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's Climate Observation Division (COD)

Outline

- **Overview**
- **Recent highlights**
  - **Global Oceans**

  (NOAA 2014 Hurricane Prediction)
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Global SST Predictions**

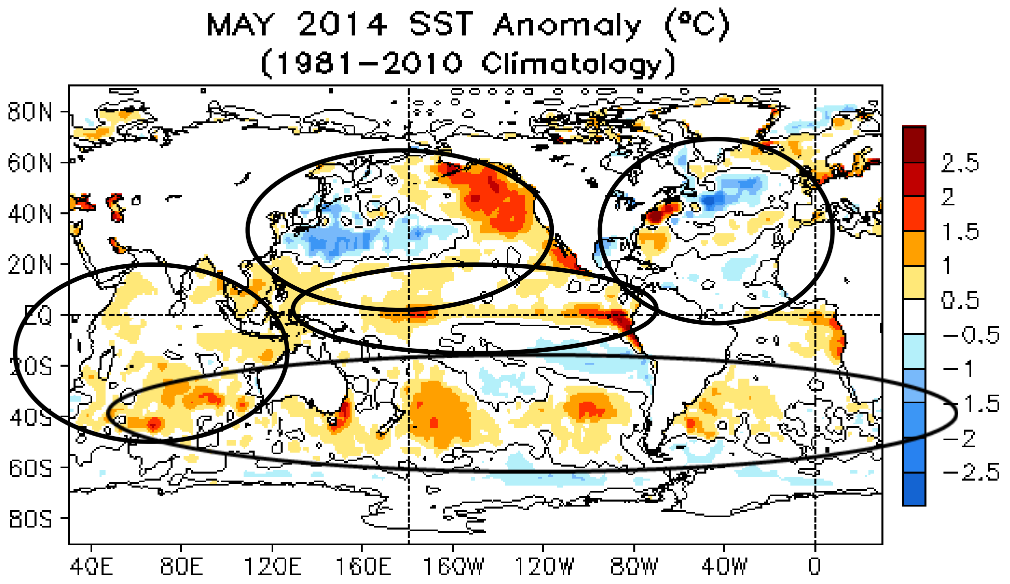
  (Possibility of occurrence of an El Nino in 2014/15)

Overview

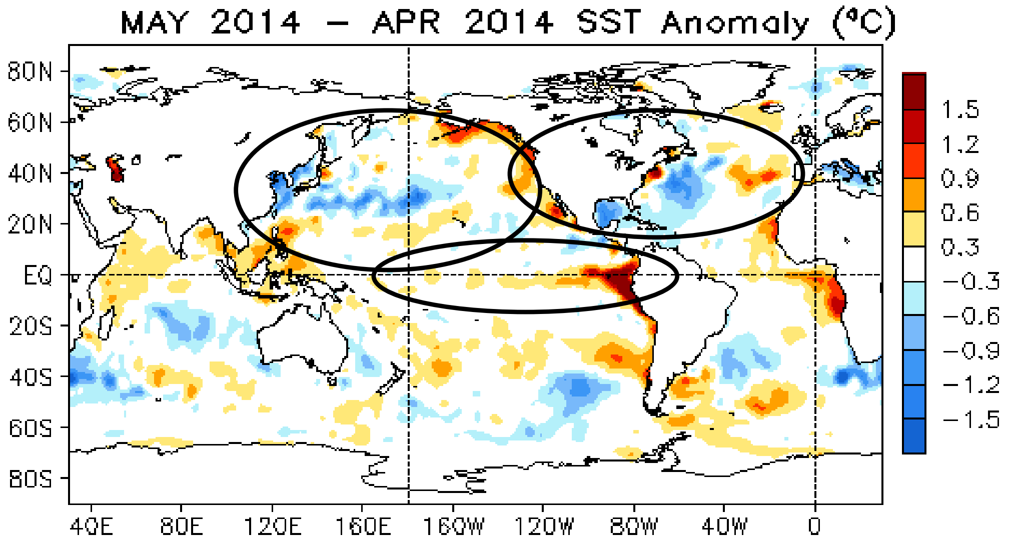
- **Pacific Ocean**
  - **ENSO neutral condition continued with OIv2 NINO3.4=0.46°C in May 2014.**
  - **Positive anomalies of subsurface ocean temperature along the equator weakened in May 2014.**
  - **Majority of models predicted an El Nino starting this summer.**
  - **NOAA "ENSO Diagnostic Discussion" on 5 June 2014 continually issued "El Nino Watch" and suggested that "Chances of El Niño are 70% during the Northern Hemisphere summer and reach 80% during the fall and winter."**
  - **PDO switched to positive phase in Mar and strengthened in Apr-May with PDO index =1.2 in May 2014.**
- **Indian Ocean**
  - **Positive SSTA presented in the whole Indian Ocean in May 2014.**
- **Atlantic Ocean**
  - **NAO switched into negative phase with NAOI=-0.8 in May 2014.**
  - **Tripole pattern of SSTA presented in North Atlantic in May 2014.**
  - **NOAA predicts near-normal or below-normal 2014 Atlantic hurricane season.**

Global Oceans

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



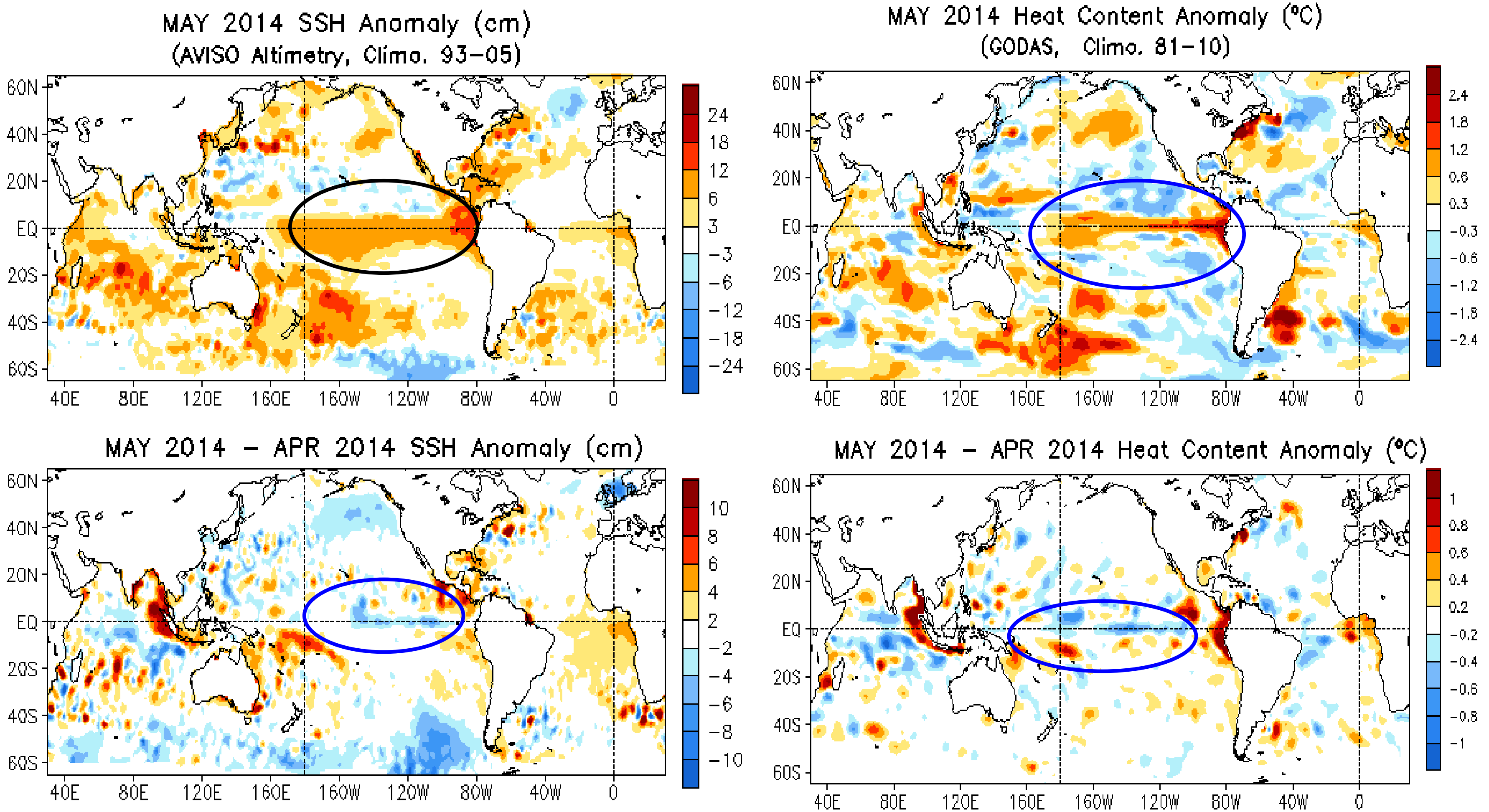
- **Positive SSTA in the equatorial central and eastern Pacific.**
- **Positive phase of PDO associated SSTA in North Pacific.**
- **Tripole SSTA pattern in the North Atlantic.**
- **Positive SSTA in the Indian Ocean.**
- **Some SSTAs in the South Ocean.**



- **Large positive SSTA tendencies in the eastern equatorial Pacific Ocean.**
- **Negative SSTA in Mid-latitudes of N. Pacific.**
- **Some cooling tendencies in the northwestern Atlantic.**

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.

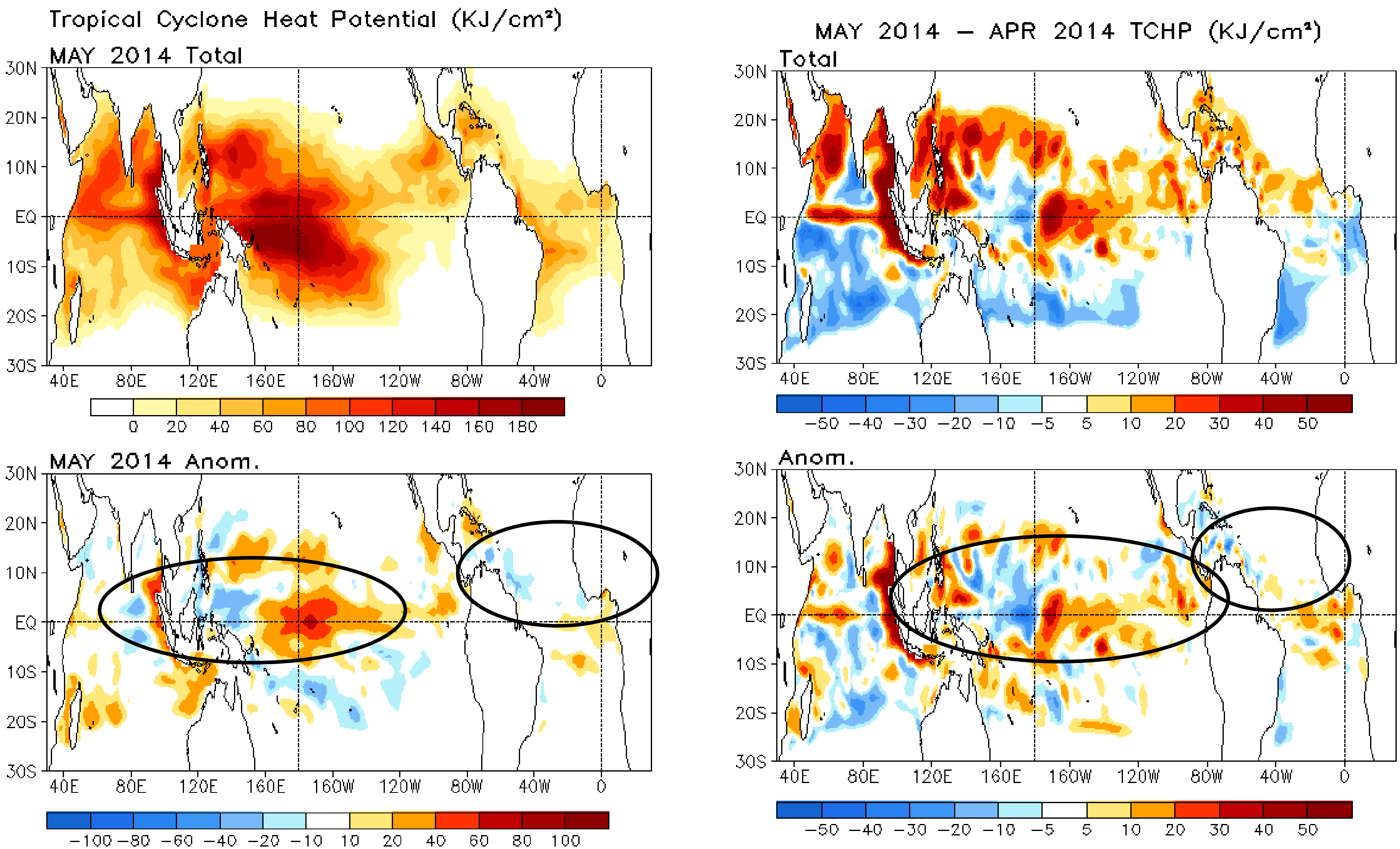
Global SSH and HC300 Anomaly & Anomaly Tendency



- The SSHA was overall consistent with HC300A: Positive (negative) HC300A is tied up with positive (negative) SSHA.

- Positive SSH/HC200 anomalies presented in the central and eastern equatorial Pacific.

- Negative SSHA /HC300A tendency in the central and eastern equatorial Pacific is associated with Kelvin wave activity.



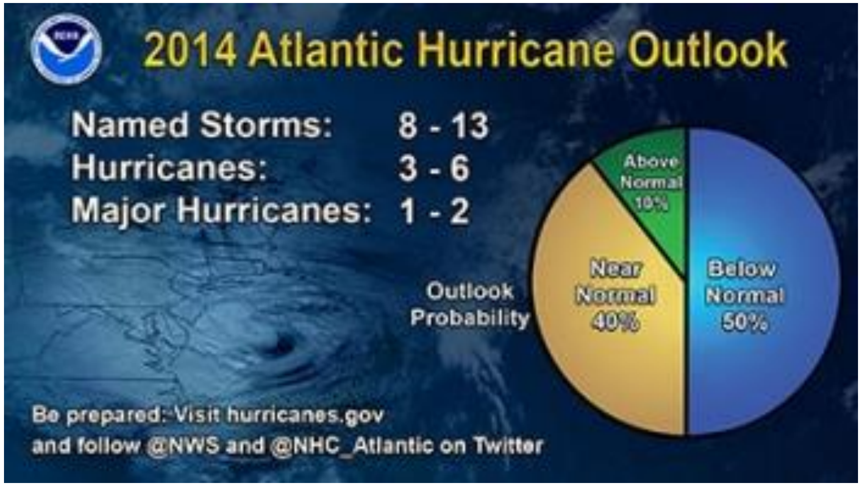
- **Positive TCHP anomalies presented in the c. equatorial Pacific and negative ones in the w. Pacific.**
- **Small negative anomalies were observed over the tropical North Atlantic Ocean.**
- **The tendency was positive (negative) in the tropical e. (w.) Pacific and small in the tropical N. Atlantic.**

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

NOAA Predicts Near-Normal or Below-Normal 2014 Atlantic Hurricane Season

(http://www.noaanews.noaa.gov/stories2014/20140522_hurricaneoutlook_atlantic.html)

	2014 prediction (issued on May 22) (1981-2010)
Named storms	8-13 (12.1)
Hurricanes	3-6 (6.4)
Major hurricanes	1-2 (2.7)



- The main driver of this year's outlook is the anticipated development of El Niño this summer.

- El Niño causes stronger wind shear, which reduces the number and intensity of tropical storms and hurricanes.

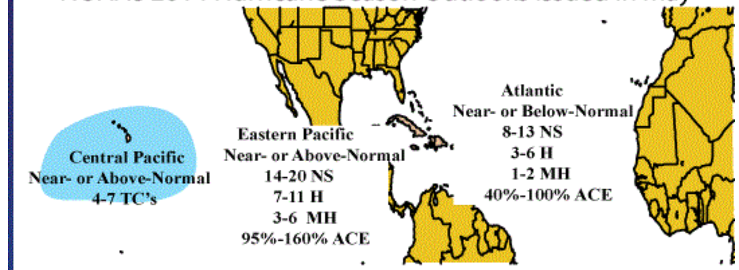
- El Niño can also strengthen the trade winds and increase the atmospheric stability across the tropical Atlantic, making it more difficult for cloud systems coming off of Africa to intensify into tropical storms.

NOAA Predicts Near or Above-Normal E. Pacific Hurricane Season in 2014

(http://www.cpc.ncep.noaa.gov/products/Epac_hurr/Epac_hurricane.html)

	2014 prediction (issued on May 22) (1981-2010)
Named storms	14-20 (15.4)
Hurricanes	6-11 (7.6)
Major hurricanes	3-6 (3.2)

NOAA's 2014 Hurricane Season Outlooks Issued in May



NOAA's 2014 Atlantic and Eastern Pacific hurricane season outlooks indicate the likely ranges (each with a70% chance) of Named Storms (NS), Hurricanes (H), Major Hurricanes (MH), and percentage of the median Acccumulated Cyclone Energy (ACE).

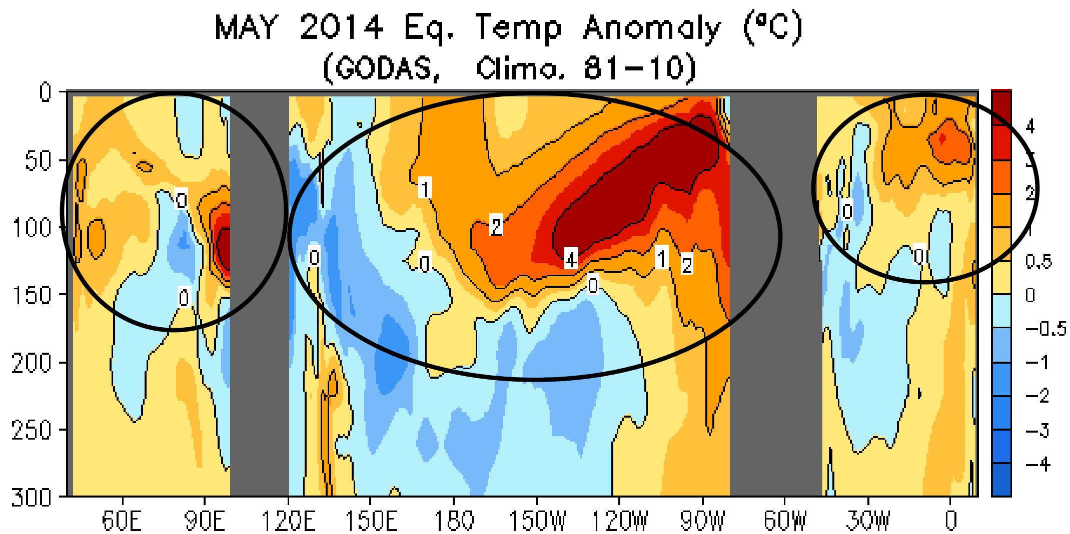
NOAA's 2014 Central Pacific hurricane season outlook indicates the likely number of tropical cyclones (TC), which include tropical depressions, tropical storms and hurricanes.

For 2014 the probabilities of each season type are:

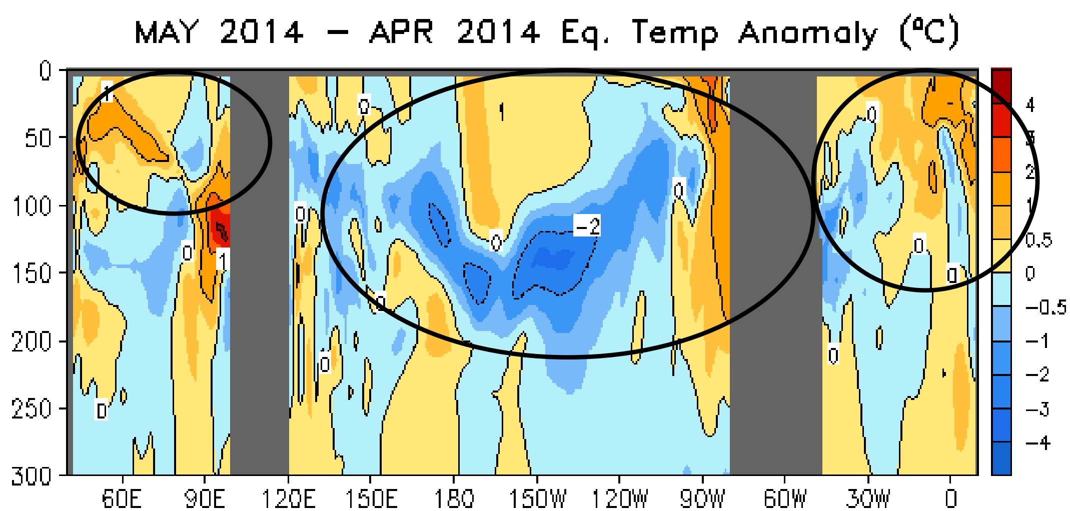
	Atlantic	Eastern Pacific	Central Pacific
Above Normal	10%	50%	40%
Near Normal	40%	40%	40%
Below Normal	50%	10%	20%

- **El Nino:** The 2014 seasonal hurricane outlook reflects the likely development of El Niño. El Niño reduces the vertical wind shear in the eastern Pacific hurricane basin, making atmospheric conditions more conducive to hurricane activity.
- **Low-activity era for eastern Pacific hurricanes:** Eastern Pacific hurricane seasons have been less active since 1995**.**

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



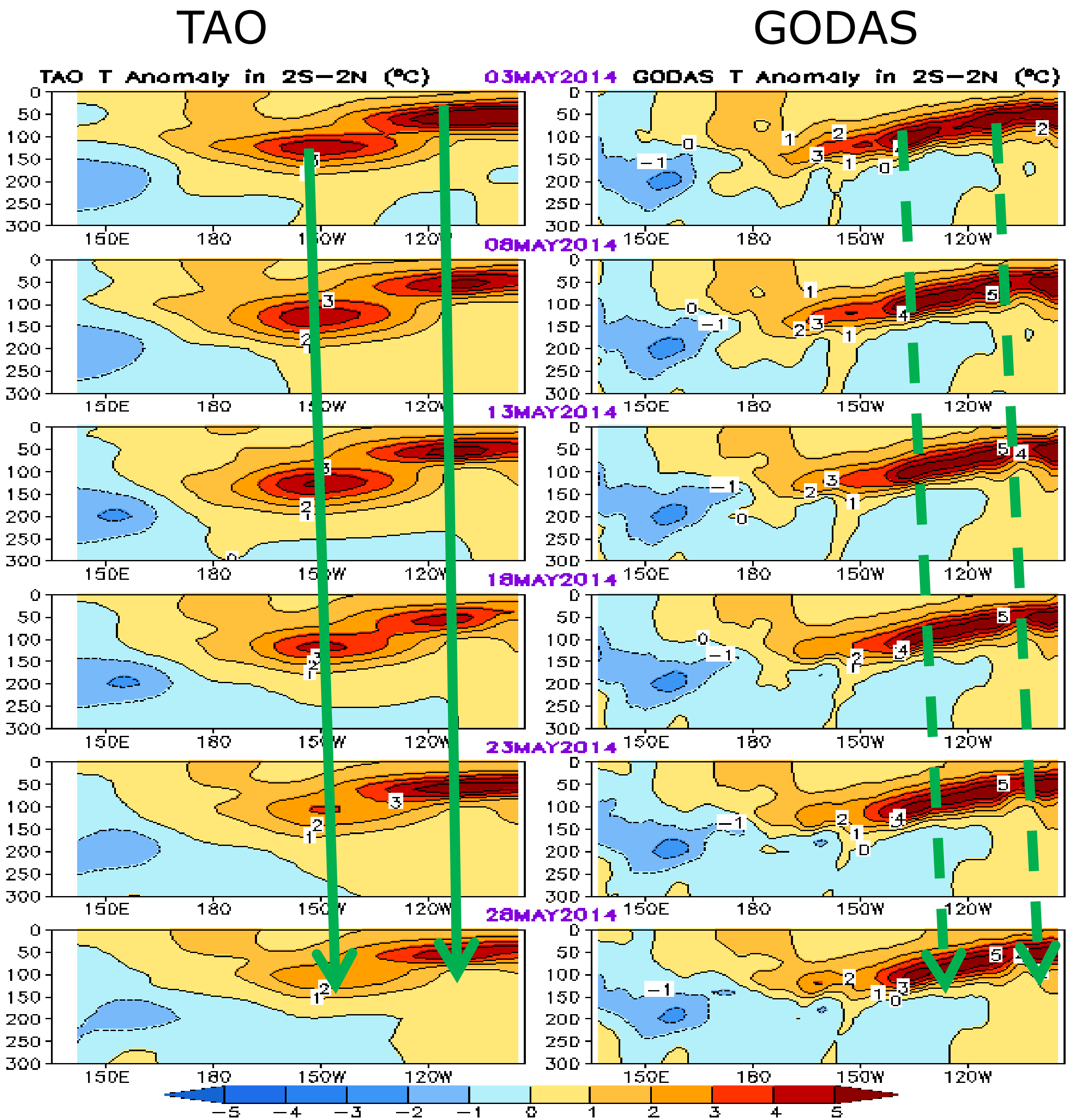
- Strong positive (weak negative) ocean temperature anomalies in the central and eastern (western) equatorial Pacific emerged.
- Ocean temperature anomalies were mainly positive in both Indian and Atlantic Oceans.



- Ocean temperature anomaly tendencies were mainly negative along the thermocline of the equatorial Pacific, suggesting a weakening tendency of subsurface ocean temperature positive anomalies.
- Some positive temperature anomaly tendencies were observed in both Indian and Atlantic 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.

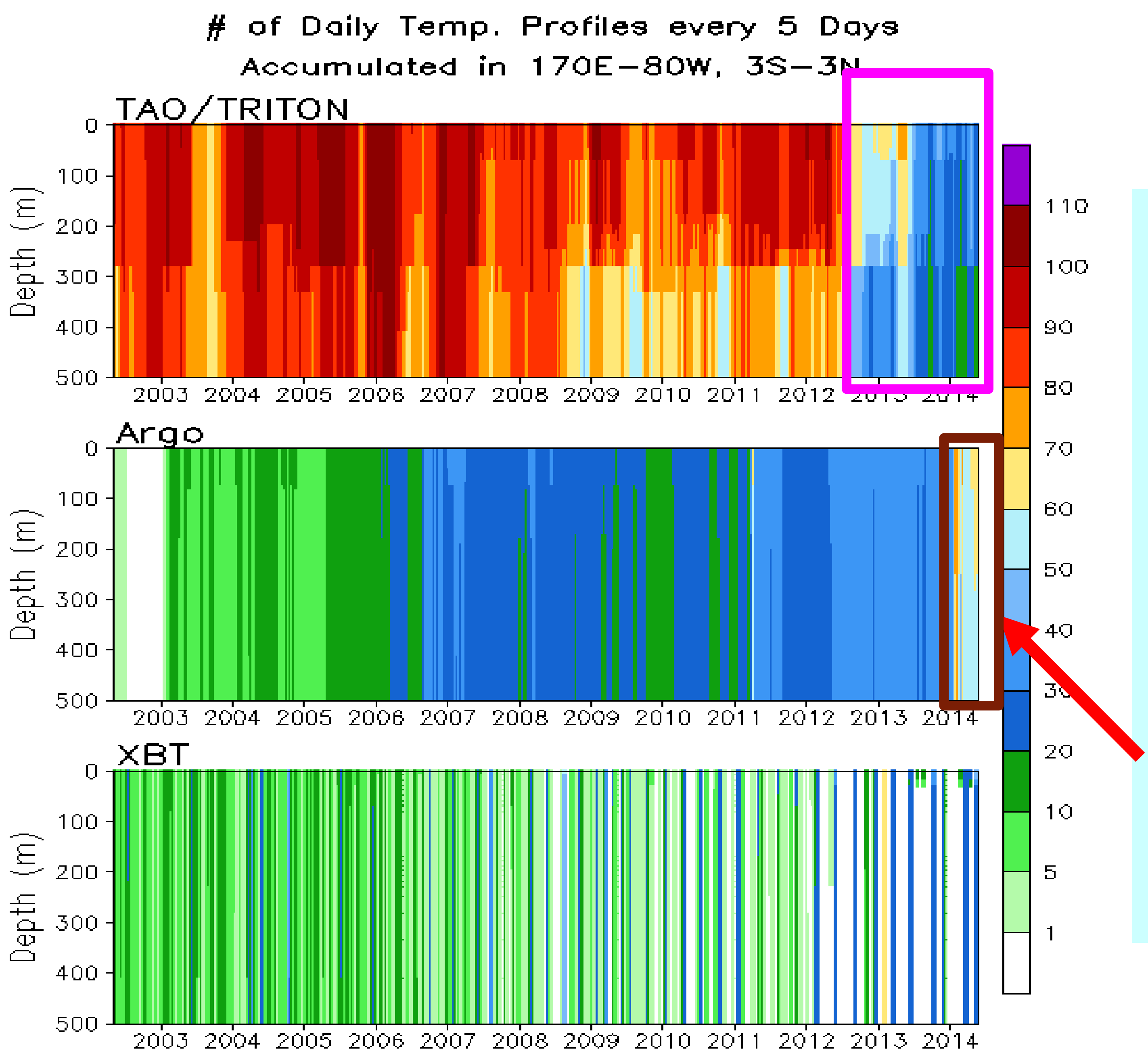
Tropical Pacific Ocean and ENSO Conditions



Equatorial Pacific Ocean Temperature Pentad Mean Anomaly:

Positive ocean temperature anomalies presented in the central and eastern Pacific and moved eastward slowly.

Some disagreements between TAO and GODAS may be partially due to lack of TAO observations recently (see next slide).

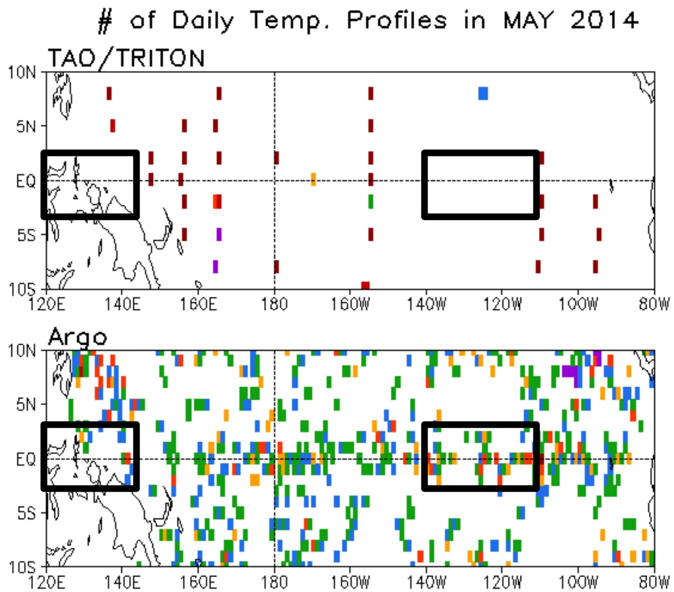


- **TAO data delivery rate decreased significantly since late 2012, and became worse since late 2013.**

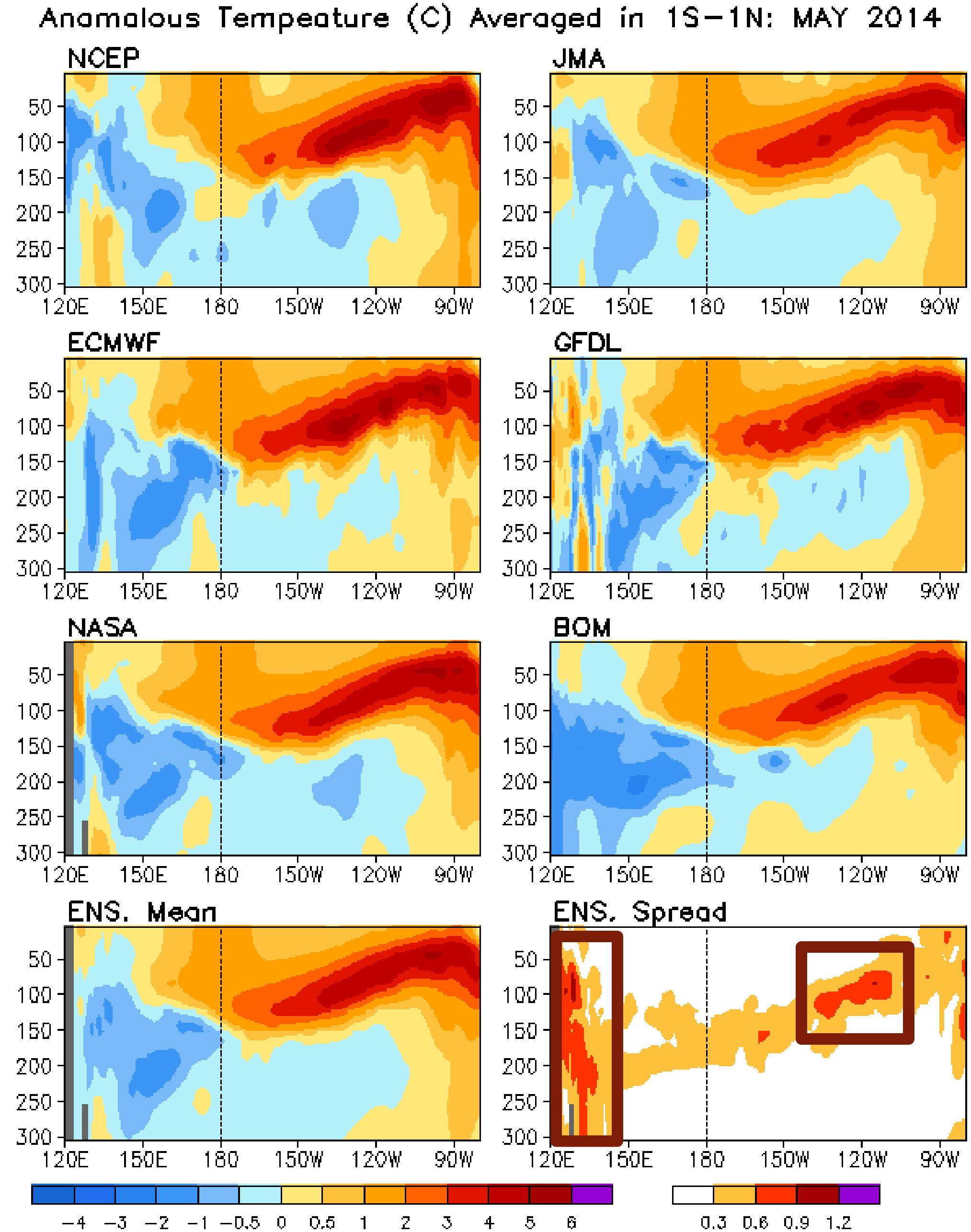
- **There was a sharp increase of Argo data since late Jan 2014.**

Real-Time Multiple Ocean Reanalysis Intercomparison

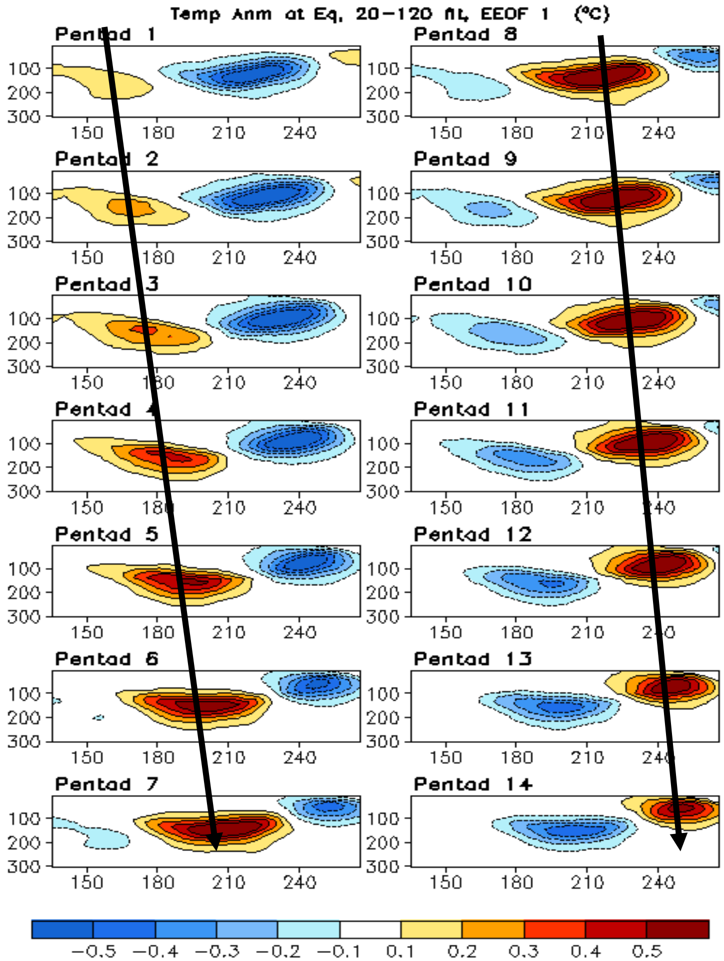
http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

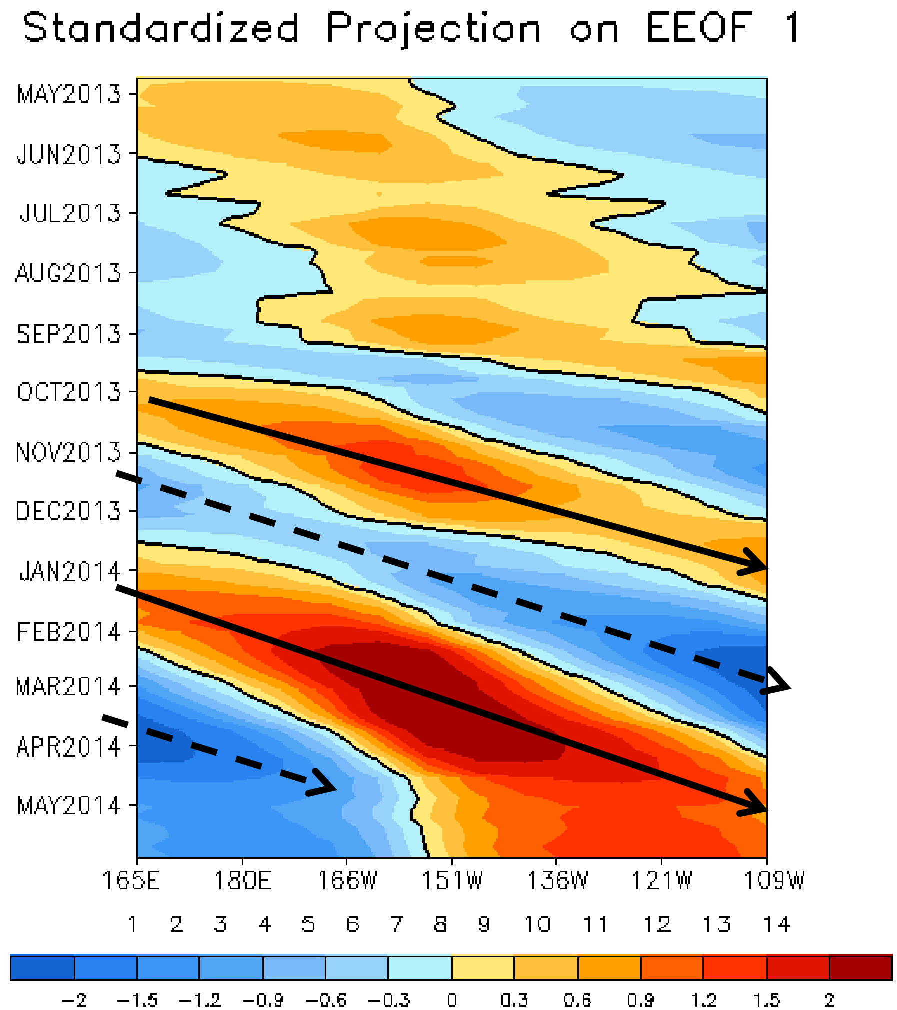


-The spread is large (>0.6C) between 140W-100W, and 120E-140E, where data distribution is poor.



Oceanic Kelvin Wave (OKW) Index



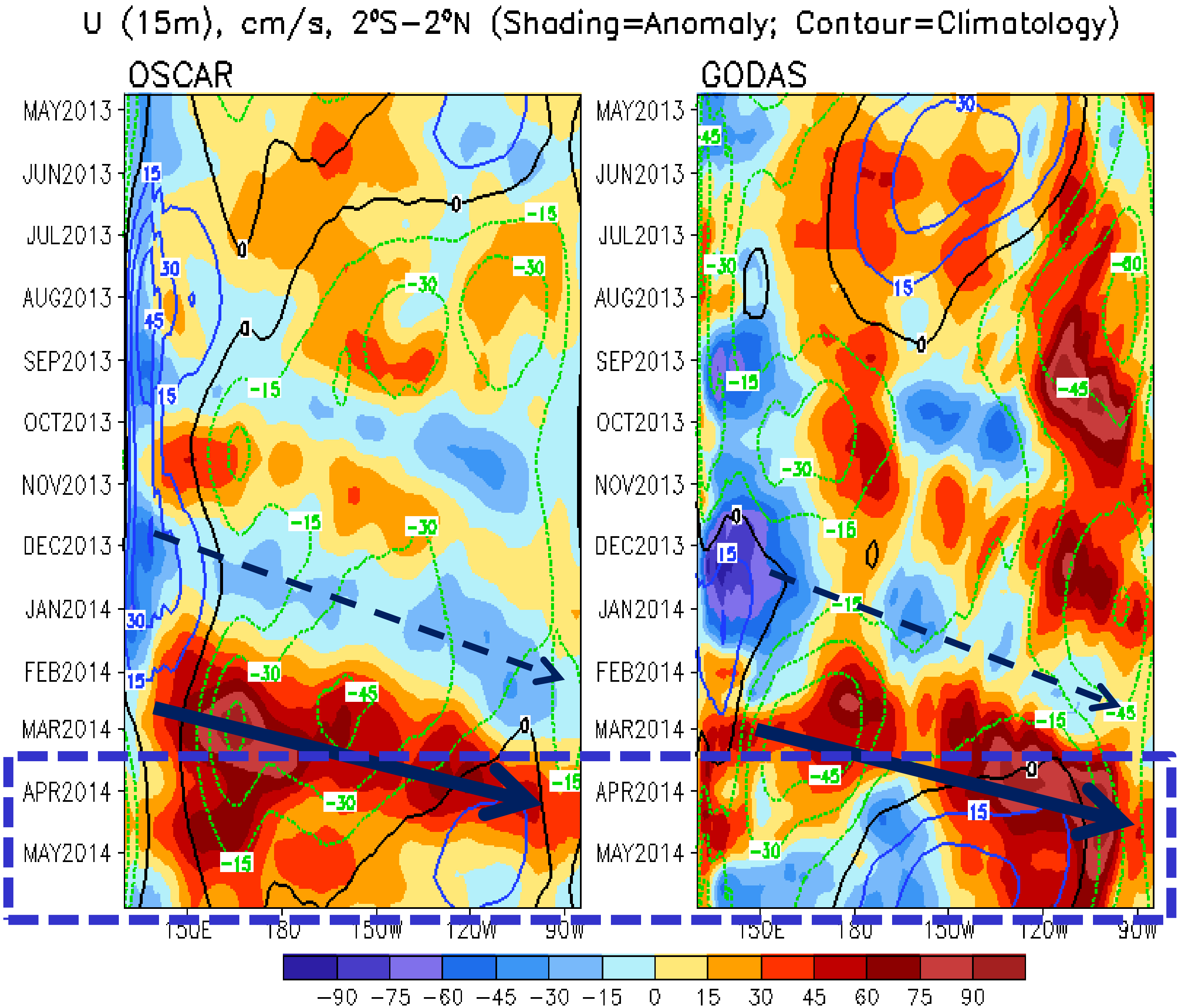


- **Downwelling OKW (solid line) emerged since Jan 2014 in the W. Pacific, while upwelling OKW initiated in mid-Feb in the W. Pacific. The upwelling may be associated with the weakening of subsurface ocean temperature positive anomalies in May 2014.**

- **OKW activities may be associated with the westerly wind burst events in Jan 2014.**

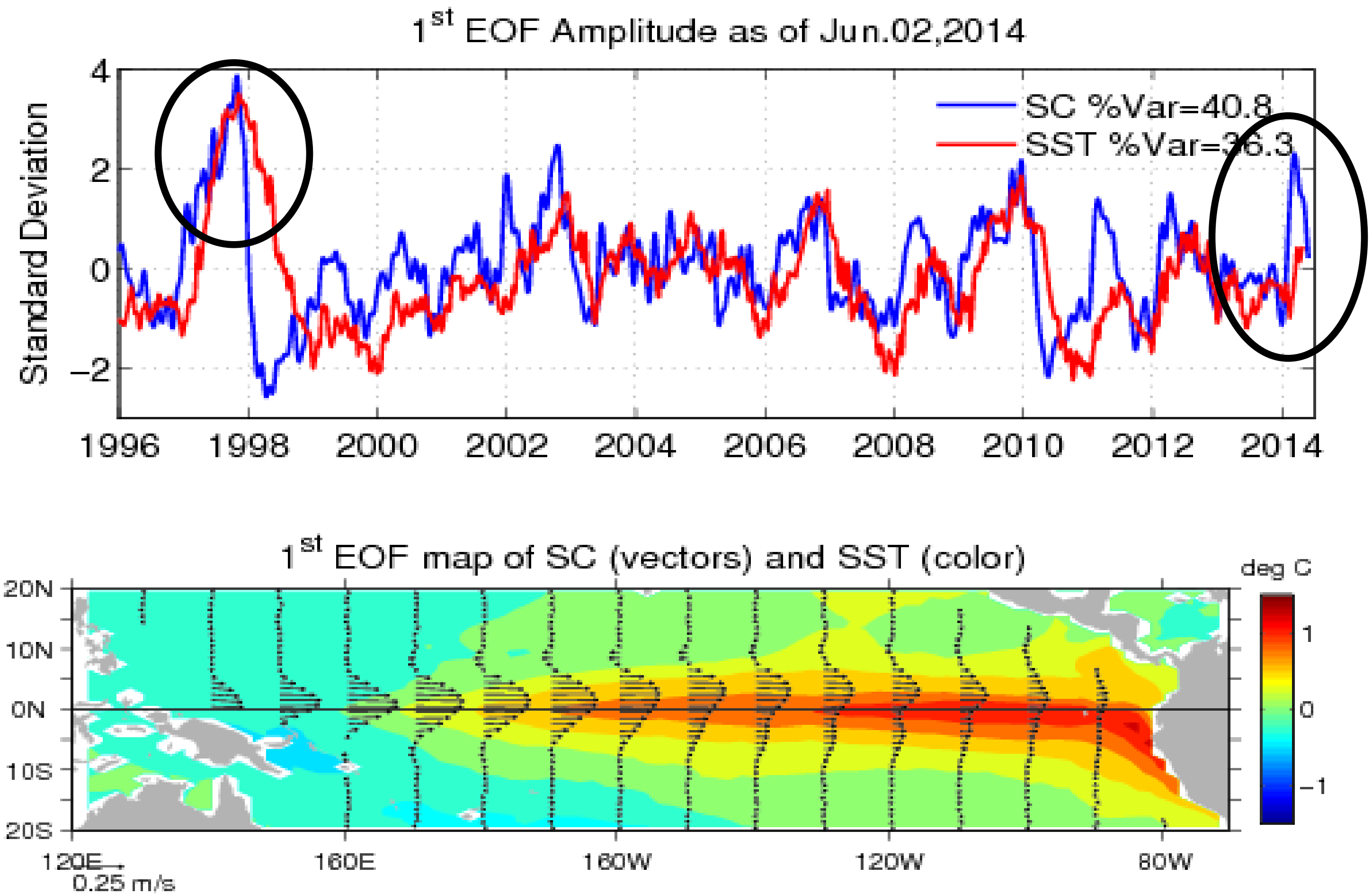
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- **Strong eastward current initiated in Feb 2014 and propagated eastward and reached the eastern boundary in the end of Mar 2014, and then weakened.**
- **That is consistent with the evolution of ocean temperature & D20 anomaly along the equatorial Pacific in the last a few months.**

ENSO cycle as indicated by 1st EOF of surface current and SST anomalies



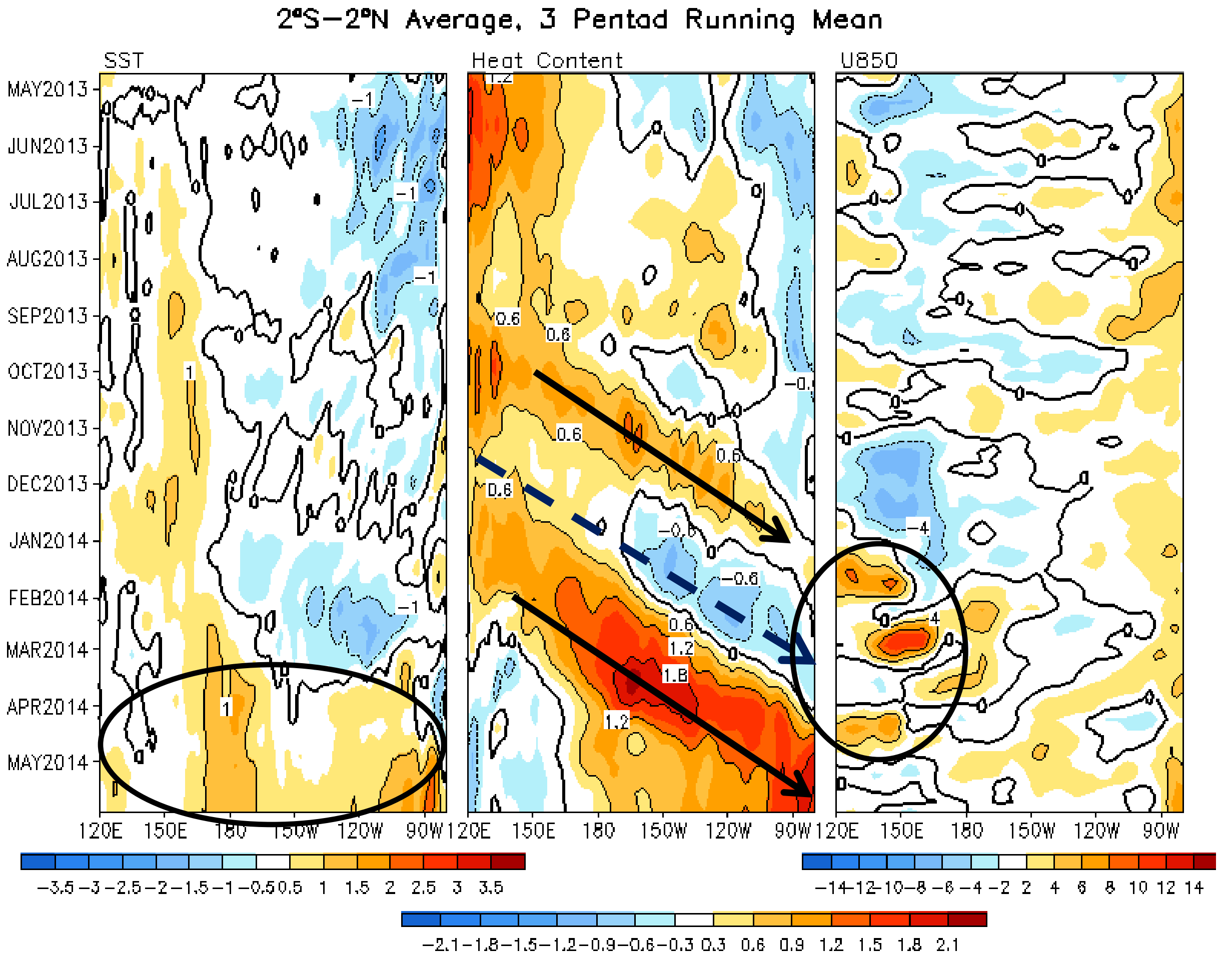
Earth & Space Research

- Eastward surface zonal current anomaly weakened significantly since Apr 2014.

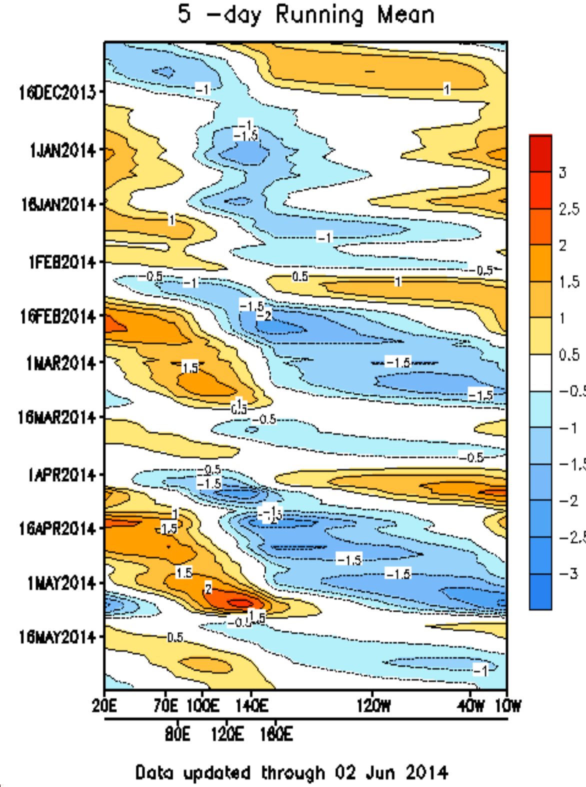
- Statistically, ocean surface zonal current anomaly leads the SSTA by a few months.

First EOF mode of ocean surface current (SC) and SST anomalies for the past decade extending through the latest 10-day period. The amplitude time series (top panel) are computed by fitting the data sets to 10-year base period eigenvectors (1993-2002). The amplitudes are then normalized by their respective standard deviations. The bottom panel shows the corresponding EOF maps, scaled accordingly. The El Niño signal can be seen as periods of positive excursions (> 1 Std. Dev.) of the amplitude time series. T the near real-time SC are the output from a diagnostic model. (see "http://www.esr.org/enso_index.html" for details)

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



CPC MJO Indices

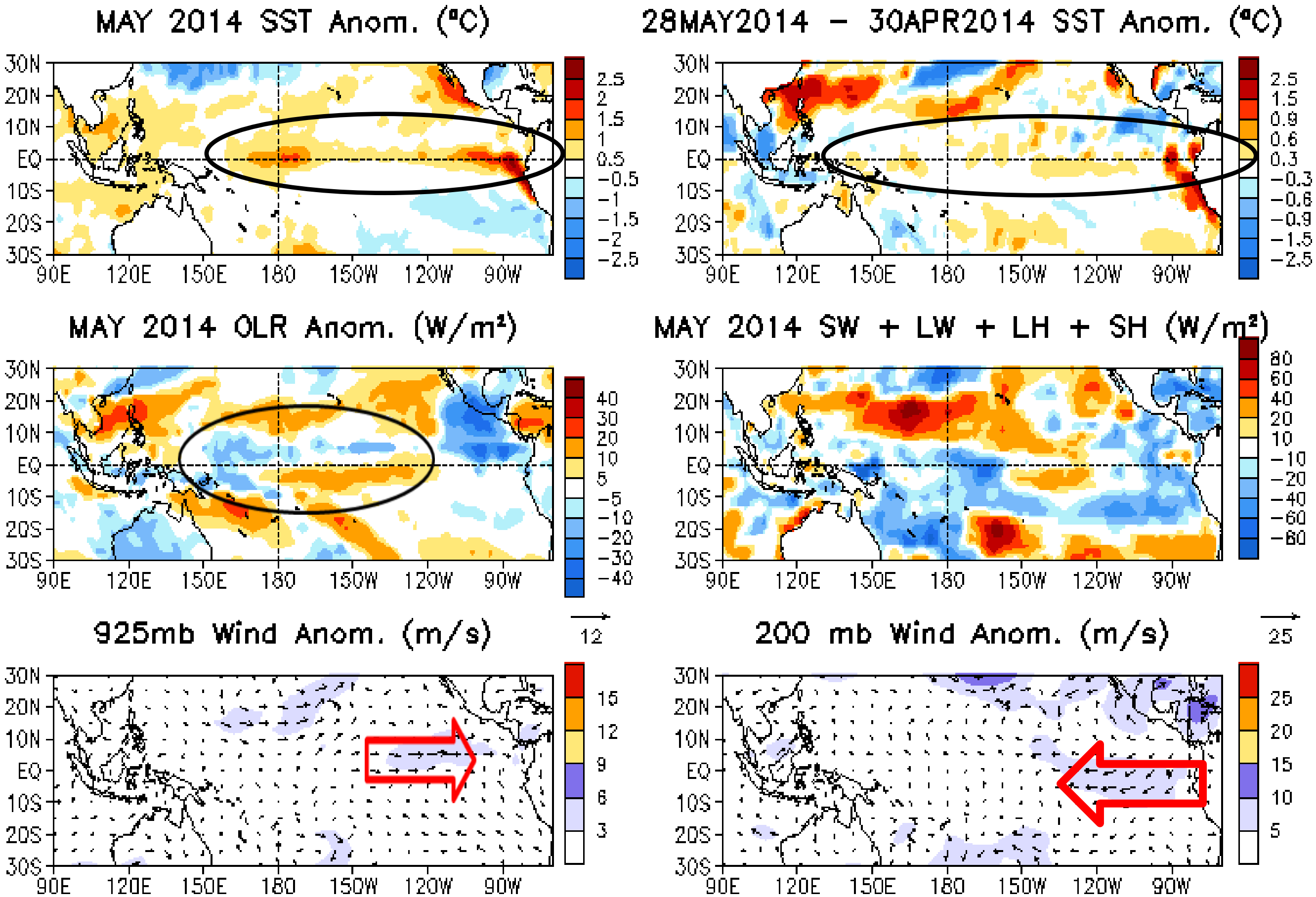


http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

- **Positive SSTA tendency along the equatorial Pacific was observed during the last 4 months.**
- **Positive HC300 anomalies initiated in Dec 2013, propagated eastward, and reached the coast in Apr 2014.**
- **3 westerly wind burst events emerged in Jan, Feb, and Apr 2014, respectively.**

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.

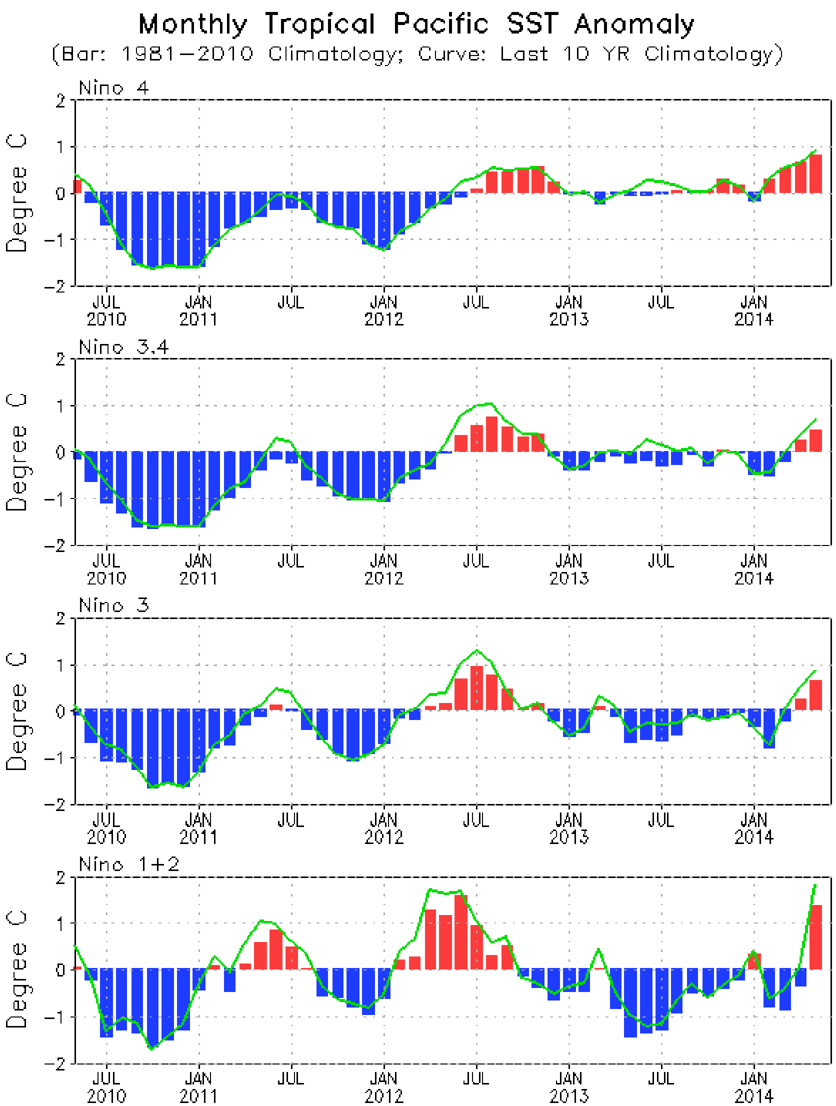
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

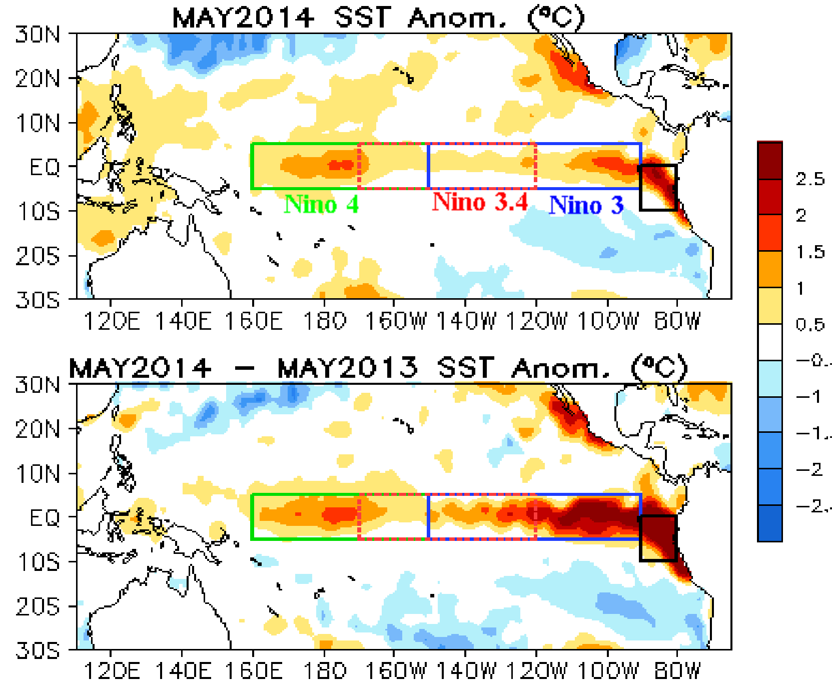


- **Positive SSTA and tendency along the equatorial Pacific were observed.**
- **OLR anomalies were small in May 2014.**
- **Small westerly (easterly) wind anomalies at 925 hPa (200 hPa) were seen in the eastern Pacific.**

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.

Evolution of Pacific NINO SST Indices





- **All NINO indices were positive and had a positive tendency in May 2014.**

- **Nino3.4 = 0.46°C in May 2014.**

- **Compared with last May, SST was much warmer in the equatorial Pacific in May 2014.**

- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

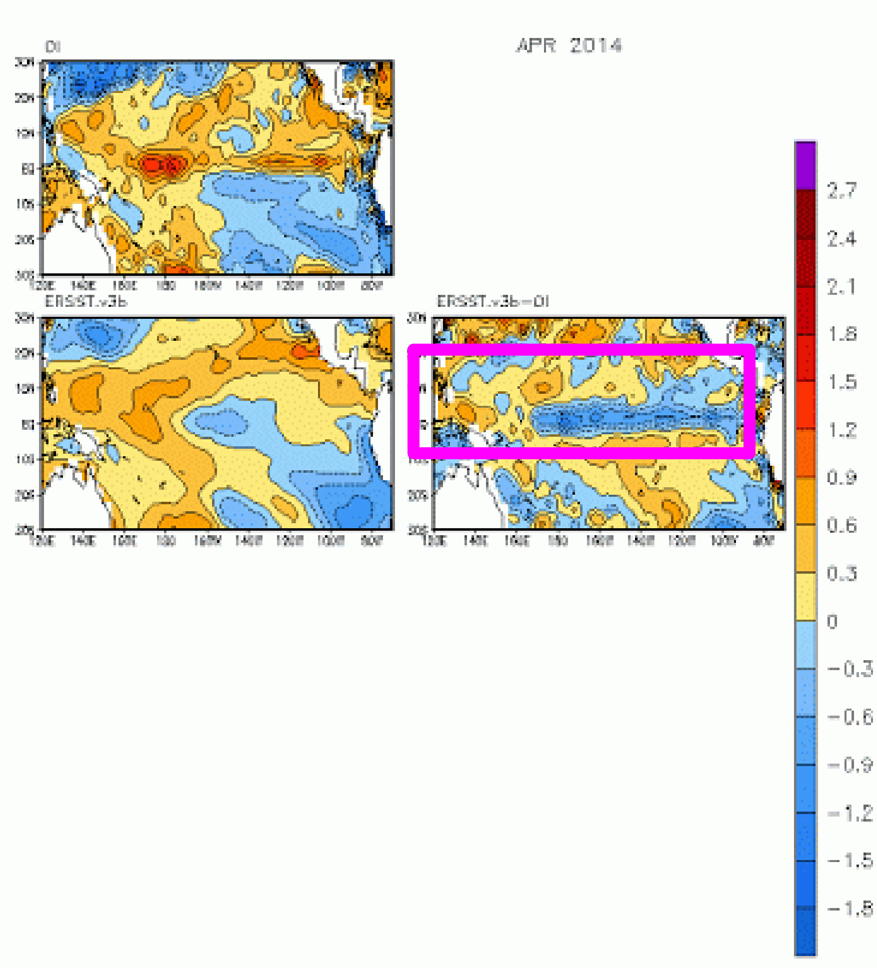
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

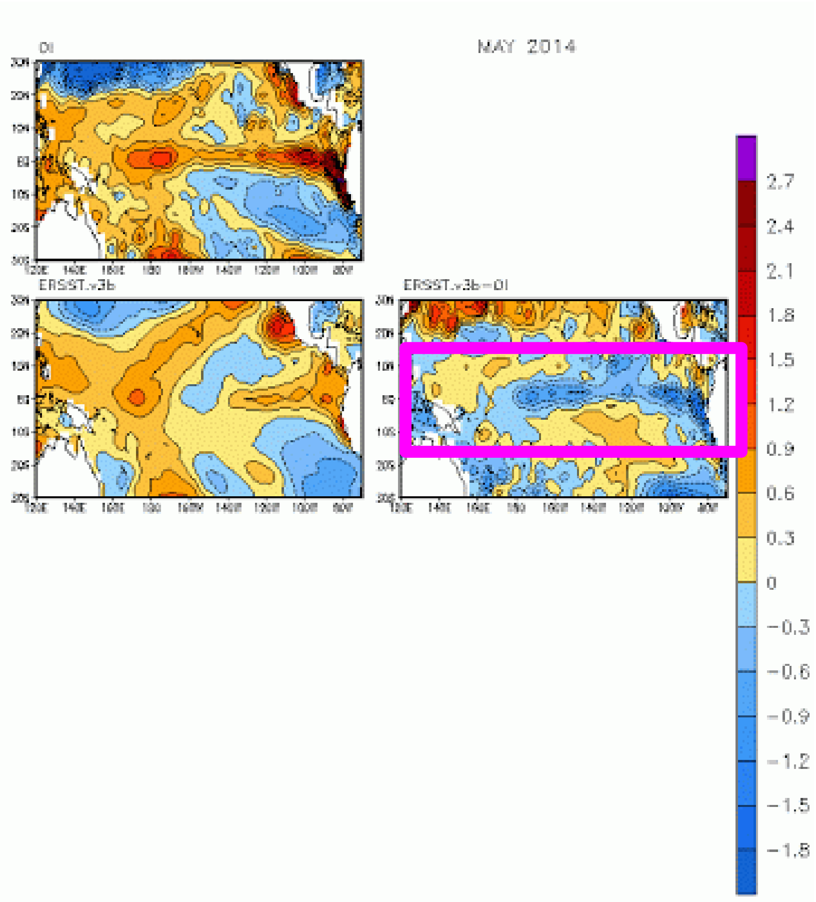
<u>SST Differences between OIv2 and ERSSTv3b</u> (From: Michelle L'Heureux)

(a) Nino3.4 in May 2014: 0.46 (OIv2), 0.14 (ERSSTv3b)

(b) in Apr and May 2014, OIv2 is warmer than ERSSTv3b in the equatorial Pacific.

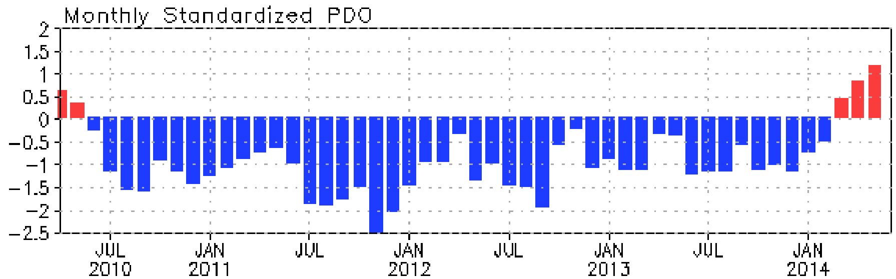
(Details see: Huang, et al., 2013: Why did large differences arise in the sea surface temperature datasets across the tropical Pacific during 2012? J. Atmos. Ocean. Tech., 30 (12), 2944-2953.)

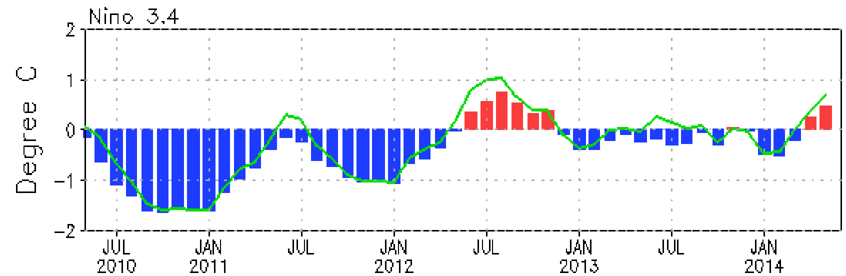


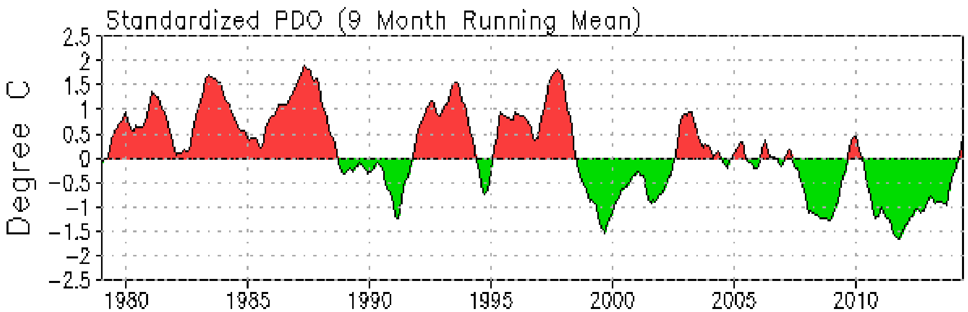


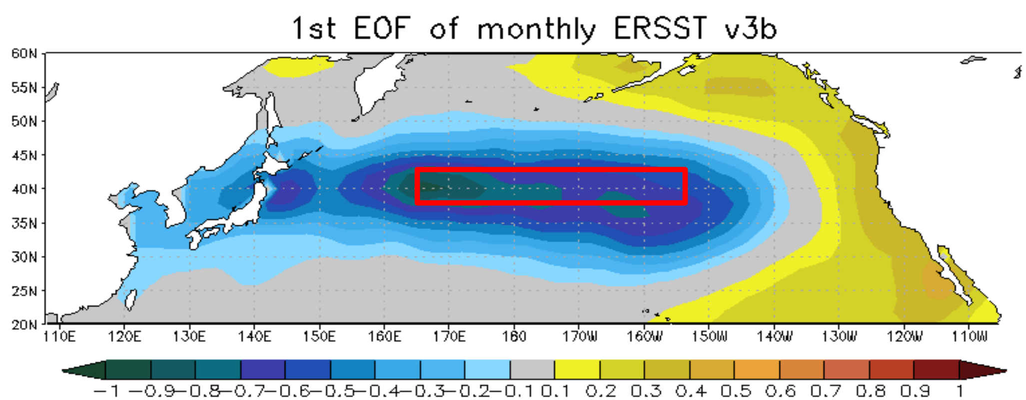
North Pacific & Arctic Oceans

PDO index









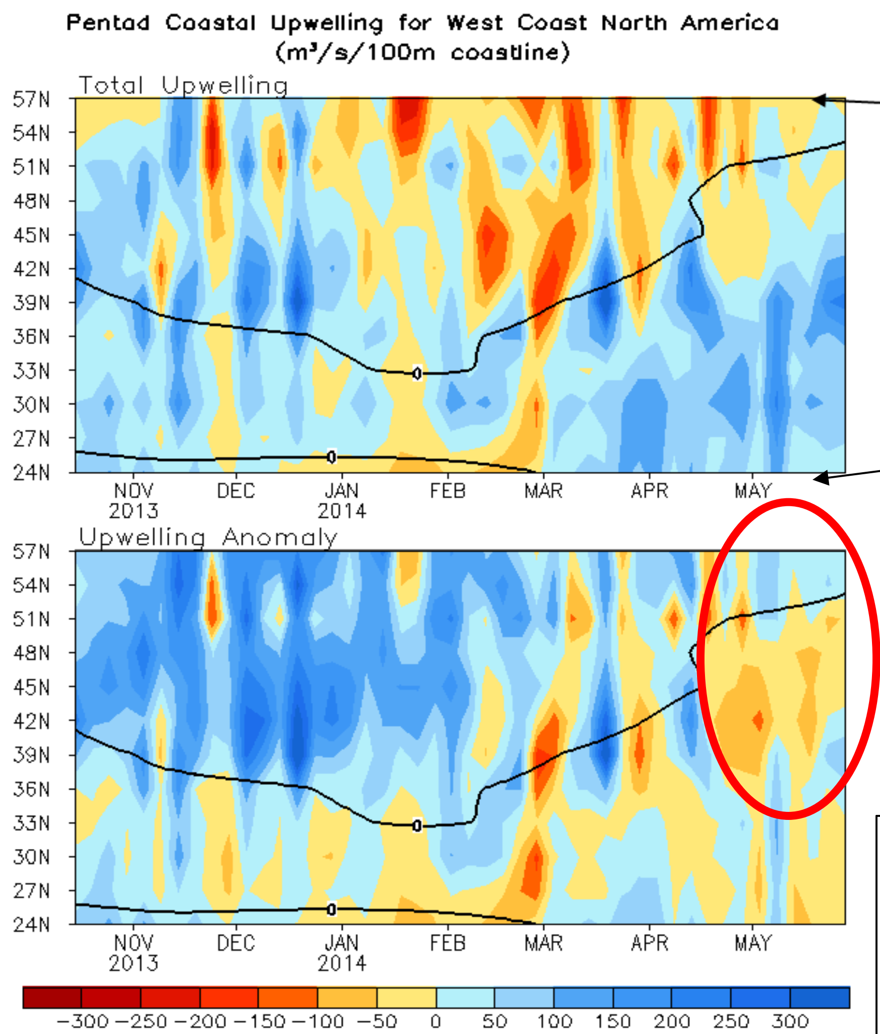
- **PDO switched to positive phase in Mar 2014 and then strengthened with PDO index =1.2 in May 2014.**

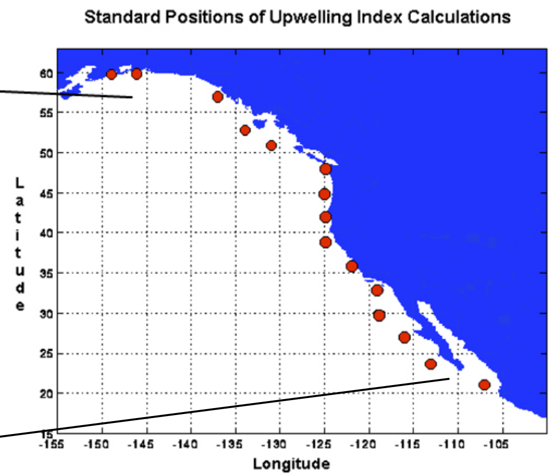
- **Statistically, ENSO and PDO are connected, may through atmospheric bridge.**

- 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.

North America Western Coastal Upwelling





- Upwelling in 36-51N weakened since second-half of Apr 2014.

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.

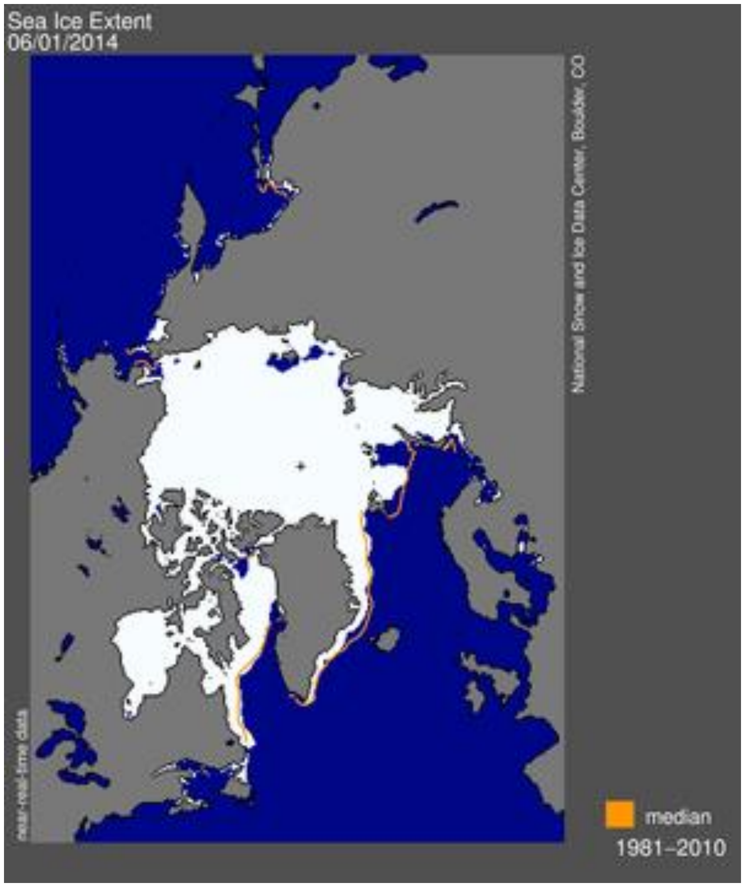
- Area below (above) black line indicates climatological upwelling (downwelling) season.

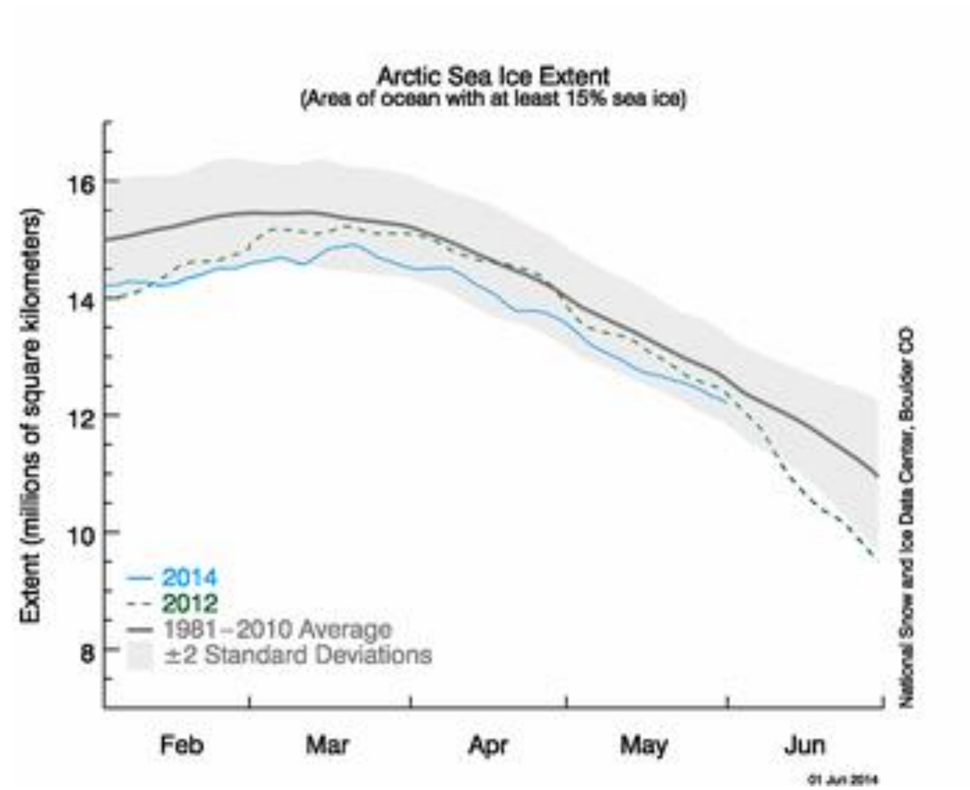
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

Arctic Sea Ice

National Snow and Ice Data Center

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

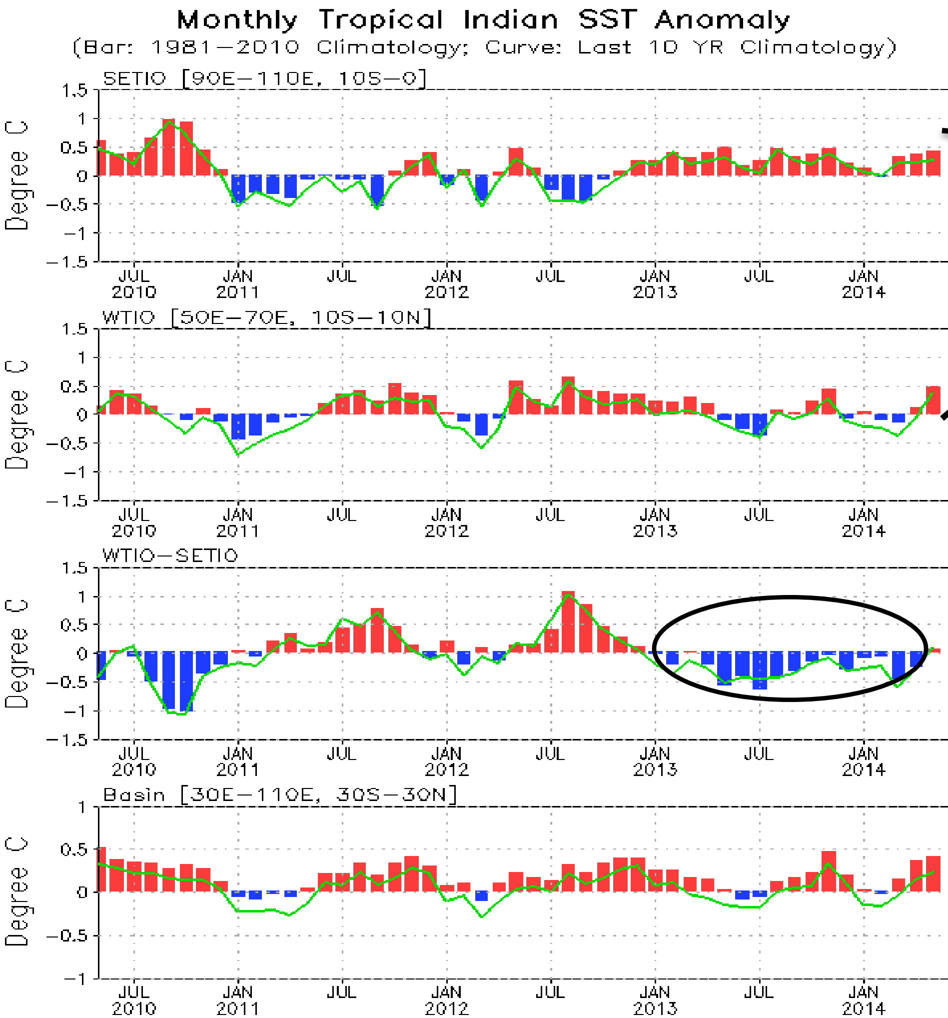


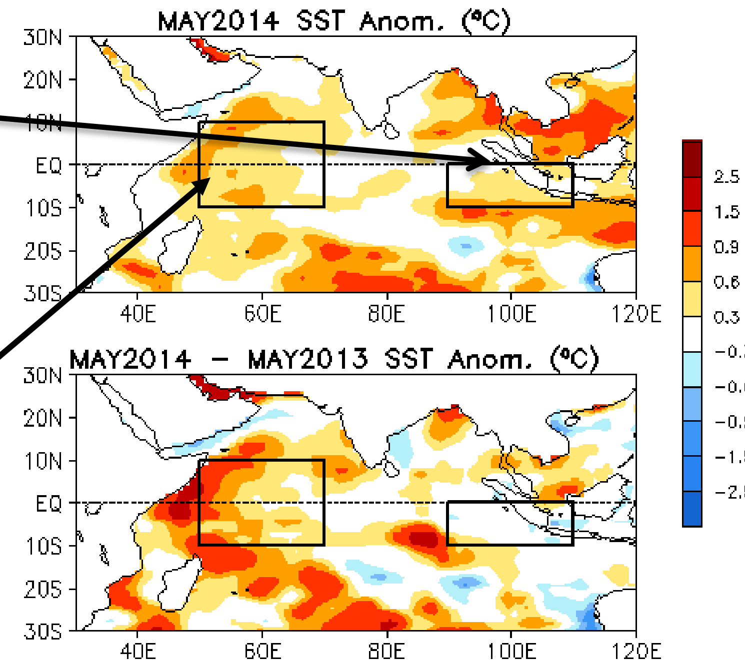


- **Arctic sea ice extent was below normal and within -2 standard deviation in May 2014.**

Indian Ocean

Evolution of Indian Ocean SST Indices





- **Positive SSTA presented in the whole Indian Ocean.**
- **Compared with May 2013, 2014 is warmer.**
- **DMI became near normal in May 2014.**

Fig. I1a. 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 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.

- Positive SSTA were in the whole Indian Ocean.
- Warming (cooling) tendency was observed in the Arabian Sea (Bay of Bengal and South China Sea) in May 2014.

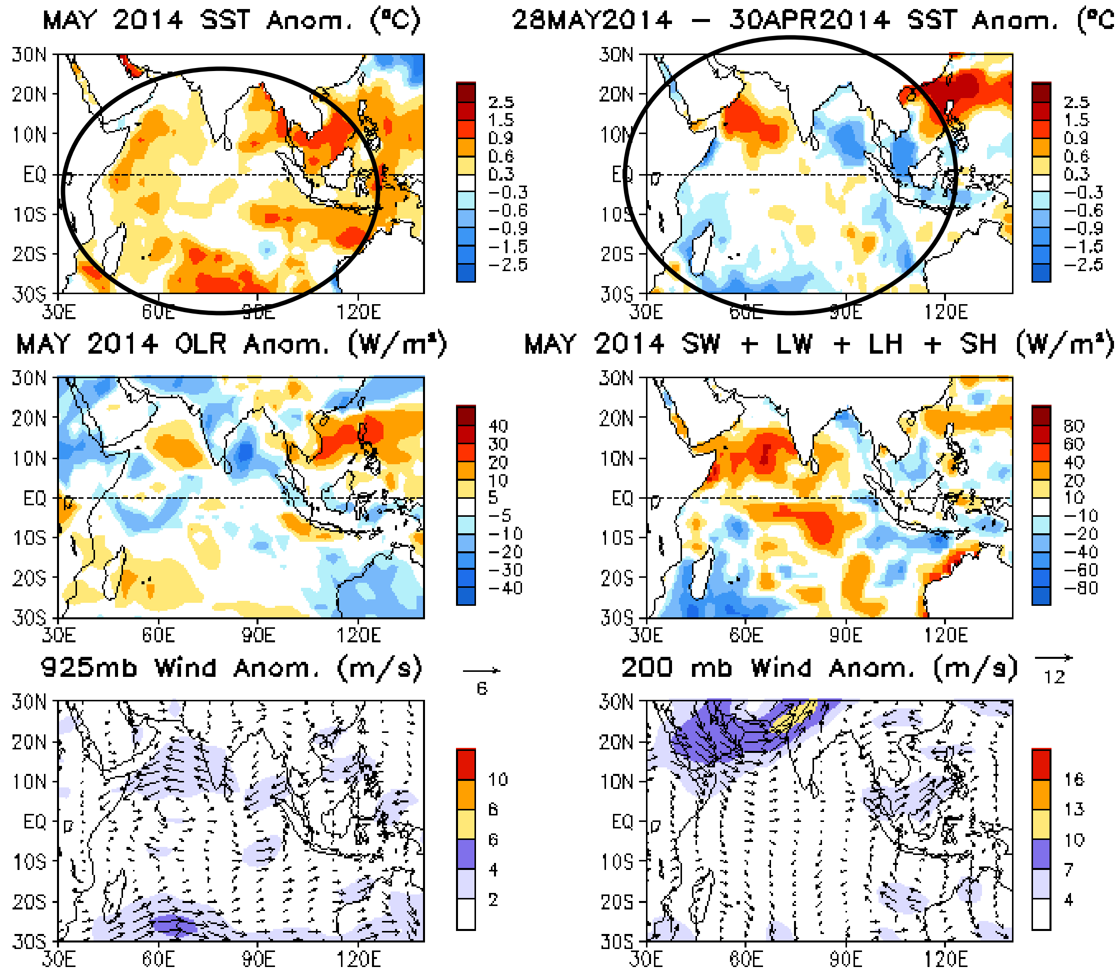
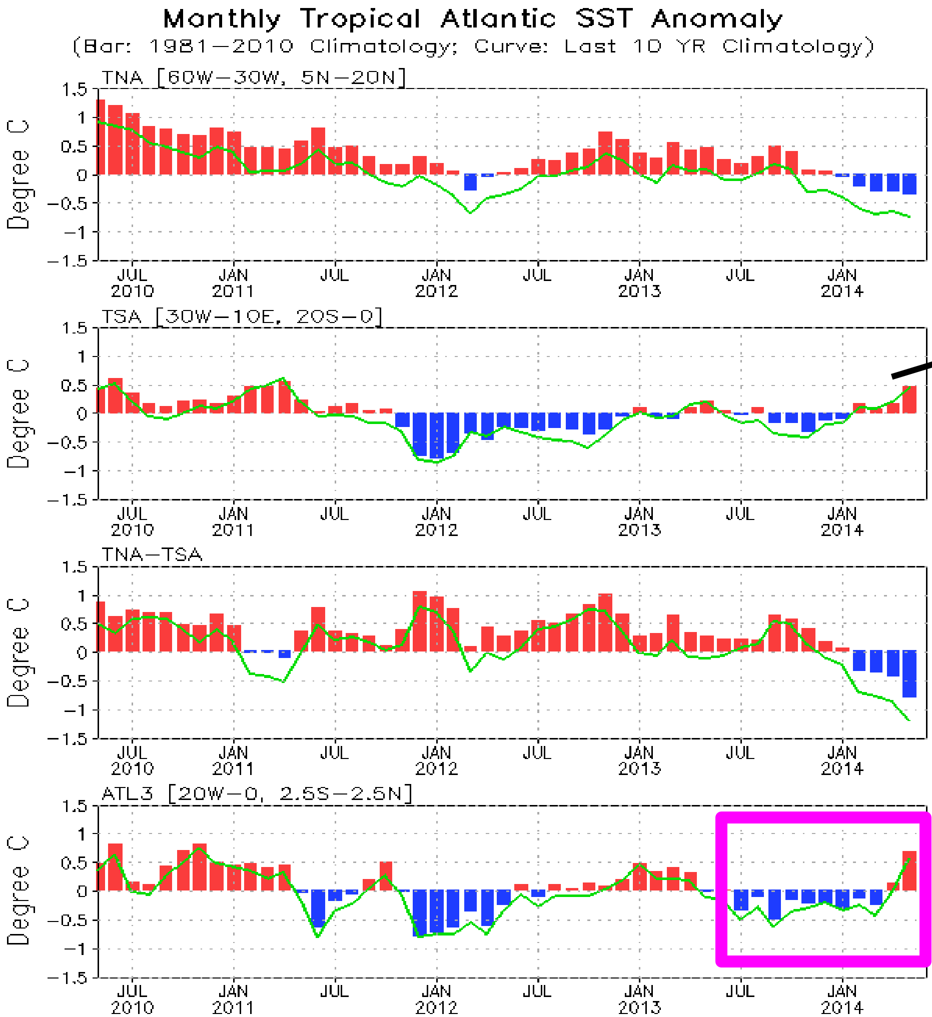
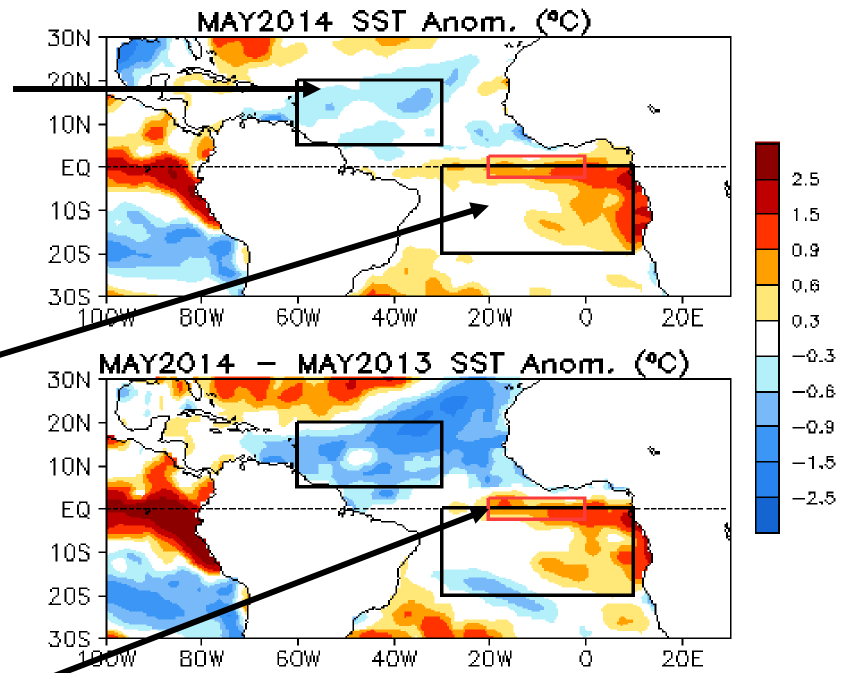


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

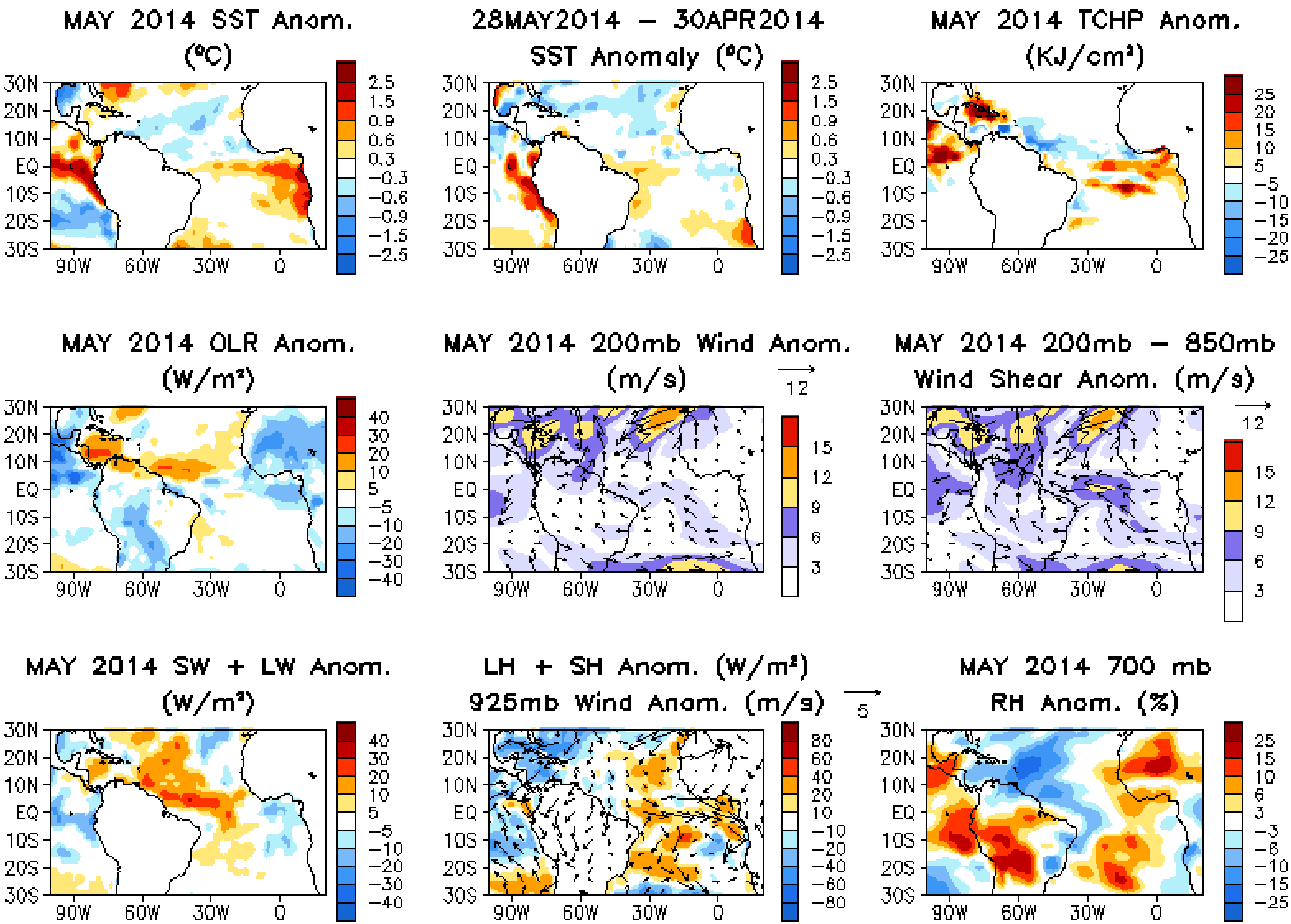




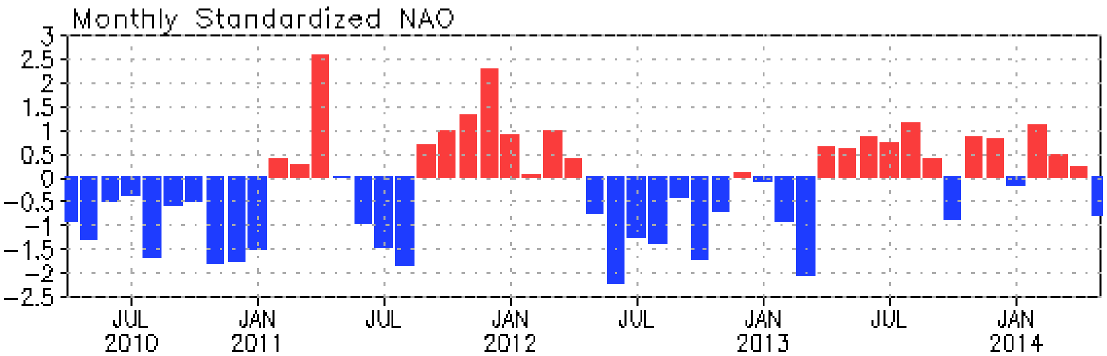
- **Tropical North Atlantic (TNA) index was negative since Jan 2014 and then strengthened.**
- **Tropical South Atlantic (TSA) index was positive since Feb 2014 and intensified in May 2014.**
- **Meridional Gradient Mode (TNA-TSA) has been switched to negative phase in Feb 2014 and then strengthened.**
- **ATL3 SSTA became strong positive in May 2014.**
- **Tropical North Atlantic in May was cooler in 2014 than in 2013.**

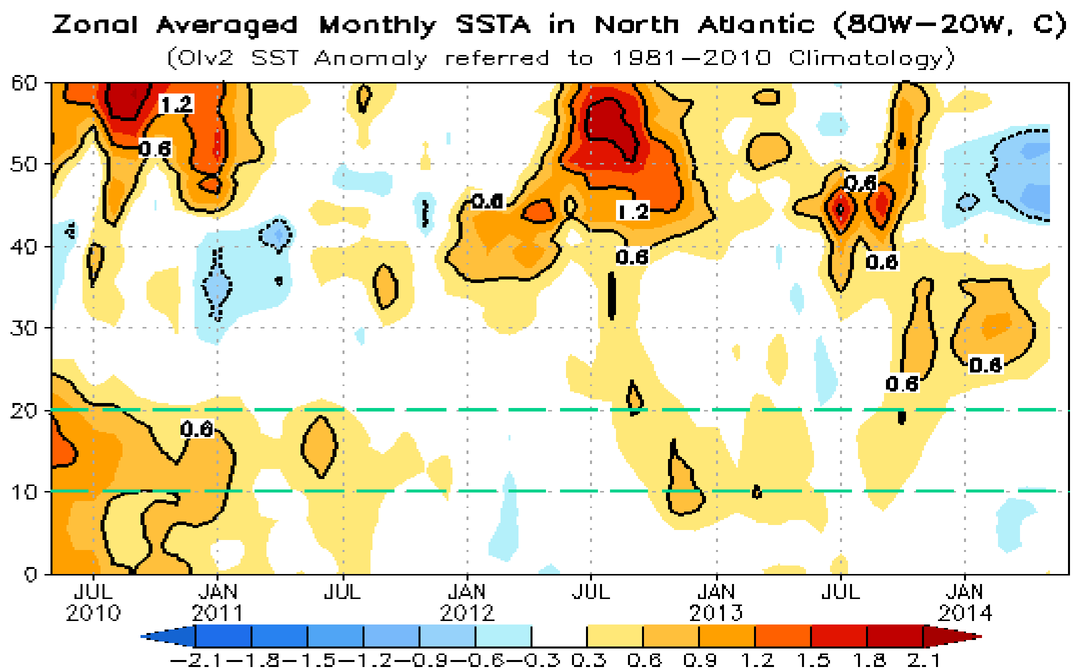
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

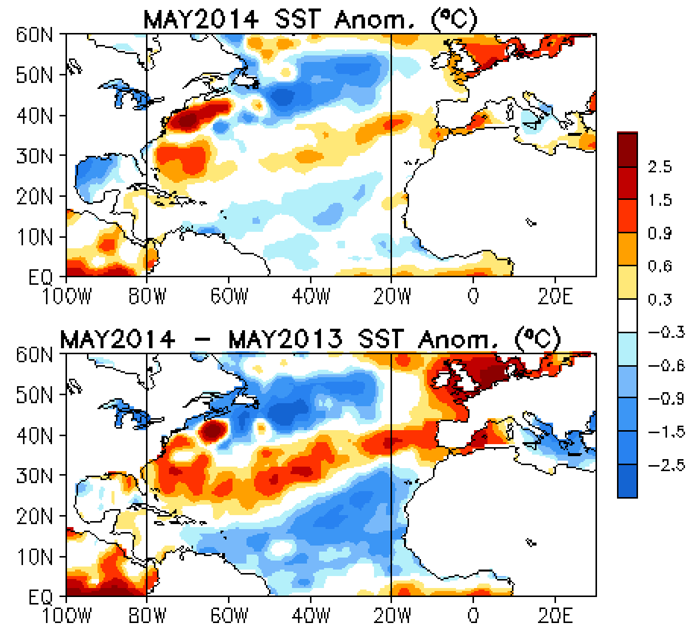
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic







- NAO switched to negative phase with NAOI=-0.8 in May 2014.
- North Atlantic tripole-like SSTAs were observed, may partially due to the forcing of positive phase of NAO in last a few months.

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

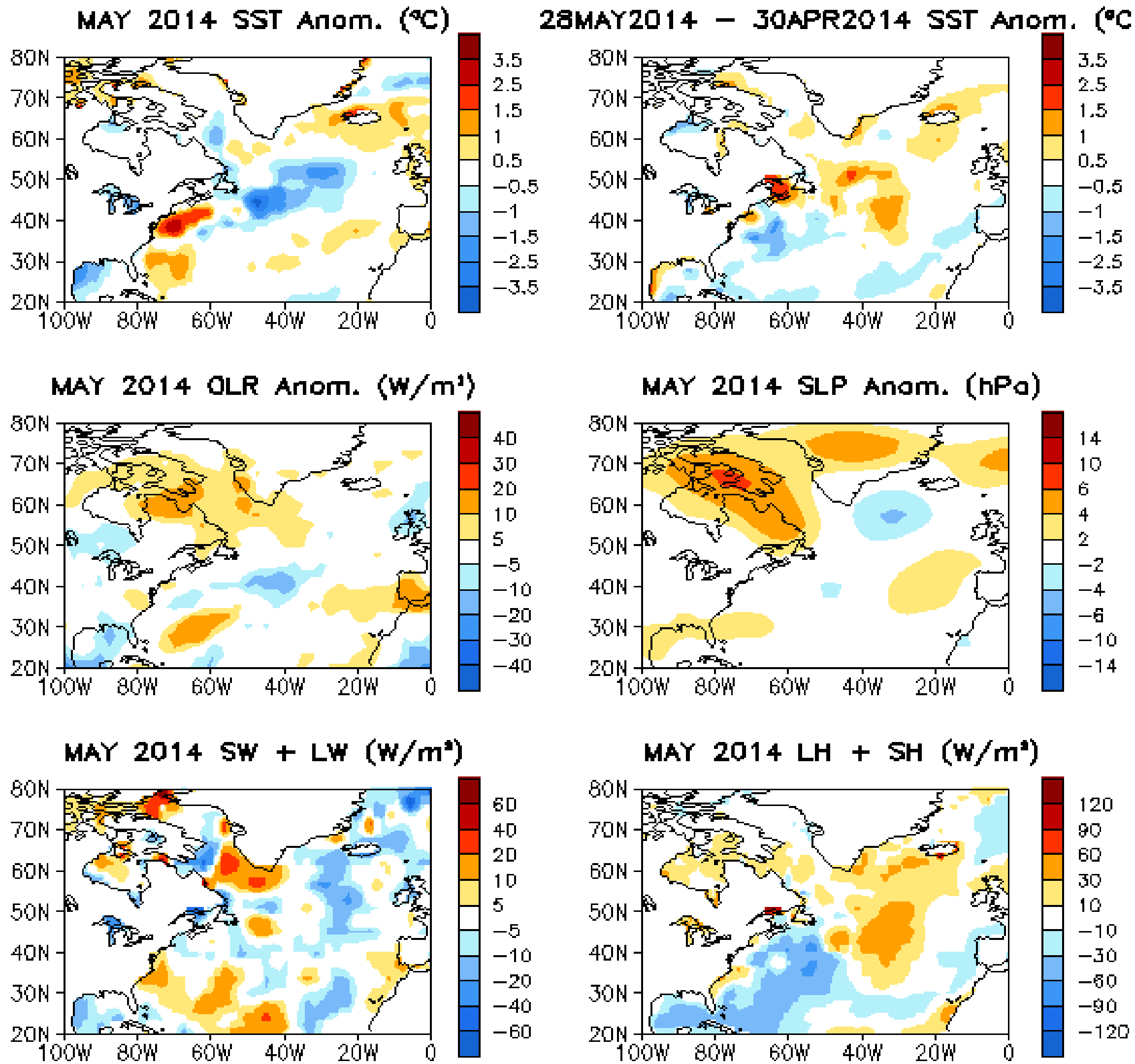
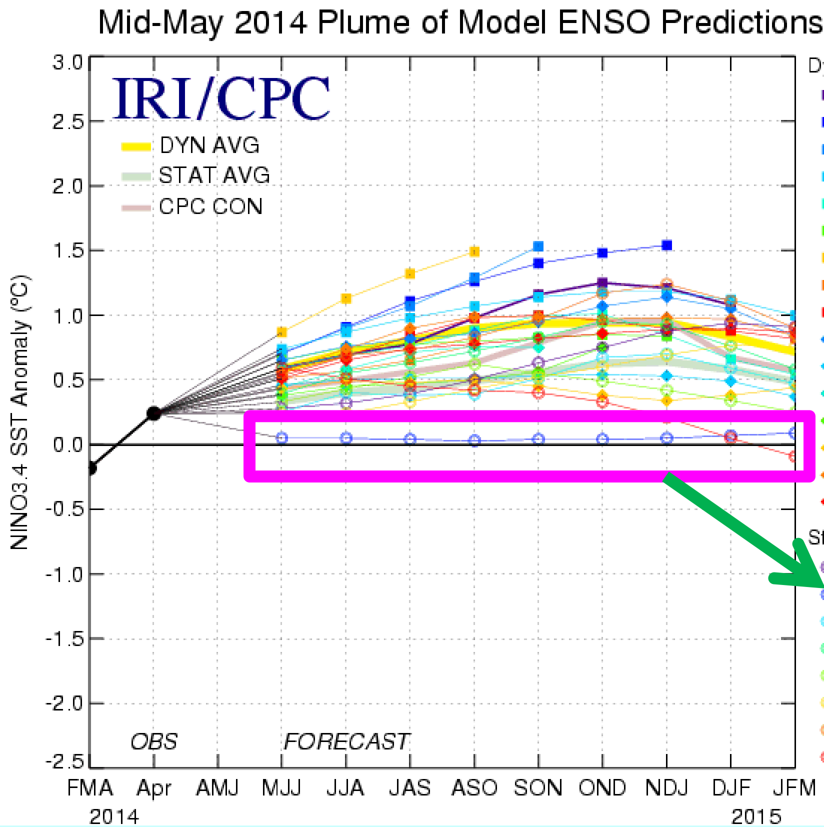
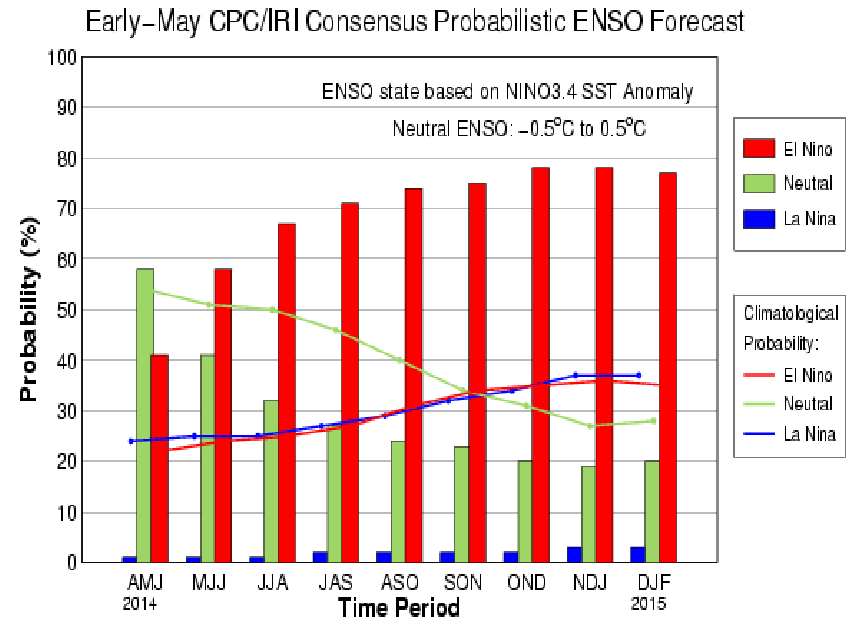


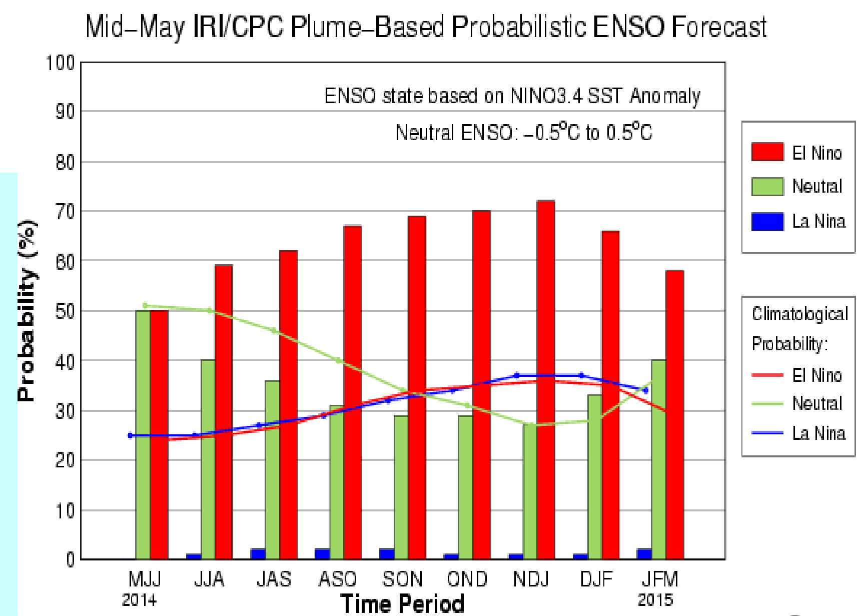
Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1981-2010 base period means.

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum





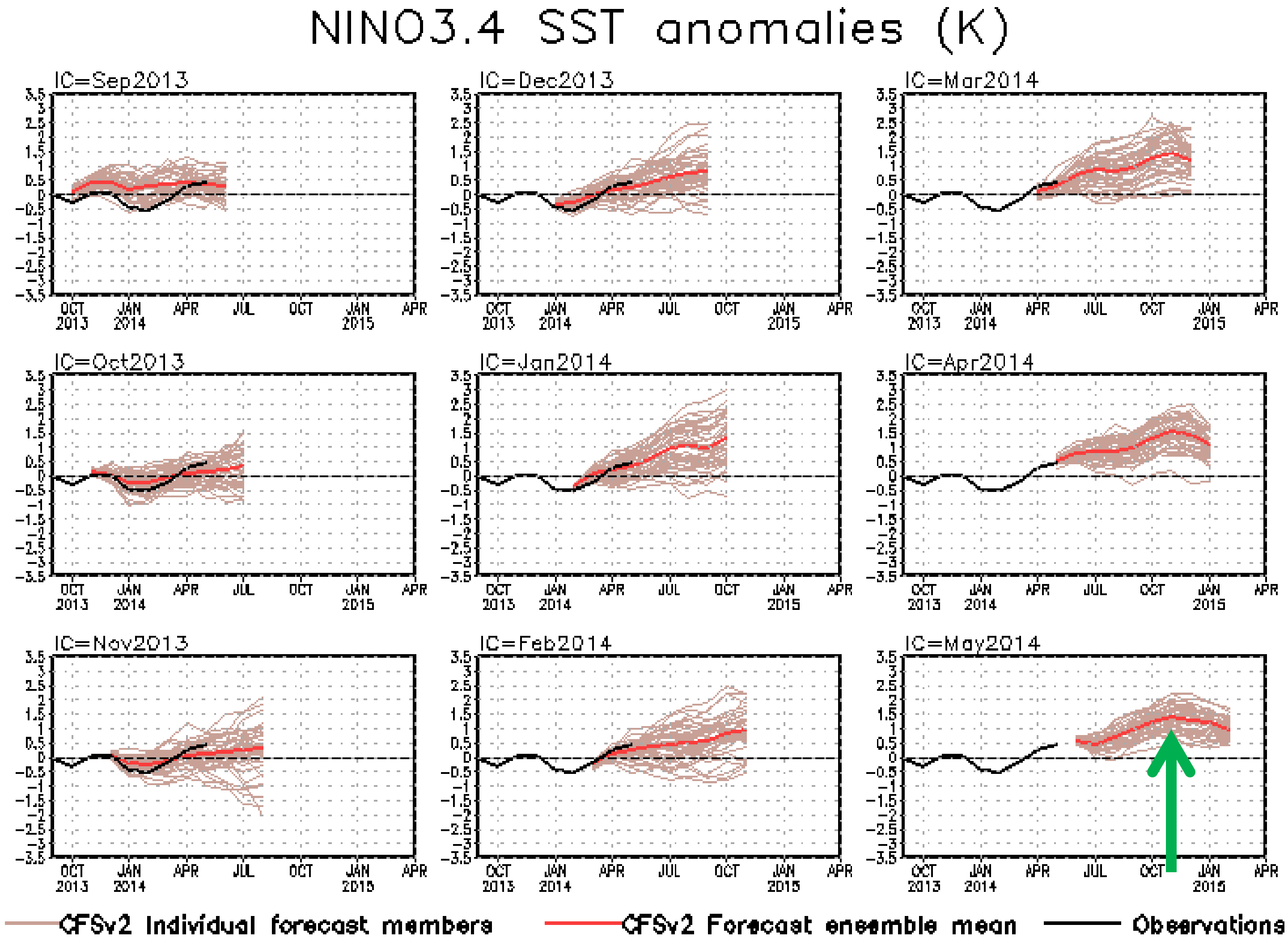


- Almost all models predicted a warming tendency and a majority of them predicted an El Nino in second half of 2014. Consensus probabilistic forecasts favor a warm phase of ENSO since JJA 2014.

- **NOAA "ENSO Diagnostic Discussion" on 5 June 2014 continually issued "El Nino Watch" and suggests that** "Chances of El Niño are 70% during the Northern Hemisphere summer and reach 80% during the fall and winter."

"If El Niño forms, the forecasters and most dynamical models, such as NCEP CFSv2, slightly favor a moderate-strength event during the Northern Hemisphere fall or winter (3-month values of the Niño-3.4 index between 1.0°C and 1.4°C)."

CFS Niño3.4 SST Predictions from Different Initial Months

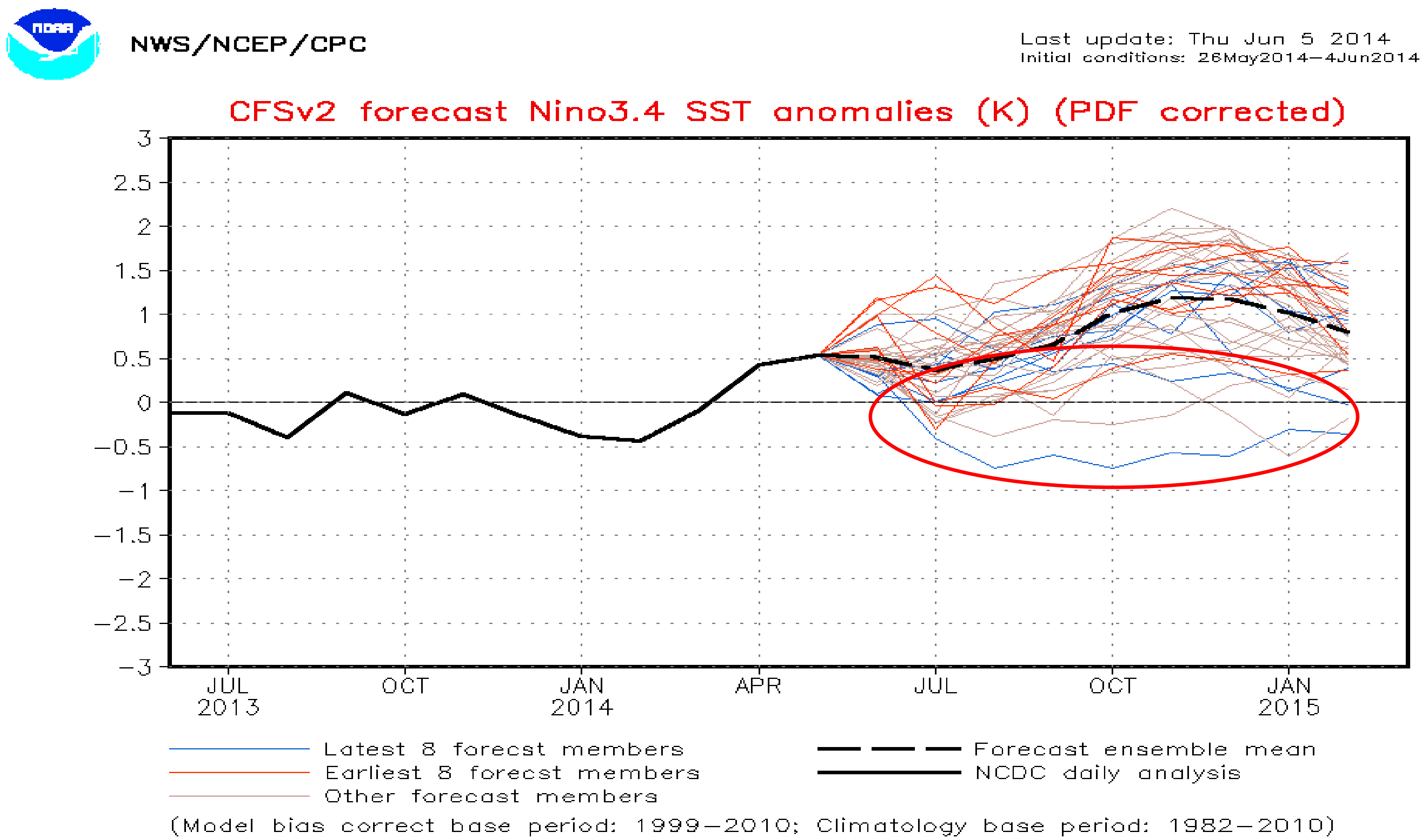


- CFSv2 predicts a warming tendency, and suggests development of an El Nino in second half of 2014.
- Latest forecasts with IC in May 2014 suggest a moderate-strength El Nino peaking in late autumn or early winter (Oct-Nov).

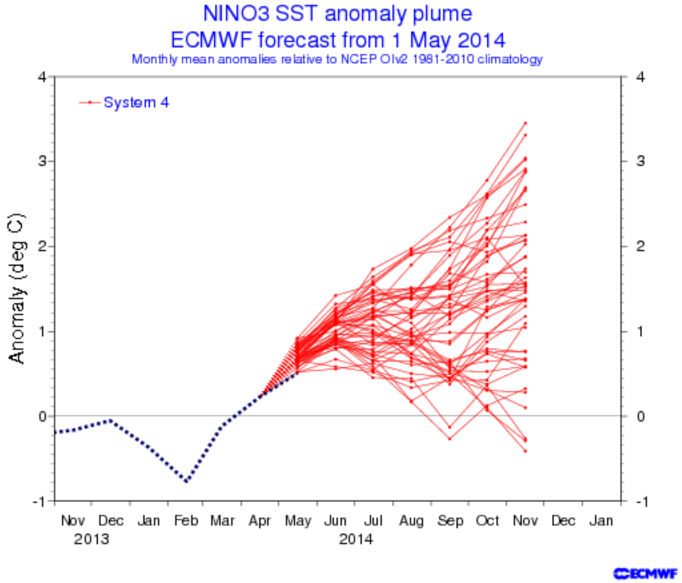
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

Latest forecasts of CFSv2 (updated 03June2014)

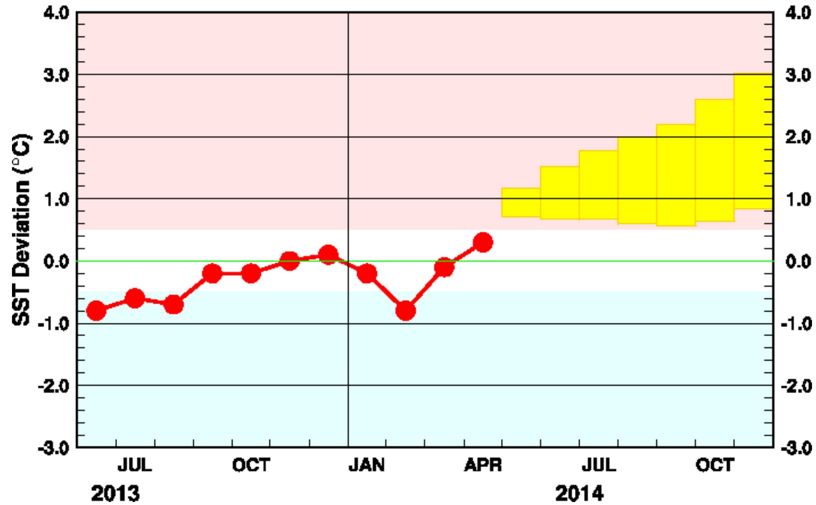
Some ensemble members predict neutral condition!



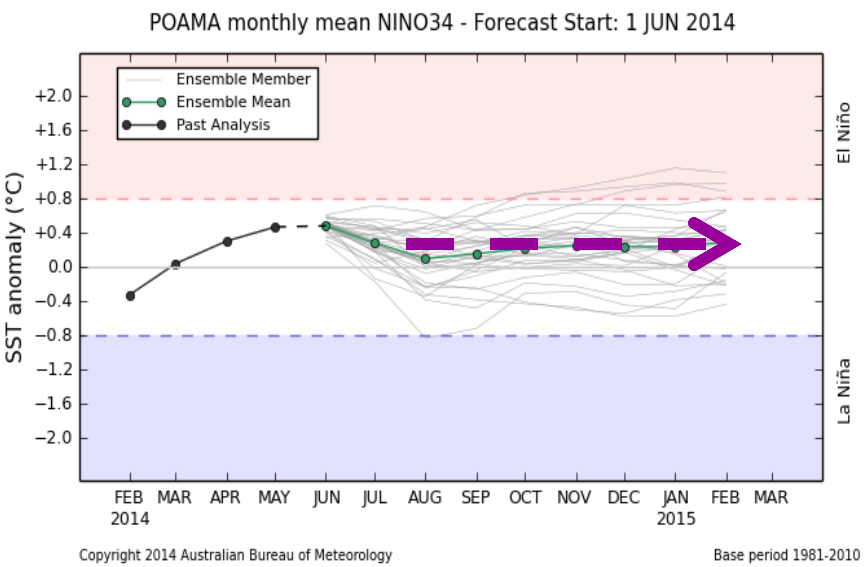
Individual Model Forecasts: Predict an El Nino/neutral in 2014



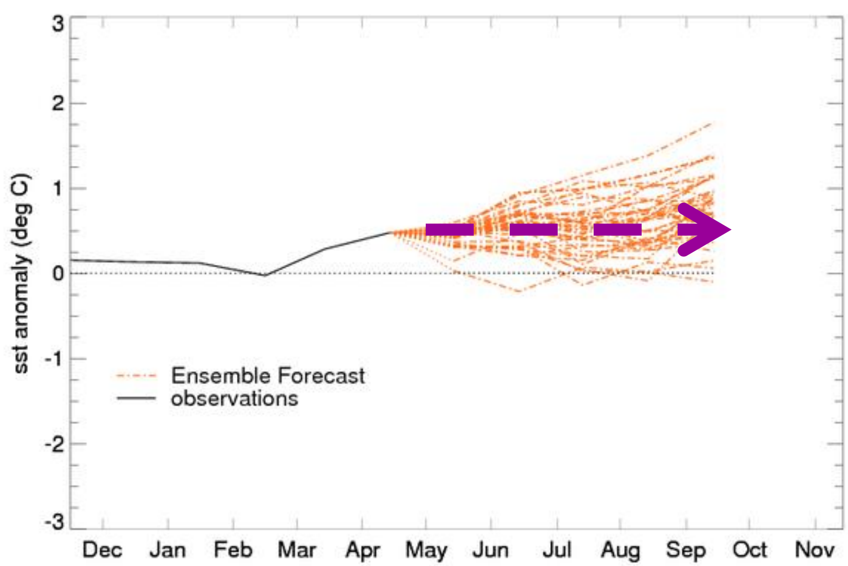
JMA: Nino3, IC=May2014



Australia: Nino3.4, IC= 1June2014



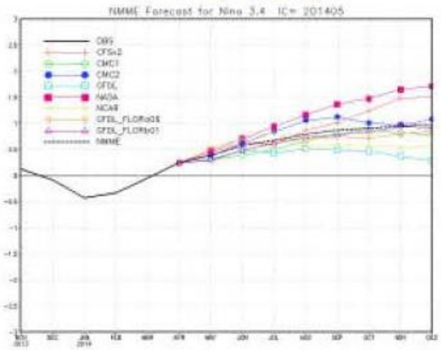
UKMO: Nino3.4, IC=May2014



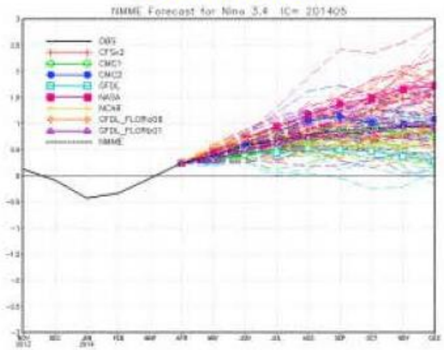
NMME: **Prediction with IC May 2014**

All predict El Nino, except that GFDL predicts neutral

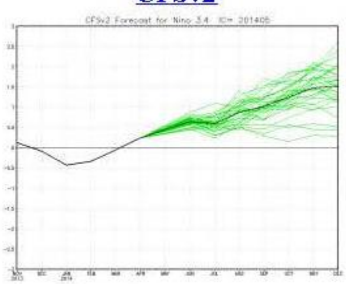
Ensemble Mean



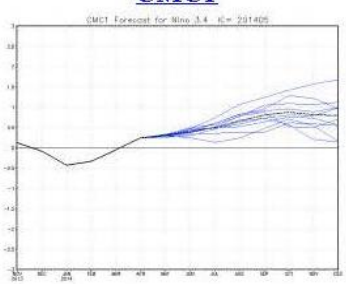
All Members



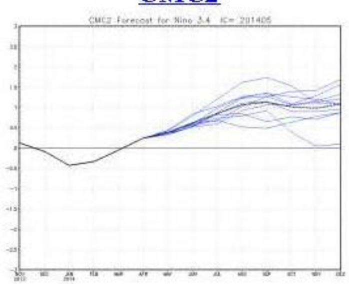
CFSv2



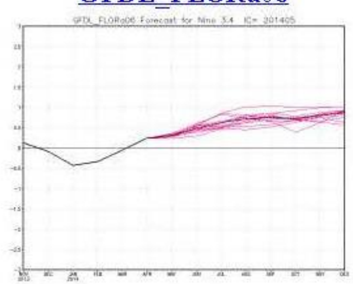
CMC1



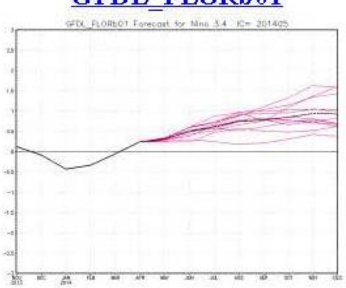
CMC2



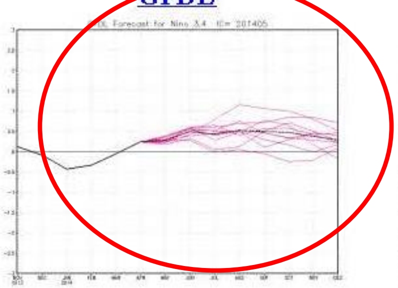
GFDL_FLORa06



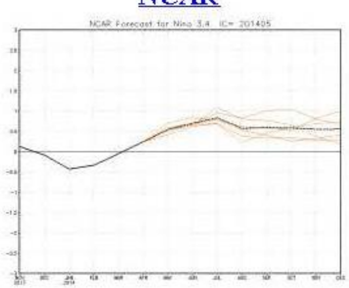
GFDL_FLORb01



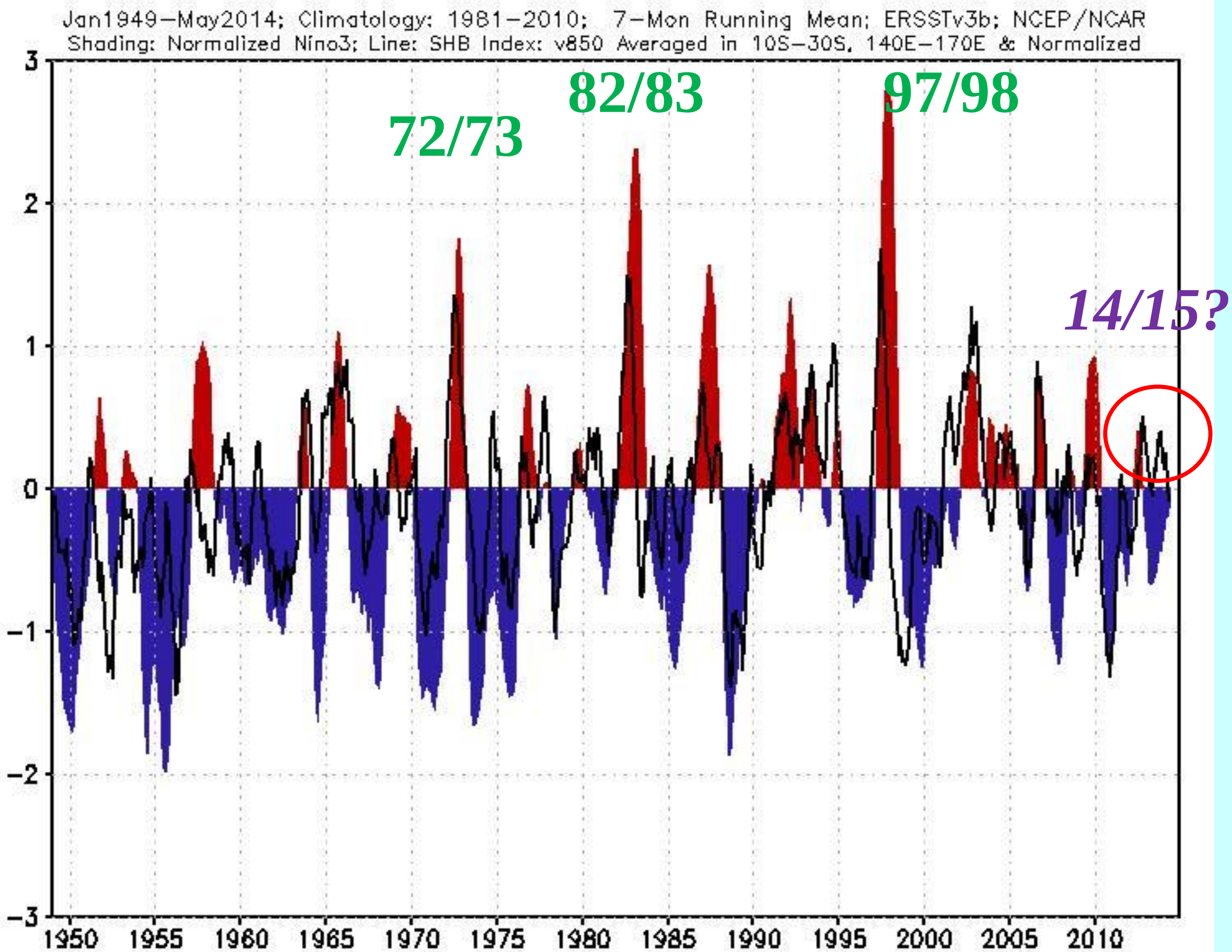
GFDL



NCAR



NASA



- **Since last winter, SHB index was positive, then decreased in recent months, and became negative in May 2014, suggesting *no major El Nino in 2014-15.***
- **Nino3 had positive tendencies in last a few months.**
- **Based on Hong et al. (2014 GRL), SHB index peaks at August with 3-mon lead to El Nino, so SHB index value in summer is a good indicator to predict if there is a strong El Nino in winter.**

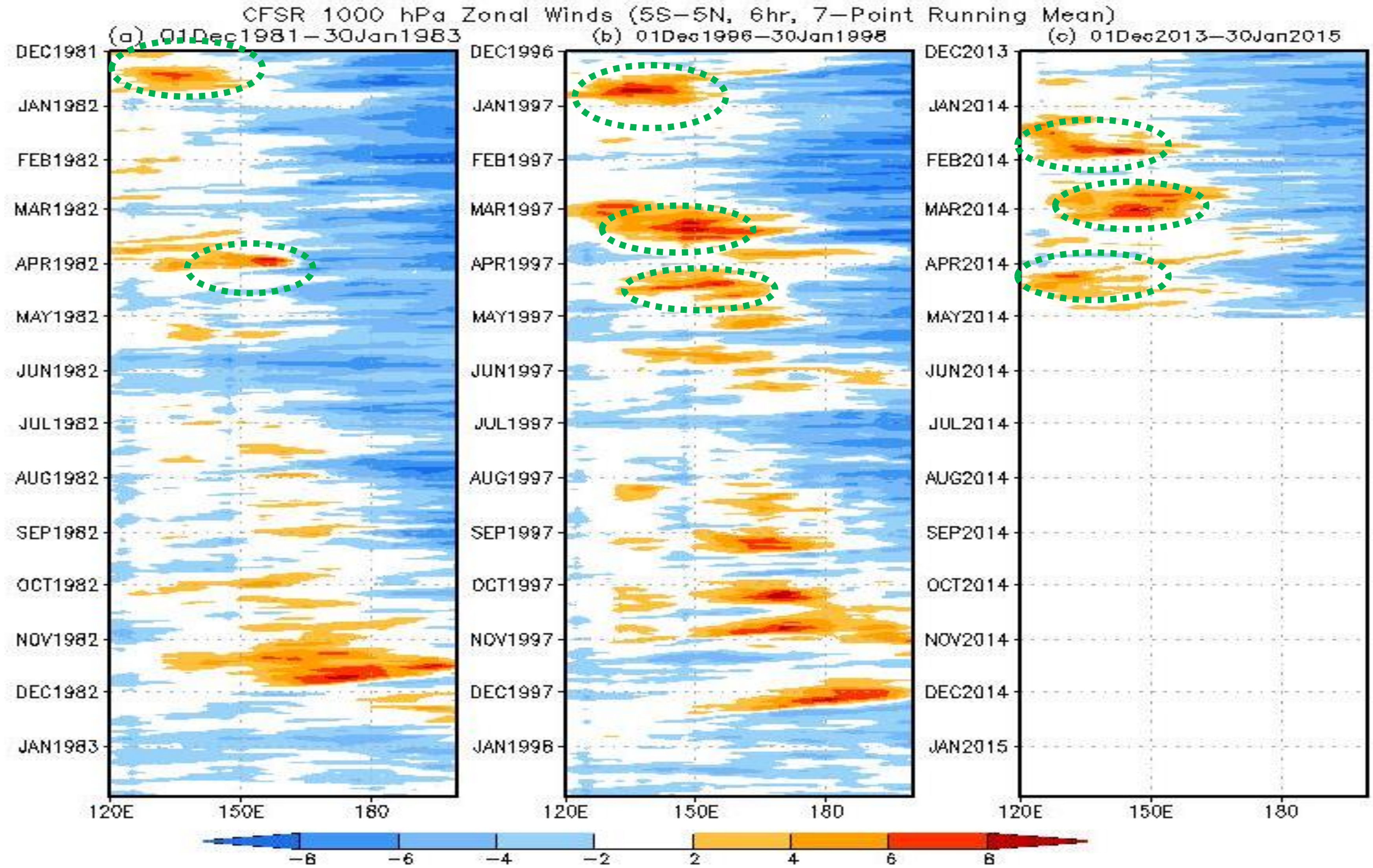
Red/blue shading: normalized Nino3
Black line: Southern Hemisphere booster (SHB) index: v850 averaged over 10°S–30°S, 140°E–170°E and normalized
ERSSTv3b and NCEP/NCAR reanalysis: 1981-2010 climatology; 7-month running mean

See: Hong, L.-C., Lin Ho and F.-F. Jin, 2014: A Southern Hemisphere Booster of Super El Niño. GRL, **41 (6),** 2142-2149

CFSR: Westerly wind burst (WWB) events

a) stronger in 1997-98 than in 1982-83

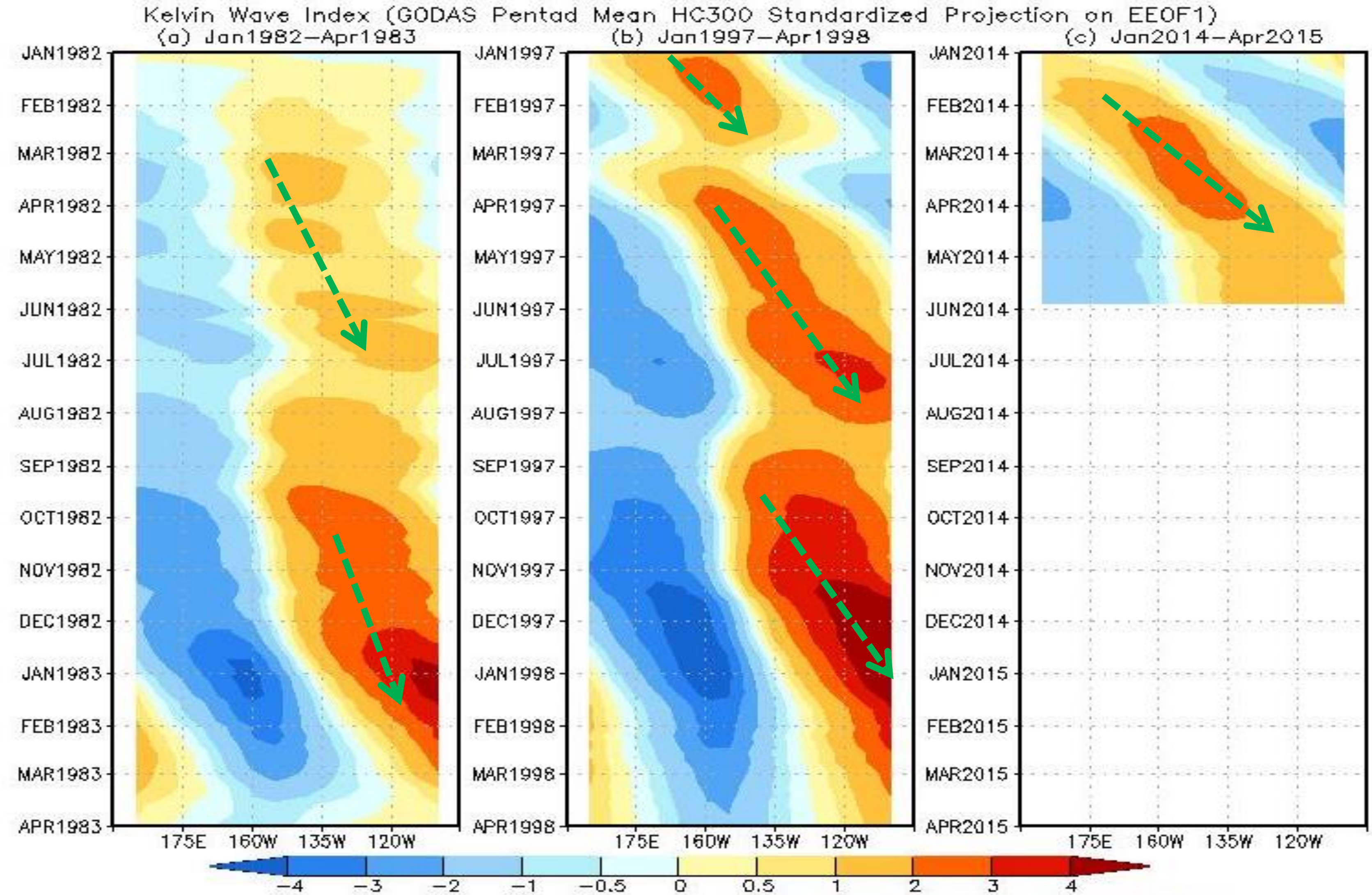
b) strong multi-WWB events in 1997-98



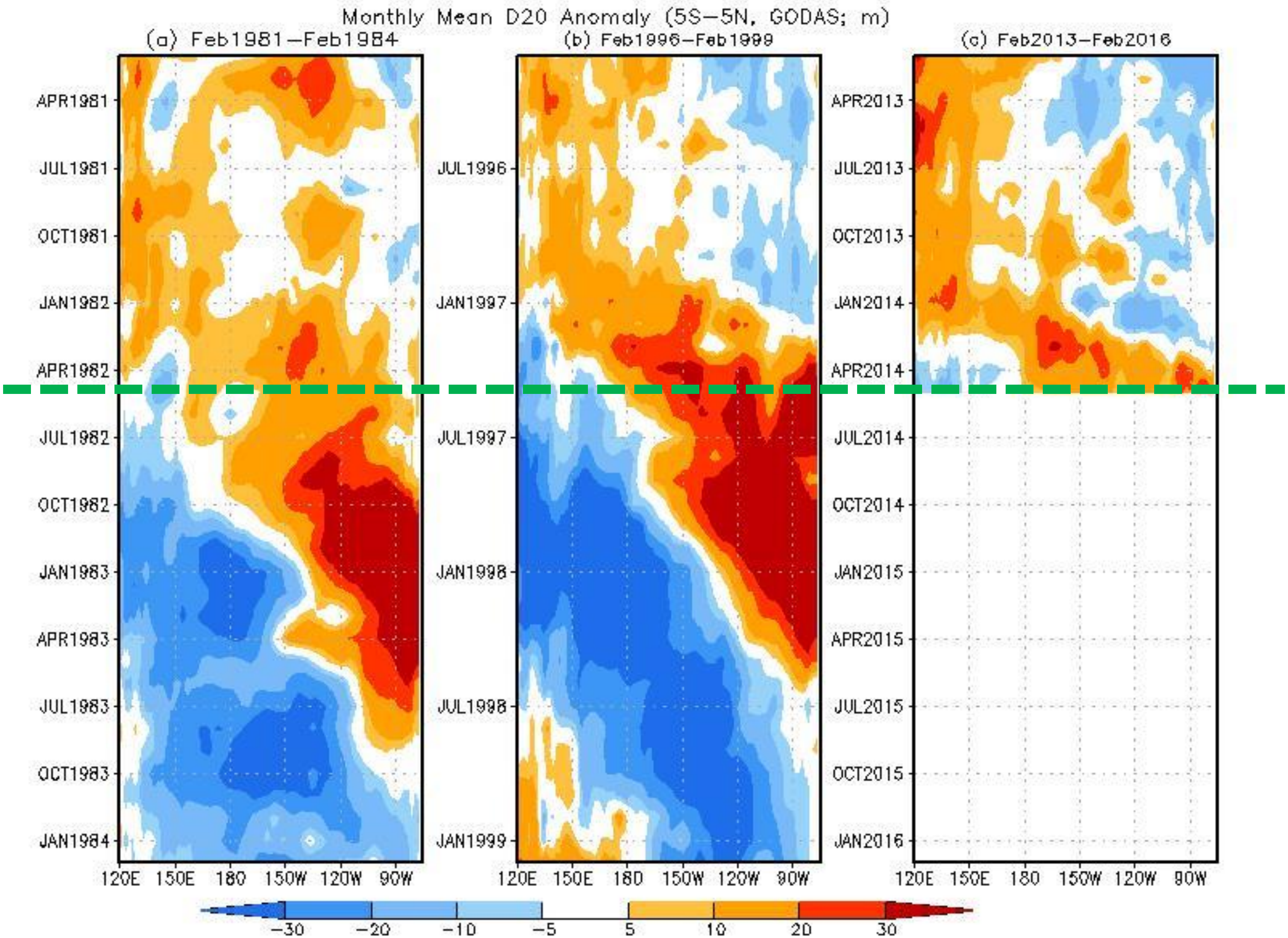
Kelvin activity

a) stronger in 1997-98 than in 1982-83

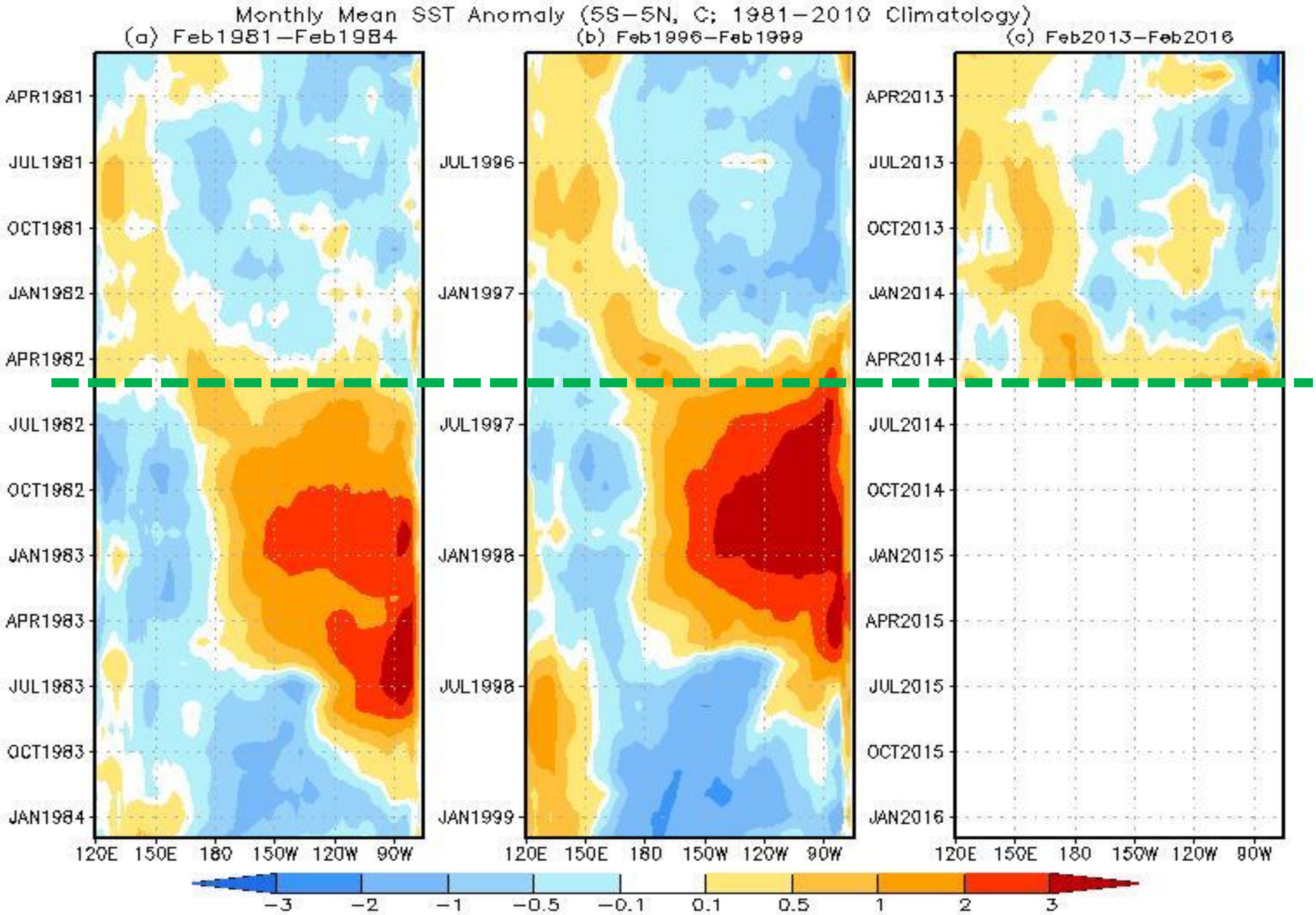
b) multi-Kelvin activity events in 1997-98



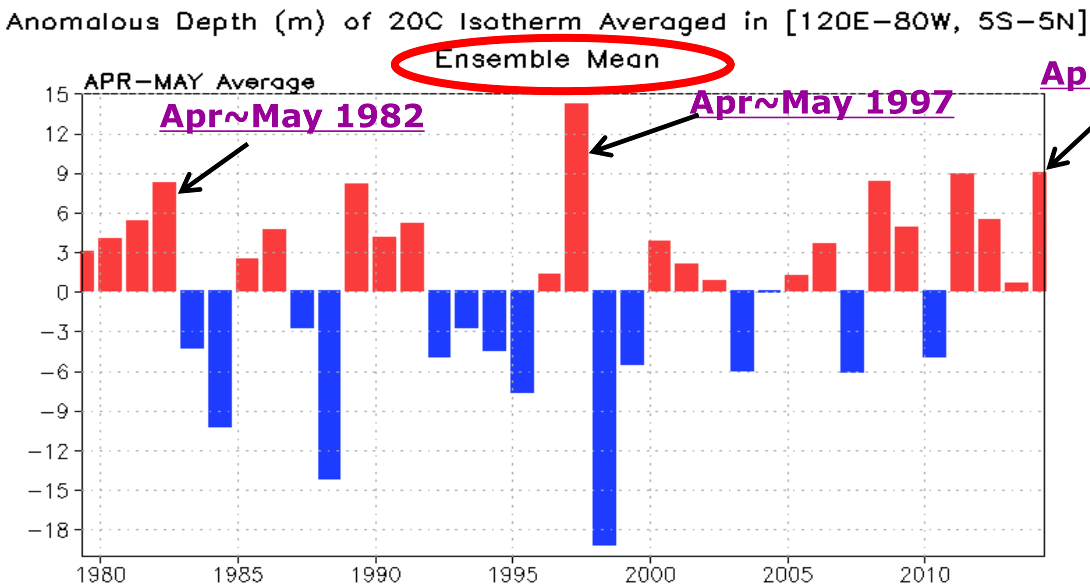
D20: Similar evolution in 1981-83, 1996-98, 2013-14



SSTA: Similar evolution in 1981-83, 1996-98, 2013-14



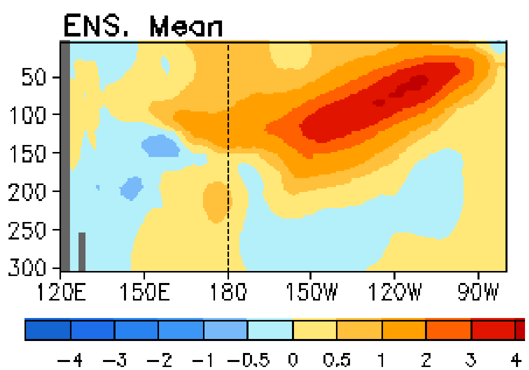
Warm Water Volume Index



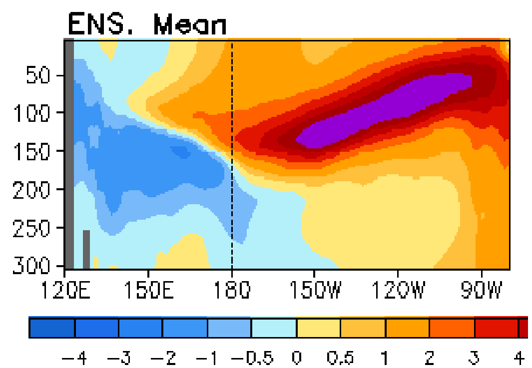
Real-Time Multiple Ocean Reanalysis Intercomparison

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

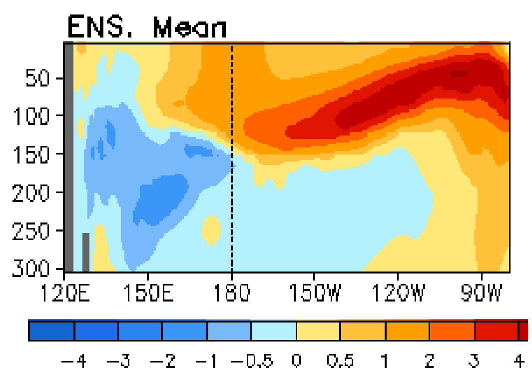
May 1982



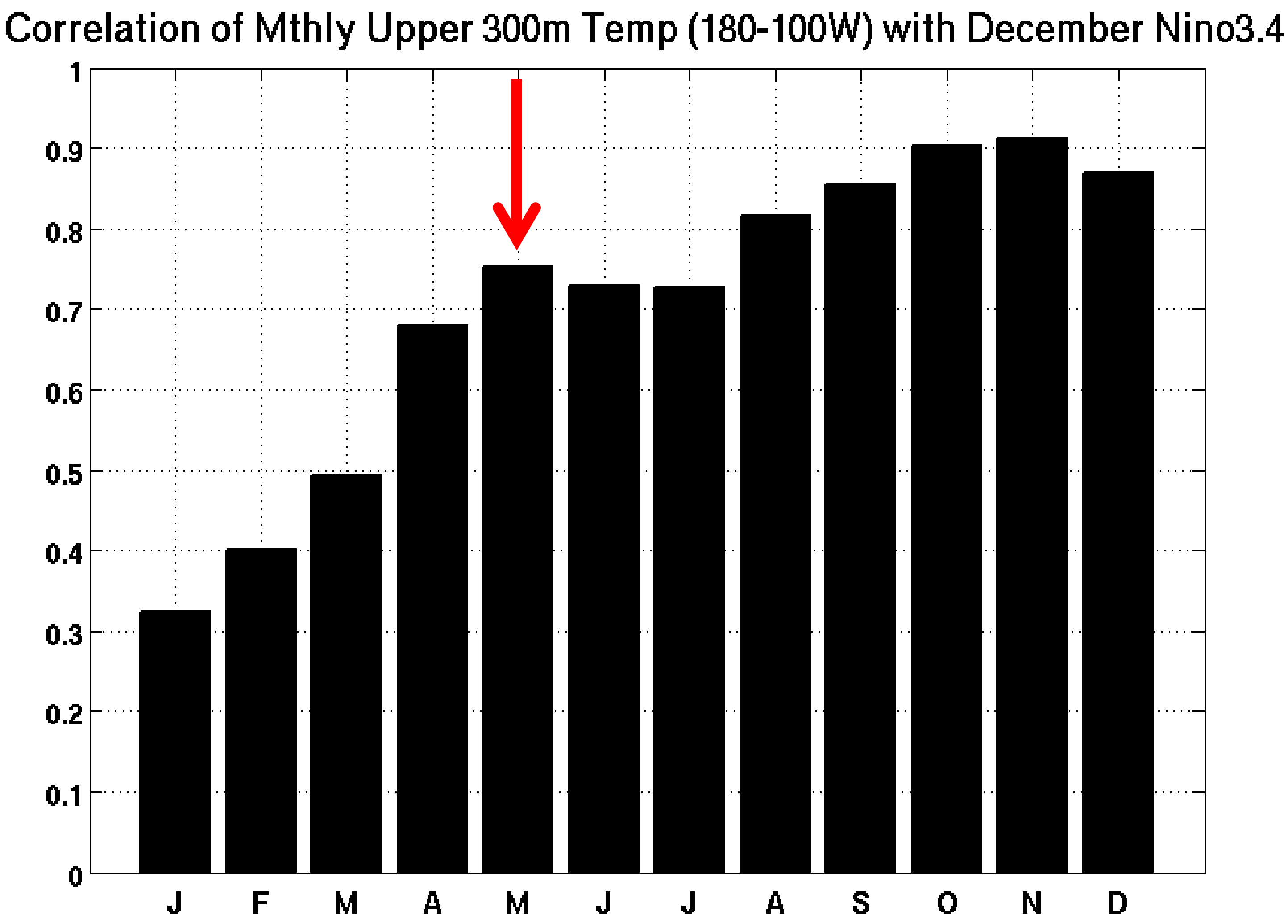
May 1997



May 2014



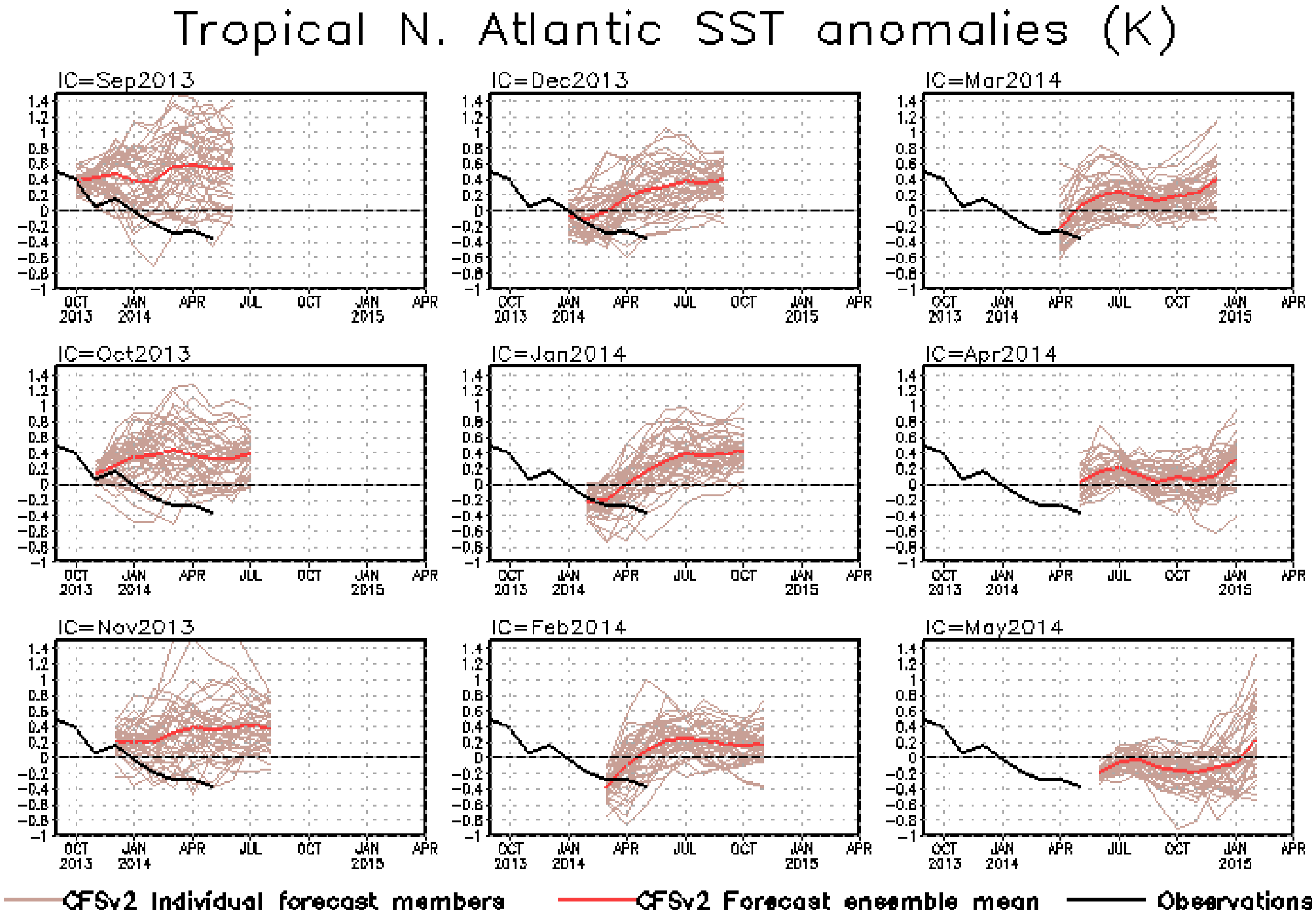
Correlation of Dec Nino3.4 with HC300 Anomaly



Correlation of Dec Nino3.4 with E. Pacific HC300 in May is larger than 0.7.

From: Michelle L'Heureux

CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



- Forest from May 2014 IC calls for near-normal SST in the tropical North Atlantic next 9 months.

- Large warm biases were seen in the forecasts with ICs in last 9 months.

TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].

Fig. M3. CFS Tropical North Atlantic (TNA) 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). Anomalies were computed with respect to the 1981-2010 base period means.

Overview

- **Pacific Ocean**
  - **ENSO neutral condition continued with OIv2 NINO3.4=0.46°C in May 2014.**
  - **Positive anomalies of subsurface ocean temperature along the equator weakened in May 2014.**
  - **Majority of models predicted an El Nino starting this summer.**
  - **NOAA "ENSO Diagnostic Discussion" on 5 June 2014 continually issued "El Nino Watch" and suggested that "Chances of El Niño are 70% during the Northern Hemisphere summer and reach 80% during the fall and winter."**
  - **PDO switched to positive phase in Mar and strengthened in Apr-May with PDO index =1.2 in May 2014.**
- **Indian Ocean**
  - **Positive SSTA presented in the whole Indian Ocean in May 2014.**
- **Atlantic Ocean**
  - **NAO switched into negative phase with NAOI=-0.8 in May 2014.**
  - **Tripole pattern of SSTA presented in North Atlantic in May 2014.**
  - **NOAA predicts near-normal or below-normal 2014 Atlantic hurricane season.**

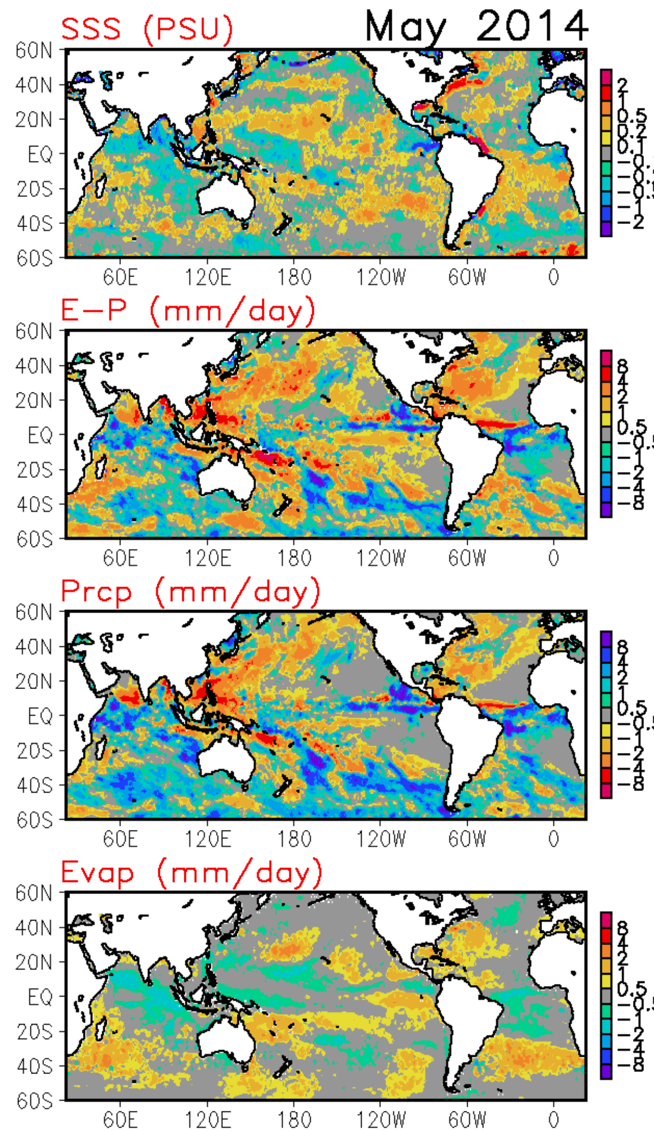
Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for May 2014

- Sea water freshened over western equatorial Pacific and eastern Indian oceans and salted over central northern Pacific, SE Pacific, and majority of the Atlantic.

- SSS changes over the Pacific and the Indian oceans are attributable largely to the fresh water flux, while those over the Atlantic seem to be caused by other



- Data used

  SSS :

  Blended Analysis of Surface Salinity (BASS)

  (a CPC-NESDIS/NODC-NESDIS/STAR joint effort)

  (Xie et al. 2014)

  ftp.cpc.ncep.noaa.gov/precip/BASS

  Precipitation:

  CMORPH adjusted satellite precipitation estimates

  Evaporation:

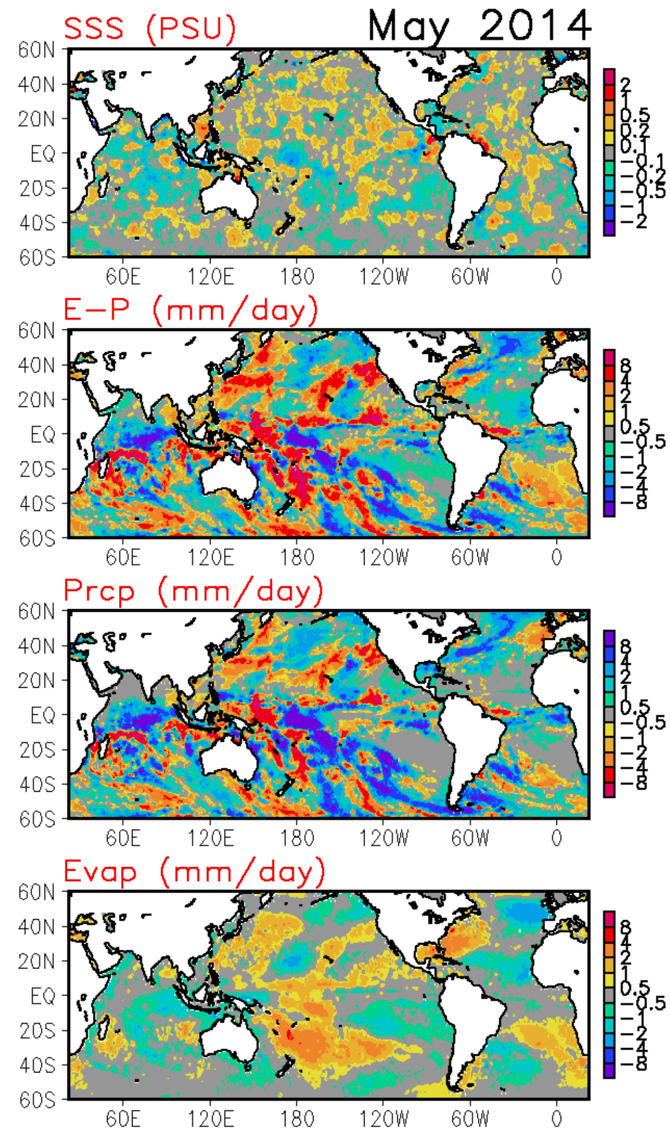
  CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for May 2014

- Majority of the western equatorial Pacific and Indian ocean continue to be freshened in association with the fresh water flux, especially the precipitation;

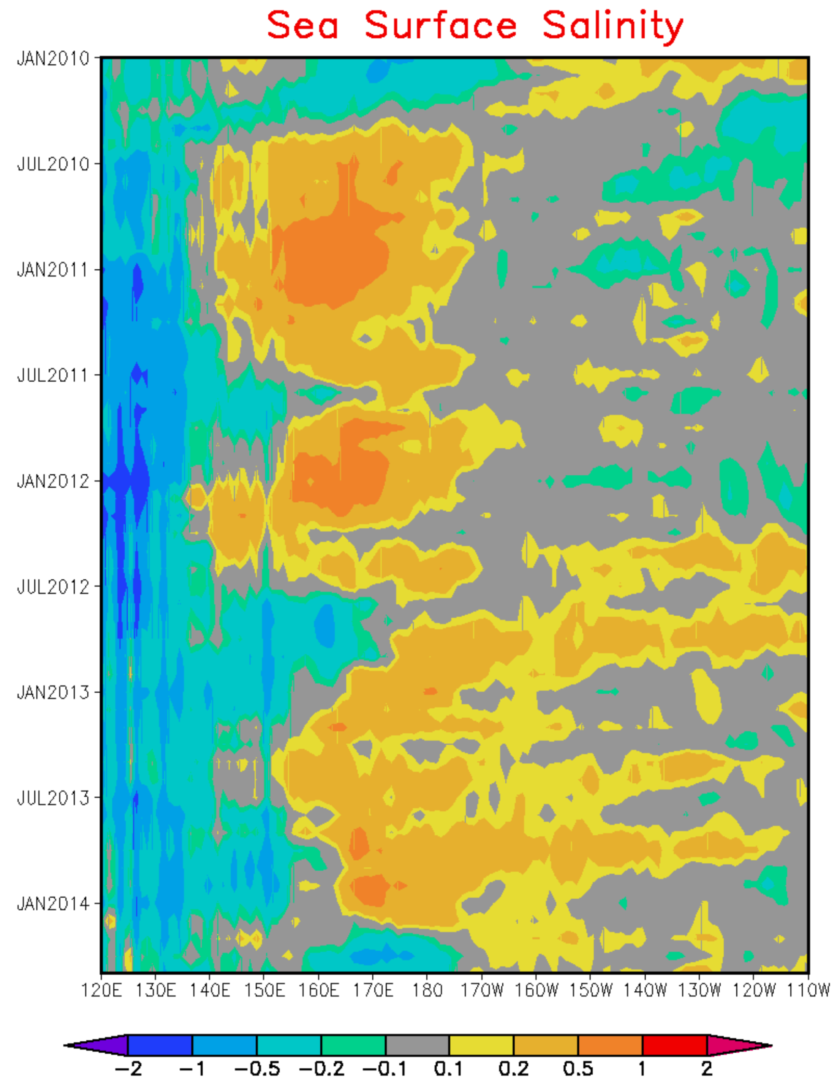
- SSS anomaly presents weak but positive tendency over a large portion of the Atlantic ocean that does not seem to be closely related to E-P variations



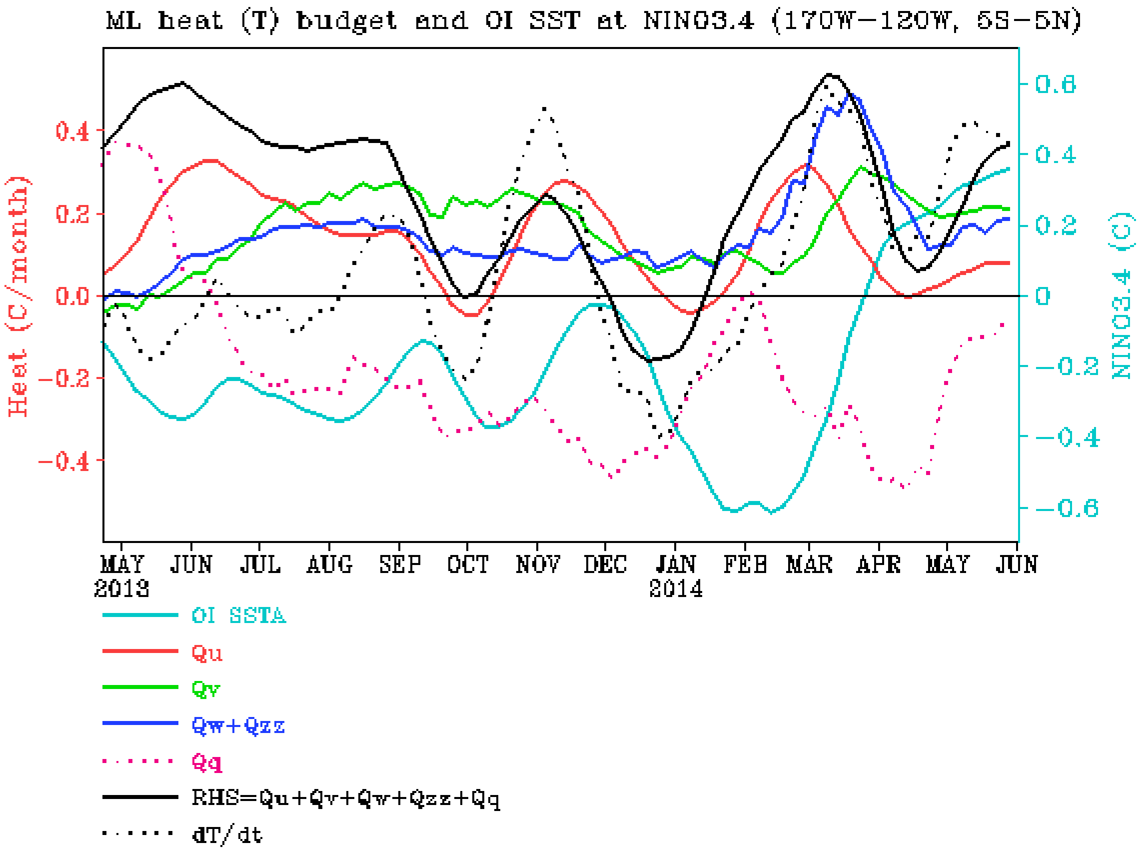
Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific

- Hovemoller diagram for equatorial SSS anomaly (5^oS-5^oN);
- SSS exhibits negative / positive anomalies over the Western / Central-Eastern Pacific over recent three years;
- Negative SSS anomaly continues all the way slightly east of the date line;



NINO3.4 Heat Budget



- **SSTA tendency (dT/dt) in NINO3.4 (dotted line) was positive since Feb 2014.**

- **Both Qu, Qv and Qw+Qzz were positive in last a few months.**

- **The total heat budget term (RHS) agreed with the tendency (dT/dt) since mid-Mar 2014.**

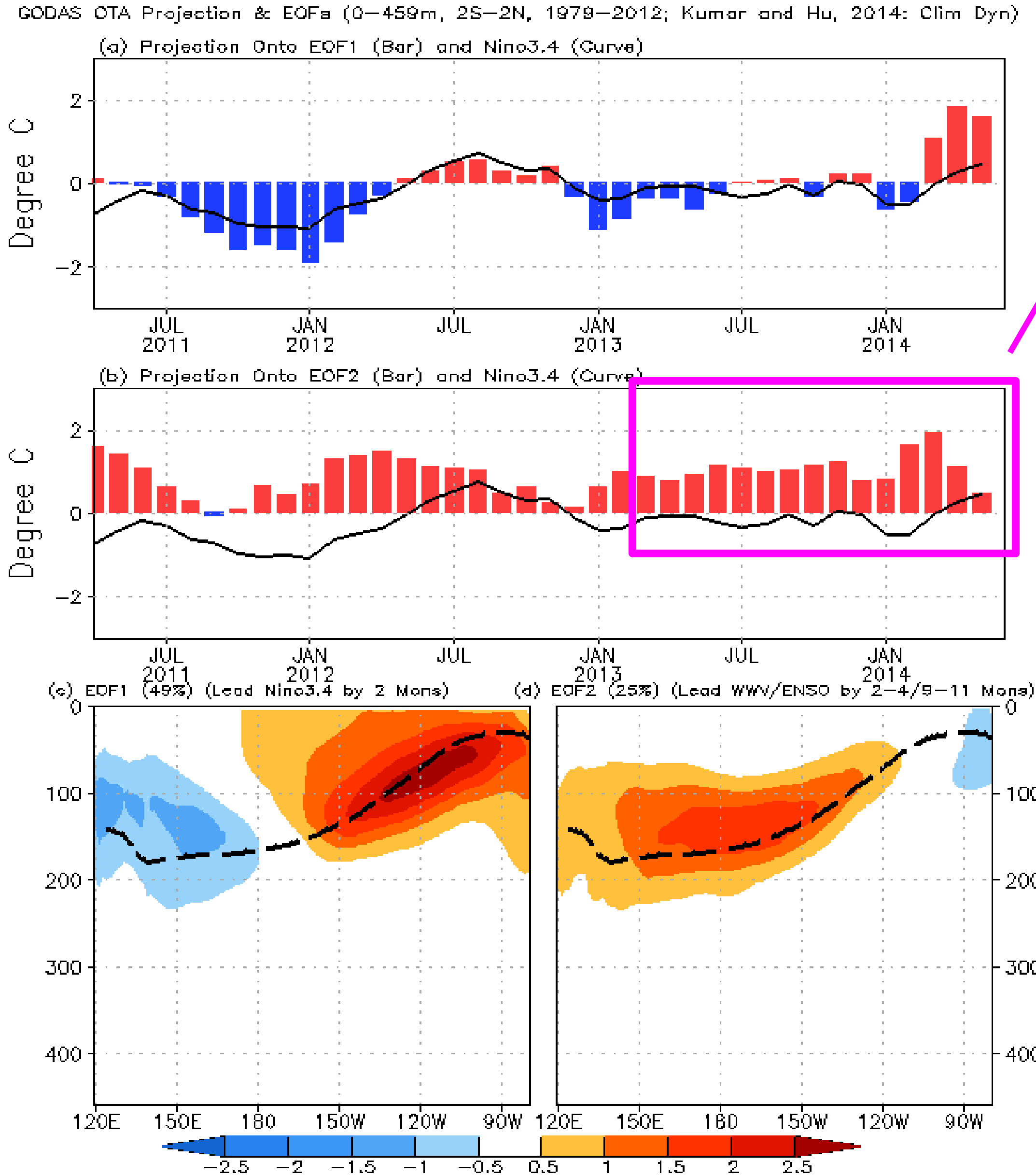
Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

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



Equatorial subsurface ocean temperature monitoring: The recharge process weakened since Apr 2014.

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, Z-Z Hu (2014) Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn., 42 (5-6), **1243-1258.** *DOI: 10.1007/s00382-013-1721-0*.

Warm Water Volume (WWV) and NINO3.4 Anomalies

- WWV is defined as average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN]. 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.

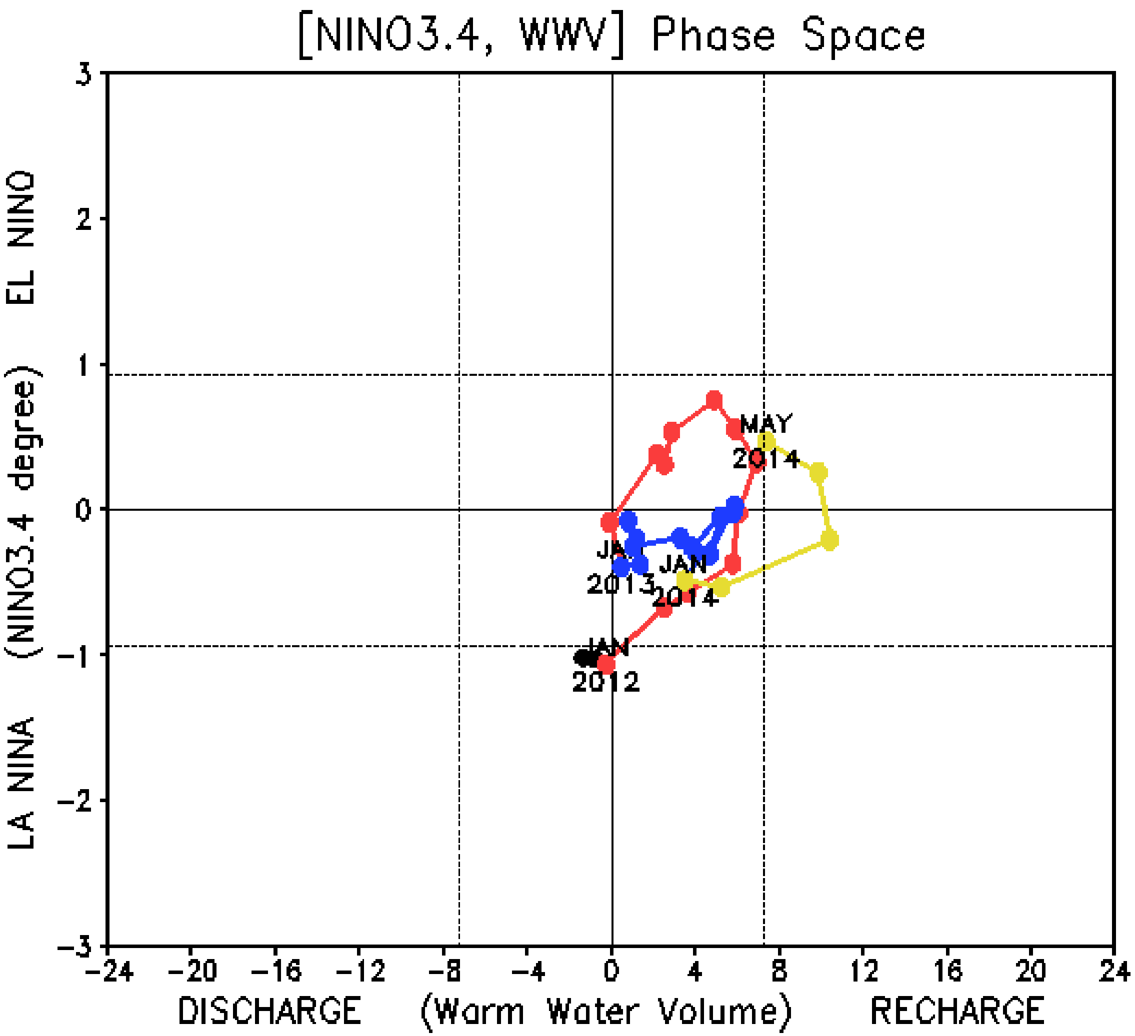
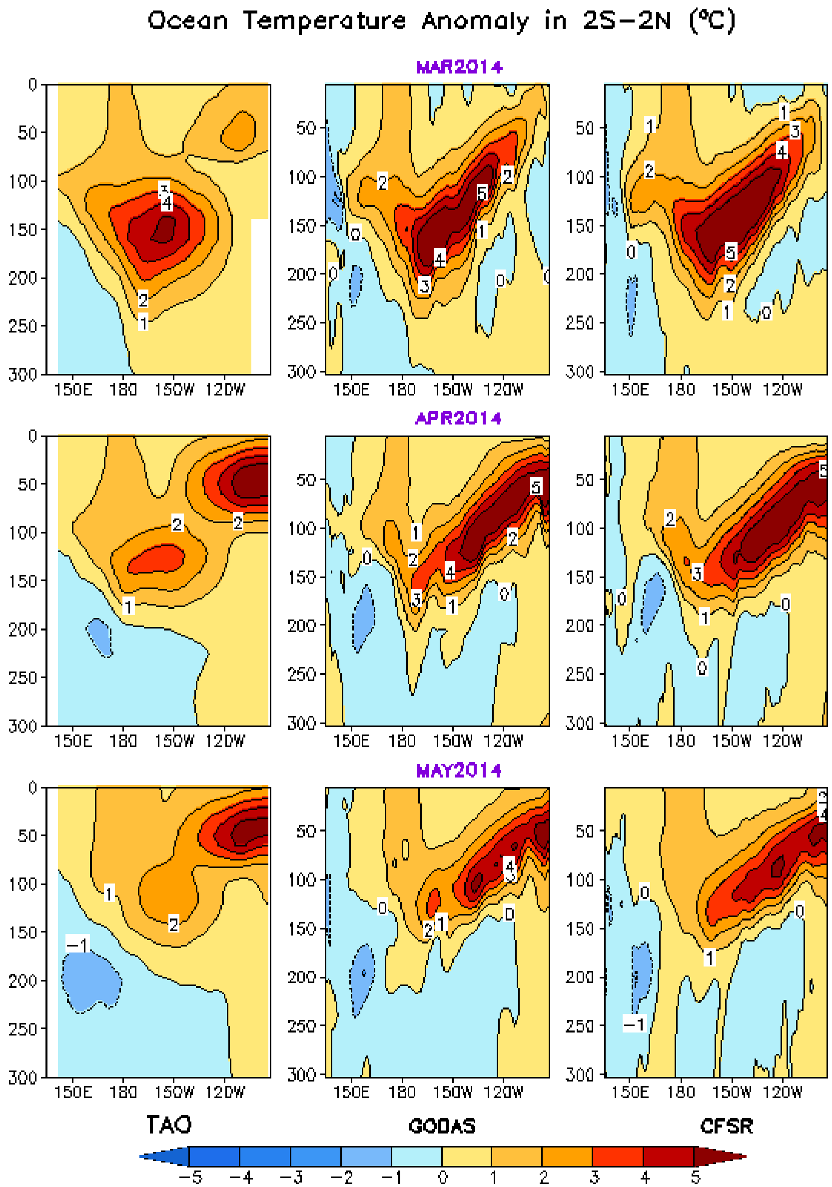
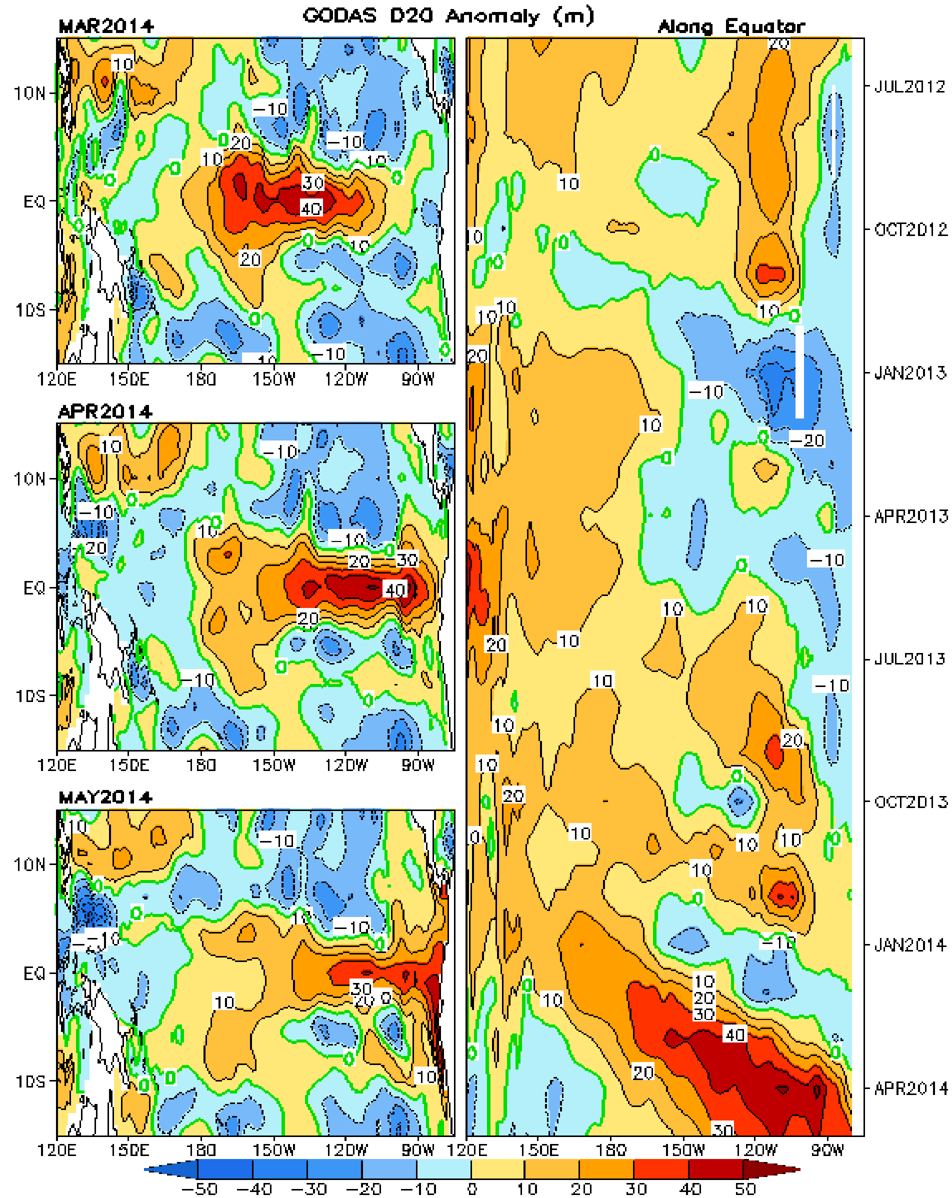
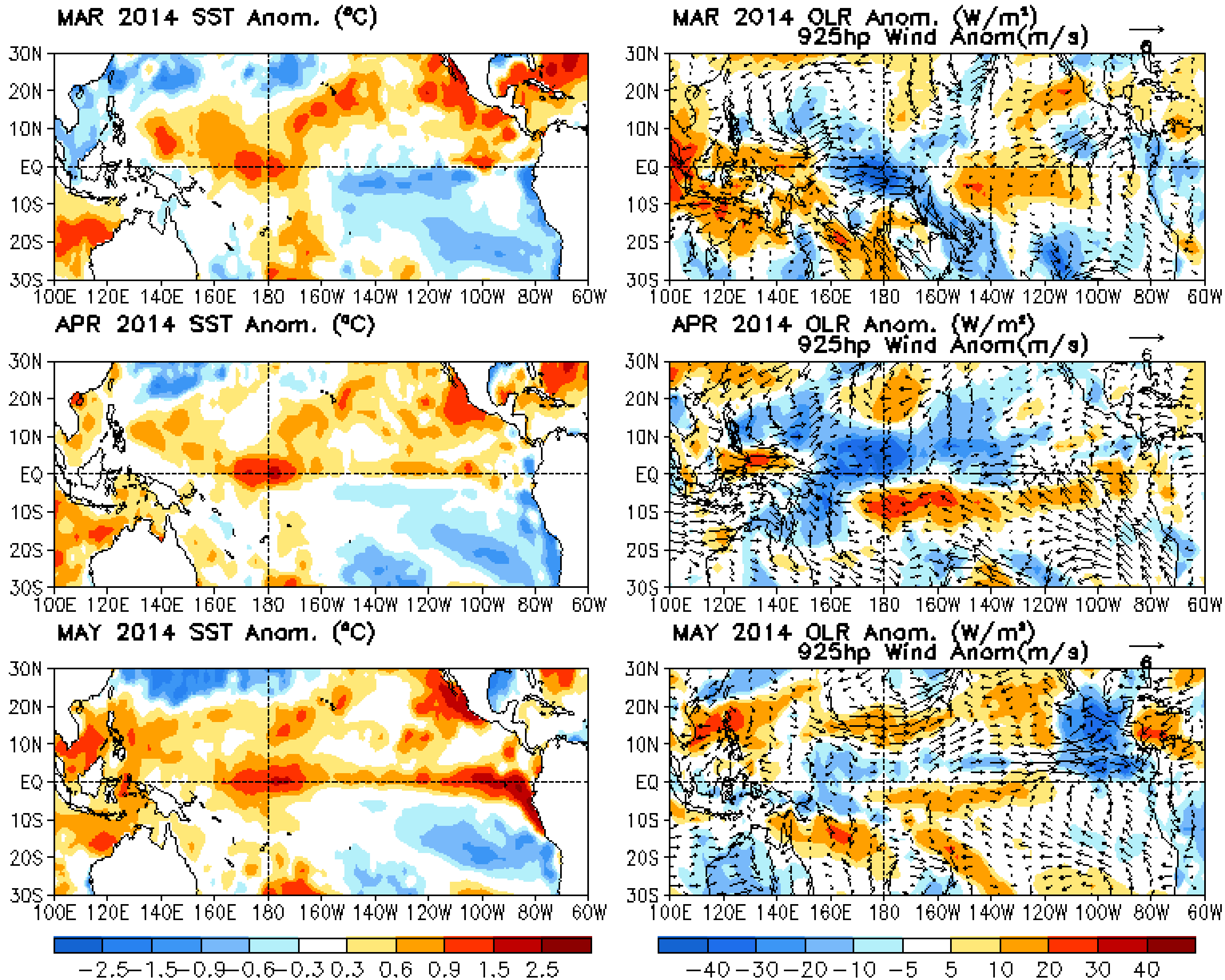


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

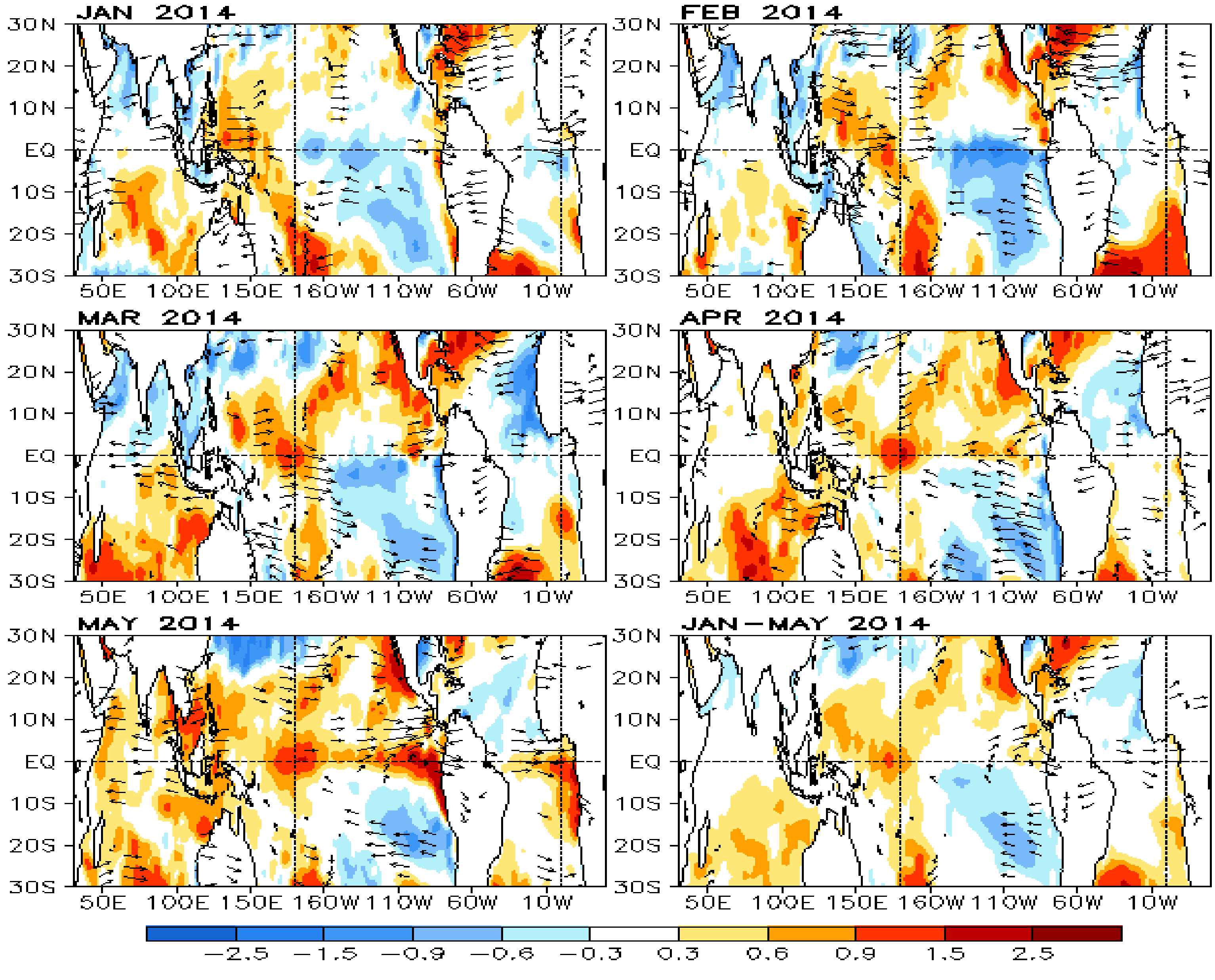
Ocean Temperature and D20 Anomaly (intensified and eastward propagation)






MAR 2014 SST Anom. (°C)
MAR 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
APR 2014 SST Anom. (°C)
APR 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
MAY 2014 SST Anom. (°C)
MAY 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
6
30N 20N 10N EQ 10S 20S 30S
100E 120E 140E 160E 180 160W 140W 120W 100W 80W 60W
−2.5 −1.5 −0.9 −0.6 −0.3 0.3 0.6 0.9 1.5 2.5
−40 −30 −20 −10 −5 5 10 20 30 40

Evolution of SST and 850mb Wind Anom.



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

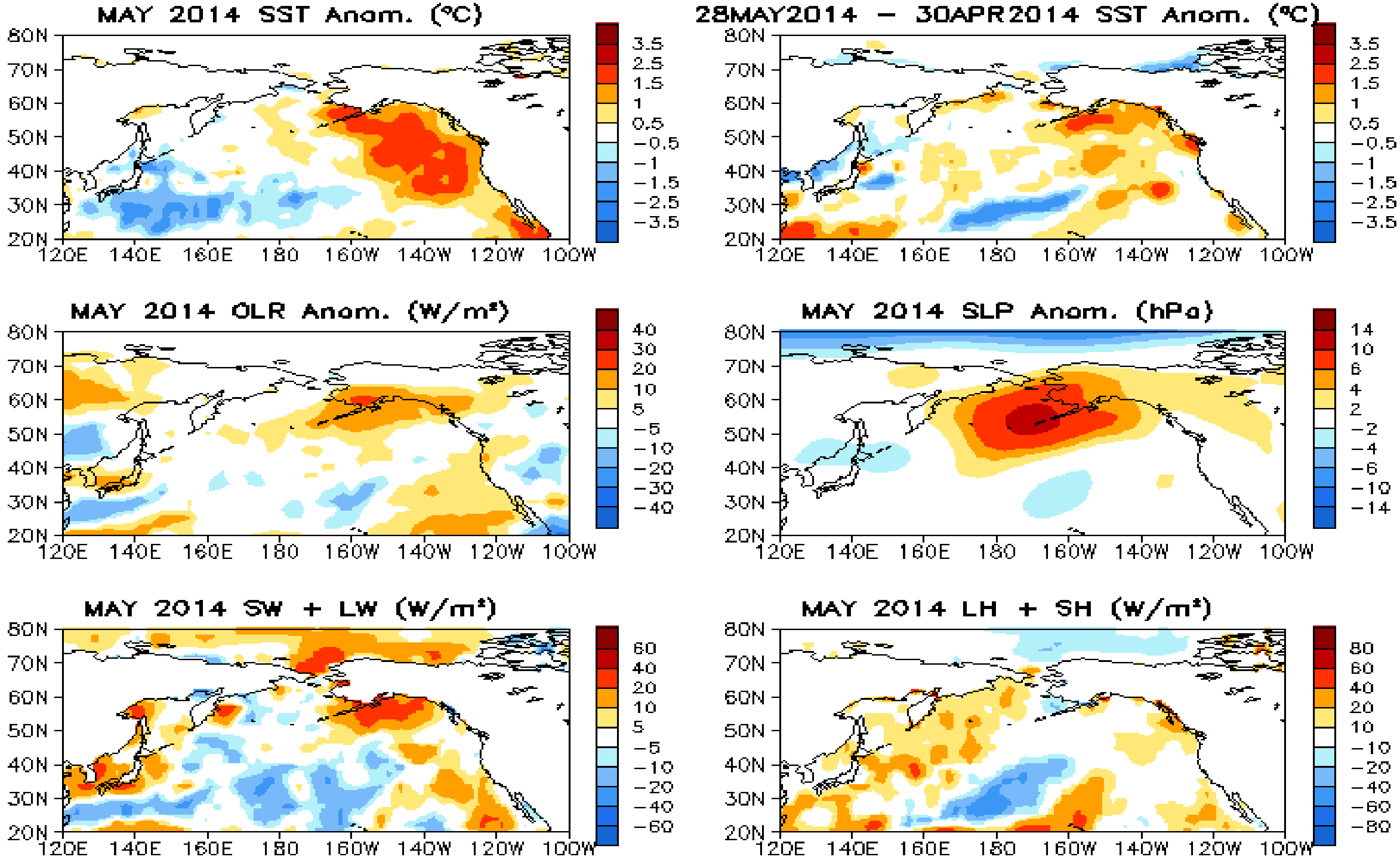
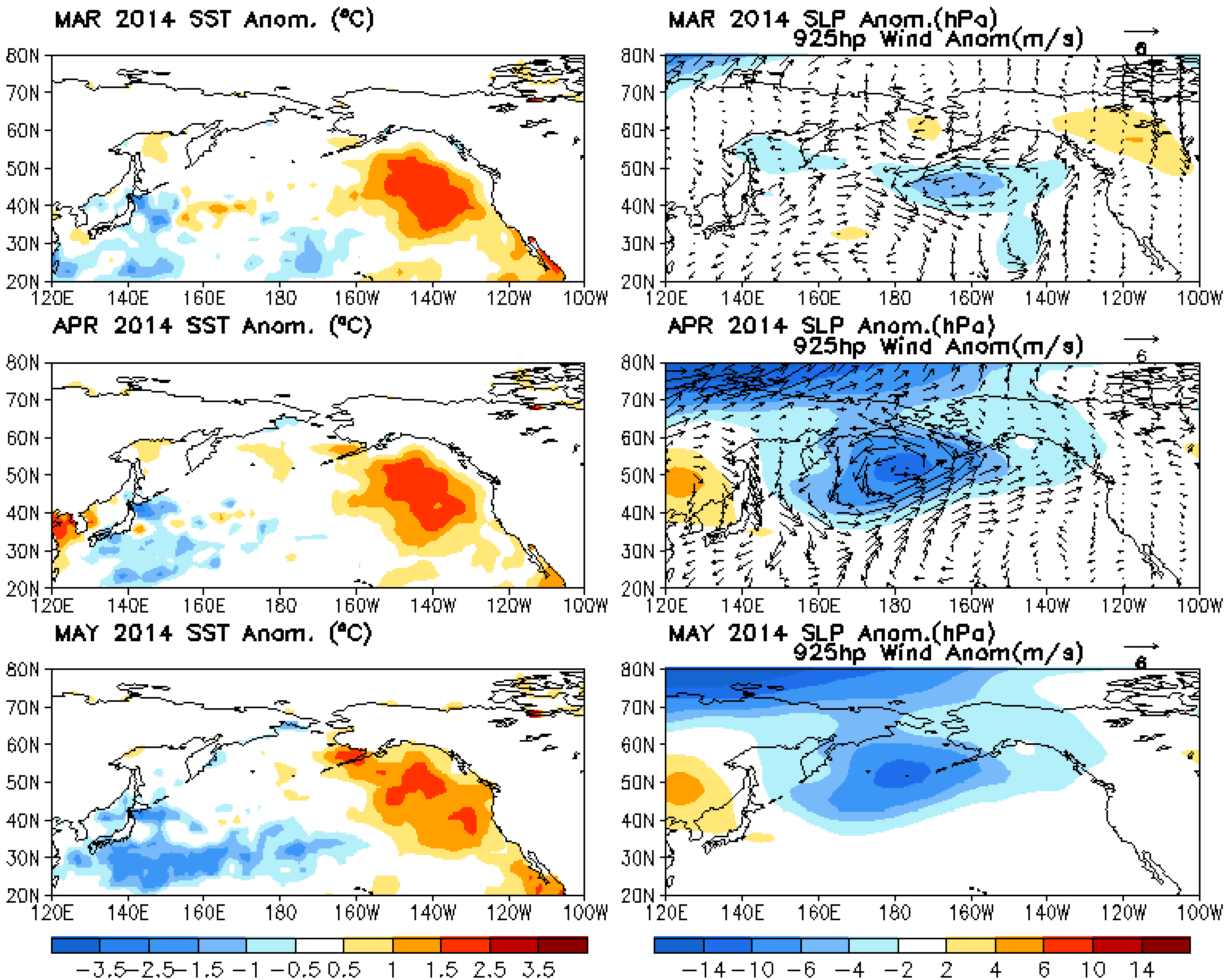
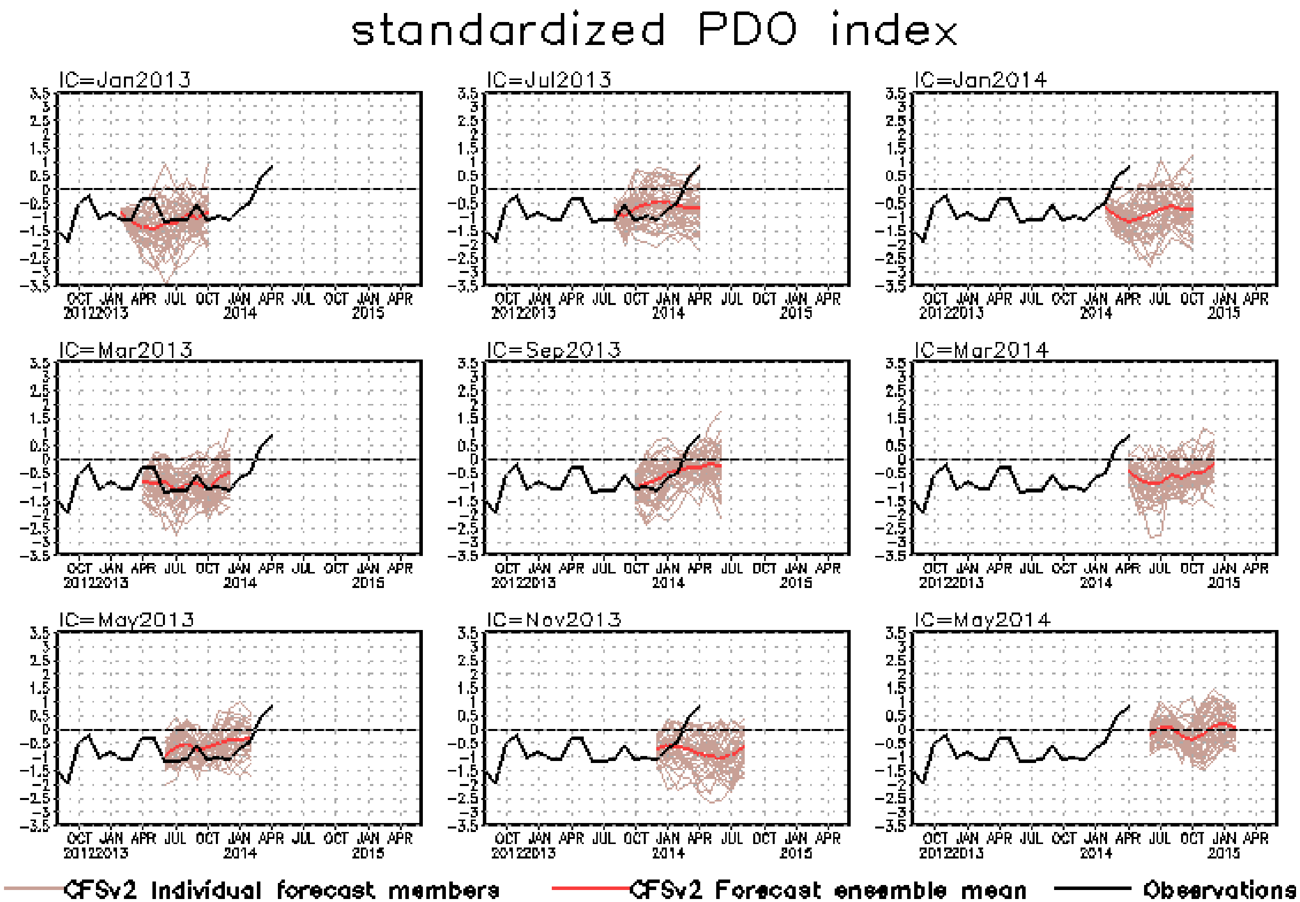


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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.



MAR 2014 SST Anom. (°C)
MAR 2014 SLP Anom.(hPa)
925hp Wind Anom(m/s)
6
APR 2014 SST Anom. (°C)
APR 2014 SLP Anom.(hPa)
925hp Wind Anom(m/s)
6
MAY 2014 SST Anom. (°C)
MAY 2014 SLP Anom.(hPa)
925hp Wind Anom(m/s)
6
80N
70N
60N
50N
40N
30N
20N
120E 140E 160E 180 160W 140W 120W 100W
−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

CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



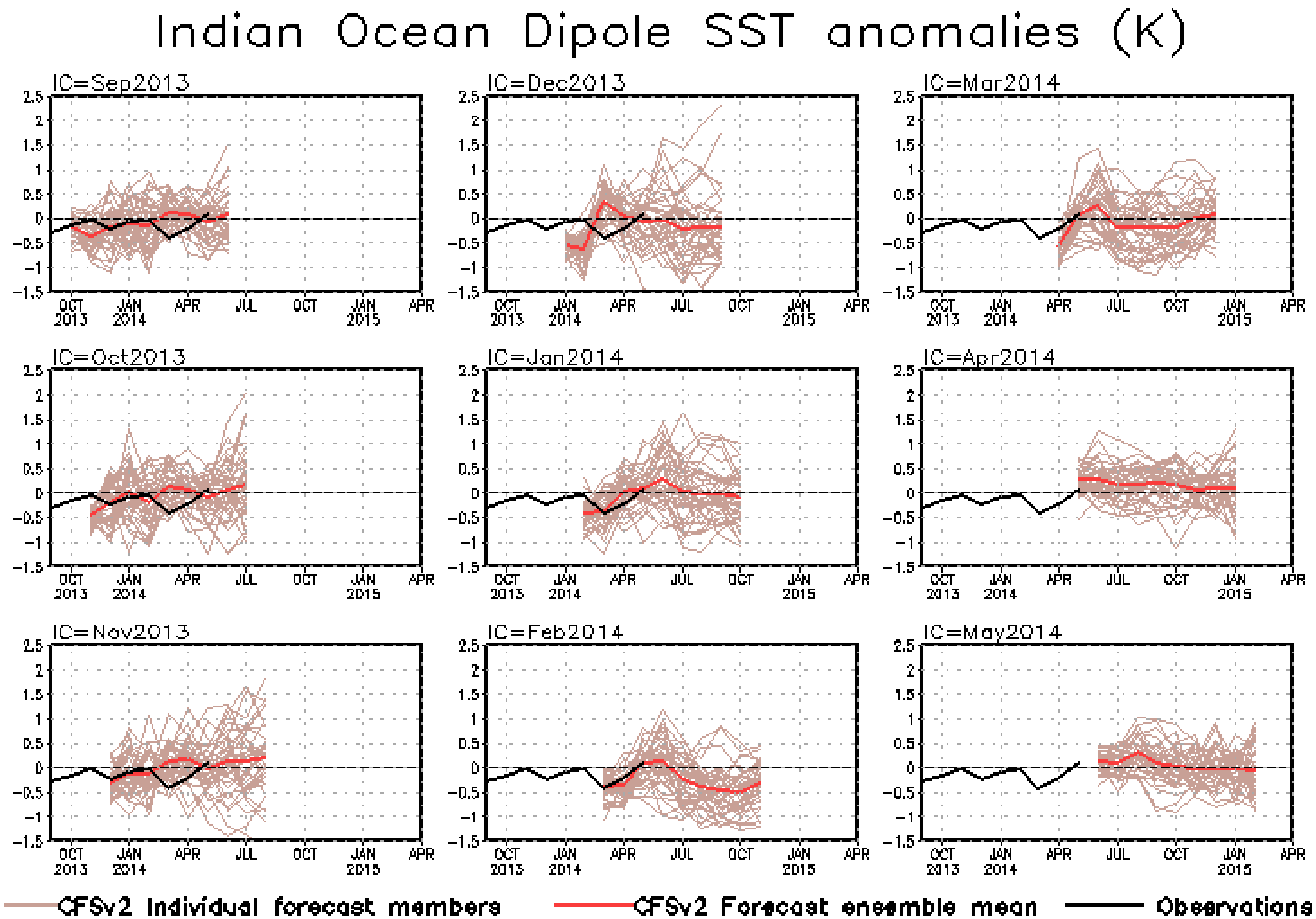
- Forecast from May 2014 IC calls for weak PDO in next 9 months.

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.

Fig. M4. CFS Pacific Decadal Oscillation (PDO) index 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). Anomalies were computed with respect to the 1981-2010 base period means.

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]

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.

Recent Evolution of Equatorial Indian SST (ºC), 0-300m Heat Content (ºC), and 850-mb Zonal Wind (m/s) Anomalies

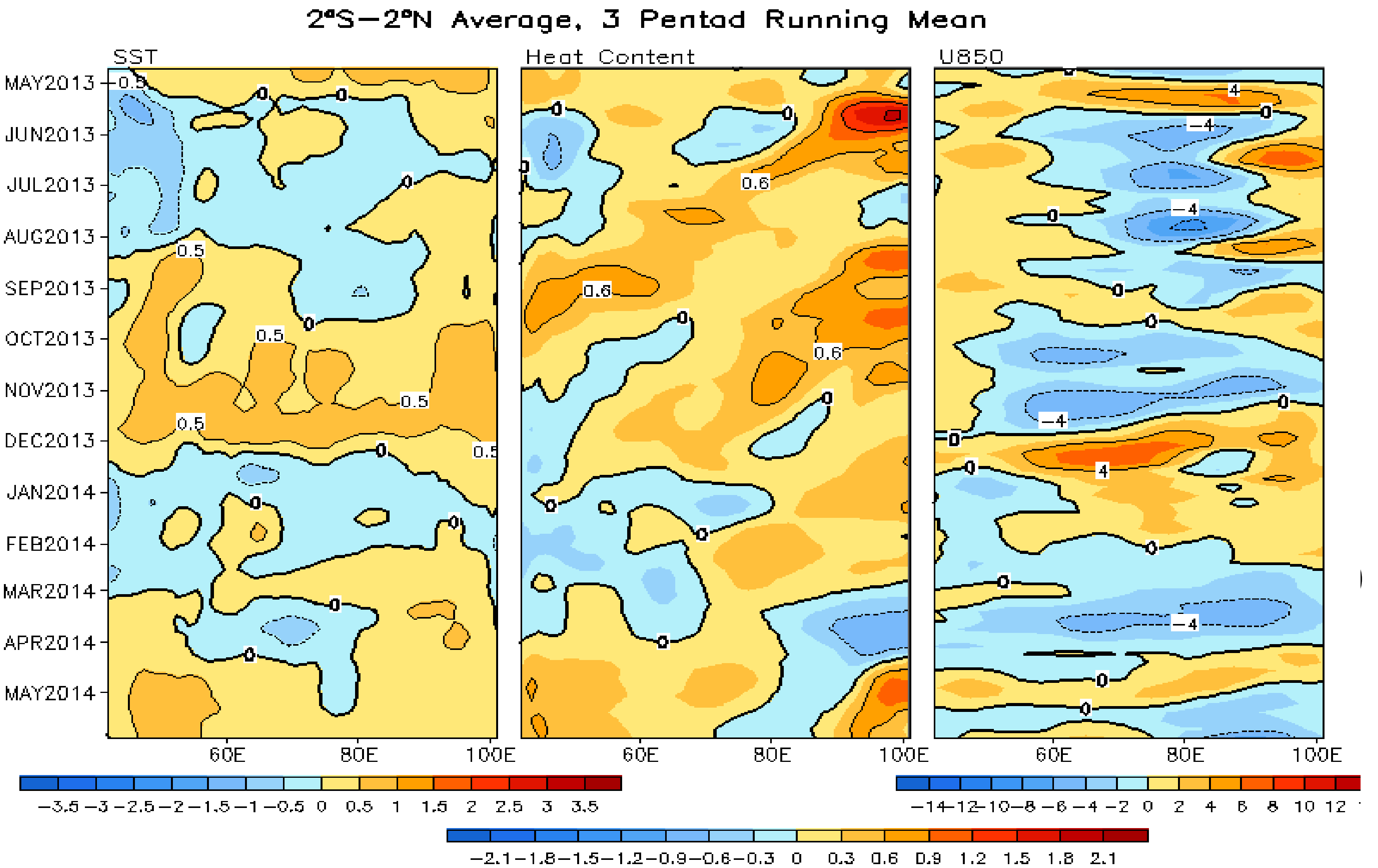
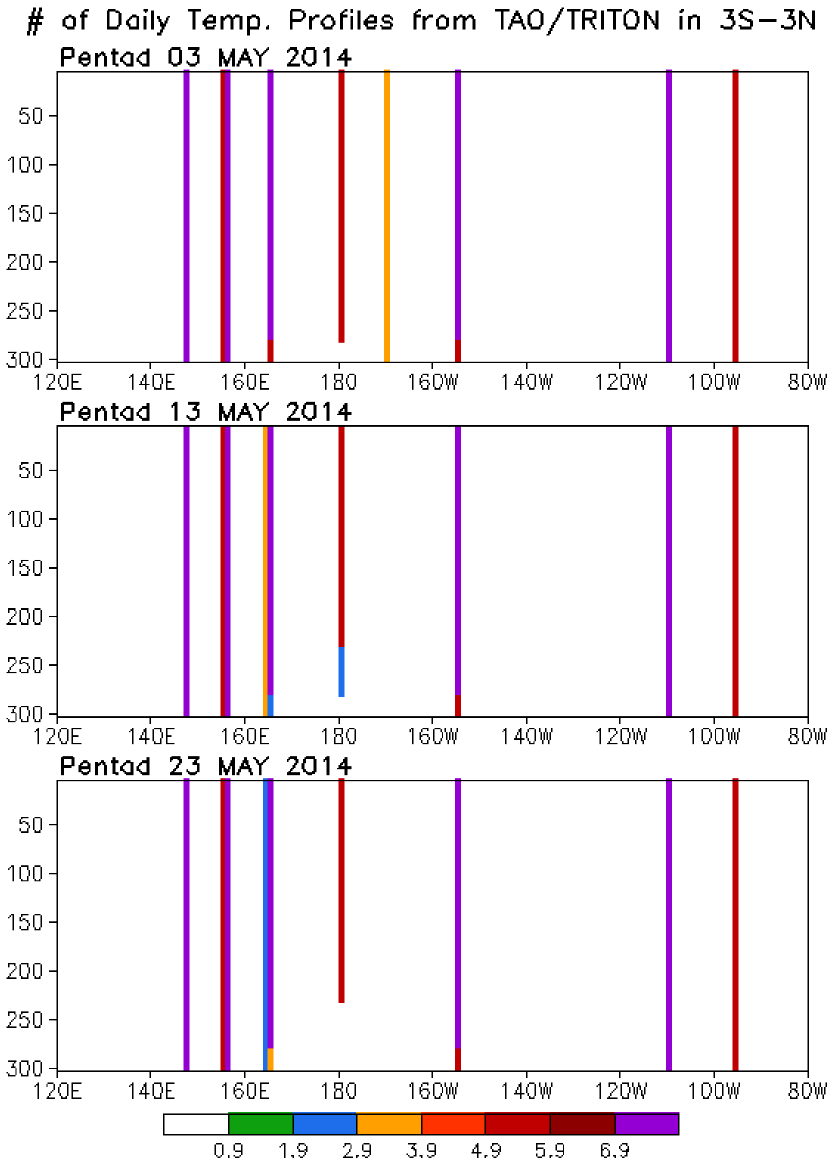
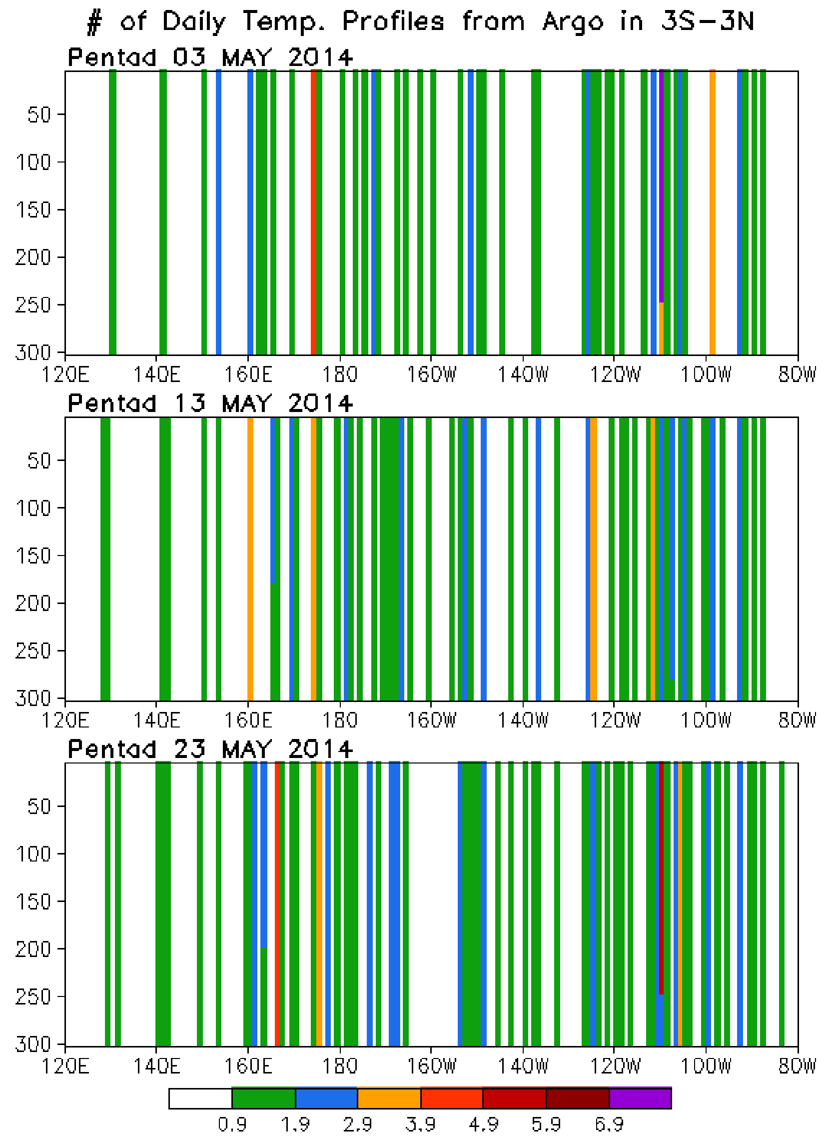


Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period pentad means.

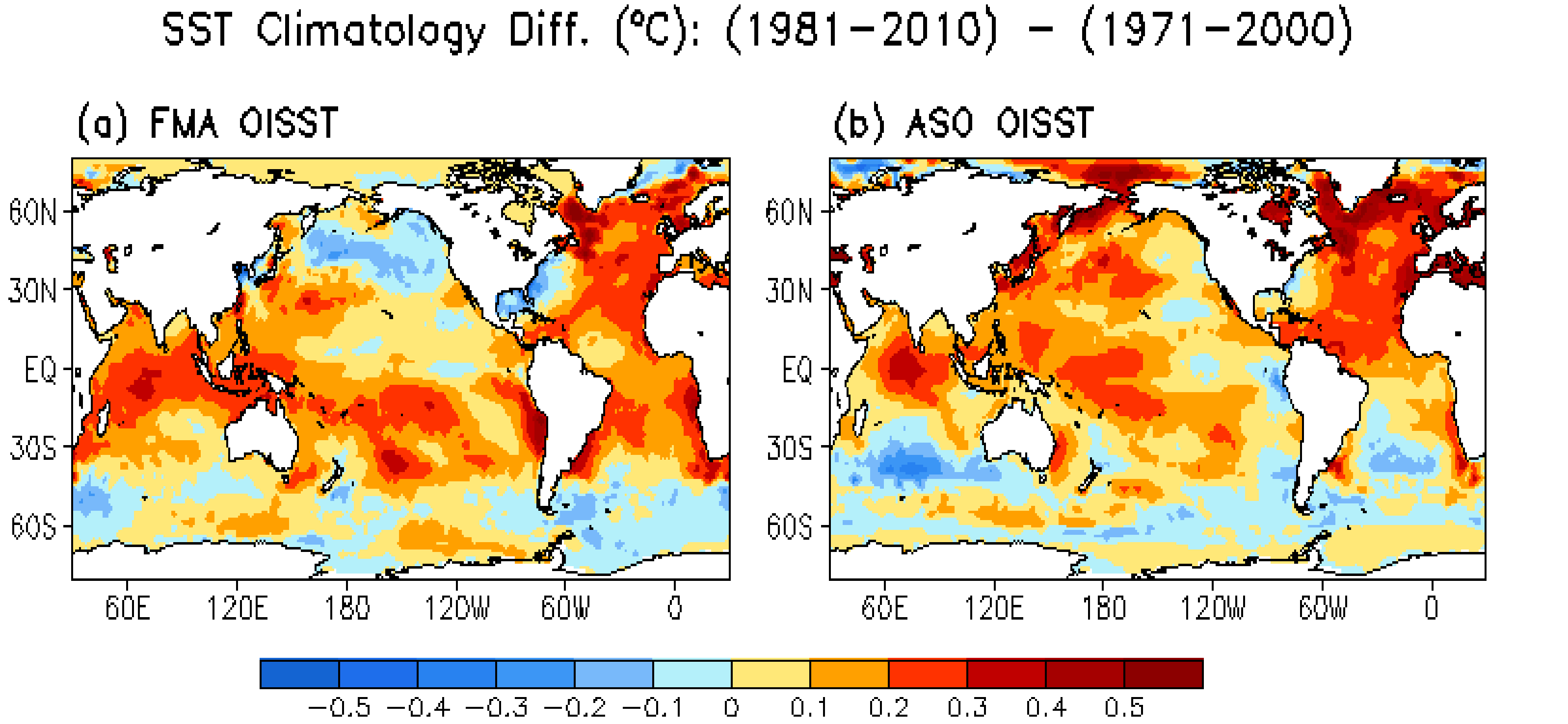


# of Daily Temp. Profiles from TAO/TRITON in 3S−3N
Pentad 03 MAY 2014
Pentad 13 MAY 2014
Pentad 23 MAY 2014
50
100
150
200
250
300
120E 140E 160E 180 160W 140W 120W 100W 80W
0.9 1.9 2.9 3.9 4.9 5.9 6.9



# of Daily Temp. Profiles from Argo in 3S−3N
Pentad 03 MAY 2014
Pentad 13 MAY 2014
Pentad 23 MAY 2014
50
100
150
200
250
300
120E 140E 160E 180 160W 140W 120W 100W 80W
0.9 1.9 2.9 3.9 4.9 5.9 6.9

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 0.2°C over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2°C 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.**

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)**

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!

Real Time Multiple Ocean Reanalysis Intercomparison

(with contributions from NCEP, ECMWF , JMA , GFDL , NASA , BOM based on 1981-2010 Climatology)

(Background Information)

Tropical Pacific Ocean

- **Climate Indices**
  - Depth of 20C isotherm anomaly in NINO3: last 4 years last 15 years 1979-present
  - Depth of 20C isotherm anomaly in NINO4: last 4 years last 15 years 1979-present
  - Upper 300m heat content anomaly in NINO3: last 4 years last 15 years 1979-present
  - Upper 300m heat content anomaly in NINO4: last 4 years last 15 years 1979-present
  - Warm Water Volume: last 4 years last 15 years 1979-present
  - Warm Water Volume average in last two months ending in:
    Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

- **Spatial Maps**
  - Equatorial temperature anomaly: last month month before last month 1979-present
  - Depth of 20C isotherm anomaly: last month month before last month 1979-present
  - Upper 300m heat content anomaly: last month month before last month 1979-present

Global Ocean

- **Spatial Maps**
  - Equatorial temperature anomaly: last month month before last month 1979-present
  - Depth of 20C isotherm anomaly: last month month before last month 1979-present
  - Upper 300m heat content anomaly: last month month before last month 1979-present

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