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

Prepared by

Climate Prediction Center, NCEP/NOAA

October 10, 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 Ocean Observing and Monitoring Division (OOMD)

Outline

- **Overview**
- **Recent highlights**
  - ❖ Pacific/Arctic Ocean
  - ❖ Indian Ocean
  - ❖ Atlantic Ocean
- Global SST Predictions and Arctic Sea Ice outlook

❖ 2017 Atlantic Hurricane

Overview

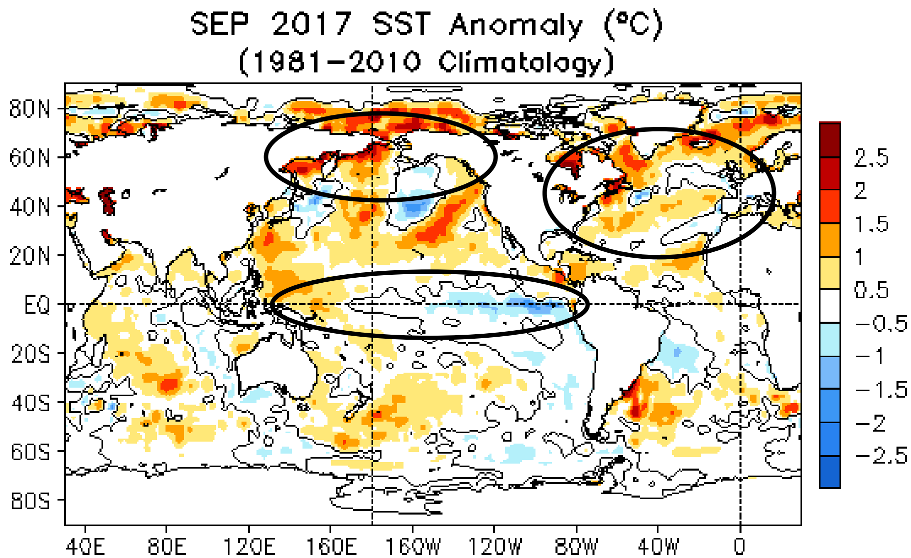
- **Pacific Ocean**
  - **NINO3.4 reached -0.5°C and OLR/low-level wind anomalies resembled the typical La Nina pattern.**
  - **Negative subsurface temperature anomalies strengthened in the central-eastern equatorial Pacific Ocean.**
  - **Dynamical and statistical models slightly favor La Nina condition in the Northern Hemisphere winter 2017/18.**
  - **PDO switched to weakly positive phase with PDO = 0.2.**
  - **Arctic sea ice extent reached its annual minimum in Sep 2017.**

- **Indian Ocean**
  - **Positive SSTA dominated in the tropical Indian Ocean.**

- **Atlantic Ocean**
  - **Atlantic hurricane were very active, with five hurricanes developed in Sep 2017.**
  - **Gulf of Mexico experienced the strongest upper ocean warming (0-150m) since 1979.**

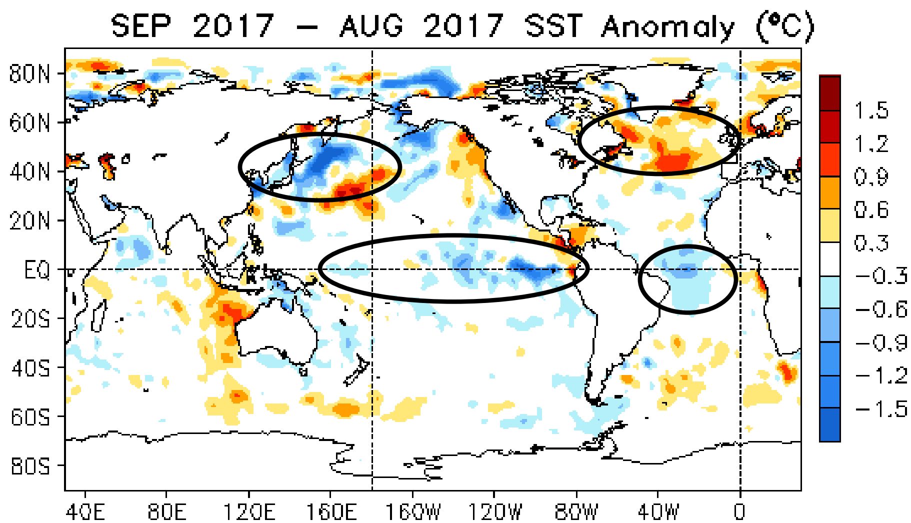
Global Oceans

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



- SST were below-normal (above-normal) in the central-eastern (western) equatorial Pacific

- Positive SSTA dominated in N. Pacific and N. Atlantic Oceans.



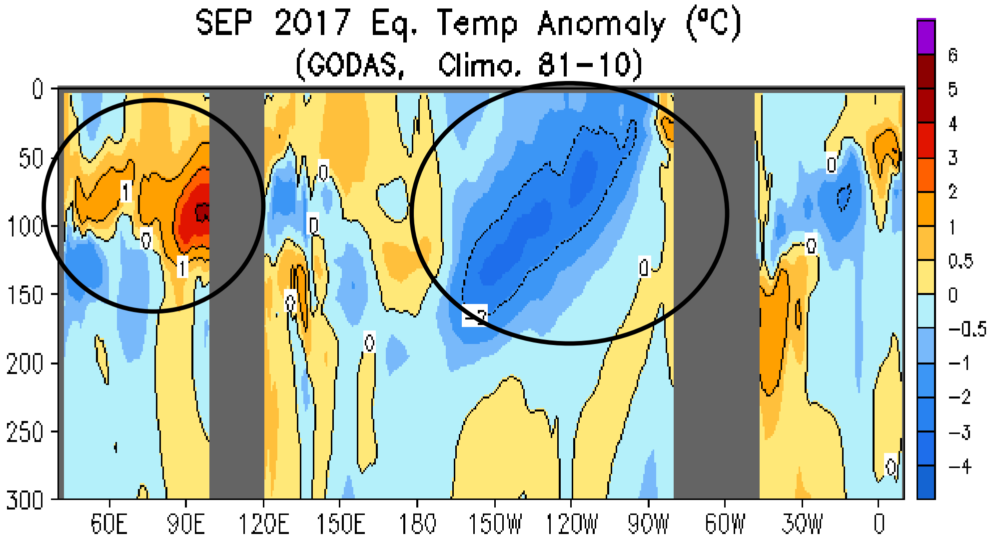
-SSTA tendencies were mostly negative across the equatorial Pacific and Atlantic Oceans.

- Strong SSTA tendencies presented in the far western N. Pacific.

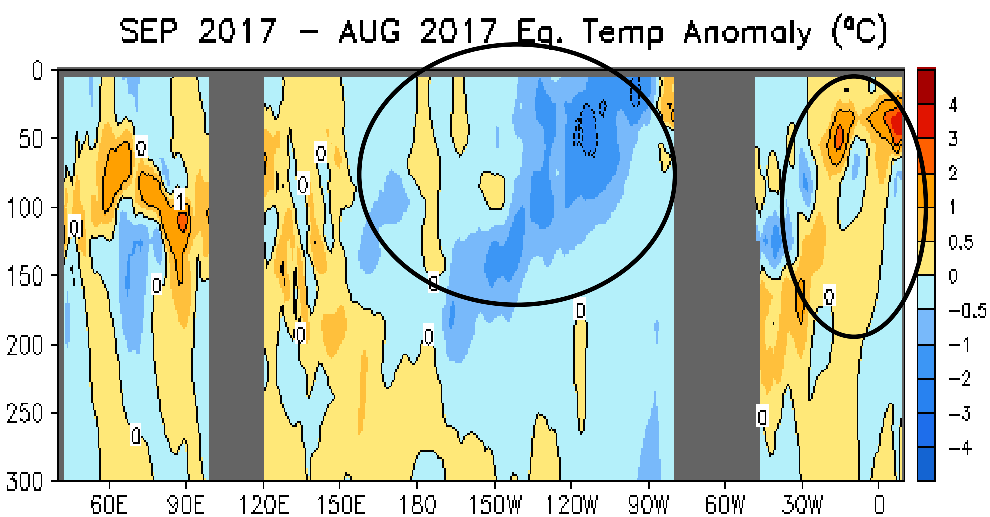
- Positive SSTA tendencies were observed in the mid latitude of N. Atlantic.

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



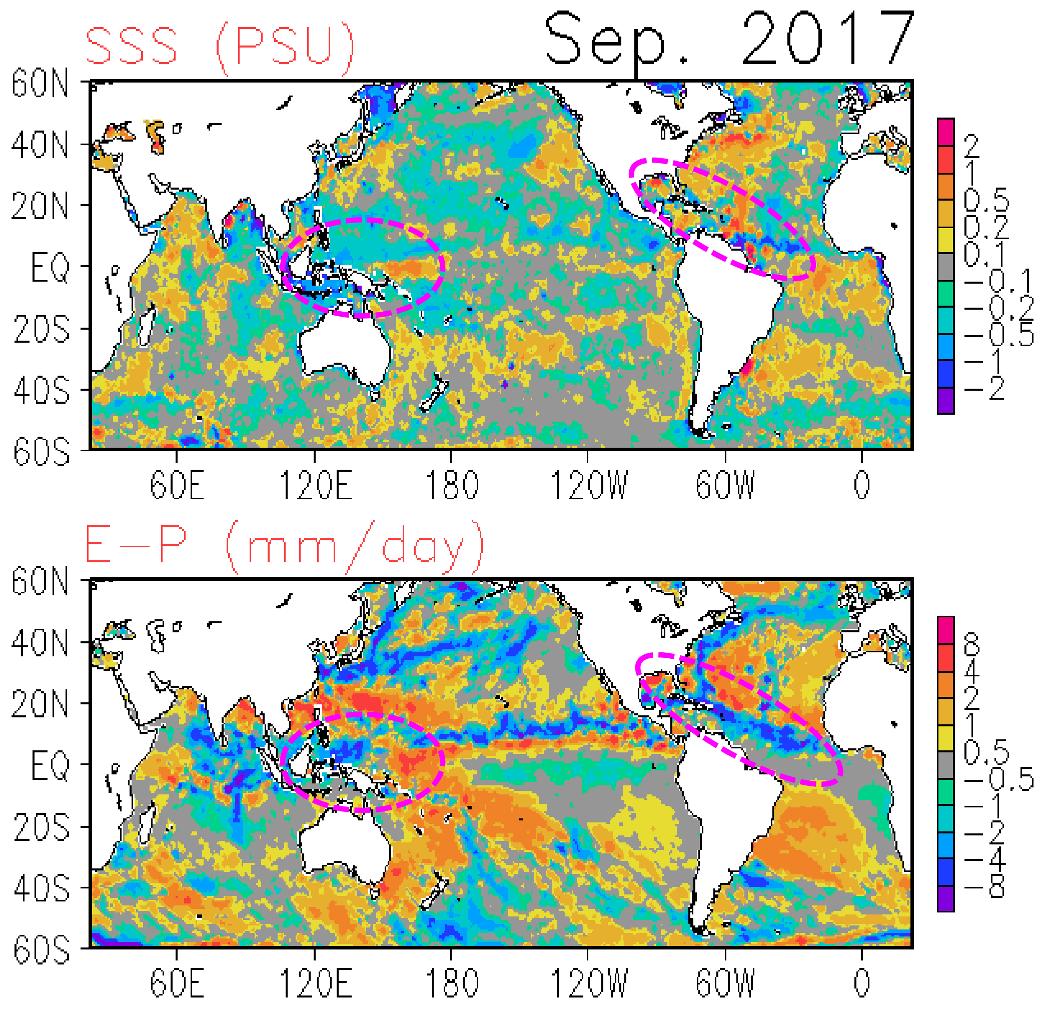
- **Ocean temperature were 3°C cooler than average near the thermocline between 170°-90°W and extended to the surface.**
- **Positive ocean temperature anomalies dominated in upper 100m of Indian Ocean.**



- **Negative tendencies dominated the equatorial Pacific.**
- **Positive tendencies presented in the eastern Atlantic 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.

Sea Surface Salinity and Freshwater Flux (E-P) Anomaly

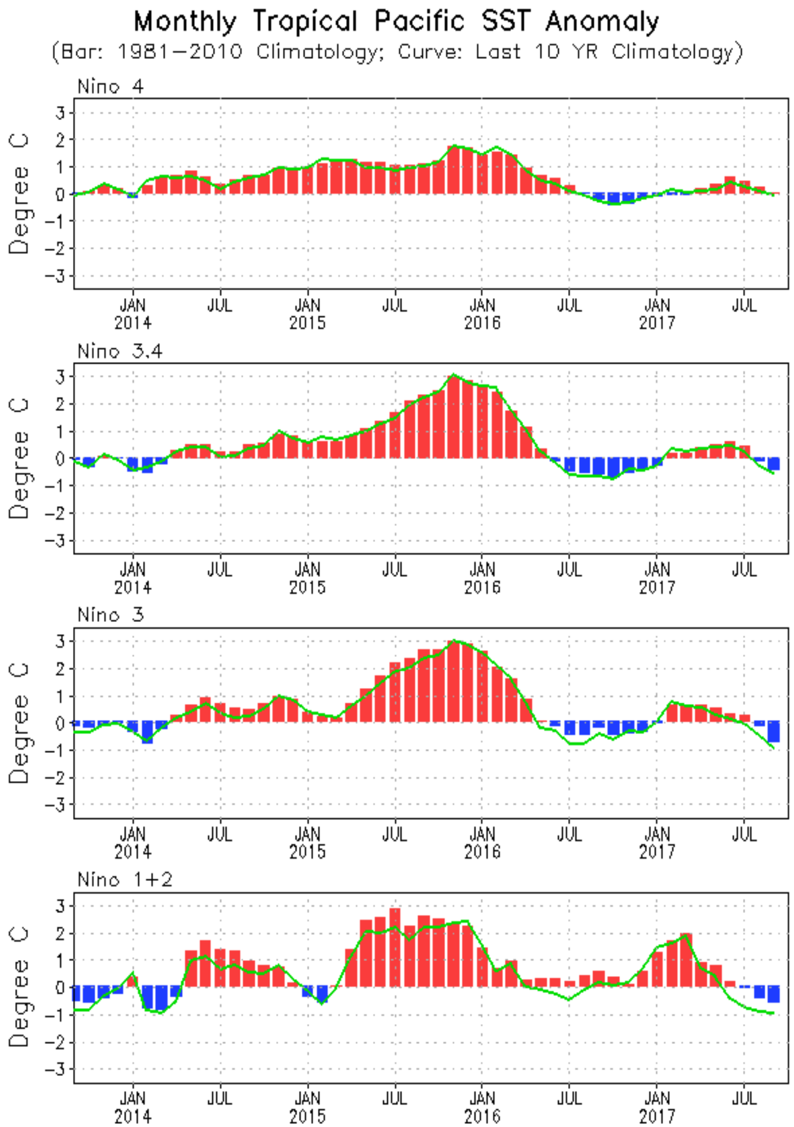


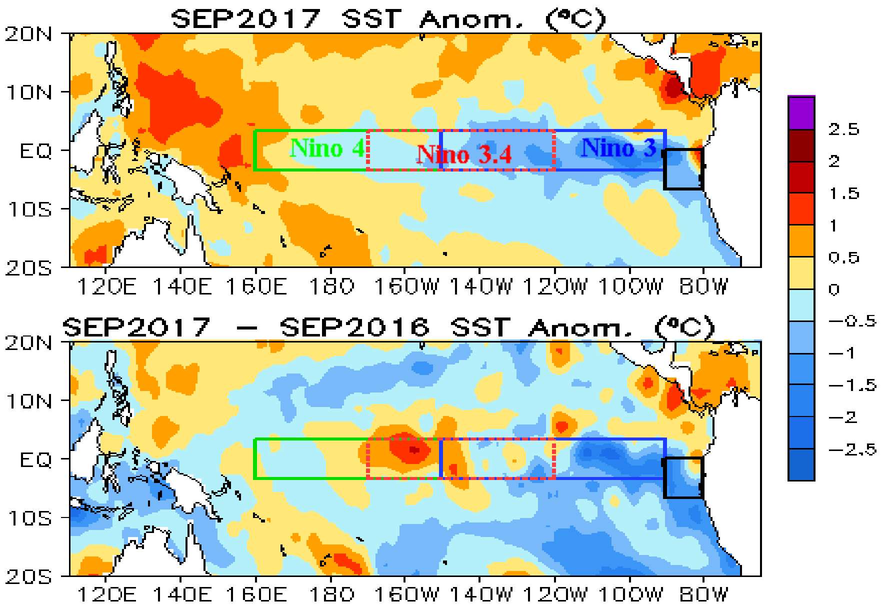
- **Fresher (saltier) than normal SSS presented near the Indonesia (Western-central) equatorial Pacific.**
- **A negative SSSA (fresher SSS) stripe extending from the equatorial Atlantic toward to the Gulf of Mexico was observed in the tropical Atlantic. Such strong anomalies were accompanied with heavy precipitation likely due to the hurricane Irma.**

SSS: Blended Analysis of Surface Salinity (BASS) based on in situ and satellite observations (Xie et al. 2014)
ftp.cpc.ncep.noaa.gov/precip/BASS
Precipitation: CMORPH adjusted satellite precipitation estimates
Evaporation: CFSR

Tropical Pacific Ocean and ENSO Conditions

Evolution of Pacific NINO SST Indices

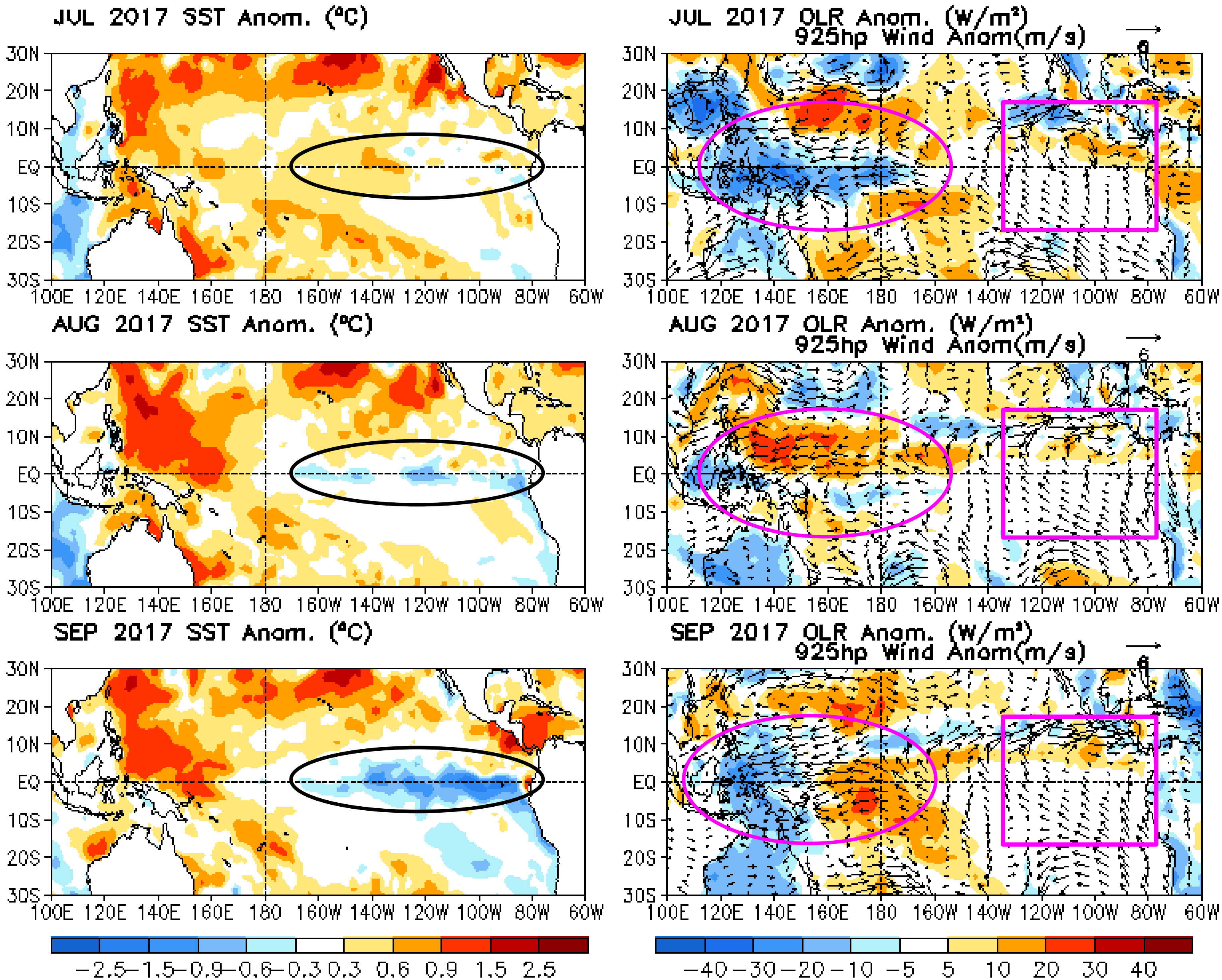




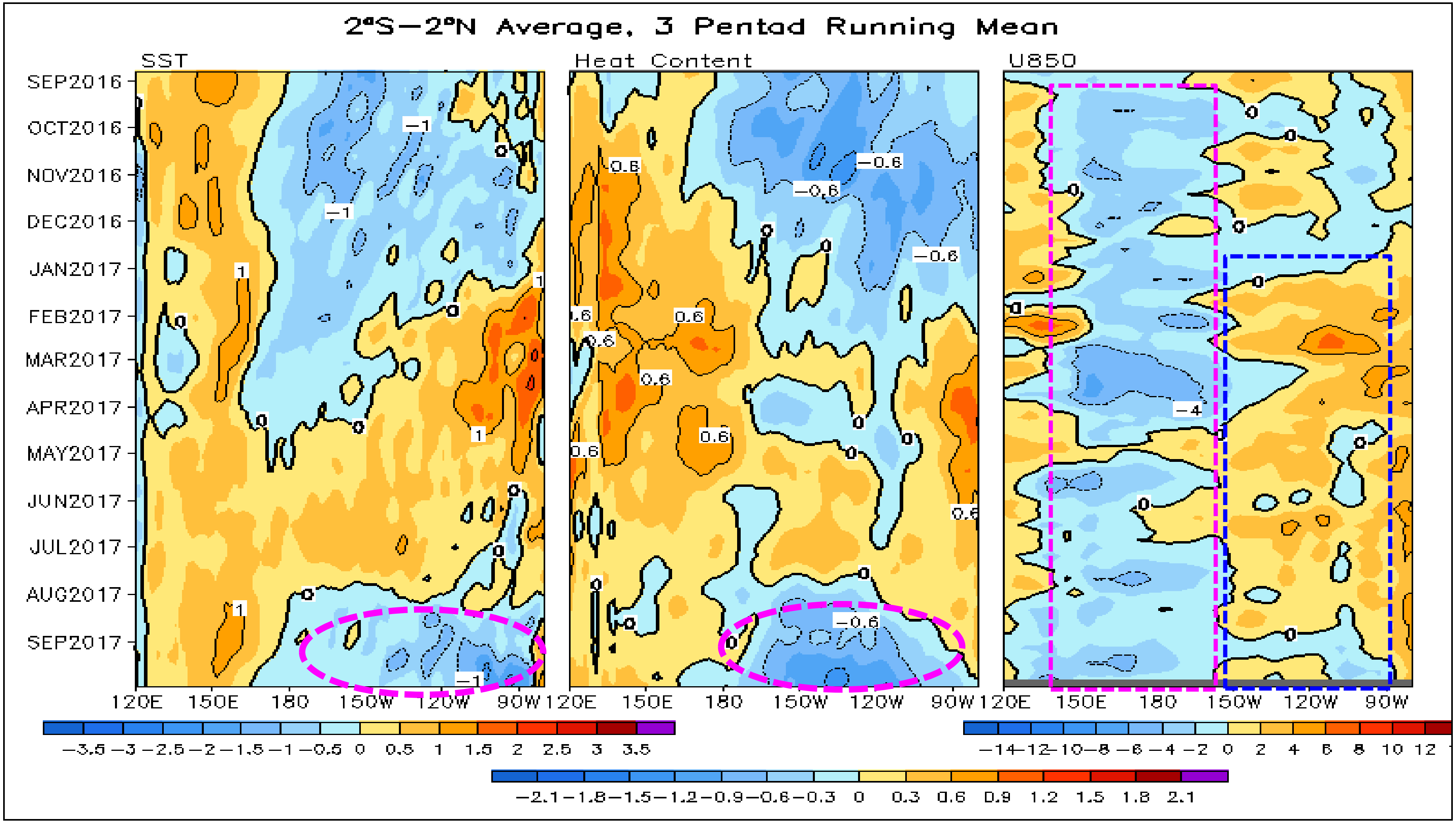
- **Negative Nino 3.4, Nino 3 and Nino 1+2 anomalies strengthened in Sep 2017.**
- **Nino3.4 = -0.5°C in Sep 2017.**
- **Compared with last Sep, the central (eastern) equatorial Pacific was warmer (colder) in Sep 2017.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v4.**

Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°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.

Last Three Month SST, OLR and 925hp Wind Anomalies



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

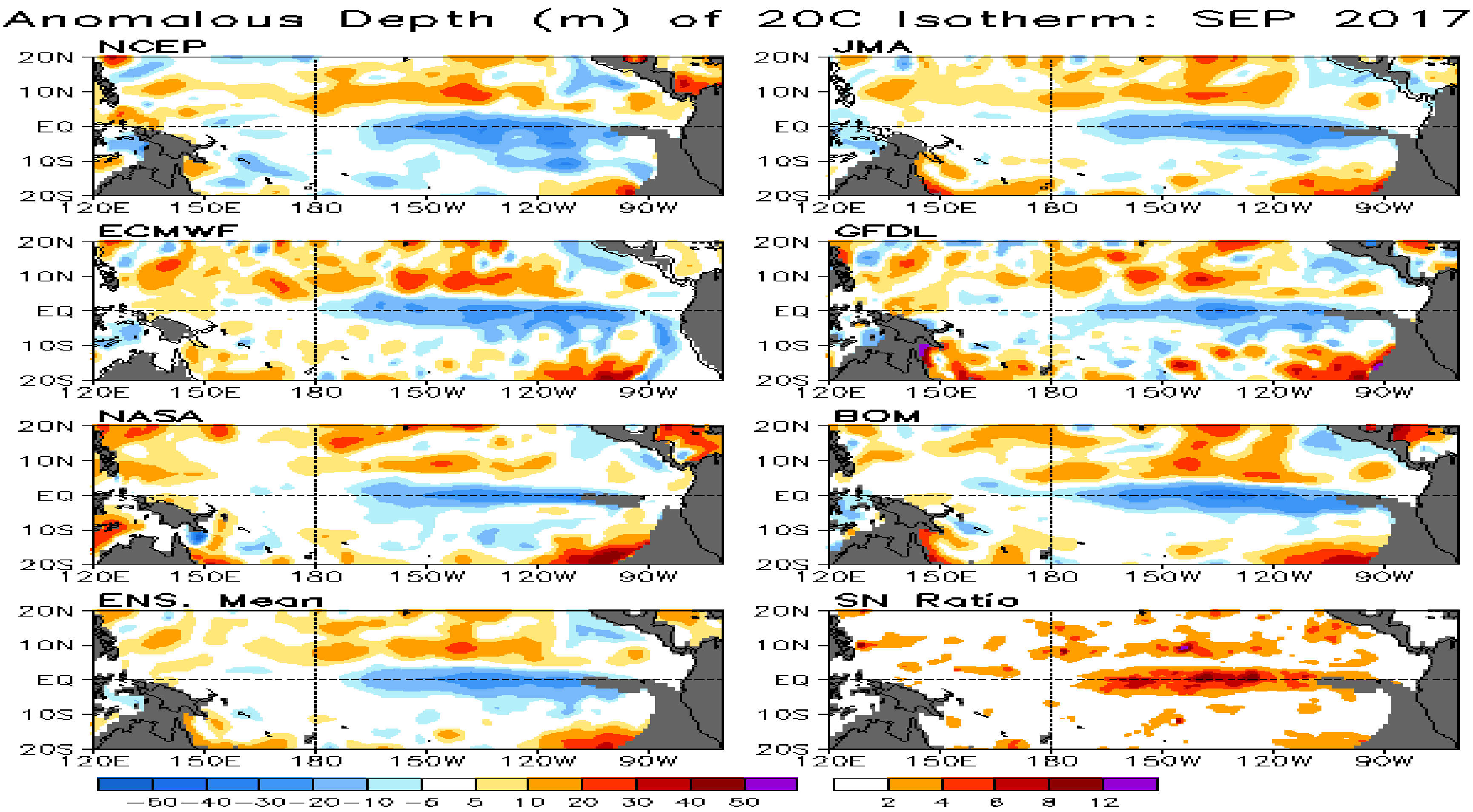


- **Negative SSTAs persisted in the central-eastern equatorial Pacific in Sep 2017.**
- **Negative HC300A strengthened in the central-eastern Pacific in Sep 2017.**
- **Low-level easterly wind anomalies generally prevailed over the western-central Pacific in the last 13 month , while westerly wind anomalies persisted in the eastern Pacific since Jan 2017.**

Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1981-2010

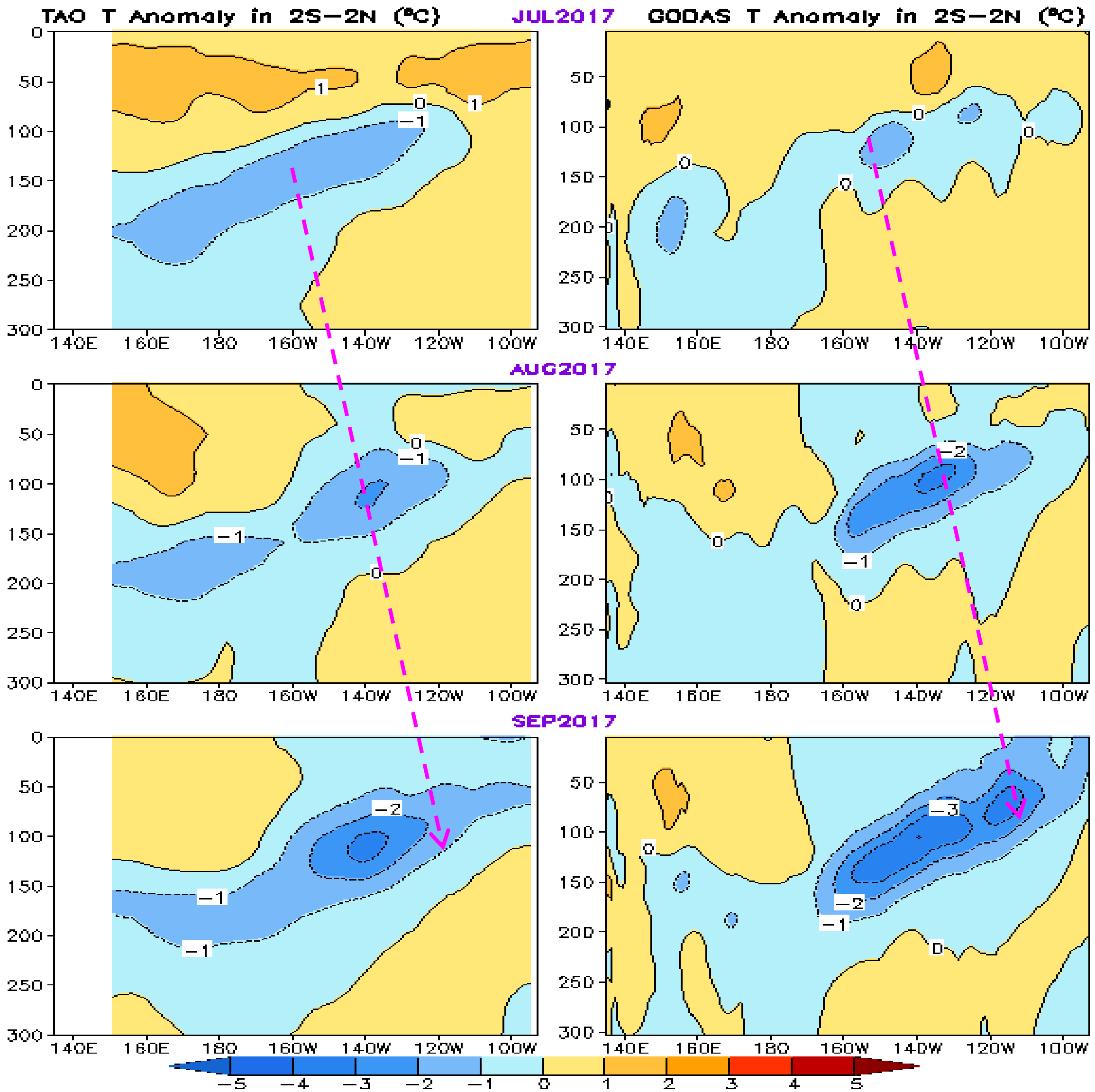
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html)



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

Equatorial Pacific Ocean Temperature Monthly Mean Anomaly

TAO GODAS

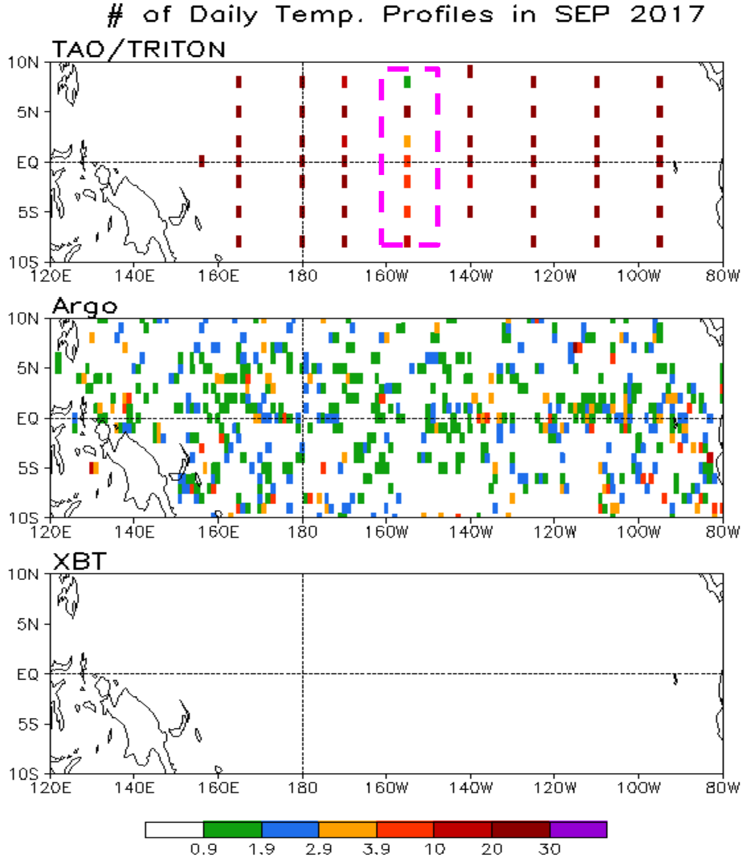


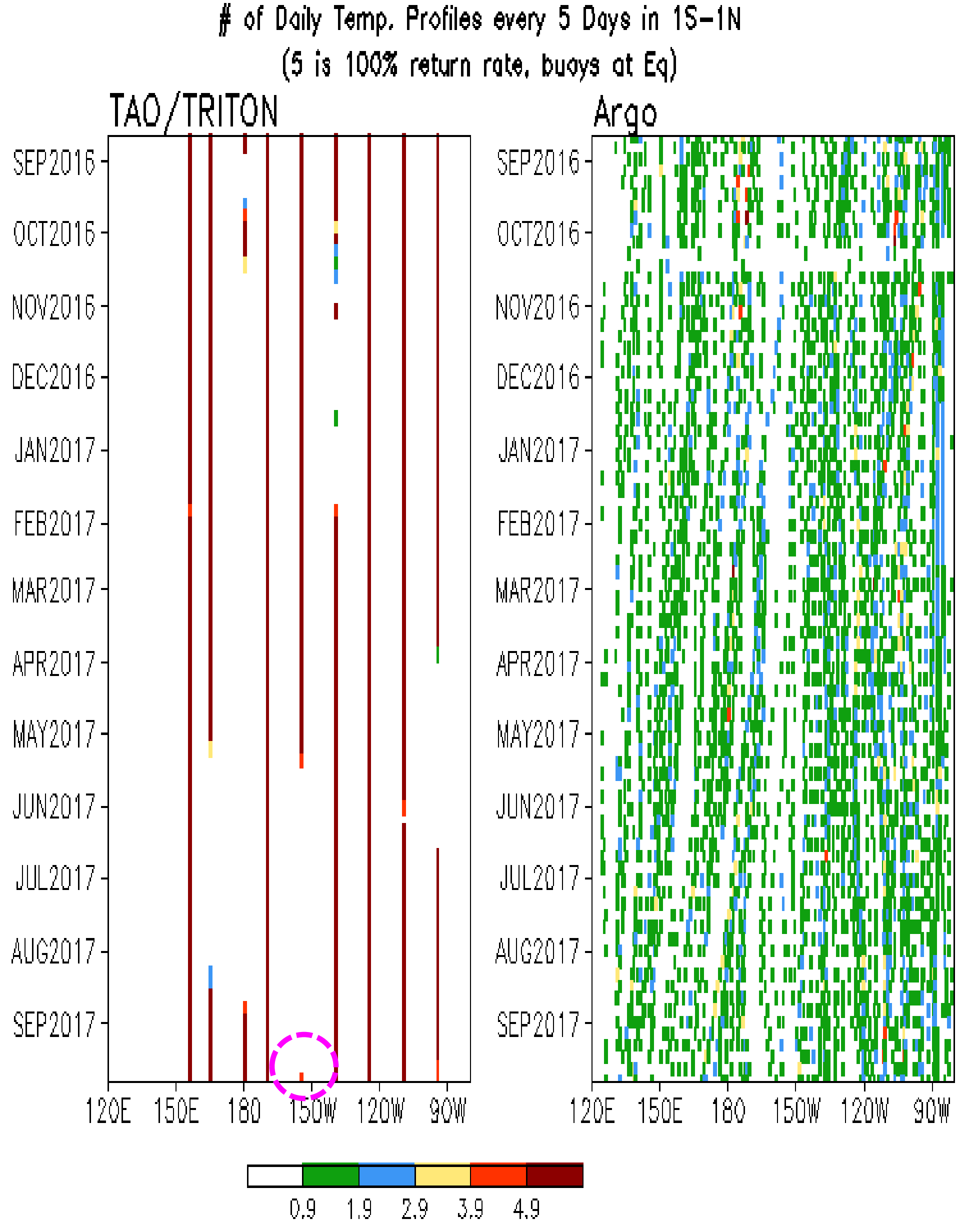
- Negative temperature anomalies strengthened and propagated eastward in the last three months.

- Subsurface cooling in GODAS was stronger than in TAO data.

- Large differences between TAO and GODAS in the central equatorial Pacific were partially associated with the missing TAO data at the three moorings (2°N, Eq, 2°S) along the 155°W line).

Temperature Profiles in the Tropical Pacific Ocean

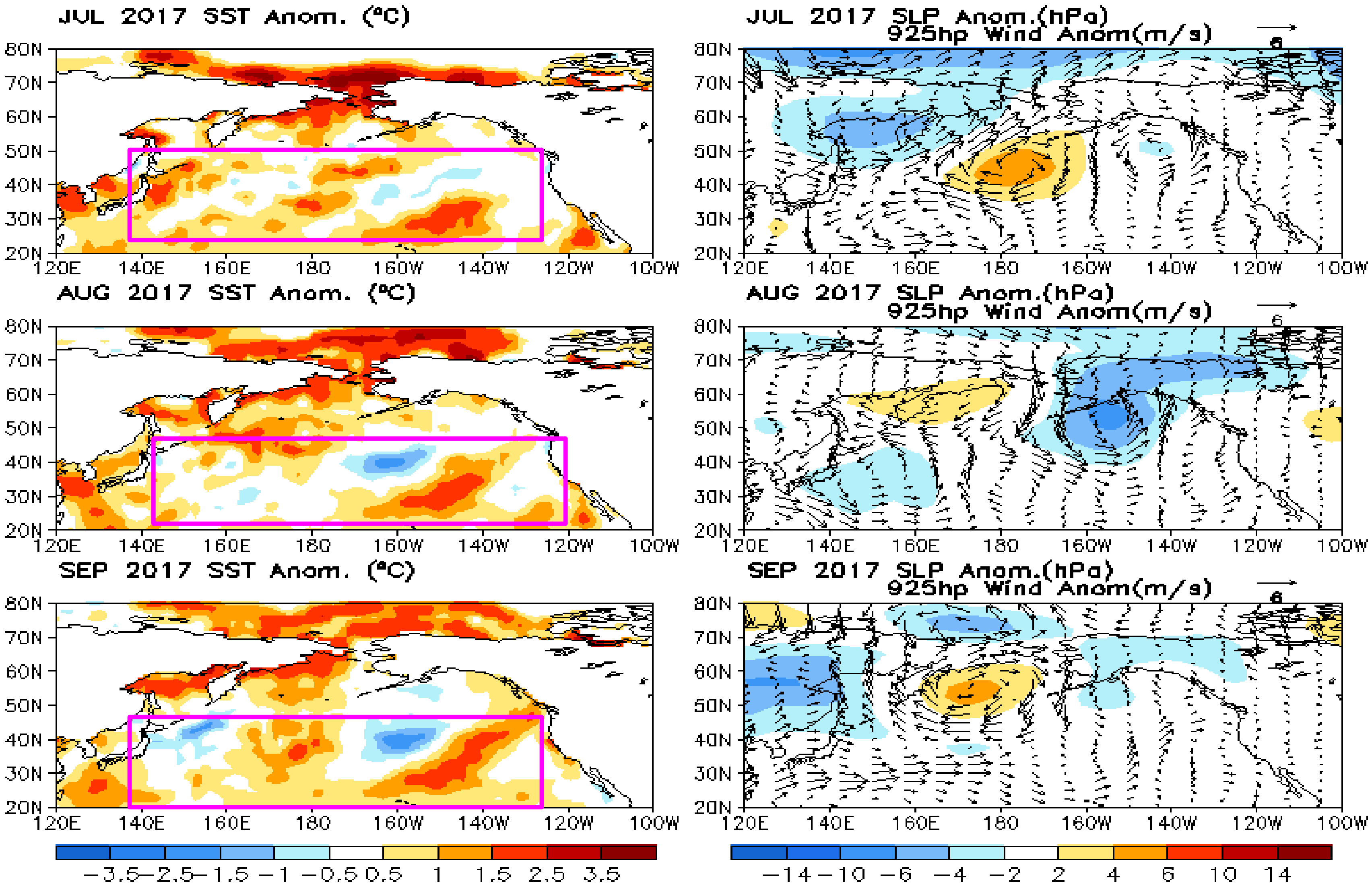




- National Data Buoy Center have restored most of equatorial moorings along 155°W line by the end of September.

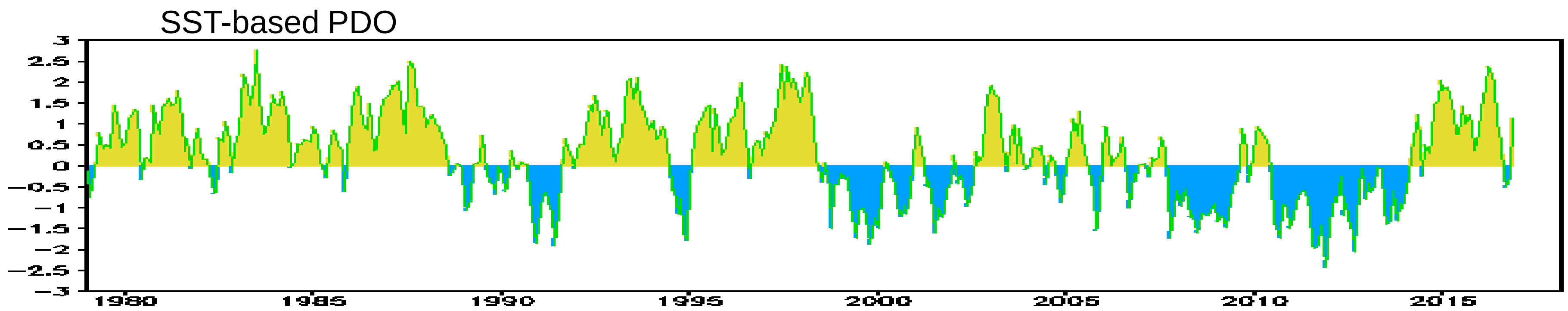
North Pacific & Arctic Oceans

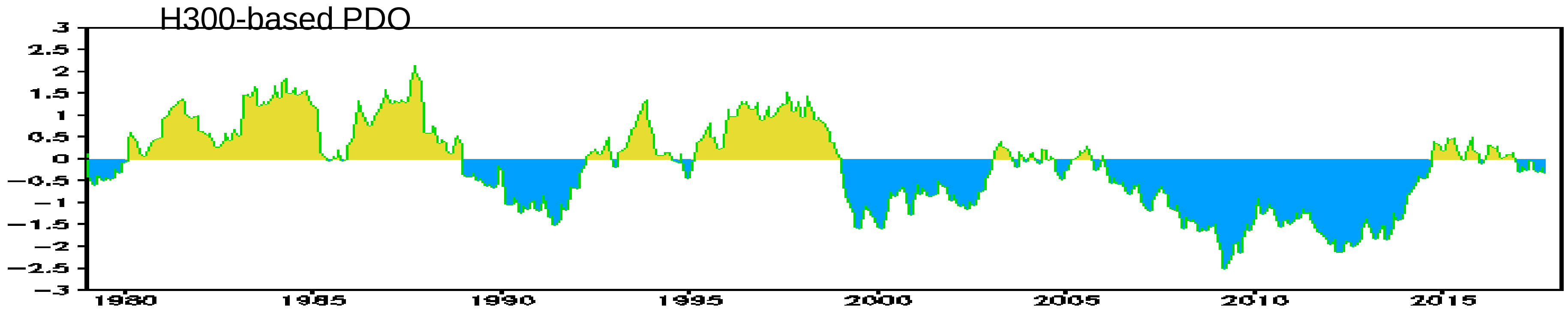
Last Three Month SST, SLP and 925hp Wind Anomalies



- SST warming persisted in the Artic Ocean and the high latitudes of North Pacific.
- SST anomalies between 20°-50°N varied month by month, owing to the high frequency changes in the atmospheric circulation.

Two Oceanic PDO indices



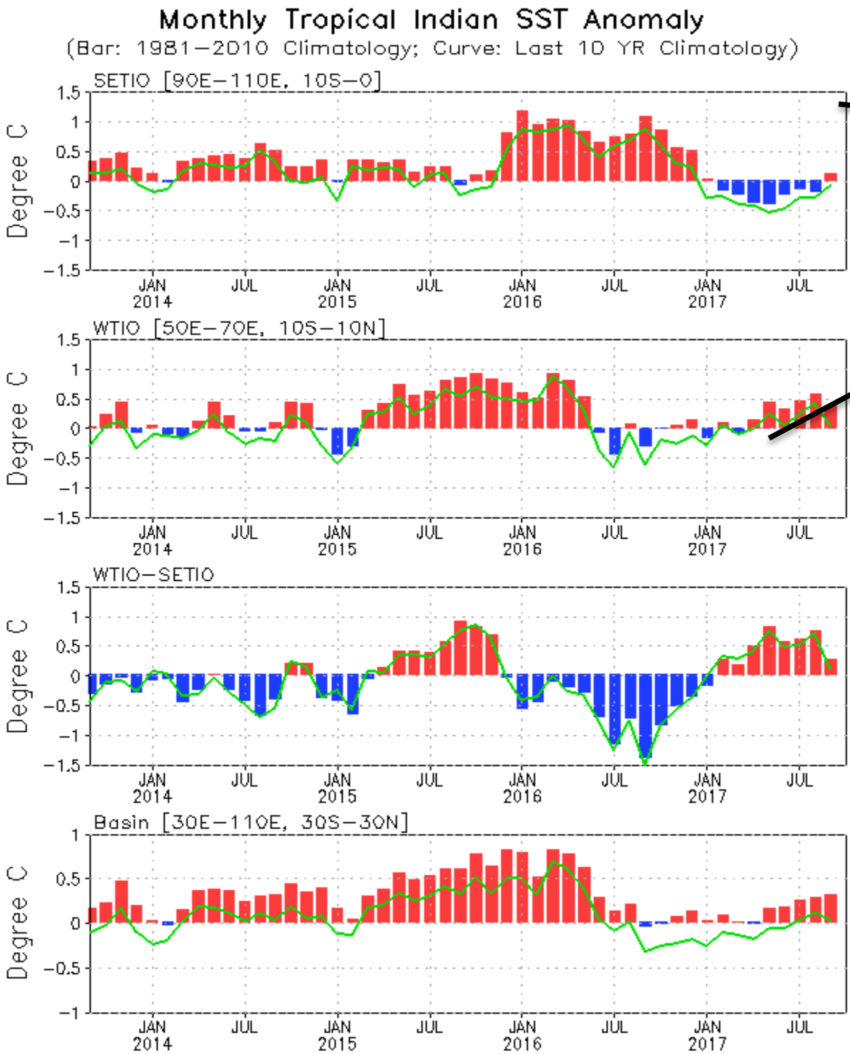


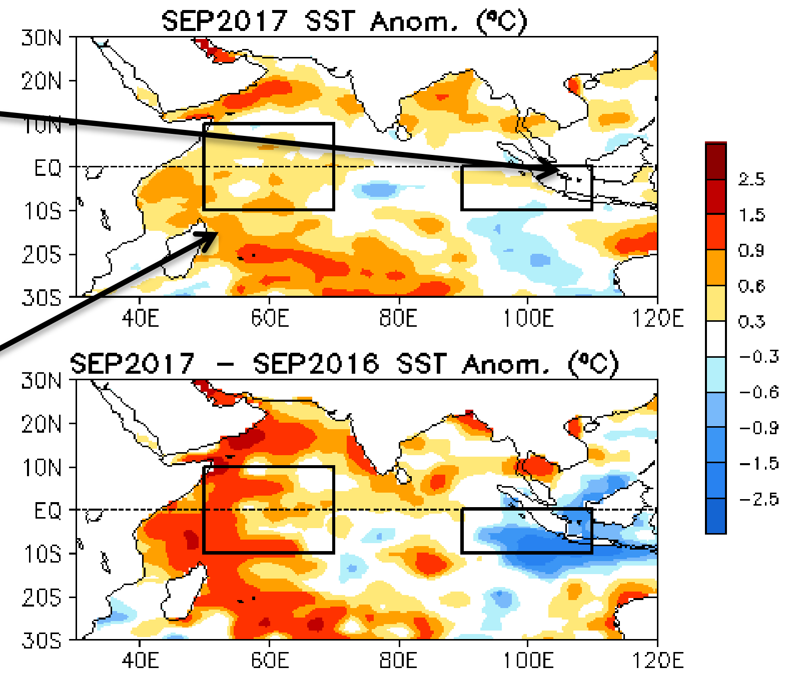
- **SST-based PDO index switched to positive phase in Sep 2017, with PDO index =0.2.**
- **Negative H300-based PDO index has persisted 10 months since Nov 2016, with HPDO = -0.3 in Sep 2017.**
- **SST-based PDO index has considerable variability both on seasonal and decadal time scales.**

SST-based 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. H300-based Pacific Decadal Oscillation is defined as the projection of monthly mean H300 anomalies from NCEP GODAS onto their first EOF vector in the North Pacific.

Indian Ocean

Evolution of Indian Ocean SST Indices





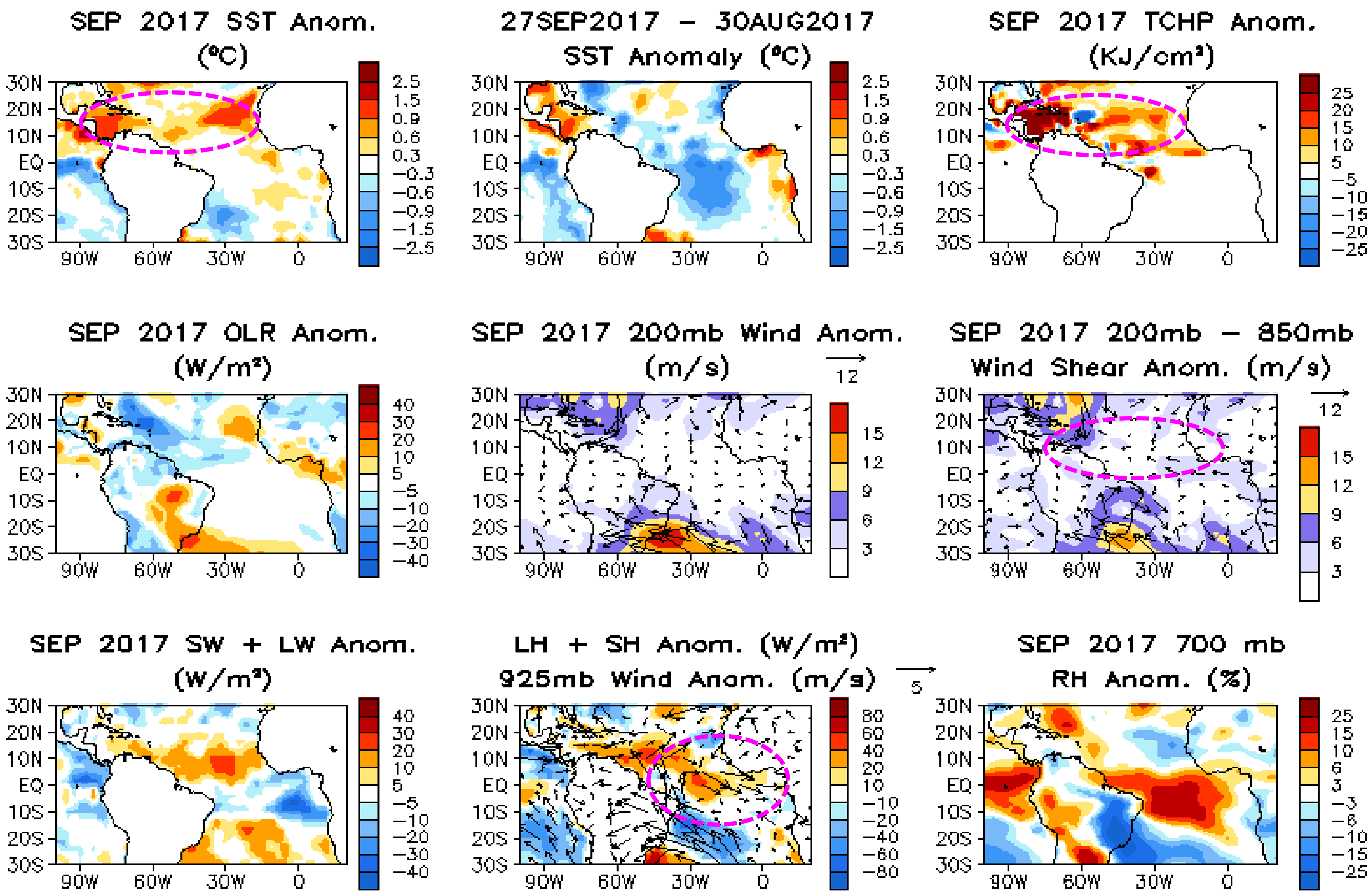
- **SSTAs were positive in both the western and the eastern Indian Ocean.**
- **Positive Dipole index weakened in Sep 2017.**
- **Basin index was positive since May 2017.**

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°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

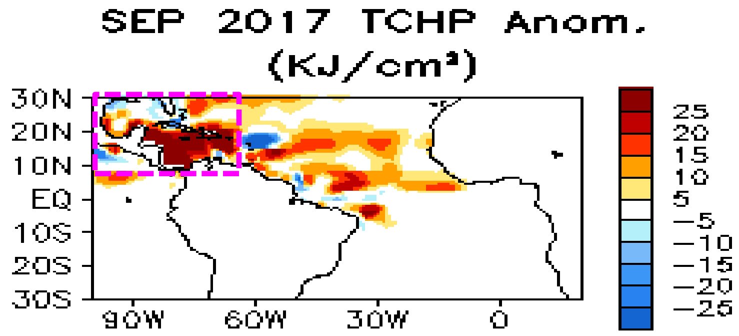
Tropical Atlantic:

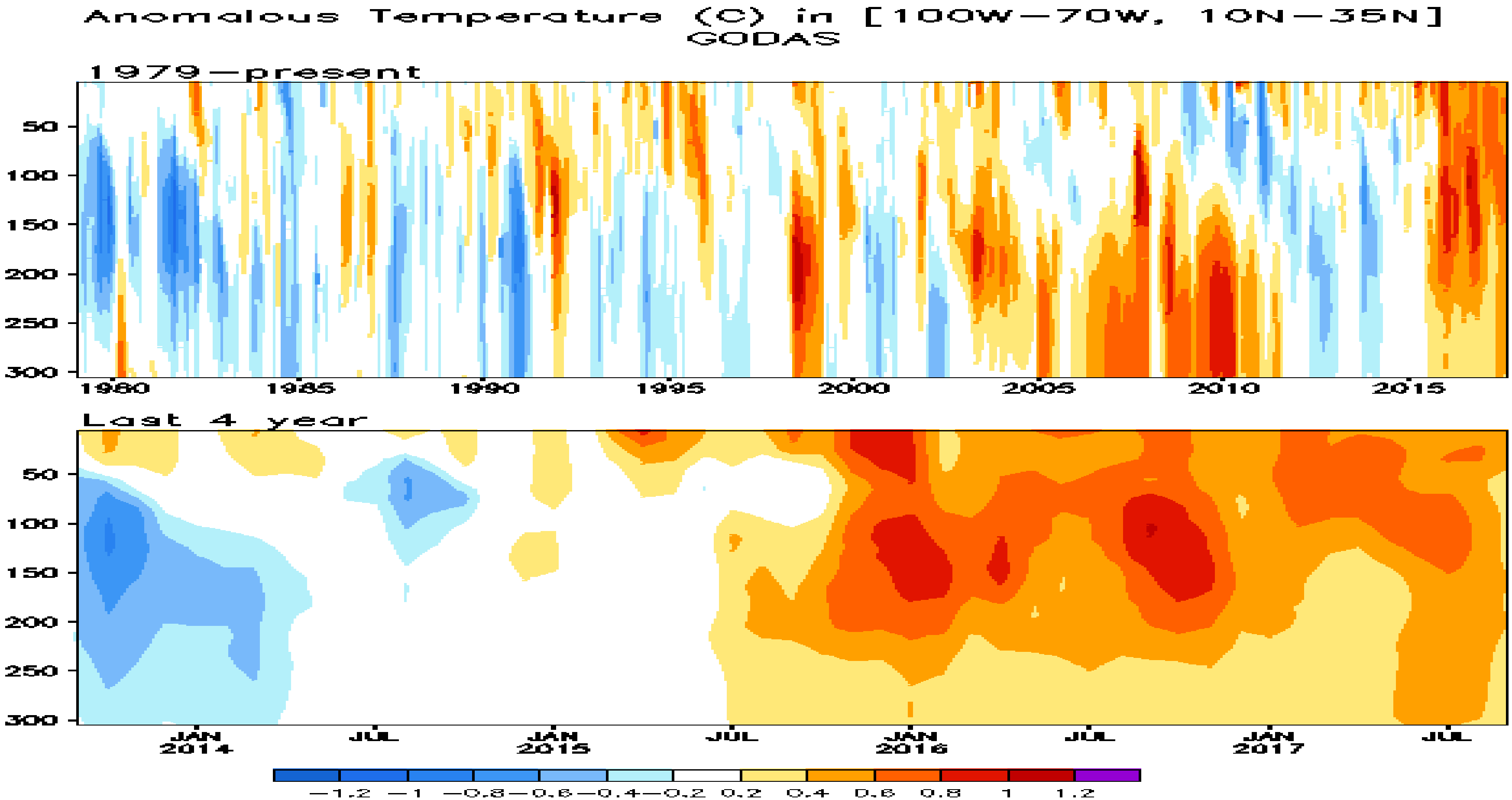
SST, SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, TCHP, 925-mb/200-mb Winds anom.



Warming in Gulf of Mexico and Caribbean Sea

- **Gulf of Mexico and Caribbean Sea experienced the strongest upper ocean warming (0-200m) since 1979.**





Conditions Associated with Active 2017 Atlantic Hurricane Season

Dr. Gerry Bell

Lead Seasonal Hurricane Forecaster
Climate Prediction Center/ NOAA/NWS

Presented to CPC Ocean Briefing
10 October, 2017

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

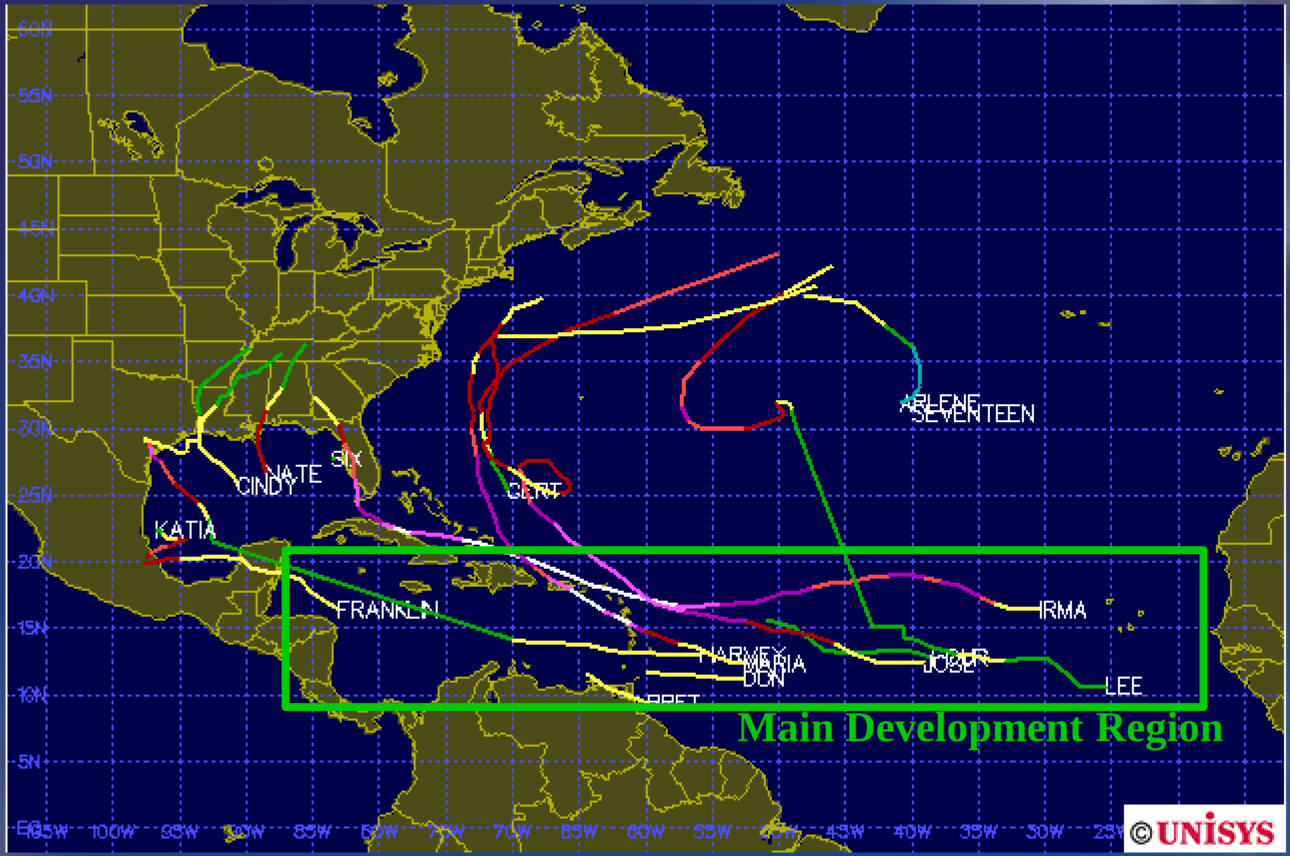
Motivating Concept Behind Hurricane Season Outlooks

While hurricanes are ultimately a weather phenomena, the regional conditions within the MDR which largely control the number, strength, and duration of hurricanes, often last for months/ seasons at a time, and have strong climate links (Gray 1984; Bell and Chelliah 2006).

By predicting key climate patterns (ENSO and Atlantic Multi-Decadal Oscillation) and their combined impacts, we can often predict the regional hurricane-controlling conditions within the MDR and thus the strength of the upcoming hurricane season.

NOAA's Atlantic hurricane season outlook is updated in early August to coincide with peak months of the hurricane season (August-October), when 95% of all hurricanes and major hurricanes form.

2017 Storm Tracks To Date



The activity in the Main Development Region (MDR) during August-October determines the strength of the hurricane season.

Aug-Sep 2017 featured 6 storms forming in the MDR. Five became major hurricanes.

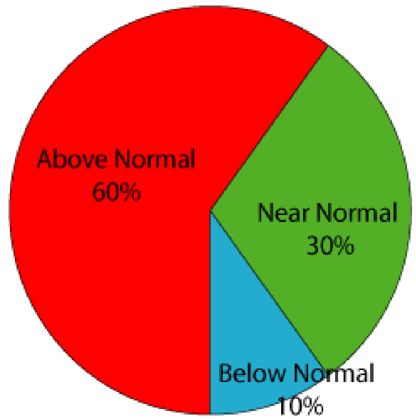
NOAA's Updated 2017 Atlantic Hurricane Season Outlook

Issued August 9, 2017

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

Probability of Season Type

Updated Outlook Issued 9 August



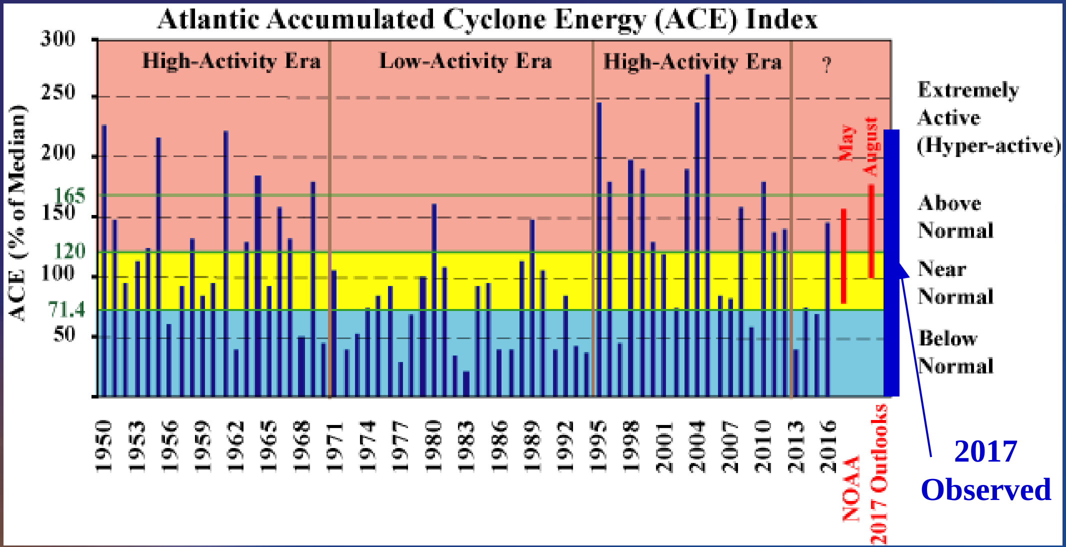
Predicted Activity

70% Probability For Each Range

	August Update	Observed
Named Storms	14-19	14
Hurricanes	5-9	9
Major Hurricanes	2-5	5
ACE (% median)	100-170%	229%

Outlook indicated that 2017 could be the most active season since 2010.

The 2017 Atlantic Outlook in a Historical Perspective

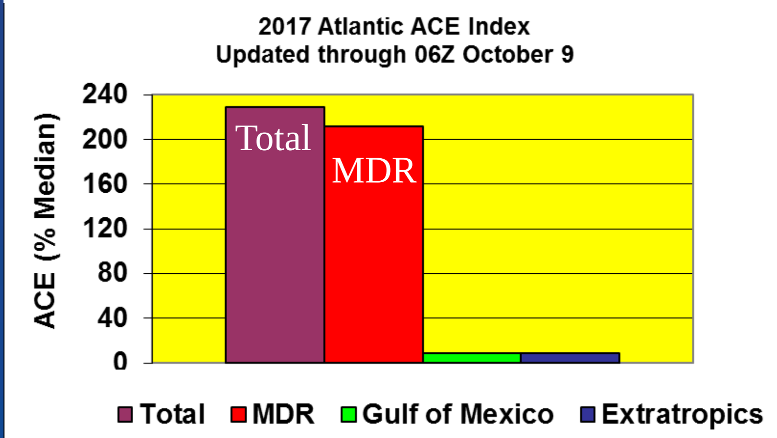


Based on ACE, 2017 is the most active Atlantic hurricane season since 2005, and the first extremely active season since 2010.

The overall 2017 activity is comparable to some of the stronger seasons seen since 1995.

Extremely active seasons typically have far more landfalling storms in the U.S. and Caribbean Sea regions.

ACE contribution from storms forming in different regions

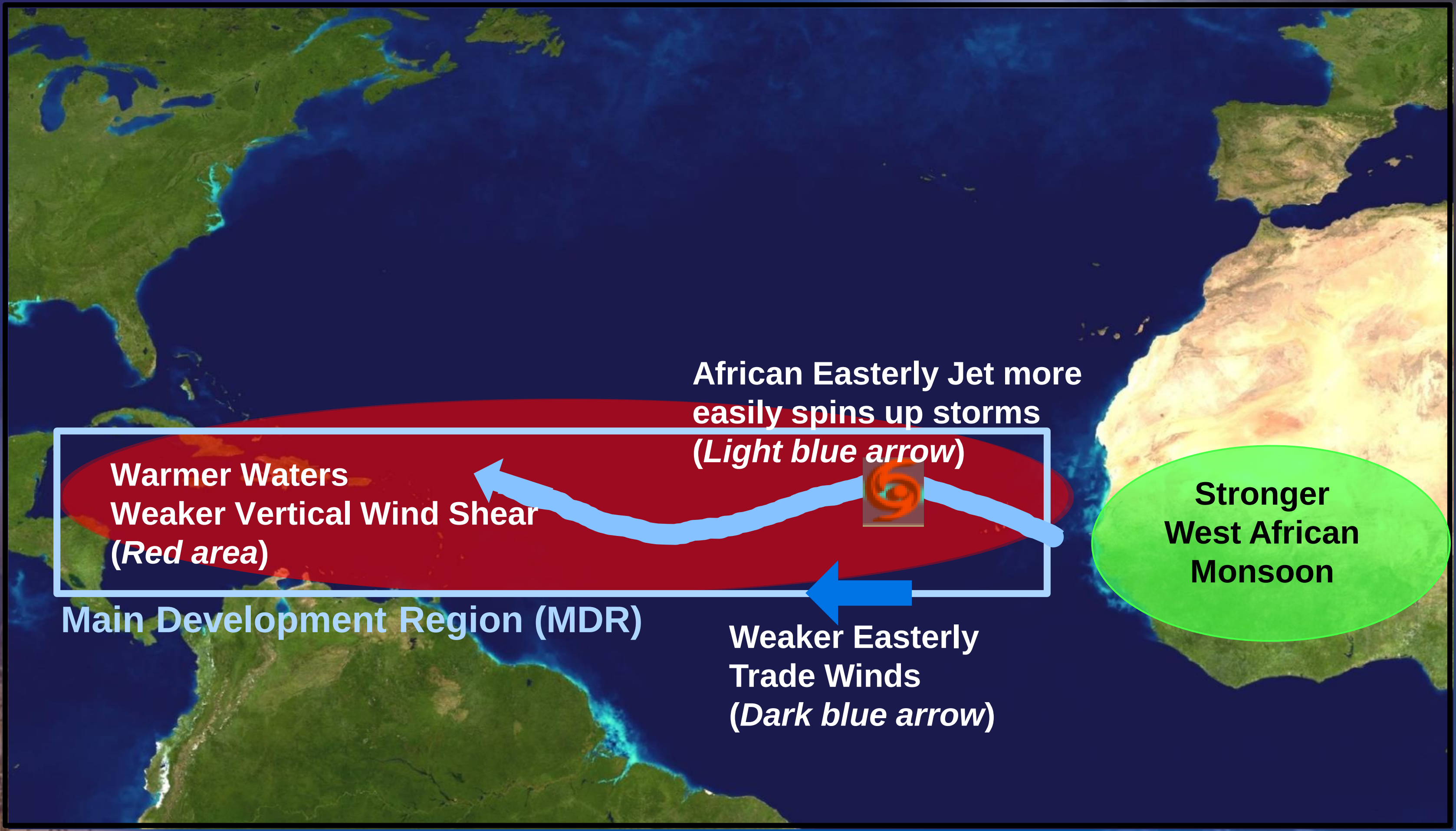


During 2017, storms first named in the MDR account for 92% of the total ACE.

The 5 major hurricanes which formed in the MDR produced 90% of the seasonal ACE, especially, MH Irma, MH Jose, and MH Maria.

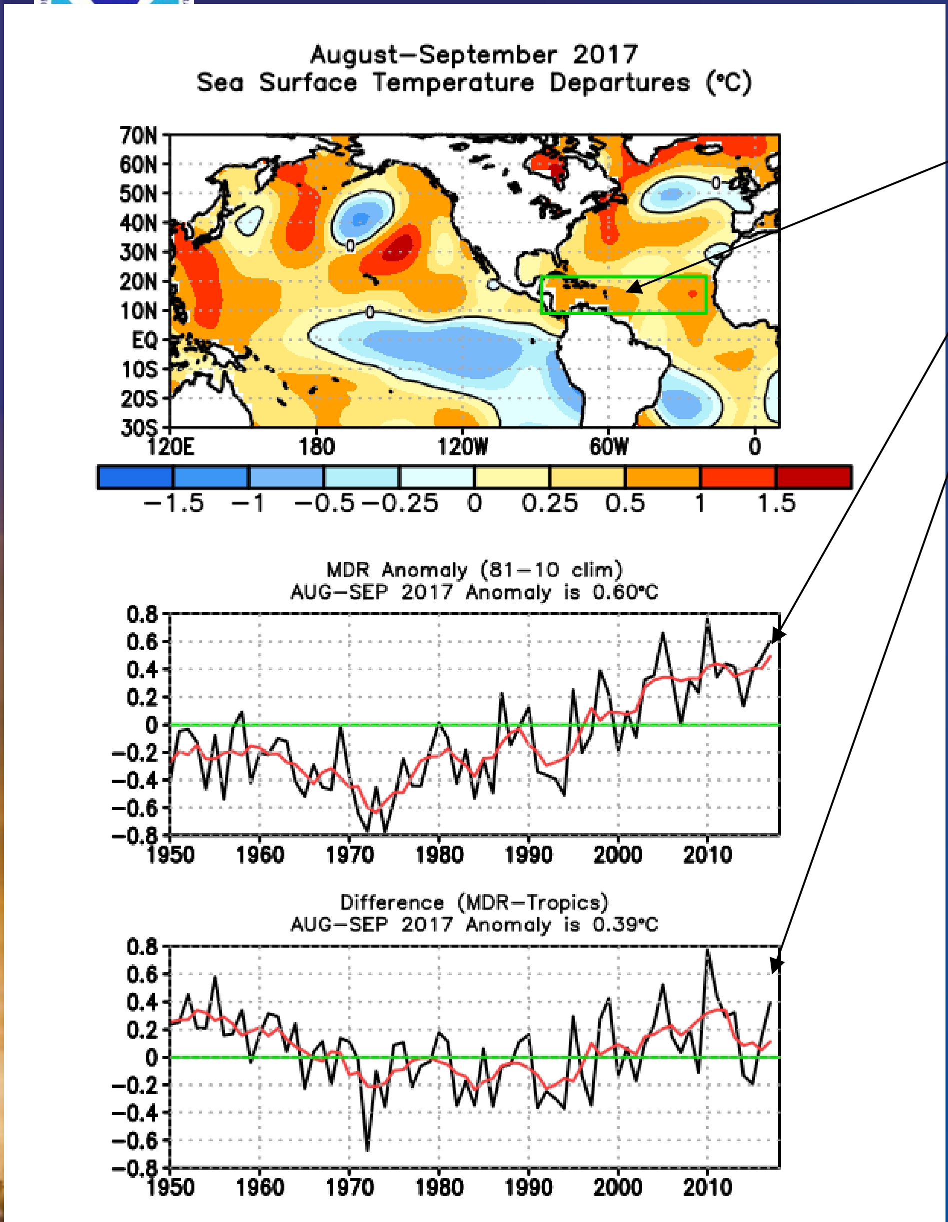
ACE index measures overall season strength by accounting for the combined intensity and duration of tropical storms and hurricanes.

Predicted Conditions During August-October 2017 Typify Warm Phase of Atlantic Multi-Decadal Oscillation (AMO)



This inter-related set of conditions within the MDR is typical of other above-normal seasons, and is consistent with the warm phase of the AMO (Bell and Chelliah, JCLI, 2006)

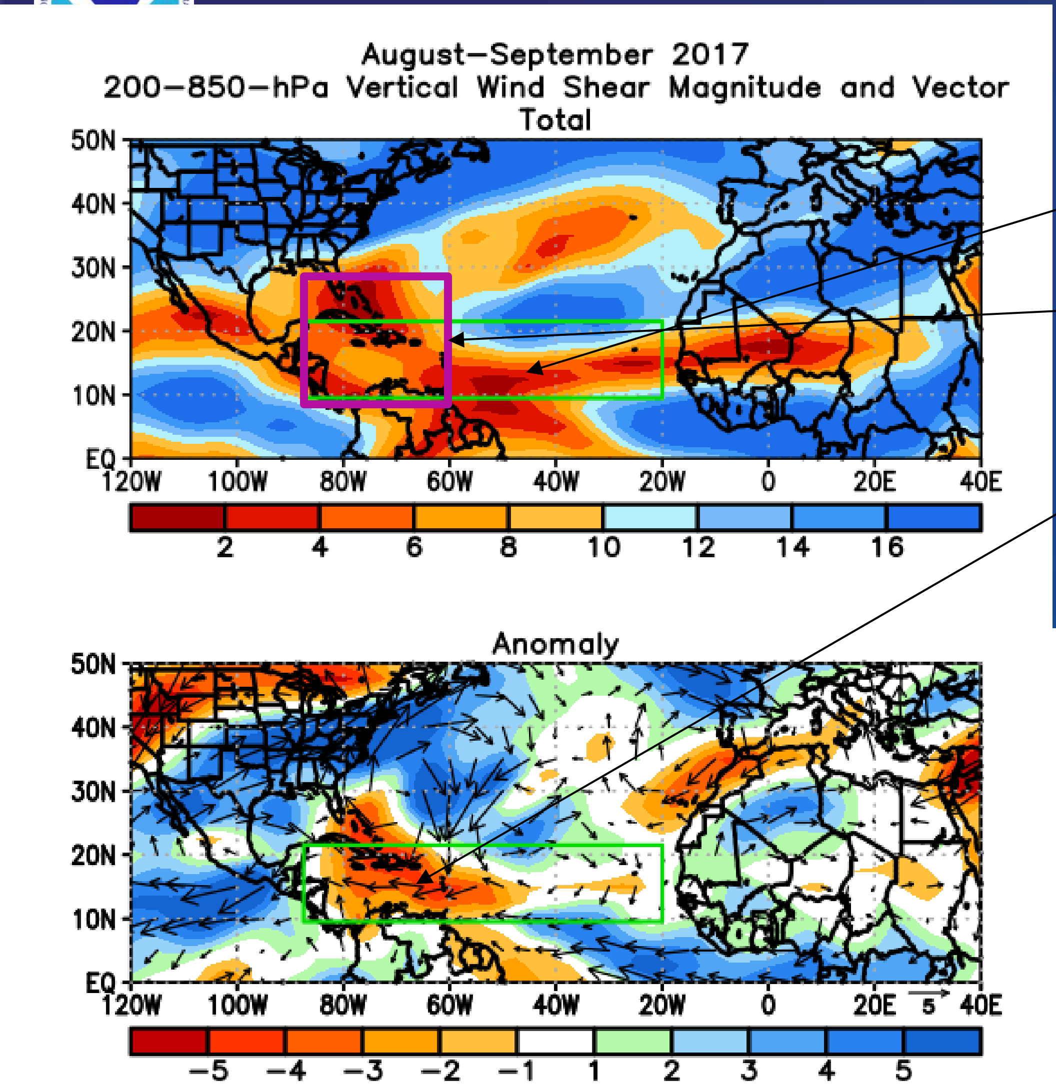
Atlantic SSTs (ERSST-V4) During Aug-Sep 2017



Area-averaged SSTs in MDR:

- **Well above average (+ 0.6 ºC)**
- **3rd warmest since 1950.**
- **Warmer (+0.39 ºC) than remainder of global Tropics.**
- **Continued warm phase of AMO (Kaplan AMO index)**

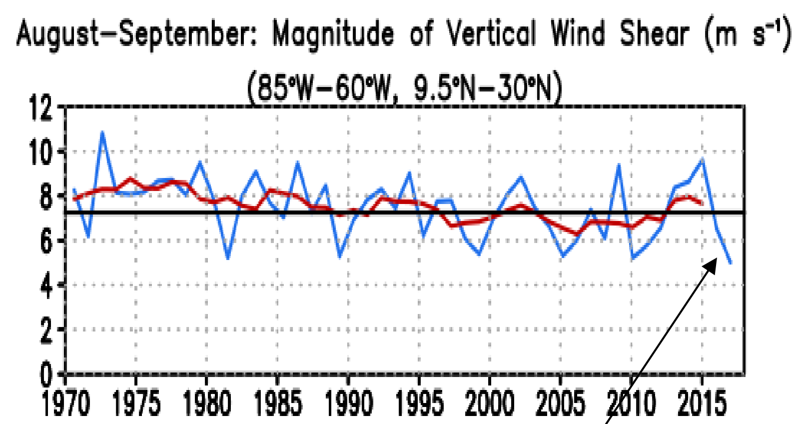
200-850 hPa Vertical Wind Shear (m s^{-1})



Weak shear across MDR typifies other active seasons.

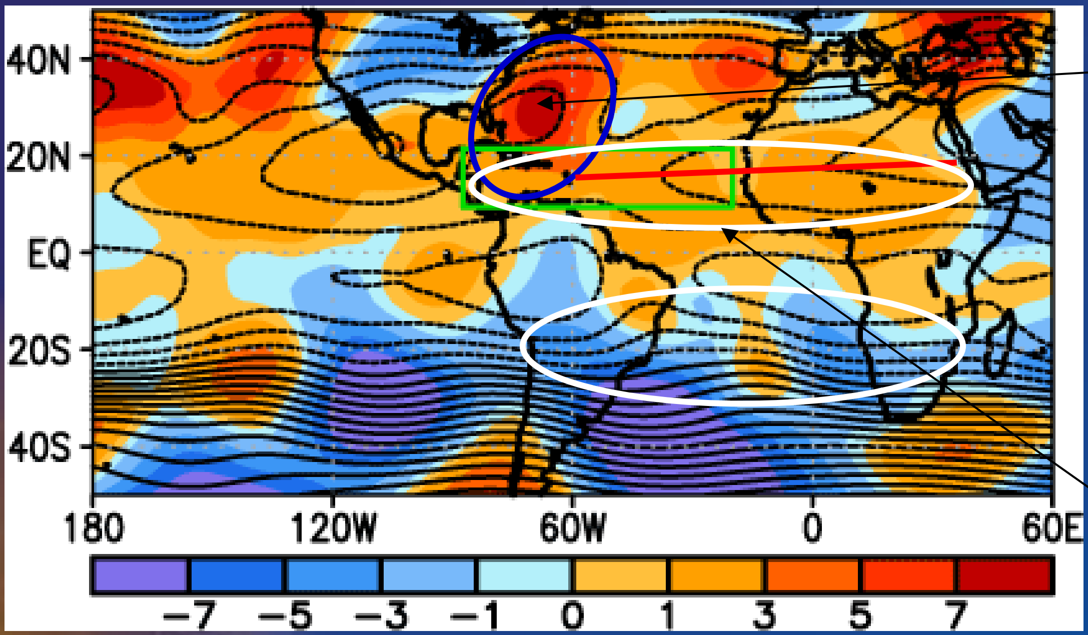
Exceptionally weak shear in western portion of basin typifies extremely active seasons.

The most anomalously weak shear extended across the Caribbean Sea.



The vertical wind shear in the western portions of the MDR and subtropical North Atlantic was comparable to the weakest on record.

Aug-Sep 2017: 200-hPa Streamfunction



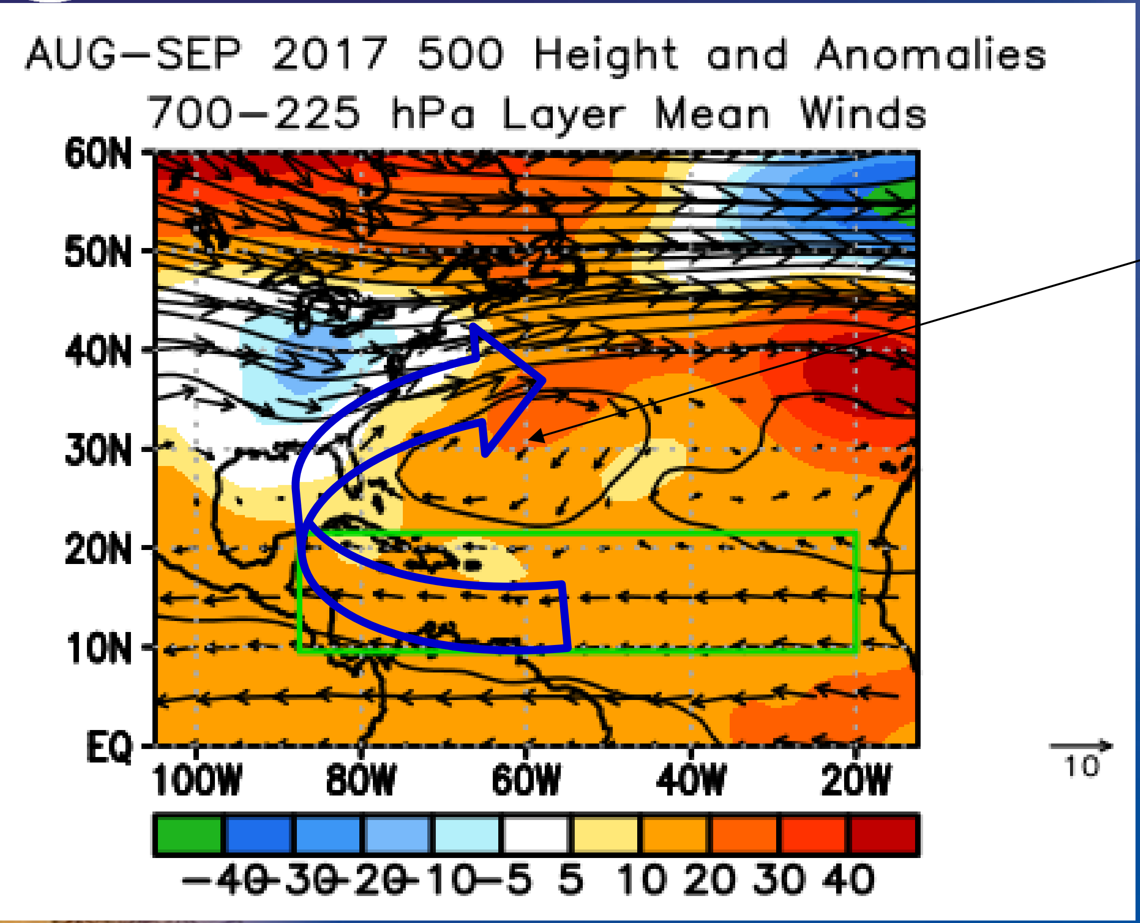
- Strong ridge (instead of climatological trough) over western portion of hurricane basin produces extended area of weak vertical wind shear.
- Favors stronger hurricanes in western part of basin.
- Similar to 2003-2005 extremely active seasons.

- Ridge is part of larger-scale amplified subtropical ridge extending to eastern Africa.

Amplified upper-level subtropical ridges in both hemispheres typify extremely active seasons.

This inter-hemispheric symmetry indicates that the local circulation anomalies within MDR are associated with a **much large-scale signal** (Typical of stronger west African monsoon system and warm phase of AMO) (Bell and Chelliah 2006).

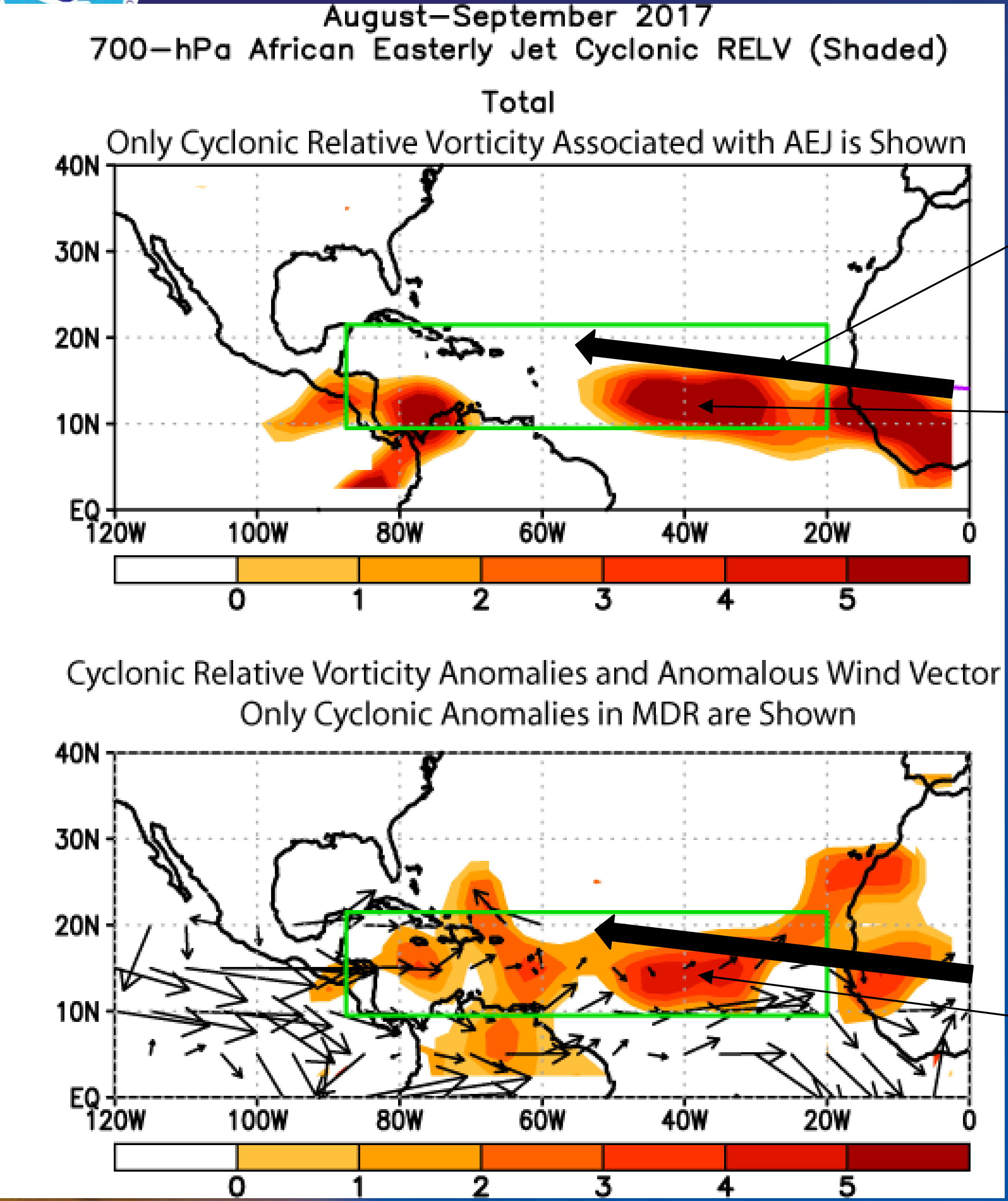
Aug-Sep 2017: 500-hPa Heights and Steering Winds



Strong Ridge

Steering current typical of seasons with multiple U.S. hurricane landfalls.

Aug-Sep 2017: Trade Winds and African Easterly Jet Typify an Active Season



African Easterly Jet (AEJ) shifted north of normal.

Strong cyclonic relative vorticity along equatorward flank of AEJ extends well northward across eastern half of MDR.

Weaker trade winds (westerly anomalies) across southern MDR result in enhanced cyclonic relative vorticity along equatorward flank of AEJ.

Summary

NOAA correctly predicted the overall set of conditions within the MDR during 2017, and also correctly anticipated the potential for an extremely active season.

NOAA under-predicted the extreme duration of some major hurricanes (Predicted ACE was too low).

The extreme MH durations are linked directly to very strong and persistent ridge in western portion of Atlantic hurricane basin (similar to 2003-2005), which is superimposed on warm AMO conditions.

The strength and persistence of that ridge is generally not predictable in the absence of La Niña.

Very challenging to correctly predict major hurricane intensities and duration, which are key components of a seasonal hurricane outlook.

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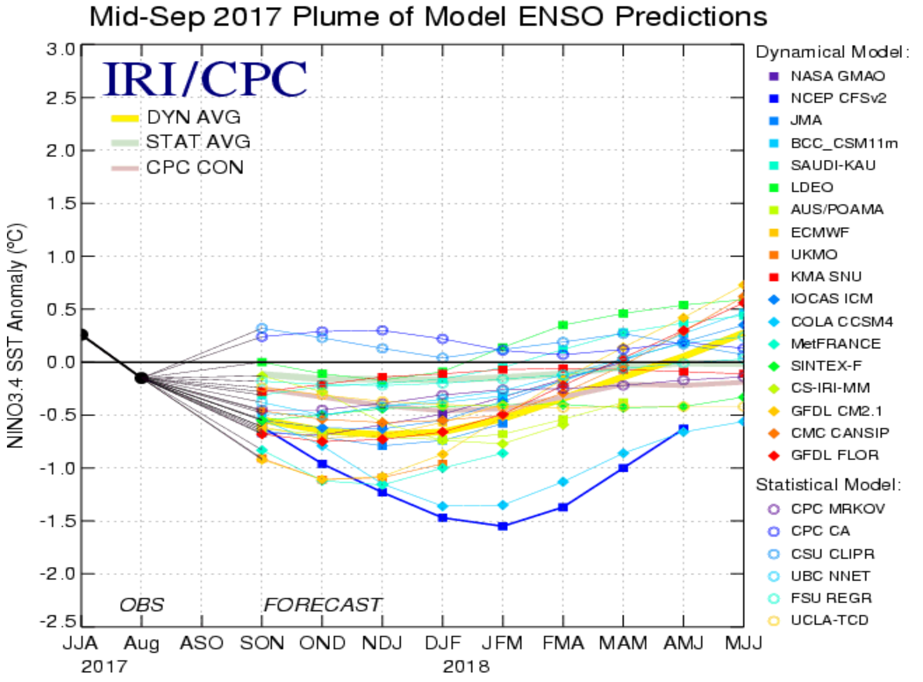
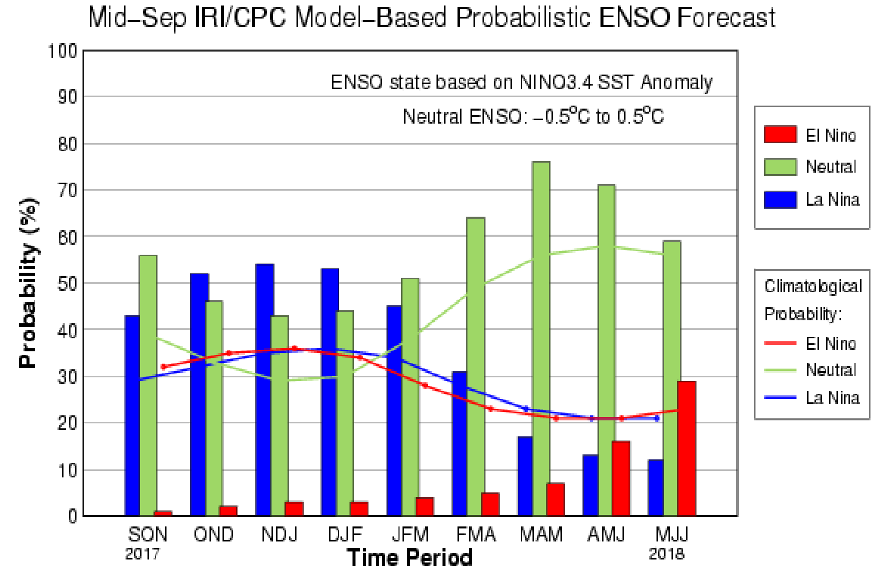
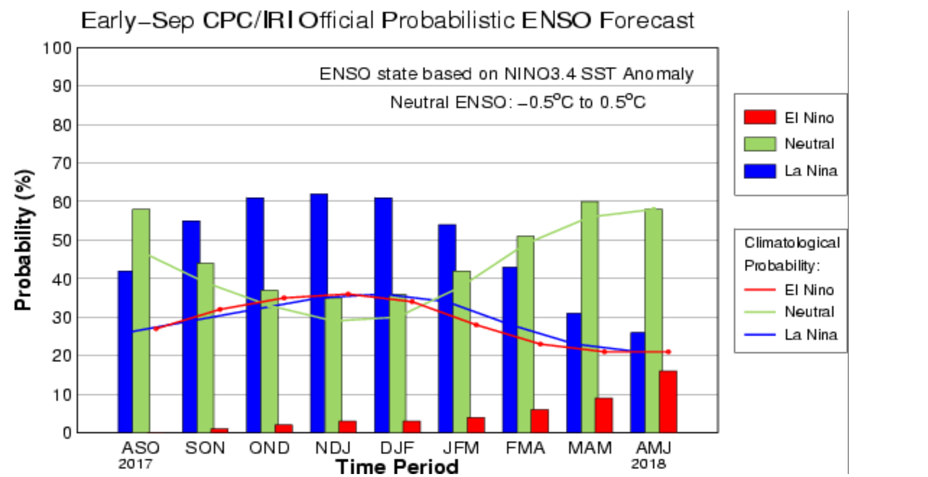
http://www.cpc.ncep.noaa.gov/products/hurricane/

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum



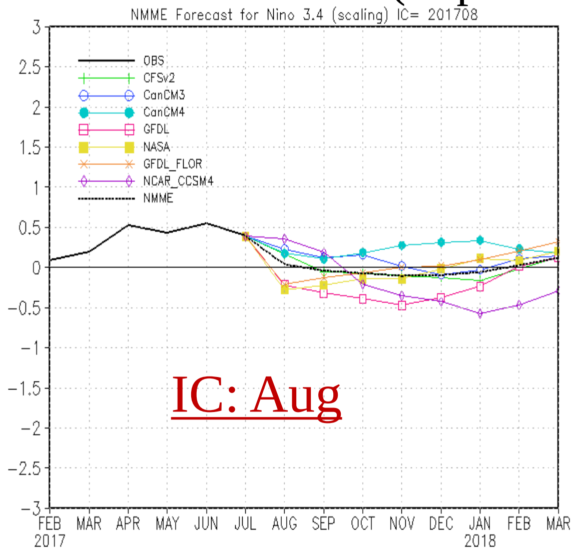


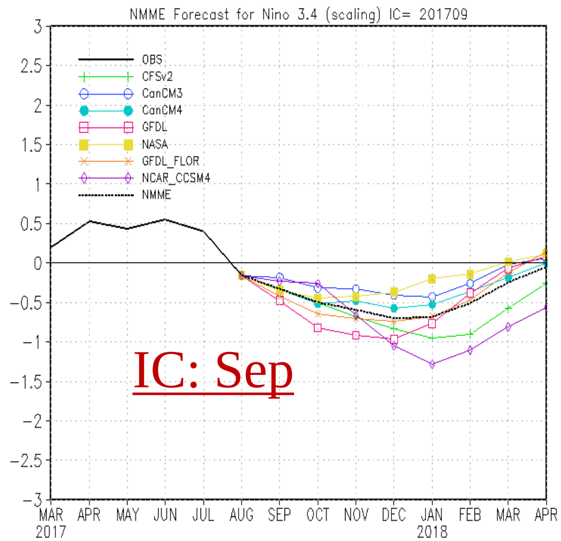


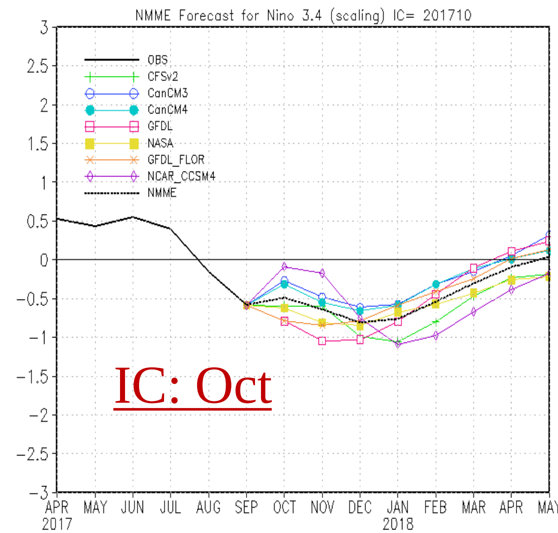
- La Niña is favored (~55%-60%) during the Northern Hemisphere fall and winter 2017-18.

NMME Model Predictions

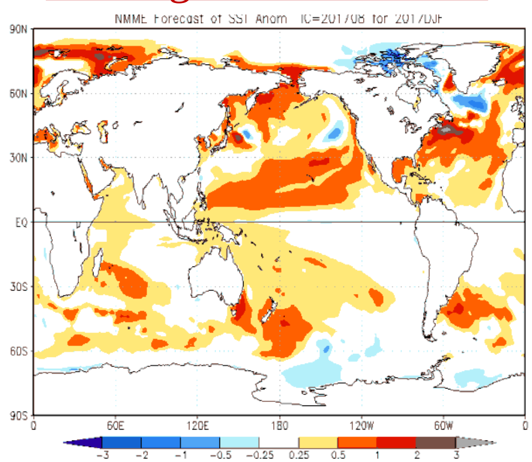
(http://www.cpc.ncep.noaa.gov/products/NMME/)



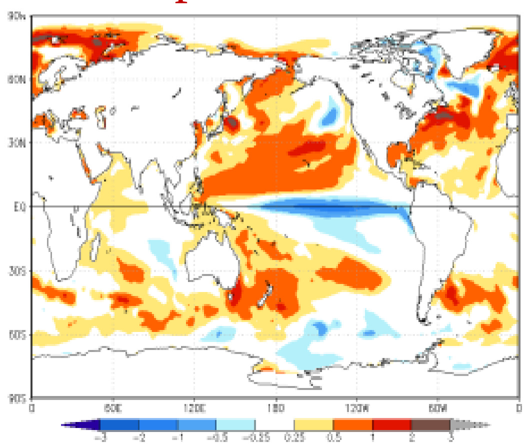




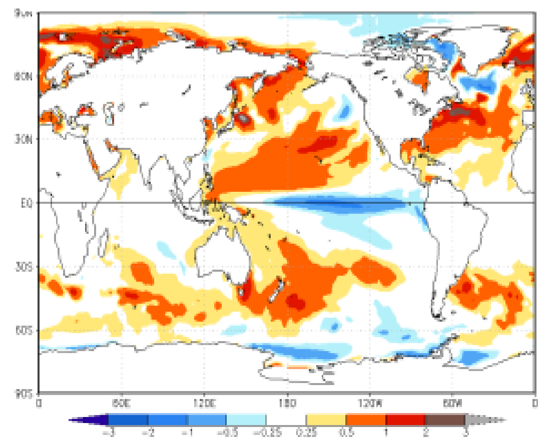
IC: Aug For 2017 DJF



IC: Sep For 2017 DJF

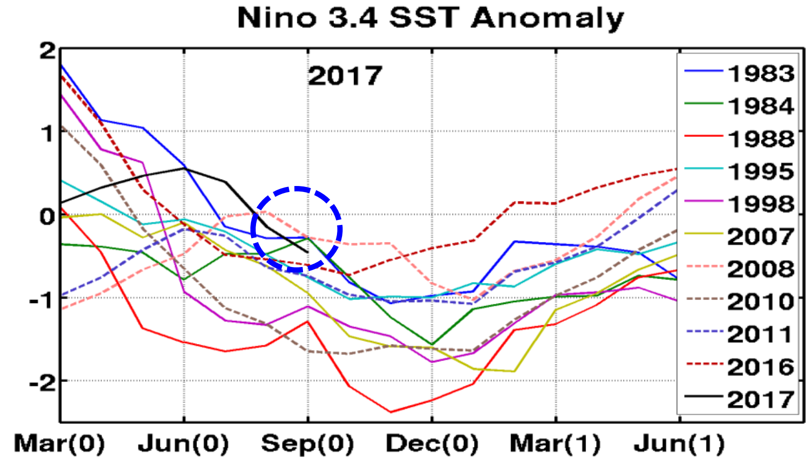


IC: Oct For 2017 DJF

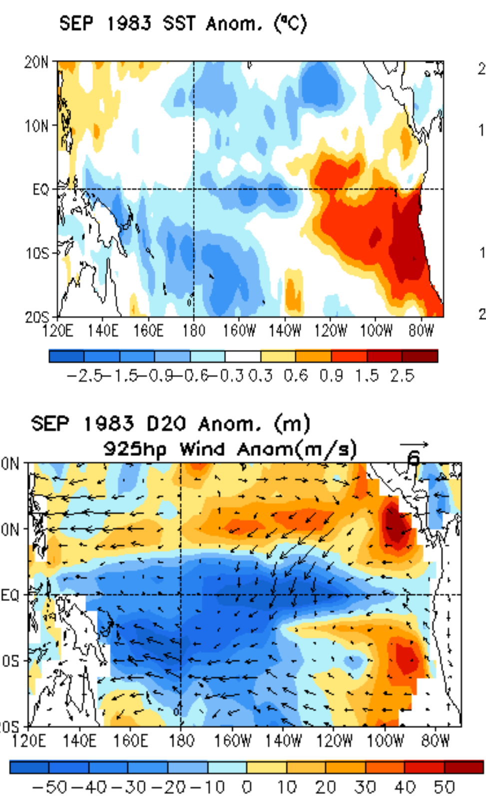


- Latest NMME ensemble mean forecast (black dash line) favors boundary La Nina condition in winter 2017/18.

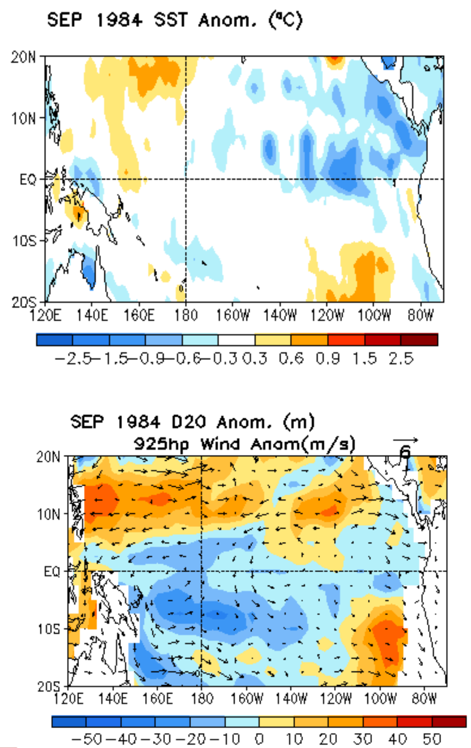
SST,D20 and 925hp Wind anomalies in September



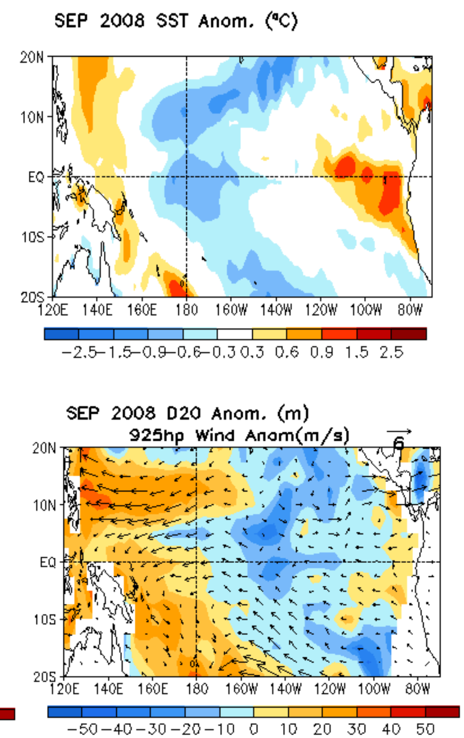
1983



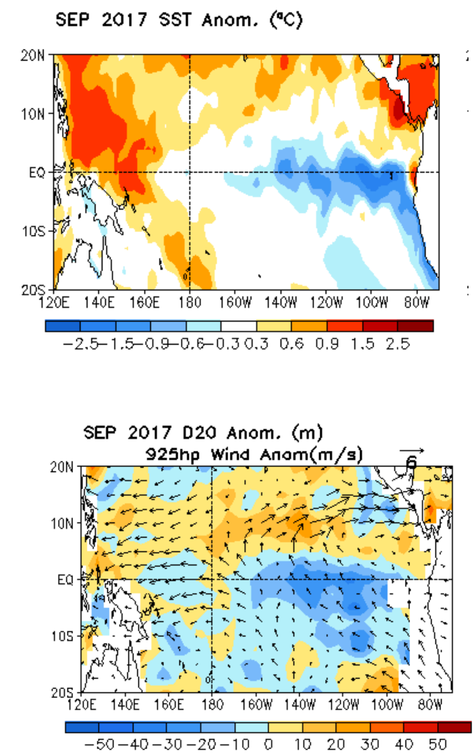
1984



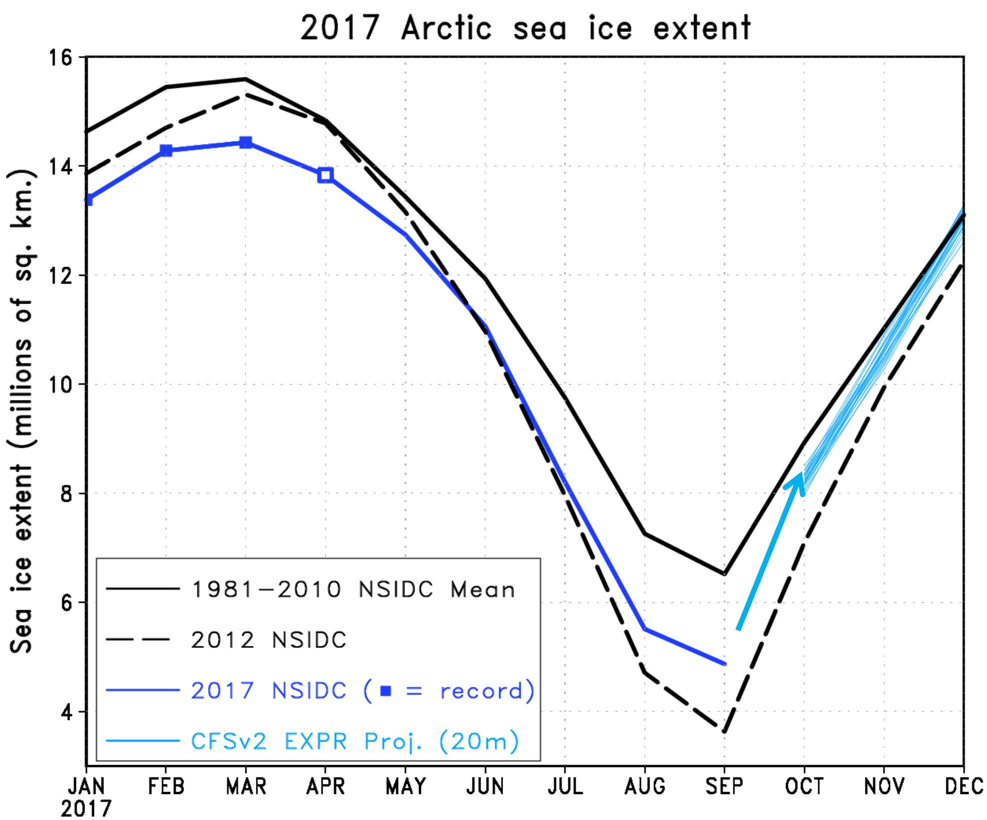
2008

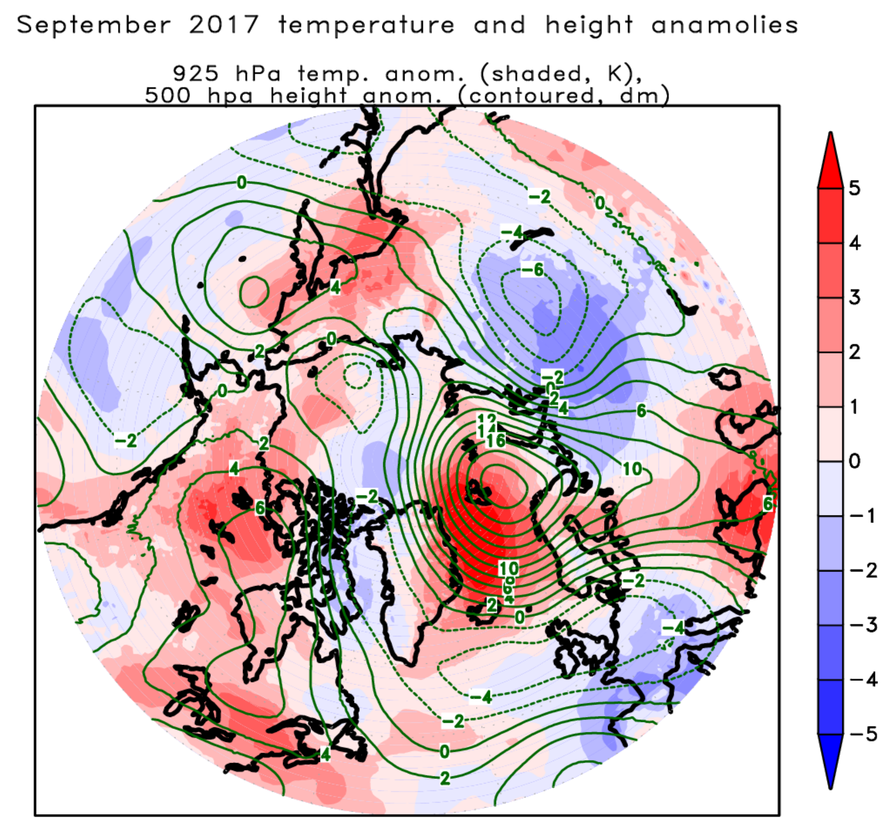


2017



Experimental CFSv2 forecast



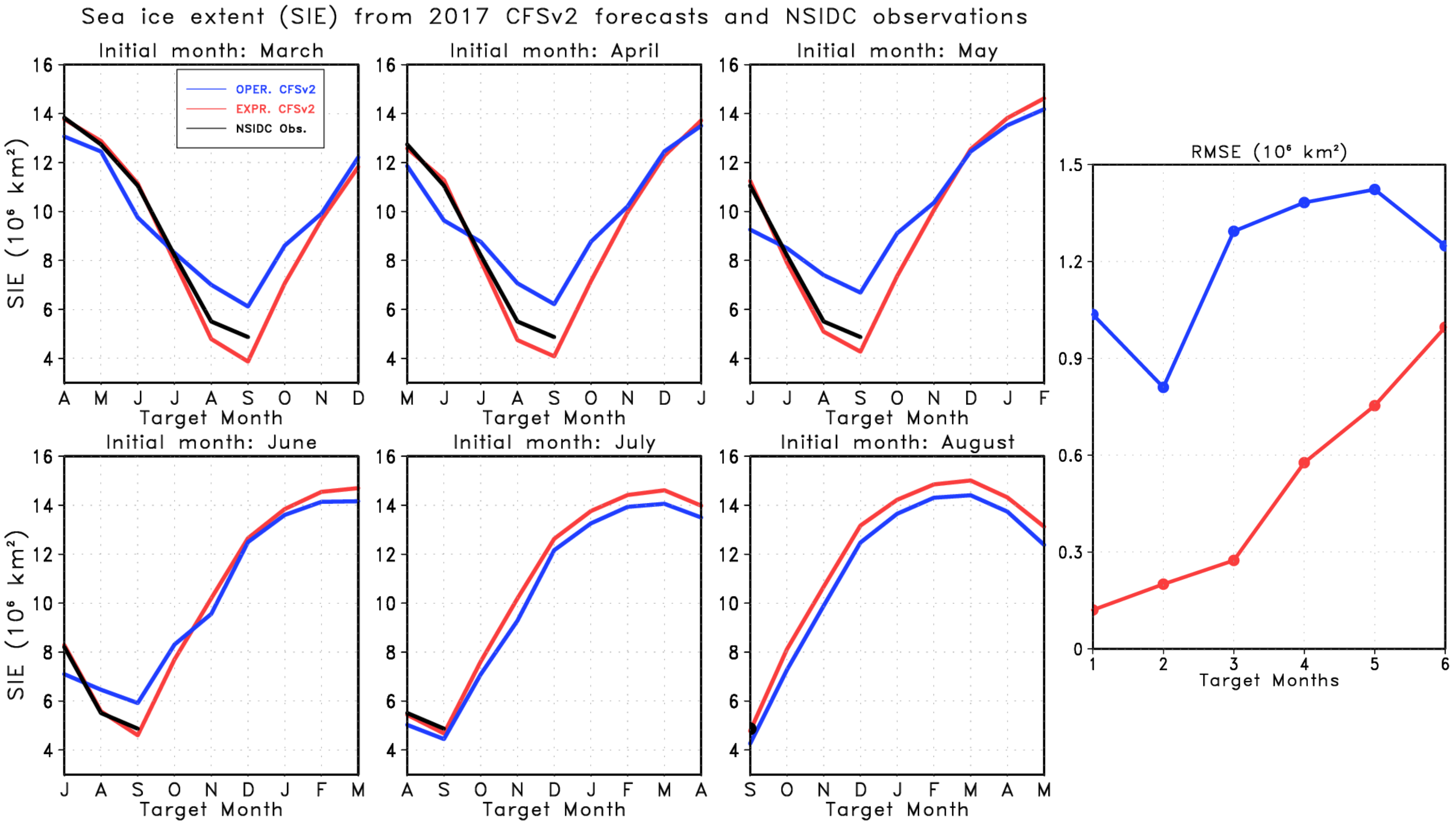


-Arctic sea ice extent for September was <u>4.87 million km^2</u> making it 7th lowest in the satellite record extending back to 1979. The SIE value was slightly higher than in 2015 and 2016.

-Near neutral temperature anomalies existed in the Central Arctic Ocean with warm anomalies surrounding, particularly in the North Atlantic Ocean and Chukchi Sea.

-Experimental CFSv2 forecast shows sea ice extent to remain below the 1981-2010 average for the next 3 months.

(Courtesy of Thomas Collow)



-**Ensemble means of experimental and operational CFSv2 SIE forecasts are plotted.**

-**Experimental CFSv2 forecasts had more skill than the operational, even at longer lead times (For RMSE, only the March forecast is considered for lead time=6). Experimental performed much better at shorter leads.**

Acknowledgements

- Drs. Yan Xue ,Zeng-Zhen Hu and Arun Kumar: reviewed PPT, and provided insight and constructive suggestions and comments
- Dr. Gerry Bell provided 2017 Atlantic Hurricane briefing
- Drs. Li Ren and Pingping Xie: Provided SSS slides
- Drs. Thomas Collow and Wanqiu Wang: Provided sea ice prediction slides
- Dr. Emily Becker provided NMME plots

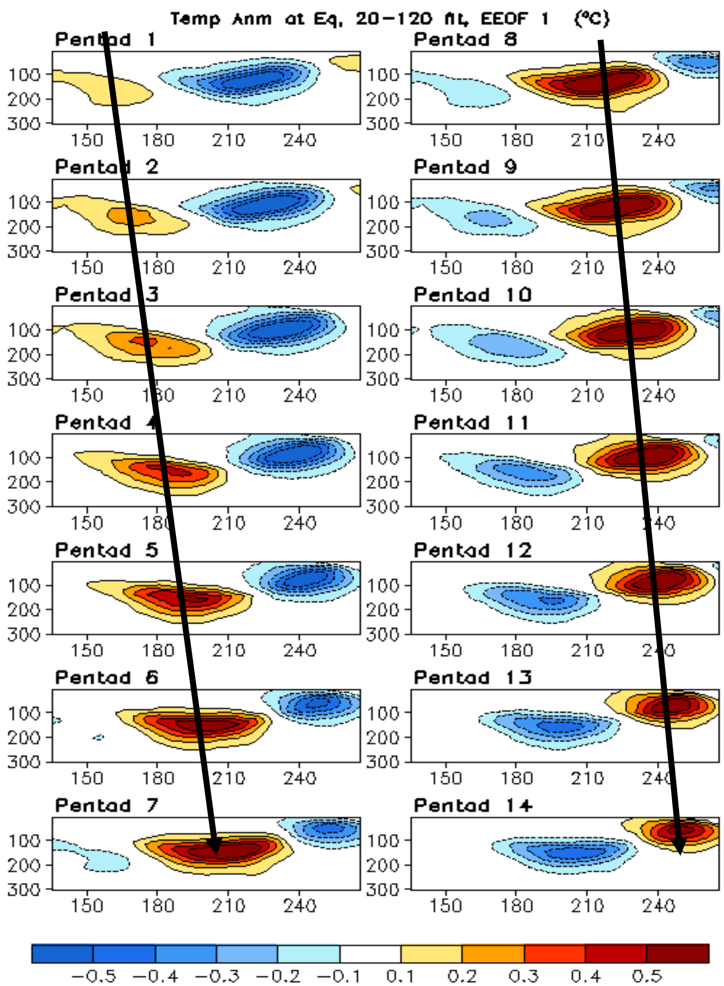
Data Sources and References

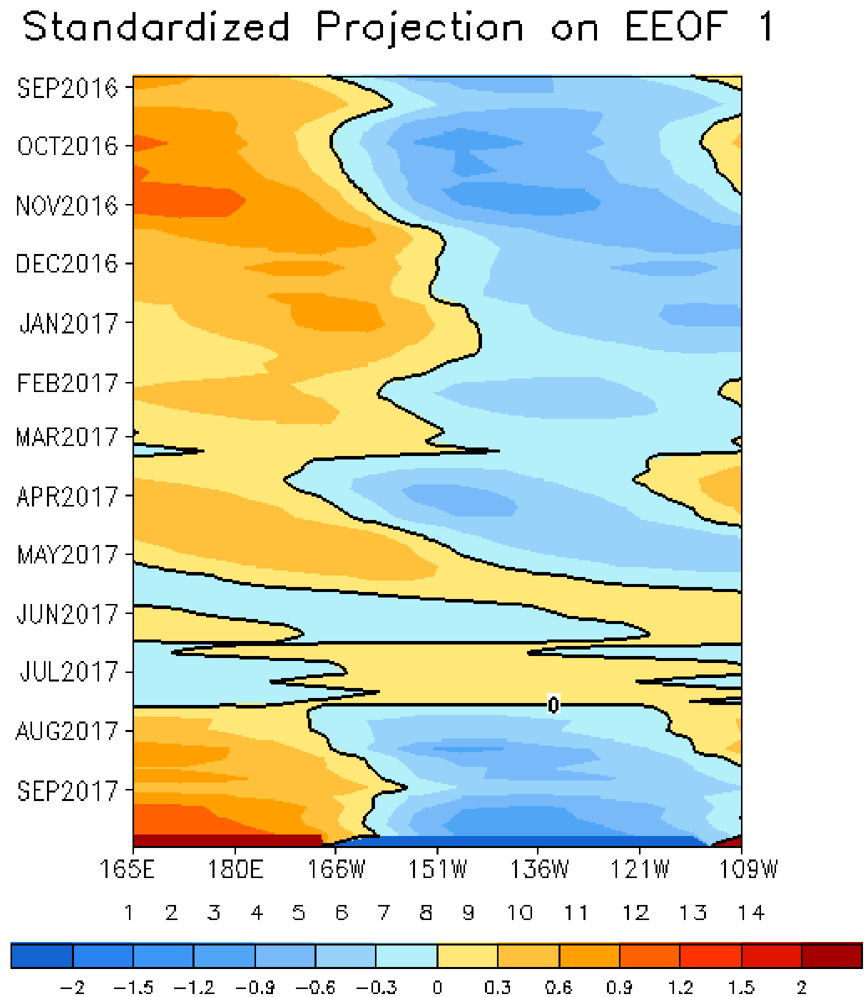
- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **NCEP CDAS winds, surface radiation and heat fluxes**
- **NESDIS Outgoing Long-wave Radiation**
- **NDBC TAO data (http://tao.ndbc.noaa.gov)**
- **PMEL TAO equatorial temperature analysis**
- **NCEP's Global Ocean Data Assimilation 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

Oceanic Kelvin Wave (OKW) Index

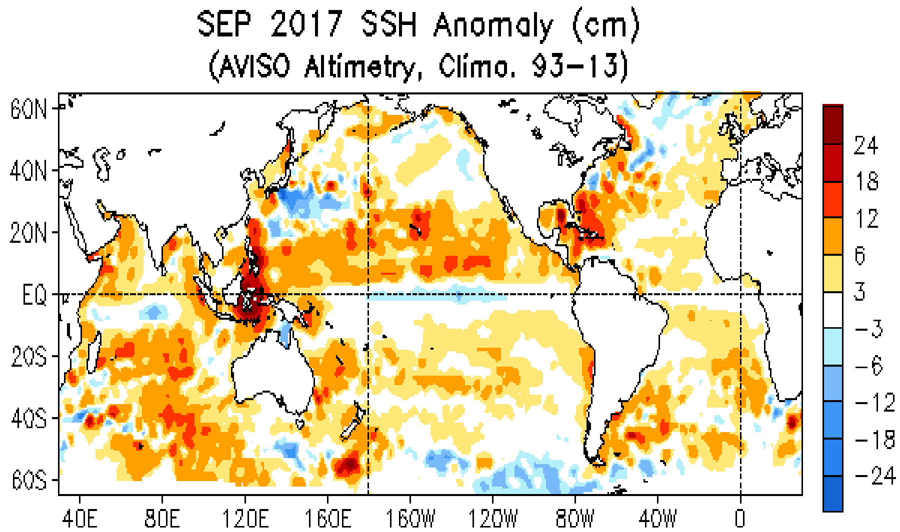


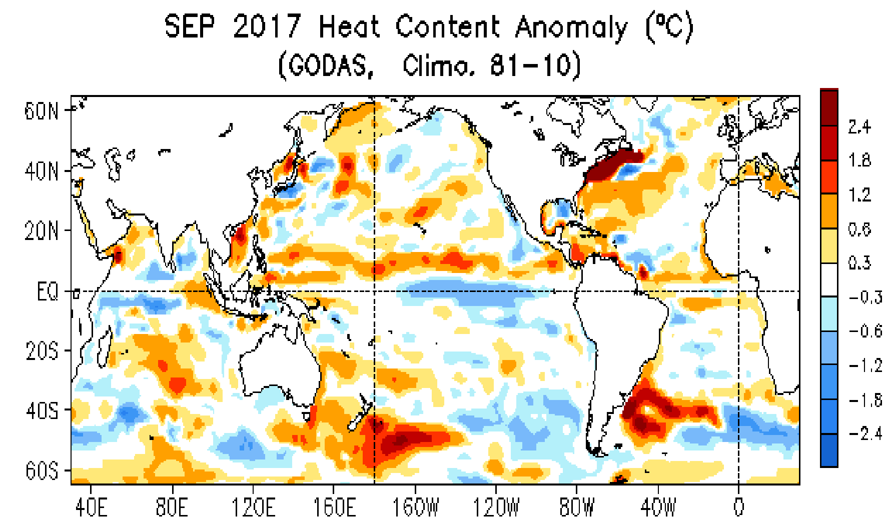


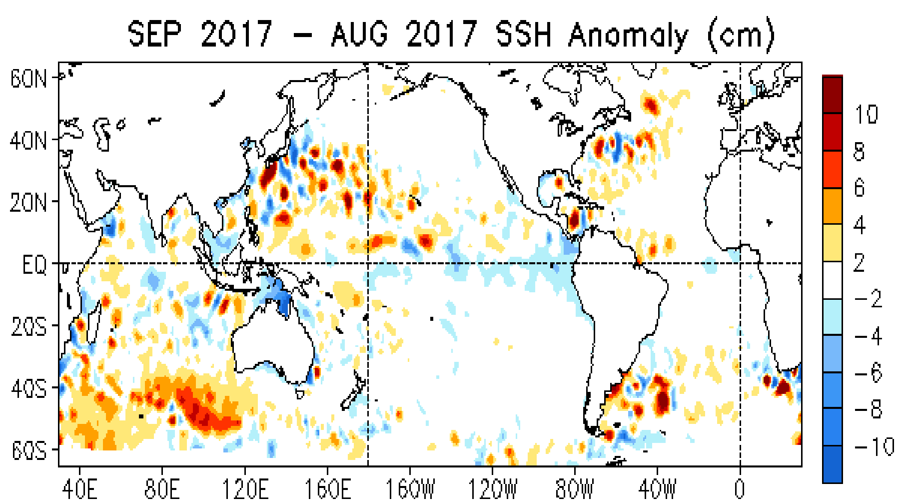
- An upwelling OKW emerged around 166w-151W in late July and propagated to the eastern Pacific during Aug 2017.

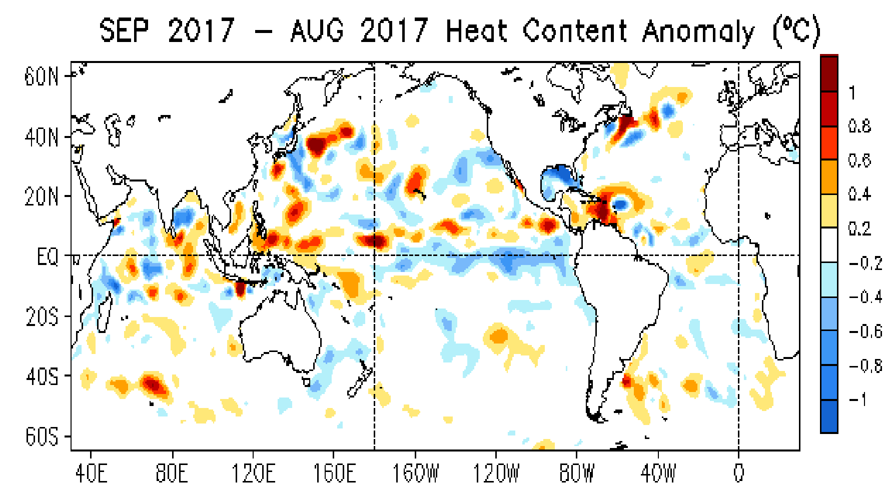
- *(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)*

Global SSH and HC300 Anomaly & Anomaly Tendency









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

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

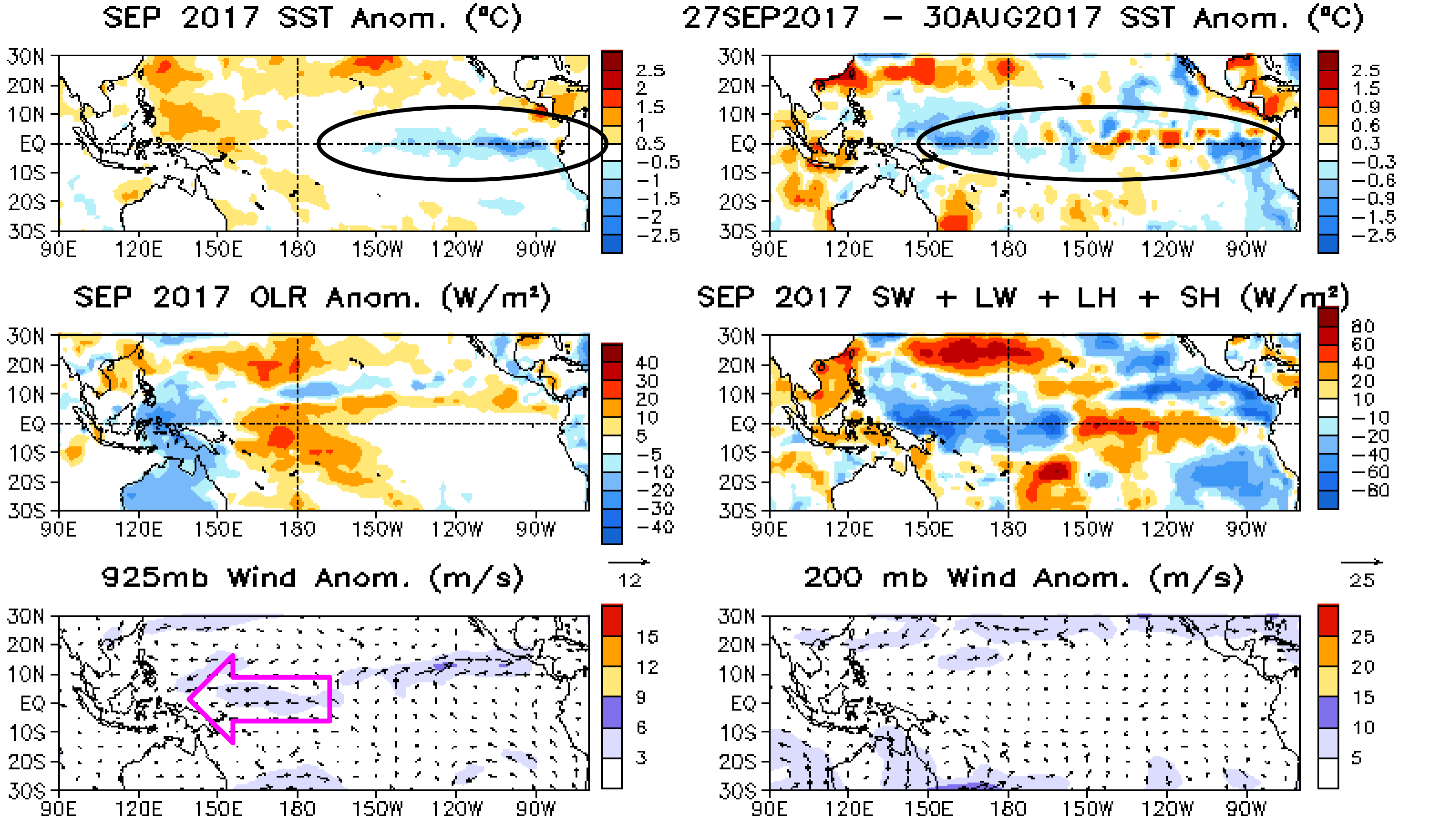
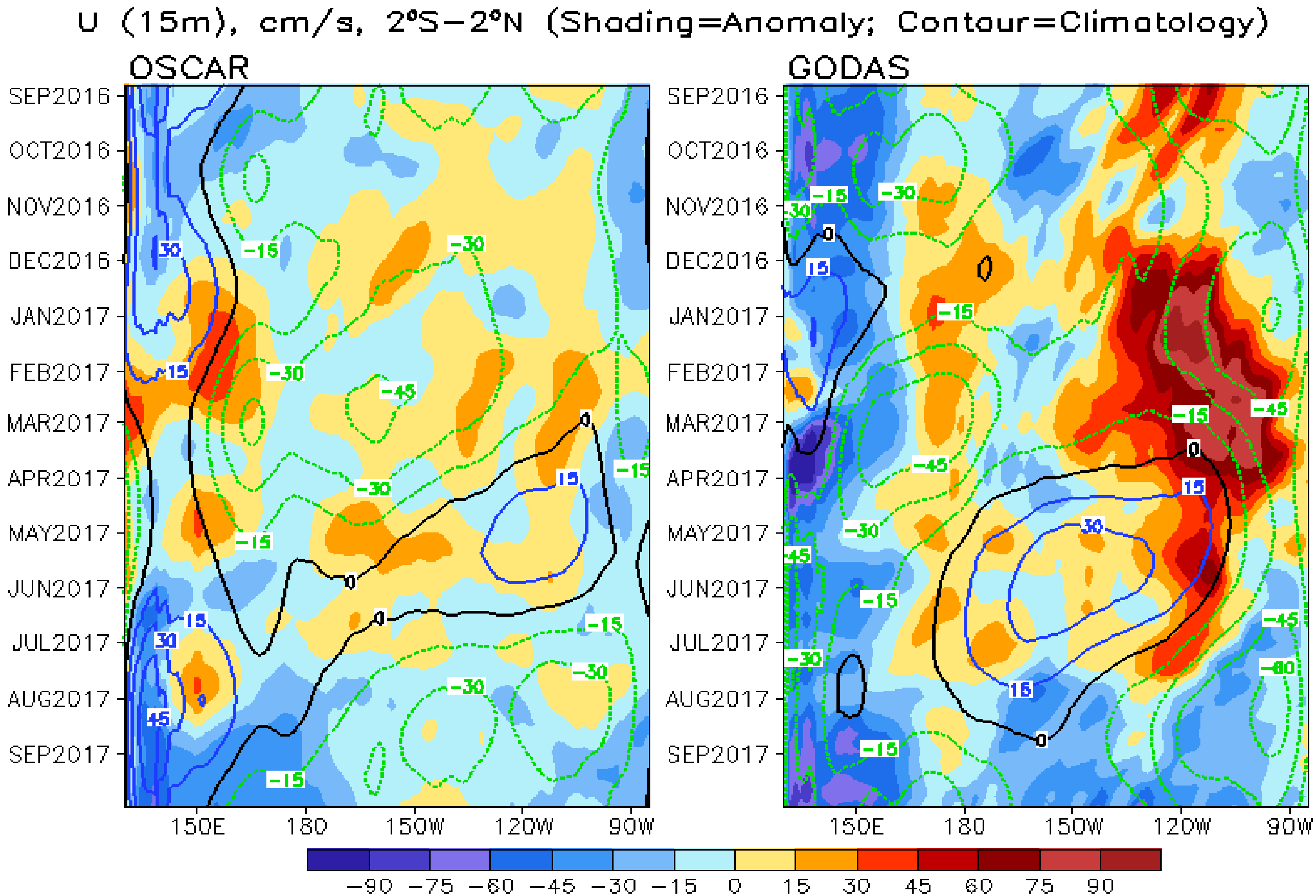
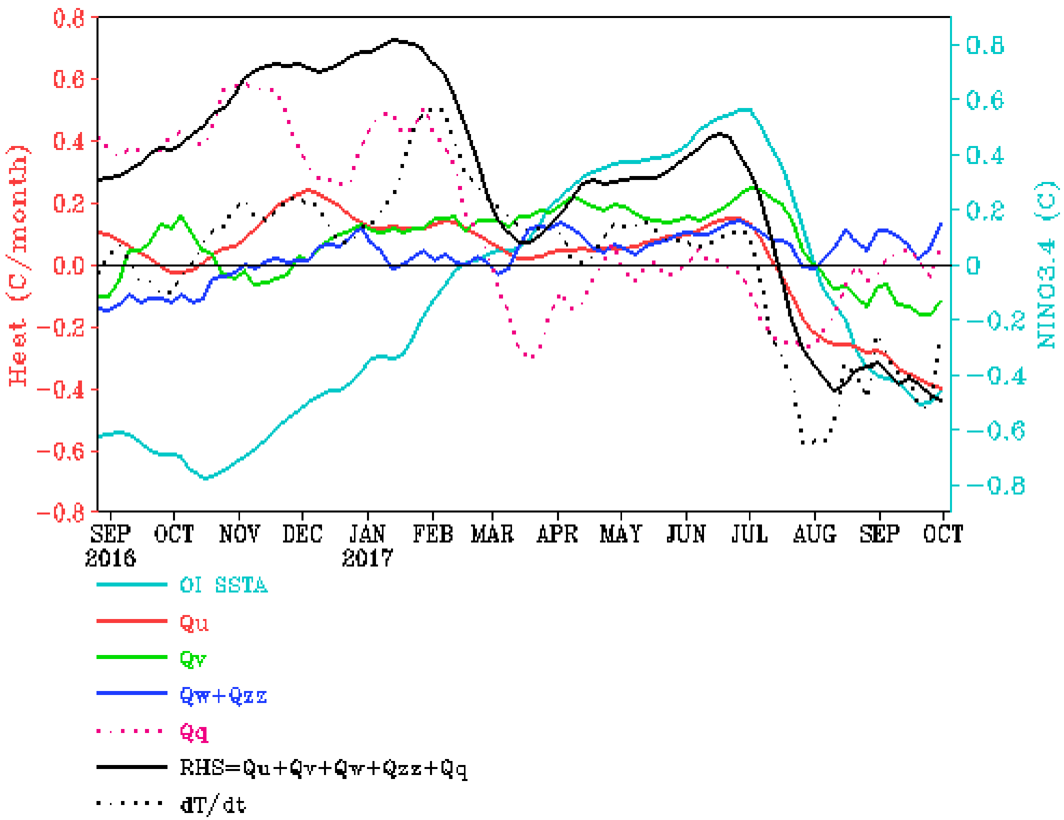


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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



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.

- Zonal advection Qu and meridional advection Qv were the major factors contributing to the negative SSTA tendency.

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

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

- **Positive SSTA dominated in the tropical Indian Ocean.**
- **SSTA tendency was small in the tropics, which may not be mainly determined by heat flux anomalies.**

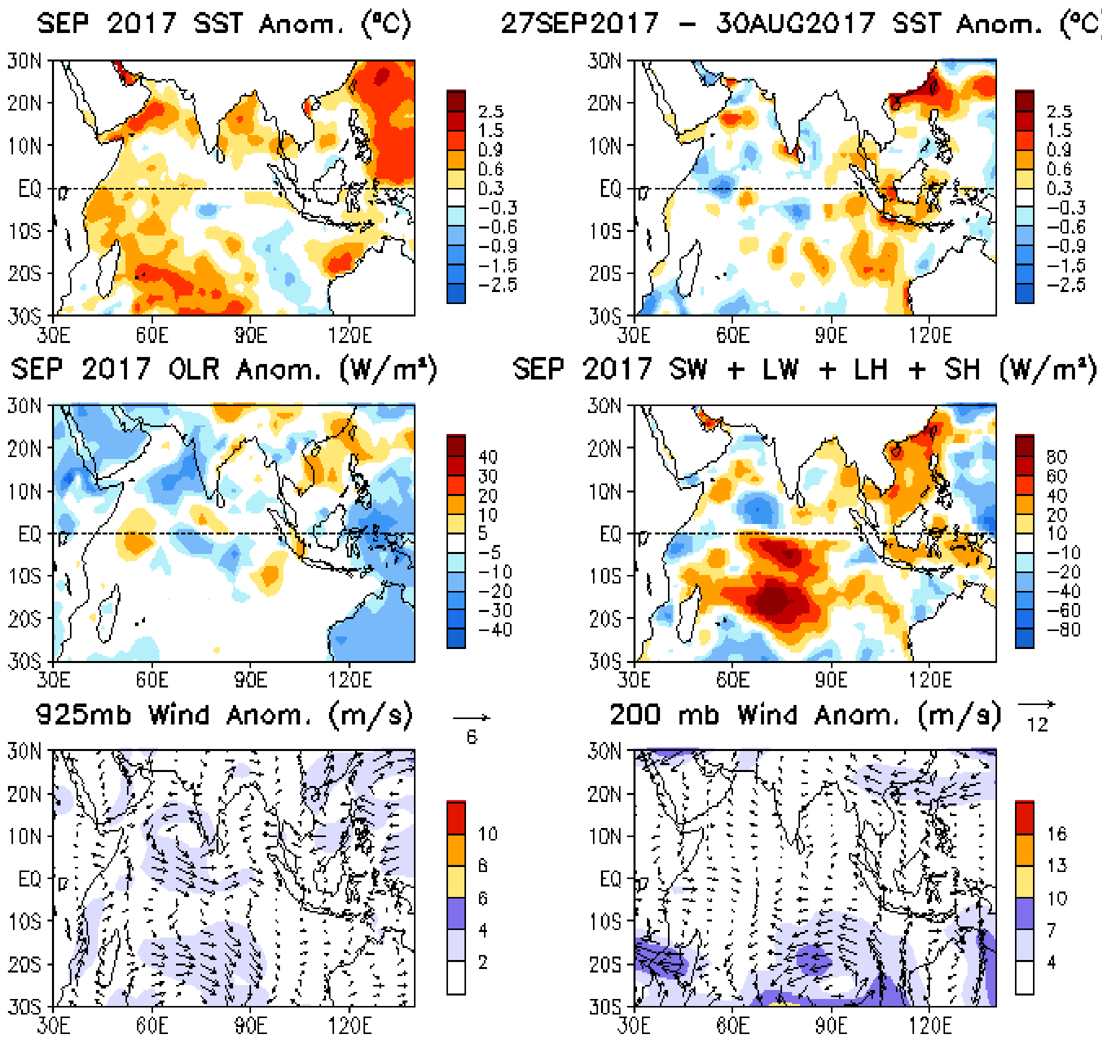
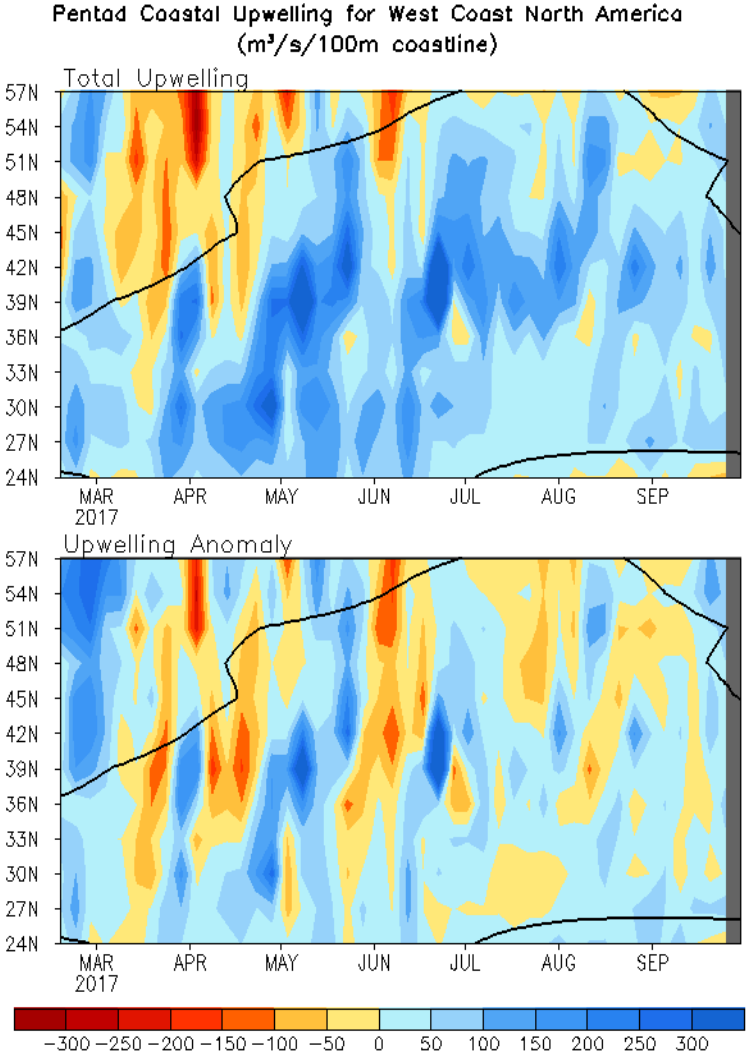
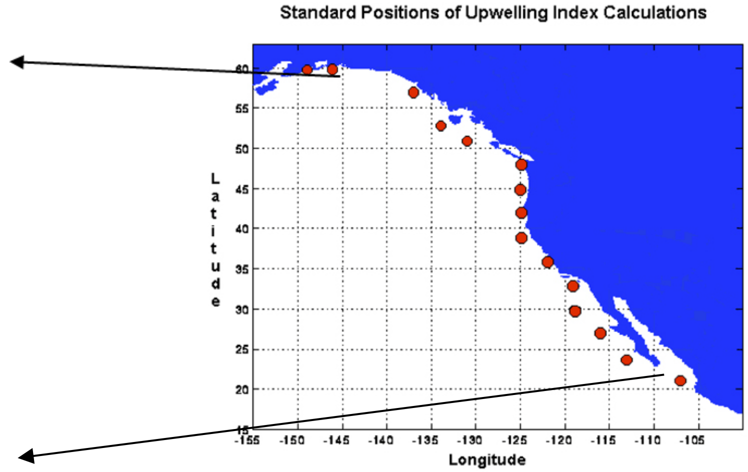


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

North America Western Coastal Upwelling





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

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

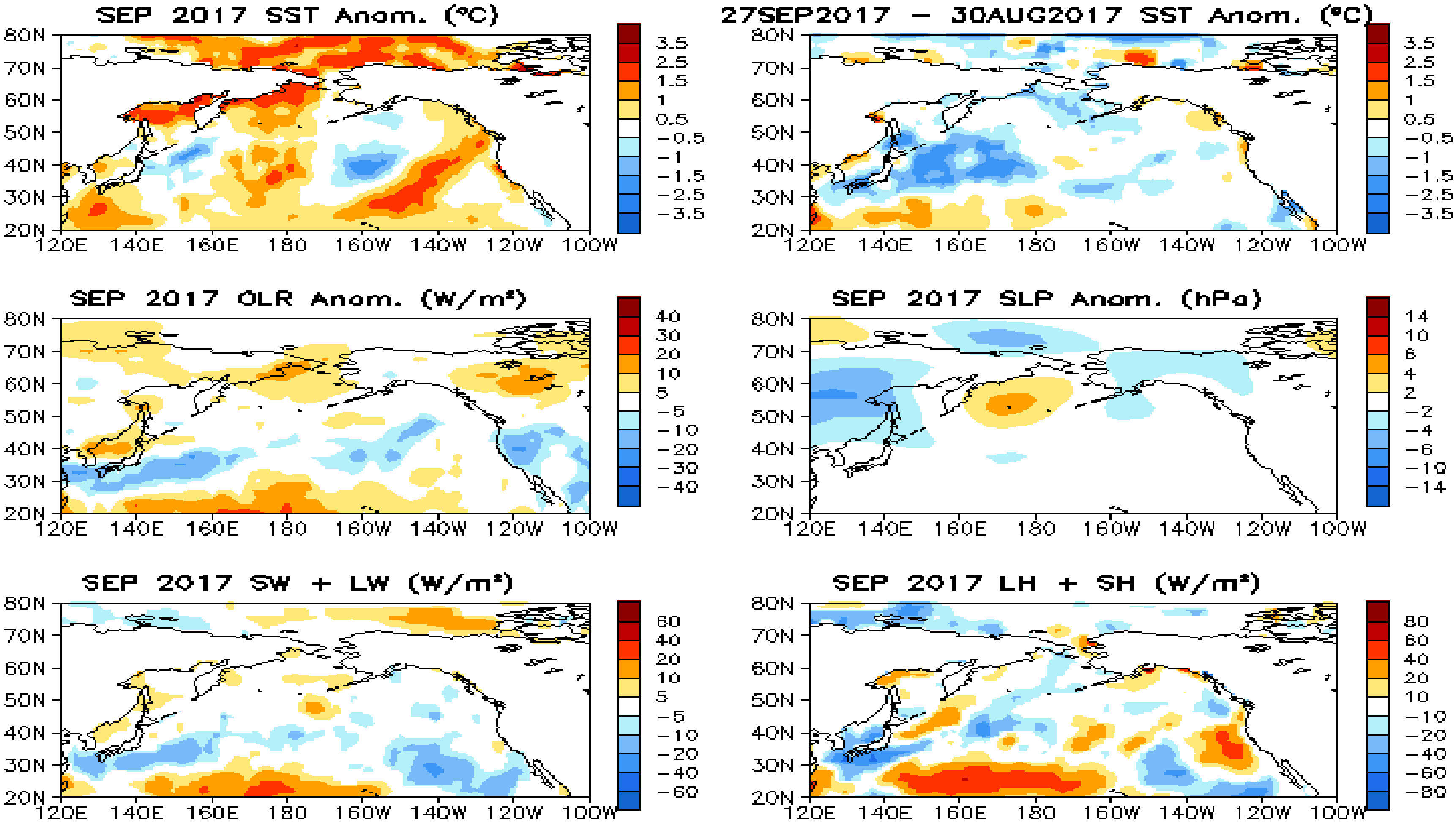
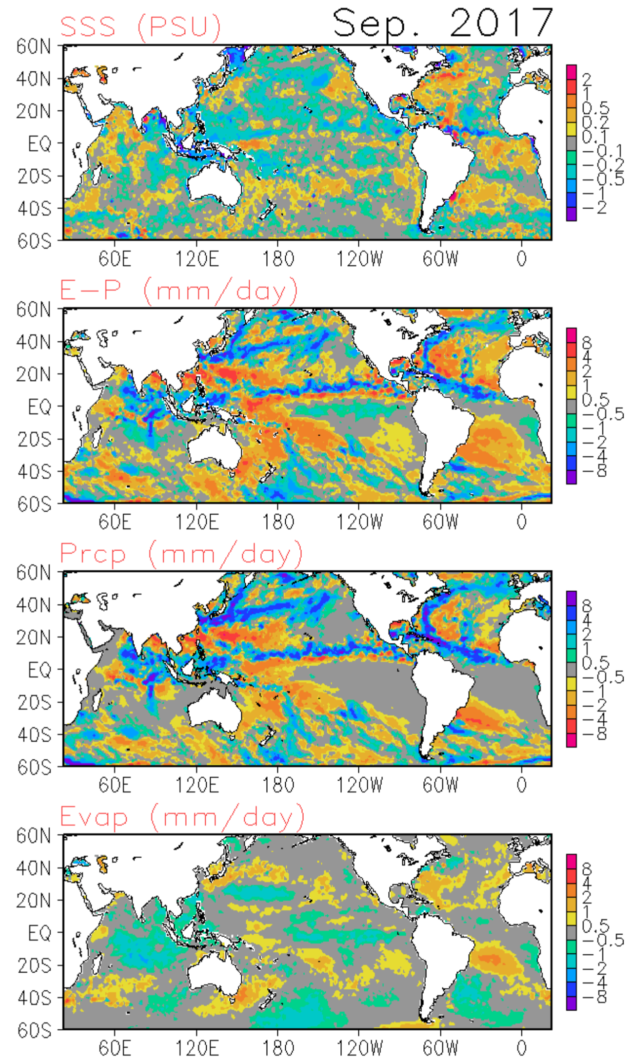


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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.

Global Sea Surface Salinity (SSS)

Anomaly for September 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 positive SSS anomaly in the western equatorial Pacific Ocean became stronger, which is co-incident with reduced precipitation. A strong negative SSS appeared in the equatorial Atlantic Ocean, particularly in the west region extending north-west ward. Such strong anomalies accompany with heavy precipitation likely due to hurricane Irma. The negative SSS anomaly in the Sea of Okhotsk continues. The SSS anomaly in the north of Bay of Bengal changes to neutral or slightly negative although there is still less freshwater input in this region.



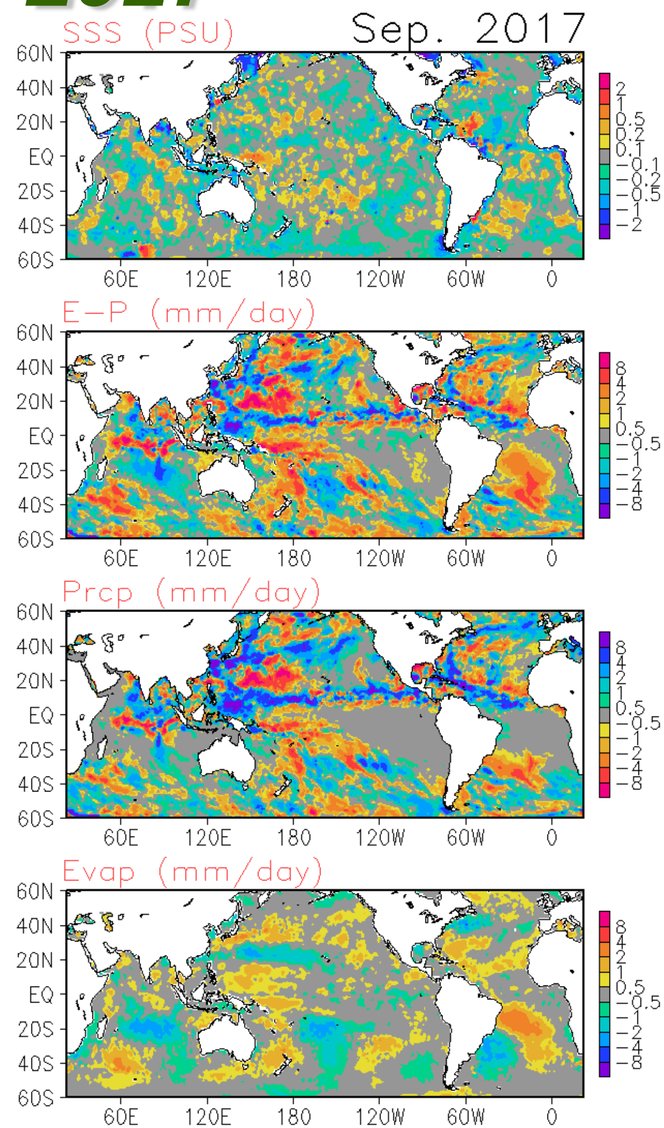
- **Data used**

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 September 2017

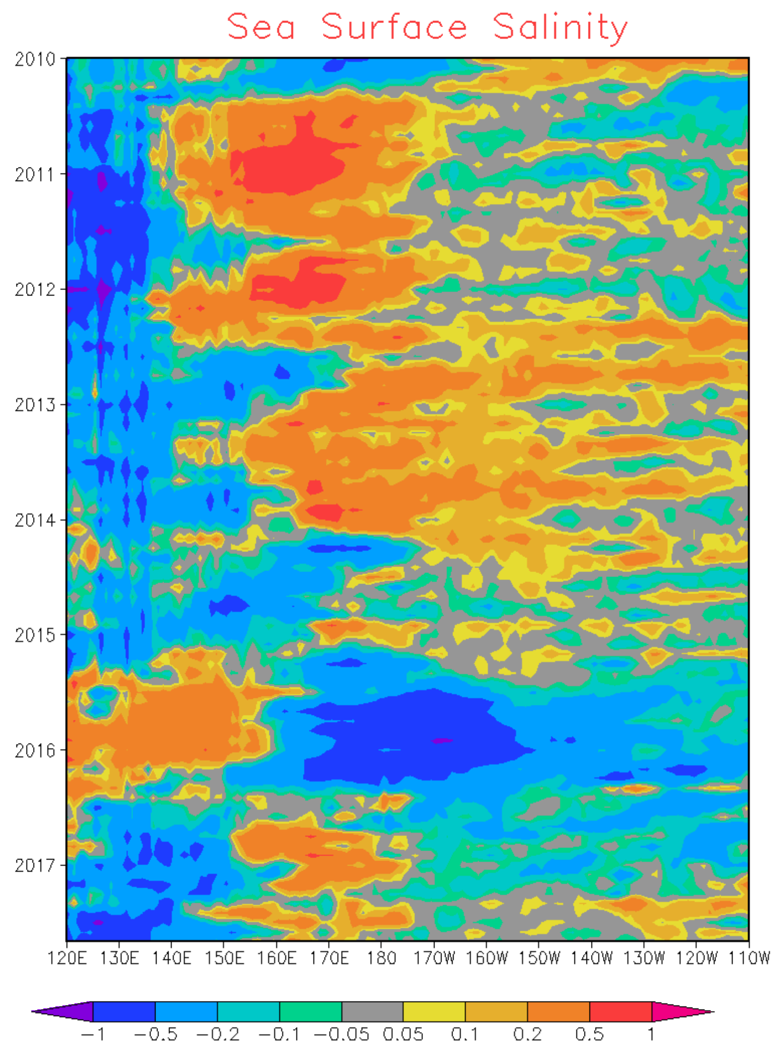
Compared with last month, the SSS in the north of Bay of Bengal significantly decreased with continuing less freshwater input indicating that ocean advection and/or mixing plays a dominant role for this change. The SSS in the west Equatorial Pacific Ocean is increasing with less precipitation. Large amount of precipitation along the path way of hurricane Irma in the equatorial Atlantic Ocean decreases the SSS in those regions. The SSS in the Sea of Okhotsk continues decreasing with not much freshwater change, which suggests that the ocean advection and/or mixing contributes to this change.



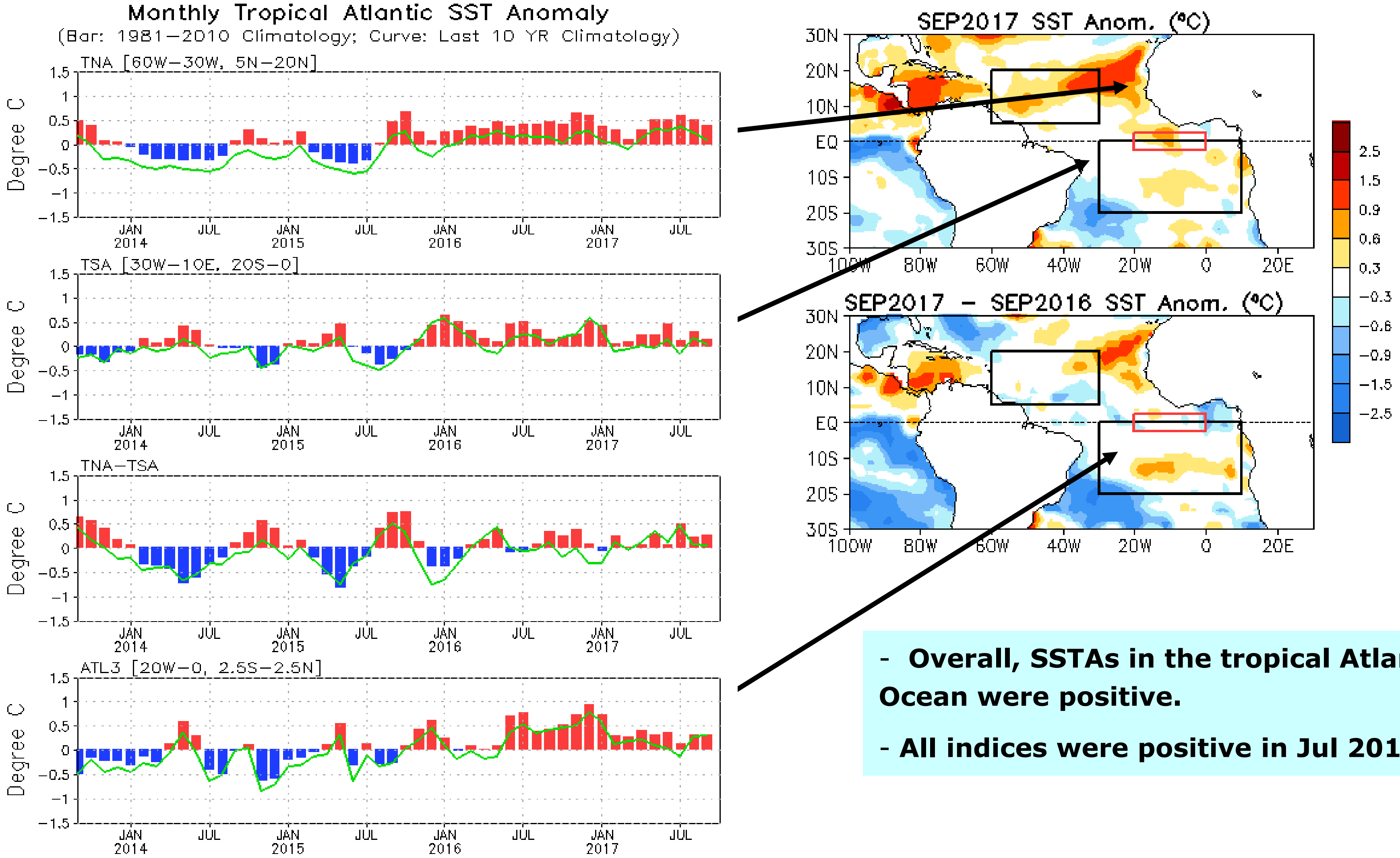
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

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 **(5˚S-5˚N);**
- In the western equatorial Pacific Ocean, from 120°E to 150°E, the strong negative SSS signal continues. The positive SSS anomaly signal between 150°E and 170°W is changing to be centered between 160°E and 180°W as the negative signal in the west was intruding to the east. Meanwhile, there are little change between 170°W and 140°W with positive SSS anomaly continuing in east of 130°W.



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 (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.

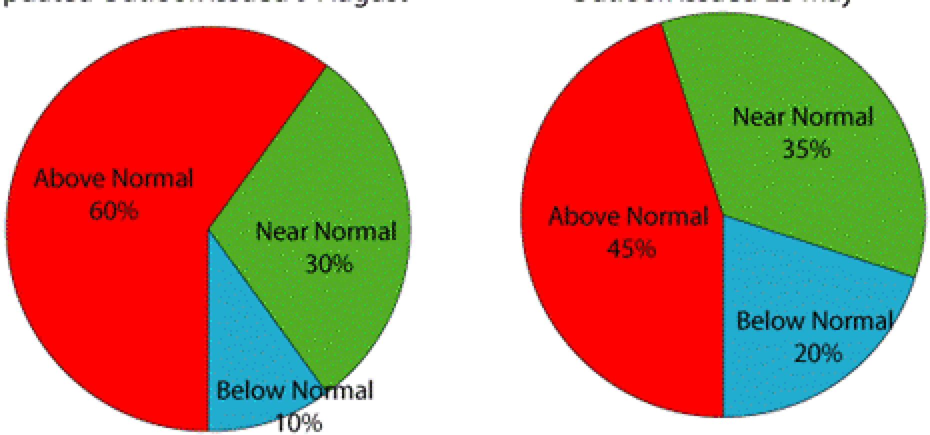
2017 Atlantic Hurricane Season

(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

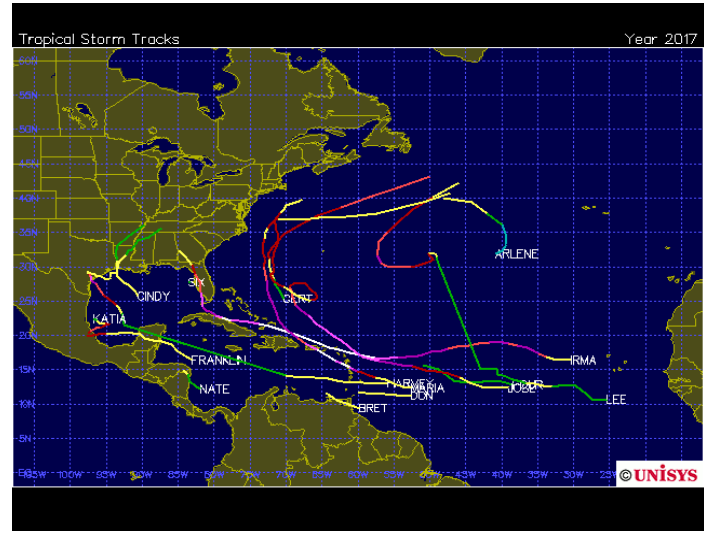
Probability of Season Type



Predicted Activity

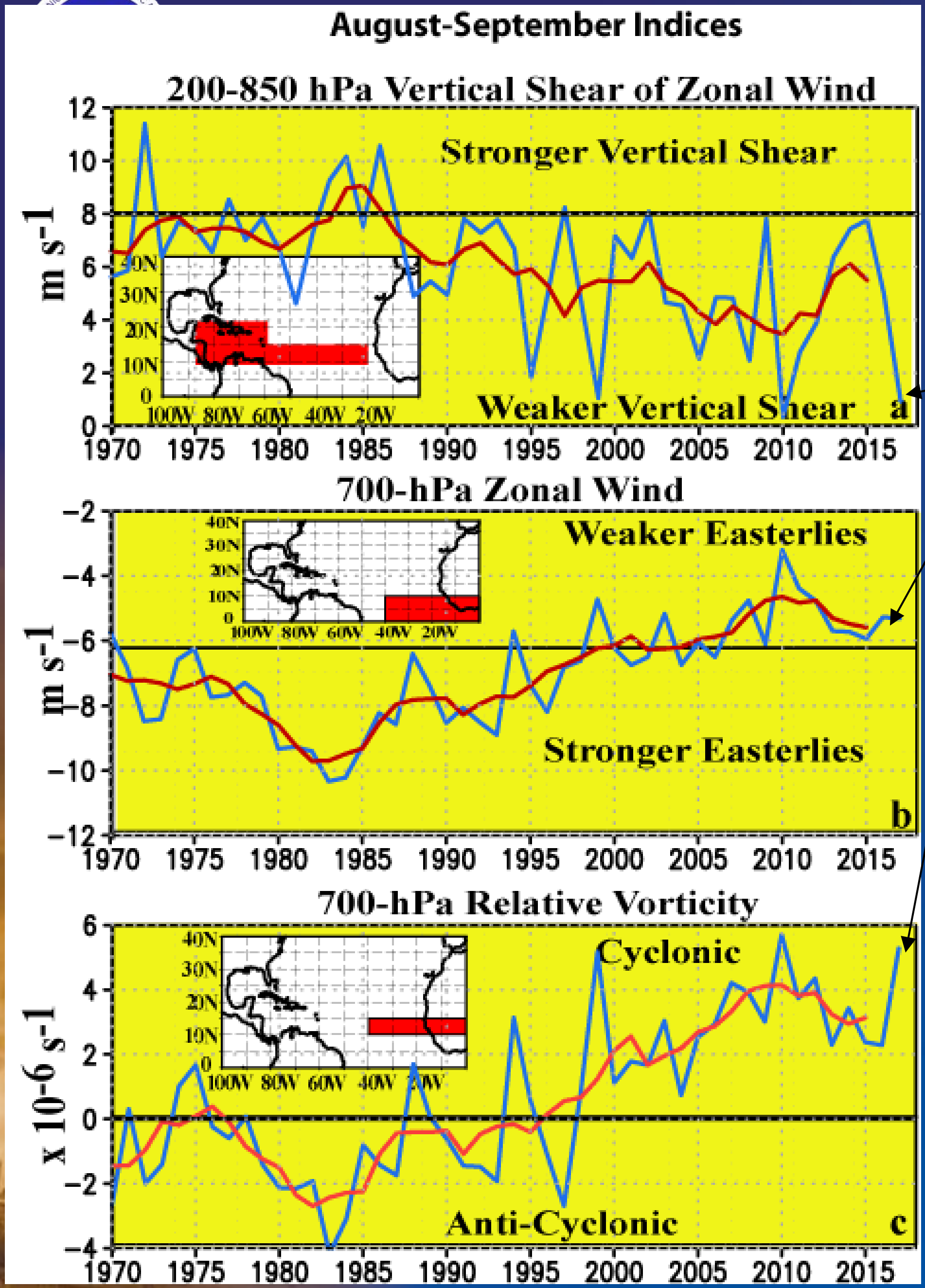
70% Probability For Each Range

	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%	



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

- Hurricane was very active in Sep 2017, with five Hurricanes (3 major hurricanes) formed in N. Atlantic.
- Fourteen tropical storms with 8 reaching hurricane category (5 major hurricane) formed in by Oct. 5.

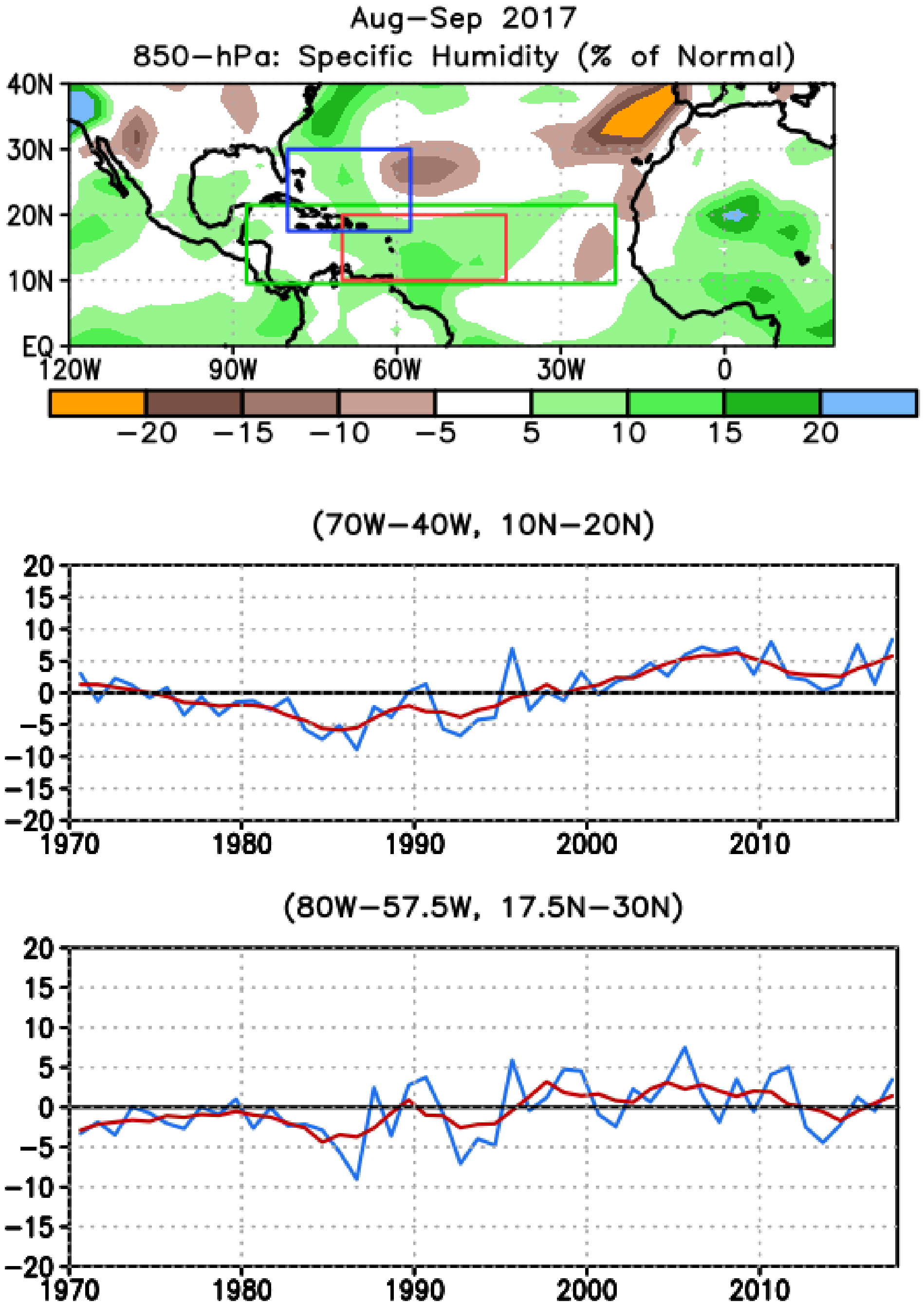


Aug-Sep 2017 featured:

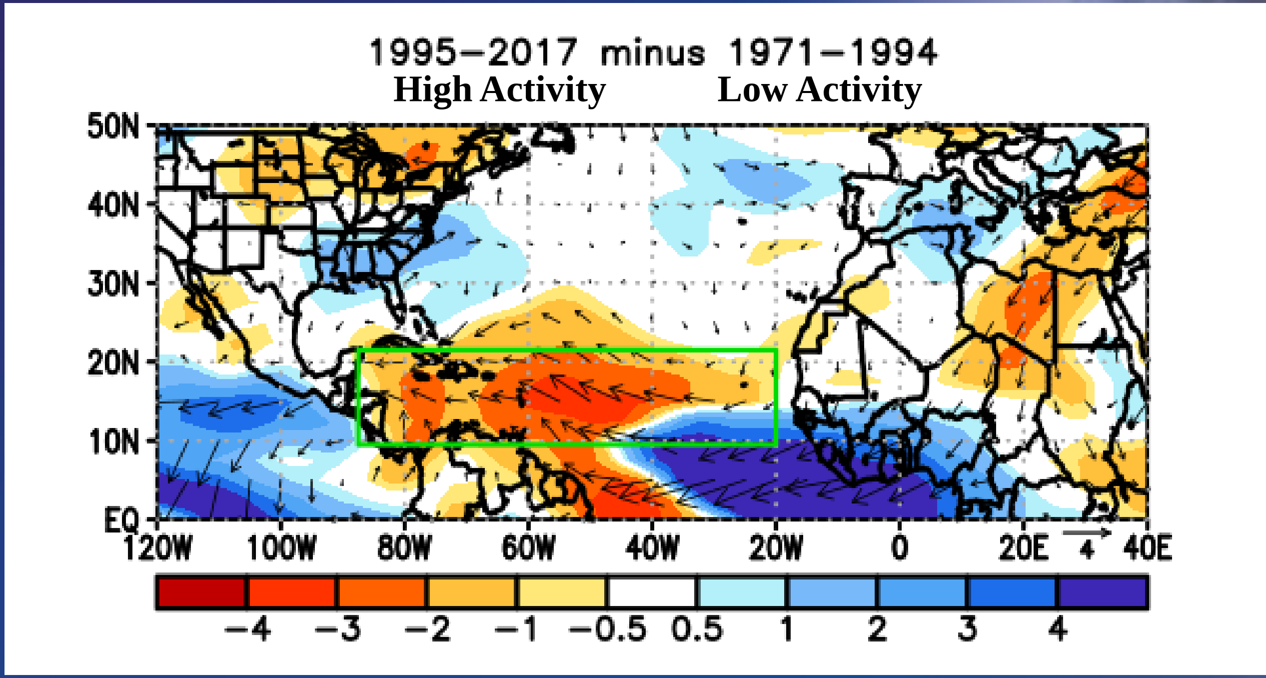
•Significantly weaker vertical shear of zonal wind

•Weaker easterly trade winds

•Strong cyclonic shear along equatorward flank of African Easterly Jet

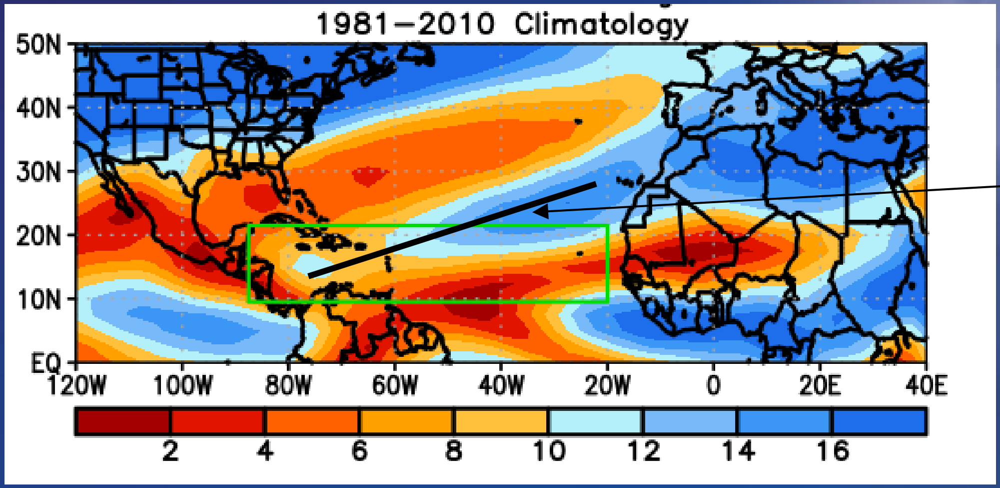

Aug–Sep 2017
850–hPa: Specific Humidity (% of Normal)
40N
30N
20N
10N
EQ
120W
90W
60W
30W
0
−20
−15
−10
−5
5
10
15
20
(70W–40W, 10N–20N)
20
15
10
5
0
−5
−10
−15
−20
1970
1980
1990
2000
2010
(80W–57.5W, 17.5N–30N)
20
15
10
5
0
−5
−10
−15
−20
1970
1980
1990
2000
2010

200-850 hPa Vertical wind shear
High-activity era versus Low-activity era

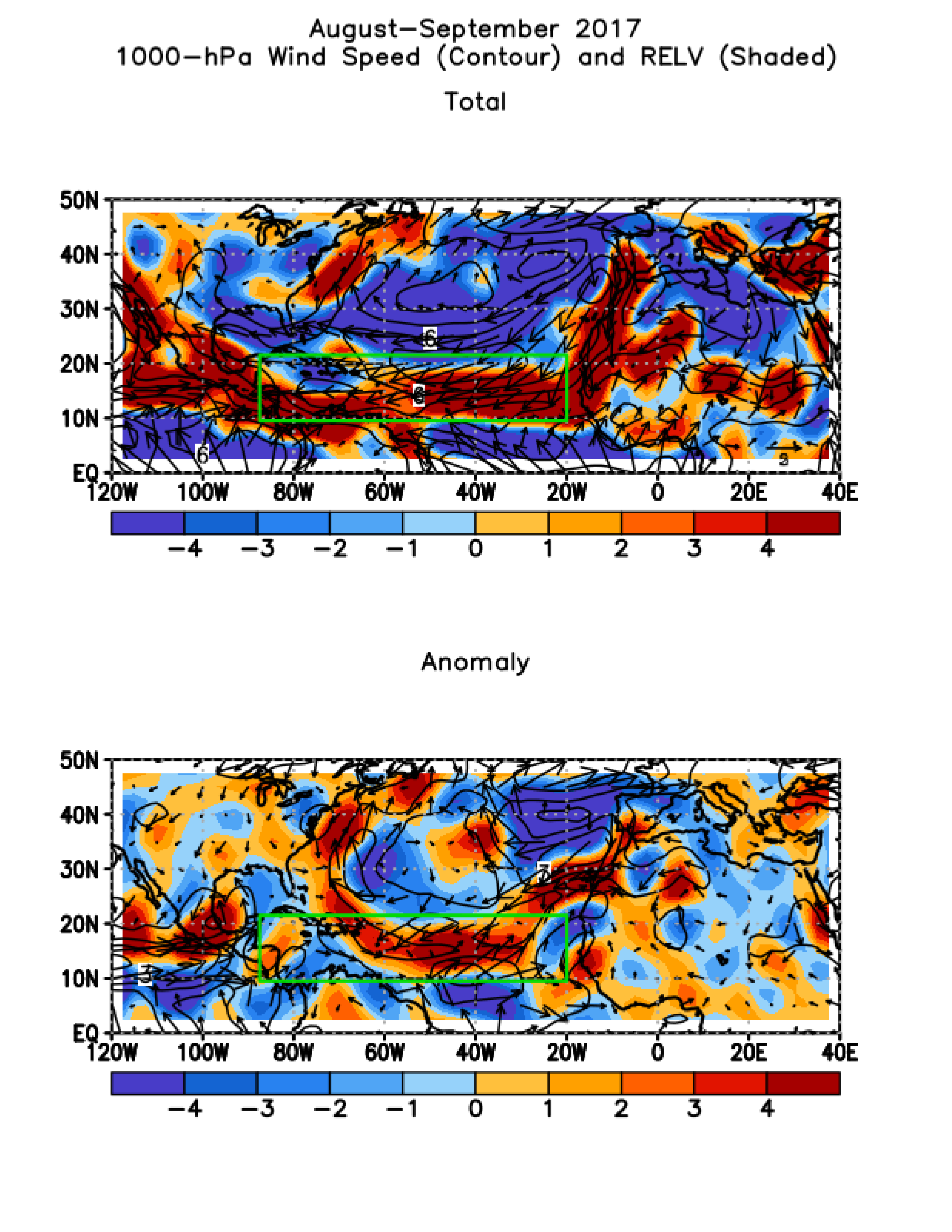


The large-scale differences in vertical wind shear between the high- and low-activity era's typifies an enhanced west African monsoon system, which features weaker low-level easterly trade winds and strong upper-level easterlies (Bell and Chelliah, 2006)

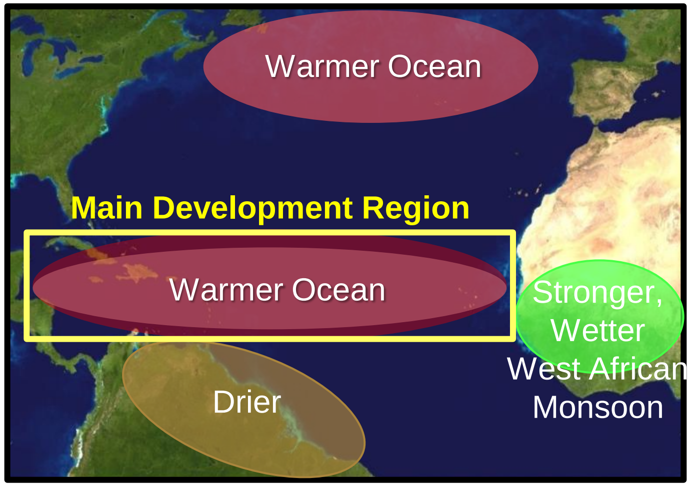
August-September Climatology
200-850 hPa Vertical Wind Shear (m s^{-1})



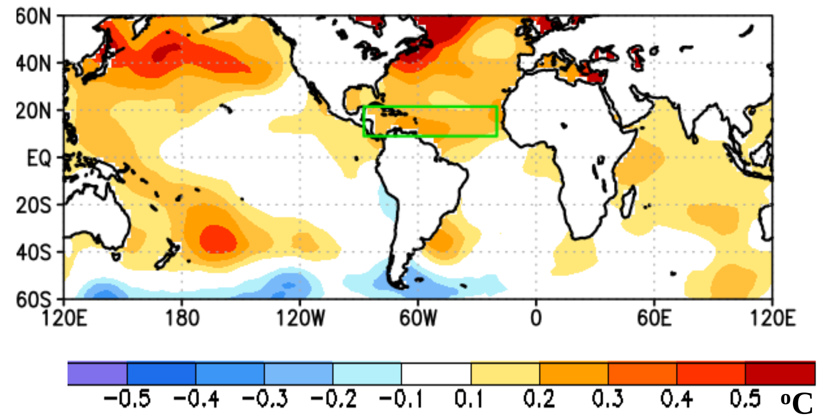
Axis of stronger shear


August–September 2017
1000–hPa Wind Speed (Contour) and RELV (Shaded)
Total
50N
40N
30N
20N
10N
EQ
120W 100W 80W 60W 40W 20W 0 20E 40E
−4 −3 −2 −1 0 1 2 3 4
Anomaly
50N
40N
30N
20N
10N
EQ
120W 100W 80W 60W 40W 20W 0 20E 40E
−4 −3 −2 −1 0 1 2 3 4

Warm Phase of the AMO

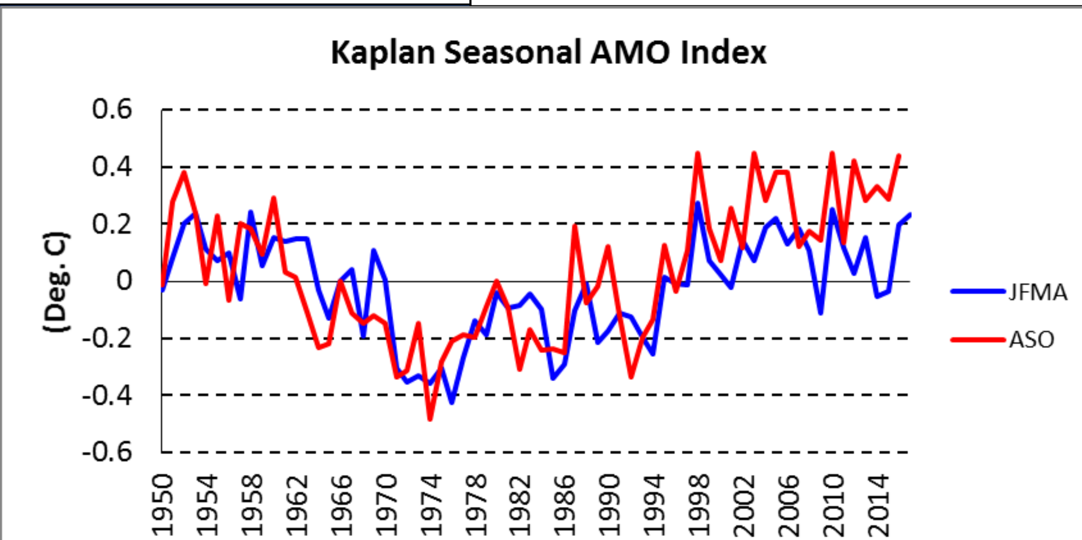


August-September 1995-2017
Sea Surface Temperature (SST) Departures (°C)

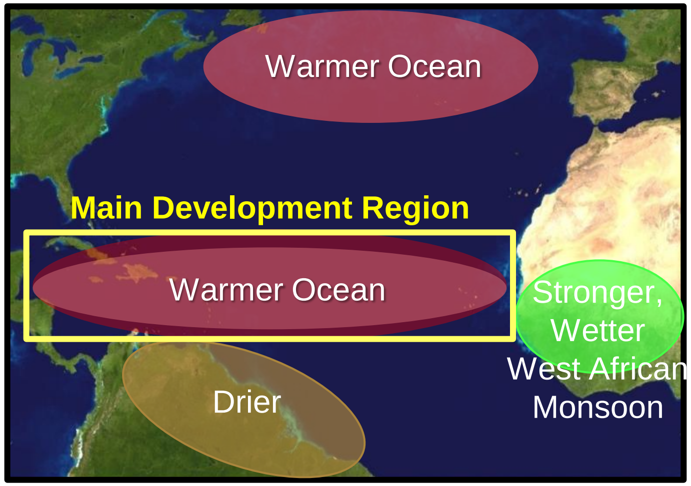


This climate pattern is called the Atlantic Multi-Decadal Oscillation (AMO). It produces key ingredients of an active Atlantic hurricane season. It is also associated with weaker central and eastern Pacific hurricane seasons.

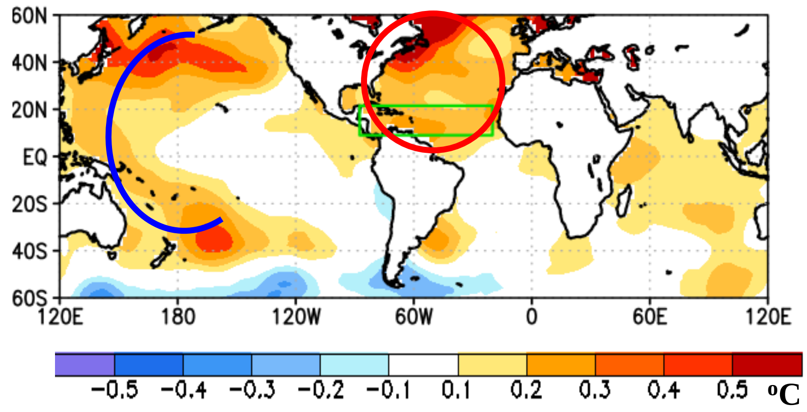
Since 1995, the suppressed hurricane activity in the central and eastern Pacific has been associated with the warm AMO phase (red circle) and with a horseshoe-shaped pattern above-average SSTs (blue arc) in the western Pacific.



Warm Phase of the AMO

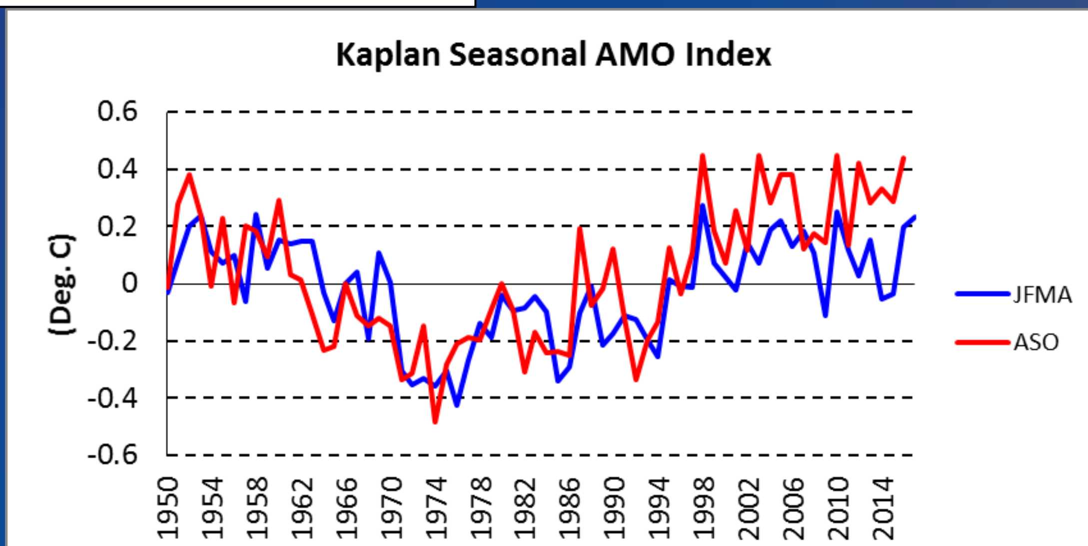


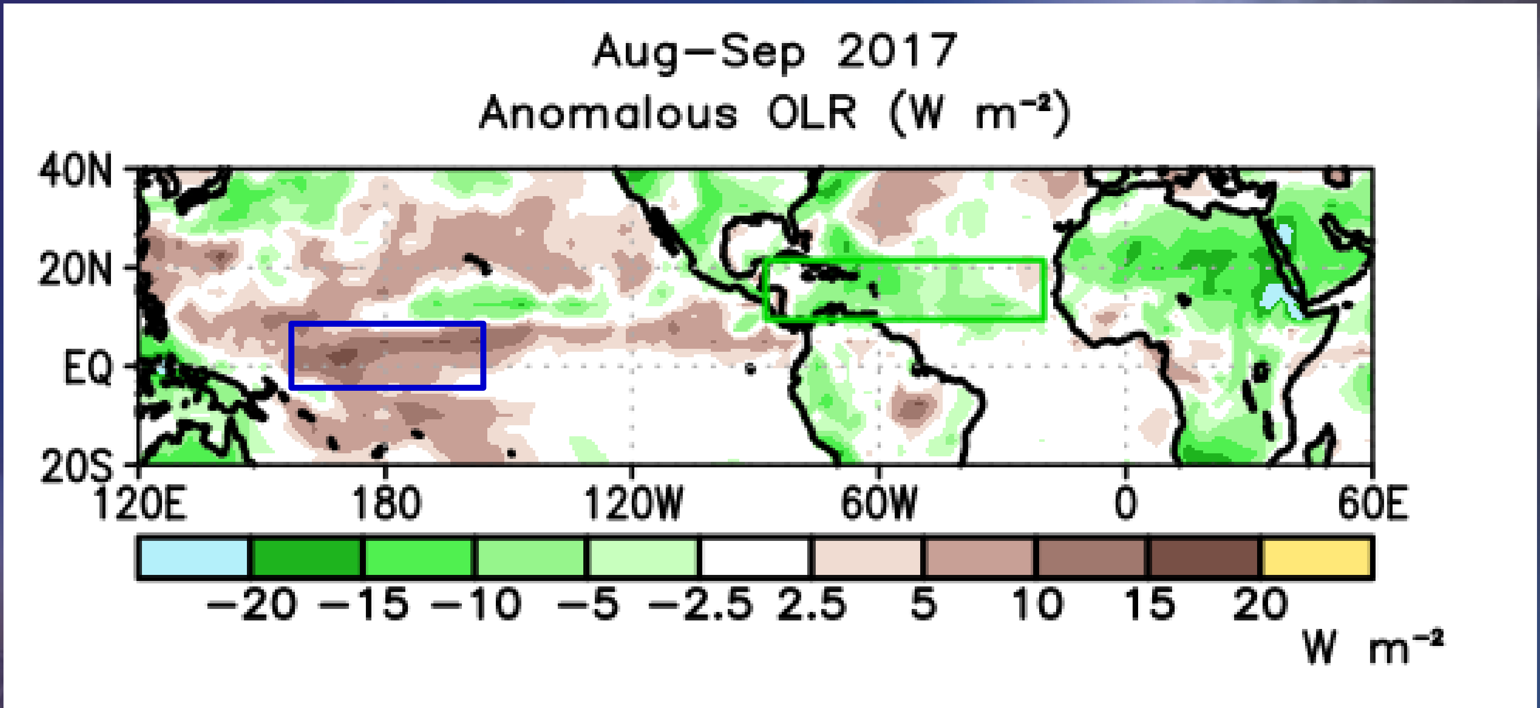
August-September 1995-2017
Sea Surface Temperature (SST) Departures (°C)



This climate pattern is called the Atlantic Multi-Decadal Oscillation (AMO). It produces key ingredients of an active Atlantic hurricane season. It is also associated with weaker central and eastern Pacific hurricane seasons.

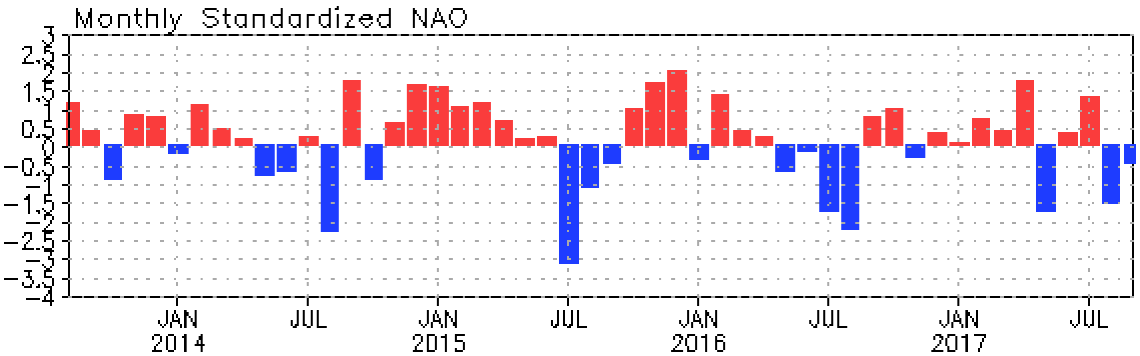
Since 1995, the warm AMO phase (red circle) has been present.

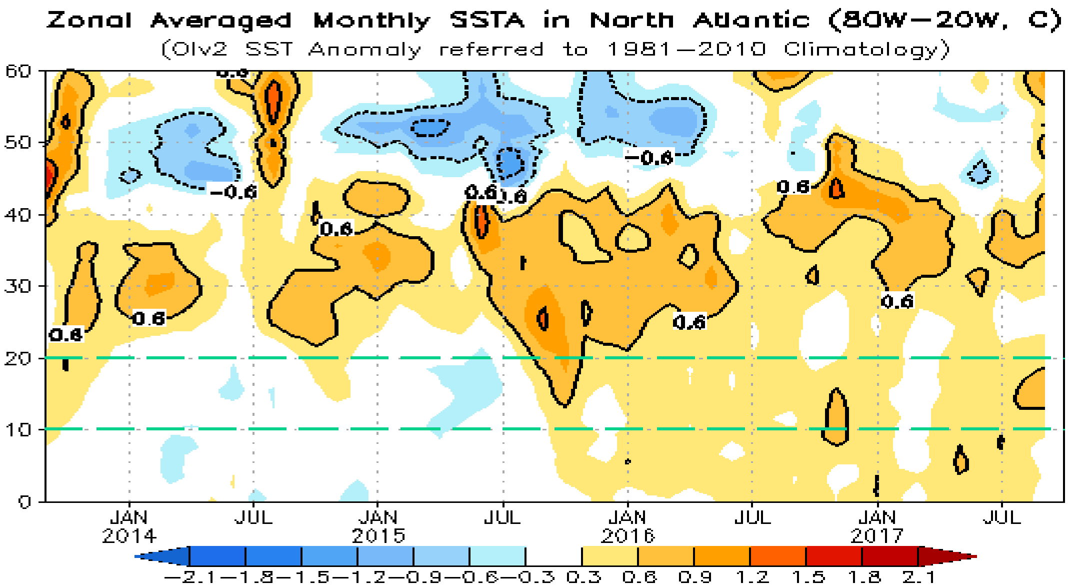


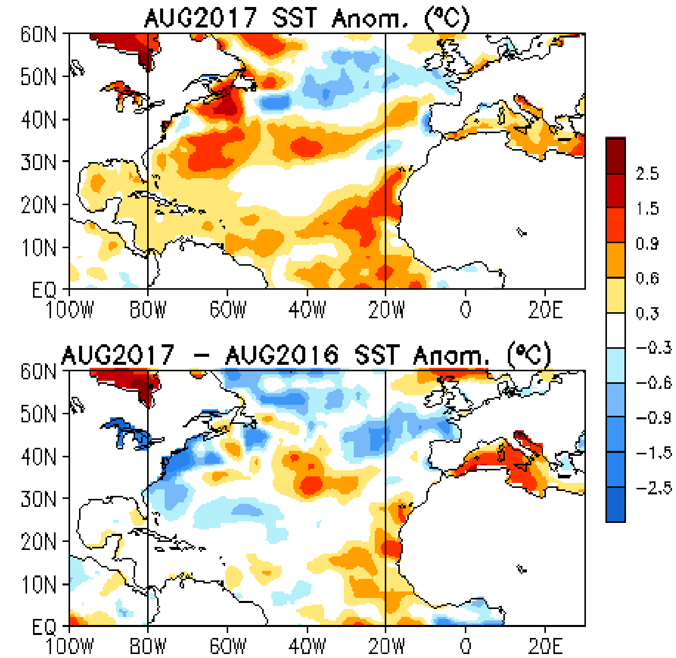


Aug–Sep 2017
Anomalous OLR (W m⁻²)
40N
20N
EQ
20S
120E
180
120W
60W
0
60E
−20 −15 −10 −5 −2.5 2.5 5 10 15 20
W m⁻²

NAO and SST Anomaly in North Atlantic







- Negative NAO index weakened in Sep 2017, NAOI =-0.5.

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.

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

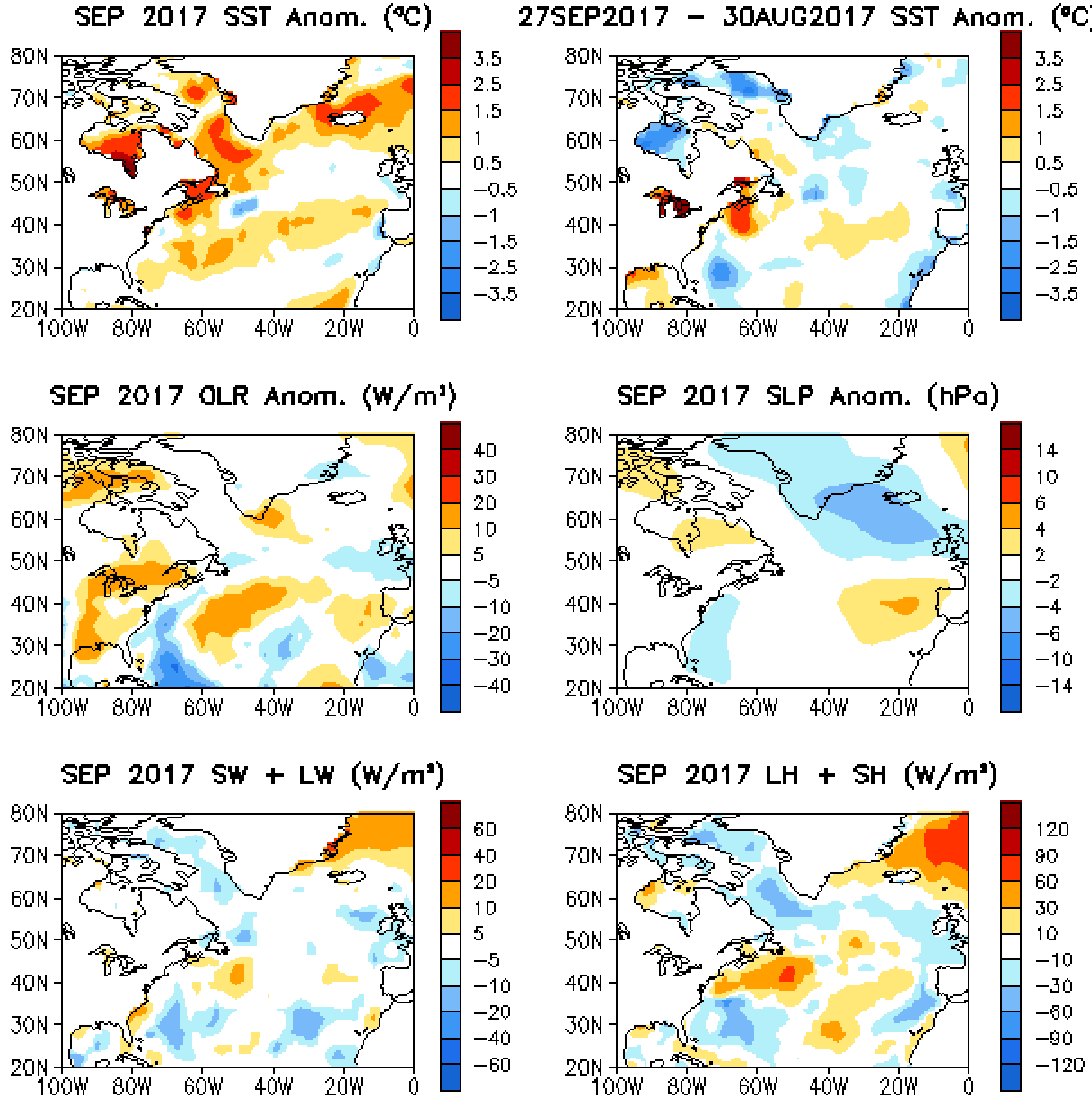
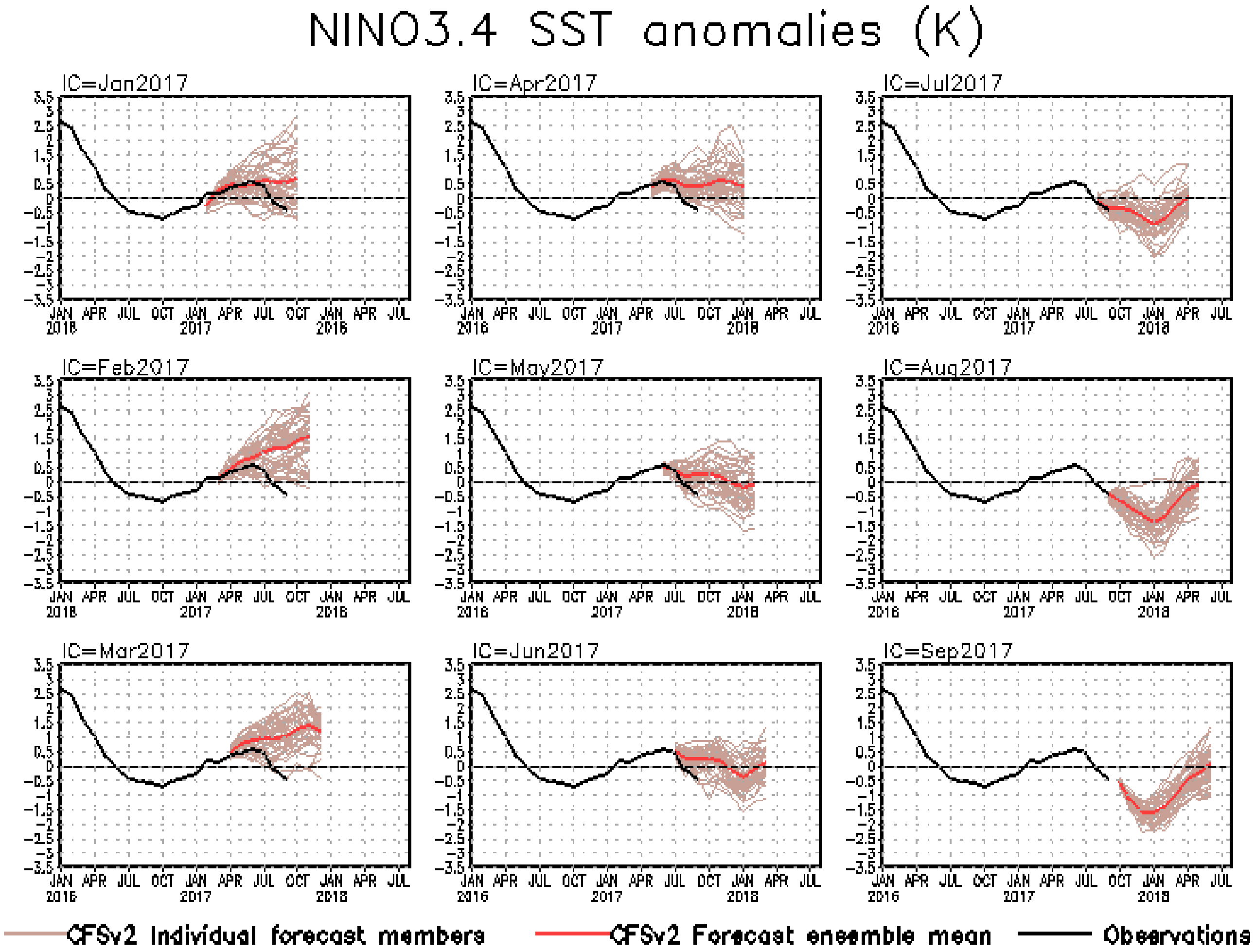


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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-Jun 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.

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.

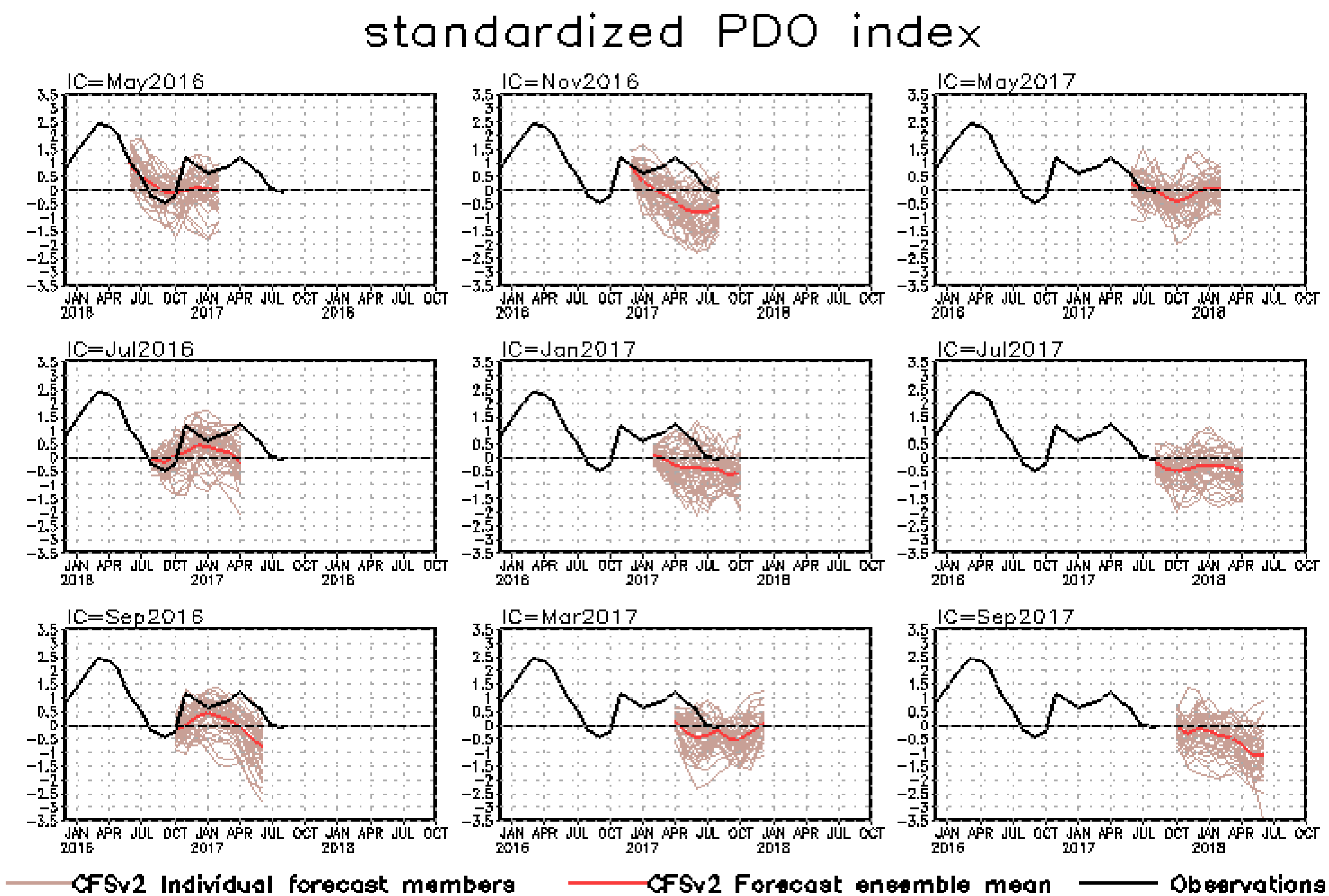
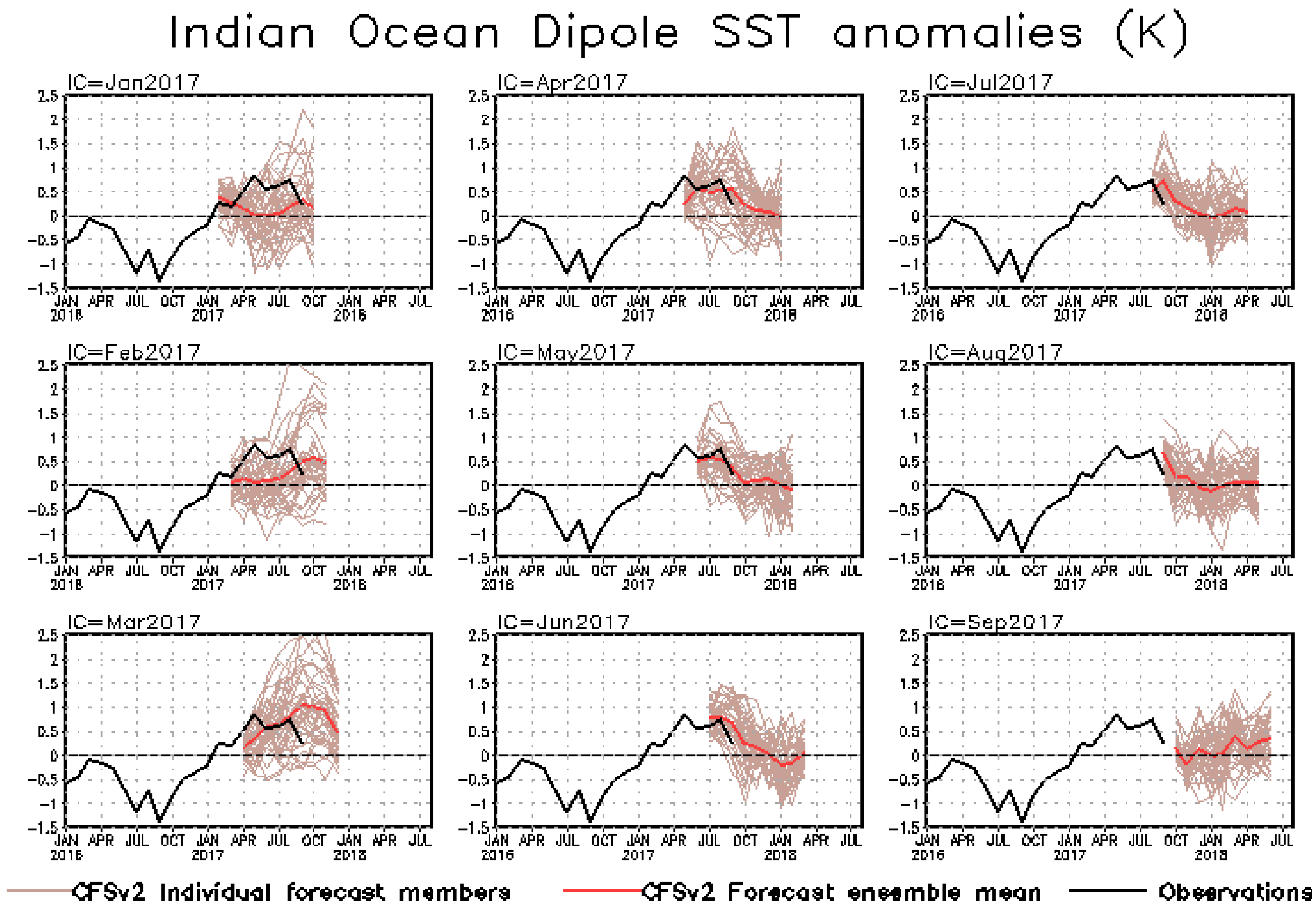


Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black).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

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

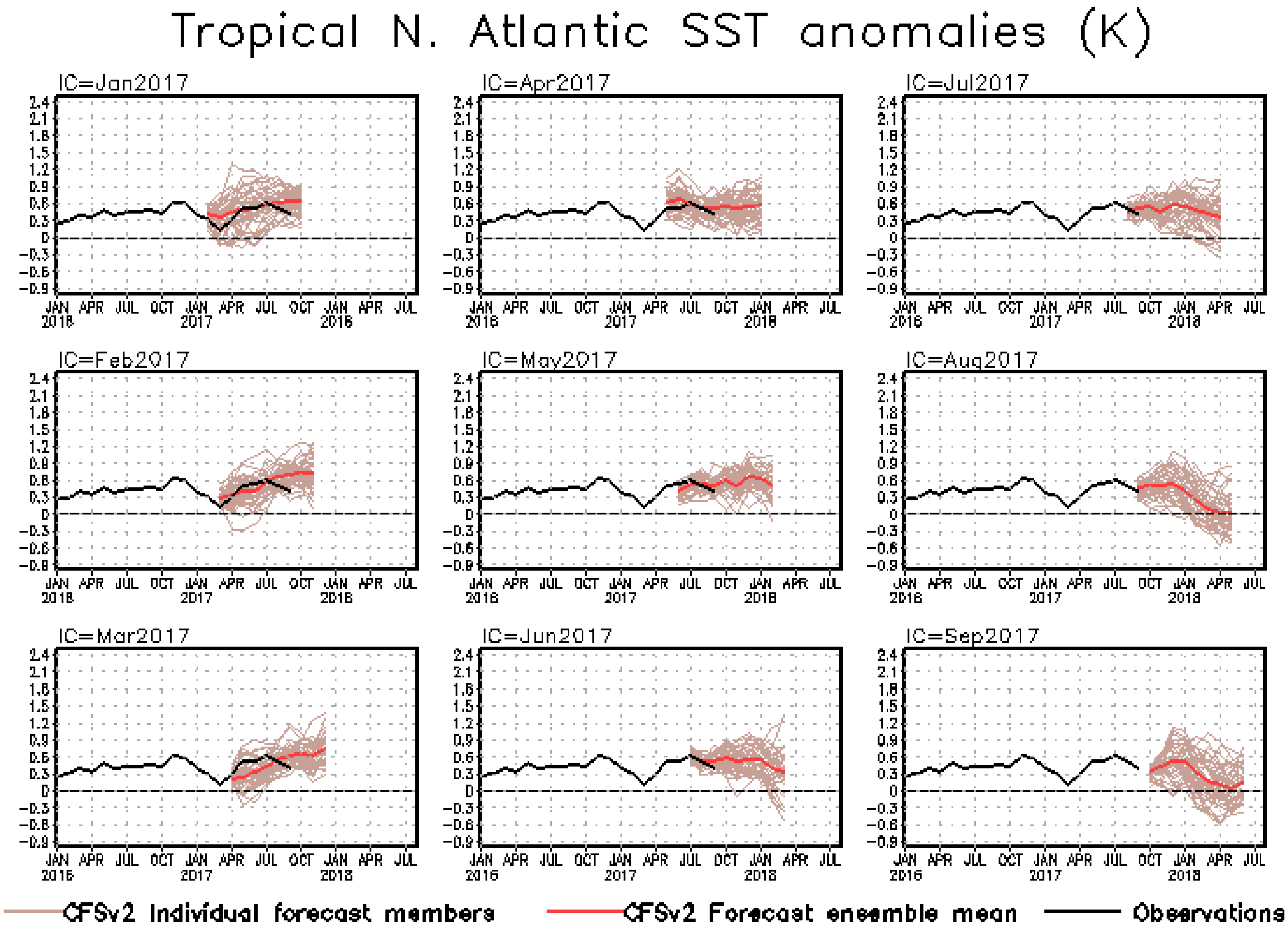
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

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.

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].

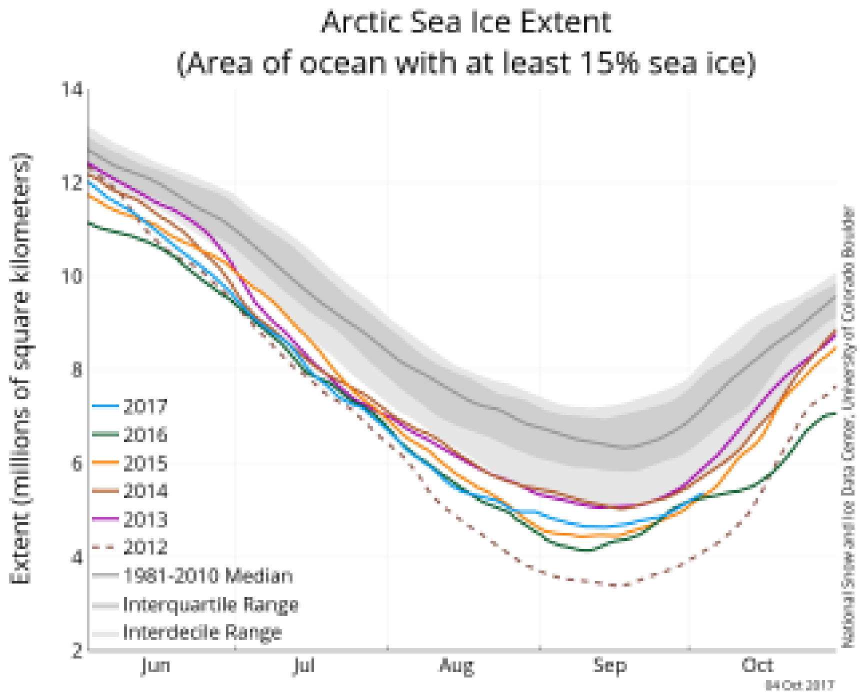


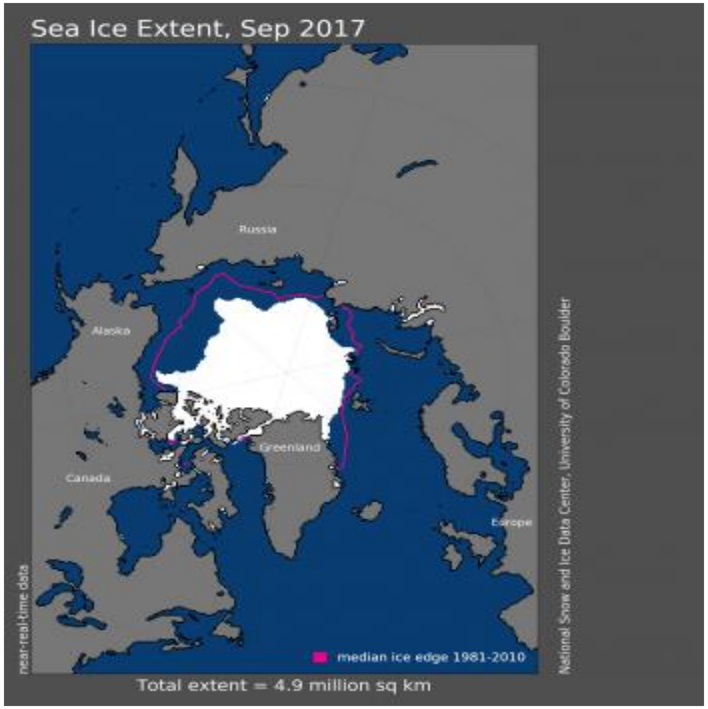
- Latest CFSv2 predictions call persistently above normal SST in the tropical N. Atlantic through winter 2017/18.

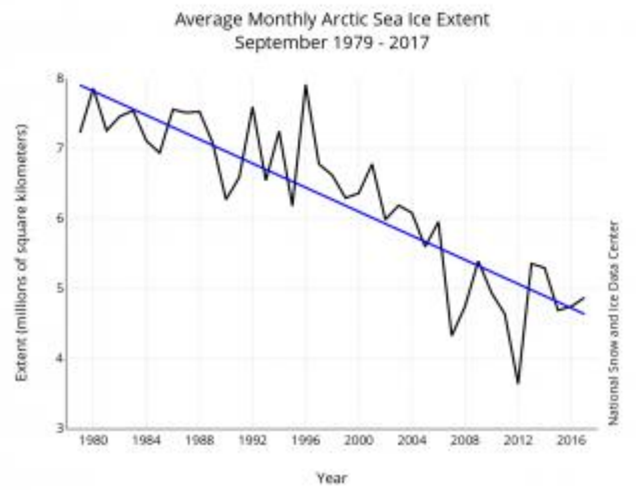
Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

Arctic Sea Ice

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

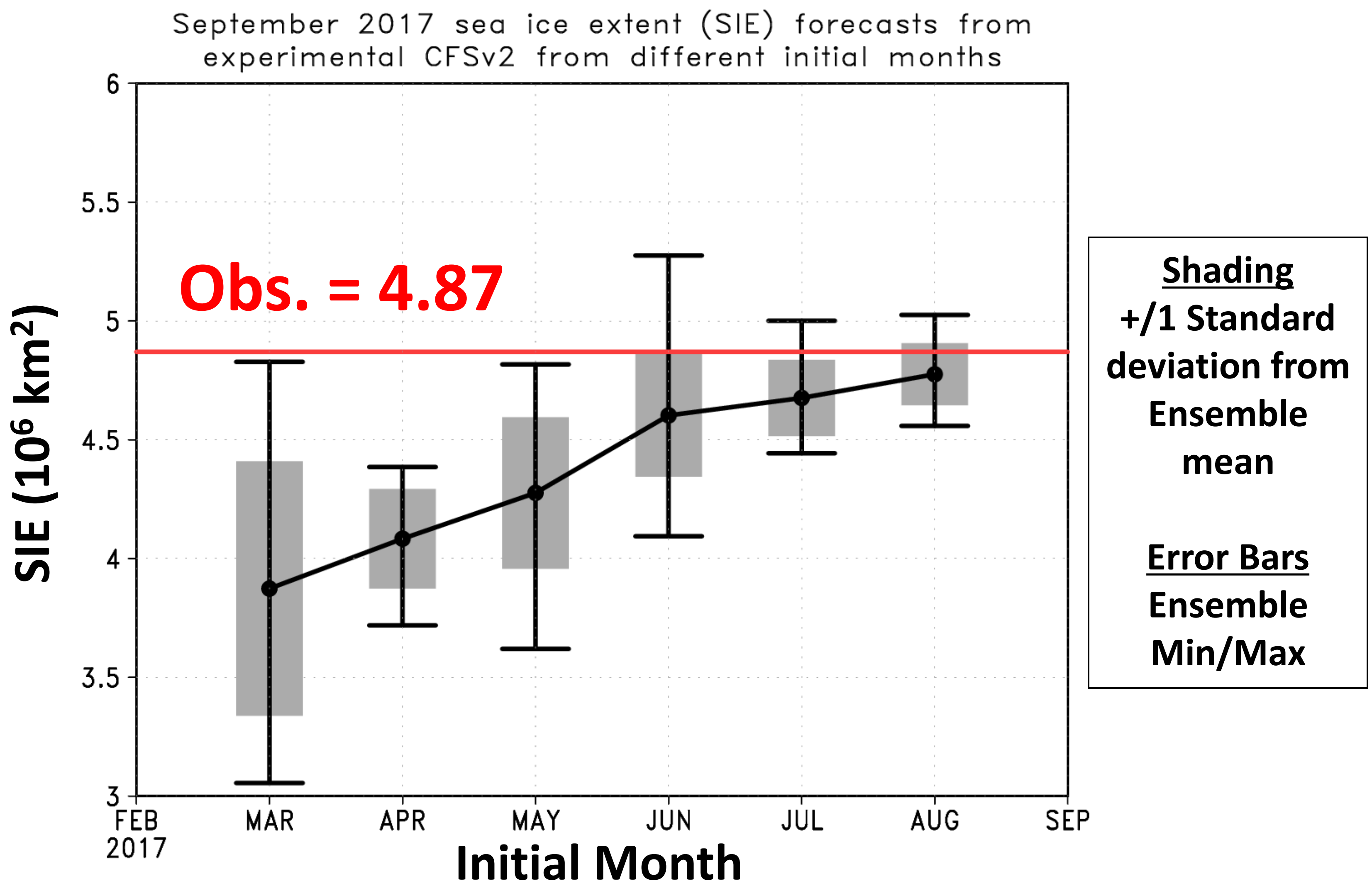




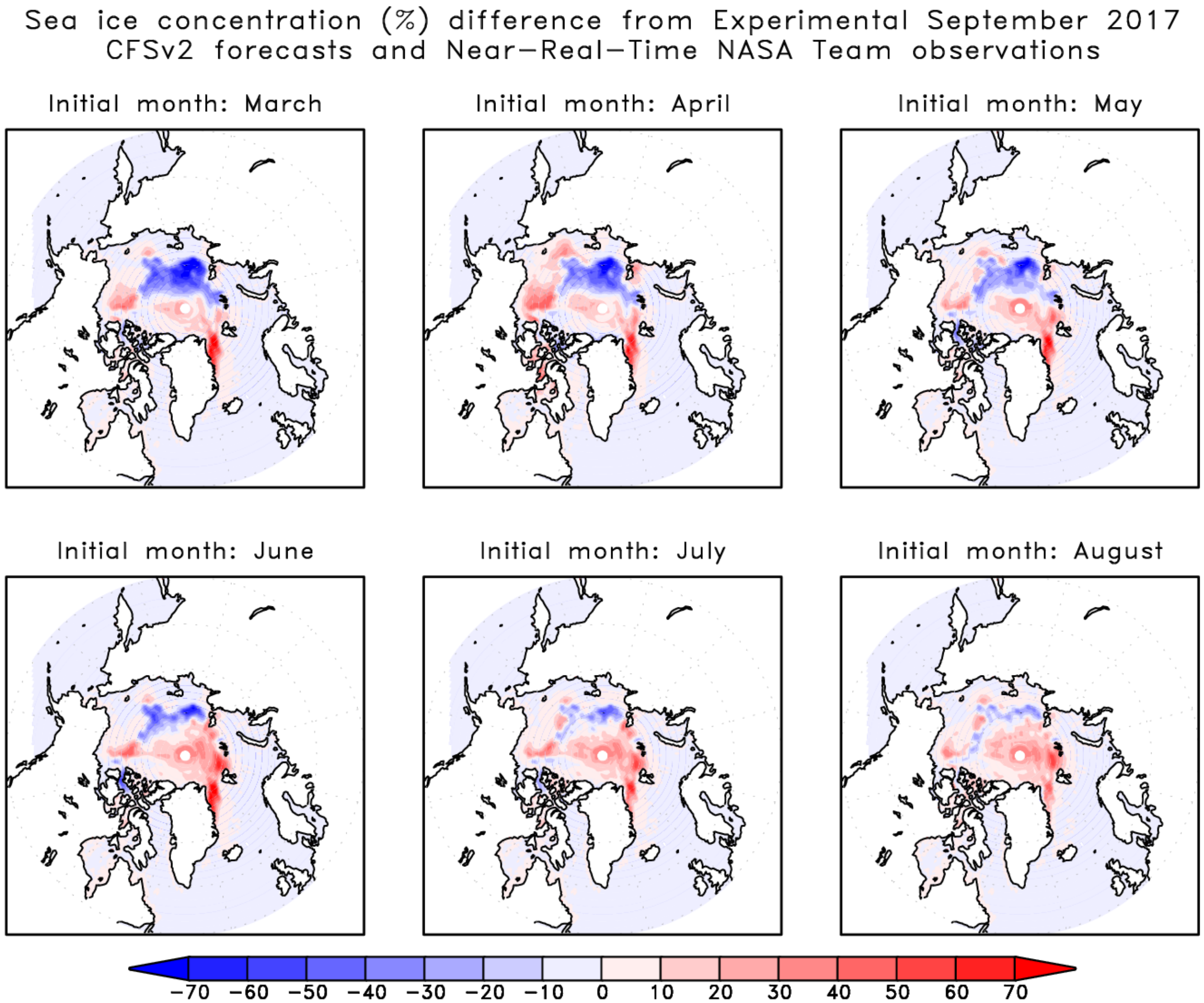


- Artic sea ice reached its annual minimum extent in Sep 2017.

- Arctic sea ice extent averaged for Sep 2017 ranks the eighth lowest in the satellite record.



Arctic sea ice volume was at a record low early in the year resulting in low prediction for September SIE. As the volume became less of an outlier in the summer, the forecast improved being within the ensemble spread for June, July, and August initializations.



Negative ice concentration biases are present in March-May initializations but gradually disappear beginning in June. Slight positive biases in Central Arctic in all initializations is likely due to the use of both NASA Team and Bootstrap data in the bias corrected forecasts. NASA Bootstrap has higher sea ice concentration values then the NASA Team data being used in this comparison.

NMME Model Predictions