Global Ocean Monitoring: Recent Evolution, Current Status, and Predictions

Prepared by

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http://www.cpc.ncep.noaa.gov/products/GODAS/

This project to deliver real-time ocean monitoring products is implemented by CPC in cooperation with NOAA Ocean Climate Observation Program (OCO)

Outline

- **Overview**

- **Recent highlights**

  – **Global Oceans**
  (Possible factors caused less-active Atlantic hurricane in 2013)

  – **Pacific/Arctic Ocean**
  (Possible factors result in the differences between OIv2 and ERSSTv3b SST in Pacific)

  – **Indian Ocean**

  – **Atlantic Ocean**

Global SST Predictions

Overview

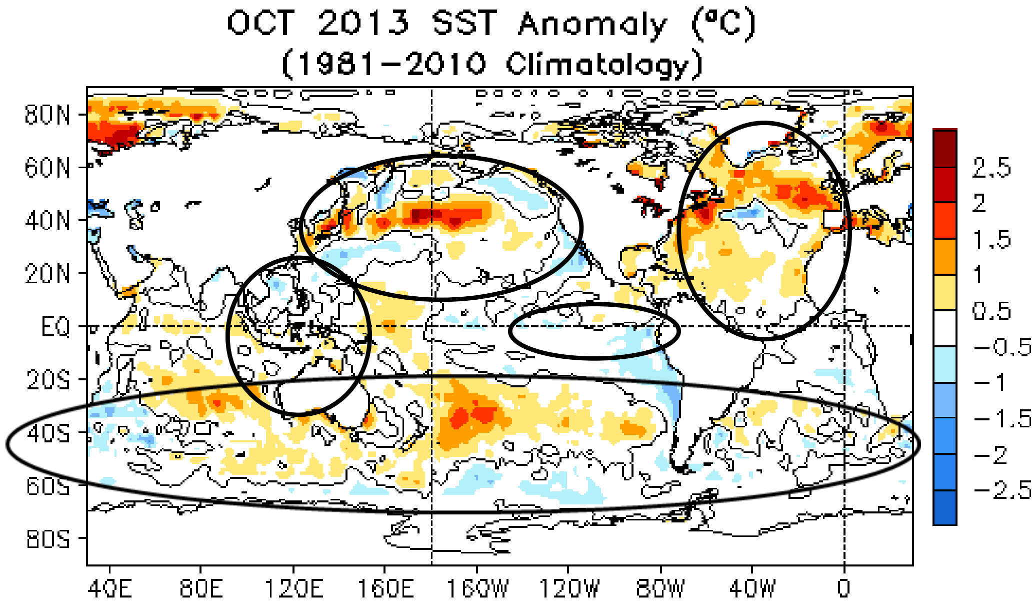
- **Pacific and Arctic Oceans**
  - ENSO-neutral condition continued during Oct 2013 with Nino3.4=-0.3C.
  - NOAA officially forecast ENSO-neutral condition to continue in the Northern Hemisphere spring 2014.
  - Negative PDO phase strengthened slightly in Oct 2013 and PDO index = -0.8 in Oct 2013, and NCEP CFSv2 predicted negative phase of PDO will continue.
  - Arctic sea ice extent in Oct 2013 was below-normal, but larger than Oct 2012.

- **Indian Ocean**
  - SSTs were slightly above-normal in the tropics, and negative dipole index was weakened continually since Aug 2013.

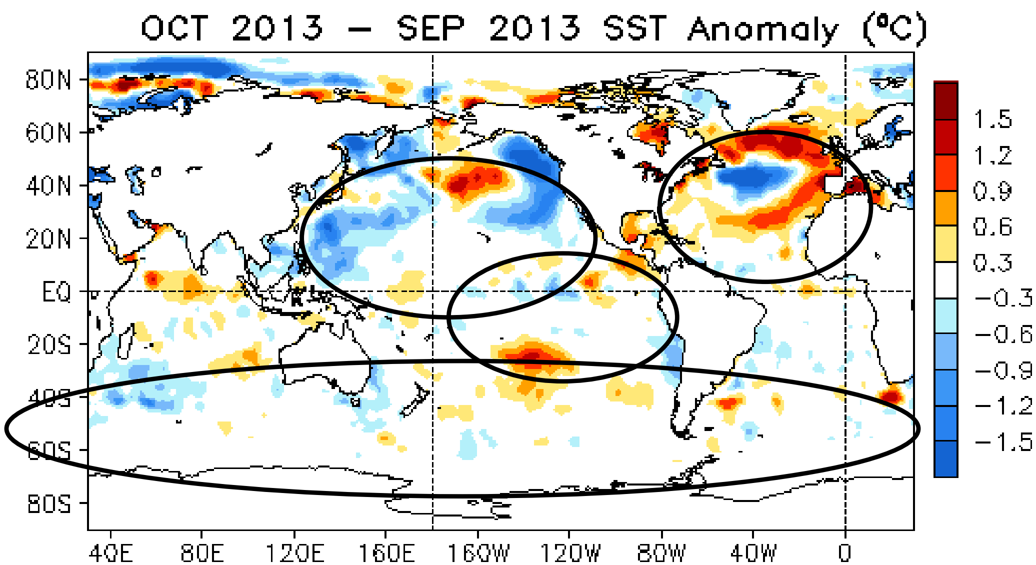
- **Atlantic Ocean**
  - NAO switched from positive to negative phase in Oct 2013 and NAO index =-0.9 in Oct 2013.
  - SSTs were still above-normal in the tropical North Atlantic main hurricane development region in Oct 2013.

Global Oceans

Global SST Anomaly (^{0}C) and Anomaly Tendency



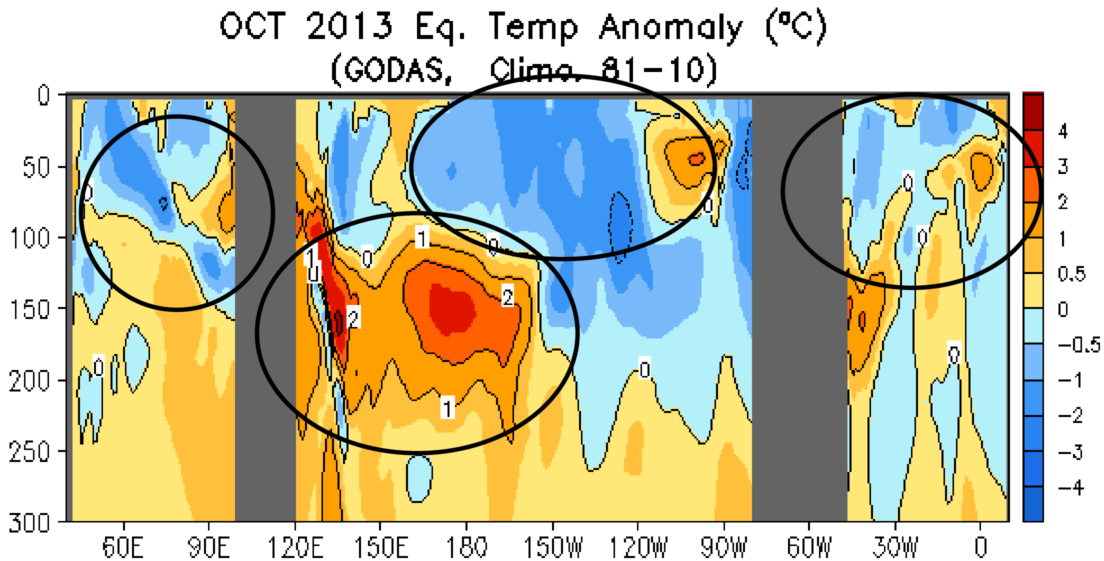
- Small negative SSTA presented in the eastern tropical and NW Pacific.
- Negative phase of PDO associated SSTA pattern continued in N. Pacific.
- Positive SSTA was observed in the N. Atlantic Ocean.



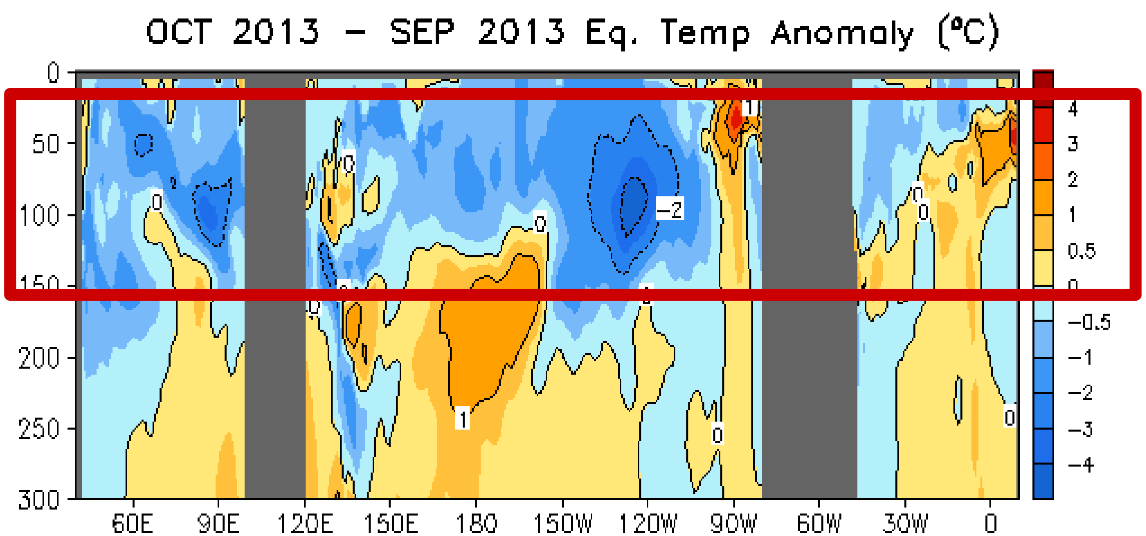
- Tendency was small in the equatorial central and eastern Pacific.
- Cooling tendency presented in the NW Pacific.
- SSTA associated with negative phase of PDO strengthened.
- A very strong horse-shoe pattern was observed in the N. Atlantic, may caused by negative phase of NAO.

Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

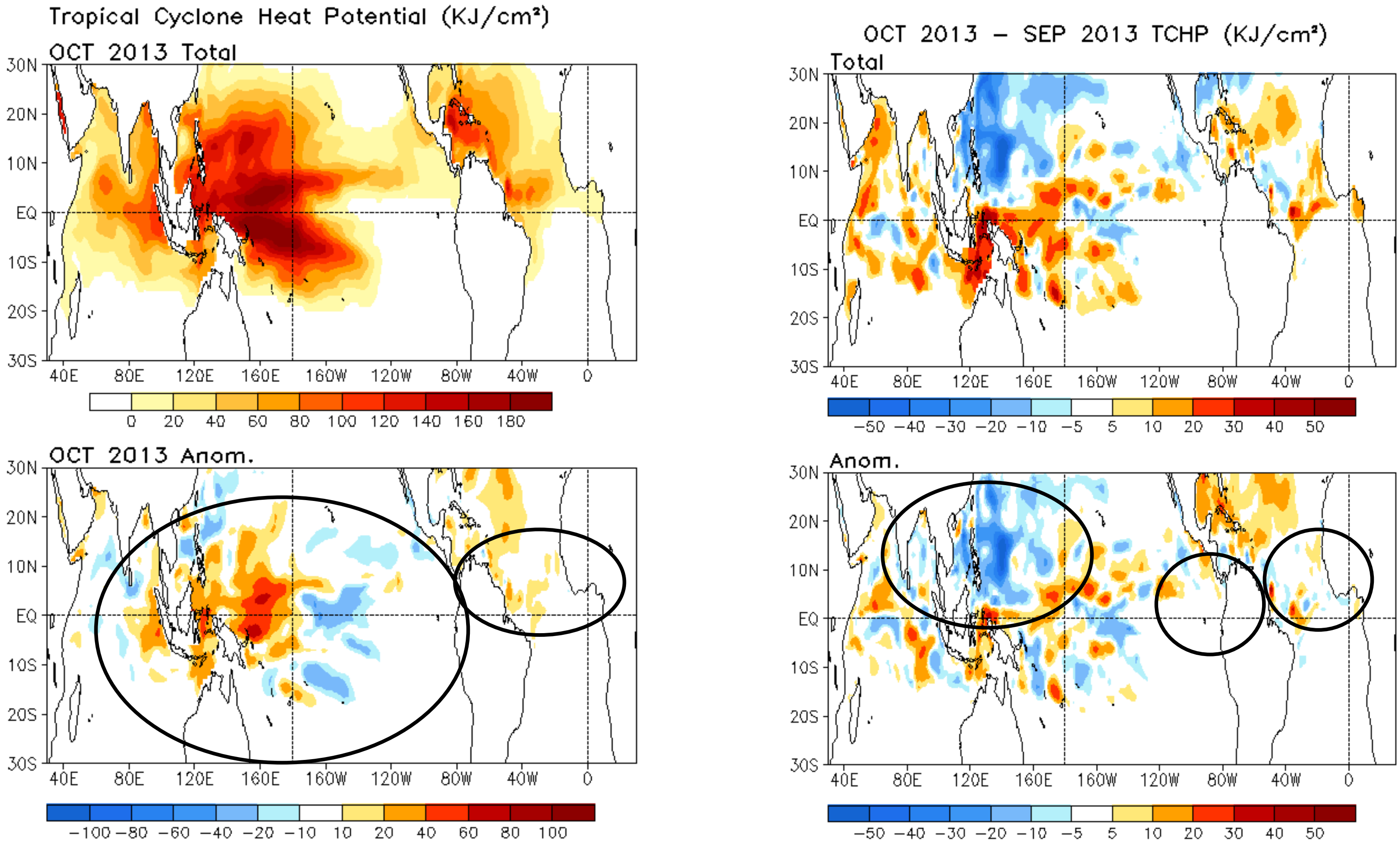


- **Negative (positive) ocean temperature anomalies generally occupied above (below) 100-150 m for all Oceans.**



- **Cooling (warming) tendency was observed in above (below) 100-150 m for all Oceans.**

Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.



- **Positive TCHP anomalies presented in the w. Pacific and negative ones in the c. and e. Pacific.**
- **Small positive anomalies were observed over the tropical N. Atlantic Ocean.**
- **The anomaly tendency was small in both the tropical N. Atlantic and tropical e. Pacific, but it is large and negative in NW Pacific.**

TCHP field is the anomalous heat storage associated with temperatures larger than 26℃.

NOAA Predicted an Above-Normal Atlantic Hurricane Season in 2013

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml

http://en.wikipedia.org/wiki/Accumulated_cyclone_energy)

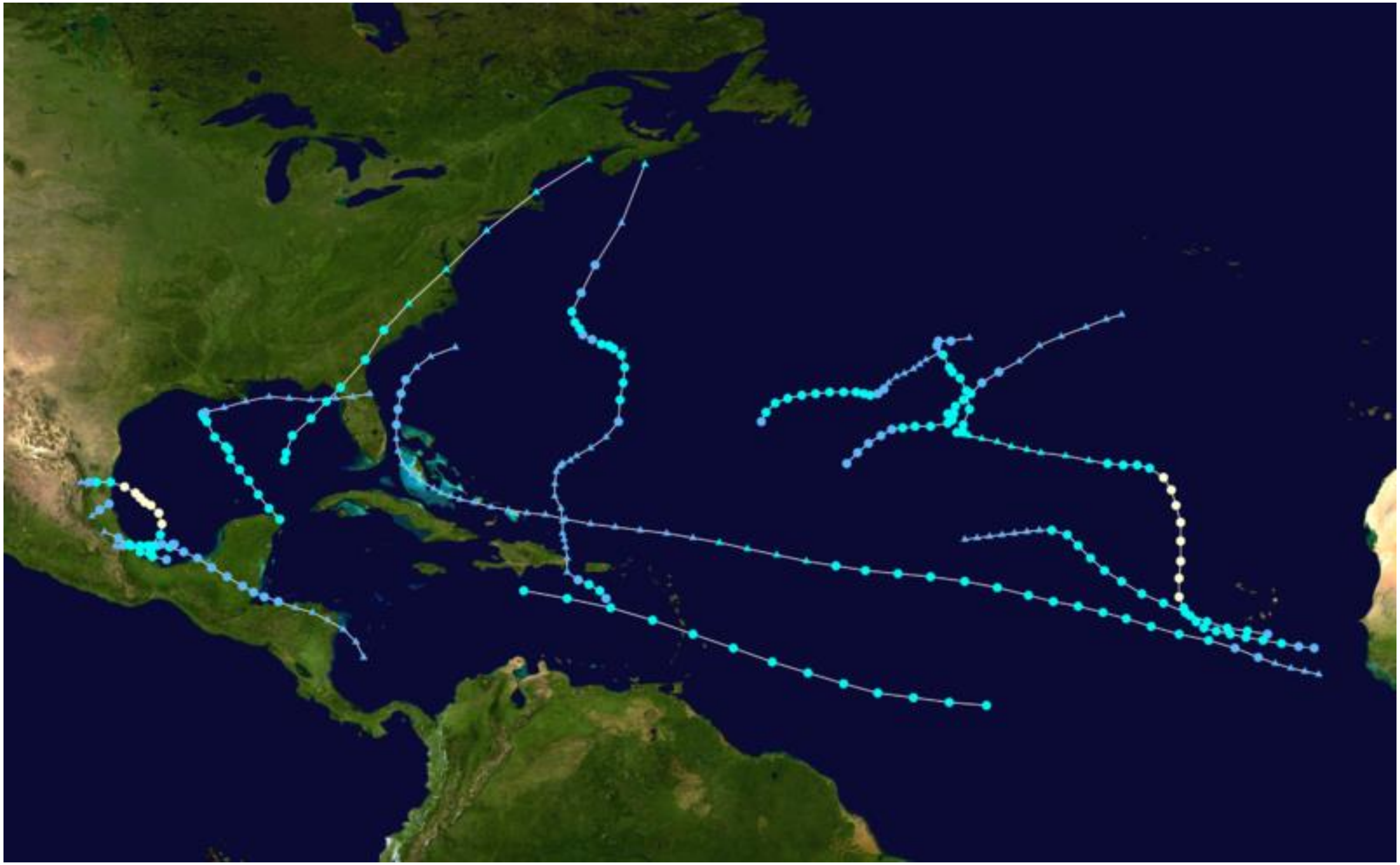
	Climatology (1981-2010)	2013 May prediction	2013 Aug prediction	**Observations (by Nov. 6)**
Named storms	12.1	13-20	**13-19**	**12**
Hurricanes	6.4	7-11	**6-9**	**2**
Major hurricanes	2.7	3-6	**3-5**	**0**

- **<u>The ongoing set of atmospheric and oceanic conditions include:</u>**

- An expected continuation of above-average sea surface temperatures (SSTs) across the tropical Atlantic Ocean and Caribbean Sea, that have been producing increased Atlantic hurricane activity since 1995;

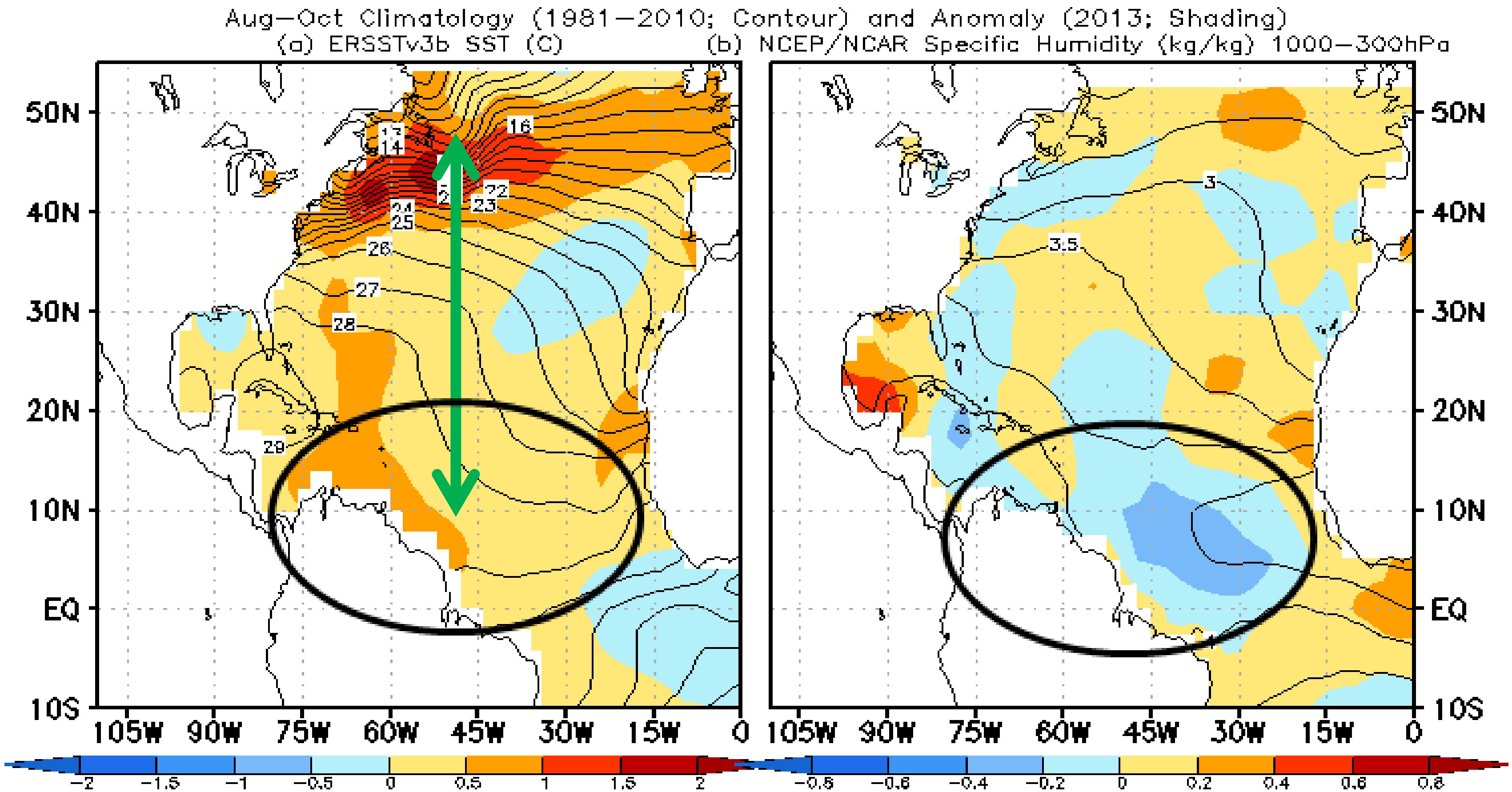
- A likely continuation of ENSO-neutral conditions in 2013 (i.e., no El Niño or La Niña); meaning El Niño is not expected to develop and suppress the hurricane season.

By Nov. 6, 2013: 12 total storms, 2 hurricanes; 0 major hurricanes



Since 1960, there were four years without major hurricanes in the Atlantic Ocean: 1994, 1986, 1972 and 1968.

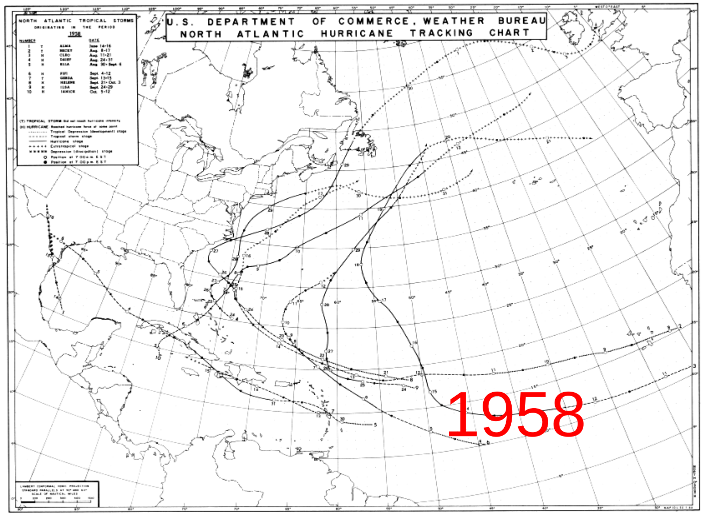
2013 Aug-Oct: In spite of positive SSTA, negative moisture and strong meridional gradients of SSTA, which may not favor the development of convergence and deep convection-evaporation-heat feedback in the tropical N. Atlantic, then the hurricane formation.

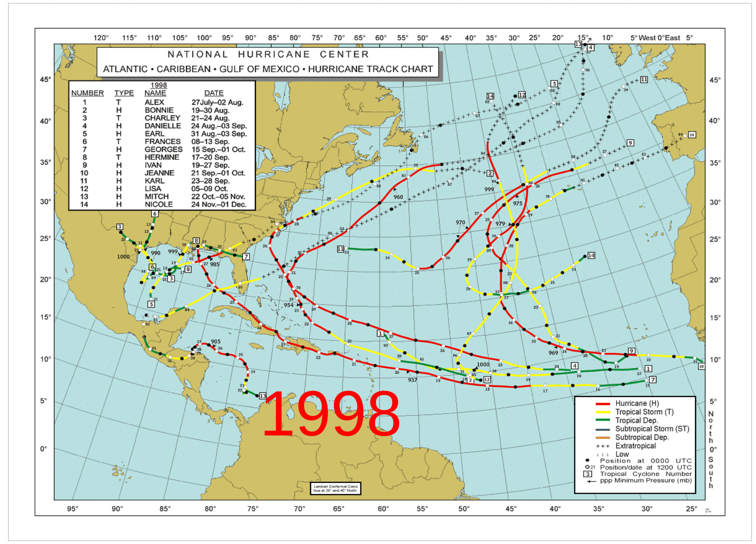


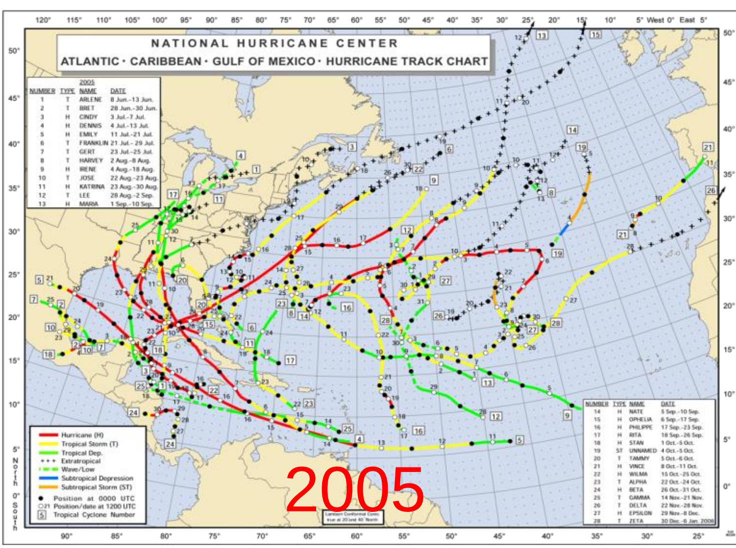
It seems that both local SST and moisture anomalies and SSTA meridional gradient may be matters for hurricane generation.

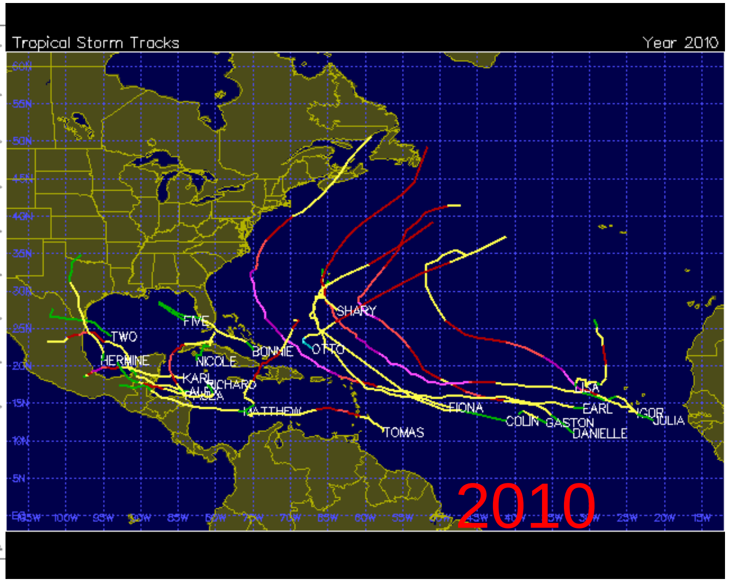
Atlantic Hurricane Activity in 1958, 1998, 2005, 2010

<Hu, Z.-Z., A. Kumar, B. Huang, Y. Xue, W. Wang, and B. Jha, 2011: Persistent atmospheric and oceanic anomalies in the North Atlantic from Summer 2009 to Summer 2010. *J. Climate,* **24(22)**, 5812-5830.>







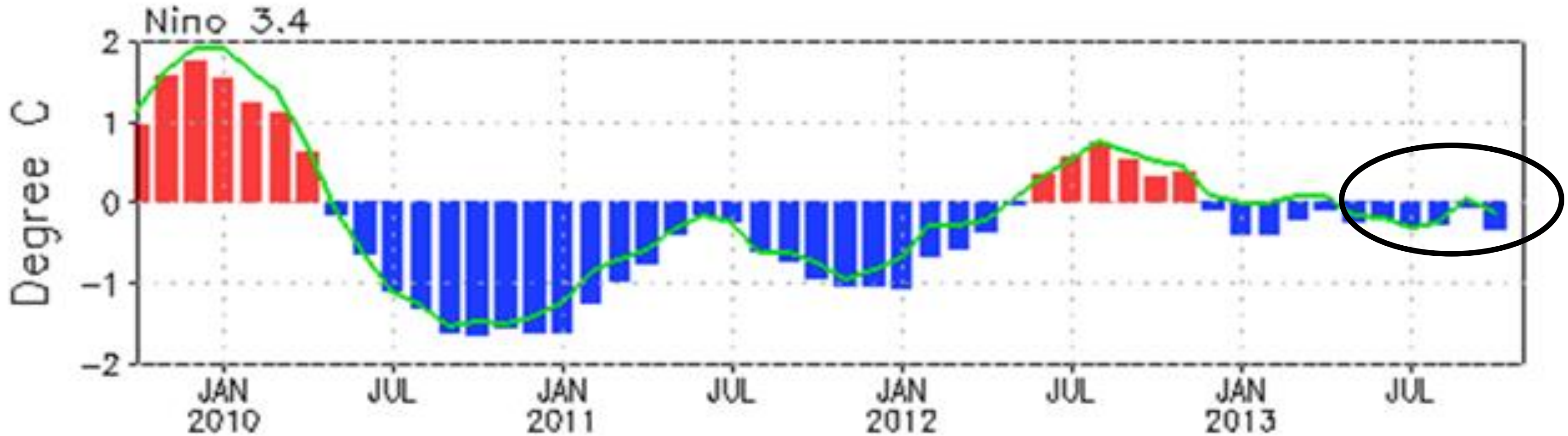


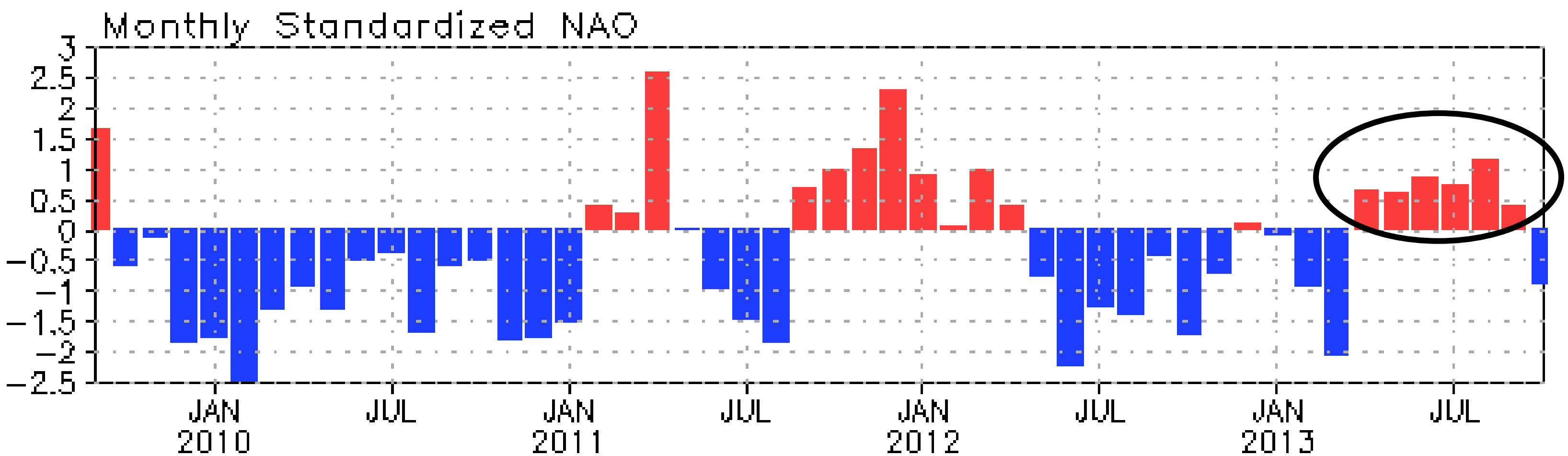
The 4 years that had a similar juxtaposition of a warm ENSO (decay phase) and negative phase of the NAO, i.e., 1958, 1998, 2005, and 2010 had above-normal Atlantic hurricane seasons.

The Atlantic Accumulated Cyclone Energy (ACE) index value in the North Atlantic (http://en.wikipedia.org/wiki/Accumulated_cyclone_energy) is 121 in 1958, 182 in 1998, 248 in 2005, **and 165 in 2010.**

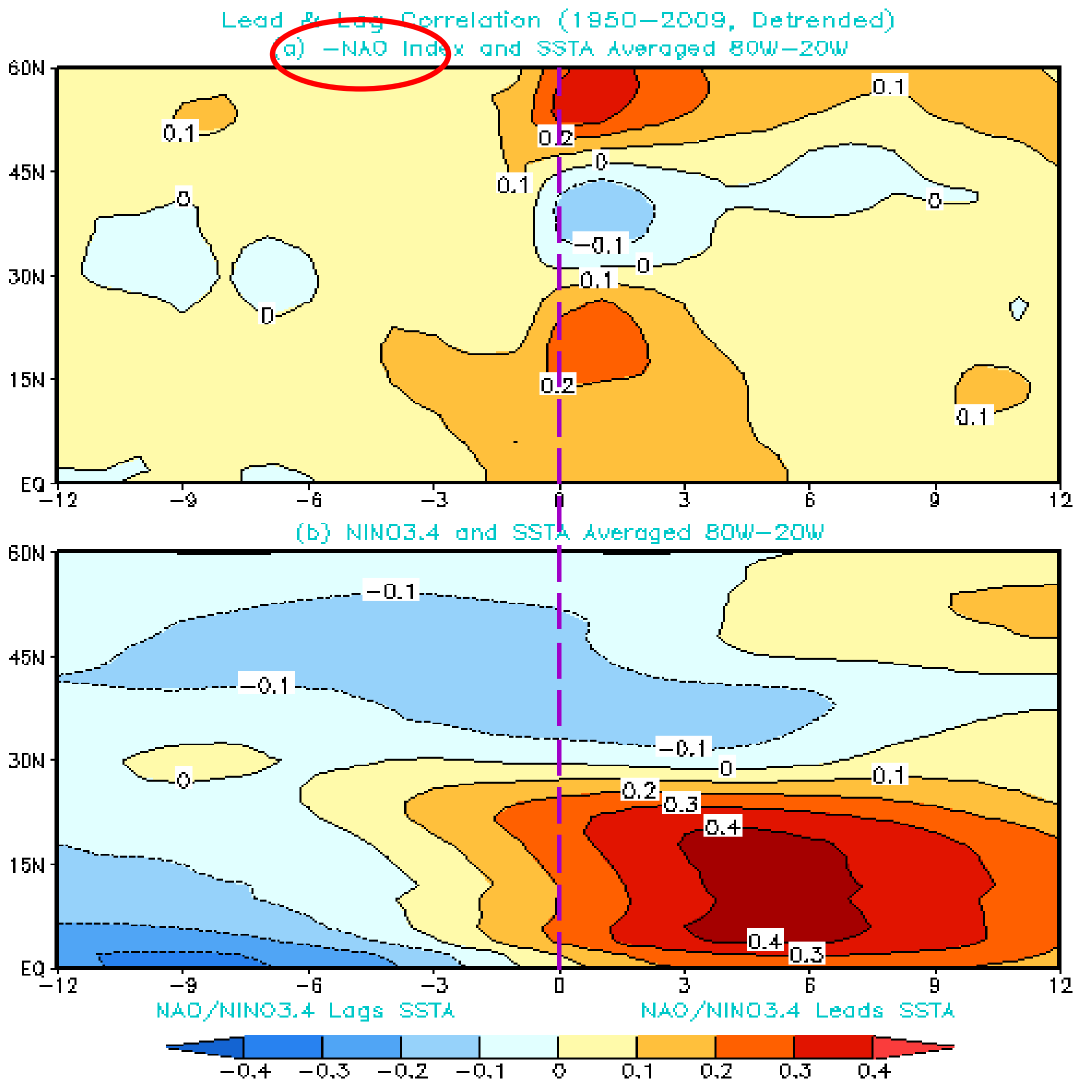
For 1950-2009, the mean of ACE is 101 and the median is 88.0.

2013 Jul-Sep: Neutral phase of ENSO and positive phase of NAO: not favour Atlantic hurricane formation





Historical Connection of SST with Nino3.4 & NAO



(a) ENSO signal propagates into the tropical N. Atlantic in 3-8 months late.

(b) NAO’s impact on SST is mainly with 0-3 months lag.

© ENSO mainly affects the tropical N. Atlantic, and NAO’s impact is mainly in the mid-high latitudes.

<Hu, Z.-Z., A. Kumar, B. Huang, Y. Xue, W. Wang, and B. Jha, 2011: Persistent atmospheric and oceanic anomalies in the North Atlantic from Summer 2009 to Summer 2010. *J. Climate*, **24(22)**, 5812-5830.>

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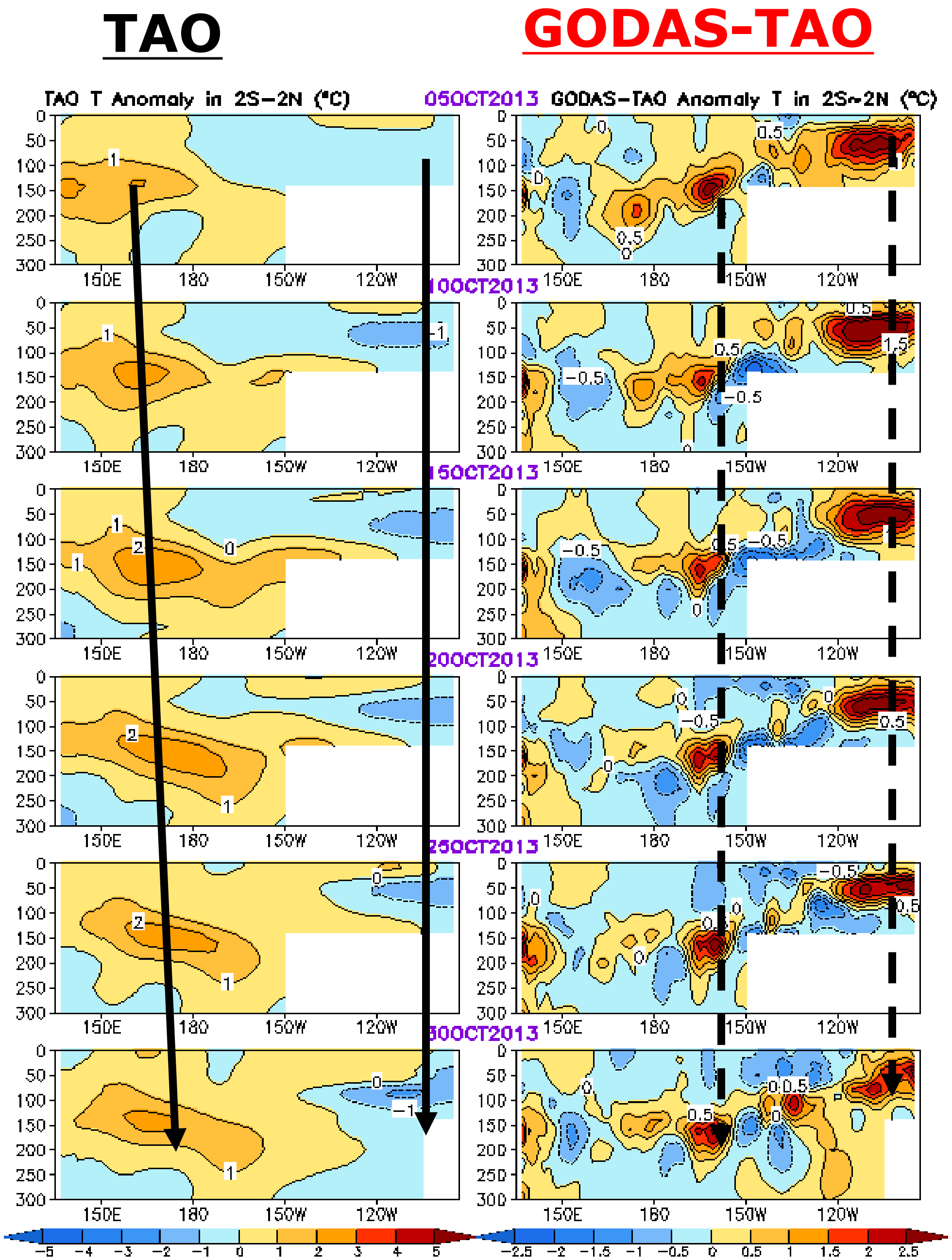
Tropical Pacific Ocean and ENSO Conditions

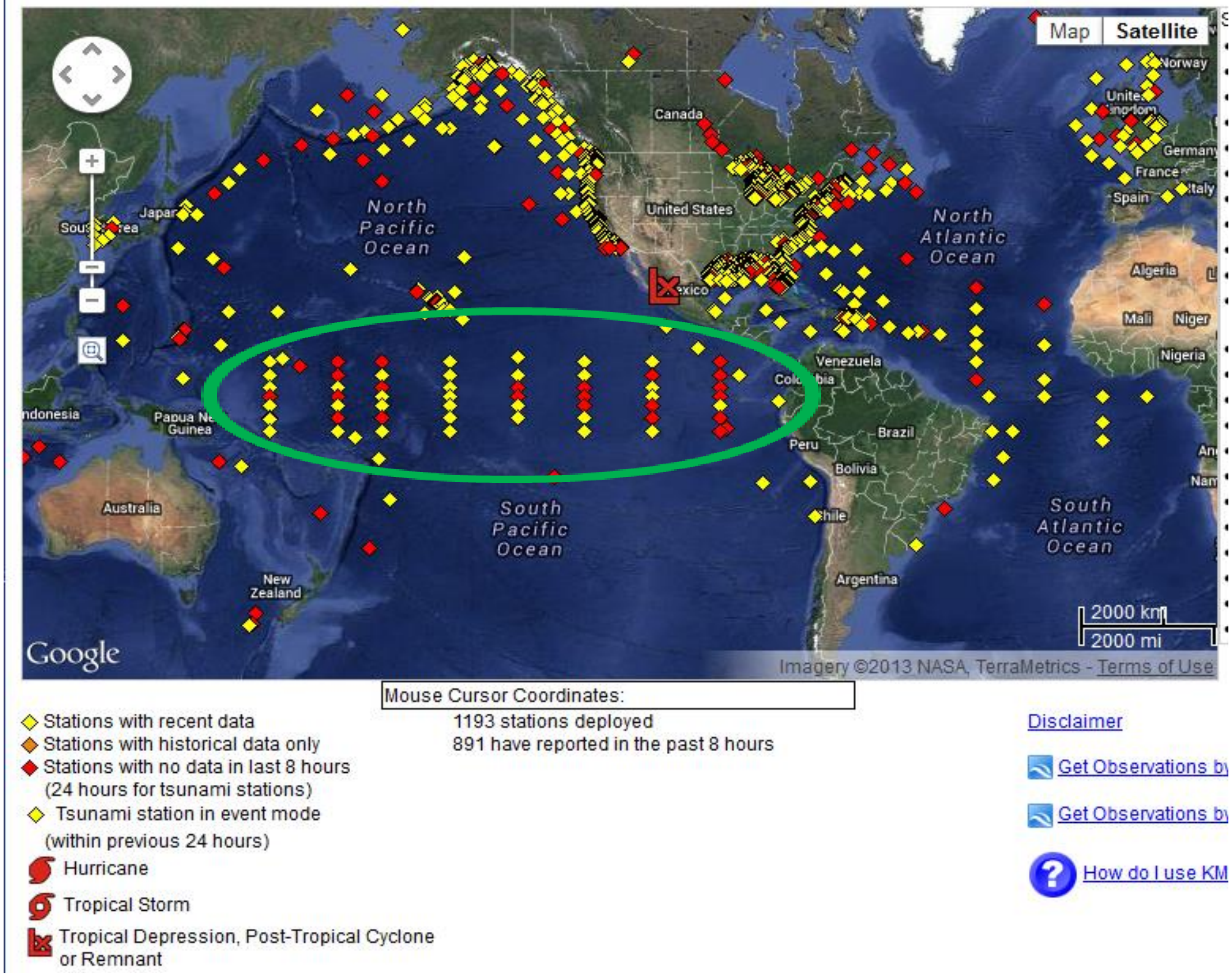
Pentad Mean Equatorial Pacific Temperature Anomaly



- Positive temperature anomalies in the c. and w. Pacific presented and propagated slowly eastward.
- Negative temperature anomalies in the e. Pacific did not have clear propagation.
- However, the differences between TAO and GODAS were still large in the c. and e. Pacific (165W, 100W). **What causes the differences?**

Status of TAO/TRITON Data Delivery

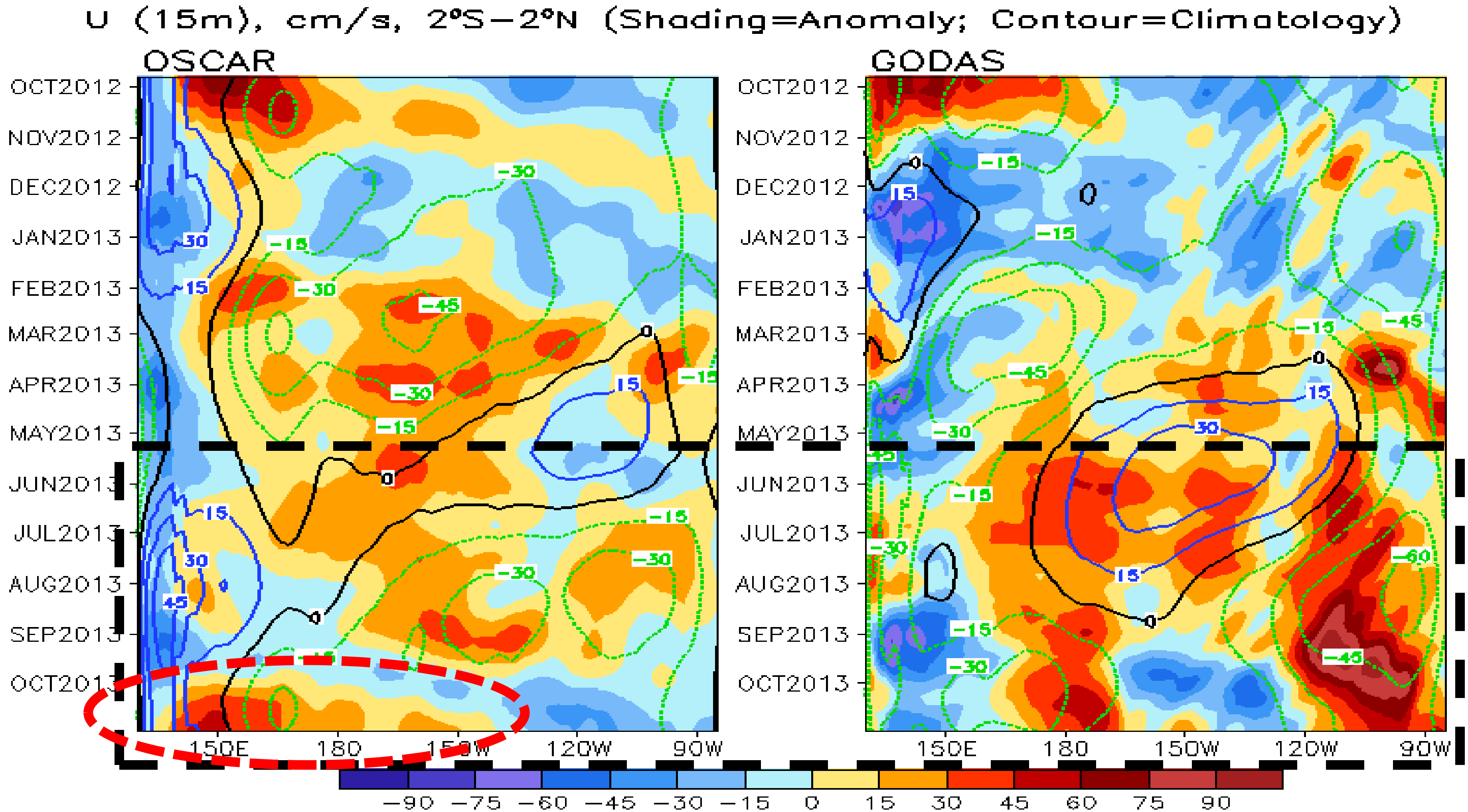
http://www.ndbc.noaa.gov   http://www.pmel.noaa.gov/tao/jsdisplay/



Beginning of Nov 2013

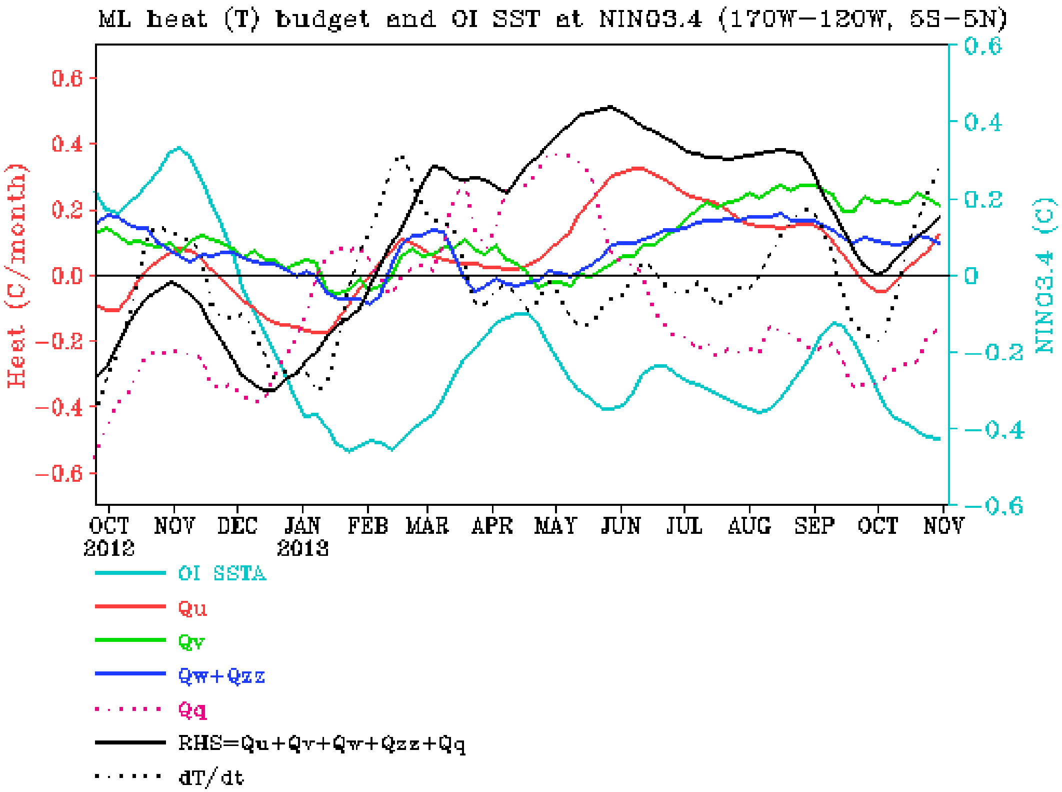
- **The TAO/TRITON array in the whole tropical Pacific has encountered significant outages.**

Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **Since Oct 2013, eastward anomaly current was observed in OSCAR.**
- **Since May 2013, some clear differences were noted for both anomaly and climatology between OSCAR and GODAS.** ***Is that due to TAO data missing?***

NINO3.4 Heat Budget



- **SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) changed from negative to positive in Oct 2013.**

- **All the advection terms were positive since mid-May 2013.**

- **The thermodynamical term (Qq) was negative since Jun 2013.**

- **The RHS and dT/dt had large differences during Mar-Sep 2013.**

Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

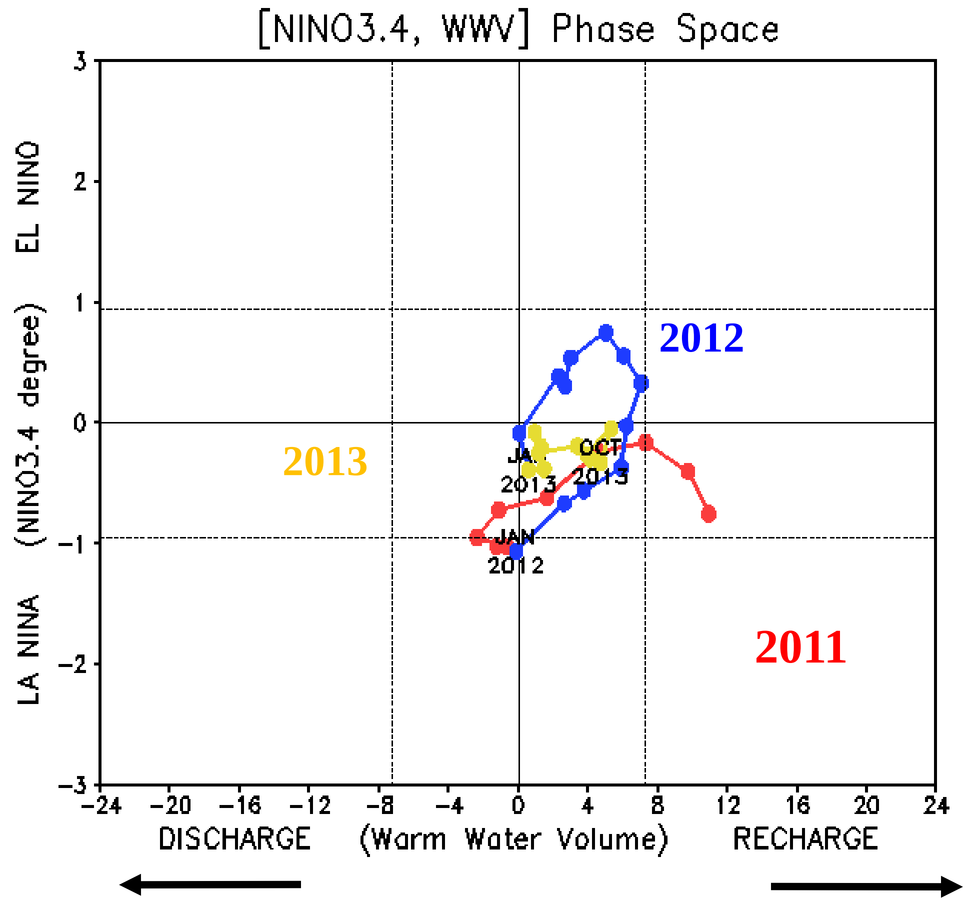
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

Warm Water Volume (WWV) and NINO3.4 Anomalies

- WWV is defined as average of depth of 20°C in [120°E-80°W, 5°S-5°N]. Statistically, peak correlation of Nino3 with WWV occurs at 7 month lag (Meinen and McPhaden, 2000).

- Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).

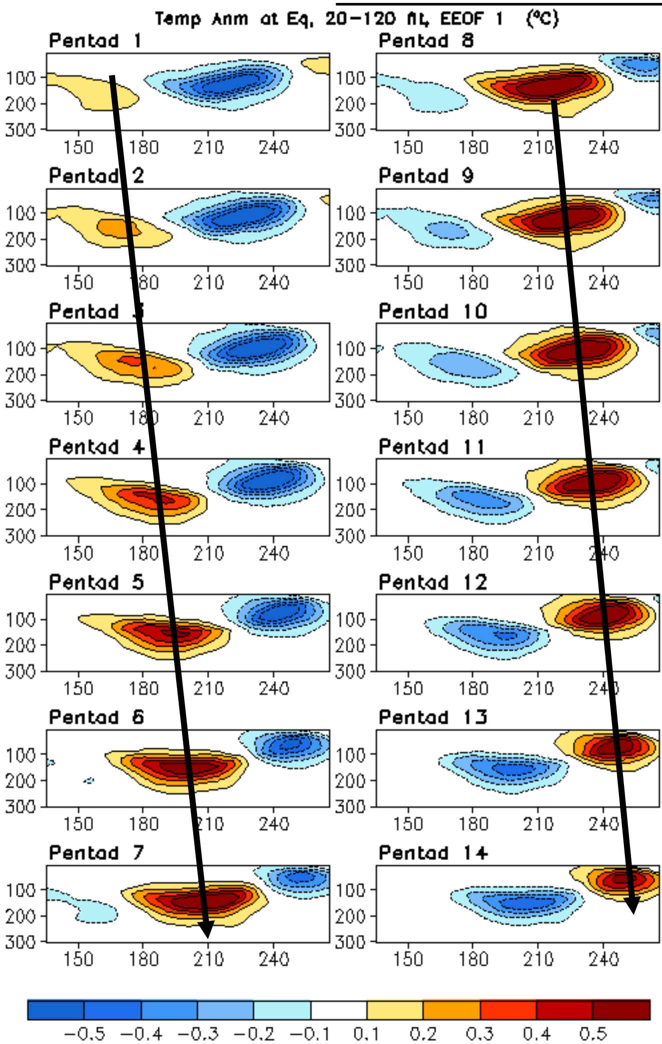
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.

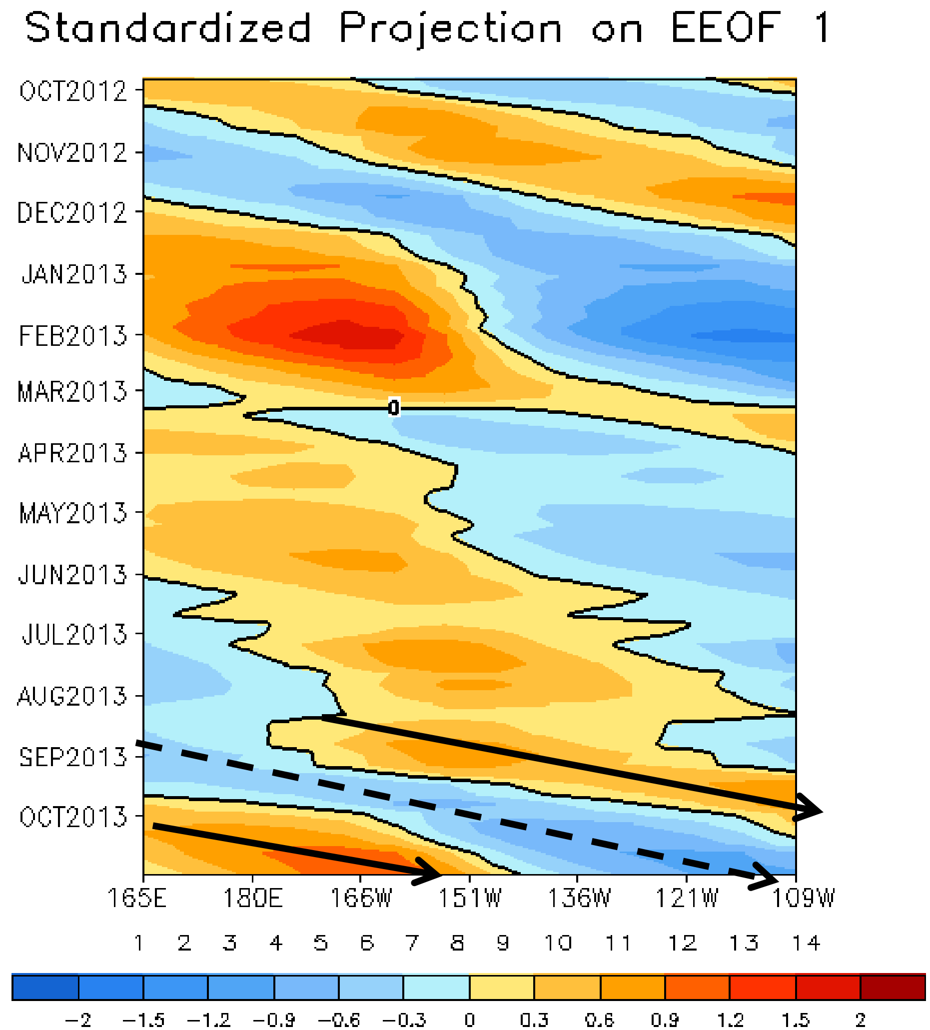


- ENSO cycle was still in heat recharge phase, but the amplitude is small.

Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

Oceanic Kelvin Wave Indices

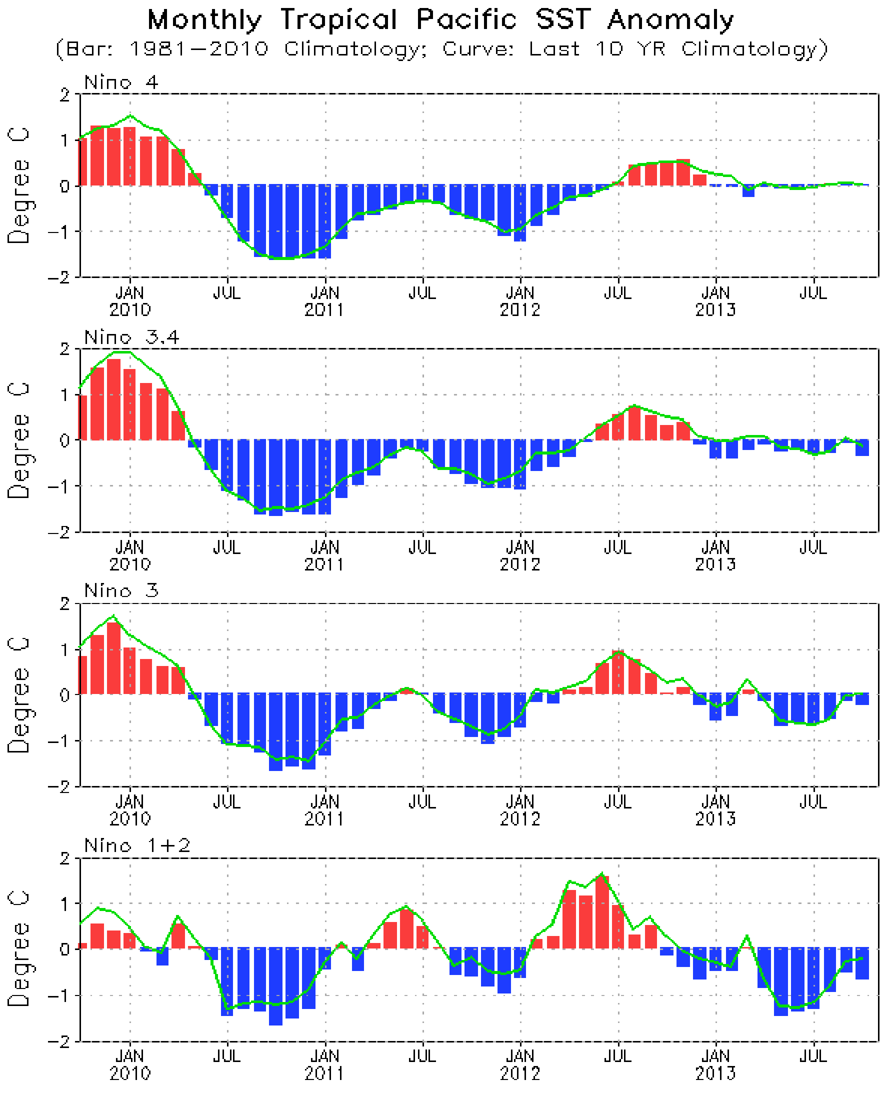


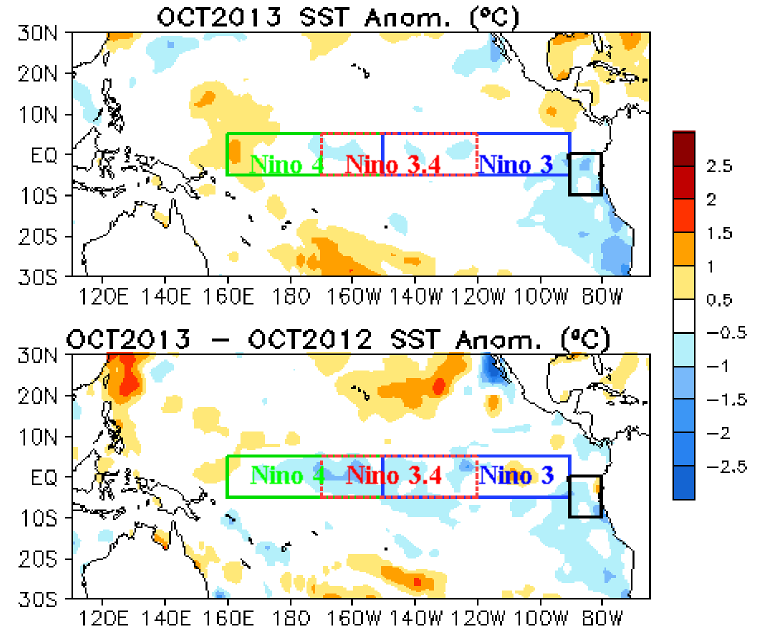


- **Since Mid-Aug 2013, Kelvin wave –like propagation was observed, consistent with the pentad ocean temperature anomaly shown in slide 15.**

- *Oceanic Kelvin wave indices are defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF 1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).*

Evolution of Pacific NINO SST Indices

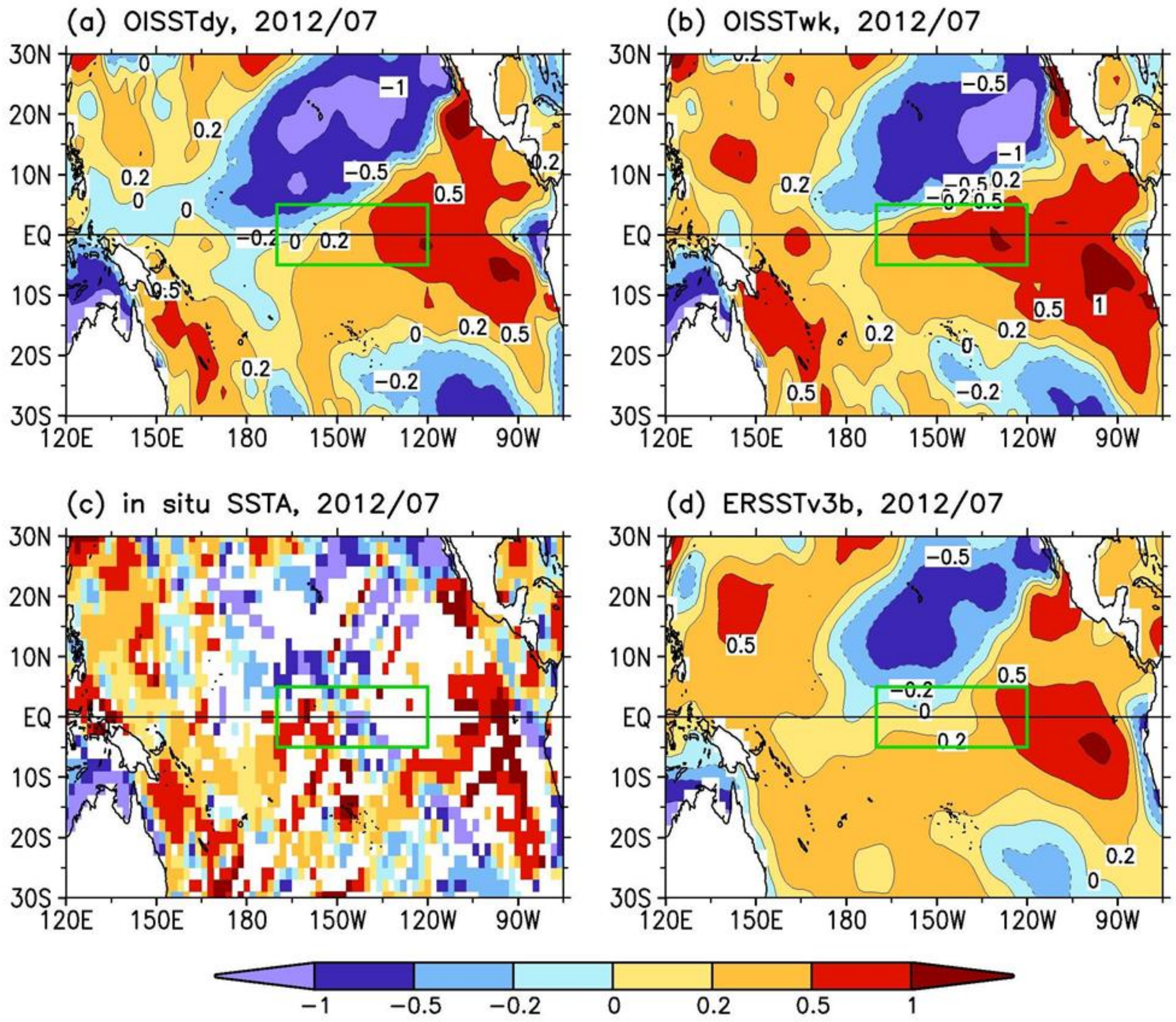




- **All Nino indices were negative or zero with Nino1+2=-0.6C, Nino3=-0.2C, Nino3.4=-0.3C, Nino4=0.0C.**
- ***The indices were calculated based on OIv2 SST. They may have some differences compared with those based on ERSST.v3b.***

Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 (bar) and last ten year (green line) means.

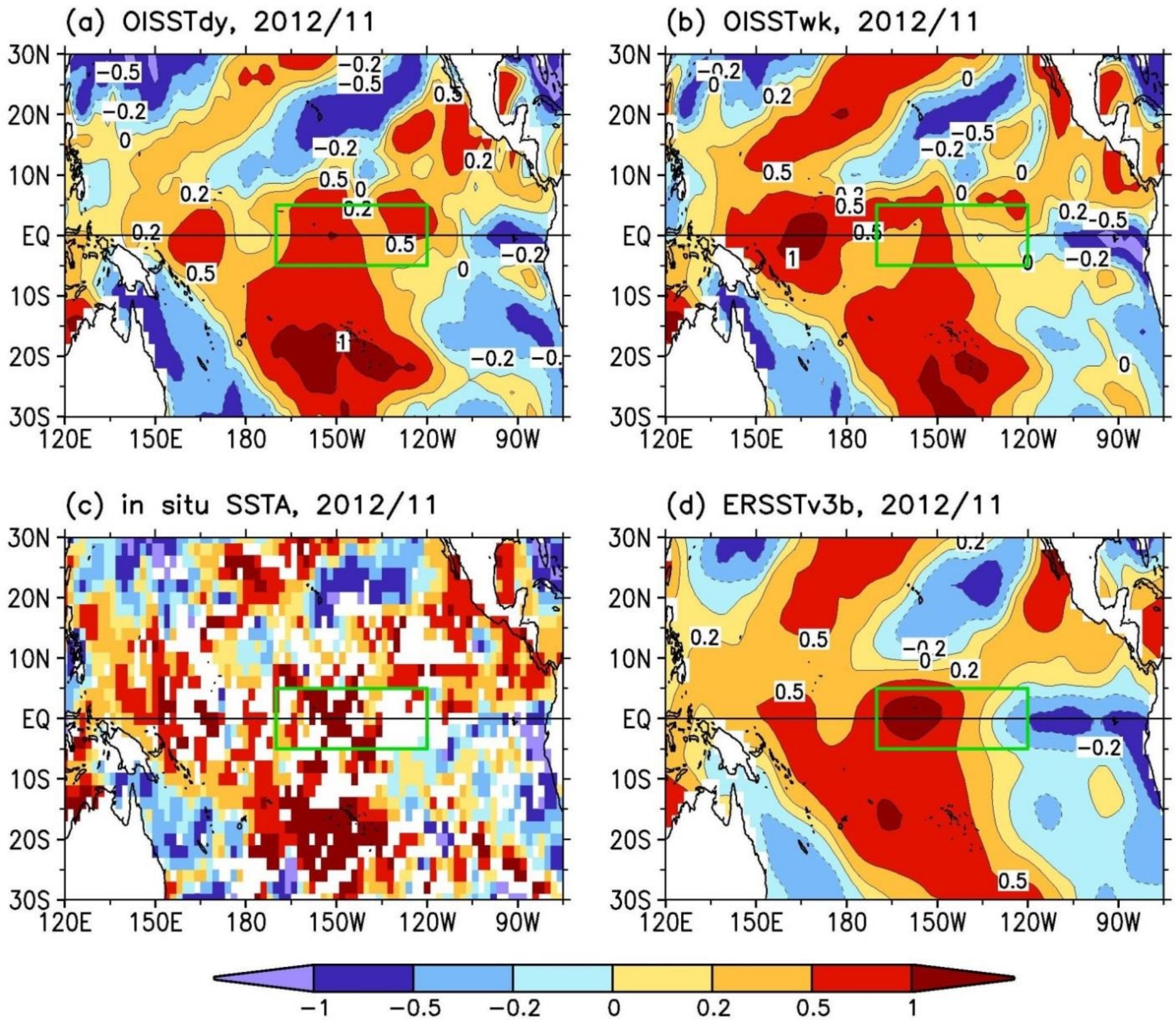
SSTA of **July 2012** in (a) OISSTdy, (b) OISSTwk, (c) *In situ* SSTA, and (d) ERSSTv3b.
(Shadings and contours are in unit of °C. The green rectangle box indicates the Niño3.4 region)



From: Huang, B., M. L'Heureux, J. Lawrimore, C. Liu, H.-M. Zhang, V. Banzon, Z.-Z. Hu, and A. Kumar, 2013: Why did large differences arise in the sea surface temperature datasets across the tropical Pacific during 2012? *J. Atmos. Ocean. Tech.* (published online).

SSTA of **Nov 2012** in (a) OISSTdy, (b) OISSTwk, (c) *In situ* SSTA, and (d) ERSSTv3b.

(Shadings and contours are in unit of °C. The green rectangle box indicates the Niño3.4 region)



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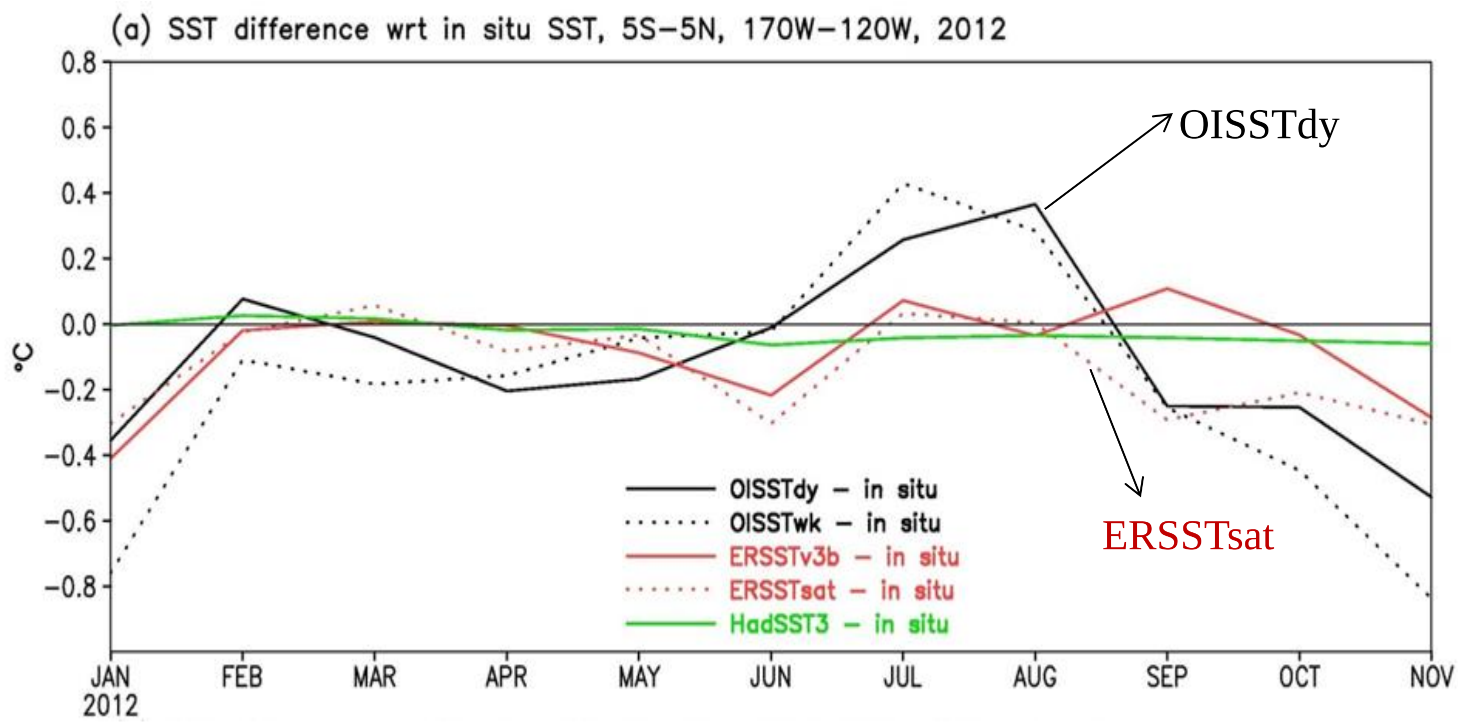
Statistics: Jan1982-Dec2012 (^{O}C)

	OIv2	ERSST v3b	OIv2-ERSSTv3b (OIv2/ERSSTv3b, %)	Compared with ERSSTv3b
$30^{O}S-30^{O}N$ Mean	26.17	26.20	-0.03	OIv2 is slightly cooler in tropics
$30^{O}S-30^{O}N$ Standard Deviation	0.160	0.156	102.5%	OIv2 has larger variability in the tropics
Nino3.4 Mean	27.02	27.11	-0.09	OIv2 is slightly cooler in Nino3.4 region
Nino3.4 Standard Deviation	0.956	0.878	108.9%	OIv2 has larger variability in the Nino3.4 region

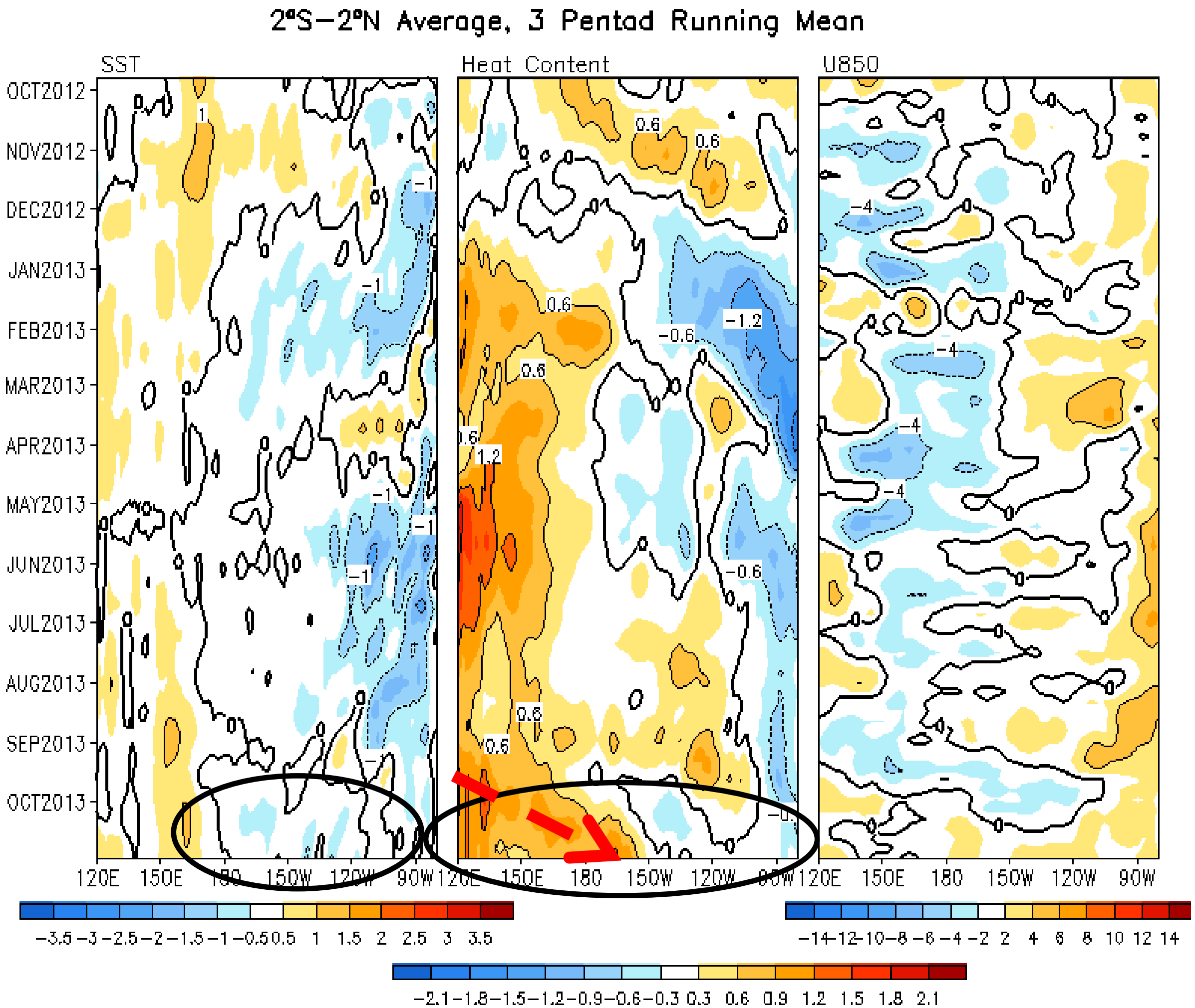


(1) The differences between ERSSTsat and OISSTdy are mostly associated with the different schemes for bias adjustment applied to the satellite-based SSTs, thus suggesting that the differences in the Niño3.4 index between ERSSTv3b and OISSTdy may result from the inclusion and bias adjustment of satellite data in OISSTdy.

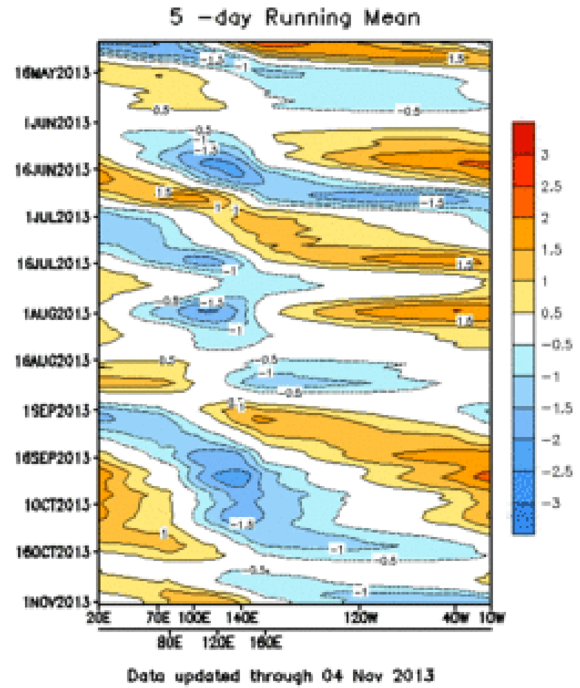
(2) Sometime, ERSST3b is better/worse than OIv2.

Huang, B., M. L'Heureux, J. Lawrimore, C. Liu, H.-M. Zhang, V. Banzon, Z.-Z. Hu, and A. Kumar, 2013: Why did large differences arise in the sea surface temperature datasets across the tropical Pacific during 2012? J. Atmos. Ocean. Tech. (published online).

Equatorial Pacific SST (ºC), HC300 (ºC), u850 (m/s) and OLR(W/m²)Anomalies



CPC MJO Indices

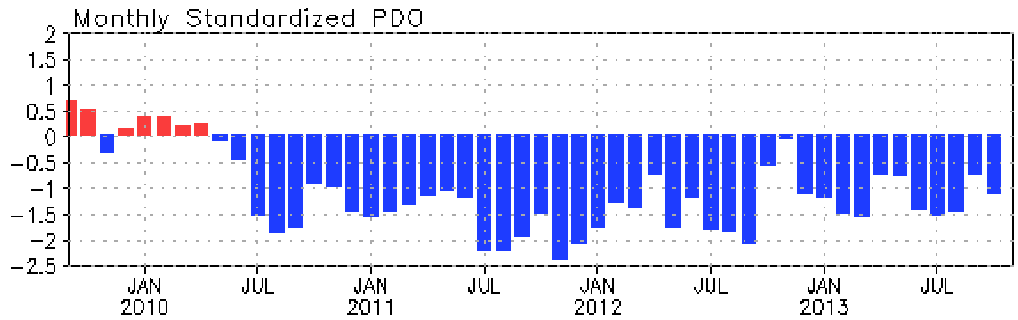


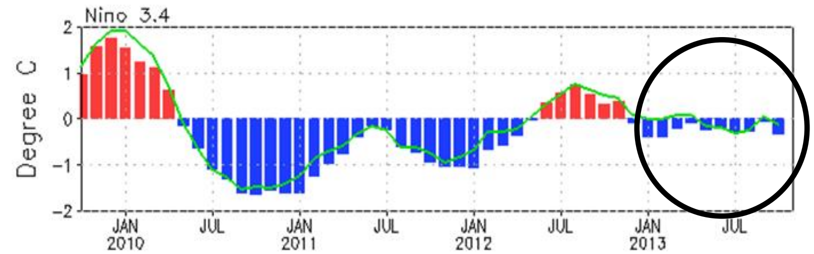
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

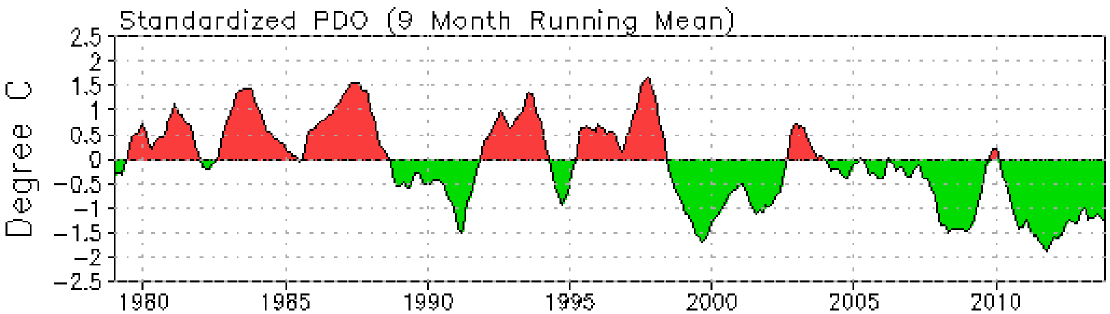
Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. SST is derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1981-2010 base period pentad means respectively.

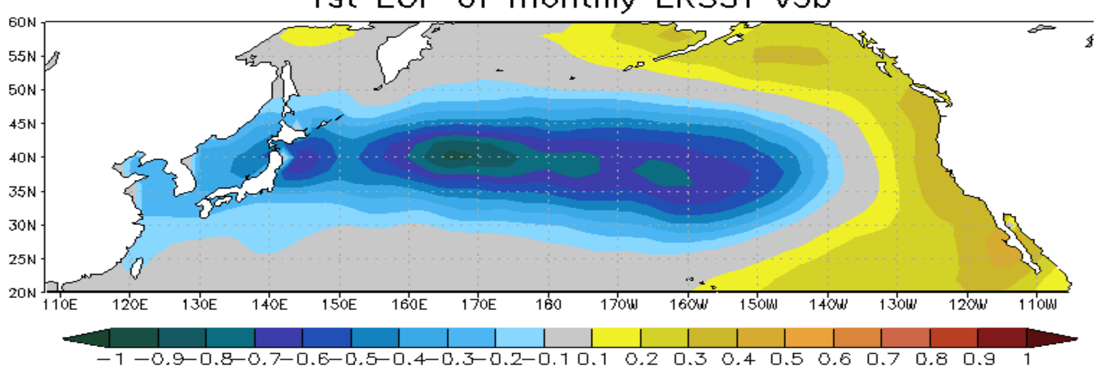
North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index





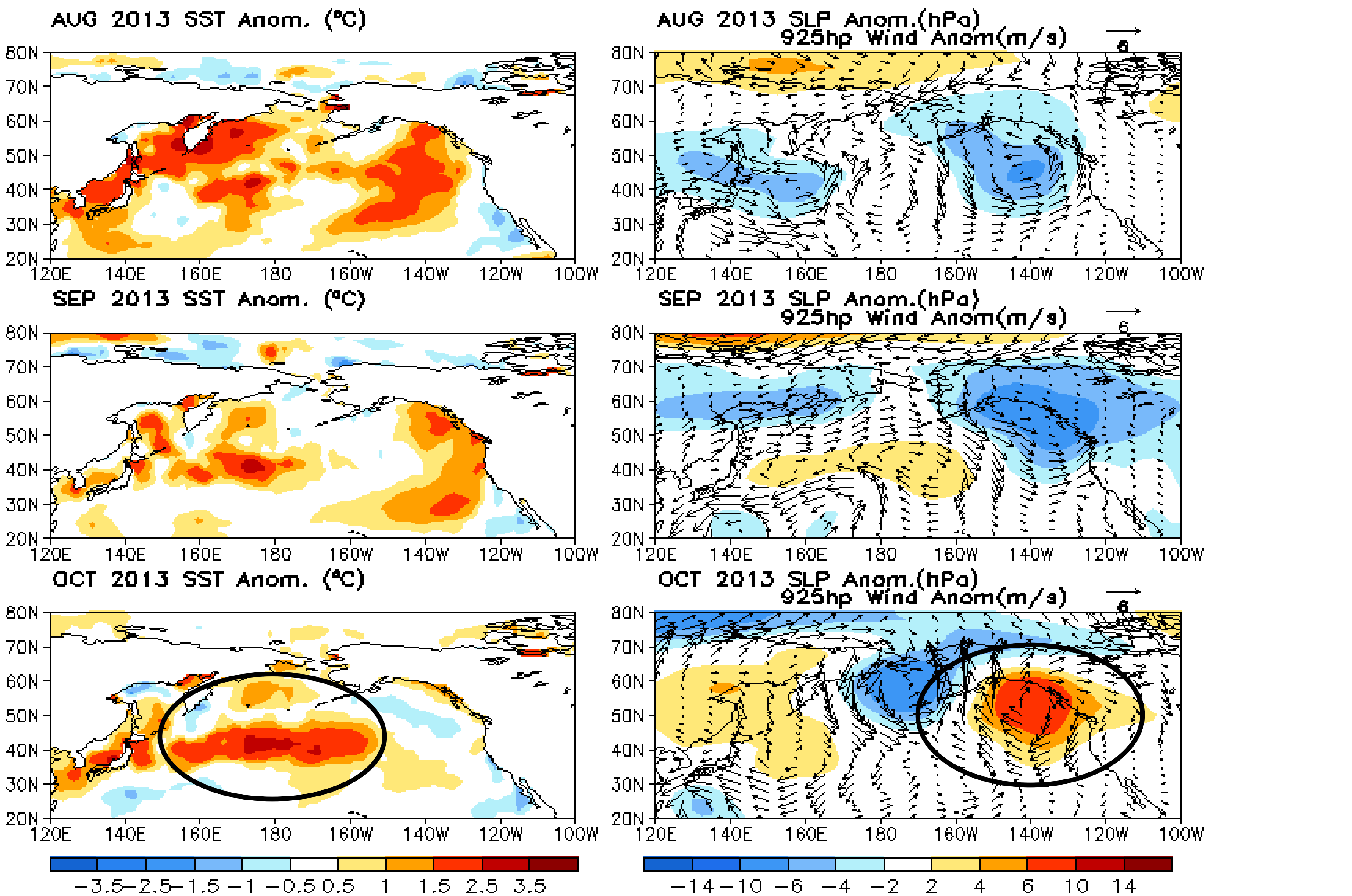




- **Negative PDO phase since May 2010 has persisted for more than 3 years now, and the PDO index strengthened slightly in Oct 2013 and PDO index=-0.8 in Oct 2013.**
- **The apparent connection between Nino3.4 and PDO indices suggests connections between tropics and extra-tropics.**
- **However, the negative phase of PDO during Jun-Nov 2012 seems not connected with the positive Nino3.4 SSTA.**

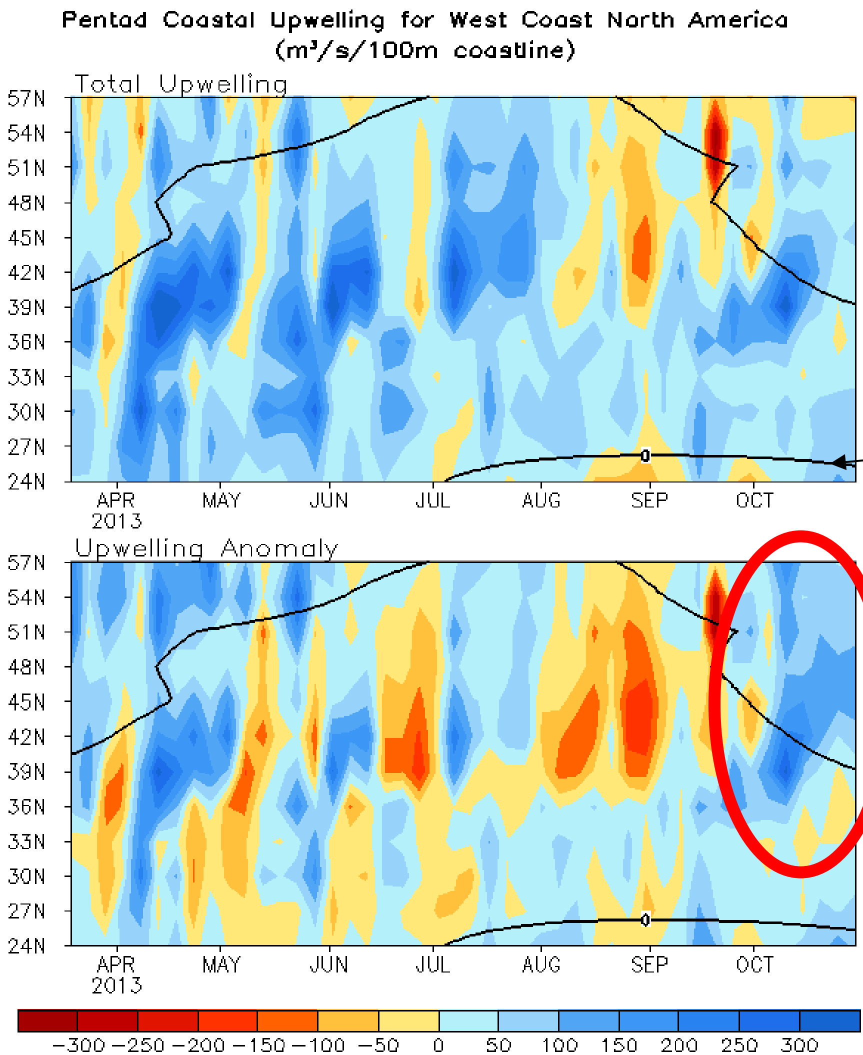
- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**
- **The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.**

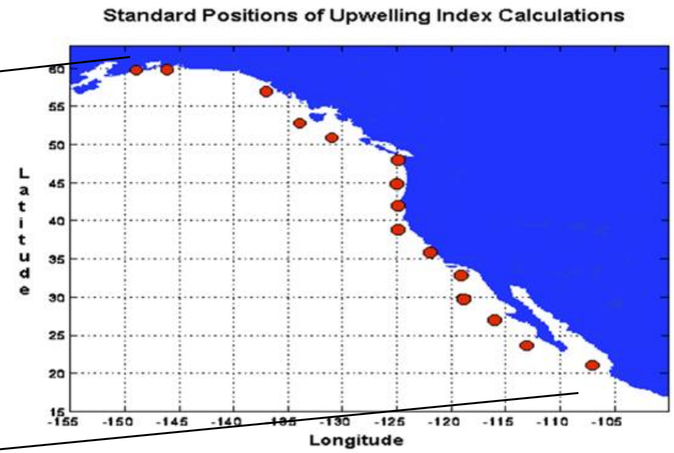
Last Three Month SST, SLP and 925hp Wind Anom.



- **Negative phase of PDO associated SSTA persisted and the positive SSTA strengthened in the central N. Pacific in Oct 2013.**
- **Positive SLP anomaly presented in Gulf of Alaska region and northerly wind anomaly was observed along NE Pacific coast in Oct 2013.**

North America Western Coastal Upwelling





- Downwelling in mid-high latitudes was suppressed in Oct 2013, consistent with the SLP and surface wind anomalies.

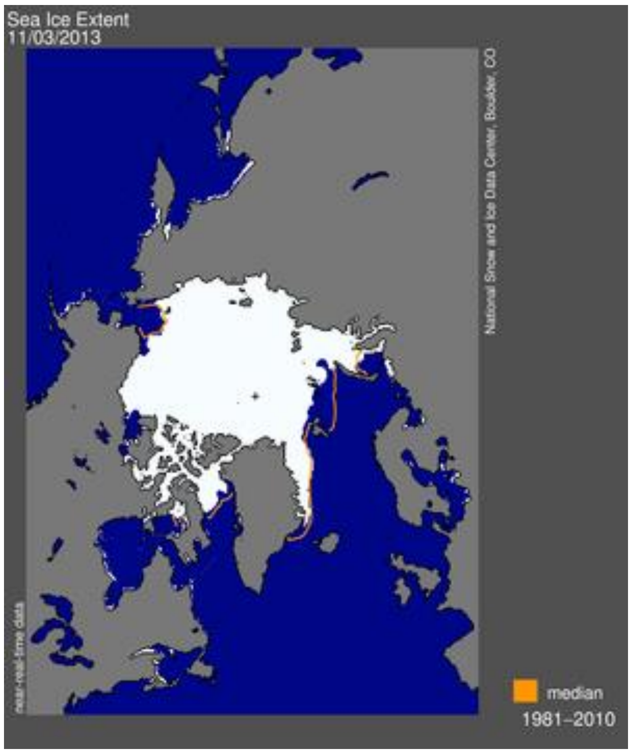
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1981-2010 base period pentad means.

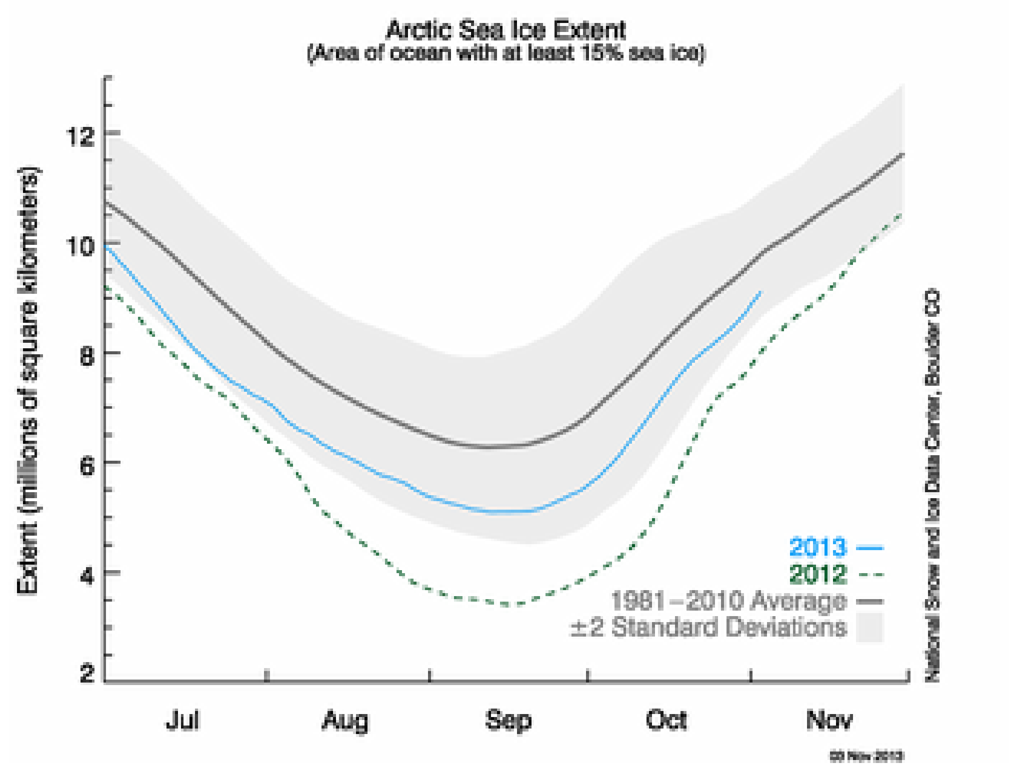
- Area below (above) black line indicates climatological upwelling (downwelling) season.

- Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.

Arctic Sea Ice

http://nsidc.org/arcticseaicenews/index.html.

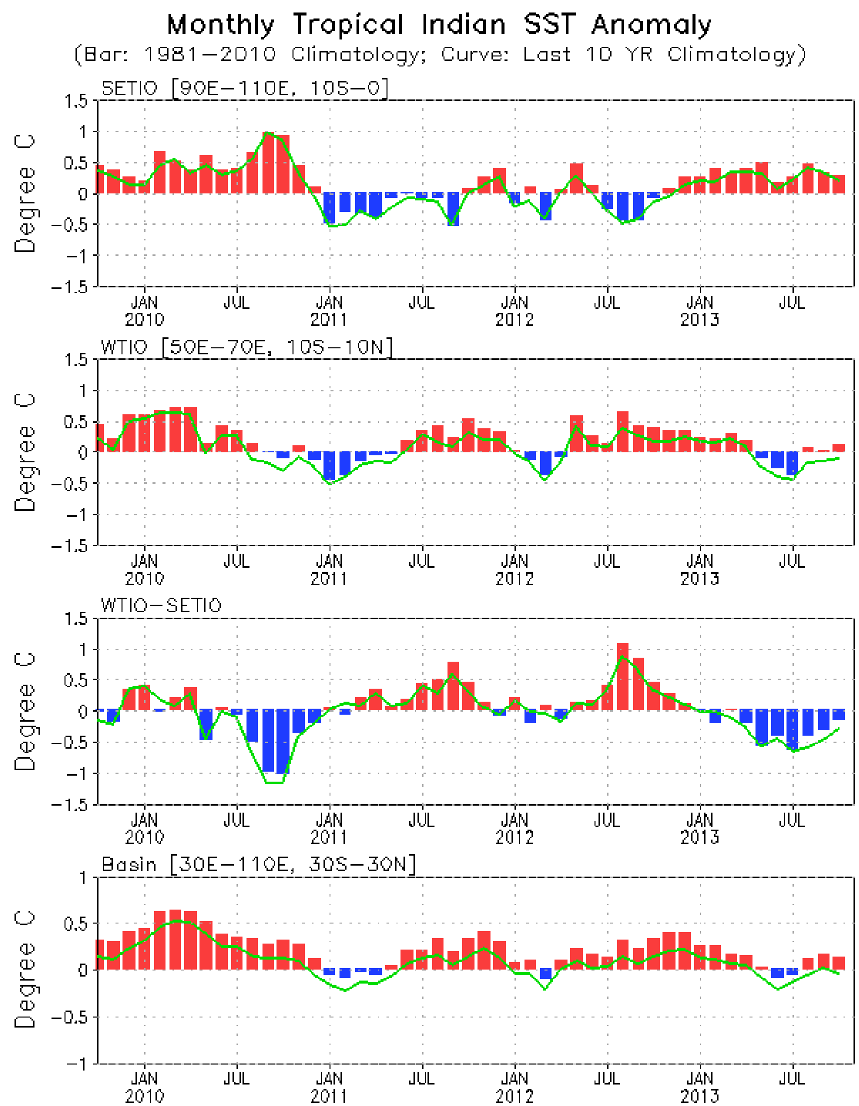


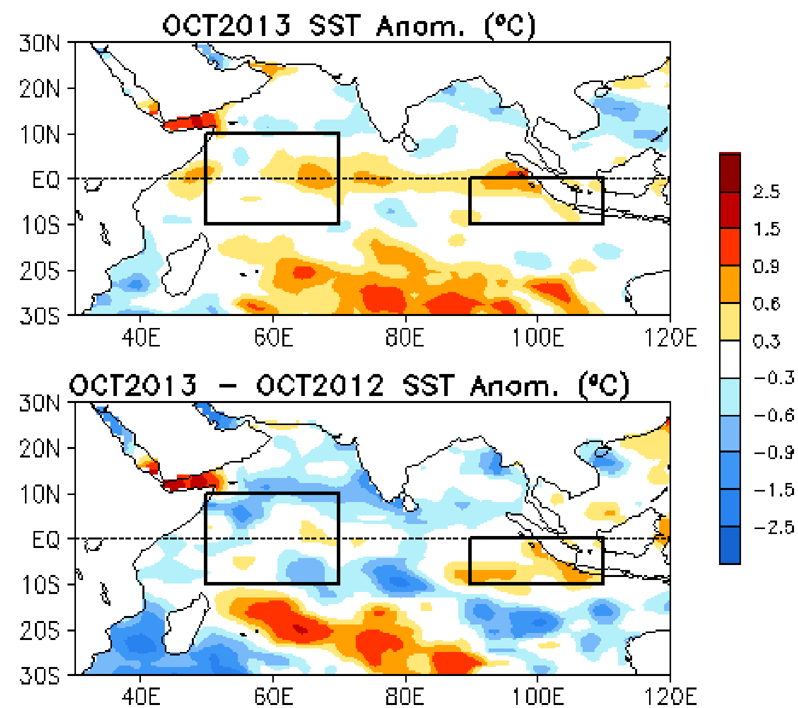


- Sea ice extent for Oct 2013 was still below-normal, but it is larger than Oct 2012 and also within the ±2 standard deviation range.

Indian Ocean

Evolution of Indian Ocean SST Indices





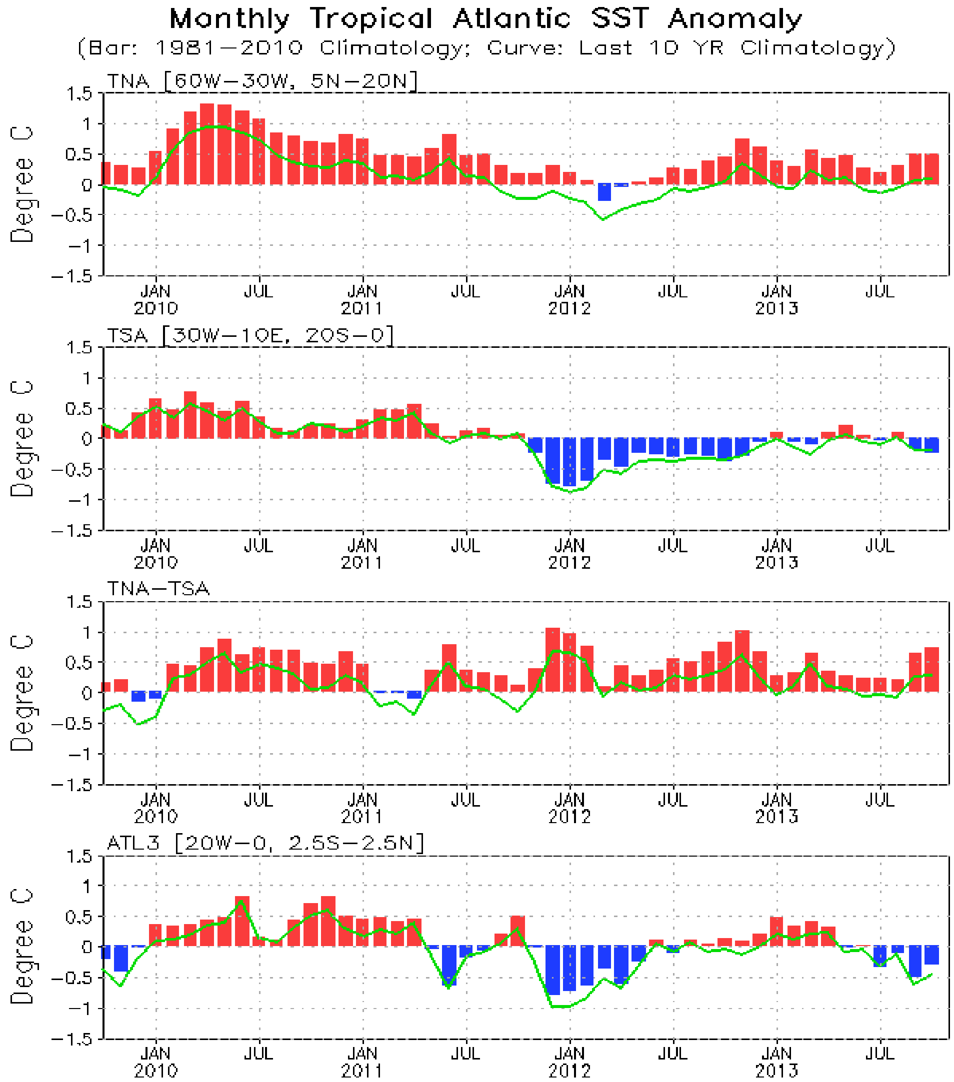
- The overall SSTA in the tropical Indian Ocean was small positive in Oct 2013.

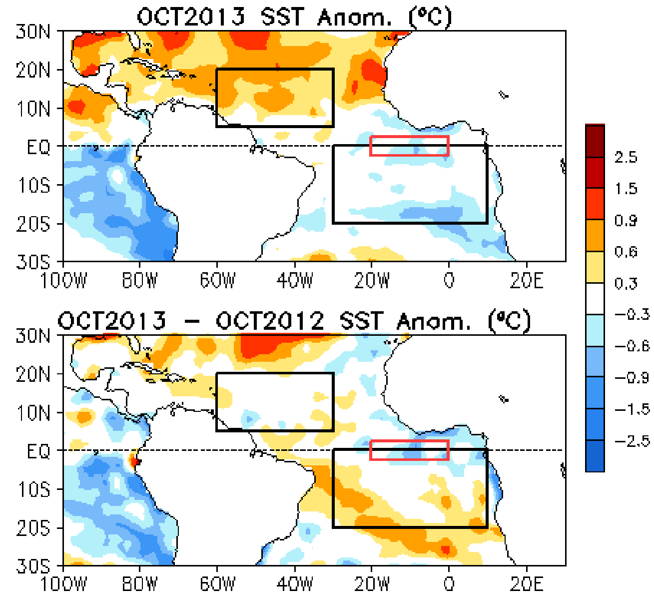
- DMI was negative since Apr 2013, weakened since Aug 2013.

Fig. 11a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and departures from the 1981-2010 base period means and the recent 10 year means are shown in bars and green lines.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

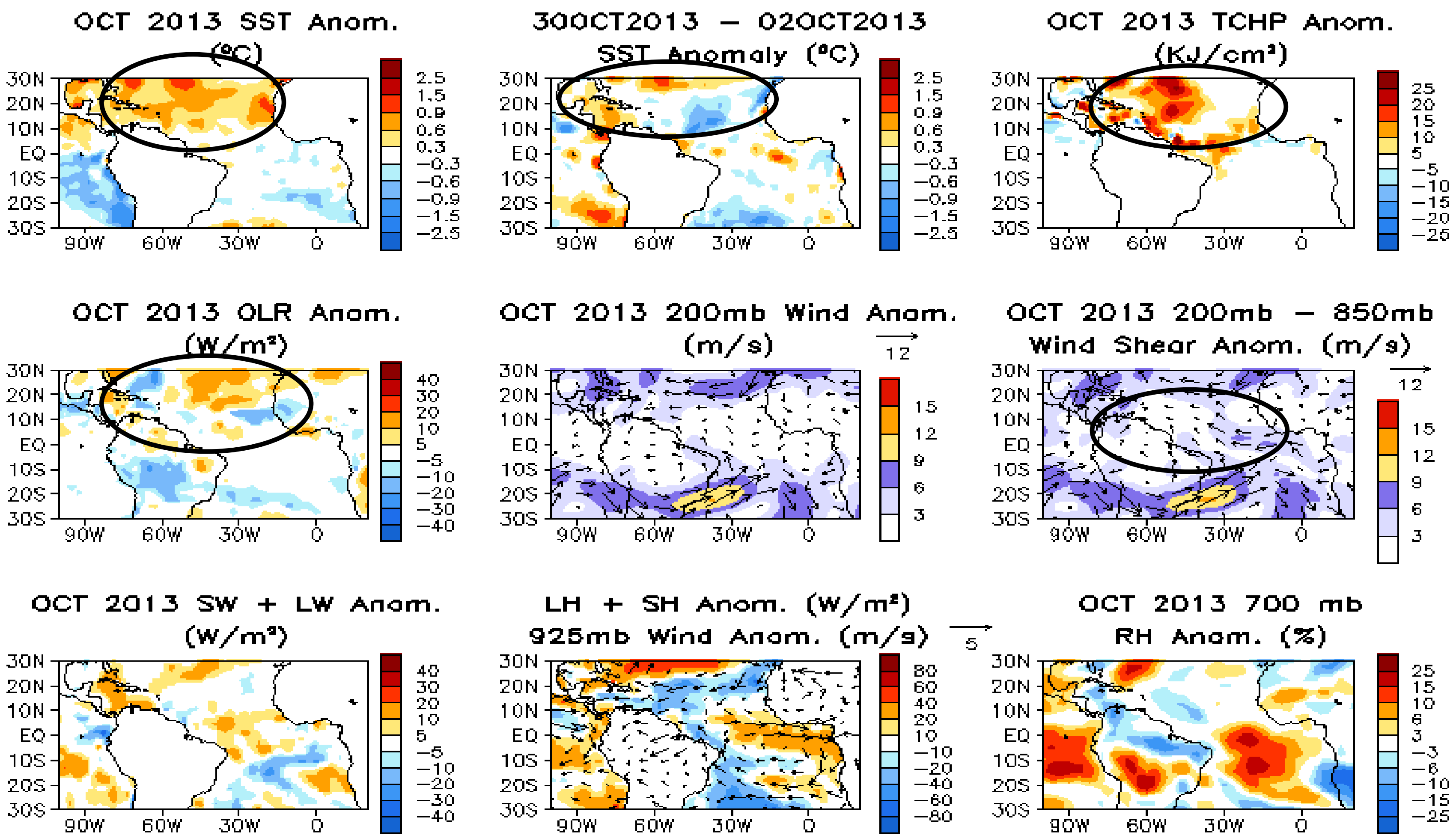




- The tropical N. (S.) Atlantic SST was above (below)-normal in Oct 2013.
- SSTA in the tropical N. Atlantic (TNA) was positive since May 2012.
- Meridional Gradient Mode index (TNA-TSA) was positive since May 2011.
- ATL3 SSTA was negative since Jul 2013.

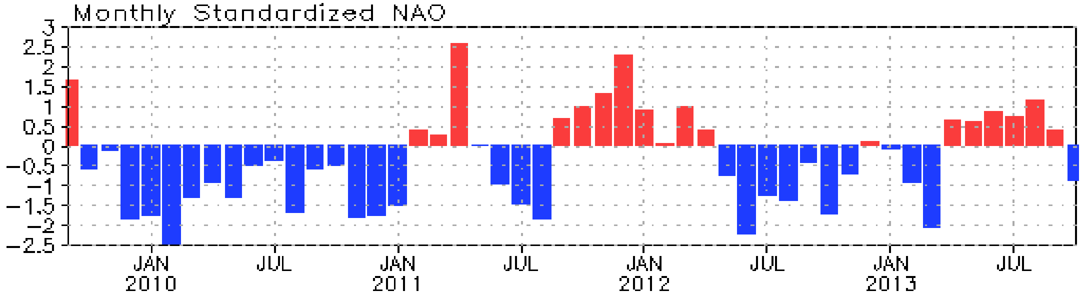
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and departures from the 1981-2010 base period means and the recent 10 year means are shown in bars and green lines.

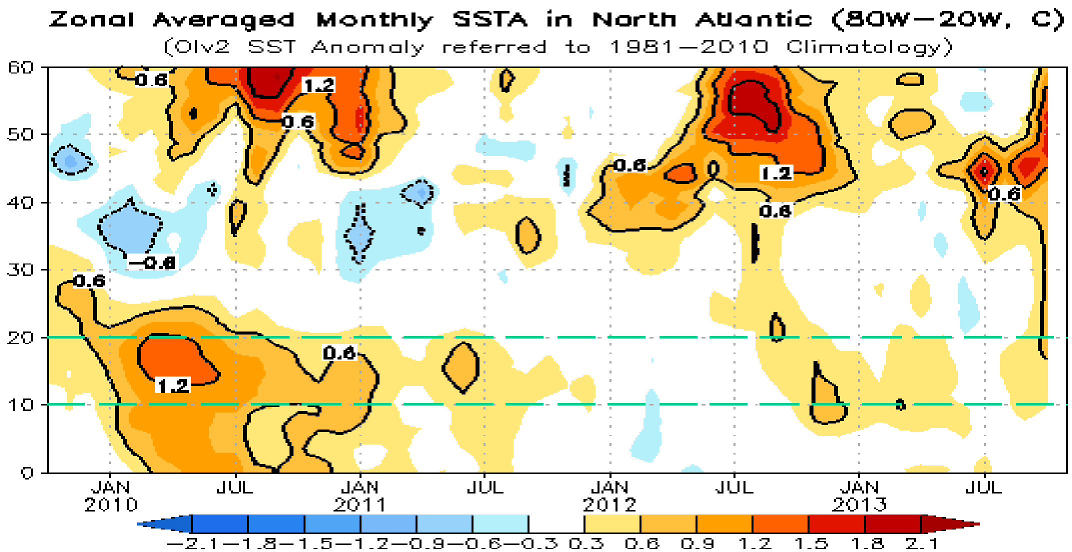
Tropical Atlantic:

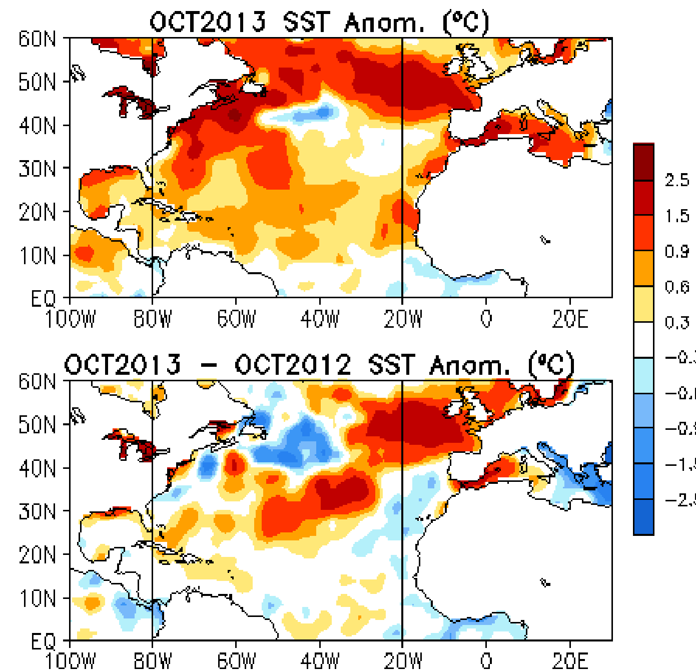


- Above-normal SST presented in the hurricane Main Development Region (MDR).
- Cooling tendency was observed in the eastern and warming in the western Atlantic and Gulf of Mexico.
- TCHP was positive and mainly in the NW Atlantic Ocean.
- Both suppressed and enhanced convections were observed in the tropical N. Atlantic.
- The vertical wind shear was below-normal in MDR.

NAO and SST Anomaly in North Atlantic



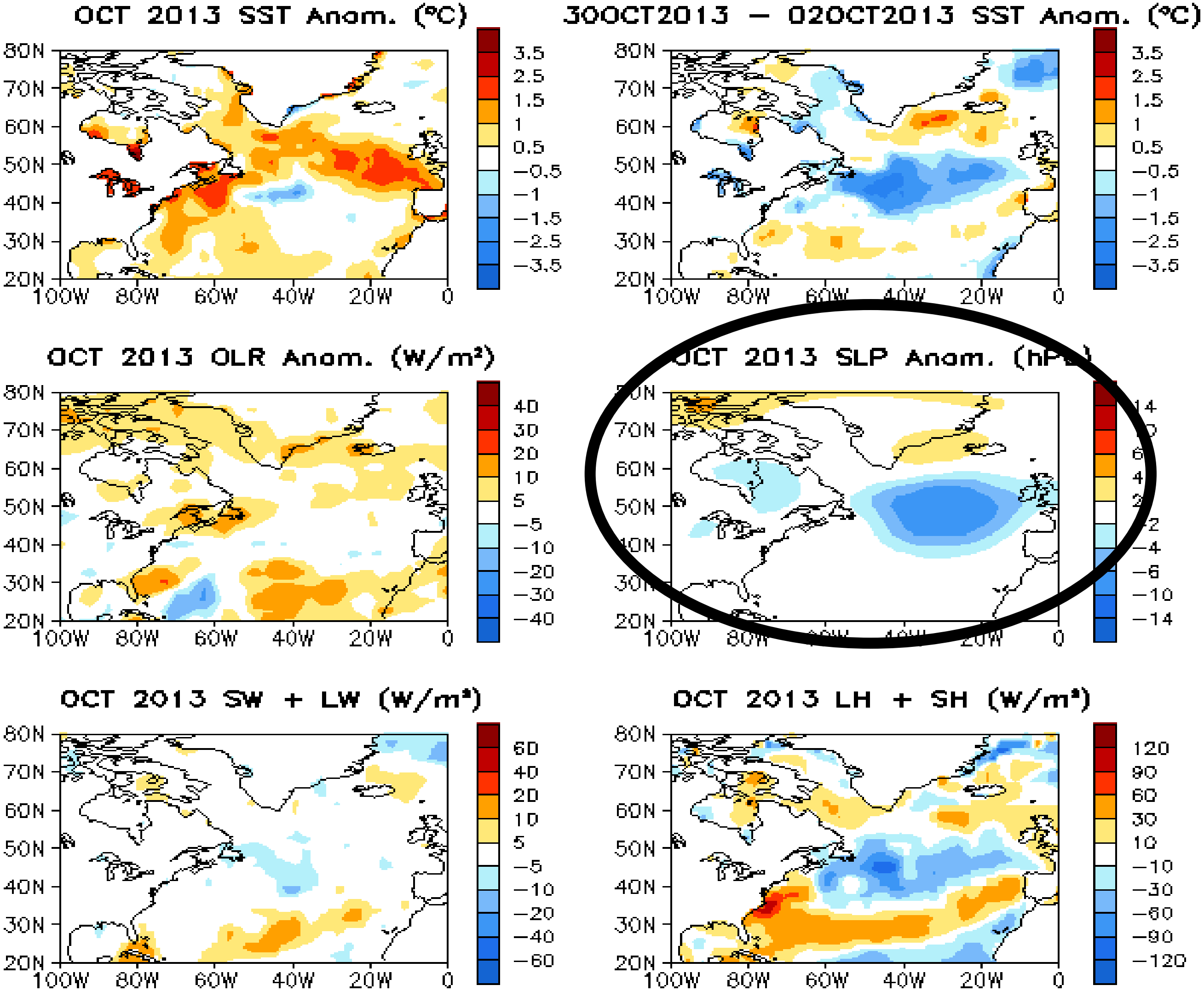




-NAO switched from positive to negative phase in Oct 2013, with NAO index = -0.9 in Oct 2013.

- The zonal mean SSTA in North Atlantic is generally related to NAO and ENSO impact (Hu et al. 2011: *J. Climate*, 24(22)).

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.



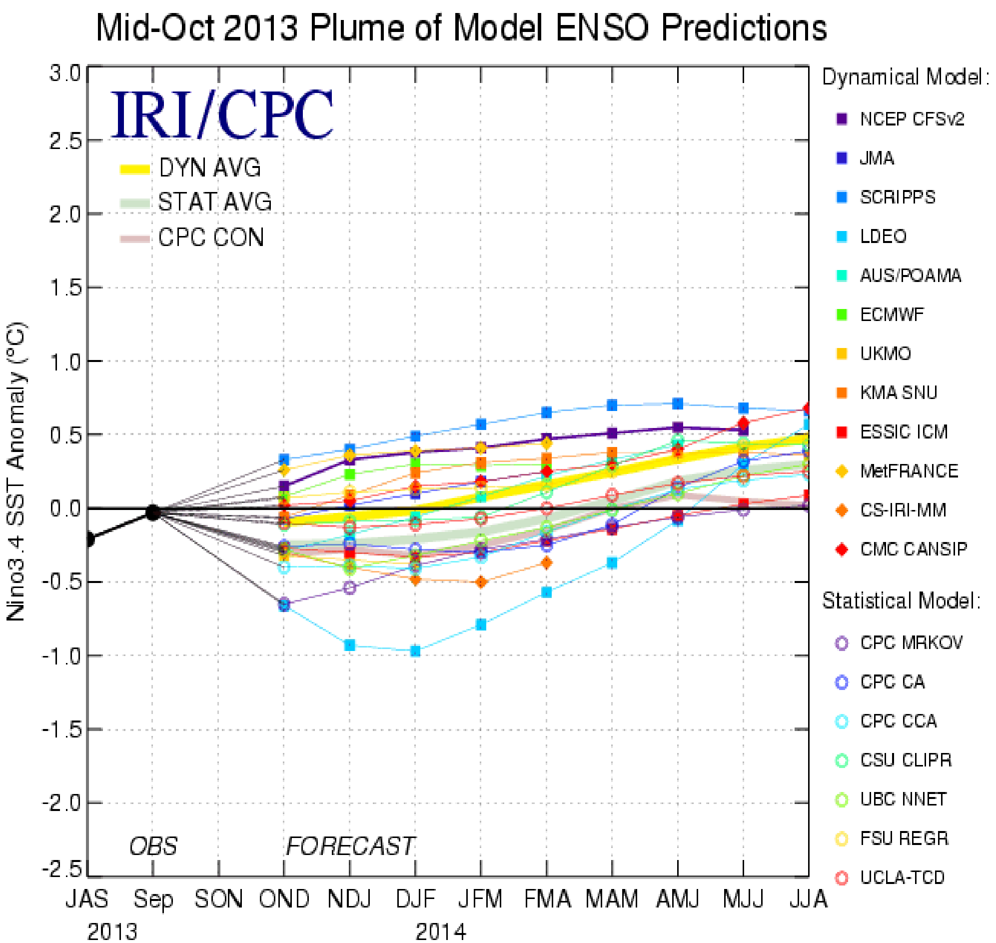
North Atlantic: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

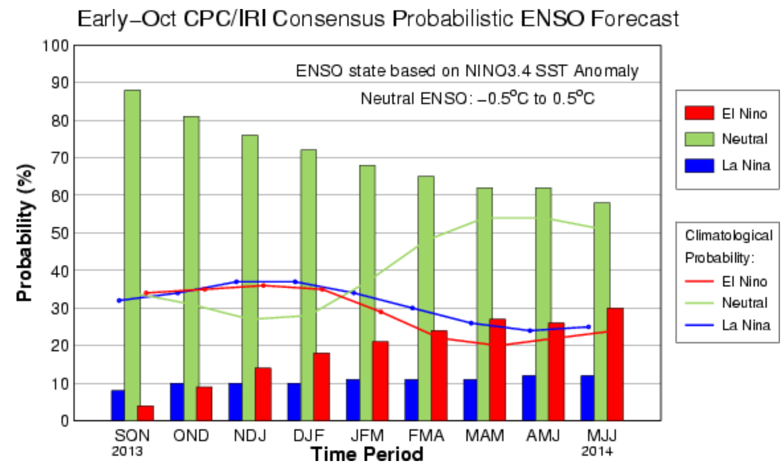
- **Negative SLP anomaly in the south and positive in the north were consistent with the negative phase of NAO index in Oct 2013.**

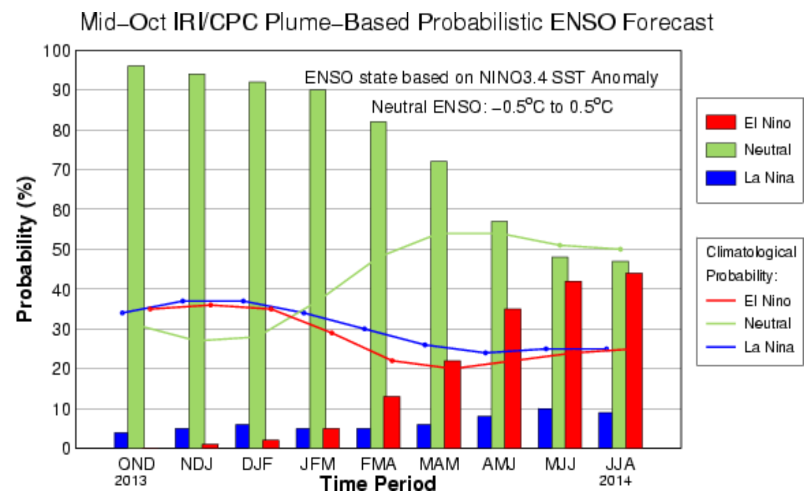
Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

Global SST Predictions

IRI/CPC NINO3.4 Forecast Plume

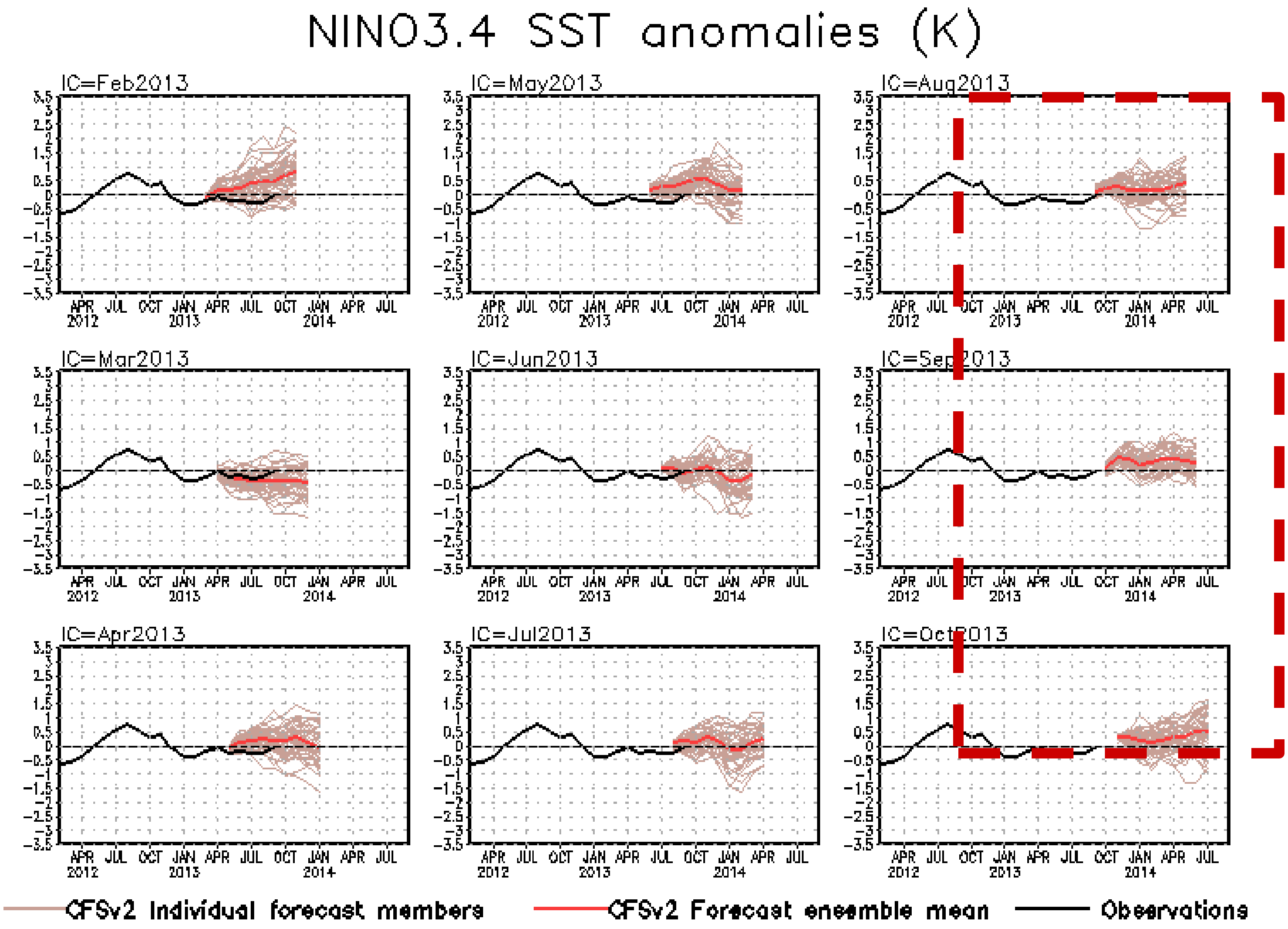






- **Majority of the models predicted ENSO-neutral until the Northern Hemisphere summer 2014.**
- **Average of forecast Nino3.4 of dynamical models was warmer than that of statistical models.**
- **The consensus forecast favors ENSO-neutral conditions until summer 2014, but the chance of occurrence of El Nino is higher than that of La Nina in 2014.**

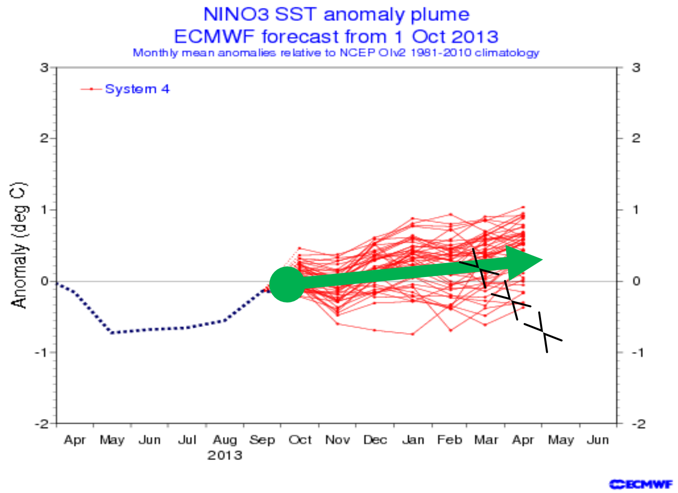
NCEP CFSv2 NINO3.4 Forecast



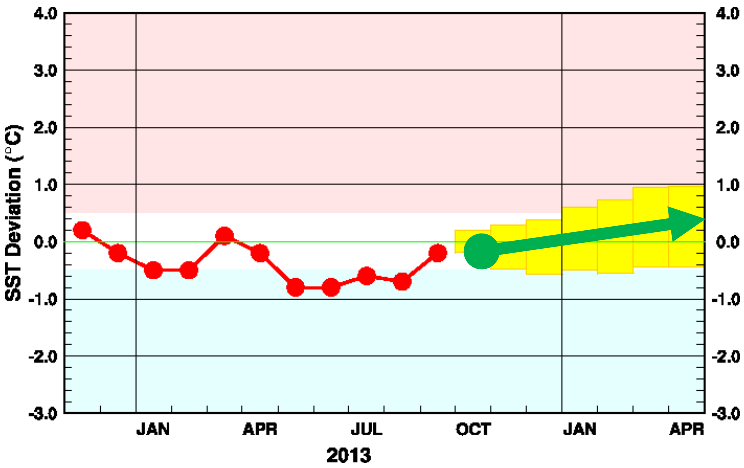
- The Nino3.4 predictions of CFSv2 from last a few month ICs called slightly above-normal SST before Summer 2014.

Individual Models: diverged results

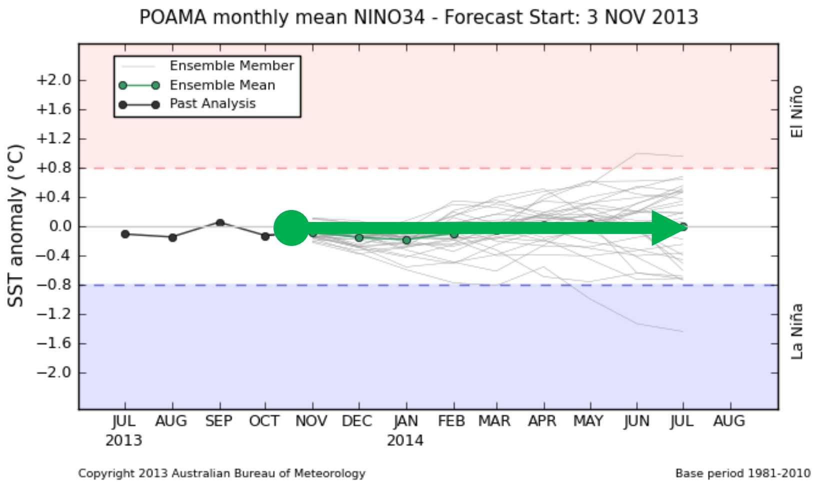
ECMWF: Nino3, IC=01Oct2013 (slightly warming up)



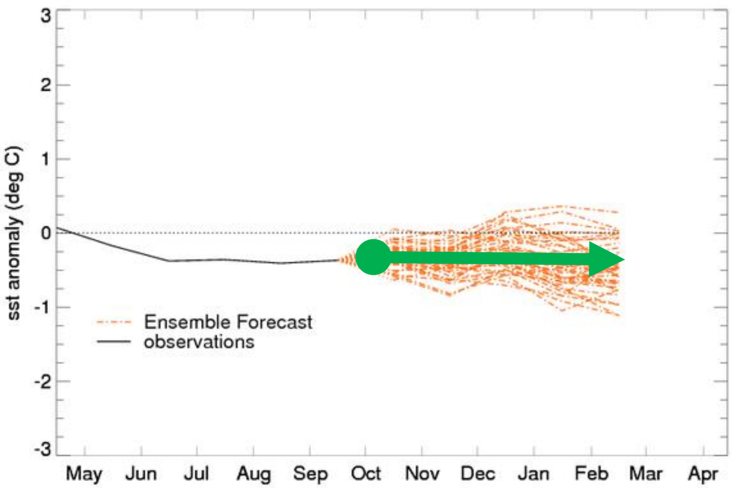
JMA: Nino3, IC=Oct2013 (slightly warming up)



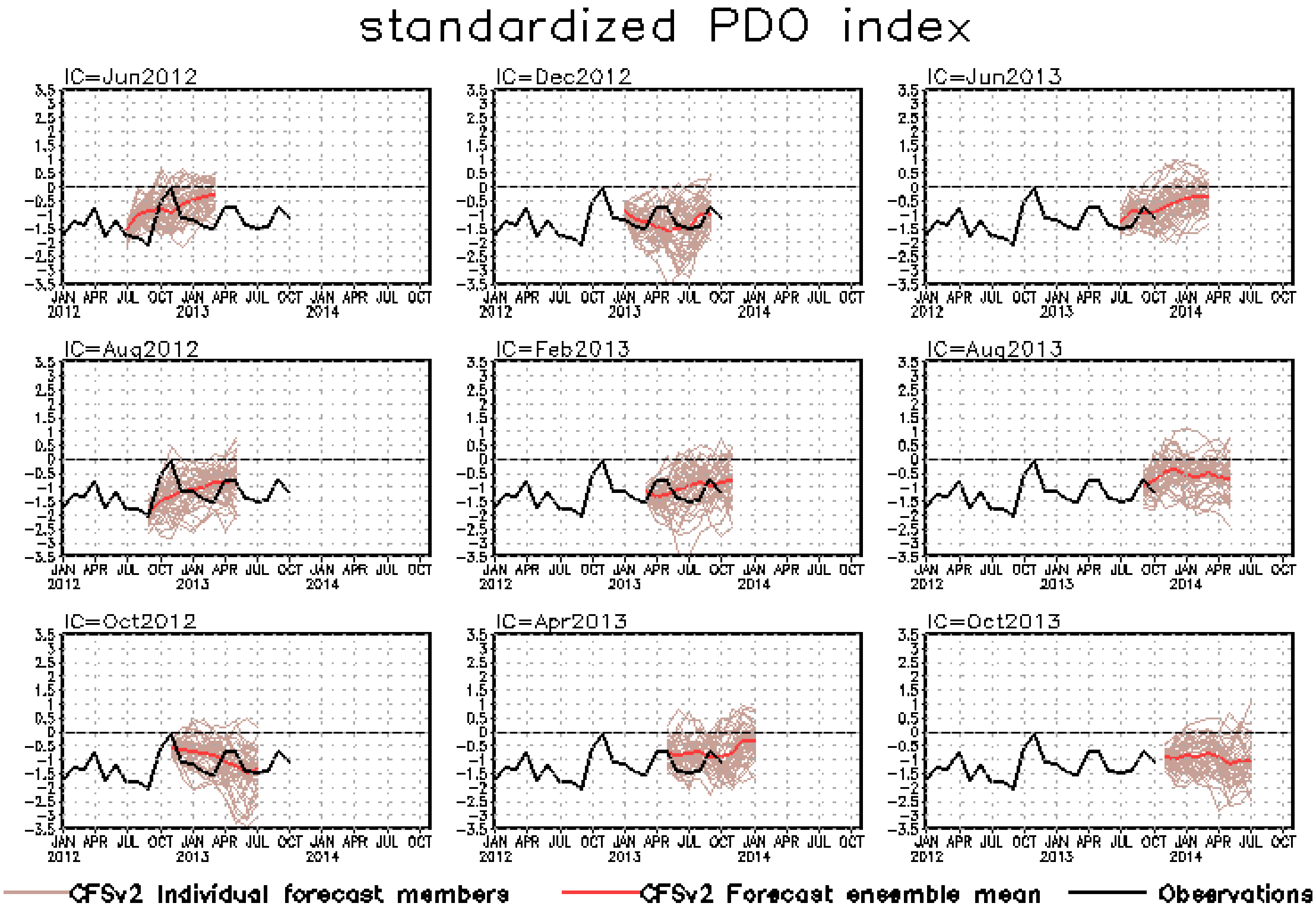
Australia: Nino3.4, IC=03Nov2013 (flat)



UKMO: Nino3.4, IC=15Oct2013 (below normal flat)



NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

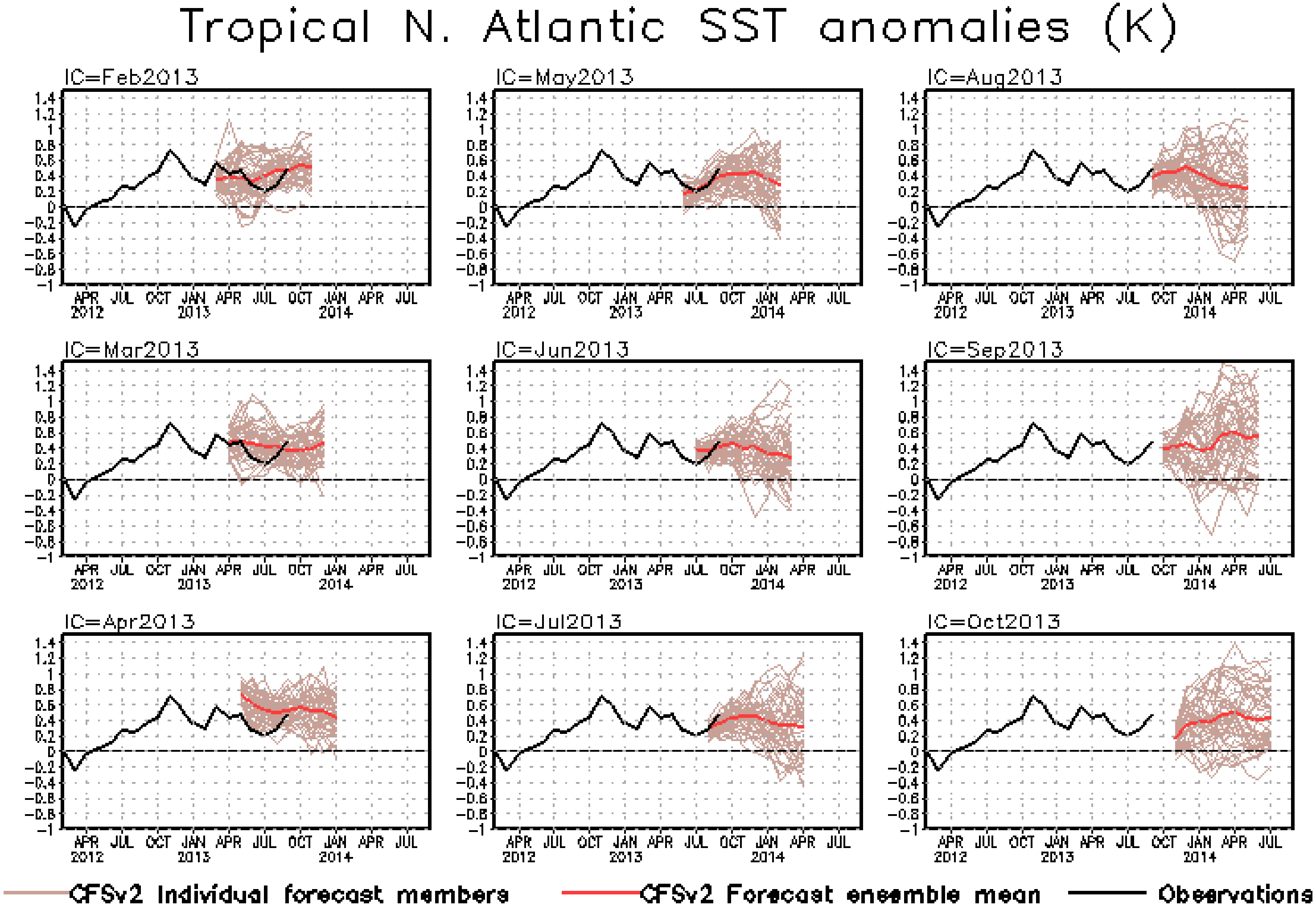


PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

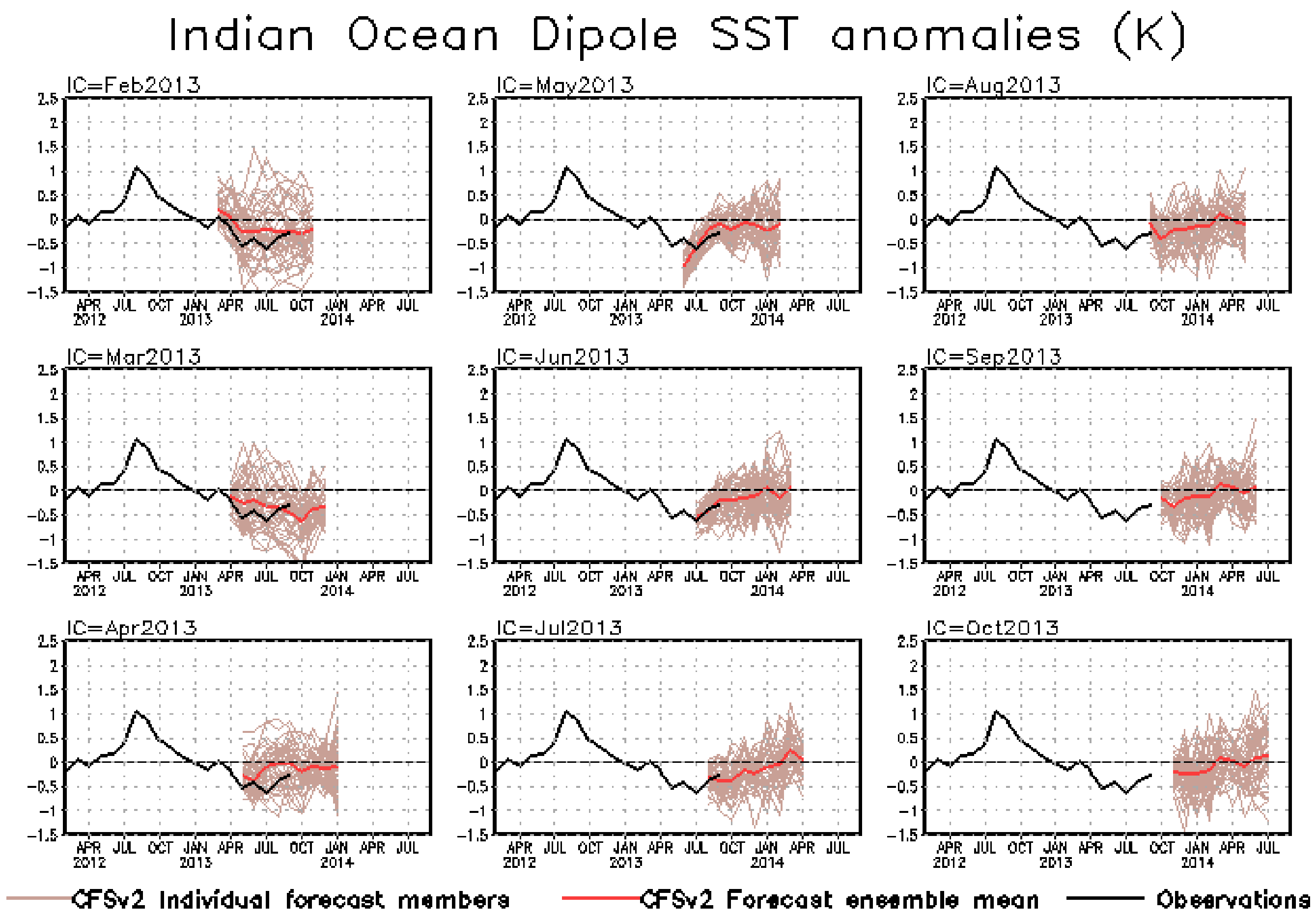
- Latest CFSv2 prediction suggested that negative phase of PDO will persist through summer 2014.

NCEP CFSv2 Tropical North Atlantic SST Forecast



- Latest CFSv2 prediction suggests that above-normal SST in the tropical N. Atlantic will continue into summer 2014.

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

SETIO = SST anomaly in [90ºE-110ºE, 10ºS-0]

WTIO = SST anomaly in [50ºE-70ºE, 10ºS-10ºN]

Latest CFSv2 prediction suggests that Indian Ocean dipole mode will be near normal until summer 2014.

Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1981-2010 base period means.

Backup Slides

http://www.cpc.ncep.noaa.gov/products/GODAS/

Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

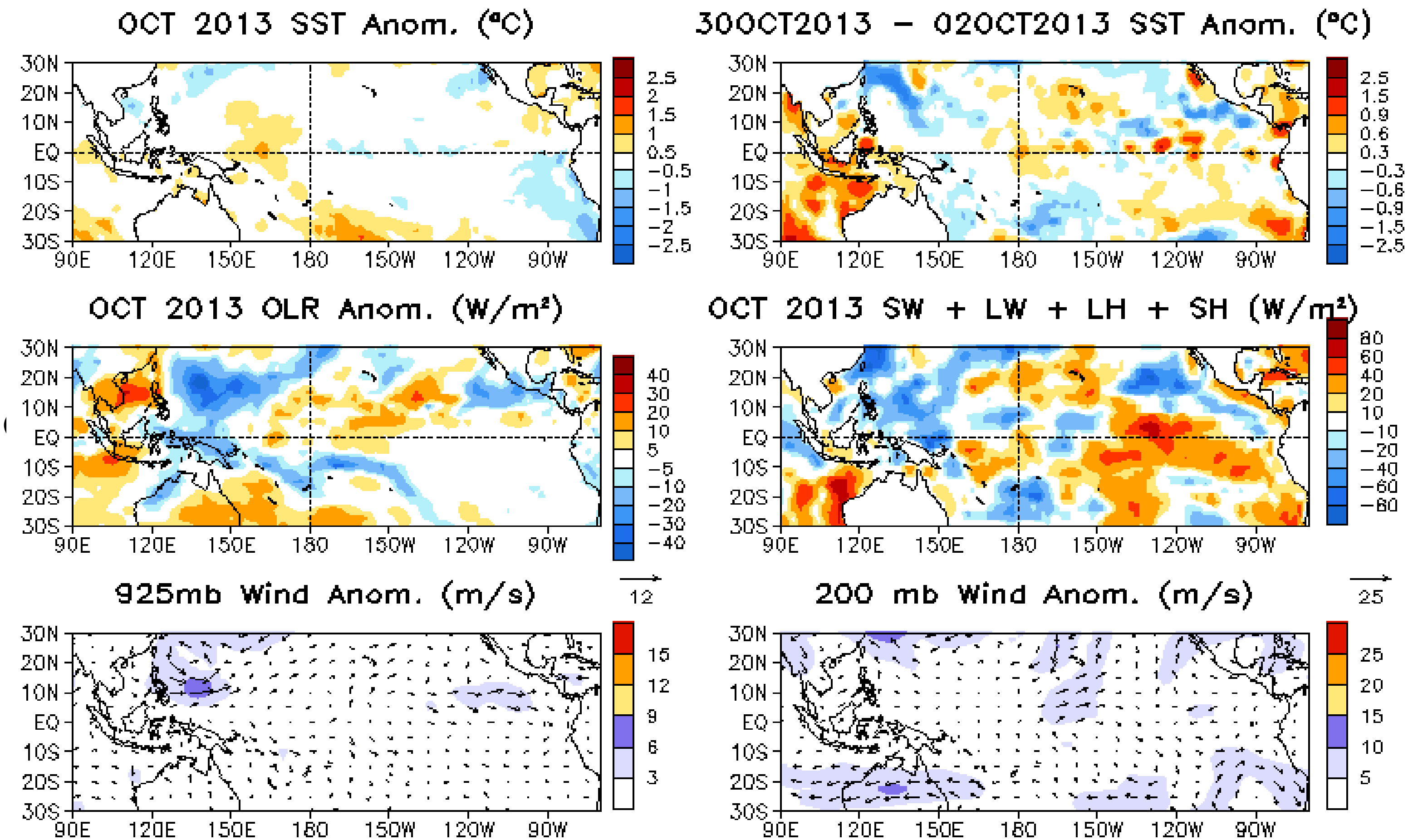
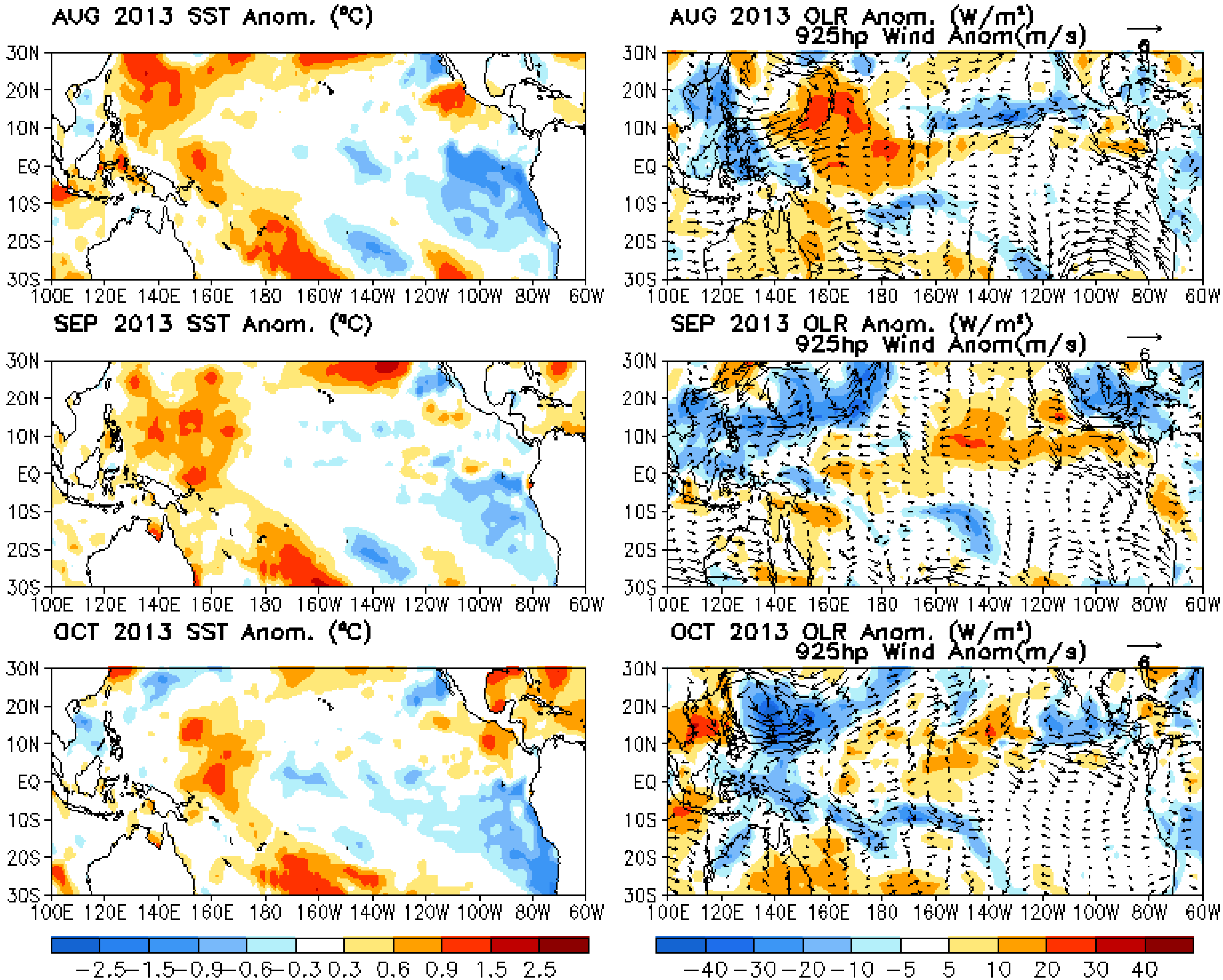
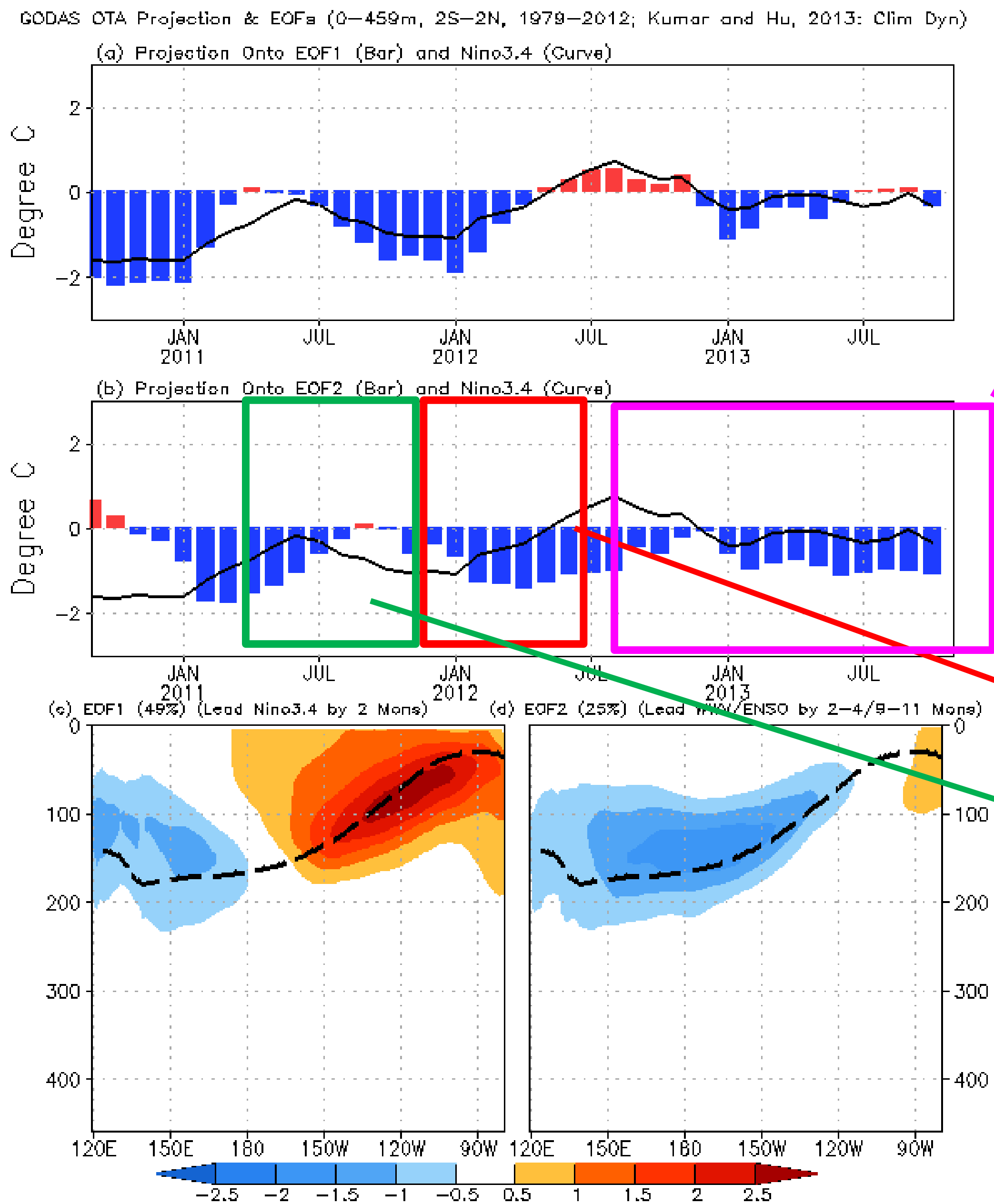


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Last Three Month SST, OLR and 925hp Wind Anom.





Equatorial subsurface ocean temperature monitoring: Right now, in recharge phase; recharge/discharge were weak in last 2 years.

Projection of OTA onto EOF1 and EOF2 (2S-2N, 0-459m, 1979-2010)

EOF1: Tilt mode (ENSO peak phase);

EOF2: WWV mode, Recharge/discharge oscillation (ENSO transition phase).

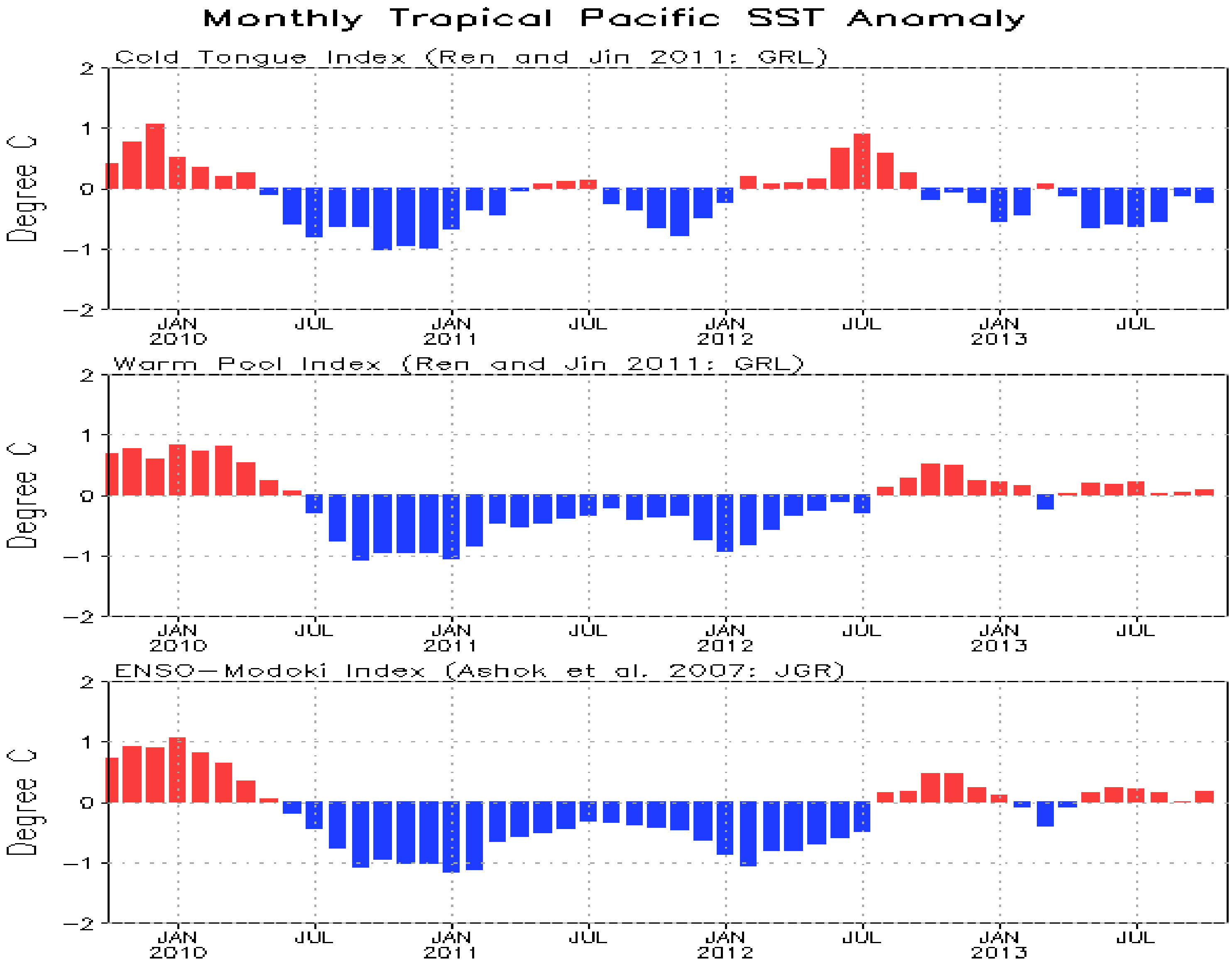
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

For details, see:

Kumar, A. and Z.-Z. Hu, 2013: Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn. DOI: 10.1007/s00382-013-1721-0 (published online).

Evolution of Pacific NINO SST Indices



North Pacific & Arctic Ocean: SST Anom., SST Anom. Tendency, OLR, SLP, Sfc Rad, Sfc Flx

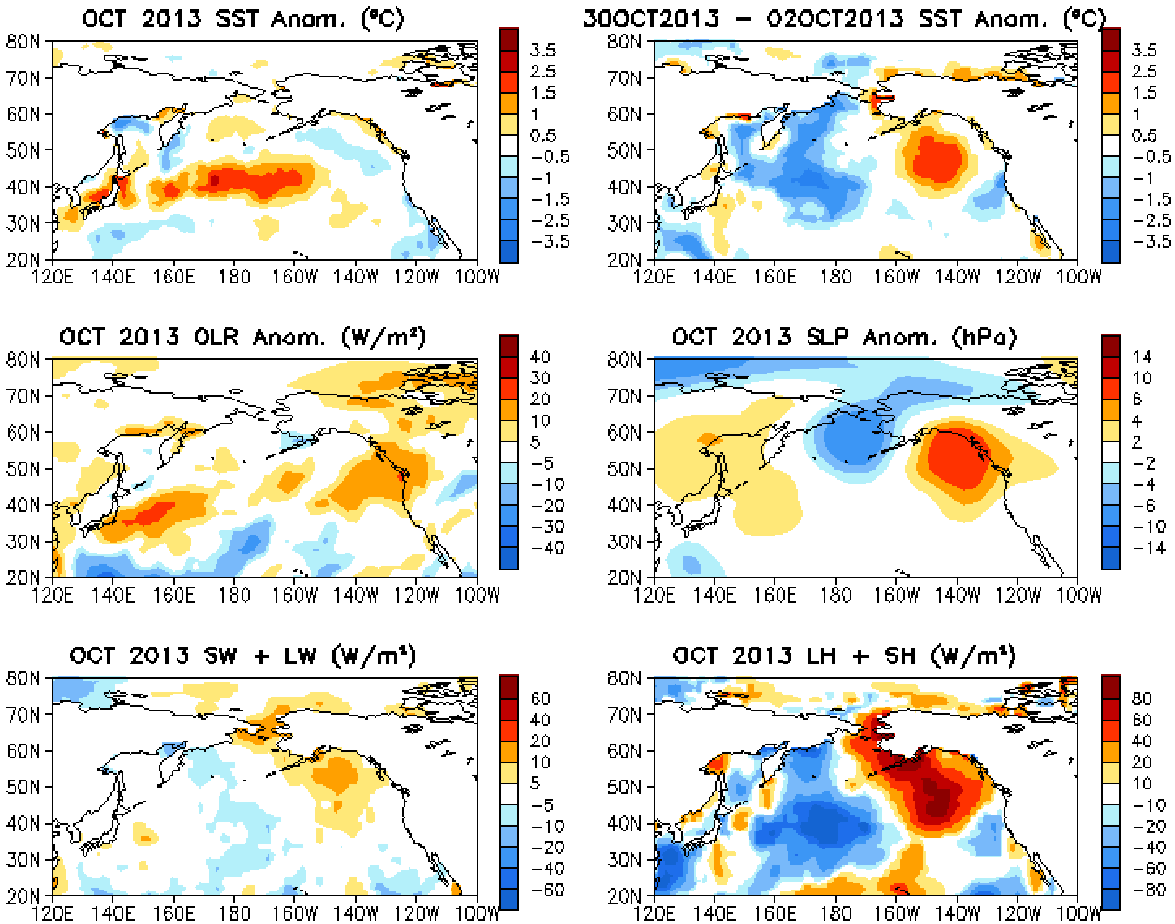


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

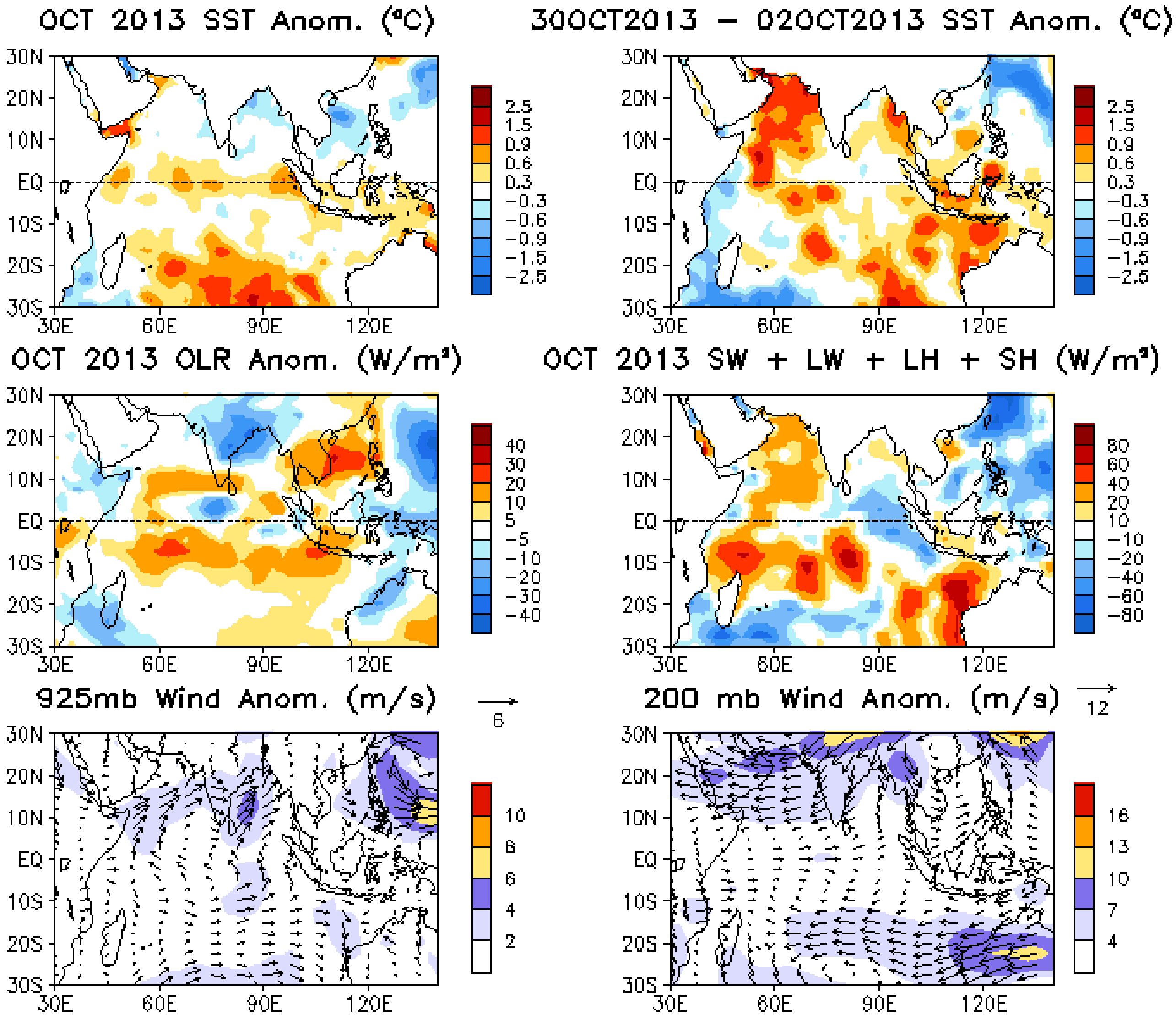
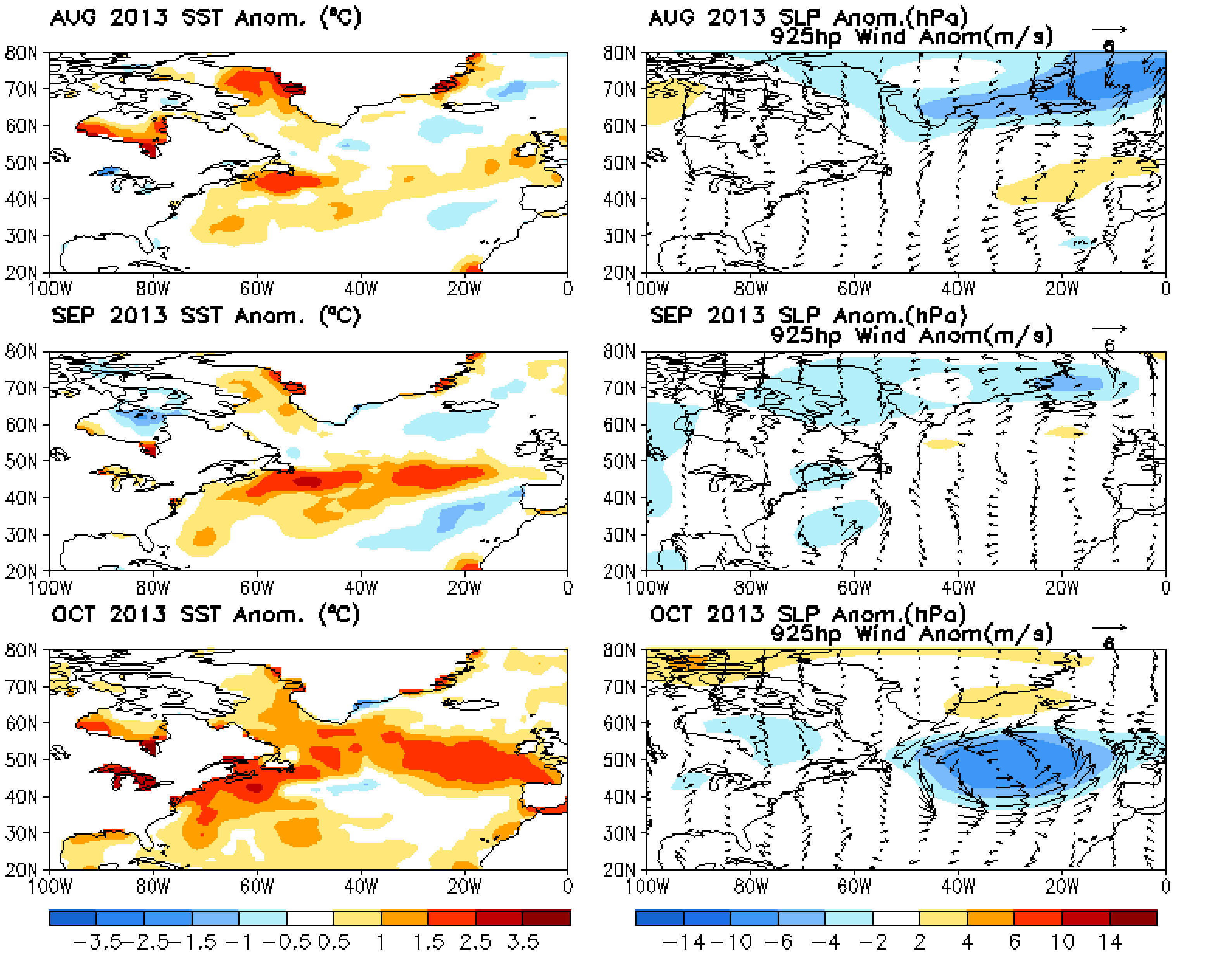


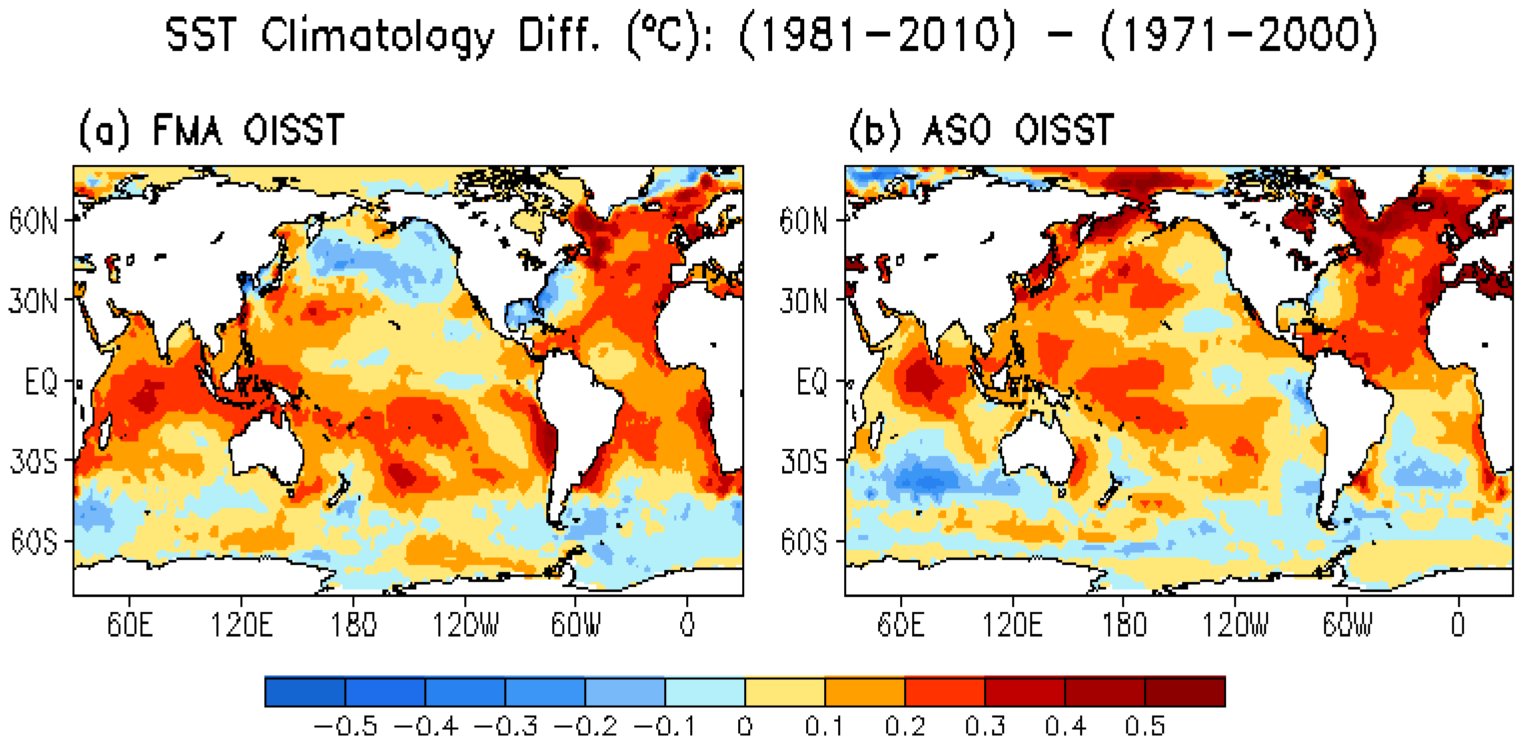
Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.


AUG 2013 SST Anom. (°C)
AUG 2013 SLP Anom.(hPa) 925hp Wind Anom(m/s)
SEP 2013 SST Anom. (°C)
SEP 2013 SLP Anom.(hPa) 925hp Wind Anom(m/s)
OCT 2013 SST Anom. (°C)
OCT 2013 SLP Anom.(hPa) 925hp Wind Anom(m/s)
6
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
−3.5 −2.5 −1.5 −1 −0.5 0.5 1 1.5 2.5 3.5
−14 −10 −6 −4 −2 2 4 6 10 14

Switch to 1981-2010 Climatology

- **SST from 1971-2000 to 1981-2010**
  - **Weekly OISST.v2, monthly ERSST.3b**
- **Atmospheric fields from 1979-1995 to 1981-2010**
  - **NCEP CDAS winds, sea level pressure, 200mb velocity potential, surface shortwave and longwave radiation, surface latent and sensible fluxes, relative humidity**
  - **Outgoing Long-wave Radiation**
- **Oceanic fields from 1982-2004 to 1981-2010**
  - **GODAS temperature, heat content, depth of 20^{o}C, sea surface height, mixed layer depth, tropical cyclone heat potential, surface currents, upwelling**
- **Satellite data climatology 1993-2005 unchanged**
  - **Aviso Altimetry Sea Surface Height**
  - **Ocean Surface Current Analyses – Realtime (OSCAR)**

Be aware that new climatology (1981-2010) was applied since Jan 2011



1971-2000 SST Climatology (Xue et al. 2003):
http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst_clim.htm

1981-2010 SST Climatology: http://origin.cpc.ncep.noaa.gov/products/people/yxue/sstclim/

- The seasonal mean SST in February-April (FMA) increased by more than 0.2ºC over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2ºC in high-latitude N. Pacific, Gulf of Mexico and along the east coast of U.S.

- Compared to FMA, the seasonal mean SST in August-October (ASO) has a stronger warming in the tropical N. Atlantic, N. Pacific and Arctic Ocean, and a weaker cooling in Gulf of Mexico and along the east coast of U.S.

Data Sources and References

- Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)
- NCEP CDAS winds, surface radiation and heat fluxes
- NESDIS Outgoing Long-wave Radiation
- NDBC TAO data (http://tao.noaa.gov)
- PMEL TAO equatorial temperature analysis
- NCEP's Global Ocean Data Assimilation System temperature, heat content, currents (Behringer and Xue 2004)
- Aviso Altimetry Sea Surface Height
- Ocean Surface Current Analyses – Realtime (OSCAR)

Please send your comments and suggestions to Yan.Xue@noaa.gov. Thanks!