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

Prepared by

Climate Prediction Center, NCEP/NOAA

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

This project to deliver real-time ocean monitoring products is implemented by CPC in cooperation with NOAA's Climate Observation Division (COD)

Outline

- **Overview**

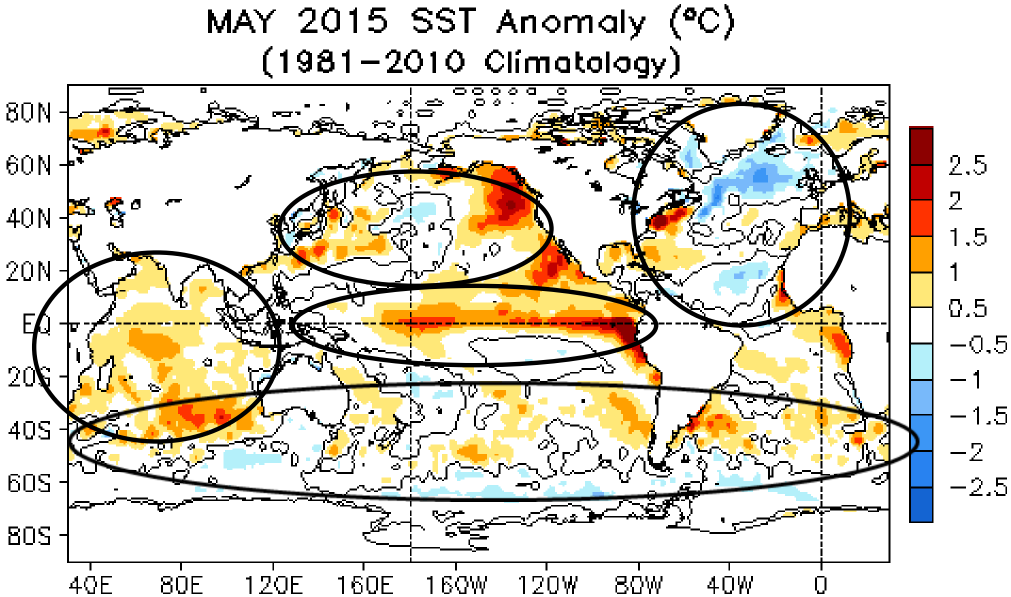
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Global SST Predictions**
- NOAA hurricane outlook summary for 2015 season
- Is an extreme El Nino coming in 2015/2016?

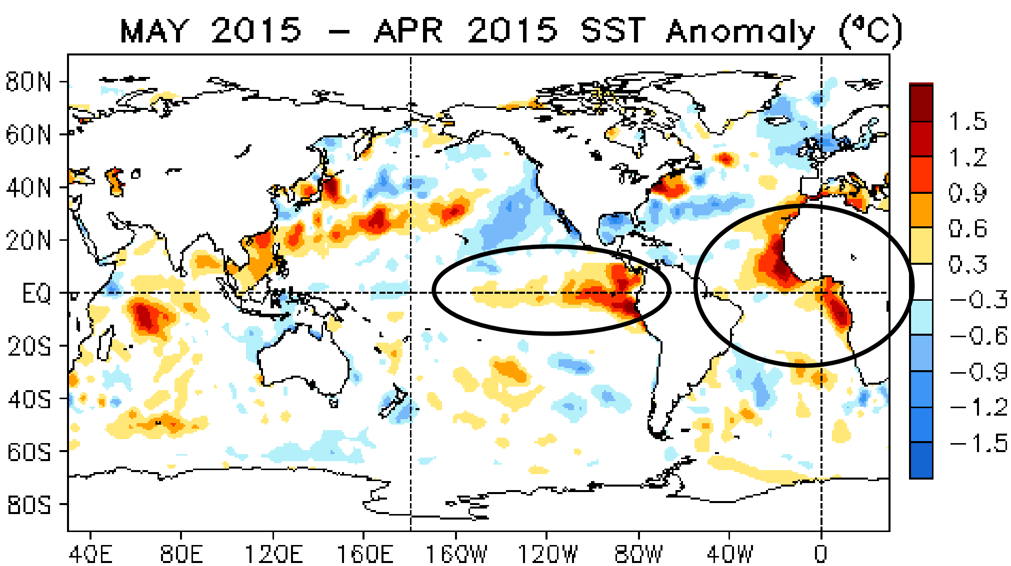
Overview

- **Pacific Ocean**
  - NOAA "ENSO Diagnostic Discussion" on 15 May 2015 suggested "There is an approximately 90% chance that El Niño will continue through Northern Hemisphere summer 2015, and a greater than 80% chance it will last through 2015."
  - Majority of models predicted an El Nino in 2015, and some predicted a strong El Nino and a few favored ENSO neutral conditions in 2015.
  - Positive SSTAs were observed in the central and eastern tropical Pacific and strengthened in the eastern Pacific with NINO3.4=1.0^{o}C in May 2015.
  - Positive anomalies of subsurface ocean temperature along the equator persisted and propagated eastward slowly in May 2015.
  - Positive phase of PDO has persisted for 11 months and weakened, with PDOI=0.8 in May 2015.
- **Indian Ocean**
  - Positive SSTAs were in the whole Indian Ocean.
- **Atlantic Ocean**
  - Positive phase of NAO has persisted for 7 months and weakened with NAOI=0.2 in May 2015, causing a horseshoe-like pattern of SSTA in N. Atlantic.

Global Oceans

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

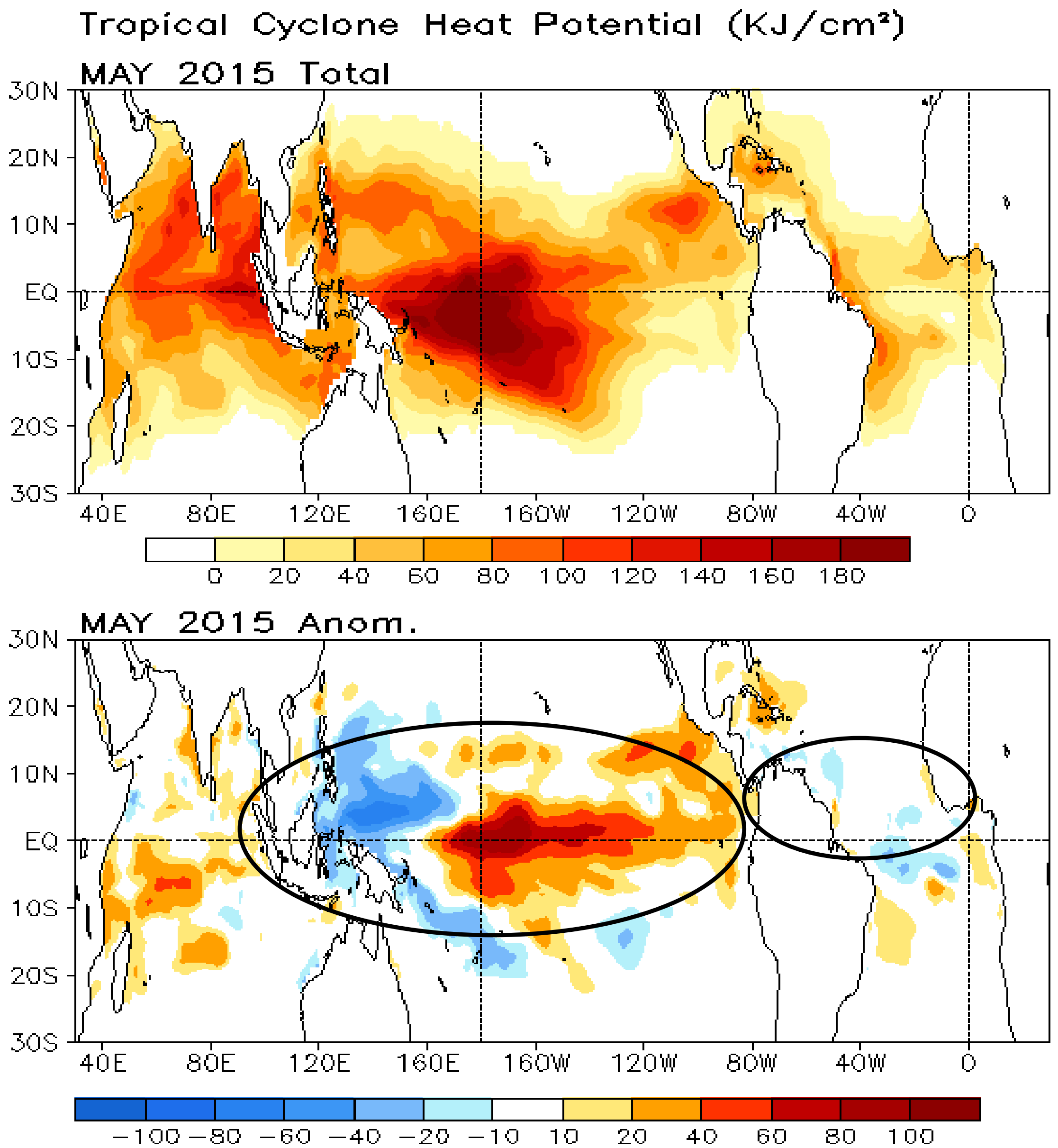




- **Positive SSTA was observed in the central and eastern tropical Pacific, and it was strong in the central Pacific and along the Central American coast.**
- **Strong positive SSTA presented in the NE Pacific and was associated with positive phase of PDO.**
- **Horseshoe-like SSTA persisted in the North Atlantic.**
- **Positive SSTA presented in the Indian and Southern Oceans.**

- **SSTA tendencies were large in the eastern equatorial Pacific and along the southern and central American coast, as well as African coast.**

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.



- Positive TCHP anomalies presented in the central and eastern equatorial Pacific and negative ones in the western Pacific.

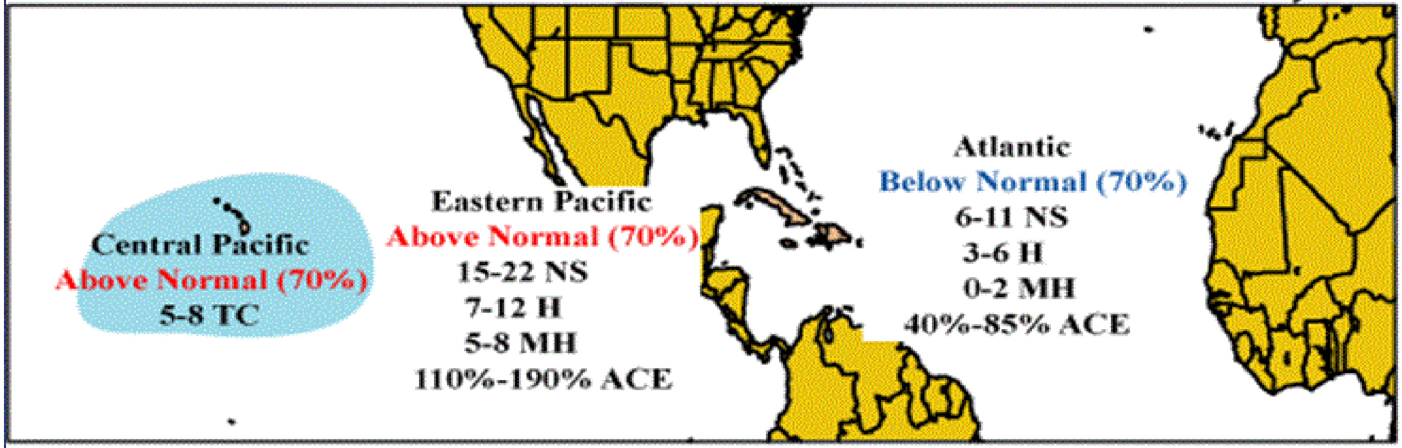
- Small anomalies were seen over the tropical North Atlantic Ocean.

TCHP field is the anomalous heat storage associated with temperatures larger than 26 ℃.

NOAA Outlooks of Hurricane Season in 2015

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane2015/)

NOAA's 2015 Hurricane Season Outlooks Issued in May



NOAA's 2015 Atlantic and Eastern Pacific seasonal hurricane outlooks indicate the likely ranges (each with a 70% chance) of Named Storms (NS), Hurricanes (H), Major Hurricanes (MH), and percentage of the median Acccumulated Cyclone Energy (ACE).

NOAA's 2015 Central Pacific seasonal hurricane outlook indicates the likely numbers of tropical cyclones (TC), with a 70% chance. TC's include tropical depressions, tropical storms and hurricanes.

For 2015 the probabilities of each season type are:

	Atlantic	Eastern Pacific	Central Pacific
Above Normal	10%	70%	70%
Near Normal	20%	25%	25%
Below Normal	70%	5%	5%

NOAA Outlooks of 2015 Hurricane Season

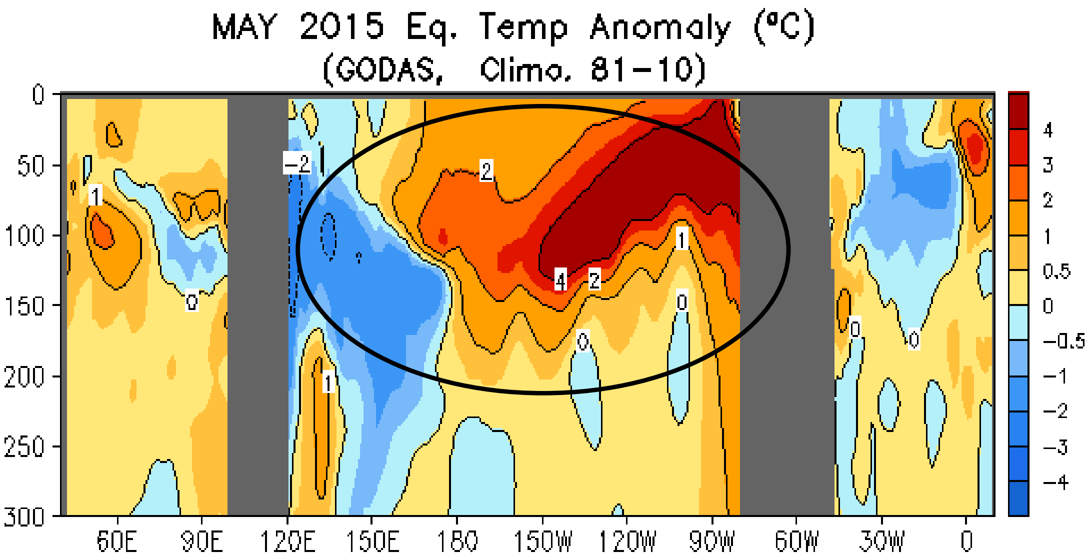
(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane2015/)

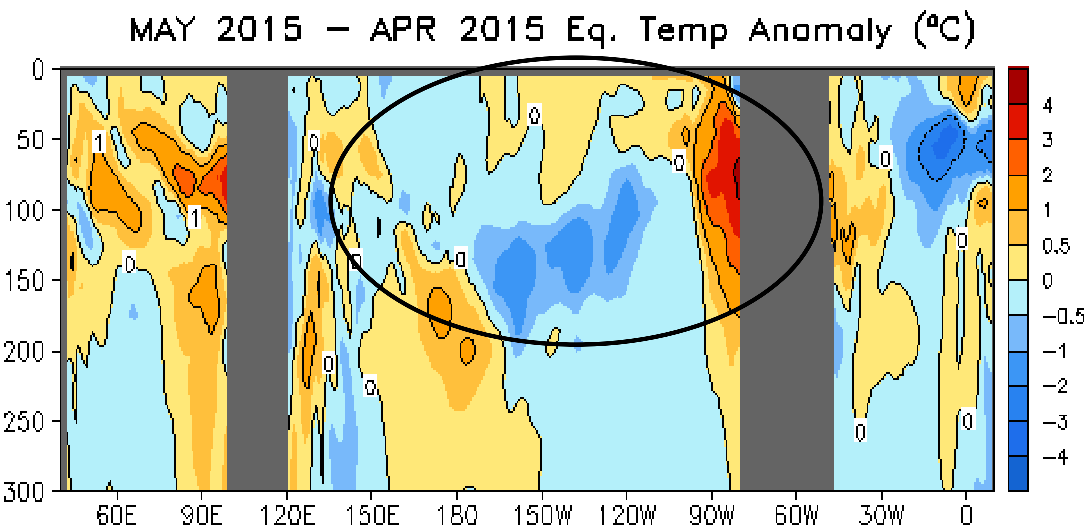
Atlantic	2015 prediction (issued on May 27) (1981-2010)
Named storms	6-11 (12.1)
Hurricanes	3-6 (6.4)
Major hurricanes	0-2 (2.7)

Eastern Pacific	2015 prediction (issued on May 27) (1981-2010)
Named storms	15-22 (15.4)
Hurricanes	7-12 (7.6)
Major hurricanes	5-8 (3.2)

- "2015 seasonal hurricane outlook reflects the persistence and possible strengthening of the already developed El Niño during the hurricane season."
- "The outlook takes into account dynamical model predictions from the NOAA CFS, NOAA GFDL FLOR-FA, ECMWF, UKMO, the EUROpean Seasonal to Inter-annual Prediction (EUROSIP) ensemble, along with ENSO forecasts from statistical and dynamical models contained in the suite of Niño 3.4 SST forecasts compiled by the IRI and the NOAA CPC."

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



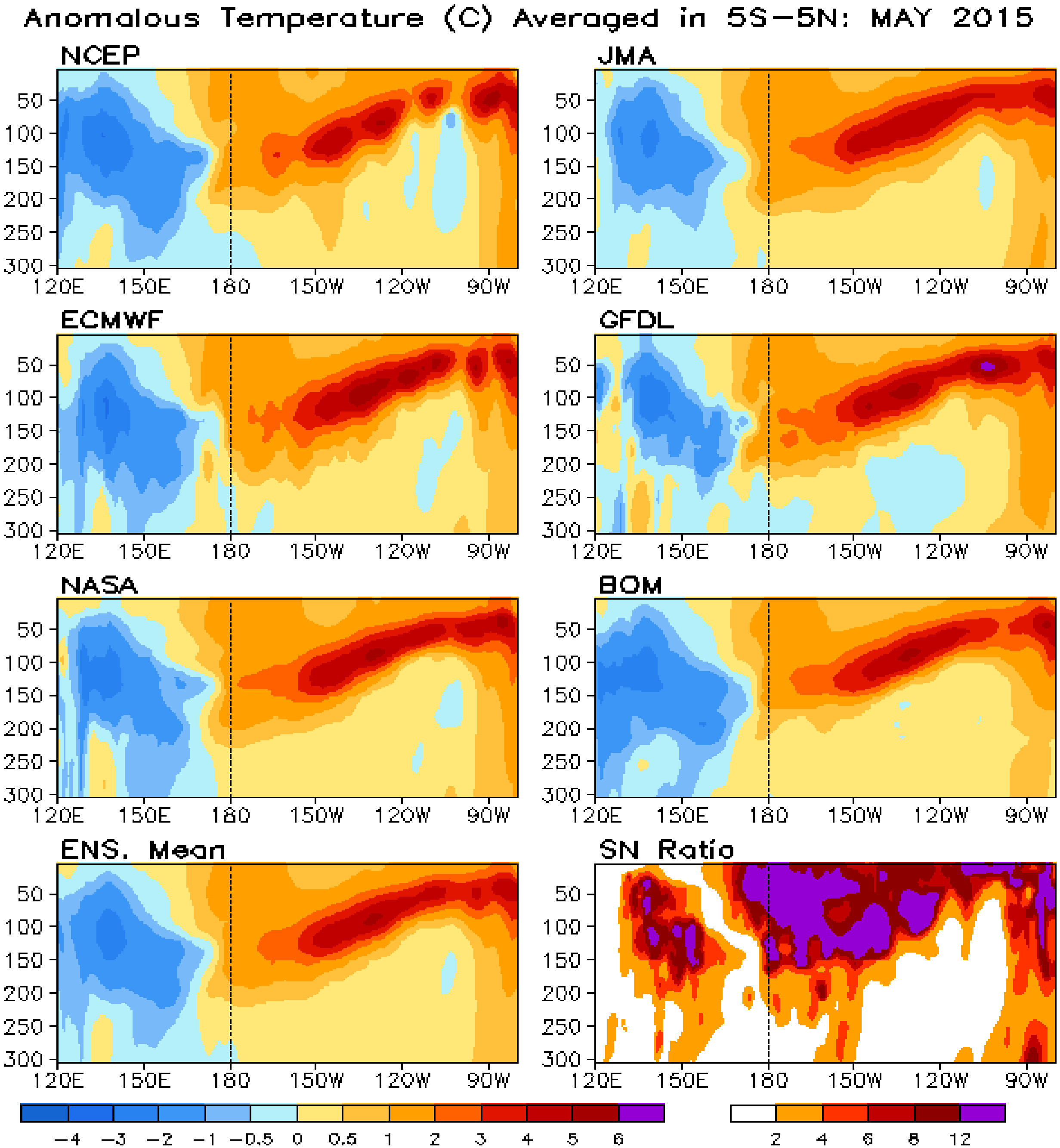


- Strong positive (negative) ocean temperature anomalies presented in the central and eastern (western) equatorial Pacific.

- Both positive and negative ocean temperature anomalies were observed in the Atlantic Ocean, and positive anomalies were dominated in the Indian Ocean.

- Ocean temperature tendencies were positive near in the far eastern Pacific and some negative ones in the central and eastern 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.



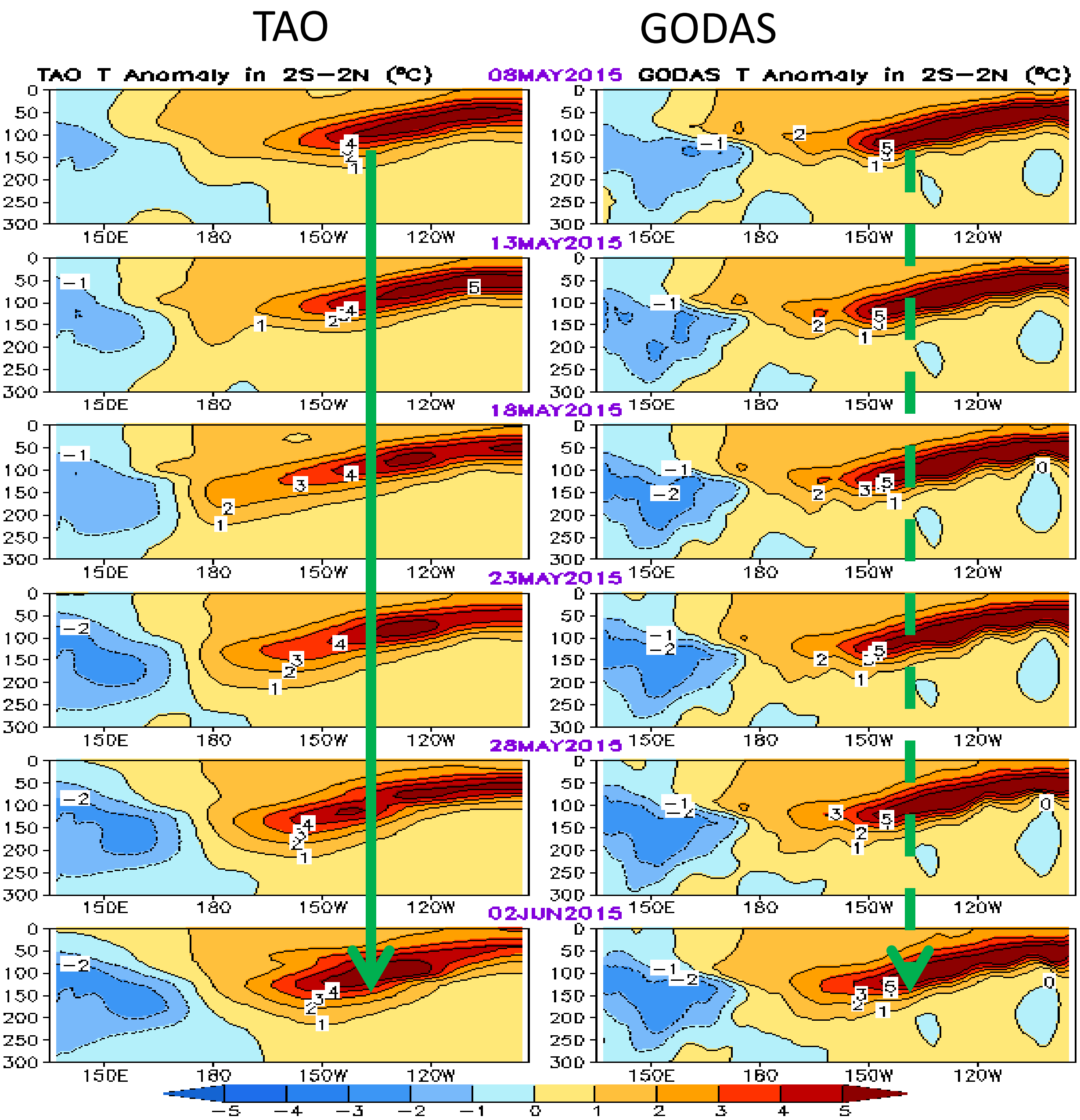
Multiple Ocean Reanalyses: Ocean Temperature along the equator

- **Overall, the anomalous pattern was similar for 6 re-analyses.**

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

Tropical Pacific Ocean and ENSO Conditions

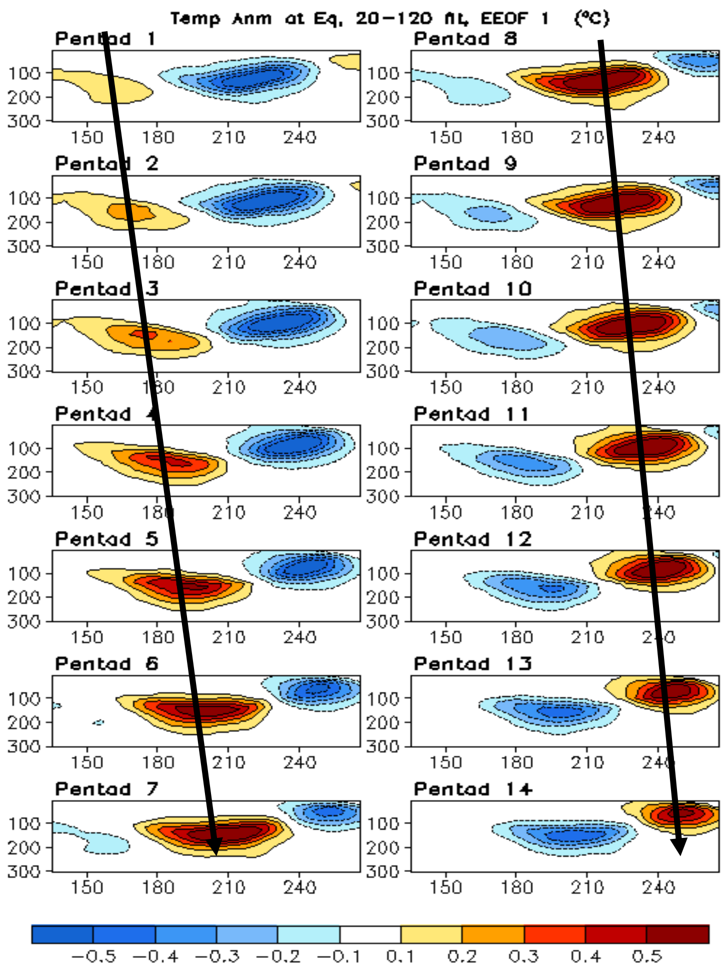
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

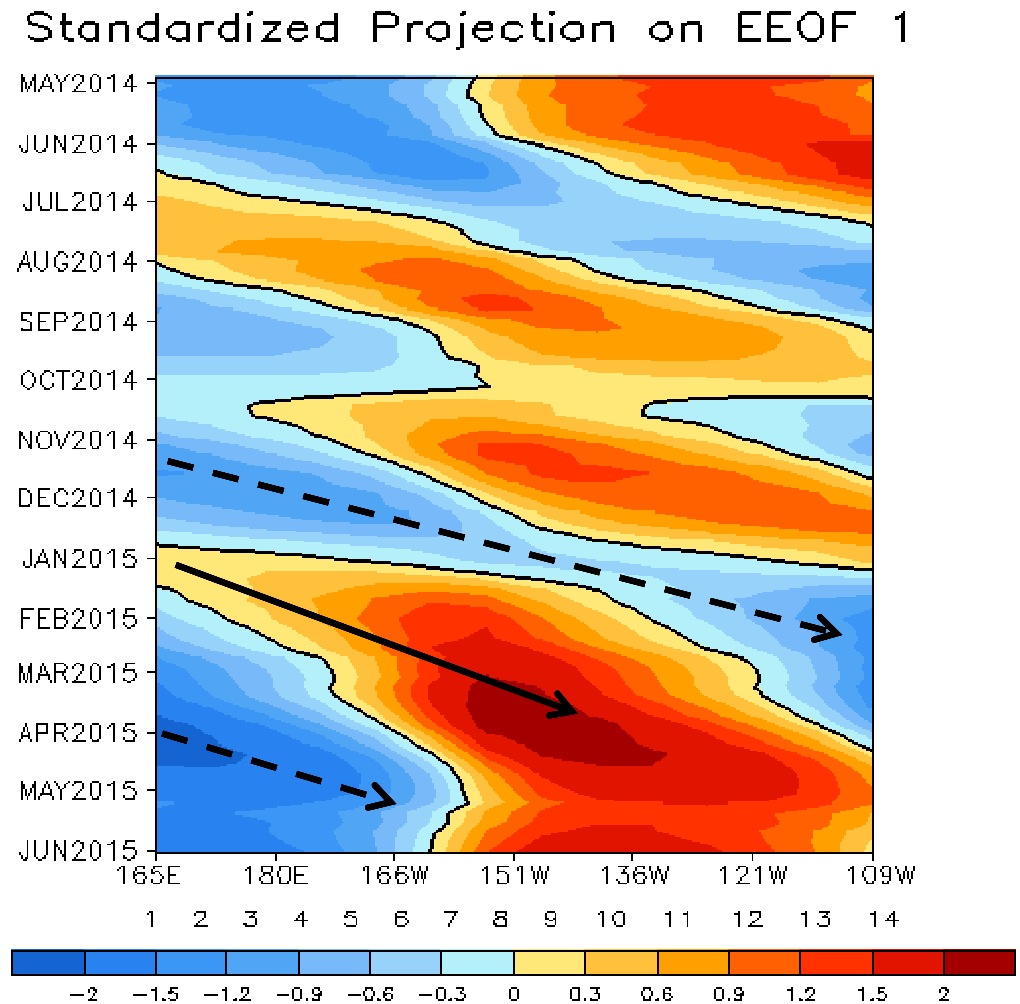


- Strong positive ocean temperature anomalies persisted and propagated eastward slowly.

- Both the intensity and propagation are comparable in recent months between GODAS and TAO.

Oceanic Kelvin Wave (OKW) Index



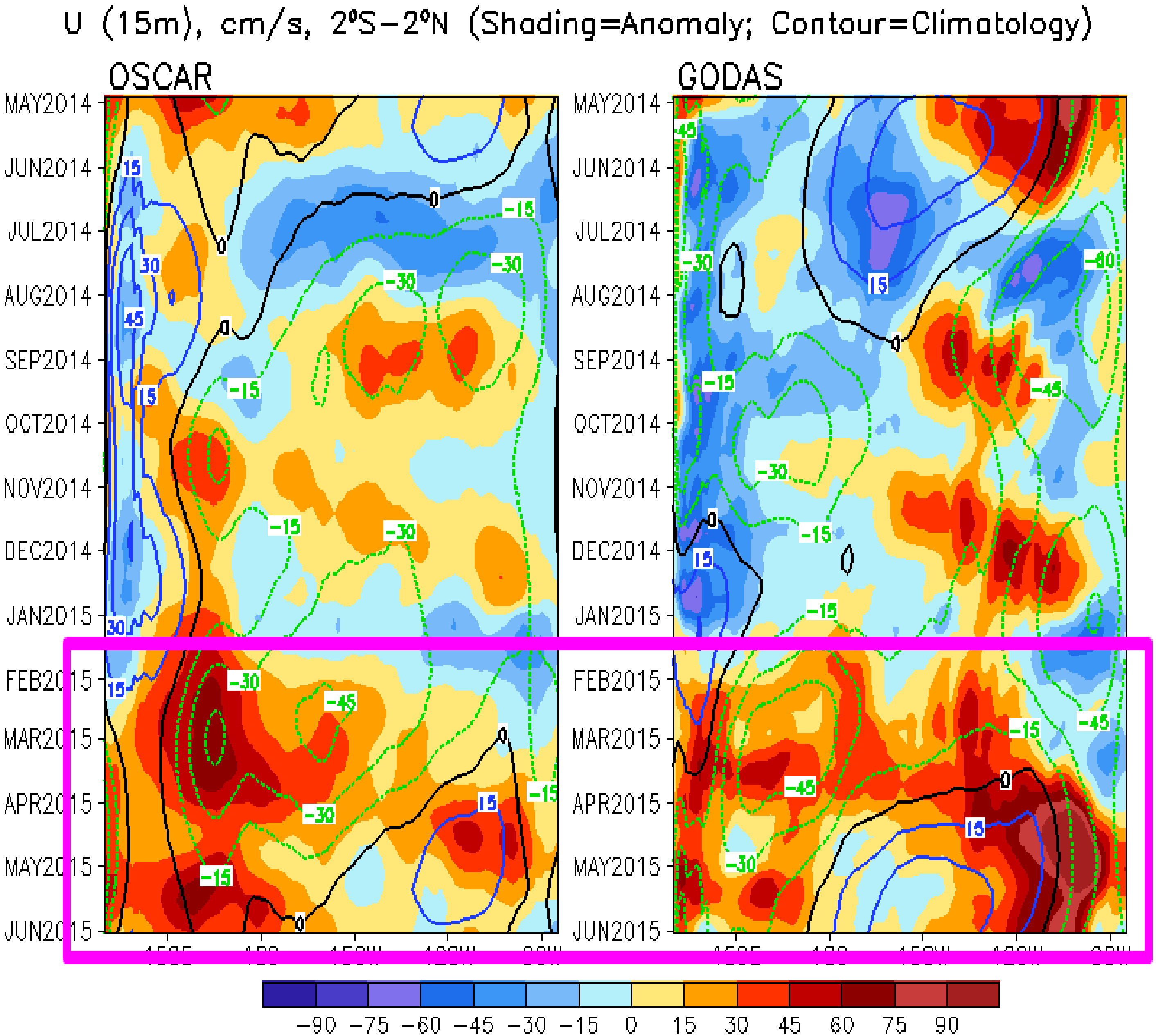


- **Downwelling OKW (solid line) emerged since Jan 2015 in the C. Pacific, while upwelling OKW initiated later in the W. Pacific. The downwelling may be associated with the observed subsurface ocean warming.**

- **Since May 2015, stationary-like variations were observed.**

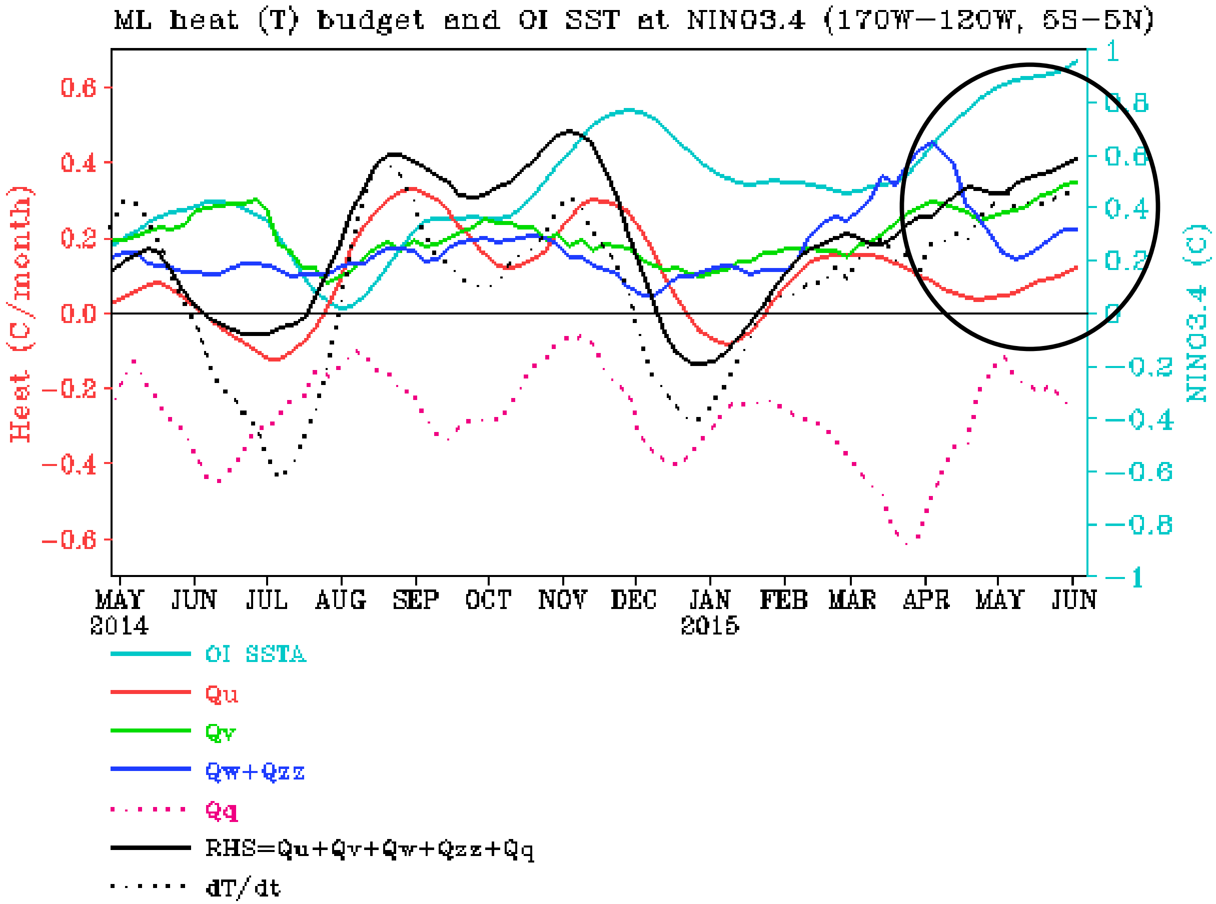
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- The anomalous current patterns were similar between OSCAR and GODAS.
- Anomalous eastward current initiated in Jan 2015 and slightly strengthened in Feb-Mar 2015, leading to positive zonal advective feedback.

NINO3.4 Heat Budget



- Observed SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was positive since mid-Jan 2015, consisting with the total heat budget term (RHS; solid black line).

- All dynamical terms (Qu, Qv, Qw+Qzz) were positive since Feb 2015, and heat flux term (Qq) was negative.

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.

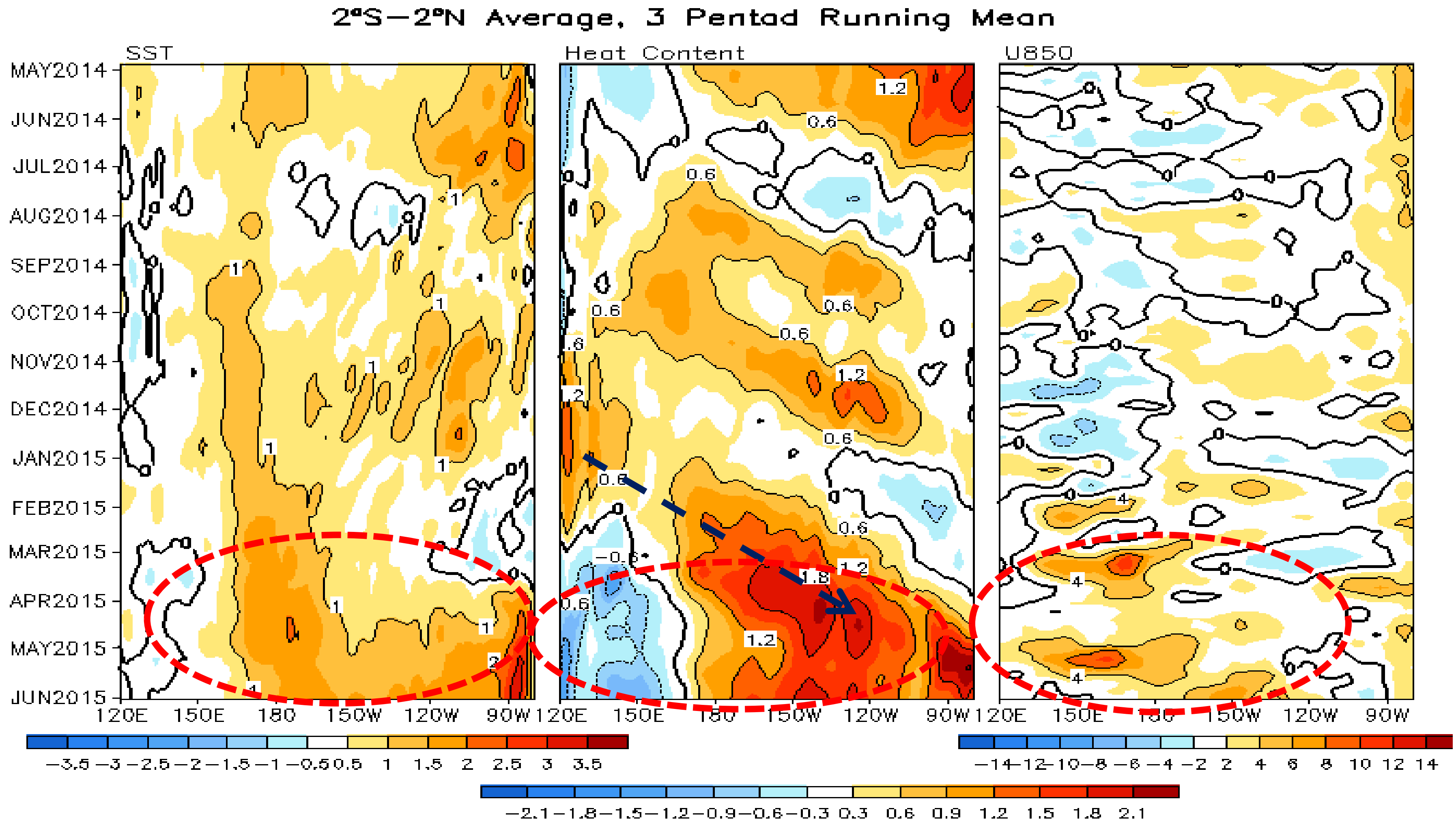
Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

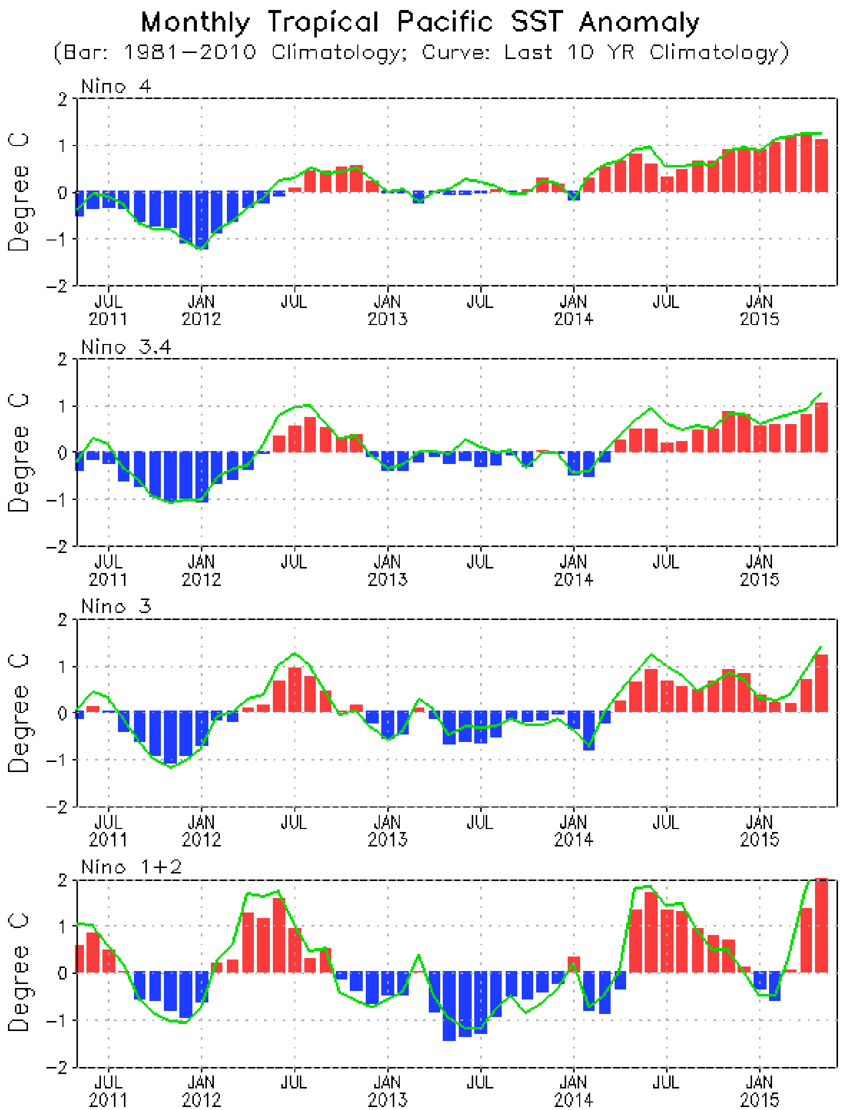
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

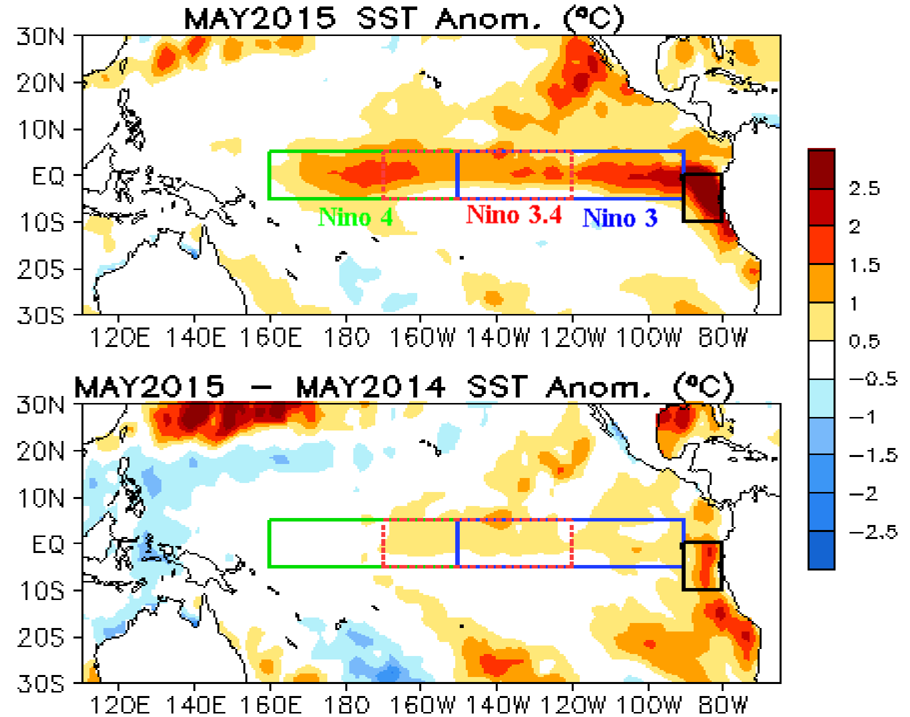
Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) Anomalies



- **Positive SSTA presented in the central-eastern equatorial Pacific in May 2015.**
- **Positive HC300 anomalies initiated in Dec. 2014, and propagated eastward then largely became stationary since Feb 2015, consistent with ocean surface current and subsurface ocean temperature anomalies.**
- **Low-level westerly wind anomalies were dominated in the past 3-4 months.**

Evolution of Pacific NINO SST Indices





- **All NINO indices were positive and strengthened (or persisted for Nino4) in May 2015.**

- **Nino3.4 slightly strengthened and = 1.0°C in May 2015.**

- **Compared with last May, the central and eastern equatorial Pacific as well as the central and southern American coast were warmer in May 2015.**

- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

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

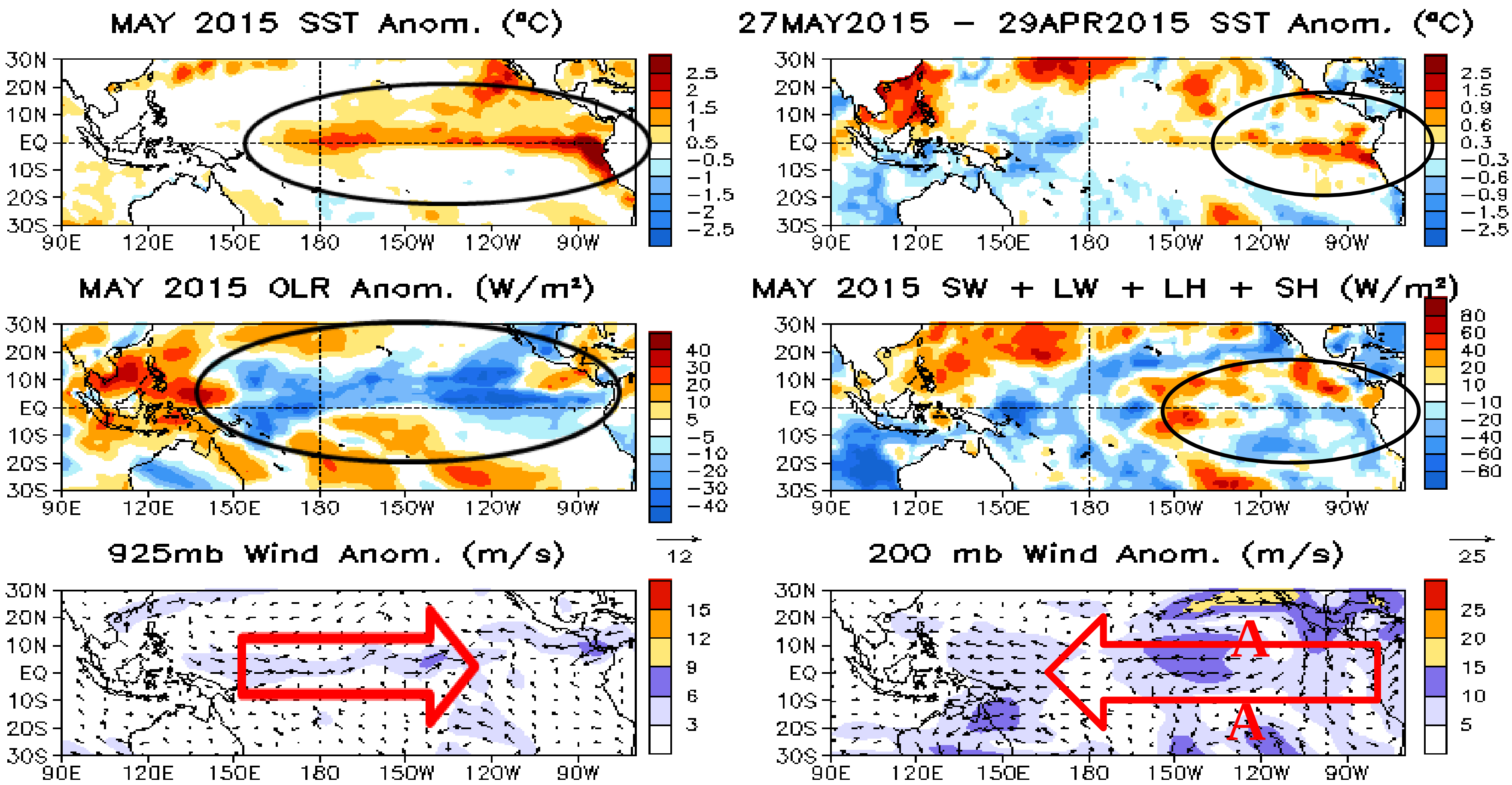
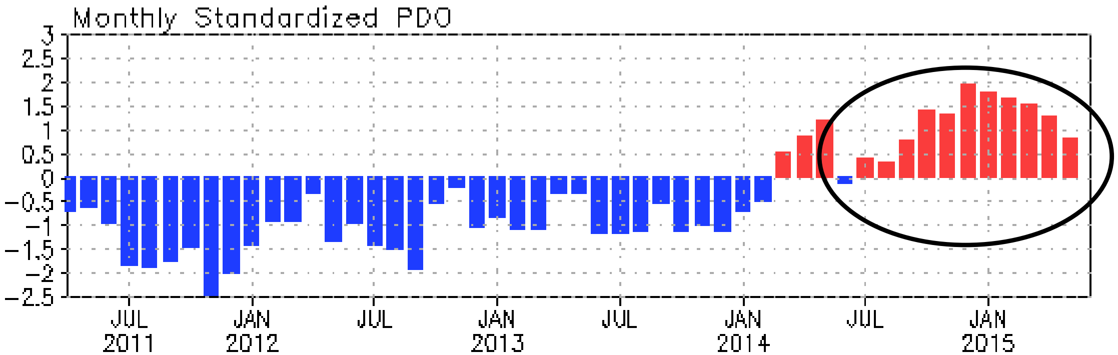
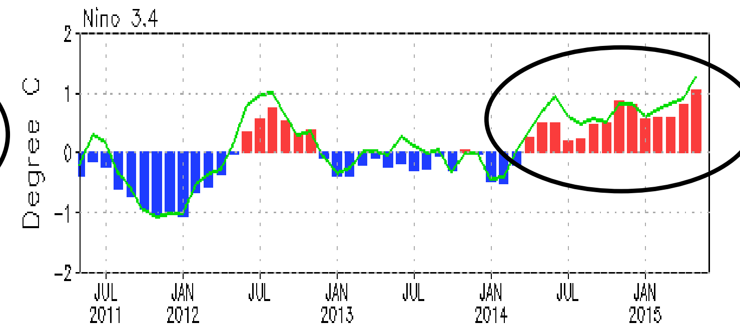


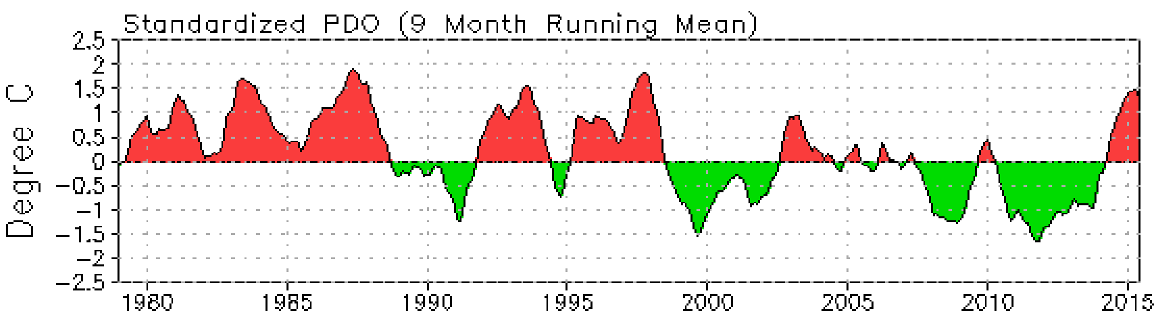
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

North Pacific & Arctic Oceans

PDO index

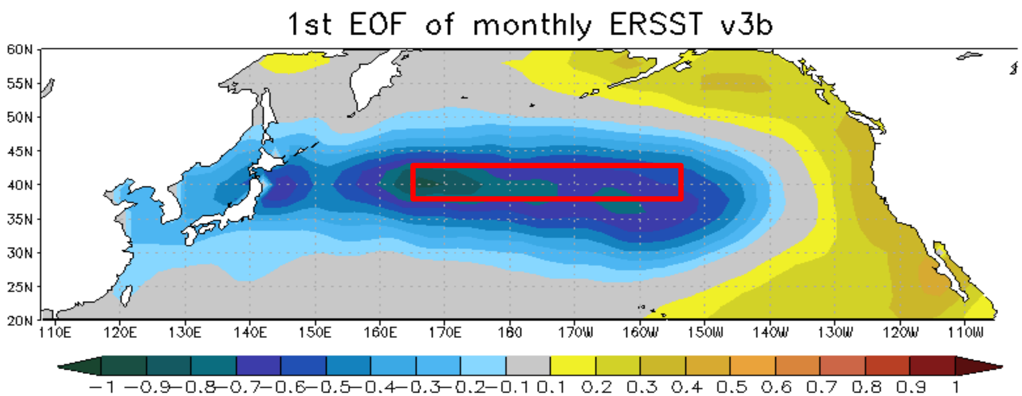






- The positive phase of PDO has persisted 11 months since Jul 2014 and weakened with PDO index =0.8 in May 2015.

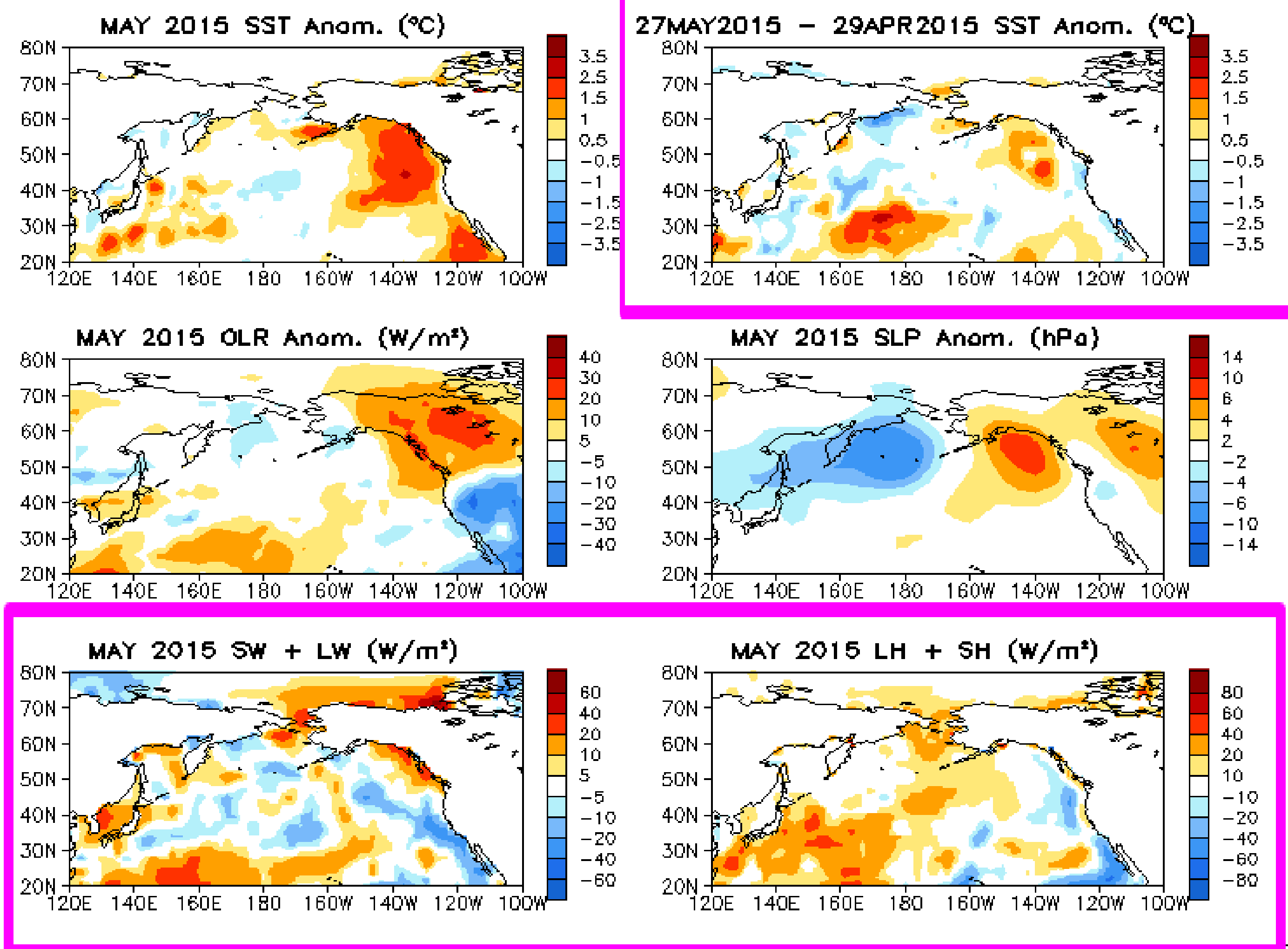
- Statistically, ENSO leads PDO by 3-4 months, may through atmospheric bridge.



- 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.

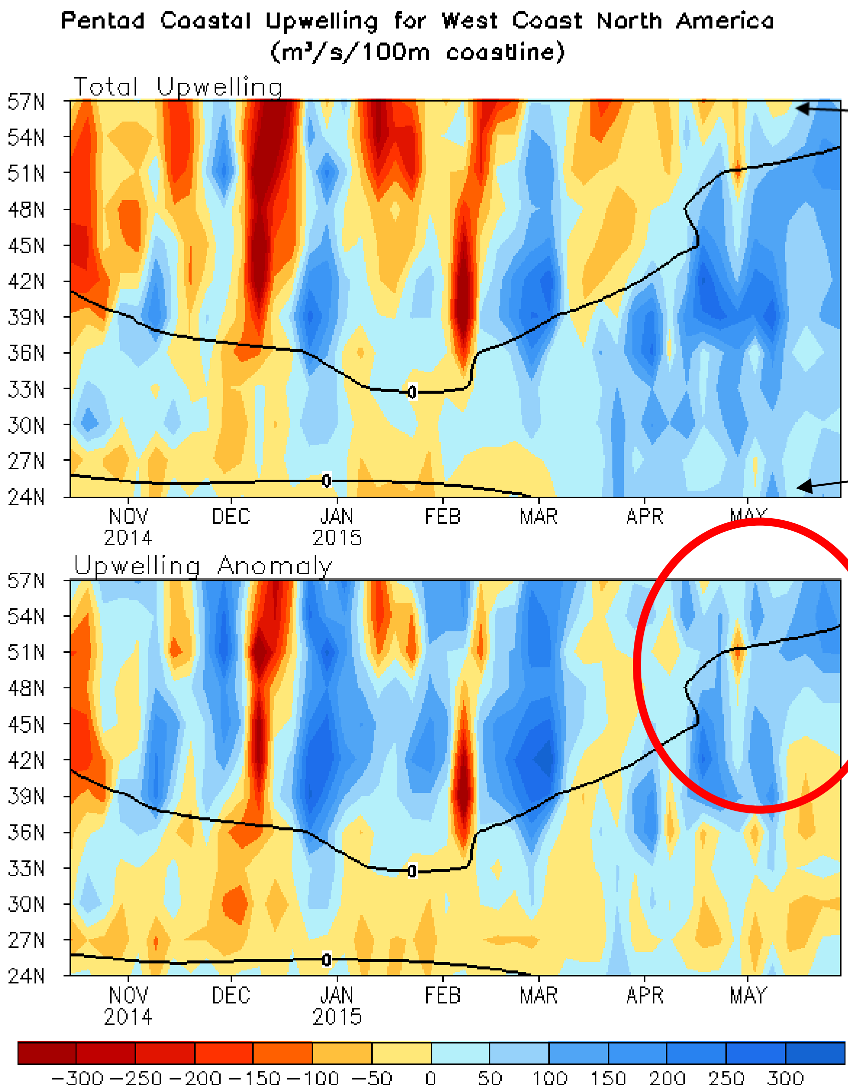
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

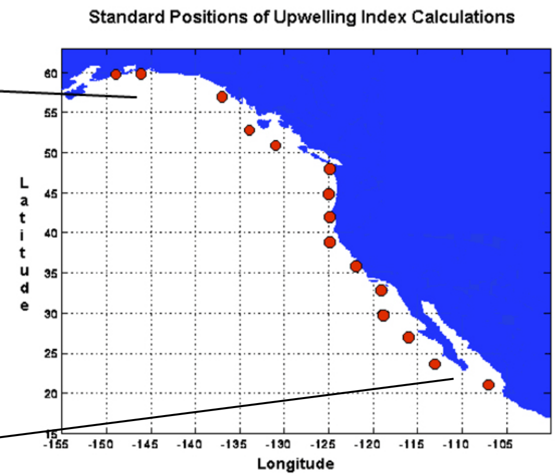


- **Positive SSTA presented in the NE Pacific, consistent with the positive phase of PDO (previous slide).**
- **The SSTA tendency was partially driven by heat flux.**

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.

North America Western Coastal Upwelling





- Anomalous upwelling was observed in mid and high-latitudes in Apr-May 2015.

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.

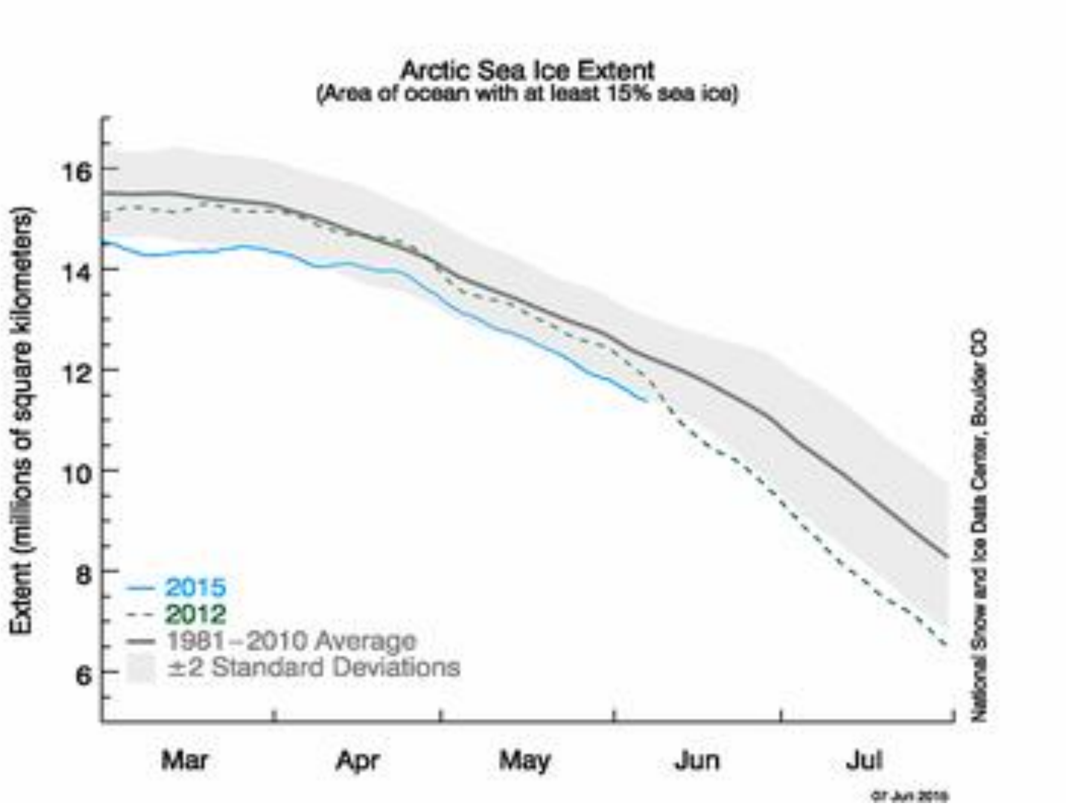
- Area below (above) black line indicates climatological upwelling (downwelling) season.

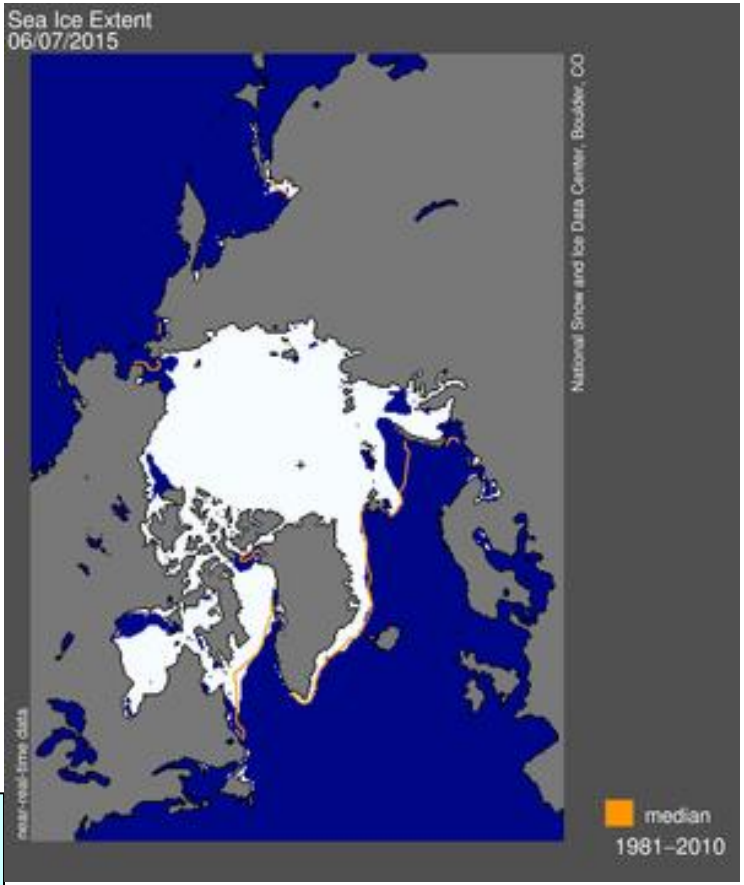
- Climatologically upwelling season progresses from Mar to Jul along the west coast of North America from 36°N to 57°N.

Arctic Sea Ice

National Snow and Ice Data Center

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



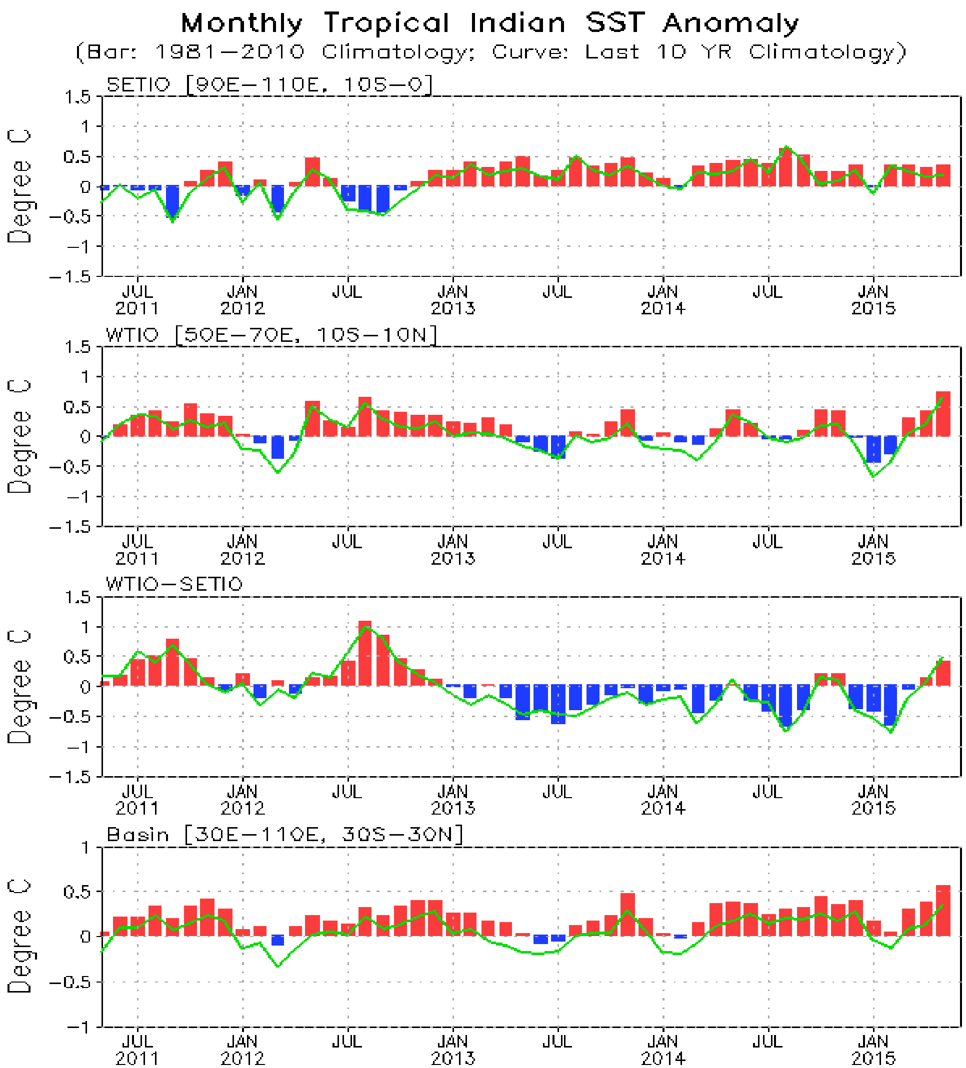


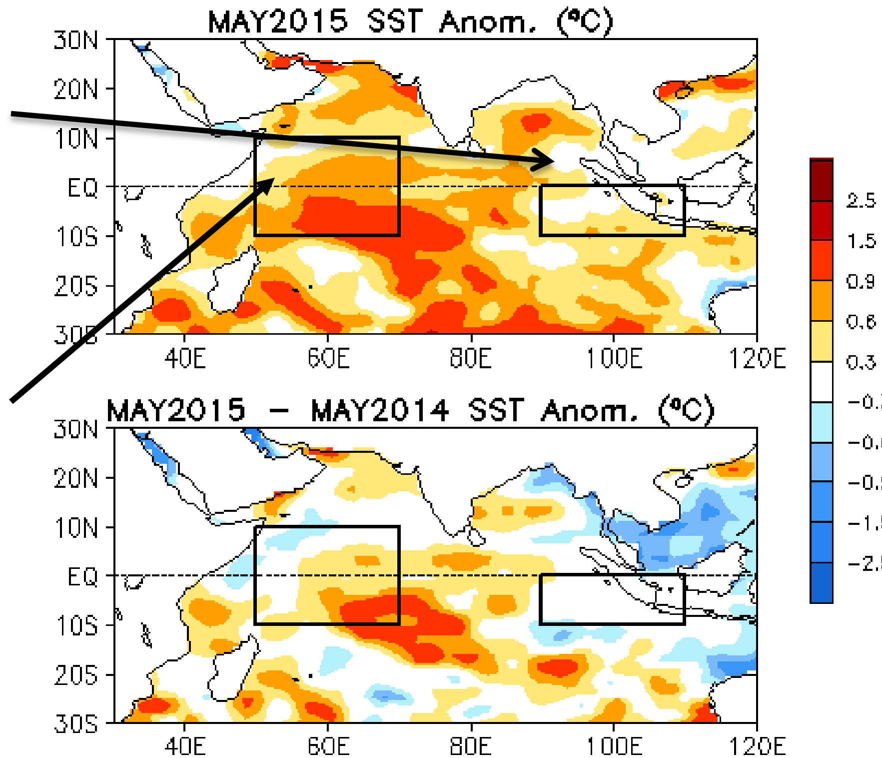
- **Arctic sea ice extent was below normal in May 2015 and near -2 standard deviations.**

- **"Melt season is underway, and sea ice in the Arctic is retreating rapidly. At the end of May, ice extent was at daily record low levels."**

Indian Ocean

Evolution of Indian Ocean SST Indices



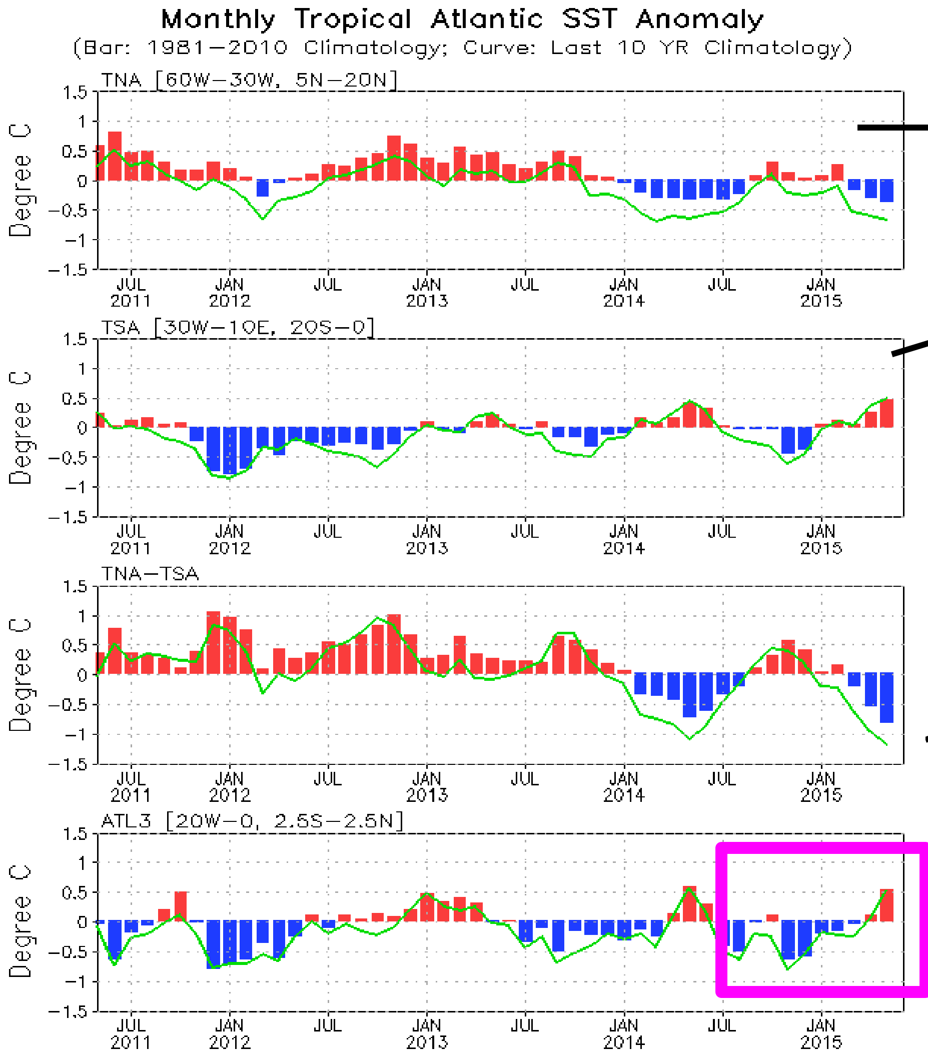


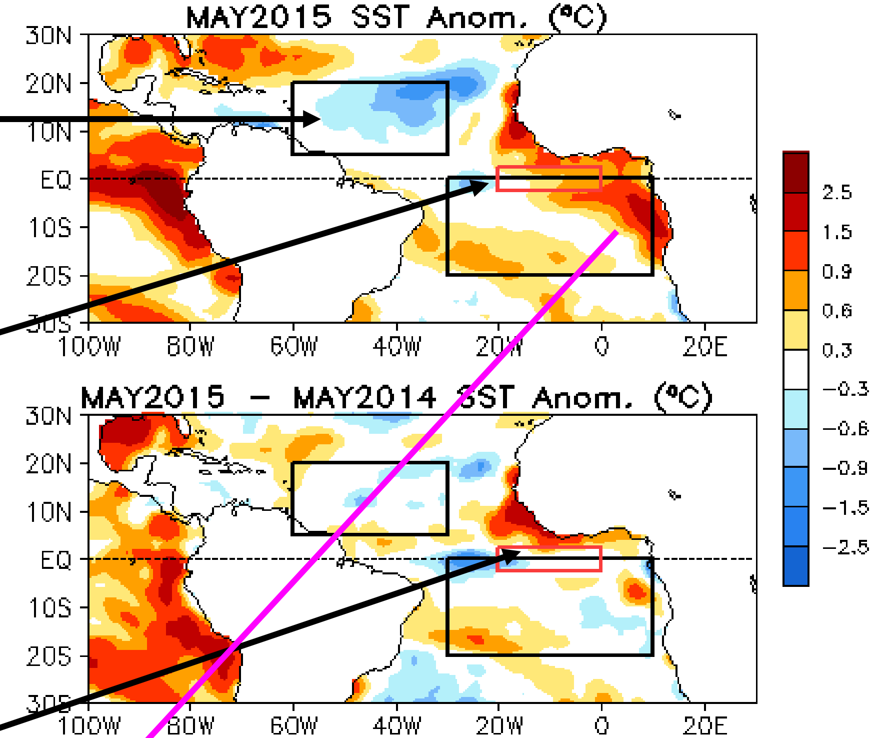
- **Positive SSTA was in the whole Indian Ocean.**
- **DMI shifted to positive phase since Apr 2015 and strengthened in May 2015.**

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

Evolution of Tropical Atlantic SST Indices

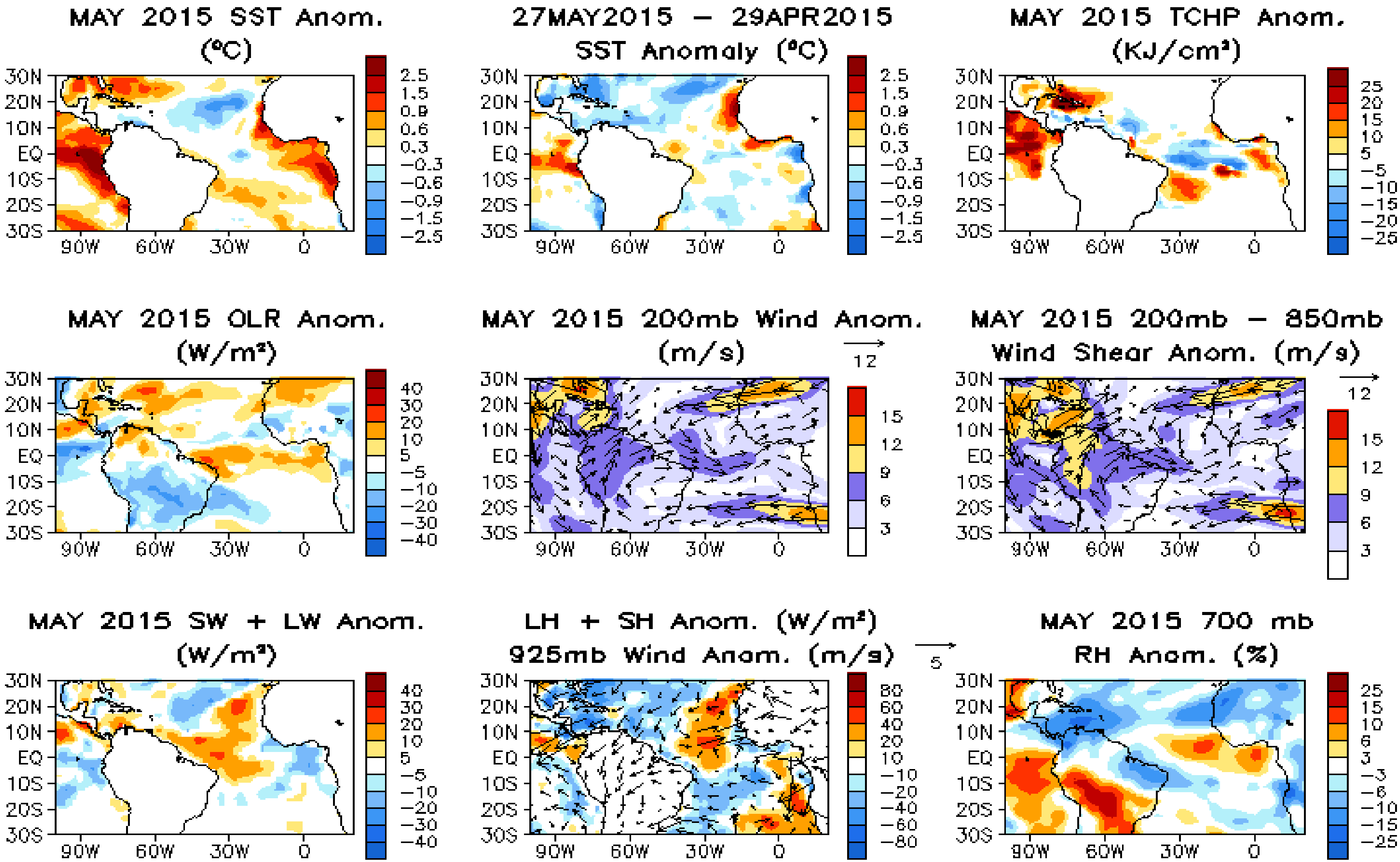




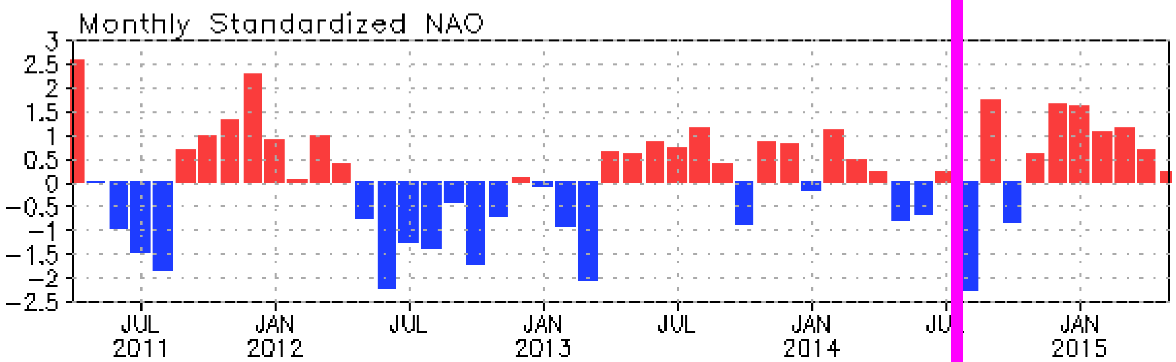
- Cooling persisted in the NE Atlantic (MDR).
- Warming in the SW African coast (the Benguela Niños) sometime may trigger an Atlantic Nino (Hu and Huang 2007: J Climate).
- ATL3 was positive and dipole index was negative.

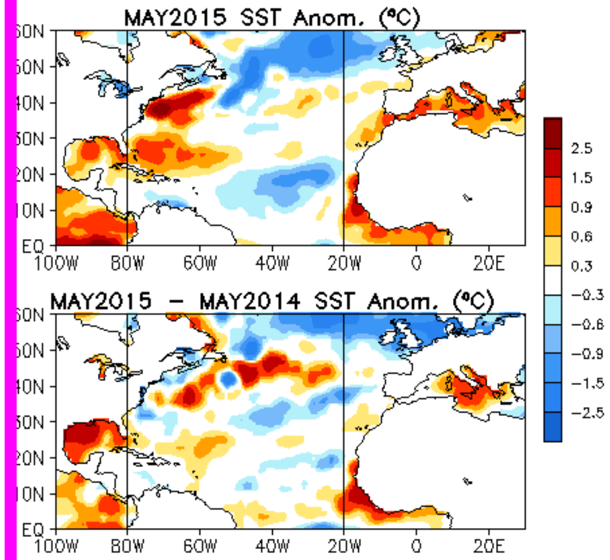
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between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

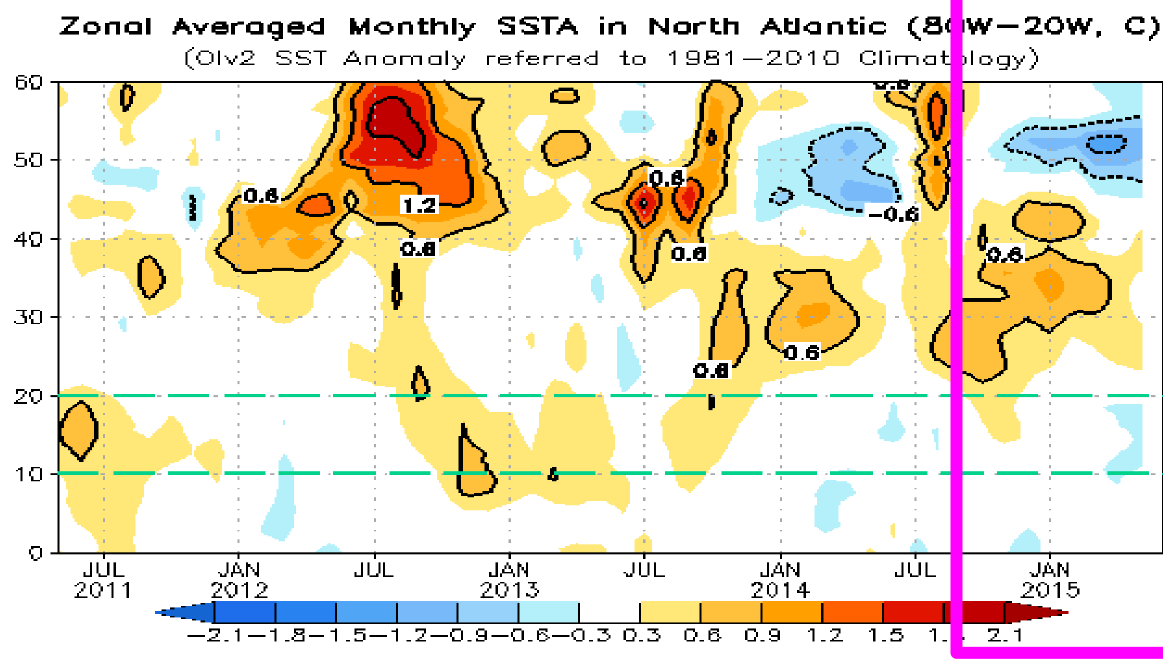
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic







- Positive phase of NAO has persisted 7 months and weakened with NAOI=0.2 in May 2015.
- SSTA was a horseshoe-like pattern, which was due to the persistent positive phase of NAO.

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

- SSTA tendency showed a horseshoe-like pattern, which was driven by heat flux due to the persistent positive phase of NAO.

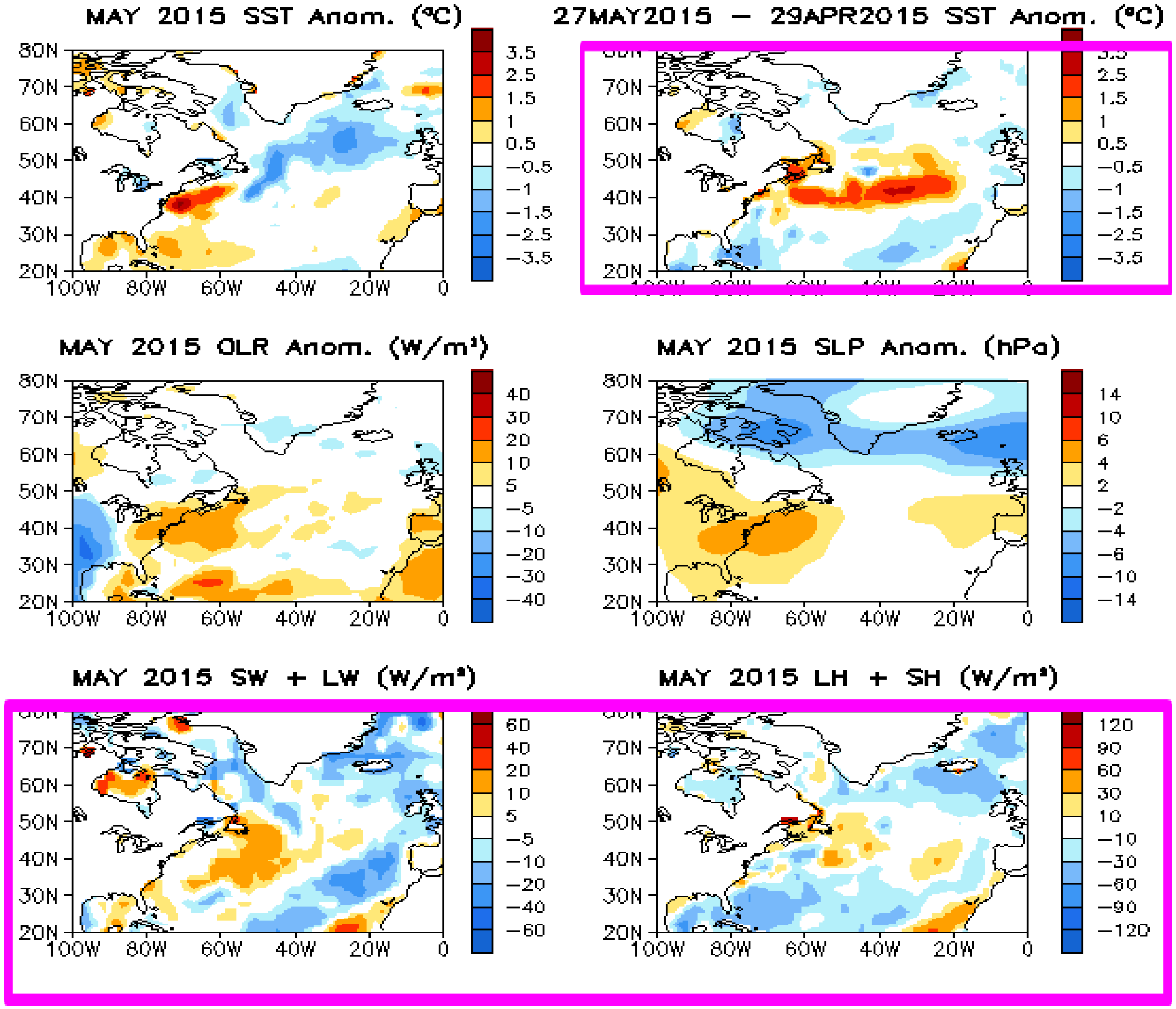
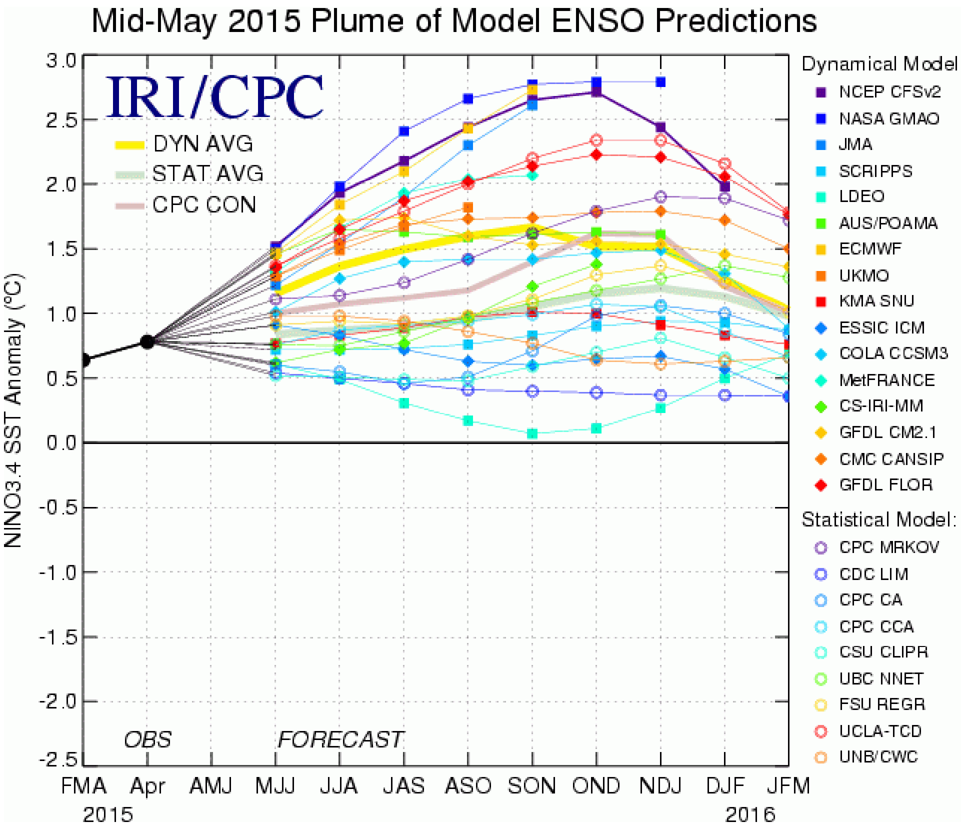
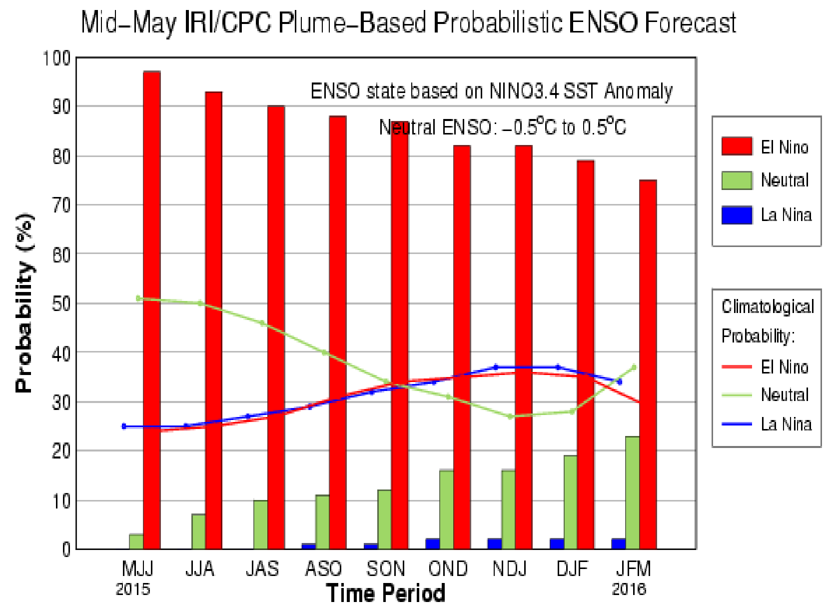


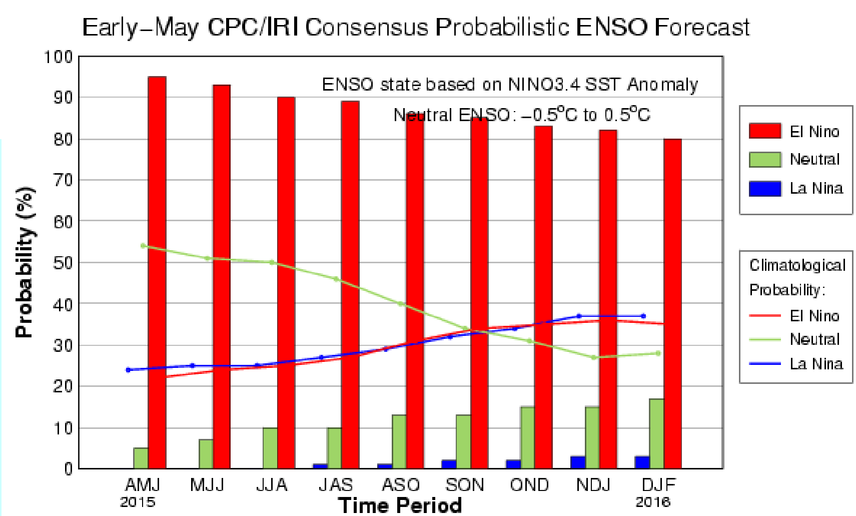
Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum

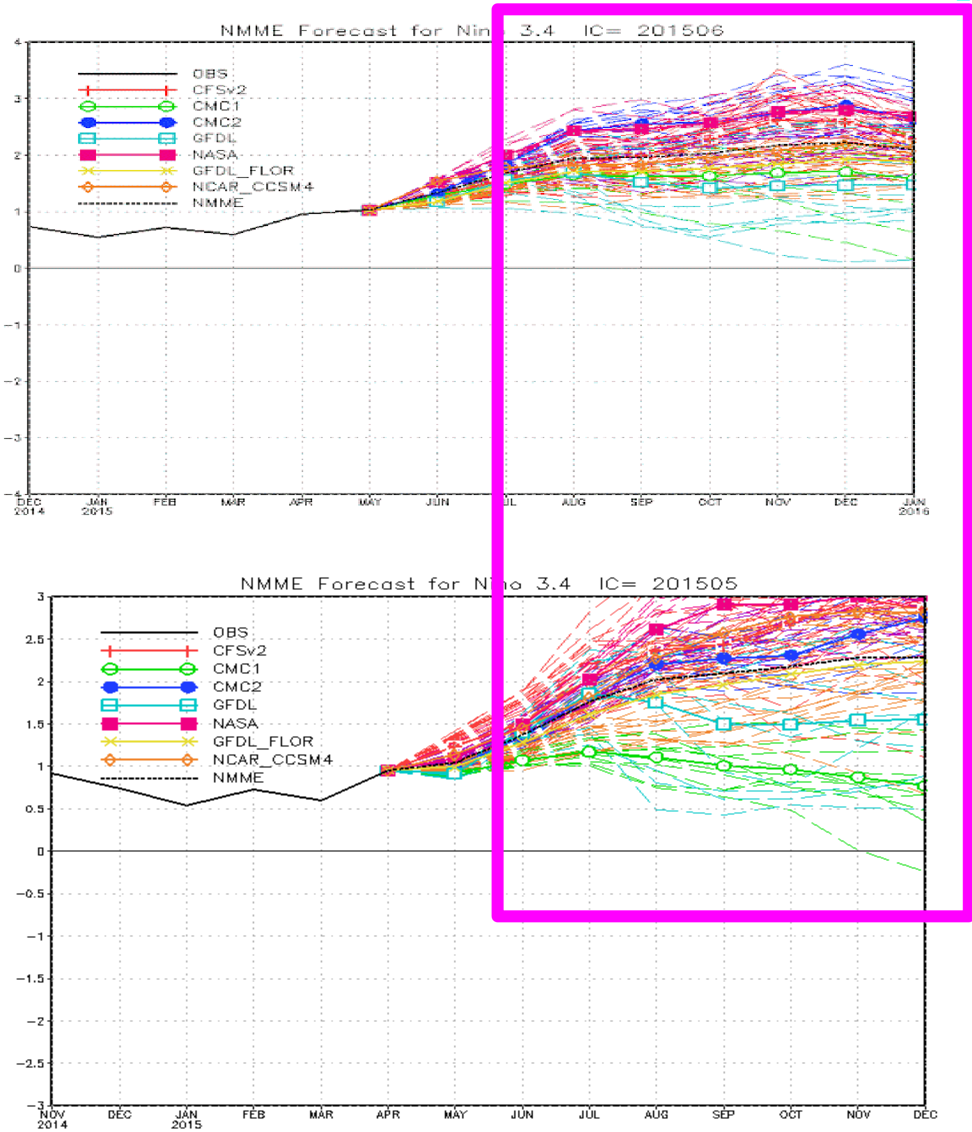


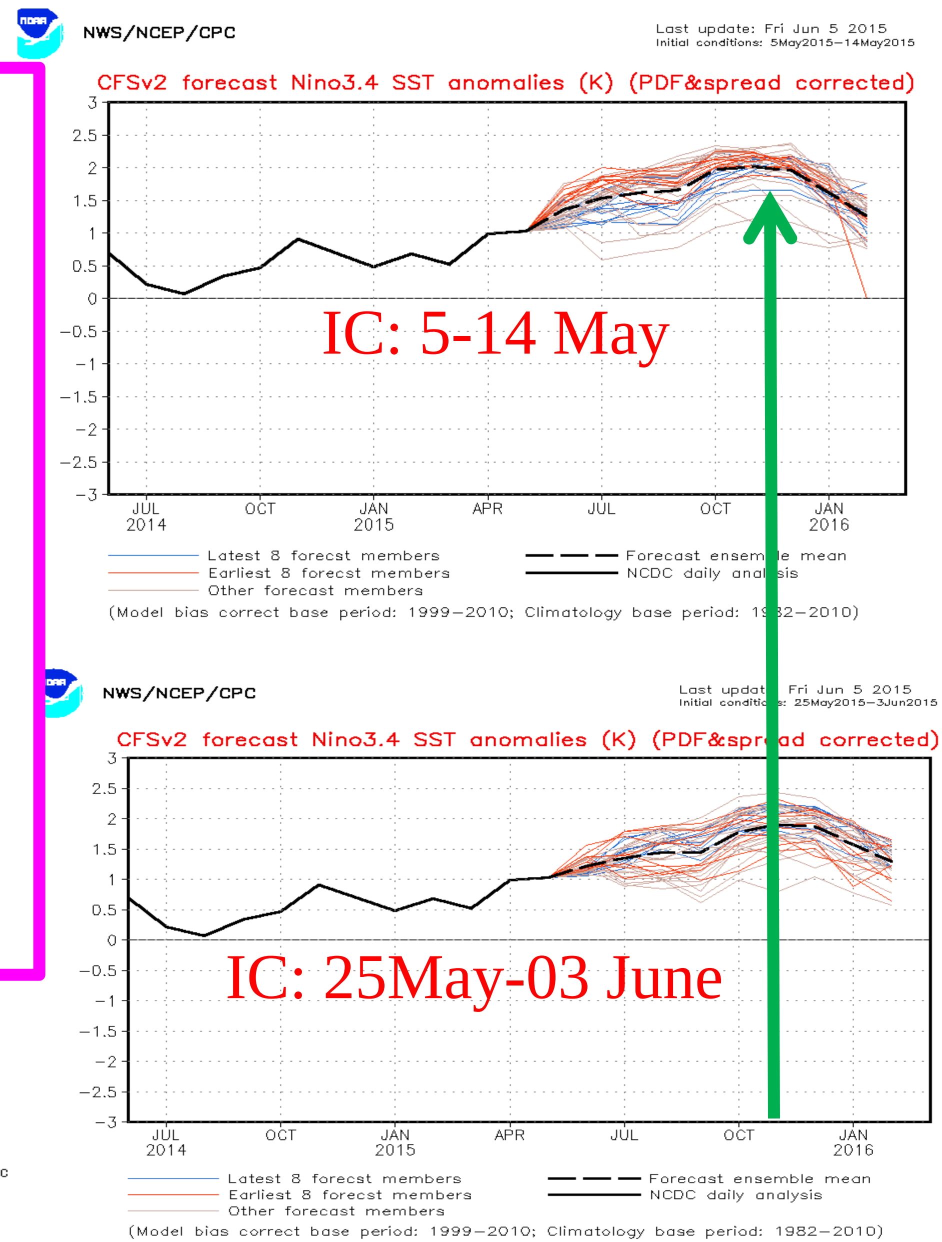




- **Majority of models predicted an El Nino in 2015, and some predicted a strong El Nino and a few favored ENSO neutral conditions in 2015.**
- **NOAA "ENSO Diagnostic Discussion" on 14 May 2015 suggested that "***There is an approximately 90% chance that El Niño will continue through Northern Hemisphere summer 2015, and a greater than 80% chance it will last through 2015.***"**

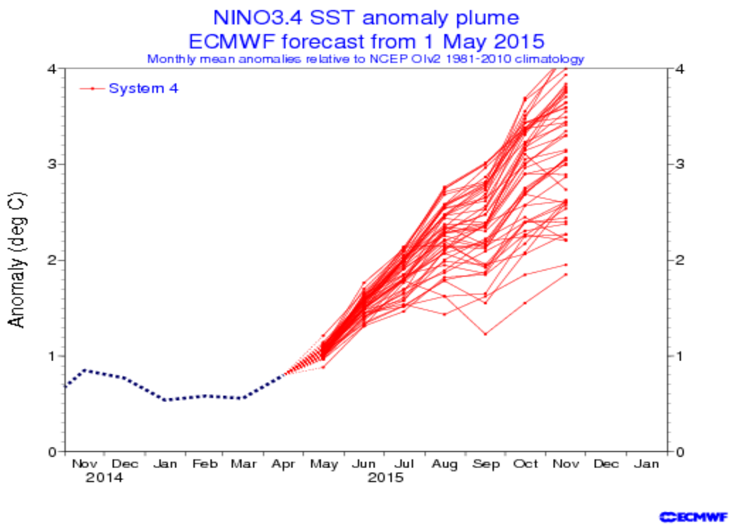
NMME & CFSv2


NMME Forecast for Nino 3.4 IC= 201506
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
DEC 2014
JAN 2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN 2016
NMME Forecast for Nino 3.4 IC= 201505
NOV 2014

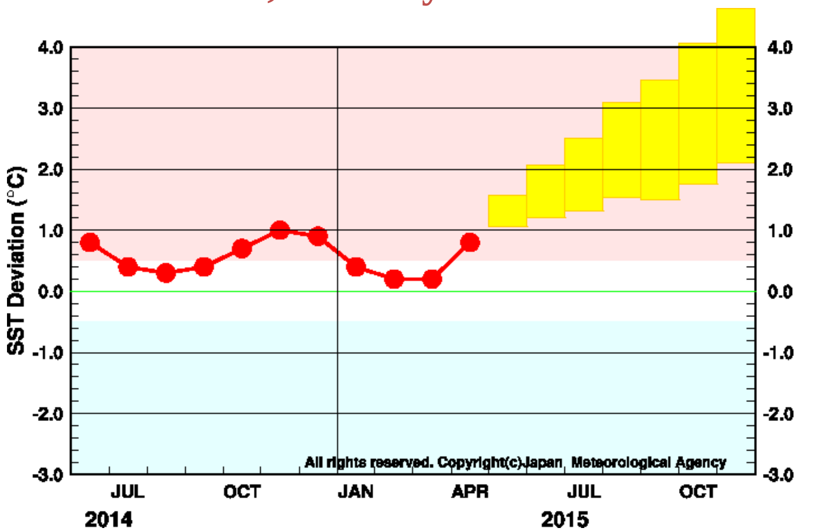

NWS/NCEP/CPC
Last update: Fri Jun 5 2015
Initial conditions: 5May2015–14May2015
CFSv2 forecast Nino3.4 SST anomalies (K) (PDF&spread corrected)
IC: 5-14 May
JUL 2014
OCT
JAN 2015
APR
JUL
OCT
JAN 2016
Latest 8 forecst members
Earliest 8 forecst members
Other forecast members
Forecast ensemble mean
NCDC daily analysis
(Model bias correct base period: 1999–2010; Climatology base period: 1982–2010)
NWS/NCEP/CPC
Last update: Fri Jun 5 2015
Initial conditions: 25May2015–3Jun2015
CFSv2 forecast Nino3.4 SST anomalies (K) (PDF&spread corrected)
IC: 25May-03 June

Individual Model Forecasts: strong warming or little tendency

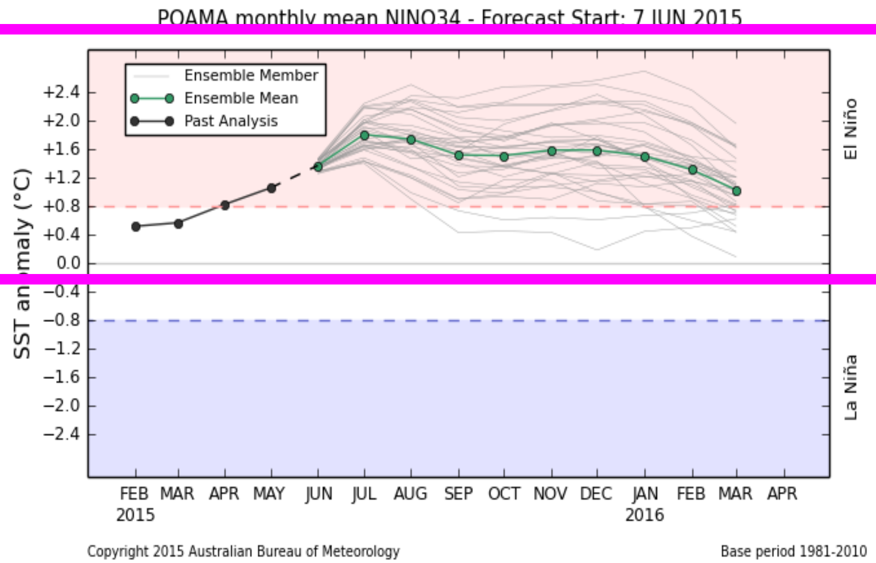
EC: Nino3.4, IC=01 May 2015



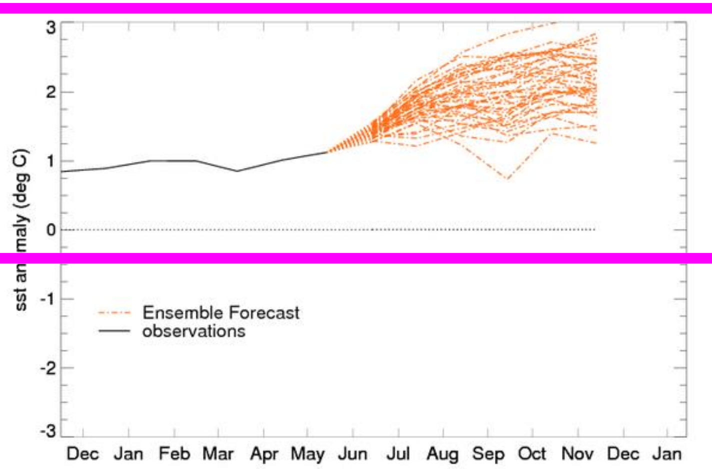
JMA: Nino3, IC=May2015



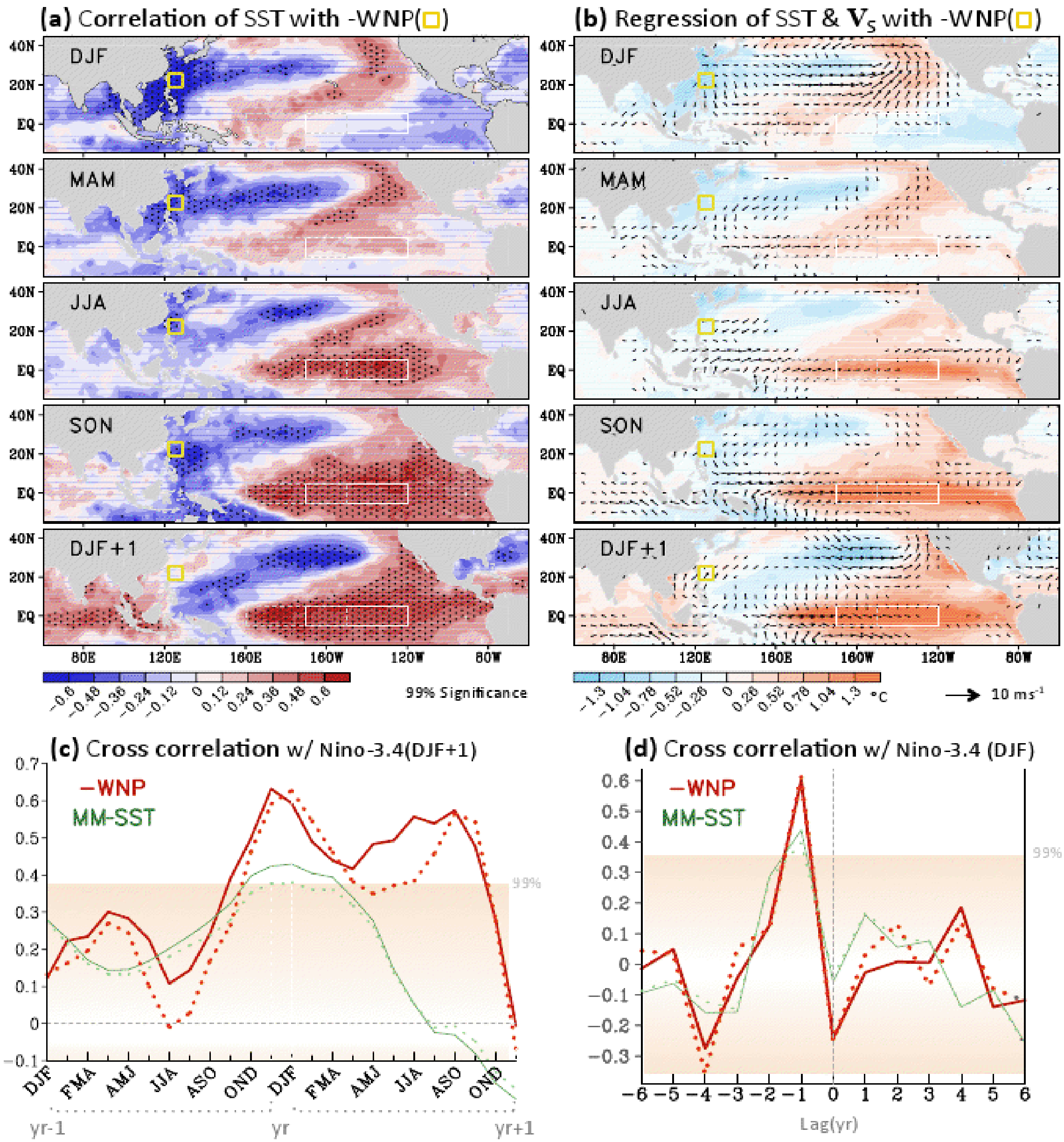
Australia: Nino3.4, IC=7 June 2015



UKMO: Nino3.4, IC=June 2015



Western North Pacific Variability and ENSO



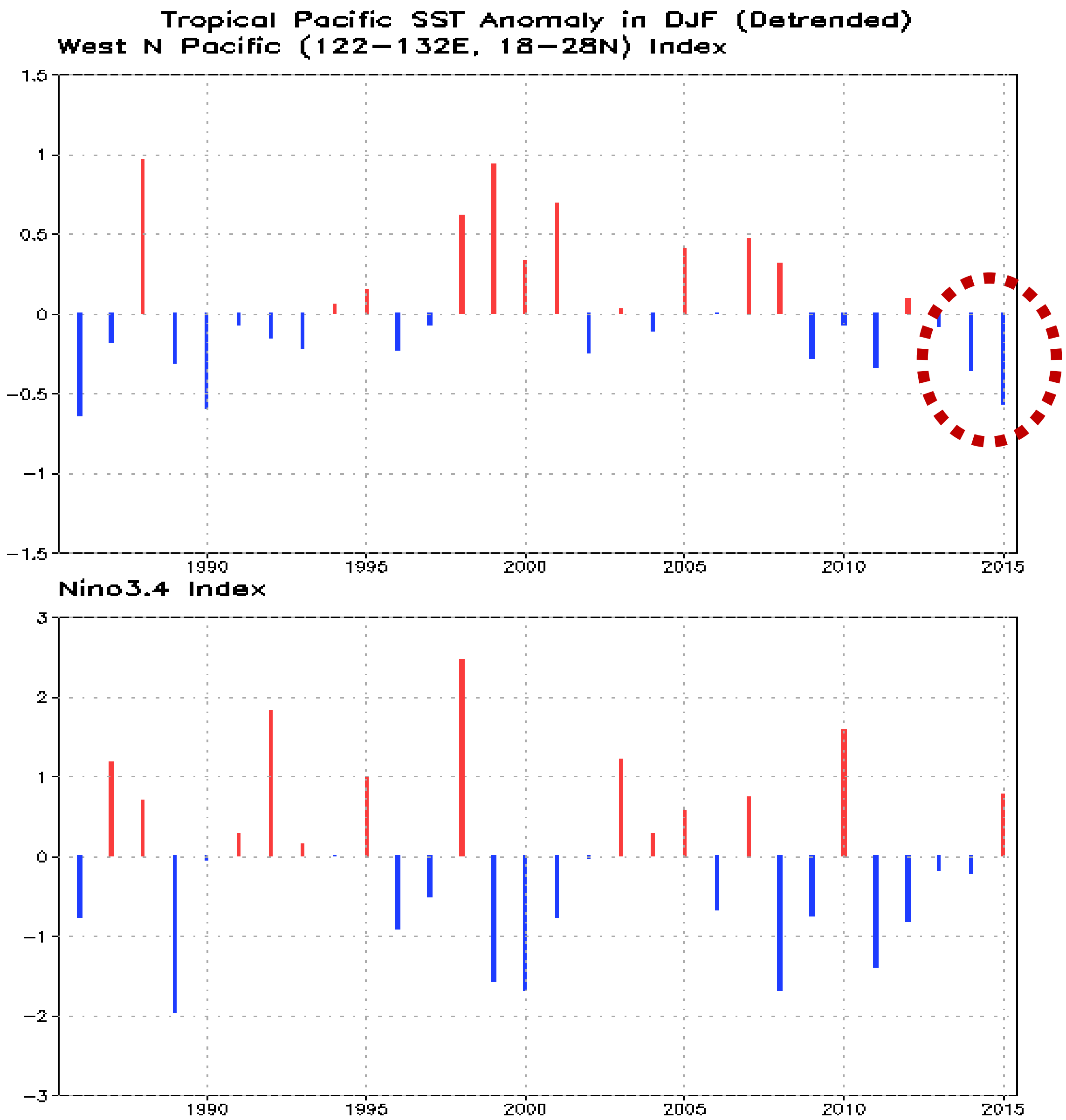
(a)DJF Cooling over the WNP is followed by a warming in the equatorial Pacific in next winter

(b)The correlation between WNP and ENSO is higher than that between meridional mode and ENSO.

(c) The frequency of WNP variability is higher than ENSO.

From:

Wang, S.-Y., M. L'Heureux, and H.-H. Chia, 2012: ENSO Prediction One Year in Advance Using Western North Pacific Sea Surface Temperatures. GRL, 39, L05702. DOI: 10.1029/2012GL050909.

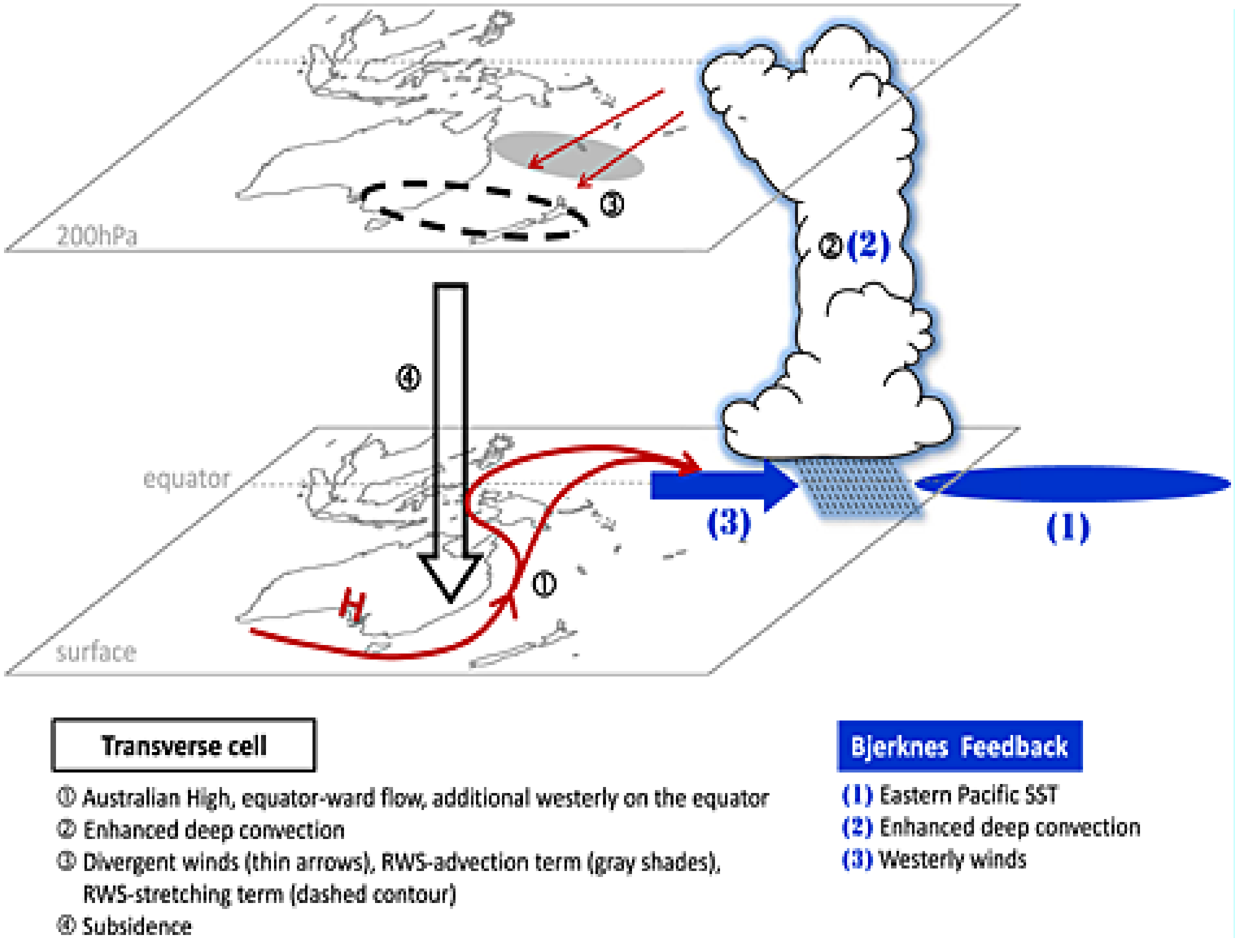


WNP and Nino3.4 indices:

2014/15DJF WNP index was negative (≈-0.6), predicting an El Nino event in 2015/16.

An index to monitor if a strong El Nino occurs

(Hong, L.-C., Lin Ho and F.-F. Jin, 2014: A Southern Hemisphere Booster of Super El Niño. GRL, 41 (6), 2142-2149)



Positive Feedbacks:

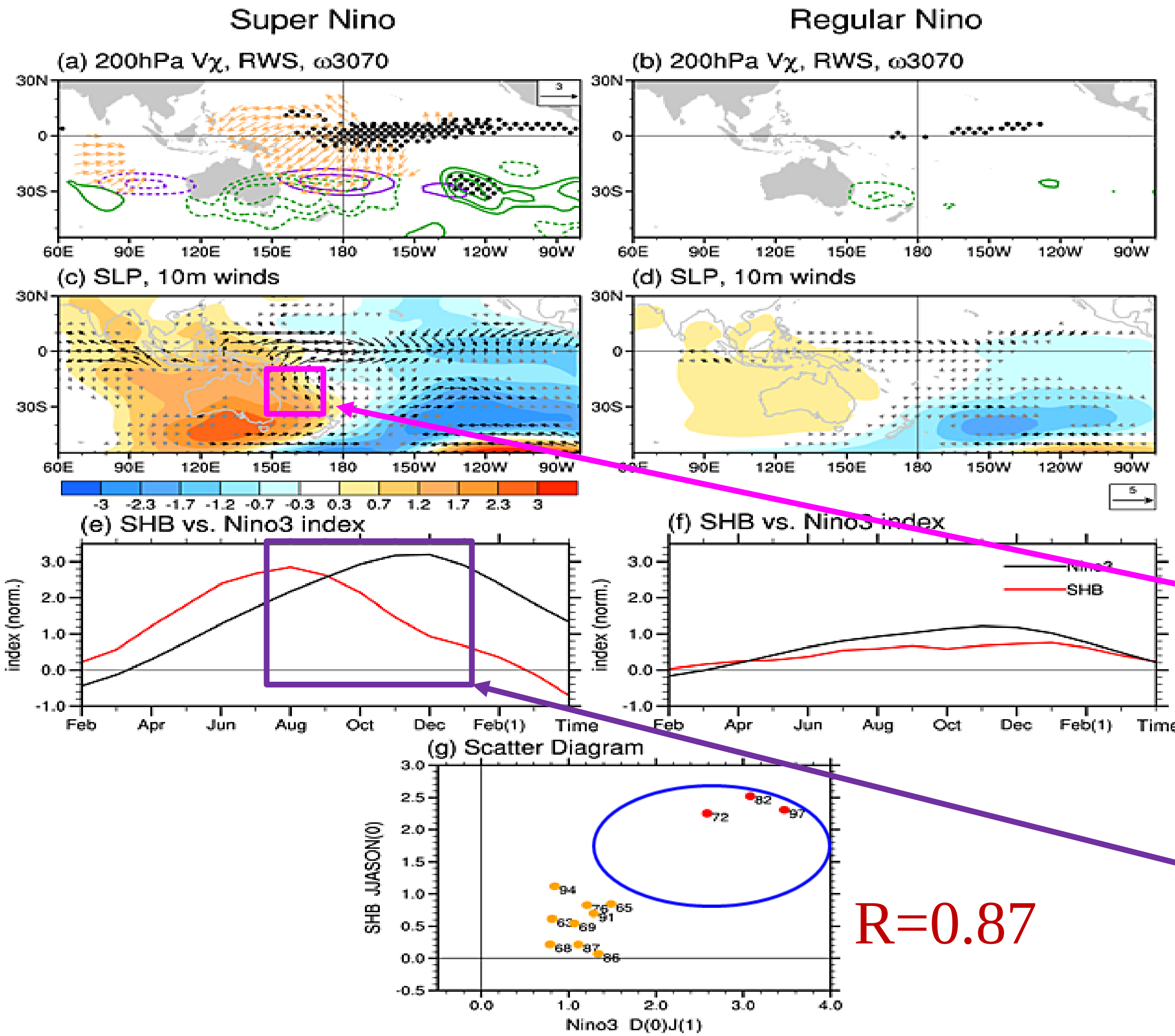
Enhanced convections over the central equatorial Pacific (anomalous divergence at 200 hPa)

-> Strengthening subsidence and the Australian High (equator-ward low-level wind)

-> Intensifying low-level westerly winds along the equator and the Bjerknes feedback

-> developing super El Nino.

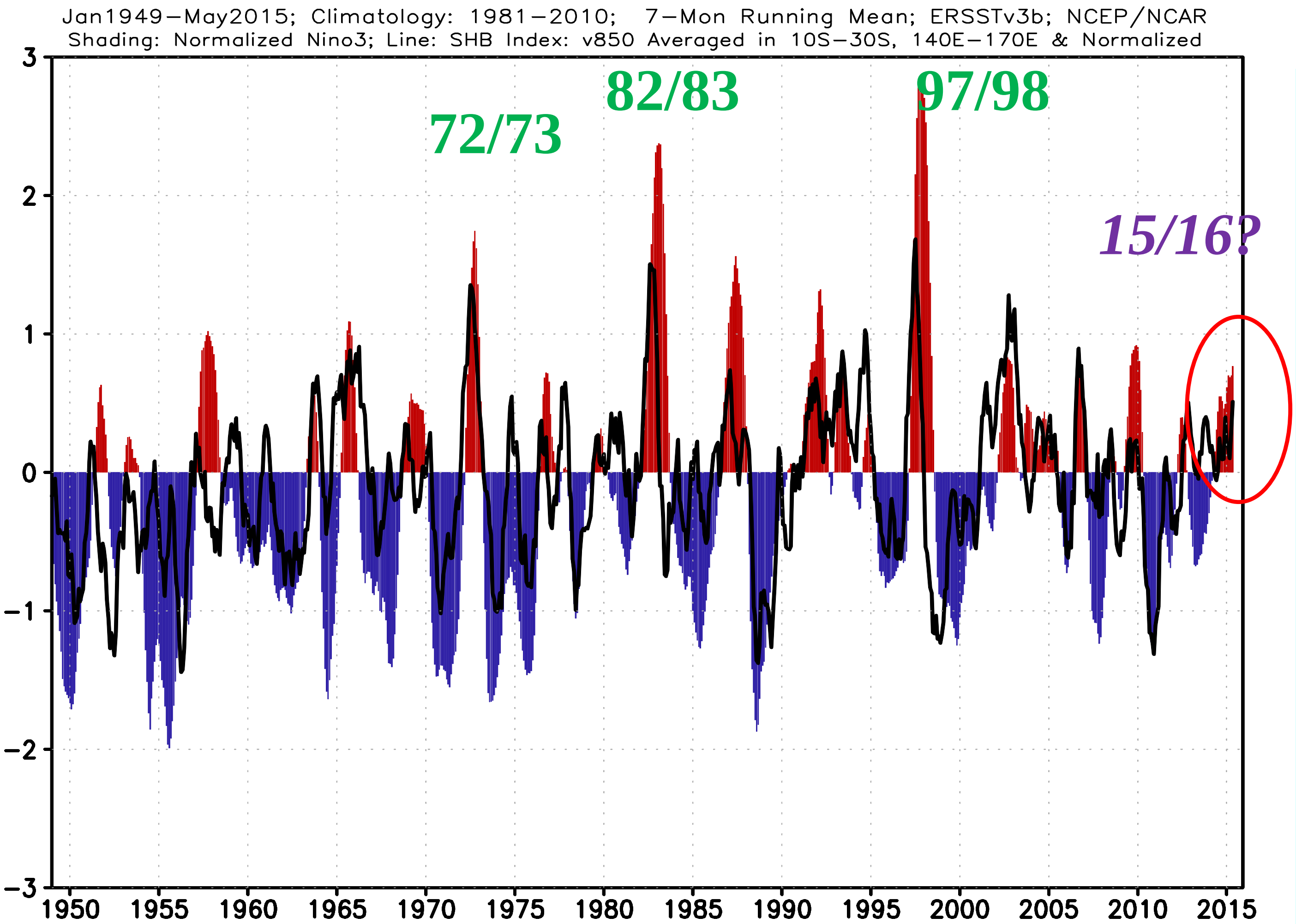
Fig. 4. Schematic diagram of super El Niño development, illustrating how a transverse cell with main features in the SH (marked by numbers inside open circles) interacts with the Bjerknes feedback regime in the central equatorial Pacific (depicted by large blue numbers in parentheses).



- *1972/73, 1982/83, 1997/98 super El Nino composite (left) and 9 regular El Nino (1952-2010) composite (right).*
- *HadISST & ERA40: ; 1958-2001 climatology; 6 mon-8 yr band pass filter.*
- *GFDL-ESM2M 500 yr free run also used.*
- **SH booster (SHB) index: v850 averaged over 10°S–30°S, 140°E–170°E and normalized.**
- **JJASON SHB leads Nino3 by 3 months during super El Nino onset/developing stage. SHB > 2 STD in summer-autumn may result in super El Nino in winter.**

Fig. 2. JJASON(0) mean composite maps of (a) anomalous 200 hPa divergent winds (only wind speed >1.1 m/s is shown by vector), 200 hPa Rossby wave source (RWS) in the SH (green denotes RWS induced by vortex stretching and purple denotes RWS caused by advection of vorticity via anomalous divergent winds; contour interval is 1e11 1/s2, and zero contours are omitted), vertical pressure velocity averaged over 300–700 hPa (only upward motion<-0.012 Pa/s is shown by filled dot) and (c) anomalous SLP (shading; hPa), 10m winds (only wind speed>0.4 m/s is shown by vector, and wind speed>0.8 m/s is highlighted in black) for super El Niño composite. (e) Normalized SHB index (red) and normalized Niño-3 index from Feb of the El Niño year to Apr of the following year for super El Niño composite. Fig. 2b, 2d, and 2f are the same as Fig. 2a, 2c, and 2e, respectively, except for regular El Niño composite. (g) Scatter diagram of normalized JJASON(0) mean SHB index against normalized D(0)J(1) mean Niño-3 index for the 12 El Niño events; red denotes super El Niño year and orange denotes regular El Niño year.

(Hong, L.-C., Lin Ho and F.-F. Jin, 2014: A Southern Hemisphere Booster of Super El Niño. GRL, 41 (6), 2142-2149)



- Since last winter, SHB index was positive and increasing.

- Nino3 had positive tendencies in last a few months.

- Based on Hong et al. (2014 GRL), SHB index peaks at August with 3-mon lead to El Nino, so SHB index value in summer is a good indicator to predict if there is a strong El Nino in winter.

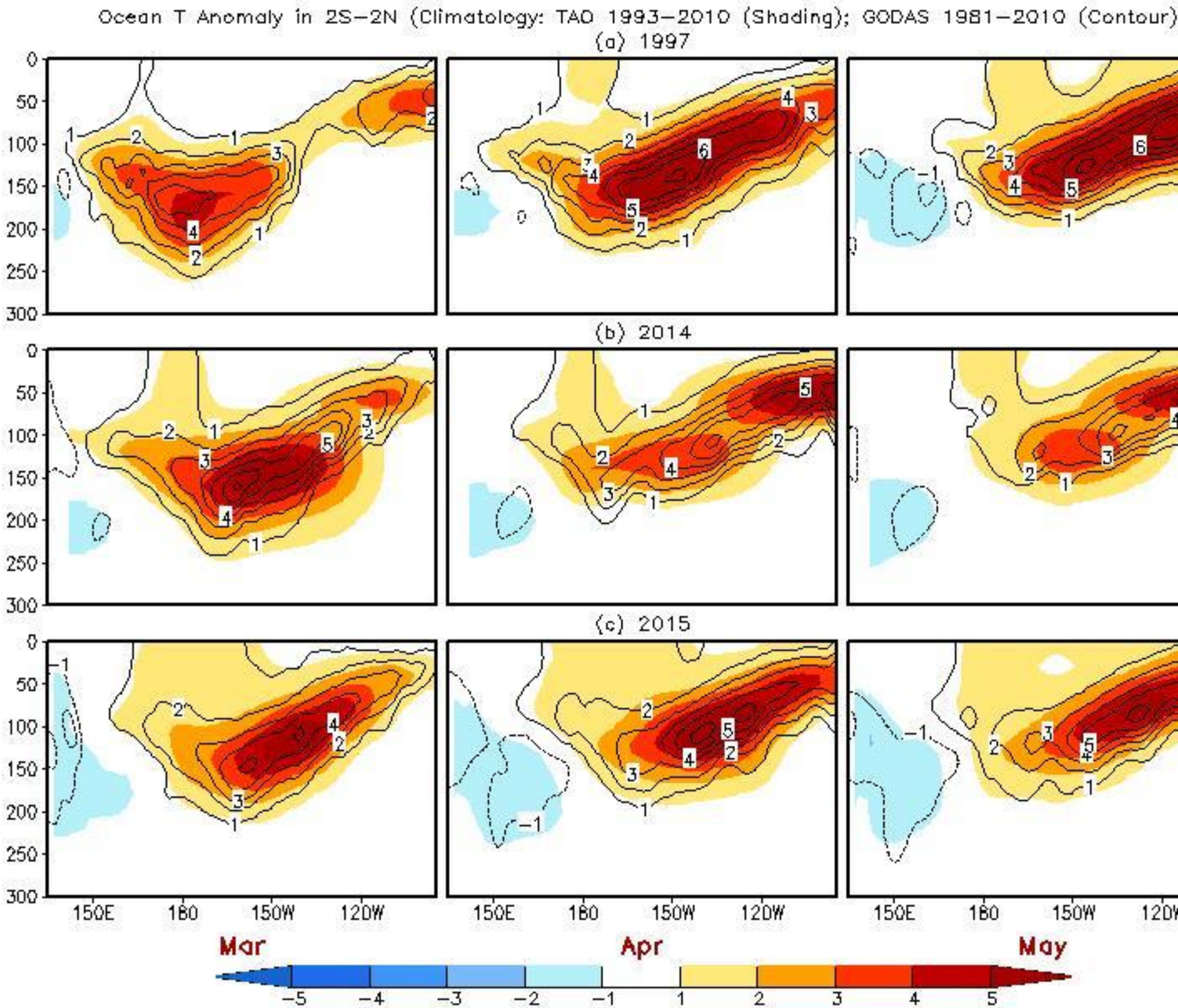
Red/blue shading: normalized Nino3

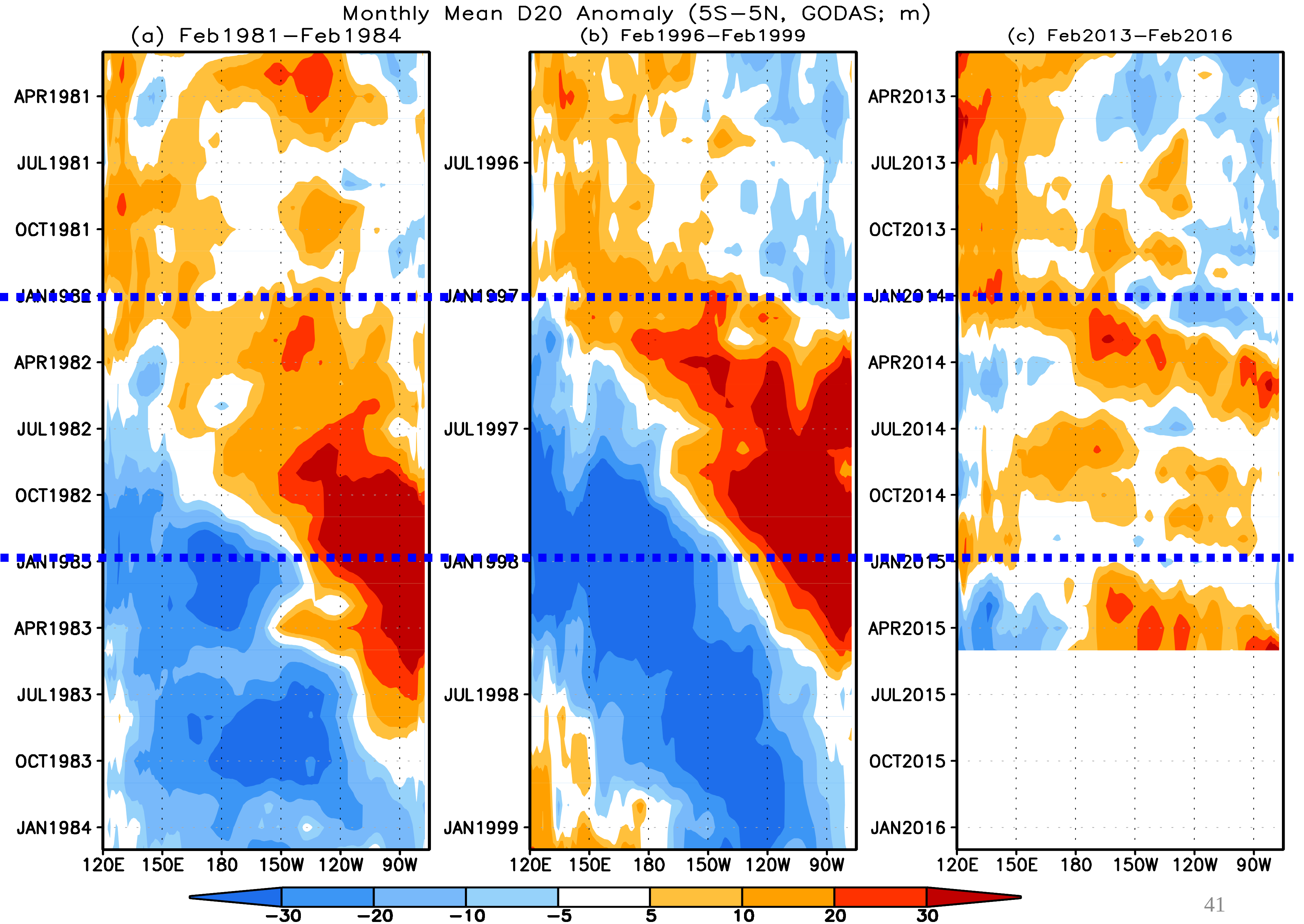
Black line: Southern Hemisphere booster (SHB) index: v850 averaged over 10°S–30°S, 140°E–170°E and normalized

ERSSTv3b and NCEP/NCAR reanalysis: 1981-2010 climatology; 7-month running mean

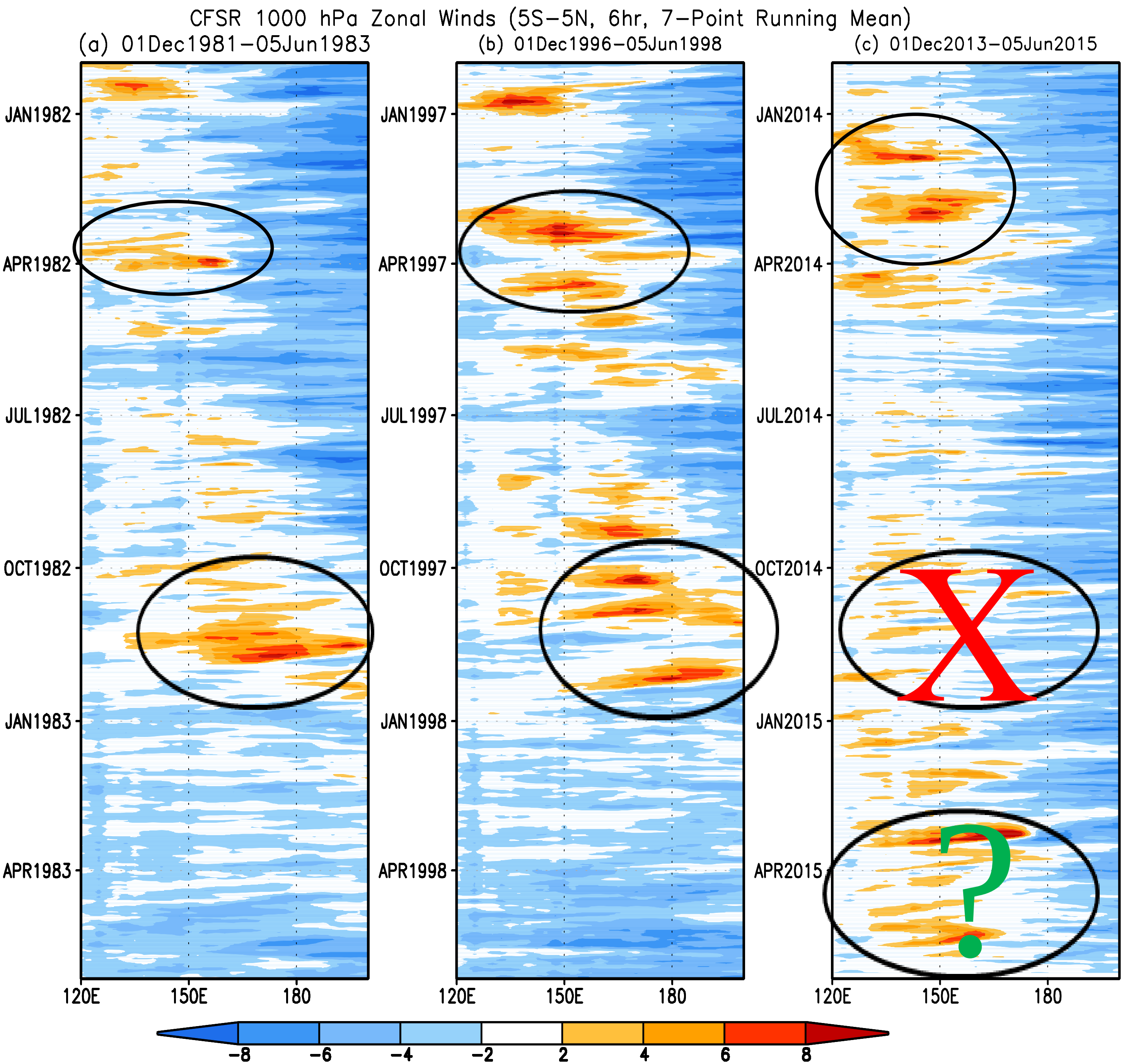
•See: Hong, L.-C., Lin Ho and F.-F. Jin, 2014: A Southern Hemisphere Booster of Super El Niño. GRL, 41 (6), 2142-2149.

Subsurface Ocean T Anomaly in Mar, Apr, and May 1997, 2014, 2015





Monthly Mean D20 Anomaly (5S–5N, GODAS; m)
(a) Feb1981–Feb1984
(b) Feb1996–Feb1999
(c) Feb2013–Feb2016
APR1981
JUL1981
OCT1981
JAN1982
APR1982
JUL1982
OCT1982
JAN1983
APR1983
JUL1983
OCT1983
JAN1984
JUL1996
JAN1997
JUL1997
JAN1998
JUL1998
JAN1999
APR2013
JUL2013
OCT2013
JAN2014
APR2014
JUL2014
OCT2014
JAN2015
APR2015
JUL2015
OCT2015
JAN2016
120E 150E 180 150W 120W 90W
−30 −20 −10 −5 5 10 20 30



U1000

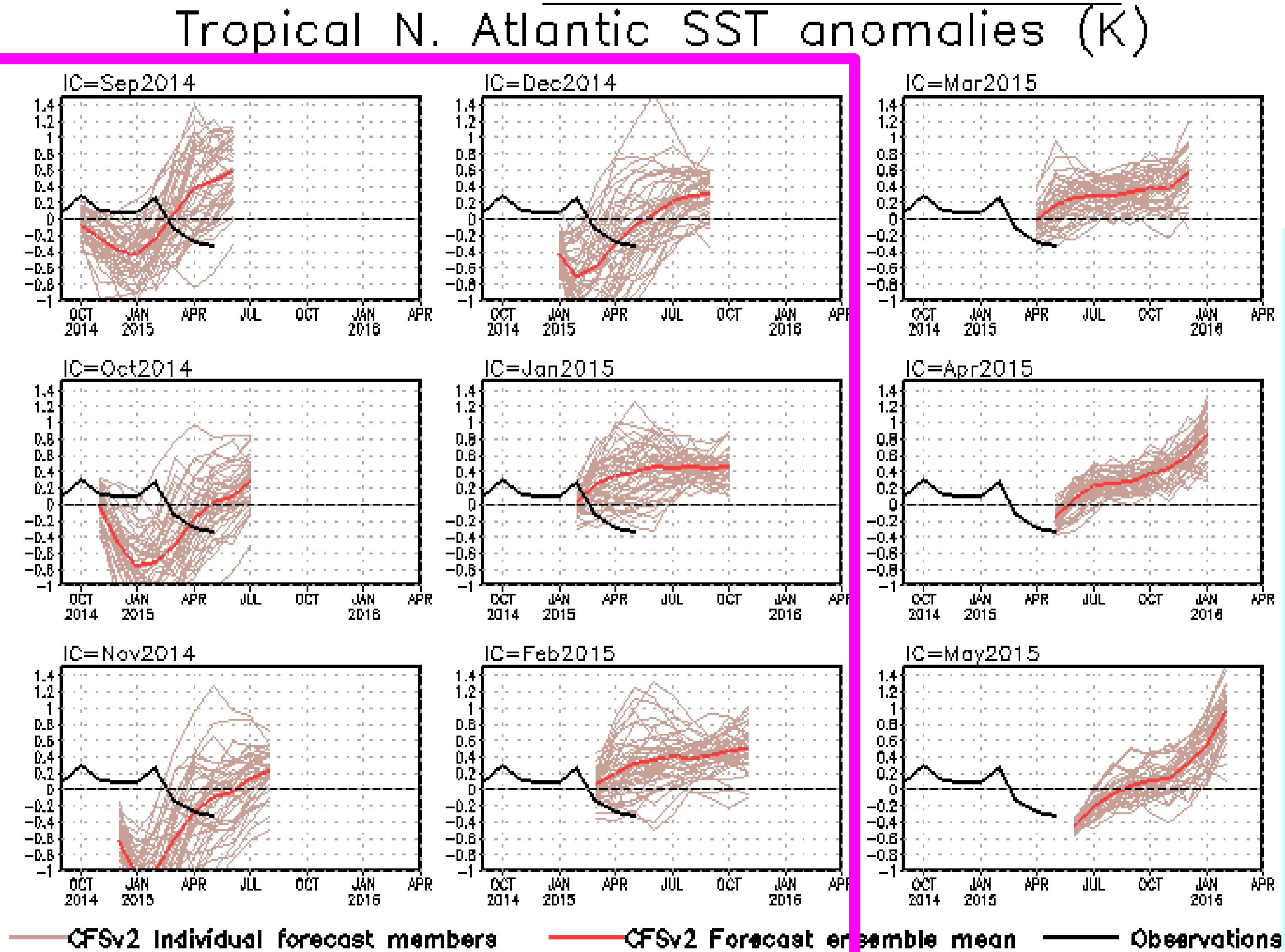
Anomaly in

1982-83,

1997-98,

2014-15

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].

- Predictions initiated in Oct-Dec 2004 may be biased by errors in the Atlantic in CFSR.
- Latest CFS2 prediction calls a warming tendency in North Atlantic during summer-winter 2015.

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.

Overview

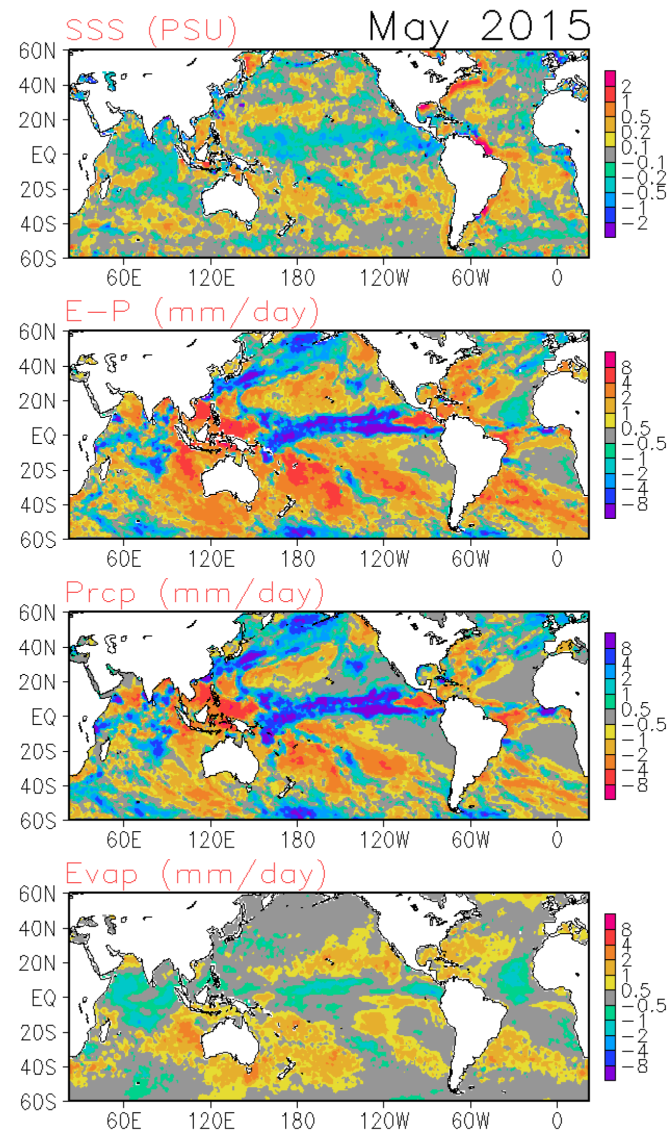
- **Pacific Ocean**
  - **NOAA “ENSO Diagnostic Discussion” on 15 May 2015 suggested “There is an approximately 90% chance that El Niño will continue through Northern Hemisphere summer 2015, and a greater than 80% chance it will last through 2015.”**
  - **Majority of models predicted an El Nino in 2015, and some predicted a strong El Nino and a few favored ENSO neutral conditions in 2015.**
  - **Positive SSTAs were observed in the central and eastern tropical Pacific and strengthened in the eastern Pacific with NINO3.4=1.0°C in May 2015.**
  - **Positive anomalies of subsurface ocean temperature along the equator persisted and propagated eastward slowly in May 2015.**
  - **Positive phase of PDO has persisted for 11 months and weakened, with PDOI=0.8 in May 2015.**
- **Indian Ocean**
  - **Positive SSTAs were in the whole Indian Ocean.**
- **Atlantic Ocean**
  - **Positive phase of NAO has persisted for 7 months and weakened with NAOI=0.2 in May 2015, causing a horseshoe-like pattern of SSTA in N. Atlantic.**

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for May 2015

- Global SSS pattern is characterized by a zonally oriented belt of negative anomalies across the equatorial Pacific, regions of negative anomalies over the NW pacific and tropical Indian ocean and positive anomalies over the NW Atlantic ocean, all of them largely attributable to the variations in E-P, especially in 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:

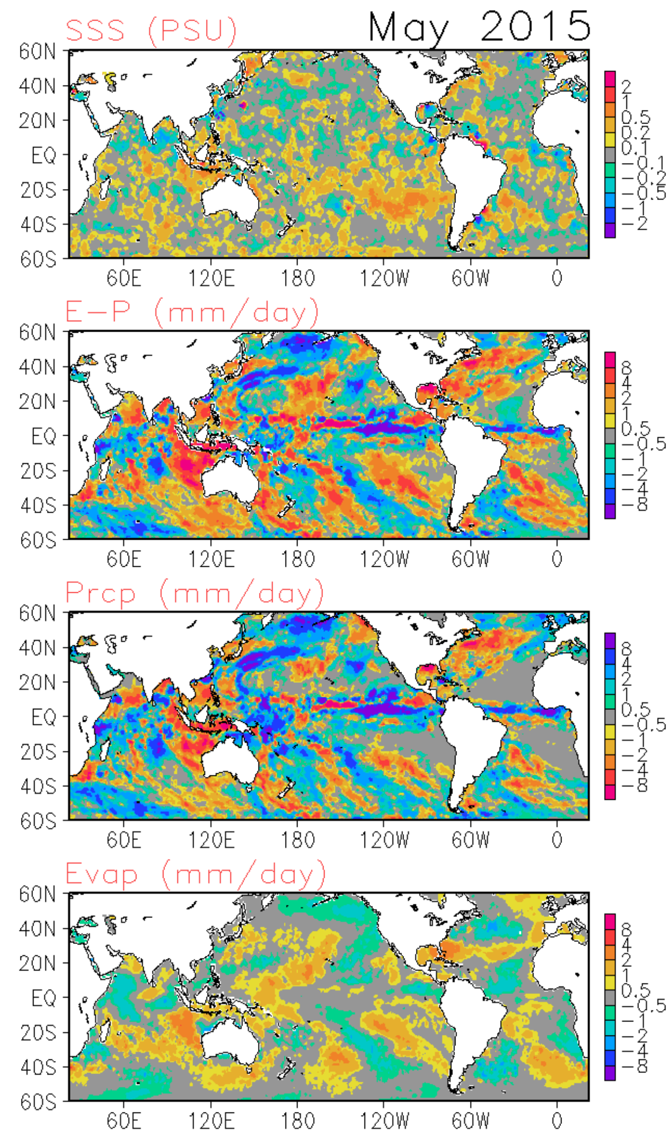
  CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for May 2015

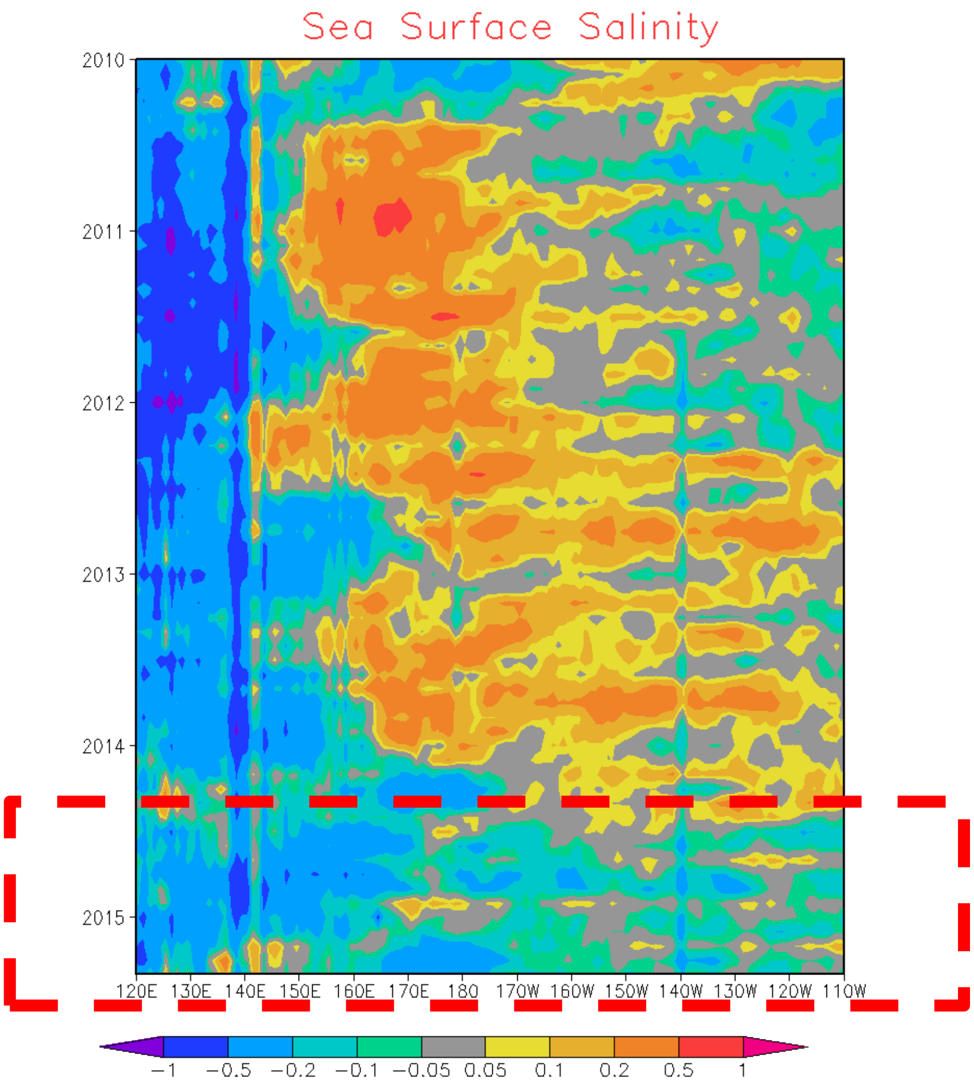
- SSS anomaly becomes fresher over most regions of the equatorial Pacific and NW Pacific

- Positive SSS tendencies are also noticed over SE Pacific and NW Atlantic, attributable at least partially to the tendencies in E-P.

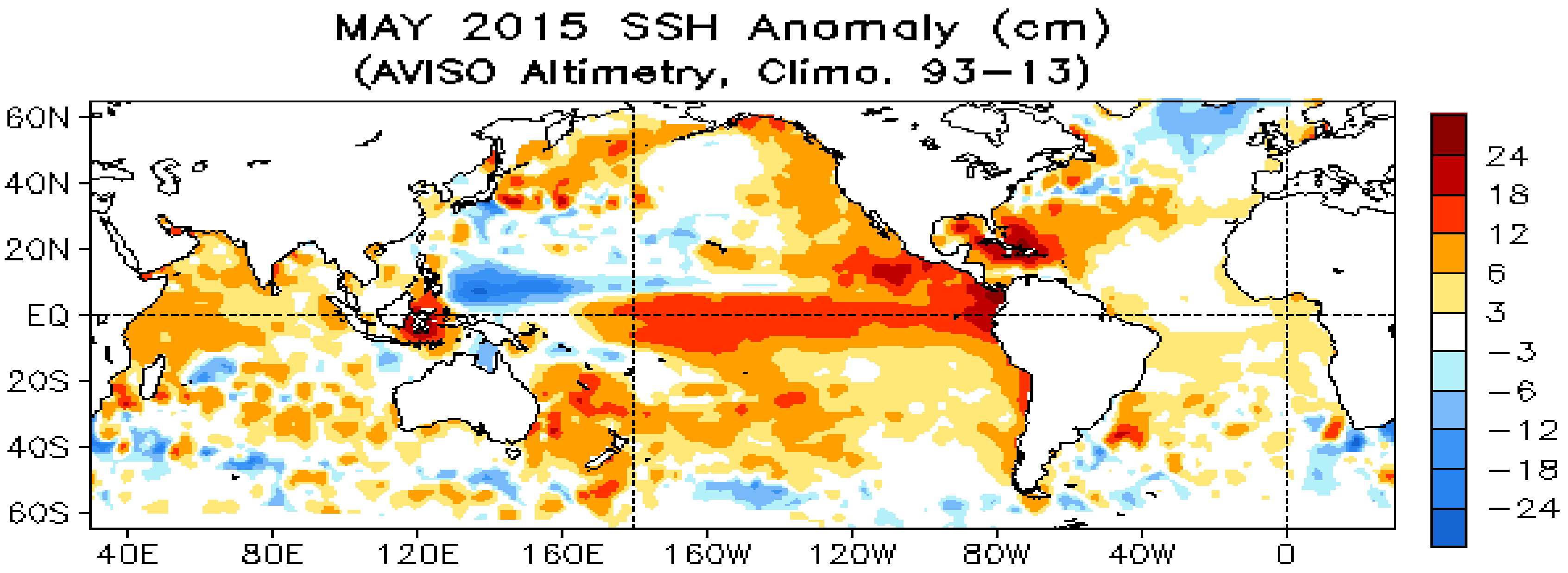


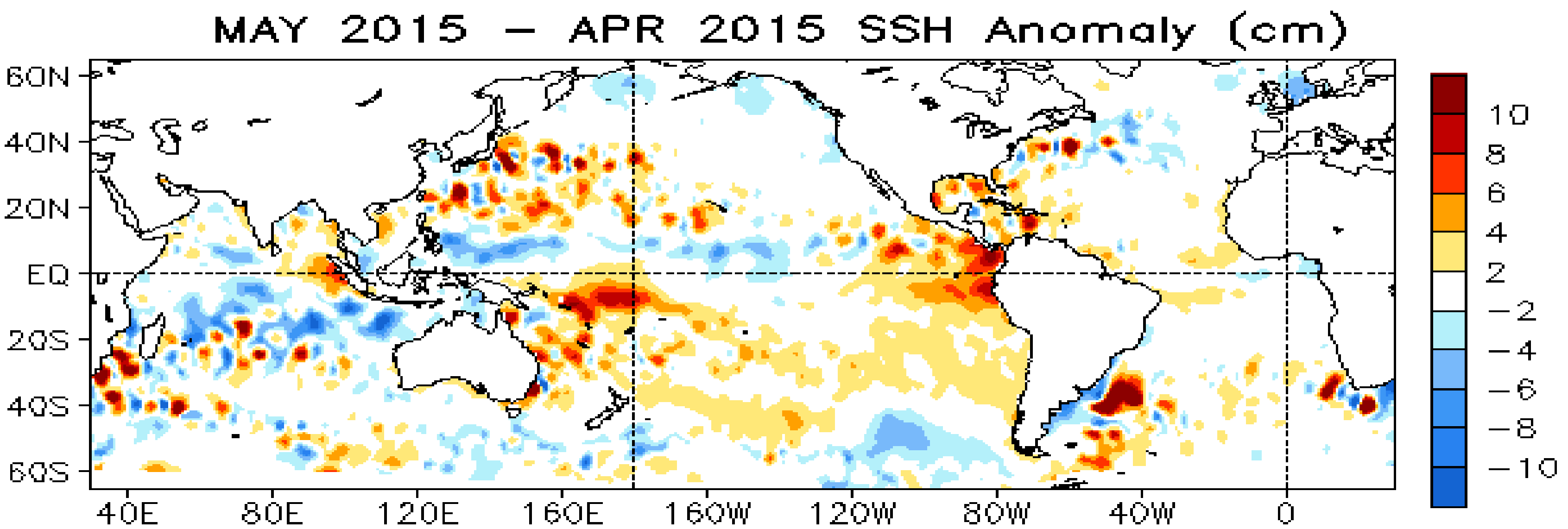
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

- Please note that the color scale is changed from this month
- Hovemoller diagram for equatorial SSS anomaly **(10ºS-10ºN);**
- Negative SSS anomaly enhanced in recent months over the equatorial western and central Pacific;
- In May 2015, the negative anomaly averaged over the equatorial belt extended across the entire Pacific basin;

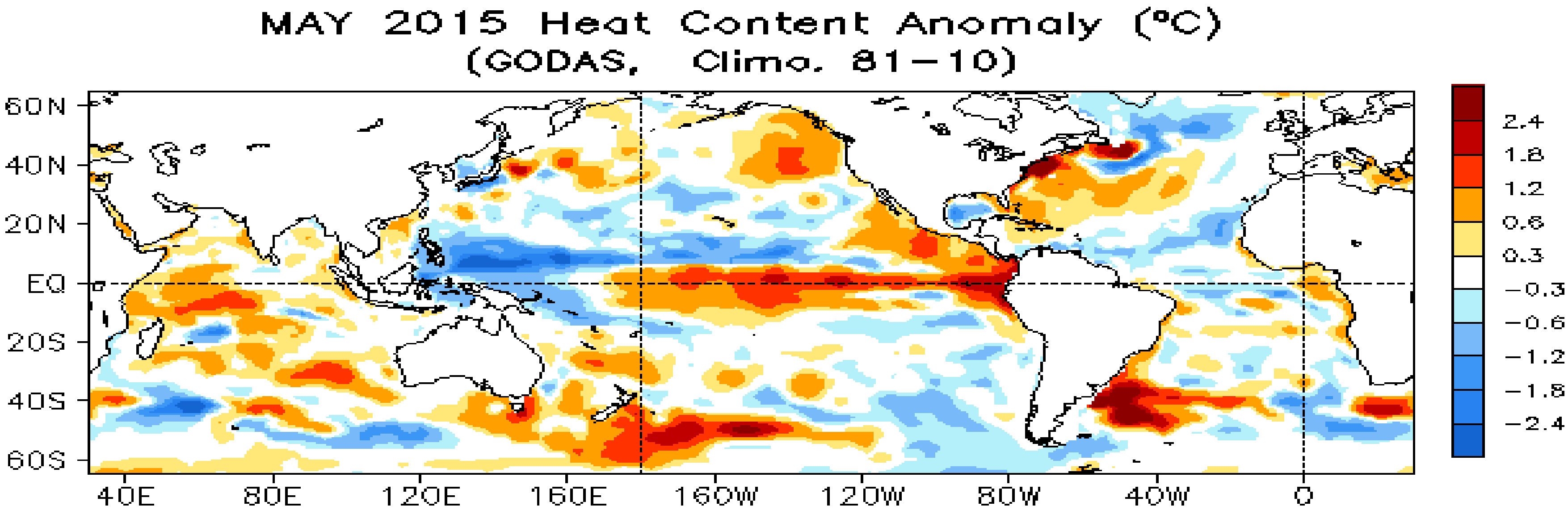


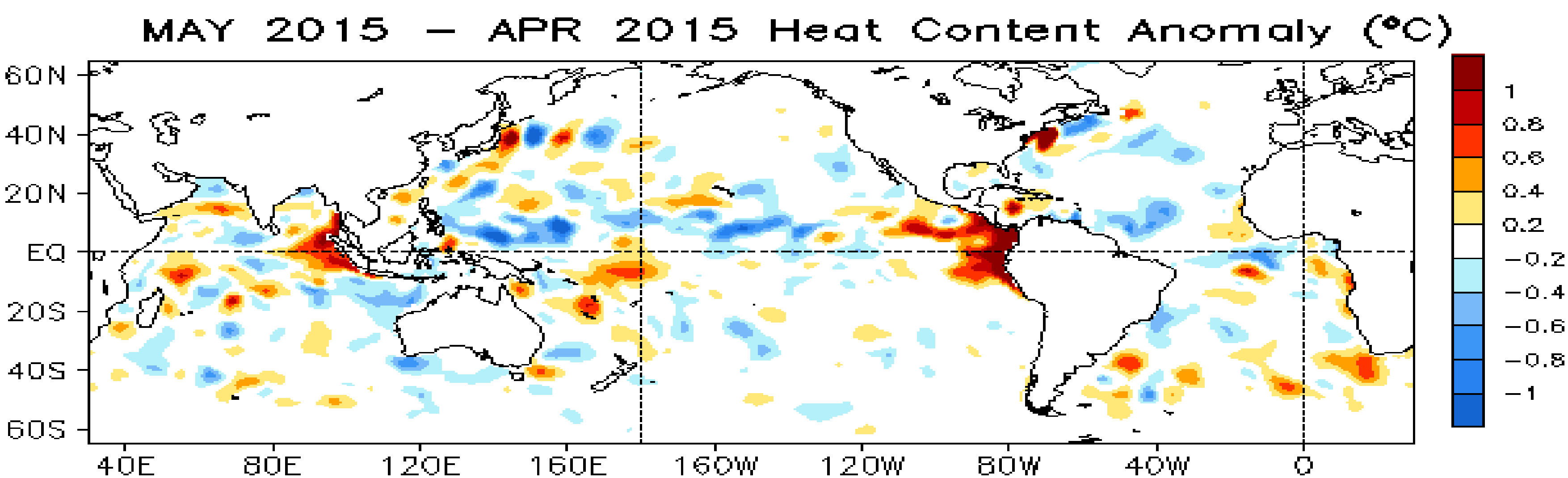
Global SSH Anomaly (cm) and Anomaly Tendency





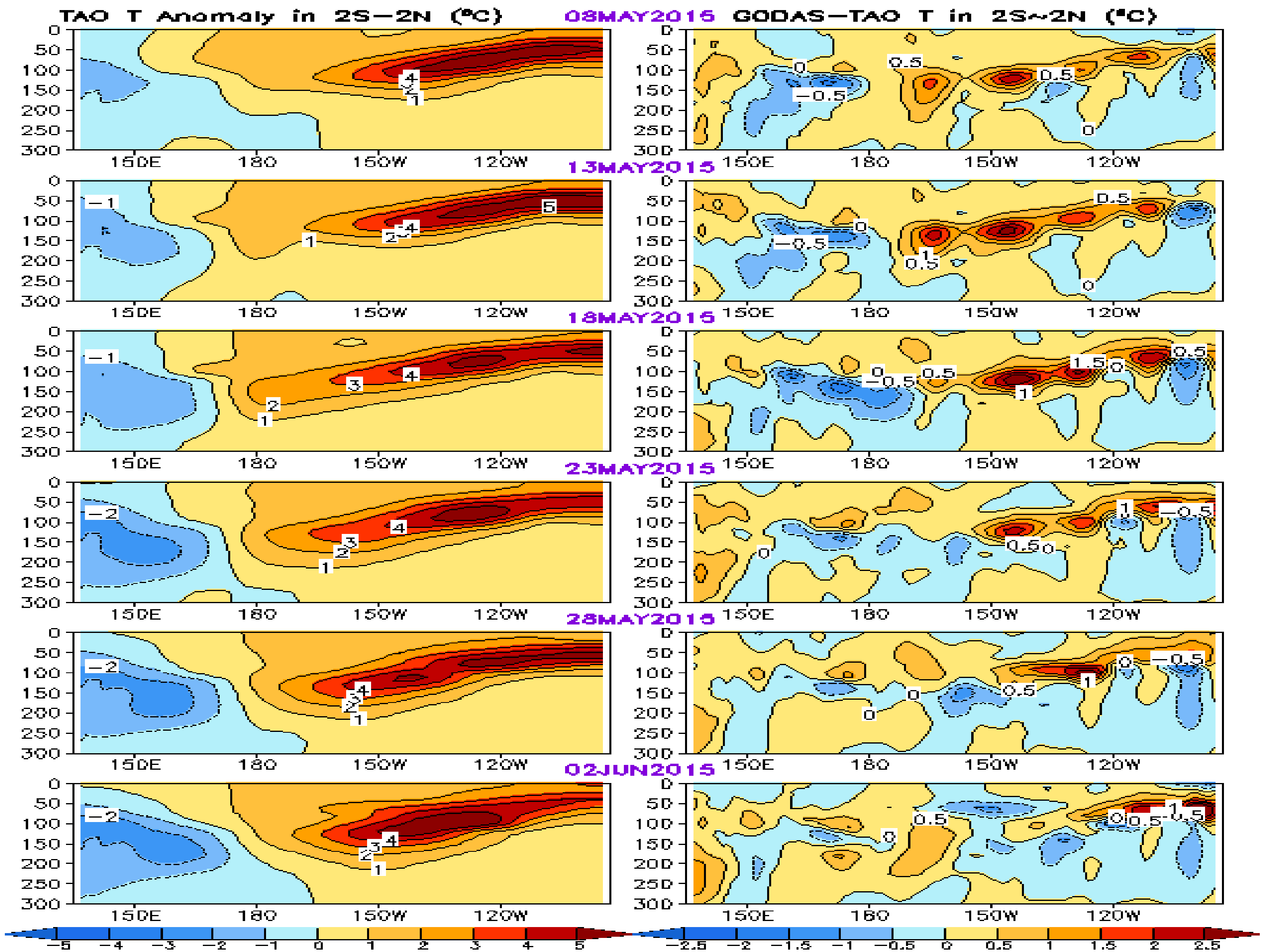
Global HC Anomaly (cm/°C) and Anomaly Tendency





Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

TAO Anomaly GODAS-TAO T Anomaly



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.**

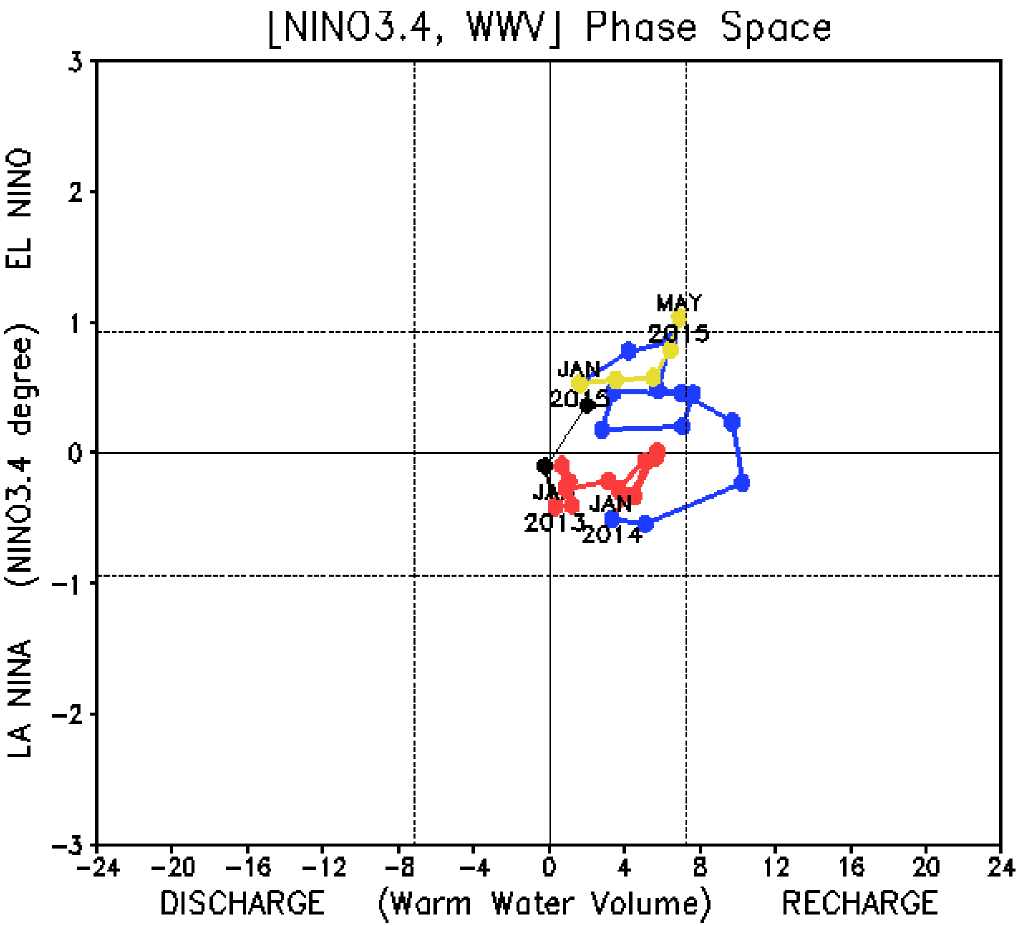
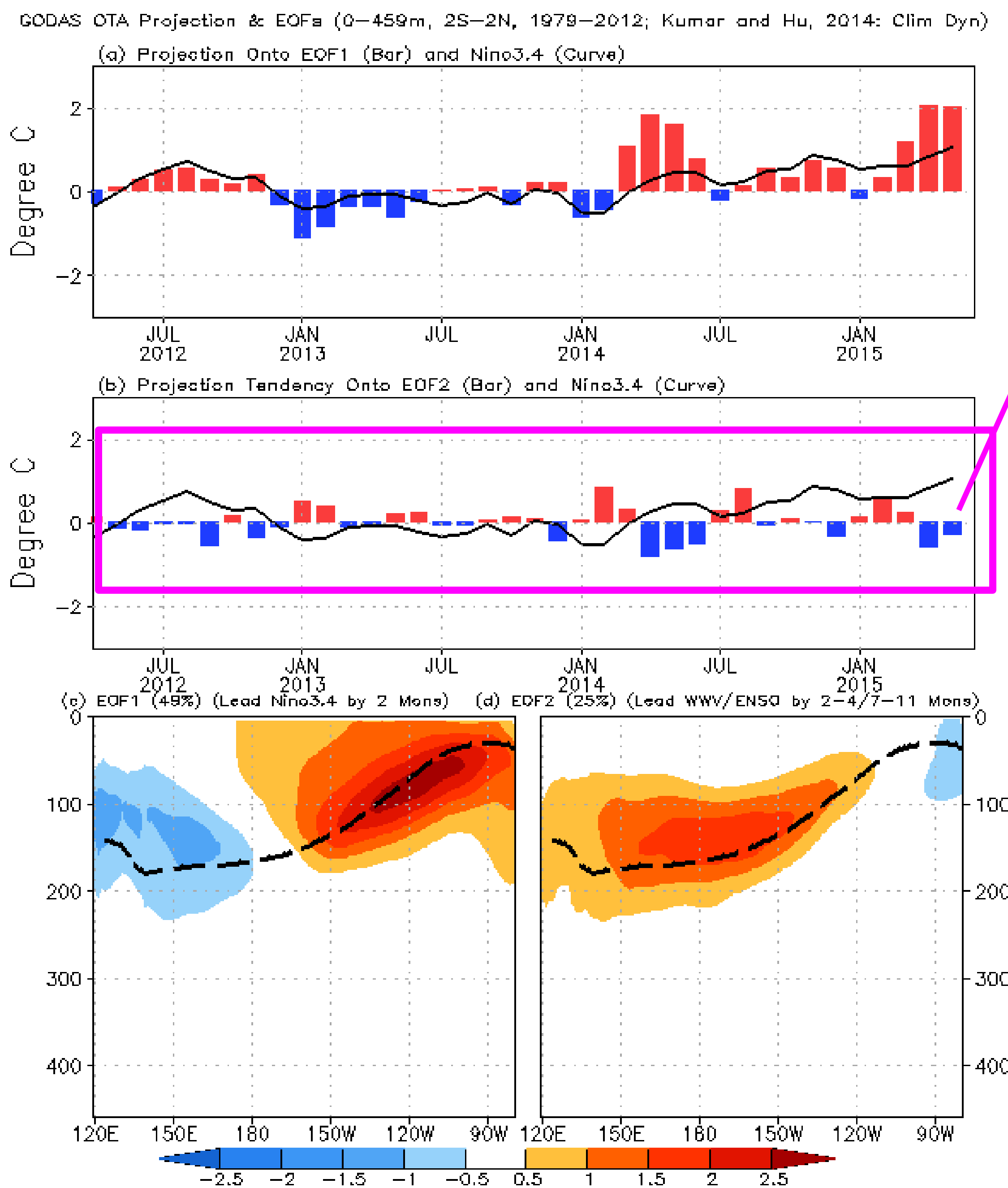


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



<u>Equatorial subsurface ocean temperature monitoring: Right now, it was in discharge phase; Overall recharge/discharge were weak in last 2-3 years.</u>

<u>Projection of OTA onto EOF1 and EOF2 (2S-2N, 0-459m, 1979-2010)</u>

EOF1: Tilt mode (ENSO peak phase);

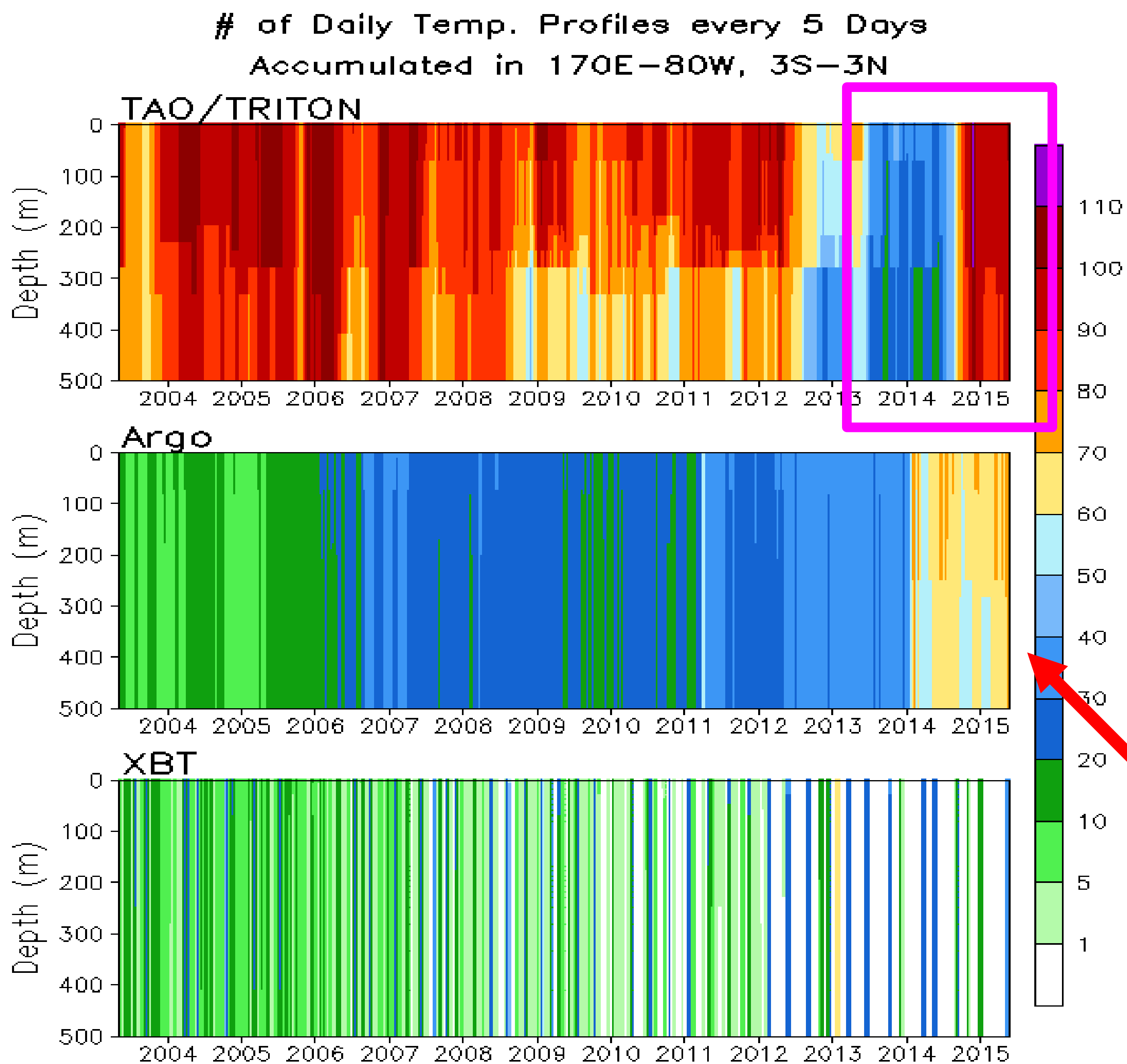
EOF2: WWV mode, Recharge/discharge oscillation (ENSO transition phase).

Recharge process: heat transport from outside of equator to equator : <u>Negative -> positive phase of ENSO</u>

Discharge process: heat transport from equator to outside of equator: <u>Positive -> Negative phase of ENSO</u>

<u>For details, see:</u>

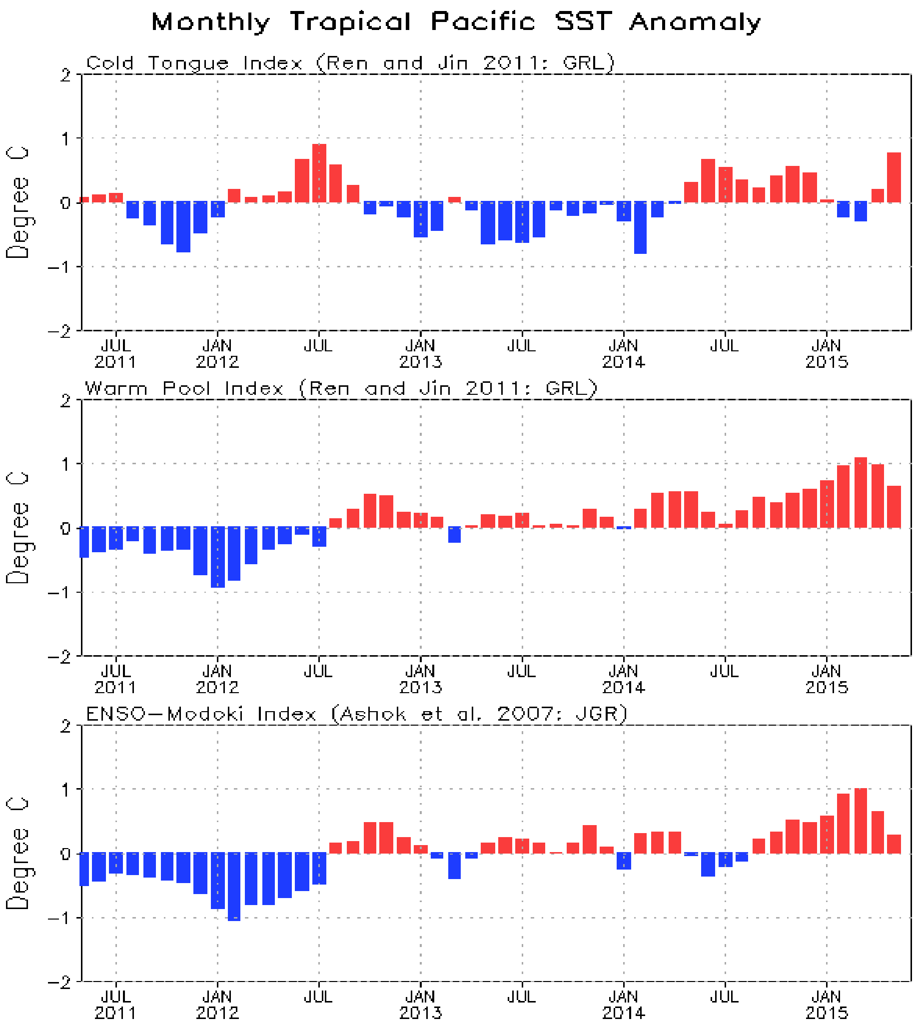
Kumar A, Z-Z Hu (2014) Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn., 42 (5-6)**, 1243-1258.** *DOI: 10.1007/s00382-013-1721-0*.

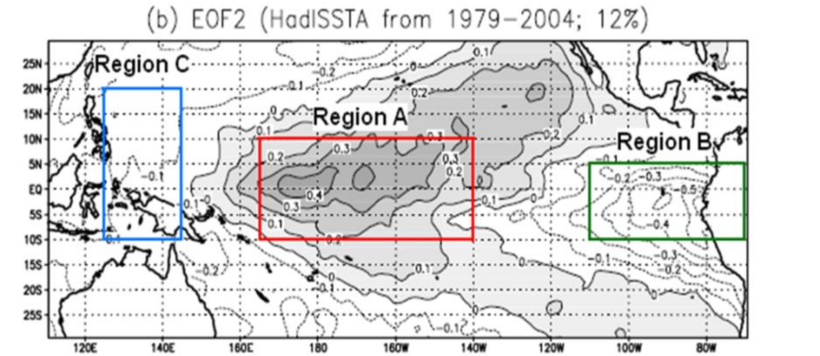


- TAO data delivery rate decreased significantly during late 2012 to mid-2014, and largely recovered since late 2014.

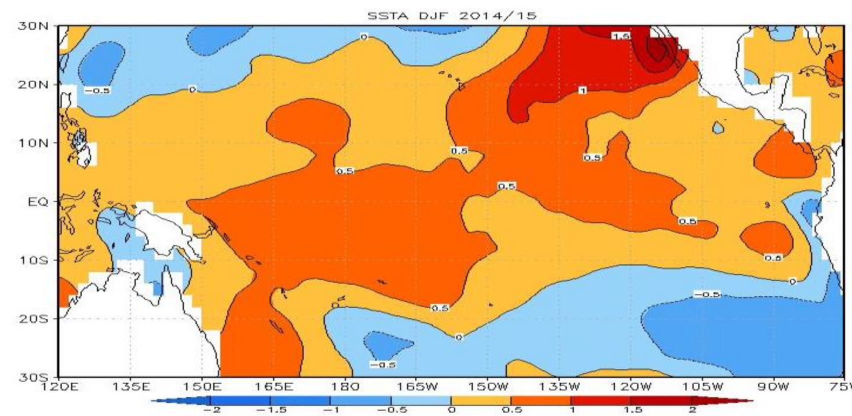
- There was a sharp increase of Argo data since late Jan 2014.

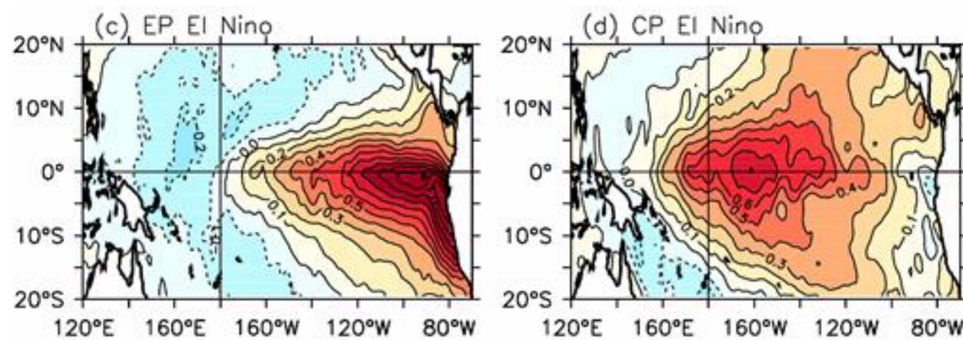
Evolution of Pacific NINO SST Indices





From: http://bobtisdale.blogspot.com/2009/07/comparison-of-el-nino-modoki-index-and.html

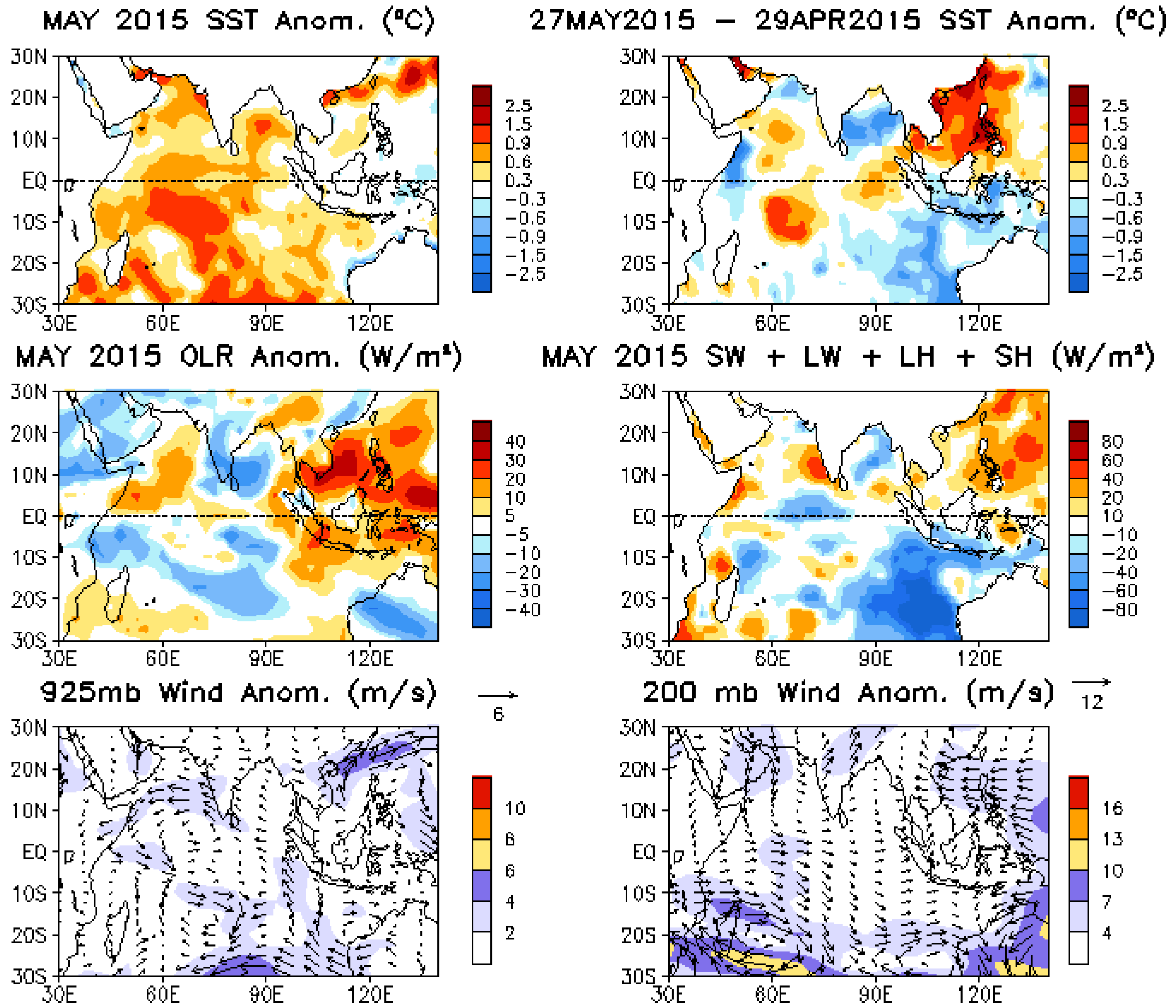




- **The SSTA evolution in 2014/15 was more similar to the pattern associated with central Pacific (warm pool) El Nino, or ENSO-Modoki.**

Kao and Yu (2009)

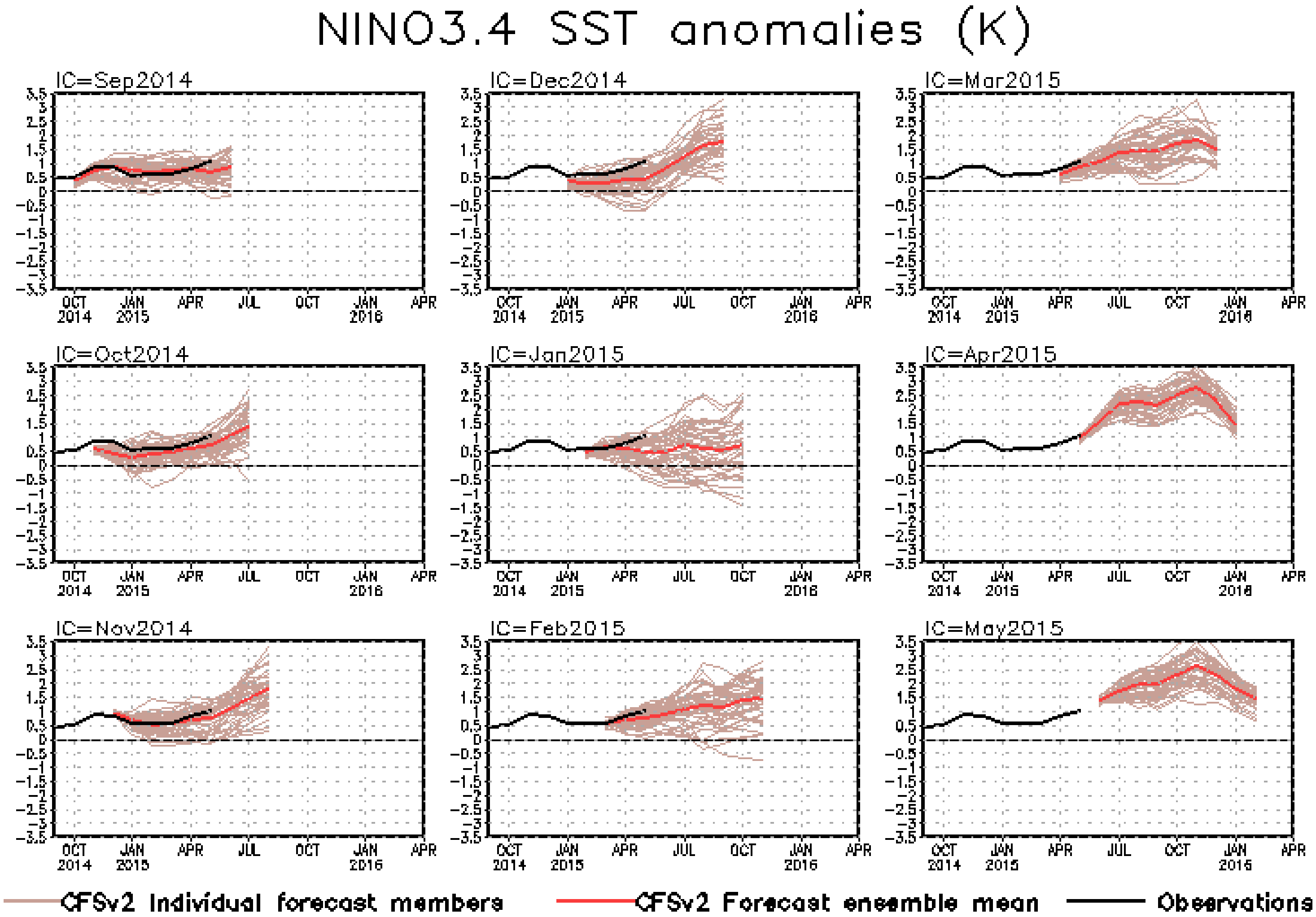
Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.



- **Positive SSTA was in the whole basin.**

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.

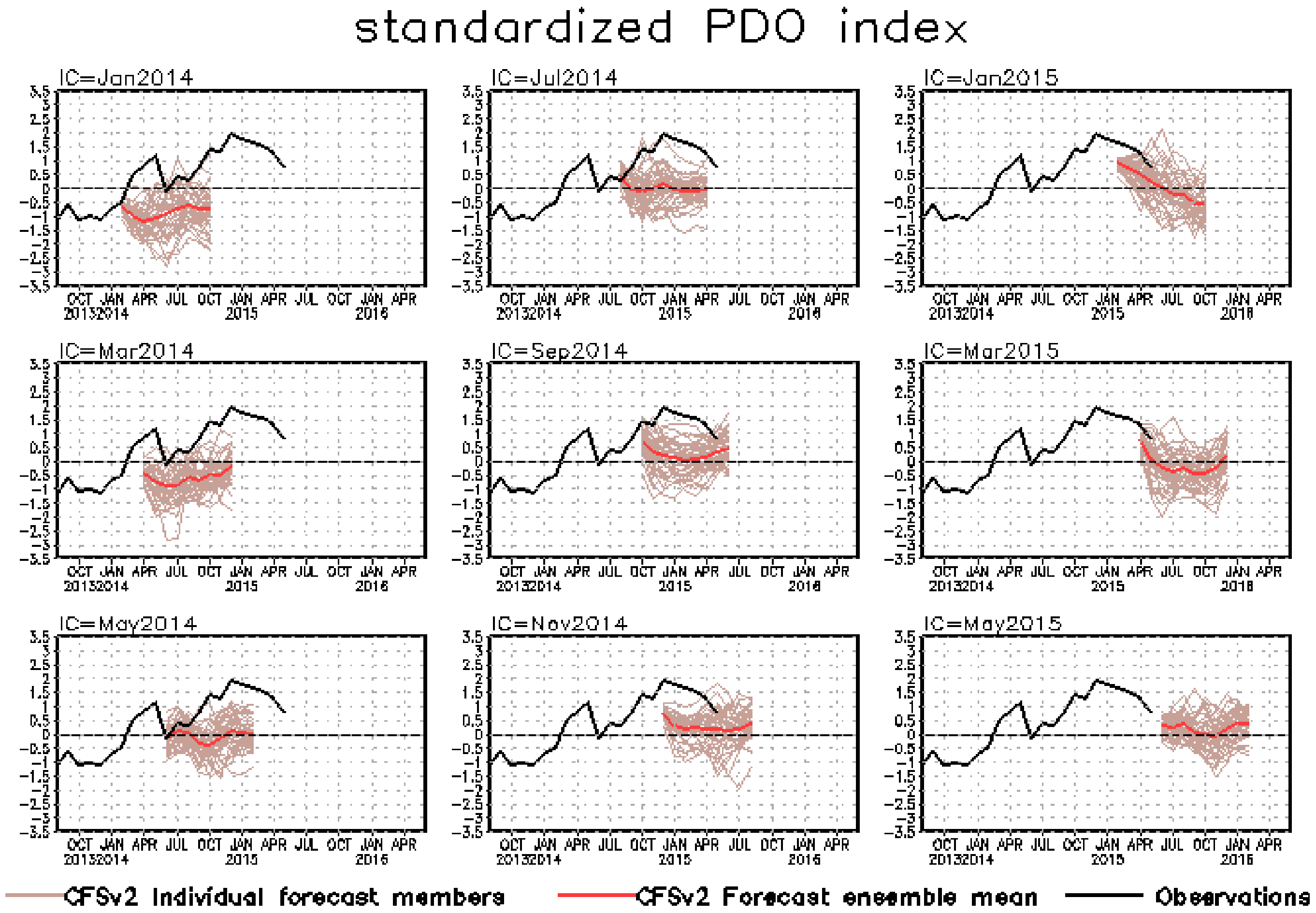
CFS Niño3.4 SST Predictions from Different Initial Months



- CFSv2 predicts a warming tendency, and suggests development of a El Nino in 2015 and peaks in Nov 2015.

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



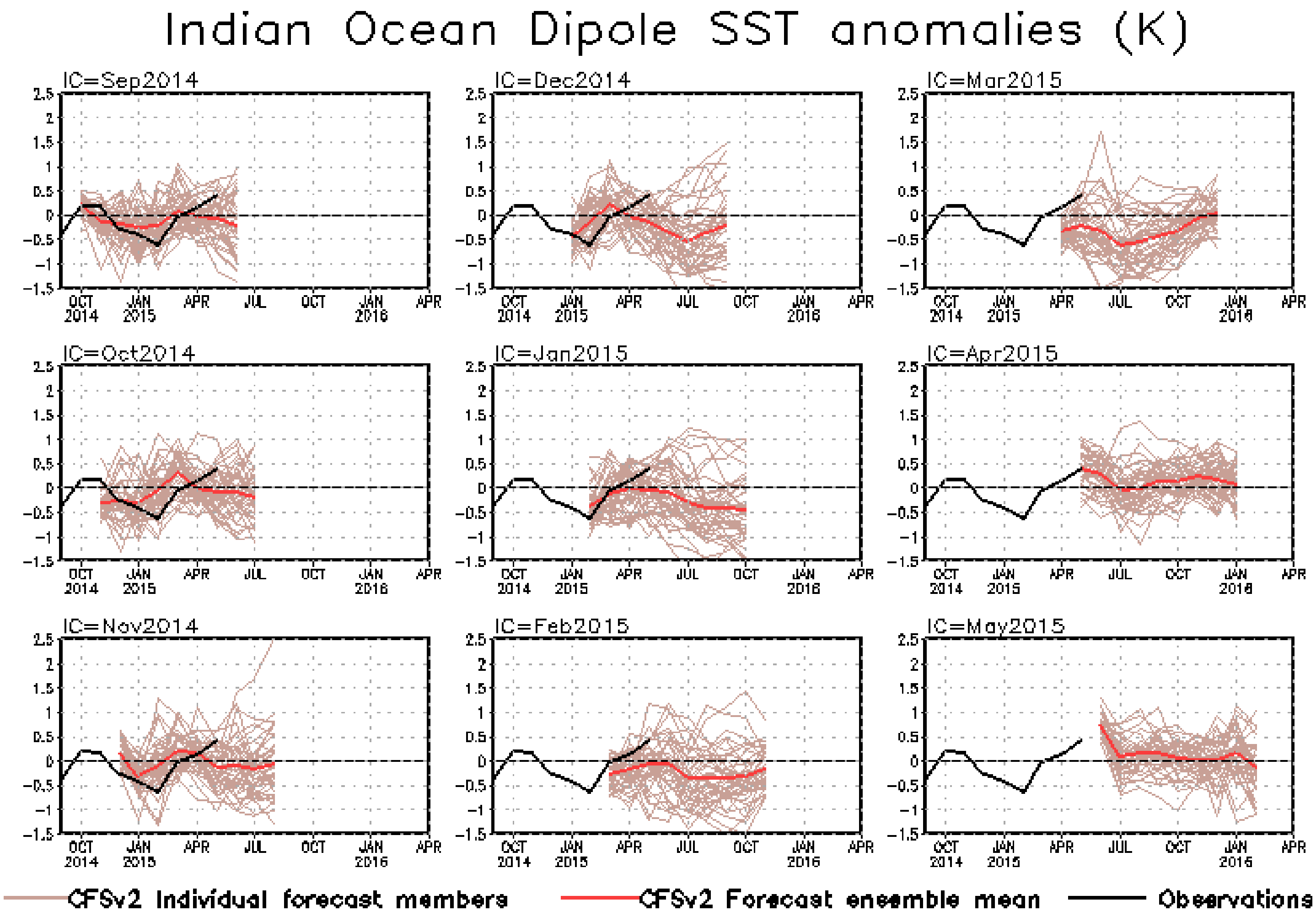
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- CFSv2 predicts a downward tendency of PDO, and neutral phase since summer 2015.

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

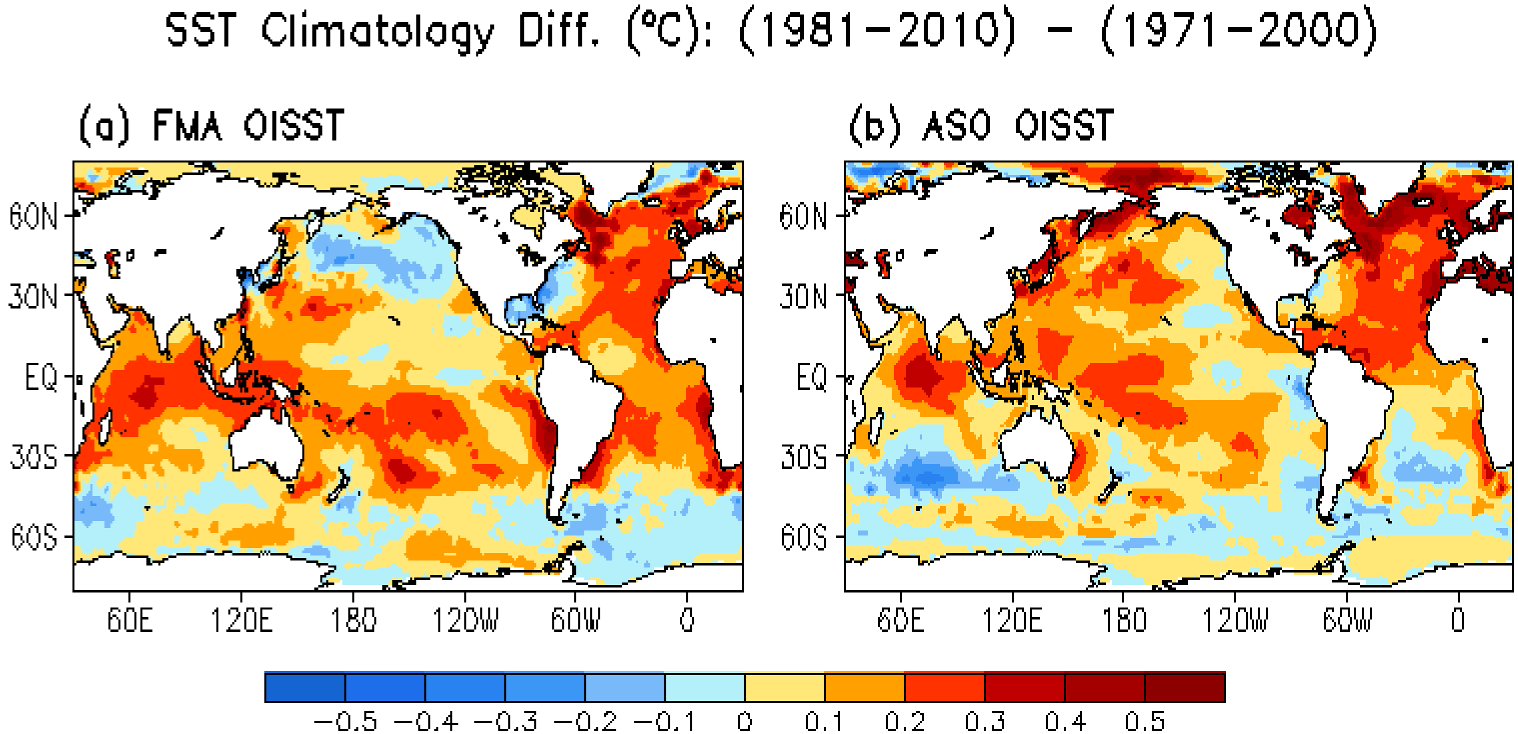
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

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

- **CFSv2 predicts neutral phase of IOD since summer 2015.**

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.

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.

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)**

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!