Estimation of Outgoing Longwave Radiation from AIRS Radiance Measurements

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Outline

- Motivation
- Method
- Training regression coefficients
- Results
- Summary and next work

Motivation

AIRS:

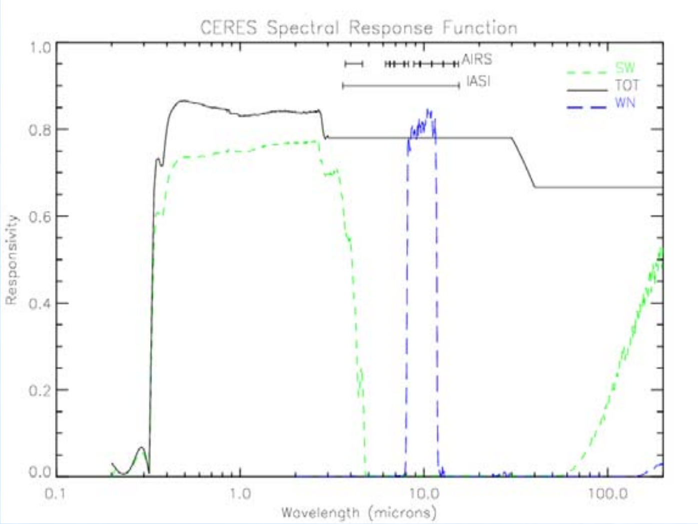
- 2378 channel spectrometer in 3.74 - 15.4 μm.
- More information content than AVHRR and HIRS.
- High radiometric accuracy and long-term spectral stability.

CERES:

- Three-channel broadband radiometer.
- High radiometric accuracy and high accuracy of CERES OLR.

➢ Directly estimate TOA OLR from AIRS hyper-spectral radiance measurements. CERES SSF LW outgoing fluxes is used as ‘truth’ .

- Avoid bias in RTA.
- Avoid errors in level 2 products.



Method: principle component regression

AIRS OLR is a least square regression between CERES OLR and principal component scores of AIRS radiances:

$$OLR = A_0 + \sum_{k=1}^{K} A(k) \bullet P(k)$$

$$\mathrm{P(k)} = \begin{pmatrix} \mathrm{PCS(1)} \\ \mathrm{PCS(2)} \\ \ldots \\ \mathrm{PCS(K)} \end{pmatrix}$$

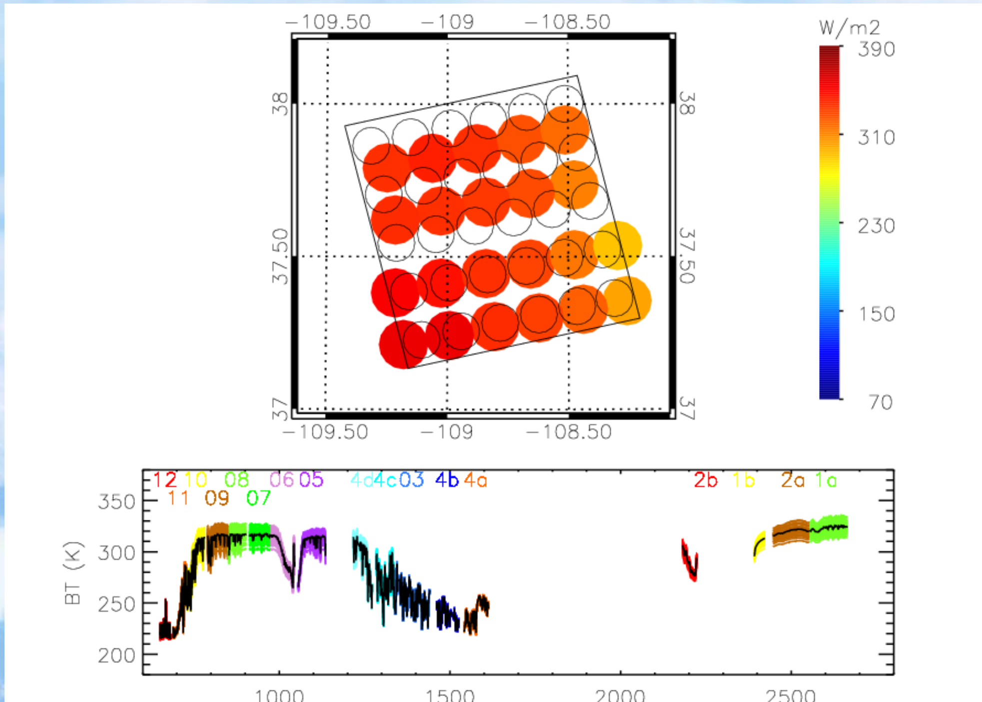
where, A are regression coefficients at eight regimes of viewing angle. PCS are AIRS radiance principle component scores:

$$PCS(k) = \frac{E^T(k,n) \bullet \Delta\Theta(n)}{\sqrt{\lambda(k)}}$$

$$\Delta\Theta(n) = \frac{R(n) - \langle R \rangle (n)}{NE\Delta N(n)}$$

where, λ(k) and E(n, k) are eigenvalues and eigenvectors of covariance matrix of AIRS normalized radiance, got from another training ensemble of AIRS radiances.

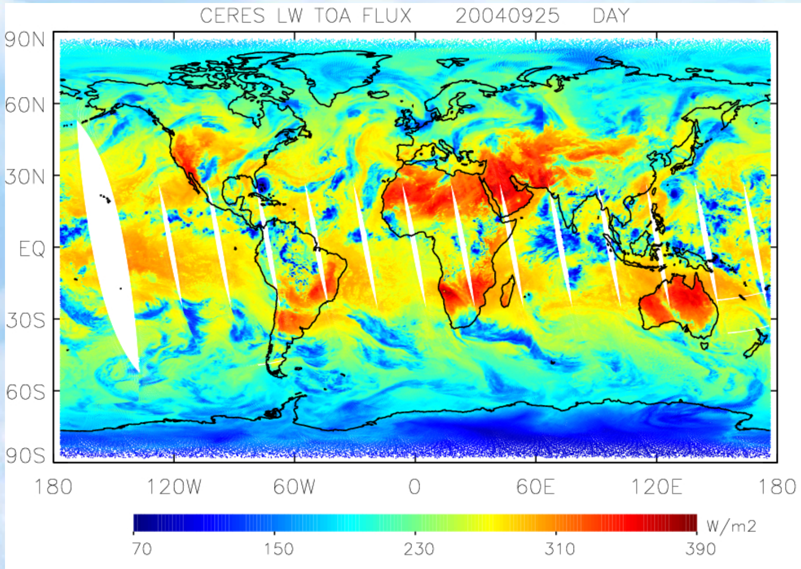
Collocation of AIRS and CERES measurements

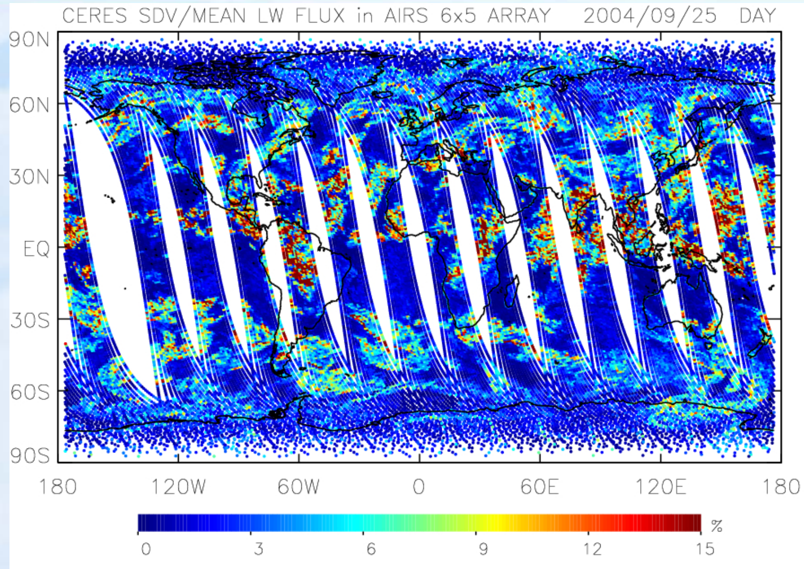


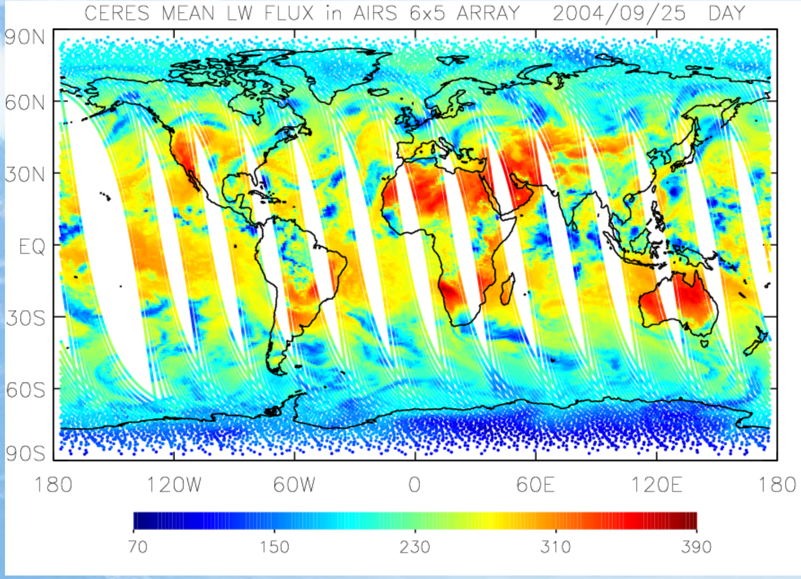
Up panel: black circles are AIRS footprints. Color rounds are CERES TOA longwave fluxes.
Low panel: color lines are AIRS BT within AIRS 6x5 array. Black line is their mean BT of its 1707 'pristine' channels.

- AIRS: 1.1° x 0.6° FOV 13.5 km at nadir
- CERES: 1.3° x 2.6° FOV 20 km at nadir
- **Big box**: 6x5 array of AIRS FOVs
- Averaging CERES OLR and AIRS radiances in big box in order to minimize the effect of the differences in the view and scanning properties of two instruments.

Mean and CV of CERES outgoing longwave fluxes in big box







Define: coefficient variation (CV) of CERES OLR in the big box:

CV = 100.* STDDEV / MEAN

- CV ≤ 5% uniform scenes, used to training regression coefficients
- CV > 5% non-uniform scenes

Training and test ensembles

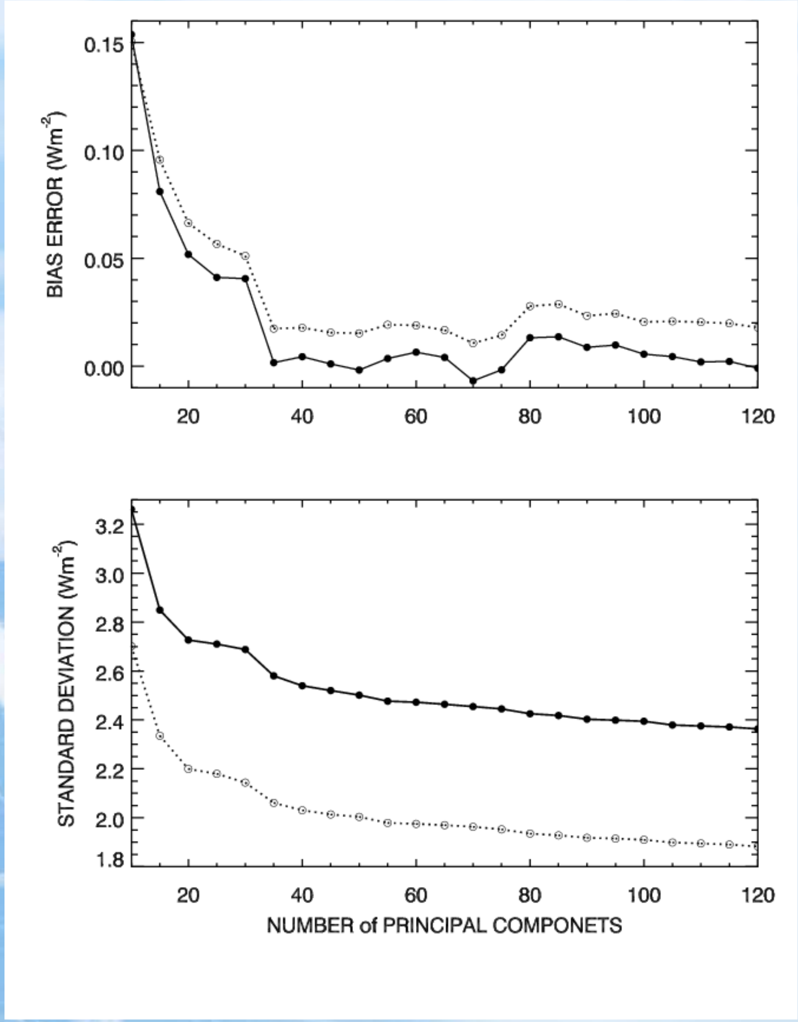
Training ensemble: 16 days

Nov. 25, 2003	Nov. 12, 2005
Jan. 20, 2004	Mar. 6, 2006
Apr. 13, 2004	Jun. 3, 2006
Jul. 6, 2004	Sept. 6, 2006
Oct. 26, 2004	Dec. 6, 2006
Feb. 15, 2005	Feb. 26, 2007
May 12, 2005	May 12, 2007
Aug. 11, 2005	Jul. 26, 2007
Total:1,521,993 pairs	

Test ensemble: 8 days

Jun 6, 2004
Nov. 23, 2004
Mar 15, 2005
Sept. 8, 2005
May 20, 2006
Jul. 12, 2006
Jan. 1, 2007
Aug. 24, 2007
Total: 759,669 pairs

Determination of No. of AIRS radiance eigenvectors

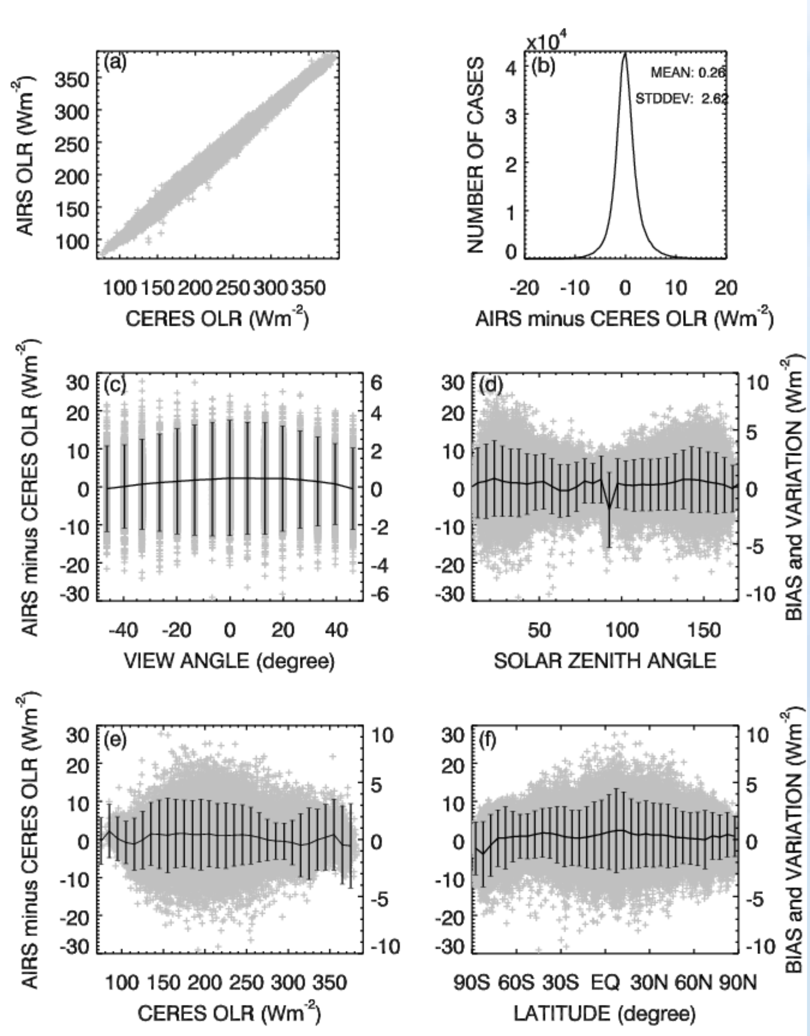


Solid line: all-sky scenes; dotted line: uniform scenes

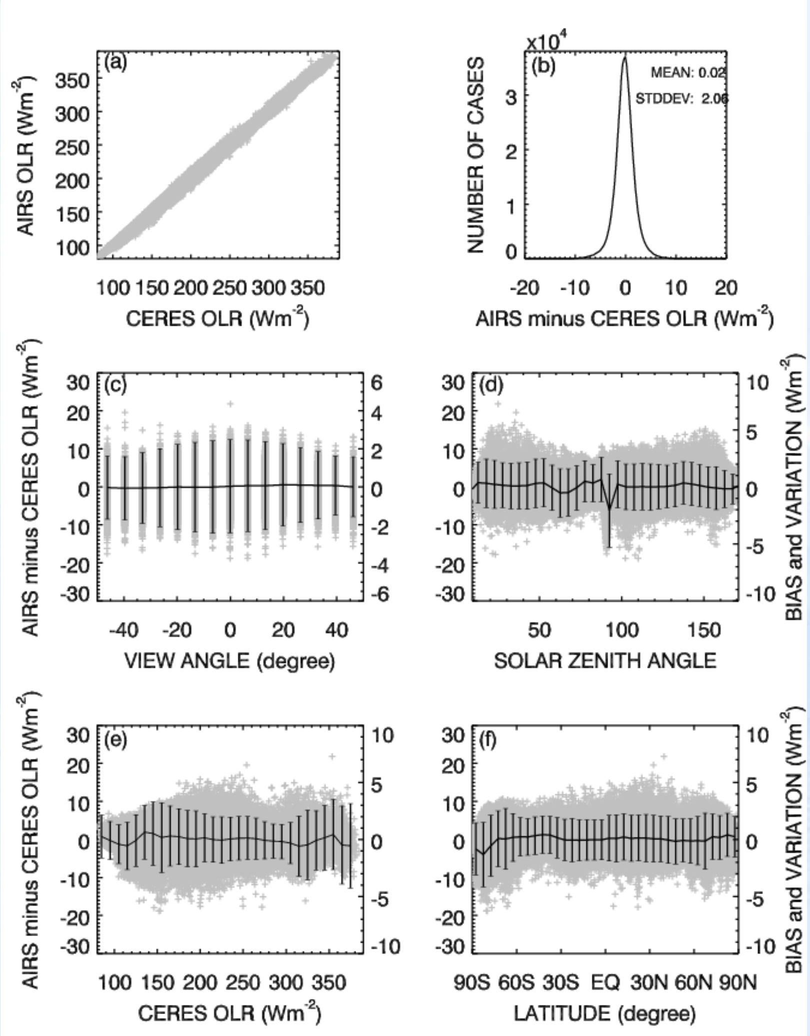
- Lower biases when the no. of principle components from 35 to 75.
- K=35, reduce biases when OLR ≥ 310 Wm^{-2}.
- ➢ To training regression coefficients: K=35 and use uniform scenes only.

Statistics for the test ensemble

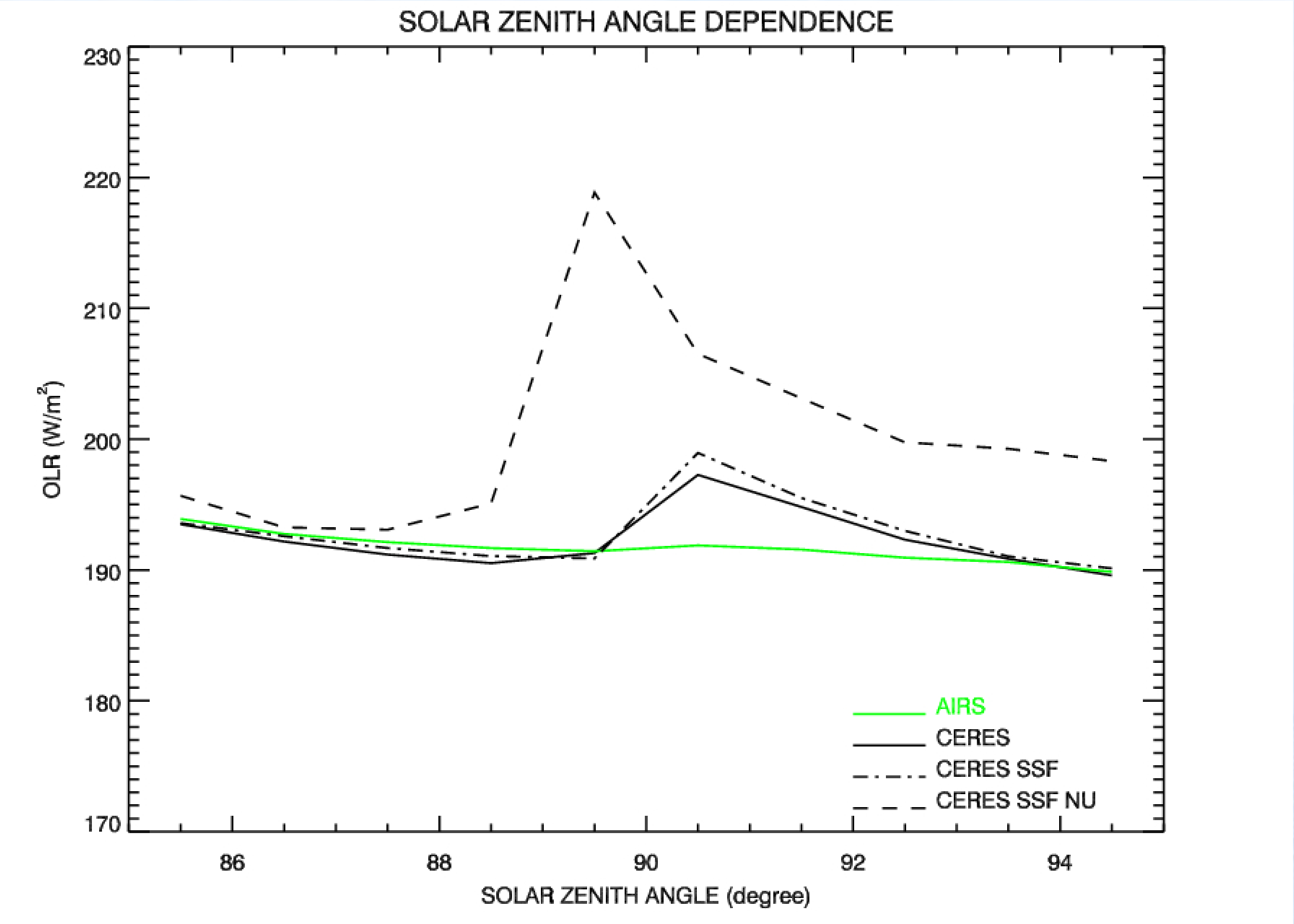
ALL scenes



Uniform scenes

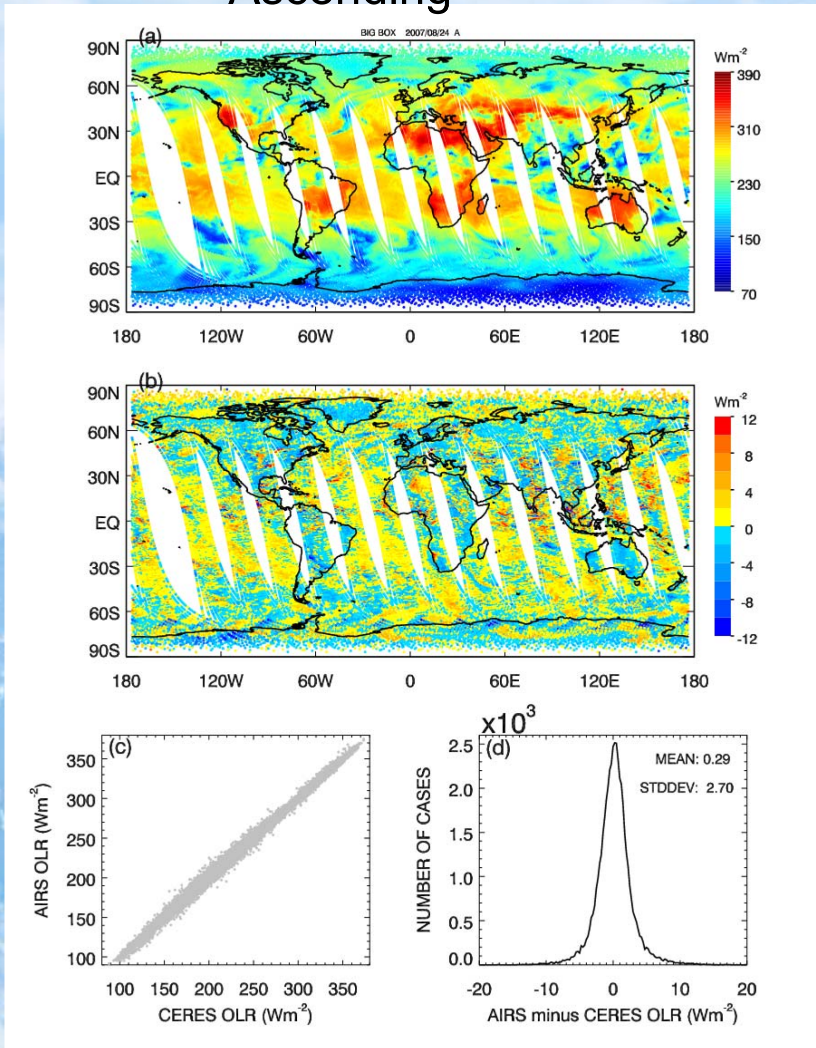


AIRS and CERES OLR in twilight region

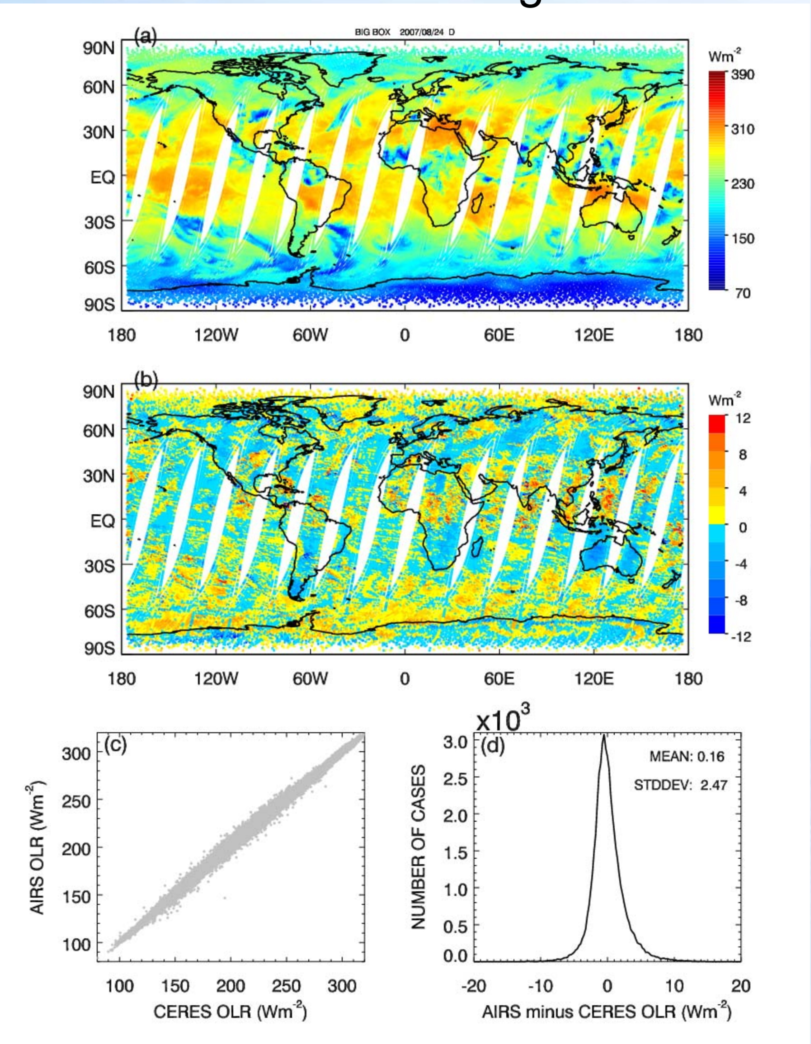


AIRS OLR in big box

Ascending

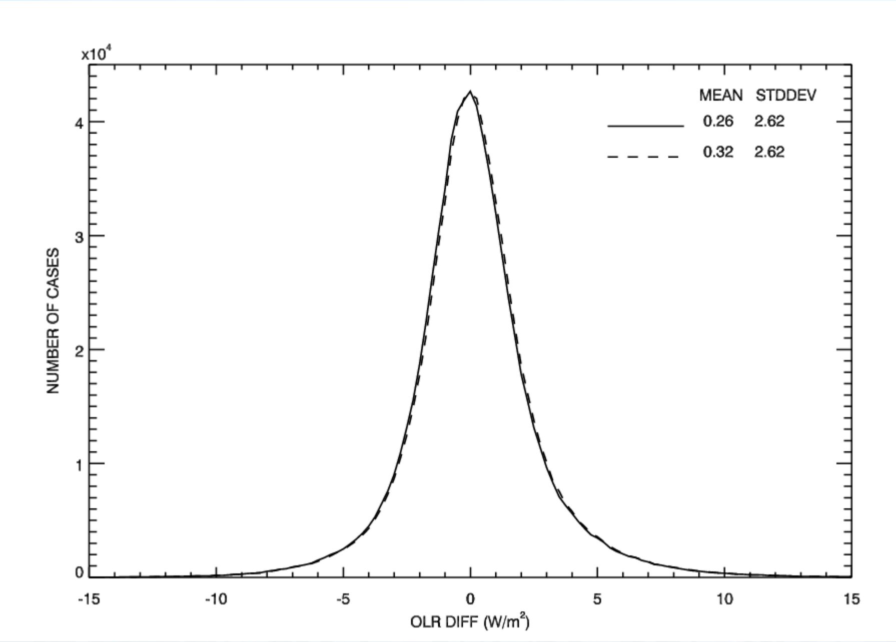


Descending



Sensitive study 1: impact of spatial average

- Apply regression coefficients to AIRS mean spectra in big box (solid line).
- Apply regression coefficients to each AIRS spectrum in big box, then average 30 OLR values (dashed line).



Sensitive study 2: impact of the temporal coverage of the training ensemble

Training ensemble

Nov. 25, 2003	Nov. 12, 2005
Jan. 20, 2004	Mar. 6, 2006
Apr. 13, 2004	Jun. 3, 2006
Jul. 6, 2004	Sept. 6, 2006
Oct. 26, 2004	Dec. 6, 2006
Feb. 15, 2005	Feb. 26, 2007
May 12, 2005	May 12, 2007
Aug. 11, 2005	Jul. 26, 2007

- Method 1: training the coefficients using all the training ensemble (**16 days**).
- Method 2: training the coefficients using subset of the training ensemble (**7 days** in red color).
- Apply two set coefficients to the test ensemble.

Biases of the test ensemble (Units in Wm^{-2})

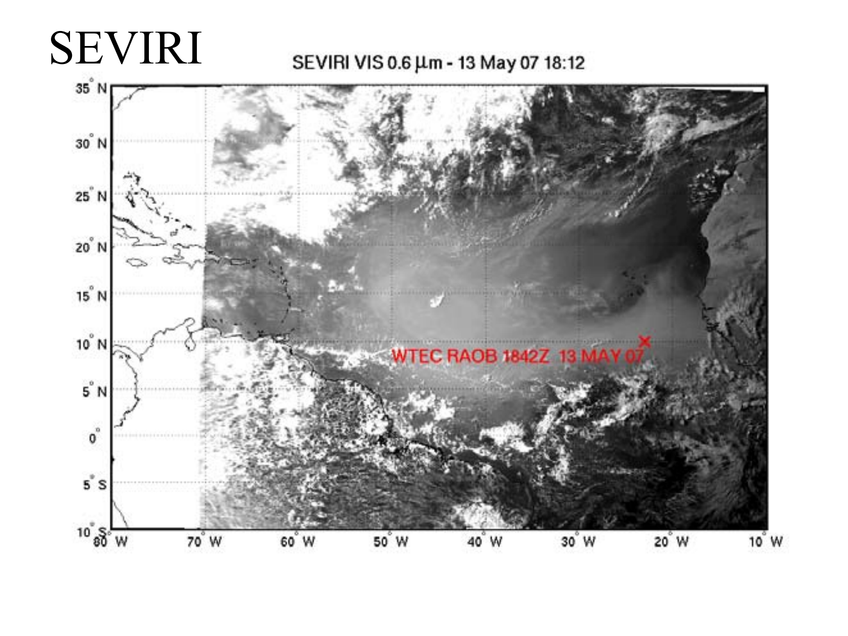
Days	Uniform scenes		Non-uniform scenes		All-sky scenes	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
Jun 6, 2004	0.16	0.13	1.31	1.37	0.42	0.41
Nov. 23, 2004	-0.28	-0.33	0.88	0.93	-0.02	-0.05
Mar 15, 2005	0.18	0.14	1.11	1.16	0.39	0.37
Sept. 8, 2005	0.31	0.27	1.13	1.17	0.50	0.48
May 20, 2006	-0.03	-0.06	1.12	1.17	0.24	0.23
Jul. 12, 2006	0.09	0.04	1.00	1.04	0.31	0.28
Jan. 1, 2007	-0.27	-0.31	0.86	0.90	-0.03	-0.05
Aug. 24, 2007	-0.01	-0.07	1.03	1.06	0.23	0.19

Standard deviation error of the test ensemble (Units in Wm^{-2})

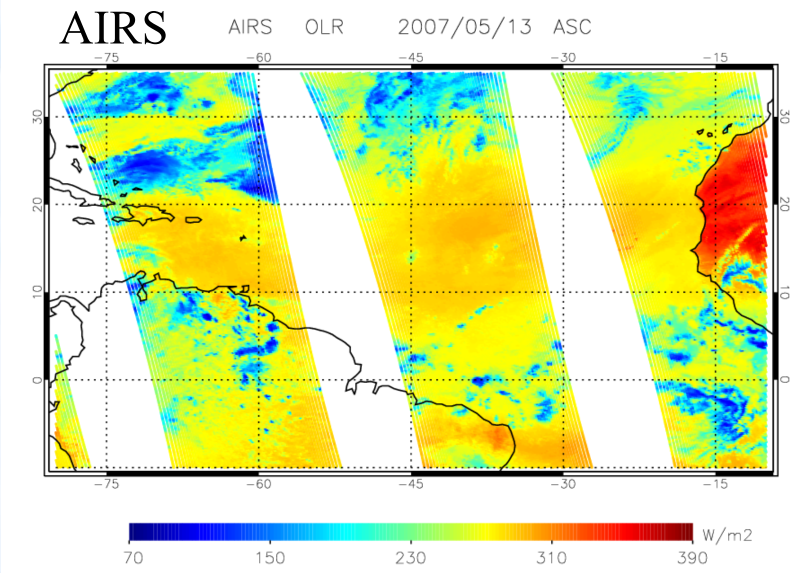
Days	Uniform scenes		Non-uniform scenes		All-sky scenes	
	Method 1	**Method 2**	**Method 1**	**Method 2**	**Method 1**	**Method 2**
Jun 6, 2004	2.02	2.02	3.82	3.81	2.59	2.60
Nov. 23, 2004	2.08	2.09	3.90	3.89	2.65	2.67
Mar 15, 2005	2.07	2.07	3.96	3.94	2.65	2.65
Sept. 8, 2005	2.08	2.07	3.83	3.81	2.62	2.61
May 20, 2006	2.04	2.04	3.82	3.82	2.62	2.63
Jul. 12, 2006	2.03	2.02	3.78	3.76	2.60	2.60
Jan. 1, 2007	2.12	2.13	3.72	3.70	2.59	2.60
Aug. 24, 2007	1.96	1.95	3.87	3.86	2.56	2.55

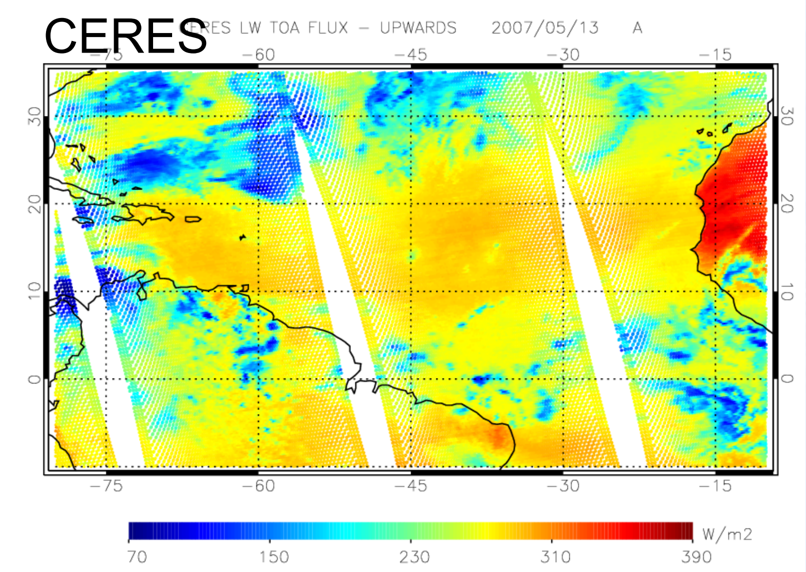
AIRS and CERES OLR in full resolution

Saharan dust outflow event on May 13, 2007

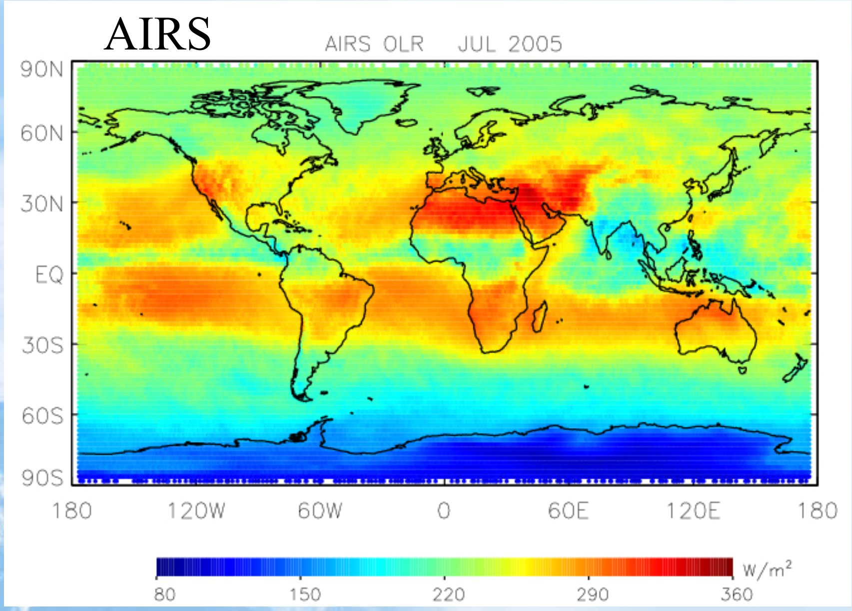


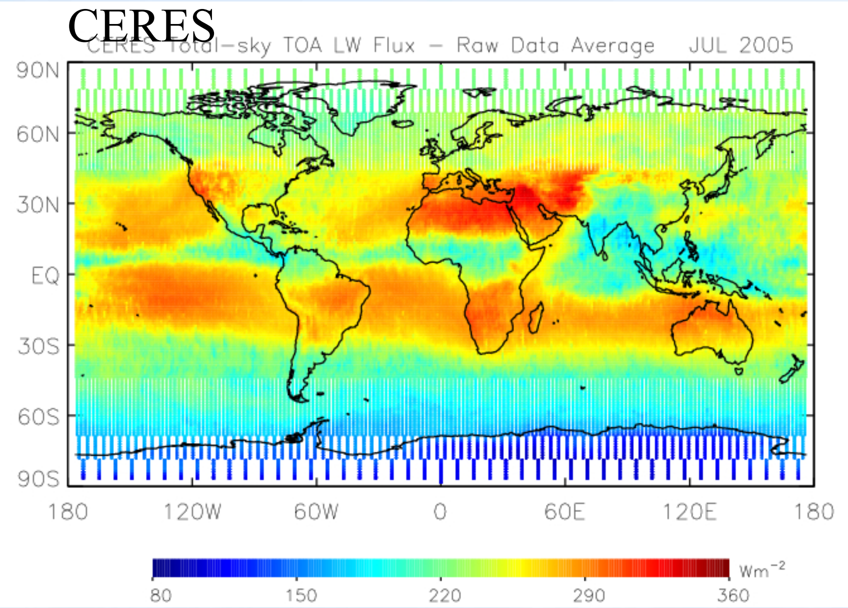
In courtesy of Nick Nalli





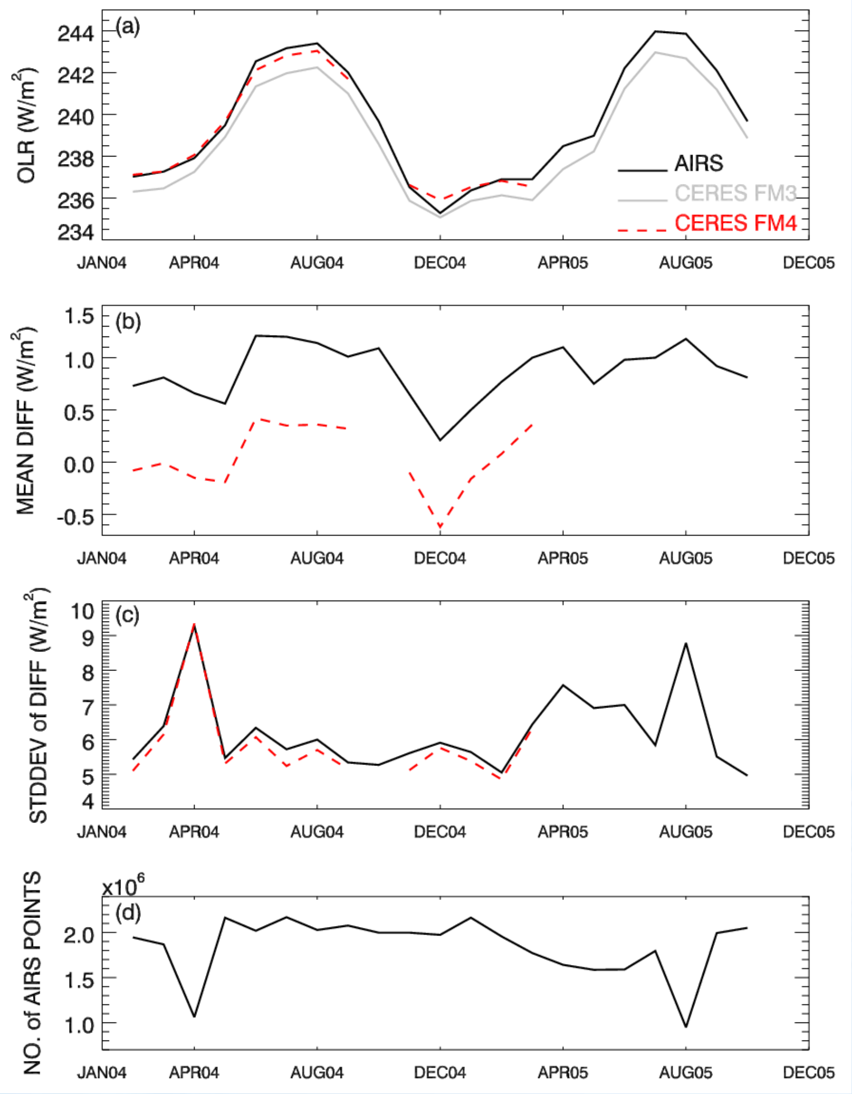
AIRS and CERES Monthly OLR in July 2005



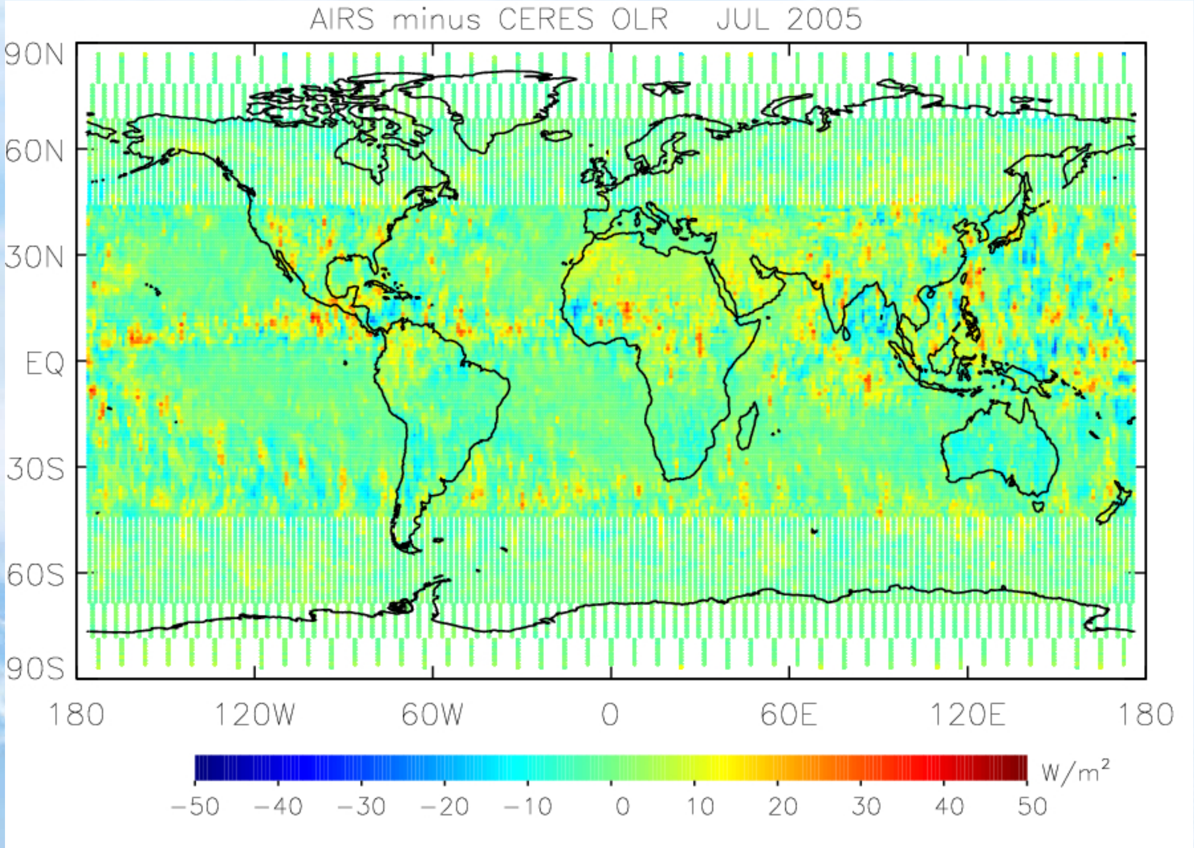


- AIRS monthly OLR is built from 0.5°x2° daily gridded radiance dataset.
- CERES monthly OLR is the total-sky TOA longwave flux (**raw data average**) from CERES Aqua FM3 Edition2A **SRBAVG** dataset.

Global monthly AIRS and CERES OLR



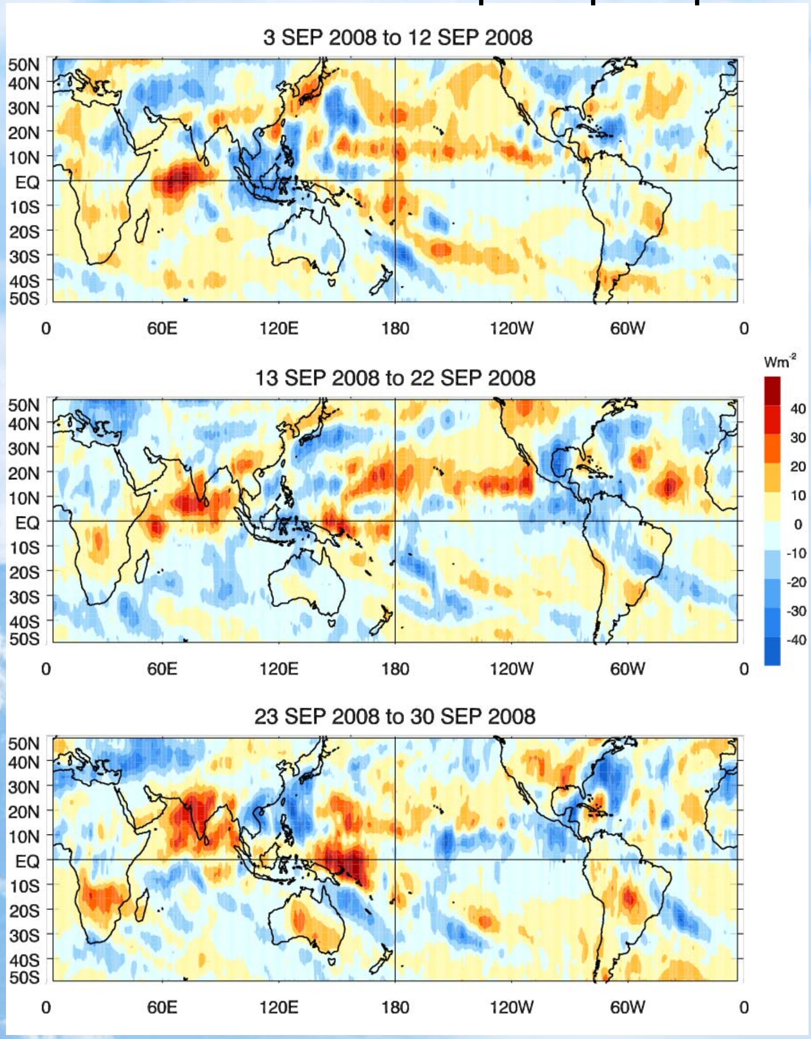
Monthly OLR difference



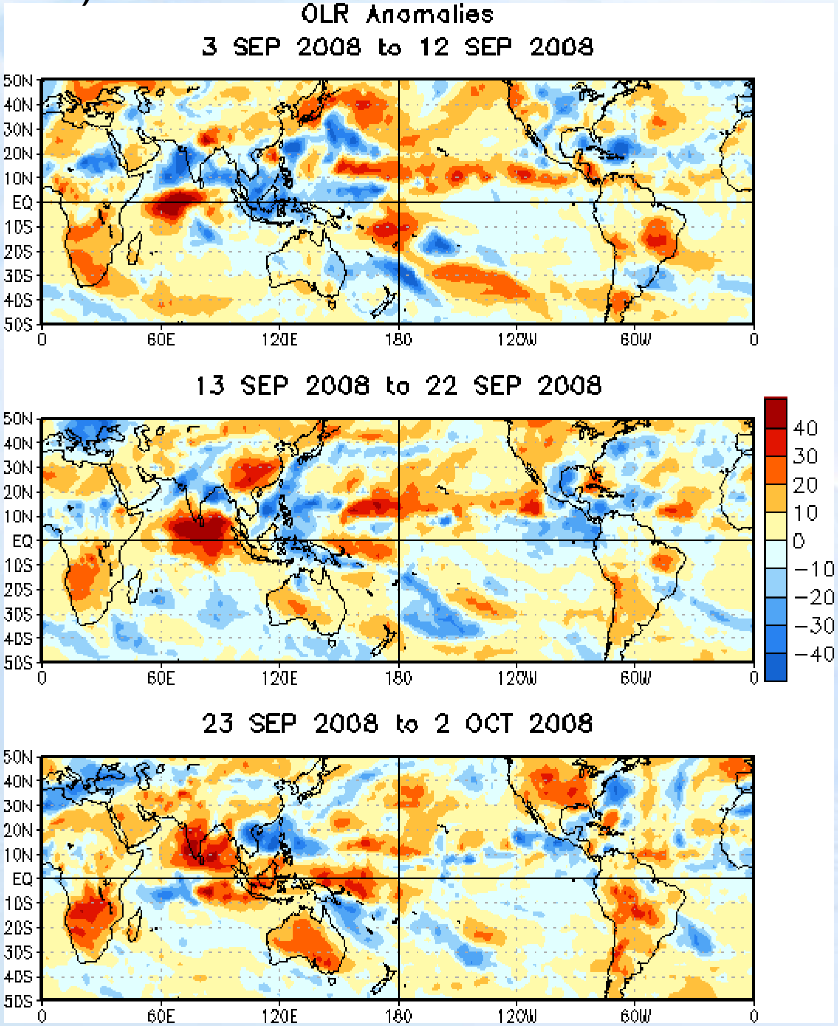
- Larger variation of OLR difference due to spatial sampling discrepancy.
- Produce AIRS level-3 OLR from AIRS level1b radiances.

AIRS and AVHRR OLR anomalies

Monitor anomalies of tropical precipitation (MJO)



AIRS OLR Anomalies relative to the mean from 2004 to 2008



AVHRR (in courtesy of NOAA/CPC)

Summary

- AIRS OLR is a principal component regression with CERES TOA outgoing longwave fluxes.
- Biases and standard deviation error of AIRS OLR is near to zero and within 3 Wm^{-2} , compared with CERES longwave fluxes in big box.
- There is slight angular dependence, but large difference in twilight region due to over-estimated CERES OLR.

Next Works

- Produce CERES-like IASI OLR.
  - Four times observation per day.
  - Can be used to monitor ERBS using CrIS in future NPOESS.
- Comparison with current AIRS version 5 level 2 OLR products that are calculated from atmospheric status and surface and cloud properties. Use AIRS 3°X3° gridded dataset and CERES FSW dataset.
- Level 3 OLR products: daily and monthly OLR in 0.5° x 0.5° grids derived from AIRS full-resolution radiances?