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 Ocean Climate Observation Program (OCO)

Outline

- **Overview**

- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**

- **Global SST Predictions**

- **Current ENSO status and prediction**
- **Will Pacific 'Blob' be back?**

Overview

➢ Pacific Ocean

- ❑ Negative SSTA persisted in the central-eastern Pacific with Nino3.4 = -0.6ºC.
- ❑ ENSO-neutral condition continued in Sep 2016.
- ❑ CFSv2 forecast La Nina conditions in the Northern Hemisphere fall and winter 2016-17.
- ❑ SST warming continued in the N. E Pacific (Pacific ‘Blob’).
- ❑ PDO became weakly negative with PDO = -0.5 in Sep 2016.
- ❑ The daily minimum of Arctic sea ice extent in 2016 was tied with 2007 as the second lowest in the Satellite record.

➢ Indian Ocean

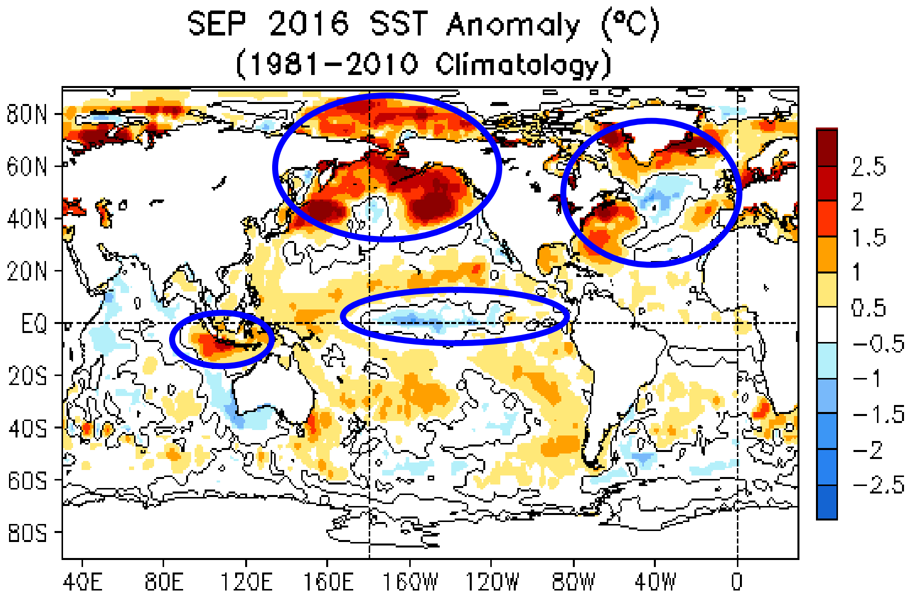
- ❑ Dipole Mode Index reached -1.4ºC in Sep 2016, which was the lowest record since 1982.
- ❑ Negative SSTA dominated in the Indian Ocean.

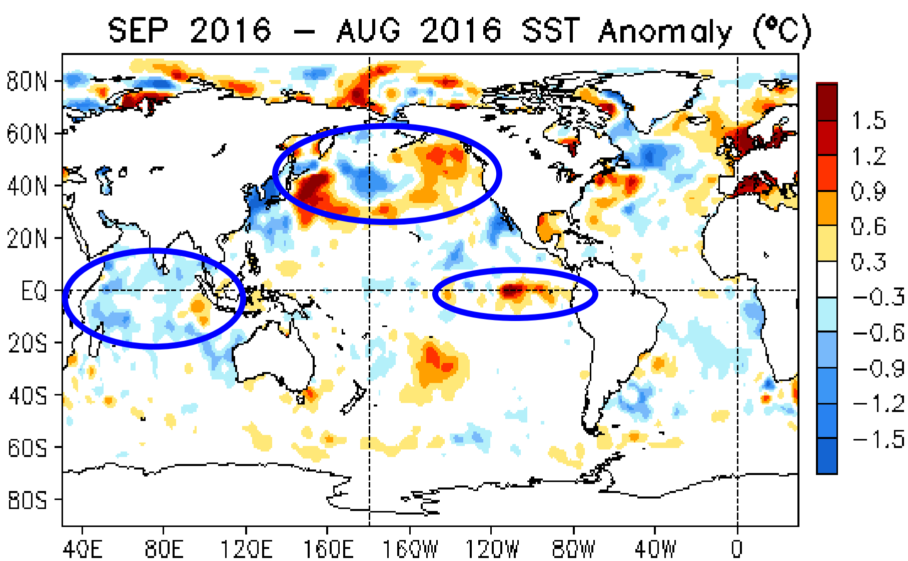
➢ Atlantic Ocean

- ❑ NAO switched to positive in Sep 2016.
- ❑ SSTA were well above-average along the eastern coast of North America.

Global Oceans

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



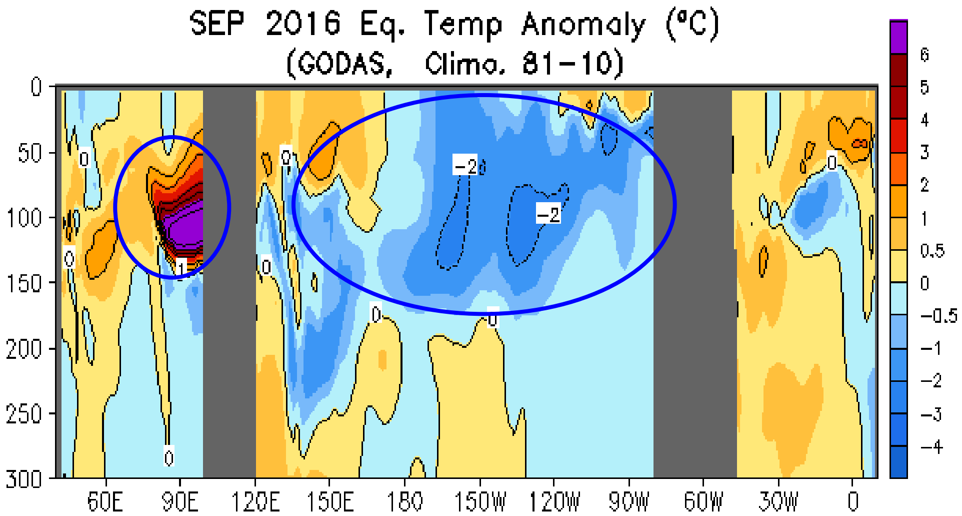


- **Negative SSTA continued in a narrow band along the C.-E. equatorial Pacific, and surrounded by positive SSTA in off-equatorial regions and the W.-C. Pacific.**
- **Strong positive SSTA presented south of Sumatra.**
- **Strong positive SSTA persisted in the high-latitude N. Pacific and near the Bering strait.**
- **Positive SSTA occupied the E. coast of N. America and subpolar north Atlantic.**

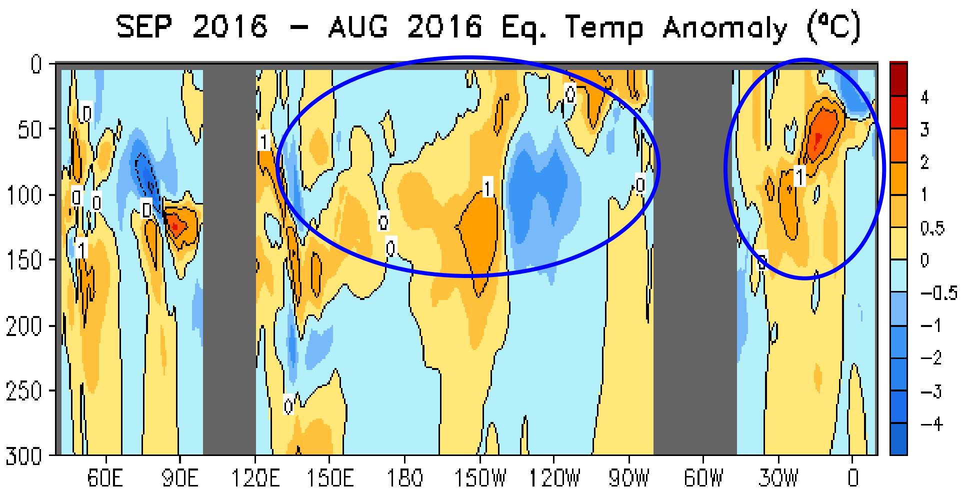
- **Large SSTA tendencies presented in the North Pacific.**
- **Positive SSTA tendency was observed in the E. equatorial Pacific.**
- **Negative SSTA tendency dominated in the tropical Indian Ocean.**

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

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



- Negative temperature anomalies continued along the thermocline in the whole Pacific, while positive temperature anomalies were confined near the surface in the W.-C. Pacific.
- Strong positive temperature anomalies persisted in the eastern Indian Ocean.



- Positive temperature anomaly tendency dominated the W.-C. Pacific near the thermocline and the far E. Pacific in the upper 50m.
- Positive temperature anomaly tendency dominated the 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.

Tropical Pacific Ocean and ENSO Conditions

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

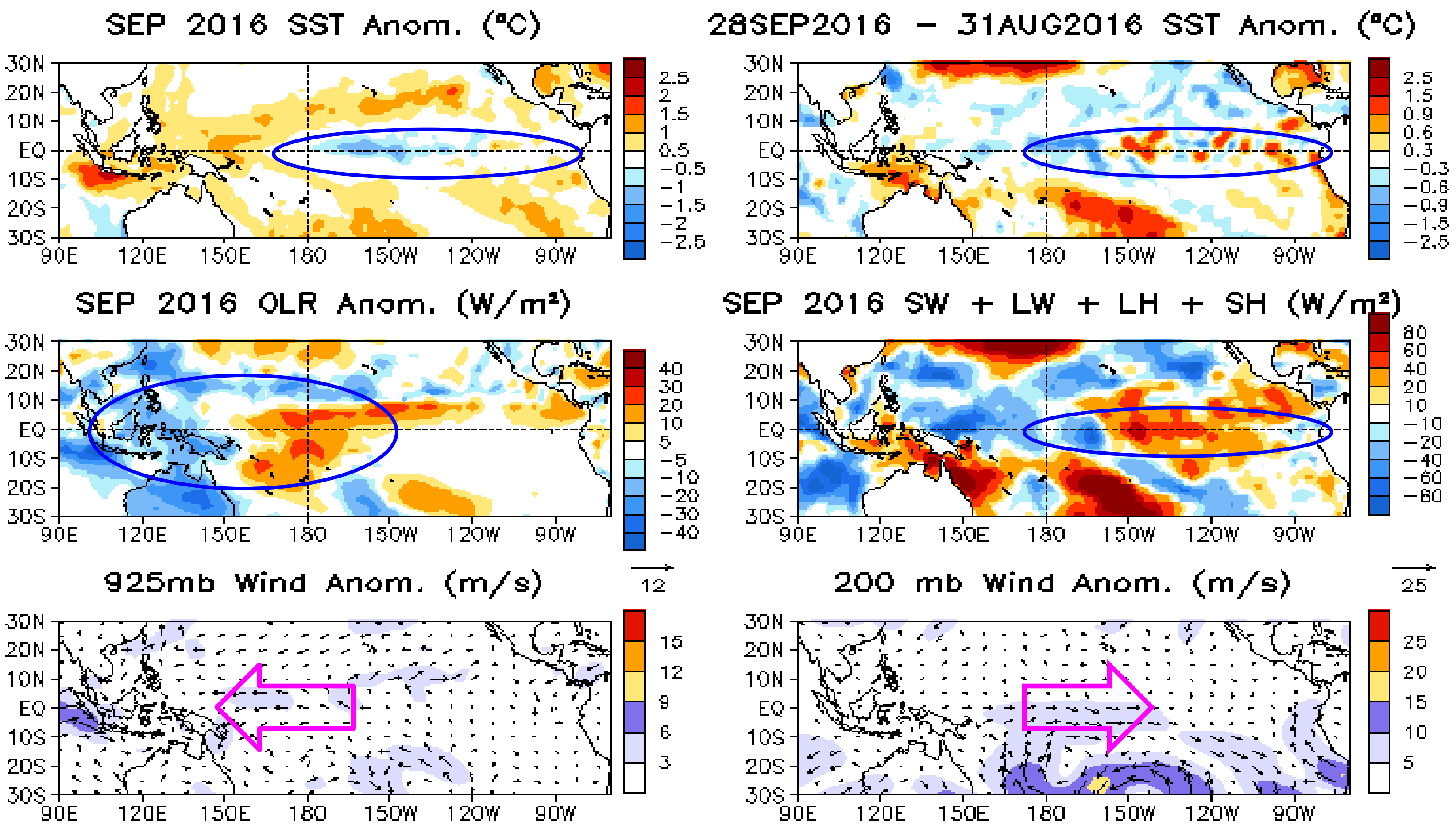
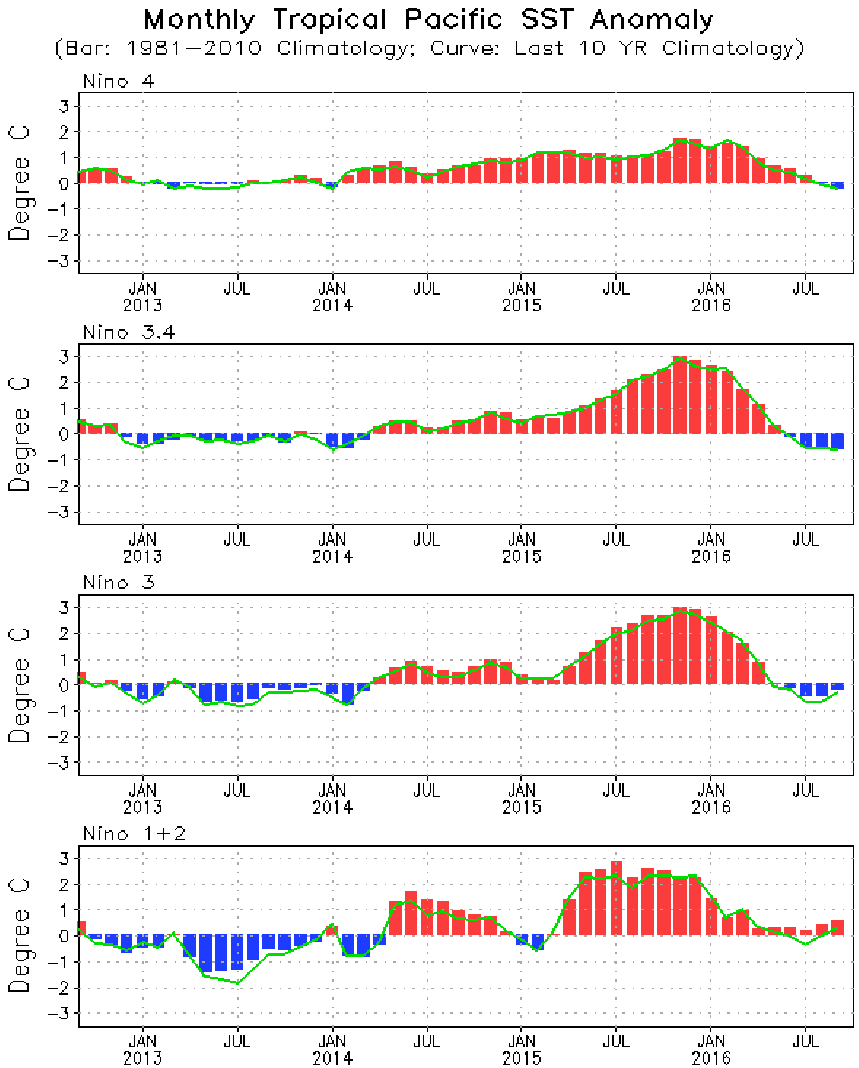
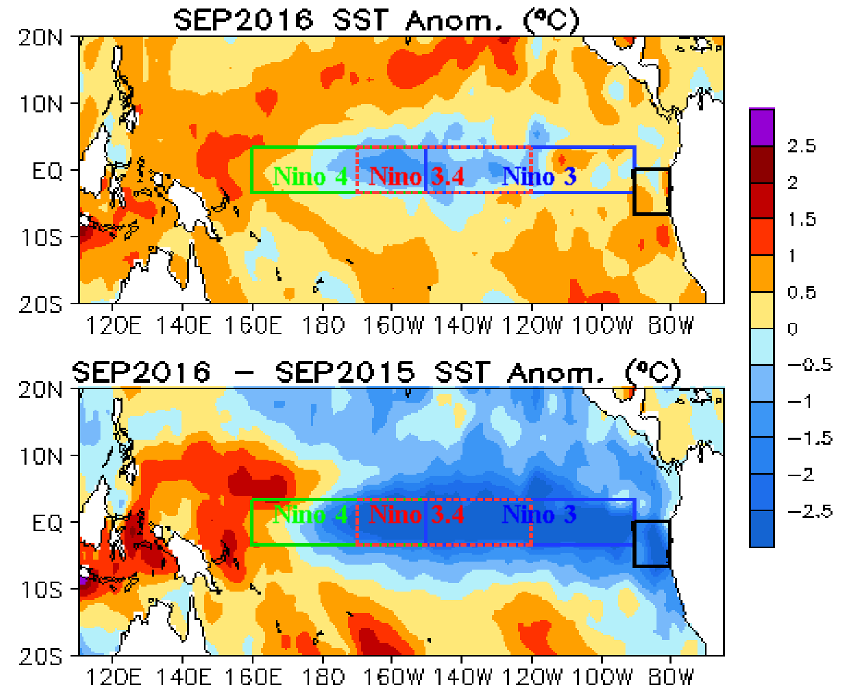


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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





- Nino4 and Nino 3.4 cooled slightly, with Nino3.4 = -0.6°C in Sep 2016.

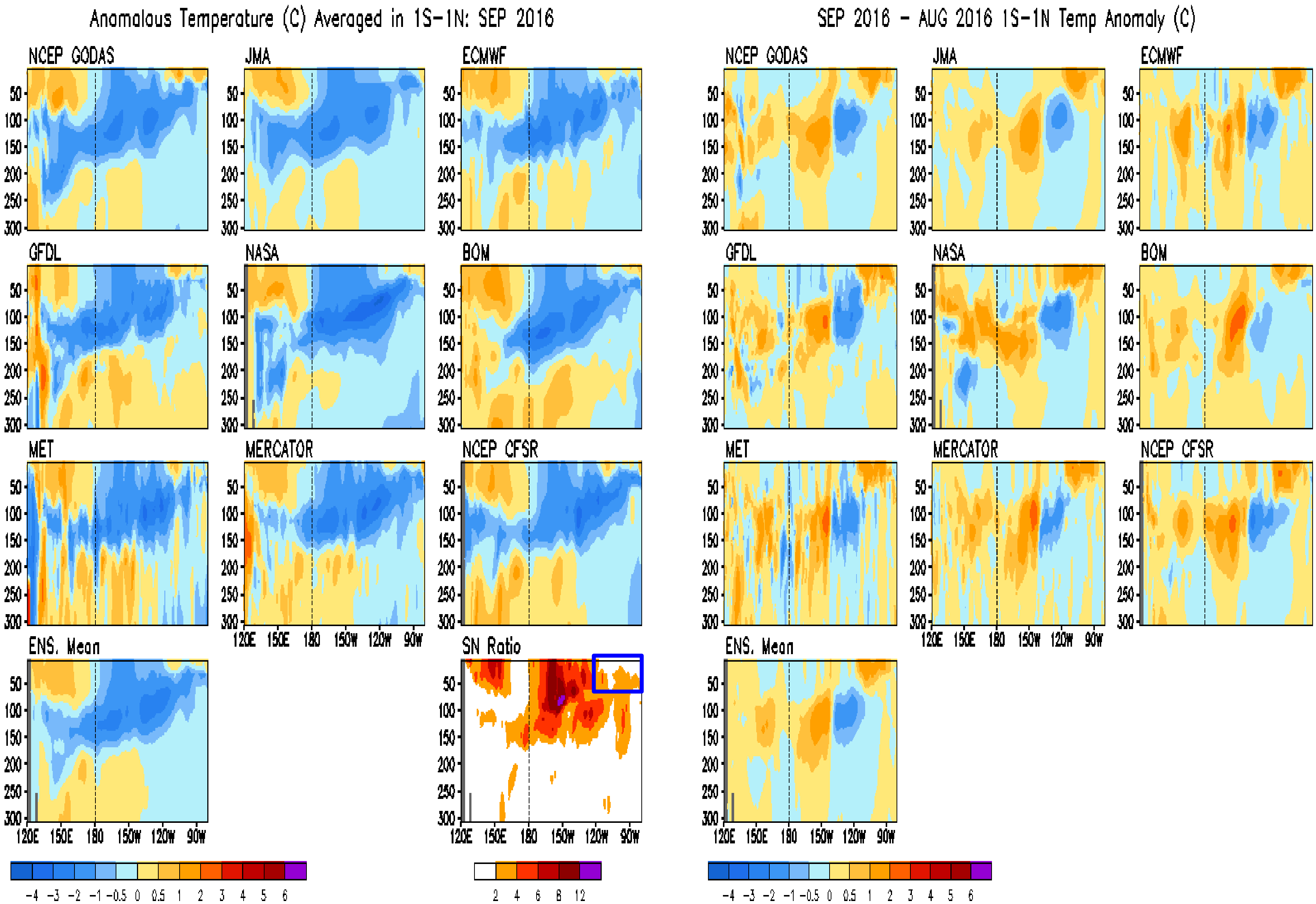
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v4.

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 (bar) and last ten year (green line) means.

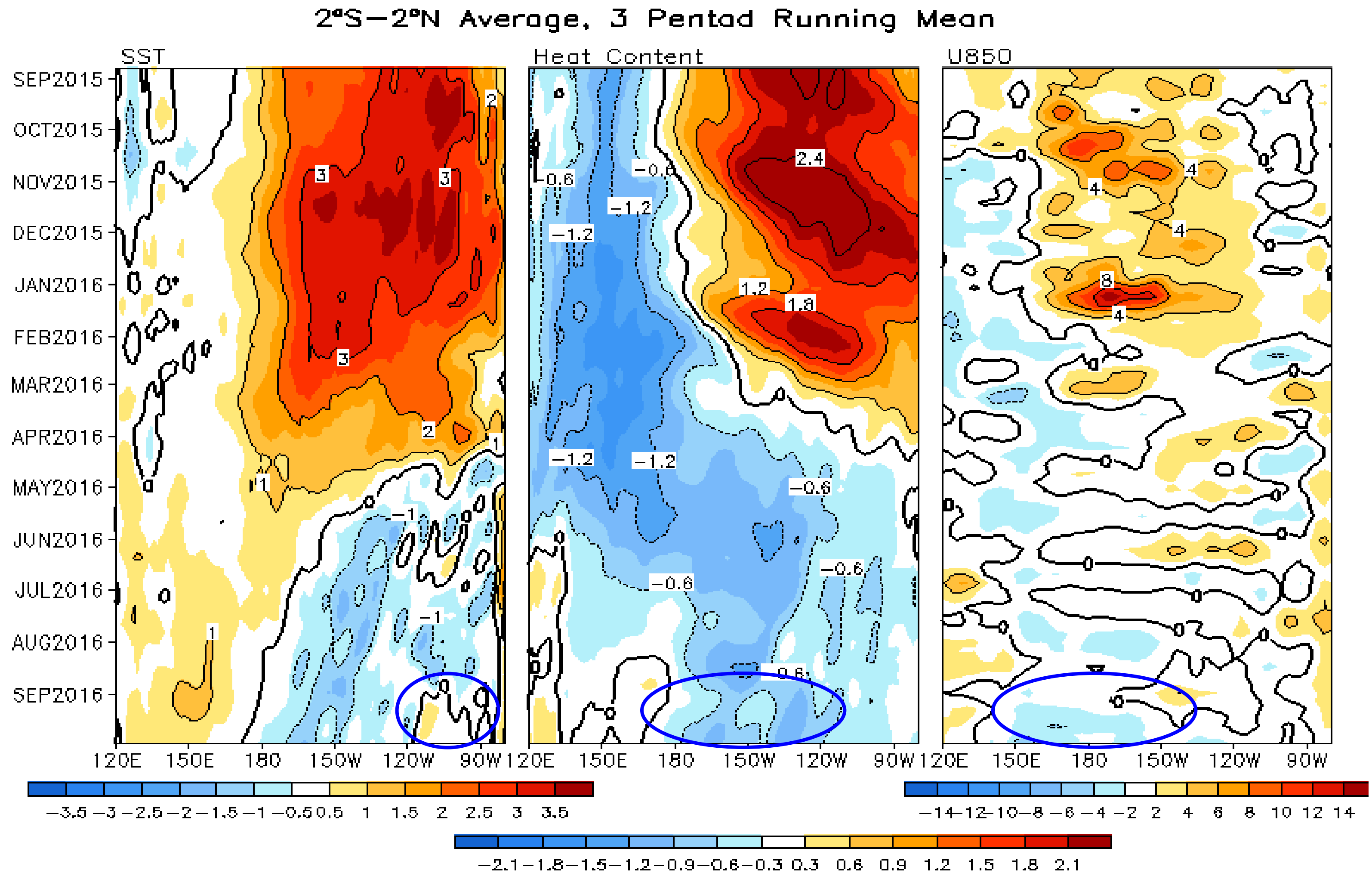
Real-Time Ocean Reanalysis Intercomparison: Temperature

Climatology : 1993-2013

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



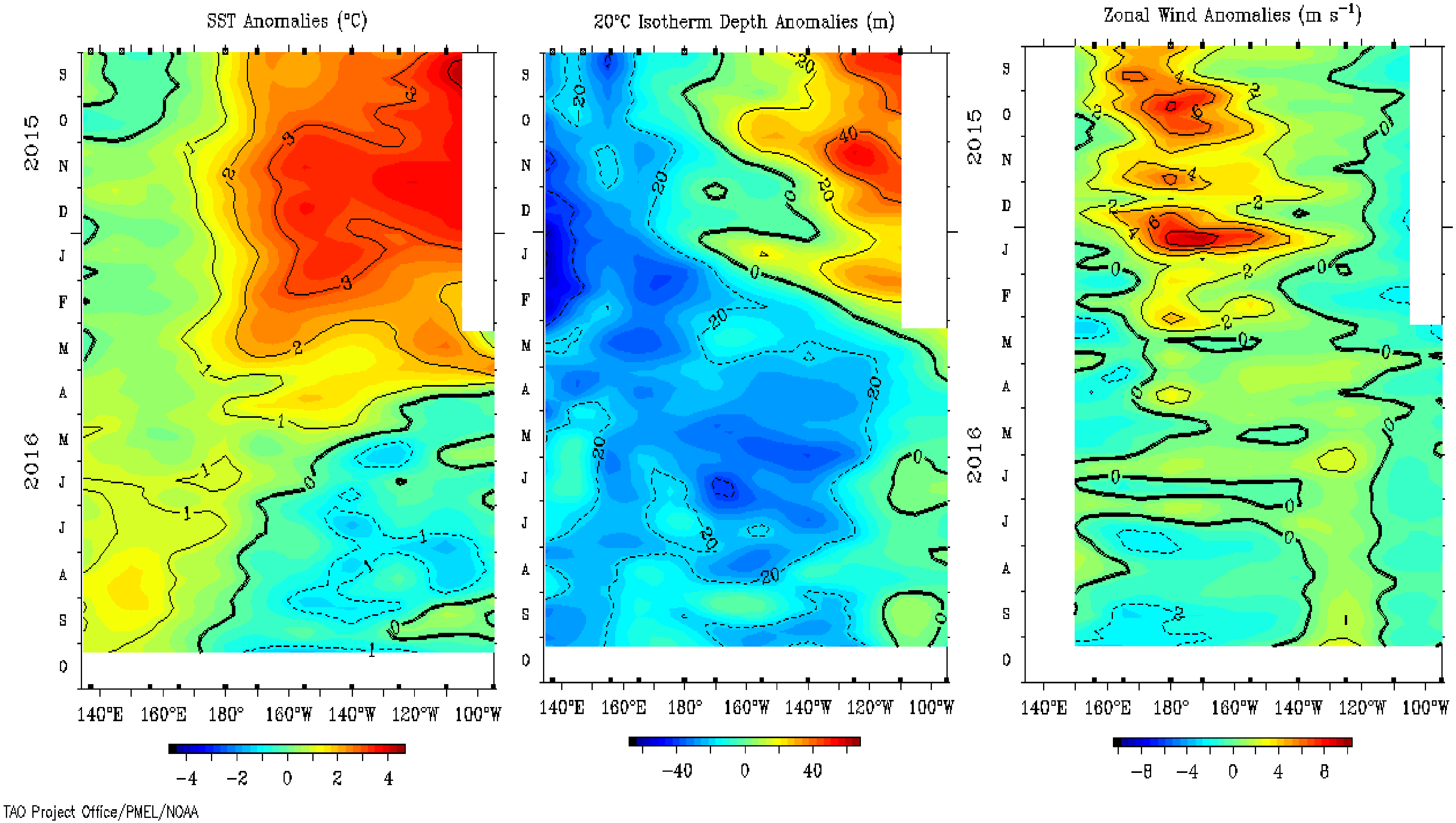
Equatorial Pacific SST (°C), HC300 (°C), U850 (m/s) Anomalies



- **Negative SSTA disappeared in the E. Pacific in Sep 2016.**
- **Negative H300 anomalies have strengthened slightly east of the date line since the mid-Sep.2016.**
- **Easterly wind anomalies emerged across the C.-E Pacific Ocean.**

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

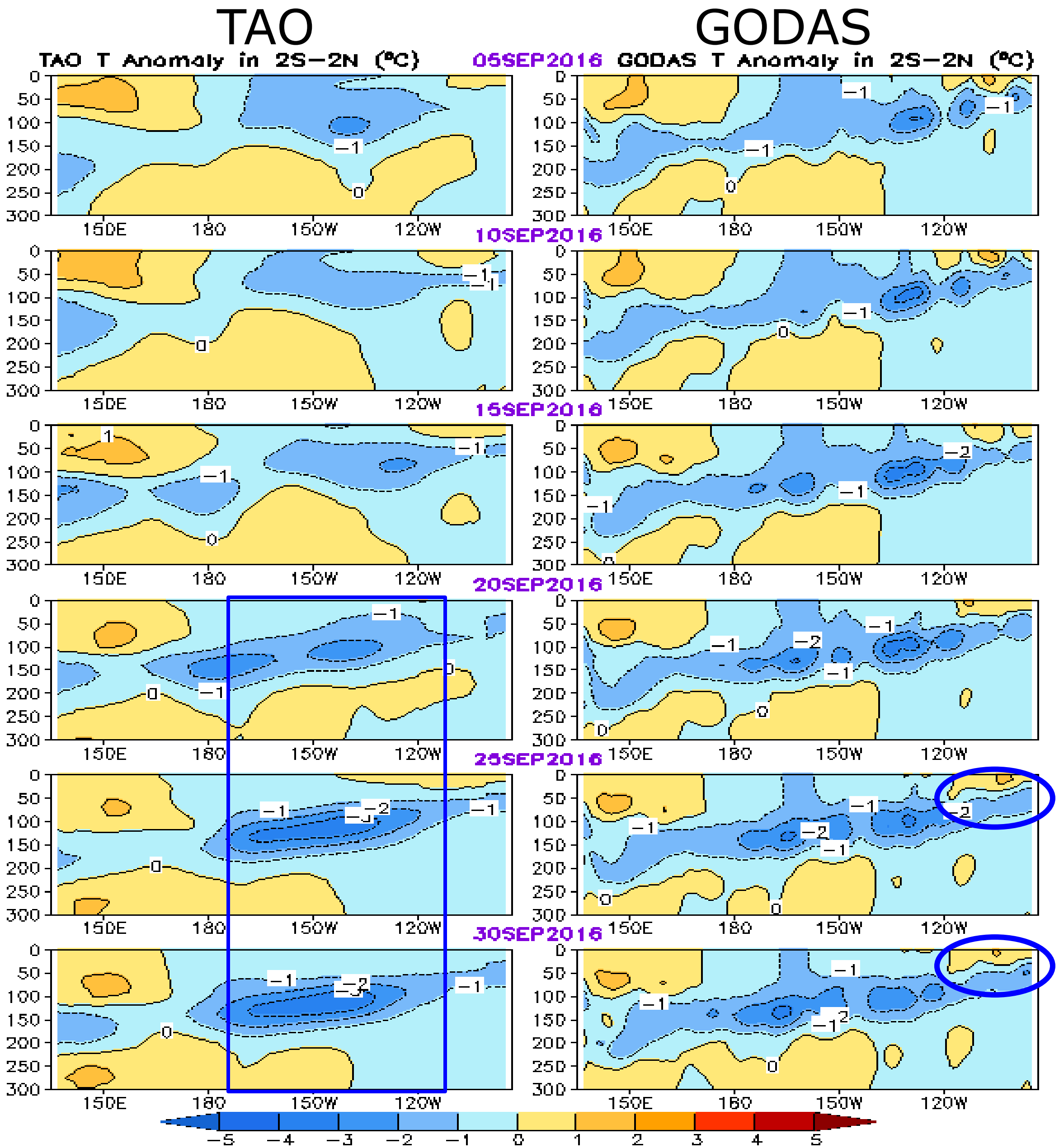
Five Day SST, 20C Isotherm Depth and Zonal Wind Anomalies [2S-2N]



(http://www.pmel.noaa.gov/tao/jsdisplay/)

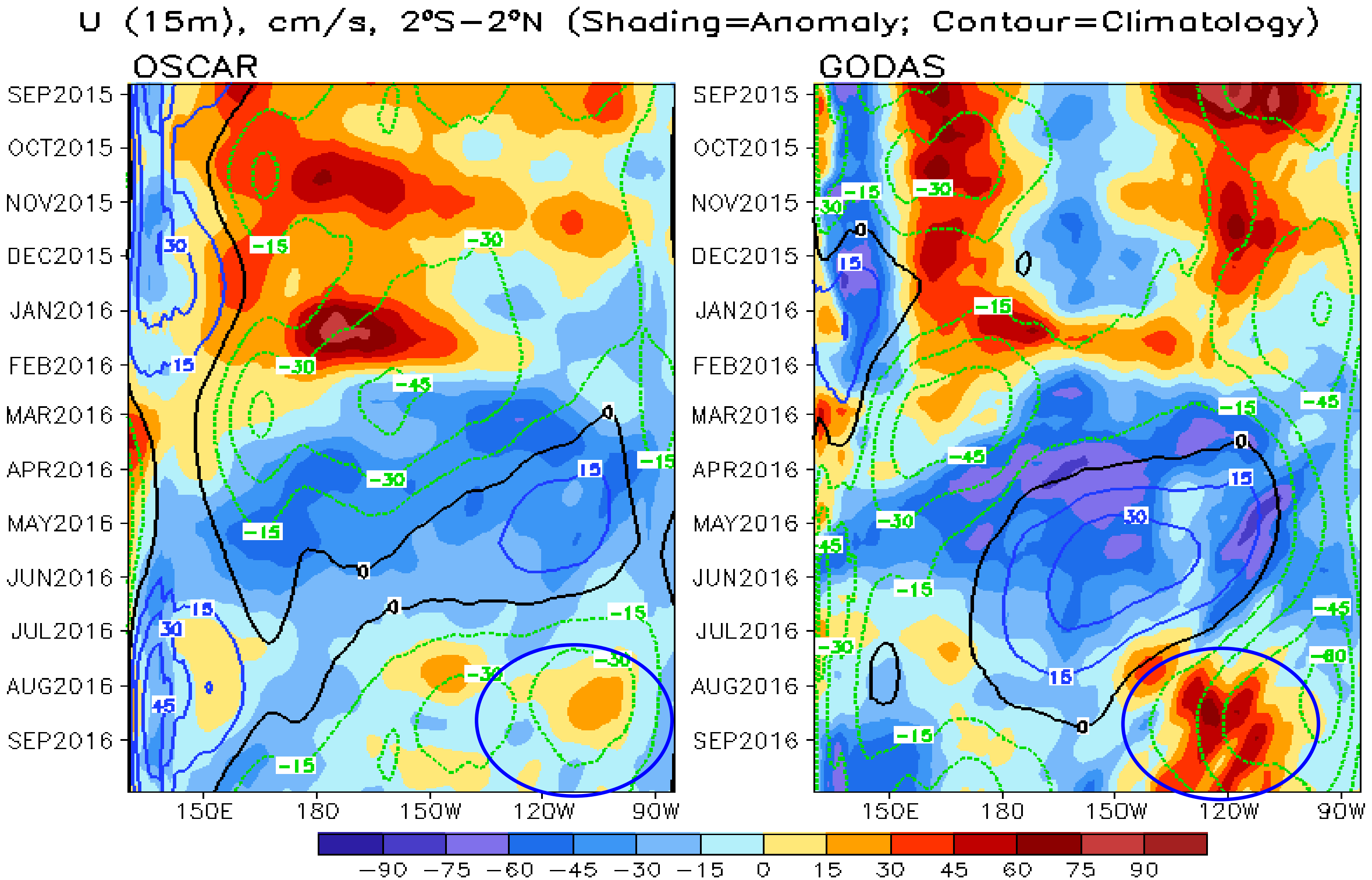
- Surface easterly wind anomalies presented in the W.-C. Pacific since mid-Sep, which will probably enhance/maintain negative d20 anomalies in the next couple months.

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



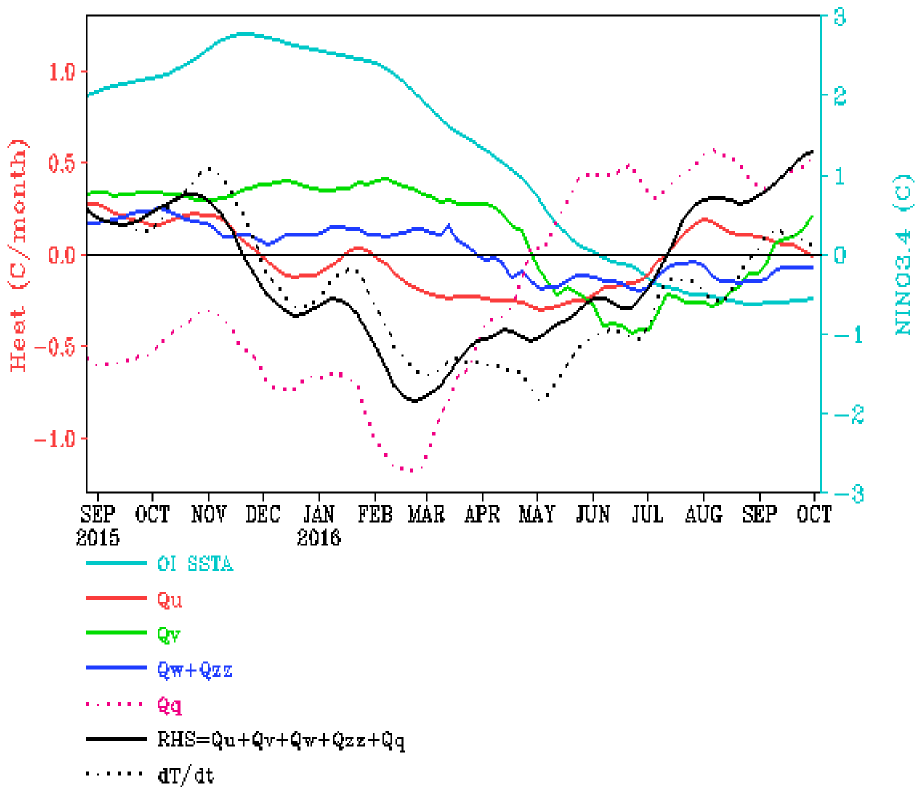
- Negative temperature anomalies have strengthened in the C.-E. Pacific near the thermocline in the last three pentads.

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



- Eastward zonal current anomalies in GODAS were much stronger than those in OSCAR since Jun. 2016.

NINO3.4 Heat Budget



- Observed SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was small in Sep 2016.

-Dynamical terms (Qv, Qw+Qzz, Qu) were near zero in September.

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;

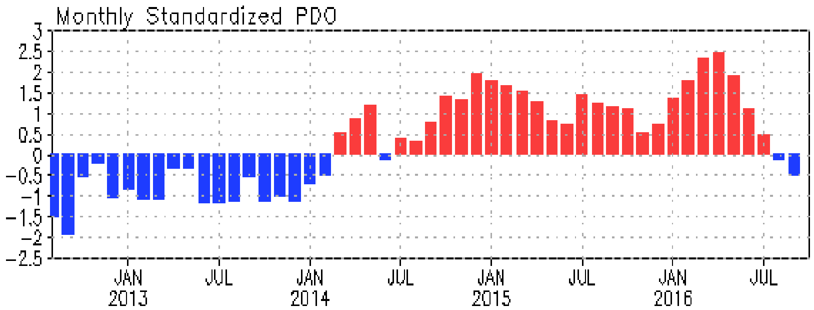
Qw: Vertical entrainment; Qzz: Vertical diffusion

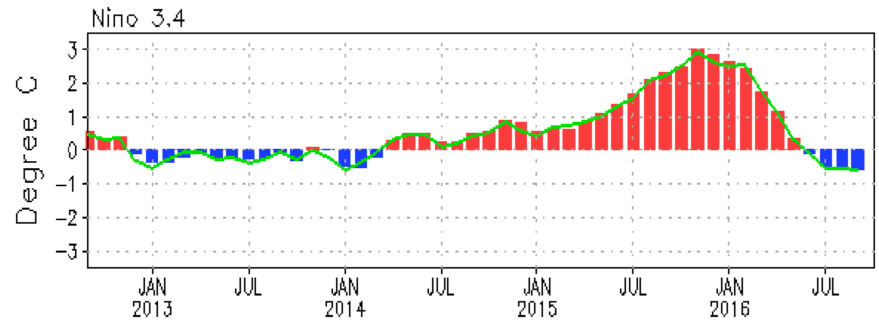
Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

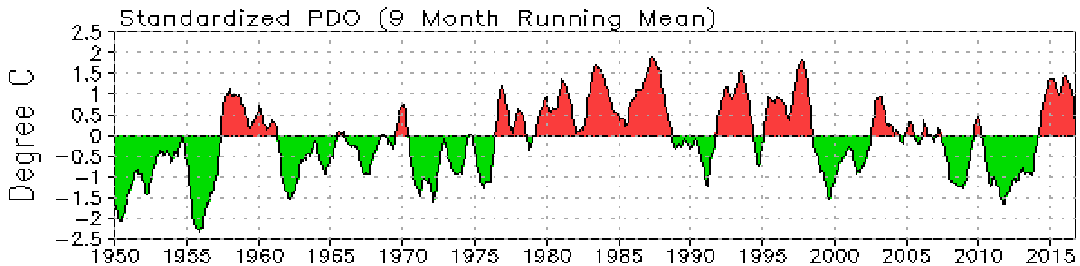
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

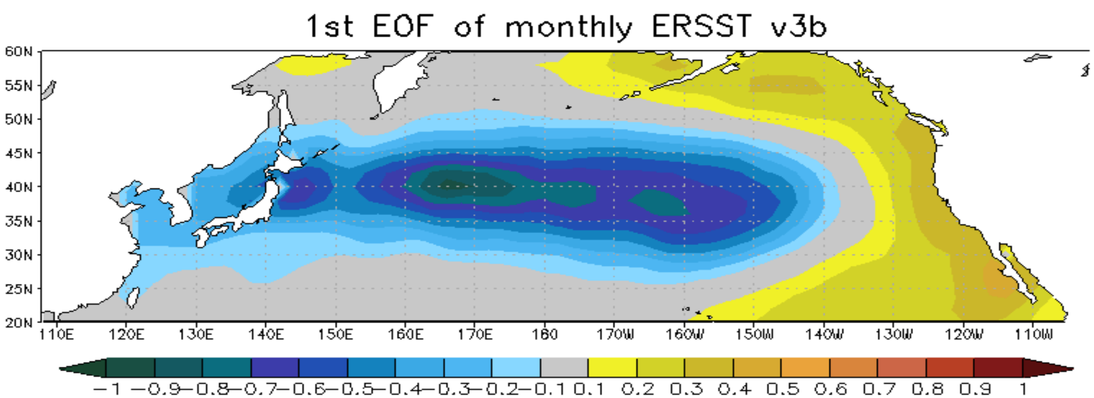
North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index









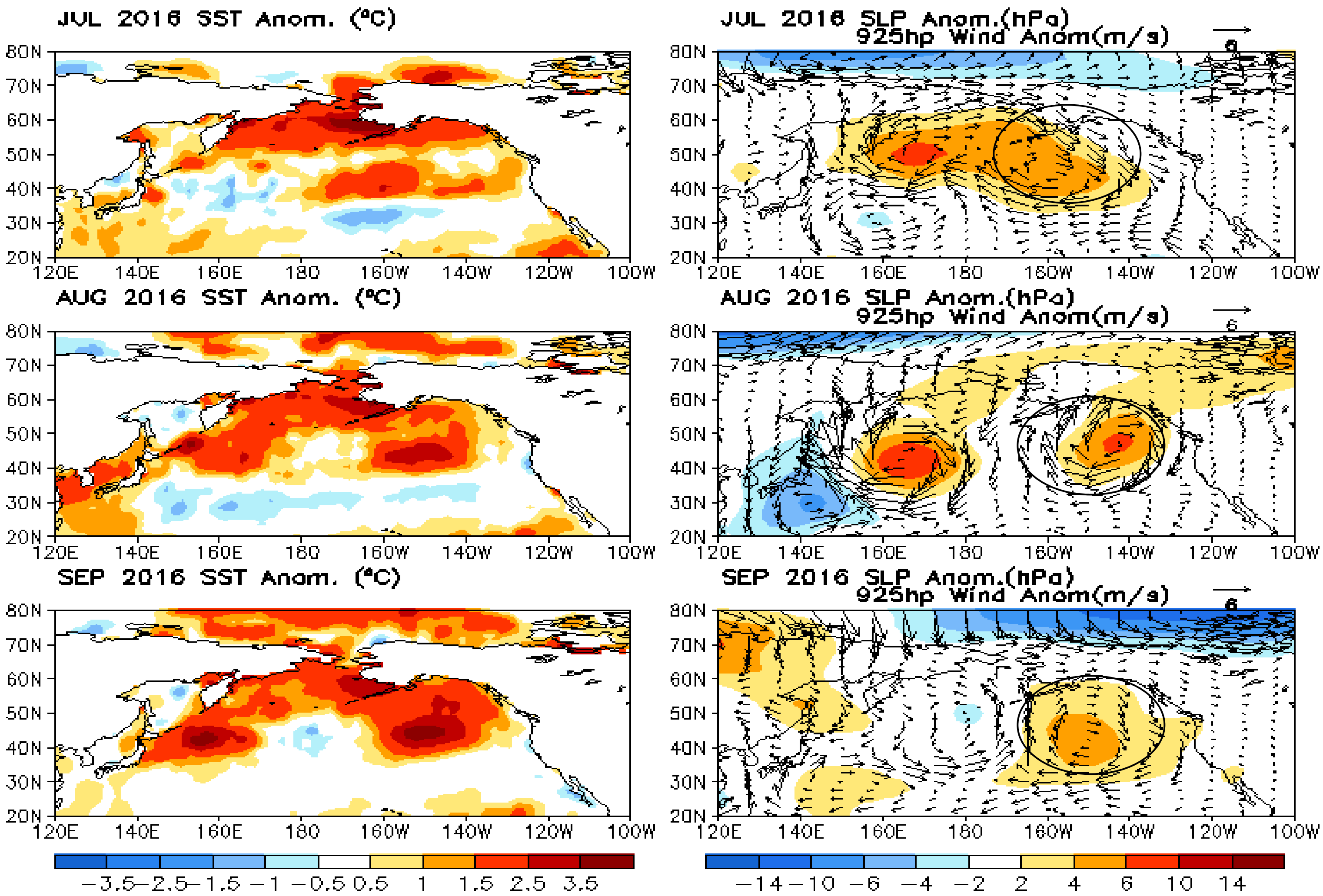
- Negative PDO enhanced slightly in Sep with PDO index = -0.5.

- Statistically, ENSO leads PDO by 3-4 months, may through atmospheric bridge.

- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

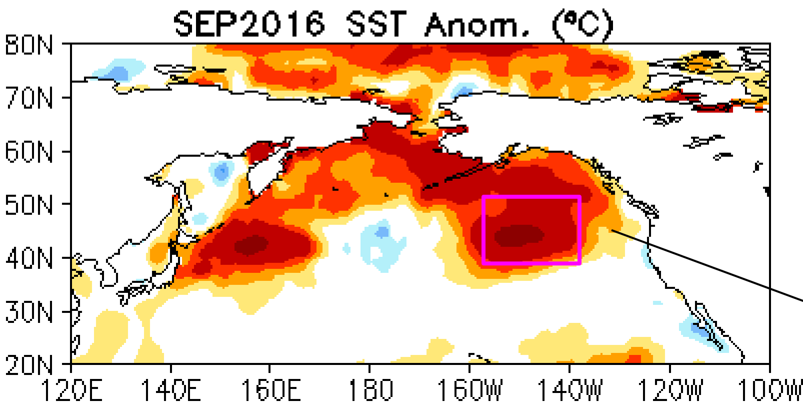
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

Last Three Month SST, SLP and 925hp Wind Anom.

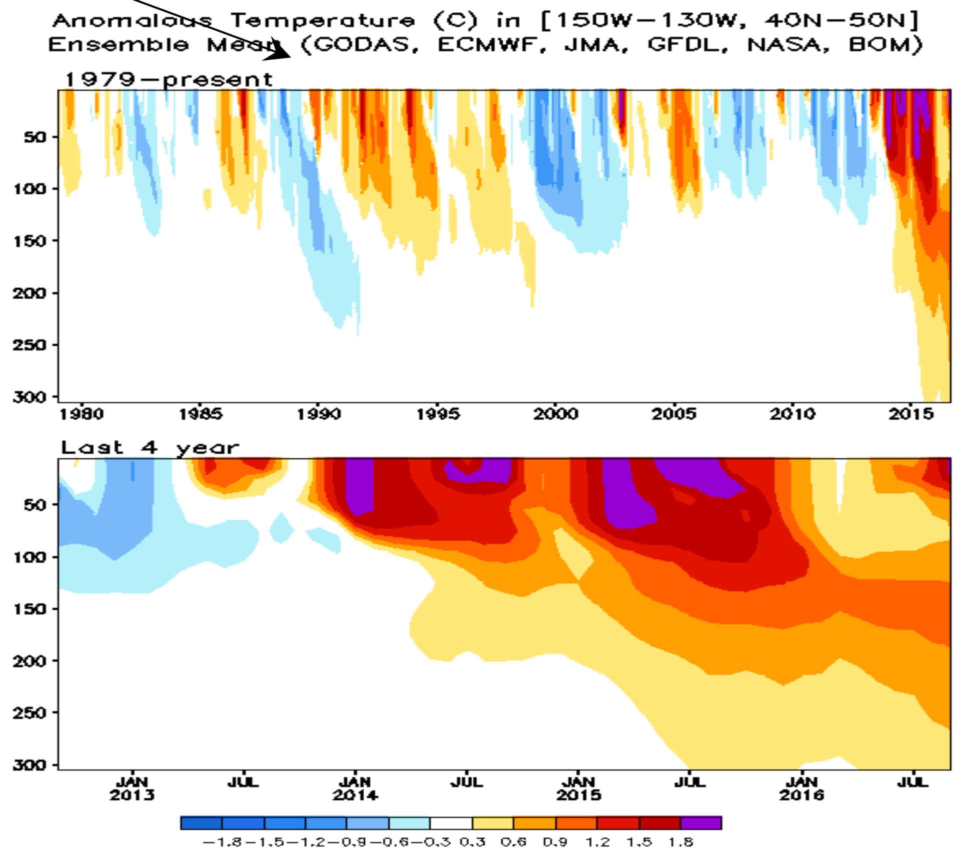


- **Strong positive SSTA persisted in the NE Pacific since Aug 2016.**
- **Anomalous anti-cyclone persisted near the western coast of U.S.A in the last three months.**

“Blob” in North Pacific

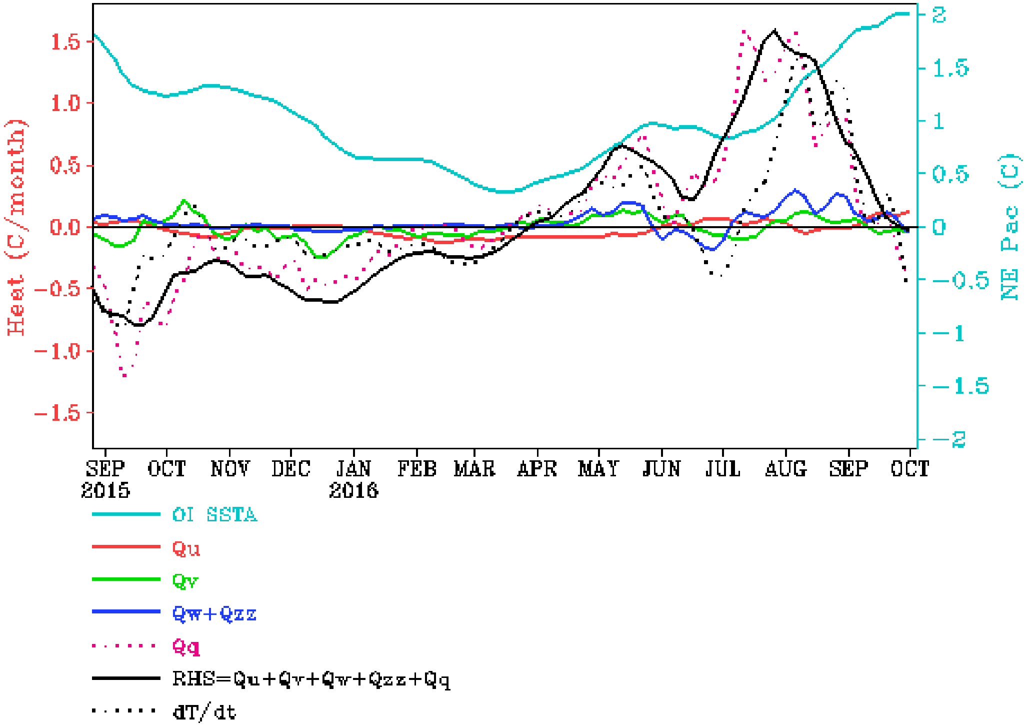


- **Between winters of 2013/14 and 2015/16, northeast Pacific experienced the strongest SST warming ever recorded, referred to as “Blob” by Bond et al. (2015)**
- **Warming has gradually extended to 300m since the late 2013.**
- **Near surface warming has re-emerged and intensified since Jun 2016.**



NE Pac Heat Budget

[150W-130W,40N-50N]



- Observed positive SSTA tendency (dT/dt) in NE Pac region (dotted black line) increased rapidly in Jul and decreased to below-normal in Sep 2016.

- Qq was the primary factor modulating the tendency and reduced vertical mixing played the secondary role .

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

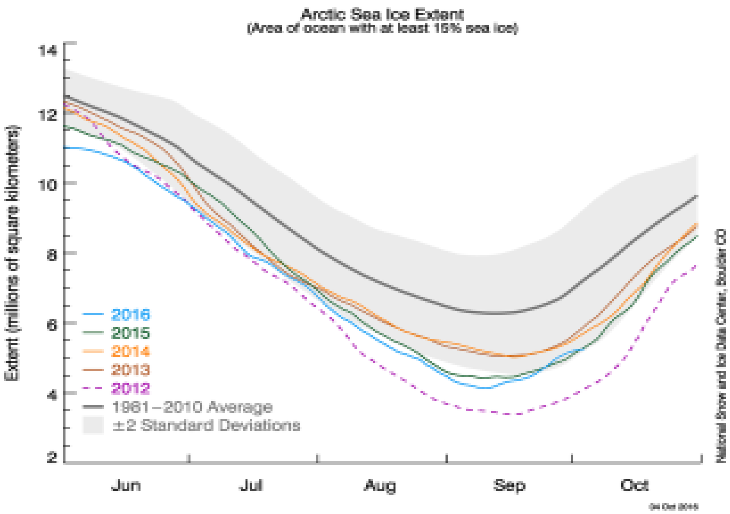
Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

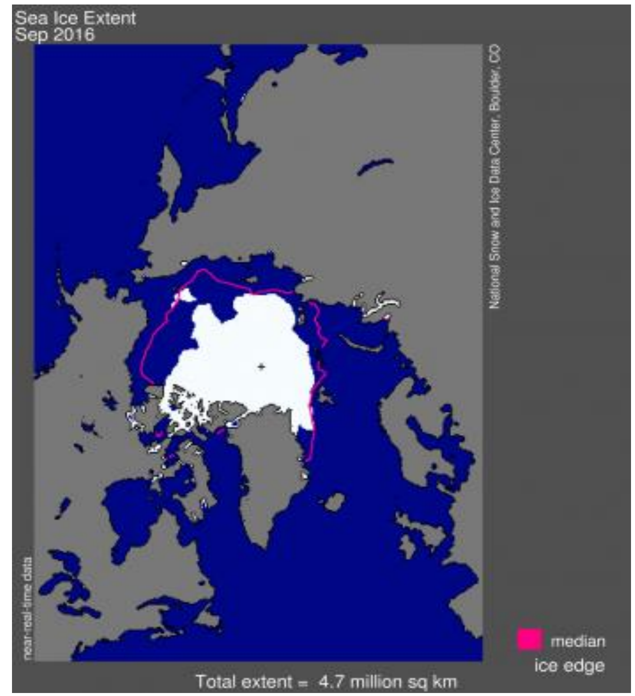
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

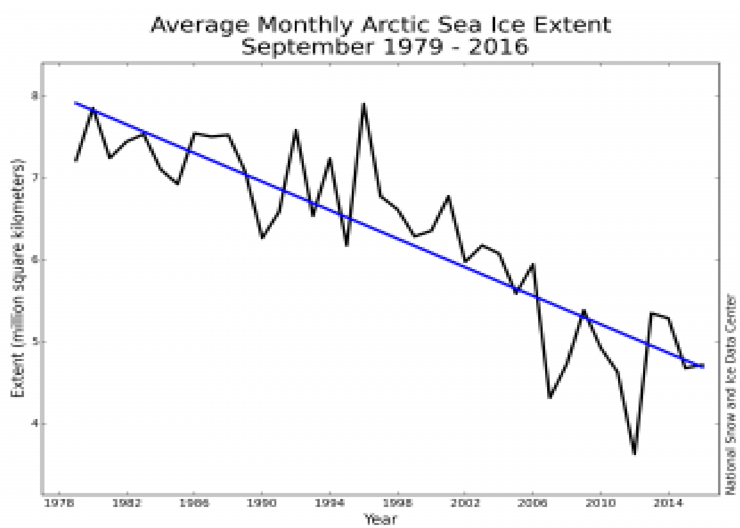
Arctic Sea Ice

National Snow and Ice Data Center

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







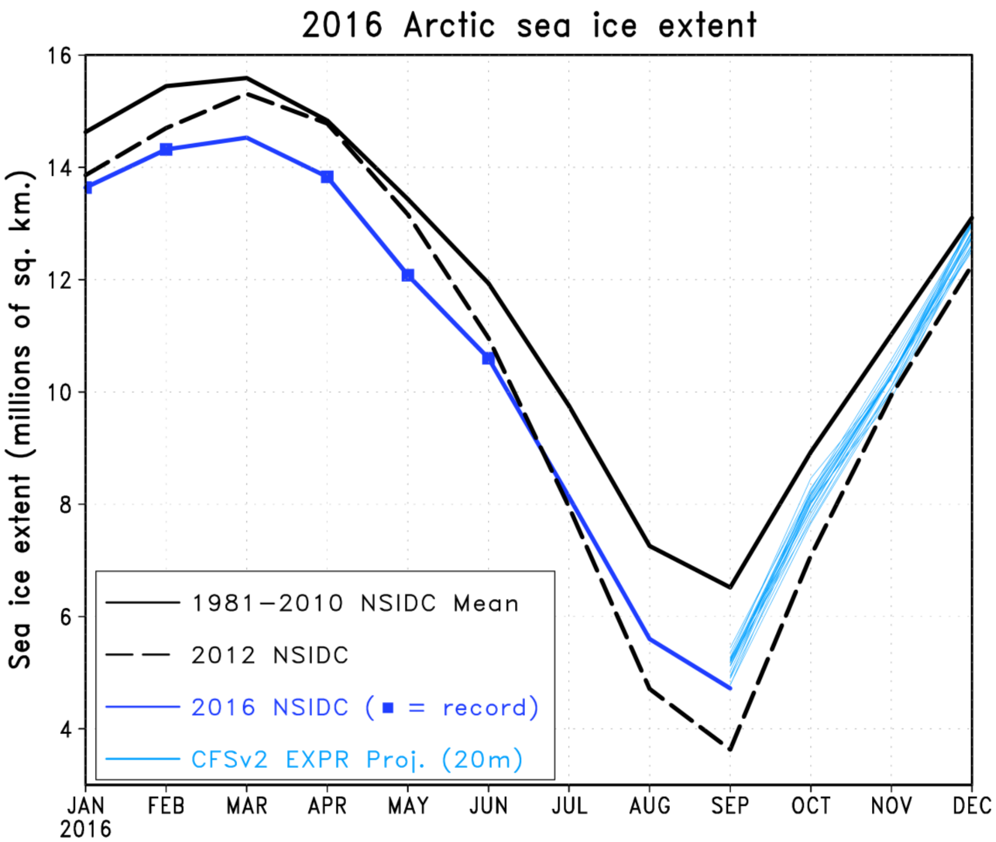
- The seasonal minimum for 2016 was tied with 2007 as the second lowest and the average for Sep ranked the fifth lowest in the Satellite record.

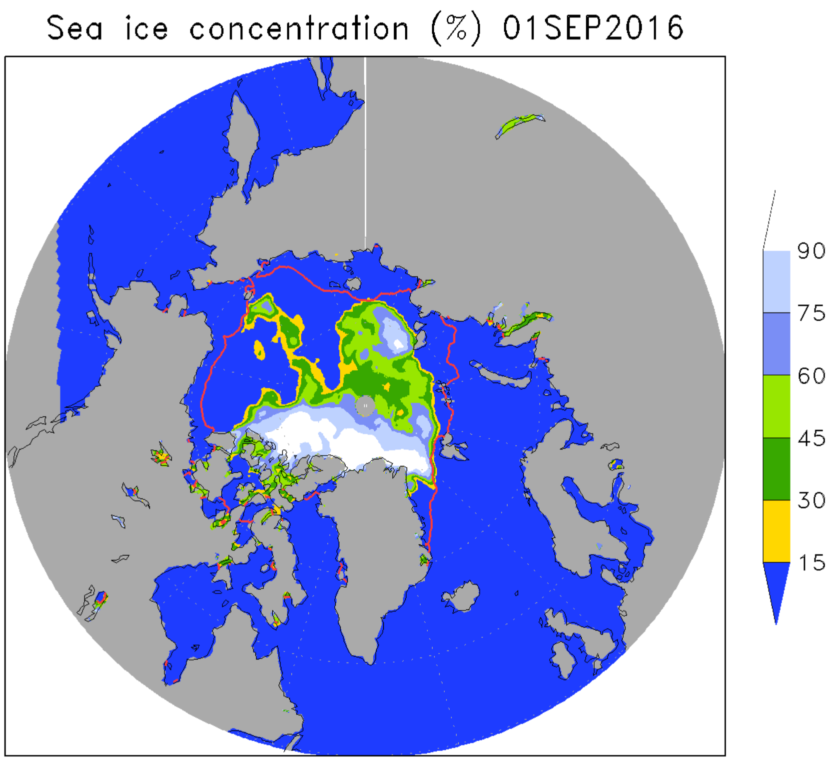
- Arctic sea ice extent has increased rapidly since Sep 10.

CPC Experimental Arctic Sea Ice Prediction

(Wanqiu Wang and Thomas Collow)

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



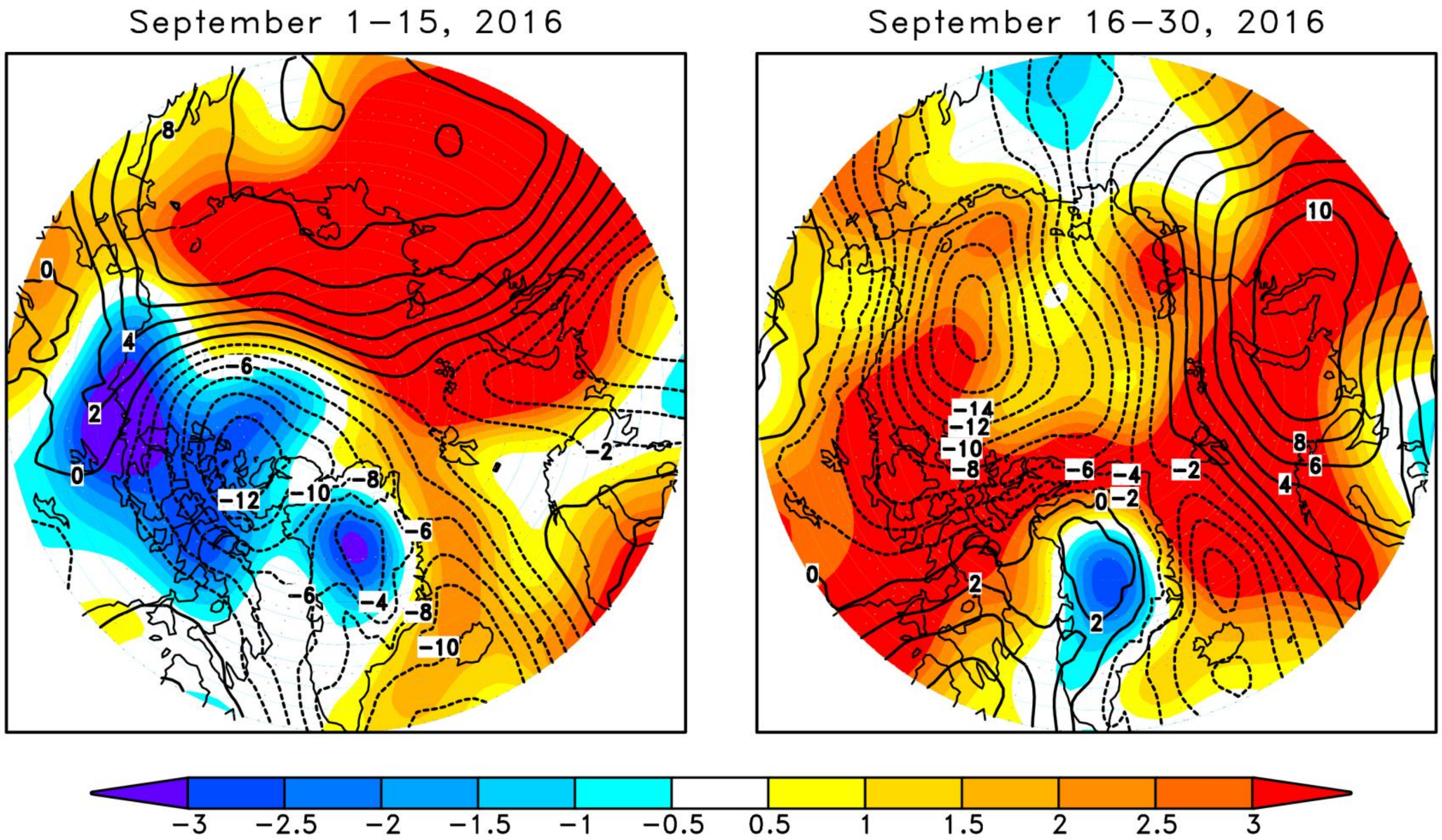


-Daily sea ice minimum reached on September 10 ($4.10 * 10^6$ km^2, ties with 2007 for 2nd lowest since 1979).

- Monthly mean sea ice extent was $4.72 * 10^6$ km^2 (5th lowest since 1979) indicating rapid ice freeze after the daily minimum

(Provided by Thomas W. Collow)

925 mb temp. anomaly (K, shaded) and MSL pressure anomaly (mb, contour) from CFSR with respect to the 1981–2010 period



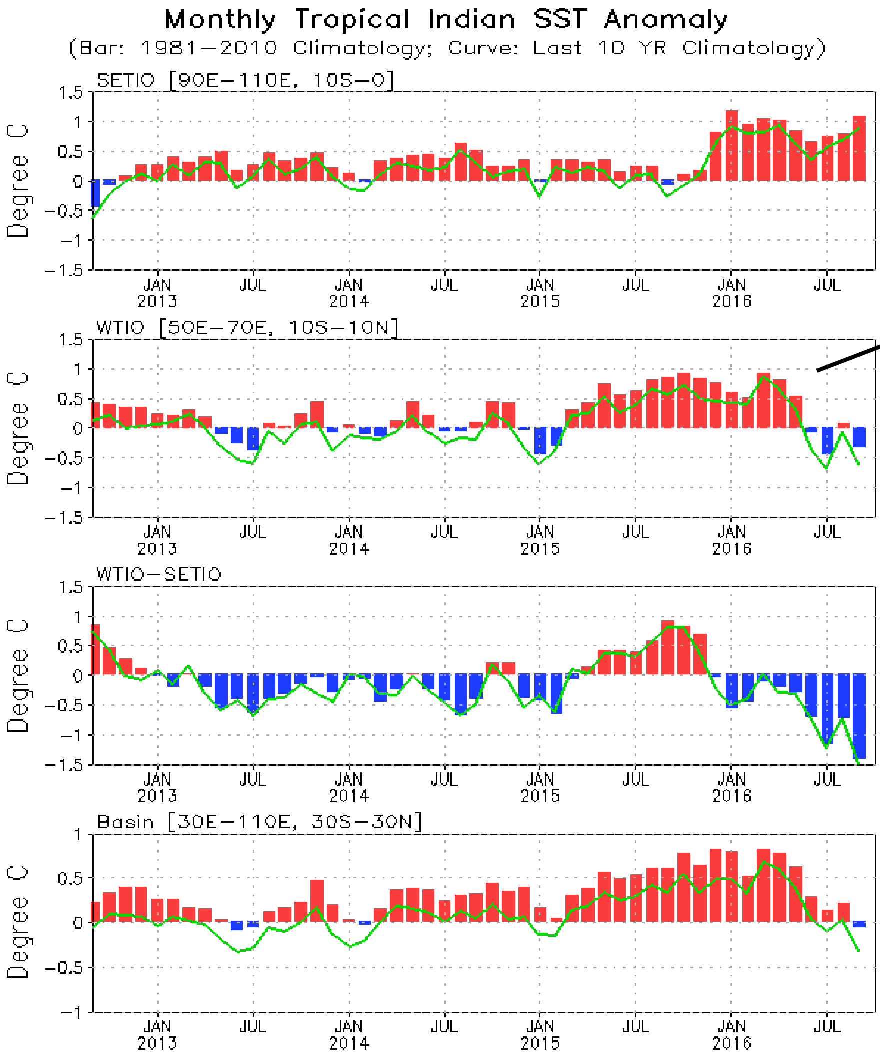
The first half of September featured a strong high pressure anomaly in addition to a positive 925 mb temperature anomaly over Siberia extending into the Arctic. These warm temperatures allowed for continued sea ice melt in early September.

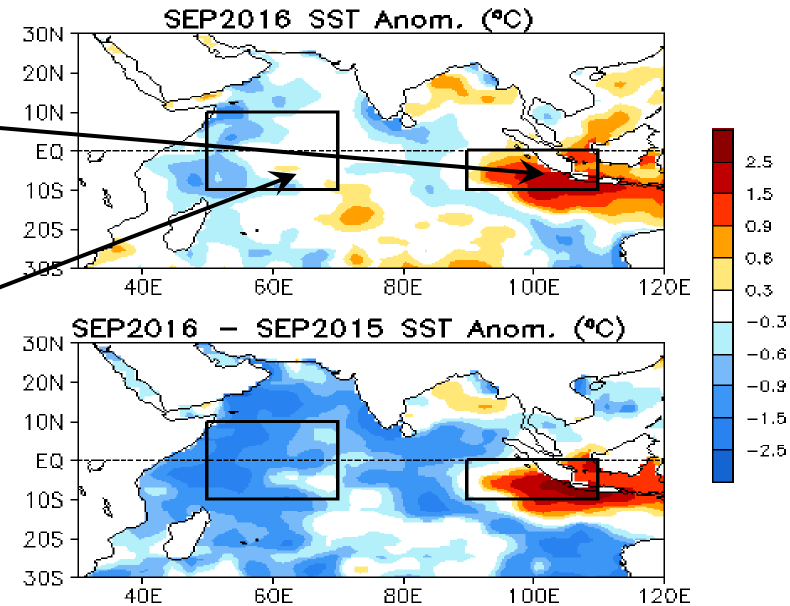
This high pressure anomaly shifted by the second half of the month and the associated positive temperature anomaly decayed as well. Decreased temperatures combined with loss of solar radiation resulted in rapid freeze up of open water in the central Arctic.

(Provided by Thomas W. Collow)

Indian Ocean

Evolution of Indian Ocean SST Indices

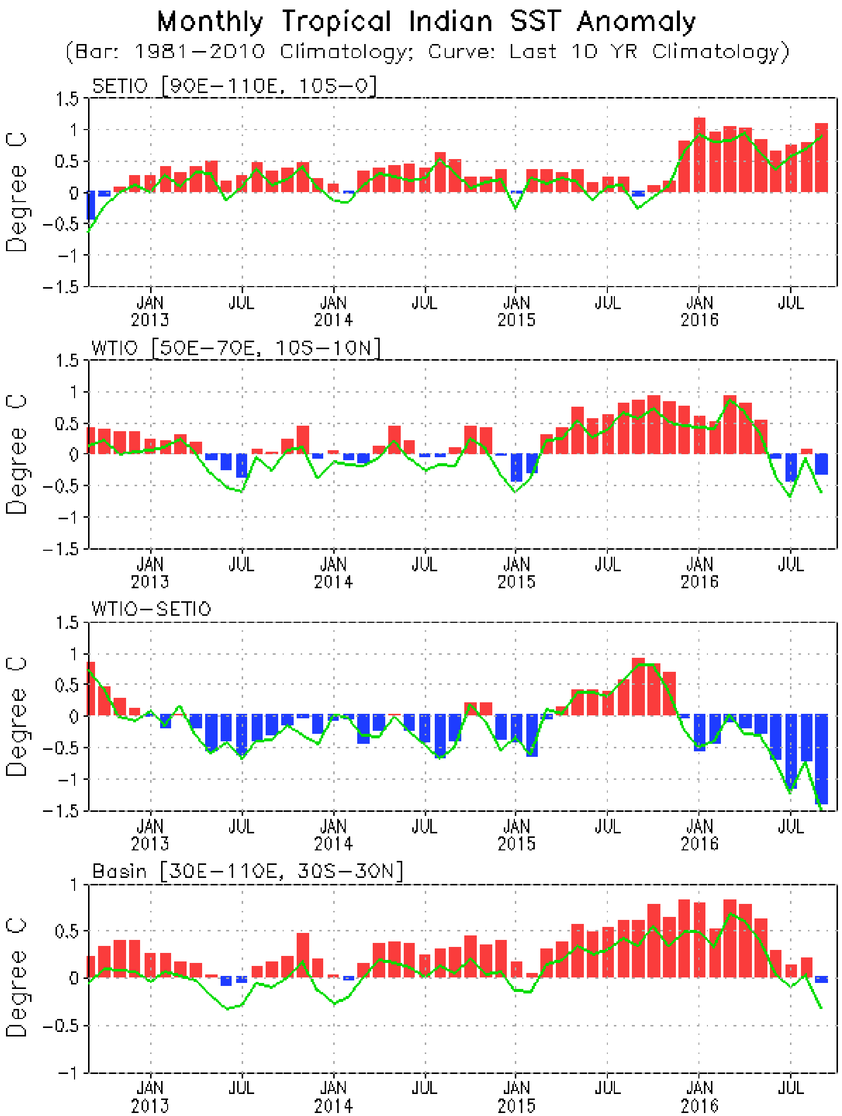


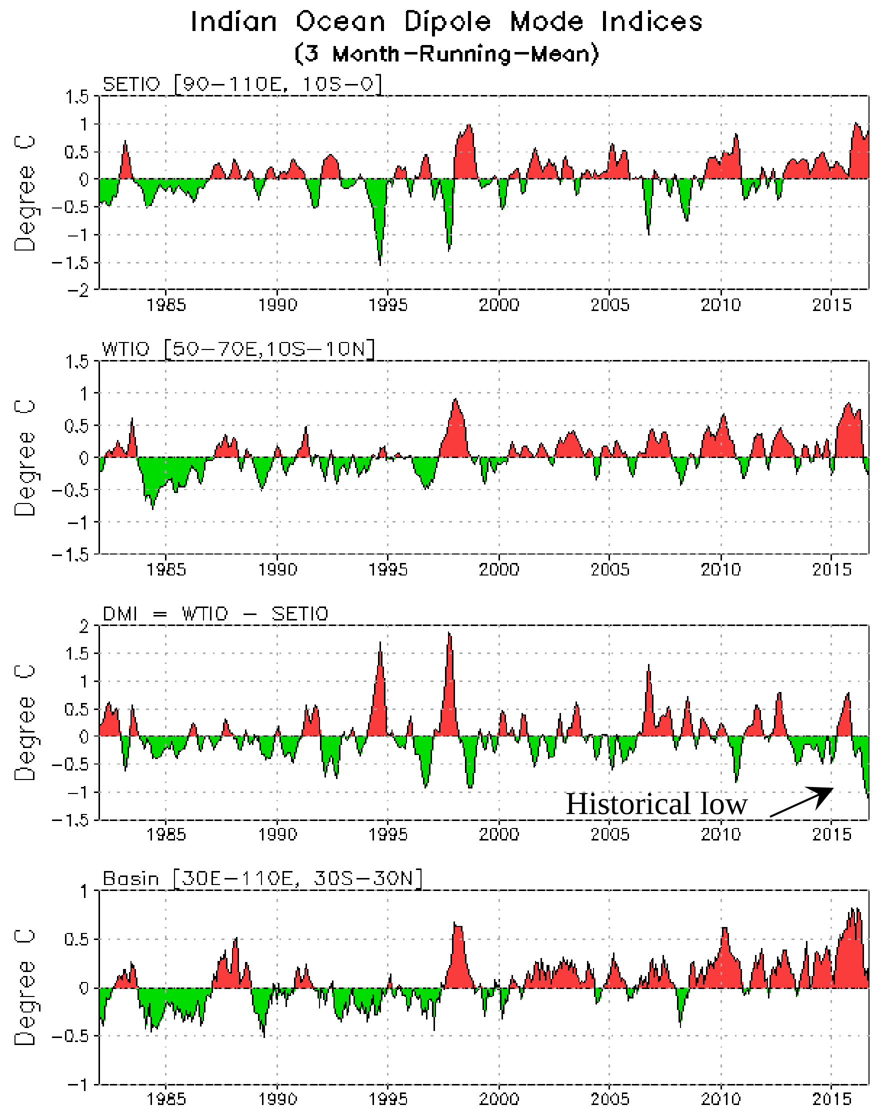


- SETIO has been strong positive (> +0.7°C) since Dec 2015.
- DMI enhanced in Sep with DMI = -1.4°C.
- The long-persistent basin wide warming ended in Sep 2016.

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 departures from the 1981-2010 base period means and the recent 10 year means are shown in bars and green lines.

Evolution of Indian Ocean SST Indices





- DMI has reached the historical low in Sep 2016 since 1982.

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

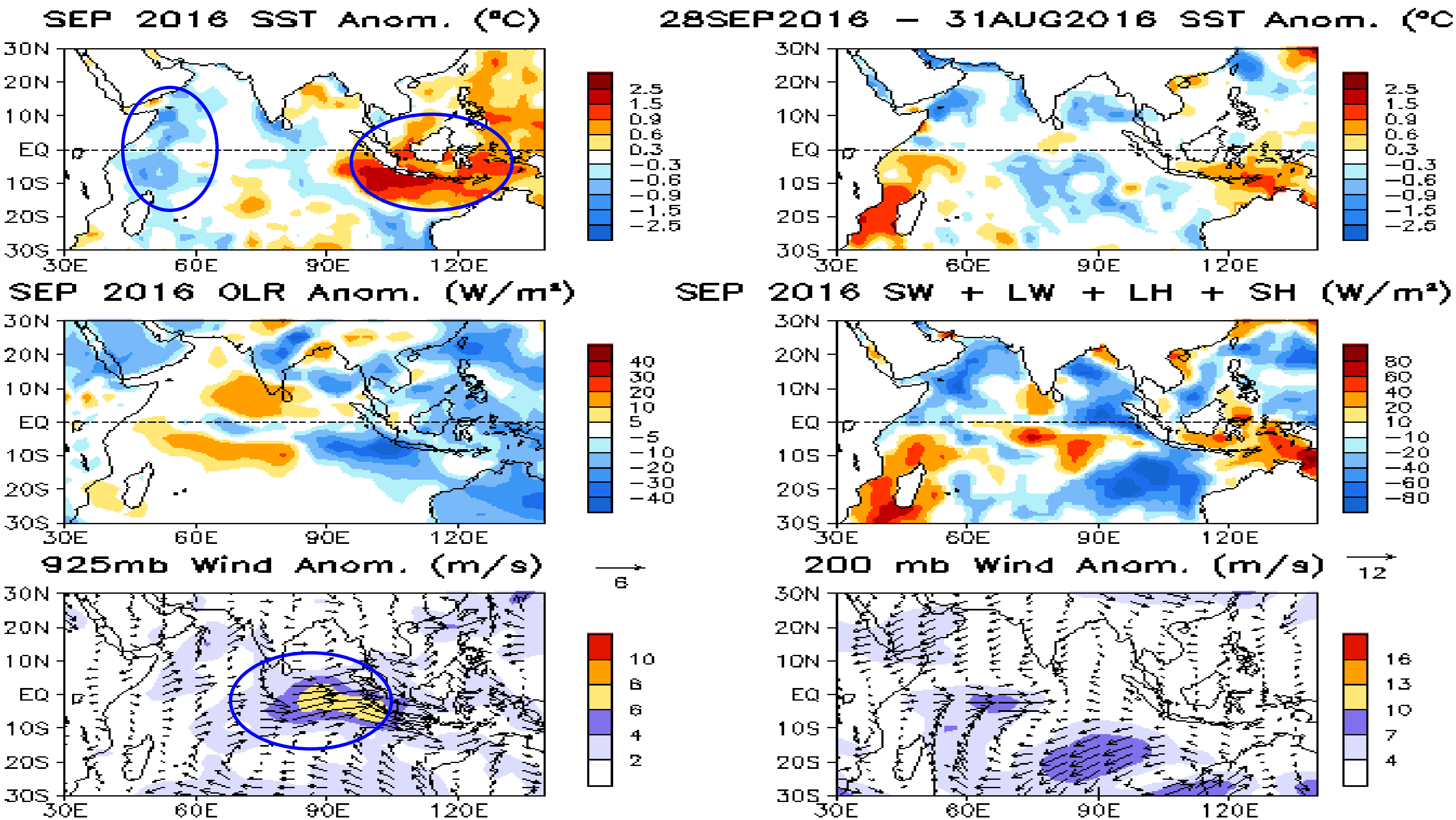
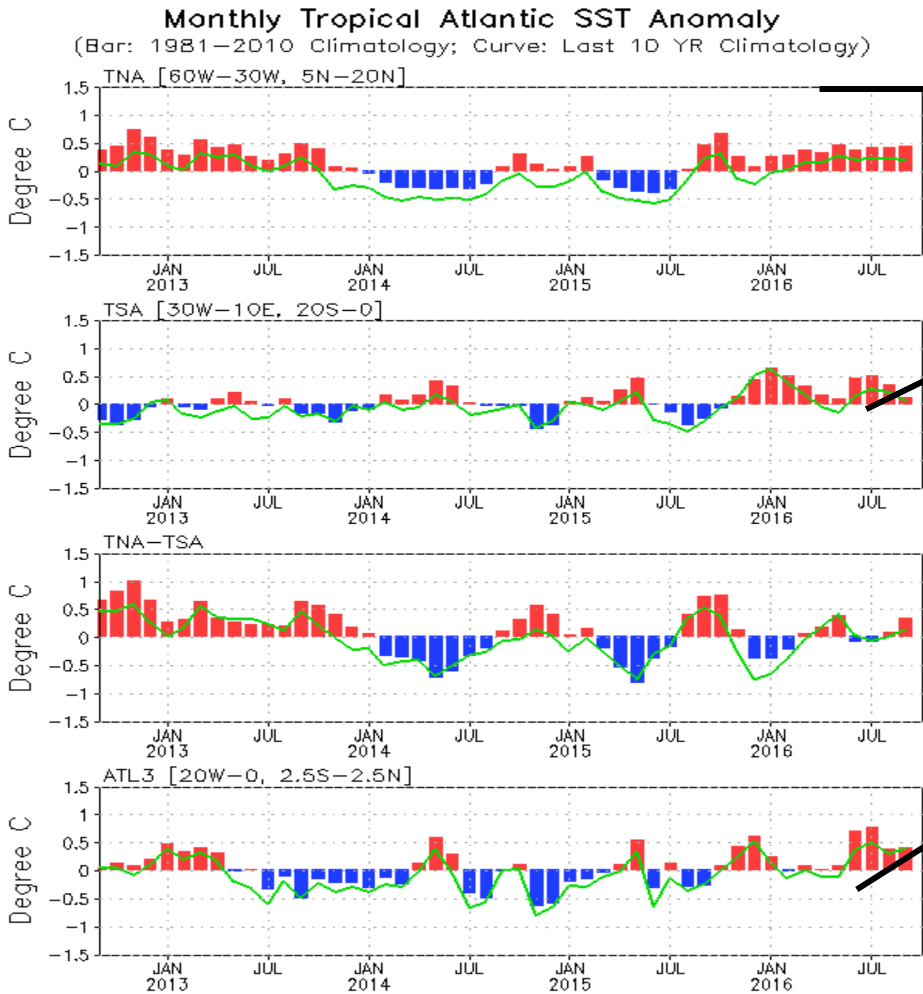
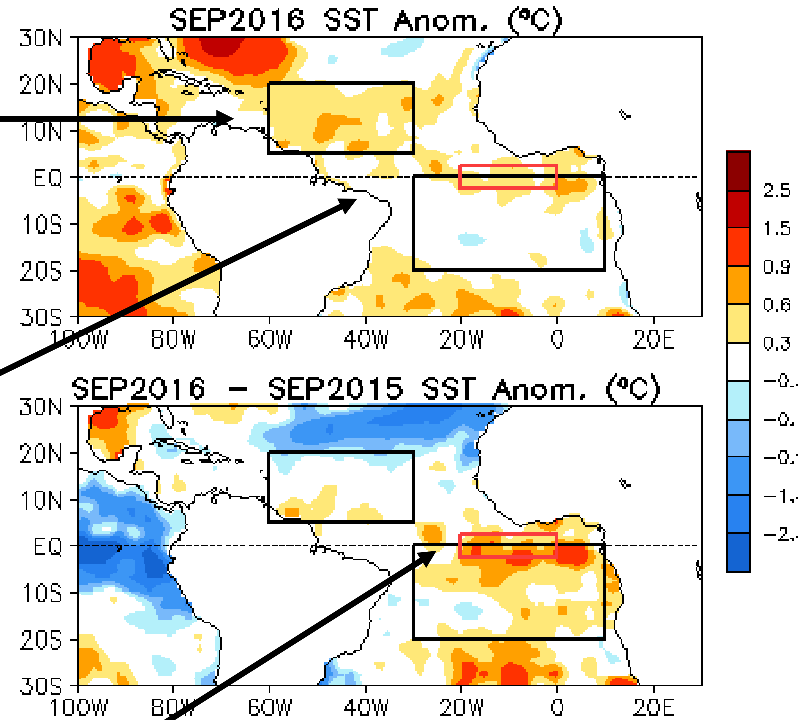


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices



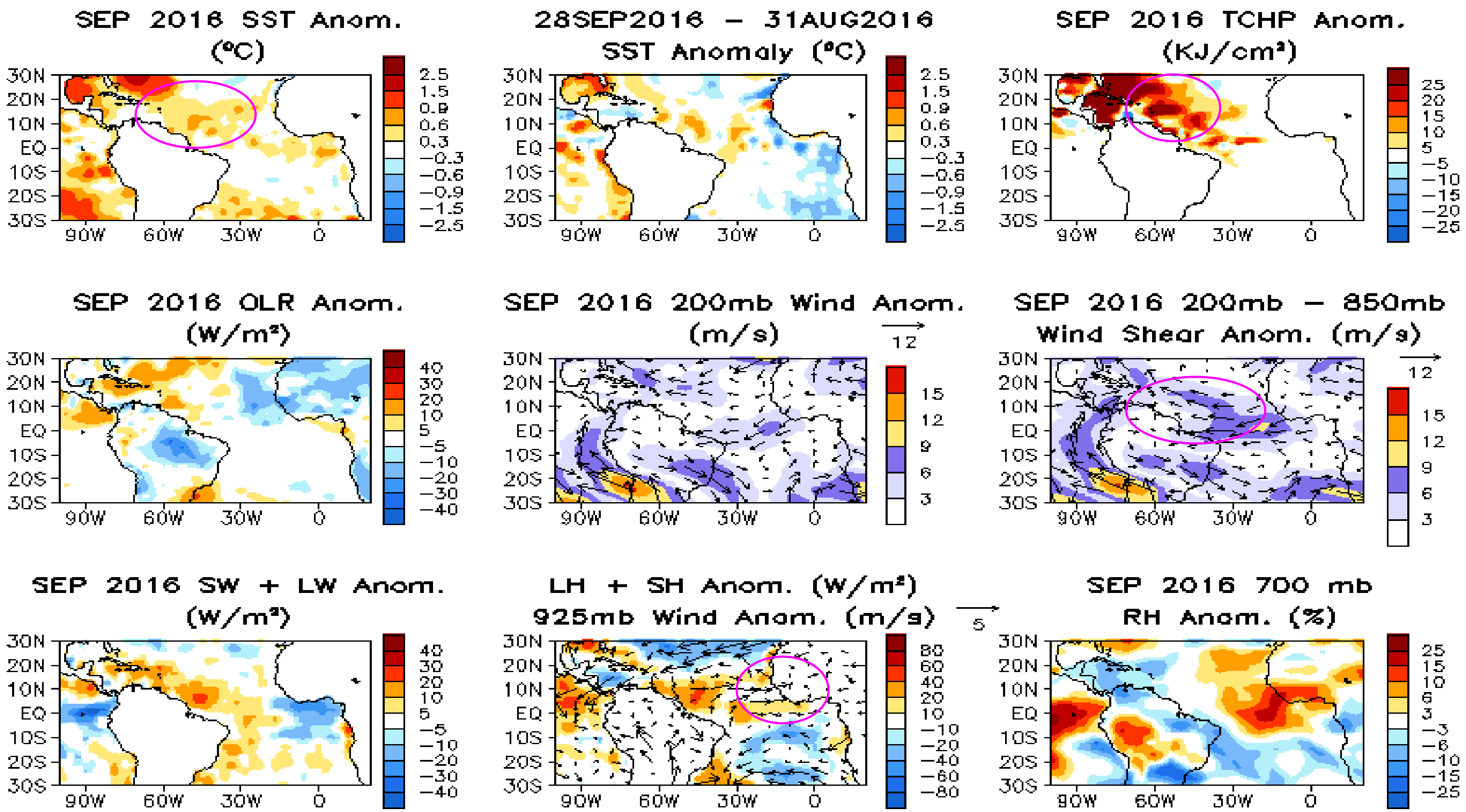


- ATL3 index continued to be above-average in Sep 2016.
- SSTA in the TNA has been above-normal since Aug 2015.
- Positive Meridional Gradient Mode index increased in Sep 2016.

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

Tropical Atlantic:

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



- Above-normal SSTA and TCHP presented in the hurricane Main Development Region (MDR) .
- Below-normal vertical wind shear presented in MDR, which is favourable for hurricane activity.
- Westerly low-level wind blew towards the western Africa, indicating enhanced west African monsoon.

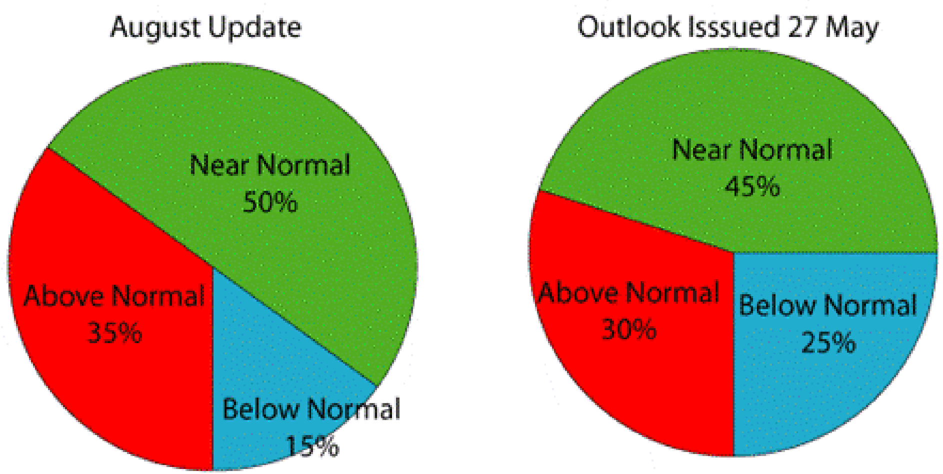
2016 Atlantic Hurricane Season

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

NOAA's Updated 2016 Atlantic Hurricane Season Outlook

85% Chance of Near-Normal or Above-Normal Season

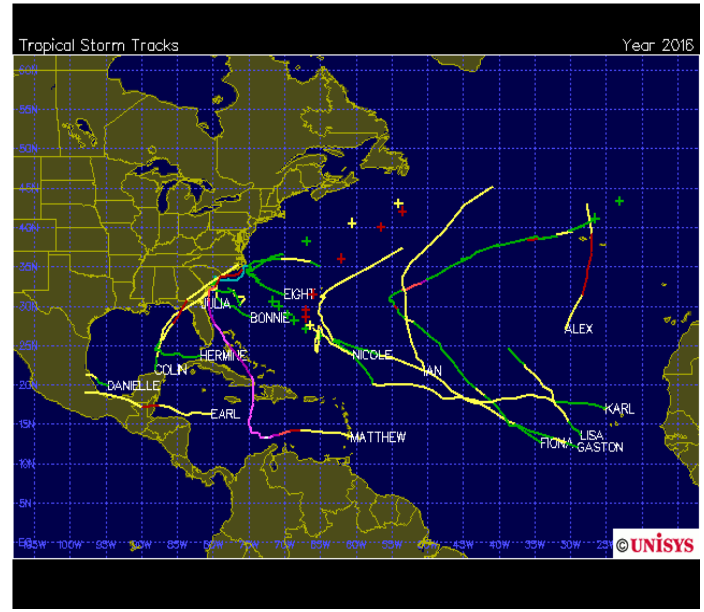
Probability of Season Type



Predicted Activity

70% Probability For Each Range

	August Update	May Outlook	Season Averages (1981-2010)
Named Storms	12-17	10-16	12
Hurricanes	5-8	4-8	6
Major Hurricanes	2-4	1-4	3



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

- Fourteen tropical storms with 6 reaching hurricane category formed in N. Atlantic by Oct.11.

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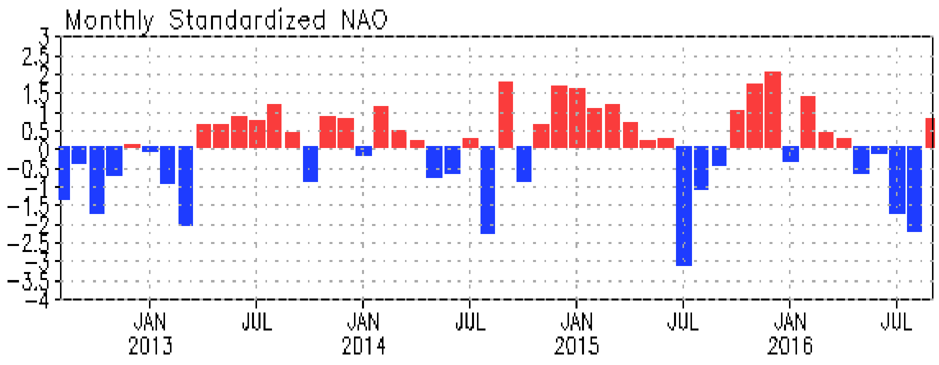
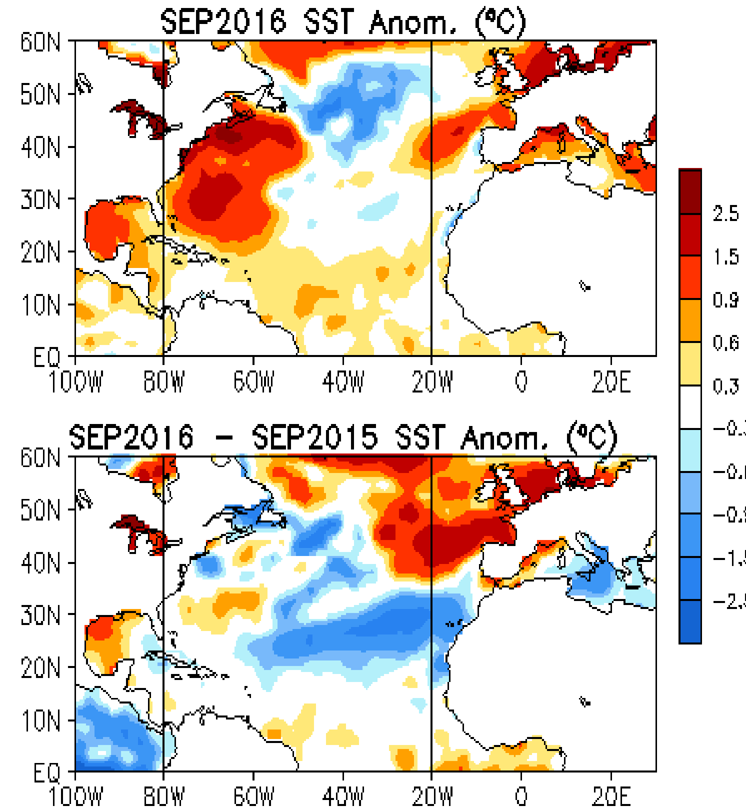
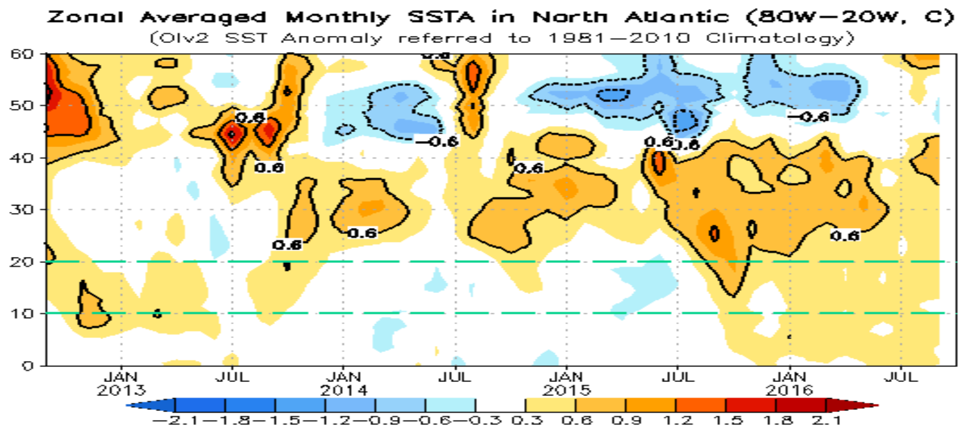
NAO and SST Anomaly in North Atlantic





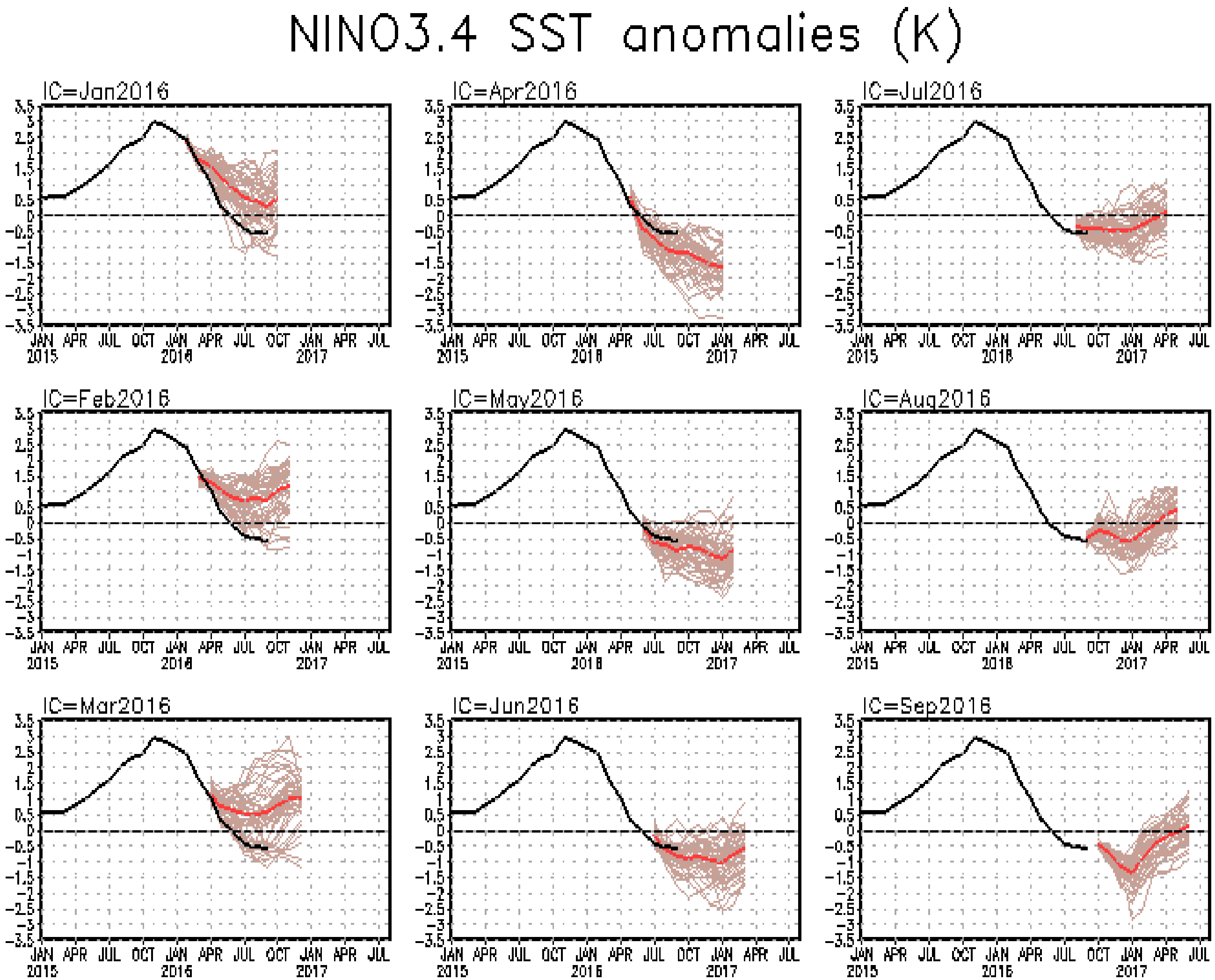


- NAO switched to positive, with NAOI= 0.7 in Sep 2016.
- Strong positive SSTA persisted along the E. coast of North America.

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

Global SST Predictions

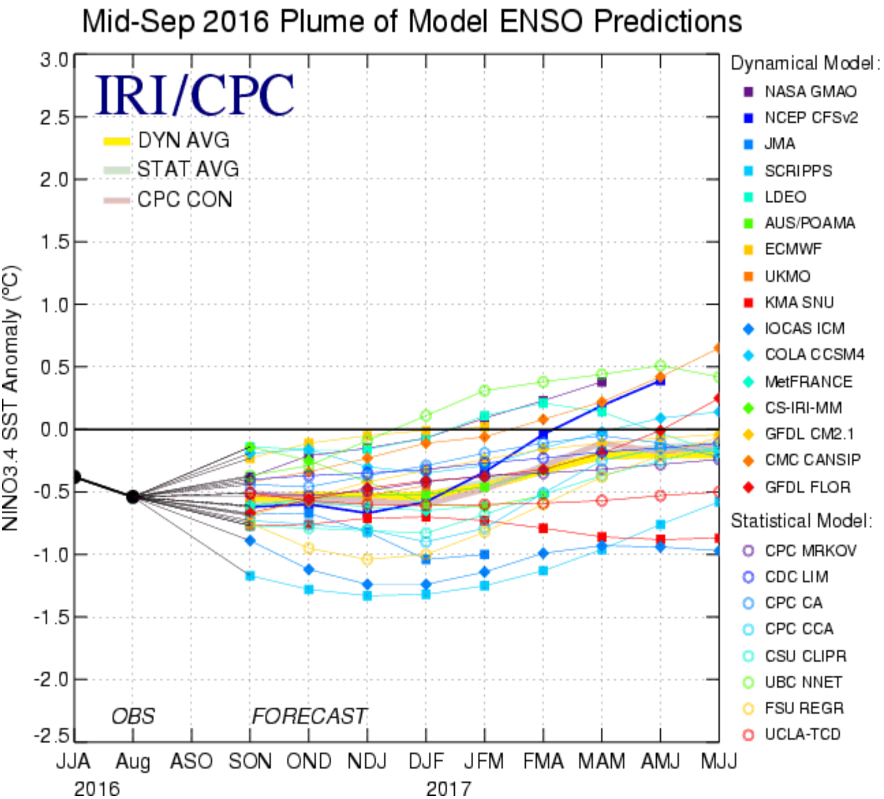
CFS Niño3.4 SST Predictions from Different Initial Months

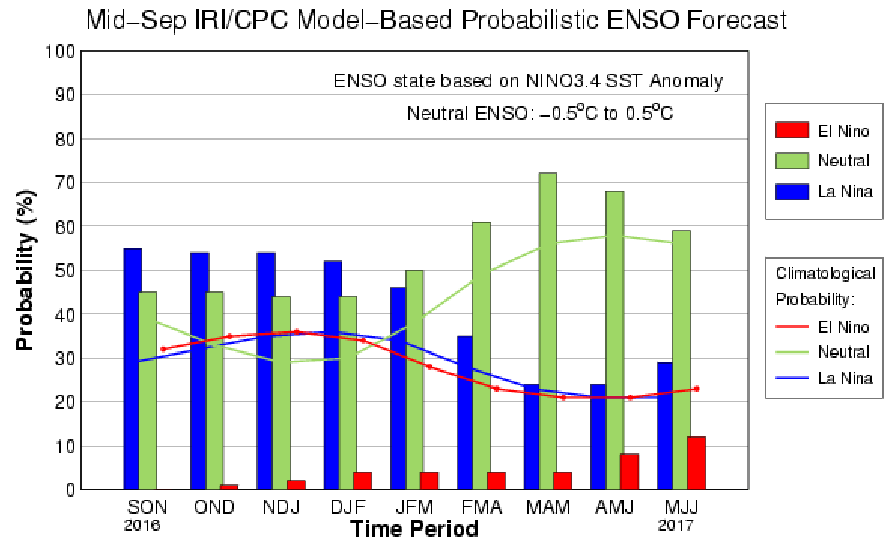


- Latest CFSv2 predictions call for a weak La Nina during the Northern Hemisphere fall and winter 2016-17.

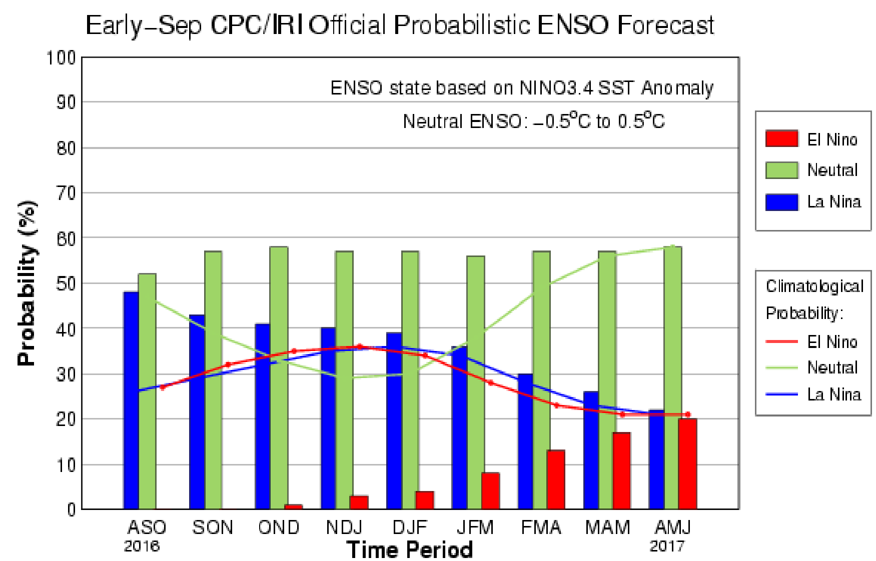
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

IRI NINO3.4 Forecast Plum

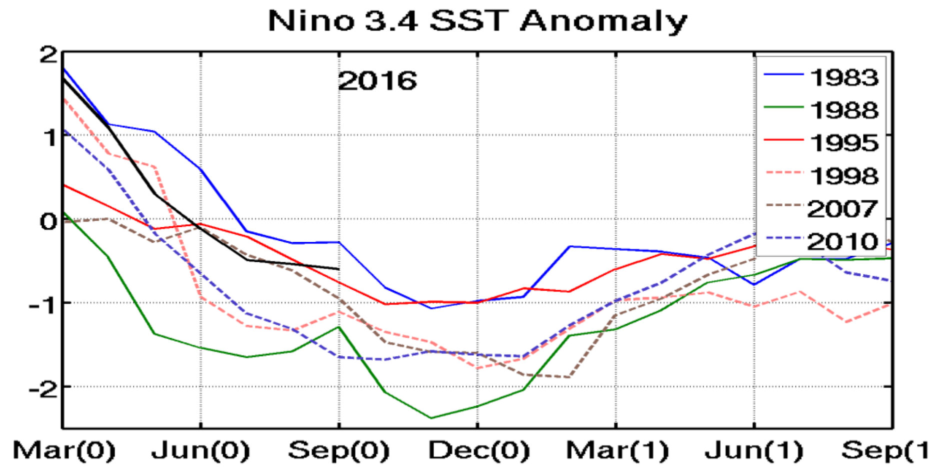




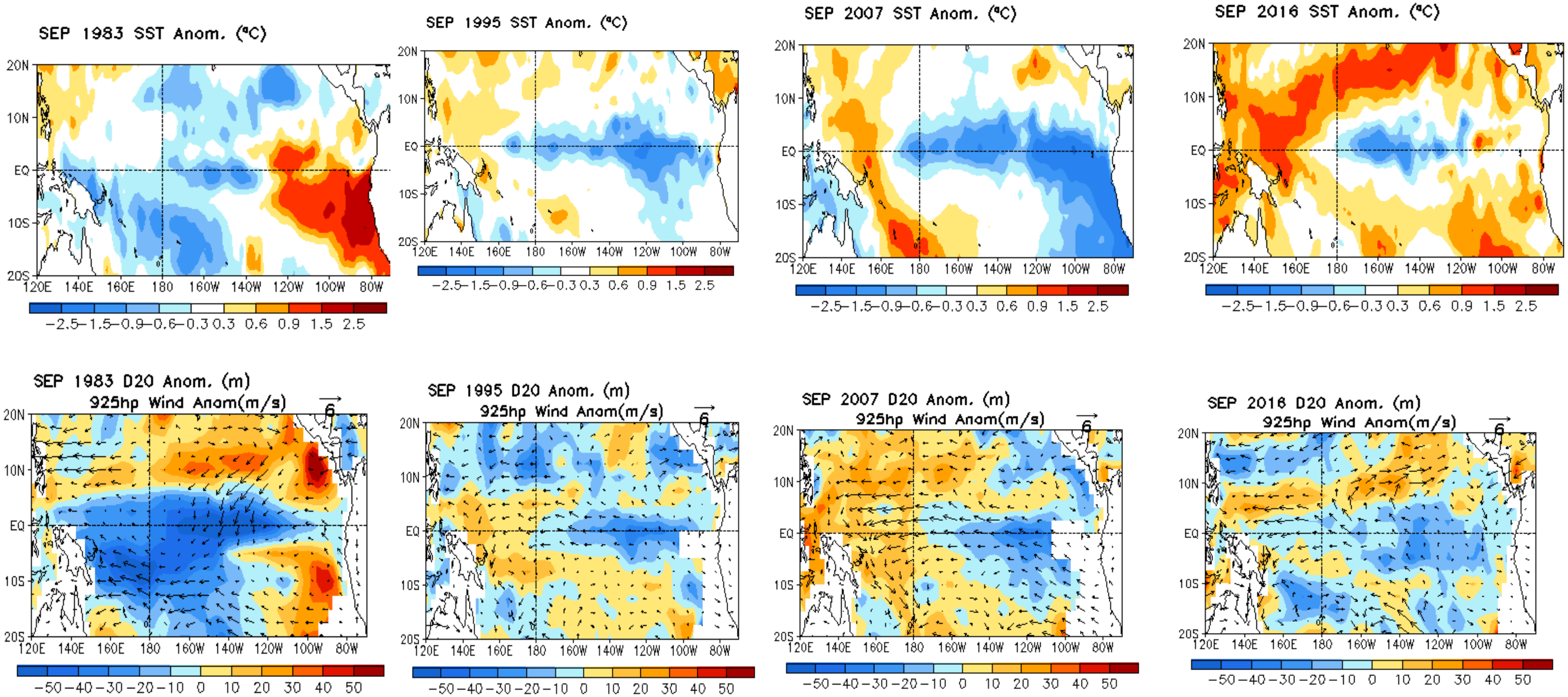
- **Multi-model averages favor borderline La Niña or neutral conditions during fall, then weakening to cool-neutral in the coming winter.**



SST,D20 and 925hp Wind anomalies in September



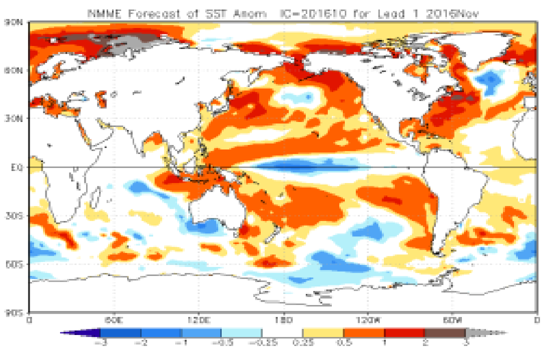
1983 1995 2007 2016

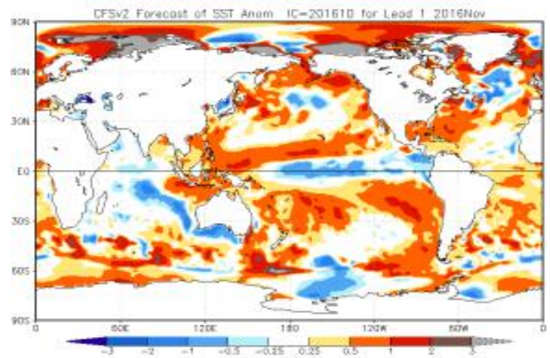


NMME & NCEP CFSv2 SST Predictions

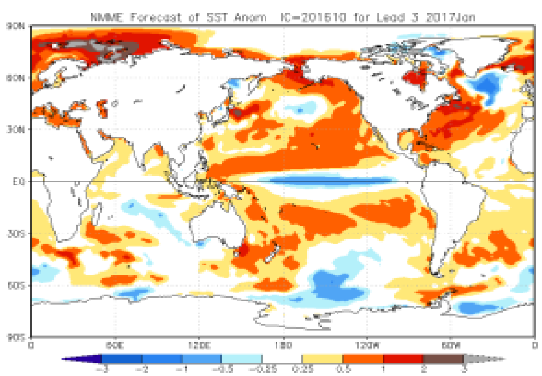
NMME **CFSv2**

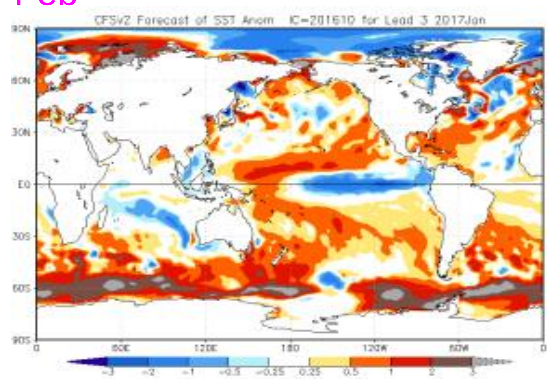
2016 Nov



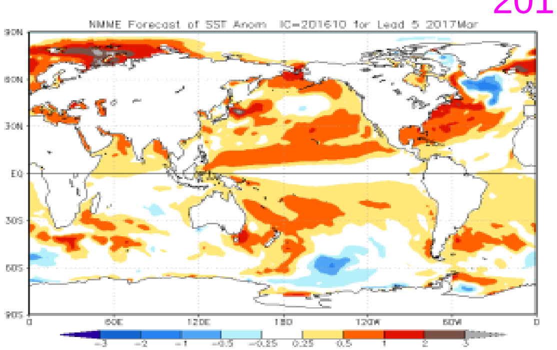


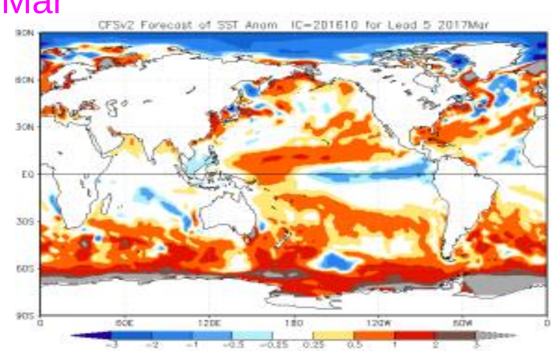
2017 Feb

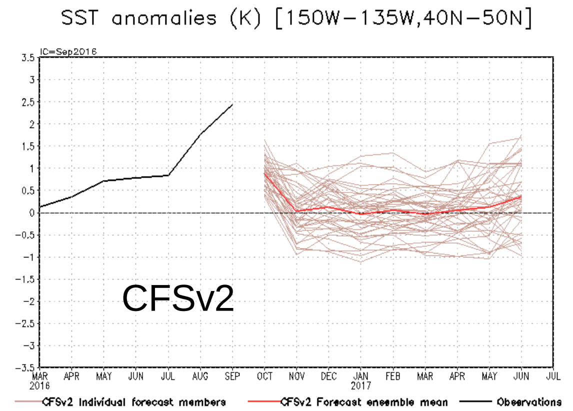




2017 Mar

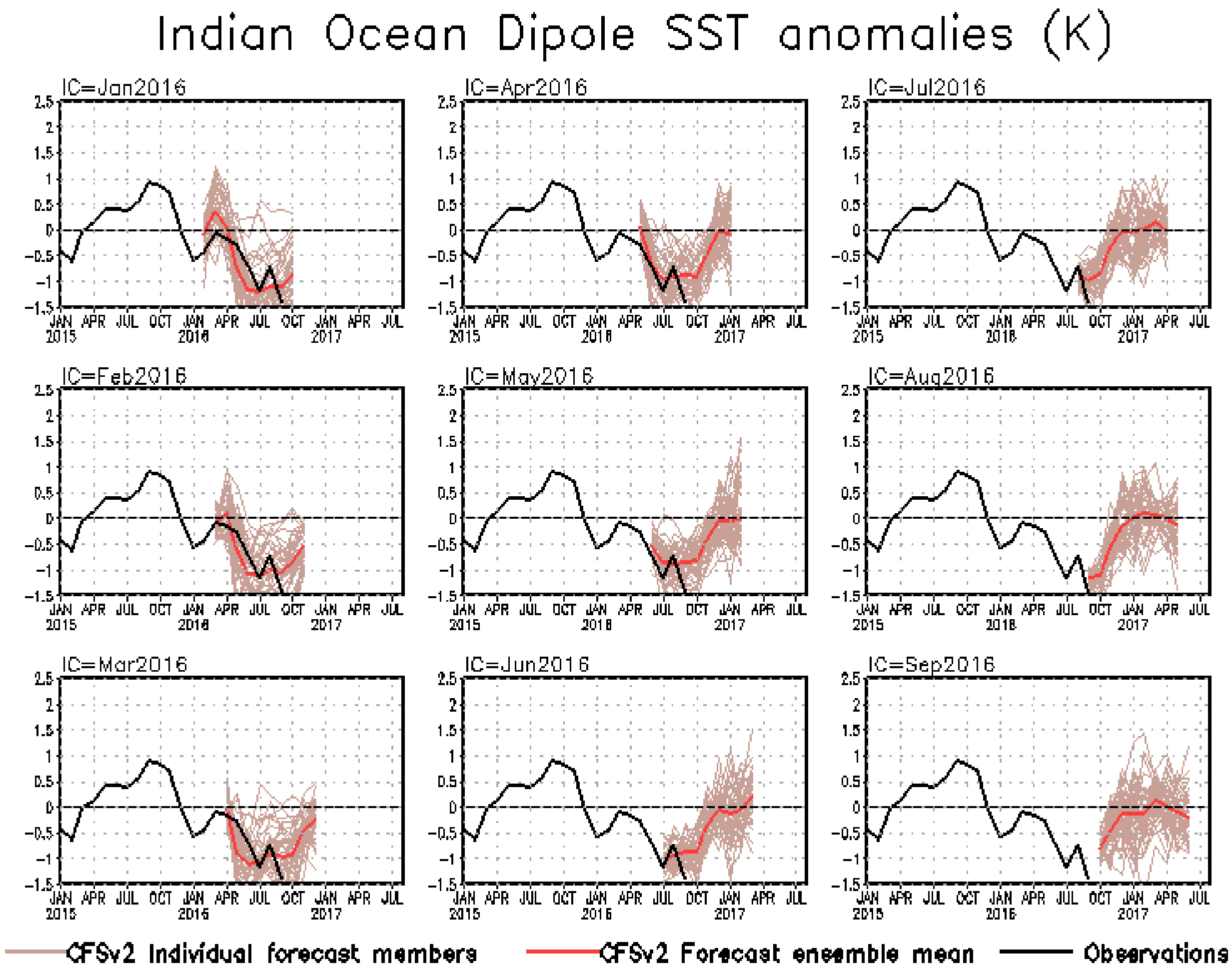






- **CFSv2 forecast SST warming in N.E Pacific will dissipate rapidly by Nov 2016.**
- **NMME indicates SST warming in N.E Pacific will continue through the Northern Hemisphere winter 2016-17.**

CFSv2 DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

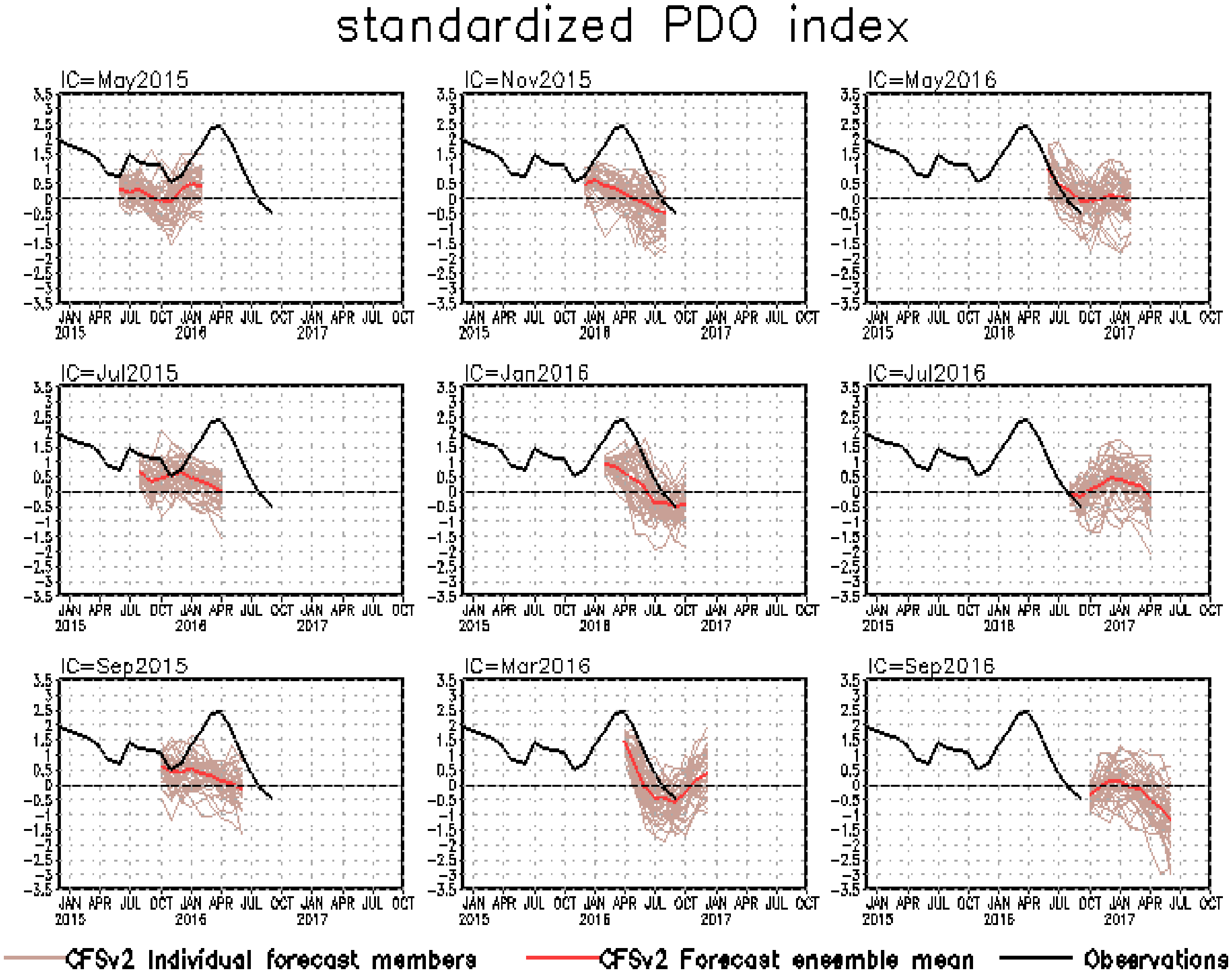
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- **CFSv2 has persistently forecast negative DMI to develop during the northern hemisphere summer and fall 2016 since Nov 2015 I.C..**
- **Latest CFSv2 forecasts DMI will return to neutral in winter 2016.**

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.

PDO Forecast by NCEP CFSv2

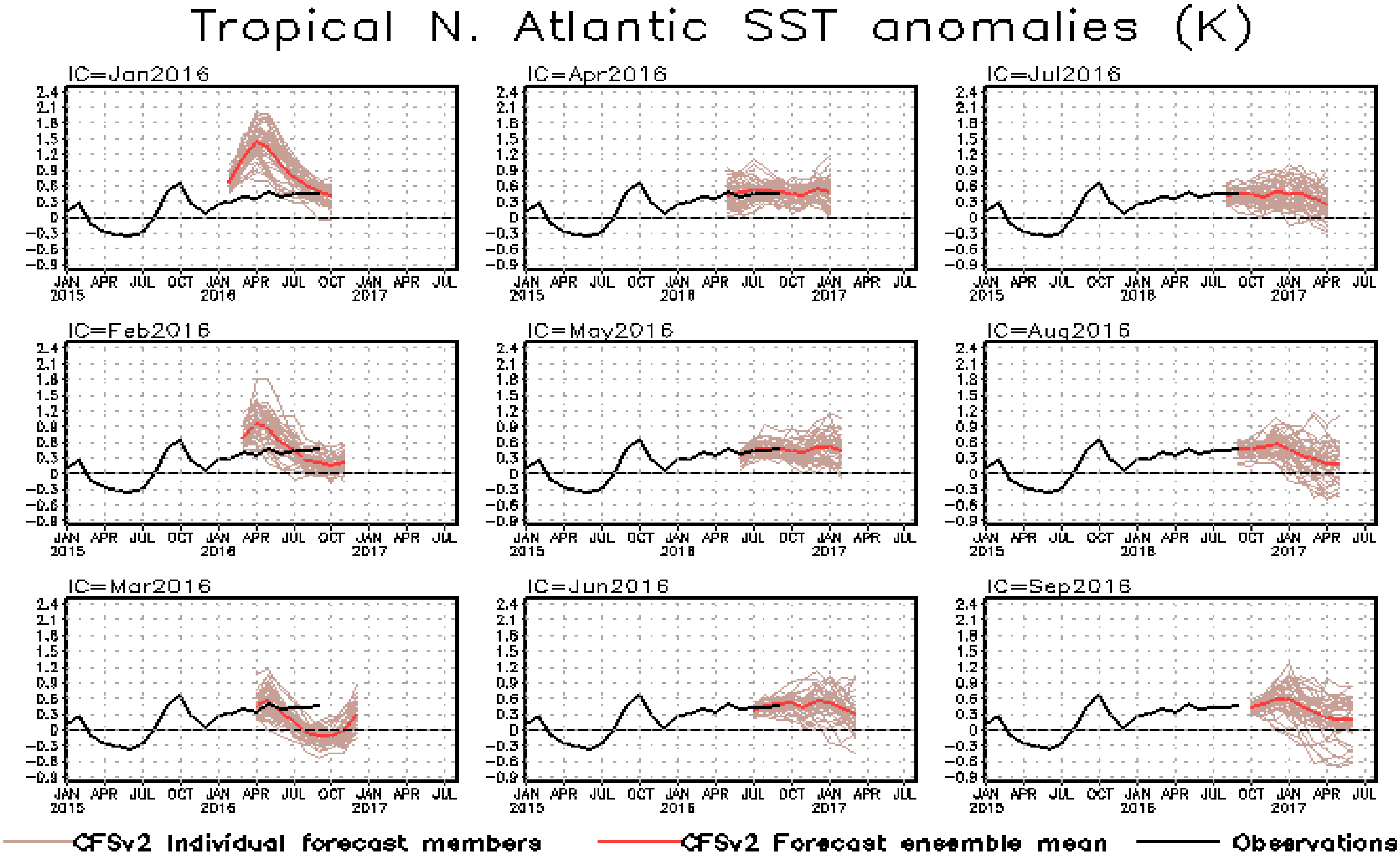


- CFSv2 forecasts PDO will remain near-neutral during the northern hemisphere fall and winter 2016-17.

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.

Tropical North Atlantic SST Forecast by NCEP CFSv2



- CFSv2 forecast the tropical North Atlantic SST will be weakly above-normal during the norther hemisphere fall and winter 2016-17.

Overview

➢ Pacific Ocean

- ❑ Negative SSTA persisted in the central-eastern Pacific with Nino3.4 = -0.6ºC.
- ❑ ENSO-neutral condition continued in Sep 2016.
- ❑ CFSv2 forecast La Nina conditions in the Northern Hemisphere fall and winter 2016-17.
- ❑ SST warming continued in the N. E Pacific (Pacific 'Blob').
- ❑ PDO became weakly negative with PDO = -0.5 in Sep 2016.
- ❑ The daily minimum of Arctic sea ice extent in 2016 was tied with 2007 as the second lowest in the Satellite record.

➢ Indian Ocean

- ❑ Dipole Mode Index reached -1.4ºC in Sep 2016, which was the lowest record since 1982.
- ❑ Negative SSTA dominated in the Indian Ocean.

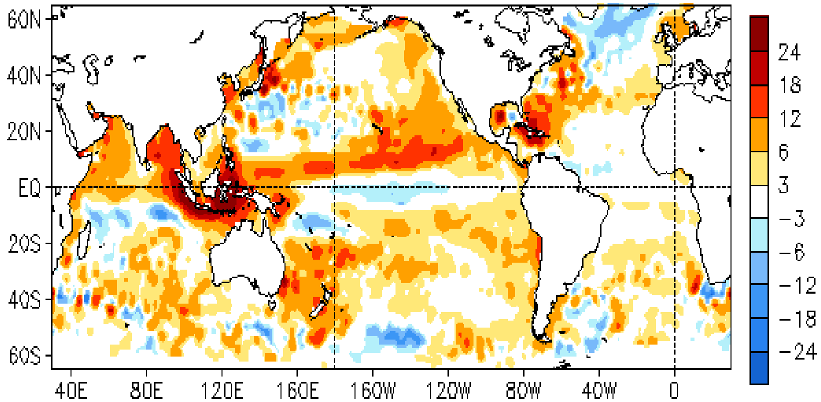
➢ Atlantic Ocean

- ❑ NAO switched to positive in Sep 2016.
- ❑ SSTA were well above-average along the eastern coast of North America.

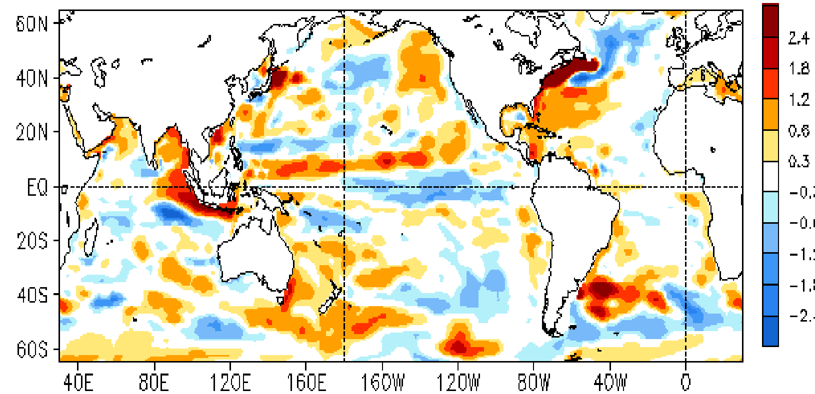
Backup Slides

Global SSH and HC300 Anomaly & Anomaly Tendency

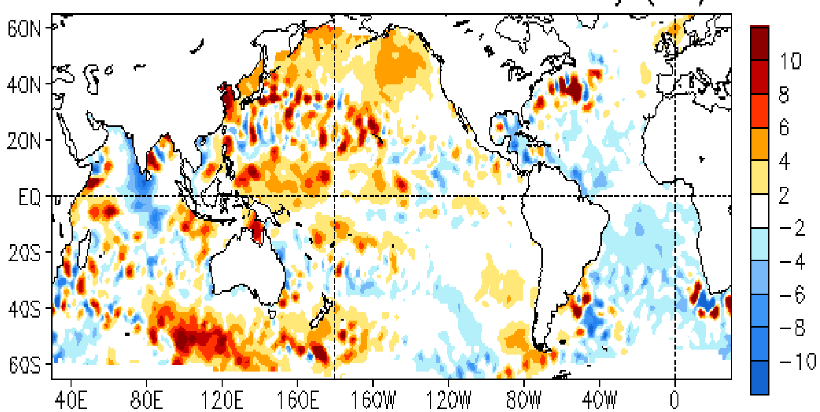
SEP 2016 SSH Anomaly (cm)
(AVISO Altimetry, Climo. 93-13)



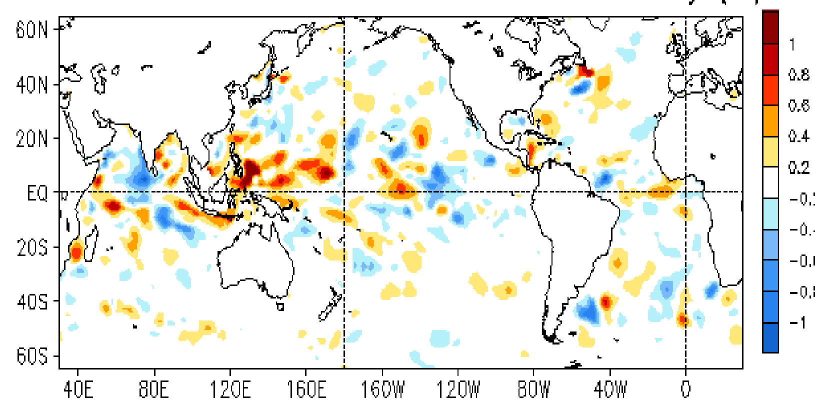
SEP 2016 Heat Content Anomaly (°C)
(GODAS, Climo. 81-10)



SEP 2016 – AUG 2016 SSH Anomaly (cm)



SEP 2016 – AUG 2016 Heat Content Anomaly (°C)



- **The SSHA was overall consistent with HC300A: Positive (negative) HC300A is tied up with positive (negative) SSHA.**
- **Both SSHA and HC300A were weakly negative along the equatorial Pacific, reflecting the neutral phase of ENSO.**
- **Negative SSHA tendency dominated in the C.-E. Pacific.**

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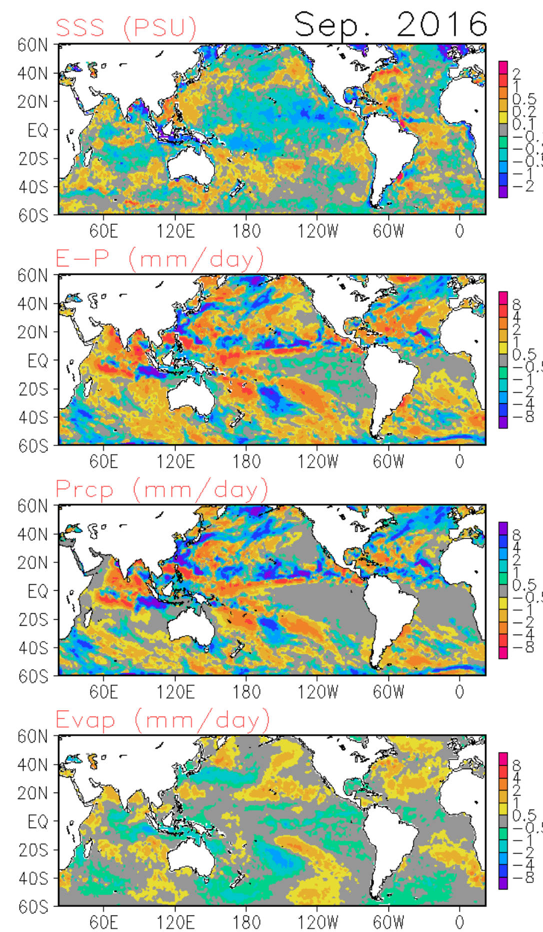
Global Sea Surface Salinity (SSS)
Anomaly for September 2016

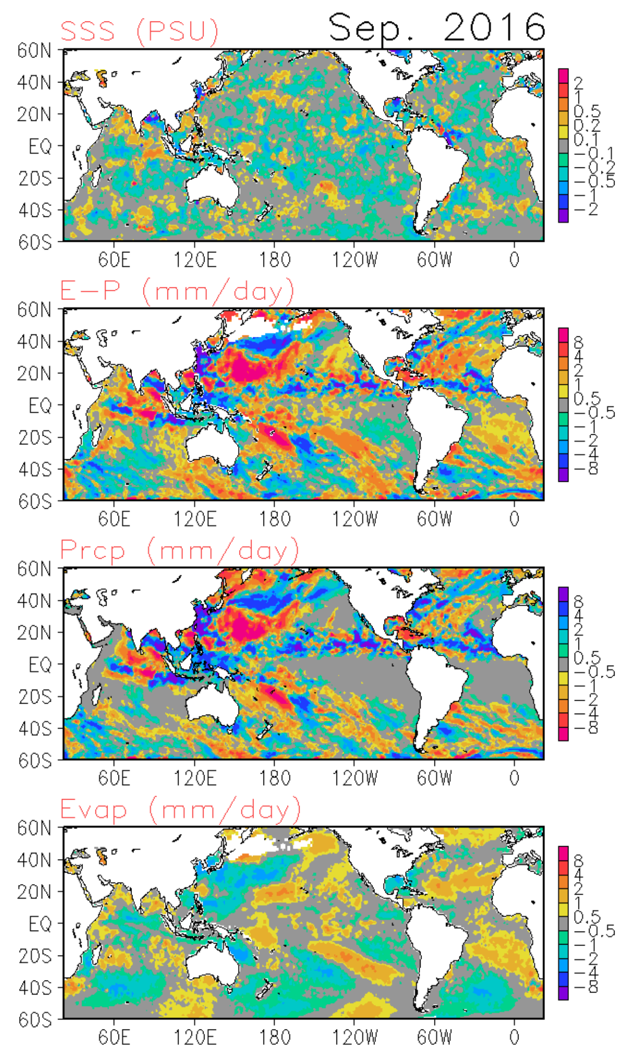
- NOTE: Since Aquarius terminated operations, the blended SSS analysis is from in situ and SMOS only from June 2015. Please report to us any suspicious data issues!
- The ENSO is very likely in neutral condition in this month with no significant salinity changes along the Equator. Large area of decreased SSS was observed in the east basin of North Pacific subtropics and west basin of South Pacific subtropics. However, the freshwater flux in these regions was reduced which indicates that the ocean advection contributes to the freshening in these areas. Significant freshening in the Indo-Pacific region was co-incident with the increased freshwater flux mostly due to heavy precipitation.



- **Data used**
  - **SSS :**
    - **Blended Analysis of Surface Salinity (BASS) V0.Y (a CPC-NESDIS/NODC-NESDIS/STAR joint effort) (Xie et al. 2014)**
    - **ftp.cpc.ncep.noaa.gov/precip/BASS**
  - **Precipitation:**
    - **CMORPH adjusted satellite precipitation estimates**
  - **Evaporation:**
    - **CFS Reanalysis**

Global Sea Surface Salinity (SSS)
Tendency for September 2016

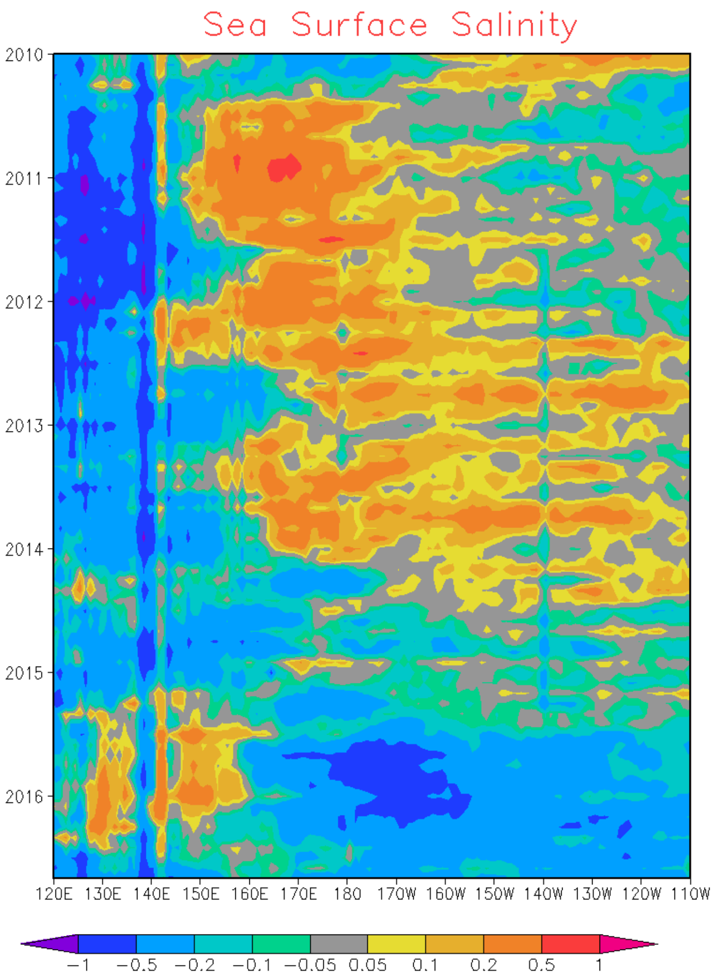
Compared with last month, the SSS in the central of Bay of Bengal significantly decreased with increasing precipitation. The SSS in the northern part of Bay of Bengal was also decreased. However, the precipitation was reduced suggesting that the ocean advection bring low salinity water into this region. The SSS in east China Sea significantly decreased likely due to the heavy rain fall brought by Typhoon Malakas.



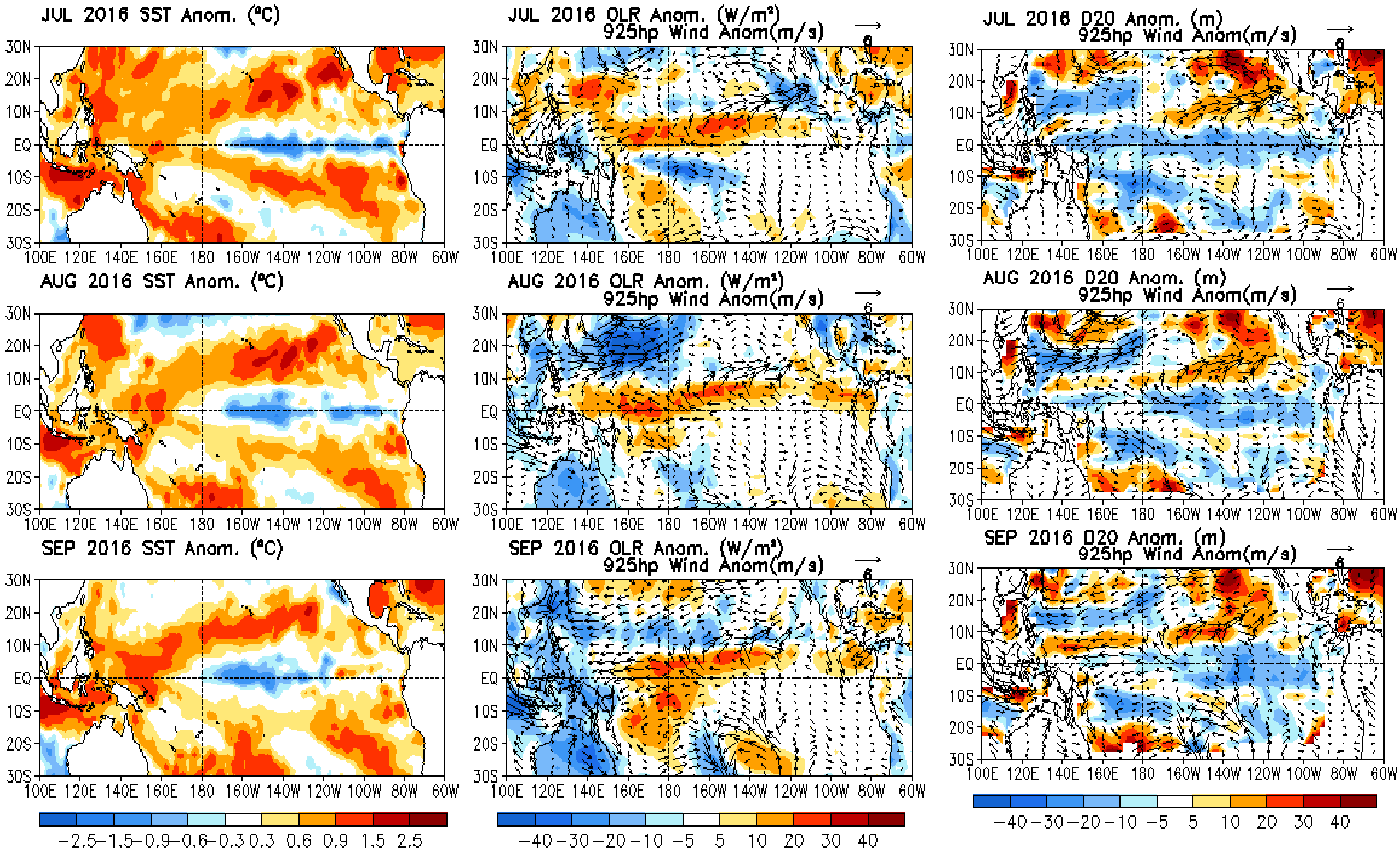
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

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

- The anomaly evolution in this region shows similar pattern as last month. The negative SSS in the Eastern Equatorial Pacific from 160ºE to 110ºW is changing to neutral. At the meantime, the positive SSS anomaly over the western Pacific from 130ºE – 160ºE is likely changing to negative.



Last Three Month SST, OLR, D20 and 925hp Wind Anom.

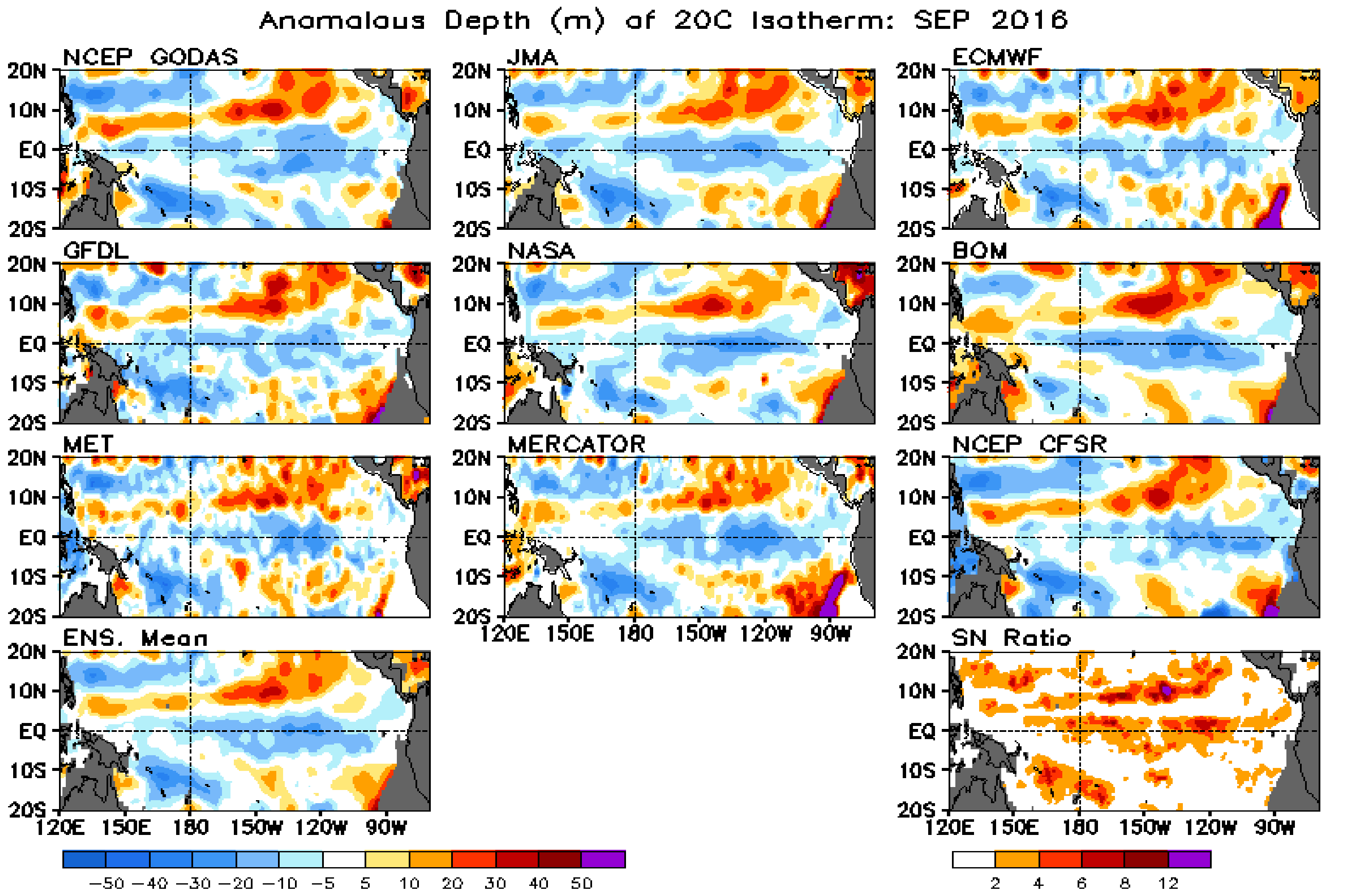


- Negative SSTA enhanced slightly and extended westward in the past three months.
- Positive SSTA and D20A persisted in the N.E tropical Pacific.
- Surface easterly wind anomalies persisted in the western Pacific, consistent with enhanced convection over the Maritime Continent and in the eastern Indian Ocean.

Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1993-2013

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

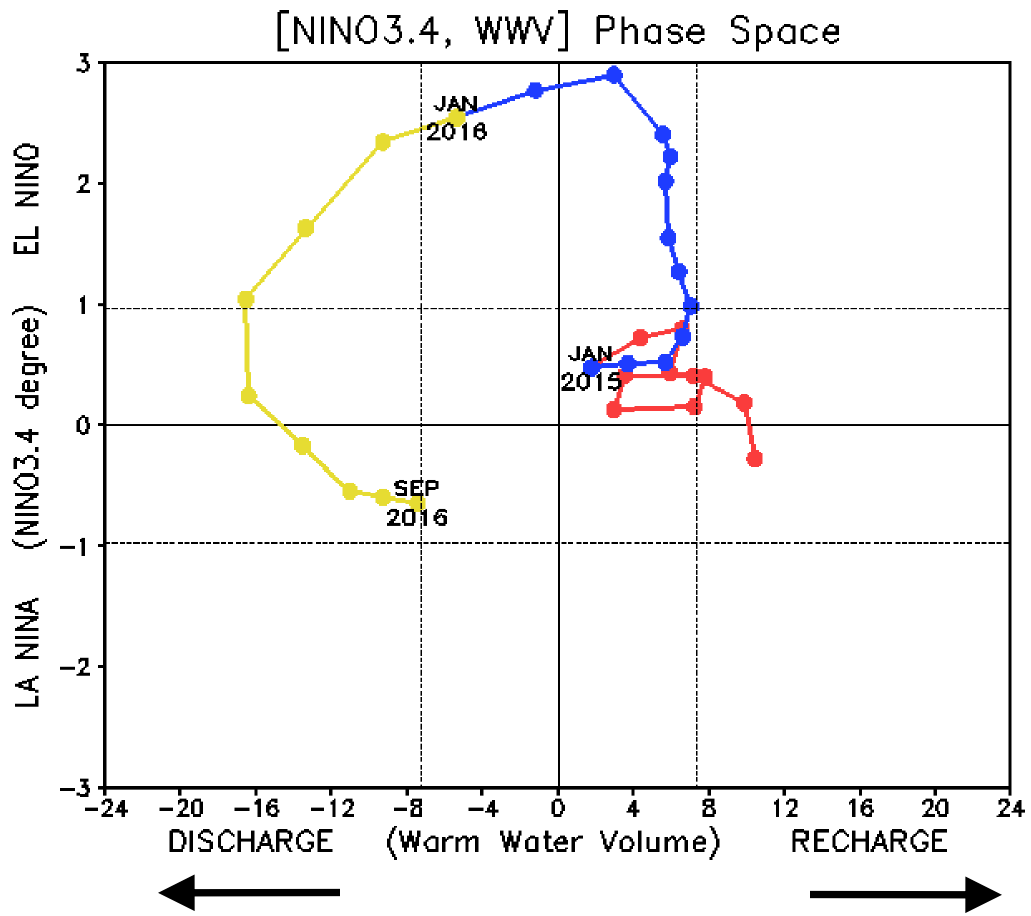


Warm Water Volume (WWV) and NINO3.4 Anomalies

- **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).**

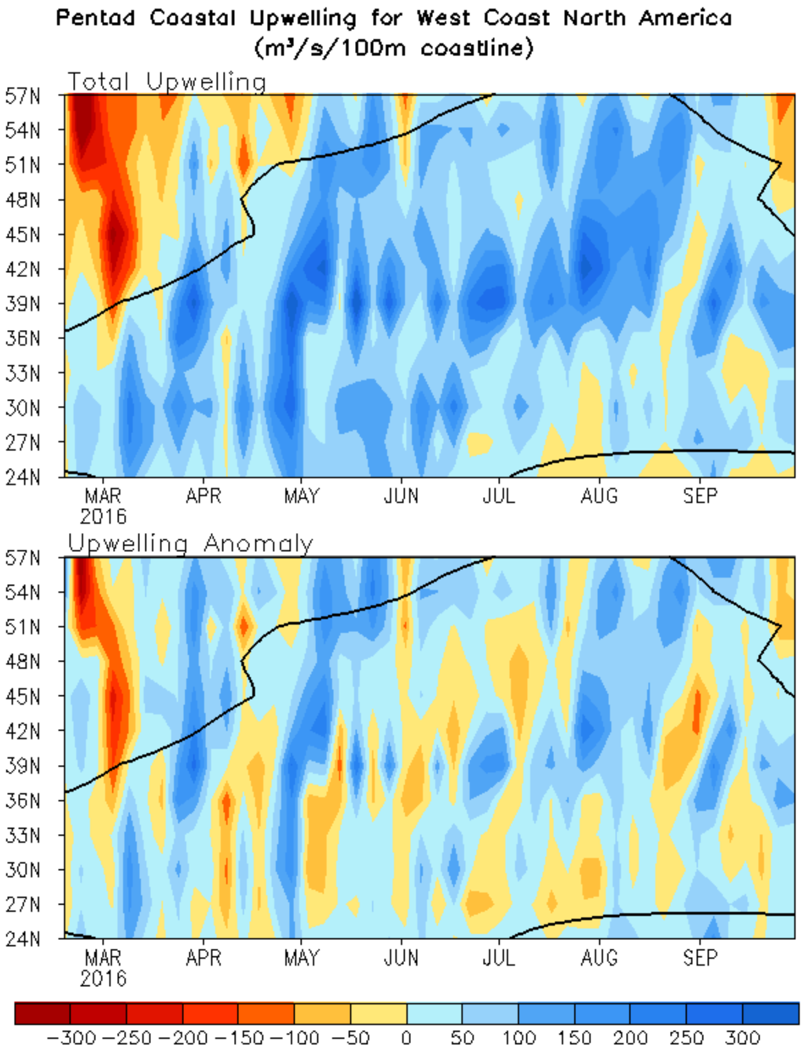
- **Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.**



- Equatorial Warm Water Volume (WWV) has started to recharge since May 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.

North America Western Coastal Upwelling



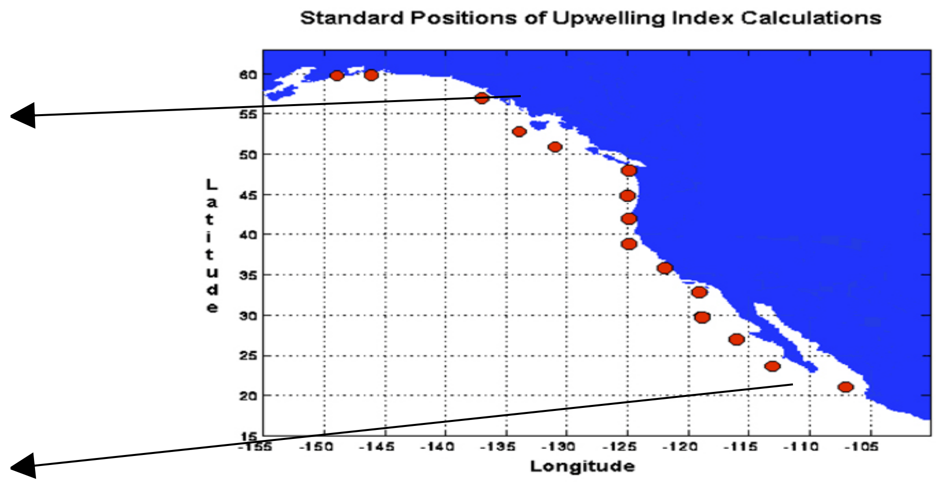


Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1981-2010 base period pentad means.

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

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

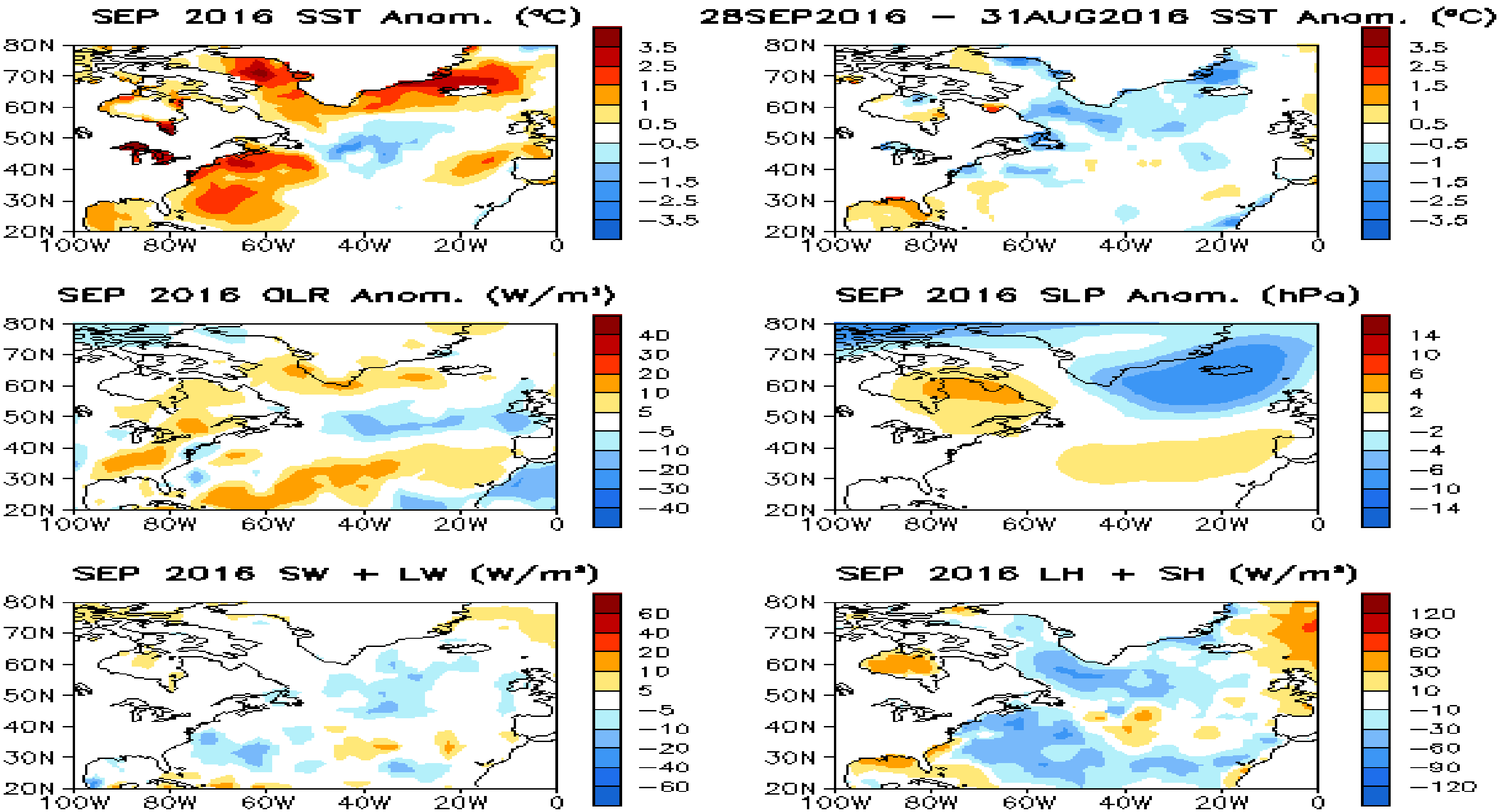
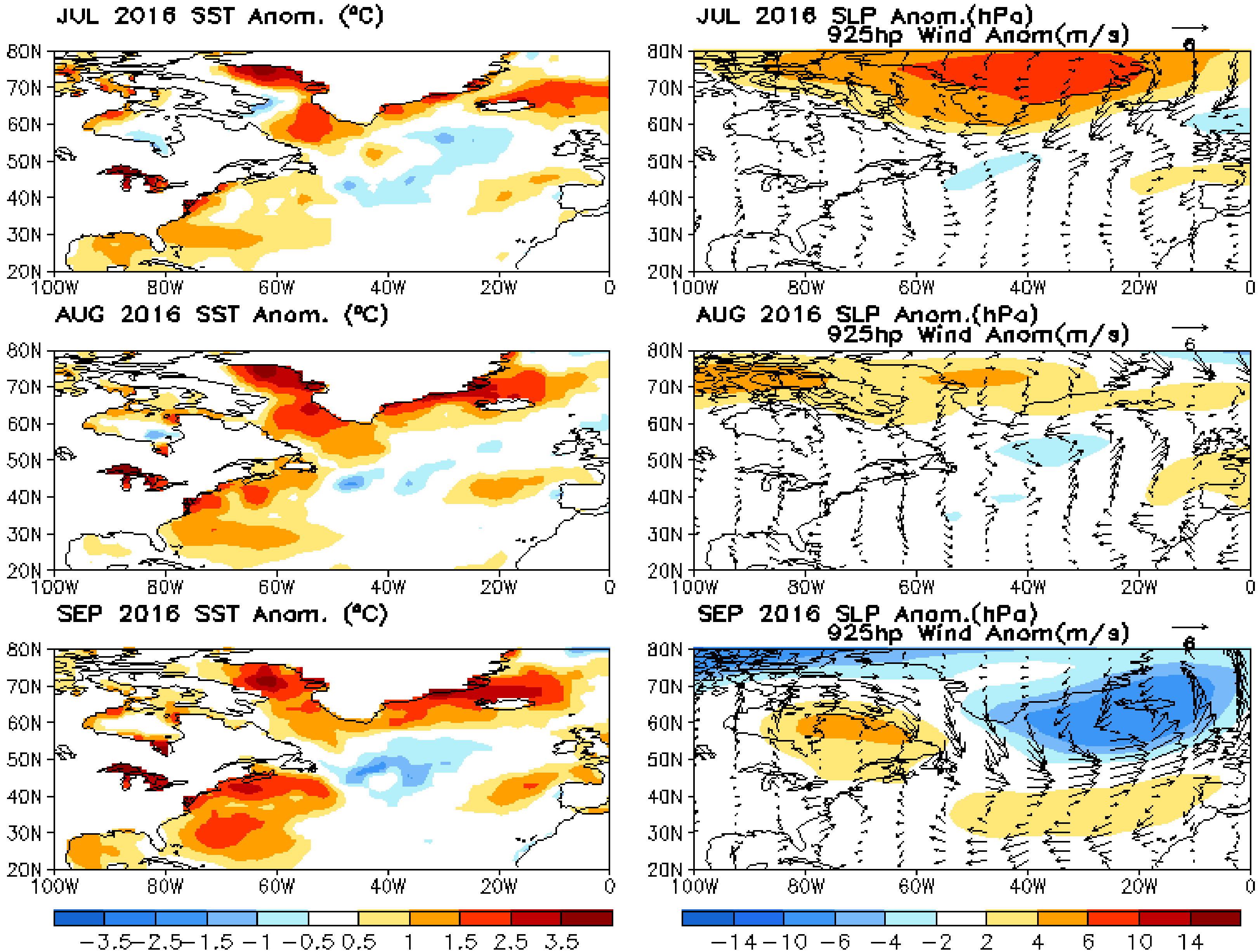


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

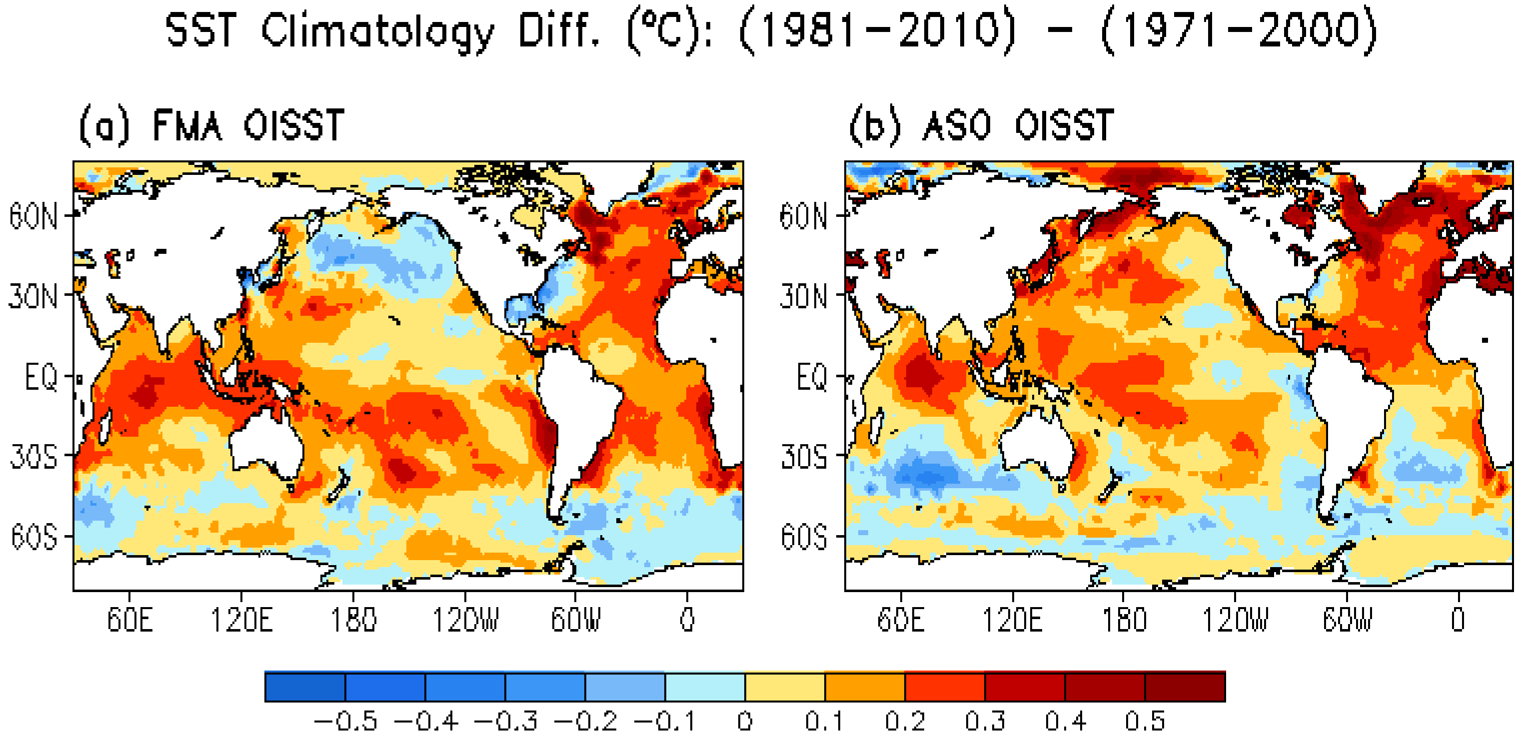
Last Three Month SST, SLP and 925hp Wind Anom.



Switch to 1981-2010 Climatology

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

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



1971-2000 SST Climatology (Xue et al. 2003): http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst_clim.htm

1981-2010 SST Climatology: http://origin.cpc.ncep.noaa.gov/products/people/yxue/sstclim/

- **The seasonal mean SST in February-April (FMA) increased by more than 0.2°C over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2°C in high-latitude N. Pacific, Gulf of Mexico and along the east coast of U.S.**
- **Compared to FMA, the seasonal mean SST in August-October (ASO) has a stronger warming in the tropical N. Atlantic, N. Pacific and Arctic Ocean, and a weaker cooling in Gulf of Mexico and along the east coast of U.S.**

Data Sources and References

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

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