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

Prepared by

Climate Prediction Center, NCEP/NOAA

March 10, 2016

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**

*** What are the differences between 1982-83, 1997-98 and 2015-16 El Ninos?**

*** Will a La Nina emerge in 2016-17?**

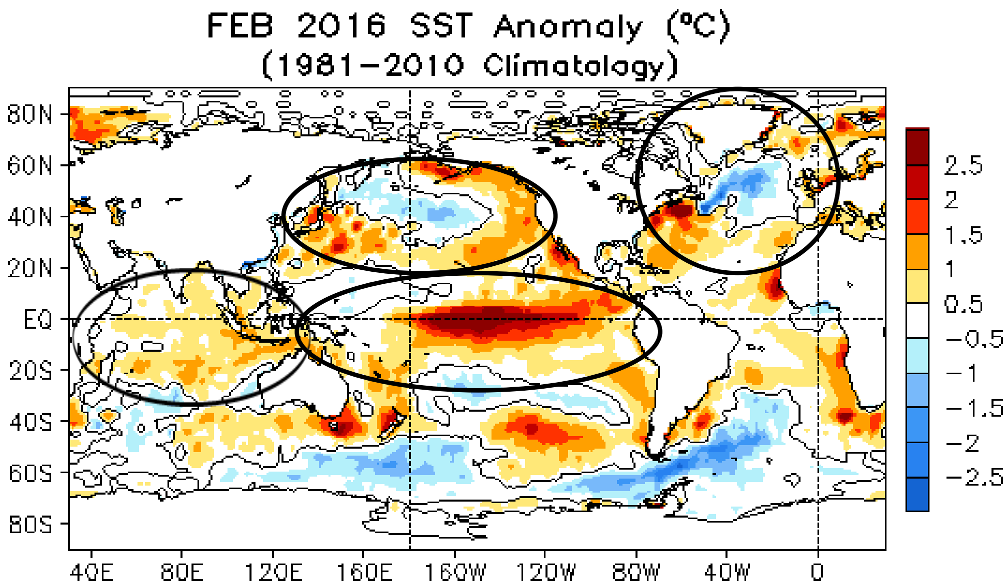
*** What are possible impacts of significant cold biases in CFSR in the tropical Atlantic Ocean on recent CFSv2 forecasts?**

Overview

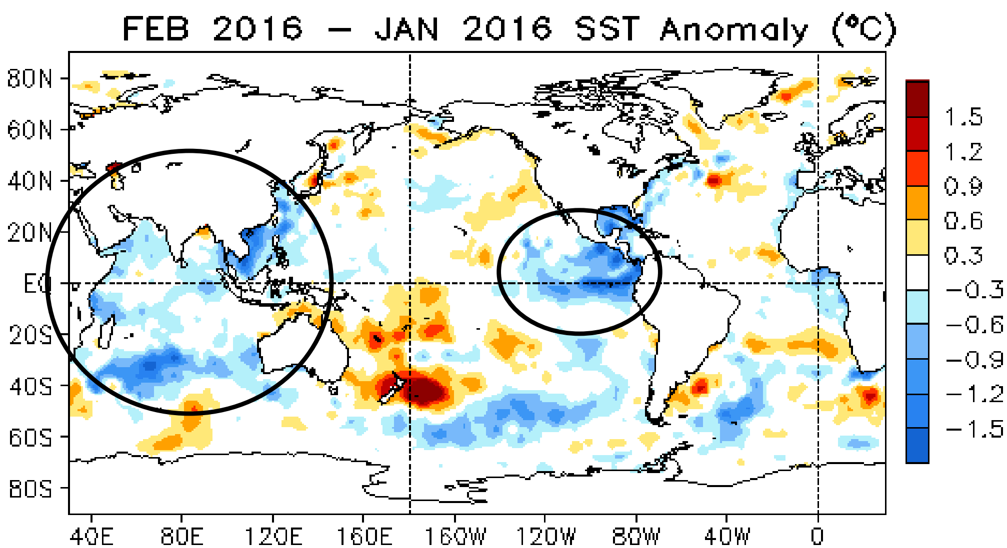
- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 10 Mar 2016 issued "El Nino Advisory" and suggested that *"A transition to ENSO-neutral is likely during late Northern Hemisphere spring or early summer 2016, with close to a 50% chance for La Niña conditions to develop during the fall."***
  - **Positive SSTAs persisted in the central tropical Pacific with NINO3.4=2.4ºC in Feb 2016 and weakened in the east.**
  - **Strong negative ocean temperature anomalies mainly along the thermocline strengthened in the western and central Pacific and propagated eastward.**
  - **Positive phase of PDO has persisted for 20 months, and strengthened with PDOI=1.76 in Feb 2016.**
- **Indian Ocean**
  - **Positive SSTA was larger in the east than in the west.**
- **Atlantic Ocean**
  - **NAO switched to positive phase with NAOI=1.35 in Feb 2016, causing a horseshoe-like pattern of SSTA in N. Atlantic.**

Global Oceans

Global SST Anomaly (^0C) and Anomaly Tendency



- Strong positive SSTA in the central tropical Pacific associated with El Nino persisted.
- SSTA pattern in N. Pacific was associated with positive phase of PDO.
- Horseshoe-like SSTA presented in N. Atlantic.
- SSTA was positive in the whole Indian Ocean.

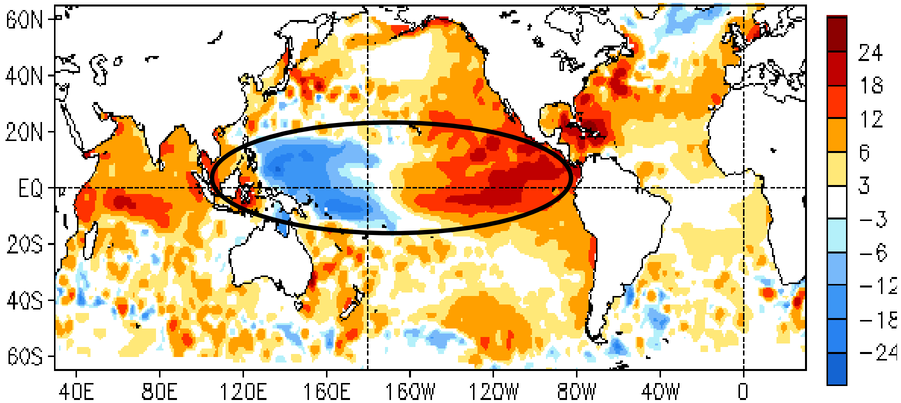


- Positive SSTA associated with El Nino in the eastern tropical Pacific significantly weakened.
- Negative SSTA tendencies were observed in the Indian and NW. Pacific Oceans.

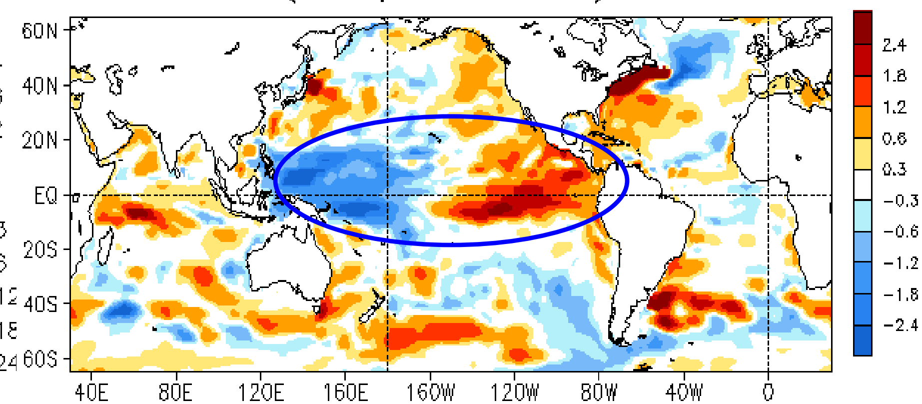
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency

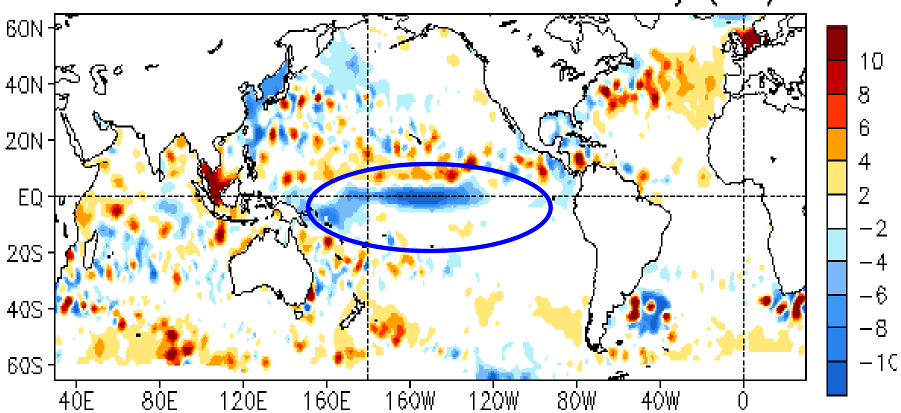
FEB 2016 SSH Anomaly (cm)
(AVISO Altimetry, Climo. 93-13)



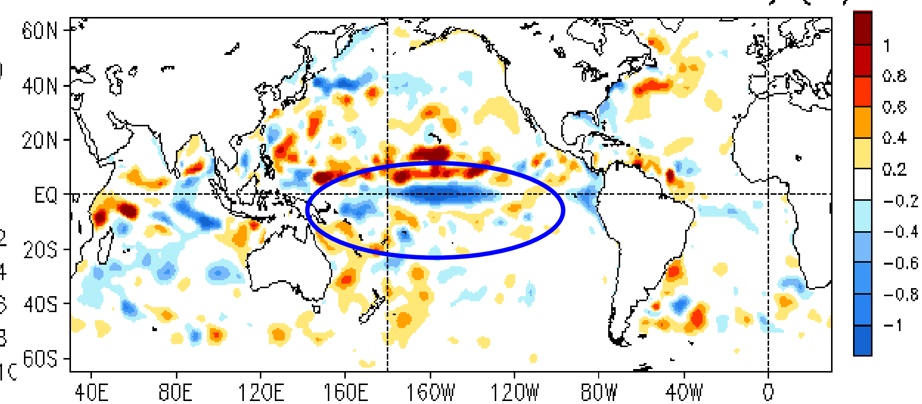
FEB 2016 Heat Content Anomaly (°C)
(GODAS, Climo. 81-10)



FEB 2016 – JAN 2016 SSH Anomaly (cm)

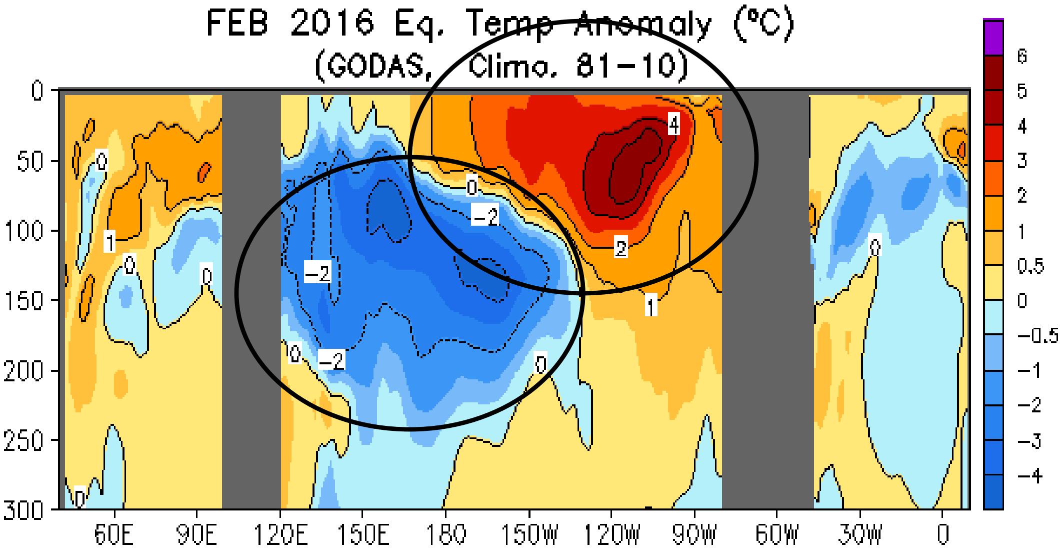


FEB 2016 – JAN 2016 Heat Content Anomaly (°C)

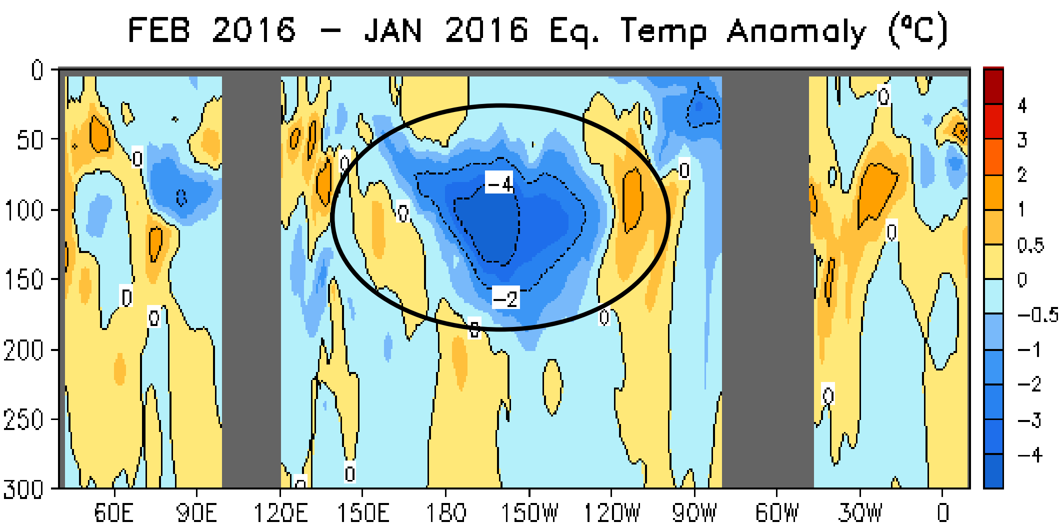


- The SSHA was overall consistent with HC300A: Positive (negative) HC300A is tied up with positive (negative) SSHA.
- Both SSHA and HC300A showed a dipole pattern in the tropical Pacific with negative in the west and positive in the east, consisting with the feature in mature phase of El Nino.
- Negative tendencies of SSHA and HC300A were observed in the central and eastern equatorial Pacific, indicating eastward propagation of cold subsurface anomaly and a decay tendency of El Nino.

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



- **Strong negative ocean temperature anomalies mainly presented along the thermocline in the western and central Pacific.**
- **Positive ocean temperature anomalies presented near the surface and in the eastern Pacific along the thermocline.**

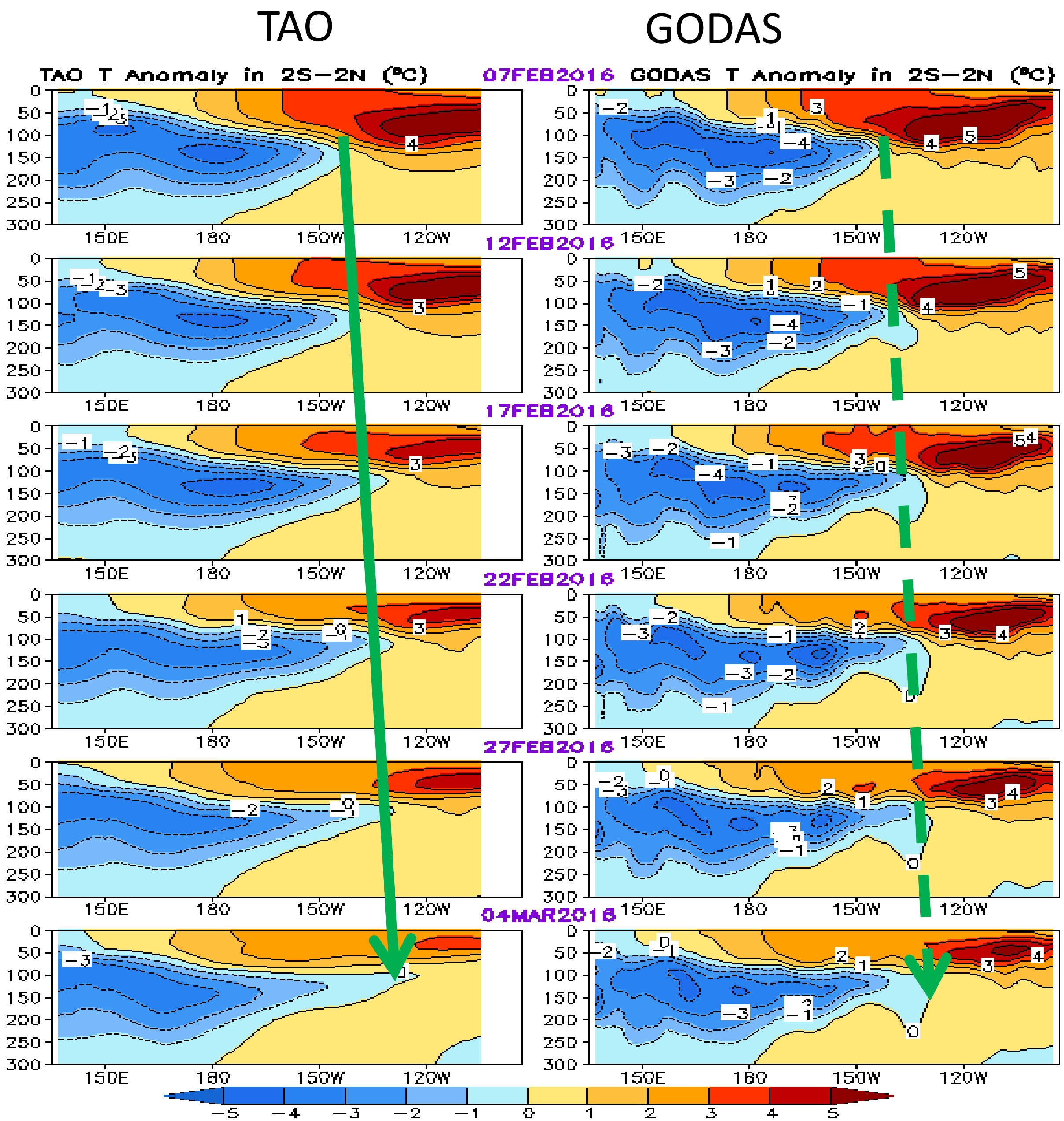


- **Remarkable negative ocean temperature anomaly tendencies were observed in the central Pacific, suggesting an eastward propagation of the negative ocean temperature anomalies along the thermocline.**

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.

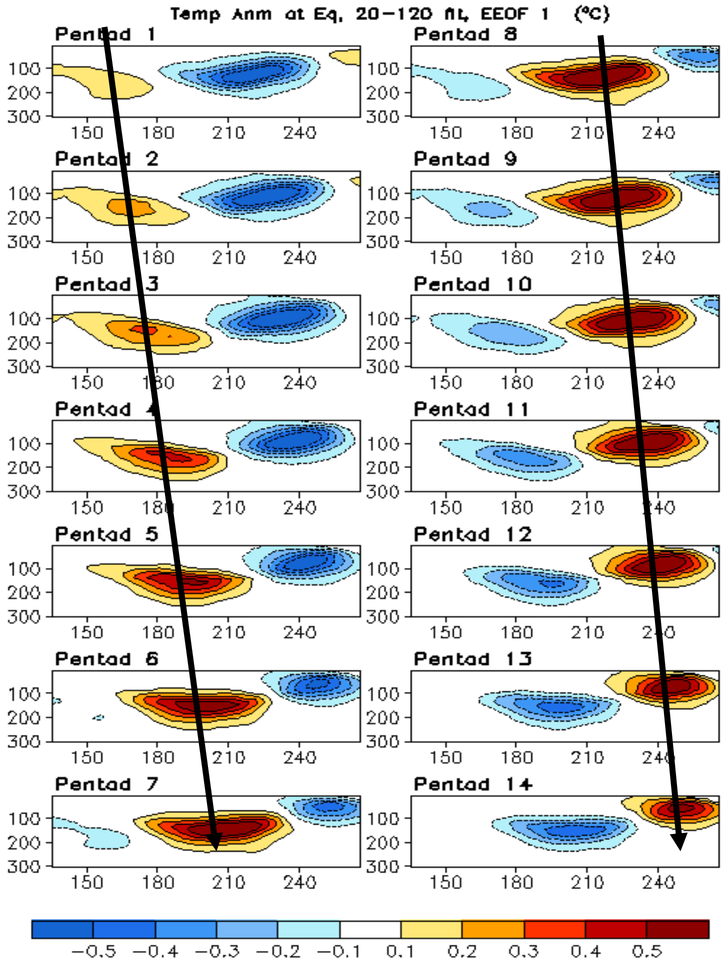
Tropical Pacific Ocean and ENSO Conditions

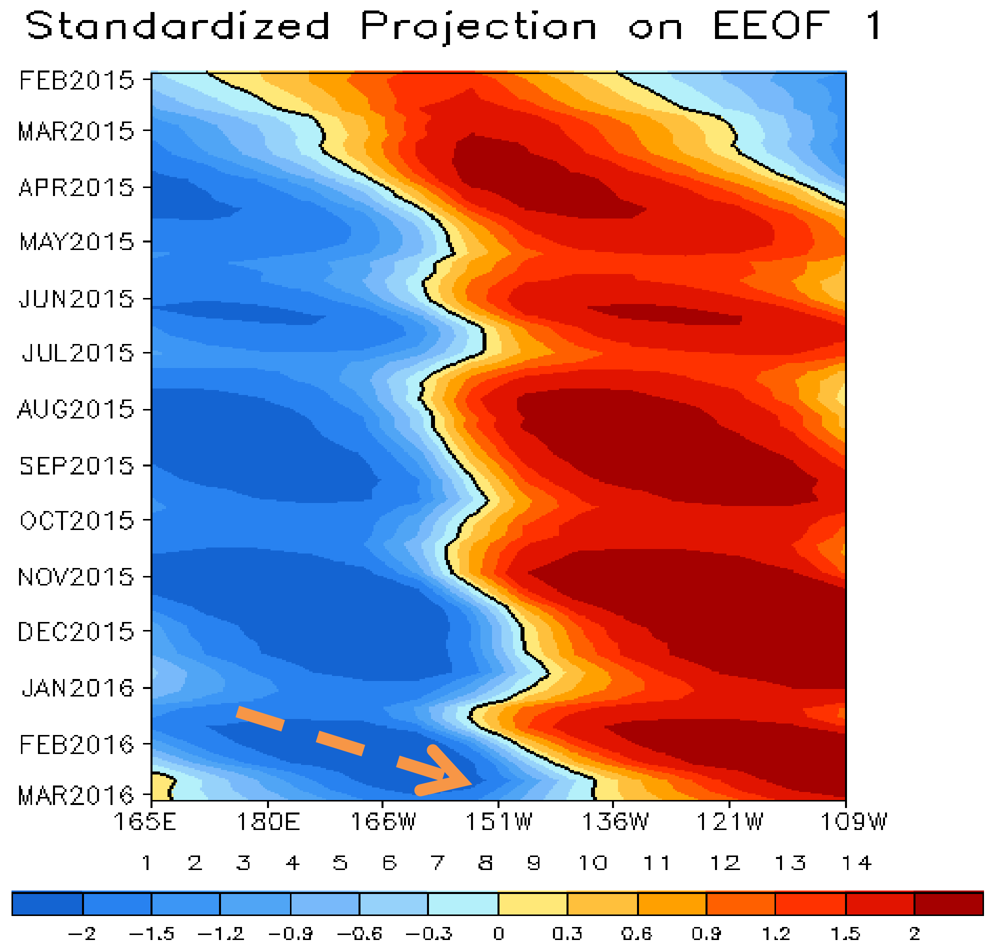
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- **Positive ocean temperature anomalies in the east weakened, and negative ones in the west strengthened and propagated eastward.**
- **Compared with TAO, both the negative and positive anomalies in GODAS were stronger and had more small scale variations.**
- **But, both the anomalous pattern and propagation are comparable.**

Oceanic Kelvin Wave (OKW) Index



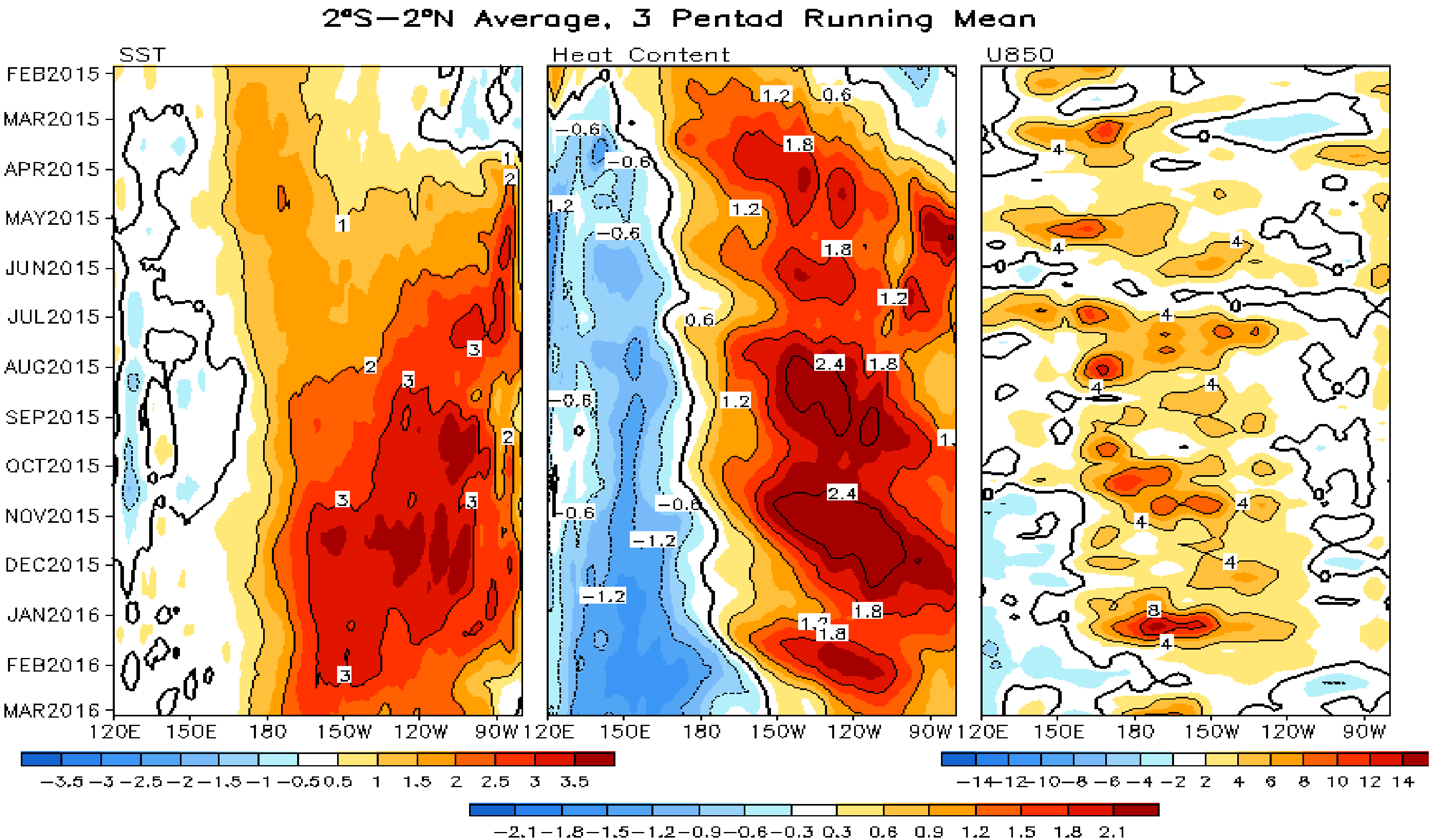


- **Upwelling OKW (dashed line) emerged since Jan 2016 in the western Pacific. The upwelling may be associated with the observed strengthening of subsurface ocean cooling in the western Pacific and the eastward propagation.**

- **During May 2015-Jan 2016, stationary variations were dominant.**

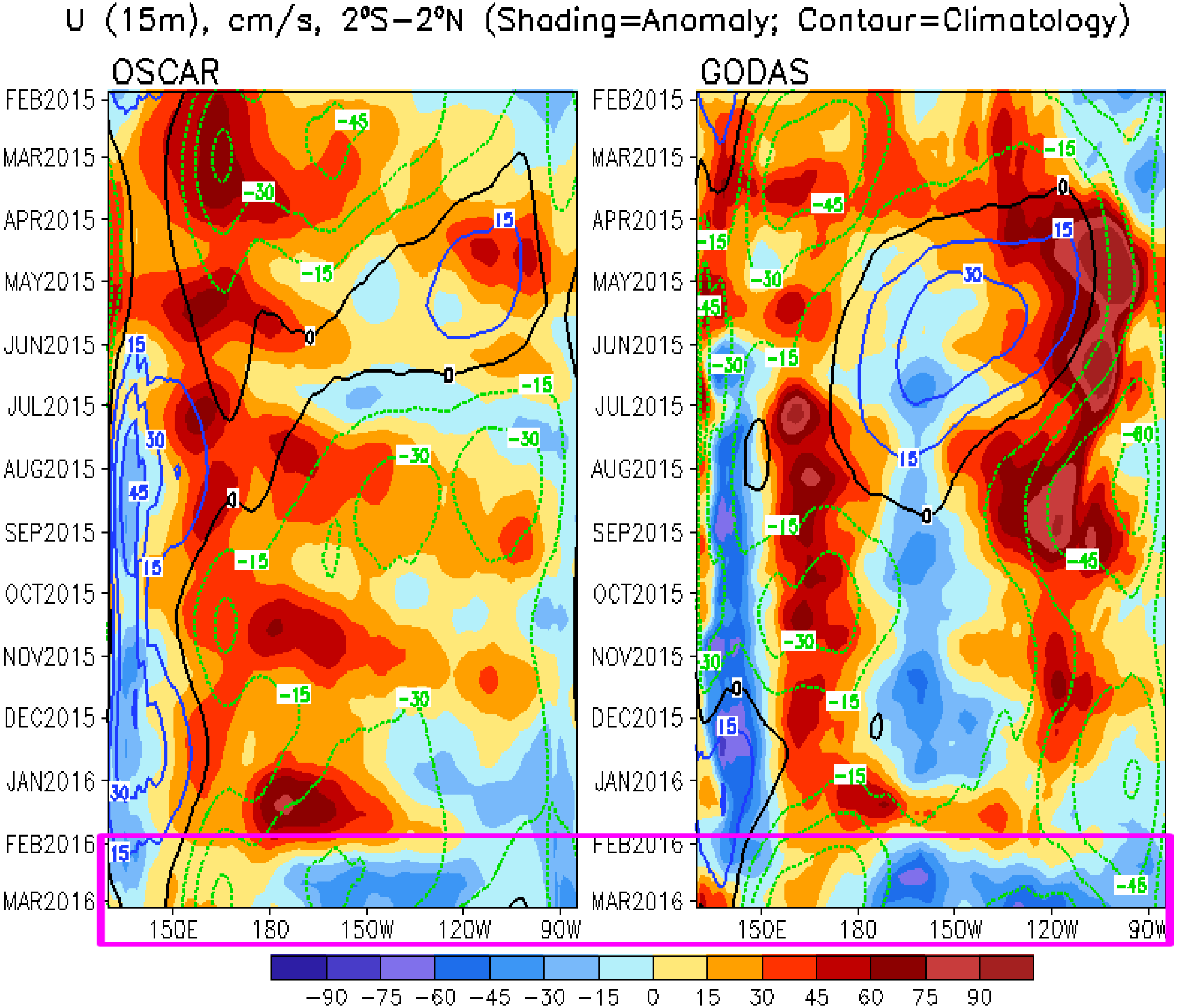
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- **Positive SSTA in the central and eastern equatorial Pacific weakened since Dec 2015.**
- **Positive HC300A weakened, and negative ones strengthened and propagated eastward.**
- **Low-level westerly wind anomalies weakened in the past two months.**

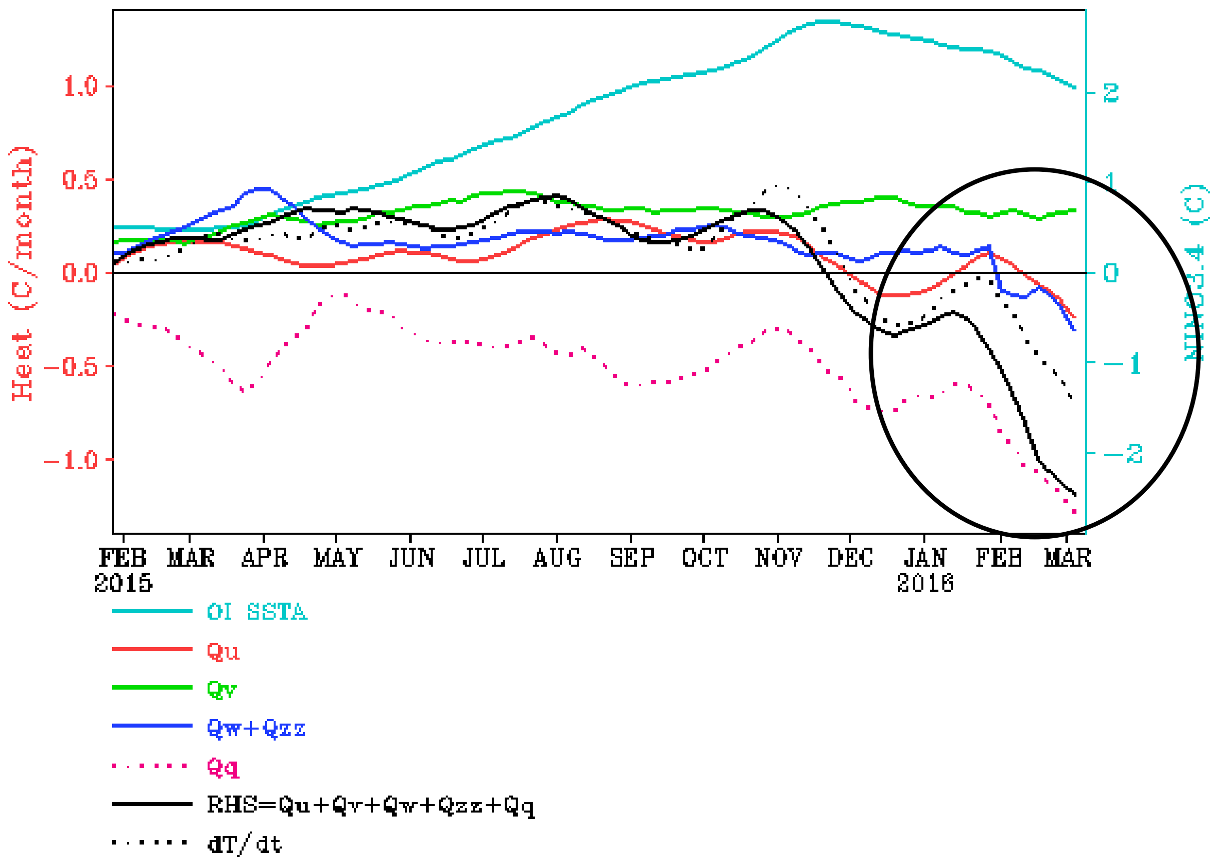
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- The anomalous current patterns were similar between OSCAR and GODAS.

- Anomalous westward current initiated in Feb 2016. That was favorable for a cooling tendency in the central-eastern Pacific SSTA

NINO3.4 Heat Budget



- **Observed SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) became negative since Dec 2015.**

- **Except Qv, all other dynamical terms (Qu, Qw+Qzz) as well as heat flux term (Qq) were negative in Feb 2016, consistent with decay of El Nino.**

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

Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

Warm Water Volume (WWV) and NINO3.4 Anomalies

- **WWV is defined as average of depth of 20°C in [120°E-80°W, 5°S-5°N].** **Statistically, peak correlation of Nino3 with WWV occurs at 7 month lag** **(Meinen and McPhaden, 2000).**
- **Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).**
- **Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.**

- **Equatorial Warm Water Volume (WWV) has been rapidly discharging since Nov 2015.**

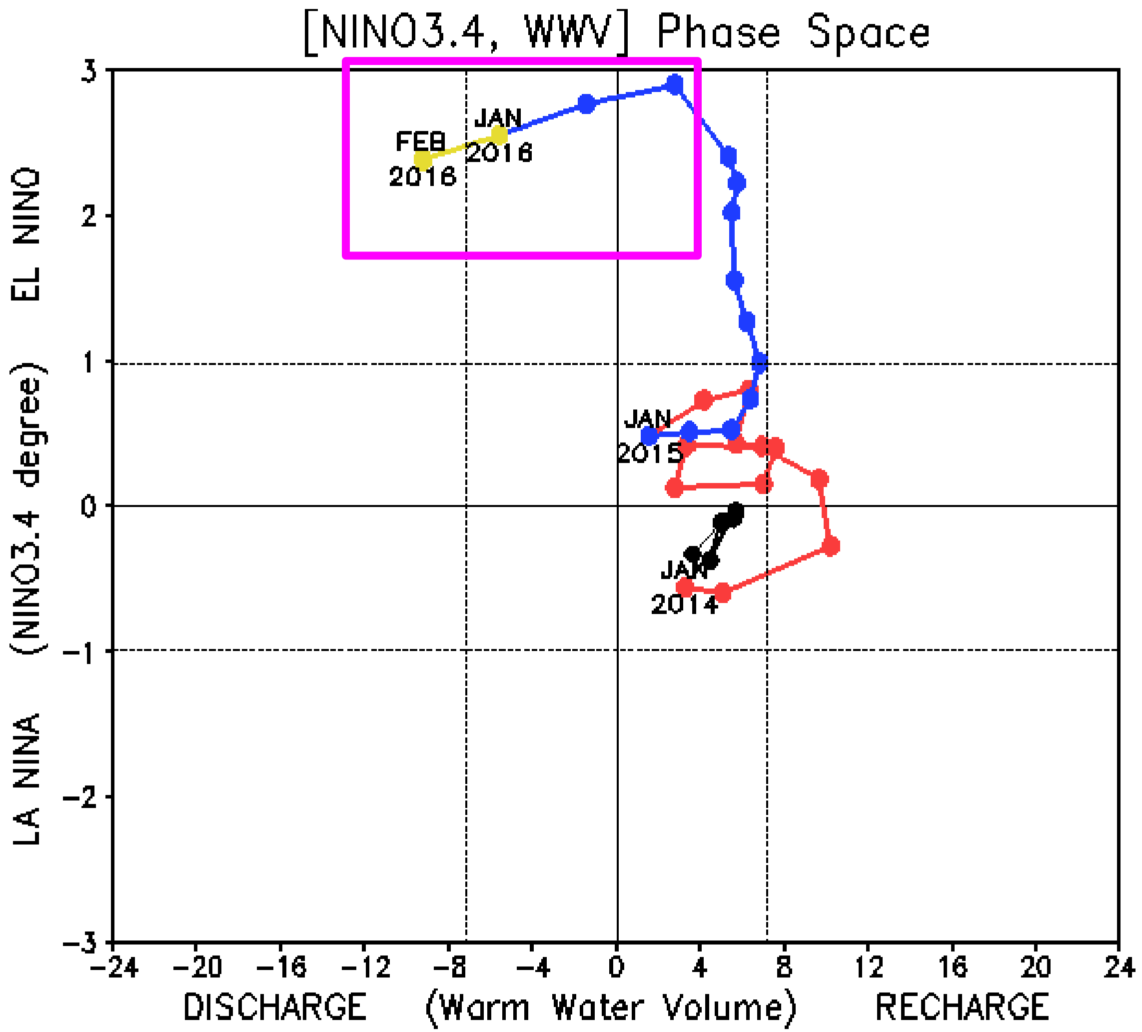
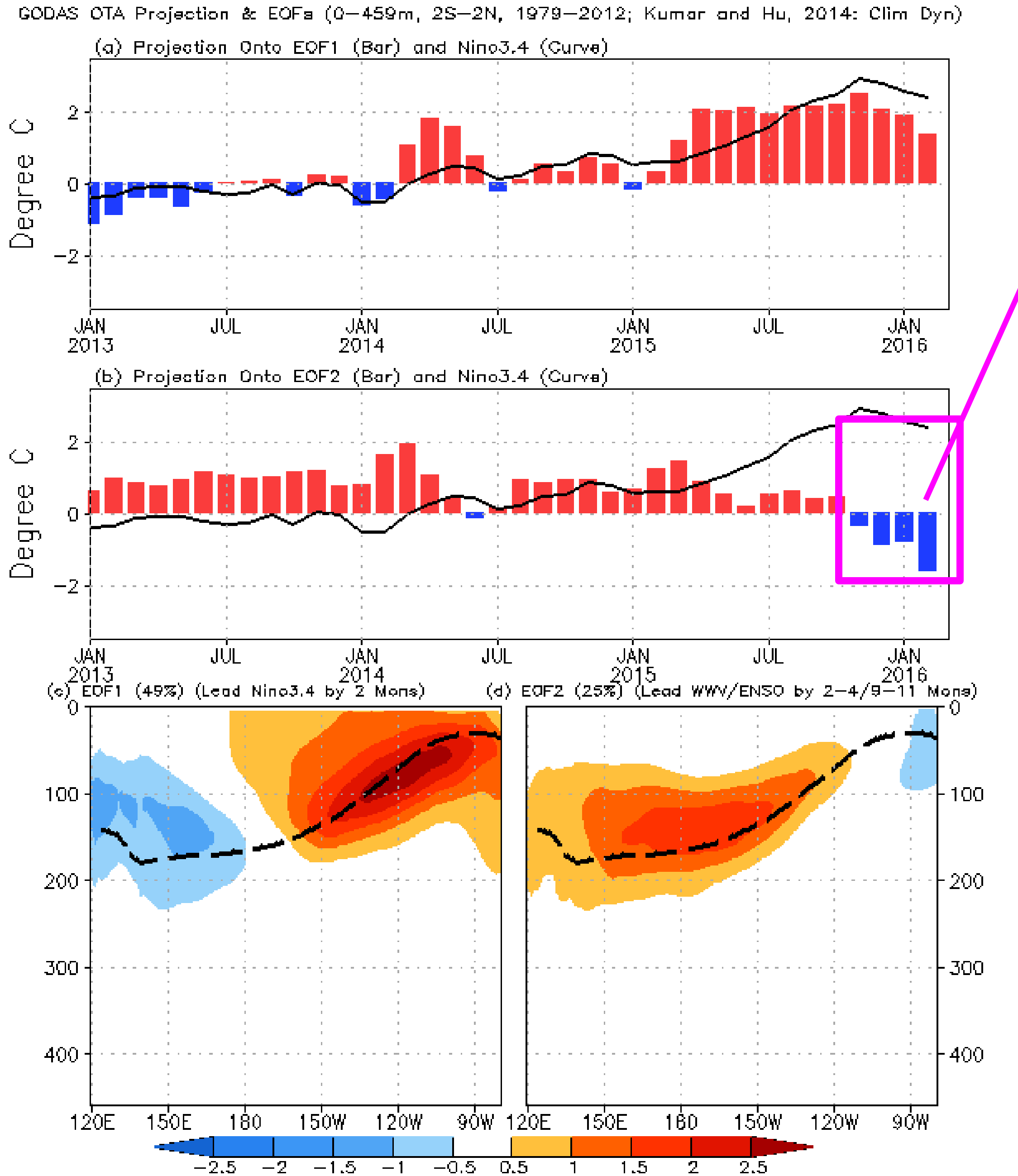


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



Equatorial subsurface ocean temperature monitoring: Right now, ENSO switched to discharge phase since Nov 2015.

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).

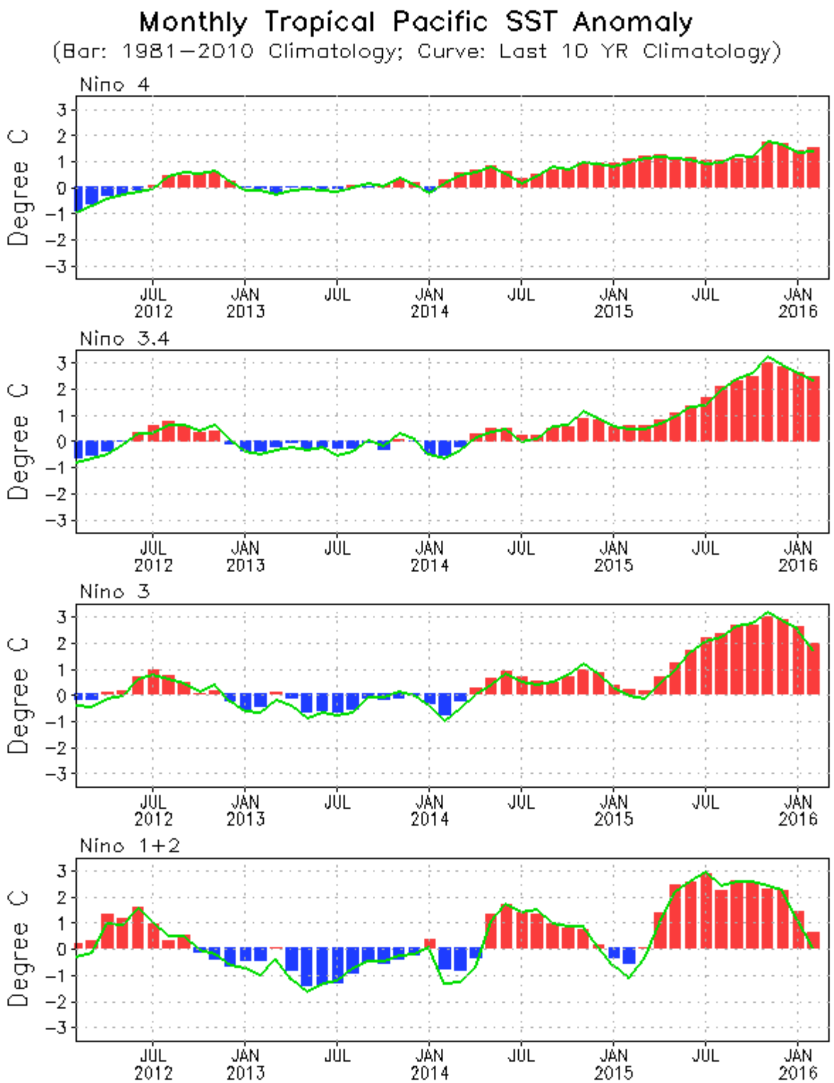
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

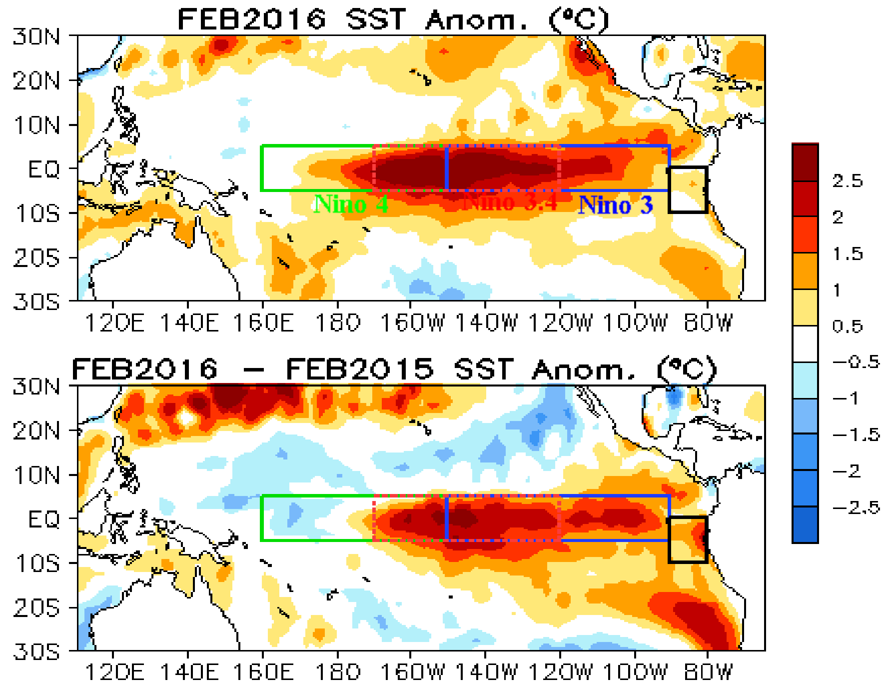
Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

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*.

Evolution of Pacific NINO SST Indices





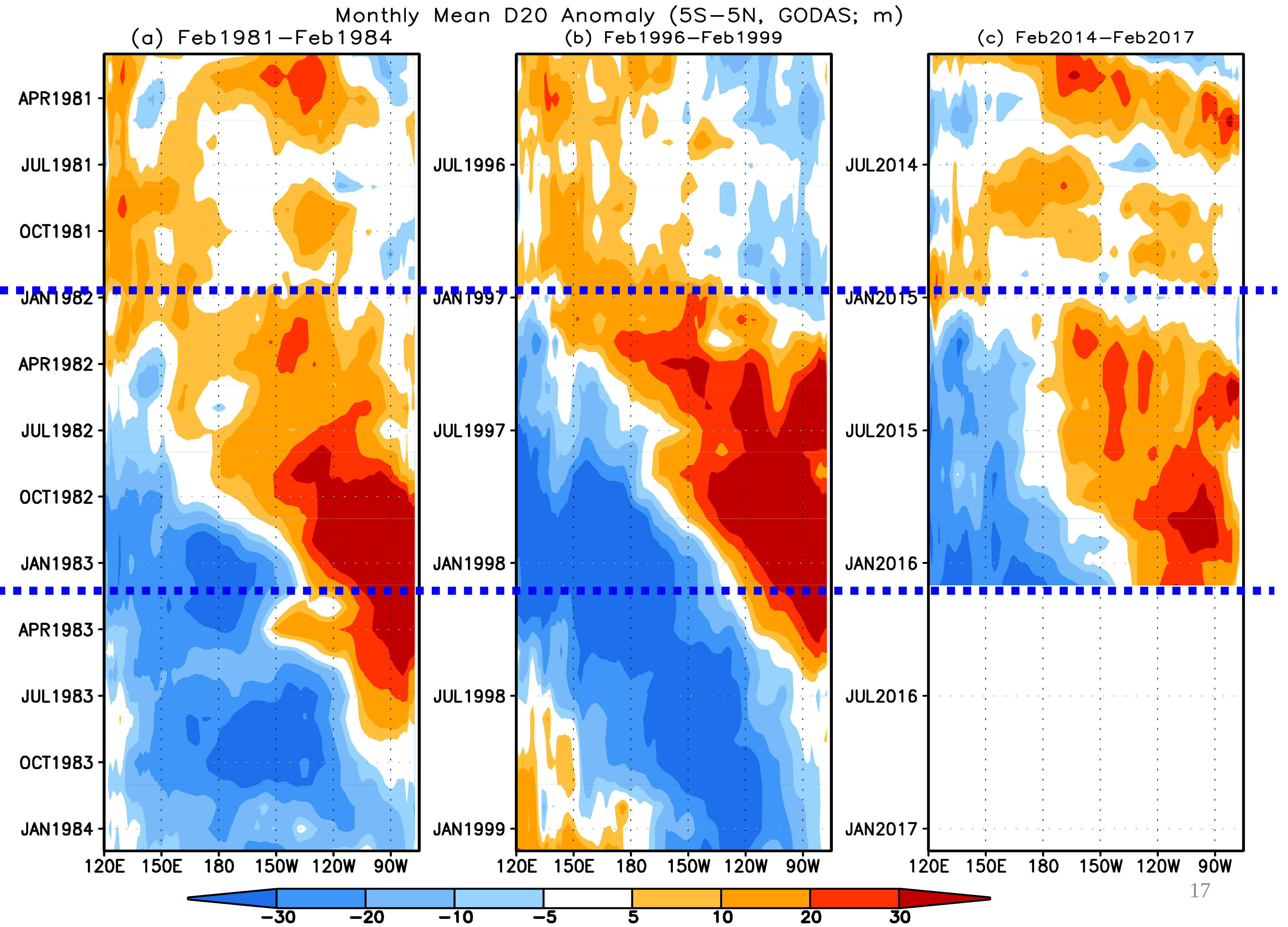
- Nino1+2, 3, and 3.4 indices were positive and weakened; Nino4 slightly strengthened in Feb 2016.

- Nino3.4 = 2.4°C in Feb 2016.

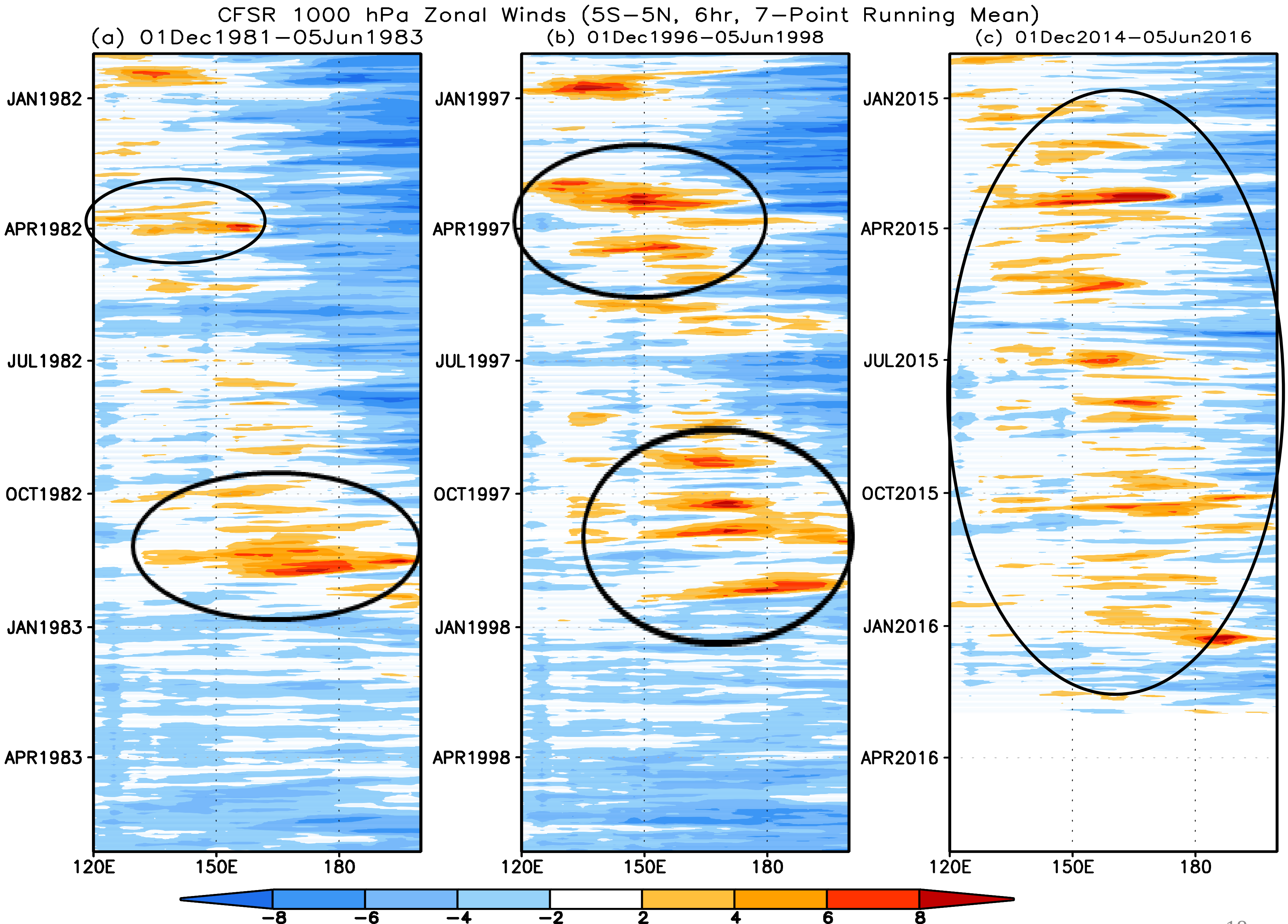
- Compared with last Feb, the central and eastern equatorial Pacific was much warmer in Feb 2016.

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

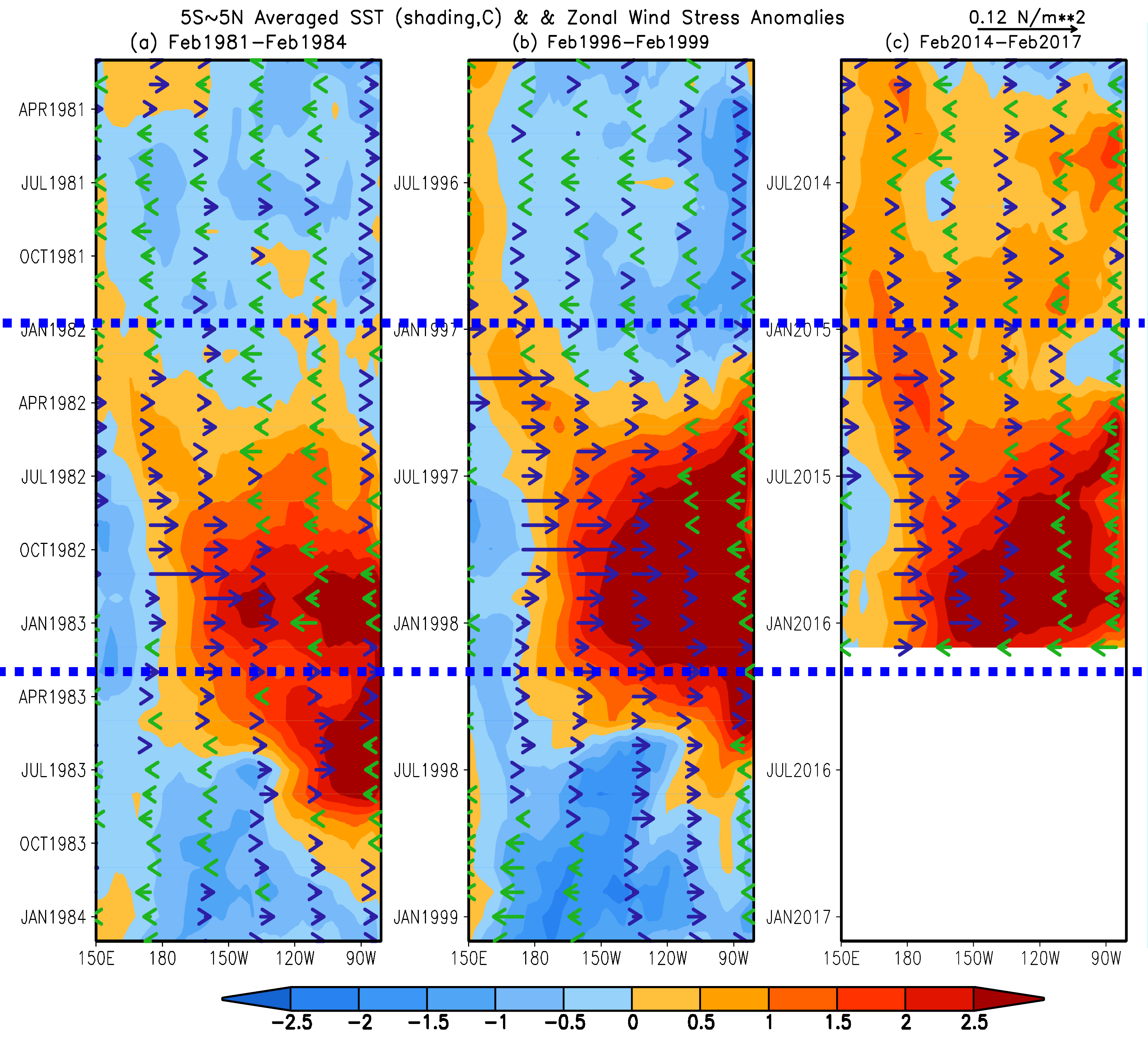
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.



Monthly Mean D20 Anomaly (5S–5N, GODAS; m)
(a) Feb1981–Feb1984
(b) Feb1996–Feb1999
(c) Feb2014–Feb2017
APR1981
JUL1981
OCT1981
JAN1982
APR1982
JUL1982
OCT1982
JAN1983
APR1983
JUL1983
OCT1983
JAN1984
JUL1996
JAN1997
JUL1997
JAN1998
JUL1998
JAN1999
JUL2014
JAN2015
JUL2015
JAN2016
JUL2016
JAN2017
120E
150E
180
150W
120W
90W
–30
–20
–10
–5
5
10
20
30



CFSR 1000 hPa Zonal Winds (5S–5N, 6hr, 7–Point Running Mean)
(a) 01Dec1981–05Jun1983
(b) 01Dec1996–05Jun1998
(c) 01Dec2014–05Jun2016
JAN1982
APR1982
JUL1982
OCT1982
JAN1983
APR1983
JAN1997
APR1997
JUL1997
OCT1997
JAN1998
APR1998
JAN2015
APR2015
JUL2015
OCT2015
JAN2016
APR2016
120E
150E
180
−8
−6
−4
−2
2
4
6
8



Compared with 1982-83 and 1997-98, *in 2015-16,*

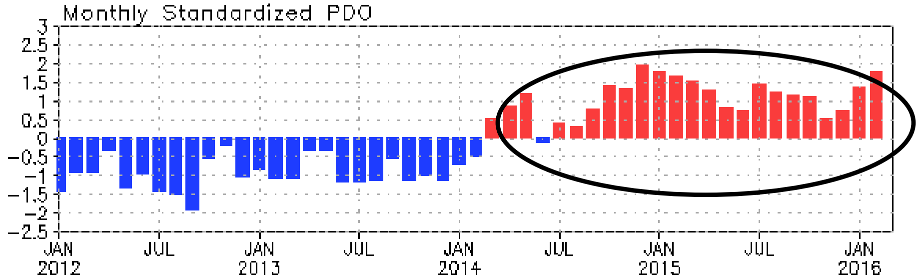
(a) D20 anomaly was smaller;

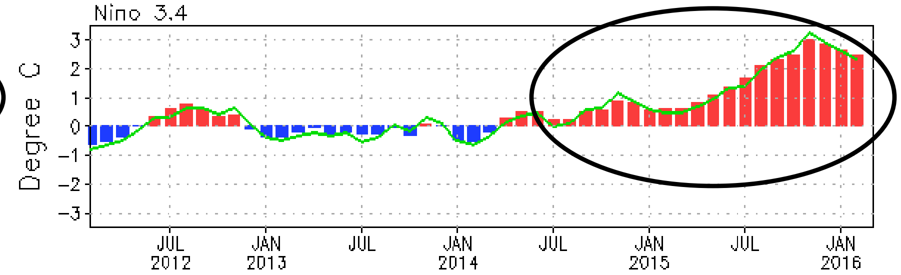
(b) WWB and low-level westerly anomaly were weaker, but lasted a longer period;

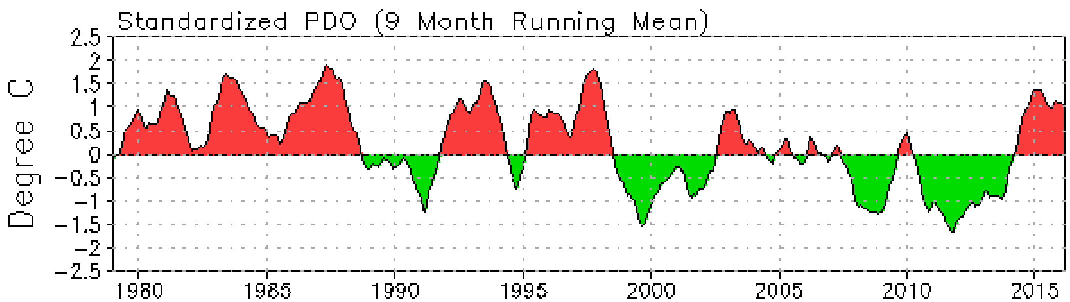
(c) Maximum SSTA was more confined in the Nino3.4 region.

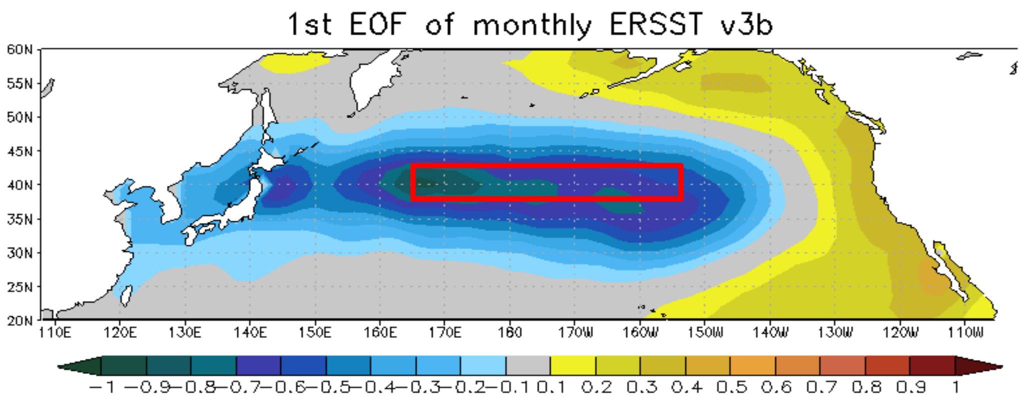
North Pacific & Arctic Oceans

PDO index







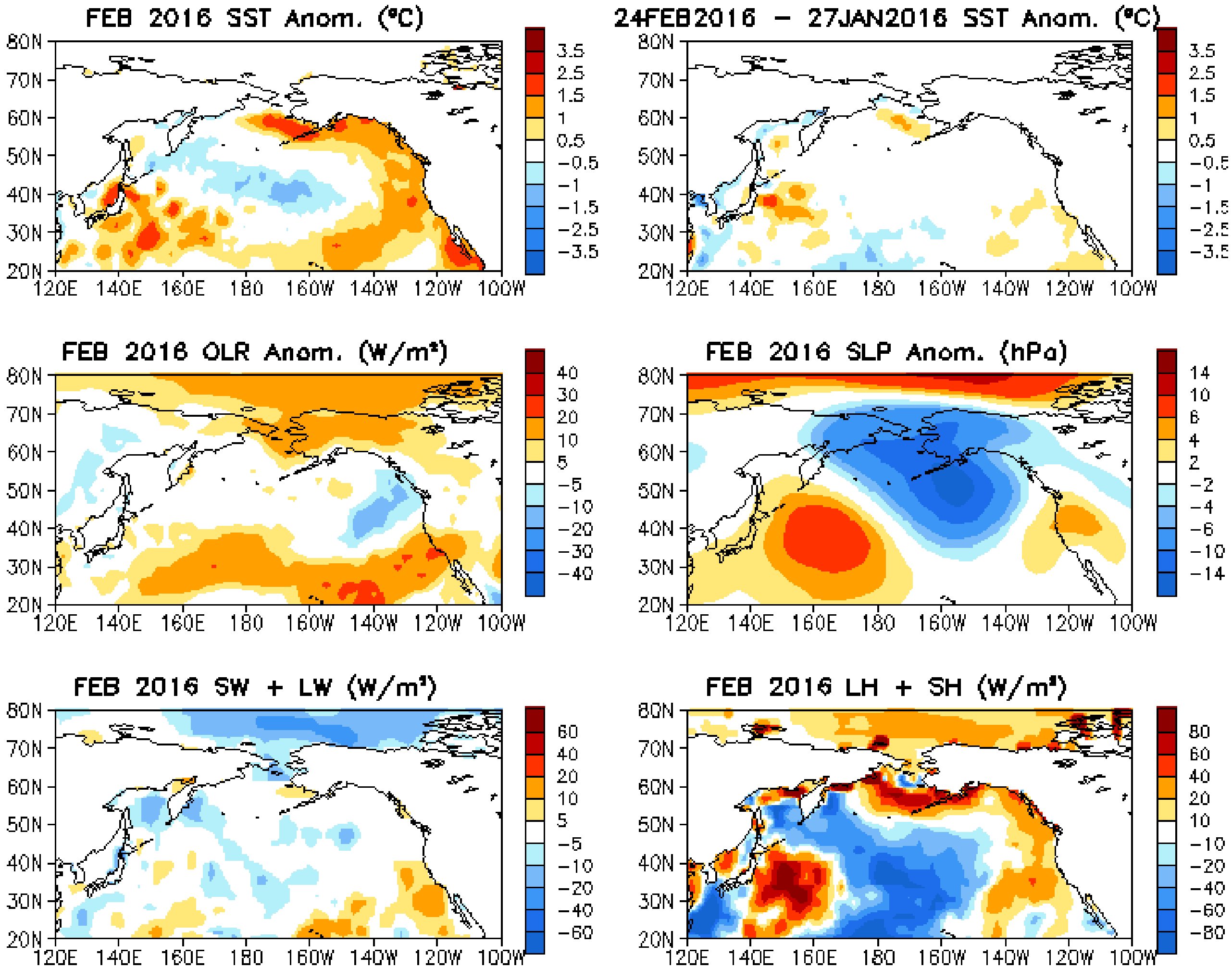


- **The positive phase of PDO index has persisted 20 months since Jul 2014, and strengthened with PDO index =1.76 in Feb 2016.**

- **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.**

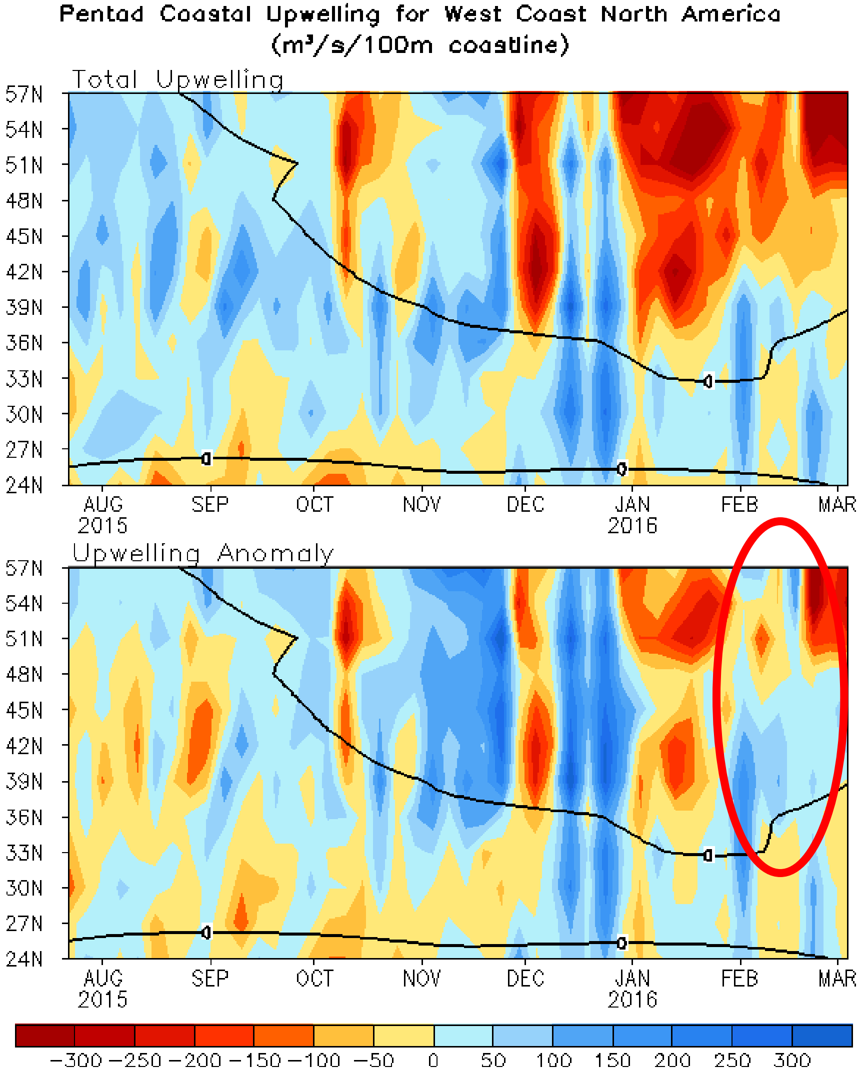
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

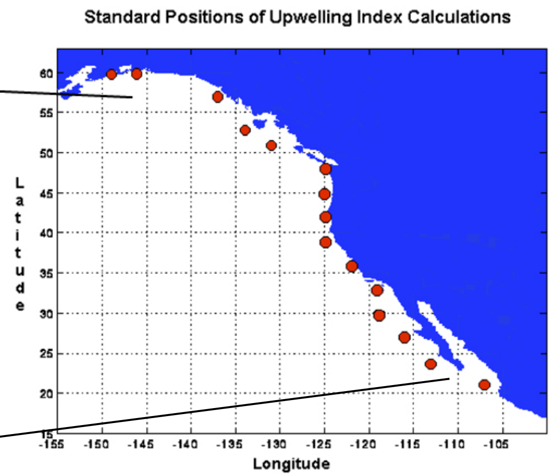


- **Positive SSTA presented in the NE Pacific, consistent with the positive phase of PDO index (previous slide).**
- **The SST tendency was small in N. Pacific.**
- **Below-normal SLP presented in the high latitudes, and above-normal one was observed in the NW Pacific and SW North America.**

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





- Both anomalous upwelling and downwelling presented in Feb 2016.

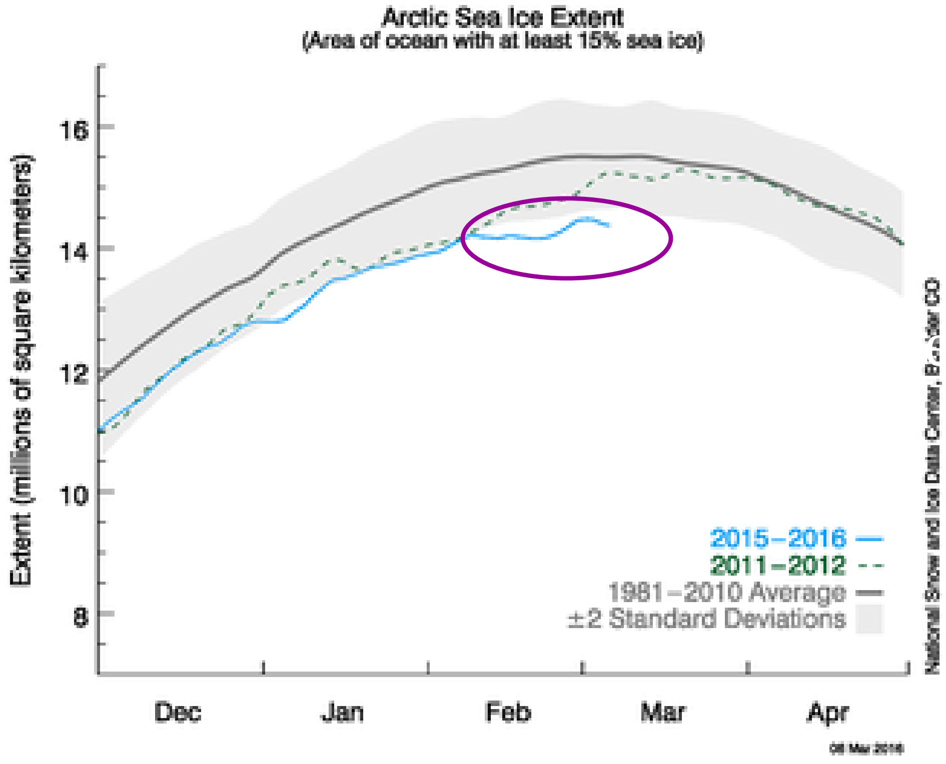
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport 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

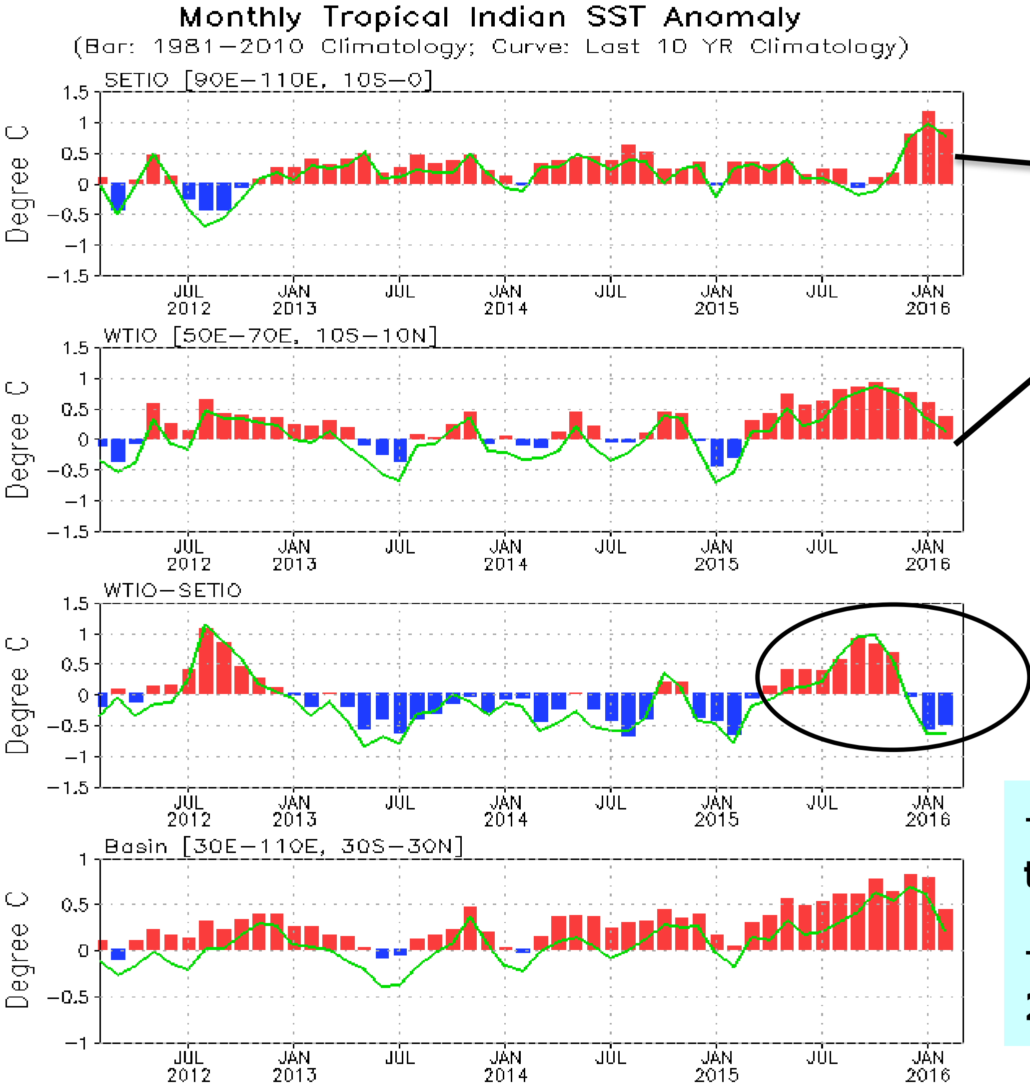
http://nsidc.org/arcticseaicenews/index.html

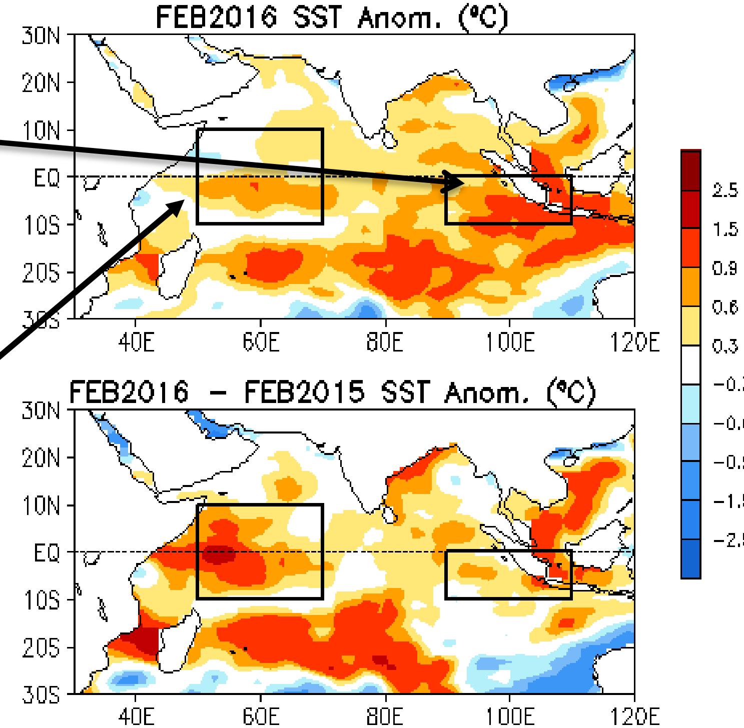


- **Arctic sea ice extent in Feb 2016 was smaller than -2 standard deviations and less than that in 2011-12.**

Indian Ocean

Evolution of Indian Ocean SST Indices





- **Positive SSTA was larger in the east than in the west.**
- **DMI was below normal since Dec 2015.**

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 larger in the east than in the west.**
- **SSTA tendency was largely determined by heat flux.**
- **Convections were enhanced over the northern basin.**

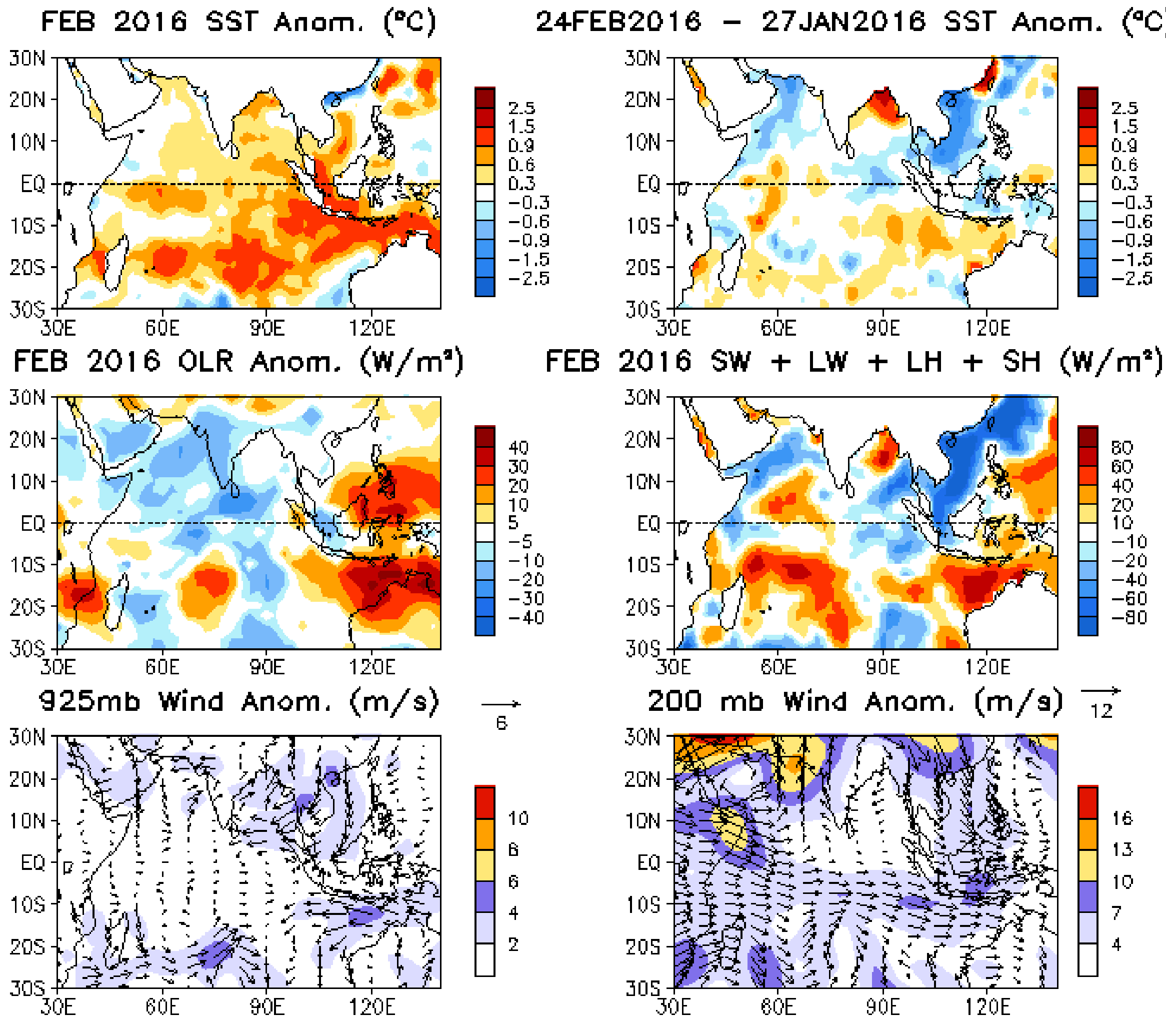
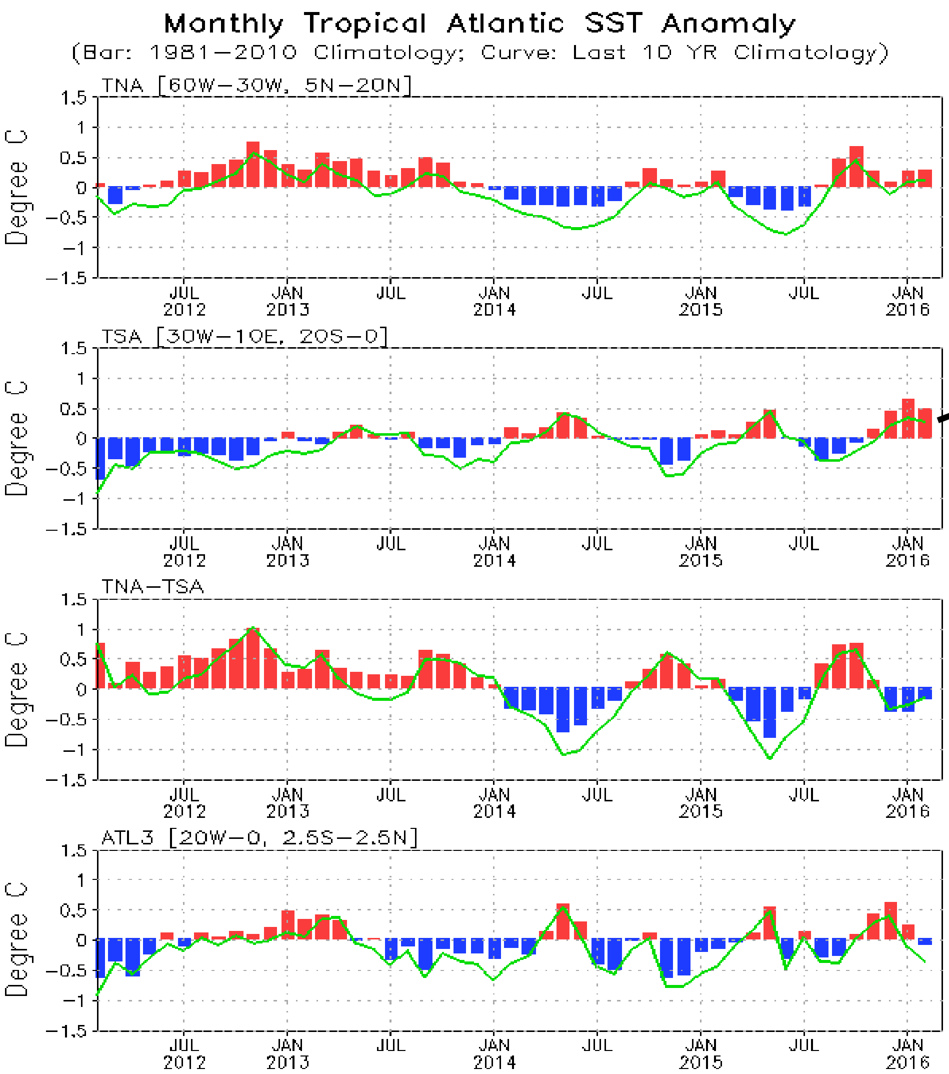
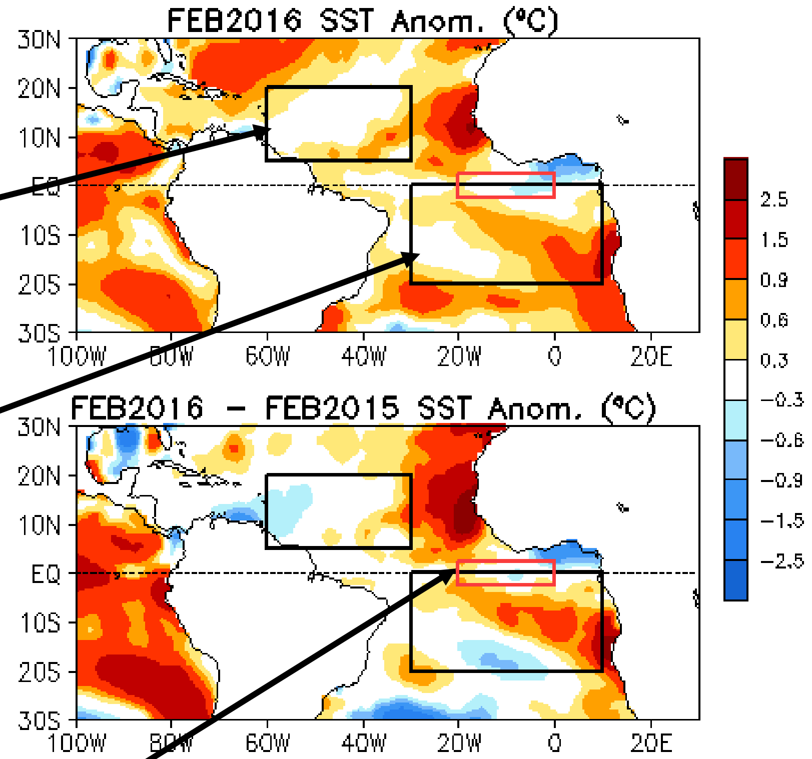


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

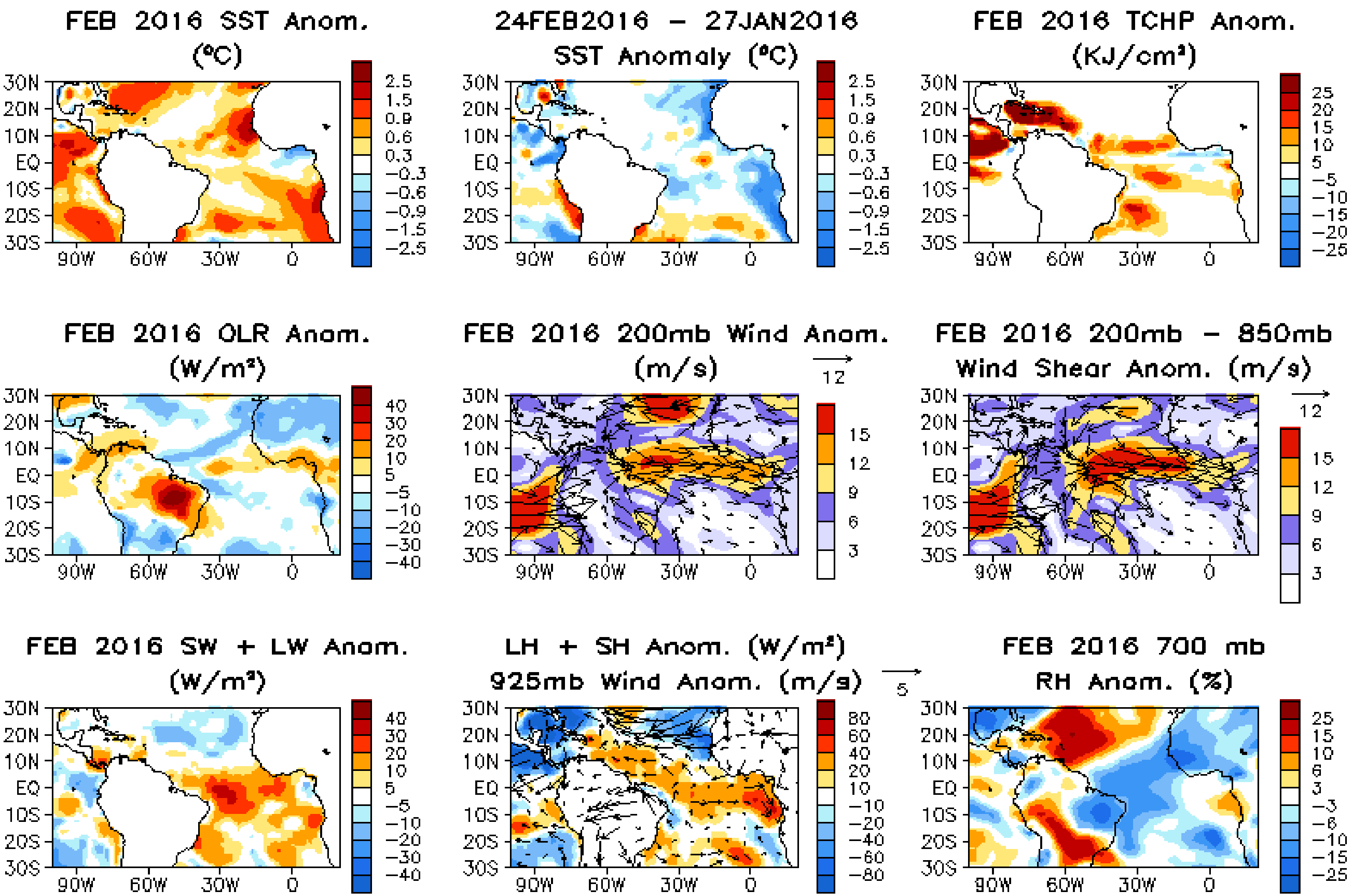




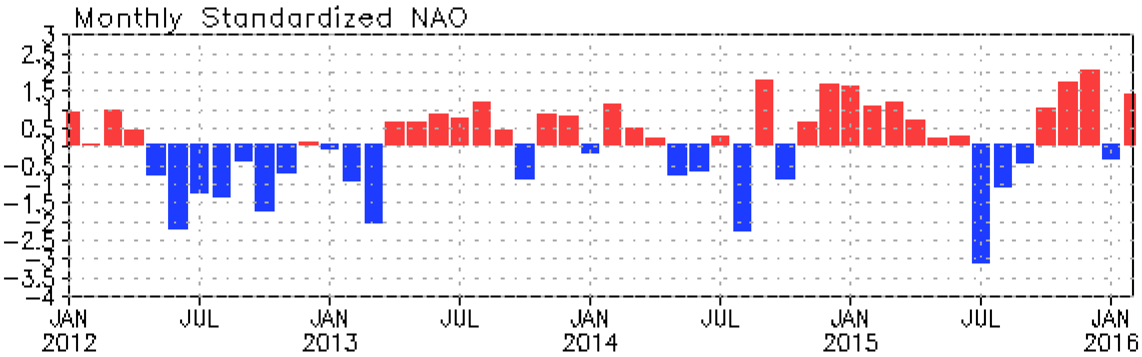
- All indices, except TSA, had small values in Feb 2016.

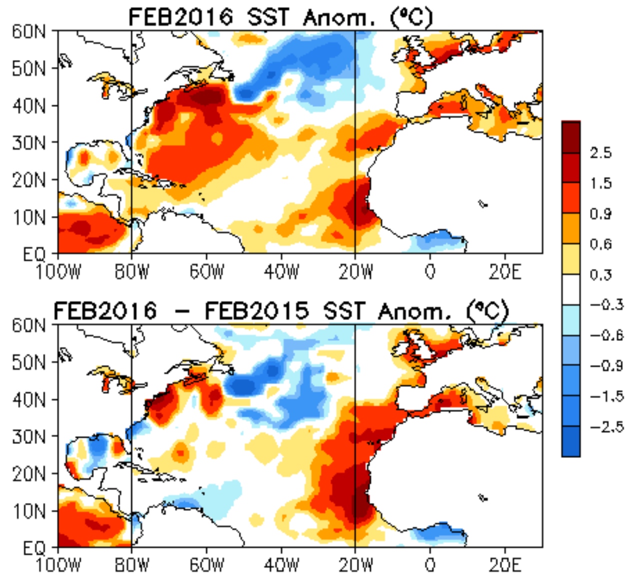
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between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

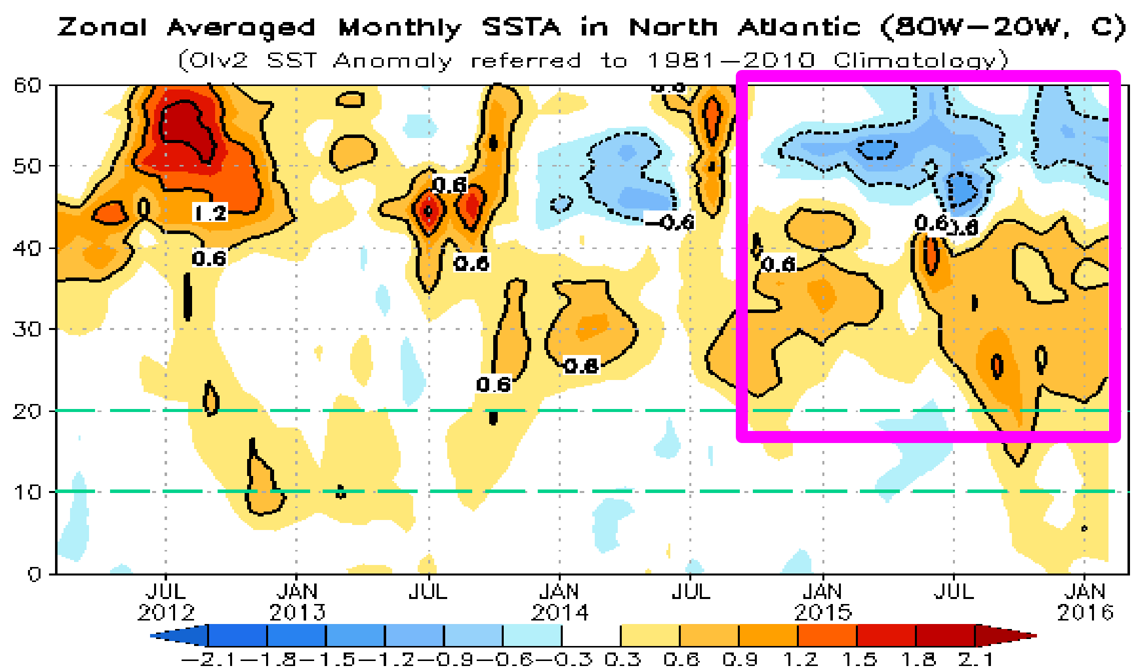
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic





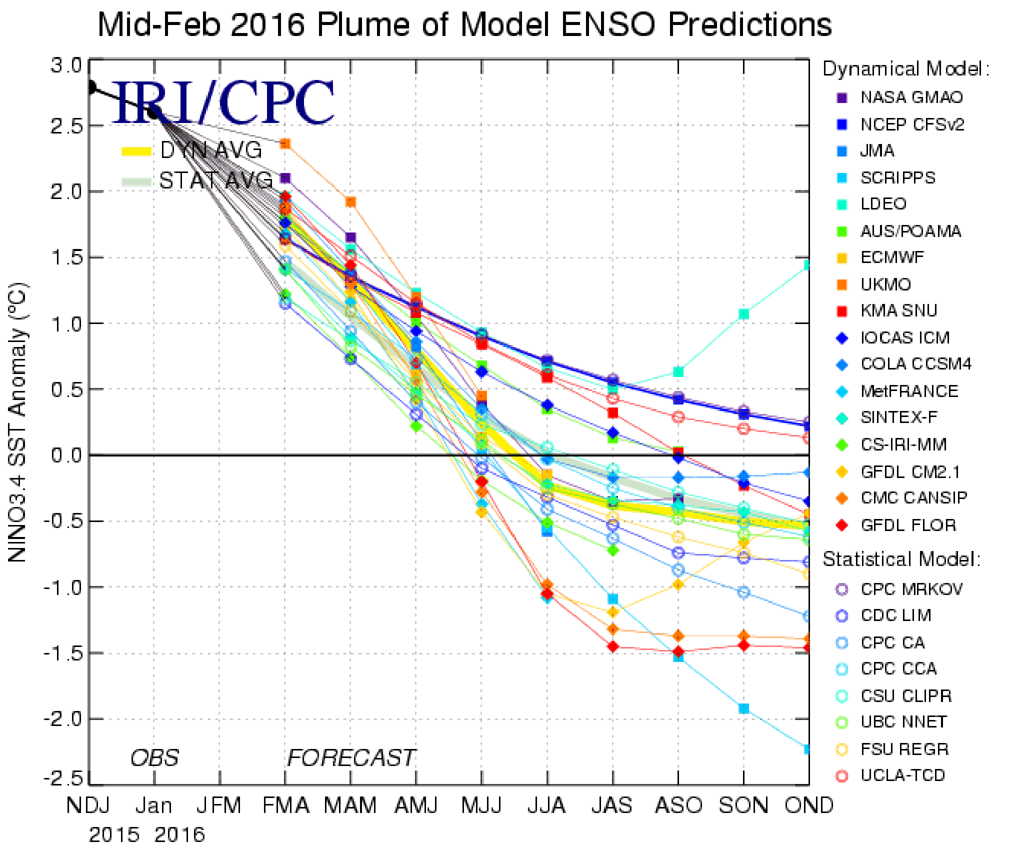


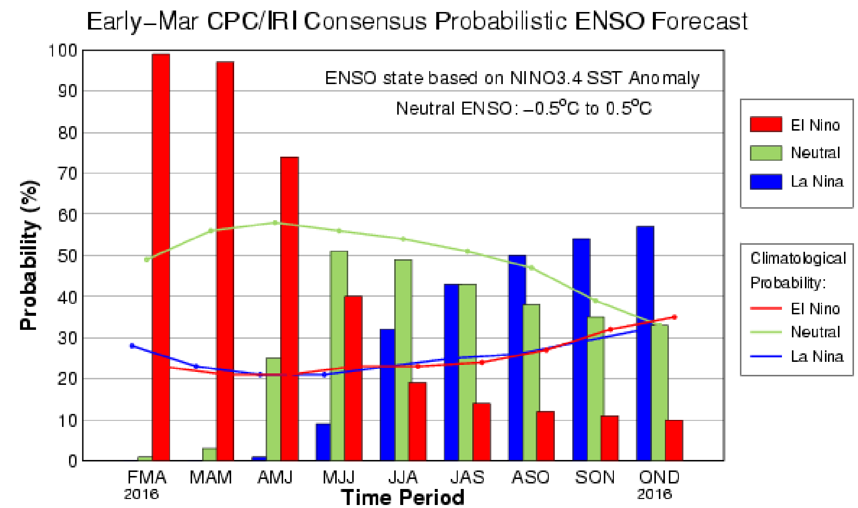
- NAO switched to positive phase with NAOI=1.35 in Feb 2016.
- SSTA was positive in the middle latitudes and negative in the high latitudes, may be due to the influence of positive phase of NAO.

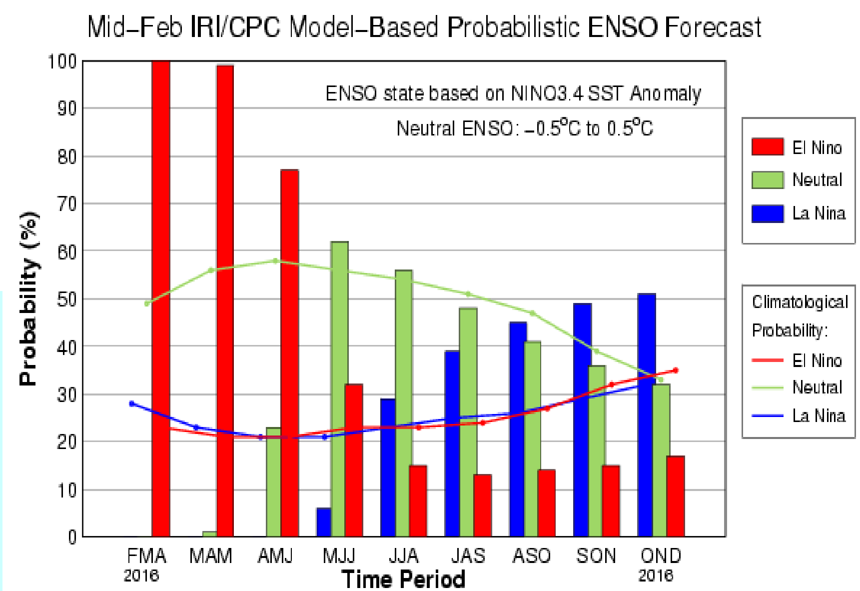
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum



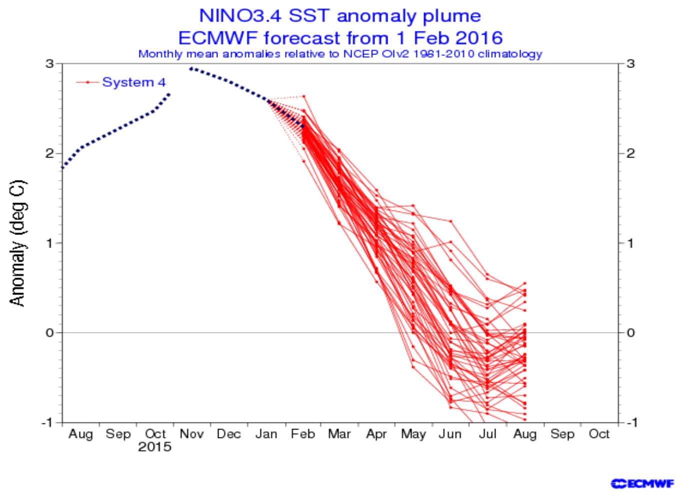




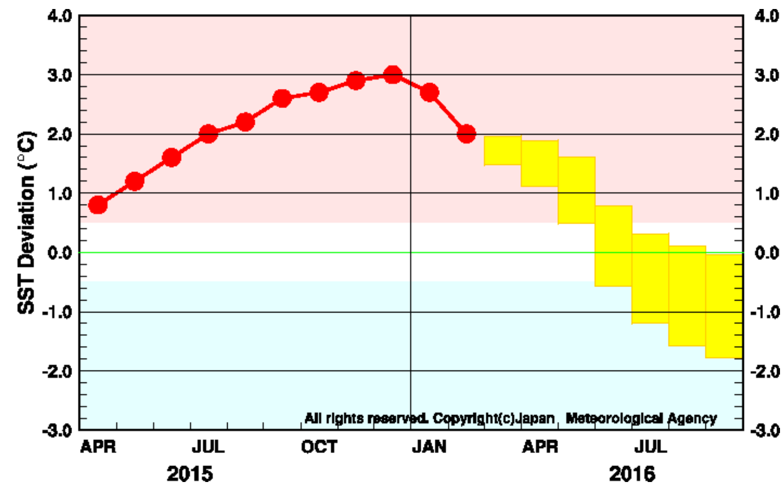
- **Some models predicted a La Nina or neutral started since the second half of 2016 and some models favor El Nino.**
- **NOAA "ENSO Diagnostic Discussion" on 10 Mar 2016 issued "El Nino Advisory" and suggested that** ***"A transition to ENSO-neutral is likely during late Northern Hemisphere spring or early summer 2016, with close to a 50% chance for La Niña conditions to develop during the fall."***

Individual Model Forecasts: neutral or La Nina

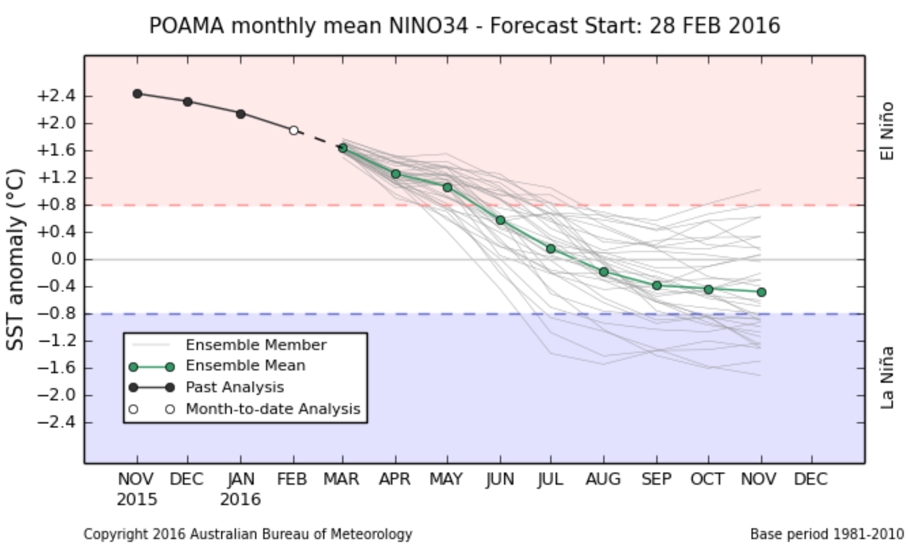
EC: Nino3.4, IC=01Feb 2016



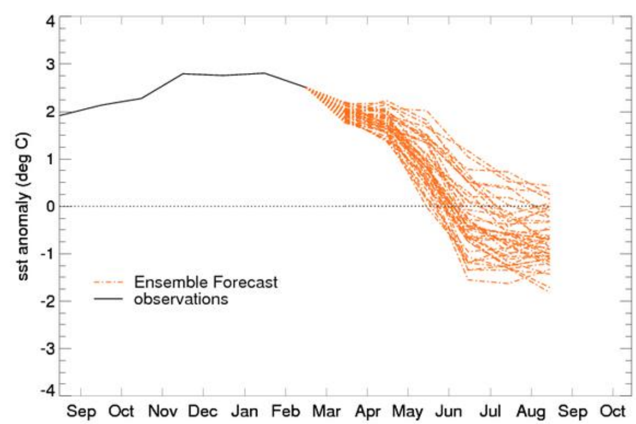
JMA: Nino3, IC=Mar 2016



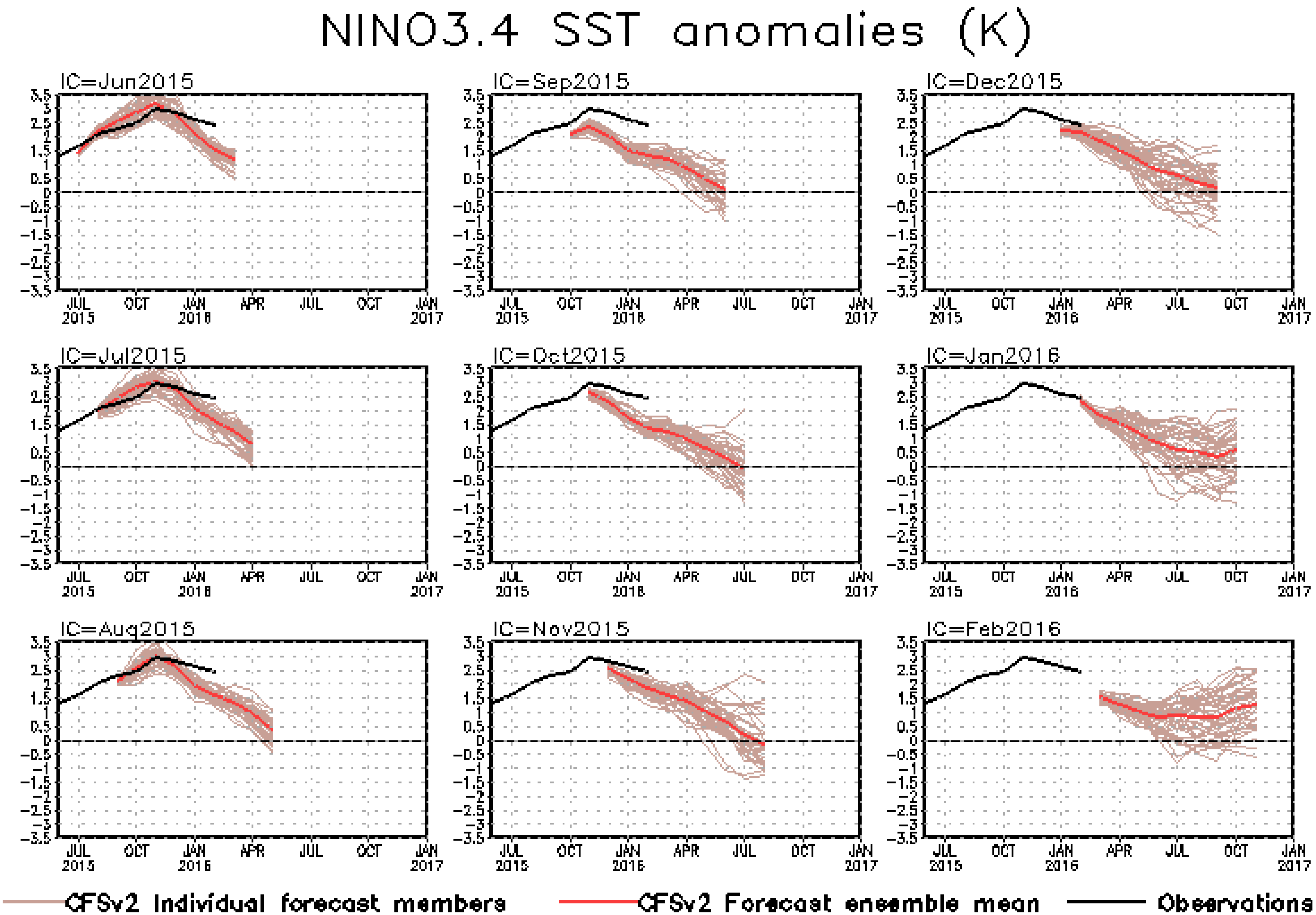
Australia: Nino3.4, IC=28Feb 2016



UKMO: Nino3.4, IC=Mar 2016

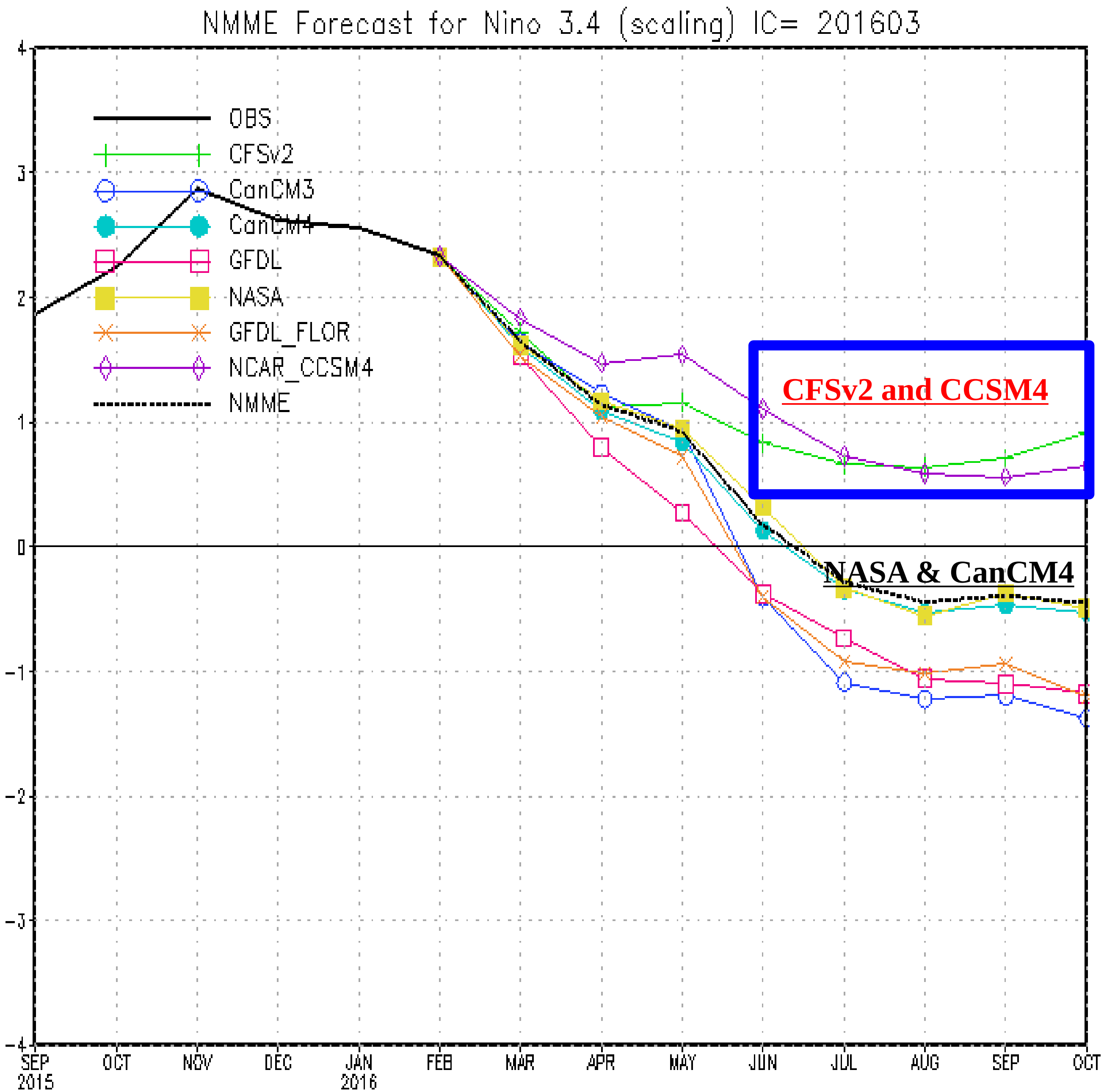


CFS Niño3.4 SST Predictions from Different Initial Months



- CFSv2 predictions had cold biases with ICs in Jun-Dec 2015.

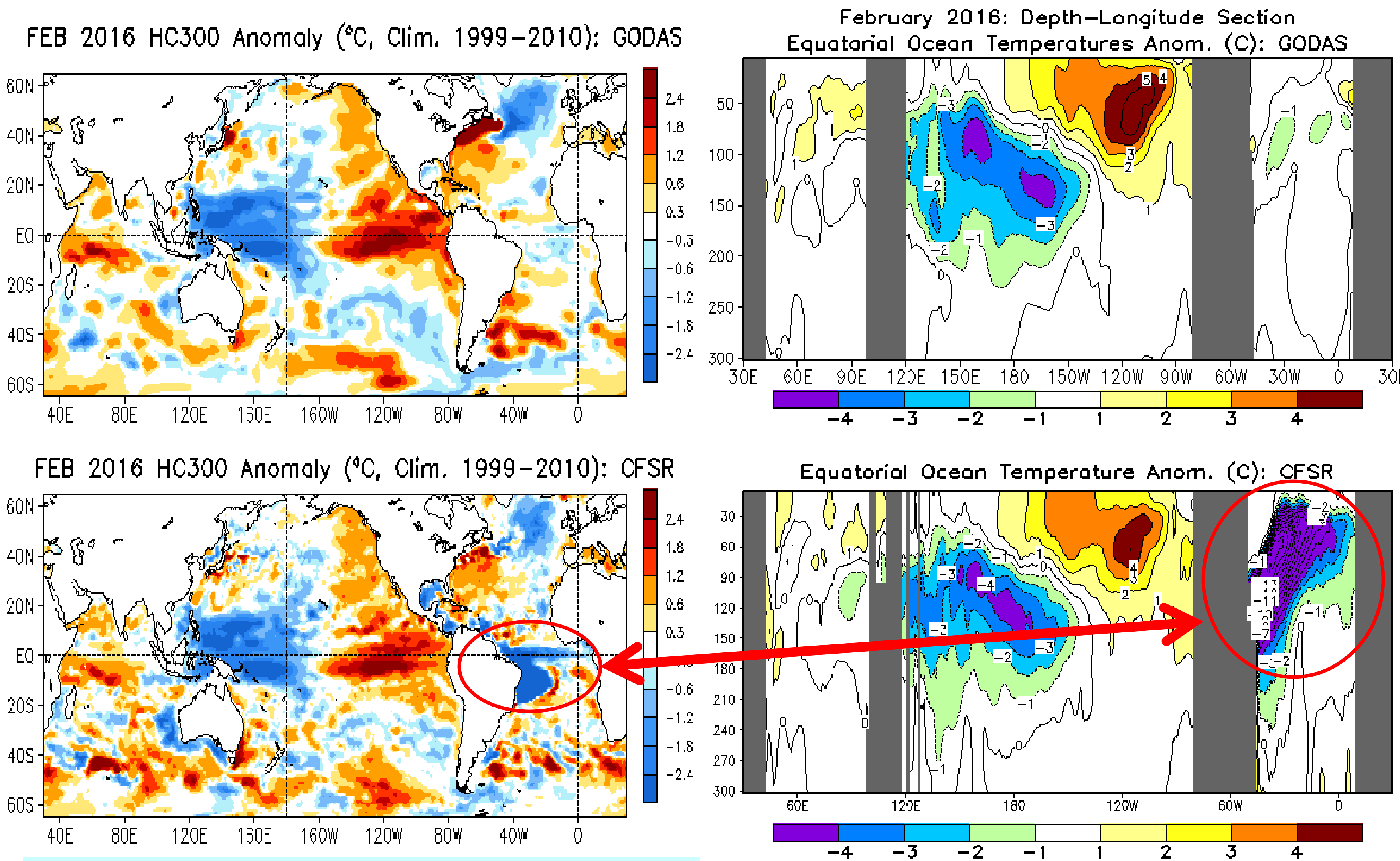
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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



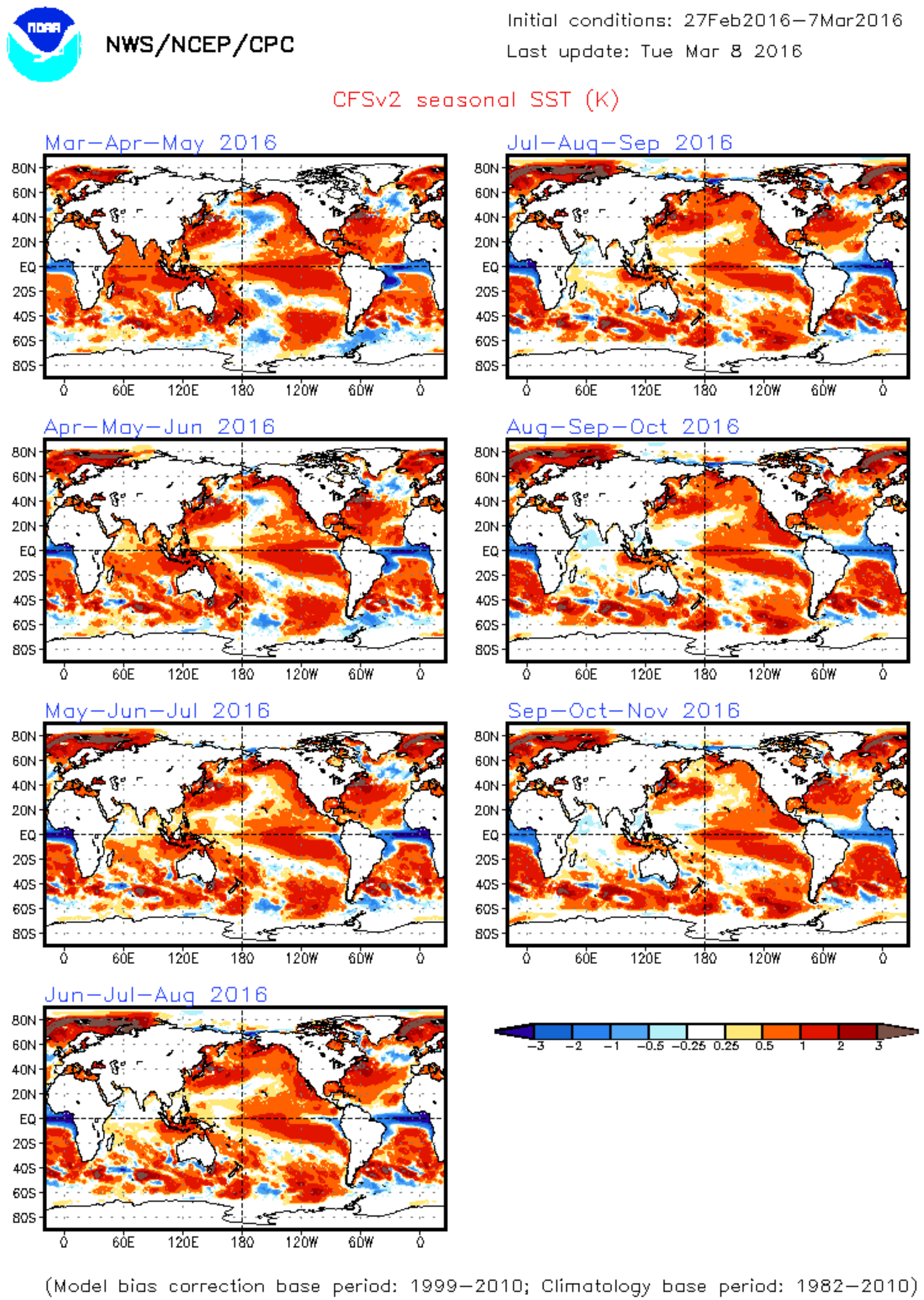
- Both CFSv2 and CCSM4 call for El Nino conditions (NINO3.4 > +0.5C) to continue into summer and fall 2016, while other NMME models suggest a transition to La Nina conditions in later summer and fall.

- Interestingly both the CFSv2 and CCSM4 use the CFSR ocean ICs.

Did cold biases in CFSR cause the slow decay of El Niño in CFSv2 Forecasts?



- Significant cold biases in the tropical Atlantic were noted in CFSR ocean ICs, that started around spring 2015, and grew to be -10C colder than the GODAS by the end of 2015.
- The Atlantic cold biases in the CFSR probably have influenced the ENSO forecast in CFSv2 and CCSM4 to some extend (provided by Dr. Yan Xue).



Predicted strong negative SSTA in the equatorial Atlantic may be associated with strong cold biases in CFSR ICs.

The predicted cold SST in the tropical Atlantic might influence SST prediction in the eastern Pacific associated with ENSO evolution.

Will La Niña follow El Niño? What the past tells us

Author: Anthony G. Barnston; Thursday, January 28, 2016

https://www.climate.gov/news-features/blogs/enso/will-la-ni%C3%B1a-follow-el-ni%C3%B1o-what-past-tells-us

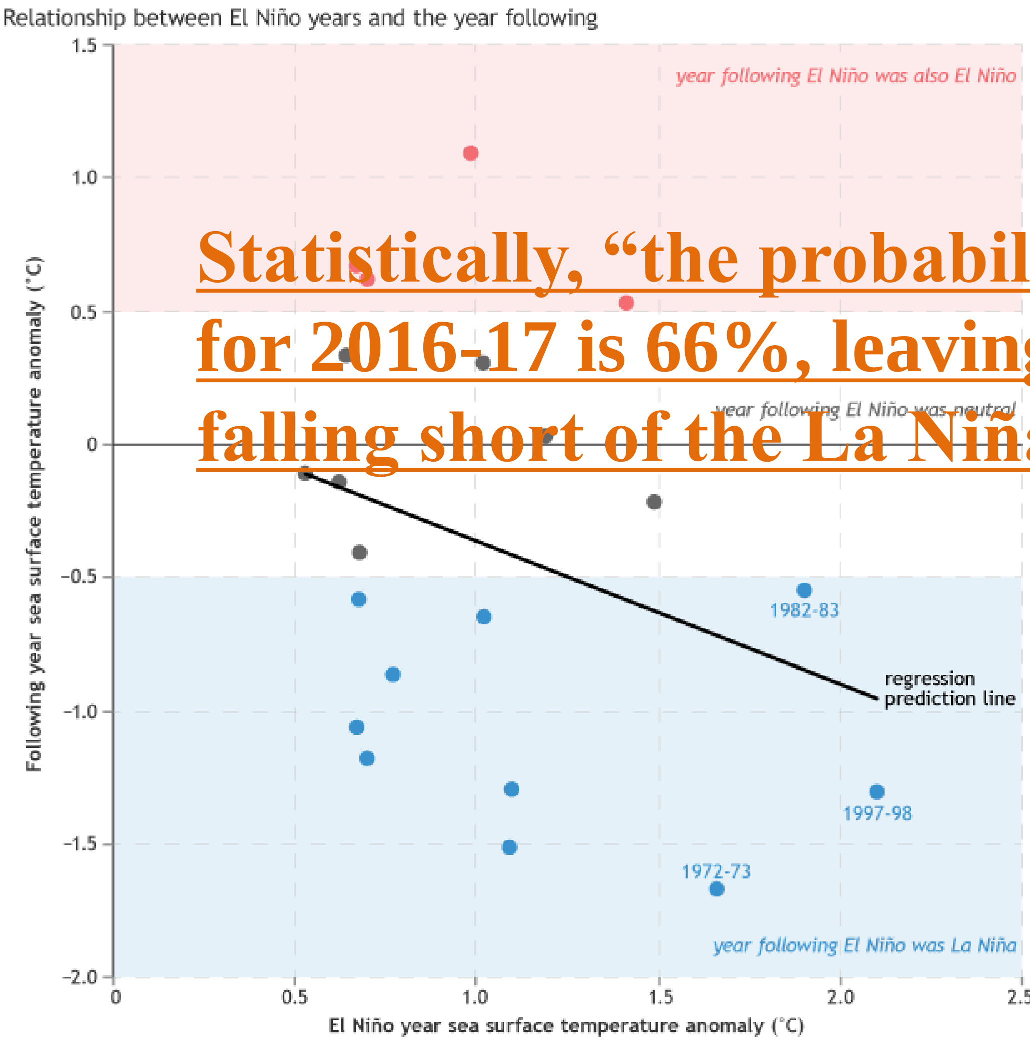
SST anomalies following strong El Niño events

El Niño year	Average ONI (Aug-Mar)	Average ONI one year later
1972-73	**1.66**	**-1.67**
1982-83	**1.90**	~~-0.55~~
1997-98	**2.10**	-1.30
AVERAGE	**1.89**	3939

Will La Niña follow El Niño? What the past tells us

Author: Anthony G. Barnston; Thursday, January 28, 2016

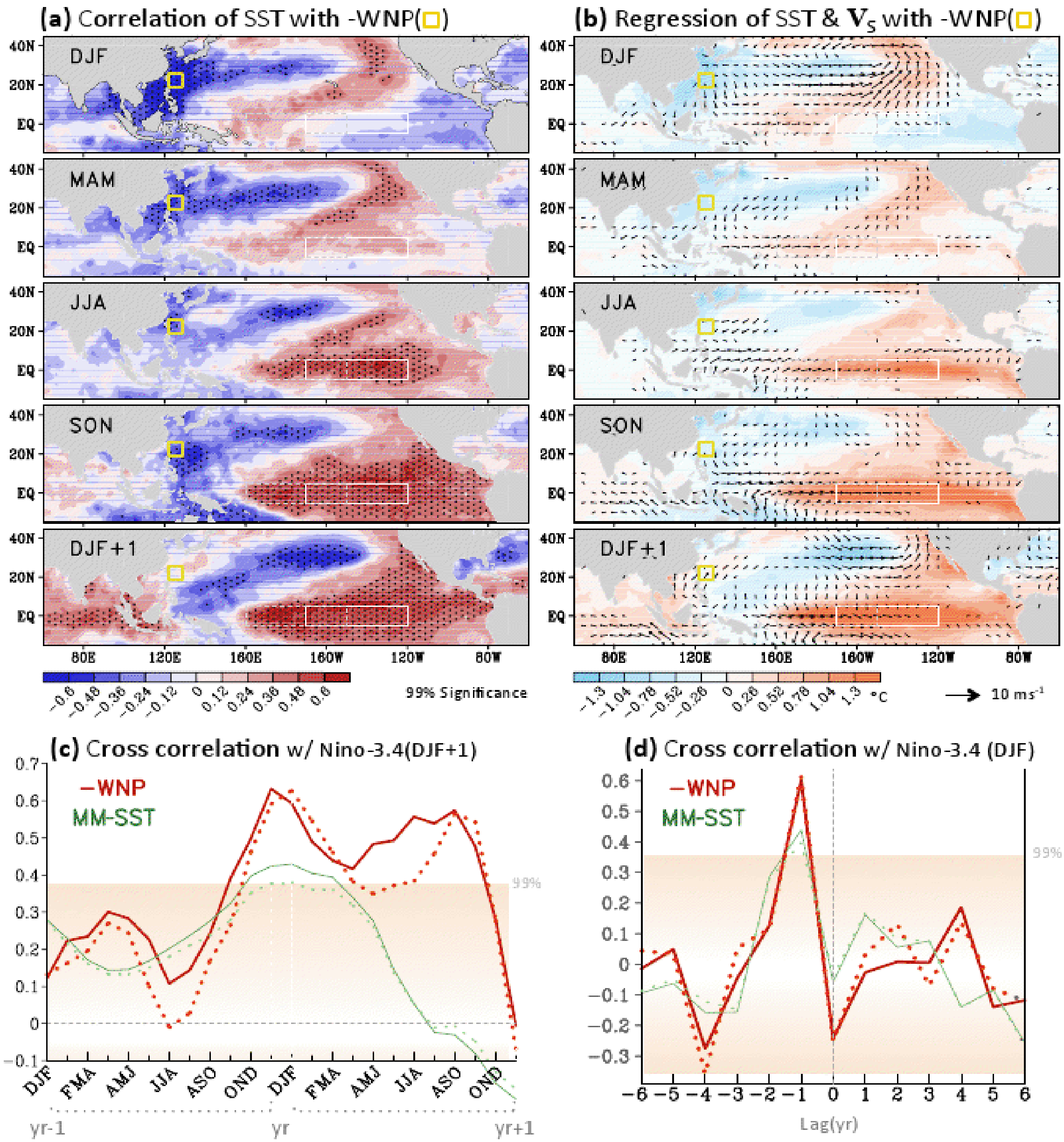
https://www.climate.gov/news-features/blogs/enso/will-la-ni%C3%B1a-follow-el-ni%C3%B1o-what-past-tells-us



Statistically, “the probability of getting La Niña for 2016-17 is 66%, leaving a 34% chance for falling short of the La Niña threshold.”

Scatterplot showing the relationship between the ENSO state (using the 6-running-season ONI definition) for years having an El Niño (x-axis), and the ENSO state the following year. Each dot represents one pair of “year 1 vs. year 2” ENSO states for El Niños observed since 1950. The downward sloping line is a simple linear regression fit to the data points, defined so that the square of the errors (the vertical distance from each point to the line) is mathematically minimized. A forecast for the ENSO state for the year following an El Niño can be made using the line, by setting the x-axis value to the ENSO state value for the El Niño year, and finding the y-axis value of the line for that x-axis value. For example, if the ENSO state for the first (El Niño) year is 1.8, the estimate for the ENSO state for the next year would be about -0.8. The high standard error, and thus high uncertainty (see footnotes 6 and 7), is caused by the large errors of the points with respect to the line—i.e., many of the points are far above or below the line. That high uncertainty is indicated by the weakness of the correlation coefficient (-0.31) for the points in the scatterplot.

Western North Pacific Variability and ENSO



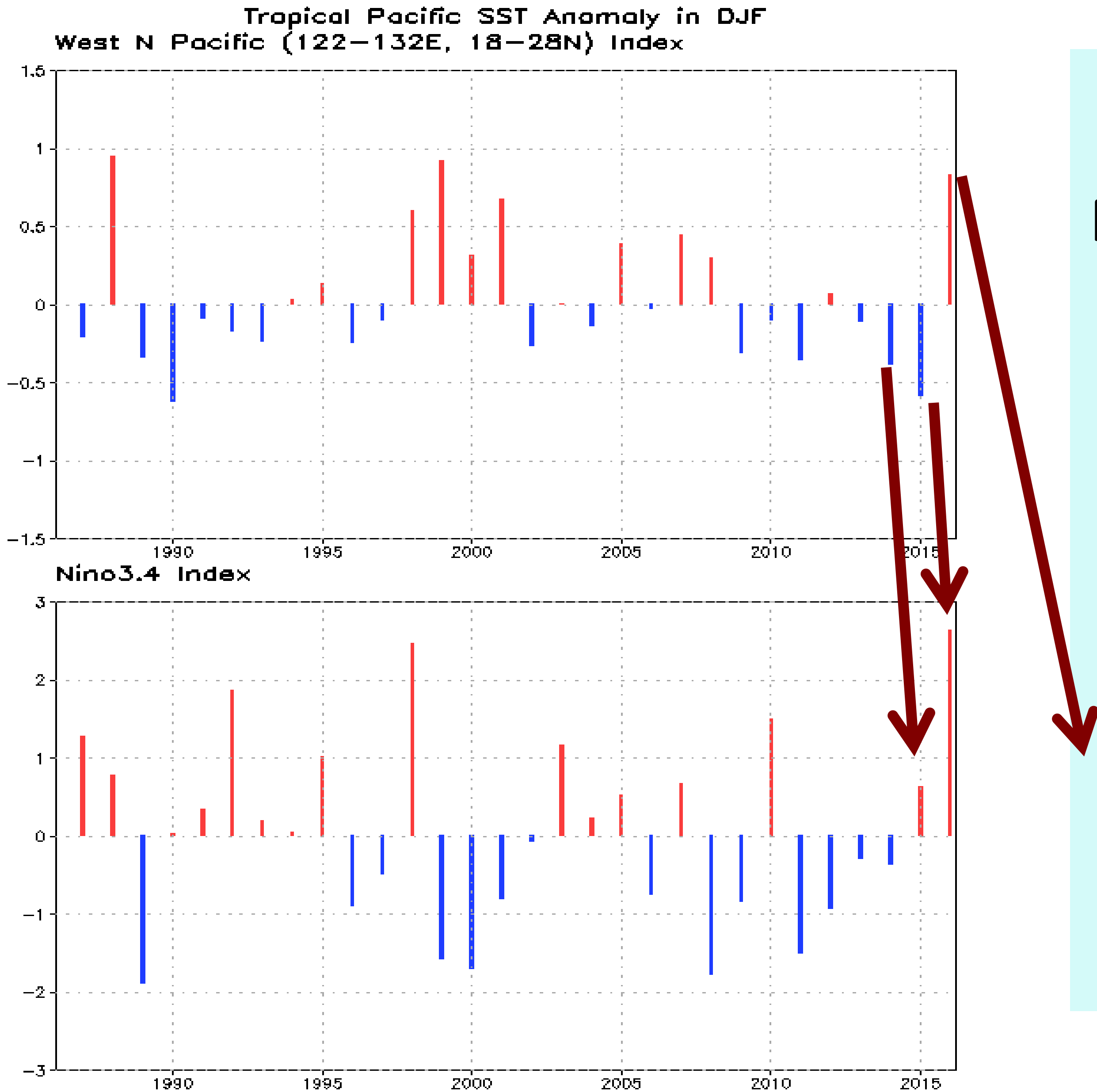
(a)DJF Cooling over the WNP is followed by a warming in the equatorial Pacific in next winter

(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.



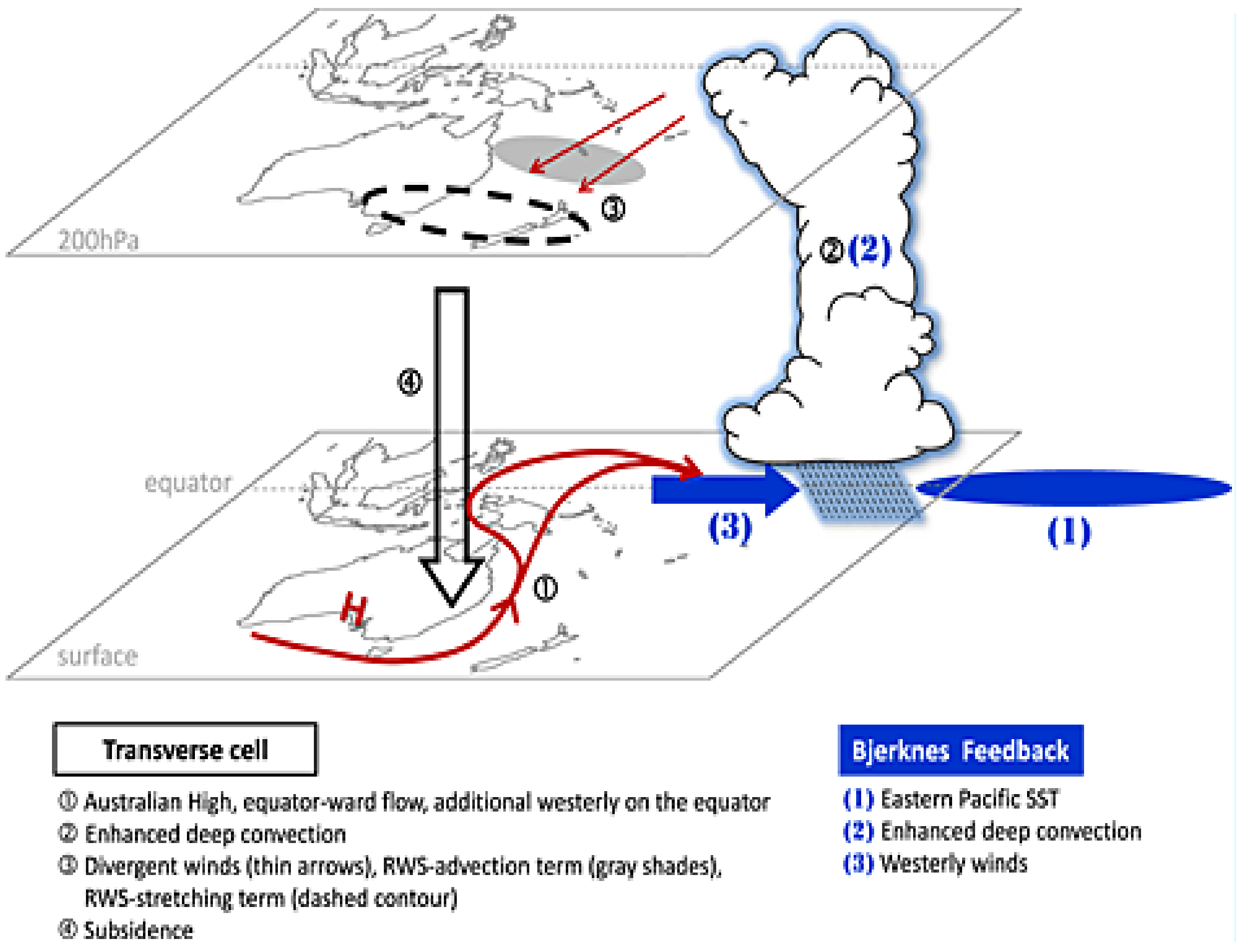
WNP and Nino3.4 indices:

(a) 2014/15 DJF WNP index was negative (≈-0.6), correctly predicted an El Nino event in 2015-16.

(b) 2015/16 DJF WNP index was large positive (>1.5), predicting a La Nina in 2016-17.

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. GRL, 41 (6), 2142-2149)



Positive Feedbacks:

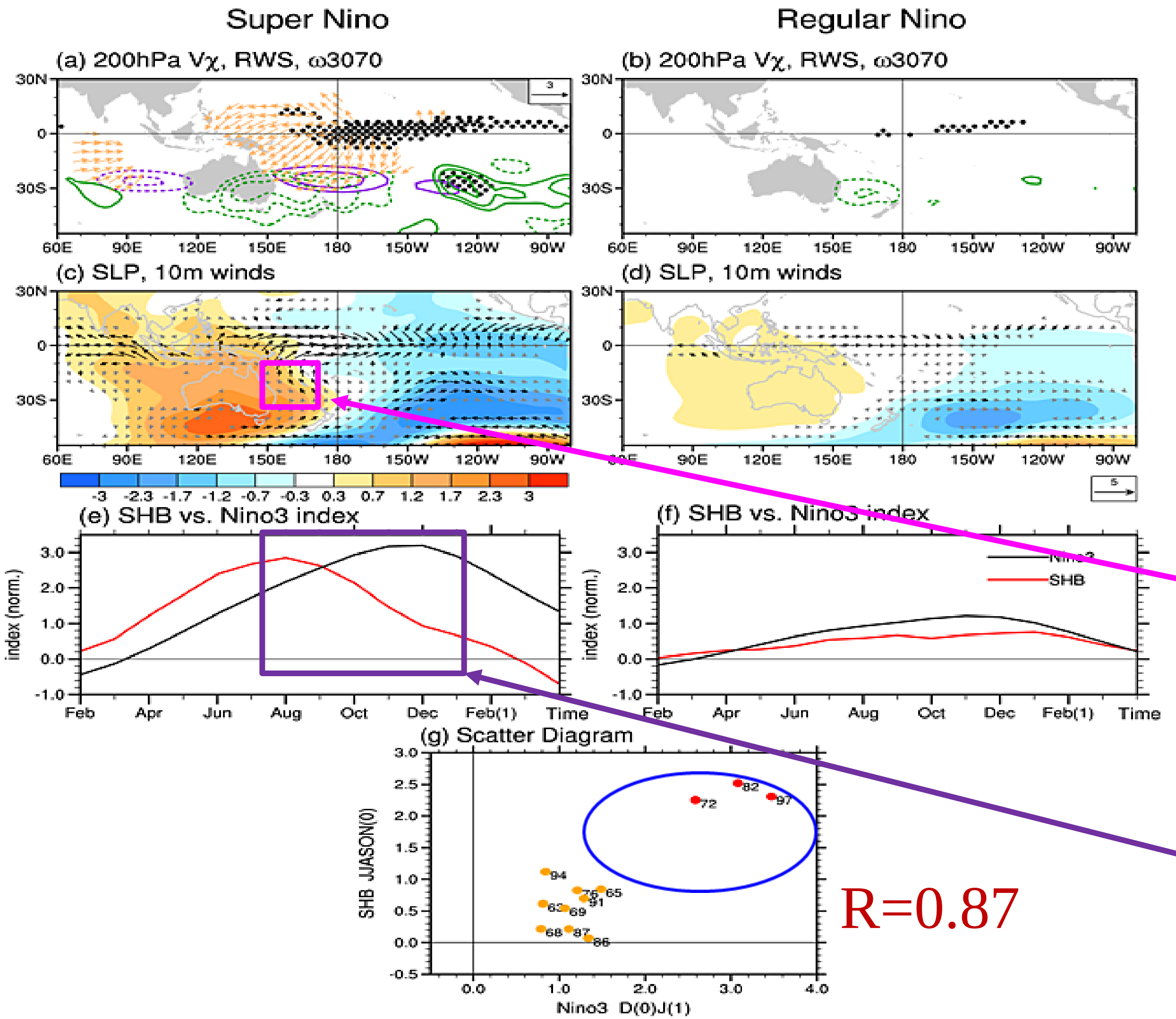
Enhanced convections over the central equatorial Pacific (anomalous divergence at 200 hPa)

-> 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.

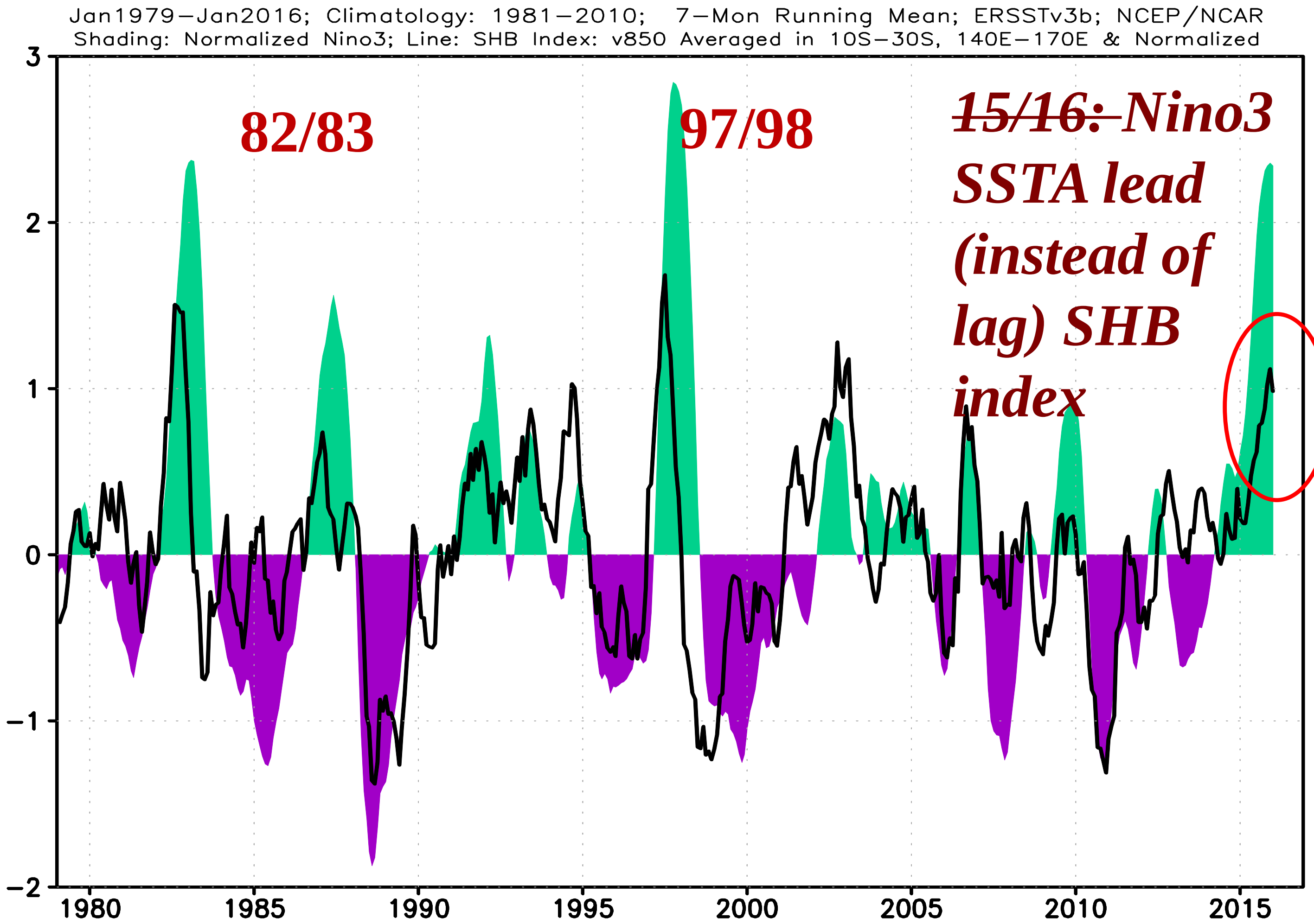
Fig. 4. Schematic diagram of super El Niño development, illustrating how a transverse cell with main features in the SH (marked by numbers inside open circles) interacts with the Bjerknes feedback regime in the central equatorial Pacific (depicted by large blue numbers in parentheses).



- *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.

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

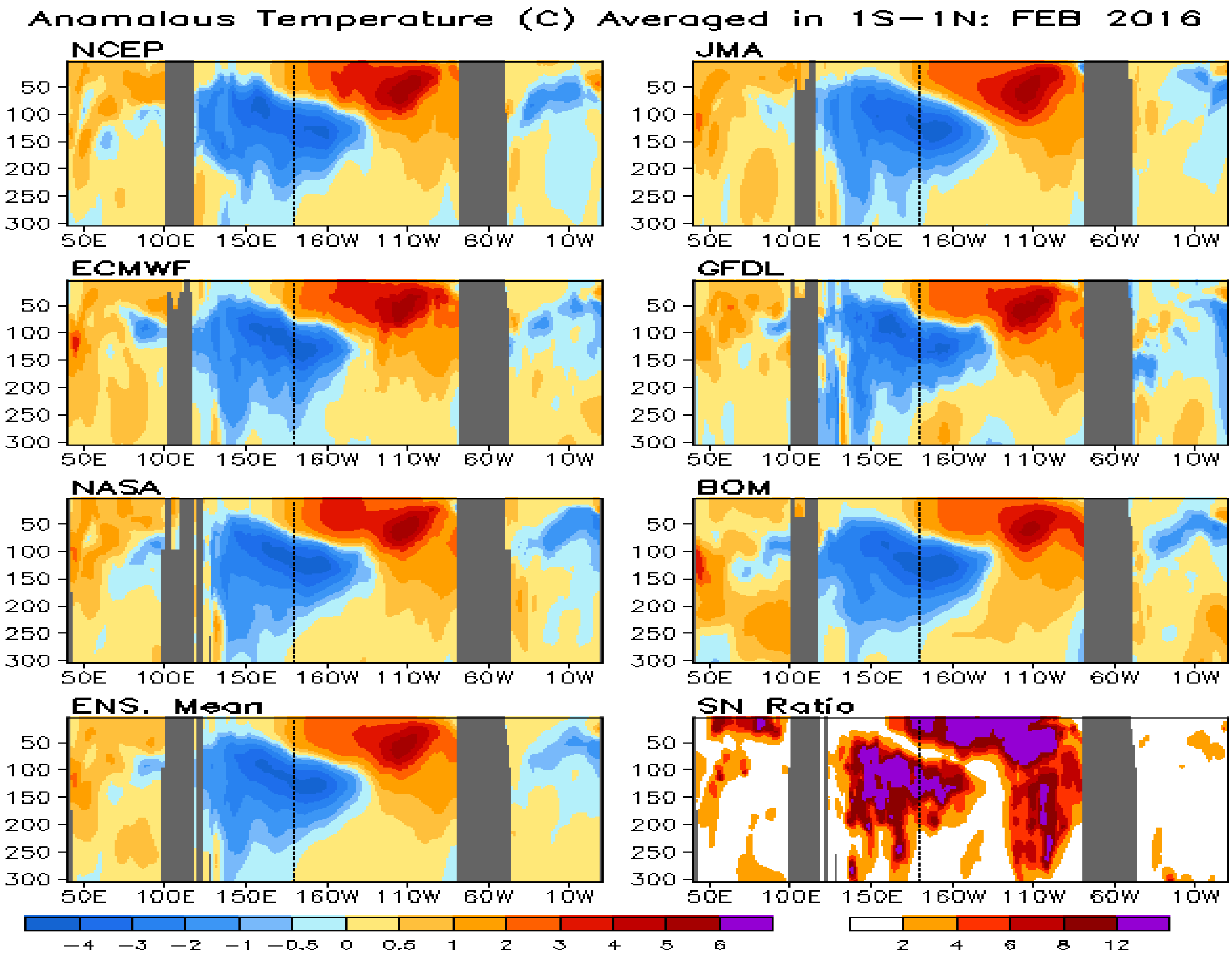


- **Since last winter, SHB index was positive and increasing.**
- **Nino3 had positive tendencies in last a few months.**
- **Based on Hong et al. (2014 GRL), SHB index peaks at August with 3-mon lead to El Nino, so SHB index value in summer is a good indicator to predict if there is a strong El Nino in winter.**

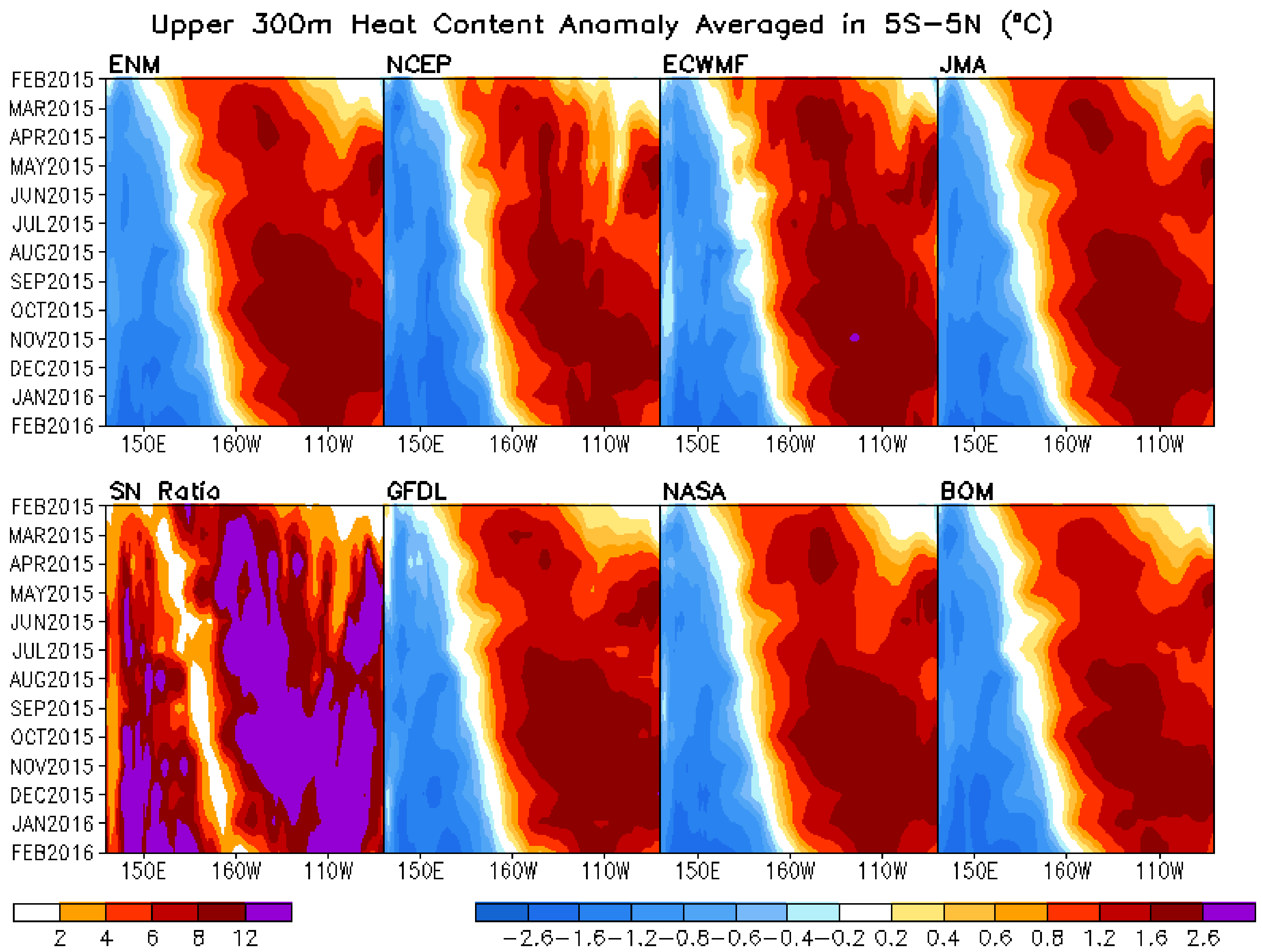
Red/blue shading: normalized Nino3
Black line: Southern Hemisphere booster (SHB) index: v850 averaged over 10°S–30°S, 140°E–170°E and normalized
ERSSTv3b and NCEP/NCAR reanalysis: 1981-2010 climatology; 7-month running mean

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

Backup Slides



Anomalous Temperature (C) Averaged in 1S-1N: FEB 2016
NCEP
JMA
ECMWF
GFDL
NASA
BOM
ENS. Mean
SN Ratio
50
100
150
200
250
300
50E 100E 150E 160W 110W 60W 10W
-4 -3 -2 -1 -0.5 0 0.5 1 2 3 4 5 6
2 4 6 8 12

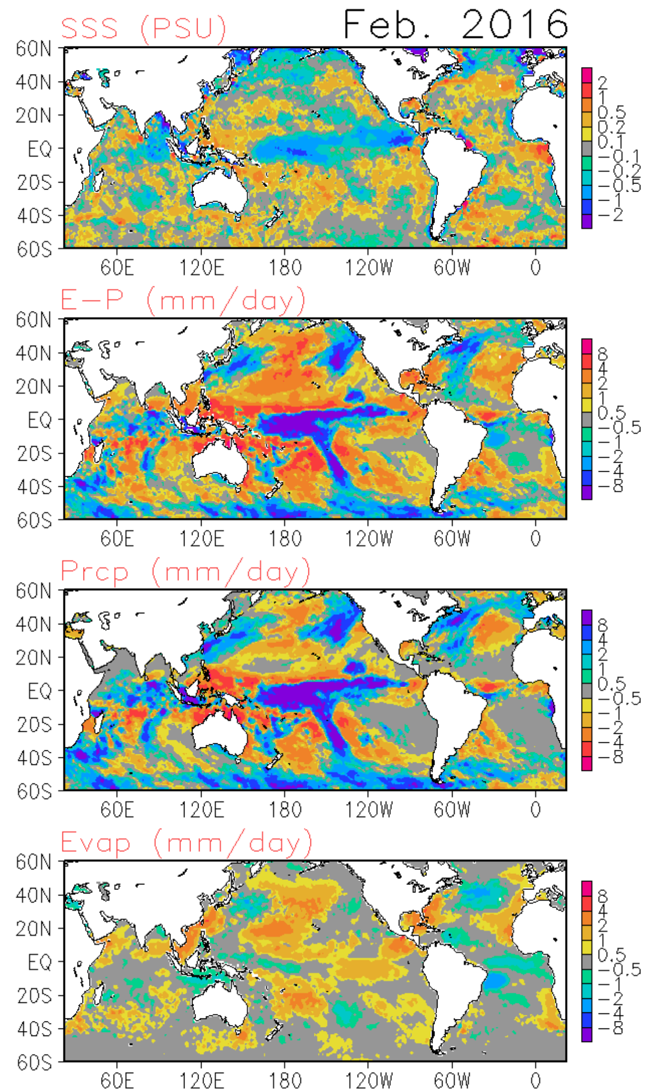


Upper 300m Heat Content Anomaly Averaged in 5S-5N (°C)
ENM
NCEP
ECWMF
JMA
SN Ratio
GFDL
NASA
BOM
FEB2015
MAR2015
APR2015
MAY2015
JUN2015
JUL2015
AUG2015
SEP2015
OCT2015
NOV2015
DEC2015
JAN2016
FEB2016
150E
160W
110W
2 4 6 8 12
−2.6 −1.6 −1.2 −0.8 −0.6 −0.4 −0.2 0.2 0.4 0.6 0.8 1.2 1.6 2.6

Global Sea Surface Salinity (SSS)

Anomaly for Feb. 2016

- NOTE: Since Aquarius terminated operations, the blended SSS analysis is from in situ and SMOS only from June 2015. Please report to us any suspicious data issues!
- The El Nino condition continues in this month producing positive precipitation anomaly over the eastern and central tropical Pacific Ocean and negative anomaly in the western tropical Pacific Ocean. The enhanced flux water flux maintains the fresh SSS anomaly across most of the tropical Pacific. Both precipitation and evaporation anomalies are reduced over the NW Pacific and Atlantic oceans over the storm track regions. Positive precipitation anomaly in the equatorial Indian Ocean likely causes the SSS fresher in the region.



- **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

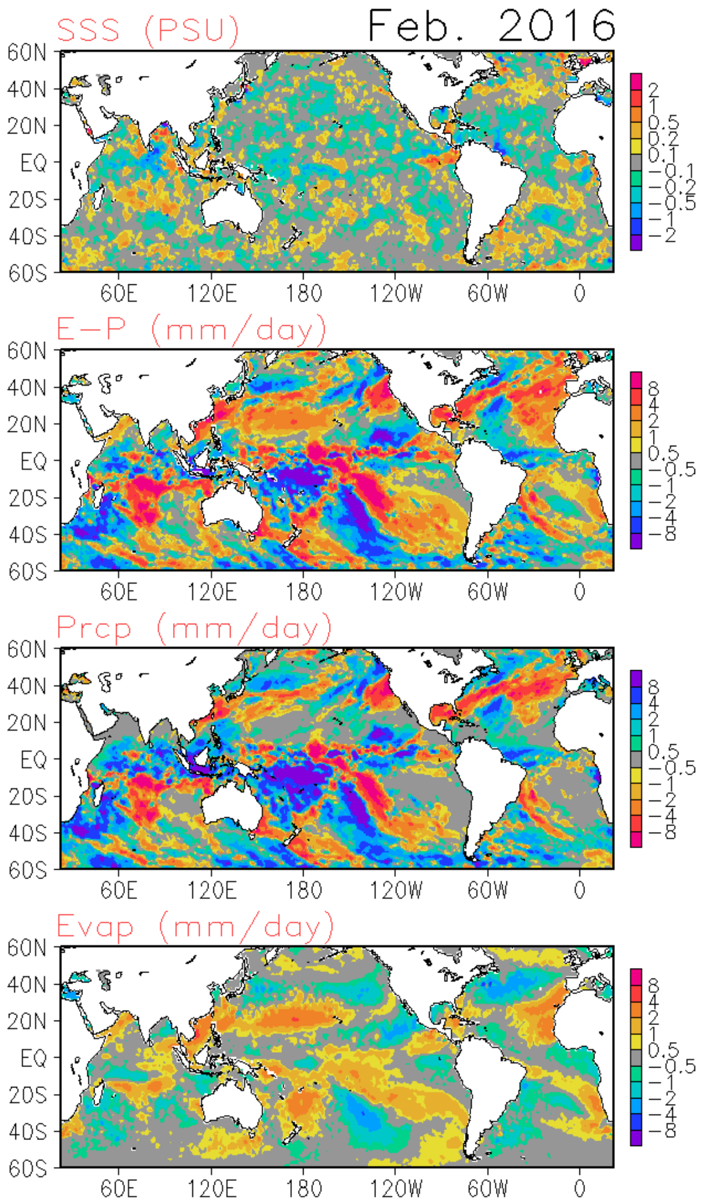
Evaporation:

CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for Feb. 2016

- Overall, the SSS anomaly patterns for February are similar to those for the previous month. The SSS anomaly over the eastern Pacific becomes saltier attributable to reduced precipitation there. The SSS anomaly over the western Pacific, meanwhile, are fresher due to the enhanced precipitation anomaly. Negative SSS anomaly tendency is observed over the equatorial Indian Ocean, with positive tendency appeared over tropical Indian ocean south of the equator and over the Bay of Bengal.

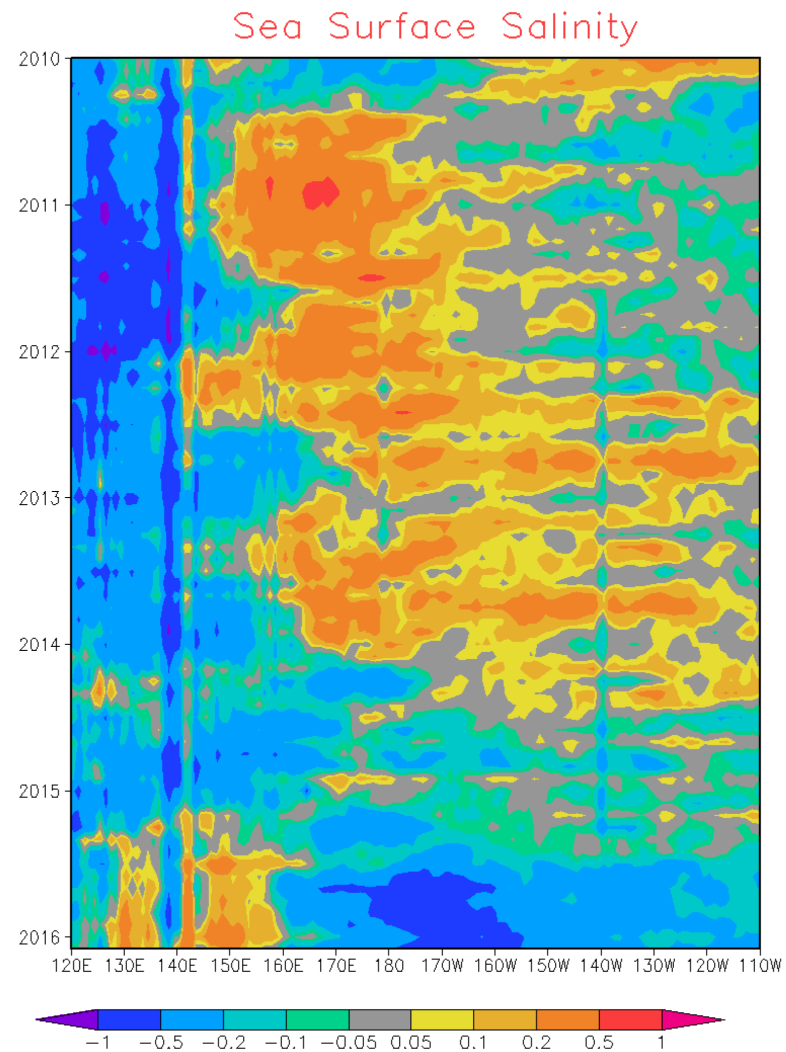


Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific

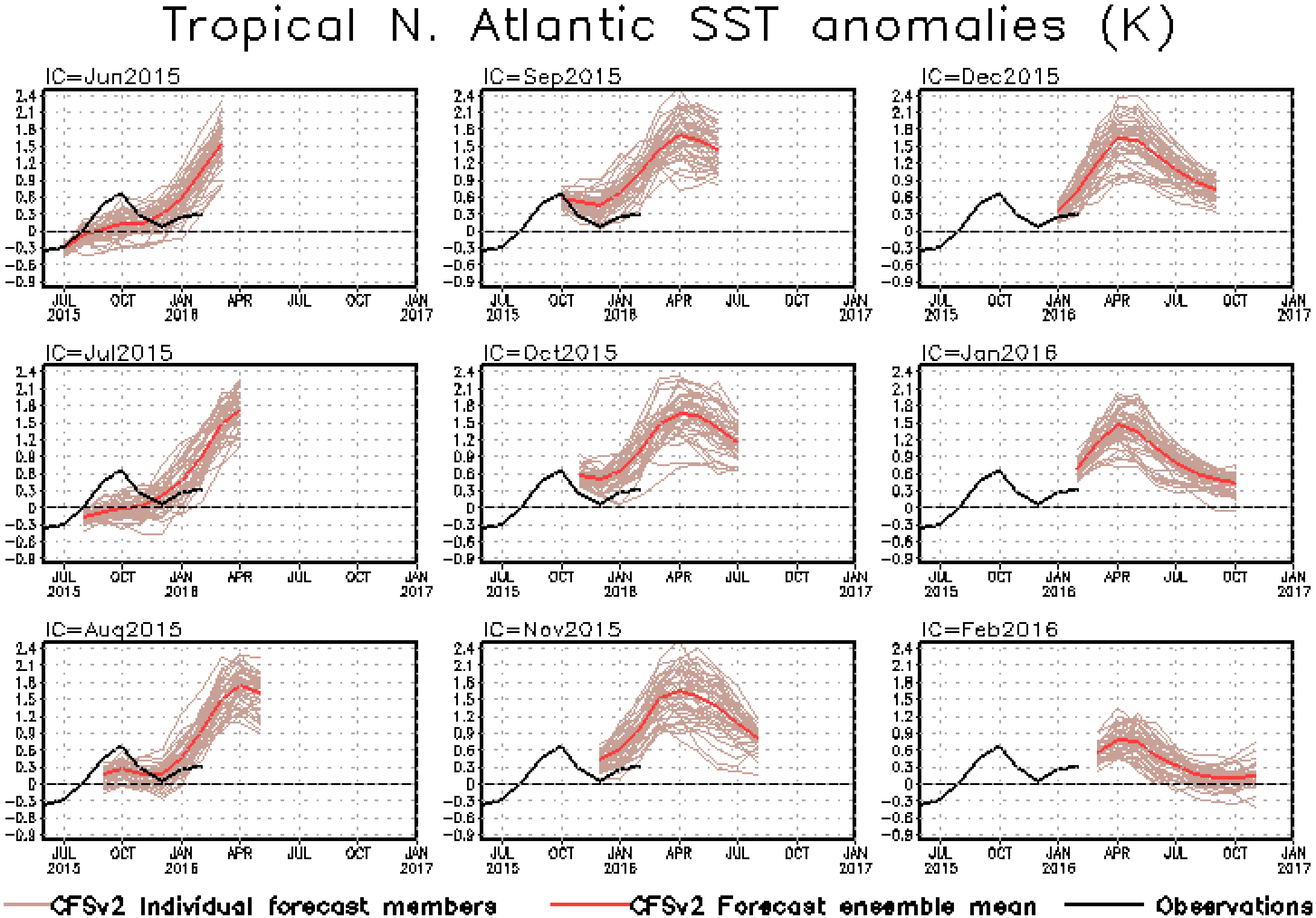
- Hovemoller diagram for equatorial SSS anomaly **(10ºS-10ºN);**

- Strong negative SSS anomaly continues over the central and eastern Pacific, with the center of the maximum SSS anomaly moving slightly eastward. However, the longitude position of the maximum fresh SSS anomaly has been staying around 165ºW over the recent two months. At the meantime, a stretch of positive SSS anomaly remains over the western Pacific and eastern Indian Ocean from 130ºE – 160ºE;



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

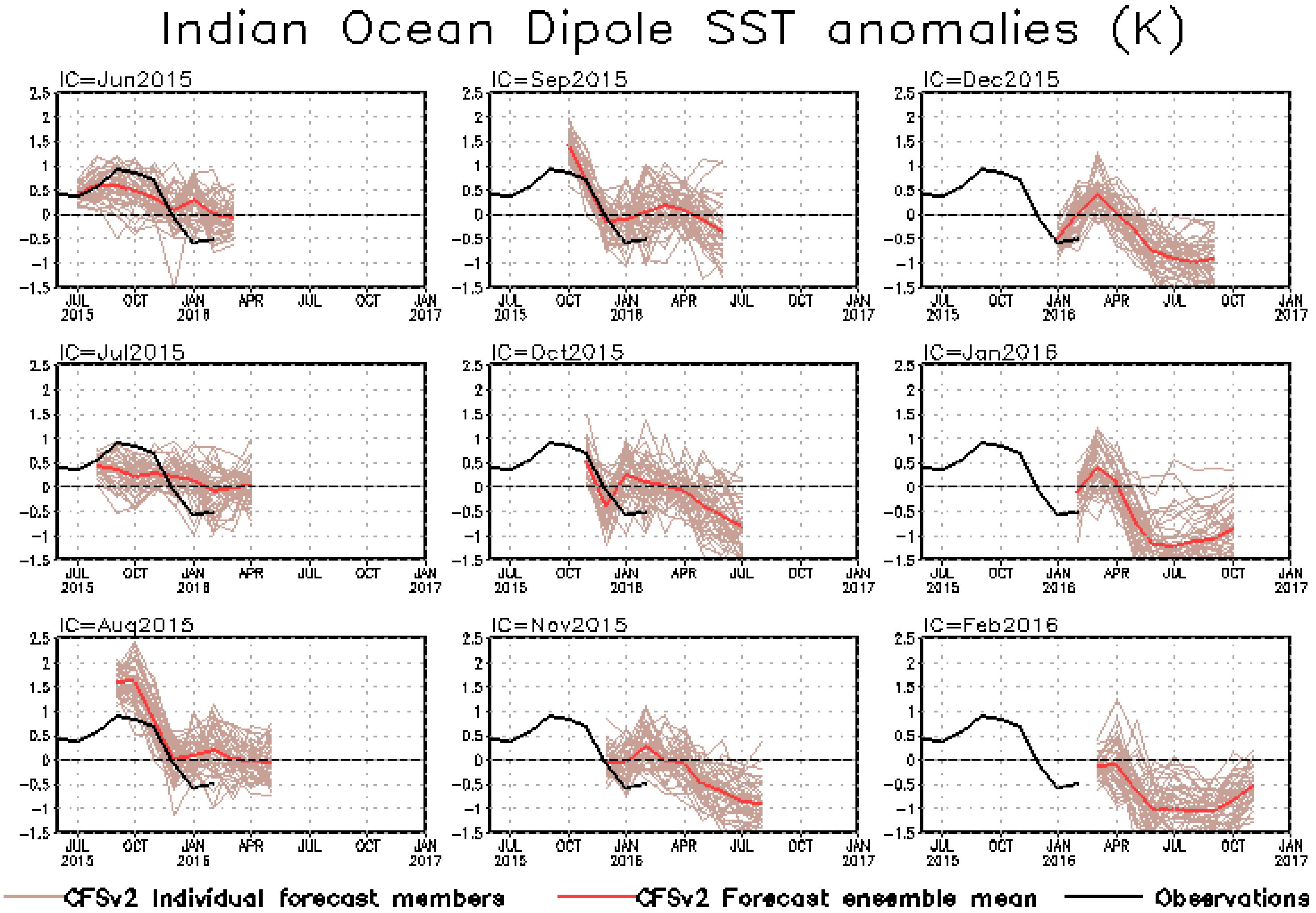
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].



- Latest CFSv2 predictions call slightly above normal SSTA in tropical N. Atlantic in summer and autumn 2016.

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.

NCEP CFS DMI SST Predictions from Different Initial Months



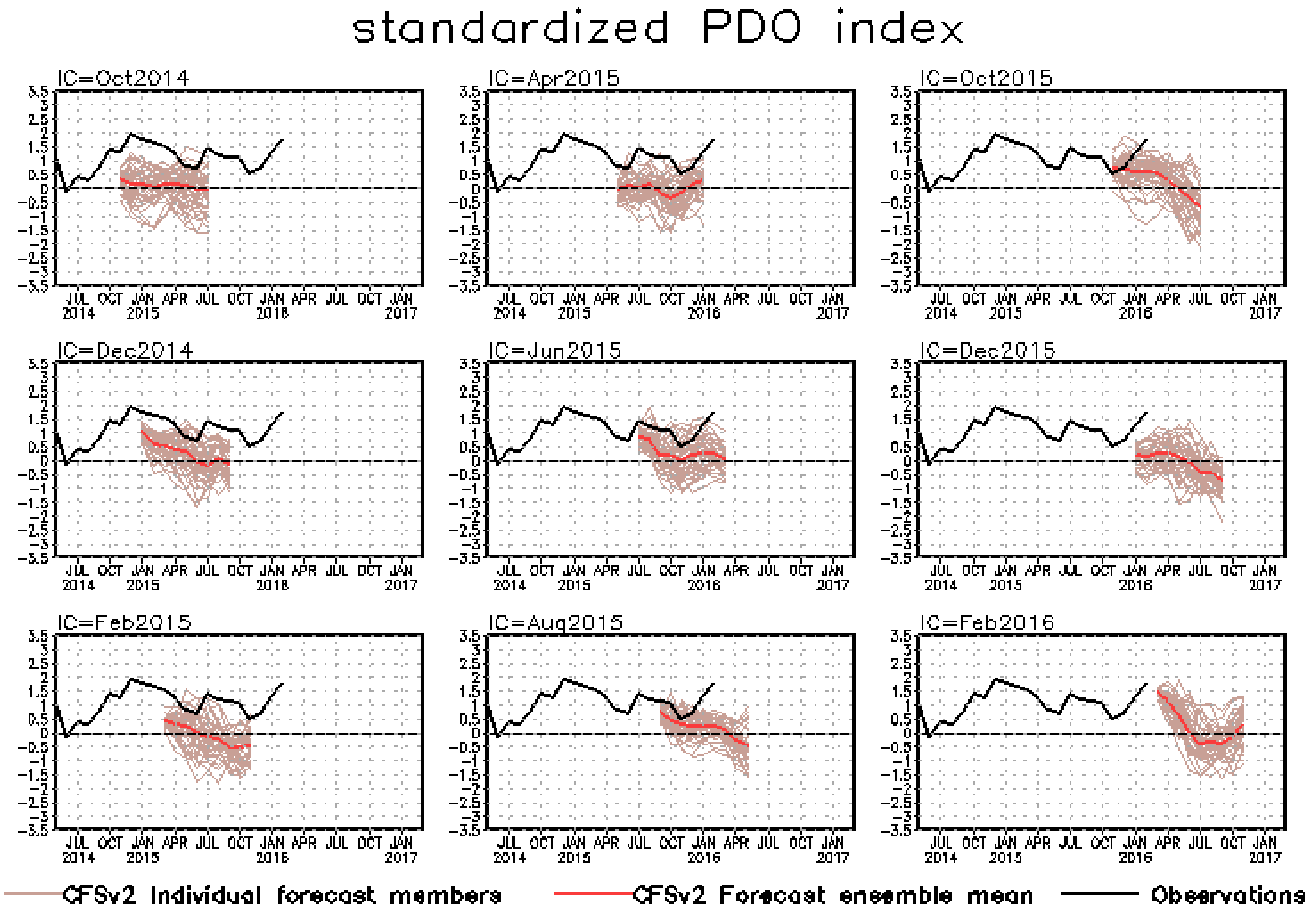
DMI = WTIO- SETIO

SETIO = SST anomaly in [90°E-110°E, 10°S-0]

WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

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 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 neutral phase since summer 2016.

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.

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

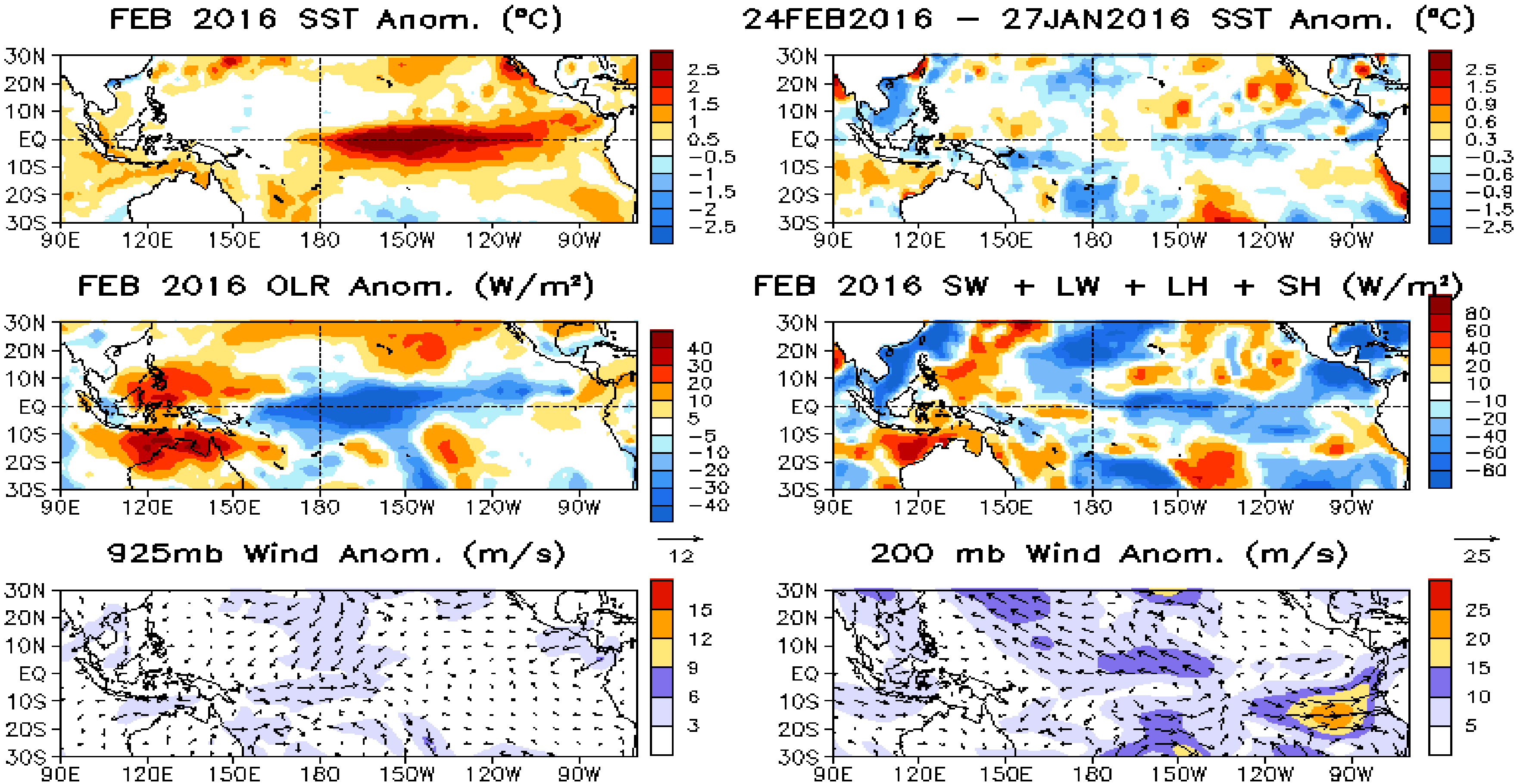


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

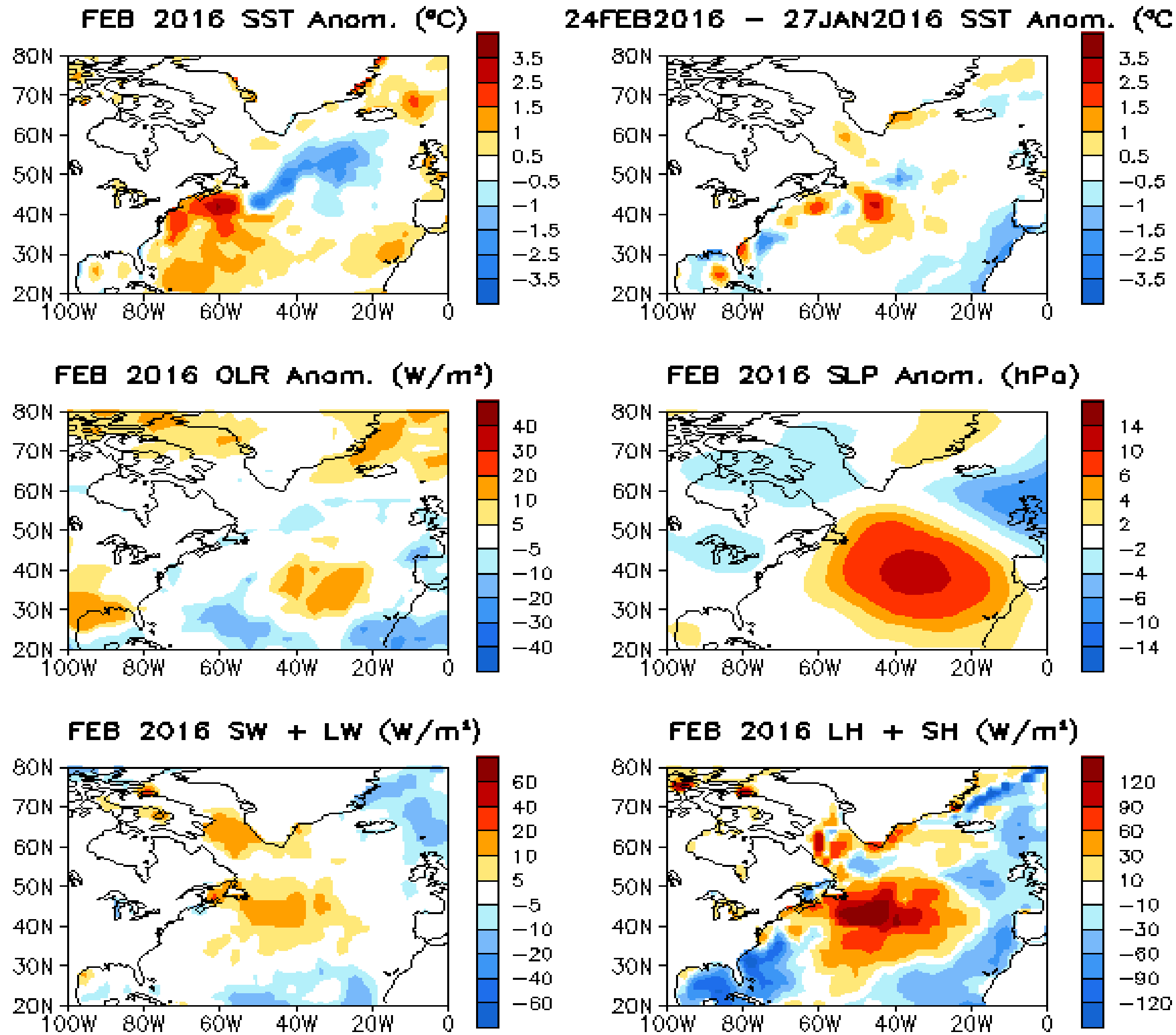


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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.ndbc.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!

Overview

- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 10 Mar 2016 issued "El Nino Advisory" and suggested that "*A transition to ENSO-neutral is likely during late Northern Hemisphere spring or early summer 2016, with close to a 50% chance for La Niña conditions to develop during the fall.*"**
  - **Positive SSTAs persisted in the central tropical Pacific with NINO3.4=2.4°C in Feb 2016 and weakened in the east.**
  - **Strong negative ocean temperature anomalies mainly along the thermocline strengthened in the western and central Pacific and propagated eastward.**
  - **Positive phase of PDO has persisted for 20 months, and strengthened with PDOI=1.76 in Feb 2016.**
- **Indian Ocean**
  - **Positive SSTA was larger in the east than in the west.**
- **Atlantic Ocean**
  - **NAO switched to positive phase with NAOI=1.35 in Feb 2016, causing a horseshoe-like pattern of SSTA in N. Atlantic.**