

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

- **Positive SST anomalies strengthened in the equatorial central-eastern Pacific, with Nino 3.4 = 0.6°C.**
- **Atmosphere circulation in the tropical Pacific continued to be near-normal in July 2012.**
- **NCEP CFSv1 and CFSv2 models predict an El Nino will develop in August 2012, and lasts through Northern Hemisphere winter.**
- **Negative PDO phase strengthened in July 2012, with PDO=-1.8, and has last for 27 months since May 2010.**
- **Arctic sea ice extent was the second lowest in the satellite record.**

▪ Indian Ocean

- **Indian Ocean Dipole was near-normal since Nov 2011.**

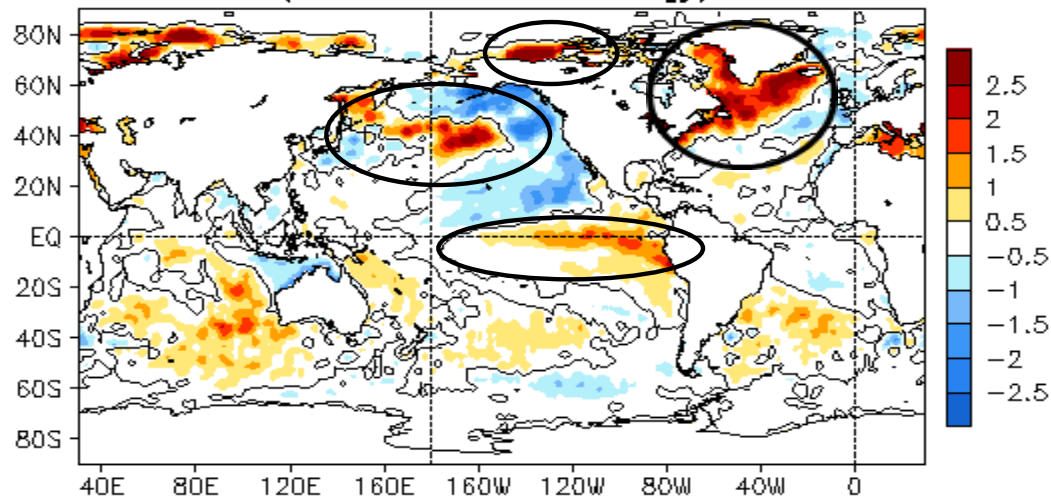
▪ Atlantic Ocean

- **Near-normal SSTA continued in the hurricane Main Development Region(MDR).**
- **NOAA predicted near-normal condition of hurricane activity in 2012.**
- **Negative NAO index persisted in the past three months, contributing to a strong warming in the high-latitude N. Atlantic.**

Global Oceans

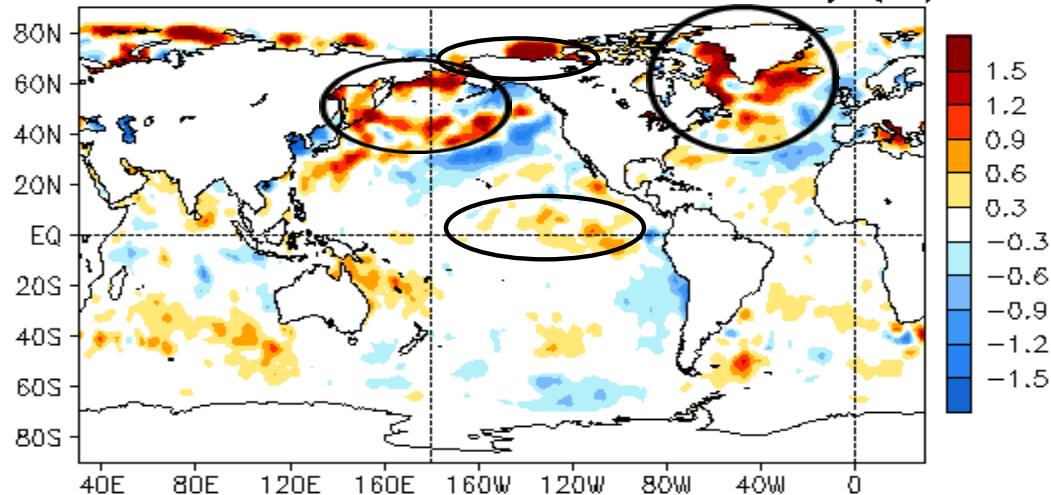
Global SST Anomaly ($^{\circ}\text{C}$) and Anomaly Tendency

JUL 2012 SST Anomaly ($^{\circ}\text{C}$)
(1981–2010 Climatology)



- Positive SST anomalies presented in the central-eastern equatorial Pacific.
- Large positive SST anomalies presented in the Arctic Ocean, subpolar North Atlantic, and along the Gulf Stream.
- Negative PDO-like pattern presented in North Pacific.
- Negative(positive) SST anomalies presented north of Australia (in southeast subtropical Indian Ocean).

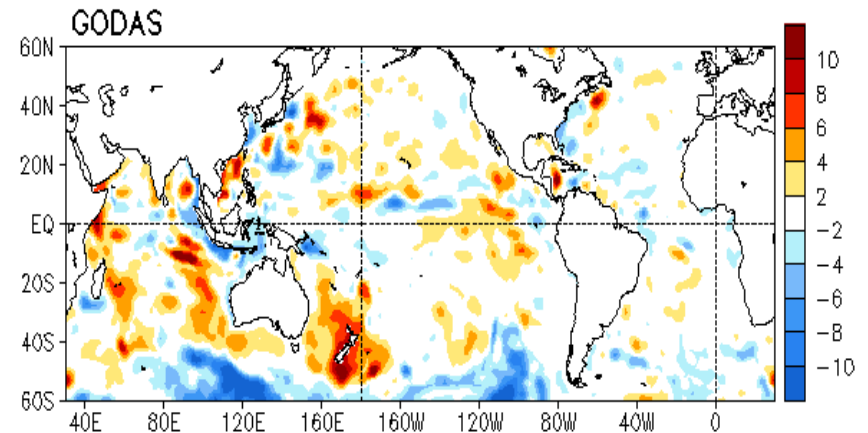
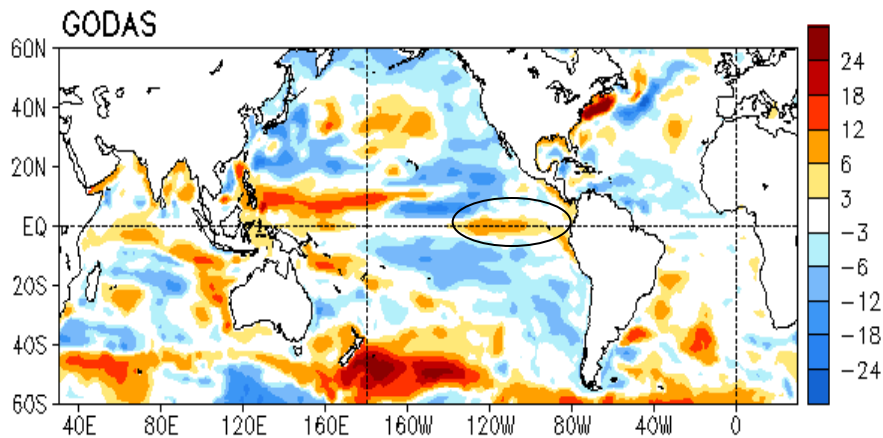
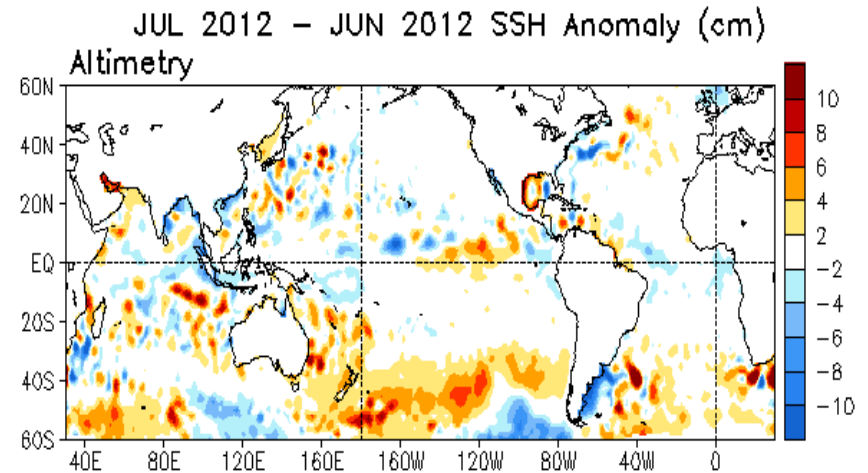
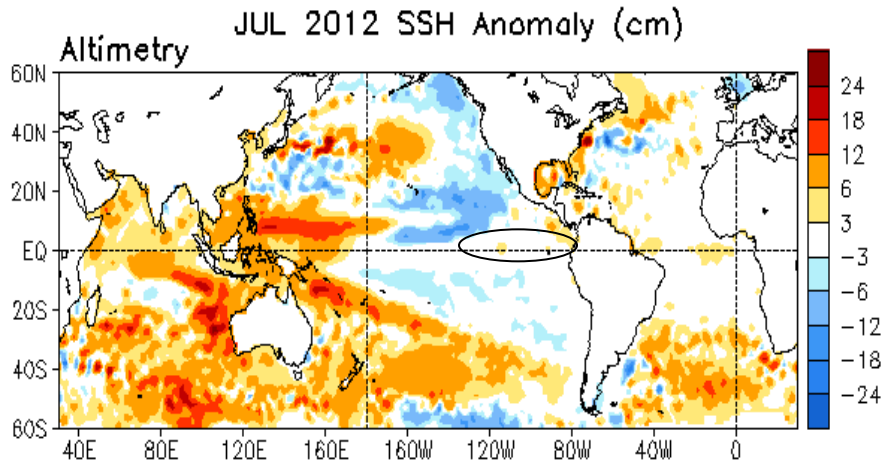
JUL 2012 – JUN 2012 SST Anomaly ($^{\circ}\text{C}$)



- A weak warming tendency presented in the central-eastern equatorial Pacific.
- A strong warming tendency presented in the Arctic Ocean, subpolar North Atlantic and the western-central North Pacific.

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.

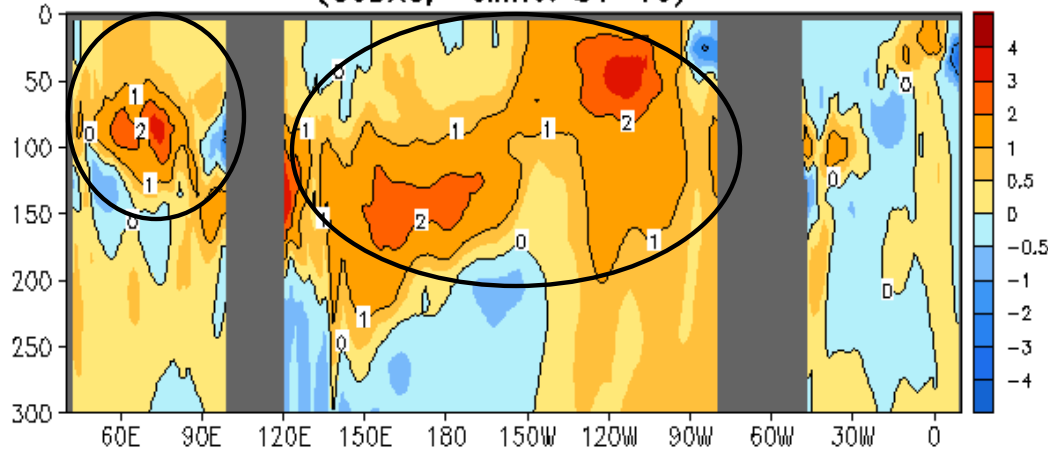
Global SSH Anomaly and Anomaly Tendency



- **Negative PDO-like SSHA pattern presented, consistent with negative PDO-like SSTA pattern**
- **SSHA in the eastern equatorial Pacific was higher in GODAS than in altimetry.**
- **SSHA changed little in July 2012.**

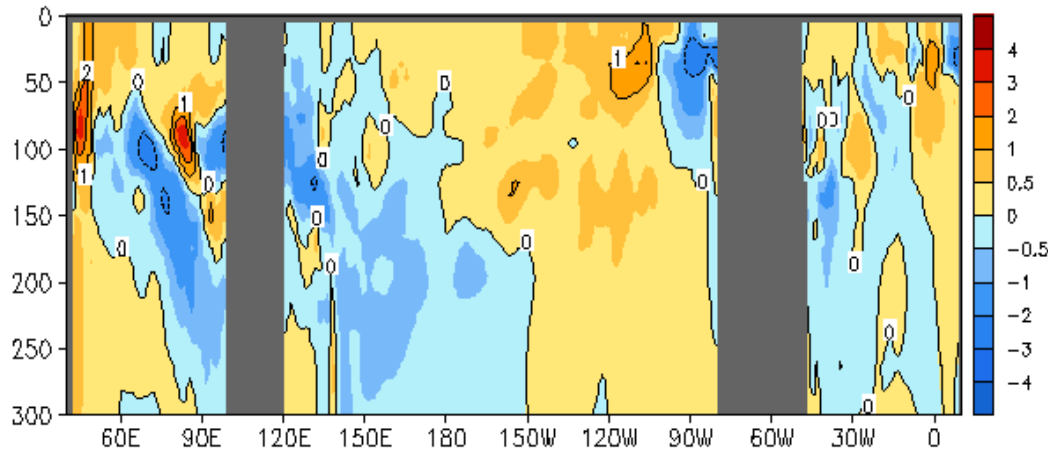
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

JUL 2012 Eq. Temp Anomaly (°C)
(GODAS, Clímo. 81-10)



- Positive temperature anomalies continued to occupy near the thermocline in the equatorial Pacific Ocean.
- Positive anomalies were dominated at 50-150m in the equatorial Indian Ocean.

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

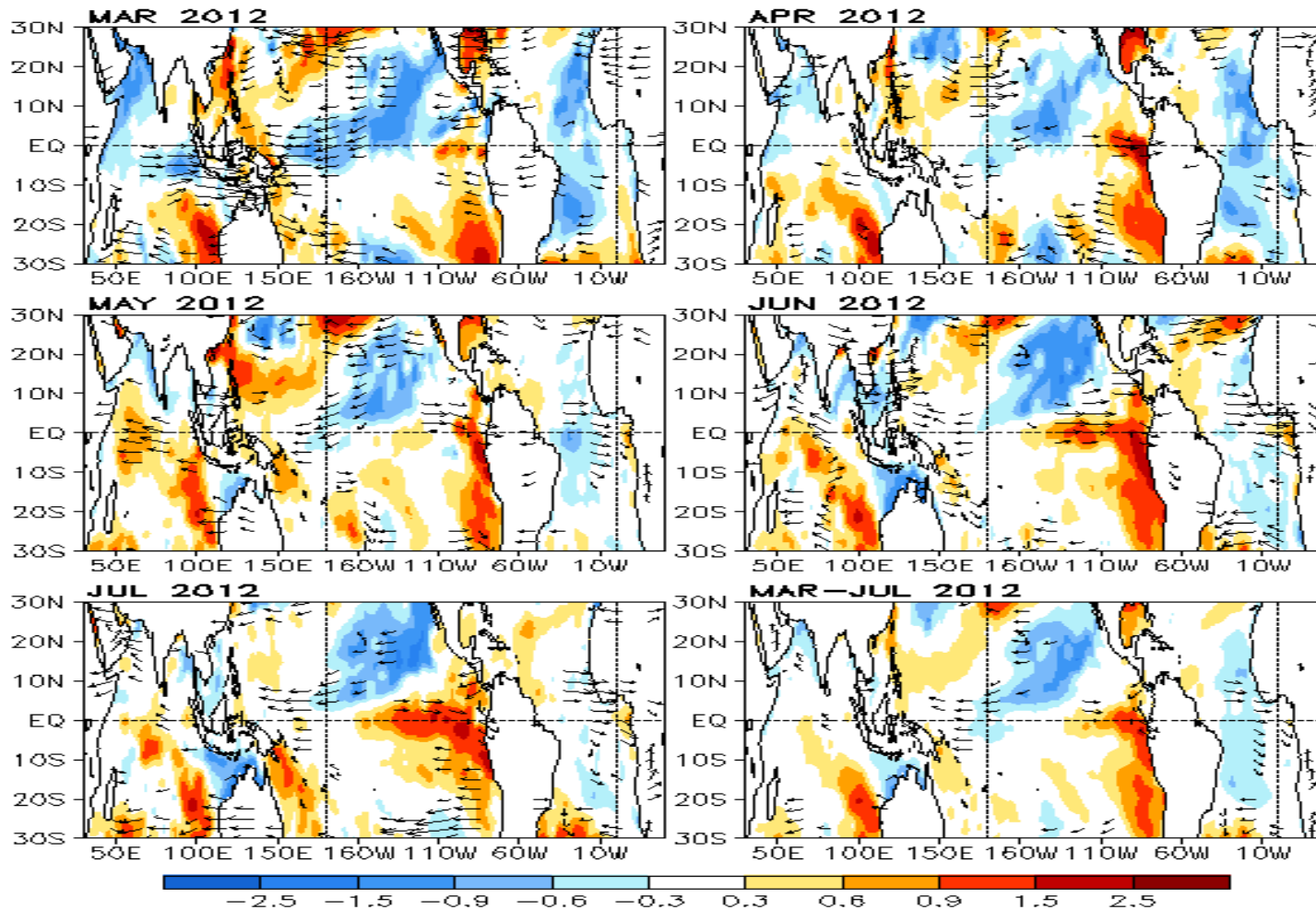


- Warming tendency presented in the central-eastern equatorial Pacific.
- Cooling tendency presented near the thermocline in the western and far eastern Pacific Ocean.

Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

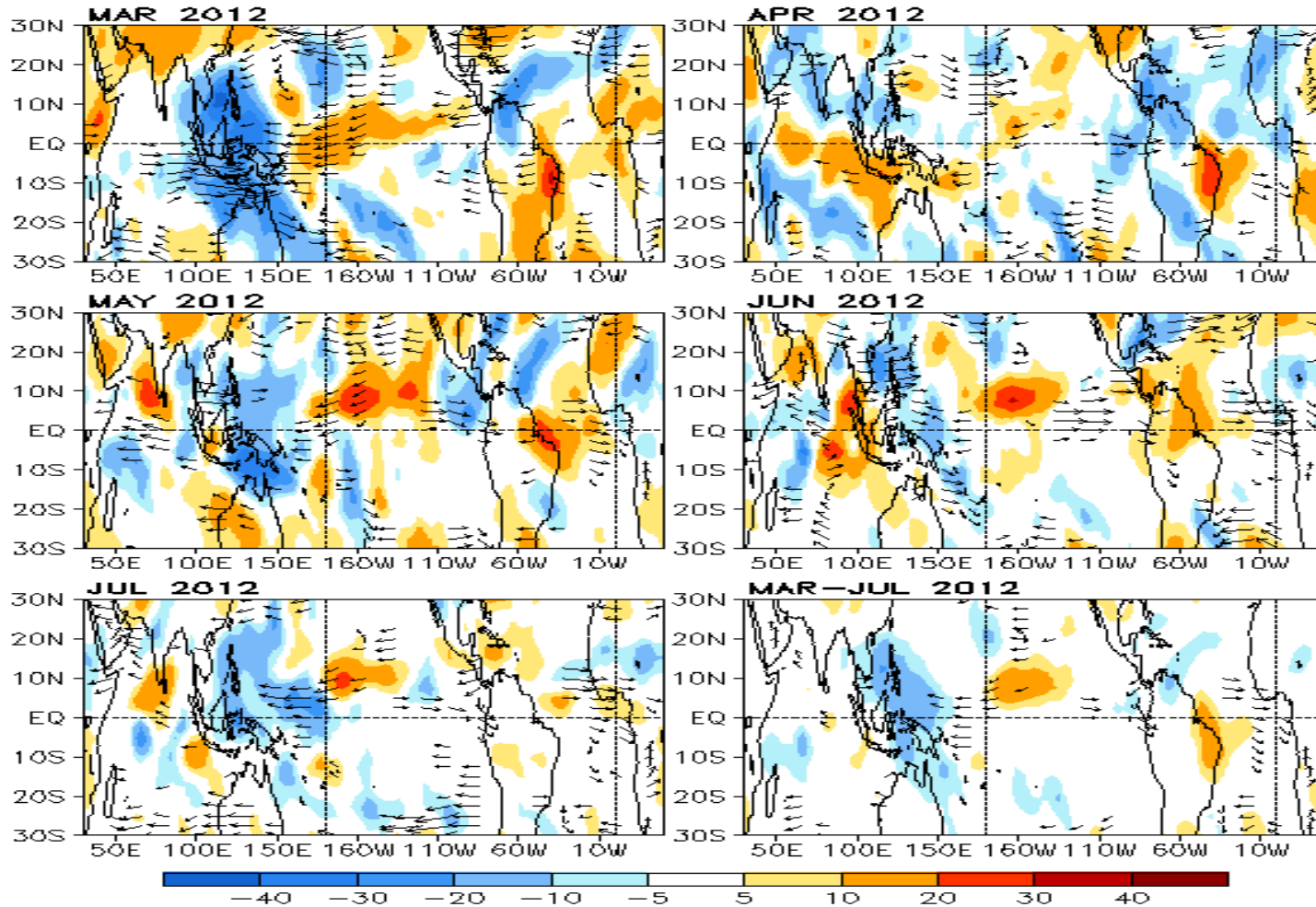
Tropical Pacific Ocean and ENSO Conditions

Recent Evolution of SST and 850mb Wind Anom.



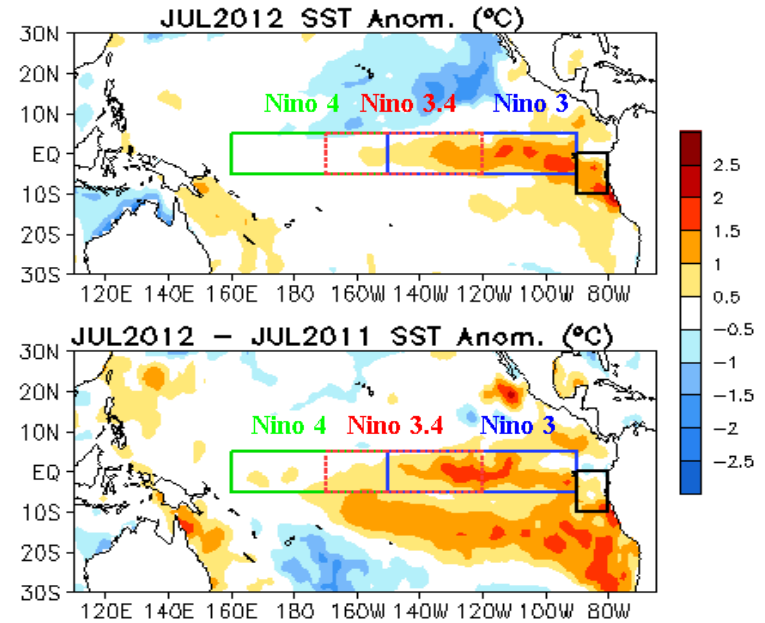
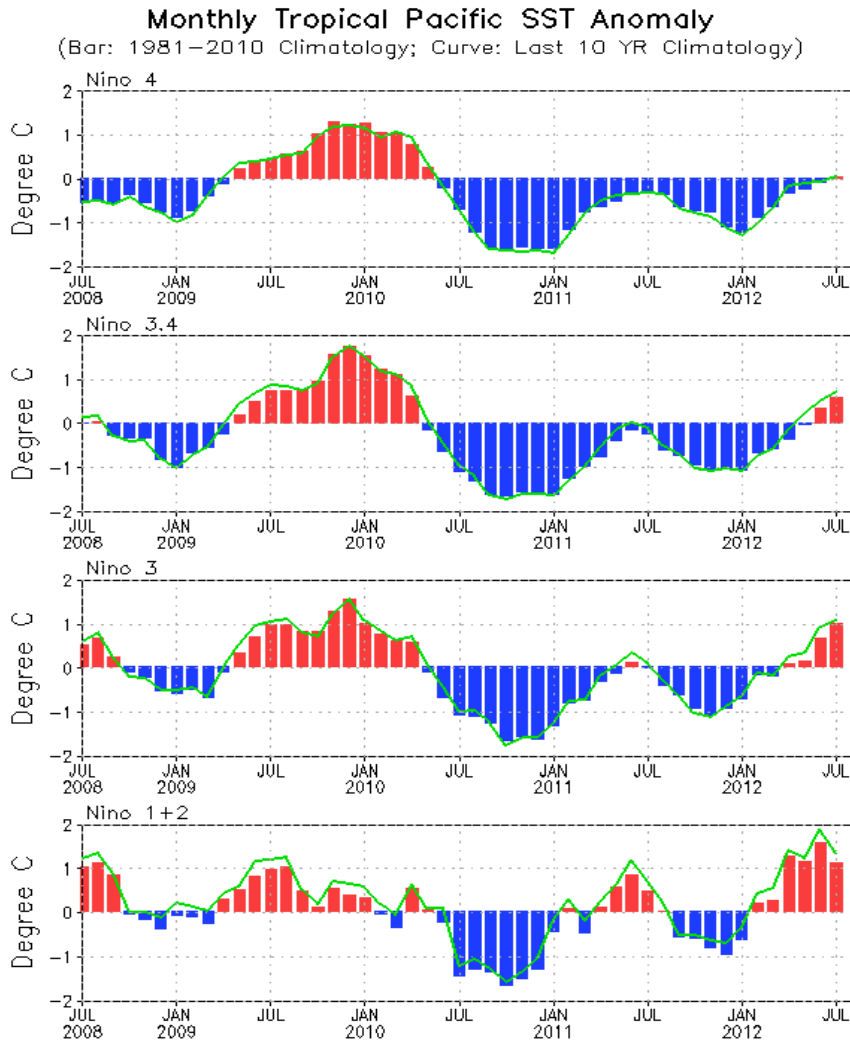
- Easterly wind anomalies persisted near Dateline in the equatorial Pacific from Mar to Jul 2012.
- Accompanying the persistent easterly wind anomalies are persistent westerly wind anomalies in the eastern equatorial Pacific, indicating a persistent low-level divergence in the central-eastern Pacific.

Recent Evolution of OLR and 850mb Wind Anom.



- The dipole OLR anomalies, implying enhanced (suppressed) convection over the Maritime Continent and western tropical Pacific (in the central tropical Pacific), have persisted from May to July 2012.

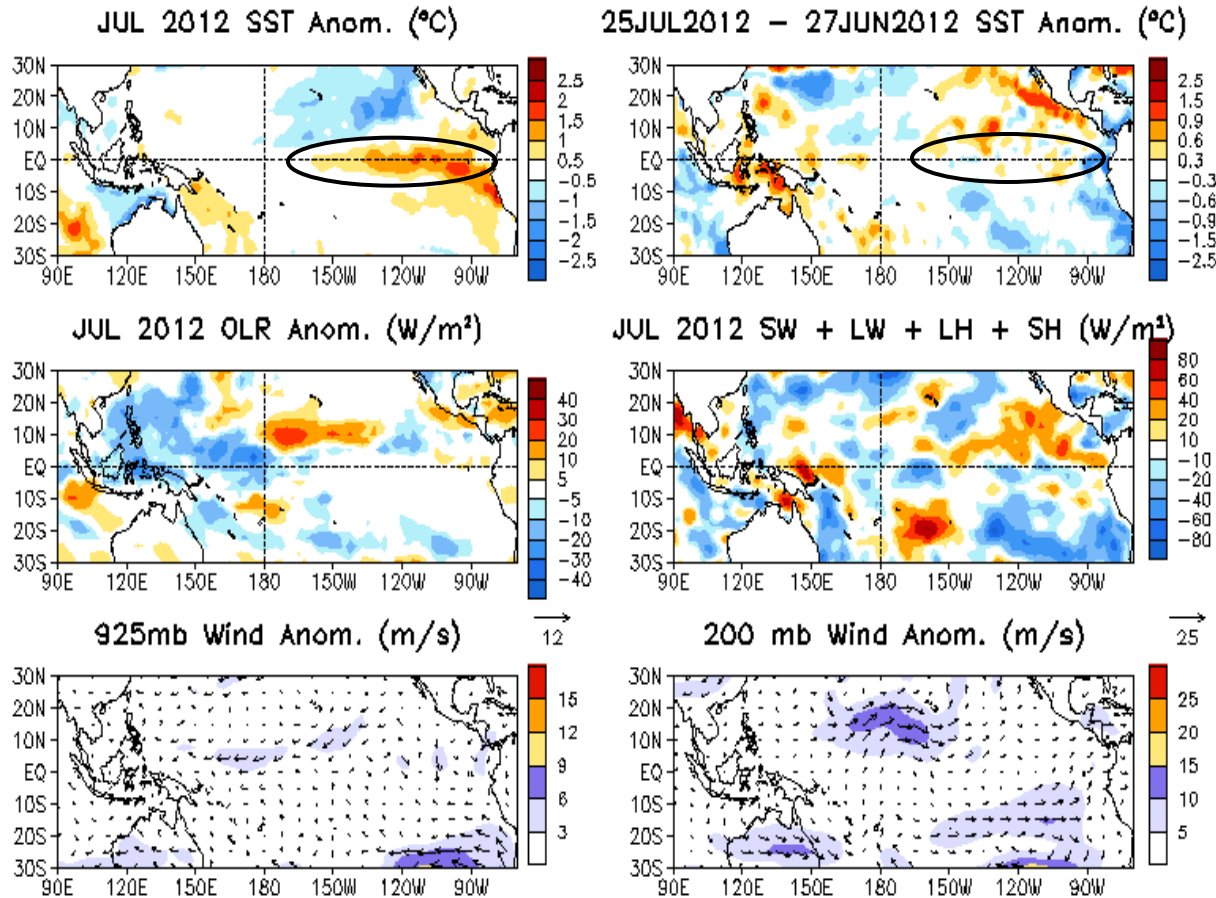
Evolution of Pacific NINO SST Indices



- Niño indices were above normal, with Niño 3.4 index = 0.6°C in July 2012 .
- 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 July 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.

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



- Equatorial SSTA were more than 0.5°C above average east of 160°W in July.

- Eastern equatorial warming strength in July was similar with that in June.

- Atmosphere circulation was near-normal in July.

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

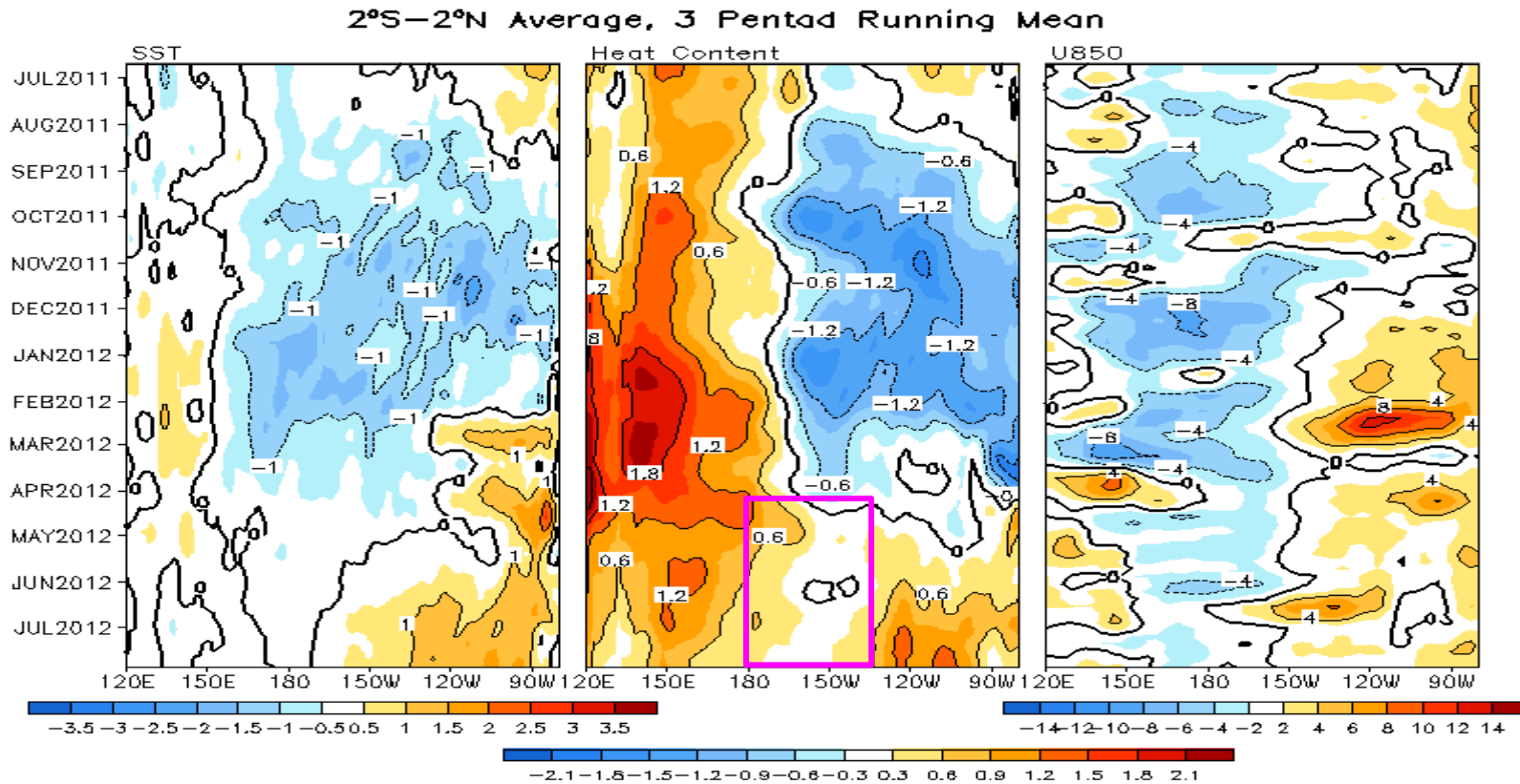


Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST is derived from the NCEP OI 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.
- 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.
- HC300 anomalies in the central equatorial Pacific experienced near-average condition since May 2012.
- La Nina conditions dissipated in Apr 2012 and ENSO-neutral conditions prevailed since May 2012 .

Warm Water Volume (WWV) and NINO3.4 Anomalies

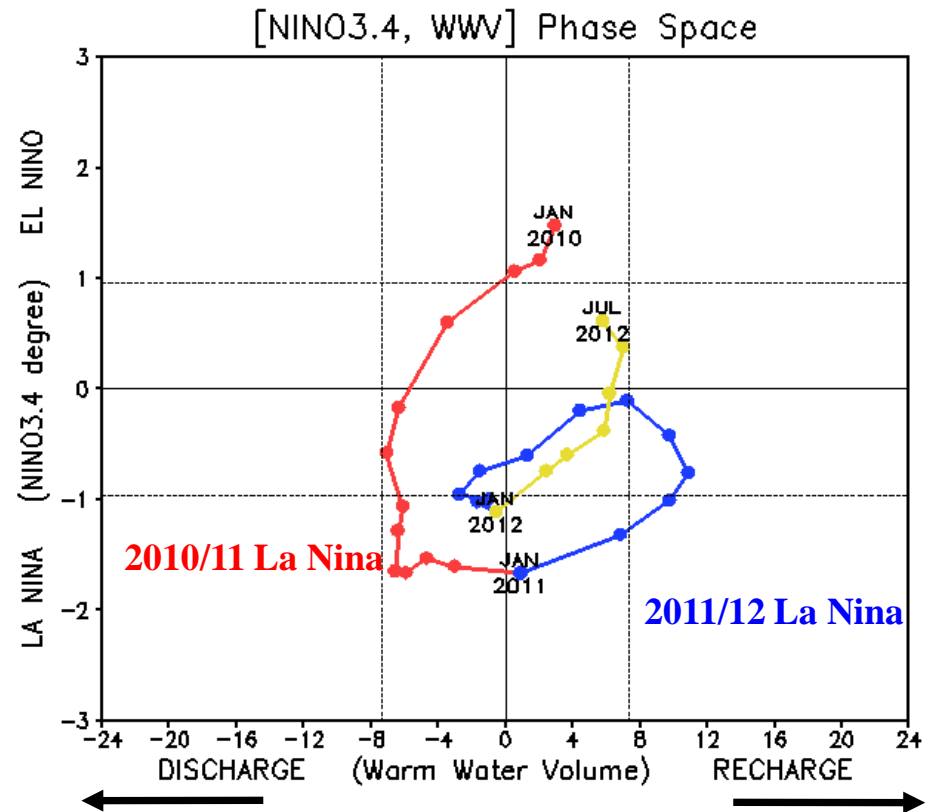
- WWV is defined as average of depth of 20°C in [120°E-80°W, 5°S-5°N].

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).

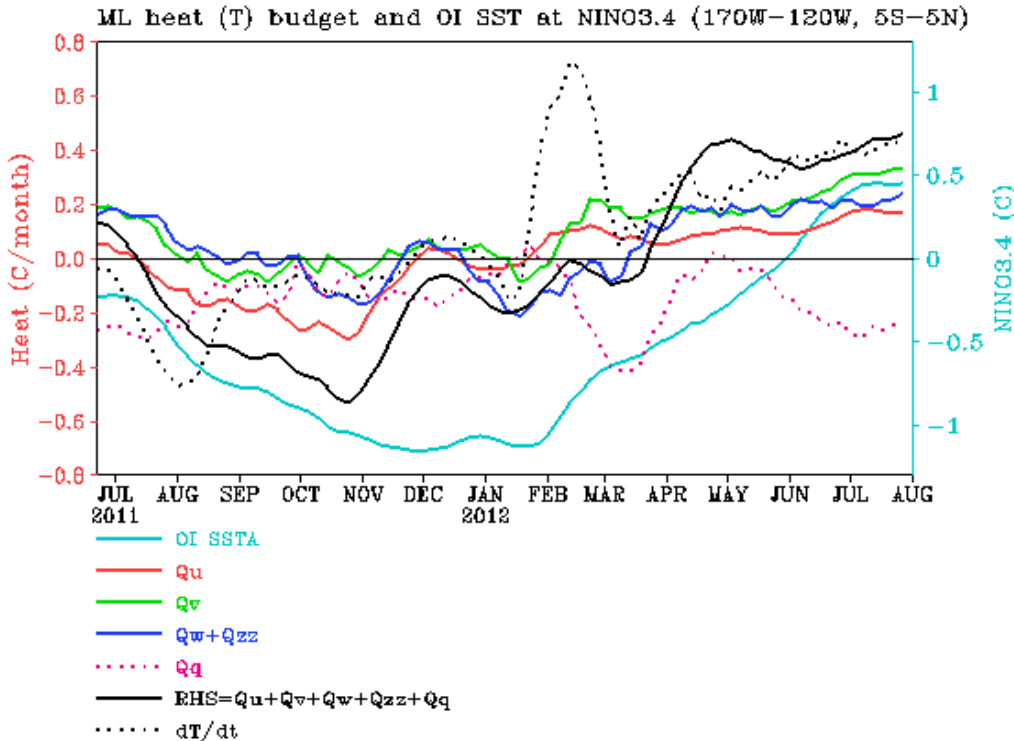
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



- WWV decreased slightly in July, ending the increasing trend of WWV in recharge process since Jan 2012.

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.

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, contributing to the warming tendency.

- 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.

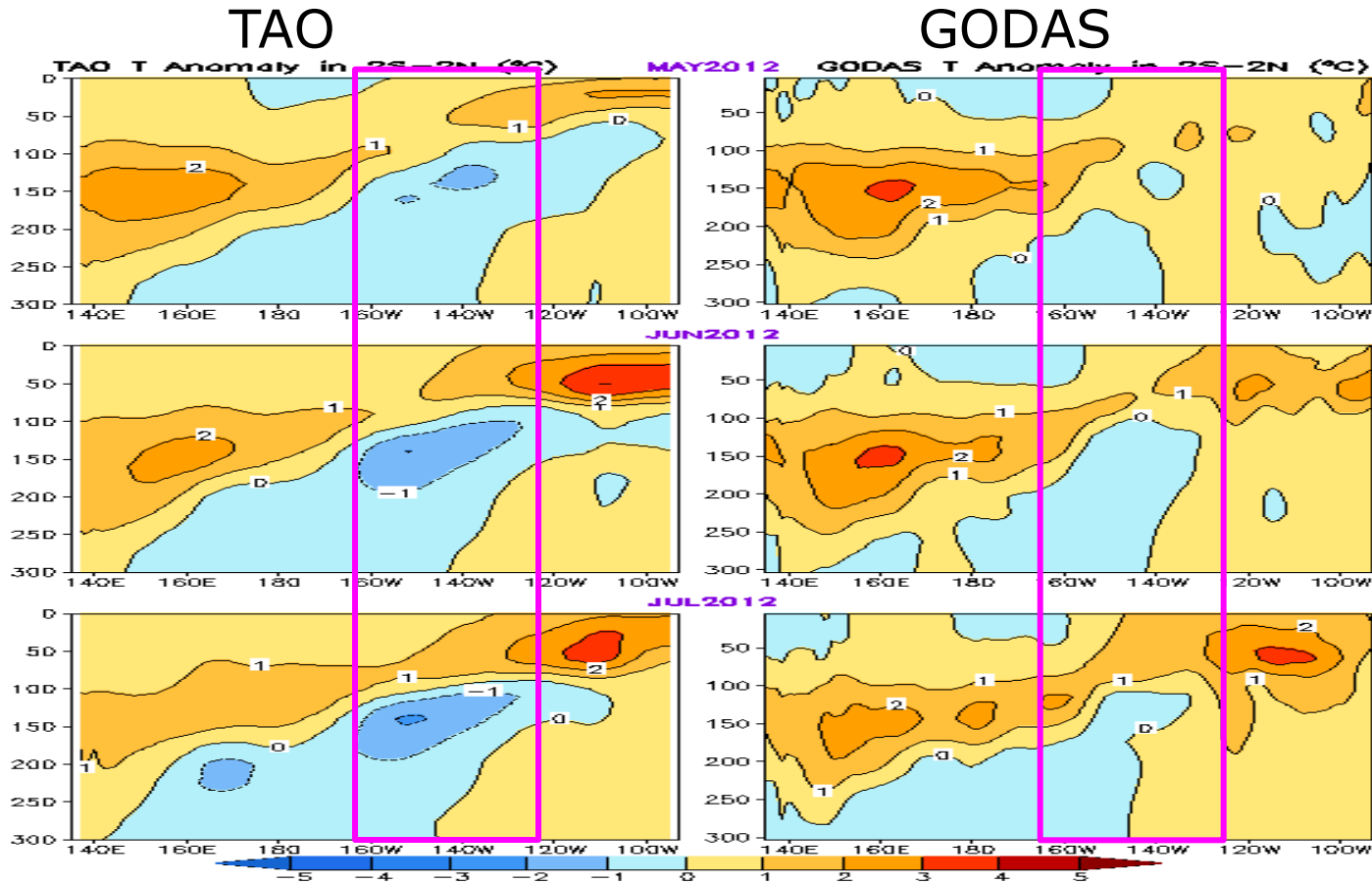
Q_u : Zonal advection; Q_v : Meridional advection;

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

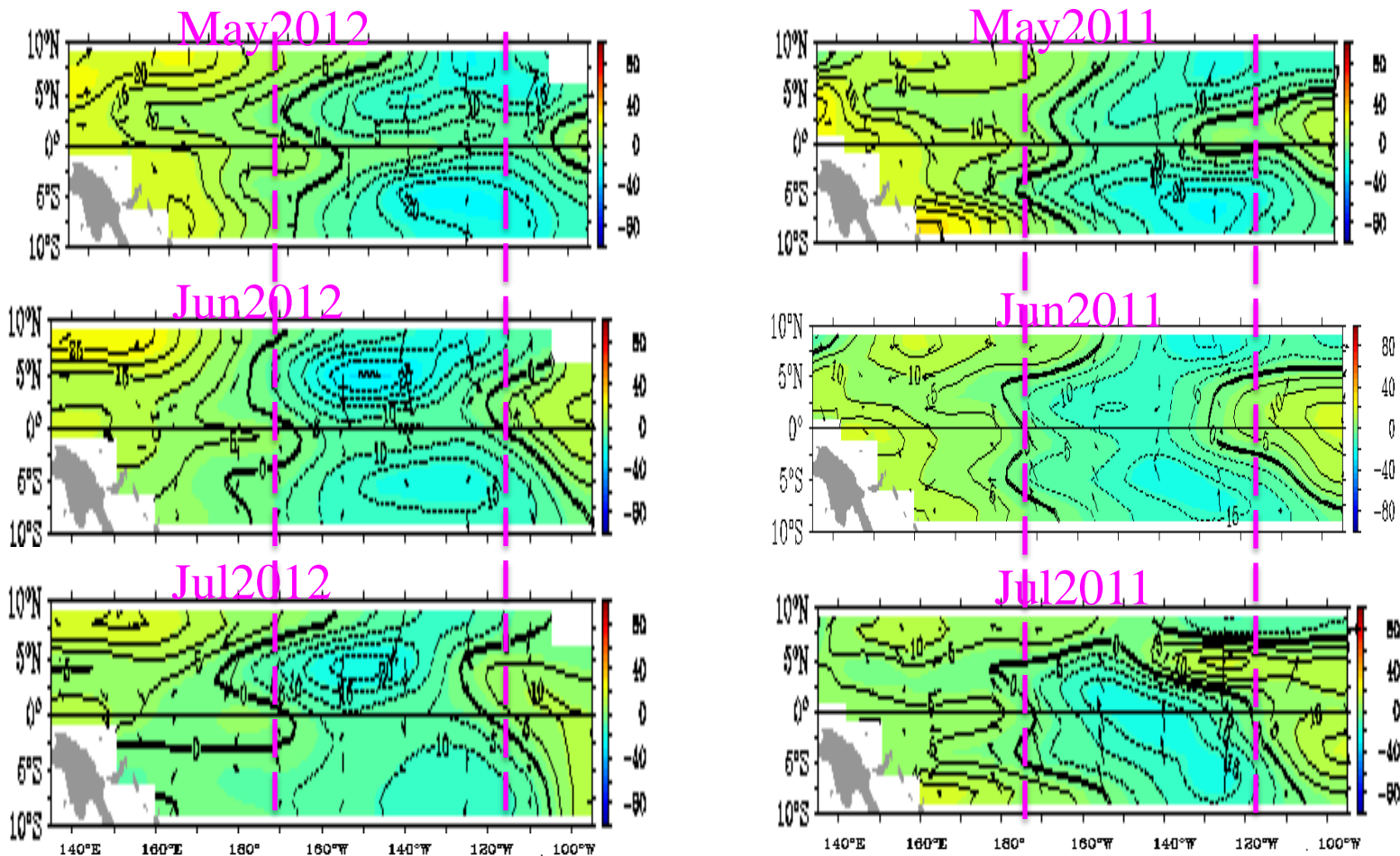
Recent Evolution of Equatorial Pacific Ocean Temperature



- Positive anomaly near the thermocline decreased slightly in July in the far eastern equatorial Pacific.
- Cooling at 100-250m near the central Pacific continued in July .
- Compared with TAO, GODAS is too warm at 100-250 m depth between 160W-120W.

Recent Evolution of Depth of 20C Isotherm Anomaly (m)

TAO

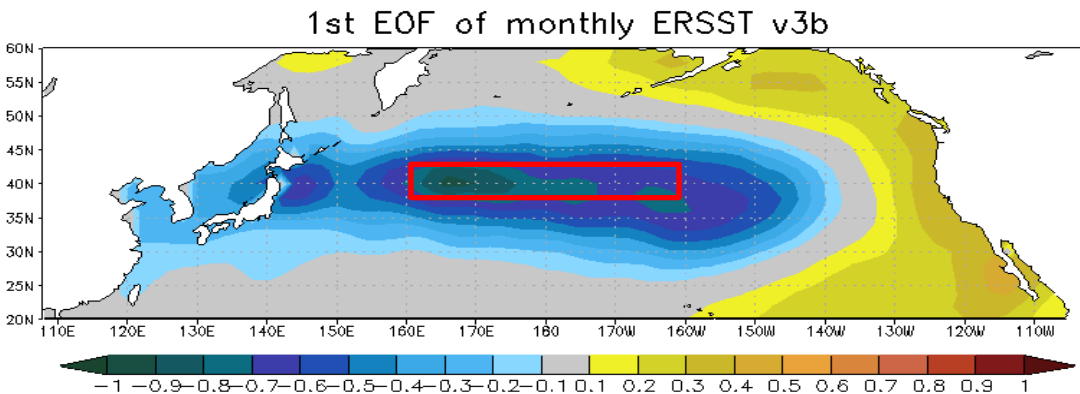
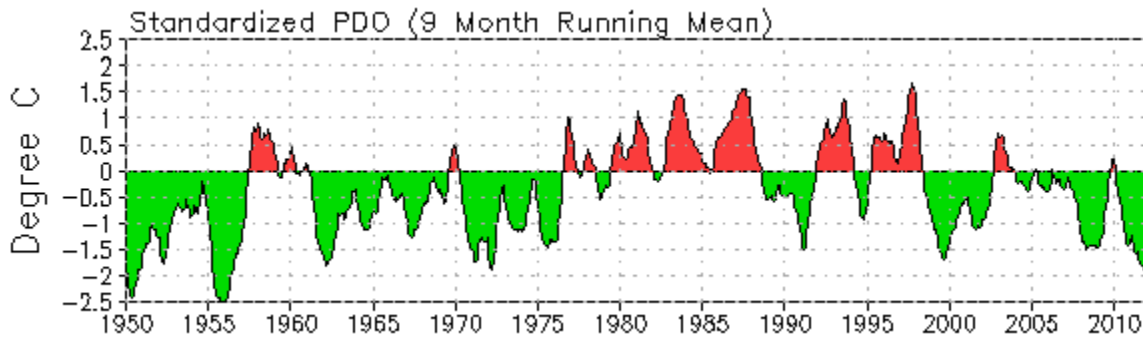
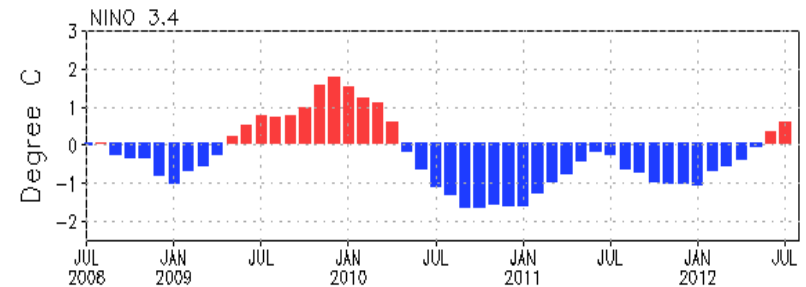
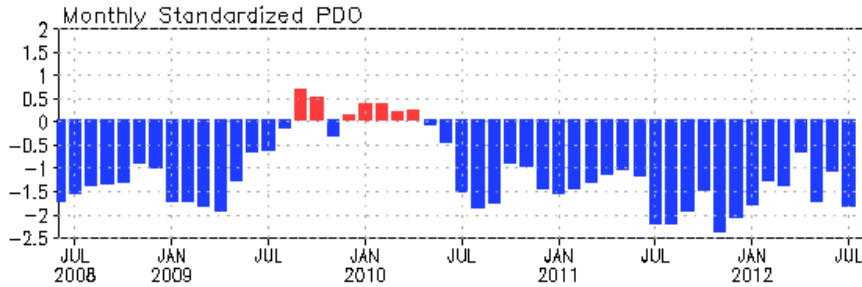


<http://www.pmel.noaa.gov/tao/jsdisplay/>

- **Negative d20 anomaly dominated in the central tropical Pacific Ocean since May 2012.**
- **Similar negative D20 pattern in the central tropical Pacific was observed during the 2011/2012 La Nina.**

North Pacific & Arctic **Oceans**

PDO index



- Negative PDO phase since May 2010 has persisted for 27 months now, and the PDO index strengthened in July 2012 with PDO index = -1.8

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

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

- 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

- Large Positive SSTA presented in the western-central North Pacific and Arctic ocean.

- Large positive SW+LW anomalies were observed in the central North Pacific and the Arctic ocean, leading to significant warming in these regions.

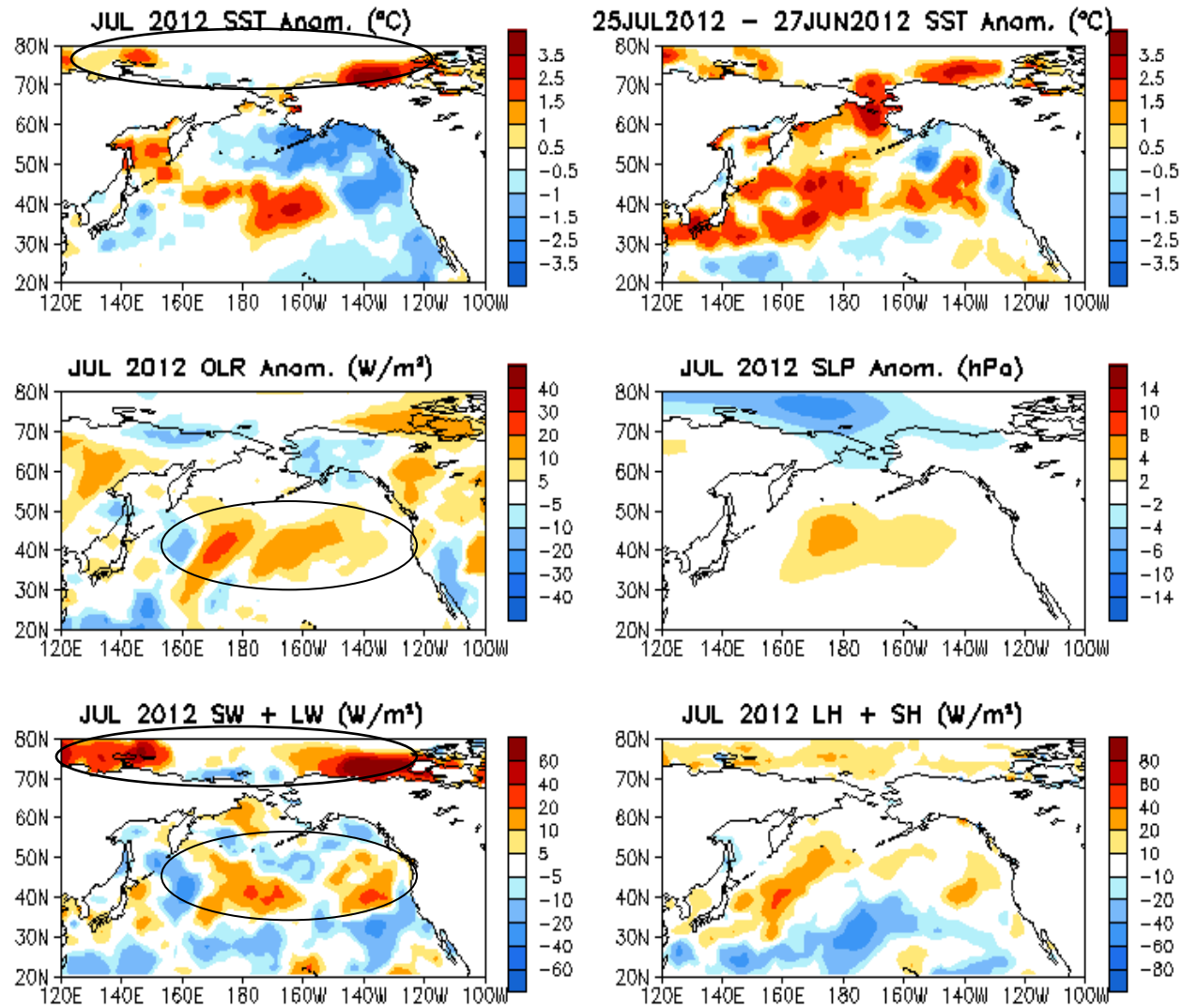
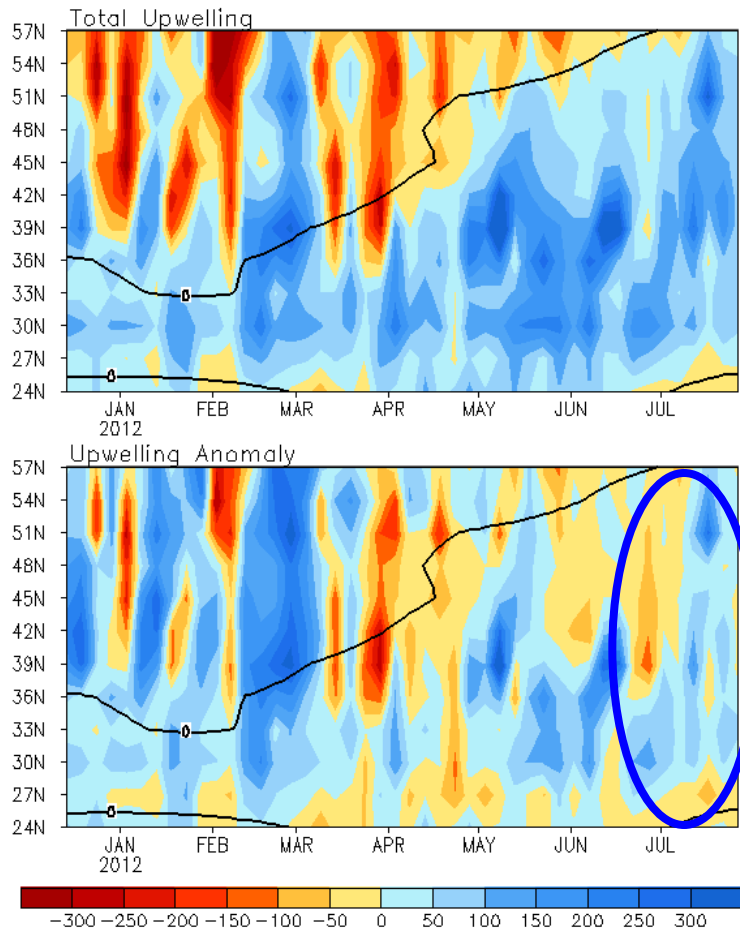


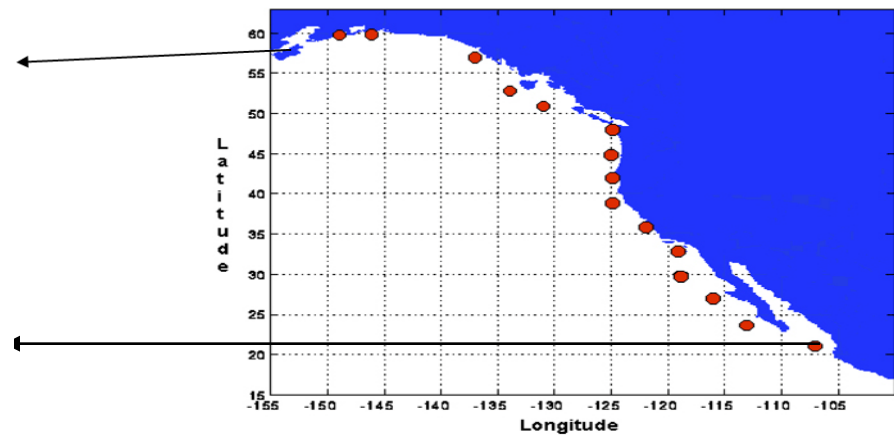
Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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 along most of the coast in July 2012.

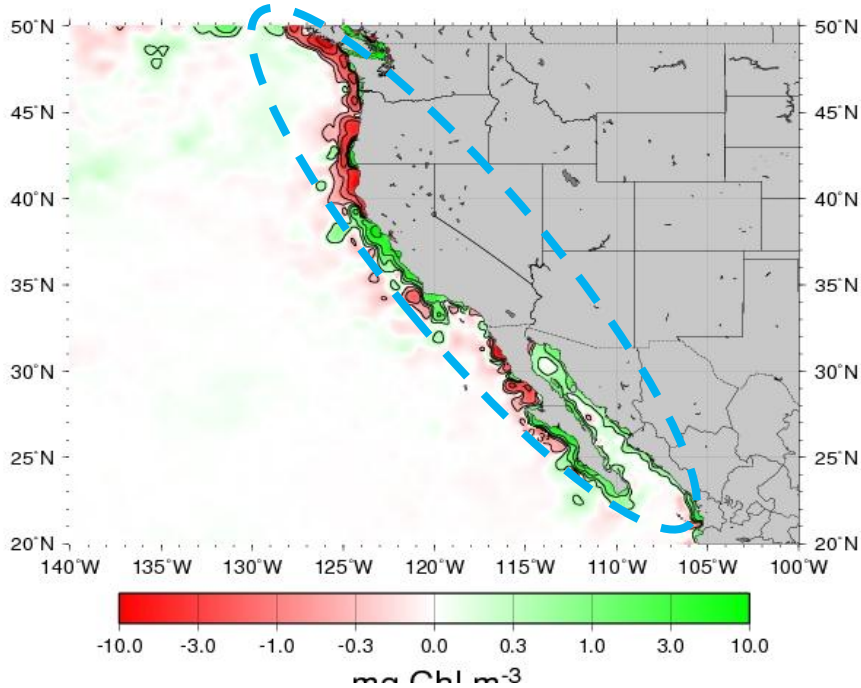
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

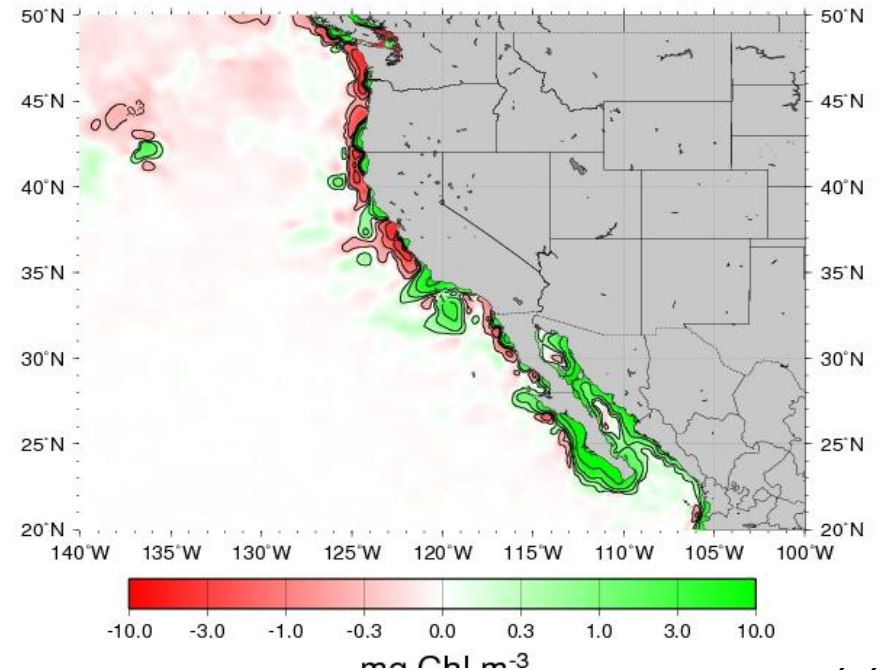
<http://coastwatch.pfel.noaa.gov/FAST>

MODIS Aqua Chlorophyll a Anomaly for July, 2012



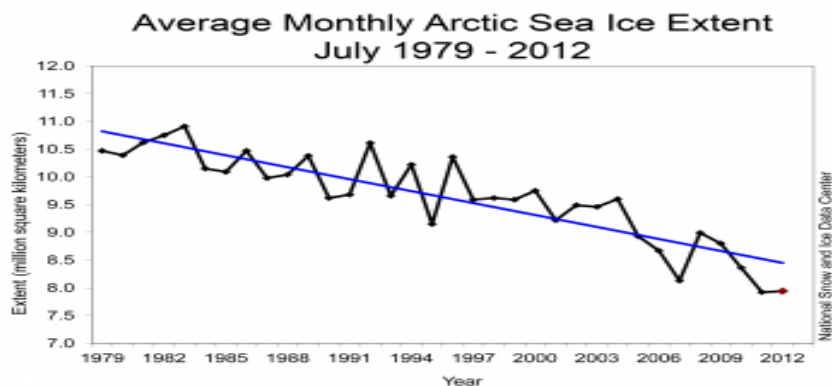
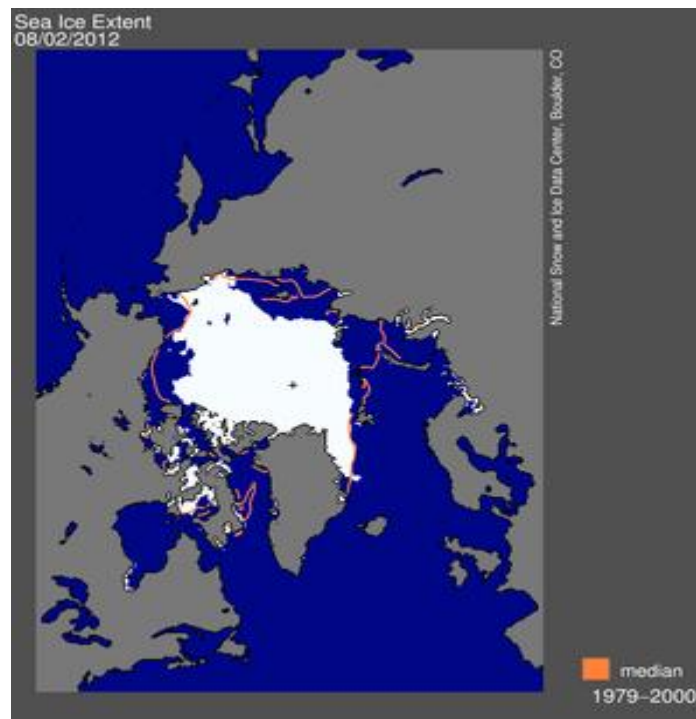
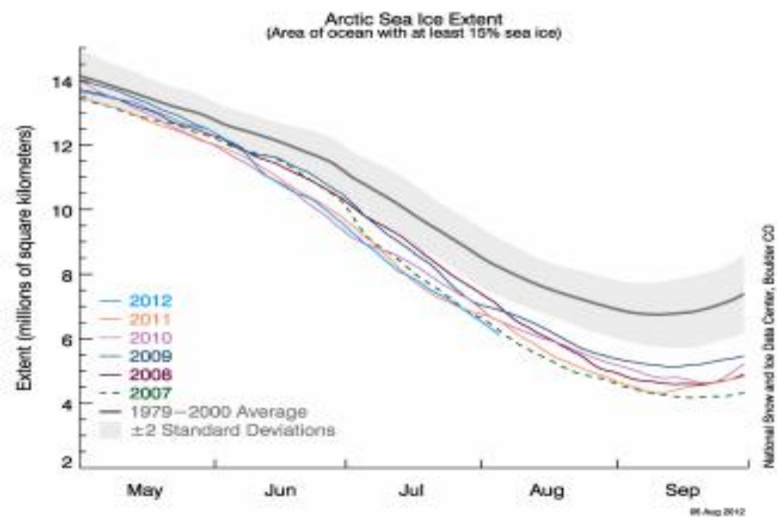
- Negative Chlorophyll anomaly along the coast was inconsistent with the enhanced upwelling .

MODIS Aqua Chlorophyll a Anomaly for June, 2012



Arctic Sea Ice

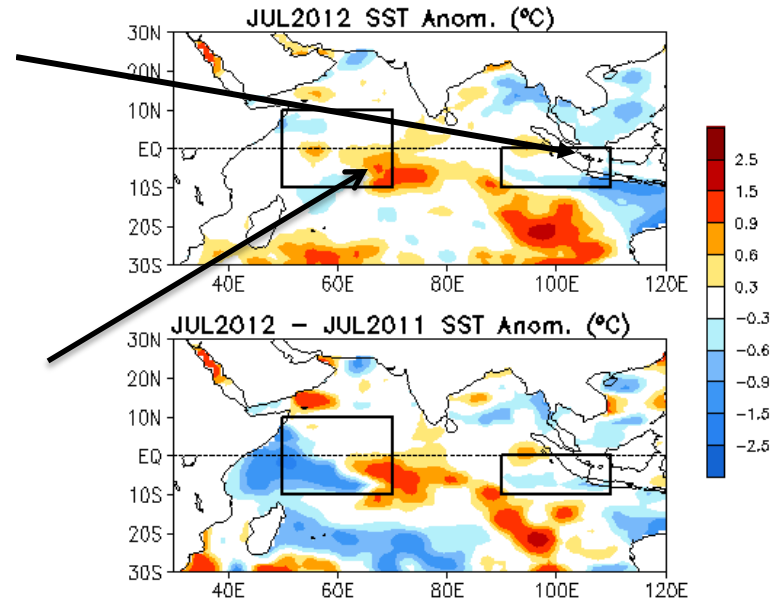
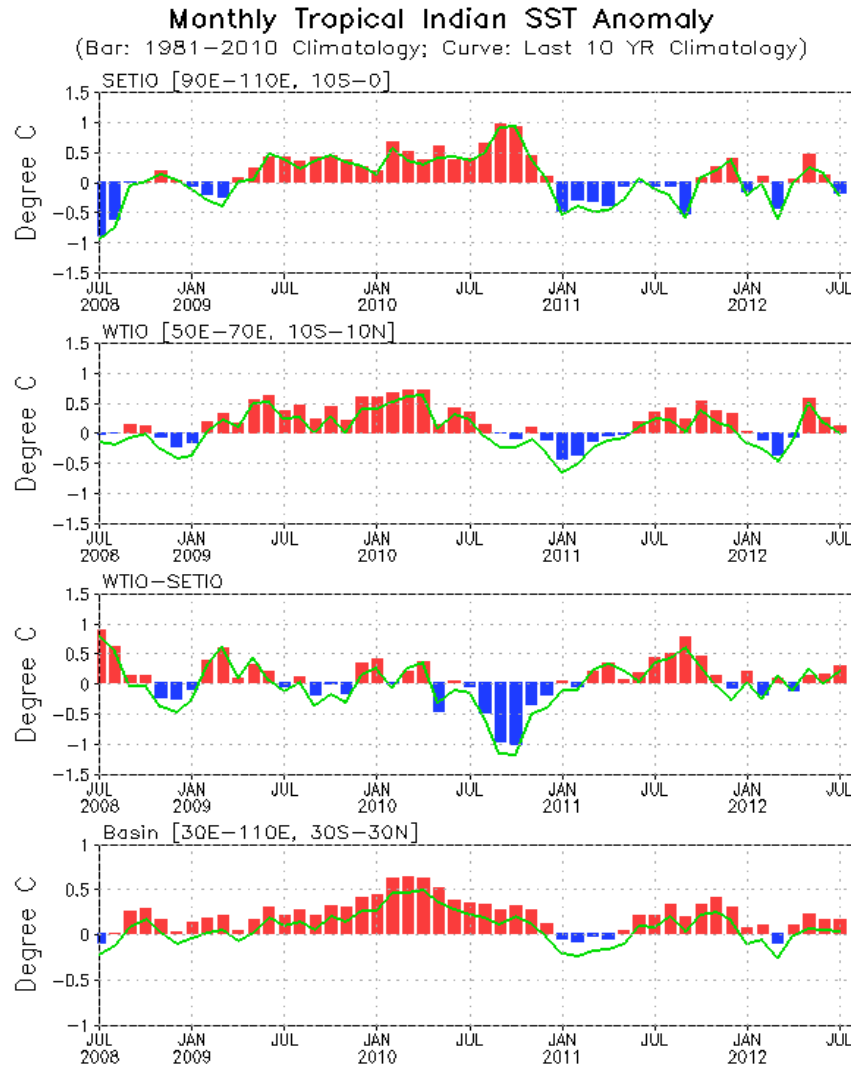
<http://nsidc.org/arcticseaicenews/index.html>



- The Arctic sea ice extent in July 2012 was the second historical low in the satellite record, behind 2011.

Indian Ocean

Evolution of Indian Ocean SST Indices



-Both western and SE tropical Indian indices were near normal in July.

- DMI was near-normal since Nov 2011.

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.

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

- Convection was enhanced (suppressed) south (north) of the equator in the tropical Indian Ocean.
- Low-level wind anomalies, dominated by northerly and north-westerly, were consistent with convection anomalies.
- SSTA tendency was largely consistent with surface heat flux anomalies.

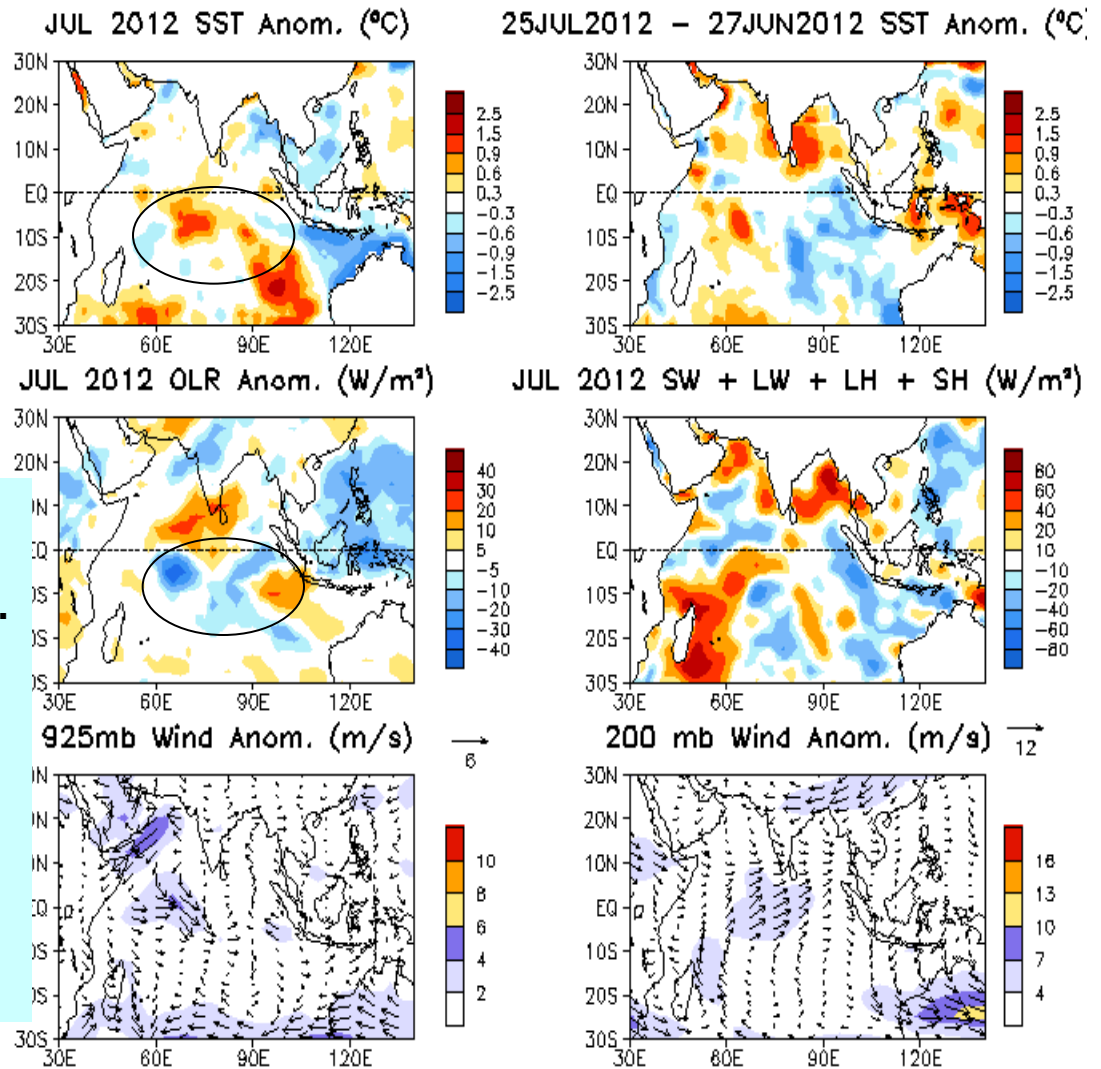


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Tropical and North Atlantic **Ocean**

Evolution of Tropical Atlantic SST Indices

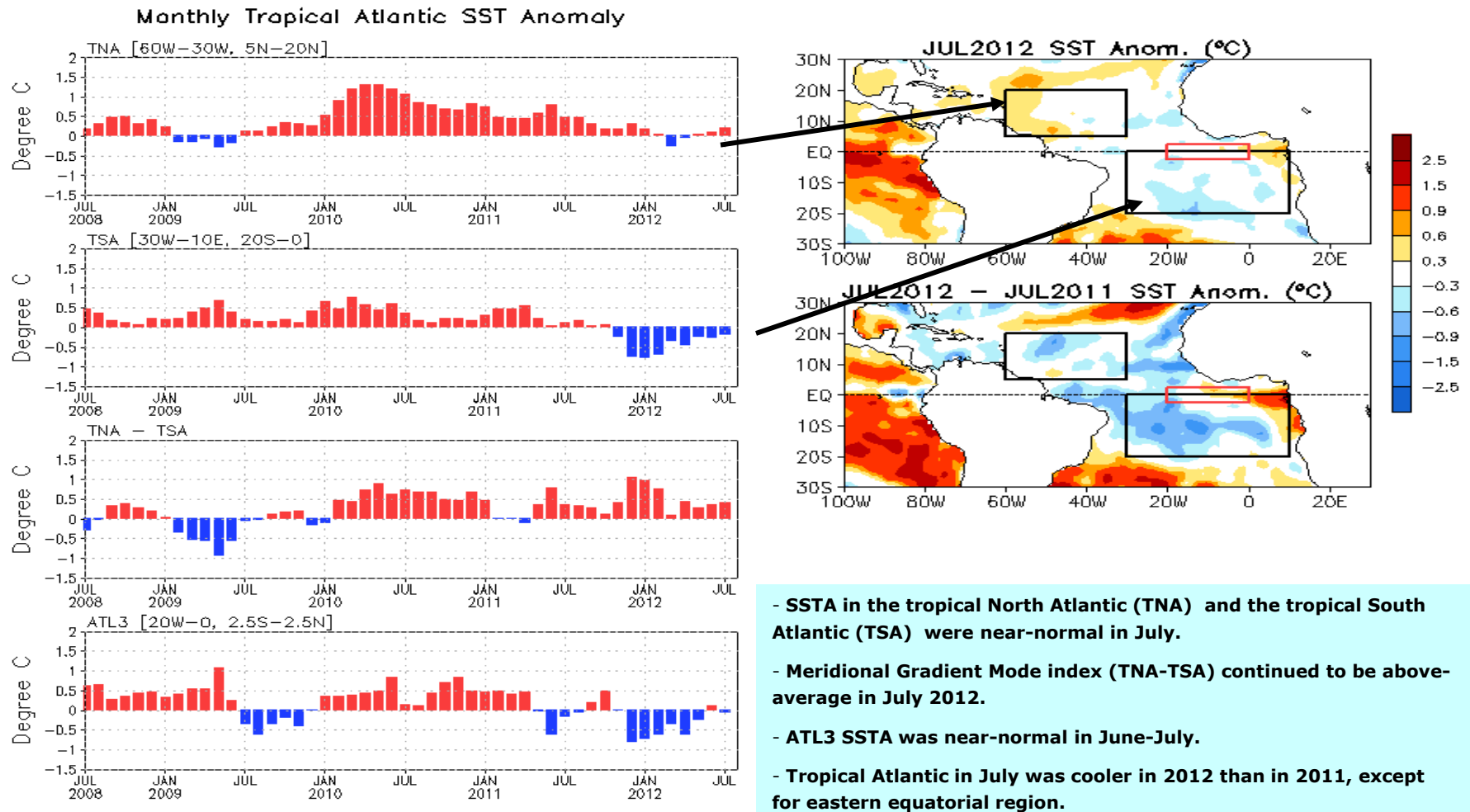
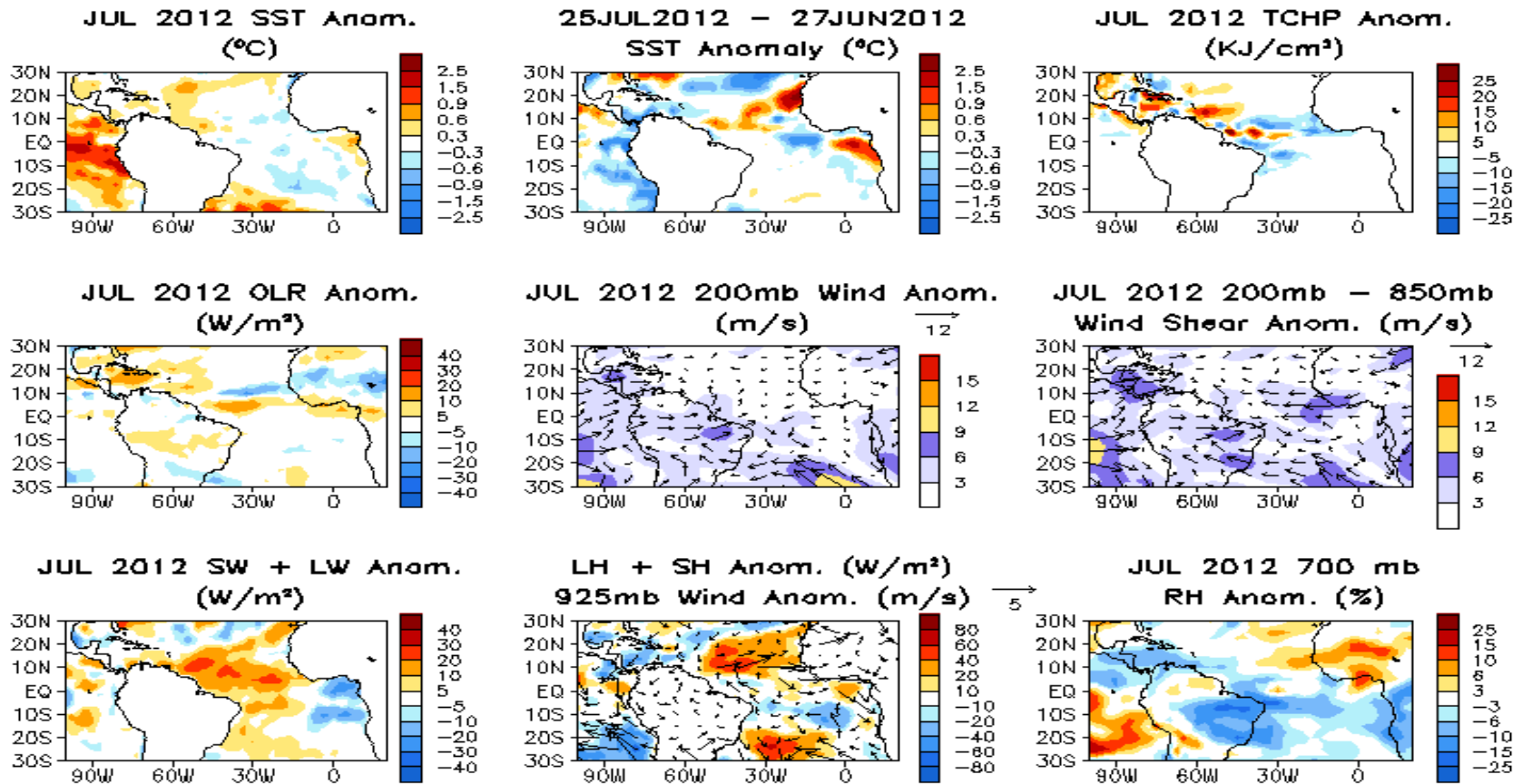


Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between 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

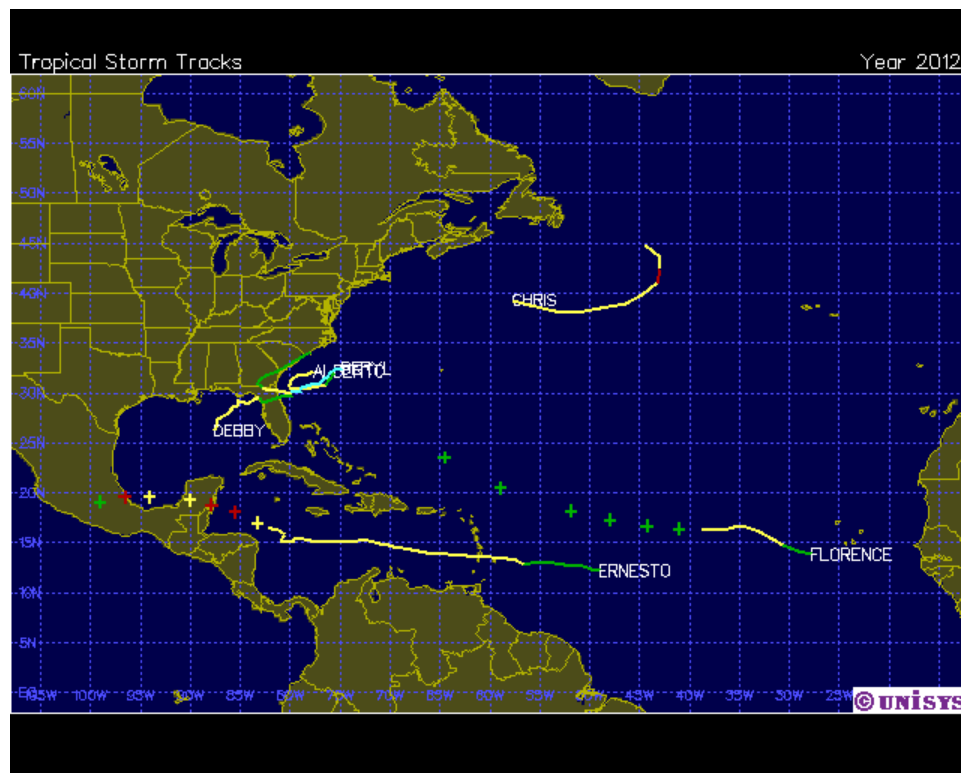


- Near-normal SSTA continued in the hurricane Main Development Region(MDR) .
- Convection was suppressed near the Caribbean Sea, consistent with the negative RH anomaly.
- Enhanced vertical wind shear presented across the hurricane main development region.

NOAA Predict a near-Normal Atlantic Hurricane Season in 2012

(<http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml>
(<http://weather.unisys.com/hurricane/atlantic/2012/index.php>)

	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.**
- **5 tropical storms and 1 hurricane-1 were formed in the North Atlantic by Aug 06.**

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

- Large SSTA presented in the high-latitudes of North Atlantic Ocean.
- SST tendency was consistent with surface heat flux anomalies.

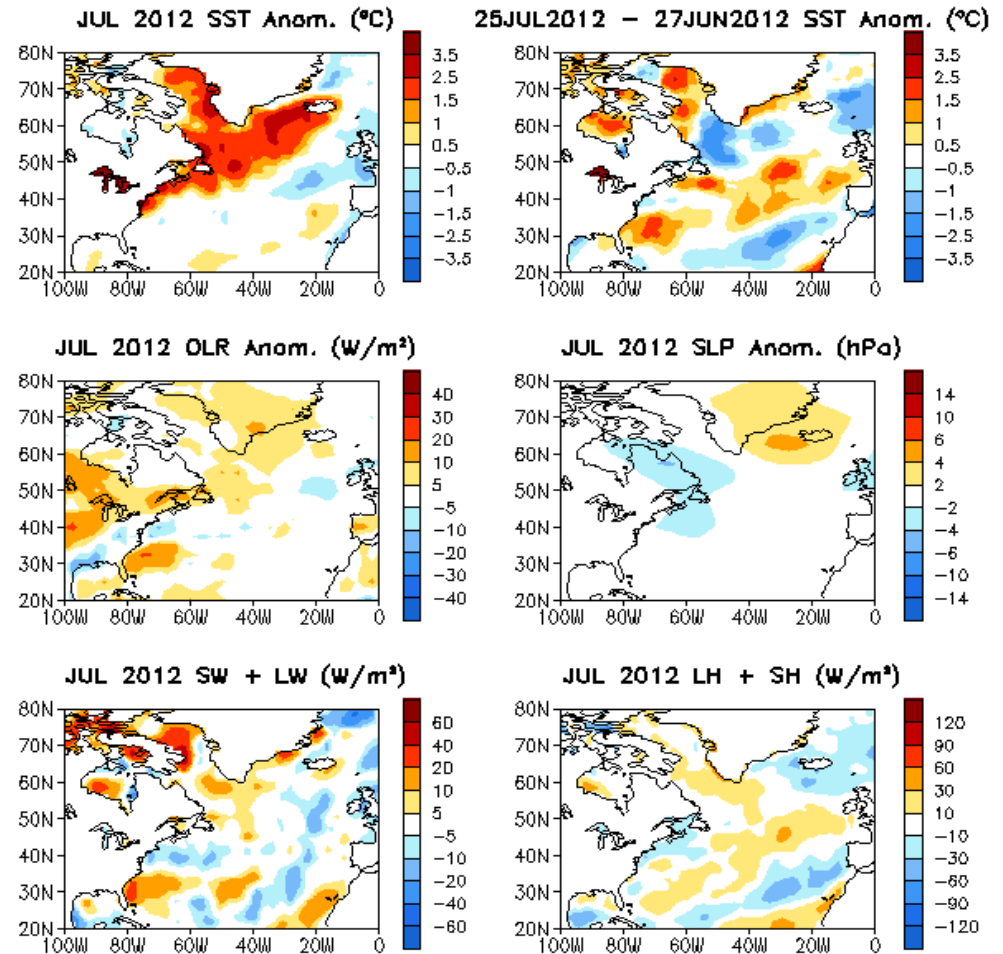
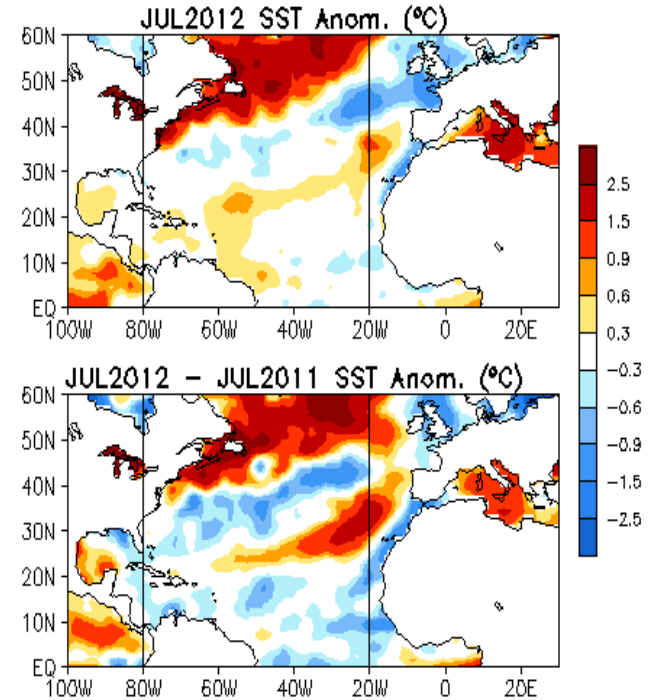
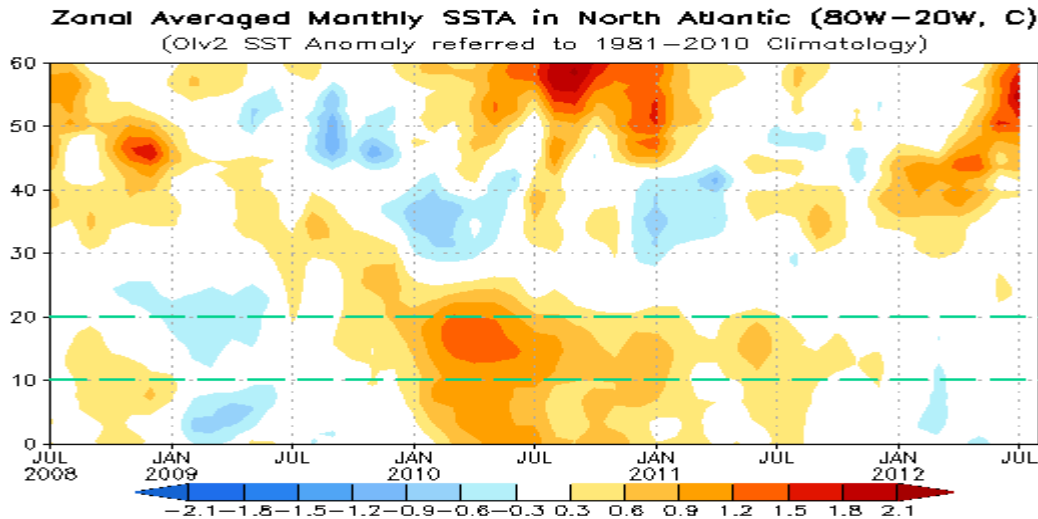
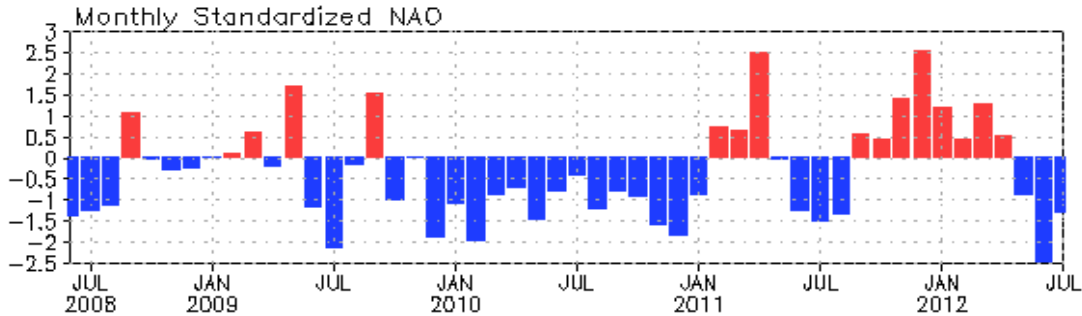


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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



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

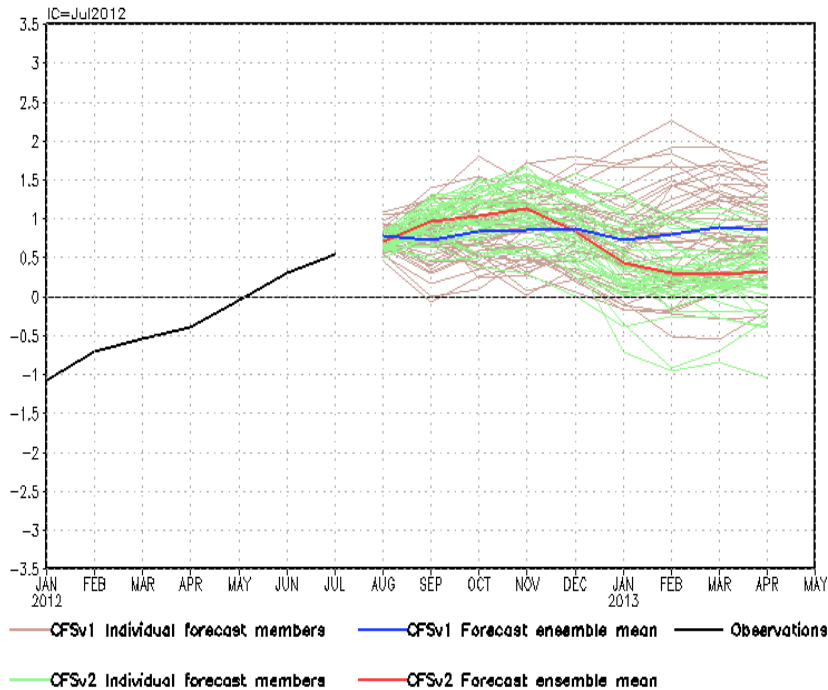
-Large negative NAO index persisted over three months, contributing to the strong warming in the high-latitude N. Atlantic.

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

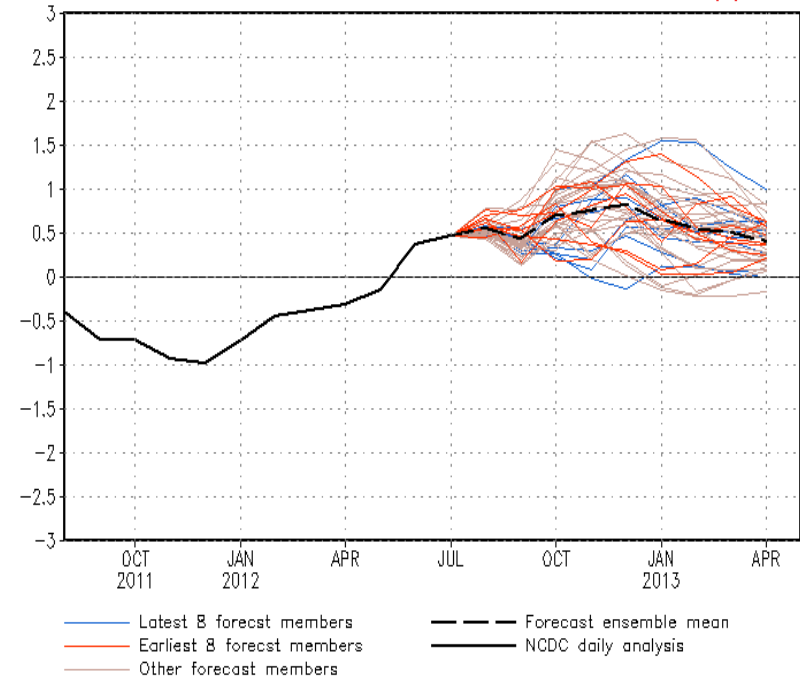
NINO3.4 SST anomalies (K)



NWS/NCEP/CPC

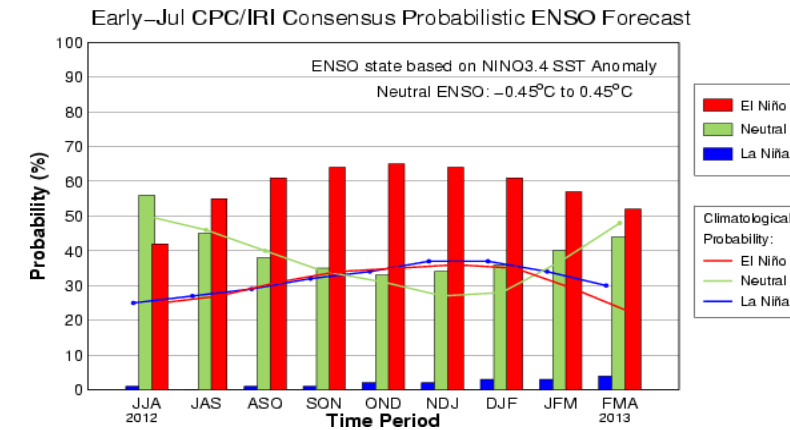
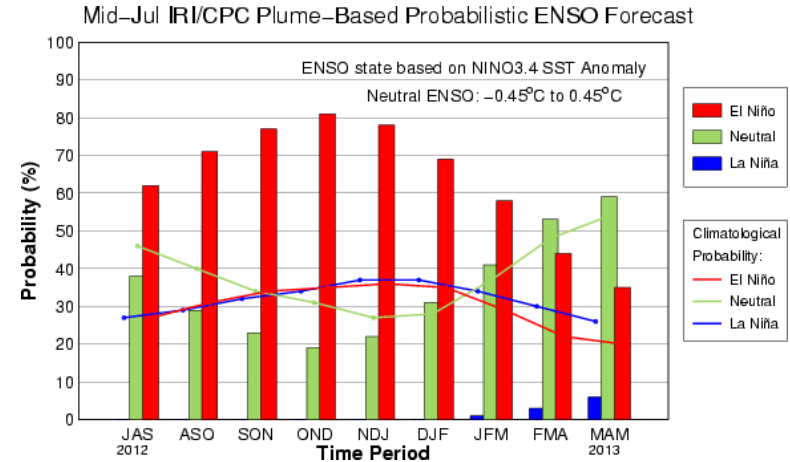
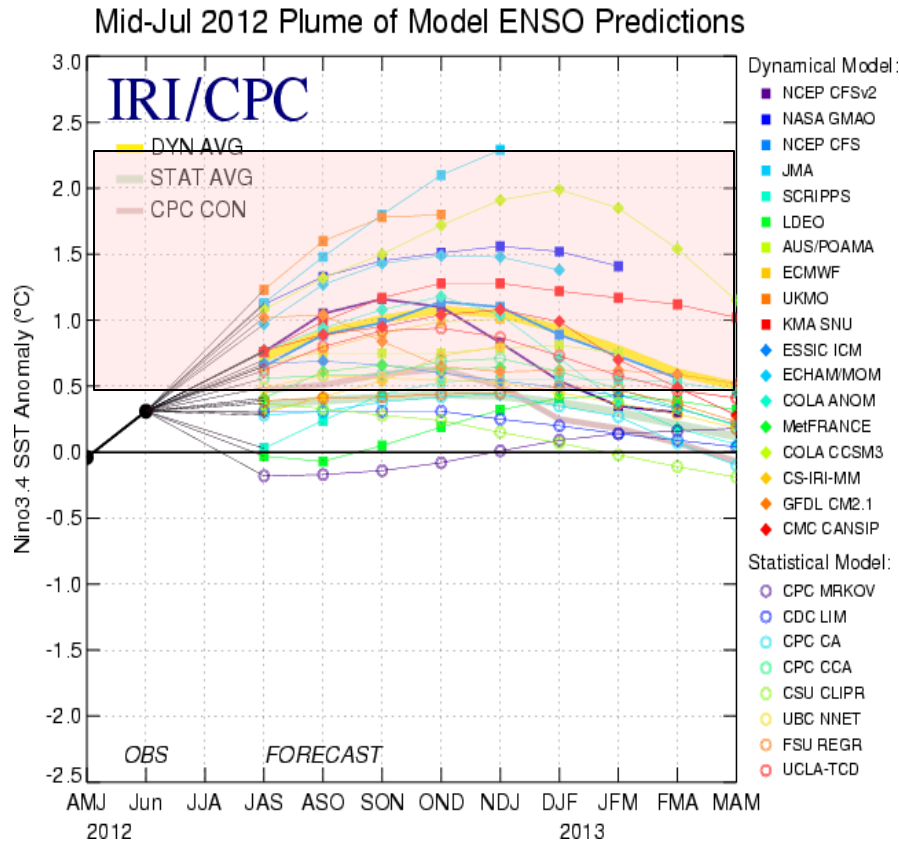
Last update: Fri Aug 3 2012
 Initial conditions: 23Jul2012-1Aug2012

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



- Both CFSv1 and CFSv2 suggested an El Niño event would develop in the coming seasons.

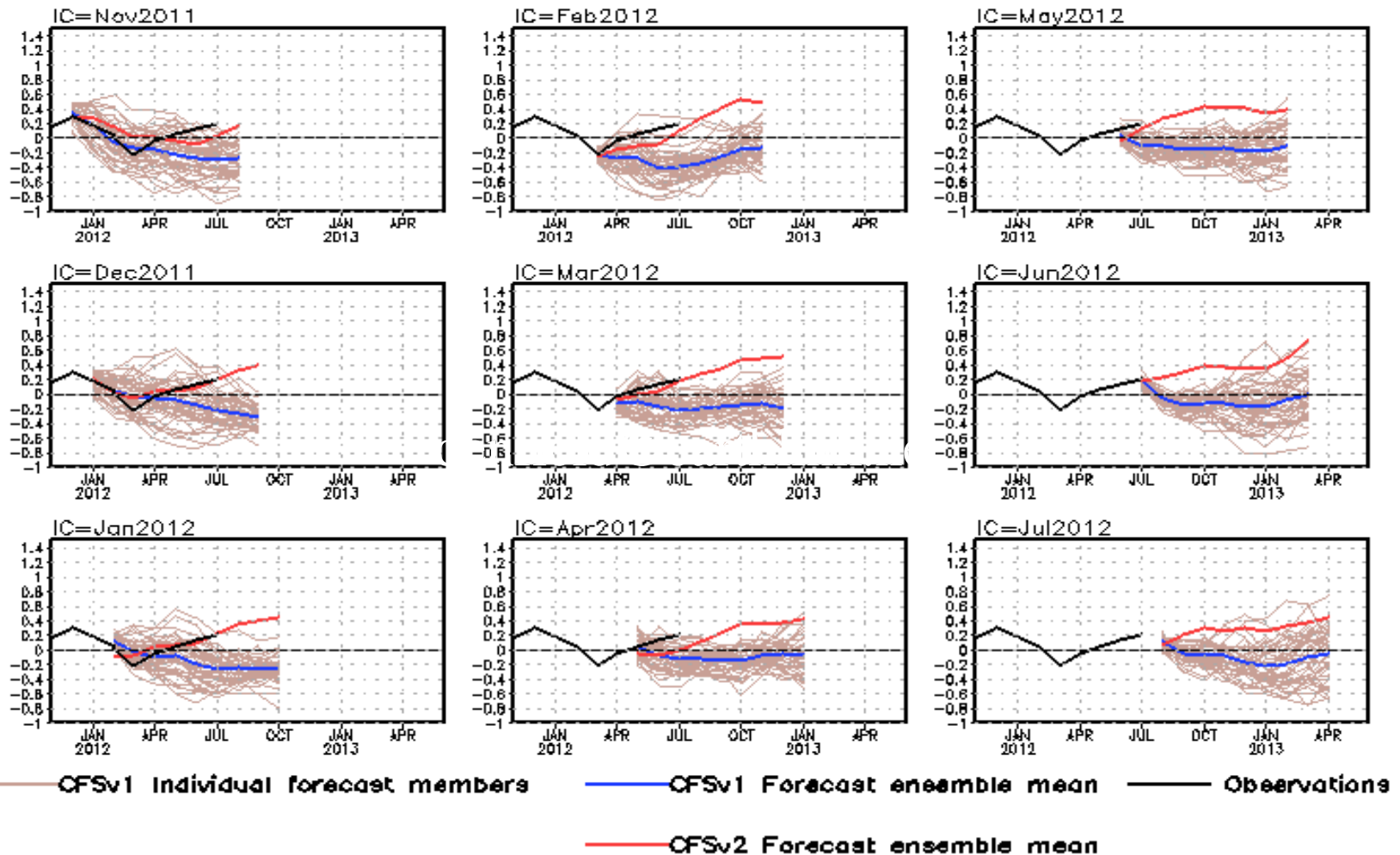
IRI NINO3.4 Forecast Plum



- 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

- **Positive SST anomalies strengthened in the equatorial central-eastern Pacific, with Nino 3.4 = 0.6°C.**
- **Atmosphere circulation in the tropical Pacific continued to be near-normal in July 2012.**
- **NCEP CFSv1 and CFSv2 models predict an El Nino will develop in August 2012, and lasts through Northern Hemisphere winter.**
- **Negative PDO phase strengthened in July 2012, with PDO=-1.8, and has last for 27 months since May 2010.**
- **Arctic sea ice extent was the second lowest in the satellite record.**

▪ Indian Ocean

- **Indian Ocean Dipole was near-normal since Nov 2011.**

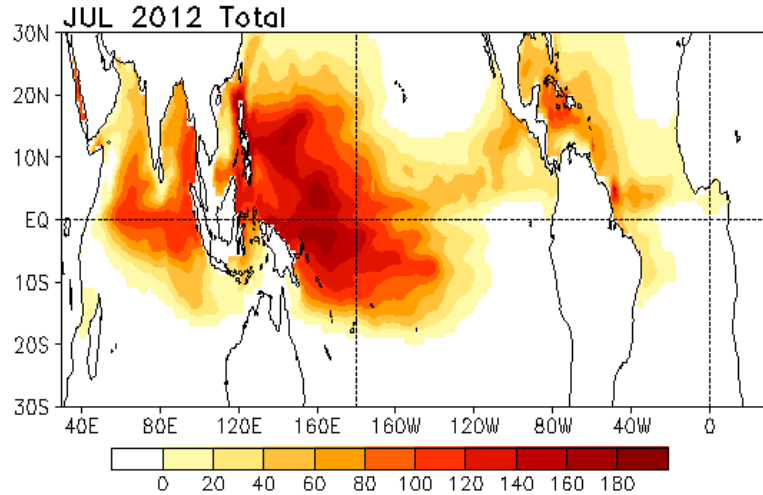
▪ Atlantic Ocean

- **Near-normal SSTA continued in the hurricane Main Development Region(MDR).**
- **NOAA predicted near-normal condition of hurricane activity in 2012.**
- **Negative NAO index persisted in the past three months, contributing to a strong warming in the high-latitude N. Atlantic.**

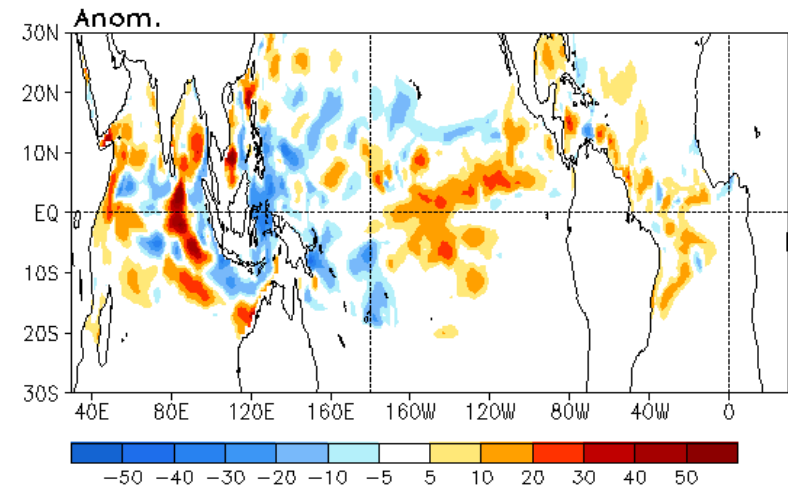
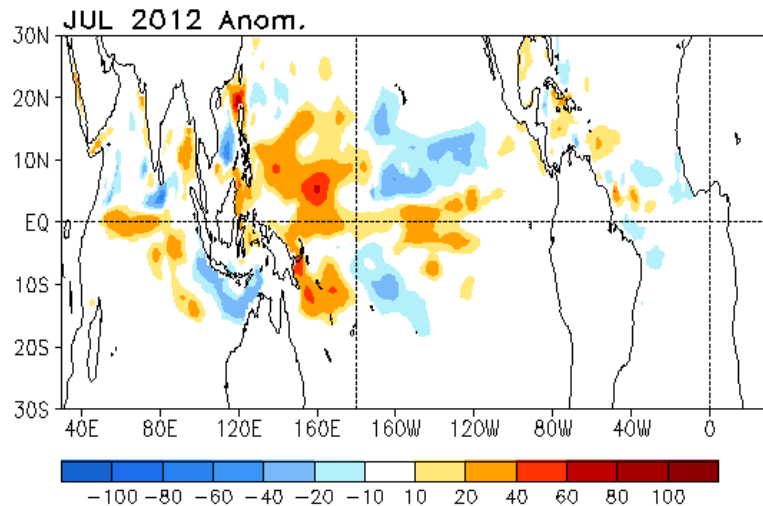
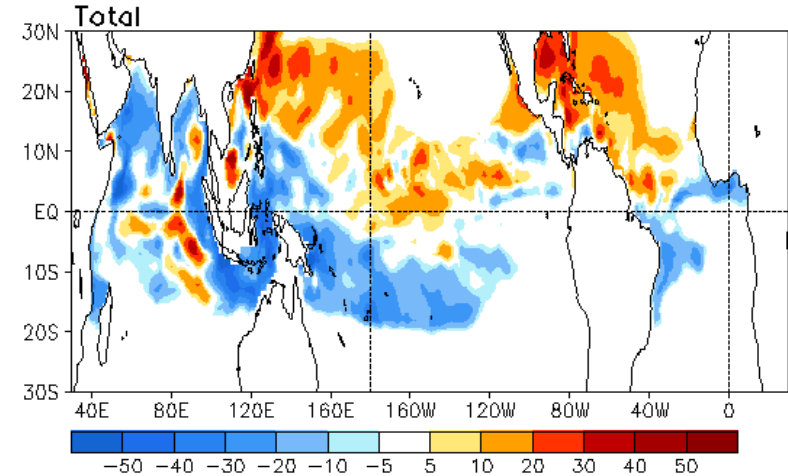
Backup Slides

Tropical Cyclone Heat Potential and Tendency

Tropical Cyclone Heat Potential (KJ/cm^2)



JUL 2012 - JUN 2012 TCHP (KJ/cm^2)

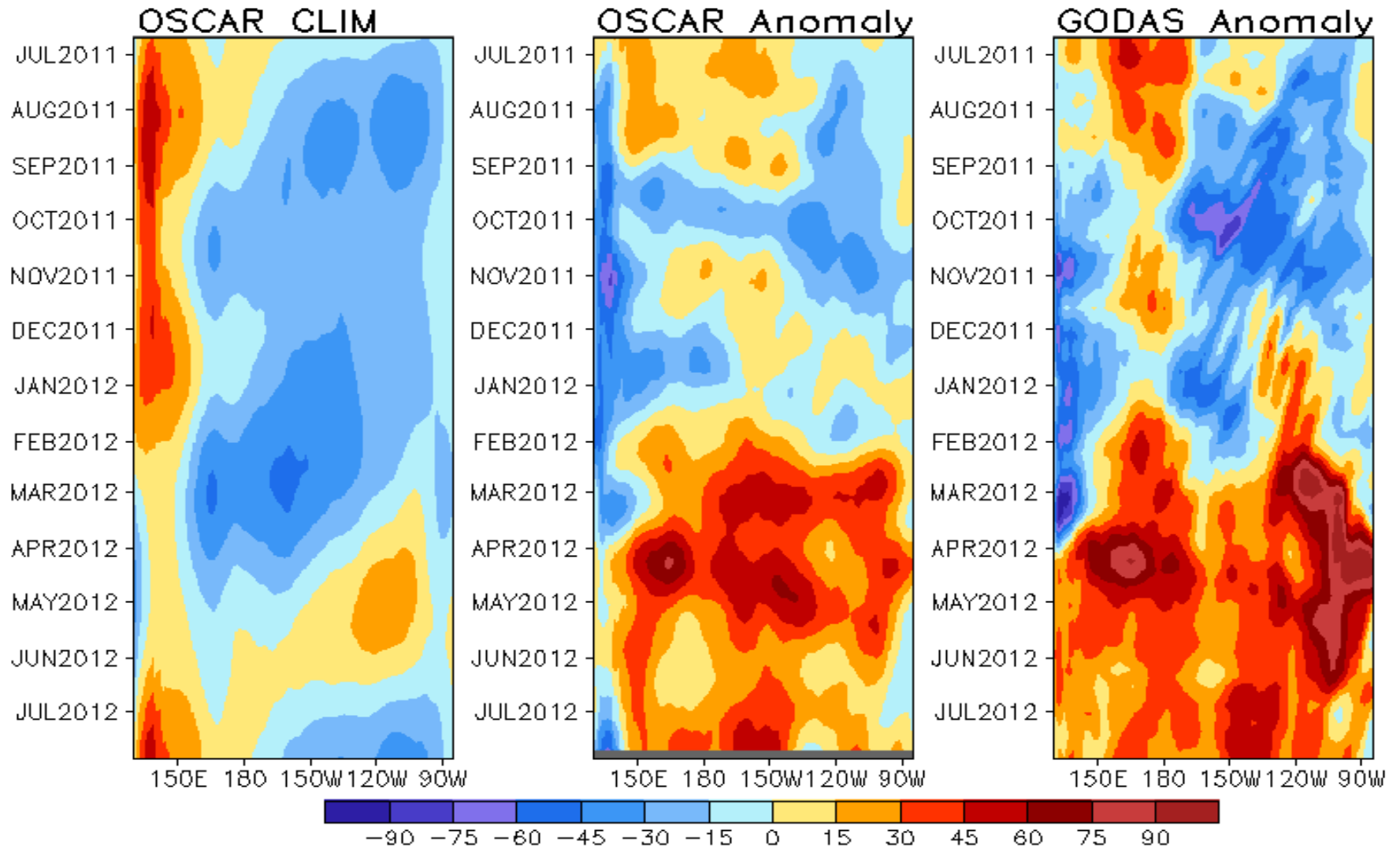


- Positive TCHP anomalies presented in the western Pacific and negative ones in the central and eastern Pacific off the equator.
- Both the anomalies and the tendencies over the Atlantic Ocean were small.

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

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

U (15m), cm/s, 2°S–2°N



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

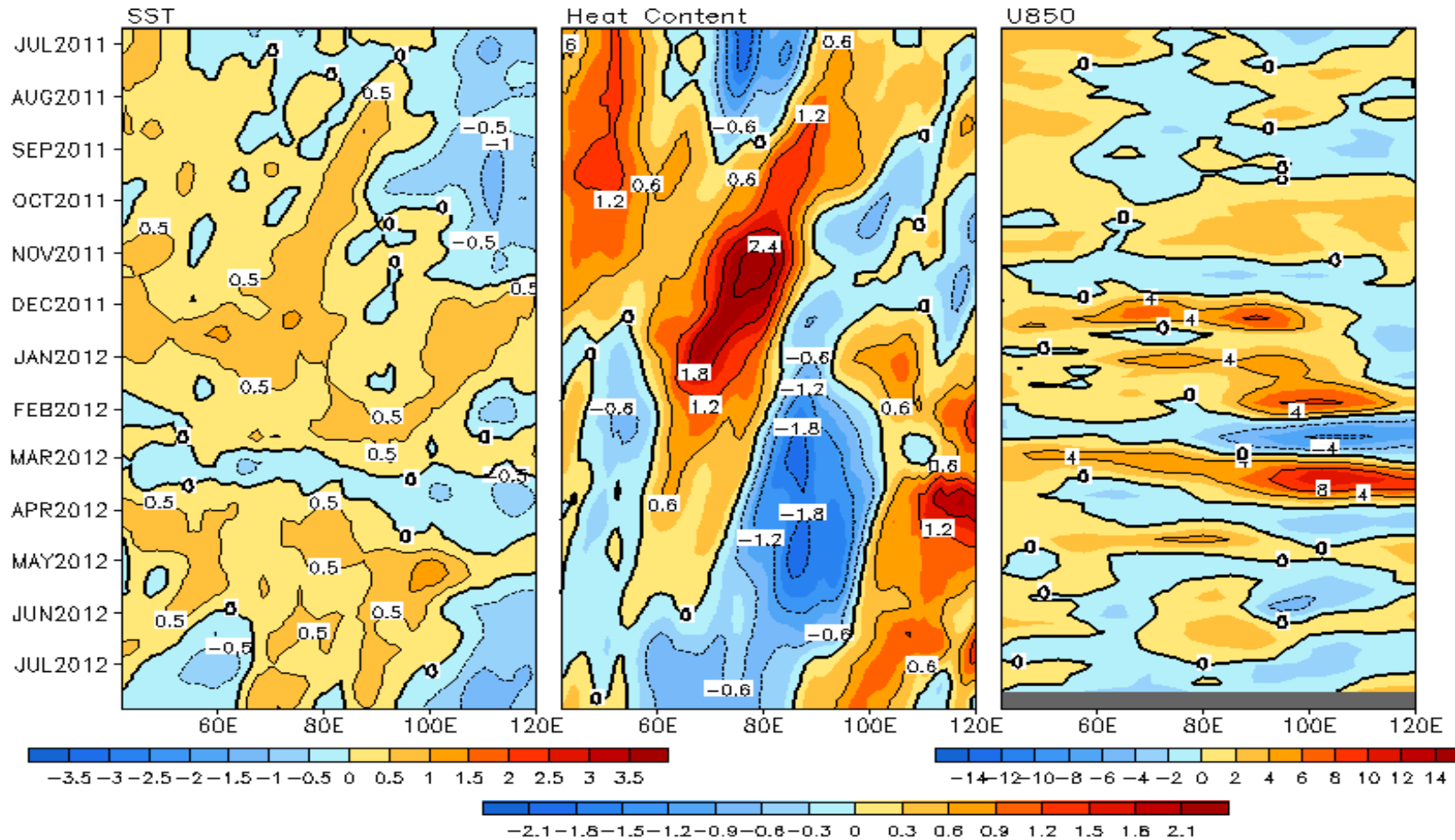


Fig. 13. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S–2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S–5°N. SST are derived from the NCEP OI 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.

CFS Niño3.4 SST Predictions from Different Initial Months

Niño3.4 SST anomalies (K)

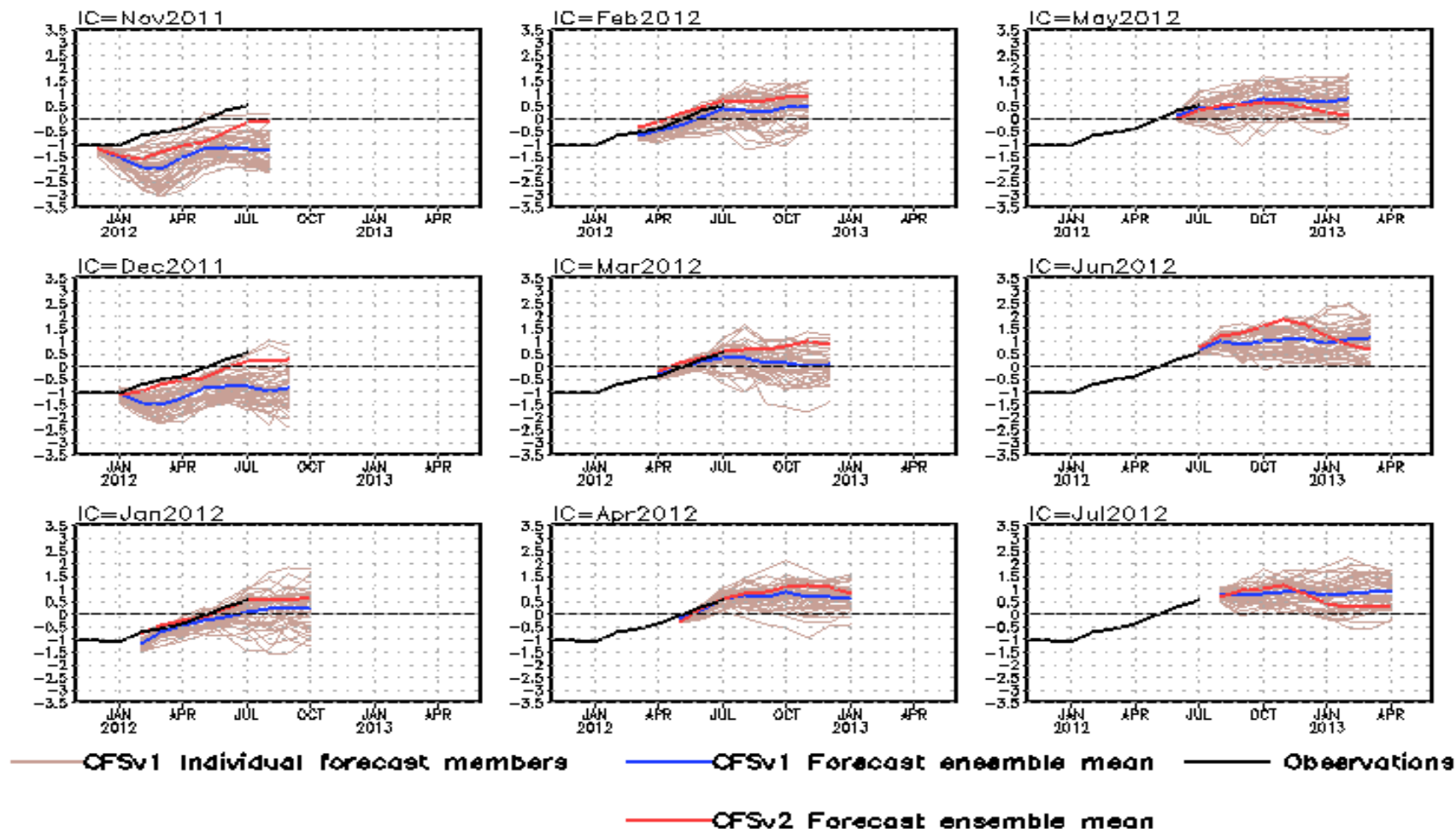
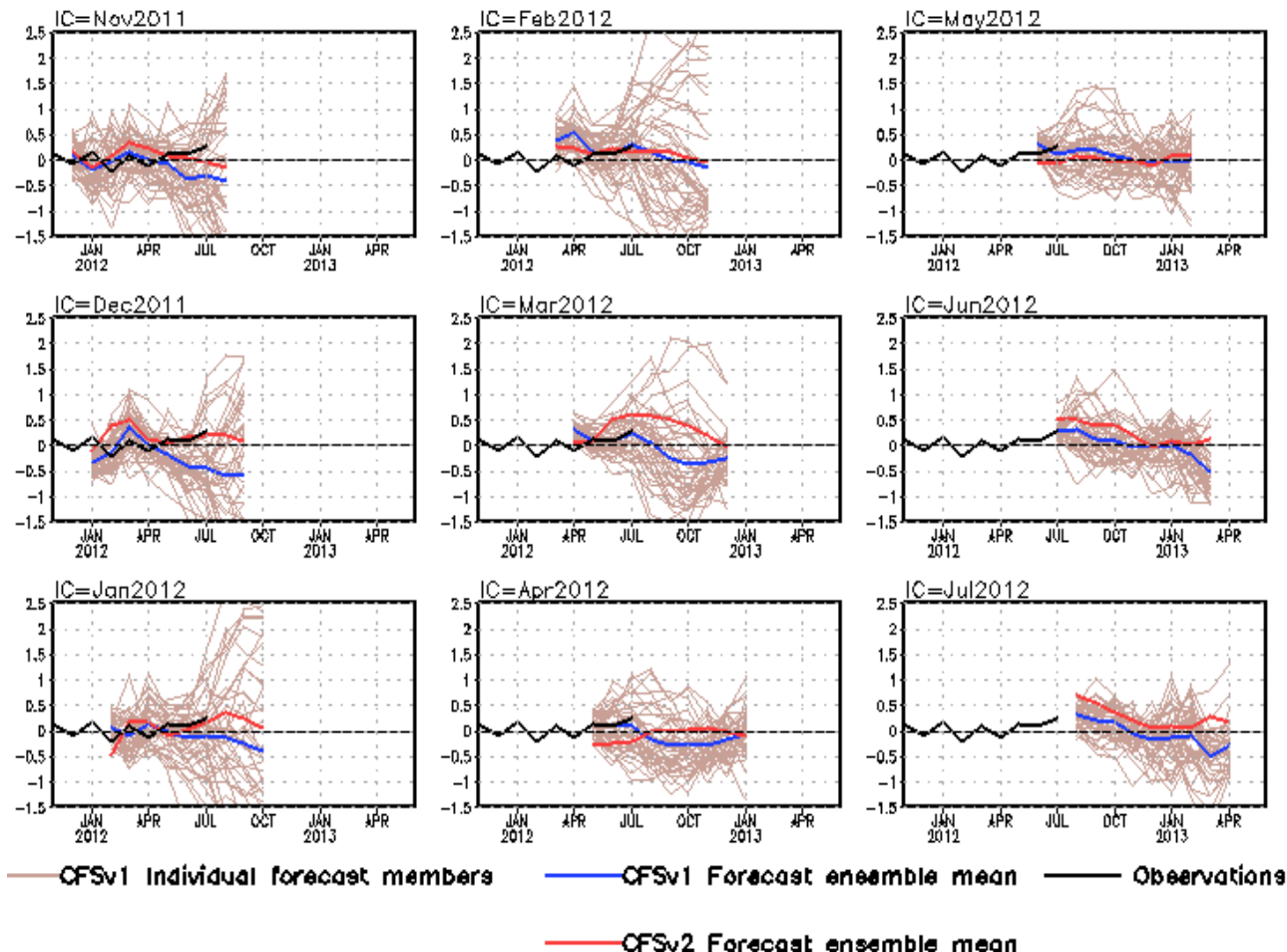


Fig. M1. CFS Niño3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

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]

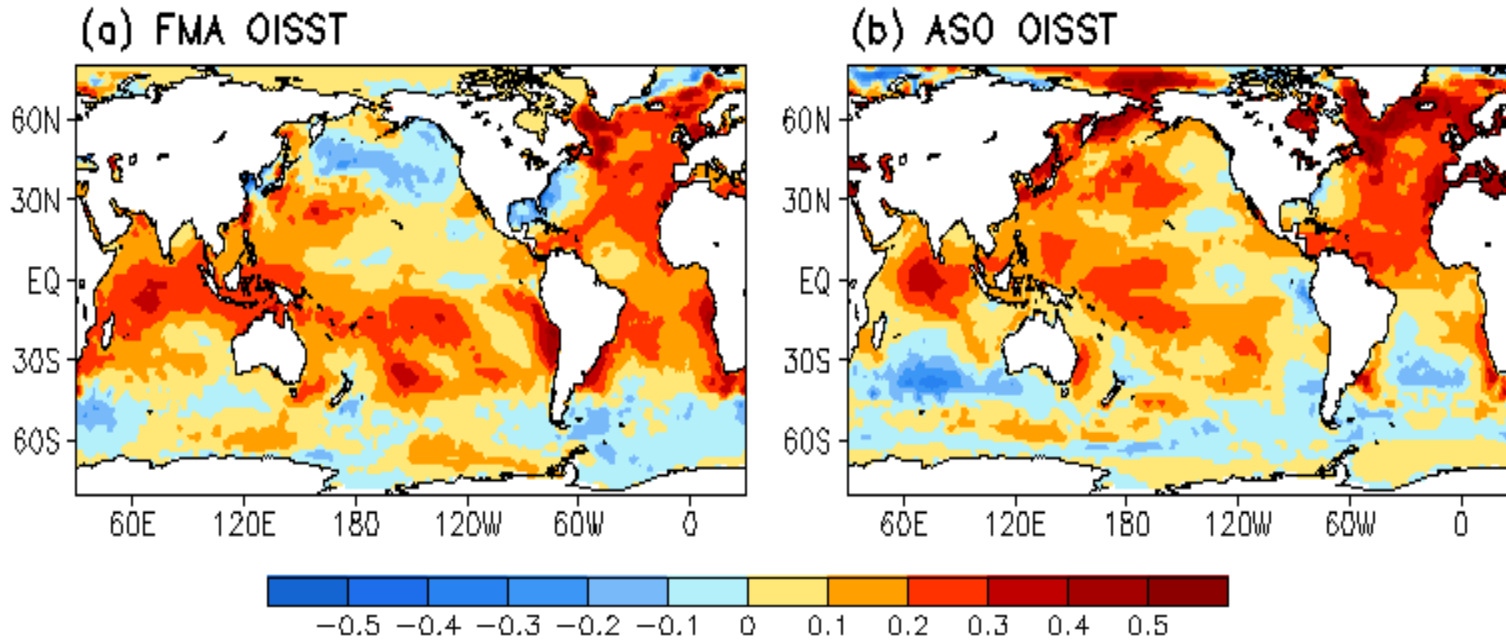
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast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

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!