

# 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**

# Overview

## ▪ Pacific and Arctic Oceans

- ENSO-neutral conditions continued with NINO3.4=0.3°C in June 2012.
- CFSv1 and CFSv2 predict an El Nino developing by July-September 2012. An El Nino watch was issued by NOAA “ENSO Diagnostic Discussion”
- Negative PDO phase since May 2010 has persisted for 26 months.
- Arctic sea ice extent retreated rapidly in June 2012 and reached the second historical low in the satellite record.

## ▪ Indian Ocean

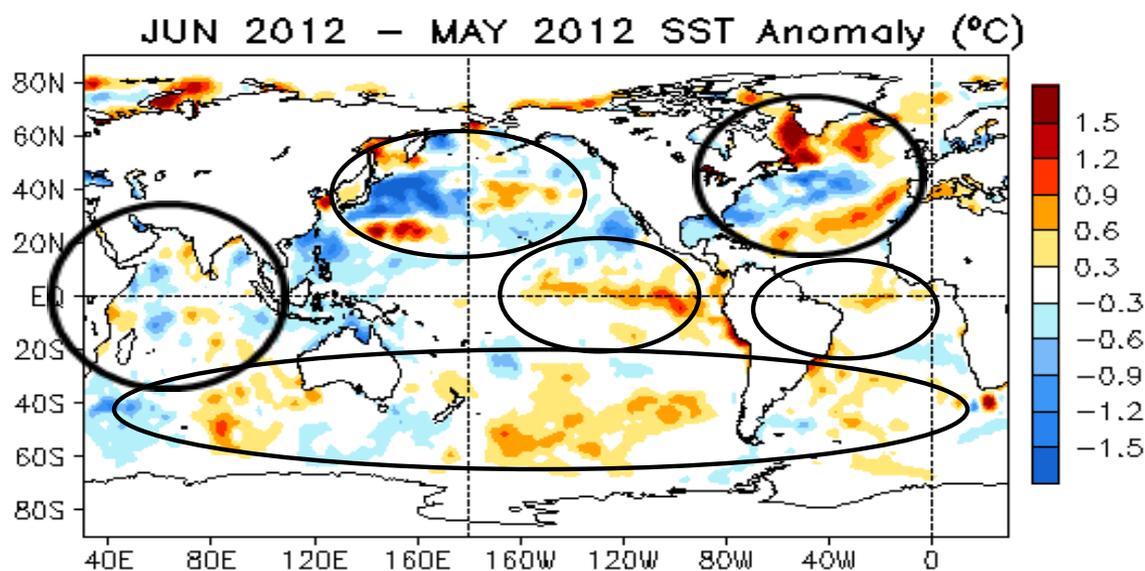
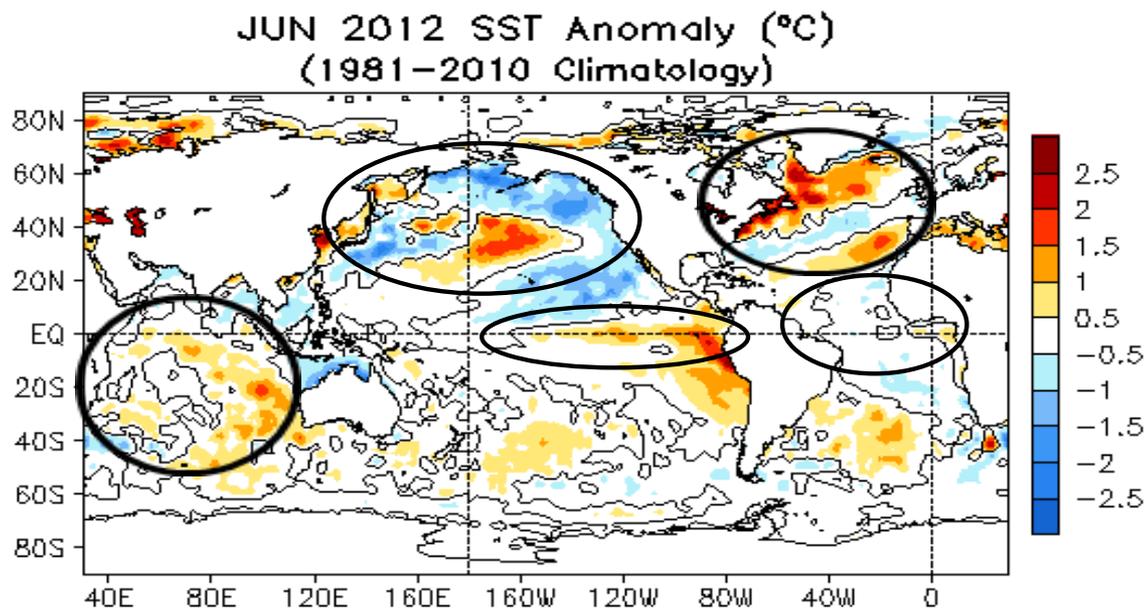
- Positive SSTA presented in the tropical and southeastern Ocean.

## ▪ Atlantic Ocean

- ATL3 SSTA transited to positive phase in June 2012.
- NOAA predicted near-normal condition of hurricane activity in 2012.

# Global Oceans

# Global SST Anomaly ( $^{\circ}\text{C}$ ) and Anomaly Tendency

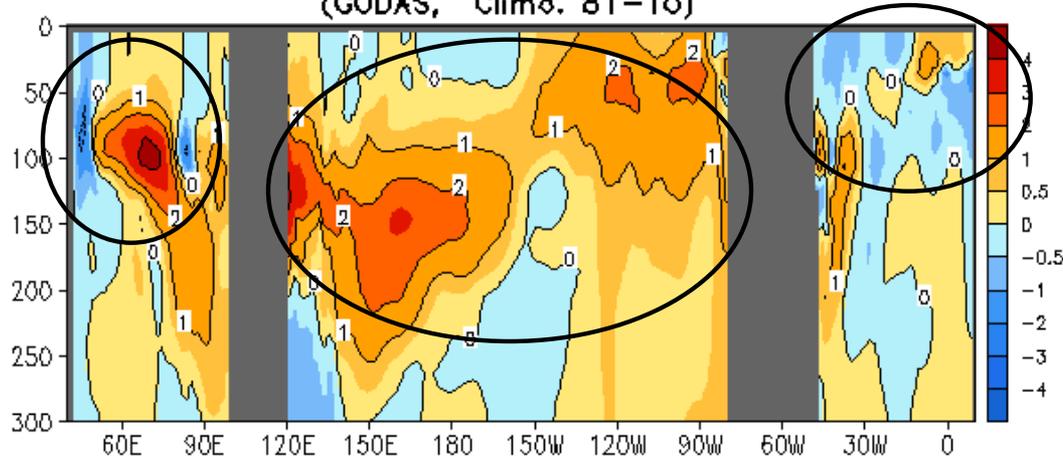


- Positive SSTA developed in the central-eastern equatorial Pacific Ocean.
- Neutral condition presented in the tropical Atlantic Ocean.
- Positive SSTA persisted in the tropical and SE Indian Ocean.
- A tripole-like SSTA was observed in the North Atlantic Ocean.
- Negative PDO-like pattern persisted.
- Large tendencies emerged in the South Ocean.

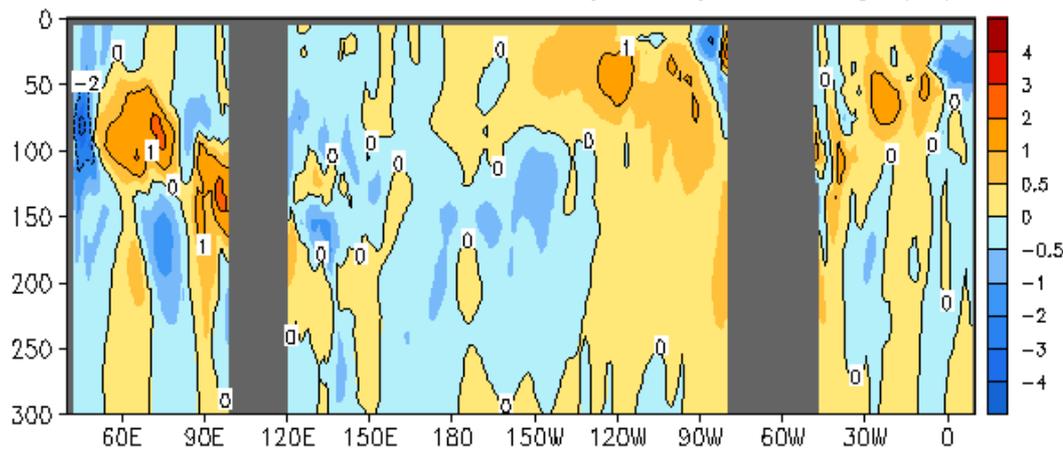
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981–2010 base period means.

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

JUN 2012 Eq. Temp Anomaly (°C)  
(GODAS, Climo. 81-10)



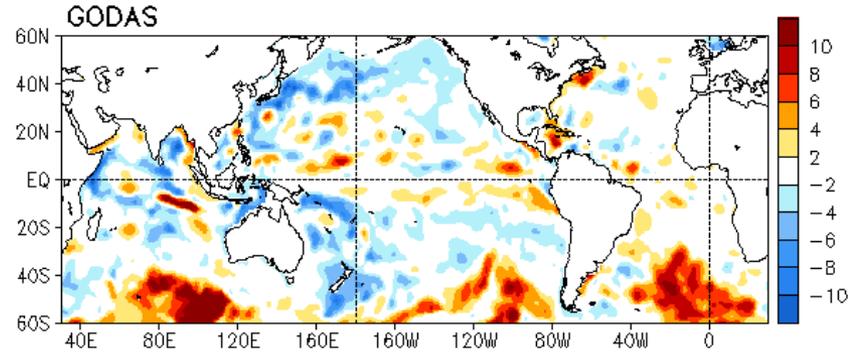
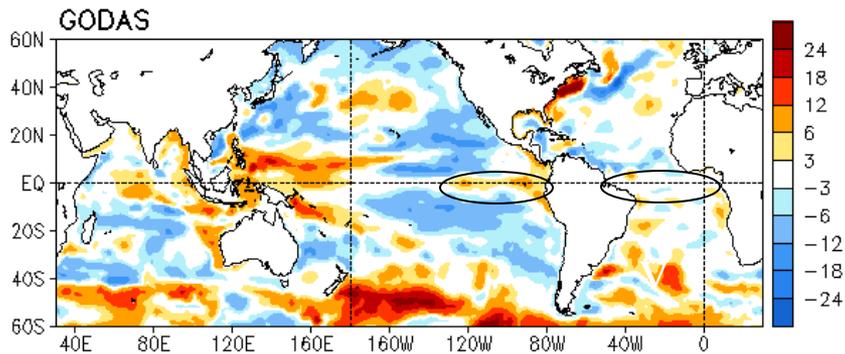
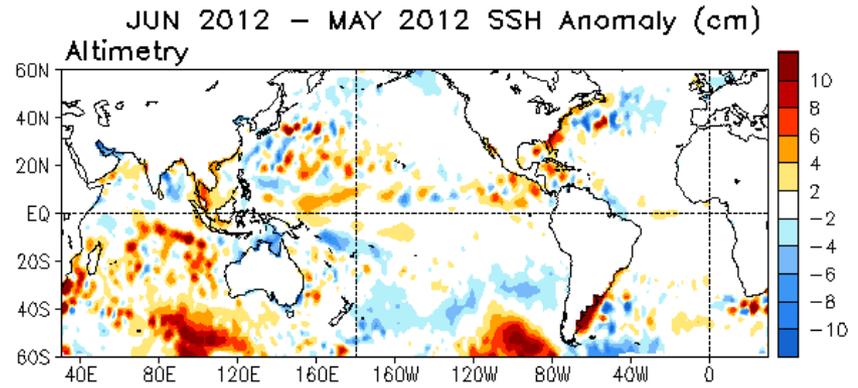
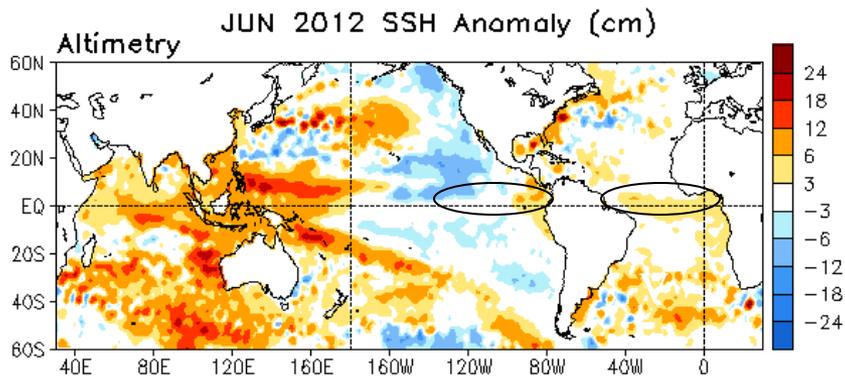
JUN 2012 - MAY 2012 Eq. Temp Anomaly (°C)



- Positive temperature anomalies occupied near the thermocline in the equatorial Pacific Ocean.
  - Positive anomalies were dominated in the equatorial Indian Ocean.
  - Both positive and negative anomalies presented at top 150m of the equatorial Atlantic.
- 
- Warming tendency presented in the central-eastern equatorial Pacific, central equatorial 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.**

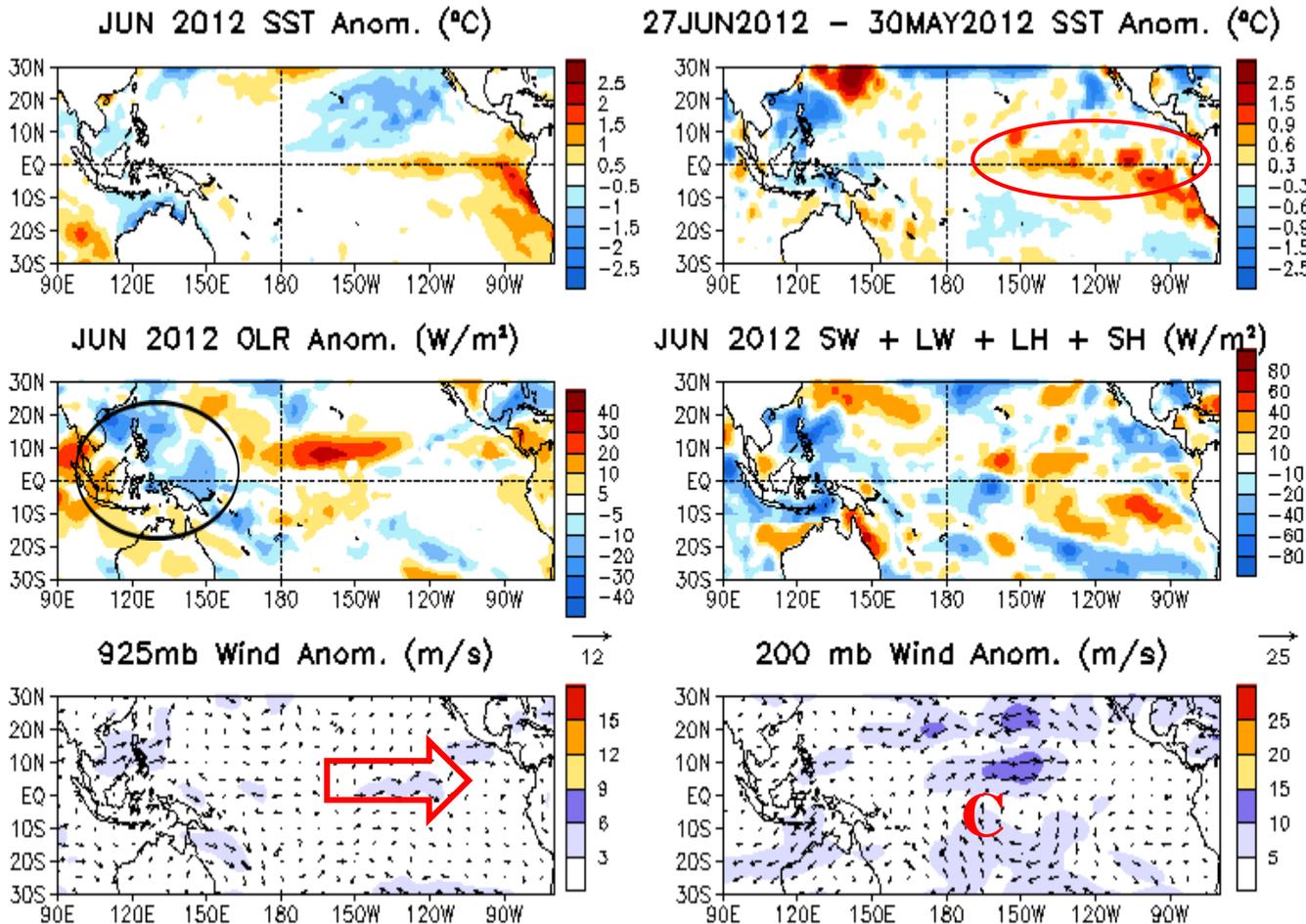
# Global SSH Anomaly and Anomaly Tendency



- Negative PDO-like SSHA pattern presented, consistent with negative PDO-like SSTA pattern
- Above-normal SSHA only presented in the far eastern equatorial Pacific in the Altimetry, while positive SSHA extended to the central equatorial Pacific in GODAS .
- Positive SSHA along the equatorial Atlantic was underestimated in GODAS.

# Tropical Pacific Ocean and ENSO Conditions

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



- Positive SSTA exceeding 0.5°C presented across the eastern Pacific Ocean.
- Enhanced convection in the western tropical Pacific weakened in June 2012.
- The warming tendency was consistent with a weakening of the low-level trade wind across the central-eastern equatorial 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 (°C), HC300 (°C), u850 (m/s) Anomalies

2°S–2°N Average, 3 Pentad Running Mean

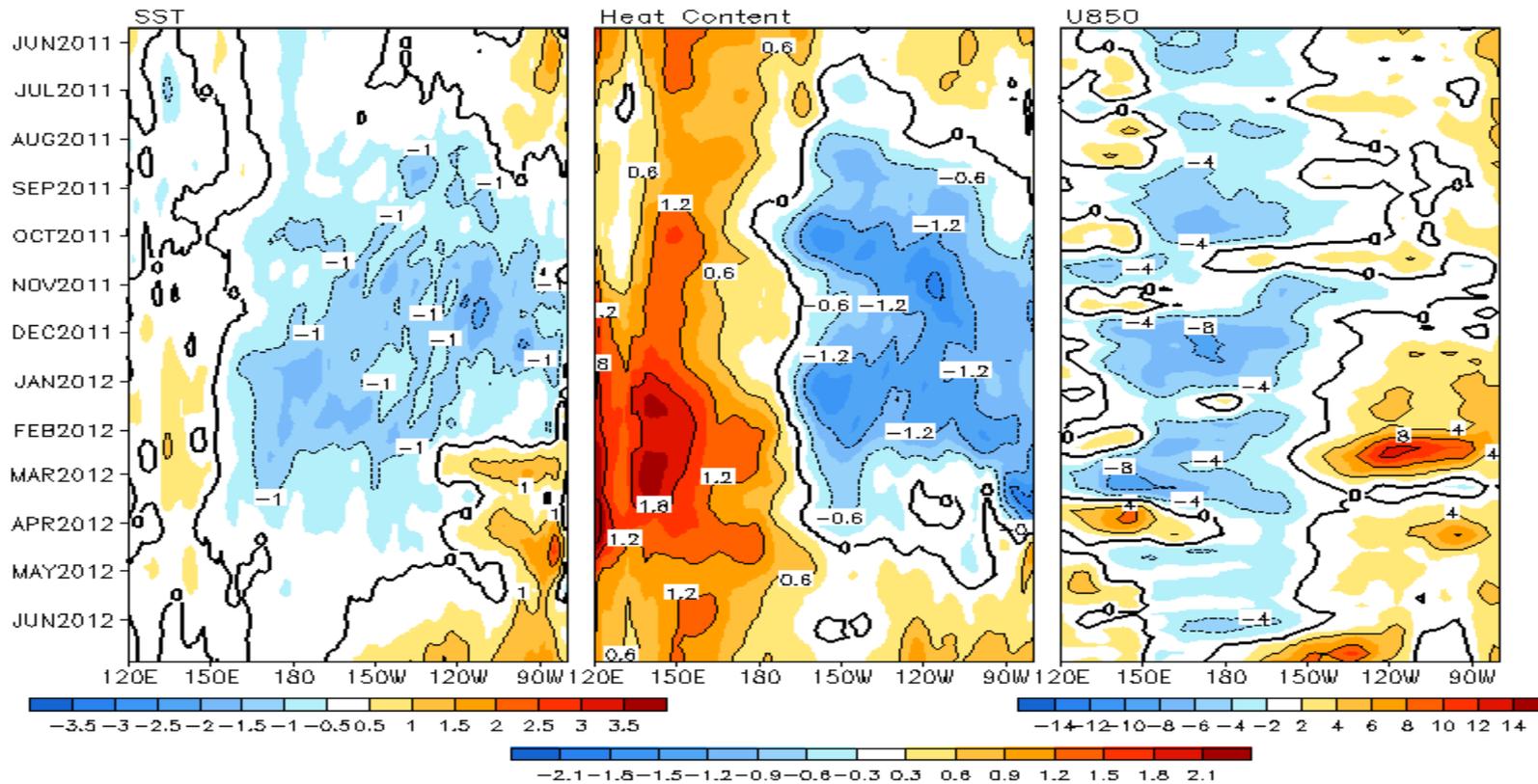
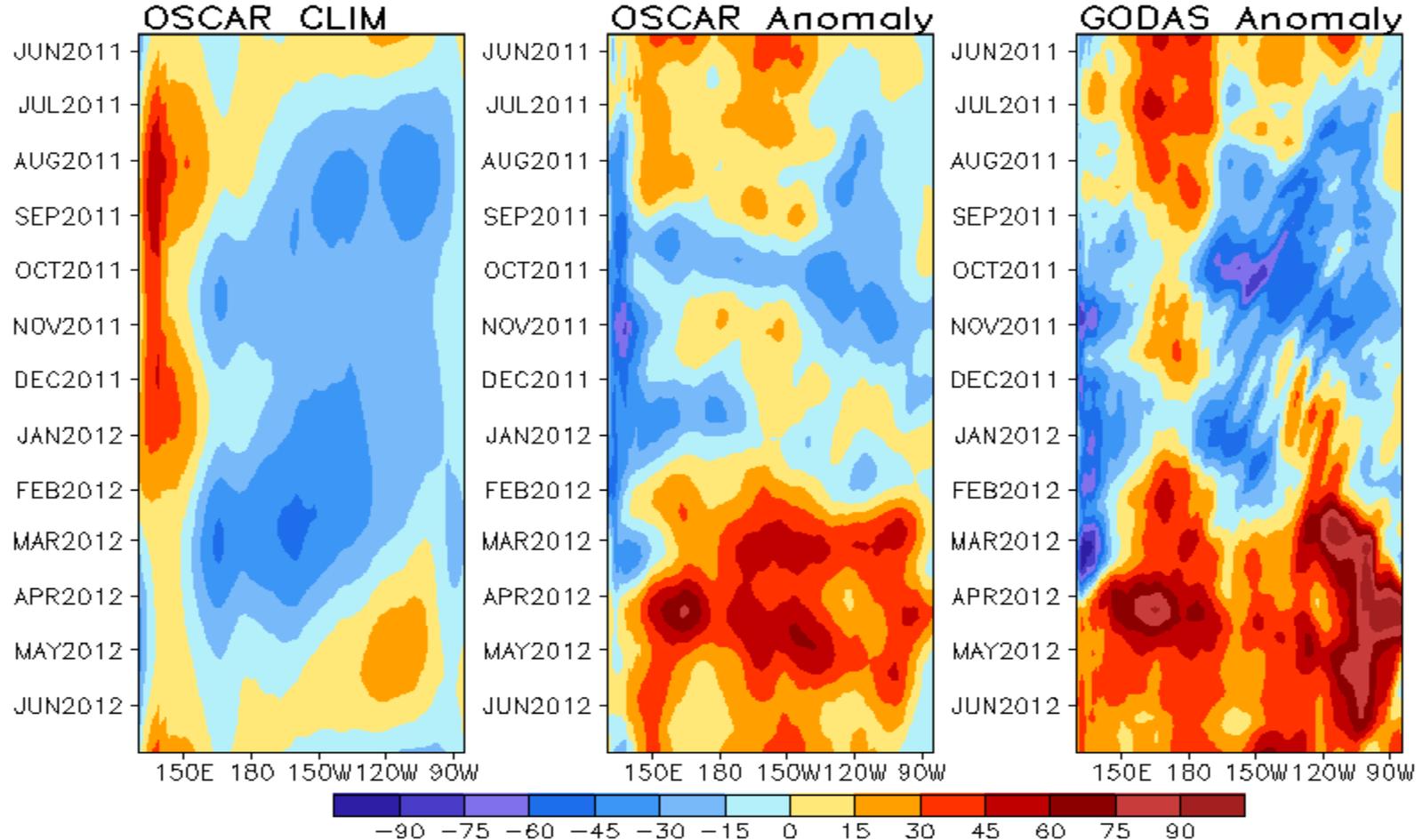


Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S–2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S–5°N. SST is derived from the NCEP OI 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.

- Positive SSTA developed in the east since Feb 2012 and extended to central equatorial Pacific Ocean in June 2012.
- La Nina conditions dissipated in Apr 2012 and ENSO-neutral conditions prevailed since May 2012
- Strong westerly wind anomalies emerged in the central Pacific in June 2012, consistent with the development of positive SST and HC300 anomalies in the eastern Pacific.

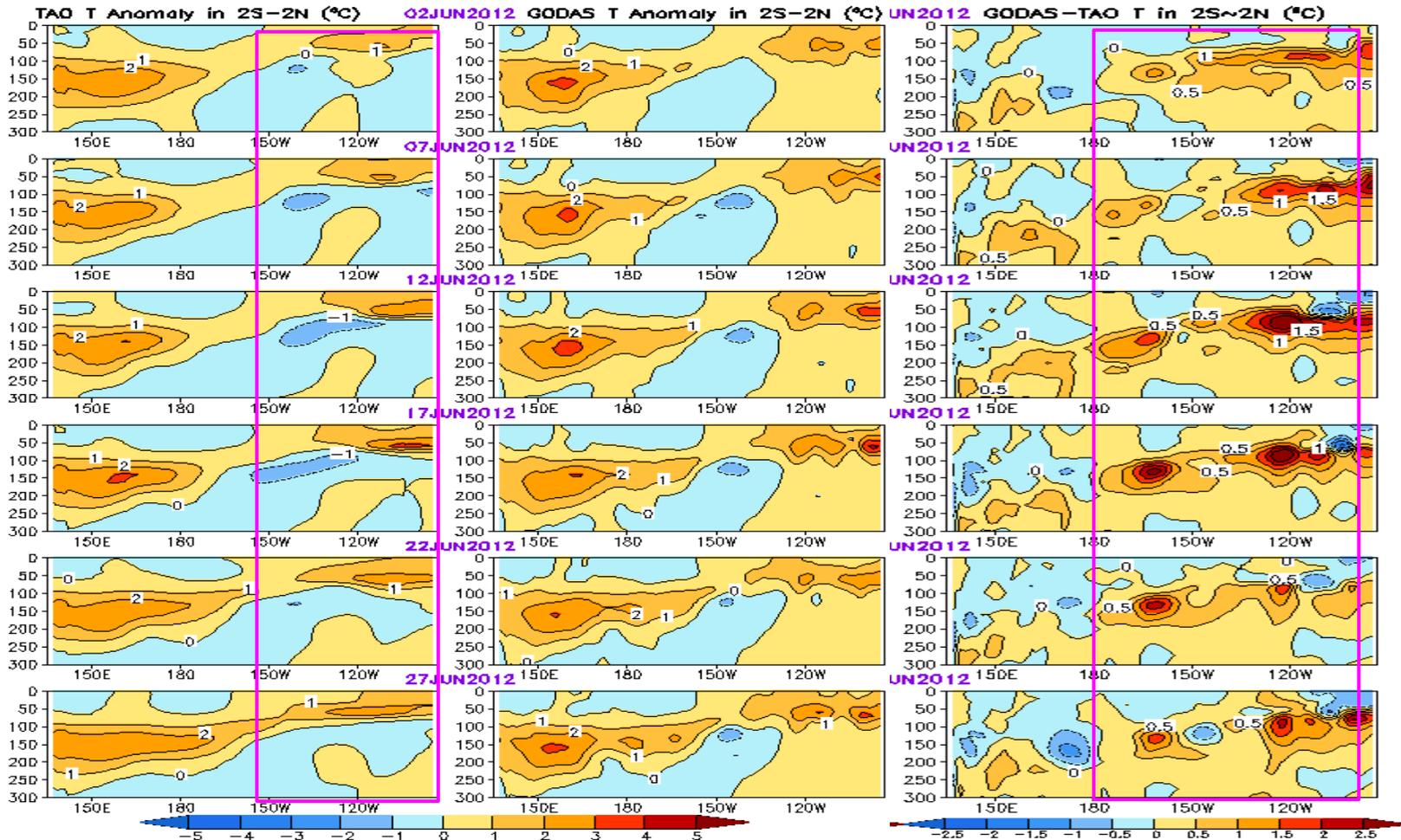
## Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)

U (15m), cm/s, 2°S–2°N



- Surface zonal current anomaly has become positive since October 2011, consistent with the transition from La Nina to ENSO-neutral conditions in May 2012.
- Large eastward zonal anomalies since February 2012 favoured SST warming trend in the eastern equatorial Pacific.
- Positive surface zonal current anomalies simulated by GODAS were too strong compared with those of the OSCAR currents.

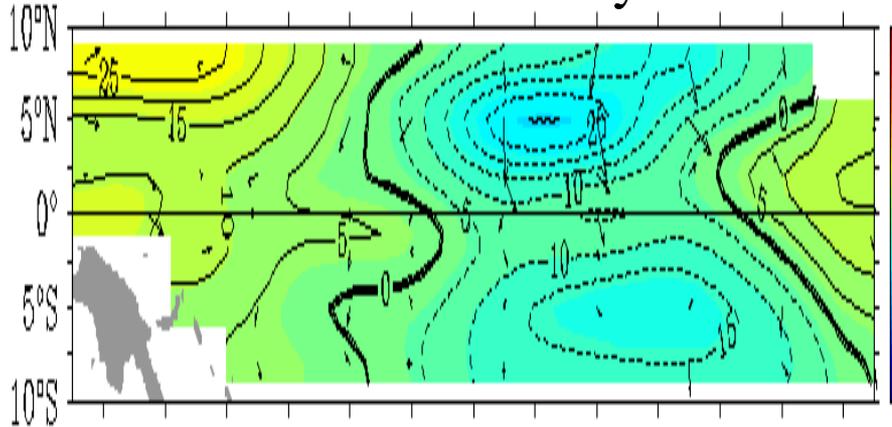
# Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



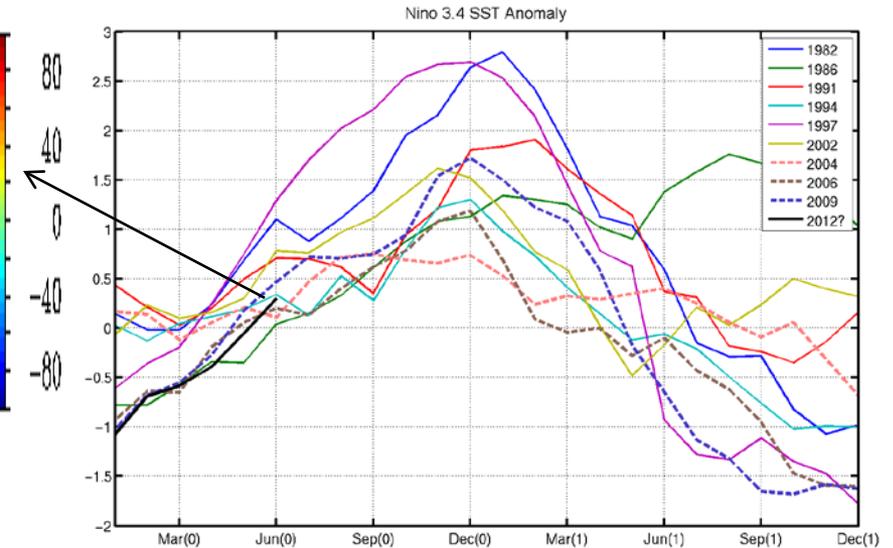
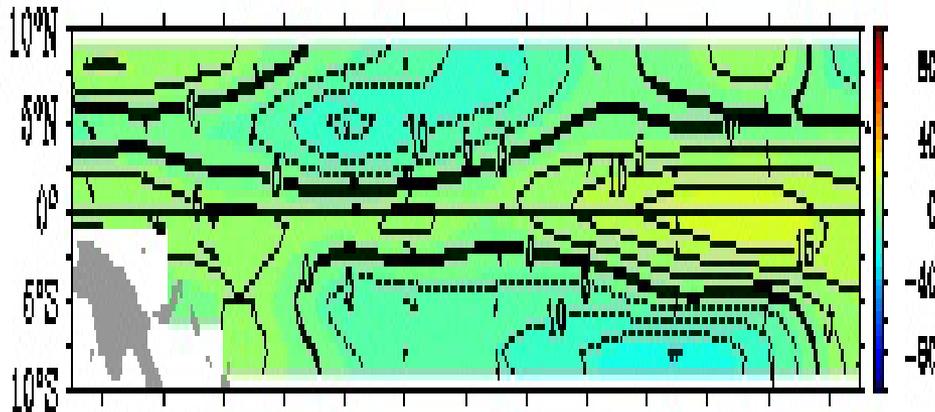
- Positive anomaly near the thermocline increased slightly in June, favoring the SST warming in the eastern Pacific.
- Negative anomaly emerged about 100-150m between 150W-120W.
- Compared with TAO, GODAS is too warm at 100-250 m depth.

# 20C Isotherm Depth Anomaly (m)

## June 2012 Anomaly



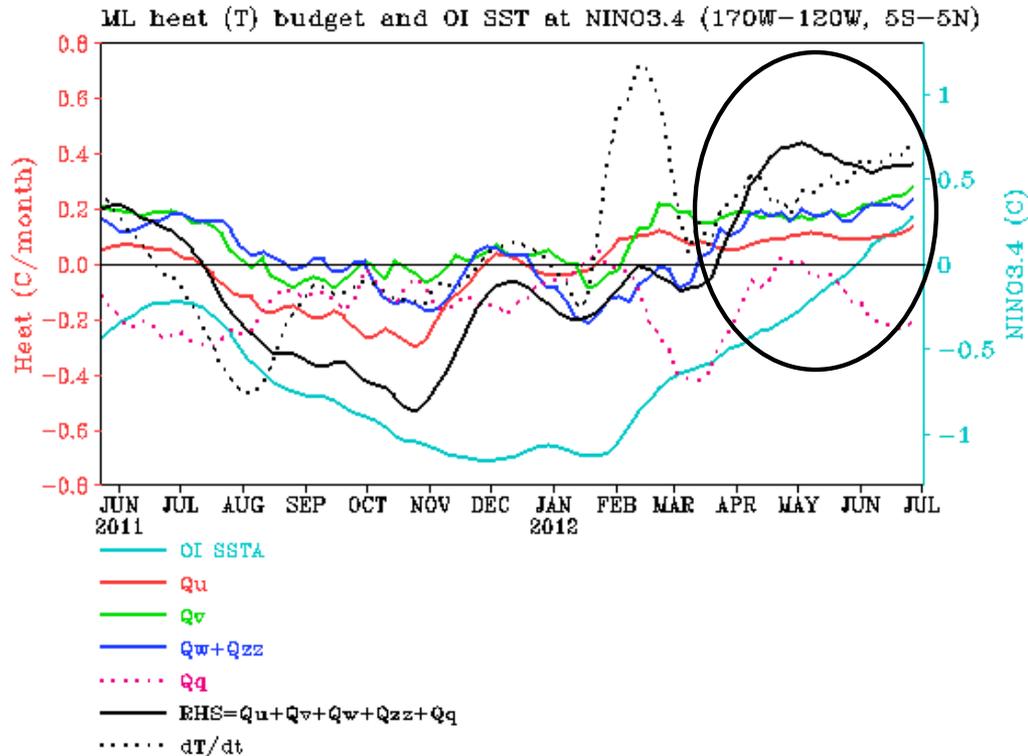
## June 2009 Anomaly



- Negative d20 anomaly dominated in the central tropical Pacific Ocean in June 2012, in contrast with positive d20 anomaly near the equator in June 2009 (development period of 2009/10 El Niño event).

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

# NINO3.4 Heat Budget



- SSTA tendency (dT/dt) in NINO3.4 region (dotted line) was positive since mid-Jan 2012, indicating the warming tendency in the eastern and central Pacific.

- All dynamical terms ( $Q_u$ ,  $Q_v$ ,  $Q_w+Q_{zz}$ ) were positive since Mar 2012.

- The total heat budget term (RHS) was consistent with the observed tendency (dT/dt) since mid-Mar 2012.

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.

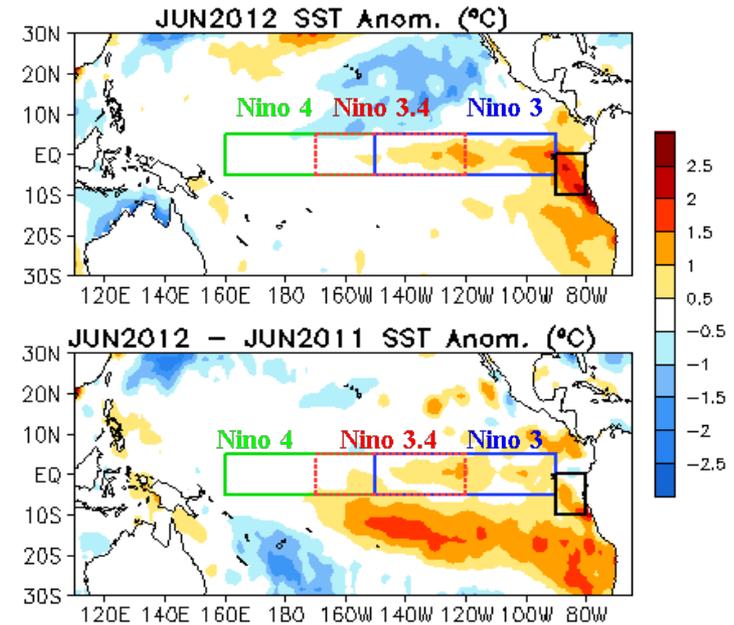
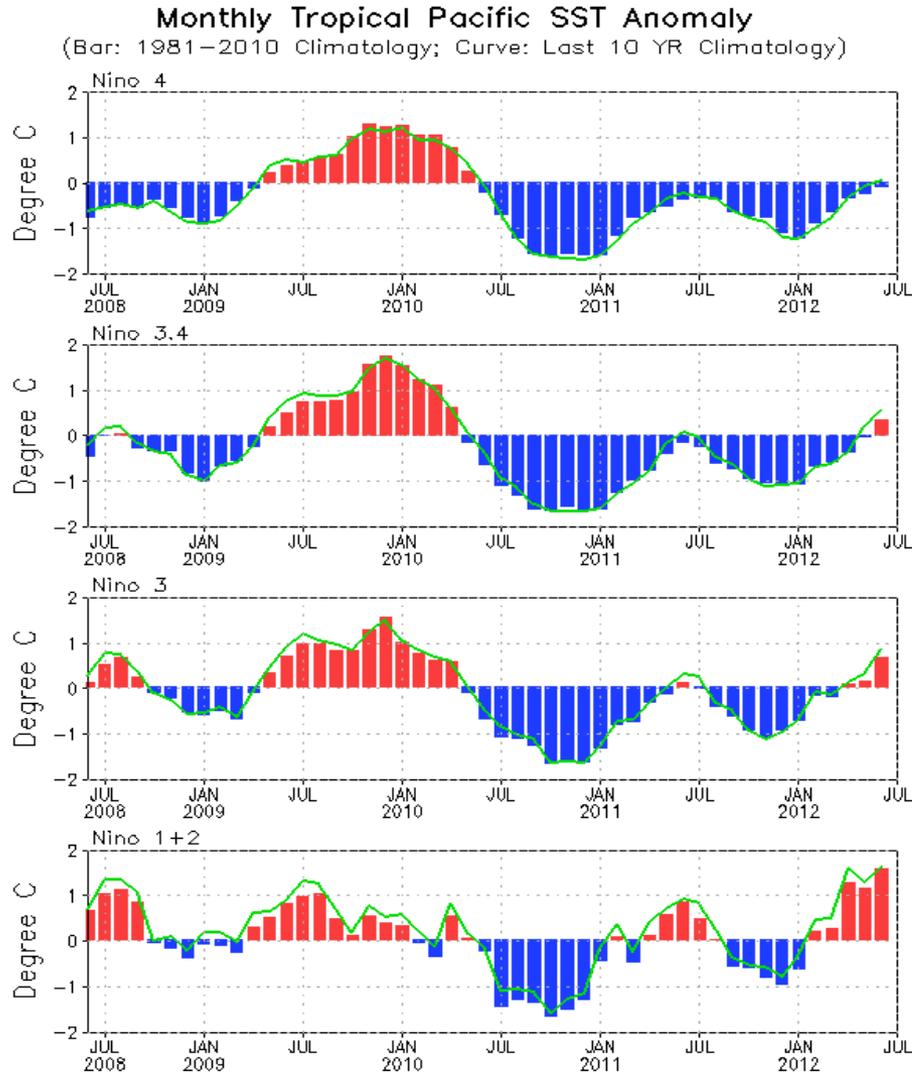
$Q_u$ : Zonal advection;  $Q_v$ : Meridional advection;

$Q_w$ : Vertical entrainment;  $Q_{zz}$ : Vertical diffusion

$Q_q$ :  $(Q_{net} - Q_{open} + Q_{corr})/pcph$ ;  $Q_{net} = SW + LW + LH + SH$ ;

$Q_{open}$ : SW penetration;  $Q_{corr}$ : Flux correction due to relaxation to OI SST

# Evolution of Pacific NINO SST Indices

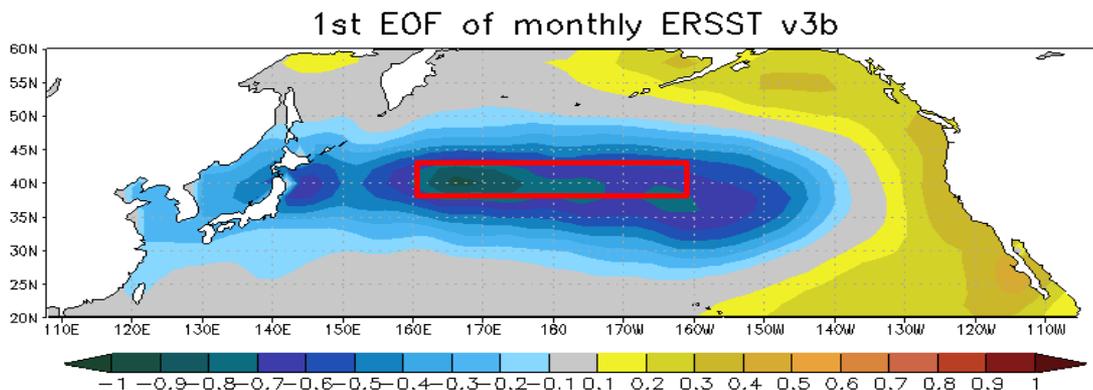
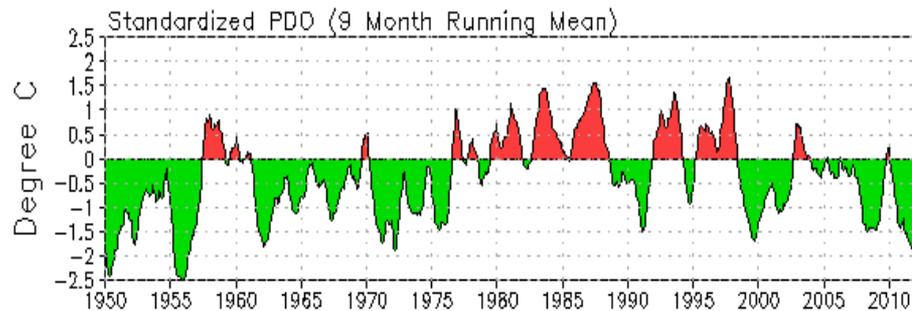
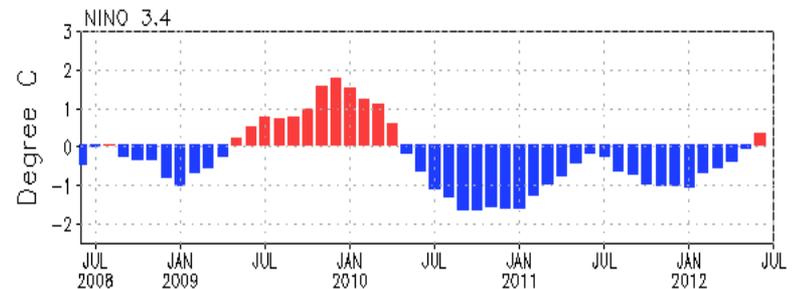
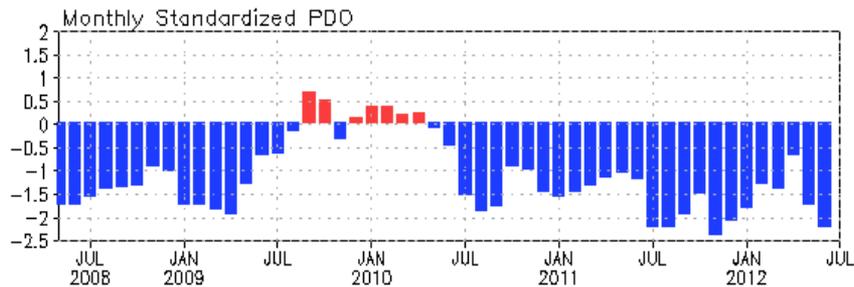


- ENSO-neutral condition continued in June 2012.
- Except for Niño 4 index, other Niño indices were above normal in June 2012.
- Niño 3.4 index = 0.3°C in June.
- The distribution of SSTA was asymmetric between the north and south Pacific. Compared with last June, SST was much warmer in the tropical-subtropical S. Pacific in June 2012.
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.

**Fig. P1a.** Niño 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.

# North Pacific & Arctic Oceans

# PDO index



- Negative PDO phase since May 2010 has persisted for 26 months now, and the PDO index strengthened in June 2012 with PDO index = -2.2.

- The apparent connection between NINO3.4 and PDO index may suggest impact of the tropics on the North Pacific SST variability through atmospheric bridge.

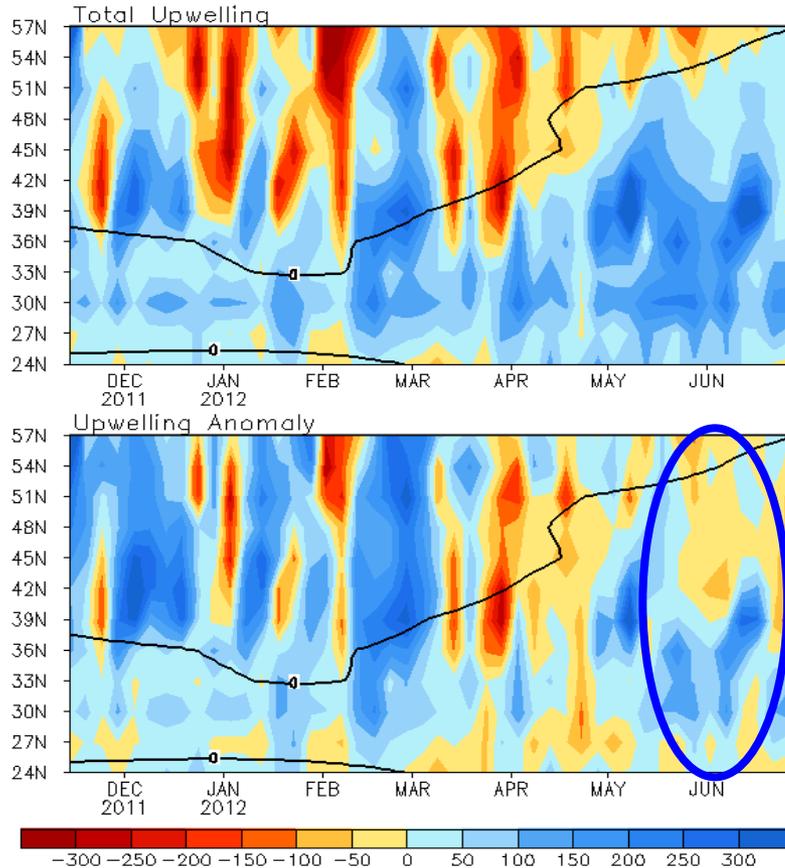
- However, the strengthening of negative phase of PDO in June 2012 seems not connected with the positive Nino3.4 SSTA.

- Pacific Decadal Oscillation is defined as the 1<sup>st</sup> 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.

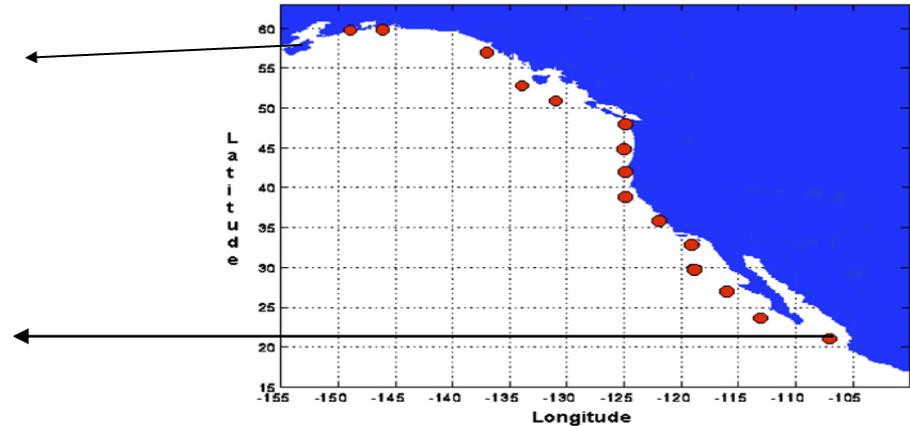
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

# North America Western Coastal Upwelling

Pentad Coastal Upwelling for West Coast North America  
( $\text{m}^3/\text{s}/100\text{m coastline}$ )



Standard Positions of Upwelling Index Calculations



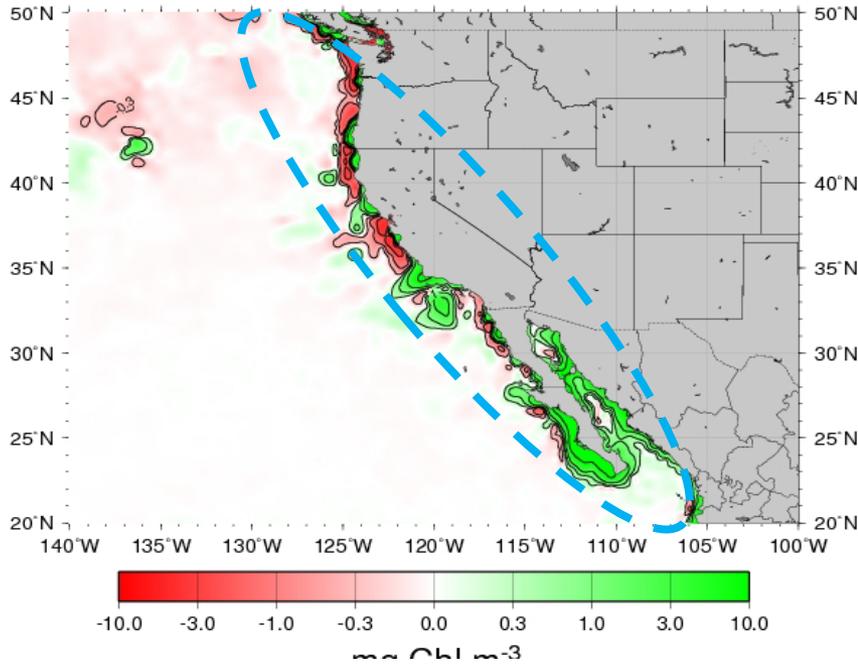
- Upwelling enhanced (weakened)  
south (north) of 36N in June 2012.

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 ( $\text{m}^3/\text{s}/100\text{m coastline}$ ). 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.

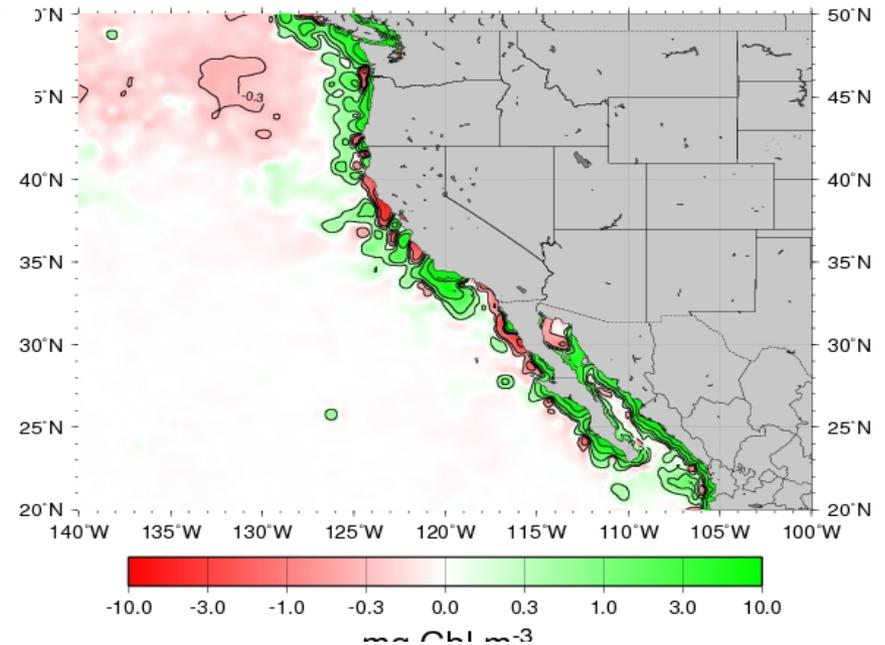
# Monthly Chlorophyll a Anomaly

MODIS Aqua Chlorophyll a Anomaly for June, 2012



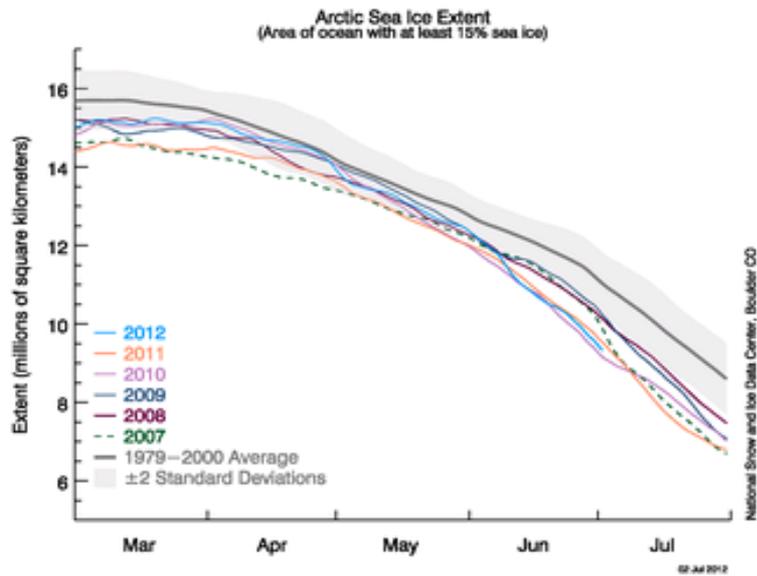
- Positive(negative) Chlorophyll a anomaly presented south(north) of 36N along the coast.
- It is consistent with the upwelling anomaly along the coast.

MODIS Aqua Chlorophyll a Anomaly for May, 2012

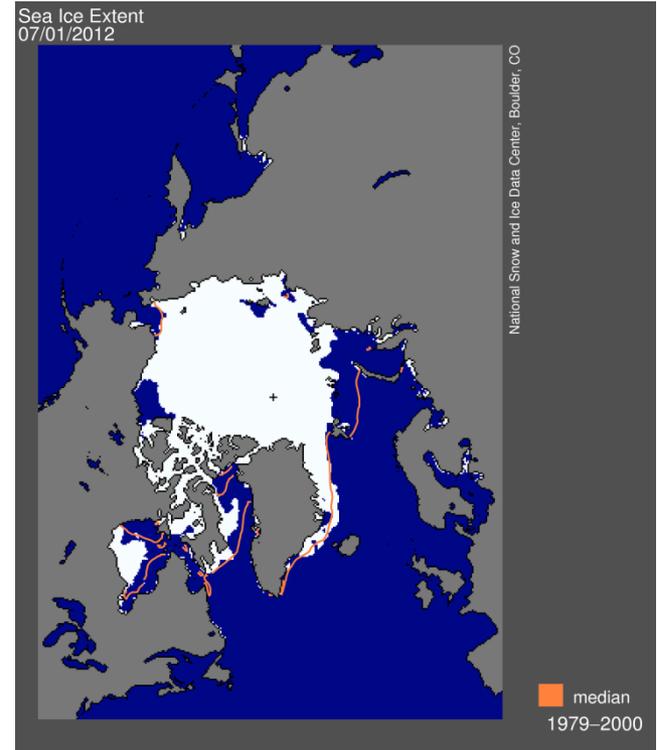


# Arctic Sea Ice

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

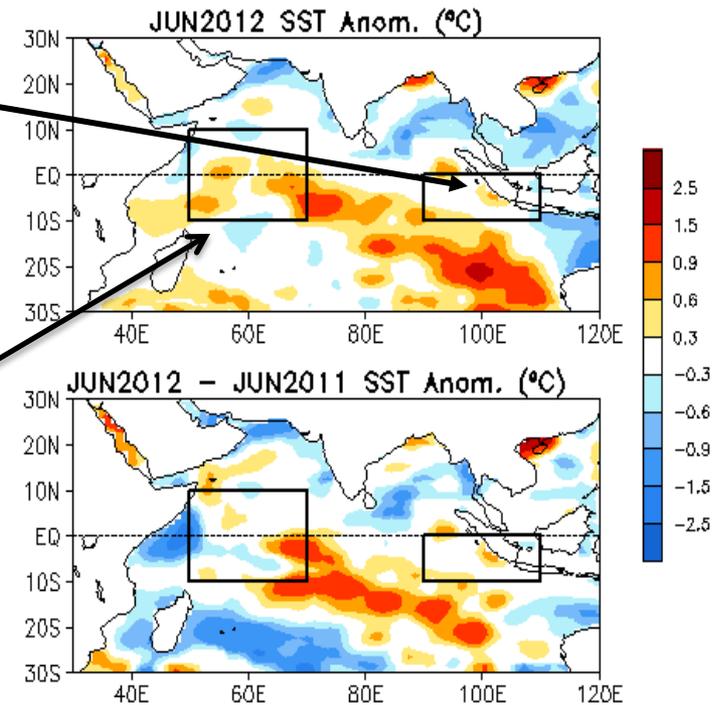
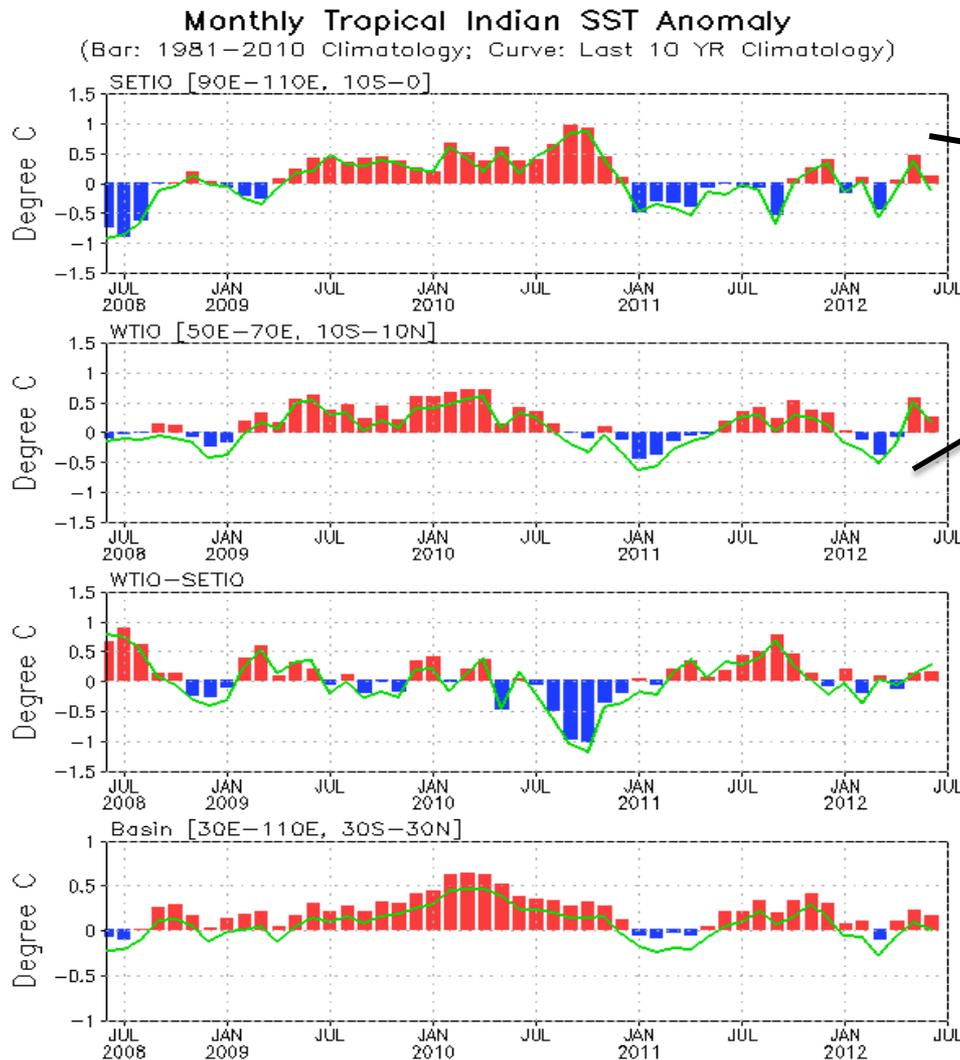


- Arctic sea ice extent retreated rapidly in June 2012 and reached the second historical low in the satellite record.



# Indian Ocean

# Evolution of Indian Ocean SST Indices

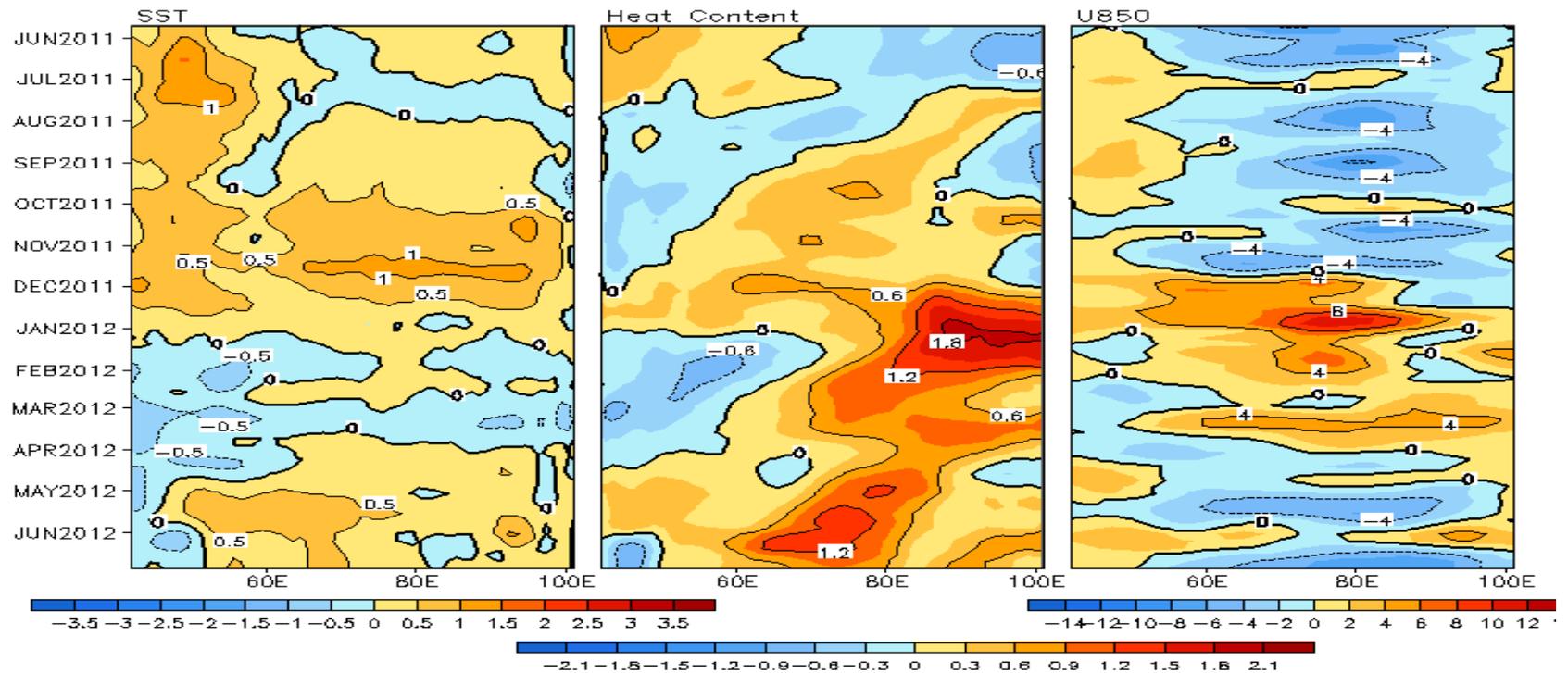


- Positive SSTA weakened in the Western and SE Indian Ocean.
- Compared with 2011, the equatorial and tropical S. Indian Ocean was warmer.
- DMI was near-normal since Nov 2011.

**Fig. 11a. 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.**

# Recent Evolution of Equatorial Indian SST ( $^{\circ}\text{C}$ ), 0-300m Heat Content ( $^{\circ}\text{C}$ ) and 850-mb Zonal Wind (m/s)

$2^{\circ}\text{S}-2^{\circ}\text{N}$  Average, 3 Pentad Running Mean

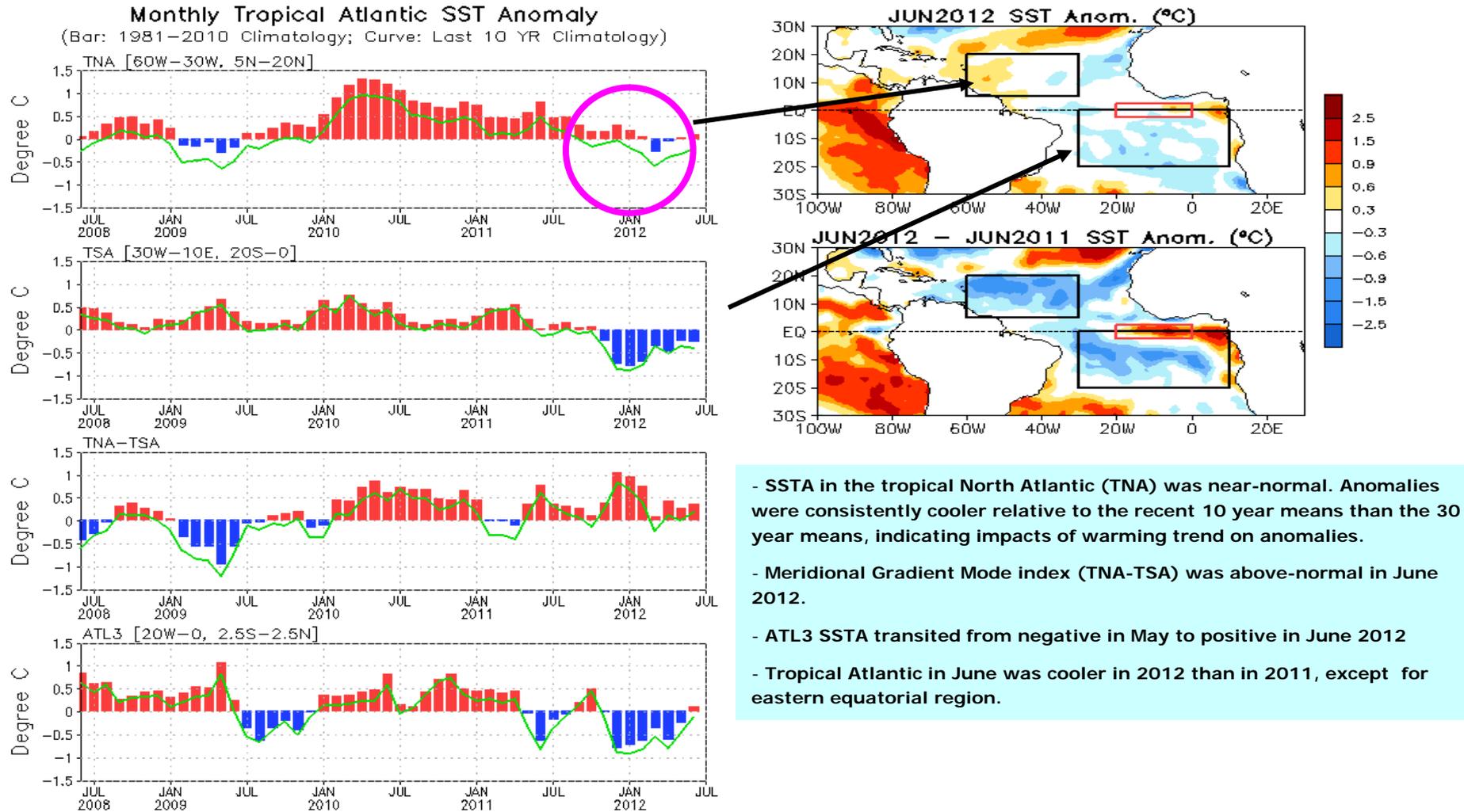


- Above normal SSTA dominated since Apr 2012.
- Easterly wind anomalies presented since Apr 2012.

Fig. 13. 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  $2^{\circ}\text{S}-2^{\circ}\text{N}$  and Outgoing Long-wave Radiation (OLR, right) averaged in  $5^{\circ}\text{S}-5^{\circ}\text{N}$ . SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

# Tropical and North Atlantic Ocean

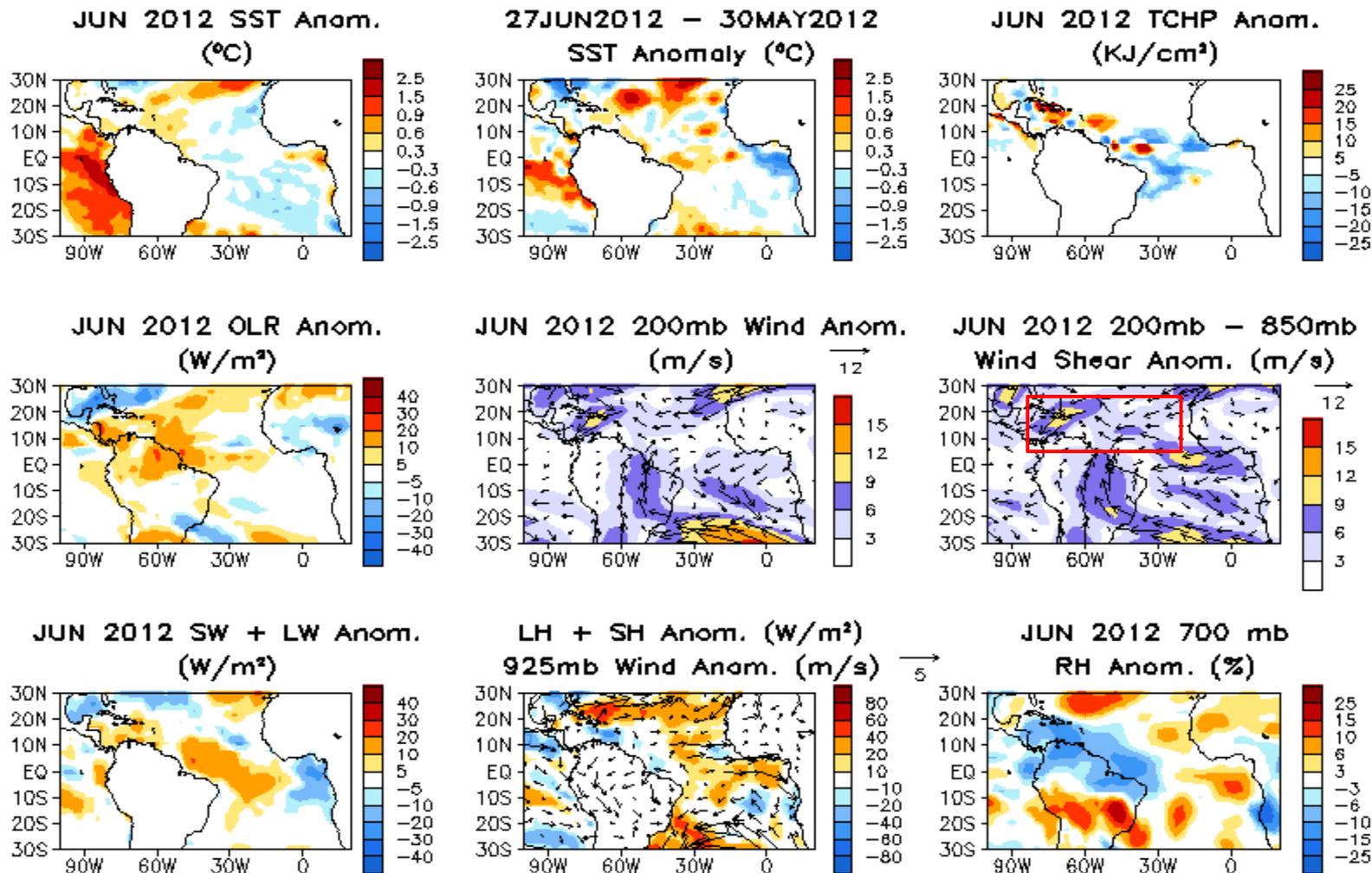
# Evolution of Tropical Atlantic SST Indices



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

# Tropical Atlantic:

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



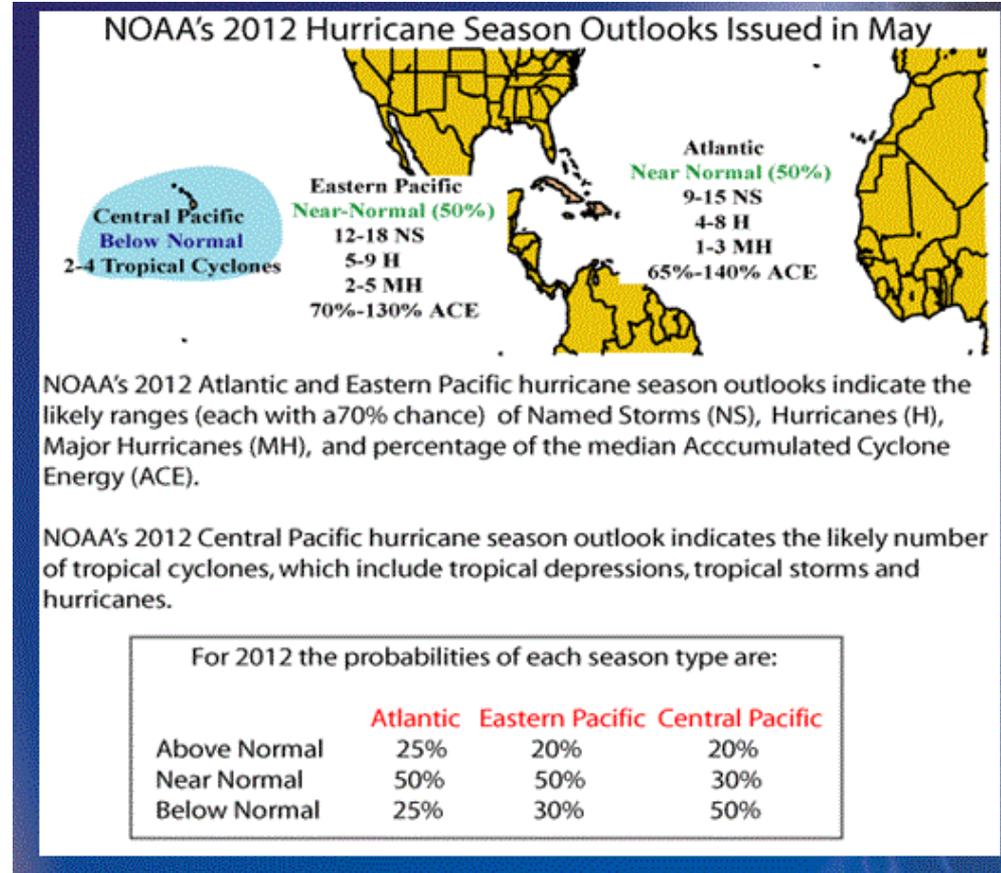
- Near-normal SSTA continued across the northern tropical Atlantic in June 2012.
- Convection was depressed near the Caribbean Sea, consistent with the negative RH anomaly.
- Enhanced vertical wind shear across the Hurricane main development region.

# NOAA Predict a near-Normal Atlantic Hurricane Season in 2012

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

[http://en.wikipedia.org/wiki/Accumulated\\_cyclone\\_energy](http://en.wikipedia.org/wiki/Accumulated_cyclone_energy))

	2012 prediction (issued on May 24) (1951-2000)
Named storms	9-15 (10)
Hurricanes	4-8 (6)
Major hurricanes	1-3 (2)
ACE %	65-140 (75-117)



- Low frequency: increased Atlantic hurricane activity since 1995.
- Expected near-average SSTs across much of the tropical Atlantic Ocean and Caribbean Sea.

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

- Positive SSTA along the American coast decreased in June 2012.
- Large positive SW+LW anomalies emerged in the high-latitudes of N. Atlantic, leading to significant SST warming.
- SST tendency was consistent with surface heat flux anomalies.

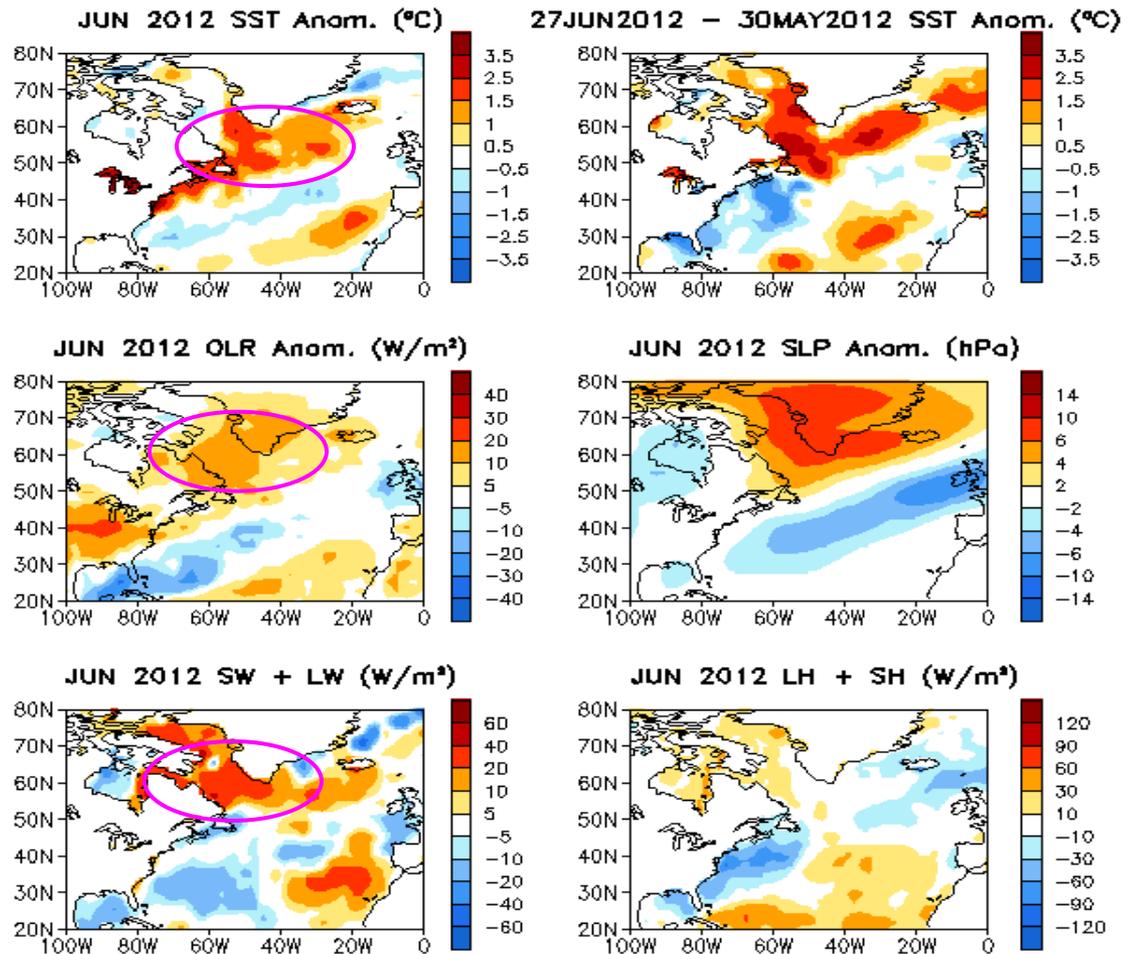
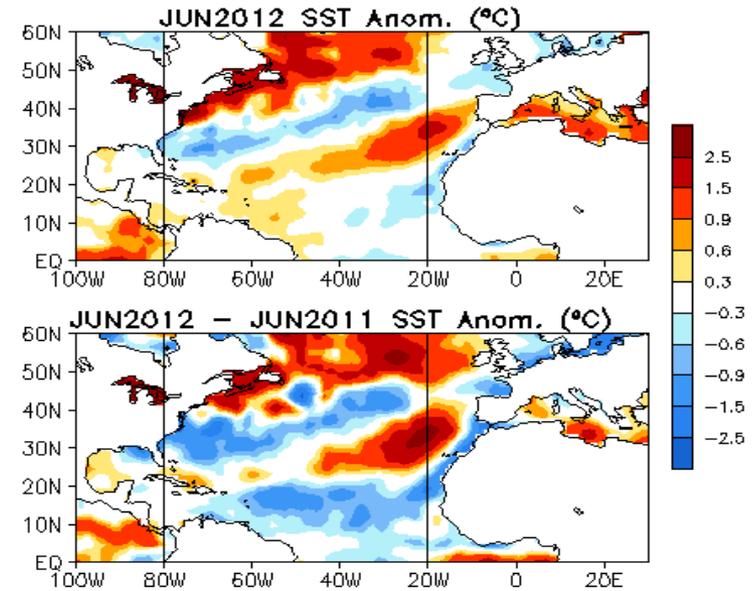
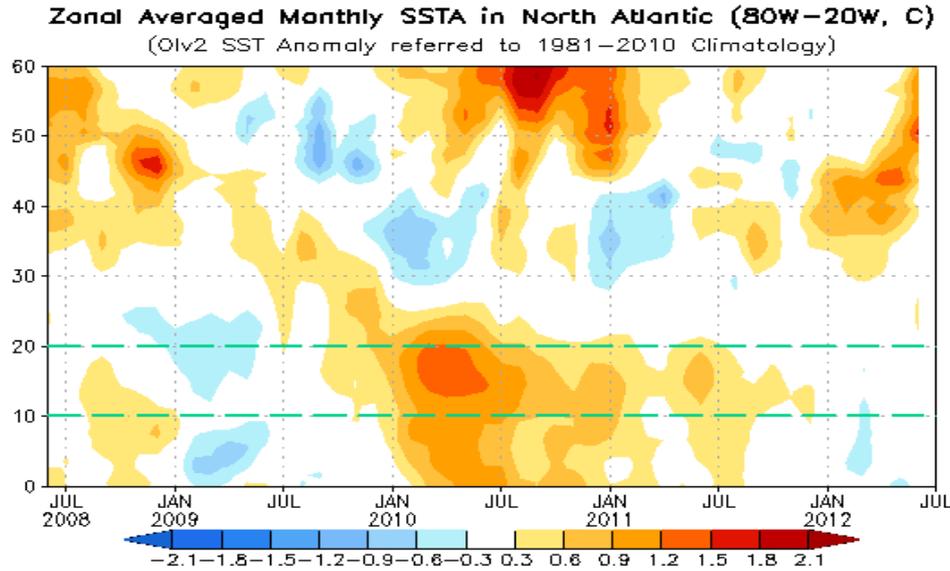


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

# NAO and SST Anomaly in North Atlantic



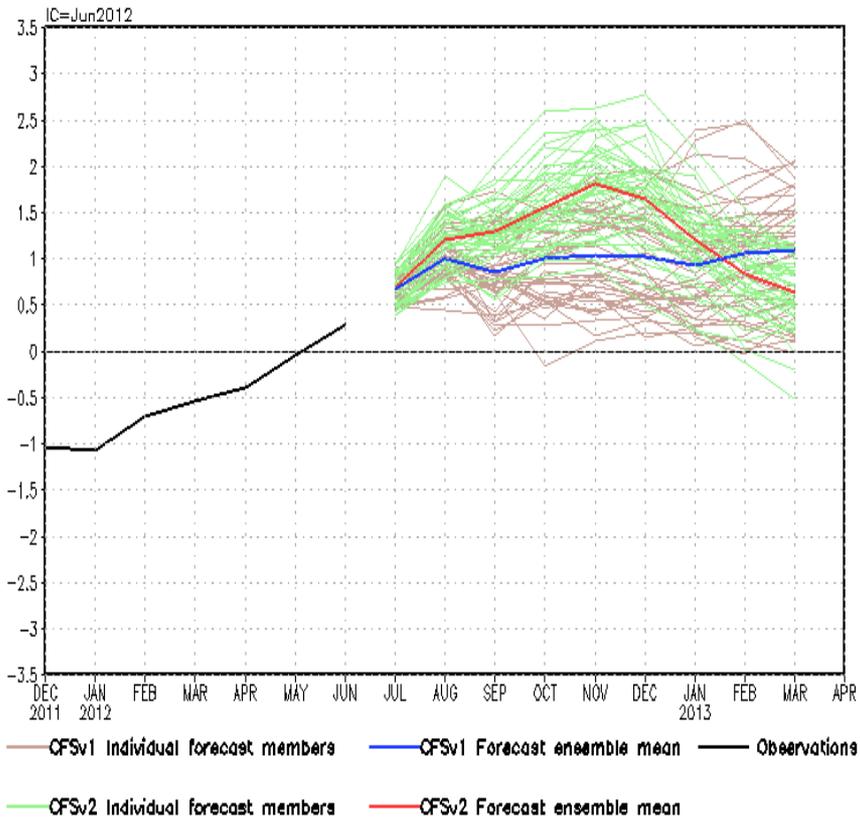
- Negative NAO-like pattern presented in the North Atlantic Ocean
- High-latitude North Atlantic SSTA are closely related to NAO index (negative NAO leads to SST warming and positive NAO leads to SST cooling).
- Positive SSTA along the North American Atlantic coast persisted in June 2012.

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 CFSv1 and CFSv2 NINO3.4 Forecast

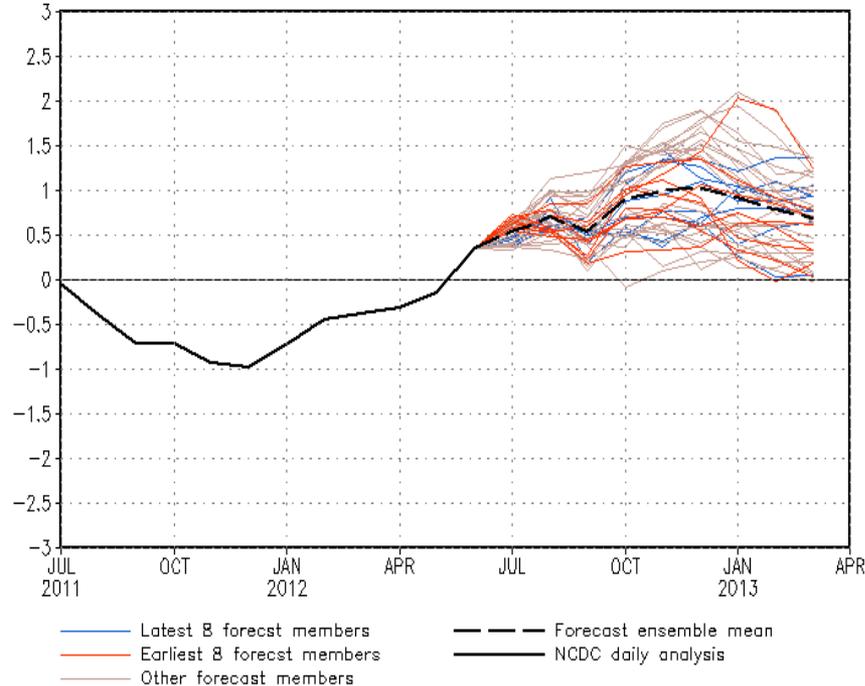
NINO3.4 SST anomalies (K)



NWS/NCEP/CPC

Last update: Mon Jul 2 2012  
Initial conditions: 21Jun2012–30Jun2012

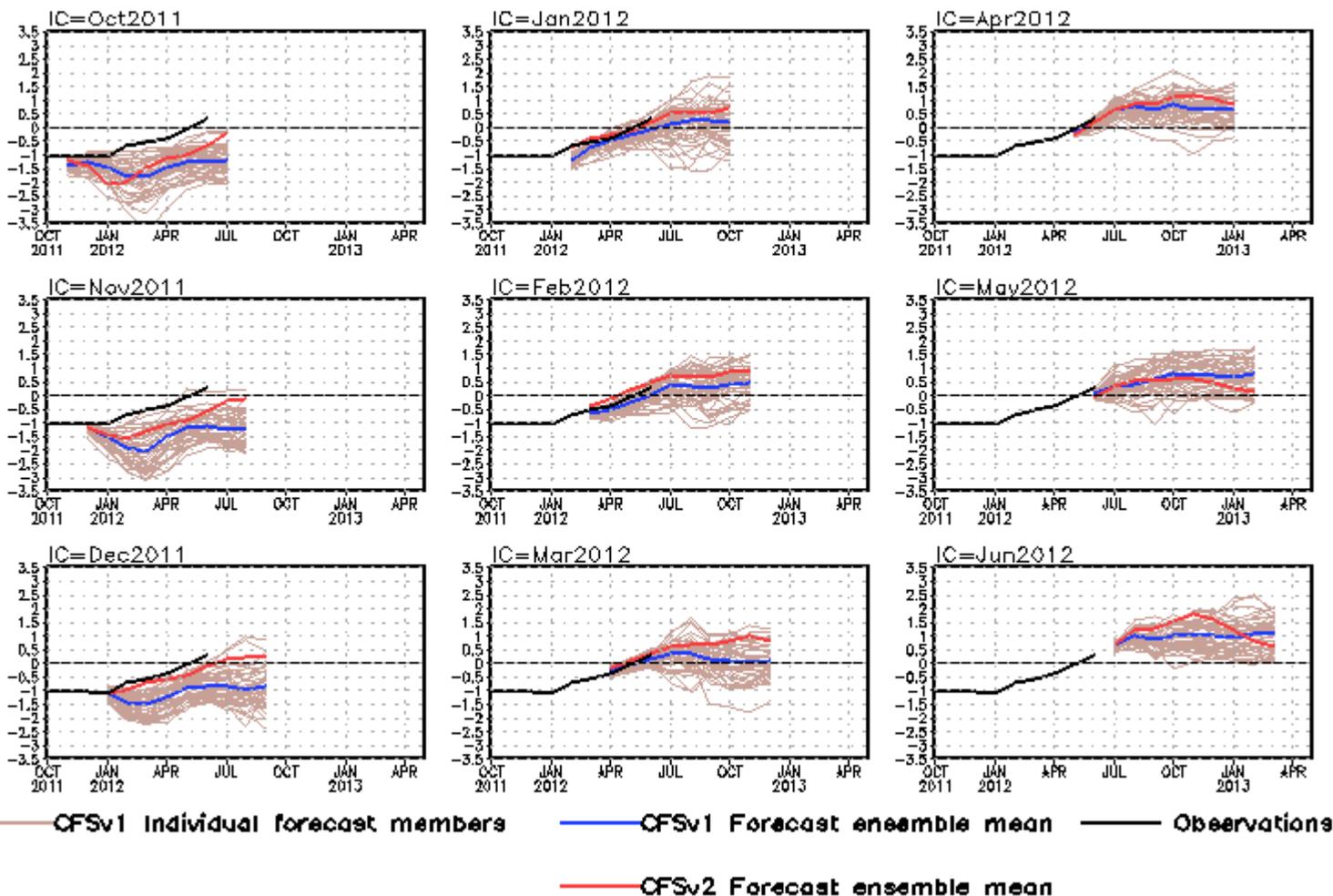
PDF corrected CFS forecast Nino3.4 SST anomalies (K)



- CFSv1 predicted a weak El Niño event while CFSv2 call for a moderate El Niño event development by July-September 2012.

# CFS Niño3.4 SST Predictions from Different Initial Months

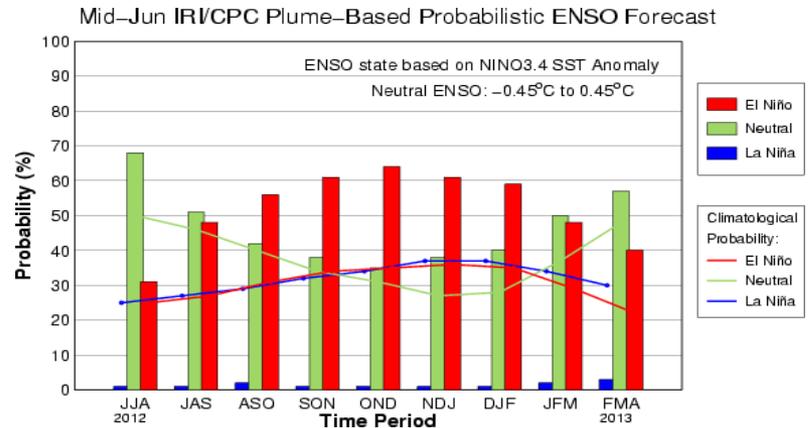
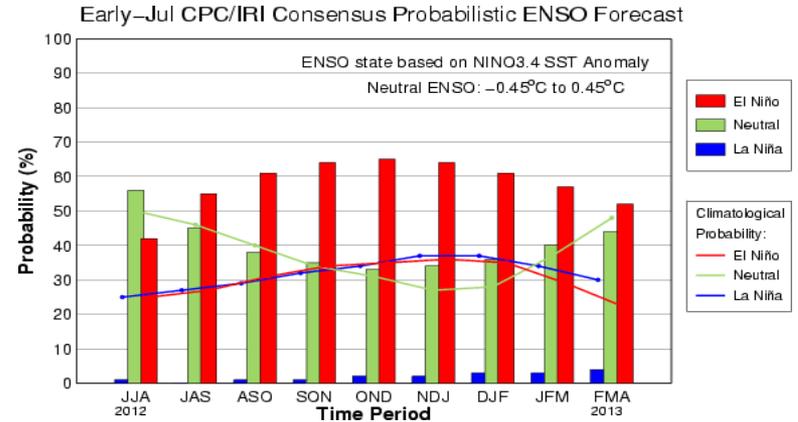
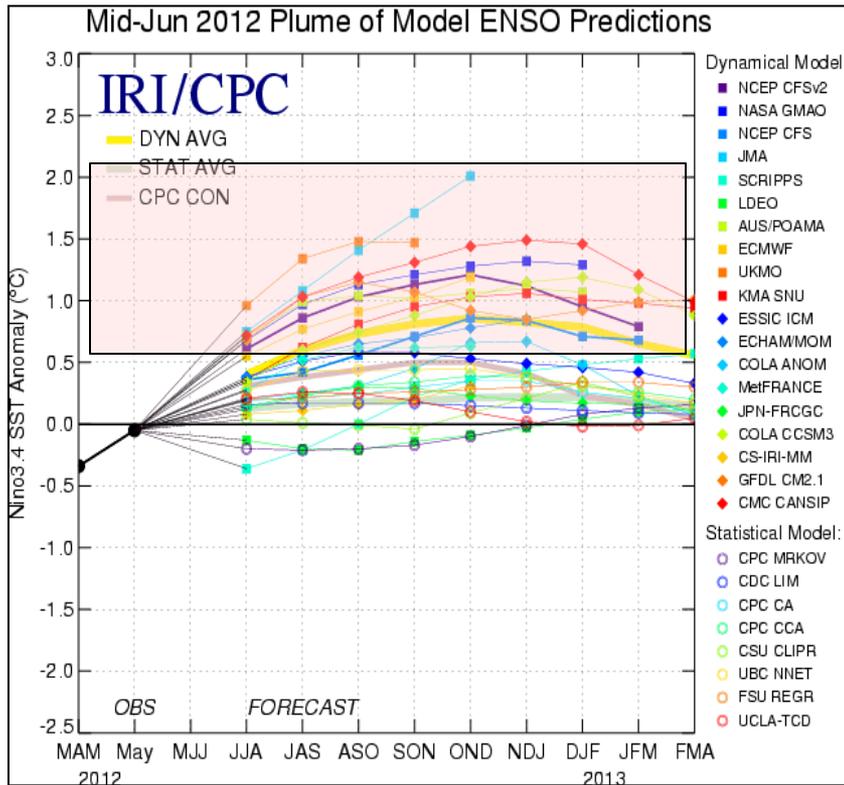
## Niño3.4 SST anomalies (K)



CFSv2 prediction was warmer than CFSv1, except with IC in May, CFSv2 prediction is *cooler* than that of CFSv1 after summer 2012.

Fig. M1. CFS Niño3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

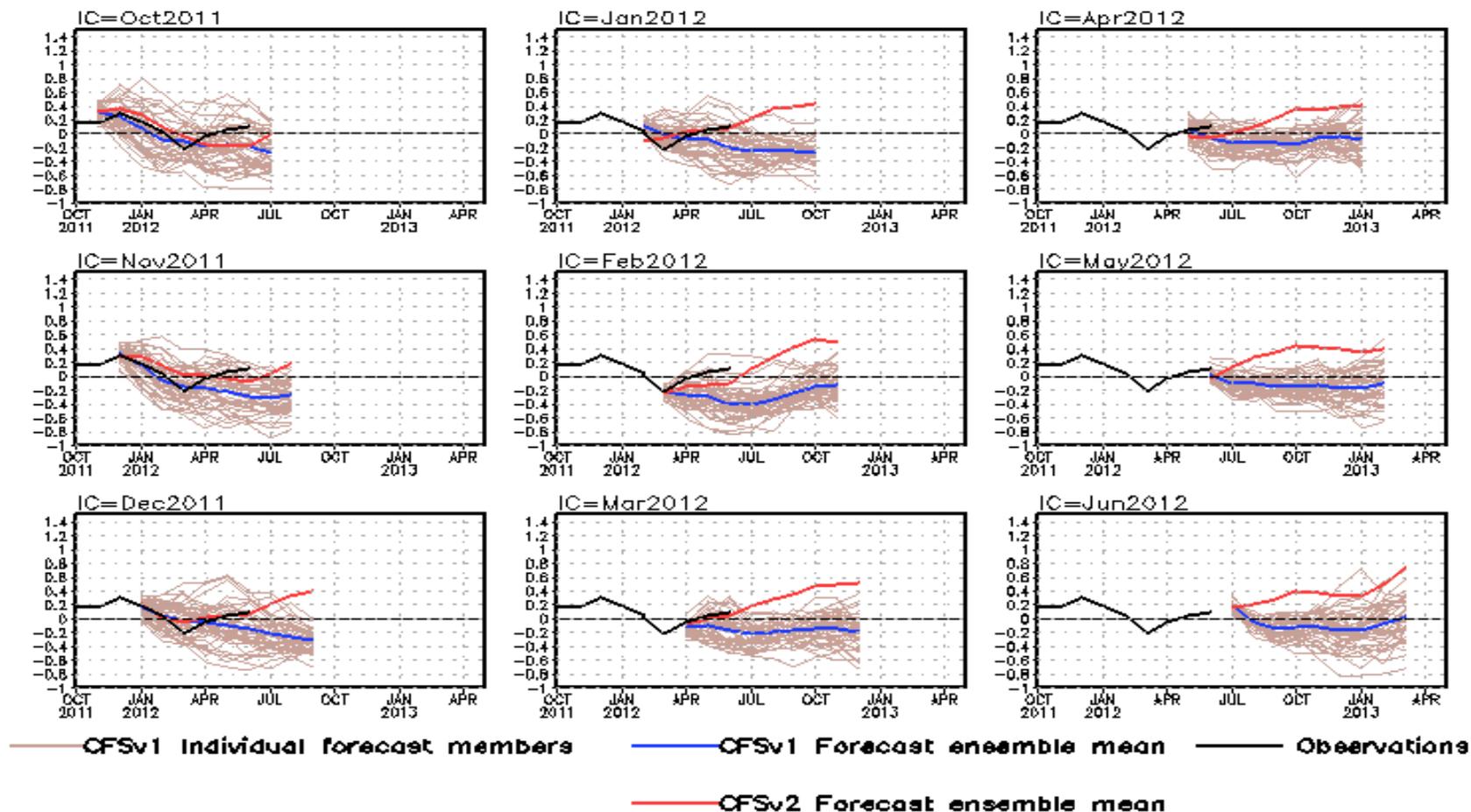
# IRI NINO3.4 Forecast Plum



- A majority of dynamical models predicted an El Niño would develop since summer 2012, while statistical models tended to favor the continuation of ENSO-neutral condition.
- Official probabilistic forecast favors an El Niño from ASO to DJF 2012.
- NOAA "ENSO Diagnostic Discussion" in July suggests that "Chances increase for El Niño beginning in July-September 2012".

# NCEP CFSv1 and CFSv2 Tropical North Atlantic SST Forecast

## Tropical N. Atlantic SST anomalies (K)



CFSv1 predicted below-normal SST in the tropical N. Atlantic and CFSv2 predicted above-normal during the second half year of 2012.

# Overview

## ▪ Pacific and Arctic Oceans

- ENSO-neutral conditions continued with NINO3.4=0.3°C in June 2012.
- CFSv1 and CFSv2 predict an El Nino developing by July-September 2012. An El Nino watch was issued by NOAA “ENSO Diagnostic Discussion”
- Negative PDO phase since May 2010 has persisted for 26 months.
- Arctic sea ice extent retreated rapidly in June 2012 and reached the second historical low in the satellite record.

## ▪ Indian Ocean

- Positive SSTA presented in the tropical and southeastern Ocean.

## ▪ Atlantic Ocean

- ATL3 SSTA transited to positive phase in June 2012.
- NOAA predicted near-normal condition of hurricane activity in 2012.

# Backup Slides

# 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 (Wyrтки 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.

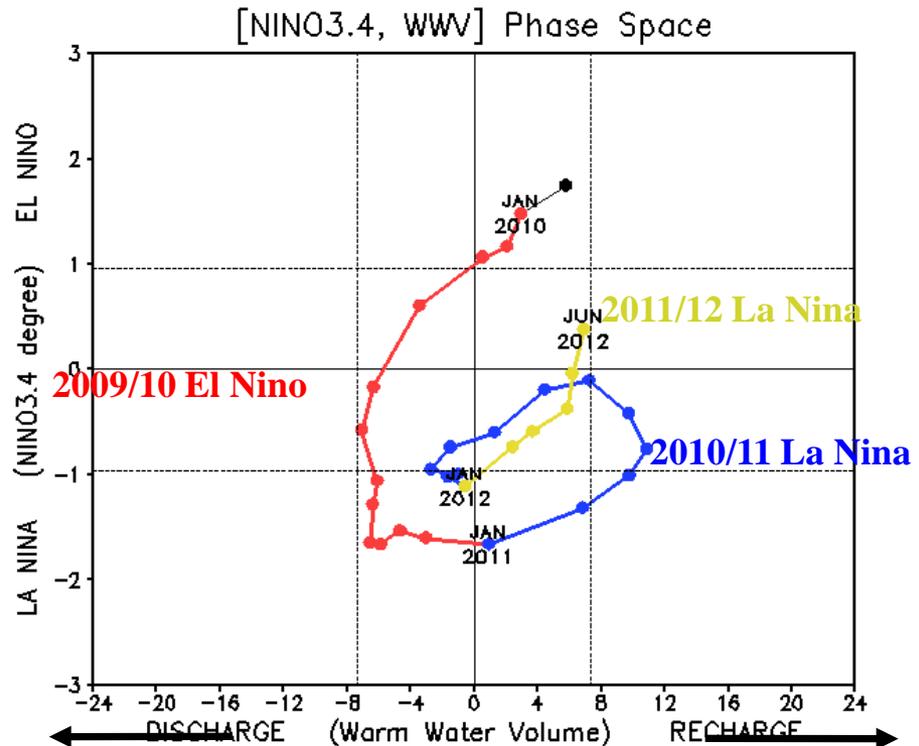
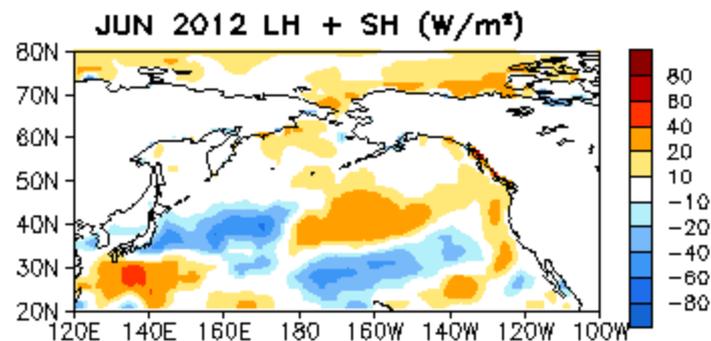
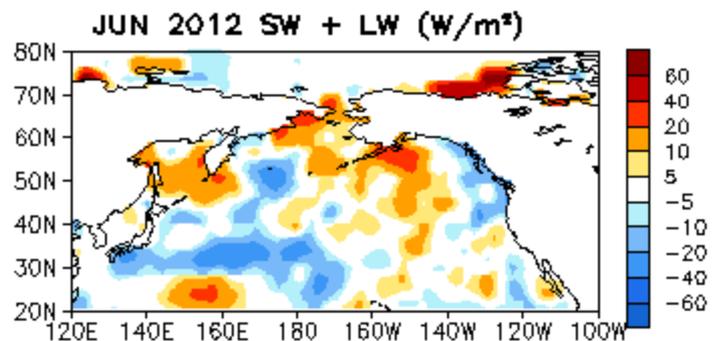
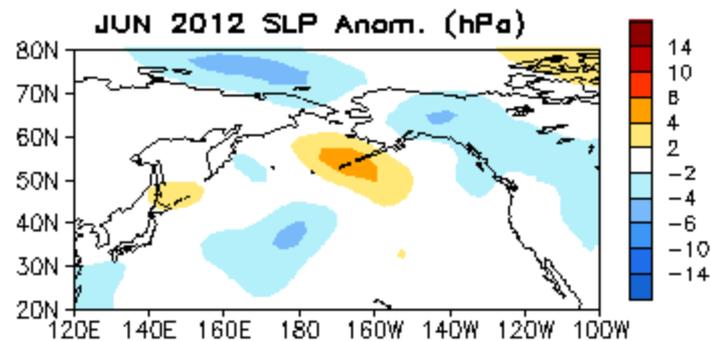
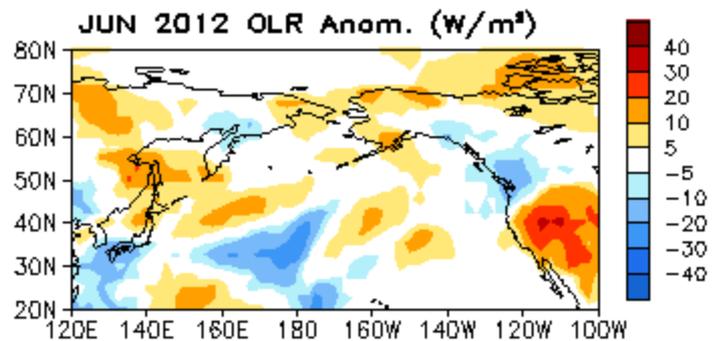
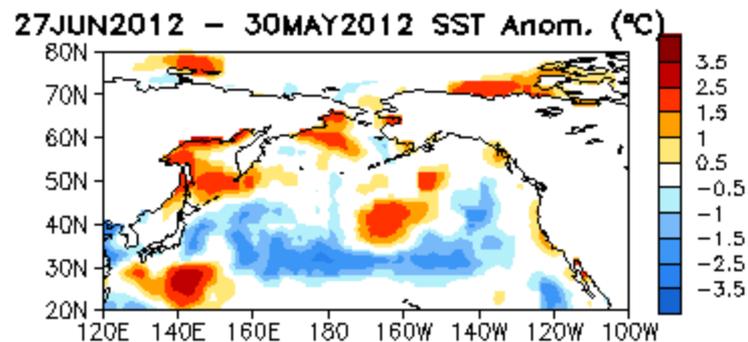
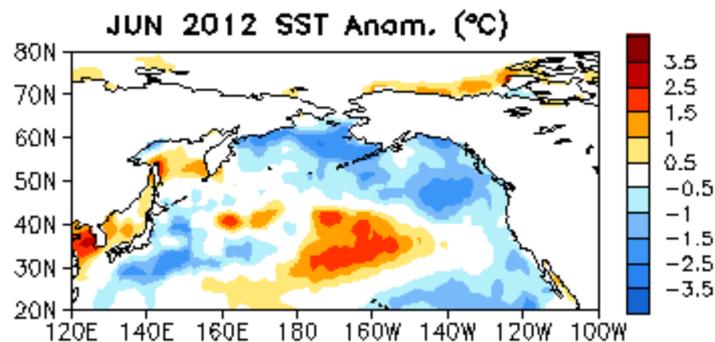


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

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



# Recent Evolution of 10°S Indian SST (°C), 0-300m Heat Content (°C), and 850-mb Zonal Wind (m/s) Anomalies

12°S–8°S Average, 3 Pentad Running Mean

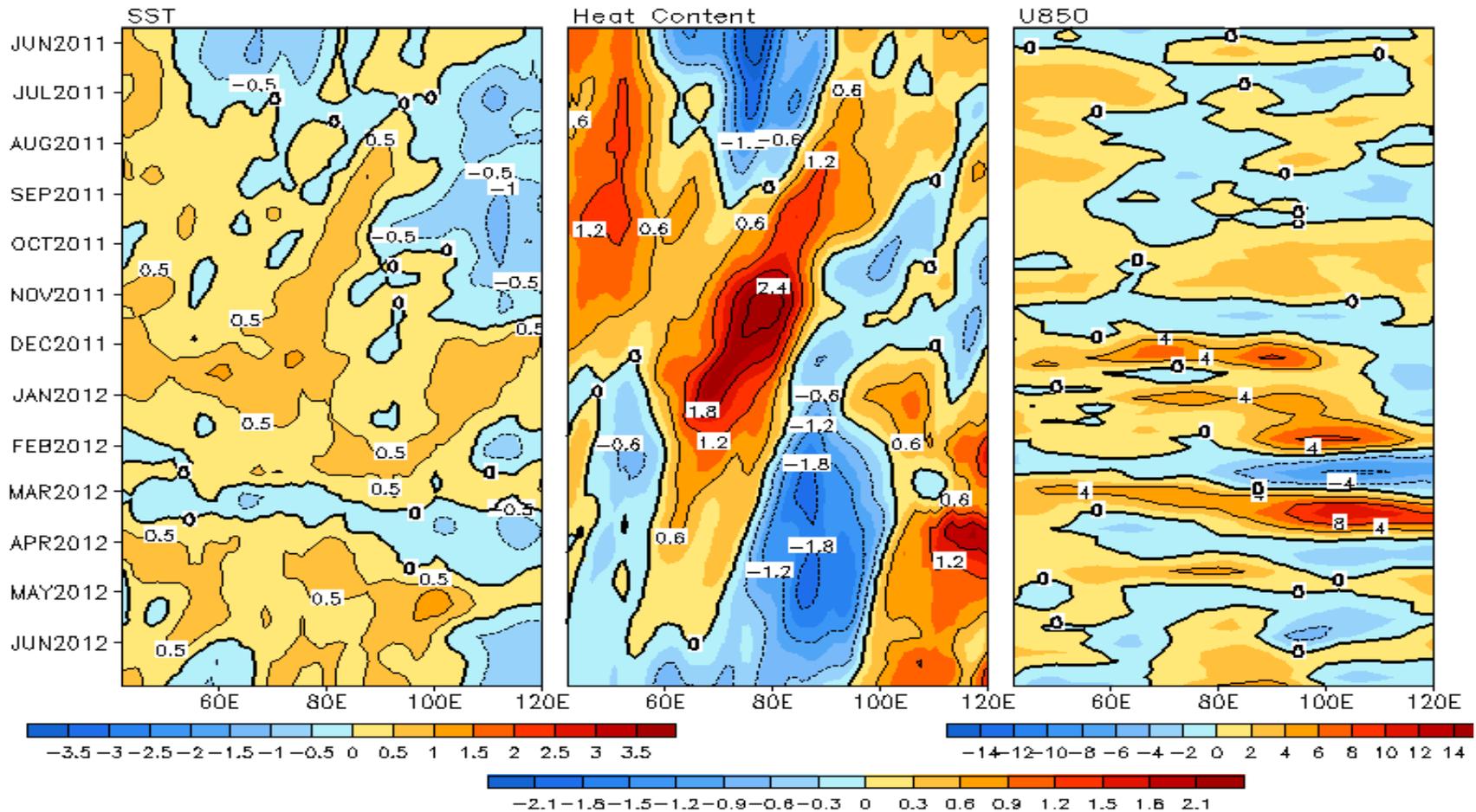
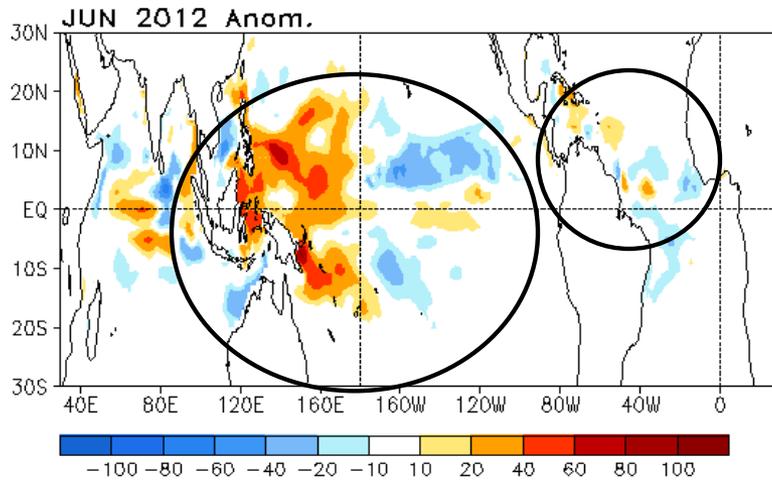
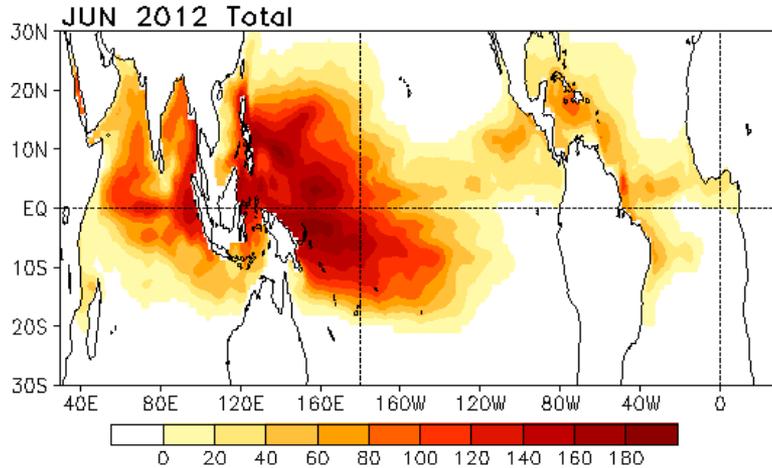


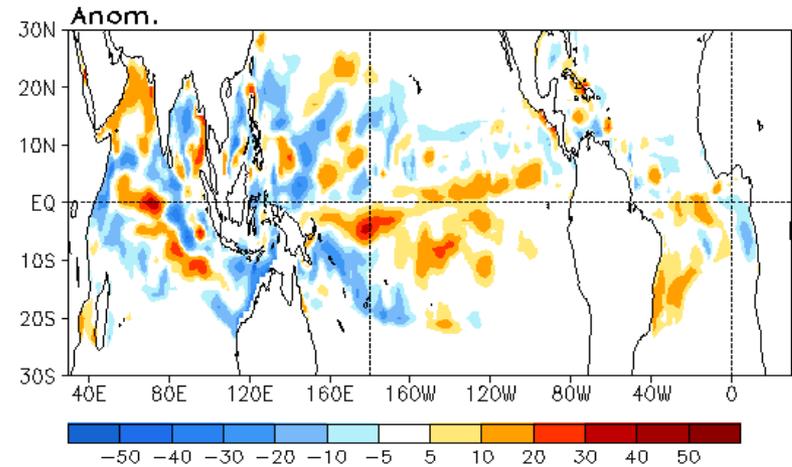
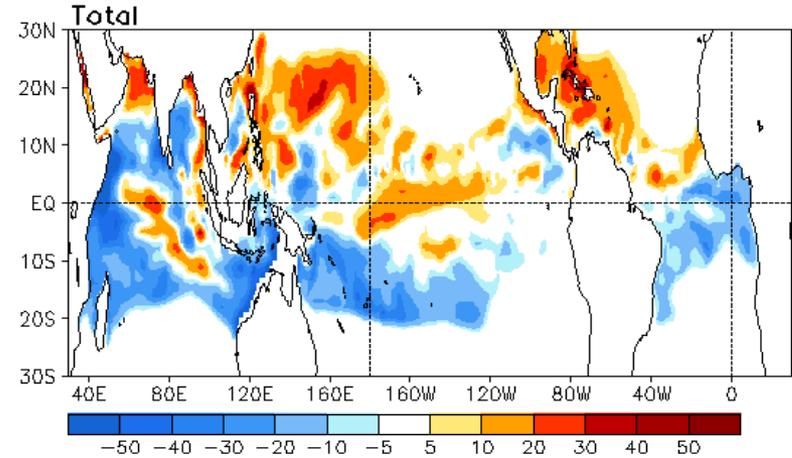
Fig. 13. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S–2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S–5°N. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies are departures from the 1981–2010 base period pentad means.

# Tropical Cyclone Heat Potential and Tendency

Tropical Cyclone Heat Potential ( $\text{KJ}/\text{cm}^2$ )



JUN 2012 - MAY 2012 TCHP ( $\text{KJ}/\text{cm}^2$ )

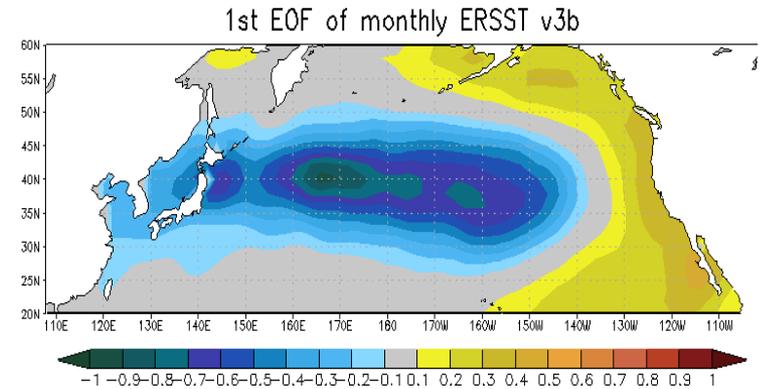
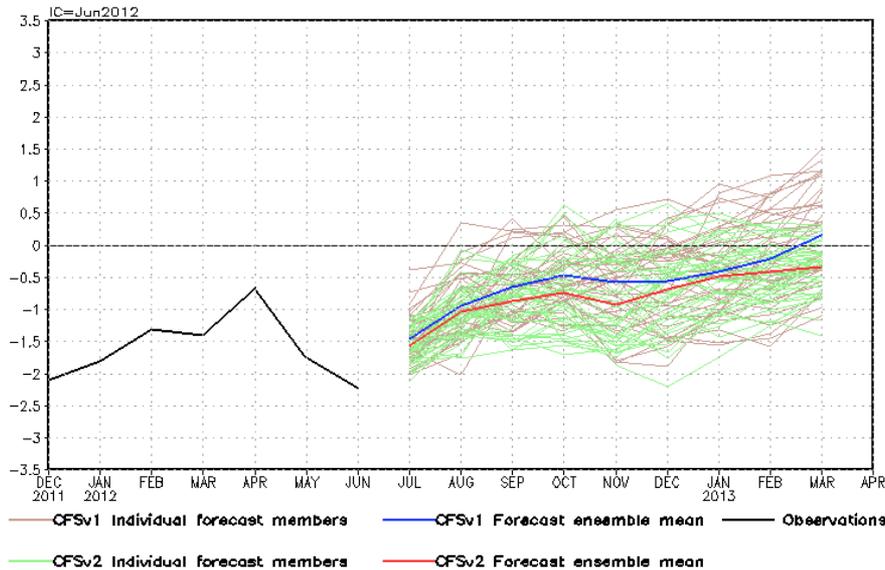


- Positive TCHP anomalies presented in the western Pacific and negative ones in the central and eastern Pacific off the equator.
- Both the anomalies and the tendencies over the Atlantic Ocean were small.

*TCHP field is the anomalous heat storage associated with temperatures larger than  $26^\circ\text{C}$ .*

# NCEP CFSv1 and CFSv2 PDO Forecast

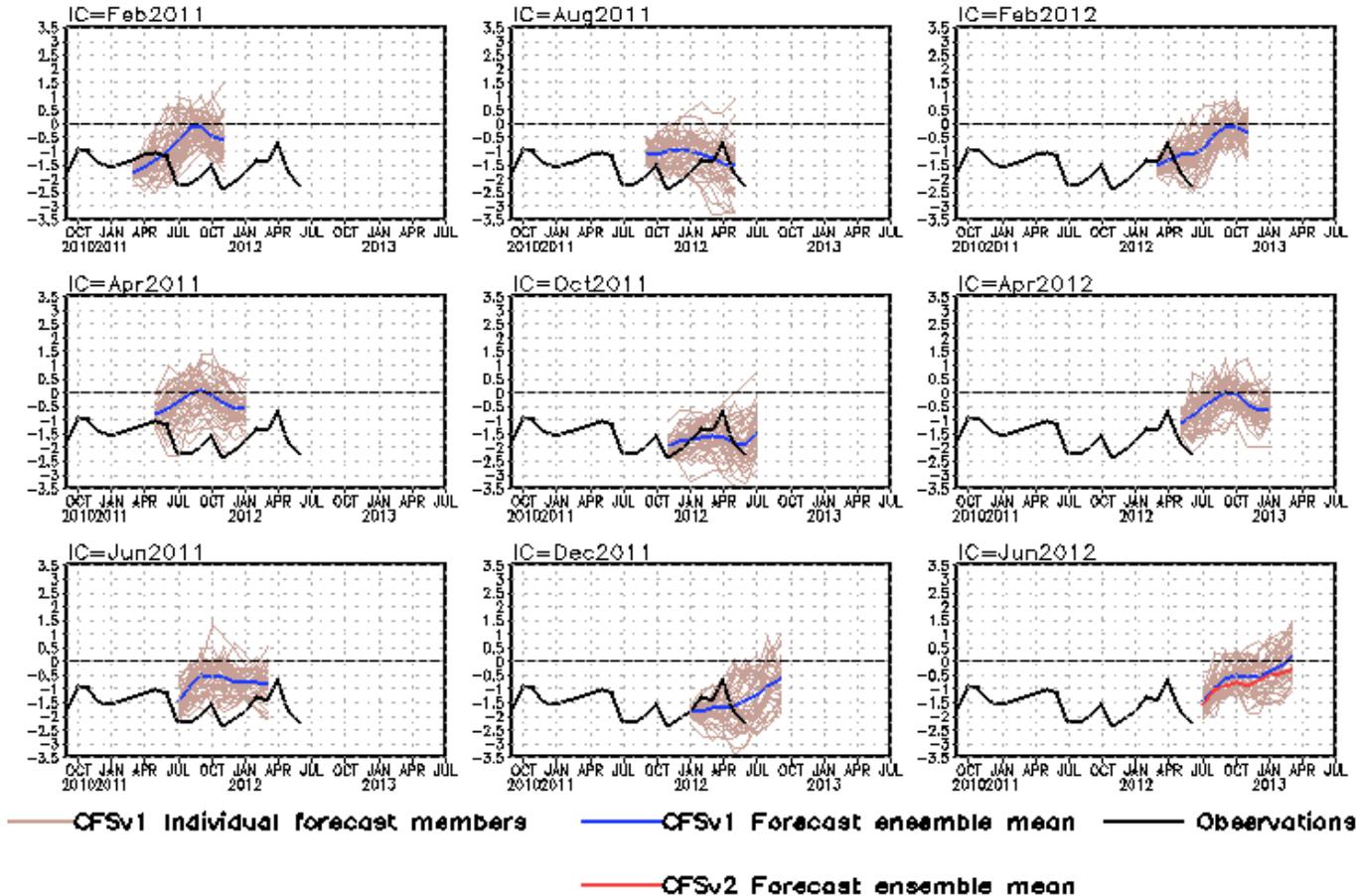
standardized PDO index



- Pacific Decadal Oscillation is defined as the 1<sup>st</sup> EOF of monthly ERSSTv3b 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.

# CFS Pacific Decadal Oscillation (PDO) Index Predictions

standardized PDO index



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

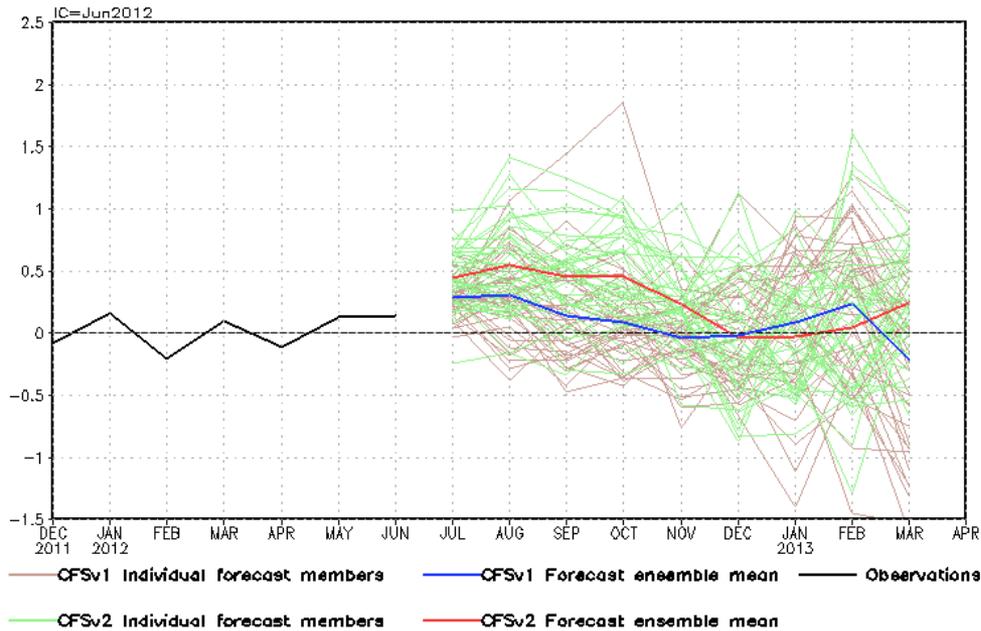
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

# NCEP CFSv1 and CFSv2 Indian Ocean Dipole Model Index

## Forecast

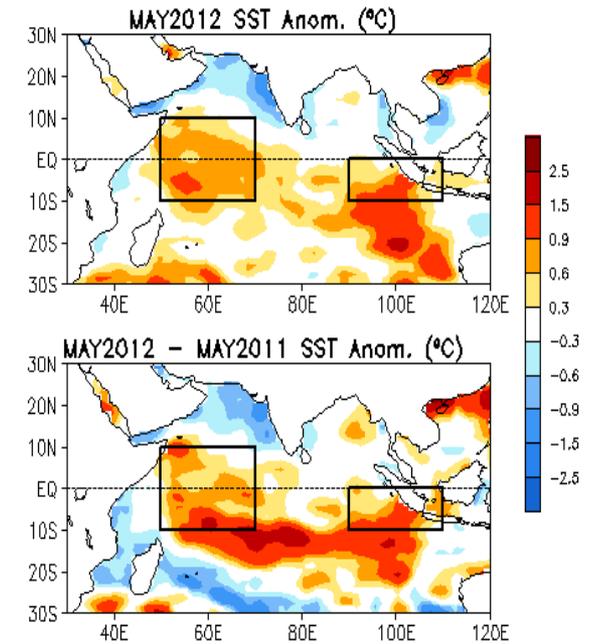
Indian Ocean Dipole SST anomalies (K)



DMI = WTIO - SETIO

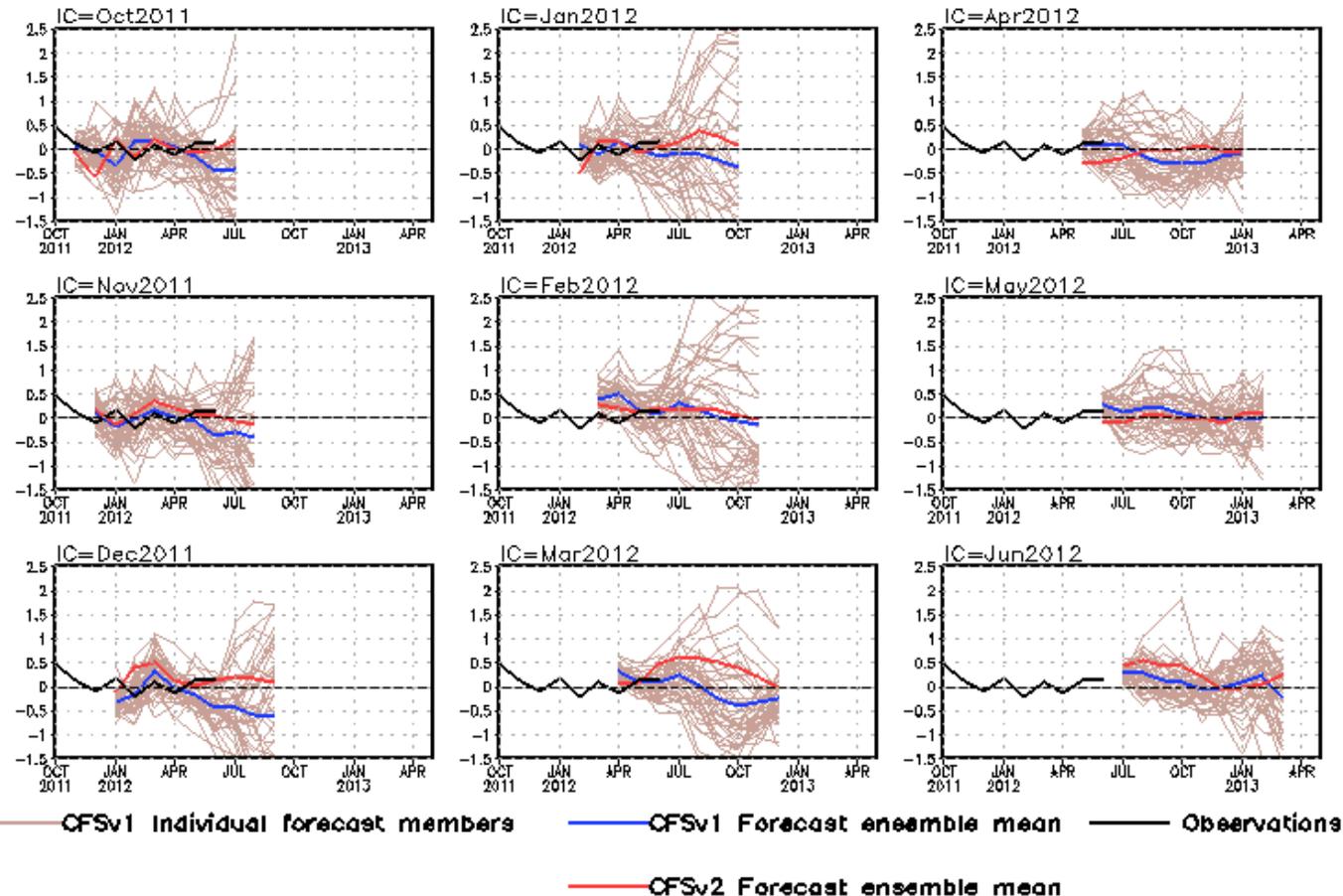
SETIO = SST anomaly in  
[90°E-110°E, 10°S-0]

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



# NCEP CFS DMI SST Predictions from Different Initial Months

## Indian Ocean Dipole SST anomalies (K)



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]

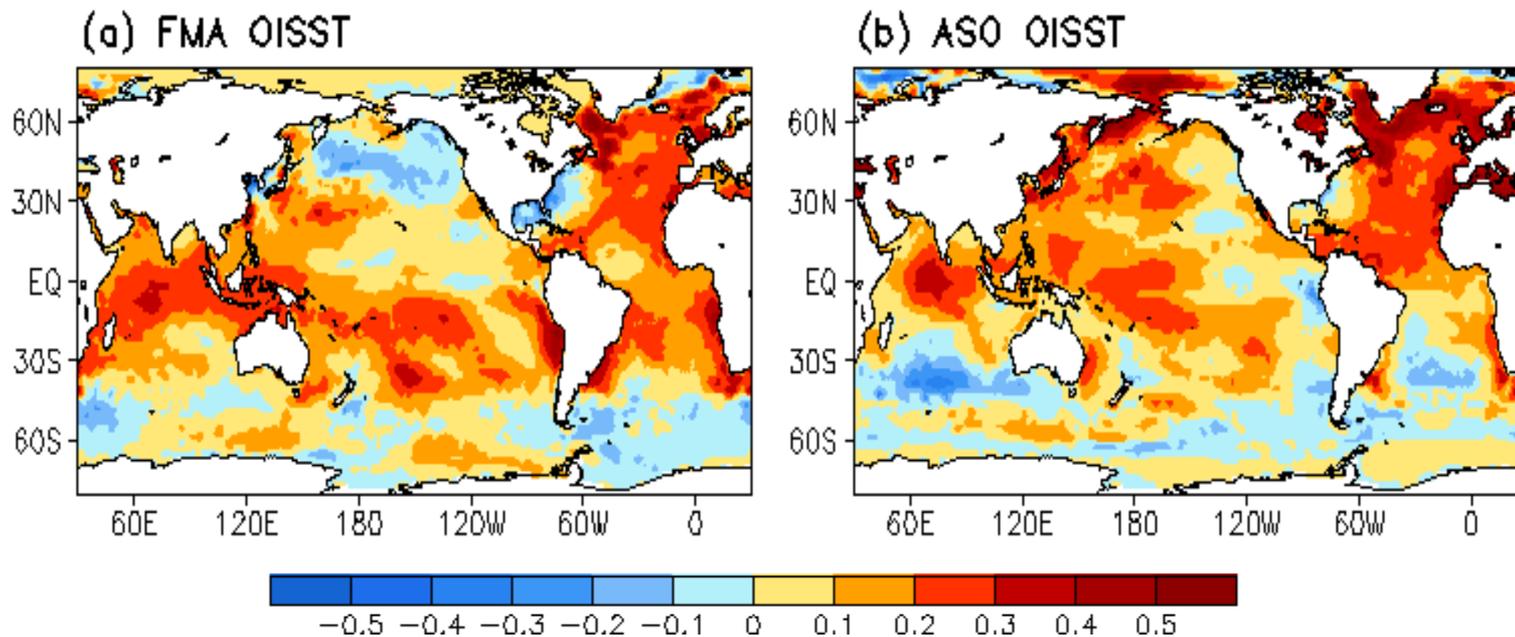
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast 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

SST Climatology Diff. ( $^{\circ}\text{C}$ ): (1981–2010) – (1971–2000)



**1971-2000 SST Climatology (Xue et al. 2003):**

[http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst\\_clim.htm](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  $0.2^{\circ}\text{C}$  over much of the Tropical Oceans and N. Atlantic, but decreased by more than  $0.2^{\circ}\text{C}$  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](mailto:Yan.Xue@noaa.gov). Thanks!