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**

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

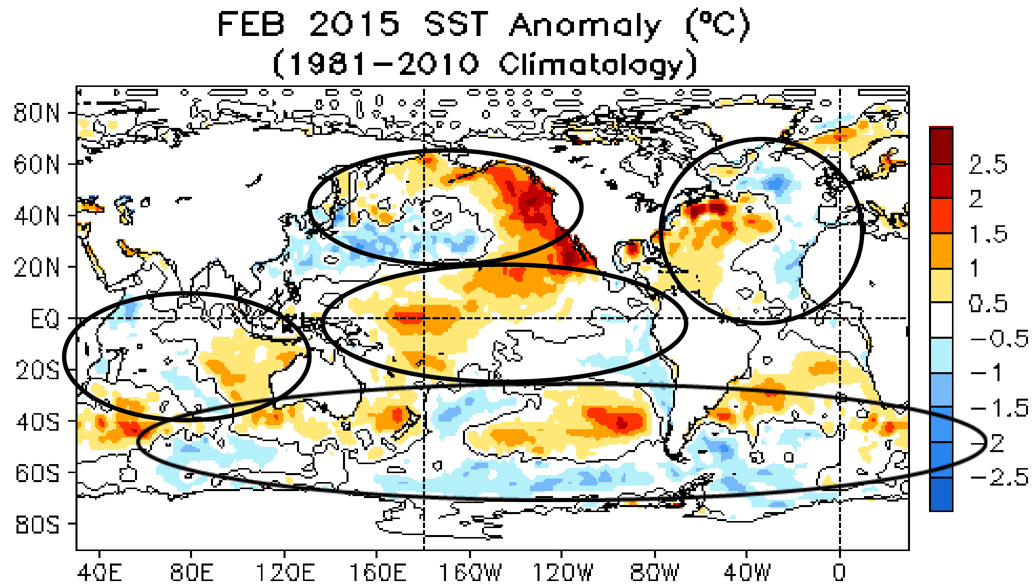
(Why CPC believes El Nino conditions were observed in February 2015?)

Overview

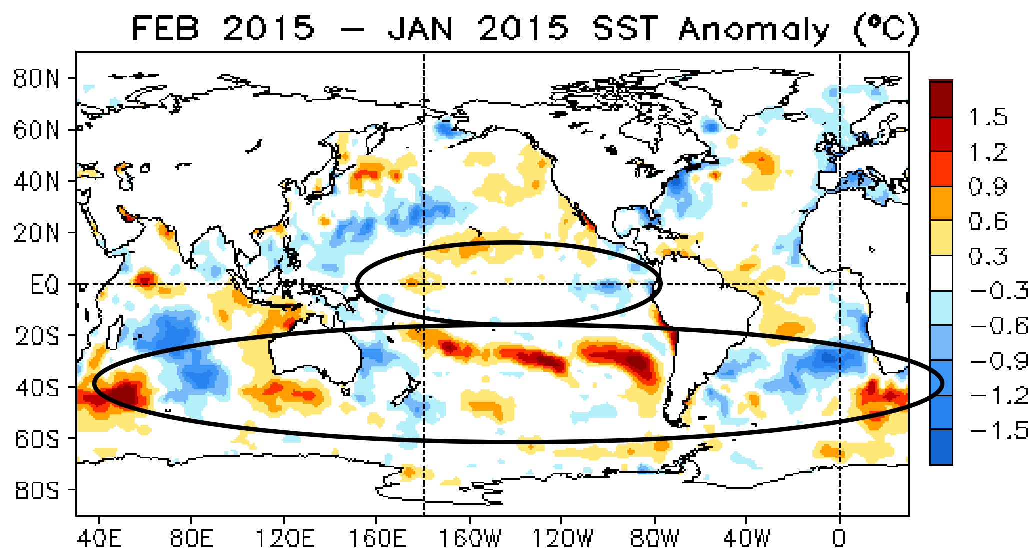
- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 05 March 2015 issued "El Nino Advisory" and suggested that "*There is an approximately 50-60% chance that El Niño conditions will continue through Northern Hemisphere summer 2015.*"**
  - **Positive SSTAs were mainly in the central tropical Pacific with NINO3.4=0.6°C in Feb 2015.**
  - **Positive anomalies of subsurface ocean temperature along the equator strengthened in Feb 2015.**
  - **Majority of dynamical models predicted a warming tendency and majority of statistical models favor neutral in 2015.**
  - **Positive phase of PDO has persisted for 8 months, with PDOI=1.6 in Feb 2015.**
- **Indian Ocean**
  - **SSTAs were small with positive (negative) in the east (west).**
- **Atlantic Ocean**
  - **Positive phase of NAO has persisted for 4 months with NAOI=1.1 in Feb 2015, causing a horseshoe-like pattern of SSTA in N. Atlantic.**

<u>Global Oceans</u>

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



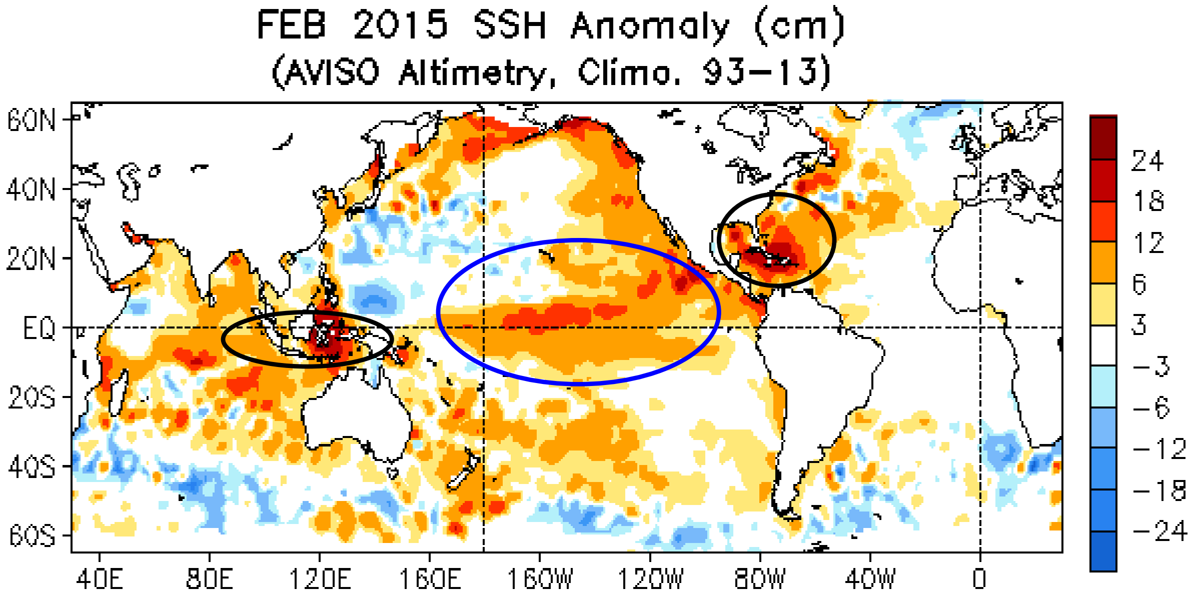
- Strong positive (weak negative) SSTA was observed in the central (eastern) tropical Pacific.
- Strong positive SSTA presented in the NE Pacific and was associated with positive phase of PDO.
- Horseshoe-like SSTA occurred in the North Atlantic.
- Positive (negative) SSTA existed in the eastern (western) Indian Ocean.

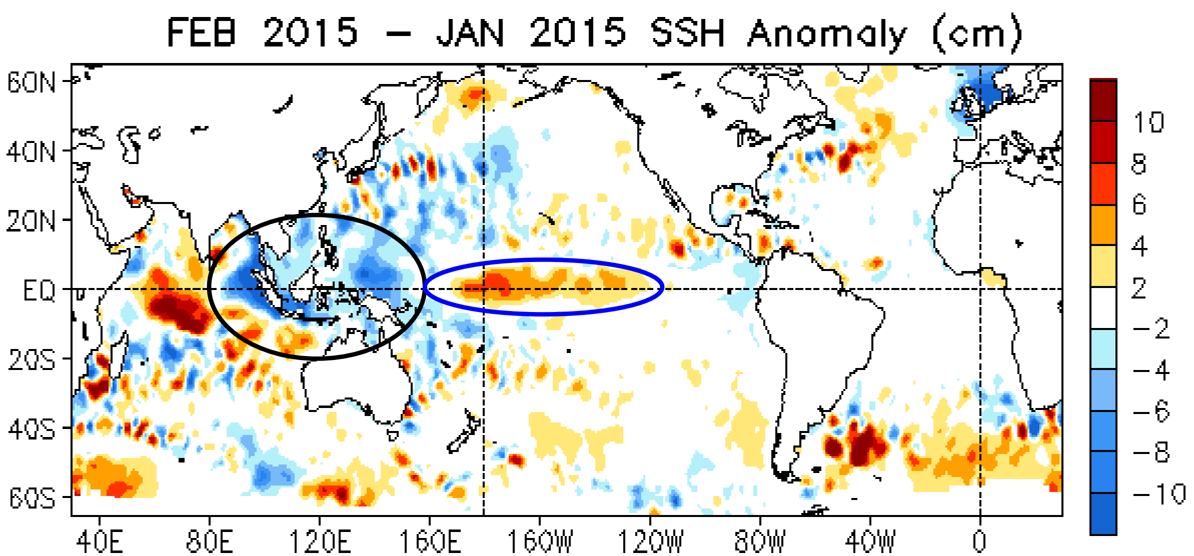


- Positive (negative) SST tendencies were observed in the central (eastern) equatorial Pacific Ocean, and some strong anomalies also in South Ocean.

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 Anomaly (cm) and Anomaly Tendency

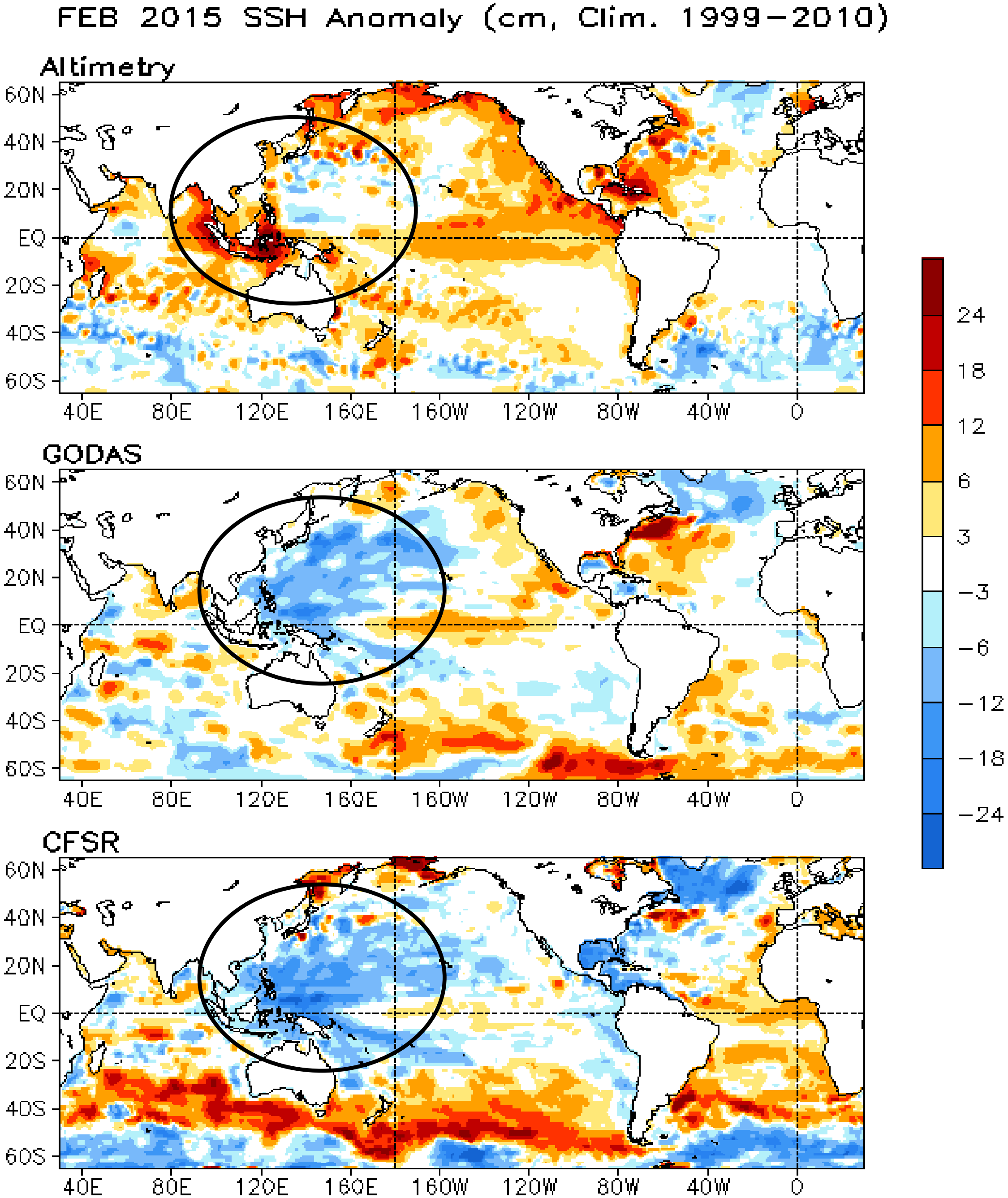




- SSHAs were not very consistent with SSTAs.

- Positive SSHAs presented in the central and eastern Pacific Ocean, in Gulf of Mexico and Caribbean Sea, and around Marine Continent. These anomalies might be tied up with subsurface ocean temperature anomalies.

- Positive SSHA tendency in the central and eastern tropical Pacific may be linked to the downwelling Kelvin wave.



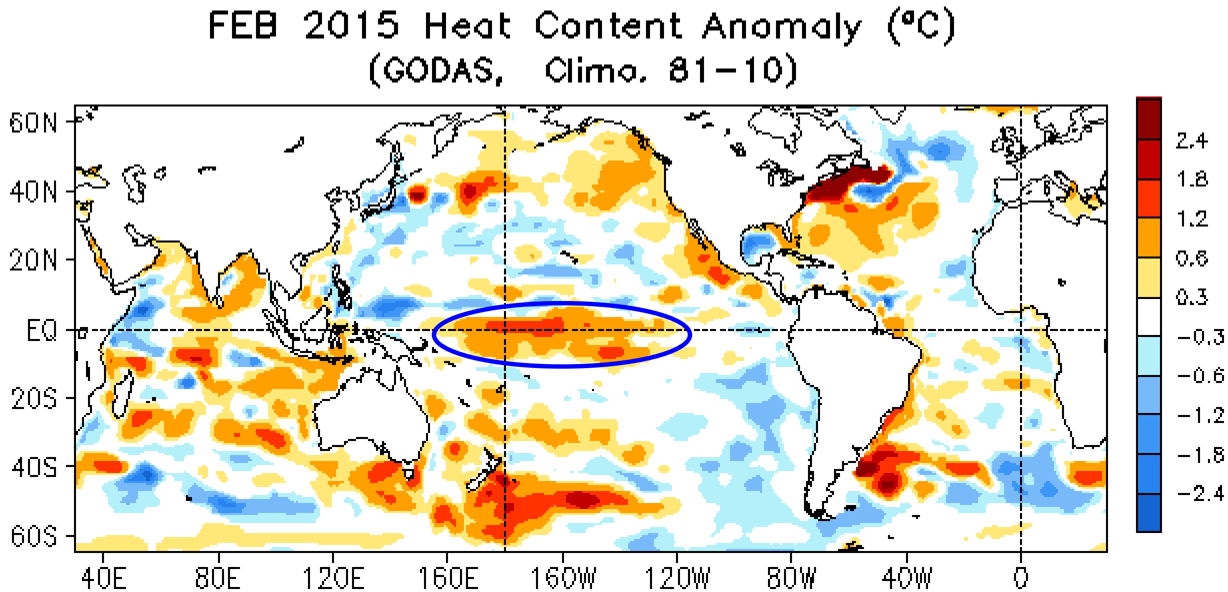
Obvious differences of SSH Anomalies:

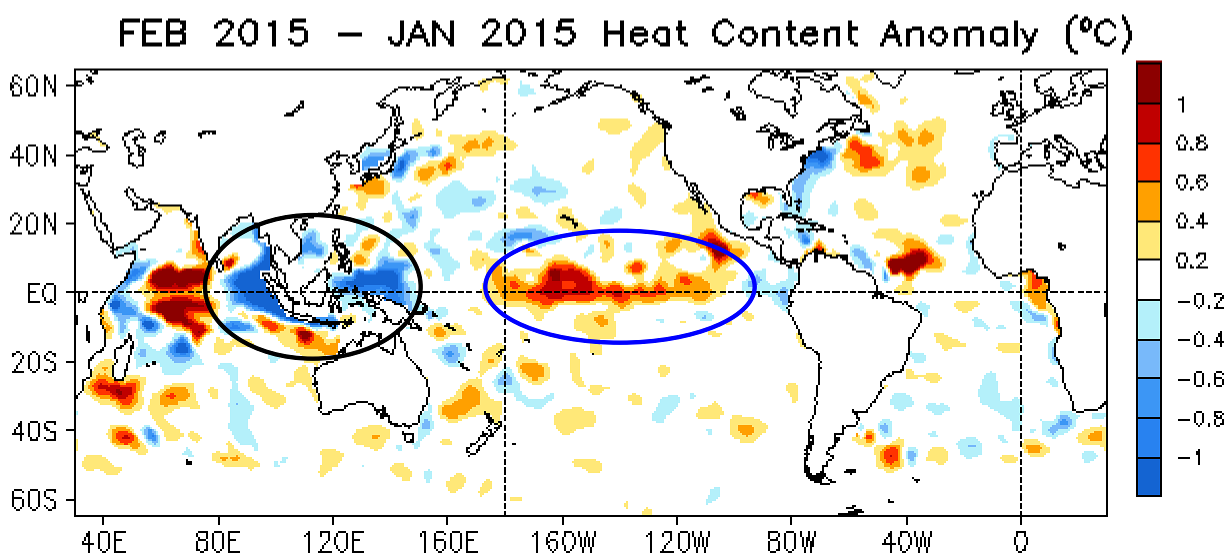
Altimetry

GODAS

CFSR

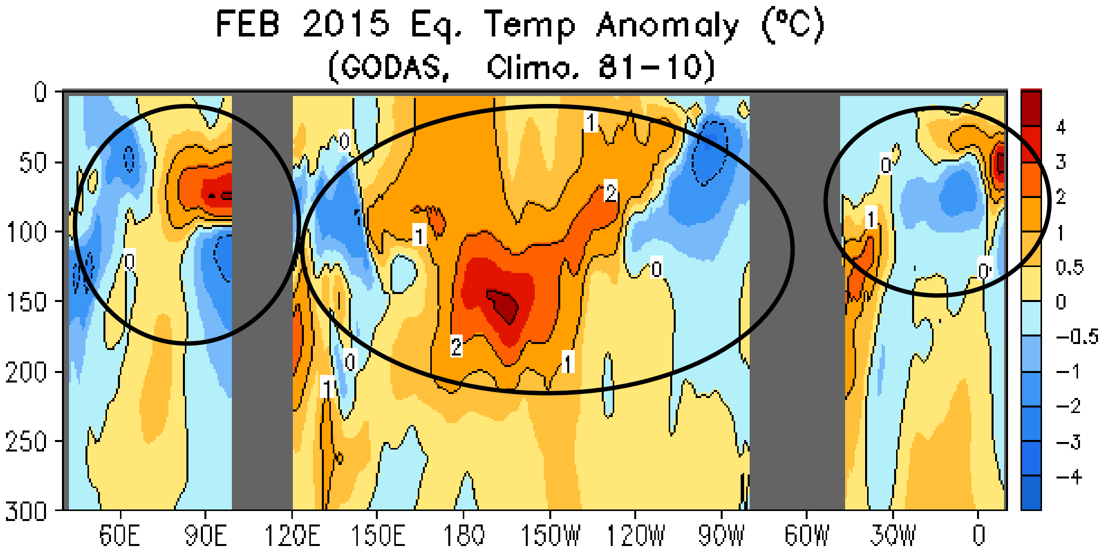
Global HC Anomaly (cm/°C) and Anomaly Tendency





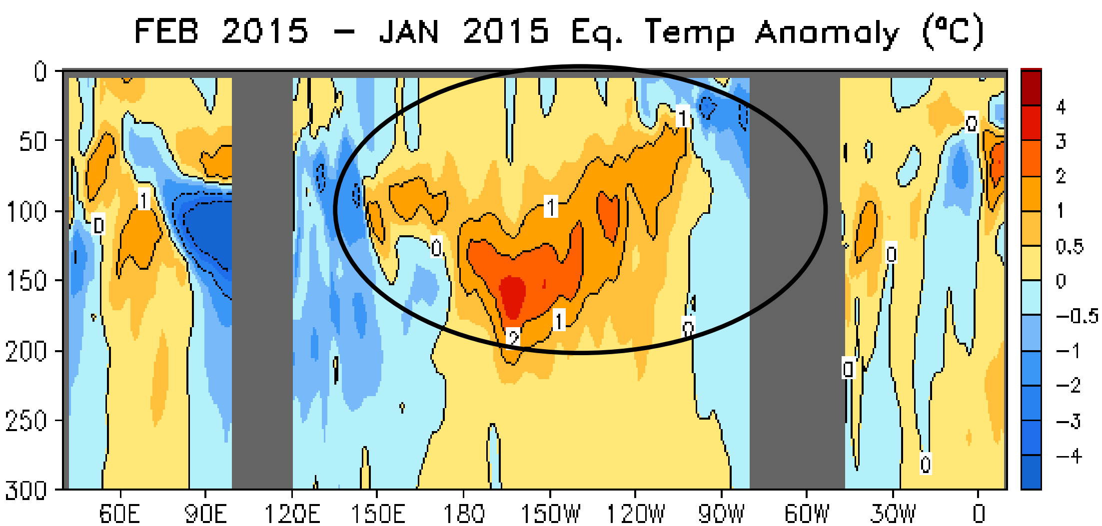
- HCAs were overall consistent with SSHAs, particularly in the tropical Pacific.

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



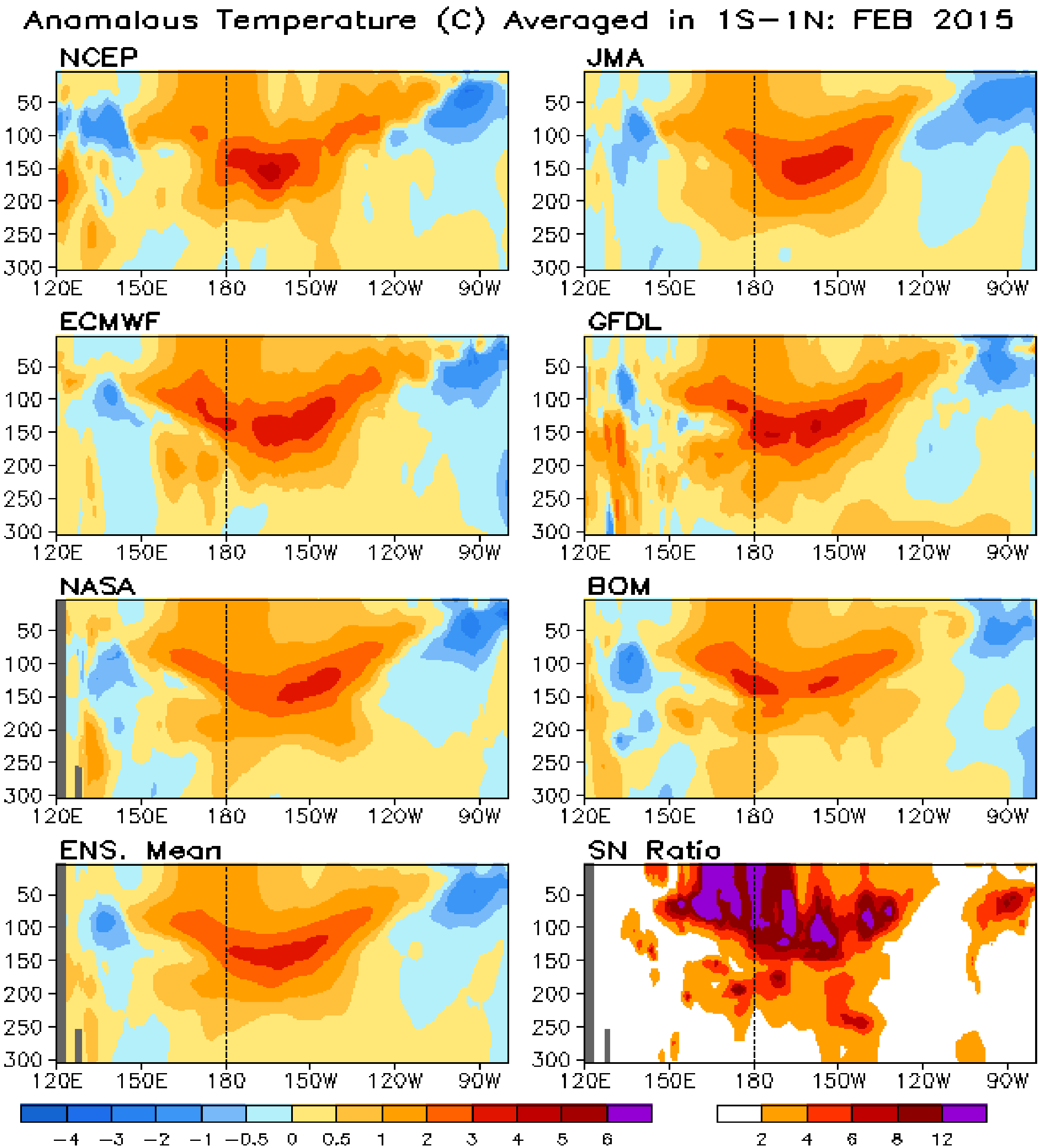
- Strong positive (weak negative) ocean temperature anomalies presented in the central (eastern and western) equatorial Pacific.

- Both positive and negative ocean temperature anomalies were observed in the Indian and Atlantic Oceans.



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

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.



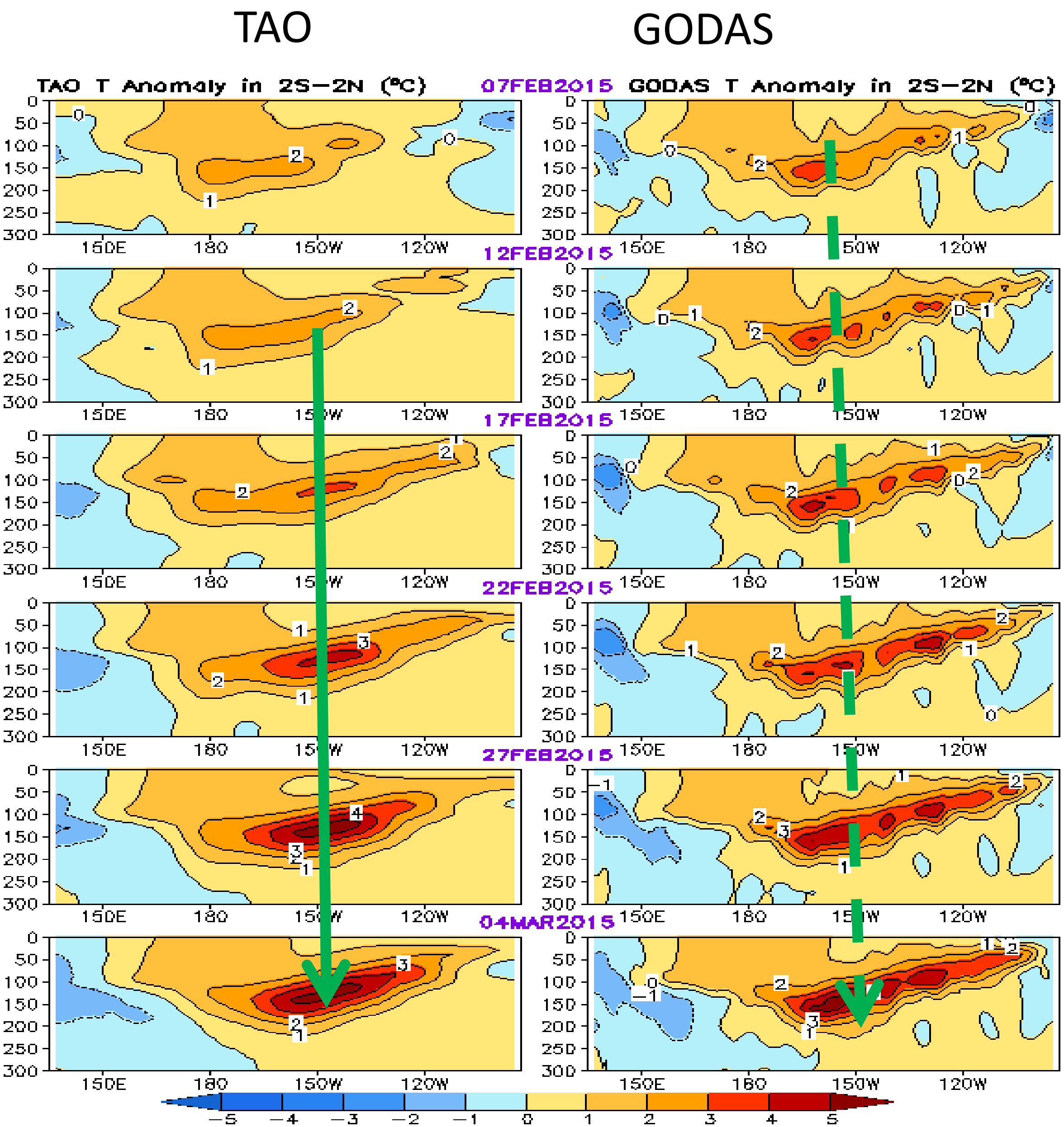
Multiple Ocean Reanalyses: Ocean Temperature along the equator

- **Overall, the anomalous pattern is similar for 6 re-analyses.**

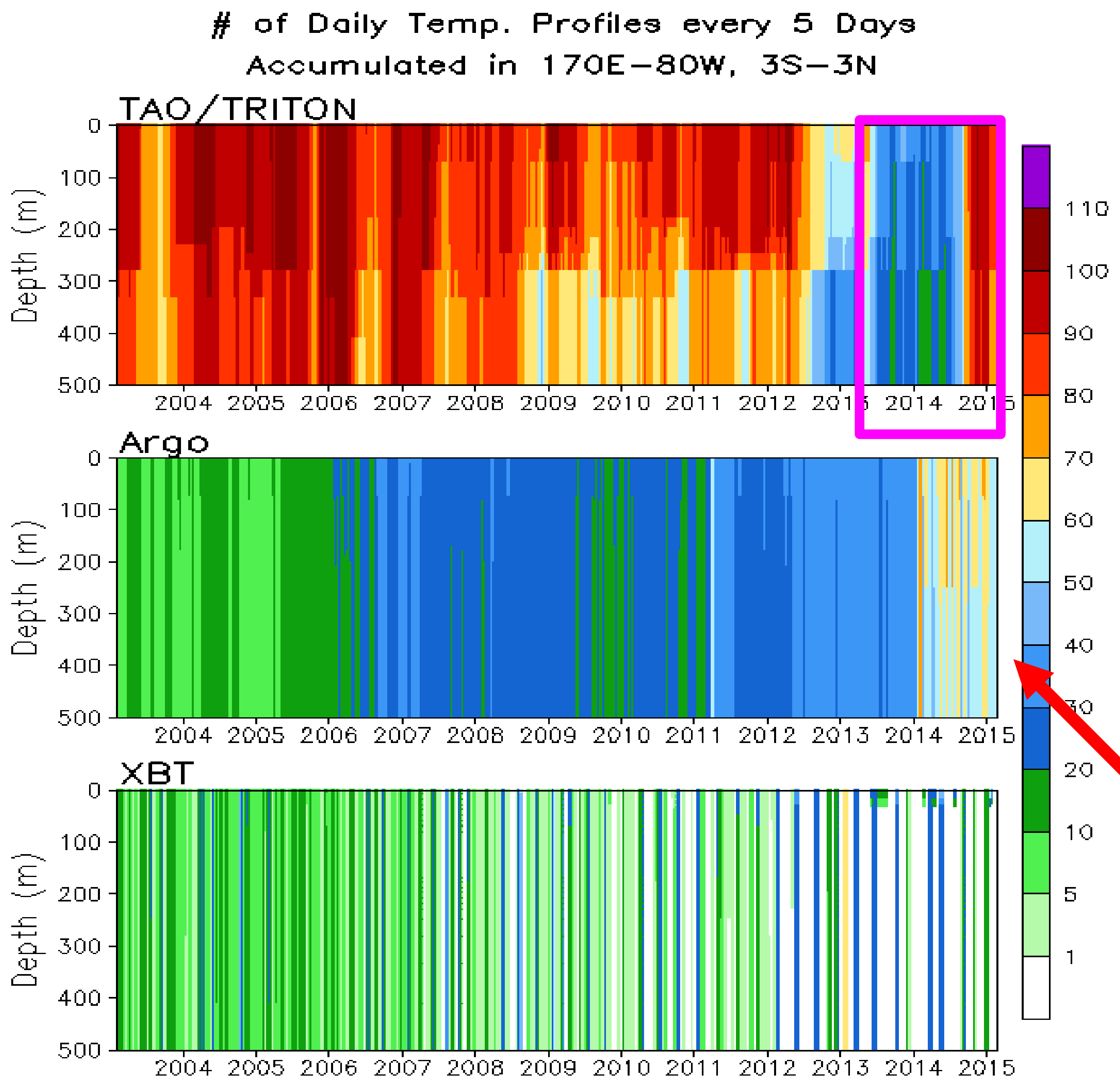
-(http://origin.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html)

Tropical Pacific Ocean and ENSO Conditions

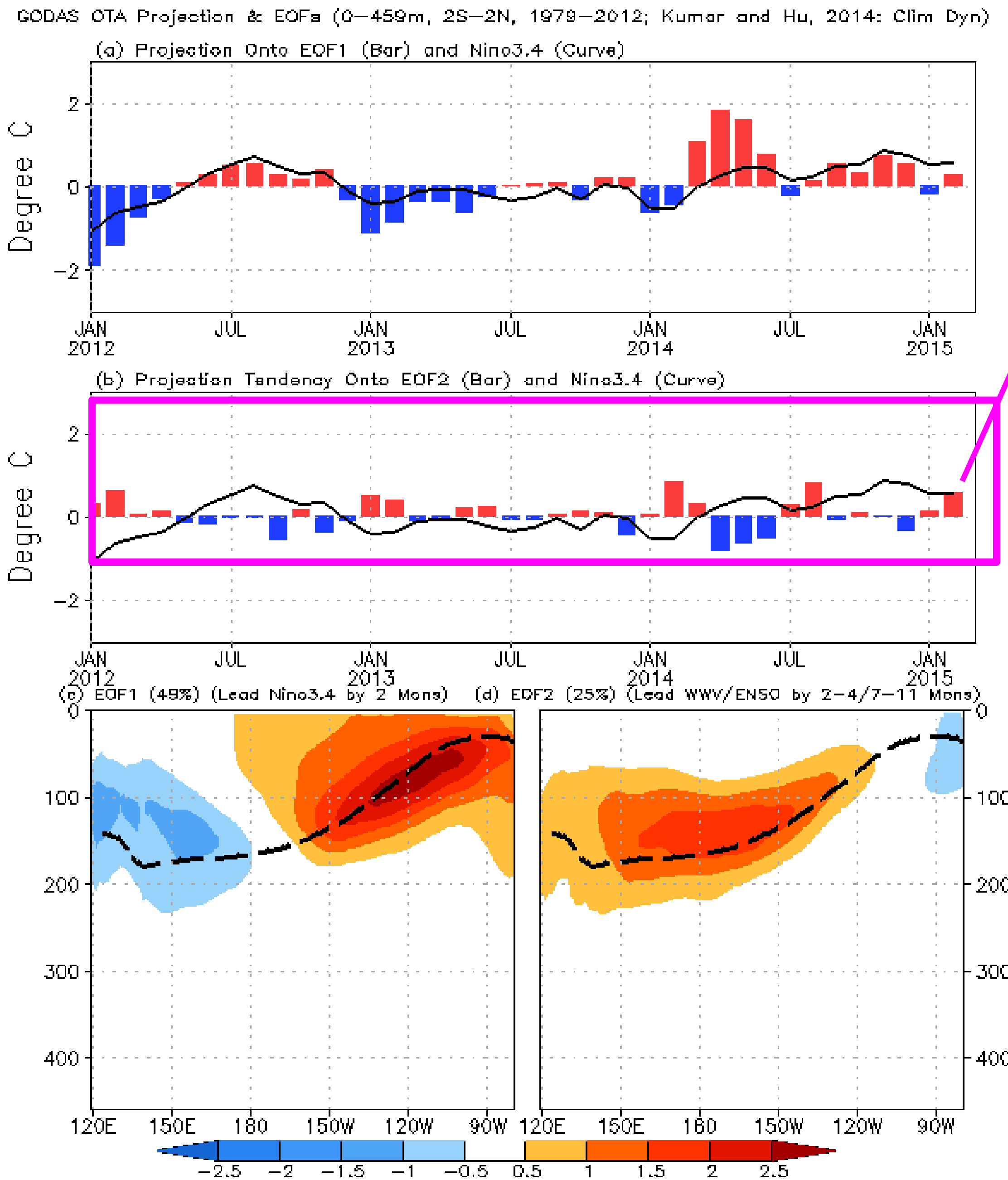
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- **Strong positive ocean temperature anomalies strengthened and *slowly* propagated eastward.**
- **Compared with TAO, GODAS had more smaller scale variations.**
- **Both the intensity and propagation are comparable in recent pentads.**
- **Is this due to the recovery of TAO data delivery rate?**



- **TAO data delivery rate decreased significantly during late 2012 to mid-2014, and largely recovered since late 2014.**
- **There was a sharp increase of Argo data since late Jan 2014.**



Equatorial subsurface ocean temperature monitoring: Right now, it was in recharge phase; Overall recharge/discharge were weak in last 2-3 years.

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

EOF1: Tilt mode (ENSO peak phase);

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

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

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

For details, see:

Kumar A, 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.**

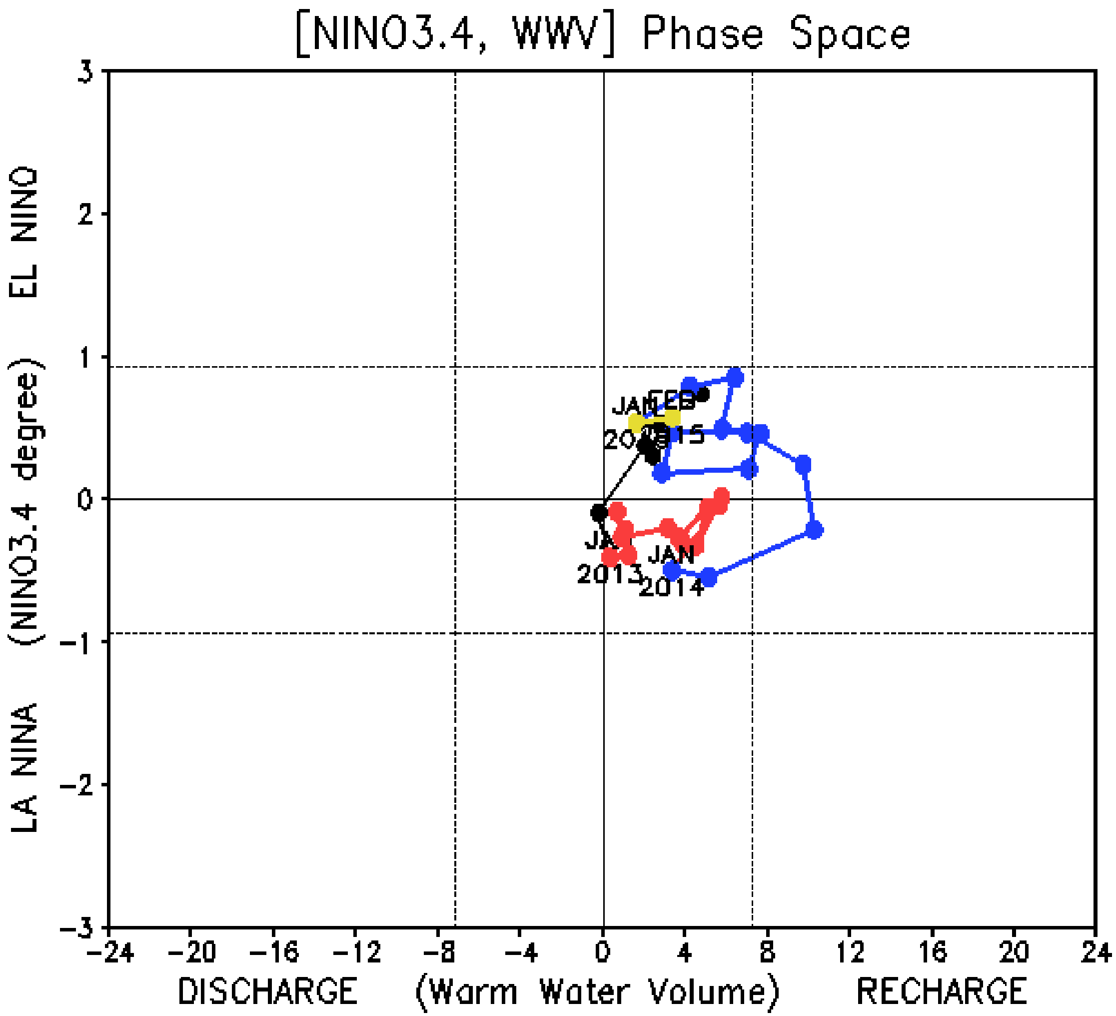
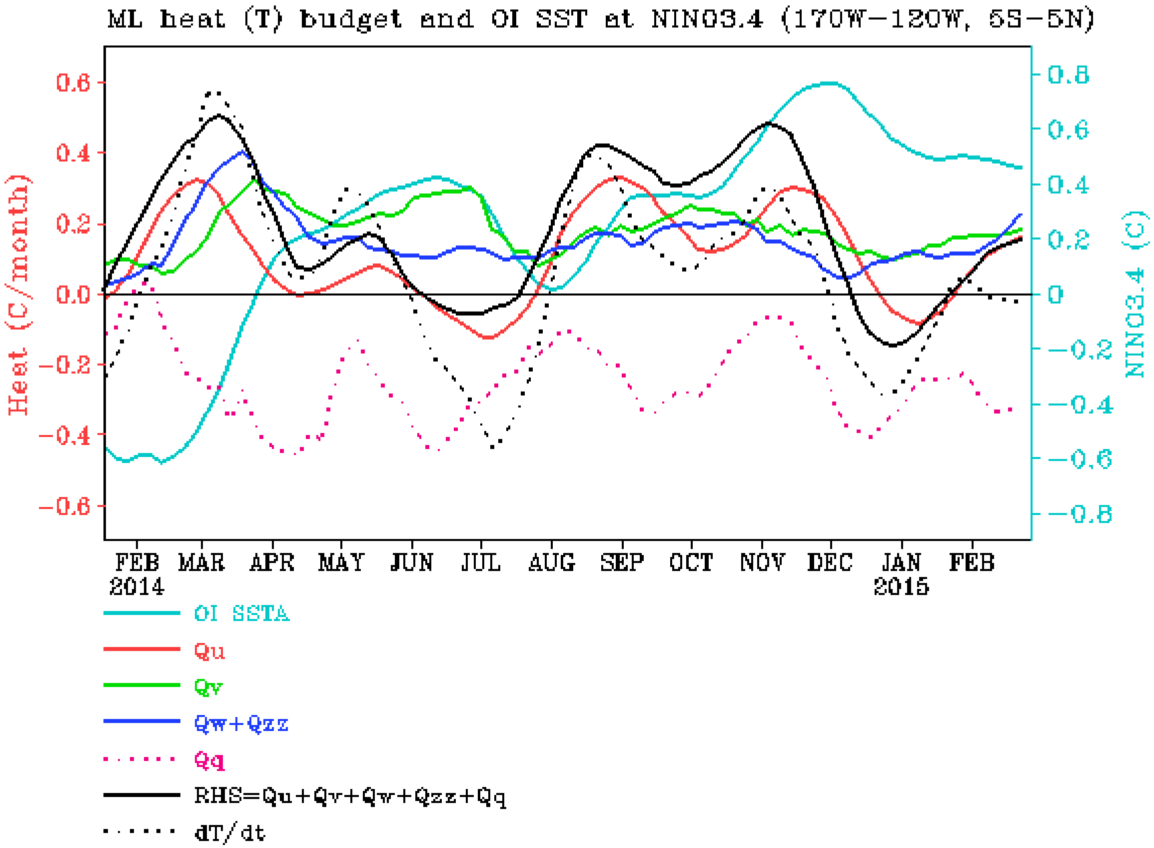


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

NINO3.4 Heat Budget



- **Observed SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was close to zero in Feb 2015.**

- **All dynamical terms (Qu, Qv, Qw+Qzz) were positive and heat flux term (Qq) was negative in Feb 2015.**

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.

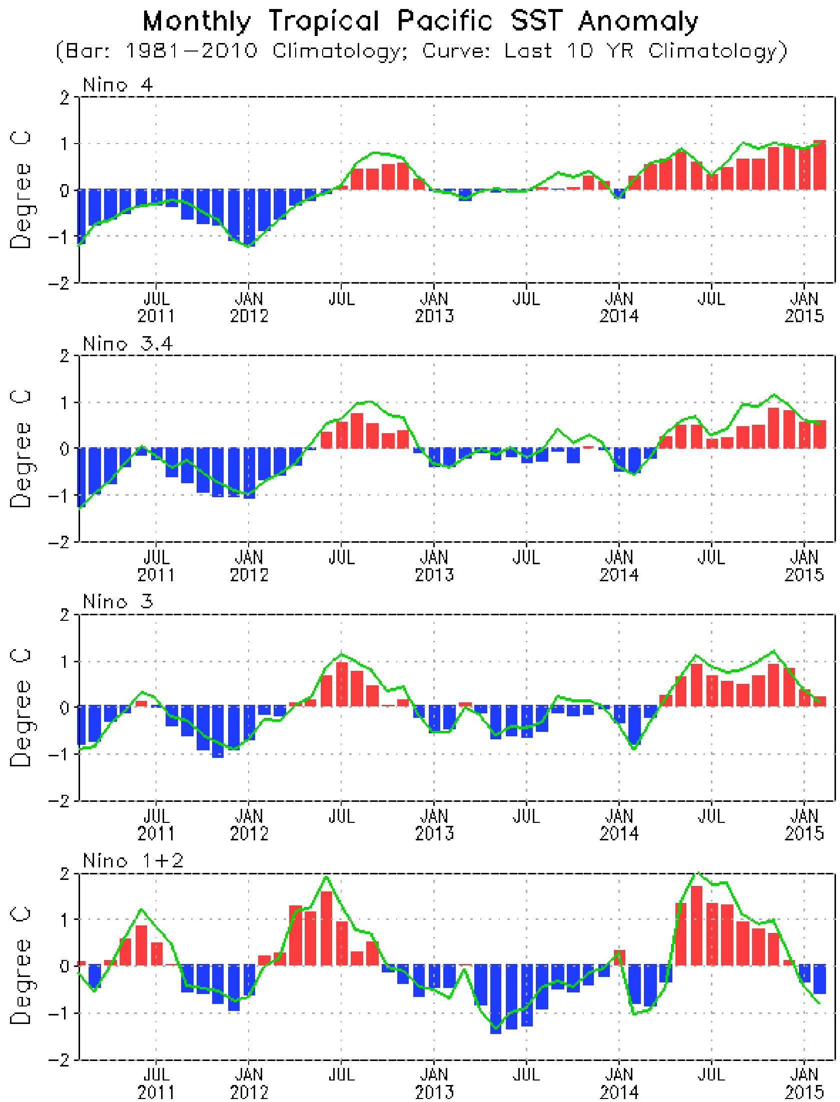
Qu: Zonal advection; Qv: Meridional advection;

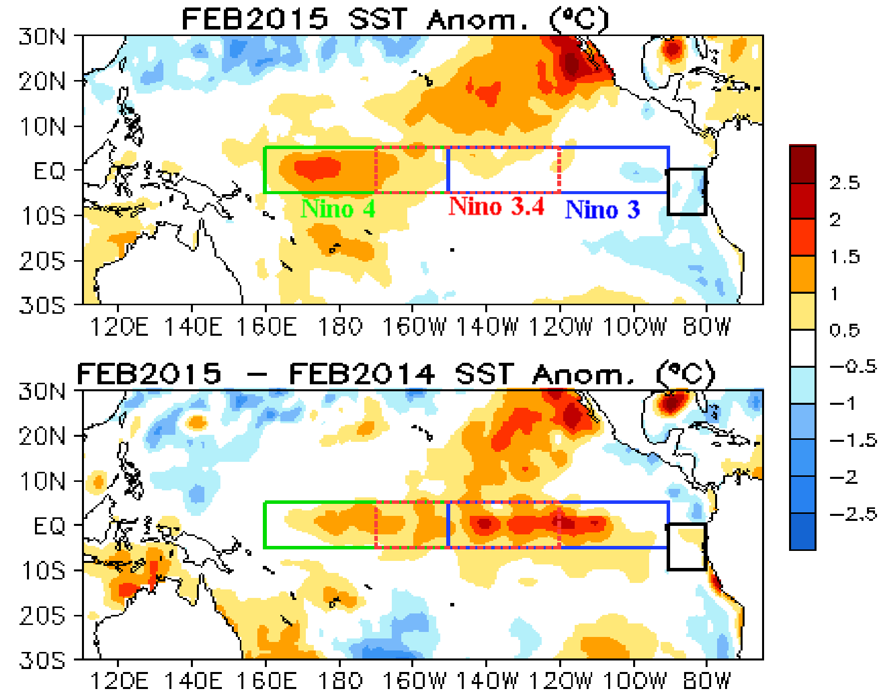
Qw: Vertical entrainment; Qzz: Vertical diffusion

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, were positive; Nino4 strengthened and Nino3 weakened in Feb 2015.

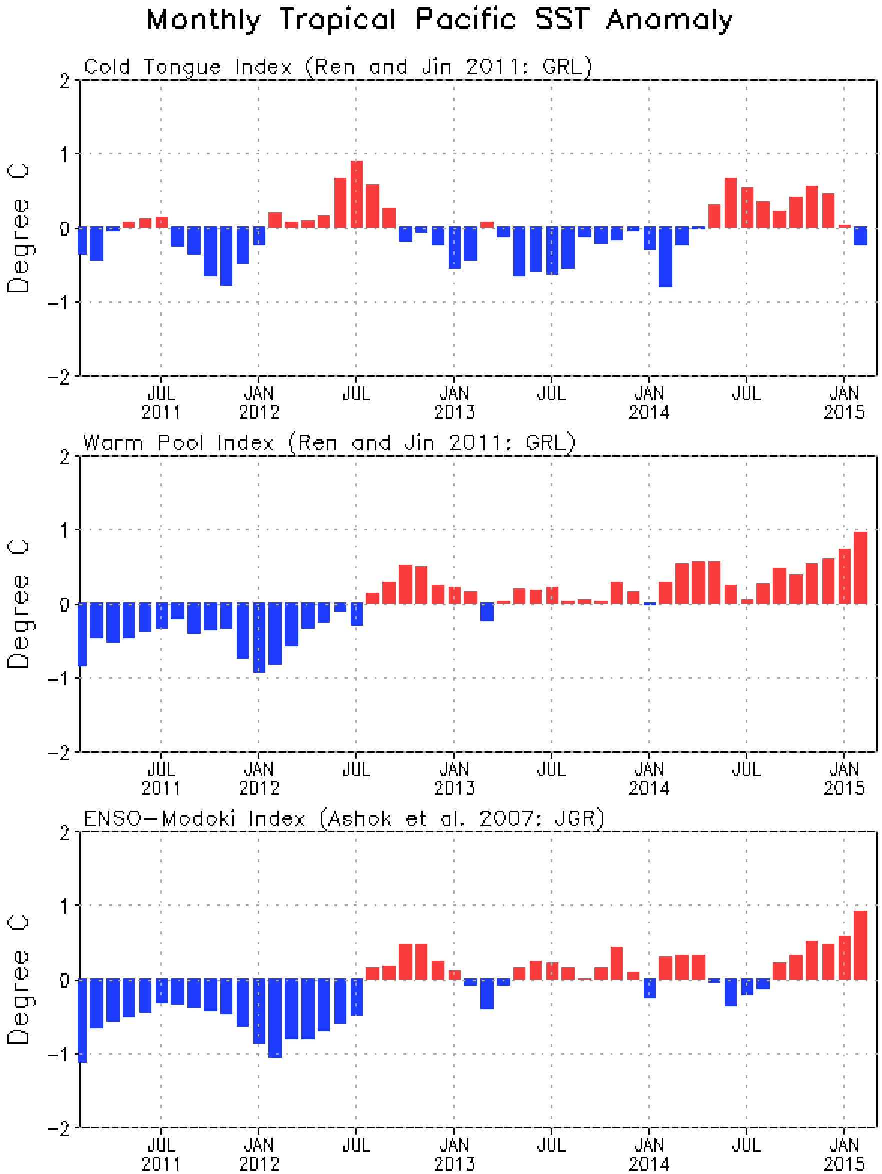
- Nino3.4 = 0.6°C in Feb 2015.

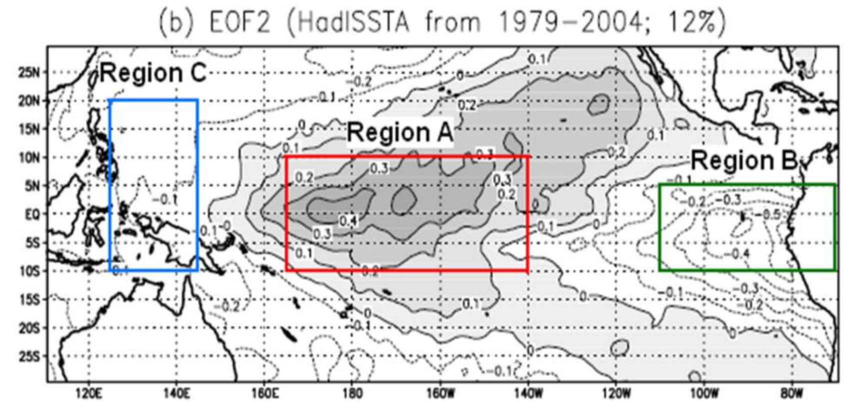
- Compared with last Feb, the central and eastern equatorial Pacific was warmer in Feb 2015.

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

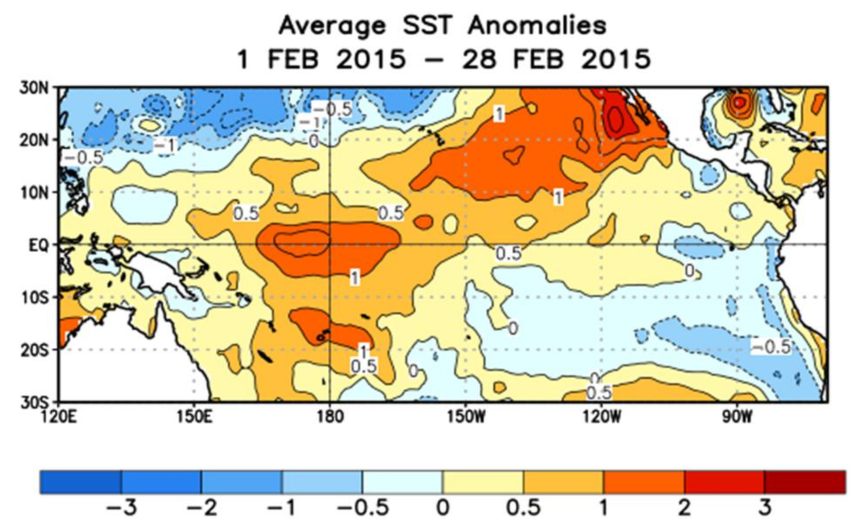
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Evolution of Pacific NINO SST Indices



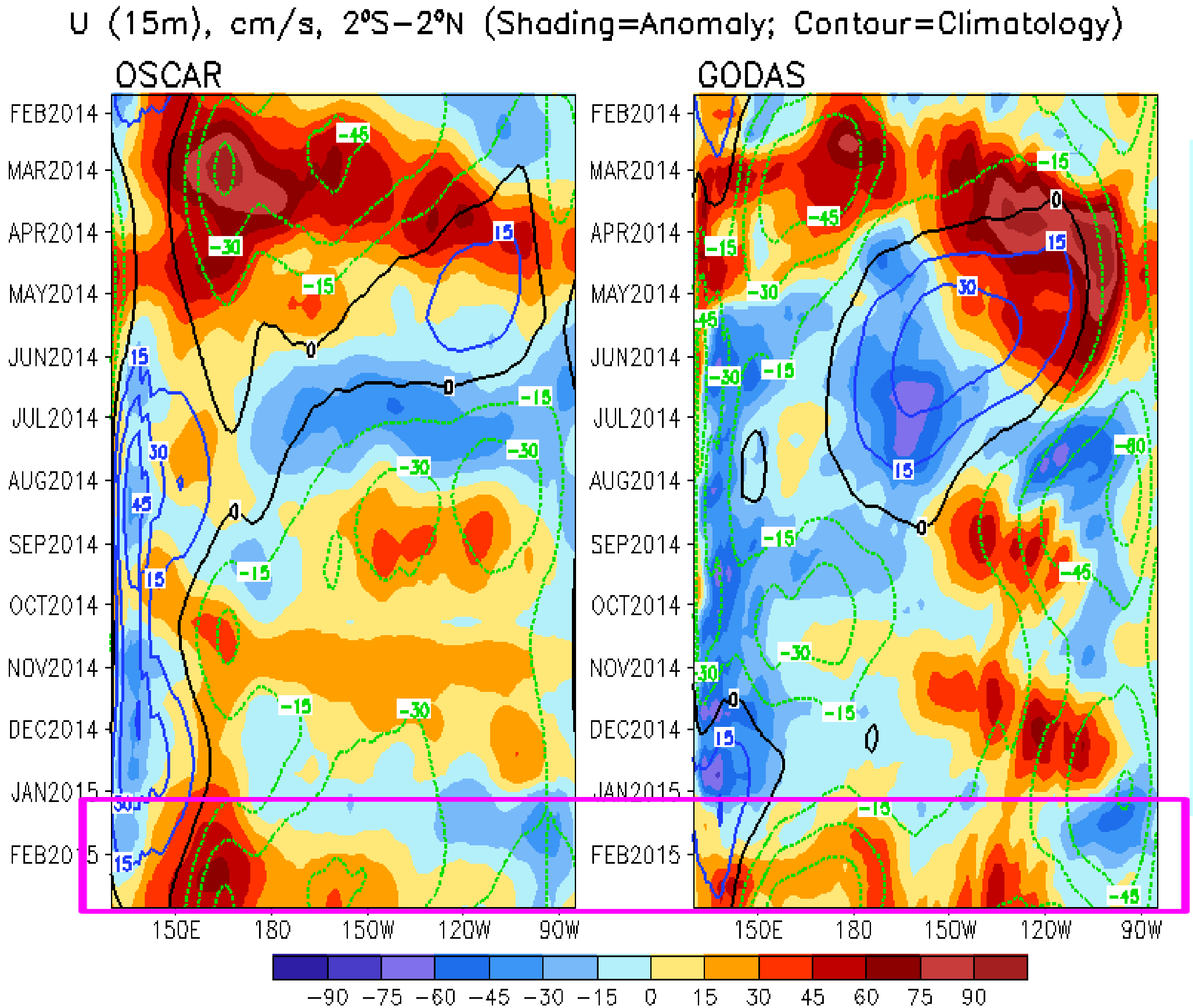


From: http://bobtisdale.blogspot.com/2009/07/comparison-of-el-nino-modoki-index-and.html



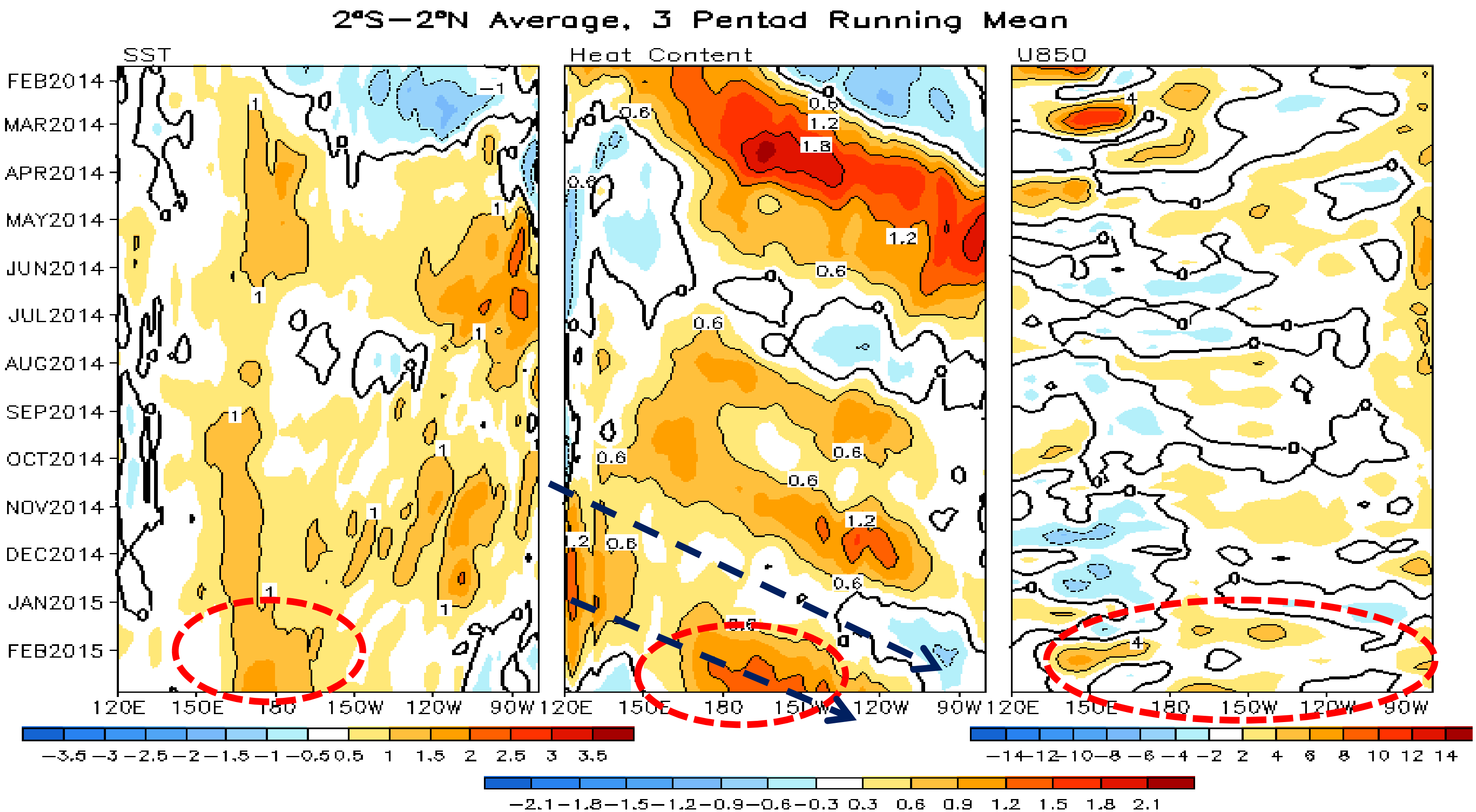
- The SSTA evolution in 2014/15 is more similar to the pattern associated with Central Pacific (warm pool) El Nino, or ENSO-Modoki.

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



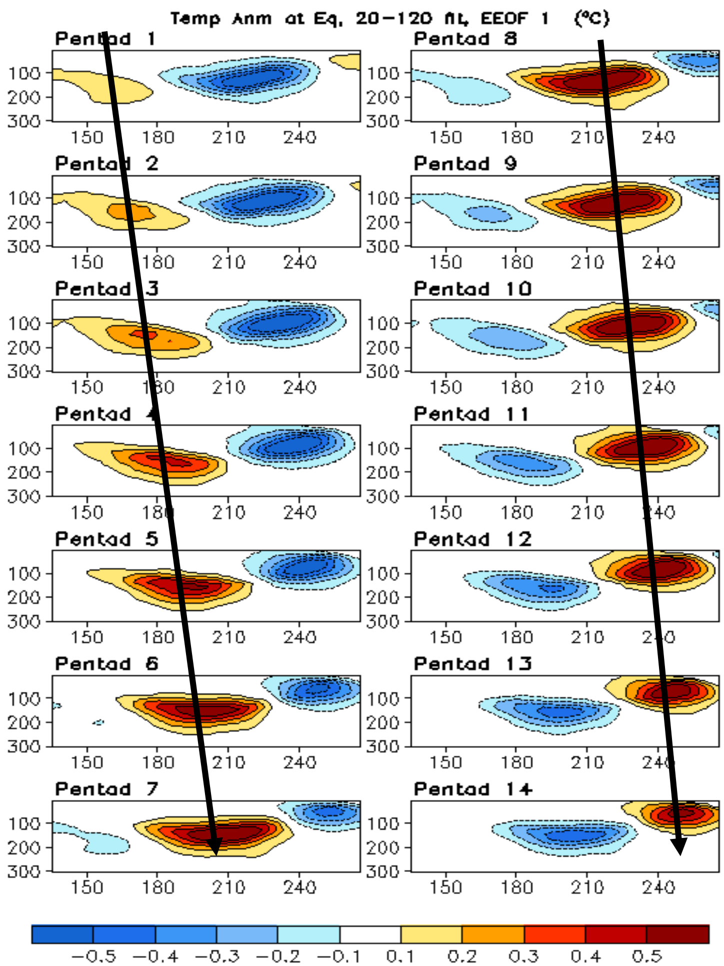
- **The anomalous current patterns were similar between OSCAR and GODAS.**
- **Weak anomalous eastward current initiated in Jan 2015 and propagated eastward.**

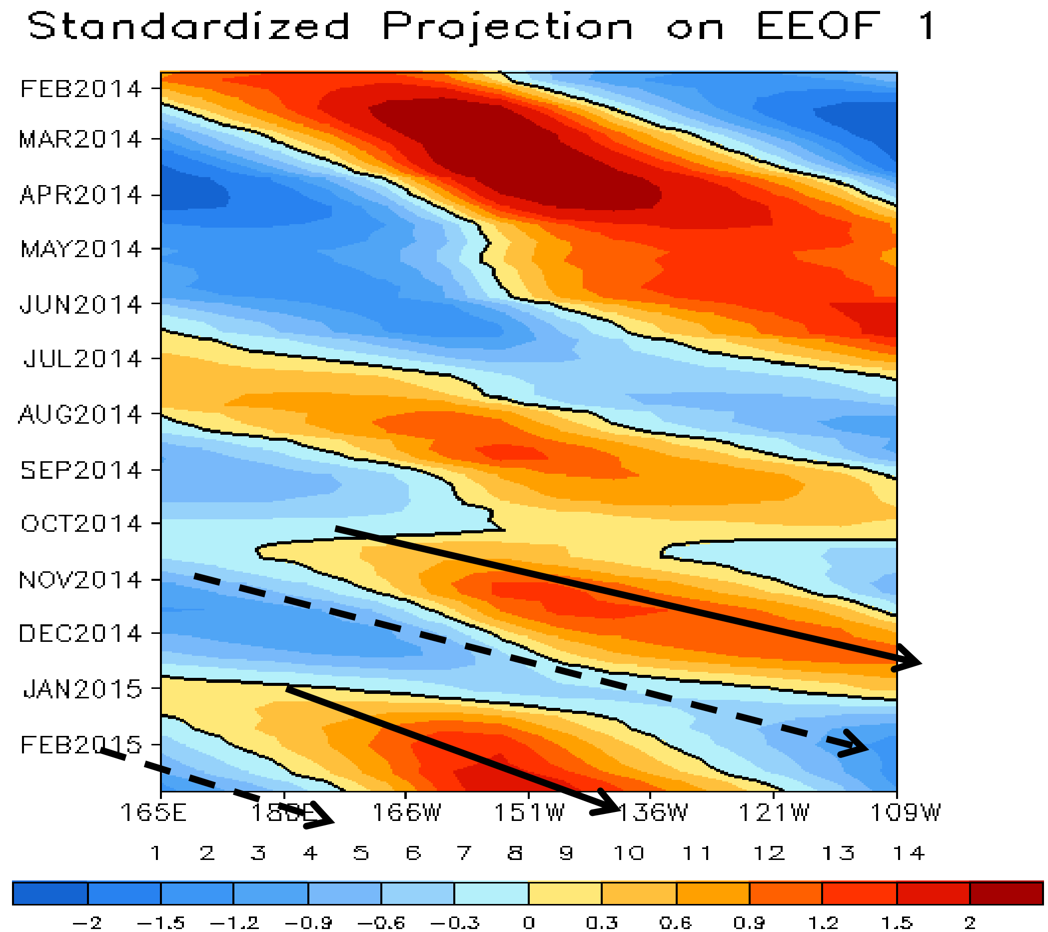
Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) Anomalies



- **Positive (negative) SSTA presented in the central (eastern) equatorial Pacific in Feb 2015.**
- **Positive HC300 anomalies initiated in Dec. 2014, and propagated eastward, consistent with ocean surface current anomalies (last slide)**
- **Low-level westerly wind anomalies were more frequent in the past two months, which seems to indicate weak coupling between positive SSTA and westerly wind anomalies.**

Oceanic Kelvin Wave (OKW) Index



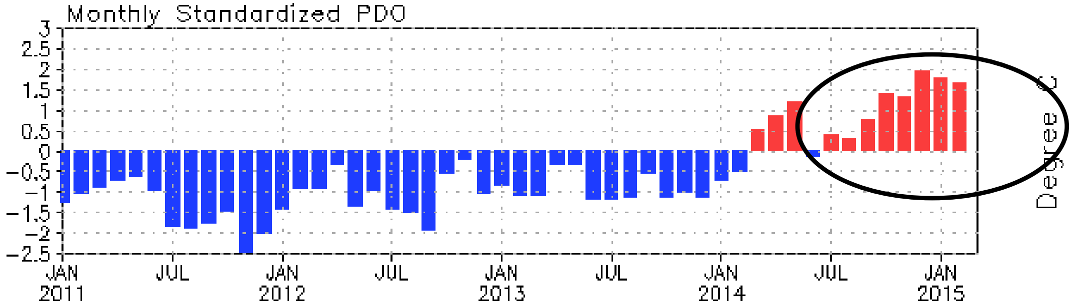


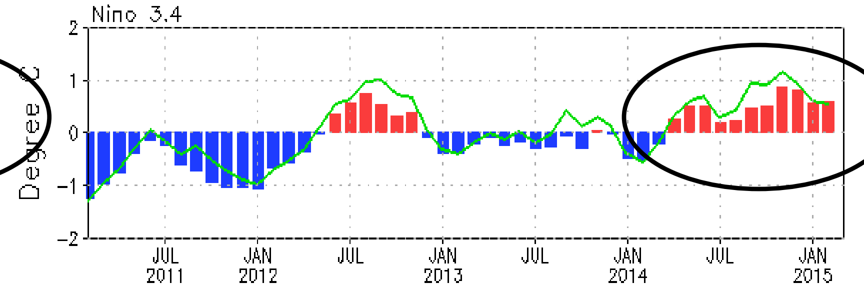
- **Downwelling OKW (solid line) emerged since Jan 2015 in the C. Pacific, while upwelling OKW initiated in mid-Jan in the W. Pacific. The downwelling may be associated with the observed subsurface ocean warming.**

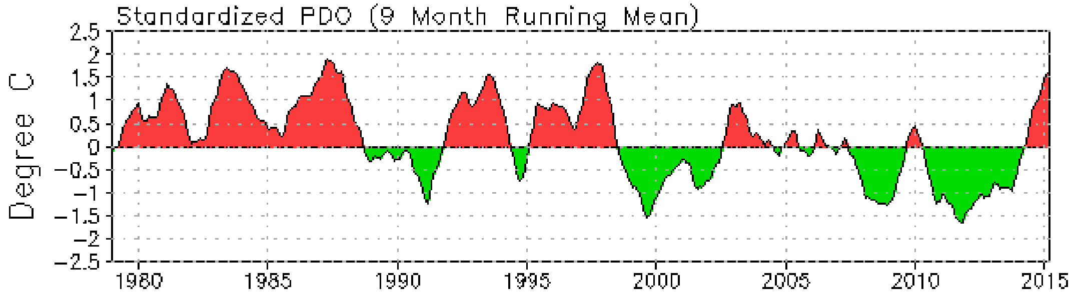
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

North Pacific & Arctic Oceans

PDO index

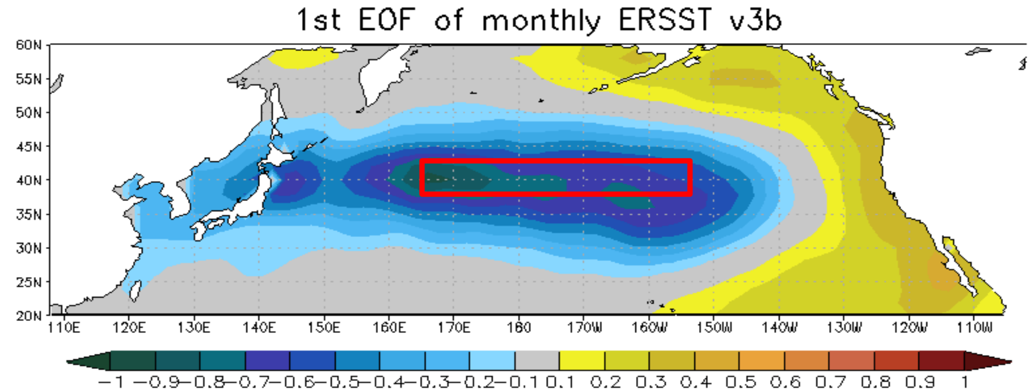






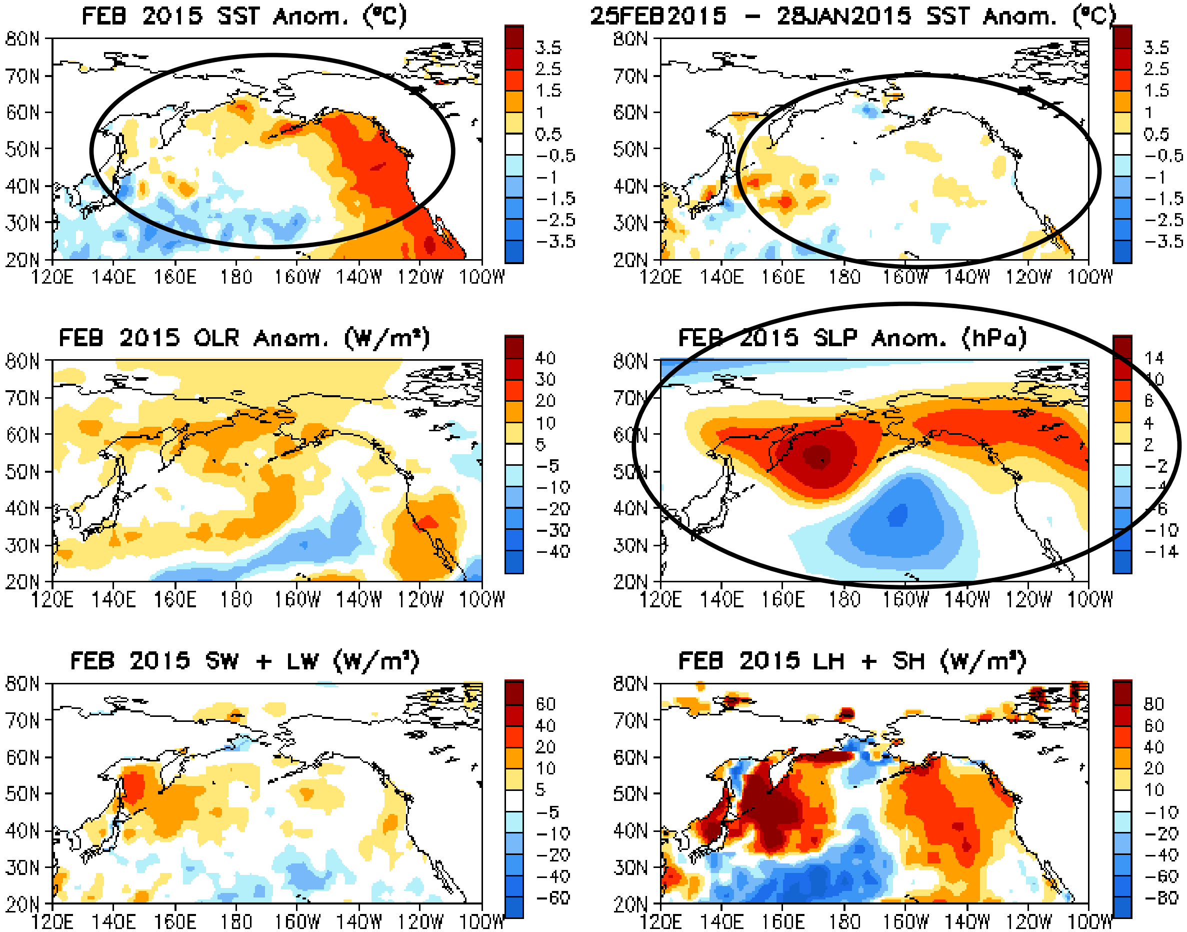
- **The positive phase of PDO index has persisted 8 months since Jul 2014 with PDO index =1.6 in Feb 2015.**

- **Statistically, ENSO leads PDO by 3-4 months, 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.**

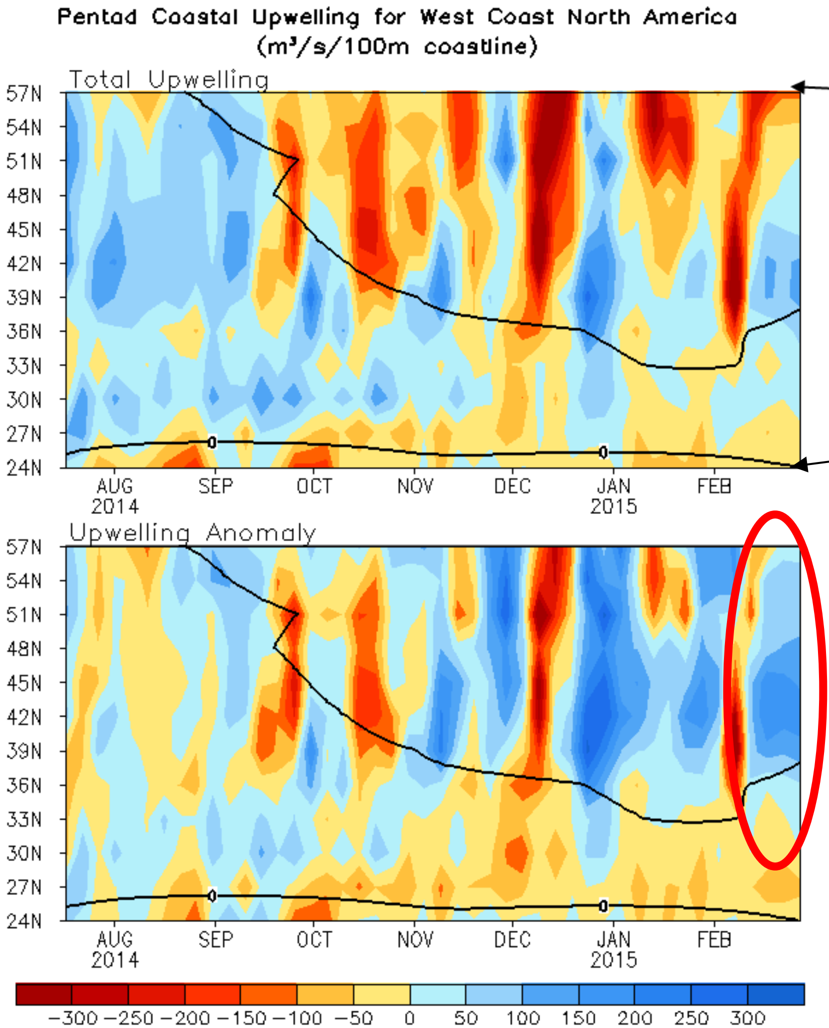
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

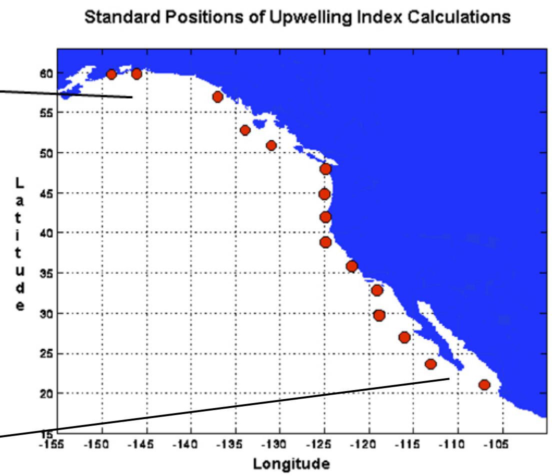


- **Positive SSTA presented in the NE Pacific, consistent with the positive phase of PDO index (previous slide).**
- **The SST tendency was small in North Pacific and may be associated with LH+SH.**
- **Above-normal SLP presented in the high latitudes and below-normal one was observed in the central North Pacific.**

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.

North America Western Coastal Upwelling





- Anomalous upwelling were observed in 36N northward in Feb. 2015, suggesting weakening of downwelling.

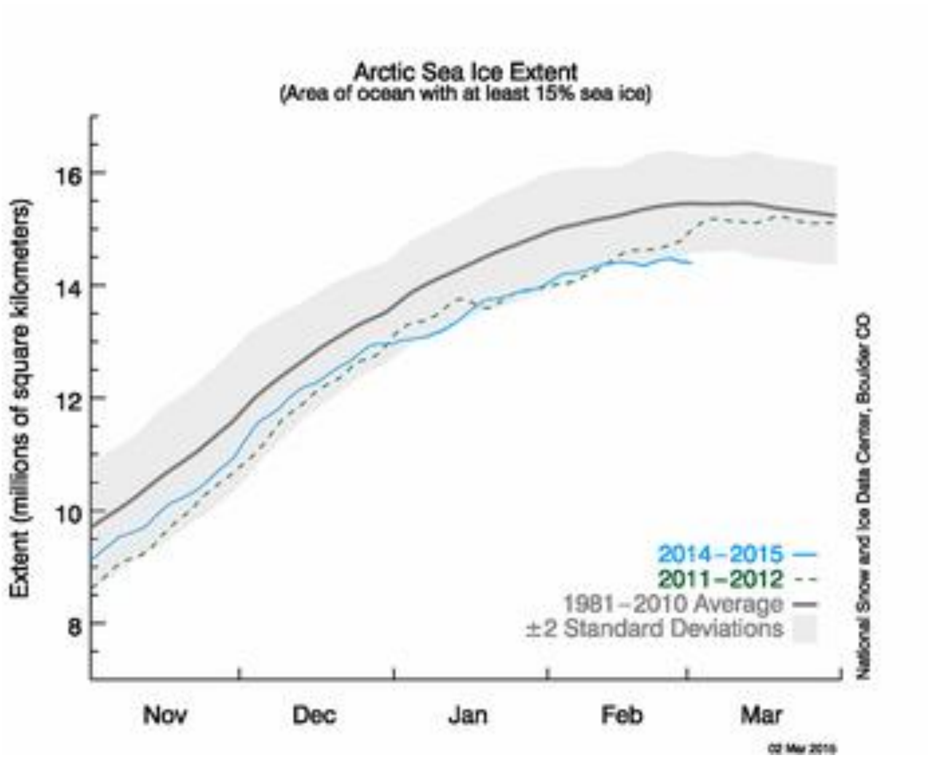
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

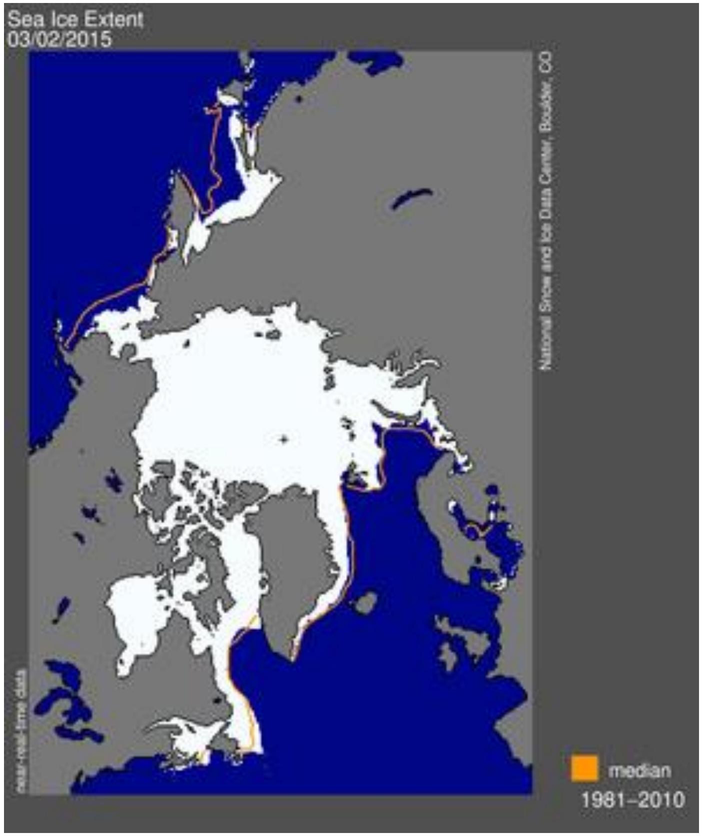
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

Arctic Sea Ice

National Snow and Ice Data Center

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

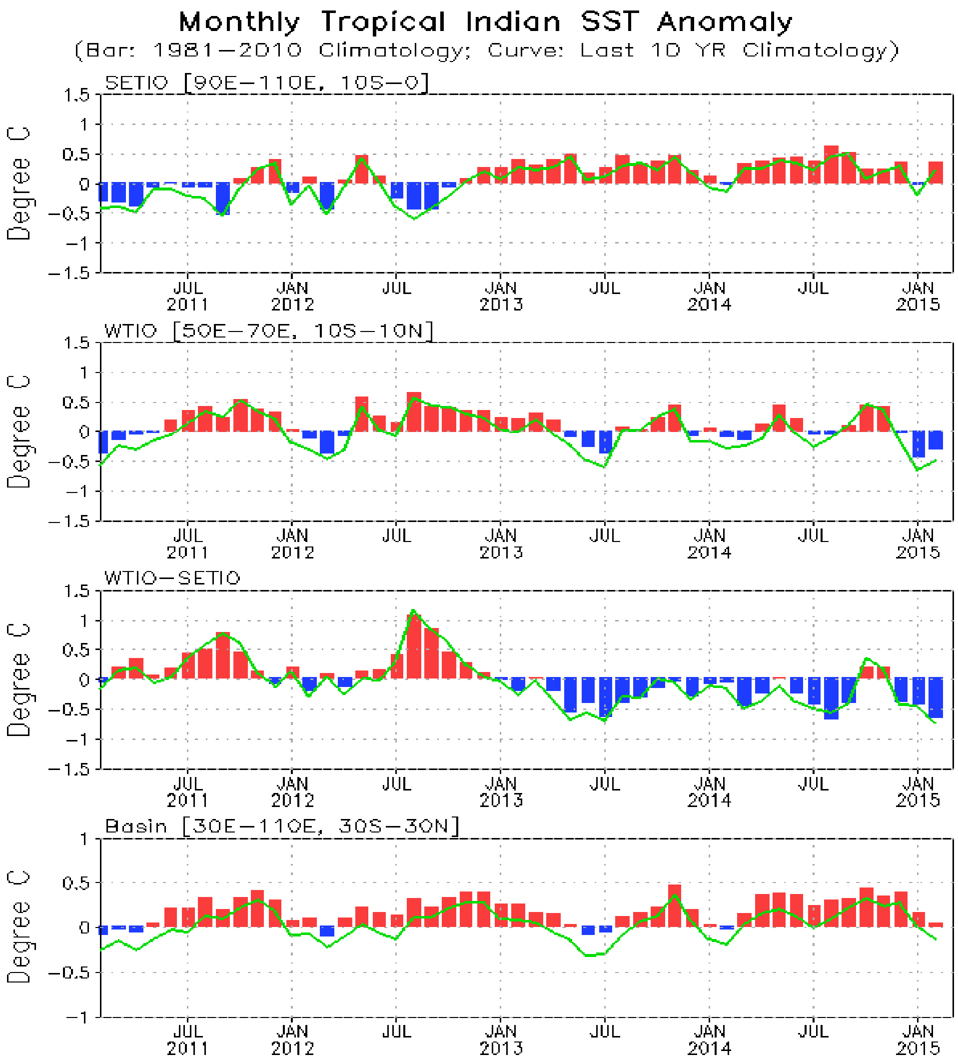


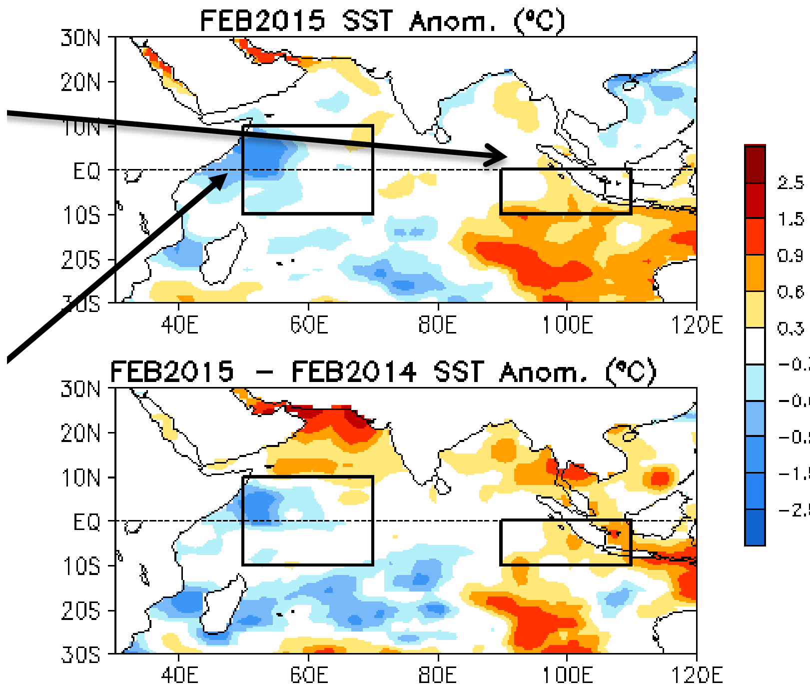


- **Arctic sea ice extent in Jan-Feb 2015 was close to -2 standard deviations and comparable to that in 2011-12.**

Indian Ocean

Evolution of Indian Ocean SST Indices



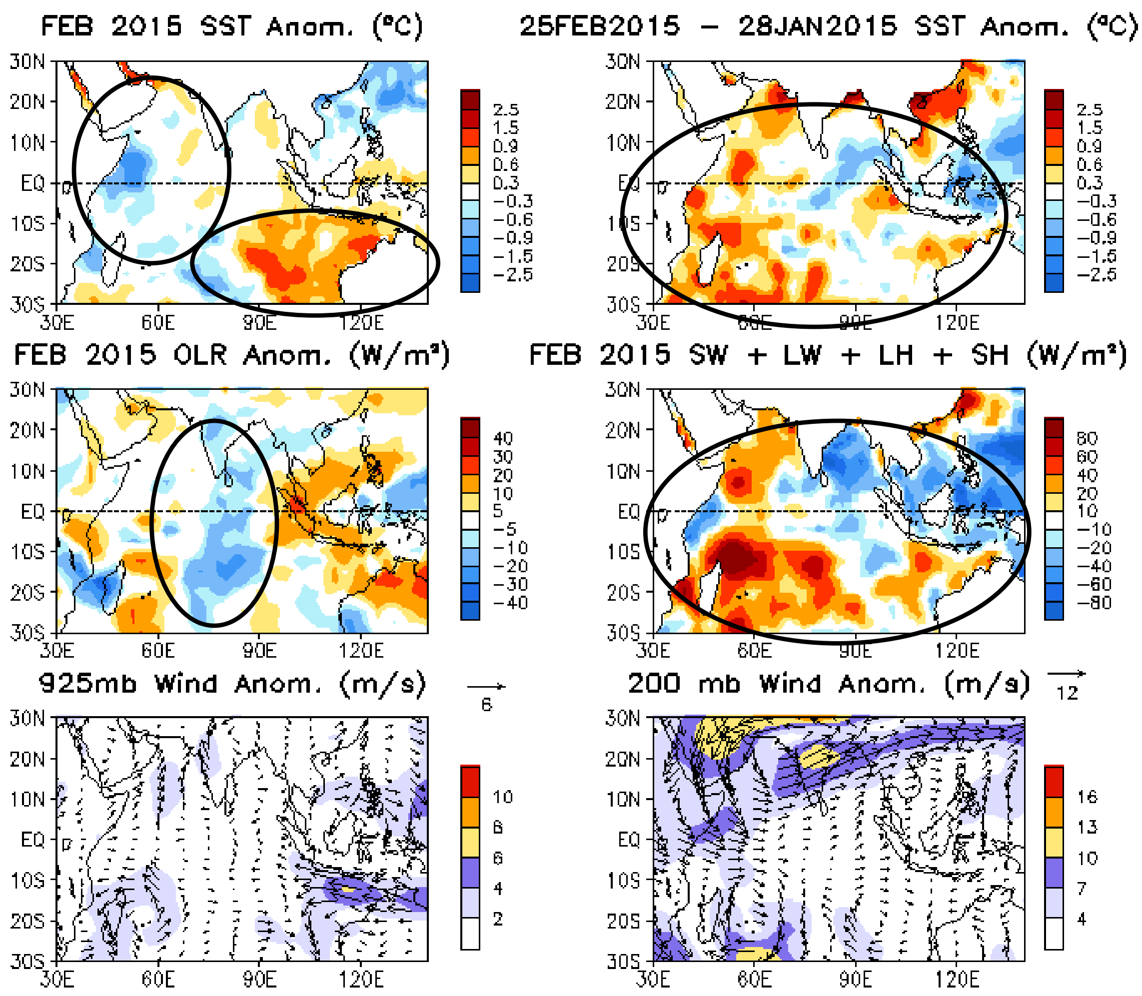


- Positive (negative) SSTA was in the east (west).

- DMI was below normal since Dec 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.

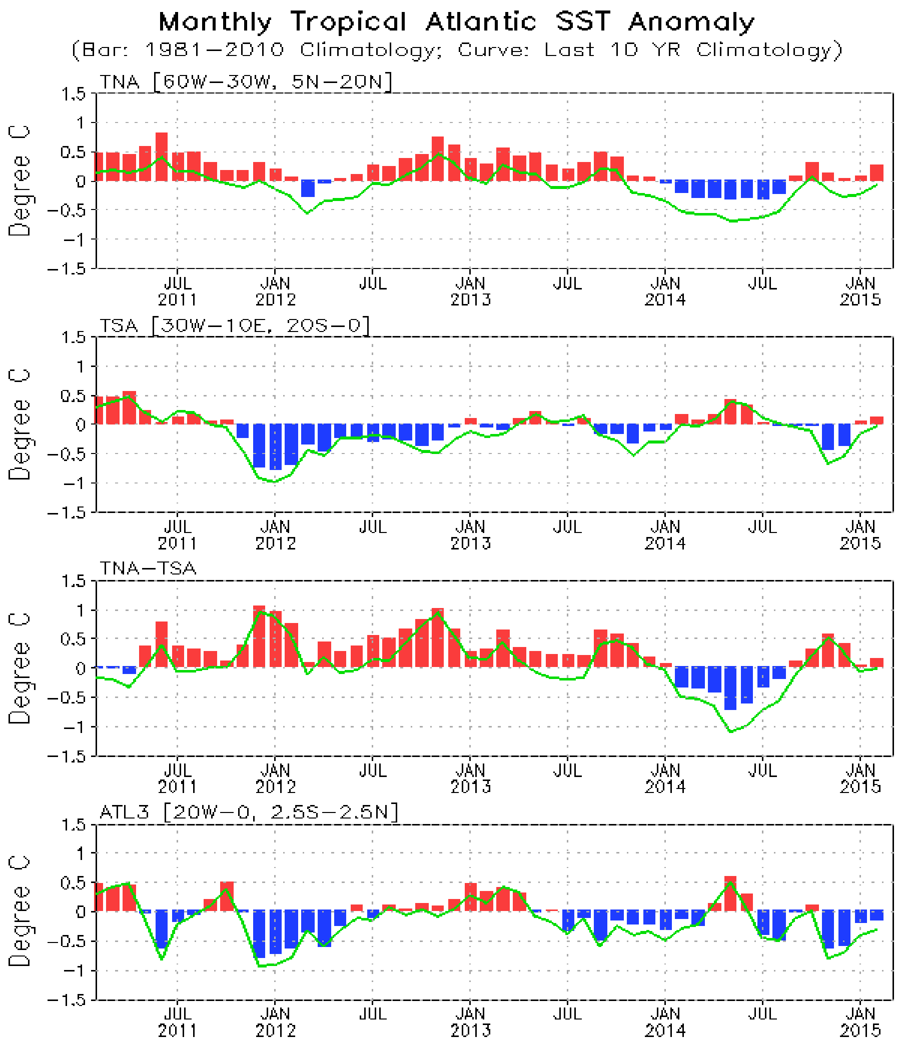


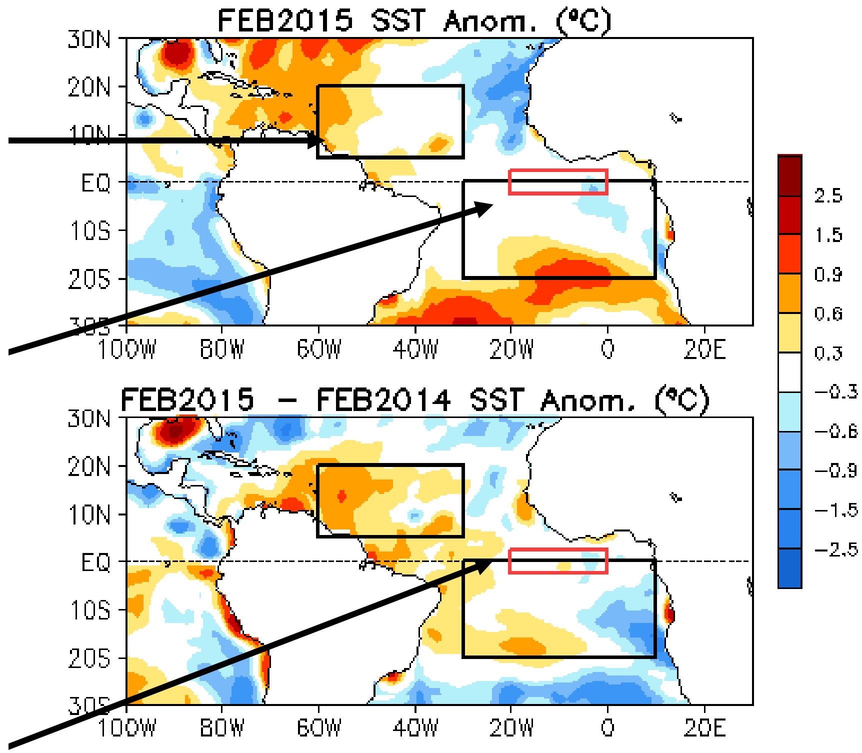
- **Positive (negative) SSTA was in the east (west).**
- **SSTA tendency was largely determined by heat flux.**
- **Convections were enhanced over the central basin.**

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

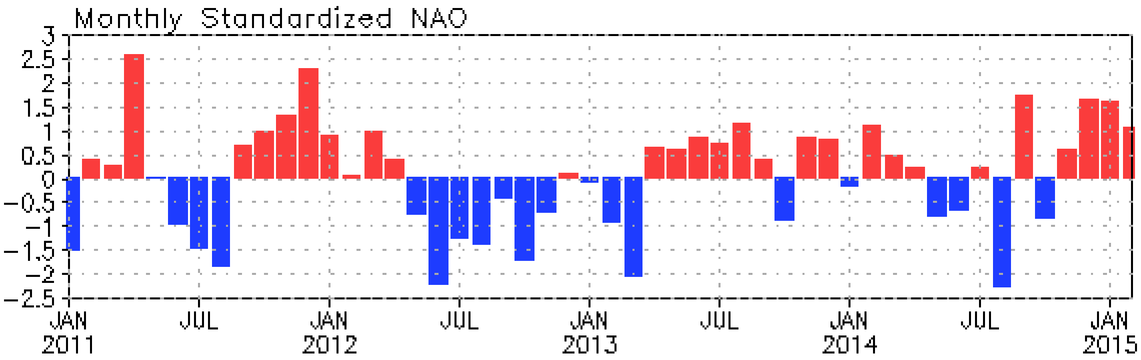


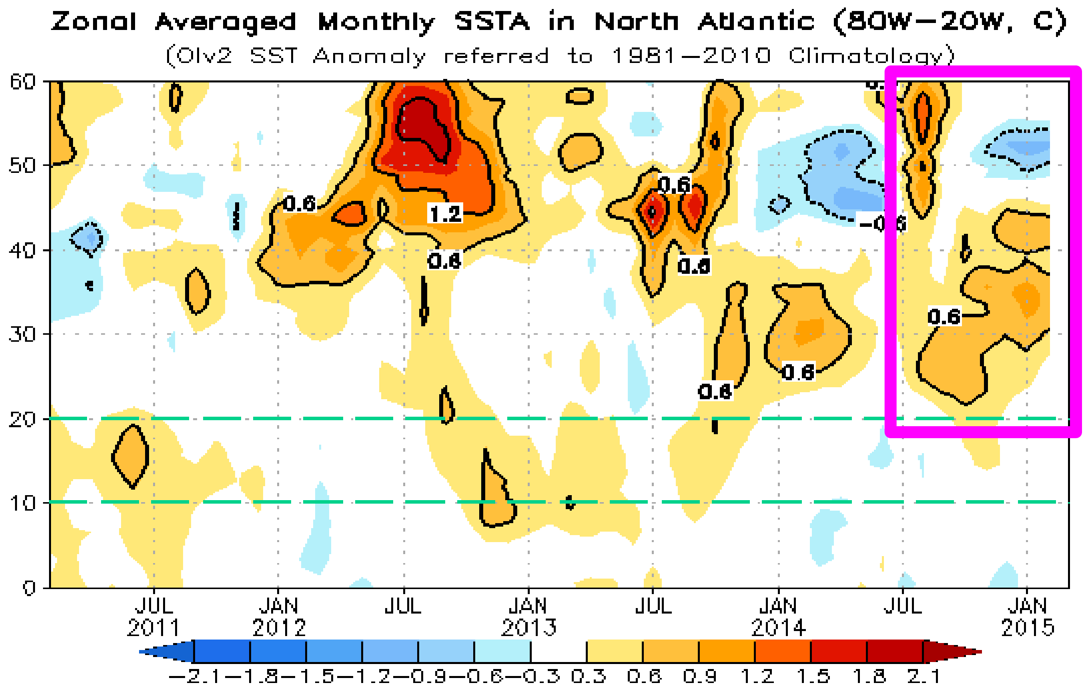


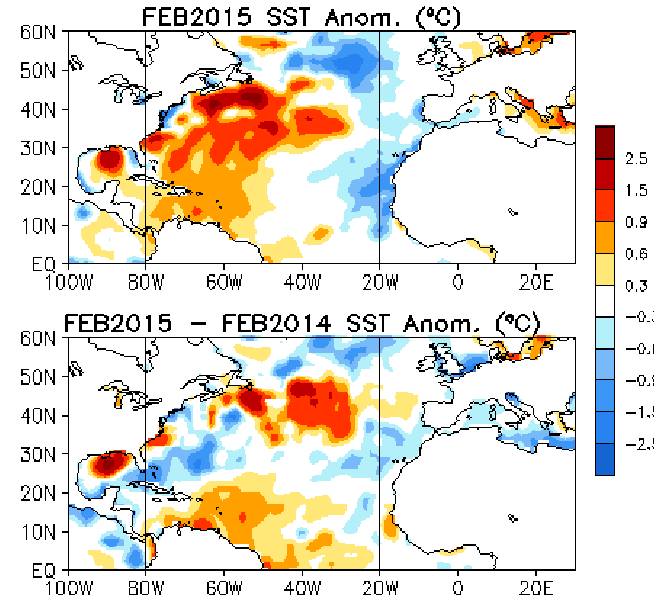
- All indices had small values in recent months.

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.

NAO and SST Anomaly in North Atlantic







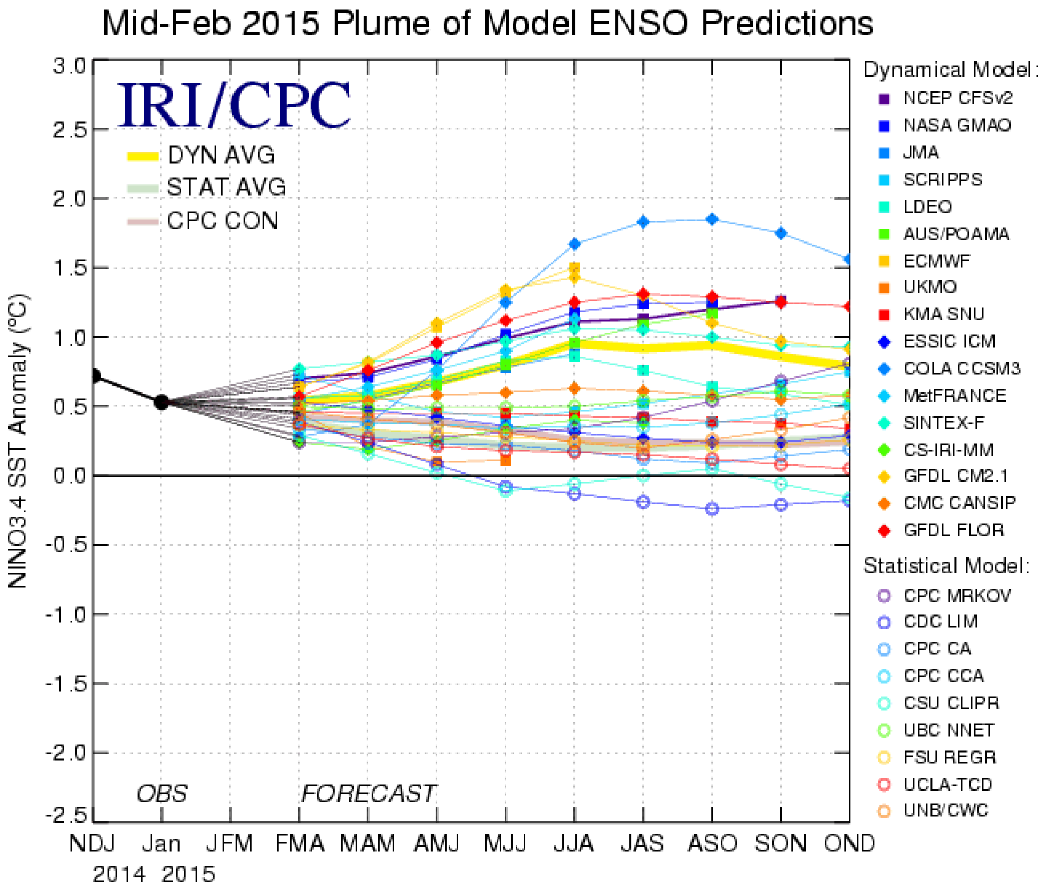
- Positive phase of NAO has persisted 4 months with NAOI=1.1 in Feb 2015.

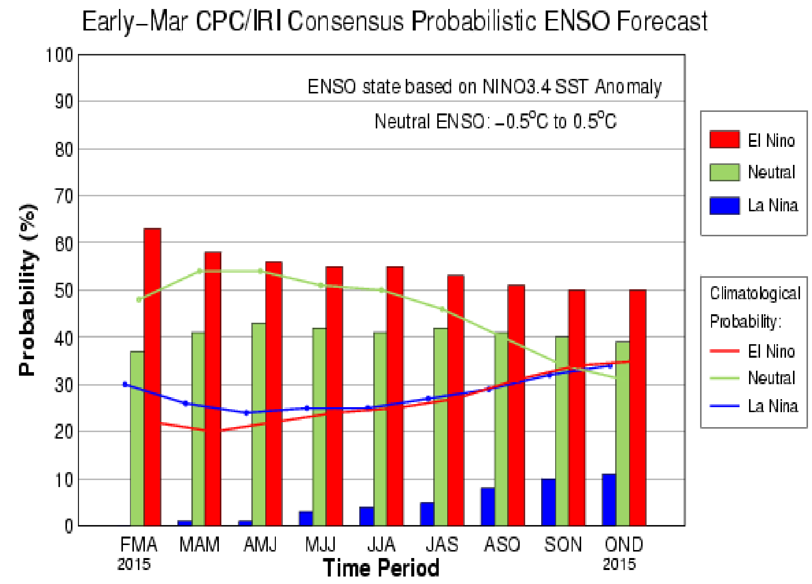
- SSTA showed a horseshoe-like pattern, which may be due to the influence of persistent positive phase of NAO.

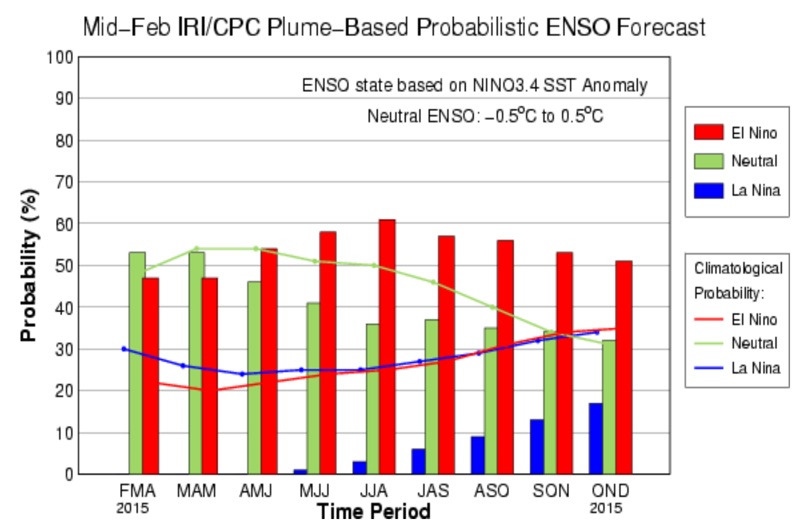
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum

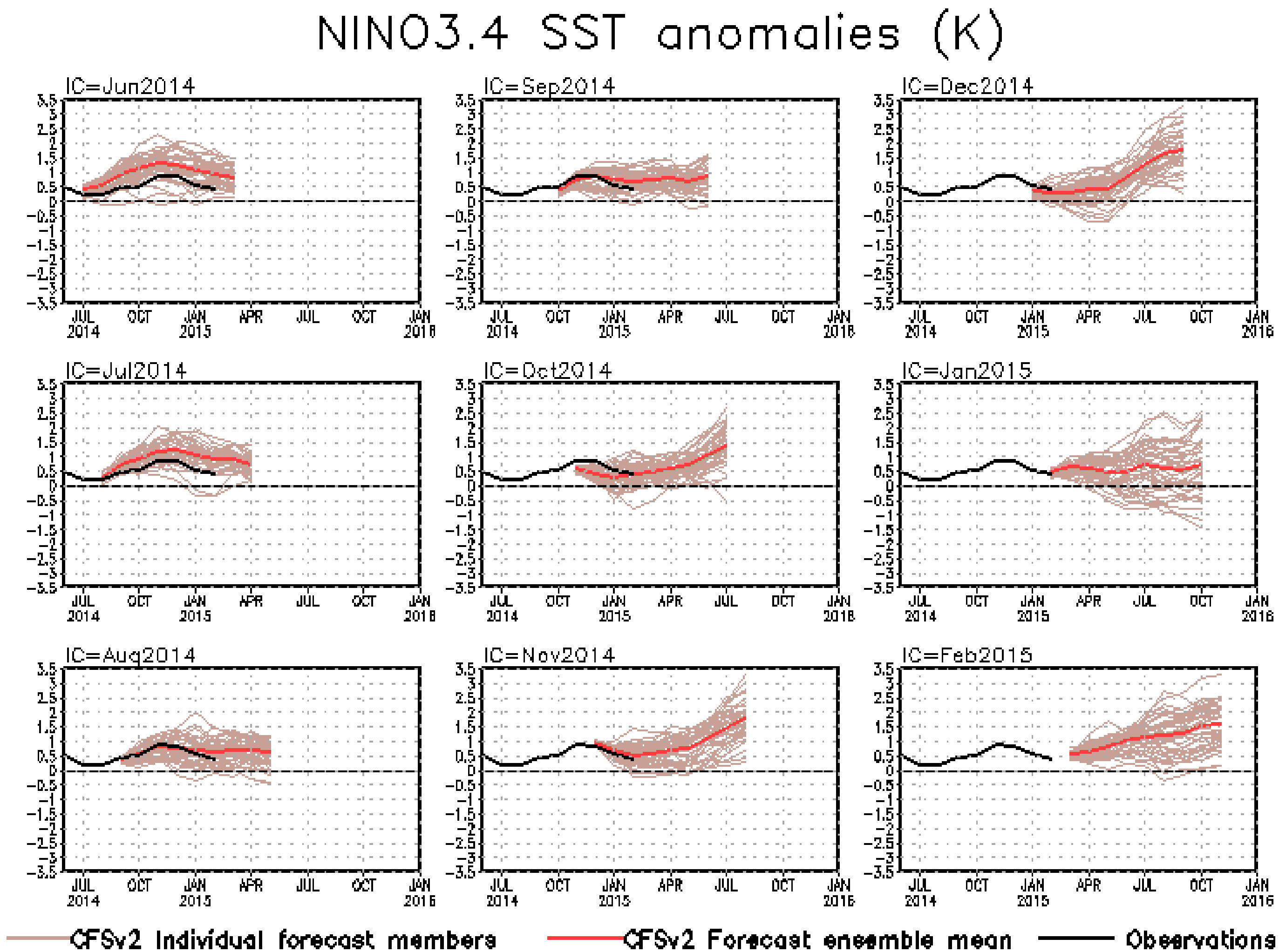






- **Majority of dynamical models predicted a warming tendency in 2015, but majority of statistical models favor ENSO neutral in 2015.**
- **NOAA "ENSO Diagnostic Discussion" on 05 March 2015 issued "El Nino Advisory" and suggested that "There is an approximately 50-60% chance that El Niño conditions will continue through Northern Hemisphere summer 2015."**

CFS Niño3.4 SST Predictions from Different Initial Months

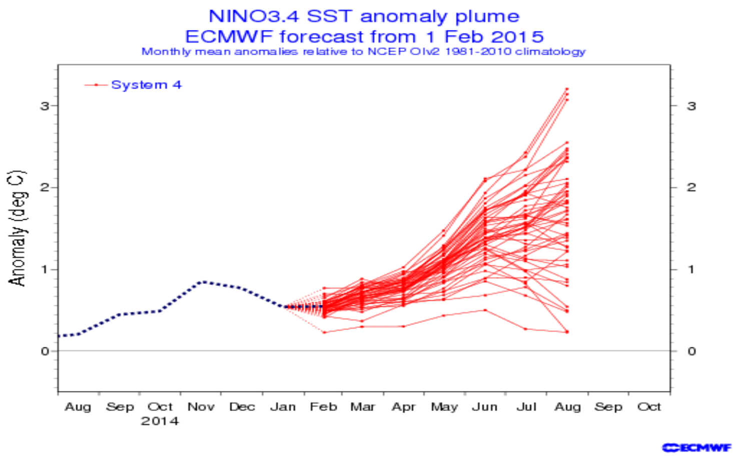


- CFSv2 predicts a warming tendency, and suggests development of a El Nino in 2015.

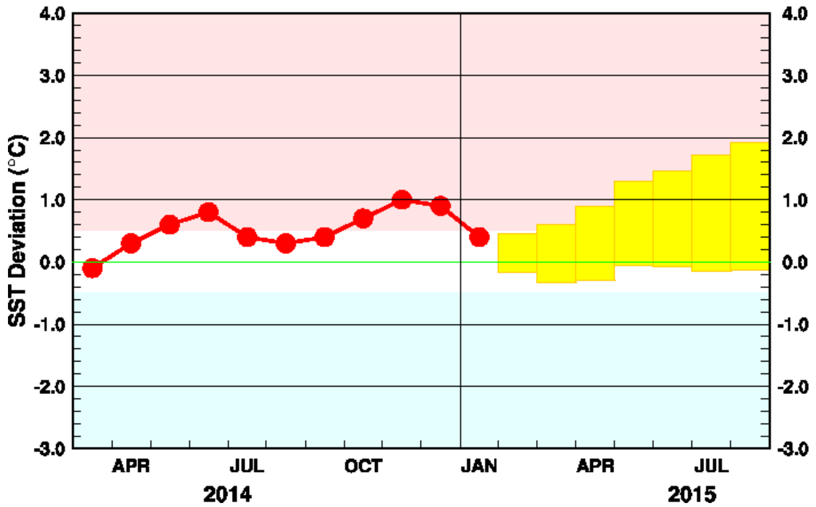
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

Individual Model Forecasts: warming tendency or neutral

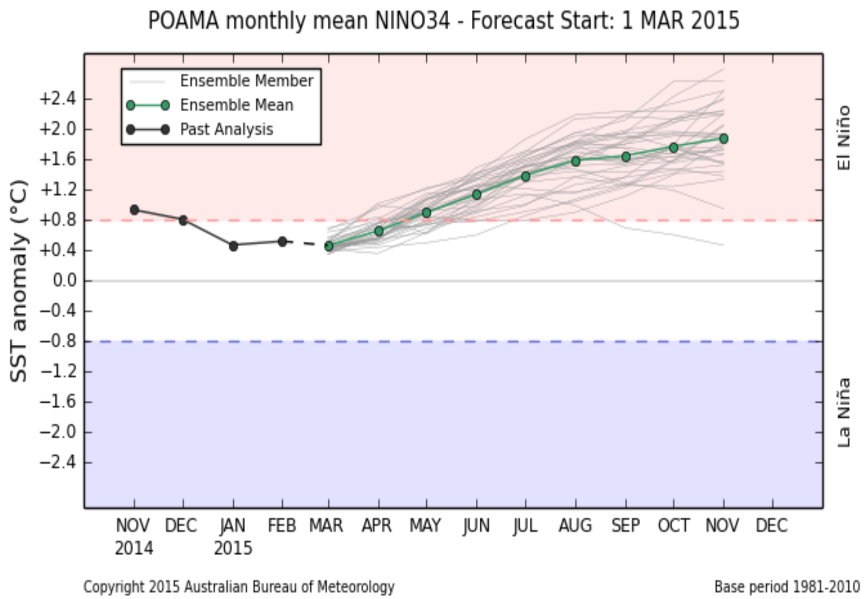
EC: Nino3.4, IC=01Feb 2015



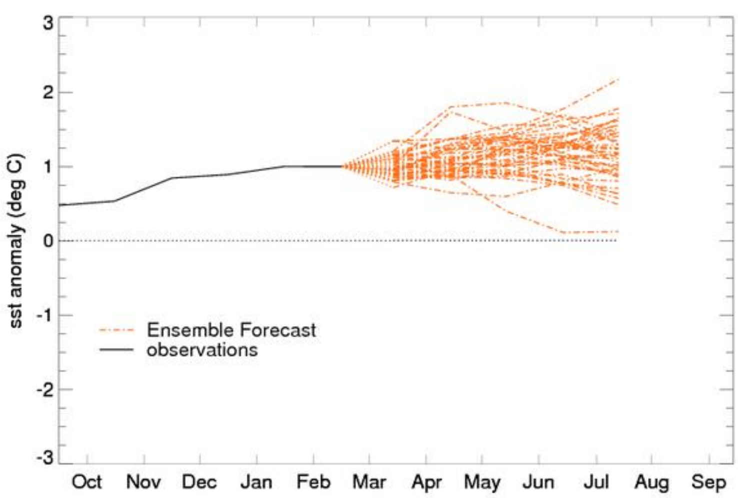
JMA: Nino3, IC=Feb 2015



Australia: Nino3.4, IC=01Mar 2015



UKMO: Nino3.4, IC=Mar 2015



Why CPC believes El Nino conditions were observed in February 2015**?**

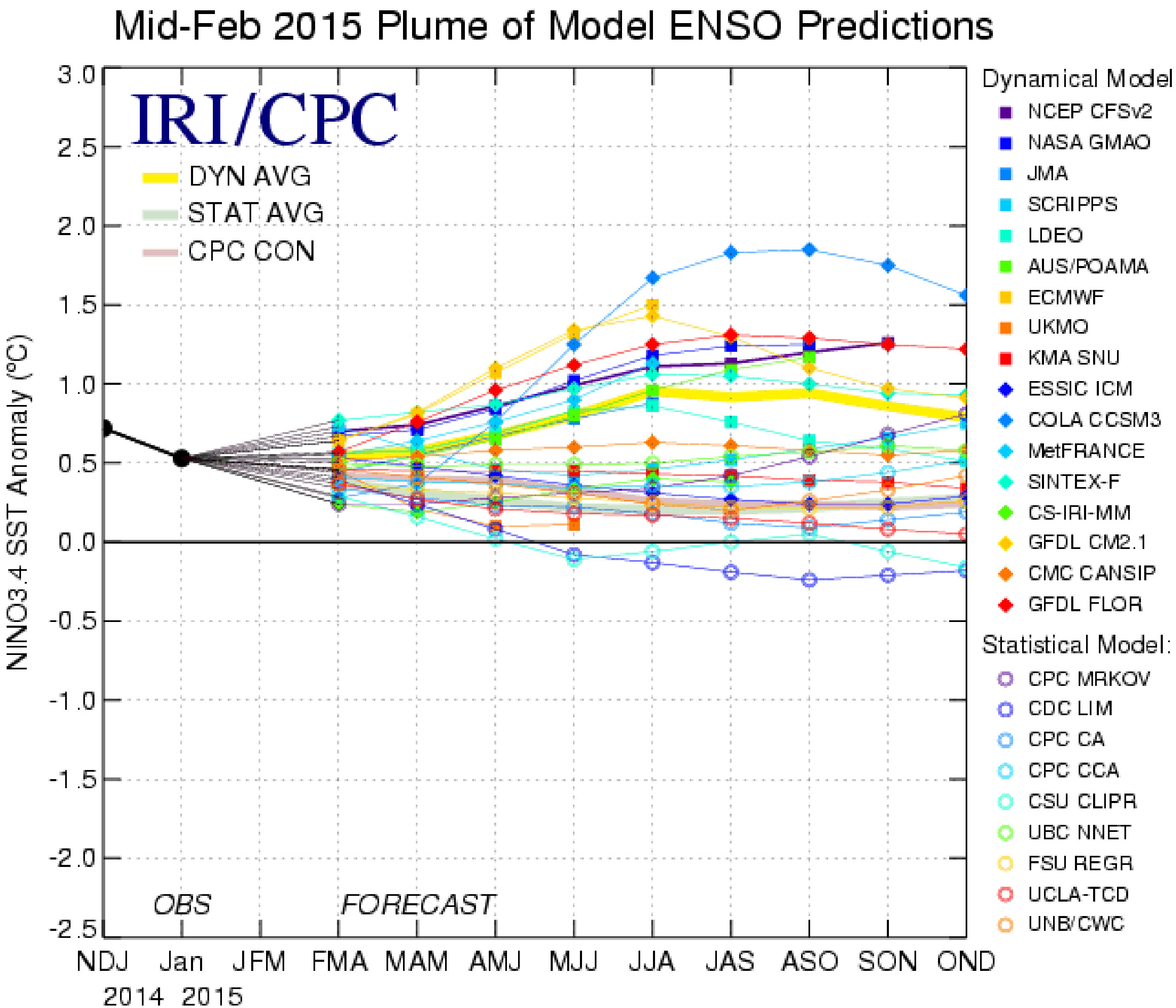
Oceanic Nino Index (ONI): 3 month running mean of ERSST.v3b SSTAs in the Nino 3.4 region.
For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Time	ONI
2014 ASO	0.2
2014 SON	0.5
2014 OND	0.7
2014/2015 NDJ	0.7
2014/2015 DJF	0.6
2015 JFM	? (>0.45)

*El Niño or La Niña Advisory: conditions are observed and expected to continue.

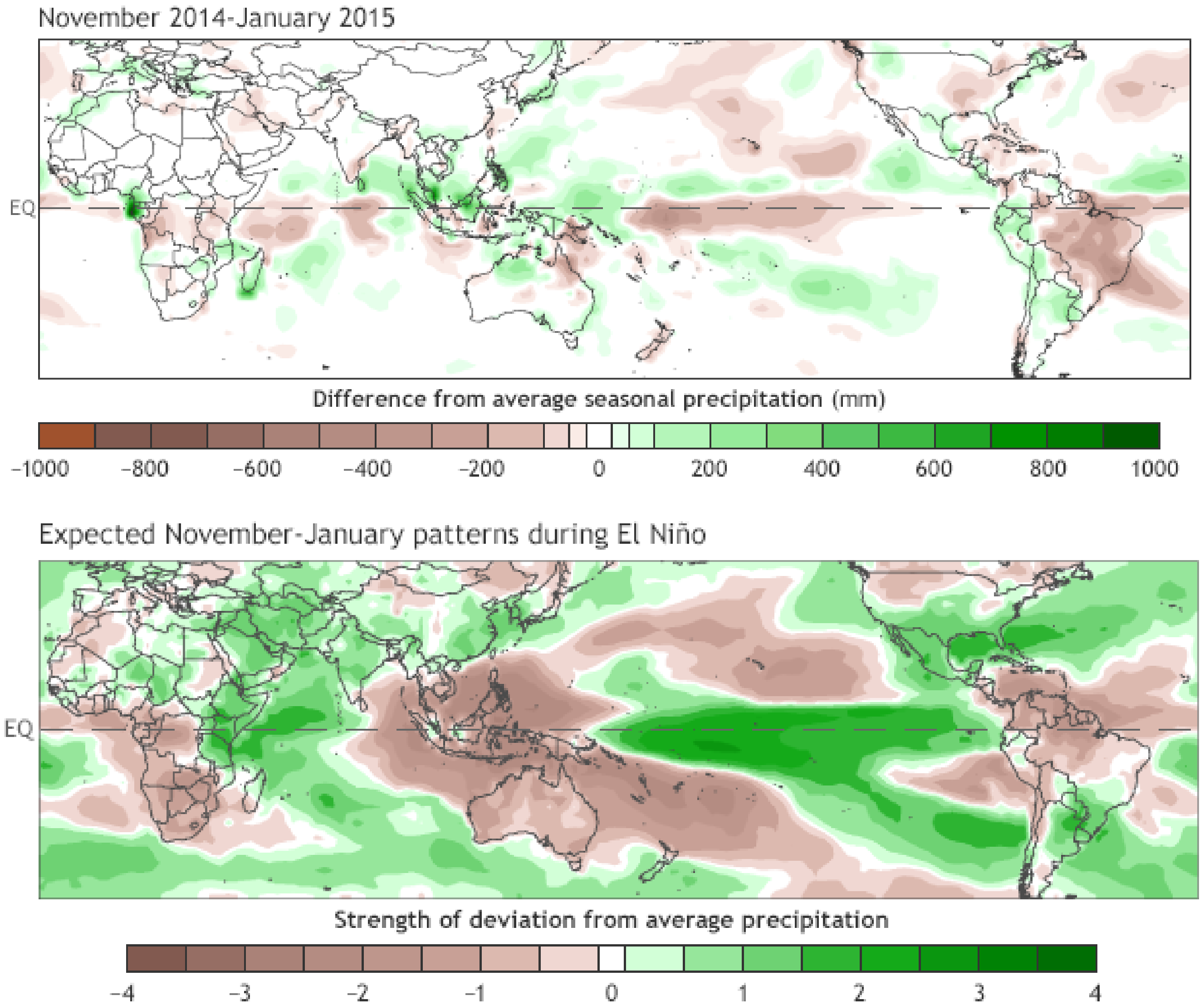
El Niño conditions: one-month positive SST anomaly of +0.5 or greater in the Niño-3.4 region and an expectation that the 3-month ONI threshold will be met.
La Niña conditions: one-month negative SST anomaly of −0.5 or less in the Niño-3.4 region and an expectation that the 3-month ONI threshold will be met.
AND
***An atmospheric response* typically associated with El Niño/ La Niña over the equatorial Pacific Ocean.**

IRI NINO3.4 Forecast Plum



- **Majority of dynamical models predicted a warming tendency in 2015, but majority of statistical models favor ENSO neutral in 2015.**

Do recent global precipitation anomalies resemble those of El Niño (by Anthony Barnston)?

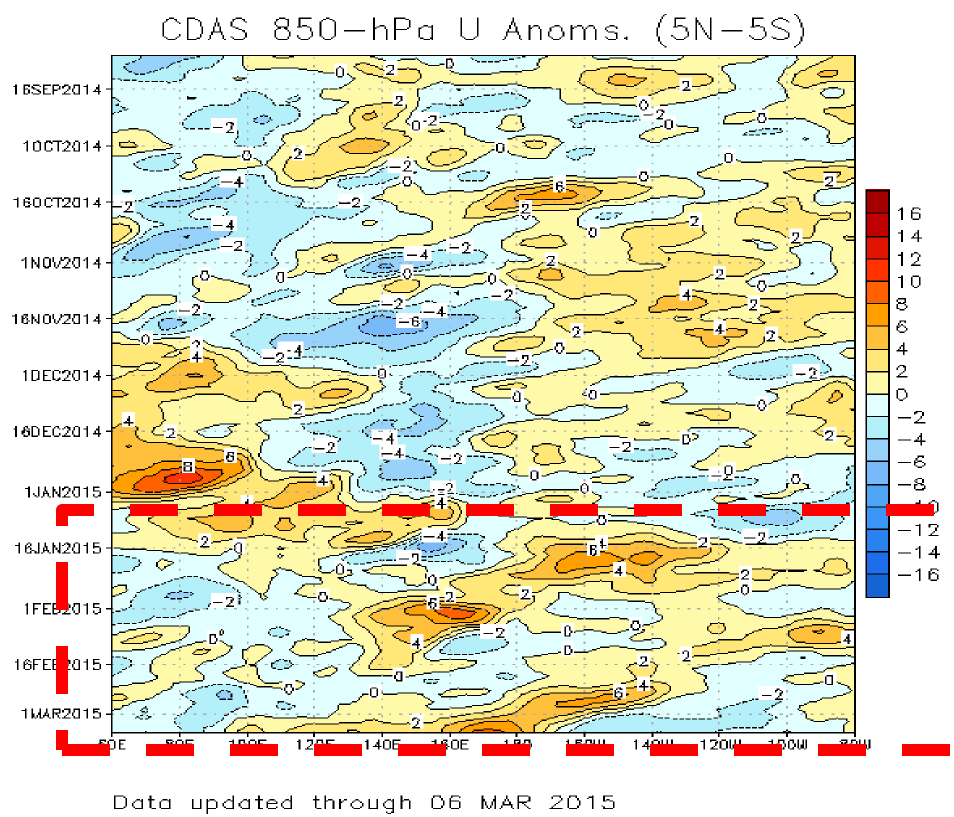


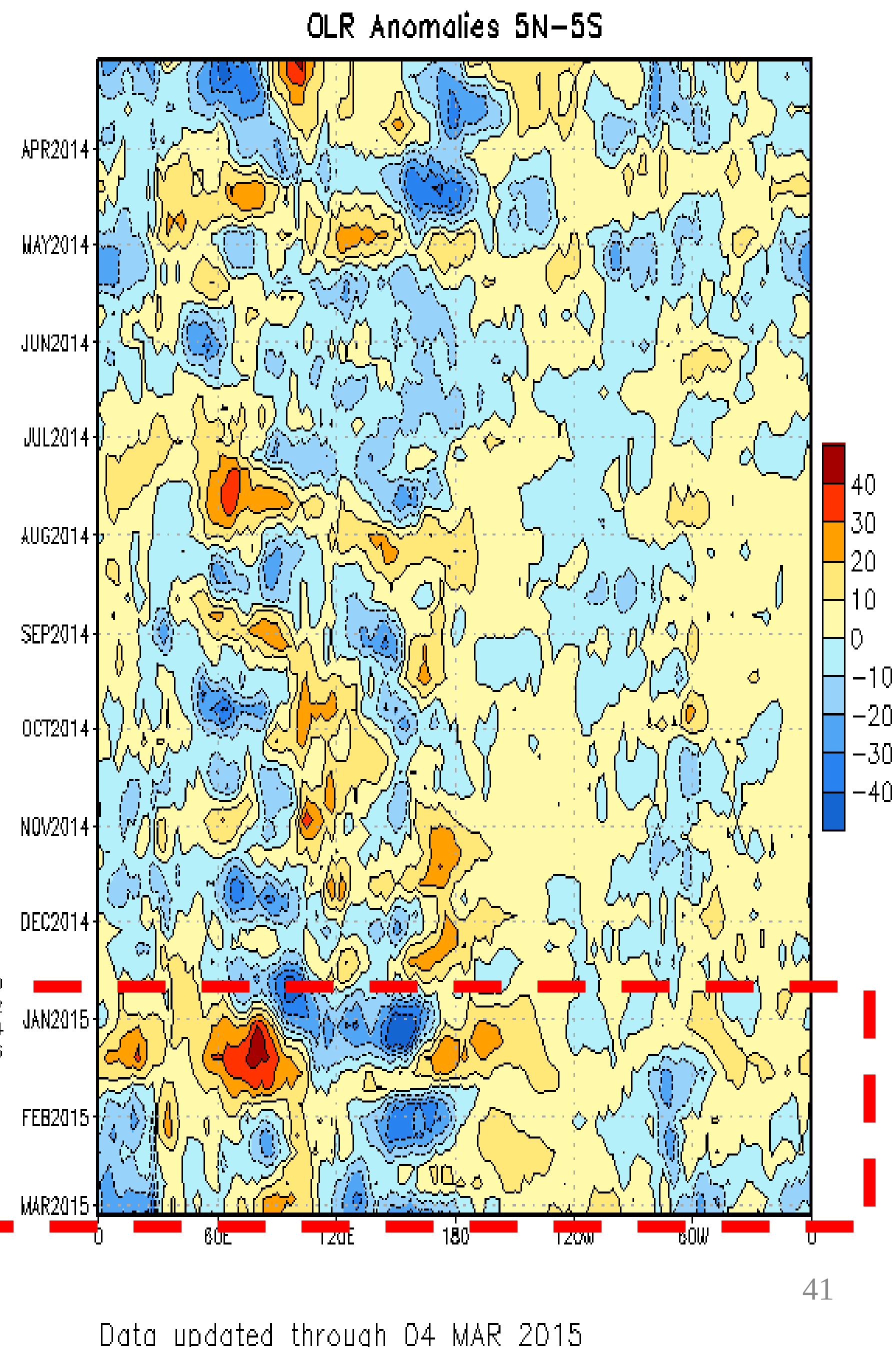
Barnston said:

"Bottom Line: So far in 2014-15, we have not seen large-scale precipitation anomalies over the globe (including the United States) that clearly resemble those expected during El Niño."

http://www.climate.gov/news-features/blogs/enso/do-recent-global-precipitation-anomalies-resemble-those-el-ni%C3%B1o

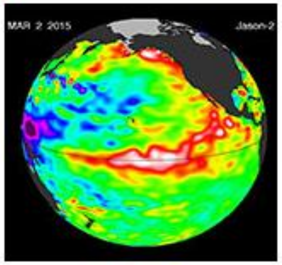
Recently, westerly wind anomalies were observed over the east-central equatorial Pacific

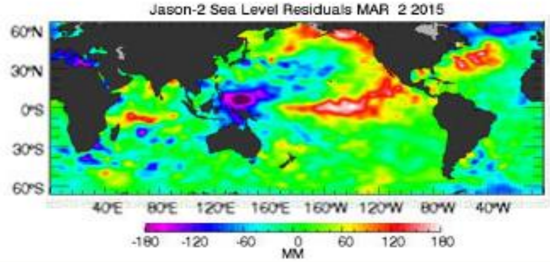




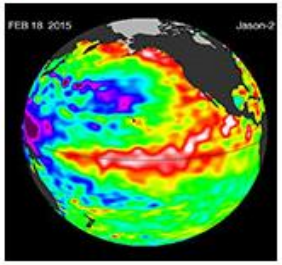
2015

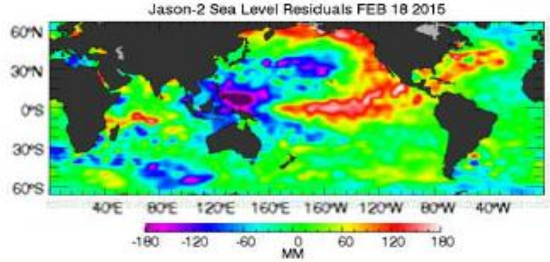
03/02/2015



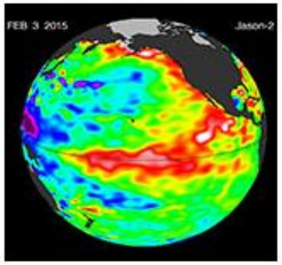


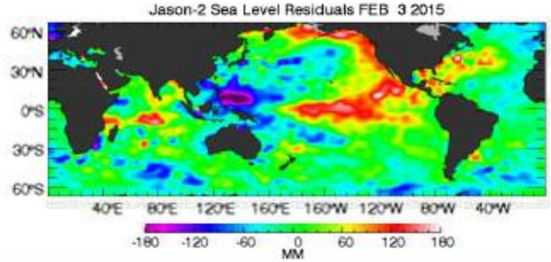
02/18/2015





02/03/2015





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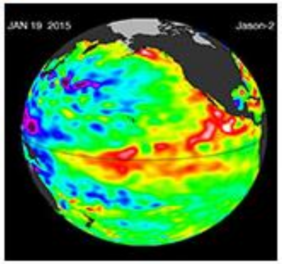
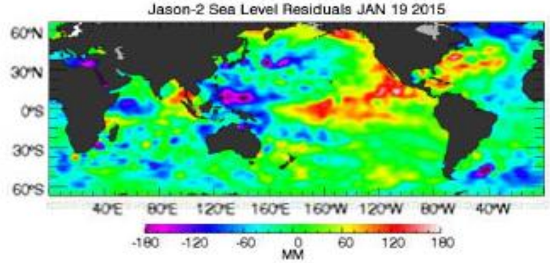
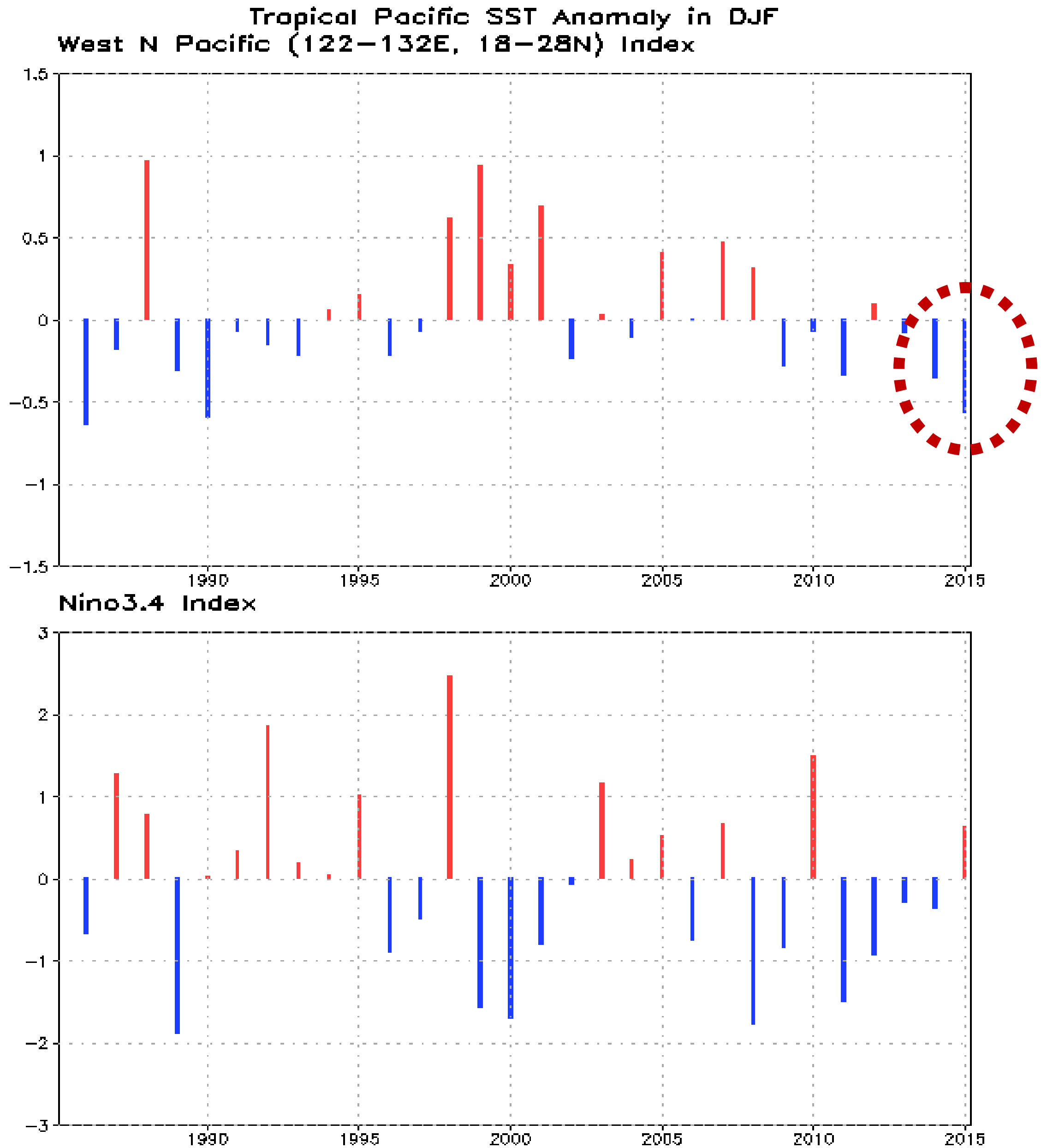




https://sealevel.jpl.nasa.gov/science/elninopdo/latestdata/archive/

Strong SSHA in the equatorial Pacific



WNP and Nino3.4 indices:

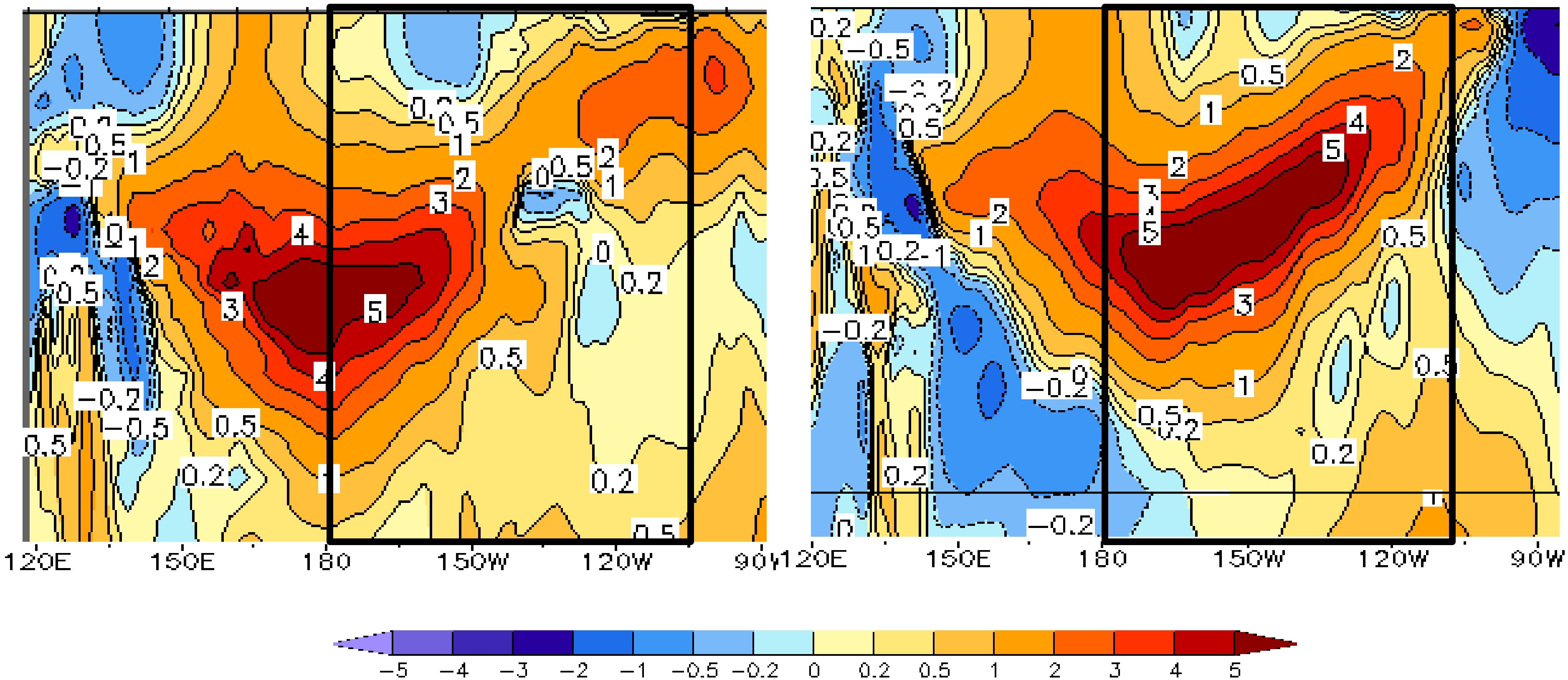
Compared with 2013/14 DJF, 2014/15 DJF WNP index was negative with even larger amplitude (-0.57), more favoring an El Nino event in 2015/16.

(*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.)*

The cases of 1997-1998 and 2014-2015

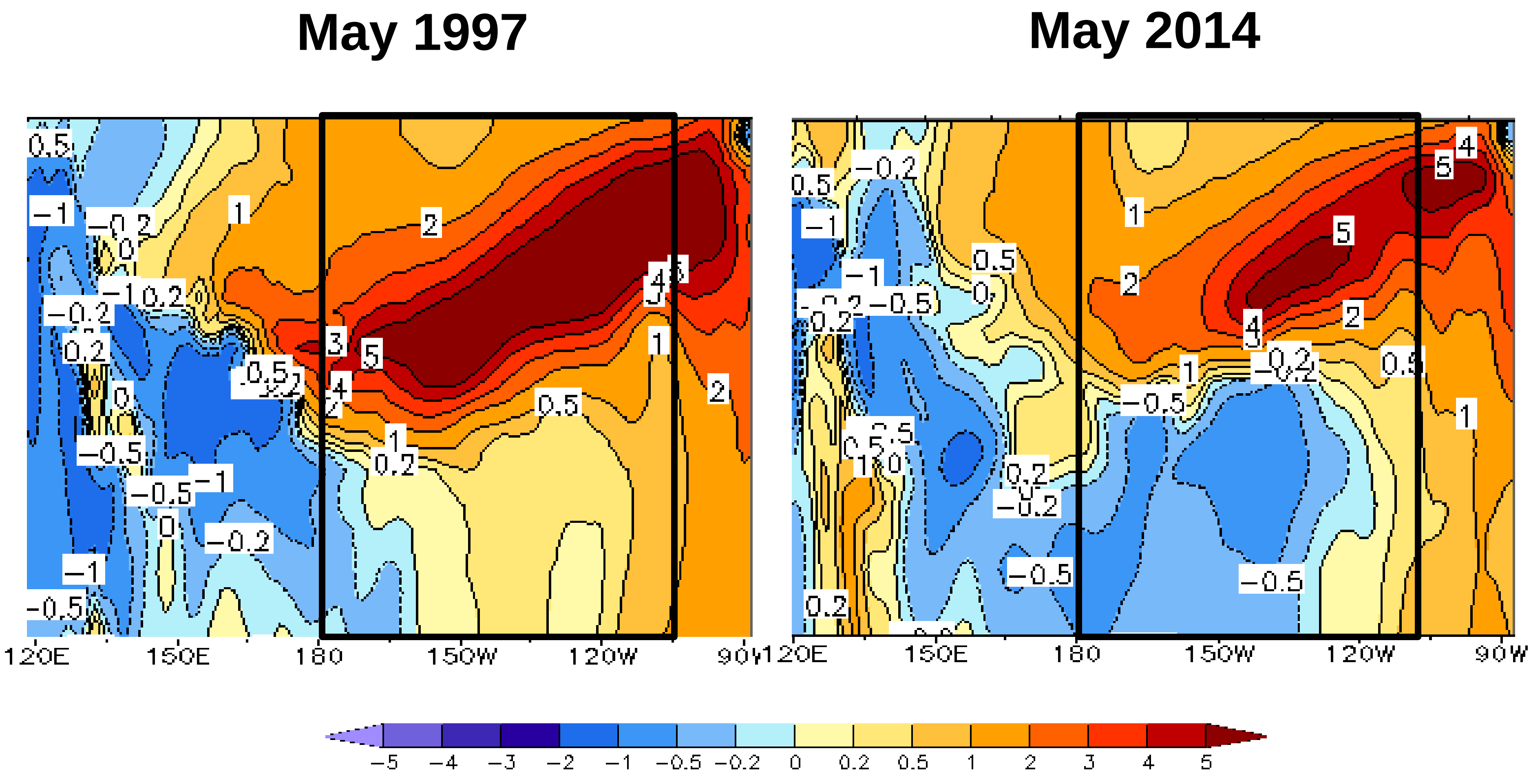
Equatorial Depth Longitude Temperature Anomalies

March 1997 **March 2014**



From Mike Halpert

The cases of 1997-1998 and 2014-2015
Equatorial Depth Longitude Temperature Anomalies



From Mike Halpert

Overview

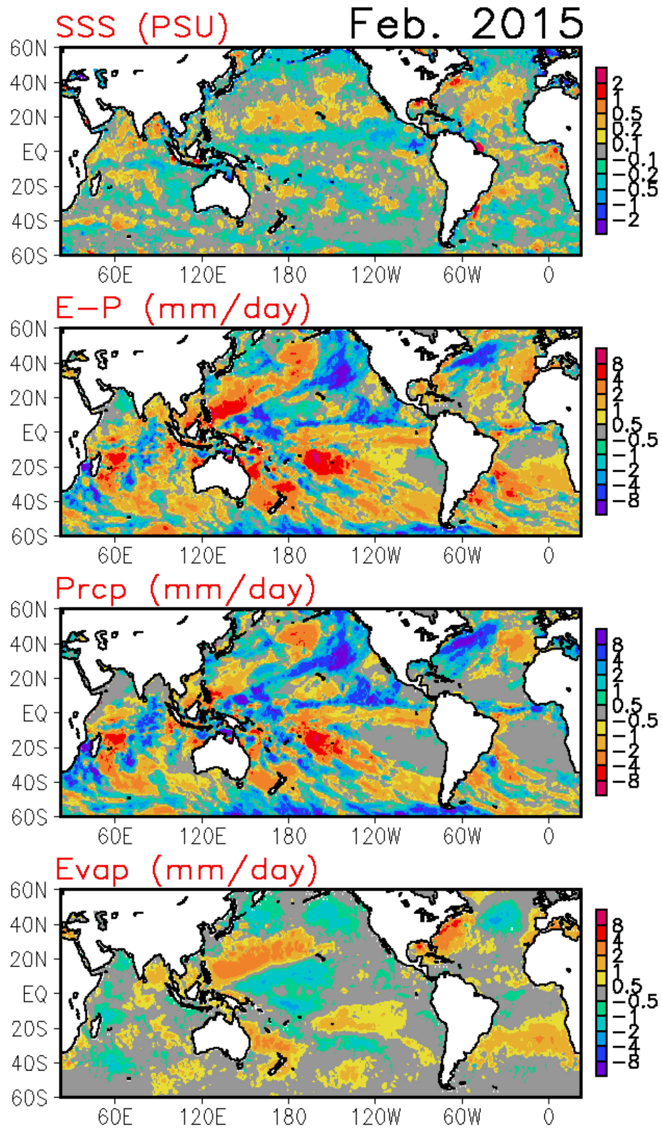
- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 05 March 2015 issued "El Nino Advisory" and suggested that "*There is an approximately 50-60% chance that El Niño conditions will continue through Northern Hemisphere summer 2015.*"**
  - **Positive SSTAs were mainly in the central tropical Pacific with NINO3.4=0.6^{o}C in Feb 2015.**
  - **Positive anomalies of subsurface ocean temperature along the equator strengthened in Feb 2015.**
  - **Majority of dynamical models predicted a warming tendency and majority of statistical models favor neutral in 2015.**
  - **Positive phase of PDO has persisted for 8 months, with PDOI=1.6 in Feb 2015.**
- **Indian Ocean**
  - **SSTAs were small with positive (negative) in the east (west).**
- **Atlantic Ocean**
  - **Positive phase of NAO has persisted for 4 months with NAOI=1.1 in Feb 2015, causing a horseshoe-like pattern of SSTA in N. Atlantic.**

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for February 2015

- Anomaly of fresh water flux, dominated by that of precipitation, is characterized by the northward shift of the Pacific ITCZ, a narrow but intensified ITCA over the Atlantic, and an intensified ITCZ over the central Indian Ocean;
- A direct consequence of the fresh water flux changes, zonally extended bands of positive and negative SSS anomaly are observed over the equatorial Pacific, while negative SSS is observed over the equatorial Atlantic and the central Indian oceans;



- Data used

SSS :

Blended Analysis of Surface Salinity (BASS) V0.Y

(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:

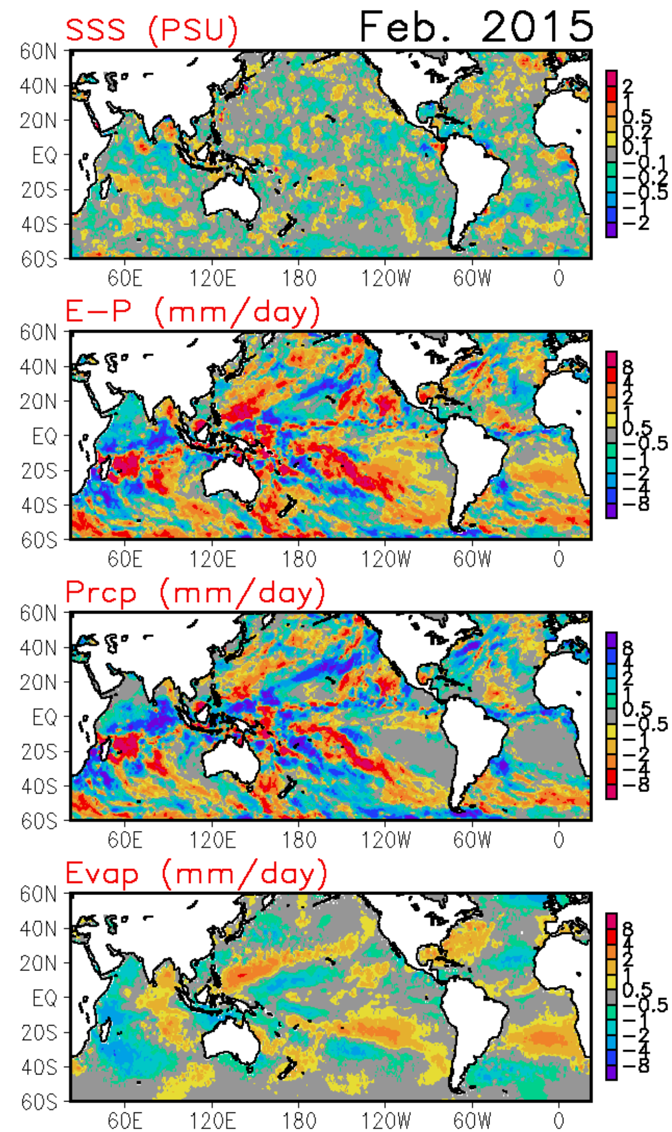
CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for January 2015

- SSS anomaly becomes fresher over central Pacific and tropical Indian Ocean, and over western south Pacific beneath the SPCZ although not in a tightly organized manner;

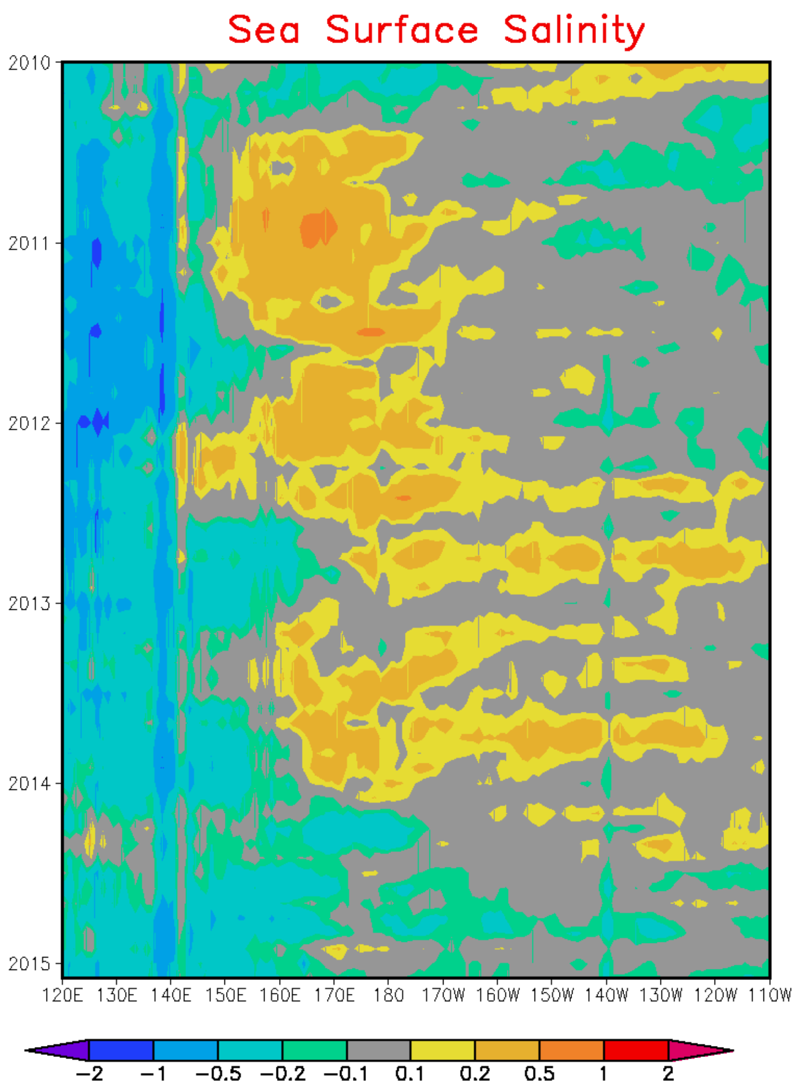
- Positive and negative SSS anomalies are also noticed over the Bay of Bengal and off the northern coast of the South America, respectively, possibly attributable to the changes in the river runoffs there;



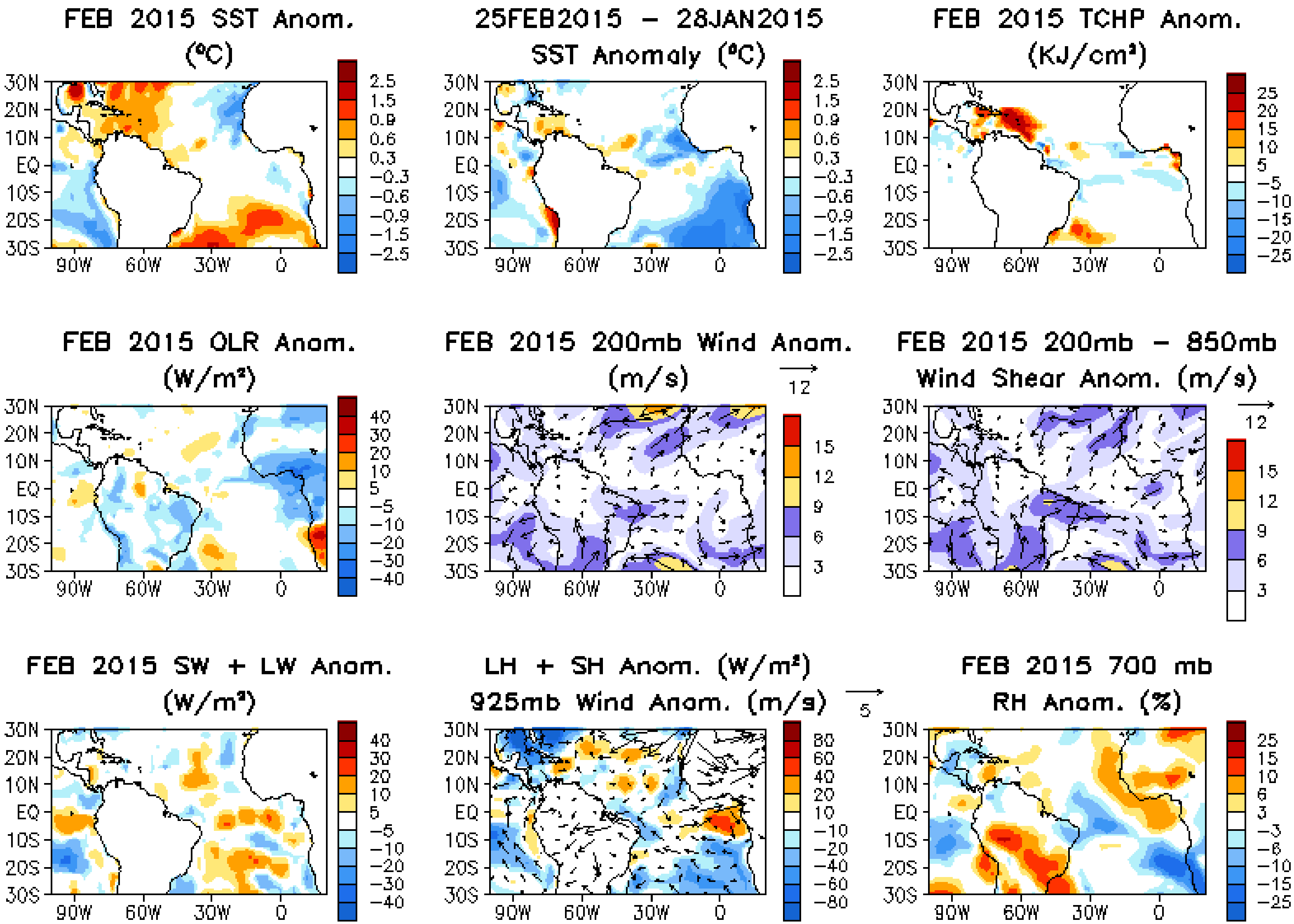
Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific

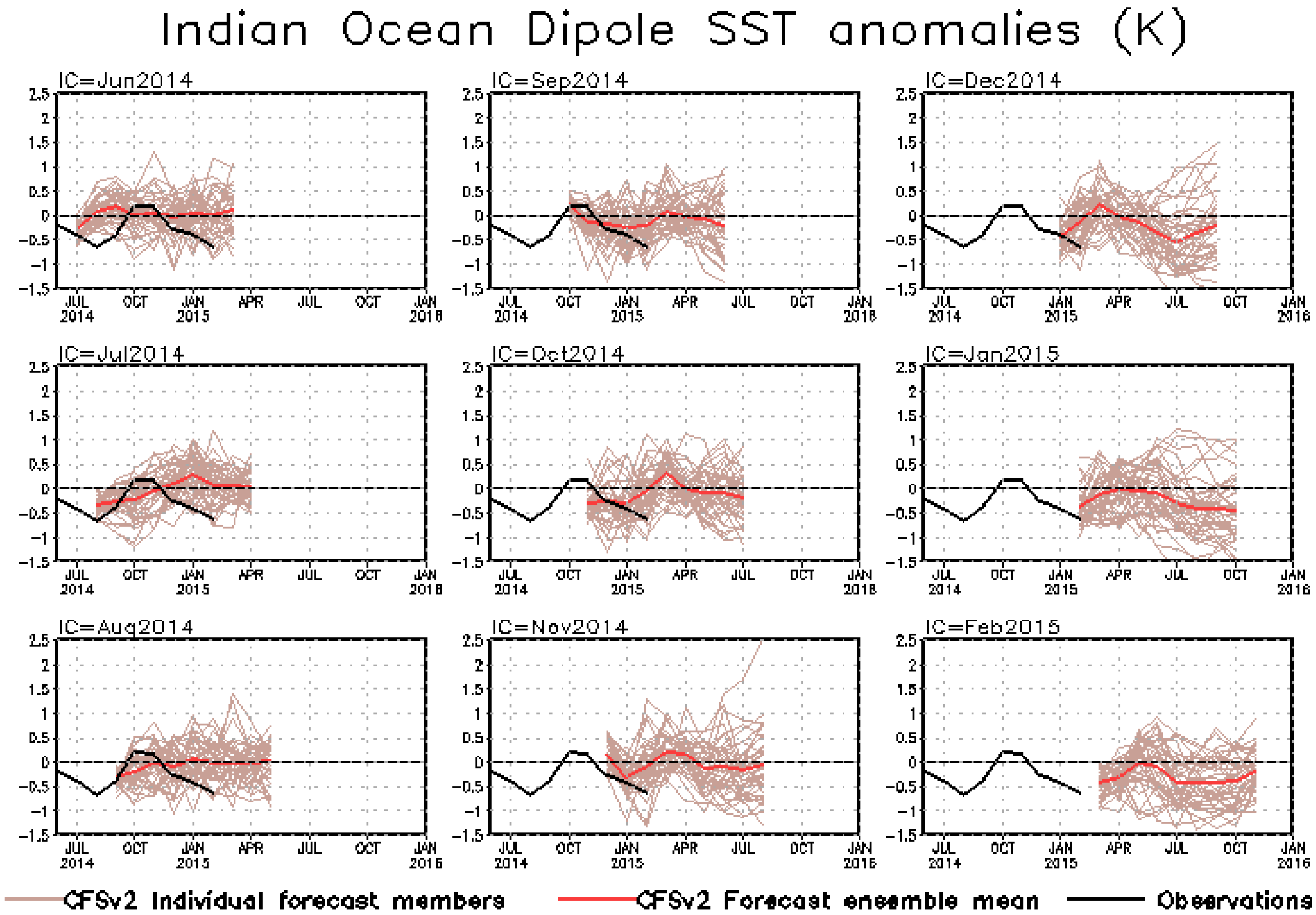
- Hovemoller diagram for equatorial SSS anomaly **(10ºS-10ºN);**
- Negative SSS anomaly presents gradual eastward extension over the equatorial Pacific since later 2013
- In February 2015, the negative anomaly averaged over the equatorial belt is weak but extends all the way across the entire equatorial Pacific basin;



Tropical Atlantic:



NCEP CFS DMI SST Predictions from Different Initial Months



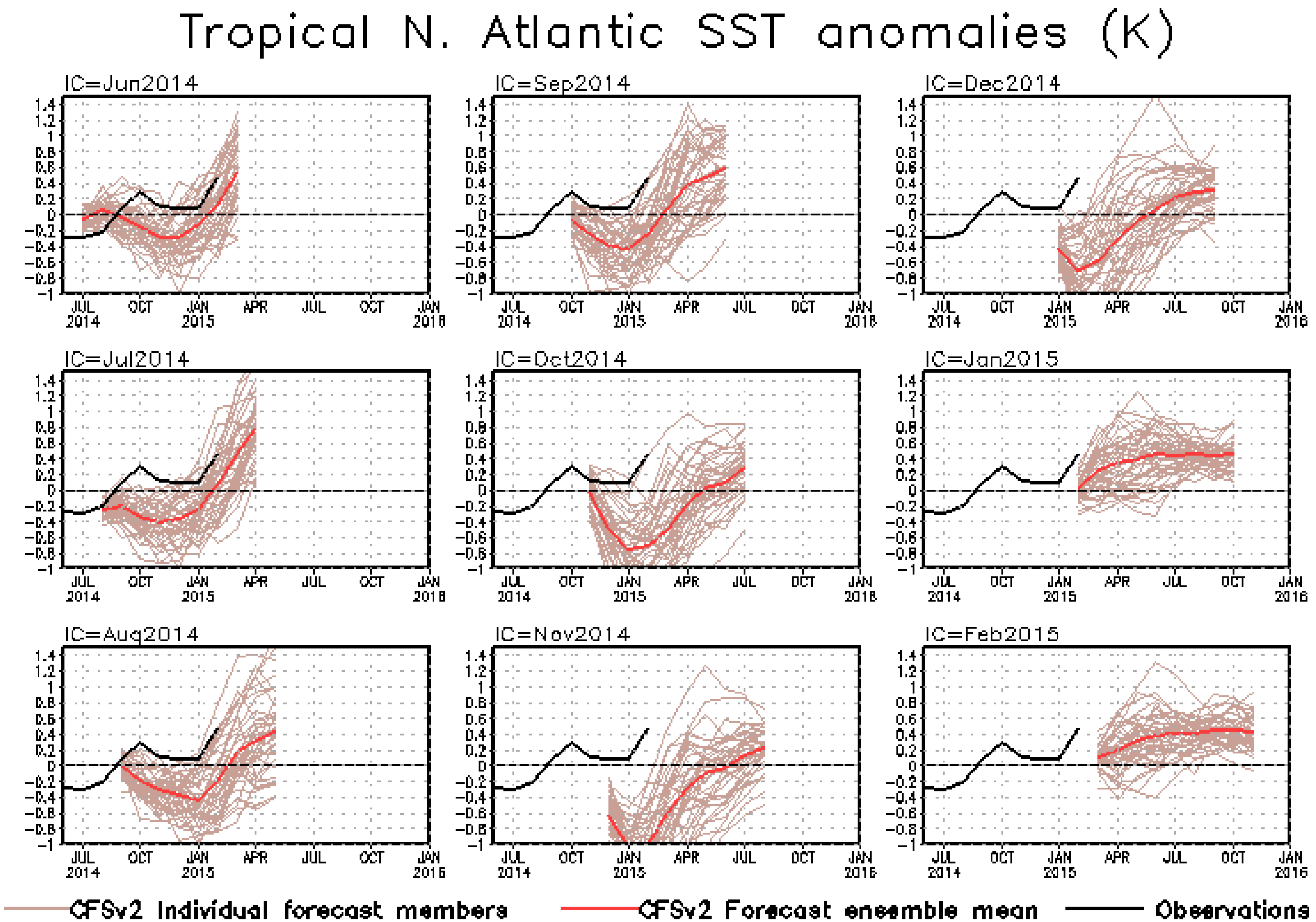
DMI = WTIO- SETIO

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.

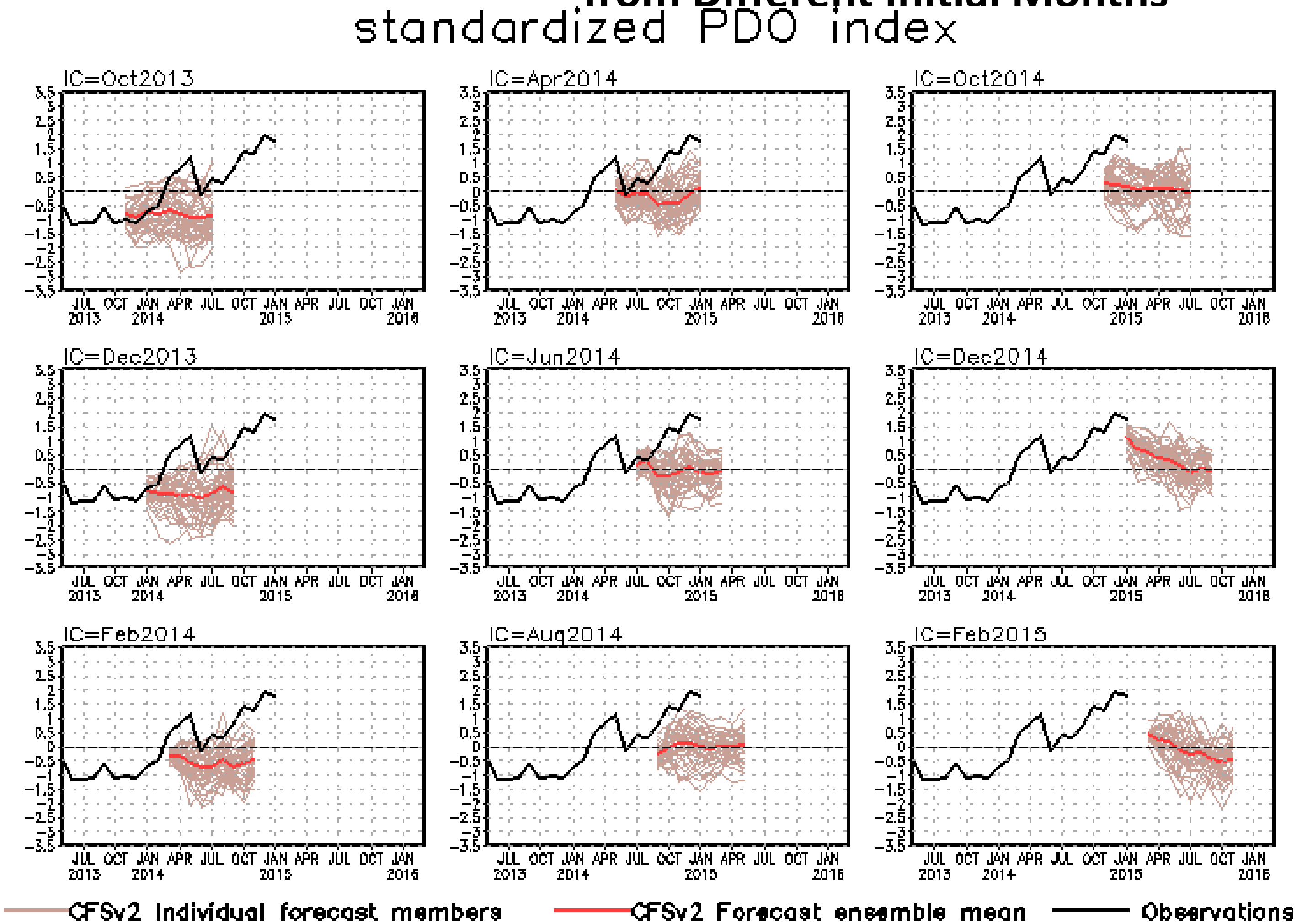
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



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



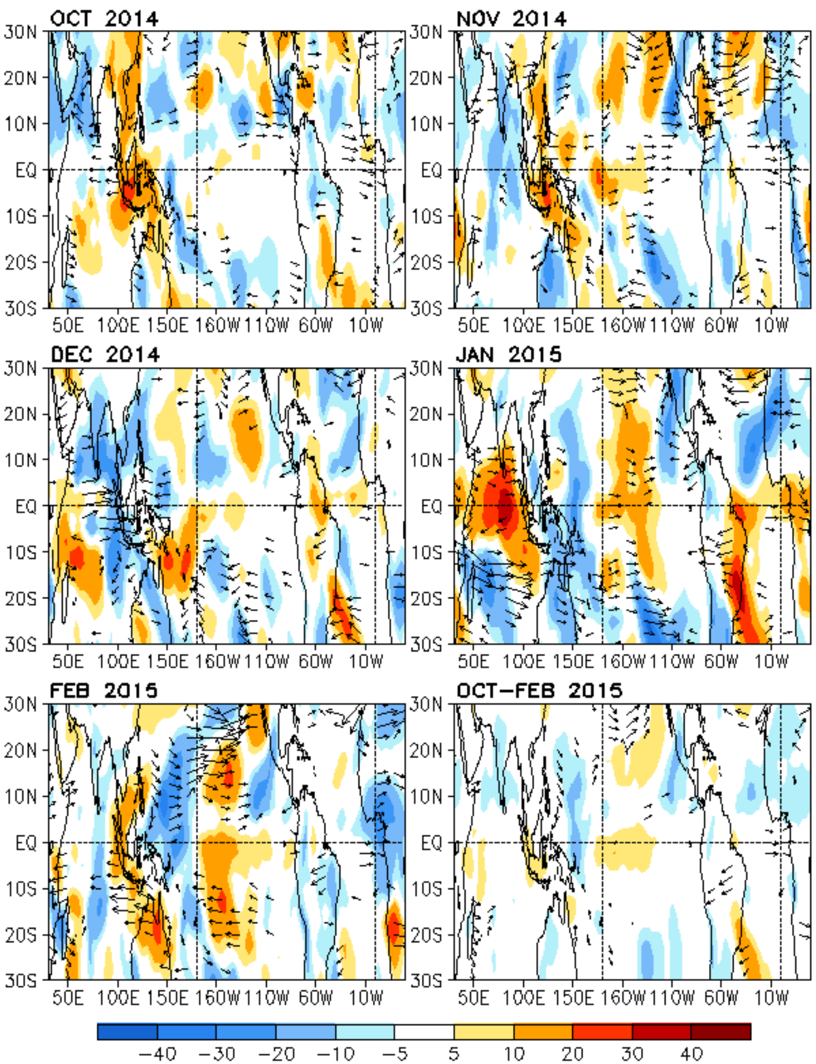
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

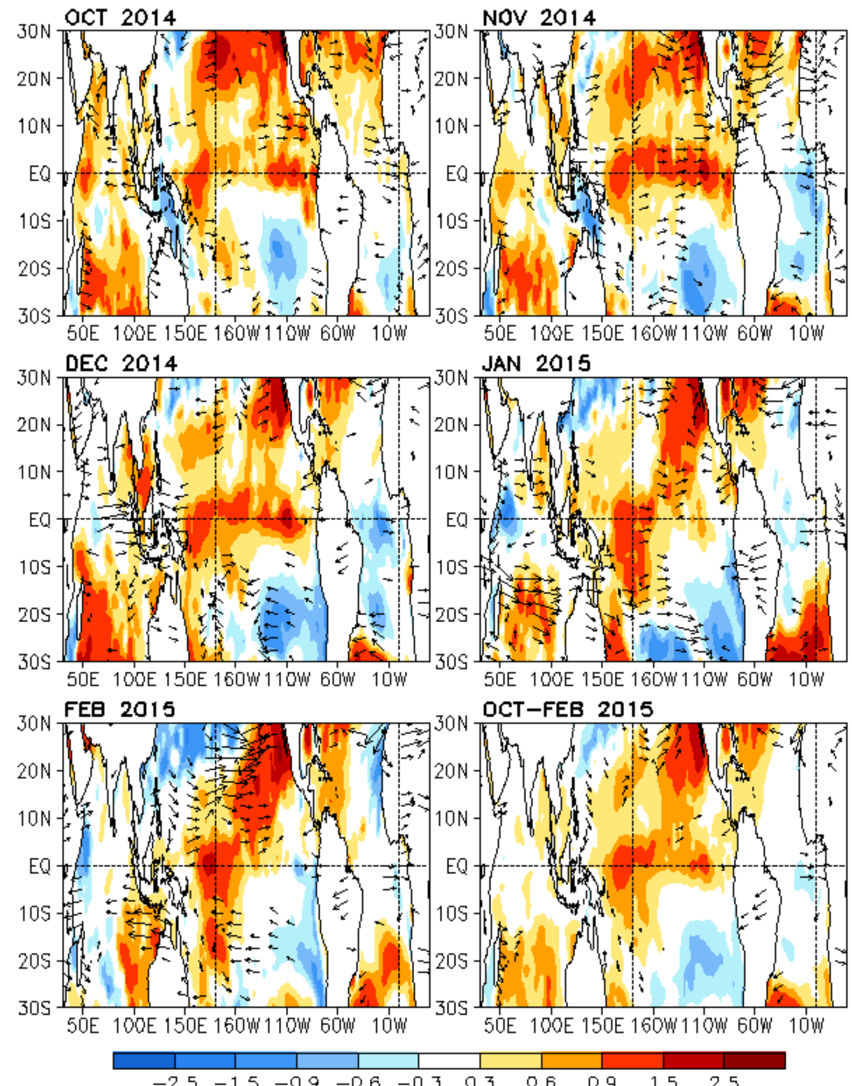
- CFSv2 predicts a downward tendency of PDO, and negative phase since summer 2015.

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.

OLR and UV850



SSTA and UV850



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

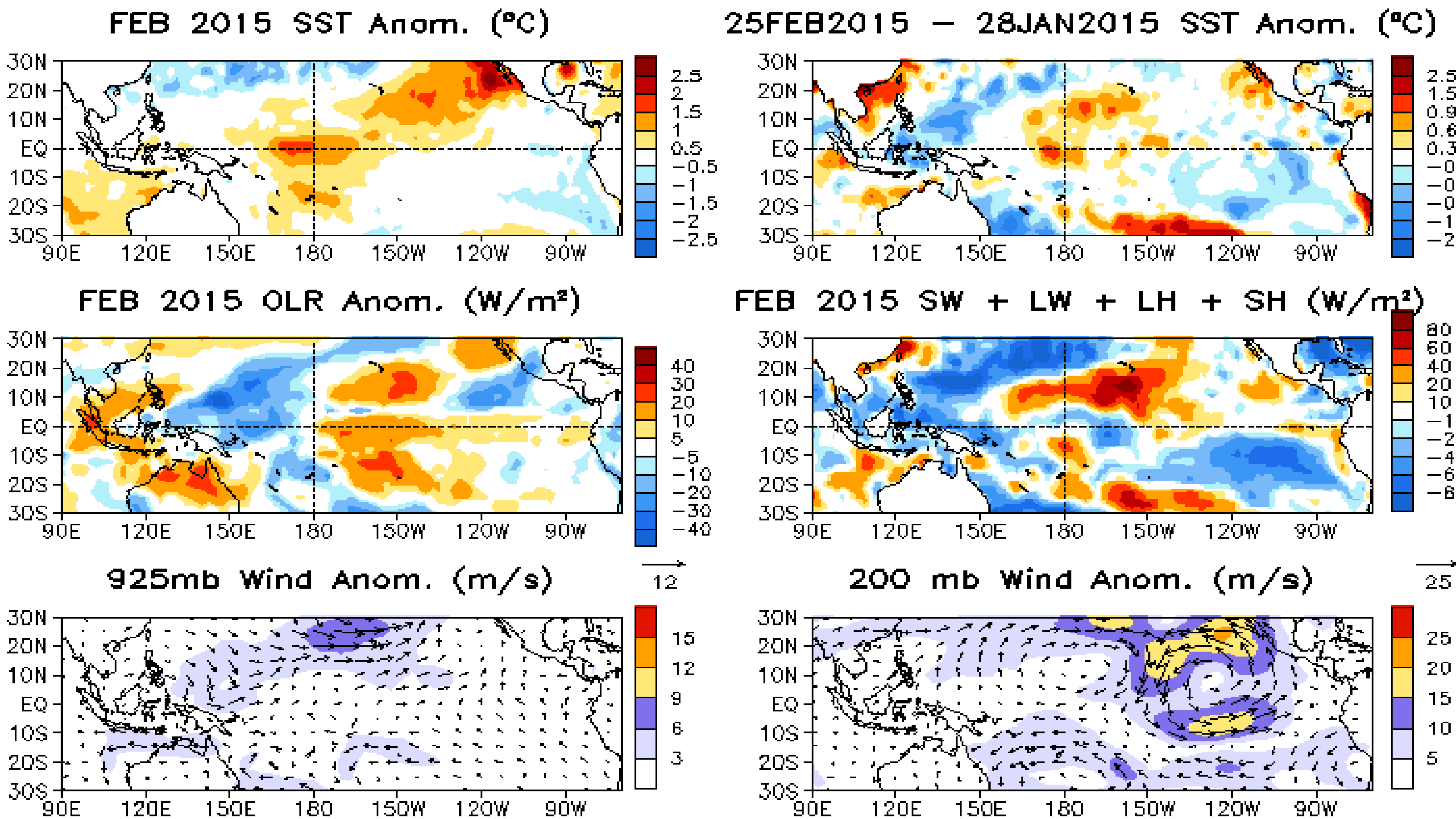


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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

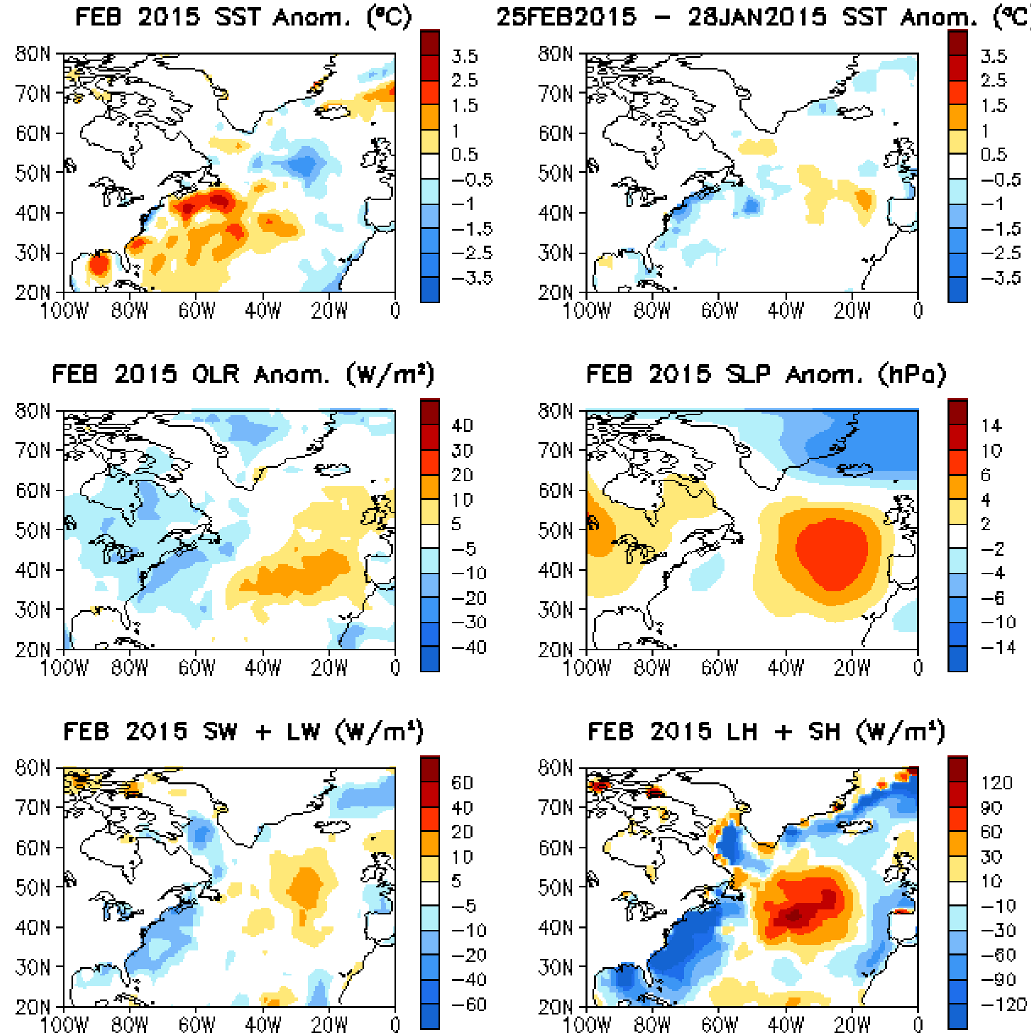
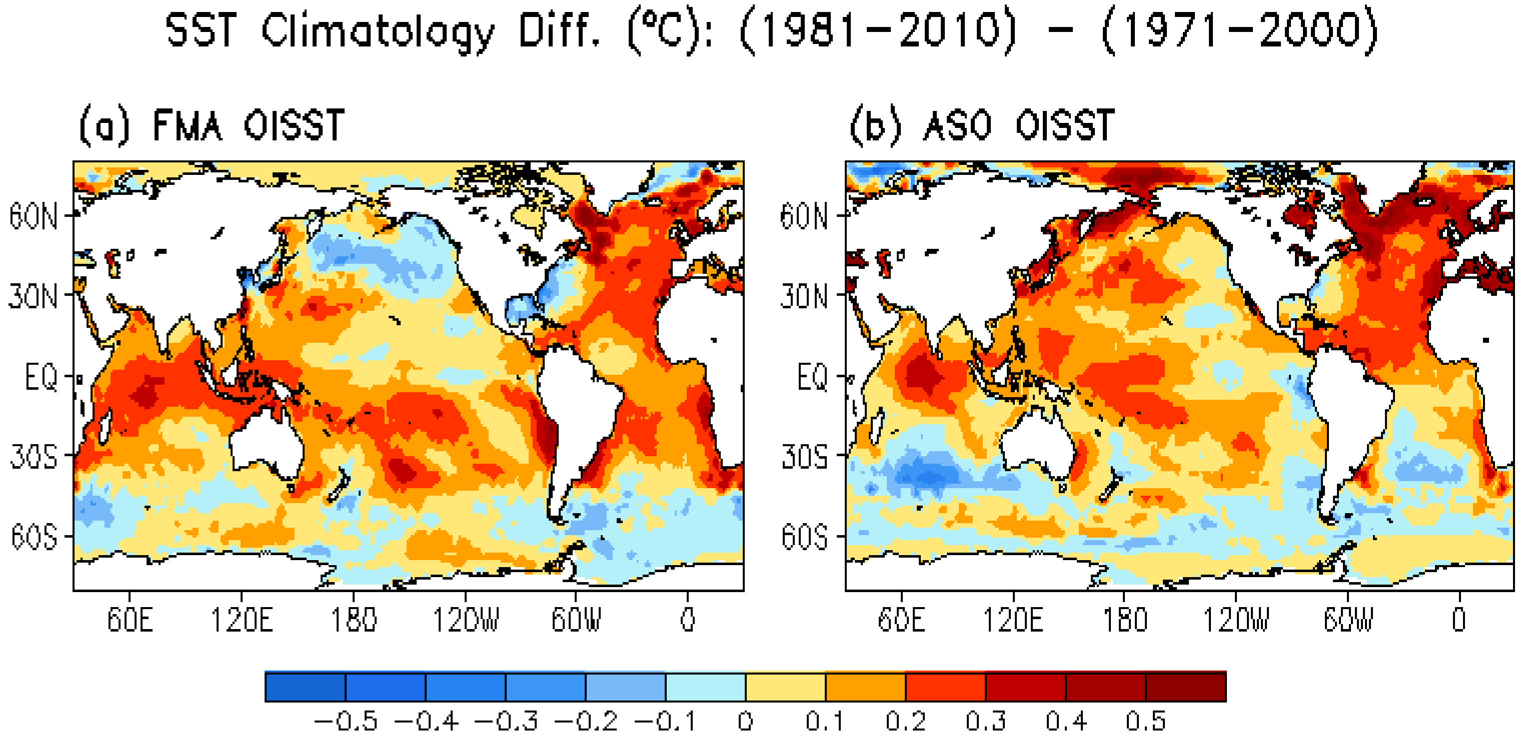


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

NOAA Operational Definitions for El Niño and La Niña

El Niño: characterized by a positive ONI greater than or equal to +0.5ºC.

La Niña: characterized by a negative ONI less than or equal to -0.5ºC.

By historical standards, to be classified as a full-fledged El Niño or La Niña *episode*, these thresholds must be exceeded for a period of at least 5 consecutive overlapping 3-month seasons.

CPC considers El Niño or La Niña *conditions* to occur when the monthly Niño3.4 OISST departures meet or exceed +/- 0.5°C along with consistent atmospheric features. These anomalies must also be forecasted to persist for 3 consecutive months.

Creation of the NOAA ENSO Outlook

(from Michelle L'Heureux and Mike Halpert)

ENSO Alert System:

El Niño or La Niña Watch:
Favorable for development of ENSO within the next six (6) months.

El Niño or La Niña Advisory: conditions are observed and expected to continue.

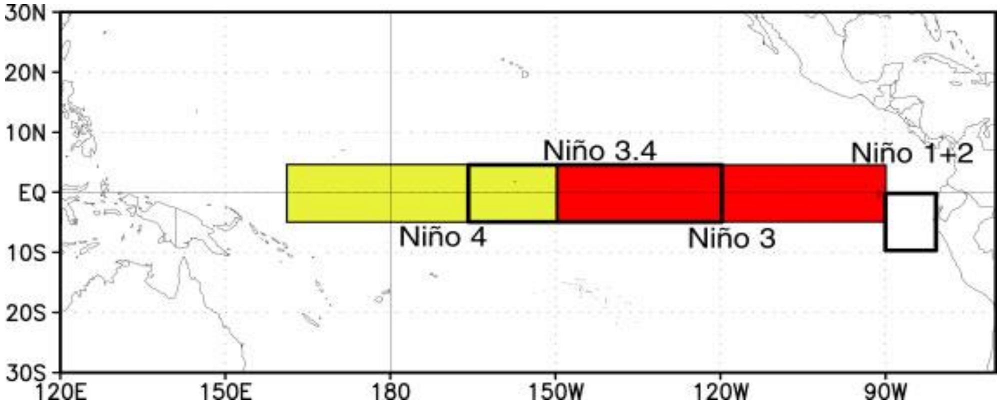
Final El Niño or La Niña Advisory: conditions have ended.

NA: El Niño or La Niña conditions are not observed or expected to develop in the equatorial Pacific basin.

What is the criteria for an ENSO Advisory? (from Michelle L'Heureux)

The ENSO Alert System is based on El Niño and La Niña "conditions" that allows the NOAA to be able to issue watches/ advisories in real-time.

The value of the ONI is to define episodes retrospectively.



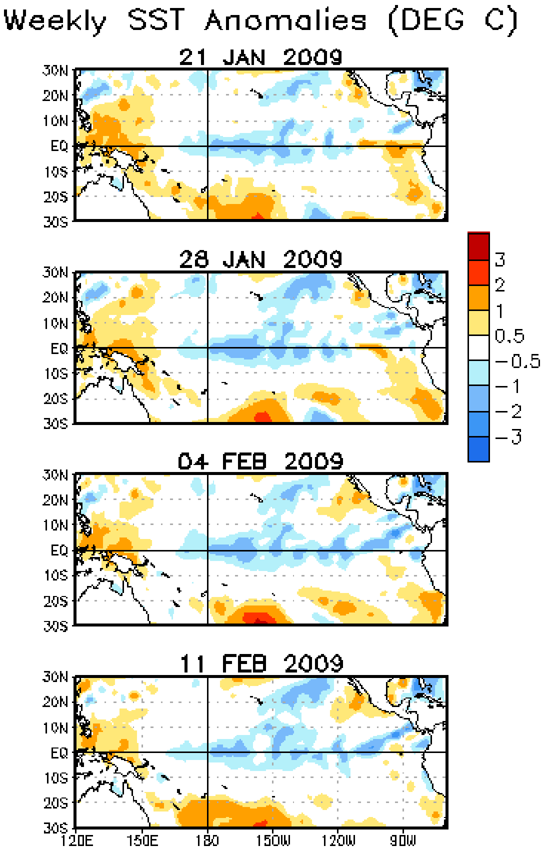
El Niño conditions: one-month positive SST anomaly of +0.5 or greater in the Niño-3.4 region and an expectation that the 3-month ONI threshold will be met.

La Niña conditions: one-month negative SST anomaly of −0.5 or less in the Niño-3.4 region and an expectation that the 3-month ONI threshold will be met.

AND

***An atmospheric response* typically associated with El Niño/ La Niña over the equatorial Pacific Ocean.**

What products do we use to monitor ENSO (From Mike Halpert)?



Weekly and monthly graphics of the tropical Pacific:

* sea surface temperature (SST)
* subsurface temperature
* sea level pressure (i.e. SOI)
* outgoing longwave radiation (OLR)
* Various levels of winds (850/200-hPa)
* velocity potential + streamfunction