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**

  (A new product of CPC: Sea Surface Salinity)

  – **Pacific/Arctic Ocean**

  – **Indian Ocean**

  – **Atlantic Ocean**

  – **Global SST Predictions**

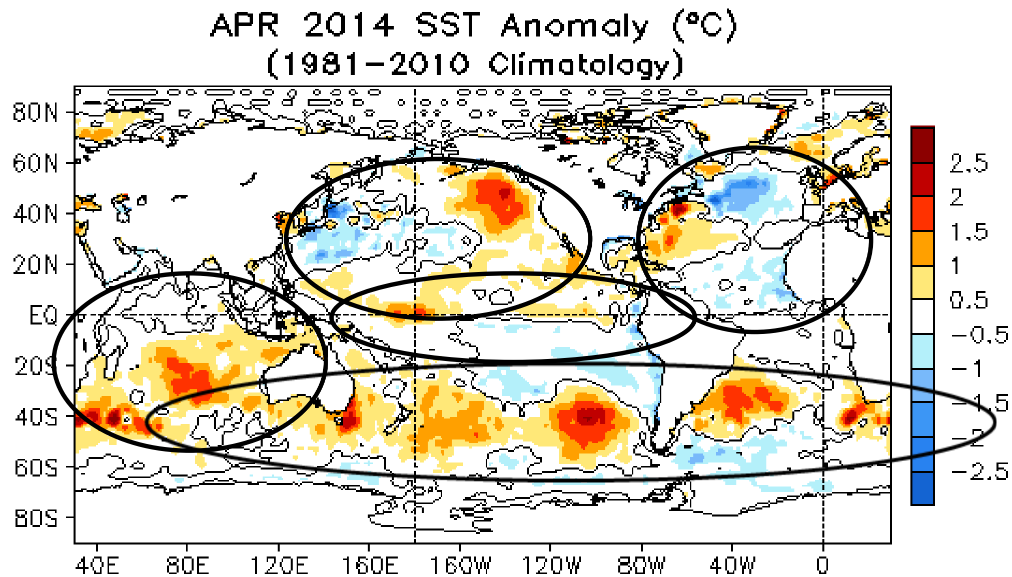
  Possibility of occurrence of an El Nino in 2014/15

Overview

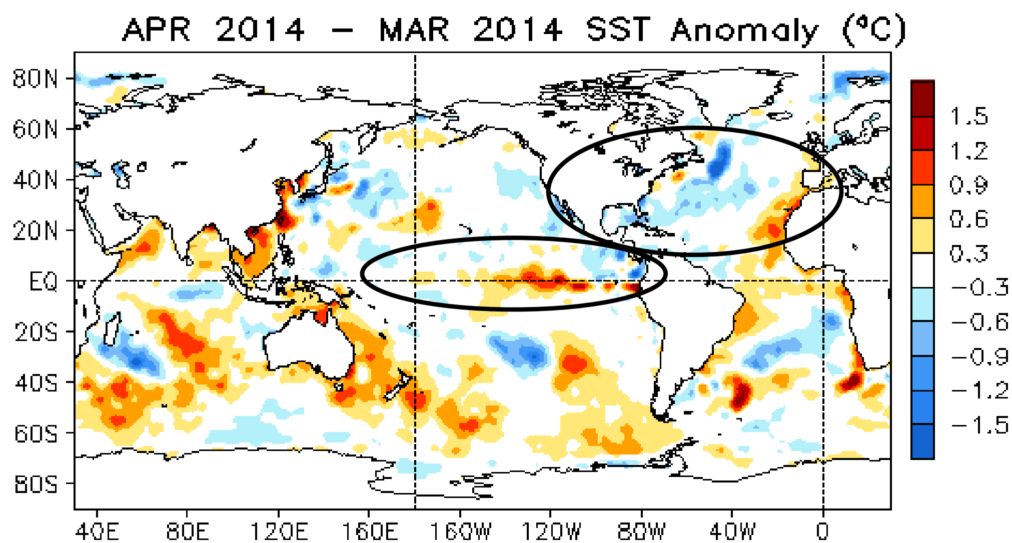
- **Pacific Ocean**
  - **ENSO neutral condition continued with NINO3.4=0.2°C in Apr 2014.**
  - **Positive anomalies of subsurface ocean temperature along the equator propagated eastward and some surface westerly wind anomalies in the equatorial Pacific were observed in Apr 2014.**
  - **All models predicted a warming tendency in this year, and majority of the models predicted an El Nino starting this summer.**
  - **NOAA "ENSO Diagnostic Discussion" on 8 May 2014 issued "El Nino Watch" and suggests that "Chance of El Niño increases during the remainder of the year, exceeding 65% during summer".**
  - **PDO switched to positive phase in Mar 2014 and strengthened in Apr 2014 with PDO index =0.81.**
- **Indian Ocean**
  - **Positive SSTA mainly presented in the tropical southern Indian Ocean in Apr 2014.**
- **Atlantic Ocean**
  - **NAO switched into positive phase in Feb 2014 and NAOI=0.19 in Apr 2014.**
  - **Tripole pattern of SSTA presented in North Atlantic in Apr 2014.**

Global Oceans

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



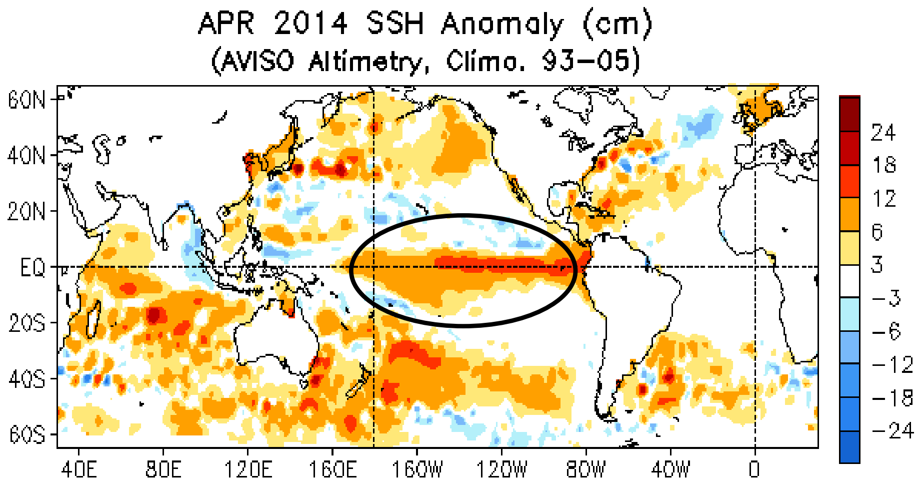
- **SSTA became positive in the equatorial eastern Pacific.**
- **Positive (negative) SSTA persisted in the northeastern (southwestern) Pacific.**
- **Tripole SSTAs continued in the North Atlantic.**
- **Positive SSTAs presented in the tropical southern Indian Ocean.**
- **Some large SSTAs existed in the South Ocean.**

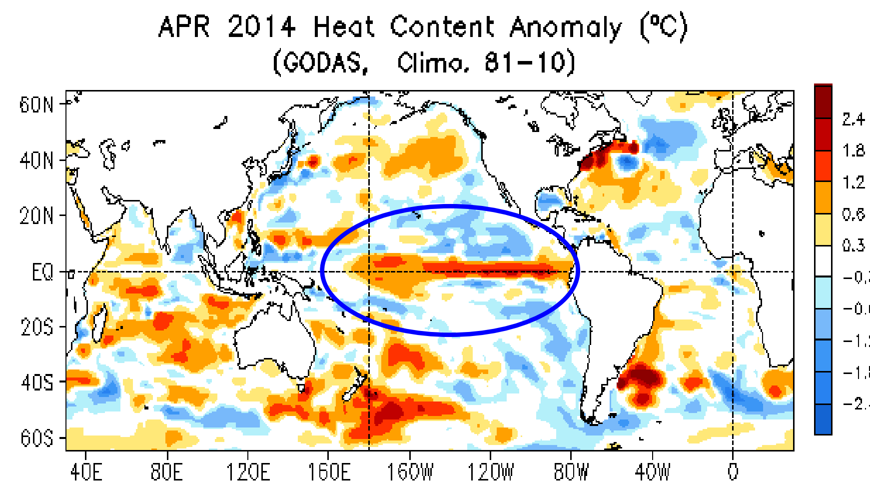


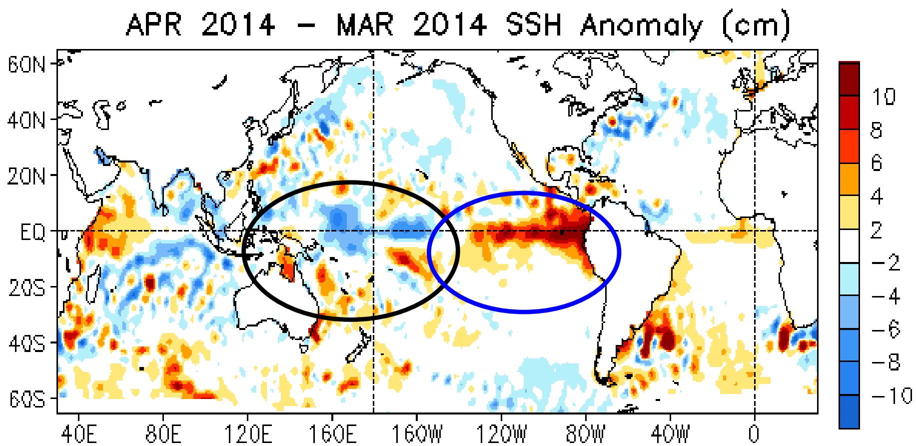
- **Large positive SSTA tendencies were observed in the eastern equatorial Pacific Ocean, due to downwelling Kelvin waves.**
- **Some cooling tendencies presented in the mid-latitudes of North Atlantic.**

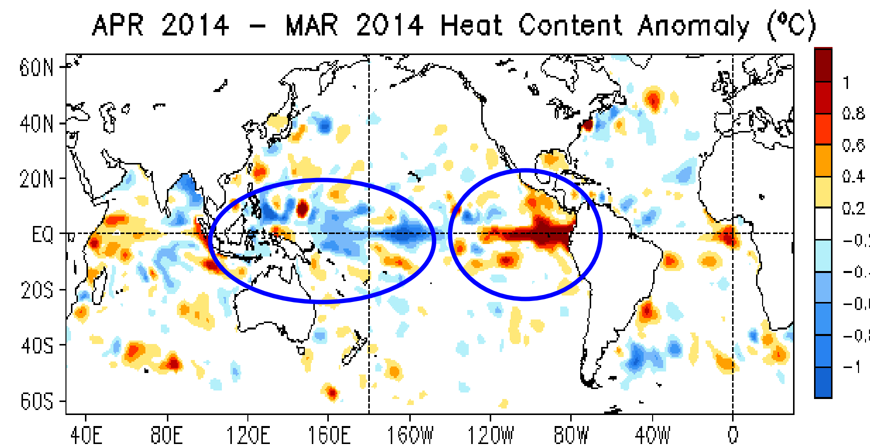
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency





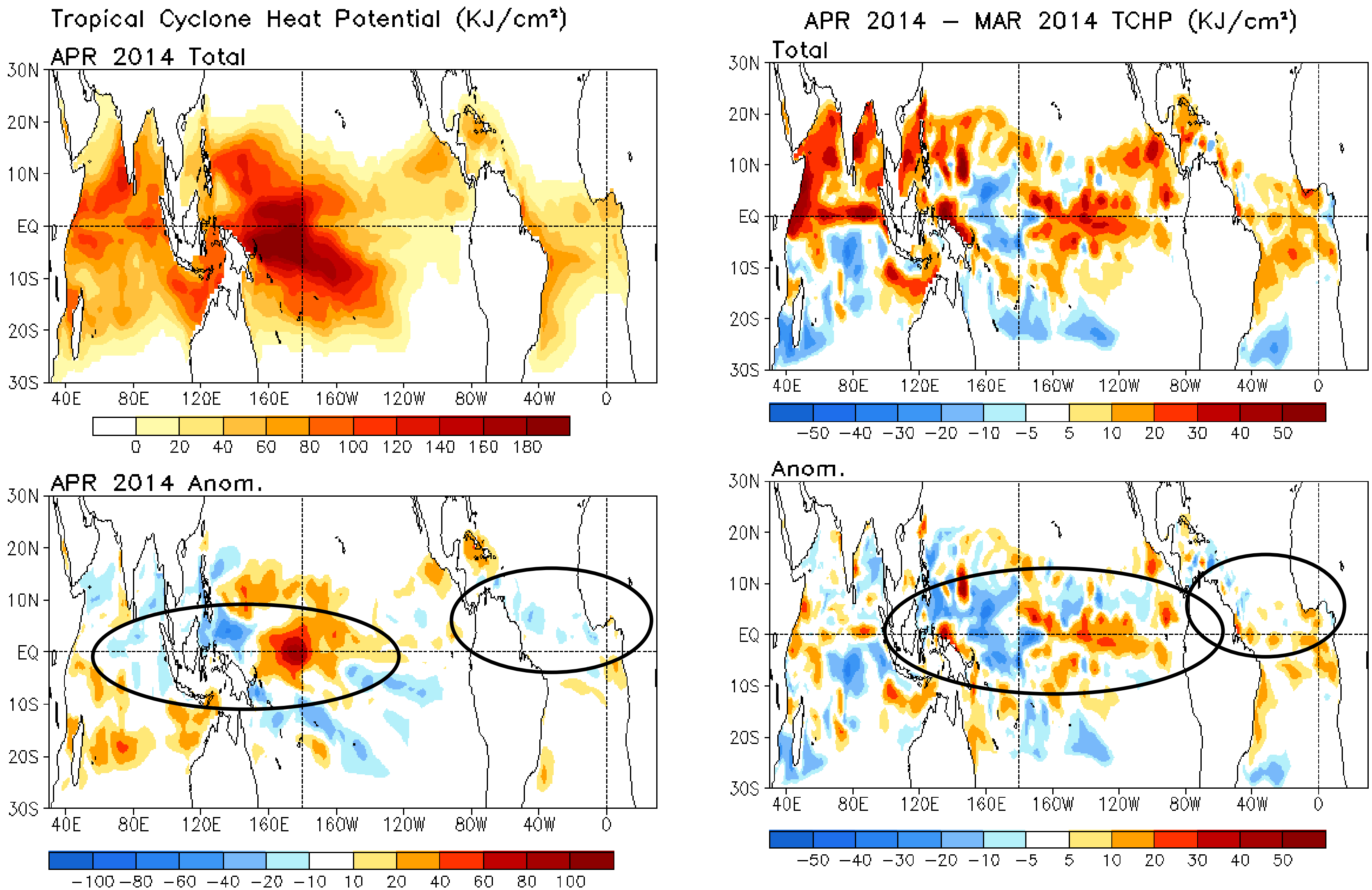




- The SSHA was overall consistent with HC300A: Positive (negative) HC300A is tied up with positive (negative) SSHA.

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

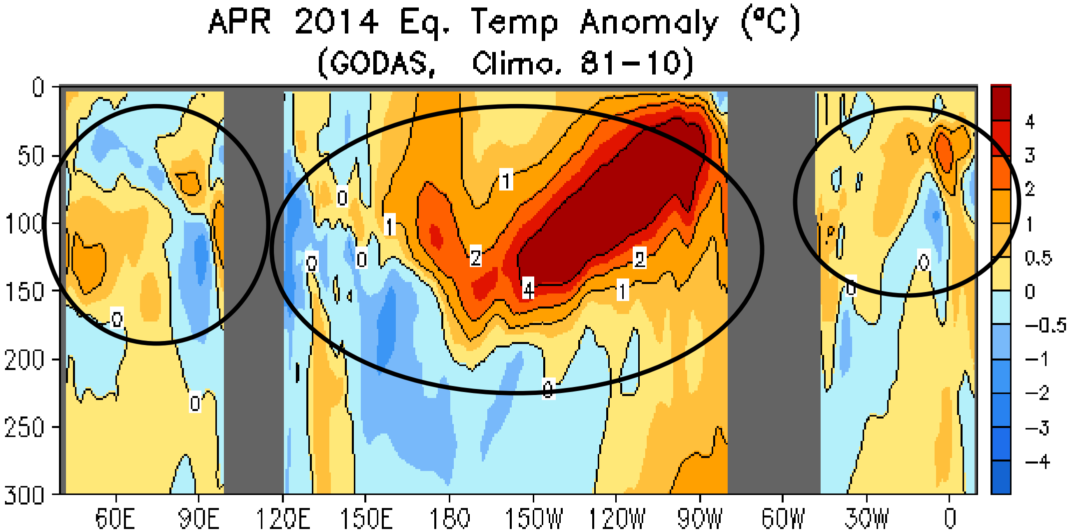
- Negative (positive) SSHA /HC300A tendency in the western and central (eastern) equatorial Pacific is associated with Kelvin wave activity and may indicate the potential development of El Nino.



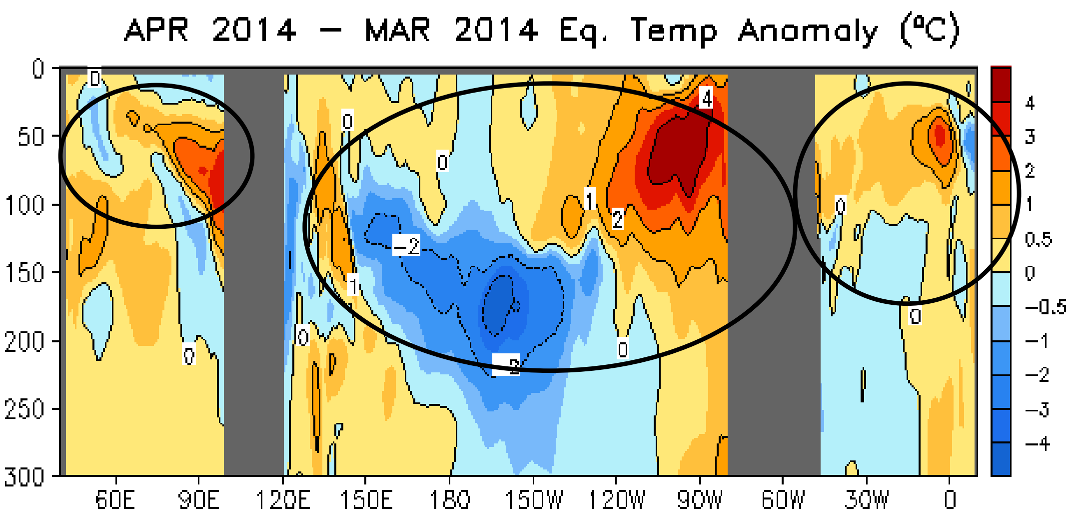
- **Positive TCHP anomalies presented in the c. equatorial Pacific and negative ones in the w. Pacific.**
- **Small negative anomalies were observed over the tropical North Atlantic Ocean.**
- **The tendency was positive (negative) in the tropical e. (w.) Pacific and small in the tropical N. Atlantic.**

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

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2^{O}S-2^{O}N



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



- Ocean temperature anomaly tendencies were positive (negative) in the eastern (central) Pacific, suggesting an eastward propagation of the ocean temperature anomalies along the equatorial Pacific thermocline.
- 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.

Global Sea Surface Salinity (SSS)

Anomaly for April 2014

- Sea water freshened over western Pacific and eastern Indian oceans and salted over northern Pacific and northern Atlantic, attributable largely to the fresh water flux especially the precipitation anomaly

- In particular, positive precipitation anomaly of large magnitude observed over tropical western Pacific

- Data used

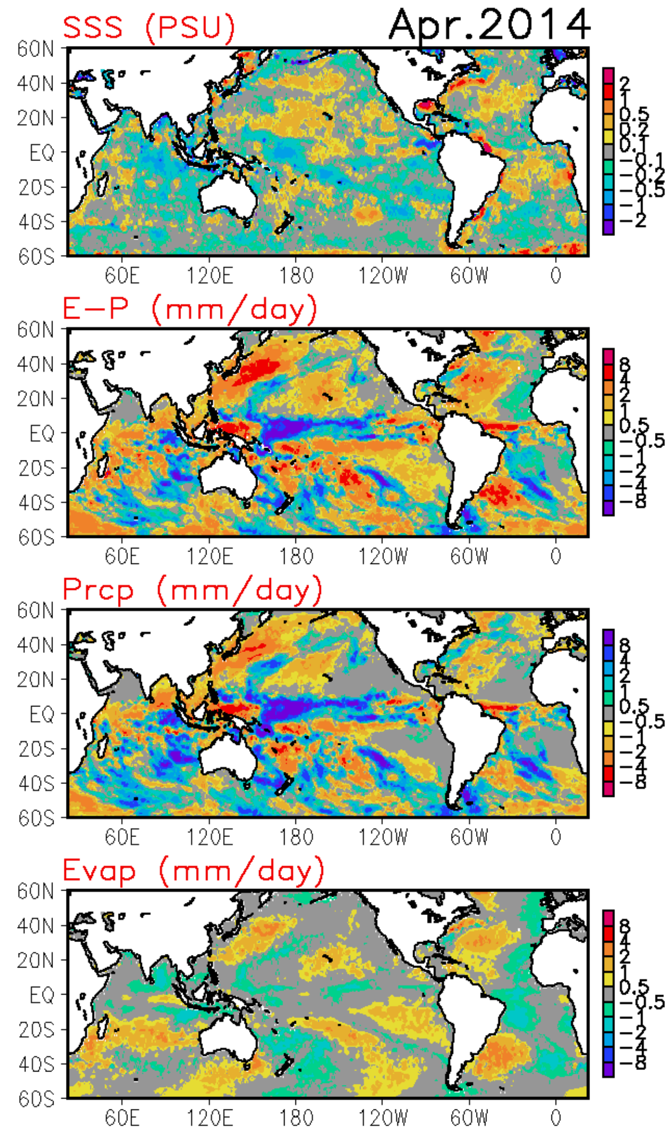
  SSS :

  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

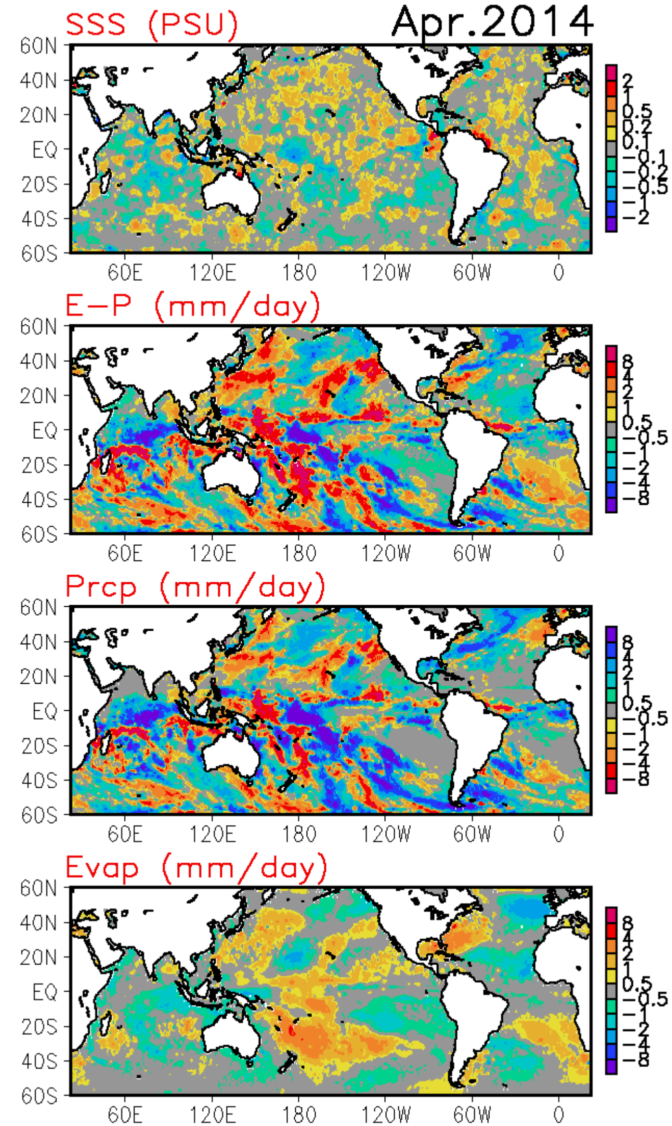


Global Sea Surface Salinity (SSS)

Tendency for Apr-Mar 2014

- Freshened SSS anomaly over western Pacific and eastern Indian oceans in association with the positive fresh water flux. In particular, intensified SPCZ precipitation over the western Pacific substantially freshened the ocean over this monthly period.

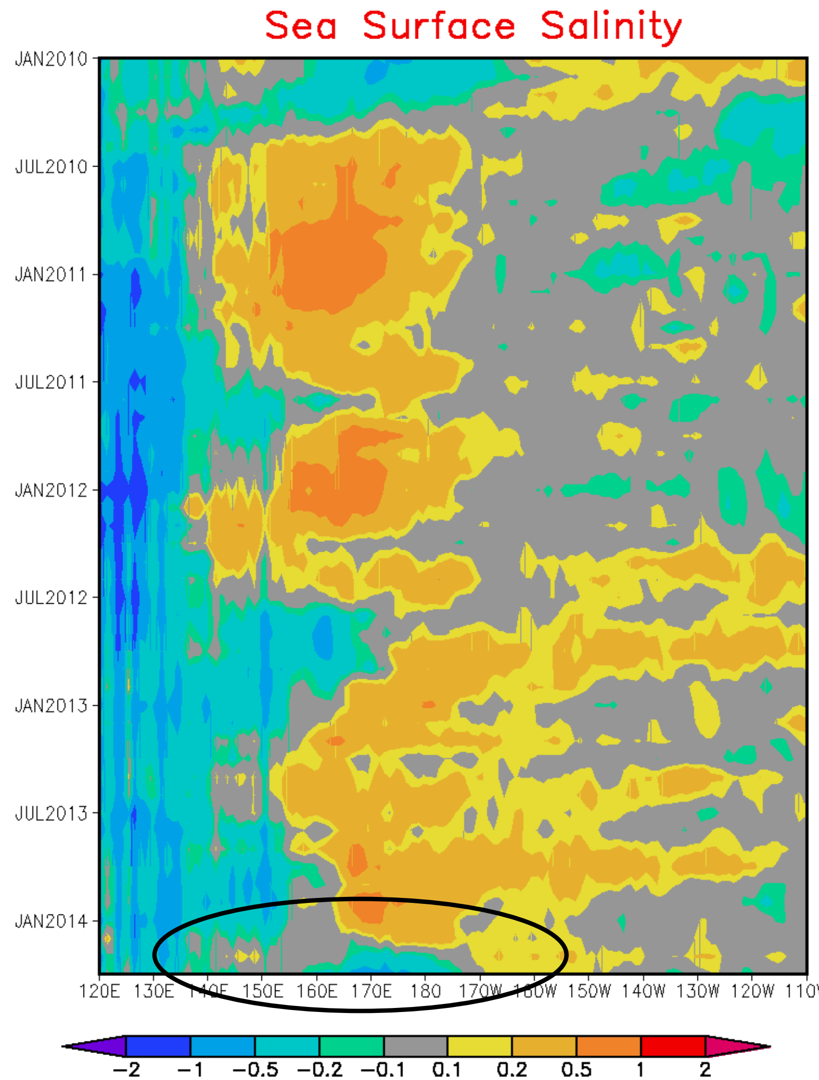
- Positive SSS anomaly off the northern coast of the South America continent needs further examinations with regard to the SSS analysis reliability and river run off



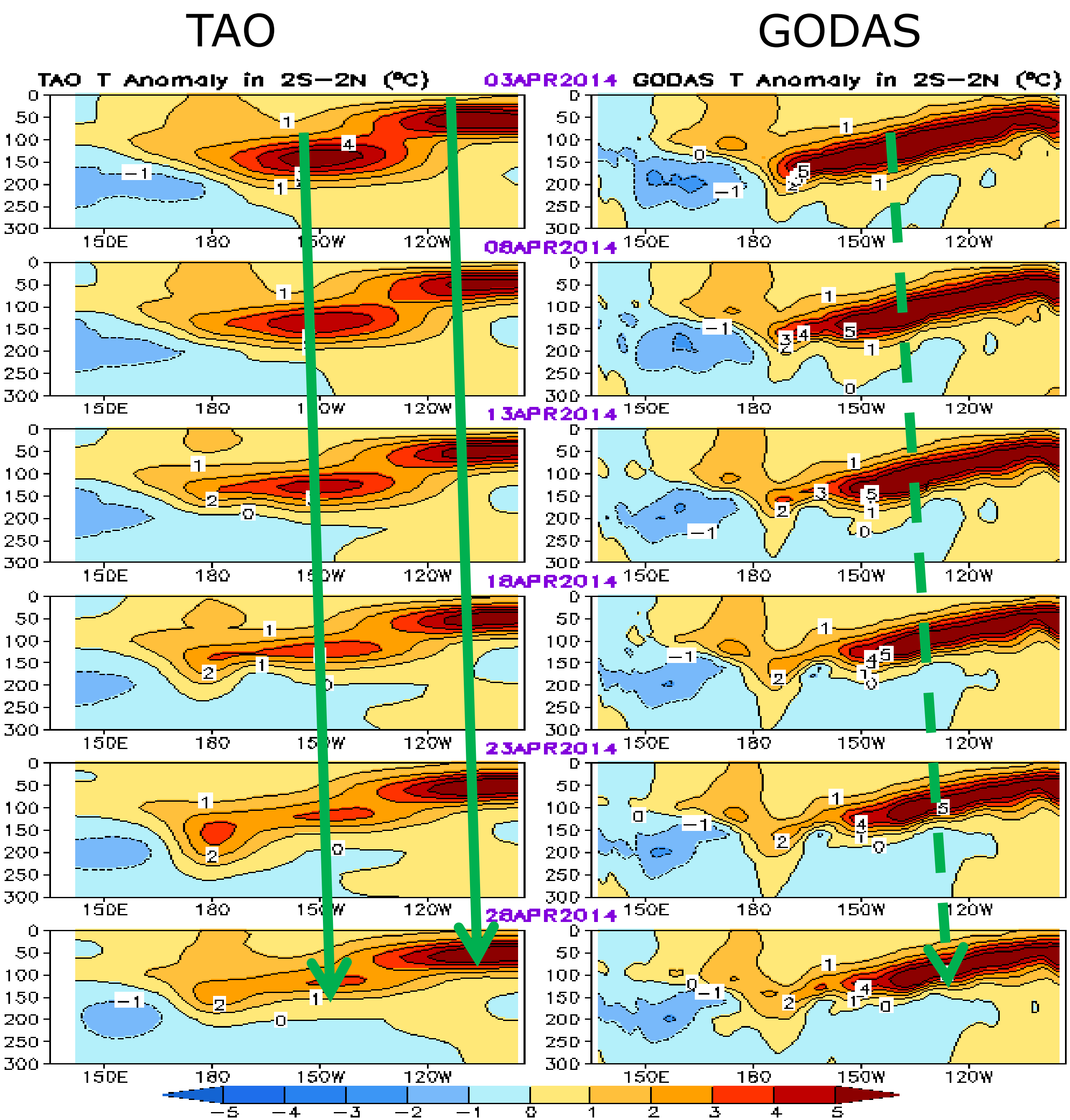
Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific

- Hovemoller diagram for equatorial SSS anomaly (5°S-50°N);
- SSS exhibits negative / positive anomalies over the Western / Central-Eastern Pacific over recent three years;
- Negative SSS anomaly intensifies and extends eastward and reaches to the dateline last month;

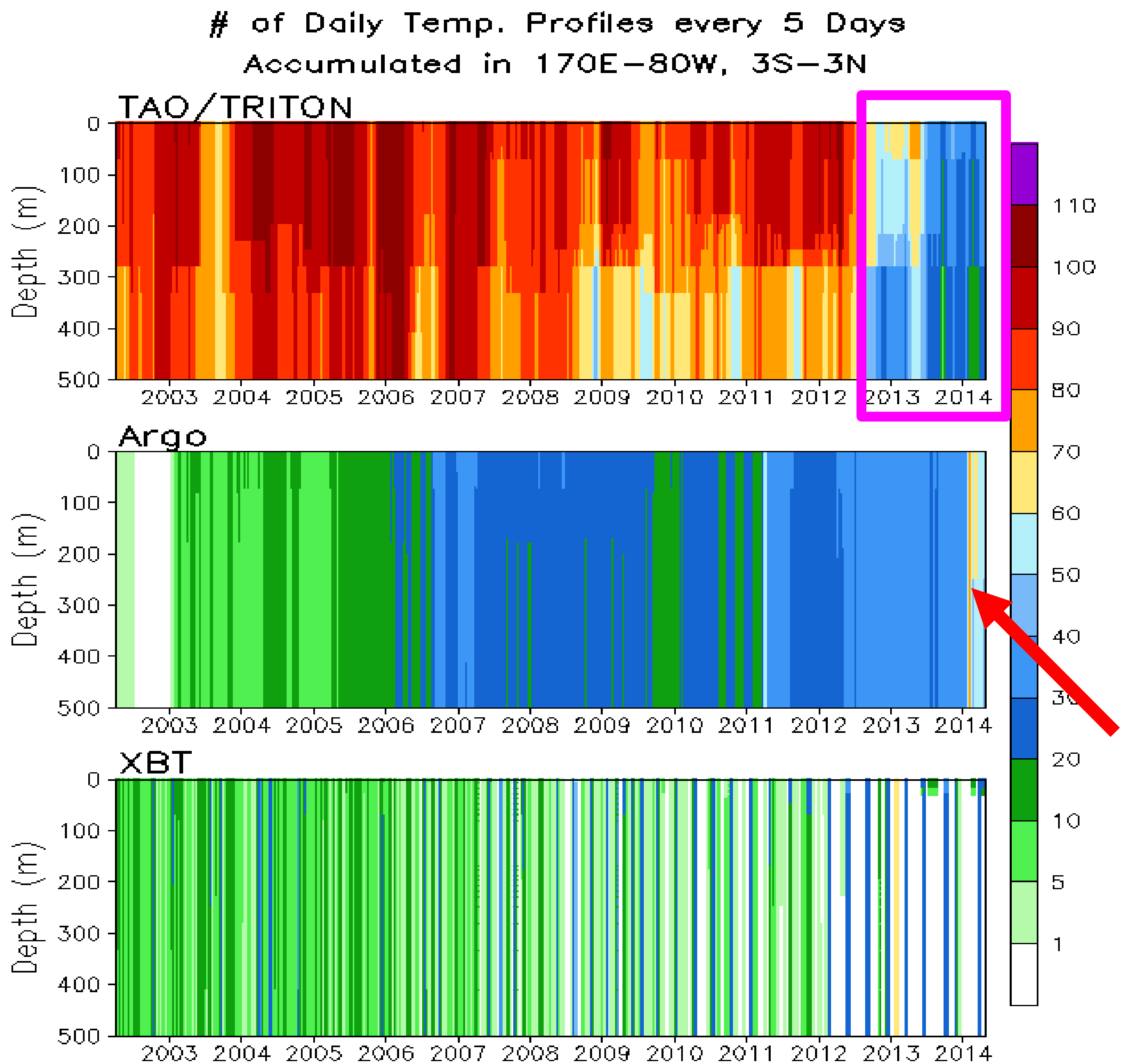


Tropical Pacific Ocean and ENSO Conditions

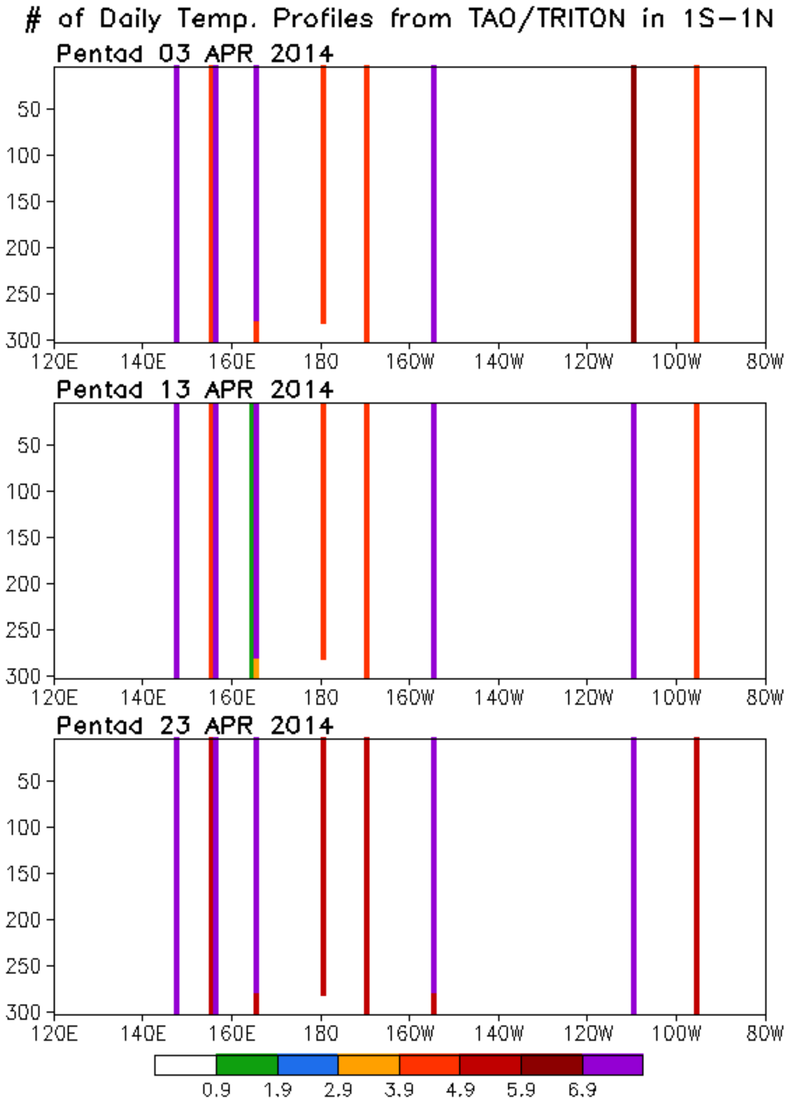


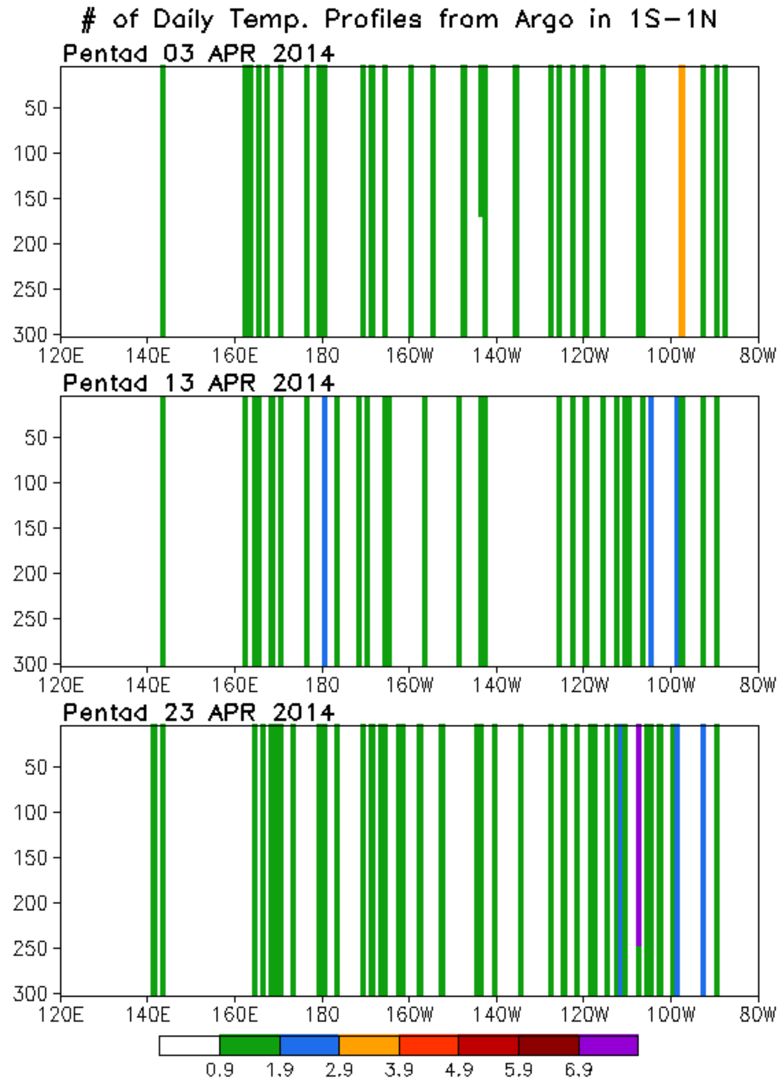
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly:

The disagreement between TAO and GODAS may be partially due to shortage 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.**



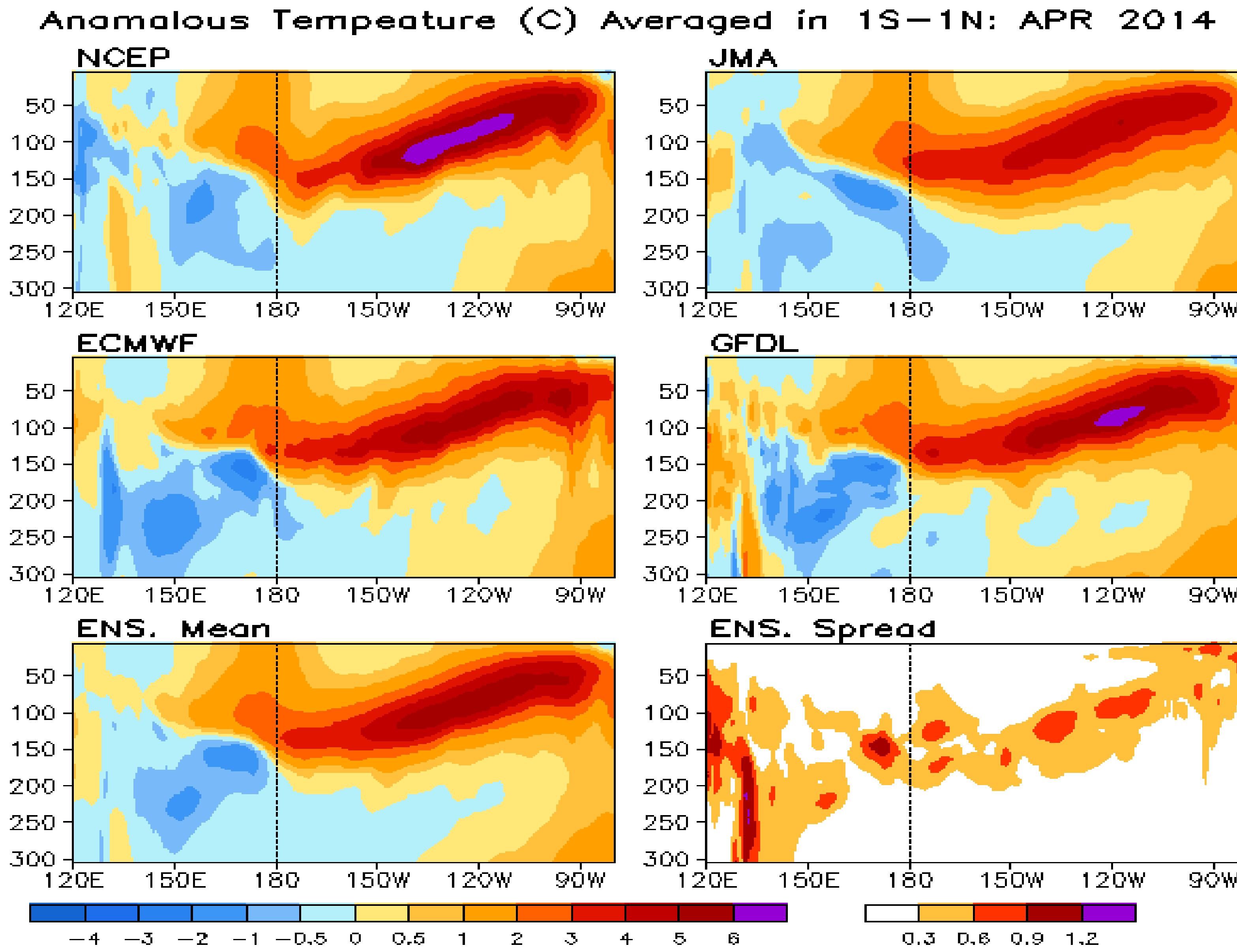


- **TAO data delivery rate decreased significantly since late 2012 (http://origin.cpc.ncep.noaa.gov/products/GODAS/insitu/anum_zt.gif).**

- **There were recovery of the eastern moorings in Apr 2014!**

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

Multiple Ocean Reanalyses: Temp. Anom. along the Equator



CPC Home > GODAS Home > CPC Monthly Ocean Briefing > Real Time Ocean Reanalysis Intercomprison

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

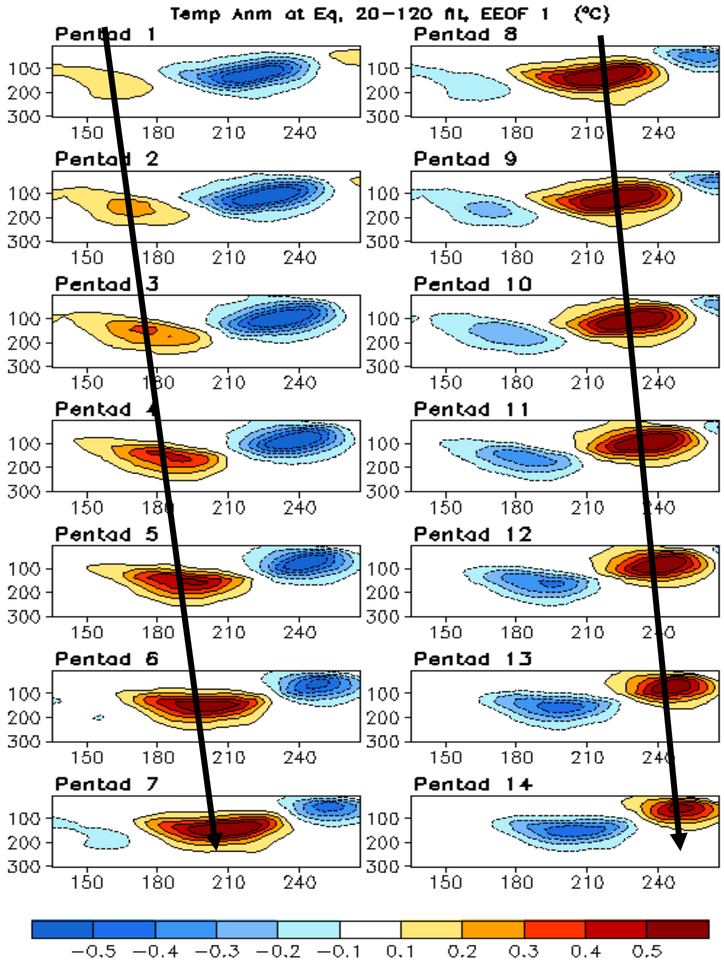
- **Climate Indices**
  - Depth of 20C isotherm anomaly in NINO3: last 4 years last 15 years 1979-present
  - Depth of 20C isotherm anomaly in NINO4: last 4 years last 15 years 1979-present
  - Upper 300m heat content anomaly in NINO3: last 4 years last 15 years 1979-present
  - Upper 300m heat content 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

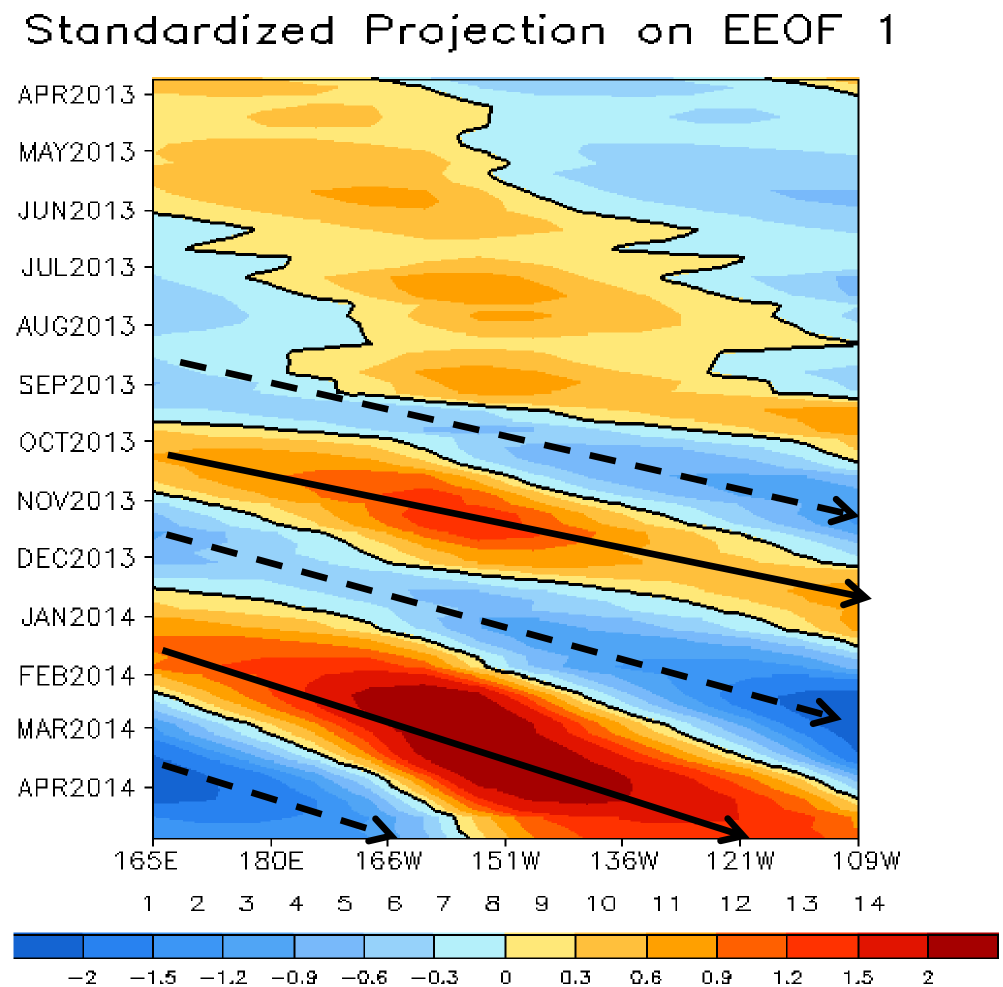
Global Ocean

- **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

Oceanic Kelvin Wave (OKW) Index



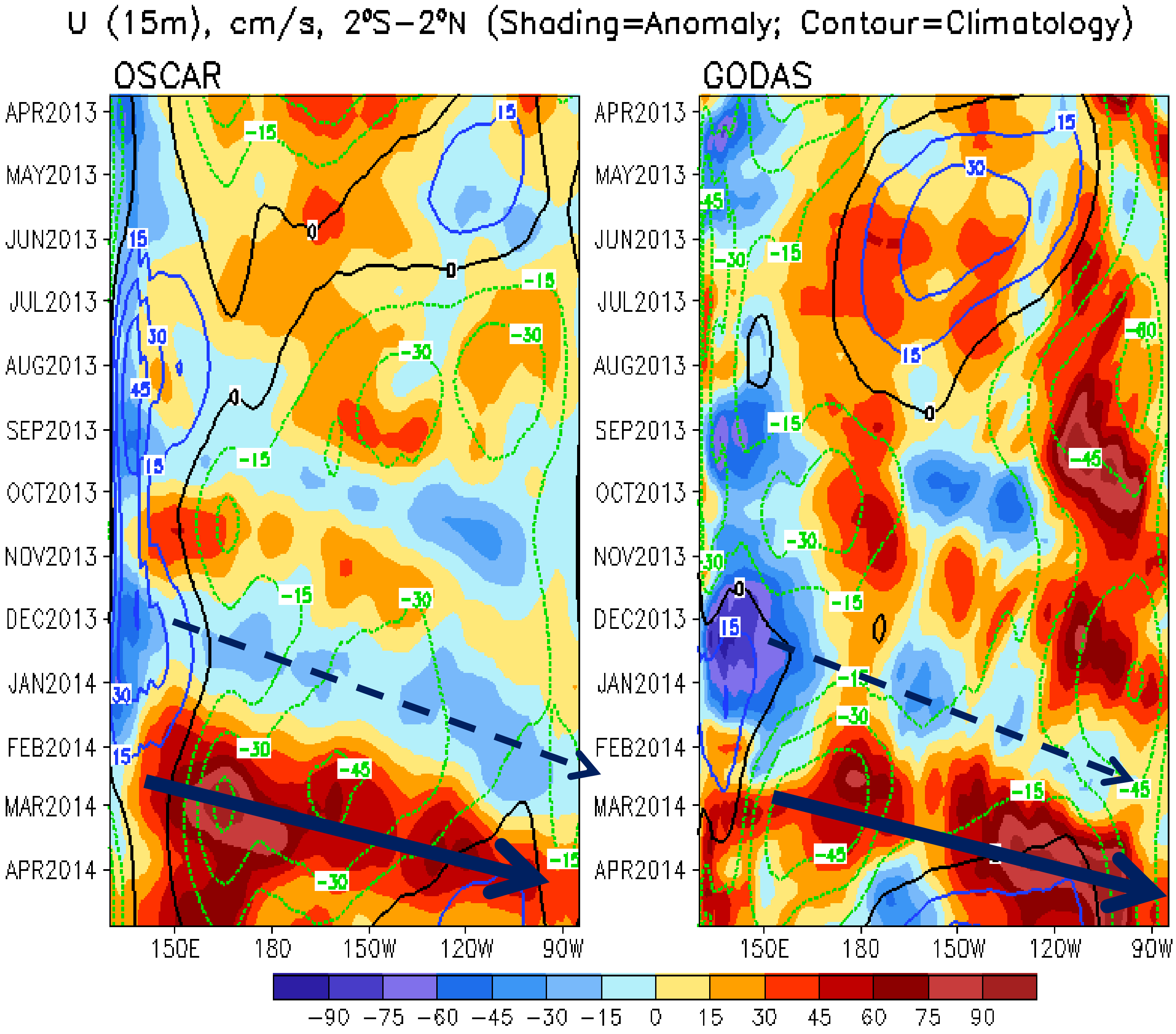


- Downwelling OKW (solid line) emerged since Jan 2014 in the W. Pacific, while upwelling OKW initiated in mid-Feb in the W. Pacific.

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

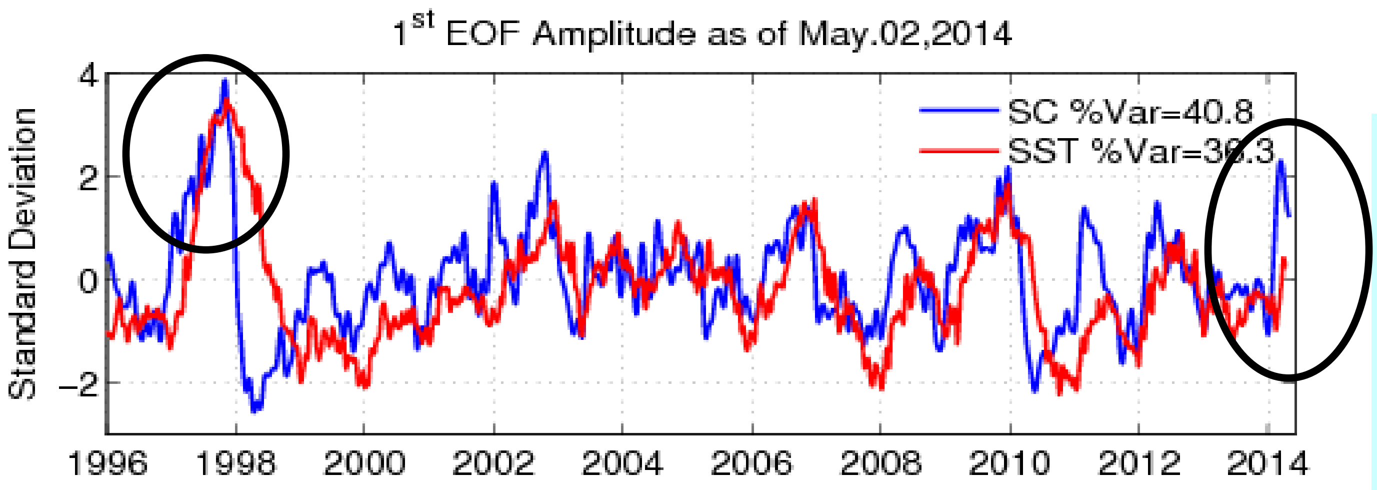
- OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).

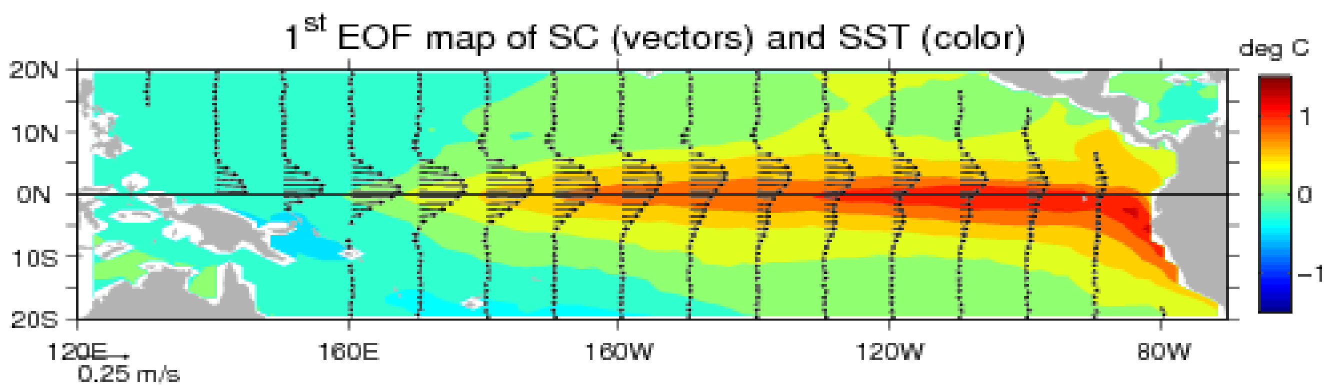
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **The anomalous current pattern was generally similar between OSCAR and GODAS in the last 6-7 months.**
- **Strong eastward current initiated in Feb 2014 and propagated eastward and reached the eastern boundary in the end of Mar 2014.**
- **That is consistent with the evolution of ocean temperature & D20 anomaly along the equator Pacific in the last a few months.**

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





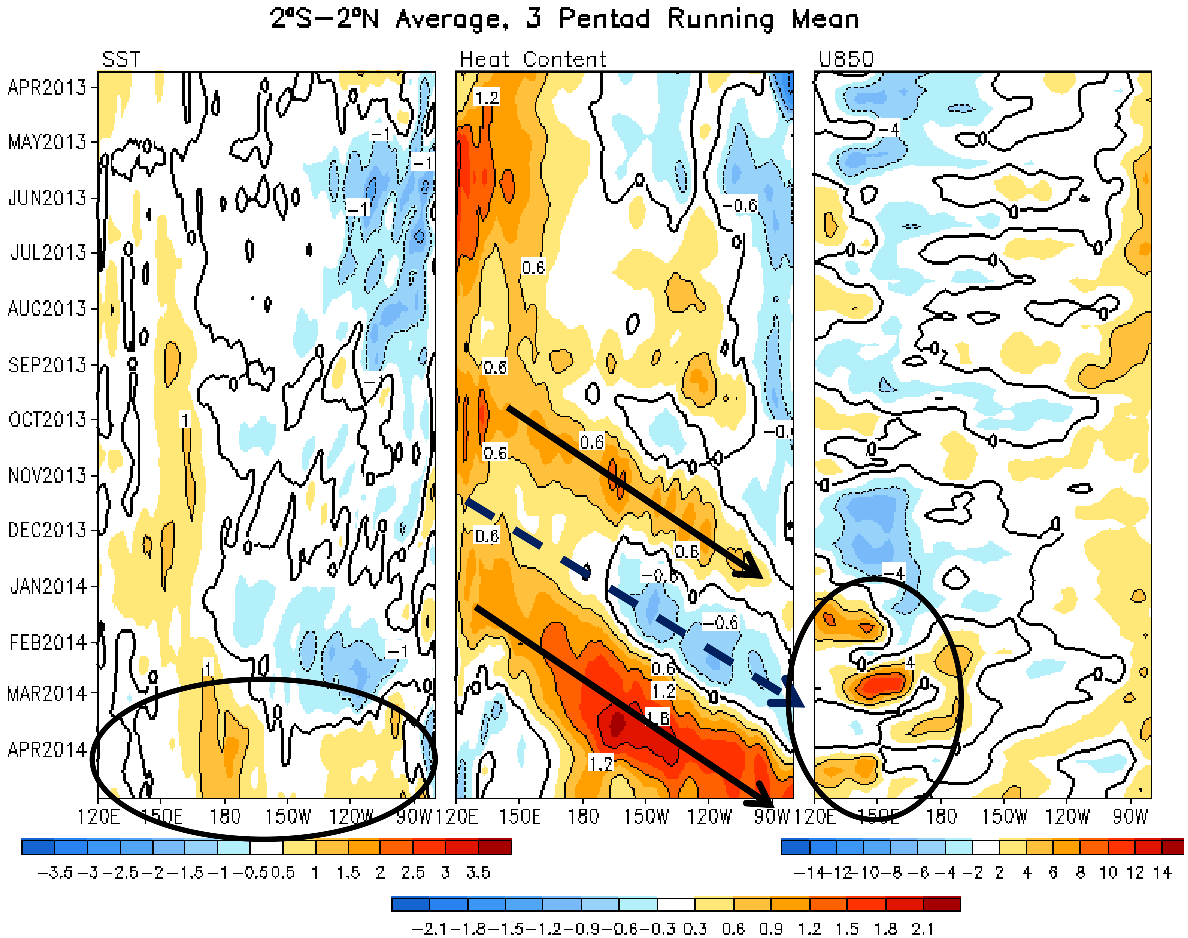
Earth & Space Research

- Westward surface zonal current anomaly weakened recently, and it is weaker than that associated with 1997/98 El Nino.

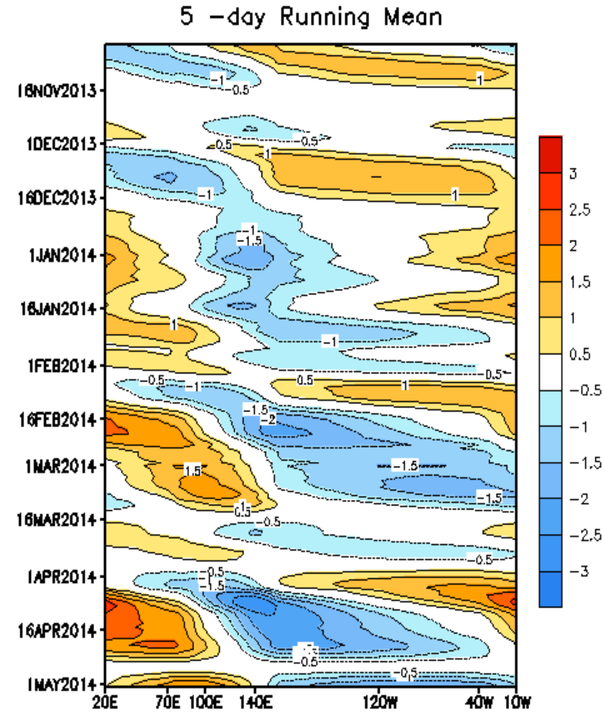
- Statistically, ocean surface zonal current anomaly leads the SSTA by a few months.

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 3 months.**
- **Positive HC300 anomalies initiated in Dec 2013 and propagated eastward.**
- **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

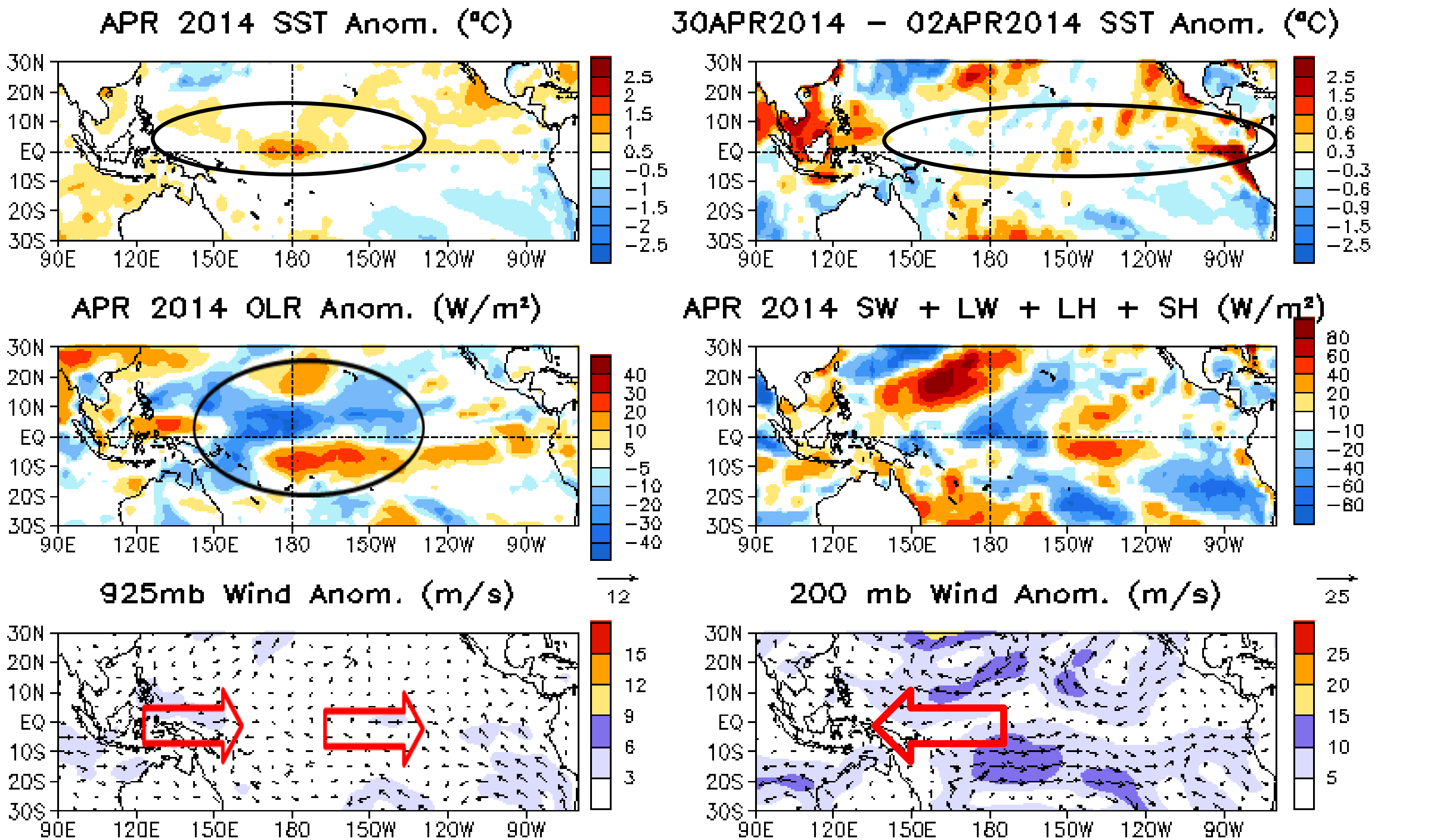
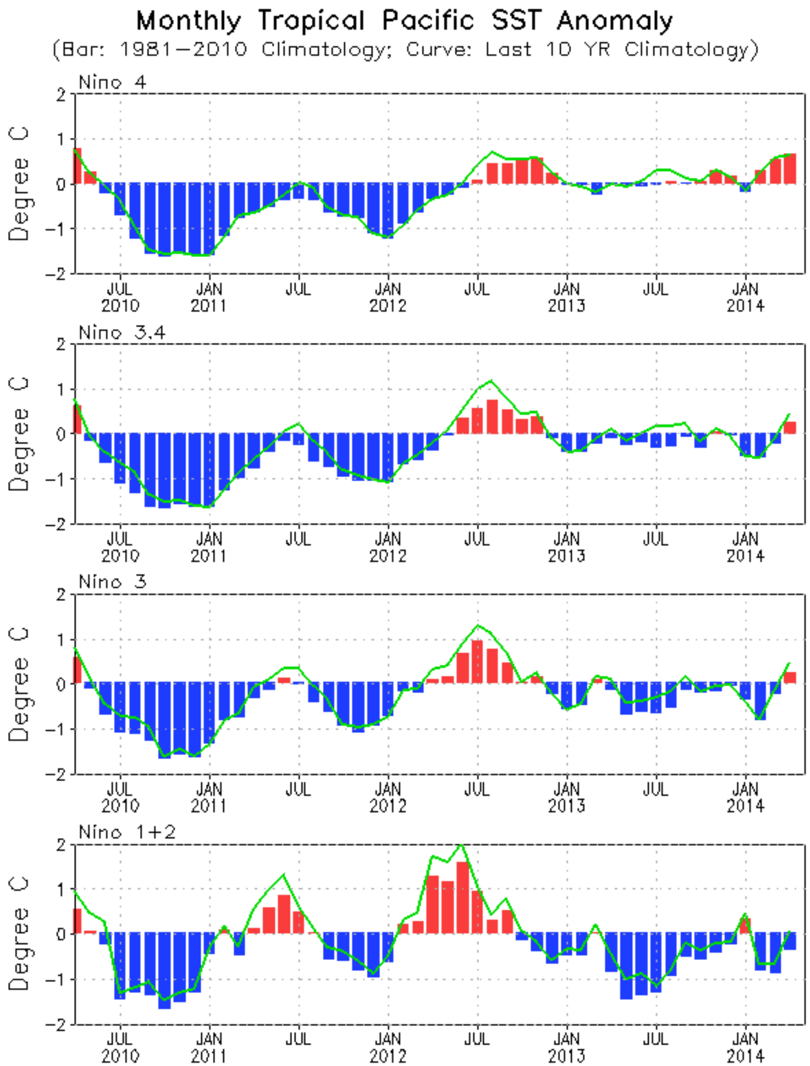
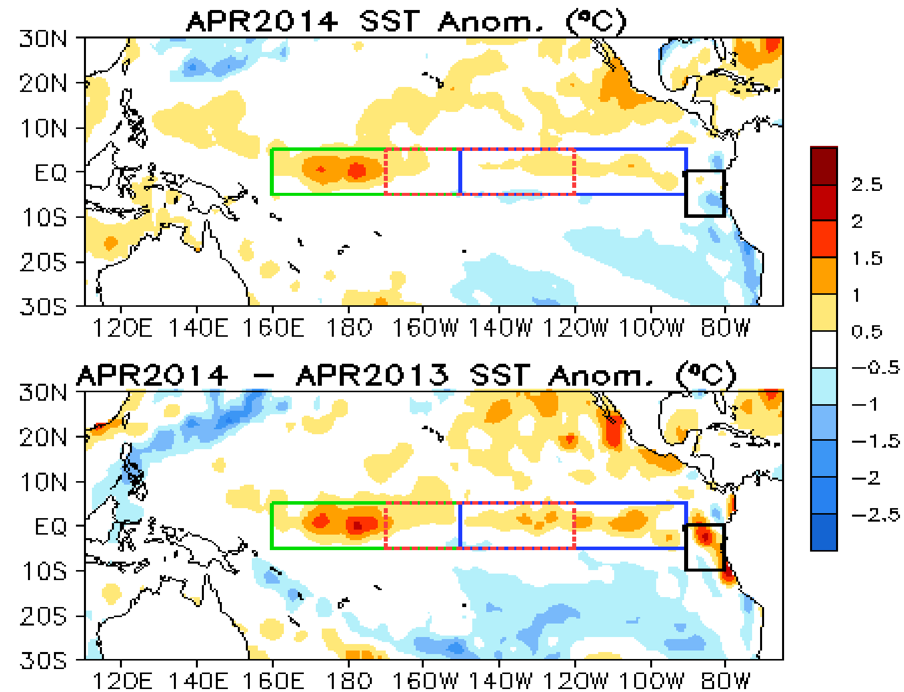


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 had a positive tendency since Mar 2014.**

- **Nino3.4 = 0.2°C in Apr 2014.**

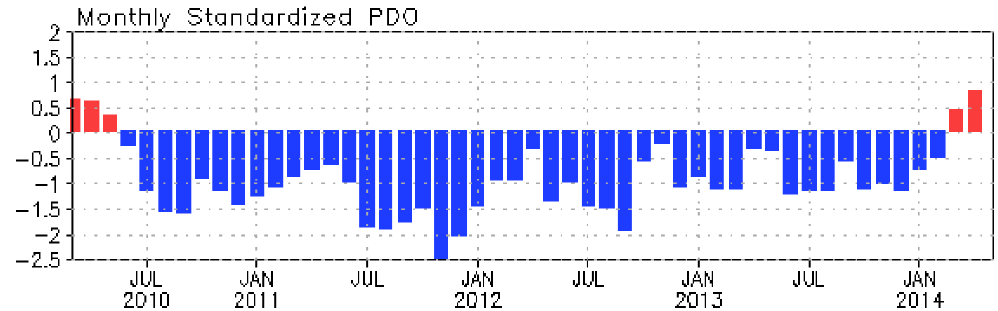
- **Compared with last Apr, SST was warmer in the equatorial Pacific in Apr 2014.**

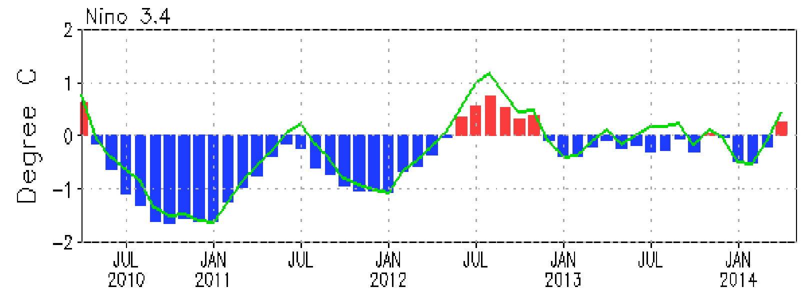
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

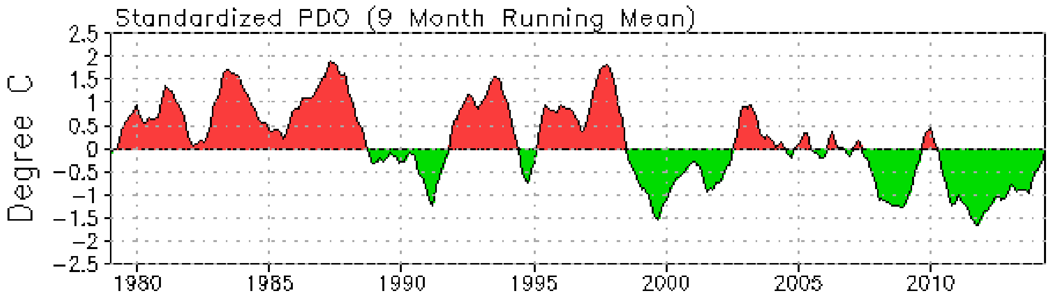
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

North Pacific & Arctic Oceans

PDO index

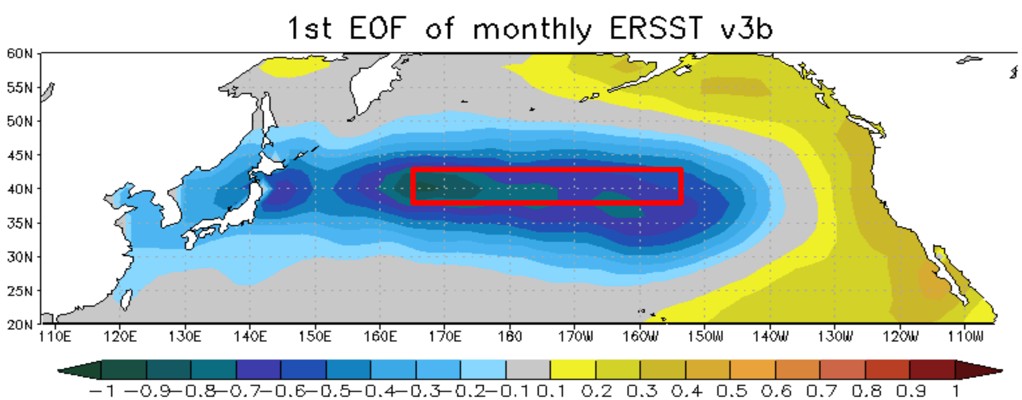






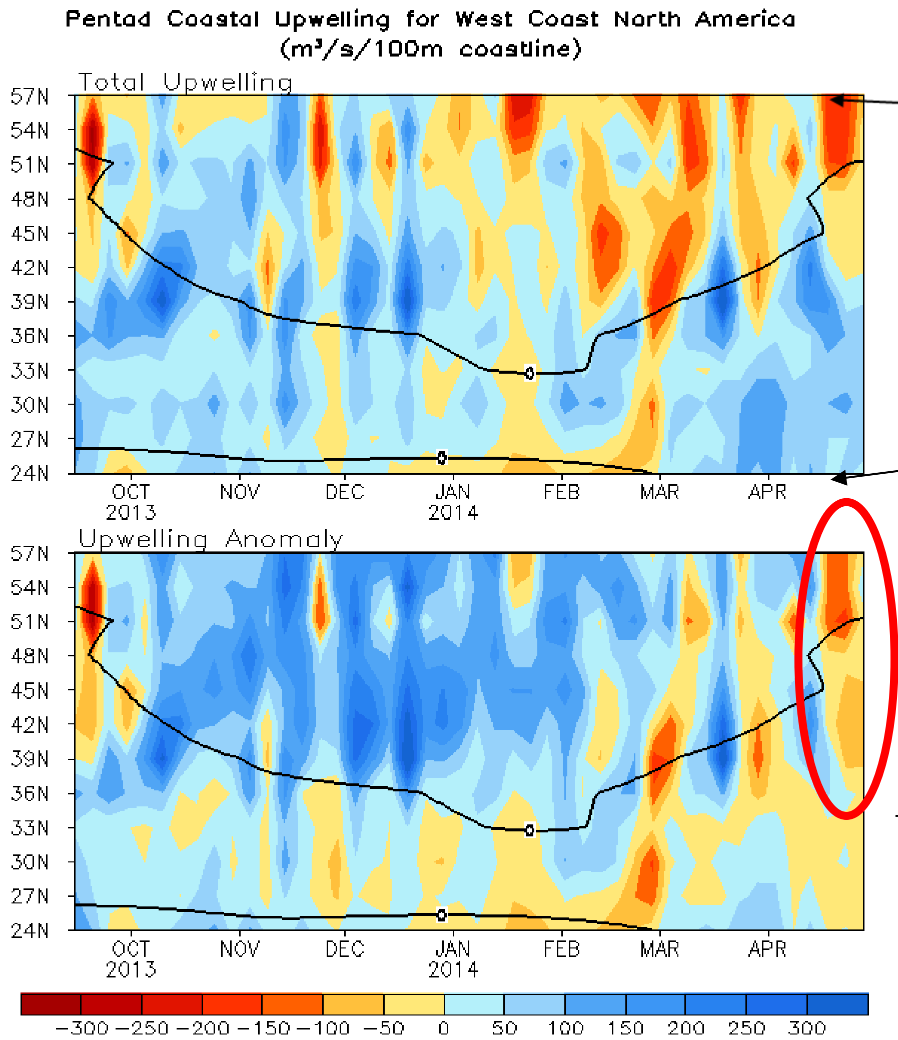
-PDO switched to positive phase in Mar 2014 and strengthened in Apr 2014 with PDO index =0.81.

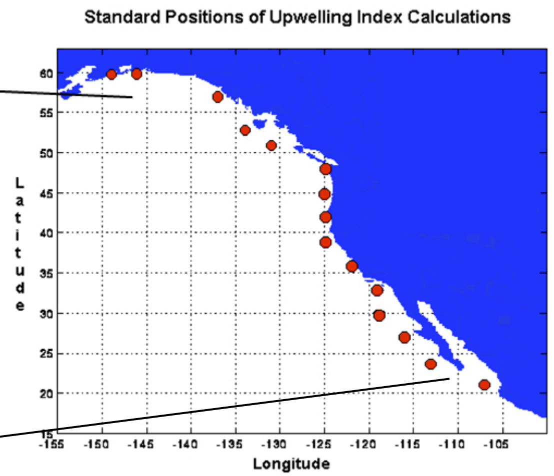
- Statistically, ENSO and PDO are connected, may through atmospheric bridge.



- 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





- **Anomalous downwelling in 36-57N was observed in second-half of Apr 2014.**

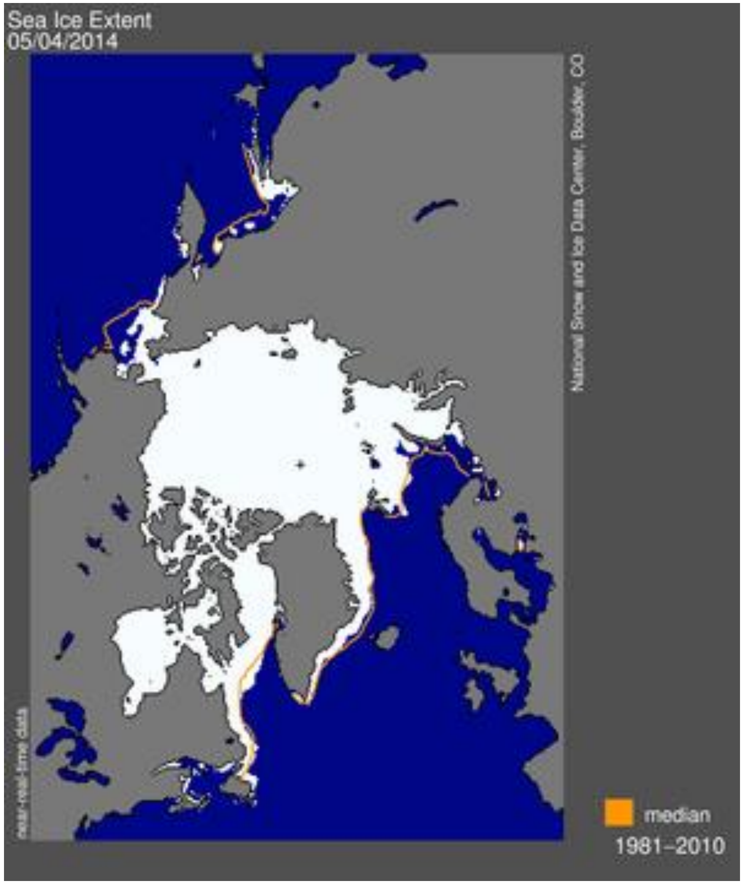
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point (m³/s/100m coastline). Anomalies are departures from the 1981-2010 base period pentad means.

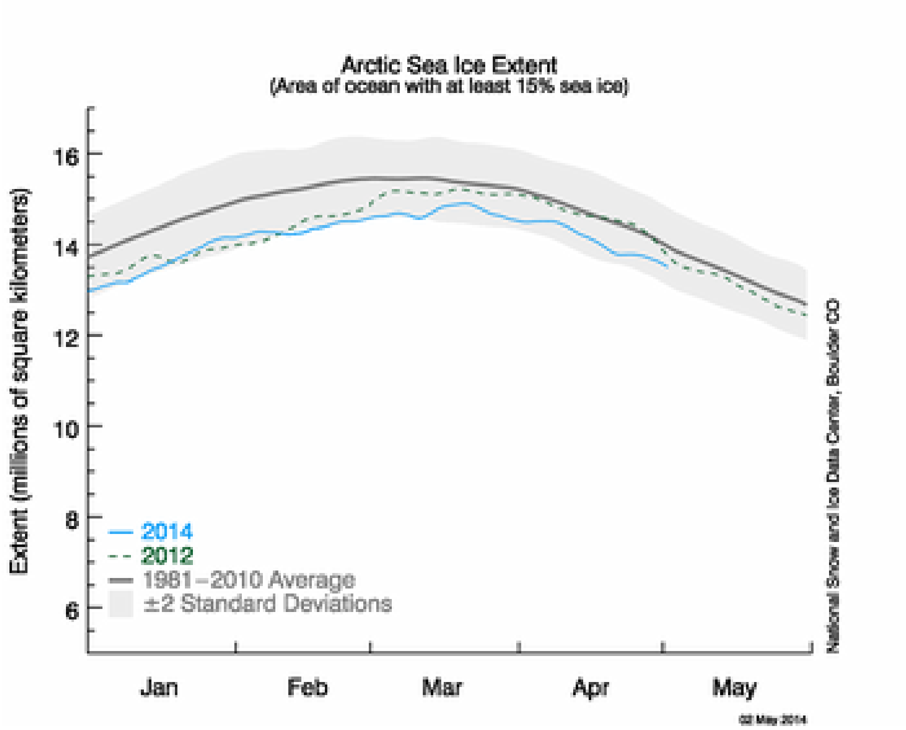
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.**

Arctic Sea Ice

National Snow and Ice Data Center

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

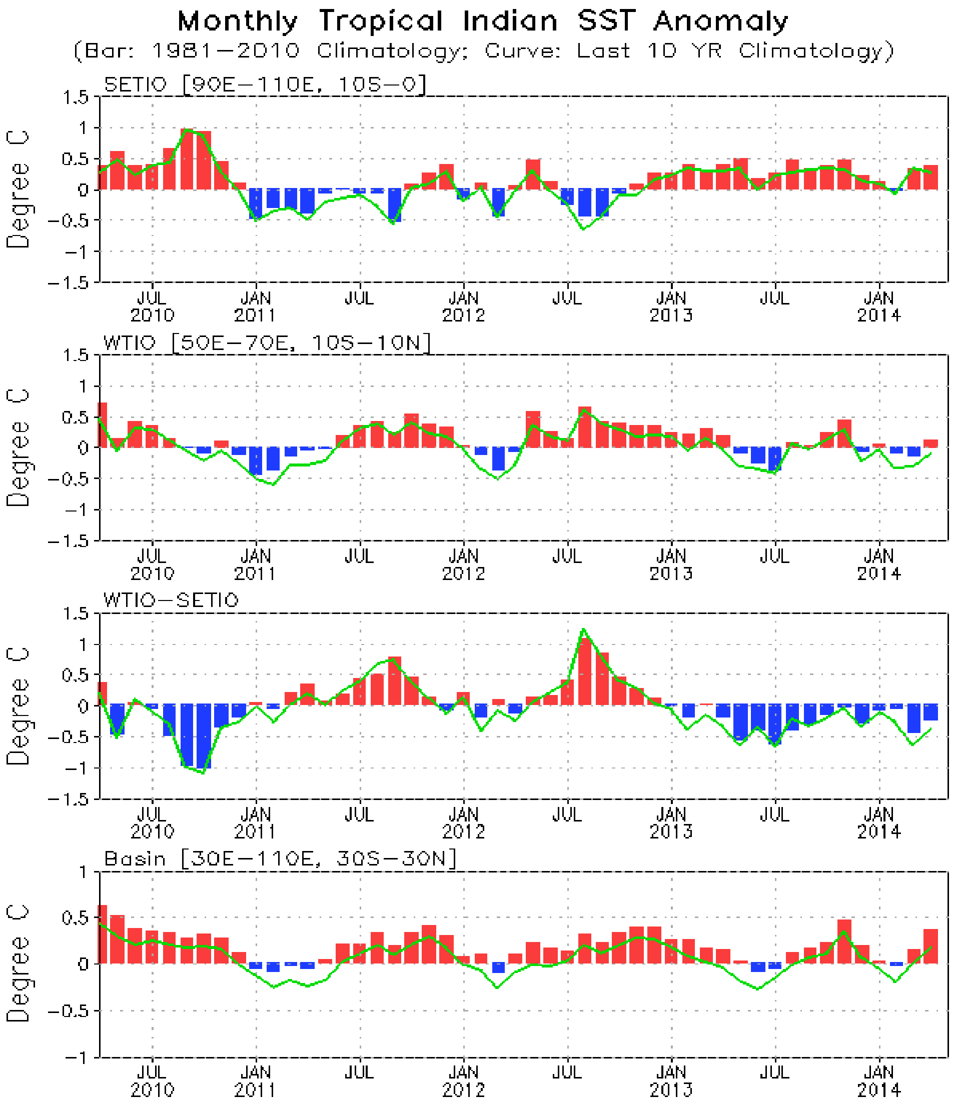


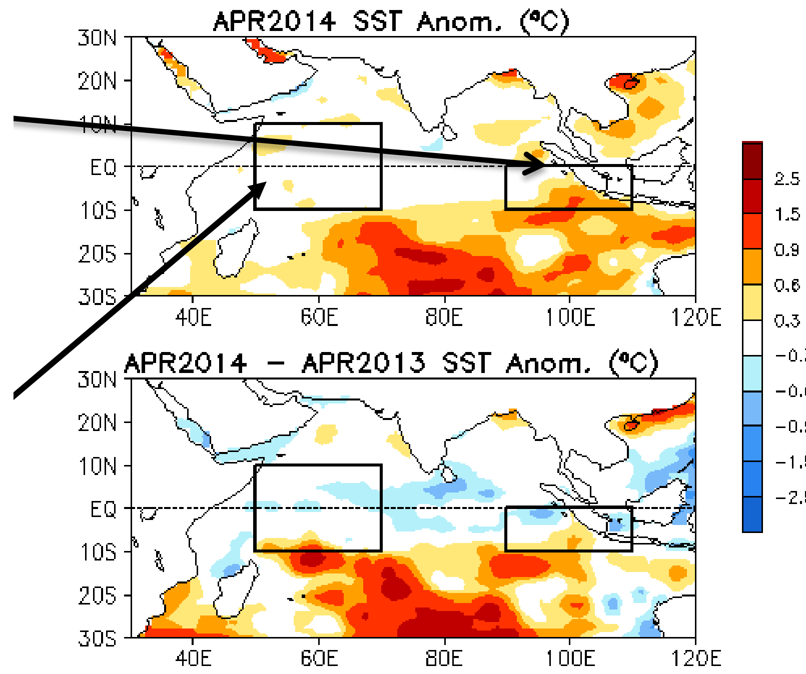


- Arctic sea ice extent was below normal and within -2 standard deviation in Apr 2014.

Indian Ocean

Evolution of Indian Ocean SST Indices





- **Positive SSTA mainly presented in the tropical southern Indian Ocean.**
- **DMI was below normal since Apr 2013.**

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 was ↘ mainly in the southern Indian Ocean.

- Warming (cooling) tendency was observed in the northern (southern) Indian Ocean and meridional anomaly gradient decreased in Apr 2014.

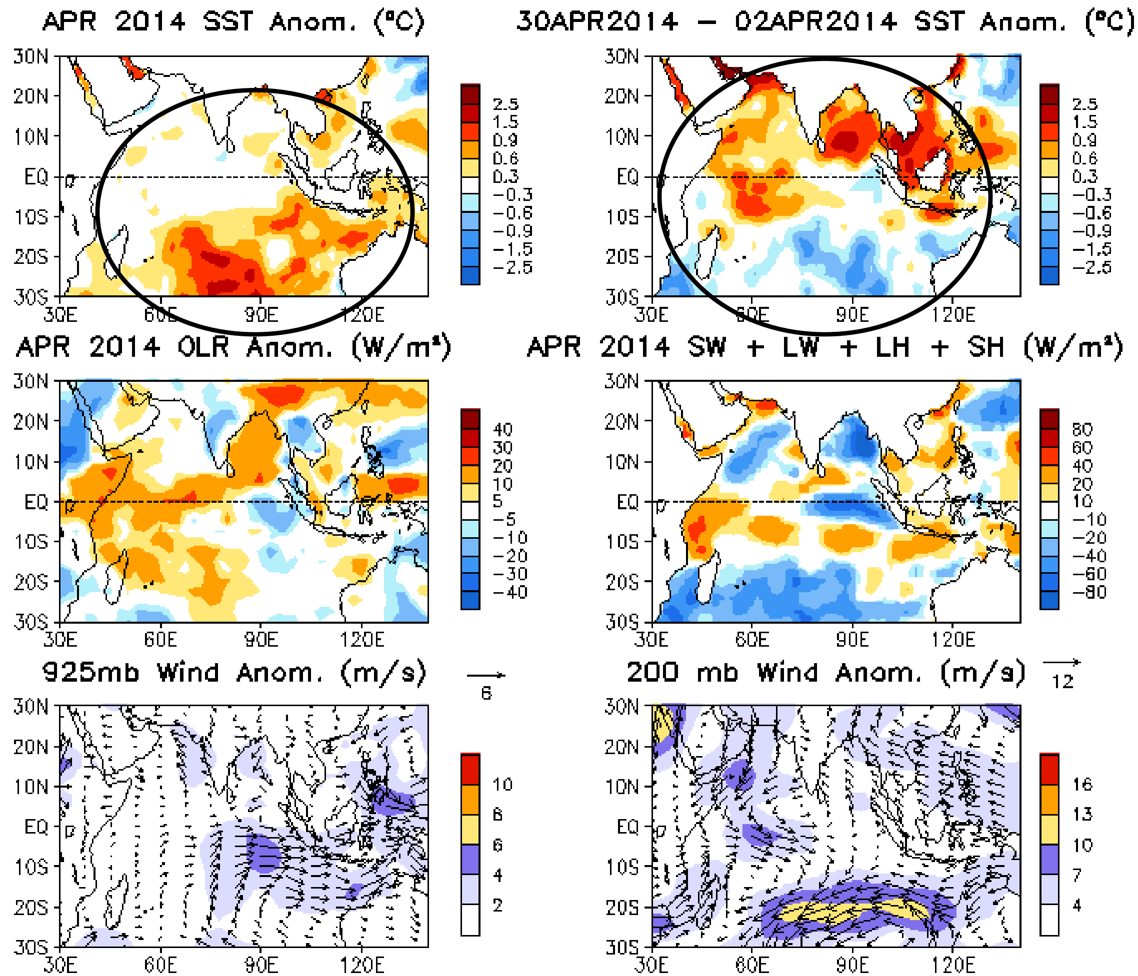
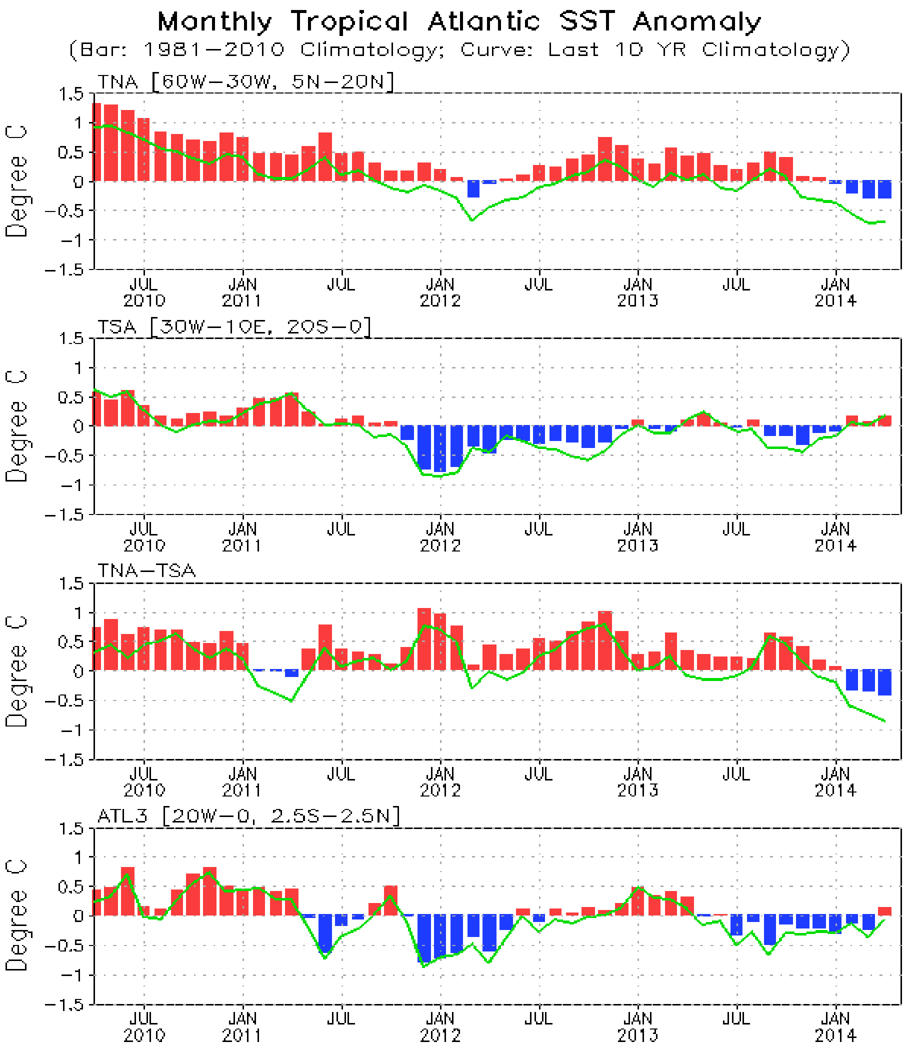
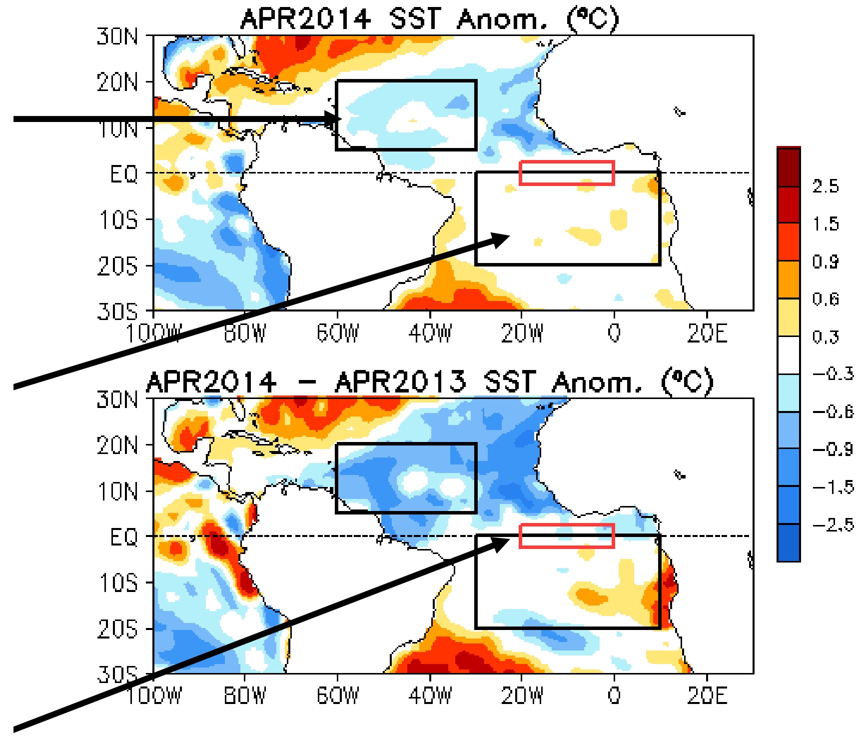


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

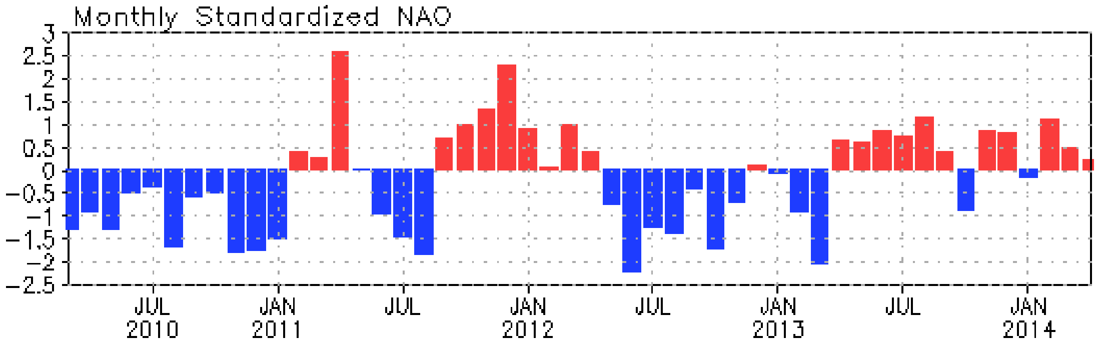


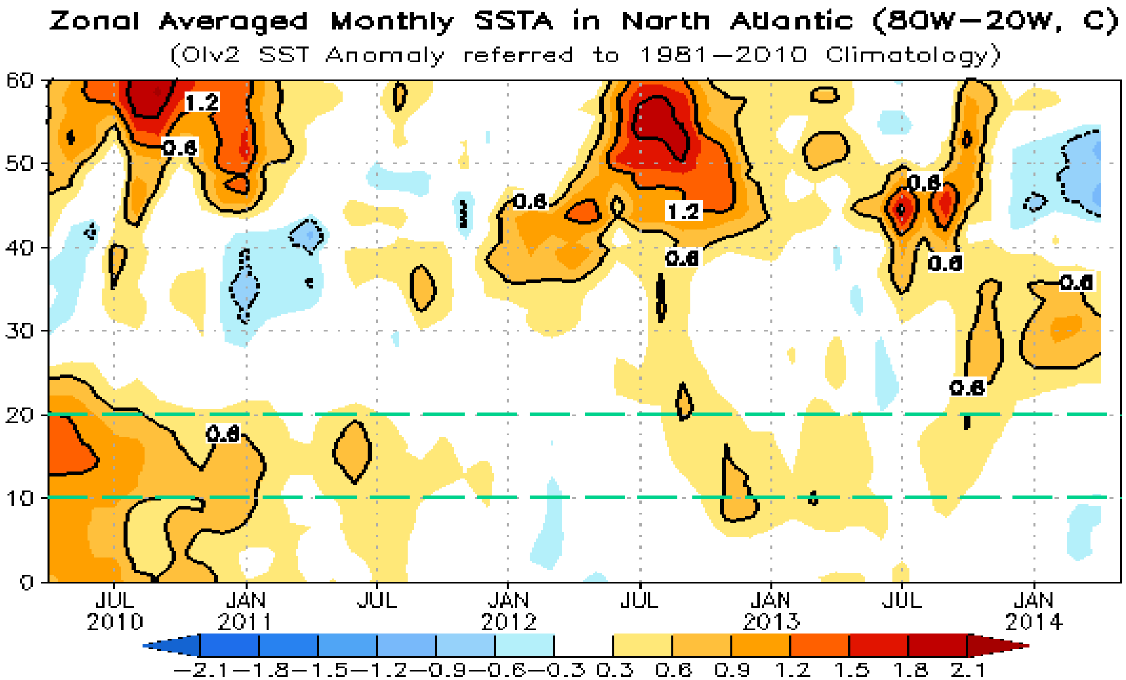


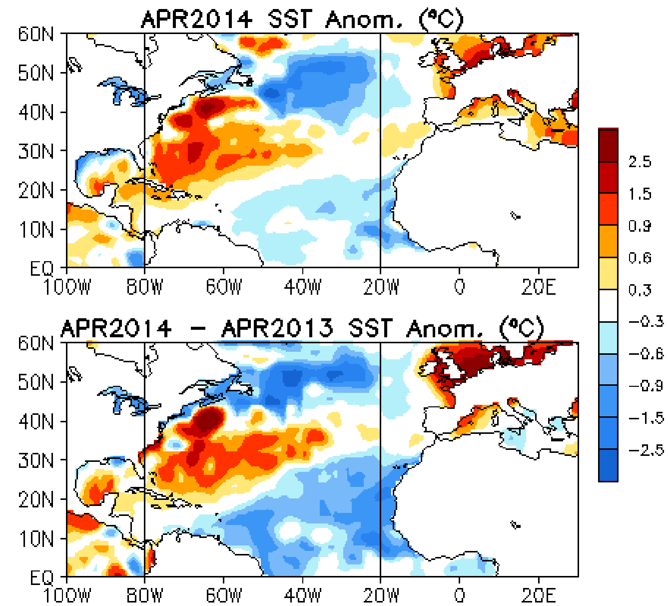
- **Tropical North Atlantic (TNA) index was small since Nov 2013.**
- **Tropical South Atlantic (TSA) index was small since Dec 2012.**
- **Meridional Gradient Mode (TNA-TSA) has been switched to negative phase in Feb 2014.**
- **ATL3 SSTA became small positive in Apr 2014.**
- **Tropical North Atlantic in Apr 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 (°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 anomalies are departures from the 1981-2010 base period means.

NAO and SST Anomaly in North Atlantic







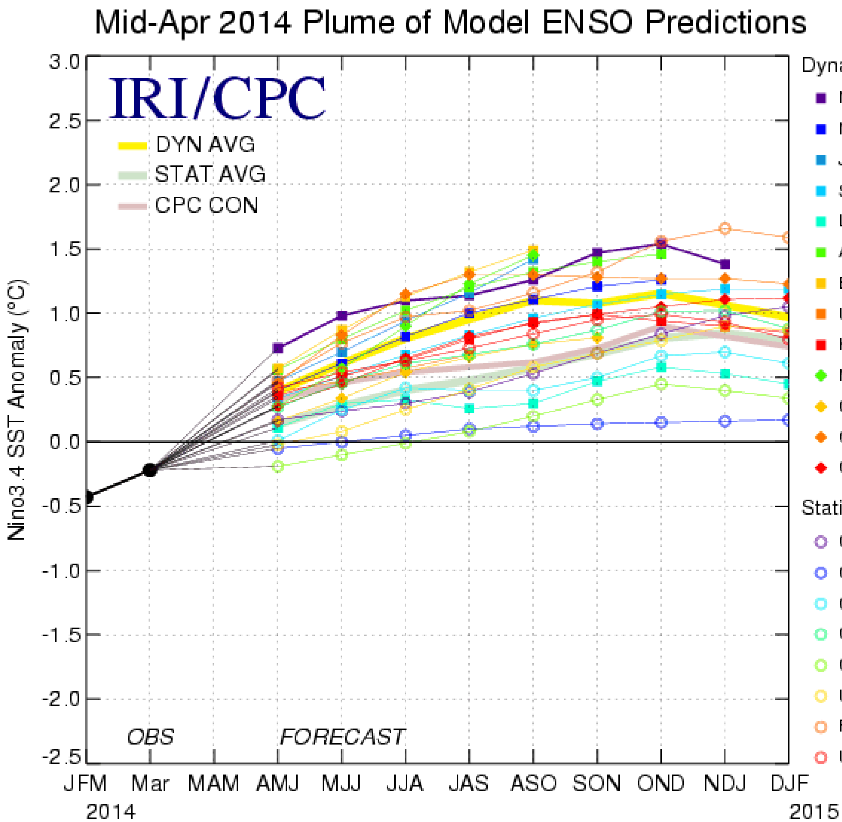
- Positive phase of NAO persisted and weakened with NAOI=0.19 in Apr 2014.

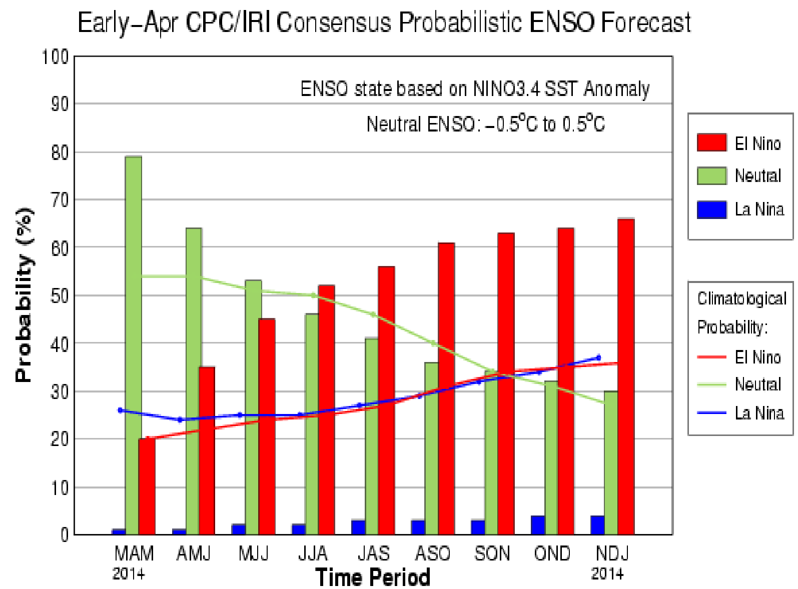
- North Atlantic tripole-like SSTAs were observed, may partially due to the forcing of positive phase of NAO .

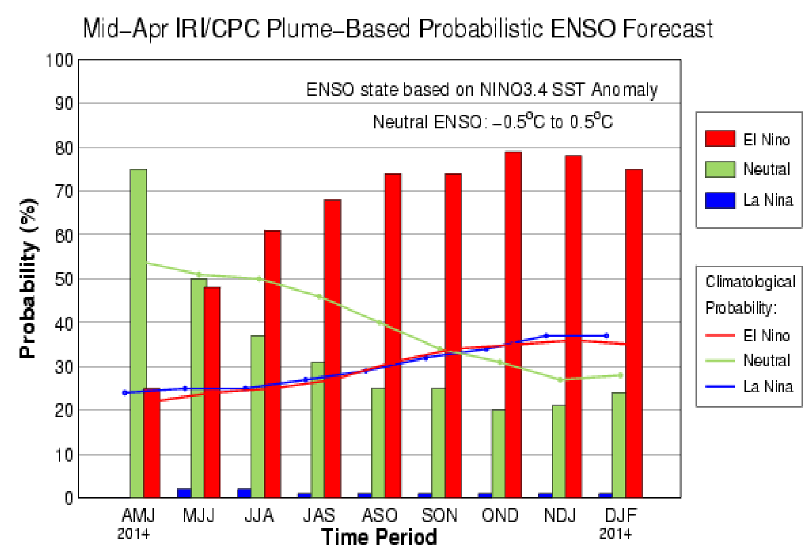
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum





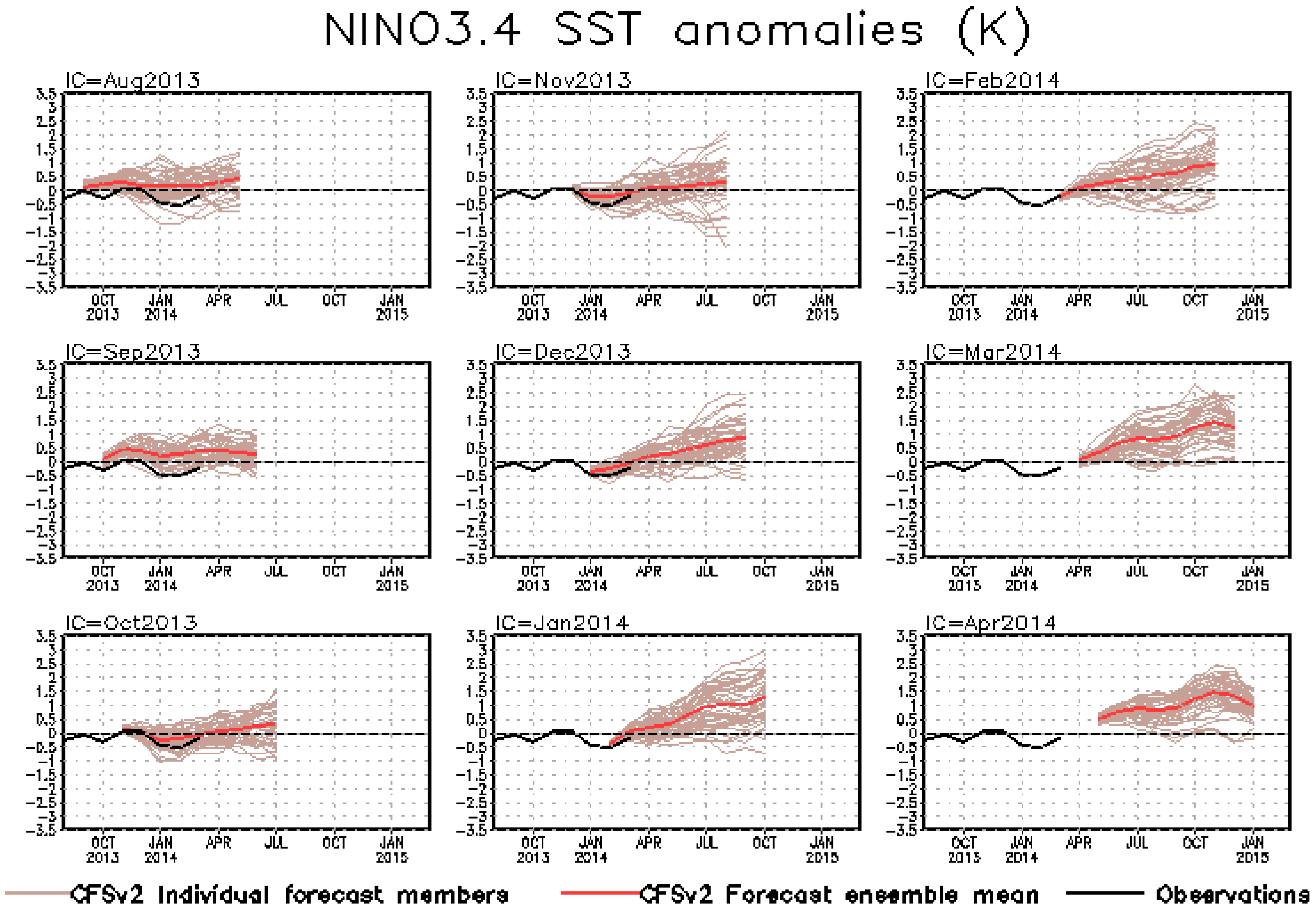


- All models predicted a warming tendency and a majority of them predicted an El Nino in second half of 2014.

- Consensus probabilistic forecasts favor a warm phase of ENSO since JJA 2014.

- NOAA "ENSO Diagnostic Discussion" on 8 May 2014 issued "El Nino Watch" and suggests that ***"Chance of El Niño increases during the remainder of the year, exceeding 65% during summer"***

CFS Niño3.4 SST Predictions from Different Initial Months

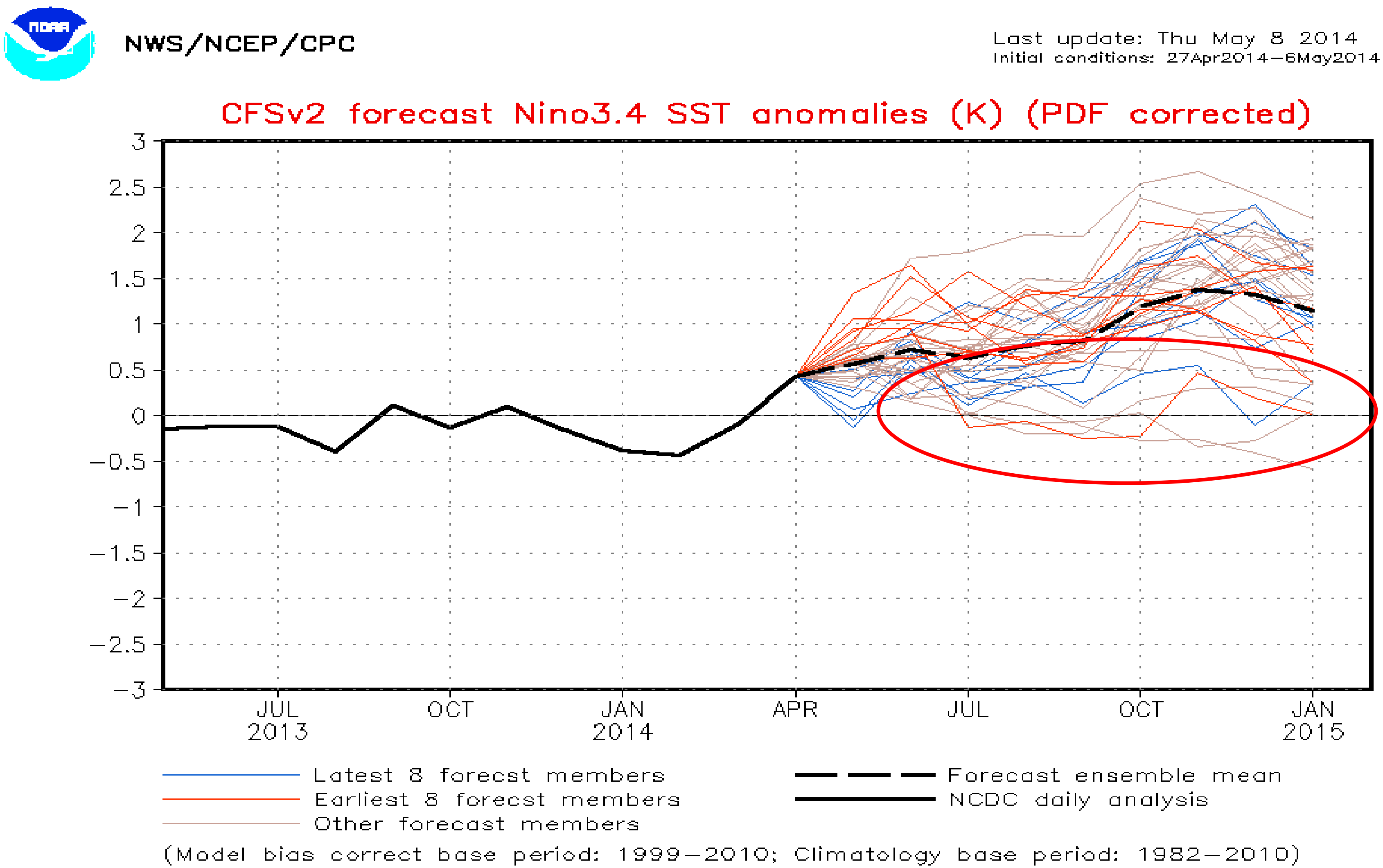


- CFSv2 predicts a warming tendency, and suggests development of an El Nino in second half of 2014.

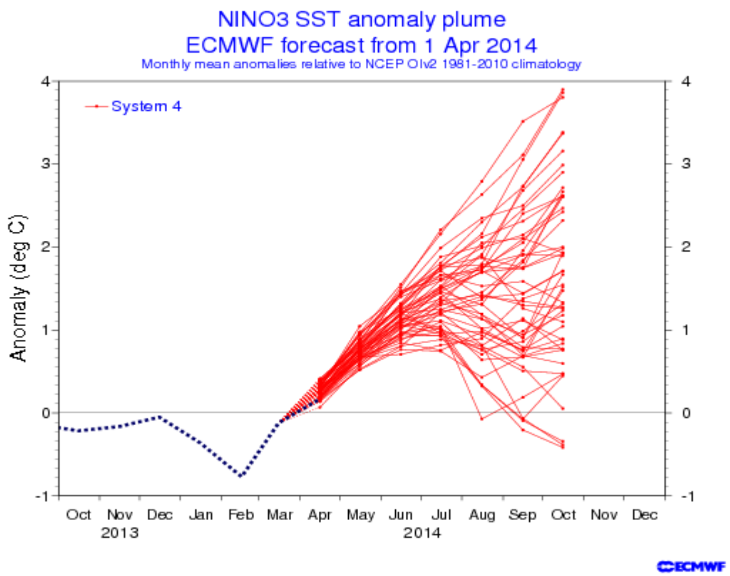
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

Latest forecasts of CFSv2 (updated 08May2014)

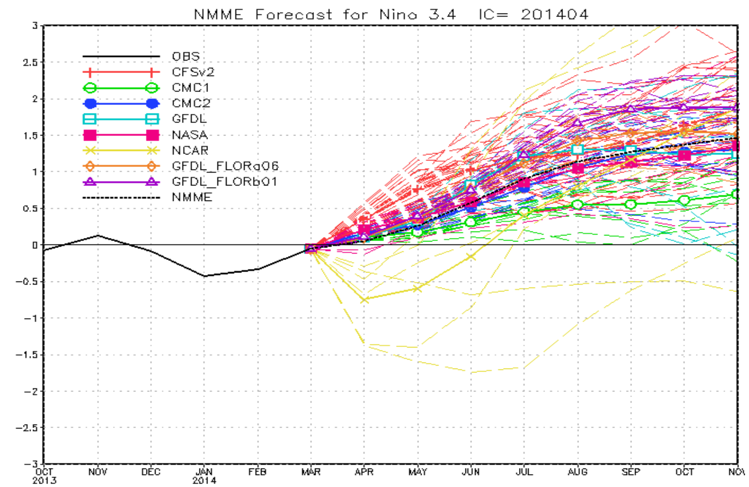
Some ensemble members predict neutral condition!



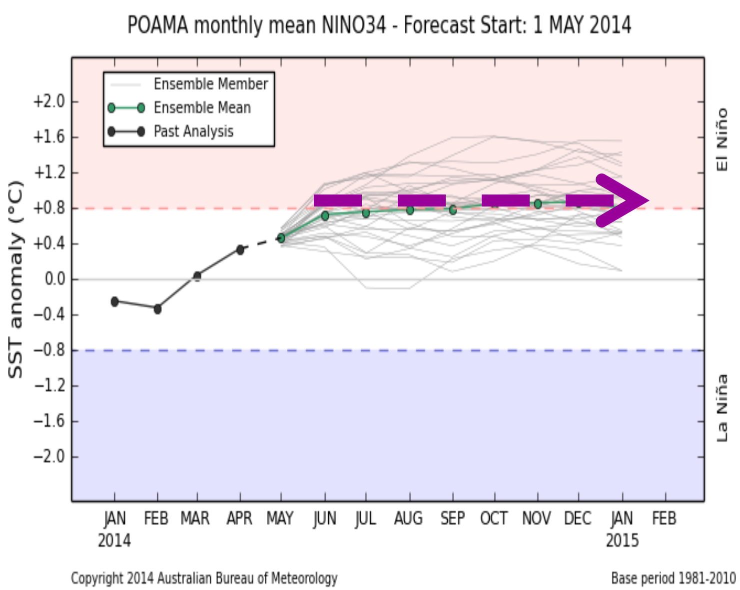
Individual Model Forecasts: Predict an El Nino in 2014



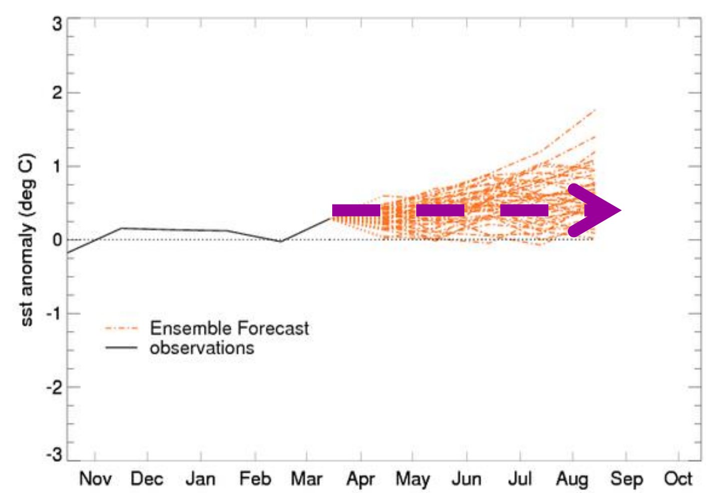
NMME: Nino3, IC=Apr 2014



Australia: Nino3.4, IC= 1 May2014



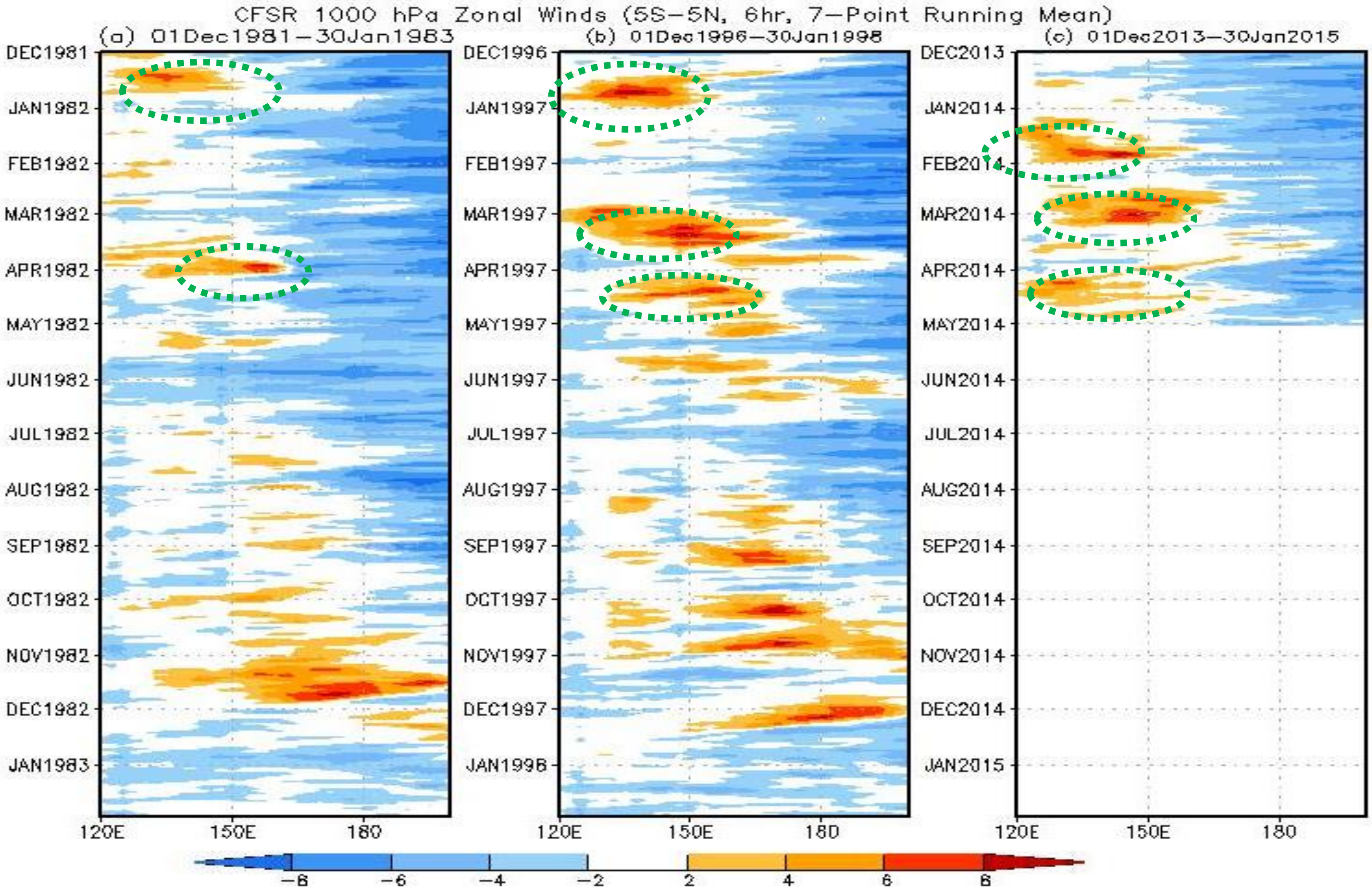
UKMO: Nino3.4, IC=Apr2014



CFSR: Westerly wind burst (WWB) events

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

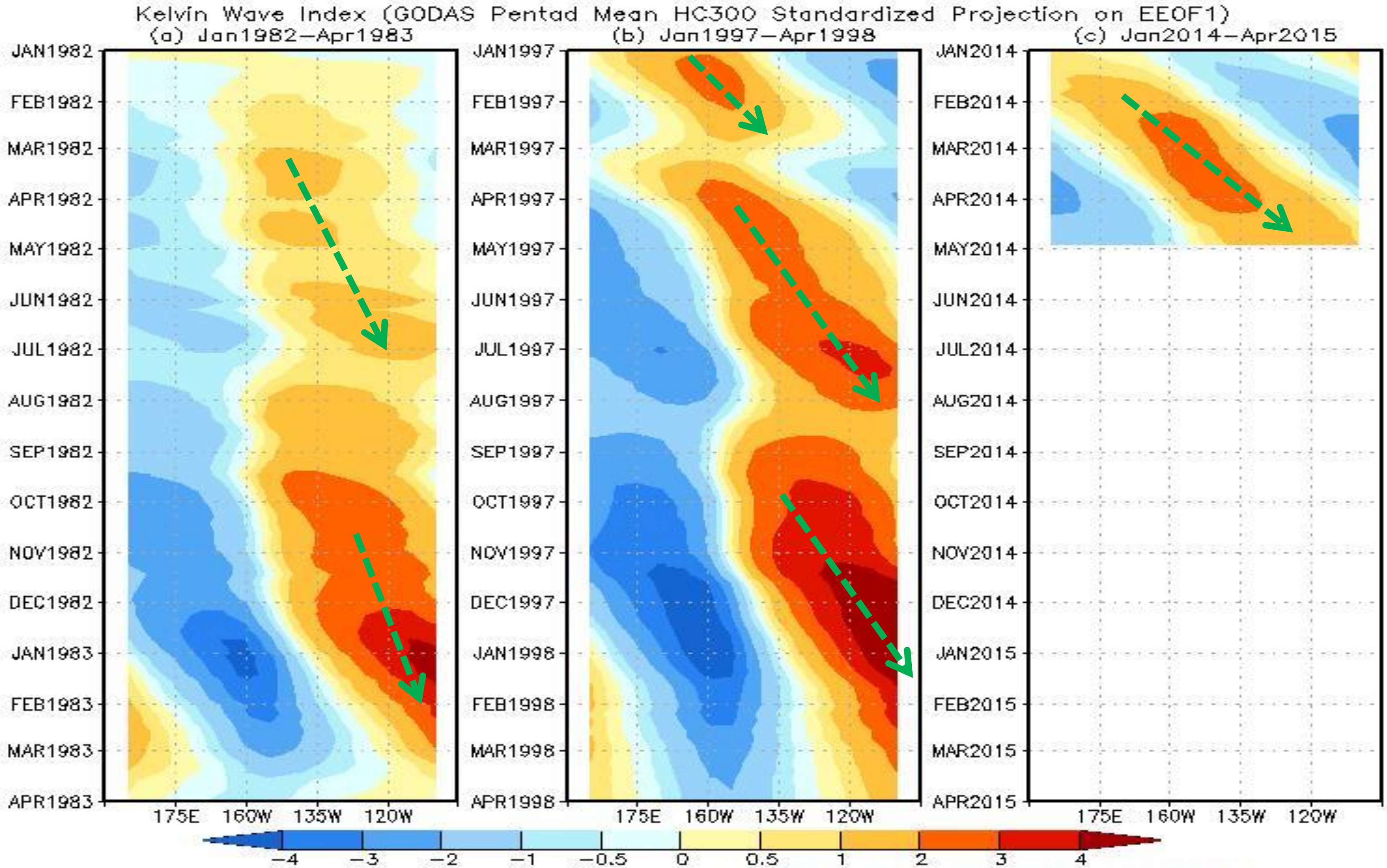
b) strong multi-WWB events in 1997-98



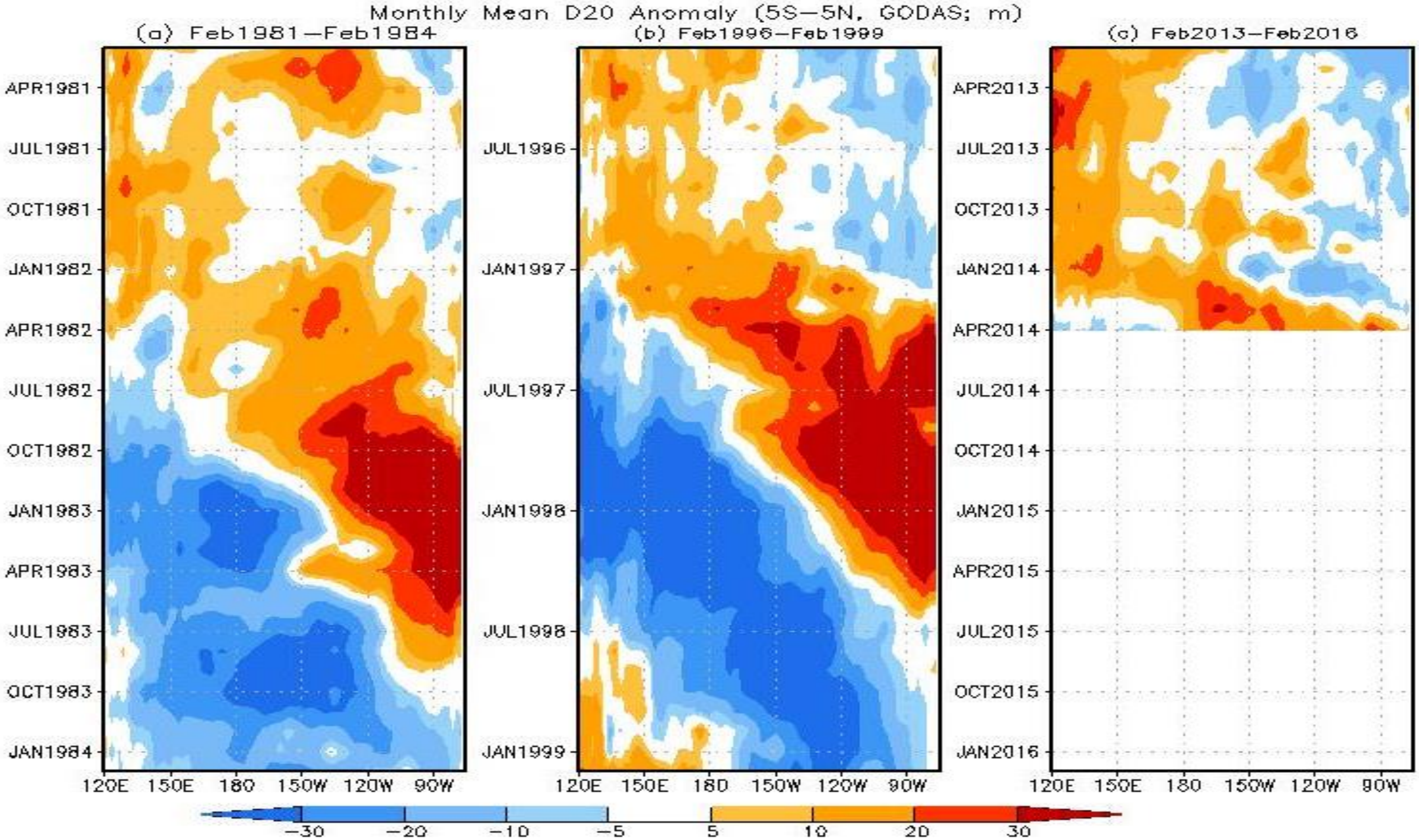
Kelvin activity

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

b) multi-Kelvin activity events in 1997-98

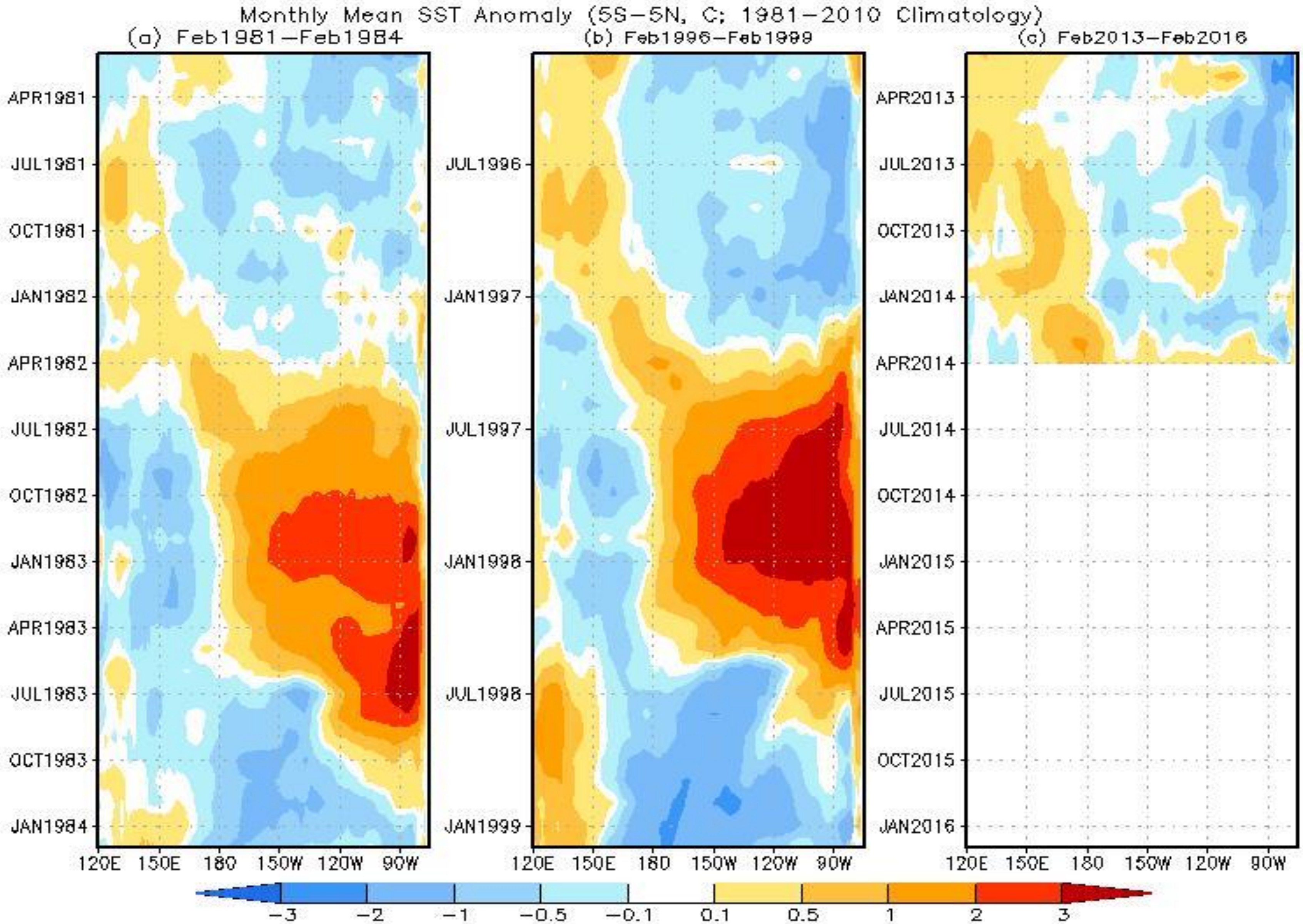


D20: Similar evolution in 1981-83, 1996-98, 2013-14

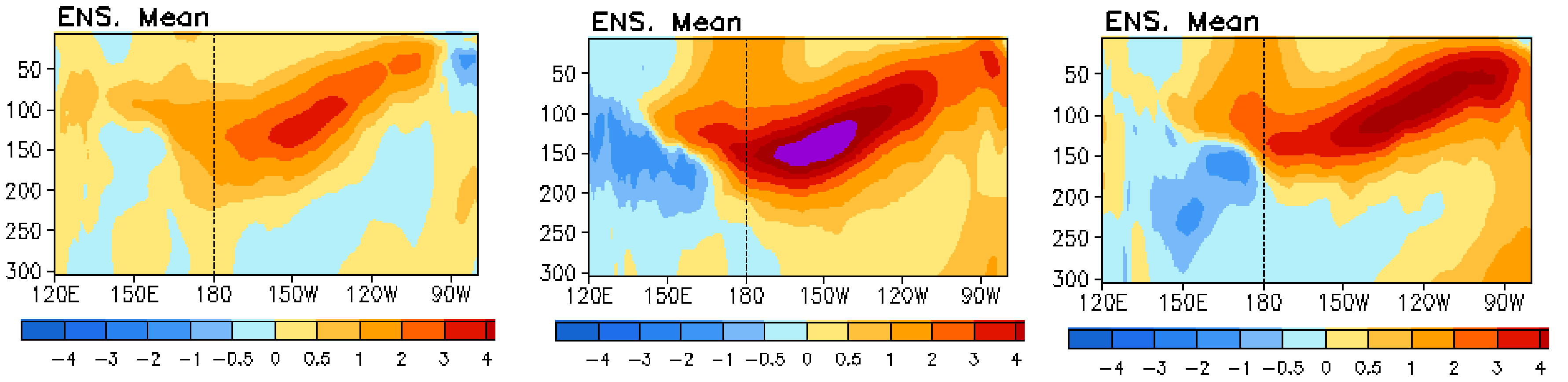


- Eastward propagation of strong positive equatorial subsurface temperature anomalies since Jan 2014 is accompanied by two strong westerly wind burst events in Jan and Feb.
- The strong positive anomalies near the thermocline in the equatorial Pacific are comparable to those in spring 1997.

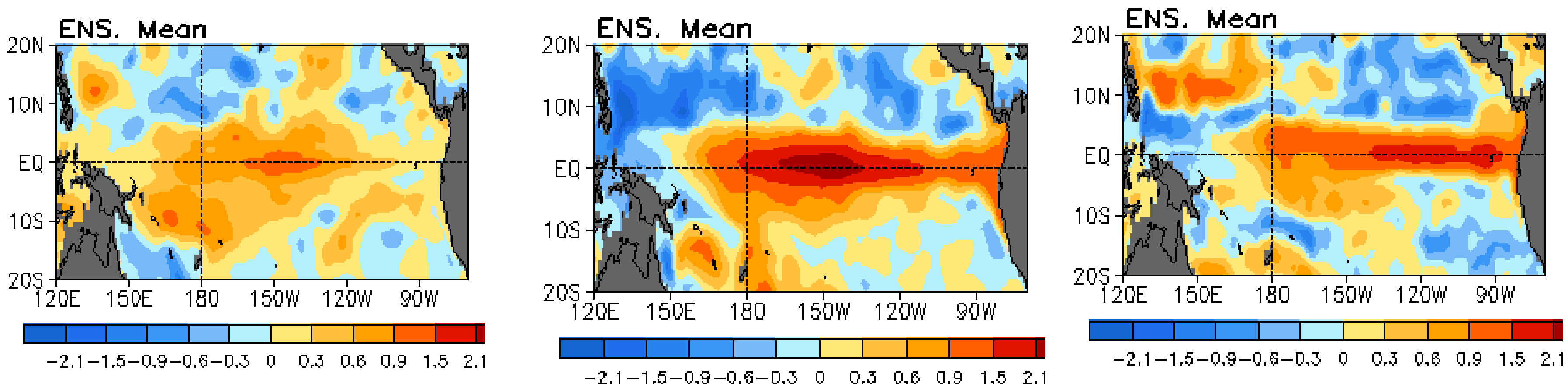
SSTA: Similar evolution in 1981-83, 1996-98, 2013-14



Anomalous Temperature Average In 1S-1N

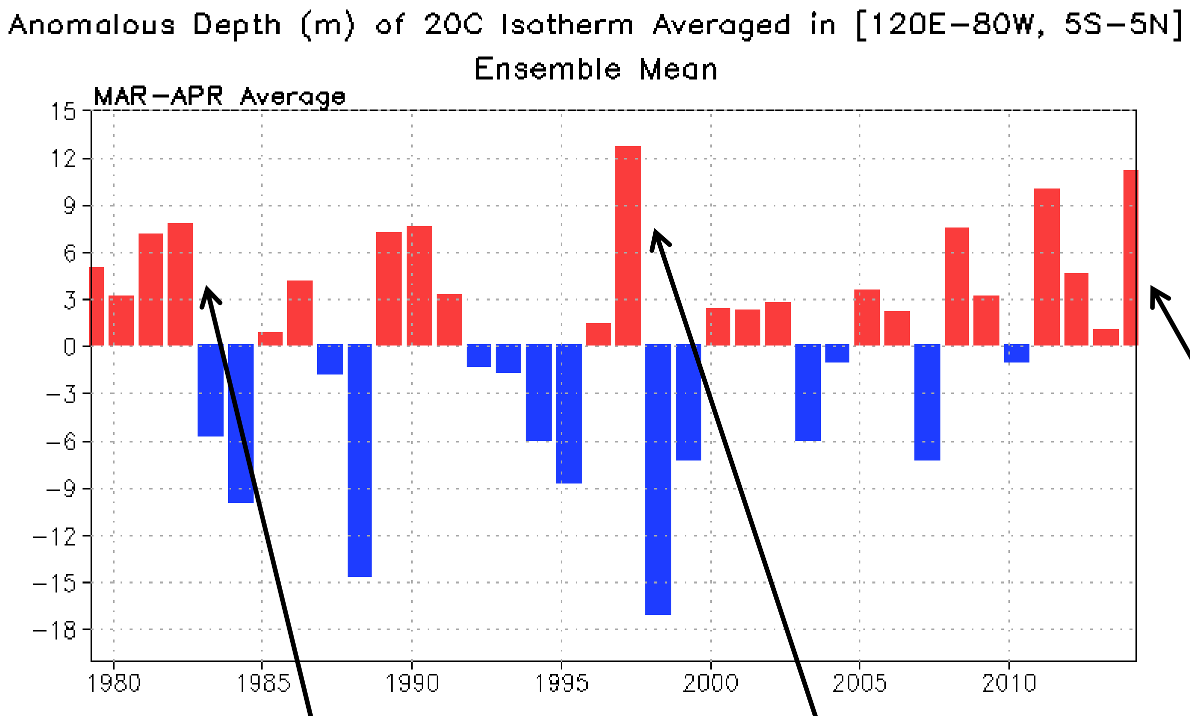


Apr 1982 **Apr 1997** **Apr 2014**

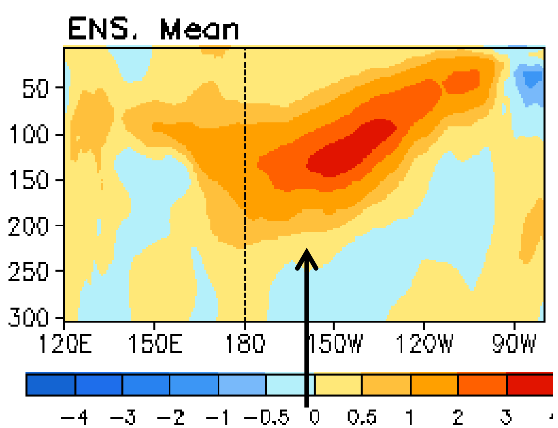


Anomalous Upper 300m Heat Content

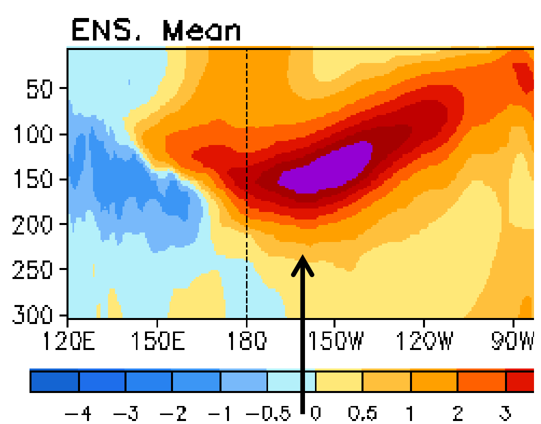
Warm Water Volume Index



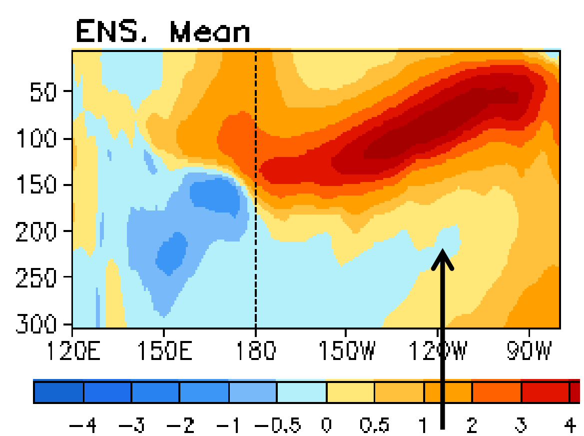
Mar~Apr 1982



Mar~Apr 1997

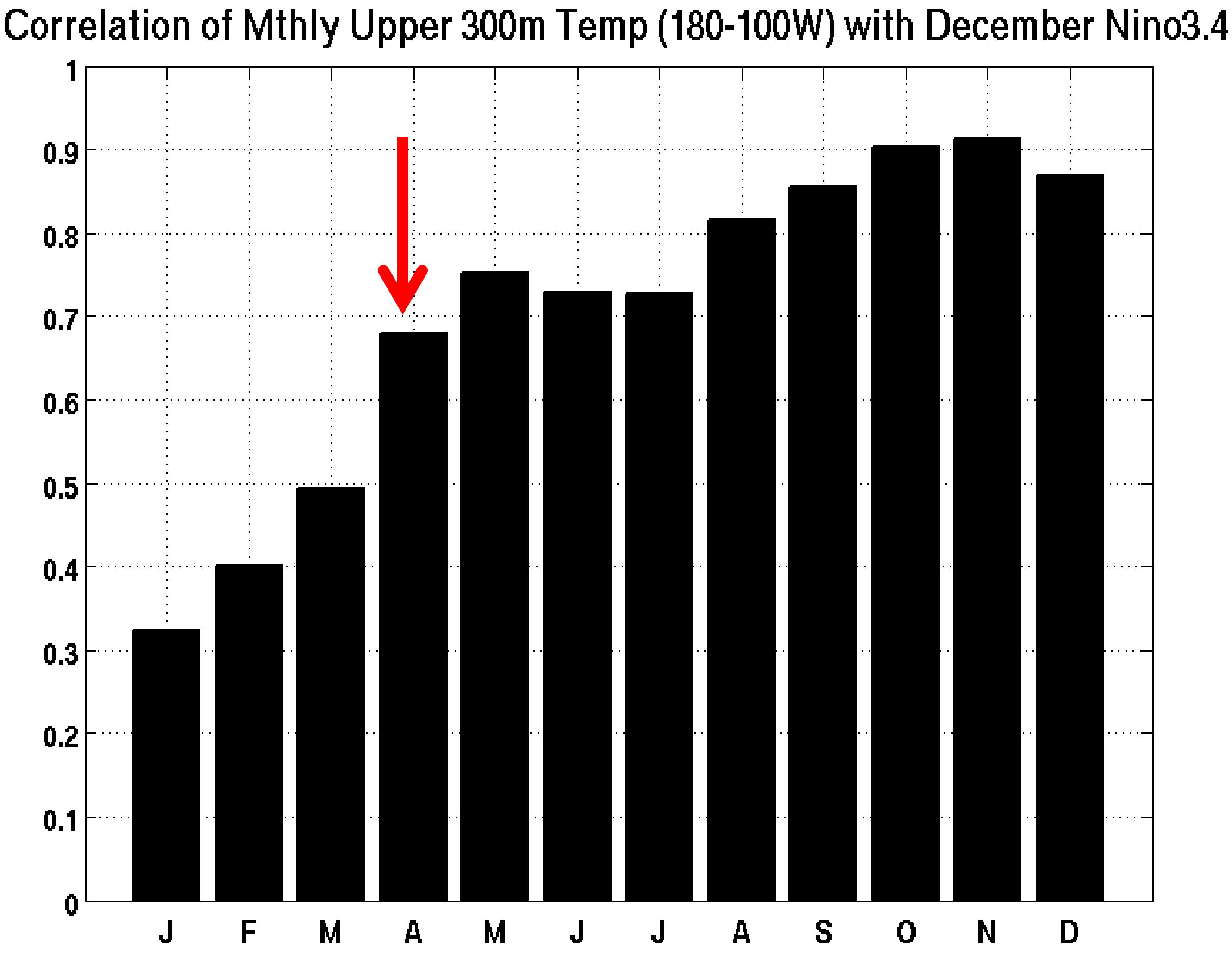


Mar~Apr 2014



Anomalous Temperature Average in 1S-1N

Correlation of Dec Nino3.4 with HC300 Anomaly



Correlation of Dec Nino3.4 with E. Pacific HC300 is less than 0.7.

Ranking of April HC300 in the eastern Pacific (180-100W) during 1979-2014:

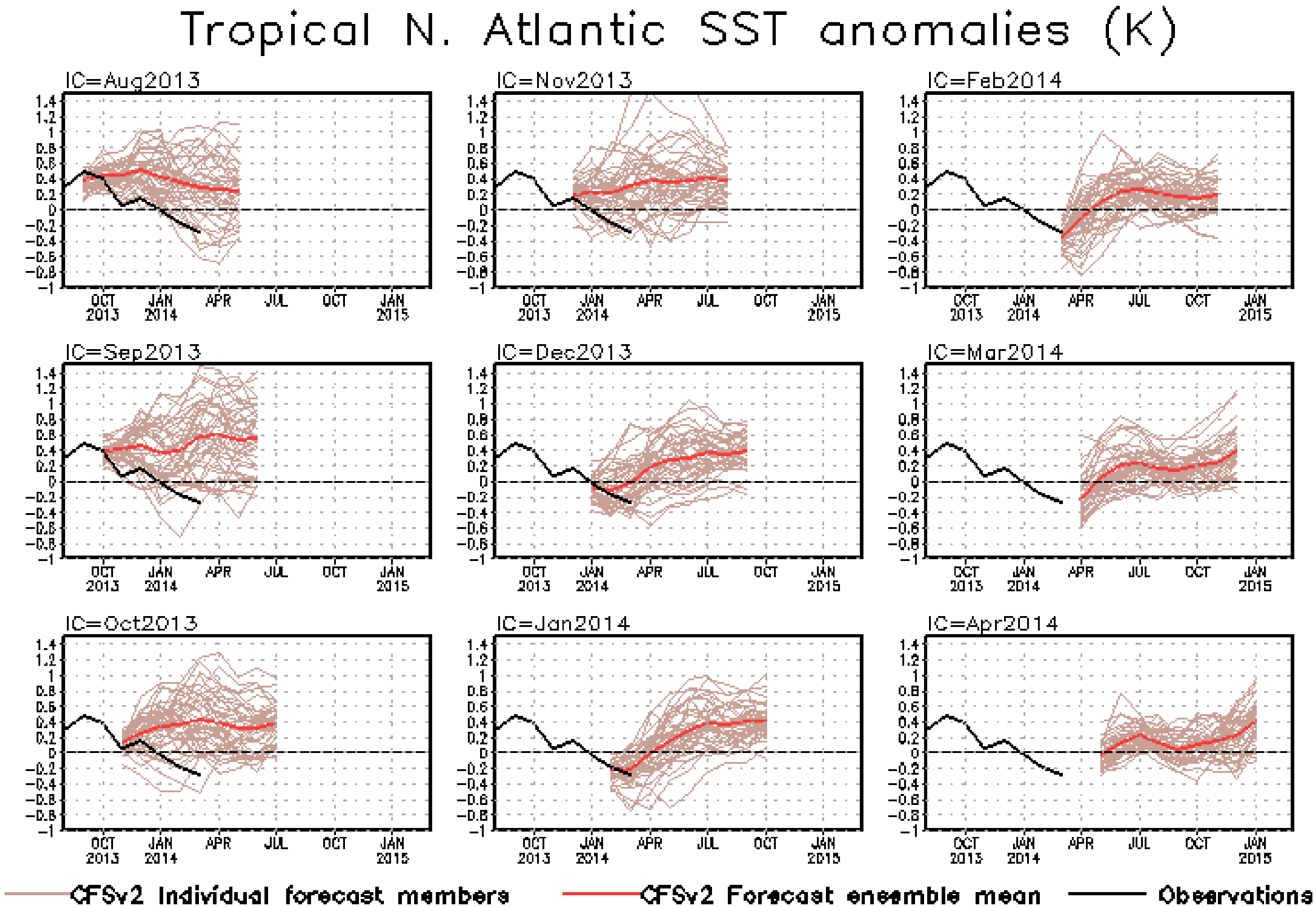
1st: 1997 (2.8)

2nd: 2014 (1.7)

3rd: 1982 (1.1)

From: Michelle L'Heureux

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



- Forest from Apr 2014 IC calls for slightly above-normal SST in the tropical North Atlantic next 9 months.

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

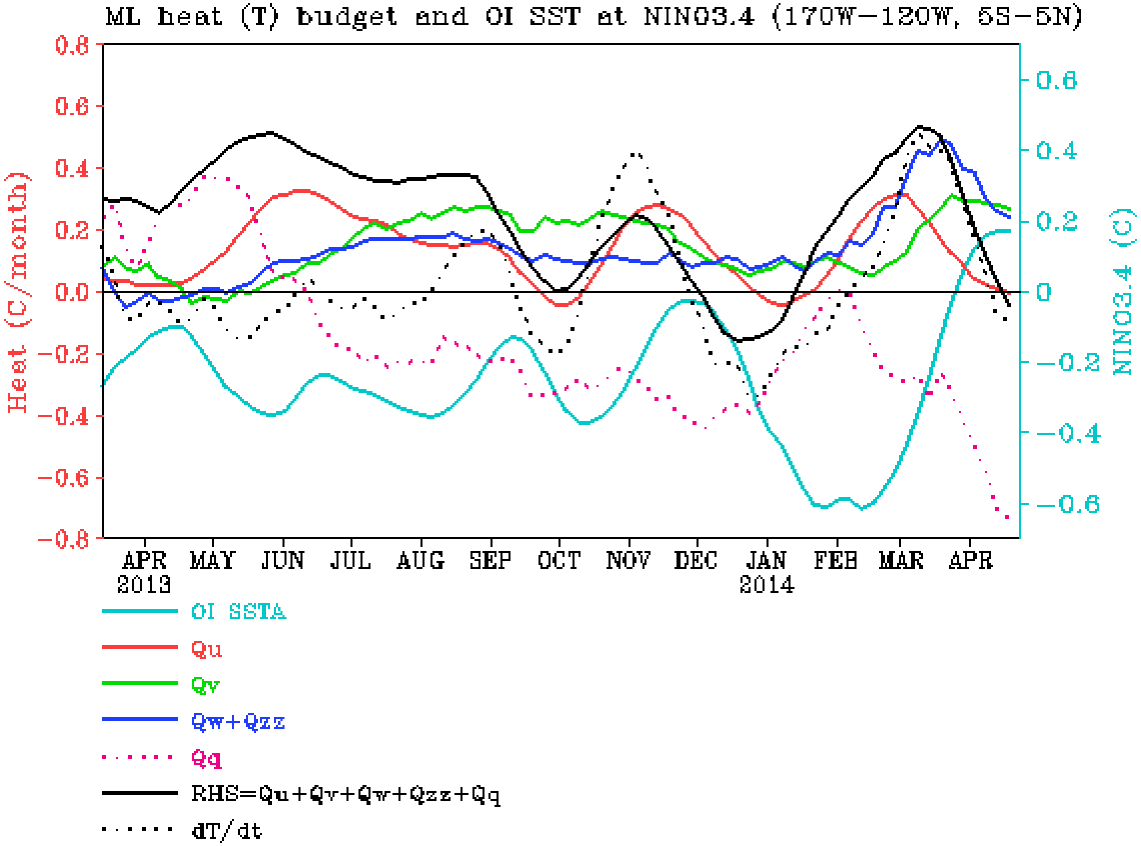
Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

Overview

- **Pacific Ocean**
  - **ENSO neutral condition continued with NINO3.4=0.2°C in Apr 2014.**
  - **Positive anomalies of subsurface ocean temperature along the equator propagated eastward and some surface westerly wind anomalies in the equatorial Pacific were observed in Apr 2014.**
  - **All models predicted a warming tendency in this year, and majority of the models predicted an El Nino starting this summer.**
  - **NOAA "ENSO Diagnostic Discussion" on 8 May 2014 issued "El Nino Watch" and suggests that "Chance of El Niño increases during the remainder of the year, exceeding 65% during summer".**
  - **PDO switched to positive phase in Mar 2014 and strengthened in Apr 2014 with PDO index =0.81.**
- **Indian Ocean**
  - **Positive SSTA mainly presented in the tropical southern Indian Ocean in Apr 2014.**
- **Atlantic Ocean**
  - **NAO switched into positive phase in Feb 2014 and NAOI=0.19 in Apr 2014.**
  - **Tripole pattern of SSTA presented in North Atlantic in Apr 2014.**

Backup Slides

NINO3.4 Heat Budget



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

- **Both Qu, Qv and Qw+Qzz were positive in the last a few months and decreased since mid-Mar 2014.**

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

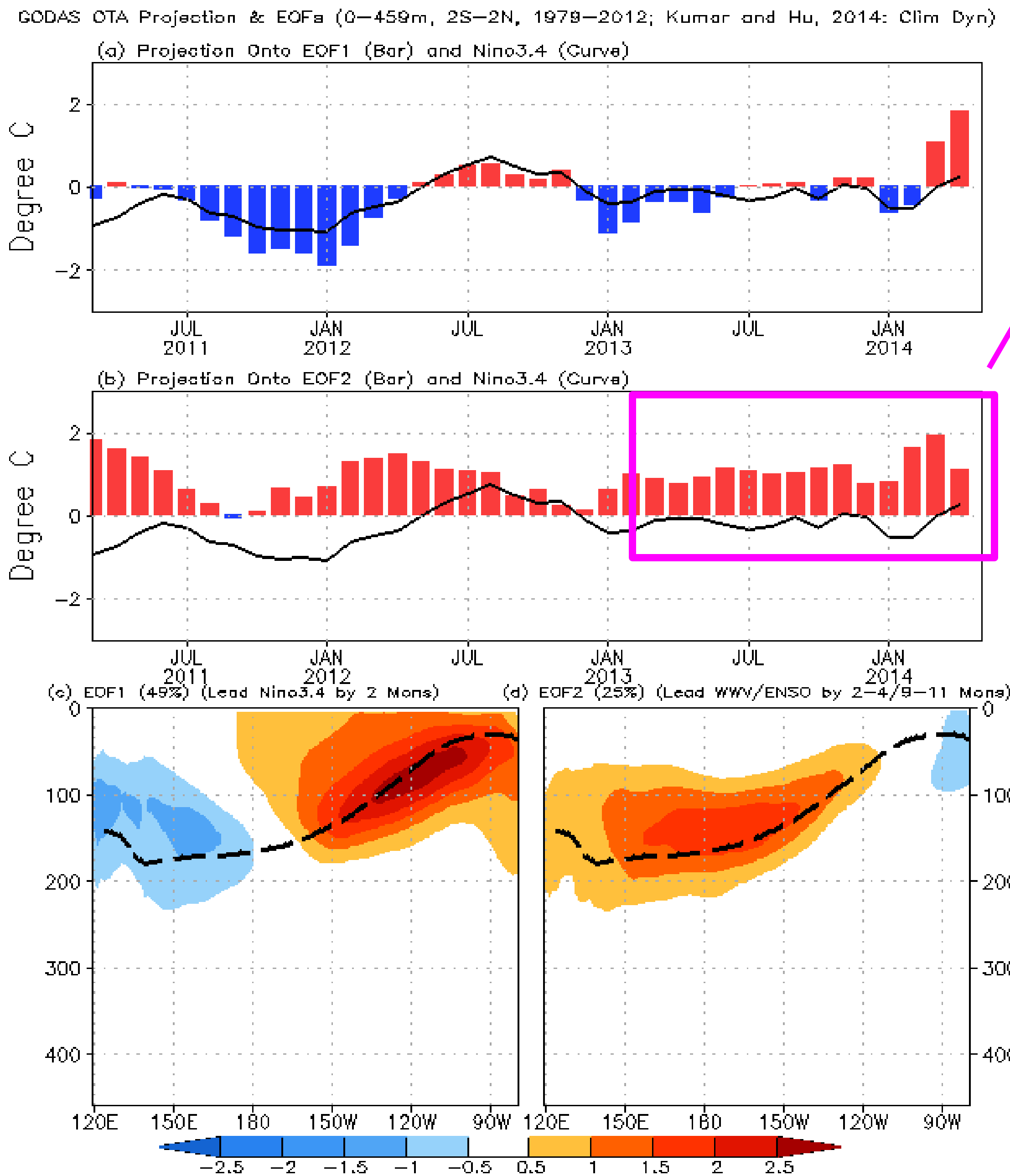
Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

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 in 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 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.

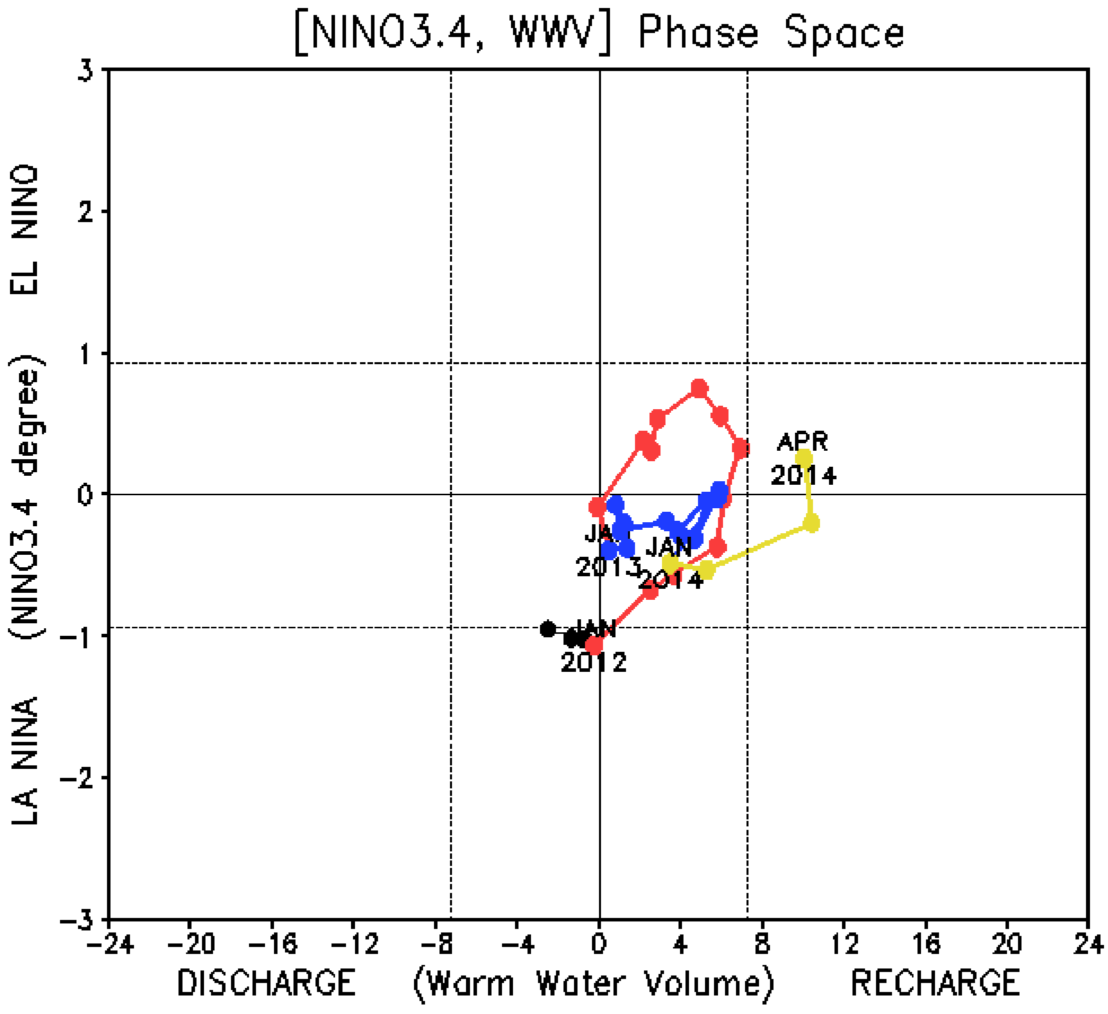
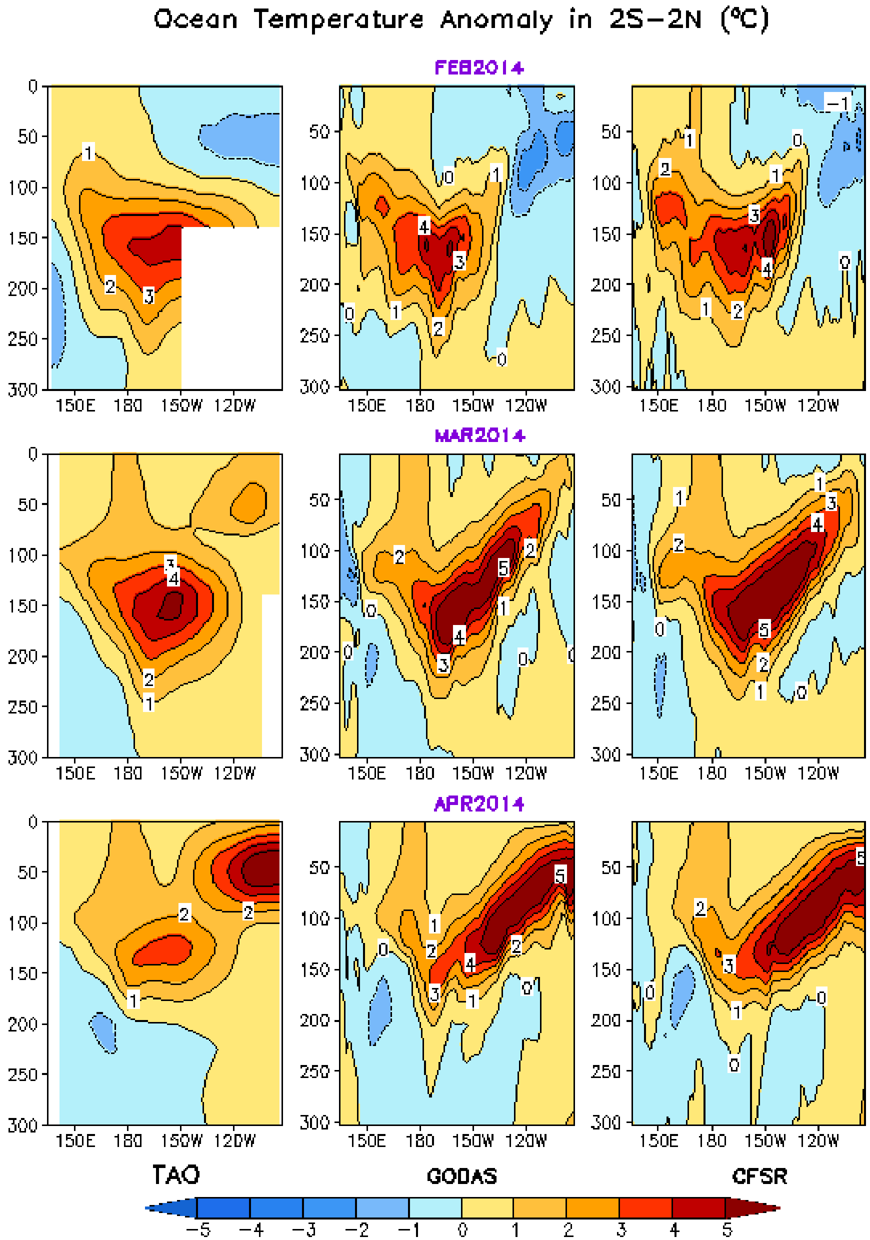
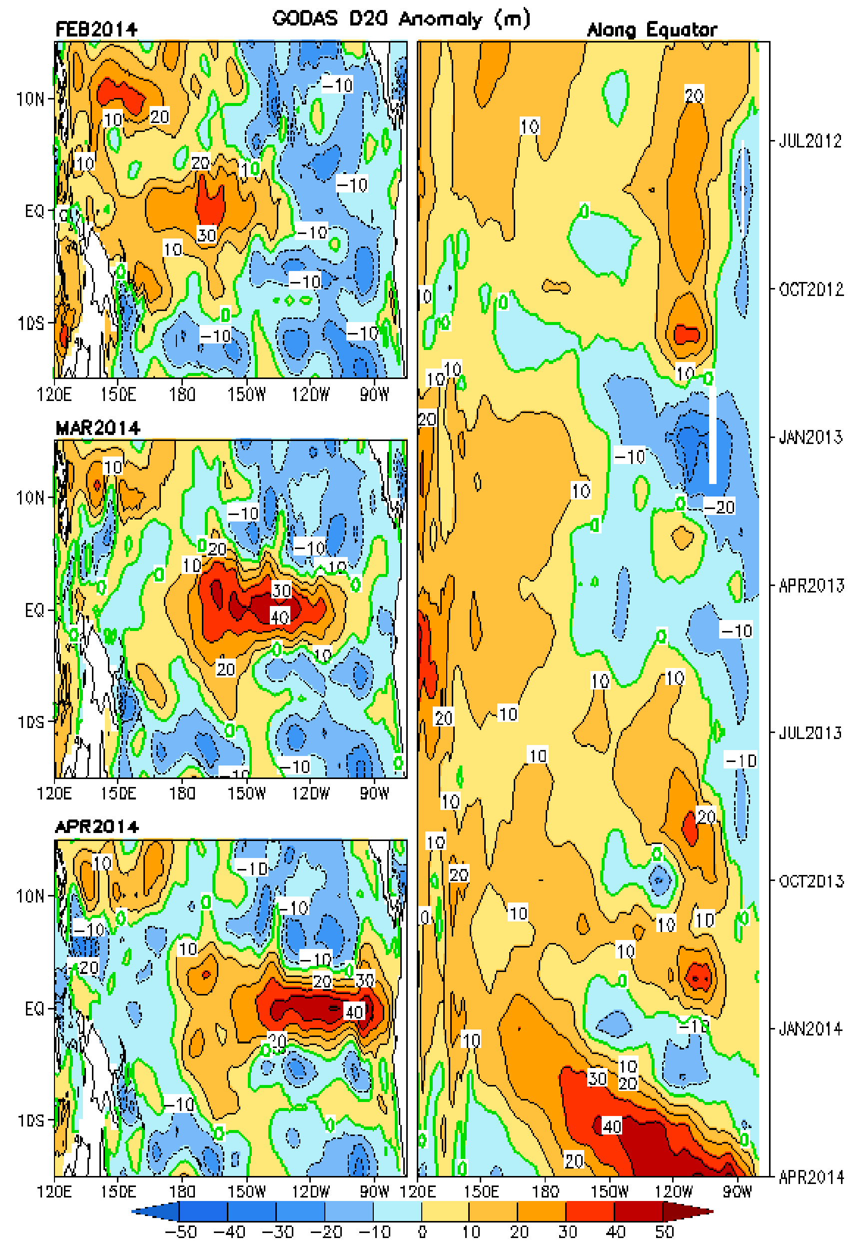
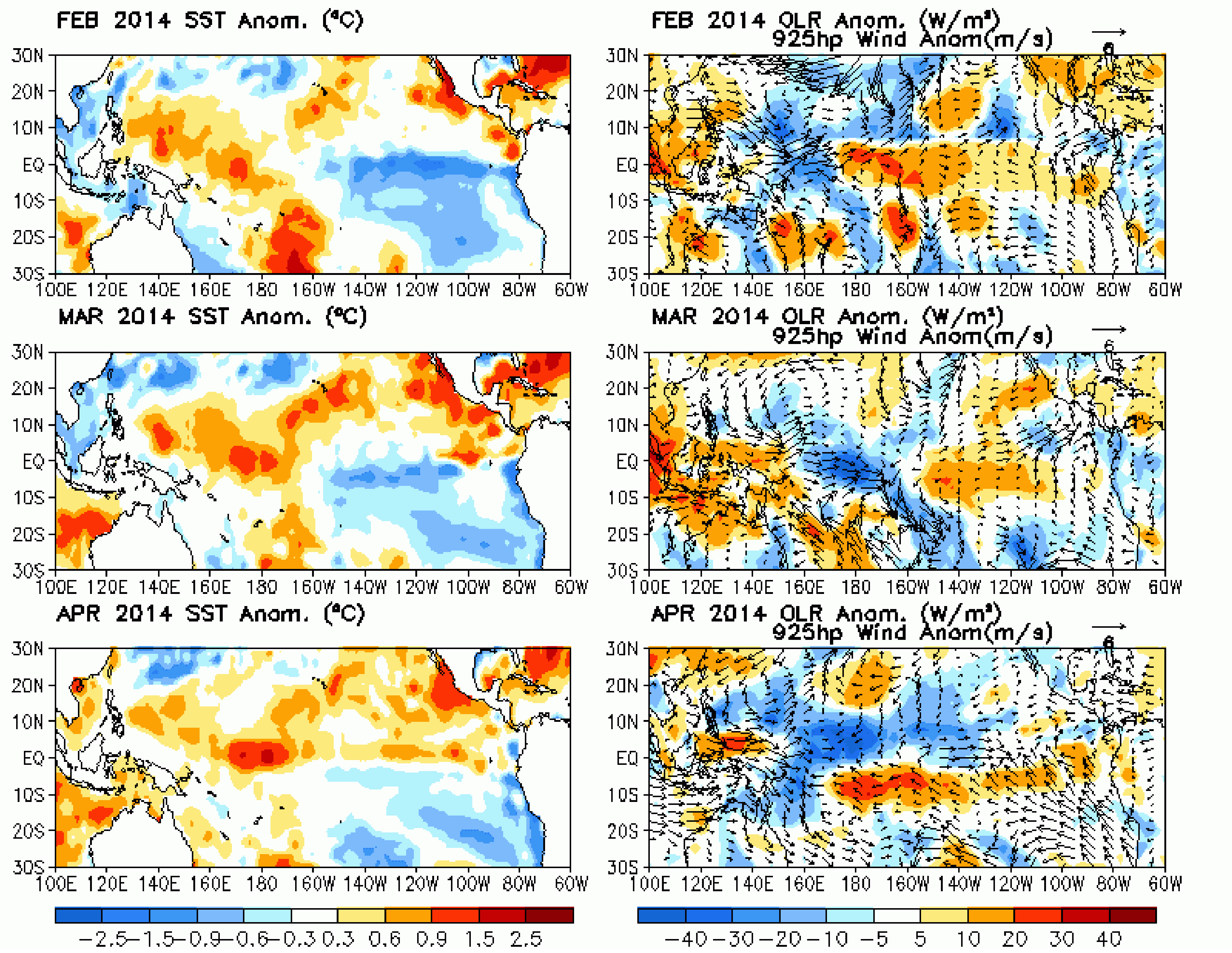


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

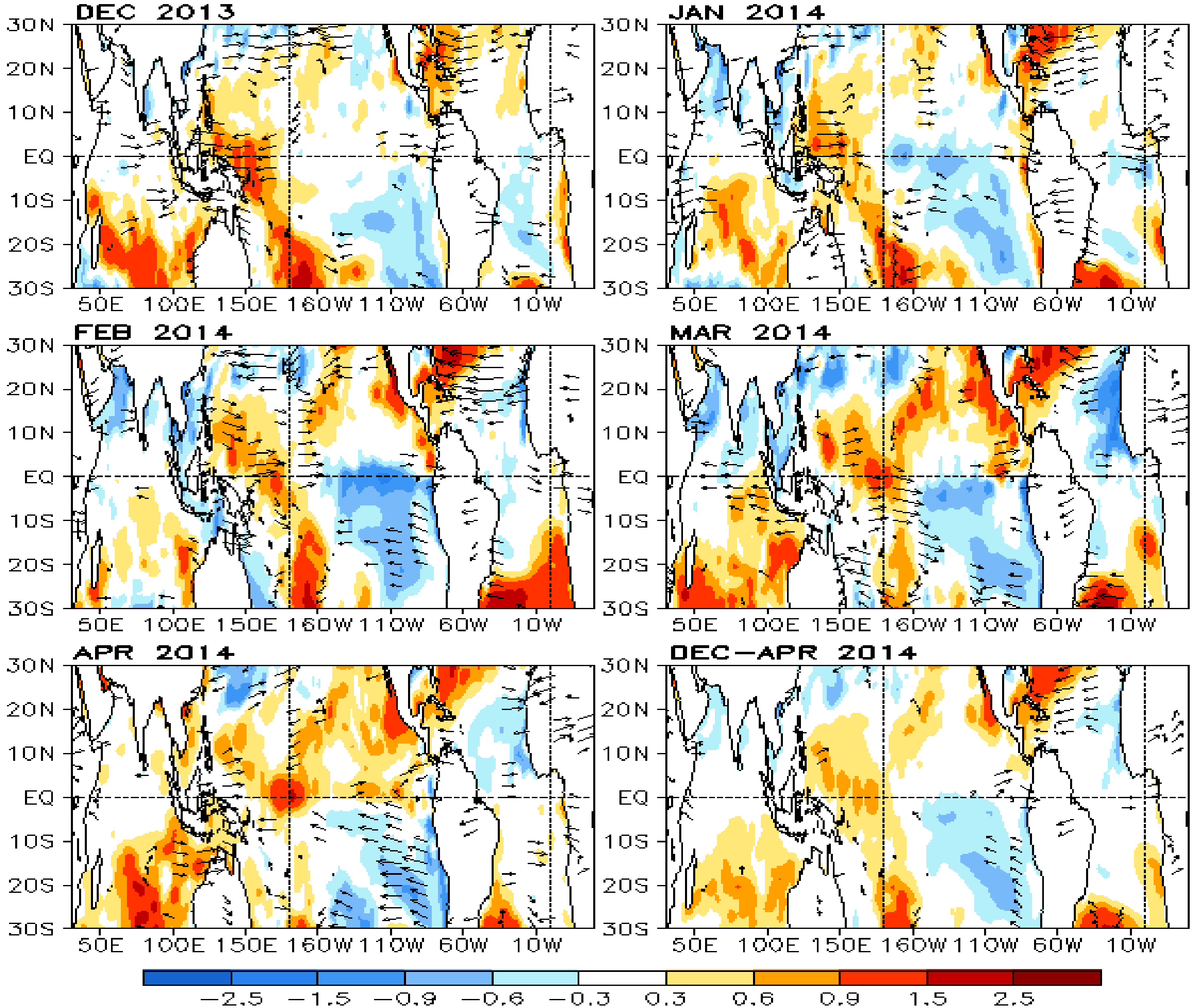
Ocean Temperature and D20 Anomaly (intensified and eastward propagation)

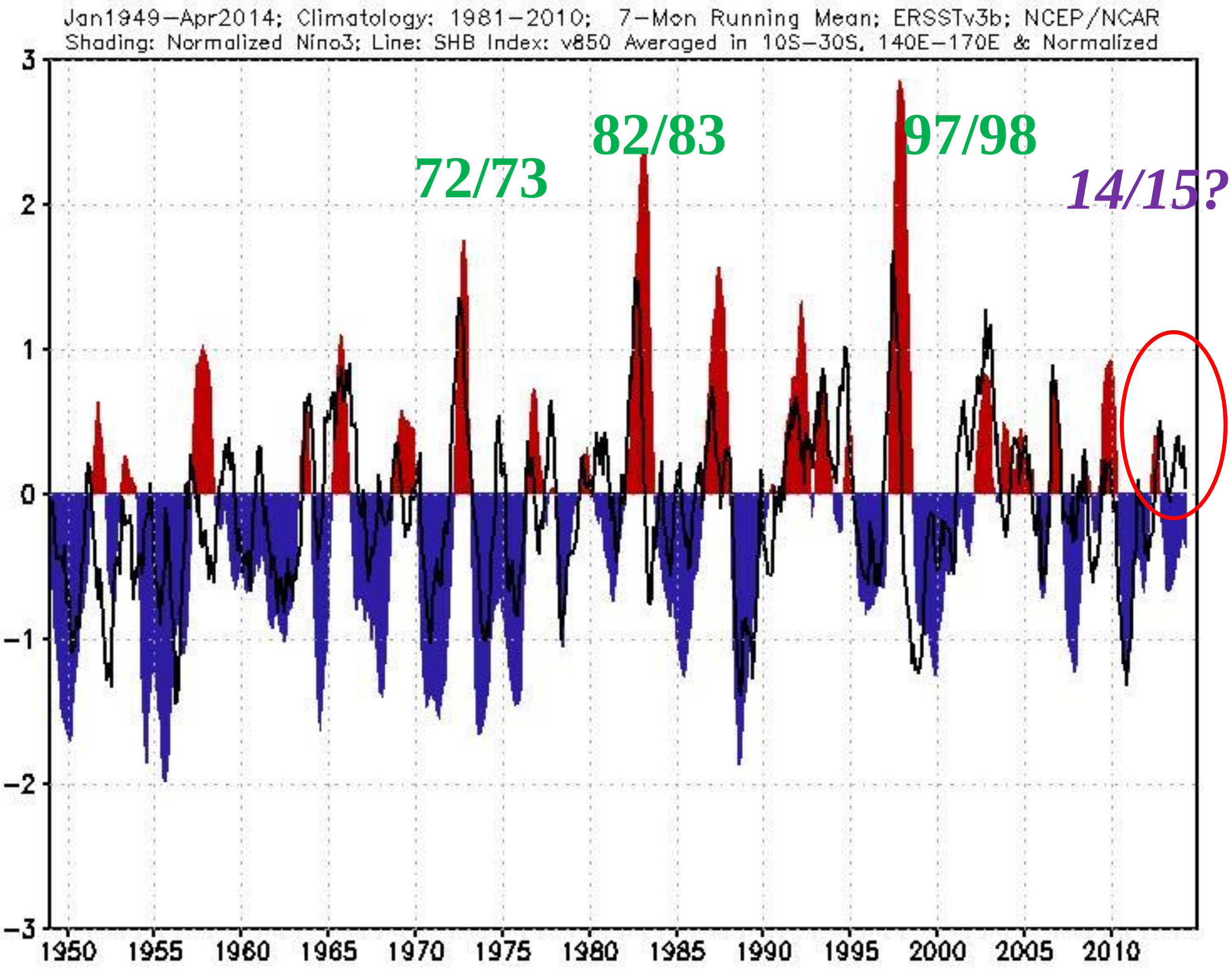





FEB 2014 SST Anom. (°C)
FEB 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
MAR 2014 SST Anom. (°C)
MAR 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
APR 2014 SST Anom. (°C)
APR 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
30N 20N 10N EQ 10S 20S 30S
100E 120E 140E 160E 180 160W 140W 120W 100W 80W 60W
6
−2.5 −1.5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





- Since last winter, SHB index was positive and decreasing in recent months
- 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

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

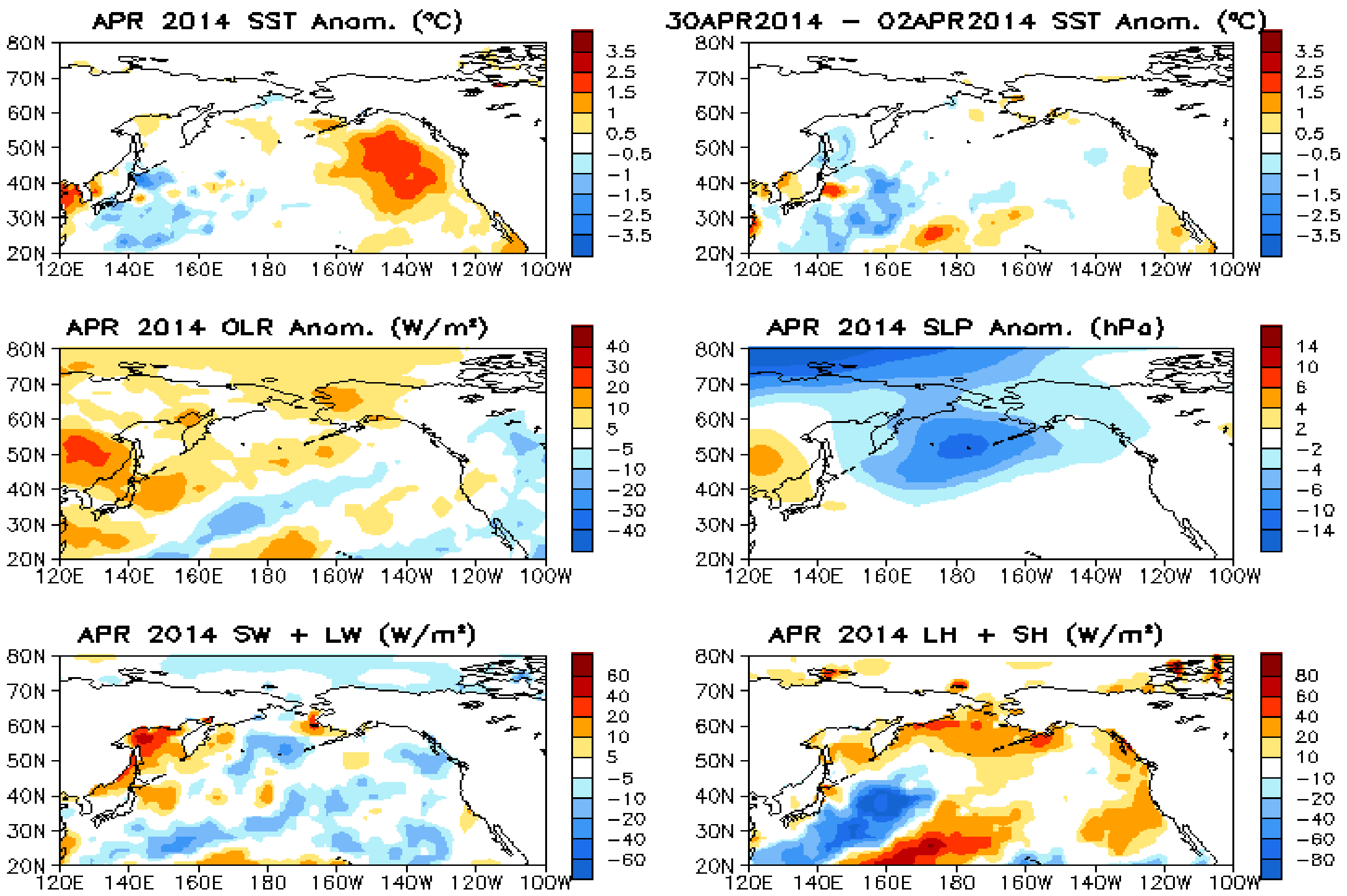
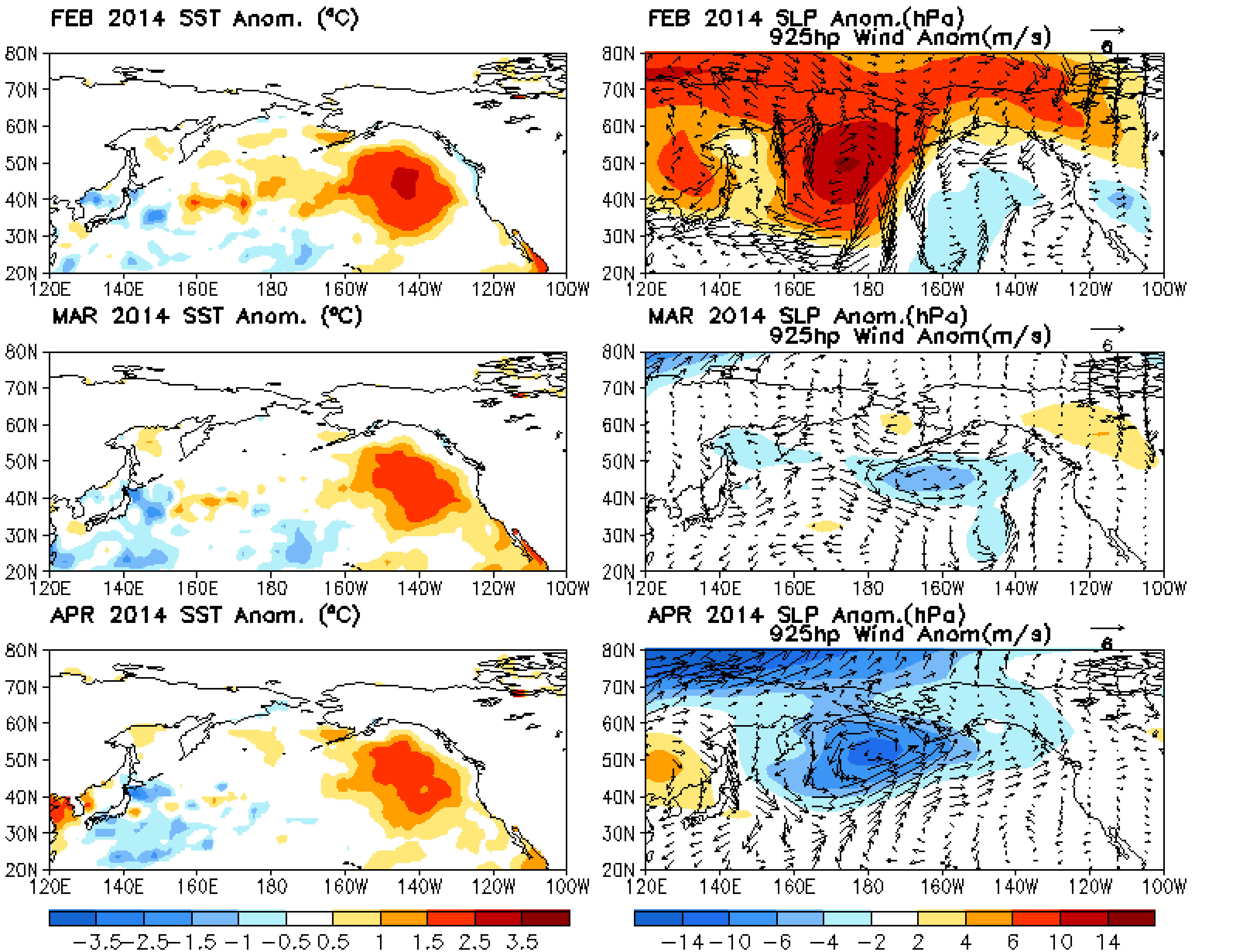
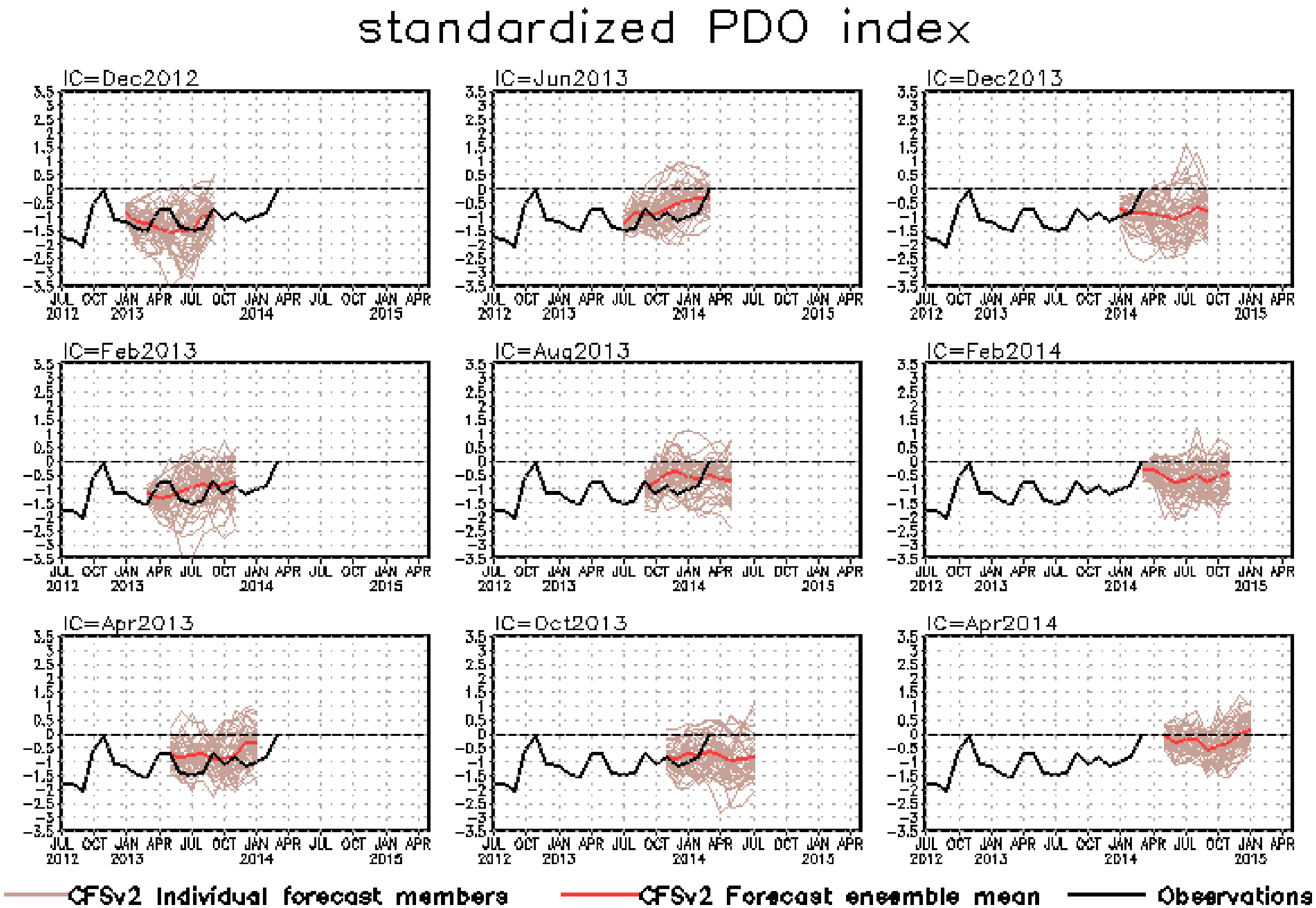


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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


FEB 2014 SST Anom. (°C)
FEB 2014 SLP Anom.(hPa)
925hp Wind Anom(m/s)
6
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
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



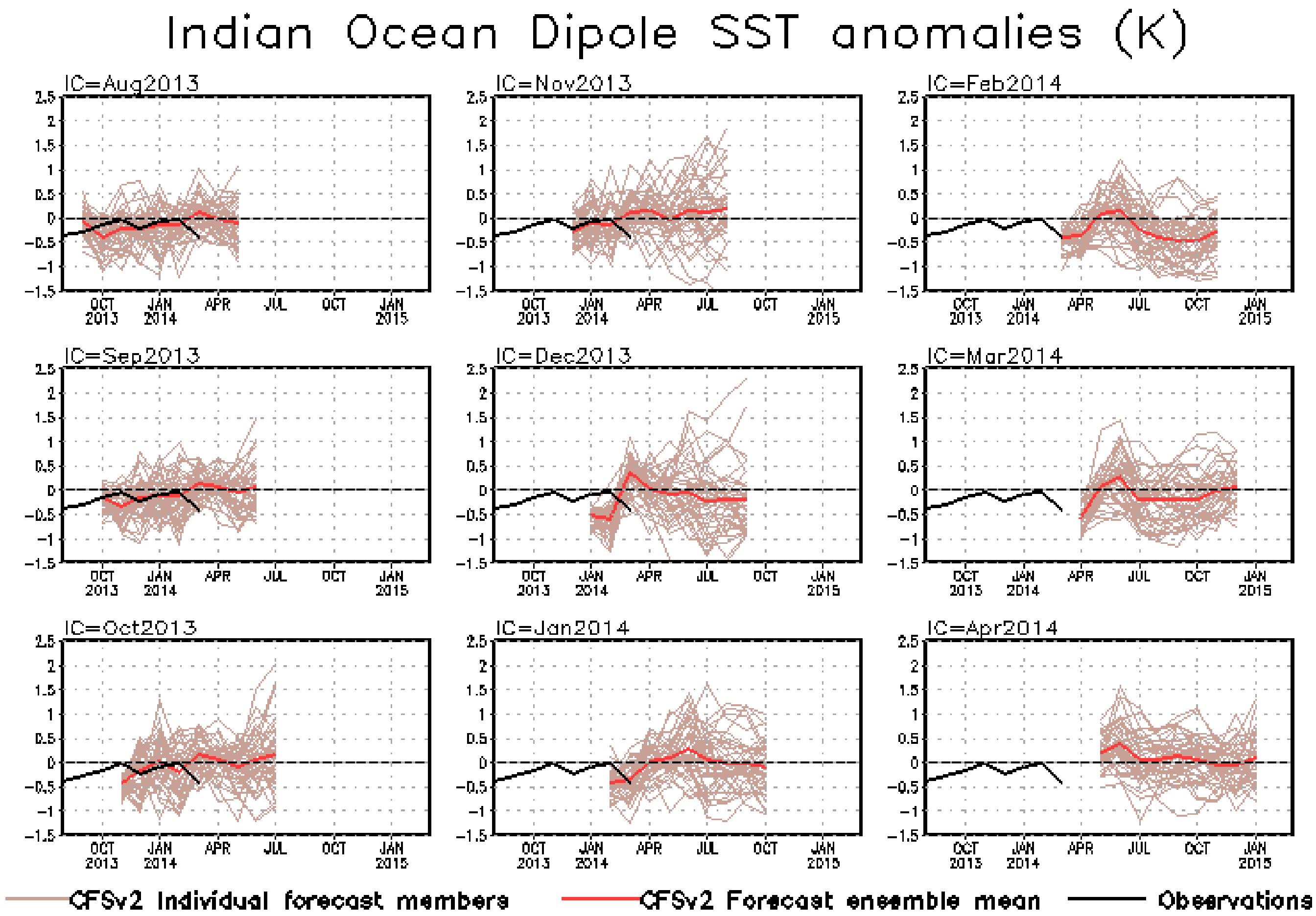
- Forest from Apr 2014 IC calls for weak PDO in next 9 months.

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 (°C), 0-300m Heat Content (°C), and 850-mb Zonal Wind (m/s) Anomalies

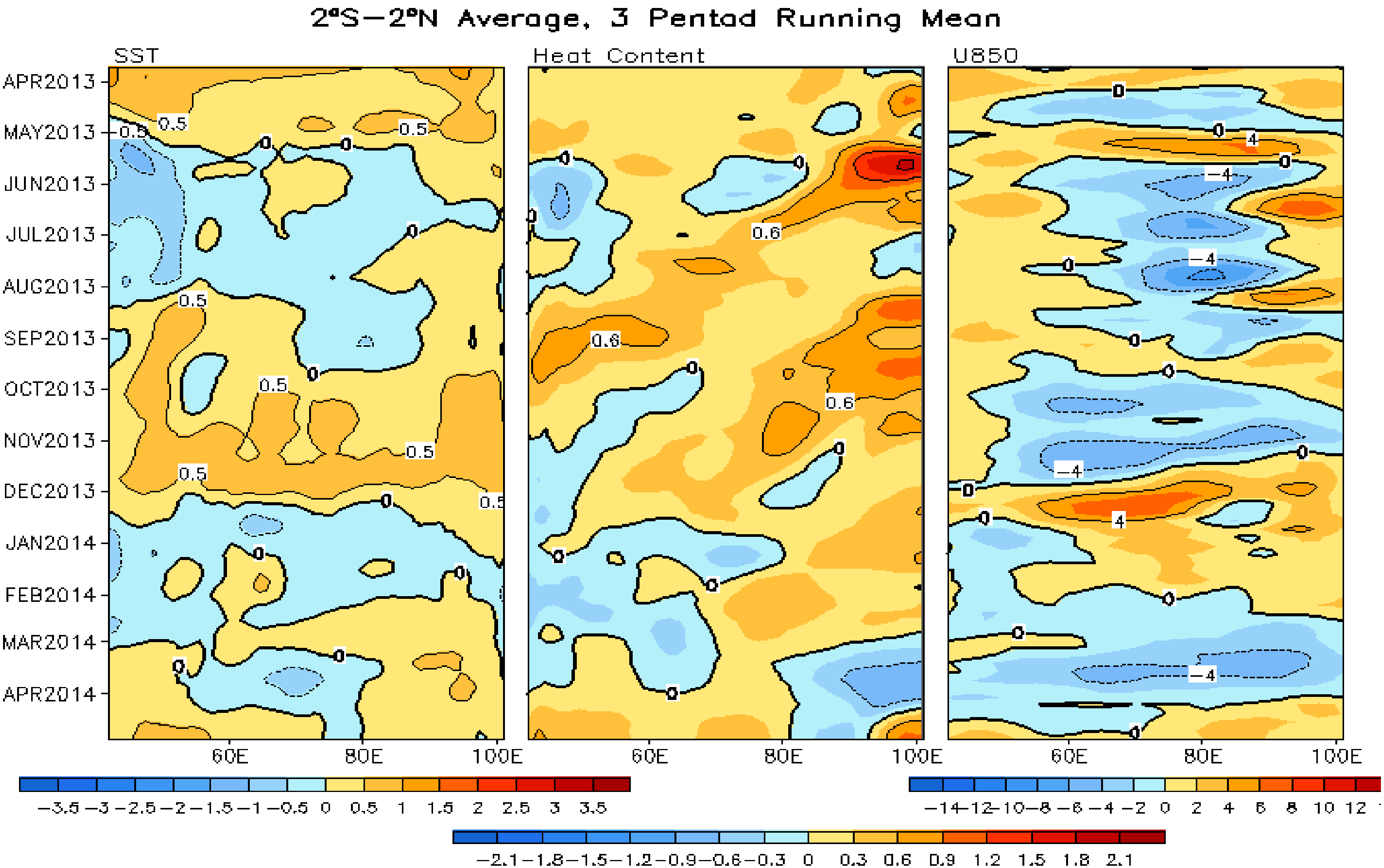
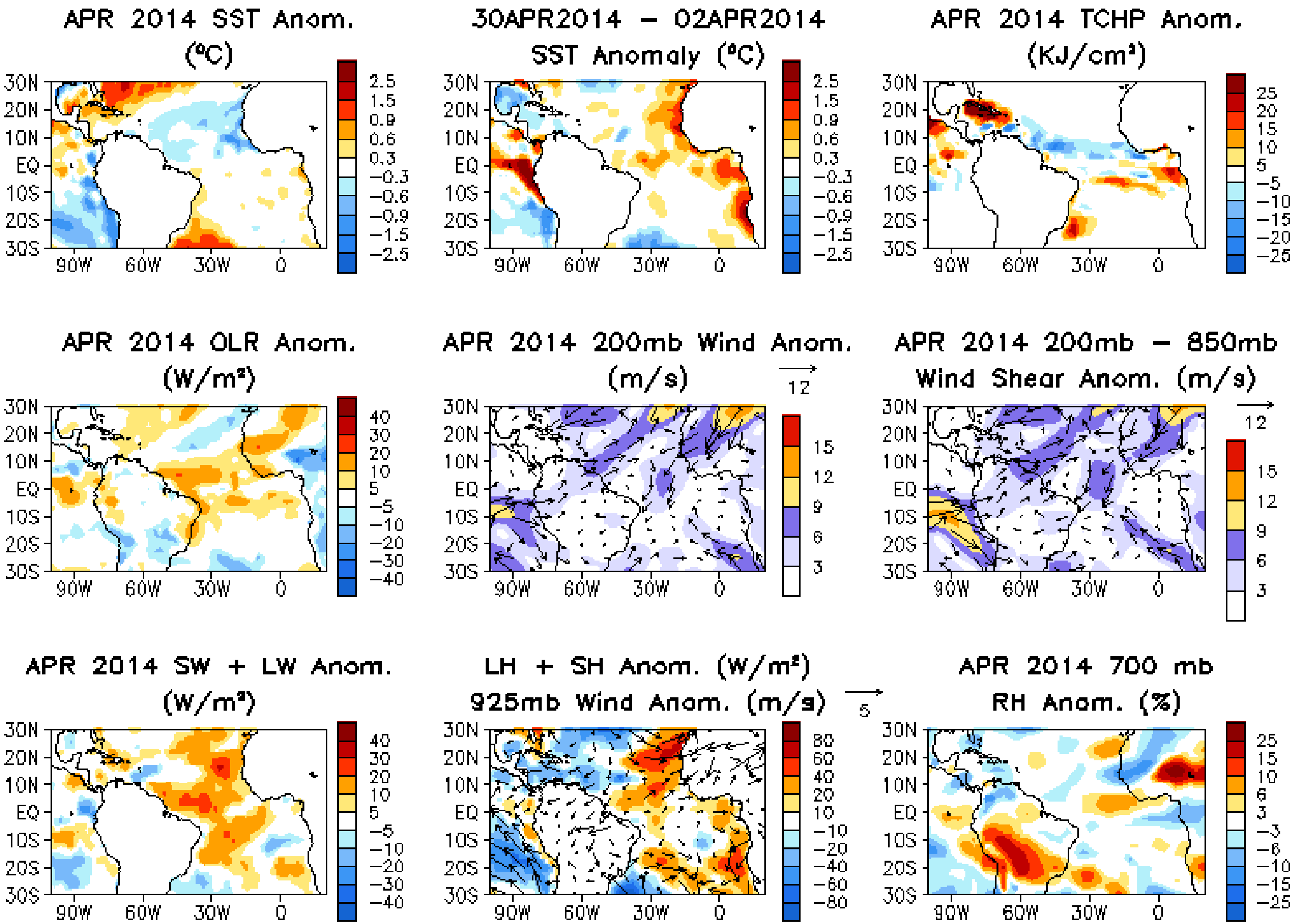
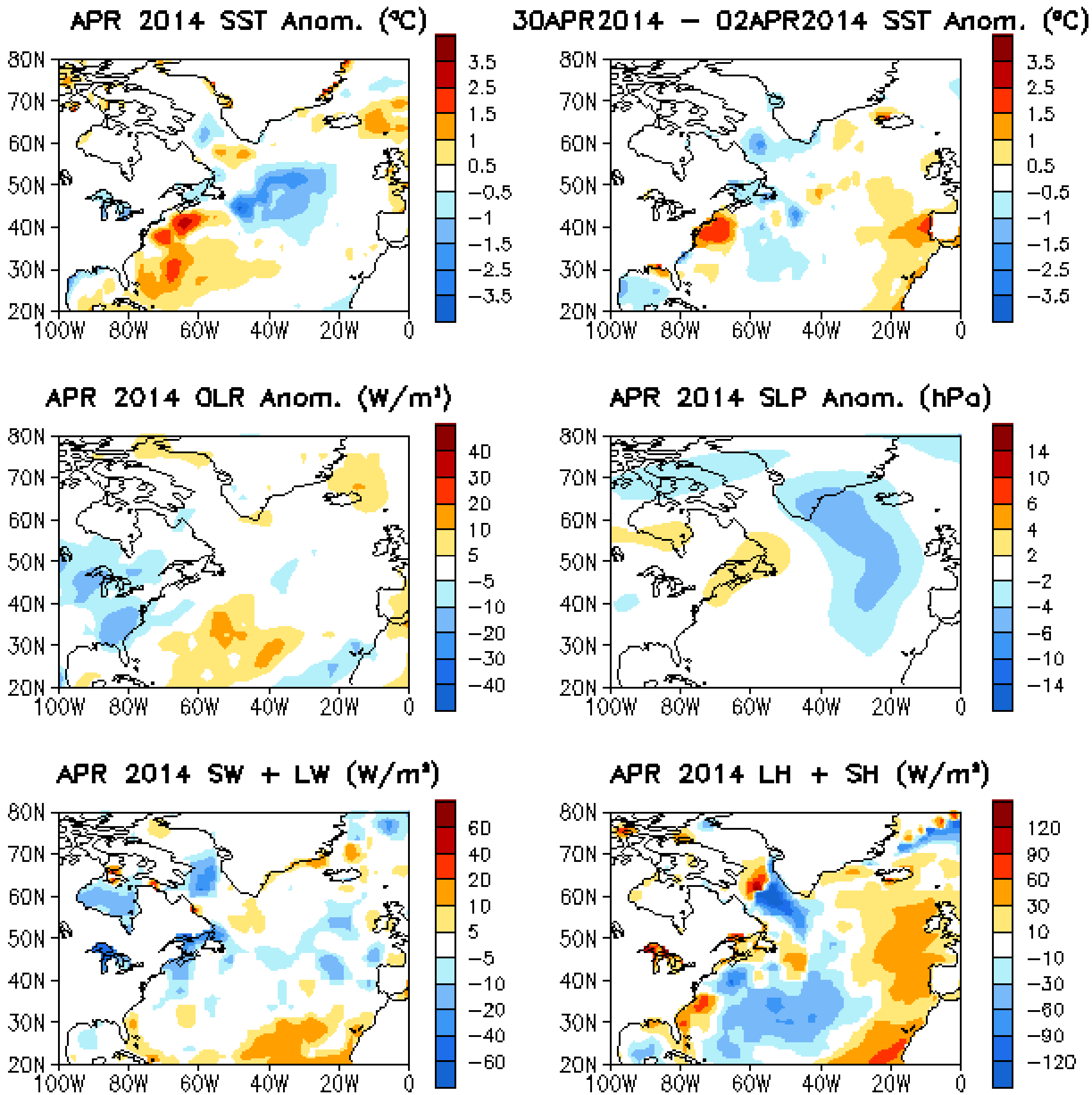


Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI 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.

Tropical Atlantic:



North Atlantic:



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

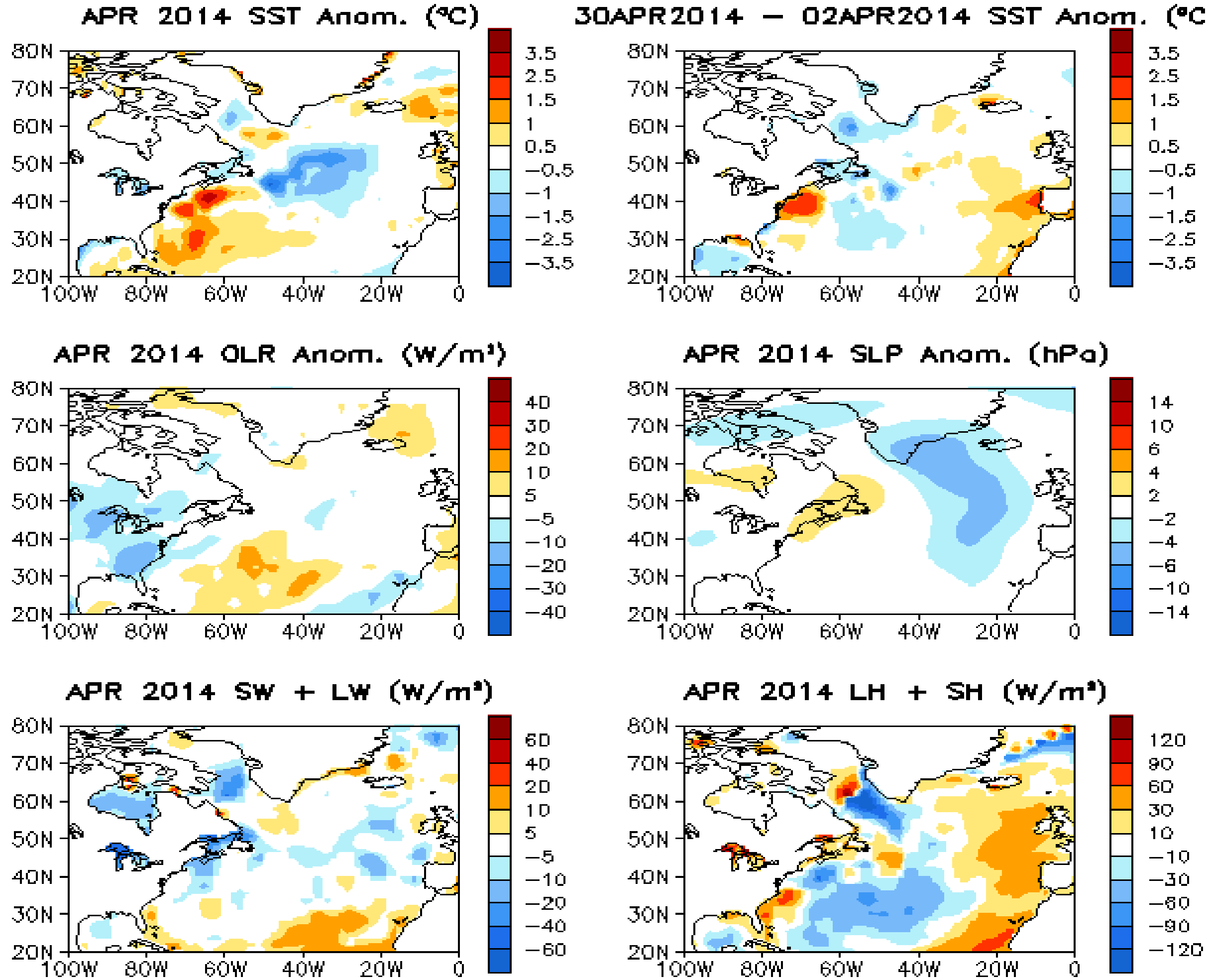
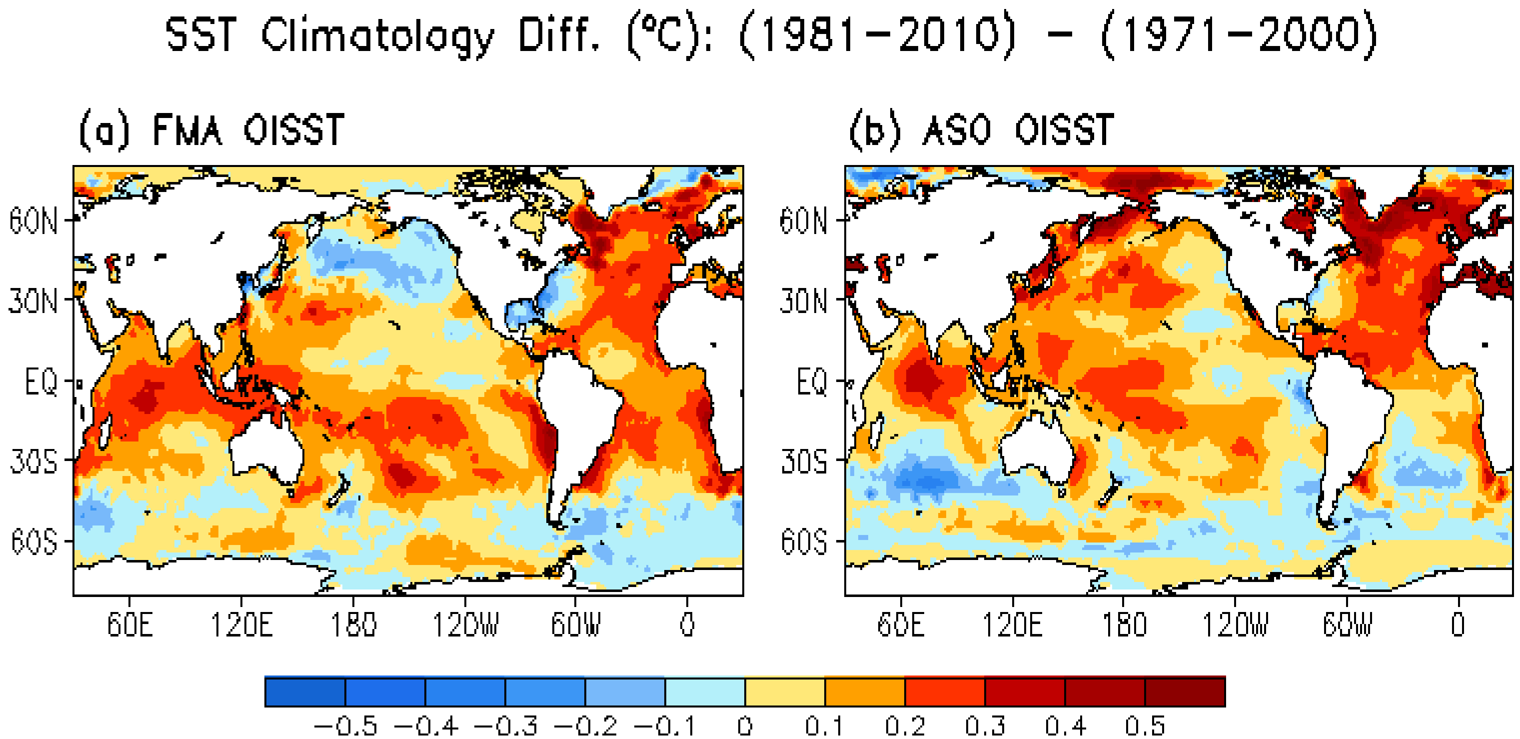


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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!