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

Prepared by

Climate Prediction Center, NCEP/NOAA

November 9, 2017

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

This project to deliver real-time ocean monitoring products is implemented by CPC in cooperation with NOAA's 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**

❖ ***Tropical Cyclone Heat Potential Index Based on Real-time Ocean Reanalysis Intercomparison Products***

❖ ***Arctic Sea Ice Anomaly Correlation Skill by Experimental CFSv2***

❖ ***2017 west African Monsoon and its relationship with SST***

Overview

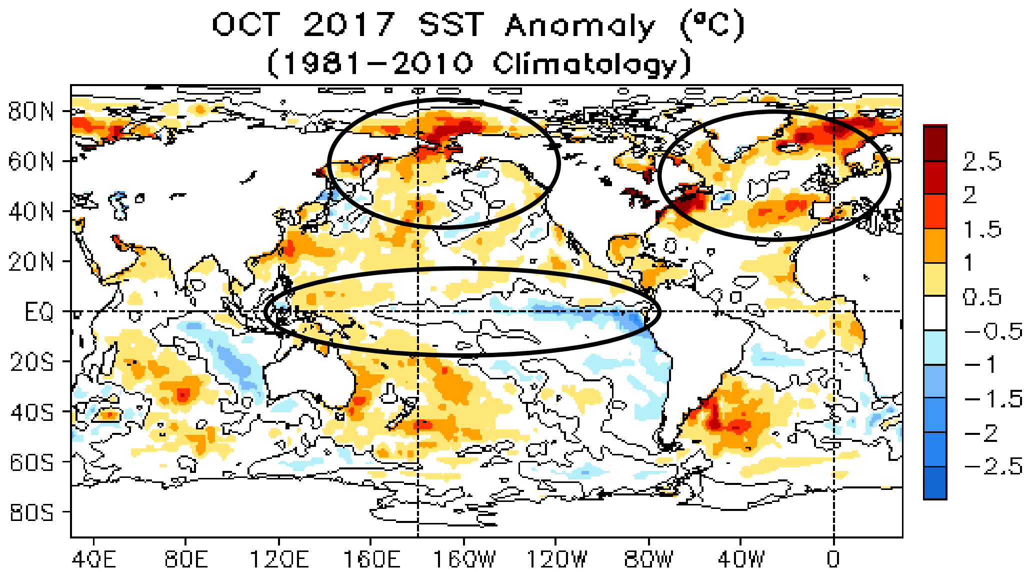
- **Pacific Ocean**
  - **ENSO cycle: developing from neutral into cold condition during Oct 2017.**
  - **NOAA "ENSO Diagnostic Discussion" on 9 Nov 2017 suggested "La Niña conditions are predicted to continue (~65-75% chance) at least through the Northern Hemisphere winter 2017-18".**
  - **PDO switched to weakly negative phase with PDO = -0.2.**
  - **Arctic sea ice extent in Oct 2017 ranked the fifth minimum since 1979.**
  - **Experimental CFSv2 forecast predicted below-averaged sea ice extent in the Northern Hemisphere winter 2017/18.**

- **Indian Ocean**
  - **Indian dipole index was near average in Oct 2017.**

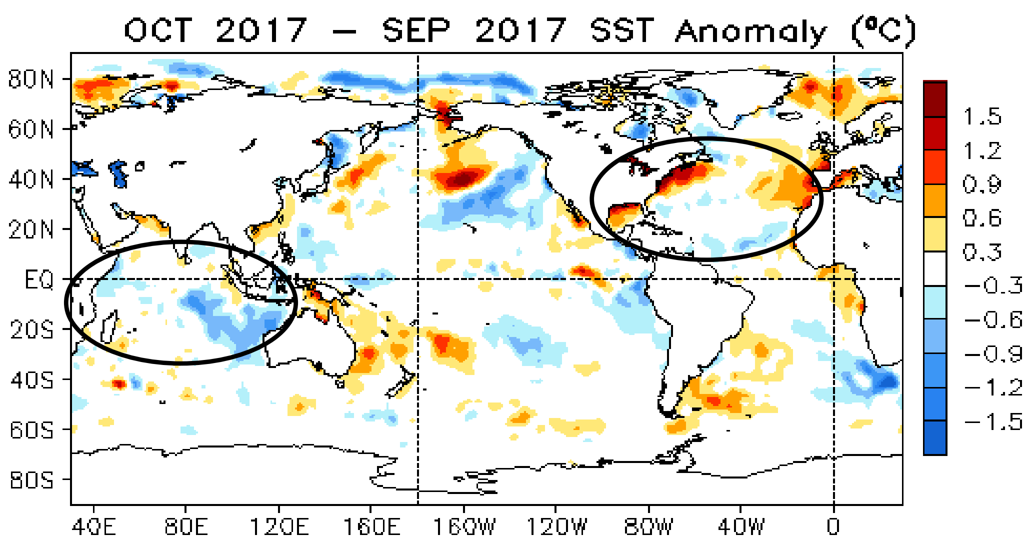
- **Atlantic Ocean**
  - **Tropical cyclone heat potential and SST anomalies in the Atlantic MDR were well above average in 2017 Hurricane season.**
  - **West African monsoon was extremely active during Aug-Sep 2017.**

Global Oceans

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



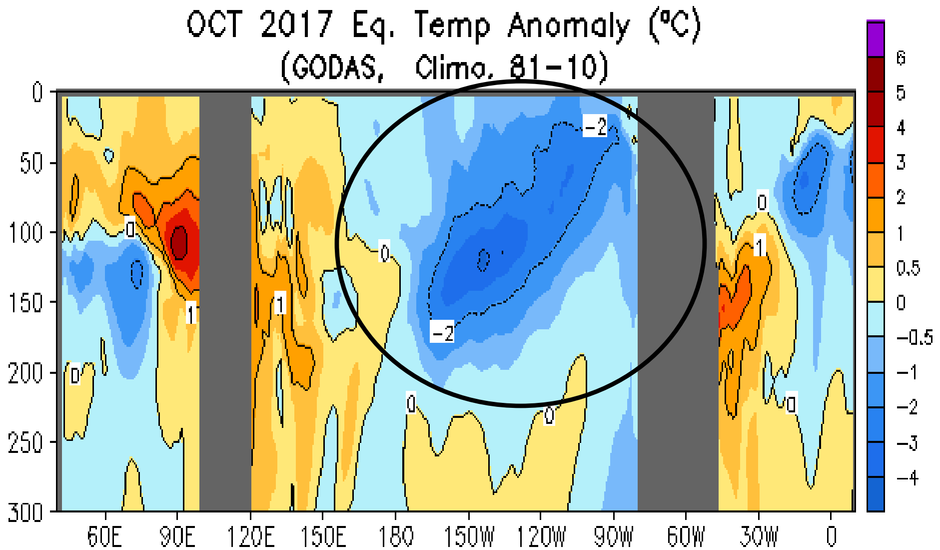
- SST were below-normal (above-normal) in the central-eastern (western) equatorial Pacific
- Positive SSTA dominated in N. Pacific and N. Atlantic Oceans.



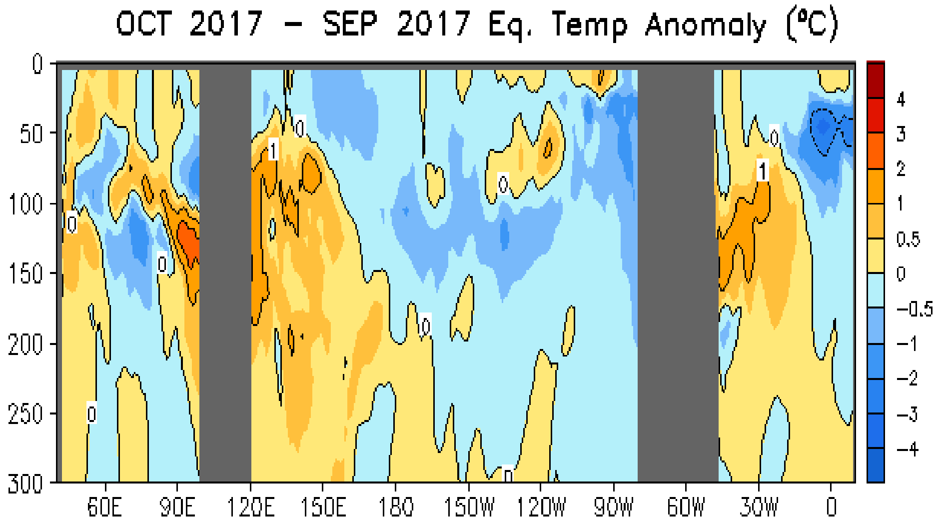
- SSTA tendency were mostly negative in the tropical Indian Ocean.
- Strong SSTA tendencies presented in the N. Pacific Ocean.
- Positive SSTA tendencies were observed in Gulf of Mexico and along the eastern coast of N. America.

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



- Negative (positive) temperature anomalies presented in the central-eastern (western) Pacific.
- Positive ocean temperature anomalies continued in upper 100m of Indian Ocean.

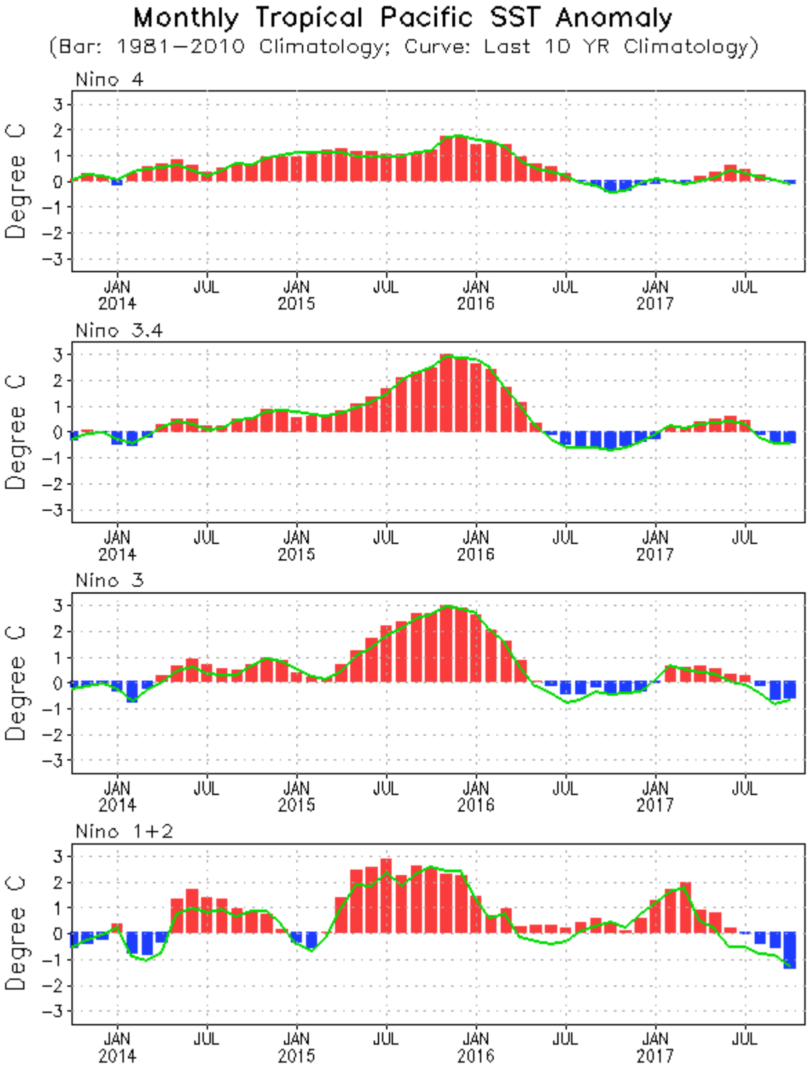


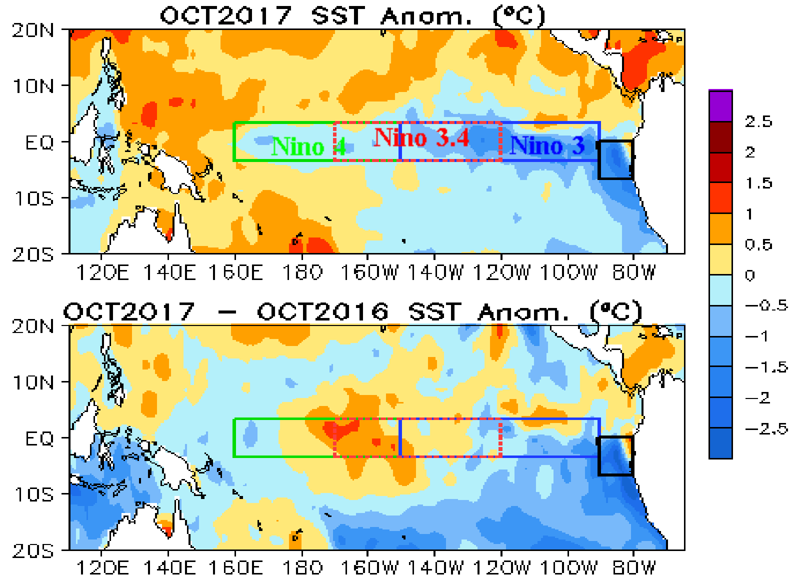
- Subsurface temperature tendencies were mostly negative across the central-eastern equatorial Pacific.
- Positive tendencies presented in the equatorial western Pacific.

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





- **Negative Nino 1+2 index strengthened substantially in Oct 2017.**
- **Nino3.4 = -0.5°C in Oct 2017.**
- **Compared with last Oct, the central (eastern) equatorial Pacific was warmer (colder) in Oct 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.

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

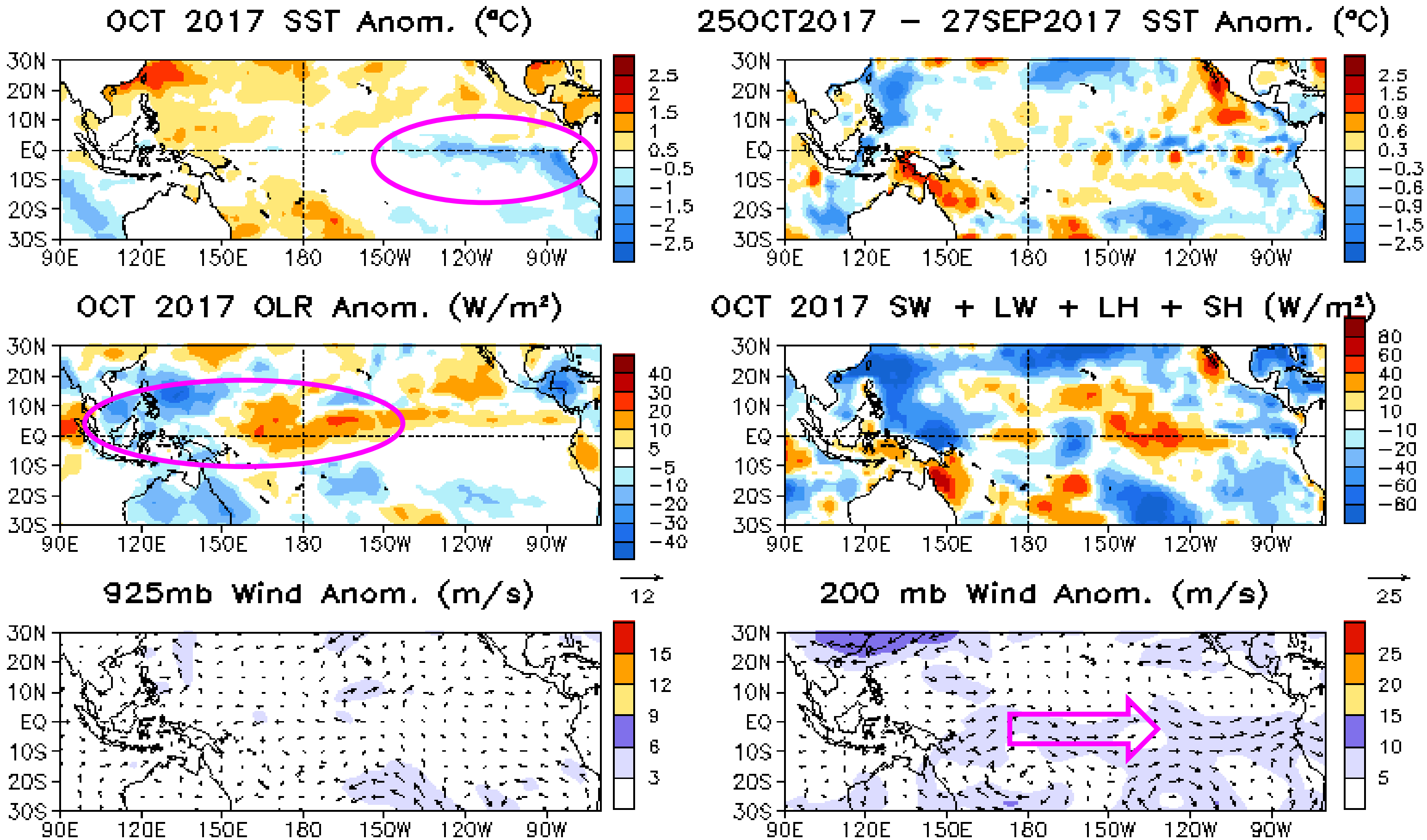
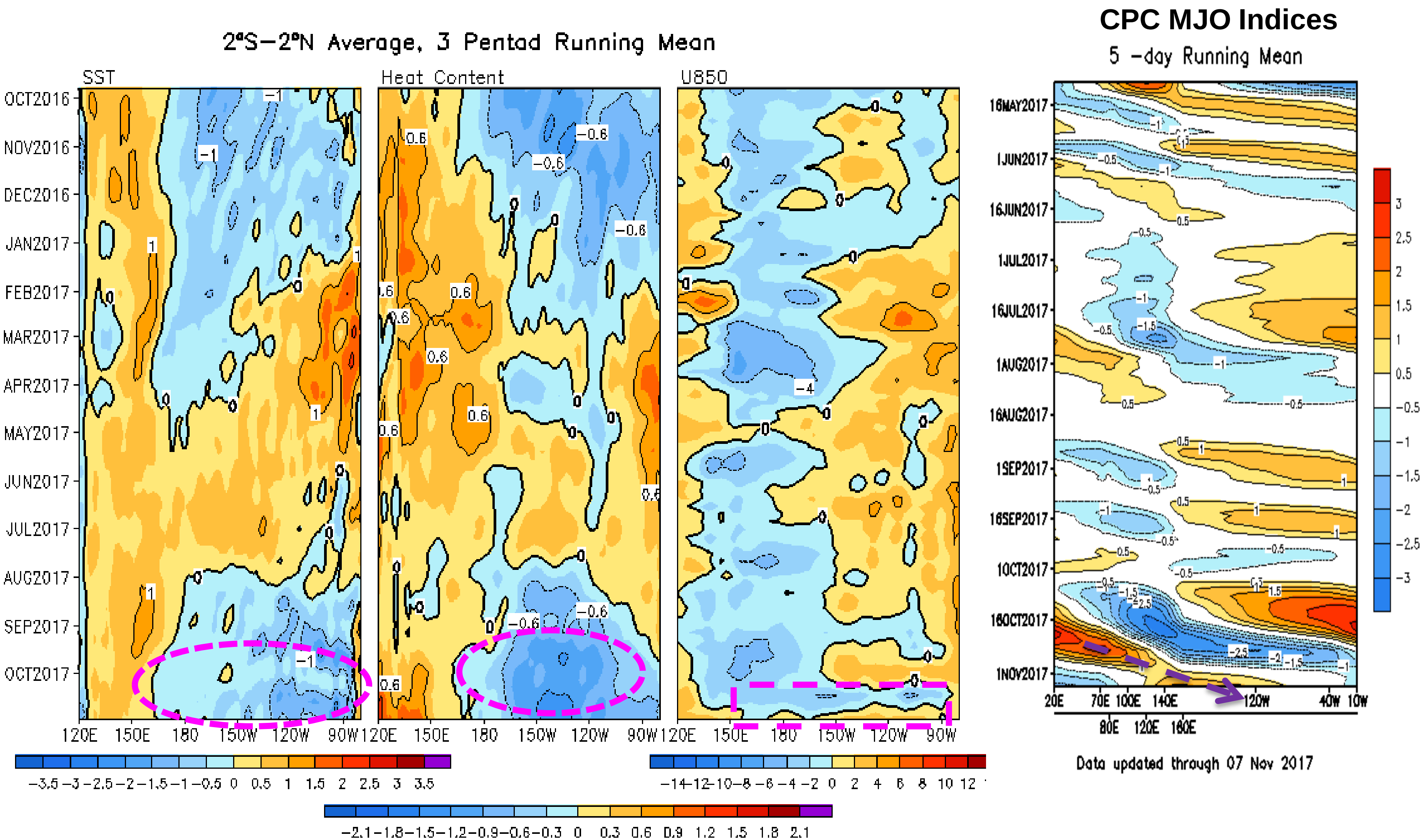


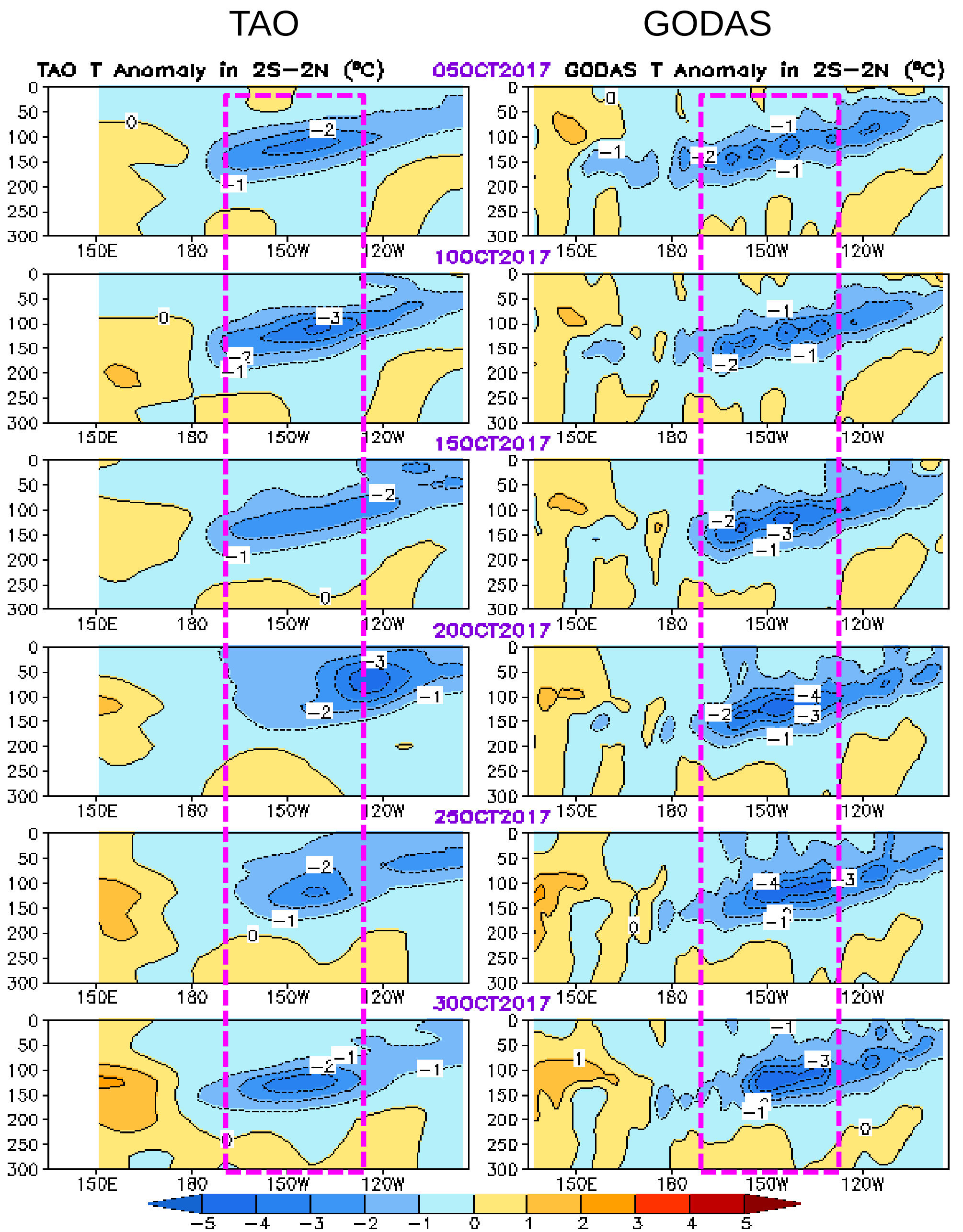
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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



- Negative SSTAs persisted in the central-eastern equatorial Pacific in Oct 2017.
- Negative HC300A strengthened slightly in the central Pacific in Oct 2017.
- MJO has contributed to the eastward shift of low-level westerly wind anomalies since mid-Oct 2017.

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



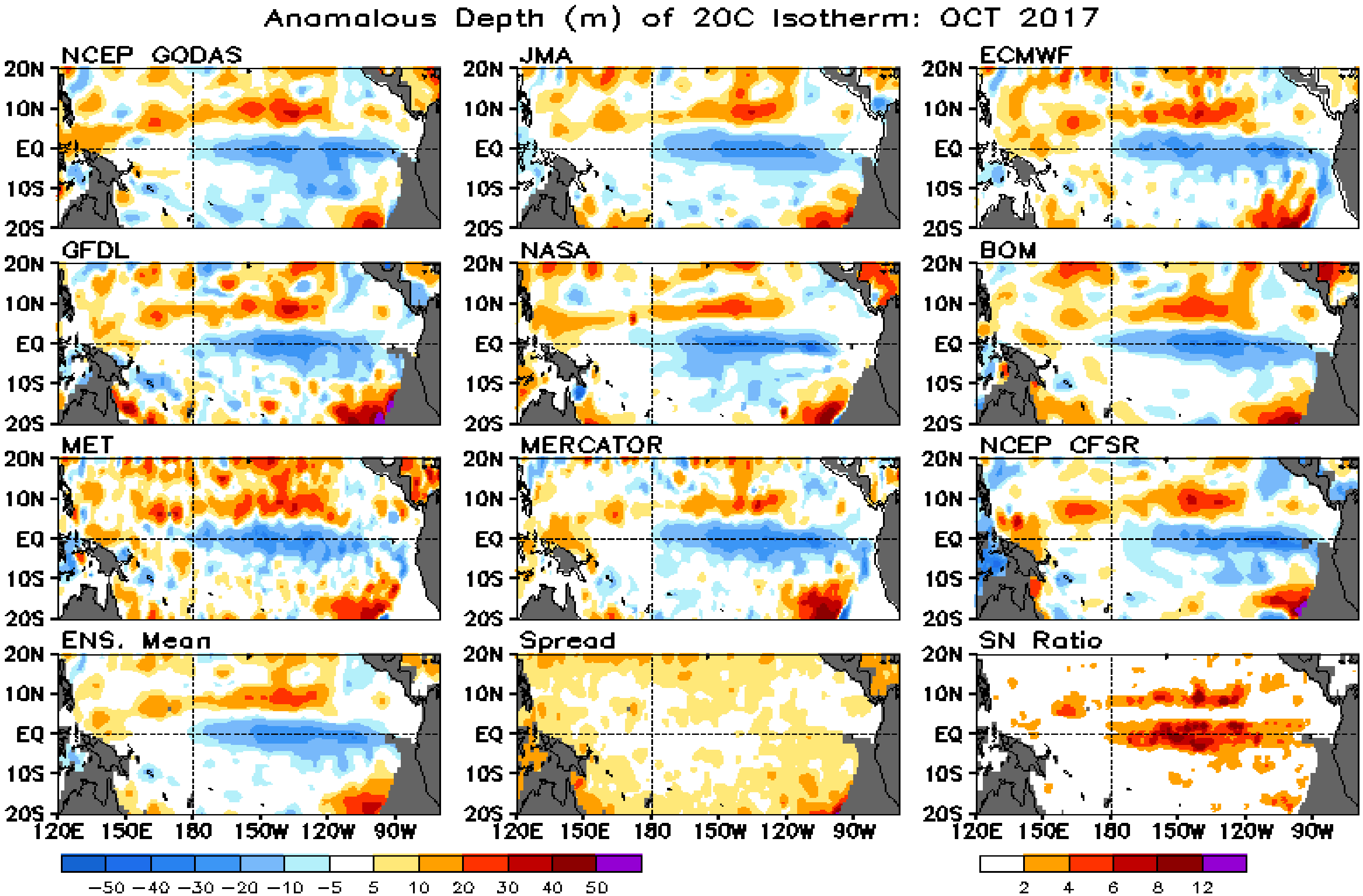
- Subsurface temperature in TAO cooled substantially around [170°W-130°W] in the last two pentads.

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

Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1993-2013

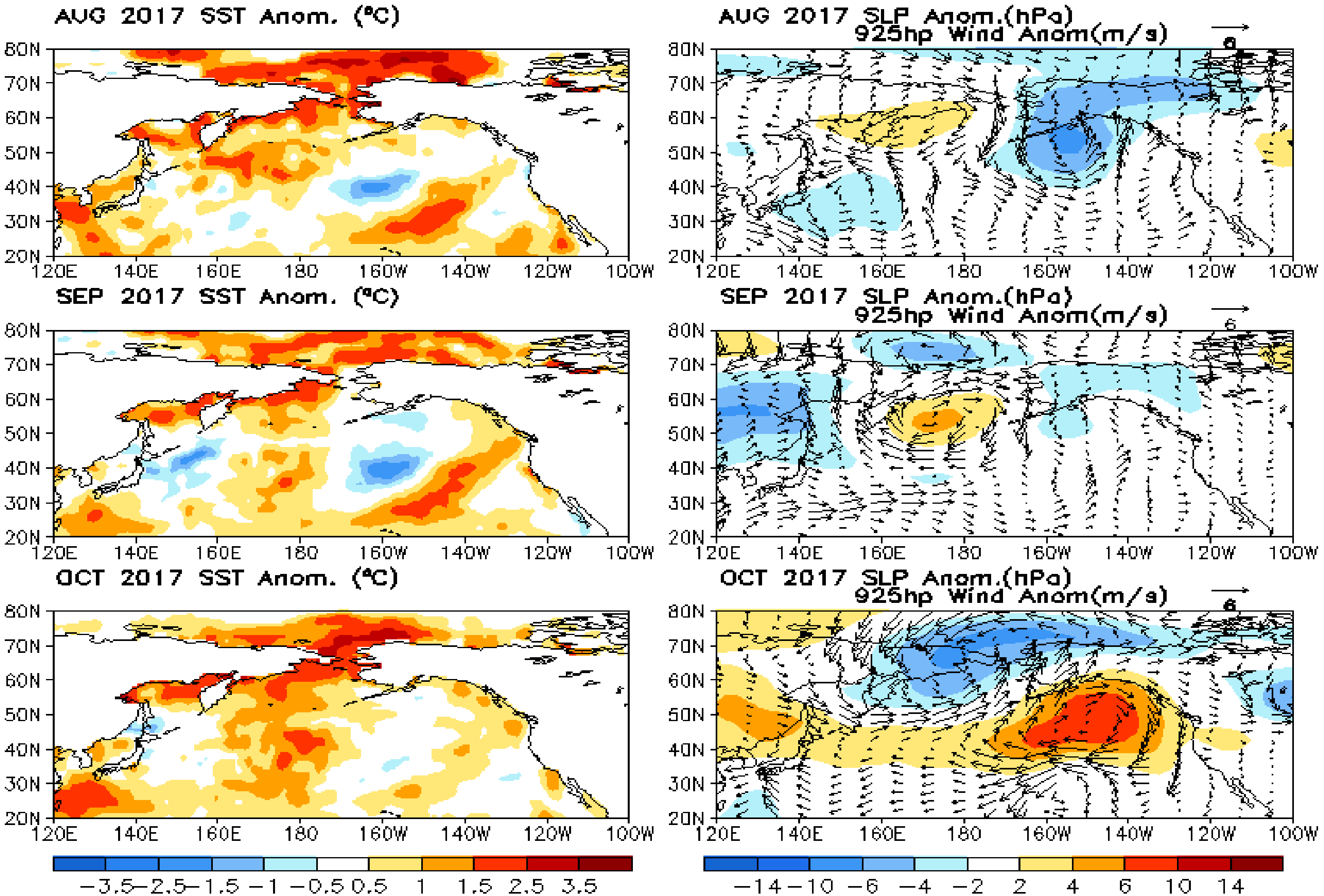
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)



- **Negative D20 anomalies continued in the central-eastern equatorial Pacific in all nine reanalyses.**

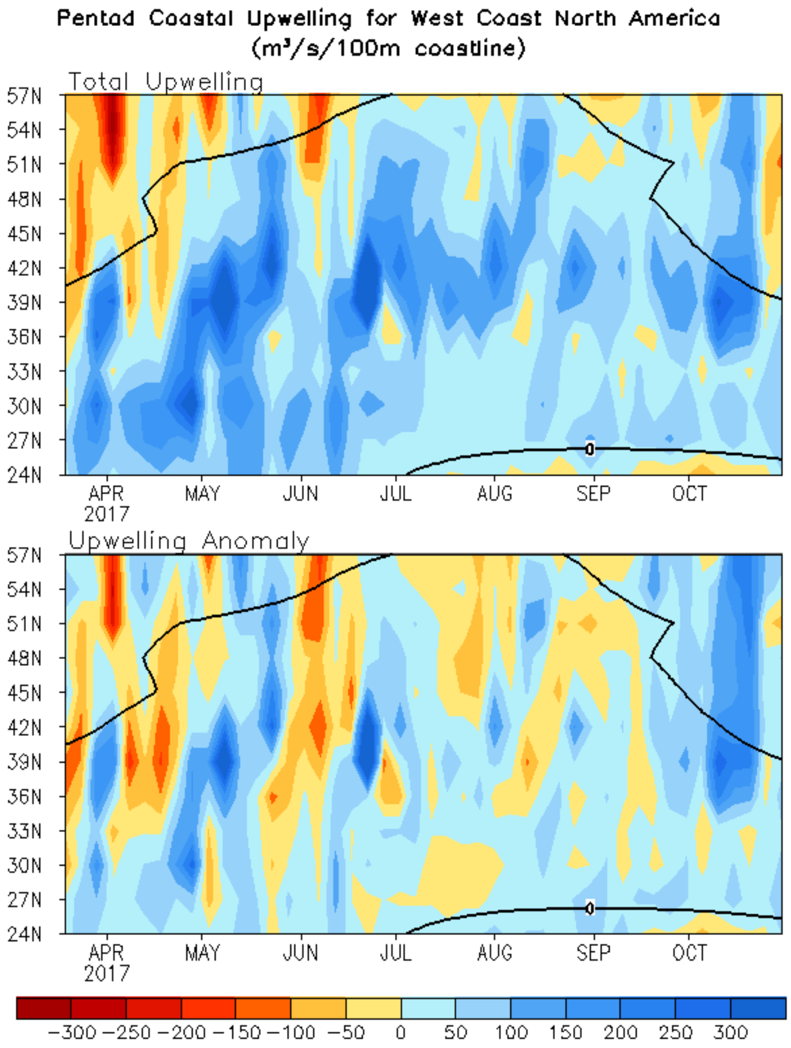
North Pacific & Arctic Oceans

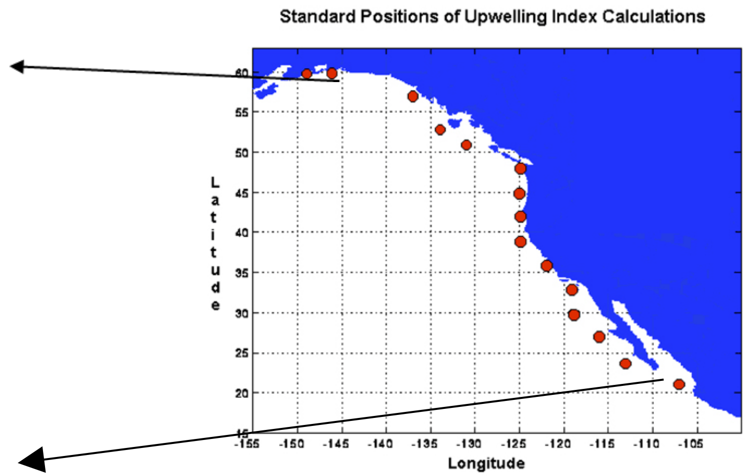
Last Three Month SST, SLP and 925hp Wind Anomalies



- 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.

North America Western Coastal Upwelling



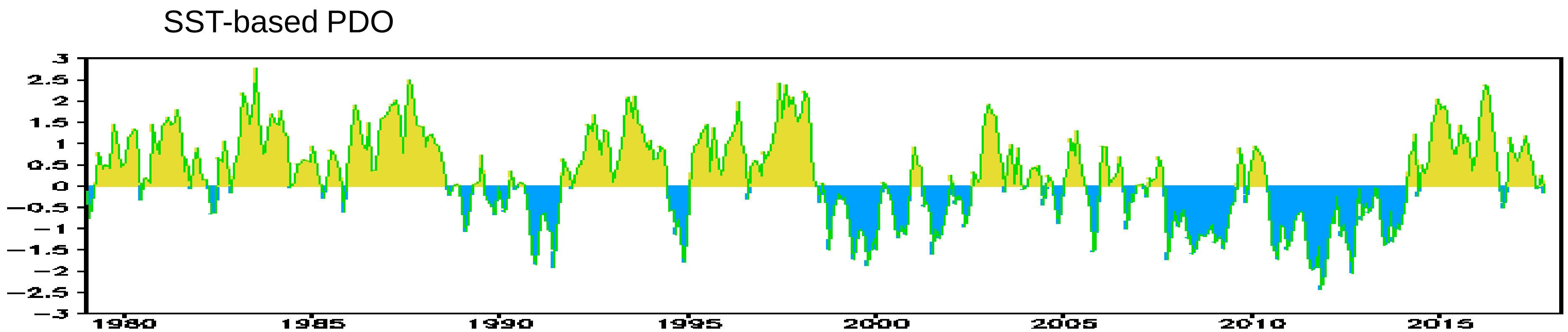


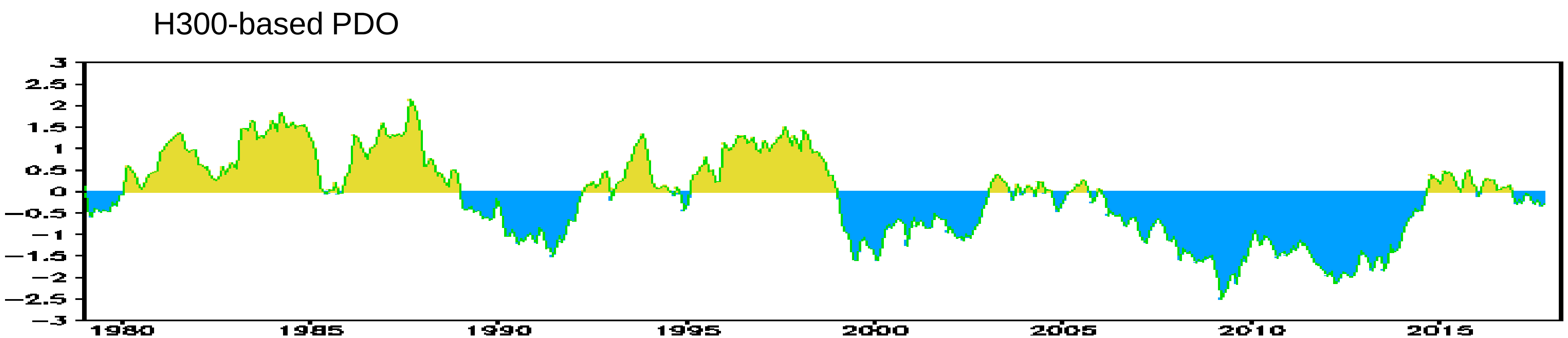
- Anomalous upwelling was observed along the coast in Oct 2017, owing to the northwesterly winds.

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.**

Two Oceanic PDO indices



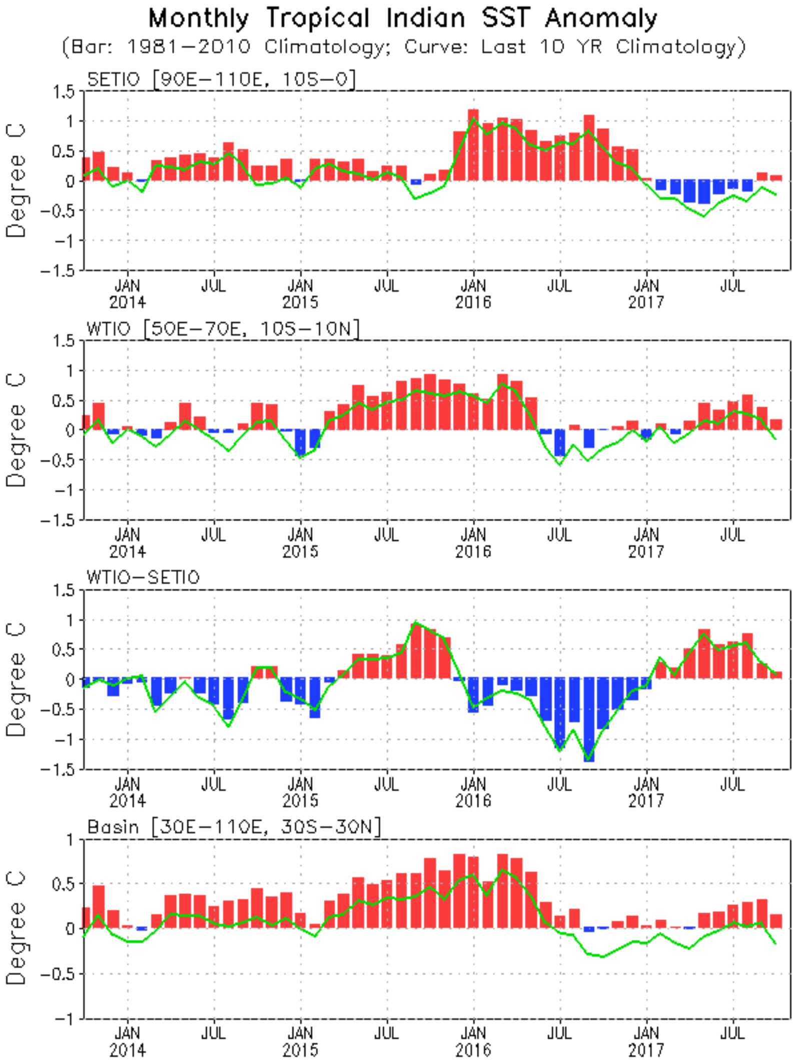


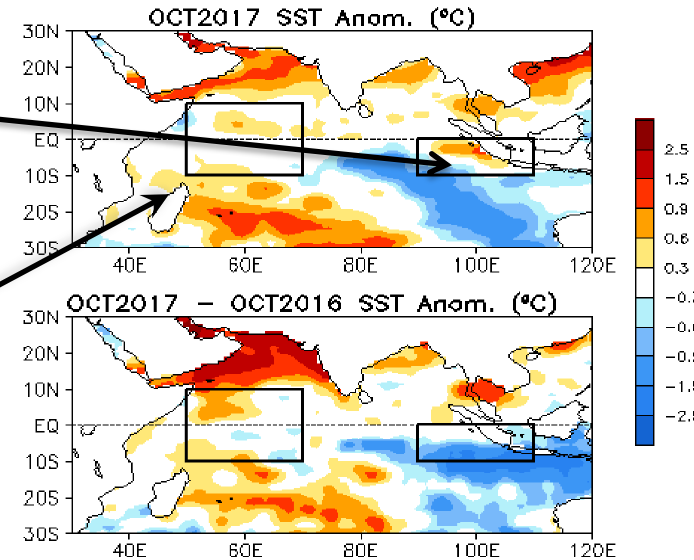
- **SST-based PDO index switched to negative phase in Oct 2017, with PDO index =-0.2.**
- **Negative H300-based PDO index has persisted 11 months since Nov 2016, with HPDO = -0.3 in Oct 2017.**
- **SST-based PDO index has considerable variability on both seasonal and decadal time scales.**

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





- **SST warming in the W. tropical Indian weakened in Oct 2017.**
- **Strong negative SSTA emerged in the southeastern Indian Ocean.**

-**Dipole index was near normal in Oct 2017.**

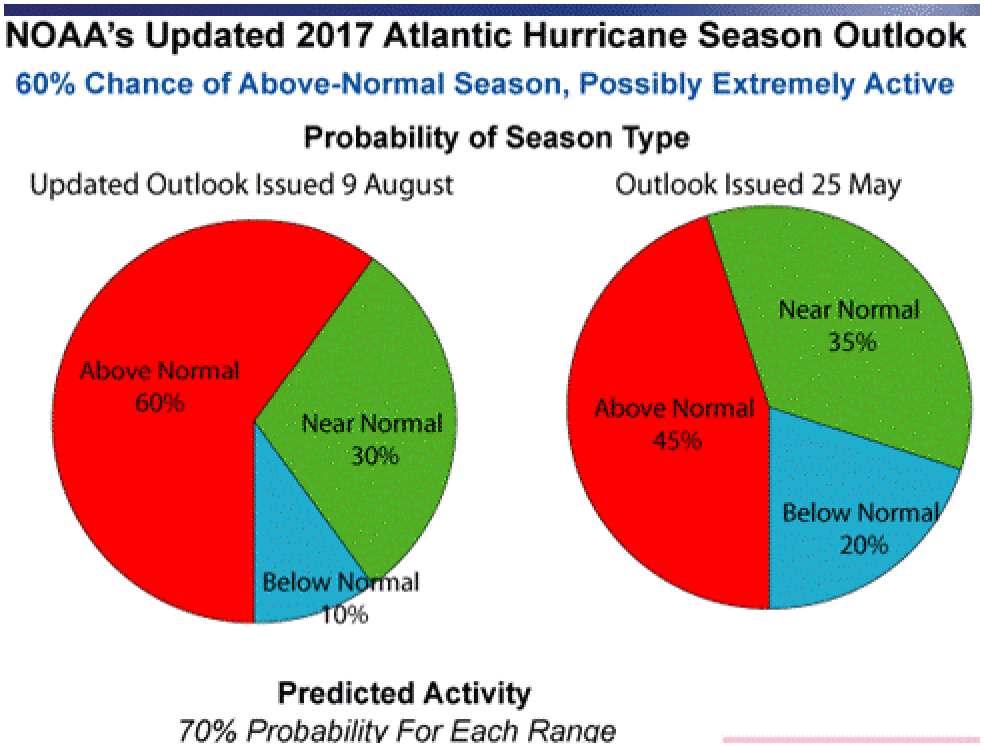
- **Basin index was positive since May 2017.**

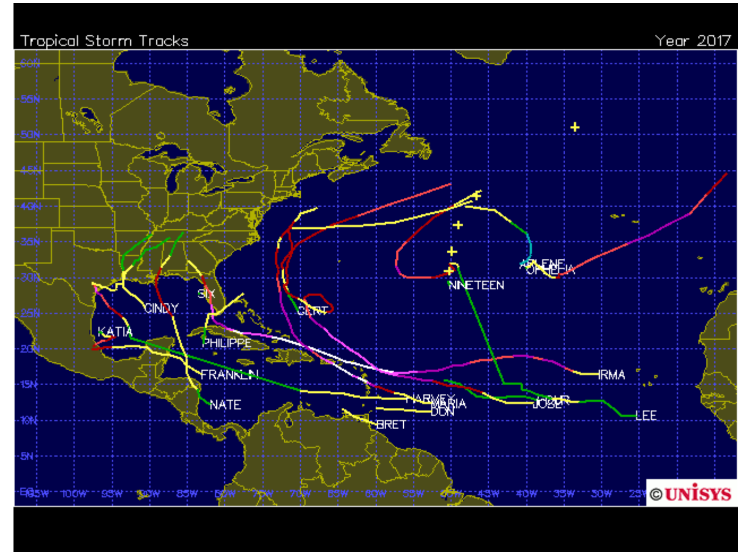
Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Tropical and North Atlantic Ocean

2017 Atlantic Hurricane Season

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



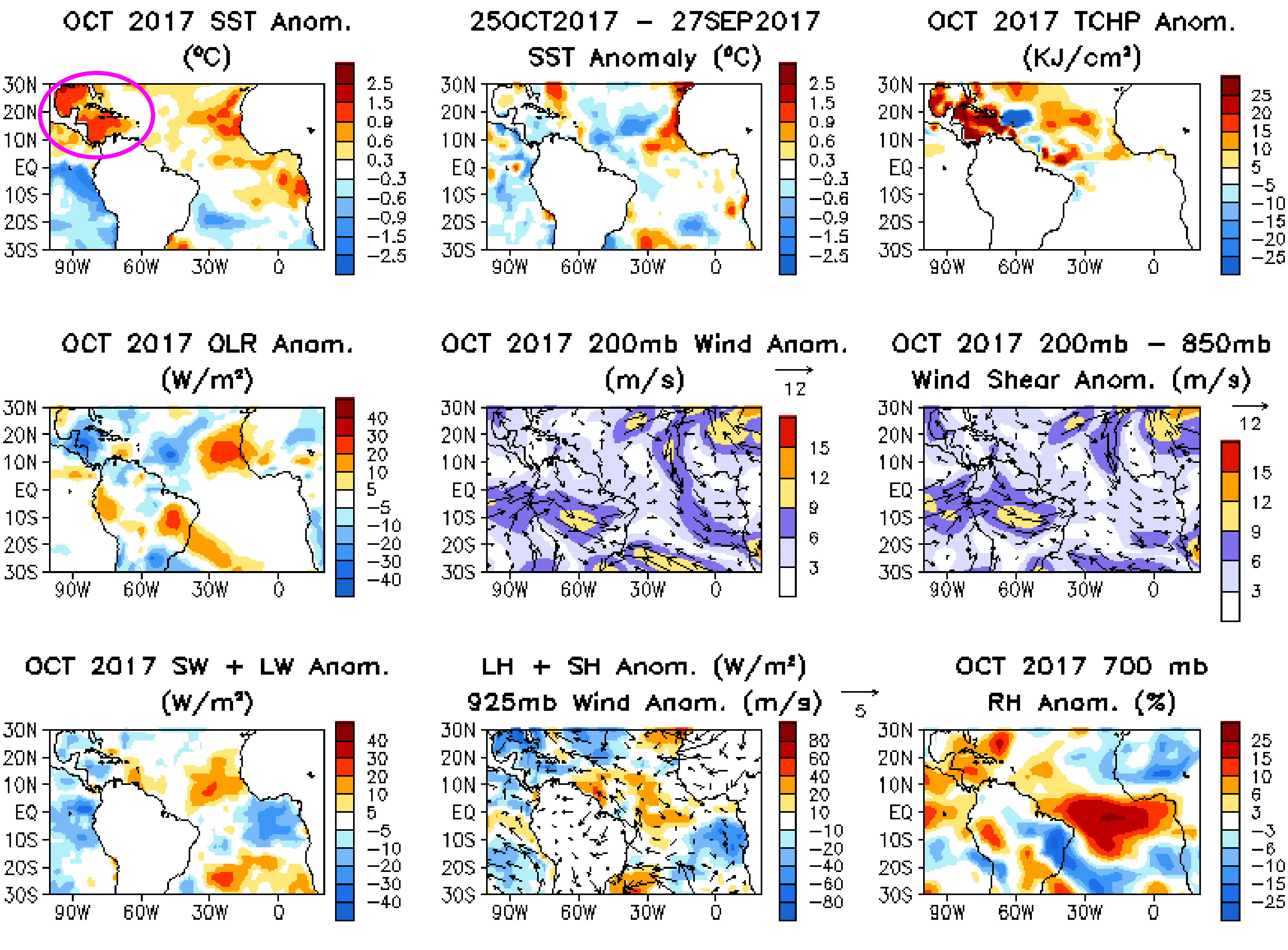


(http://weather.unisys.com/hurricane)

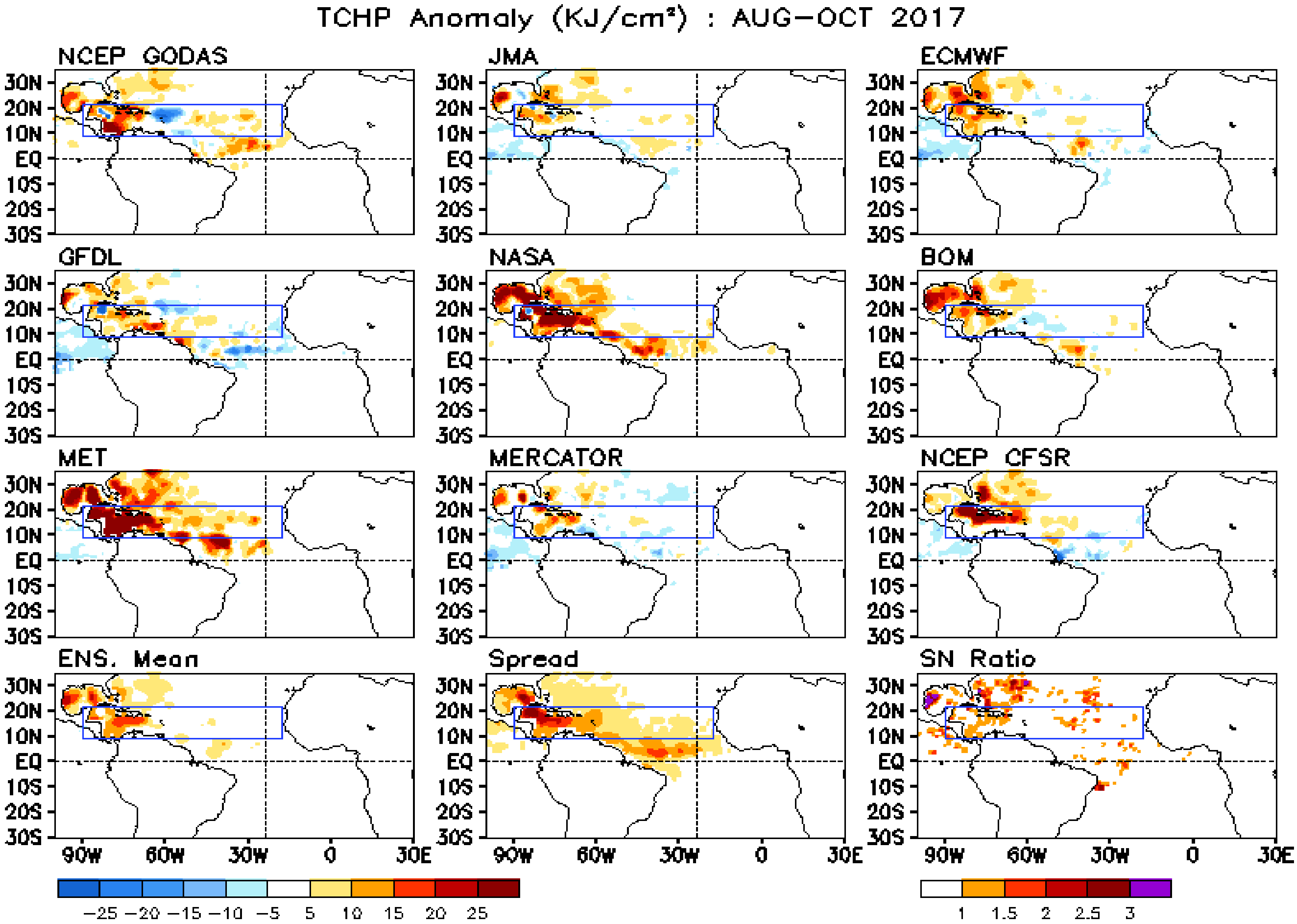
N.Atlantic	Observation by Nov 8, 2016	August Update 60% Above normal	May Outlook 45% above-normal	Season Average 1981-2010
Named storms	17	14-19	11-17	**12**
Hurricanes	10	5-9	5-9	**6**
Major hurricanes	6	2-5	2-4	**3**
ACE(% median)	**225%**	100-170%	75-155%	**66-103%**

Tropical Atlantic:

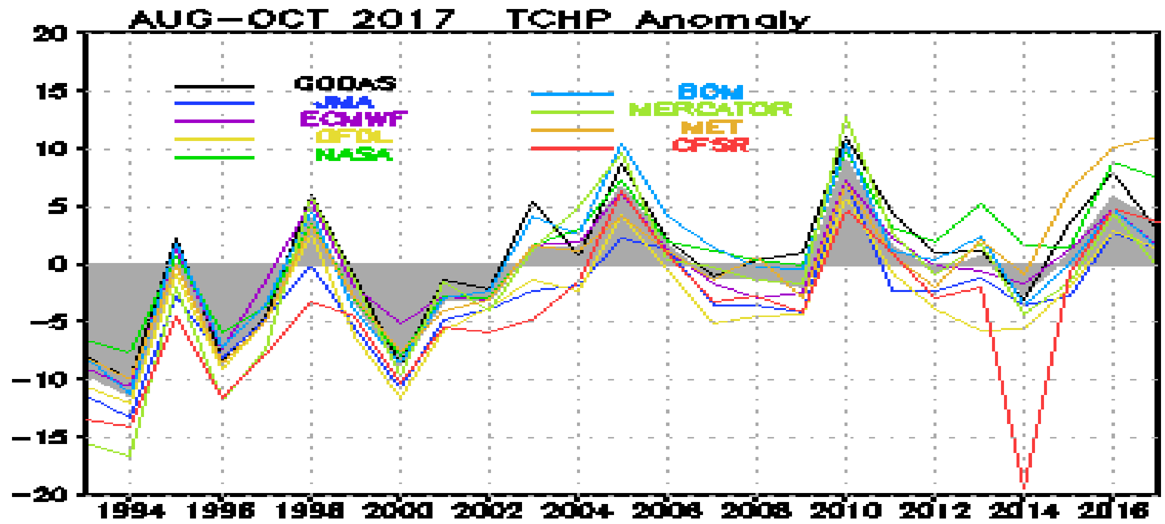
SST, SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, TCHP, 925-mb/200-mb Winds anom.

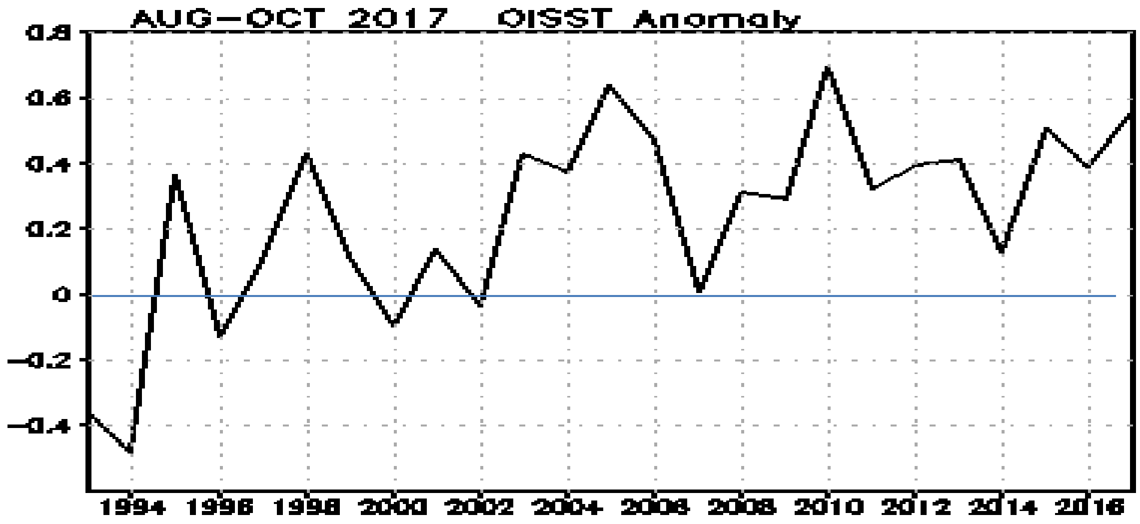


Tropical Cyclone Heat Potential (TCHP) Anomaly (KJ/cm**2)



August-October TCHP and SST anomalies in MDR



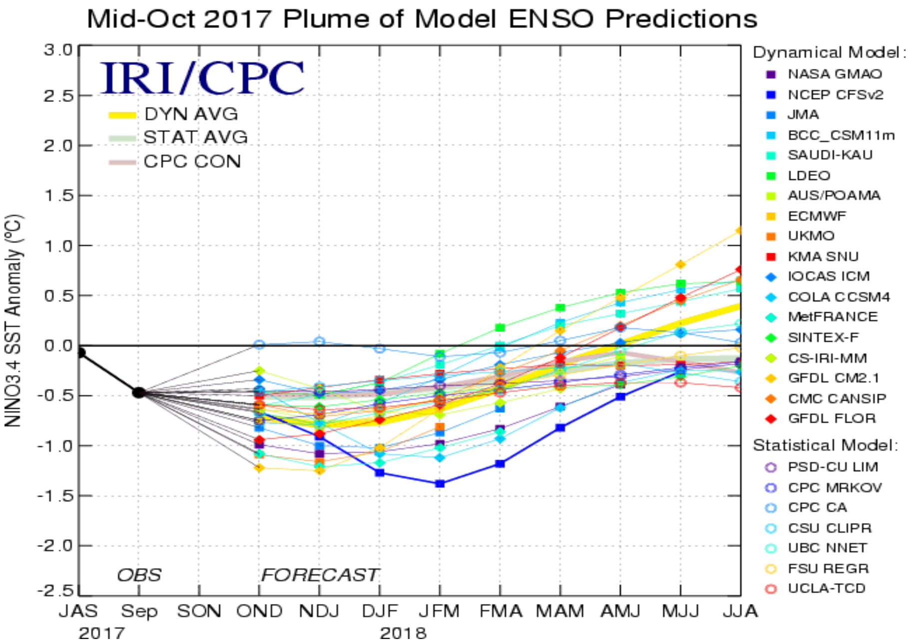


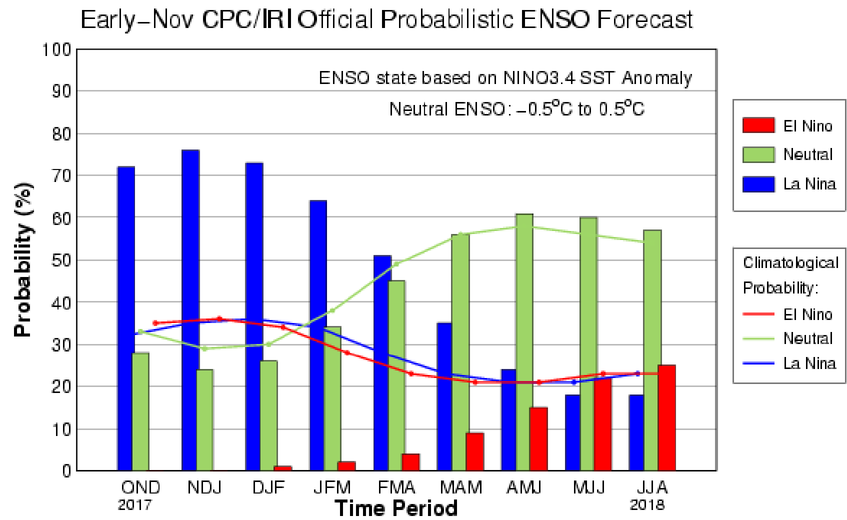
- **Aug-Oct 2017 TCHP anomaly in MDR ranked the fourth strongest since 1993.**

- **Aug-Oct 2017 SST anomaly in MDR was the 3rd warmest since 1993.**

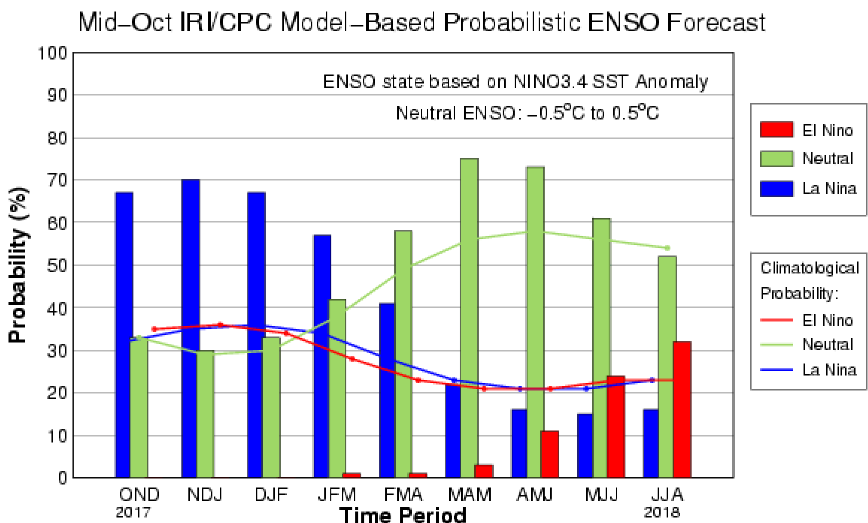
ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum



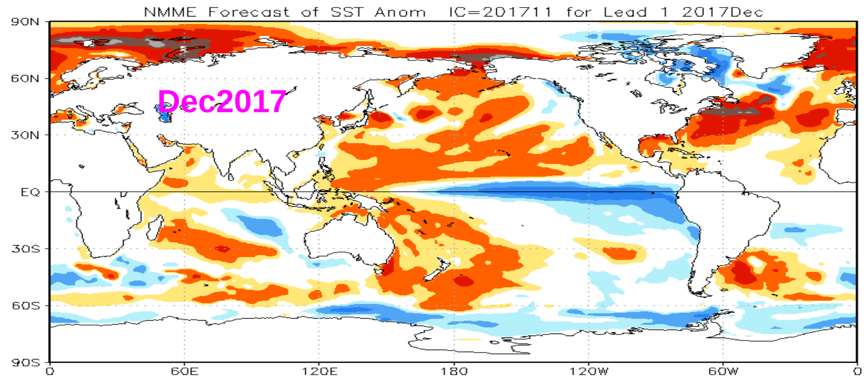


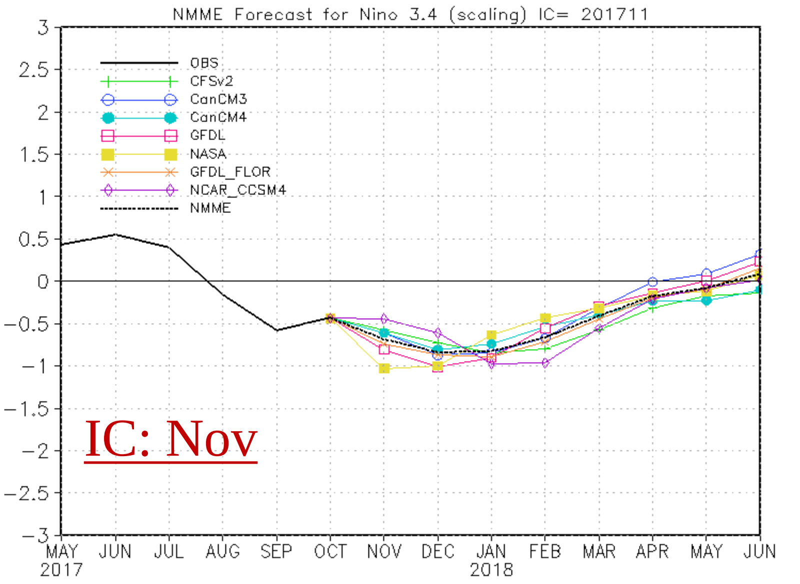
- NOAA "ENSO Diagnostic Discussion" on 9 Nov 2017 suggested "La Niña conditions are predicted to continue (~65-75% chance) at least through the Northern Hemisphere winter 2017-18".
- **CPC/IRI issued La Nina Advisory on 9 Nov 2017.**

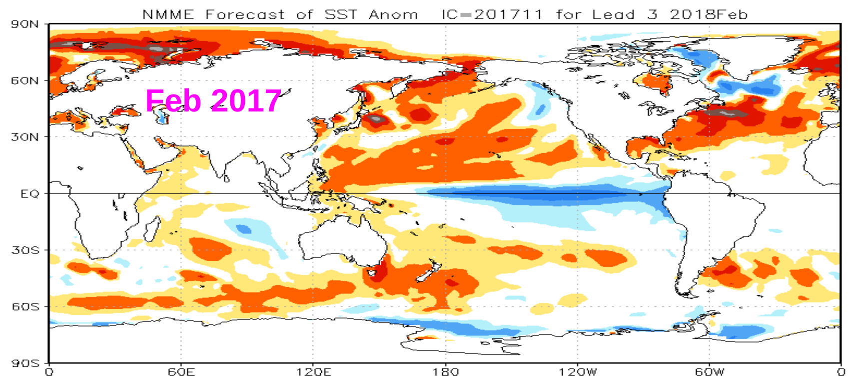


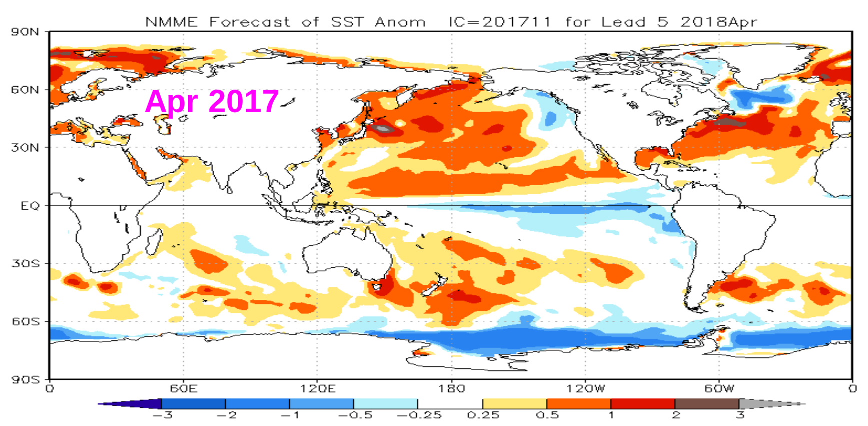
NMME Model Predictions

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

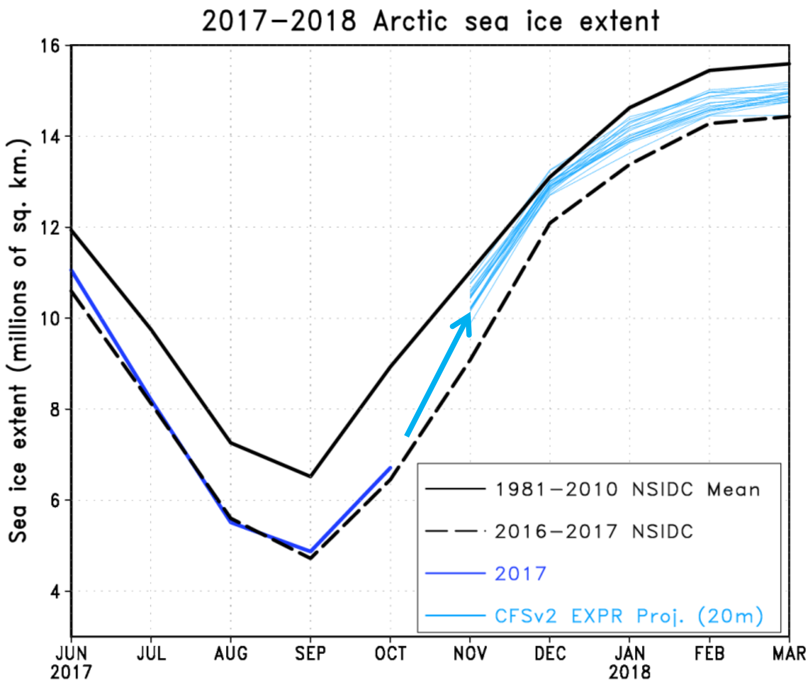


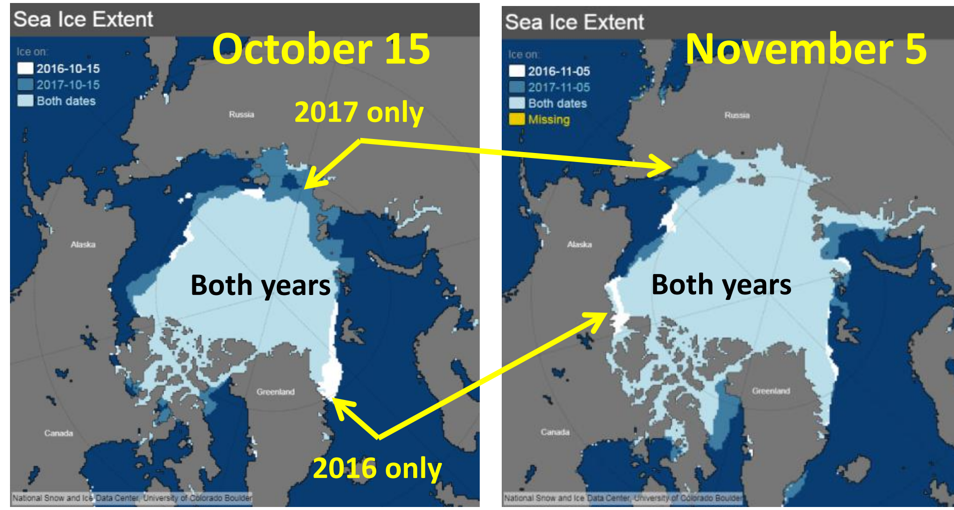






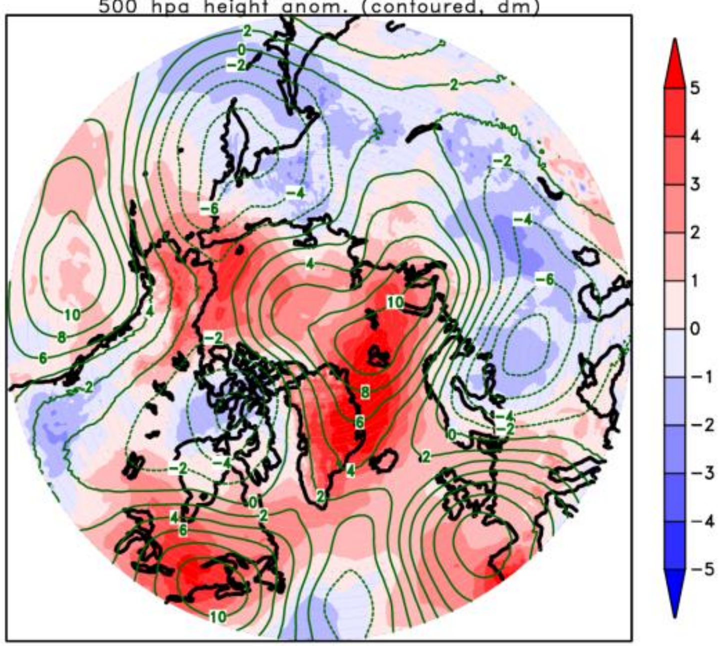
- Latest NMME ensemble mean forecast (black dash line) favors a weak La Nina condition through the Northern Hemisphere winter 2017/18.





October 2017 temperature and height anamolies

925 hPa temp. anom. (shaded, K),
500 hpa height anom. (contoured, dm)



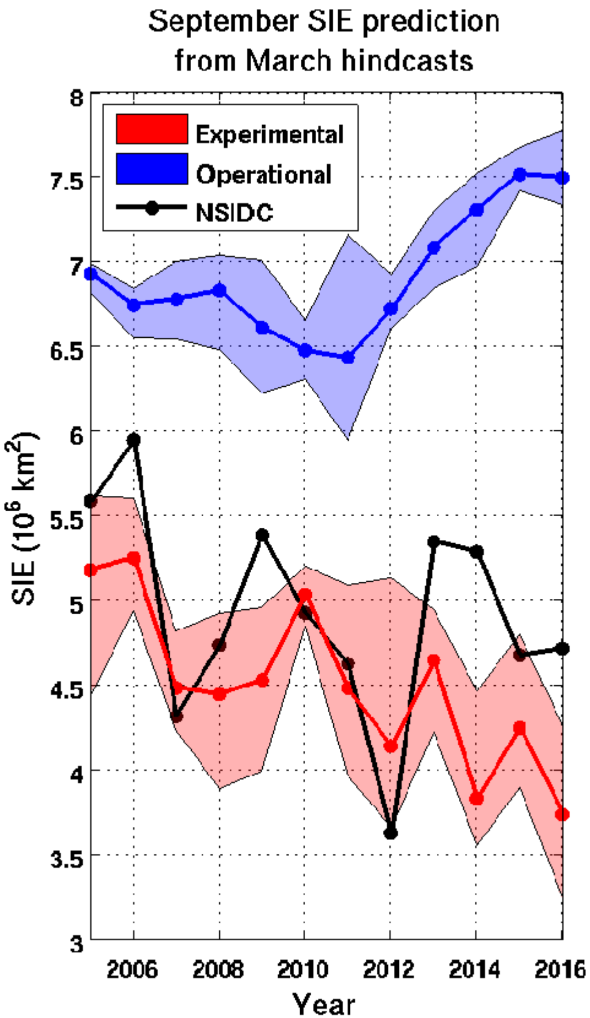
-Arctic sea ice extent for October was <u>6.71 million km^2</u> making it 5th lowest October in the satellite record extending back to 1979.

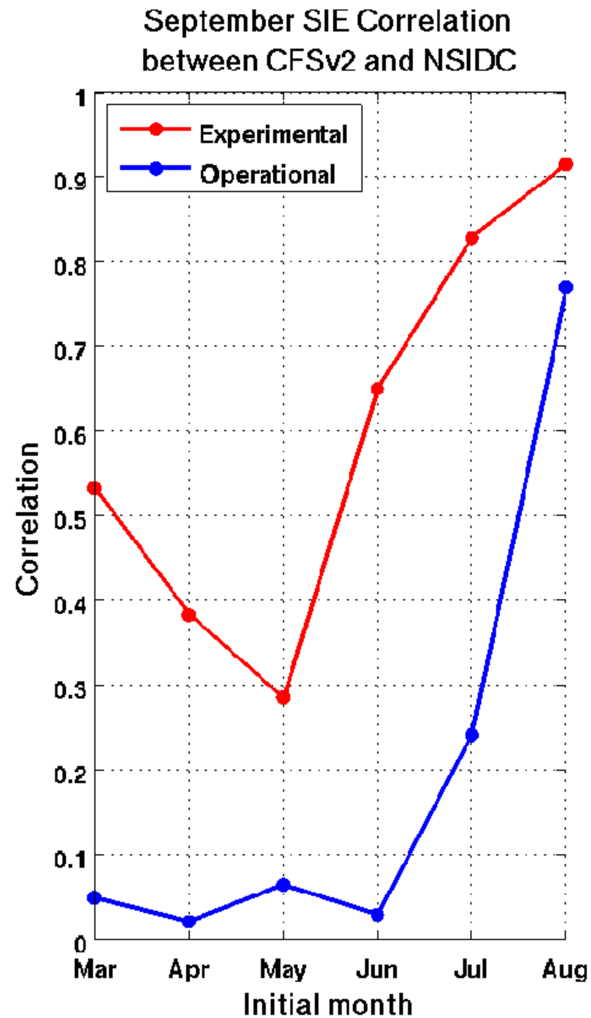
-Currently a slightly more expansive coverage exists compared to last year at this time. It is worth noting that the freeze-up rate has slowed in the last 2 weeks. The Arctic Ocean region generally had above average near surface temperatures in October 2017.

-Experimental CFSv2 forecast shows sea ice extent remaining below the 1981-2010 average but above last year's record lows.

(Courtesy of Thomas Collow)

Skill assessment of experimental hindcasts, 2005-2016





- Using the 2005-2016 hindcast dataset we show that skill of the experimental sea ice forecasts for predicting the September minimum is not just limited to an improved seasonal cycle but also improved year to year variability.
- Investigating all initial months shows a dip in year to year skill (correlation with NSIDC) in the Spring (April-May) but skill remains higher than the operational in all initial months.

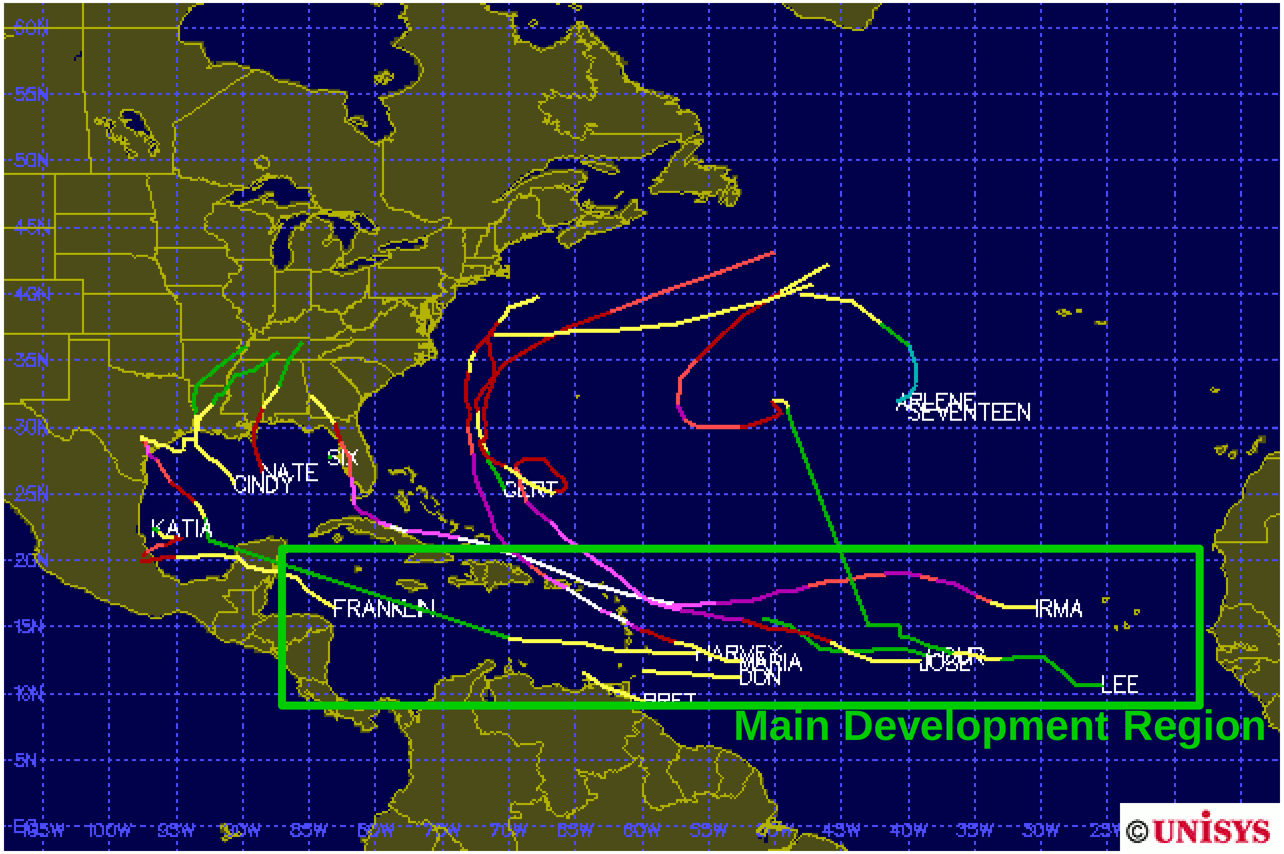
Assessment of the 2017 West African Monsoon

Wassila Mamadou Thiaw
Team Leader

CPC International Desks

Acknowledgement:
Miliaritiana Robjhon
Nick Novella

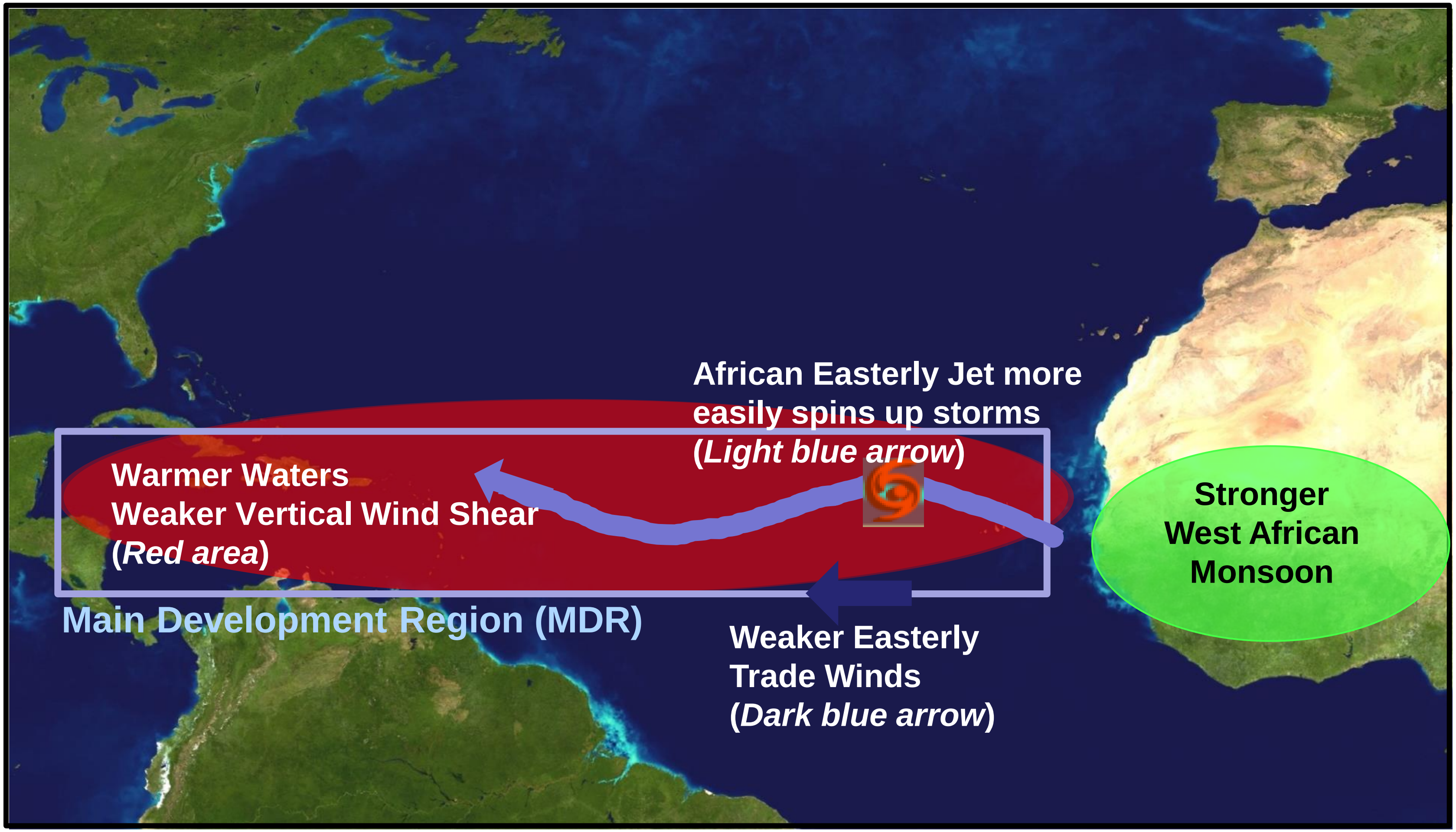
2017 Storm Tracks As of End of September



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.

Gerry Bell

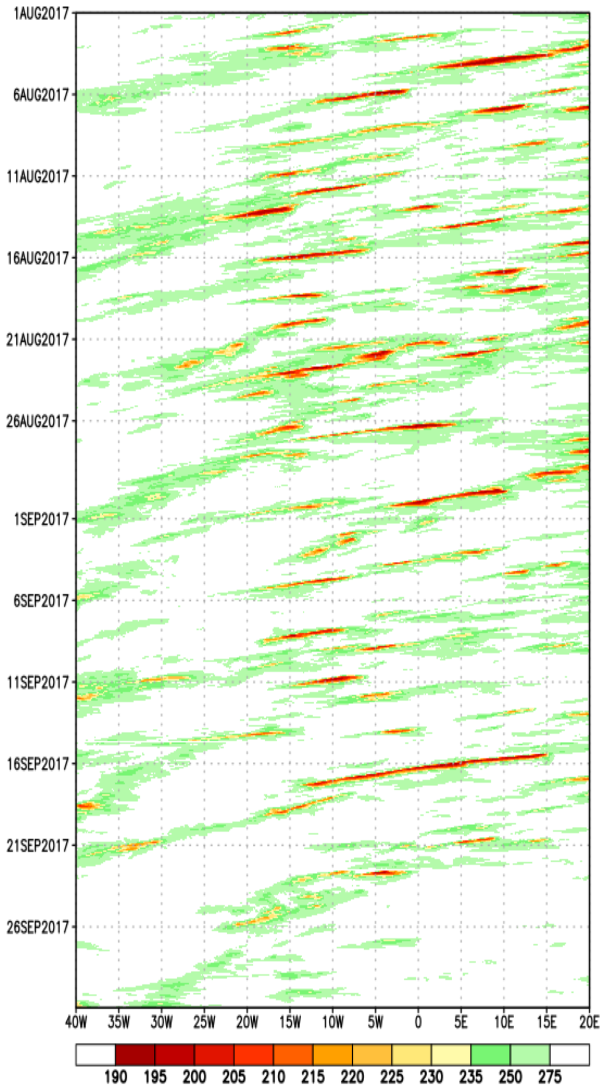
Predicted Conditions During August-October 2017
Typify Warm Phase of Atlantic Multi-Decadal Oscillation (AMO)



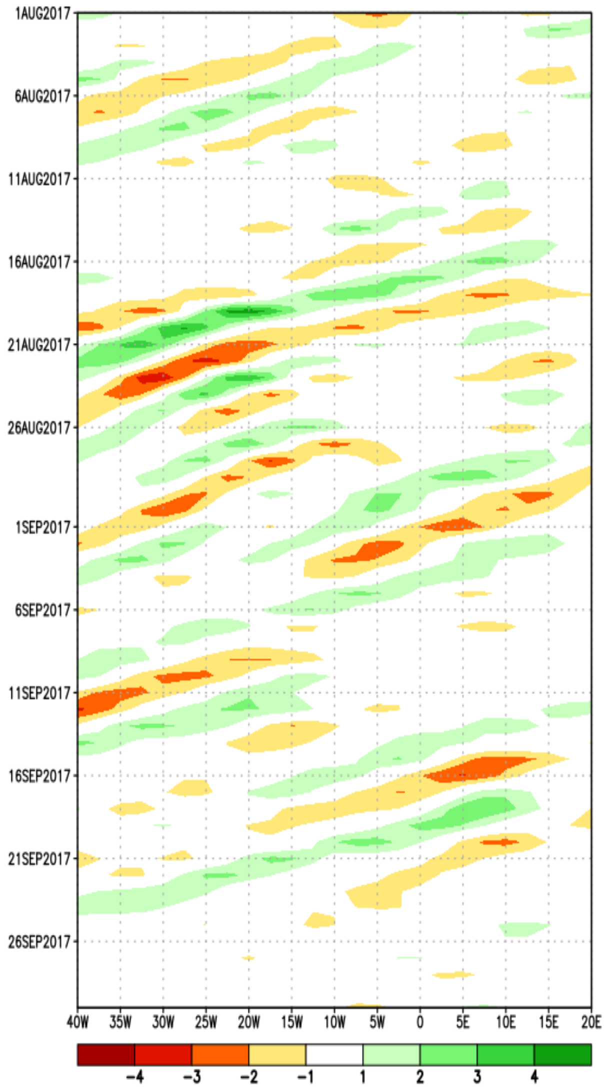
This inter-related set of conditions within the MDR is typical of other above-normal seasons, and is consistent with the warm phase of the AMO (Bell and Chelliah, JCLI, 2006)

Gerry Bell

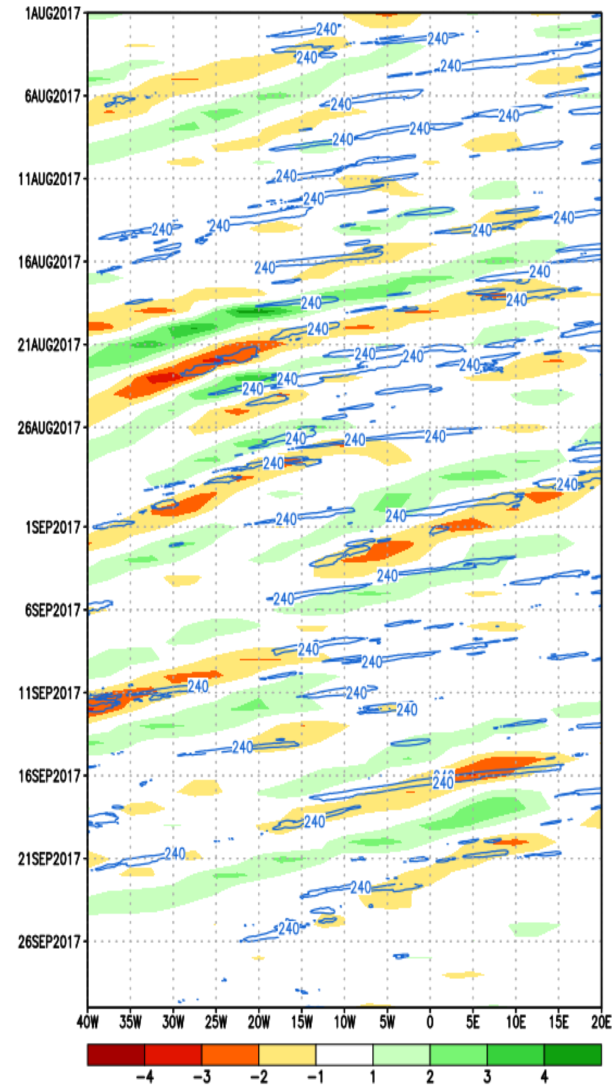
AWDs Propagation



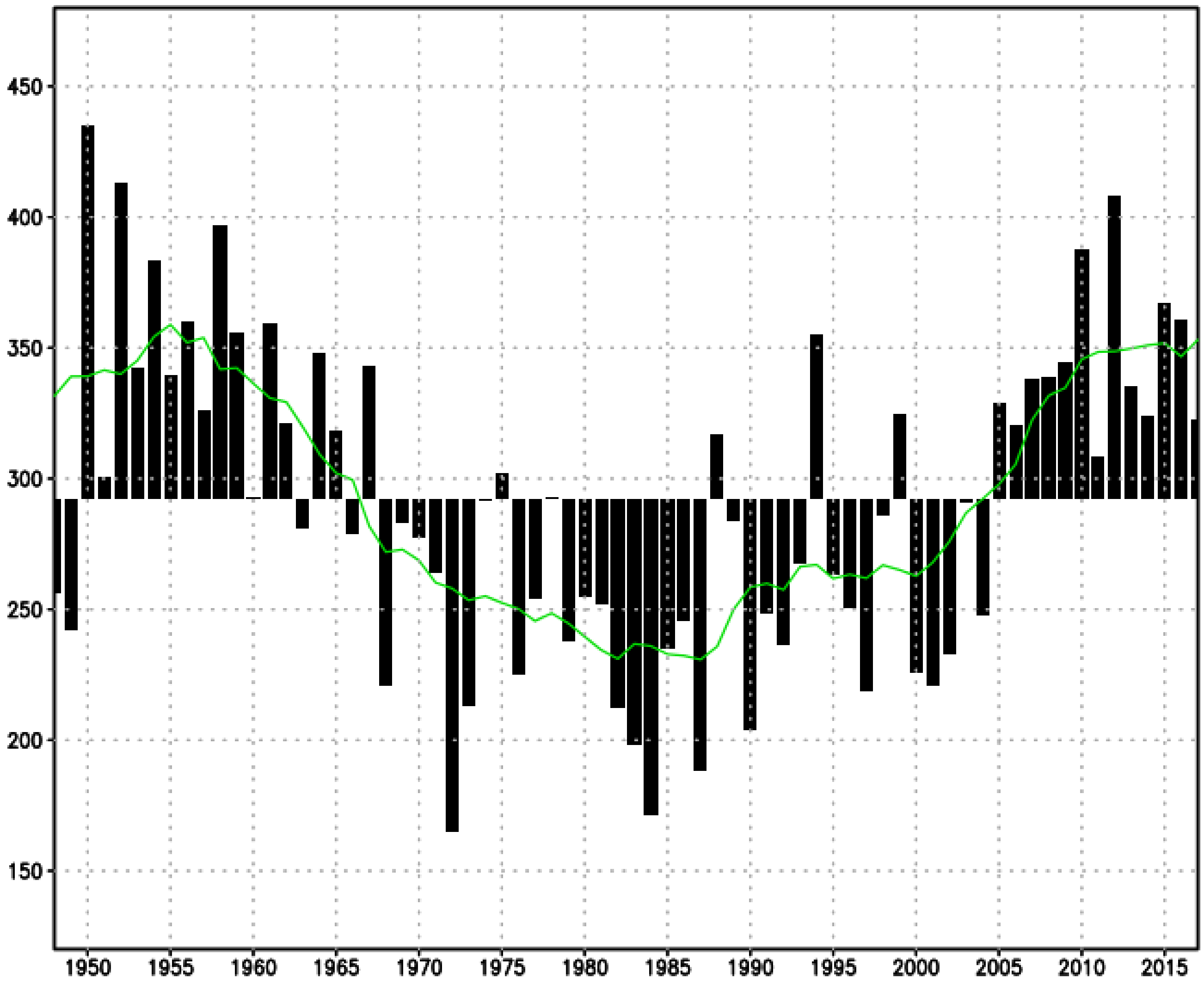
3-5 day filtered 600mb V
Lat ave: 12N-15N



V+MCS
Lat ave: 12N-15N

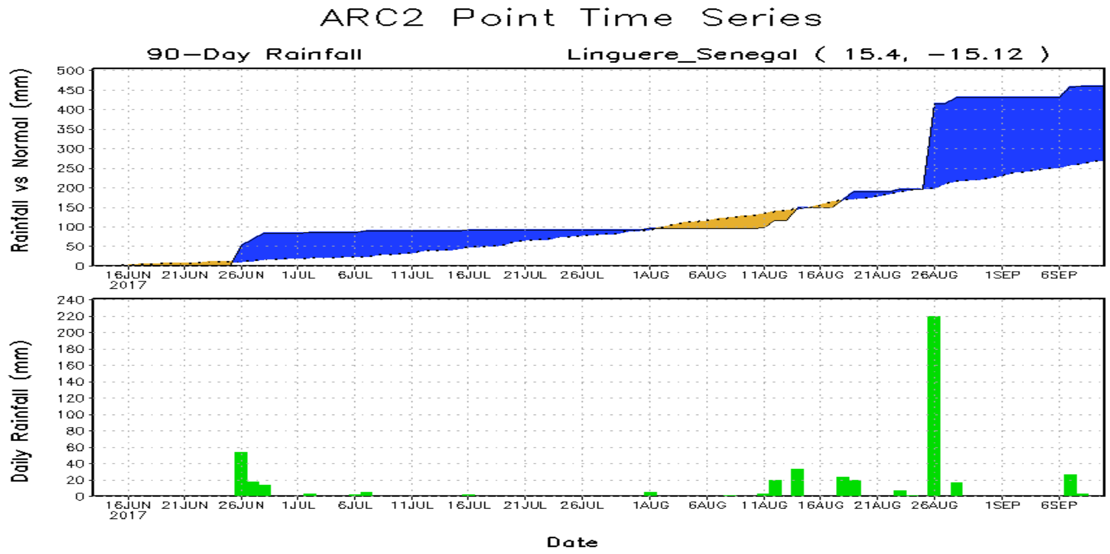


Sahel JAS Precip Index (17.5W-20.0E / 12.5N – 17.5N)



Flash Flooding in Linguere, Northern Senegal

Semi-arid city received 219 mm in less than 24 hours, Aug 26, equivalent to climatological annual total



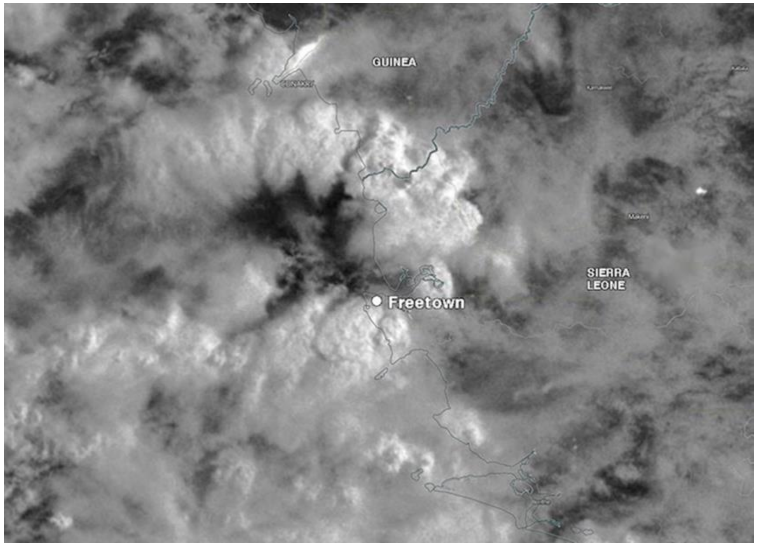
Ongoing humanitarian assistance for flood victims in Linguere

Residents in Linguere walking on flooded streets

Record Breaking Rainfall Amounts in Sierra Leone.

This is where the NH summer climatological rainfall in Africa at its maximum.

Freetown received more than 200% of normal rainfall since June 2017

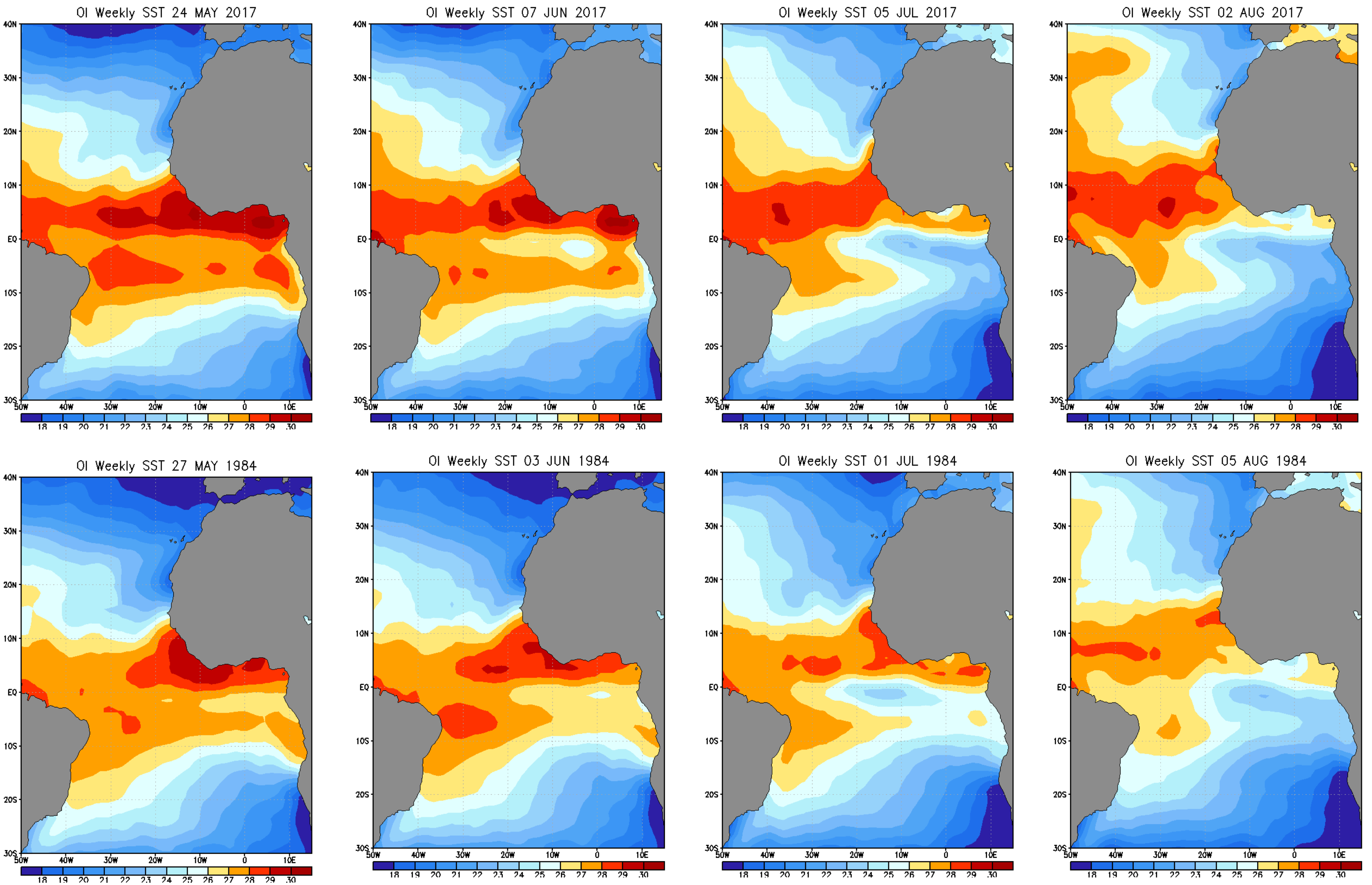


NASA VIS satellite image of heavy thunderstorms over Freetown, Sierra Leone, 0200 UTC Monday, August 14, 2017.

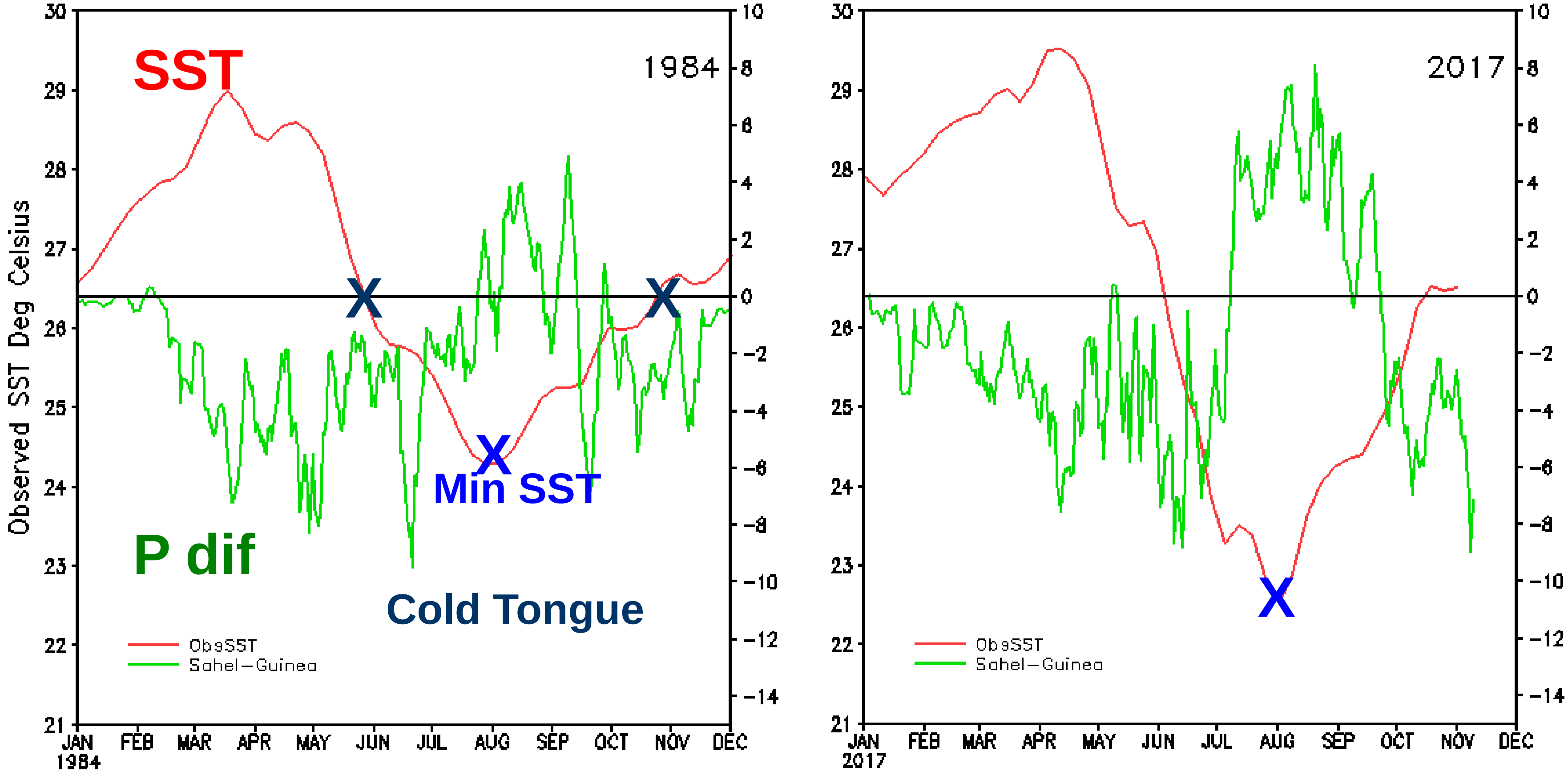
Torrential rains flooded Freetown, Sierra Leone, Aug 14th

Landslides struck the city, killing at least 312 and leaving more than 2,000 left homeless

Weekly SST 2017 (top) and 1984 (bottom)
Atlantic Cold Tongue



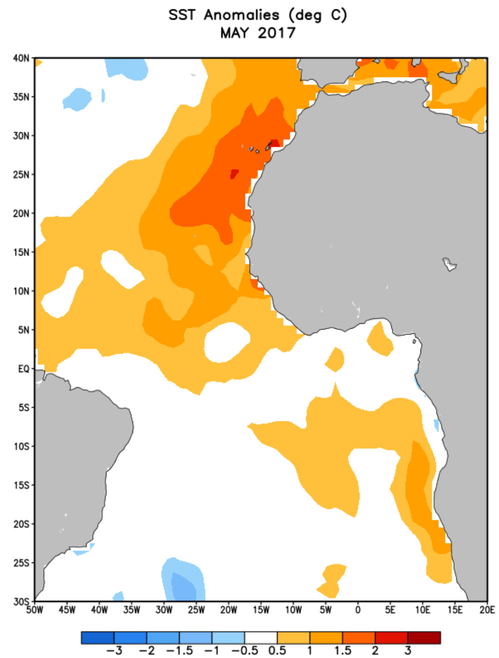
Observed Sahel – Guinea P Difference and Evolution of Equatorial Atlantic SST 2°S;0 lon

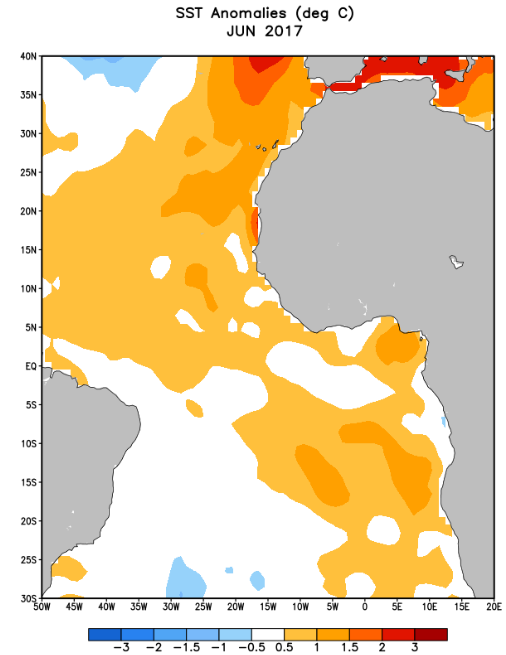


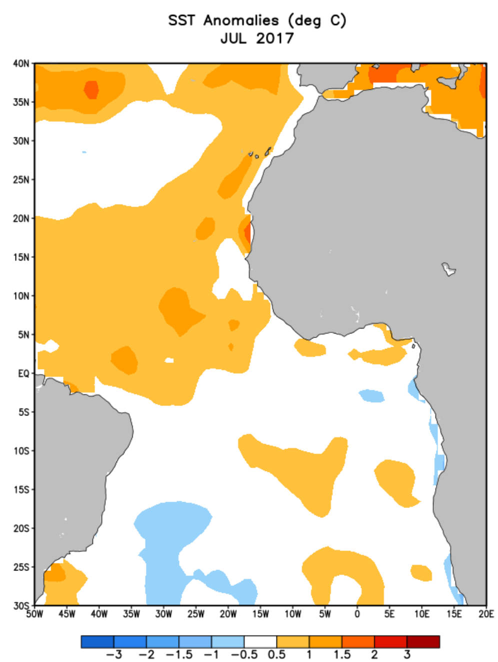
1984

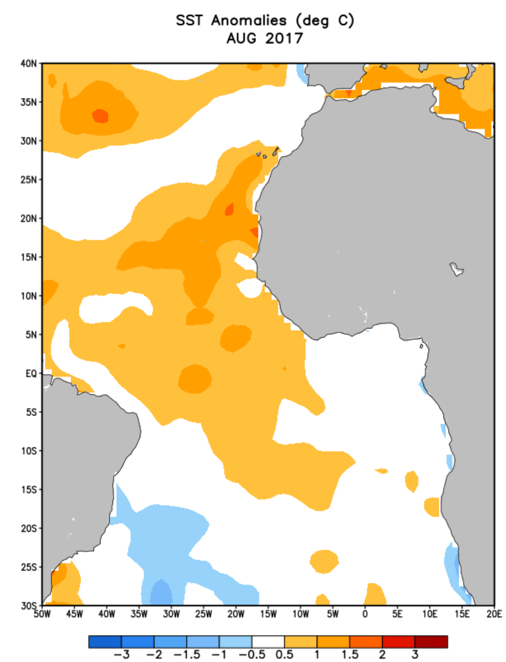
2017

SST Anomalies for May-Aug 2017

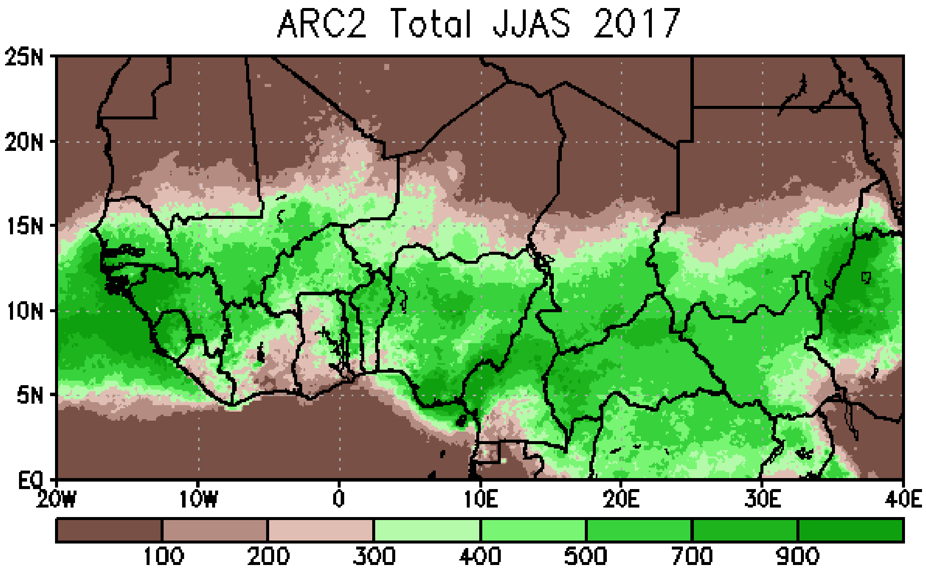


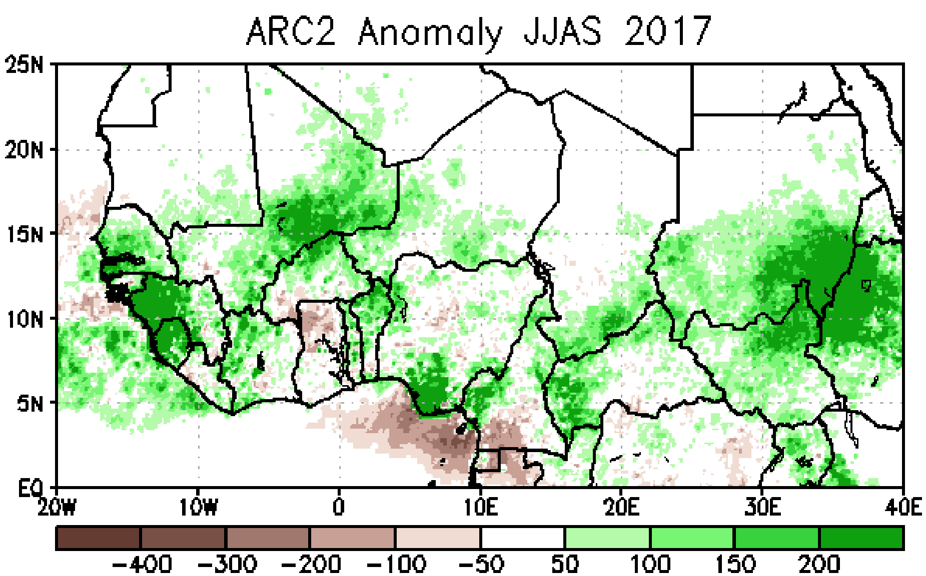


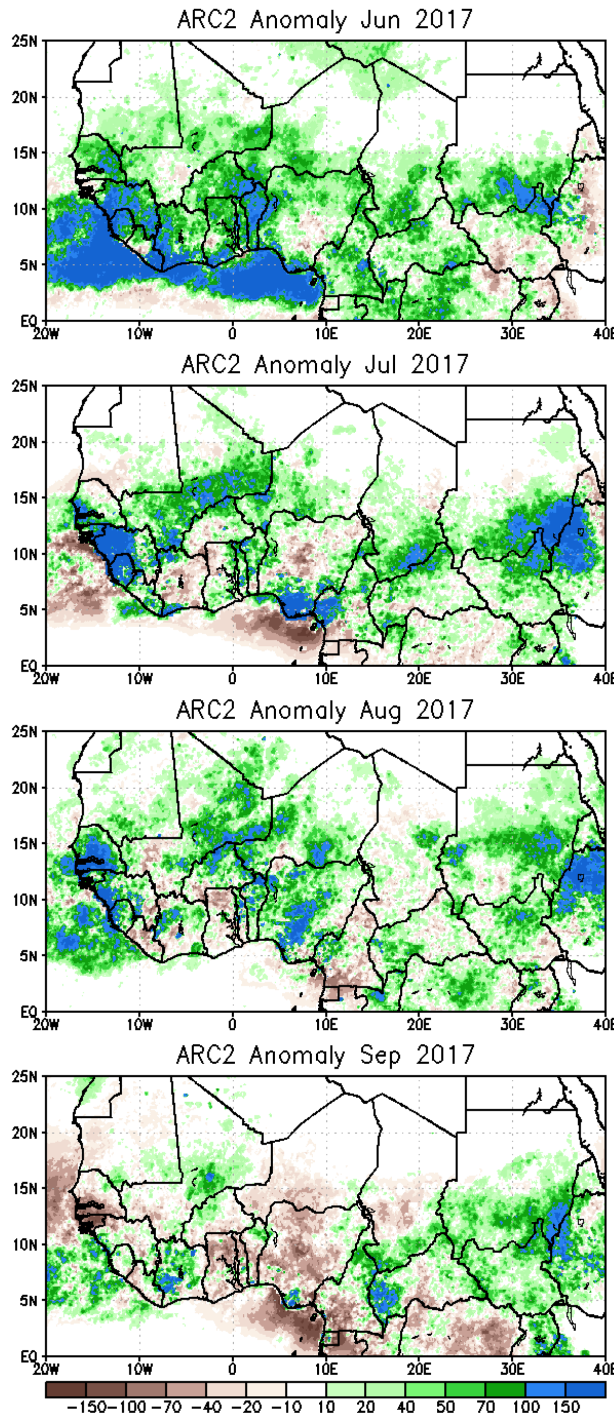




Seasonal Rainfall Total and Anomaly



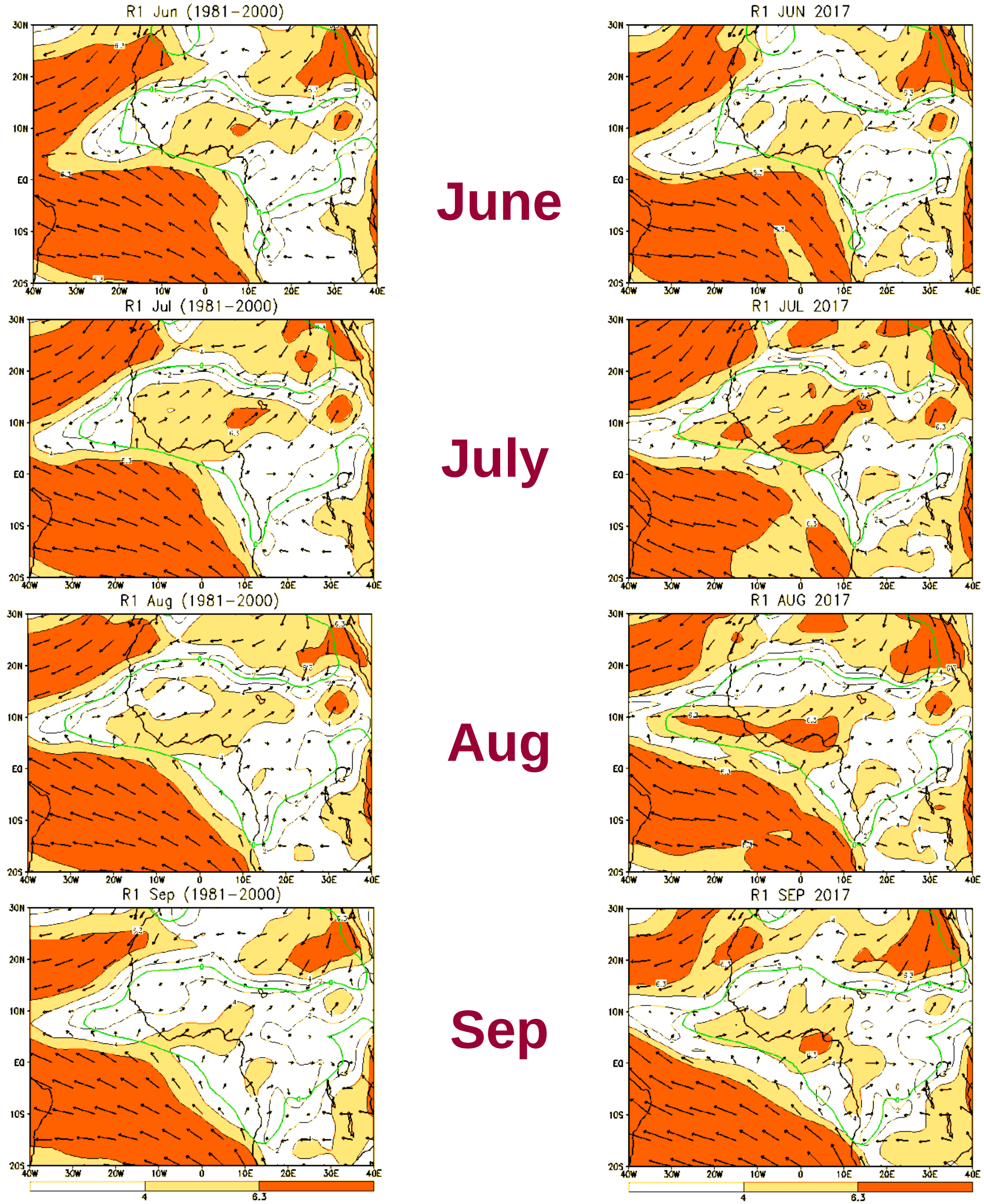




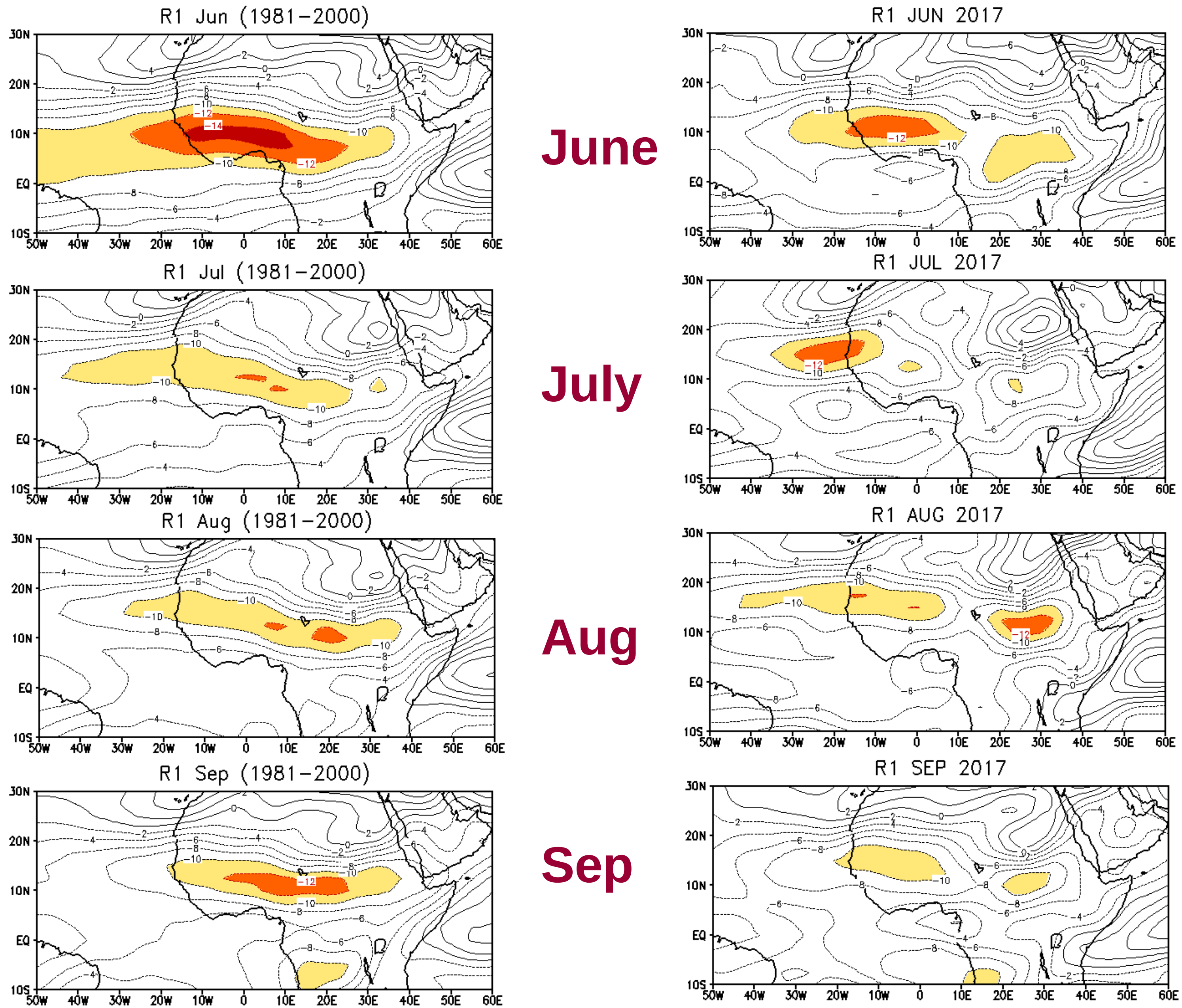
925 hPa Wind

Left Panel: Climo 1981-2000

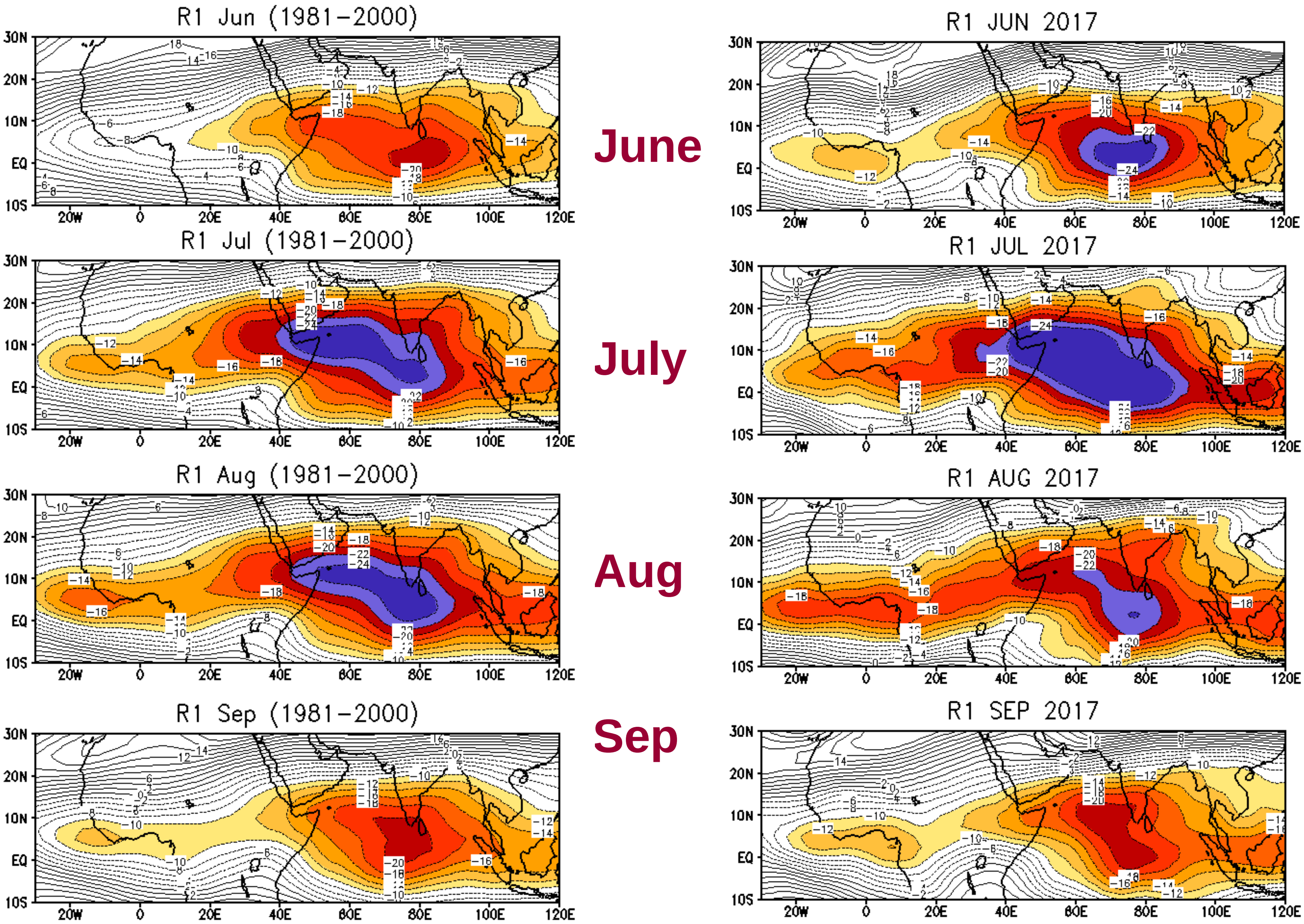
Right Panel: 2017



Zonal Wind 600 hPa – African Easterly Jet



Zonal Wind 200 hPa – TROPICAL Easterly Jet



Summary

- The West African monsoon was once again extremely active especially in August and September
- This continues the upward trend in rainfall surpluses over the Sahel over the past decade
- This trend is associated with the Atlantic multi-decadal trend that also account for the Atlantic Hurricane activity.

Acknowledgements

- Drs. Yan Xue ,Zeng-Zhen Hu and Arun Kumar: reviewed PPT, and provided insight and constructive suggestions and comments
- Dr. Michelle L'Heureux : Provided ENSO Diagnostic Discussion update
- Drs. Thomas Collow and Wanqiu Wang: Provided sea ice prediction slides
- Dr. Wassila Mamadou Thiaw: Provided West African Monsoon slides
- Drs. Li Ren and Pingping Xie: Provided SSS slides

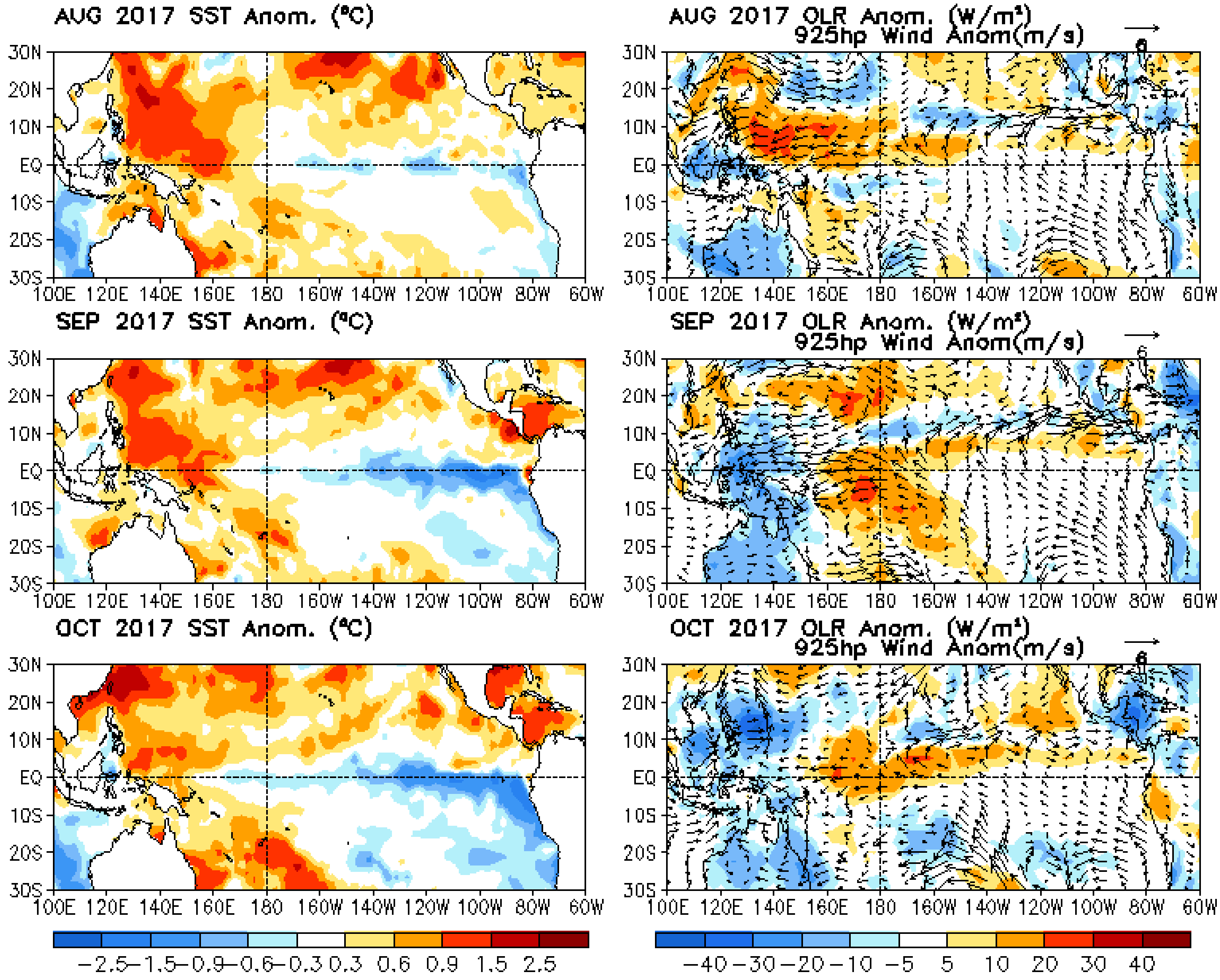
Data Sources and References

- **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!

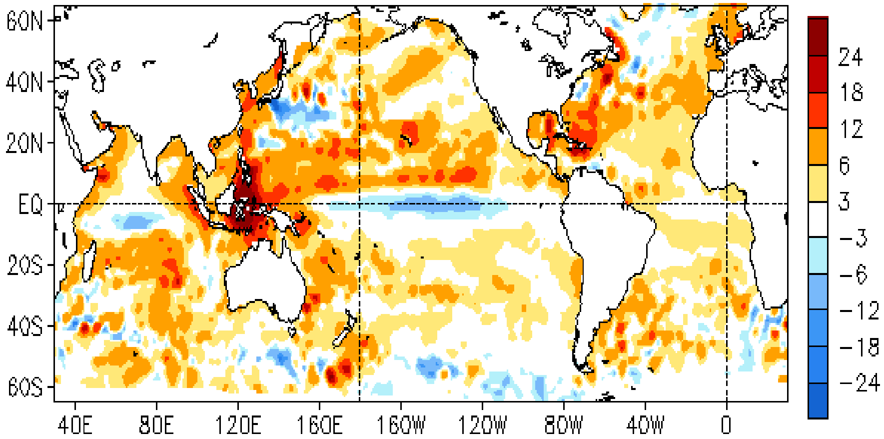
Backup Slides

Last Three Month SST, OLR and 925hp Wind Anomalies

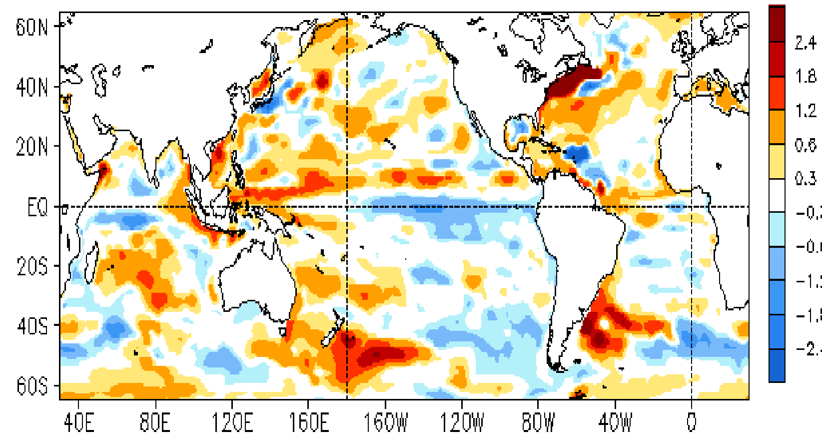


Global SSH and HC300 Anomaly & Anomaly Tendency

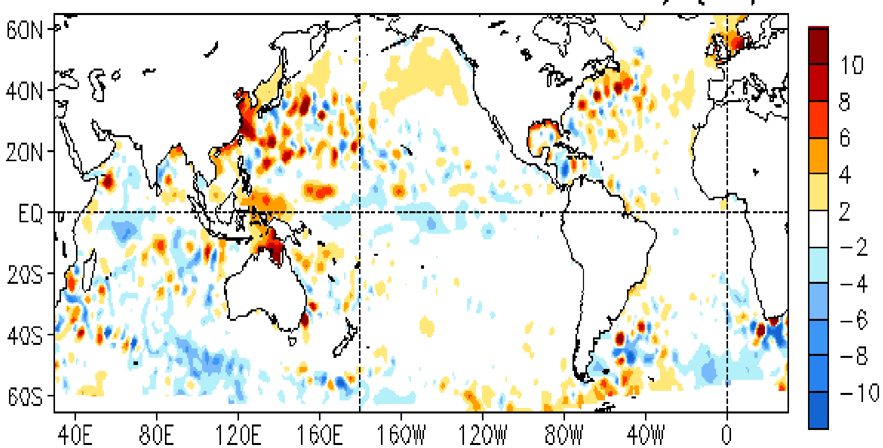
OCT 2017 SSH Anomaly (cm)
(AVISO Altimetry, Climo. 93-13)



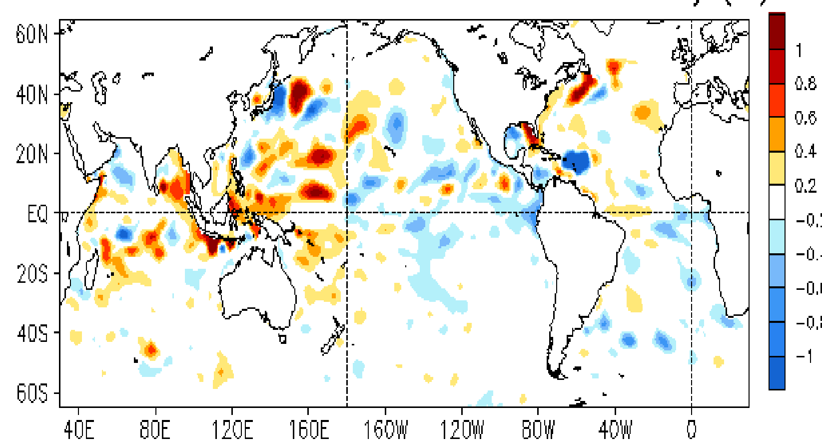
OCT 2017 Heat Content Anomaly (°C)
(GODAS, Climo. 81-10)



OCT 2017 – SEP 2017 SSH Anomaly (cm)



OCT 2017 – SEP 2017 Heat Content Anomaly (°C)

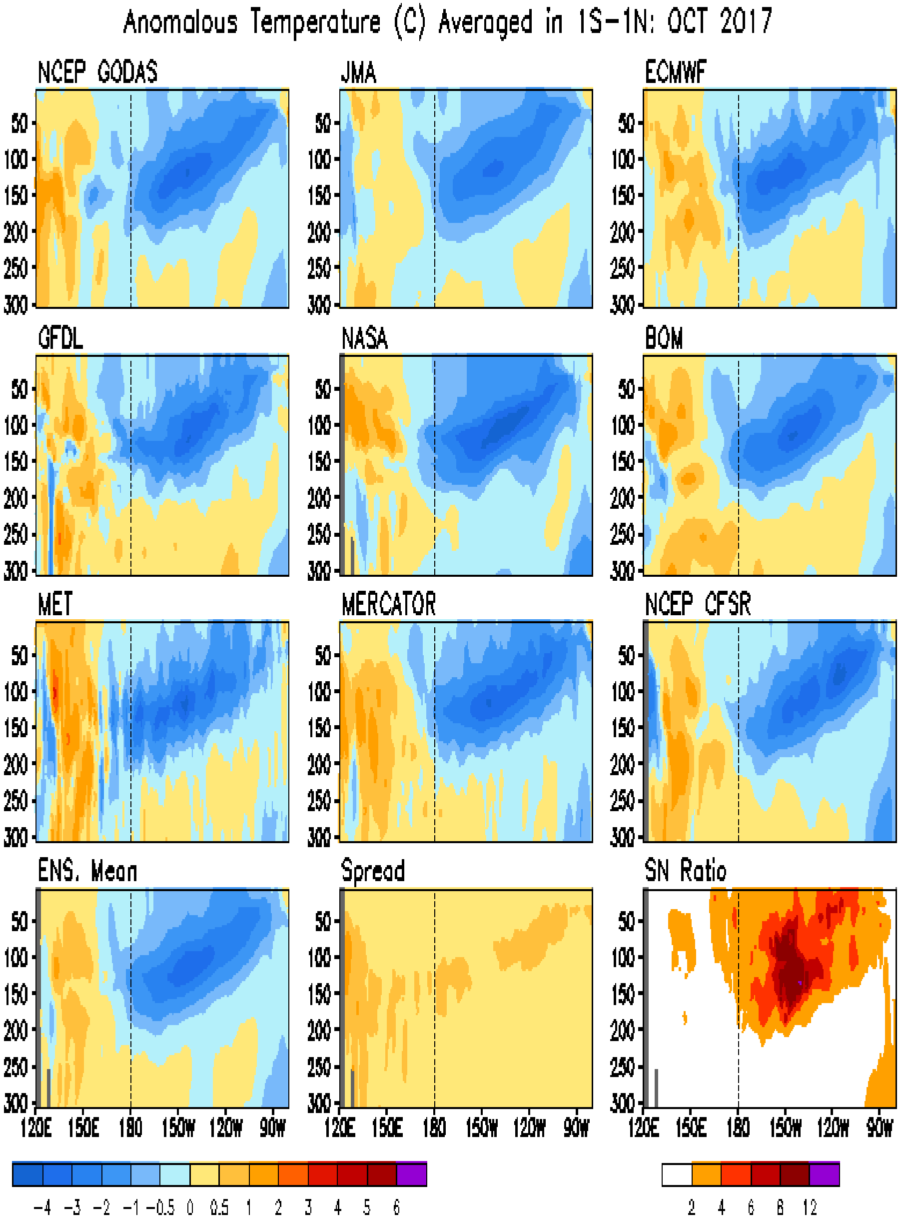


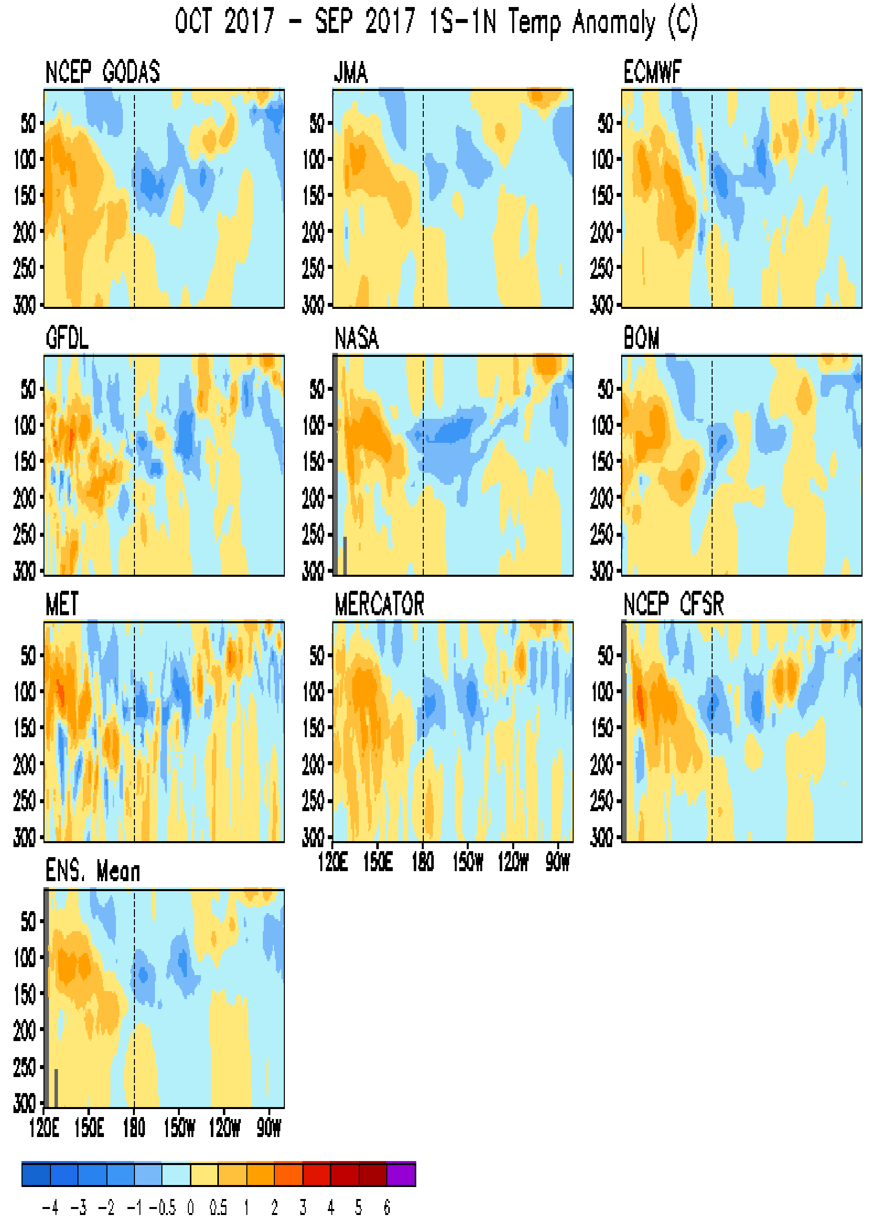
-Negative tendency was observed in both SSHA and HC300A in the central-eastern equatorial Pacific.

Real-Time Ocean Reanalysis Intercomparison: Temperature

Climatology : 1993-2013

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

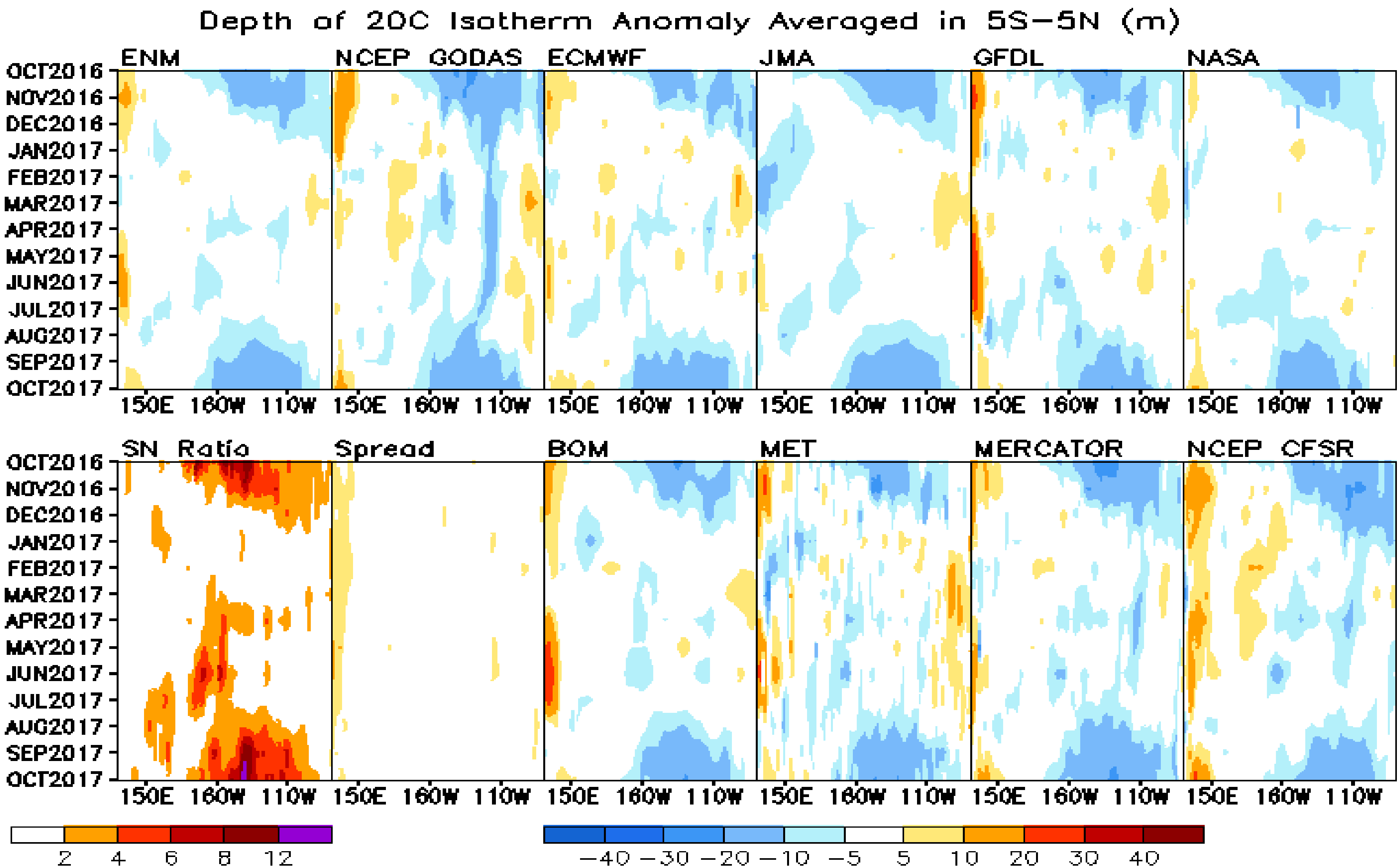




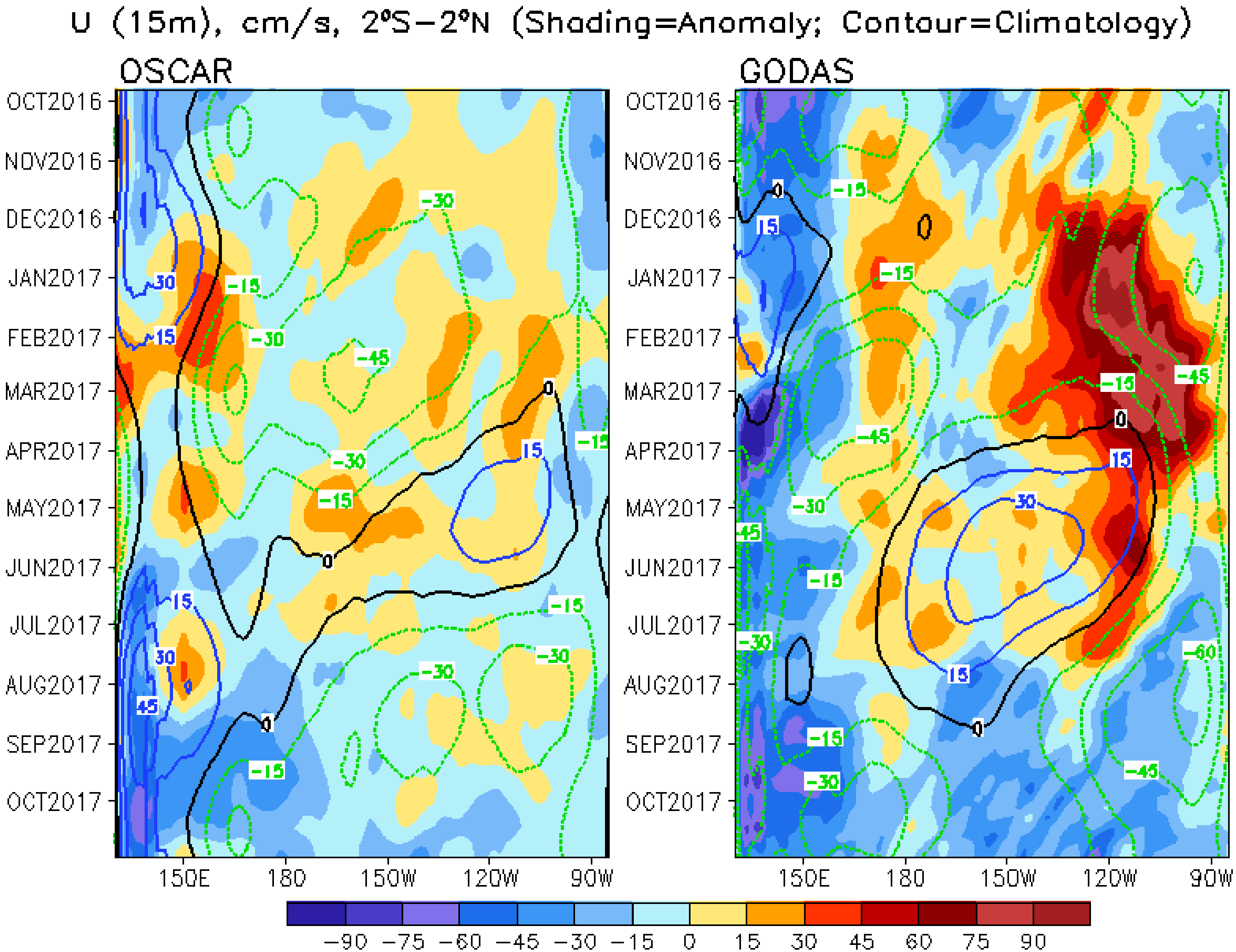
Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1993-2013

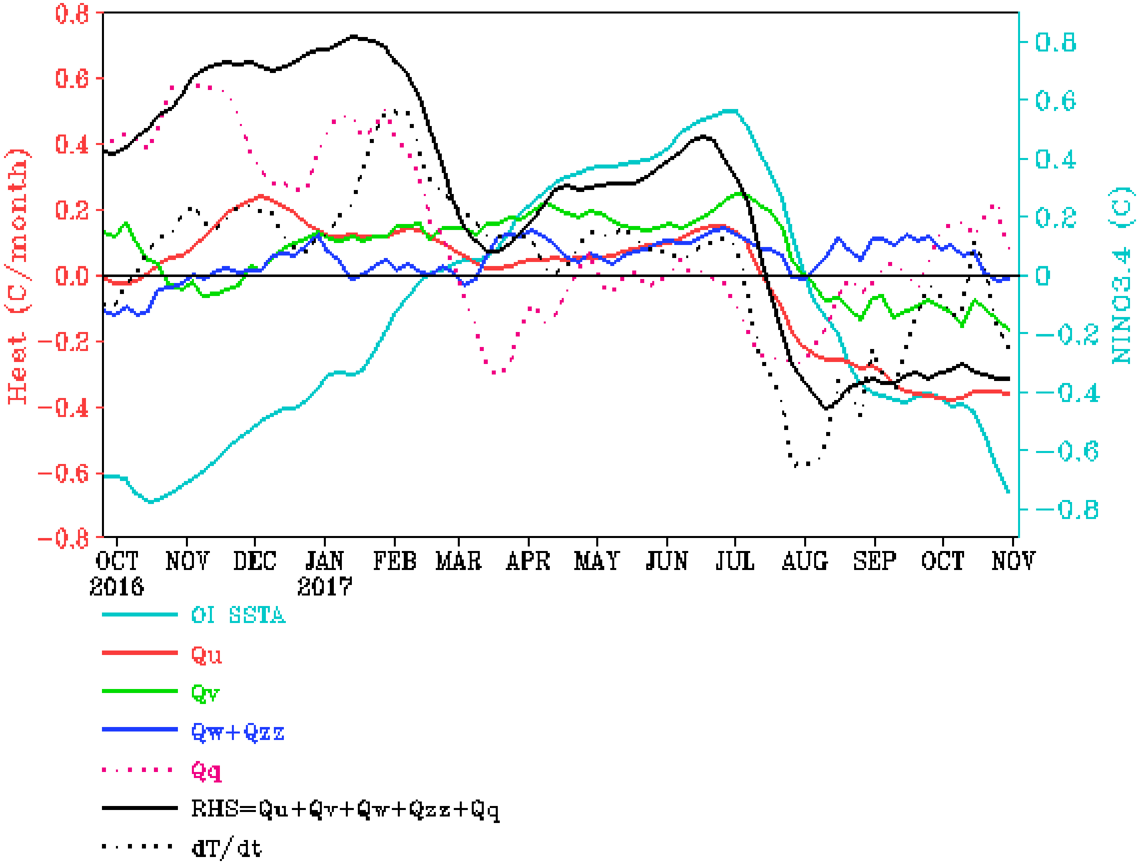
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html)



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



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.

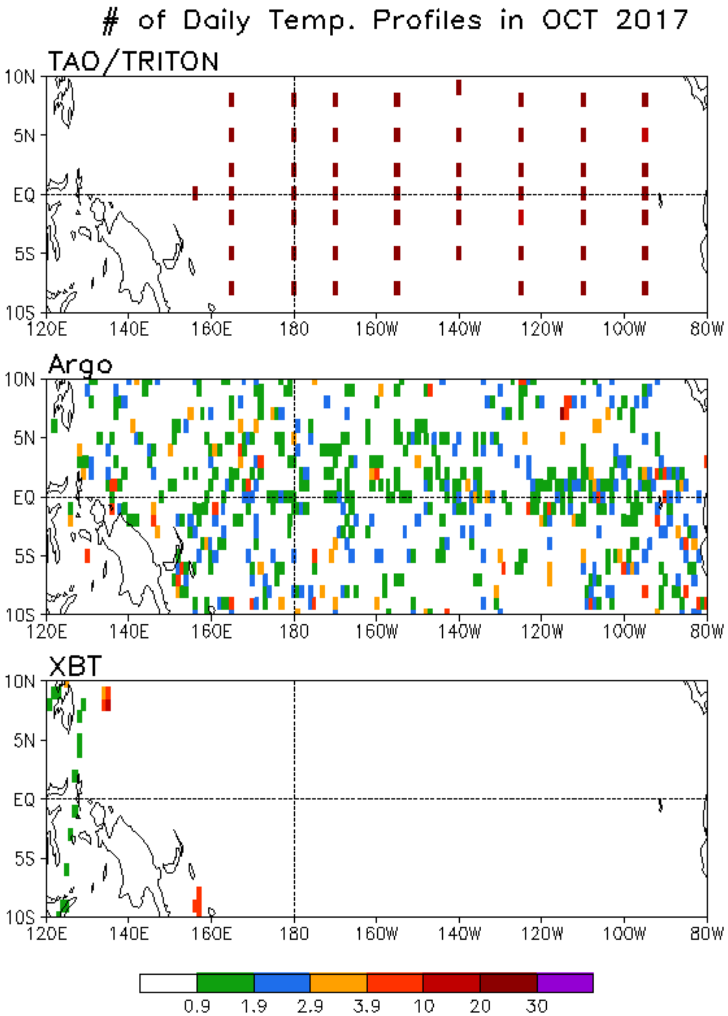
Qu: Zonal advection; Qv: Meridional advection;

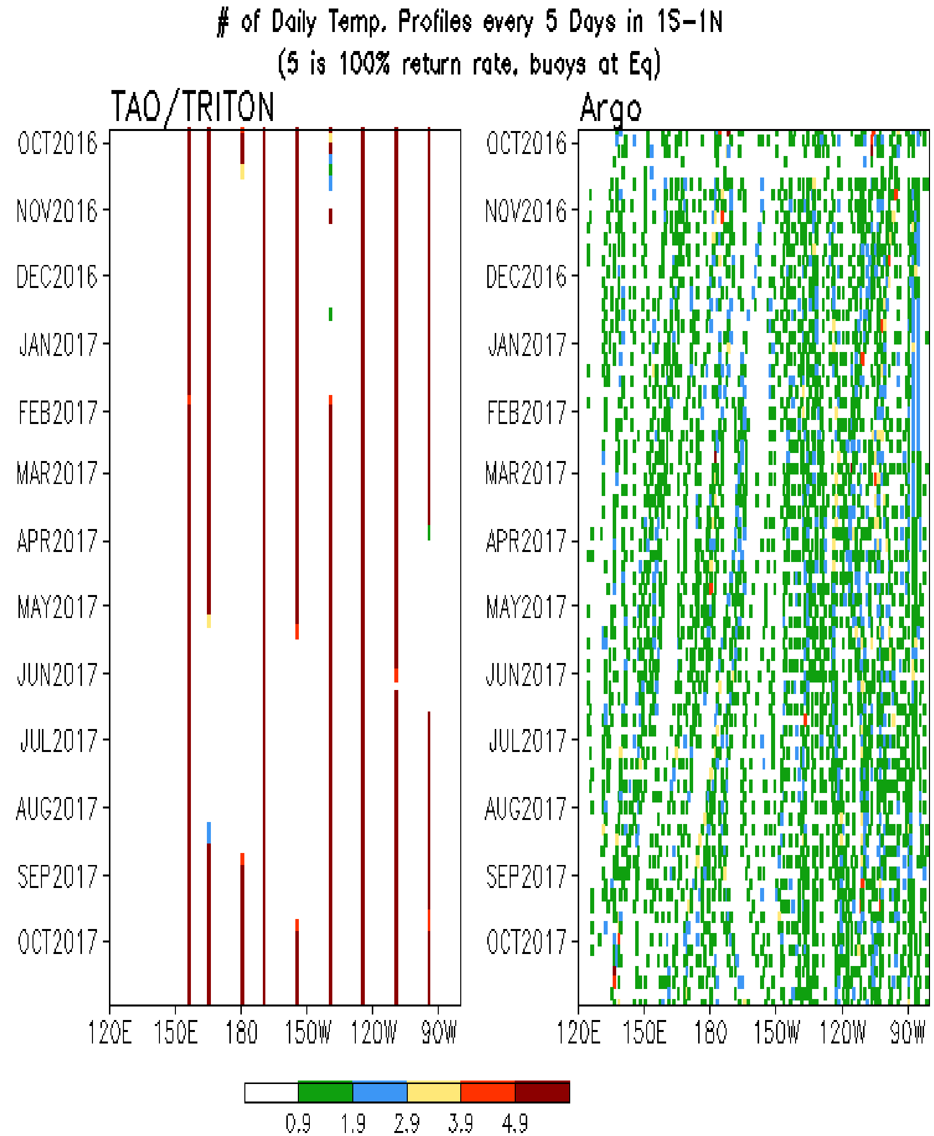
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

Temperature Profiles in the Tropical Pacific Ocean



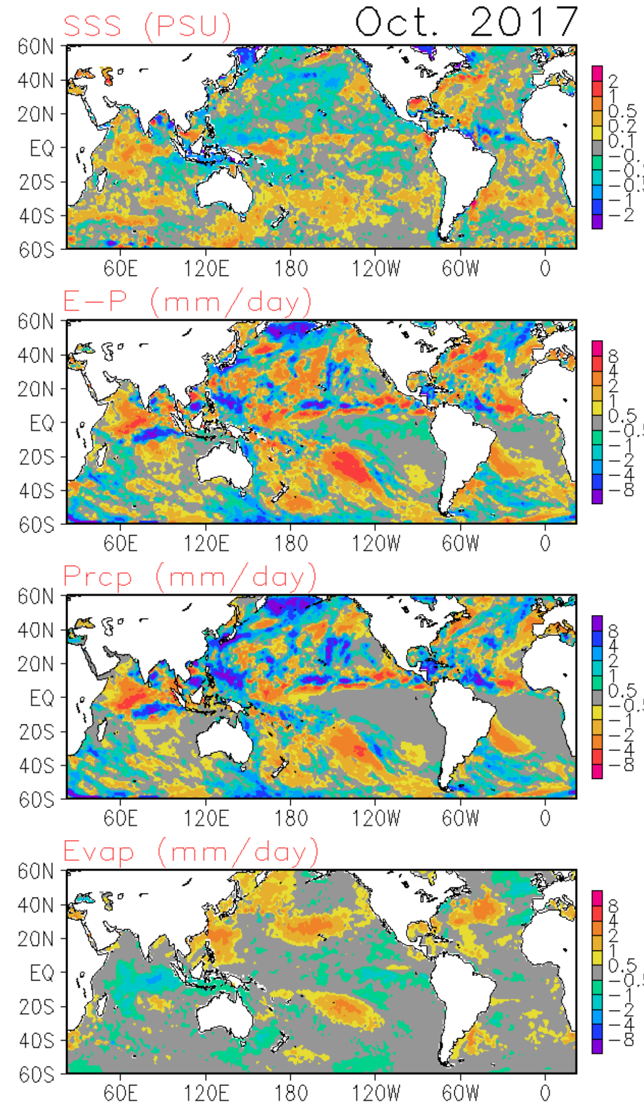


- National Data Buoy Center have restored most of equatorial moorings along 155°W line staring the end of September.

Global Sea Surface Salinity (SSS)

Anomaly for October 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 and extended to the east. Such SSS signal is co-incident with reduced precipitation. The SSS anomaly in the west and central Indian Ocean north of 20°S is positive with significantly reduced precipitation in the area. Strong negative SSS anomaly continued in the equatorial Atlantic Ocean and extended slightly to the northwest. The negative SSS anomaly in the Sea of Okhotsk continued with less freshwater input indicating that this anomaly is likely due to the oceanic advection/mixing.



- **Data used**

  SSS : Blended Analysis of Surface Salinity (BASS) V0.Z

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

  (Xie et al. 2014)

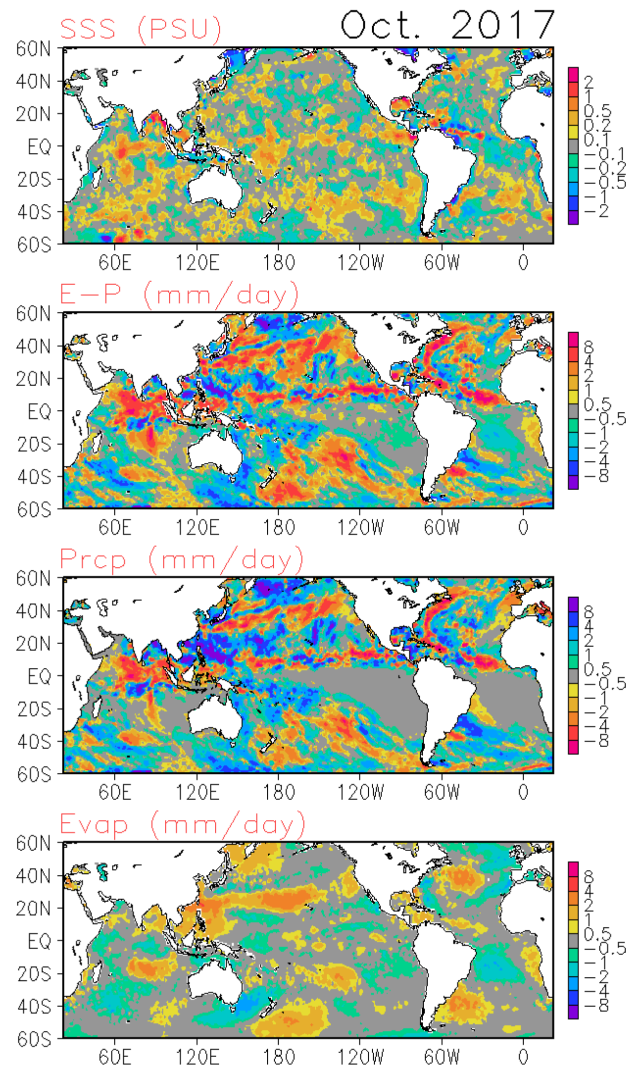
  ftp.cpc.ncep.noaa.gov/precip/BASS

  Precipitation: CMORPH adjusted satellite precipitation estimates

  Evaporation: CFS Reanalysis

Global Sea Surface Salinity (SSS)
Tendency for October 2017

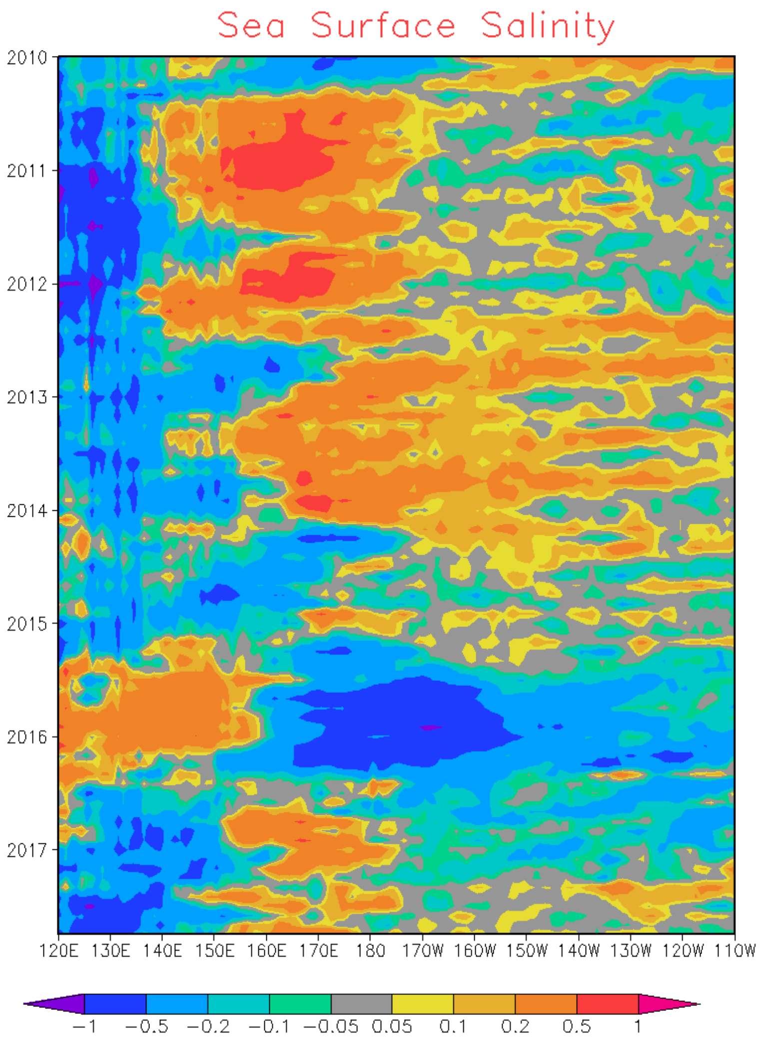
Compared with last month, the SSS in the north of Bay of Bengal significantly increased, however, the freshwater input increased indicating that ocean advection and/or mixing plays a dominant role for this change. The SSS in the west Equatorial Pacific Ocean is continually increasing with less precipitation. The SSS in the Sea of Okhotsk continues decreasing with reduced freshwater input. The increasing of SSS in the central Indian Ocean north of equator is very likely due to the precipitation reduction.



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 equatorial Pacific Ocean, from 120°E to 150°E, the strong negative SSS signal continues. The positive SSS anomaly signal between 150°E and 180° became stronger. There are not much changes east of 180°, however, the signals are weakly positive. The SSS signals in the Equatorial Pacific Ocean are in favor of La Nino.



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

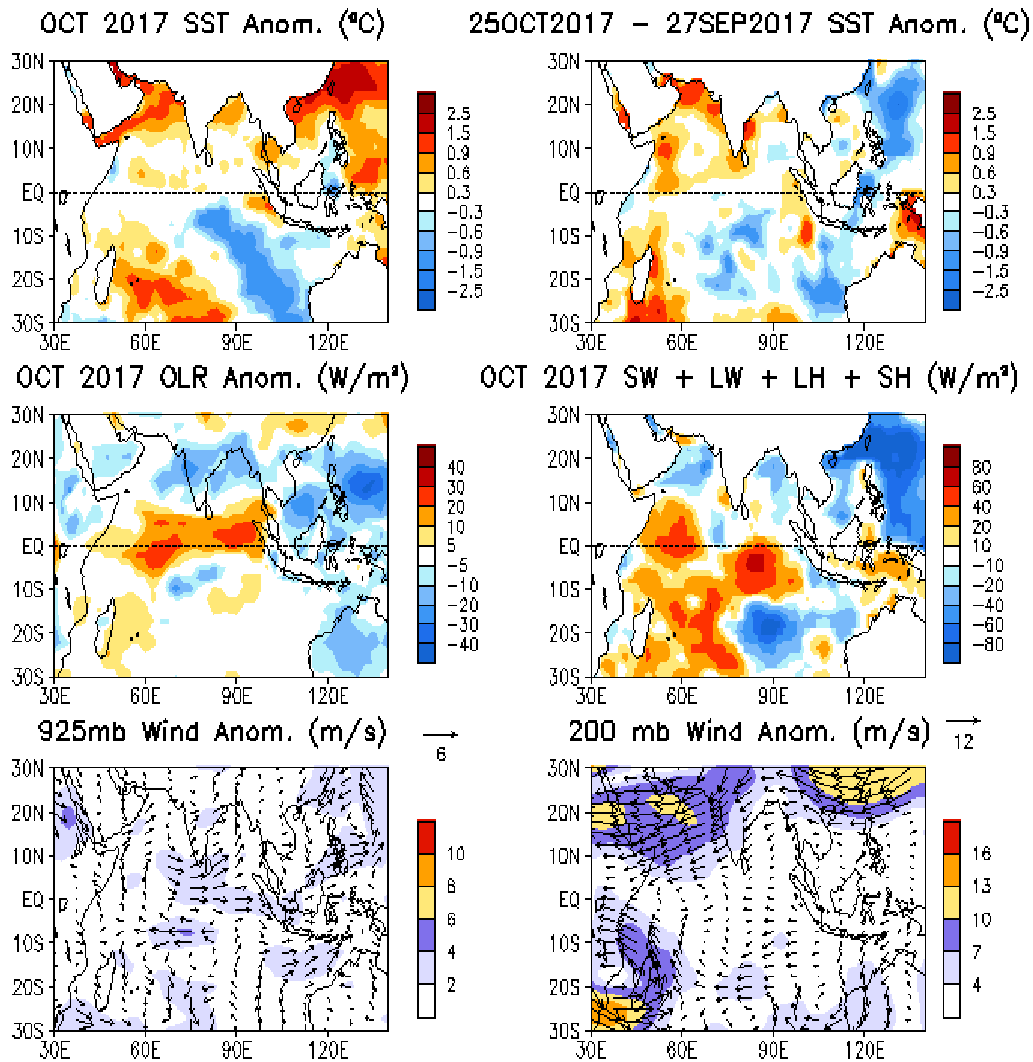


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 Pacific & Arctic Ocean: SSTA, SSTA Tend., OLR, SLP, Sfc Rad, Sfc Flx

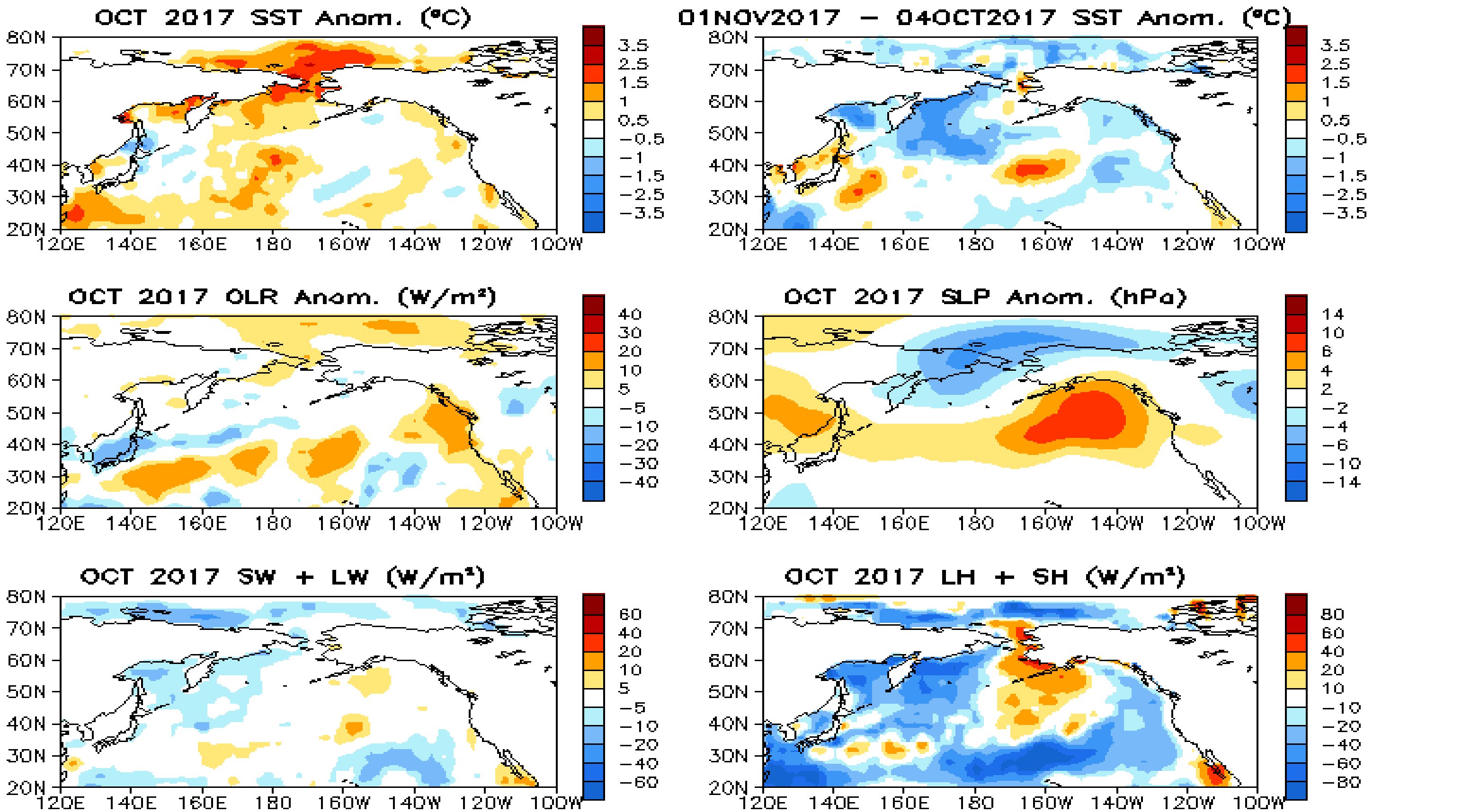
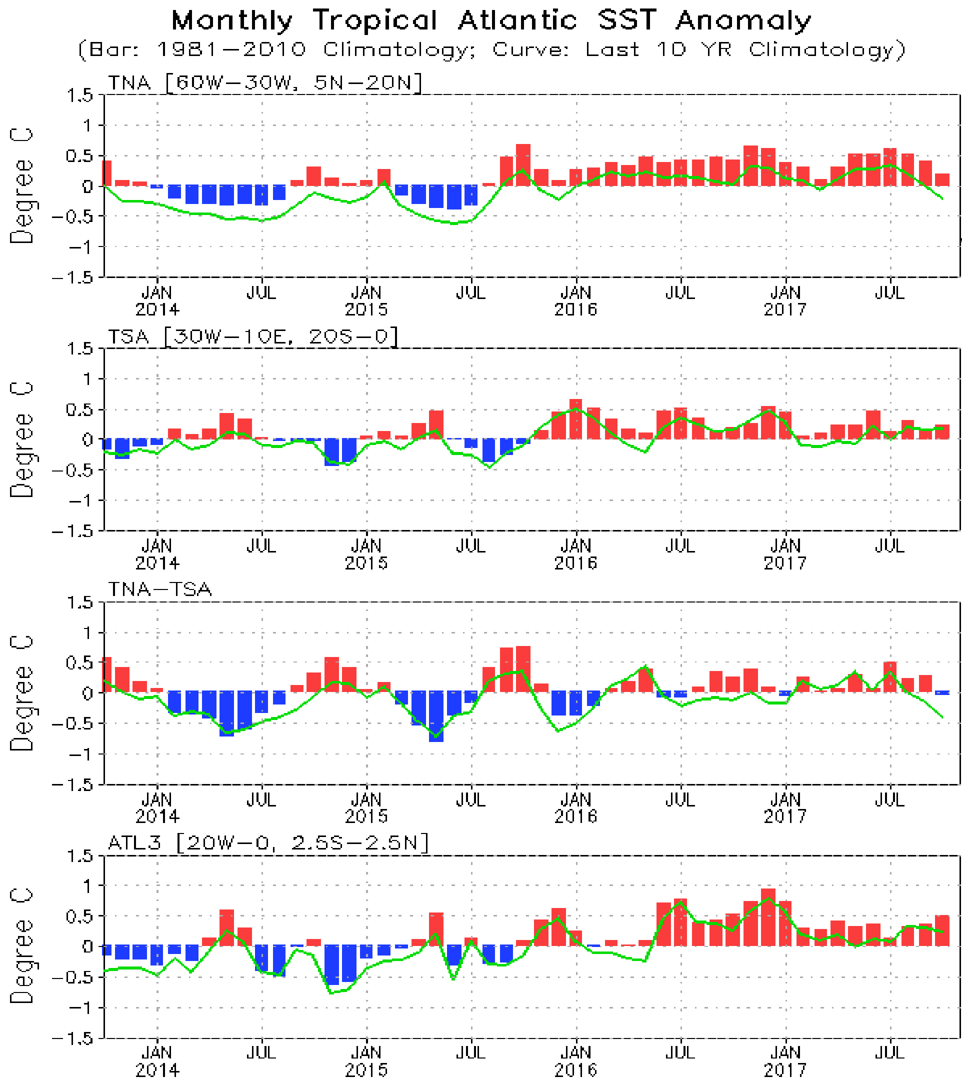
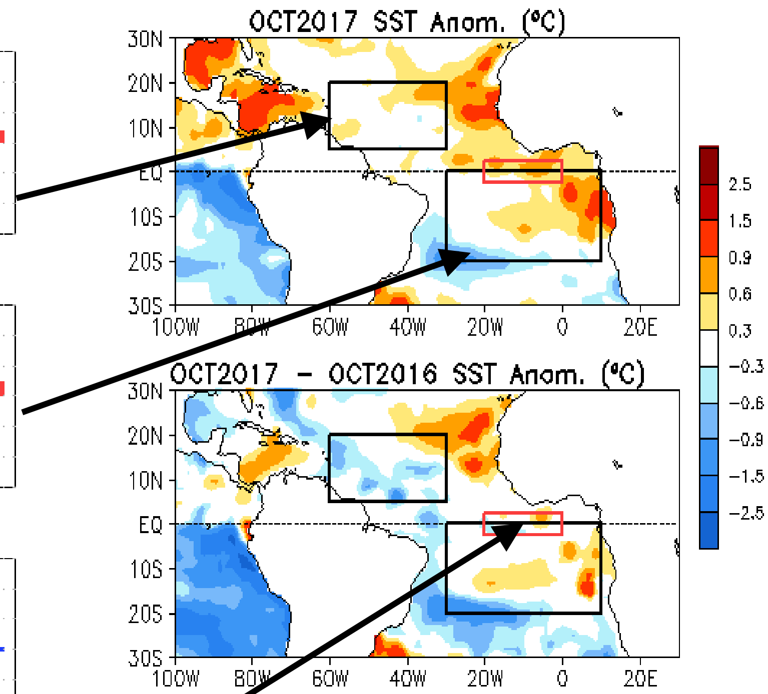


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

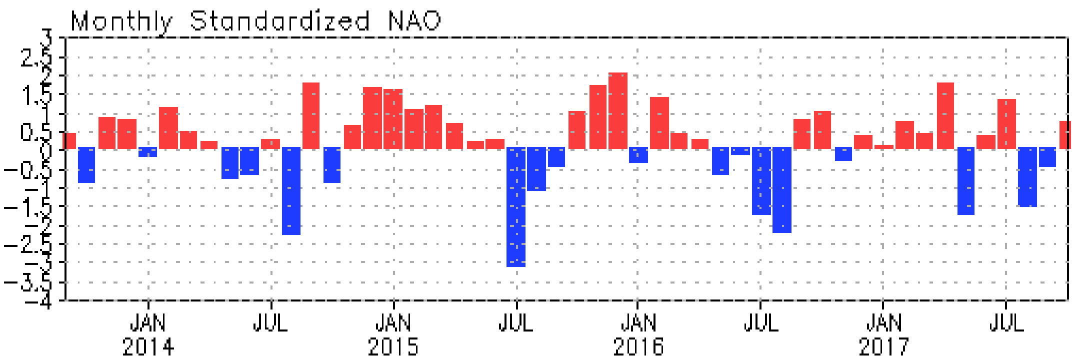


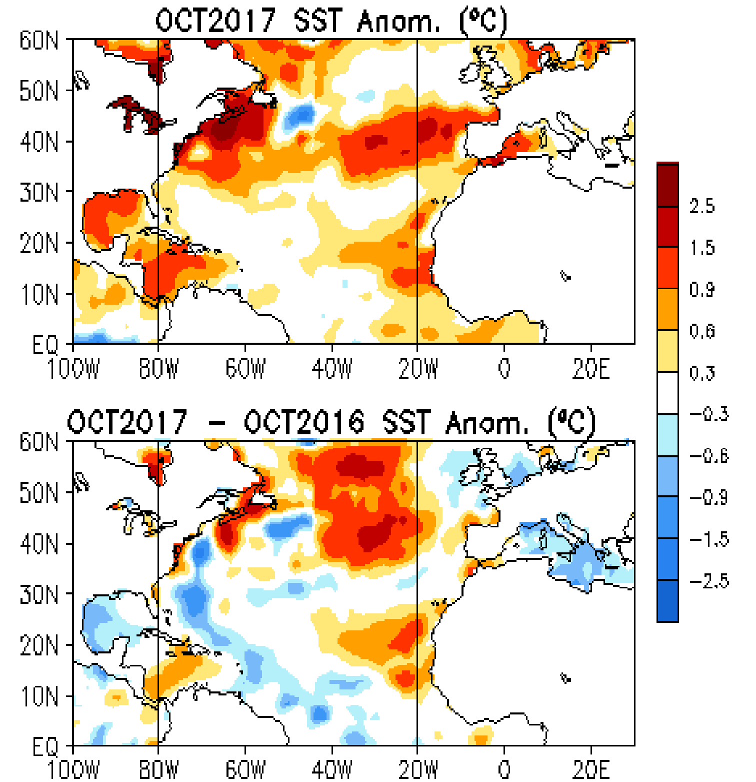


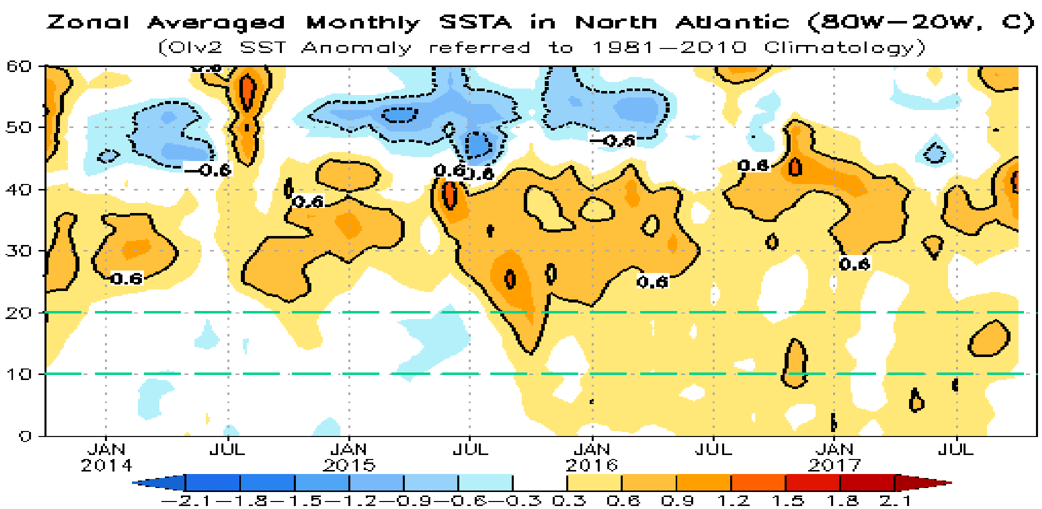
- Overall, SSTAs in the tropical Atlantic Ocean were positive.
- All indices were positive in Jul 2017.

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.

NAO and SST Anomaly in North Atlantic







- NAO index switched to positive phase, with NAOI =0.7 in Oct 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.

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

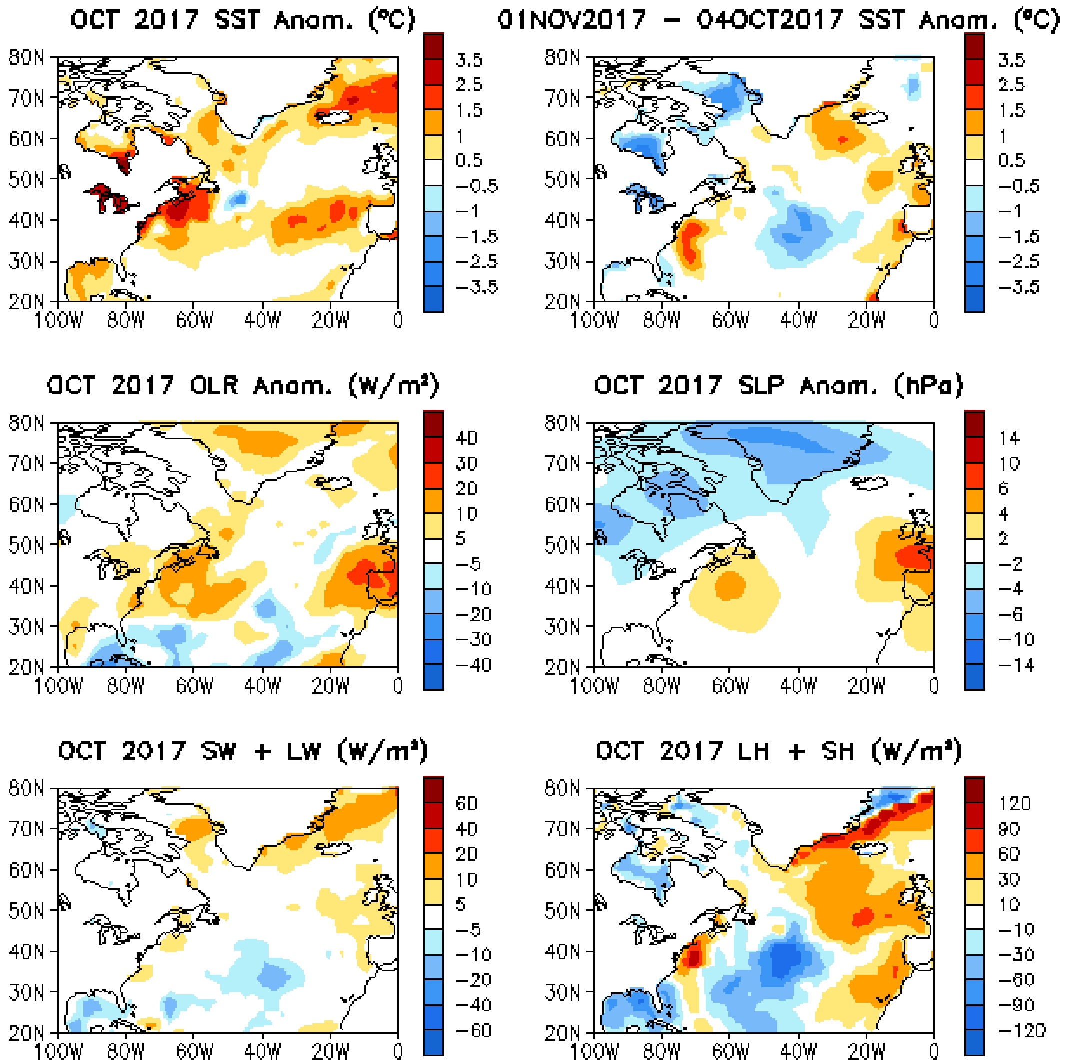
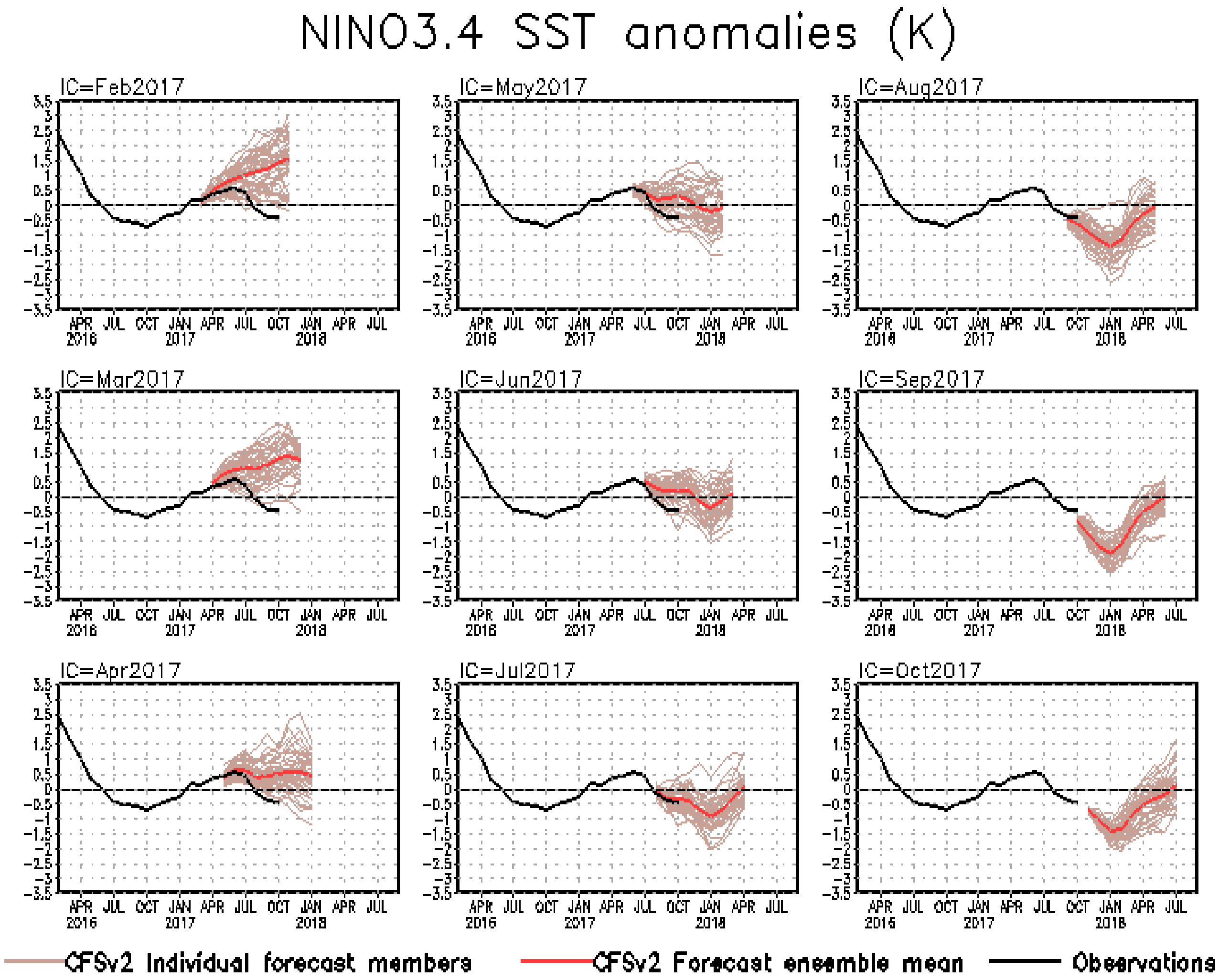


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

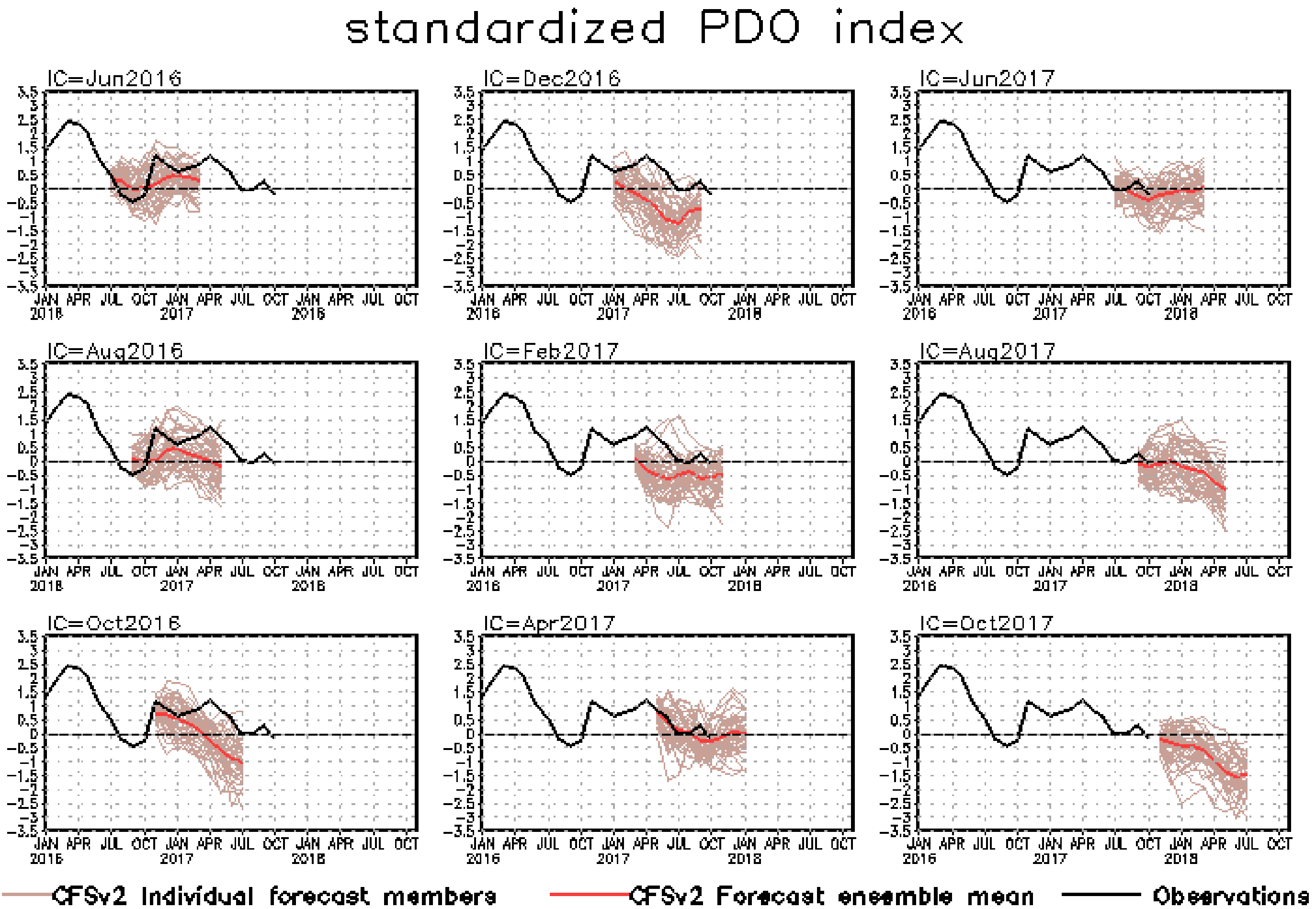
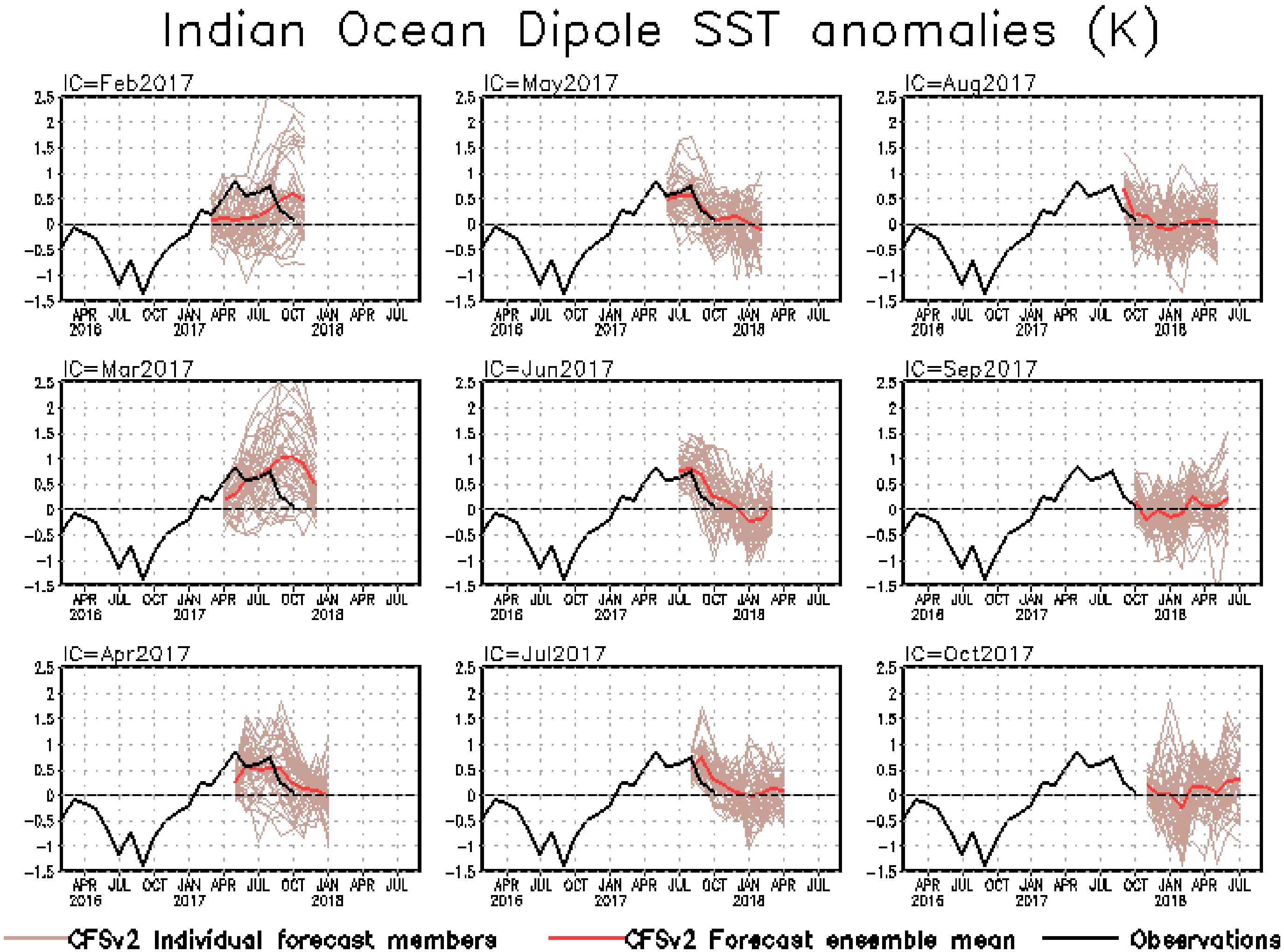


Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). 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].

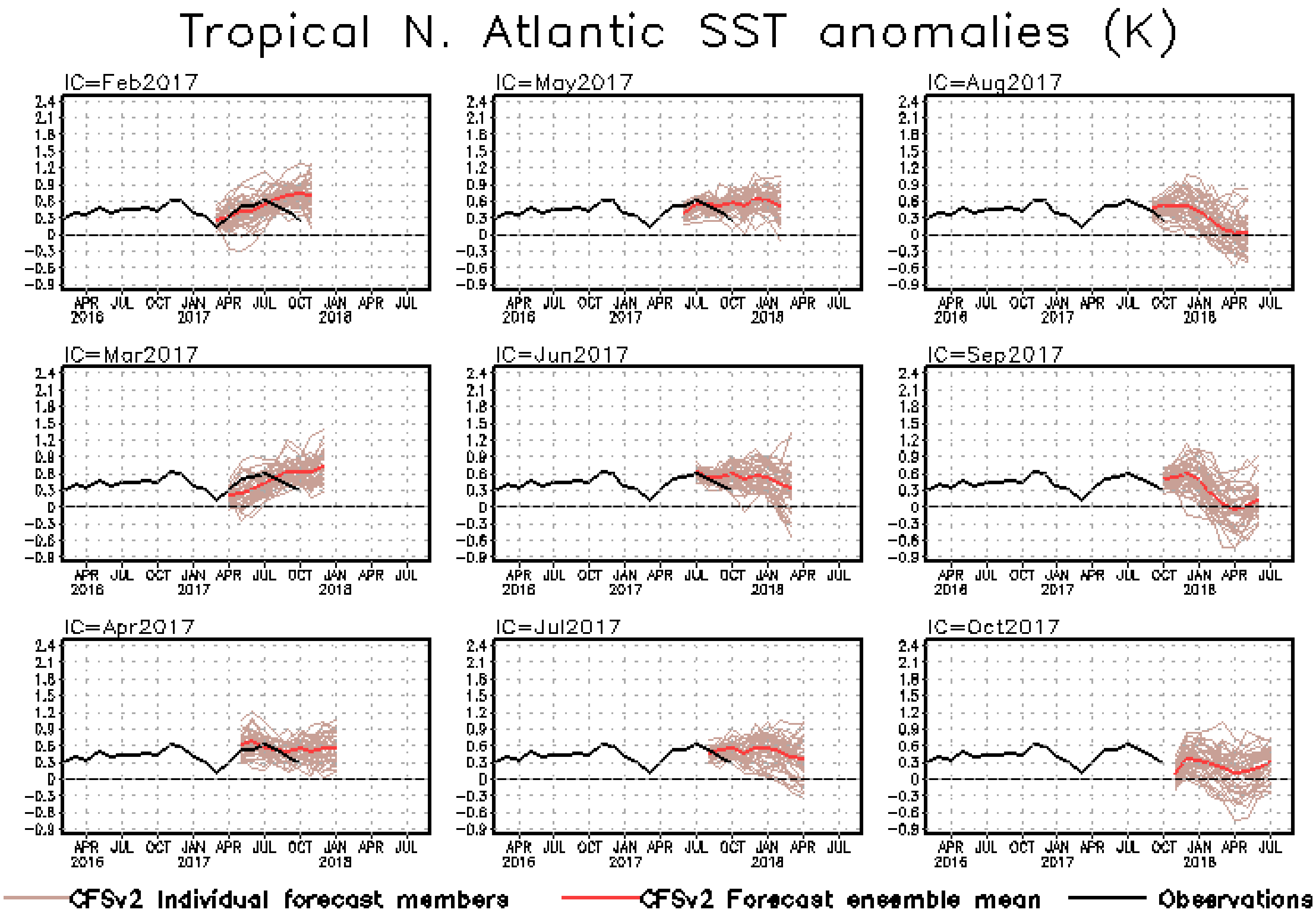


Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies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