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

Prepared by
Climate Prediction Center, NCEP/NOAA

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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**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Global SST Predictions**

(Is an El Nino coming?)

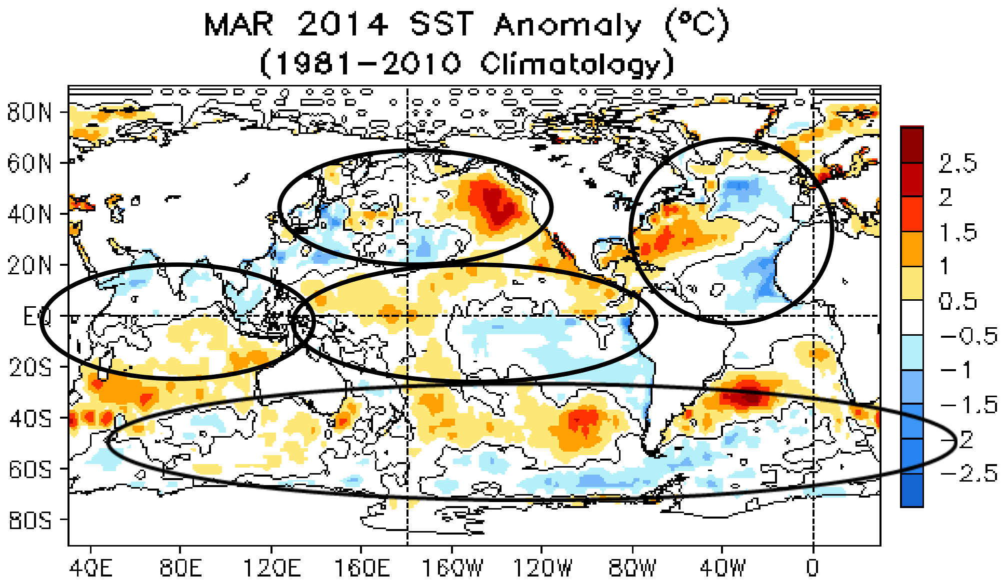
(An index to monitor if a strong El Nino occurs)

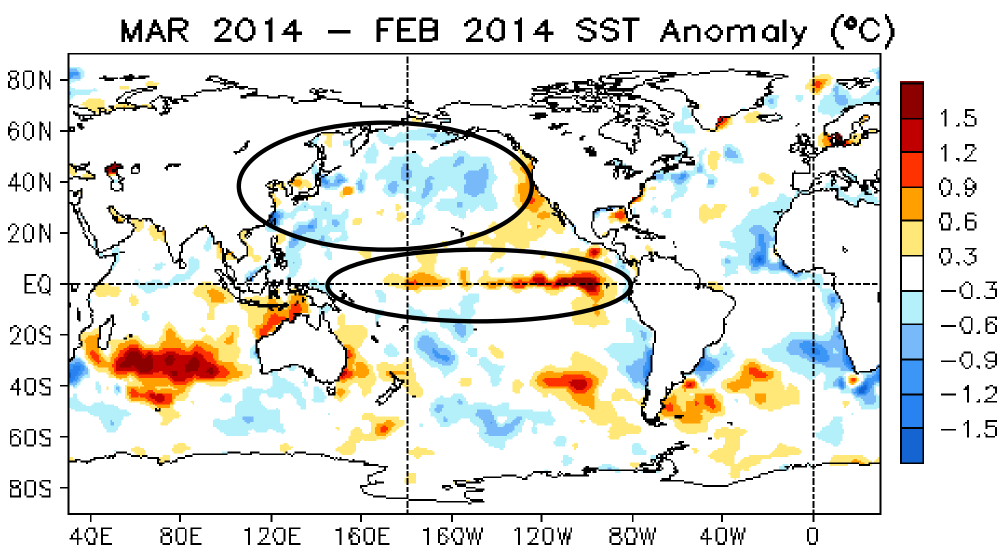
Overview

- **Pacific Ocean**
  - **ENSO neutral condition continued with NINO3.4=-0.2°C in Mar 2014.**
  - **Positive anomalies of subsurface ocean temperature along the equator propagated eastward and surface westerly wind anomaly in the equatorial Pacific was observed in Mar 2014.**
  - **All models predicted a warming tendency in this year, majority of the dynamical and some of statistical modes predicted an El Nino since this summer.**
  - **NOAA "ENSO Diagnostic Discussion" on 10 Apr 2014 issued "El Nino Watch" and suggests that "While ENSO-neutral is favored for Northern Hemisphere spring, the chances of El Niño increase during the remainder of the year, exceeding 50% by summer".**
  - **The negative PDO index has persisted near 4 years (47 months) since May 2010, and weakened significantly in Mar 2014 with PDO index =-0.02.**
- **Indian Ocean**
  - **Negative (positive) SSTA presented in the tropical northern (southern) Indian Ocean in Mar 2014.**
- **Atlantic Ocean**
  - **NAO switched into positive phase in Feb 2014 and NAOI=0.44 in Mar 2014.**
  - **Tripole pattern of SSTA presented in North Atlantic in Mar 2014.**

Global Oceans

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



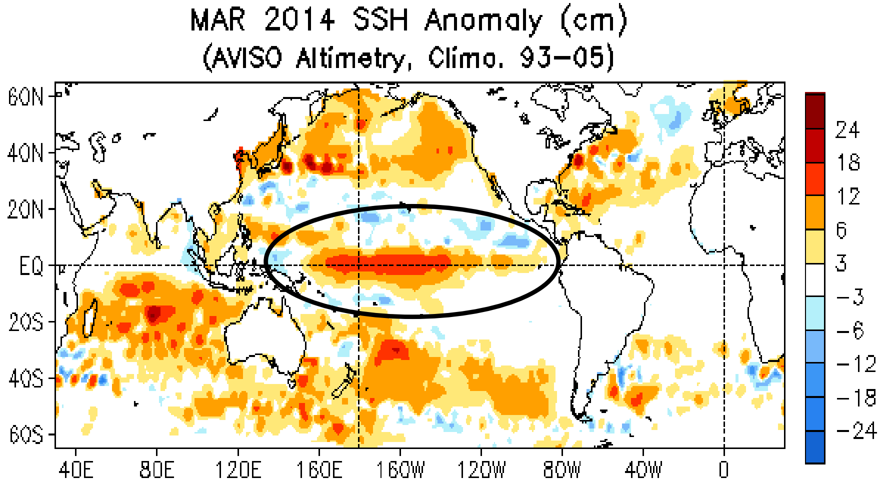


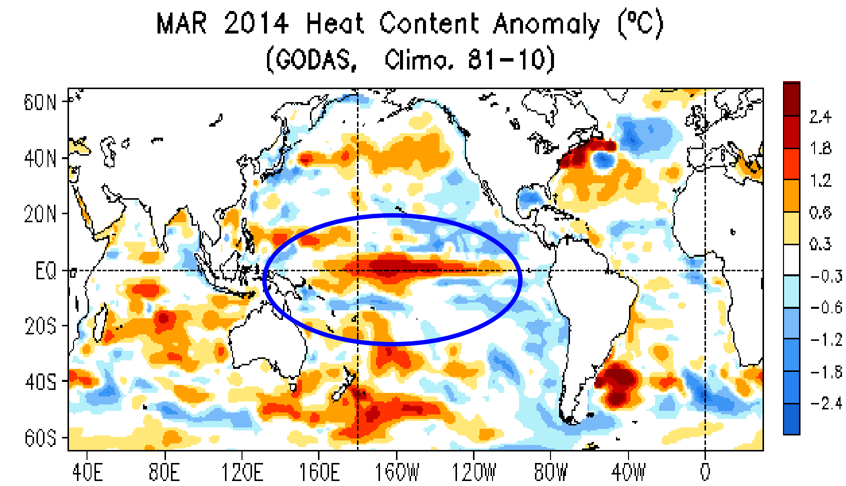
- **Positive SSTA persisted in the western and central, and near average SST in the eastern tropical Pacific.**
- **Strong positive SSTA presented in the northeastern Pacific.**
- **Tripole SSTAs emerged in the North Atlantic.**
- **Some large SSTAs existed in the South Ocean.**

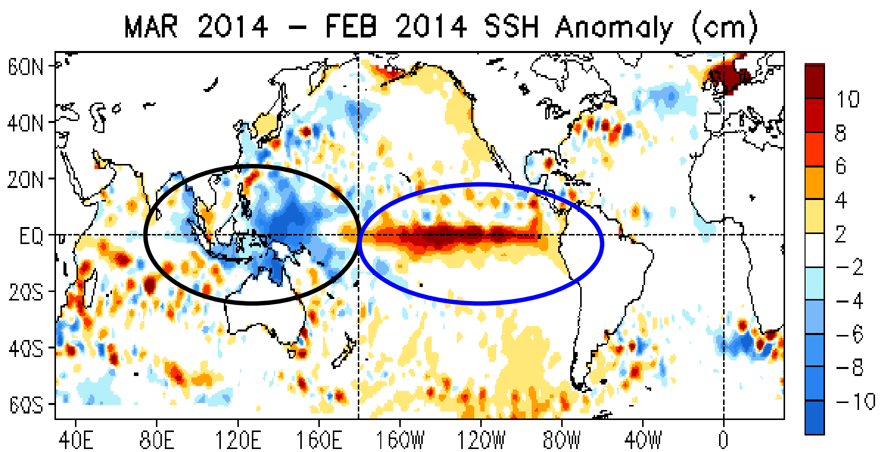
- **Large positive SSTA tendencies were observed in the central and eastern equatorial Pacific Ocean.**
- **Cooling tendencies emerged in the central and northwestern Pacific, consisting with significant weakening of negative phase of PDO.**

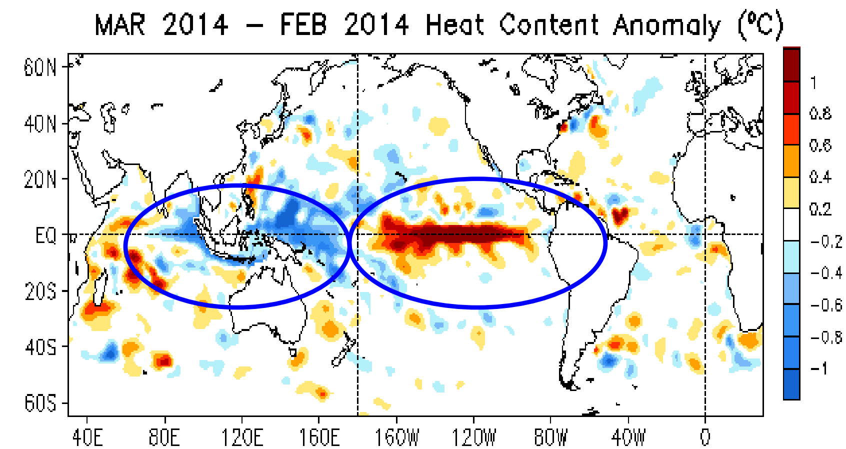
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency







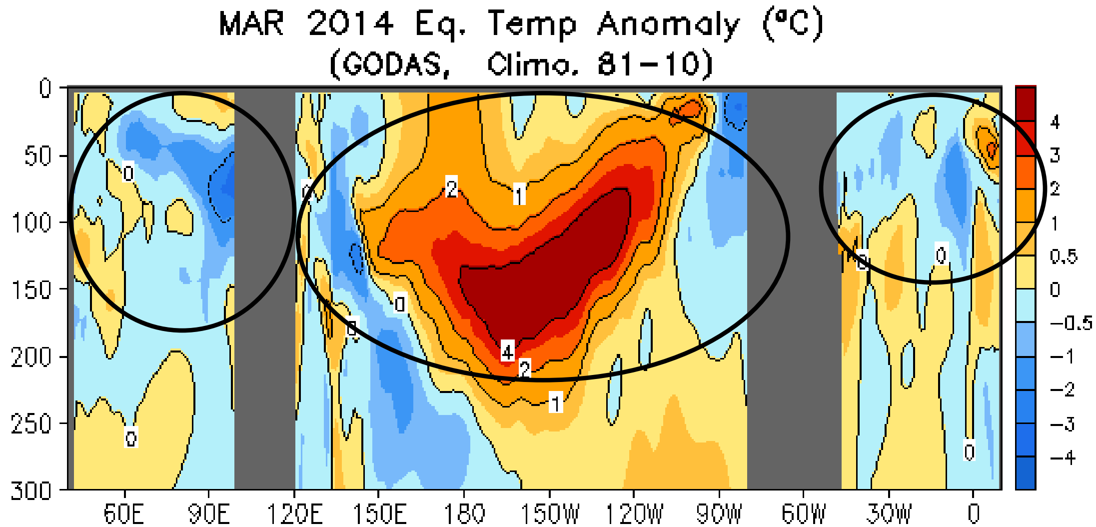


- The SSHA was overall consistent with HC300A: Positive (negative) HC300A is tied up with positive (negative) SSHA.

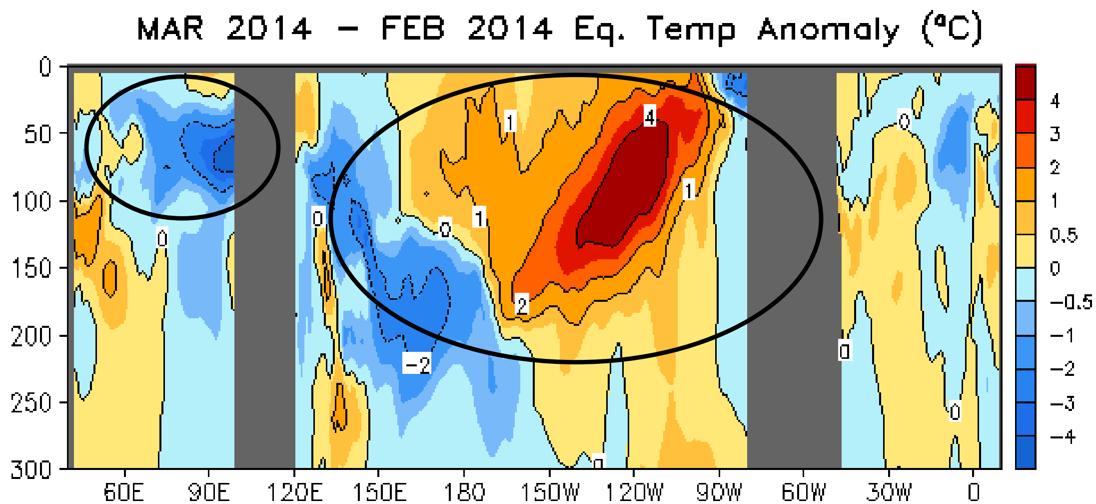
- SSH was more than 12 cm above-normal in the central Pacific in March 2014.

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

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

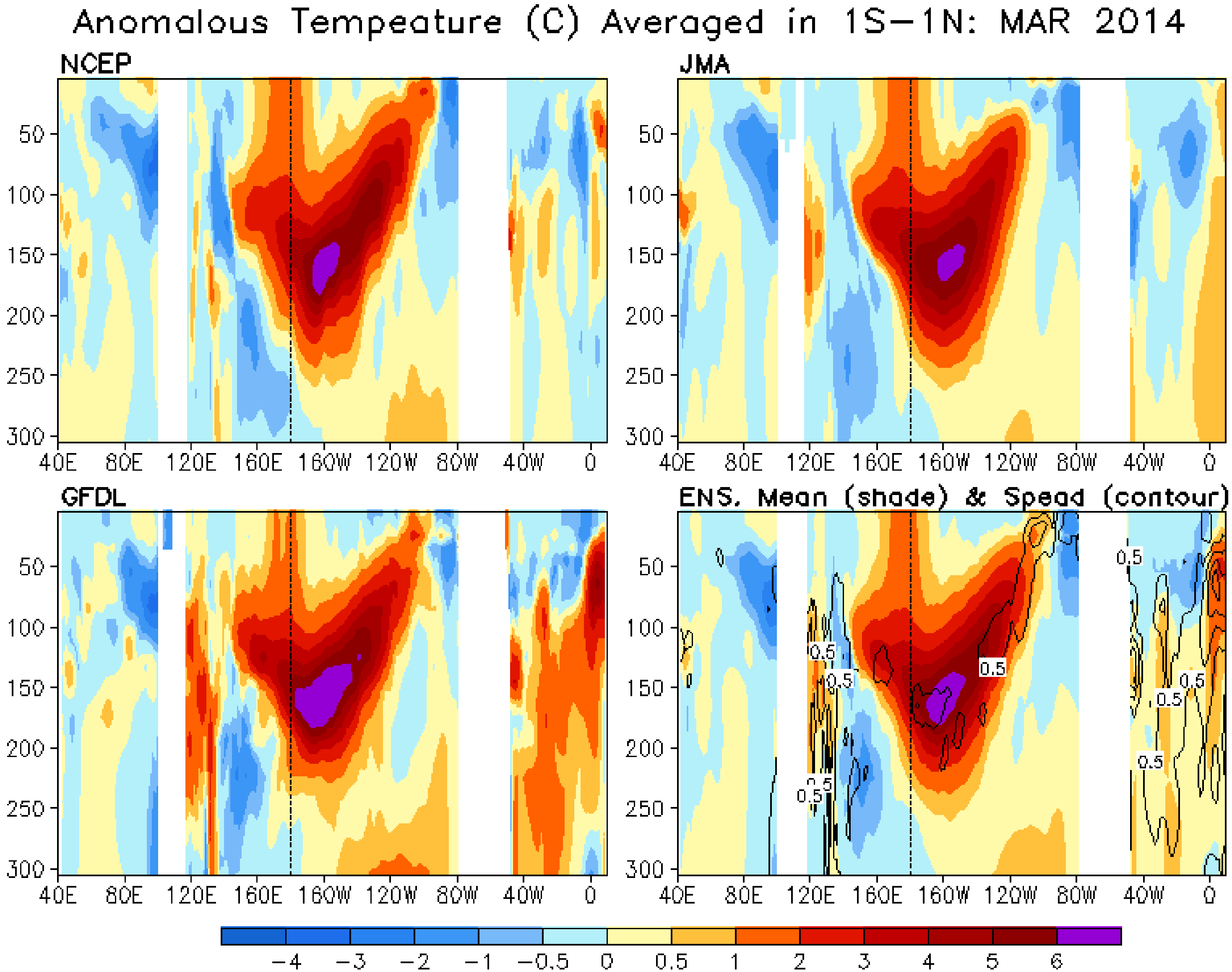


- Strong positive (weak negative) ocean temperature anomalies in the central (western and eastern coast) equatorial Pacific emerged.
- Both positive and negative ocean temperature anomalies were small in the Indian and Atlantic Oceans.



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

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.



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

Global Sea Surface Salinity (SSS)

Anomaly for March 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

SSS anomaly over many other regions, especially over the eastern Pacific seems influenced by other factors (e.g. transportation)

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

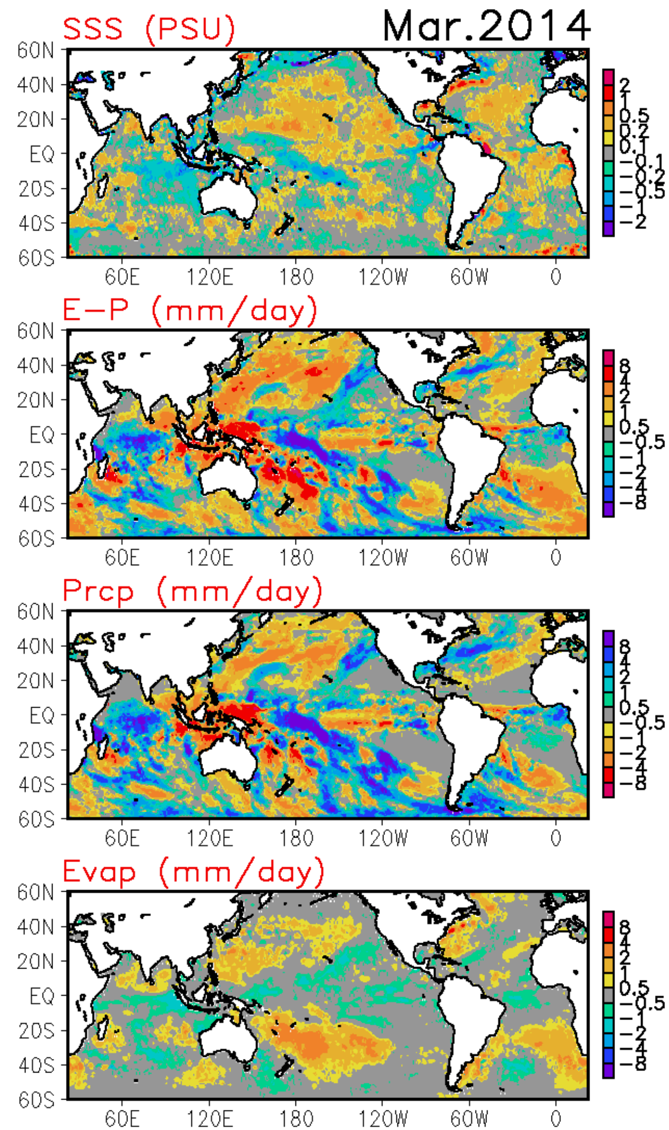
Precipitation:

CMORPH adjusted satellite precipitation estimates

Evaporation:

CFS Reanalysis

For details: ask Dr. Pingping Xie (Pingping.Xie@noaa.gov)

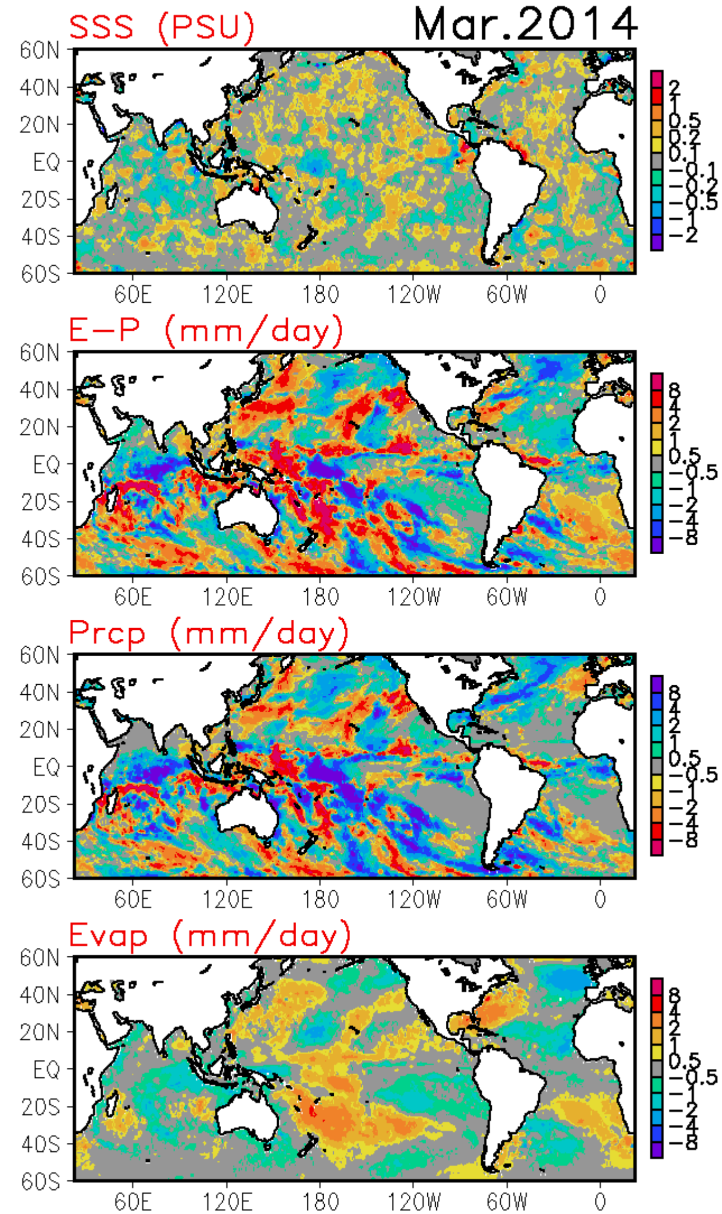


Global Sea Surface Salinity (SSS)

Anomalous Tendency Mar-Feb 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



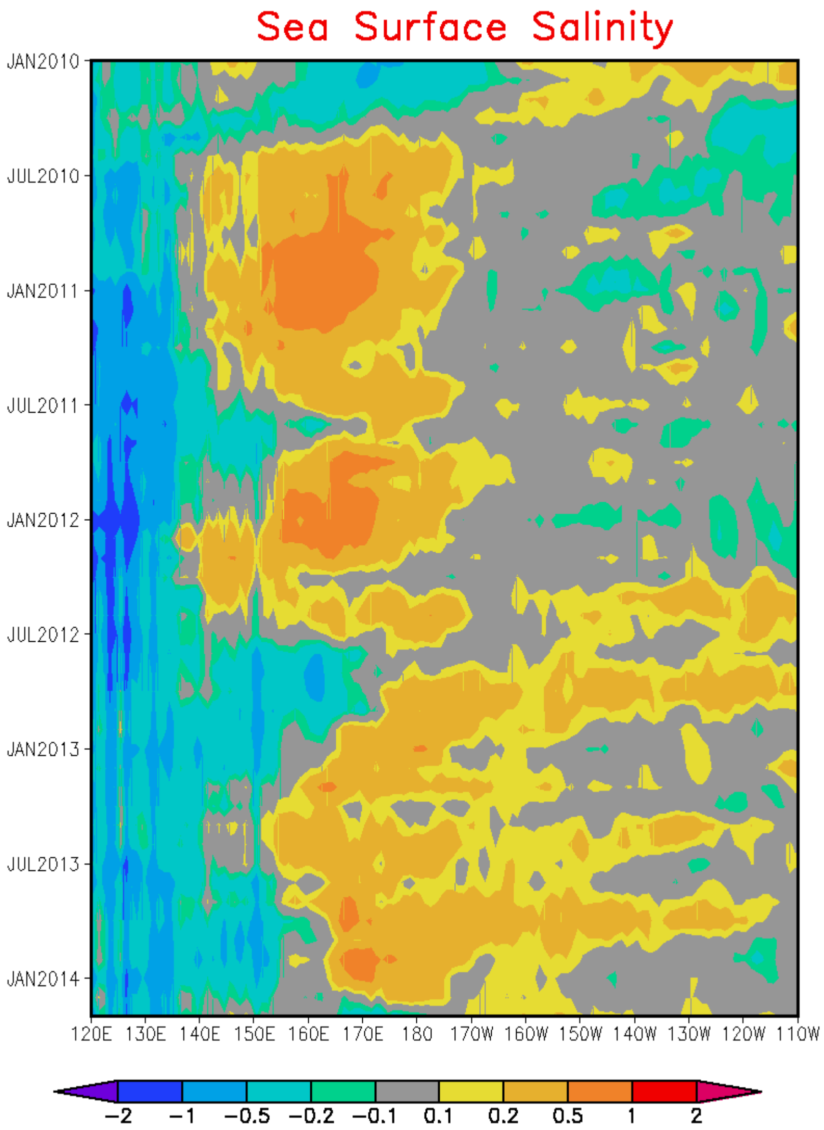
Global Sea Surface Salinity (SSS)

Anomaly Evolution along the equatorial Pacific

Hovemoller diagram for equatorial SSS anomaly (5ºS-5ºN);

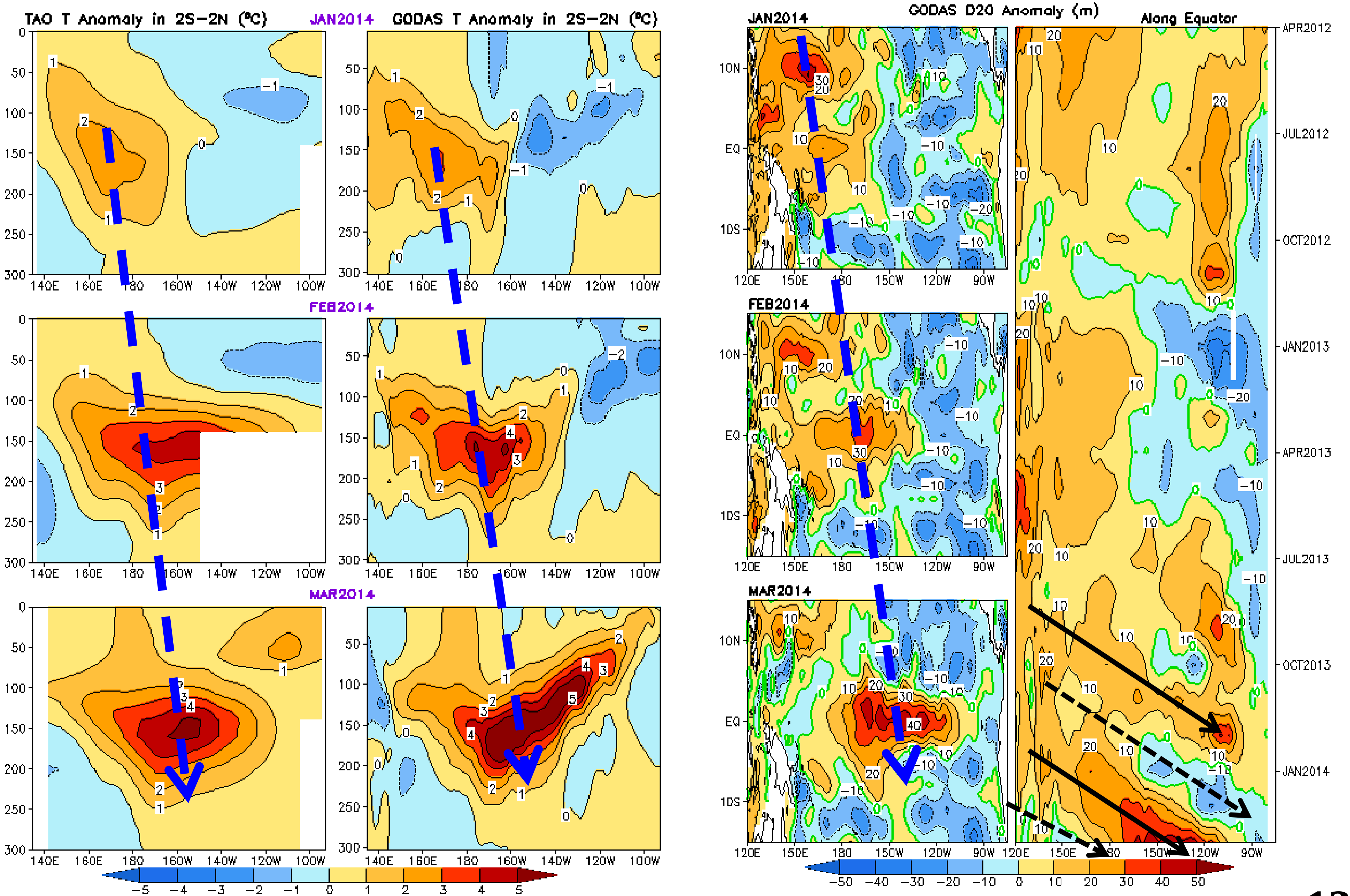
SSS exhibits negative/positive anomalies over the western/central-eastern Pacific over recent three years;

Negative SSS anomaly extends eastward and reaches to the dateline last month.

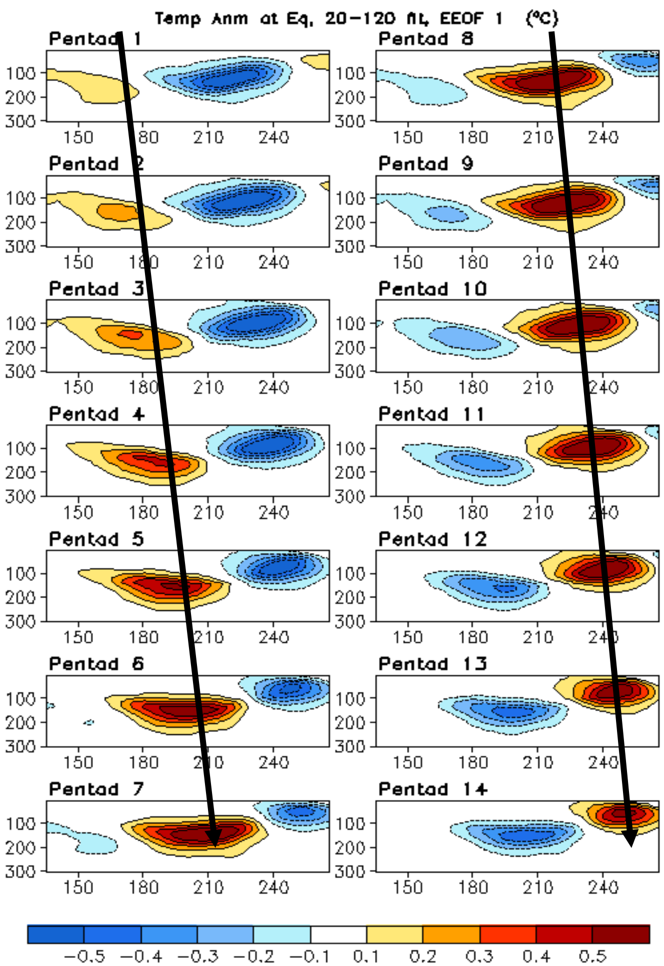


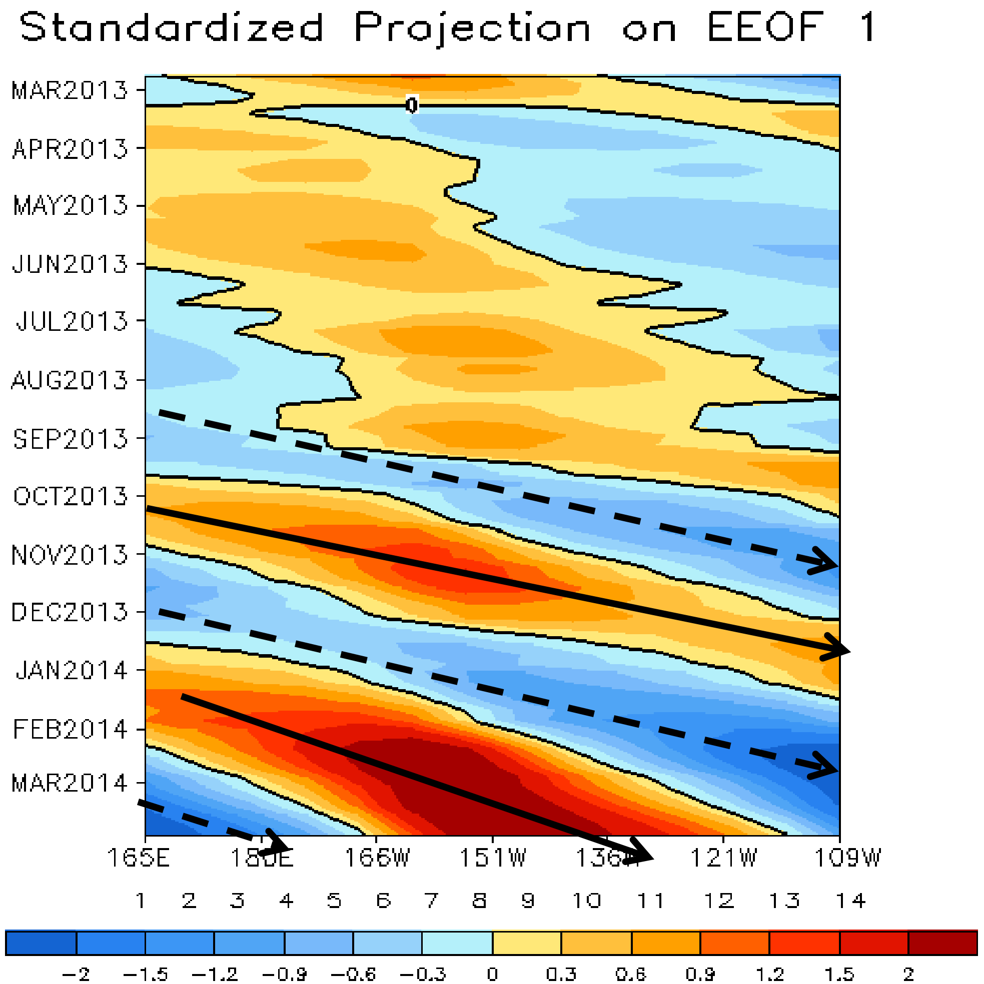
Tropical Pacific Ocean and ENSO Conditions

Ocean Temperature and D20 Anomaly (intensified and eastward propagation)



Oceanic Kelvin Wave (OKW) Index



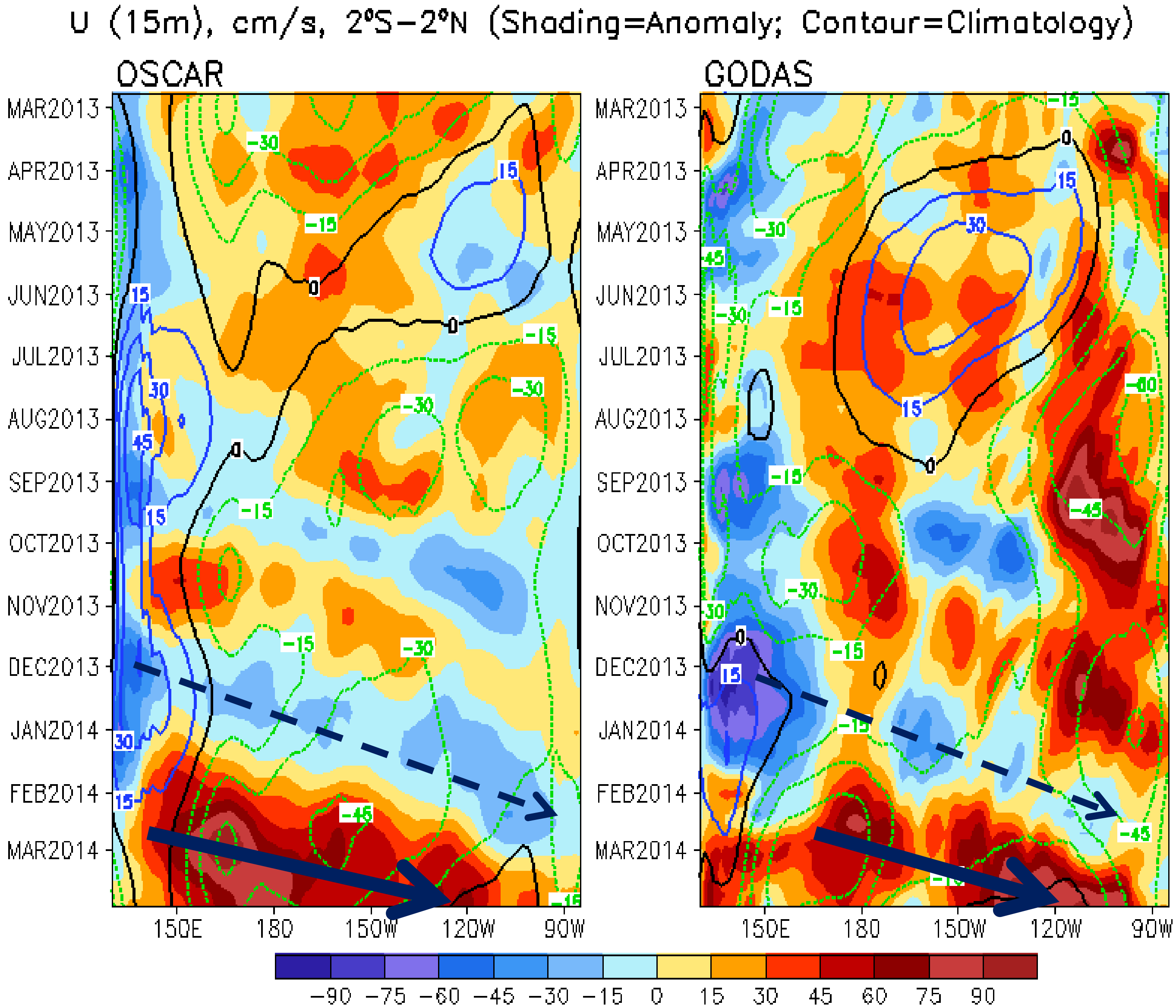


- **Downwelling OKW (solid line) emerged since Jan 2014 in the W. Pacific, while upwelling OKW initiated in mid-Feb in the W. Pacific.**

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

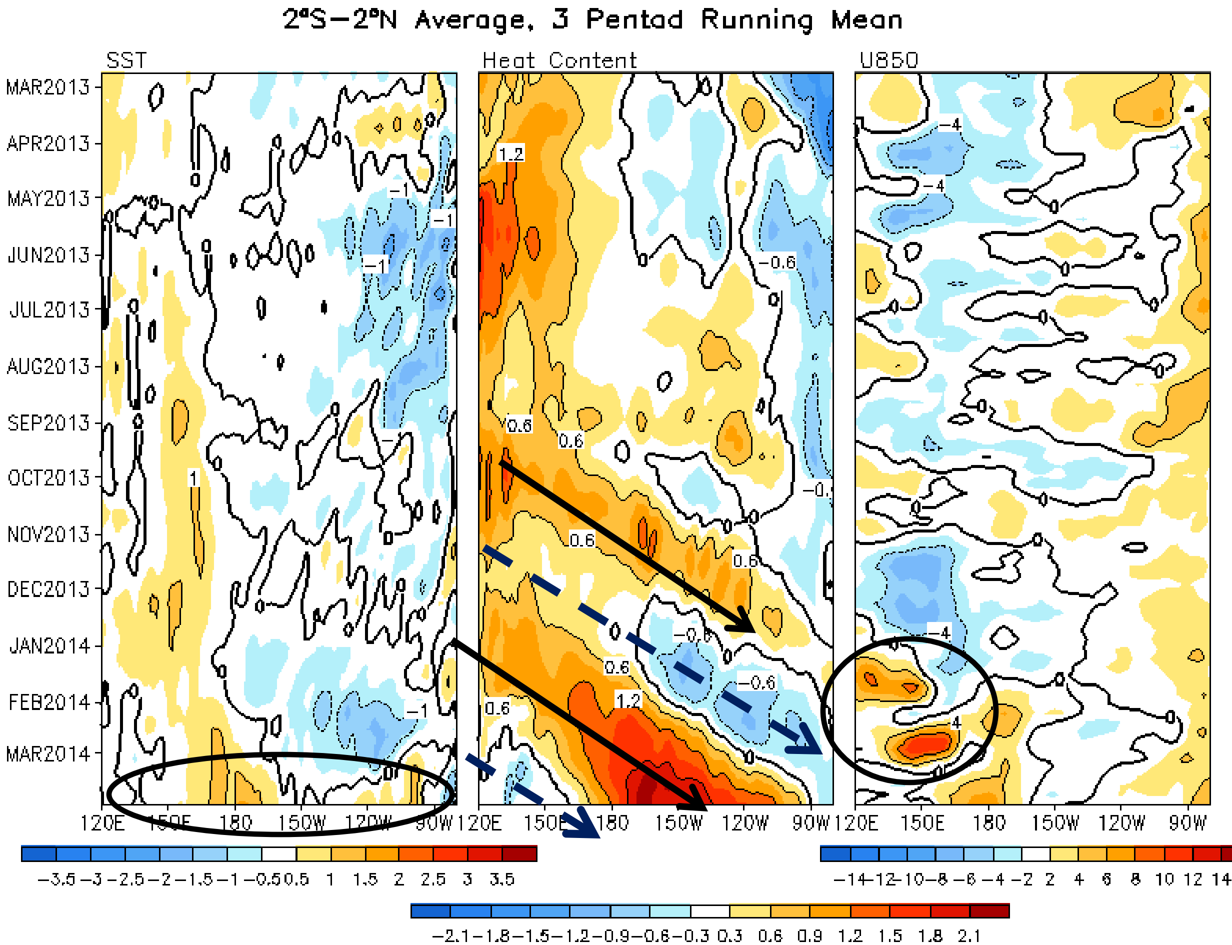
- **OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF 1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).**

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

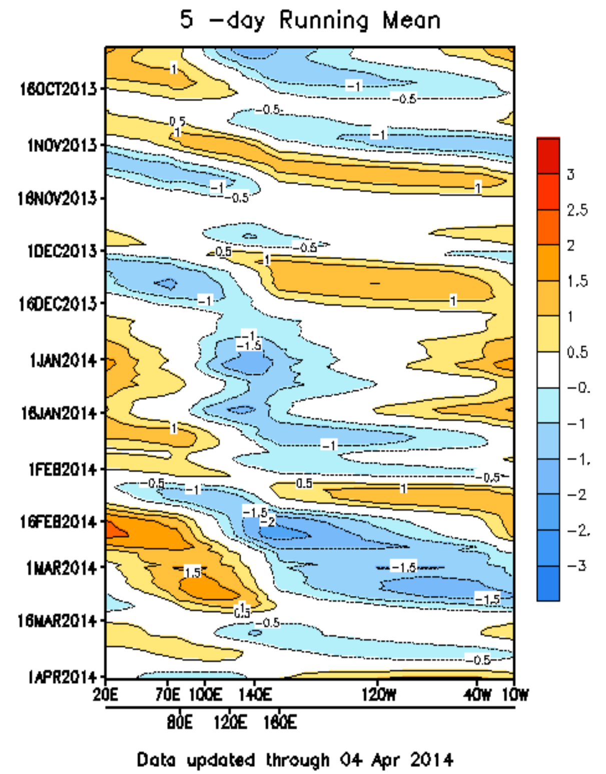


- The anomalous current pattern was similar between OSCAR and GODAS in the last about 6-7 months.
- Strong eastward current initiated in Feb 2014 and propagated eastward and reached the eastern boundary in the end of Mar 2014.
- That is consistent with the evolution of ocean temperature & D20 anomaly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

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 2-3 months.**
- **Positive HC300 anomalies initiated in Dec 2013 and propagated eastward.**
- **Westerly wind burst-like events emerged in Jan and Feb 2014.**

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

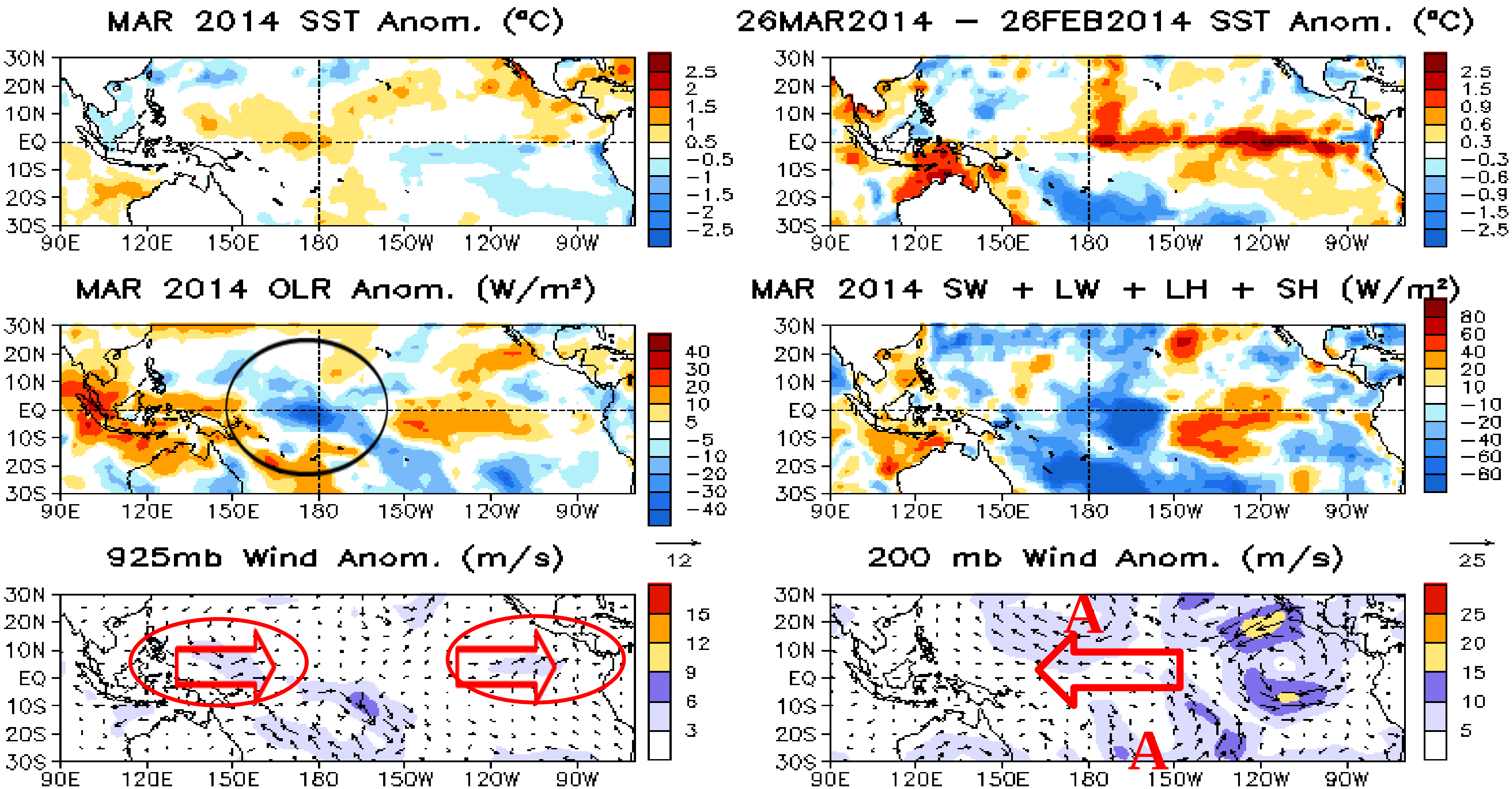
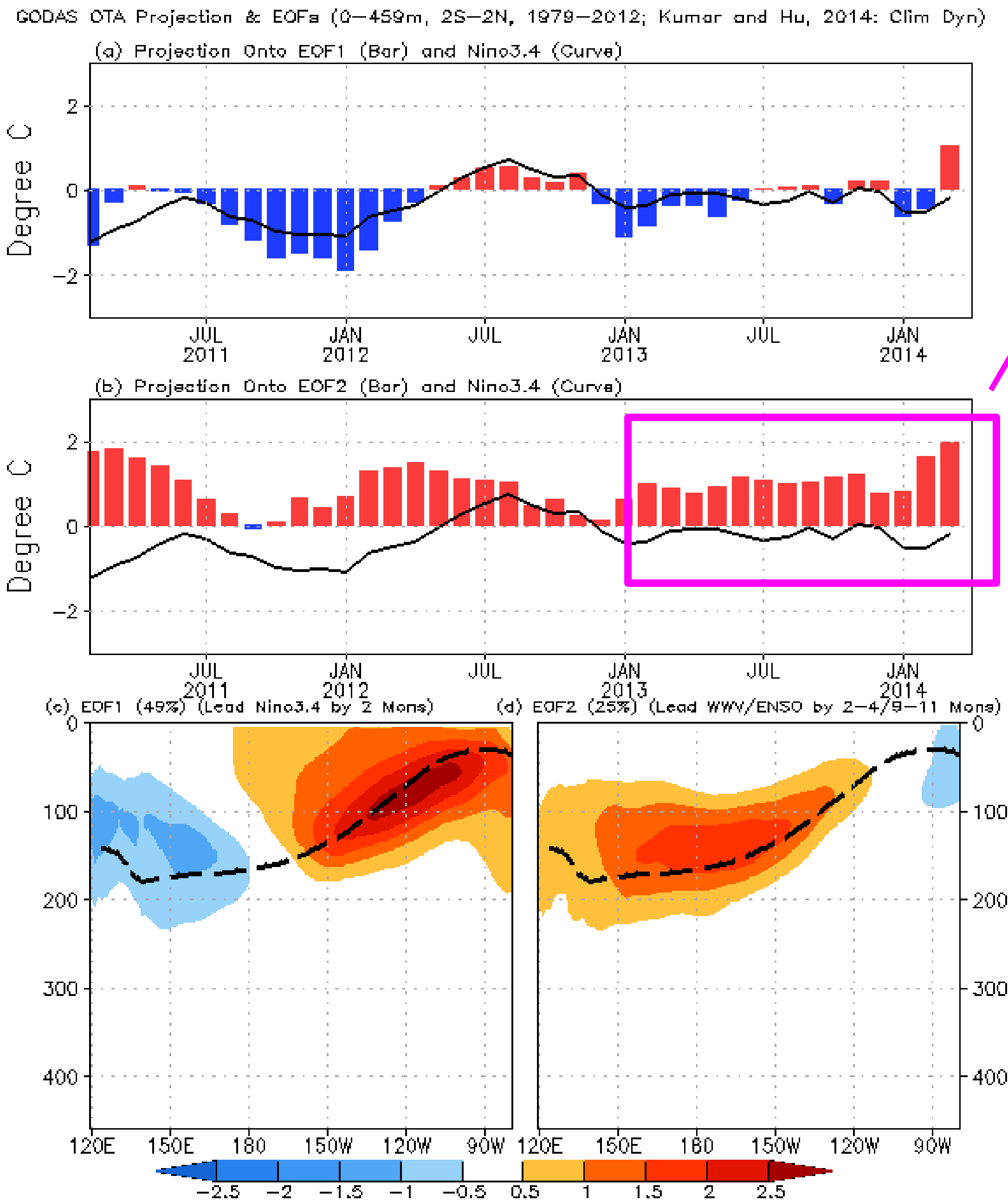


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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



Equatorial subsurface ocean temperature monitoring: Right now, it was still in recharge phase and intensified in last 2 months.

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).

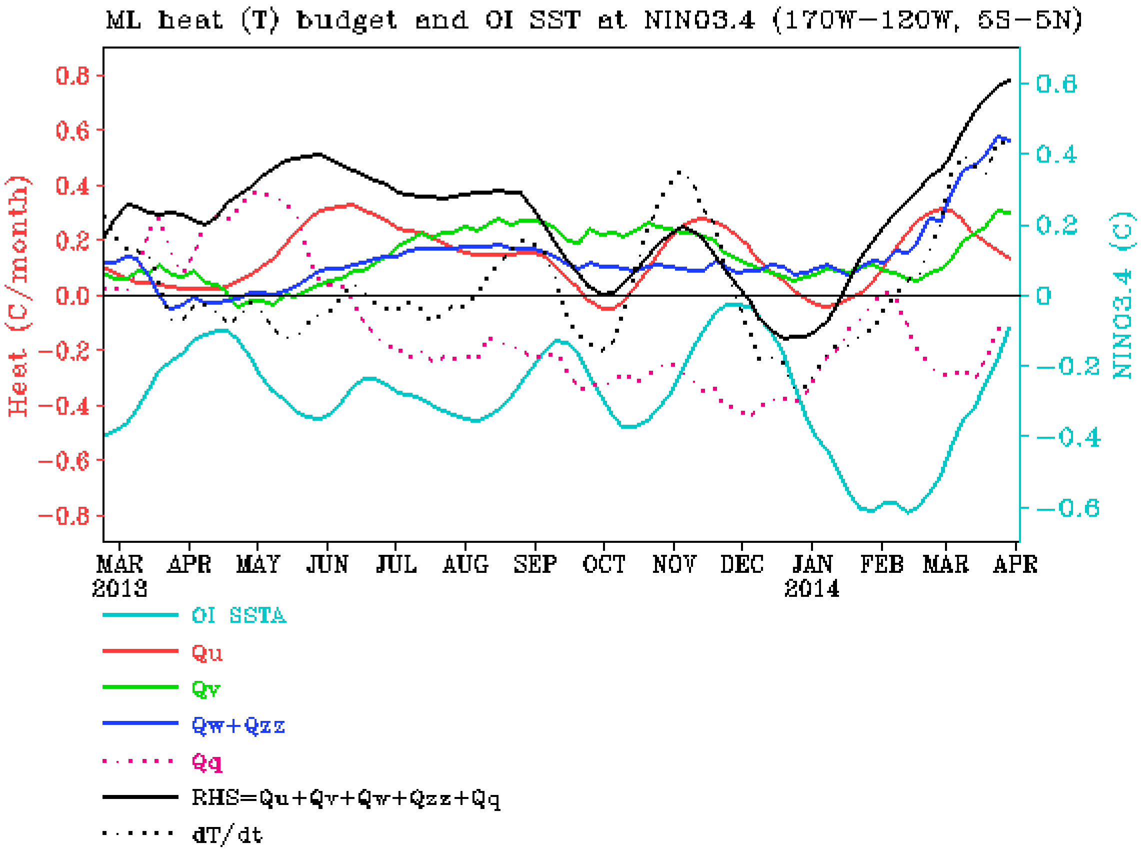
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

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*.

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 the last a few months**

- **The total heat budget term (RHS) had some warm biases compared with the tendency (dT/dt) since Dec 2013.**

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

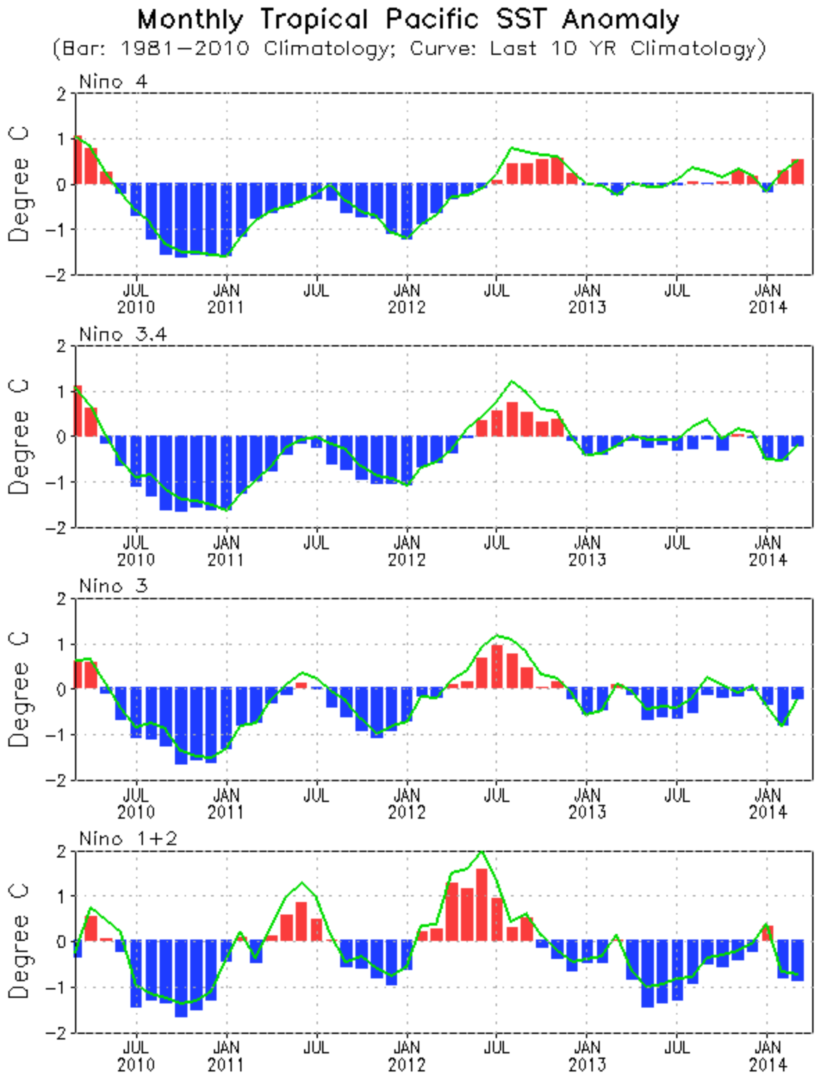
Qu: Zonal advection; Qv: Meridional advection;

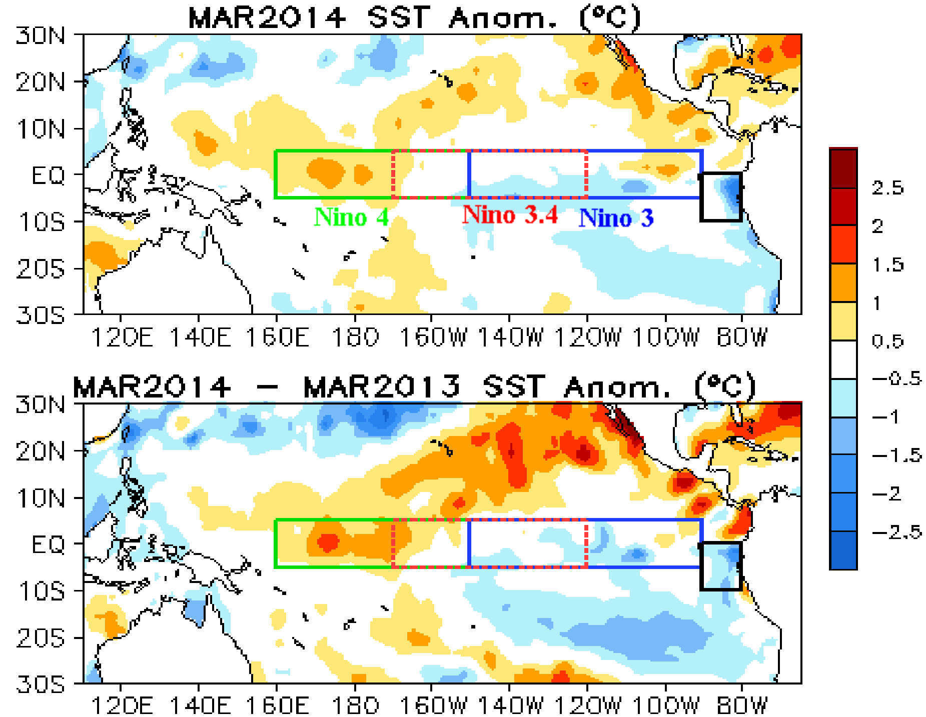
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

Evolution of Pacific NINO SST Indices





- All NINO indices, except Nino1+2, had a positive tendency in Mar 2014.

- Nino3.4 = -0.2°C in Mar 2014.

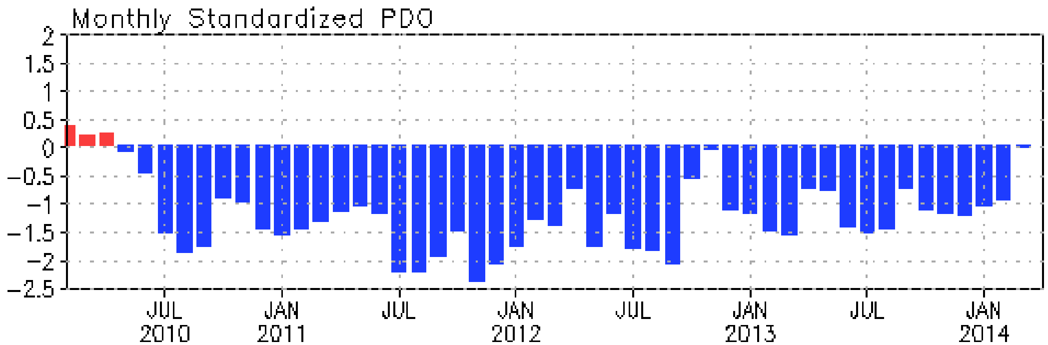
- Compared with last Mar, zonal SSTA gradient was slightly larger in the equatorial Pacific in Mar 2014.

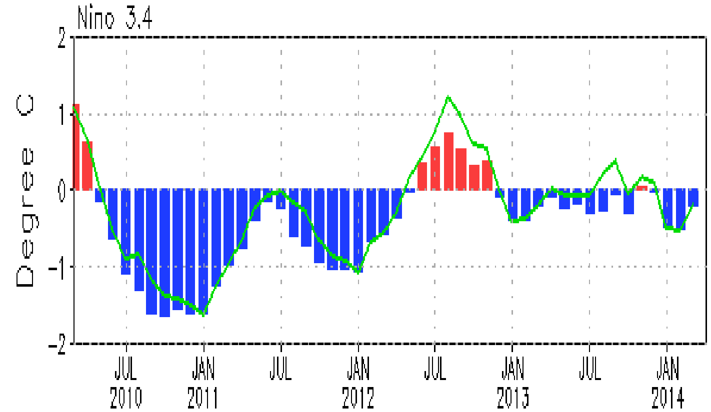
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.

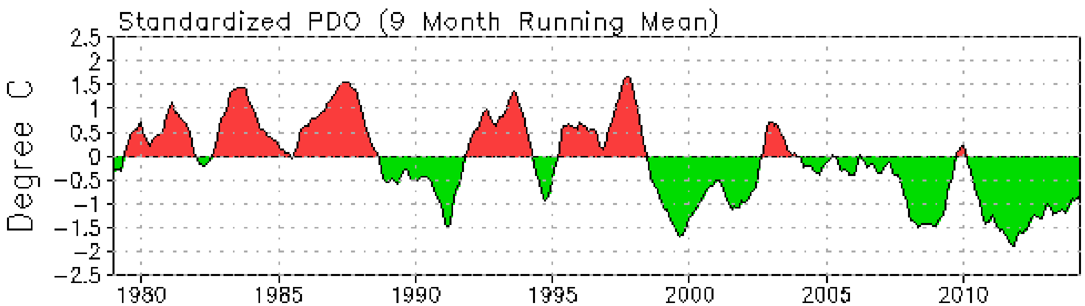
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

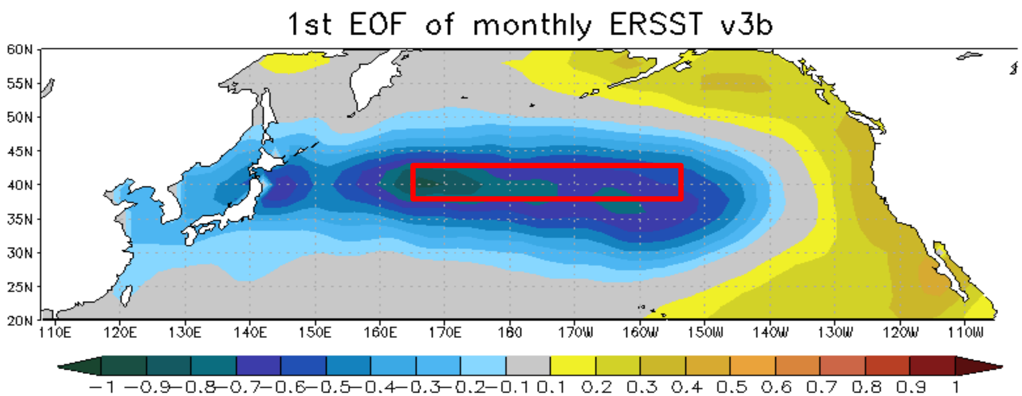
North Pacific & Arctic Oceans

PDO index







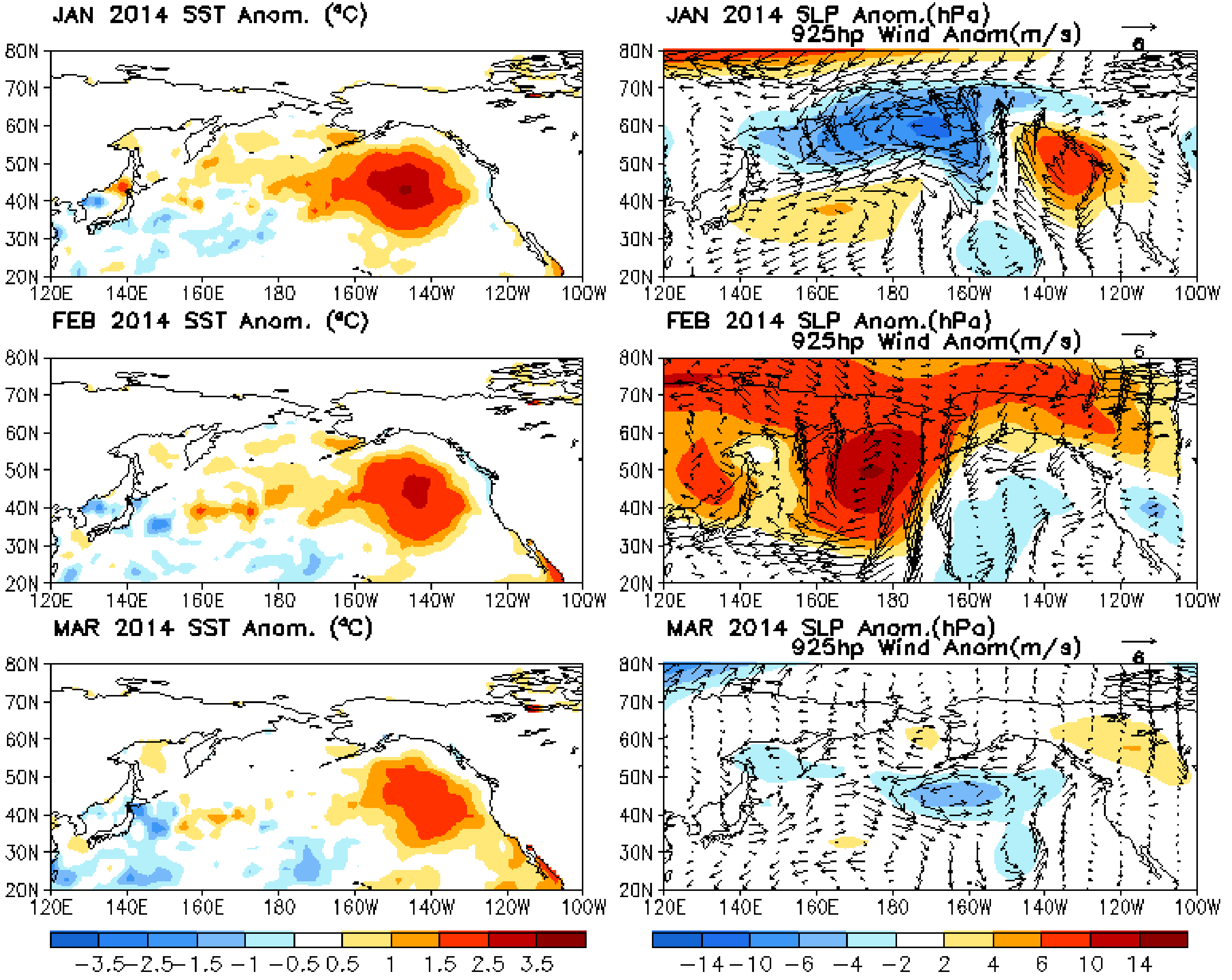


- The negative PDO index has persisted near 4 years (47 months) since May 2010, and weakened significantly in Mar 2014 with PDO index =-0.02.

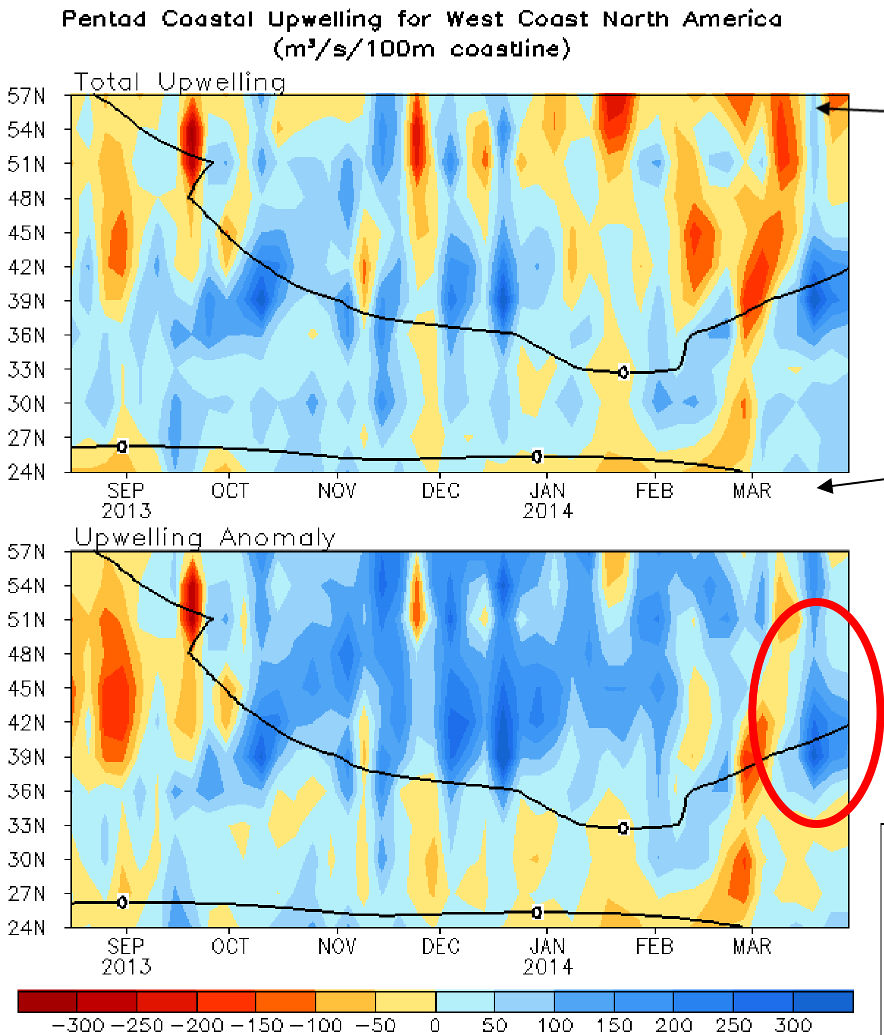
- Statistically, ENSO and PDO are connected, may through atmospheric bridge.

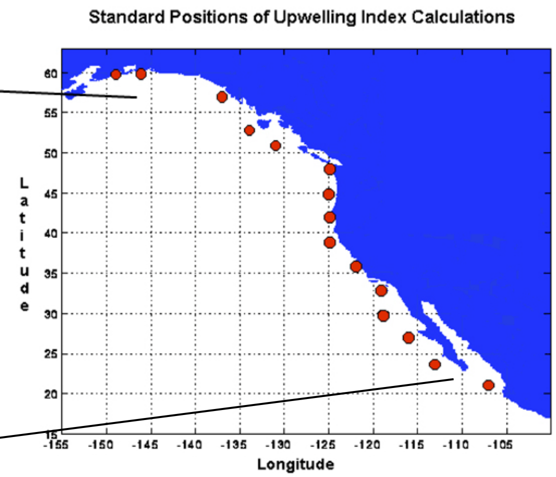
- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.


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

North America Western Coastal Upwelling





- Strong anomalous upwelling in 36-46N was observed in Mar 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.

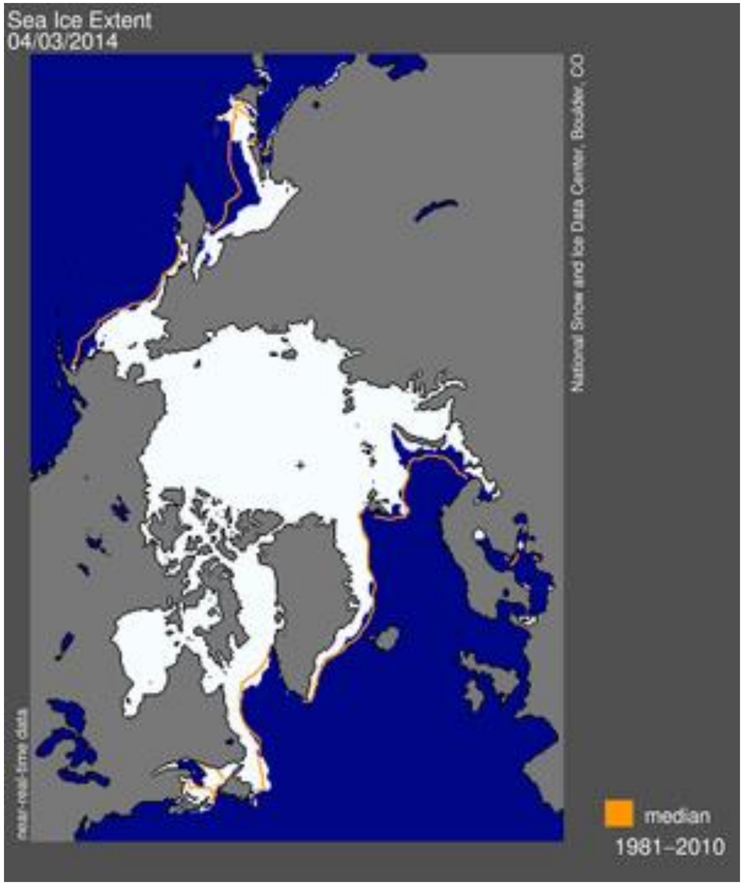
- Area below (above) black line indicates climatological upwelling (downwelling) season.

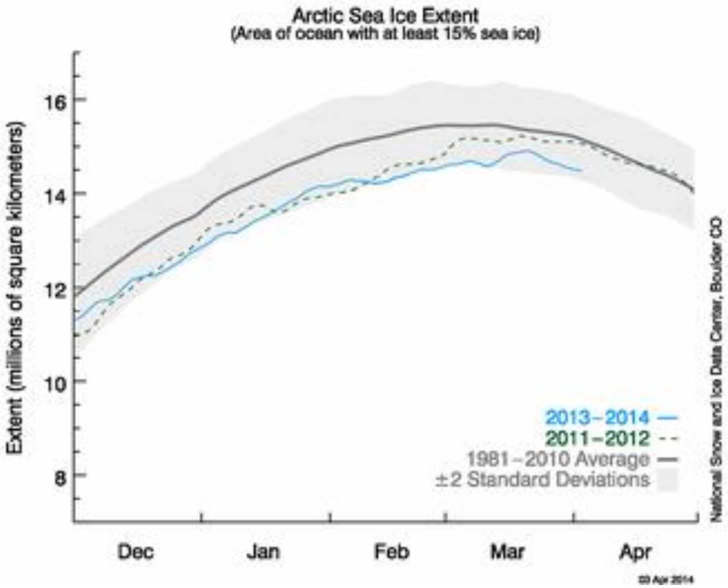
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

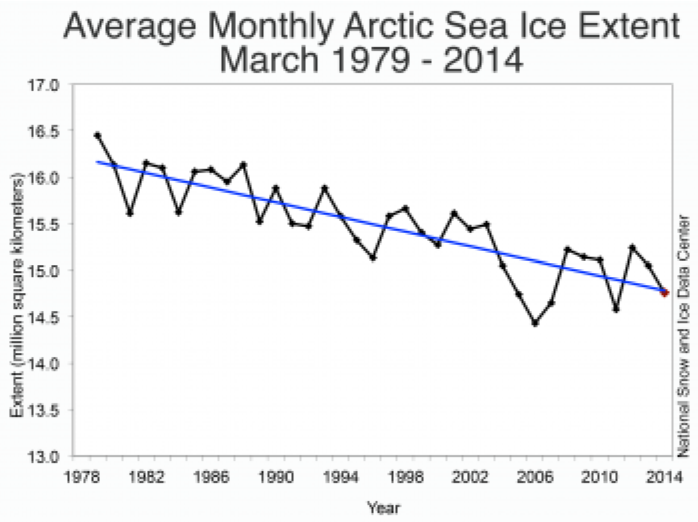
Arctic Sea Ice

National Snow and Ice Data Center

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



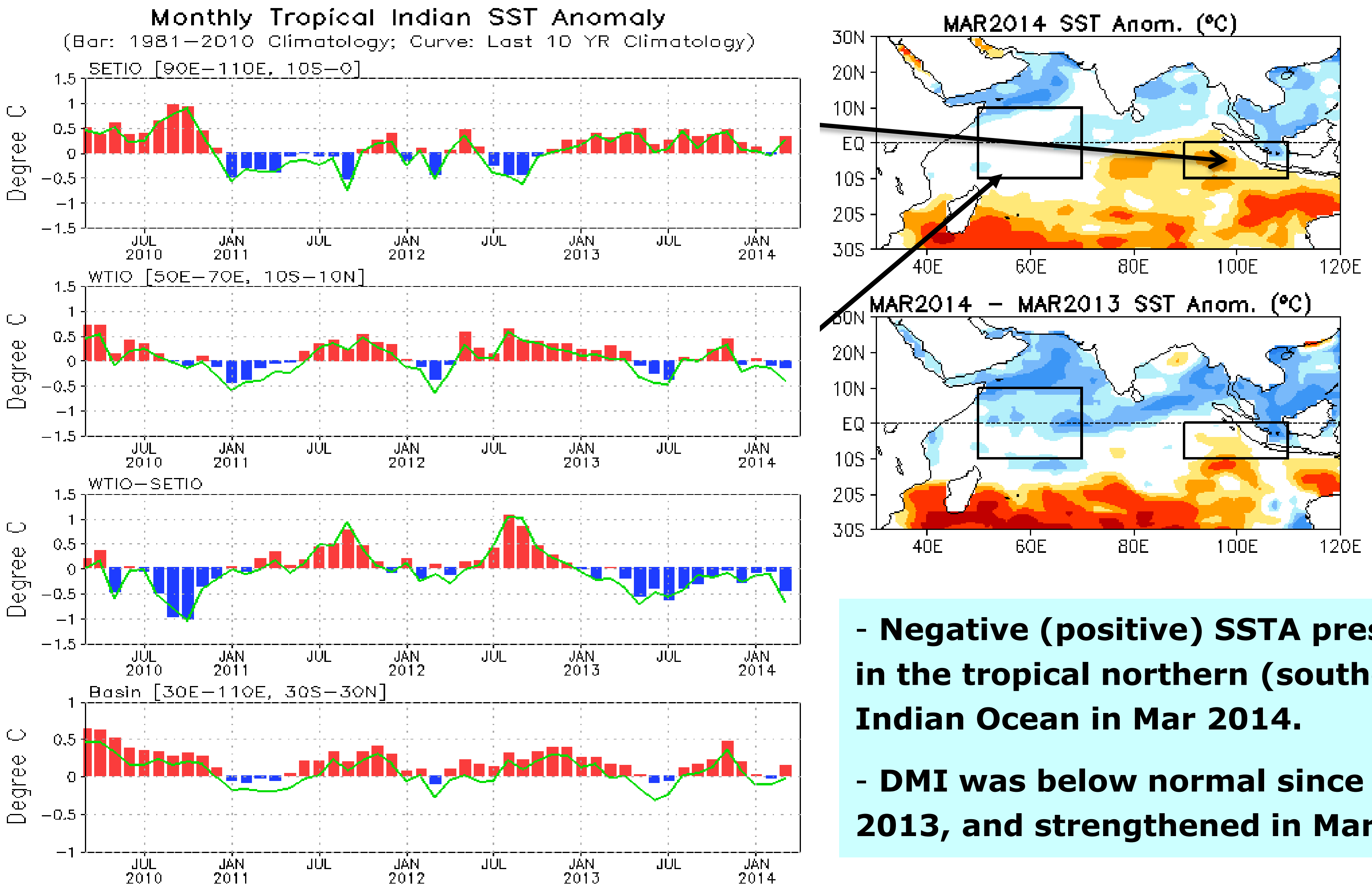




- **Arctic sea ice reached its annual maximum extent on March 21.**
- **Overall the 2014 Arctic maximum was the fifth lowest in the 1978 to 2014 record.**

Indian Ocean

Evolution of Indian Ocean SST Indices



- **Negative (positive) SSTA presented in the tropical northern (southern) Indian Ocean in Mar 2014.**

- **DMI was below normal since Apr 2013, and strengthened in Mar 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 (negative) SSTA was in the southern (northern) Indian Ocean.
- Convections were enhanced over the western and central and suppressed over the eastern Indian Ocean.

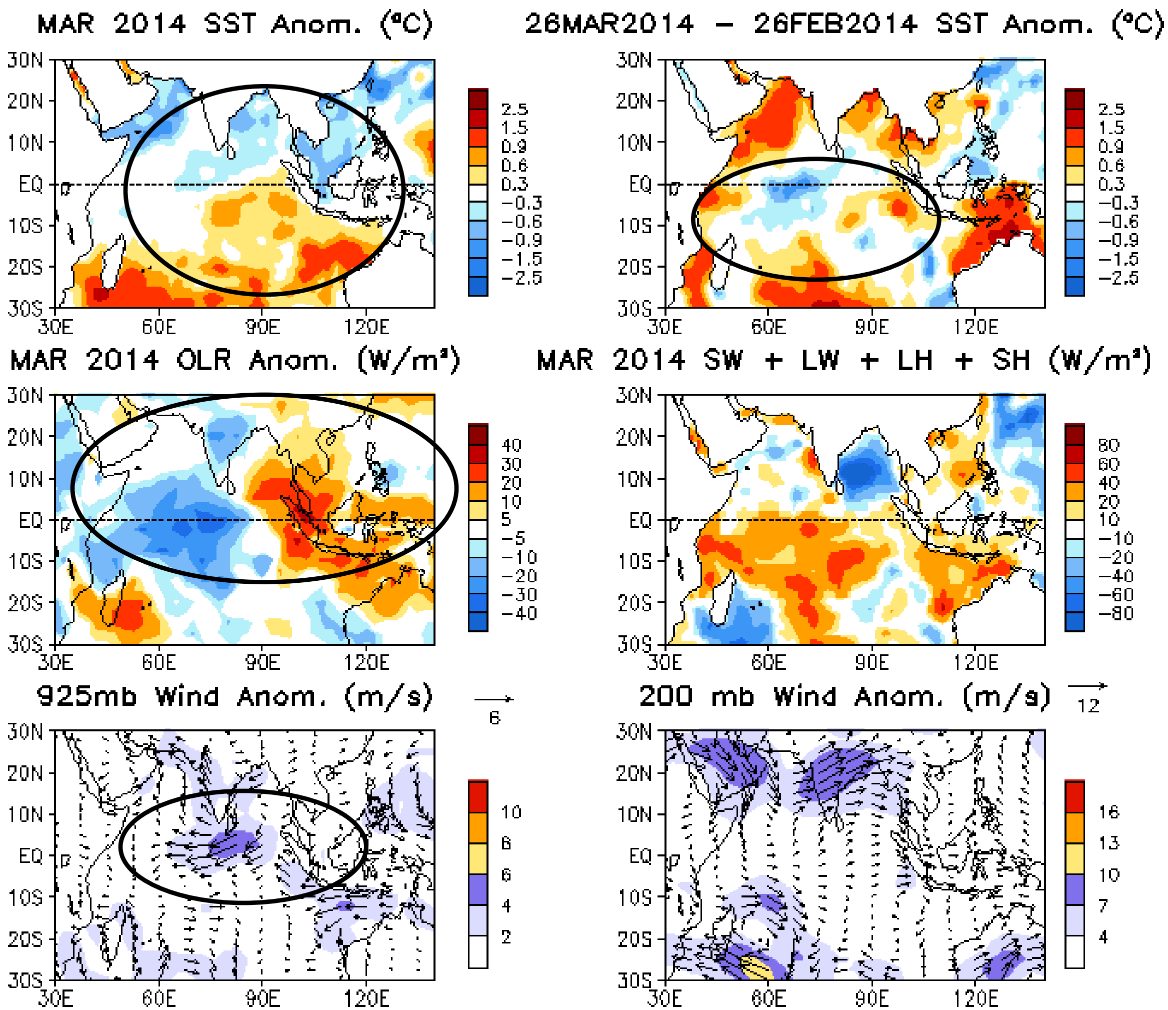
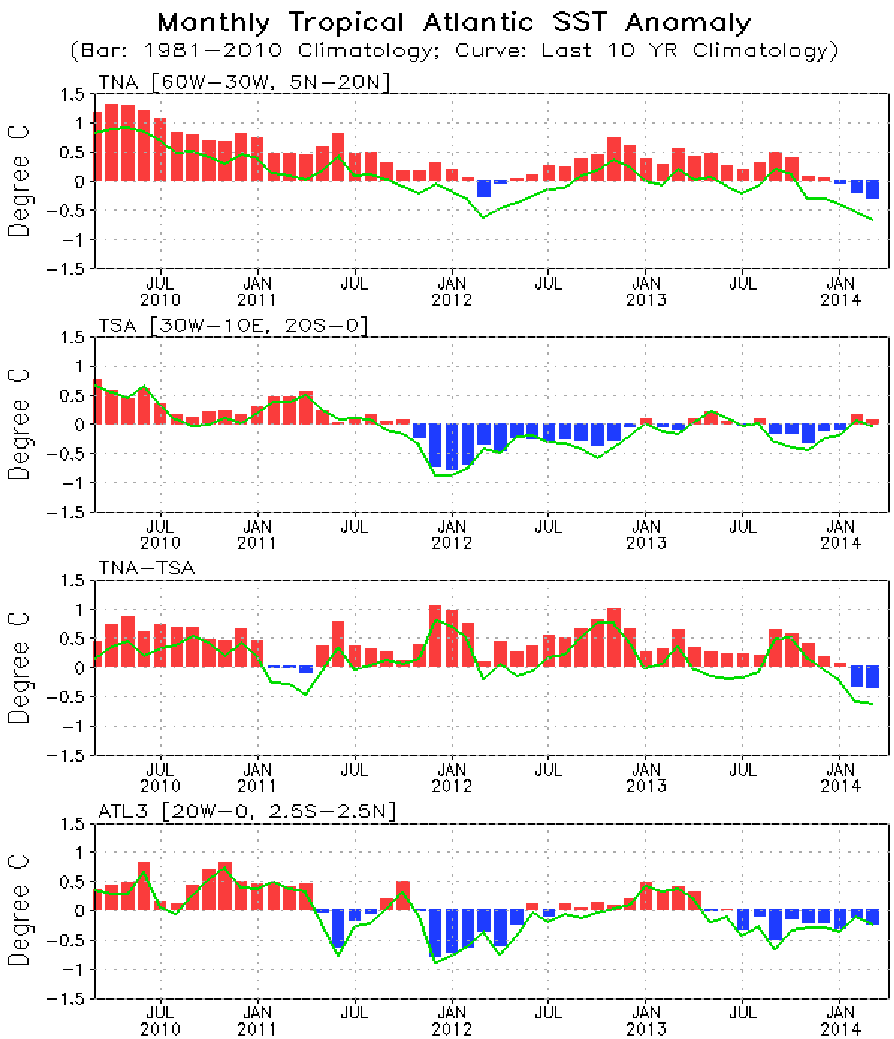
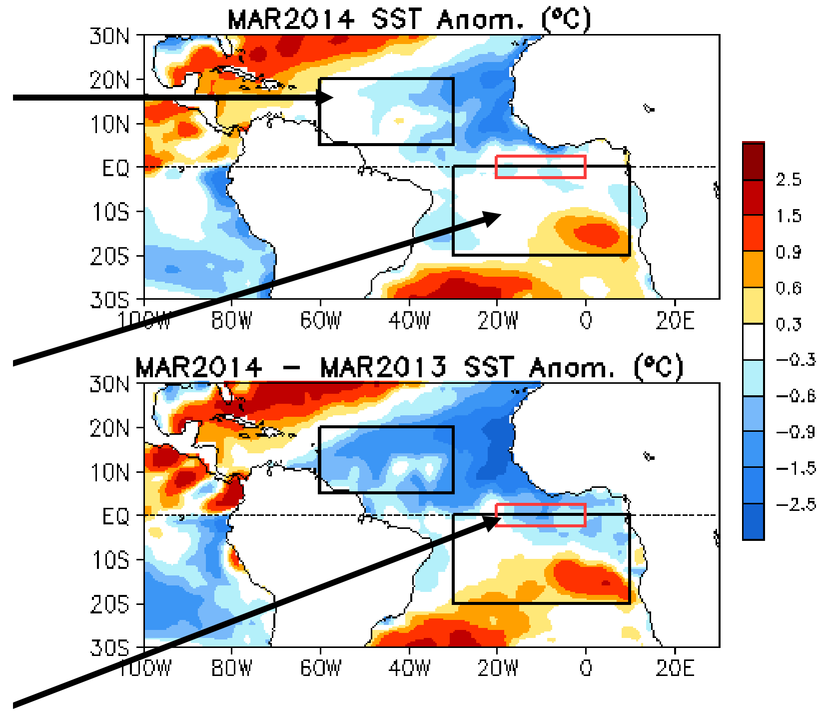


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

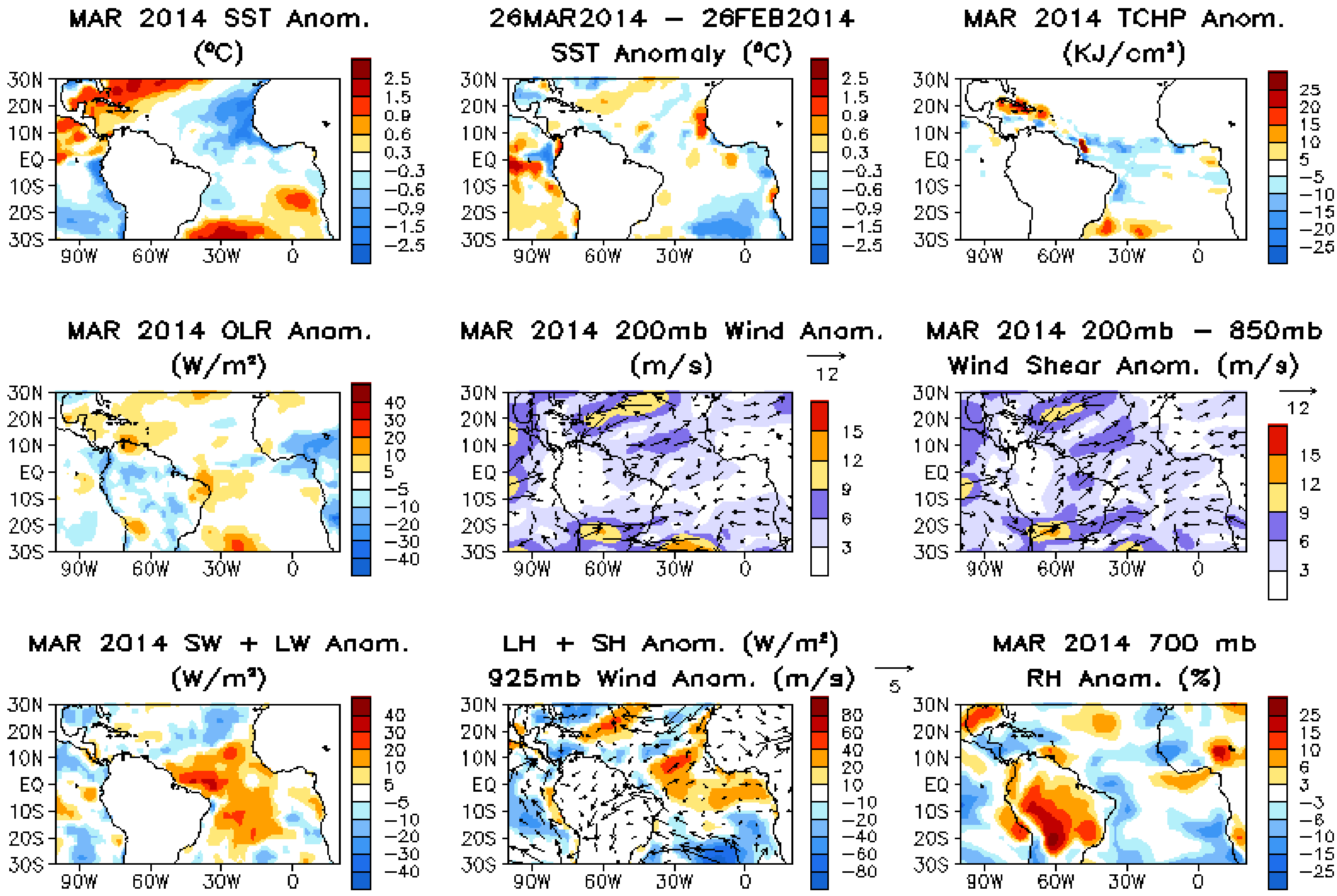




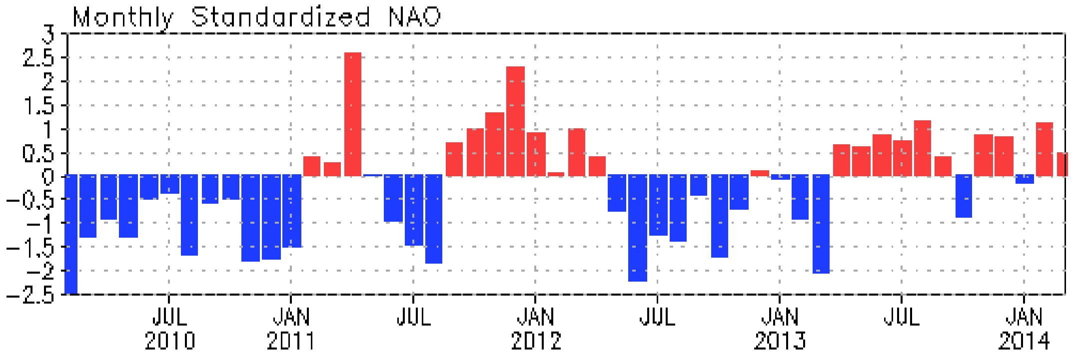
- **Tropical North Atlantic (TNA) index was small since Nov 2013.**
- **Tropical South Atlantic (TSA) index was small since Dec 2012.**
- **Meridional Gradient Mode (TNA-TSA) has been switched to negative phase in Feb 2014.**
- **ATL3 SSTA has been negative since Jul 2013.**
- **Tropical North Atlantic in Mar was cooler in 2014 than in 2013.**

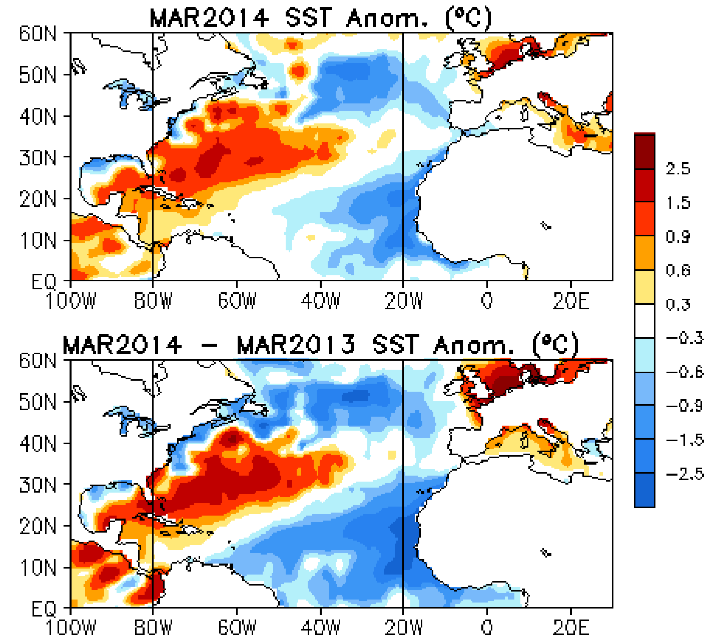
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between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

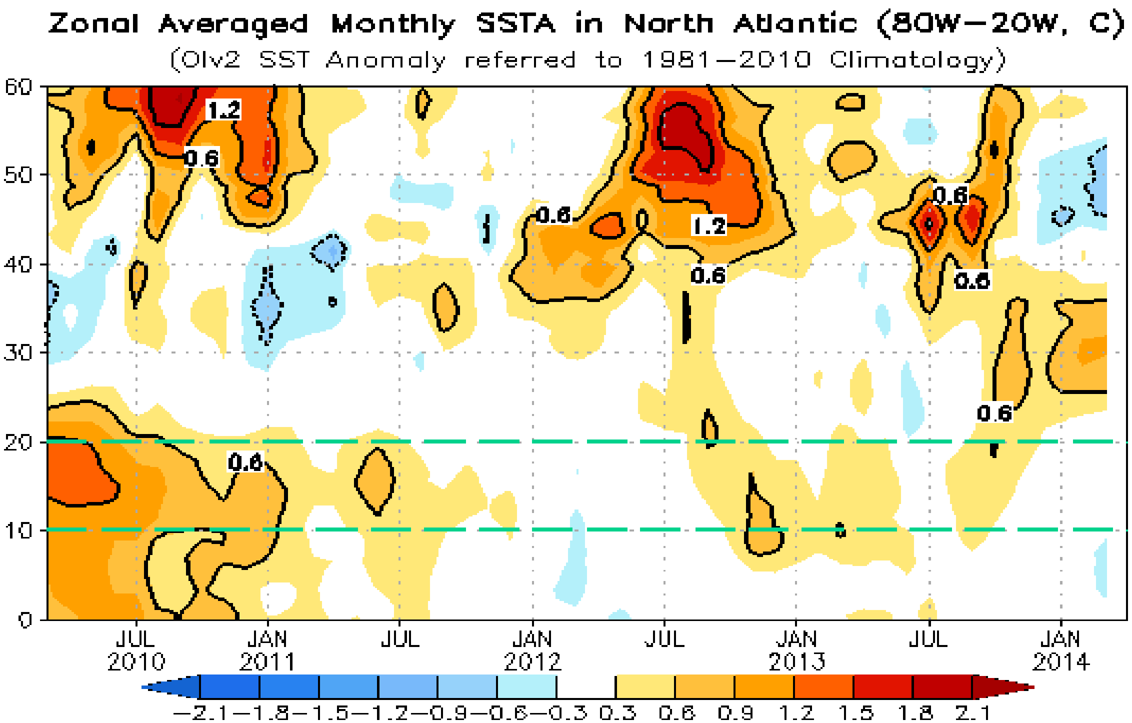
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic





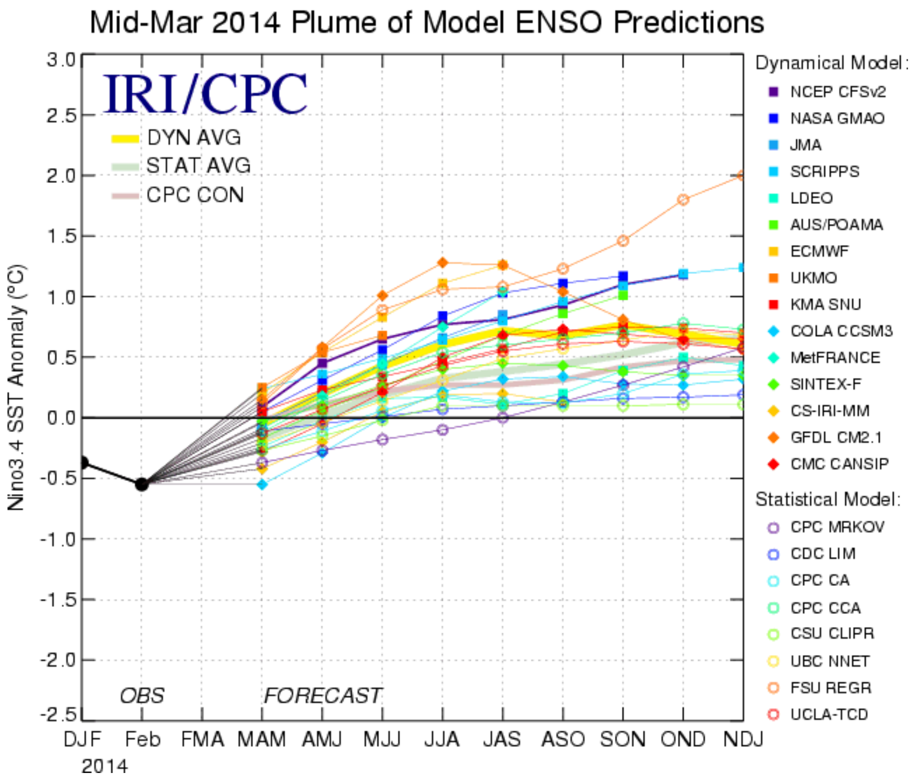


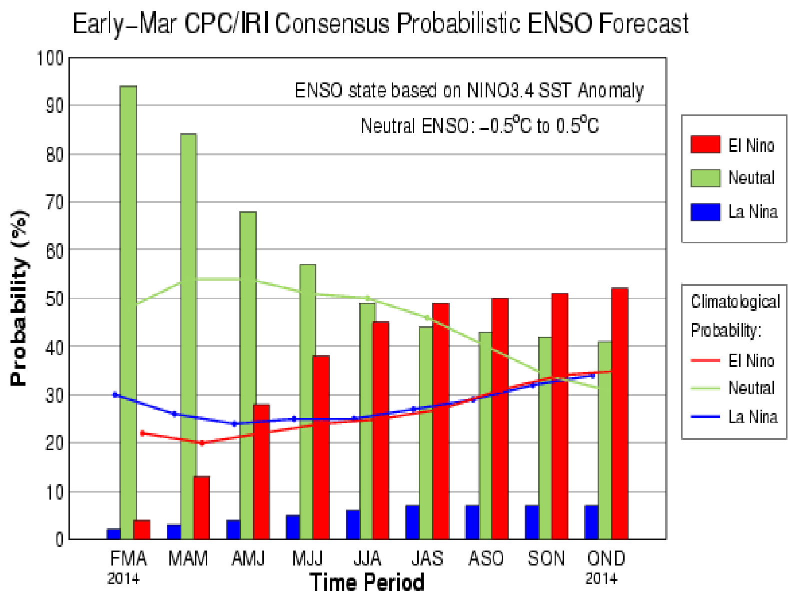
- NAO was in positive phase with NAOI=0.44 in Mar 2014.
- North Atlantic tripole-like SSTAs were observed, may partially due to the forcing of positive phase of NAO .

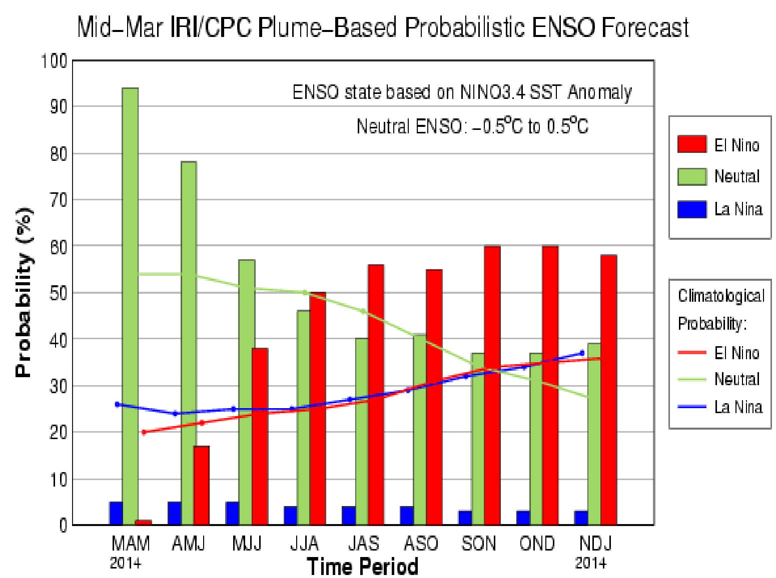
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80°W and 20°W (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum





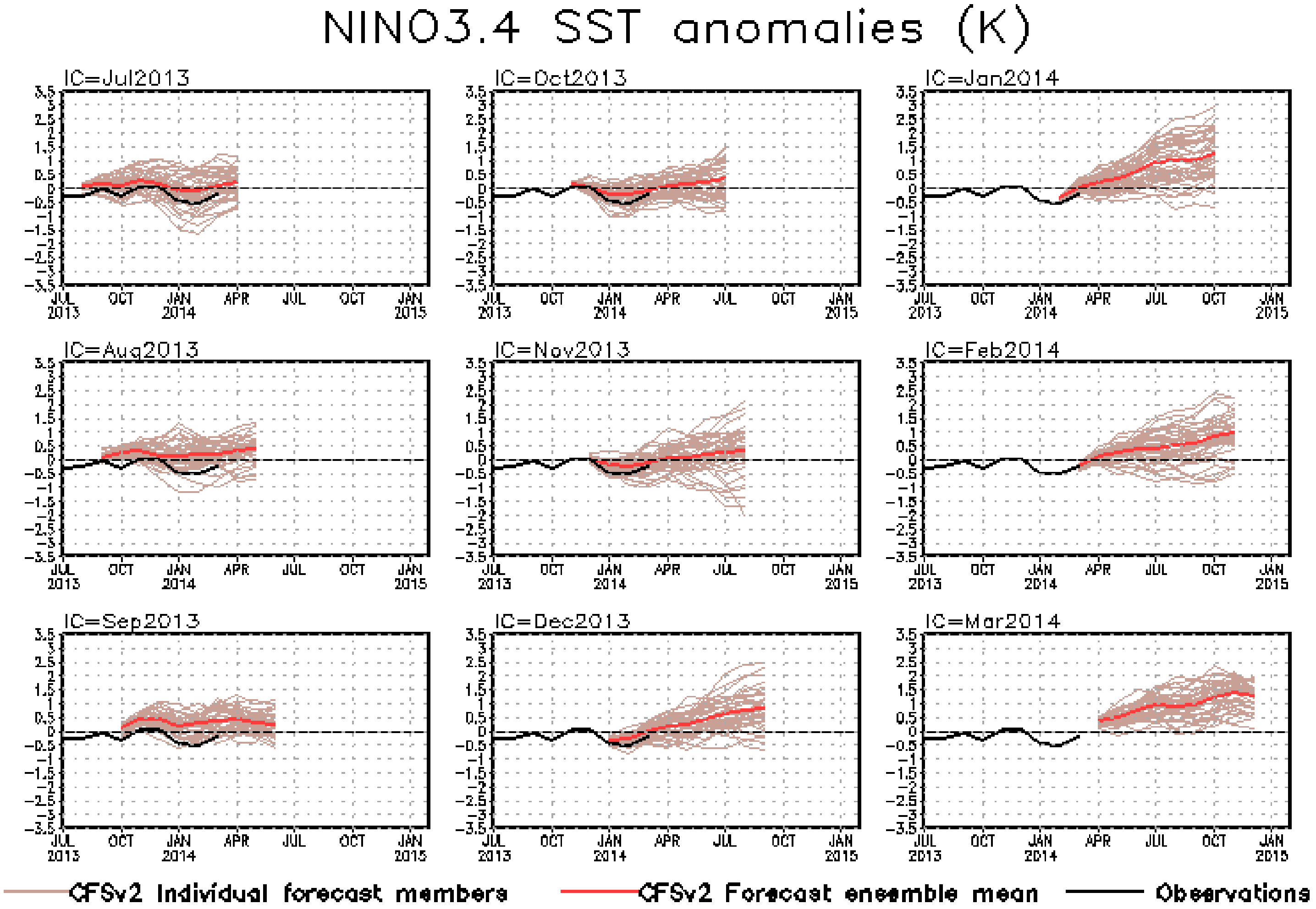


- All models predicted a warming tendency and a majority of dynamical and some of statistical models predicted an El Nino in second half of 2014.

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

- NOAA "ENSO Diagnostic Discussion" on 10 Apr 2014 issued "El Nino Watch" and suggests that "While ENSO-neutral is favored for Northern Hemisphere spring, the chances of El Niño increase during the remainder of the year, exceeding 50% by summer. "

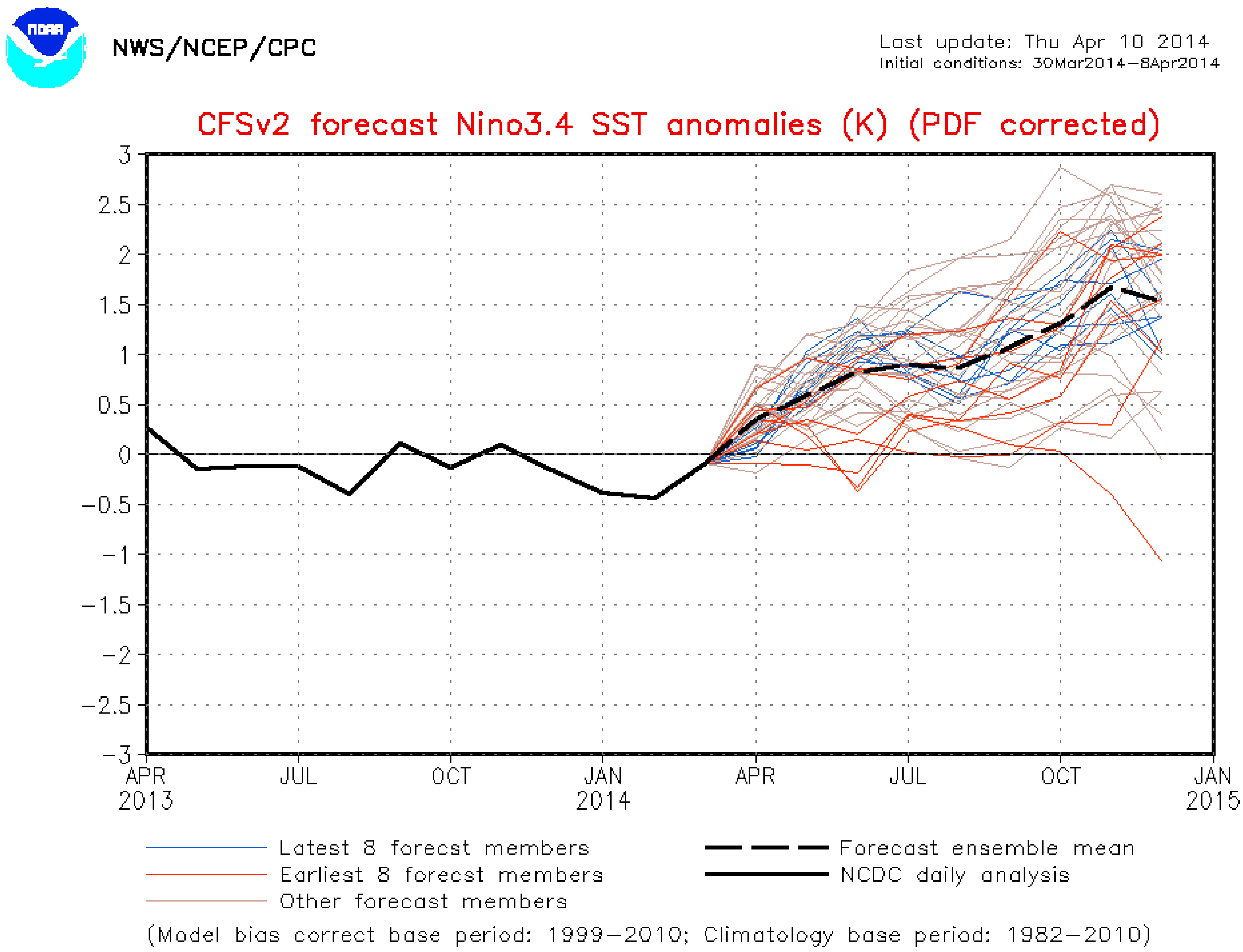
CFS Niño3.4 SST Predictions from Different Initial Months



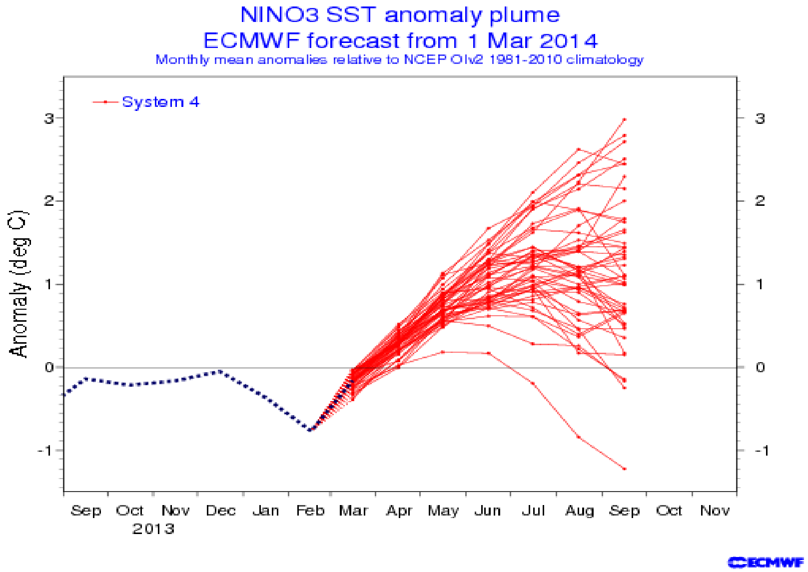
- CFSv2 predicts a warming tendency, and suggests development of an El Nino in second half of 2014.

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.

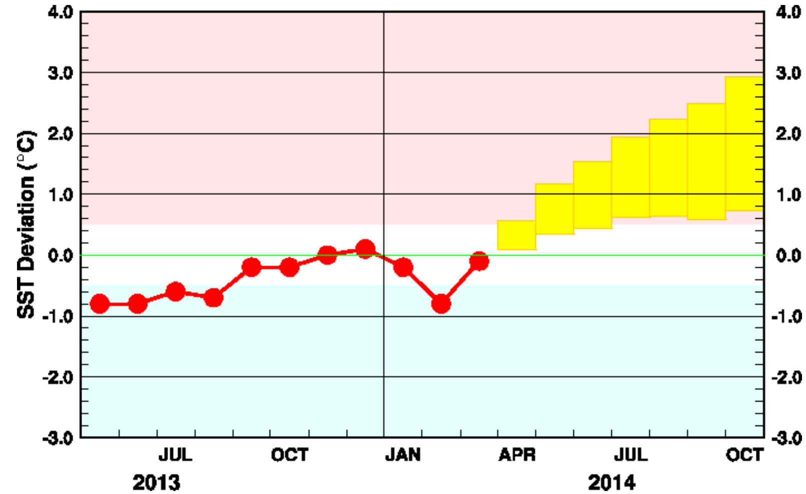
Latest forecasts of CFSv2 (updated 10Apr2014)



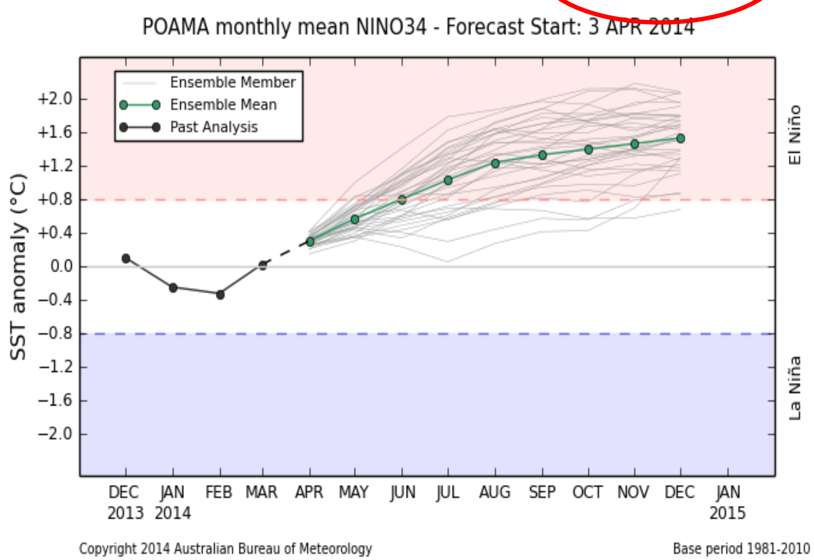
Individual Model Forecasts: Predict an El Nino in 2014



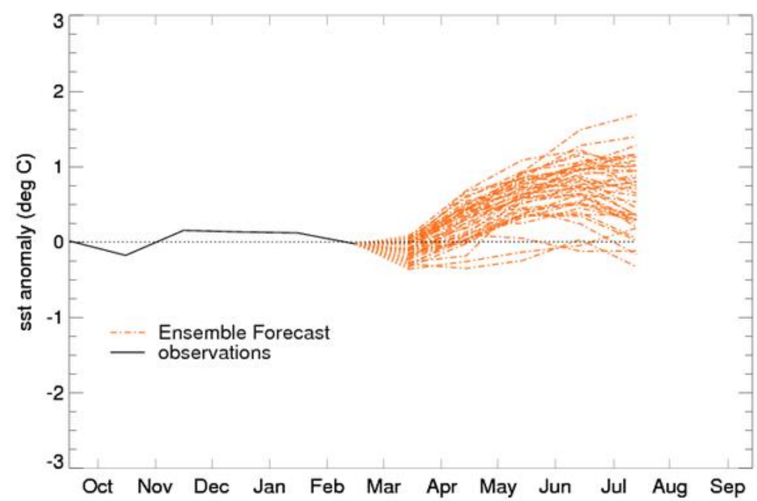
JMA: Nino3, IC=Mar 2014



Australia: Nino3.4, IC=03Apr2014



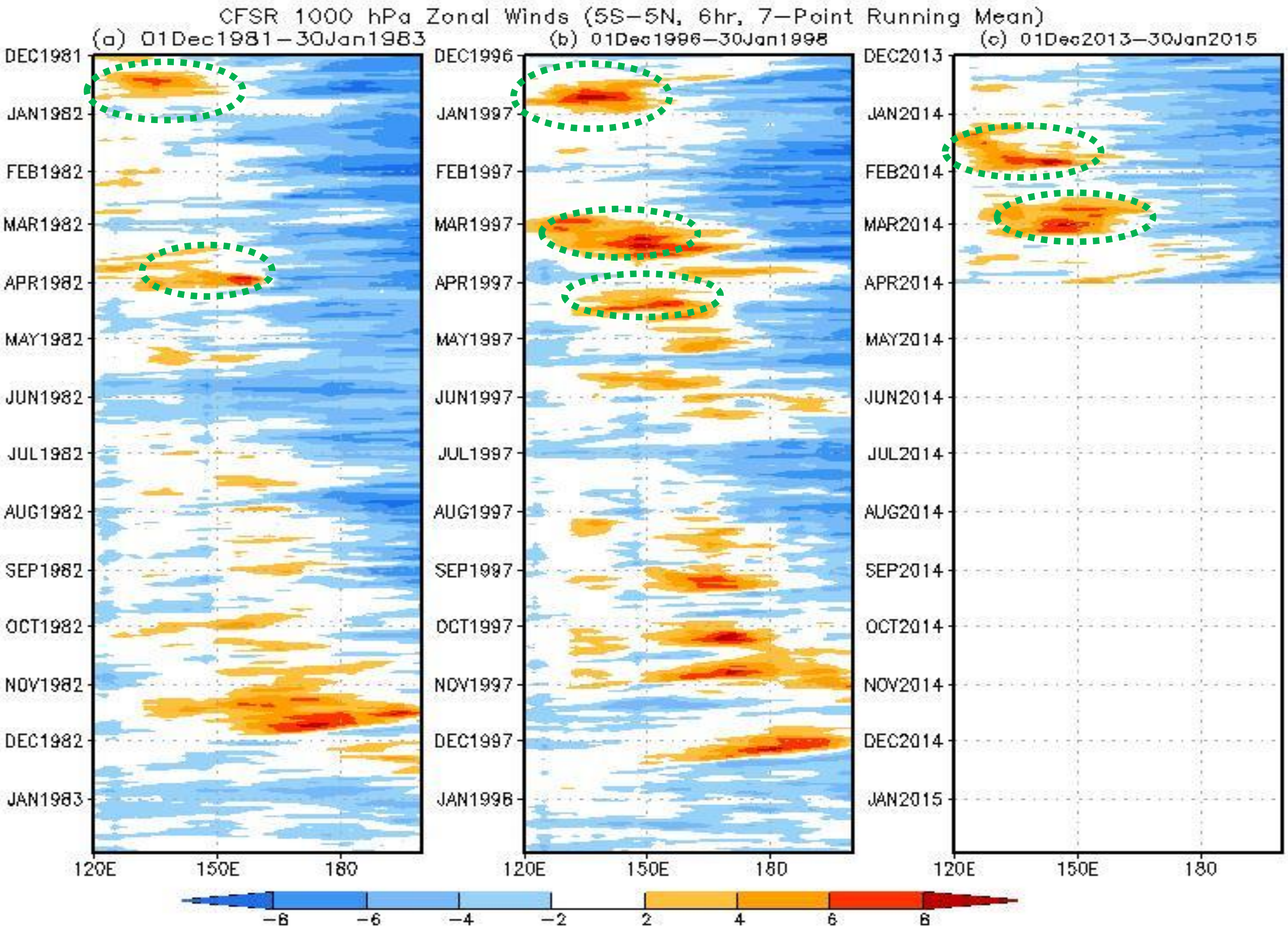
UKMO: Nino3.4, IC=Mar2014



CFSR: Westerly wind burst (WWB) events

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

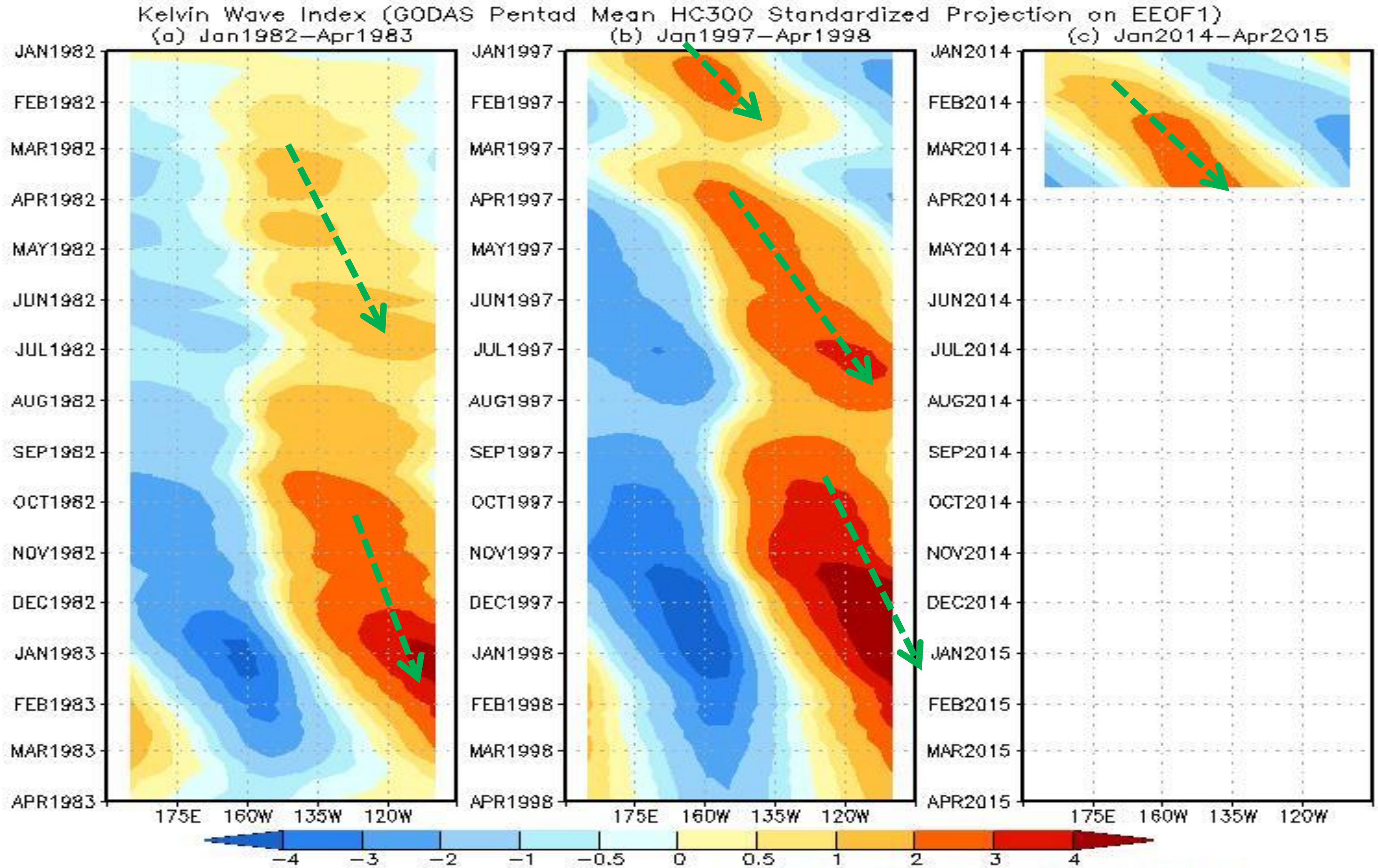
b) multi-WWB events in 1997-98



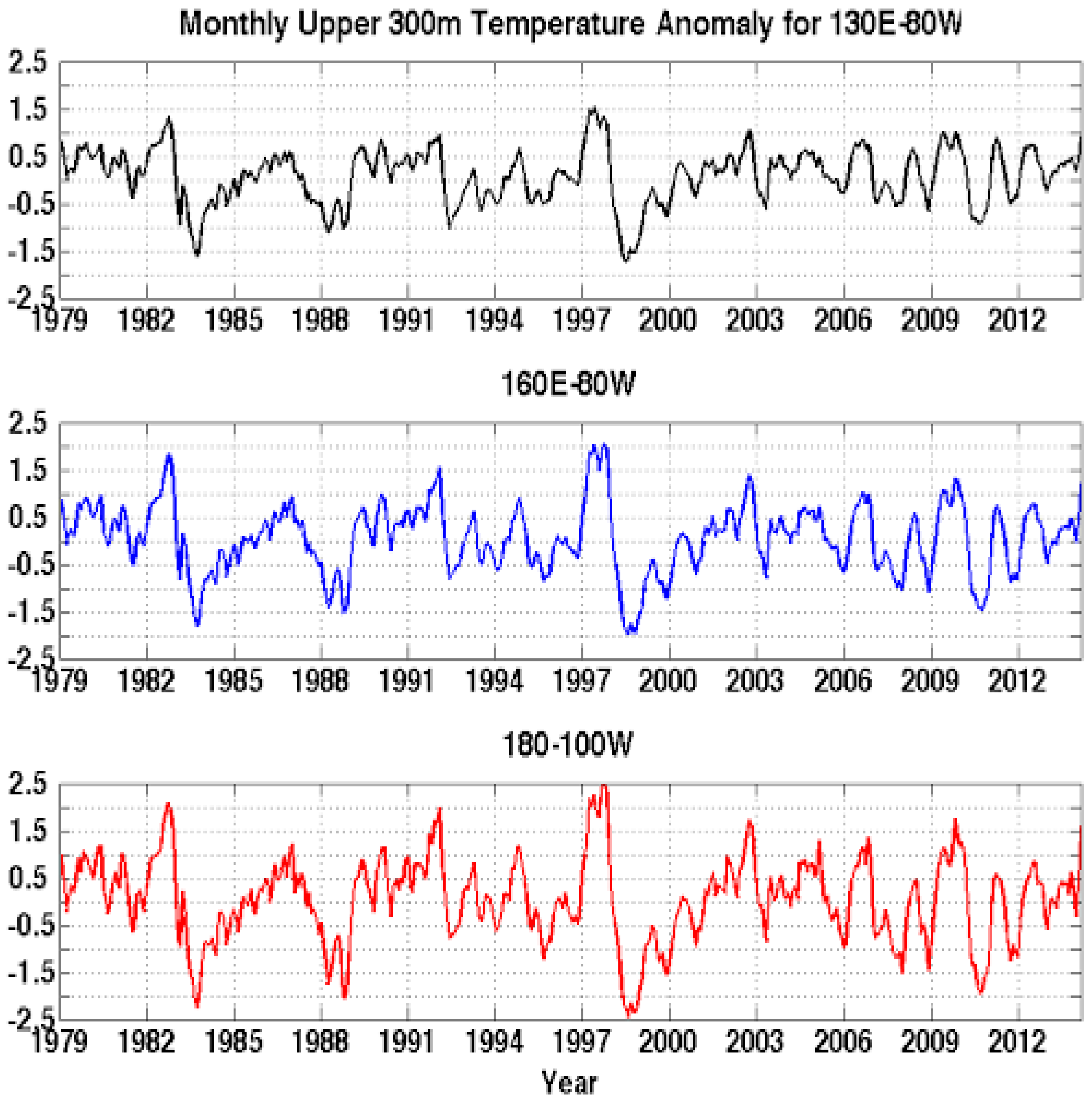
<u>Kelvin activity</u>

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

b) multi-Kelvin activity events in 1997-98



Ranking of March HC300 Anomaly

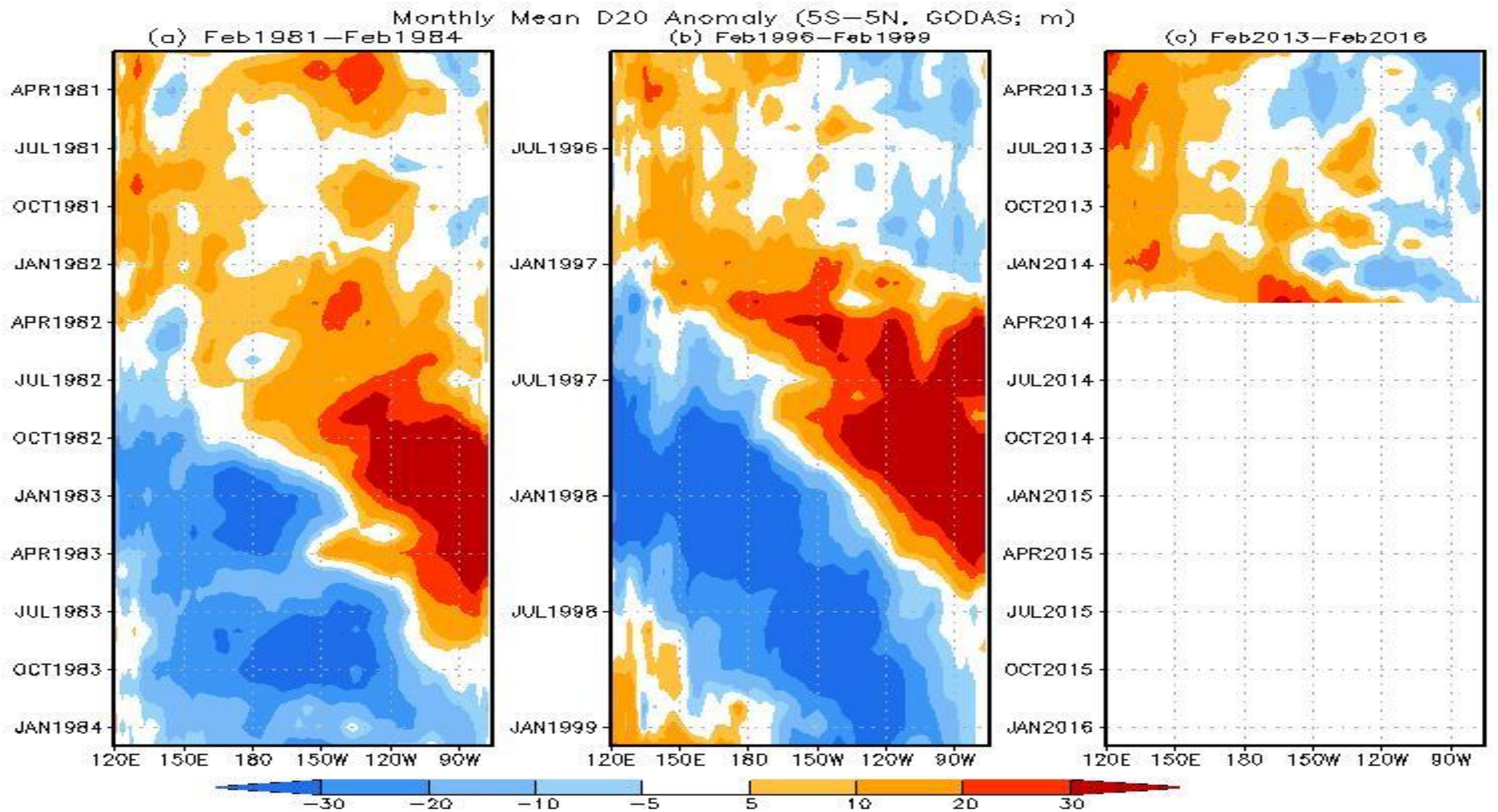


Ranking of March 2014 relative to the rest of the Marches during 1979-2014:

130E-80W: 2nd
160E-80W: 2nd
180-100W: 1st

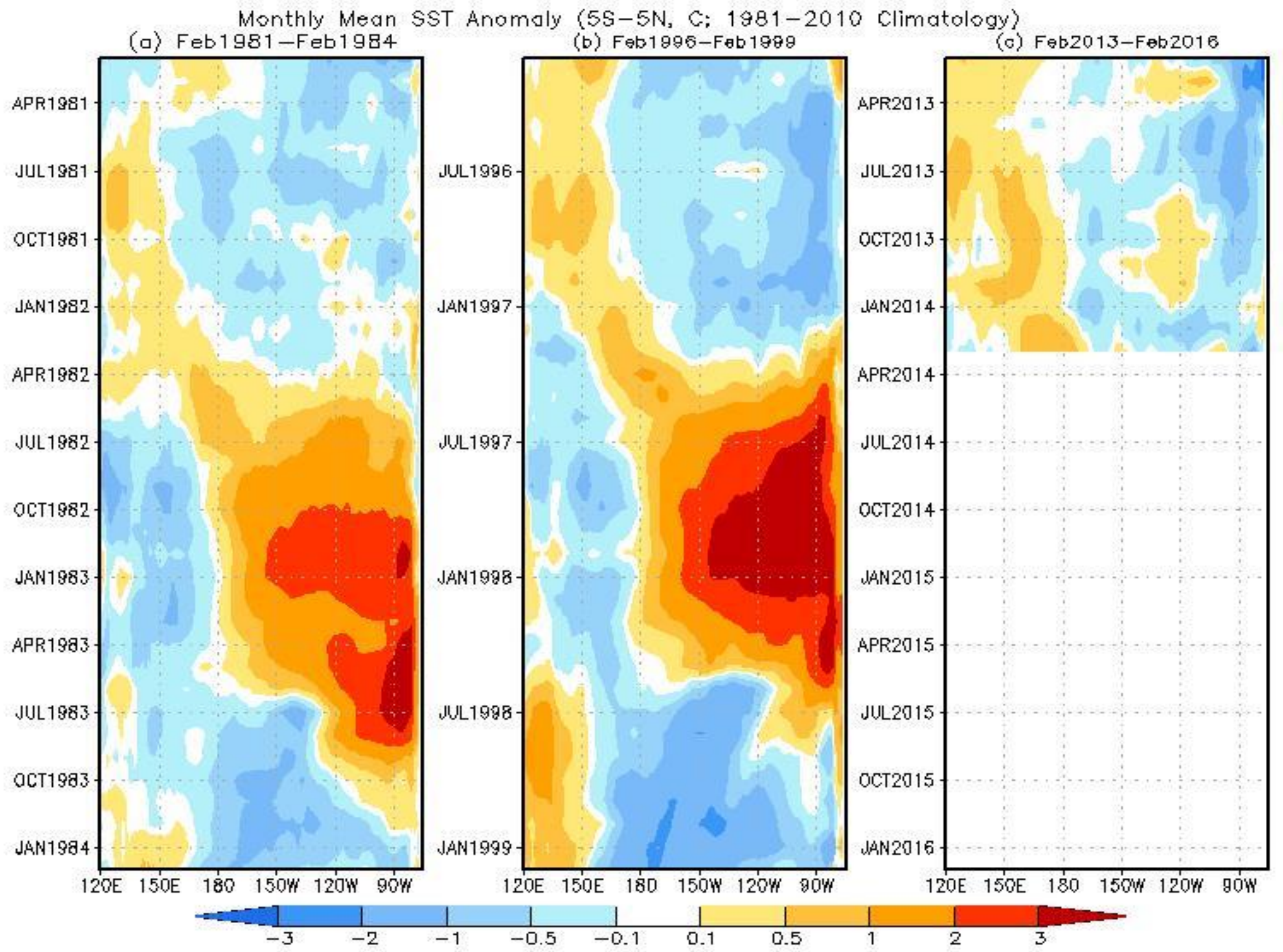
From: Michelle L'Heureux

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 as well as surface westerly wind anomalies in Mar.
- The strong positive anomalies near the thermocline in the equatorial Pacific are comparable to those in March 1997.

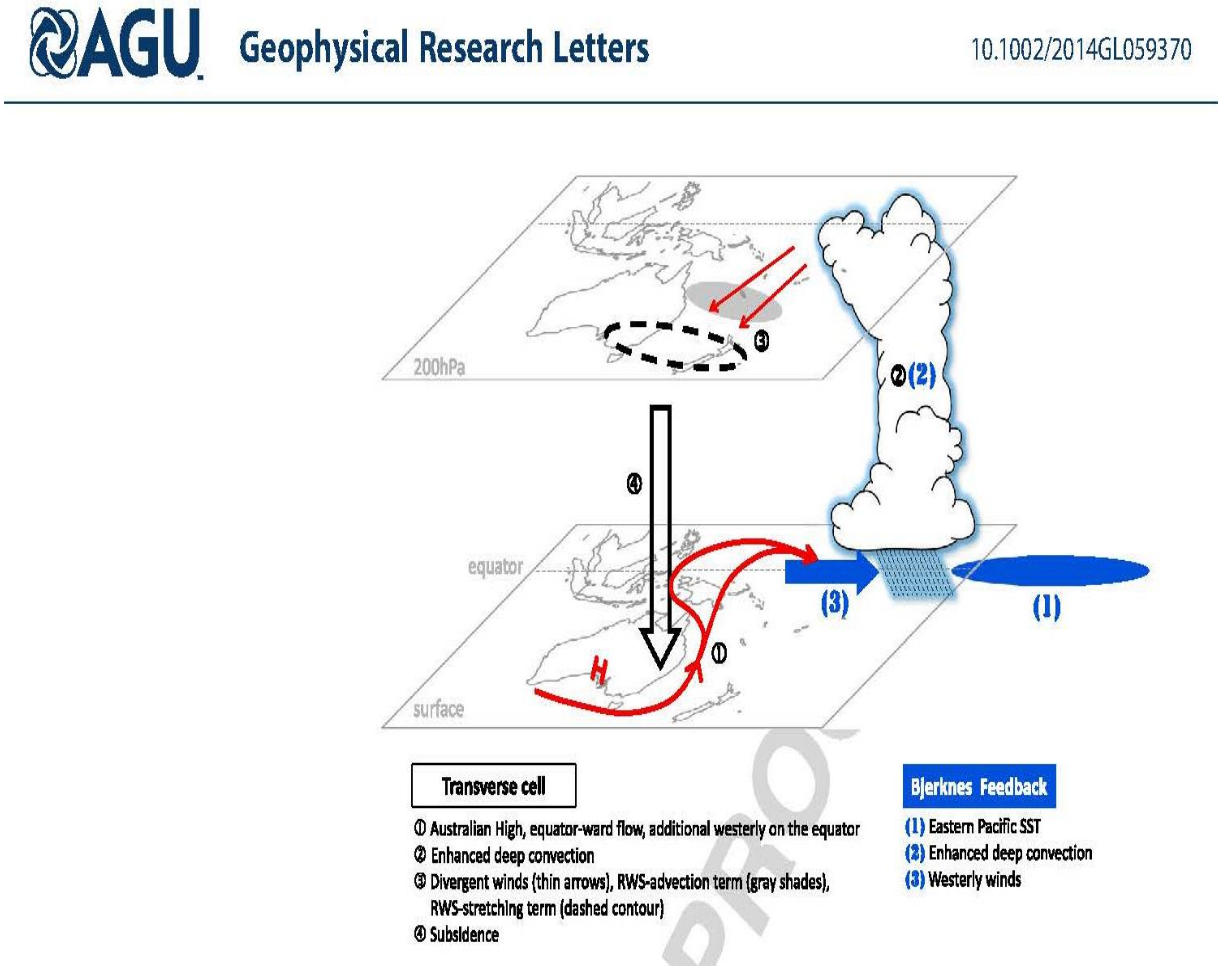
SSTA: Similar evolution in 1981-83, 1996-98, 2013-14



An index to monitor if a strong El Nino occurs

Hong, L.-C., Lin Ho and F.-F. Jin, 2014: A Southern Hemisphere Booster of Super El Niño. *Geophys. Res. Lett*. DOI: 10.1002/2014GL059370 (in press)

(Thanks to Prof. Fei-Fei Jin for his constructive suggestions and guides)



Positive Feedbacks:

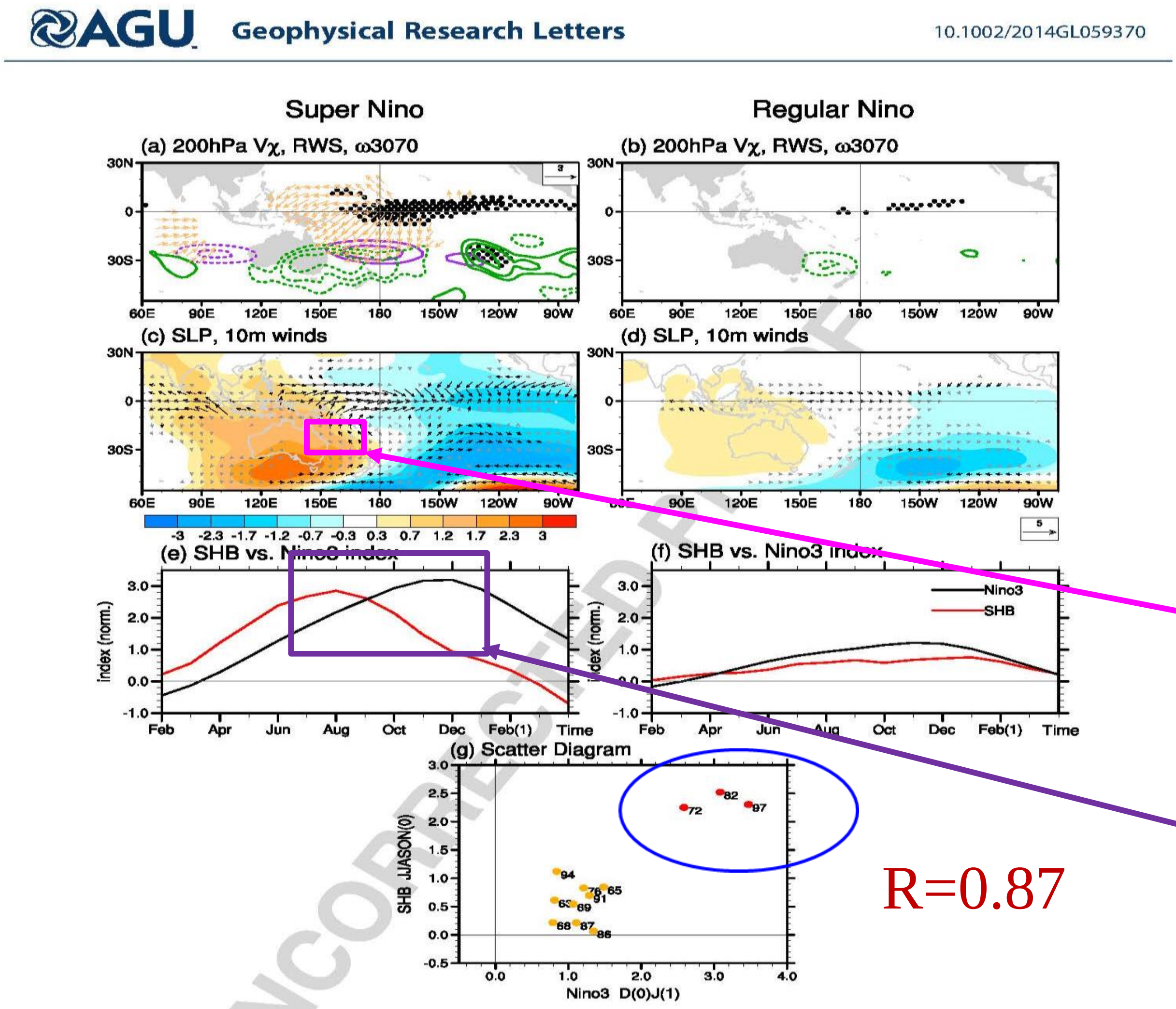
Enhanced convections over the central equatorial Pacific (anomalous divergence at 200 hPa)

-> Strengthening subsidence and the Australian High (equator-ward low-level wind)

-> Intensifying low-level westerly winds along the equator and the Bjerknes feedback

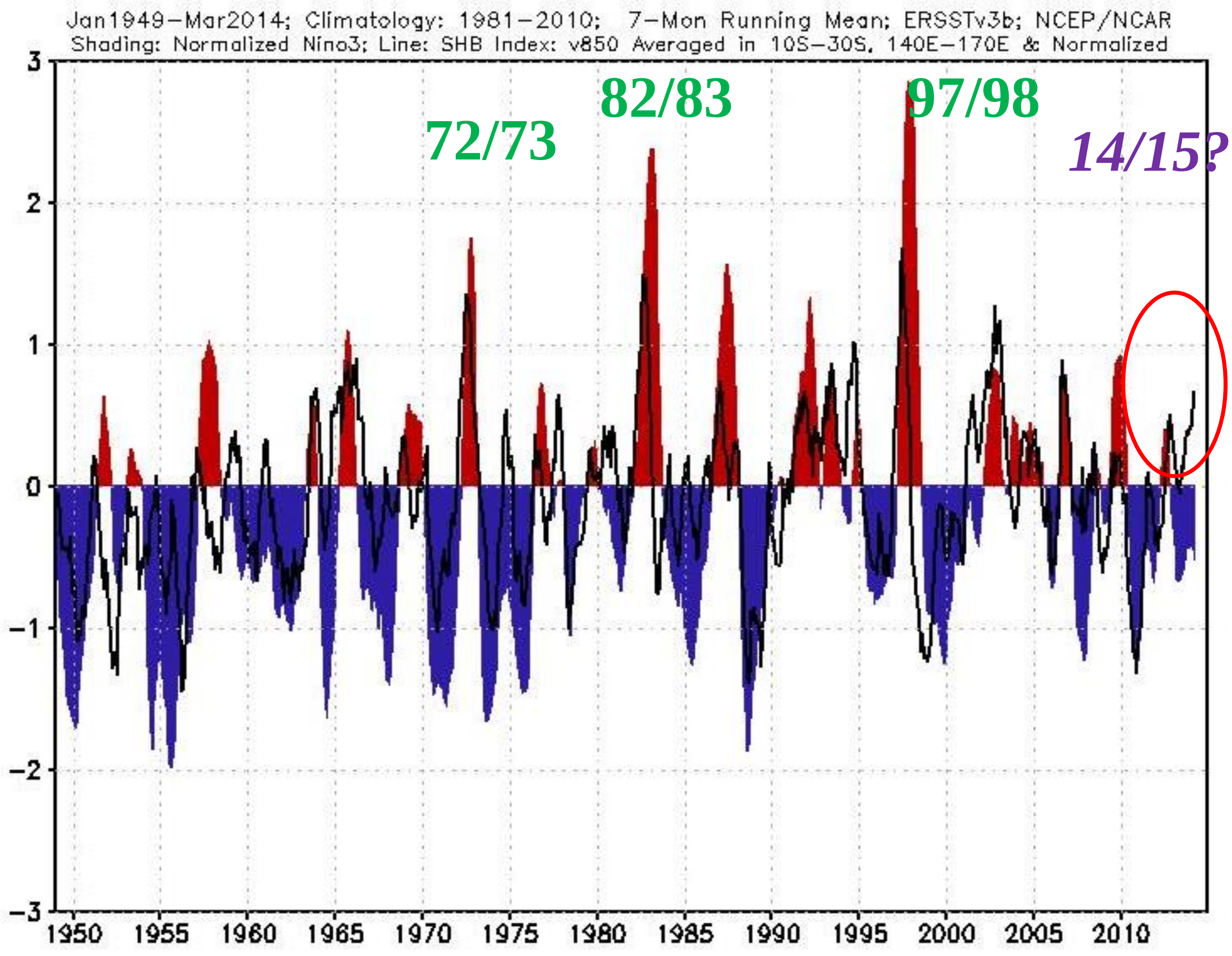
-> developing super El Nino.

Fig. 4. Schematic diagram of super El Niño development, illustrating how a transverse cell with main features in the SH (marked by numbers inside open circles) interacts with the Bjerknes feedback regime in the central equatorial Pacific (depicted by large blue numbers in parentheses).



- *1972/73, 1982/83, 1997/98 super El Nino composite (left) and 9 regular El Nino (1952-2010) composite (right).*
- *HadISST & ERA40: ; 1958-2001 climatology; 6 mon-8 yr band pass filter.*
- *GFDL-ESM2M 500 yr free run also used.*
- **SH booster (SHB) index: v850 averaged over 10°S–30°S, 140°E–170°E and normalized.**
- **JJASON SHB leads Nino3 by 3 months during super El Nino onset/developing stage. SHB > 2 STD in summer-autumn may result in super El Nino in winter.**

Fig. 2. JJASON(0) mean composite maps of (a) anomalous 200 hPa divergent winds (only wind speed >1.1 m/s is shown by vector), 200 hPa Rossby wave source (RWS) in the SH (green denotes RWS induced by vortex stretching and purple denotes RWS caused by advection of vorticity via anomalous divergent winds; contour interval is 1e11 1/s2, and zero contours are omitted), vertical pressure velocity averaged over 300–700 hPa (only upward motion<-0.012 Pa/s is shown by filled dot) and (c) anomalous SLP (shading; hPa), 10m winds (only wind speed>0.4 m/s is shown by vector, and wind speed>0.8 m/s is highlighted in black) for super El Niño composite. (e) Normalized SHB index (red) and normalized Niño-3 index from Feb of the El Niño year to Apr of the following year for super El Niño composite. Fig. 2b, 2d, and 2f are the same as Fig. 2a, 2c, and 2e, respectively, except for regular El Niño composite. (g) Scatter diagram of normalized JJASON(0) mean SHB index against normalized D(0)J(1) mean Niño-3 index for the 12 El Niño events; red denotes super El Niño year and orange denotes regular El Niño year.



- Since last winter, SHB index was positive and increasing.

- 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.

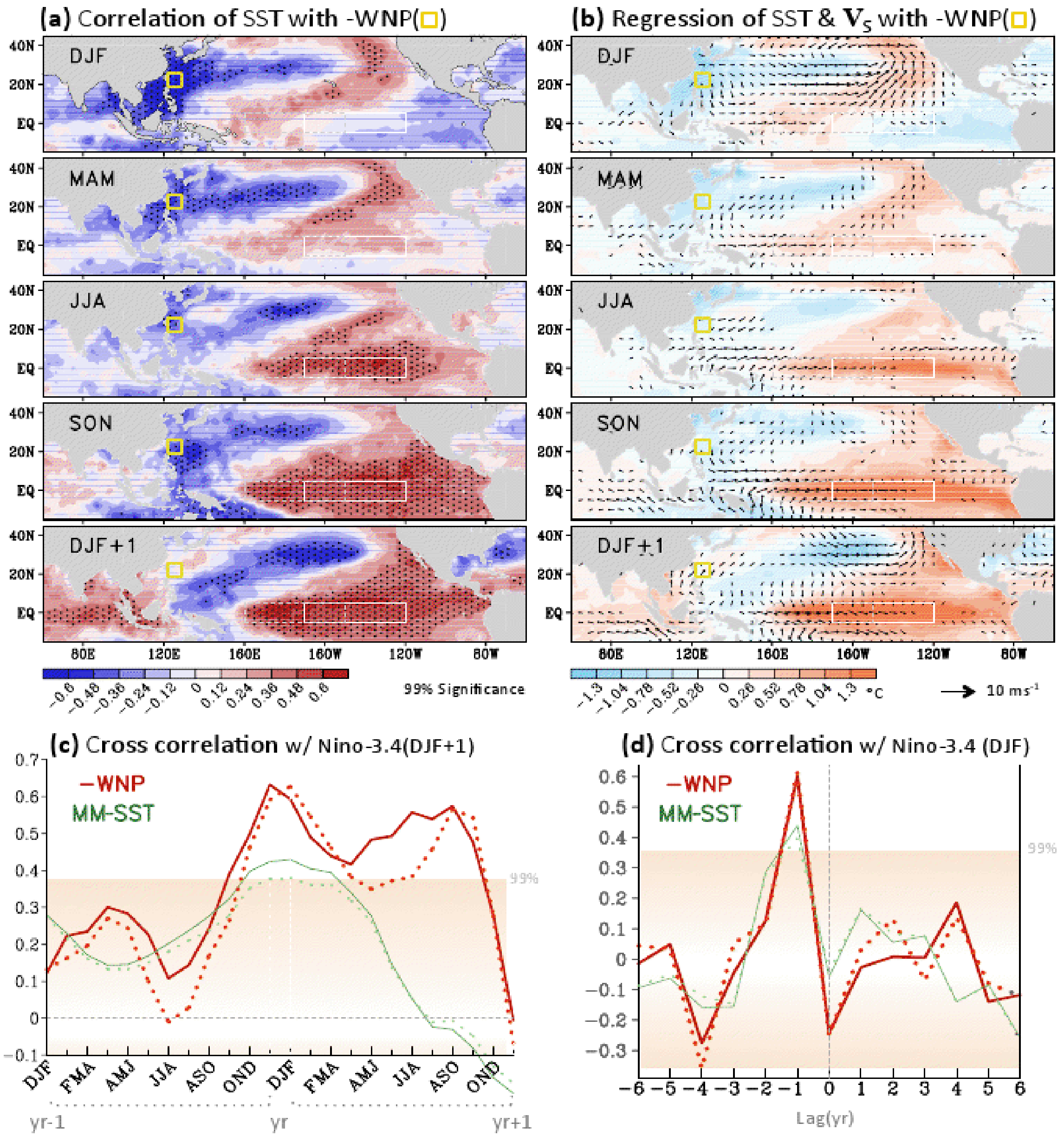
Red/blue shading: normalized Nino3

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 (in press).

Western North Pacific Variability and ENSO



(a)DJF Cooling over the WNP is followed by a warming in the equatorial Pacific in next winter

(b)The correlation between WNP and ENSO is higher than that between meridional mode and ENSO.

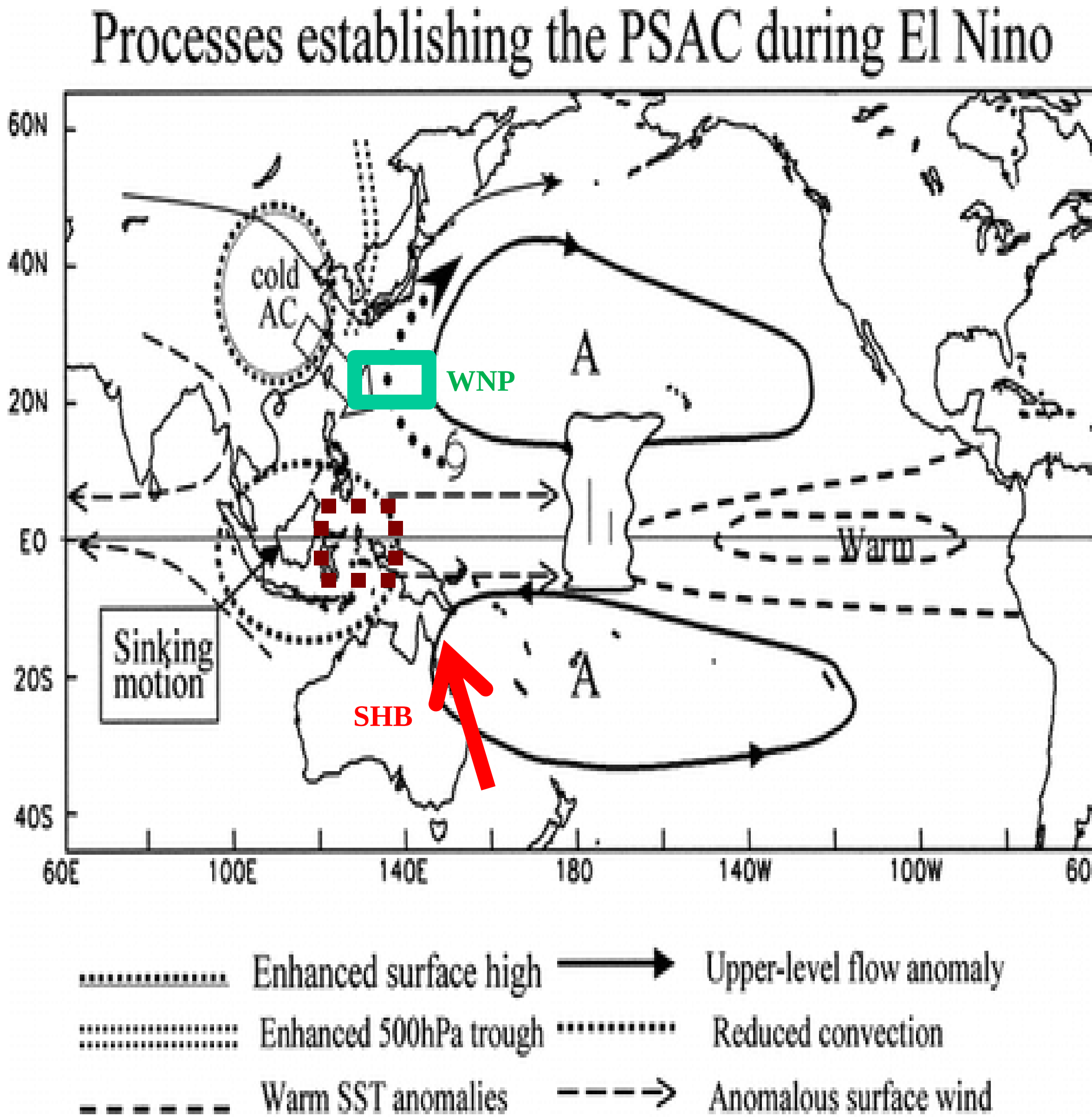
(c) The frequency of WNP variability is higher than ENSO.

From:

Wang, S.-Y., M. L'Heureux, and H.-H. Chia, 2012: ENSO Prediction One Year in Advance Using Western North Pacific Sea Surface Temperatures. GRL, 39, L05702. DOI: 10.1029/2012GL050909.

Wang and Zhang (2002) argued that the development of the Philippine Sea anticyclone is attributed to combined effects of the remote El Niño forcing, tropical-extratropical interaction, and monsoon-ocean interaction.

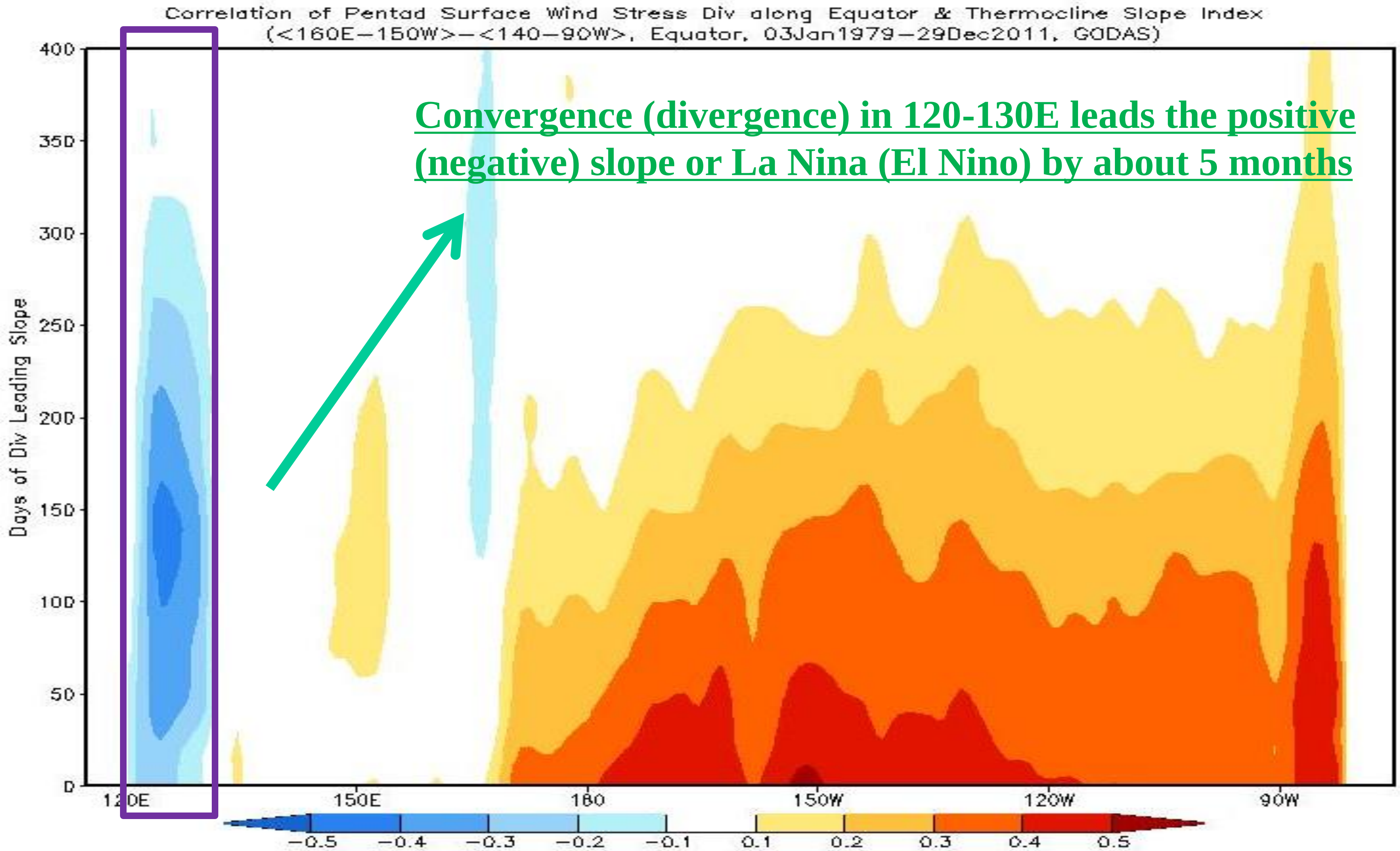
Both the WNP (122-132E, 18-28N; SSTA) and SHB (10-30S, 140-170E, v) indices seem linked with Philippine Sea anticyclone , which connects with zonal wind stress anomaly or westerly wind burst event (next slide).



Wang, B., and Q. Zhang, 2002: Pacific-East Asian teleconnection, part II: How the Philippine Sea anticyclone established during development of El Nino. J. Climate, 15, 3252-3265.

Corr of pentad surface wind stress divergence along the equator and thermocline slope index:

Surface wind stress divergence along Equator connected with thermocline slope (D20: <160E-150W>-<90-140W>, Pentad GODAS): Precedent signal around 120-130E along the equator



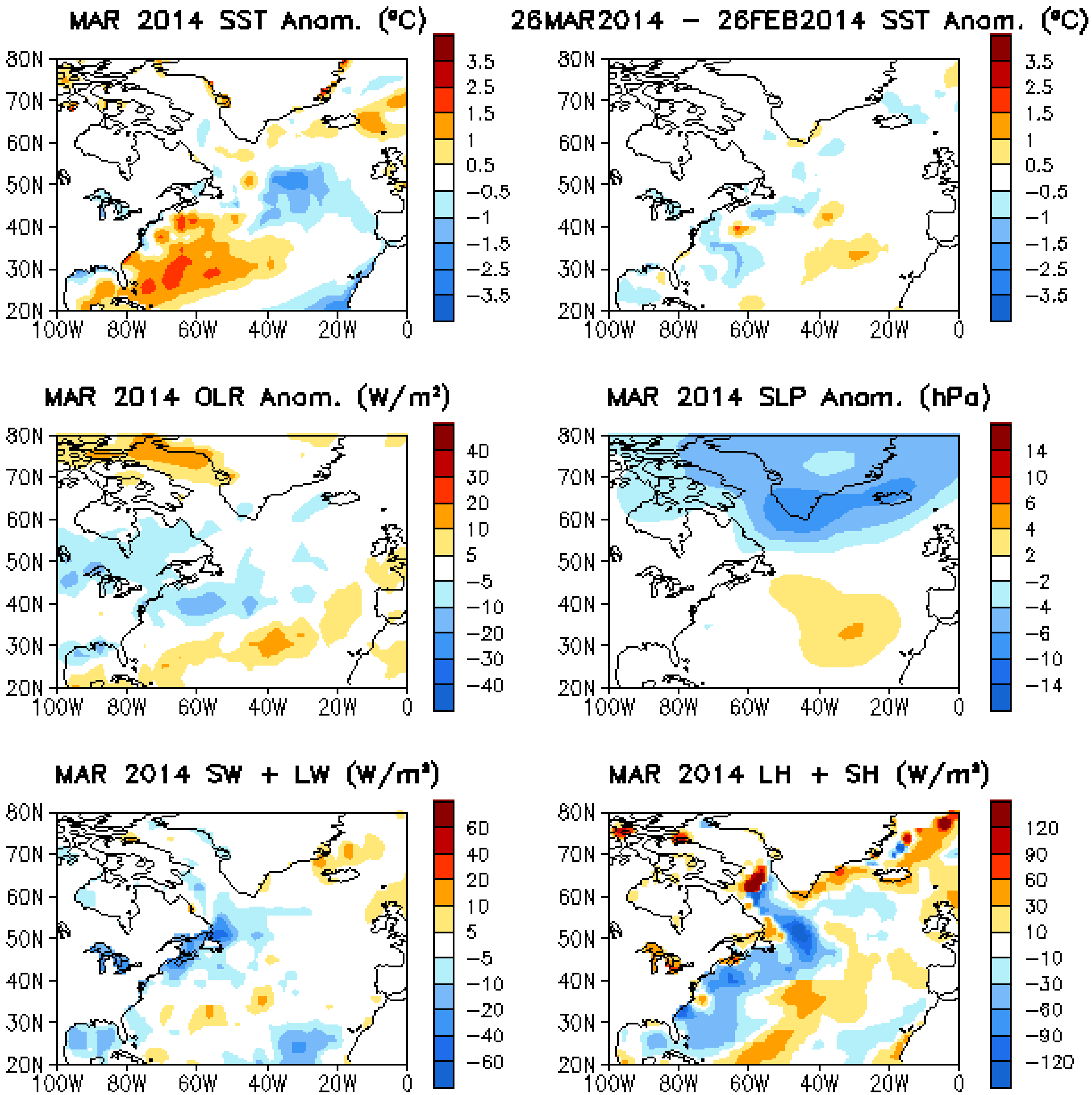
Hu, Z.-Z., A. Kumar, Y. Xue, and B. Jha, 2014: Why were some La Niñas followed by another La Niña? Clim. Dyn., 42 (3-4), 1029-1042. DOI:10.1007/s00382-013-1917-3.

Overview

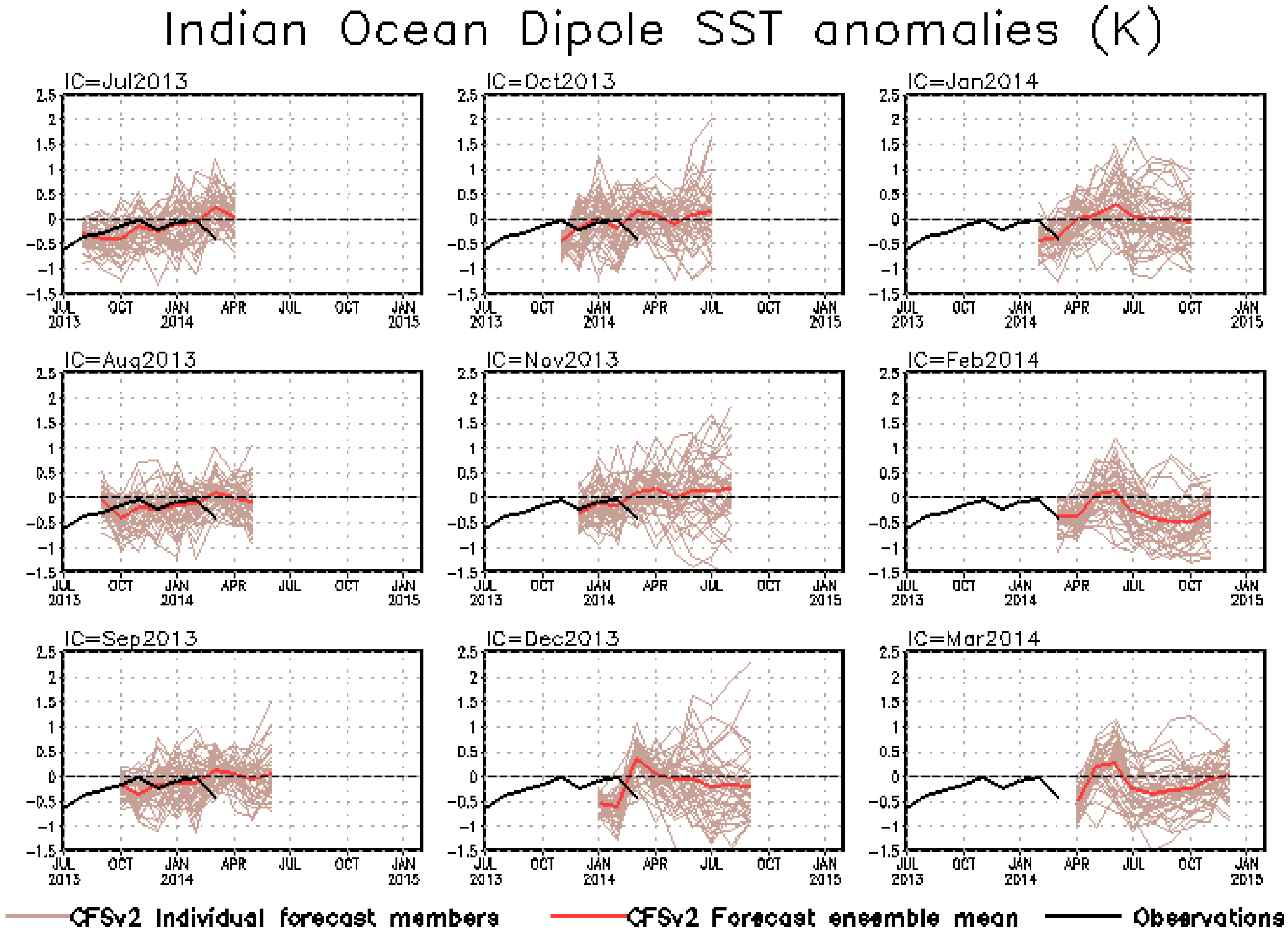
- **Pacific Ocean**
  - **ENSO neutral condition continued with NINO3.4=-0.2°C in Mar 2014.**
  - **Positive anomalies of subsurface ocean temperature along the equator propagated eastward and surface westerly wind anomaly in the equatorial Pacific was observed in Mar 2014.**
  - **All models predicted a warming tendency in this year, majority of the dynamical and some of statistical modes predicted an El Nino since this summer.**
  - **NOAA "ENSO Diagnostic Discussion" on 10 Apr 2014 issued "El Nino Watch" and suggests that "While ENSO-neutral is favored for Northern Hemisphere spring, the chances of El Niño increase during the remainder of the year, exceeding 50% by summer".**
  - **The negative PDO index has persisted near 4 years (47 months) since May 2010, and weakened significantly in Mar 2014 with PDO index =-0.02.**
- **Indian Ocean**
  - **Negative (positive) SSTA presented in the tropical northern (southern) Indian Ocean in Mar 2014.**
- **Atlantic Ocean**
  - **NAO switched into positive phase in Feb 2014 and NAOI=0.44 in Mar 2014.**
  - **Tripole pattern of SSTA presented in North Atlantic in Mar 2014.**

Backup Slides

North Atlantic:



NCEP CFS DMI SST Predictions from Different Initial Months



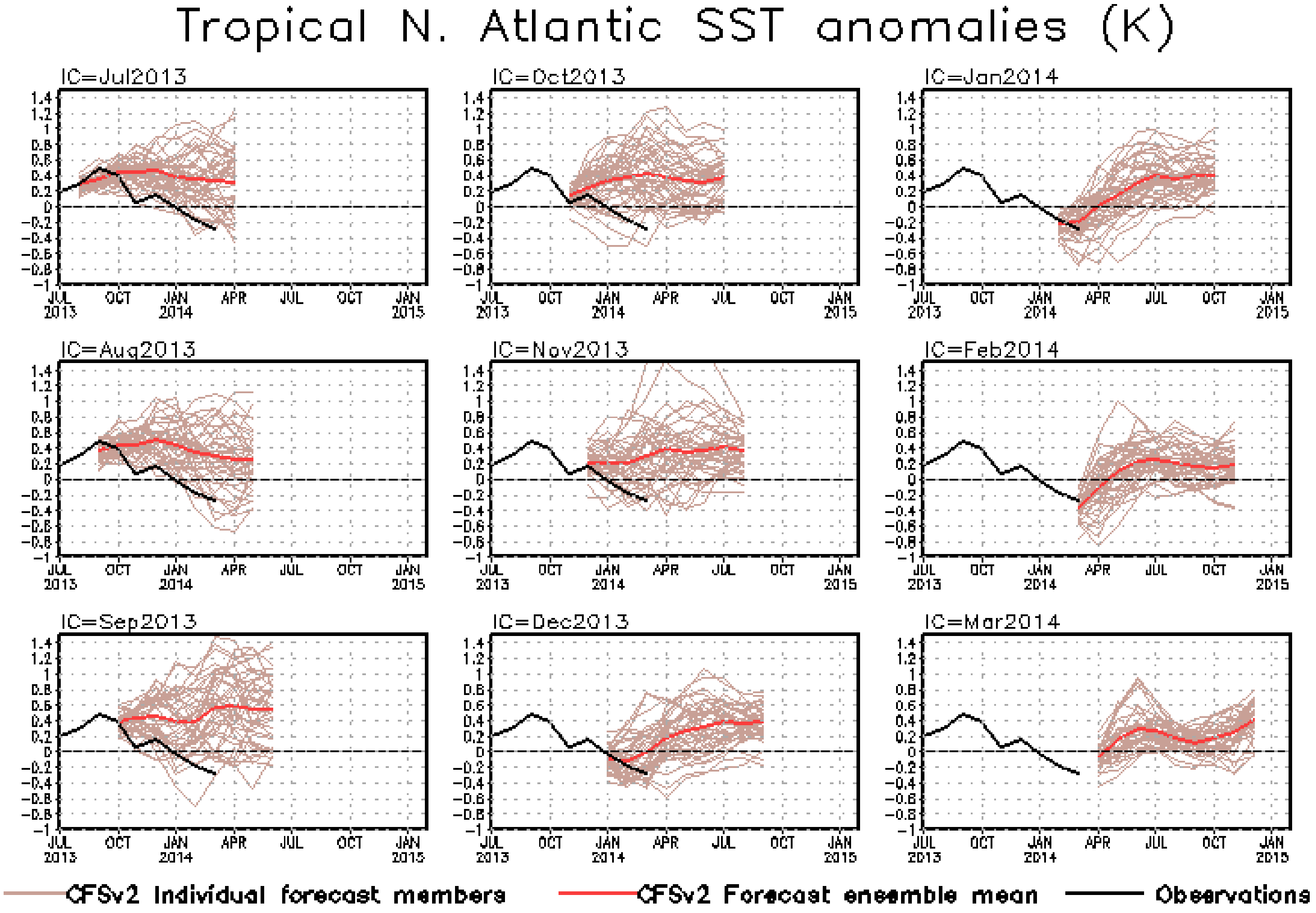
DMI = WTIO- SETIO

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.

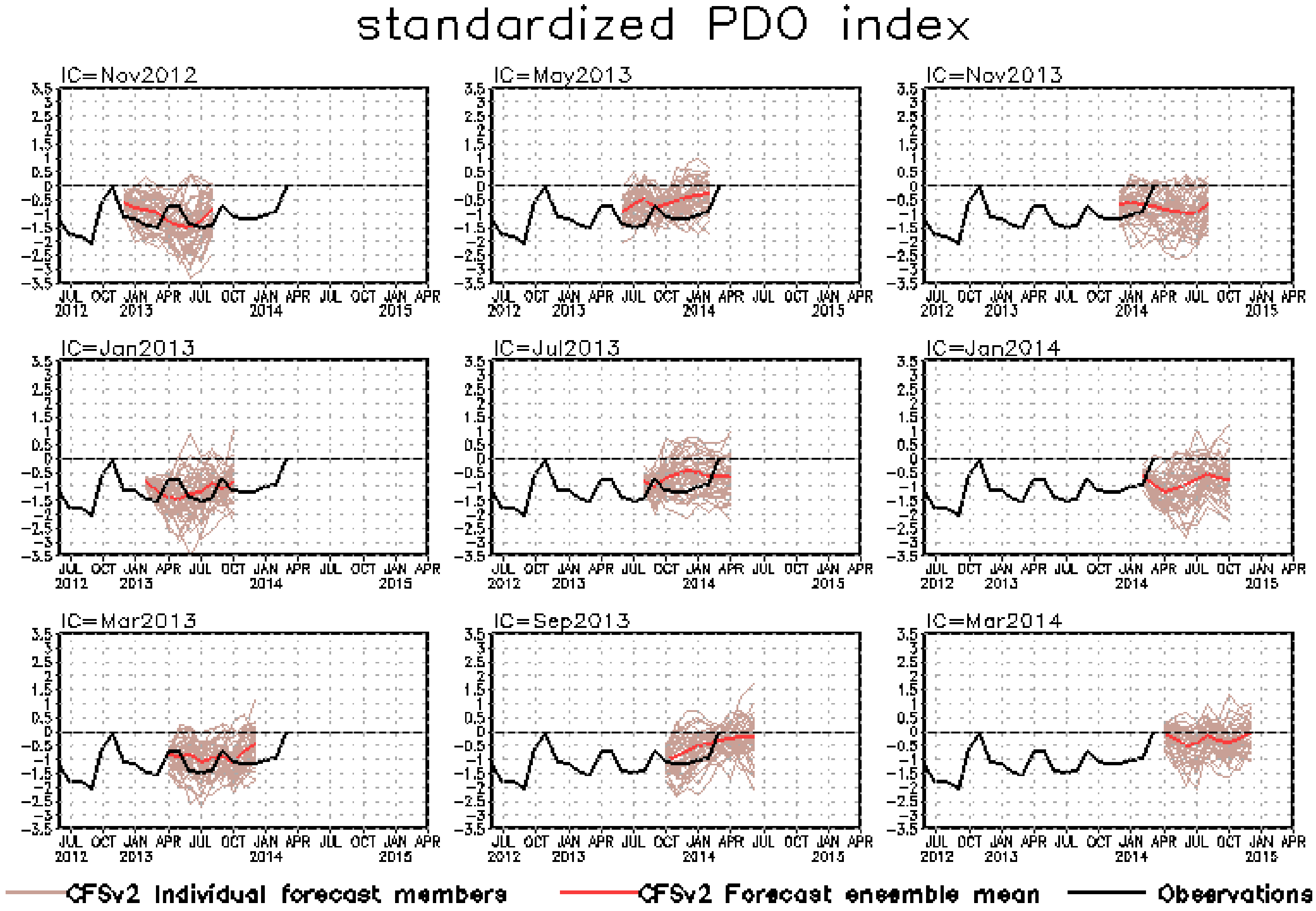
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



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.

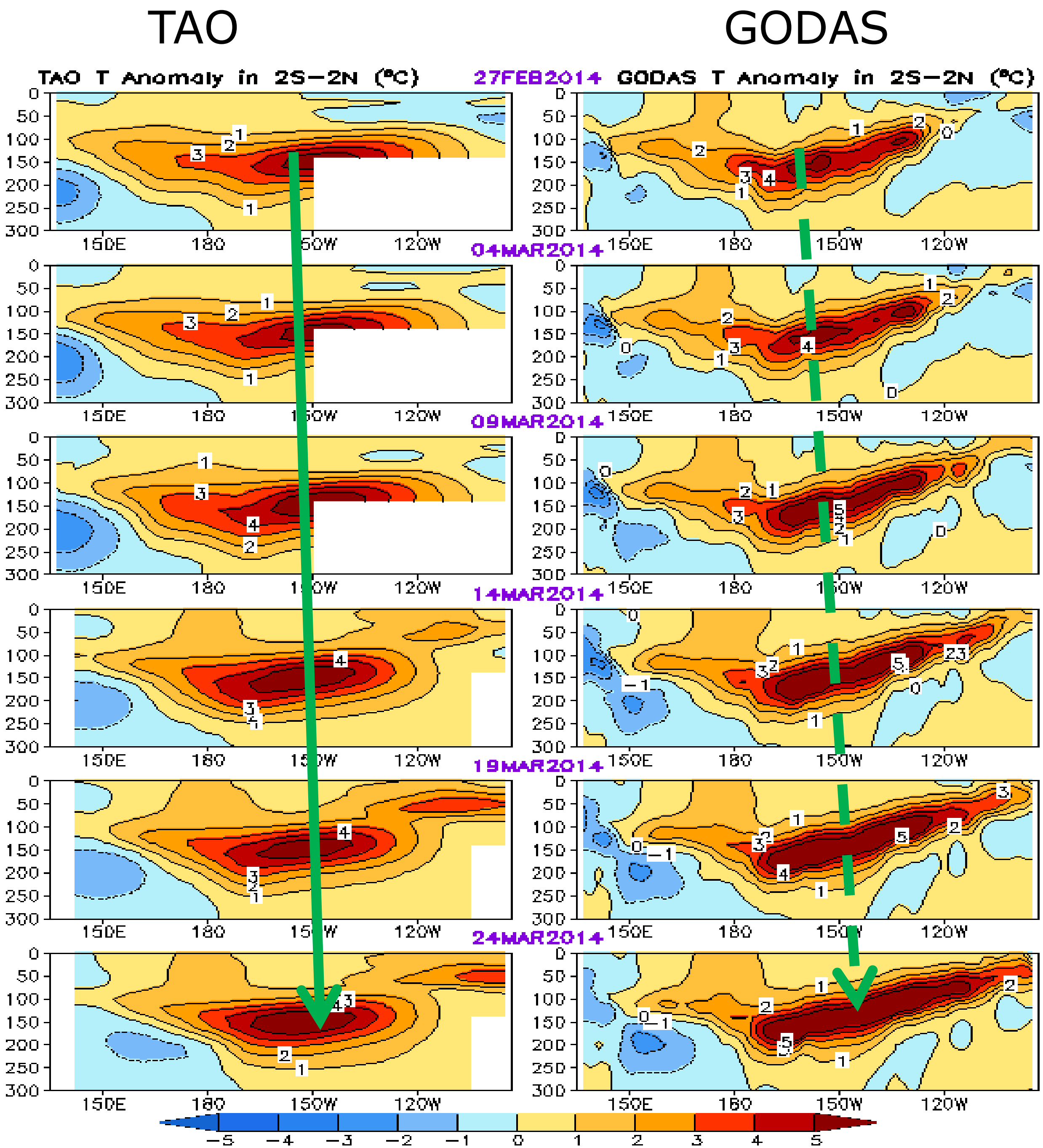
CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



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.



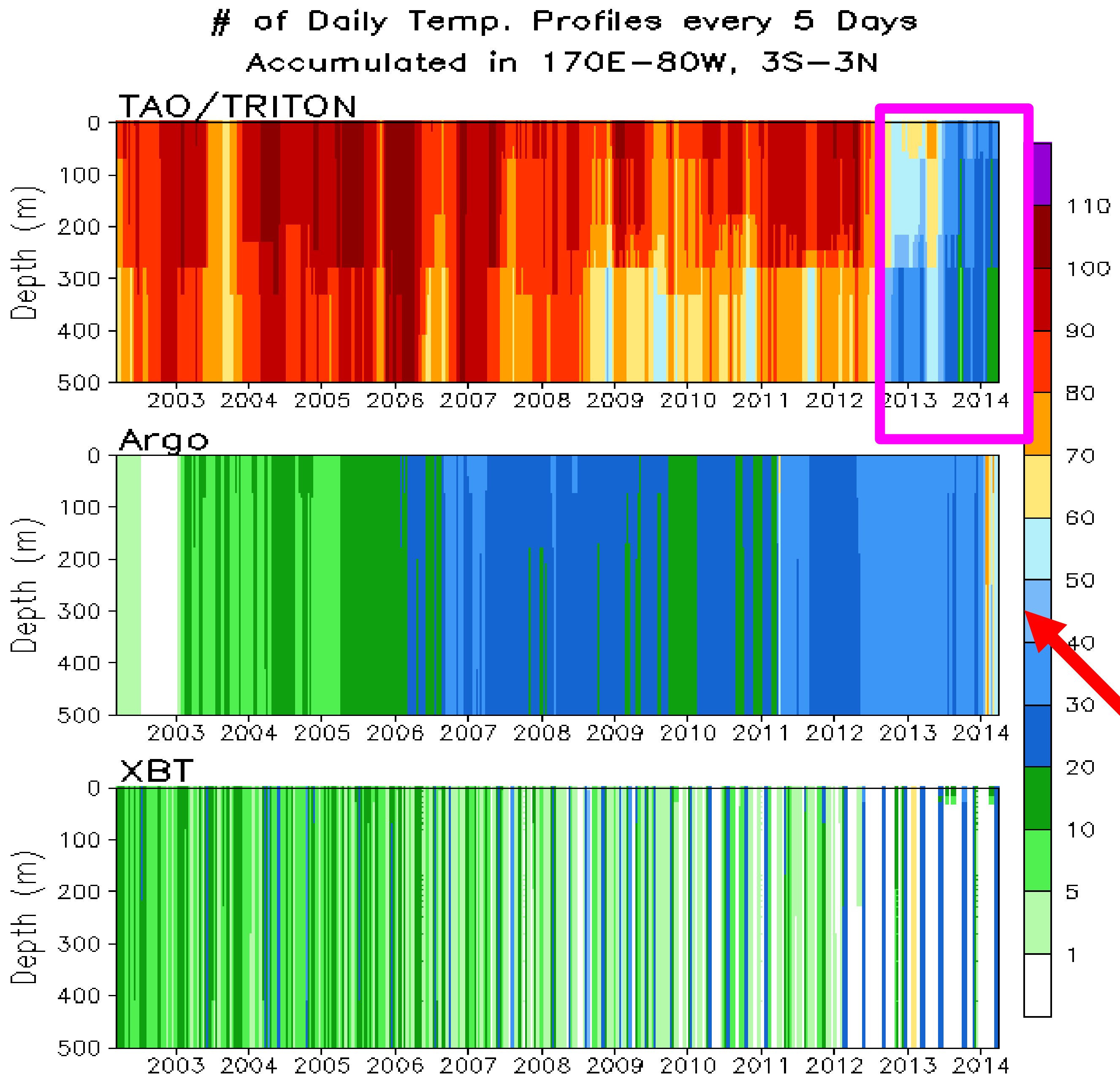
Equatorial

Pacific Ocean

Temperature

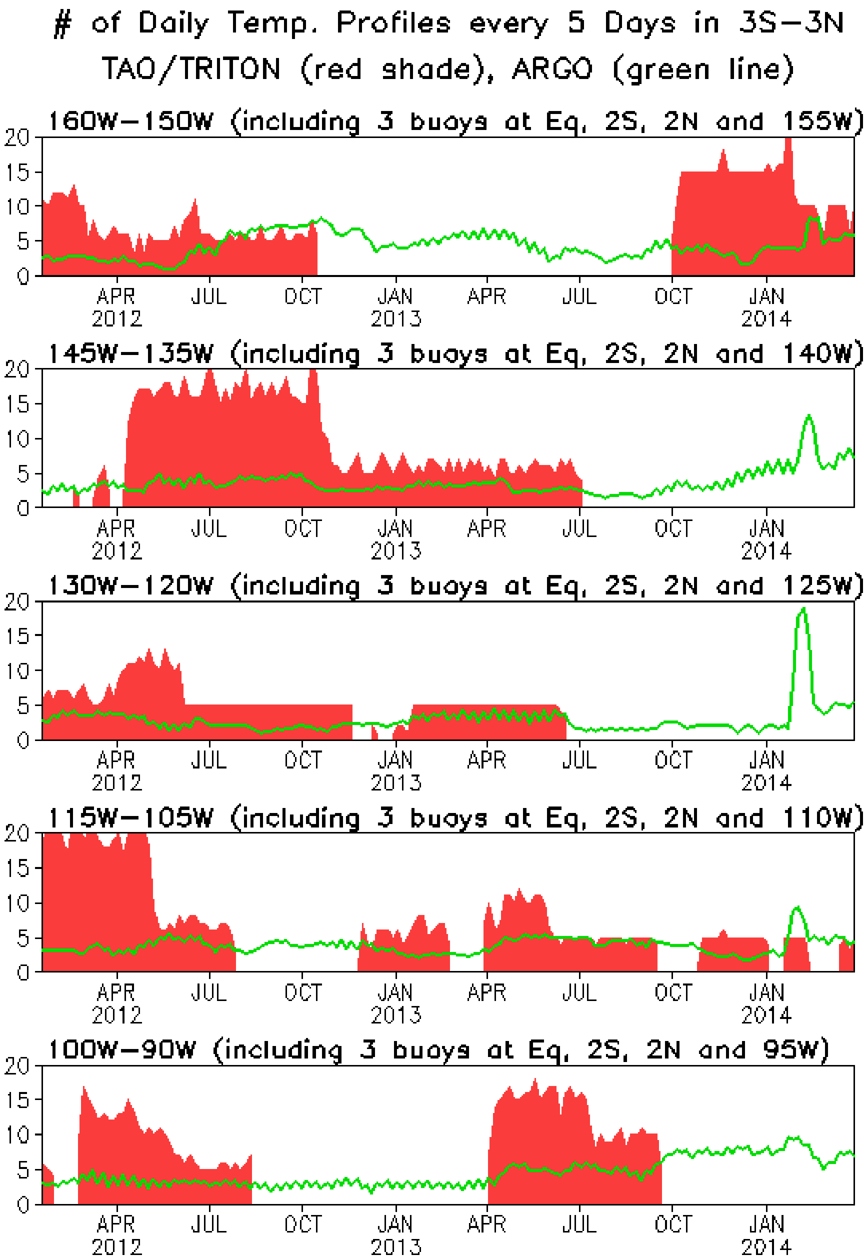
Pentad Mean

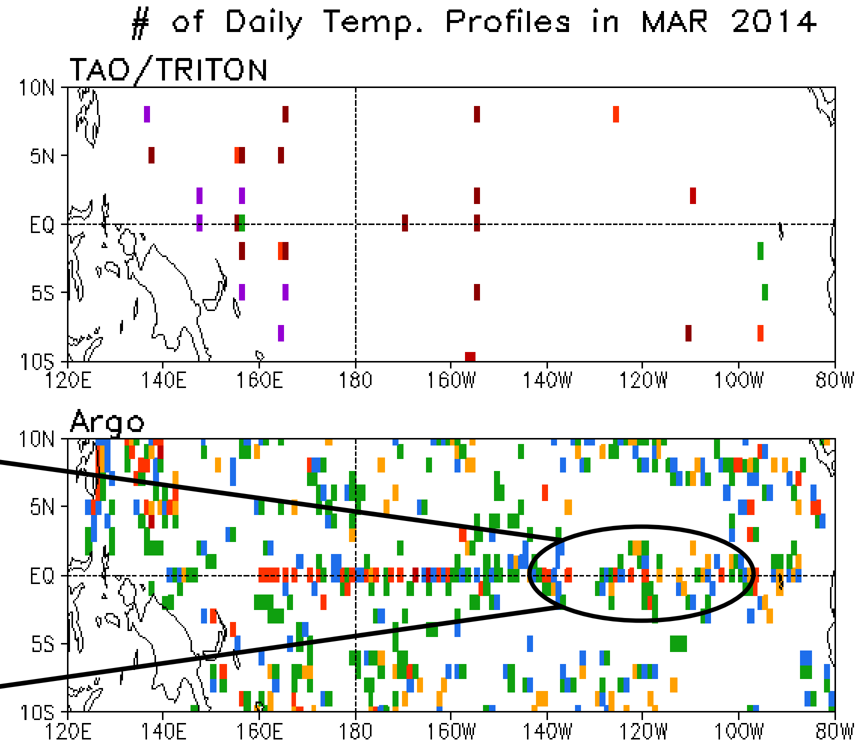
Anomaly



- **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.**





- The sharp increase of Argo data since late Jan 2014 was due to deployment of iridium Argo floats in the eastern Pacific (courtesy of Dean Roemmich

http://sio-argo.ucsd.edu/historical.html)

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

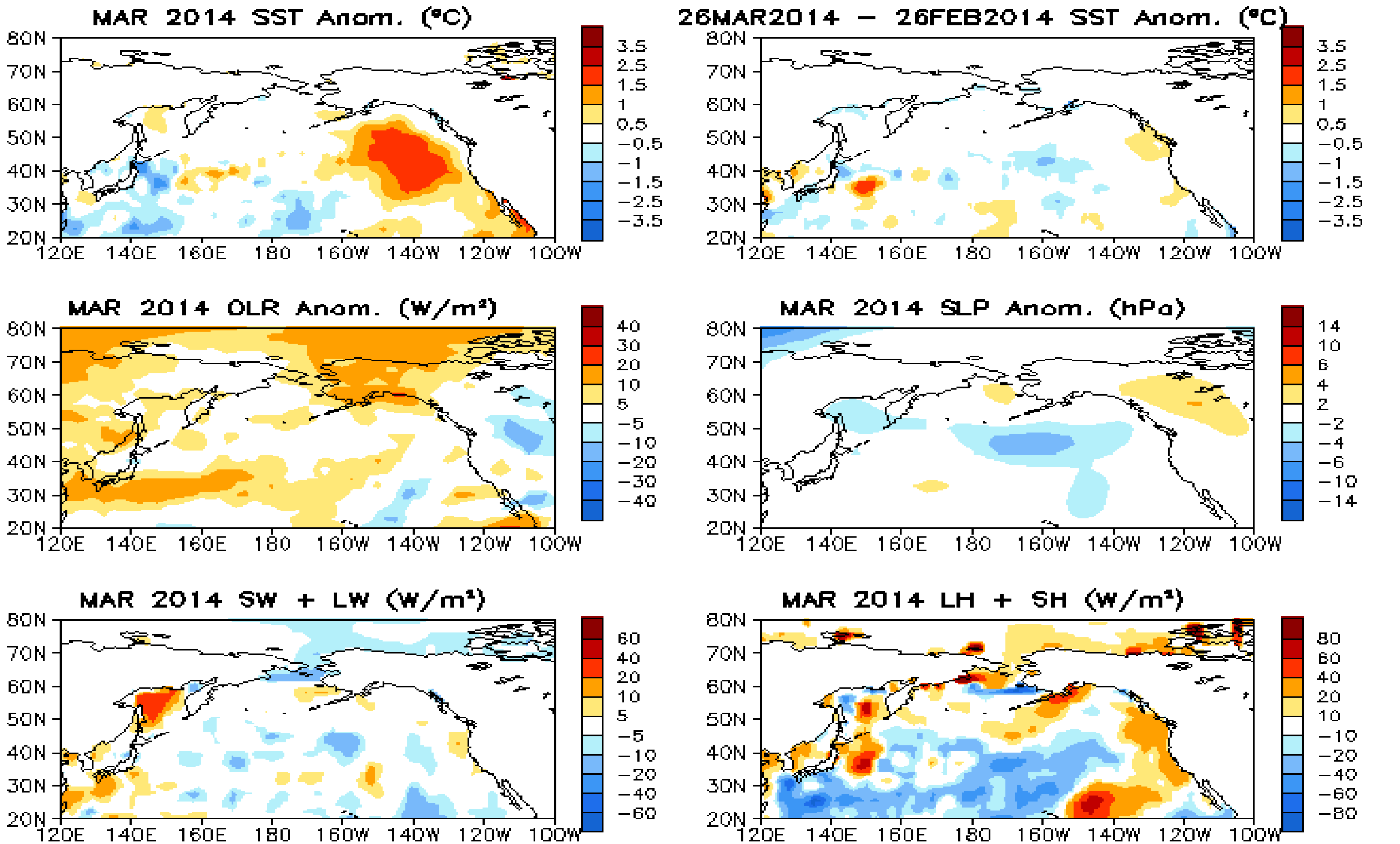
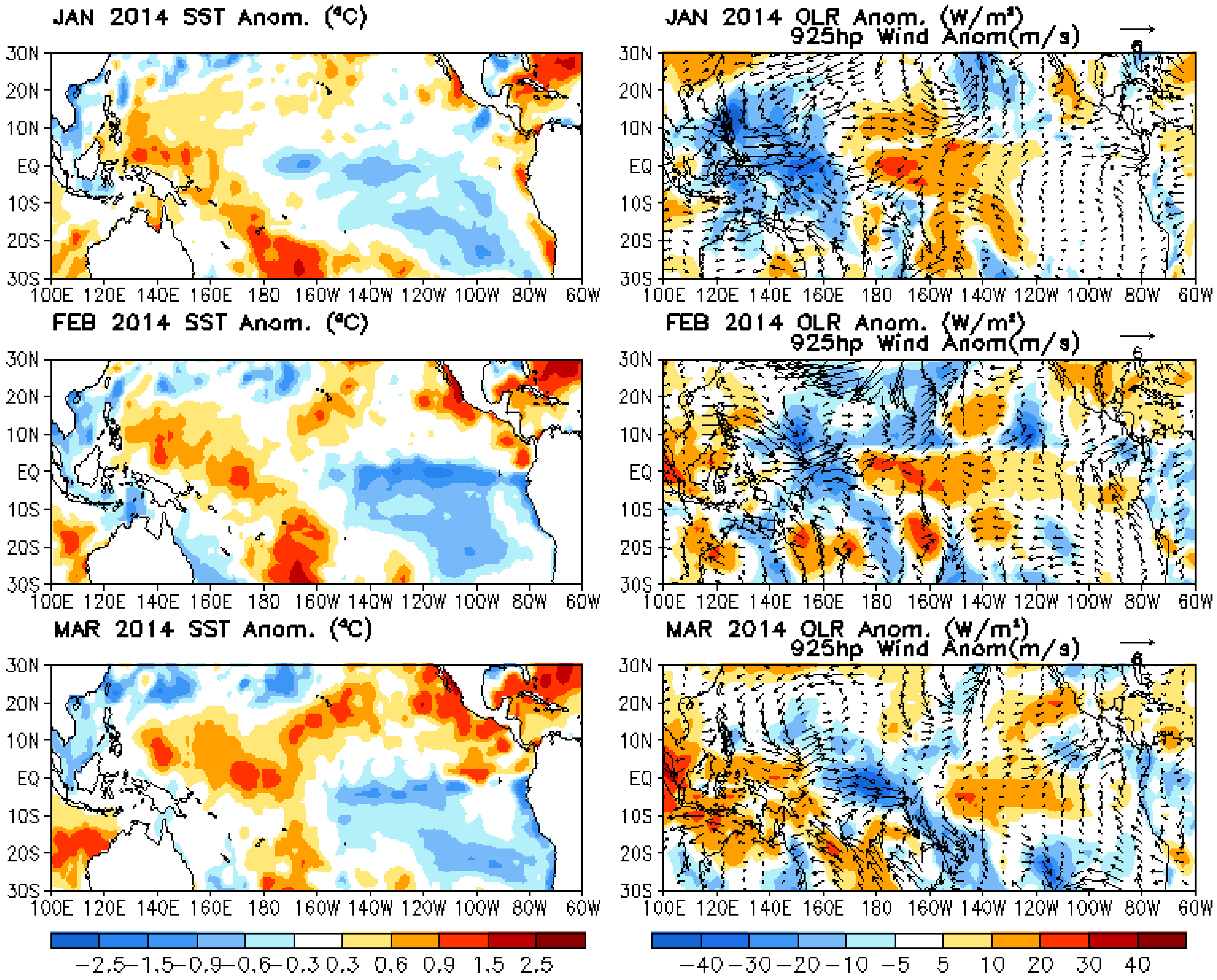


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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



JAN 2014 SST Anom. (°C)
JAN 2014 OLR Anom. (W/m²)
925hp Wind Anom(m/s)
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)
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

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.

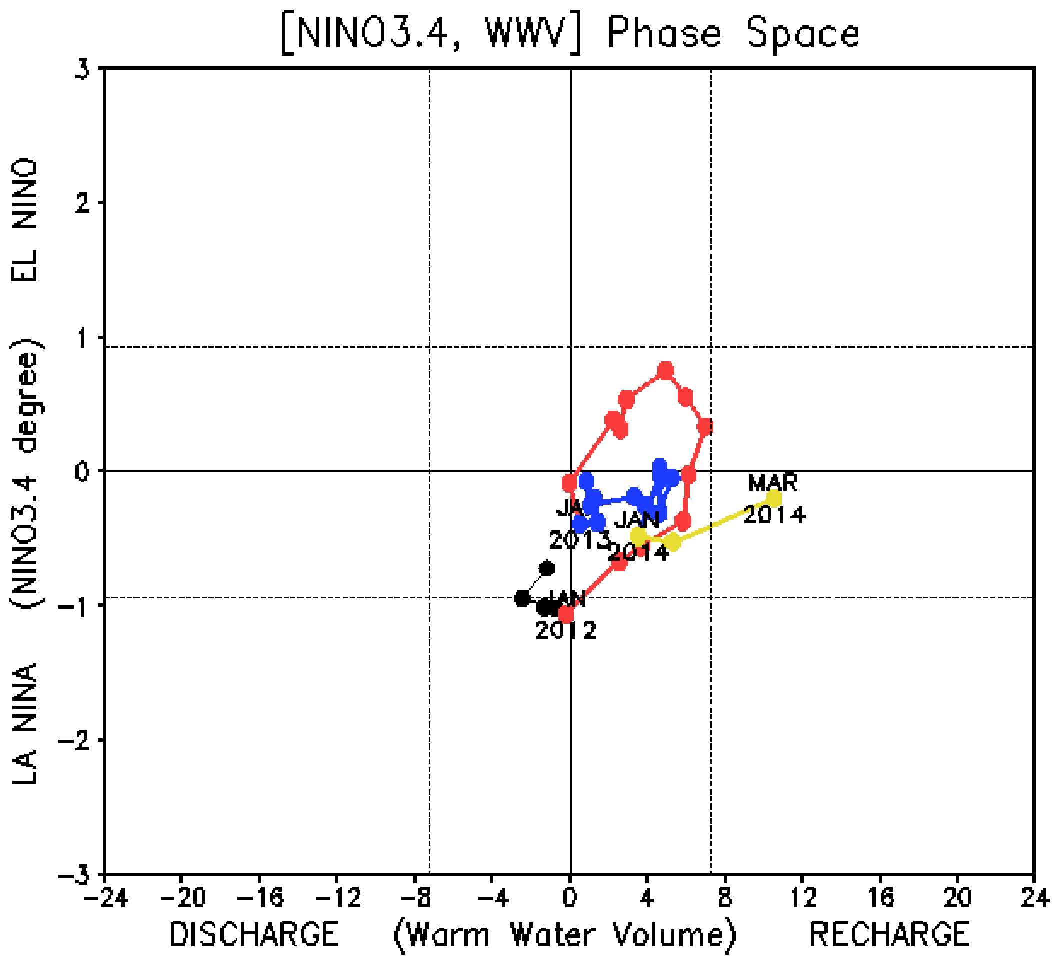


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

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

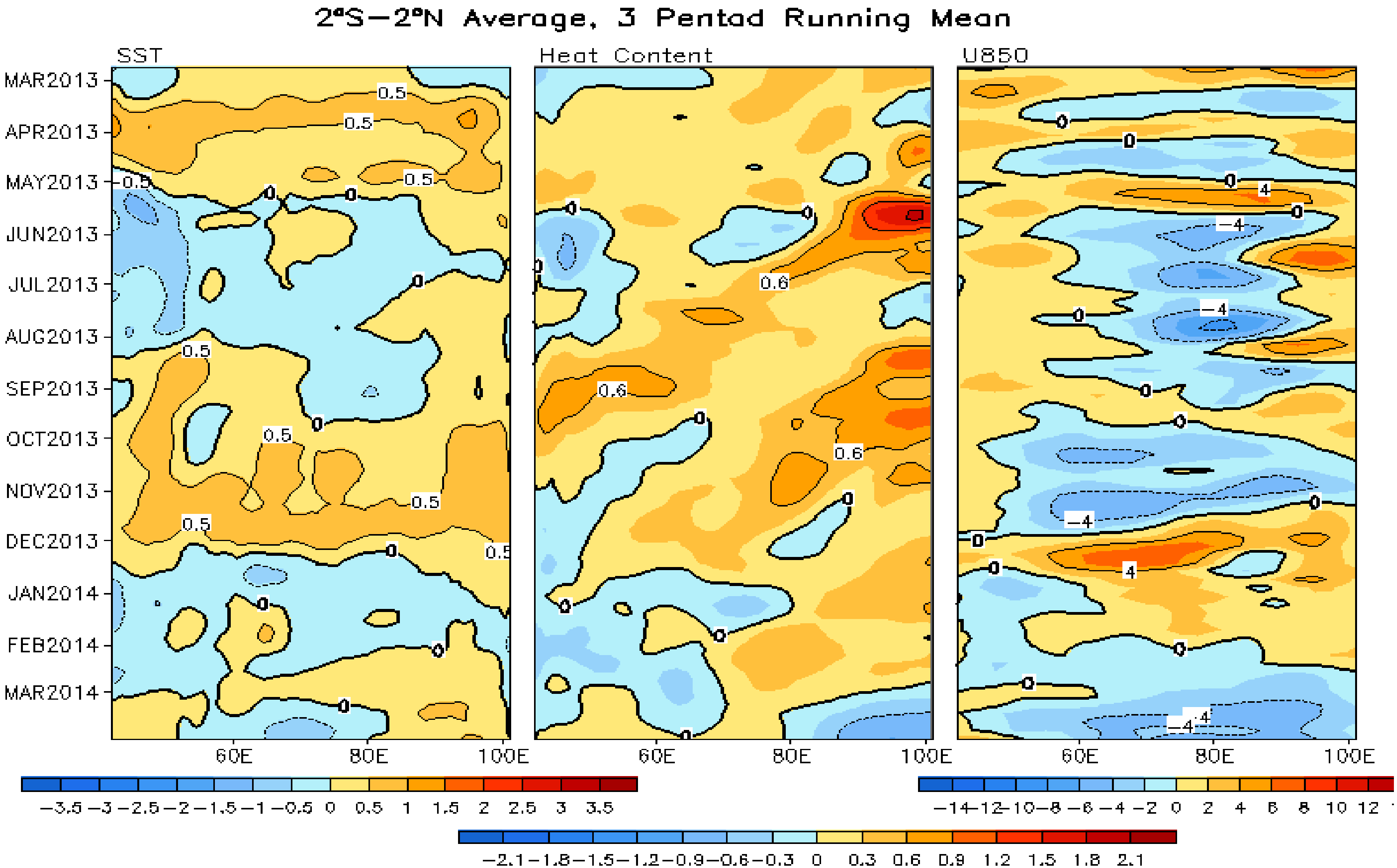


Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI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

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

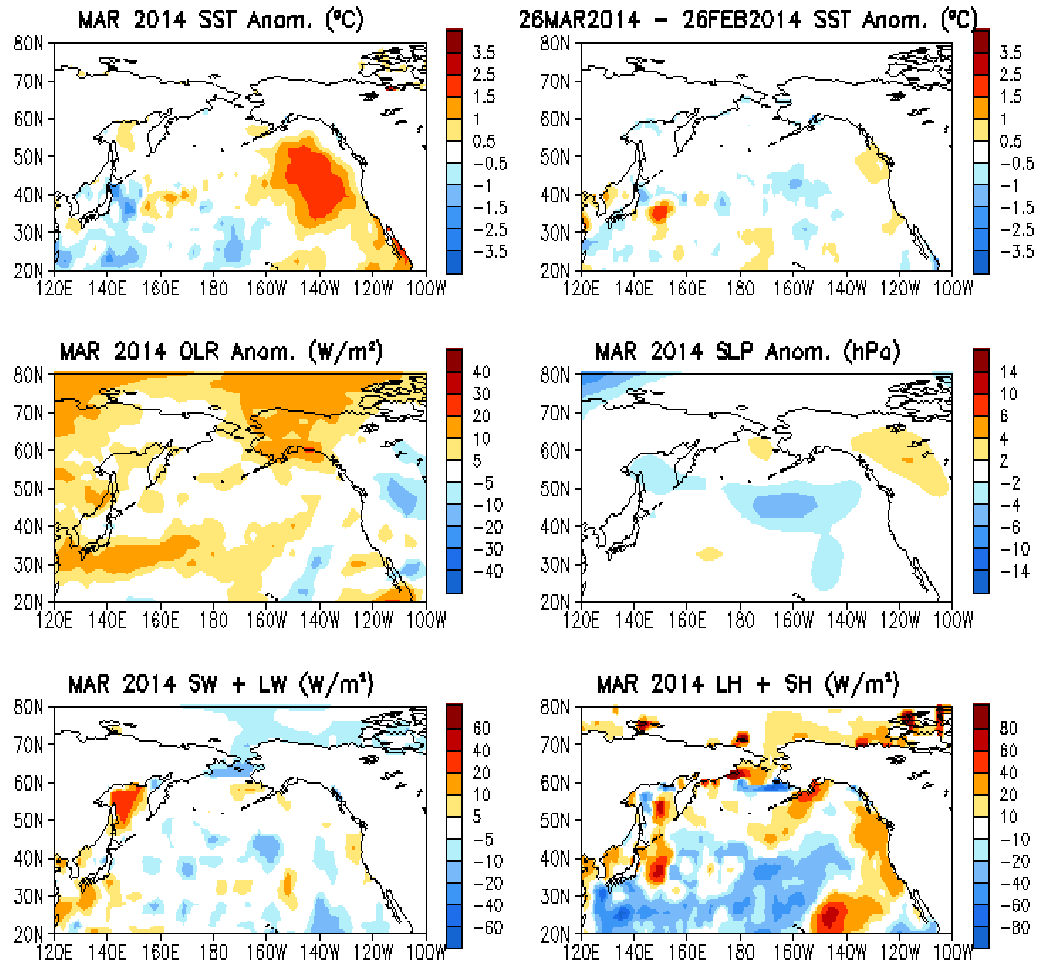
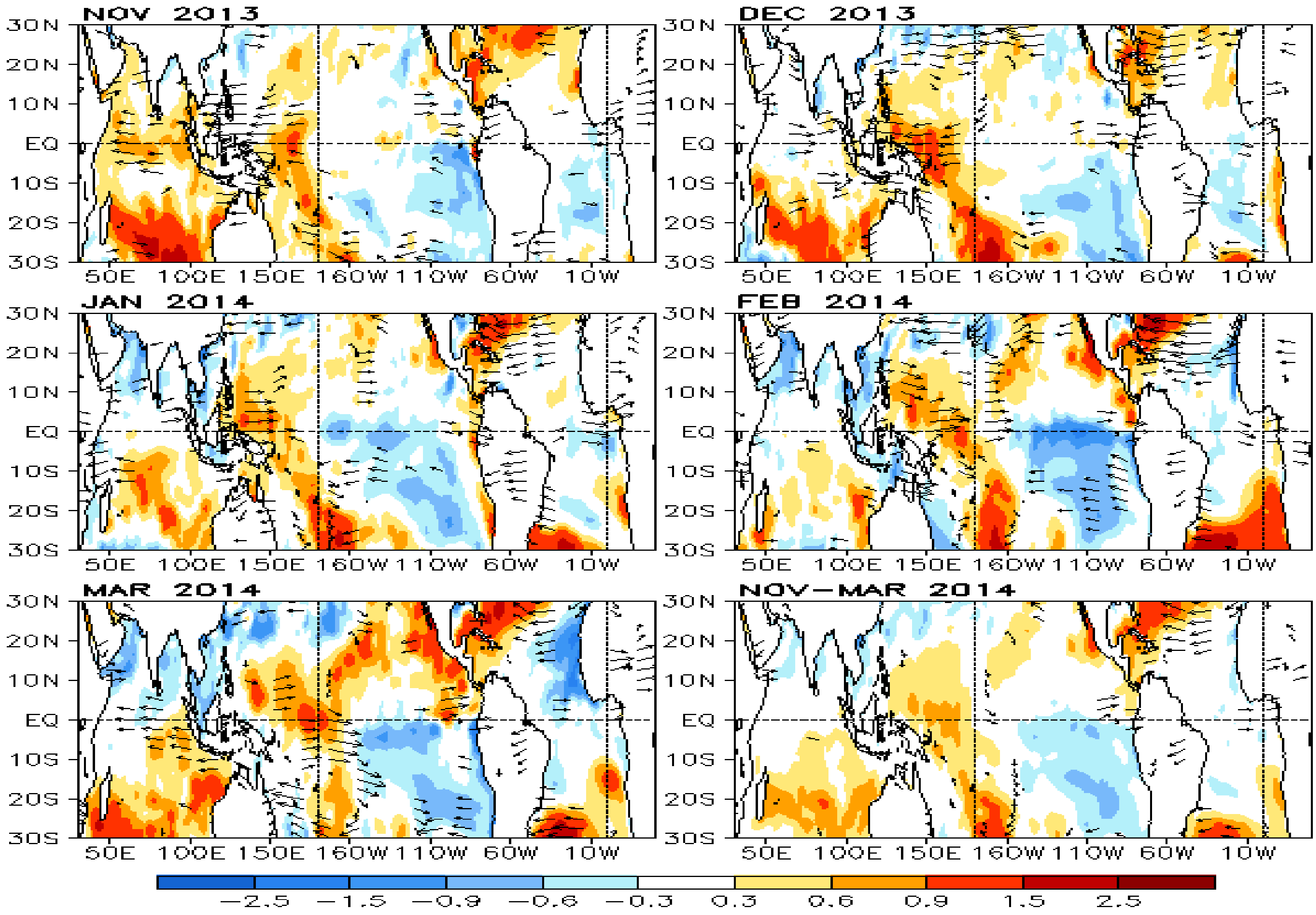
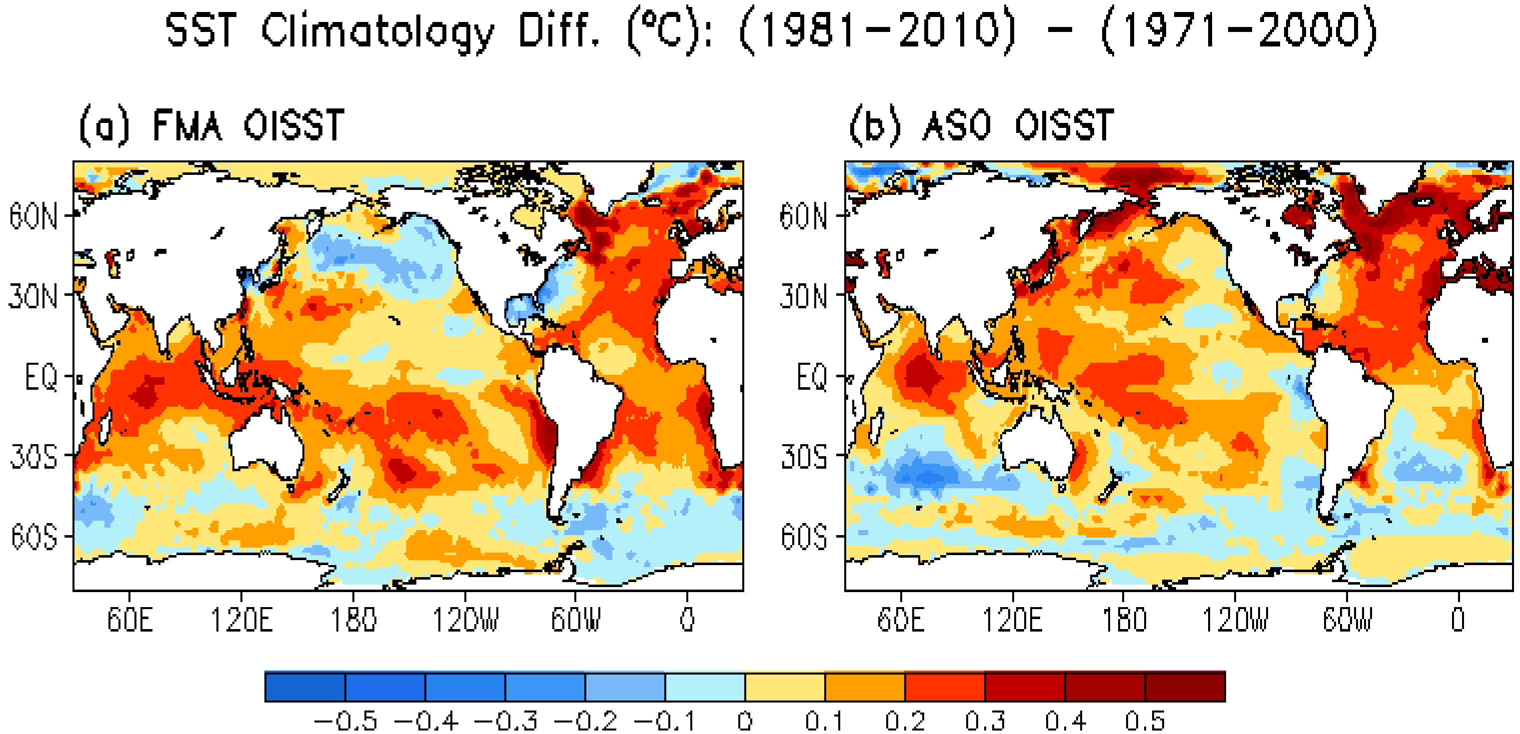


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

Evolution of SST and 850mb Wind Anom.



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°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!