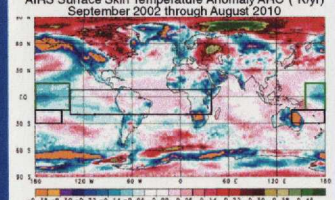
Effects of El Niño on OLR

Important Highlighted Regions

1) **El Niño Region:** 15°N to 15°S, 140°W westward to 160°E
We define the El Niño Index as the monthly mean T_{skin} anomaly averaged over the El Niño region
2) **OLR Region 1:** 8°N to 20°S, 140°W, eastward to 40°E
East of El Niño region
3) **OLR Region 2:** 15°S to 30°S, 160°W, westward to 140°E
South of El Niño region

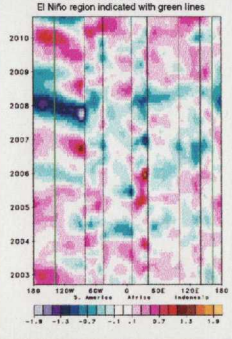


AIRS Surface Skin Temperature Anomaly ARC (°K/yr) September 2002 through August 2010



Surface Skin Temperature Anomaly (K) 8°N to 20°S

El Niño region indicated with green lines



Effects of Recent Anomaly Time Series in Sea Surface Temperature on those of Water Vapor, Clouds, and OLR

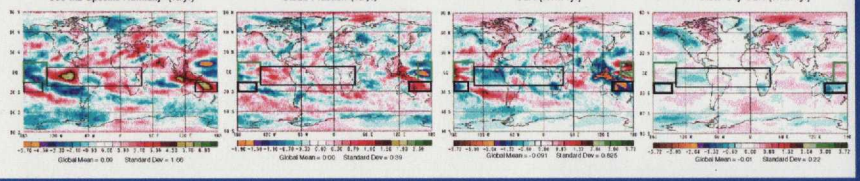
A strong equatorial SST cooling occurred from 160E westward to 120W during the period September 2002 through August 2010, surrounded by a weaker warming ring to the west. This is the result of a transition from a strong El Niño in late 2002 to a strong La Niña in 2008. Late 2009 is characterized by the beginning of another El Niño.

Average rates of change (ARC's) in 500mb specific humidity and cloud cover are in phase with those of SST in the El Niño and surrounding region causing OLR to decrease significantly near the dateline and increase in the vicinity of Indonesia. Tropical OLR ARC's in these two areas cancel each other to first order.

The negative zonal mean tropical OLR ARC results from a drop in equatorial OLR in region 1 from 140W to 40E. This results from increasing water vapor and cloud cover in this area during La Niña, with the reverse holding during El Niño.

AIRS Anomaly Average Rates of Change September 2002 through August 2010

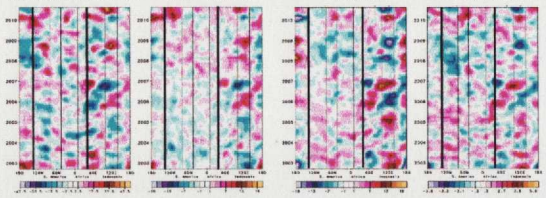
500 mb Specific Humidity (%/yr) | Cloud Fraction (%/yr) | OLR (W/m²/yr) | Clear Sky OLR (W/m²/yr)



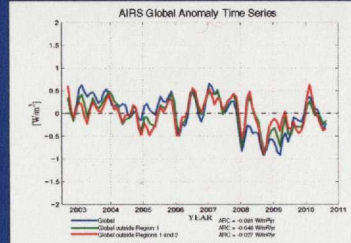
AIRS Monthly Anomalies September 2002 through August 2010

Tropics 8N to 20S Region 1 enclosed in thick black lines

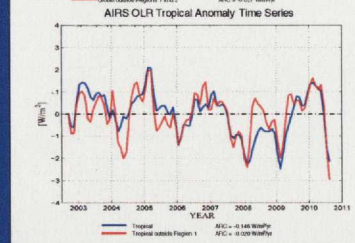
500 mb Specific Humidity (%) | Cloud Fraction (%) | OLR (W/m²) | Clear Sky OLR (W/m²)



AIRS Global Anomaly Time Series



AIRS OLR Tropical Anomaly Time Series



Attribution of Negative OLR Average Rate of Change for the Period September 2002 through August 2010 to OLR Changes in Regions 1 and 2

Recent negative global and tropical OLR ARC's are a result of phases of El Niño/La Niña oscillations

The Region 1 (8 N to 20 S, 140 W eastward to 40 E) OLR anomaly is highly correlated with the El Niño index three months earlier

2002 El Niño resulted in positive anomalies of atmospheric water vapor and cloud cover and negative anomalies of OLR over Region 1

The opposite situation occured during the 2008 - 2009 La Niña

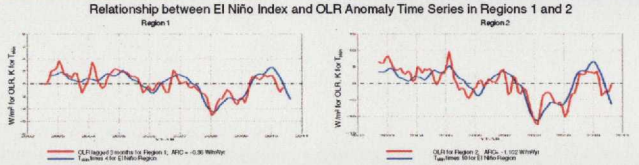
The Region 2 (20 S to 30 S, 160 W westward to 140 E) OLR anomaly is highly correlated with the concurrent El Niño index

The tropical OLR ARC of -0.146 W/m²/yr is reduced to -0.020 W/m²/yr outside of Region 1 for the tropics

The global OLR ARC of -0.091 W/m²/yr is reduced to -0.048 W/m²/yr outside of Region 1 and to -0.027 W/m²/yr outside of both Region 1 and Region 2

Relationship between El Niño Index and OLR Anomaly Time Series in Regions 1 and 2

Region 1 | Region 2



Significance of AIRS OLR and Clear Sky OLR

AIRS OLR is a computed product for each AIRS field of regard (FOR) using an OLR RTA

Input data is AIRS retrieved T_{skin}, ε_s, $T(p)$, $q(p)$, O_3, α_c, and p_{cloud}

AIRS Clear Sky OLR is also computed for each AIRS FOR using same retrieved parameters but setting $\alpha_c = 0$

CERES OLR is a measured product

If anomalies and short term ARC's of AIRS OLR closely match those of CERES OLR, then

This validates anomalies and short term ARC's of both AIRS and CERES OLR
This indirectly validates anomalies and short term ARC's of AIRS retrieved products
In addition, anomalies and short term ARC's of OLR can now be attributed to those of its component parts

Comparison of AIRS and CERES OLR

Data Used

AIRS monthly mean data obtained from Goddard DISC (Level -3).
Presented on a 1°x1° latitude-longitude grid
1:30 AM and 1:30 PM monthly mean values extracted separately and averaged together
Data extends from September 2002 through November 2010

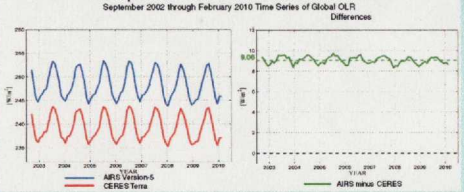
CERES SSF1 monthly mean OLR obtained from Langley ASDC
Presented on a 1°x1° latitude-longitude grid
CERES Edition-2.5 Terra extends only to February 2010

Approach: Comparison of AIRS Version-5 monthly OLR products with Terra CERES Edition-2.5 monthly mean OLR products for the overlap time period September 2002 through February 2010

CERES Aqua OLR had calibration problems in the early part of the mission and was not used for comparison purposes of CERES and AIRS anomalies.

Comparison of OLR Observations

September 2002 through February 2010 Time Series of Global OLR



Findings from Time Series of Global OLR

AIRS OLR and CERES Terra are biased with respect to each other with a small seasonal cycle

These biases are essentially constant over the 7½-year time period studied
This implies global mean ARC's of AIRS and CERES Terra OLR might agree well
To first order, both the large bias and its small seasonal cycle will be removed in the anomaly time series

AIRS version-6 OLR uses a new OLR RTA that essentially removes the 9.0 W/m² bias between AIRS and CERES Terra Edition-2.5 OLR
The new RTA was developed by AER
The improvement is mainly in the characterization of the H_2O rotation band near 300 cm⁻¹
AIRS version-6 OLR is roughly 8.5 W/m² lower than AIRS version-5 OLR

Definition of Anomalies and Short Term Average Rate of Change (ARC)

For Comparison purposes we used 7-year climatologies of AIRS and CERES

7-year monthly climatologies were generated for each grid box by averaging data for 7 Januaries, 7 Februaries, ...

The monthly anomaly for each grid box is the difference of the value for that month from its climatology

The short term average rate of change (ARC) for a grid box is the slope of the straight line passing through the 90 monthly anomaly time series (September 2002 through February 2010)

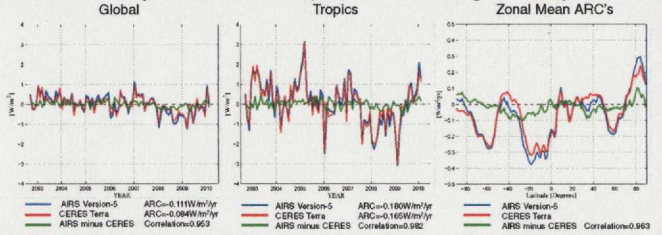
The area mean ARC is the cosine latitude weighted ARC over the area

For process studies, 8 years of AIRS products were used as well as 8-year climatologies

Validation of OLR Anomalies and Average Rates of Change

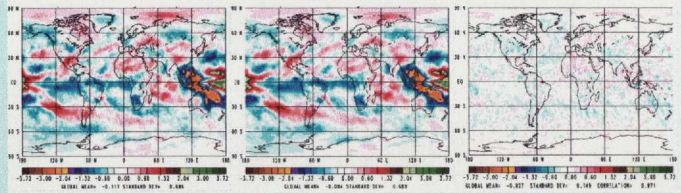
OLR Anomaly Time Series September 2002 through February 2010

Global | Tropics | Zonal Mean ARC's



OLR Anomaly Average Rate of Change September 2002 through February 2010

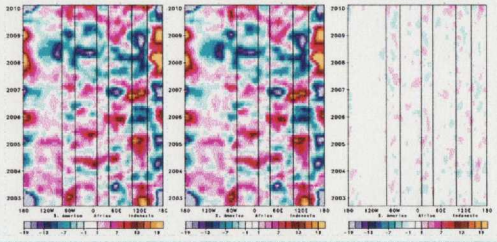
AIRS | CERES | AIRS minus CERES



Monthly Mean OLR Anomaly (W/m²) Tropics 5N to 5S

AIRS | CERES | AIRS minus CERES

Correlation = 0.993



Validation Summary

AIRS and CERES Terra OLR anomaly time series agree well in every detail in the 7½-year period under study

Global OLR decreased at a rate of roughly 0.1 W/m²/yr over the time period September 2002 through February 2010.
The majority of this global decrease originated in the tropics

OLR ARC's over this time period are not indicative of future long term OLR changes

Agreement of all details of anomaly time series as determined by both CERES and AIRS imply they are real.

It is desirable to maintain CERES and AIRS class instruments (or better) in the future, to corroborate, verify, and explain future OLR measurements.