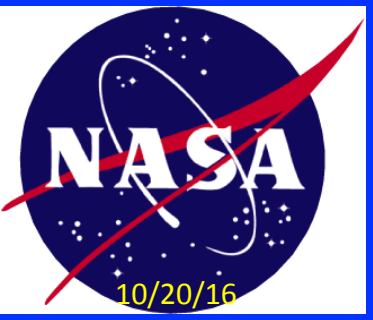
Understanding the El Nino Southern Oscillation Effects on Diurnal Outgoing Longwave Radiation

Wenying Su
NASA Langley Research Center, Hampton VA

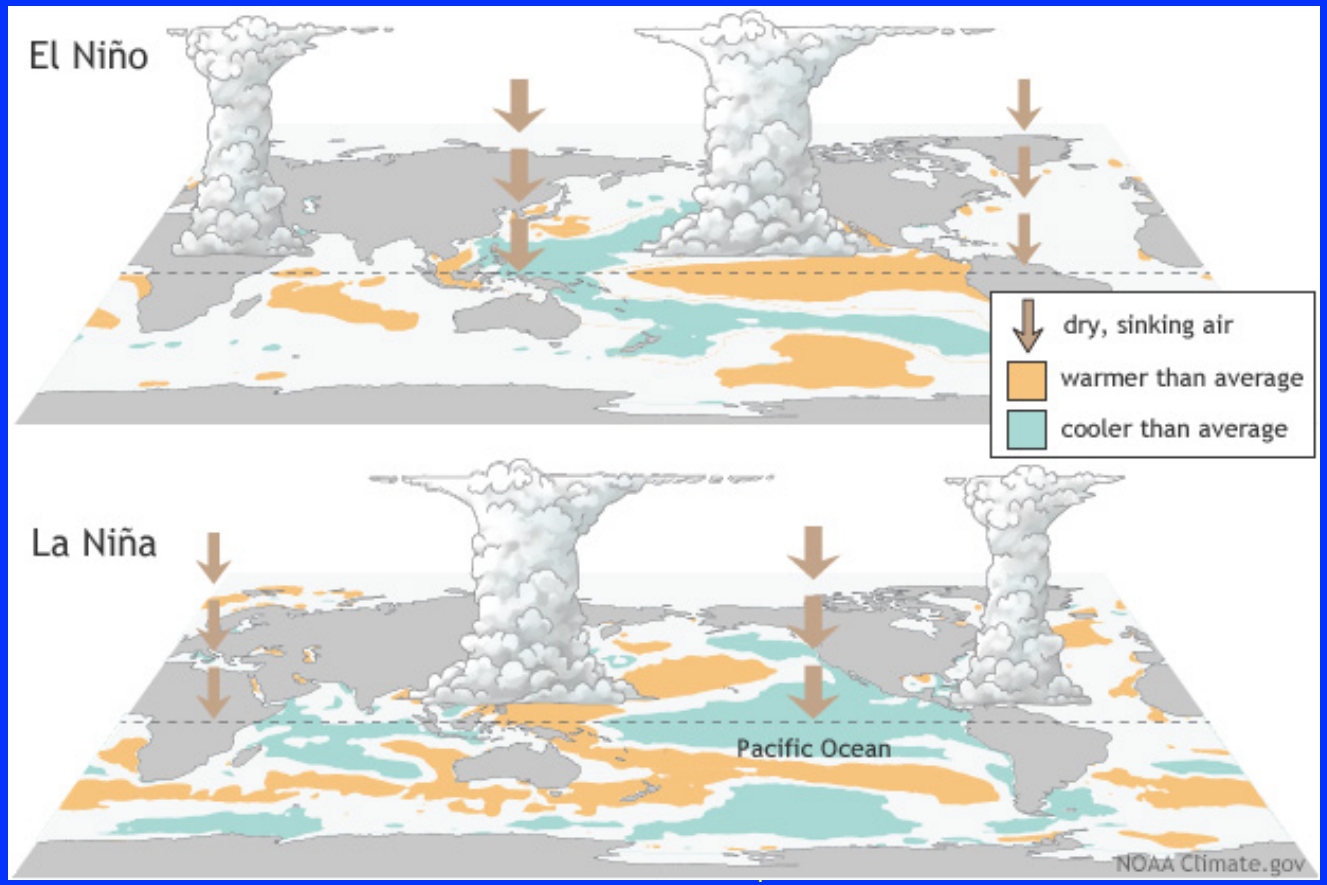
Norman Loeb
NASA Langley Research Center, Hampton VA

Lusheng Liang
SSAI/NASA Langley Research Center, Hampton VA



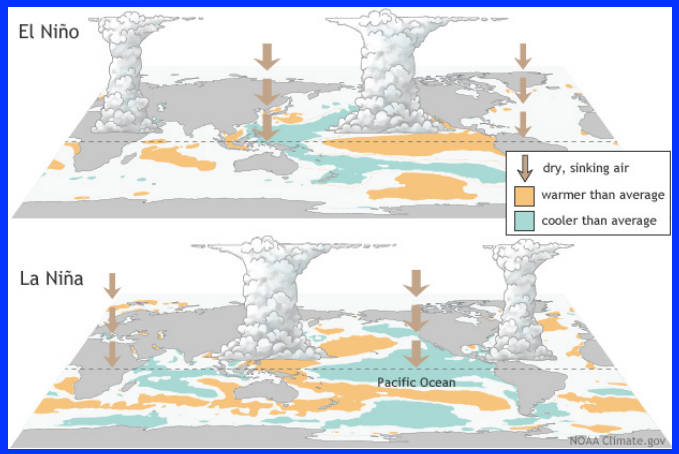
El Niño-Southern Oscillation (ENSO)

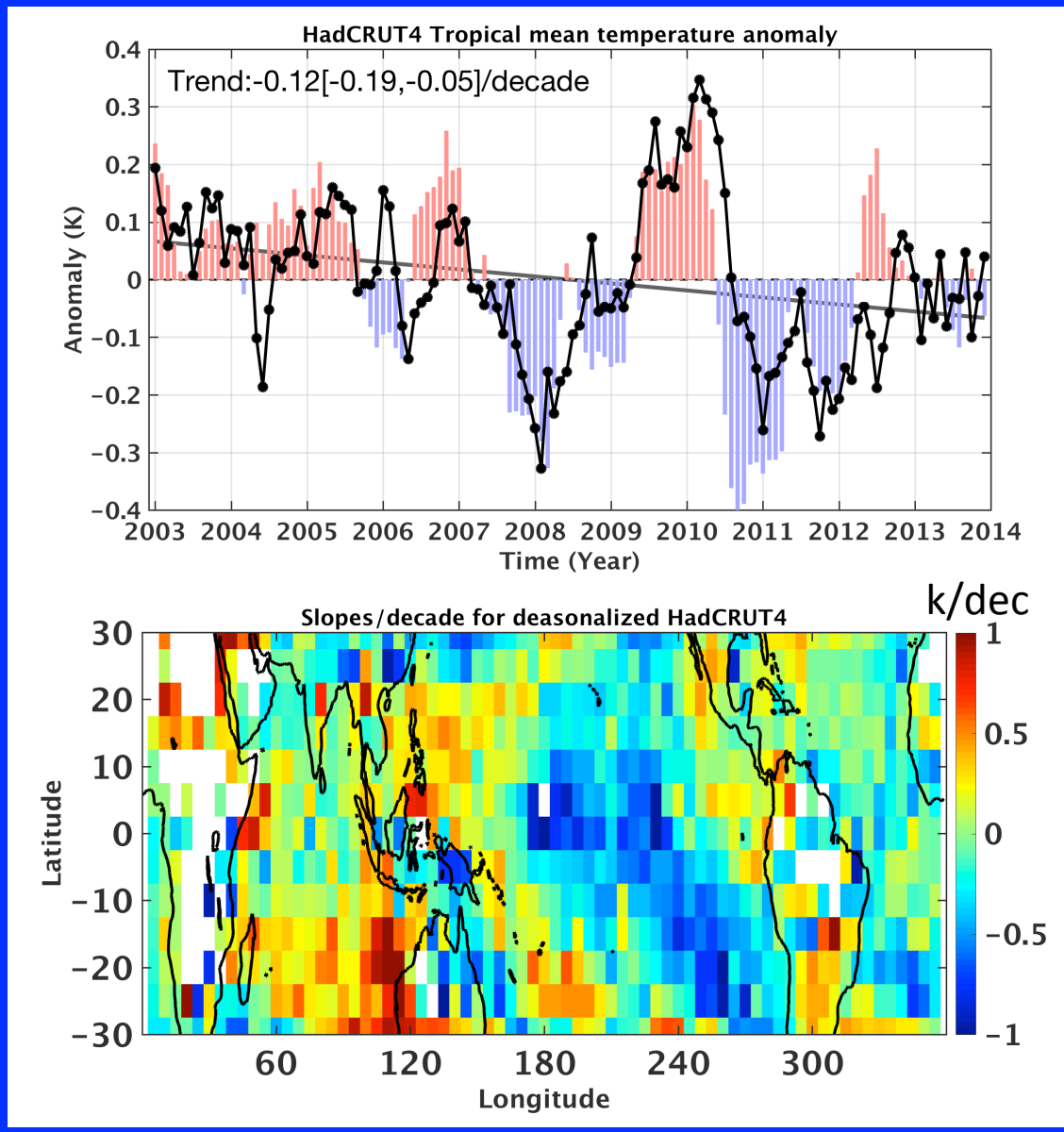
- ENSO is the leading mode of natural interannual climate variability in the tropics; it consists of two phases (El Nino and La Nina);
- During El Nino, warmer Sea Surface Temperature (SST) anomalies in the central and eastern tropical Pacific, but cooler SST anomalies in the western tropical Pacific;
- During La Nina, the opposite of the above occurs.



HadCRUT4 surface temperature trend from 2003 to 2013

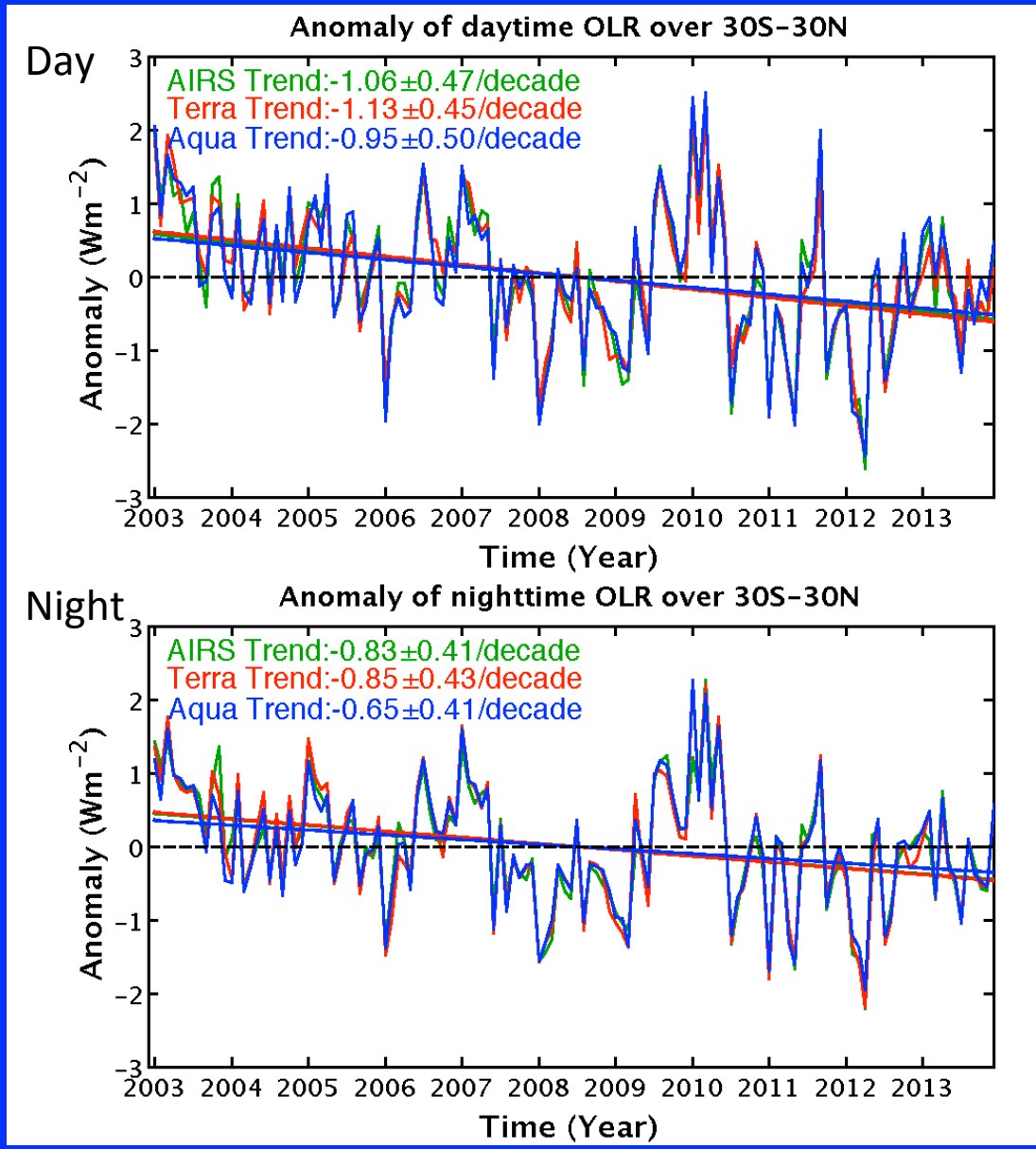
- HadCRUT4 data indicate that the tropical mean surface temperature decreases at a rate of -0.12 k/decade between 2003 and 2013;
- Regionally, the surface temperature trends show distinct features.





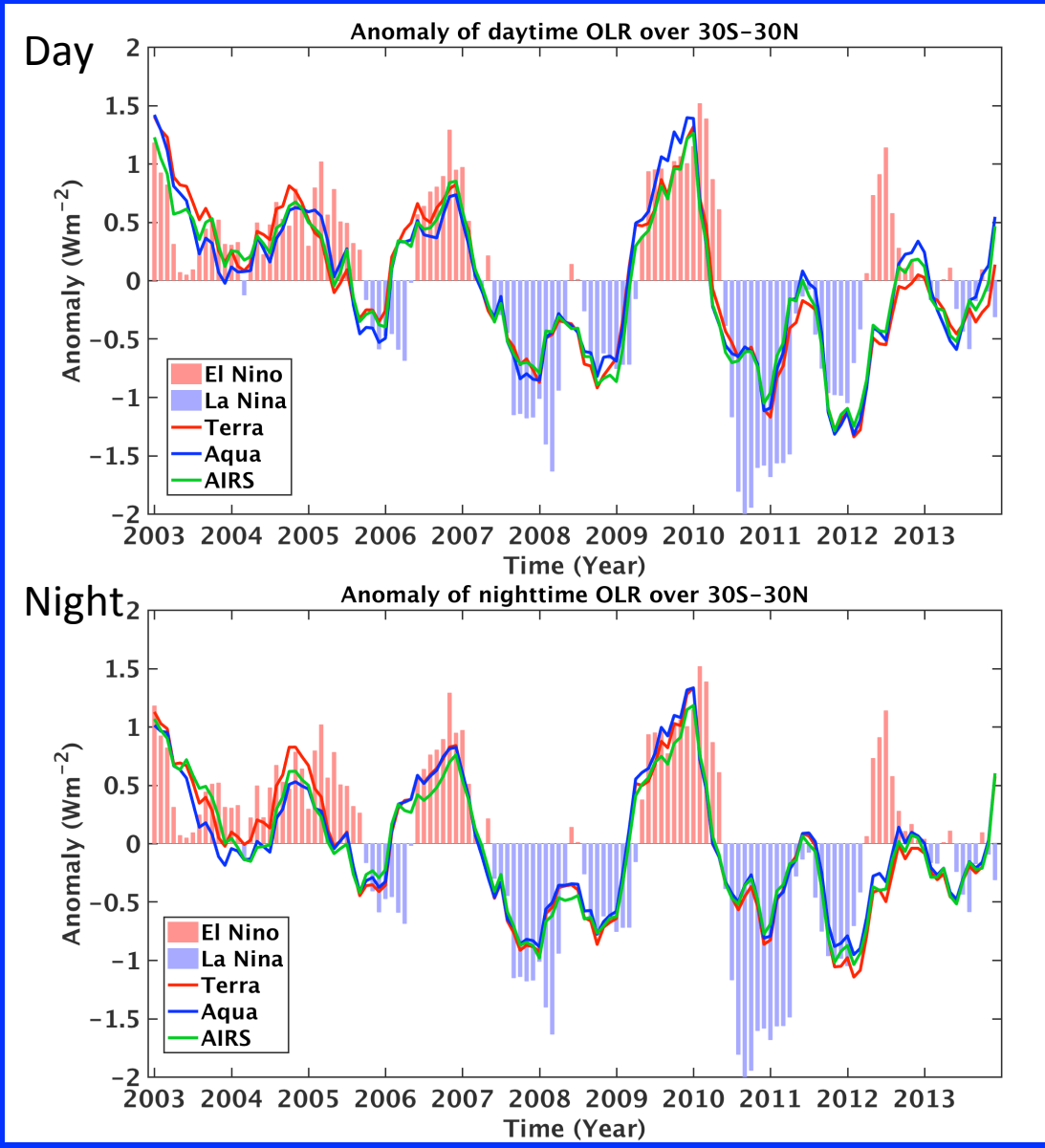
Anomalies of daytime/nighttime OLR over the tropics

- CERES OLR time series on both Terra/Aqua show decreasing trends for daytime/nighttime observations over 2003-2013 time period;
- Trends from AIRS OLR over the same time period agree with those from CERES remarkably well.
- The decreasing trends of day/nighttime OLR are also significant when we examine the tropical land and ocean separately.



OLR trends track the multivariate ENSO index very well

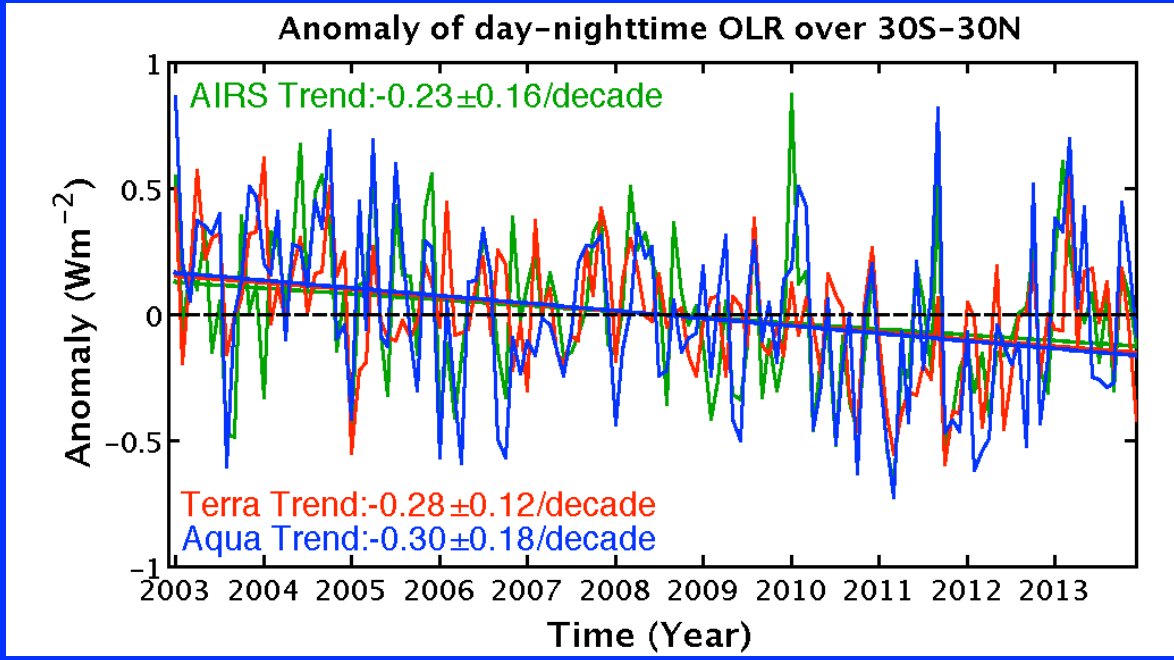
- Over the 2003-2013 time period, El Nino events dominate at the beginning while La Nina events dominate during the later period, resulting in the decreasing trends in daytime/nighttime OLR



Daytime OLR is decreasing faster than nighttime OLR

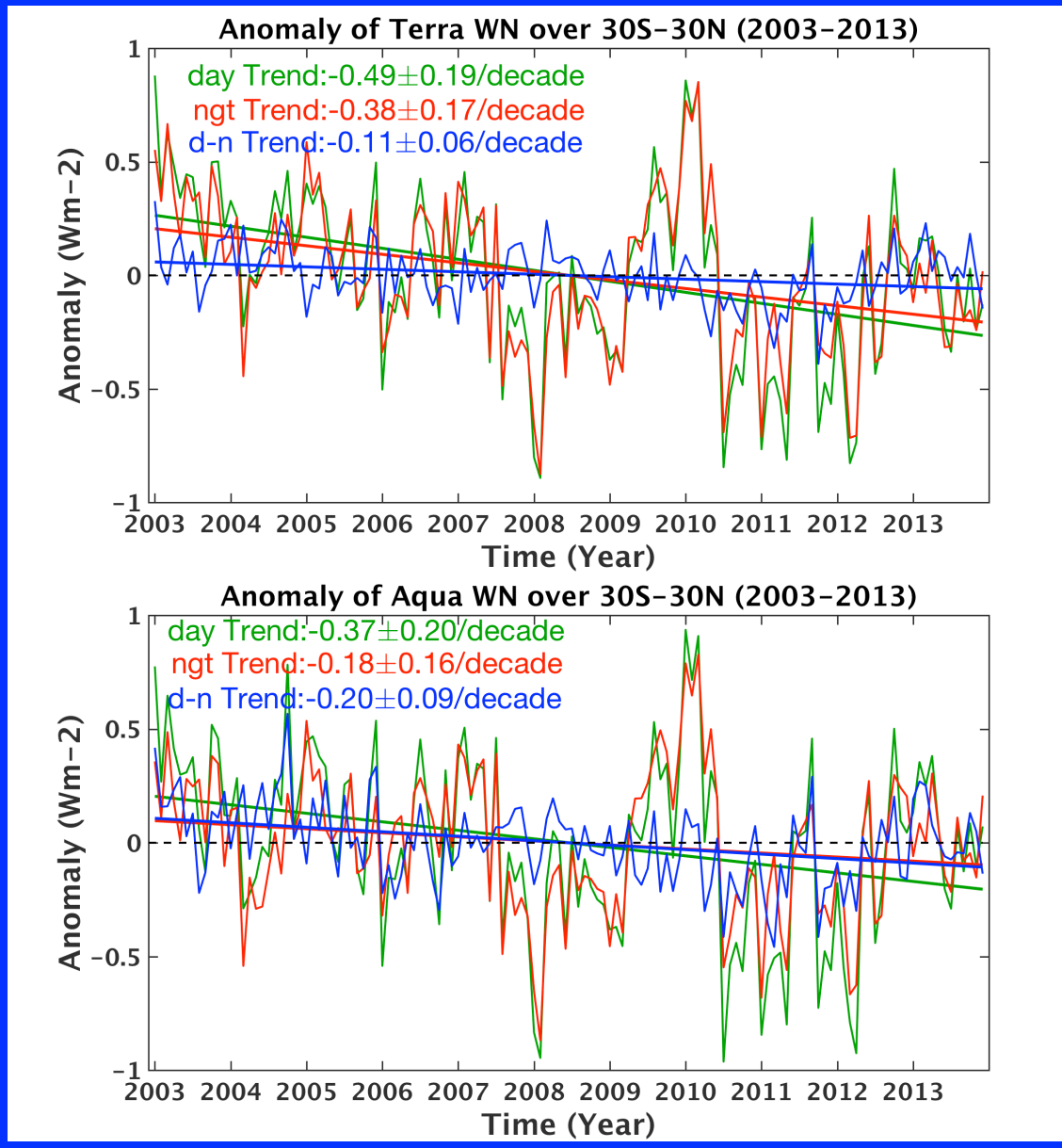
- The decreasing trends in daytime OLR is about 30% steeper than those of nighttime OLR;
- Resulting in a decreasing trend in daytime-nighttime OLR;
- Indicating that the day and night OLR difference is getting smaller over the tropics for the time period considered here.

$Wm^{-2}Decade^{-1}$	Daytime	Nighttime	Day-night
CERES/Terra	-1.13±0.45	-0.85±0.43	-0.28±0.12
CERES/Aqua	-0.95±0.50	-0.65±0.41	-0.30±0.18
AIRS	-1.06±0.47	-0.83±0.41	-0.23±0.16



All-sky window channel also shows the decreasing trends

- Both day/nighttime window fluxes show significant decreasing trends, the decreasing trends are also significant over tropical ocean and land;
- Similar to OLR, daytime window flux decreases faster than nighttime, resulting in a decreasing trend in daytime-nighttime window flux;

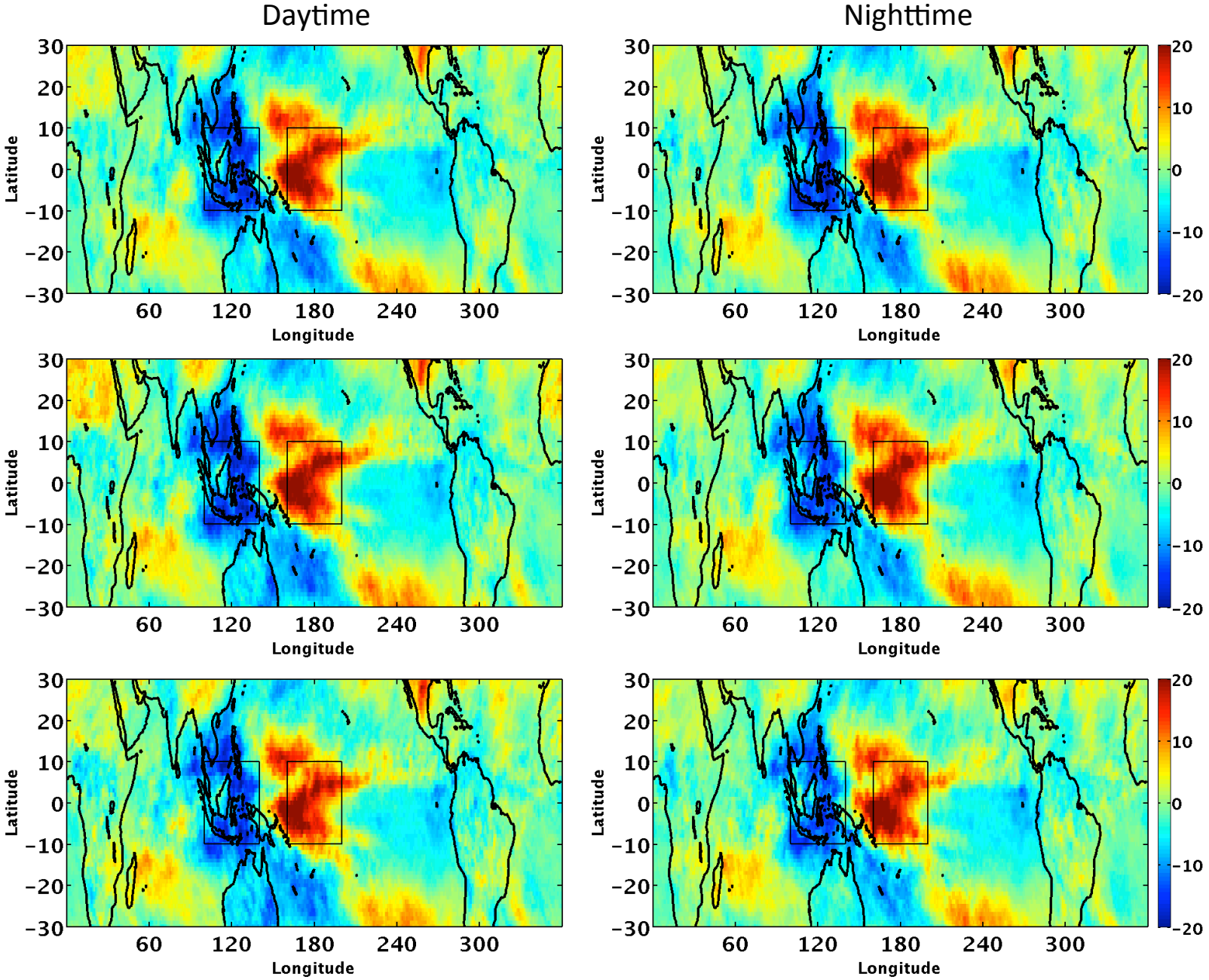


Regional day/night OLR trends (Wm-2Decade-1)

CERES/ Terra

CERES/ Aqua

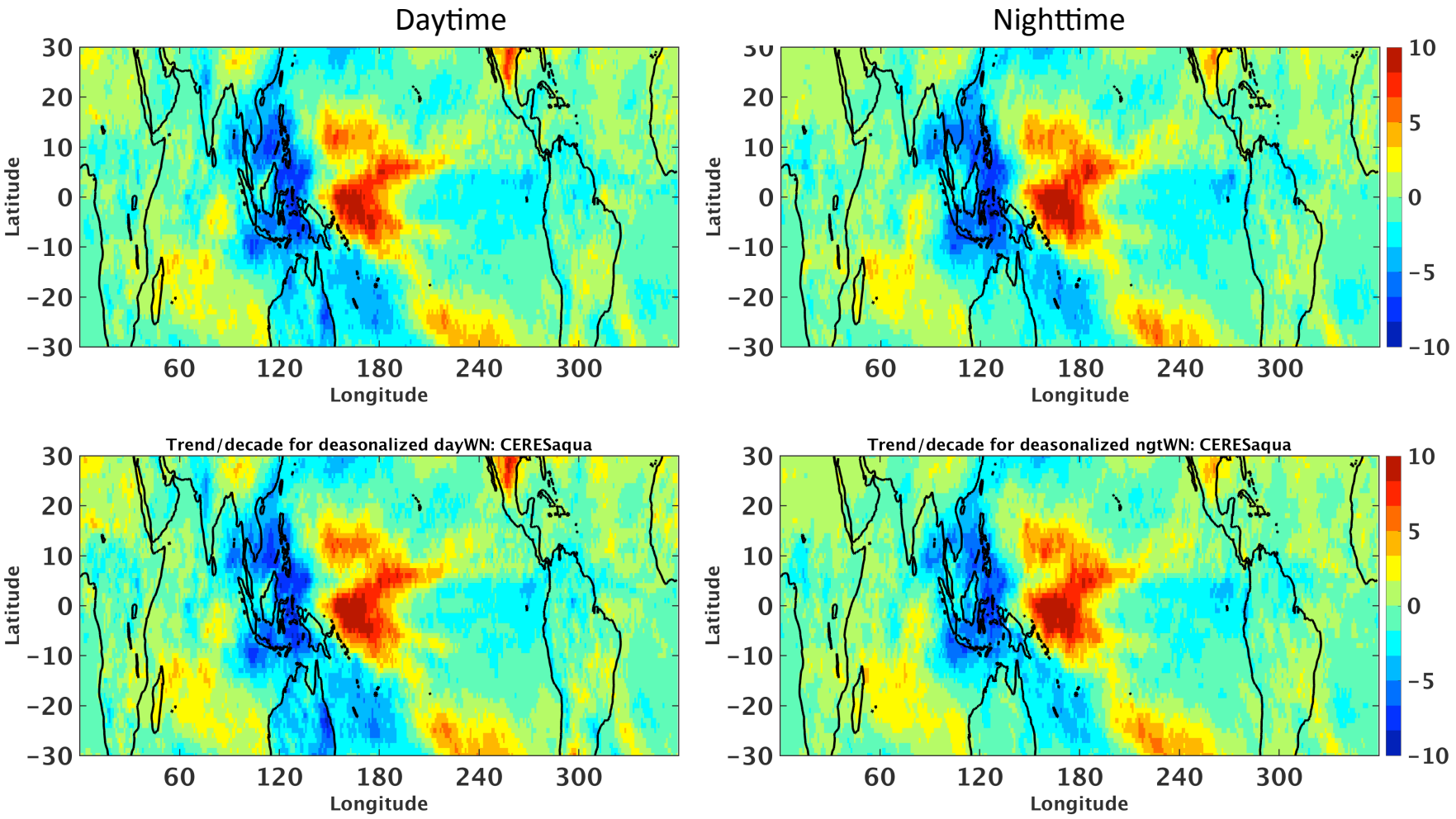
AIRS



Regional day/night WN channel flux trends (Wm-2Decade-1)

CERES/ Terra

CERES/ Aqua



High cloud (<500hPa) from CERES-MODIS

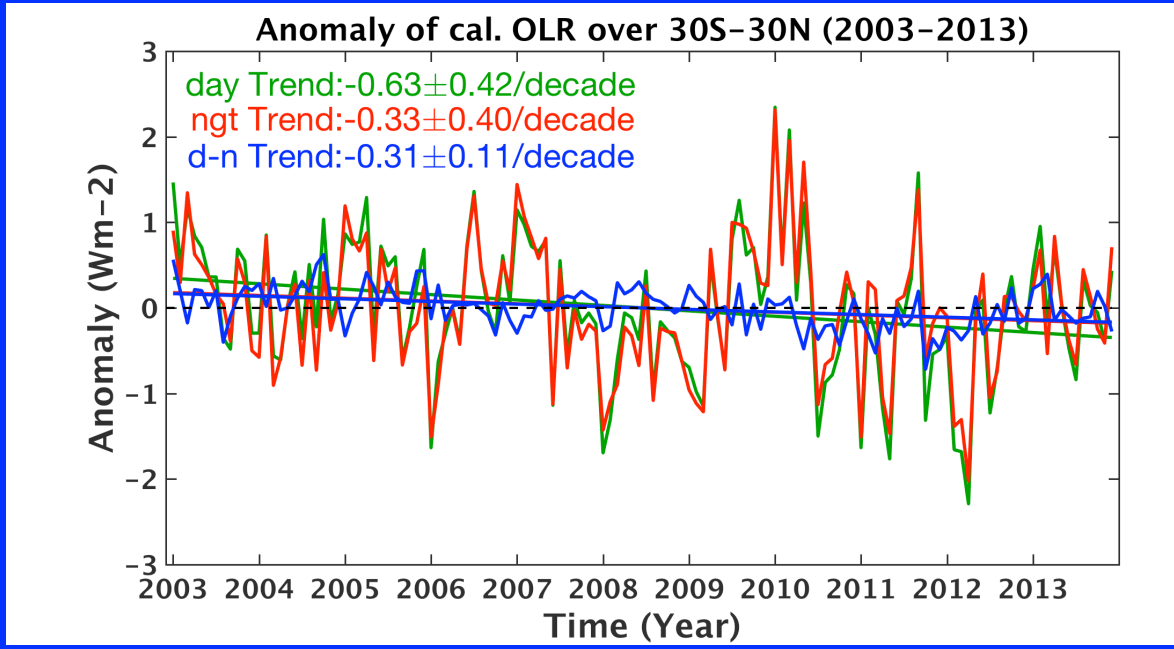
- CERES-MODIS retrieval indicates that both daytime and nighttime high cloud fraction increased over the tropics for the period considered here;
- Daytime high cloud top temperature remained unchanged while nighttime high cloud temperature increased slightly, thus compensated the larger increase of nighttime cloud fraction resulted in a larger decreasing daytime OLR trend than nighttime.

	High cloud fraction (%/ Decade)		High cloud top temp (K/ Decade)	
	Daytime	Nighttime	Daytime	Nighttime
Tropical (30N-30S)	0.44±0.27	0.51±0.37	-0.05±0.22	0.70±0.20
Tropical Ocean	0.21±0.30	0.25±0.42	0.07±0.24	0.83±0.21
Tropical Land	1.09±0.65	1.22±0.85	-0.39±0.29	0.31±0.28

OLR calculated using retrieved cloud properties also shows decreasing day-night trend

- OLR is calculated using cloud properties retrieved from MODIS measurements, and temperature/humidity profiles from GEOS 5.4.1;
- Calculated day/nighttime OLR also show decreasing trends, but a bit smaller than observations;
- But the day-night trend from the calculation agrees well with observation.

$Wm^{-2}Decade^{-1}$	Daytime	Nighttime	Day-night
CERES/Terra	-1.13±0.45	-0.85±0.43	-0.28±0.12
CERES/Aqua	-0.95±0.50	-0.65±0.41	-0.30±0.18
AIRS	-1.06±0.47	-0.83±0.41	-0.23±0.16
Calculated	-0.63±0.42	-0.33±0.40	-0.31±0.11



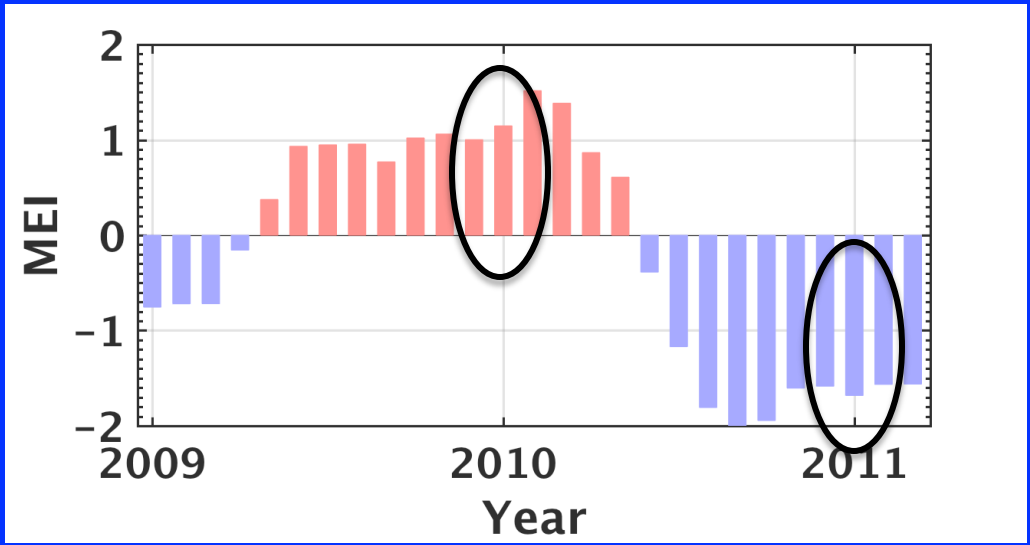
AIRS high cloud (<440hPa) trends

- AIRS daytime effective high cloud fraction increases faster than that for nighttime, while the high cloud top temperature exhibit none-significant trends for both daytime and nighttime.
- AIRS cloud retrieval algorithm is insufficient to locate the height of the thin cloud near the tropopause (Kahn et al. 2014).

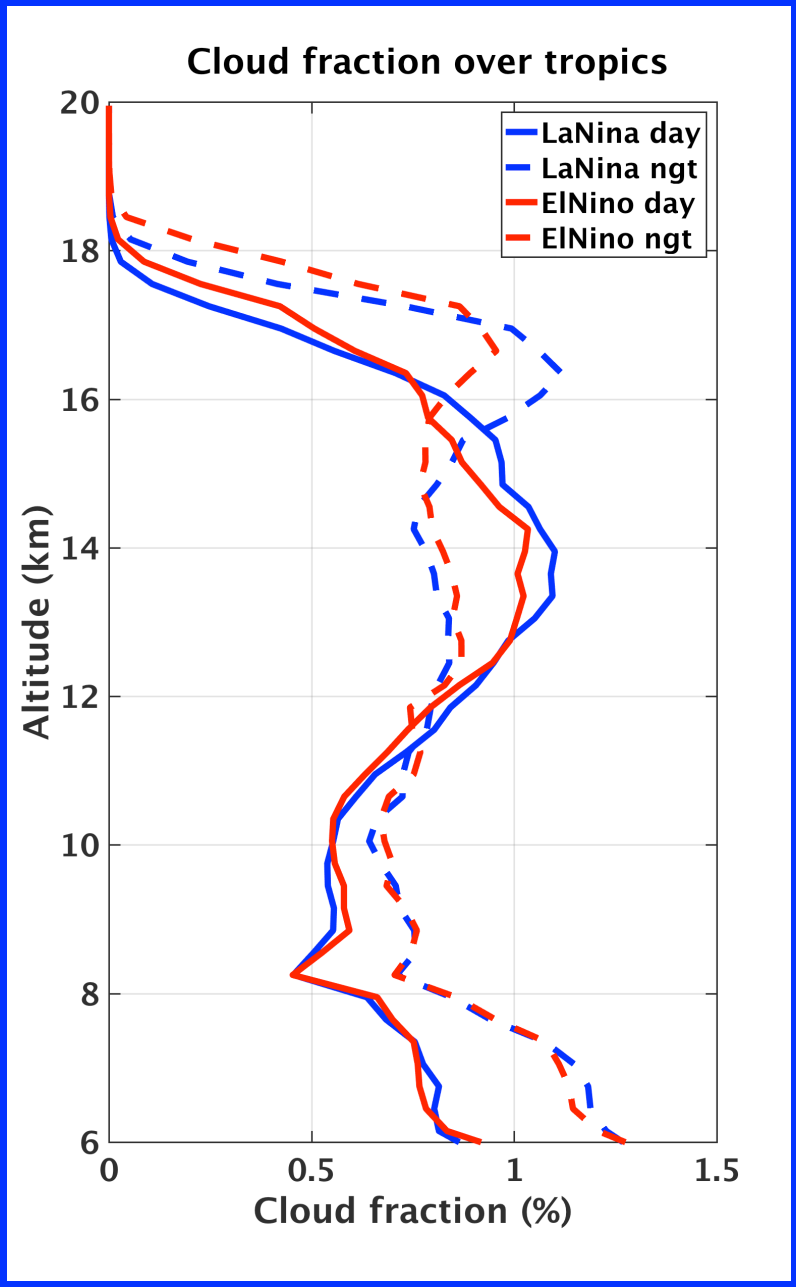
	Effective high cloud fraction (%/Decade)		High cloud top temp (K/ Decade)	
	Daytime	Nighttime	Daytime	Nighttime
Tropical (30N-30S)	0.20±0.17	0.09±0.18	0.04±0.29	-0.25±0.29
Tropical Ocean	0.04±0.20	-0.08±0.24	-0.16±0.32	-0.26±0.31
Tropical Land	0.62±0.47	0.53±0.57	0.29±0.34	-0.21±0.36

Cloud vertical distribution from CALIPSO for El Nino and La Nina periods

- CALIPSO observations were used to derived the tropical mean cloud fraction profiles:
  - 12/2009 to 02/2010 for the El Nino period;
  - 12/2010 to 02/2011 for the La Nina period;

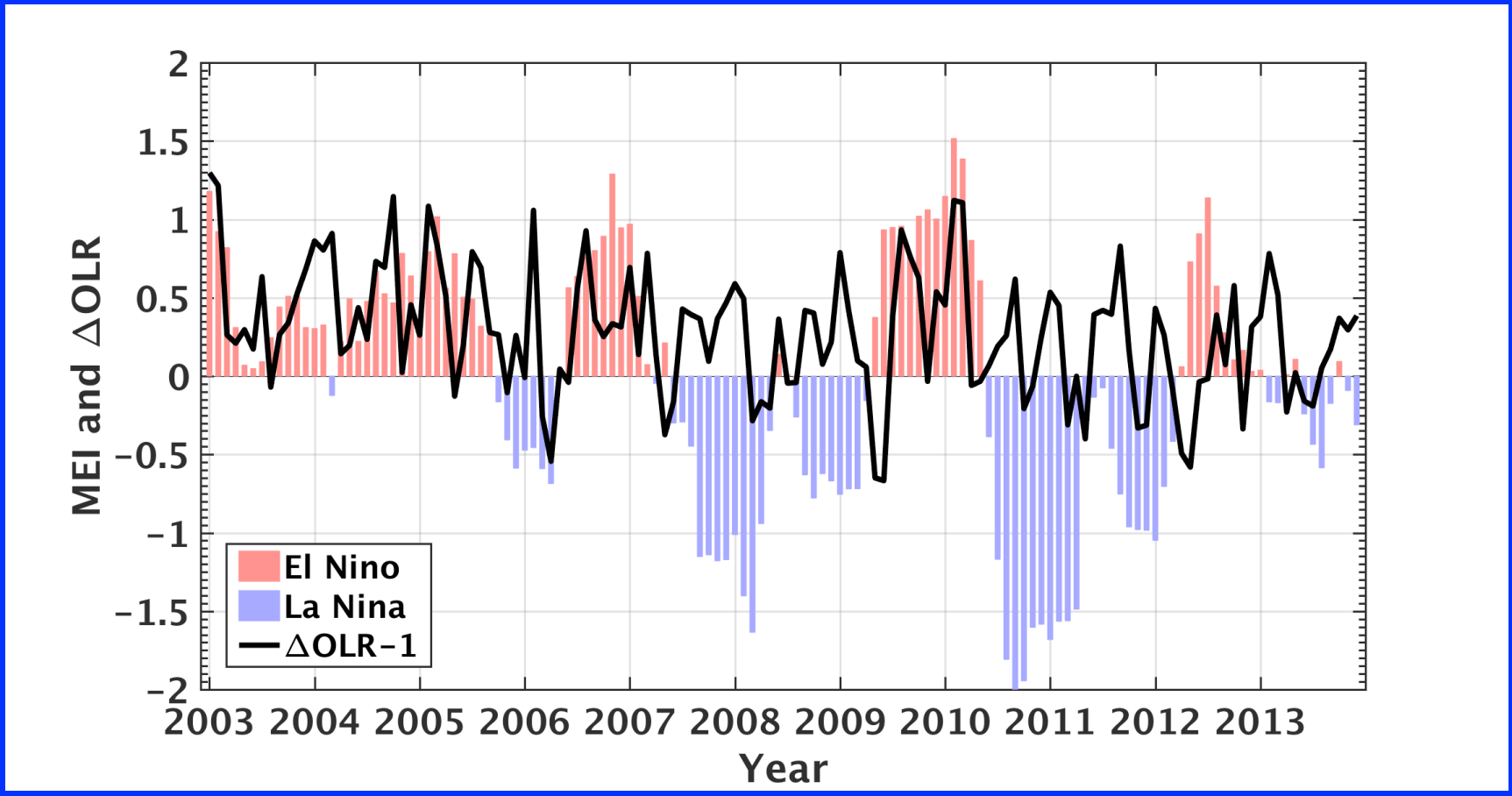


High cloud fraction (%)	Daytime	Nighttime	D-N
El Nino	28.75	33.29	-4.54
La Nina	29.16	33.38	-4.22



Relationship between day-night OLR and MEI over ocean

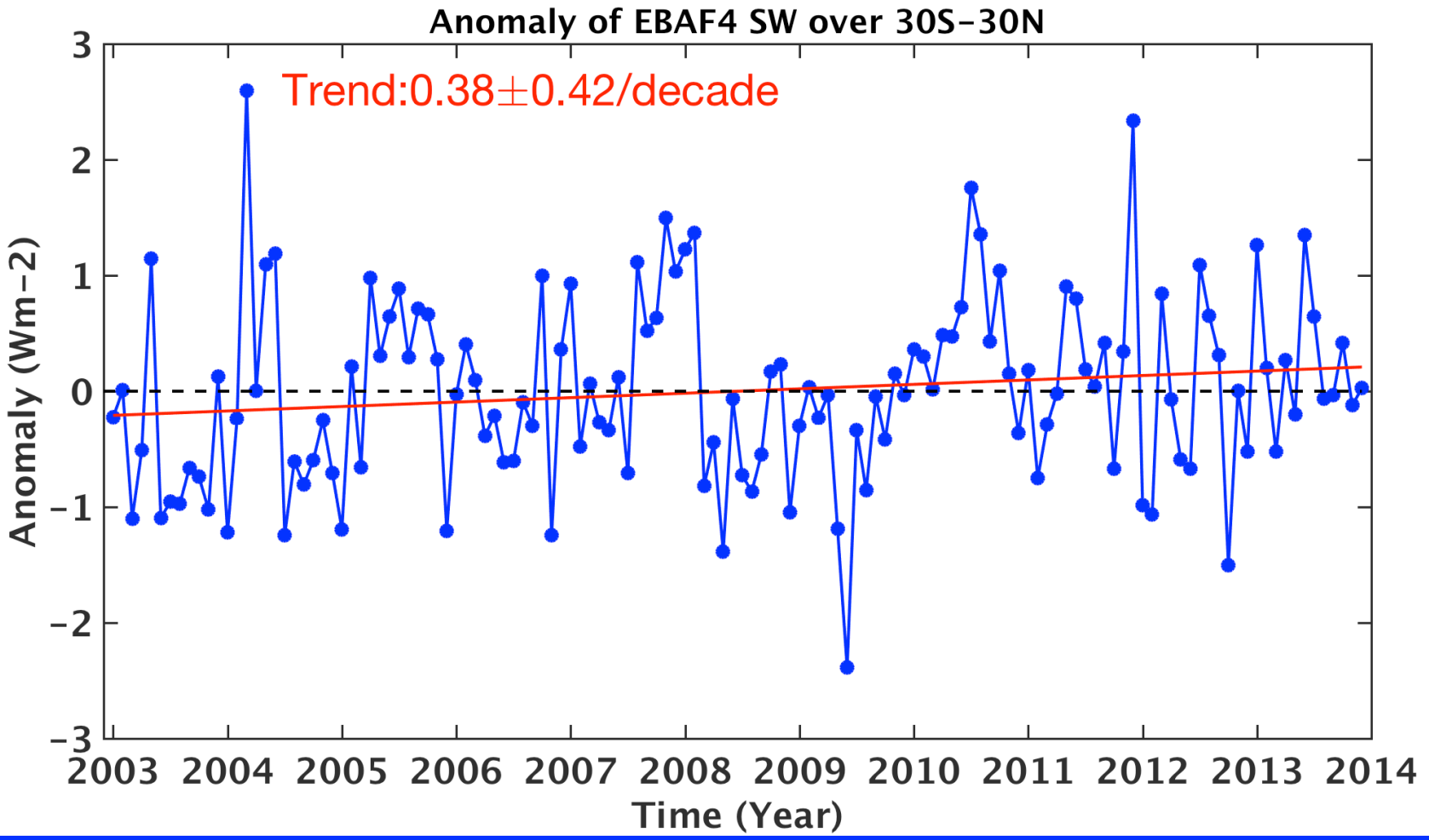
- Day and night cloud fraction difference is larger during El Nino than during La Nina;
- Day and night OLR difference is larger during El Nino than during La Nina. ΔOLR and MEI are positively correlated, with a correlation coefficient of 0.25±0.15.



Summary

- CERES and AIRS OLR time series over the tropical region for the 2003-2013 time period show decreasing trends for both daytime and nighttime measurements;
- Both CERES and AIRS daytime OLR decrease faster than their nighttime counterparts, resulting in decreasing trends in the daytime minus nighttime OLR;
- High cloud fraction increases during this time period for both daytime and nighttime;
- The altitude of high cloud top decreases, more so during nighttime than daytime.

SW anomaly


Anomaly of EBAF4 SW over 30S-30N
Trend:0.38±0.42/decade
Anomaly (Wm-2)
Time (Year)
3
2
1
0
-1
-2
-3
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014