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

Prepared by
Climate Prediction Center, NCEP/NOAA

July 8, 2013

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**
  - **(NOAA 2013 Atlantic Hurricane prediction)**
- **Global SST Predictions**

Overview

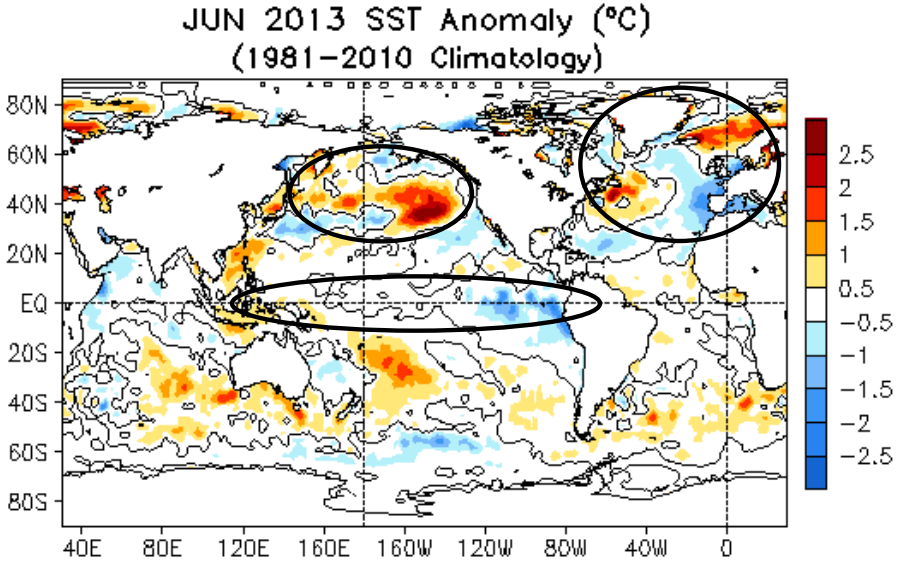
- **Pacific and Arctic Oceans**
  - **ENSO-neutral conditions continued during June 2013 and a warming tendency emerged in the eastern Pacific.**
  - **The consensus forecast favors ENSO-neutral conditions to continue into the Northern Hemisphere fall 2013.**
  - **Negative PDO phase strengthened with PDO=-1.4 in June 2013, and NCEP CFSv2 predicted negative PDO phase would continue into the coming fall.**
  - **The sea ice extent in June 2013 is higher than last year due to a slower sea ice loss rate.**

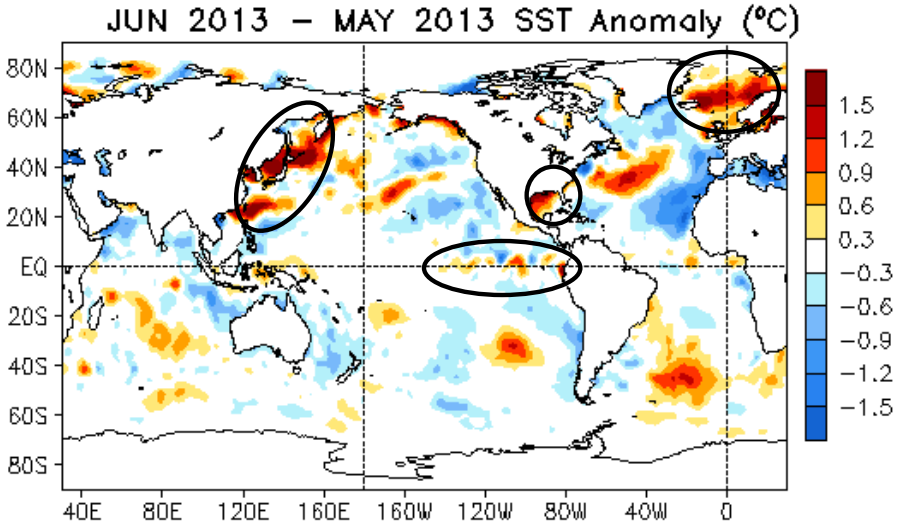
- **Indian Ocean**
  - **SSTs were above-normal in the east and slightly below-normal in the west, and negative Indian Ocean Dipole index continued in June 2013.**

- **Atlantic Ocean**
  - **Above-normal SST continued in the hurricane main development region.**
  - **NOAA predicted above-normal condition of hurricane activity in 2013.**
  - **Positive NAO index persisted in the past three months.**

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency



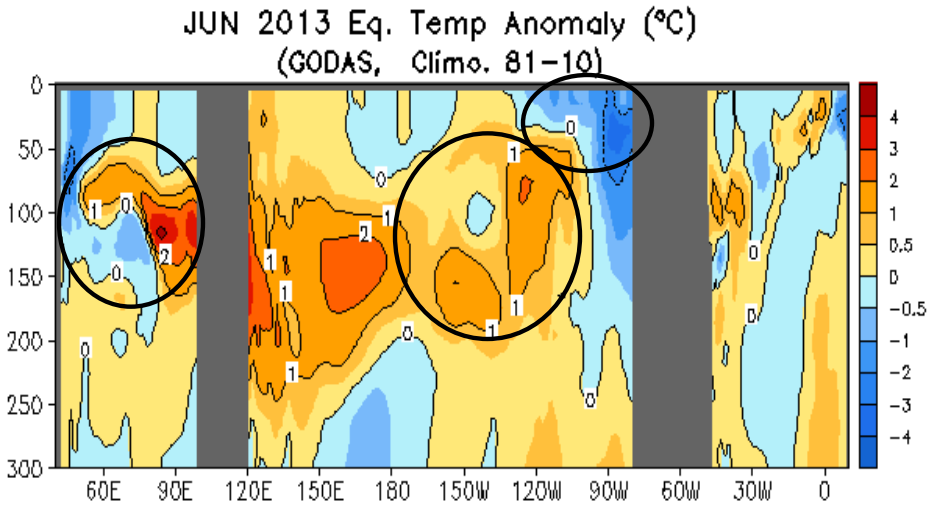


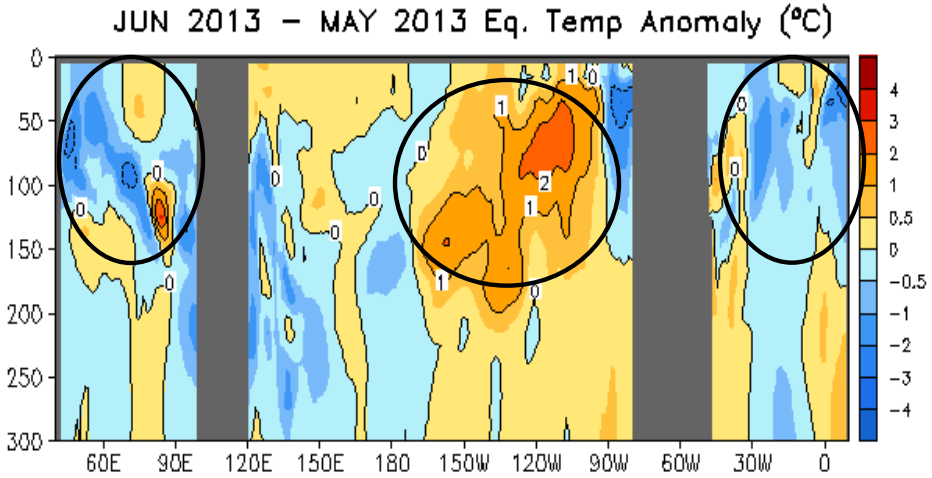
- **SST was near-normal across the western-central tropical Pacific and below average across the eastern Pacific.**
- **Negative PDO-like pattern continued in N. Pacific.**
- **Positive SSTA was observed in Norwegian Sea and near Gulf Stream, while negative SSTA presented in the eastern North Atlantic and Mediterranean Sea.**

- **A weak warming tendency was observed across the eastern equatorial Pacific.**
- **A strong warming tendency was observed in Norwegian Sea, around Gulf of Mexico and in the far western N. Pacific.**
- **A strong cooling tendency was observed in the eastern North Atlantic**

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

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





- **Negative subsurface anomalies persisted in the far eastern Pacific and positive anomalies emerged in the central Pacific.**

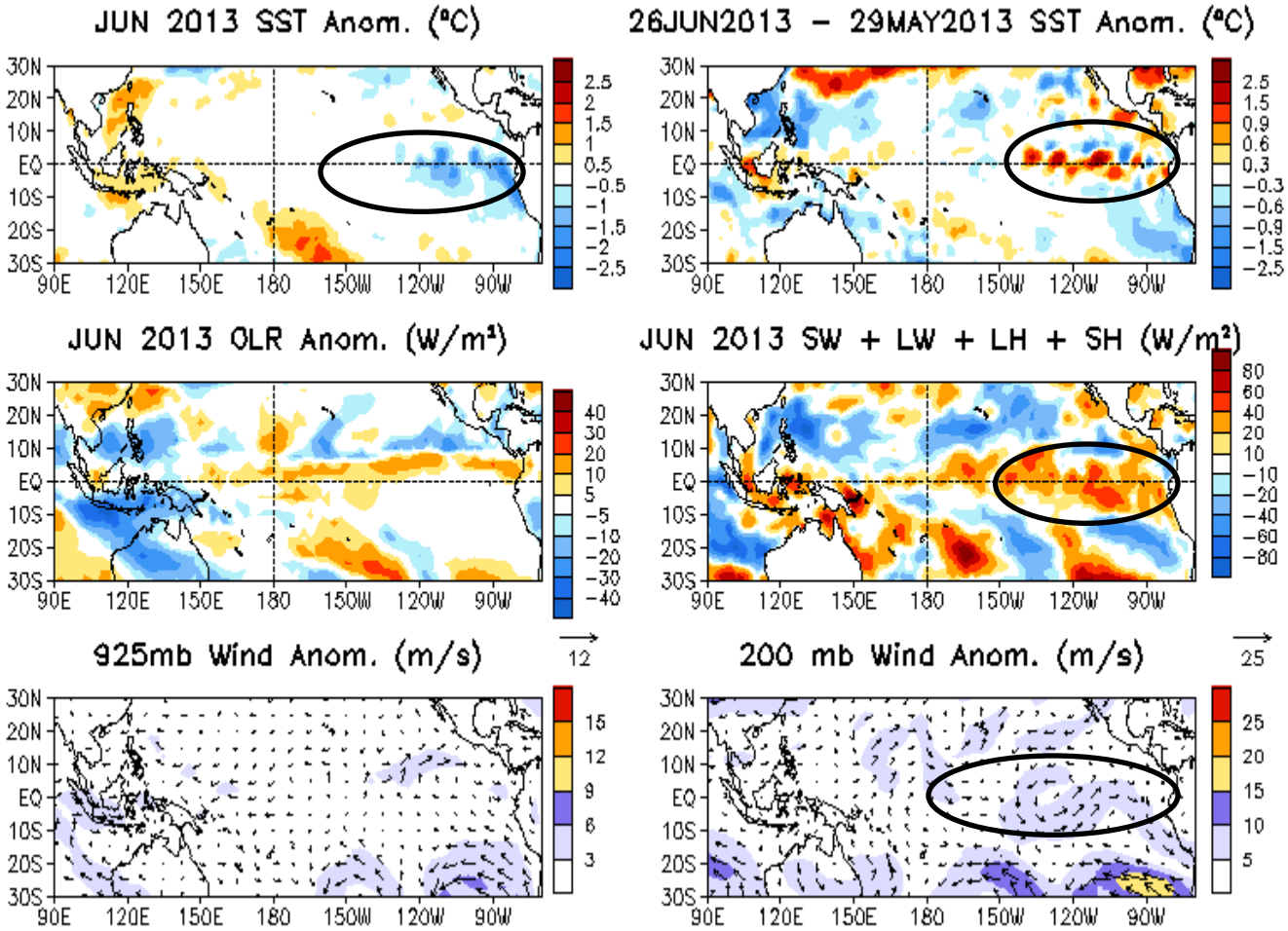
-**Positive anomalies continued to dominate at the upper 100m of equatorial Indian Ocean.**

- **A warming tendency was observed in the eastern Pacific Ocean around the thermocline.**
- **Cooling tendency prevailed around thermocline in the Indian and Atlantic Oceans**

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

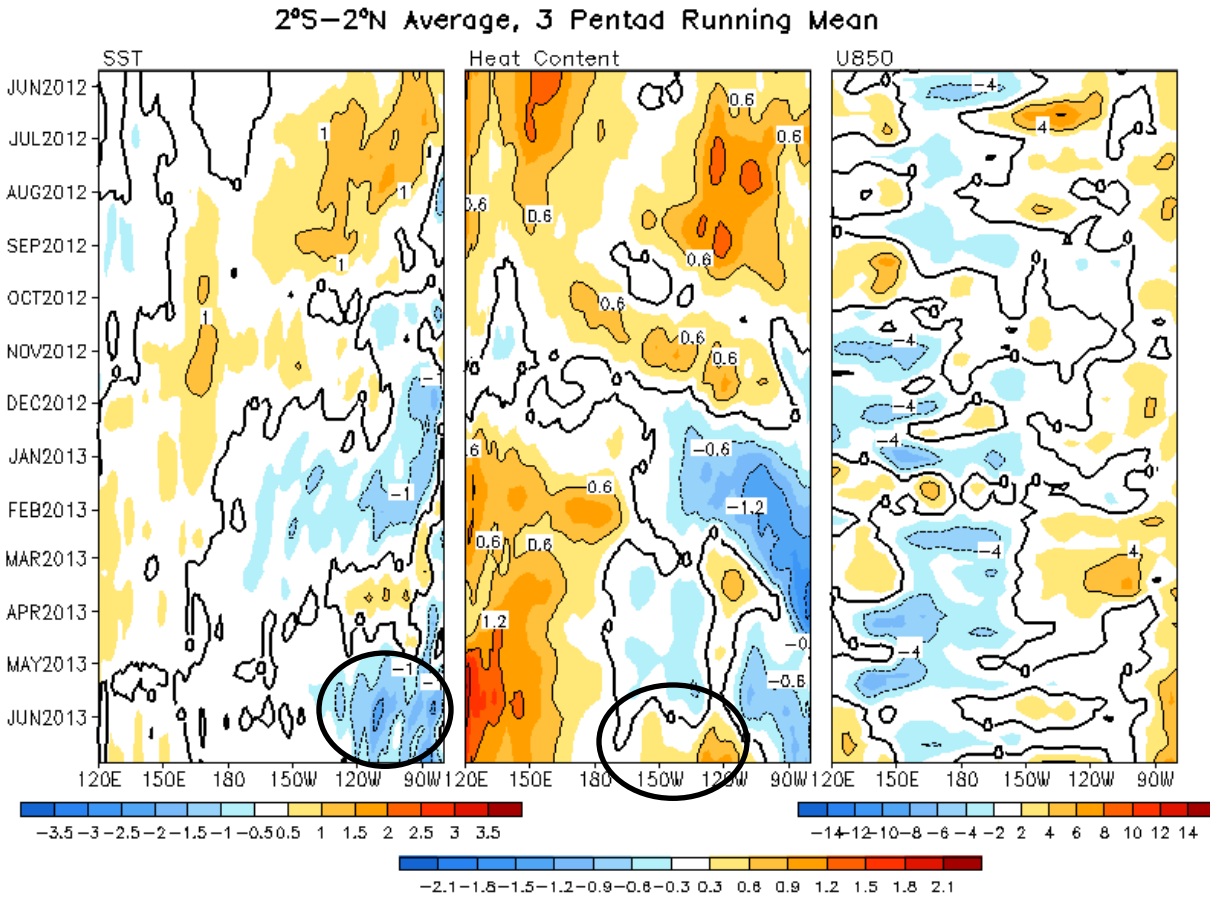
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds



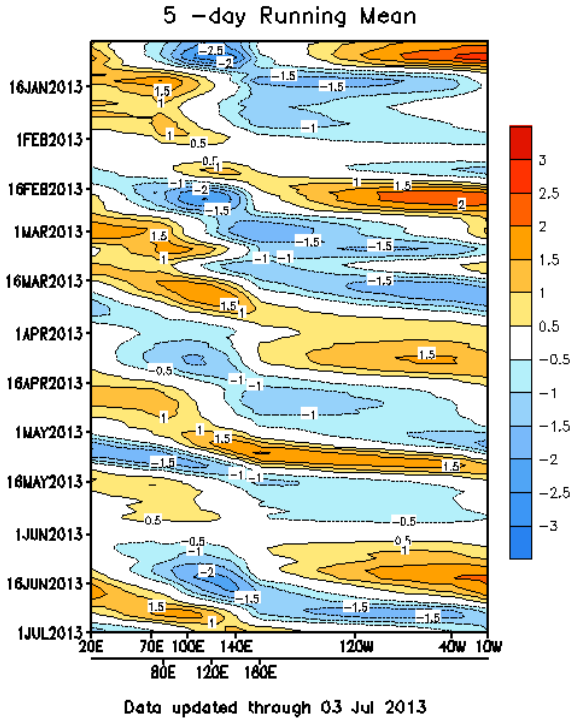
- **A positive tendency was observed in the eastern Pacific Ocean.**
- **Positive net heat flux occupied along the equator, contributing the warming tendency.**
- **Weak upper-level (200-hPa) westerly wind anomalies prevailed over the central and eastern Pacific.**

Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

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



CPC MJO Indices



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

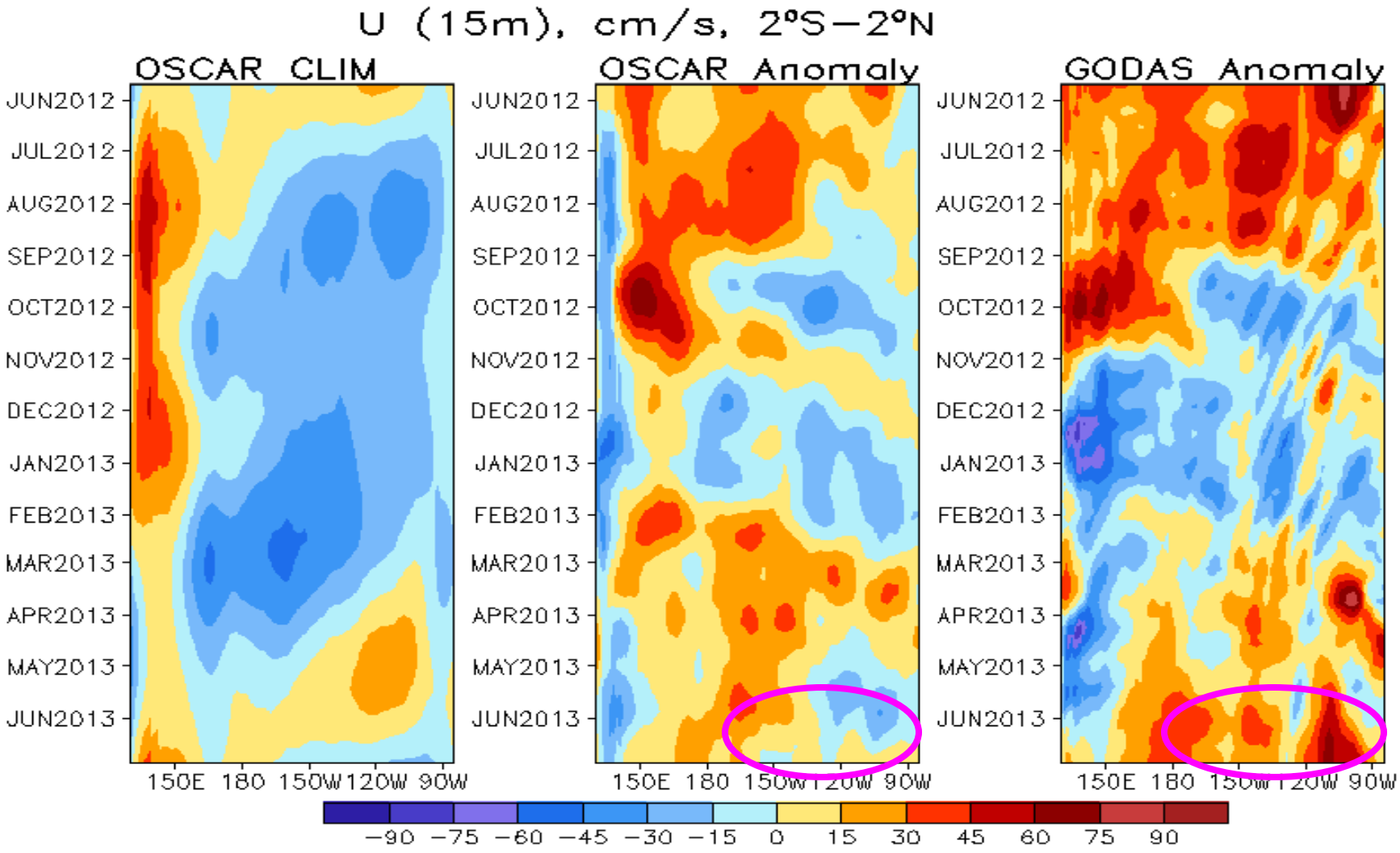
- **Negative SSTA occupied in the far eastern Pacific since May, 2013.**

- **HC300 anomalies in the east-central Pacific transited from negative to positive phase in early June, which probably contributed to the warming tendency in SST east of 150W.**

- **The sudden weakening of easterly wind anomalies west of Dateline in early June might be associated with the increased HC300 anomalies.**

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 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. 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.

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

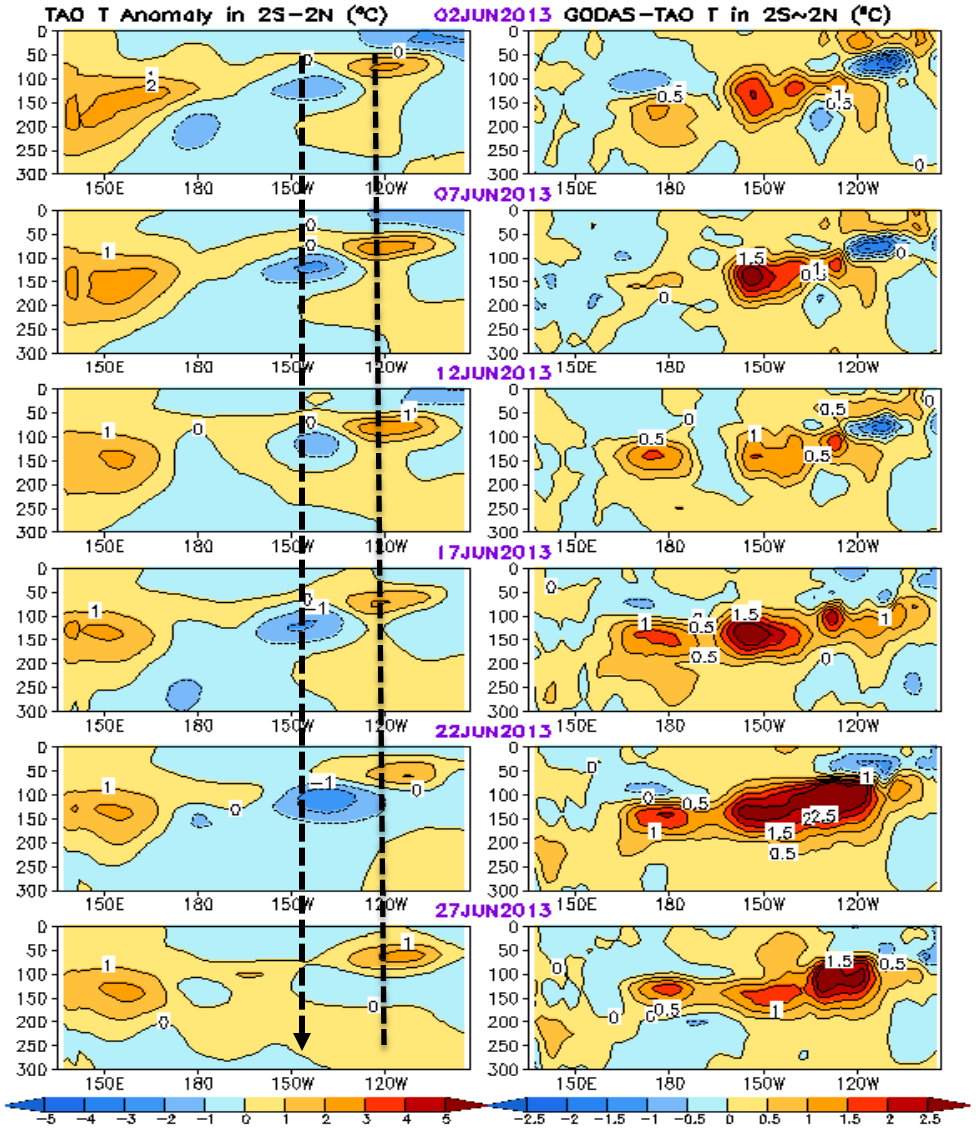


- **Near-normal zonal current from OSCAR dominated across the central-eastern Pacific , while strong positive zonal current anomalies from GODAS were observed in June 2013.**

Pentad Mean Equatorial Pacific Temperature Anomaly

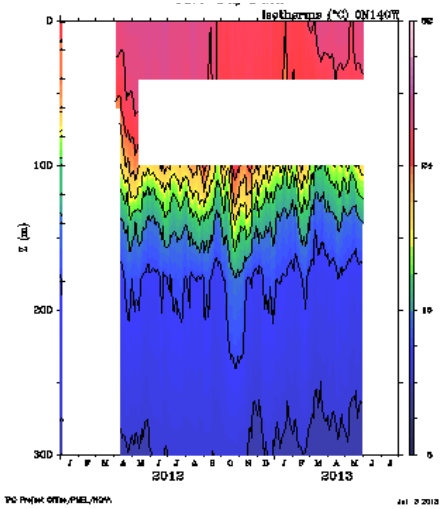
TAO

GODAS

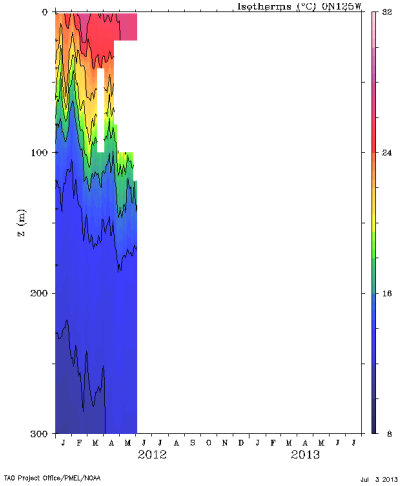


- **Positive subsurface anomalies around the thermocline persisted near 120W, while the subsurface cooling near 145W decayed in the last pentad.**
- **Discrepancies between GODAS and TAO temperature were particularly large in the eastern Pacific, which may be partially related to the missing data from the TAO moorings**

ON,140W



ON,125W

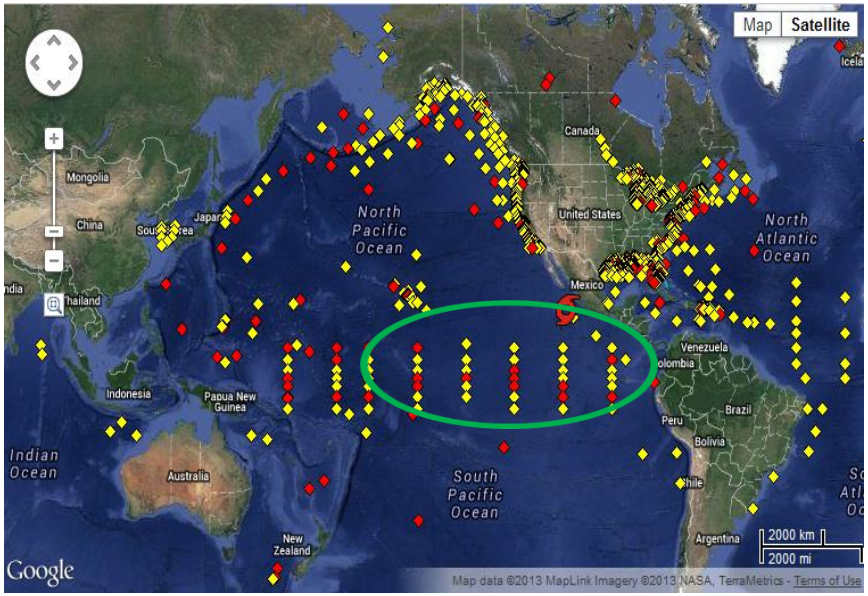


Status of TAO/TRITON Data Deliver

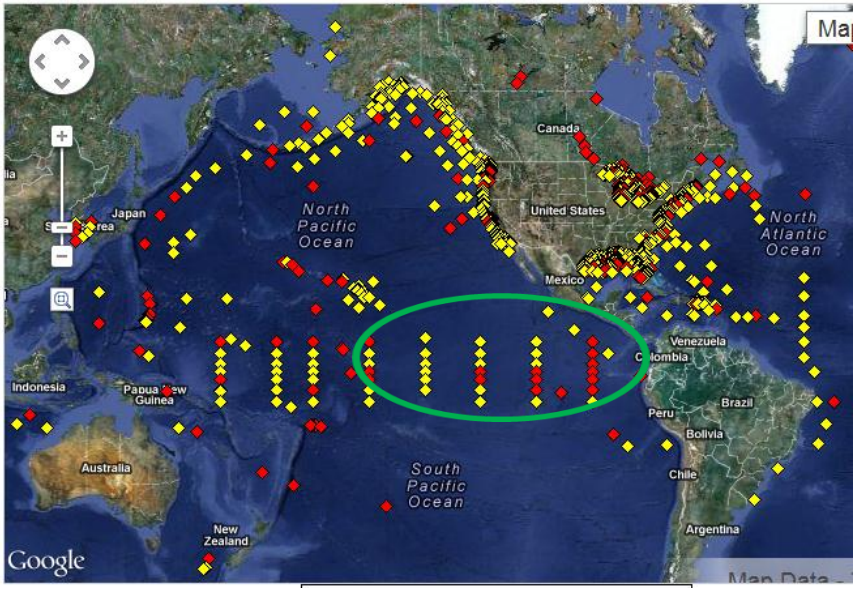
http://www.ndbc.noaa.gov

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

Beginning of July 2013

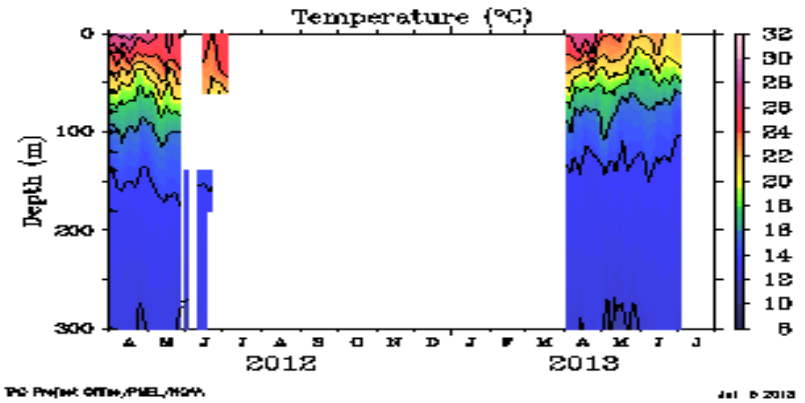


Beginning of Feb 2013

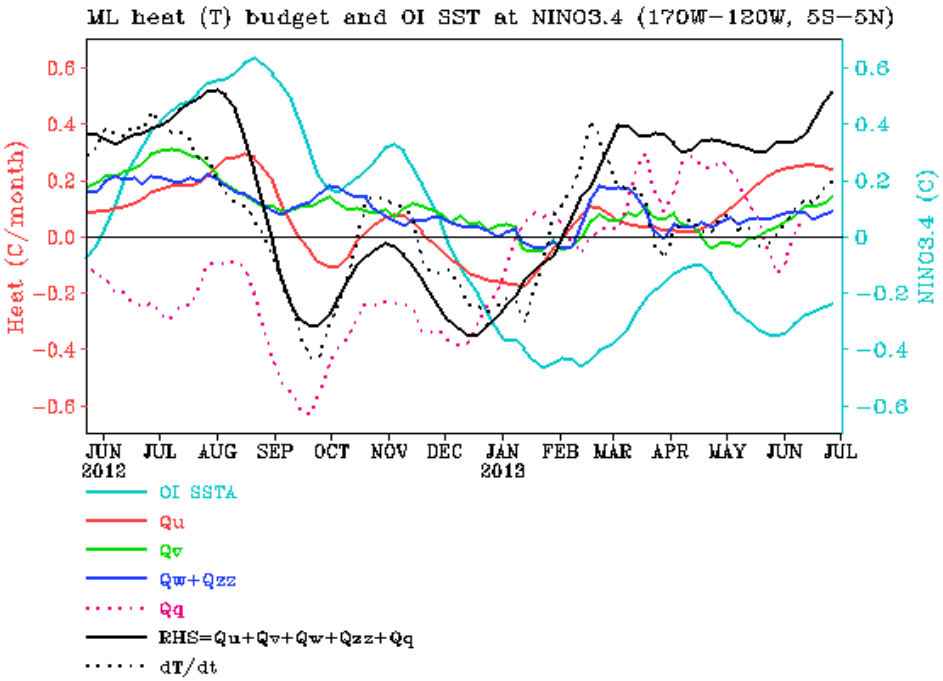


- **The TAO/TRITON array has encountered significant outages since summer 2012, particularly in the eastern part of the array.**
- **Some of the moorings along the 95W line were restored in April 2013.**

ON,95W



NINO3.4 Heat Budget



- A weak warming SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was observed in June.
- The zonal advection warming dominated the heat budget terms.
- The RHS and dT/dt had large differences during Mar-June 2013.

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.

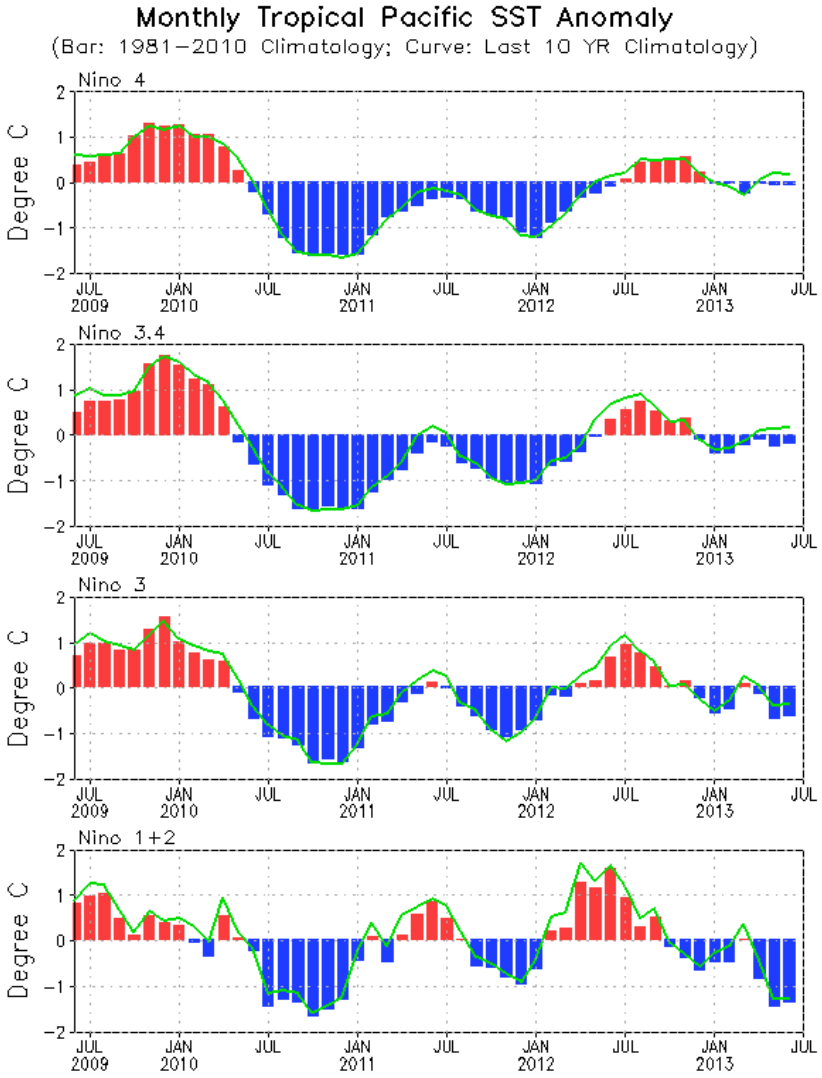
Qu: Zonal advection; Qv: Meridional advection;

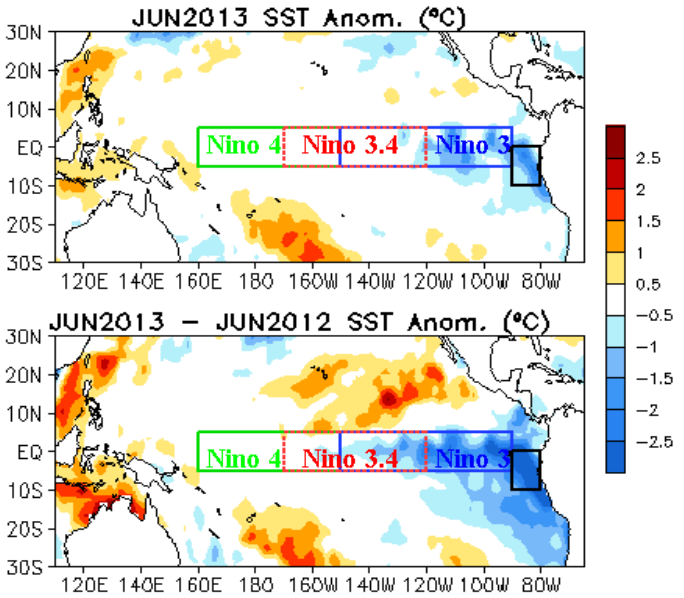
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

Evolution of Pacific NINO SST Indices



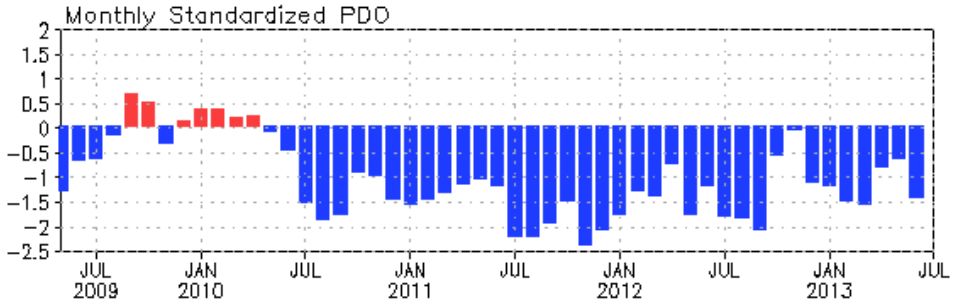


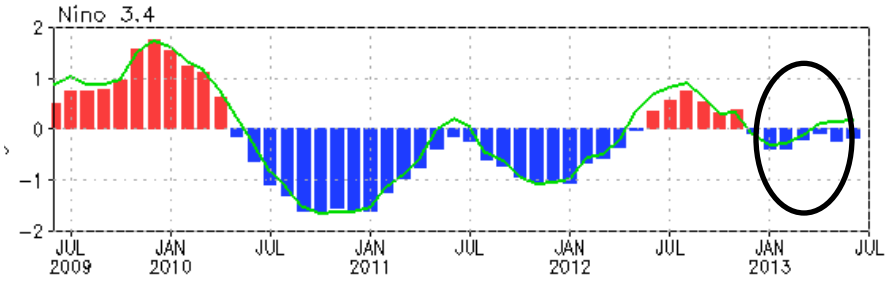
- **All Nino indices were negative, with Nino 3.4 = -0.2 °C**
- **ENSO-neutral conditions continued in June 2013.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

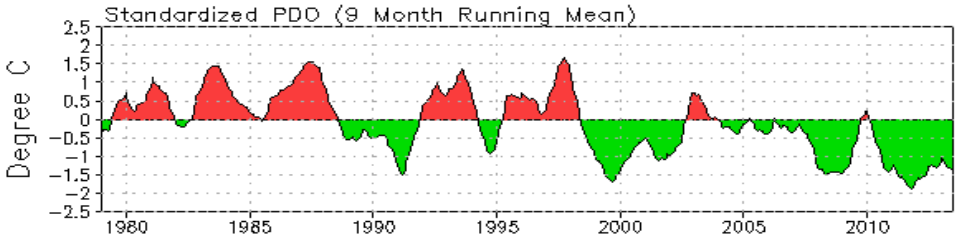
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 (bar) and last ten year (green line) means.

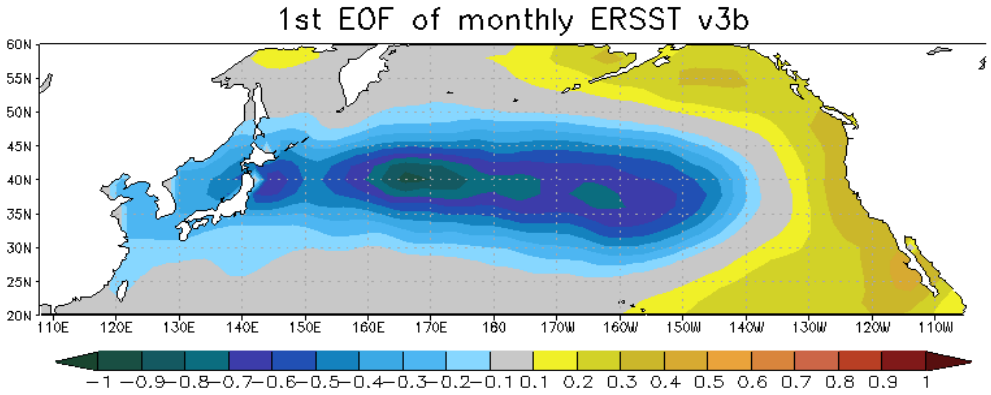
North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index









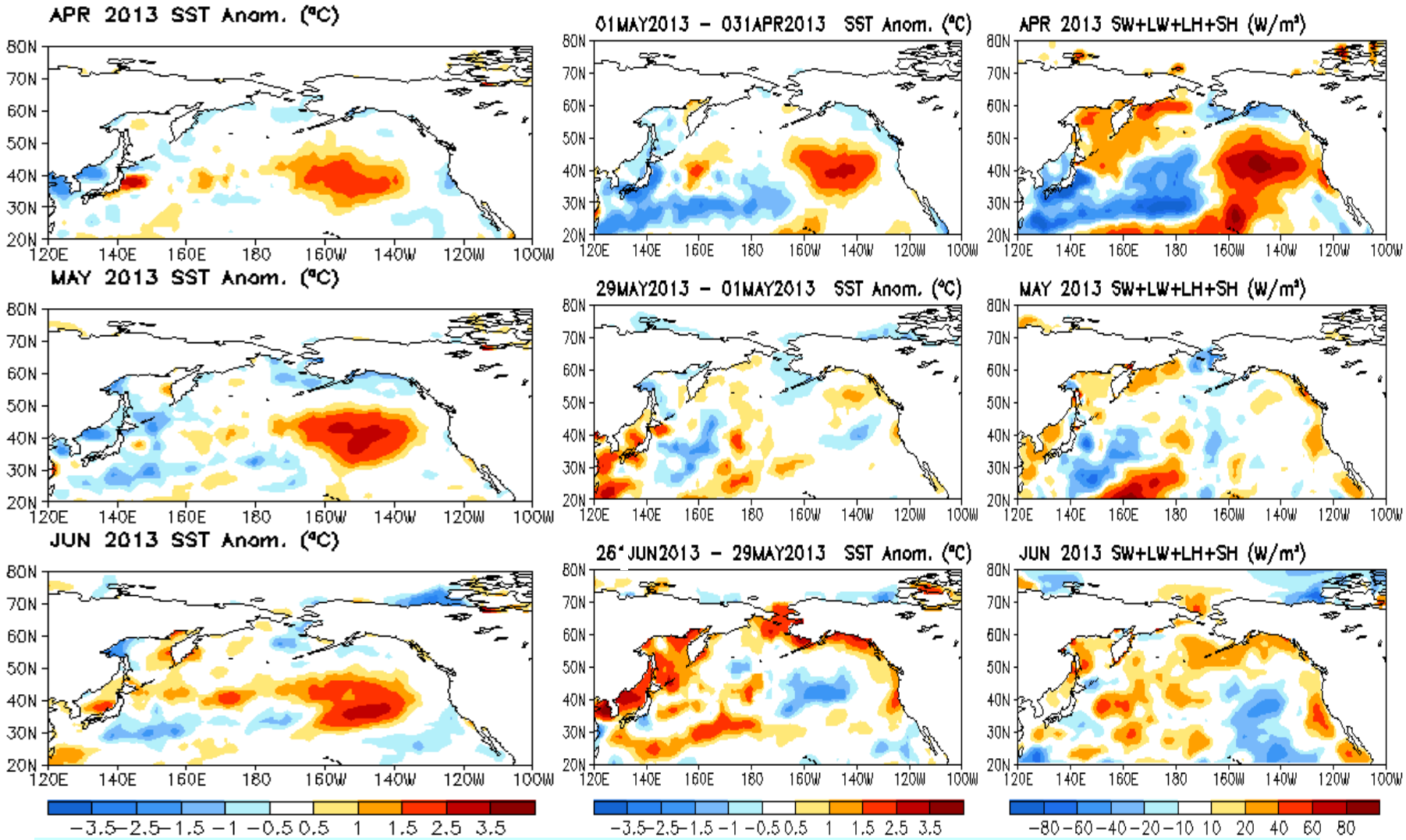
- **Negative PDO phase since May 2010 has persisted for more than 3 years (38 months) now, and the PDO index strengthened in June 2013 with PDO index = -1.4.**

- **The apparent connection between NINO3.4 and PDO index suggest connections between tropics and extratropics.**

- **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.**

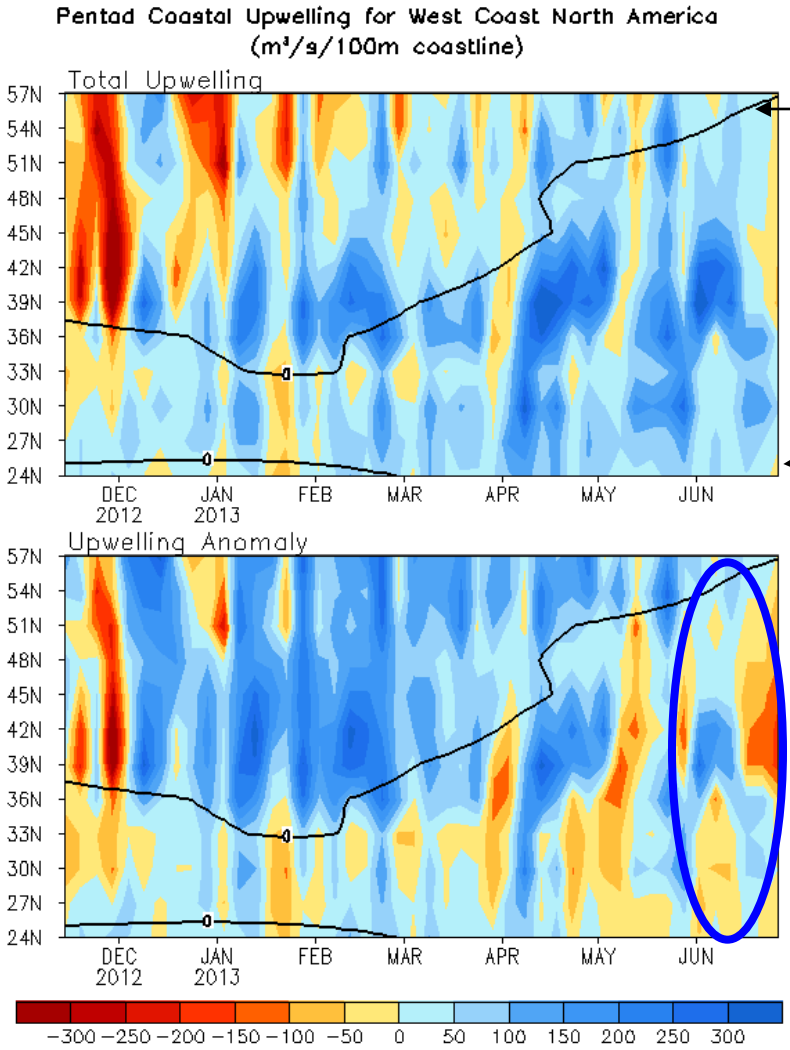
- **The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.**

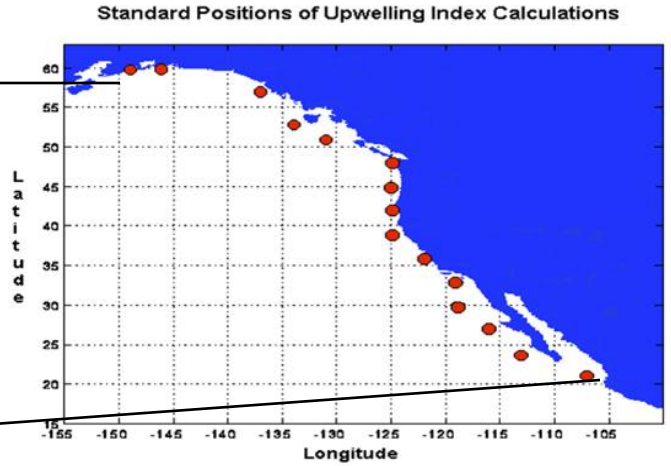
Last Three Month SST, Tendency and Surface heat flux Anom.



- **Negative phase of PDO associated SSTA intensified in June 2013.**
- **SST tendency was largely consistent with the heat flux distribution.**
- **Oceanic dynamics might be the primary factor leading to large SST tendency along the east coast of Asia.**

North America Western Coastal Upwelling





- Upwelling was suppressed for most of locations.

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.

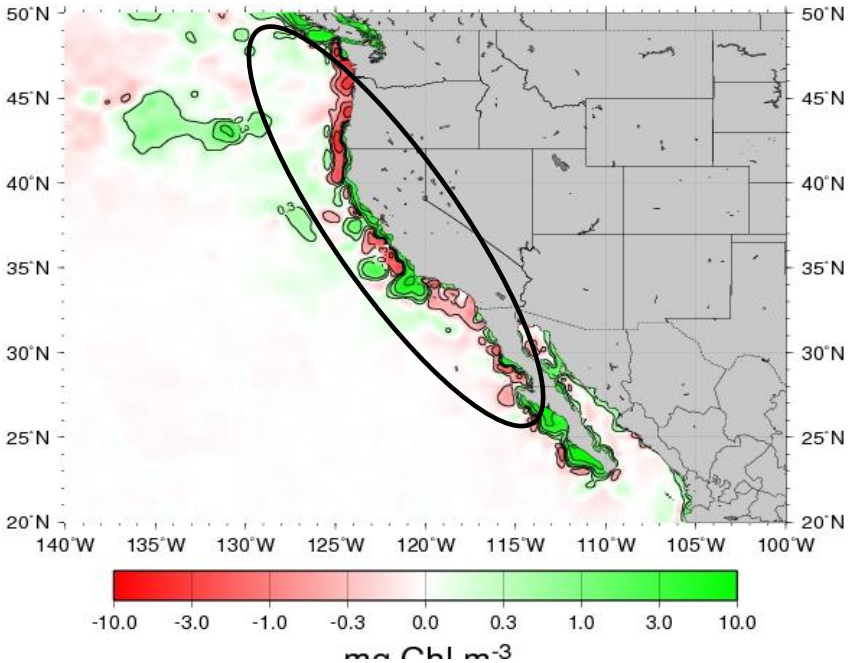
- Area below (above) black line indicates climatological upwelling (downwelling) season.

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

Monthly Chlorophyll Anomaly

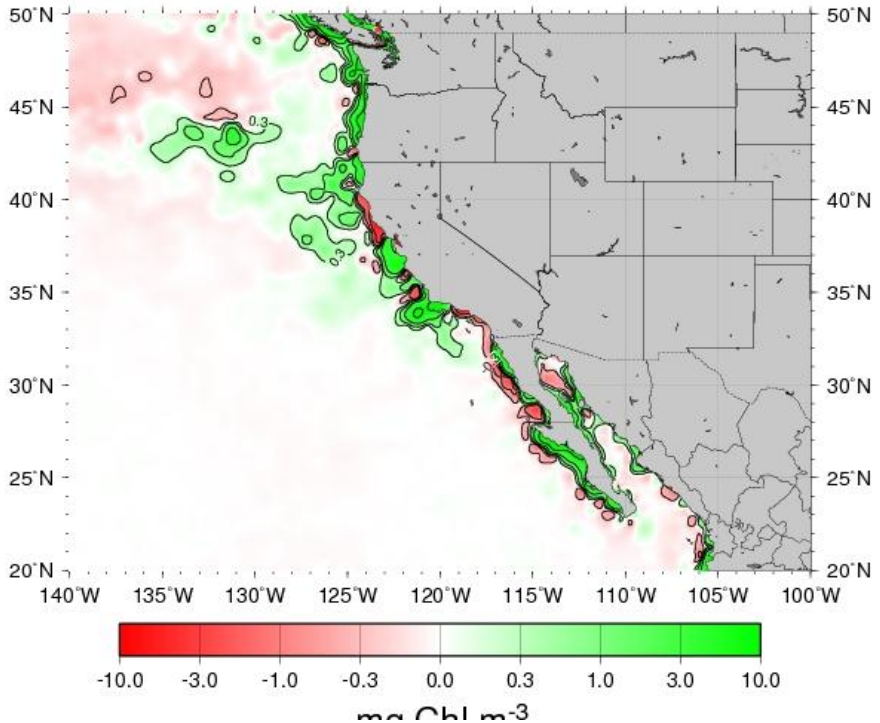
http://coastwatch.pfel.noaa.gov/FAST

MODIS Aqua Chlorophyll a Anomaly for June, 2013



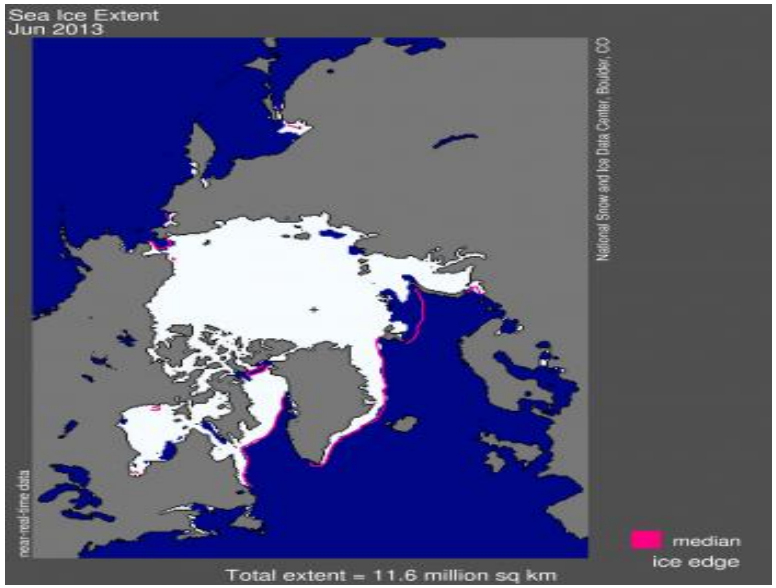
- Negative Chlorophyll anomaly along the coast was consistent with the suppressed upwelling.

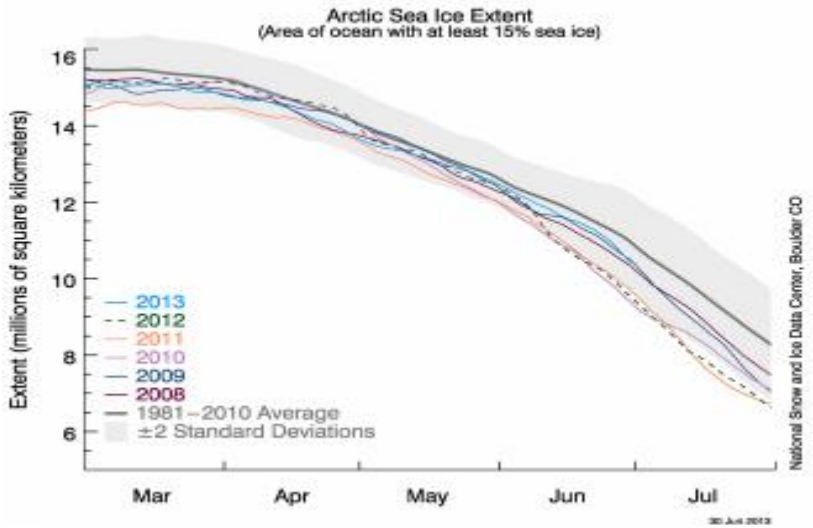
MODIS Aqua Chlorophyll a Anomaly for May, 2013

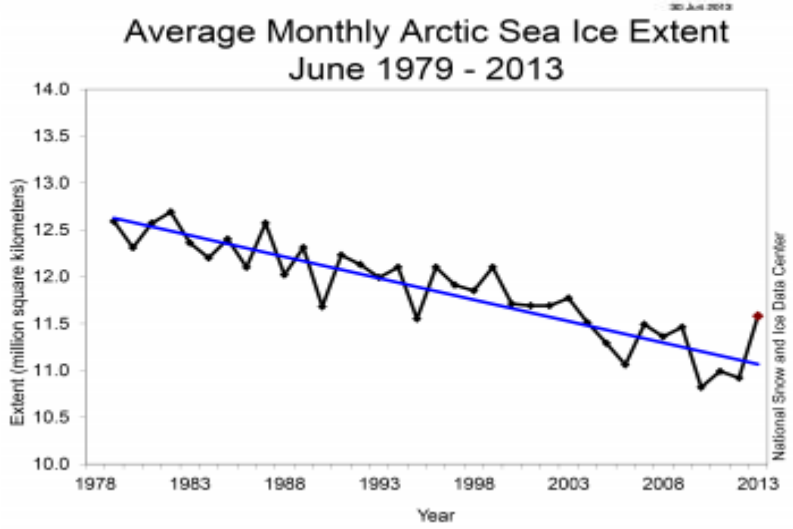


Arctic Sea Ice

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





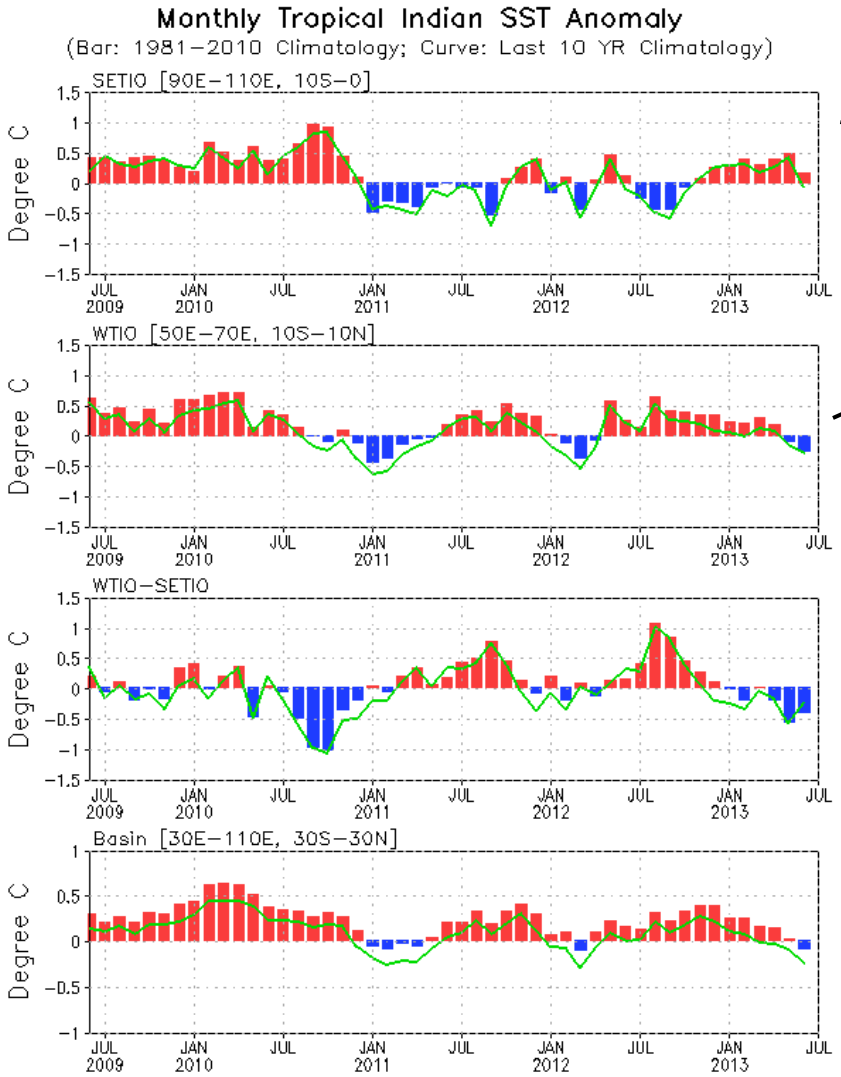


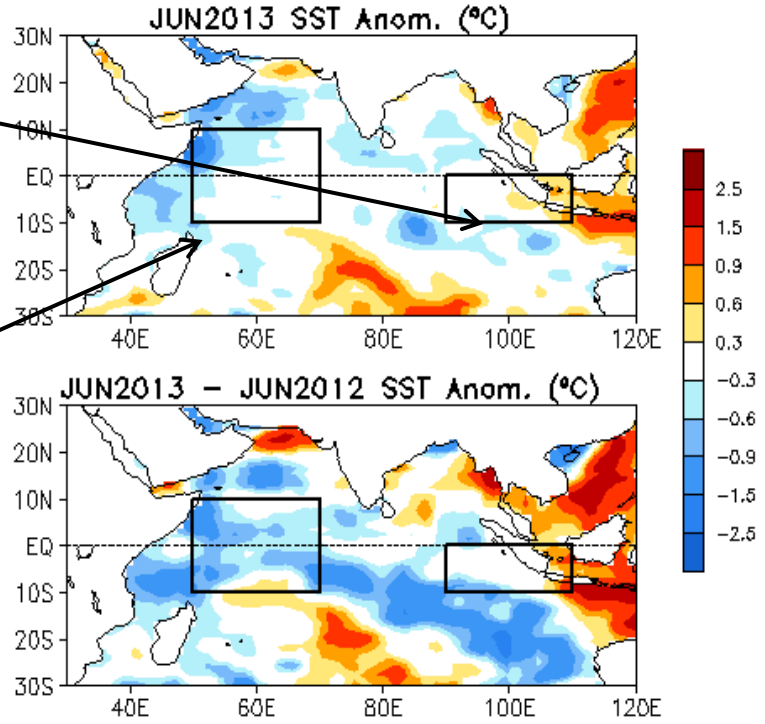
- **Average sea ice extent was below-normal in June 2013, but the ice loss rate from May to June was much slower than last year.**

- **The sea ice extent in June 2013 was higher than that in June 2012.**

Indian Ocean

Evolution of Indian Ocean SST Indices



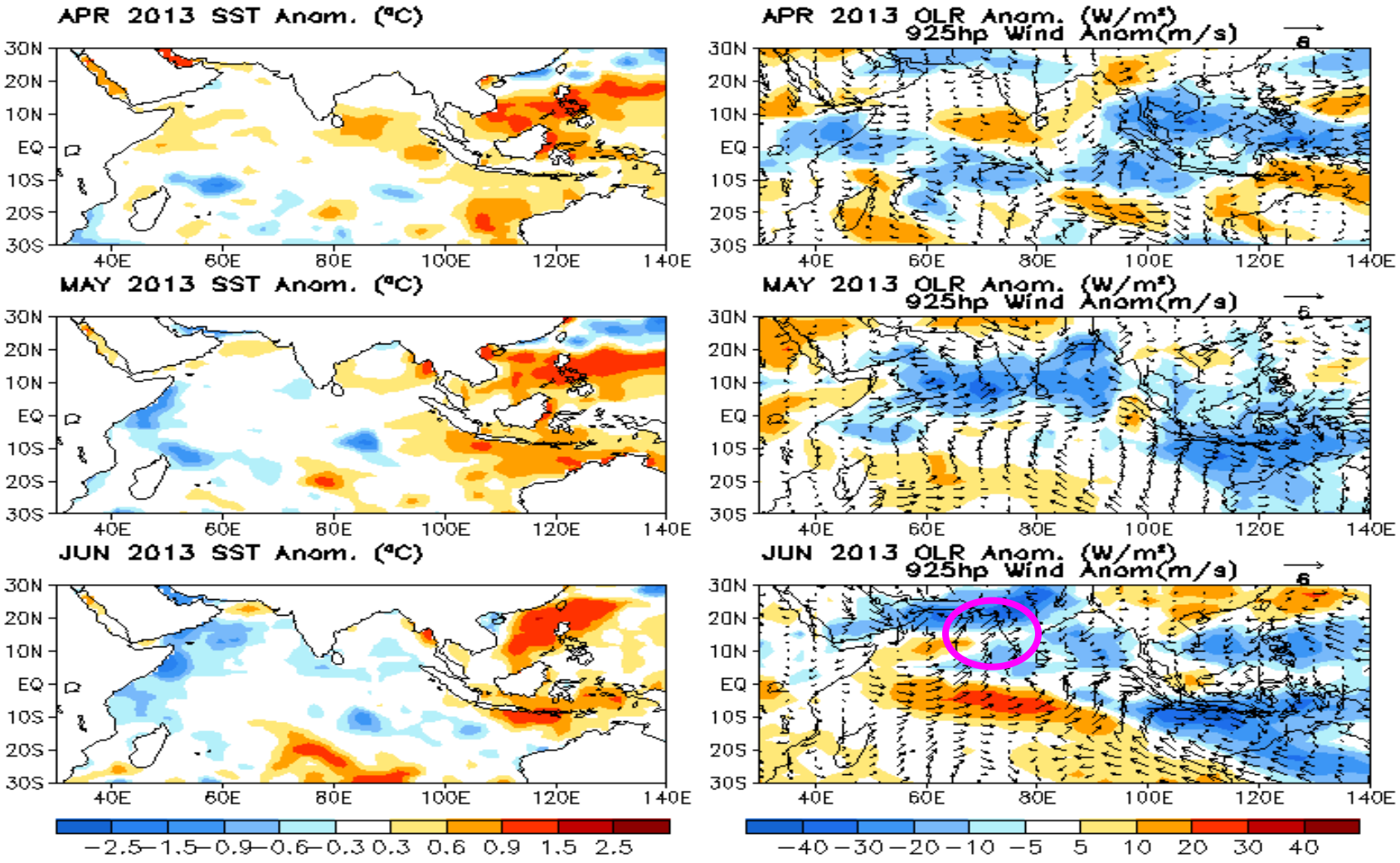


- **DMI was negative since April 2013.**

- **The basin mean SST was below-normal in June 2013.**

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, OLR and 925hp Wind Anom.

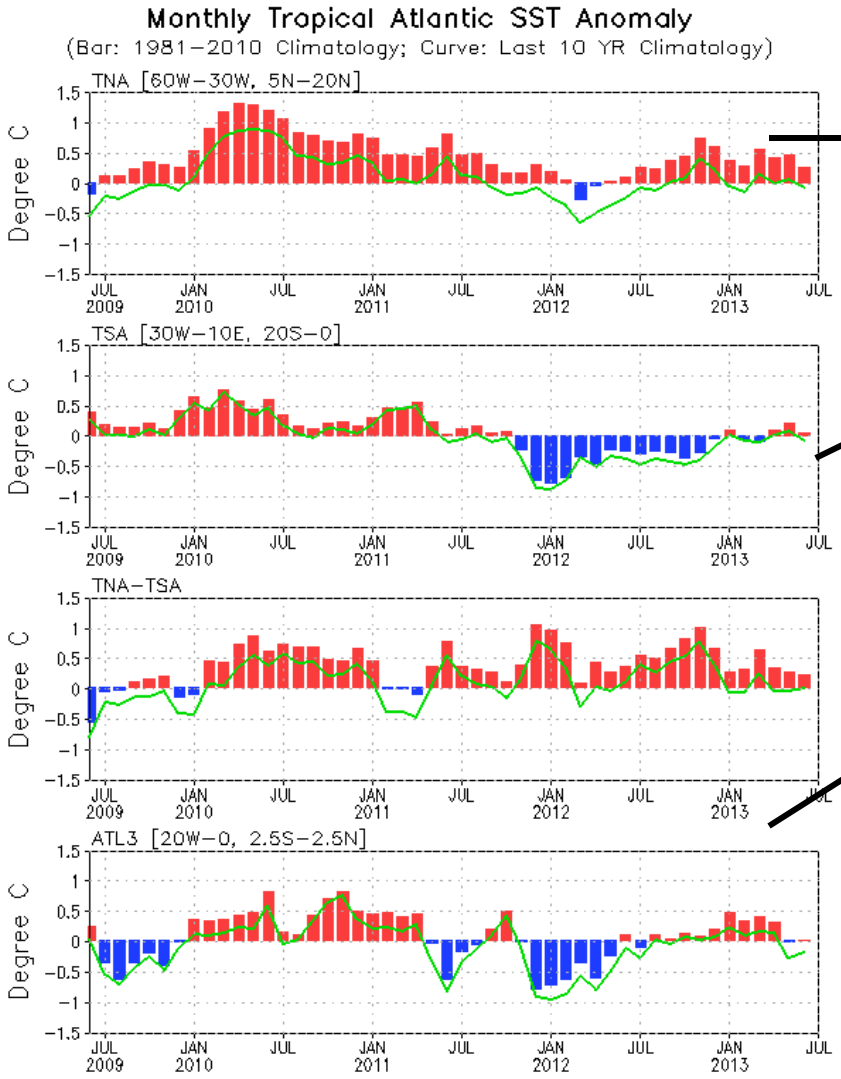


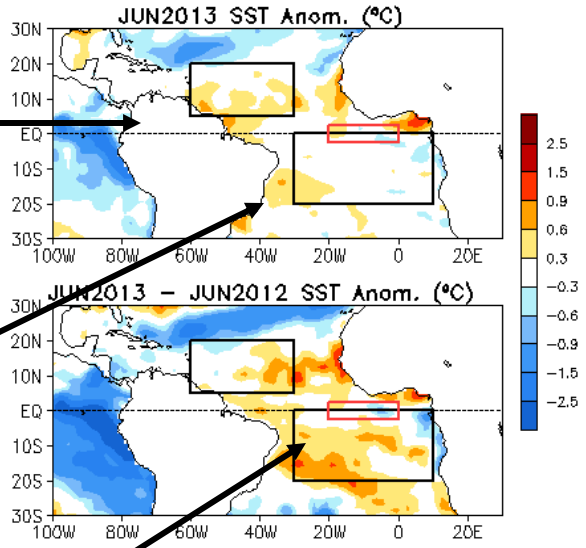
- **Southwestly low-level wind anomalies blew toward the western coast of Indian, increasing chances of rainfall over land.**

- **Convection was enhanced in the northern tropical Indian Ocean .**

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices



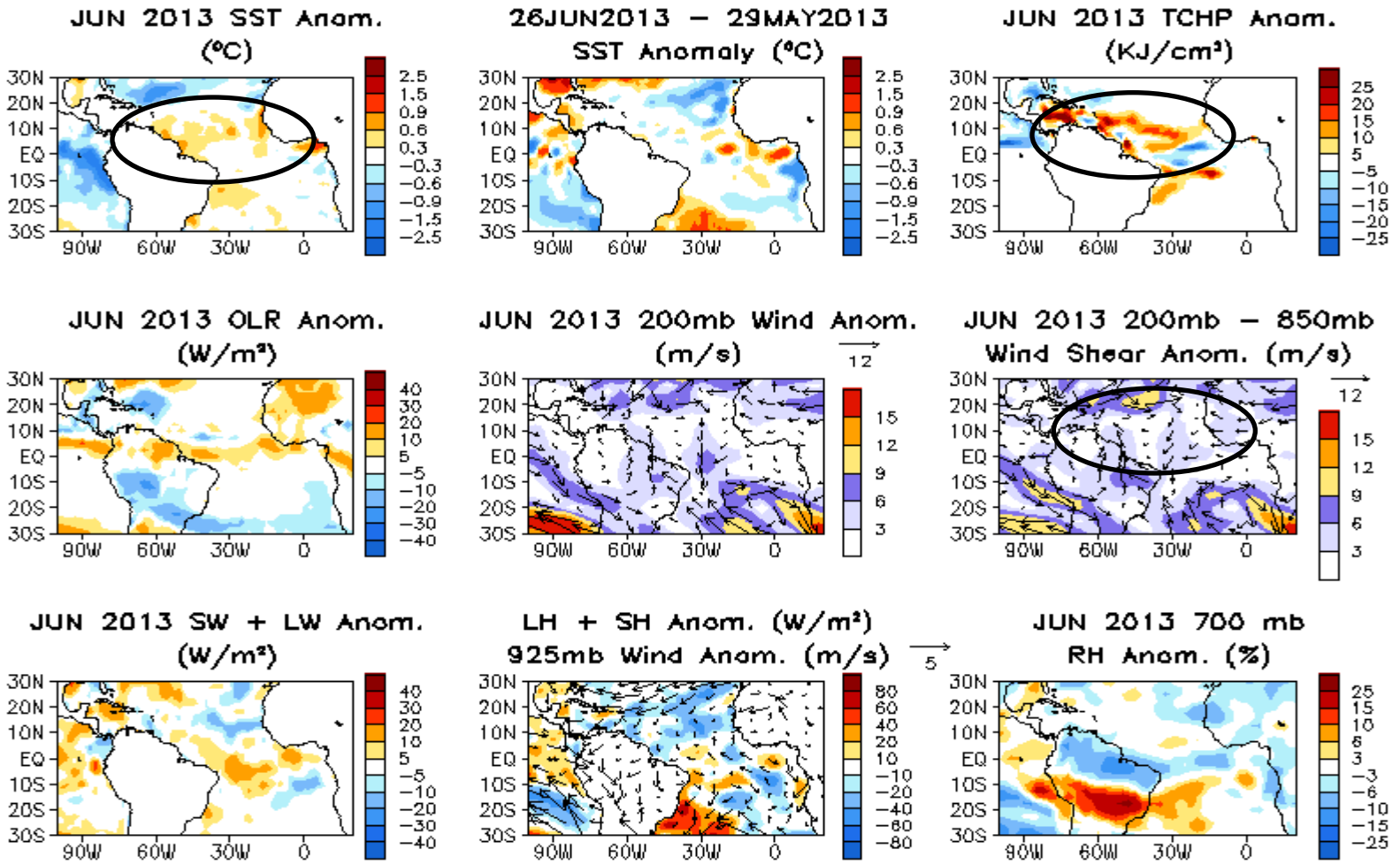


- **SSTA in the tropical North Atlantic (TNA) continued above-normal in June 2013.**
- **Meridional Gradient Mode index (TNA-TSA) was above-normal since May 2011.**
- **ATL3 SSTA was near-normal in Jun 2013.**

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., TCHP,OLR, Sfc Flx, 925-mb/200-mb Winds and RH



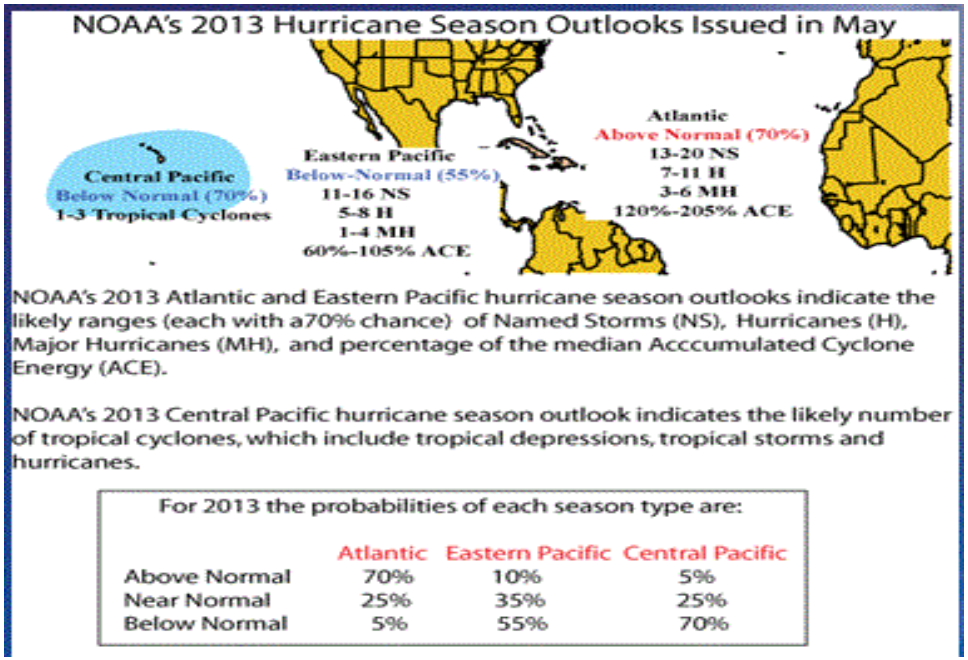
- **Above-normal SSTA and TCHP continued in the hurricane Main Development Region (MDR) .**
- **Below-normal vertical wind shear was observed in MDR.**
- **Convection was suppressed (enhanced) near the equator (Caribbean Sea).**

NOAA Predict an Above-Normal Atlantic Hurricane Season in 2013

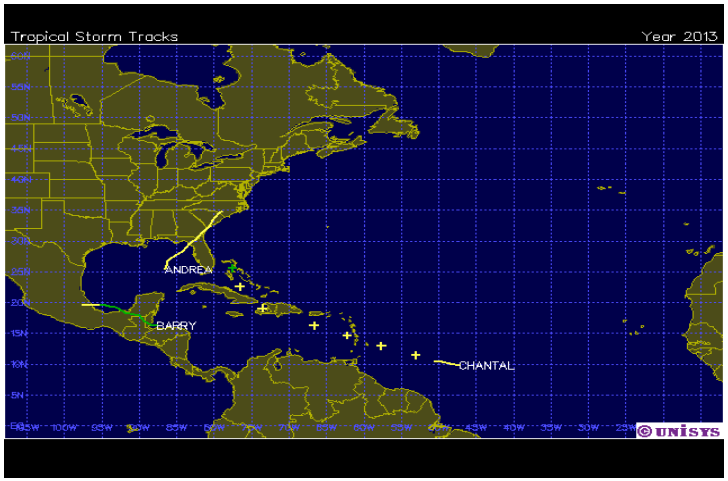
(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml

http://weather.unisys.com/hurricane/atlantic/2013/index.html)

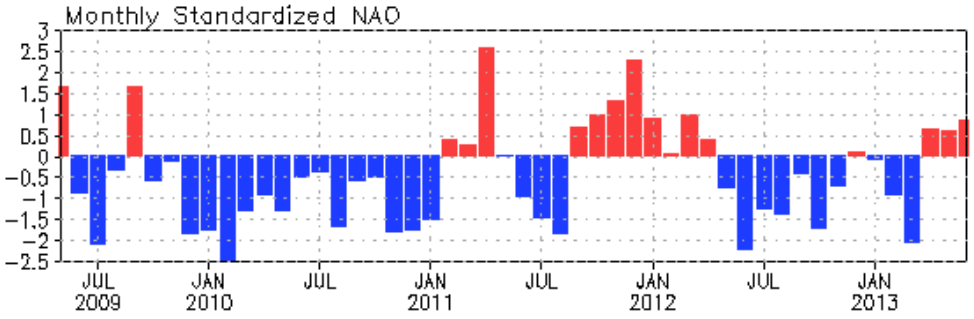
	2013 prediction (issued on May 23) (1981-2010)
Named storms	13-20 (12.1)
Hurricanes	7-11 (6.4)
Major hurricanes	3-6 (2.7)
ACE %	120-205

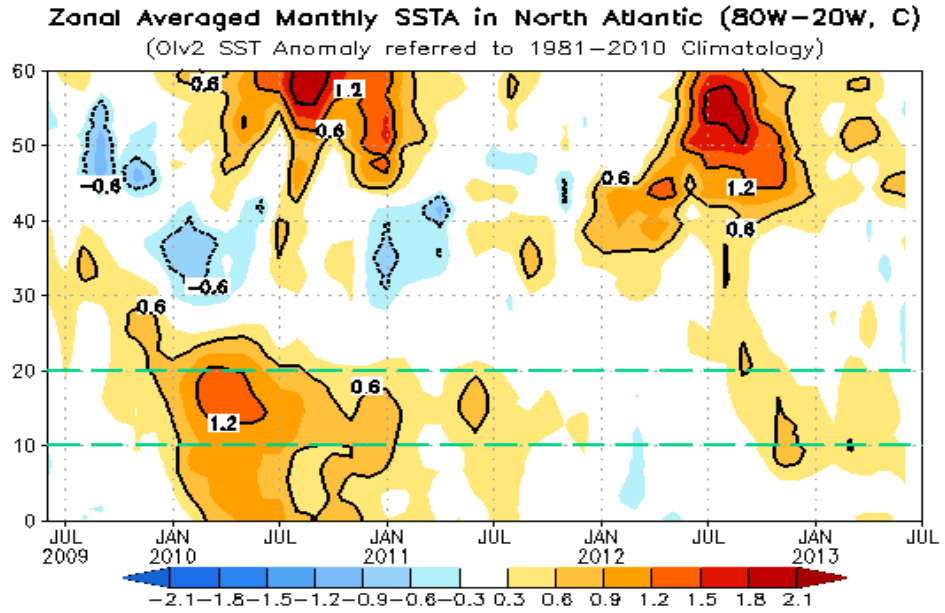


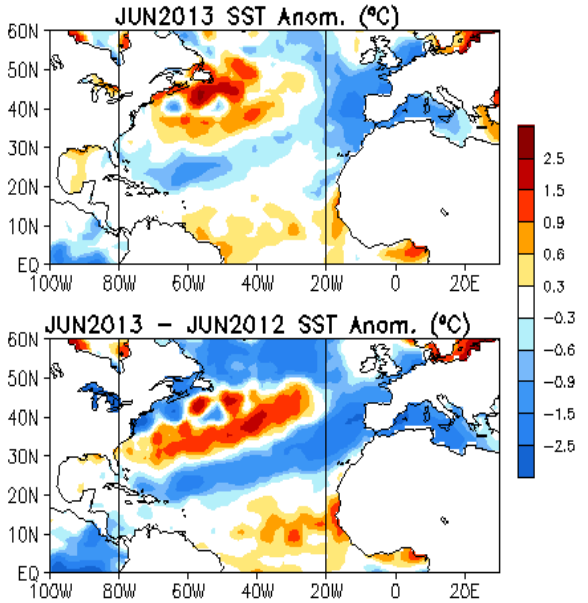
- Low frequency: increased Atlantic hurricane activity since 1995
- An expected continuation of above-average SSTs across the tropical Atlantic;
- A likely continuation of ENSO-neutral condition;
- Three tropical storms were formed in the North Atlantic by July 8



NAO and SST Anomaly in North Atlantic







- **High-latitude North Atlantic SSTA is generally closely related to NAO index (negative NAO leads to SST warming and positive NAO leads to SST cooling).**

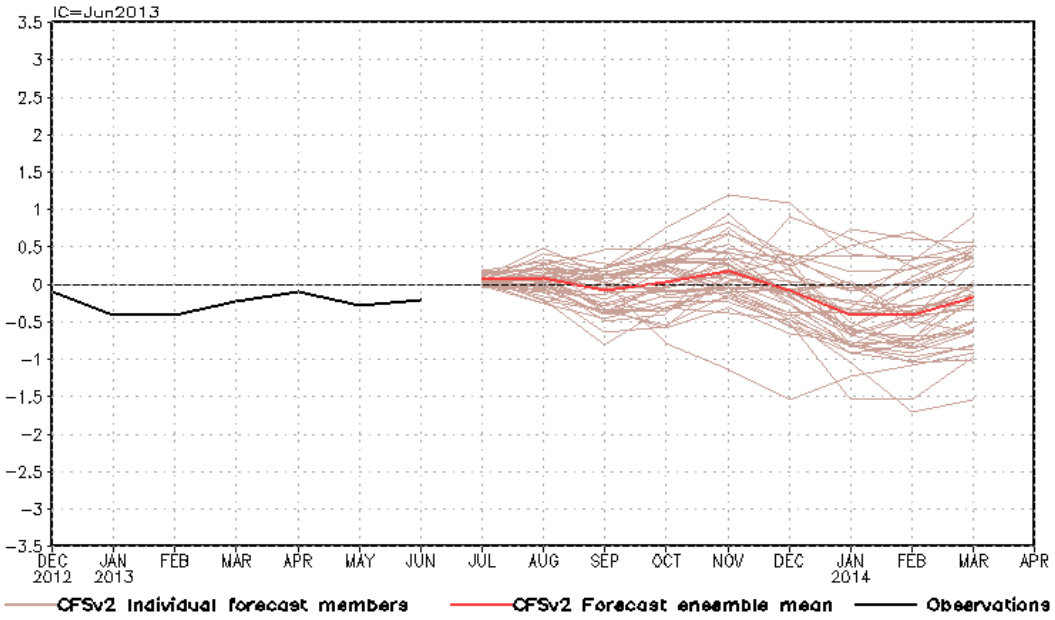
- **NAO switch from negative to positive since April 2013.**

-**In the past three hurricane seasons, positive SSTA in MDR was strong in 2010, and became weakening in subsequent two years.**

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.

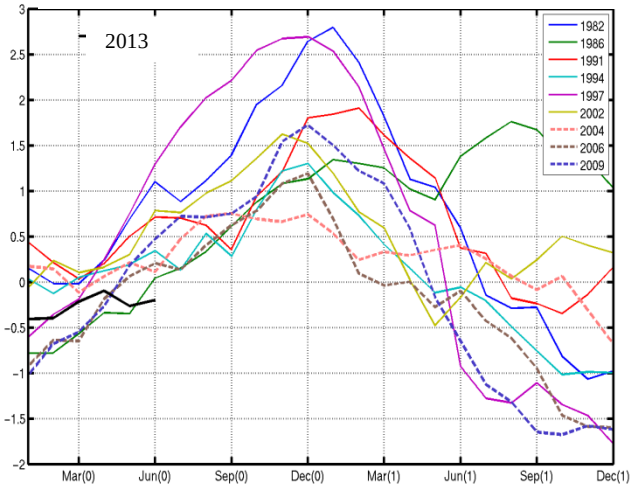
Global SST Predictions

NCEP CFSv2 NINO3.4 Forecast

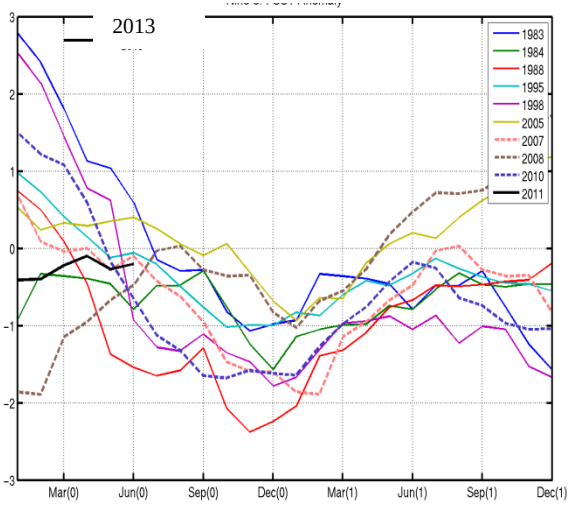


- **NCEP CFSV2 predict ENSO-neutral condition in the coming summer-autumn 2013**
- **Historical record (1980-2012) shows similar condition in June either continued ENSO neutral condition or developed La Nina event in the following winter.**

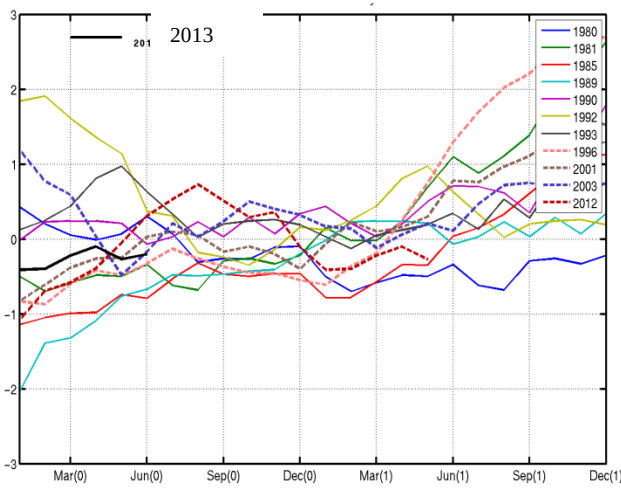
Nino3.4 El Nino Composite



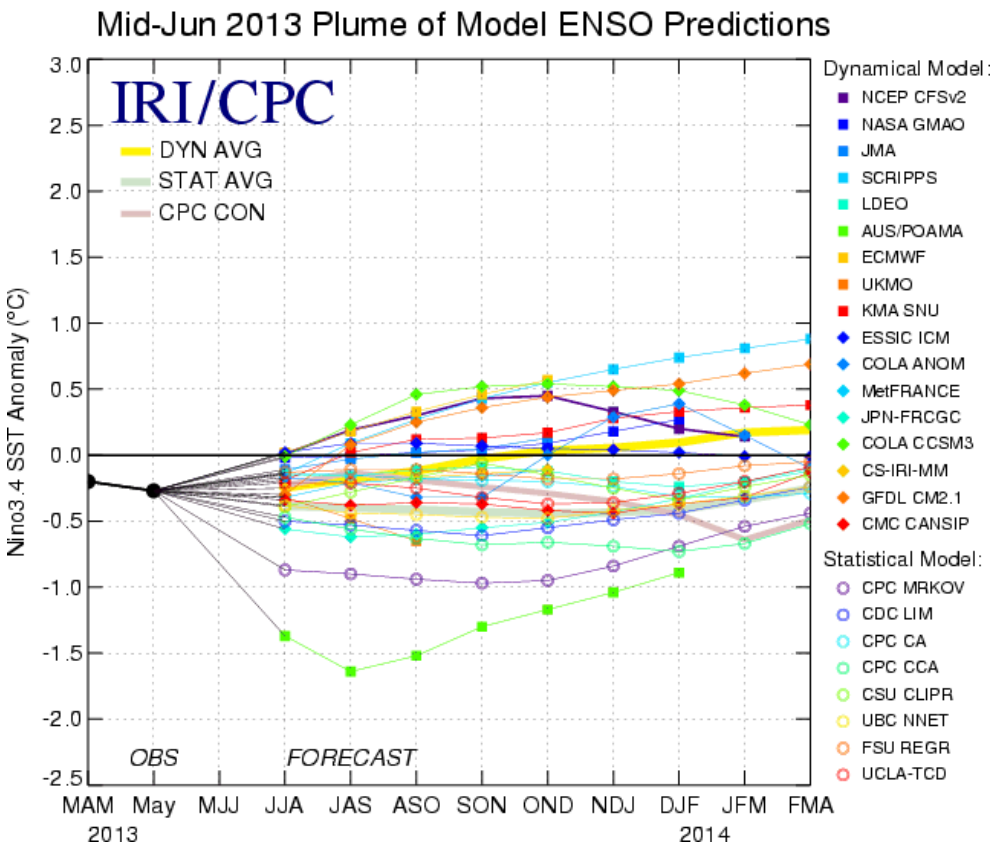
Nino3.4 La Nina Composite

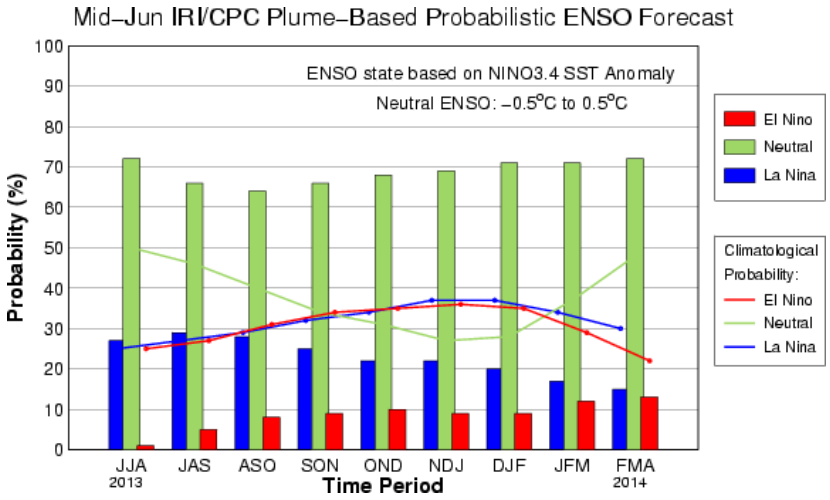


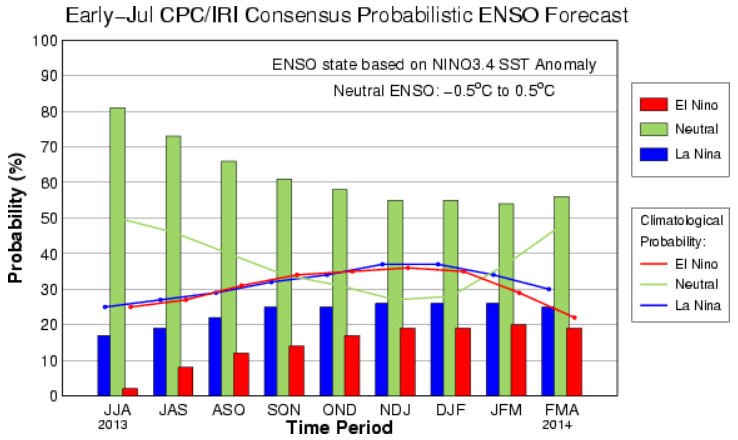
Nino 3.4 Neutral Composite



IRI/CPC NINO3.4 Forecast Plume

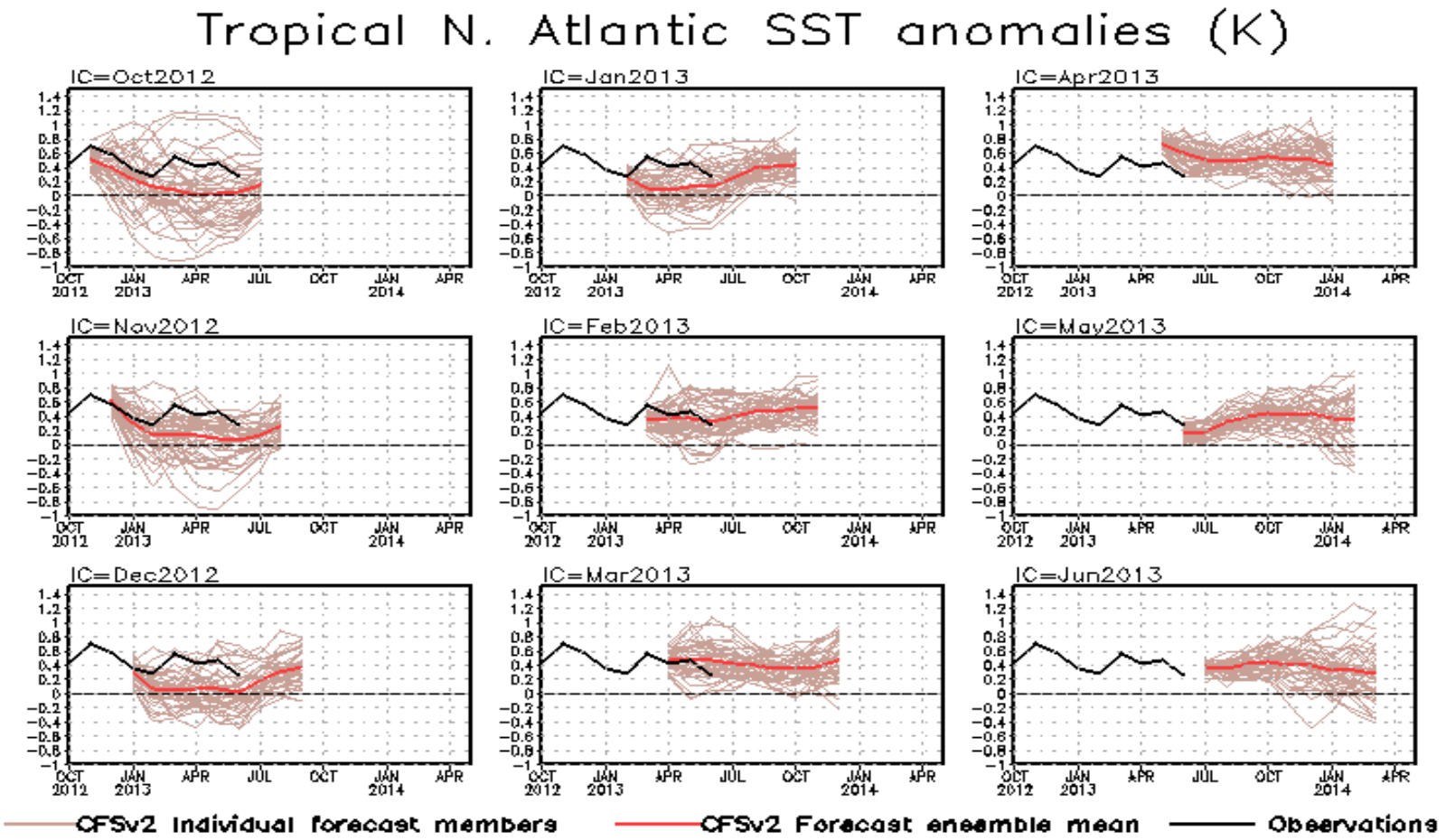






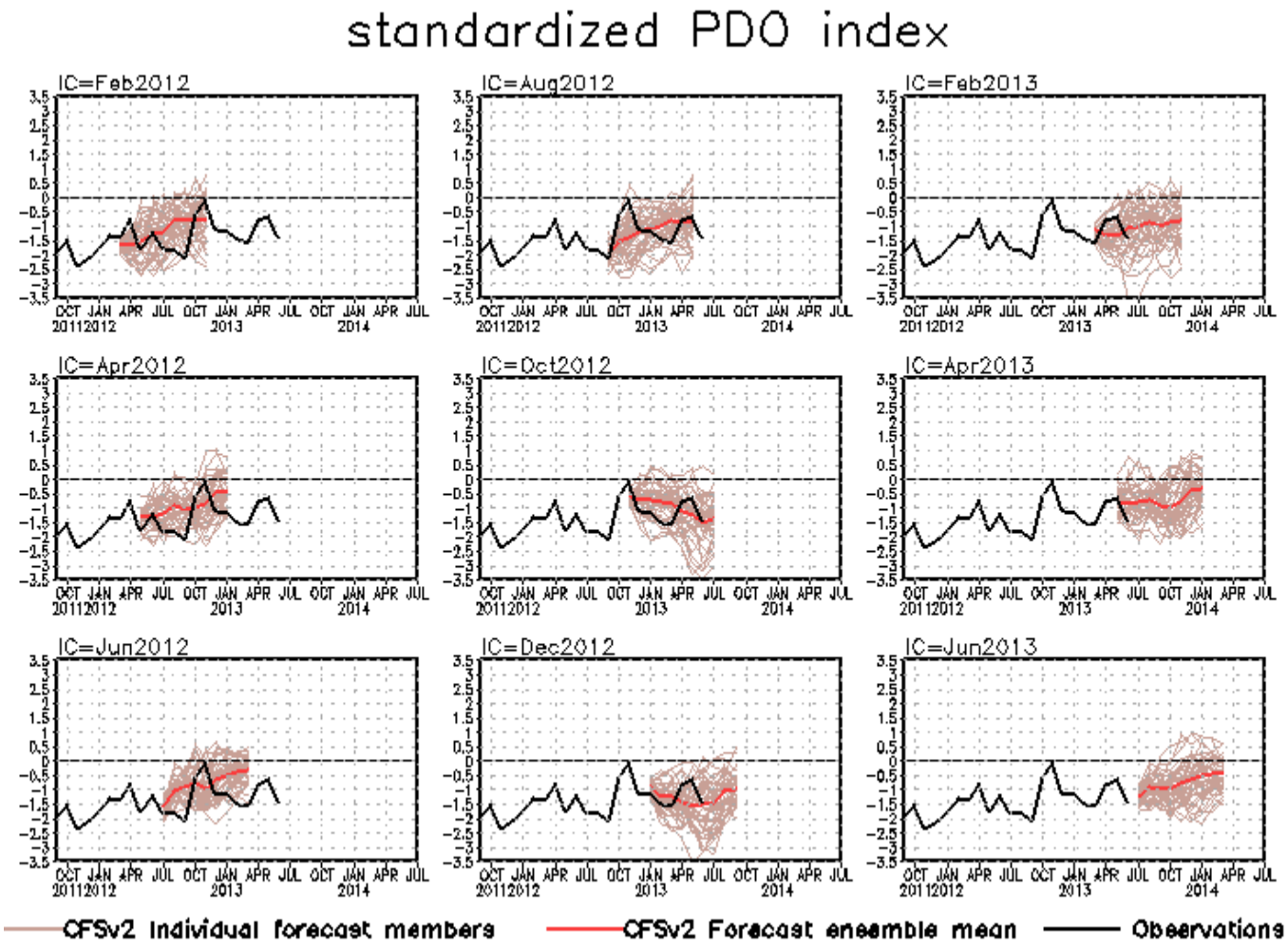
- **Most of the models predicted ENSO-neutral in the coming Northern Hemisphere summer and autumn.**
- **The consensus forecast favors ENSO-neutral conditions in the summer-autumn 2013.**

NCEP CFSv2 Tropical North Atlantic SST Forecast



- **Latest CFSv2 prediction suggests that above-normal SST in the tropical N. Atlantic will continue in summer-autumn 2013 (hurricane season).**

NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast



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.

- Latest CFSv2 prediction suggests negative PDO phase will persist through the coming fall and winter .

Overview

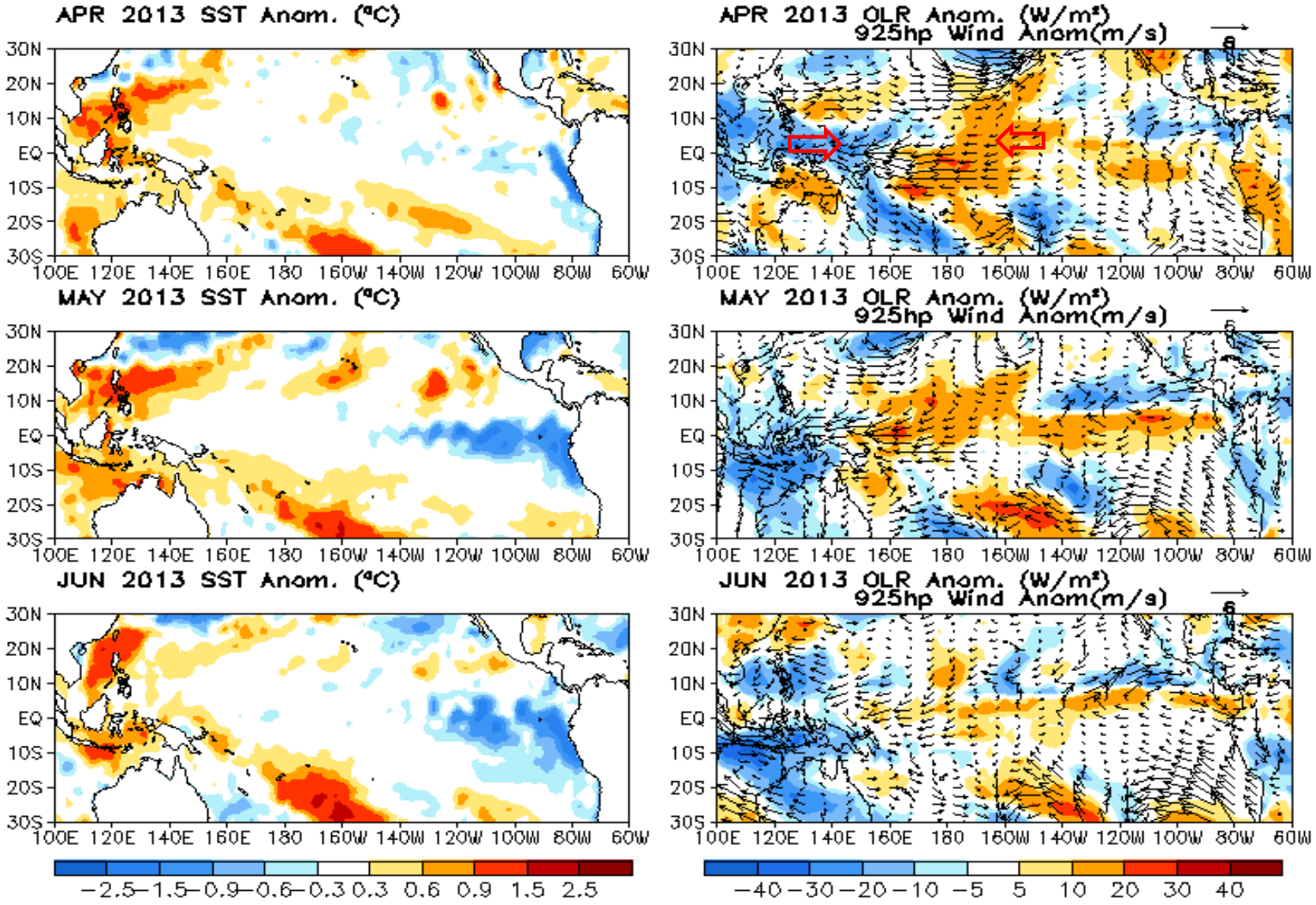
- **Pacific and Arctic Oceans**
  - **ENSO-neutral conditions continued during June 2013 and a warming tendency emerged in the eastern Pacific.**
  - **The consensus forecast favors ENSO-neutral conditions to continue into the Northern Hemisphere fall 2013.**
  - **Negative PDO phase strengthened with PDO=-1.4 in June 2013, and NCEP CFSv2 predicted negative PDO phase would continue into the coming fall.**
  - **The sea ice extent in June 2013 is higher than last year due to a slower sea ice loss rate.**

- **Indian Ocean**
  - **SSTs were above-normal in the east and slightly below-normal in the west, and negative Indian Ocean Dipole index continued in June 2013.**

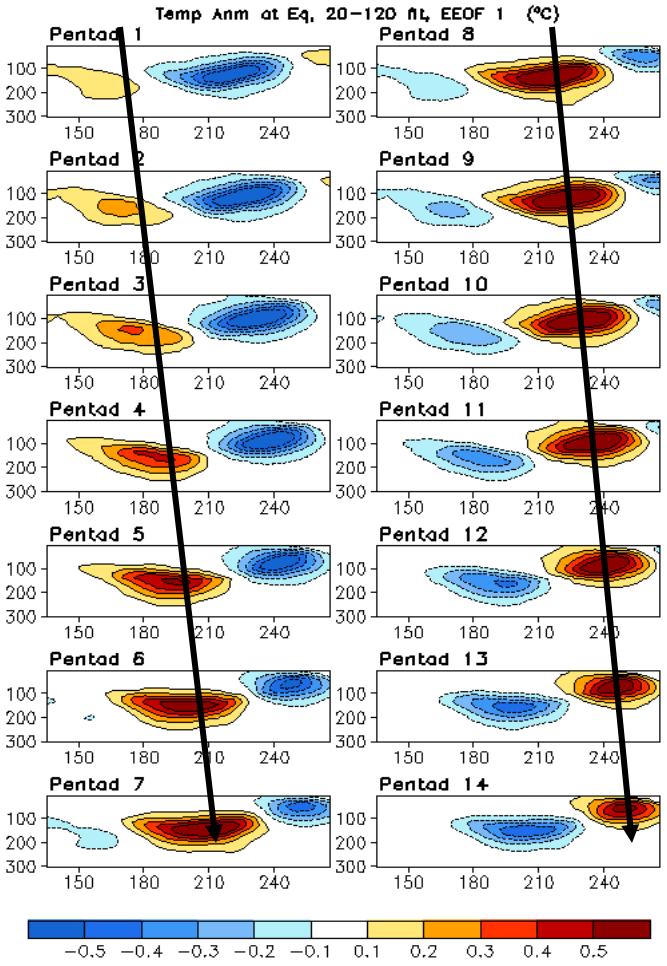
- **Atlantic Ocean**
  - **Above-normal SST continued in the hurricane main development region.**
  - **NOAA predicted above-normal condition of hurricane activity in 2013.**
  - **Positive NAO index persisted in the past three months.**

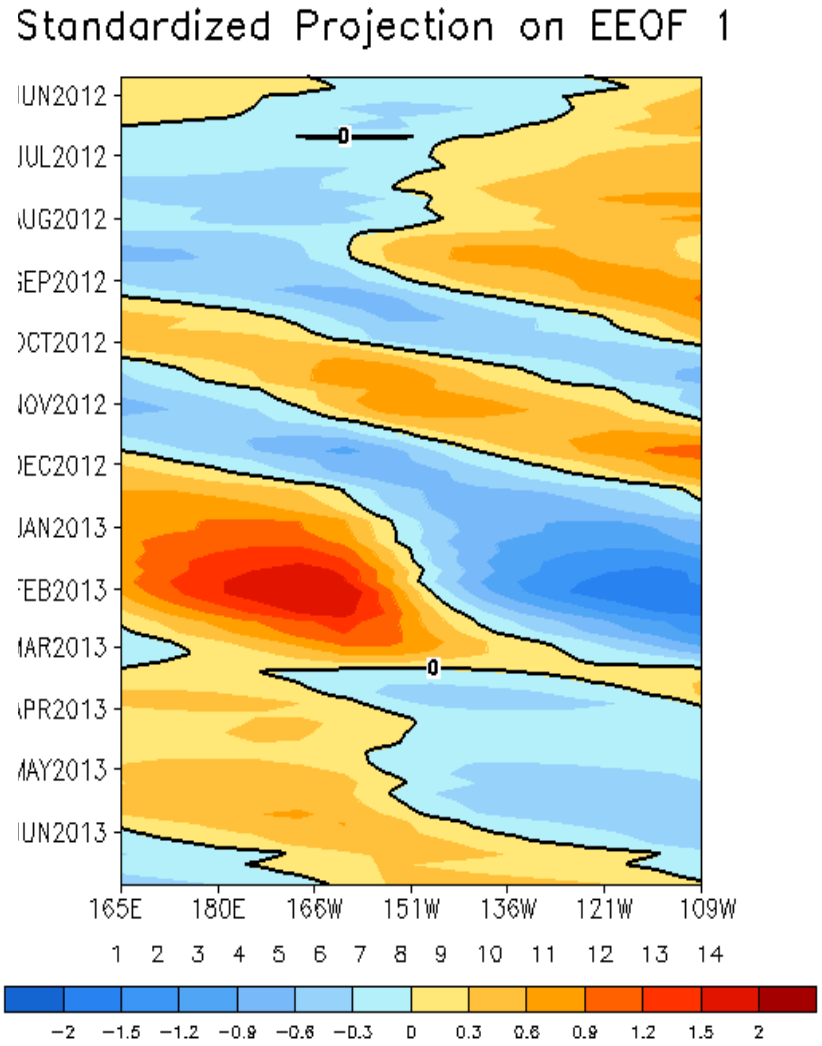
Backup Slides

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



Oceanic Kelvin Wave Indices





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

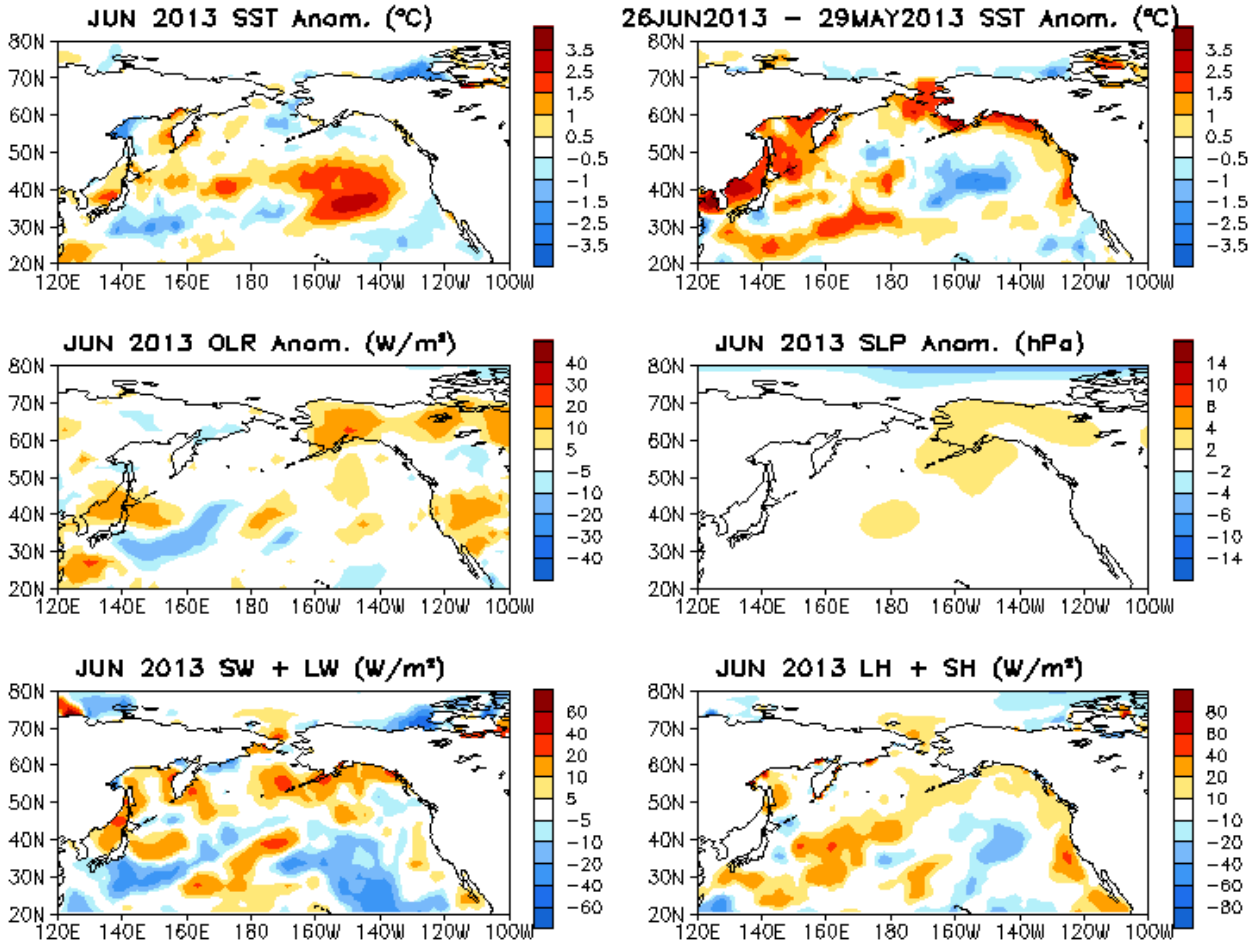
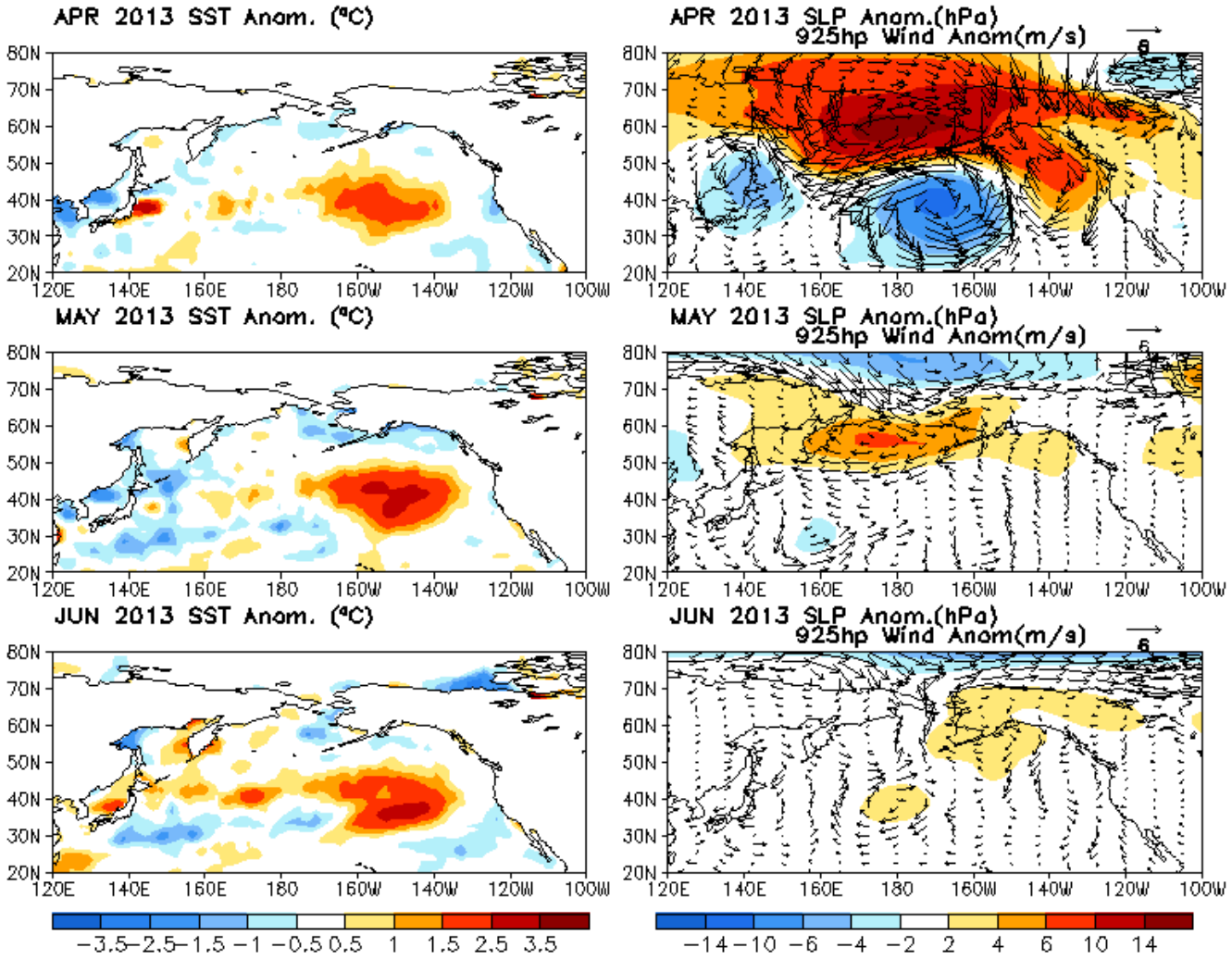


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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



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

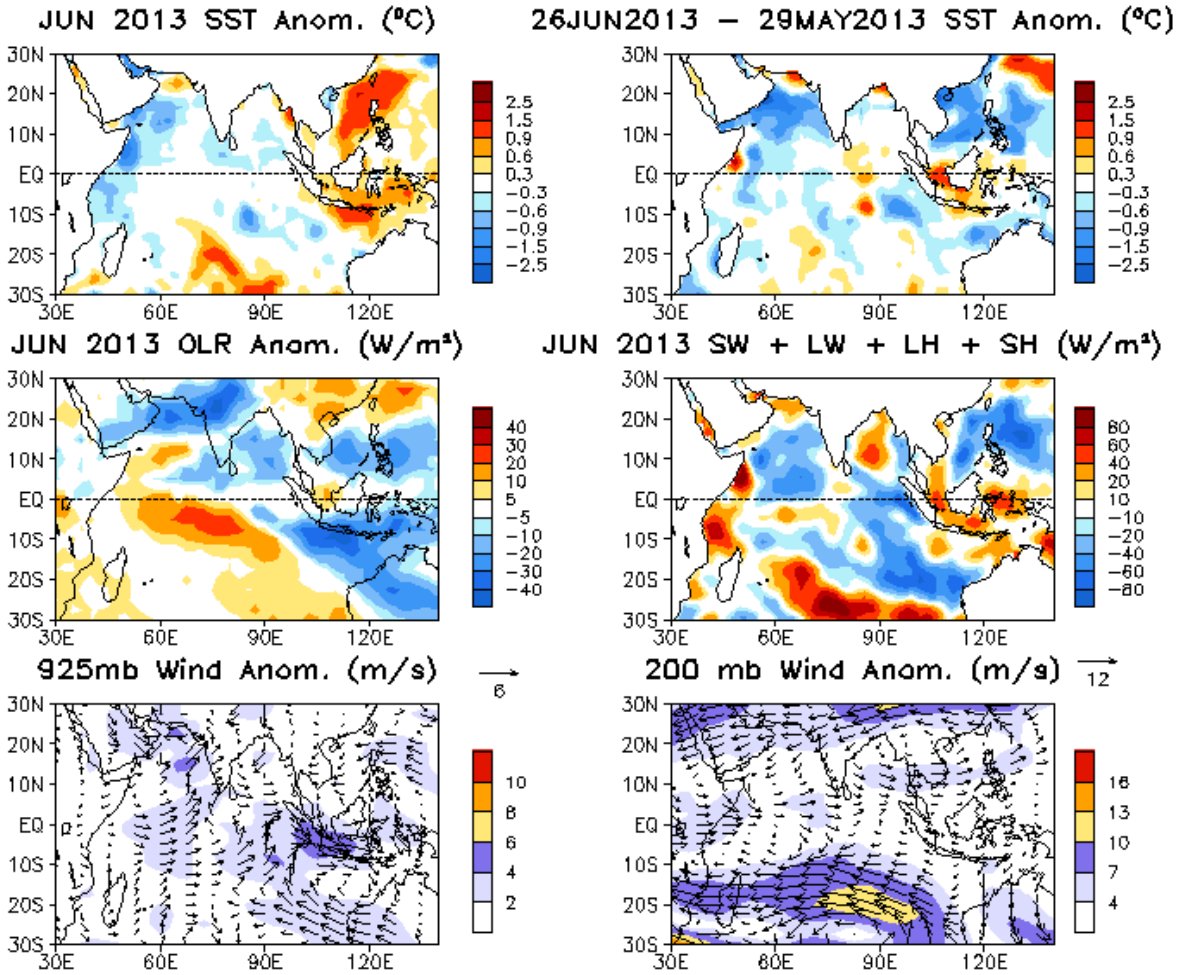


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

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

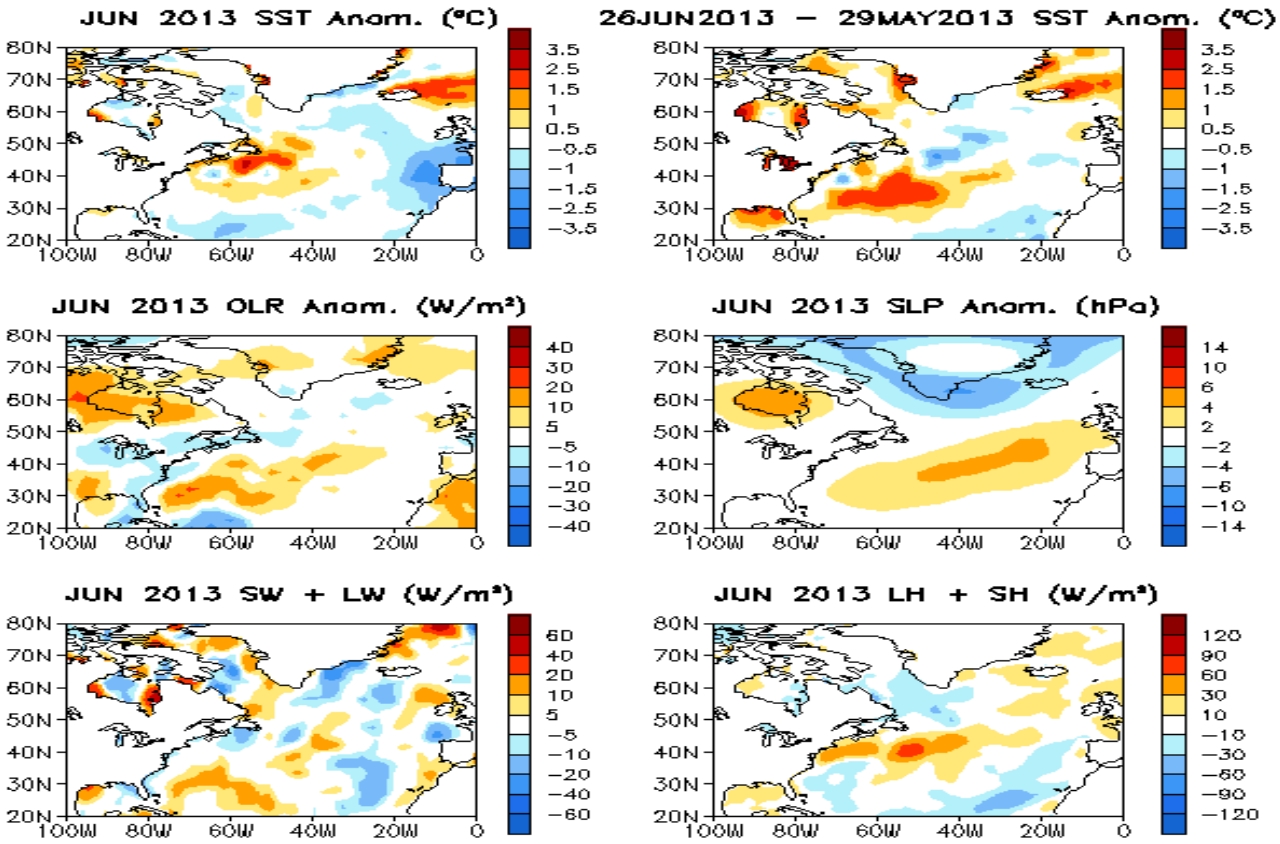
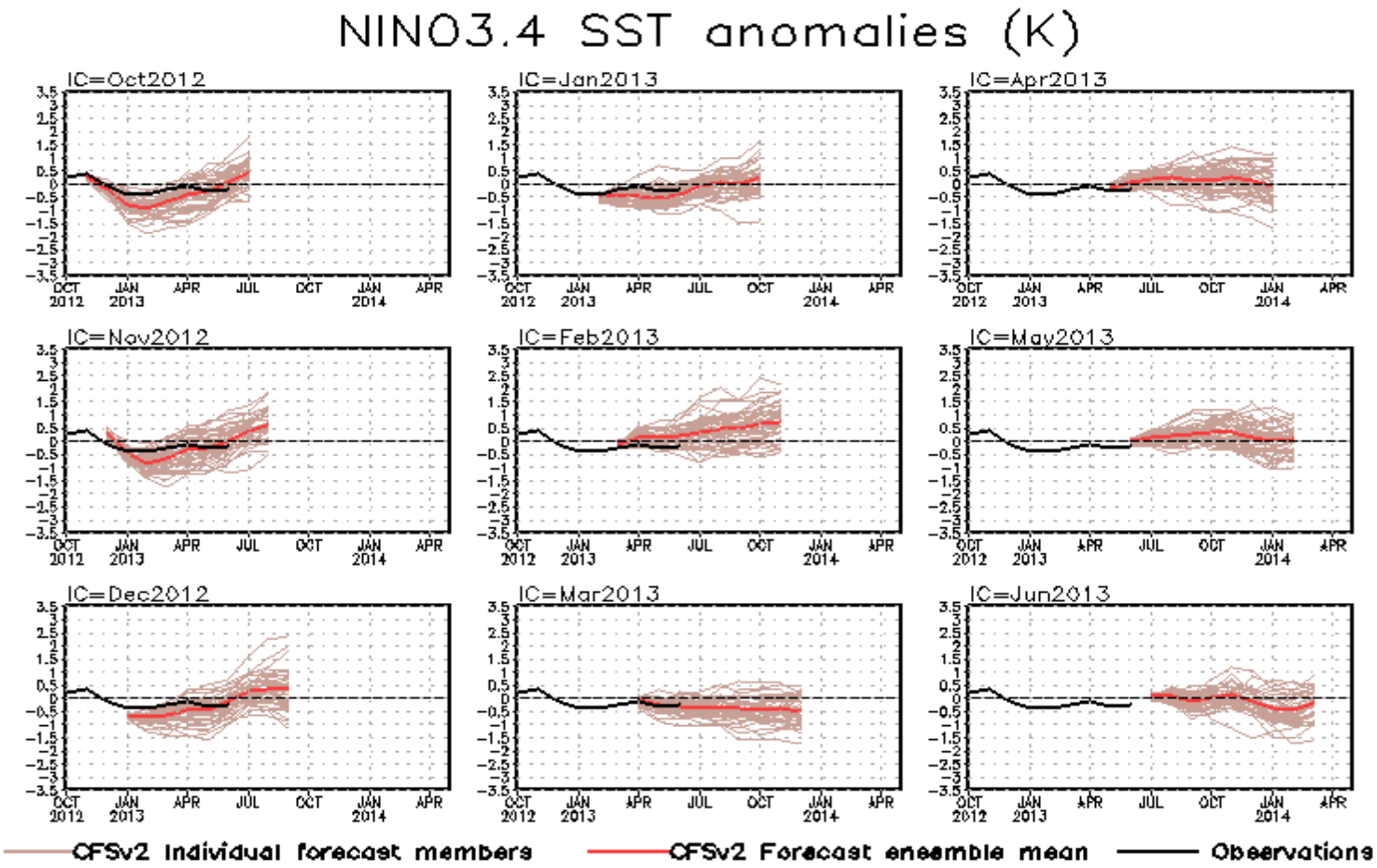
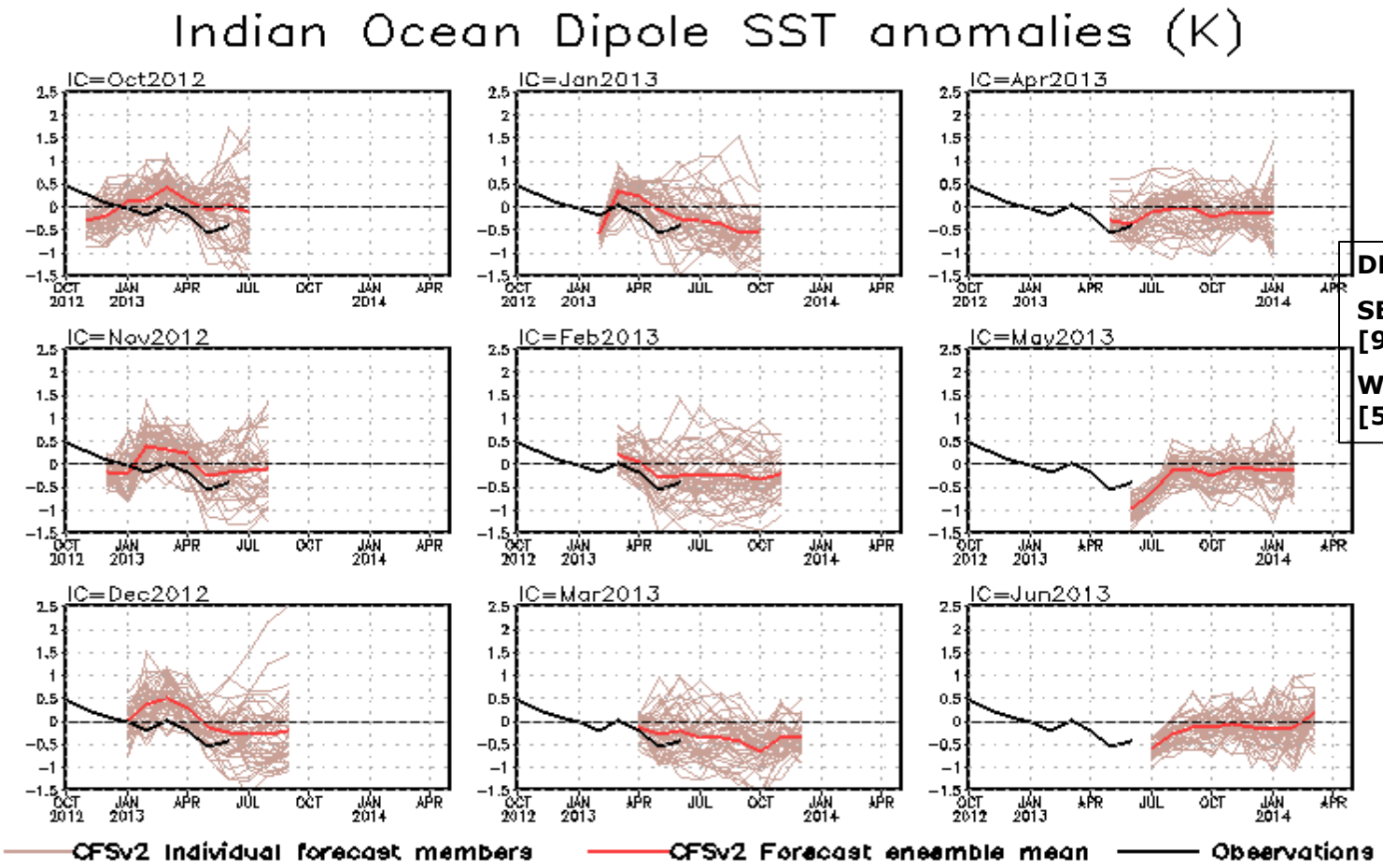


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

NCEP CFSv2 NINO3.4 Forecast



NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

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

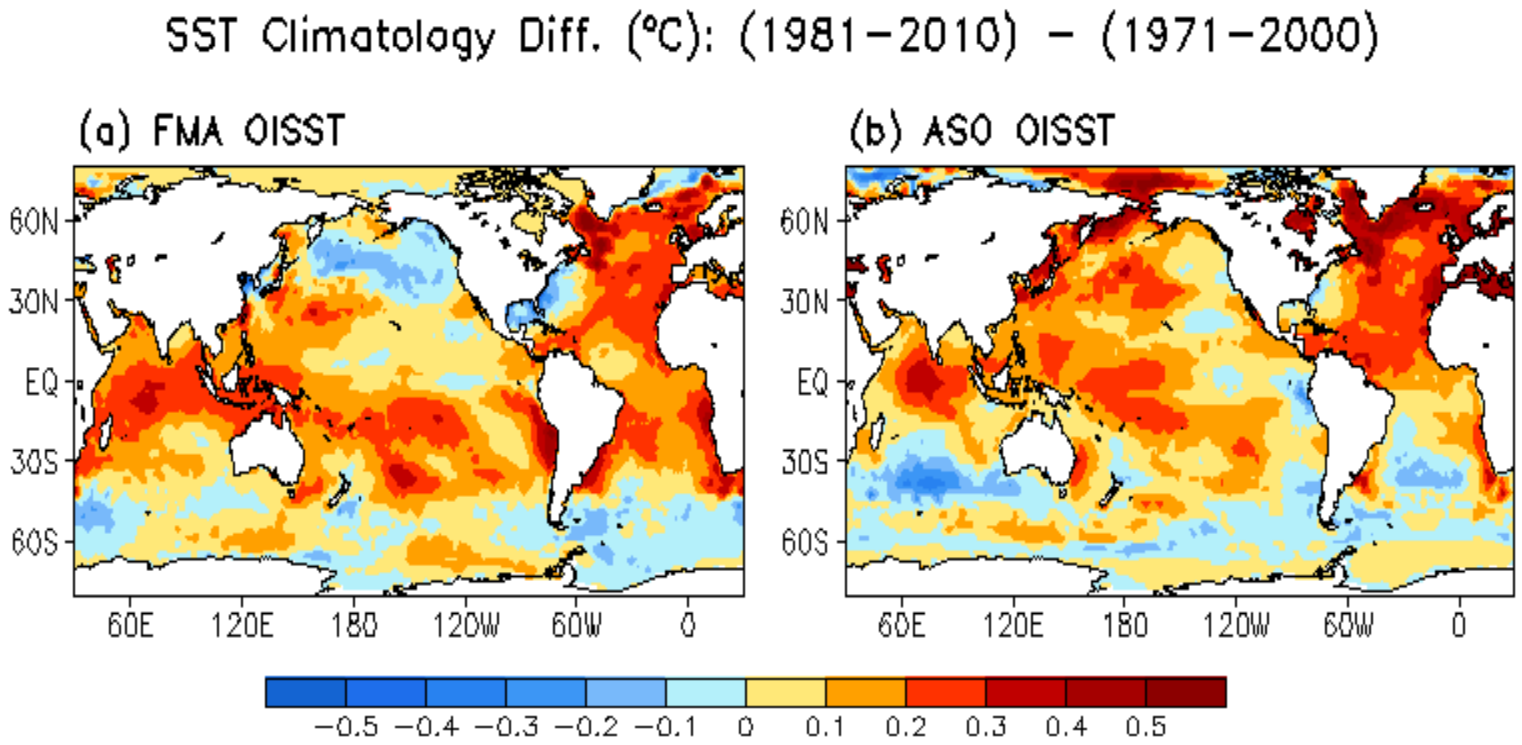
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1981-2010 base period means.

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°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!