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

Prepared by

Climate Prediction Center, NCEP/NOAA

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http://www.cpc.ncep.noaa.gov/products/GODAS/

This project to deliver real-time ocean monitoring products is implemented by CPC in cooperation with NOAA's Ocean Observing and Monitoring Division (OOMD)

Outline

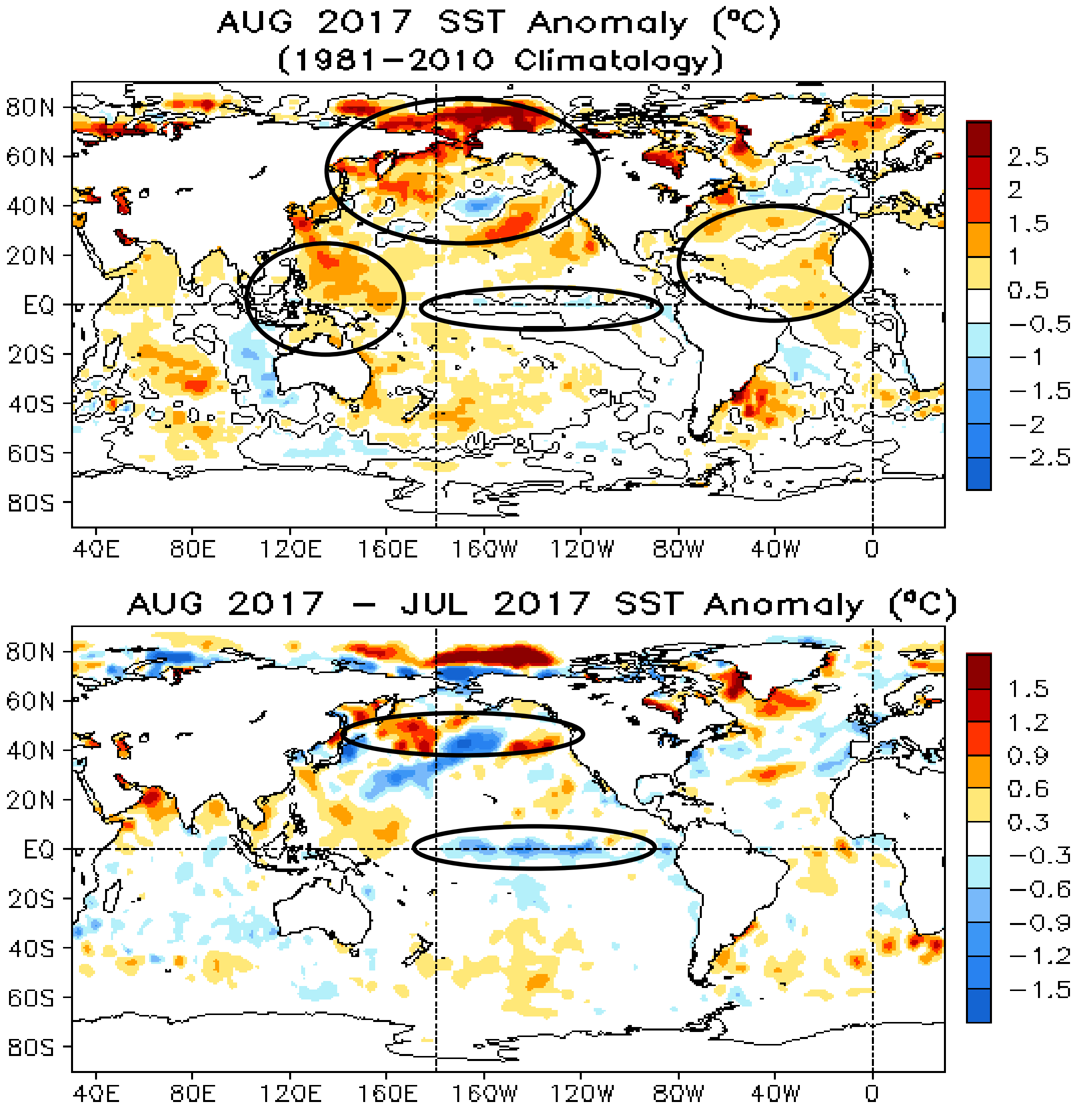
- **Overview**
- **Recent highlights**
  - ❖ Pacific/Arctic Ocean
  - ❖ Indian Ocean
  - ❖ Atlantic Ocean
- **Global SST Predictions**
  - ❖ *Possibility of La Niña condition during winter 2017/18*
  - ❖ *Hurricane Harvey and Warming in the Gulf of Mexico*

Overview

- **Pacific Ocean**
  - **ENSO-neutral condition continued in Aug 2017.**
  - **Negative subsurface temperature anomalies strengthened in the central-eastern equatorial Pacific Ocean.**
  - **Both NCEP CFSv2 and oceanic precursors favor La Nina condition in the Northern Hemisphere winter 2017/18.**
  - **PDO became weakly negative with PDO = -0.1 in Aug 2017.**
  - **Arctic sea ice extent averaged for Aug 2017 ranks the third lowest in the satellite record.**
- **Indian Ocean**
  - **Positive SSTA persisted in the western Indian Ocean and negative SSTA continued in the eastern Indian Ocean.**
- **Atlantic Ocean**
  - **Strong positive TCHP anomalies persisted in the west of Gulf of Mexico in Aug 2017.**
  - **Gulf of Mexico experienced the strongest upper ocean warming (0-150m) since 1979.**
  - **NAO switched to negative phase with NAOI=-1.5 in Aug 2017.**

Global Oceans

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

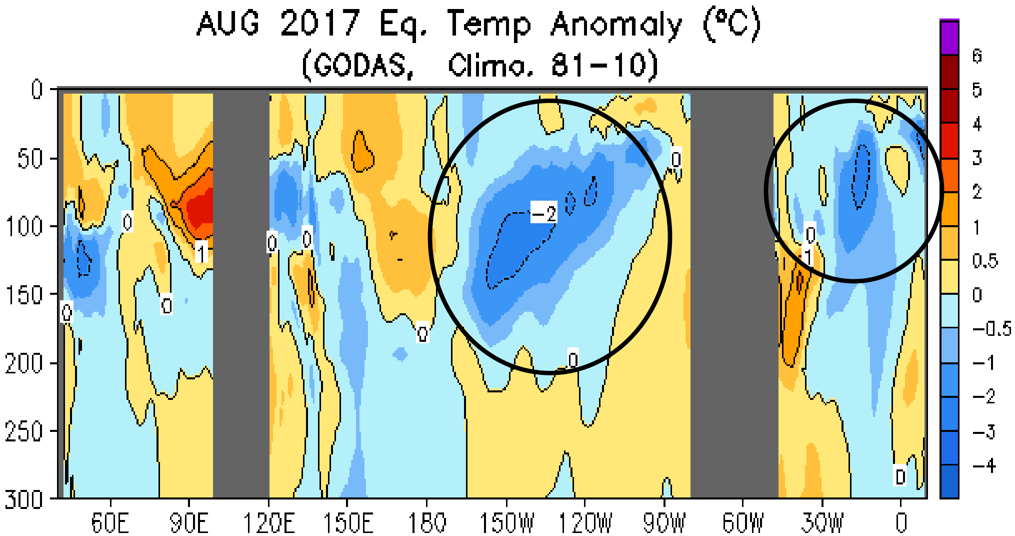


- **Strong positive SSTA (>1° C) presented in the western and north-western tropical Pacific, while weak negative SSTA dominated in the central-eastern equatorial Pacific.**
- **Positive SSTA dominated in N. Pacific.**
- **Positive SSTAs continued in the tropical N. Atlantic.**
- **In the Indian Ocean, SSTAs were positive in the west and central and negative in the east.**

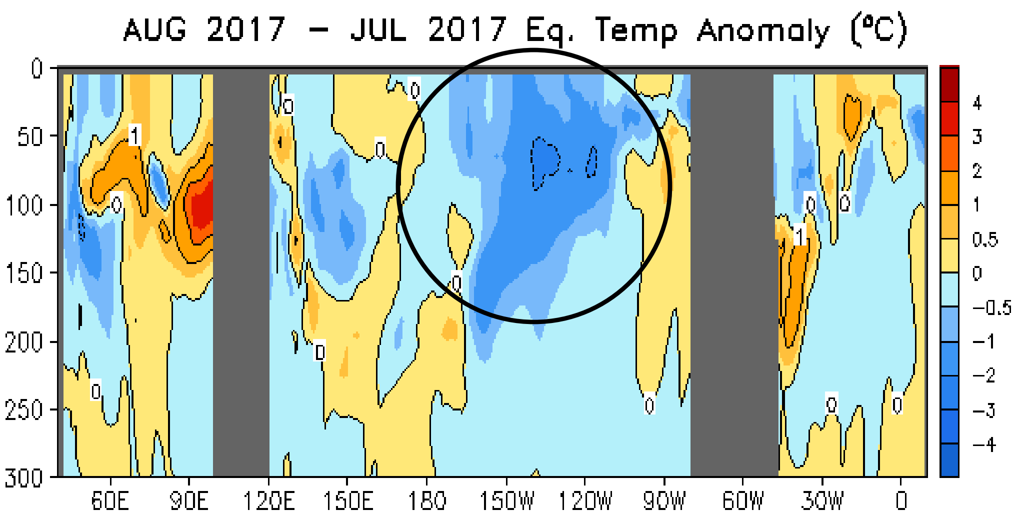
- **SSTA tendency has a dipole structure with positive (negative) tendency in the western (central-eastern) tropical Pacific.**
- **Both positive and negative SSTA tendencies presented in the N. Pacific.**

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^{O}S-2^{O}N



- Ocean temperature were 2°C cooler than average near the thermocline in the central-eastern Pacific.
- Negative ocean temperature anomalies dominated in the Atlantic Ocean.

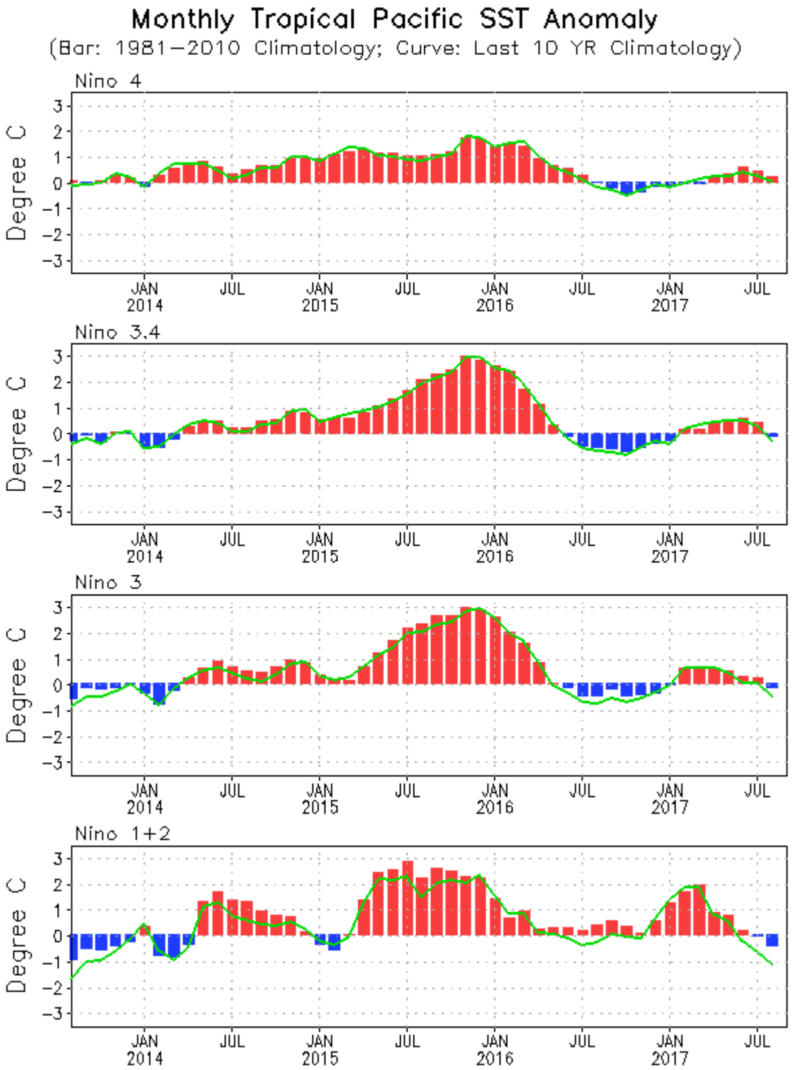


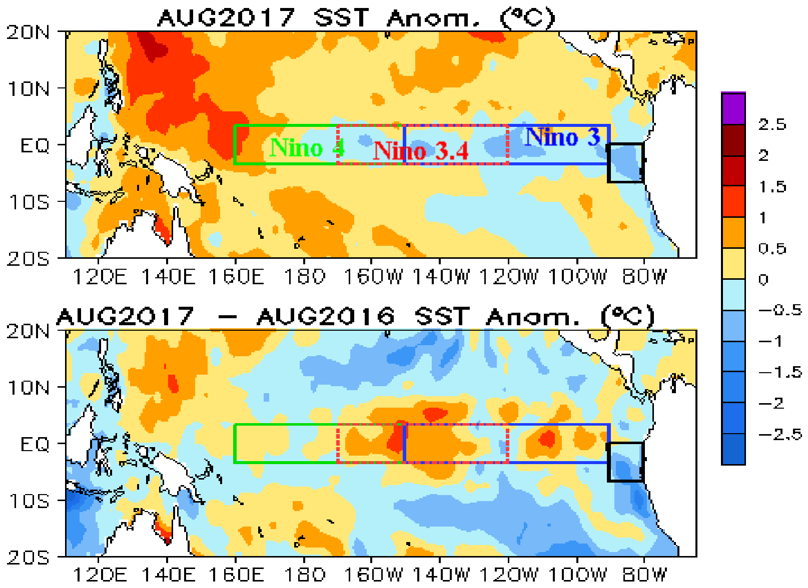
- Negative tendencies dominated the equatorial Pacific.
- Positive tendencies presented in the eastern Indian Ocean

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

Evolution of Pacific NINO SST Indices





- Nino 3.4, Nino 3 and Nino 1+2 were below-average in Aug 2017.

- Nino3.4 = -0.15ºC in Aug 2017.

- Compared with last Aug, the central and eastern equatorial Pacific was warmer in Aug 2017.

- 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 (ºC) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

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

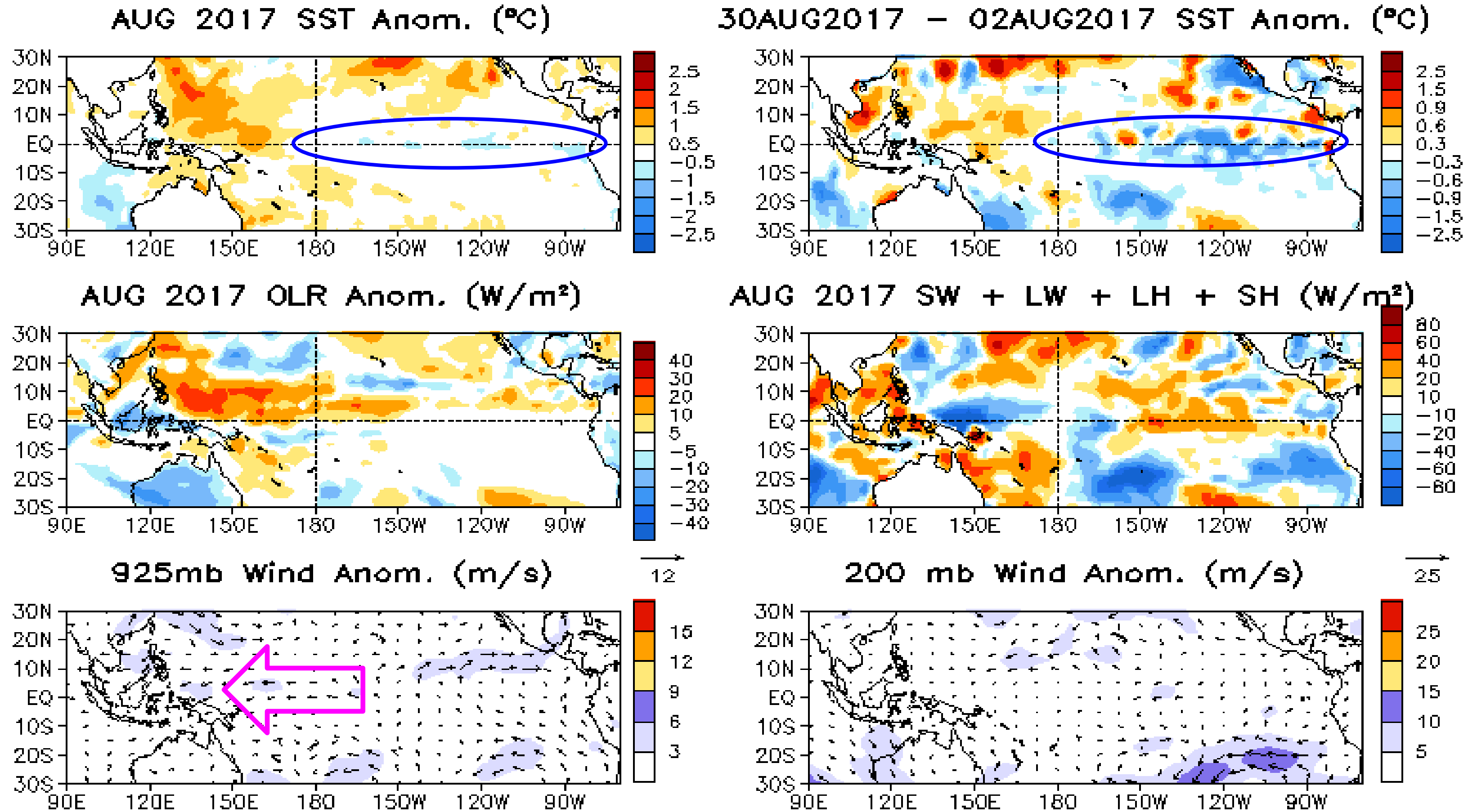
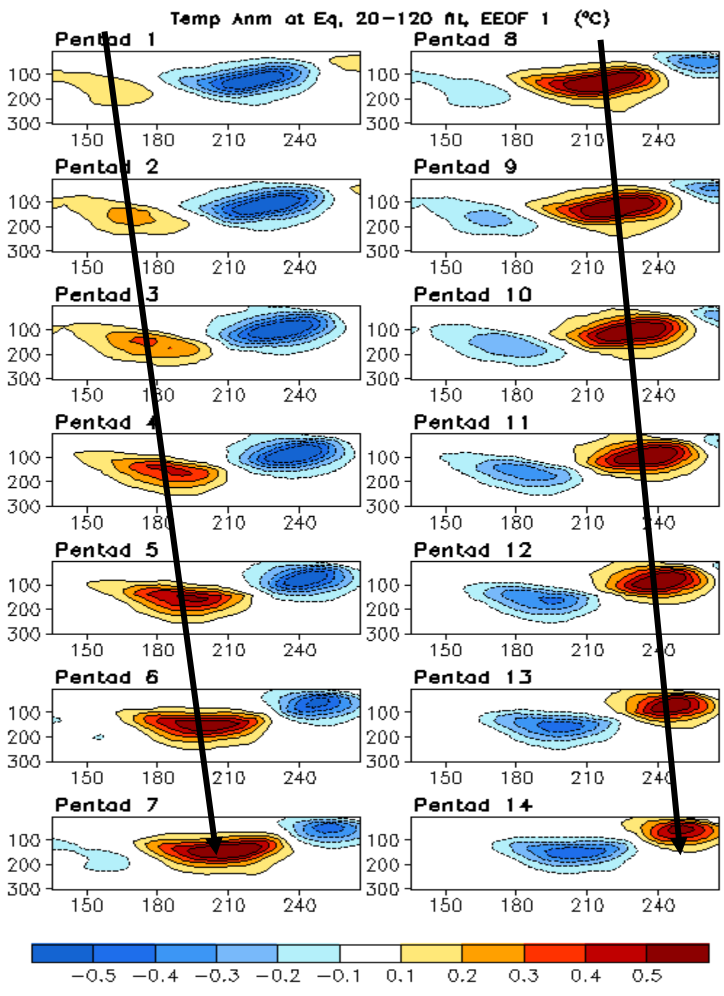
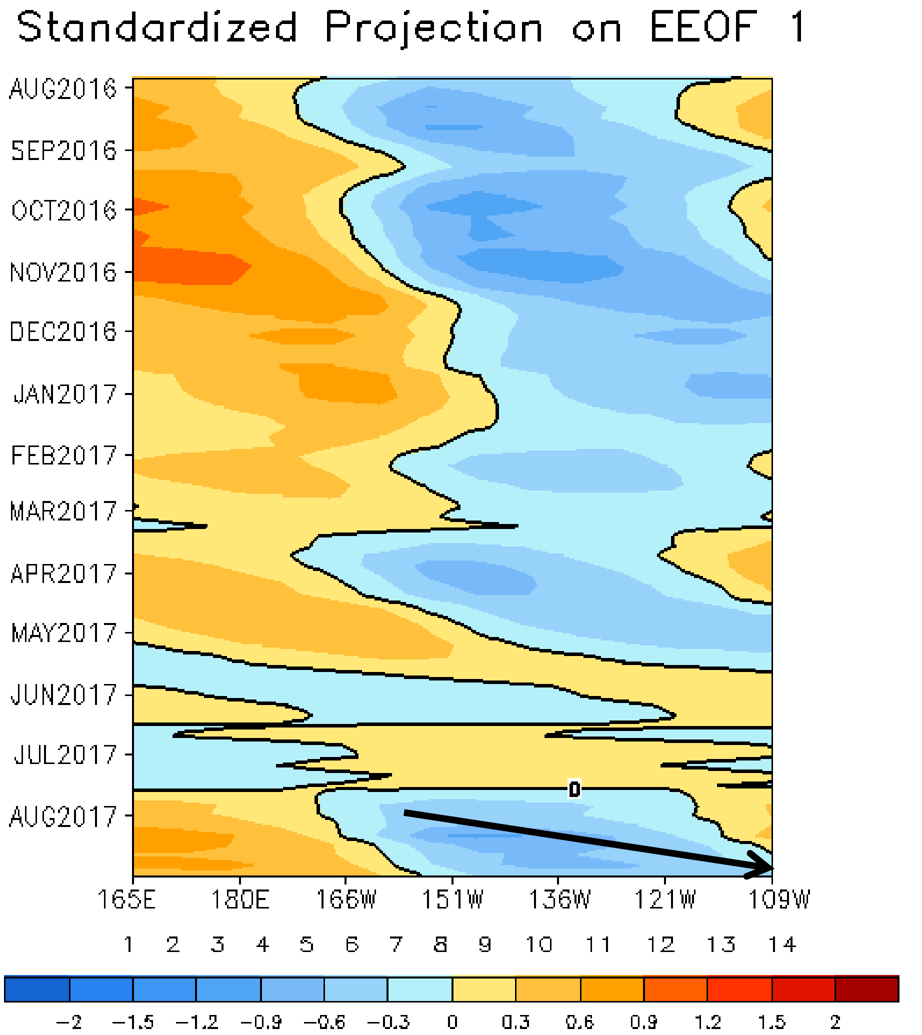


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Oceanic Kelvin Wave (OKW) Index

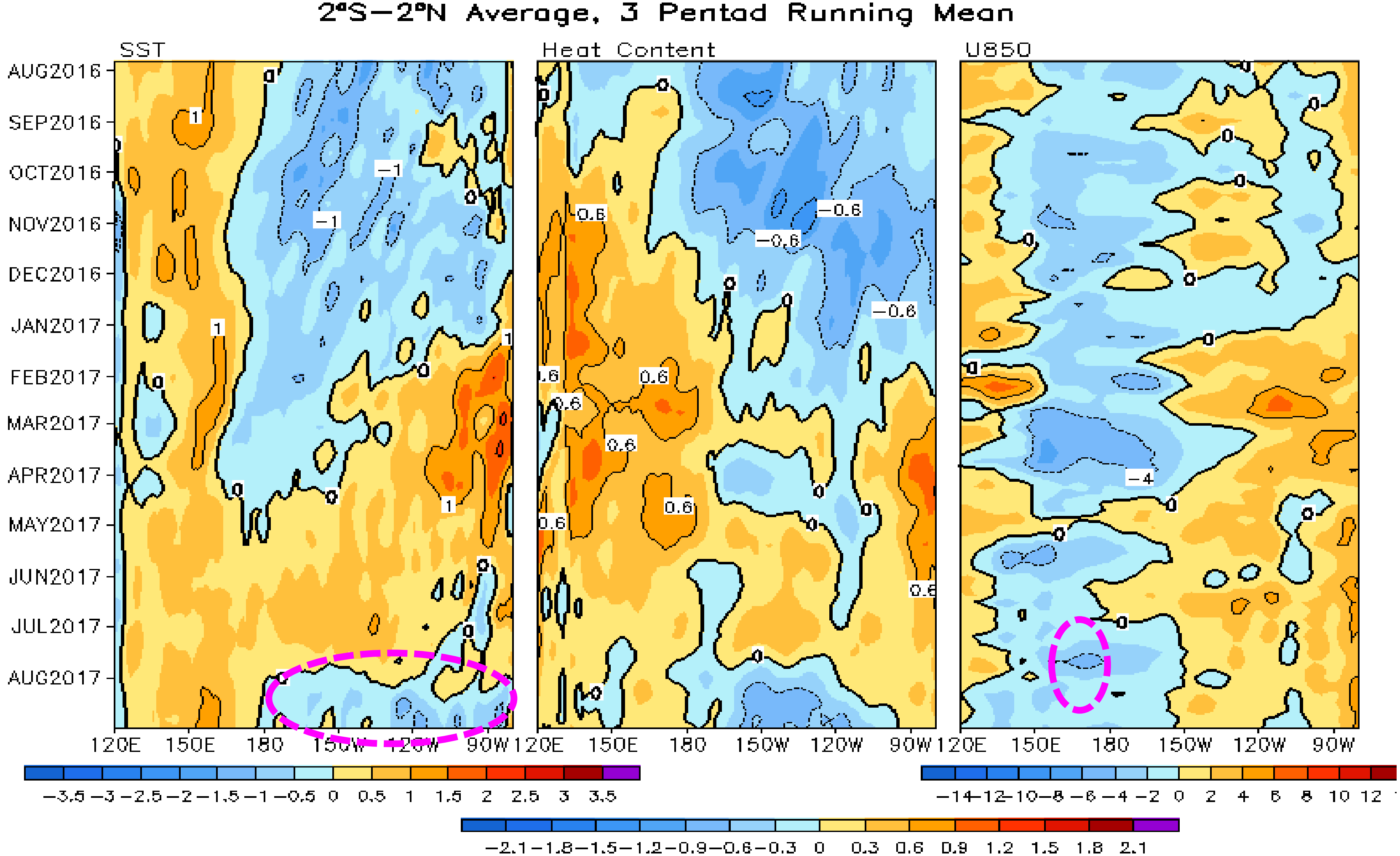




- An upwelling OKW emerged around 166w-151W in late July and propagated to the eastern Pacific during Aug 2017.

- (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

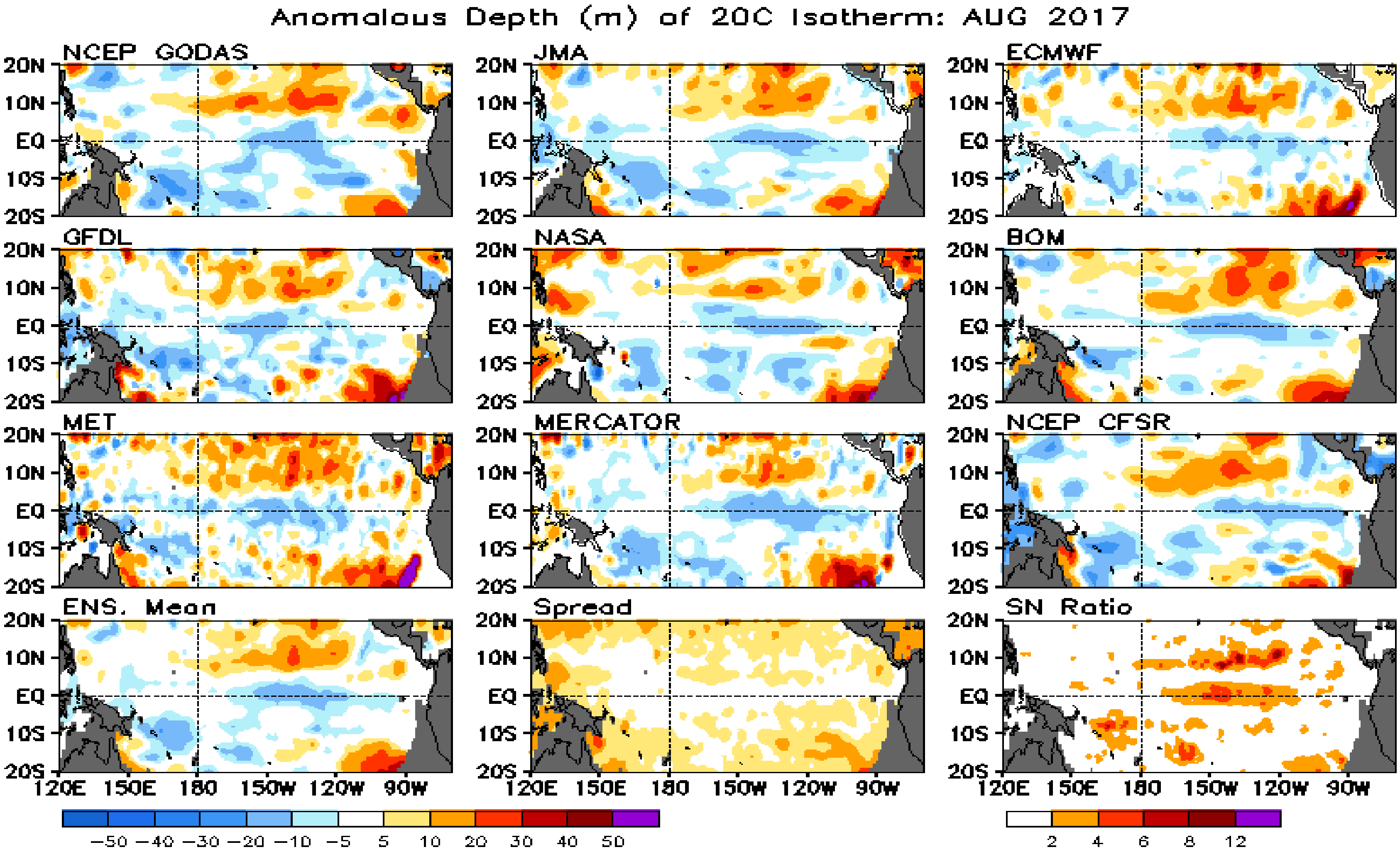


- **Positive SSTAs dissipated in the central-eastern equatorial Pacific in Aug 2017.**
- **Negative HC300A presented in the central-eastern Pacific, which was associated with an upwelling Kelvin wave initiated in late July.**
- **Low-level easterly wind anomalies generally prevailed over the western-central Pacific in the last 13 month , while westerly wind anomalies persisted in the eastern Pacific since Jan 2017.**

Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1993-2013

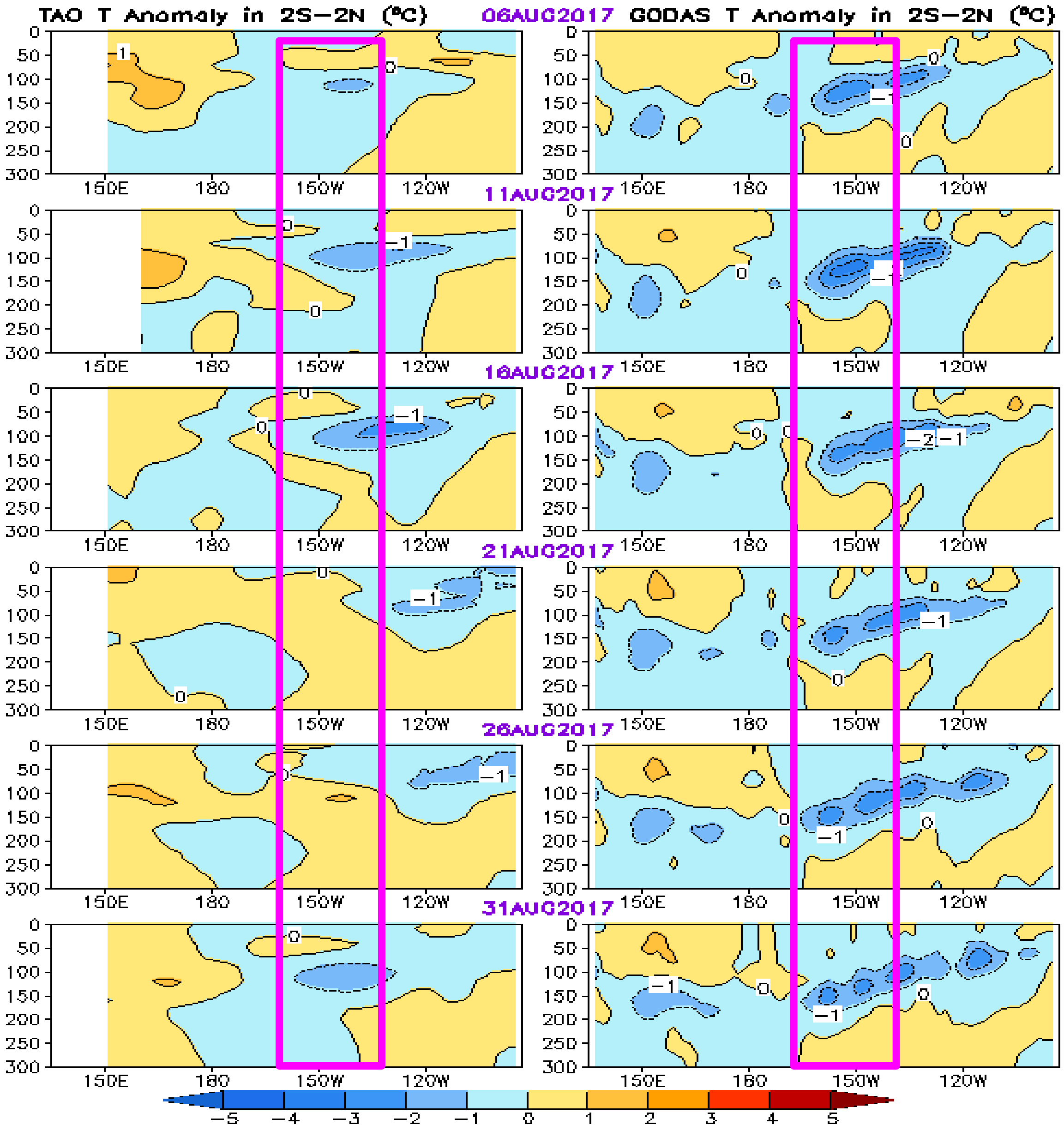
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)



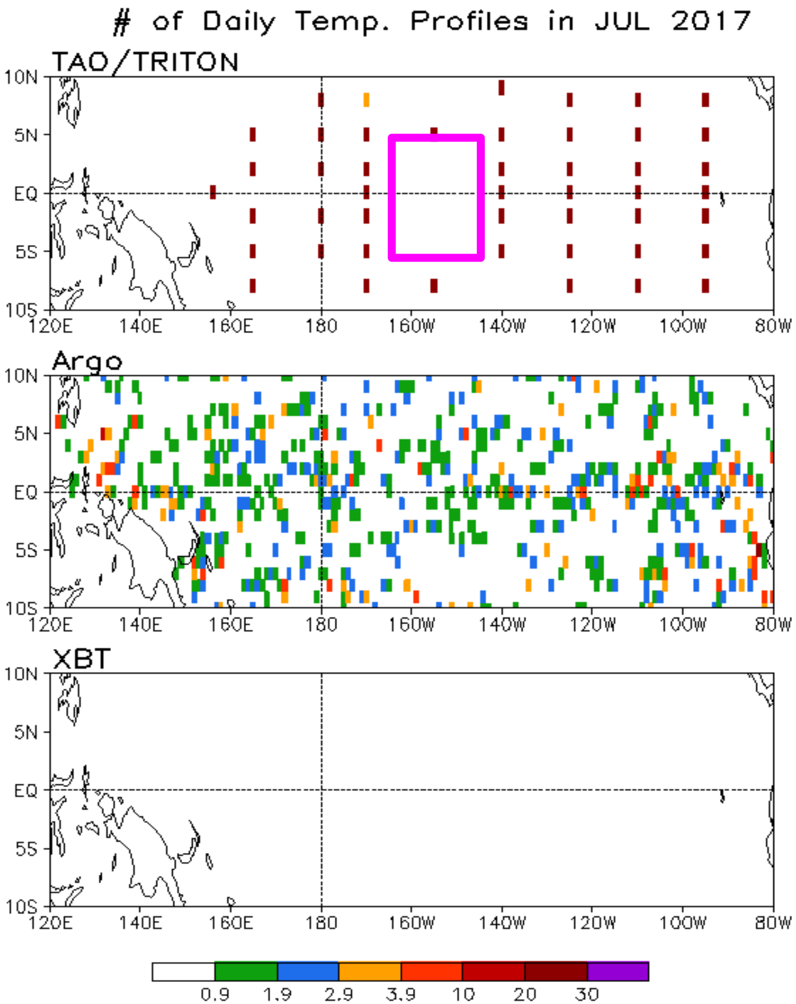
- Negative D20 anomalies were observed in the central-eastern equatorial Pacific in all nine reanalyses.

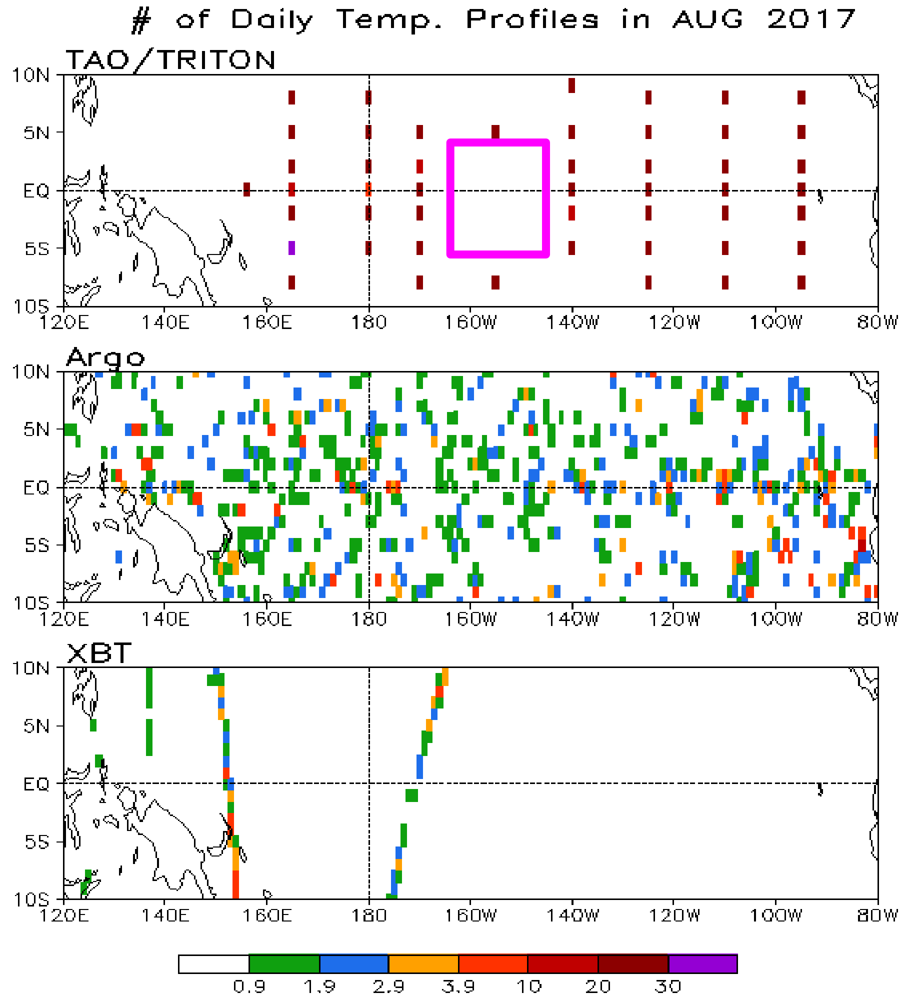
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

TAO GODAS



- Ocean temperature were about 2° C cooler than average along the thermocline between 170°W-100°W based on GODAS.
- Large differences between TAO and GODAS in the central equatorial Pacific were associated with the missing TAO data at the three moorings (2°N, Eq, 2°S) along the 155°W line (see next slide).



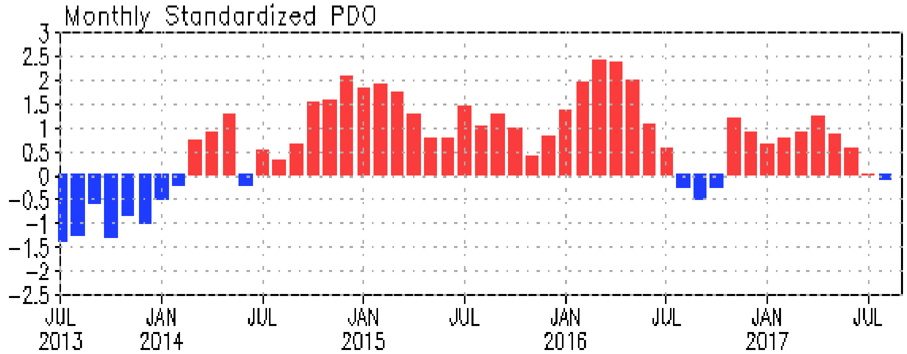


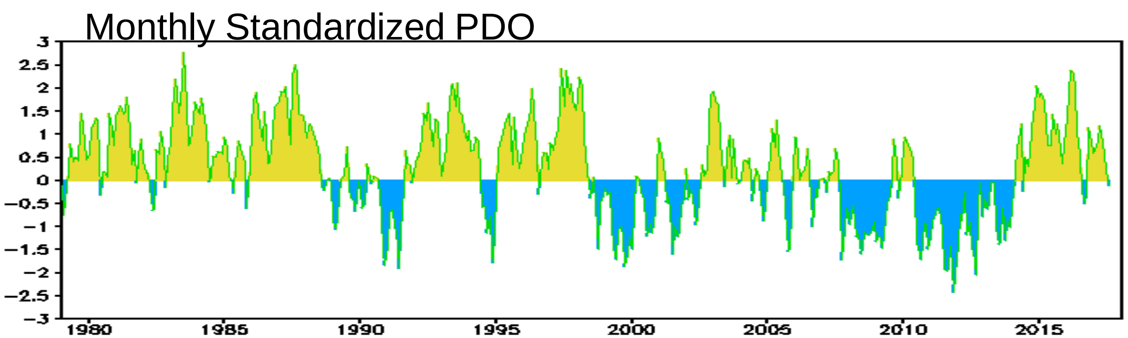
- According to Karen Grissom at NDBC , the buoy at 155W, 2N started to drift on May 29. When it drifted outside its data grid (160W - 150W by 3N - 1N) on June 20, NDBC stopped releasing data to the GTS.

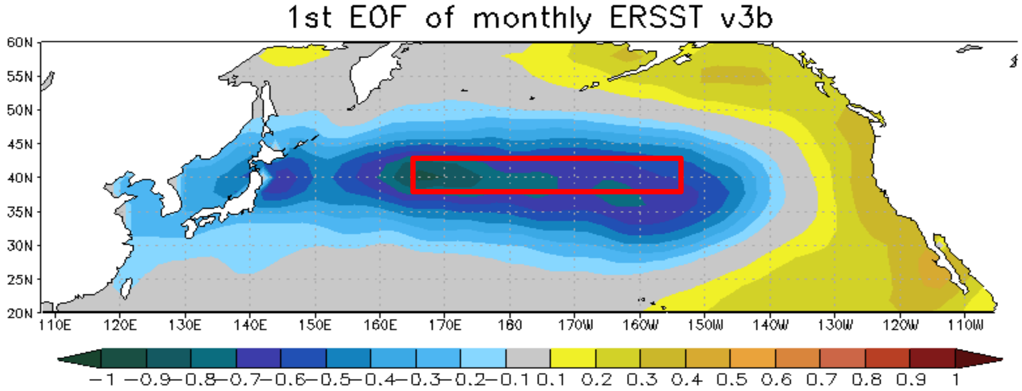
- Since the three buoys at 155W (0, 2N, 2S) had lots of missing data in the last three months, the TAO analysis may not be reliable since it was calculated as the average of the buoy temperature in nearby buoys according to Dai Mcclurg (NOAA/PMEL).

North Pacific & Arctic Oceans

PDO index based on SST data







- PDO index switched to negative phase in Aug 2017, with PDO index =-0.1.

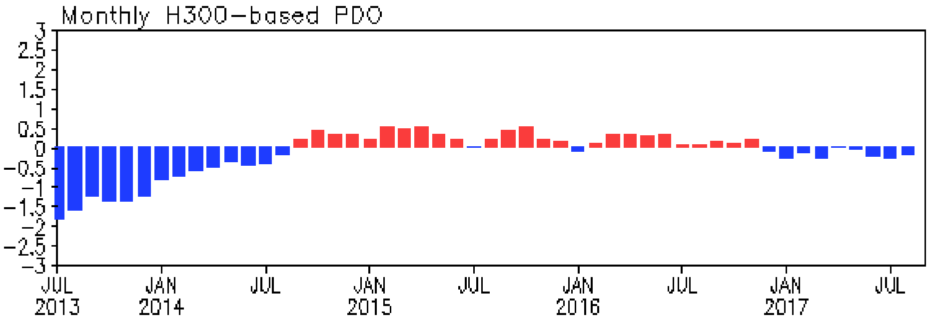
- SST-based PDO index has considerable variability both on seasonal and decadal time scales.

- 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 ERSST v4 monthly SST anomalies onto the 1st EOF pattern.

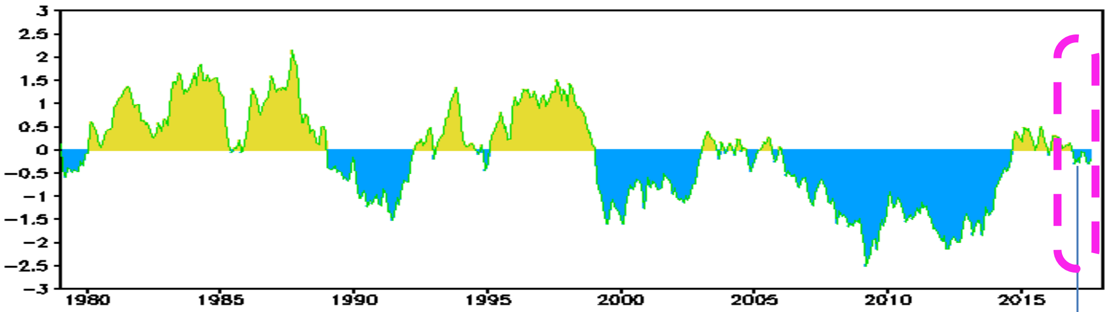
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

PDO index based on HC300 data

(http://www.cpc.ncep.noaa.gov/products/GODAS/PDO_body.html)

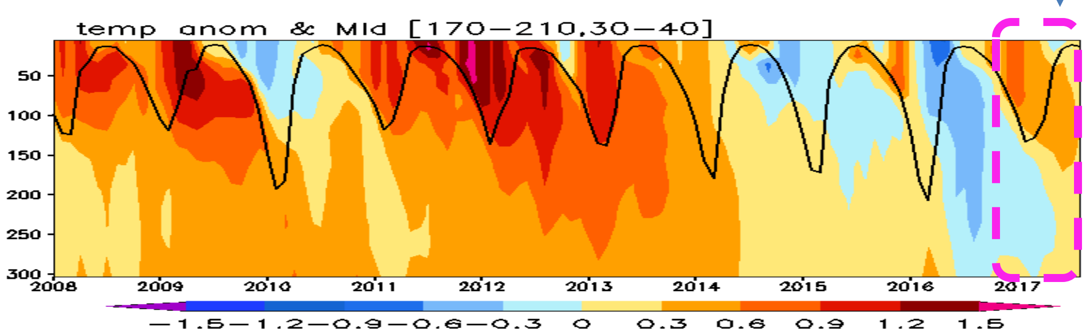


- **Negative HPDO index has persisted 9 months since Nov 2016, with HPDO = -0.2 in Aug 2017.**



- **Upper 300m Ocean Heat Content (HC300) based PDO index (HPDO) highlights the slower variability and encapsulates an integrated view of temperature variability in the upper ocean.**

Temperature anomaly averaged in [170E-150W,30N-40N]

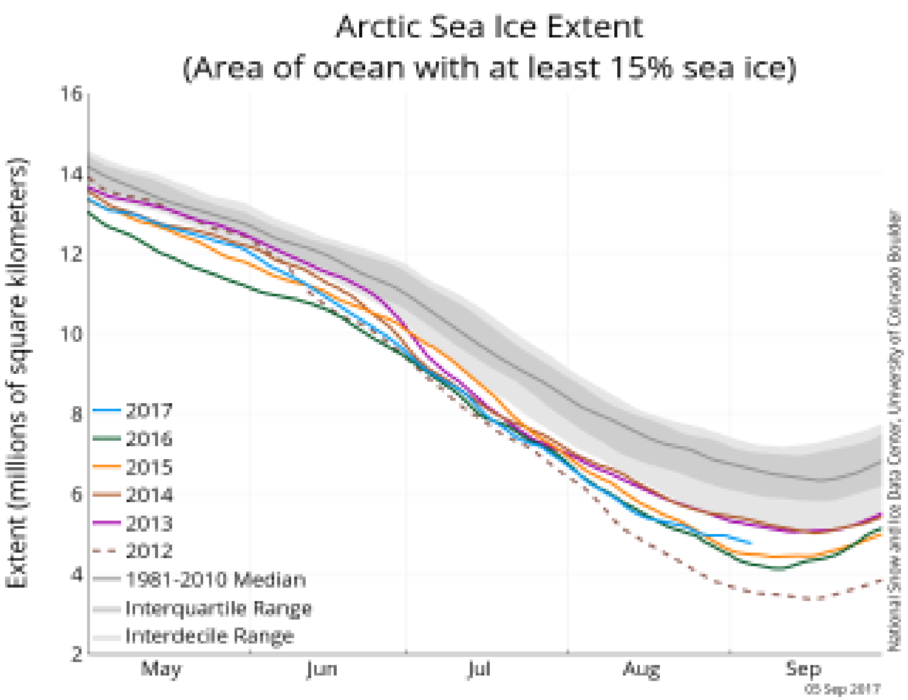


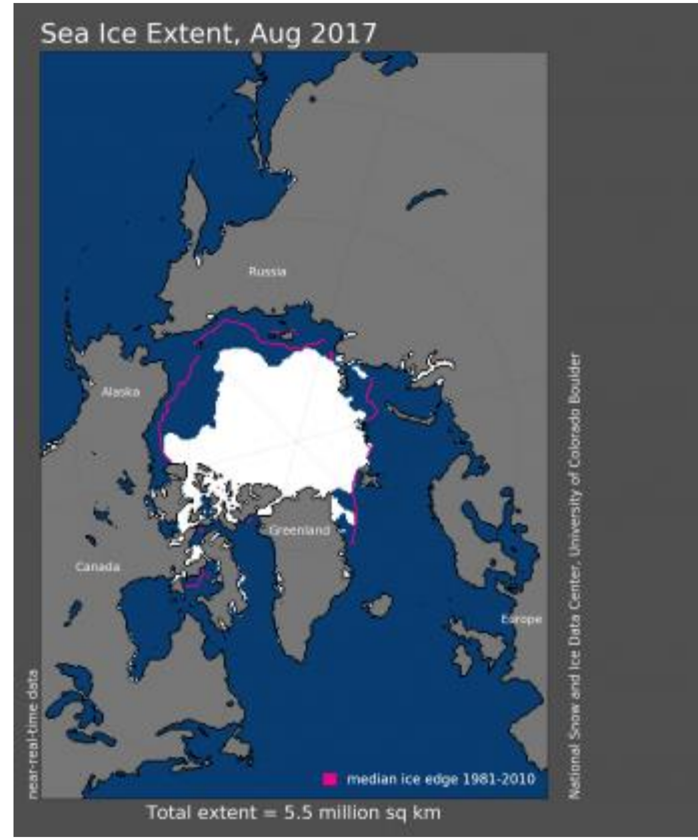
Kumar, A. and C. Wen, 2016: An Oceanic Heat Content-Based Definition for the Pacificc Decadal Oscillation. Mon. Wea. Rev., 144, 3977–3984, doi: 10.1175/MWR-D-16-0080.1.

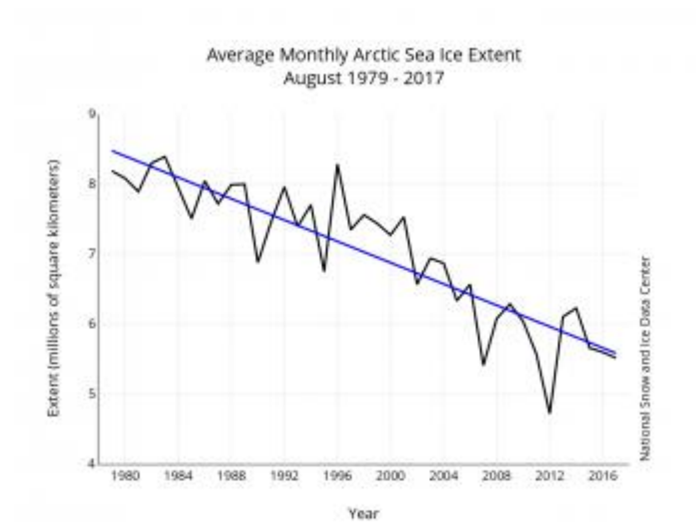
Arctic Sea Ice

National Snow and Ice Data Center

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





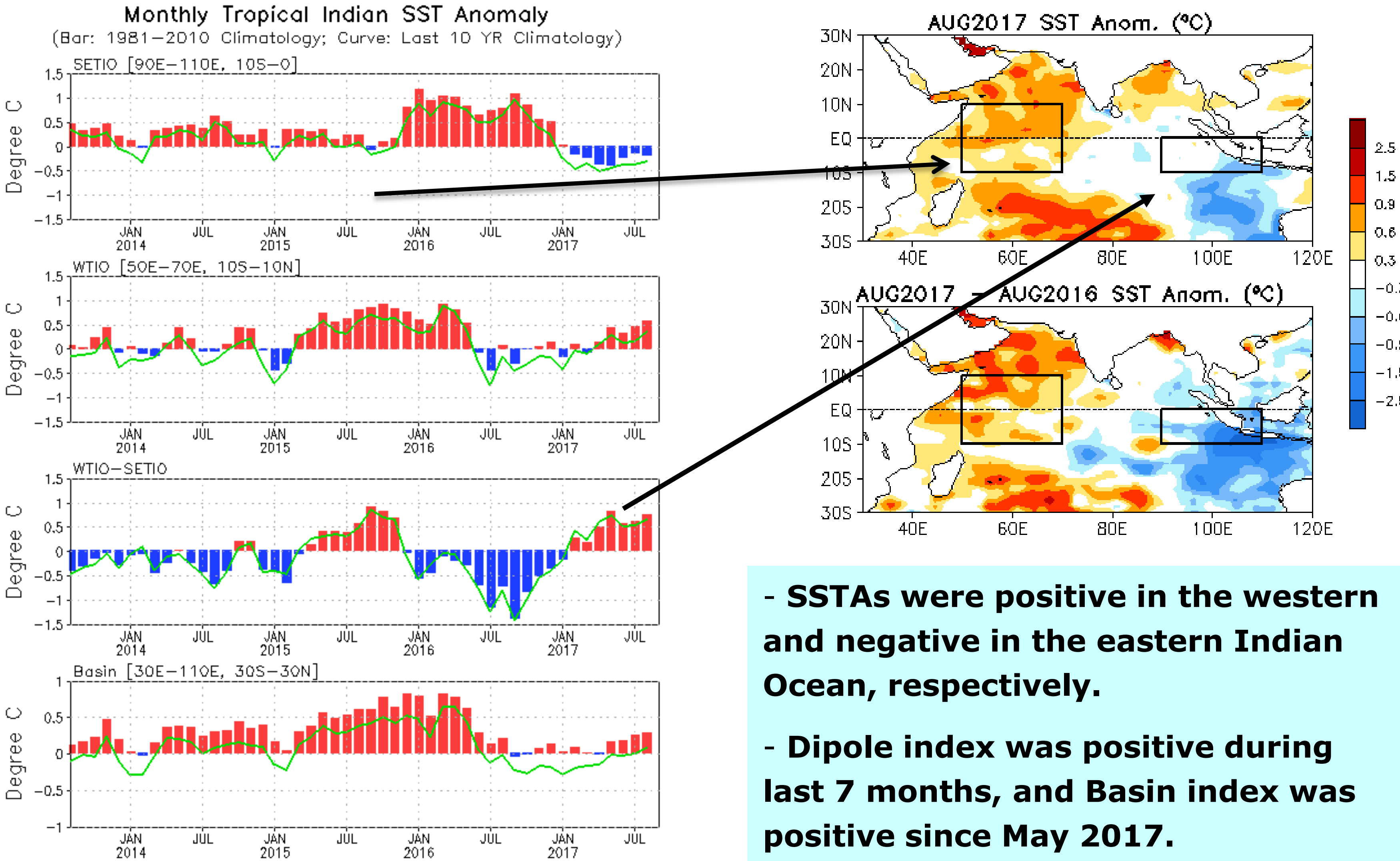


- Arctic sea ice extent averaged for Aug 2017 ranks the third lowest in the satellite record.

- The loss rate in Aug 2017 was slower than 2012, 2015 and 2016.

Indian Ocean

Evolution of Indian Ocean SST Indices



- **SSTAs were positive in the western and negative in the eastern Indian Ocean, respectively.**
- **Dipole index was positive during last 7 months, and Basin index was positive since May 2017.**

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the SETIO [90ºE-110ºE, 10ºS-0] and WTIO [50ºE-70ºE, 10ºS-10ºN] 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.

- Overall, SSTAs were positive in the west and negative in the east.
- SSTA tendency was small in the tropics, which may not be mainly determined by heat flux anomalies.

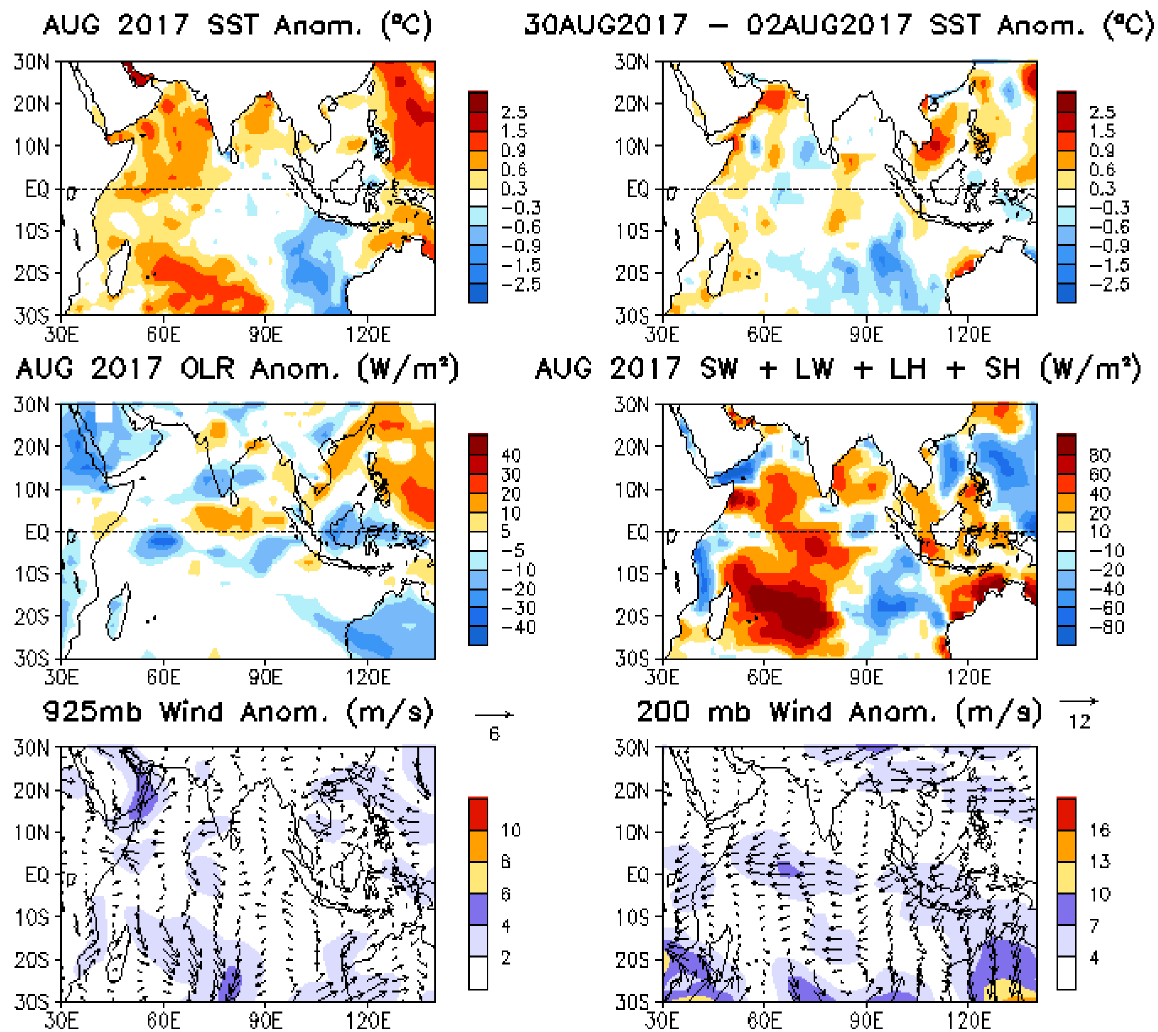
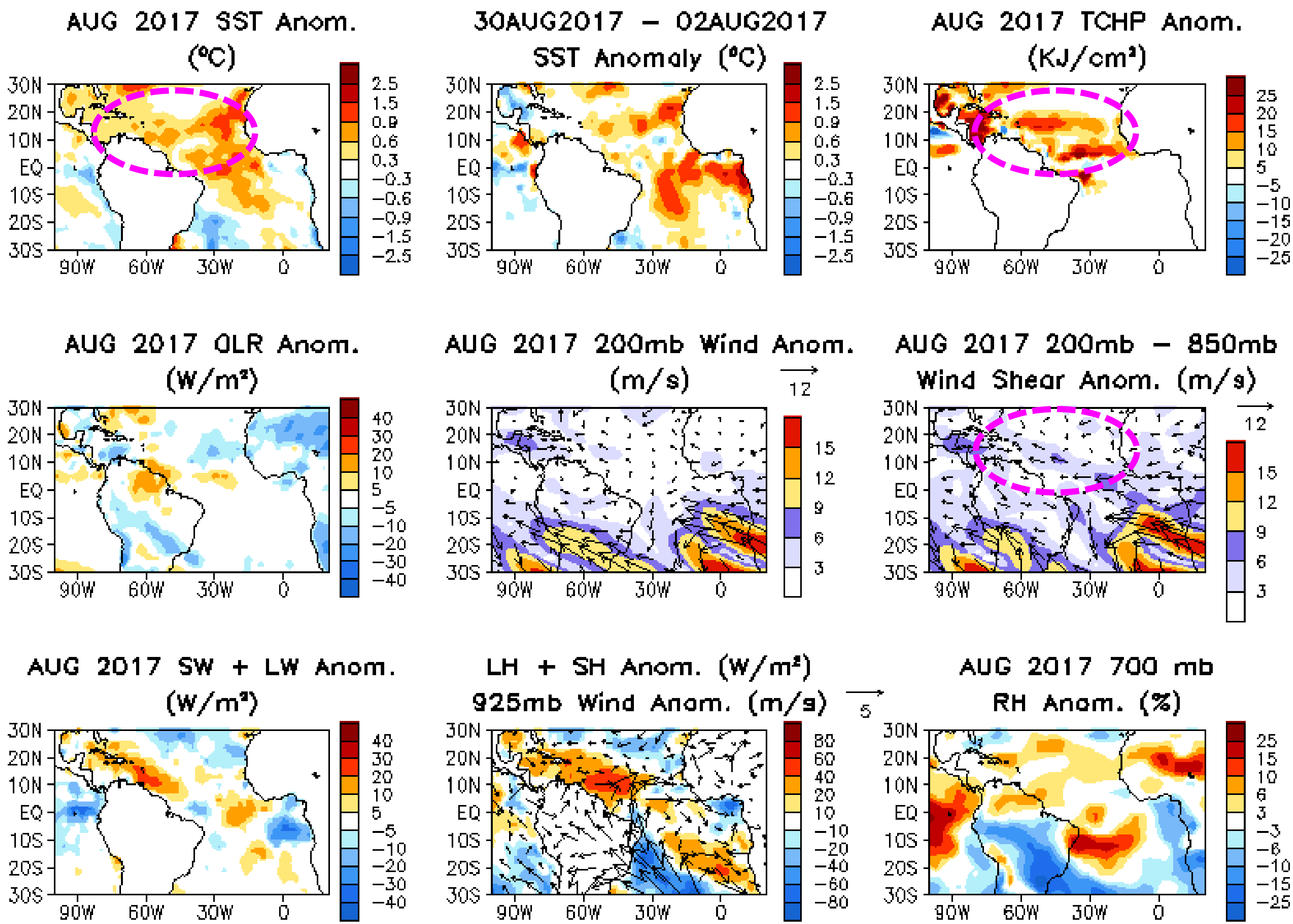


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Tropical Atlantic:

SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb/200-mb Winds



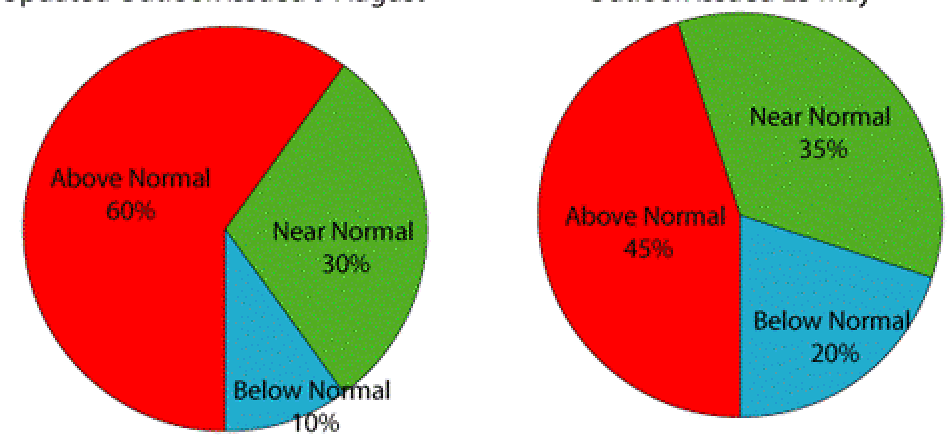
2017 Atlantic Hurricane Season

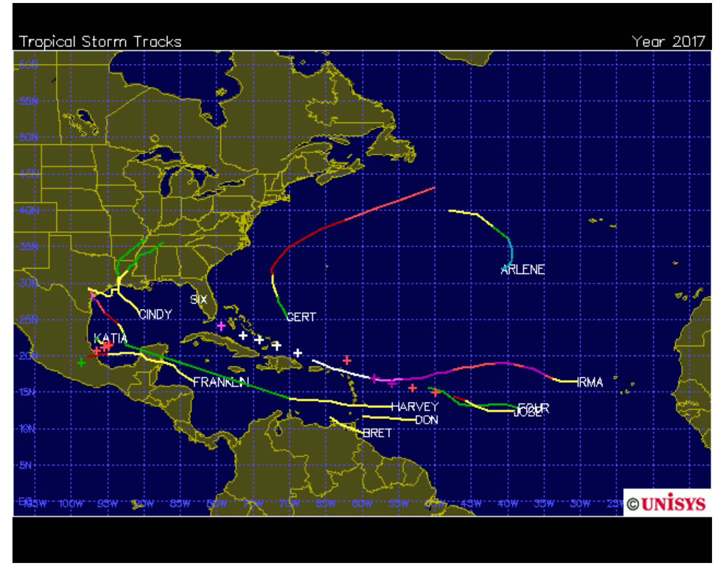
(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)

NOAA's Updated 2017 Atlantic Hurricane Season Outlook

60% Chance of Above-Normal Season, Possibly Extremely Active

Probability of Season Type





(http://weather.unisys.com/hurricane)

Predicted Activity

70% Probability For Each Range

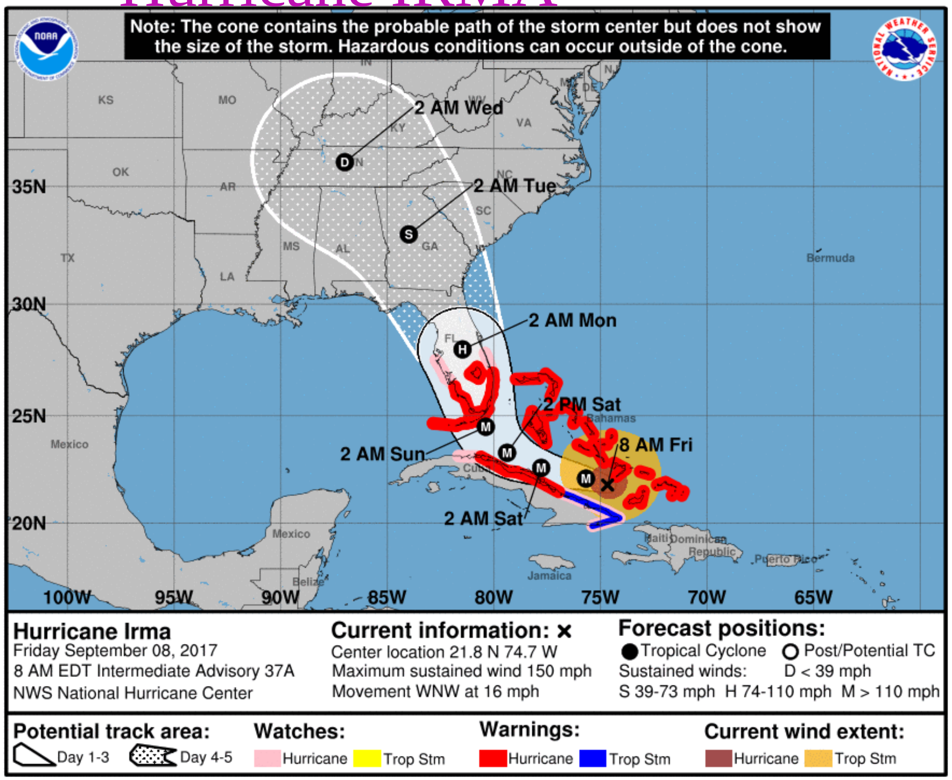
	August Update	May Outlook	Season Averages (1981-2010)
Named Storms	14-19	11-17	12
Hurricanes	5-9	5-9	6
Major Hurricanes	2-5	2-4	3
ACE (% median)	100-170%	75-155%	

- **Hurricane activity was very active since Aug 7 2017.**
- **Eleven tropical storms with 6 reaching hurricane category (3 major hurricane) formed in N. Atlantic by Sep 8.**

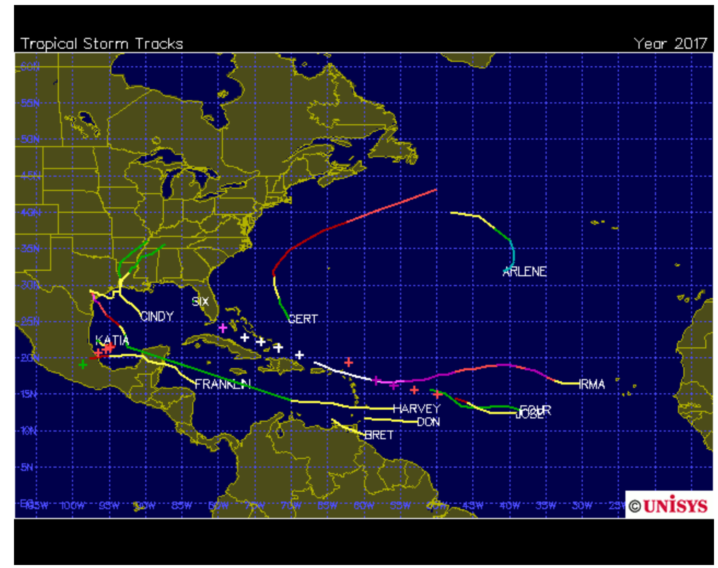
2017 Atlantic Hurricane Season

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)

Hurricane IRMA



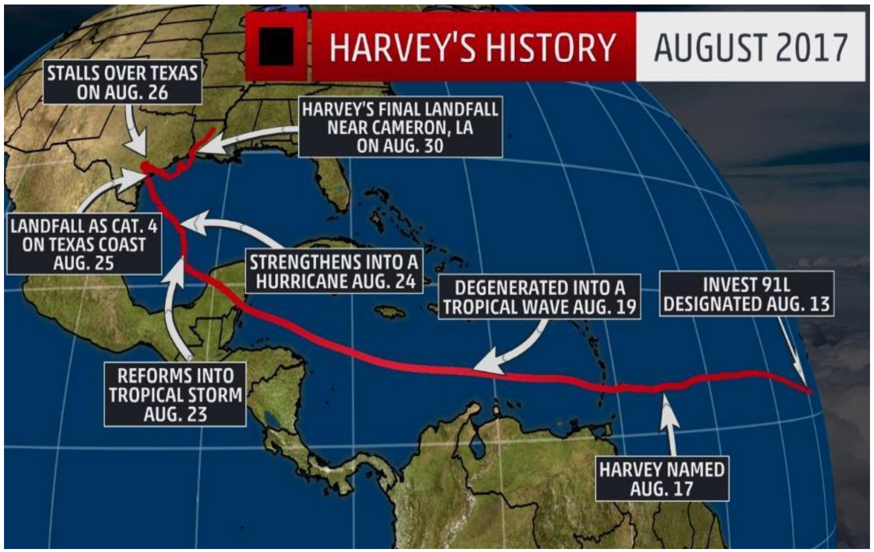
(http://www.nhc.noaa.gov/graphics_at1.shtml?cone#contents)



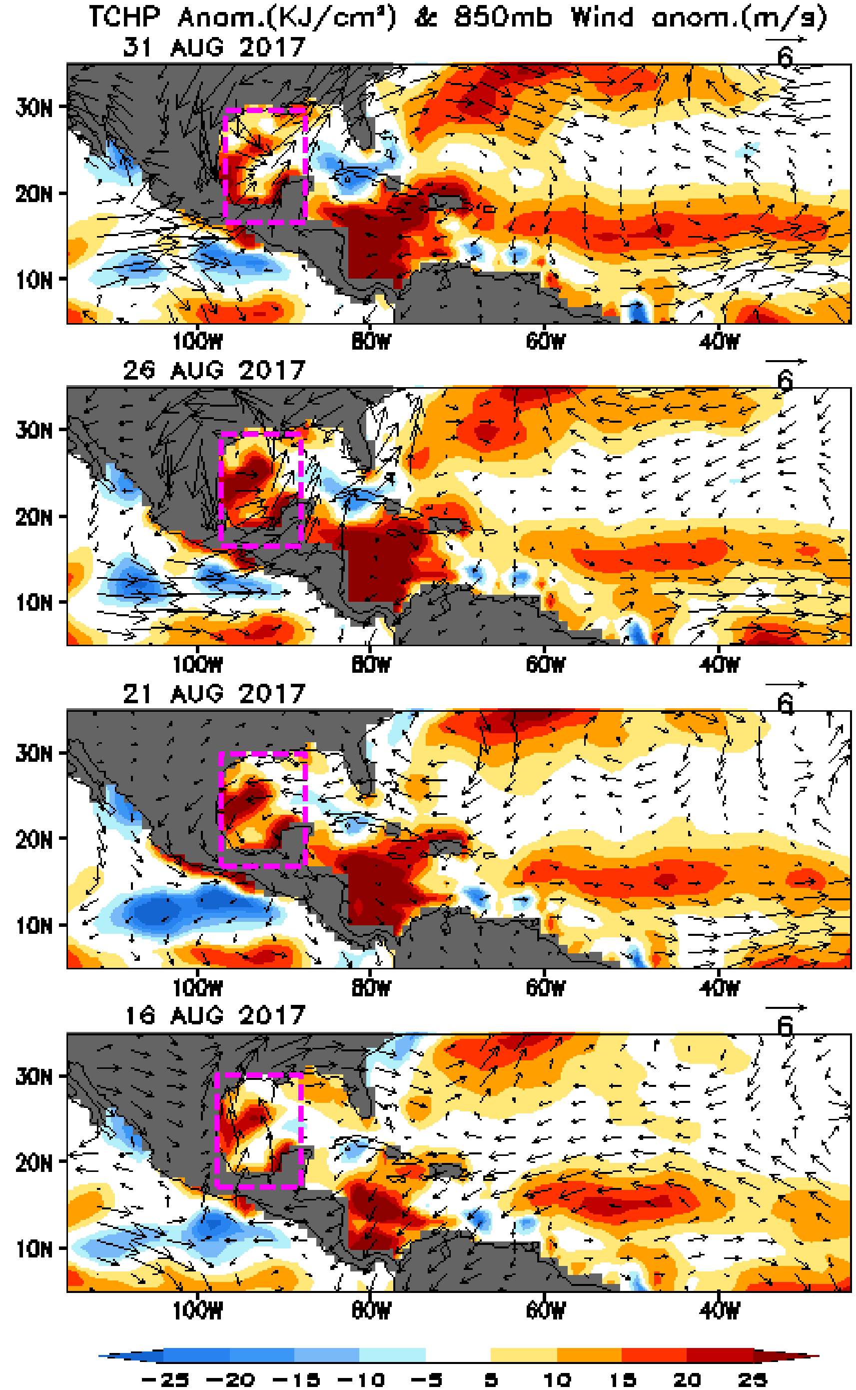
(http://weather.unisys.com/hurricane)

- Hurricane activity was very active since Aug 7 2017.
- Eleven tropical storms with 6 reaching hurricane category (3 major hurricane) formed in N. Atlantic by Sep 8.

Tropical Cyclone Heat Potential (TCHP) Anomaly & 850mb Wind Anomaly during Hurricane Harvey



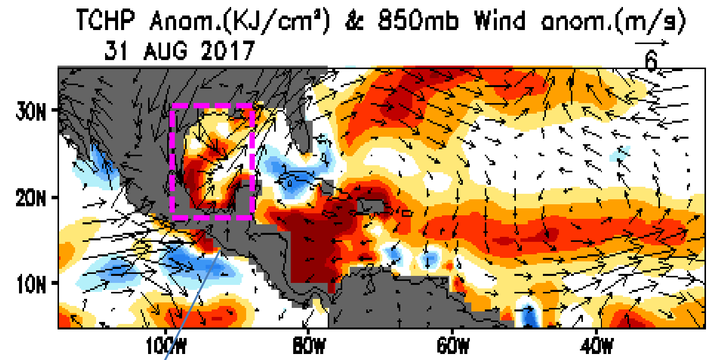
(https://weather.com/storms/hurricane/news/tropical-storm-harvey-forecast-texas-louisiana-arkansas)

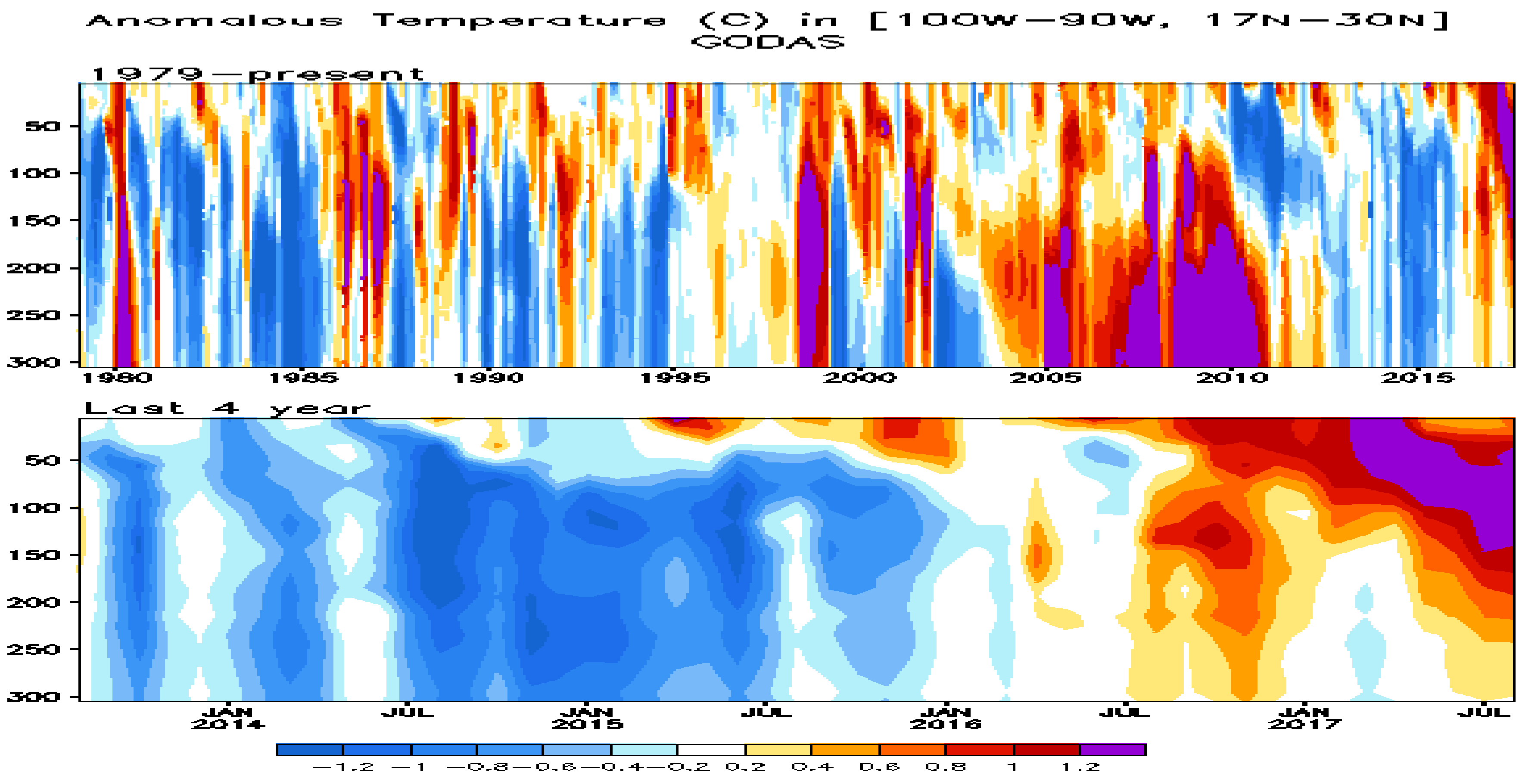


Tropical Cyclone Heat Potential (TCHP) measures the integrated energy above the 26C isotherm. TCHP anomaly is derived from NCEP GODAS and winds are from NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

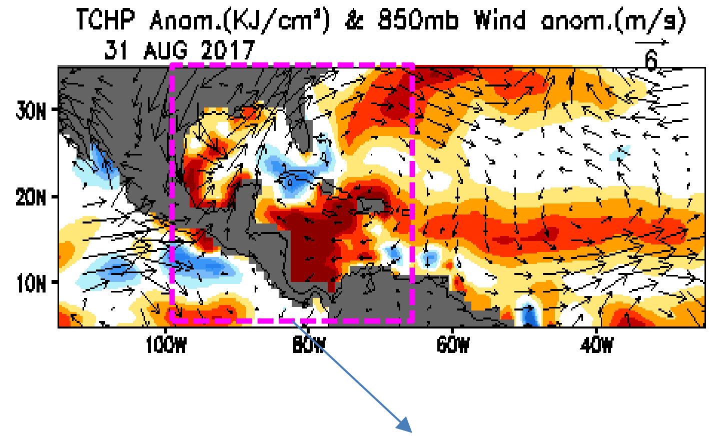
Warming in Gulf of Mexico

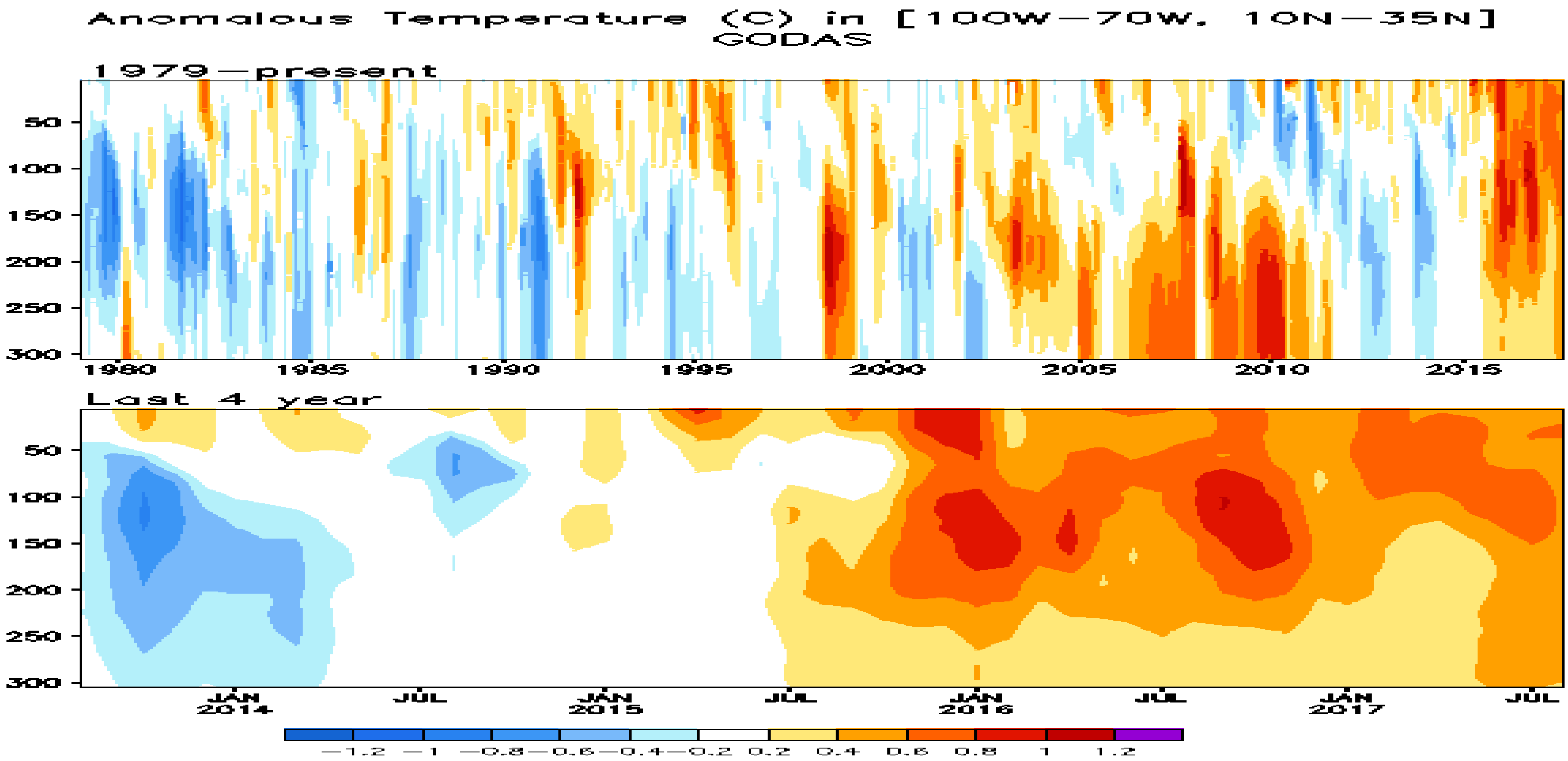
- **West Gulf of Mexico experienced the strongest upper ocean warming (0-150m) since 1979.**



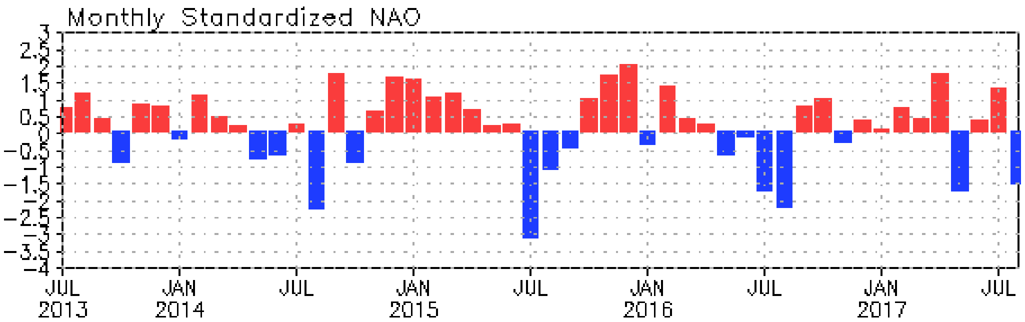


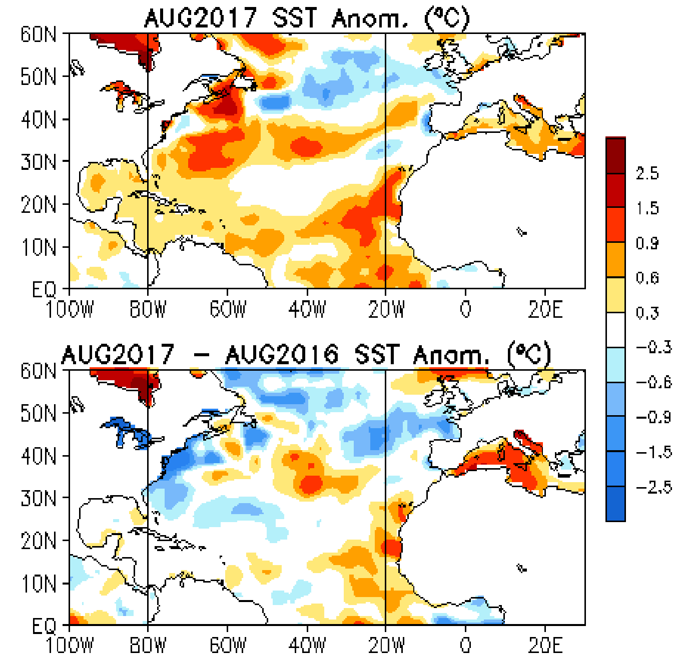
Warming in Gulf of Mexico

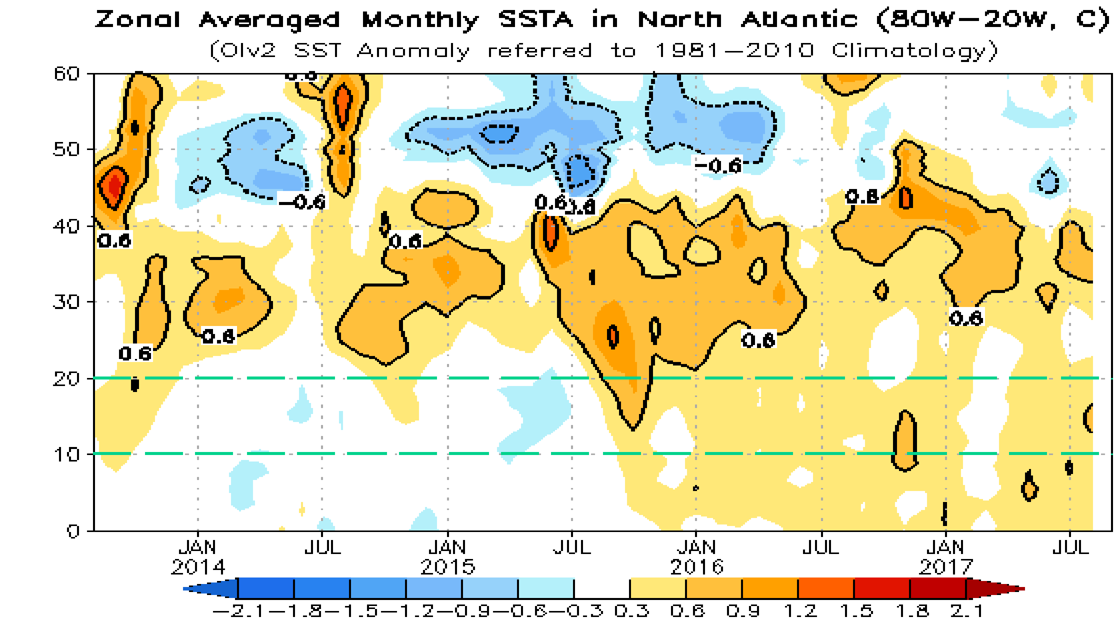




NAO and SST Anomaly in North Atlantic





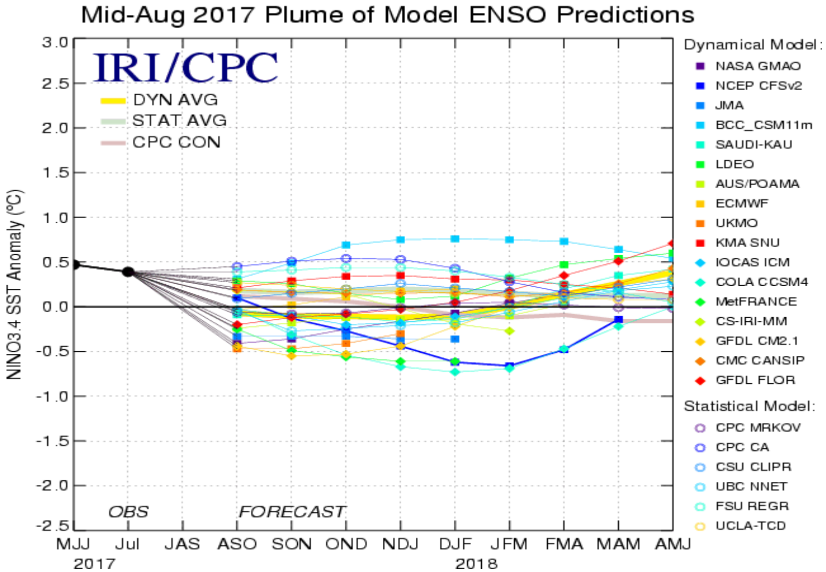


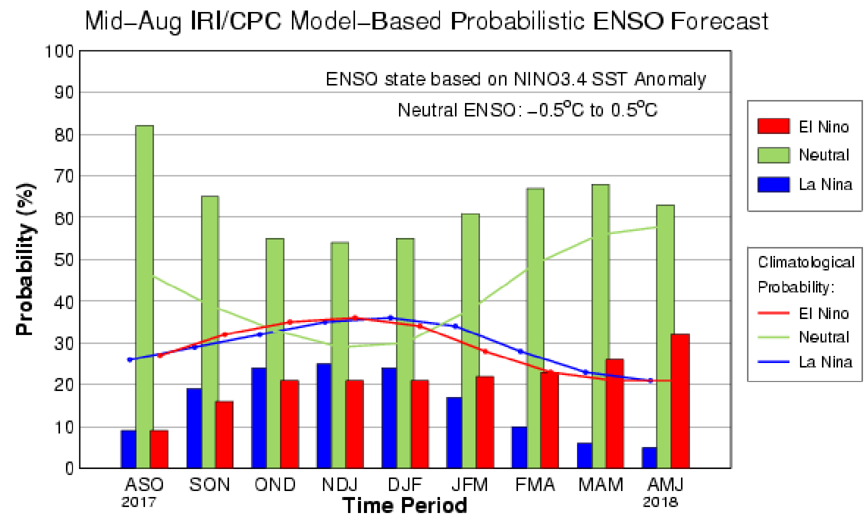
- NAO switched to negative phase, with NAOI=-1.5 in Aug 2017.

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.

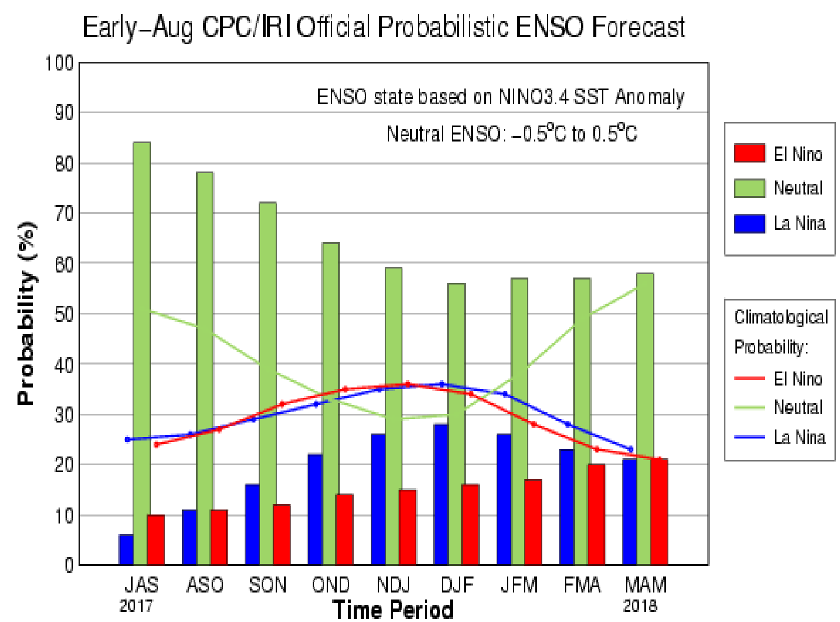
ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum

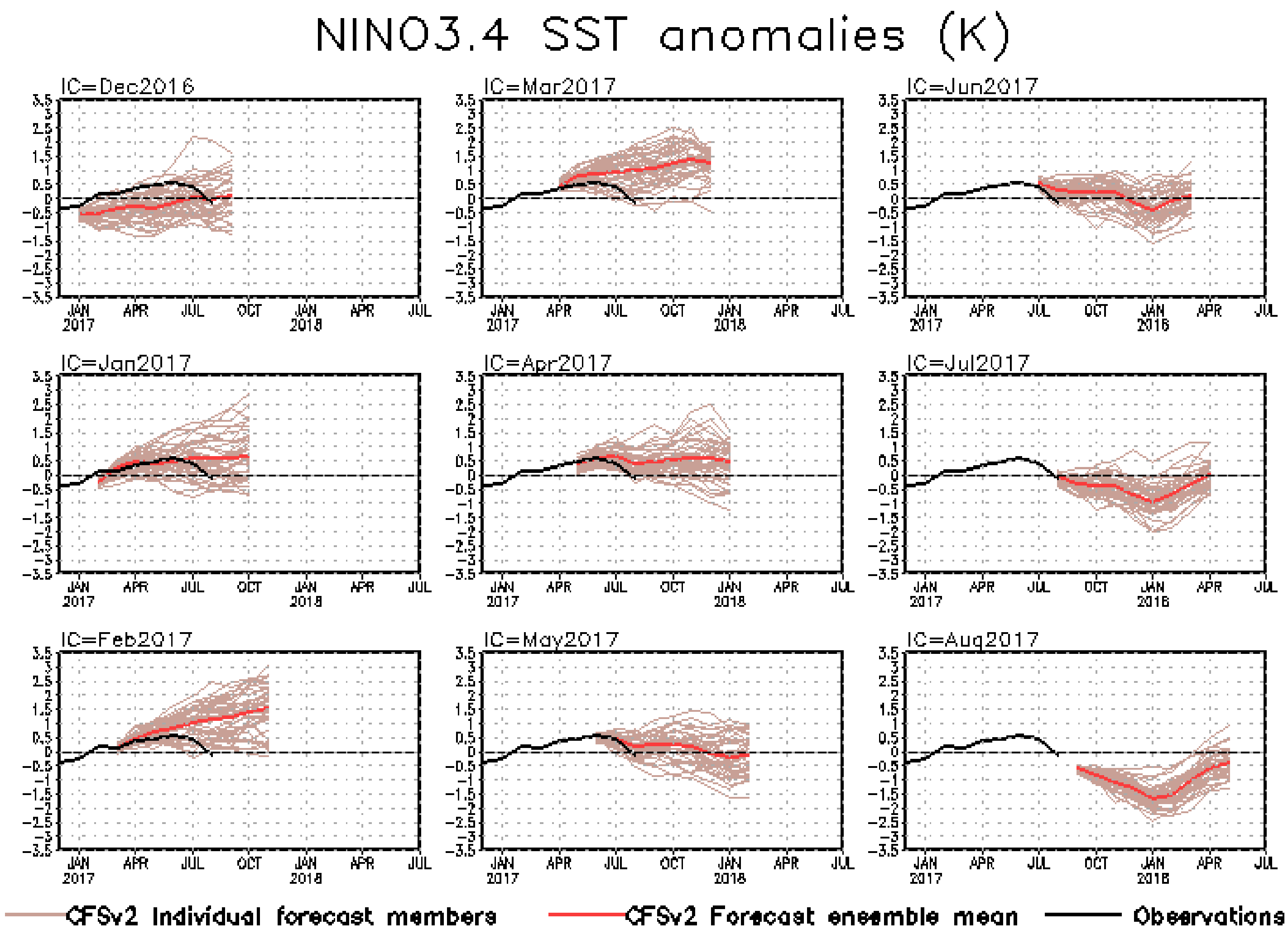




- **The majority of models favor ENSO-neutral through the Northern Hemisphere winter 2017-18 .**



CFS Niño3.4 SST Predictions from Different Initial Months

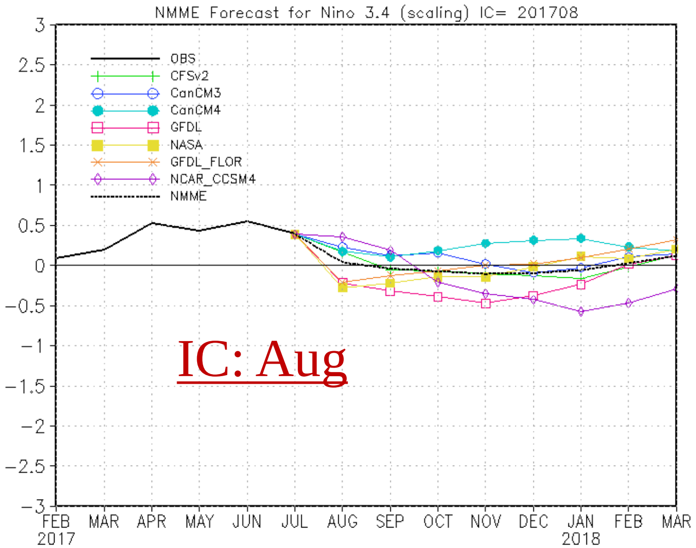


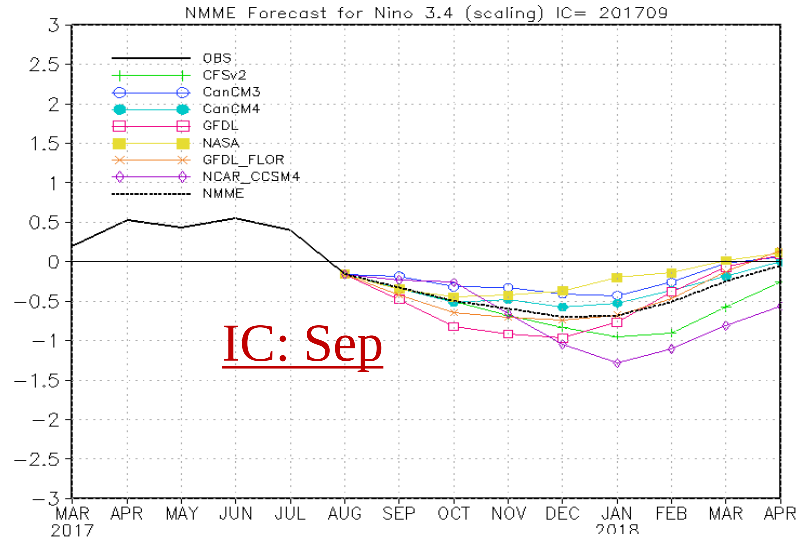
- CFSv2 predictions had cold biases with ICs in Jul-Dec 2016 and warm biases with ICs in Feb-Mar 2017.
- Latest CFSv2 forecasts call for La Nina condition in winter 2017/18.

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.

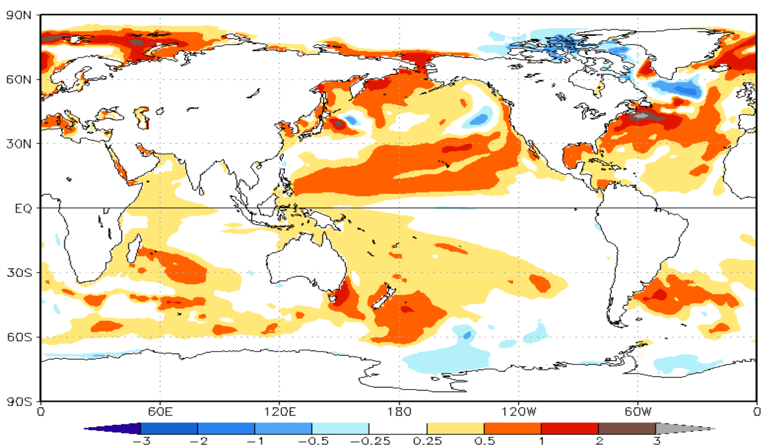
NMME Model Predictions

(http://www.cpc.ncep.noaa.gov/products/NMME/)

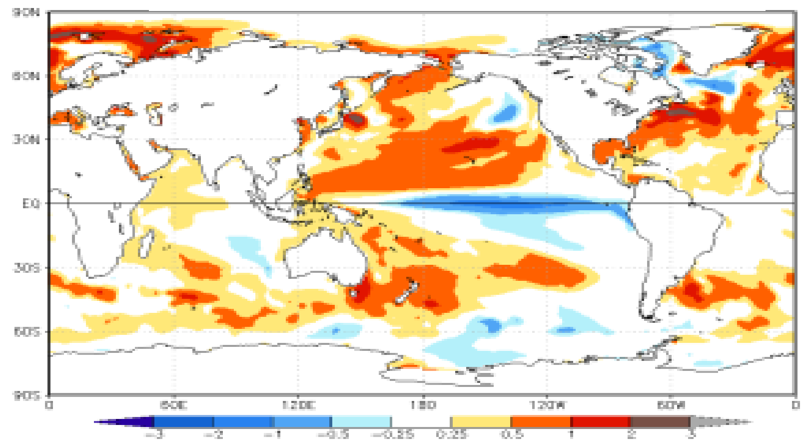




IC: Aug For 2017 DJF

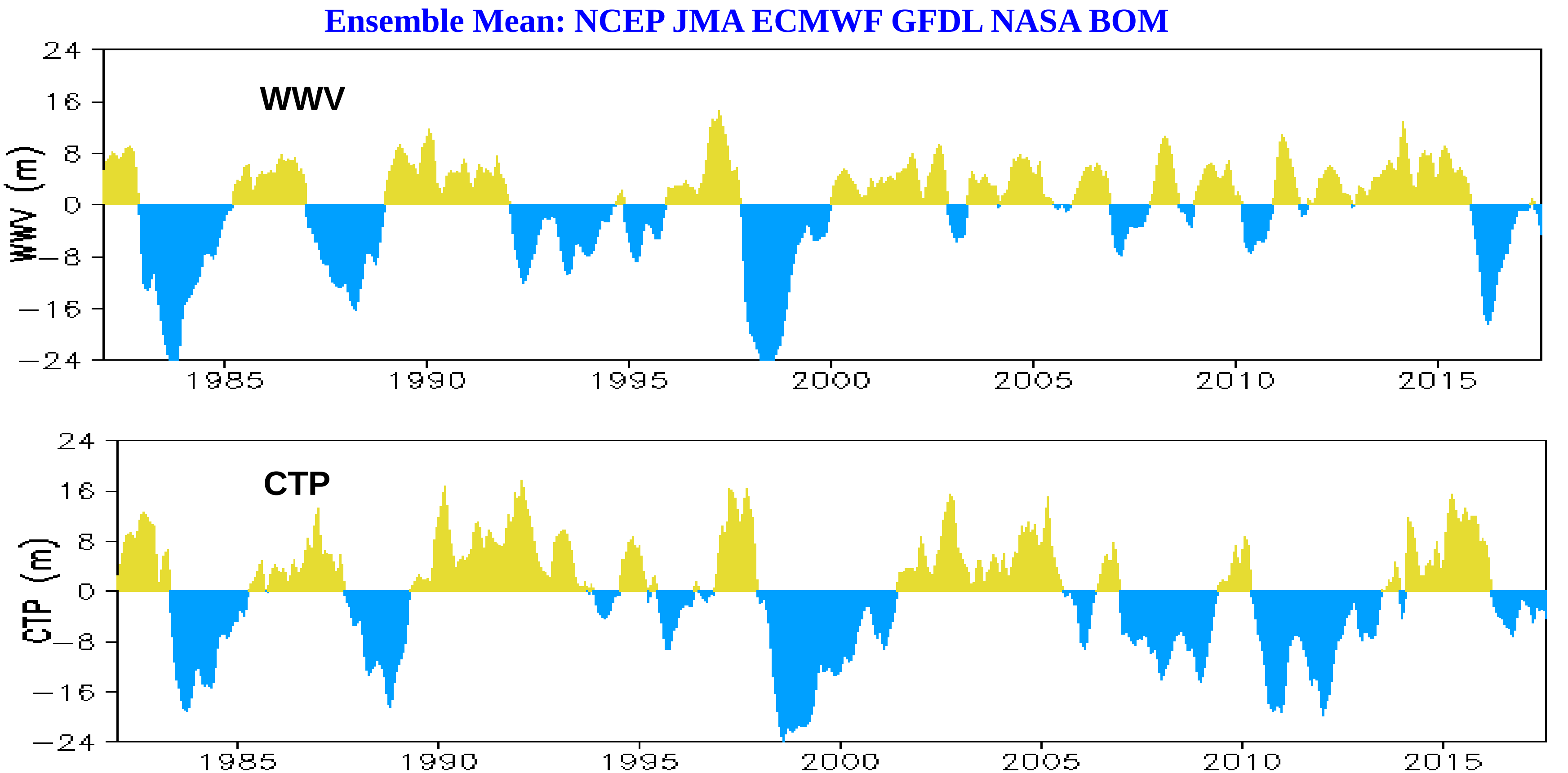


IC: Sep For 2017 DJF



- Latest NMME forecasts favor colder conditions in the tropical Pacific Ocean during winter 2017/18 than those initialized in Aug 2017.

Two ENSO Precursors Based on Thermocline Anomaly



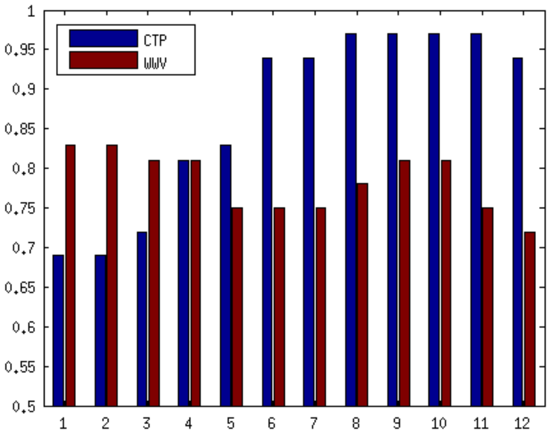
- **Warm Water Volume (WWV) index is defined as average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN]. It is inferred from the slow ocean adjustment via zonal mean heat content exchange between the equatorial and off-equatorial regions.**
- **Central tropical Pacific (CTP) index is defined as average of depth of 20ºC in [160ºW-110ºW, 10ºS-10ºN]. It includes equatorial thermocline variations involving the equatorial wave processes in response to the wind-stress-curl anomalies and off-equatorial thermocline variations related with Subtropical cells (STCs).**

Meinen, C. S., and M. J. McPhaden, 2000: Observations of warm water volume changes in the equatorial Pacific and their relationship to El Niño and La Niña. J.Climate, ***13,*** *3551-3559.*

Wen C, Kumar A, Xue Y, McPhaden MJ (2014) Changes in tropical pacific thermocline depth and their relationship to ENSO after 1999. J Climate 27:7230–7249

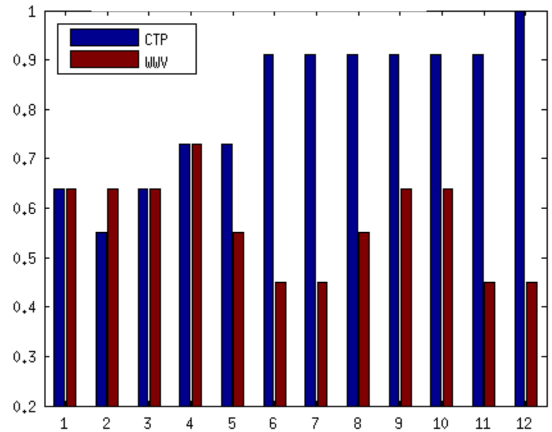
2x2 contingency table for La Nina case

Percent correct



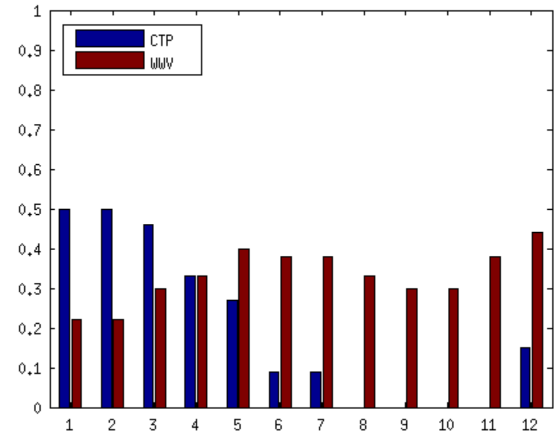
Month

Hit Rate

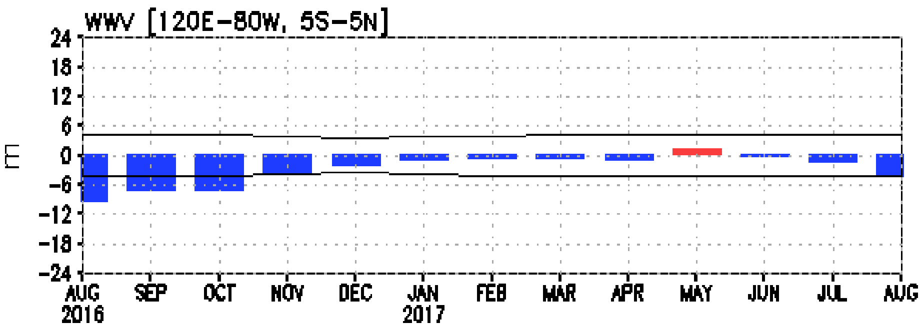


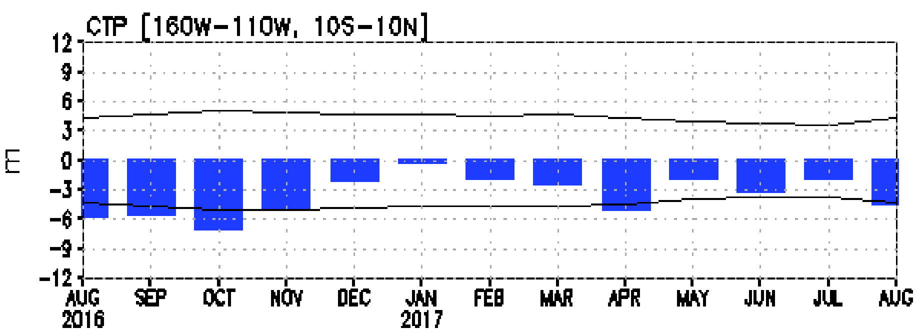
Month

False Alarm



Month

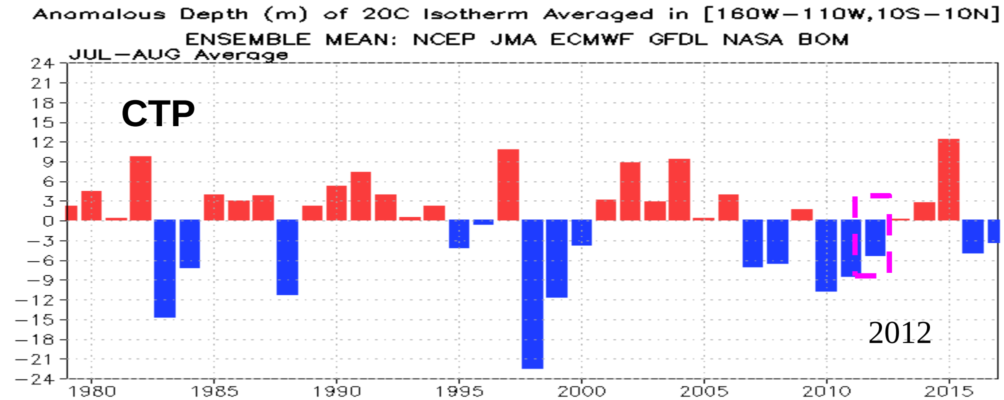




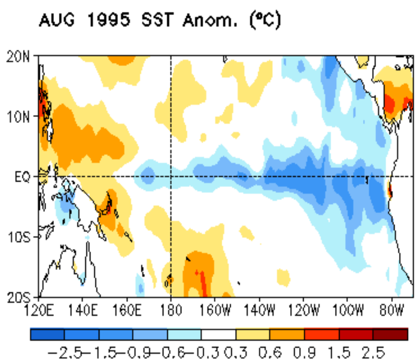
Forecast criterion: 0.5 monthly standard deviation (black lines)

- Both WWV and CTP indices were close the threshold values in Aug 2017, indicating a high probability of La Nina conditions during winter 2017/18.

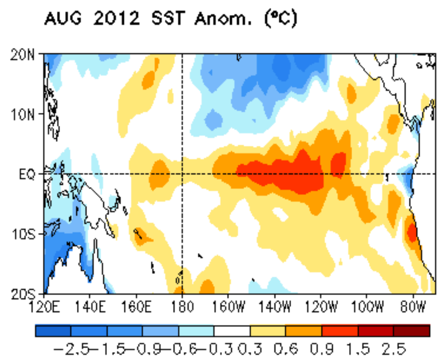
SST,D20 and 925hp Wind anomalies in August



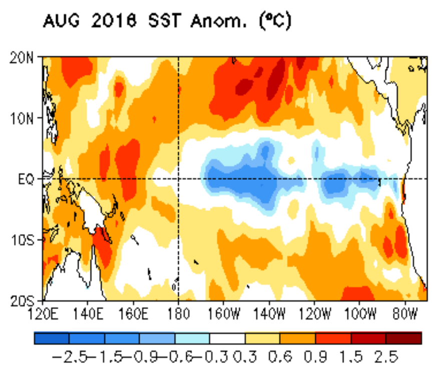
1995



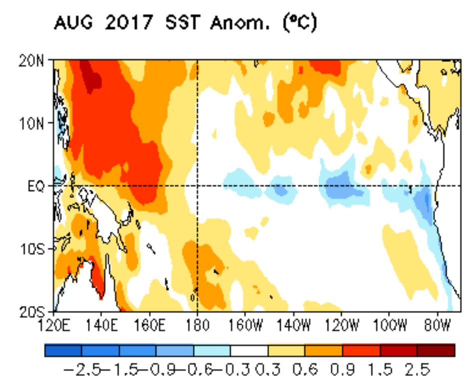
2012

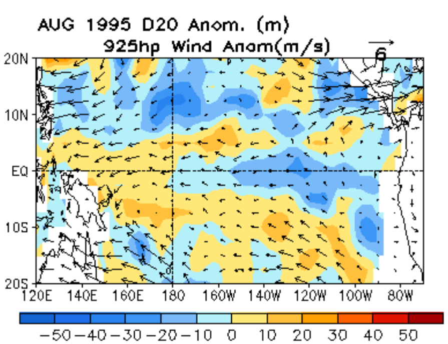


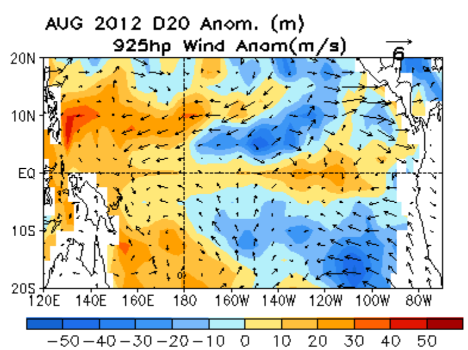
2016

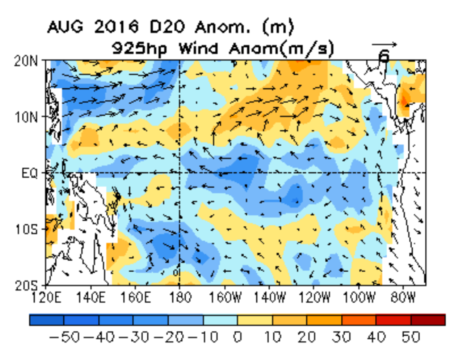


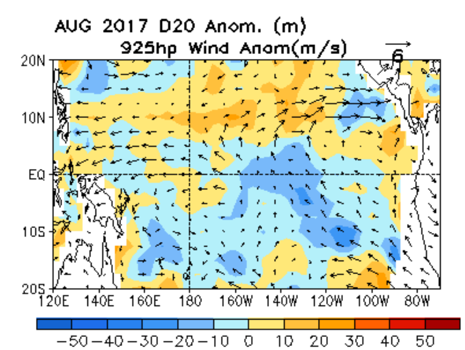
2017







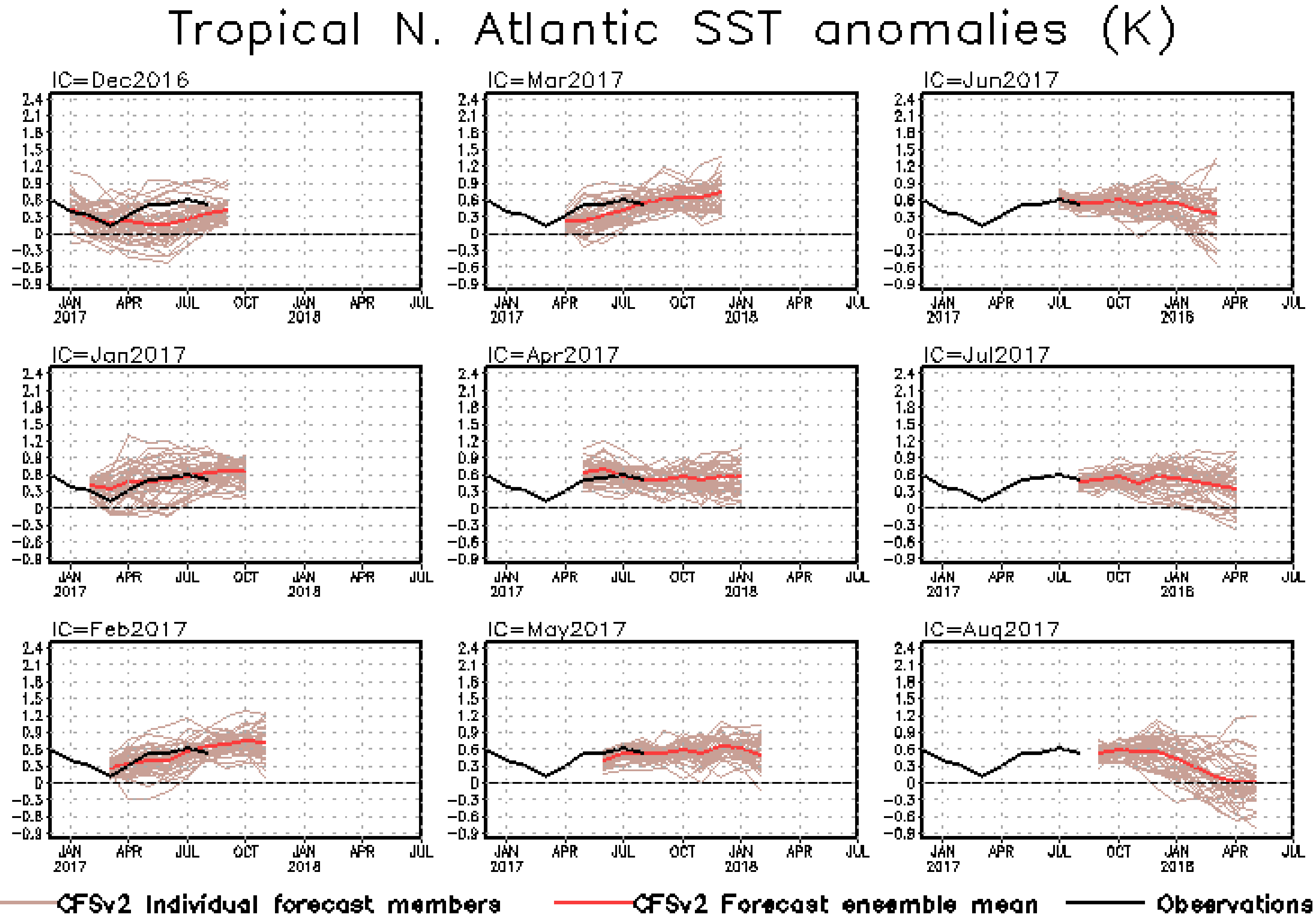




CFS Tropical North Atlantic (TNA) SST Predictions

from Different Initial Months

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



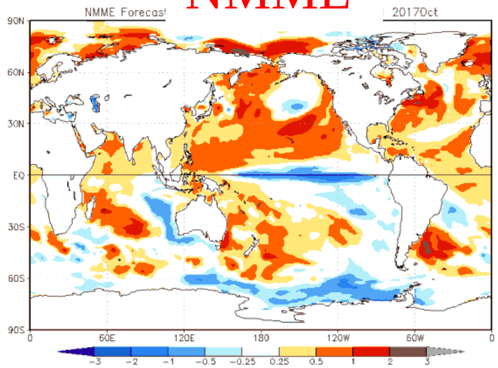
- Latest CFSv2 predictions call persistently above normal SST in the tropical N. Atlantic through winter 2017/18.

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.

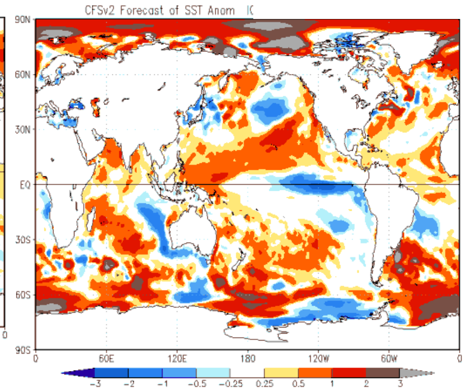
Global SST Forecast For October 2017

(http://www.cpc.ncep.noaa.gov/products/NMME/current/tmpsfc_Lead1.html)

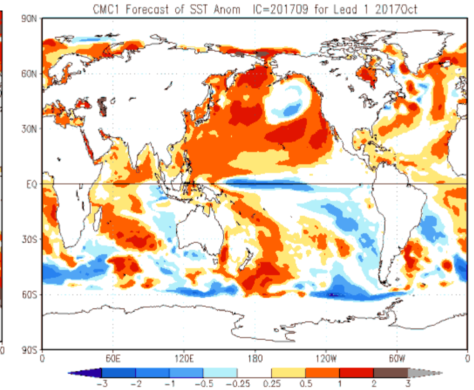
NMME



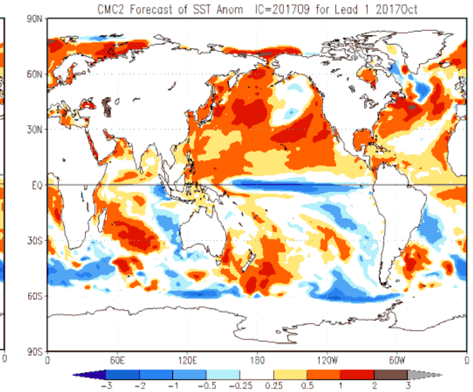
CFSv2



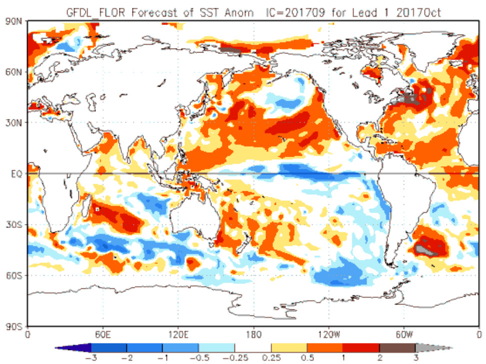
CMC1 CanCM3



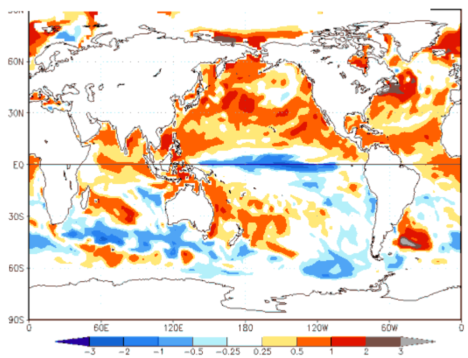
CMC2 CanCM4



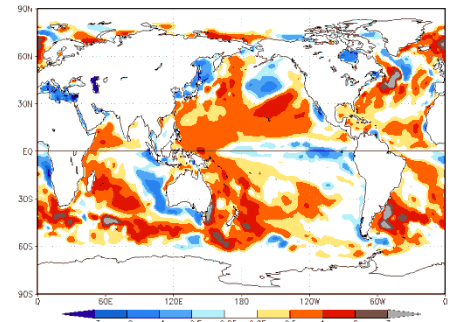
GFDL FLOR



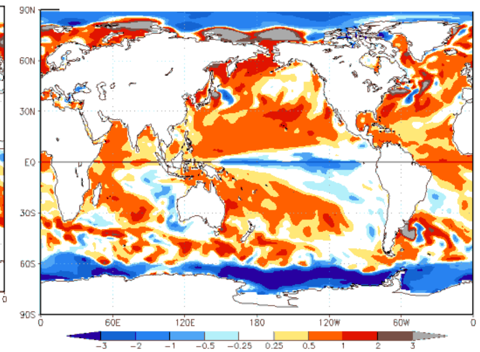
GFDL CM2.1



NCAR CCSM4



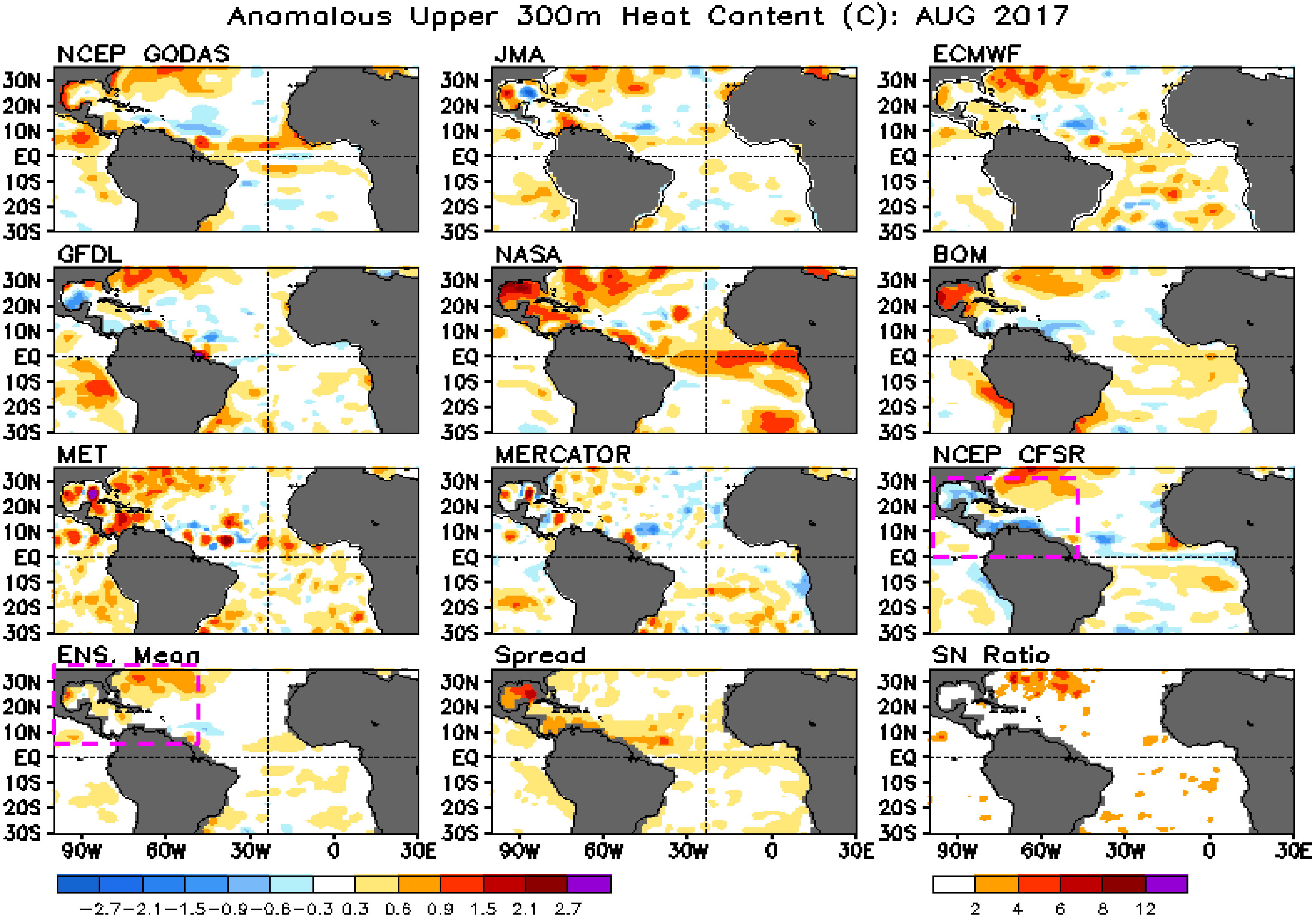
NASA GEOS5



- **CFSv2 forecasts suggest below-normal SST conditions in Gulf of Mexico in Oct 2017, while other NMME models favor above-normal SST conditions.**

Real-Time Ocean Reanalysis Intercomparison

Climatology : 1993-2013



Acknowledgements

- Drs. Arun Kumar, Yan Xue and Zeng-Zhen Hu: reviewed PPT, and provide insight and constructive suggestions and comments

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

- Drs. Thomas Collow and Wanqiu Wang: Supplied sea ice slides

- Dai Mcclurg (NOAA/PMEL): Clarified the TAO analysis interpolation

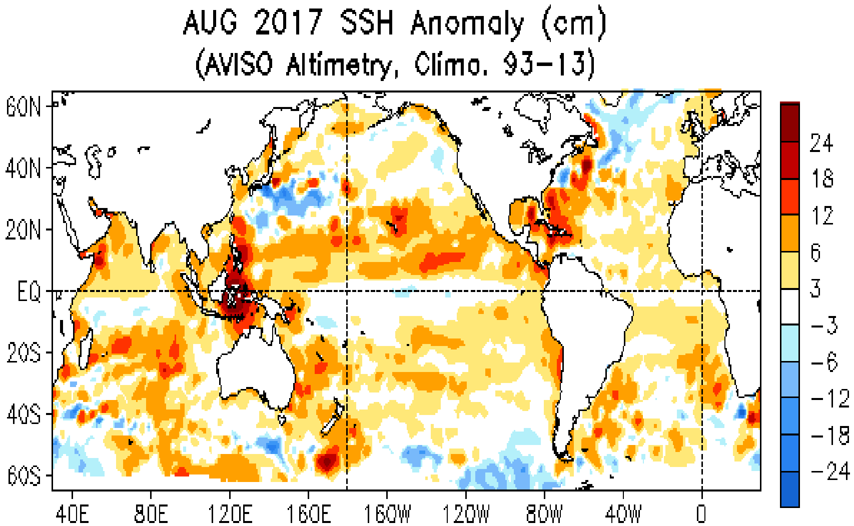
Data Sources and References

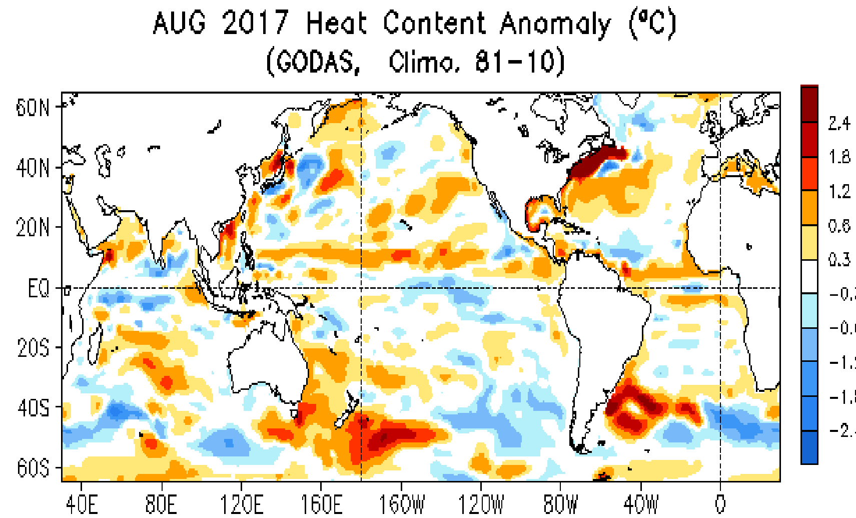
- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **NCEP CDAS winds, surface radiation and heat fluxes**
- **NESDIS Outgoing Long-wave Radiation**
- **NDBC TAO data (http://tao.ndbc.noaa.gov)**
- **PMEL TAO equatorial temperature analysis**
- **NCEP's Global Ocean Data Assimilation System temperature, heat content, currents (Behringer and Xue 2004)**
- **Aviso Altimetry Sea Surface Height**
- **Ocean Surface Current Analyses – Realtime (OSCAR)**

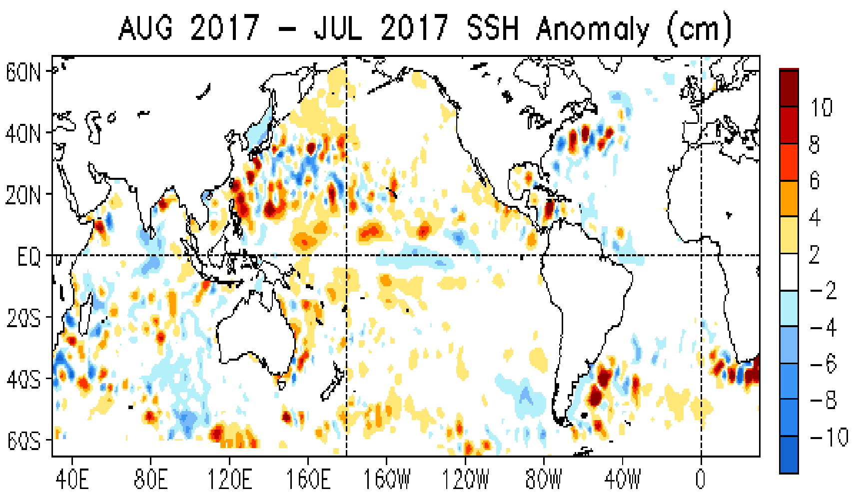
Please send your comments and suggestions to Yan.Xue@noaa.gov. Thanks!

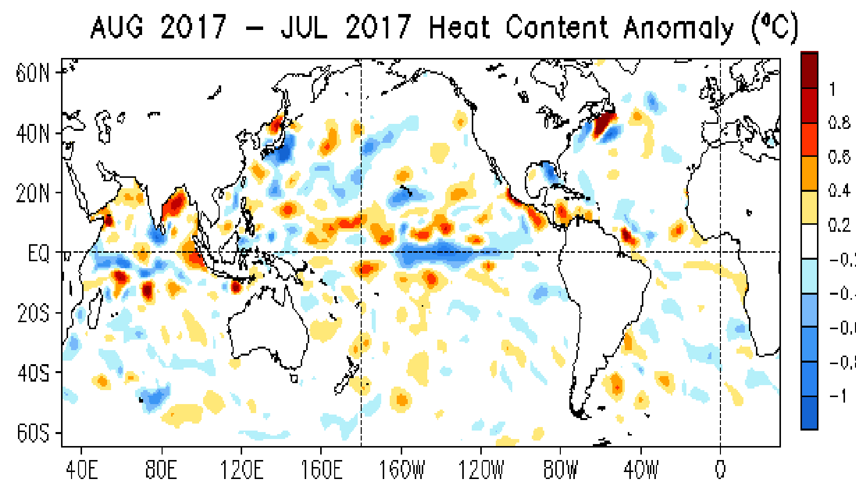
Backup Slides

Global SSH and HC300 Anomaly & Anomaly Tendency

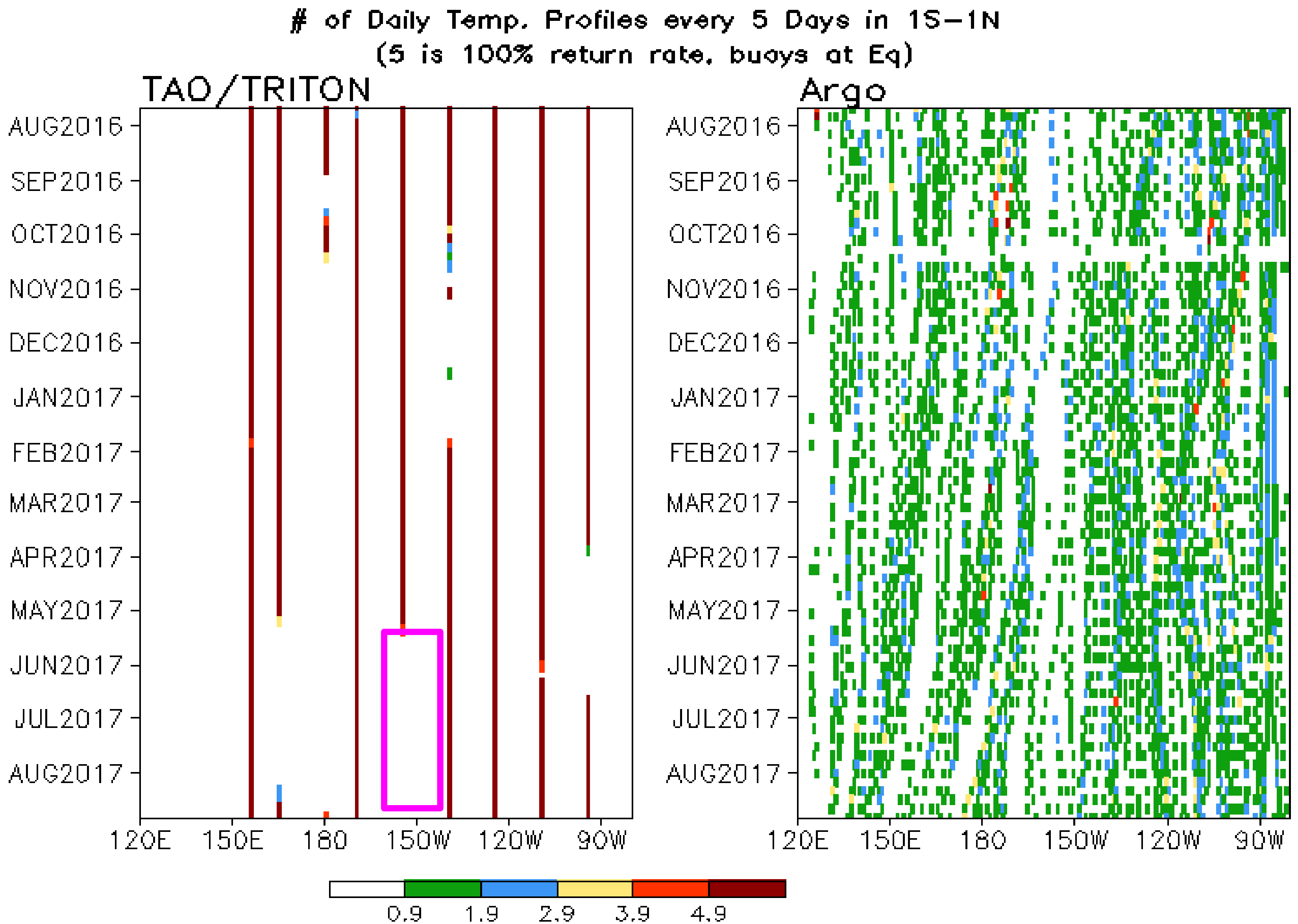








-Negative tendency was observed in both SSHA and HC300A in the central-eastern equatorial Pacific.

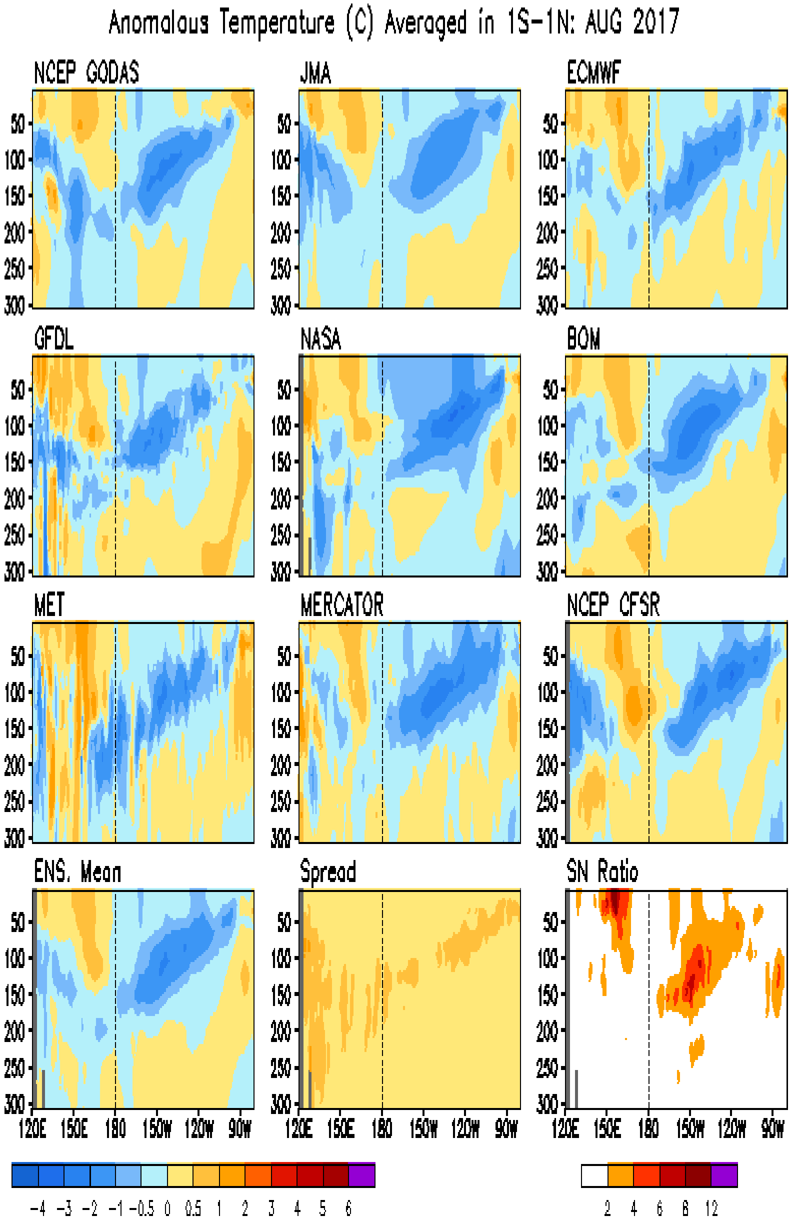


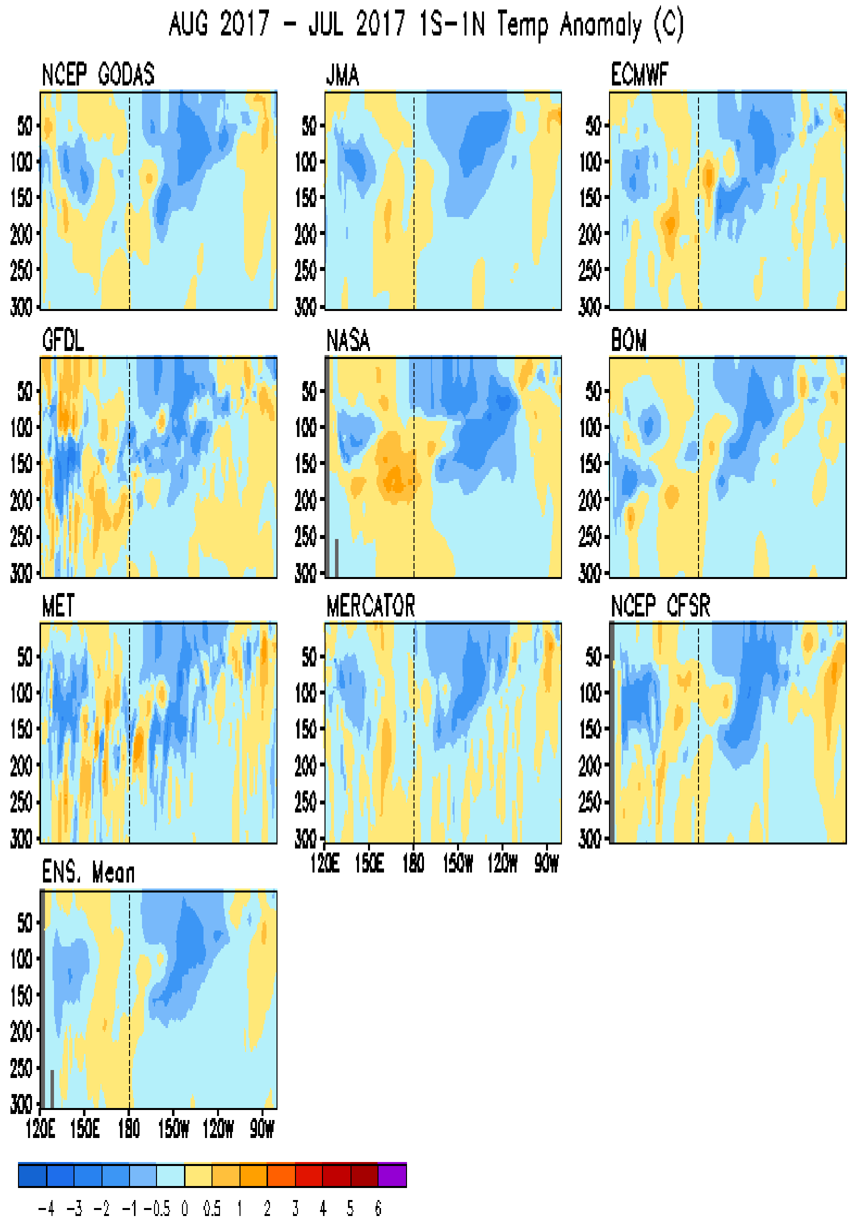
# of Daily Temp. Profiles every 5 Days in 1S-1N
(5 is 100% return rate, buoys at Eq)
TAO/TRITON
Argo
AUG2016
SEP2016
OCT2016
NOV2016
DEC2016
JAN2017
FEB2017
MAR2017
APR2017
MAY2017
JUN2017
JUL2017
AUG2017
120E
150E
180
150W
120W
90W
0.9
1.9
2.9
3.9
4.9

Real-Time Ocean Reanalysis Intercomparison: Temperature

Climatology : 1993-2013

(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)

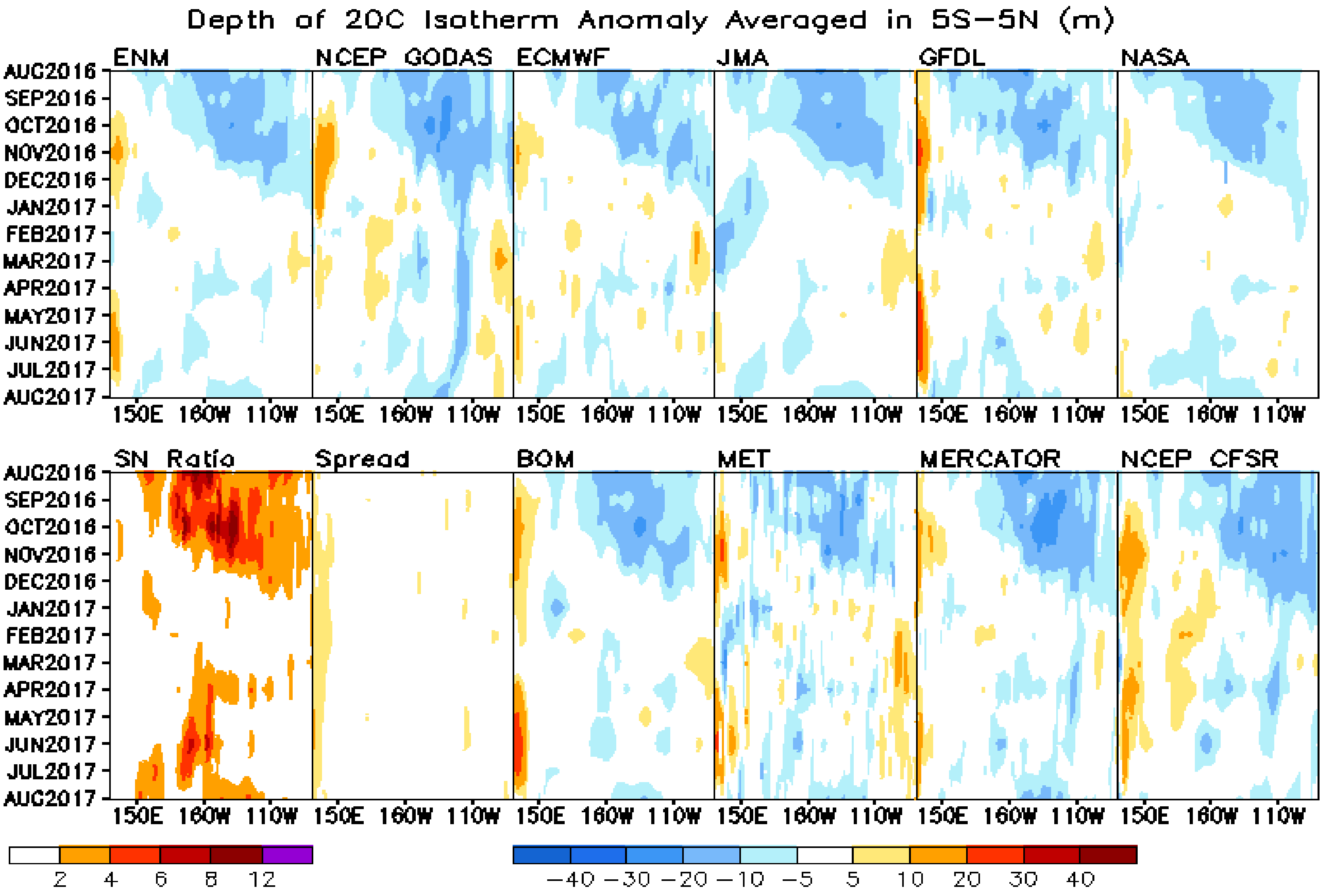




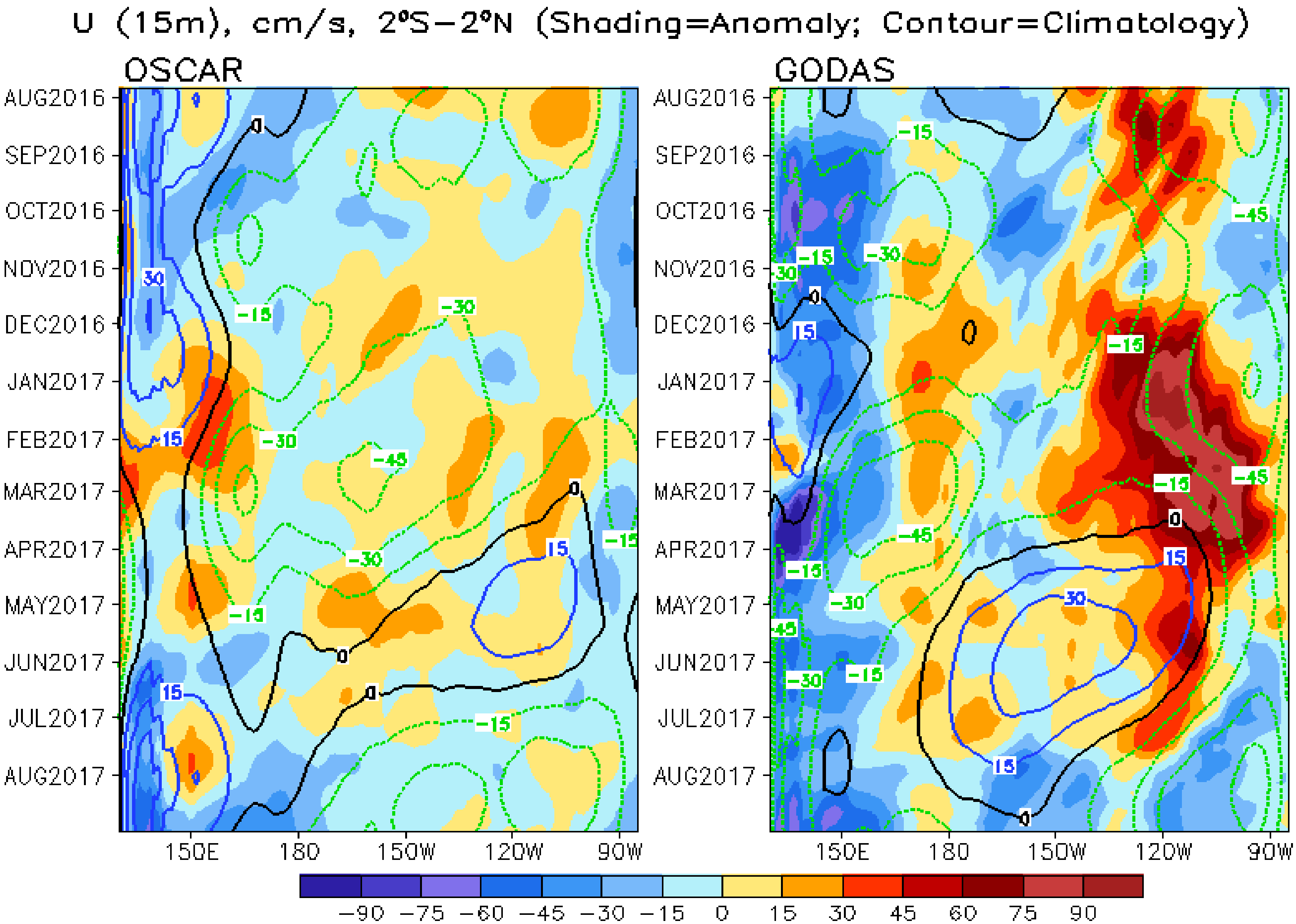
Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1993-2013

(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)



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

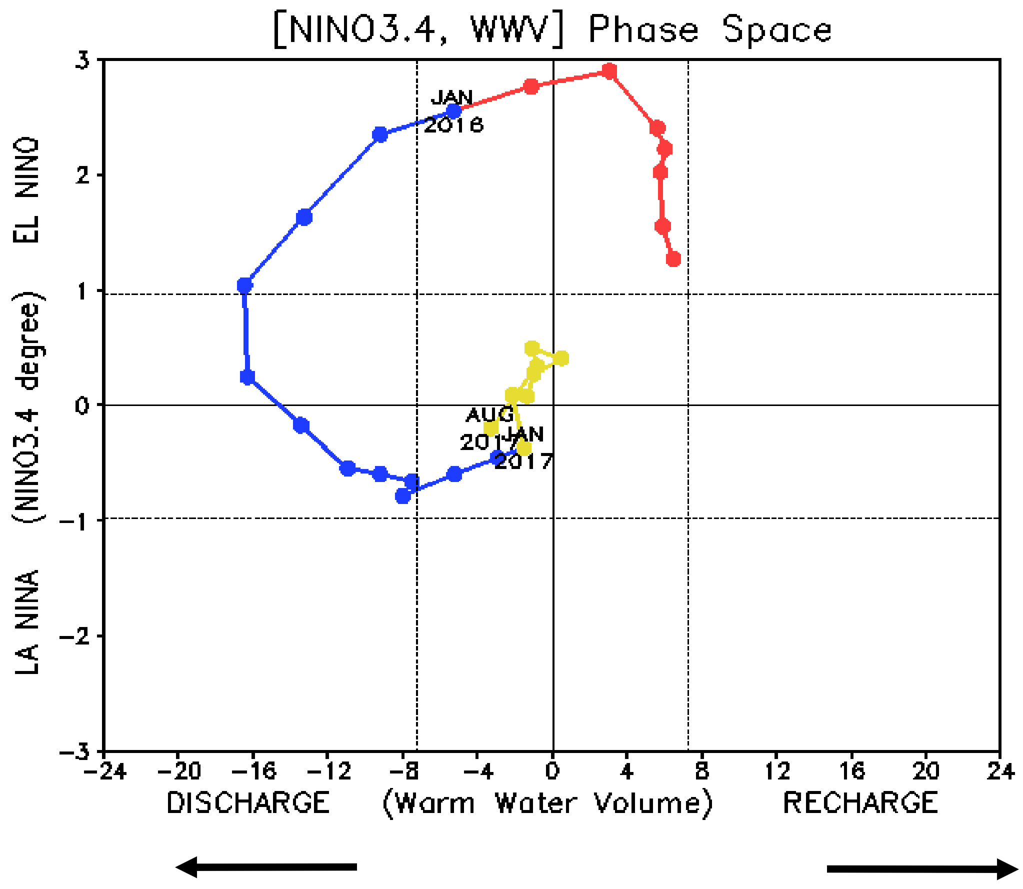


Warm Water Volume (WWV) and NINO3.4 Anomalies

- **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).**

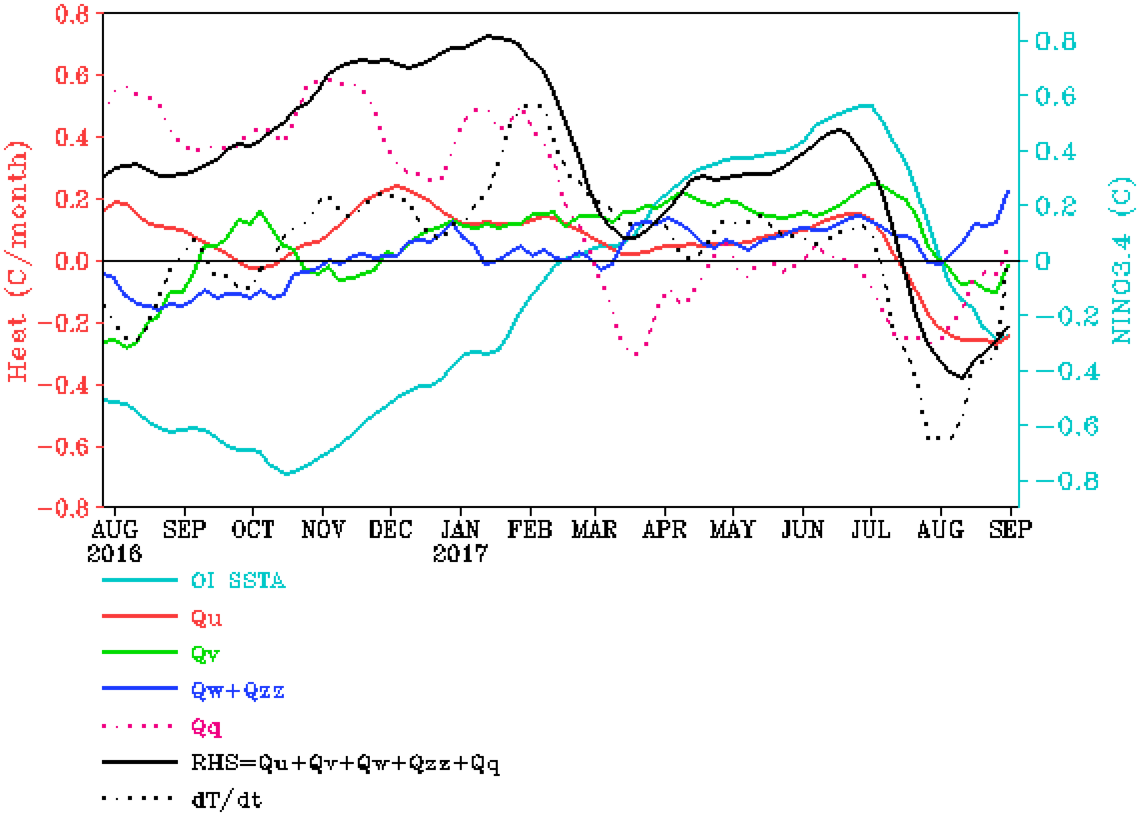
- **Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.**



- Equatorial Warm Water Volume (WWV) has been small 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.

NINO3.4 Heat Budget



- Both observed SSTA tendency (dT/dt; dotted black line) and total budget tendency (RHS; solid black line) in Nino3.4 region became negative in Jul 2017.

- All dynamical terms (zonal advection Qu, meridional advection Qv, vertical terms Qw+Qzz), as well as heat flux term (Qq) showed a decrease tendency in Jul 2017.

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.

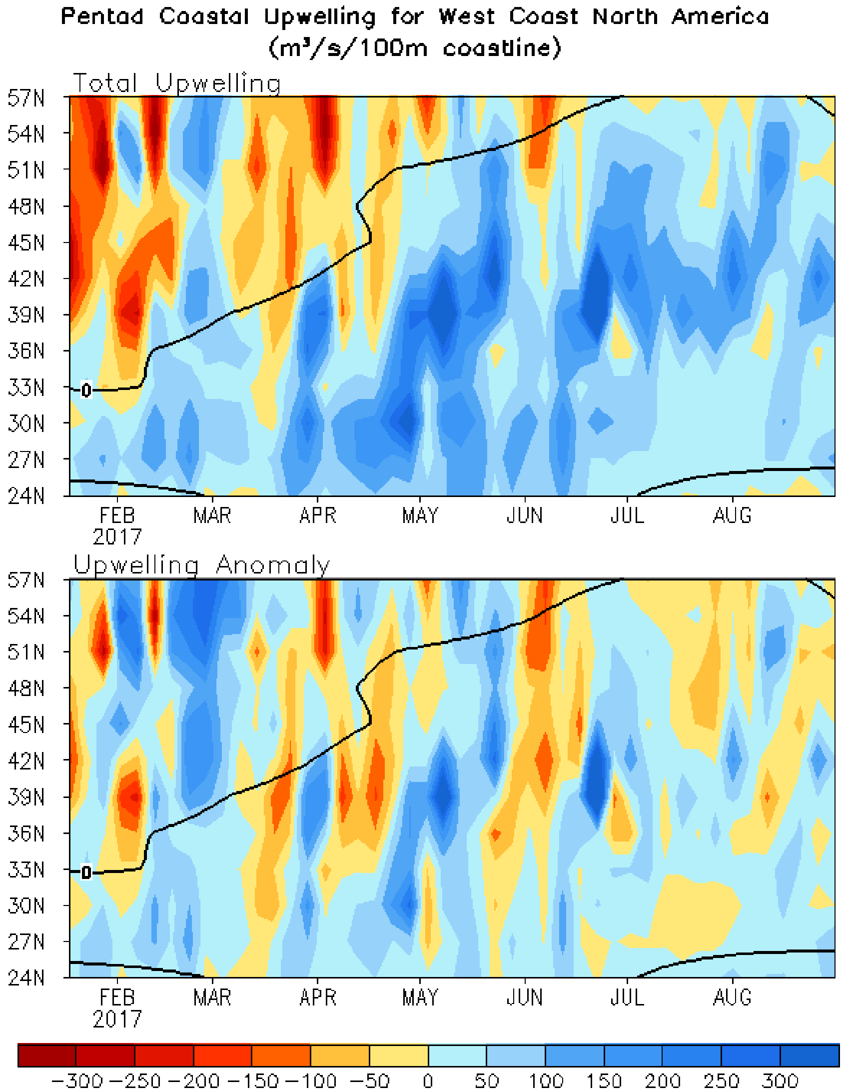
Qu: Zonal advection; Qv: Meridional advection;

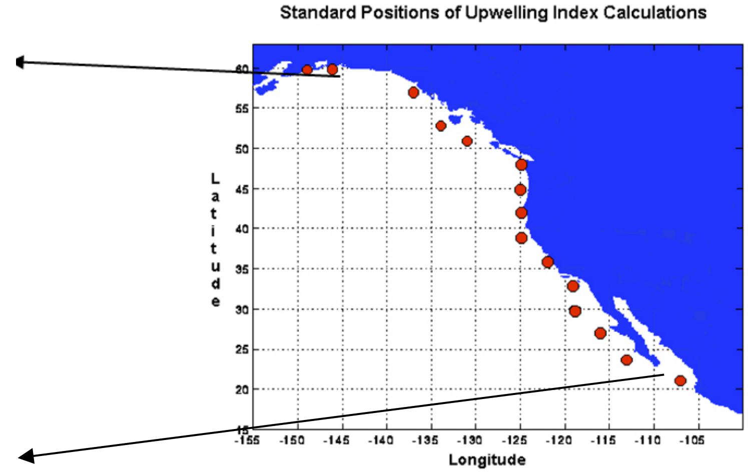
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

North America Western Coastal Upwelling





- **Both anomalous downwelling and upwelling were small along the coast in Aug 2017.**

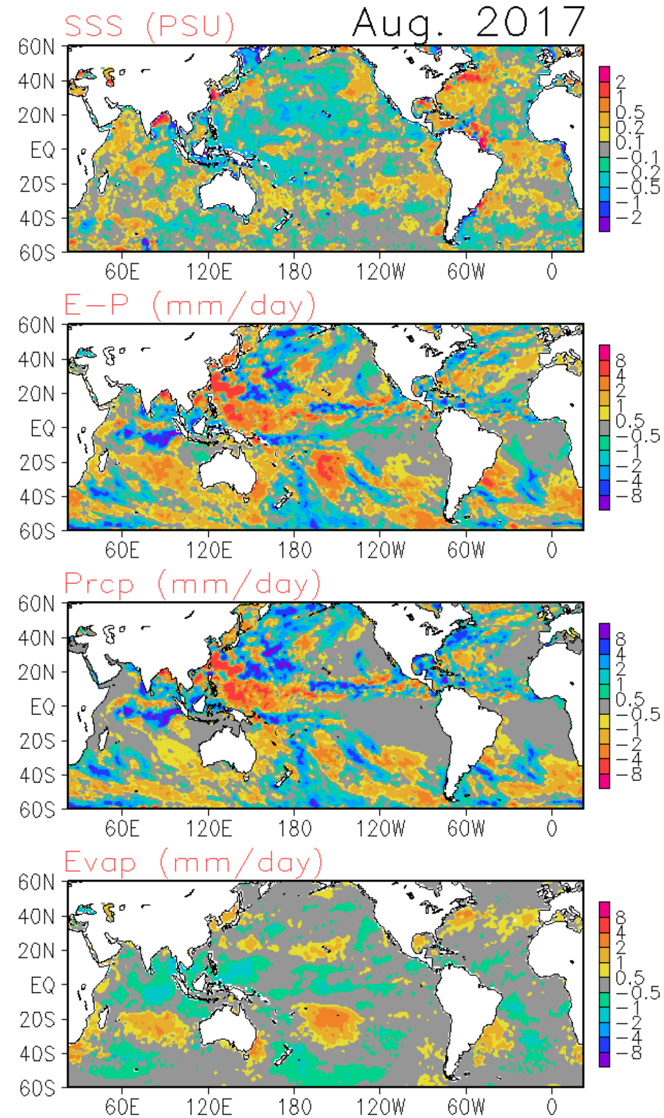
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport 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 36ºN to 57ºN.**

Global Sea Surface Salinity (SSS)

Anomaly for August 2017

- **New Update: The BASS 0.Z is released in July 2017 with the SSS from recently launched SMAP being integrated into the system. In BASS 0.Z, since June 2015, the blended SSS analysis is from in situ, SMOS and SMAP. Please report to us any suspicious data issues!**
- The SSS anomaly around 20°N in the Pacific Ocean is negative co-incident with increasing precipitation, particular in the west basin. The SSS anomaly in the west basin of South Pacific Ocean around 20°S is negative with increasing of precipitation. The positive SSS anomaly continues in the N. Atlantic ocean, but the signal moves to the west. In the S. Atlantic Ocean, the positive SSS anomaly is centered in the subtropics. The SSS anomaly in the north of Bay of Bengal became positive with significant reduction of precipitation in this area.



- **Data used**

  SSS :

  Blended Analysis of Surface Salinity (BASS) V0.Z

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

  (Xie et al. 2014)

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

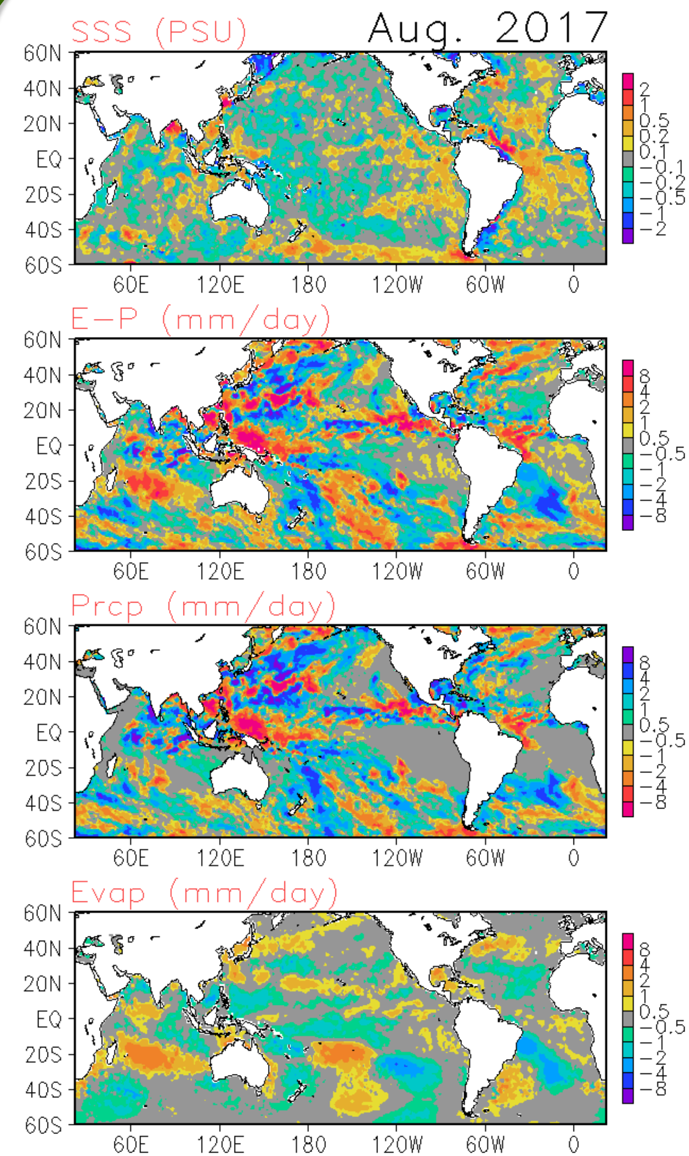
  Precipitation: CMORPH adjusted satellite precipitation estimates

  Evaporation: CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for August 2017

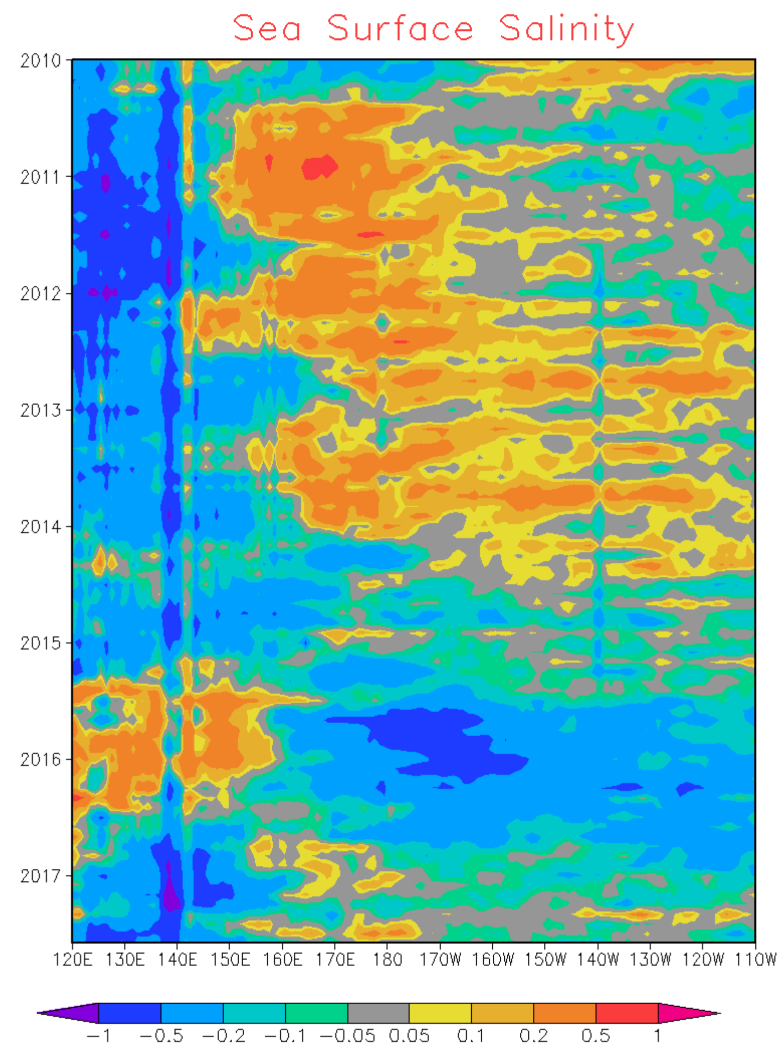
Compared with last month, the SSS in the north of Bay of Bengal significantly increased due to less freshwater input including the increased evaporation and the decreased precipitation. The SSS in the west Equatorial Pacific Ocean is continually decreasing. The SSS in the Sea of Okhotsk is significantly decreased, while the precipitation in this area is reduced. Therefore, such SSS decrease is probably mainly caused by the ocean advection/mixing. Large amount of precipitation happened in the Gulf of Mexico due to the Hurricane Harvey likely decreases the SSS in this area.



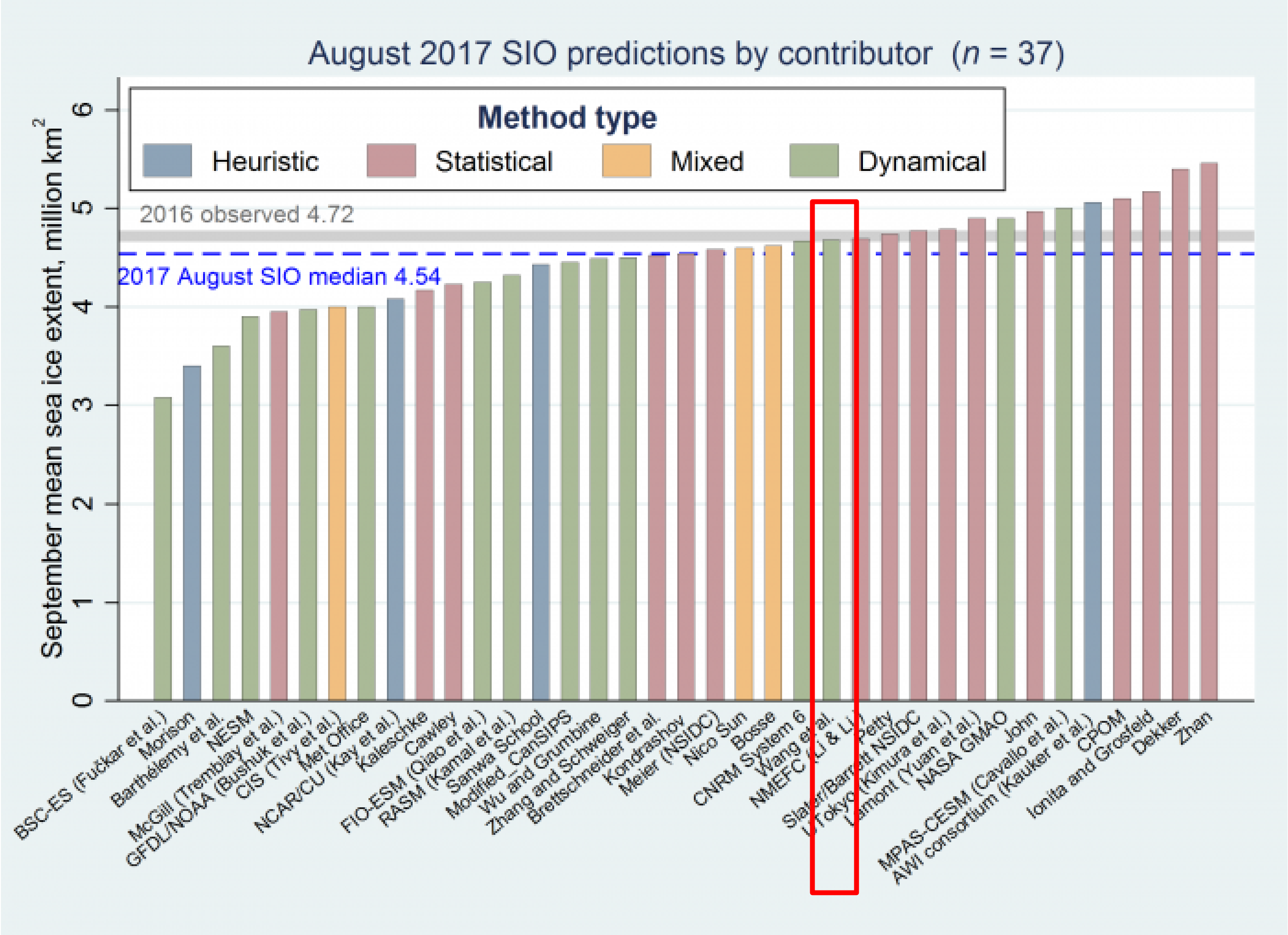
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

- Hovemoller diagram for equatorial SSS anomaly **(10ºS-10ºN);**
- In the western equatorial Pacific Ocean, from 120°E to 150°E, the strong negative SSS signal continues and extends further west in this month. The positive SSS anomaly signal in the central area (150°E to 170°W) became stronger this month. While, weaker SSS negative anomaly continues in the east region (east of 170°W).

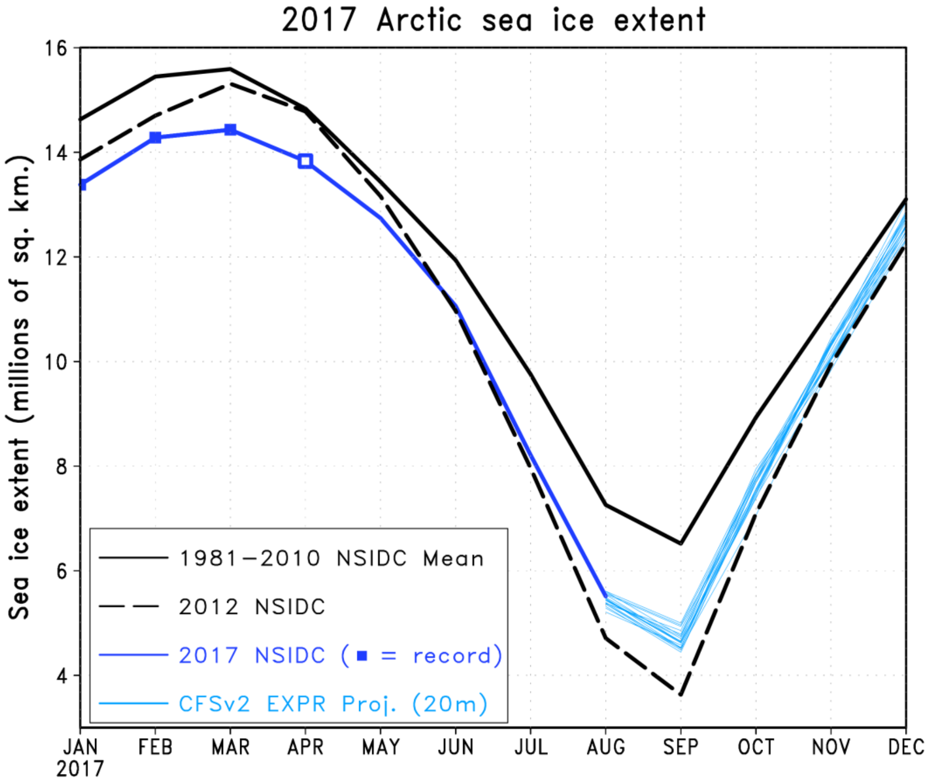


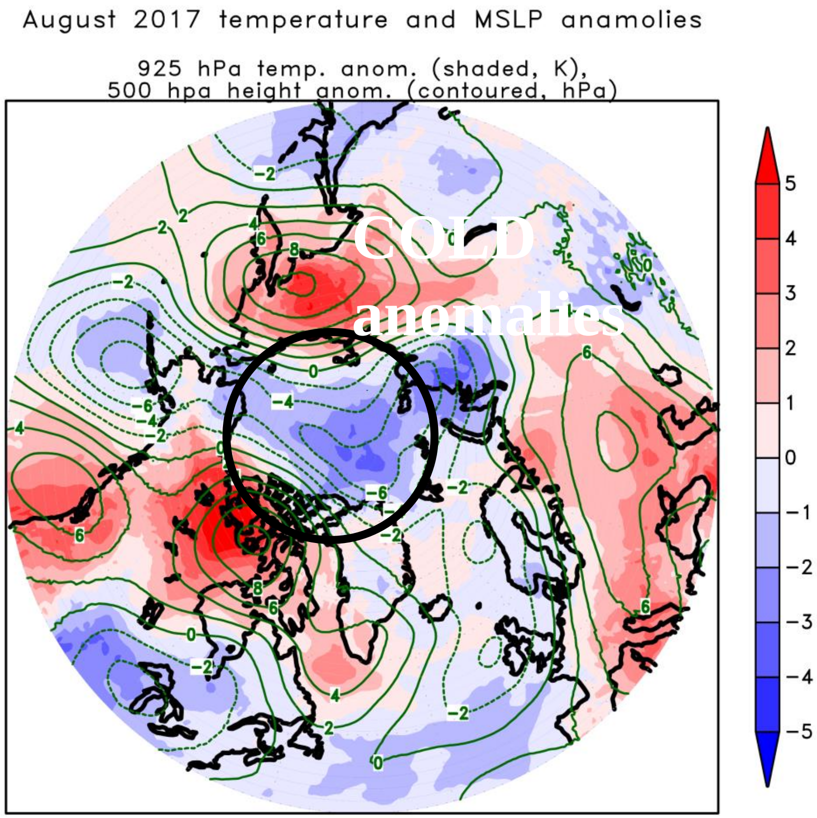
Arctic Sea Ice



-Outlooks above are based on July data. Our September sea ice extent forecast from July of 4.68 million km^2 is close to the median of all outlooks (4.54 million km^2).

-June SIPN median was 4.50 million km^2, so both our forecast and the median adjusted up slightly (Our June forecast was 4.60 million km^2)





-Arctic sea ice melt rate has slowed down during the month of August (left panel)

-Experimental July sea ice forecast was 4.68 million km^2 for the mean September sea ice extent. As of September 5th the current extent was 4.77 million km^2 and still decreasing. The sea ice melt season should conclude in the next 2 weeks with a minimum similar to that of the last 2 years. (The final monthly extent will be higher than the daily minimum).

-Cold lower tropospheric temperature anomalies in August resulted in the slow down of sea ice melt in the Central Arctic (right panel).

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

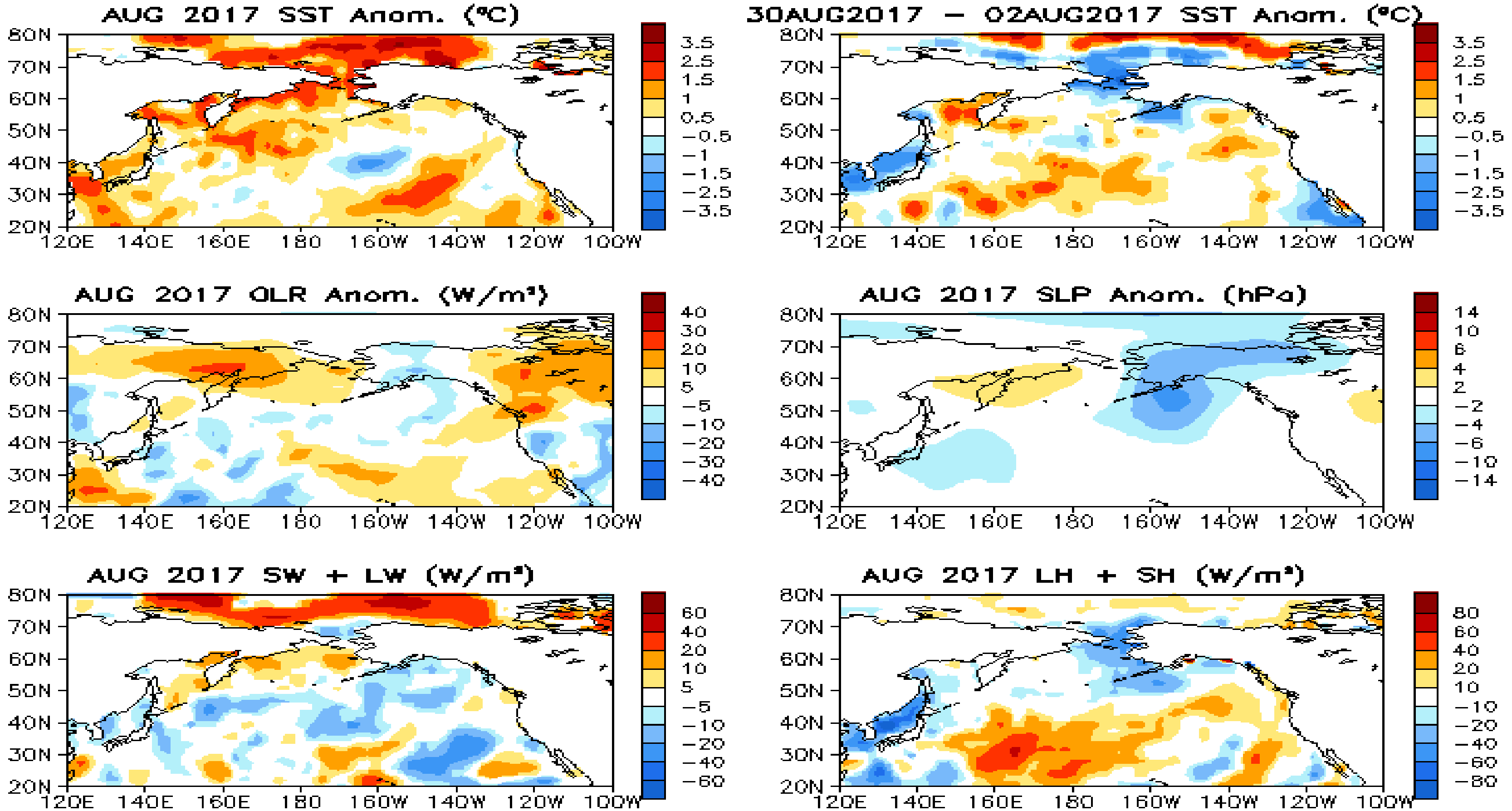
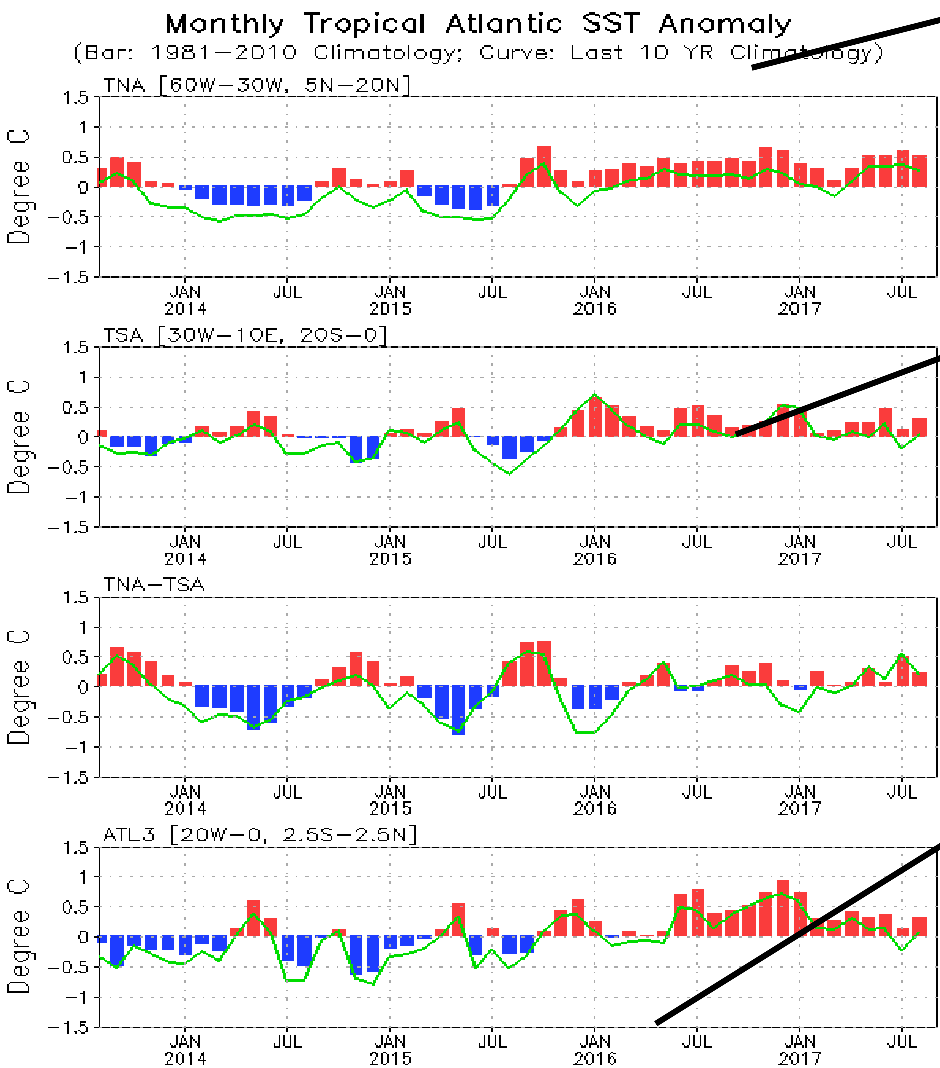
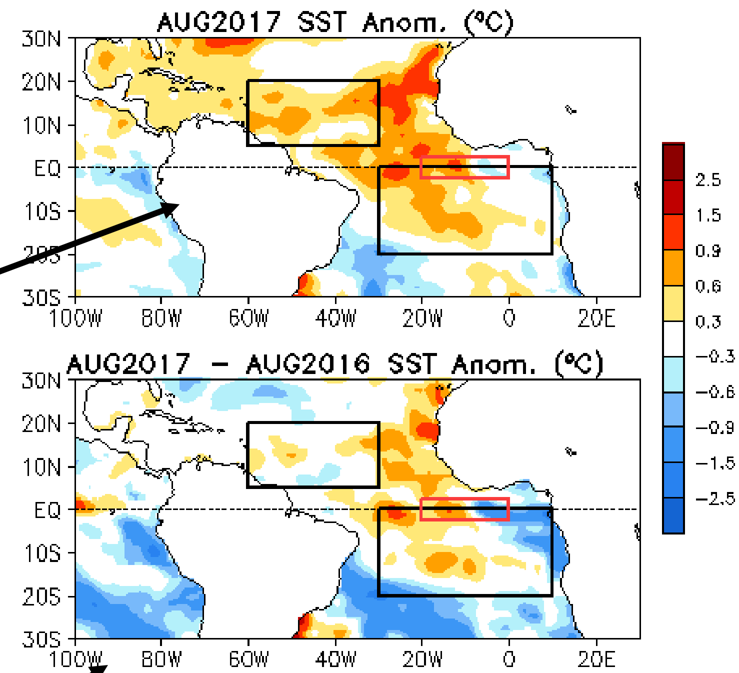


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Evolution of Tropical Atlantic SST Indices



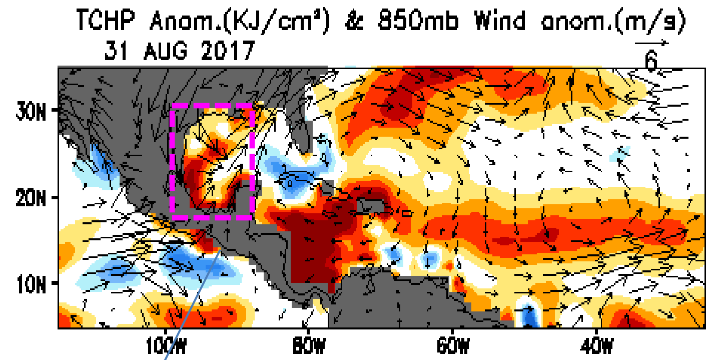


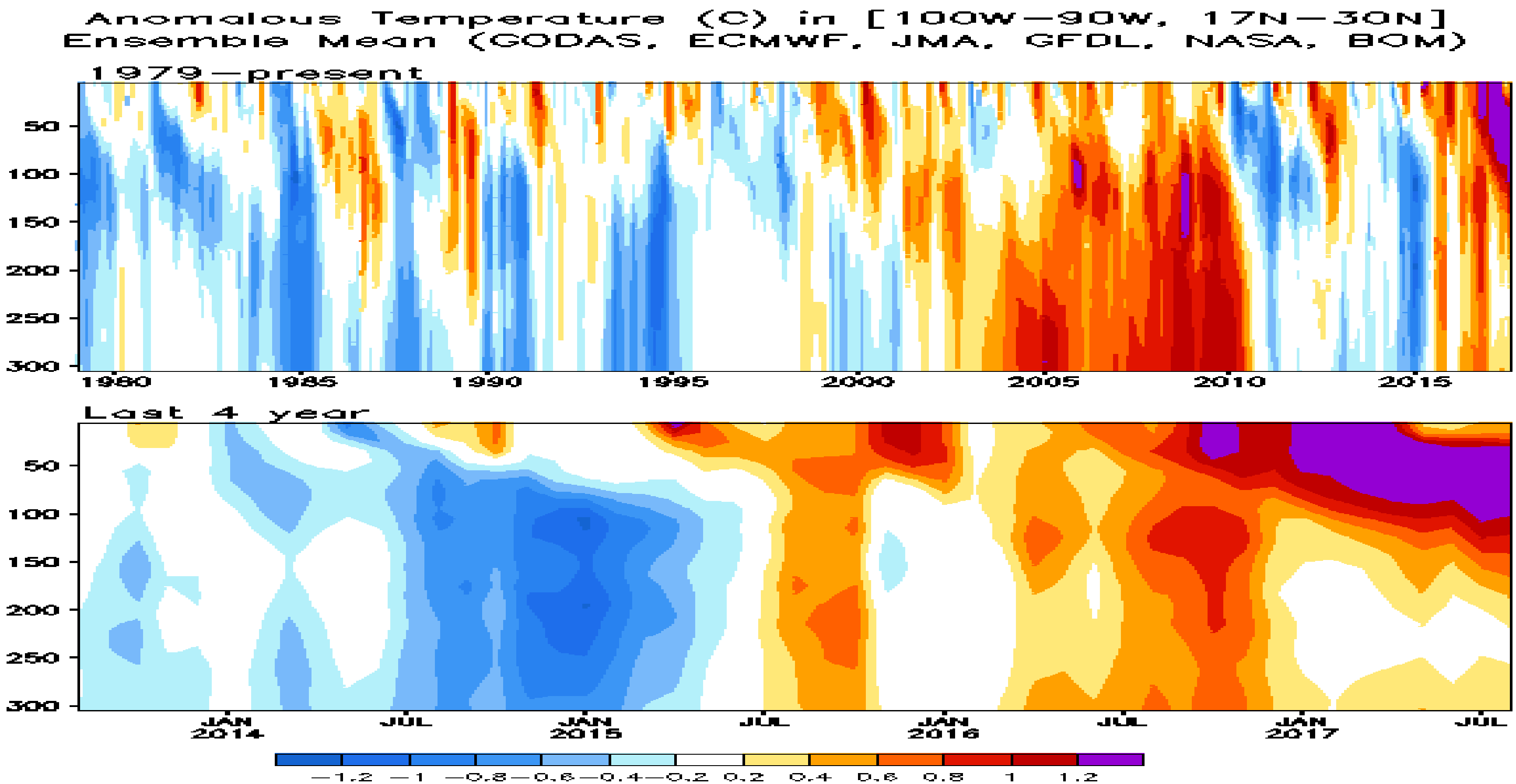
- Overall, SSTAs in the tropical Atlantic Ocean were positive.
- All indices were positive in Jul 2017.

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

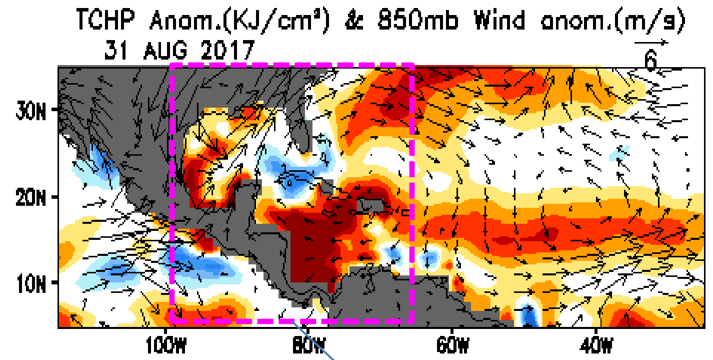
Warming in Gulf of Mexico

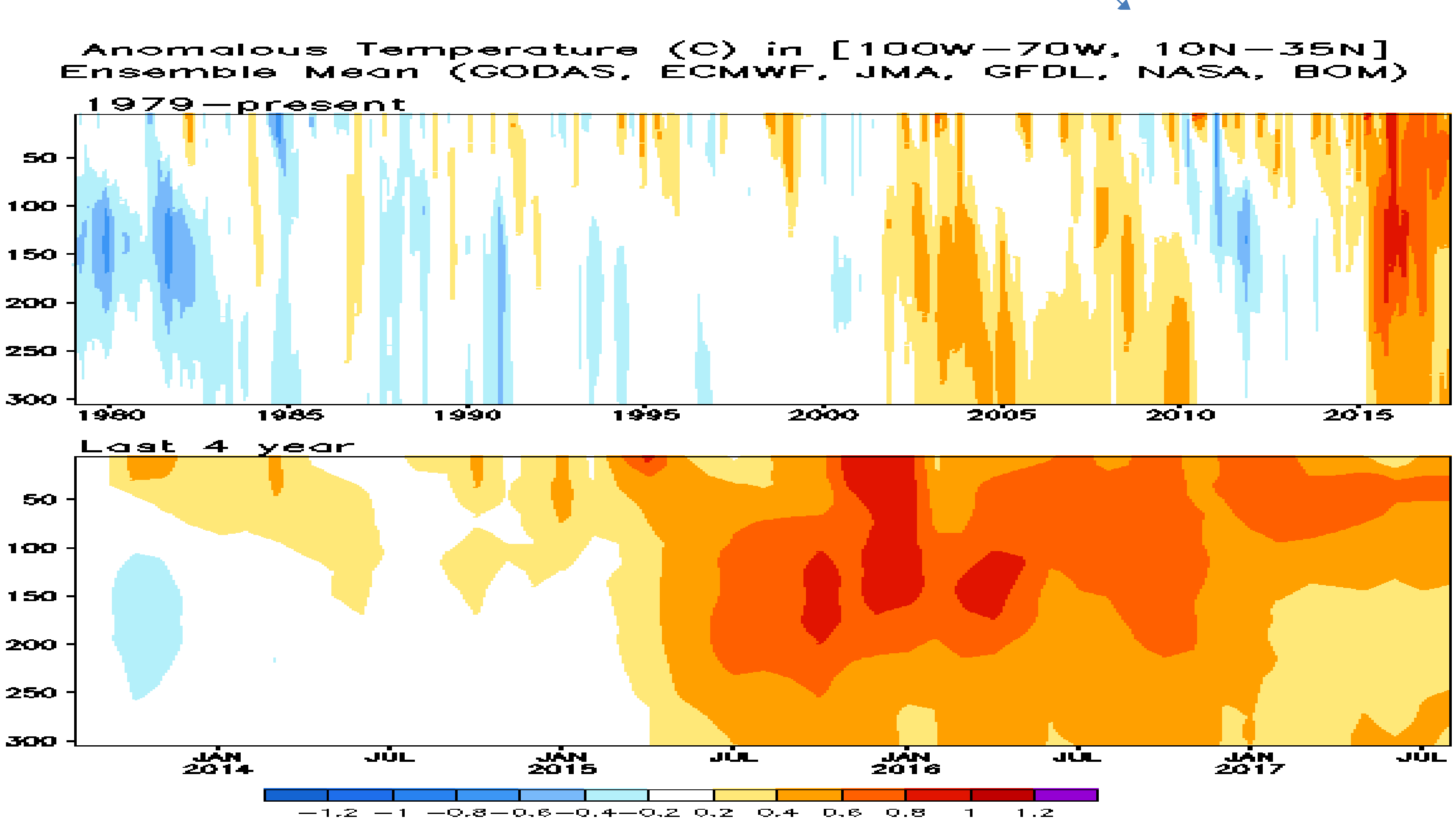
- **West Gulf of Mexico experienced the strongest upper ocean warming (0-150m) since 1979.**





Warming in Gulf of Mexico





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

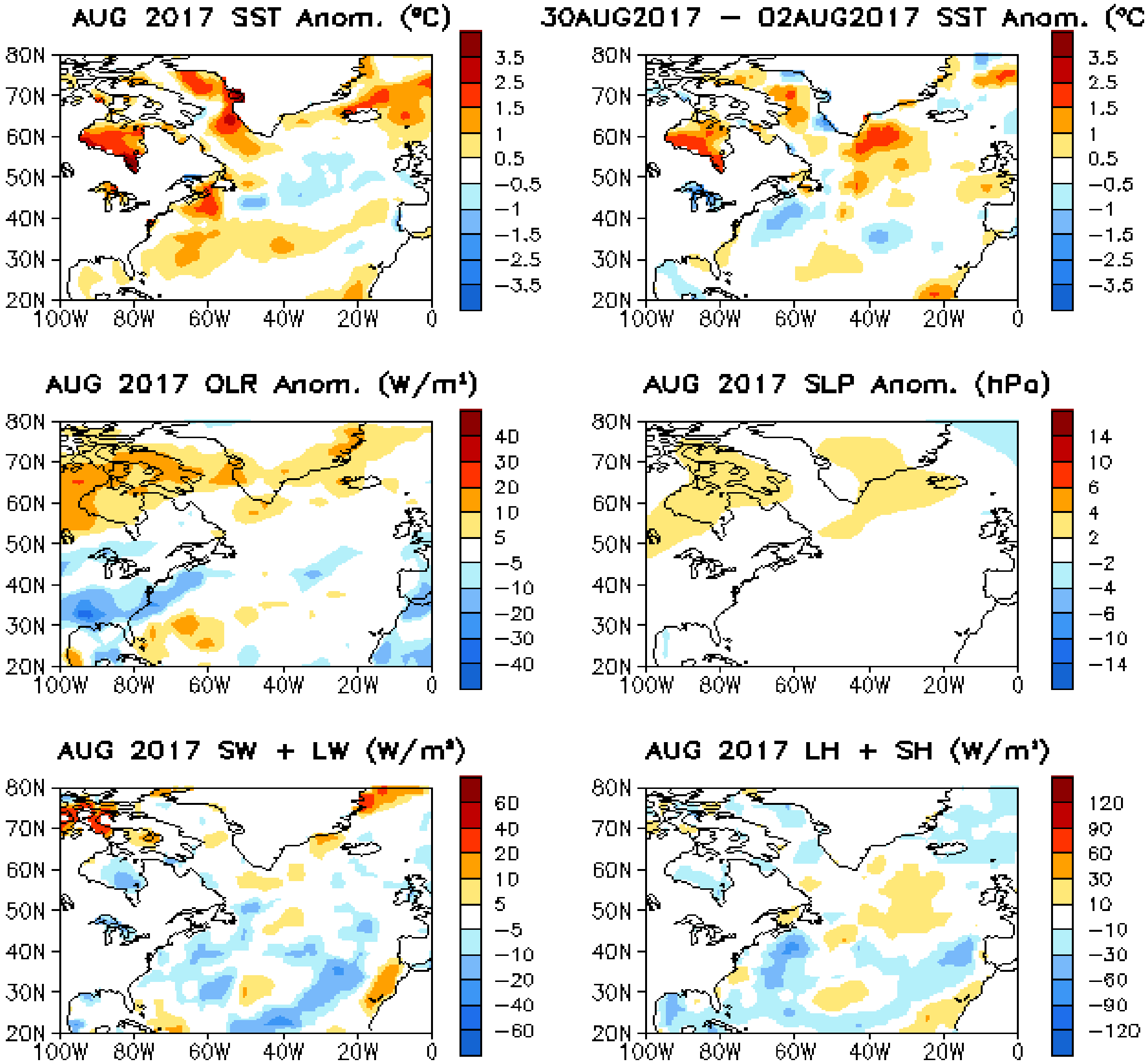
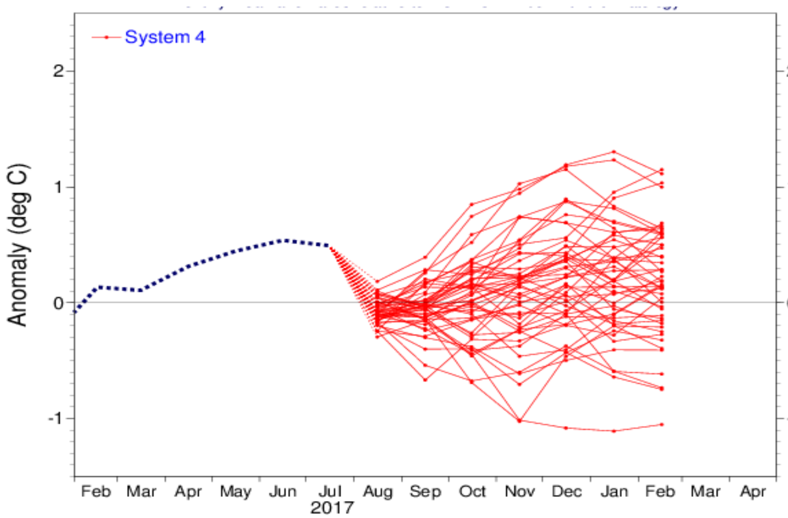


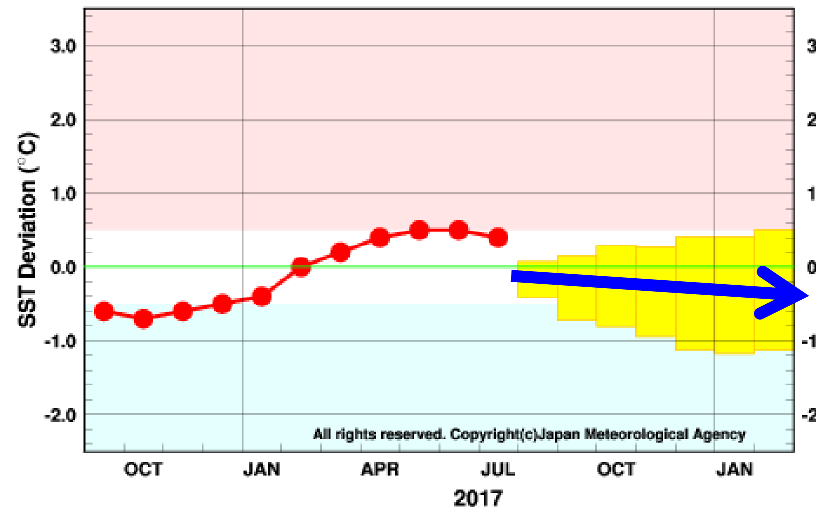
Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

Individual Model Forecasts of Nino3.4

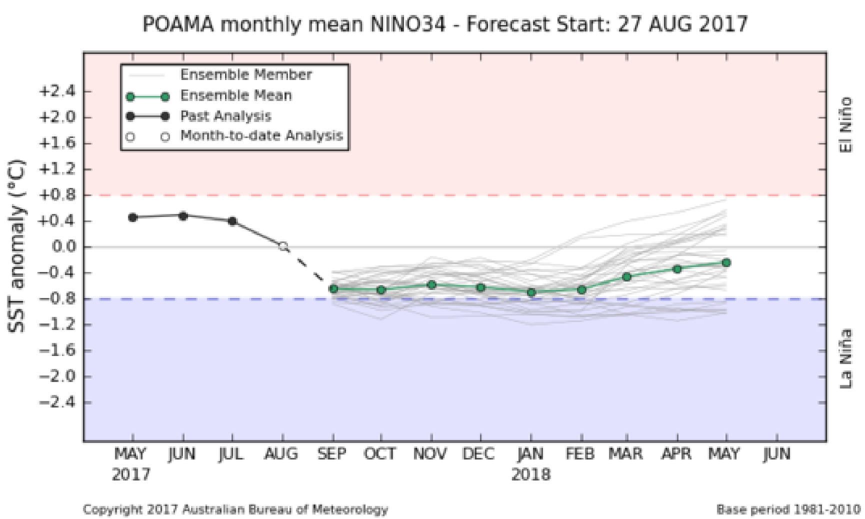
EC: IC=01Aug 2017



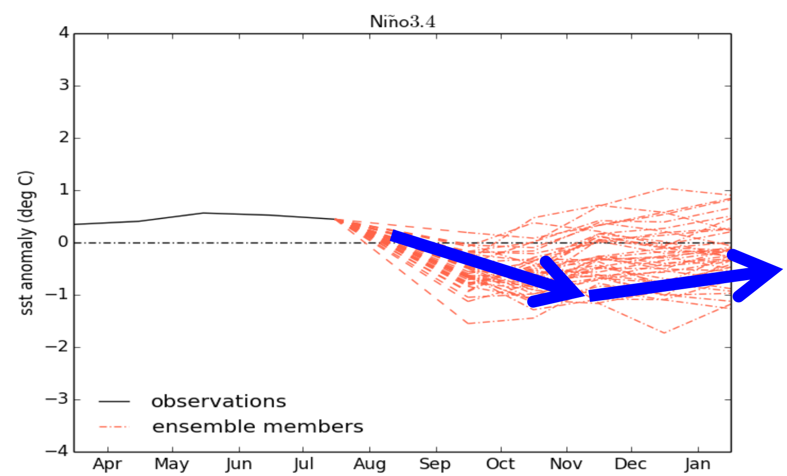
JMA: IC=Aug 2017



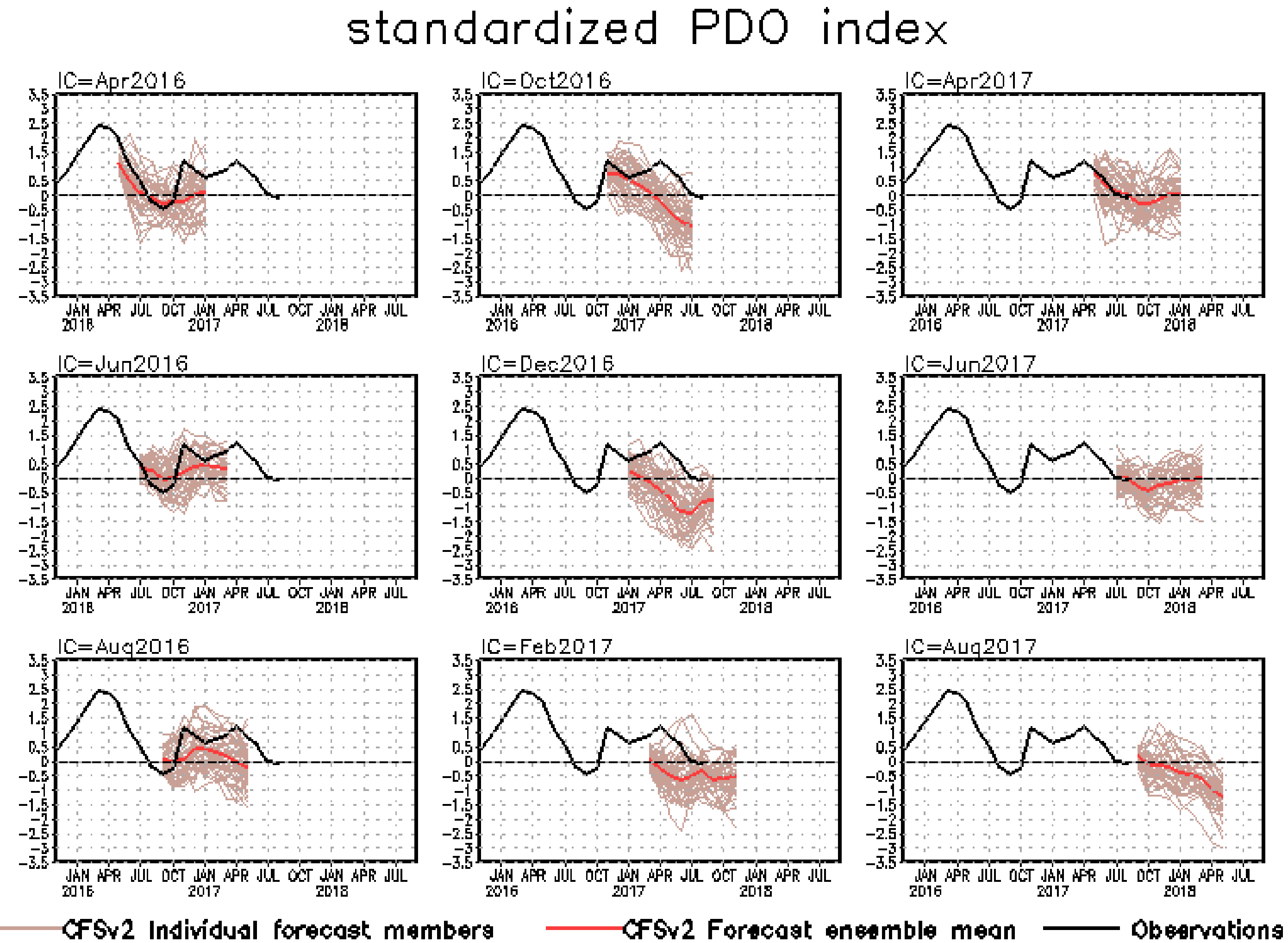
Australia: IC= 27 Aug 2017



UKMO: IC=Aug 2017



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

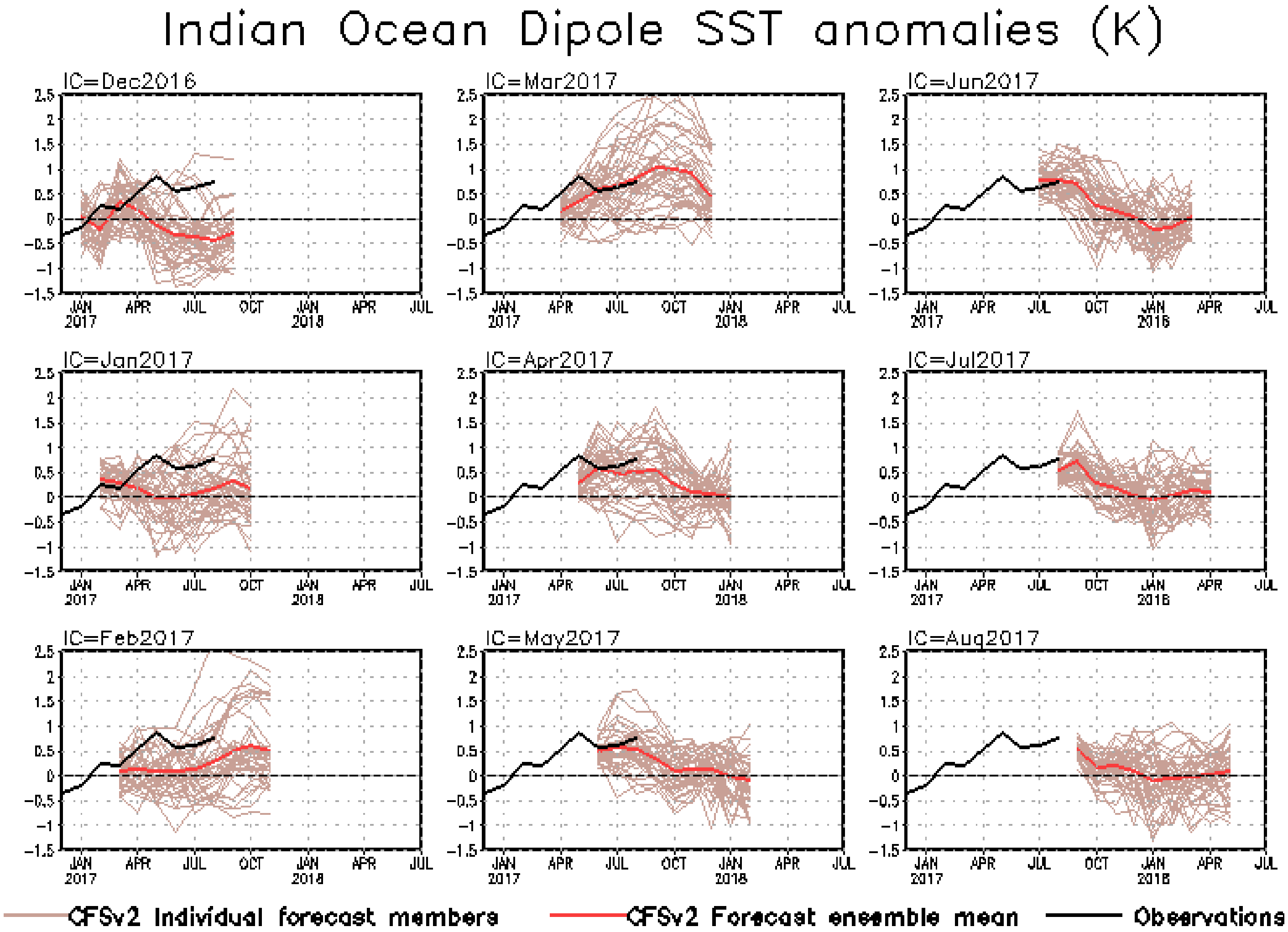


PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

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.