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

Prepared by

Climate Prediction Center, NCEP/NOAA

**March 9, 2017**

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**

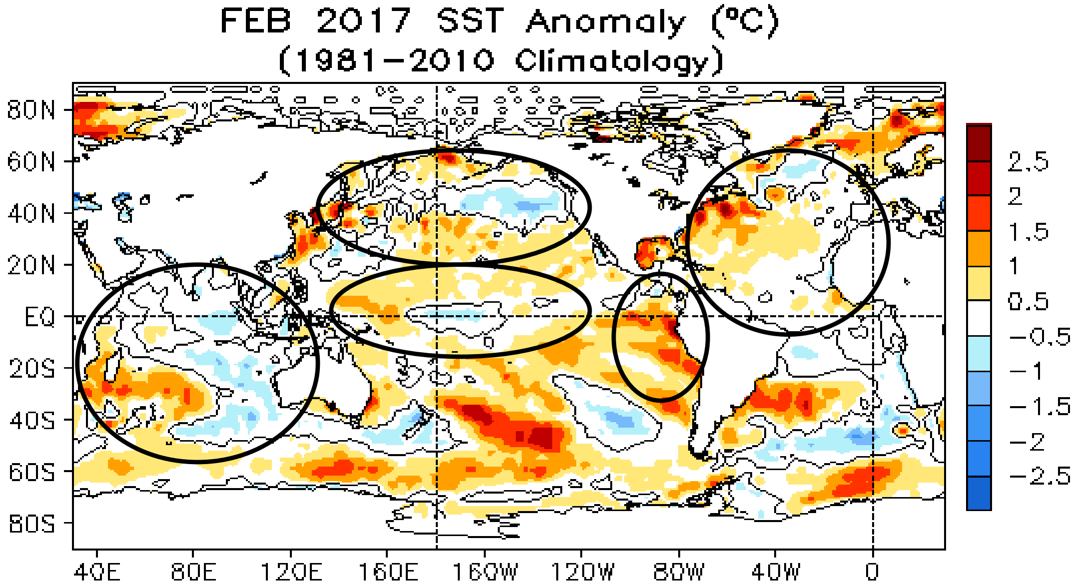
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Global SST Predictions**
    - **Predictability of N. Pacific "Blob"**
    - **Will an El Nino emerge in 2017-18?**

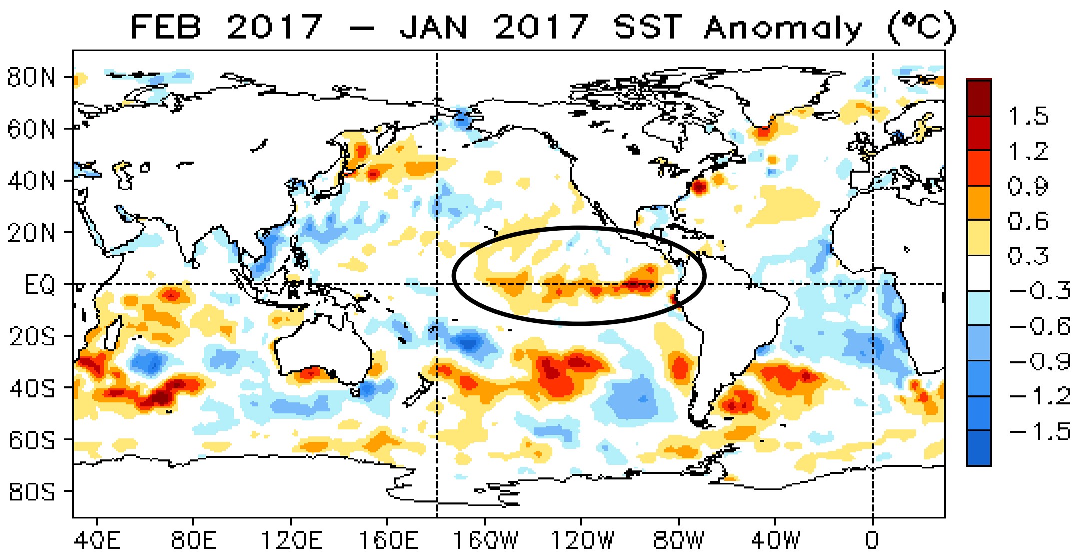
# Overview

- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 9 Mar 2017 indicated *"ENSO-neutral conditions are favored to continue through at least the Northern Hemisphere spring 2017, with increasing chances for El Niño development into the fall."***
  - **Positive SSTAs strengthened in the eastern tropical Pacific with NINO3.4=0.14°C in Feb 2017.**
  - **Subsurface ocean temperature warmed up mainly along the thermocline in the equatorial Pacific in Feb 2017.**
  - **Positive phase of PDO has persisted for 4 months with PDOI=0.73 in Feb 2017.**
- **Indian Ocean**
  - **SSTAs were near average in the tropical, and large positive in the SW in Feb 2017.**
- **Atlantic Ocean**
  - **NAO has been in positive phase since Dec 2016 with NAOI=0.69 in Feb 2017, and SSTAs were mainly positive, especially in the middle latitudes of N. Atlantic.**

# **Global Oceans**

# Global SST Anomaly ($^0$C) and Anomaly Tendency




**- Small SSTA presented in the central tropical Pacific associated with ENSO neutral, while strong positive SSTA was observed in the S. American coast.**

**- Positive SSTA in NE Pacific associated with "Blob" (positive phase of PDO) dismissed.**

**- Horseshoe-like SSTA presented in high latitudes of N. Atlantic.**

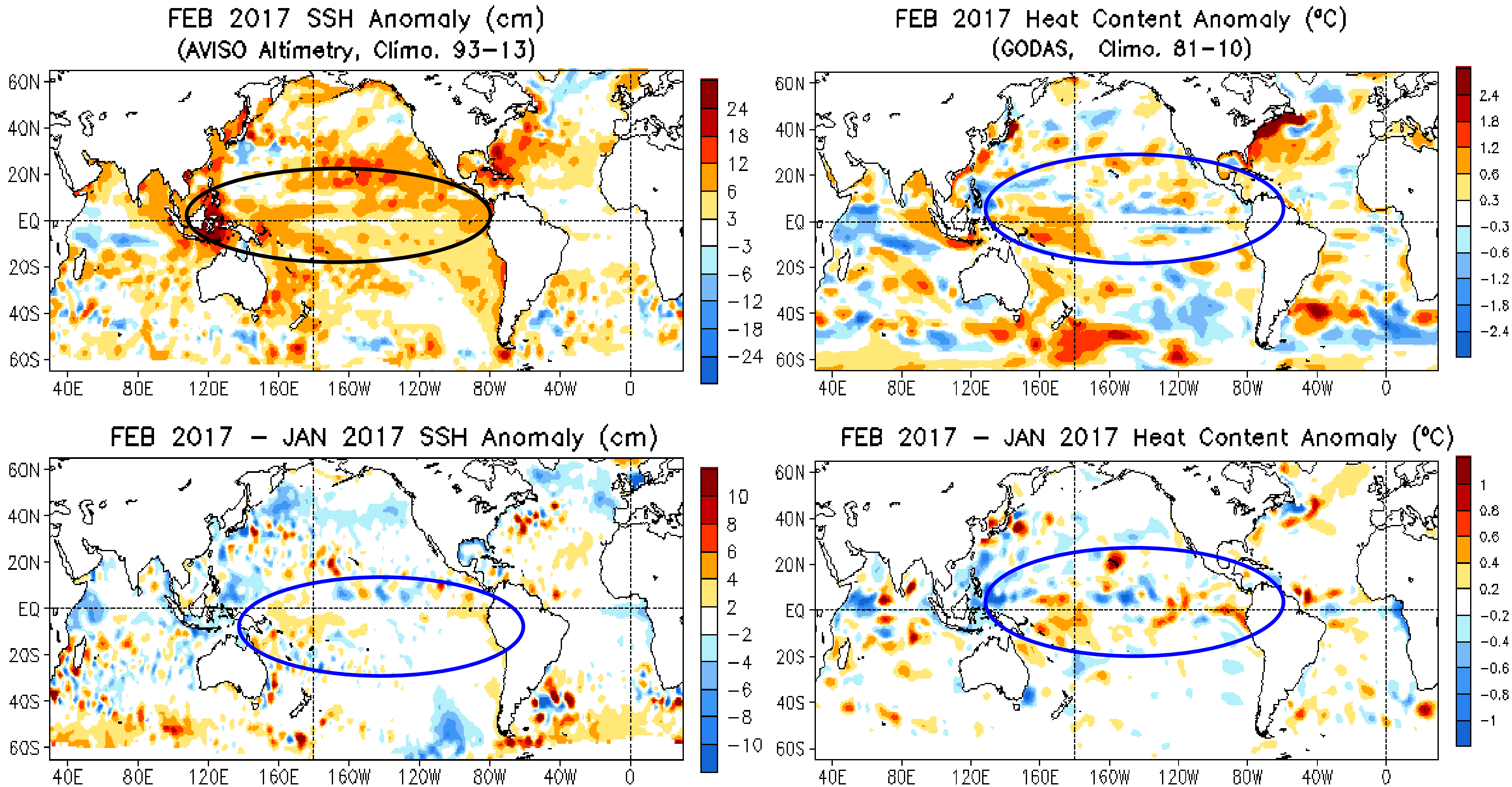
**- In Indian Ocean, SSTAs were near average in the tropical, and large positive in the SW in Feb 2017.**

**- Positive SSTA tendencies associated with La Nina decay and possible El Nino development were observed in the eastern tropical Pacific.**

**- Negative (positive) SSTA tendencies were observed in the N. Indian, NW Pacific, and tropical Atlantic Oceans (S. Indian 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 and HC300 Anomaly & Anomaly Tendency

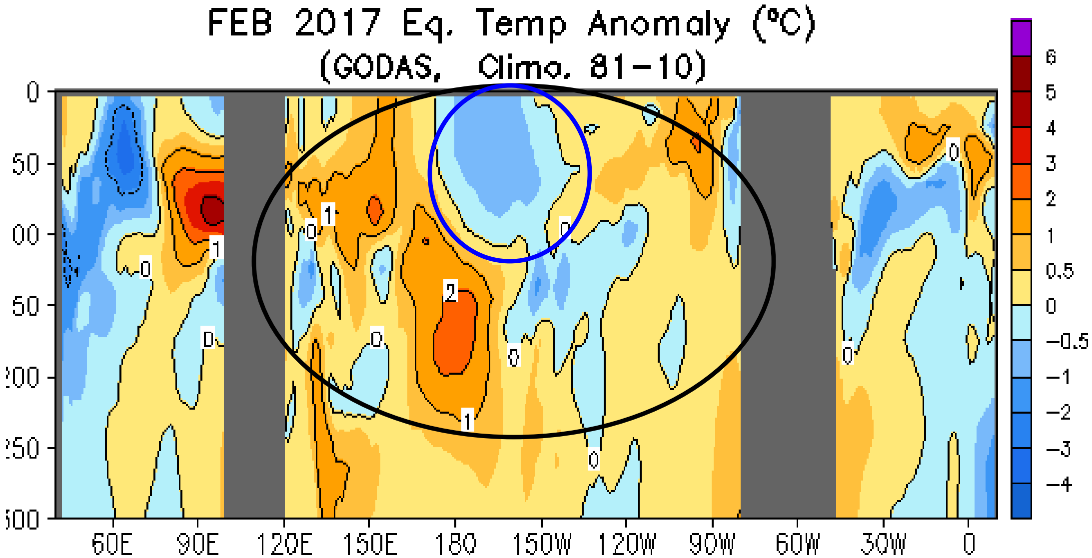



- The SSHA pattern was overall consistent with HC300A pattern, but there were many detailed differences between HC300A and SSHA.

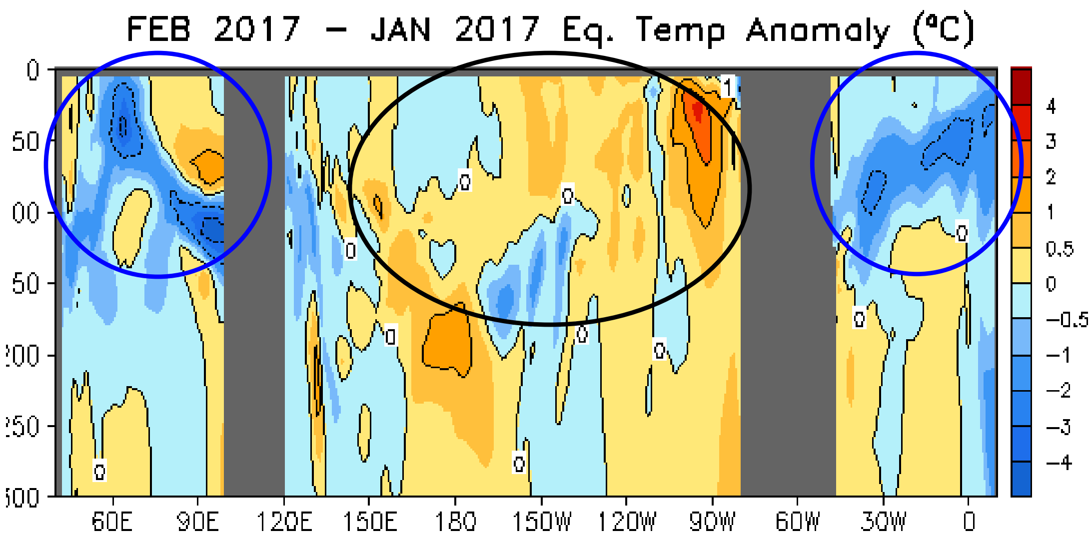
- Overall, both SSHA and HC300A were small in the tropical Pacific, consisting with neutral phase of ENSO.

- Small tendencies of SSHA and HC300A in the S. American coast may imply that the warming in the region mainly confines in the surface.

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




- **Positive ocean temperature anomalies presented along the thermocline in the western and eastern Pacific.**
- **Negative ocean temperature anomalies presented in the central Pacific.**



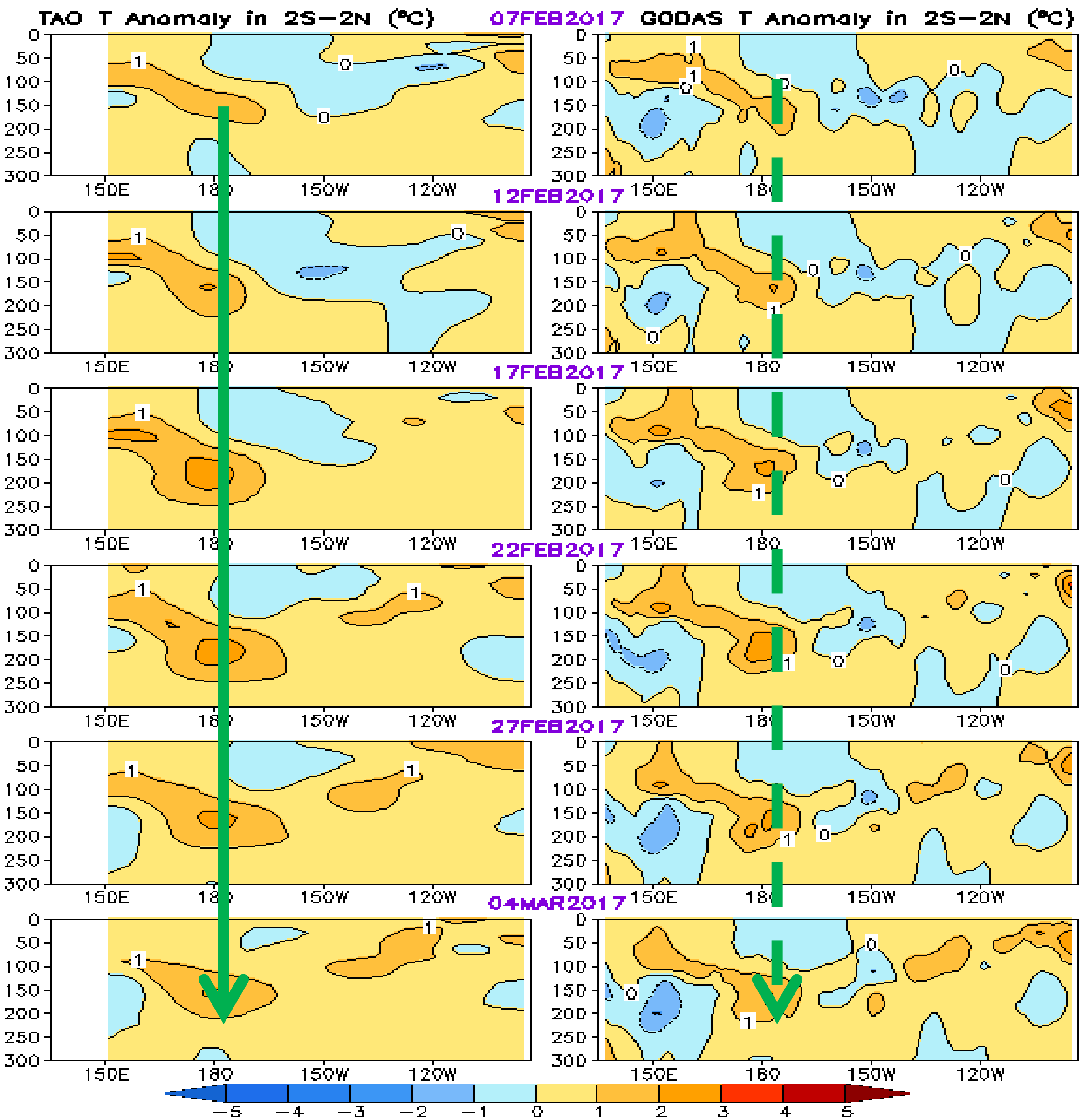

- **Overall, ocean temperature anomaly tendencies were positive, suggesting a recharging of ocean heat content.**
- **Both Indian and Atlantic Oceans had negative tendencies along the thermocline.**

**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

TAO GODAS

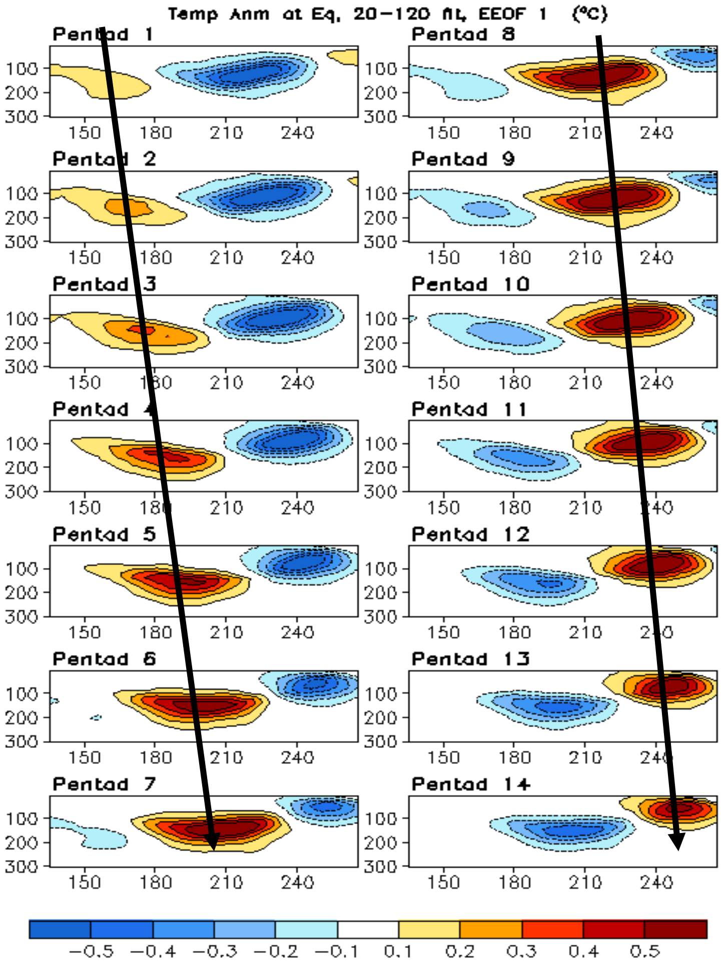


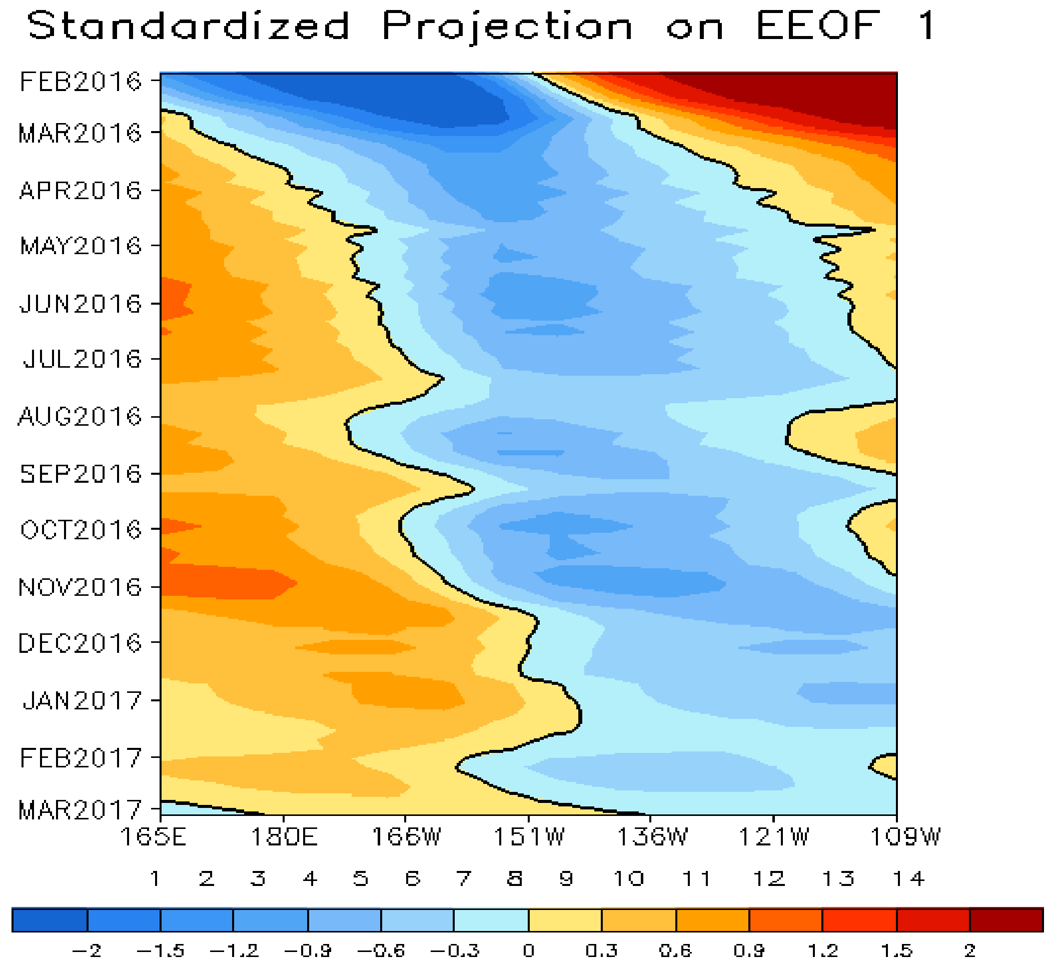

- Small positive ocean temperature anomalies in the Pacific Ocean persisted during last month.

- There was little eastward propagation.

- Both the anomalous pattern and propagation are comparable between TAO and GODAS.

# Oceanic Kelvin Wave (OKW) Index



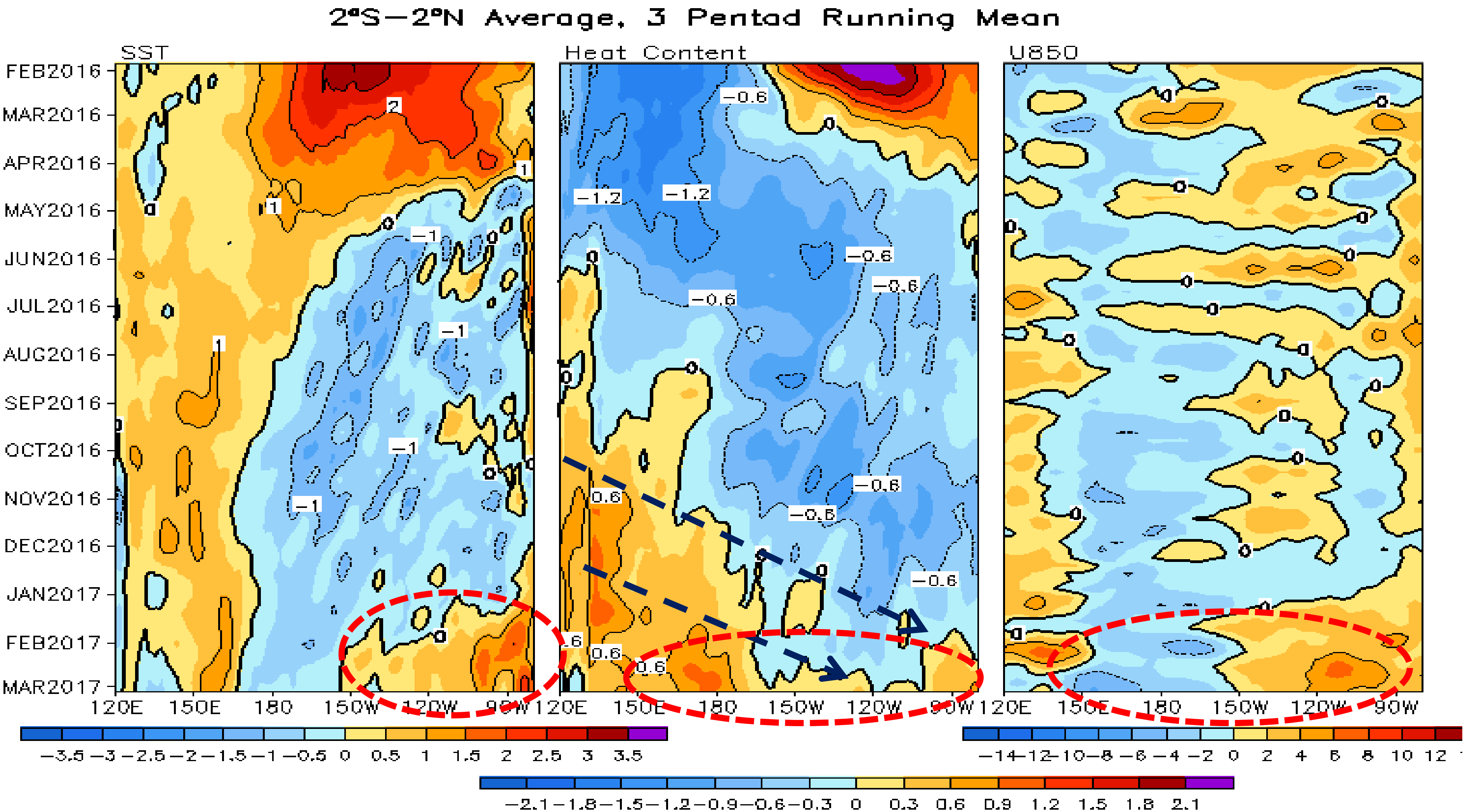




- **Positive OKW in the central and negative ones in the eastern Pacific Ocean emerged since late Oct 2016.**

- **During Dec 2016-Feb 2017, 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 eastern Pacific strengthened in last 2 months.**
- **Positive HC300A in the western Pacific also enhanced since Jan 2017 and negative anomaly transferred into positive in the central and eastern Pacific in Feb 2017.**
- **Low-level easterly (westerly) wind anomalies were observed in the western (eastern) Pacific in Feb 2017, favoring divergence in the central-eastern Pacific Ocean.**

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

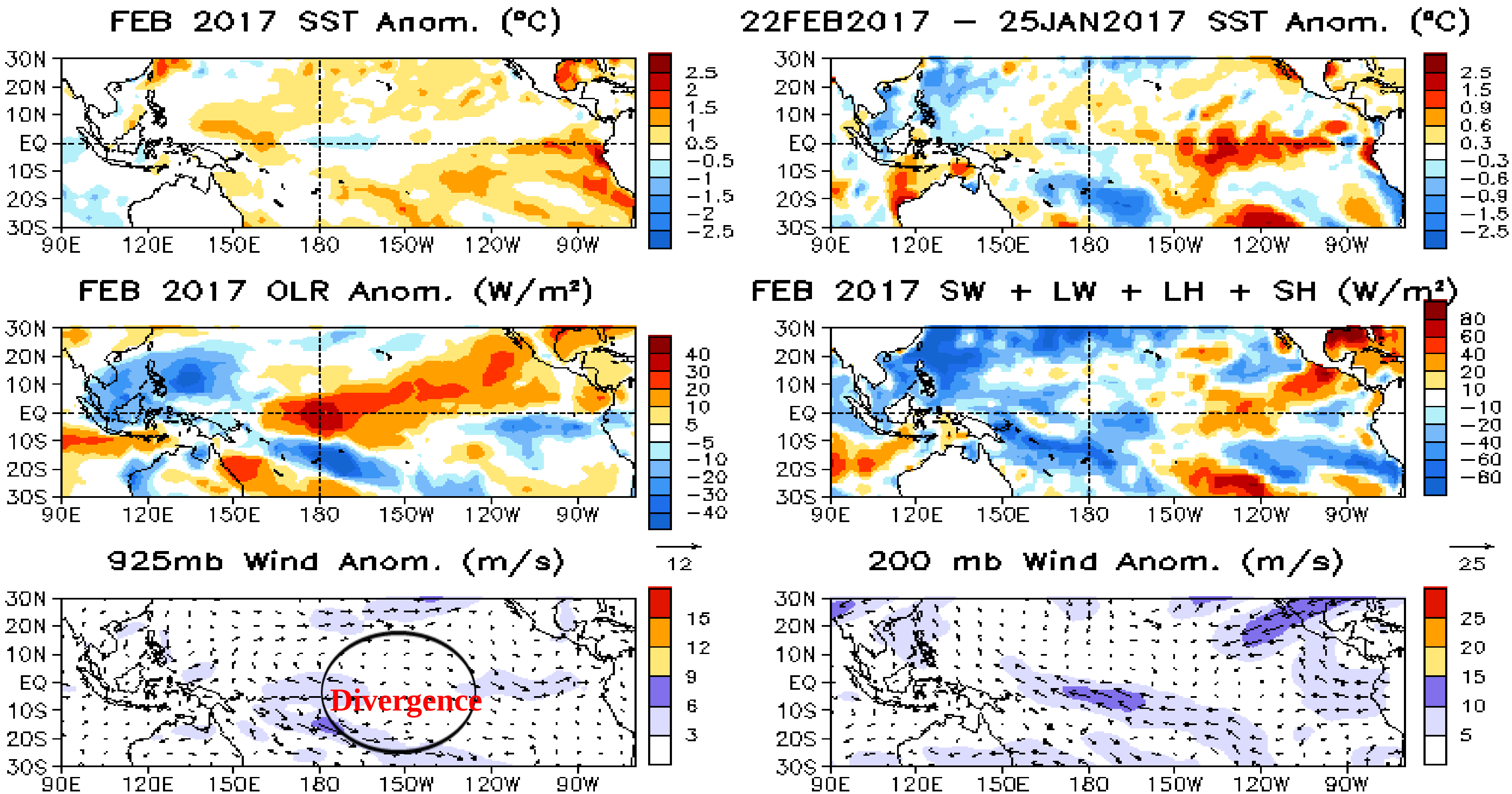
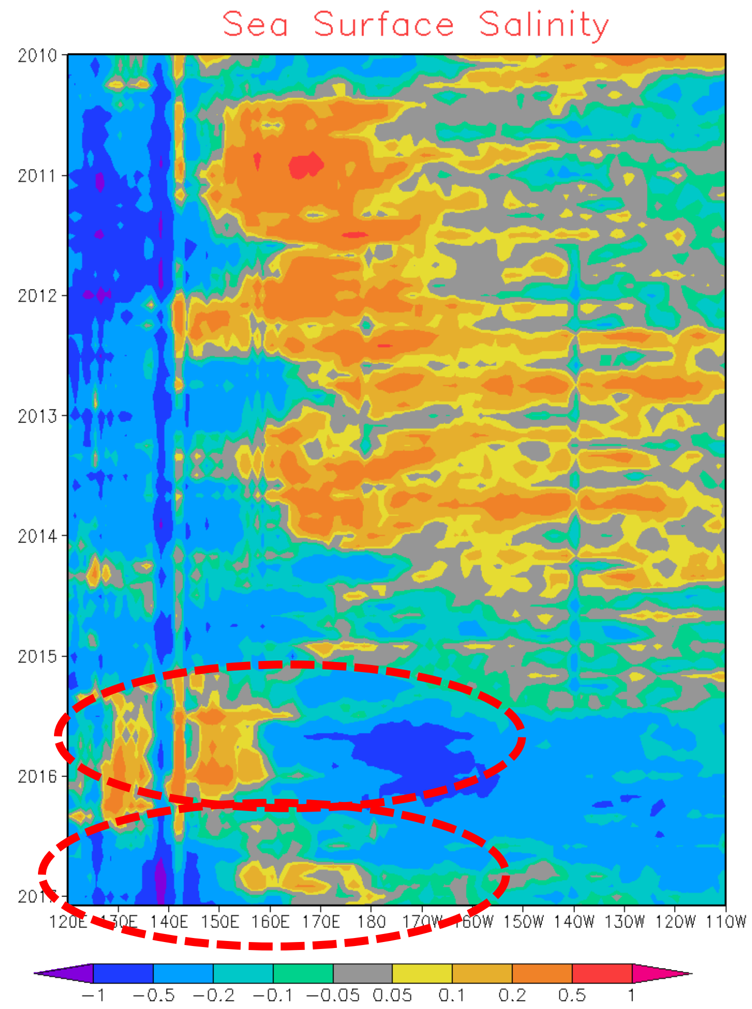



**Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

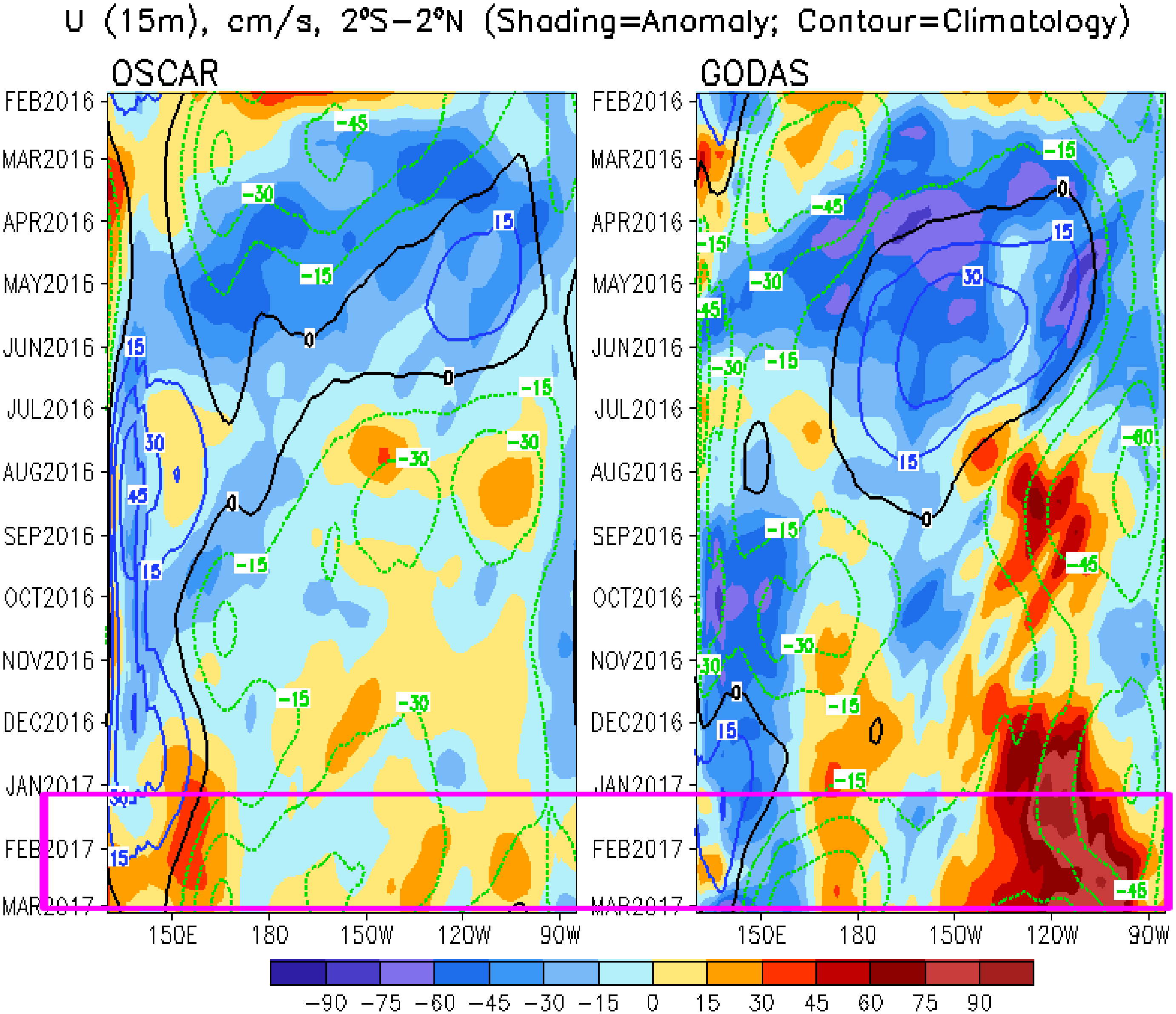
# Global Sea Surface Salinity (SSS)
## Anomaly Evolution over Equatorial Pacific

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

- The anomaly evolution in this region show some changes in this month. In the western equatorial Pacific Ocean, from 120°E to 150°E, the negative SSS signal continues. However, at the meantime, the SSS anomaly over the central Pacific Ocean, between 150ºE and 180ºE, is likely becoming neutral in this month. There are no significant changes east of 170°W.



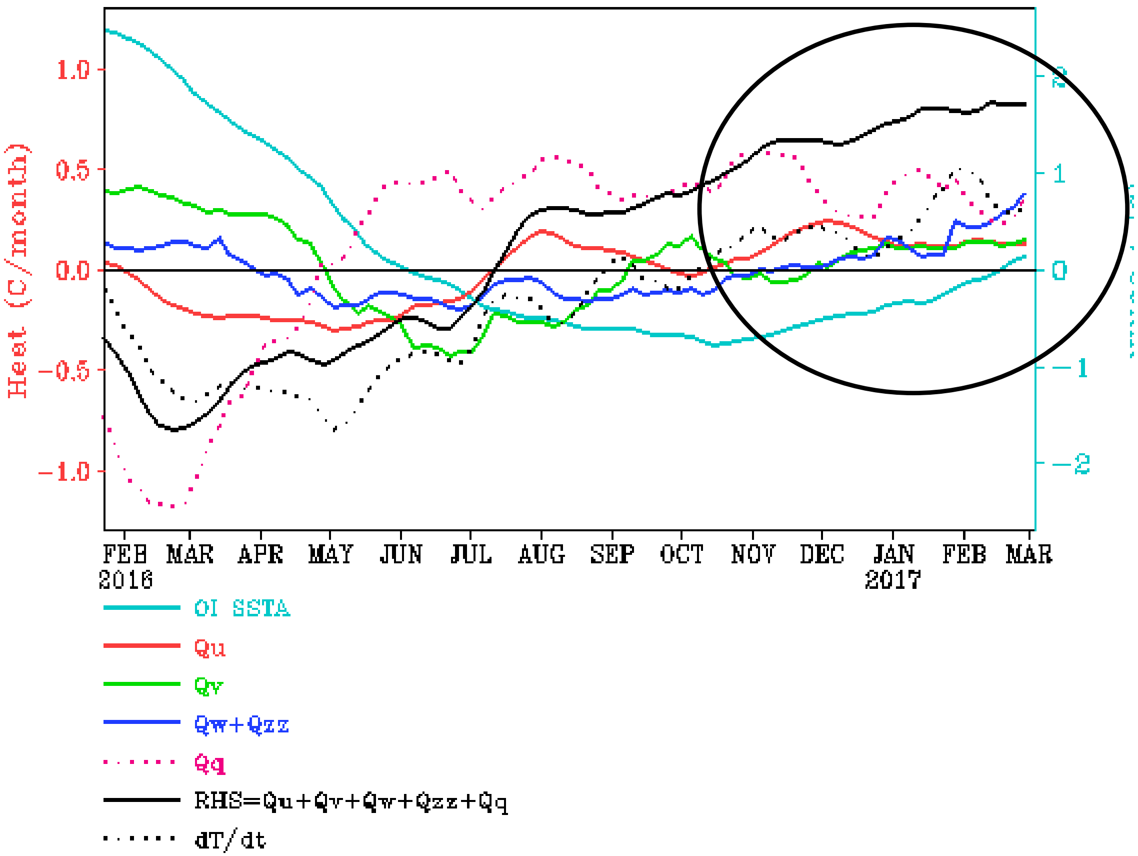
# Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)




- The anomalous currents showed large differences between OSCAR and GODAS.

- Anomalous eastward currents were dominant in the last few months in OSCAR. That was favorable for a warming tendency in the central and eastern Pacific.

# NINO3.4 Heat Budget




**- Observed SSTA tendency (dT/dt) in Nino3.4 region (dotted black line) was positive since Oct 2016, consisting with the decay of La Nina.**

**- Both dynamical terms (Qu, Qv, Qw+Qzz) and heat flux term (Qq) were positive since Dec 2016, consistent with the decay of La Nina.**

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 almost no change (small discharge) since Dec 2016.

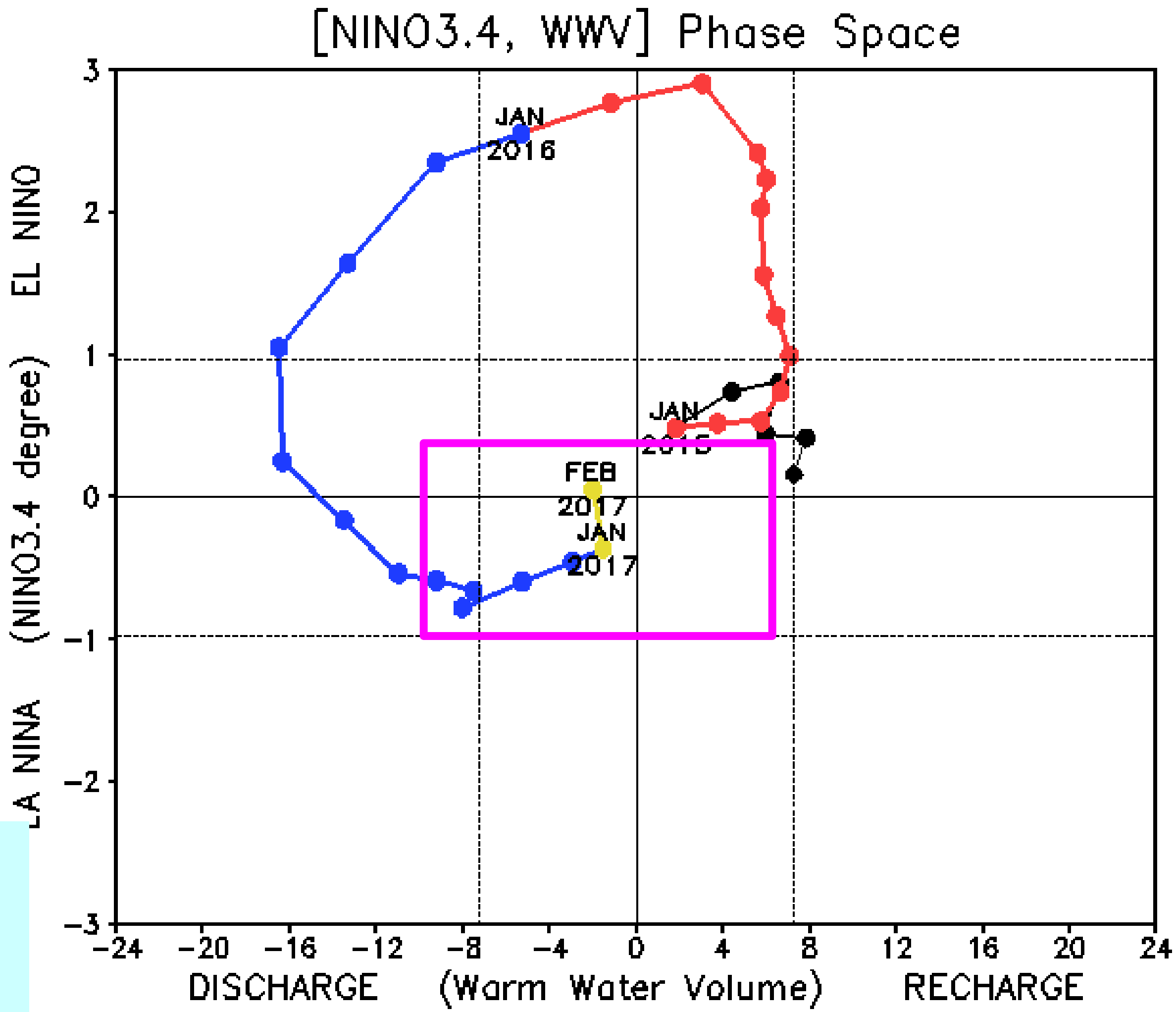
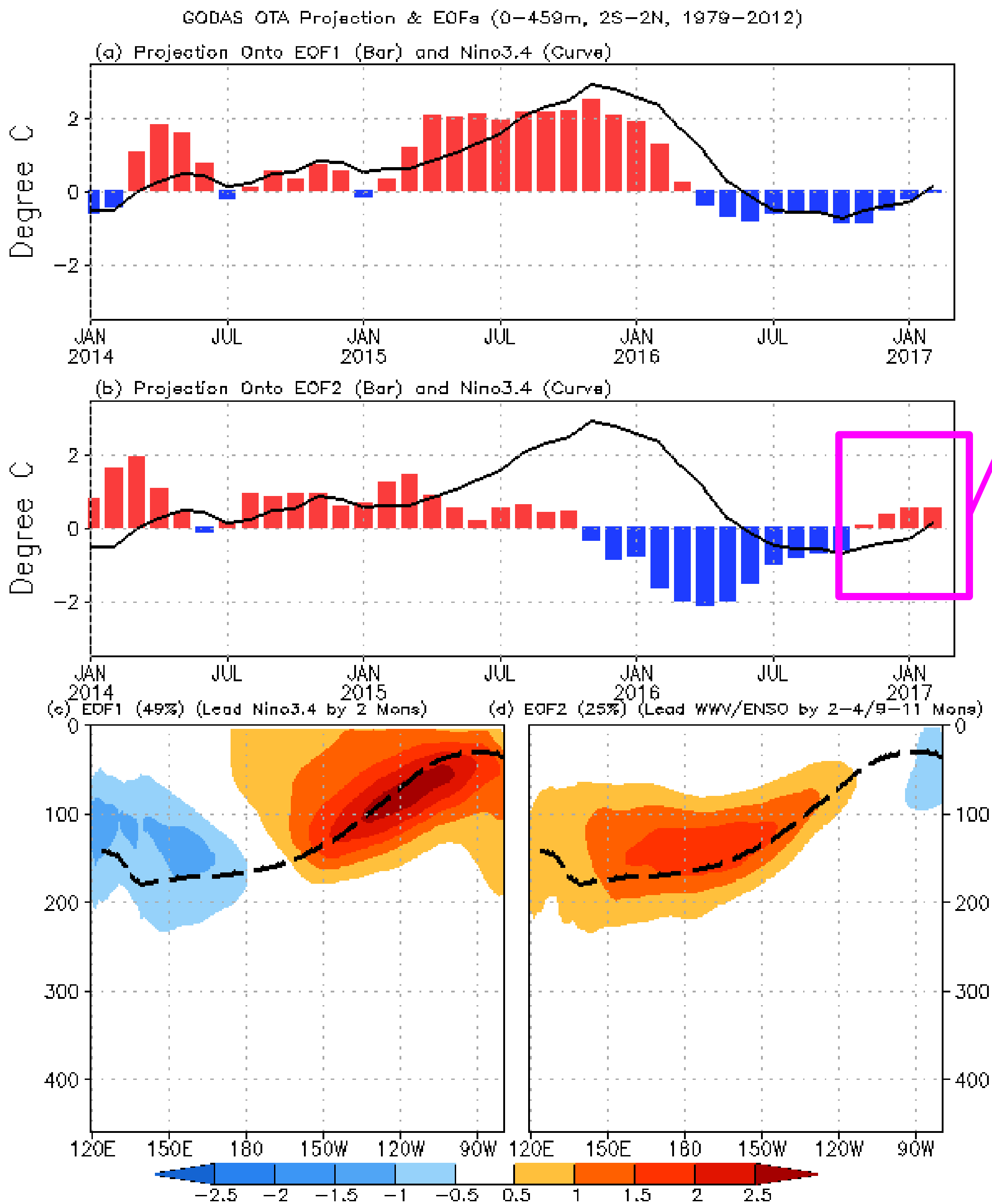



Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.




**Equatorial subsurface ocean temperature monitoring: Right now, ENSO was in recharge phase since Nov 2016.**

**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).**

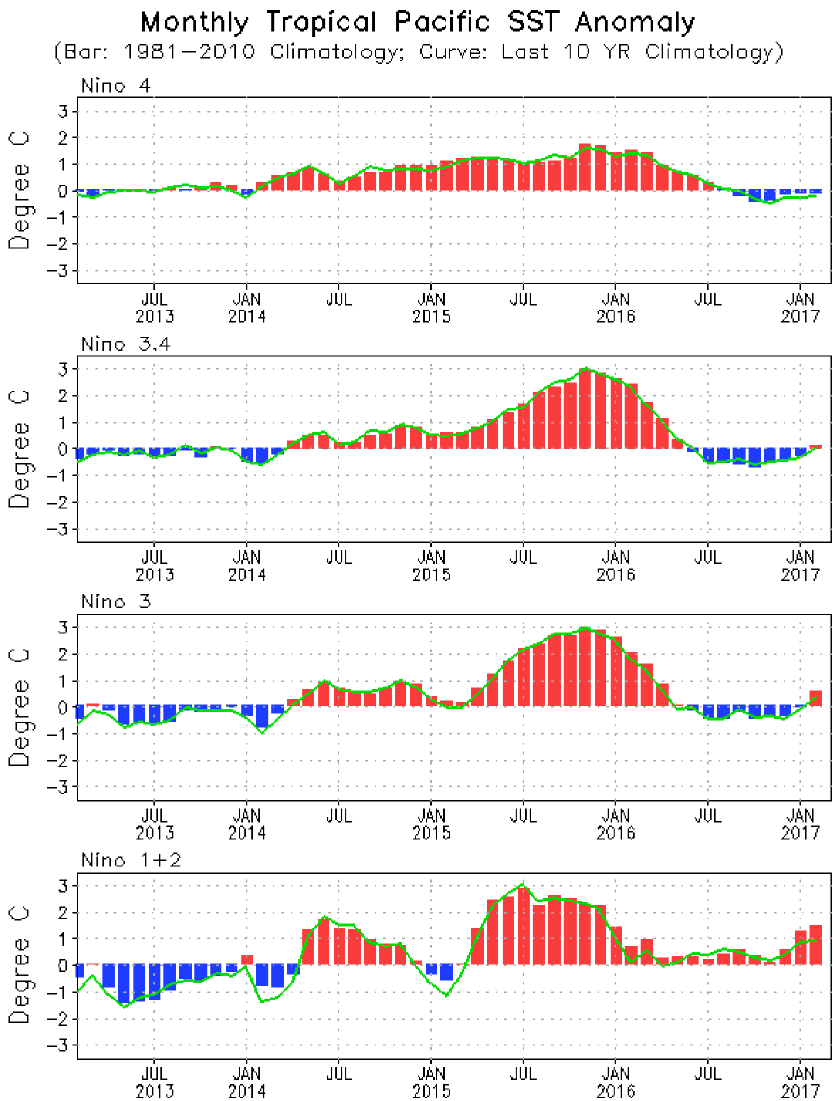
**Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO**

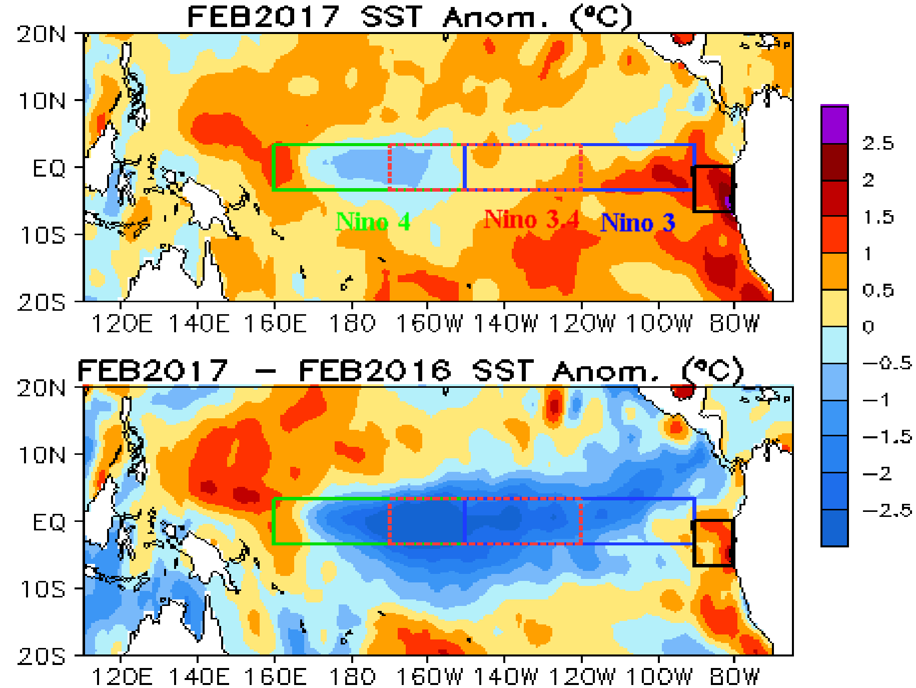
**Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO**

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; Nino4 was still small negative in Feb 2017.

- Nino3.4 = 0.14°C in Feb 2017.

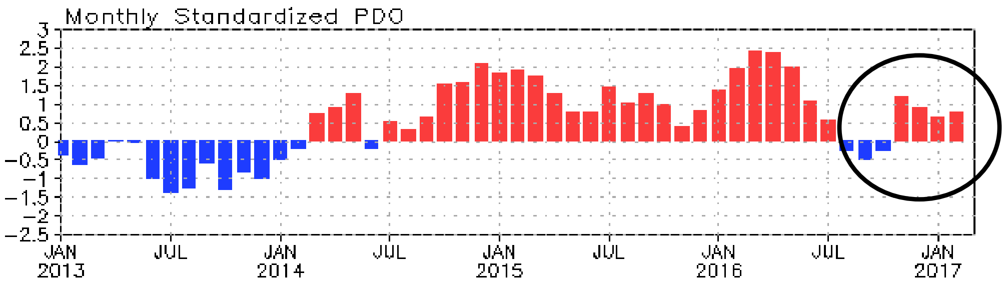
- Compared with last Feb, the central and eastern equatorial Pacific was much cooler in Feb 2017, associated with 2015/16 El Nino and 2016/17 La Nina.

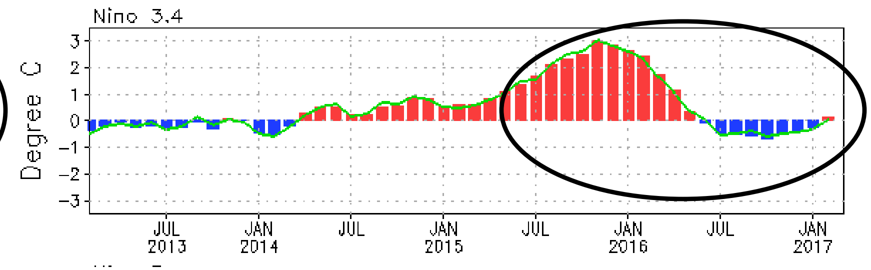
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v4.

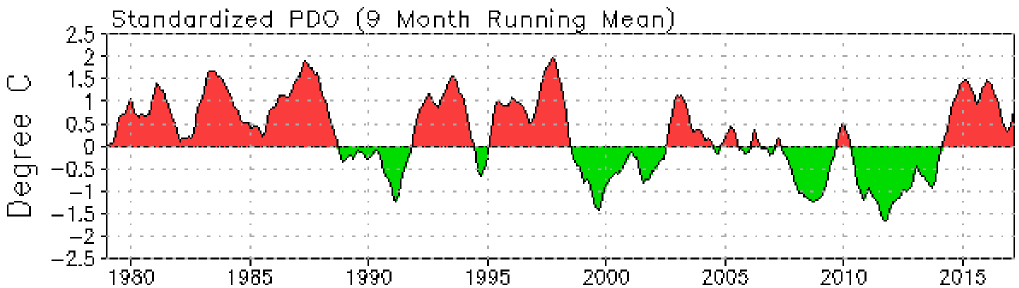
**Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.**

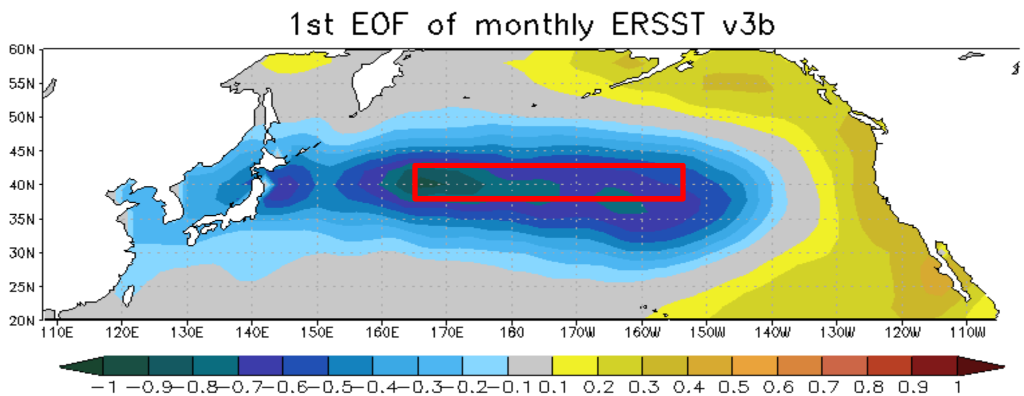
# North Pacific & Arctic Oceans

# PDO index



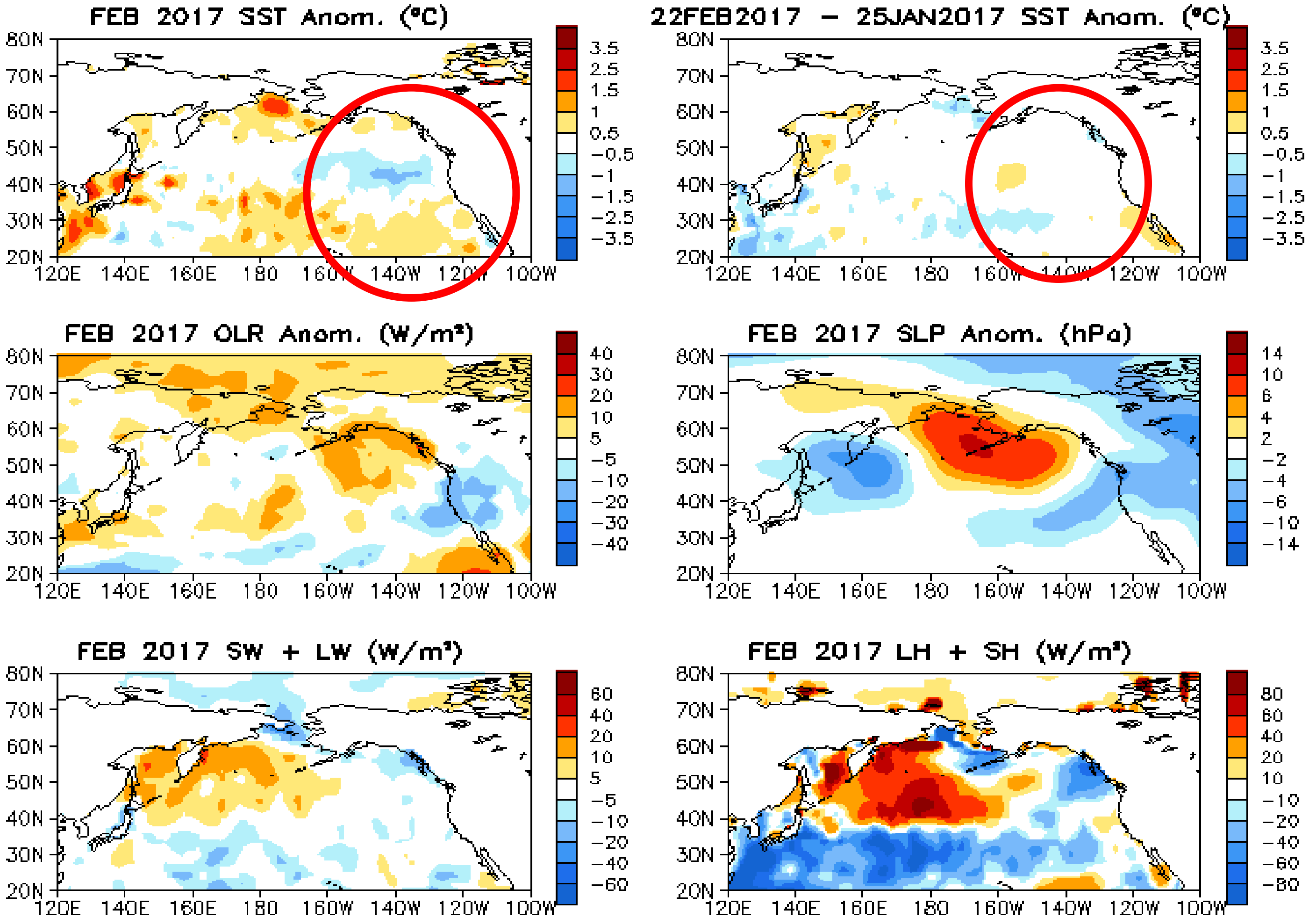

**- The positive phase of PDO index has persisted 4 months since Nov 2016 with PDO index =0.73 in Feb 2017.**

**- 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



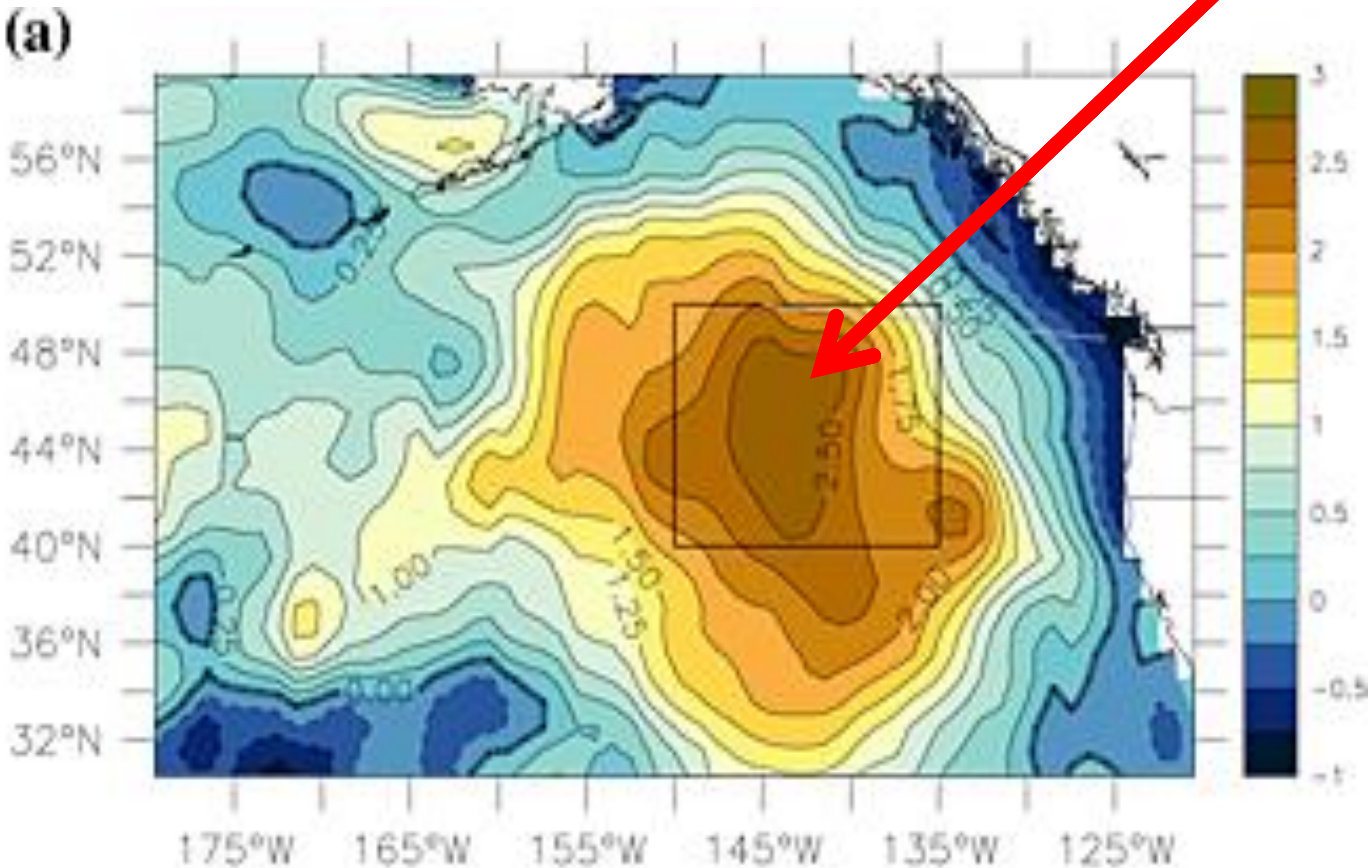

- Positive SSTA associated with so called "Blob" in the NE Pacific disappeared.

- Overall SSTA tendency was small in N. 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.**

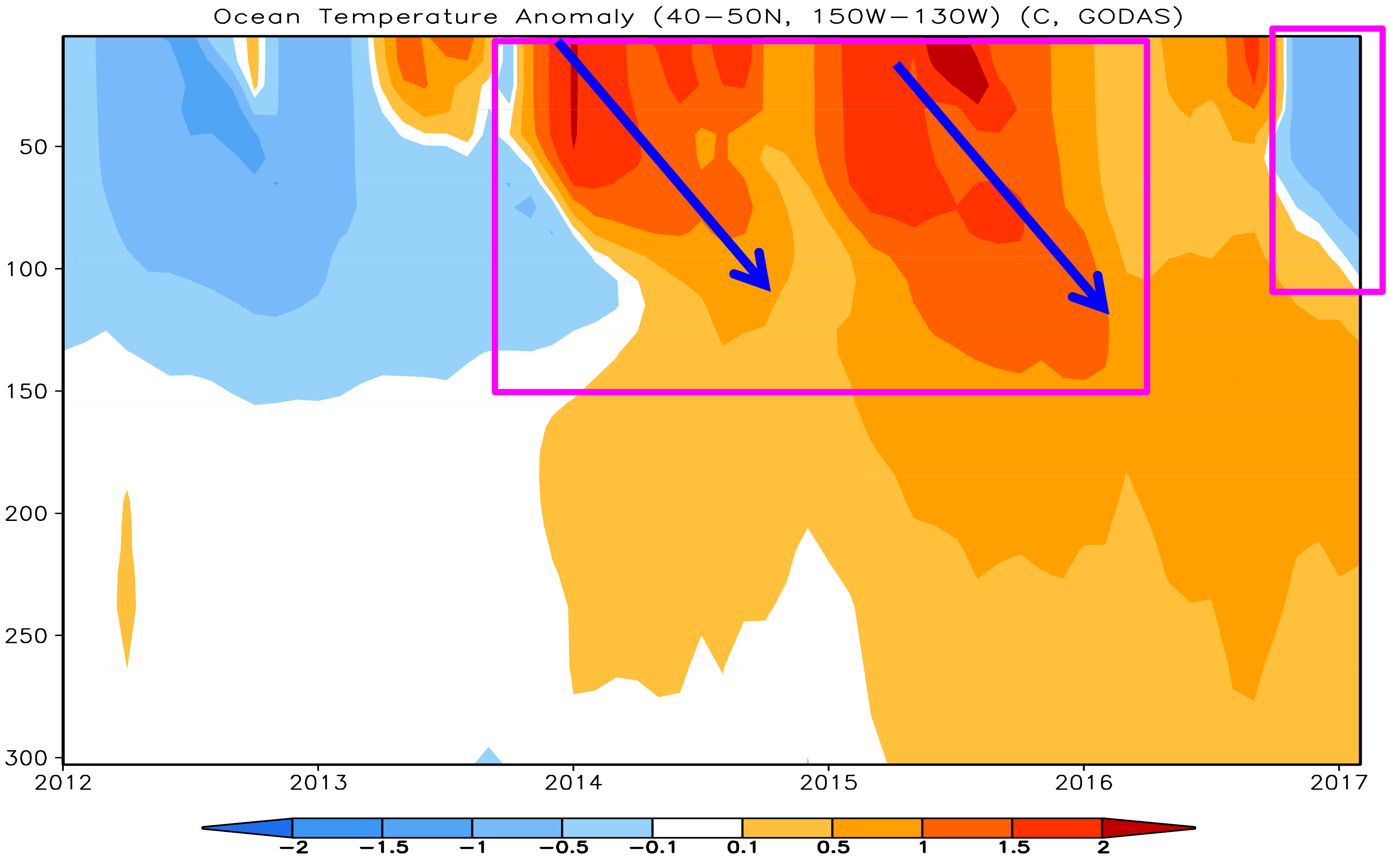
# What is "Blob"?

**Persistent warm water mass in NE Pacific during 2013-2015 (Bond et al. 2015).**

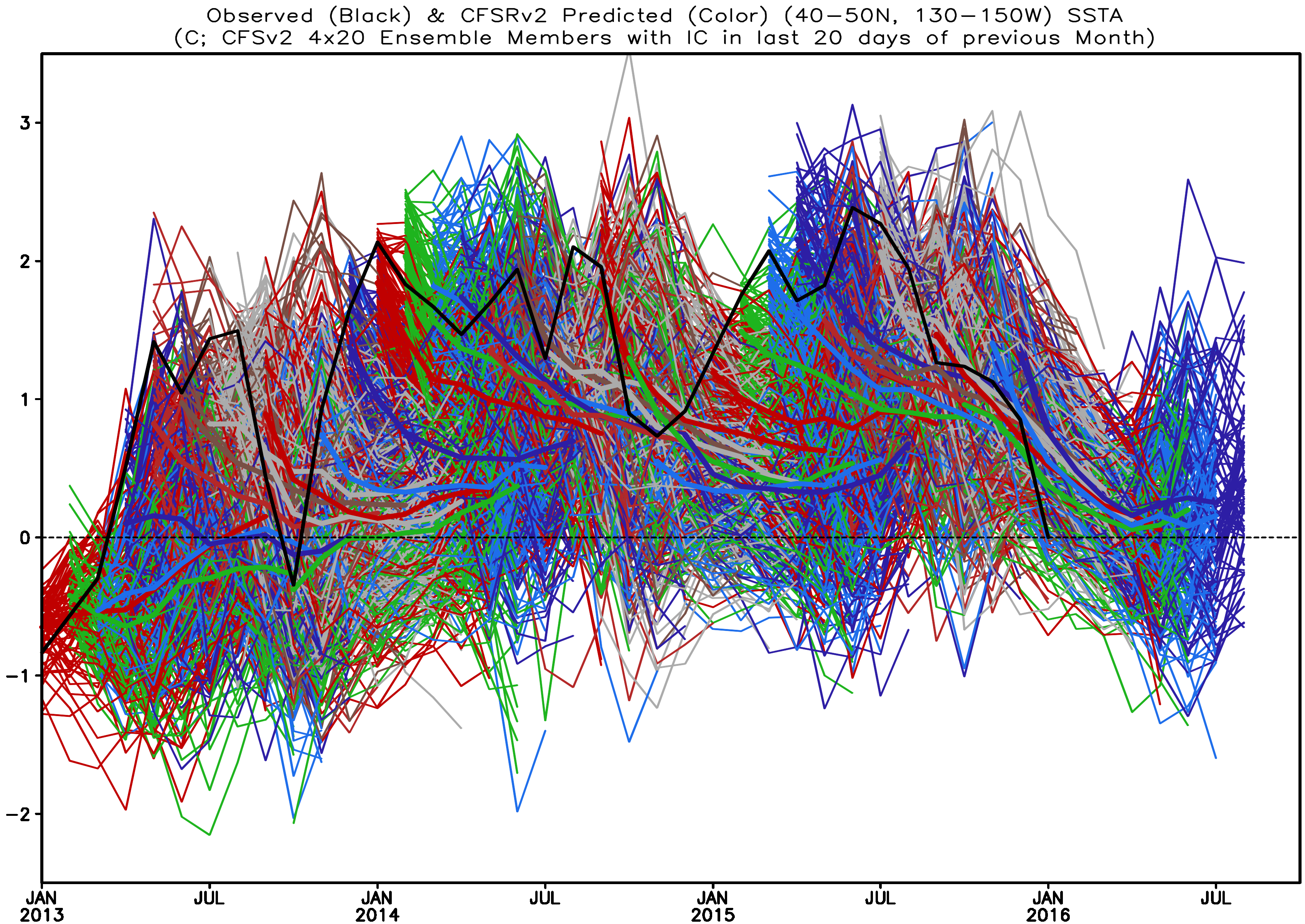



*Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua (2015), Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophys. Res. Lett.,* ***42****, 3414–3420, doi:10.1002/2015GL063306.*

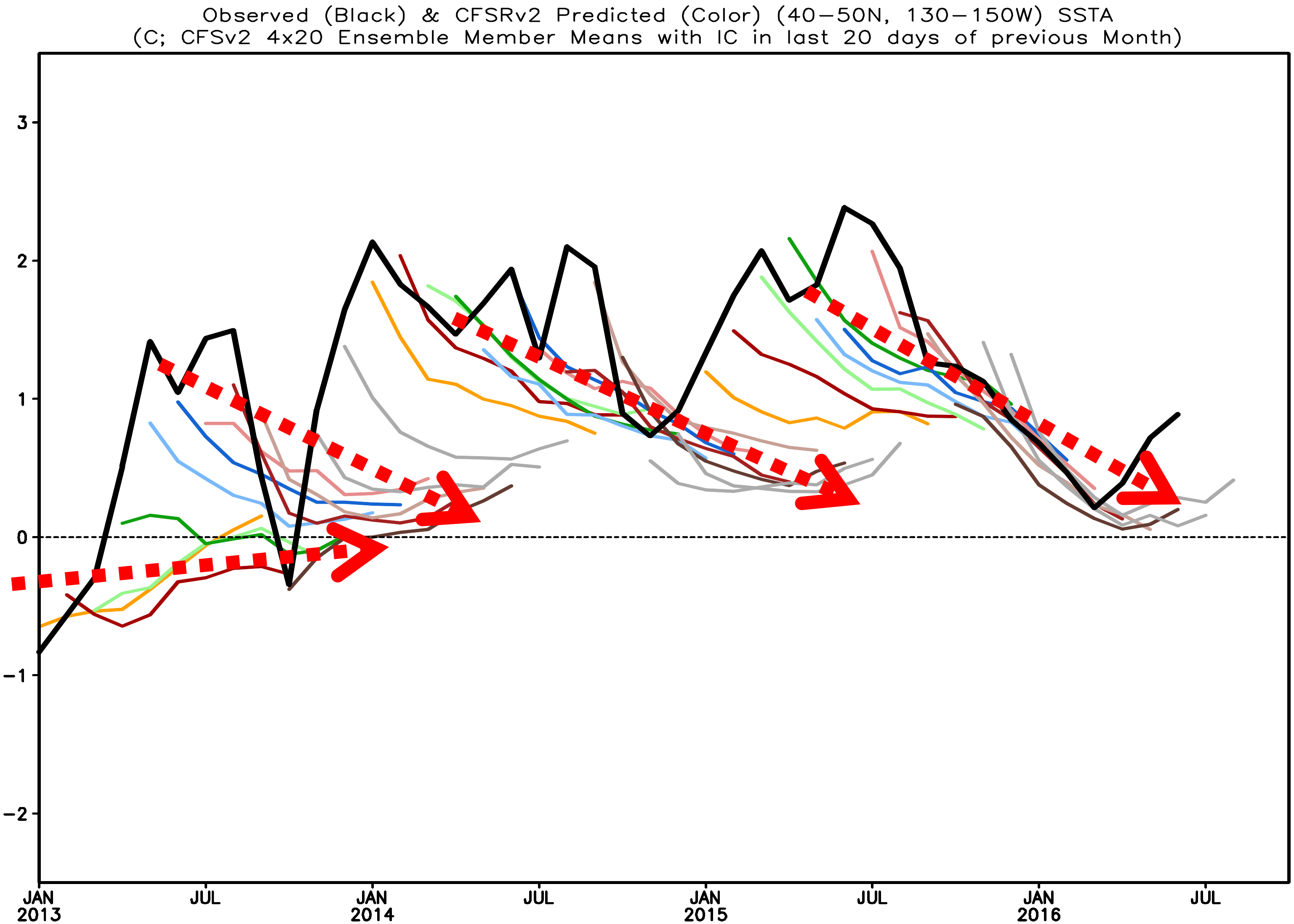
# The "Blob" dismissed since end of 2016



# CFSv2 predictions of SSTA in NE Pacific (30-50N, 150W-130W)



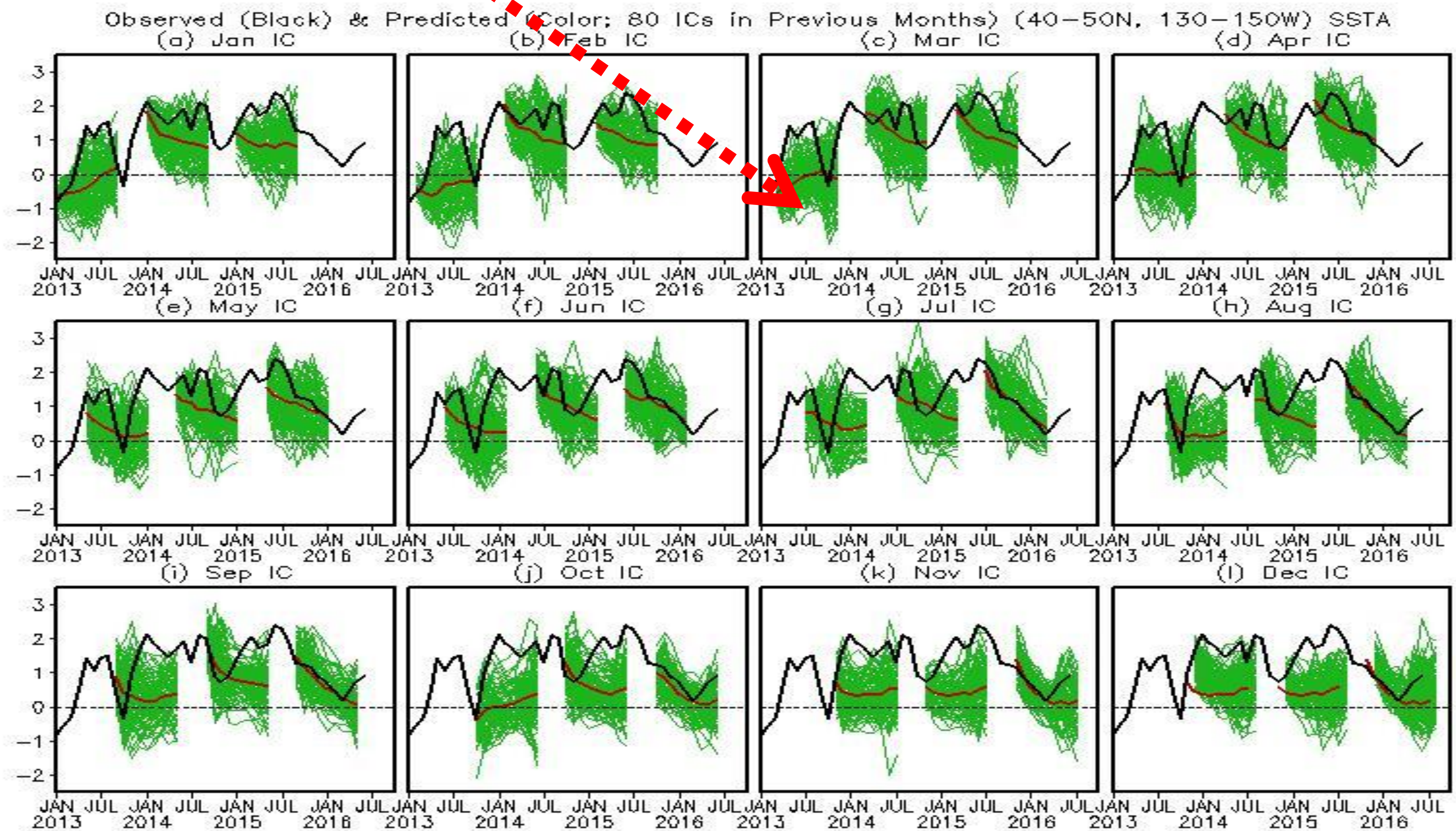
# CFSv2 predictions damped the IC anomaly in NE Pacific (30-50N, 150W-130W)




Hu, Z.-Z., A. Kumar, B. Jha, J. Zhu, and B. Huang, 2017: Persistence and predictions of the remarkable warm anomaly in the northeastern Pacific Ocean during 2014-2016. J. Climate, 30 (2), 689–702. DOI: http://dx.doi.org/10.1175/JCLI-D-16-0348.1

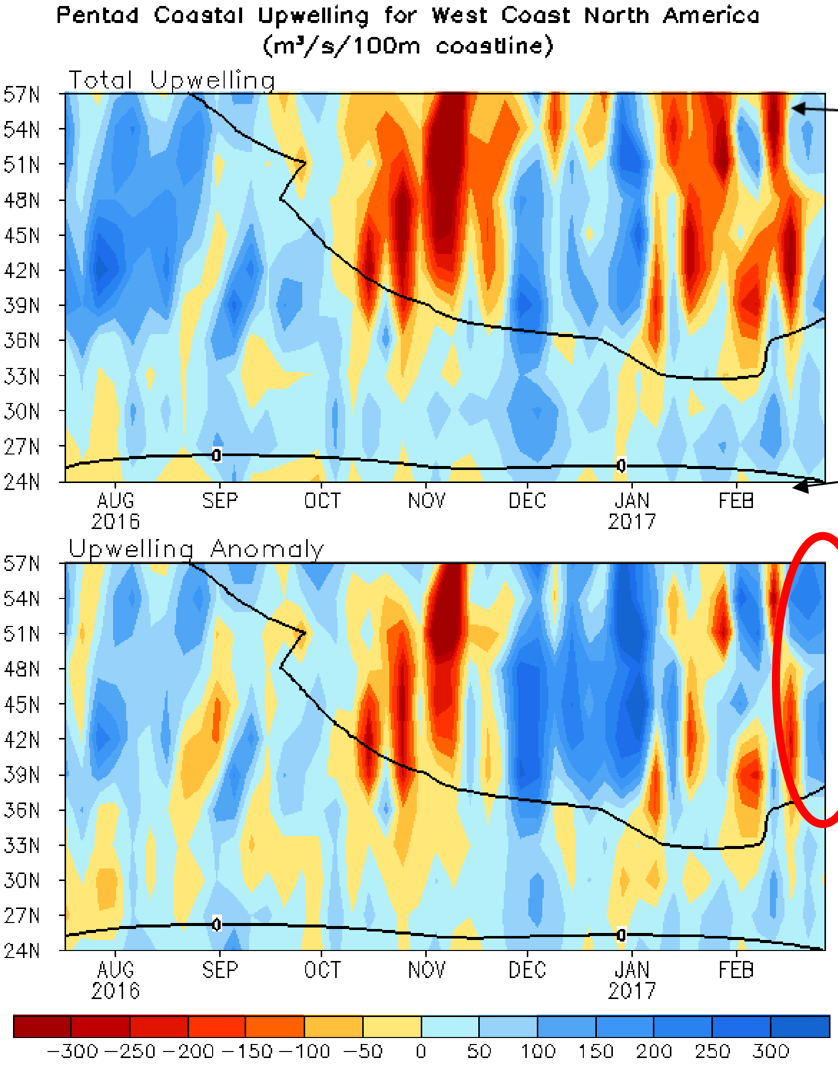
# CFSv2 predicted SSTA in NE Pacific (30-50N, 150W-130W) with IC from each Month

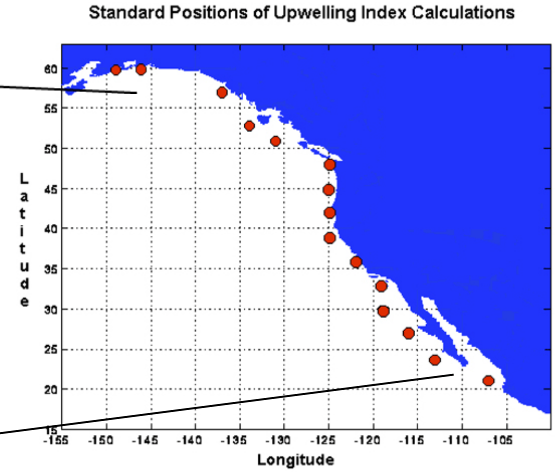
(very large spread among individual ensemble member, even at the initial conditions of 20 days window, suggests large variability of SST in the NE Pacific, implying the driving of atmosphere to the ocean)




Hu, Z.-Z., A. Kumar, B. Jha, J. Zhu, and B. Huang, 2017: Persistence and predictions of the remarkable warm anomaly in the northeastern Pacific Ocean during 2014-2016. J. Climate, 30 (2), 689–702. DOI: http://dx.doi.org/10.1175/JCLI-D-16-0348.1

# North America Western Coastal Upwelling



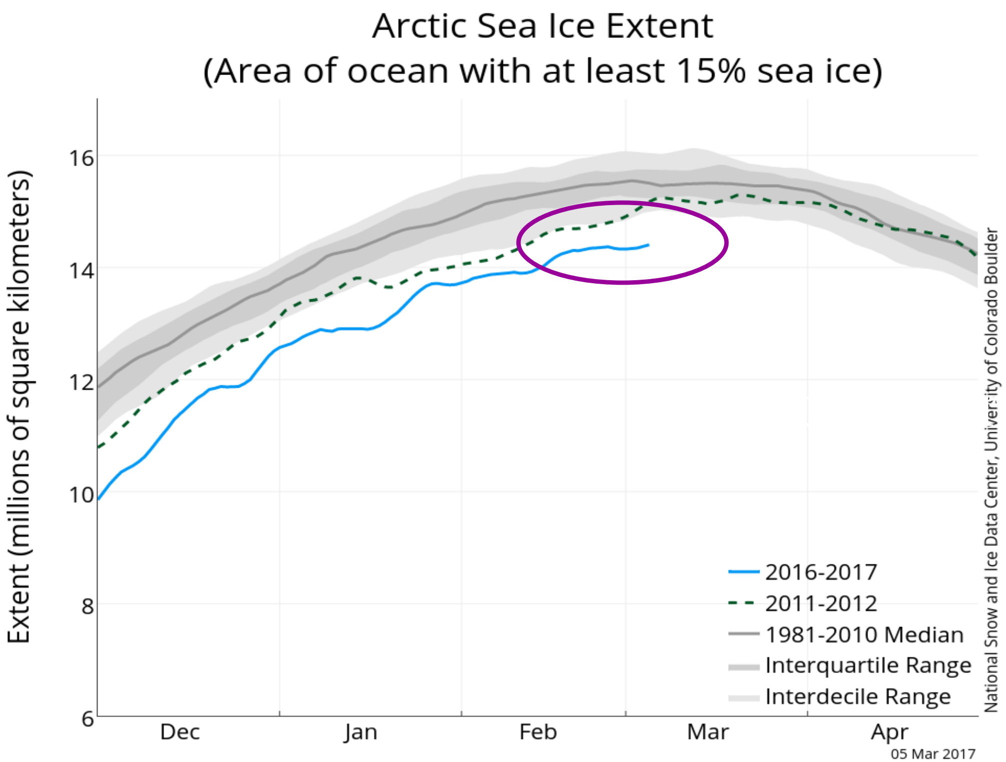

- **Recently, anomalous upwelling presented in late Feb 2017.**

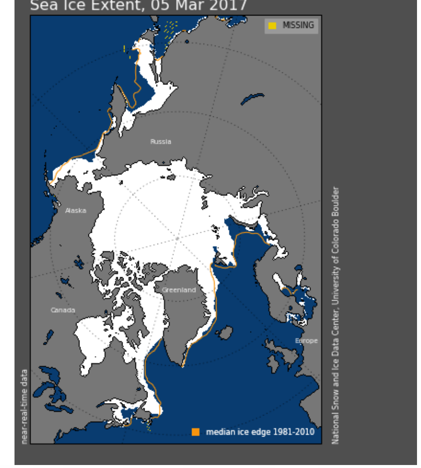
**Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

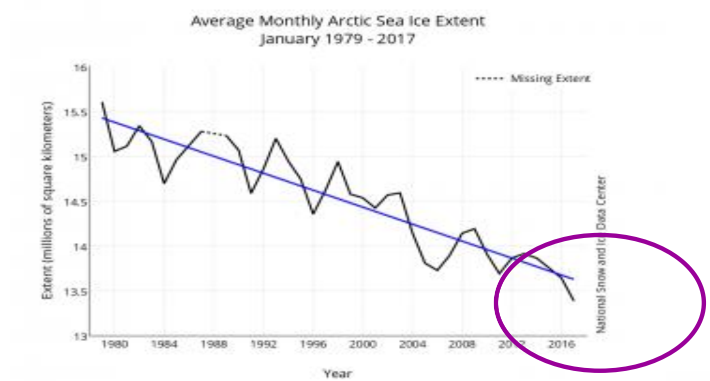
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

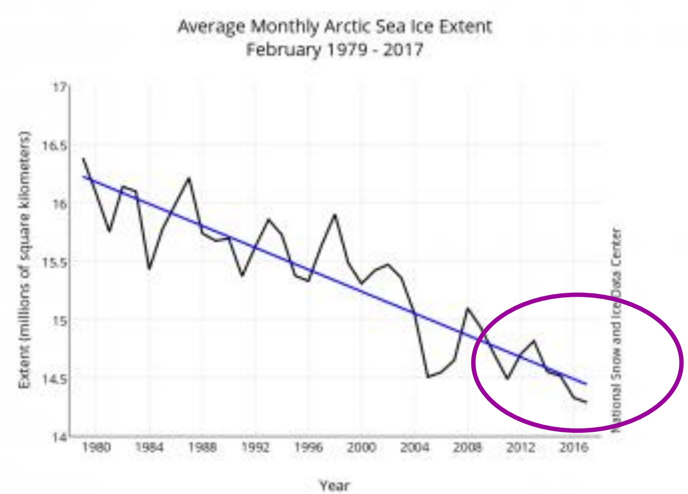
# Arctic Sea Ice

**National Snow and Ice Data Center**
**http://nsidc.org/arcticseaicenews/index.html**



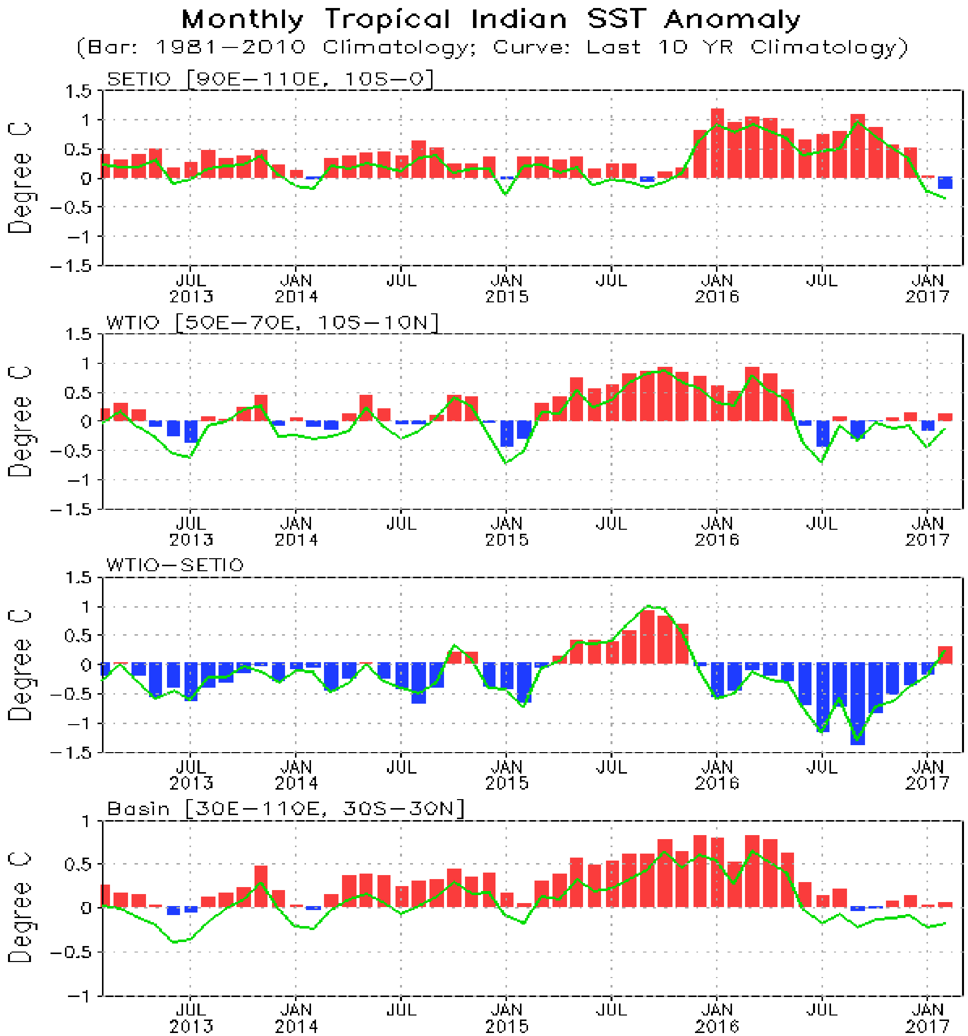



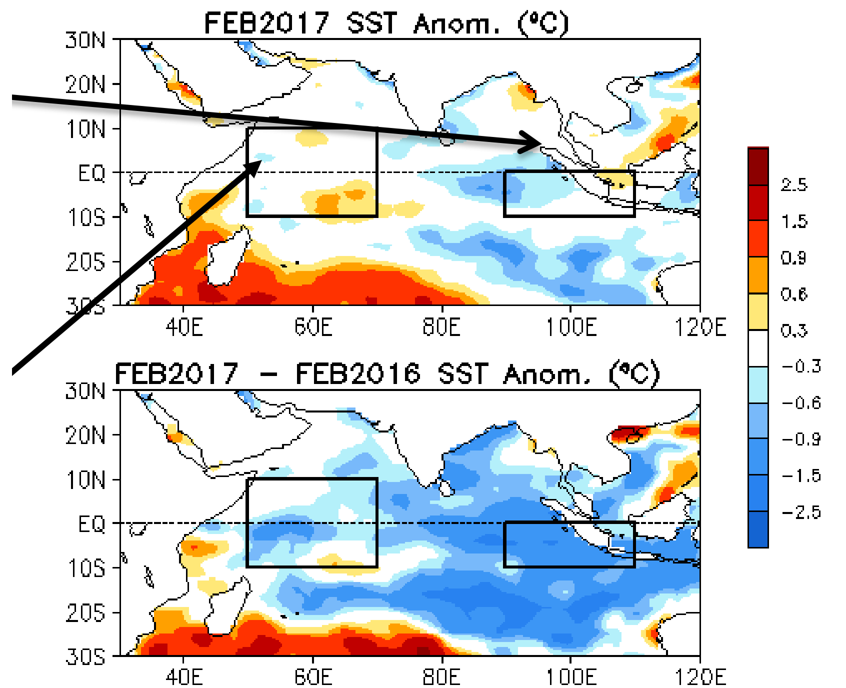

- **Arctic sea ice extent in Feb 2017 was smaller than -2 standard deviations and less than that in 2011-12.**

- **Arctic sea ice extent was lowest in the 38-year satellite record in both Jan and Feb 2017.**

# Indian Ocean

# Evolution of Indian Ocean SST Indices



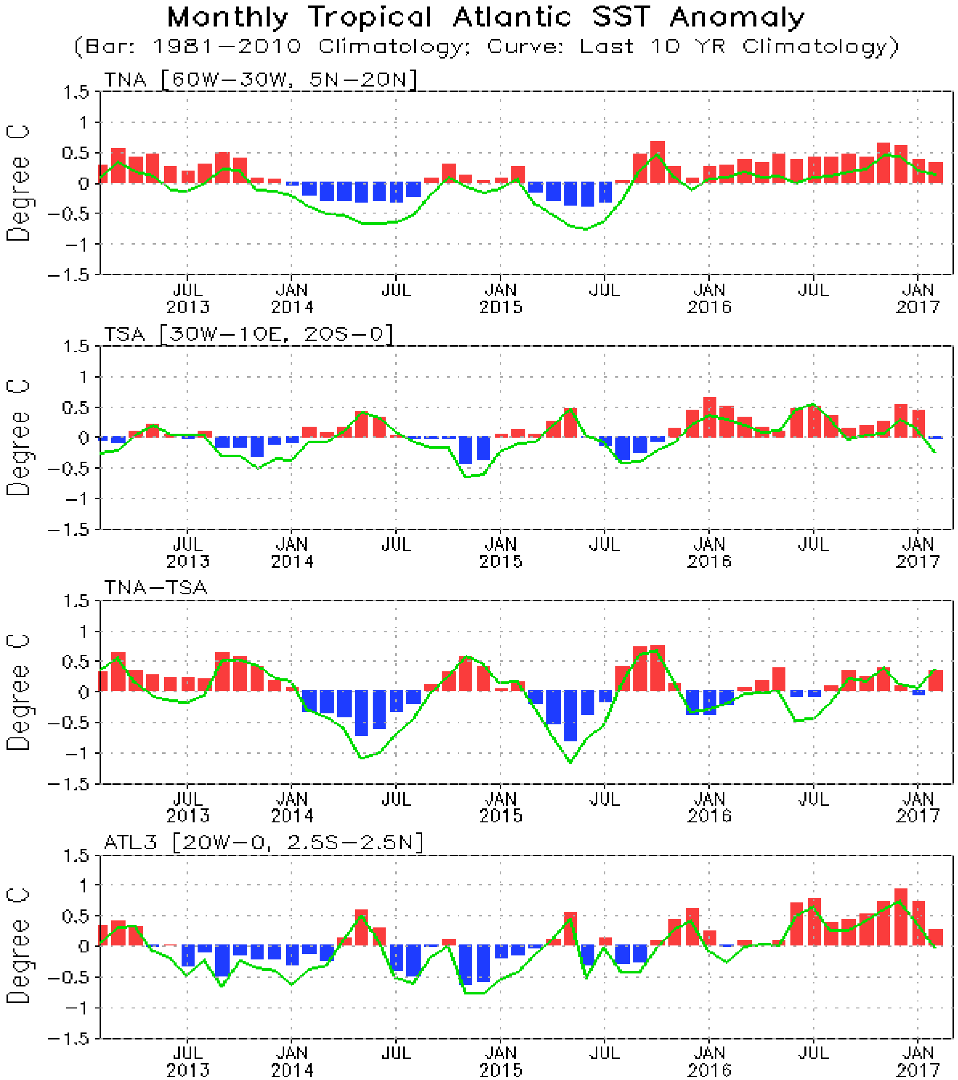

- **Overall, SSTAs were near average in the tropical, and large positive in the SW.**

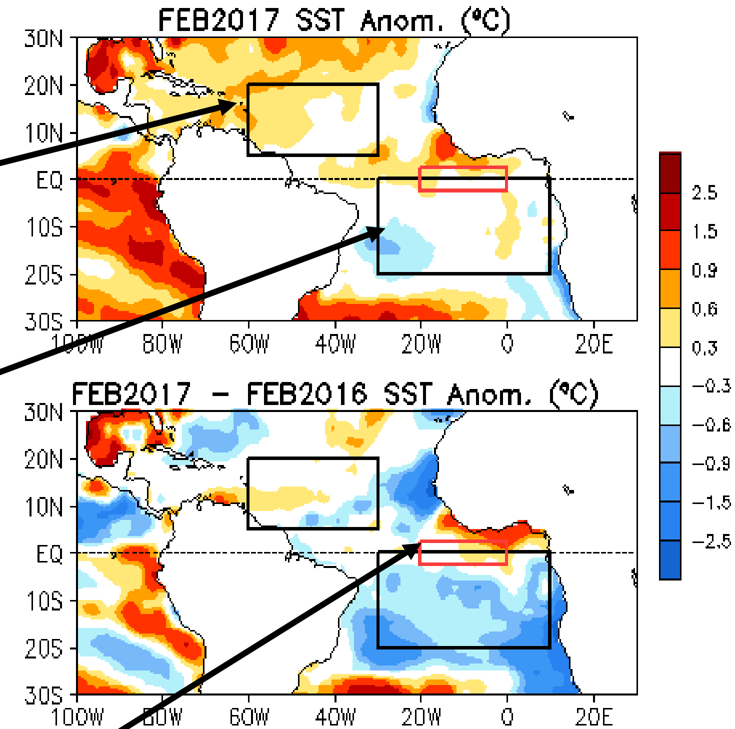
- **Values of all indices were small during last 2 months.**

**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 and North Atlantic Ocean

# Evolution of Tropical Atlantic SST Indices

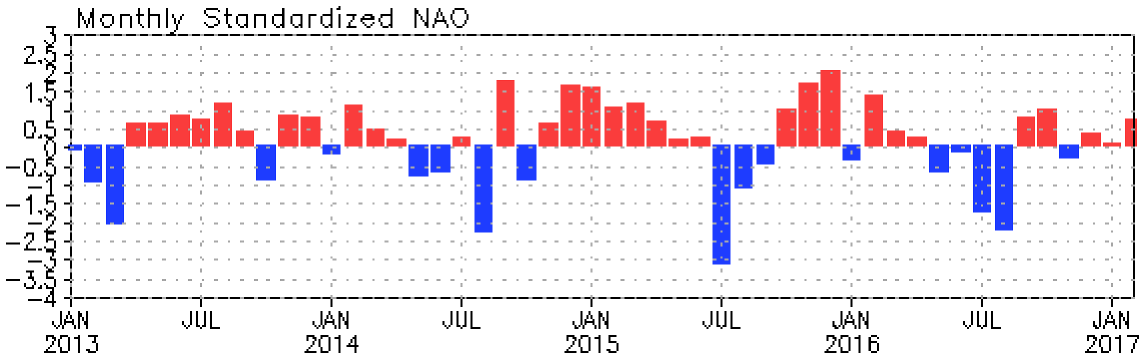


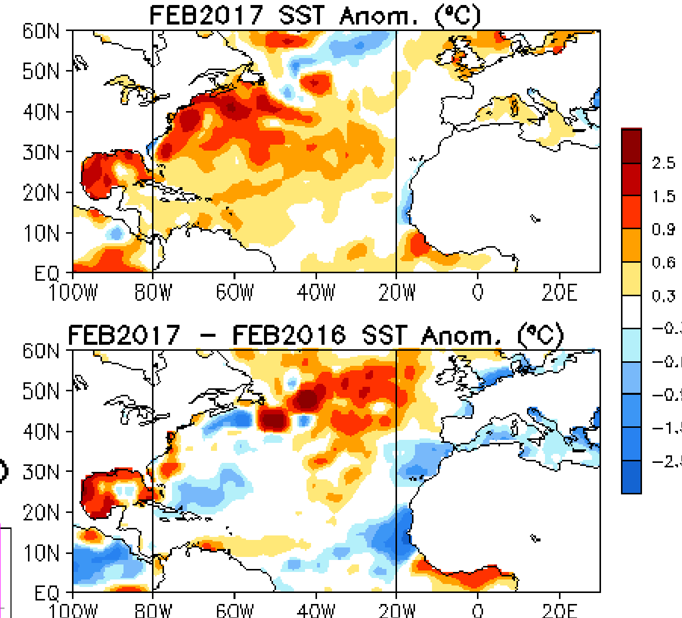



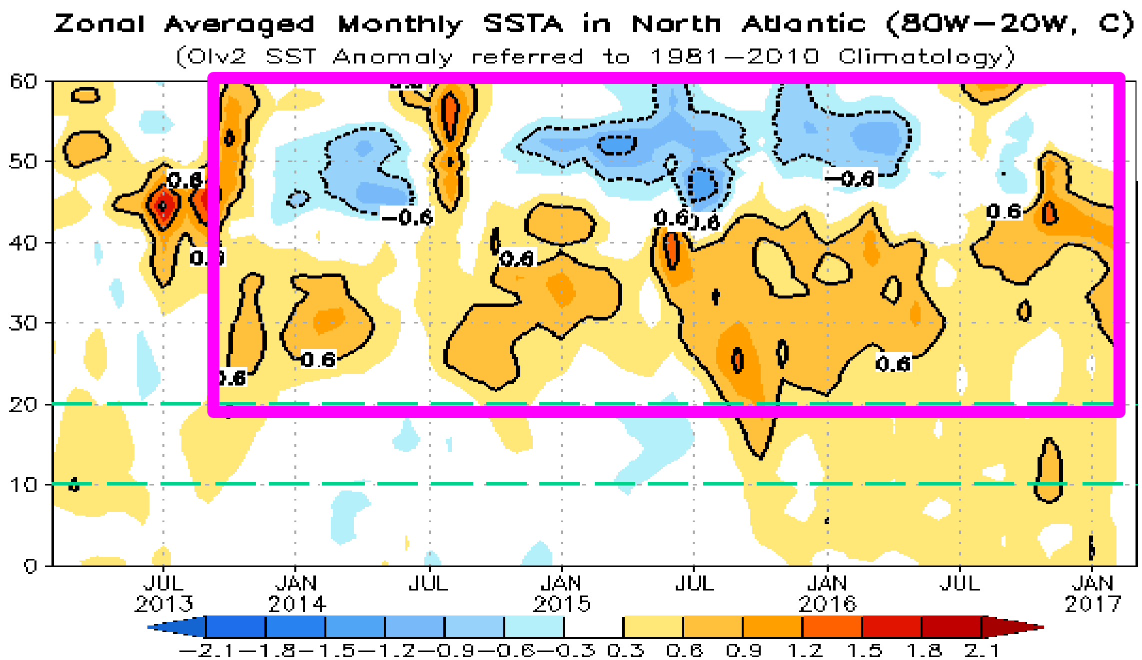

- All indices, except TSA, were positive in Feb 2017.

**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



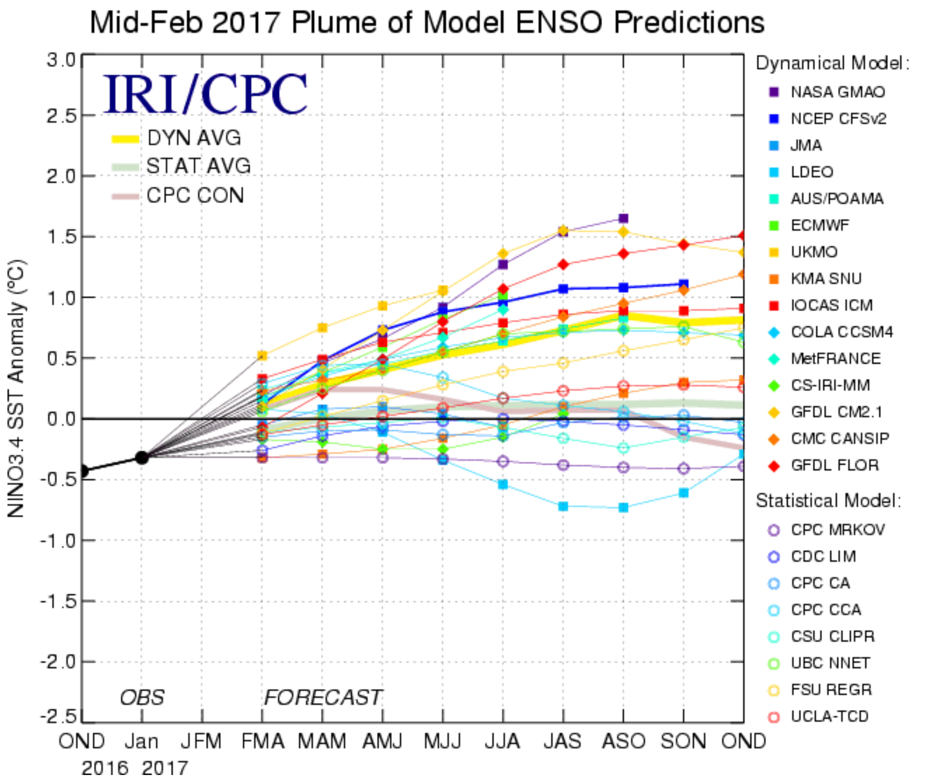

- NAO has been in positive phase since Dec 2016 with NAOI=0.69 in Feb 2017.

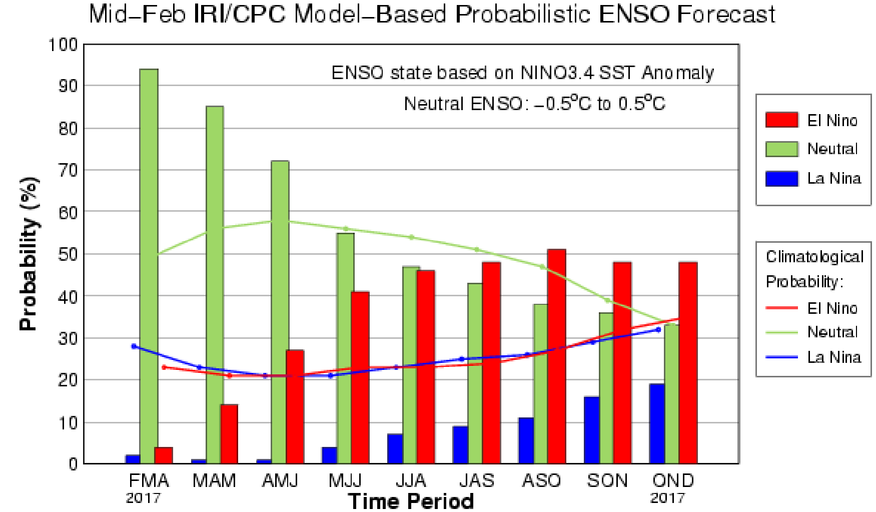
- SSTA was positive in the middle latitudes and negative in the high latitudes during last 3 years, probably due to the impact of positive phase of NAO.

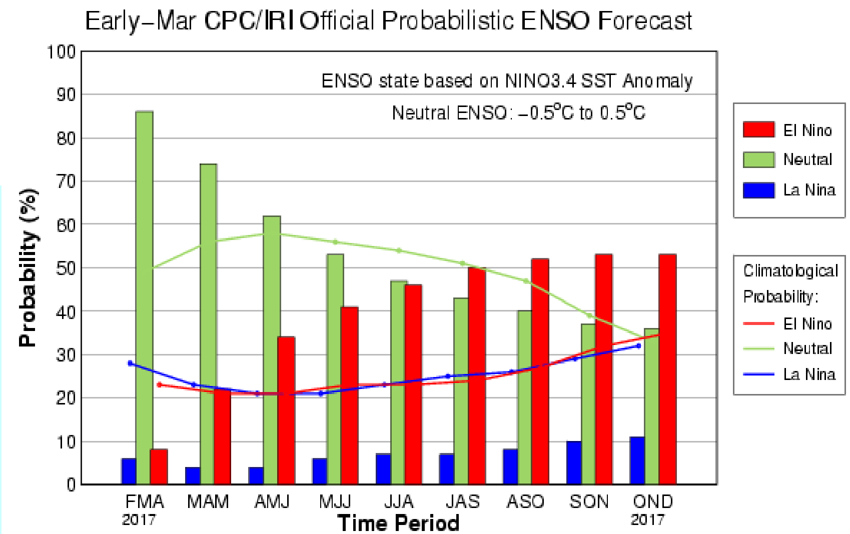
**Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis,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

# ENSO and Global SST Predictions

# IRI NINO3.4 Forecast Plum

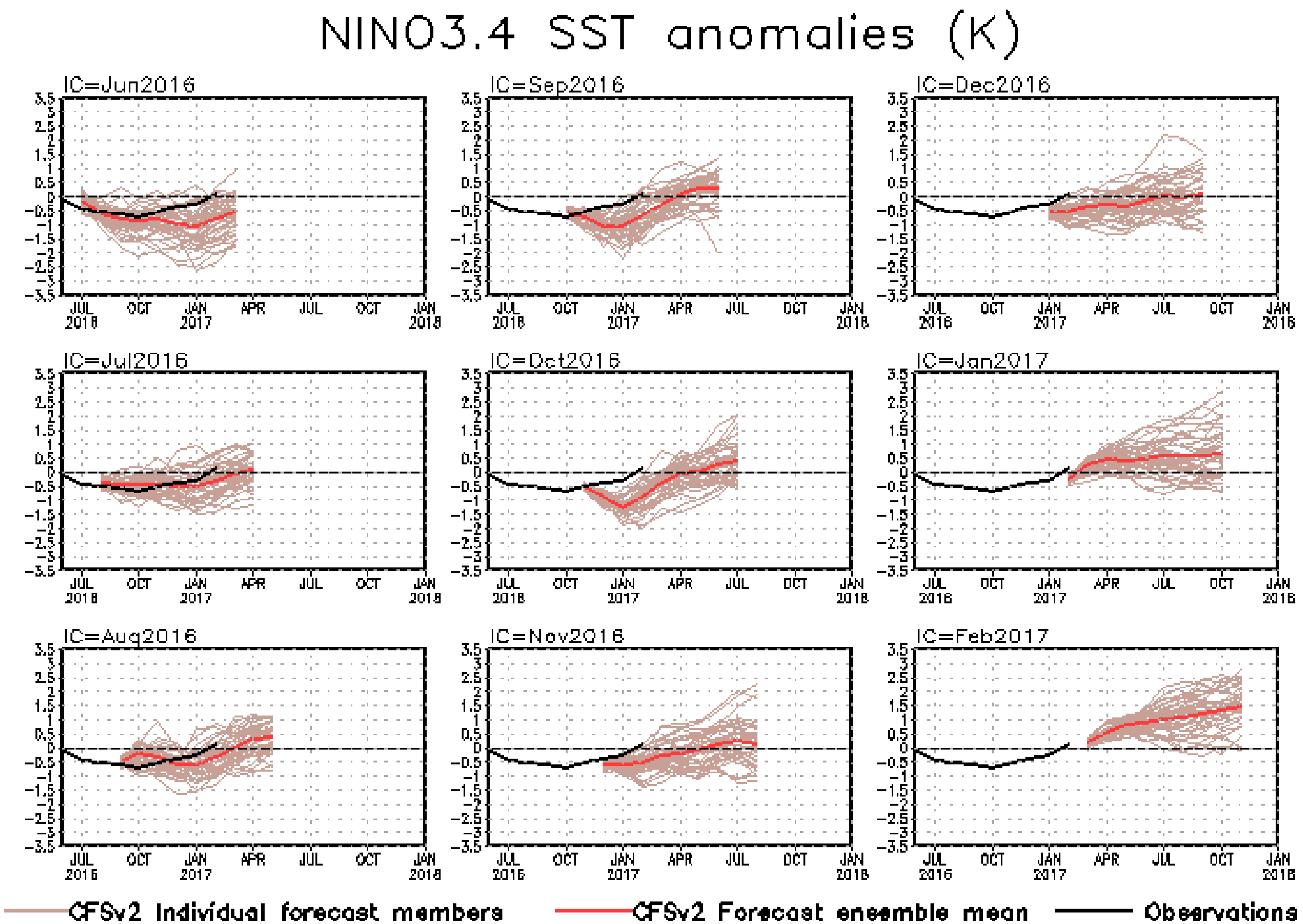



- **Majority of dynamical models call for El Nino development in summer/fall 2017, while statistical models favor continuation of neutral conditions through 2017.**
- **NOAA "ENSO Diagnostic Discussion" on 9 Mar 2017 suggested that "ENSO-neutral conditions are favored to continue through at least the Northern Hemisphere spring 2017, with increasing chances for El Niño development into the fall."**

# CFS Niño3.4 SST Predictions from Different Initial Months

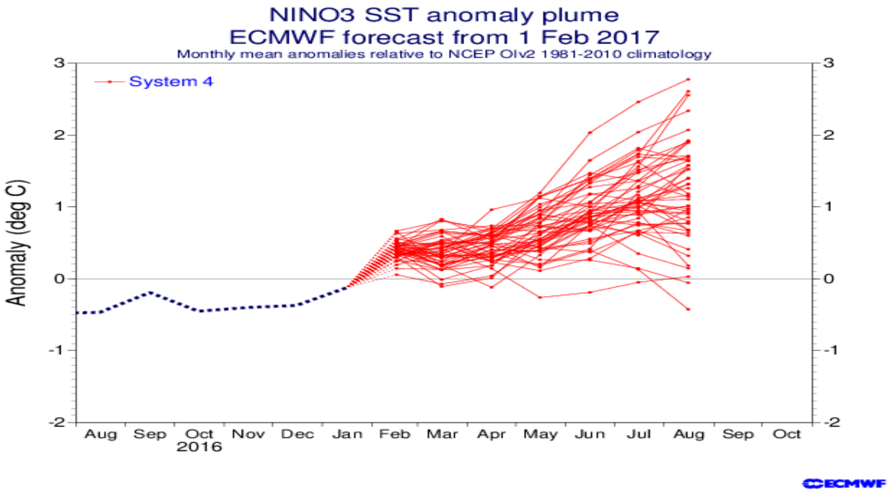



- Latest CFSv2 forecasts call for an El Nino since summer 2017.
- CFSv2 predictions had cold biases with ICs in Jun-Dec 2016.

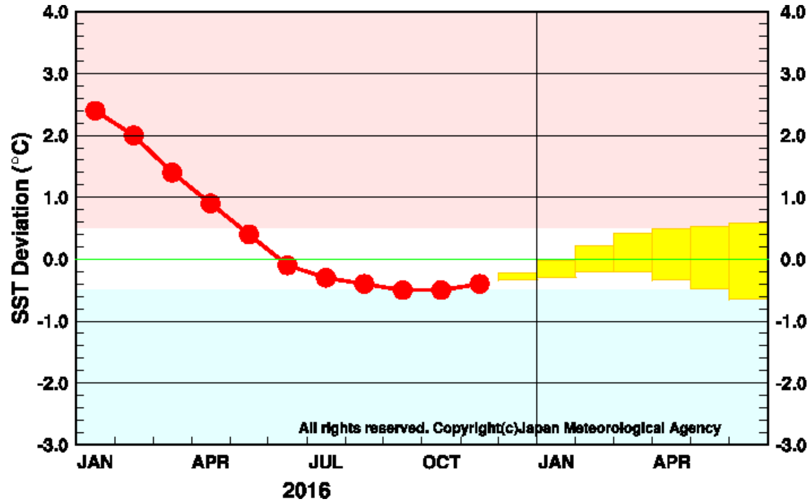
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

# Individual Model Forecasts: neutral or El Nino

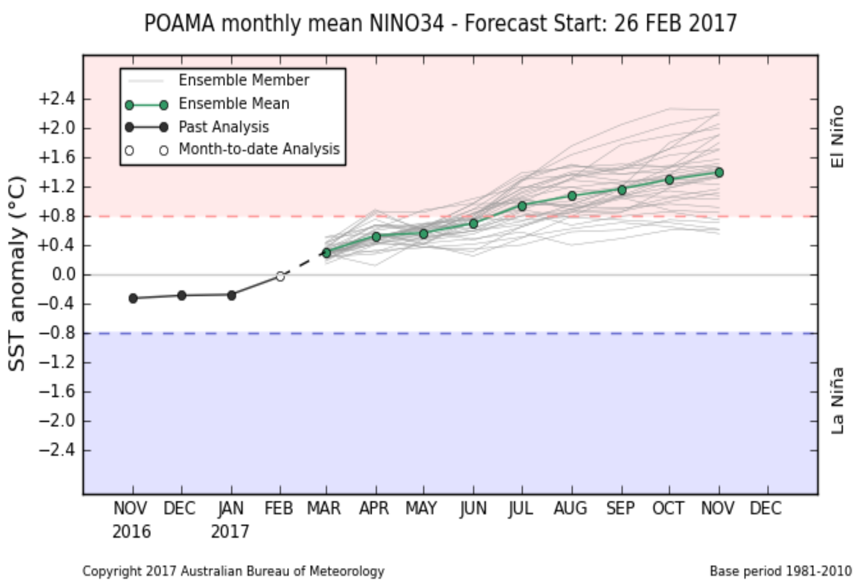
## EC: Nino3.4, IC=01Feb 2017



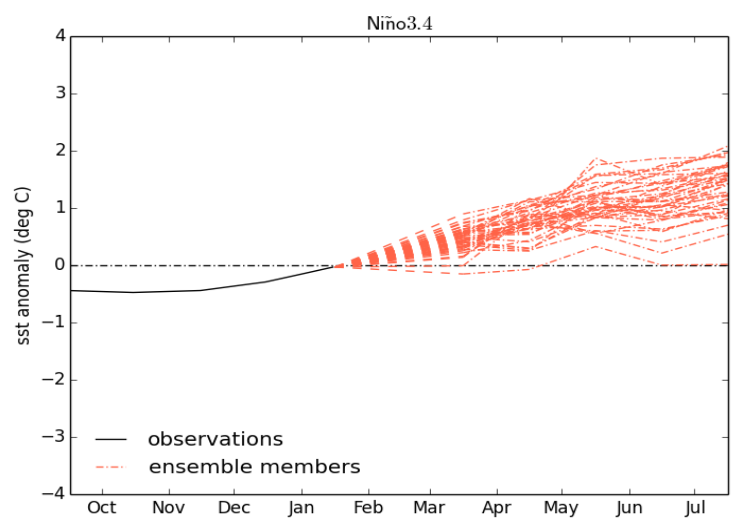

## JMA: Nino3, IC=Feb 2017

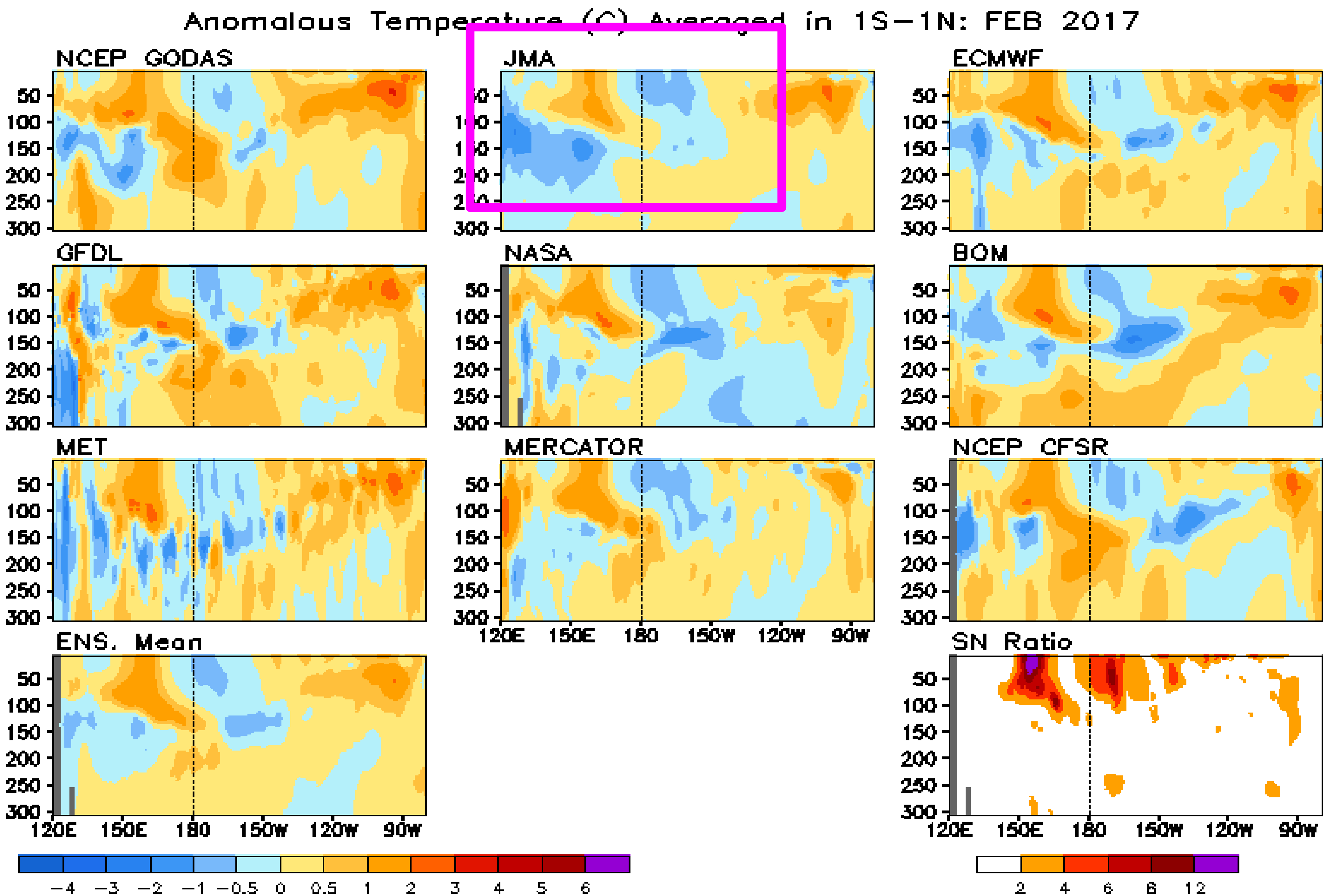



## Australia: Nino3.4, IC=26Feb 2017

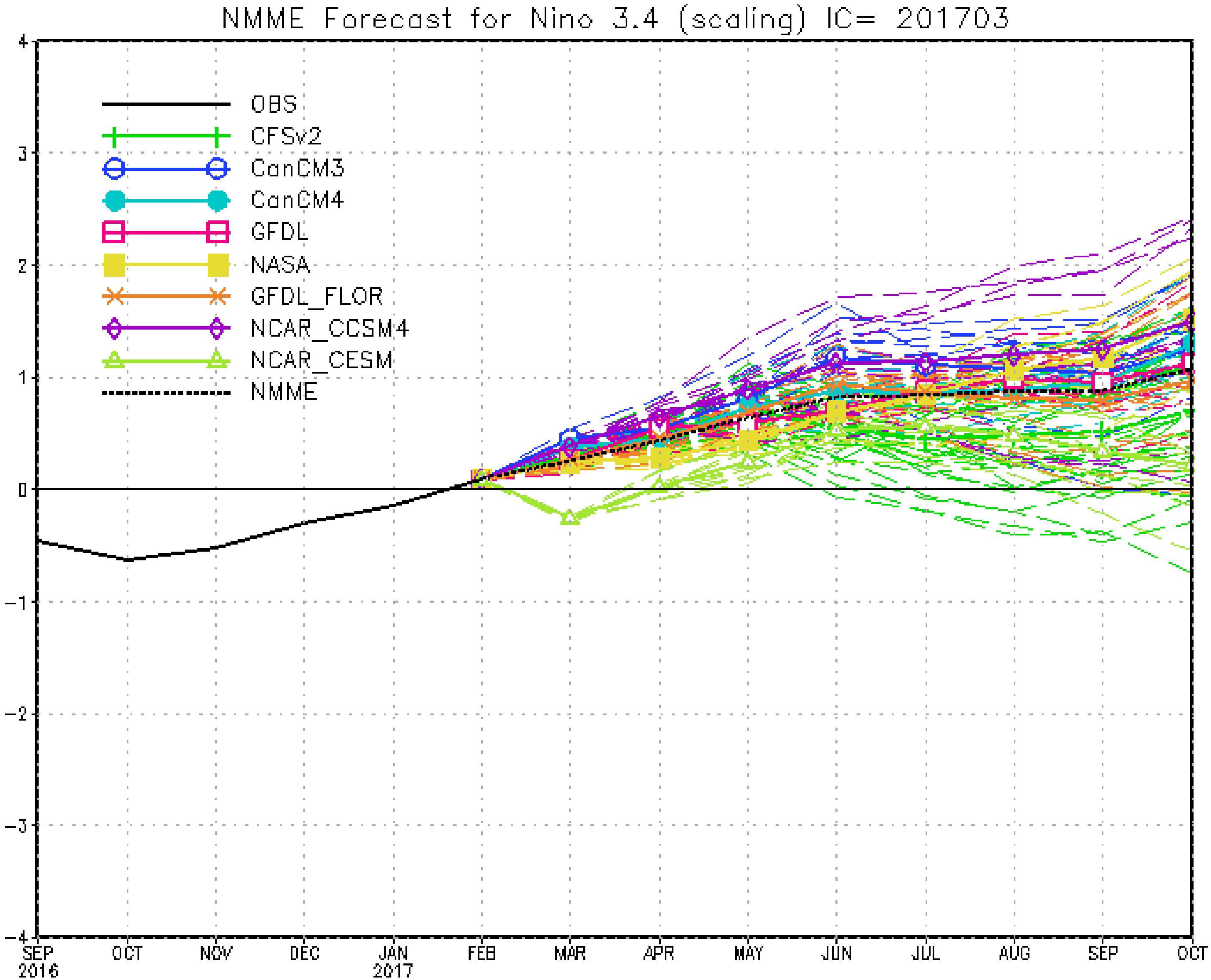



## UKMO: Nino3.4, IC=Feb 2017



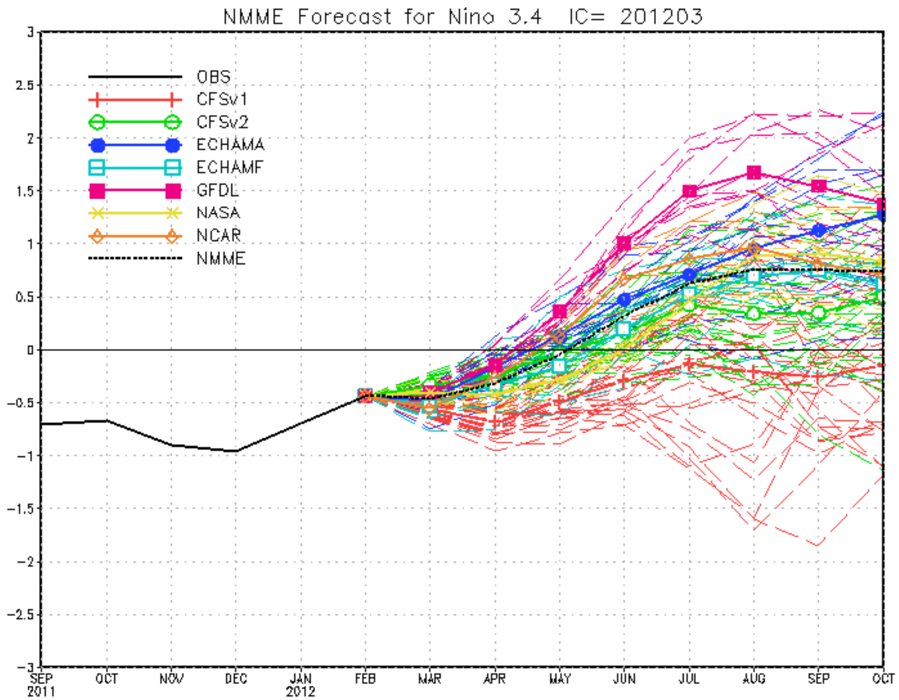


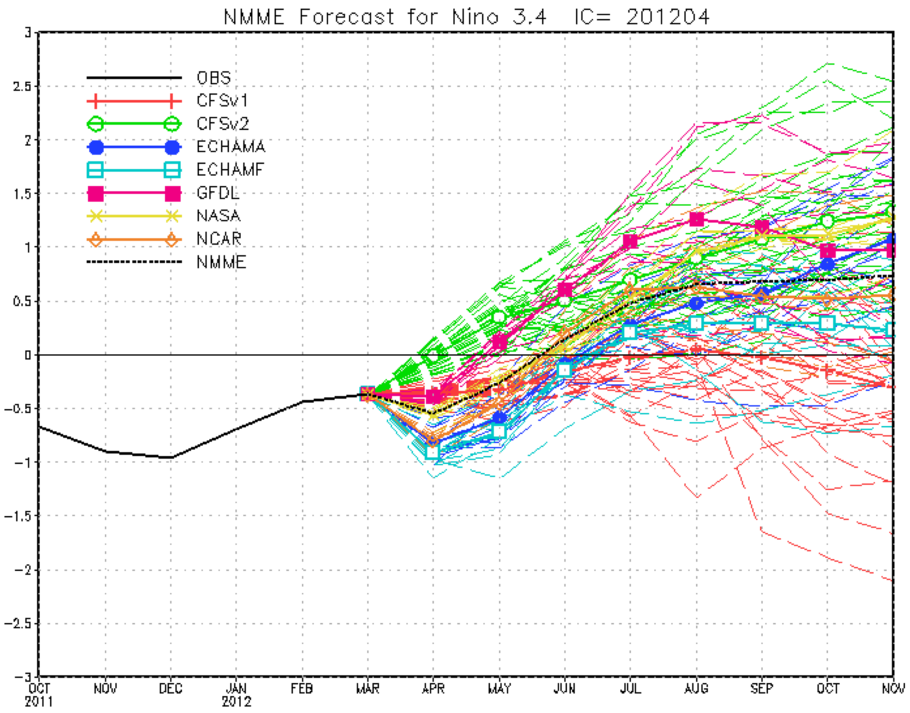
Anomalous Temperature (C) Averaged in 1S-1N: FEB 2017
NCEP GODAS
JMA
ECMWF
GFDL
NASA
BOM
MET
MERCATOR
NCEP CFSR
ENS. Mean
SN Ratio
50
100
150
200
250
300
120E
150E
180
150W
120W
90W
-4
-3
-2
-1
-0.5
0
0.5
1
2
3
4
5
6
2
4
6
8
12



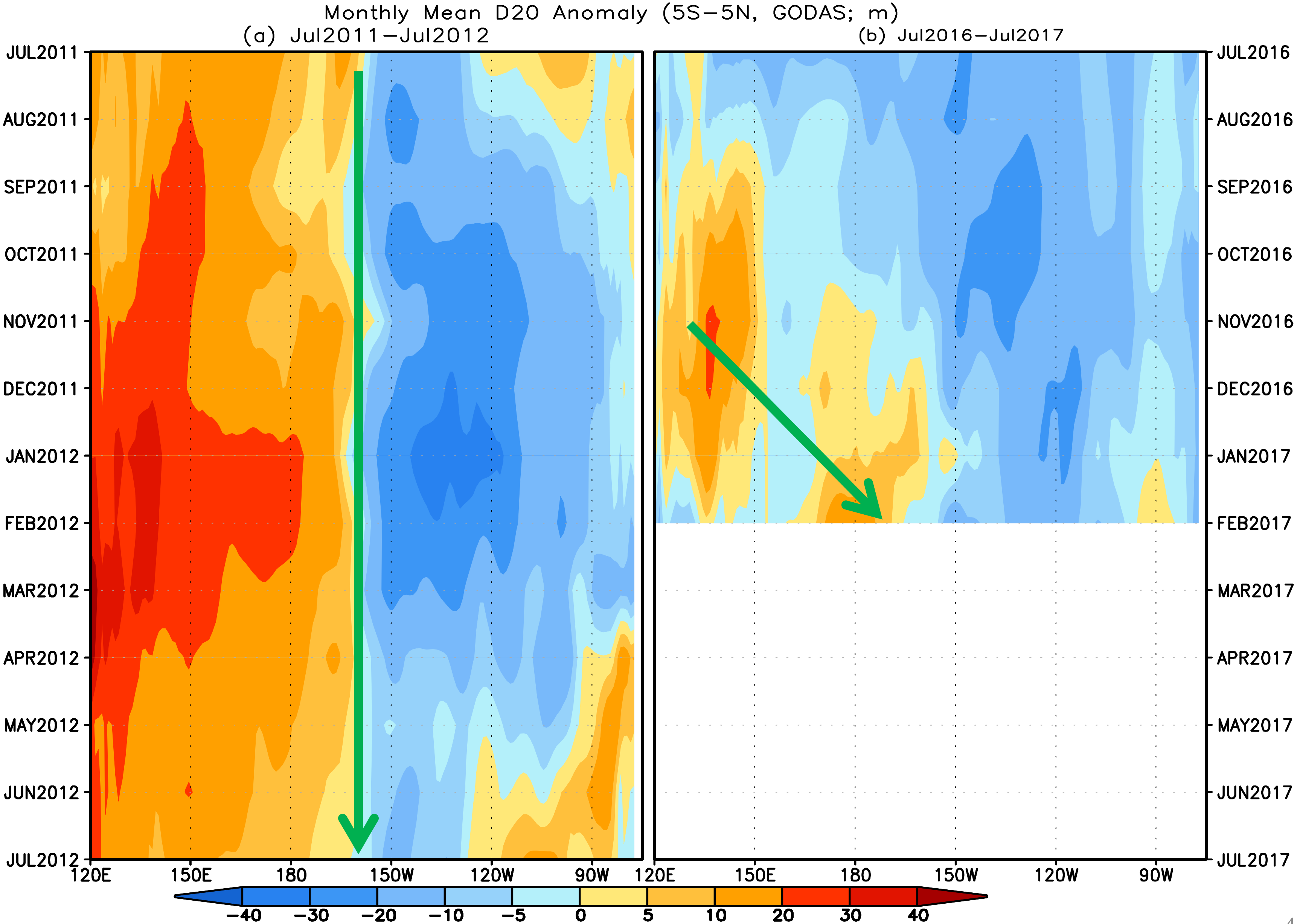

**- NMME models suggest a transition to El Nino conditions in later spring and early summer.**

# Failure Forecast in 2012 with ICs in March and April 2012

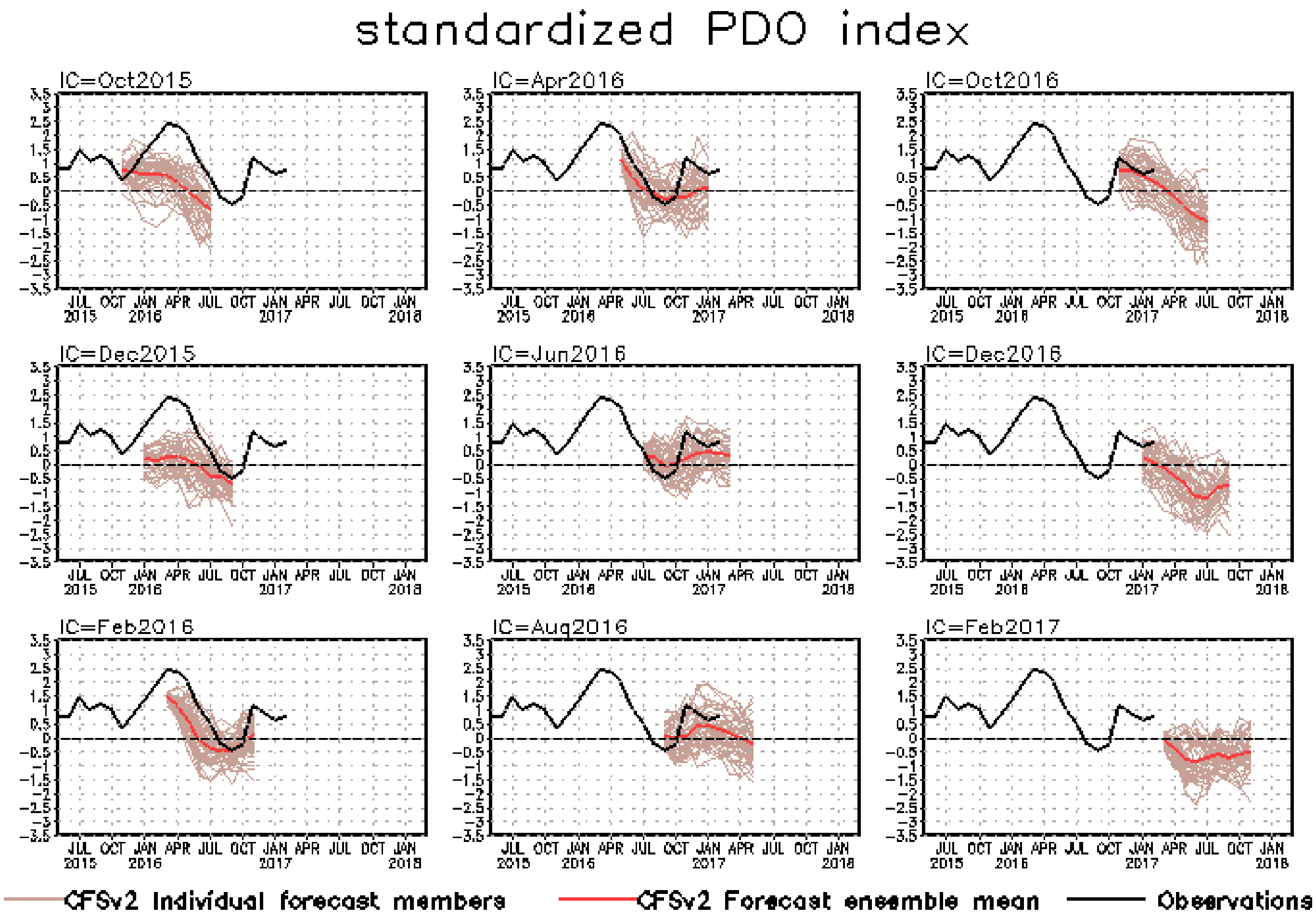


# Differences of D20 Evolution in 2011/12 and 2016/17



# 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].

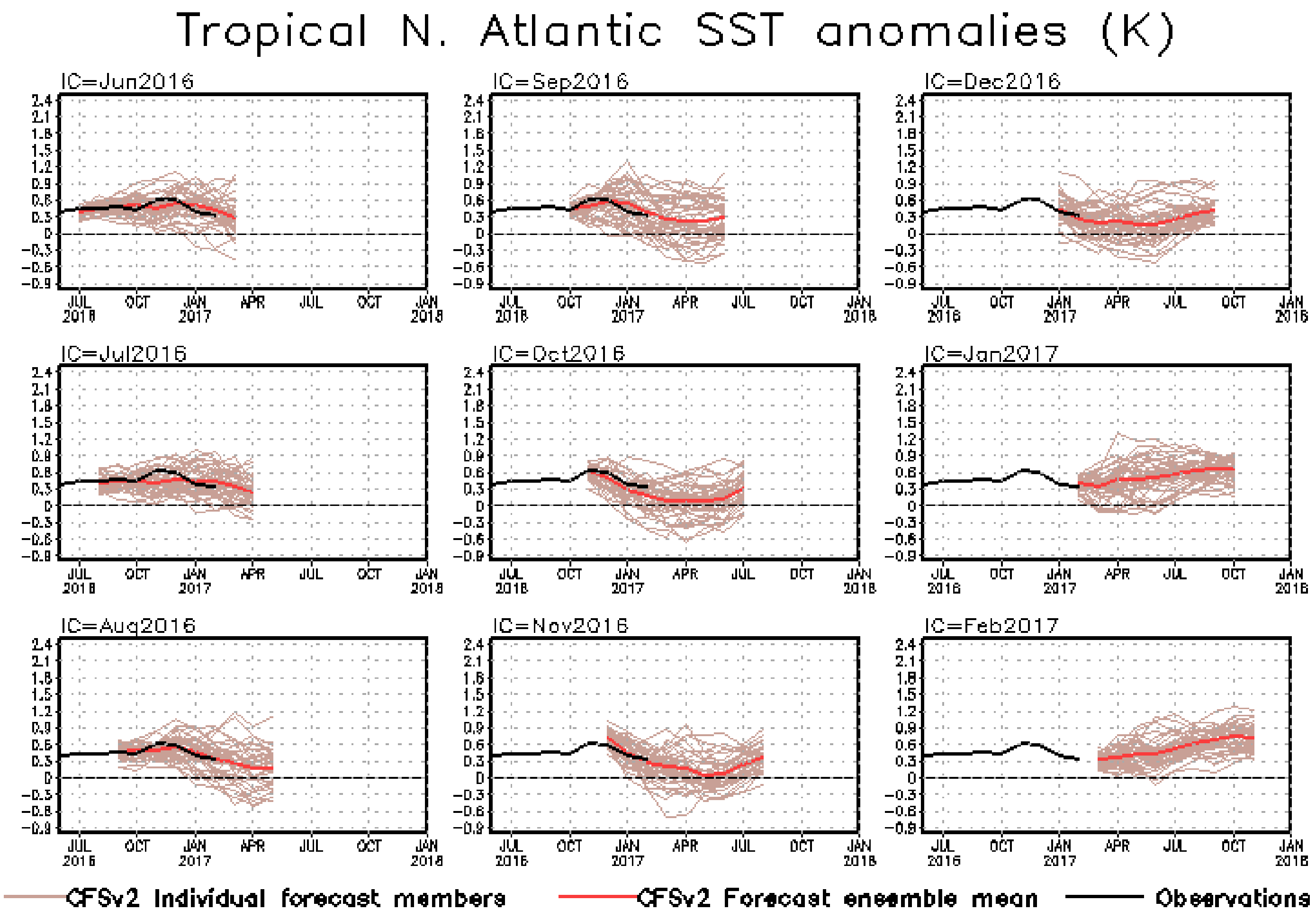
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

- CFSv2 predicts a negative phase of PDO in 2017.

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.

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

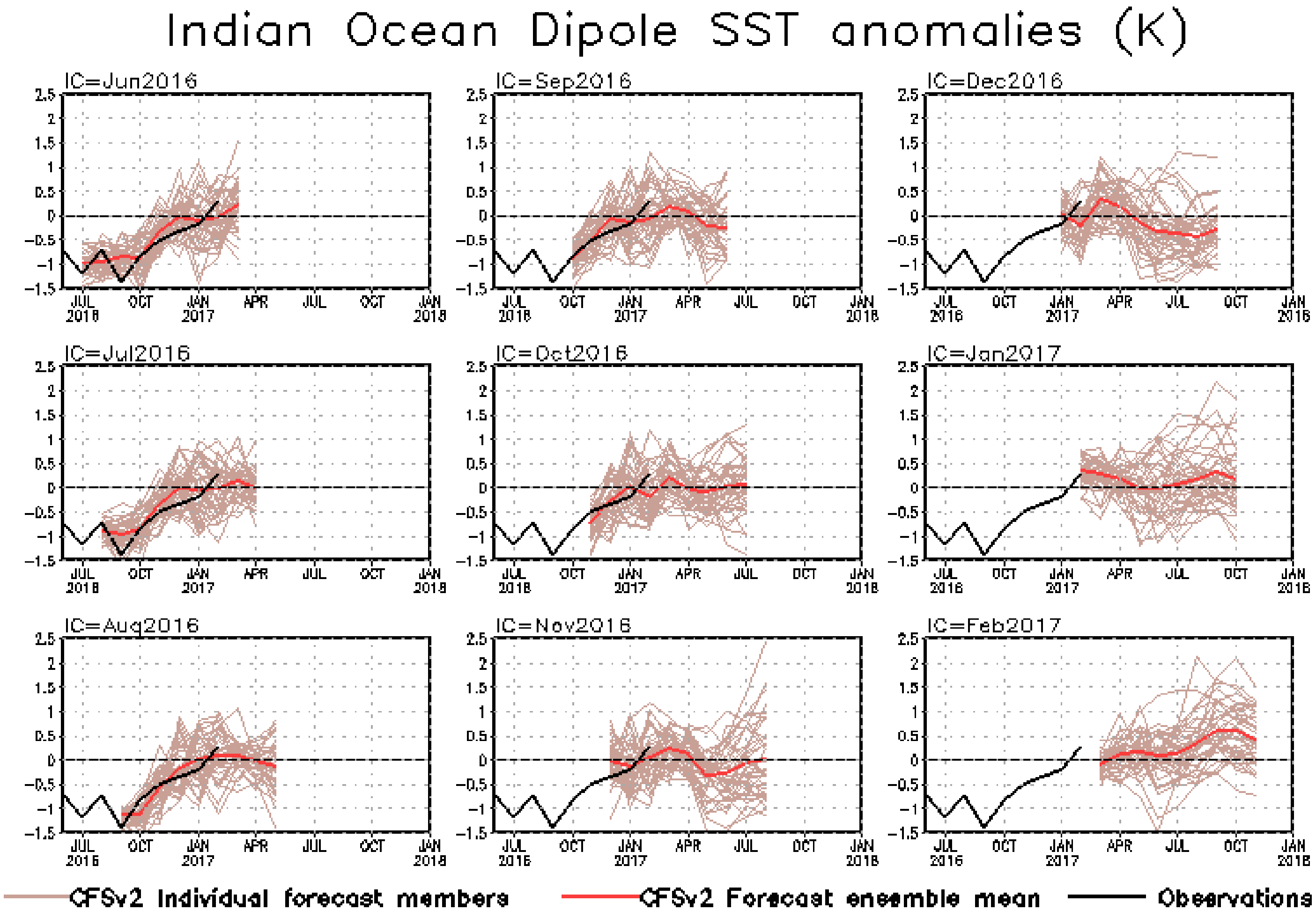
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].




- Latest CFSv2 predictions call above normal SSTA in tropical N. Atlantic in spring-autumn 2017.

**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 [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.**

# Acknowledgements


- Drs. Caihong Wen and Yan Xue: carefully review PPT, and provide insight and constructive suggestions and comments

- Drs. Li Ren and Pingping Xie: Provide SSS slides

- Dr. Emily Becker: timely provides NMME NINO3.4 plume

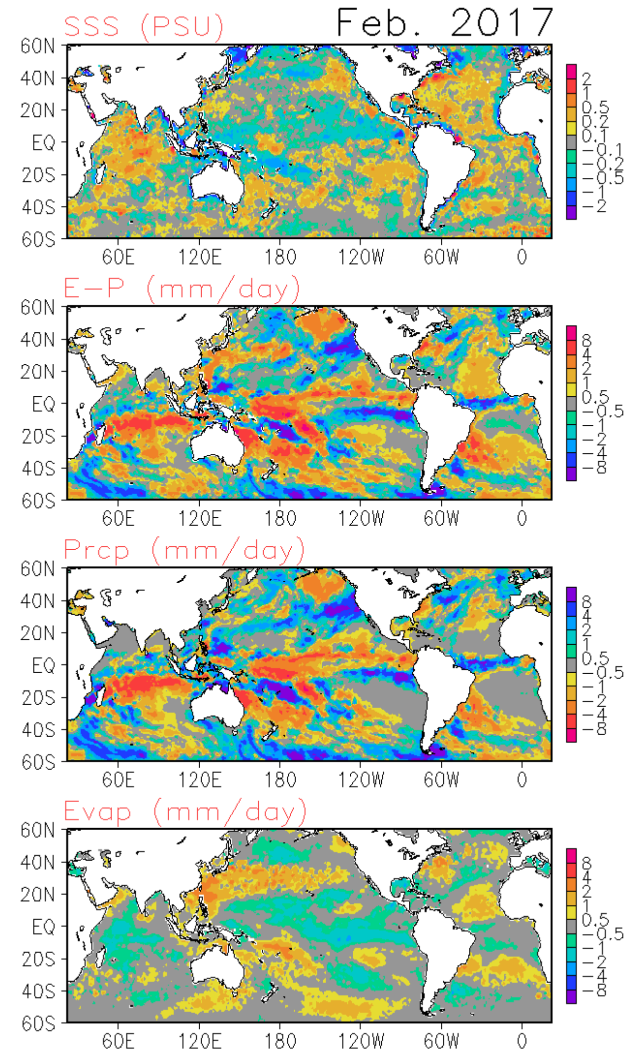
- Dr. Kathleen Dohan: updates OSCAR current

# Backup Slides

# Global Sea Surface Salinity (SSS)

## Anomaly for February 2017

- 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!
- Negative SSS anomaly are along the Equator in the Pacific Ocean, except its west basin between 160°E to the dateline. However, the reduction of precipitation exits along the majority of the Equatorial Pacific Ocean. Large scale freshening in the subarctic regions of North Pacific and North Atlantic ocean in the storm track regions continues in this month, con-incident with increasing of precipitation. However, the reduction of precipitation in the Northeast Pacific Ocean leads to the SSS becoming positive in this region. The negative SSS in the sea of Okhotsk continues with no significant E-P changes. Also, the SSS in the Bay of Bengal continues decreasing, while both the evaporation and precipitation don't show significant changes.




- **Data used**

  **SSS :**

  **Blended Analysis of Surface Salinity (BASS) V0.Y**

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

  **(Xie et al. 2014)**

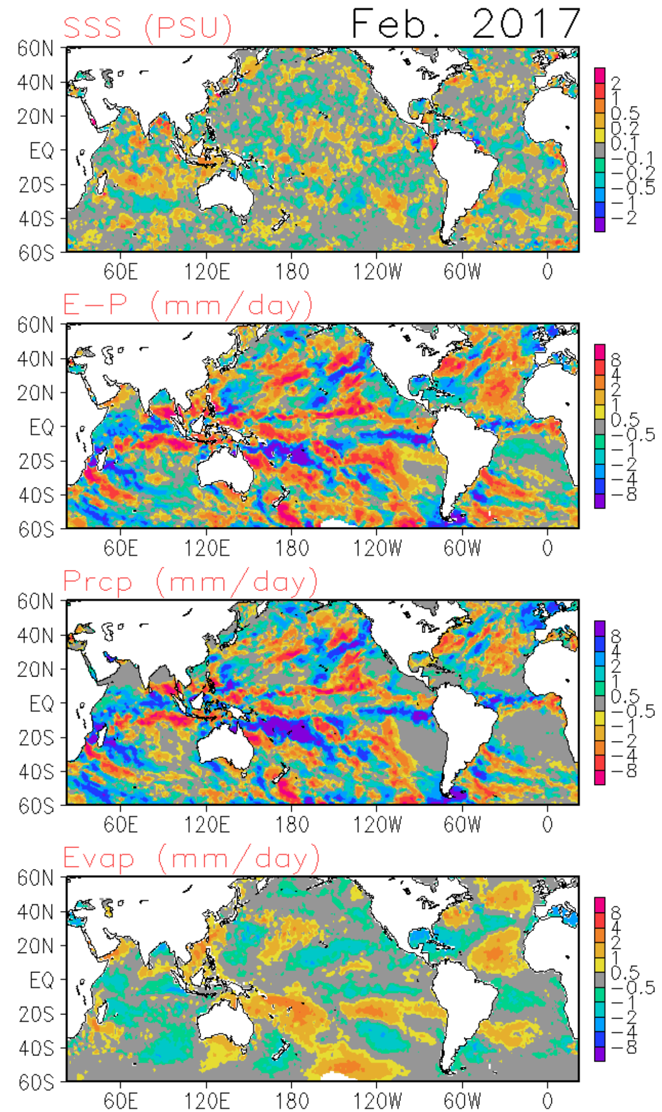
  **ftp.cpc.ncep.noaa.gov/precip/BASS**

  **Precipitation: CMORPH adjusted satellite precipitation estimates**

  **Evaporation: CFS Reanalysis**

# Global Sea Surface Salinity (SSS)
## Tendency for February 2017

Compared with last month, the salinity in the Pacific Ocean at the equatorial region show slightly increase, particularly in the central basin. The SSS continues decreasing in the north of Bay of Bengal with no significant change of precipitation but decreasing of evaporation. A large area of SSS increases appears in the subtropics of South Indian Ocean between 10°S and 30°S, with both the precipitation and evaporation decreasing. Therefore, the precipitation decrease is likely one of the reasons that cause the SSS increase in this region.



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

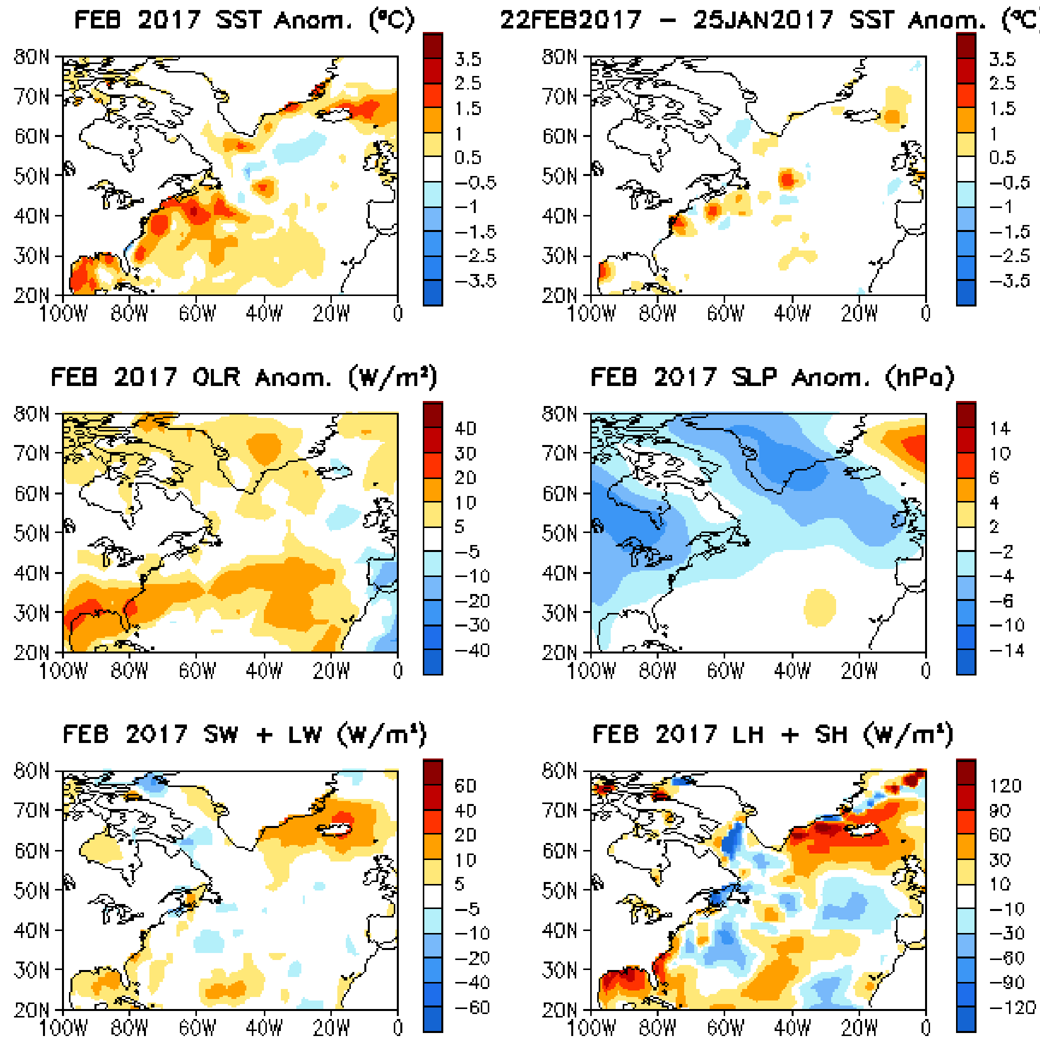



**Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

# Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

- Overall SSTAs were small in the tropical, and large in the SW.
- SSTA tendency was largely determined by heat flux.
- Convections were enhanced over the northern basin.

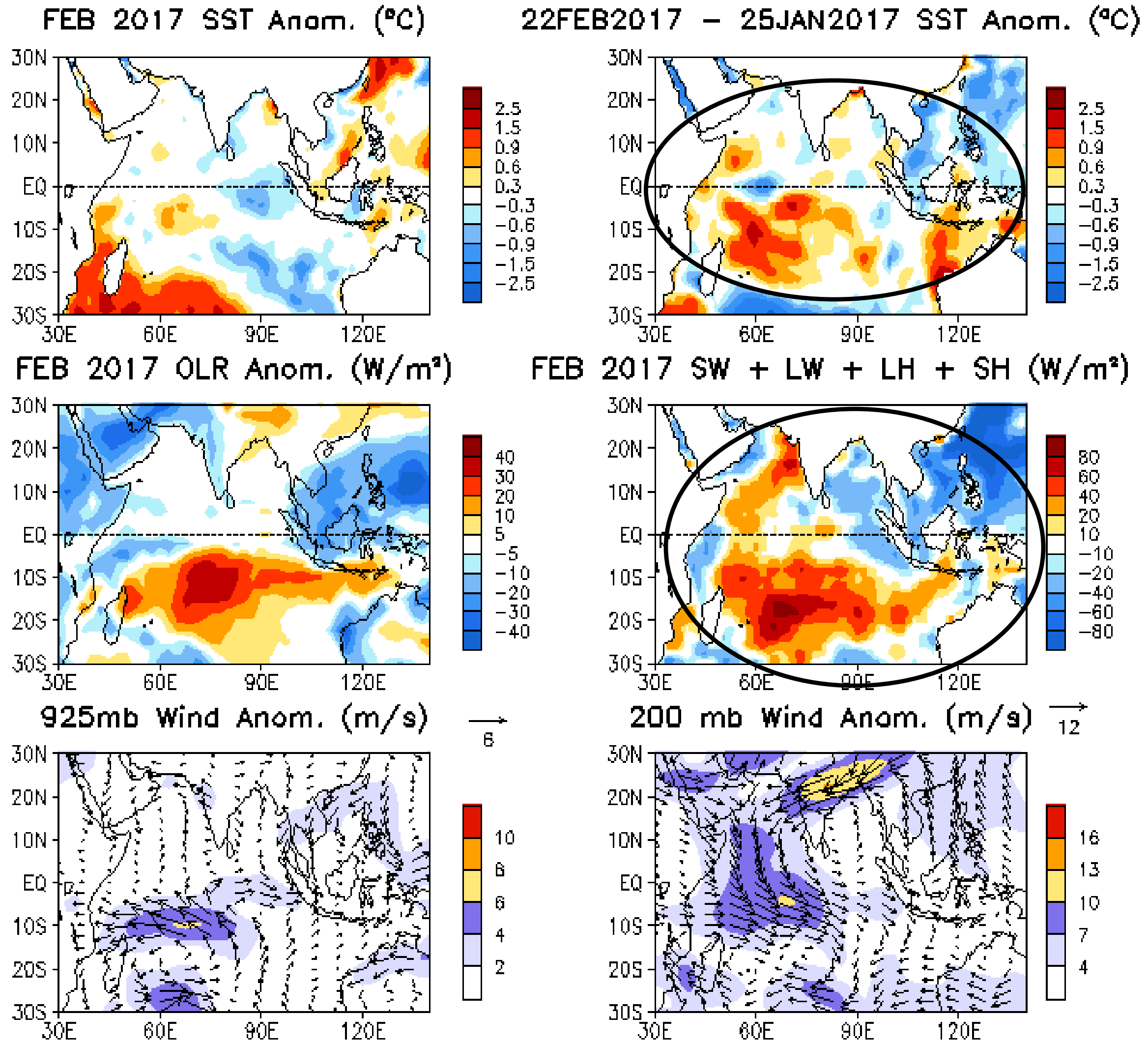
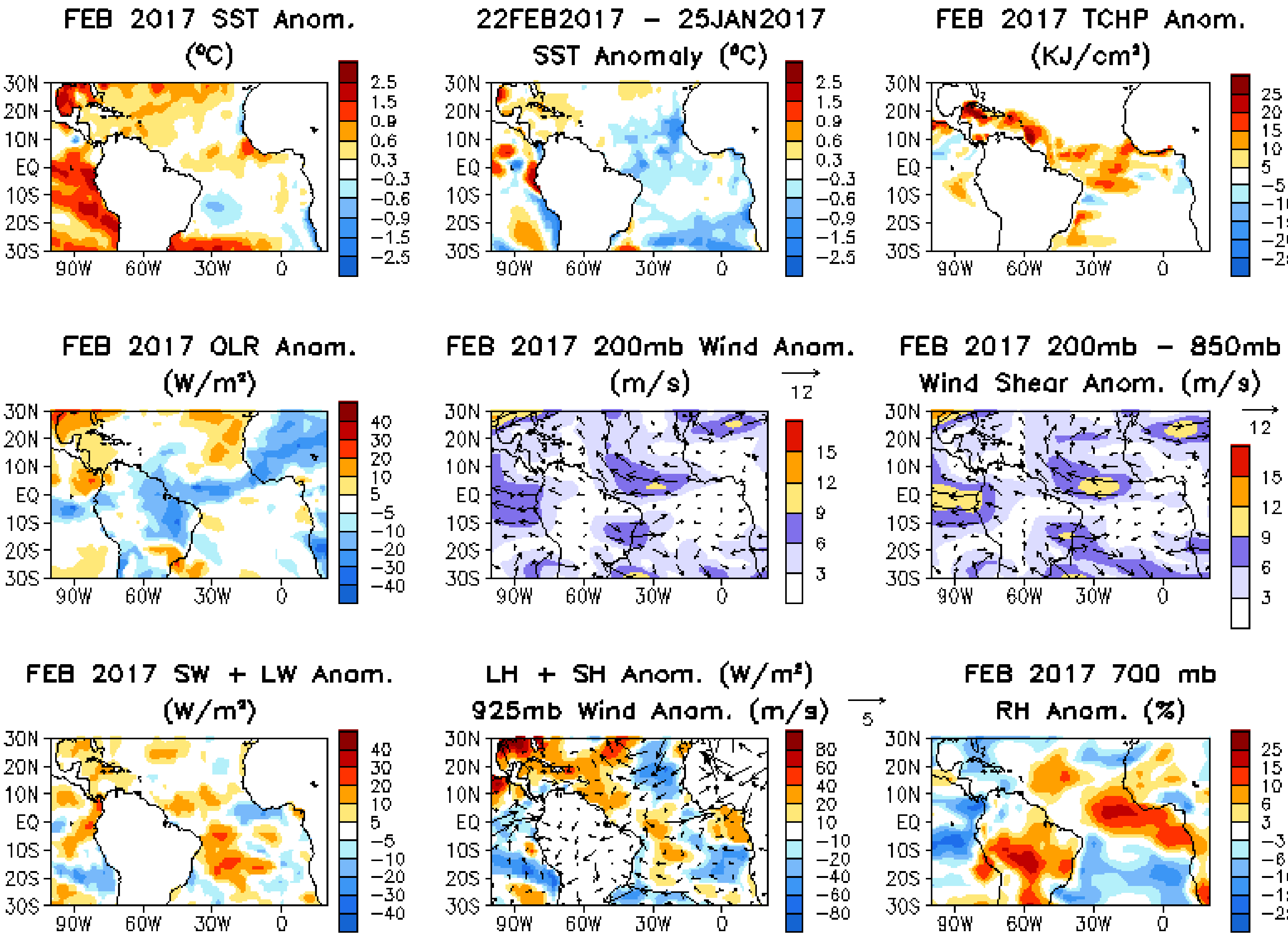



Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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



# 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!**