

# Surface and Atmospheric Response to El Niño Activity

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AIRS Sounder Science Team Meeting  
Pasadena, California  
March 18, 2014



# AIRS Version-6 Level-3 Products Used

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OLR, cloud fraction, 500 mb specific humidity, and surface skin temperature

AIRS level-3 products cover the period September 2002 through January 2014

1:30 PM and 1:30 AM level-3 products are analyzed separately from each other and have separate  $1^{\circ}\times 1^{\circ}$  monthly climatologies



# Climatologies

1°x1° 1:30 PM and 1:30 AM climatologies are based on the average value of that month for 10 consecutive years

Sept 2002 – Sept 2011      Same for Oct, Nov, Dec

Jan 2003 – Jan 2012      Same for Feb-August

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 our El Niño Index (ENI)

The ENI for a given month is the NOAA Niño-4 SST minus its climatology as computed over the same 10 consecutive years



# Part 1

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## **Comparison of Version-6 OLR with CERES Edition 2.7**

September 2002 through June 2013 when Edition 2.7 currently ends

Edition 2.7 uses both Terra CERES and Aqua CERES

CERES climatologies are based on the same 10 consecutive years as AIRS

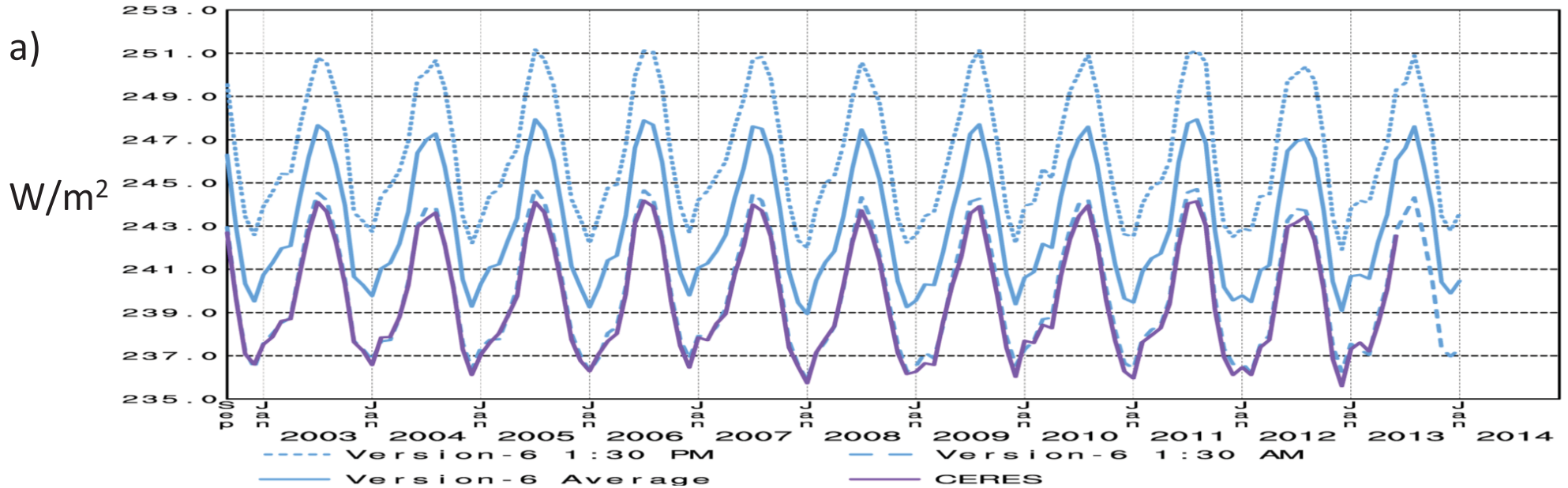
Agreement validates both the CERES and AIRS OLR data sets

This study also depicts the spatial relationship of OLR anomalies with El Niño activity



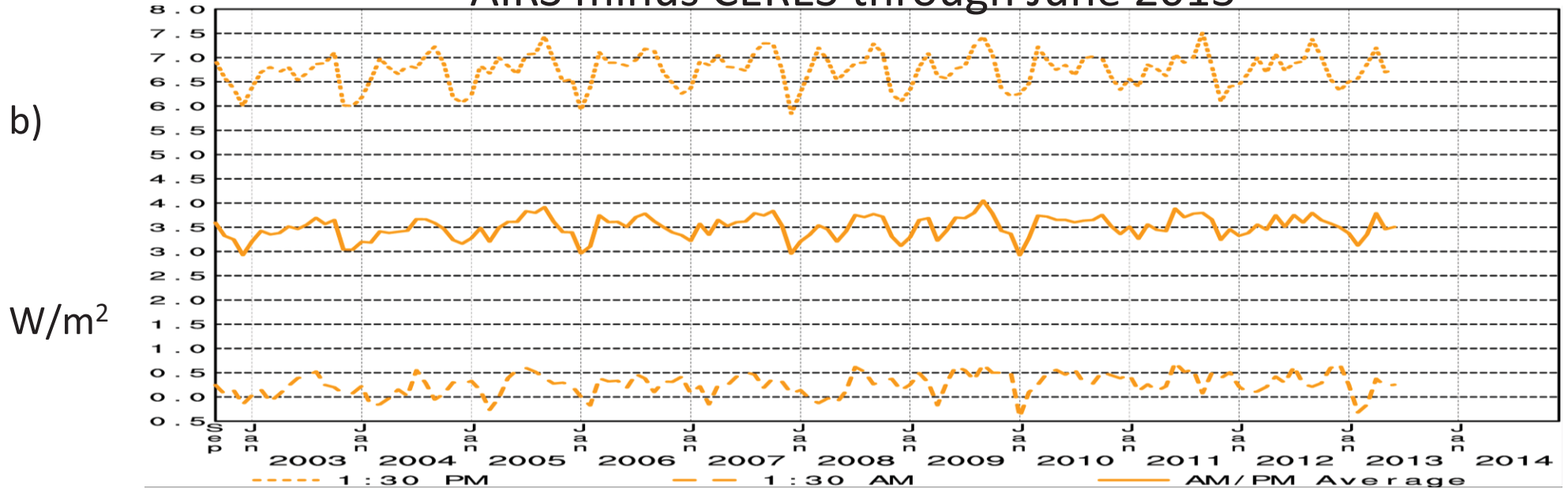
# AIRS and CERES Global Mean OLR Time Series ( $W/m^2$ ) September 2002 through January 2014

a)



## AIRS minus CERES through June 2013

b)



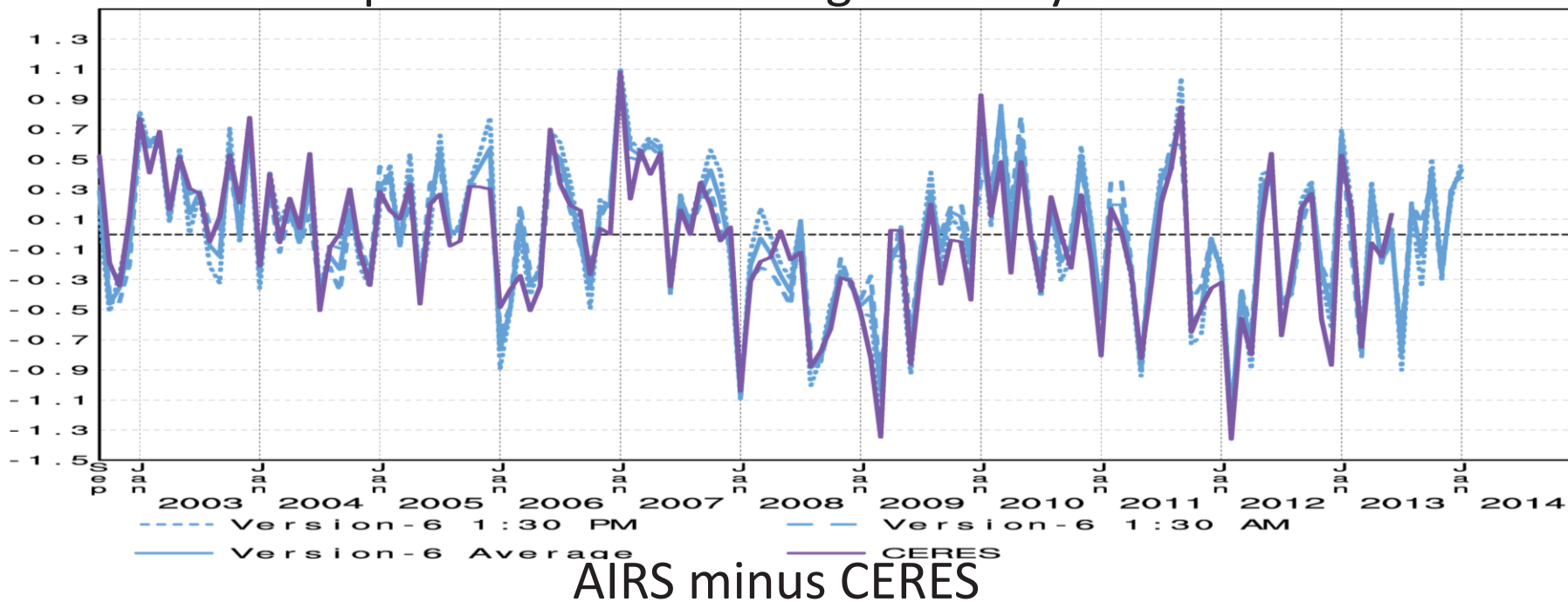
AIRS OLR values at 1:30 AM match those of CERES closely. AIRS values at 1:30 PM are higher than those at 1:30 AM by 7  $W/m^2$ . This confirms that time of day sampling is important with regard to OLR mean values.



# AIRS and CERES Global Mean OLR Anomaly Time Series ( $W/m^2$ ) September 2002 through January 2014

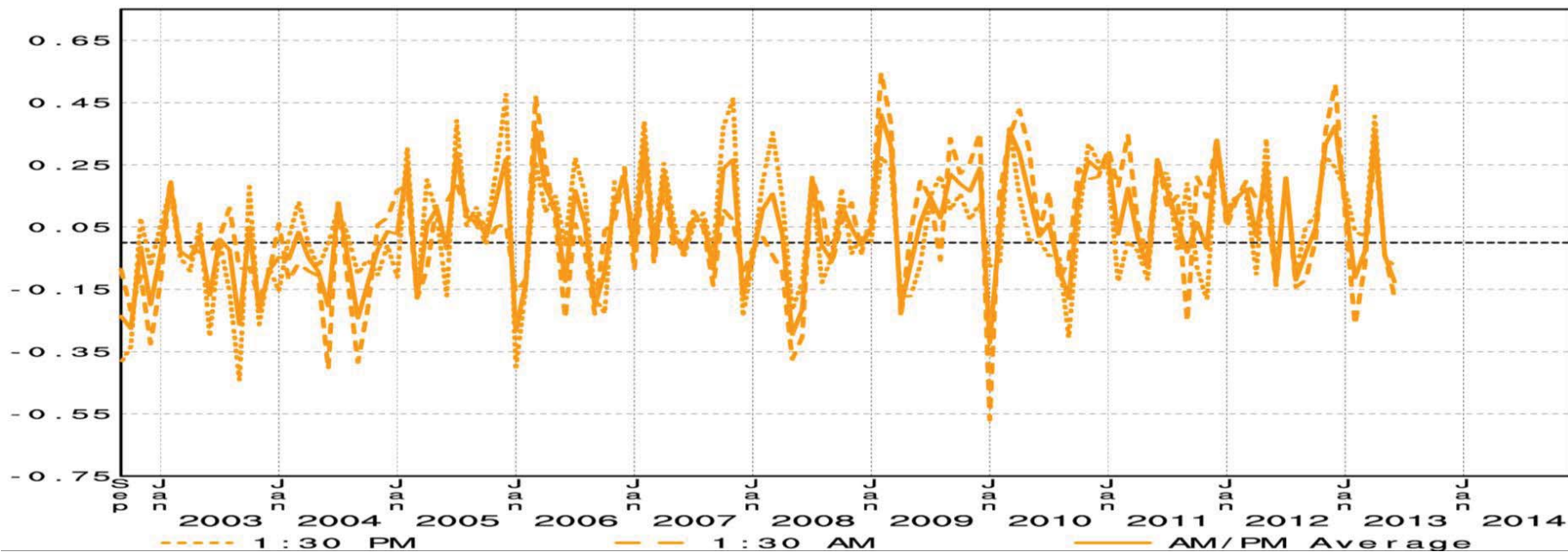
a)

$W/m^2$



b)

$W/m^2$



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 all match CERES very well





# Comparison of AIRS and CERES Global Mean OLR Anomaly Time Series September 2002 through June 2013

	<b>AIRS 1:30 PM</b>	<b>AIRS 1:30 AM</b>	<b>AIRS 1:30 AM/PM</b>	<b>CERES</b>	<b>ARCs of El Niño Index (ENI) (K/yr)</b>
<b>ARCs (W/m<sup>2</sup>/yr)</b>	-0.0329 ±0.0265	-0.0275 ±0.0226	-0.0302 ±0.0241	-0.0468 ±0.0240	-0.106 ±0.0368
<b>AIRS ARCs minus CERES ARCs</b>	0.0139 ±0.0101	0.0193 ±0.0104	0.0166 ±0.0088		
<b>AIRS/CERES Anomaly Correlations</b>	0.882	0.829	0.833		

Global mean AIRS OLR ARCs are time of day dependent

AIRS and CERES ARCs agree with each other within their individual uncertainties

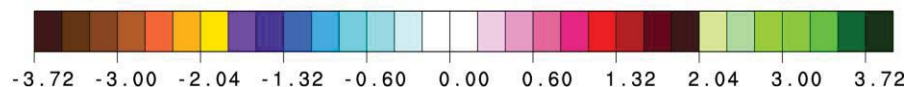
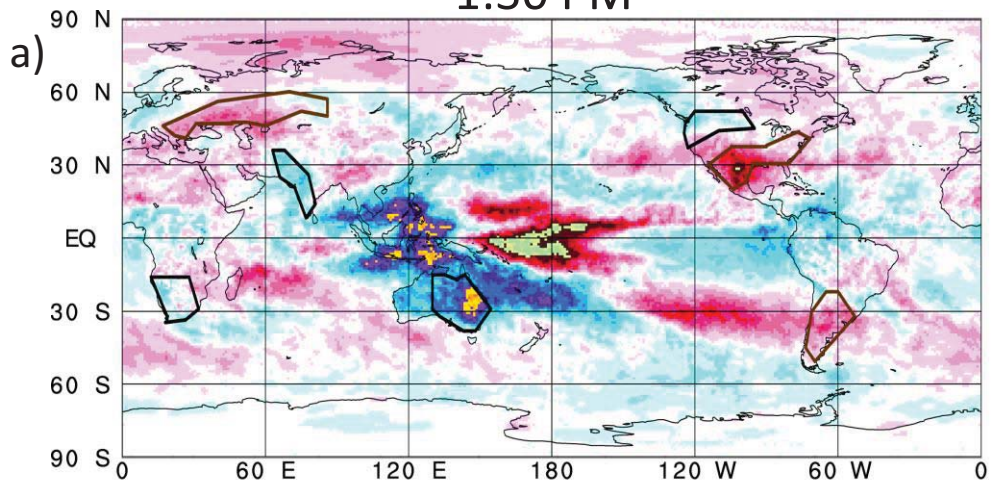
Global mean AIRS and CERES OLR ARCs are all slightly negative, with absolute values greater than their uncertainties

The decrease in OLR over this time period is related to the decrease in the ENI



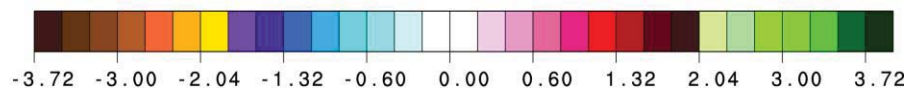
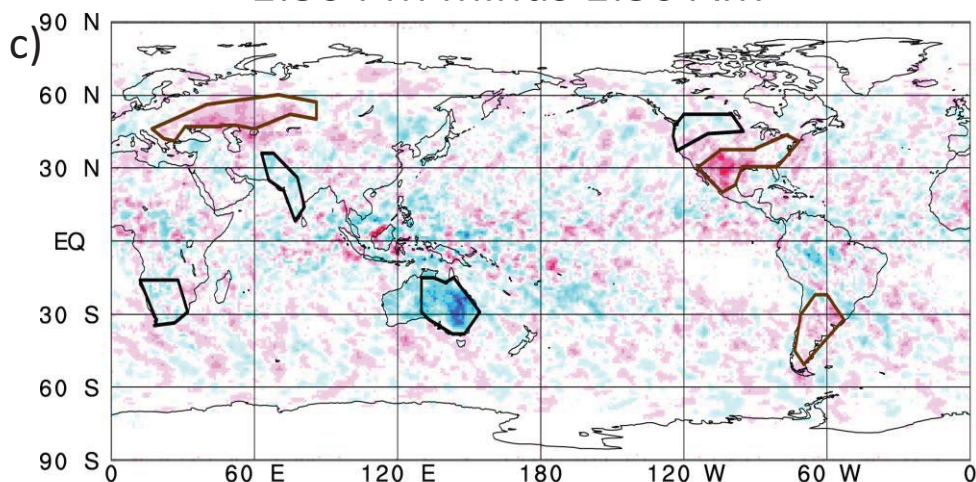
# AIRS Version-6 Day and Night OLR ARC (W/m<sup>2</sup>/yr) September 2002 through June 2013

1:30 PM



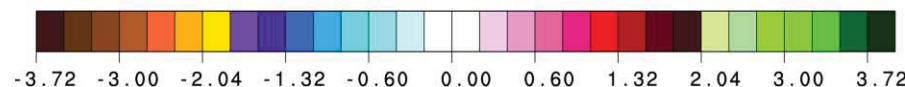
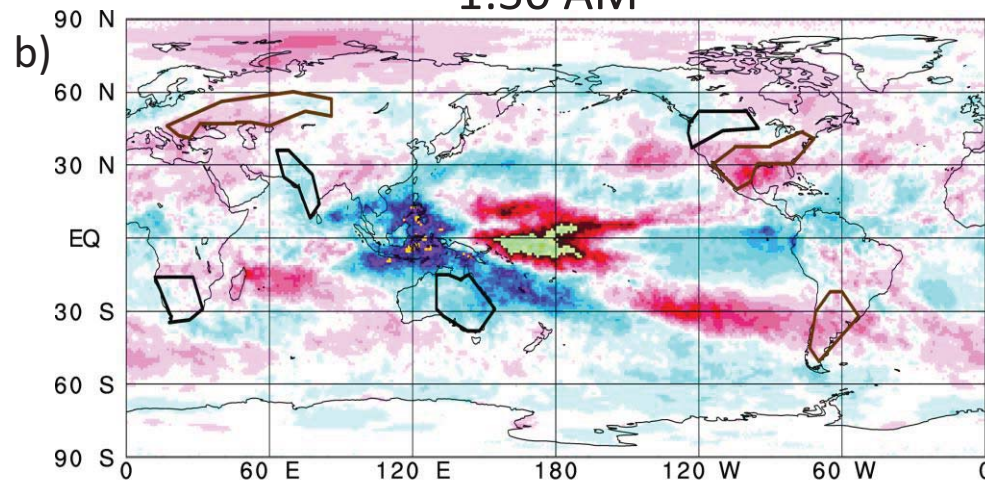
Global Mean = -0.033 Standard Dev = 0.569

1:30 PM minus 1:30 AM



Global Mean = -0.005 Standard Dev = 0.226 Correlation = 0.910

1:30 AM



Global Mean = -0.028 Standard Dev = 0.520

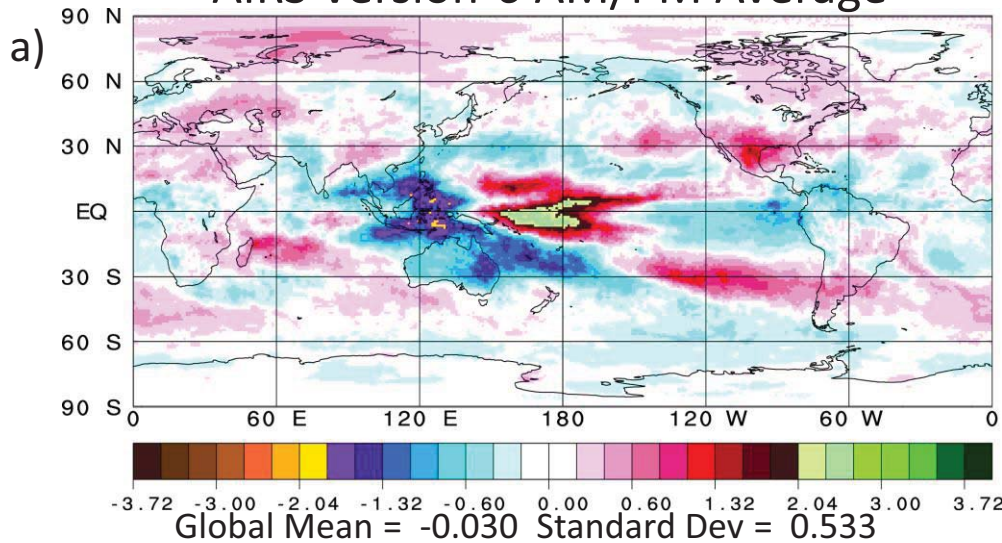
Large **negative** and **positive** Version-6 OLR ARCs occur in some land areas at 1:30 PM and are reduced considerably at 1:30 AM. The difference between global mean 1:30 PM and 1:30 AM ARCs is primarily the result of a large difference over Eastern Australia.



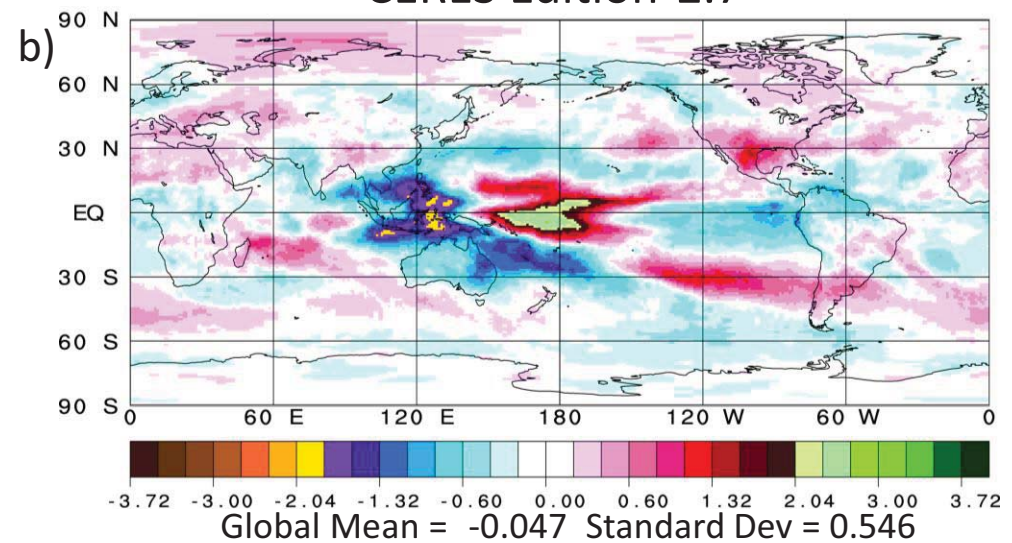


# AIRS and CERES OLR Anomaly Time Series ARCs ( $W/m^2/yr$ ) September 2002 through June 2013

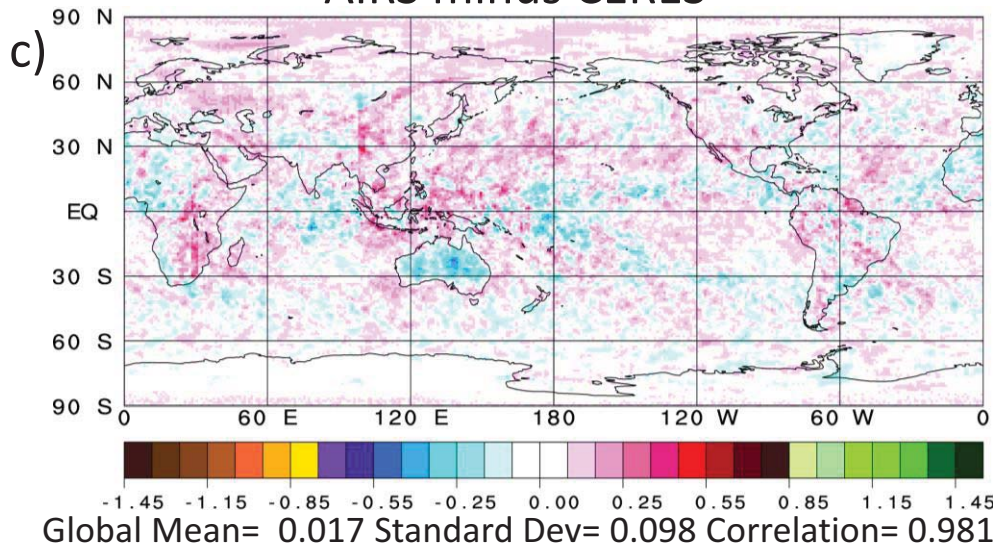
AIRS Version-6 AM/PM Average



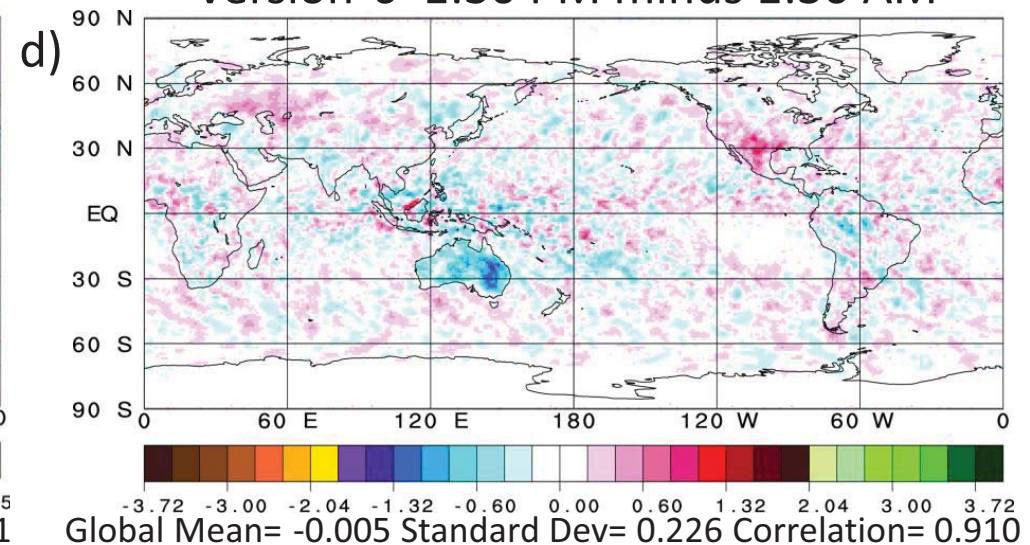
CERES Edition-2.7



AIRS minus CERES



Version-6 1:30 PM minus 1:30 AM



AIRS and CERES OLR ARCs agree well both globally and on a  $1^\circ \times 1^\circ$  spatial scale  
The largest differences between AIRS and CERES occur over Eastern Australia where OLR ARCs are very sensitive to diurnal sampling differences

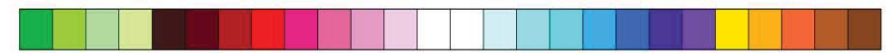
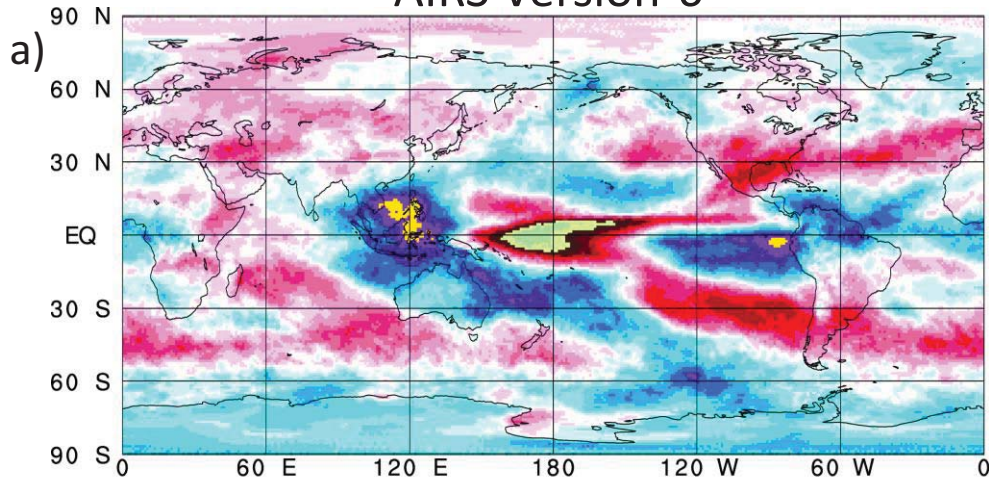




# OLR ENC's

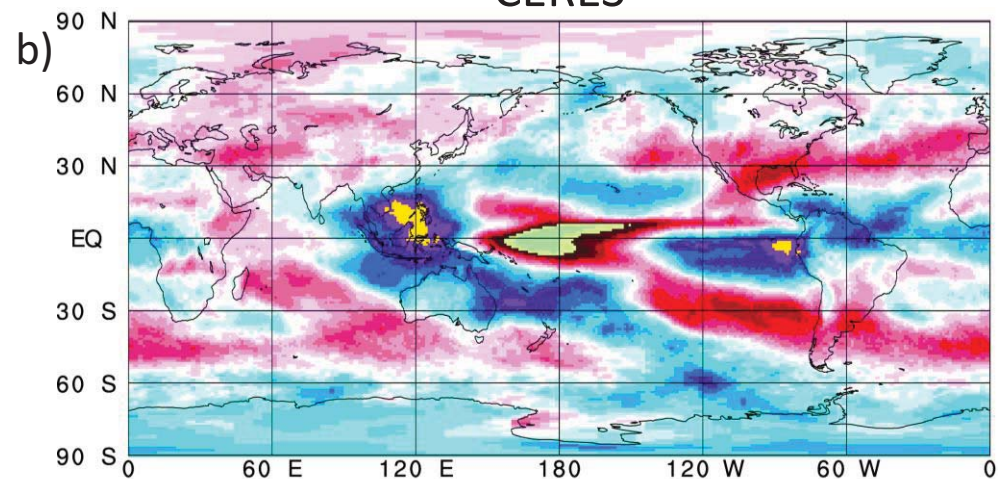
## September 2002 through June 2013

AIRS Version-6



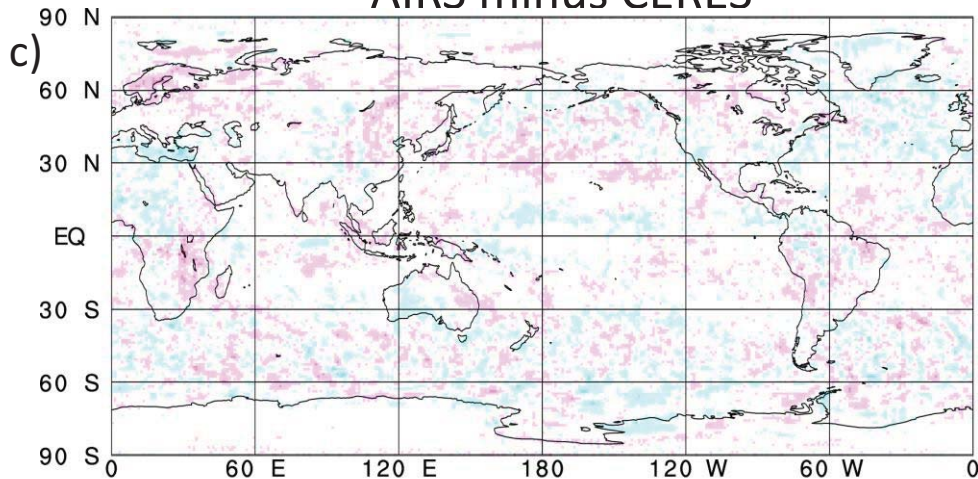
Global Mean = 0.018 Standard Dev = 0.246

CERES



Global Mean = 0.020 Standard Dev = 0.252

AIRS minus CERES



Global Mean = -0.002 Standard Dev = 0.036 Correlation = 0.986

OLR ENC's are shown with a reversed color scale compared to ARC's. Patterns of OLR ENC's are very similar to those of ARC's. Areas with positive OLR ARC's correspond to areas with negative OLR ENC's, and are both shown in reds and greens. Likewise, areas with negative OLR ARC's (blues and yellows) correspond to areas with positive OLR ENC's. The similarity of ARC's and ENC's shows that ARC's are a response to El Niño activity.

# Part 2

## Attribution of OLR Variability to those of Component Parts

OLR increases with increasing surface temperature  $T_{skin}$

OLR decreases with increasing fractional cloud cover,  $\alpha\varepsilon$ , especially for high clouds

OLR decreases with increasing 500 mb specific humidity  $q(500)$ , especially for very moist cases

The next set of viewgraphs show ARCs and ENC's of AIRS OLR,  $T_{skin}$ ,  $\alpha\varepsilon$ , and  $q(500)$  for the period September 2002 through January 2014

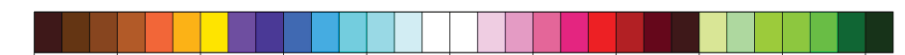
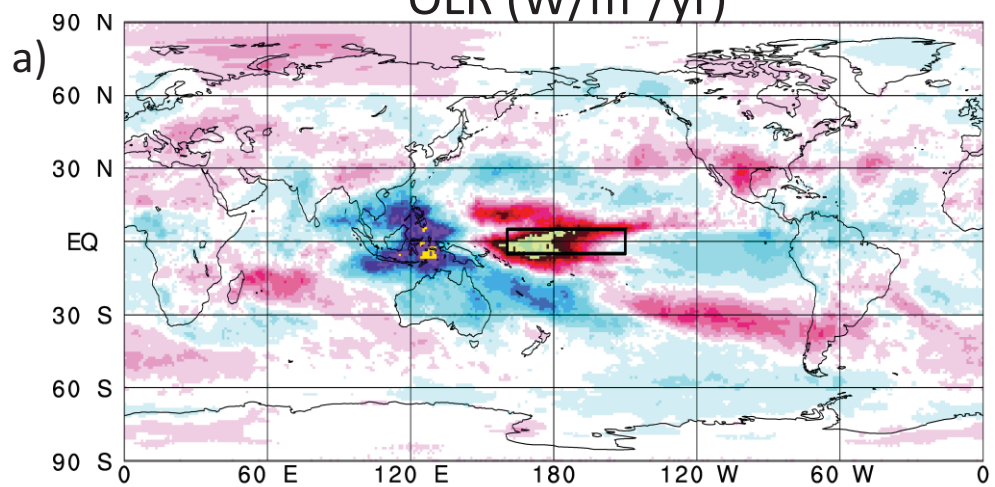
Some 1:30 PM and 1:30 AM results are shown separately





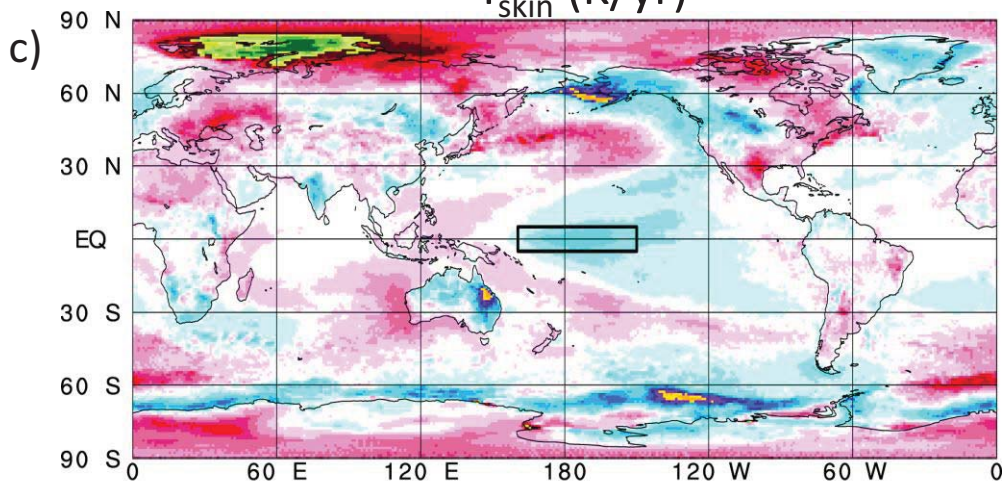
# AIRS Version-6 ARCs 1:30 AM/PM Average September 2002 through January 2014

OLR ( $W/m^2/yr$ )



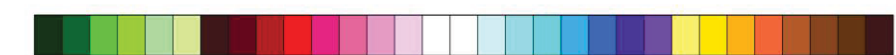
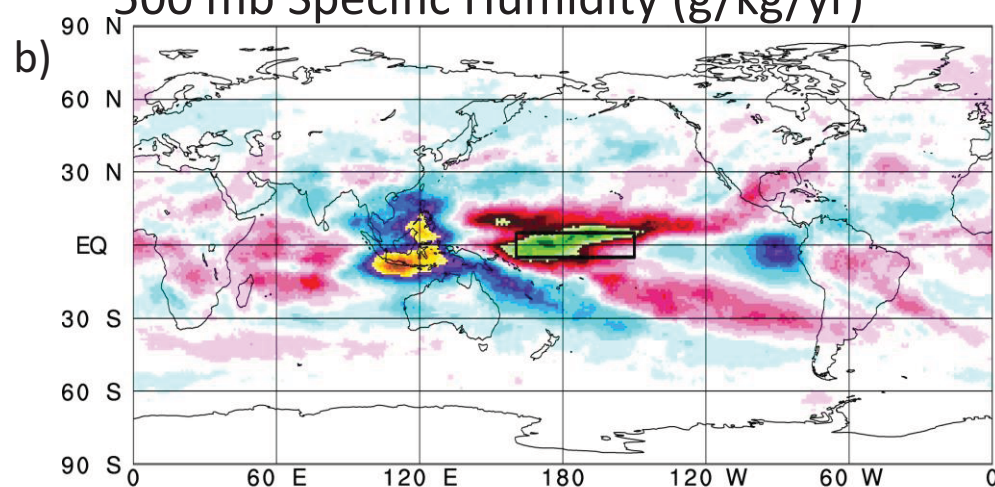
Global Mean = -0.025 Standard Dev = 0.479

$T_{skin}$  (K/yr)



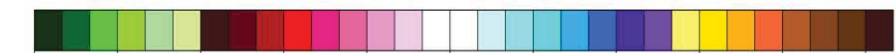
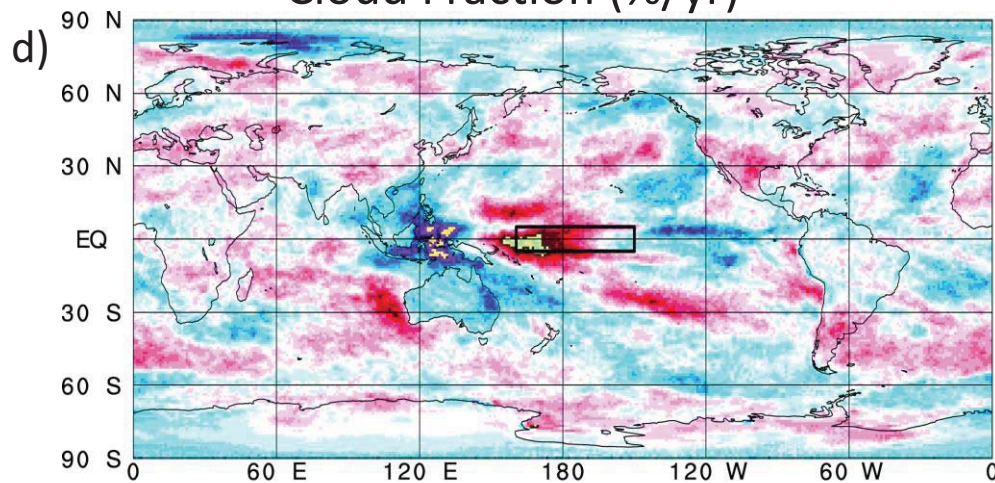
Global Mean = 0.005 Standard Dev = 0.054

500 mb Specific Humidity ( $g/kg/yr$ )



Global Mean = -0.001 Standard Dev = 1.029

Cloud Fraction (%/yr)



Global Mean = 0.034 Standard Dev = 0.283

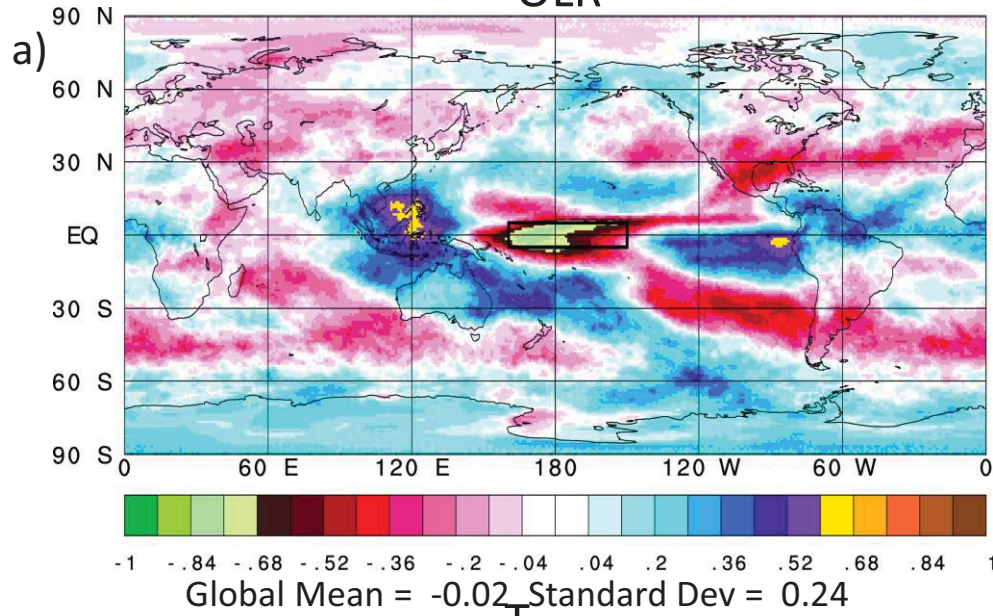
The color scale of specific humidity and cloud fraction ARCs is reversed compared to OLR and  $T_{skin}$ . The Niño 4 region, enclosed by a black box, has cooled considerably. Tropical OLR ARCs closely follow those of 500 mb specific humidity. Extra-tropical OLR follows those  $T_{skin}$ .



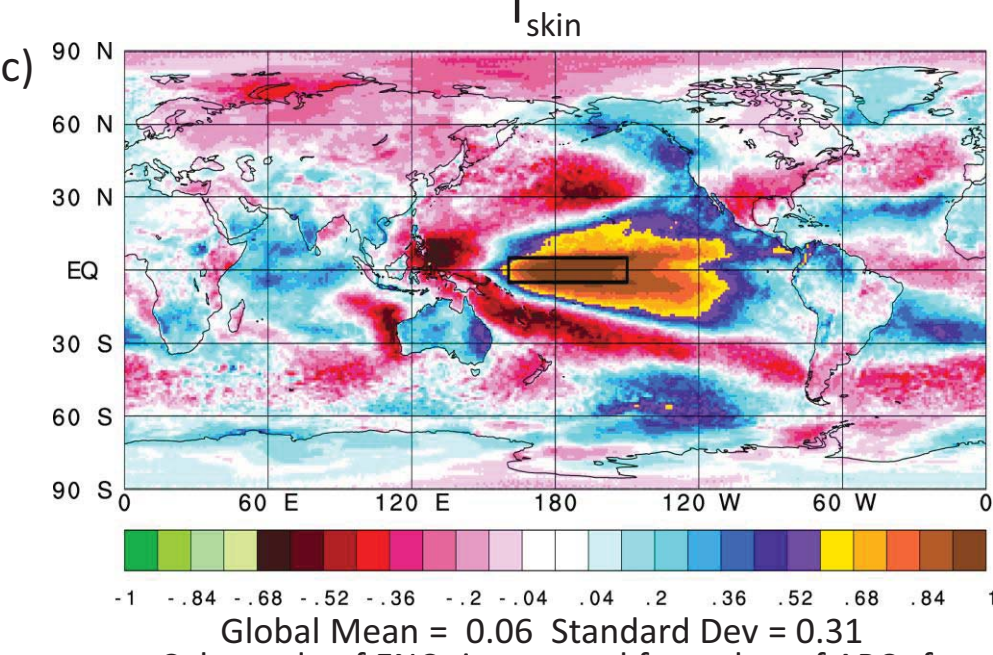
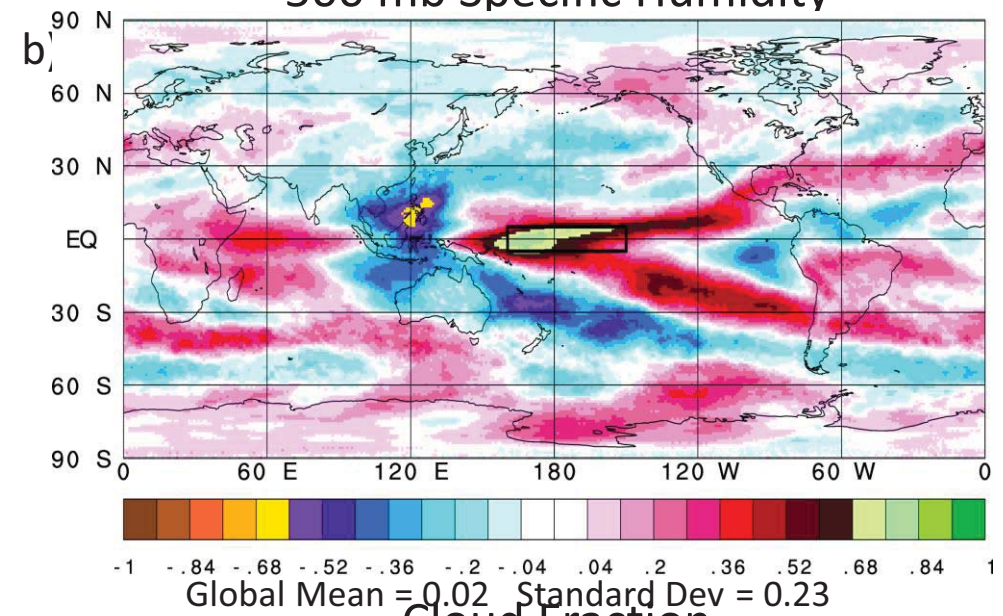


# AIRS Version-6 ENC's 1:30 AM/PM Average September 2002 through January 2014

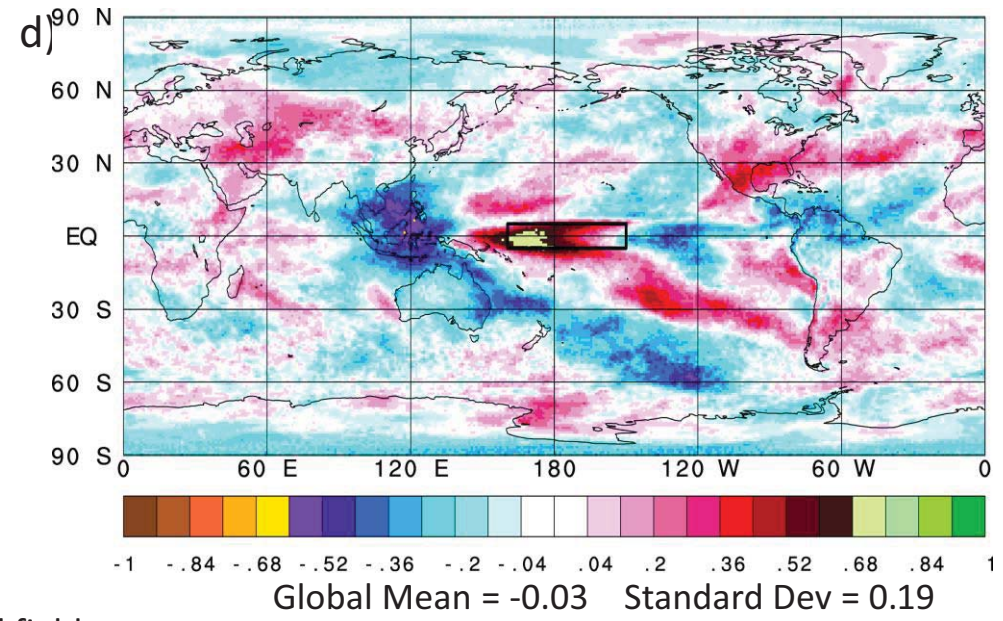
OLR



500 mb Specific Humidity



Cloud Fraction



Color code of ENC's is reversed from that of ARC's for all fields

Tropical anomalies of all parameters are strongly correlated or anti-correlated with El Niño activity

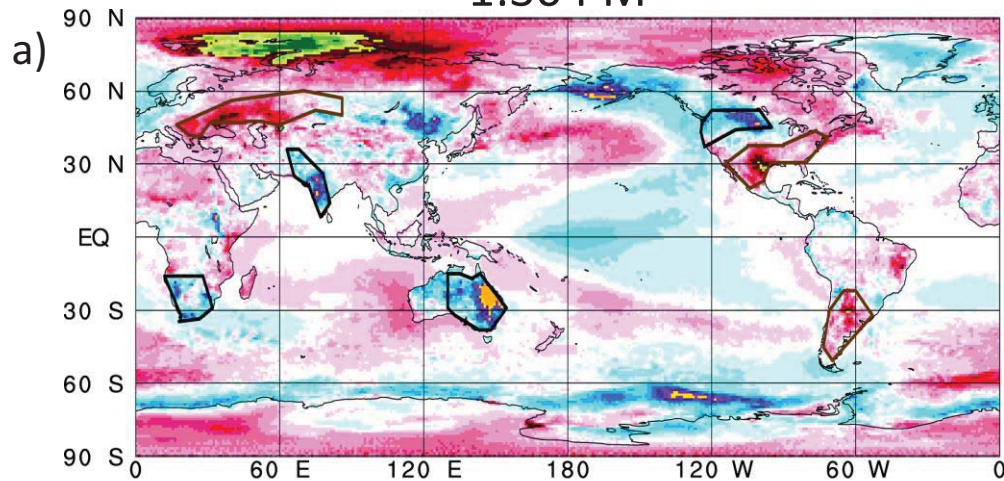
Tropical OLR ENC's primarily follow those of 500 mb specific humidity. Extra-tropical OLR ENC's follow  $T_{skin}$



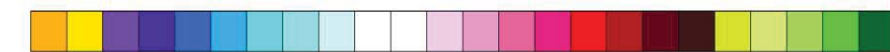
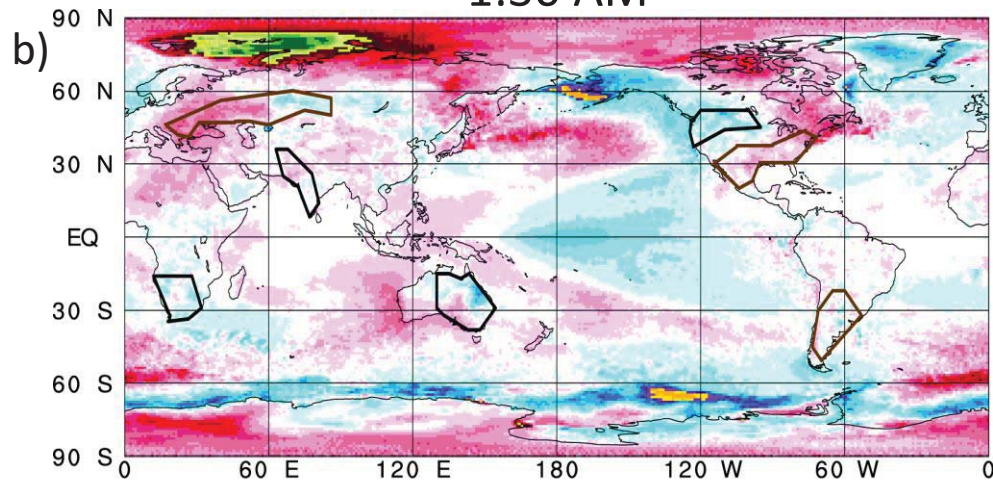


# AIRS Version-6 Day and Night $T_{skin}$ ARCs (K/yr) September 2002 through January 2014

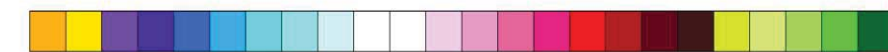
1:30 PM



1:30 AM

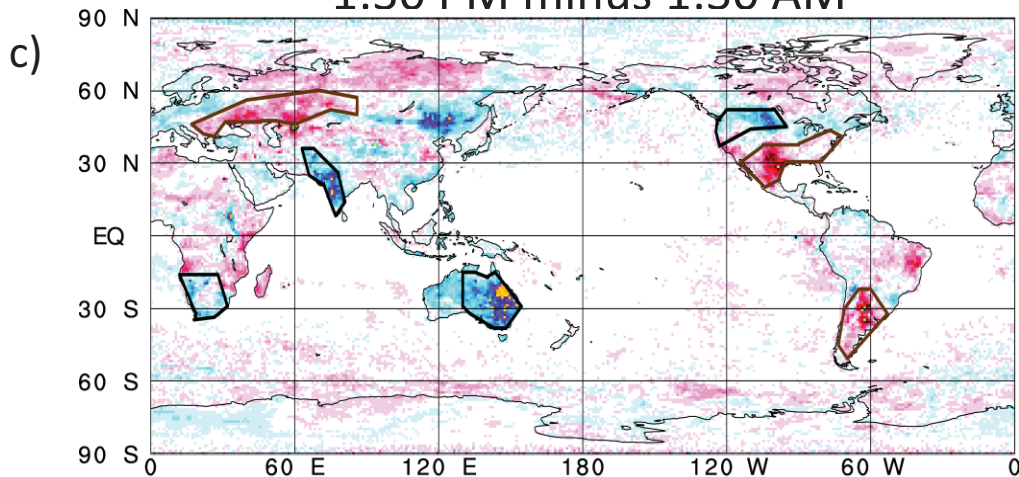


Global Mean = 0.006 Standard Dev = 0.064



Global Mean = 0.005 Standard Dev = 0.051

1:30 PM minus 1:30 AM



Global Mean = 0.001 Standard Dev = 0.042 Correlation = 0.897

Large **negative** and **positive** 1:30 PM minus 1:30 AM  $T_{skin}$  ARC differences occur in bounded areas over land

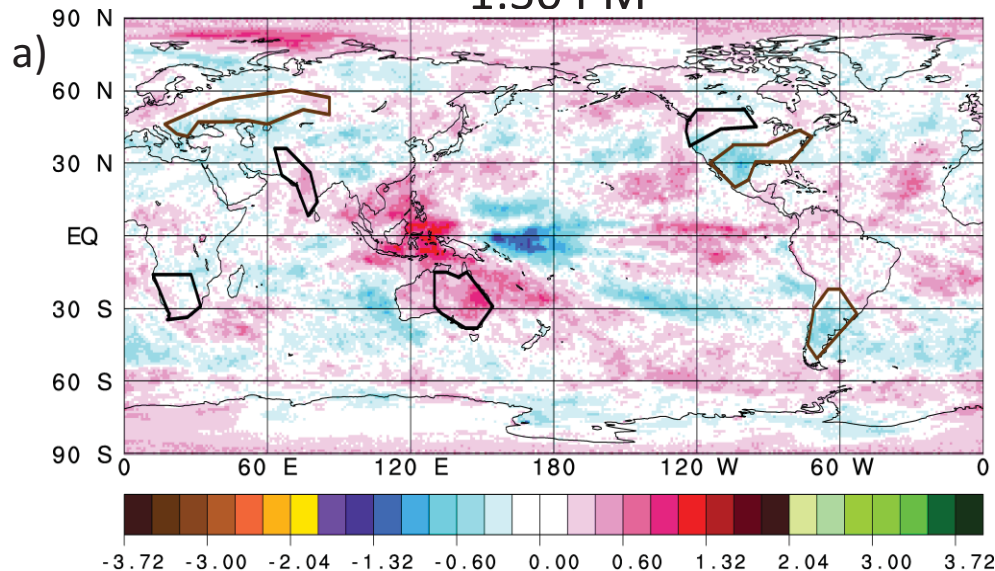
Large **negative** and **positive** Version-6  $T_{skin}$  ARCs occur in these areas at 1:30 PM but not 1:30 AM

The same phenomena showed up in OLR

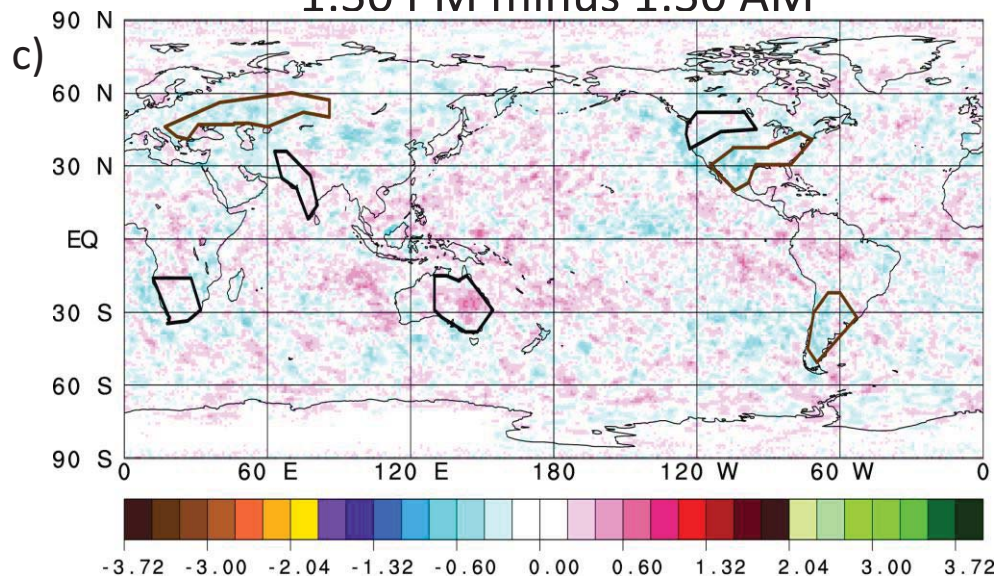


# AIRS Version-6 Day and Night Cloud Fraction ARCs (%/yr) September 2002 through January 2014

1:30 PM

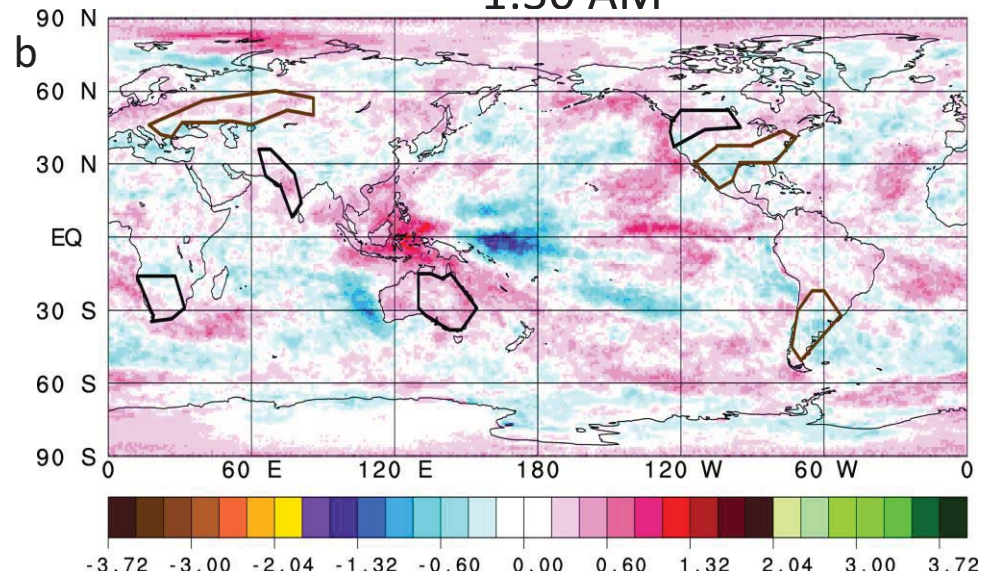


Global Mean = 0.033 Standard Dev = 0.299  
1:30 PM minus 1:30 AM



Global Mean = -0.003 Standard Dev = 0.193 Correlation = 0.785

1:30 AM



Global Mean = 0.036 Standard Dev = 0.299

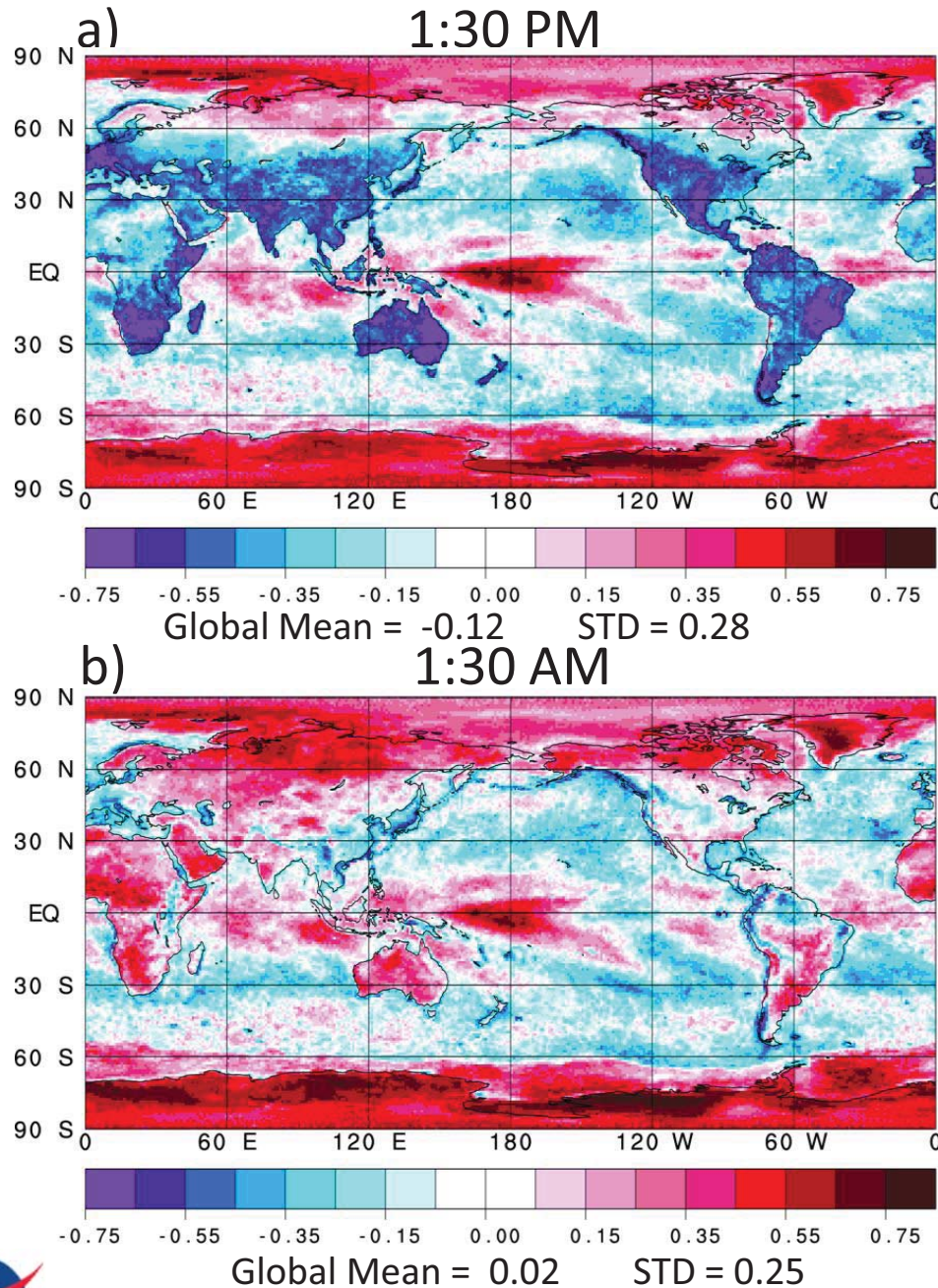
Global mean cloud cover has increased slightly both day and night.

Day/night differences are for the most part small. Areas of large **negative** day minus night  $T_{skin}$  ARCs occur where cloud cover has increased and large **positive** day minus night  $T_{skin}$  ARCs occur where cloud cover has decreased.





# Correlation of $T_{skin}$ and Cloud Fraction Anomalies September 2002 through January 2014



El Niño/La Niña activity directly affects the spatial distribution of anomalies of cloud cover, but does not directly affect land skin temperature anomalies. Rather, skin temperature anomalies over land are affected to a great extent by cloud fraction anomalies, and associated precipitation anomalies, especially during the day. Over most non-polar land areas, land skin temperature anomalies are highly negatively correlated with cloud fraction anomalies during the day (clear areas warm more during the day) and tend to be somewhat positively correlated with cloud fraction anomalies at night (clearer areas cool more at night).

# Summary

- AIRS Version-6 OLR matches CERES Edition-2.7 OLR very closely on a  $1^\circ \times 1^\circ$  latitude x longitude scale, both with regard to absolute values, and also with regard to ARCs (anomaly trends) and ENC of OLR
- Contiguous areas contain large positive or negative OLR ENCs in the tropics and mid-latitudes which are of opposite sign to their ARCs. This is because the El Niño Index has decreased over the time period studied
- 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 June 2013 (La Niña period) as a result of cooling in the Niño-4 area. This result says nothing about global mean OLR changes in the future.

