



Findings Related to Anomaly Trends of AIRS V5 L3 Products

**Joel Susskind and Gyula Molnar
NASA GSFC Sounder Research Team (SRT)**

AIRS Science Team

April 15, 2008

Pasadena, California

Definition and Significance of AIRS Trends

Definition

Data shown cover the 5 year period September 2002 - August 2007

Monthly mean fields on a $1^\circ \times 1^\circ$ grid are used for each parameter

Obtained from Goddard DAAC

5 year monthly mean climatologies were generated for each $1^\circ \times 1^\circ$ grid box

$1^\circ \times 1^\circ$ trends are defined as the slope of the linear fit through the 60 monthly anomaly values

Significance

5 year trends do not indicate anything about past or future behavior

Hopefully AIRS can provide 15 year trends which will be more significant

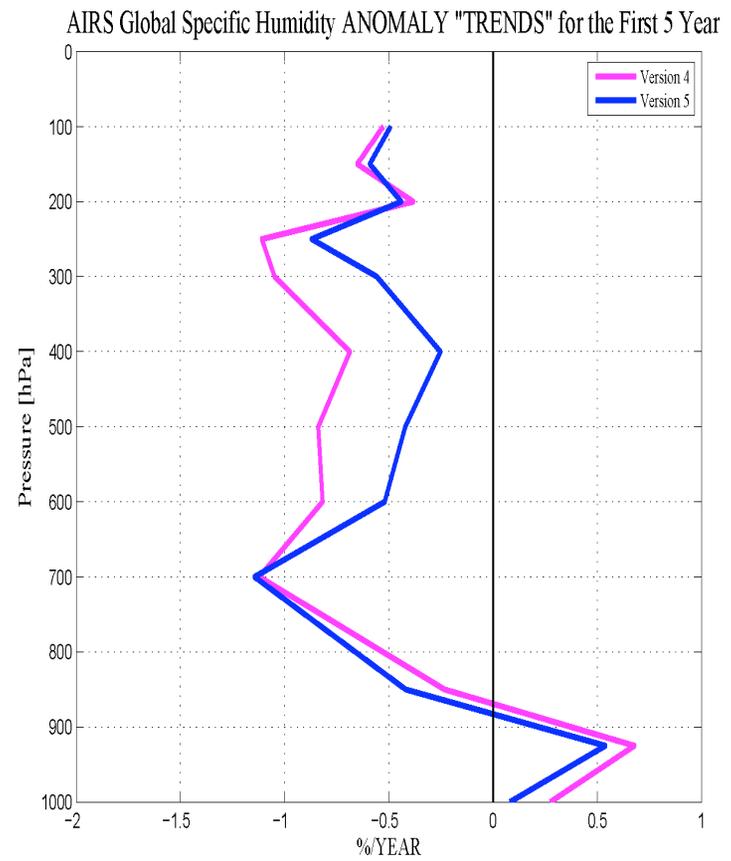
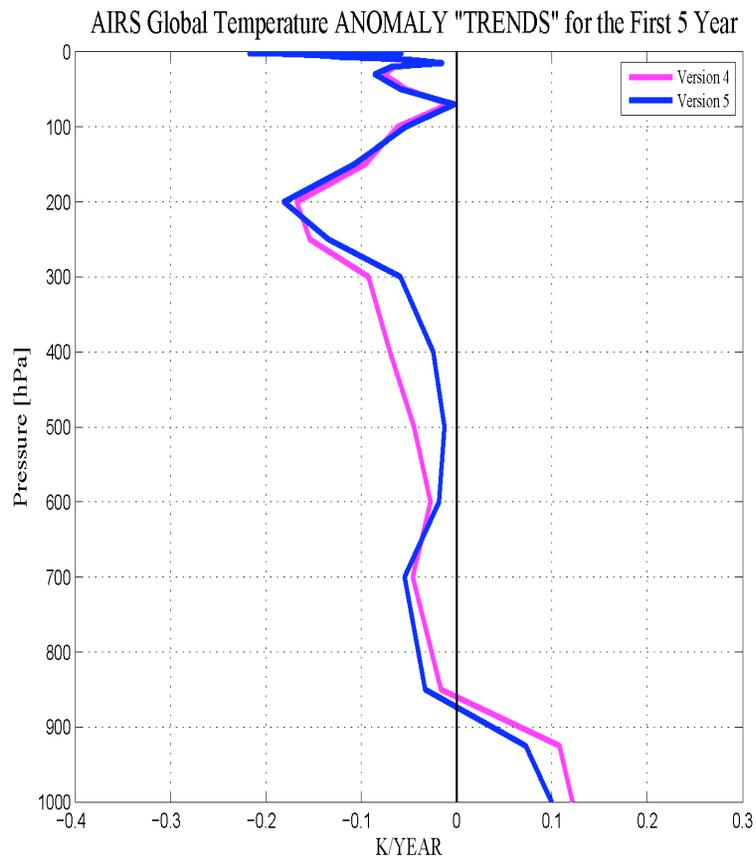
Spatial and temporal correlations of anomalies and trends of different geophysical parameters are

indicative of climate processes

AIRS data can also be used to assess climate process behavior in GCM's

Outline of the Talk

- A brief comparison of AIRS V5 and V4 temperature and moisture profile trends
- A first assessment of the accuracy of AIRS V5 temperature trends
- Spatial correlations of trends of temperature, moisture, cloud cover, and OLR anomalies
- Temporal correlations of tropical anomalies of above quantities
- Comparison of AIRS OLR and clear sky OLR trends with those of CERES products
- Proposed upgrade to AIRS OLR calculation to remove bias between AIRS and CERES



Comparisons of V5 Global Temperature and Moisture Trends with V4

General vertical structure of temperature and moisture profile both trends are similar

Warming and moistening beneath 850 mb

Cooling and drying above 850 mb

V5 trends minus V4 trends are negative beneath 700 mb and positive above 700 mb

V4 five year cooling and drying trends are much more pronounced than V5

The main difference in temperature trends probably results from

1) V5 assumes CO₂ concentration increases with time - V4 uses constant CO₂ concentration

This could add a spurious cooling component to the trend

2) V5 does not use any 15 μm channels to solve for T(p)

It is not obvious what the significance of this is with regard to trends

The main difference in humidity trends comes from changes in temperature trends

Spurious cooling/warming leads to spurious drying/moistening

There is no change in q(p) retrieval step from V4 to V5

First Assessment of Accuracy of AIRS V5 T(p) Trends

AIRS T(p) trends can be spurious for a number of reasons

- AIRS radiometric and spectral drifts

- Effects of changing CO₂ on

 - Cloud clearing

 - Regression

 - Physical retrieval

 - Quality control

We compare AIRS T(p) trends (final product) with AMSU T(p) trends (microwave product)

AMSU trends may also have spurious contributions - but none of the above

Next three figures show AIRS T(p) trends agree well with AMSU T(p) trends

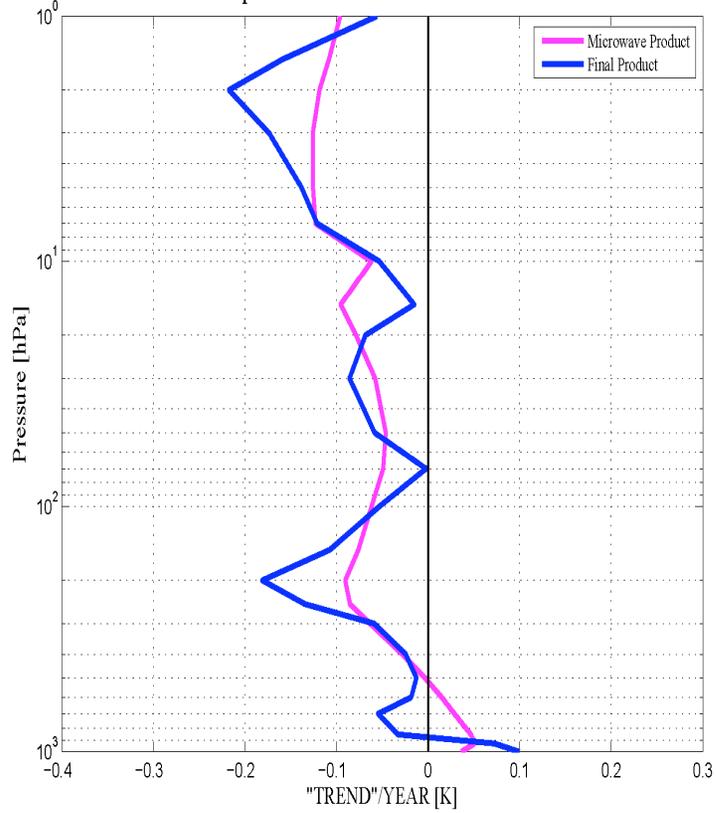
- Both in height and in space

AIRS T(p) retrieval has more vertical resolution than AMSU T(p) retrieval

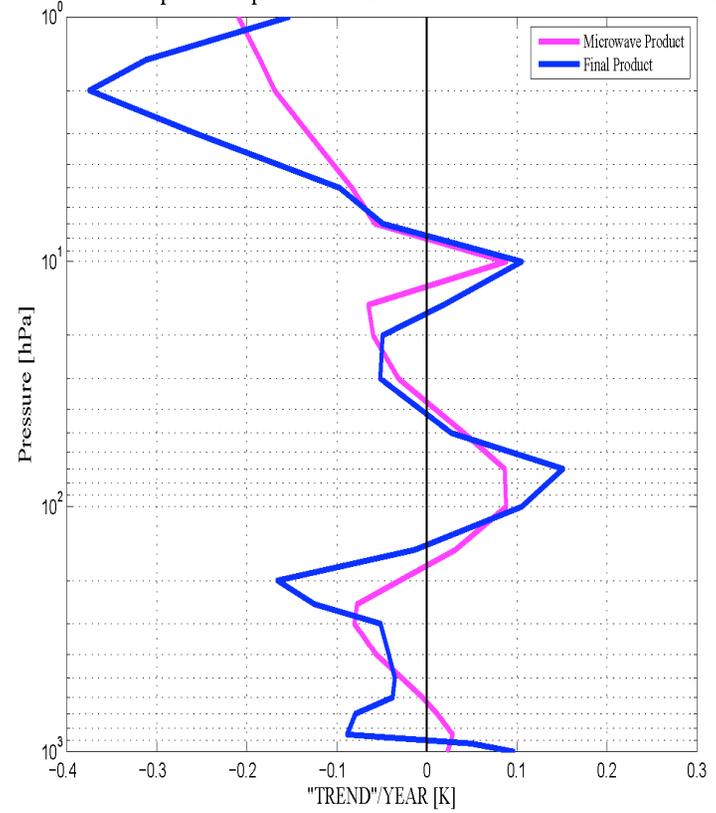
- Therefore AIRS T(p) trends have more vertical resolution than AMSU T(p) trends

AIRS coarse climate indicator trends will be compared to those of analogous Spencer and Christy products when ready

V5 AIRS Global Temperature ANOMALY "TRENDS" for the First 5 Year

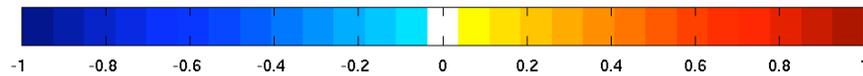
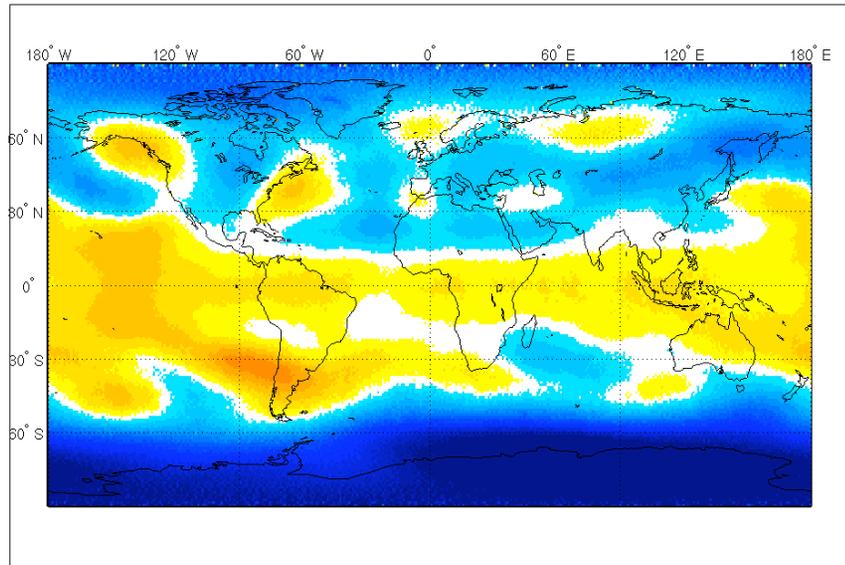


V5 AIRS Tropical Temperature ANOMALY "TRENDS" for the First 5 Year

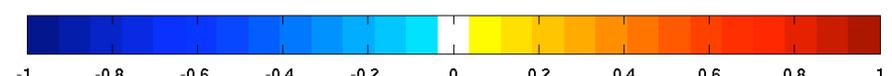
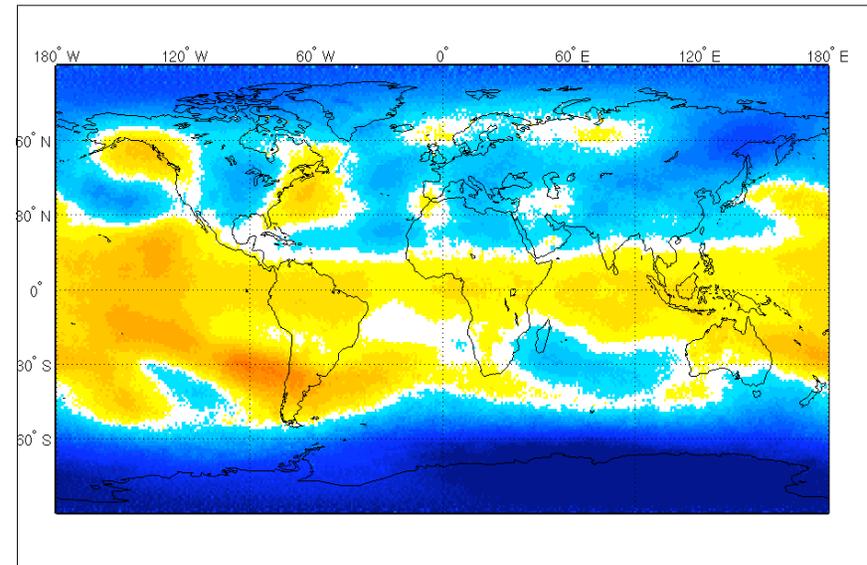


Comparison of Microwave vs. Final product Spatial Trends – Part I

Sep./02-Aug./07 Microwave Product 100 hPa Temp. Anomaly "Trend" [°C/yr]



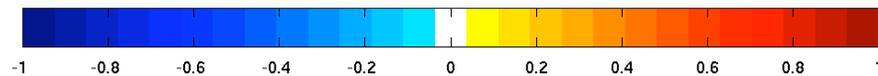
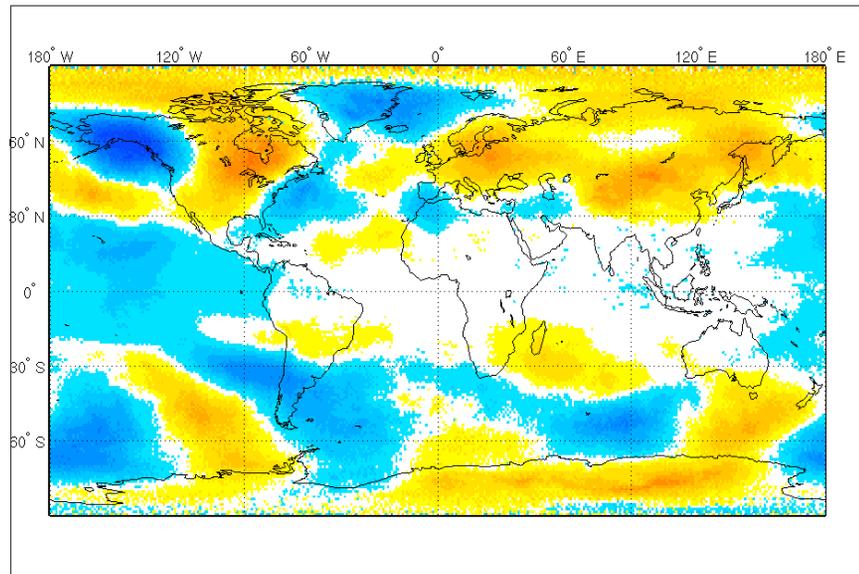
Sep./02-Aug./07 AIRS-V5 100 hPa Temp. Anomaly "Trend" [°C/yr]



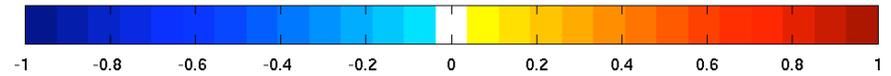
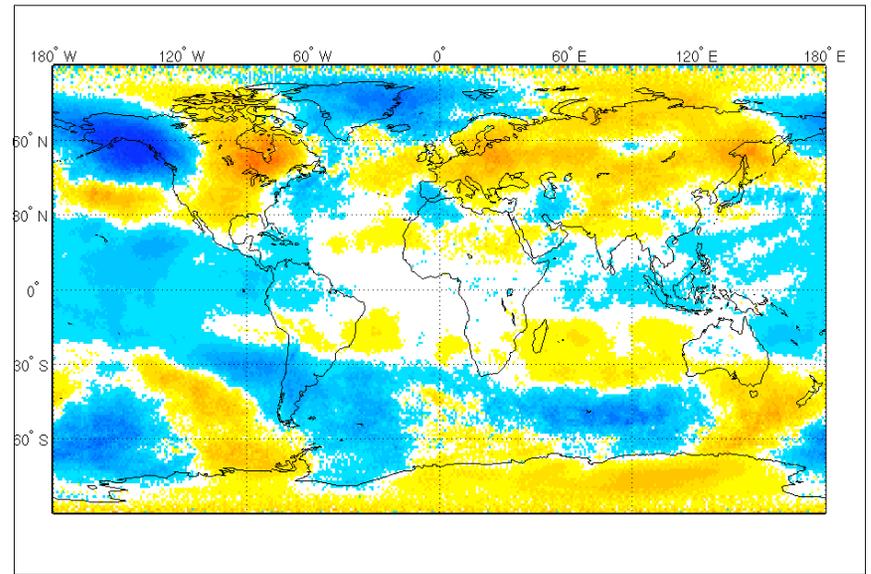
Correlation Coeff.: 0.98

Comparison of Microwave vs. Final product Spatial Trends – Part II

Sep./02-Aug./07 Microwave Product 500 hPa Temp. Anomaly "Trend" [°C/yr]



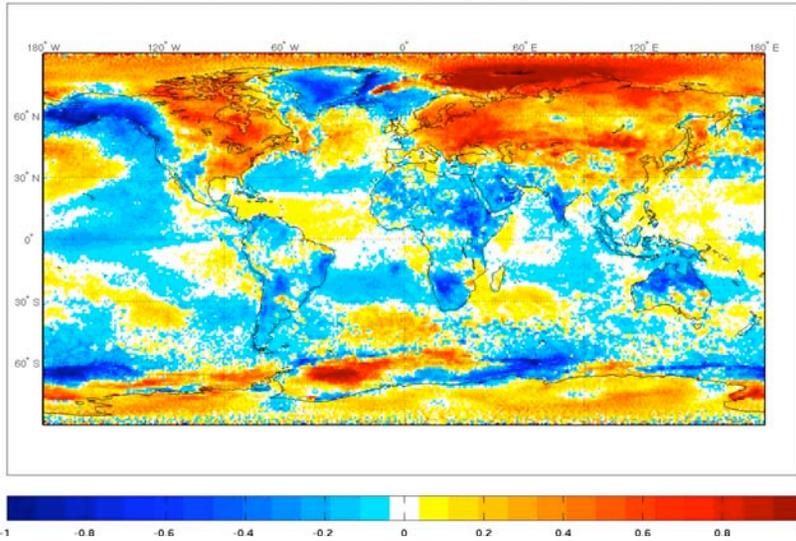
Sep./02-Aug./07 AIRS-V5 500 hPa Temp. Anomaly "Trend" [°C/yr]



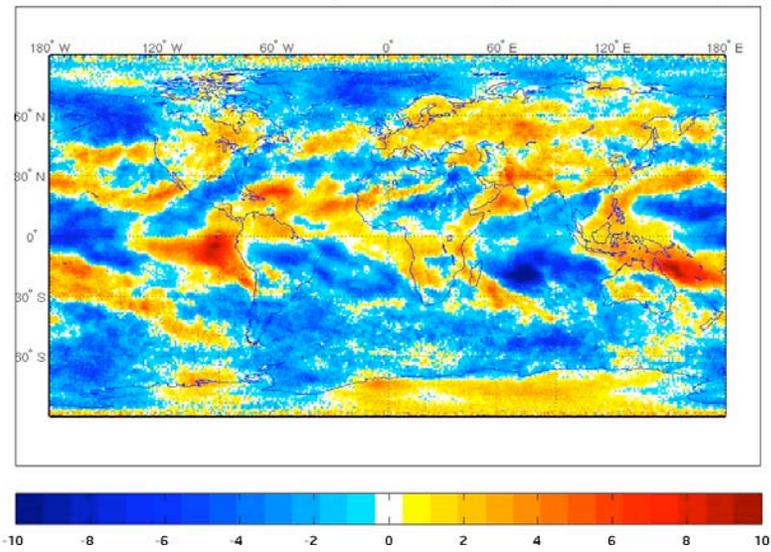
Correlation Coeff.: 0.89

1 x 1 Deg. Anomaly "trends" for the First 5 years of AIRS – Part I

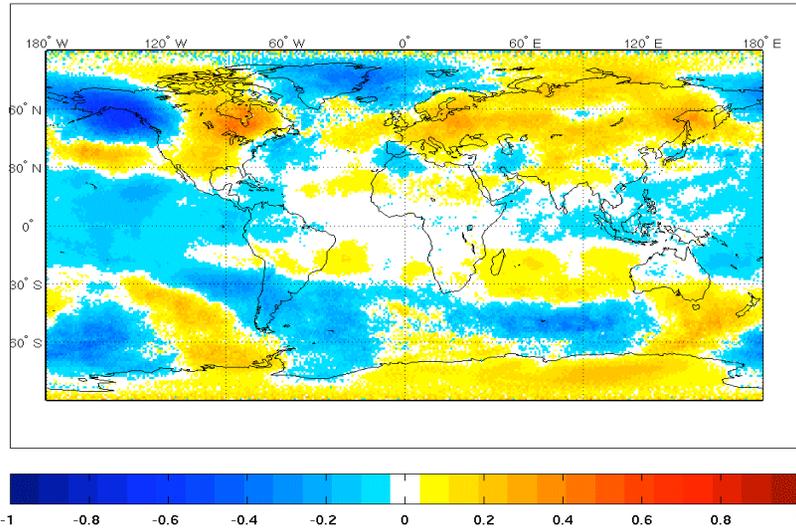
Sep./02-Aug./07 AIRS-V5 Skin Temperature Anomaly "Trend" [°C/yr]



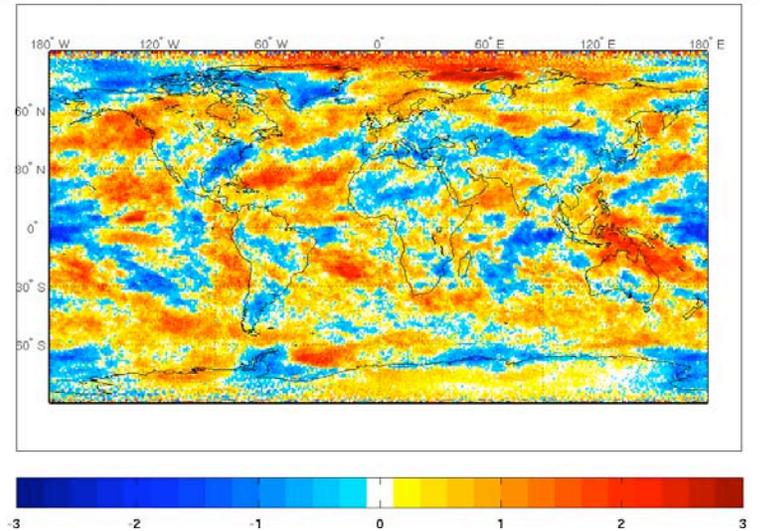
09/02-08/07 AIRS-V5 500 hPa Specific Humidity Anomaly "Trend" [%/yr]



Sep./02-Aug./07 AIRS-V5 500 hPa Temp. Anomaly "Trend" [°C/yr]

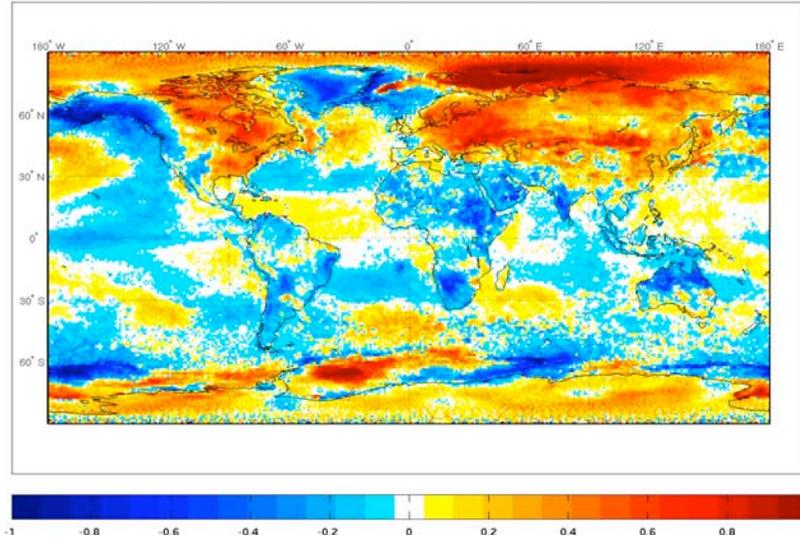


Sep./02-Aug./07 AIRS-V5 Effective Cloud Fraction Anomaly "Trend" [%/yr]

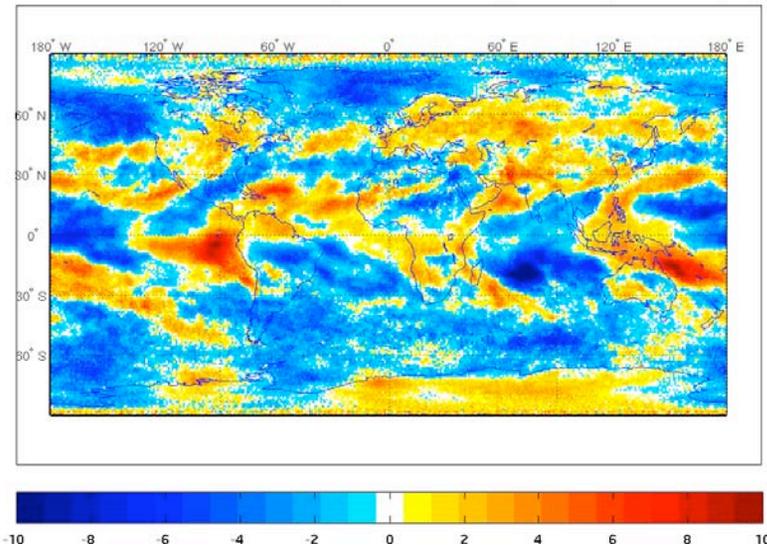


1 x 1 Deg. Anomaly "trends" for the First 5 years of AIRS - Part II

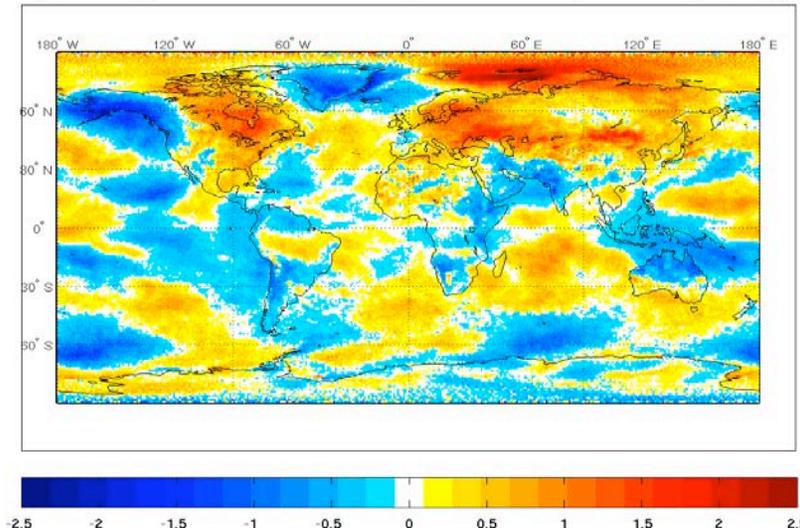
Sep./02-Aug./07 AIRS-V5 Skin Temperature Anomaly "Trend" [$^{\circ}\text{C}/\text{yr}$]



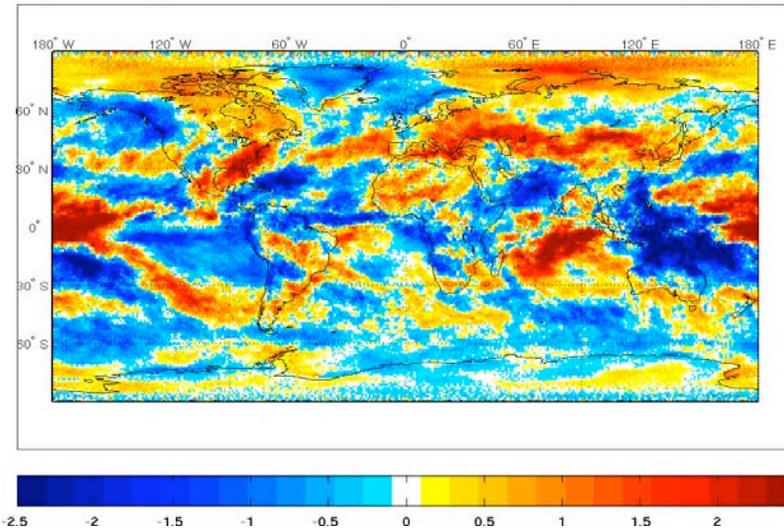
09/02-08/07 AIRS-V5 500 hPa Specific Humidity Anomaly "Trend" [%/yr]



Sep./02-Aug./07 AIRS-V5 Clear-Sky OLR Anomaly "Trend" [$\text{W}/\text{m}^2/\text{yr}$]



Sep./02-Aug./07 AIRS-V5 All-Sky OLR Anomaly "Trend" [$\text{W}/\text{m}^2/\text{yr}$]



5 Year AIRS Version 5 Area-Average “Trends”

Area/ Parameter	T_{skin} [K/yr]	T₅₀₀ [K/yr]	PCSH₅₀₀ [%/yr]	OLR_{CLR} [W/m²]/yr]	OLR [W/m²]/yr]	A_{eff}[%/yr]
Global	0.016	-0.013	-0.42	0.049	-0.020	0.26
90°N-60°N	0.231	-0.027	-1.19	0.29	0.17	0.29
60°N-30°N	0.133	0.043	0.13	0.30	0.32	0.20
30°N-0°	-0.044	-0.031	-0.13	-0.03	-0.09	0.27
0°-30°S	-0.050	-0.021	-0.15	-0.09	-0.20	0.27
30°N-60°S	-0.023	-0.036	-1.32	0.05	-0.06	0.34
60°N-90°S	0.063	-0.012	-0.81	-0.08	-0.11	0.08

5 Year AIRS Version 5 Area Average Spatial “Trend” Correlations

	T_{skin}	T_{500}	PCSH_{500}	OLR_{CLR}	OLR	A_{eff}
T_{skin}	----	0.58	0.51	0.87	0.63	0.18
T_{500}	-0.04	----	0.81	0.77	0.60	0.03
PCSH_{500}	0.12	-0.15	----	0.64	0.45	0.07
OLR_{CLR}	0.25	0.26	-0.76	----	0.72	0.14
OLR	-0.01	-0.01	-0.72	0.76	----	-0.35
A_{eff}	-0.09	-0.03	0.51	-0.58	-0.80	----

RED: Spatial correlations pole-ward of 40°

Black: Spatial correlations 23°N-23°S

+/-5 Deg. Lat. Hovmoller Diagrams for the First 5 years of AIRS

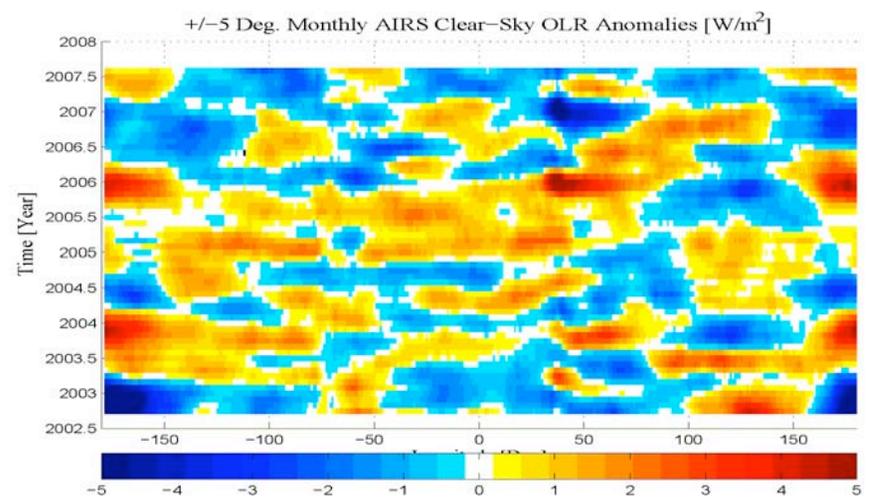
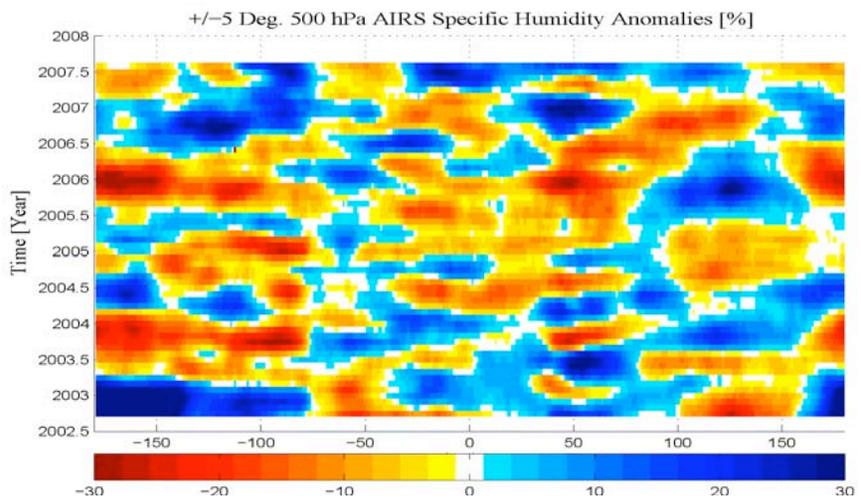
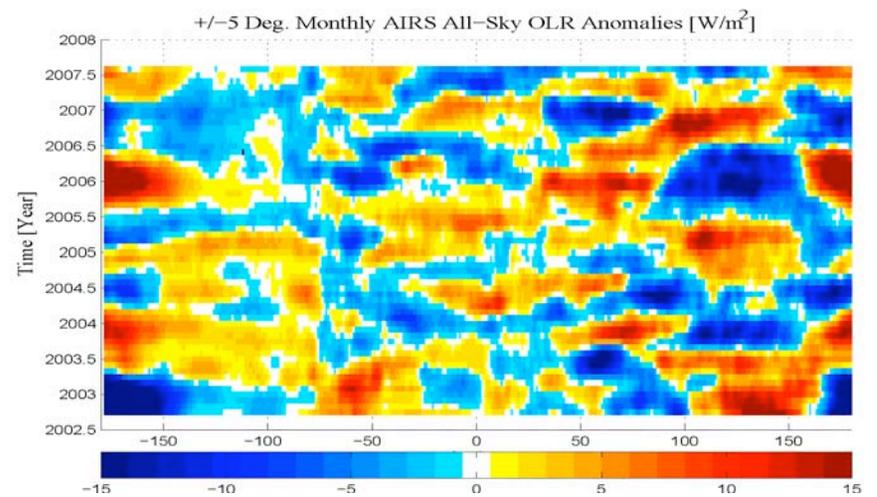
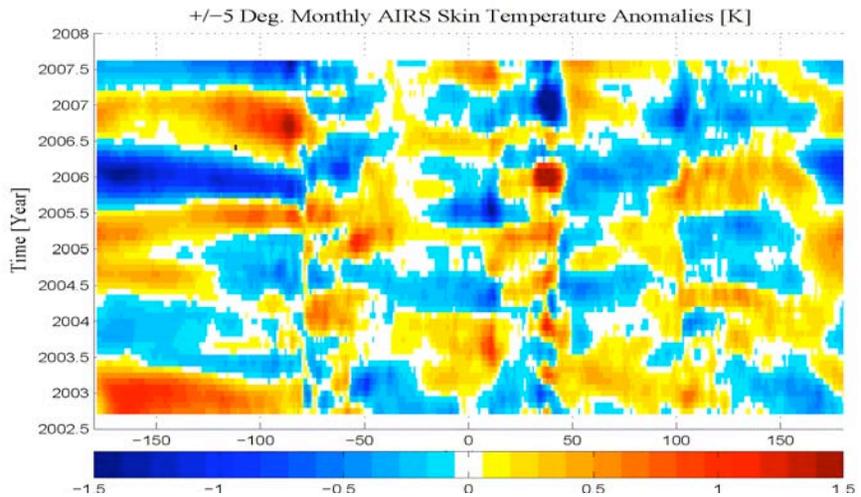


Table III: Correlations between the AIRS anomaly timeseries of selected climatic variables depicted in the equatorial (5°N-5°S) Hovmoller diagrams.

	OLR_{CLR}	$PCSH_{500}$	T_{skin}	T_{500}	OLR	A_{eff}
OLR_{CLR}	----	-0.84	-0.05	-0.01	0.78	-0.74
$PCSH_{500}$		----	0.37	0.21	-0.77	0.69
T_{skin}			----	0.45	-0.38	0.24
T_{500}				----	0.26	0.21
OLR					----	-0.92
A_{eff}						----

Computation of AIRS OLR

AIRS OLR is computed from other AIRS products

$$\text{OLR} = (1 - \alpha) \text{OLR}_{\text{CLEAR}} + \alpha \text{OLR}_{\text{CLOUD}}$$

α is effective multilayer cloud fraction

OLR_{CLR} computed for clear conditions using an RTA

OLR_{CLD} computed for overcast multilayer cloud conditions using an RTA

Version 5 OLR RTA was developed in 1982 using older line parameters - used for TOVS OLR

AER has developed an improved OLR RTA using updated line parameters

Main difference is in H_2O absorption near 300 cm^{-1}

AER OLR also allows for increasing CO_2 concentrations

Comparison of AIRS and CERES OLR Trends

AIRS OLR is computed from products

Both for all sky (all cases) and clear sky OLR (most cases)

CERES OLR is measured

CERES clear sky OLR is a subset of OLR for clear cases

AIRS and CERES OLR products and trends are complementary if they agree

If AIRS and CERES anomalies and trends agree, then

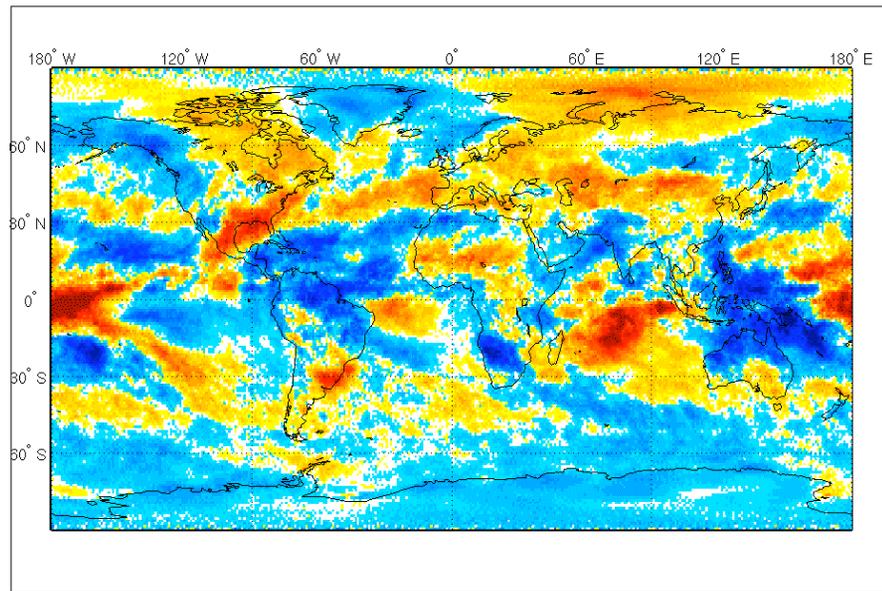
- 1) Anomalies and trends in AIRS products explain anomalies and trends in CERES observations
- 2) AIRS product anomalies and trends are indirectly validated by CERES observations

Note: AIRS V5 OLR RTA assumes a constant CO₂ concentration

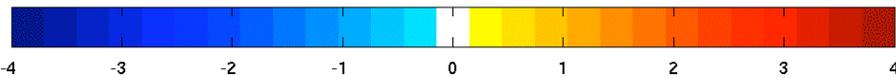
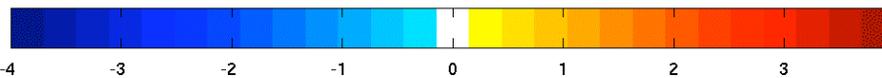
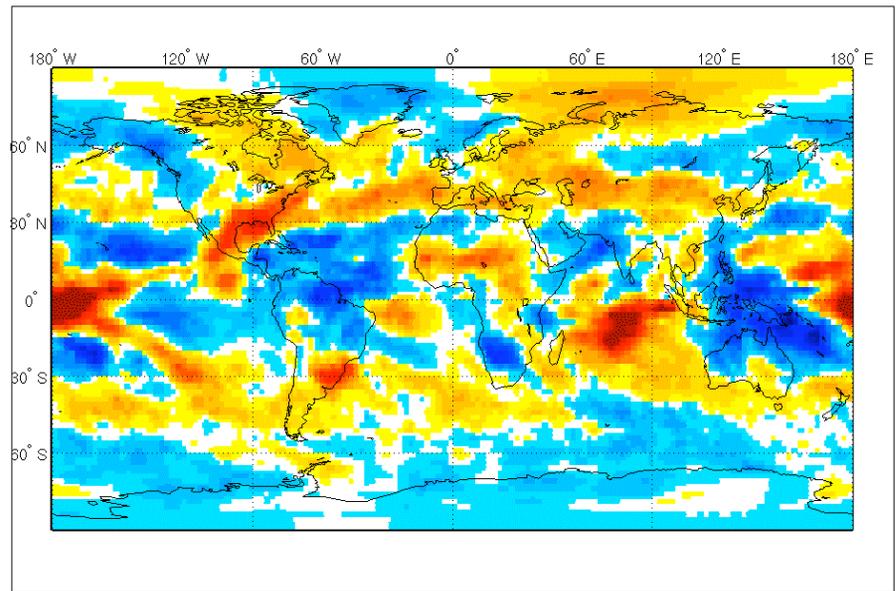
This could lead to spurious positive trend to AIRS OLR

Spatial Anomalies for the Coincident 52-Months of CERES and AIRS-V5 All-Sky OLR

Sep./02-Dec./06 AIRS-V5 All-Sky OLR Anomaly "Trend" [$\text{W/m}^2/\text{yr}$]



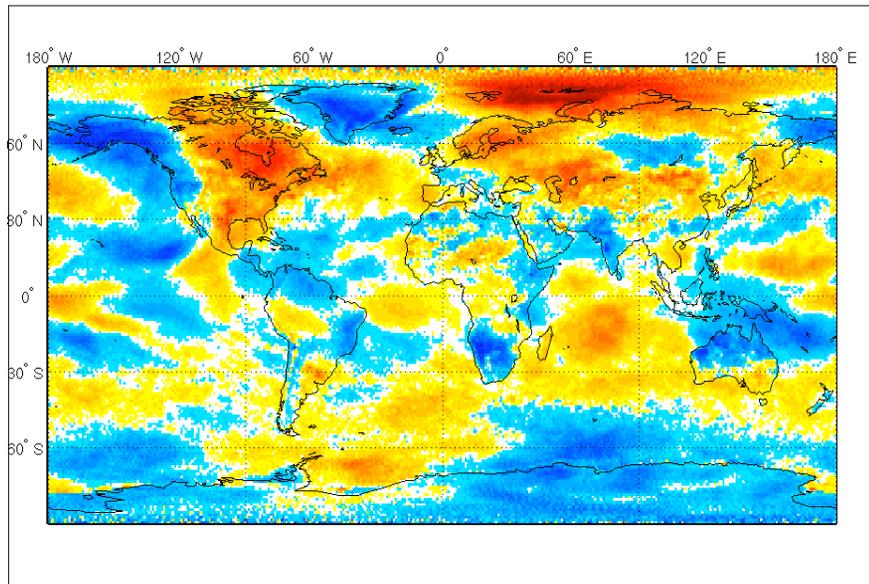
Sep./02-Dec./06 CERES All-Sky OLR Anomaly "Trend" [$\text{W/m}^2/\text{yr}$]



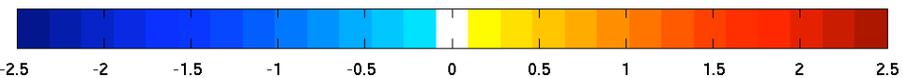
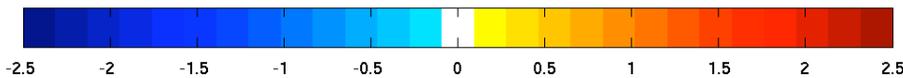
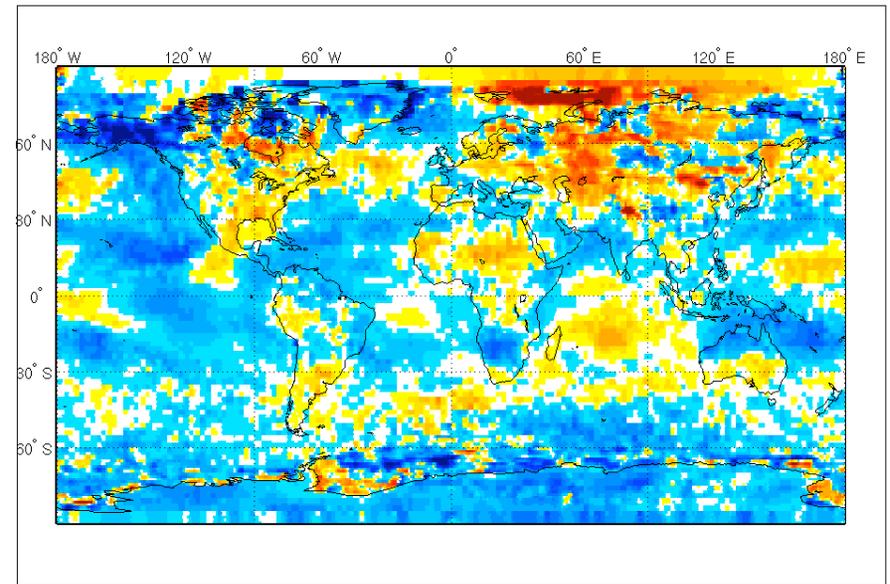
The correlation between these trendmaps is 0.97.

Spatial Anomalies for the Coincident 52-Months of CERES and AIRS-V5 Clear-Sky OLR

Sep./02-Dec./06 AIRS-V5 Clear-Sky OLR Anomaly "Trend" [$\text{W/m}^2/\text{yr}$]

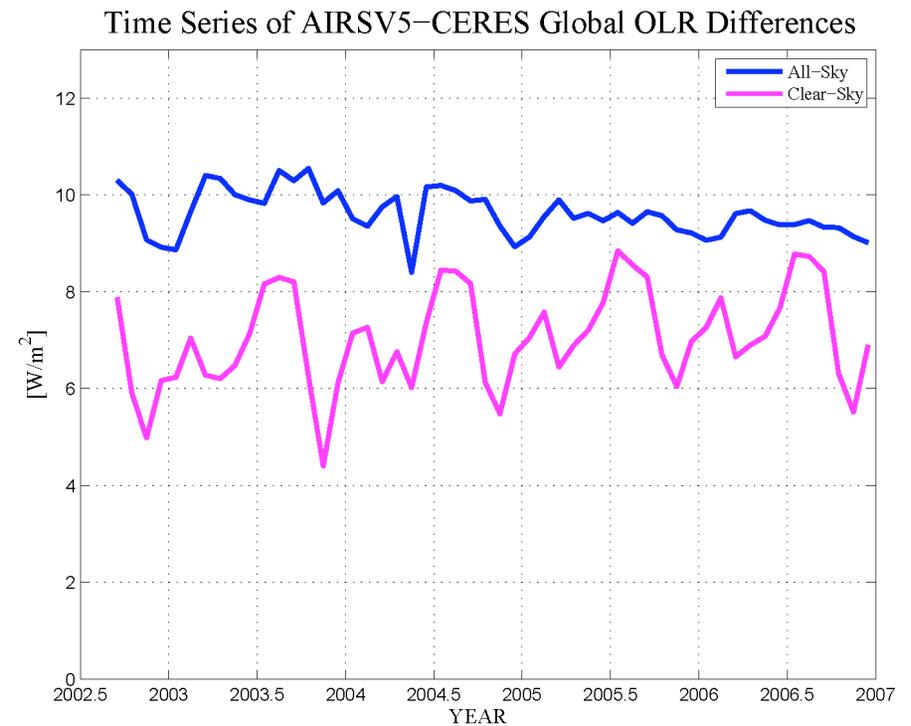
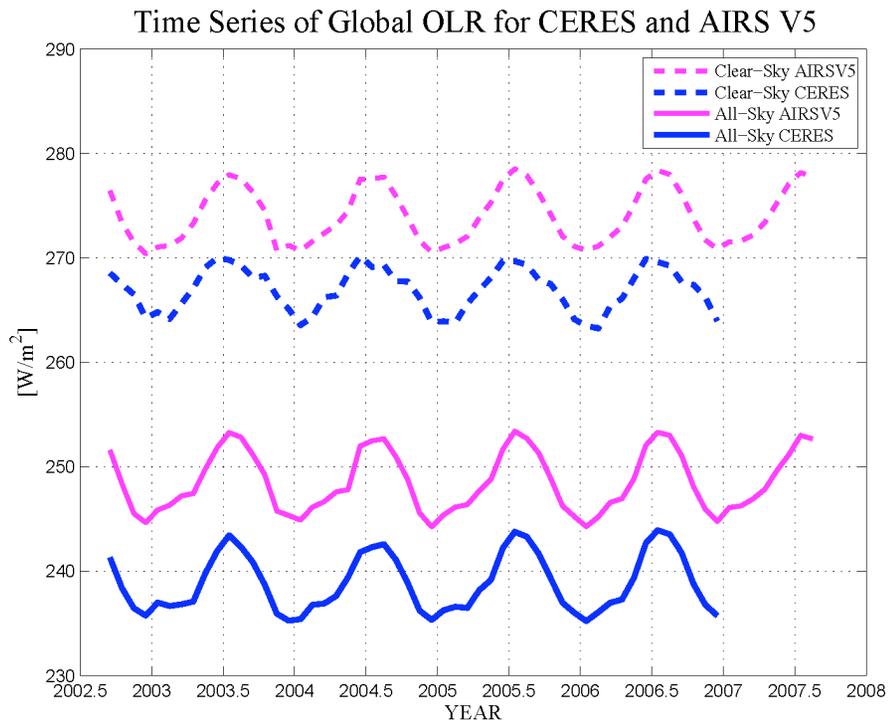


Sep./02-Dec./06 CERES Clear-Sky OLR Anomaly "Trend" [$\text{W/m}^2/\text{yr}$]



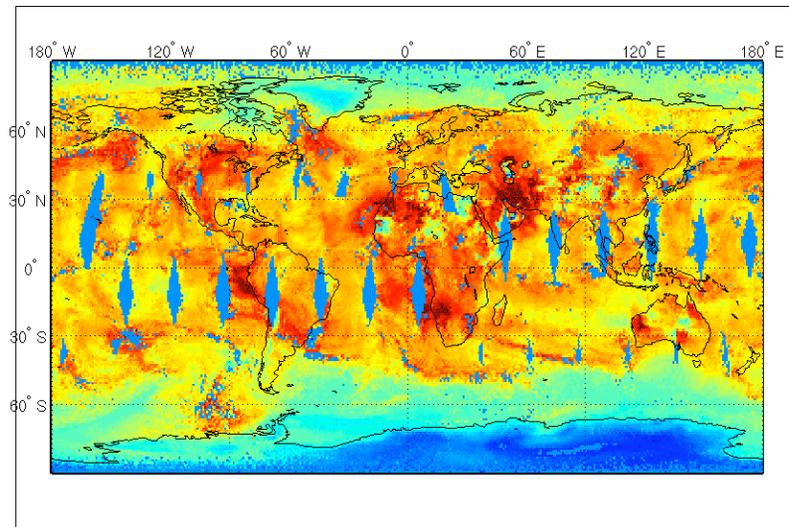
The CERES map is 'spotty' due to insufficient sampling, but the correlation is still quite high at 0.86.

Global Mean AIRSV5 vs. CERES OLR Timeseries and Biases

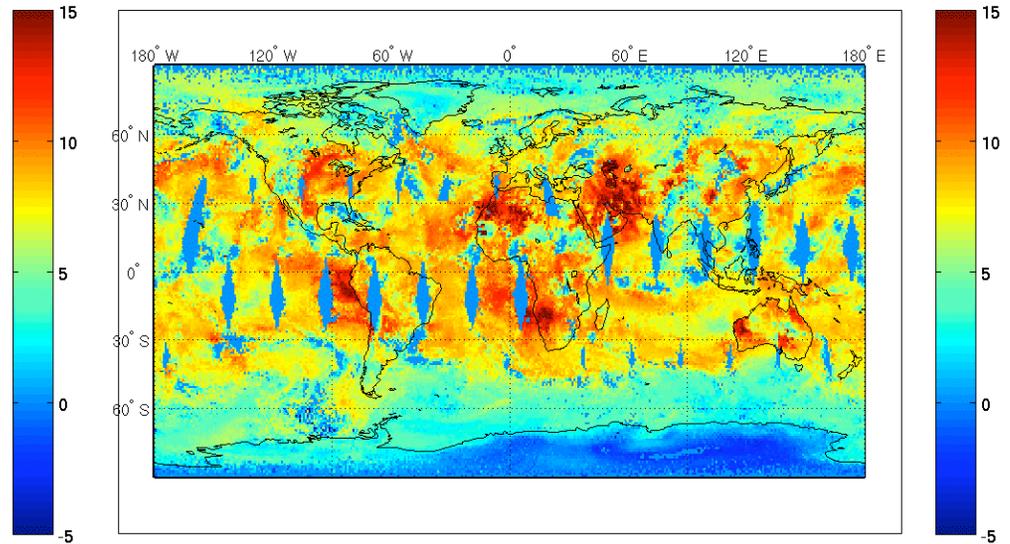


AIRS V5 vs. AER OLR Bias maps for 09/06/02

SRT V5.0 AIRS - AER Clear-Sky OLR [W/m^2] for 9/6/2002
Bias = 8.142 W/m^2 STD = 8.501 W/m^2



SRT V5.0 AIRS - AER All-Sky OLR [W/m^2] for 9/6/2002
Bias = 7.038 W/m^2 STD = 7.569 W/m^2



Summary/Future Work

- The AIRS-based climate analyses show informative and physically plausible interrelationships among temperature, humidity, clouds, OLR both on the spatial and temporal scales. GCMs, to be trusted for climate predictions, should be able to reproduce these interrelationships.
- Agreement of AIRS and CERES OLR anomalies and trends indirectly validates AIRS anomalies and trends of other geophysical parameters
- Version 6 will have:
 - New OLR code
 - Removes bias between AIRS and CERES
 - Allows for varying CO₂
 - Significantly better surface temperatures and emissivities
 - Improved temperature profiles over land

