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

Prepared by
Climate Prediction Center, NCEP

July 8, 2011

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 Office of Climate Observation (OCO)

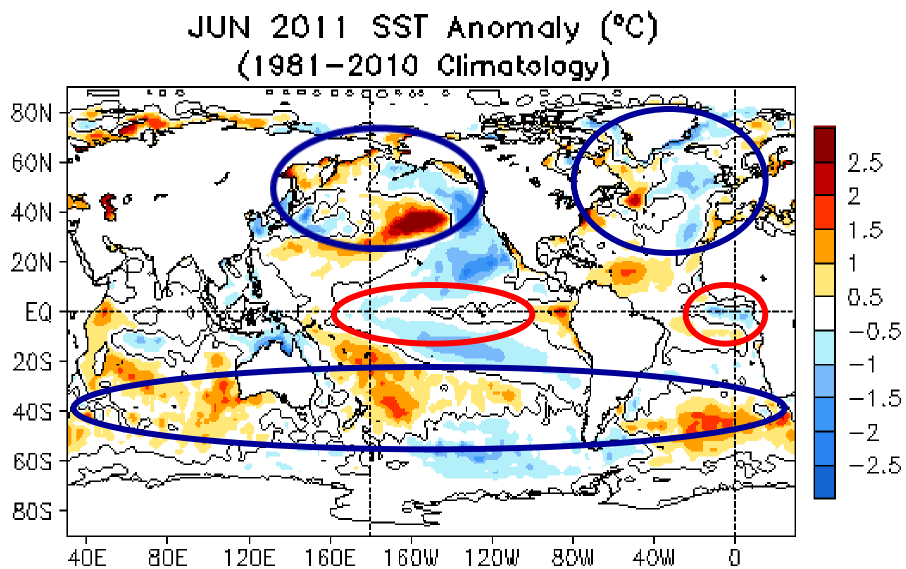
Outline

- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- CFS SST Predictions

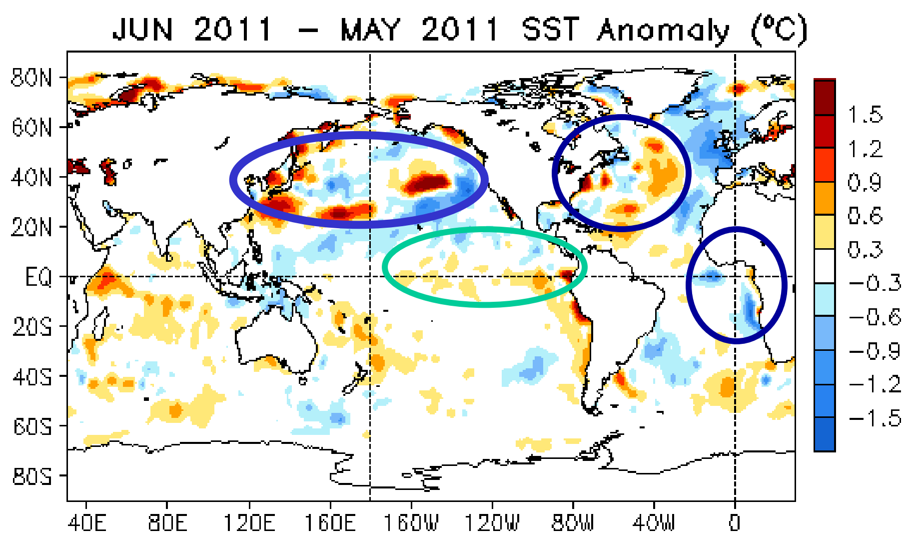
Overview

- **Pacific and Arctic Oceans**
  - **ENSO cycle: ENSO-neutral conditions prevailed with OISST NINO3.4=-0.18°C in June 2011.**
  - **NOAA/NCEP Climate Forecast System (CFS) suggests that the ENSO-neutral conditions are expected at least through the boreal summer.**
  - **Negative PDO index intensified in June 2011.**
  - **Artic sea ice extent continued to decline in June 2011 and reached the second lowest in the satellite records.**
- **Indian Ocean**
  - **Neutral SSTA conditions dominated in the deep tropical Indian Ocean.**
- **Atlantic Ocean**
  - **NAO became below-normal in June 2011.**
  - **Tripole SSTA pattern has weakened since Feb 2011.**
  - **Positive SSTA continued in the Atlantic Hurricane Main Development Region.**
  - **Below-average equatorial SSTs emerged in the eastern Atlantic Ocean**

Global SST Anomaly (⁰C) and Anomaly Tendency



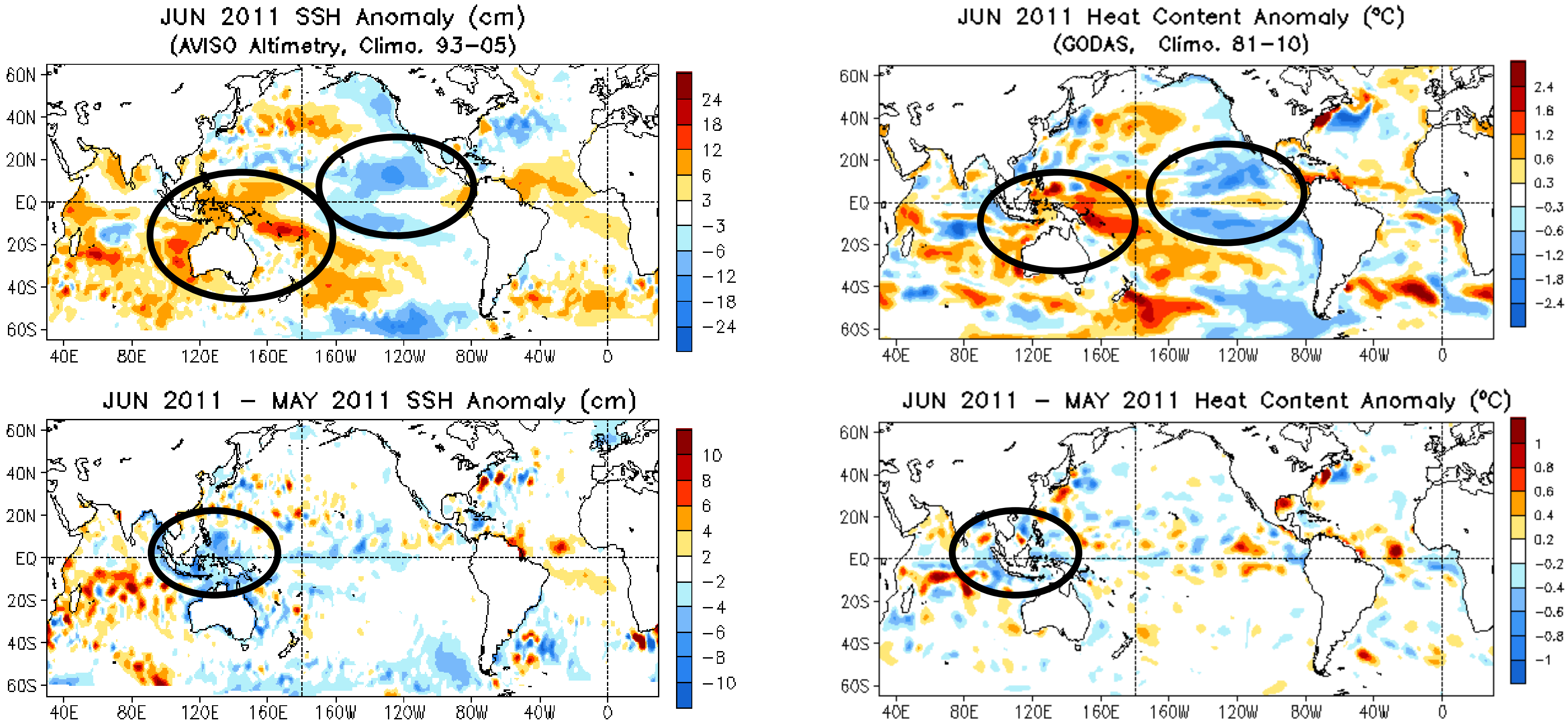
- Neutral SSTA dominated the equatorial Pacific Ocean.
- A horseshoe pattern of opposite anomalies presented in the North Pacific.
- A weak tripole SSTA pattern presented in North Atlantic.
- Positive SSTA was observed in mid-latitude southern oceans.
- Below-average equatorial SSTA emerged in the eastern Atlantic Ocean.



- A weak warming continued in the central and eastern tropical Pacific.
- The horseshoe pattern of North Pacific intensified in June.
- A moderate warming tendency was observed in the central North Atlantic.
- A moderate cooling tendency was observed in the southeast Atlantic 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 1971-2000 base period means.

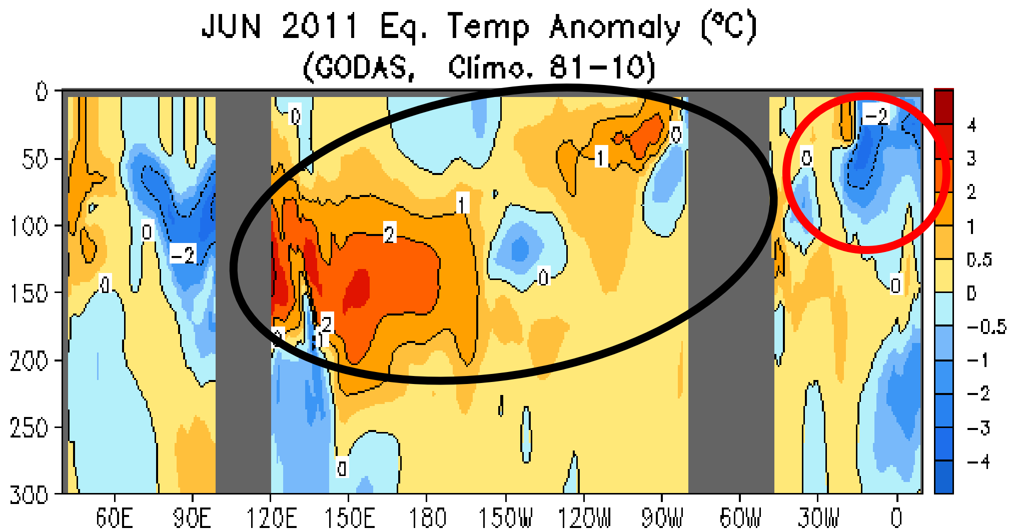
Global SSH/HC Anomaly (cm/°C) and Anomaly Tendency



- Positive SSH and Heat Content (HC) anomalies were observed in the western and southwestern tropical Pacific and near the west coast of Australia, which weakened substantially from previous month.
- Negative SSH and HC anomalies were observed off the equator in the east-central tropical Pacific, indicating the lingering effects of La Nina.
- SSH and HC anomalies as well as their tendencies were largely consistent, except in the Southern Ocean where biases in GODAS climatology are large (not shown).

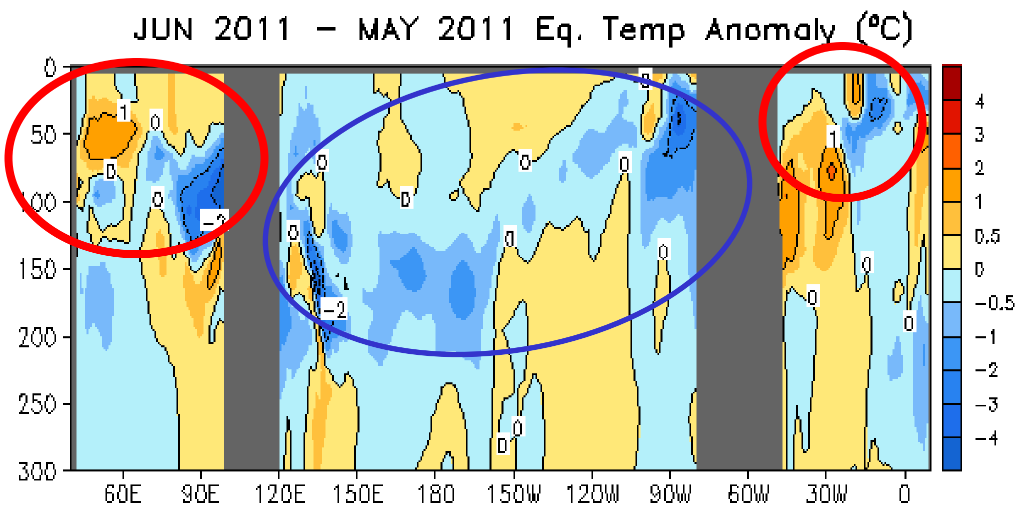
Fig. G2. Sea surface height anomalies (SSHA, top left), SSHA tendency (bottom left), top 300m heat content anomalies (HCA, top right), and HCA tendency (bottom right). SSHA are derived from http://www.aviso.oceanobs.com, and HCA from GODAS.

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



- Positive ocean temperature anomalies along the equatorial Pacific thermocline continued in June.

- Negative temperature anomalies prevailed near the equatorial thermocline of the eastern Indian and Atlantic Oceans.

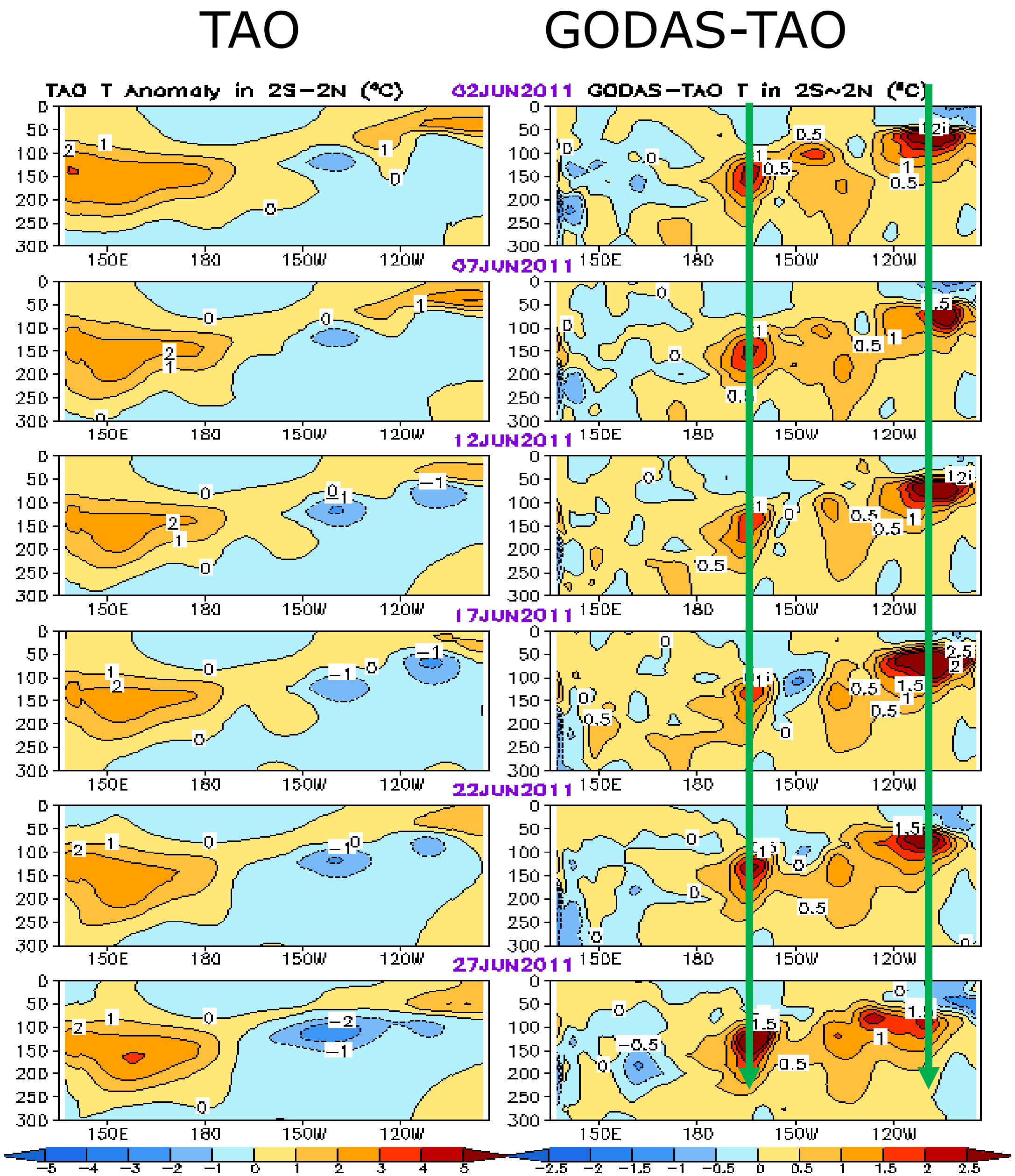


- Compared with May, positive subsurface temperature anomalies weakened in most of the equatorial Pacific.

-Both positive and negative temperature anomaly tendencies existed in the 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 1982-2004 base period means.

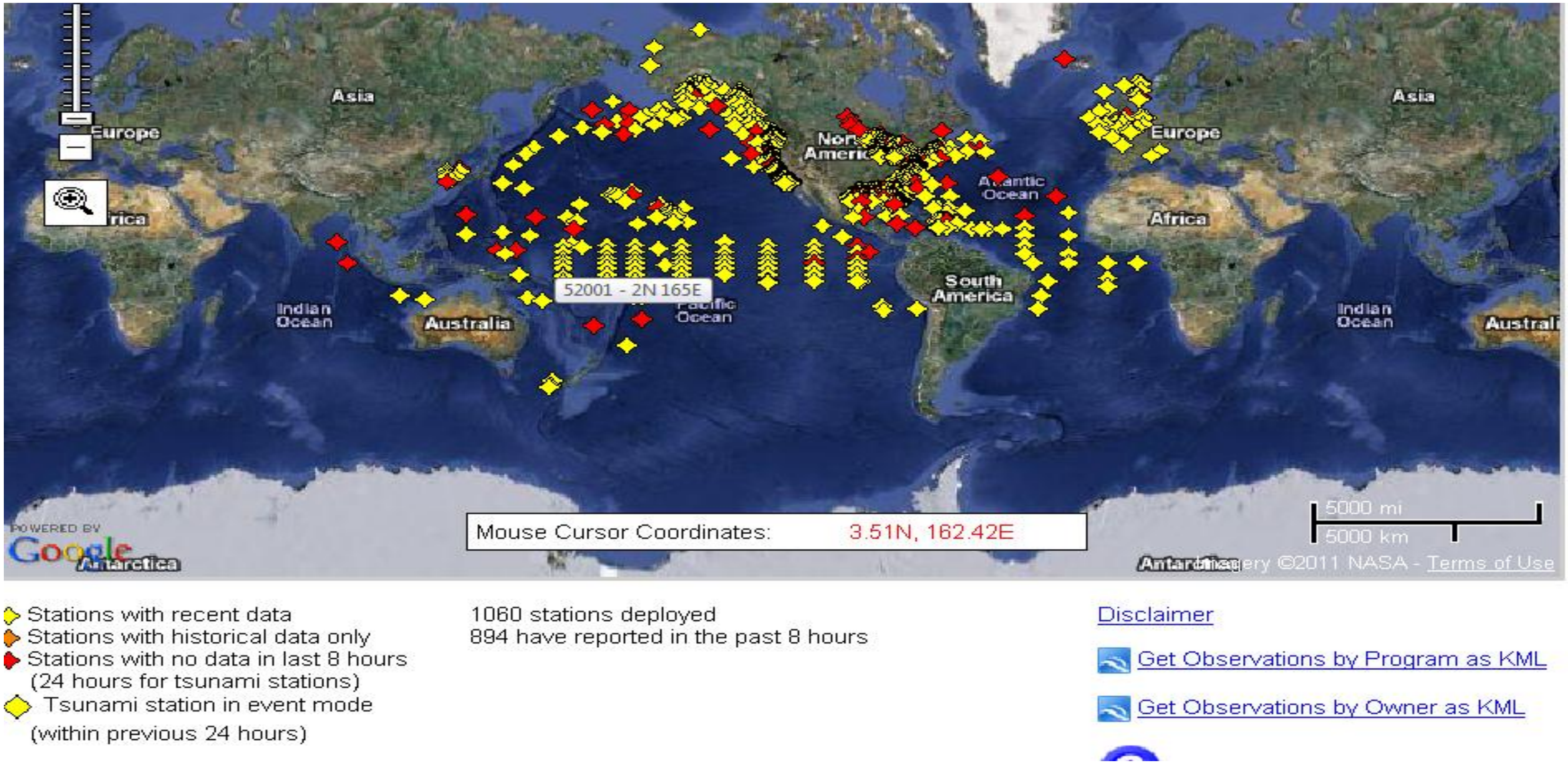
Equatorial Pacific Temperature Anomaly

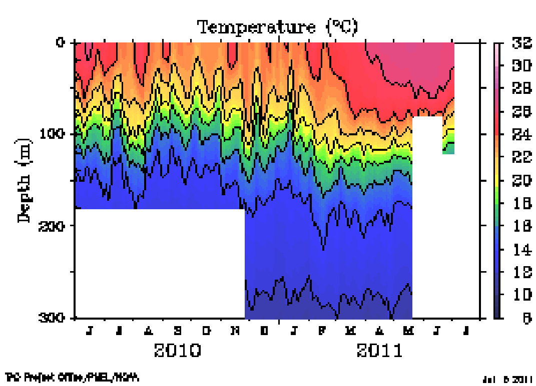


- Compared with TAO, GODAS is about 2°C too warm near the thermocline at 170W-160W and 120W-90W.

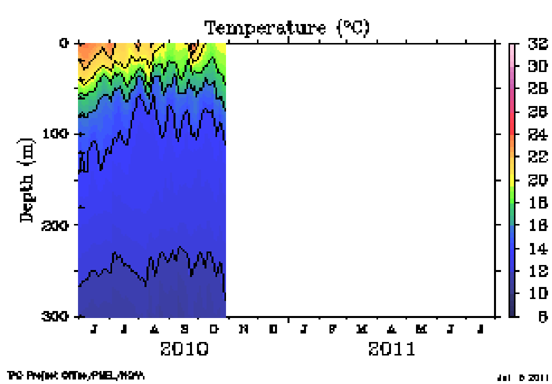
- Some TAO moorings have failed to delivery data in 2010-2011, which might have contributed to the large discrepancies between TAO and GODAS.

Some TAO moorings have failed to delivery data in 2010 and 2011

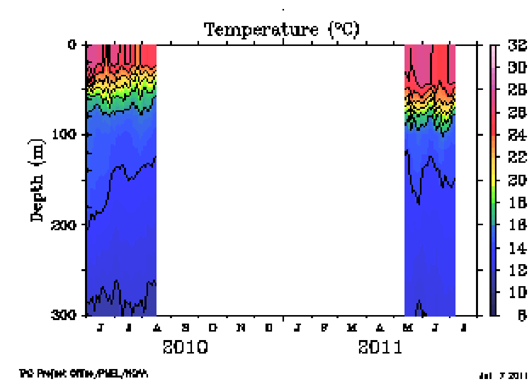




(0ºN, 140ºW)



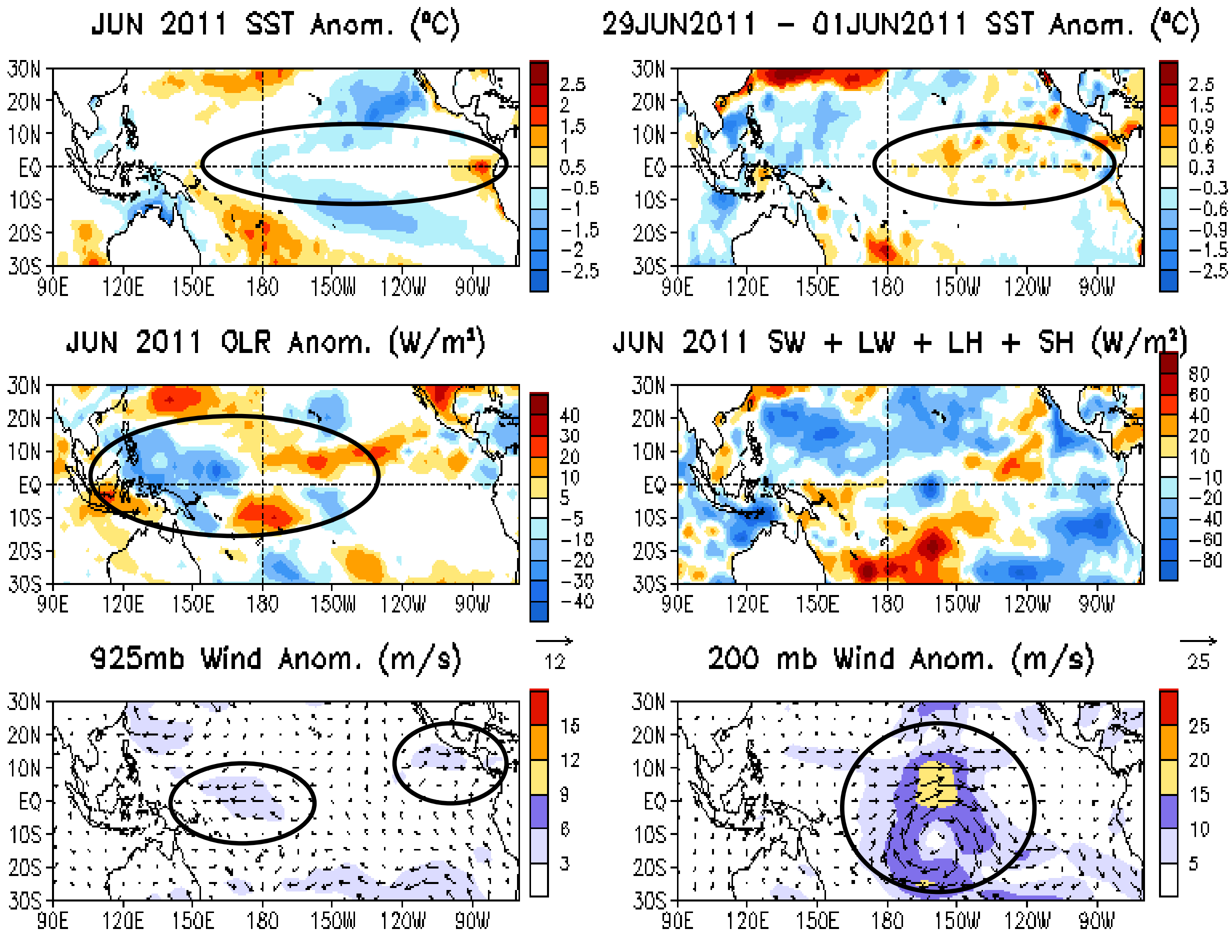
(0ºN, 110ºW)



(0ºN, 95ºW)

Tropical Pacific Ocean

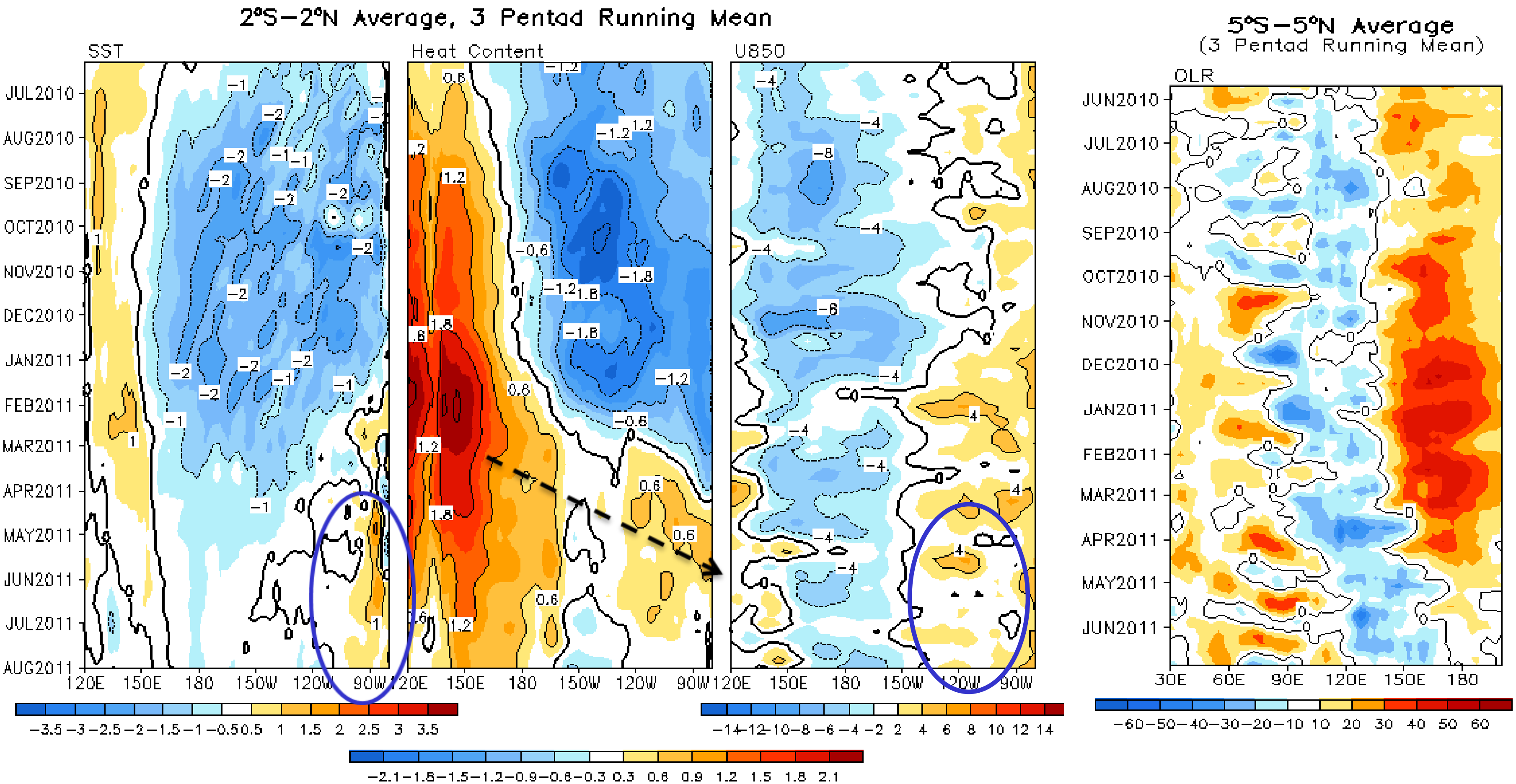
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds



- **Near-normal SST prevailed over much of the equatorial Pacific and small changes occurred in June.**
- **Convection was enhanced (suppressed) near the Philippine Sea (south of the equator near the dateline).**
- **Westerly wind anomalies in high level weakened but persisted over the central 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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

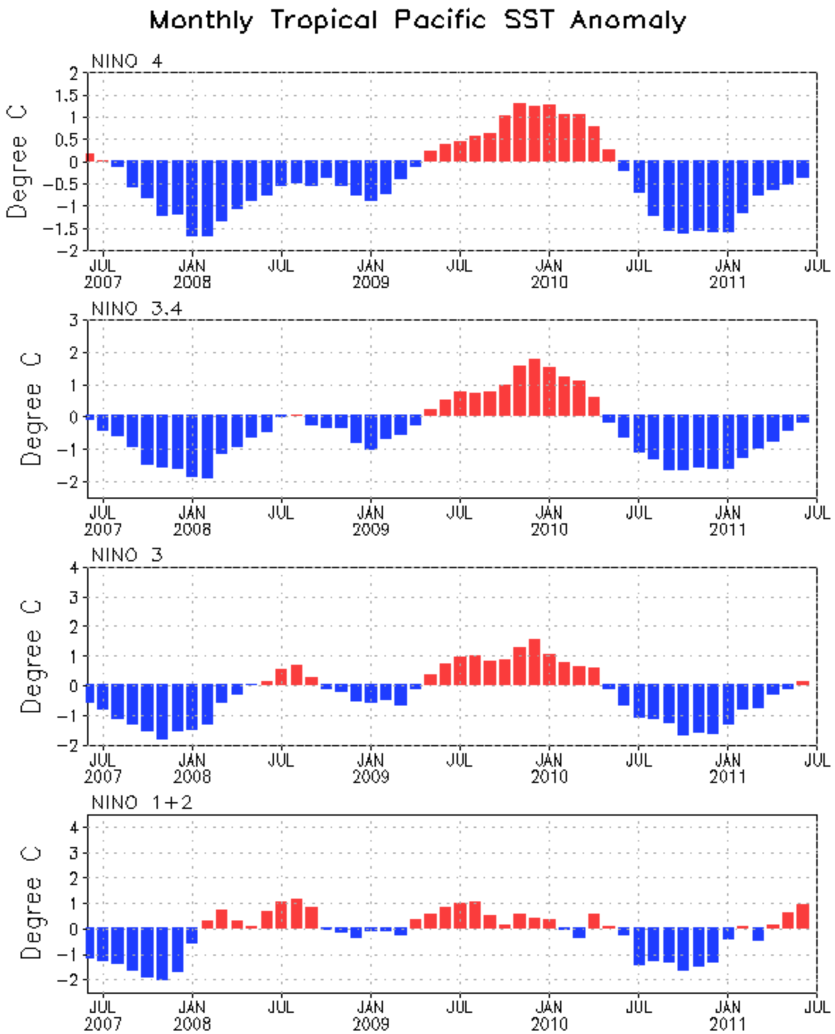
Evolution of Equatorial Pacific SST (ºC), 0-300m Heat Content (ºC), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly

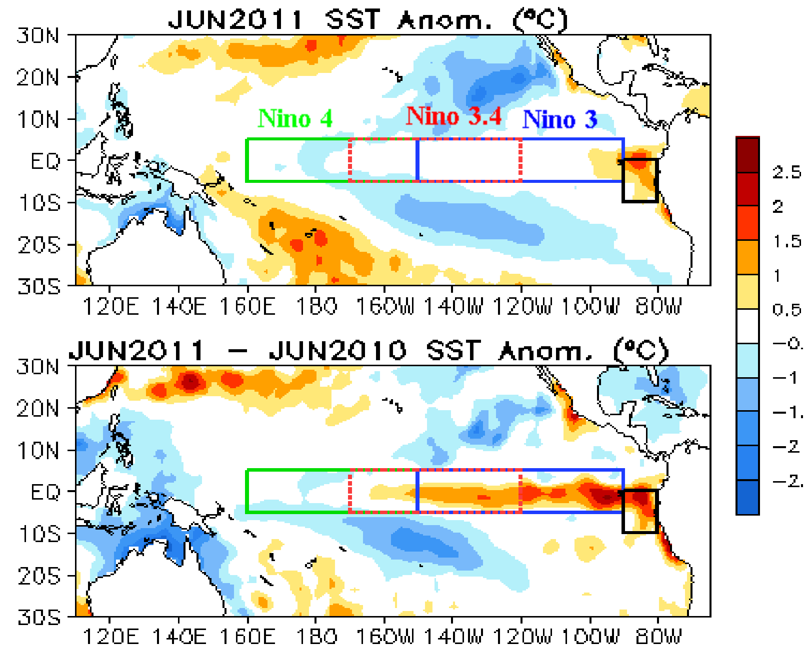


- **Positive heat content anomalies appeared in the central and eastern equatorial Pacific since Feb 2011.**
- **The SST in the far eastern equatorial Pacific was generally above-normal since Feb 2011, which might be attributed to the eastward propagation of down-welling kelvin waves and local air-sea interactions.**

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 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

Evolution of Pacific NINO SST Indices





- **Negative Nino 4 and Nino 3.4 indices weakened continuously since Jan 2011 or Dec 2010, and NINO3.4=-0.18 in June 2011**

- **ENSO-neutral conditions prevailed in June 2011.**

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

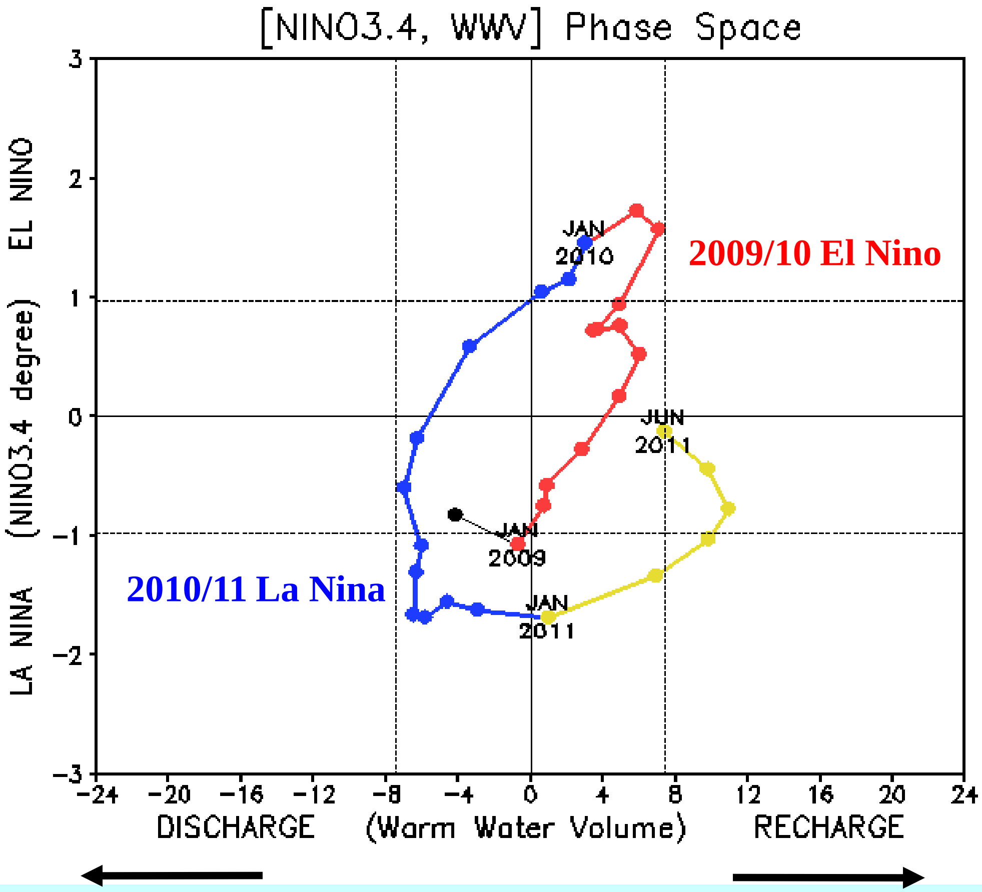
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Warm Water Volume (WWV) and NINO3.4 Anomalies

-WWV is defined as average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] (Meinen and McPhaden, 2000).

-Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).

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



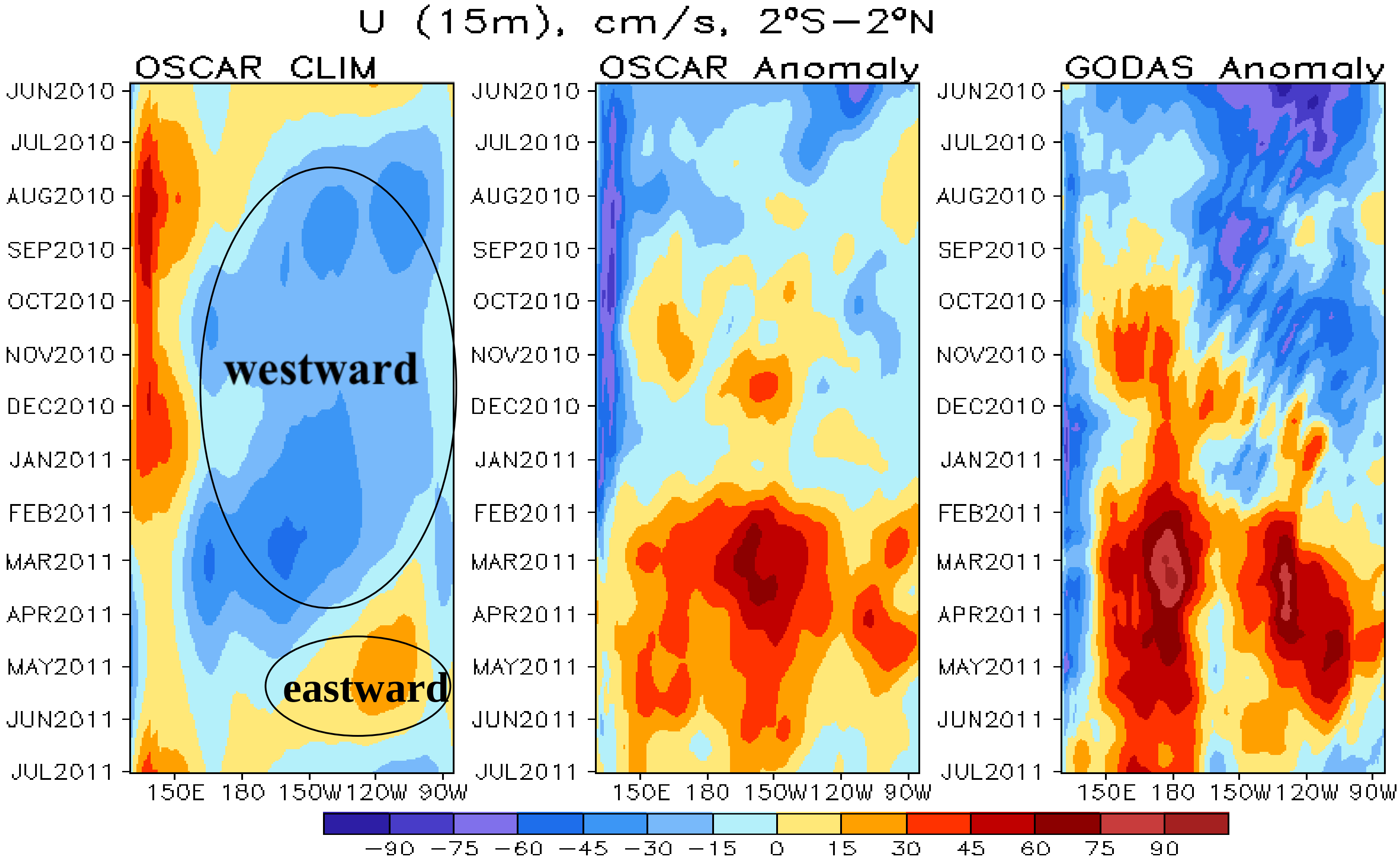
- WWV recharge enhanced significantly since Jan 2011 due to the recent downwelling Kelvin wave episodes and air-sea coupling that links the strengthening WWV with increasing NINO3.4.

- WWV recharge started to decrease since April 2011.

-ENSO-neutral conditions continued in June 2011.

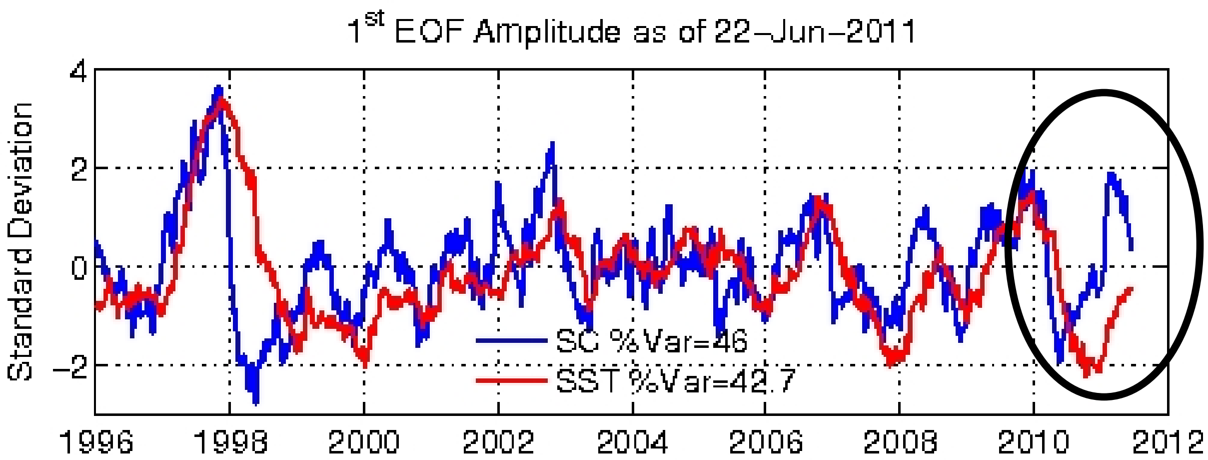
Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies for WWV (NINO 3.4) are departures from the 1982-2004 (1971-2000) base period means.

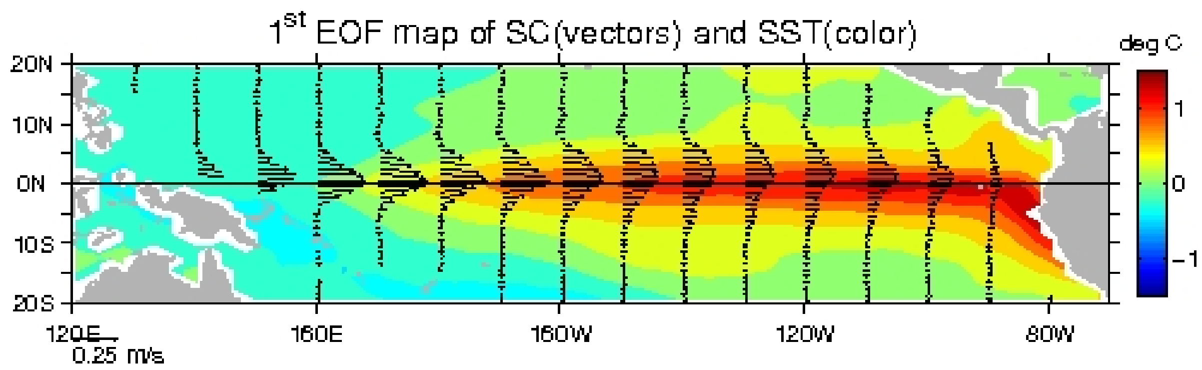
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **Eastward zonal current anomalies across the equatorial Pacific substantially weakened in June 2011.**
- **Anomalous zonal current had one maximum center between 180º-150ºW in OSCAR, and two maximum centers around 180º and 130ºW, respectively, in the GODAS, during Feb-June 2011.**
- **The estimate eastward current anomalies in GODAS were larger than in OSCAR since Feb,2011.**

ENSO cycle as indicated by 1st EOF of surface current and SST anomalies





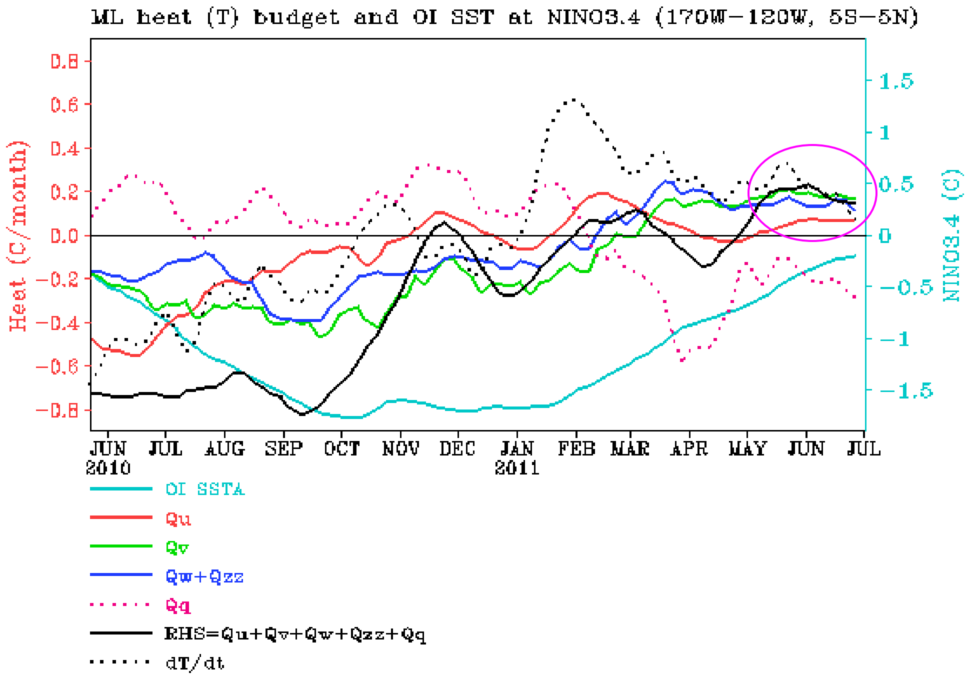
- Zonal current anomaly has become eastward since Dec 2010.

- On average, ocean surface zonal current anomaly leads the SSTA by a few months.

First EOF mode of ocean surface current (SC) and SST anomalies for the past decade extending through the latest 10-day period. The amplitude time series (top panel) are computed by fitting the data sets to 10-year base period eigenvectors (1993-2002). The amplitudes are then normalized by their respective standard deviations. The bottom panel shows the corresponding EOF maps, scaled accordingly. The El Niño signal can be seen as periods of positive excursions (> 1 Std. Dev.) of the amplitude time series. T the near real-time SC are the output from a diagnostic model.

(supplied by **Earth& Space Research**: **Dr. Kathleen Dohan** and see “http://www.esr.org/enso_index.html” for details)

NINO3.4 Heat Budget



- Positive Tendency (dT/dt) in NINO 3.4 (dotted line) weakened in June, indicating the continuous ENSO-neutral conditions.

- Dynamical terms (Qv, Qw+Qzz,Qu) were generally positive since Feb 2011.

- The thermodynamic term (Qq) was negative since Feb 2011, peaked in late Mar 2011.

- The total heat budget term (RHS) agreed with Tendency (dT/dt) well in June 2011.

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.

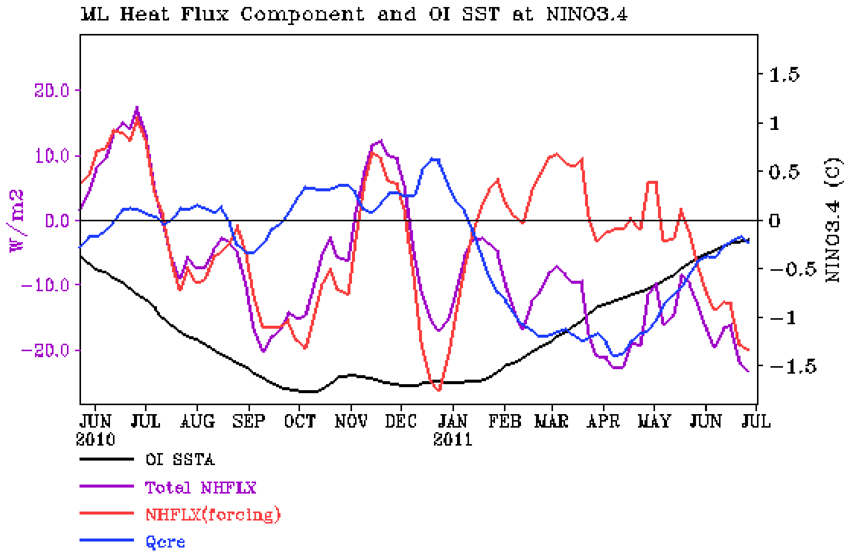
Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

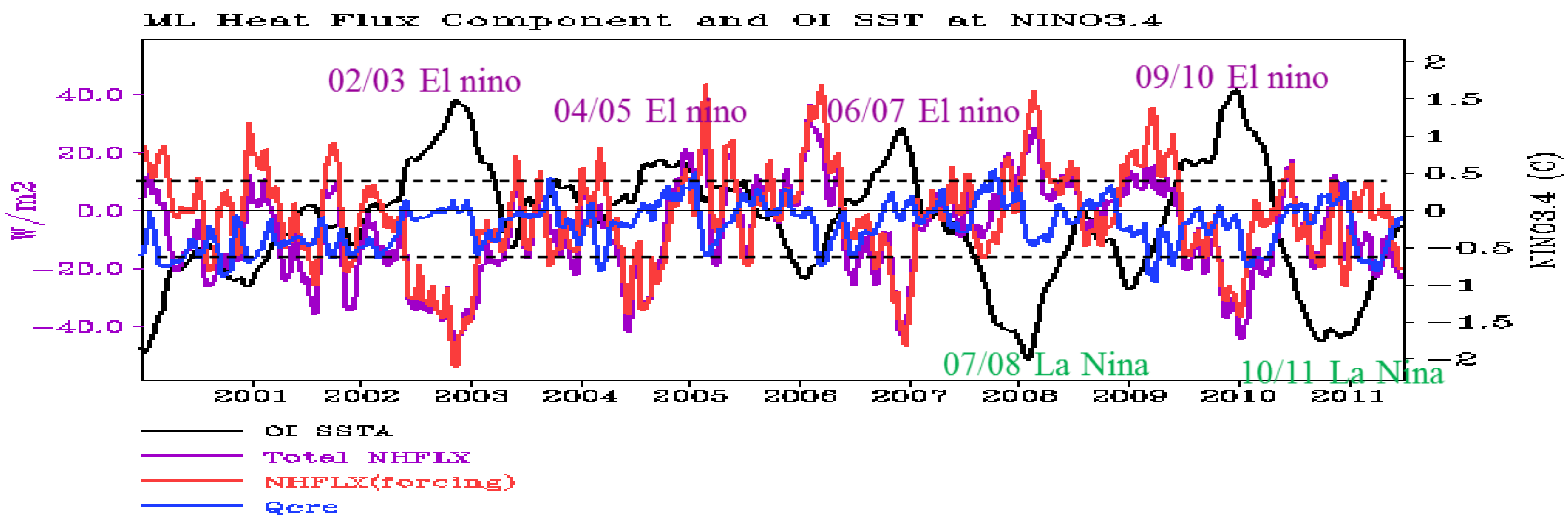
Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

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

Components of Net Heat Fluxes in GODAS

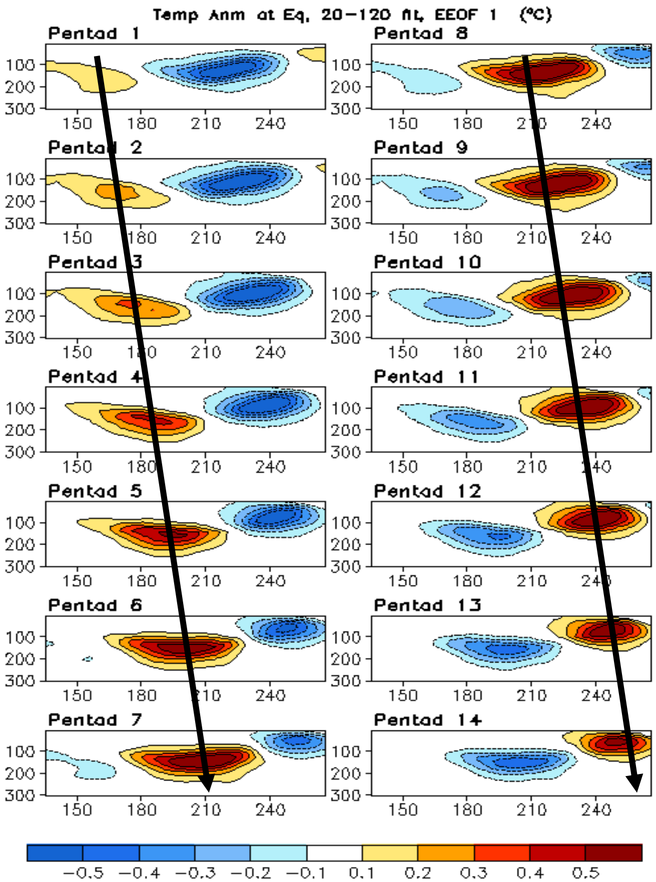


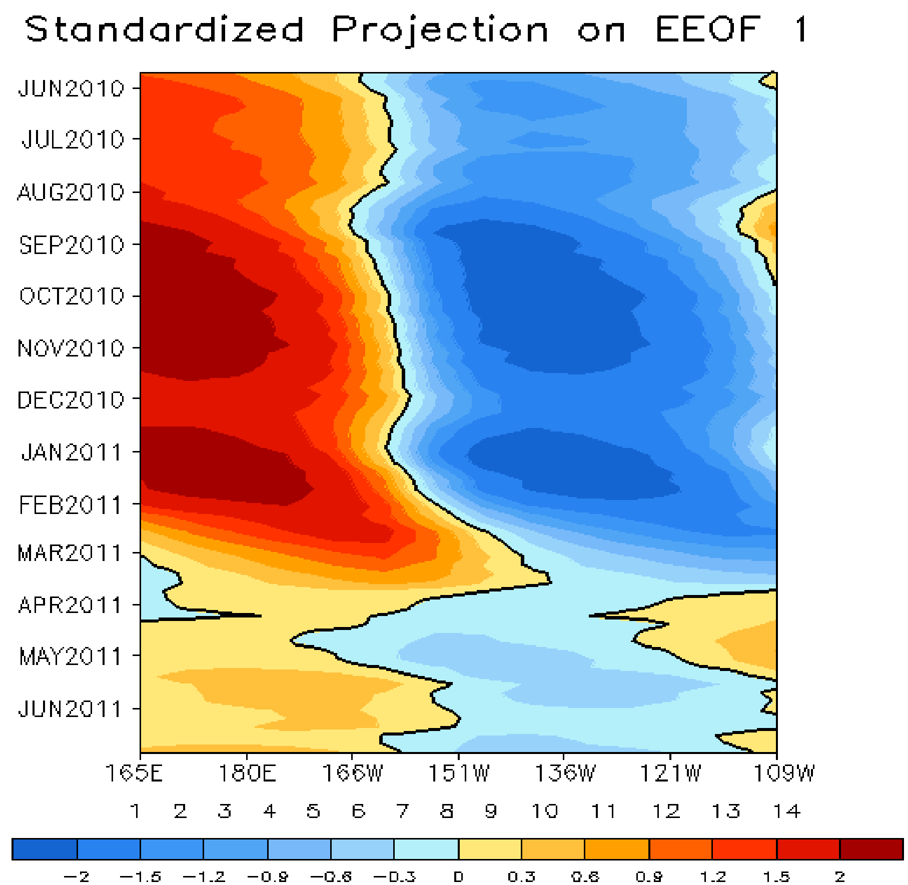
- In GODAS, the total net heat flux (**Total NHFLX**) includes the net heat flux (SW+LW+LH+SH) from R2 (**NHFLX**) and flux correction (**Qcre**) due to SST relaxation to observed SST.
- The strong cooling in **Total NHFLX** during Jan-May 2011 was largely attributed to the strong cooling in **Qcre**, which indicates that the model SST was too warm compared to observations during the period.



- **NHFLX** tends to have opposite sign to NINO3.4 during the major El Nino and La Nina events, i.e. atmospheric fluxes damp ENSO.
- However, the outphase relationship between **NHFLX** and Nino 3.4 was noticeably absent during the 2010/11 La Nina event.

Oceanic Kelvin Wave Indices



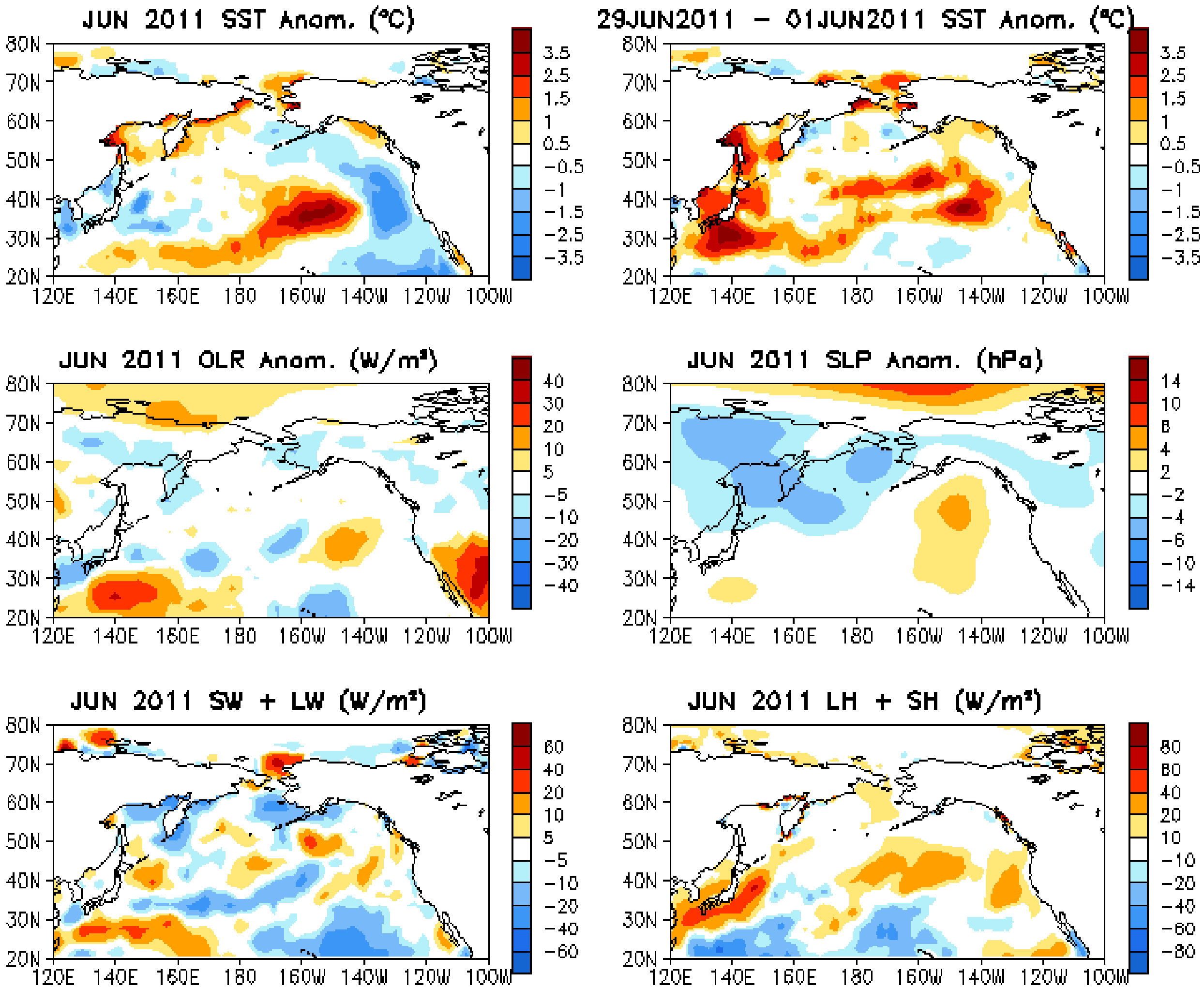


- Downwelling Kelvin wave initiated in late Jan 2011 in the W. Pacific arrived at the eastern coast in April.

- **Extended EOF (EEOF) analysis is applied to 20-120 day filtered equatorial temperature anomaly in the top 300m using 14 lagged pentads (similar to that in Seo and Xue, GRL, 2005).**
- **EEOF 1 describes eastward propagation of oceanic Kelvin wave cross the equatorial Pacific in about 70 days.**
- **Oceanic Kelvin wave indices are defined as standardized projections of total anomalies onto the 14 patterns of EEOF 1.**

North Pacific & Arctic Ocean

North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend.,



- Positive (negative) SSTA was observed in the central North Pacific (along the west coast of N. A. and near Japan) in June 2011, consistent with the negative PDO index (next slide).

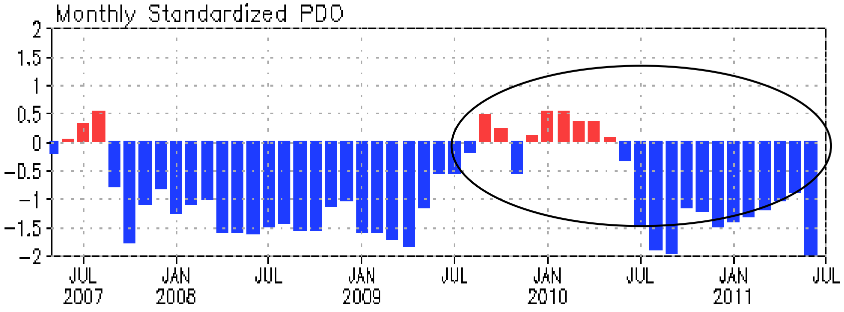
- Large SSTA warming presented over much of the western-central North Pacific, indicating the intensification of PDO-like pattern.

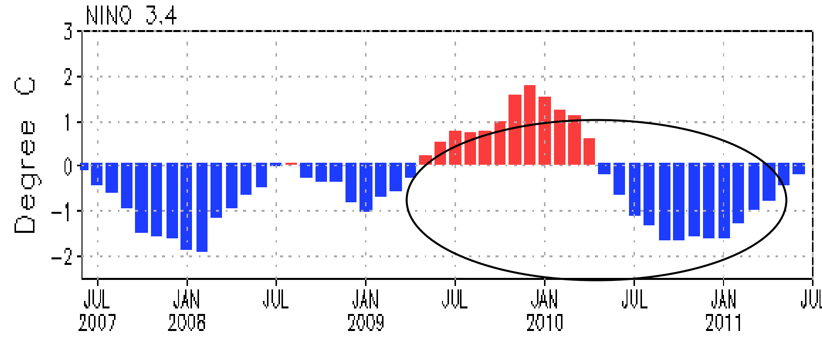
-Net surface heat flux anomalies contributed to SST warming in the North Pacific.

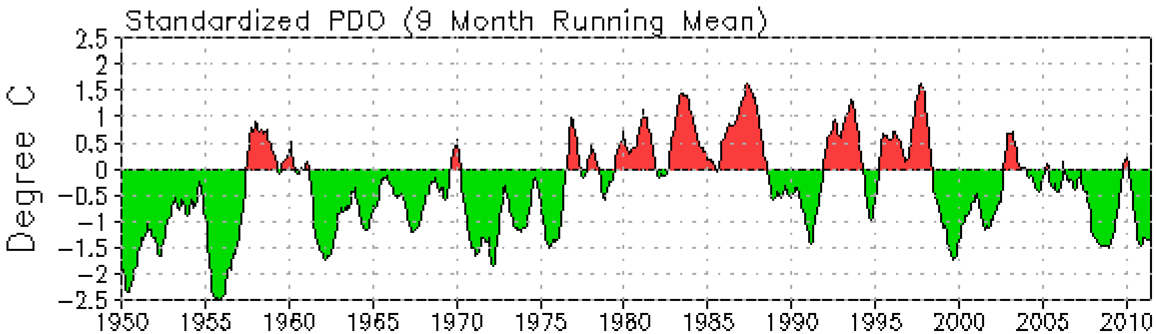
-The North Pacific High (centered at 35N,150W) expanded poleward in June.

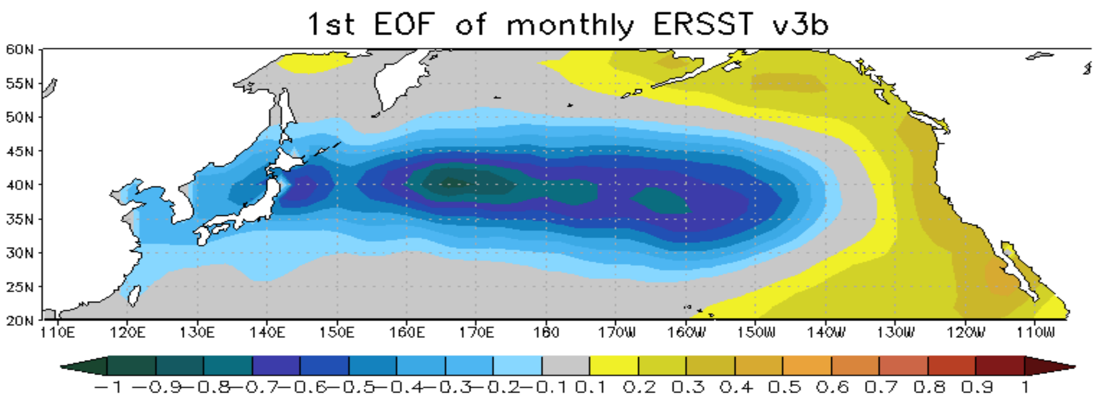
Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

PDO index









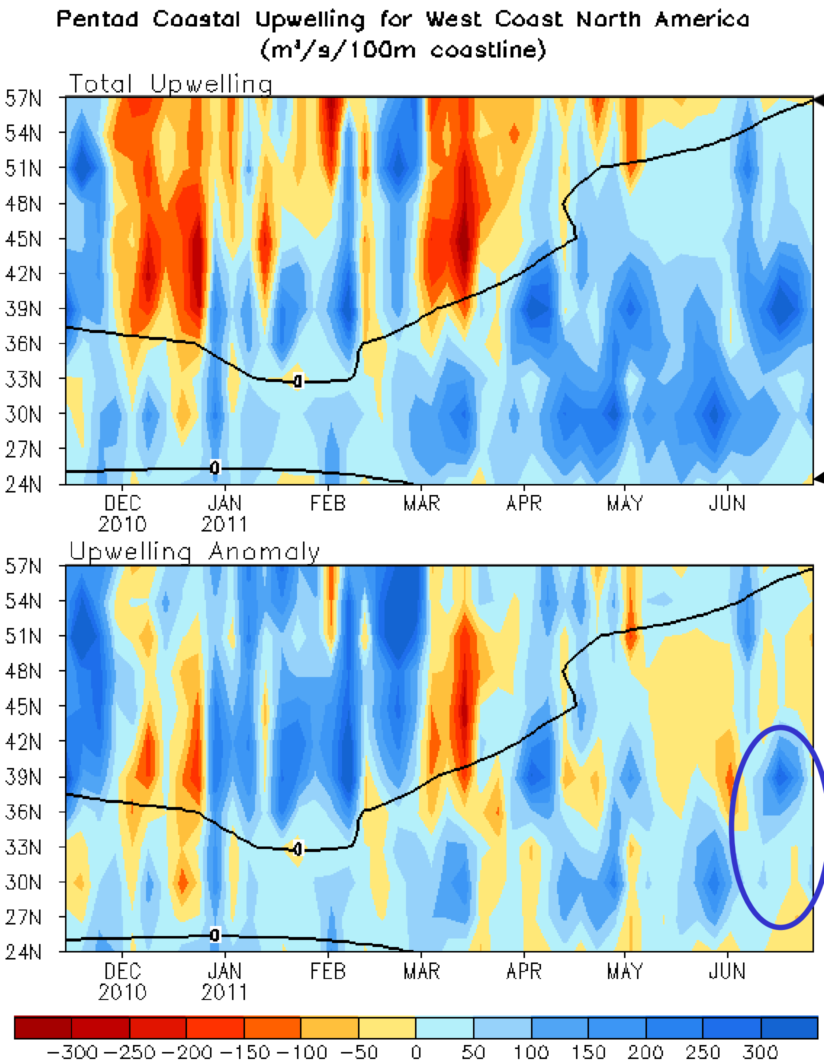
- The negative PDO index intensified substantially in June.

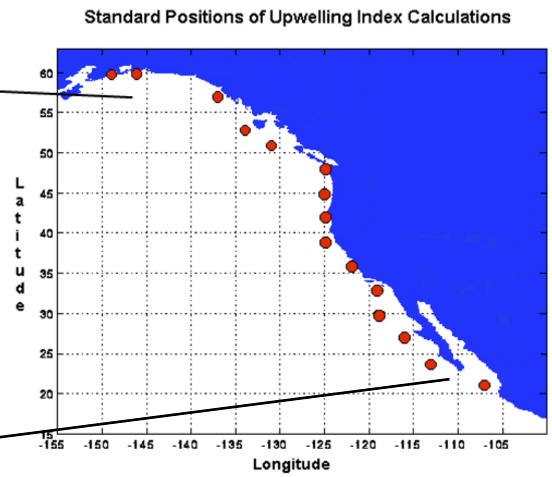
- The apparent positive correlation between NINO3.4 and PDO index suggests strong influences of the La Nina on the North Pacific SST variability through atmospheric bridge.

- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

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

North America Western Coastal Upwelling



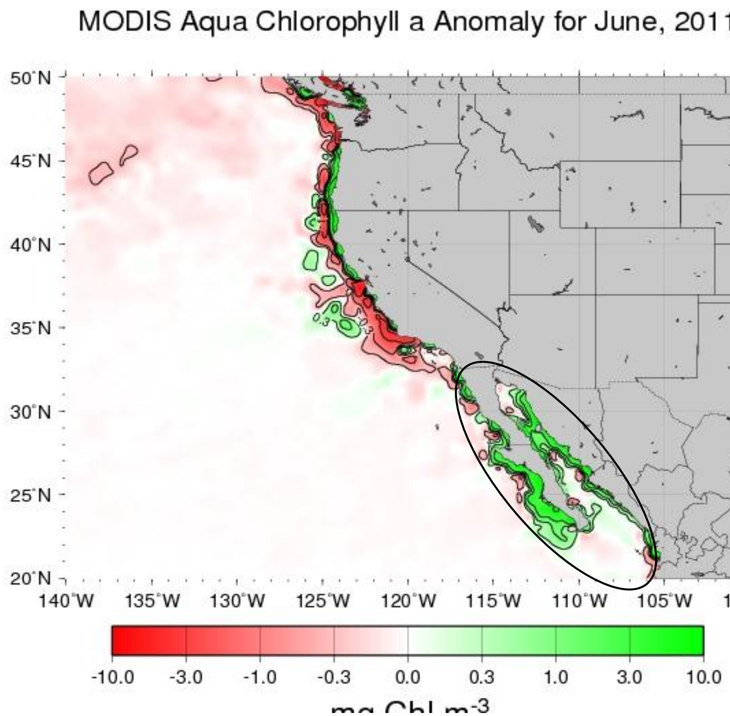


- **Upwelling was enhanced at 27°N-42°N in June 2011, consistent with the SLP anomaly pattern.**

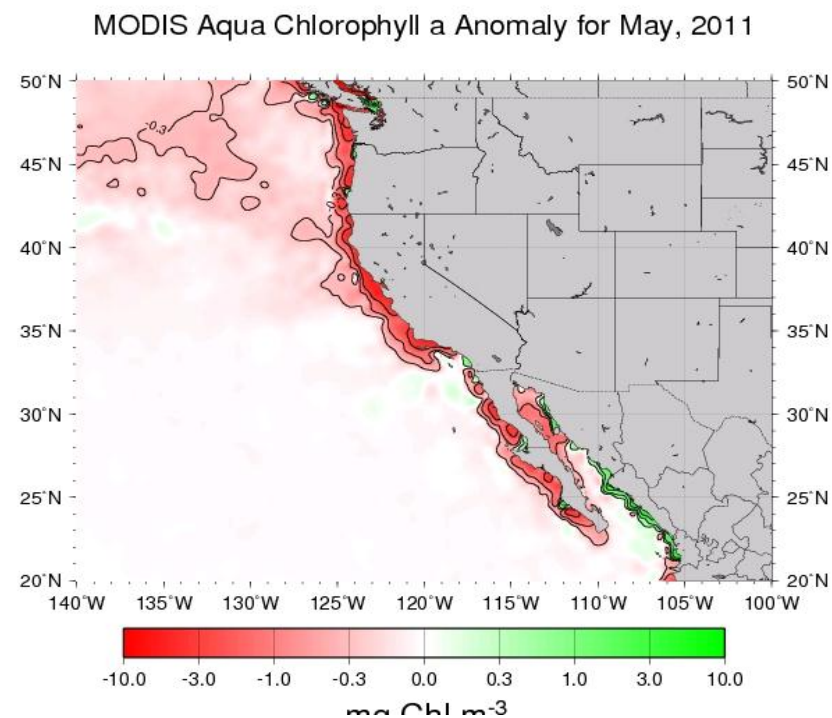
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1982-2004 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



- Chlorophyll anomalies increased along much of the coastal regions in June and positive anomalies dominated at 20N-30N.
- Enhanced upwelling contributed to increased chlorophyll anomalies

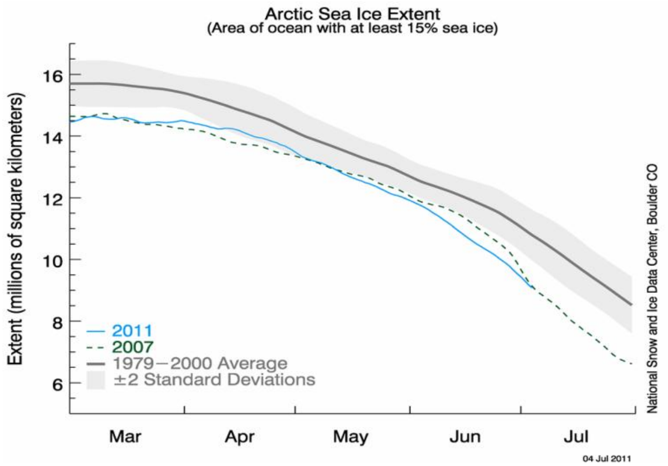


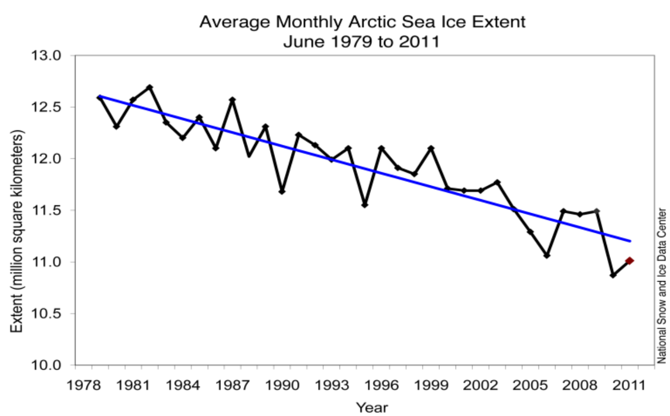
http://coastwatch.pfel.noaa.gov/FAST

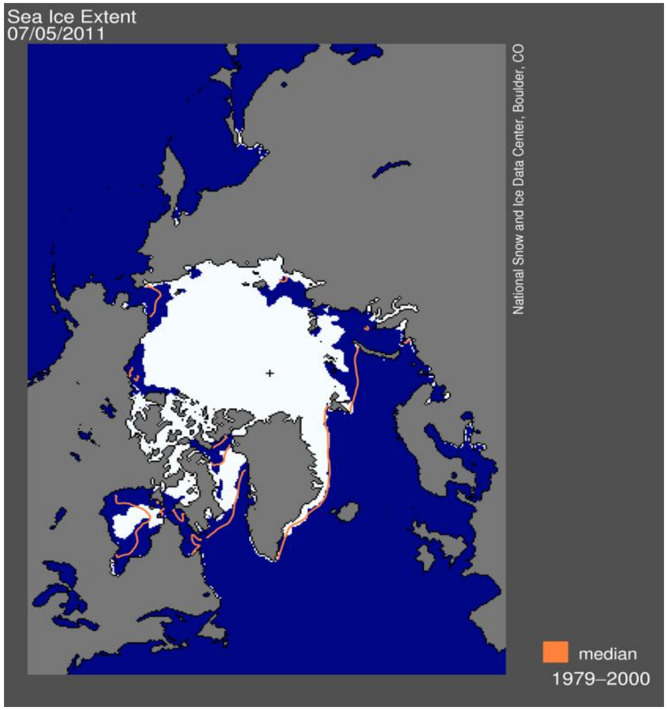
Arctic Sea Ice

National Snow and Ice Data Center

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





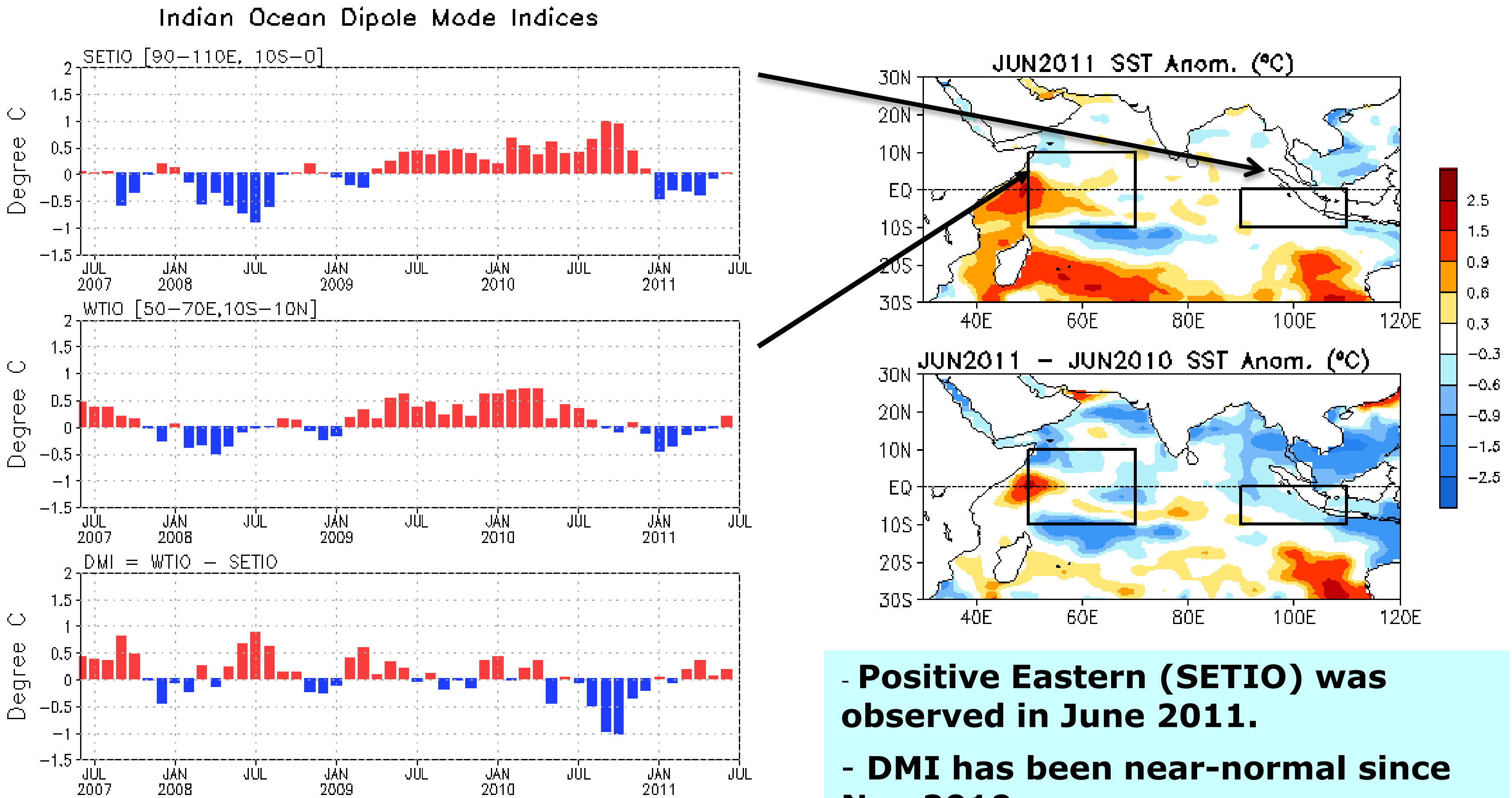


- The Arctic sea ice extent continued to decline in June 2011, which was the second lowest in the satellite records.

-The Kara Sea region had particularly low ice extent in June 2011.

Tropical Indian Ocean

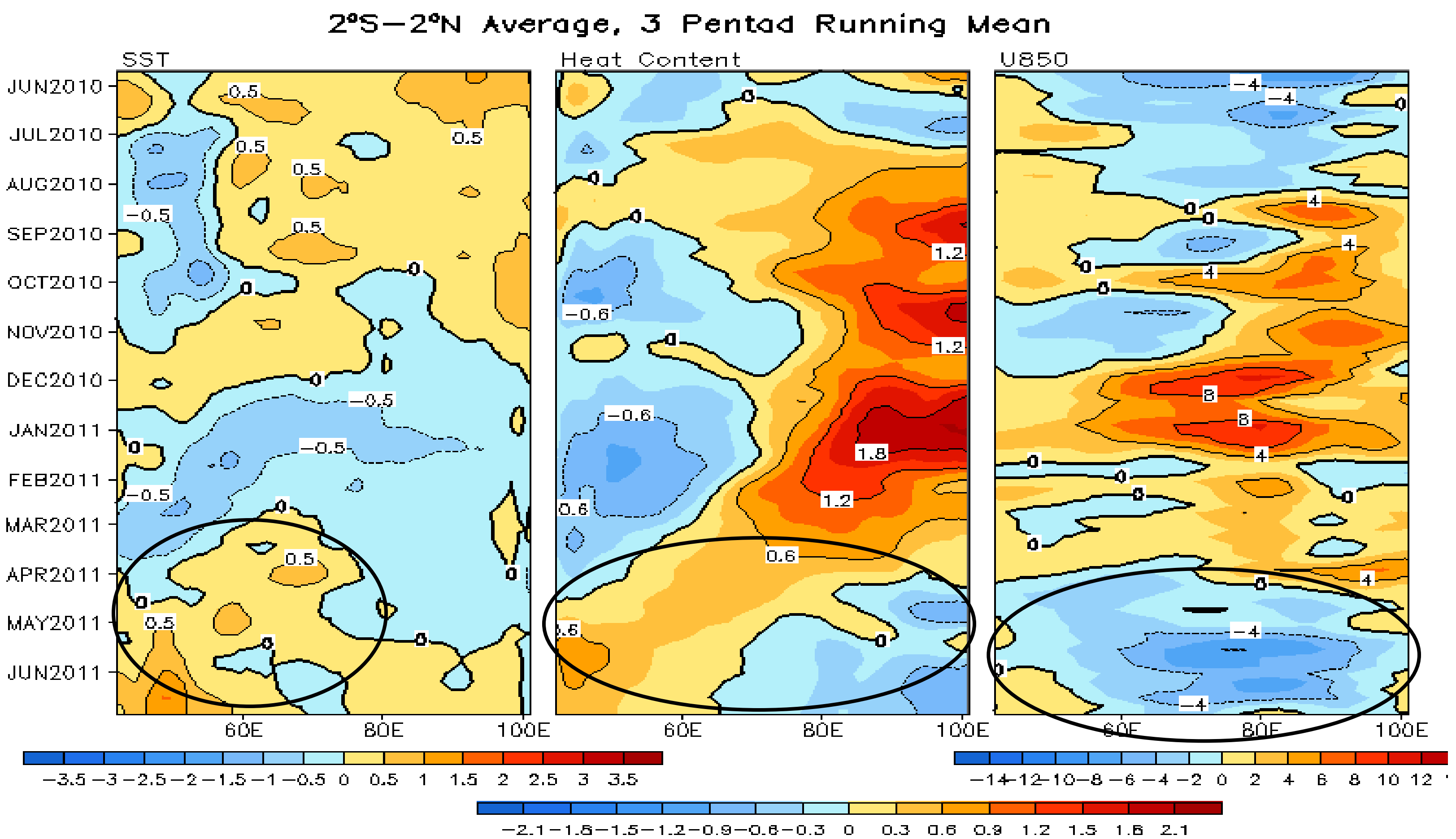
Evolution of Indian Ocean SST Indices



- **Positive Eastern (SETIO) was observed in June 2011.**
- **DMI has been near-normal since Nov 2010.**

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Recent Evolution of Equatorial Indian SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s) and OLR (W/m²) Anomalies



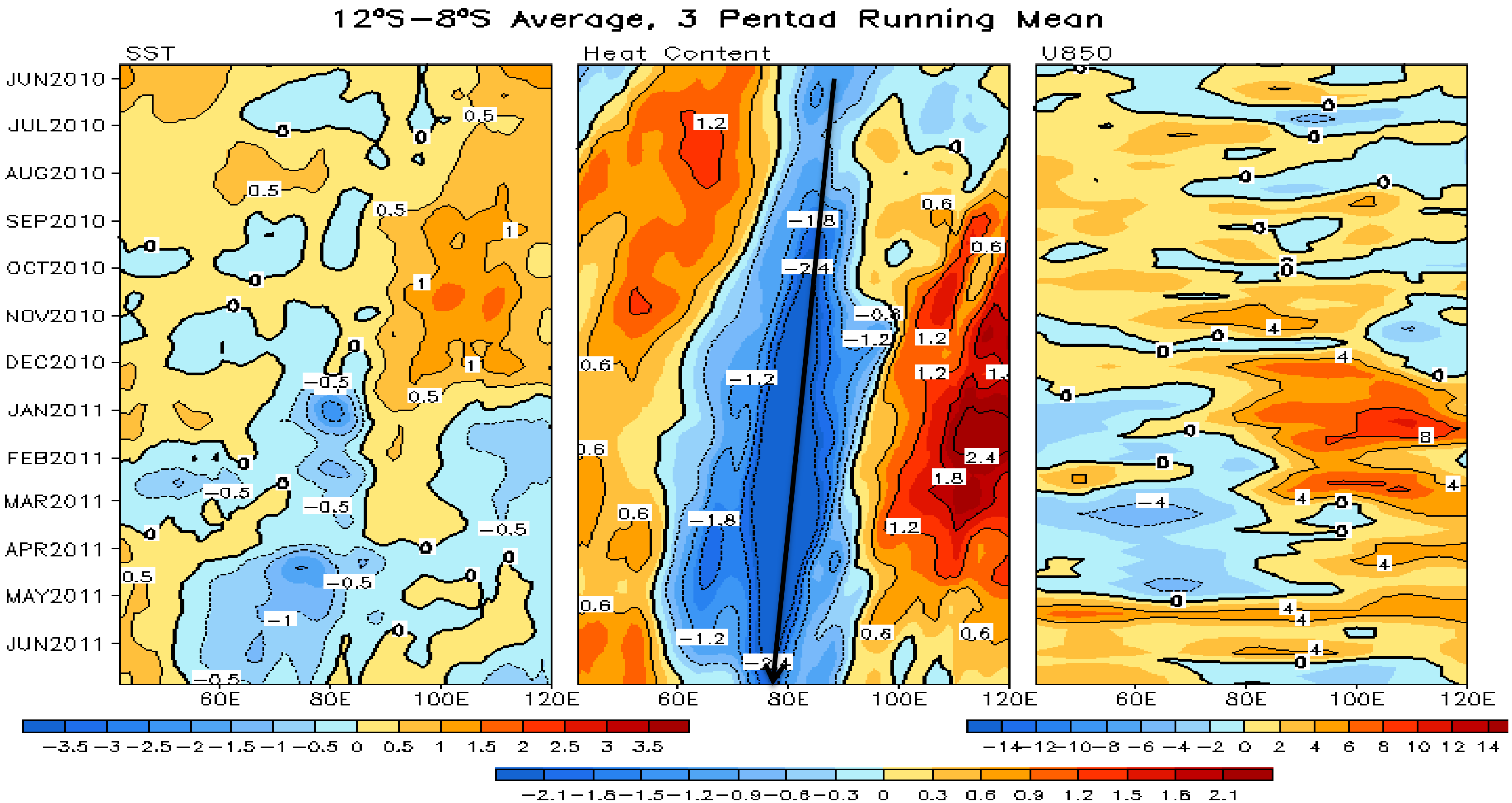
- SSTA switched to negative since mid-Dec 2010, probably due to the delayed impact of the La Nina.

But, positive SSTA emerged in the central Indian Ocean since Mar 2011.

- Positive (negative) heat content anomaly presented in the west-central (eastern) Indian Ocean in response to anomalous easterly wind forcing in the tropical Indian Ocean.

Fig. I3. 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 for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

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



- Negative SST presented around 70E since Apr 2011, which is consistent with the negative HC.
- Westerly wind anomalies prevailed over the southern tropical Indian Ocean in May 2011.
- Negative HC anomaly propagated westward since May 2010.

Fig. I4. 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 12°S-8°S 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 for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

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

- Positive SSTA was observed along the coast of equatorial Africa.
- Negative SSTA near 70°E and 12°S decreased in June.
- SSTA tendency was not very consistent with the net surface heat flux anomalies, indicating trivial influence of heat flux on SST tendency
- Convection was suppressed in most regions of the tropical Indian Ocean.

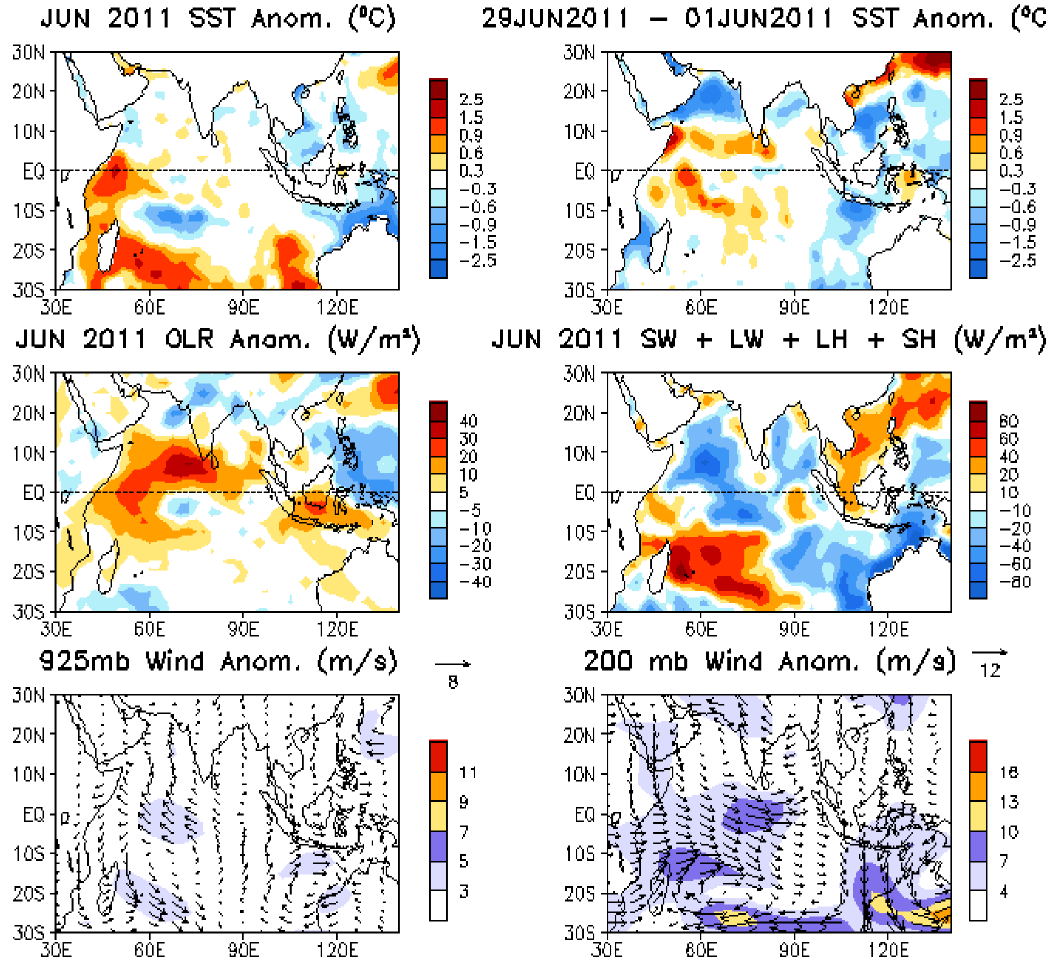
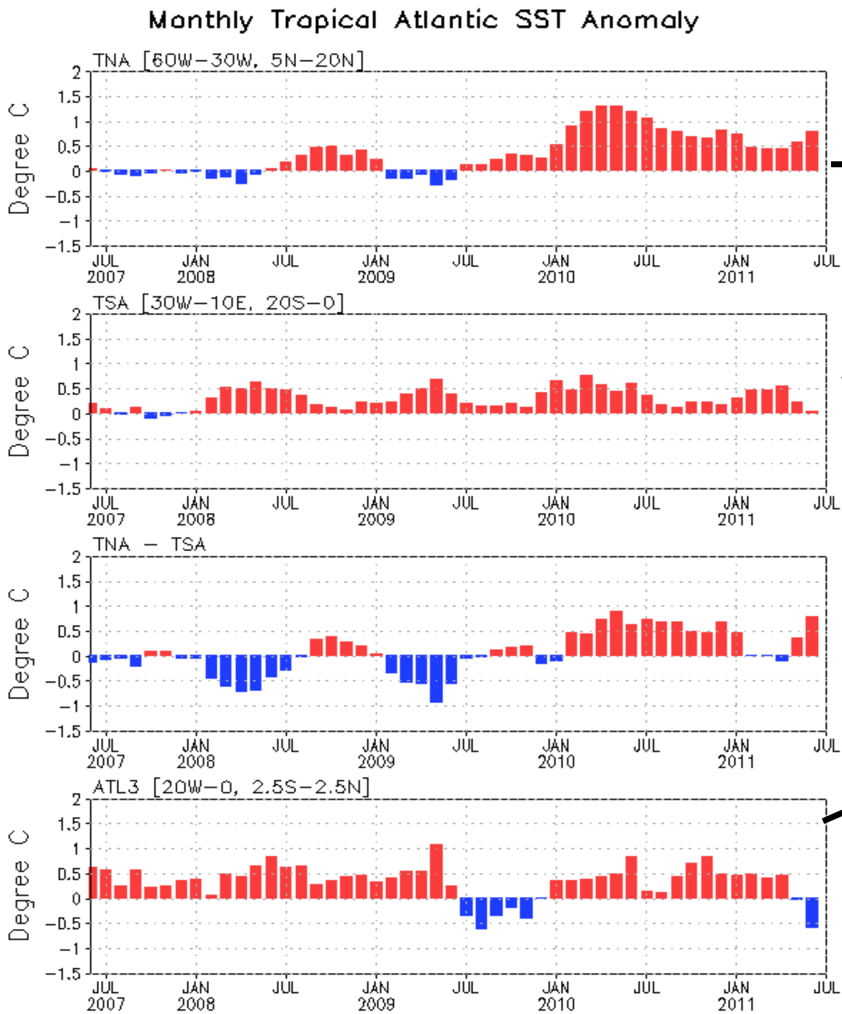
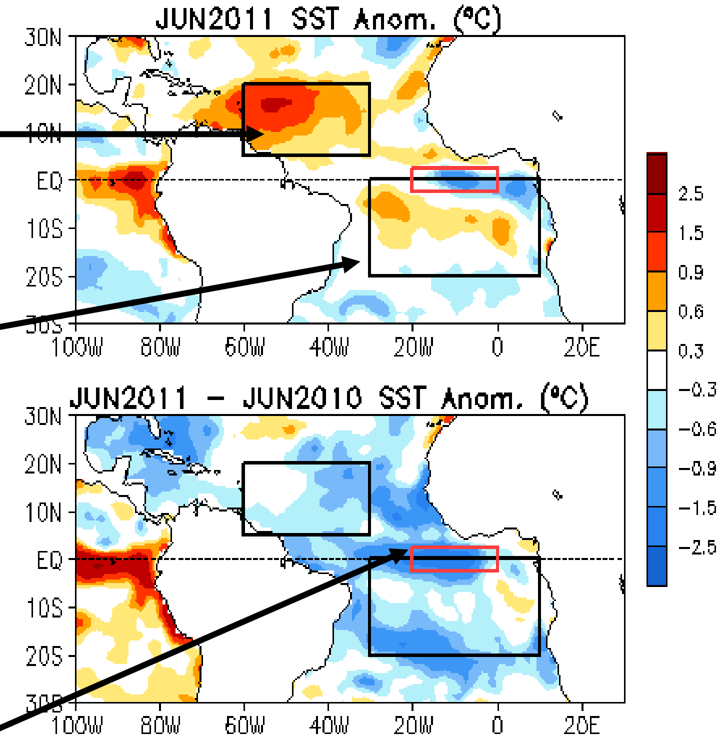


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

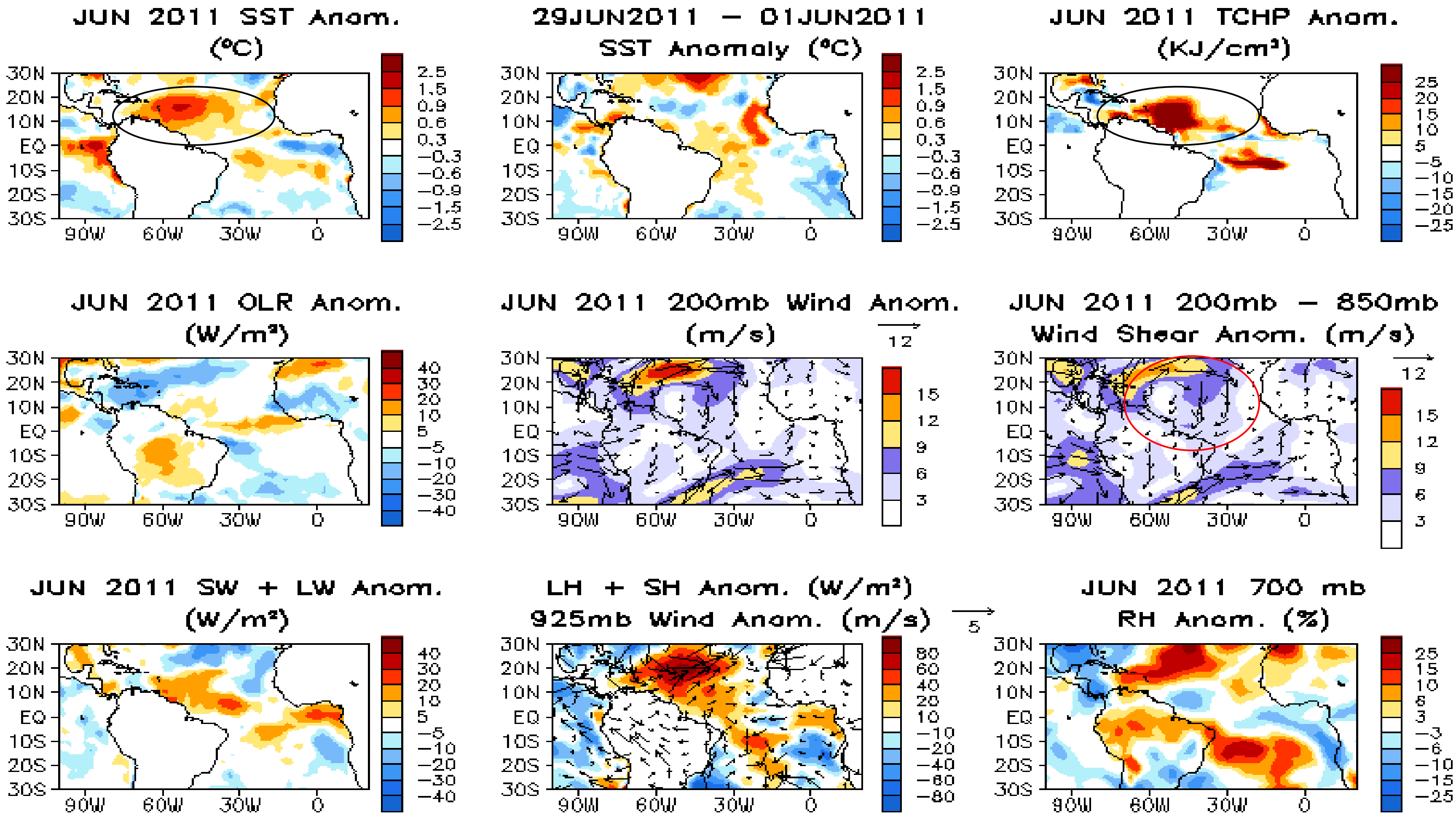




- **Positive SSTA persisted in both TNA and TSA since Feb 2011.**
- **Meridional Gradient Mode (TNA-TSA) was above-normal in June.**
- **Large negative ATL3 SST was observed in June.**

Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

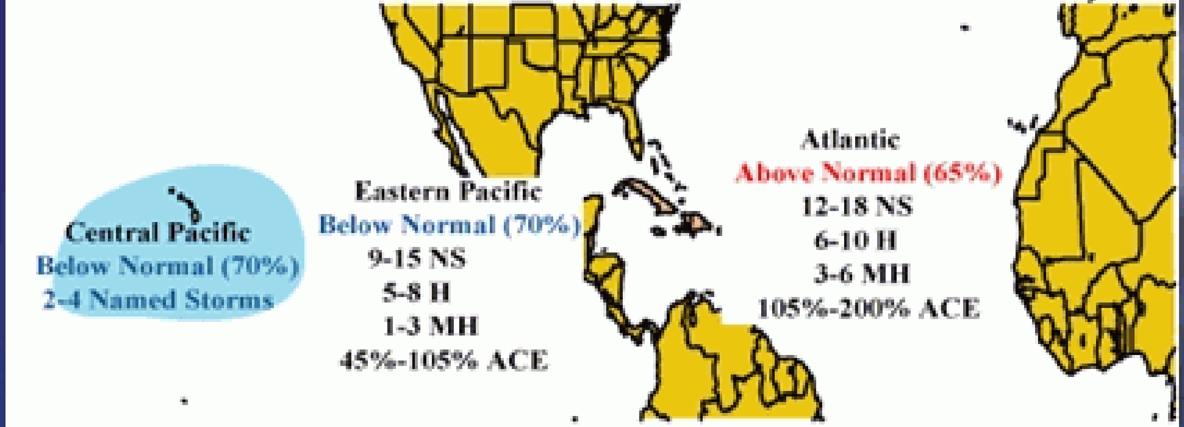
Tropical Atlantic:



- **Positive SSTA continued in the Atlantic Hurricane Main Development Region (MDR) (tropical Atlantic ocean between 9°N-21.5°N).**

- **Above-normal TCHP and easterly wind shear anomaly in hurricane MDR are favorable for hurricane development.**

NOAA's 2011 Hurricane Season Outlooks Issued in May



NOAA's 2011 seasonal hurricane outlooks indicate the likely ranges (each with a 70% chance) of Named Storms (NS), Hurricanes (H), Major Hurricanes (MH), and percentage of the median Acccumulated Cyclone Energy (ACE).

For 2011 the probabilities of each season type are:

	Atlantic	Eastern Pacific	Central Pacific
Above Normal	65%	5%	5%
Near Normal	25%	25%	25%
Below Normal	10%	70%	70%

North Atlantic Ocean

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

- Tripole SST pattern intensified in June.
- Positive SLP anomalies prevailed north of 50N.

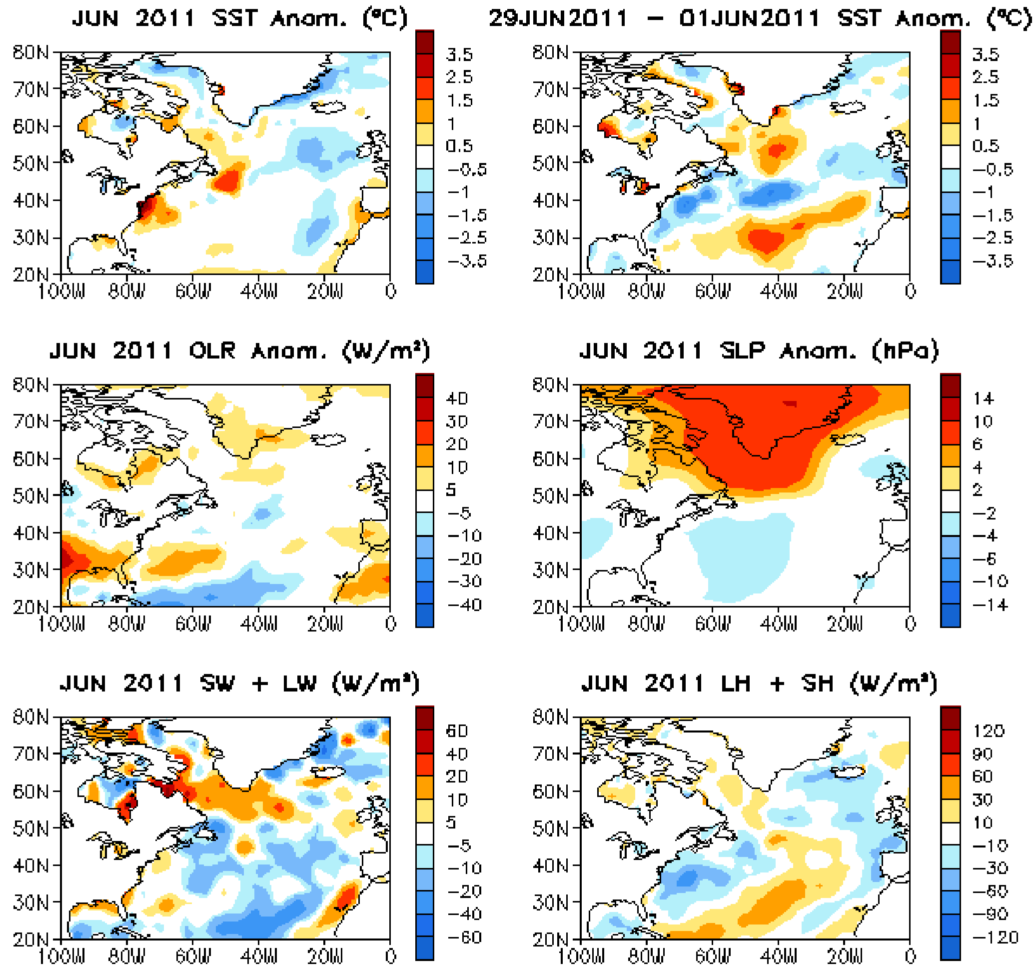
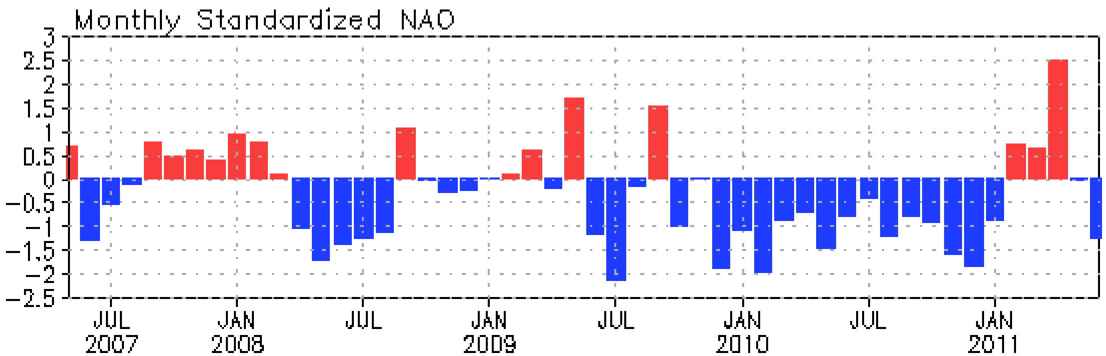
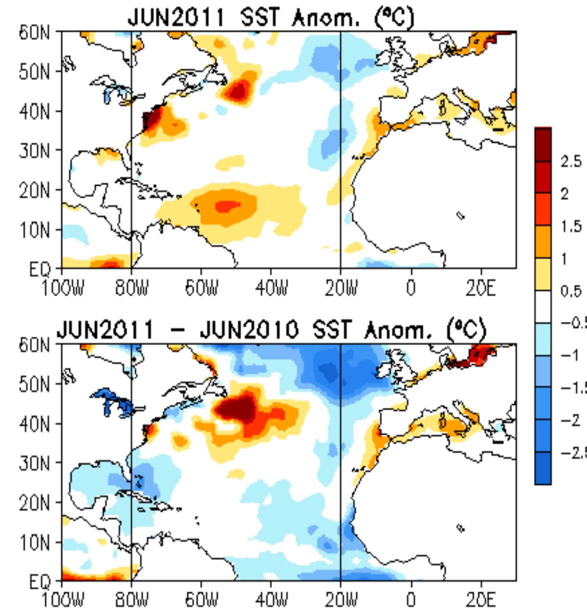
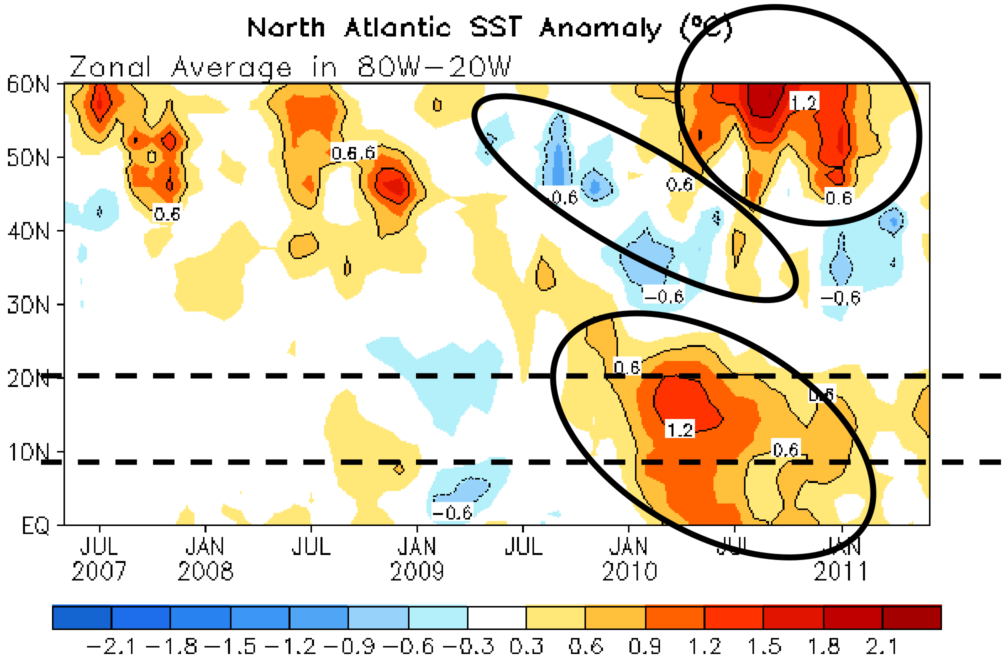


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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





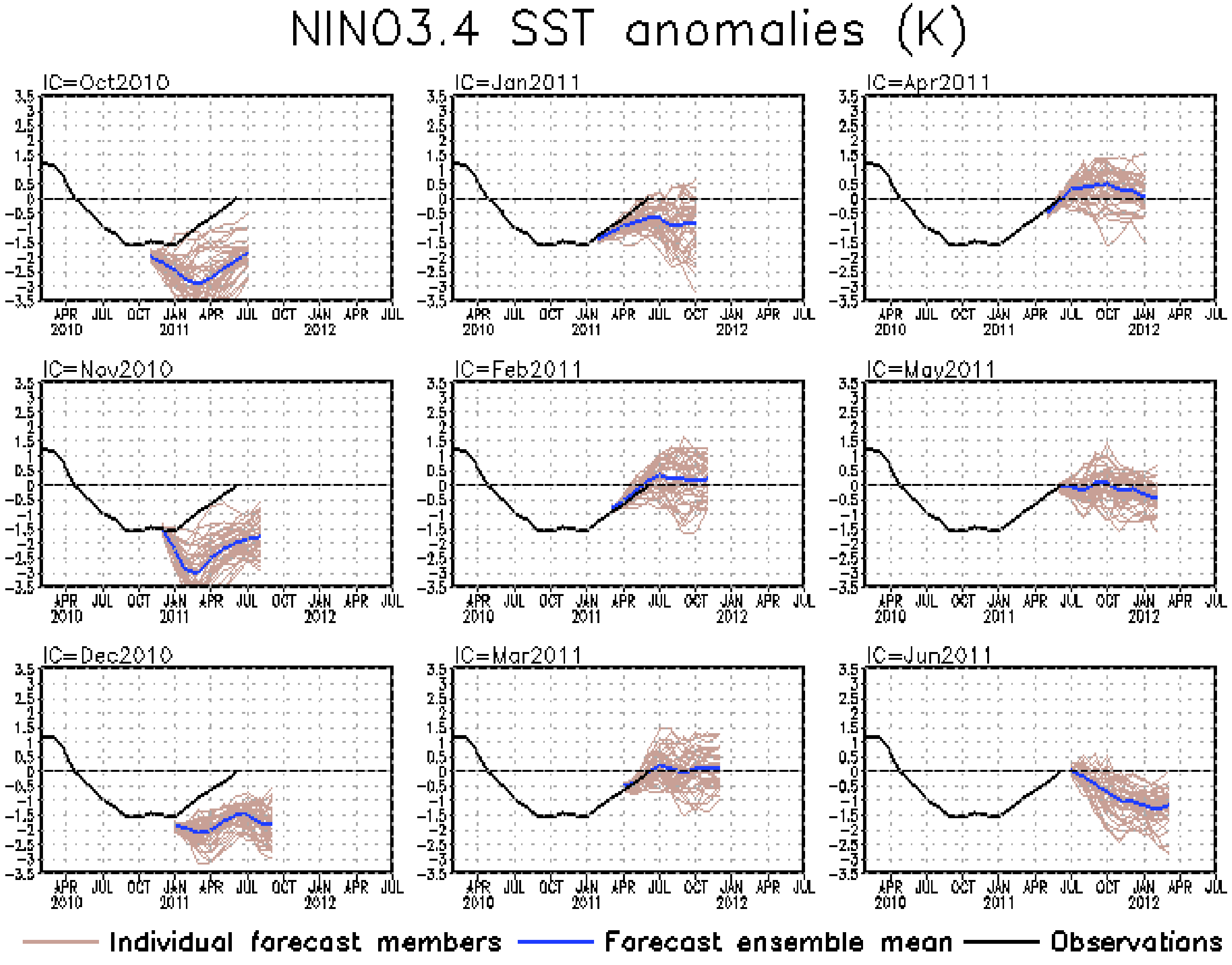


- **NAO became below-normal in June 2011**
- **The tripole or horseshoe pattern of SSTA in 2009-2011 was largely associated with the influence of NAO and ENSO cycle, as well as long-term trend and SST feedback.**

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 1971-2000 base period means.

CFS SST Predictions and Ocean Initial Conditions

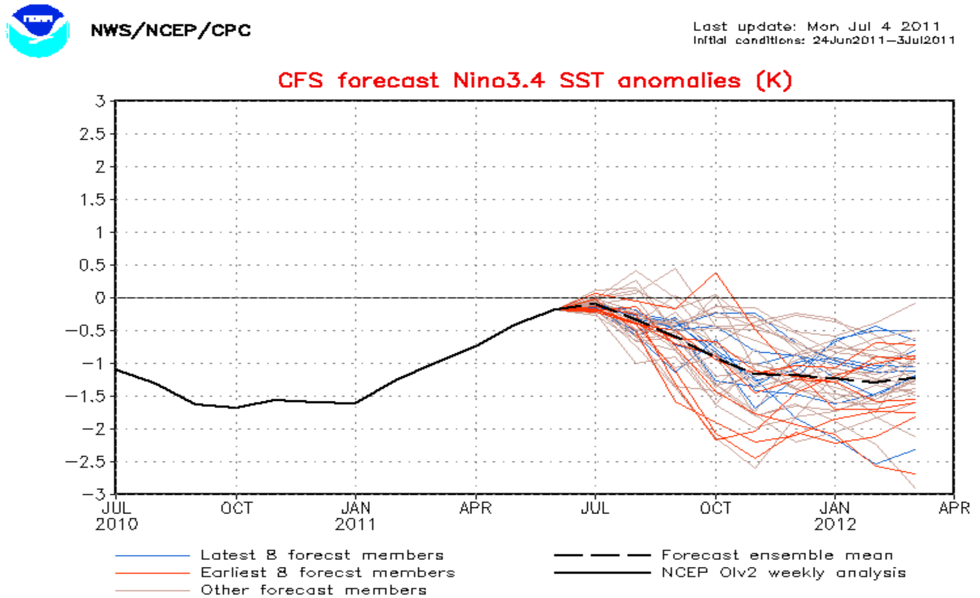
CFS Niño3.4 SST Predictions from Different Initial Months



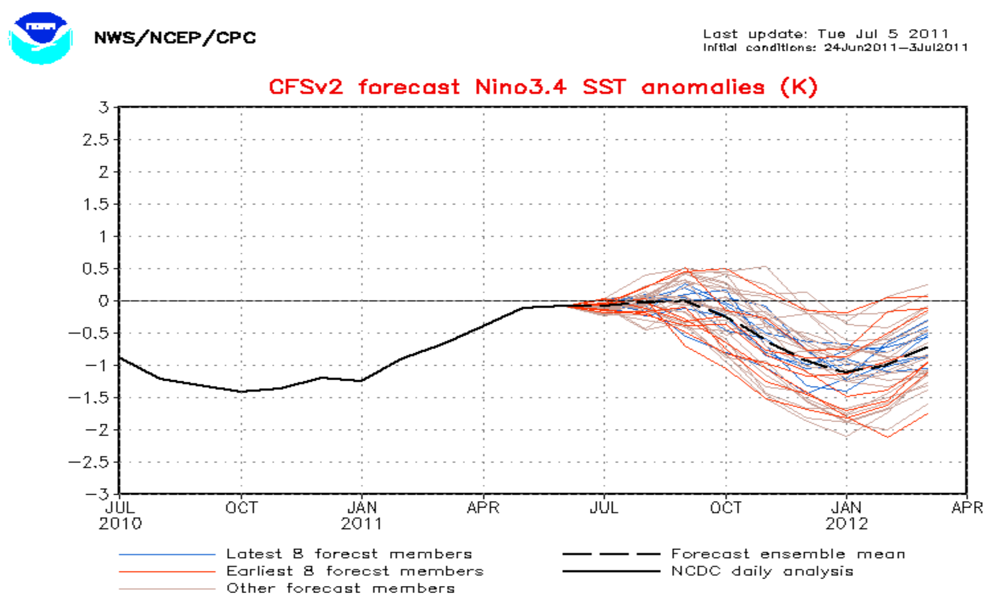
- **Forecasts from Oct 2010-Jan 2011 I.C. had cold biases. The recent cold forecast biases can be alleviated through statistical model corrections (*http://www.cpc.ncep.noaa.gov/products/people/wwang/cfs_fcst*).**

- **The latest forecasts from June 2011 I.C. suggest that La Nina conditions may develop in winter 2011/12.**

Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). 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 1971-2000 base period means.



http://www.cpc.ncep.noaa.gov/products/people/wwang/cfs_fcst/



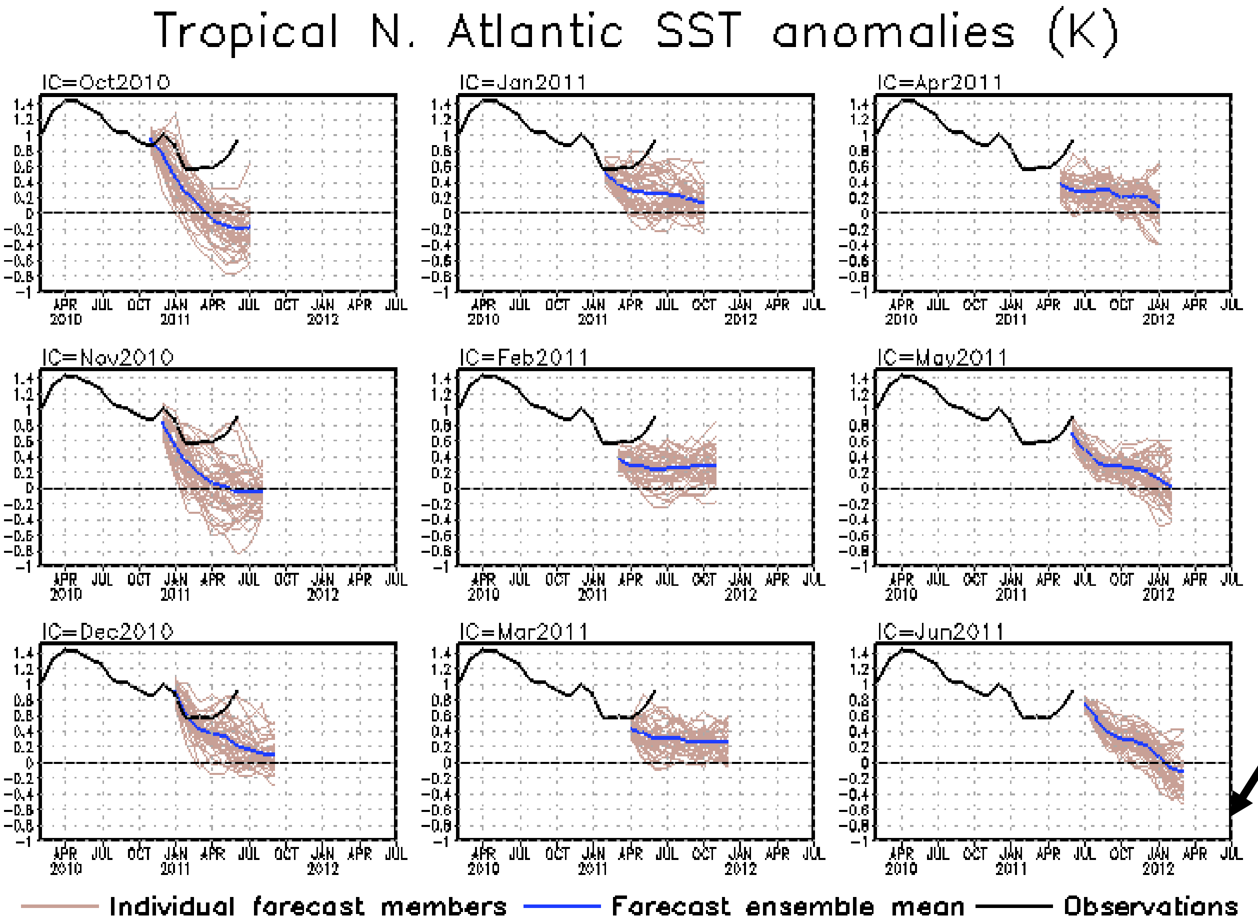
http://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml

NCEP CFSv1 and v2 ENSO Forecasts:

- Both predicted ENSO-neutral condition will continue at least through Northern summer 2011 and La Nina condition might rebound in fall and persist up to early 2012.

CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months

TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].

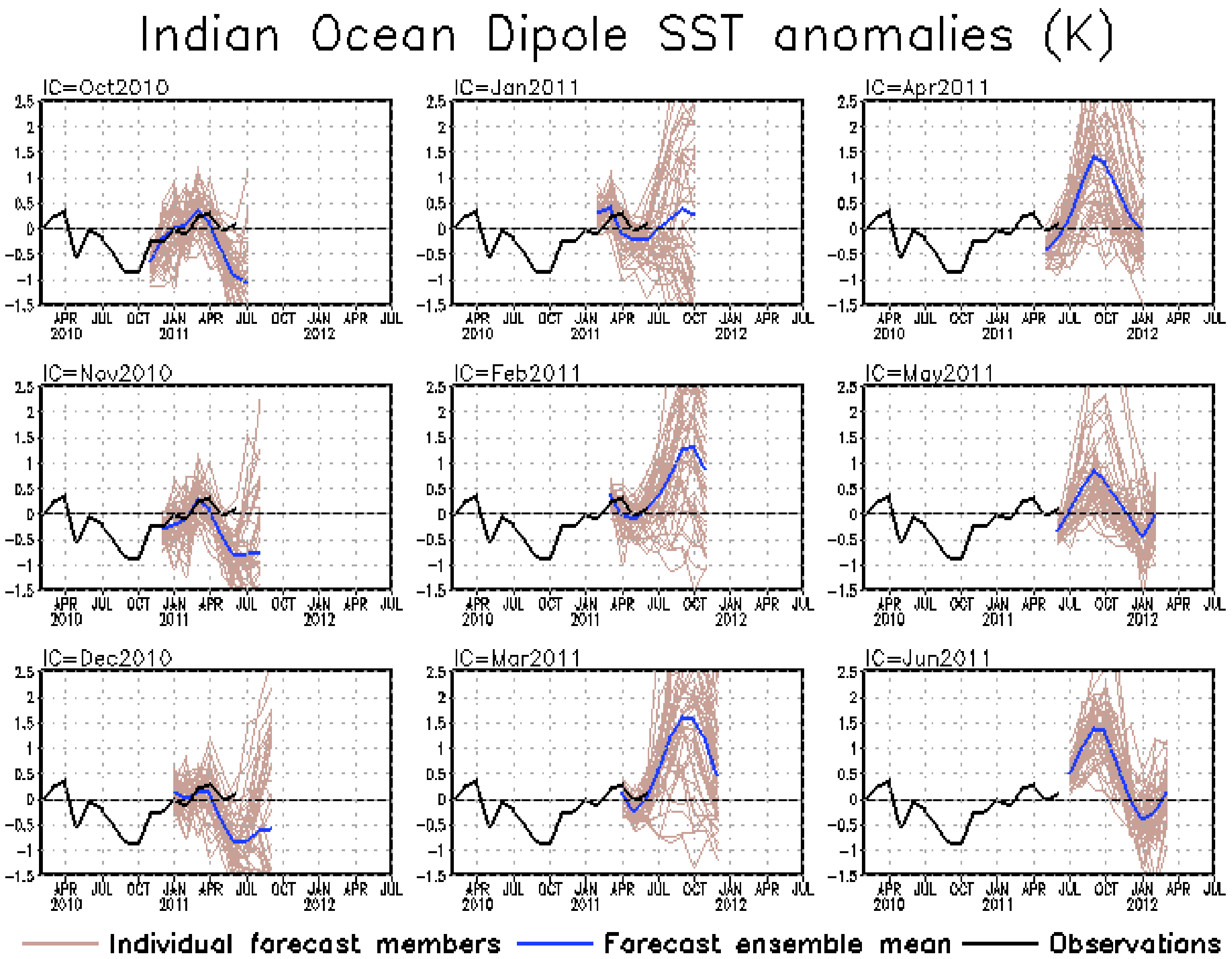


- Cold forecast biases were evident, may due to the fact that the NAO and its impact were poorly predicted.

- Latest forecasts suggest that the tropical North Atlantic SST will be near-normal in summer/fall 2011.

Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). 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 1971-2000 base period means.

CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

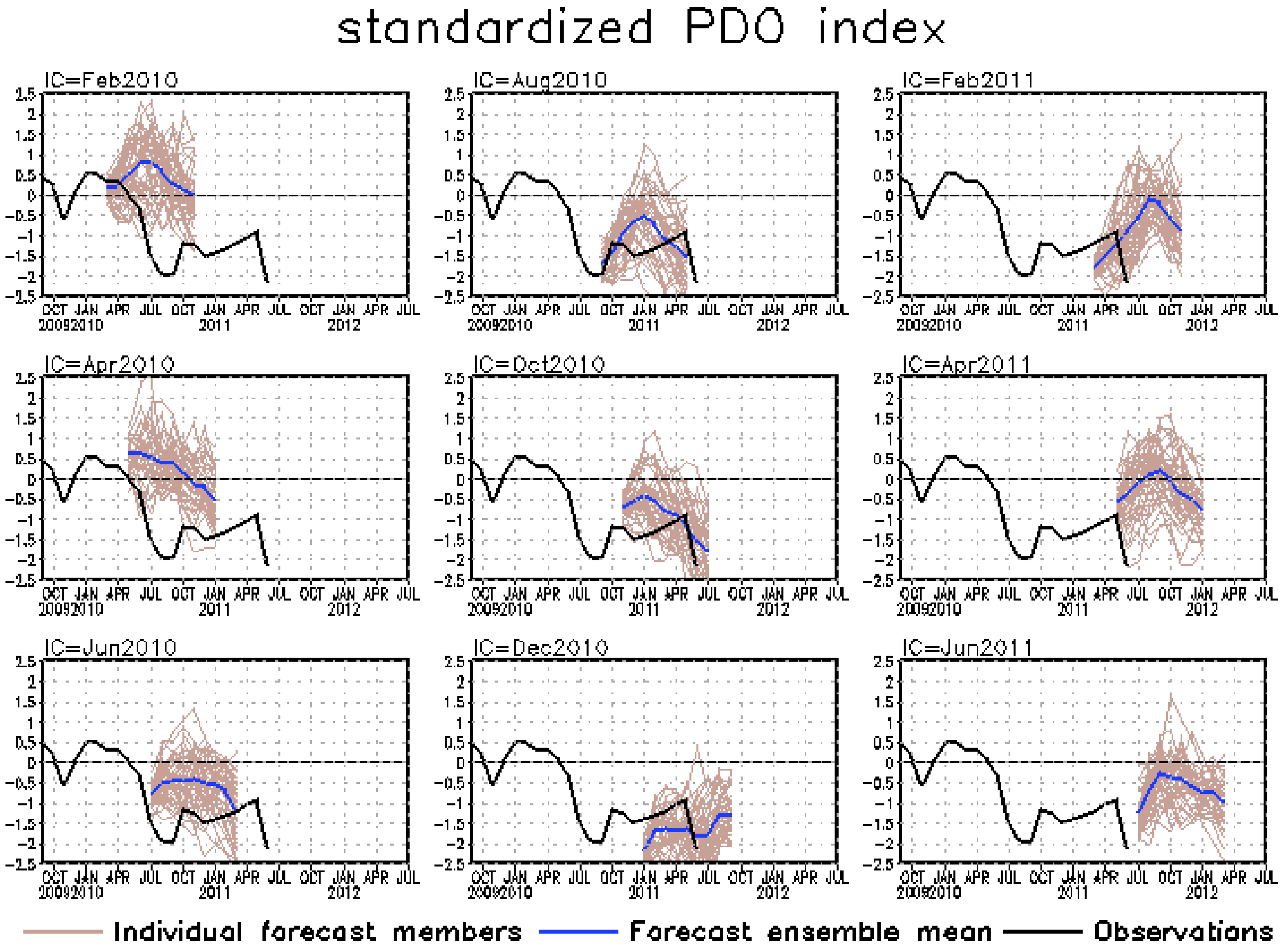
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

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

- **The spread between individual members was large, implying the uncertainty of the IOD forecasts.**
- **Forecasts from March-June 2011 I.C. suggest a positive phase of IOD will develop in summer-autumn 2011.**

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 1971-2000 base period means.

CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



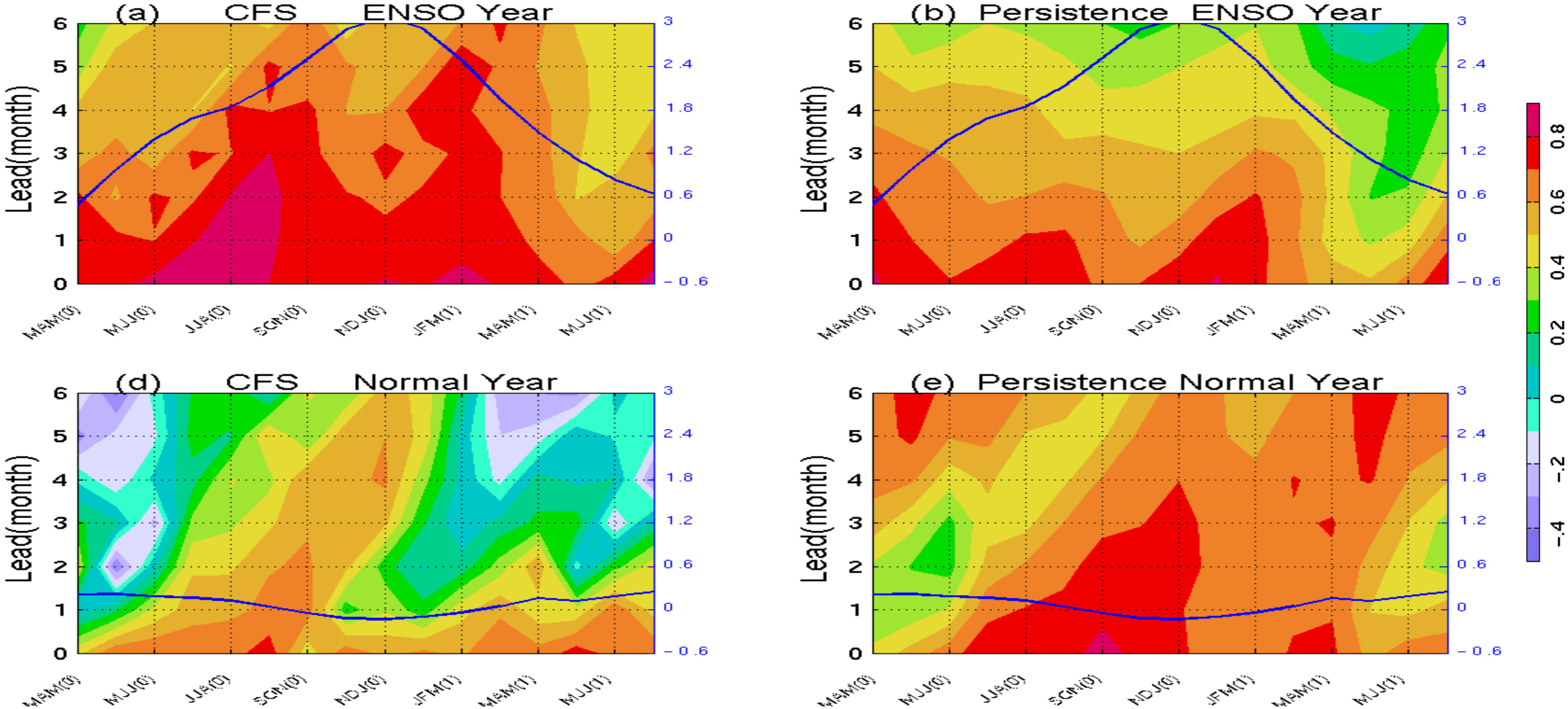
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- **Forecasts from Feb-May have large warm biases**
- **Latest forecasts suggest that the PDO will be negative throughout the second half of 2011 and into early 2012.**

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). 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 1971-2000 base period means.

Dependence of PDO skill on ENSO conditions



Shaded: Prediction skills(correlation coefficient) Blue lines: Composite Nino 3.4 anomalies
(0) indicates the year in which the event develops and (1) indicates the following year

- PDO skill is significantly higher at all leads during ENSO events than those in neutral years.
- PDO skill exhibits similar seasonality with ENSO skills.
- PDO skill has two maximums with one target at ASO(0)-SON(0) and the other target at JFM(1)-MAM(1) during ENSO years.
- PDO has no prediction skill during Spring(0) and late boreal winter(0)/Spring(1) during normal years.

Overview

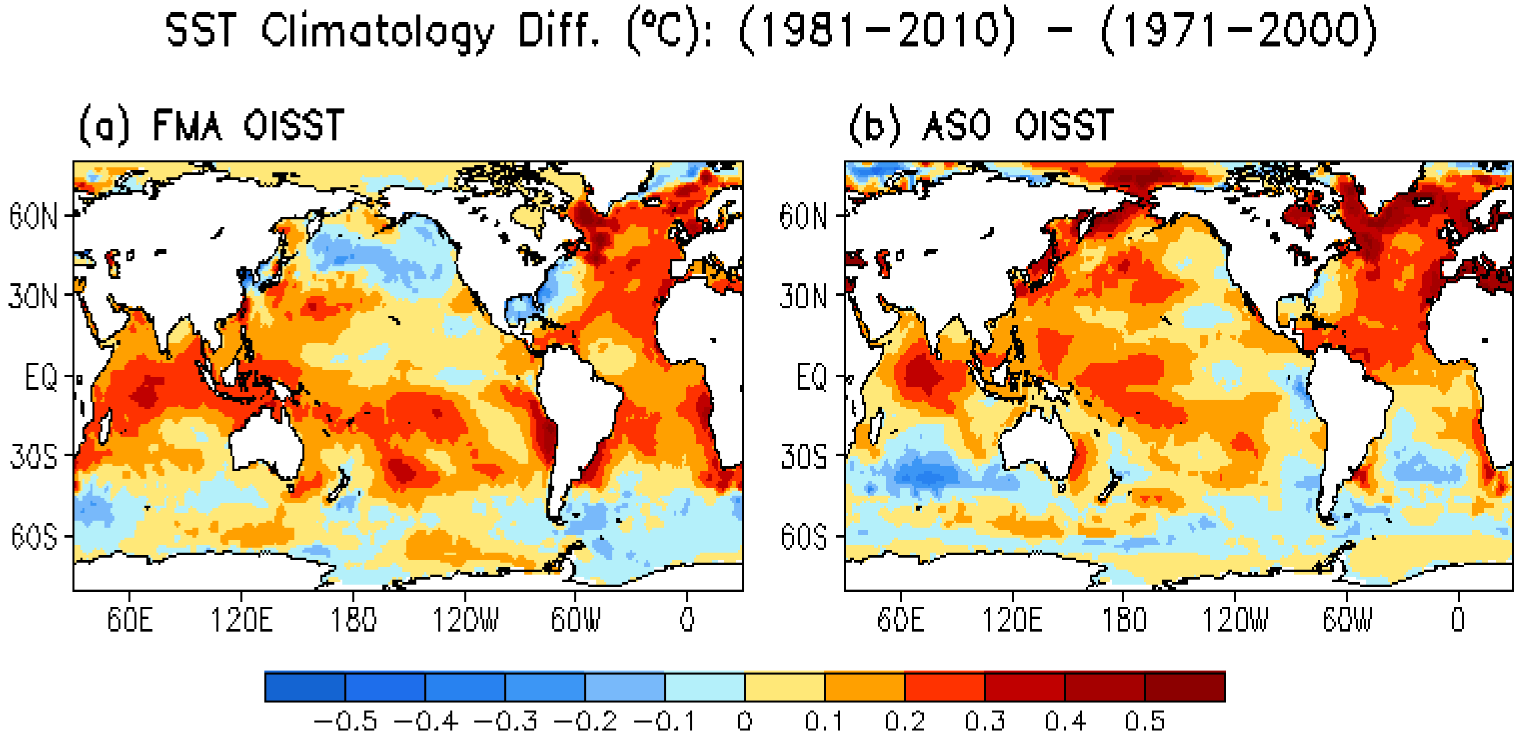
- **Pacific and Arctic Oceans**
  - **ENSO cycle: ENSO-neutral conditions prevailed with OISST NINO3.4=-0.18°C in June 2011.**
  - **NOAA/NCEP Climate Forecast System (CFS) suggests that the ENSO-neutral conditions are expected at least through the boreal summer.**
  - **Negative PDO index intensified in June 2011.**
  - **Artic sea ice extent continued to decline in June 2011 and reached the second lowest in the satellite records.**
- **Indian Ocean**
  - **Neutral SSTA conditions dominated in the deep tropical Indian Ocean.**
- **Atlantic Ocean**
  - **NAO became below-normal in June 2011.**
  - **Tripole SSTA pattern has weakened since Feb 2011.**
  - **Positive SSTA continued in the Atlantic Hurricane Main Development Region.**
  - **Below-average equatorial SSTs emerged in the eastern Atlantic Ocean**

Backup Slides

Switch to 1981-2010 Climatology

- **SST from 1971-2000 to 1981-2010**
  - **Weekly OISST.v2, monthly ERSST.3b**
- **Atmospheric fields from 1979-1995 to 1981-2010**
  - **NCEP CDAS winds, sea level pressure, 200mb velocity potential, surface shortwave and longwave radiation, surface latent and sensible fluxes, relative humidity**
  - **Outgoing Long-wave Radiation**
- **Oceanic fields from 1982-2004 to 1981-2010**
  - **GODAS temperature, heat content, depth of 20^{o}C, sea surface height, mixed layer depth, tropical cyclone heat potential, surface currents, upwelling**
- **Satellite data climatology 1993-2005 unchanged**
  - **Aviso Altimetry Sea Surface Height**
  - **Ocean Surface Current Analyses – Realtime (OSCAR)**

Be aware that new climatology (1981-2010) was applied since Jan 2011



1971-2000 SST Climatology (Xue et al. 2003): http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst_clim.htm

1981-2010 SST Climatology: http://origin.cpc.ncep.noaa.gov/products/people/yxue/sstclim/

- **The seasonal mean SST in February-April (FMA) increased by more than 0.2°C over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2°C in high-latitude N. Pacific, Gulf of Mexico and along the east coast of U.S.**
- **Compared to FMA, the seasonal mean SST in August-October (ASO) has a stronger warming in the tropical N. Atlantic, N. Pacific and Arctic Ocean, and a weaker cooling in Gulf of Mexico and along the east coast of U.S.**

Data Sources and References

- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **SST 1971-2000 base period means (Xue et al. 2003)**
- **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!