# AIRS Products Explain the Close Relationship between OLR Anomalies and the El Niño Index

Joel Susskind, Gyula Molnar, Lena Iredell

NASA GSFC Sounder Research Team

AIRS Science Team Meeting

April 24, 2012
Pasadena, CA

# Outline

- Comparison of AIRS and CERES anomaly time series of OLR
- Explanation of recent decreases in global and tropical mean values of OLR
- Data Sets Used
  - AIRS Science Team Version-5 monthly mean data obtained from Goddard DISC (level-3)

    OLR, $T_{skin}$, $q_{500}$, cloud fraction

    Data products extend to March 2012
  - CERES Science Team monthly mean data obtained from Langley ASDC

    CERES Terra EBAF (Energy Balanced And Filled) Edition 2.6r

    Data products extend to June 2011
  - AIRS/CERES comparisons are done for the period September 2002 through June 2011

# Definition of Anomalies, ARC's and ENC's

Eight-year monthly climatologies were generated for each grid box by averaging data for eight Januaries, eight Februaries, ……

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

The Average Rate of Change (ARC) for a grid box is the slope of the straight line passing through the monthly anomaly time series

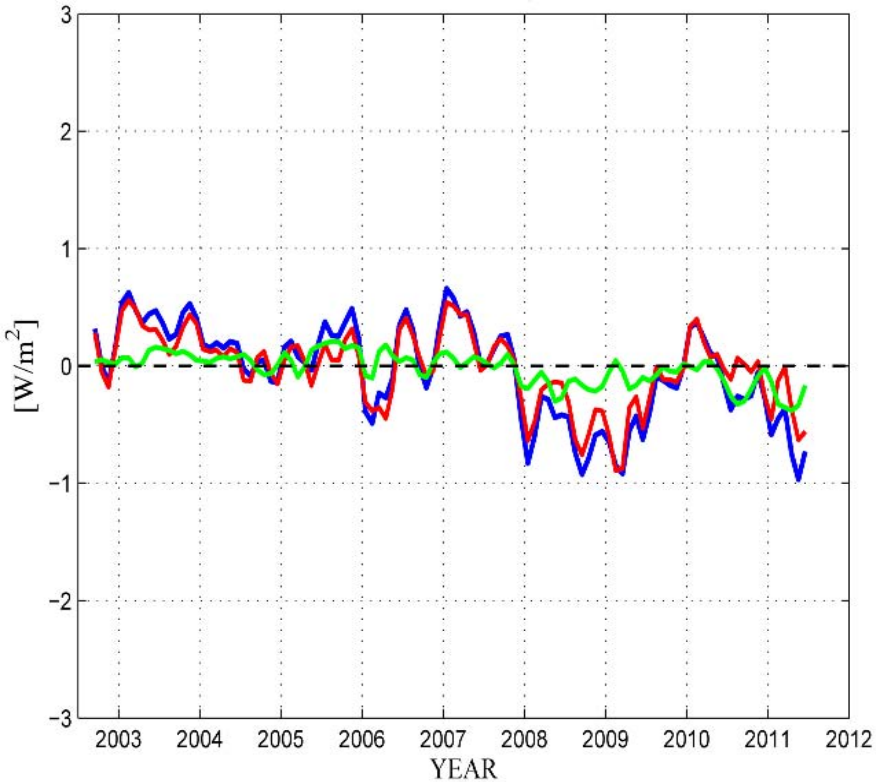
- Values of ARC's depend on the extent of the time series used
- Spatial patterns are more important than precise values

An area mean ARC is the cosine latitude weighted average ARC over the area

The El Niño Correlation (ENC) for a given grid point is the temporal correlation of the anomaly time series for that grid point with the El Niño Index. ENC's should be less time period dependent

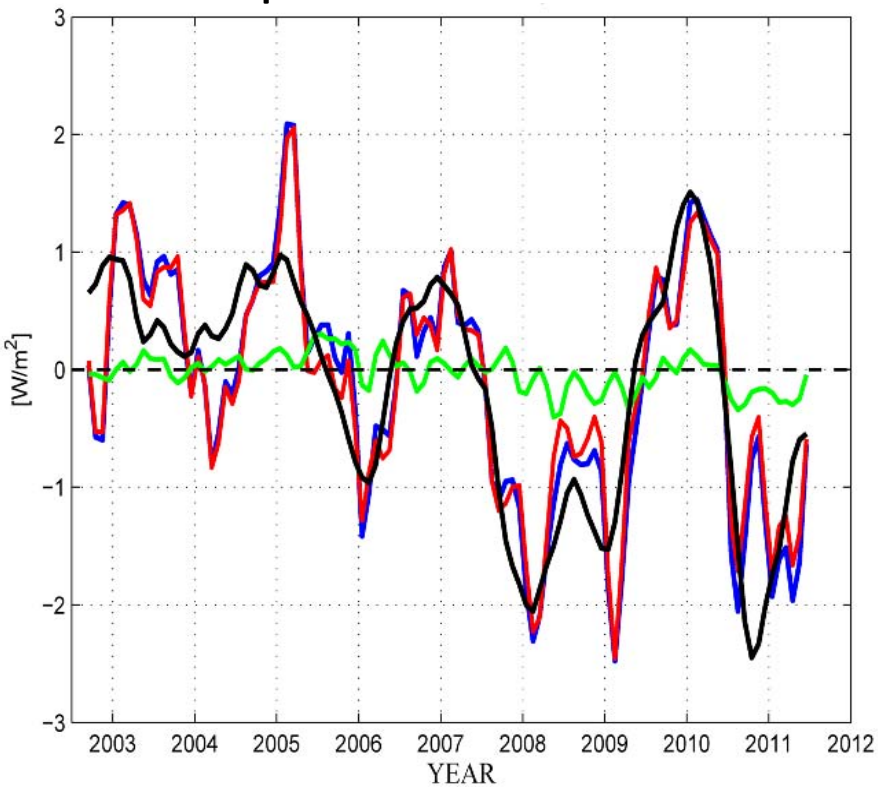
# OLR Anomaly Time Series
# September 2002 through June 2011

## Global Mean




- AIRS
- CERES
- AIRS minus CERES

## Tropical Mean




- AIRS
- CERES
- AIRS minus CERES
- 1.5 times the El Niño Index

El Niño Index ARC = -0.123 ± 0.046 K/yr

# OLR Anomaly Time Series Comparison
# September 2002 through June 2011

| Data Set | Global | Tropical |
|---|---|---|
| AIRS ARC ($W/m^2/yr$) | −0.094 ± 0.026 | −0.183 ± 0.070 |
| CERES Terra ARC ($W/m^2/yr$) | −0.059 ± 0.022 | −0.154 ± 0.066 |
| AIRS Minus CERES STD ($W/m^2$) | 0.136 | 0.155 |
| AIRS/CERES Correlation | 0.955 | 0.991 |
| AIRS ENC | 0.587 | 0.830 |
| CERES ENC | 0.523 | 0.813 |

AIRS and CERES global mean and tropical mean anomaly time series agree very closely with each other

Both show that global, and especially tropical, mean OLR have decreased over the time period under study

# Important Highlighted Regions in Subsequent Figures

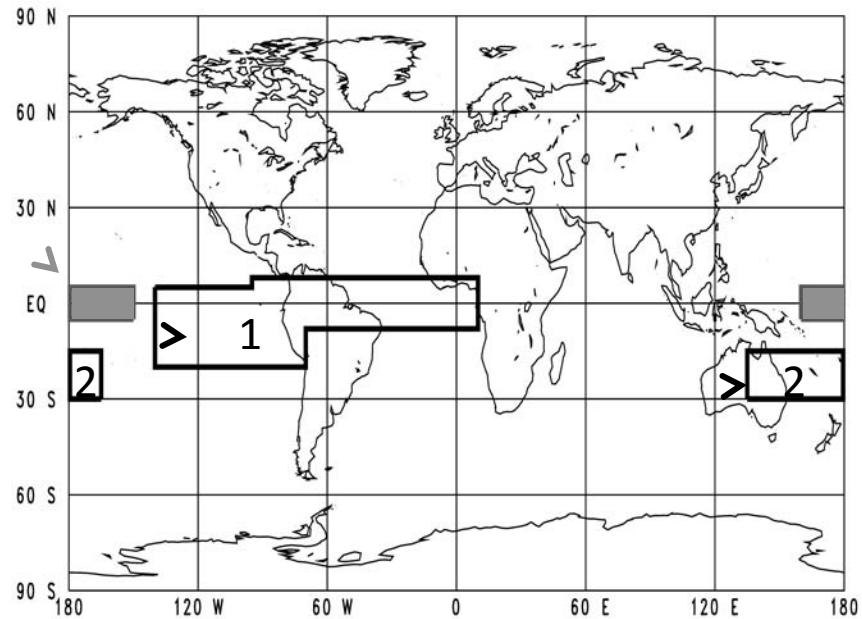
**NOAA Niño-4 Region:** We define the El Niño Index as the NOAA monthly mean $T_{skin}$ anomaly averaged over the NOAA Niño-4 region 5°N to 5°S, 150°W, westward to 160°E

**OLR Region 1:**

East of El Niño region

**OLR Region 2:**

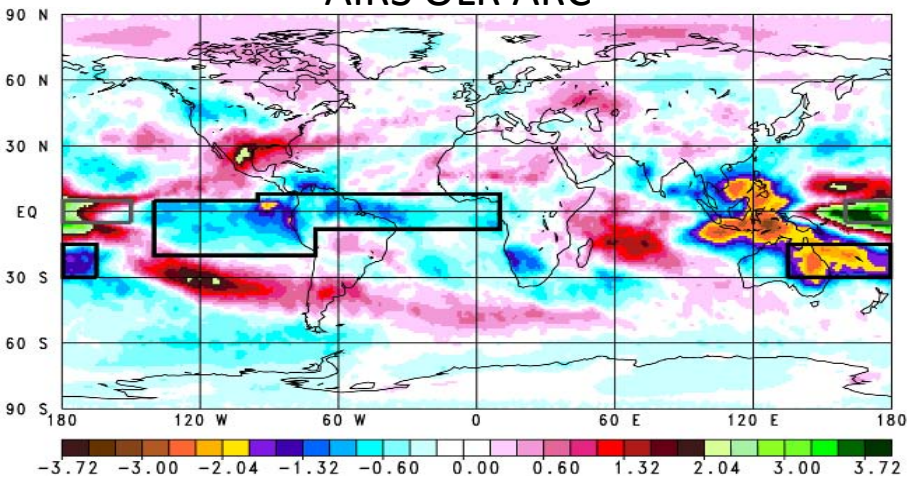
South/Southwest of El Niño region




OLR Regions 1 and 2 encompass key features shown in subsequent figures

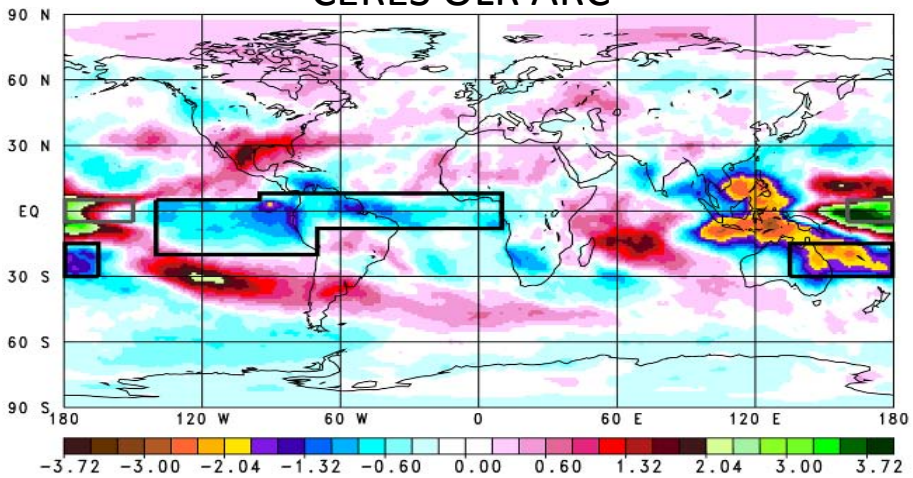
# September 2002 through June 2011

## AIRS OLR ARC



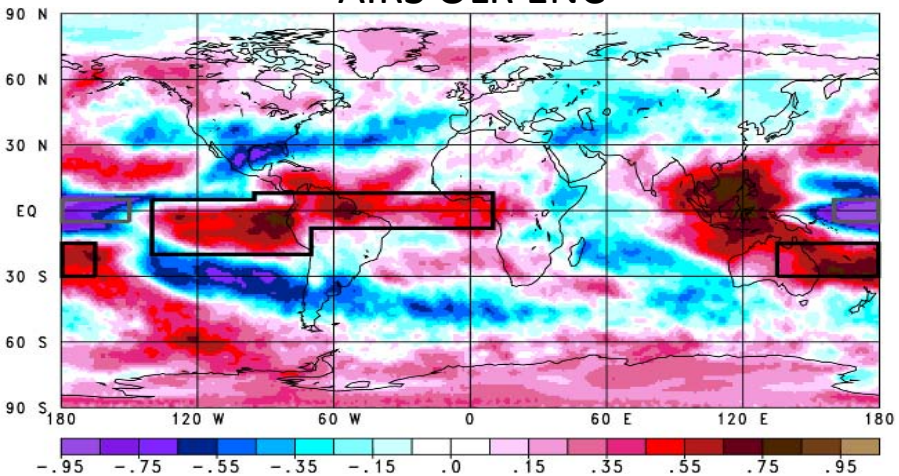

Global Mean = -0.094 STD = 0.82

## CERES OLR ARC



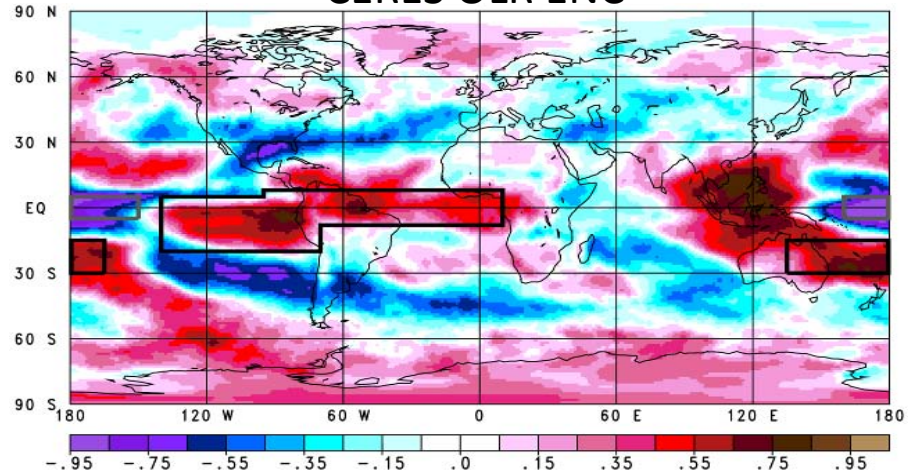

Global Mean = -0.059 STD = 0.82

## AIRS OLR ENC




Global Mean = 0.04 STD = 0.33

## CERES OLR ENC

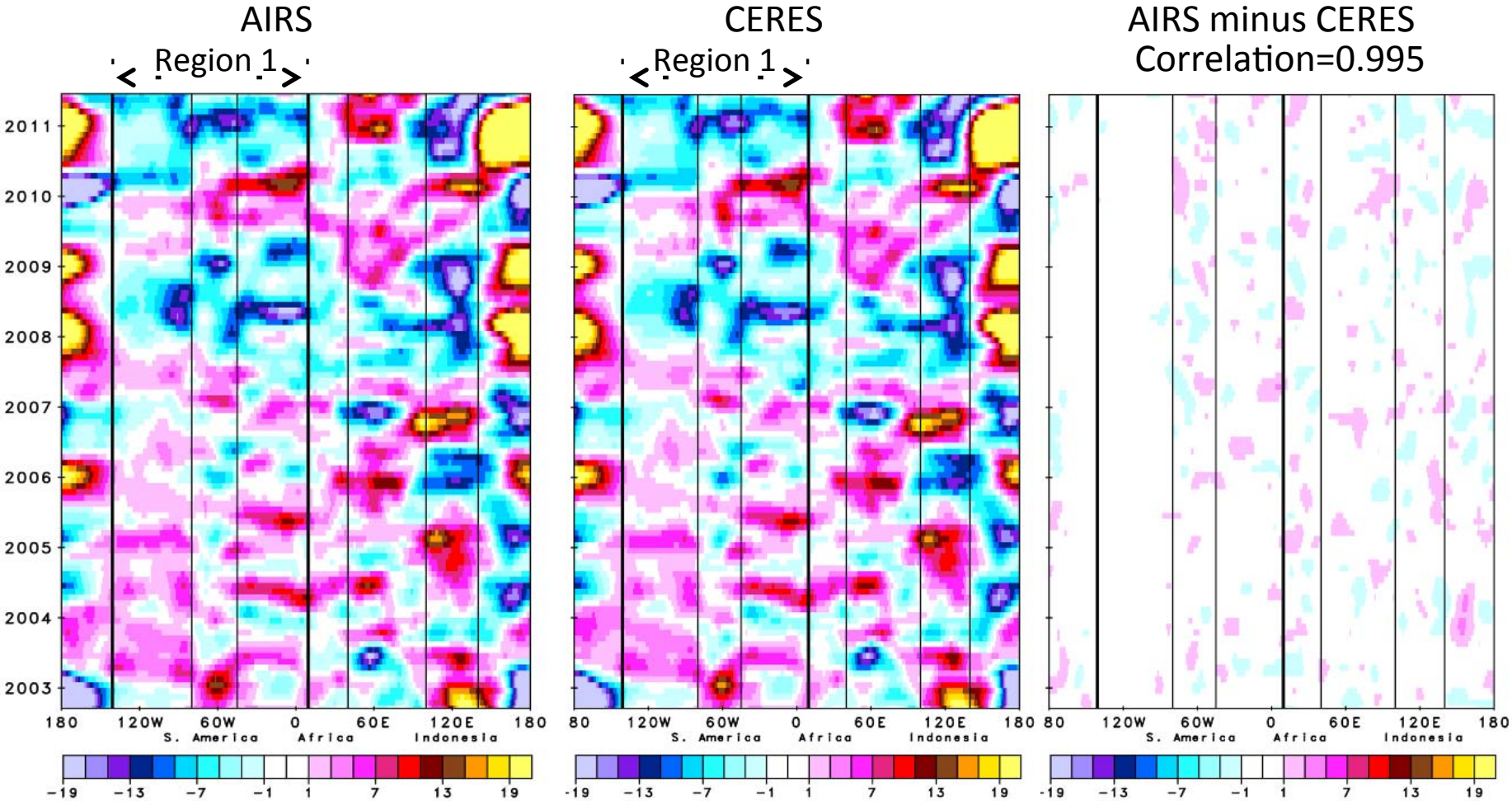



Global Mean = 0.03 STD = 0.36

OLR ARCs are very negative over Regions 1 and 2

OLR ENCs are very positive over Regions 1 and 2

# OLR Anomalies Tropics 5°N to 5°S
# Monthlies, September 2002 through June 2011

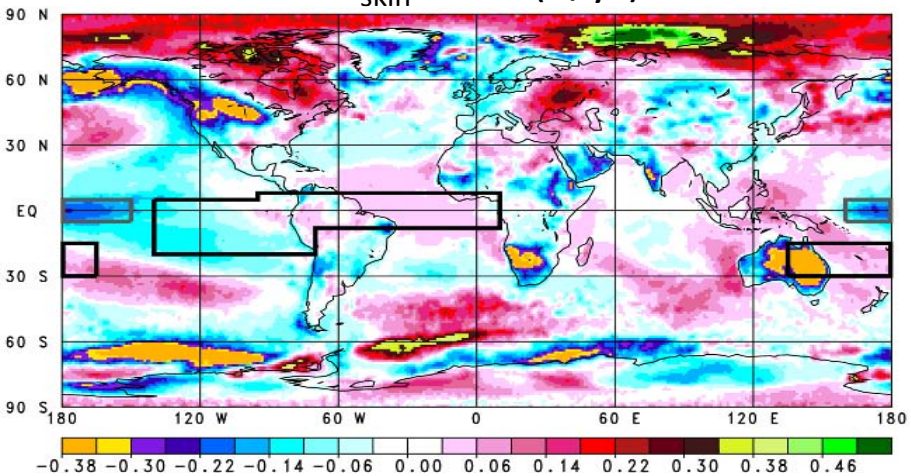



Equatorial OLR anomalies near the dateline are roughly equal, and of opposite sign, to those over Indonesia

Equatorial OLR anomalies within Region 1 are smaller than, and of opposite sign to, those near the dateline but are uncompensated for

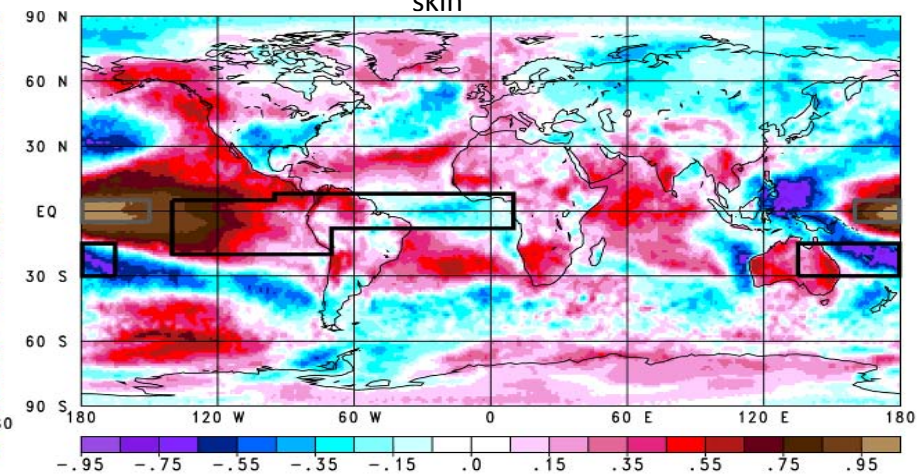
# AIRS Products September 2002 through June 2011

$T_{skin}$ ARCs (K/yr)



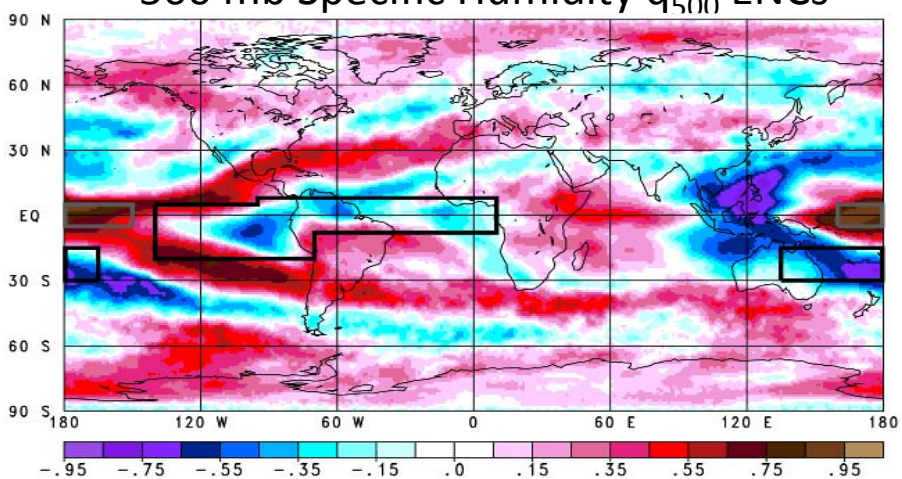

Global Mean = -0.01 STD = 0.10

$T_{skin}$ ENCs



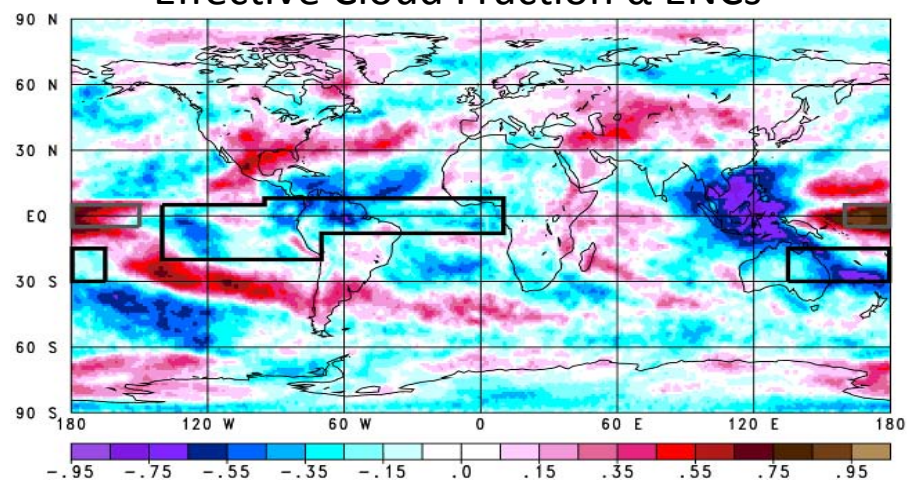

Global Mean = 0.08 STD = 0.35

500 mb Specific Humidity $q_{500}$ ENCs




Global Mean = 0.06 STD = 0.34

Effective Cloud Fraction α ENCs

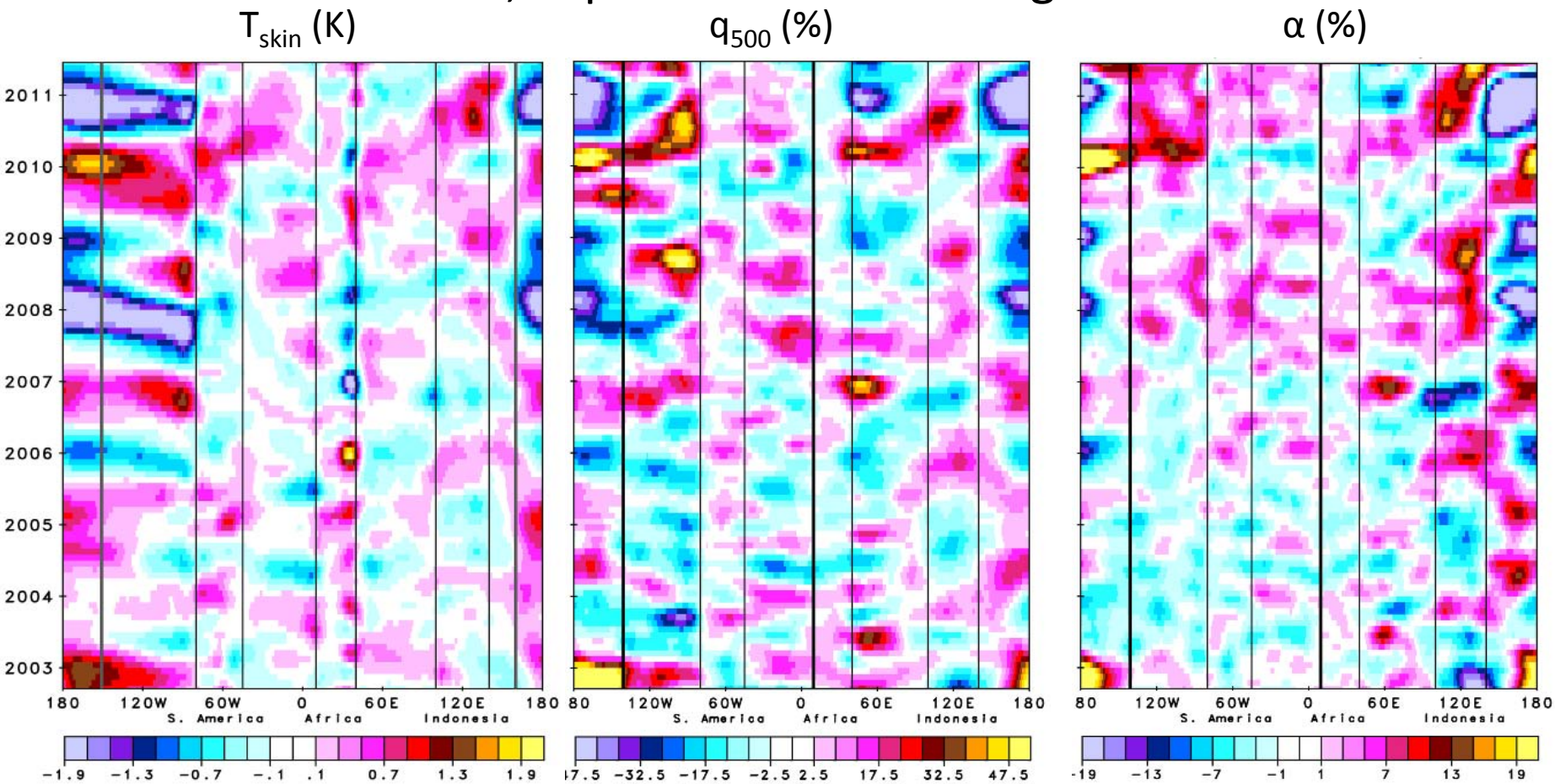



Global Mean = -0.08 STD = 0.28

$T_{skin}$ ARCs and ENCs are for the most part of opposite sign. This shows most ARCs are El Niño driven, except near the North Pole

ENCs of $q_{500}$ and α are similar to each other and are both very negative over OLR Regions 1 and 2

# AIRS Anomalies Tropics 5°N to 5°S
# Monthlies, September 2002 through June 2011




α and $q_{500}$ anomalies are in phase with those of $T_{skin}$ near the dateline and over Indonesia

α and $q_{500}$ anomalies in Region 1 are often out of phase with those at the dateline

| | AIRS | | CERES | |
|---|---|---|---|---|
| Spatial Area | OLR ARC ($W/m^2/yr$) | OLR ENC | OLR ARC ($W/m^2/yr$) | OLR ENC |
| Region1 | -0.631 ± 0.158 | 0.767 | -0.611 ± 0.154 | 0.761 |
| Region 2 | -1.660 ± 0.348 | 0.818 | -1.534 ± 0.348 | 0.825 |
| Global without Region 1 | -0.044 ± 0.020 | 0.256 | -0.011 ± 0.019 | 0.039 |
| Tropical without Region 1 | -0.037 ± 0.048 | 0.599 | -0.011 ± 0.047 | 0.511 |
| Global without Region 1&2 | -0.011 ± 0.021 | -0.098 | 0.021 ± 0.020 | -0.331 |
| Tropical without Region 1&2 | -0.005 ± 0.045 | 0.468 | 0.022 ± 0.044 | 0.362 |

# Summary

Recent AIRS and CERES OLR anomaly time series are in very close agreement on a 1° spatial scale

Both show a significant decrease in global mean and tropical mean OLR over the period September 2002 through June 2011

The degree of agreement is remarkable but the recent OLR decrease is not because it is the result of a transition from El Niño conditions to La Niña conditions

- The recent decrease in global and tropical mean OLR results from the very large negative correlations of water vapor and cloud cover in OLR Regions 1 and 2 with the El Niño Index
- Global and tropical mean OLR anomaly time series evaluated outside of Regions 1 and 2 show very little change over the period September 2002 through June 2011

My Version-6 validation talk on Thursday shows AIRS Version-6 OLR will agree even more closely with CERES OLR in terms of both absolute value and spatial anomaly trends