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

Prepared by
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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**

    El Niño, NE tropical Pacific conditions, hurricane activities
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SST predictions**

  El Niño, Blob / PDO, tropical North Atlantic

Overview

- Pacific Ocean
  - El Niño conditions further strengthened in Nov 2015 and the atmospheric and oceanic anomalies reflect a strong El Niño.
  - Most models indicate that a strong El Niño will continue through the Northern Hemisphere winter 2015-16, followed by weakening and a transition to ENSO-neutral during the late spring or early summer.
  - The current conditions and recent evolution of the 2015 El Niño were compared with those of the 1982 and 1997 El Niño.
  - Upper ocean warming associated with the "Blob" has persisted since winter 2013/2014.
- Indian Ocean
  - Positive SSTA dominated most of the tropical Indian Ocean.
  - Positive India Dipole Mode index persisted.
- Atlantic Ocean
  - Positive NAO strengthened with NAO=+1.7.
  - SSTA were well above-average along the eastern coast of North America.

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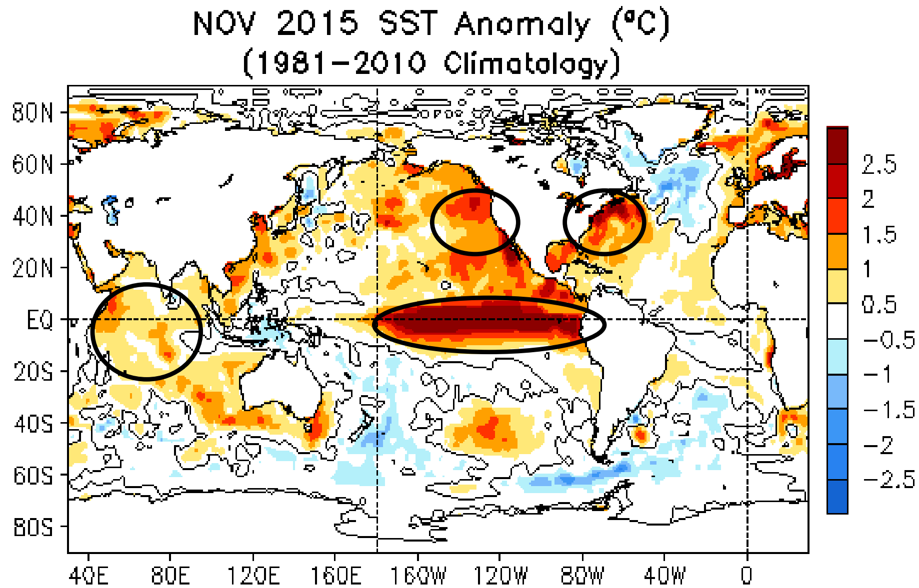
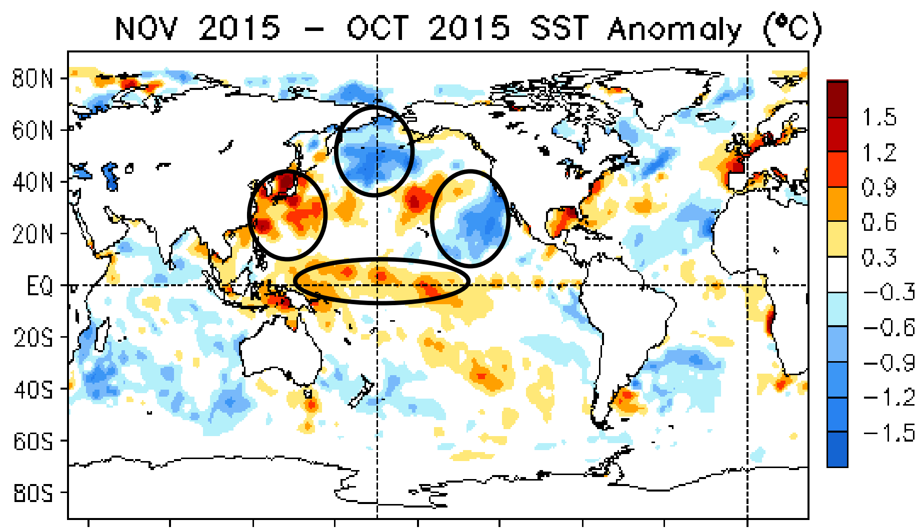
Global Oceans

Global SST Anomaly (^0C) and Anomaly Tendency

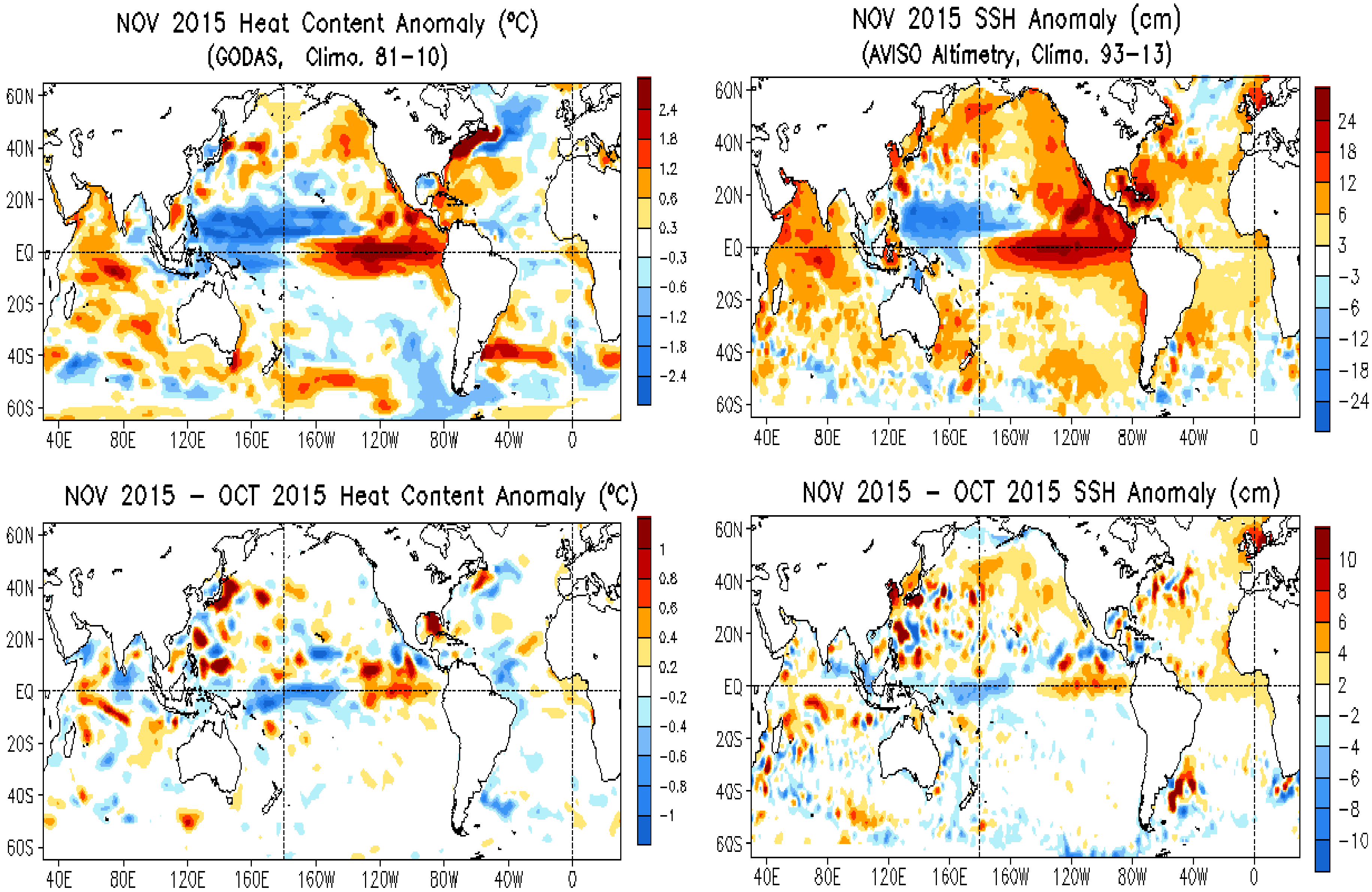


- SSTA exceeded +2.5°C across the central-eastern equatorial Pacific.
- Positive SSTA presented near the western and eastern coasts of North America.
- Positive SSTA continued in the tropical Indian Ocean.



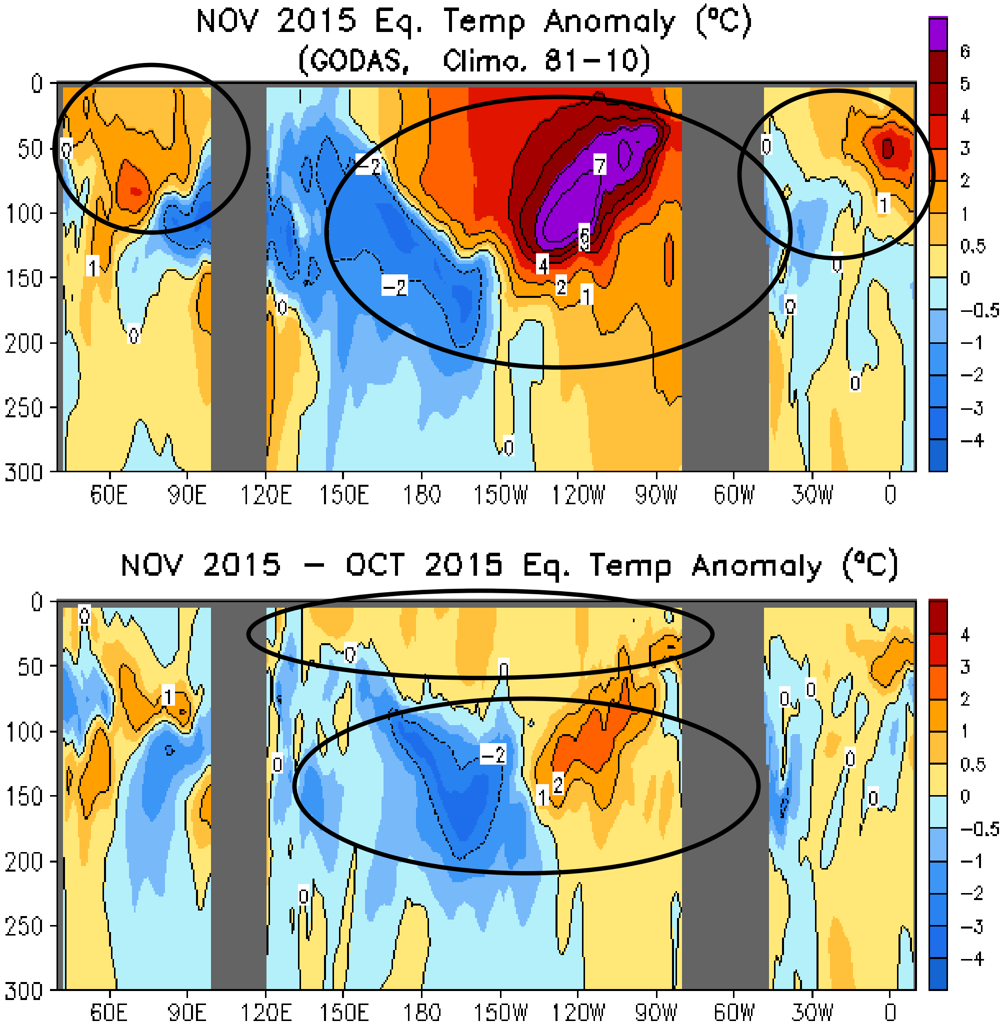
- Positive SSTA tendency was observed in the western-central equatorial Pacific and south of Japan.
- Negative SSTA tendency presented in the northeast subtropical Pacific and south of Bering Strait.

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.



- **Patterns of upper 300m ocean heat content and SSH anomaly and their tendency were largely consistent.**

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



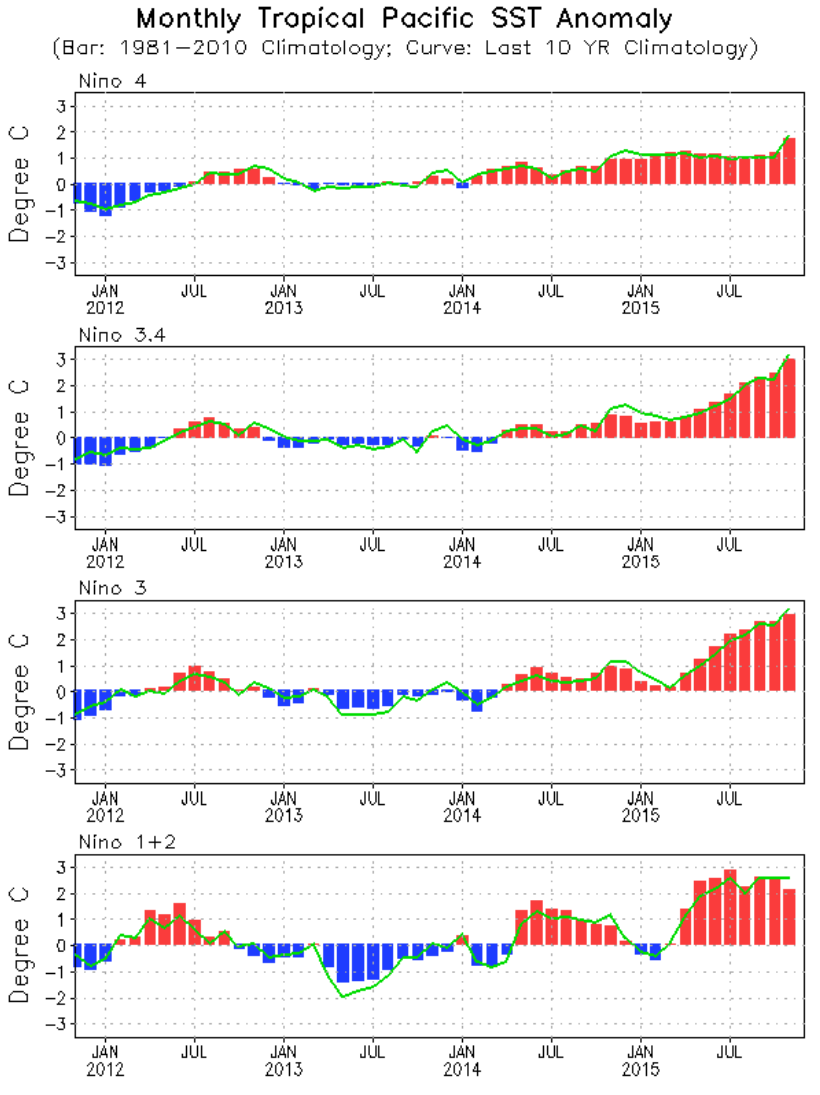
- Positive (negative) temperature anomalies presented in the central-eastern (western) equatorial Pacific.
- Positive temperature anomalies dominated in the upper equatorial Indian Ocean except at 100m depth in the far eastern Indian Ocean.
- Positive temperature anomalies dominated in the upper equatorial Atlantic Ocean.

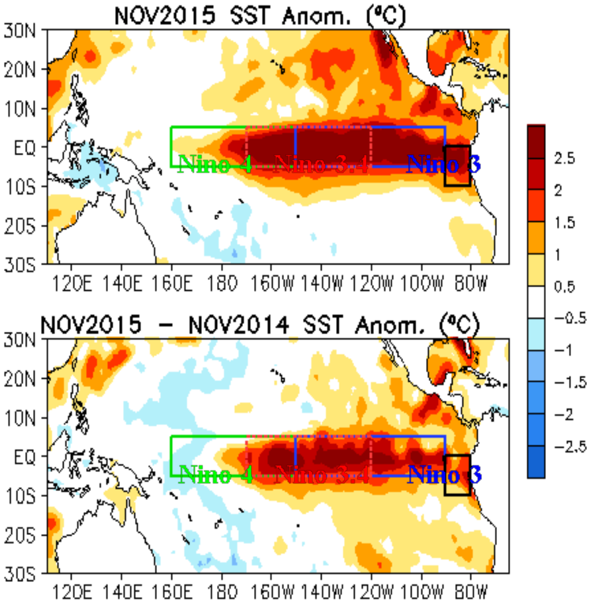
- Anomaly tendency was positive in the upper 50m of the equatorial Pacific.
- The dipole pattern of anomaly tendency near the thermocline was associated with eastward propagation of upwelling oceanic Kelvin wave.

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

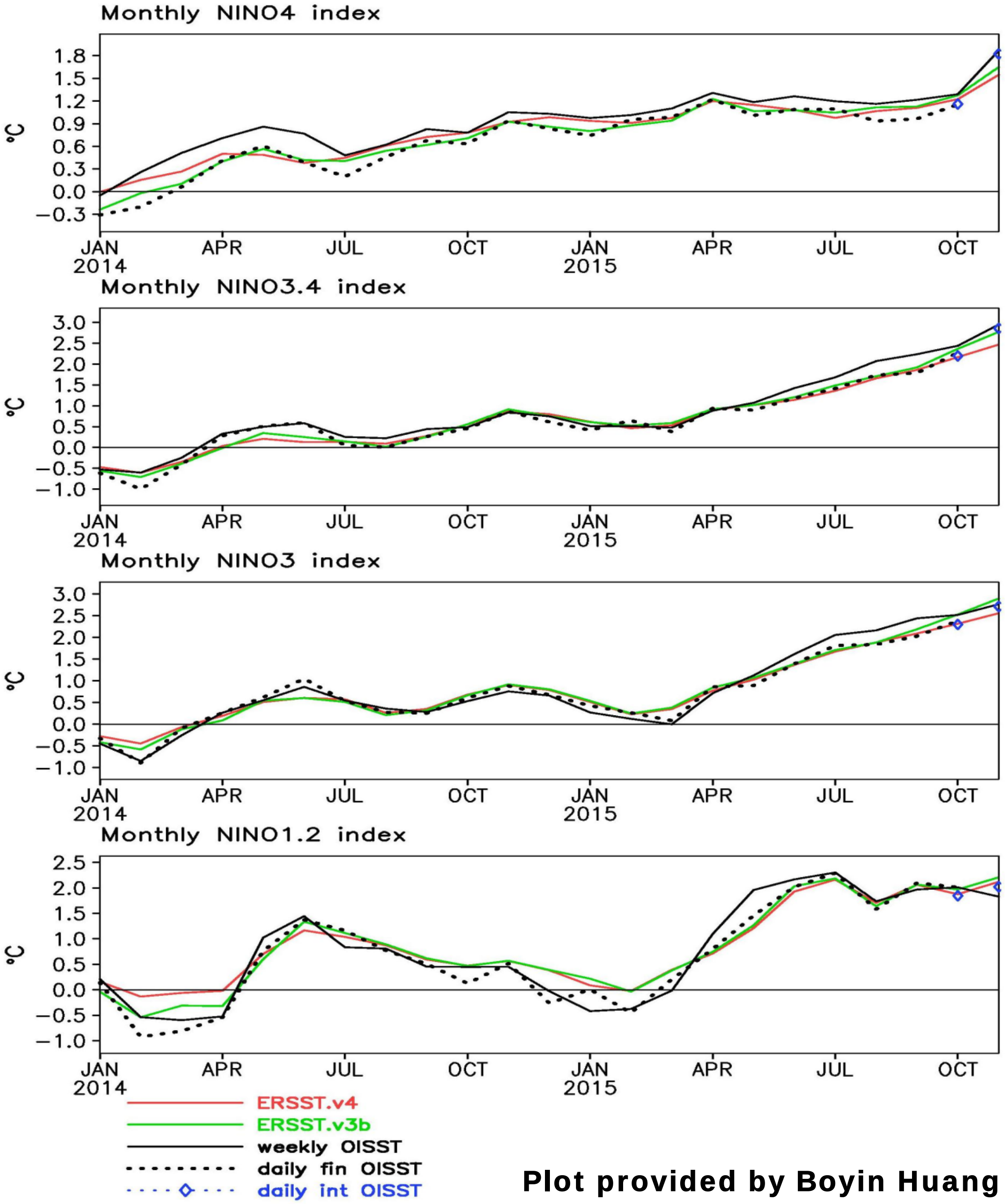
Evolution of Pacific NINO SST Indices





- **All NINO indices except NINO 1+2 increased in Nov 2015.**
- **Nino3.4 = +2.96°C in Nov 2015, which is based on weekly OI SST.**

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.

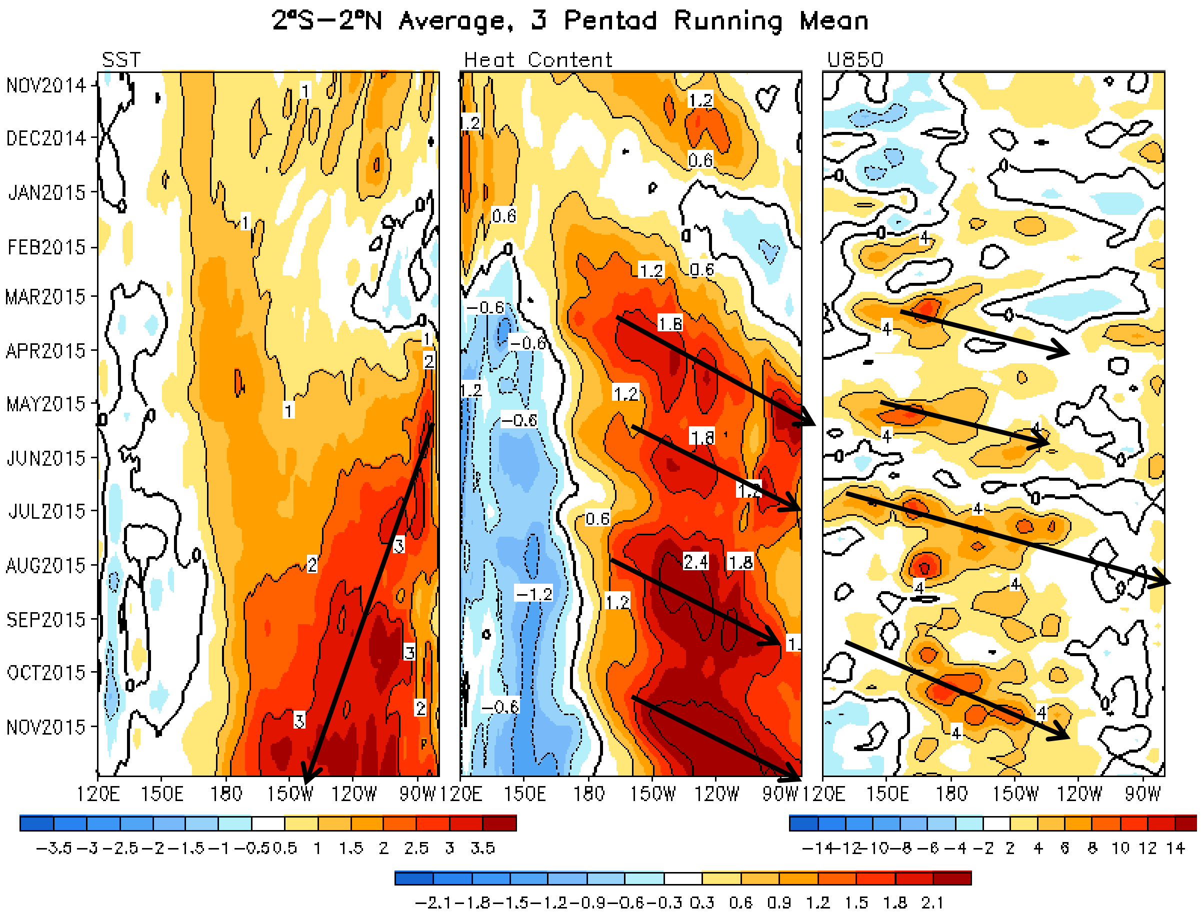


Plot provided by Boyin Huang

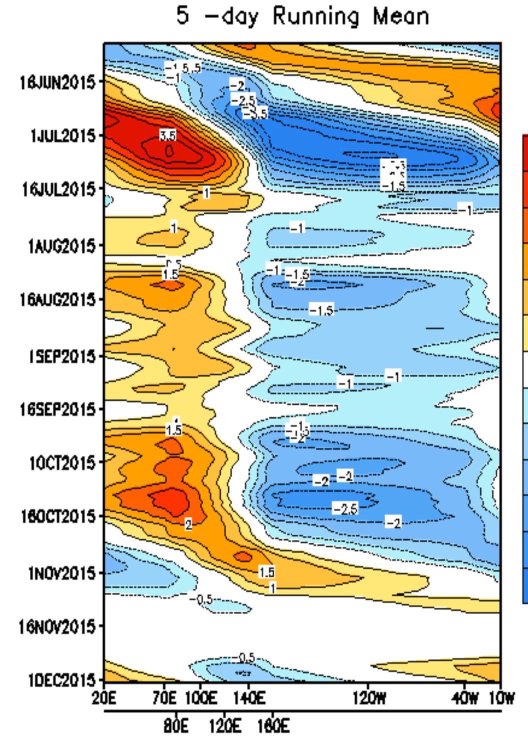
- NINO3.4 based on weekly OI SST (black line) is a few tenth degree higher than that based on ERSST.v4 (red line) in recent months.

- Note that the definition of ENSO events at NOAA (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml) is based on ERSST.v4.

Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) and OLR(W/m²) Anomalies



CPC MJO Indices



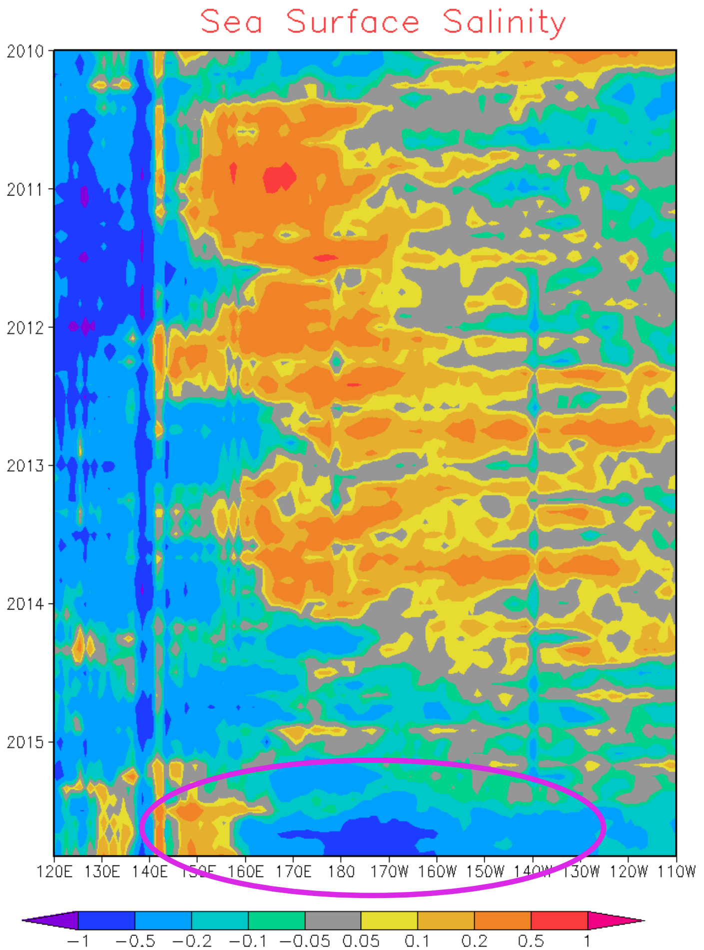
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

- Heat content anomaly was dominated by intraseasonal variability associated with four downwelling oceanic Kelvin wave episodes that were forced by four westerly wind burst events in Mar, May, Jul and Oct. The low frequency component of heat content anomaly was largely stationary.
- However, SST anomaly was dominated by westward propagation since Apr 2015.
- Easterly wind anomaly in W. Pac. persisted, while westerly wind anomaly in C.-E. Pac. weakened in Nov 2015.

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.

Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

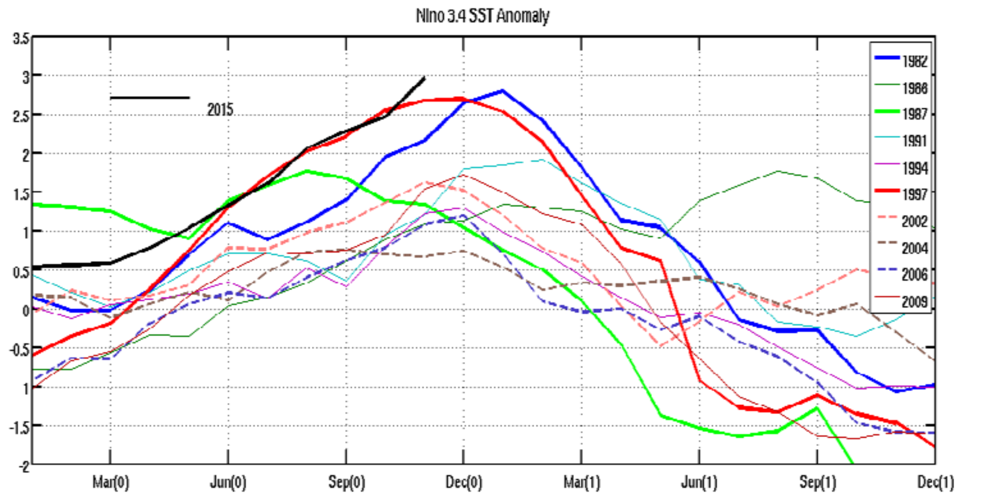
- Hovemoller diagram for equatorial SSS anomaly **(10ºS-10ºN);**
- Negative SSS anomaly strengthened over the central and eastern Pacific, with the maximum SSS anomaly located around 170ºW. At the meantime, a stretch of positive SSS anomaly continued over the western Pacific from 130ºE – 160ºE;



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

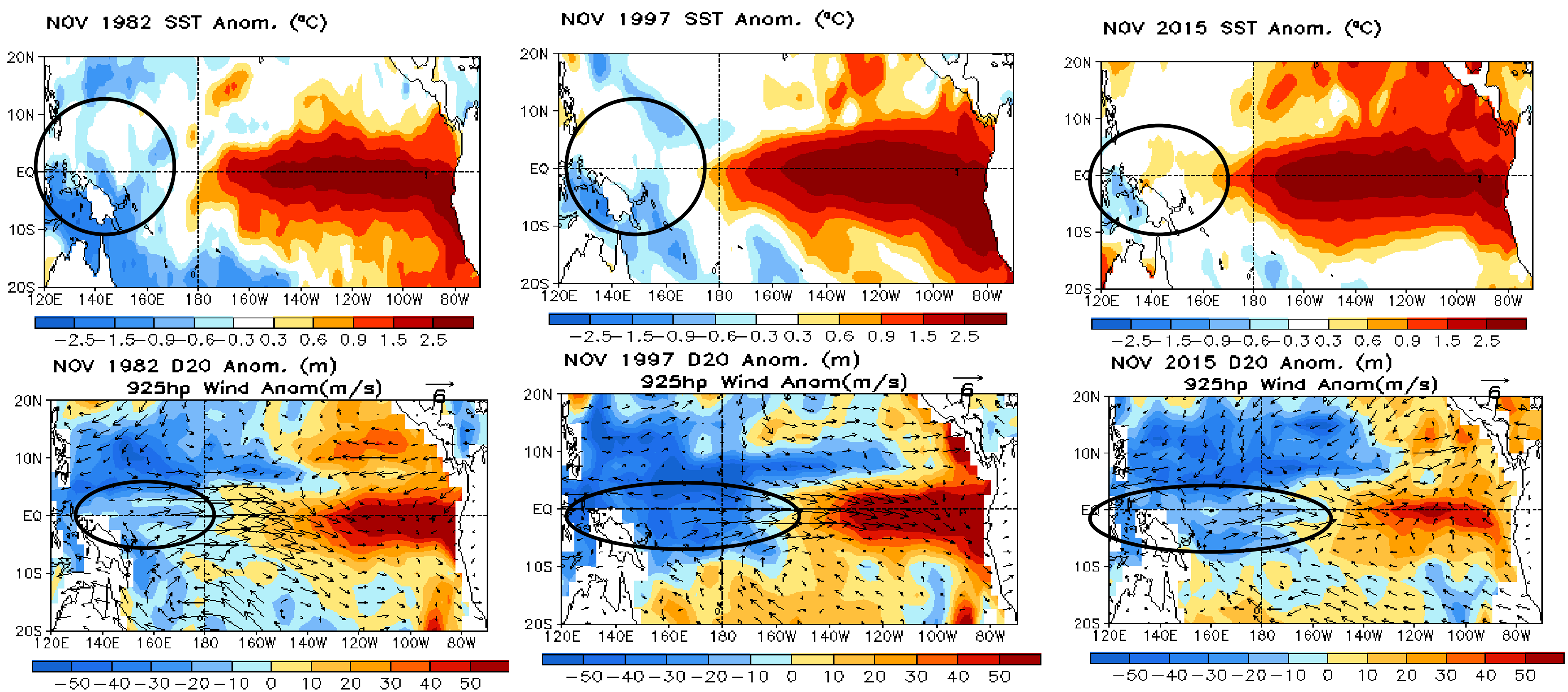
SST, D20 and 925hPa Wind Anomalies in November



1982

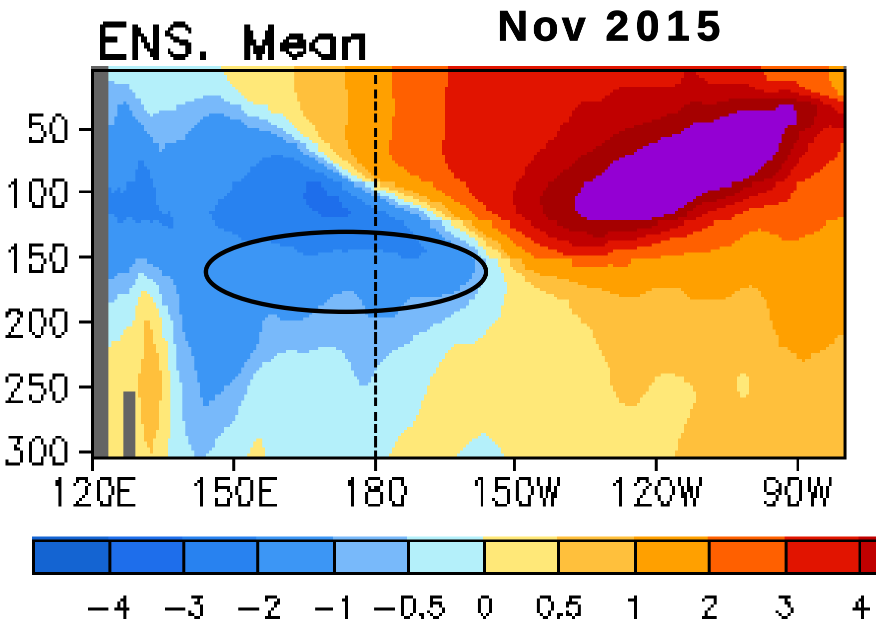
1997

2015

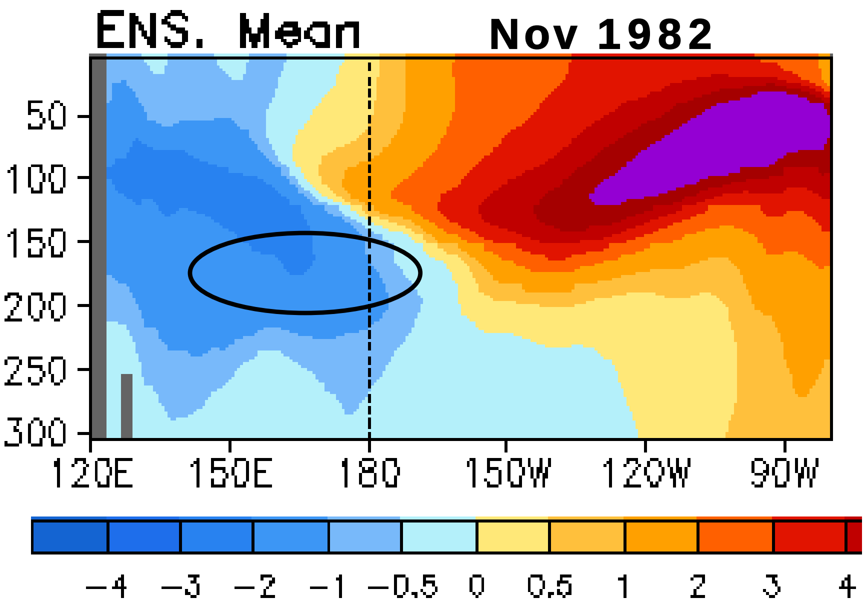


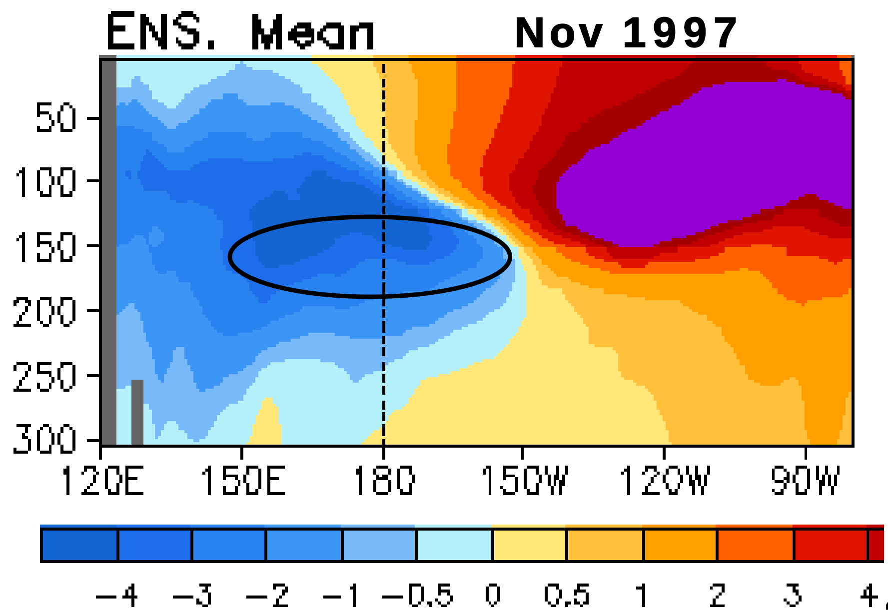
Real-time Ocean Reanalysis Intercomparison Project

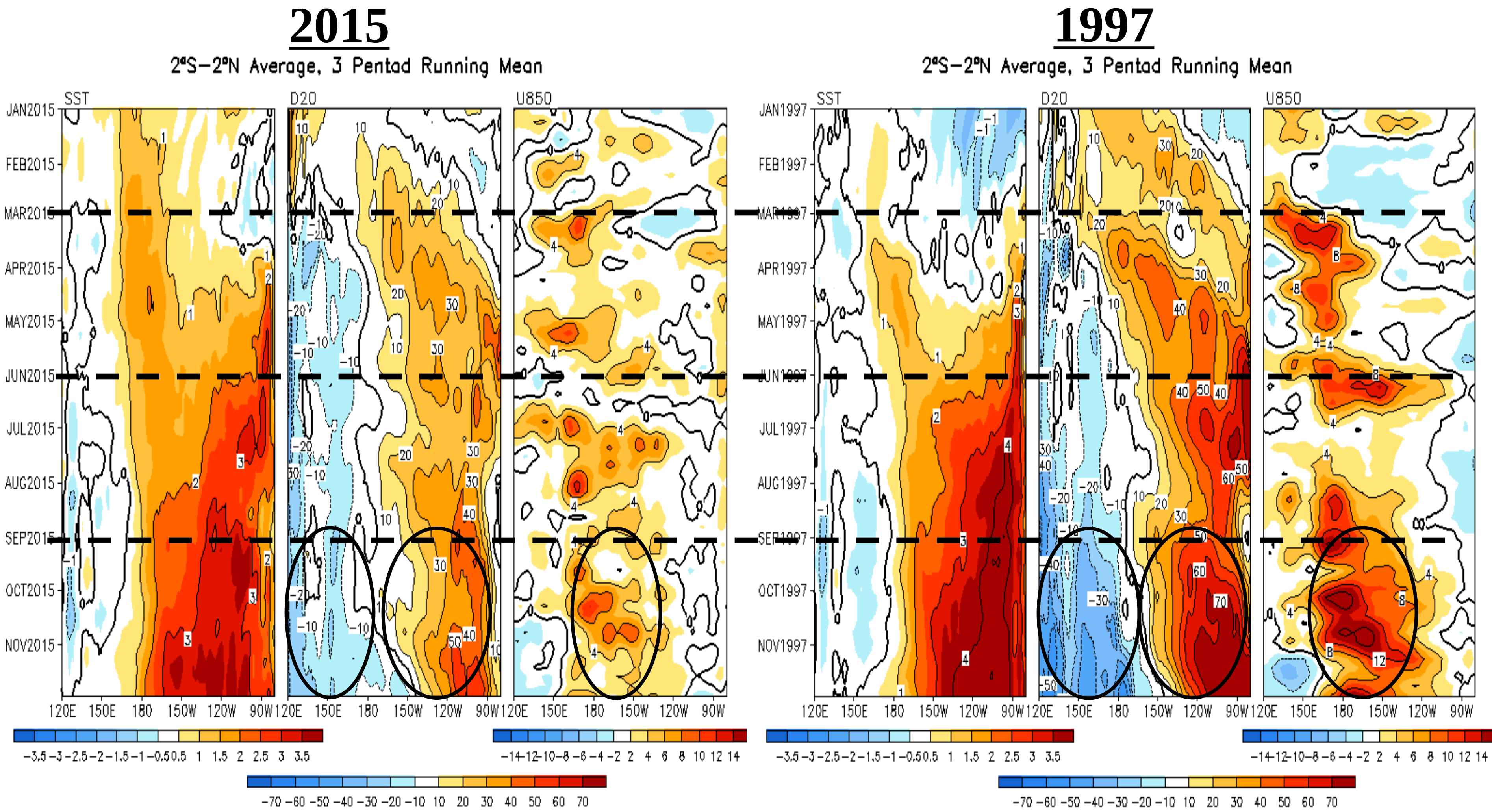
(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html)



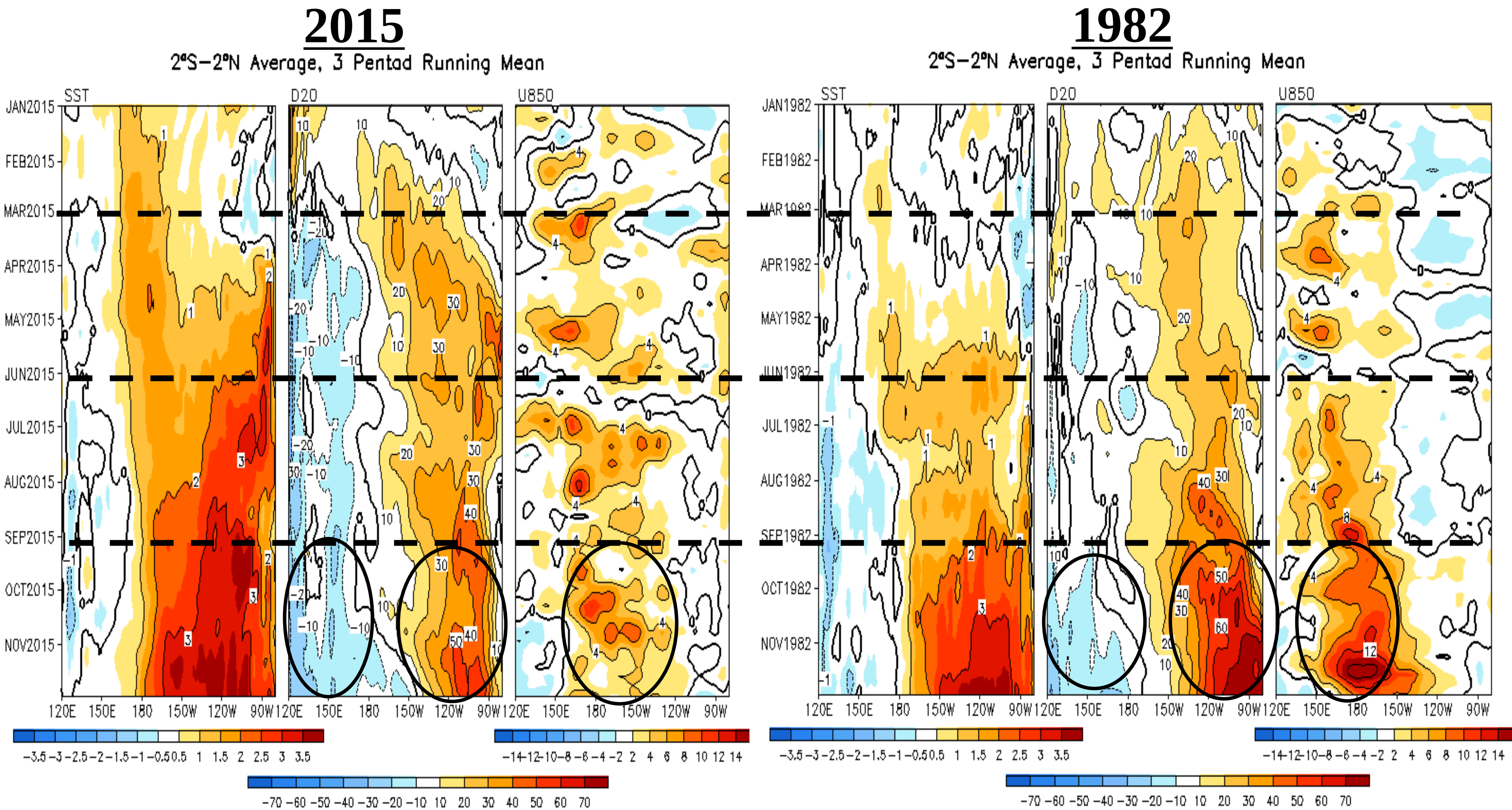
- The subsurface temperature anomaly averaged in 1ºS-1ºN in Nov 2015 was weaker than that in Nov 1997, but comparable to that in Nov 1982.



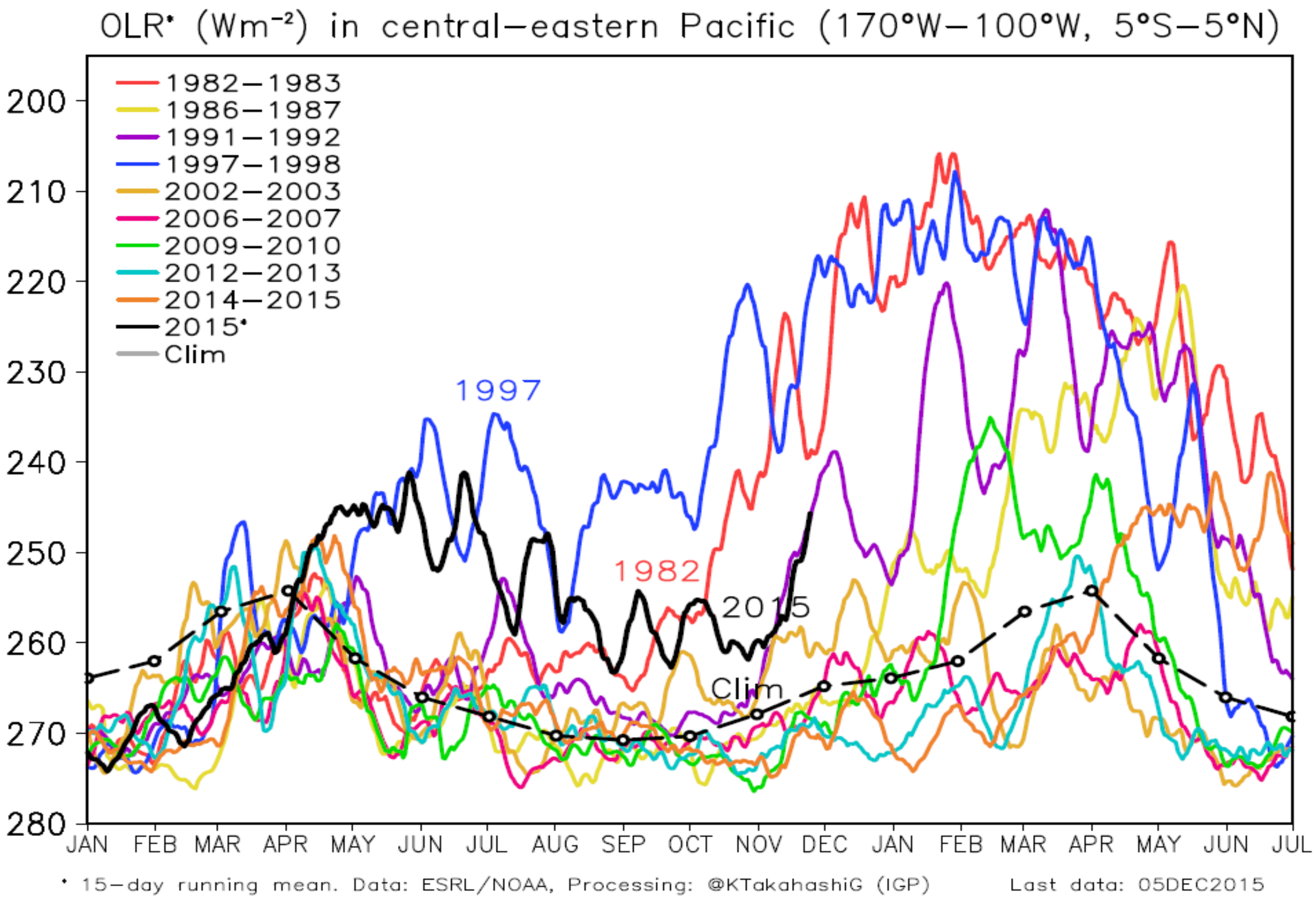




- **Compared to 1997, westerly wind anomalies in 2015 were much weaker.**
- **Consistent with weaker westerly wind anomalies, the 20ºC depth anomaly dipole, positive in the east and negative in the west, was much weaker.**



- The SST and 20ºC depth anomalies were stronger in 2015 than those in 1982 before September.
- However, associated with strong westerly wind anomalies since September 1982, the amplitude of 20ºC depth anomaly grew rapidly and became stronger than that in 2015 since then.

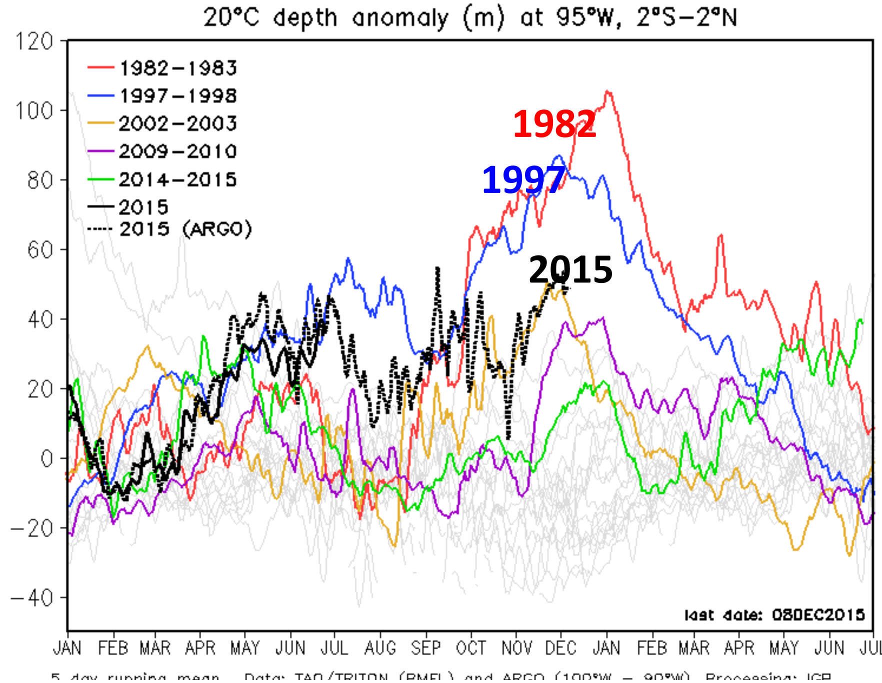


Plot provided by Ken Takahashi

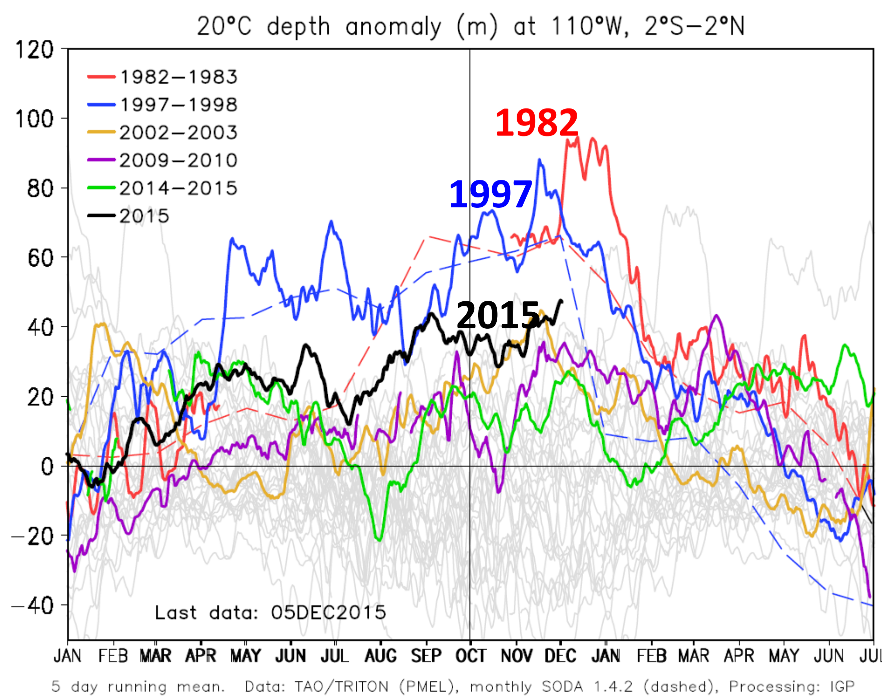
- **Enhanced convection (OLR is below climatology) in the central-eastern Pacific (170W-100W, 5S-5N) in spring/early summer 2015 was comparable to that in 1997, but it has weakened gradually since Jun 2015.**
- **Convection rebounded substantially in Nov 2015, but it was still weaker than that in 1982 and 1997 -→ possibly different impacts on teleconnection (Chiodi and Harrison 2013)?**

Eastern Pacific 20°C depth anomaly (m)

95°W, 2°S-2°N (TAO mooring and Argo data)



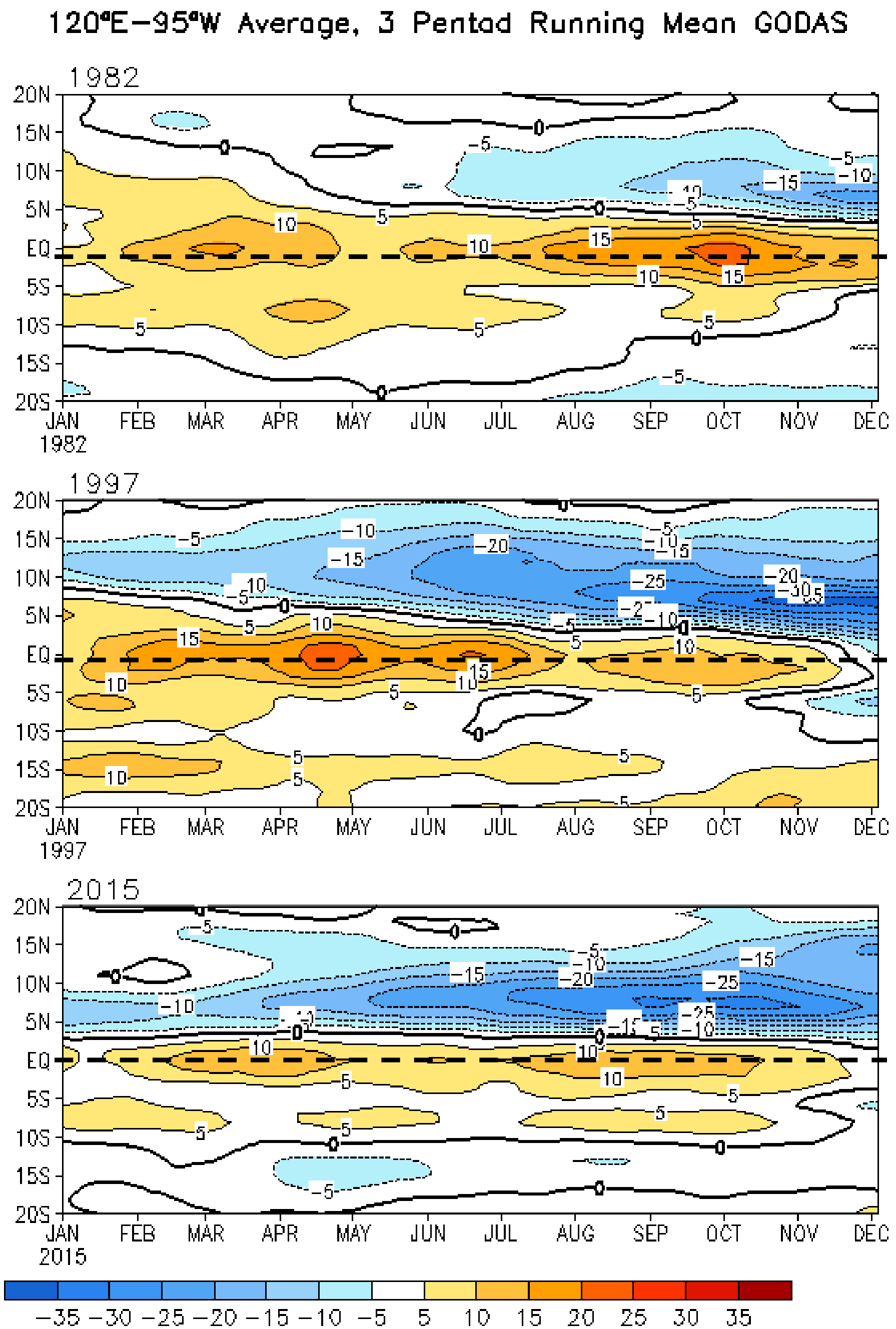
110°W, 2°S-2°N (TAO mooring and SODA 1.4.2 data)



(SODA is dashed)

In the eastern Pacific, the thermocline depth anomaly was between a third to a half of what it was in 1982 and 1997.

Plots provided by Ken Takahashi



Zonal Average of 20°C Depth anomaly

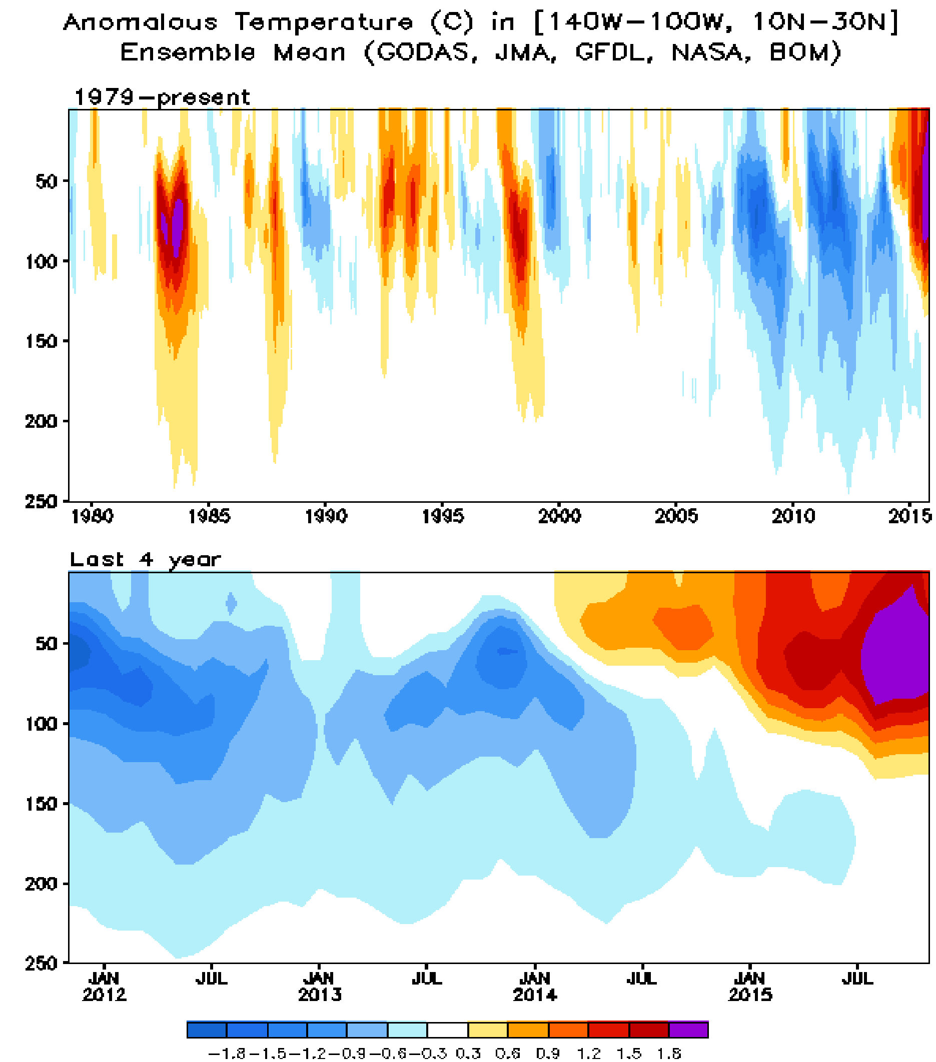
- There was warm (cold) water built up in 3S-3N (5N-10N) in spring 2015, which was similar to that in spring 1997 except the anomalies were weaker and more confined near the equator.

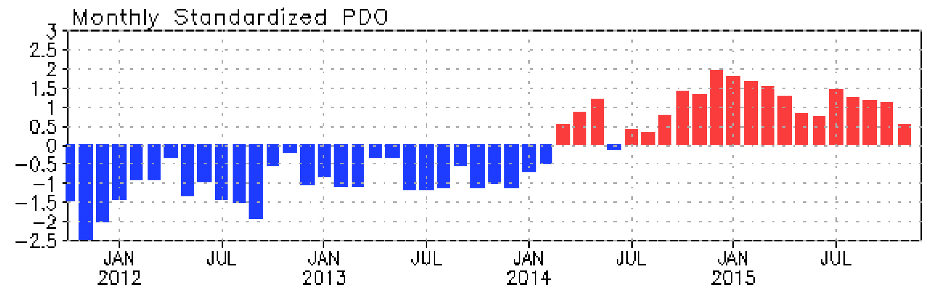
- For both the 1997 and 2015 El Nino, there was rapid enhancement of the cold anomaly around 5N-15N in spring and summer.

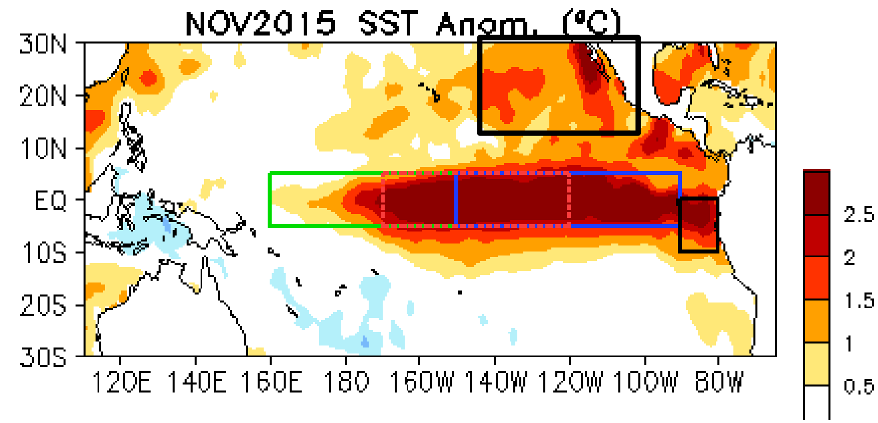
- For the 2015 El Nino, both the cold and warm anomaly weakened rapidly in Oct-Nov 2015.

- It is interesting that the timing of the discharge of warm water near the equator (from positive to near zero) was similar to that in 1997.

Strong Warming in NE Pacific







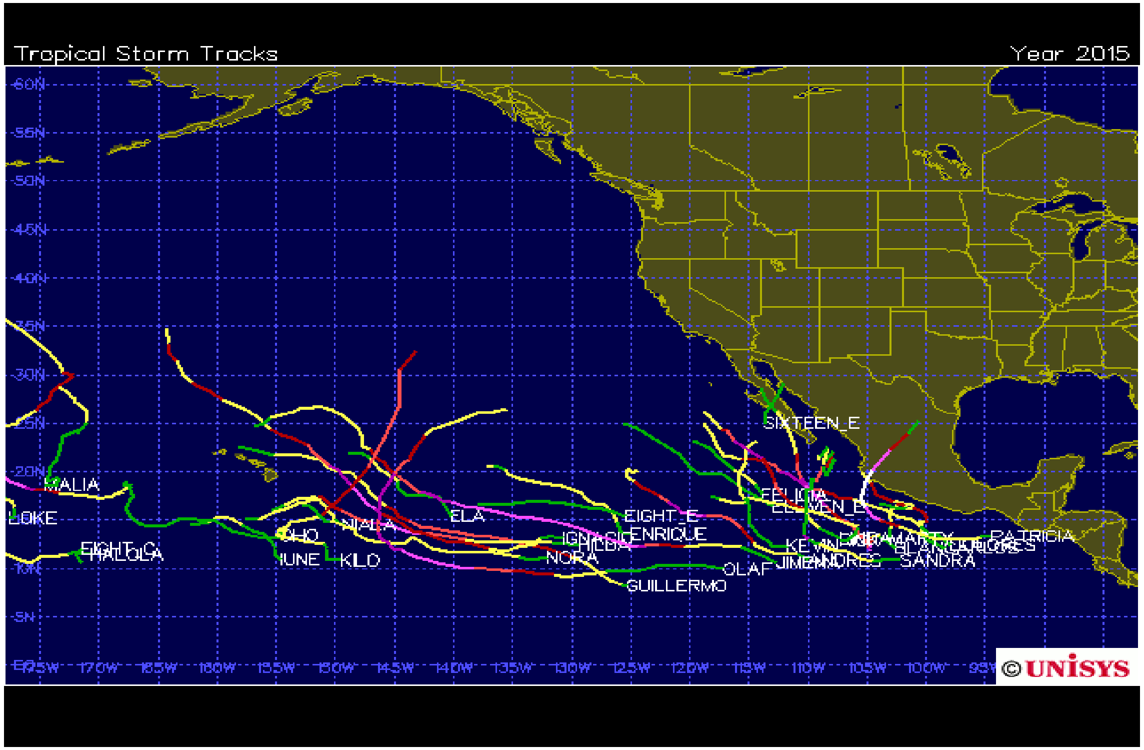
- The strong positive SSTA in the NE tropical Pacific [140°W-100°W, 10°N-30°N] emerged in early 2014, and the warming enhanced and migrated to the depth since then.

- The development of positive SSTA in the region coincided with the switch to positive PDO phase.

- Positive SSTA weakened near the surface, but persisted in the subsurface in Nov 2015.

2015 E. Pacific Hurricane Counts

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



- **E. Pacific Outlook (70% above-normal)**:

15-22 Named Storms (15 average)

7-12 Hurricanes (8 average)

5-8 Major Hurricanes (4 average)

110%-190% ACE

- **E. Pacific Counts by Dec 7**:

26 Named Storms > outlook

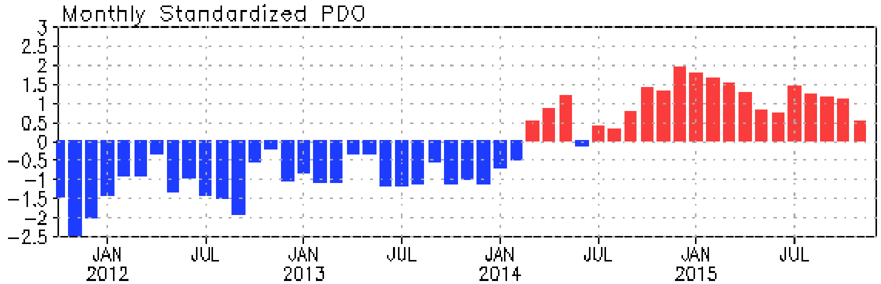
16 Hurricanes > outlook

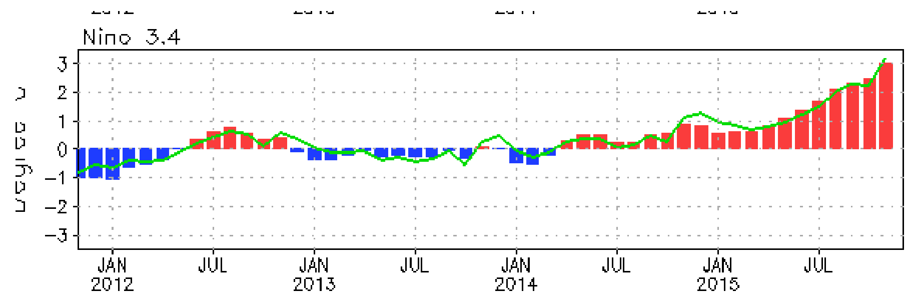
11 Major Hurricanes > outlook

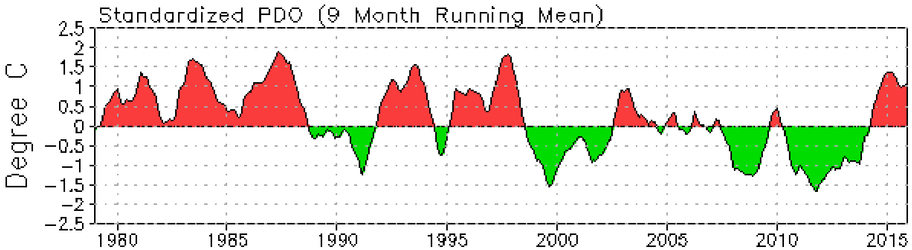
2015 is the second most active Pacific hurricane season on record (behind 1992)

North Pacific & Arctic Oceans

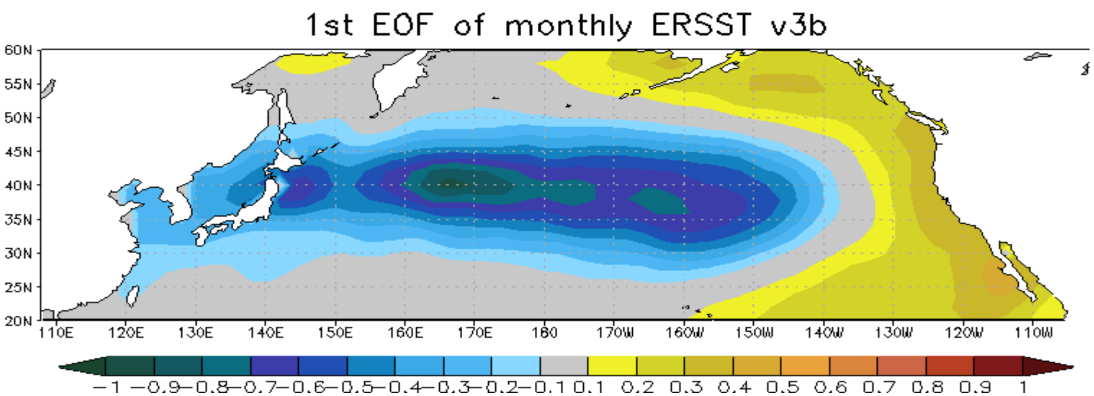
Pacific Decadal Oscillation Index





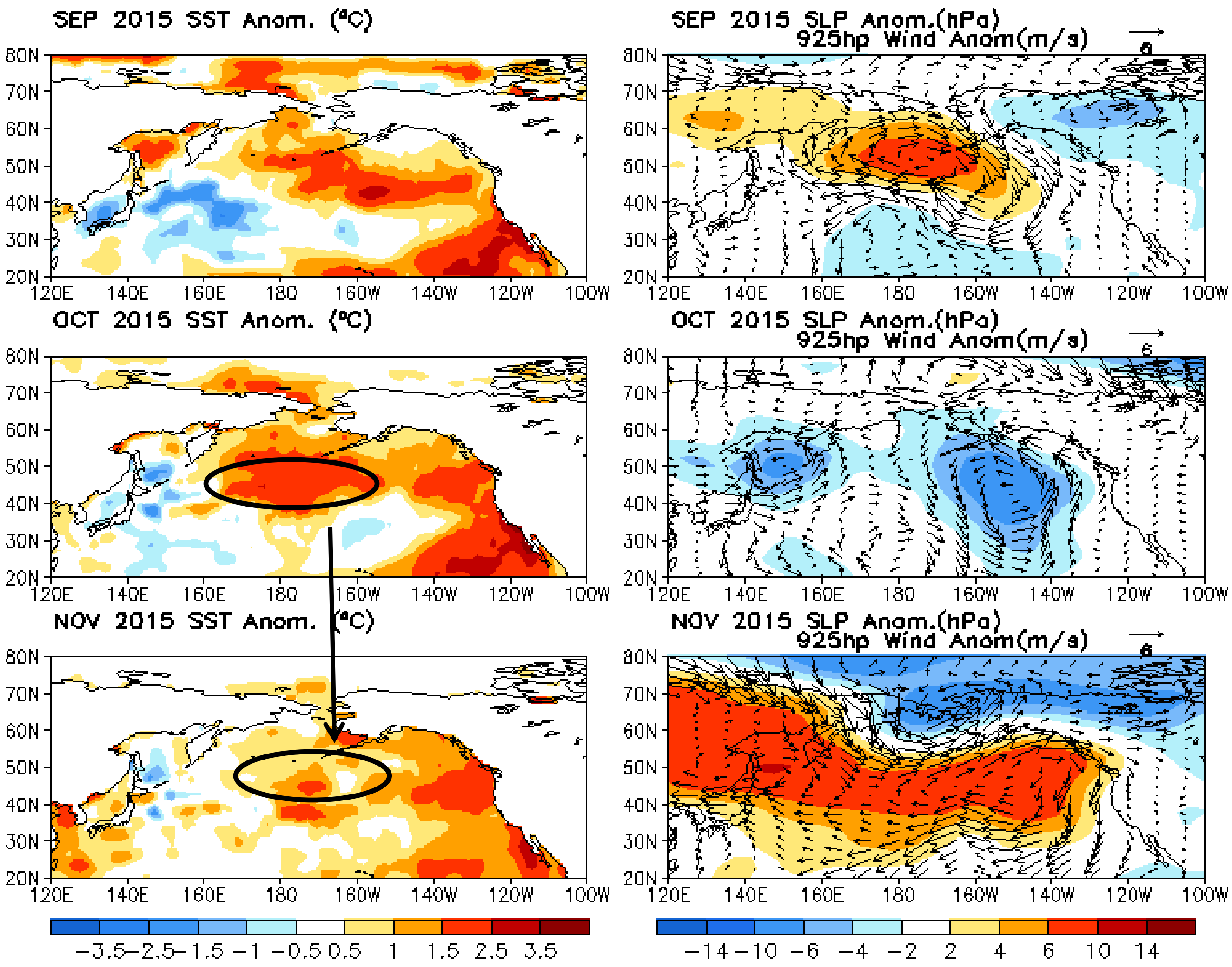


- **Positive PDO has persisted for 17 months since July 2014 and PDO weakened with PDO=+0.5 in Nov 2015.**



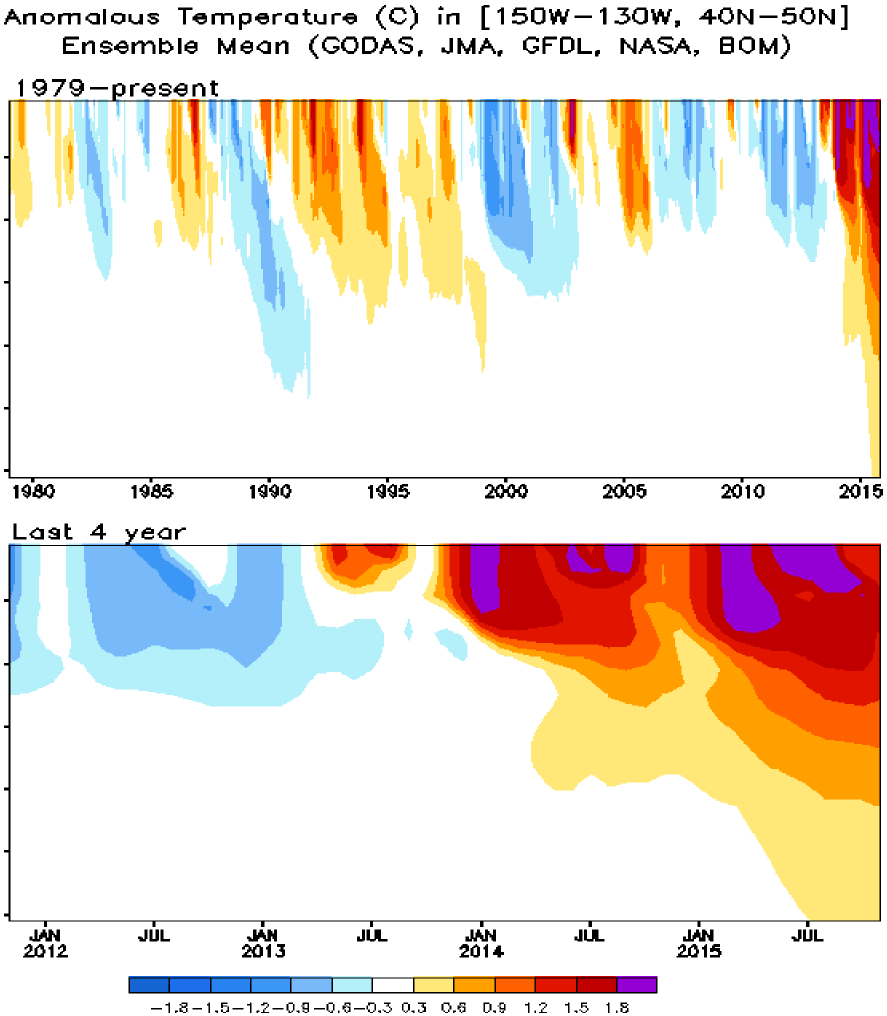
- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**
- **The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.**

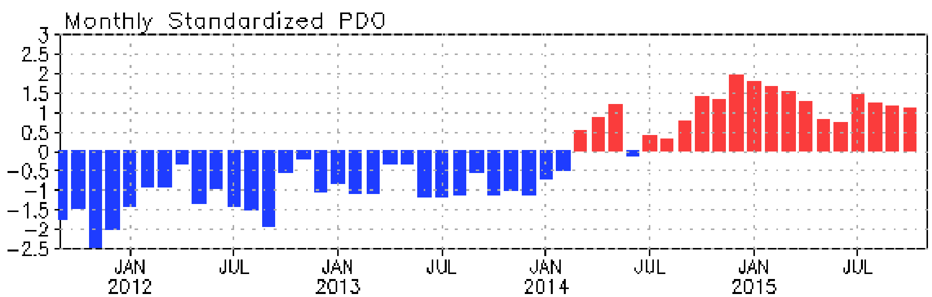
Last Three Month SST, SLP and 925hp Wind Anom.



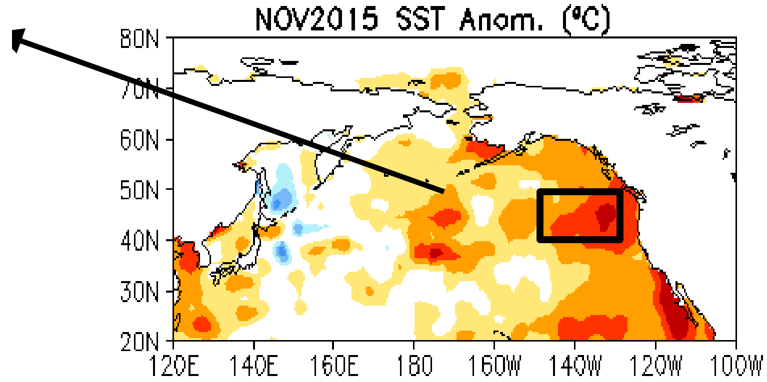
- **Positive SSTA in the central N. Pacific dissipated, contributing to weakening of positive PDO-like pattern.**

- **Anomalous anticyclone was observed near the coast of Alaska and Pacific Northwest.**





"Blob" in North Pacific

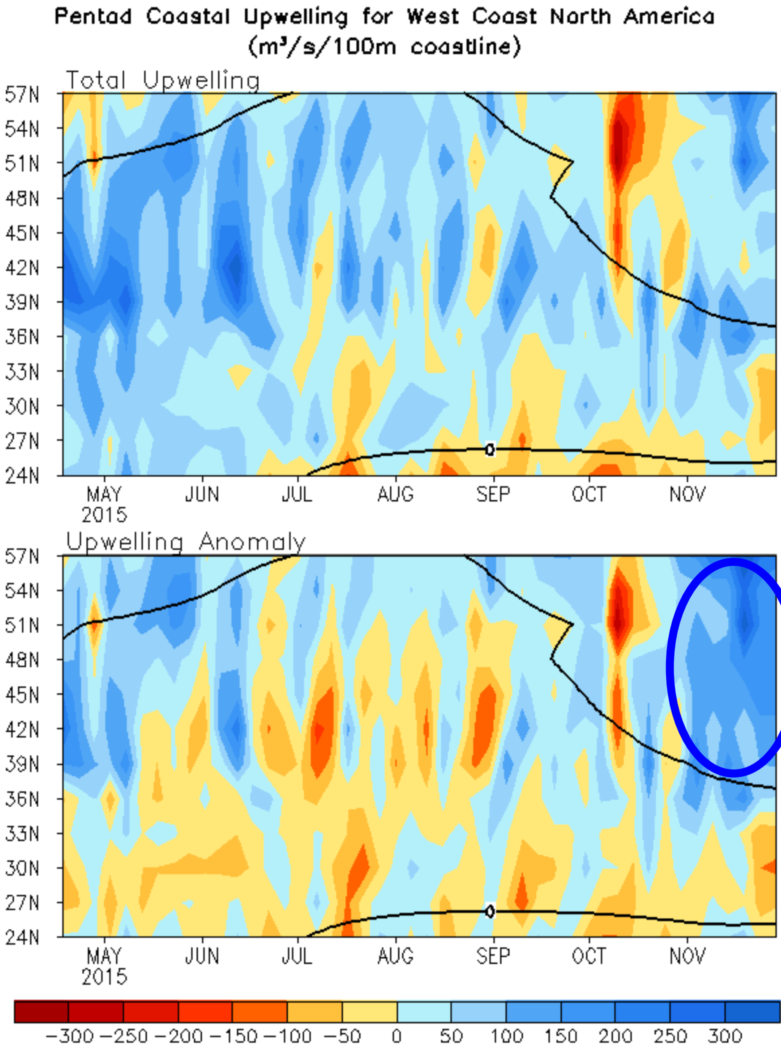


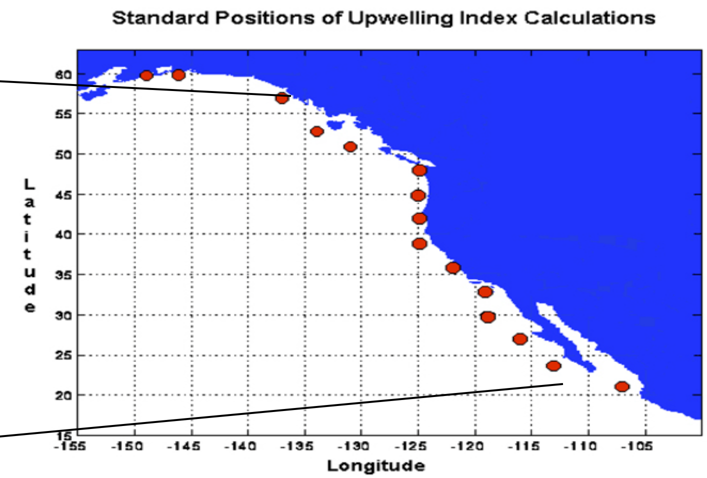
- **Record SST warming appeared near the west coast of North America in late 2013, referred to as "Blob" by Bond et al. (2015).**

- **The warming in the NE Pacific box [150°W-130°W, 40°N-50°N] started near the surface in late 2013 and has persisted and extended to depth since then.**

- **The development of the enhanced warming in late 2013 seems associated with the switch to positive PDO phase.**

North America Western Coastal Upwelling





- Consistent with anomalous anticyclone, anomalous upwelling was observed north of 36N.

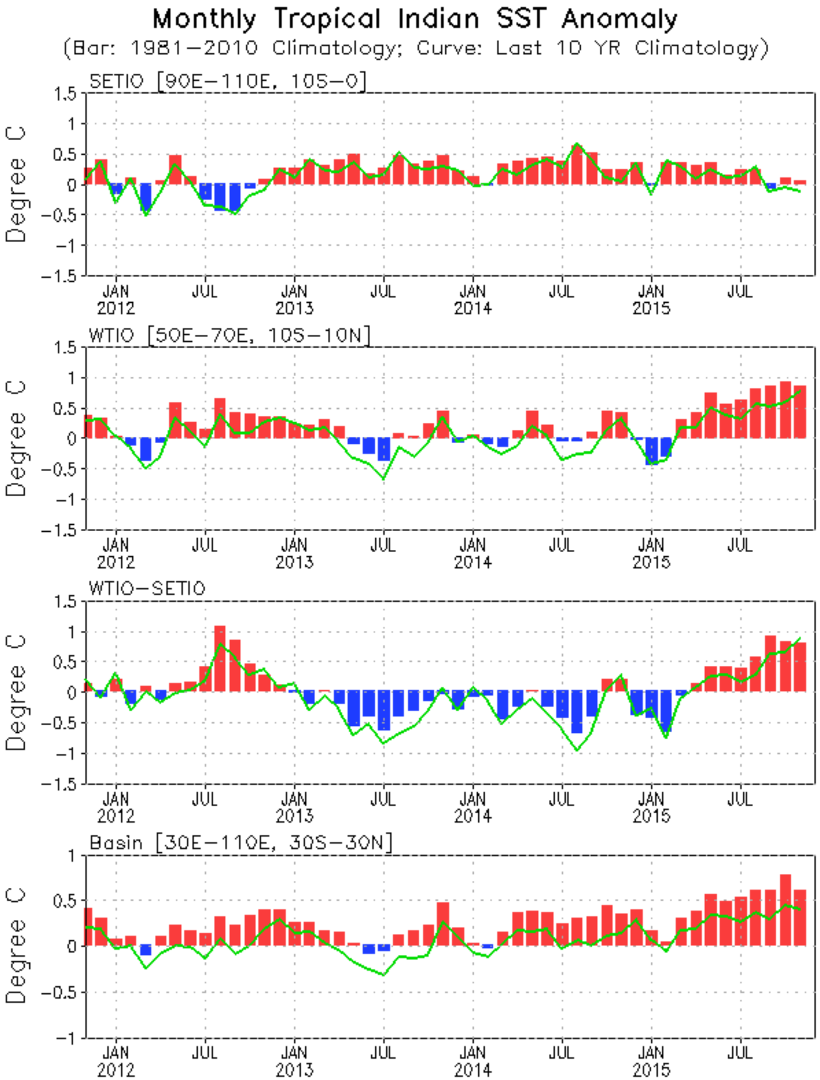
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

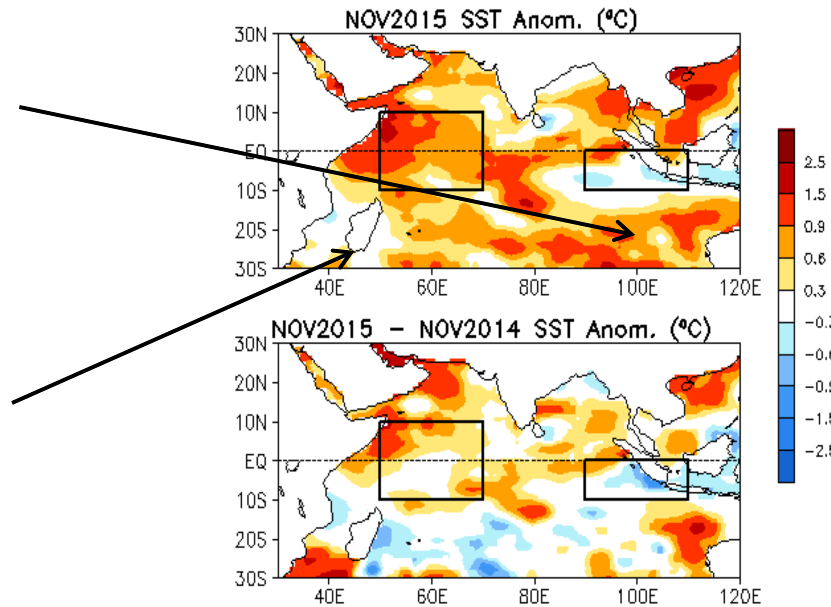
- Area below (above) black line indicates climatological upwelling (downwelling) season.

- Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.

Indian Ocean

Evolution of Indian Ocean SST Indices



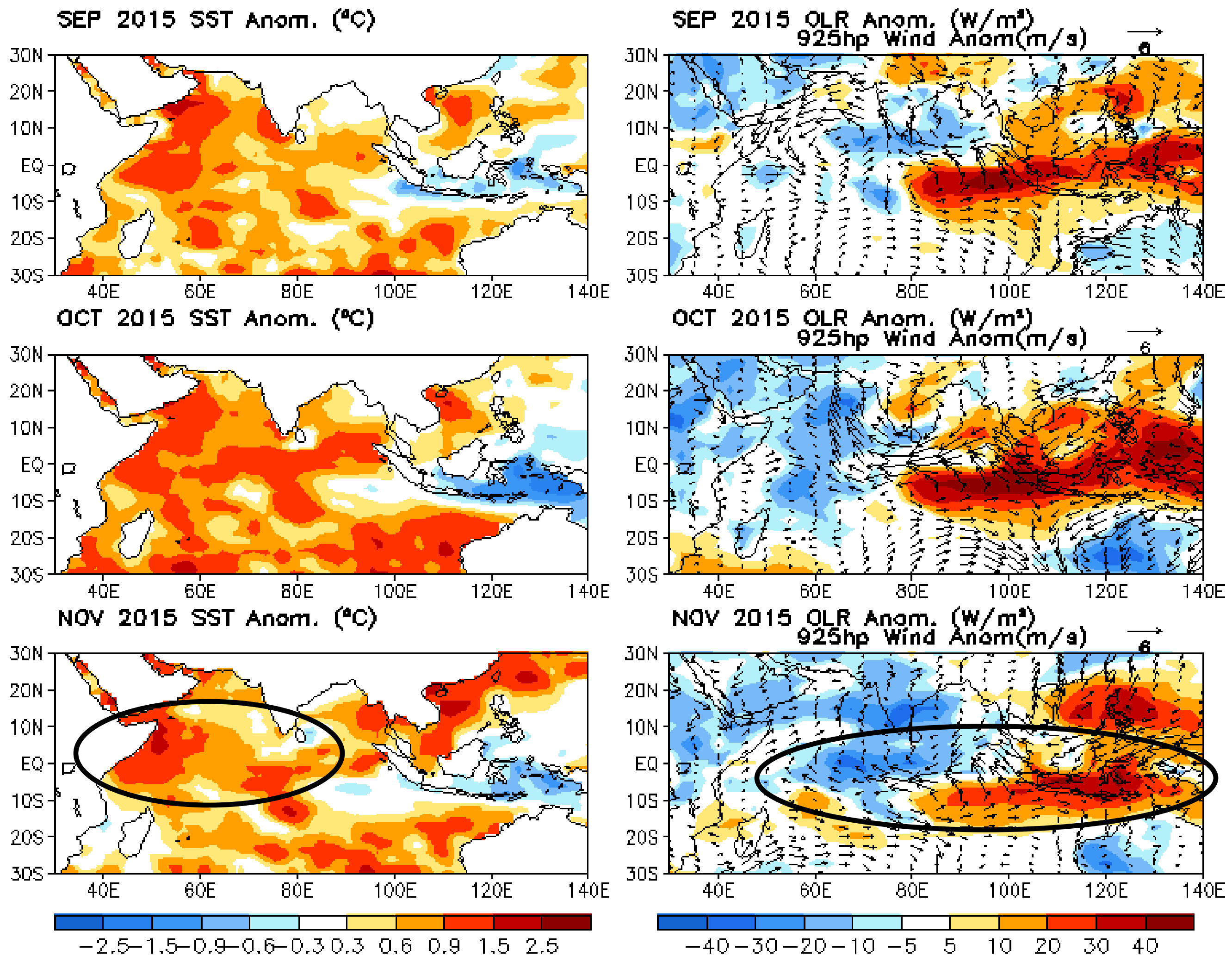


- The western tropical Indian Ocean (WTIO) warming persisted, and the Dipole Mode Index (WTIO-SETIO) has been above 0.5C in the past four months.

- The warming in the basin average SSTA continued.

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.

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

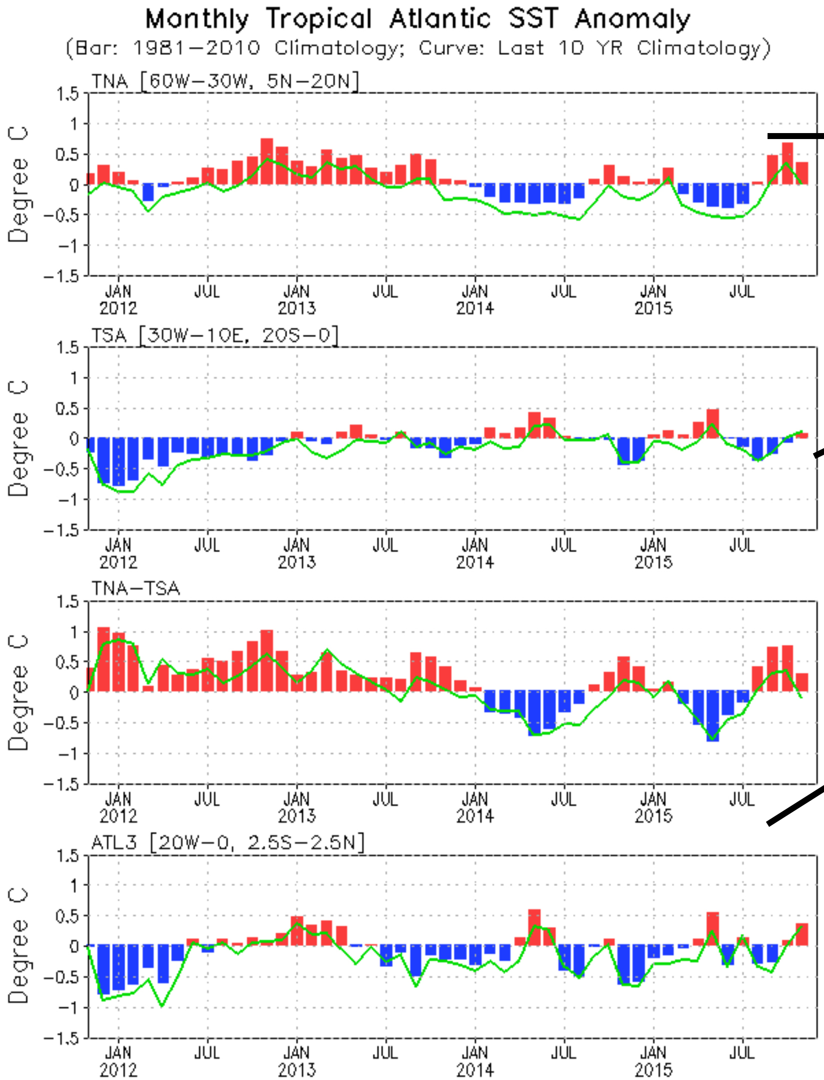


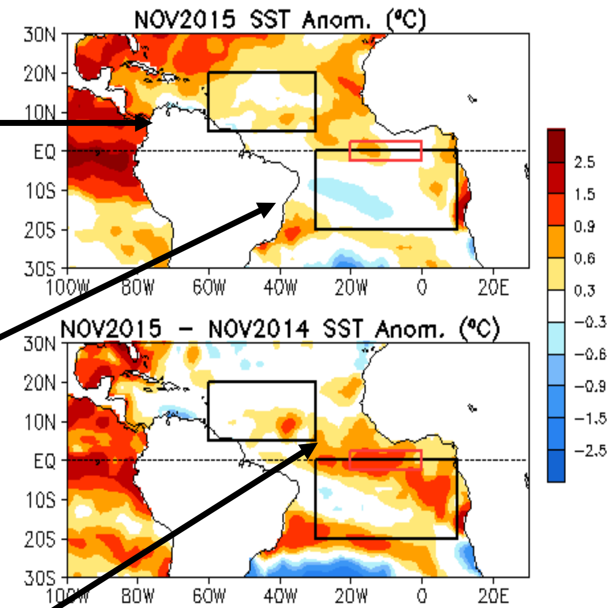
- **Positive SSTA exceeding +0.9C continued in the western-central tropical Indian Ocean.**

- **Convection was enhanced (suppressed) in the central tropical Indian Ocean (in the eastern tropical Indian Ocean and over Indonesia), which was persistent in Oct-Nov 2015.**

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

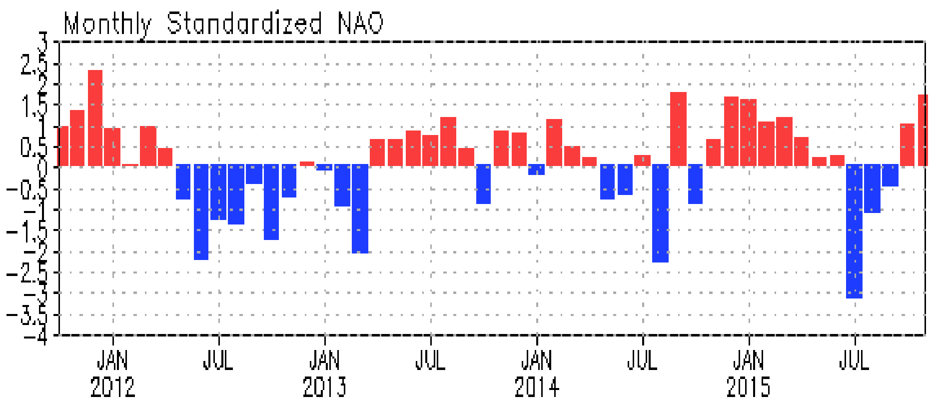


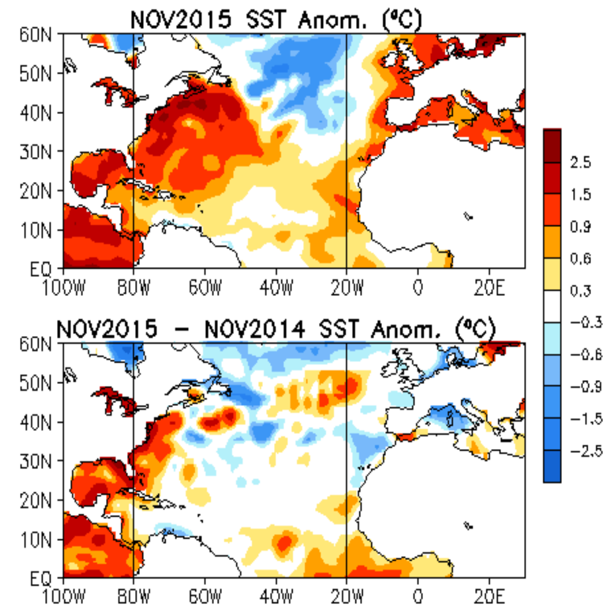


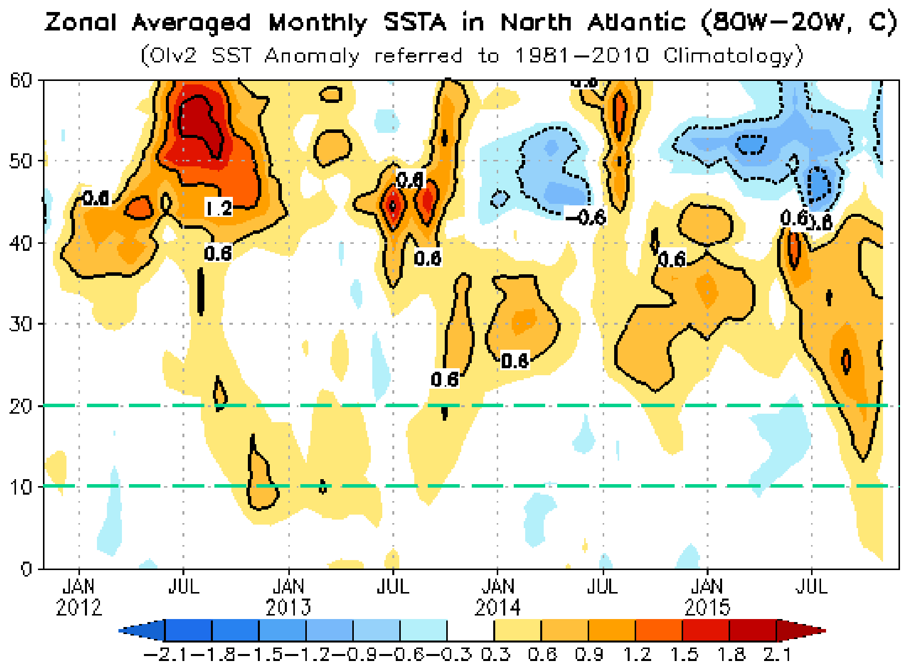
- **Positive SSTA in the tropical North Atlantic (TNA) weakened in Nov 2015.**
- **Positive Meridional Gradient Mode Index (TNA-TSA) also weakened in Nov 2015.**

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.

NAO and SST Anomaly in North Atlantic





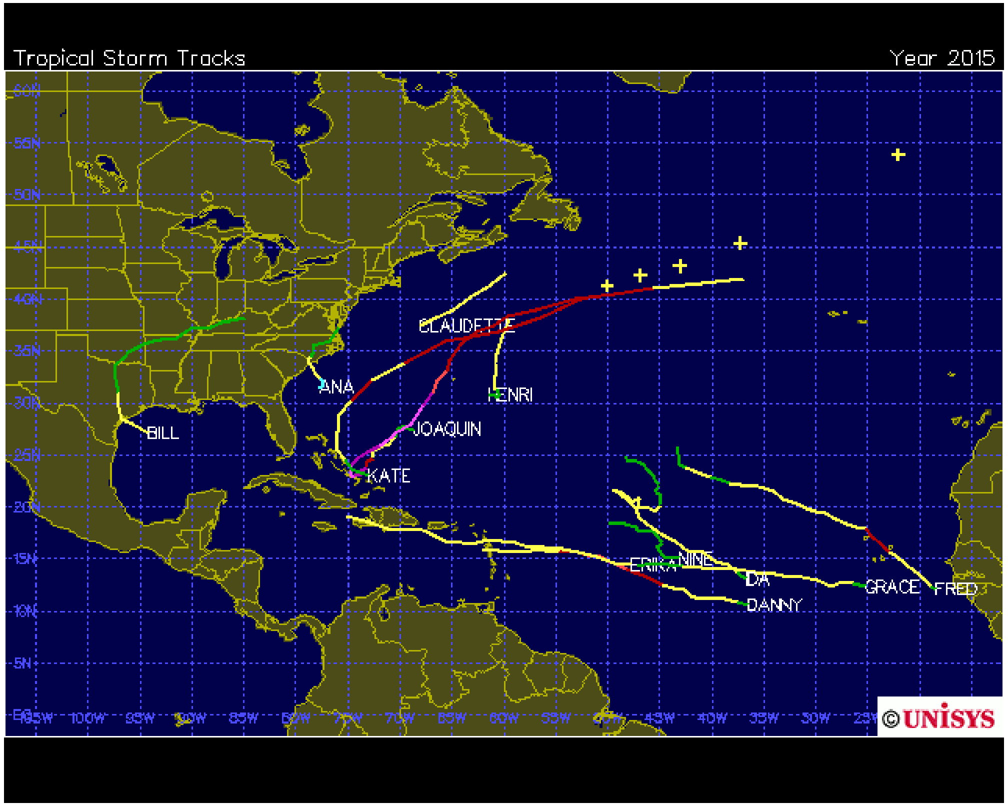


- NAO strengthened with NAO=+1.7 in Nov 2015.
- Persistent positive NAO was associated with SST cooling (warming) in high-latitude and subtropics (mid-latitude).

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.

2015 Atlantic Hurricane Counts

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



- Only four seasons since 1995 were below-normal (1997, 2009, 2013 and 2014).

- 2015 became the fifth below-normal season since 1995.

- **It marked the first time since 1995 that three consecutive seasons were below-normal.**

- **Atlantic Outlook (May update, 70% below-normal)**:

6-11 Named Storms (12 average)

3-6 Hurricanes (6 average)

0-2 Major Hurricanes (3 average)

40%-85% ACE

- **Atlantic Counts by Dec 7**:

11 Named Storms

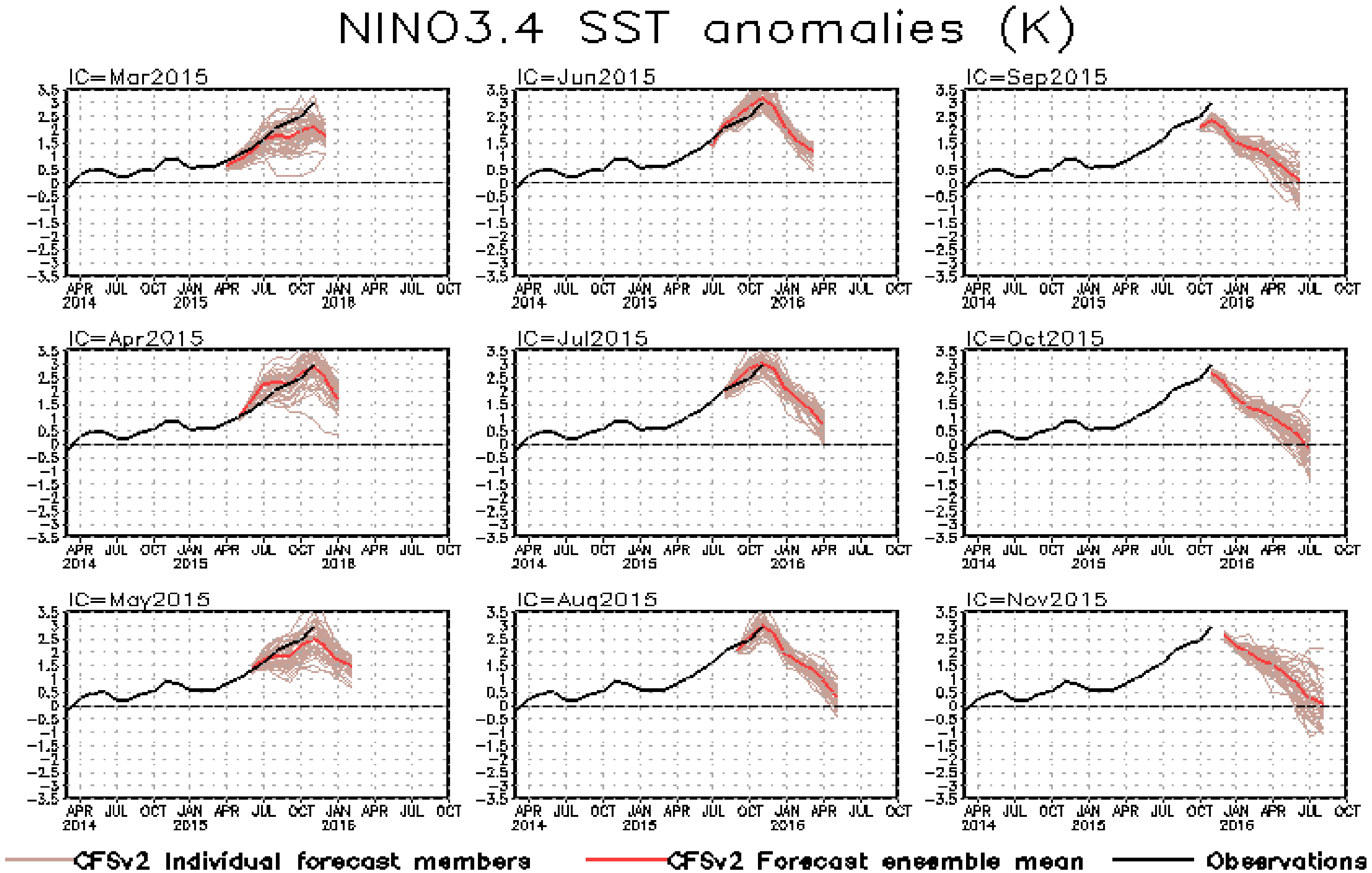
4 Hurricanes

2 Major Hurricanes

Successful outlook!

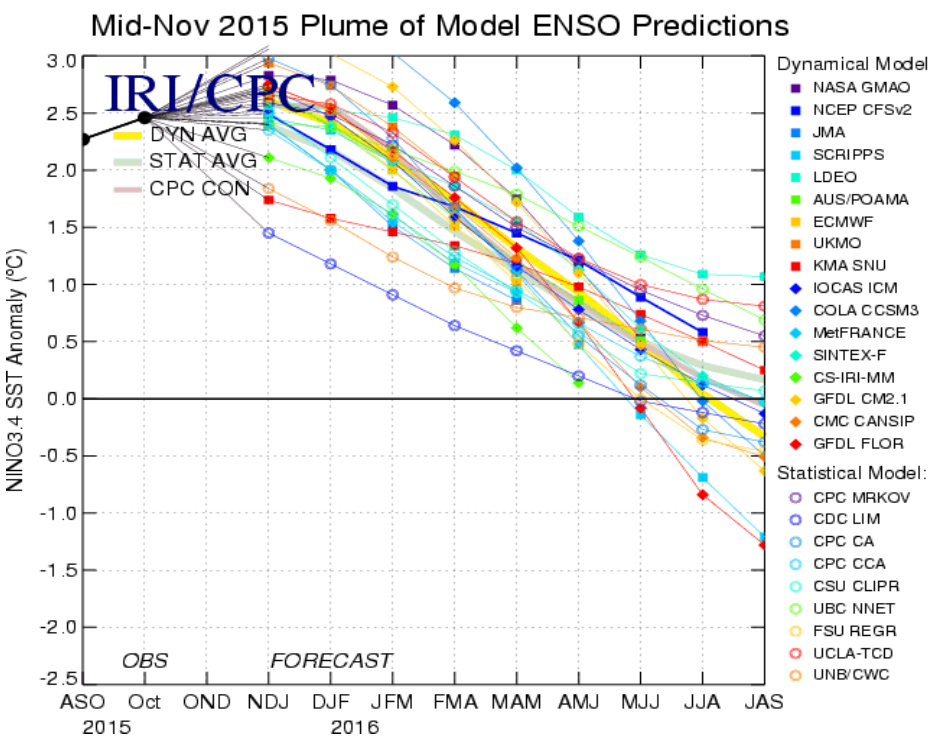
Global SST Predictions

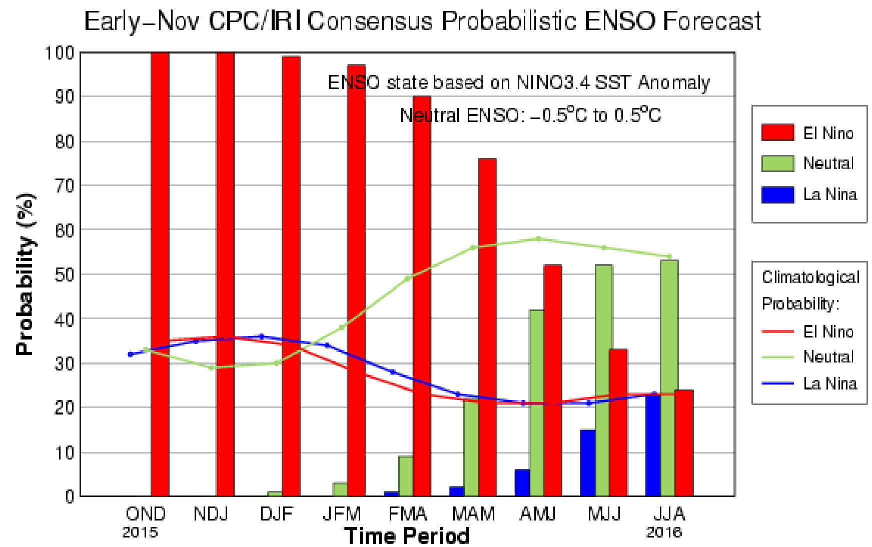
NCEP CFSv2 NINO3.4 Forecast



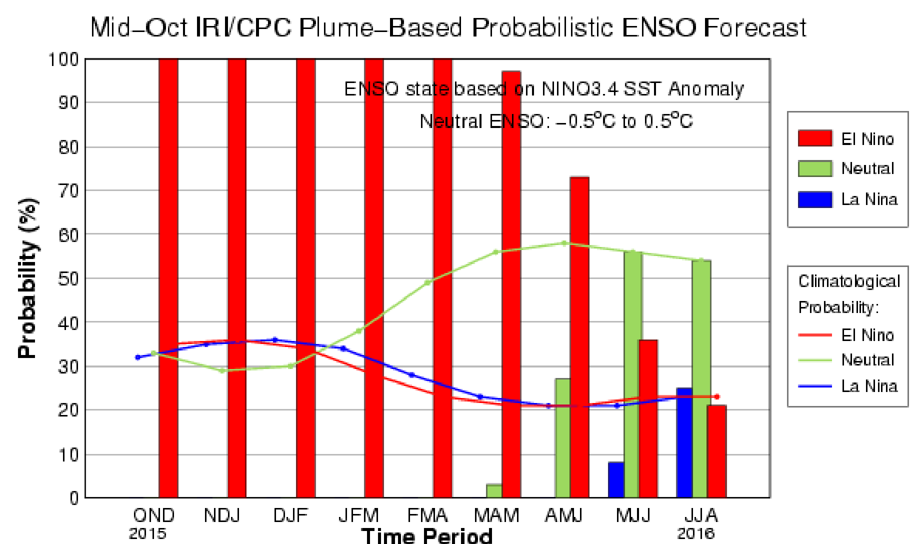
- CFSv2 predicted Nino3.4 will gradually dissipate through northern hemisphere winter/spring and transition into neutral conditions by summer 2016.
- The ensemble spread in the CFSv2 forecasts is noticeably small since Jun 2015 I.C., indicating a high confidence in the forecast.

IRI NINO3.4 Forecast Plum





- **<u>NOAA "ENSO Diagnostic Discussion" on Dec 10 2015 states</u> that "El Niño is expected to remain strong through the Northern Hemisphere winter 2015-16, with a transition to ENSO-neutral anticipated during late spring or early summer 2016."**



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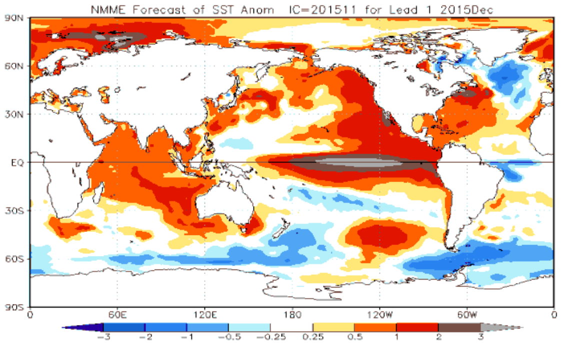
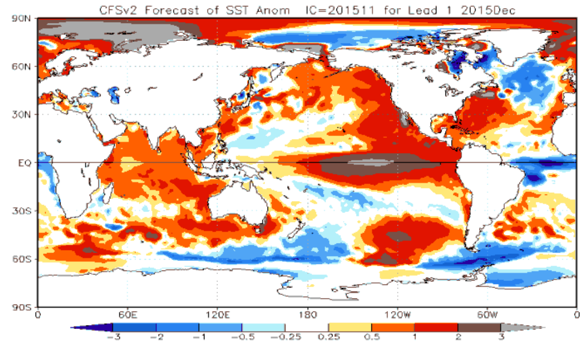
Comparison of NCEP CFSv2 and NMME SST Prediction

IC= 201511

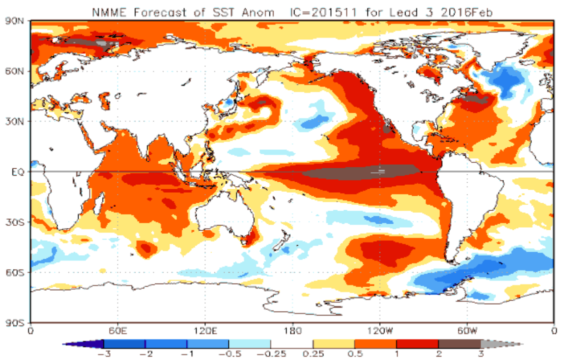
NMME 2015Dec



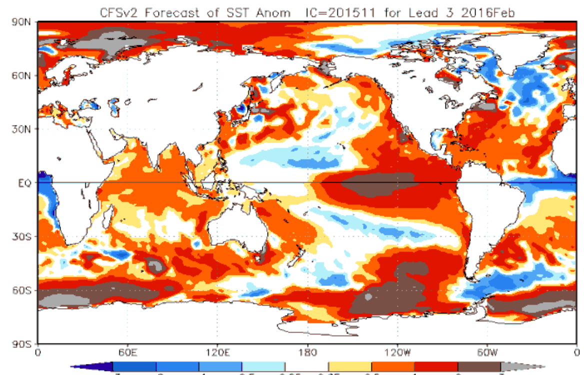
CFSv2 2015Dec



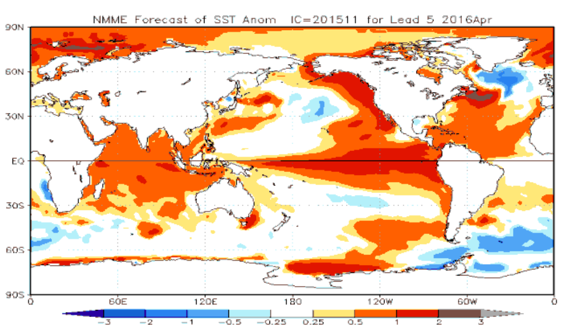
NMME 2016Feb



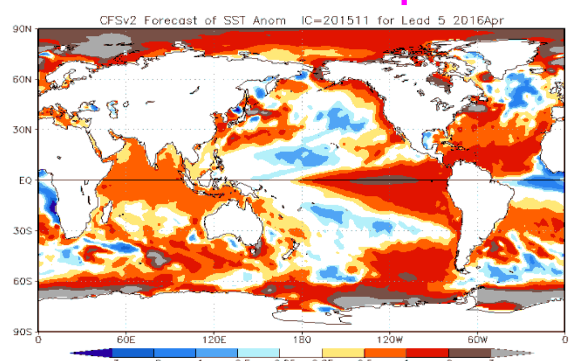
CFSv2 2016Feb



NMME 2016Apr



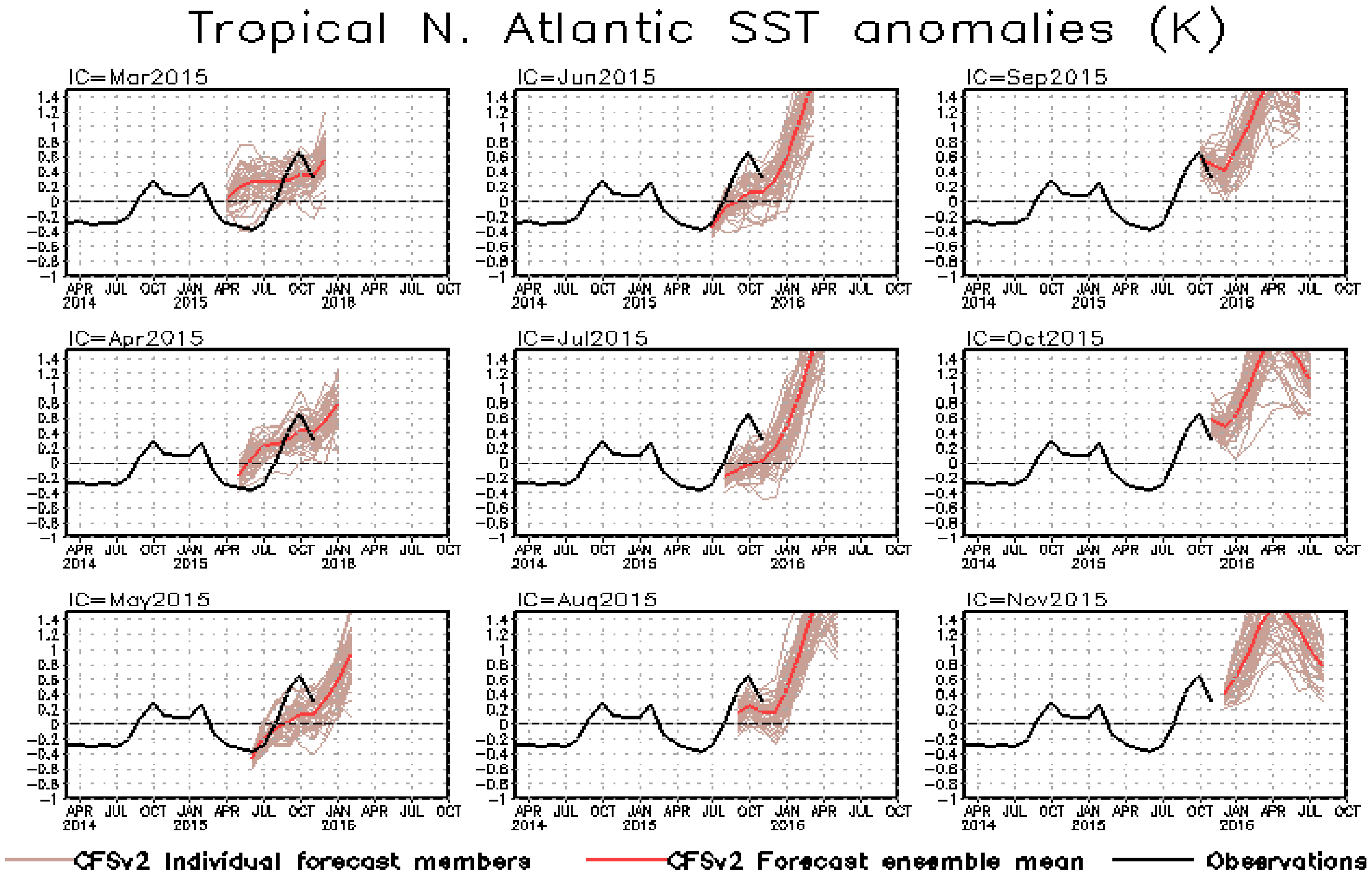
CFSv2 2016Apr



- CFSv2 predicted the "Blob" SSTA will dissipate rapidly, while NMME suggested it will persist into spring.

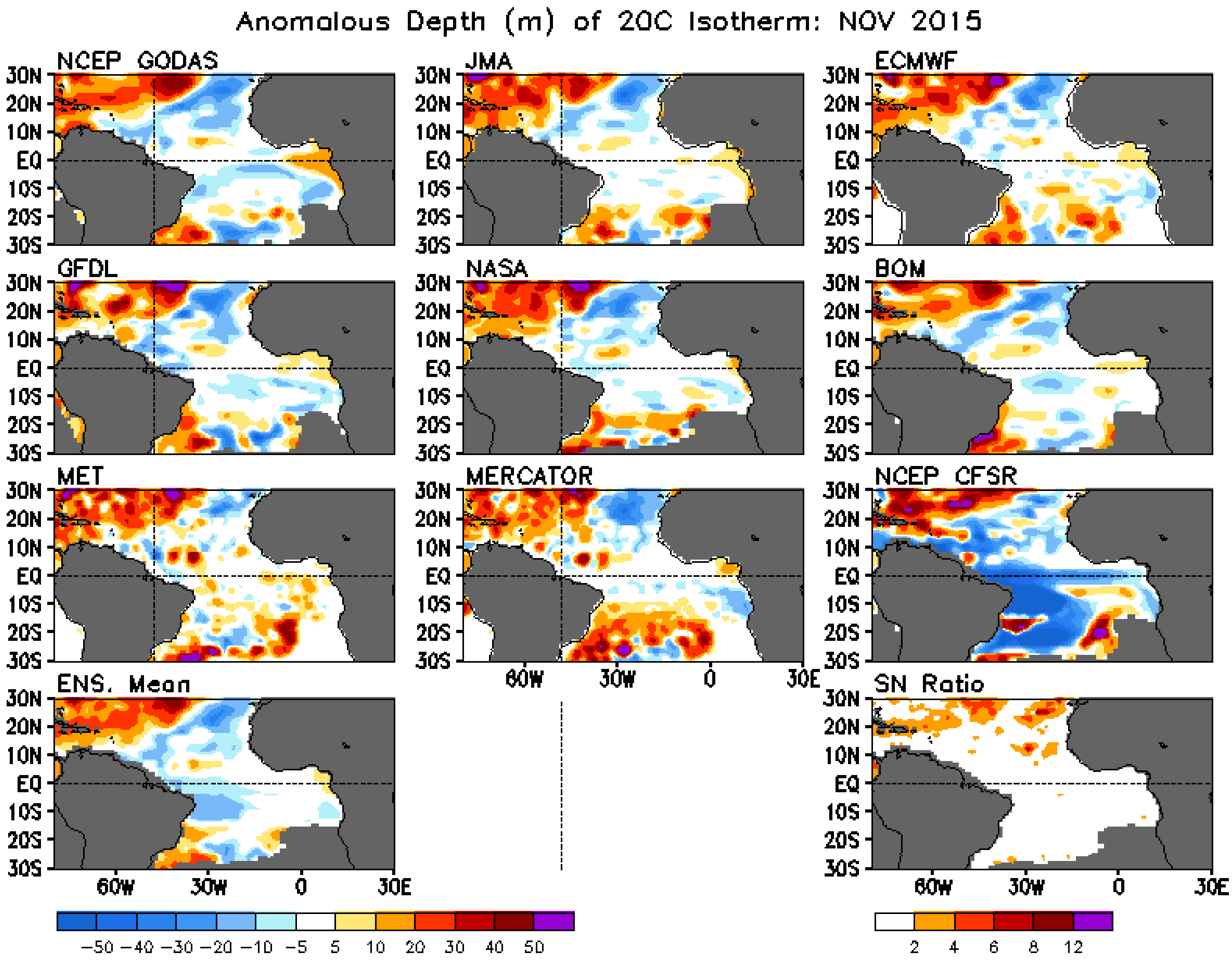
- CFSv2 predicted much stronger warming in the tropical North Atlantic in spring 2016 than NMME did.

NCEP CFSv2 Tropical North Atlantic SST Forecast



- CFSv2 predicted tropical North Atlantic SSTA will grow rapidly in early 2016.

Real-Time Multiple Ocean Reanalyses Intercomparison
(1993-2013 Climatology)



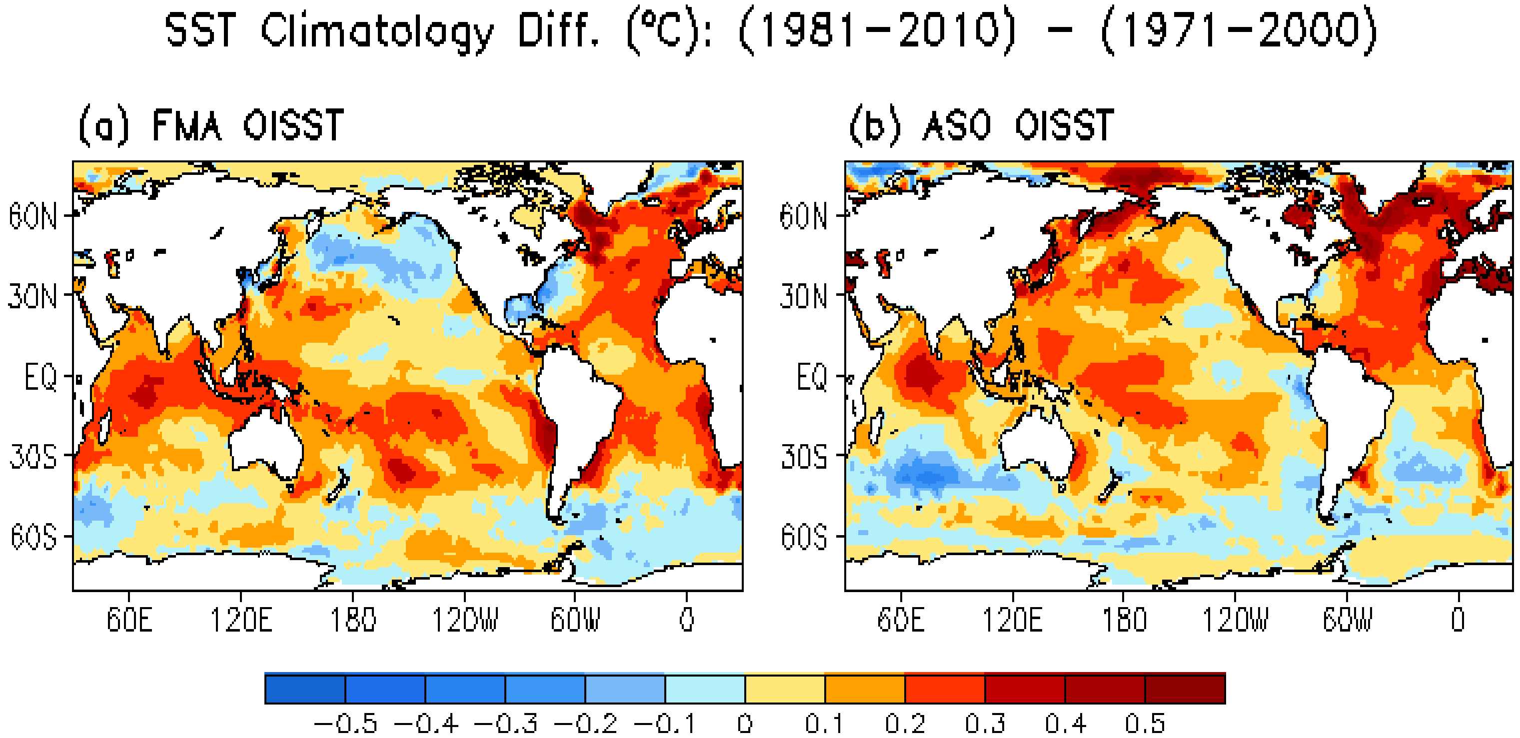
Overview

- **Pacific Ocean**
  - **El Niño conditions further strengthened in Nov 2015 and the atmospheric and oceanic anomalies reflect a strong El Niño.**
  - **Most models indicate that a strong El Niño will continue through the Northern Hemisphere winter 2015-16, followed by weakening and a transition to ENSO-neutral during the late spring or early summer.**
  - **The current conditions and recent evolution of the 2015 El Niño were compared with those of the 1982 and 1997 El Niño.**
  - **Upper ocean warming associated with the "Blob" has persisted since winter 2013/2014.**
- **Indian Ocean**
  - **Positive SSTA dominated most of the tropical Indian Ocean.**
  - **Positive India Dipole Mode index persisted.**
- **Atlantic Ocean**
  - **Positive NAO strengthened with NAO=+1.7.**
  - **SSTA were well above-average along the eastern coast of North America.**

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.**

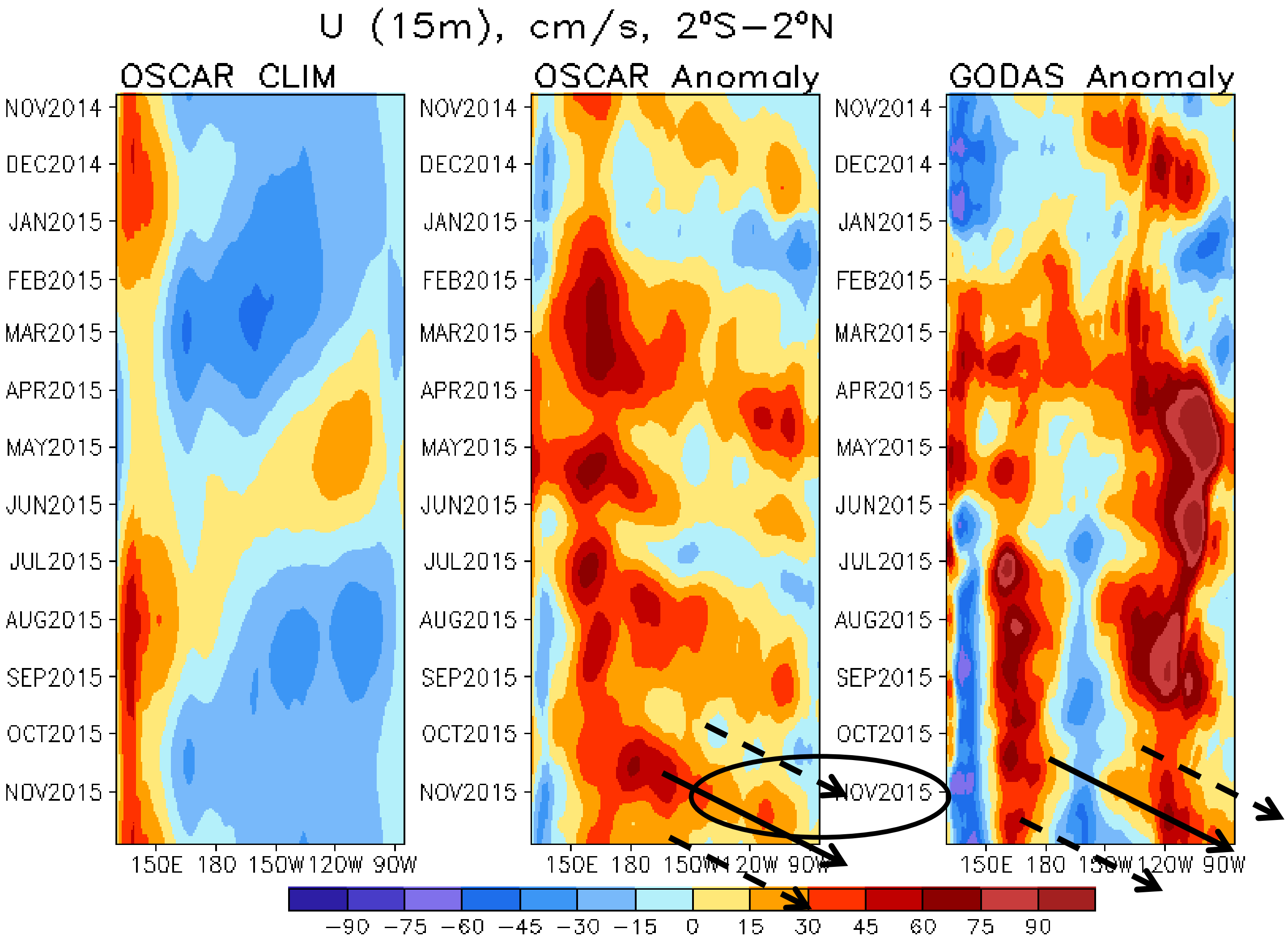
Data Sources and References

- 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!

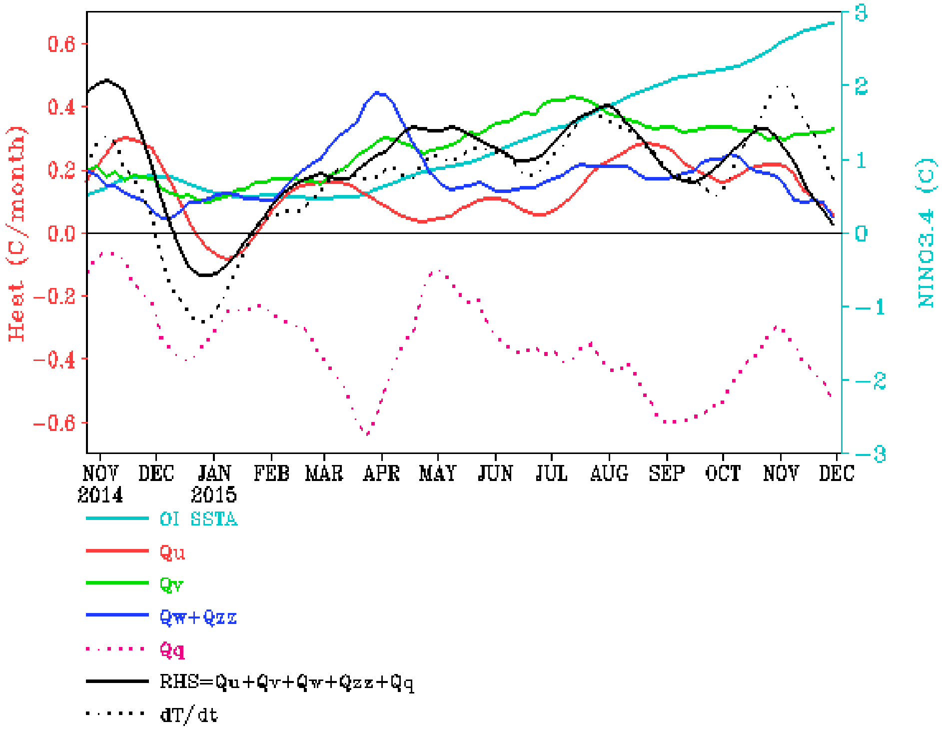
Backup Slides

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



- **Positive (negative) zonal current anomalies were associated with downwelling (upwelling) oceanic Kelvin waves.**

NINO3.4 Heat Budget



- **SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was near zero in Nov 2012, indicating a persistence in NINO3.4.**

- **All the advection terms were positive, the sum of which was largely in balance with the negative thermodynamical term (Qq).**

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

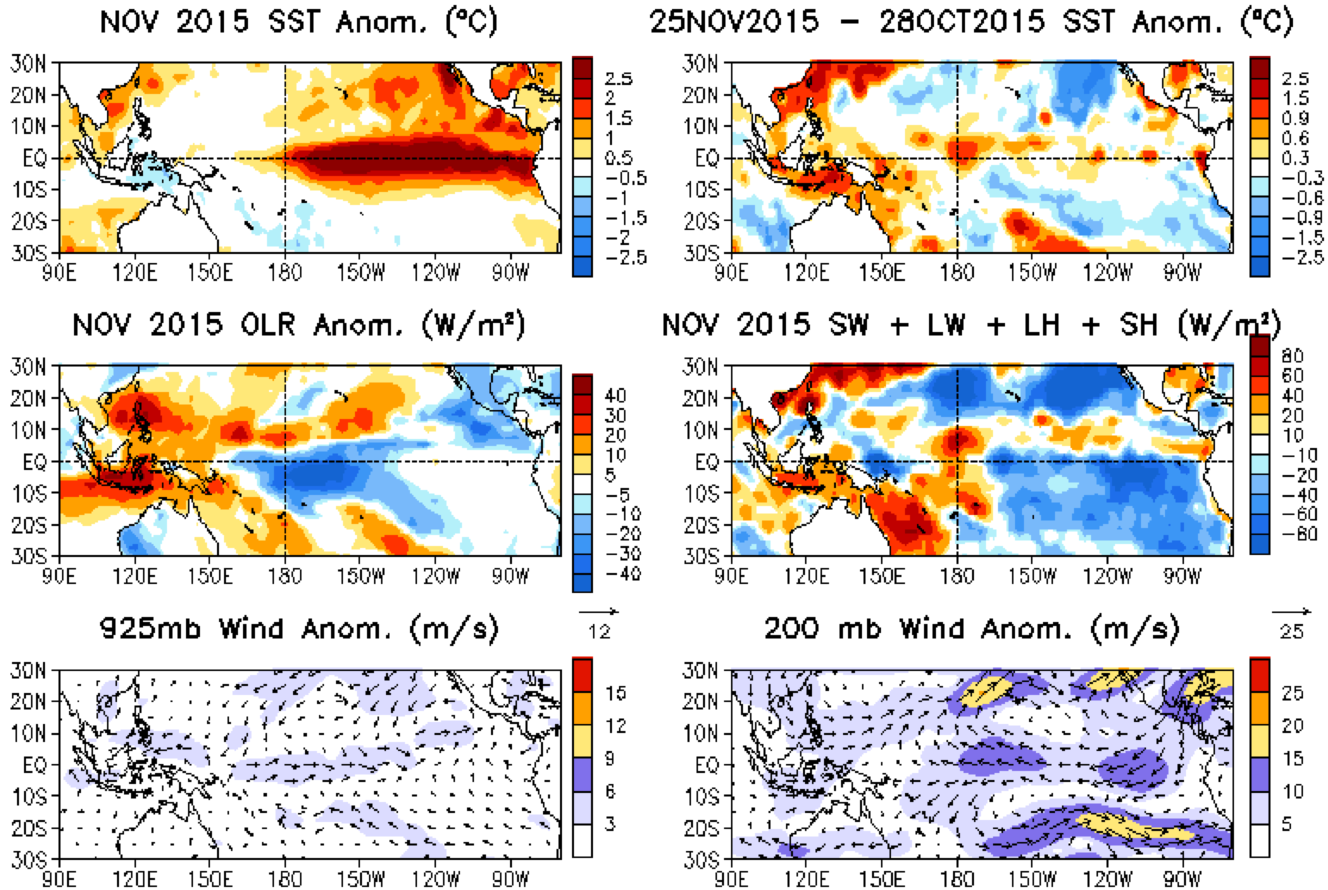


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

North Pacific & Arctic Ocean: SST Anom., SST Anom. Tendency, OLR, SLP, Sfc Rad, Sfc Flx

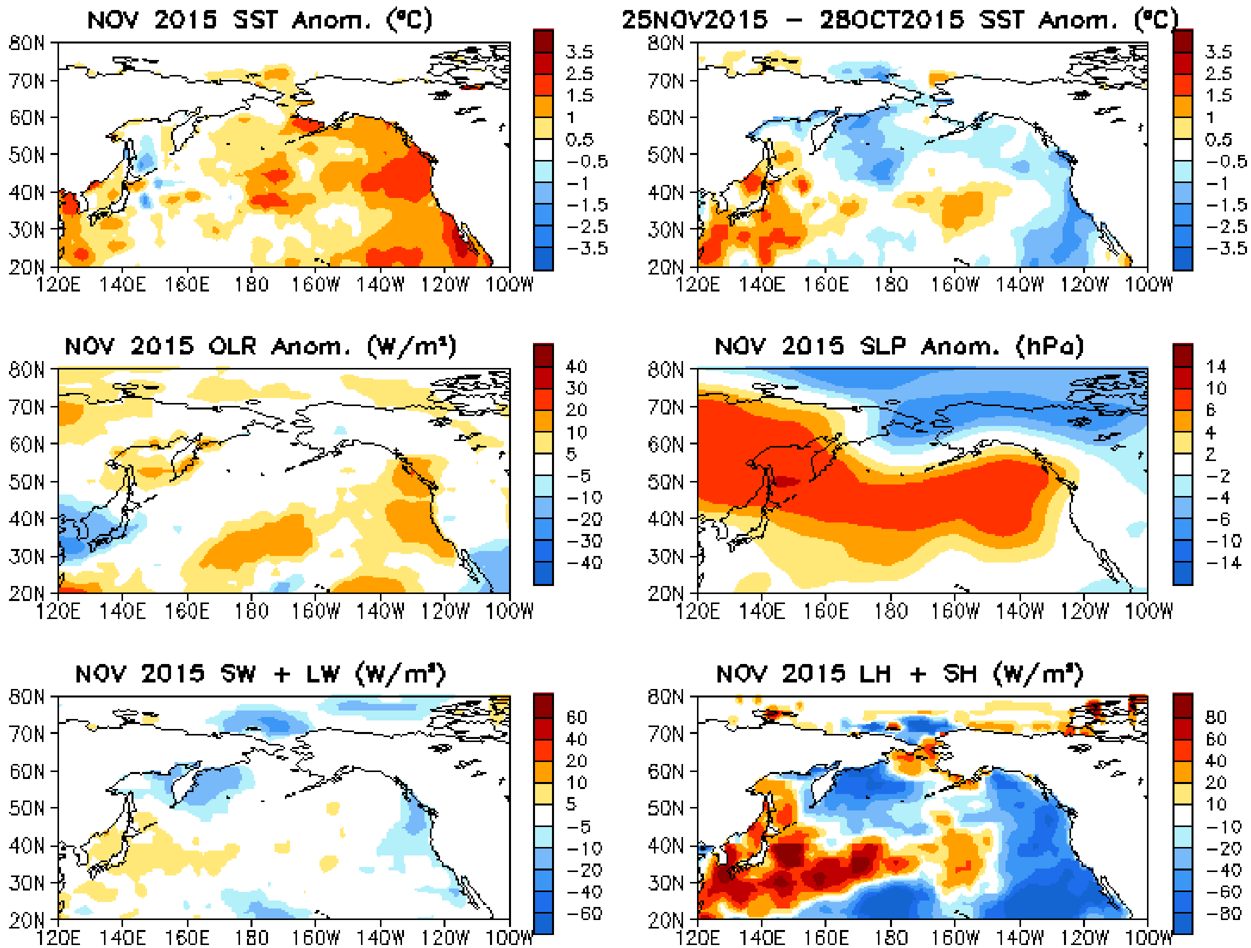


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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

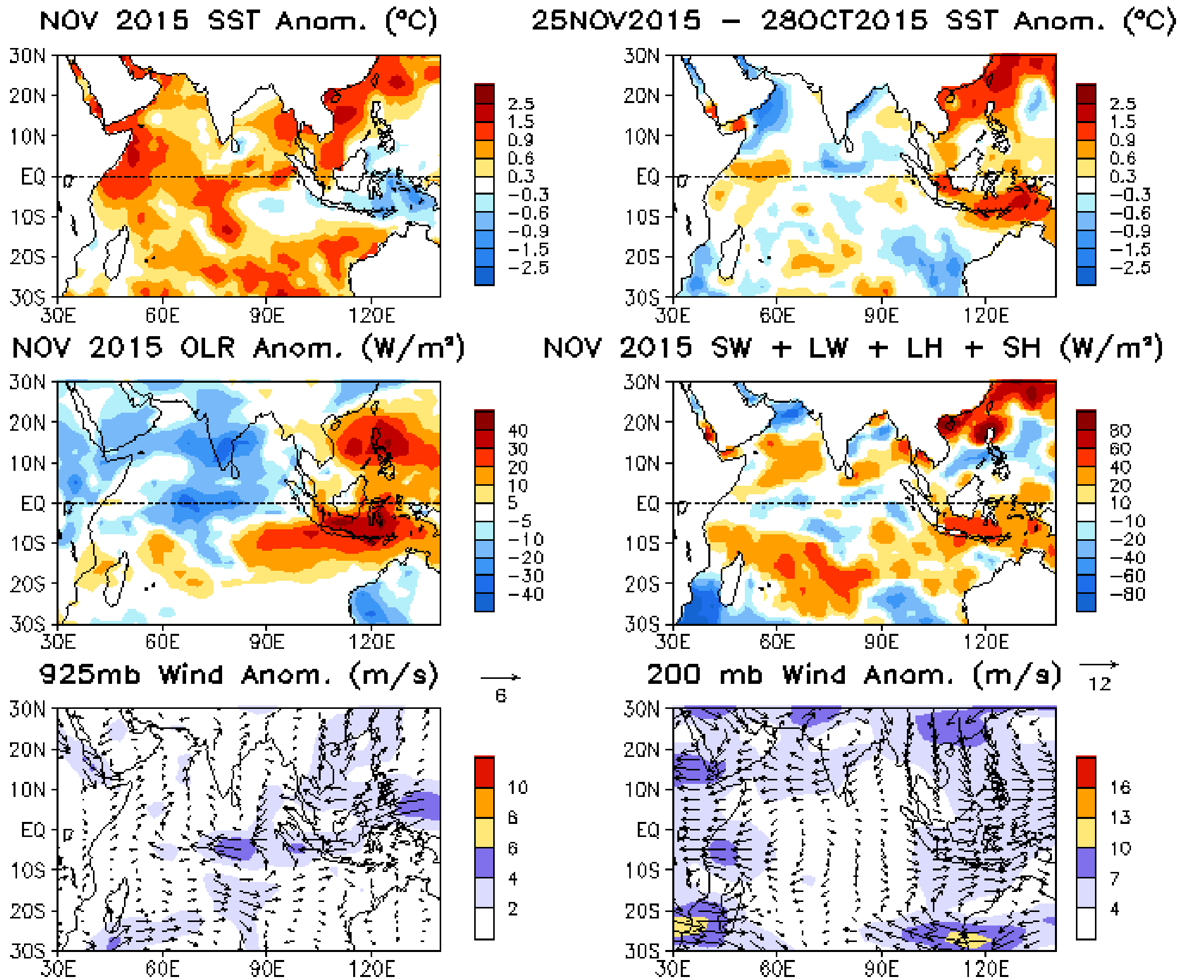


Fig. 12. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 Atlantic: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

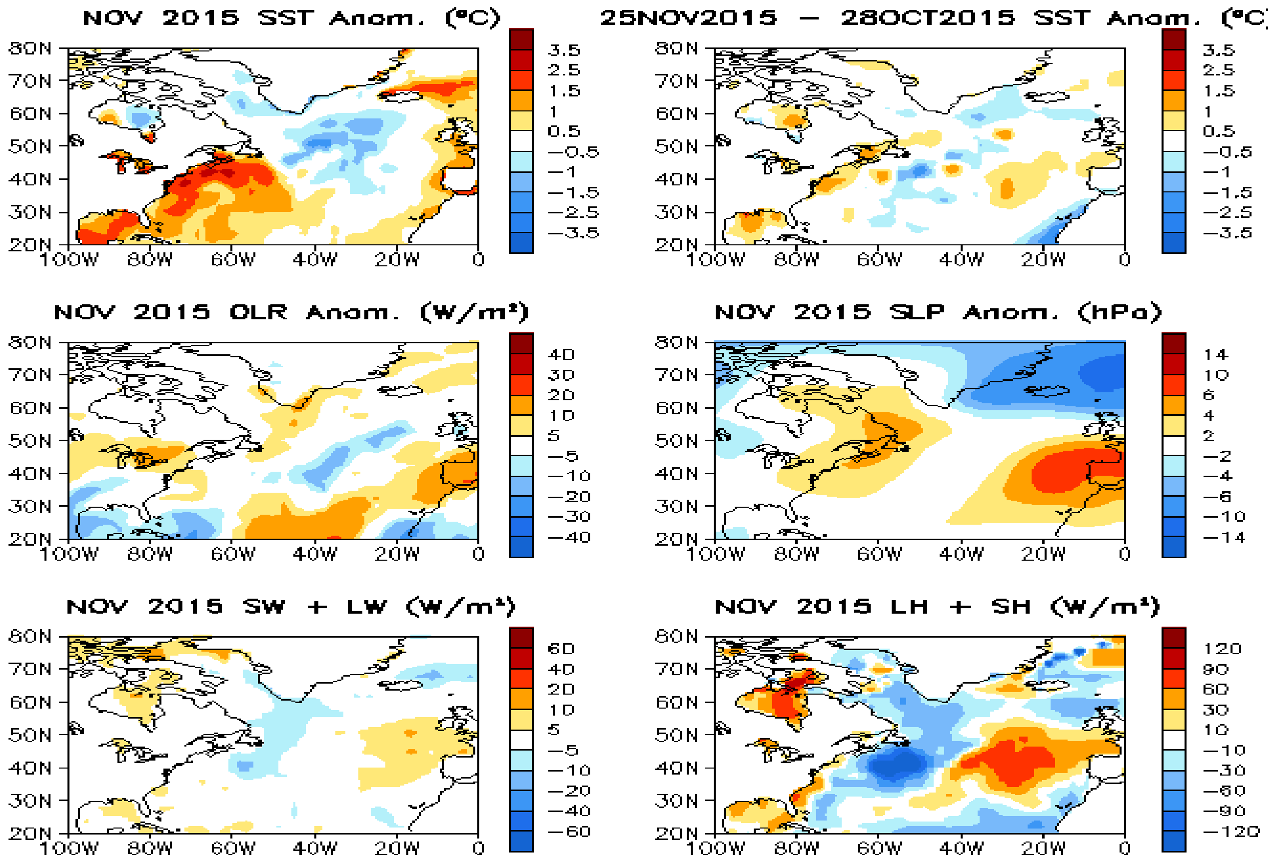
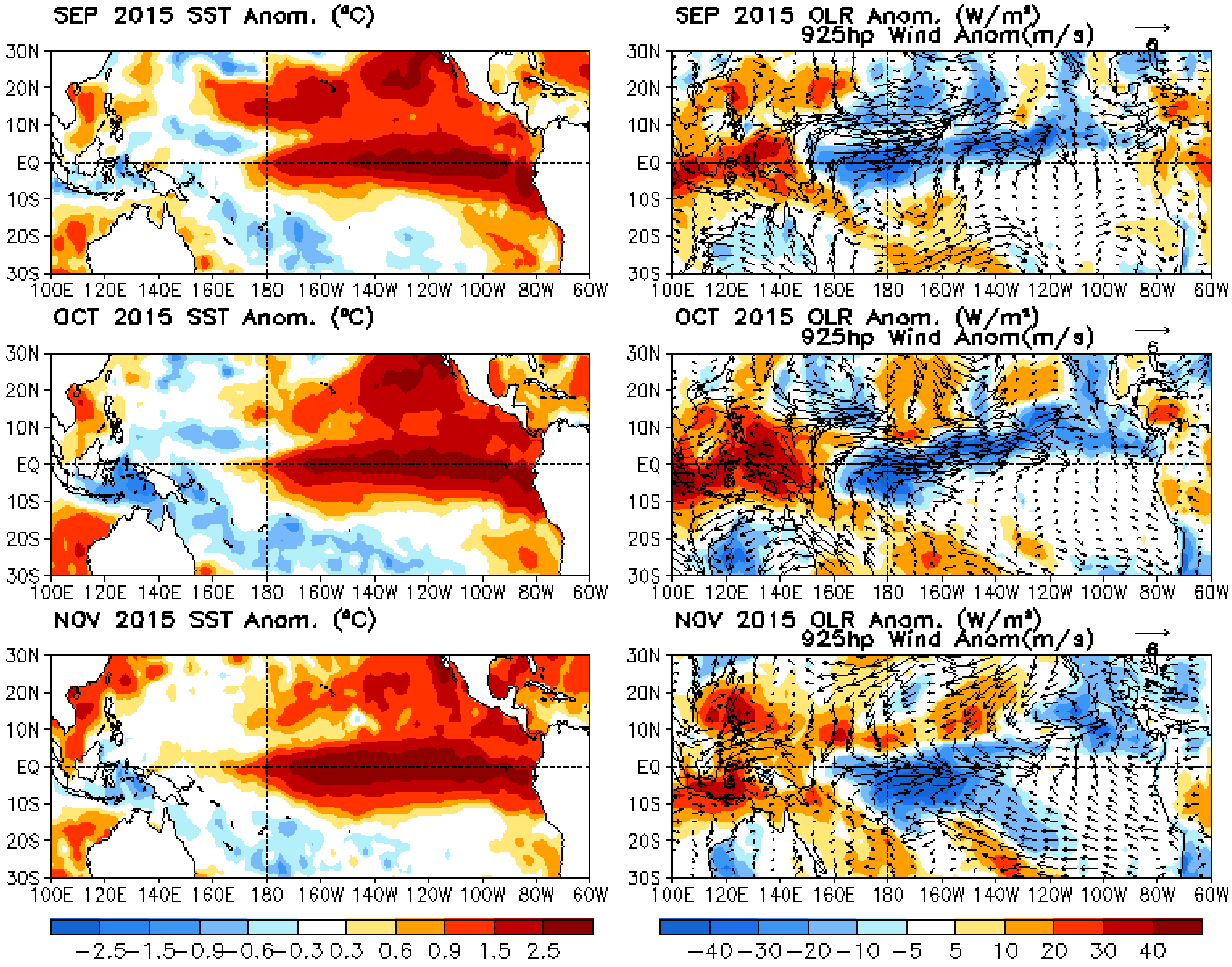


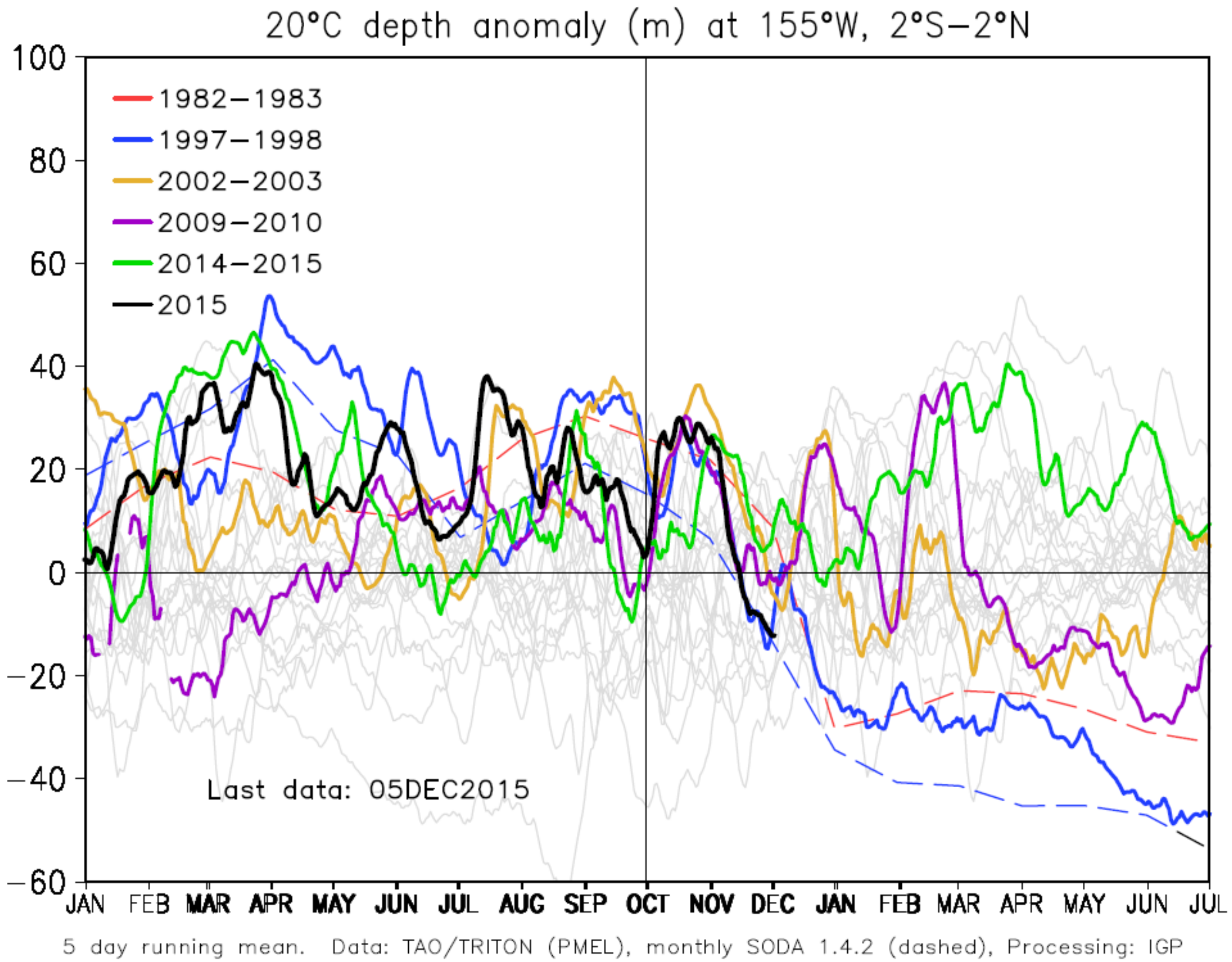
Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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, OLR and 925hp Wind Anom.



- Negative SSTA in the far W. Pacific weakened, and positive SSTA in the C.-E. Pacific extended further west.

- The atmospheric signature of the El Nino, suppressed (enhanced) convection over the Maritime Continent (near the Dateline), persisted in Nov 2015.



Plots provided by Ken Takahashi

20°C depth anomaly at [155°W, 2°S-2°N] shows that the upwelling Kelvin wave episode had contributed to a discharge of warm water volume in Nov 2015, similar to that in Nov 1997, indicating a tendency to decay in the El Nino.