

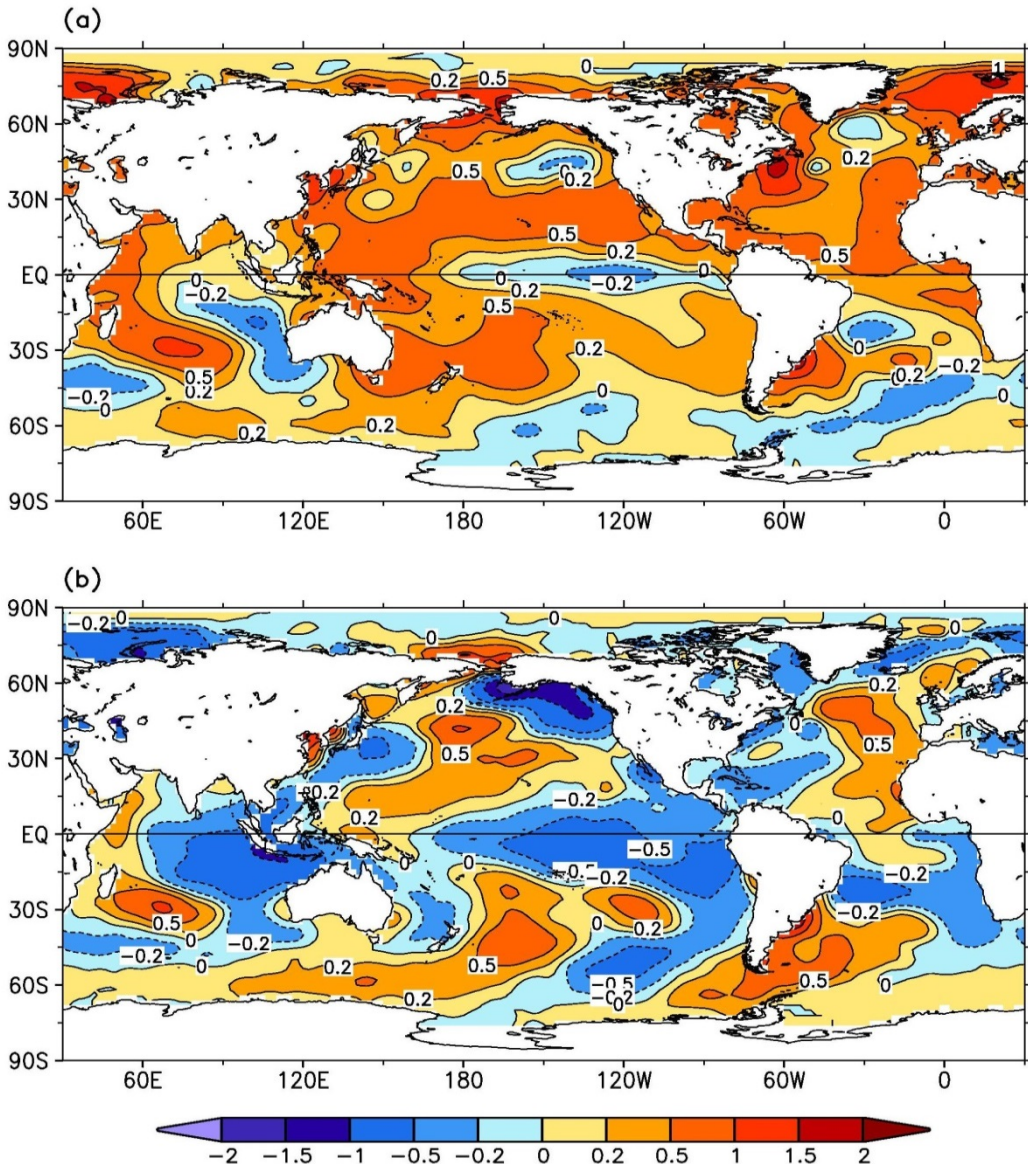
# **2017 Annual Ocean Review**

Prepared by  
Climate Prediction Center, NCEP/NOAA  
**February 9, 2018**

**<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 Ocean Climate Observation Program (OCO)

# 2017 Yearly Mean SST Anomaly and Tendency



*Global SST Section in the BAMS State of the Climate in 2017 by Huang et al.*

- Positive SSTA dominated in the global ocean with maximum warming in the western tropical and subtropical Pacific Ocean, western Indian Ocean, western North Atlantic and the Arctic Ocean.
- Negative SSTA presented in limited regions, including the equatorial central-eastern Pacific, southeastern Indian Ocean and high-latitude Southern Oceans.
- There was a cooling tendency in the central-eastern Pacific that extended to the west coast of N. America and Gulf of Alaska, and was franked by a warming to the west. This pattern was likely associated with the double dip La Nina conditions in the tropical Pacific.
- There was a cooling (warming) tendency in the eastern (western) tropical Indian Ocean, which may be partially associated with the influences of the La Nina conditions in the tropical Pacific.
- There were both warming and cooling tendency in the Atlantic Ocean and Arctic Ocean.

**Fig. 3.1. (a) Yearly mean ERSSTv5 anomaly ( $^{\circ}\text{C}$ , relative to 1981-2010 average) in 2017, (b) 2017 minus 2016 ERSSTv5 anomaly.**

# Seasonal Mean SST Anomaly in 2017

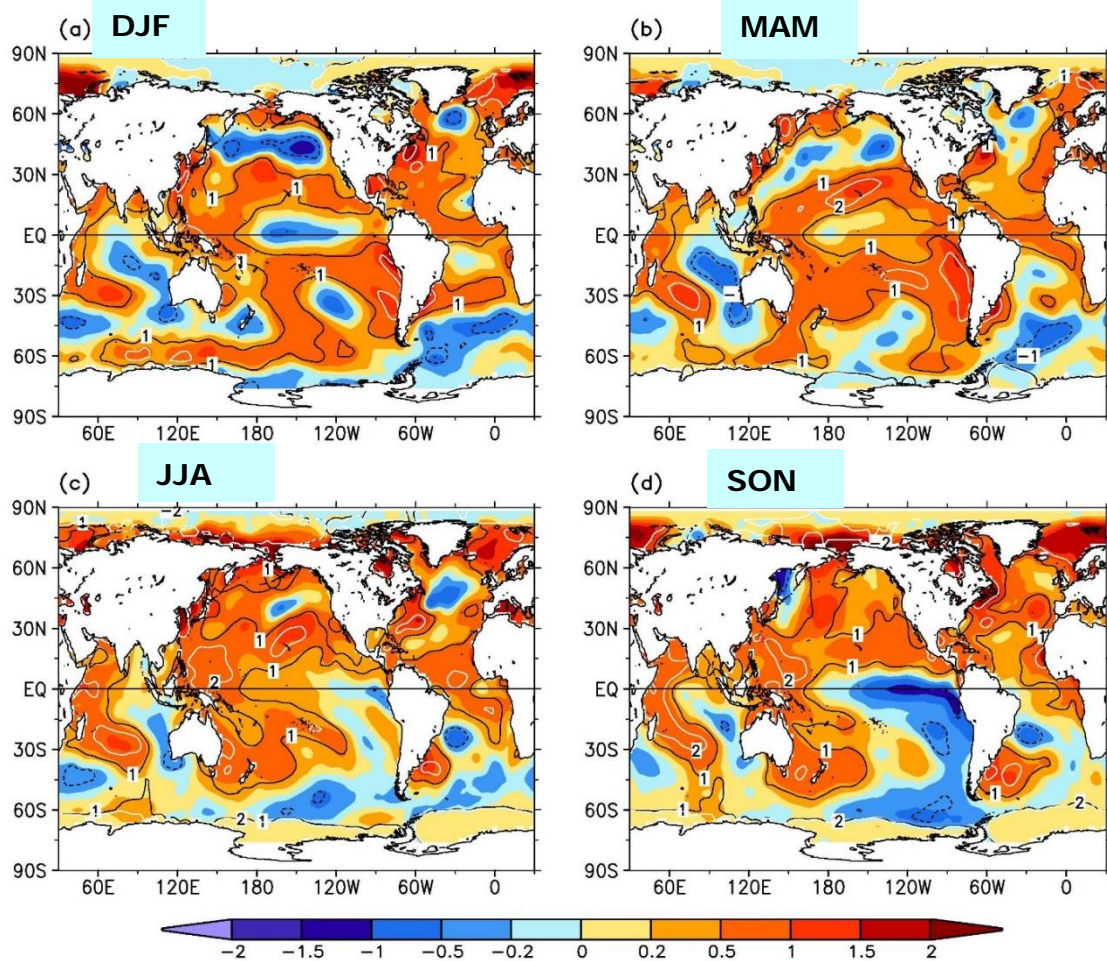
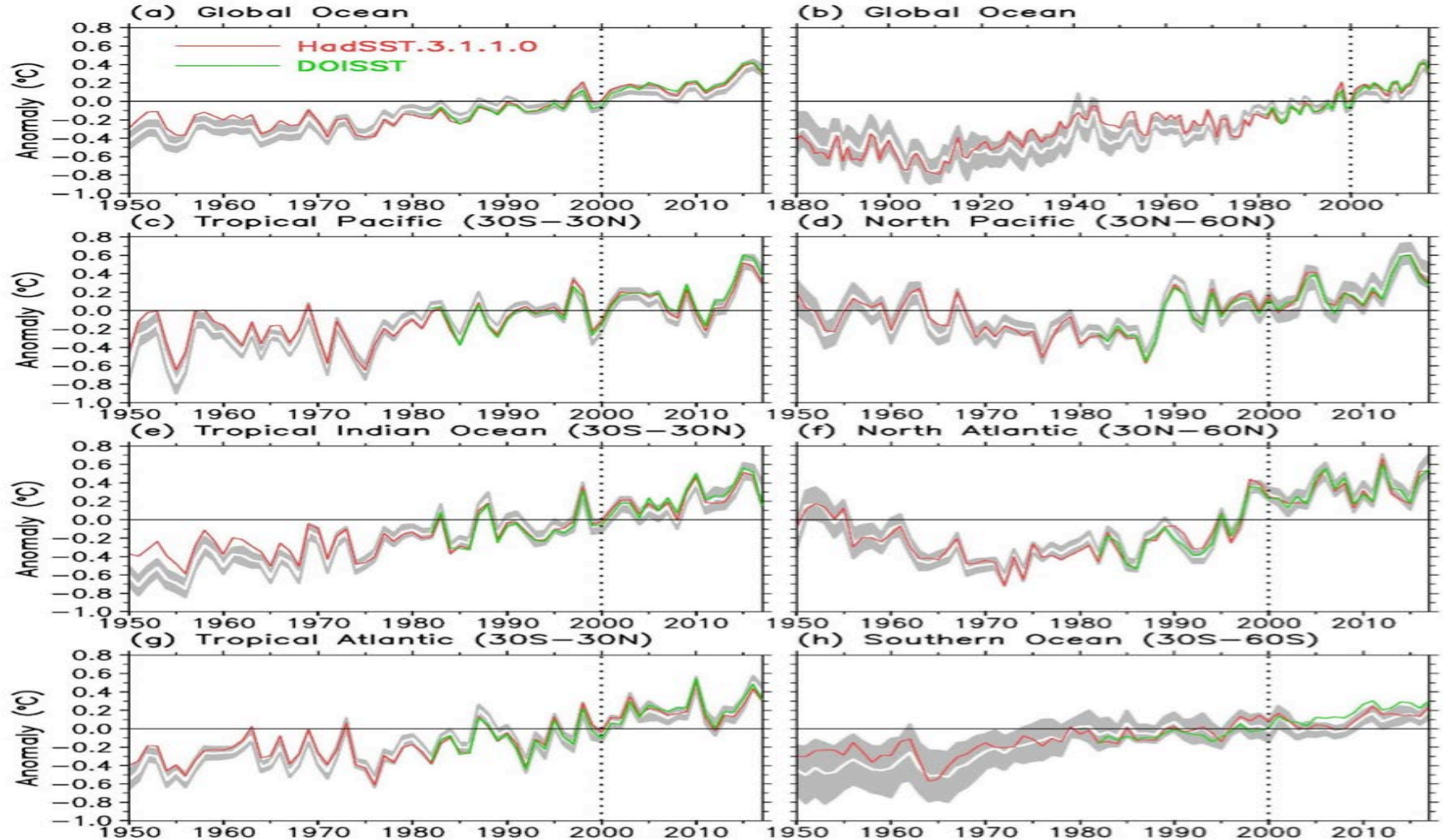


Fig. 3.2. Seasonal mean SSTA from ERSSTv5 (shading, °C, relative to 1981-2010 average) for (a) December 2016 to February 2017, (b) March to May 2017, (c) June to August 2017 and (d) September to November 2017. The normalized seasonal mean SSTA based on seasonal mean standard deviation (STD) over 1981-2010 are indicated by contours of -2 (dashed white), -1 (dashed black), 1 (solid black), and 2 (solid white).

*Global SST Section in the BAMS  
State of the Climate in 2017 by  
Huang et al.*

- Winter 2016/2017: weak cooling in eq. Pacific flanked by positive SSTA exceeding +1 STD. Positive SSTA dominated in the Atlantic Ocean and Arctic Ocean.
- Spring 2017: positive SSTA in the Pacific Ocean continued and enhanced in the southeastern Pacific with maximum exceeding +2 STD. Positive SSTA in the Atlantic Ocean continued and a dipole in the Indian Ocean persisted.
- Summer/fall 2017: Positive SSTA in the eastern Pacific transitioned to negative in summer and strengthened in fall, while positive SSTA in the western Pacific and N. Pacific persisted. The warming enhanced in the Arctic





- The ERSSTv5 (white line) is compared with daily OISST (DOISST) and HadSST.3.1.0.0. The differences are largely within the 2- $\sigma$  STD (grey shading).

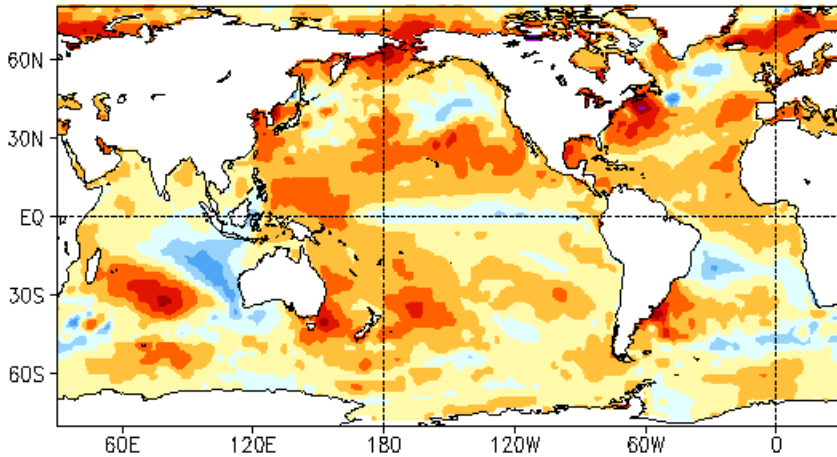
- There was a cooling from 2016 to 2017 in all ocean basins except in the North Atlantic, which was probably associated with the impacts of the La Nina conditions. The linear trend of globally averaged SSTA based on ERSSTv5 ( $^{\circ}\text{C}/\text{decade}$ ) is 0.166 in 2000-2017 and 0.099 in 1950-2017.

- The largest warming trend ( $^{\circ}\text{C}/\text{decade}$ ) in 1950-2017 was observed in the tropical Indian (0.143), tropical Atlantic Ocean (0.109) and North Atlantic (0.102).

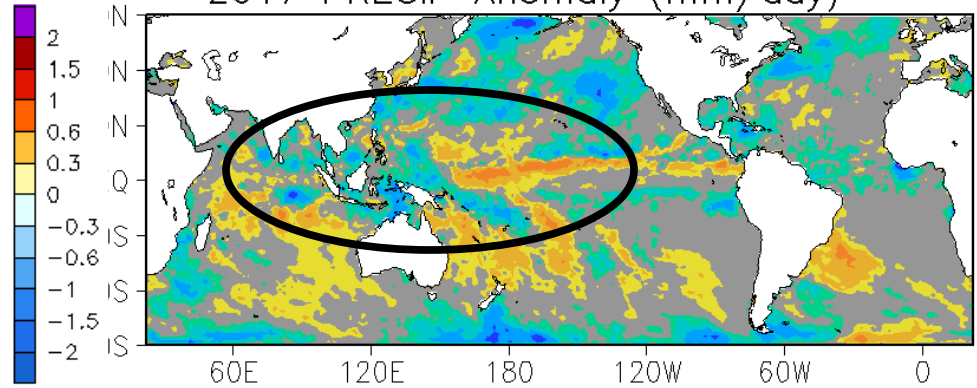
## SST Anom.

## Prec. Anom.

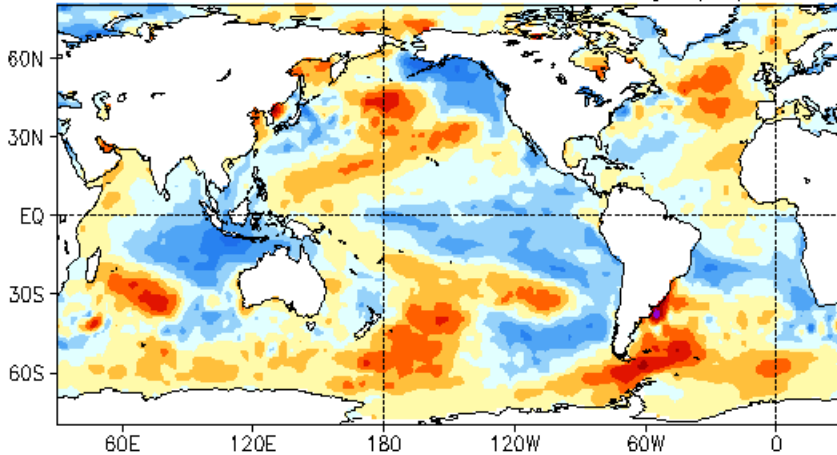
(a) 2017 SST Anomaly ( $^{\circ}\text{C}$ )



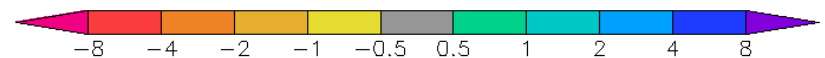
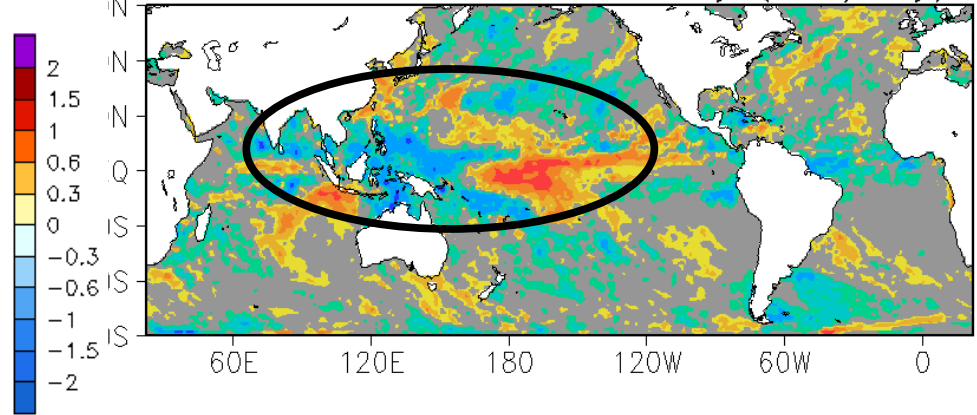
2017 PRECIP Anomaly (mm/day)



(b) 2017 - 2016 SST Anomaly ( $^{\circ}\text{C}$ )



2017 - 2016 PRECIP Anomaly (mm/day)

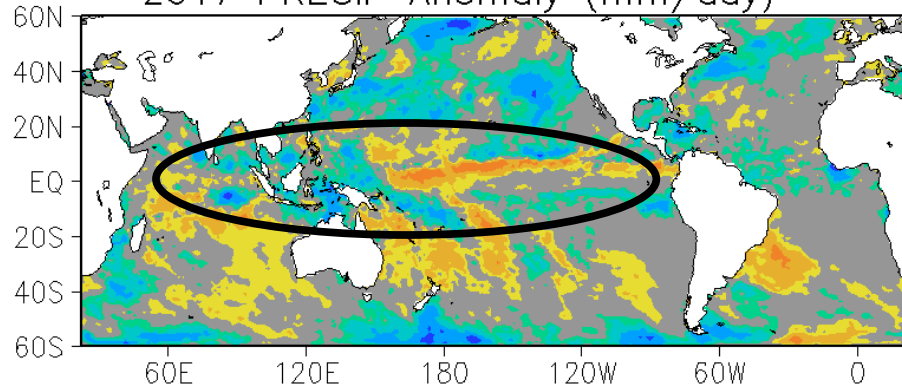


- In 2017, the prec. anomaly pattern was characterized by a tripole pattern in the Indo-Pacific region with enhanced convection over Maritime Continents and suppressed in the western tropical Indian Ocean and central tropical Pacific. Precipitation was above-normal in most of North Pacific and over the Gulf Stream and North Atlantic Current.

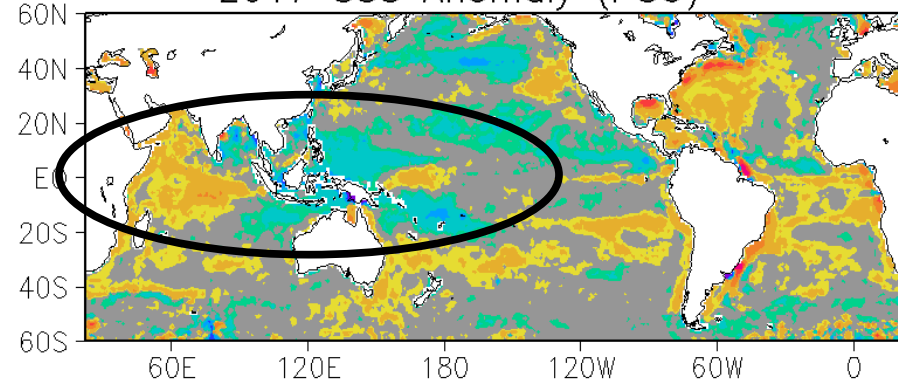
## Prec. Anom.

## SSS Anom.

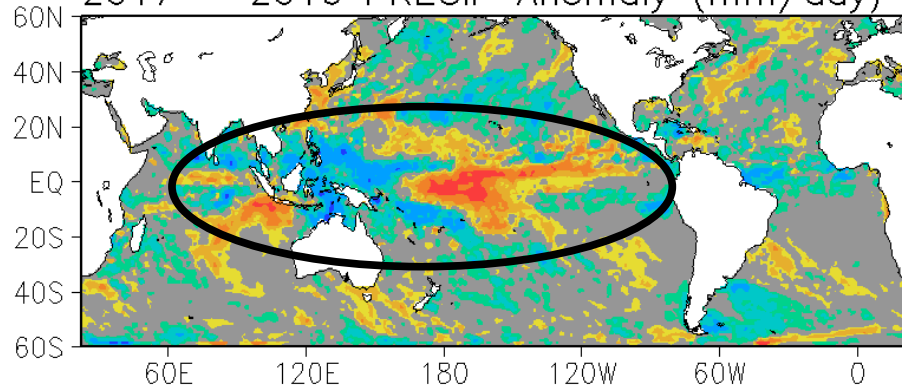
2017 PRECIP Anomaly (mm/day)



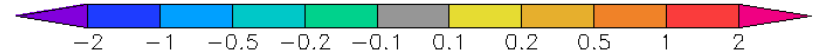
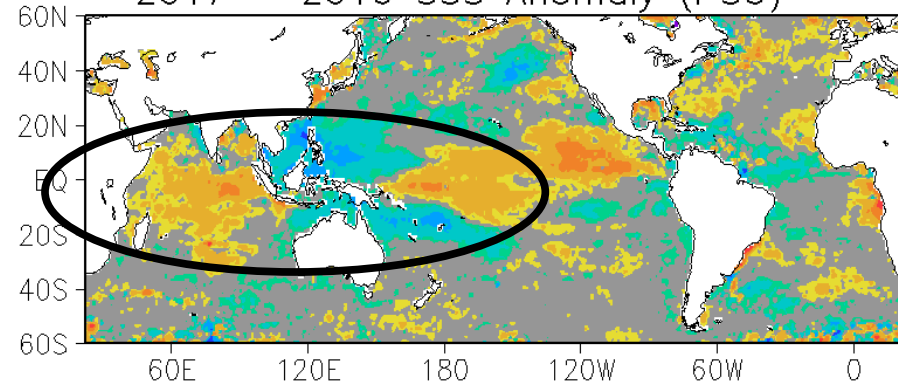
2017 SSS Anomaly (PSU)



2017 - 2016 PRECIP Anomaly (mm/day)



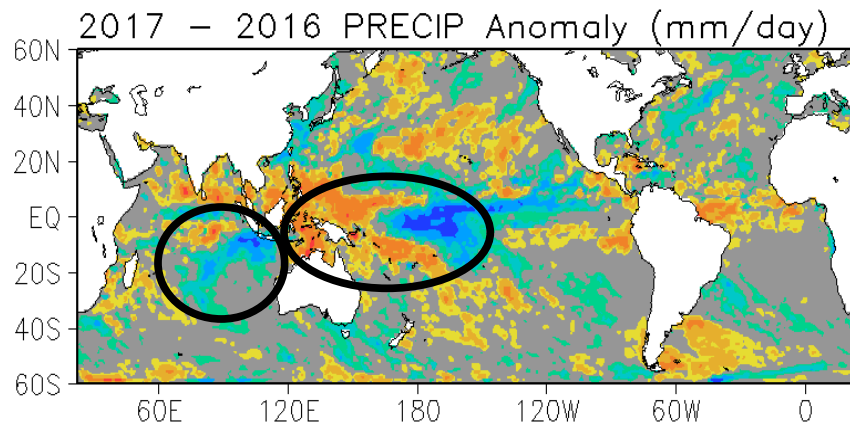
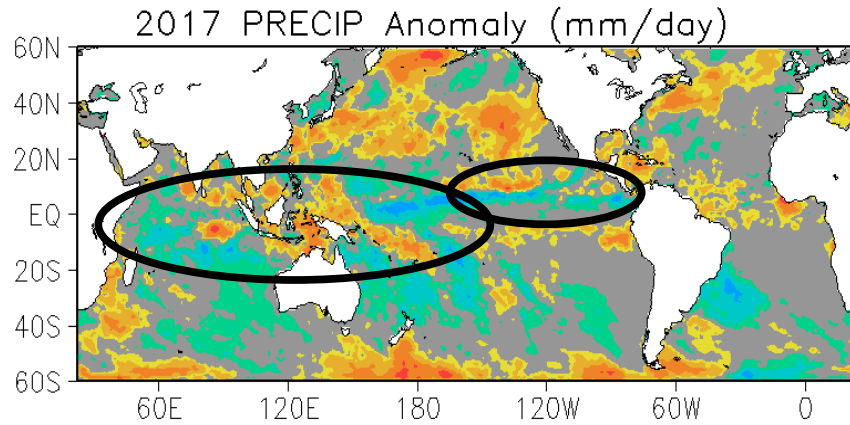
2017 - 2016 SSS Anomaly (PSU)



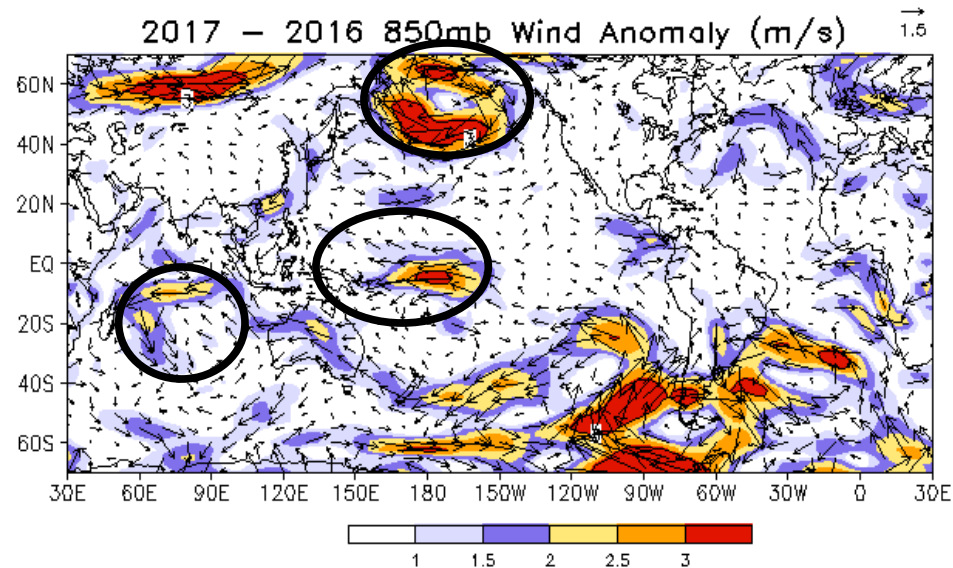
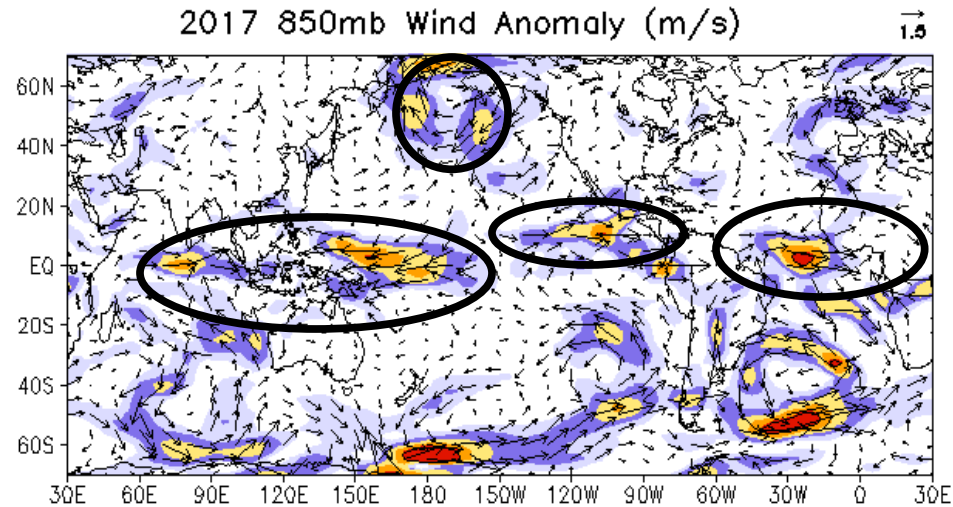
- In 2017, SSS was fresher than average in Maritime Continents, subtropical and mid-latitude North Pacific, while SSS was saltier than average in the west-central tropical Indian Ocean, central eq. Pacific, and most of the Atlantic Ocean.
- The 2017 minus 2016 SSS anom. was dominated by a tripole pattern that was consistent with the prec. anom. tendency pattern.



## Prec. Anom.

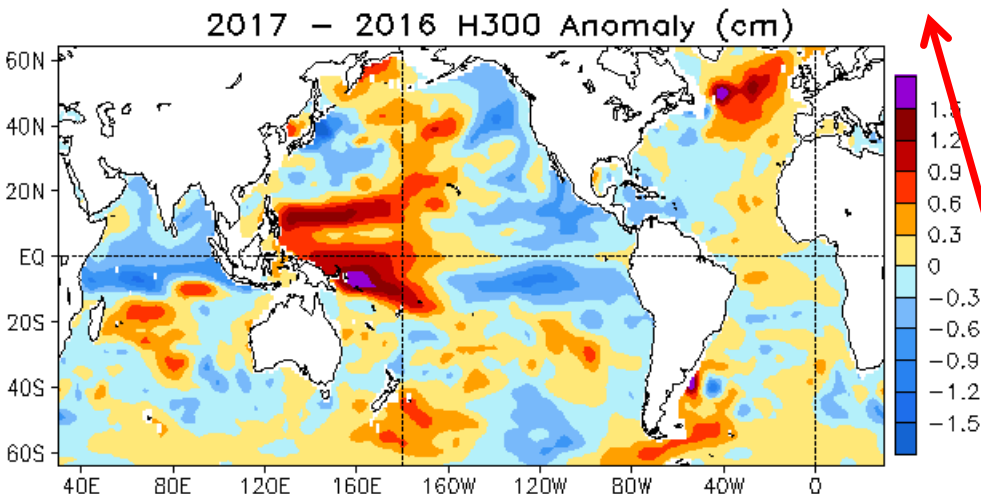
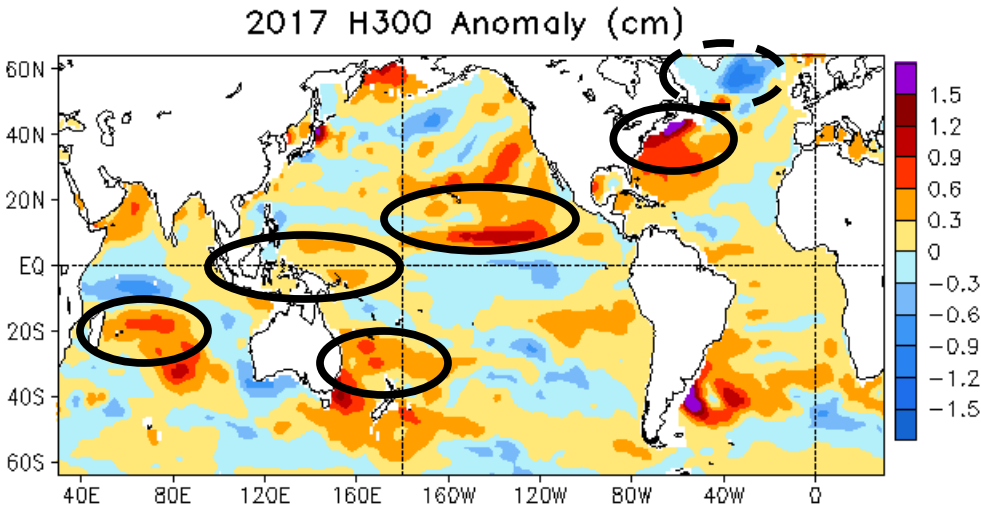


## 850mb Wind Anom.

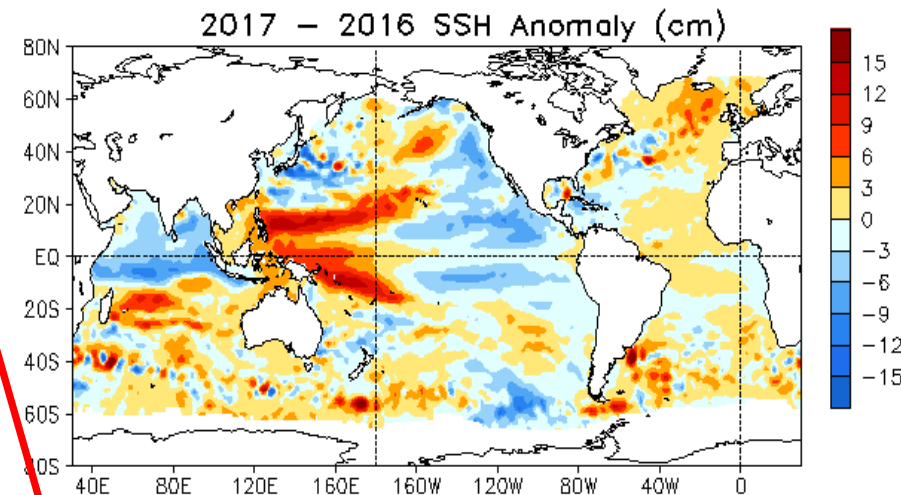
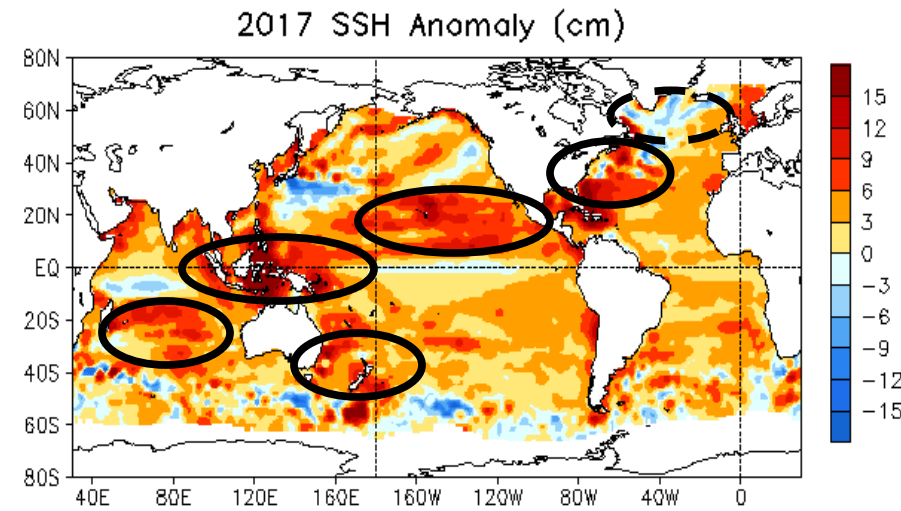


- In 2017, convergence wind anom. was observed over Maritime Continents and ITCZ. Low-level westerly wind anomaly presented over the eq. Atlantic consistent with enhanced convection over North Africa. An anticyclonic wind anomaly presented over Gulf of Alaska, consistent with the La Nina teleconnection.

## Ensemble Mean HC300 Anom.



## AVISO SSH Anom.



### Real-time Ocean Reanalysis Intercomparison Project

([http://www.cpc.ncep.noaa.gov/products/GODAS/multiora\\_body.html](http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html))

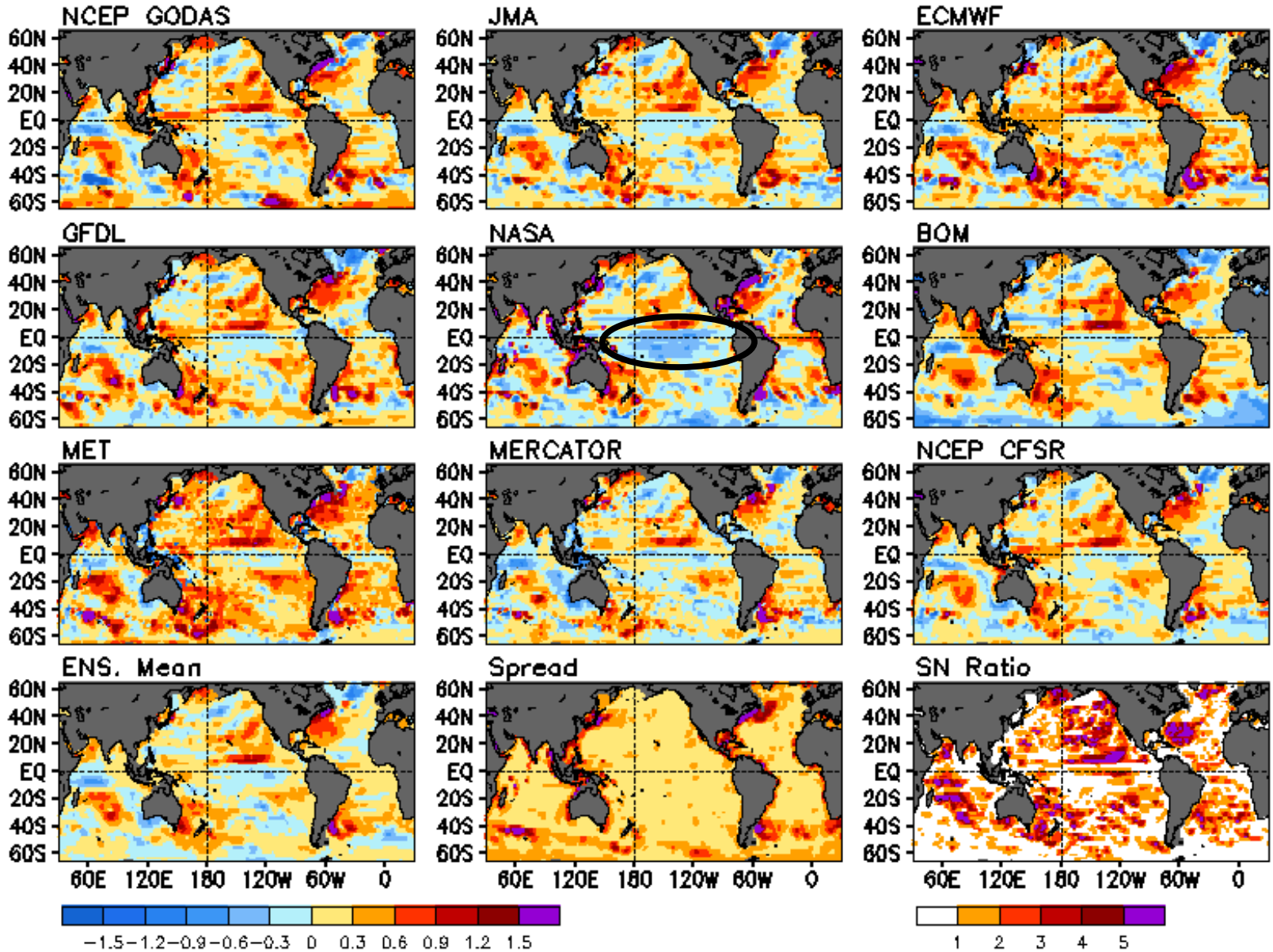
([http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93\\_body.html](http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html))

Xue et al. 2017 (see <http://rdcu.be/o4wO>)

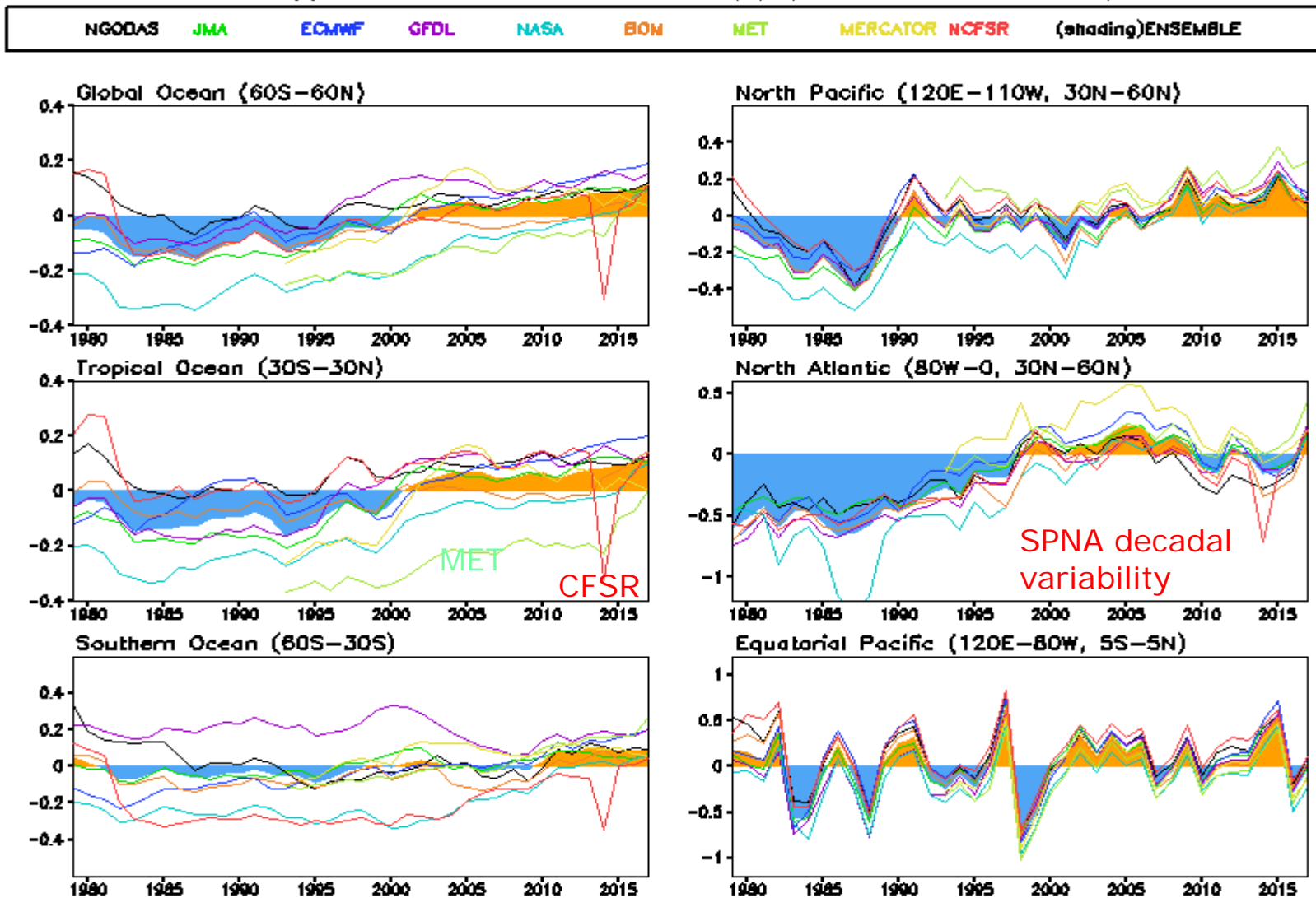


# 2017 HC300 Anom. from Individual Ocean Reanalysis, Ensemble Mean, Ensemble Spread, Signal-to-Noise Ratio

Annual averaged H300: 2017



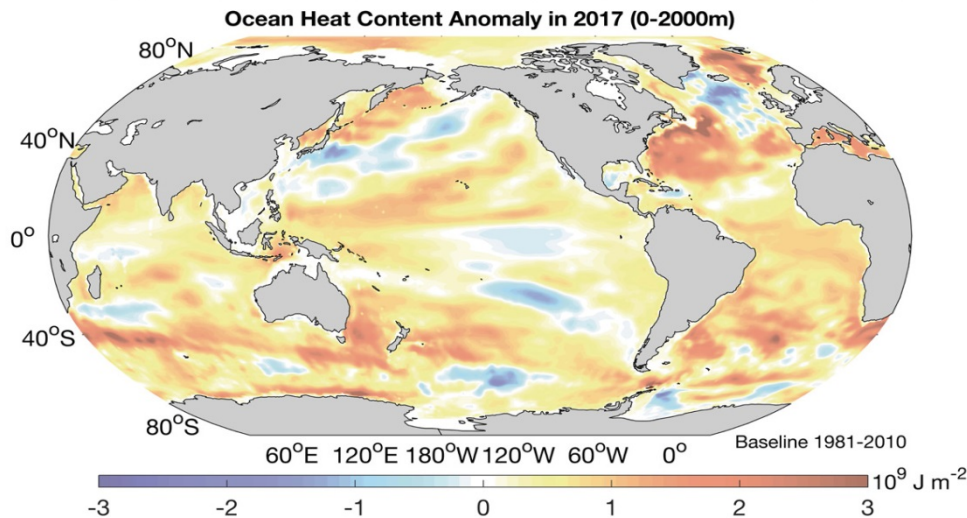
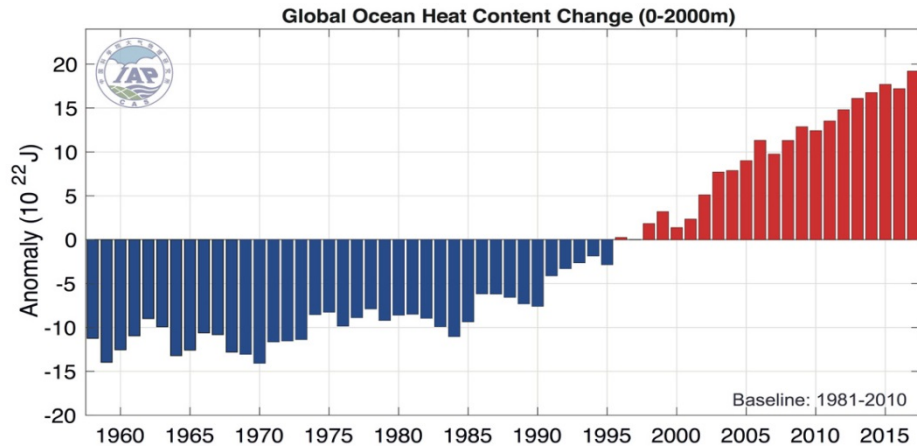
## Upper 300m Heat Content Anom.(C) (ENS Clima 1993–2013)



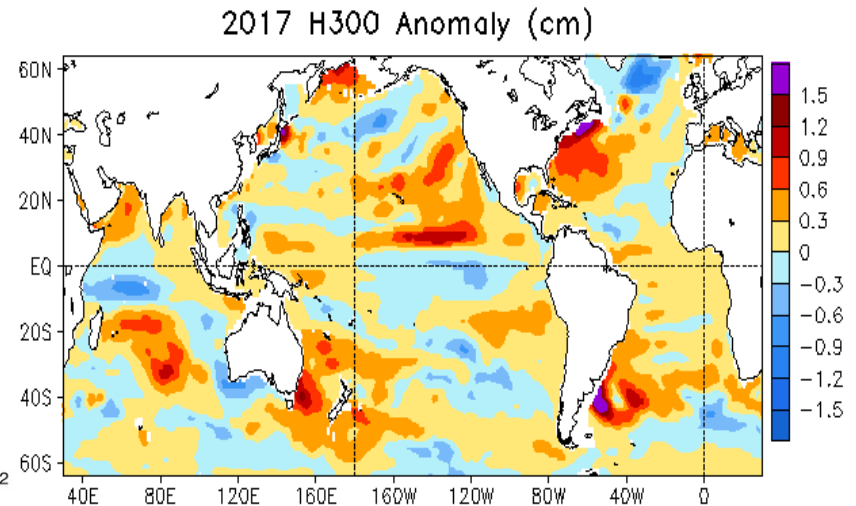
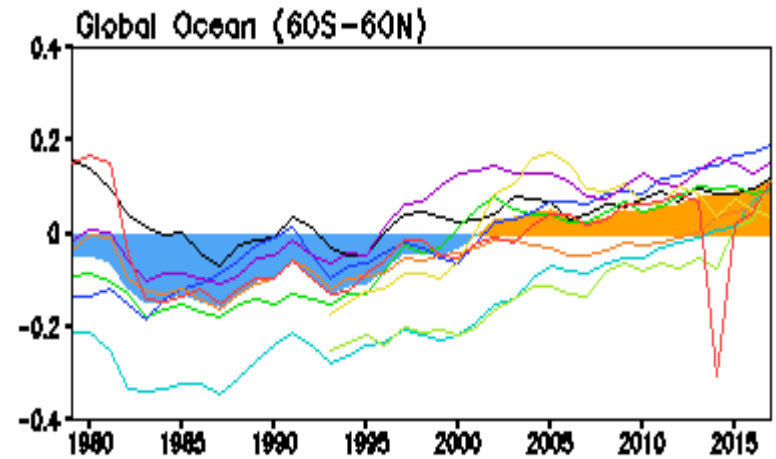
- Anom. was based on the **ensemble mean climatology in 1993-2013**, which was calculated with CFSR and MET excluded.
- The ensemble spread was largest in the tropical ocean and southern ocean, while they reduced significantly in the Argo era (since 2000).

## 0-2000m HC Anom. from IAP

<http://159.226.119.60/cheng>



## 0-300m HC Anom. from ensemble ocean reanalyses

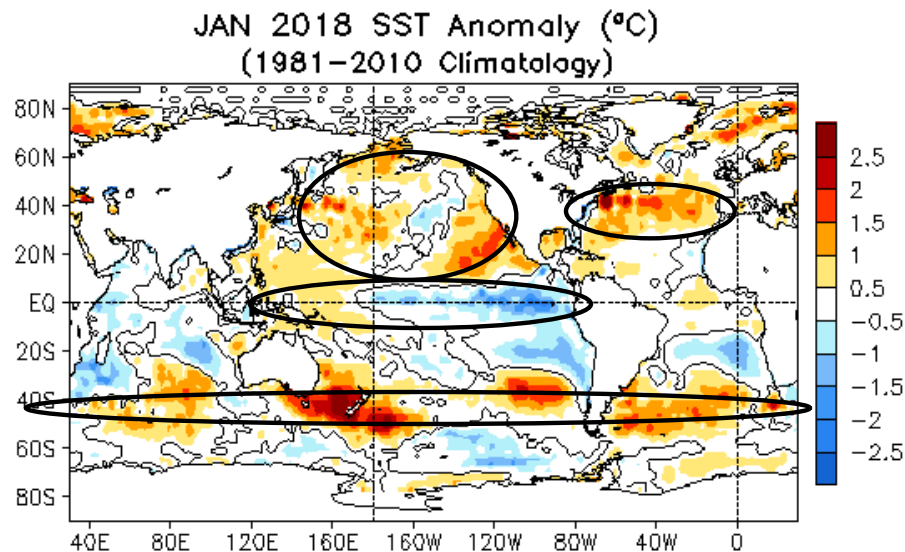


- The global ocean 0-2000m heat content anomaly index from IAP was based on in situ data
- The index suggests 2017 was the warmest year on record for the global ocean (<https://link.springer.com/content/pdf/10.1007%2Fs00376-018-8011-z.pdf>)
- The 0-2000m HC anom. pattern is similar to the 0-300m HC anom. pattern although the latter was based on ocean reanalysis products. This suggests the upper 300m contributed significantly to the record warming in the global ocean.

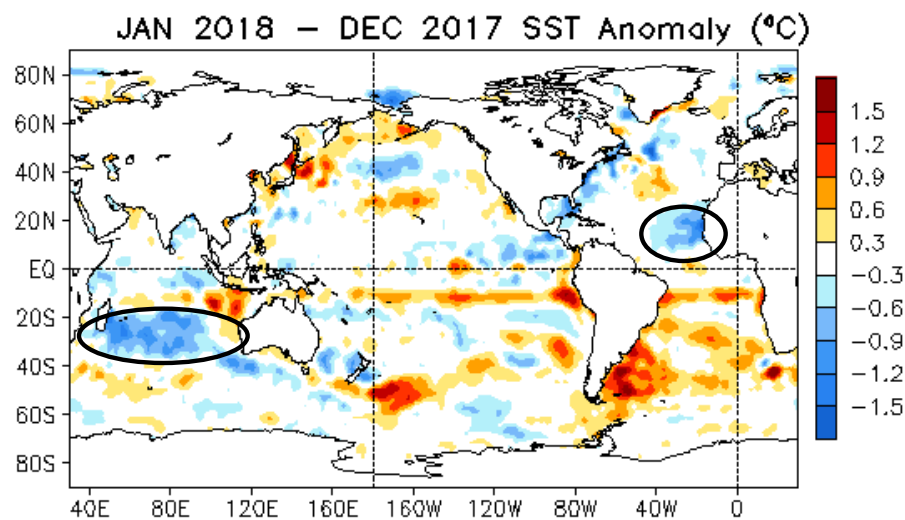


# Highlights in January 2018

# Global SST Anomaly ( $^{\circ}\text{C}$ ) and Anomaly Tendency



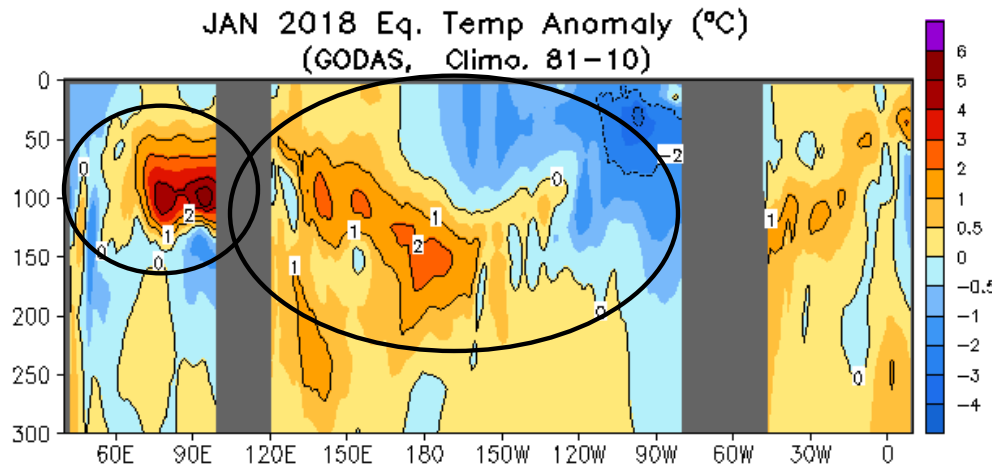
- Negative (positive) SSTA persisted in the central-eastern (western) equatorial Pacific.
- Positive SSTA dominated in North Pacific, North Atlantic, mid-latitude South Ocean.
- Negative SSTA presented in S.E. Indian Ocean, S.E. Pacific and subtropical South Atlantic.



- Negative SSTA tendency was observed in South Indian Ocean, and near the coast of North Africa.

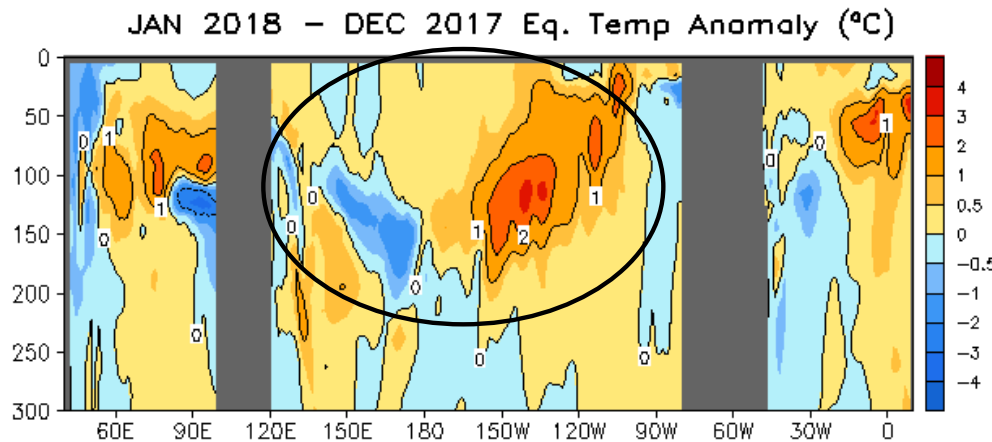
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

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



- Positive (negative) temperature anom. presented in the western Pacific (central-eastern Pacific).

- Strong positive temperature anom. presented in the eastern Indian Ocean.

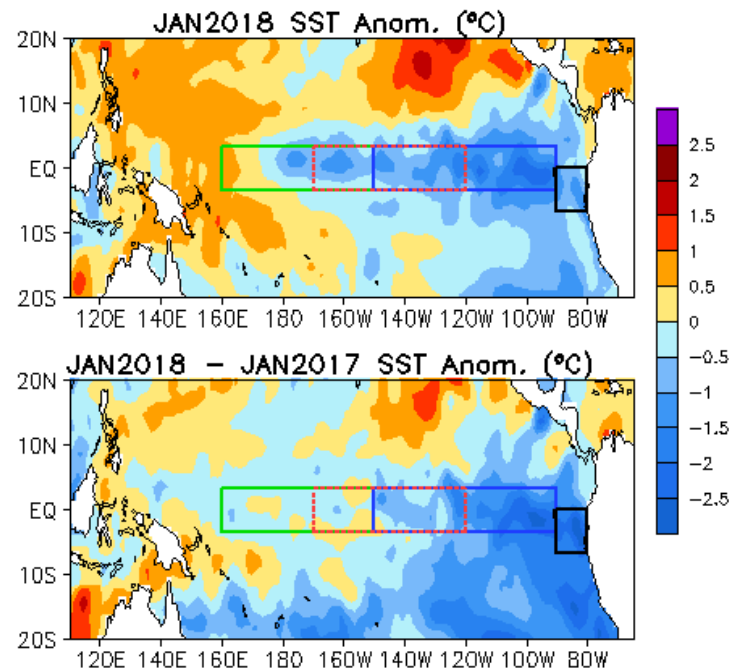
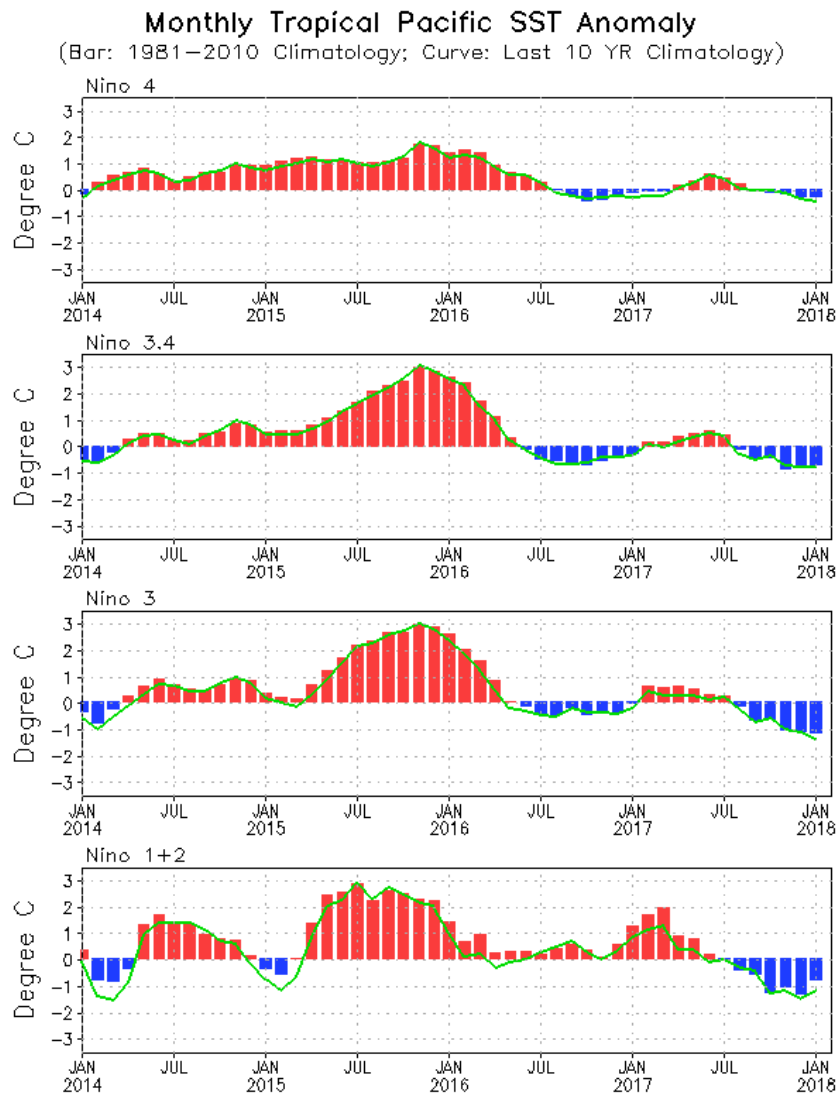


- Subsurface temperature tendency was positive (negative) near the thermocline in the central-eastern (western) equatorial Pacific, indicating eastward propagation of warm anom.

**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.**



# Evolution of Pacific NI NO SST Indices



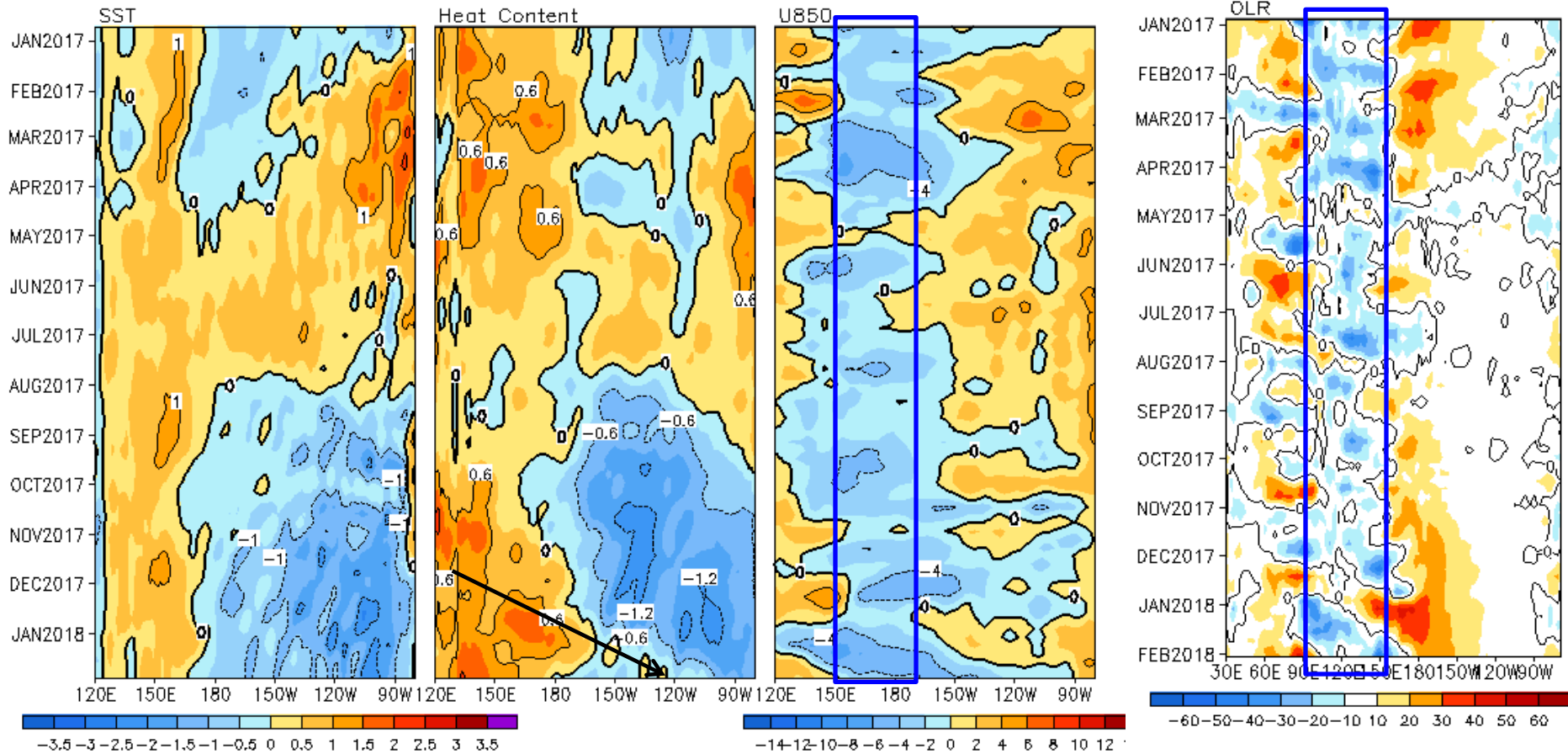
- All Nino indices were below-average in Jan 2018.
- Nino3.4 weakened slightly in Jan 2018, with Nino34 =  $-0.75^{\circ}\text{C}$ .
- Compared with last Jan, the eq. eastern Pacific and southeastern subtropical Pacific was much cooler in Jan 2018.
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v5.

**Fig. P1a.** Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies ( $^{\circ}\text{C}$ ) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981–2010 (bar) and last ten year (green line) means.

# Equatorial Pacific SST ( $^{\circ}\text{C}$ ), HC300 ( $^{\circ}\text{C}$ ), u850 (m/s) and OLR( $\text{W}/\text{m}^2$ ) Anomalies

2 $^{\circ}\text{S}$ –2 $^{\circ}\text{N}$  Average, 3 Pentad Running Mean

5 $^{\circ}\text{S}$ –5 $^{\circ}\text{N}$  Average  
(3 Pentad Running Mean)



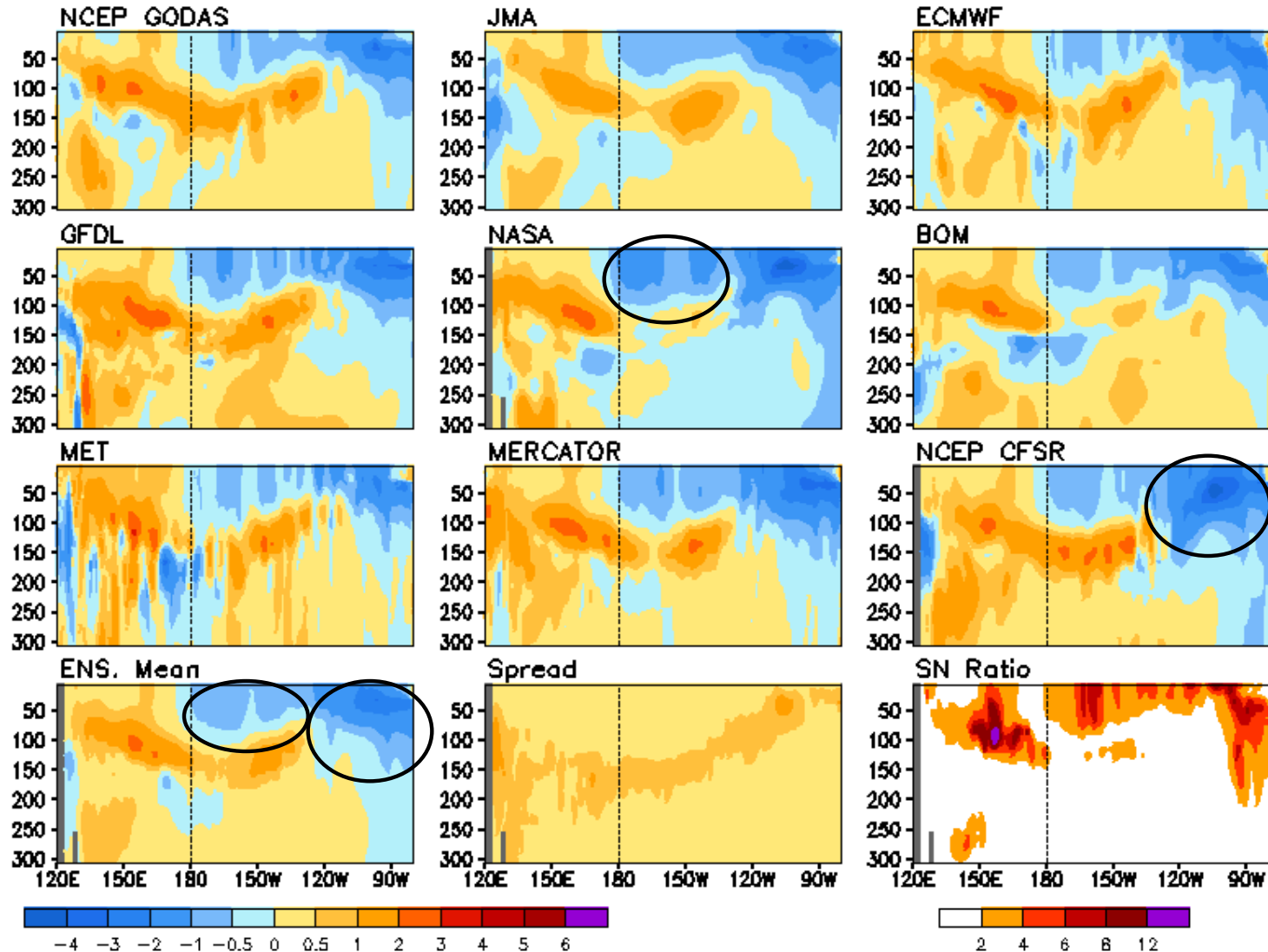
- Positive HC300A near the Dateline weakened, while negative HC300A in the central-eastern Pacific transitioned to near-neutral.
- Persistent easterly wind anomalies near the Dateline were associated with enhanced convection near 120E.
- The 2016-2018 is the 7th 'double-dip' La Niña since 1950 according to the ERSSTv5 ONI index ([http://origin.cpc.ncep.noaa.gov/products/analysis\\_monitoring/ensostuff/ONI\\_v5.php](http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php)).

Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2 $^{\circ}\text{S}$ -2 $^{\circ}\text{N}$  and Outgoing Long-wave Radiation (OLR, right) averaged in 5 $^{\circ}\text{S}$ -5 $^{\circ}\text{N}$ . SST is derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1981-2010 base period pentad means respectively.

# Real-Time Ocean Reanalysis Intercomparison: [Eq. Temp Anom.](http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)

([http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93\\_body.html](http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html))

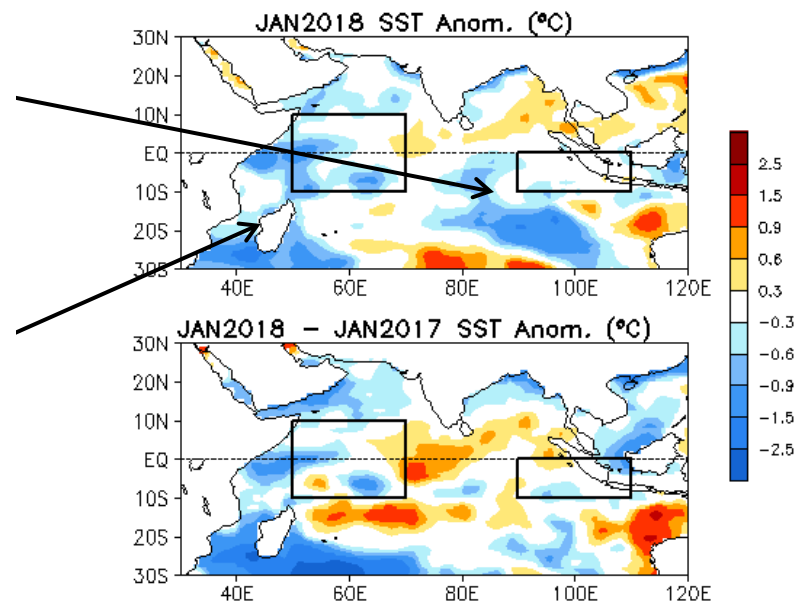
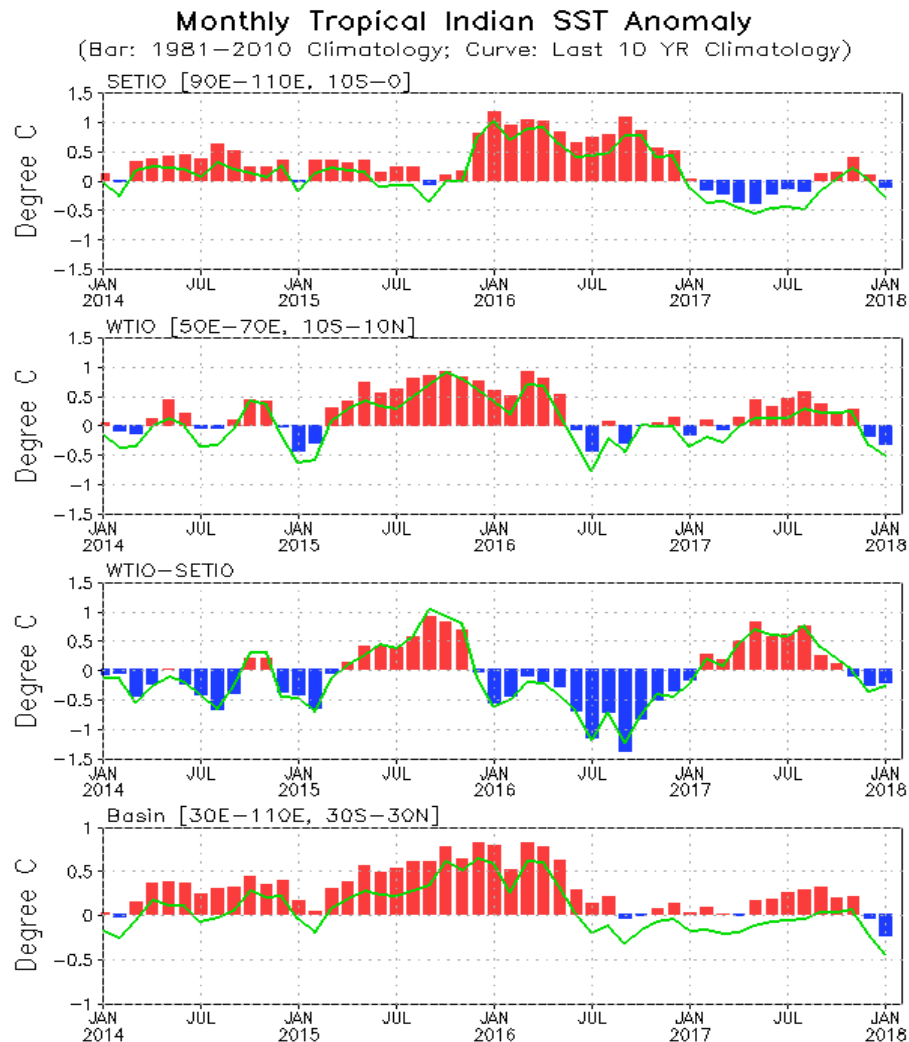
Anomalous Temperature (C) Averaged in 1S-1N: JAN 2018



- CFSR and NASA were colder than the ensemble mean in the central-eastern eq. Pacific.



# Evolution of Indian Ocean SST Indices



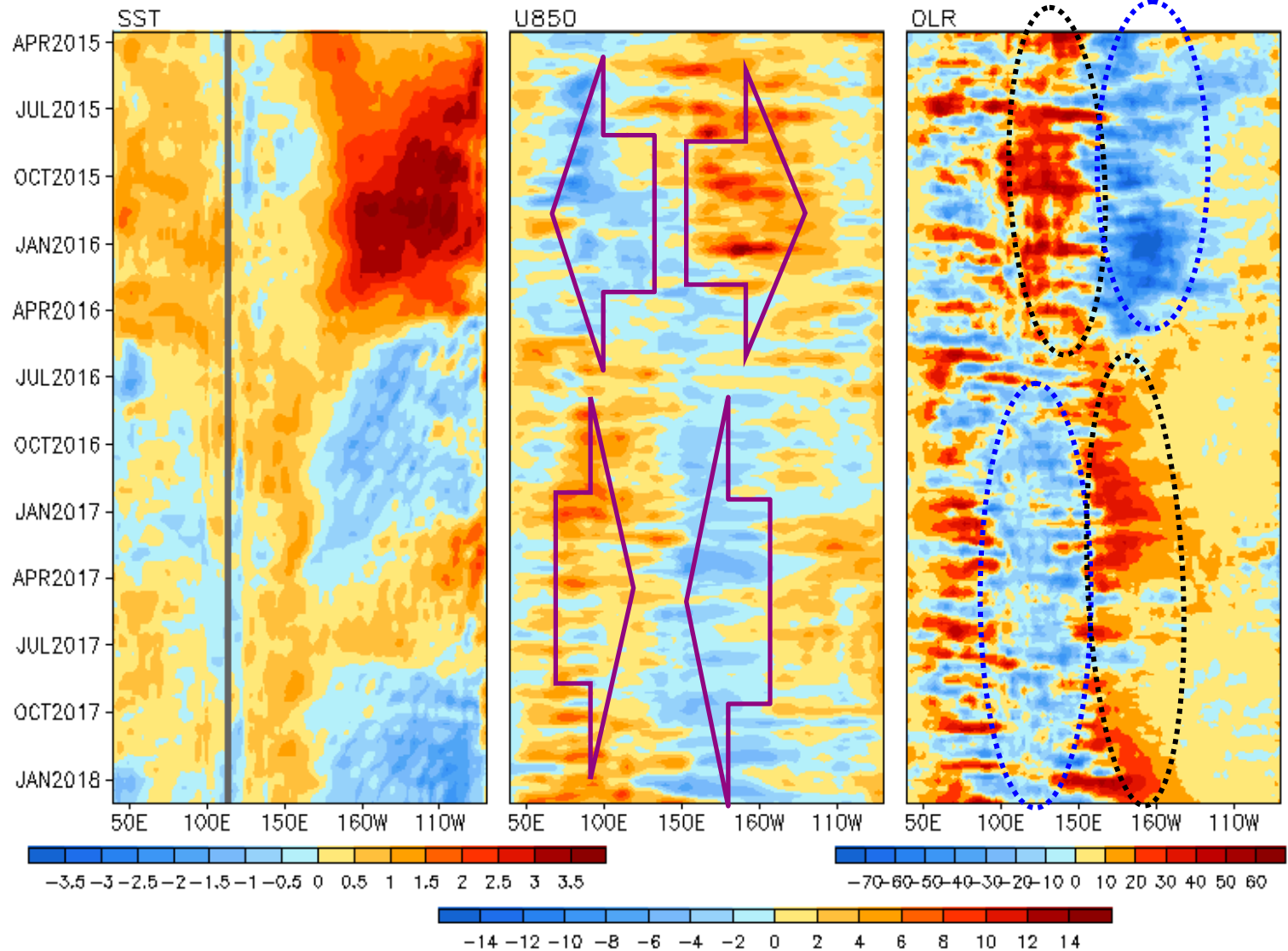
- All indices were negative in Jan 2018.

- The basin average SST in Jan 2018 had the largest negative anomaly in the past 4 years.

**Fig. 11a. 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 departures from the 1981–2010 base period means and the recent 10 year means are shown in bars and green lines.**

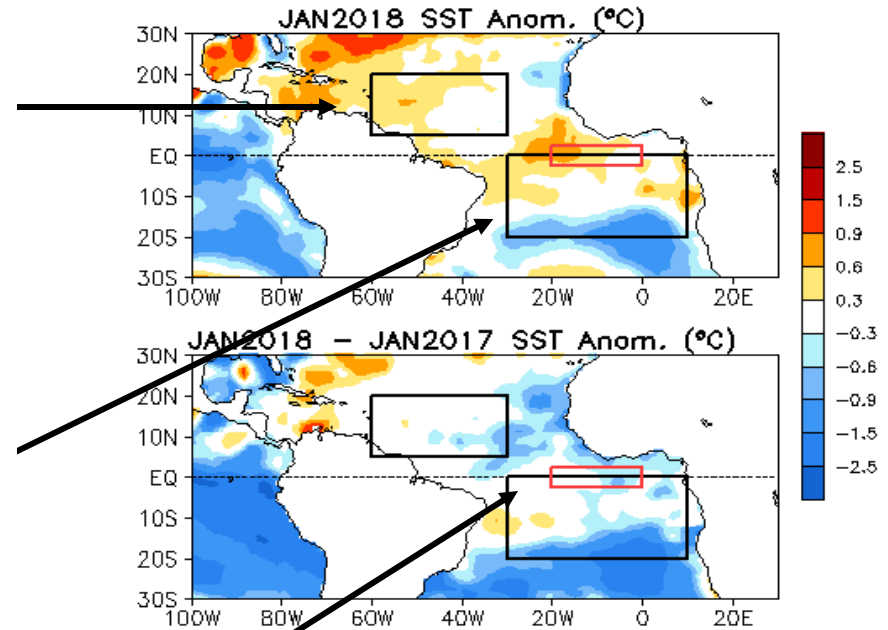
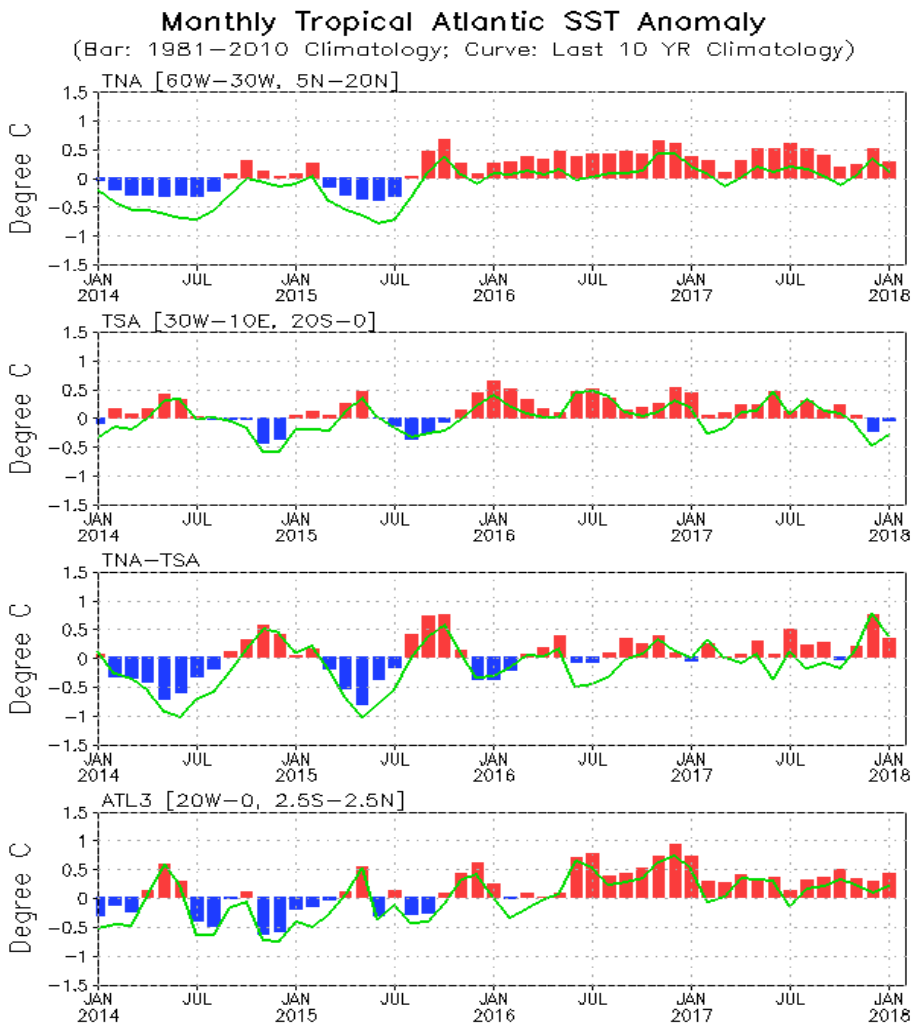
# Indo-Pacific region

2°S–2°N Average, 3 Pentad Running Mean



- Surface zonal wind and OLR anomalies across the Indo-Pacific region were largely associated with the warm and cold phase of the tropical Pacific SSTA in 2015-18.

# Evolution of Tropical Atlantic SST Indices



- SSTA was positive (negative) in the subtropical North (South) Atlantic.

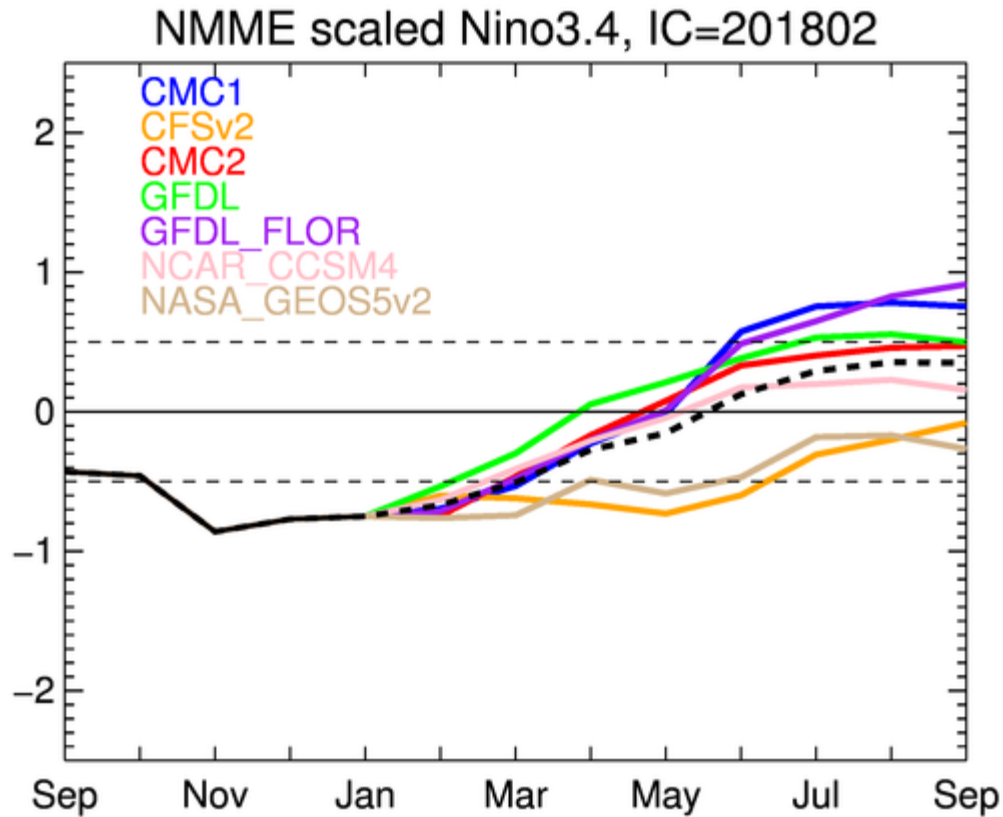
- Compare to last Jan, the subtropical South Atlantic were much cooler in Jan 2018.

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

# Global SST Predictions



# NMME NINO3.4 Forecast Plume

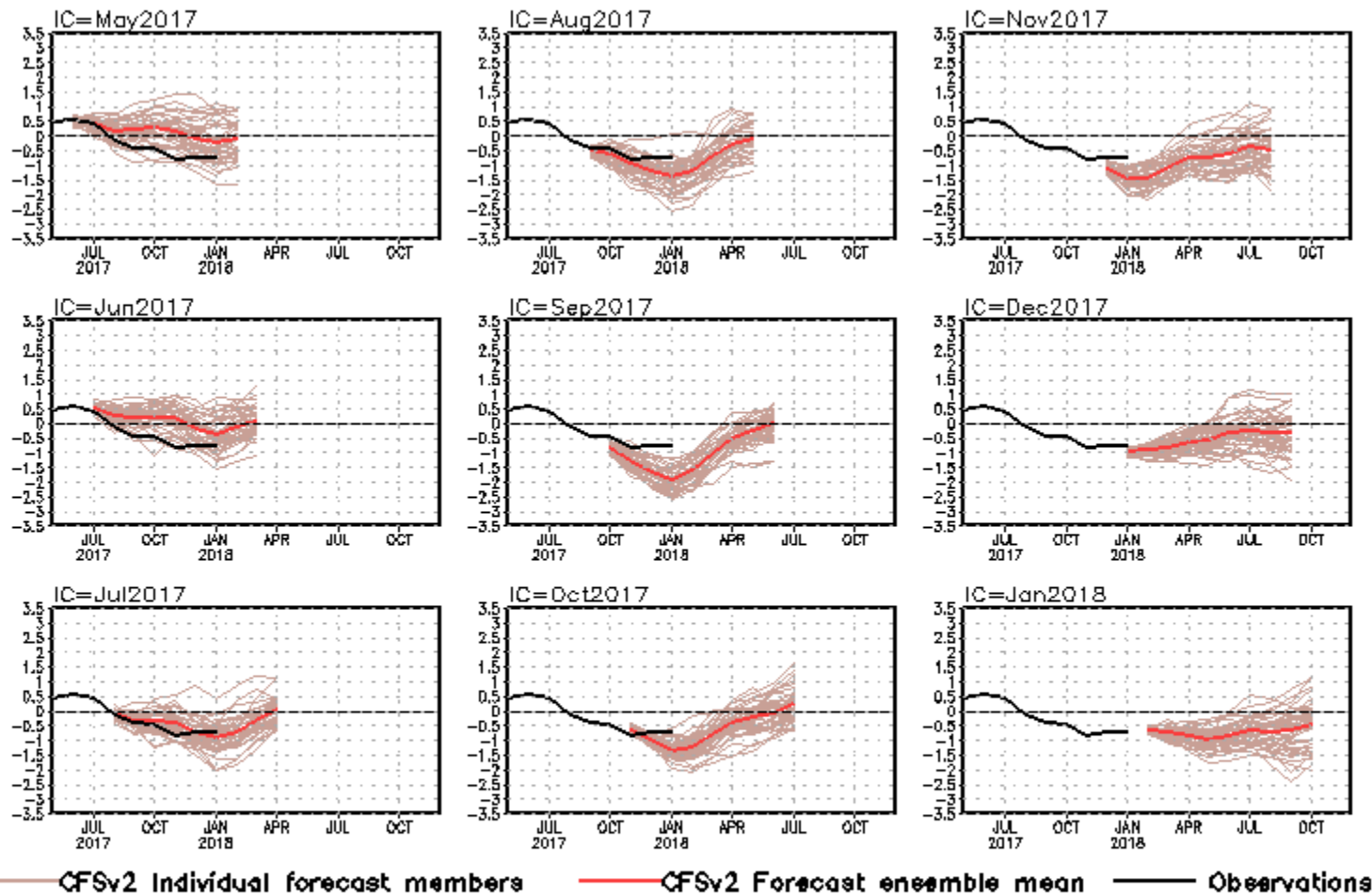


- CFSv2 and NASA\_GEOS5v2 NINO3.4 were cooler than the ensemble mean, which might be related to the colder subsurface temperature initial conditions (slide 17).
- NOAA "ENSO Diagnostic Discussion" on February 8, 2018 suggested that **"A transition from La Niña to ENSO-neutral is most likely during the Northern Hemisphere spring (~55% chance of ENSO-neutral during the March-May season) "**.



# NCEP CFSv2 NINO3.4 Forecast

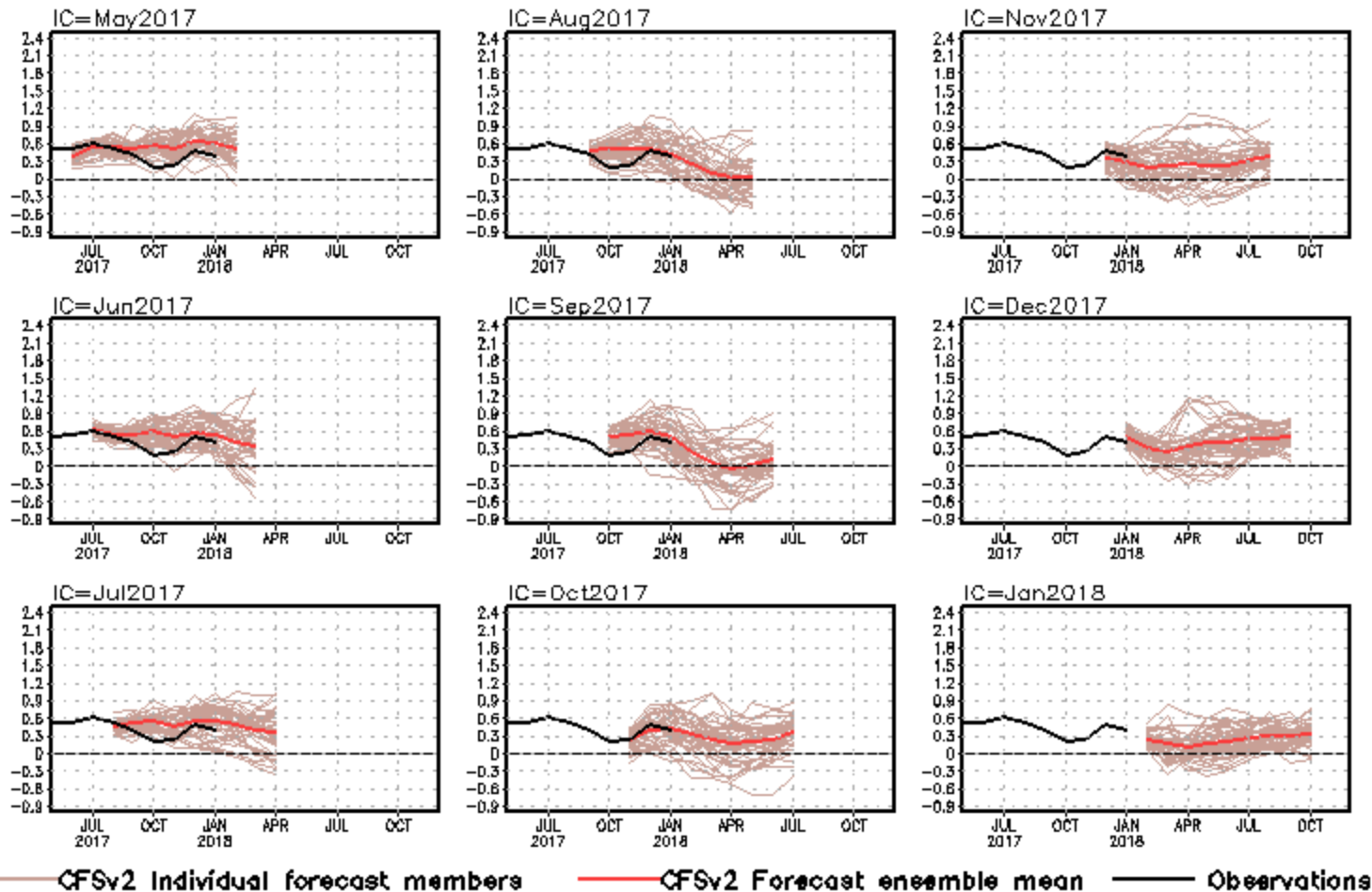
## NINO3.4 SST anomalies (K)



- Latest CFSv2 predictions (initialized from the last ten days of Jan 2018) suggest weak La Nina conditions will likely continue into spring/summer 2018.

# NCEP CFSv2 Tropical North Atlantic SST Forecast

## Tropical N. Atlantic SST anomalies (K)



- Latest CFSv2 predictions suggest tropical North Atlantic SST will remain weakly above-normal from spring to fall 2018.

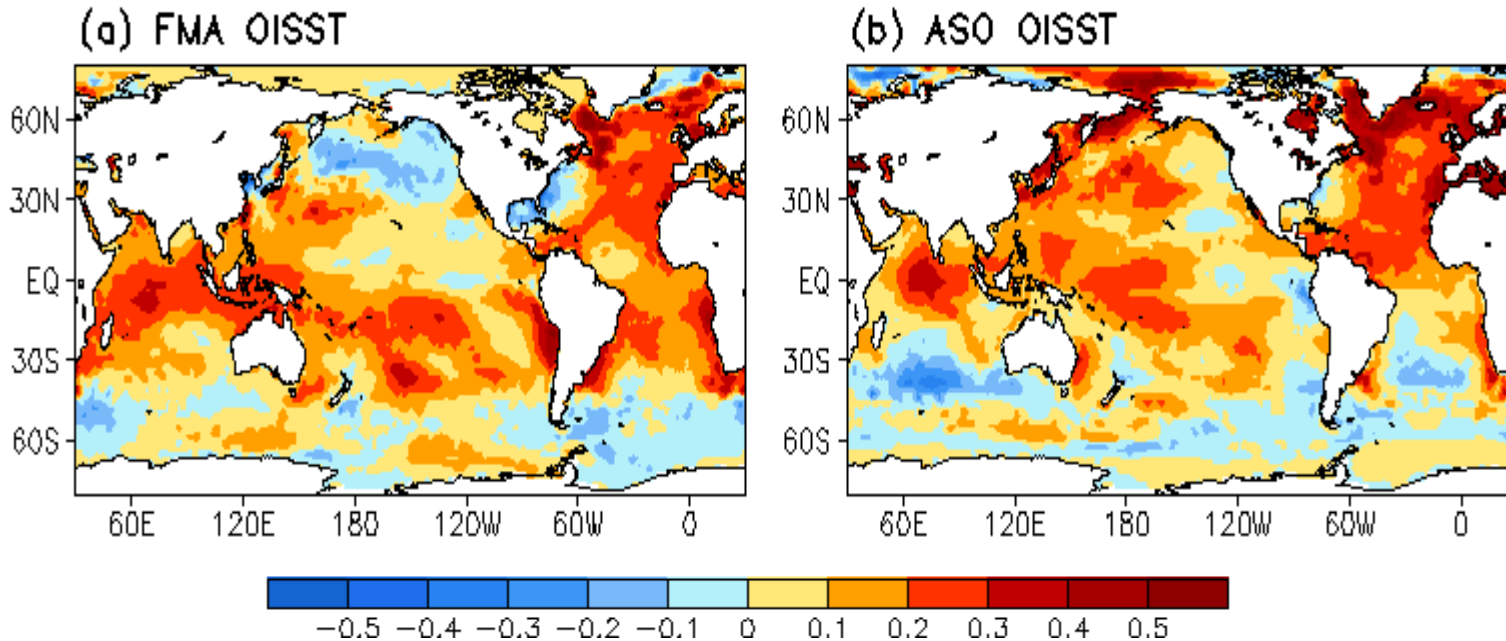
# Switch to 1981-2010 Climatology

- **SST from 1971-2000 to 1981-2010**
  - Weekly **OISST.v2**, monthly ERSST.3b
- **Atmospheric fields from 1979-1995 to 1981-2010**
  - NCEP CDAS **winds**, sea level pressure, 200mb velocity potential, surface shortwave and longwave radiation, surface latent and sensible fluxes, relative humidity
  - Outgoing Long-wave Radiation
- **Oceanic fields from 1982-2004 to 1981-2010**
  - GODAS temperature, **heat content**, depth of 20°C, sea surface height, mixed layer depth, tropical cyclone heat potential, surface currents, upwelling
- **Satellite data climatology 1993-2005 unchanged**
  - Aviso Altimetry Sea Surface Height
  - Ocean Surface Current Analyses – Realtime (OSCAR)



## Be aware that new climatology (1981-2010) was applied since Jan 2011

SST Climatology Diff. ( $^{\circ}\text{C}$ ): (1981–2010) – (1971–2000)



**1971-2000 SST Climatology (Xue et al. 2003):**

[http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst\\_clim.htm](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  $0.2^{\circ}\text{C}$  over much of the Tropical Oceans and N. Atlantic, but decreased by more than  $0.2^{\circ}\text{C}$  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.

# 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](mailto:Yan.Xue@noaa.gov). Thanks!