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

Prepared by

Climate Prediction Center, NCEP

May 6, 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)

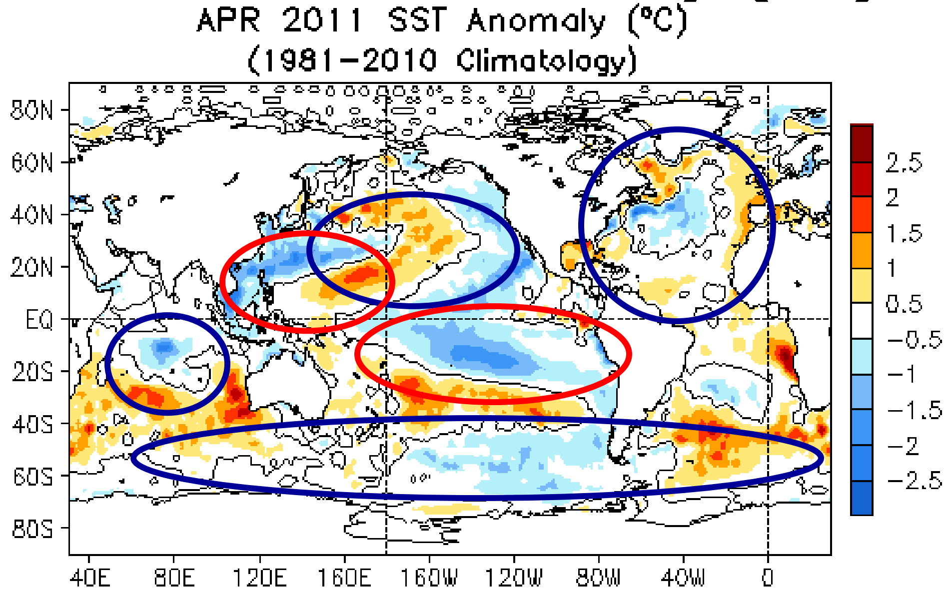
Outline

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

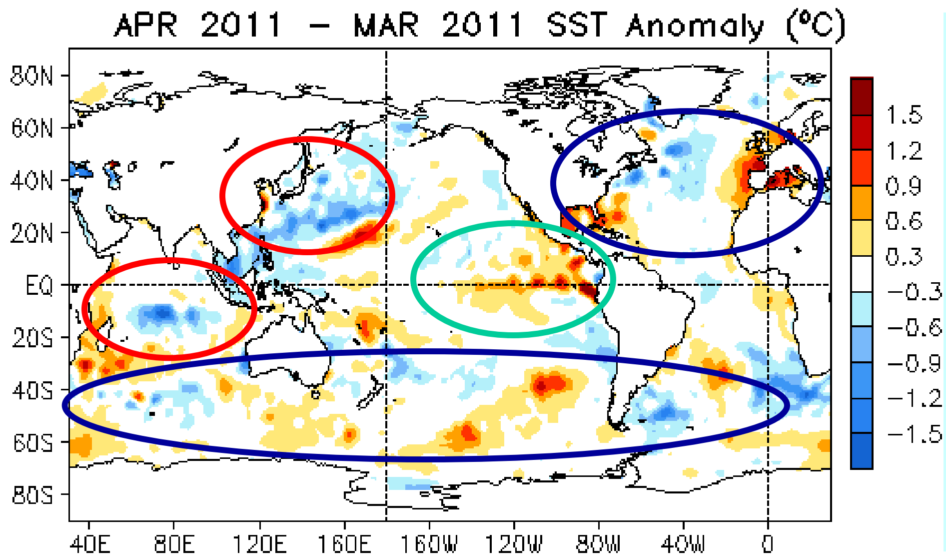
Overview

- **Pacific and Arctic Oceans**
  - **ENSO cycle: La Niña conditions continuously weakened with OISST NINO3.4=-0.77°C in Apr 2011.**
  - **NOAA/NCEP Climate Forecast System (CFS) suggests that the current La Niña is in a decay phase, and ENSO will be near neutral by May 2011.**
  - **PDO has been negative since Jun 2010, and weakened slightly since Jan 2011 with PDO index=-1.04 in Apr 2011, consistent with La Nina evolution.**
  - **Anomalous upwelling observed along the west coast of North America in Apr 2011, which might not be the dominant factor contributing to the below-normal nutrient supply in this month.**
  - **Artic sea ice extent was still well below normal in Apr 2011.**
- **Indian Ocean**
  - **Negative SSTA was dominated.**
- **Atlantic Ocean**
  - **After 16 month persistent negative phase (Oct 2009-Jan2011), NAO has switched to positive phase since Feb 2011 with NAO index = 2.5 in Apr 2011.**
  - **Tripole SSTA pattern has weakened since Feb 2011.**

Global SST Anomaly (^0C) and Anomaly Tendency



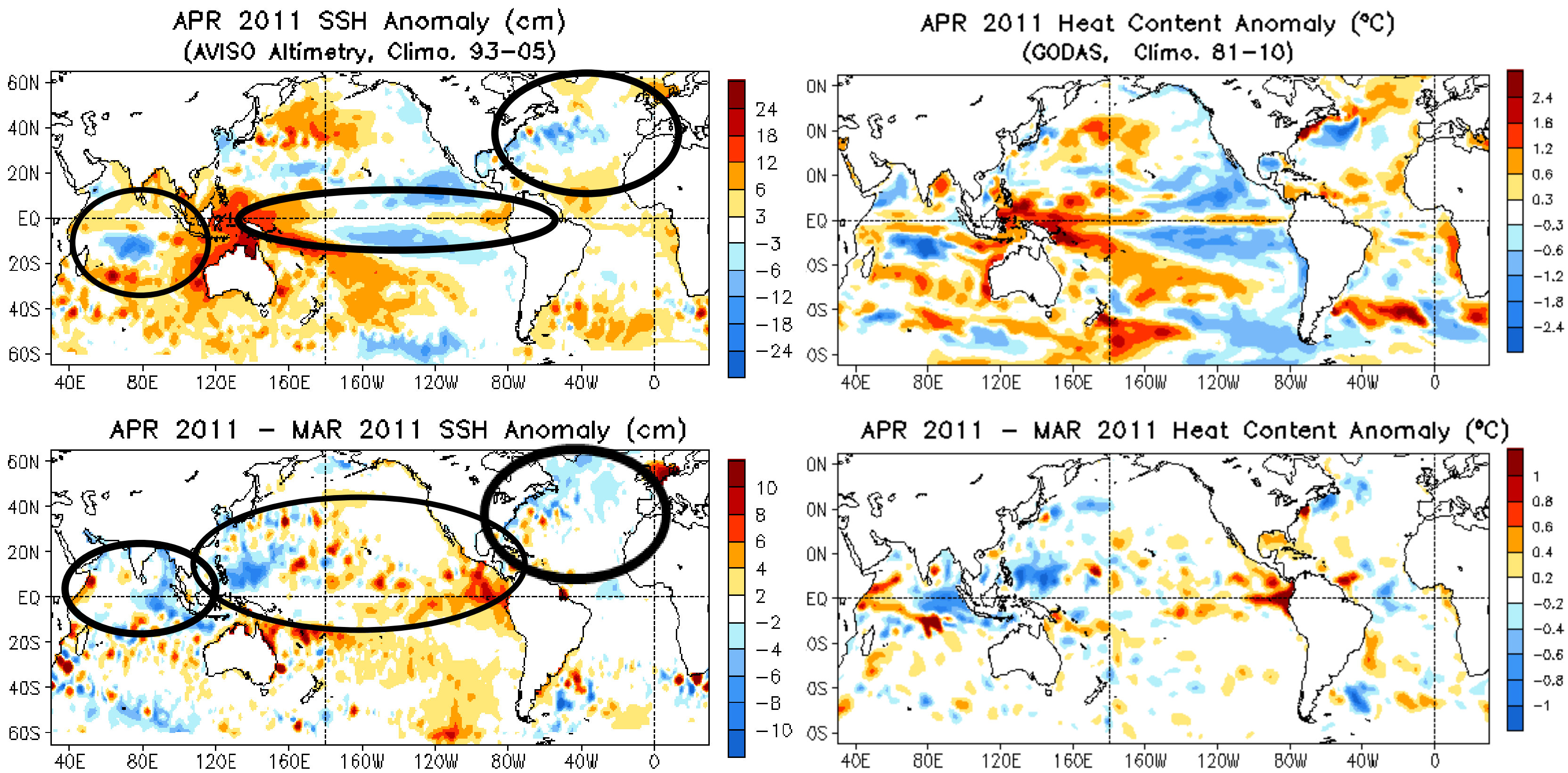
- La Nina conditions weakened continuously in the tropical central and eastern Pacific.
- SST anomaly pattern in both N & S Pacific Oceans resembles SST composites of La Nina, suggesting a connection between PDO and ENSO.
- Negative SSTA was in the Indian Ocean.
- A tripole SSTA pattern existed in North Atlantic.
- Positive SSTA was seen in mid-latitude southern oceans.



- La Nina conditions continue to weaken with positive SSTA tendency in the central and eastern tropical Pacific Ocean. Also, negative SSTA in the NW Pacific intensified.
- Cooling tendency presented in the tropical central S. Indian Ocean.
- Strong warming (cooling) tendency in the Gulf of Mexico and along the European coast(North American coast to central N. Atlantic Ocean).
- Large SSTA tendency was observed over the mid-latitude southern oceans.

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



- **In the tropical Pacific Ocean, negative (positive) SSHA and HCA presented in the central and eastern (western) basin, but the anomalies along the equatorial central and eastern Pacific weakened significantly and were positive in Apr 2011, which may result from the eastward propagation of positive anomalies by oceanic kelvin waves.**

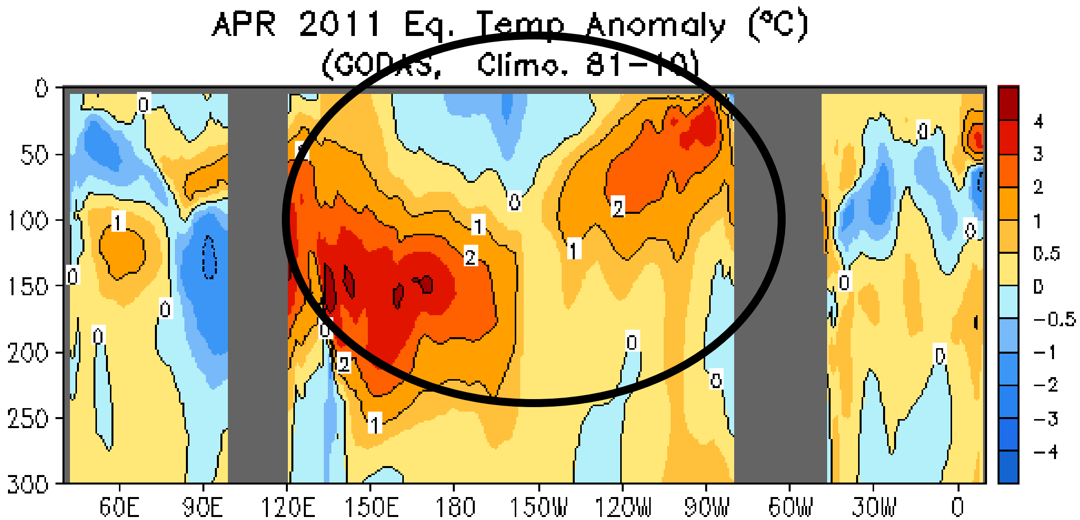
- **In the tropical Indian Ocean, positive SSHA and HCA in the eastern basin weakened. SST cooled down substantially in the tropical southern Indian Ocean, which is consistent with below-normal HC and SSH in the region.**

- **In the high latitude of North Atlantic, tripole SSHA and HCA still presented.**

- **SSHA and HCA anomalies as well as their tendencies were largely consistent, except in the Southern Ocean where biases in GODAS climatology are large (not shown).**

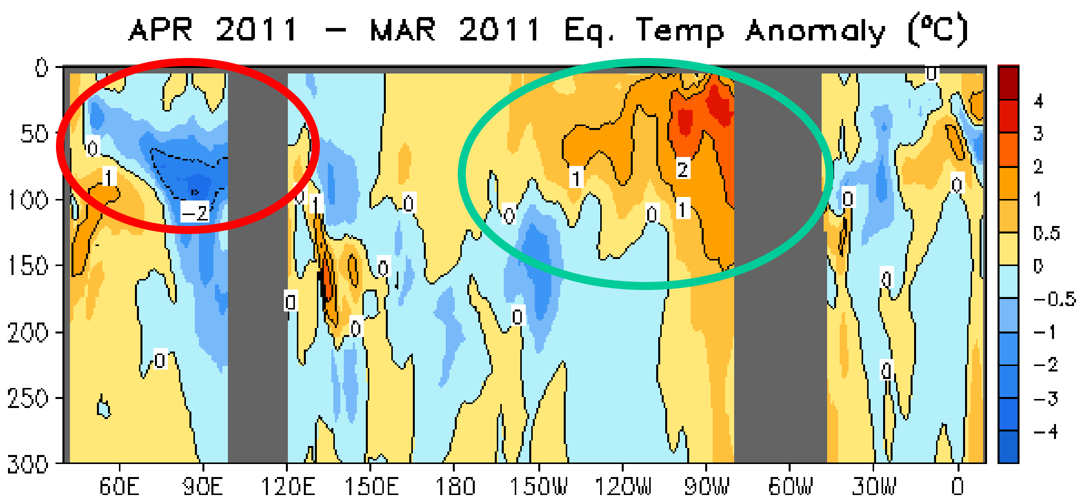
Fig. G2. Sea surface height anomalies (SSHA, top left), SSHA tendency (bottom left), top 300m heat content anomalies (HCA, top right), and HCA tendency (bottom right). SSHA are derived from http://www.aviso.oceanobs.com, and HCA from GODAS.

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



- Positive ocean temperature anomalies extented from western to the eastern Pacific along the thermocline layer and intensified in the east, which contribute to the weakening of the La Niña conditions.

- Both negative and positive temperature anomalies presented near the thermocline in the equatorial Indian Ocean and Atlantic Oceans.



- Temperature increased across much of the equatorial Pacific, particularly between 150^{o}W-90^{o}W, indicating the weakening tendency of the La Nina conditions.

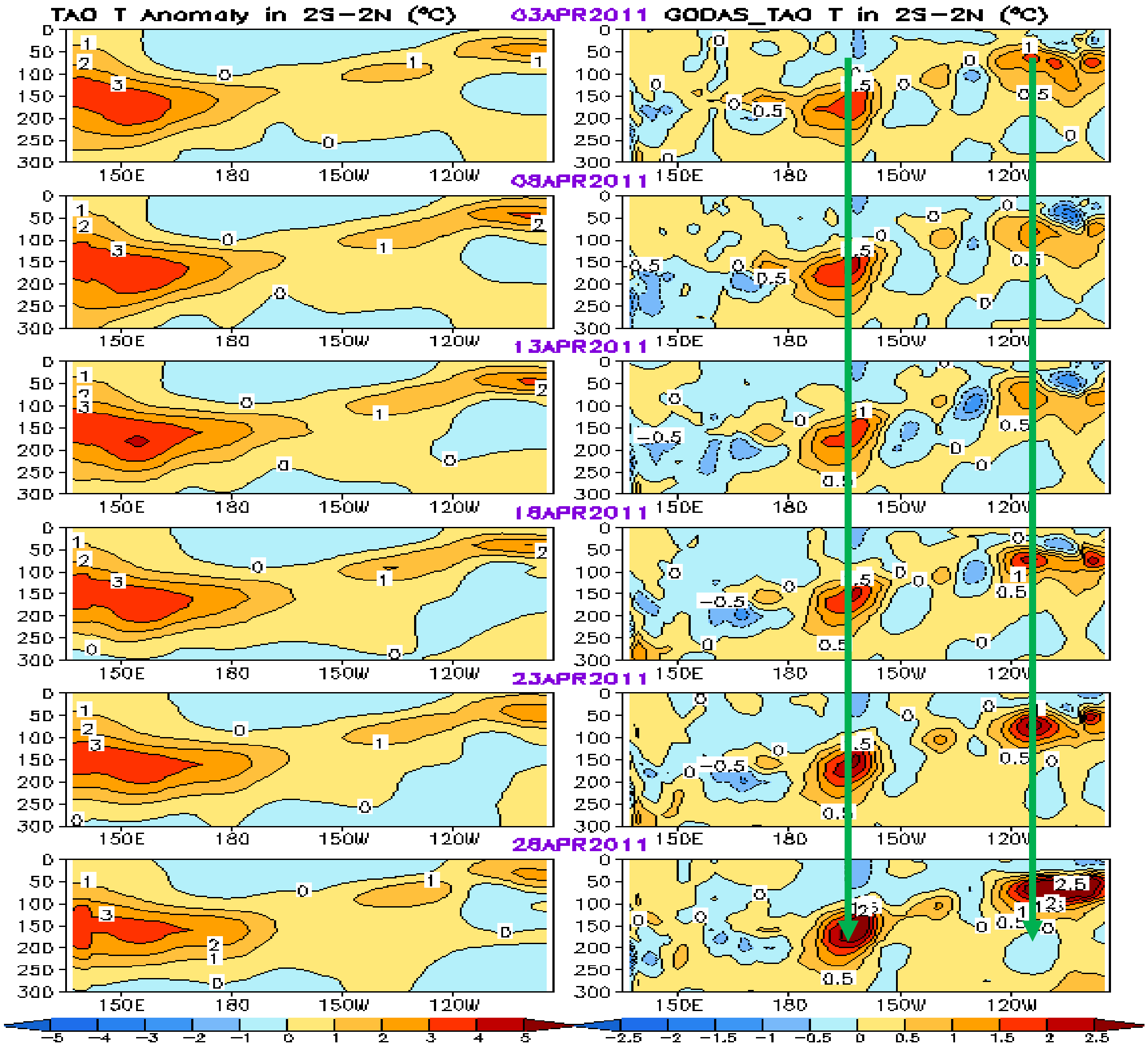
- Negative temperature anomaly tendency presented in the equatorial C. and E. Indian Ocean.

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

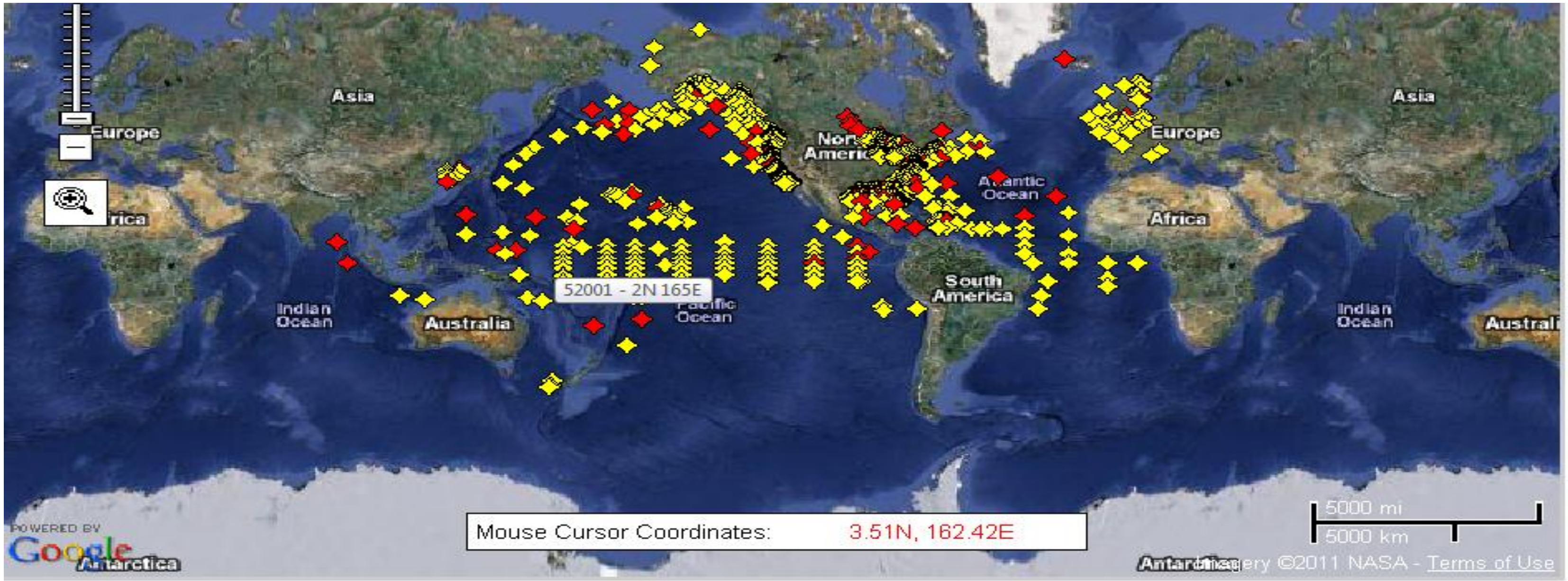
Equatorial Pacific Temperature Anomaly

TAO GODAS-TAO



- Compared with TAO, GODAS has clear warm biases in recent months with amplitude larger than 2C between 170W-160W around 200m and 3C between 120W-90W in the top 75m.
- Some TAO moorings have failed to delivery data in 2010-2011, which might have contributed to the large differences between TAO and GODAS.

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



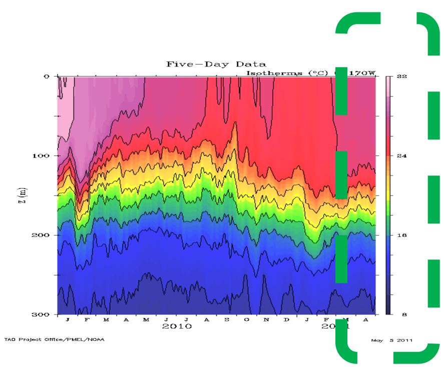
- Stations with recent data
- Stations with historical data only
- Stations with no data in last 8 hours (24 hours for tsunami stations)
- Tsunami station in event mode (within previous 24 hours)

1060 stations deployed
894 have reported in the past 8 hours

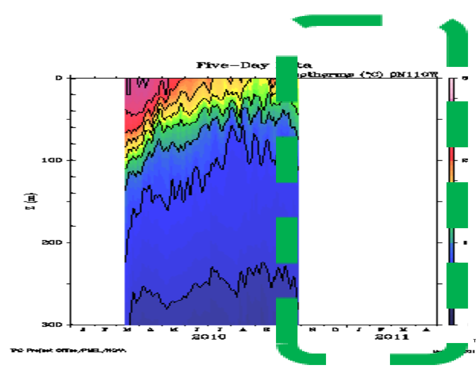
Disclaimer

Get Observations by Program as KML

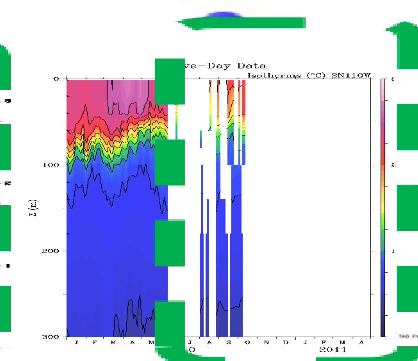
Get Observations by Owner as KML



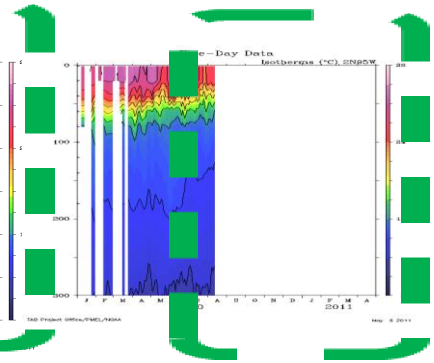
(0, 170°W)



(0°N, 110°W)



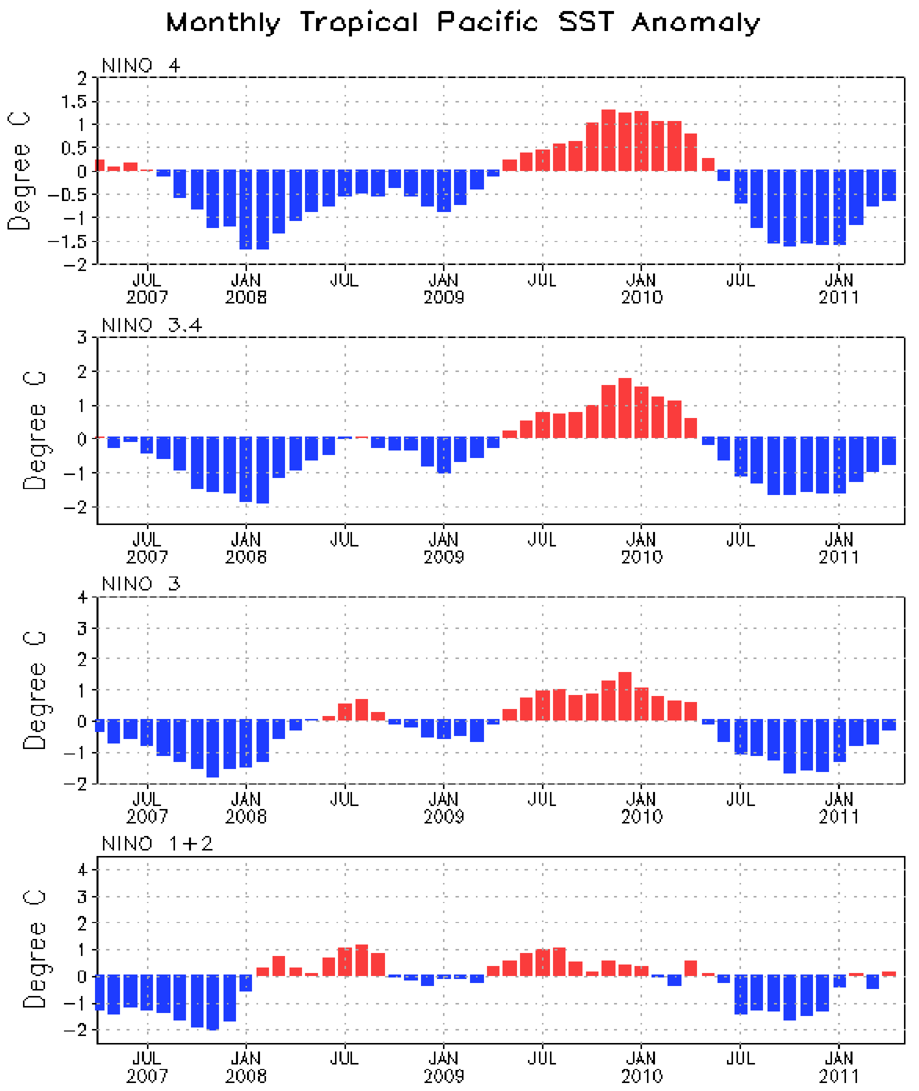
(2°N, 110°W)

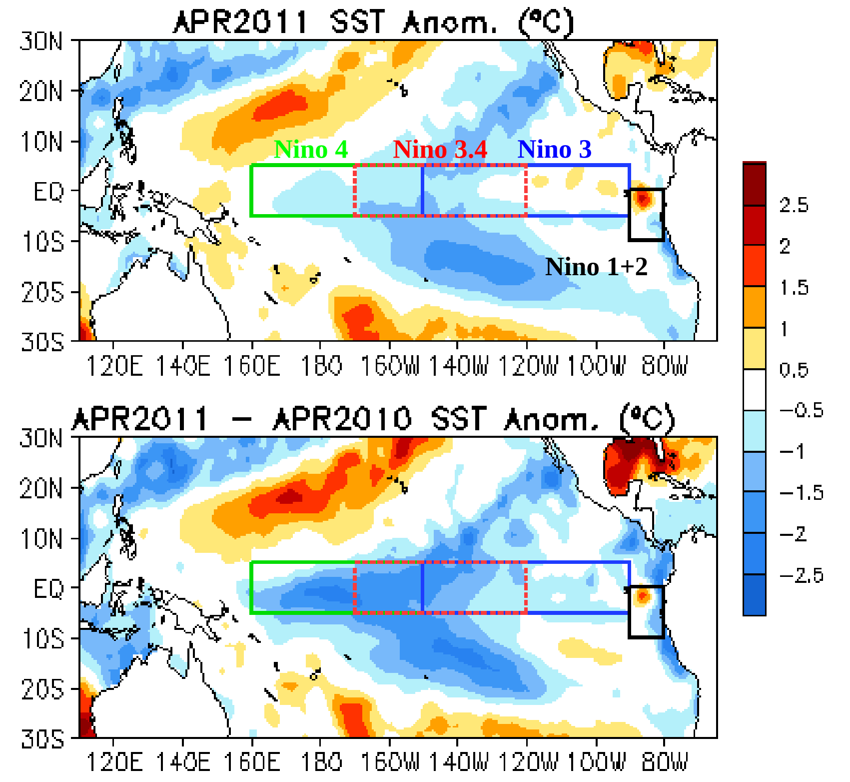


(2°N, 95°W)

Tropical Pacific Ocean

Evolution of Pacific NINO SST Indices



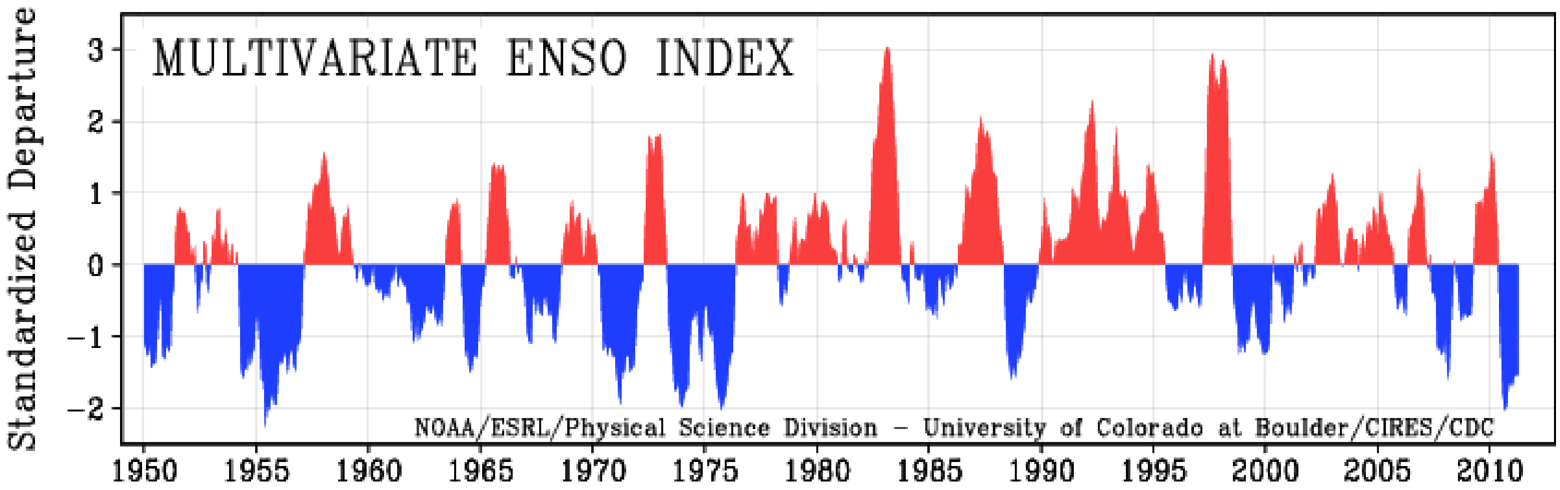


- All NINO indices weakened continuously since Jan 2011 or Dec 2010, except Nino1+2 which was near neutral since Jan 2011, and NINO3.4=-0.77 in Apr 2011.

- 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 1981-2010 base period means.

MEI updated on May 5th, 2011



- **Strong negative MEI.**
- **Atmospheric anomalies associated with the La Nina are still pronounced, although the SSTA has been decreasing significantly in Nino index regions.**

The Multivariate ENSO Index (MEI) defined based on the six main observed variables over the tropical Pacific:

Sea-level pressure (P)

Zonal (U) components of the surface wind

Meridional (V) components of the surface wind

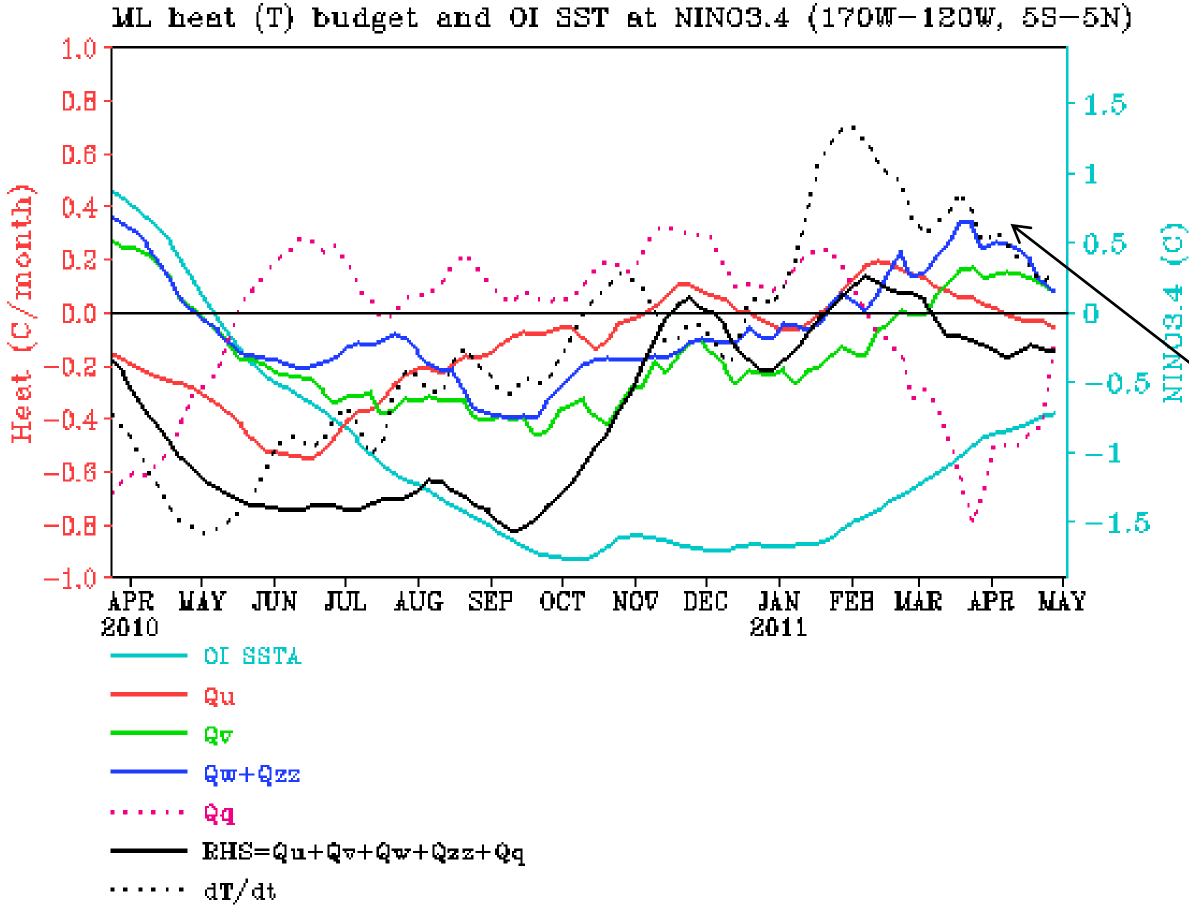
Sea surface temperature (S)

Surface air temperature (A)

Total cloudiness fraction of the sky (C)

From: http://www.esrl.noaa.gov/psd/people/klaus.wolter/MEI/

NINO3.4 Heat Budget



- Tendency (dT/dt) in NINO 3.4 (dotted line) has been positive since Jan 2011, indicating the weakening of La Nina.

- Dynamical terms (Qv, Qw+Qzz) were positive, but Qu was small negative in Apr 2011.

- The thermodynamic term (Qq) was positive during Jun 2010-Jan 2011, and negative since Feb 2011, peaked in late Mar 2011.

- The total heat budget term (RHS) indicated a warming tendency in Feb 2011 and cooling tendency since Mar 2011, but the cold bias seen compared with dT/dt, particularly since Jan 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;

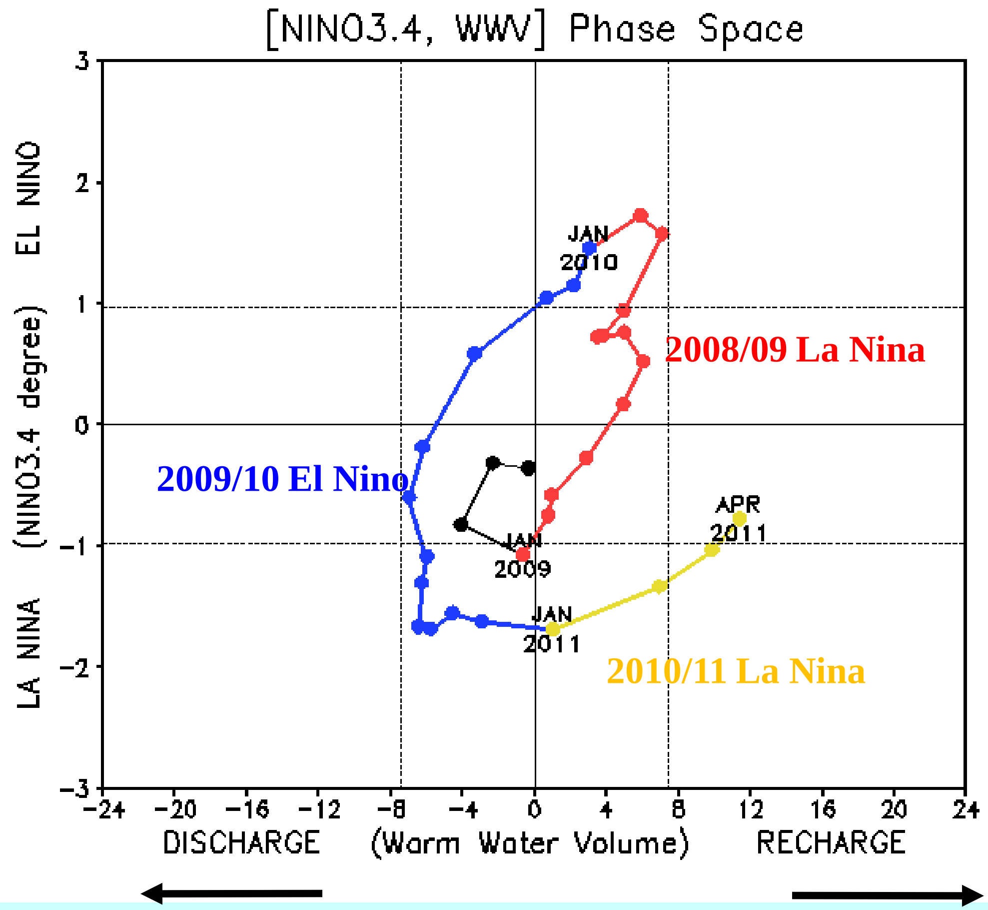
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

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.



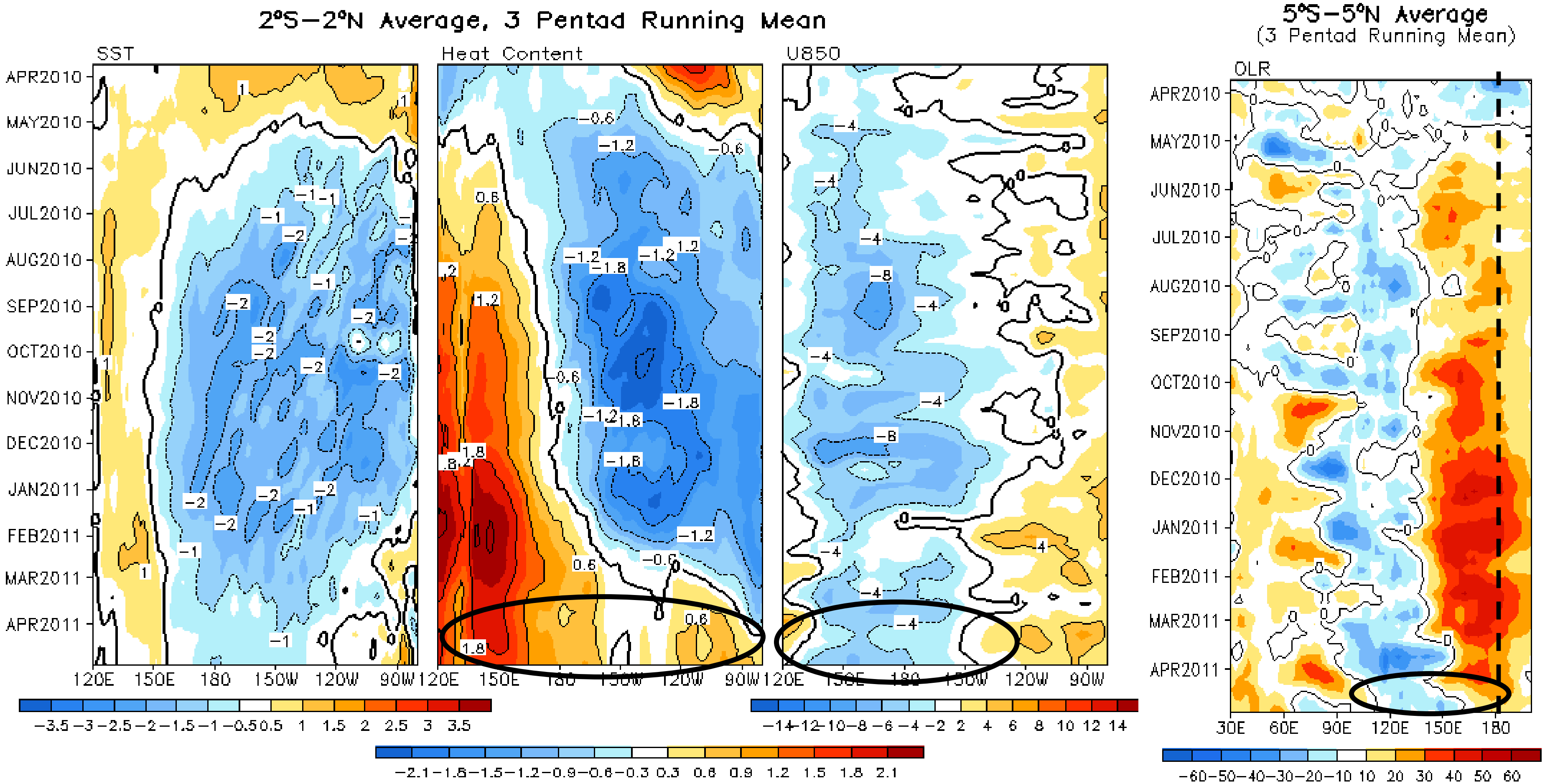
- Nino3.4 became less than -1ºC since Jul 2010, indicating moderate-strong La Nina conditions. Nino3.4 has persisted from Sep 2010 to Jan 2011 and weakened since Feb 2011.

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

- Overall consisted with the weakening tendency of La Nina conditions.

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 (1981-2010) base period means.

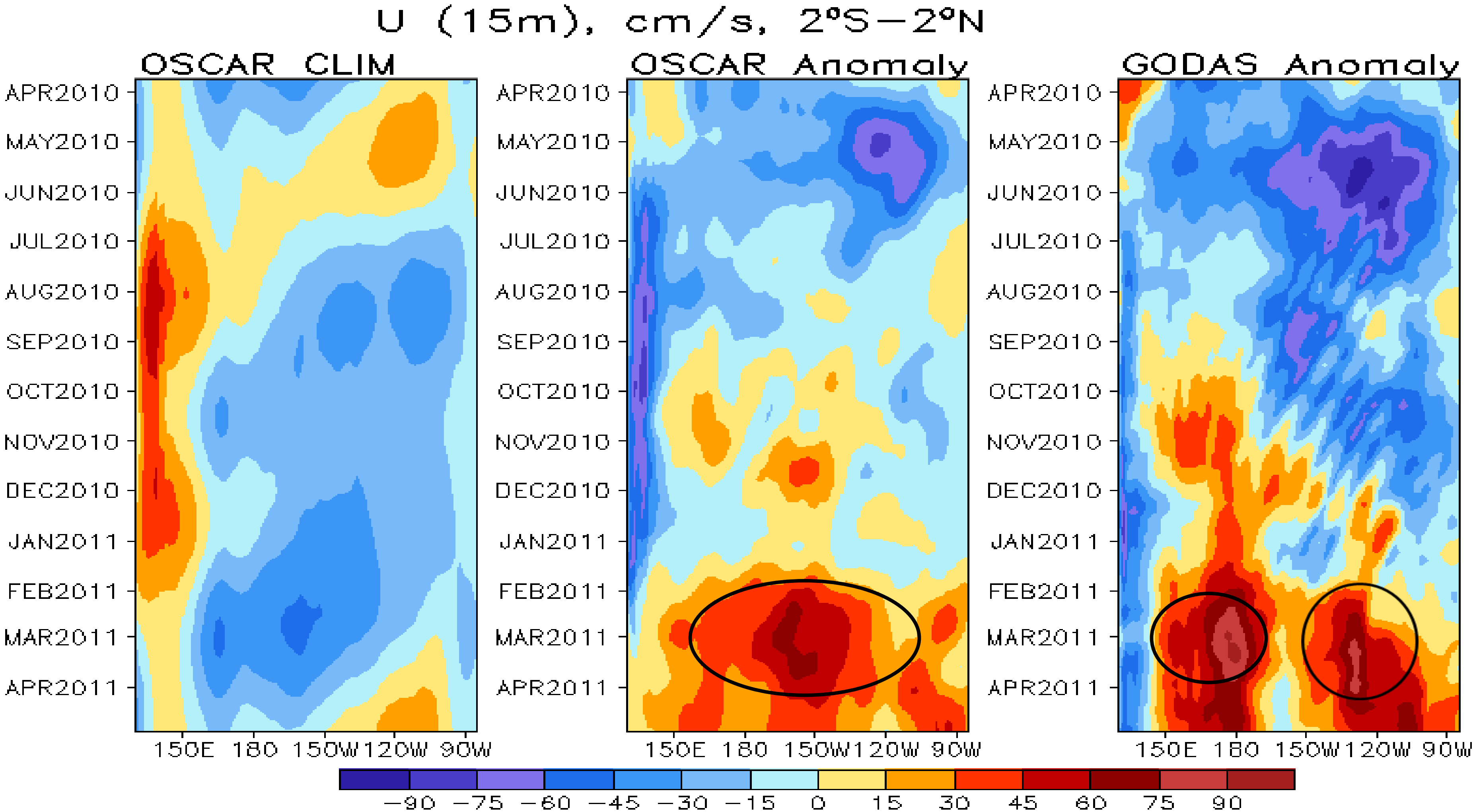
Evolution of Equatorial Pacific SST (ºC), 0-300m Heat Content (ºC), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly



- Positive HC300A presented in the whole equatorial Pacific, in response to the warming of subsurface ocean.
- The convection was enhanced (suppressed) over the Maritime Continents (the central Pacific). Weakening of the suppressed convection was evident in the equatorial central Pacific since mid-Mar 2011.

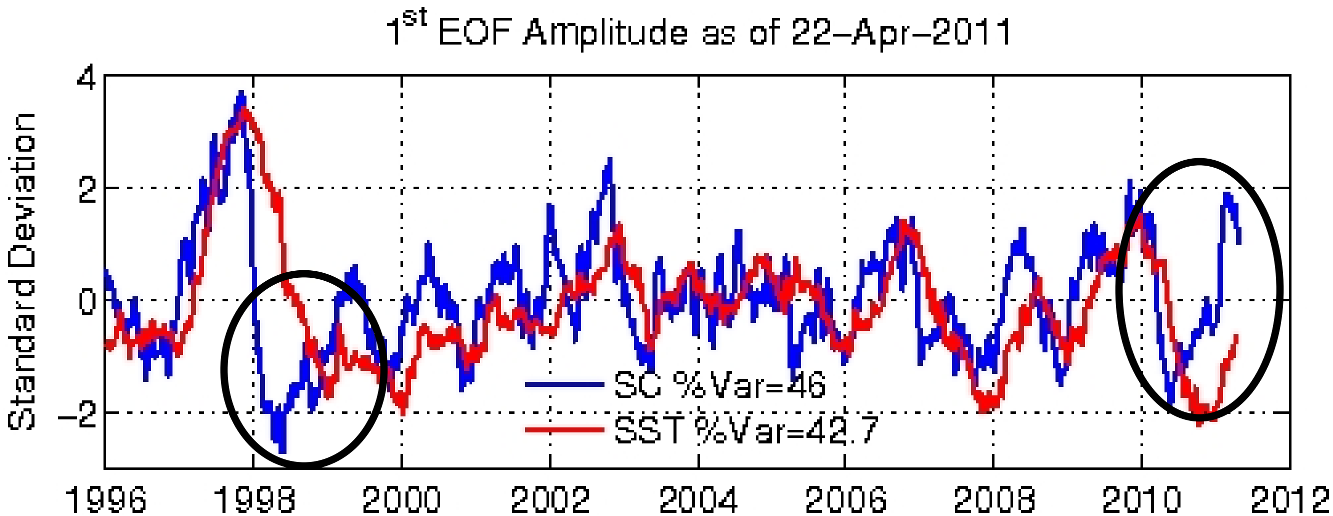
Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. SST is derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1981-2010, 1982-2004, 1979-1995 base period pentad means respectively.

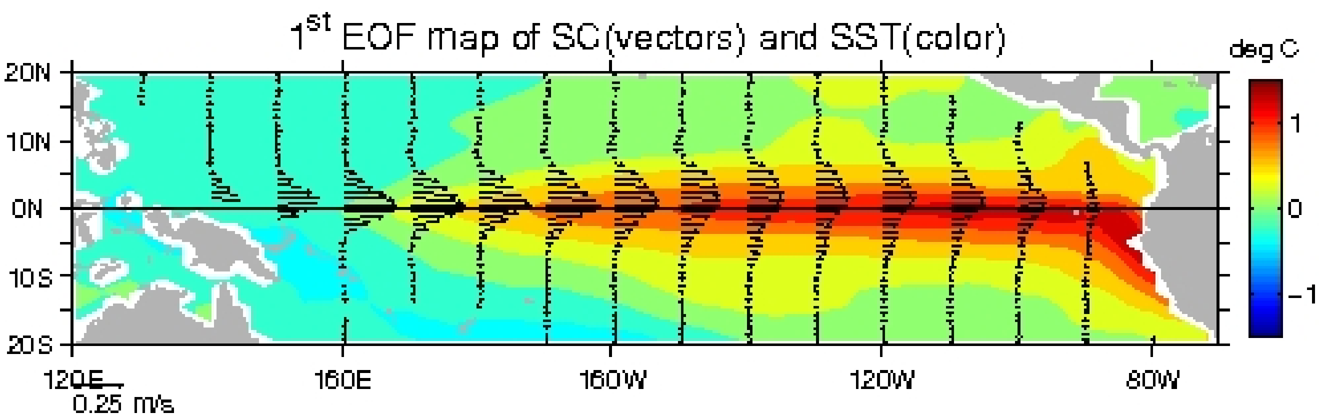
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Eastward anomalous current in the central and eastern equatorial Pacific presented since late Jan 2011 and peaked in Mar 2011, implying zonal advection contribution to the weakening tendency associated with the La Niña conditions.
- Anomalous zonal current had one maximum center between 180°-150°W in OSCAR, and two maximum centers around 180° and 130°W, respectively, in the GODAS, during Feb-Mar 2011.

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





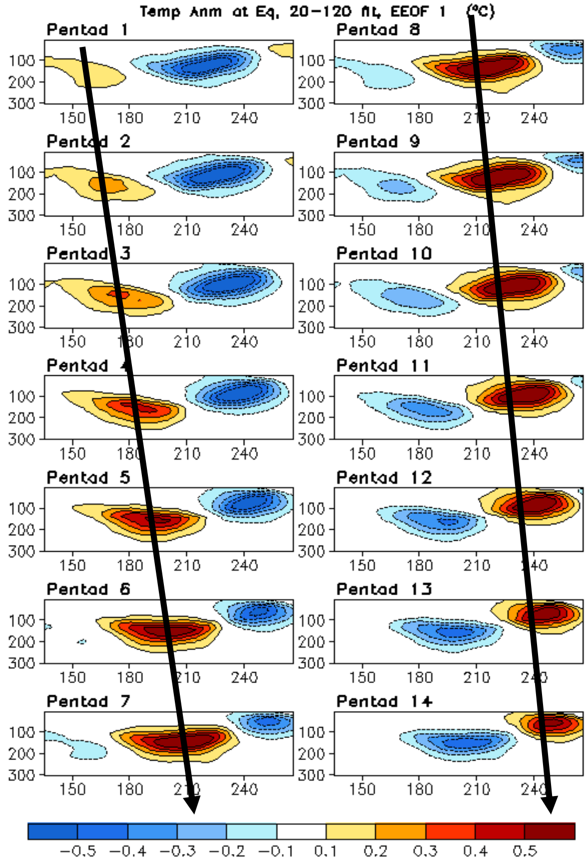
- Westward surface zonal current anomaly has weakened rapidly since Jul 2010, and the zonal current anomaly has become eastward since Dec 2010.

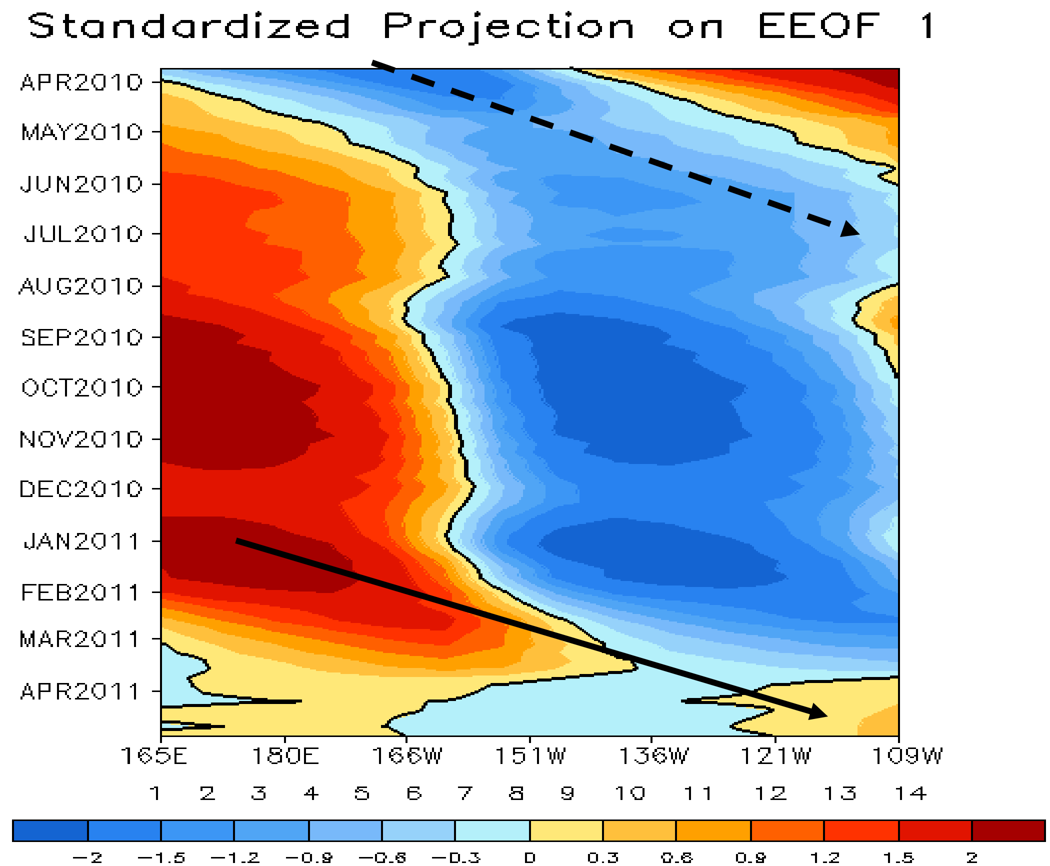
- On average, ocean surface zonal current anomaly leads the SSTA by a few months.

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)

Oceanic Kelvin Wave Indices

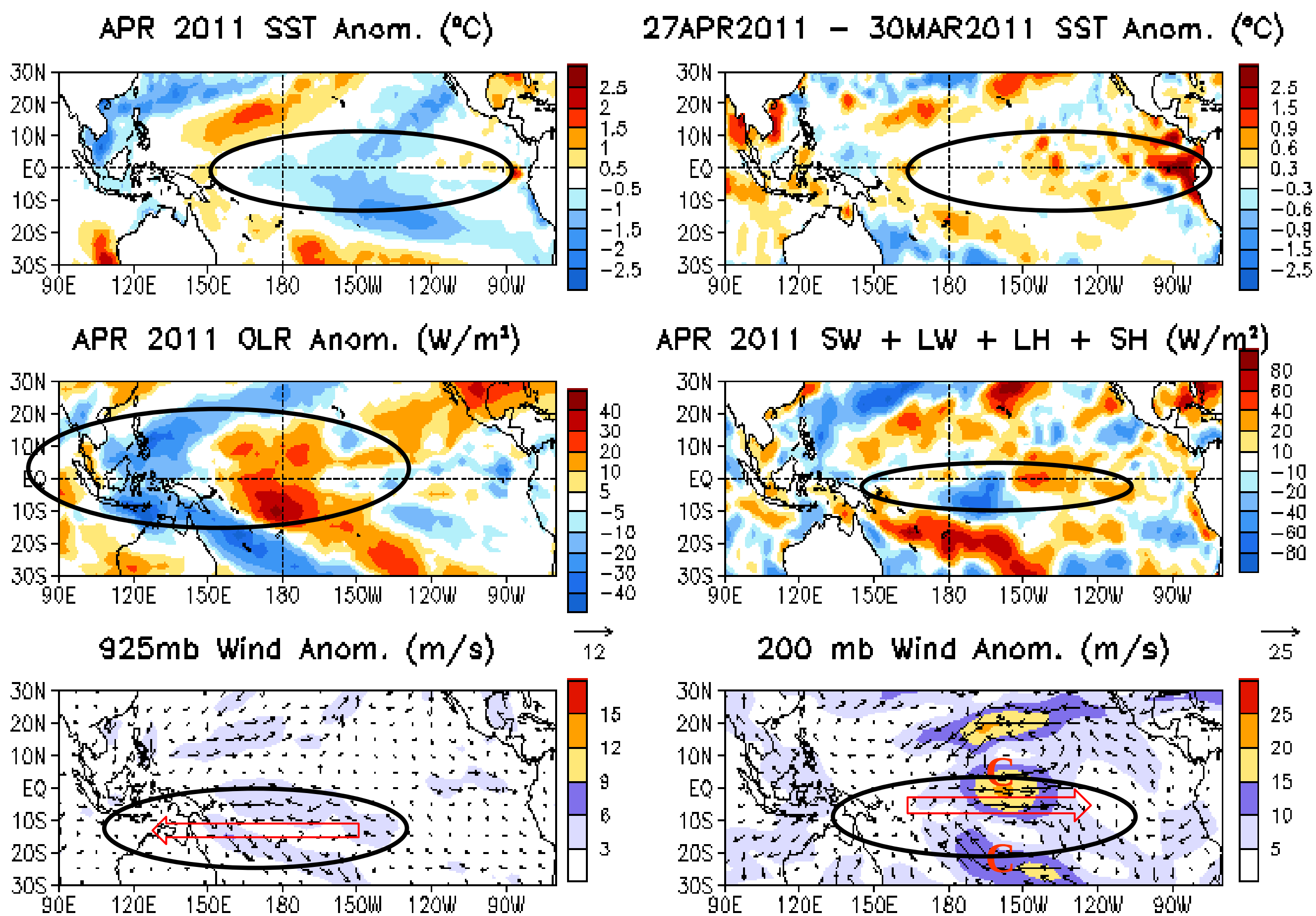




- Downwelling Kelvin wave observed in late Jan 2011 in the W. Pacific and propagated eastward, which may be a reason causing the weakening tendency of the La Nina event.

- **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.**

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

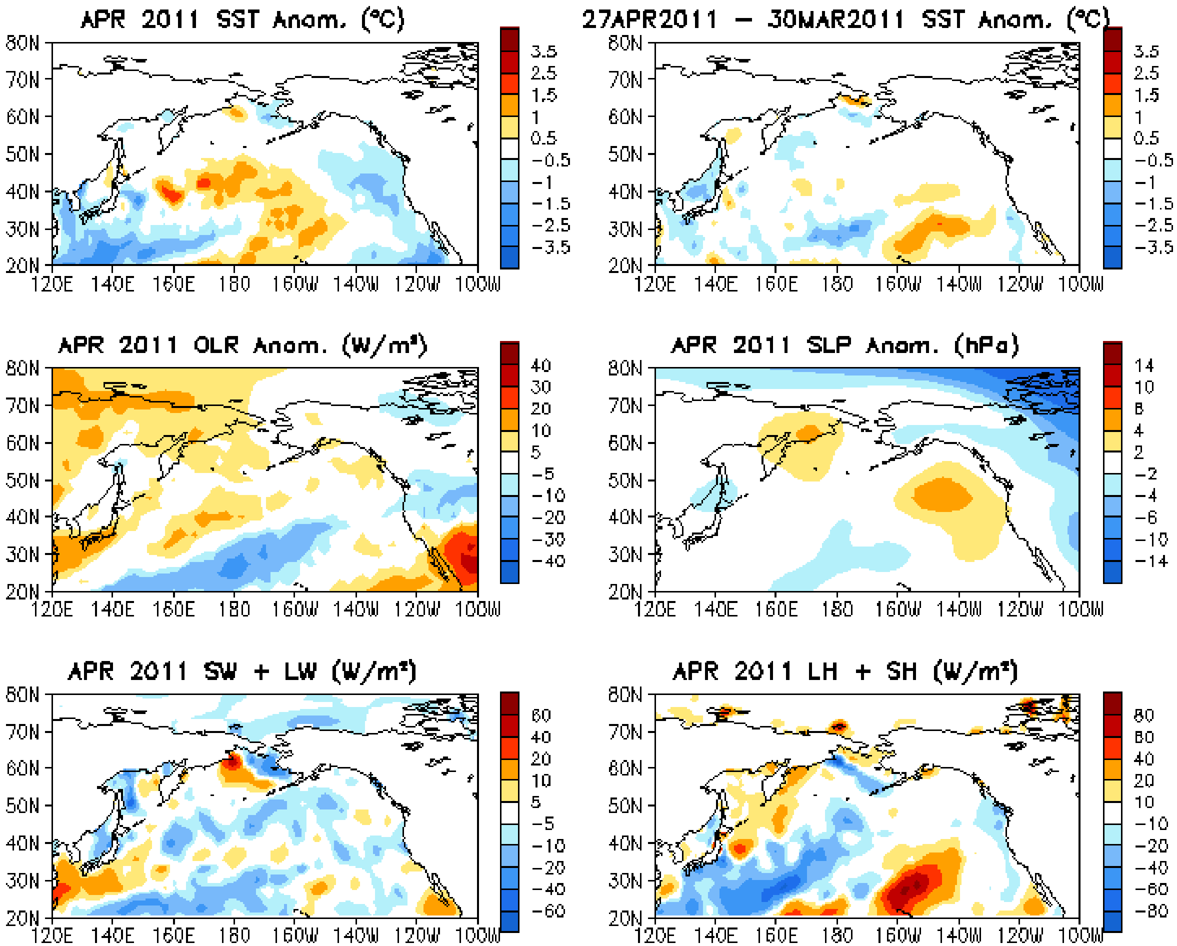


- **Negative SSTA weakened in the eastern-central equatorial Pacific in Apr 2011.**
- **Convection was active (suppressed) over the Maritime Continent (central tropical Pacific).**
- **Net surface heat flux anomalies damped the negative SSTA along the equator between 150°W-120°W.**
- **Easterly (westerly) wind anomaly in low (high) level in the western and central (central-eastern) equatorial Pacific persisted in Apr 2011.**

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 1981-2010 base period means.

North Pacific & Arctic Ocean

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



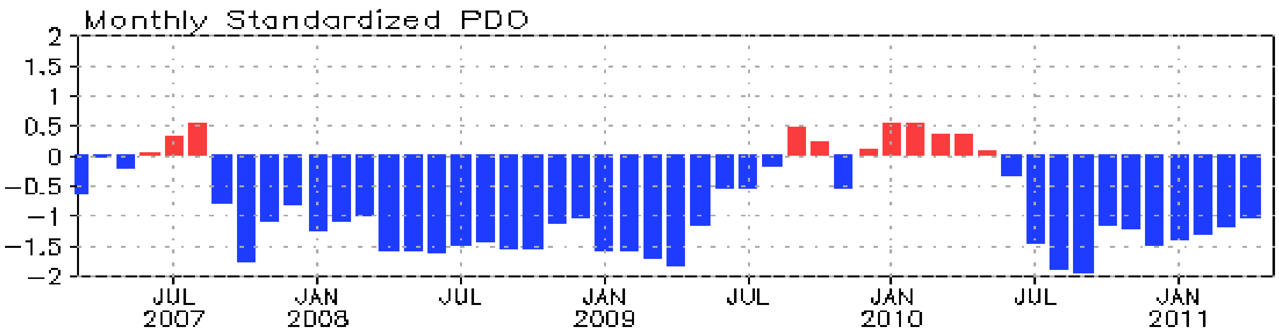
- Positive (negative) SSTA was observed in the central (eastern and southwest) N. Pacific in Apr 2011, consistent with the negative PDO index (next slide).

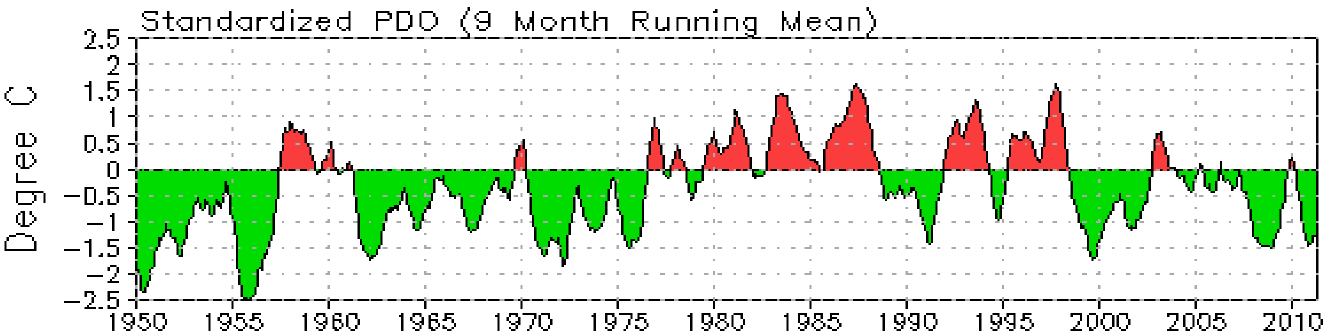
- Negative (positive) SSTA tendency presented in the west (central-east) and generally consists with total heat flux anomalies (LH+SH+SW+LW).

- Positive (negative) SLP anomaly in the Gulf of Alaska and near the coast of the Pacific Northwest (the central N. Pacific) implies anomalous northerly winds along the coast, which is favorable for upwelling.

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 1981-2010 base period means.

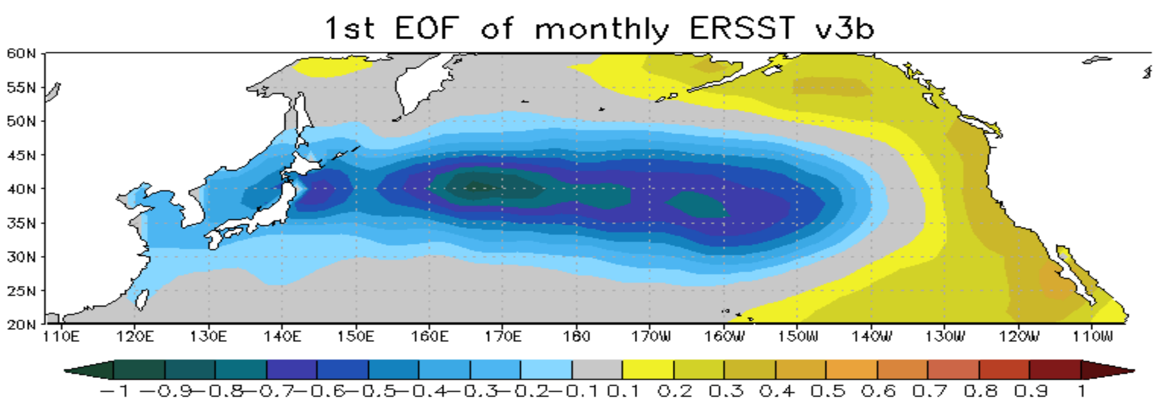
PDO index





- The PDO index was -1.04 in Apr 2011, and weakened slightly.

- The PDO index has been below normal since Jun 2010, which was coincident with the La Nina conditions.



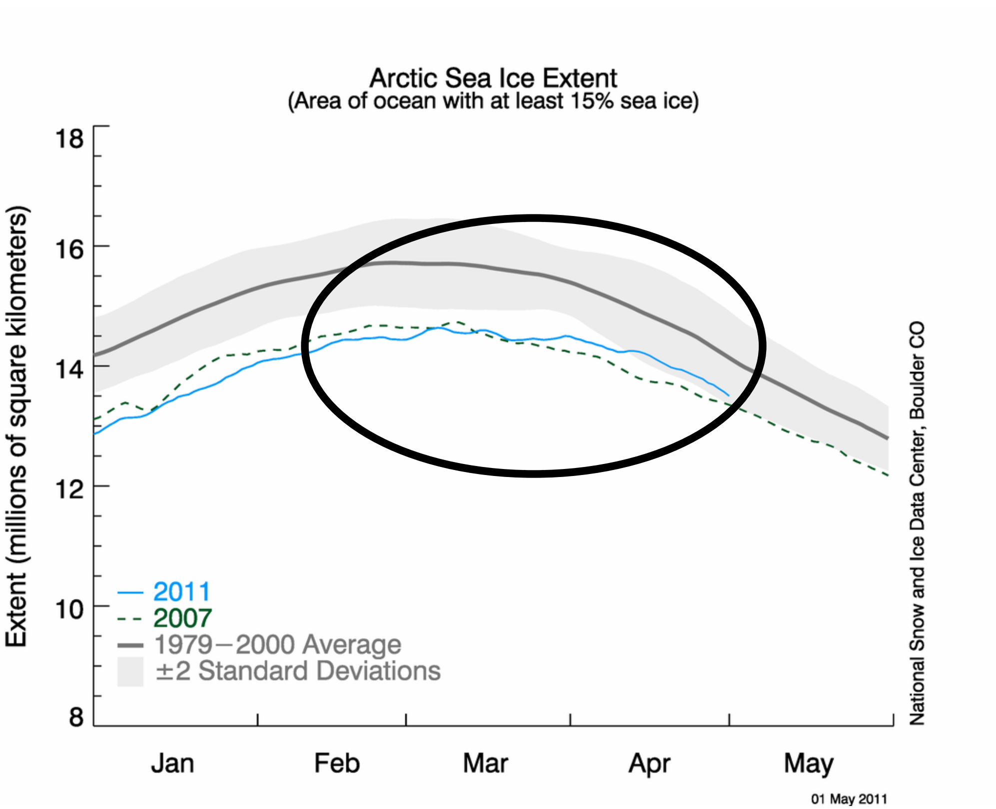
- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

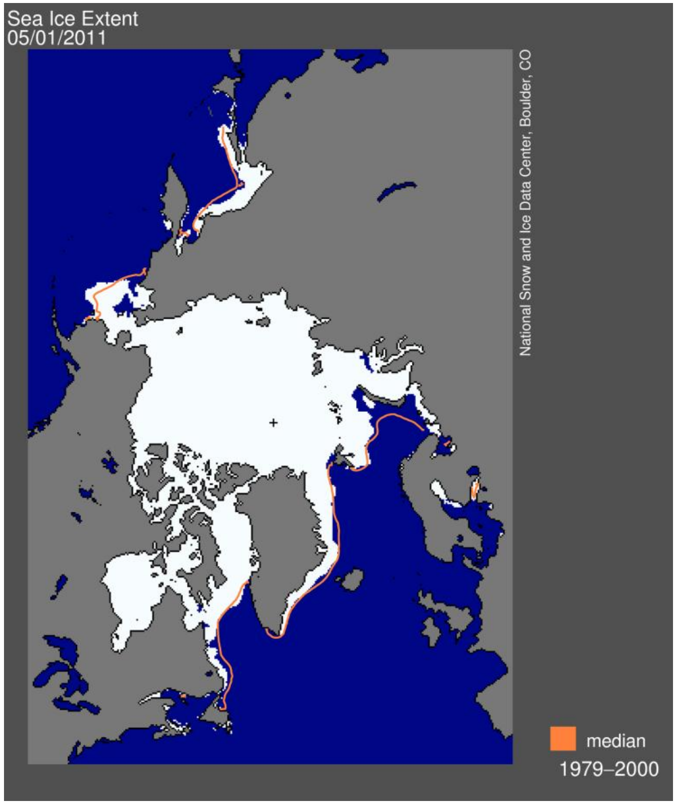
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

Arctic Sea Ice

National Snow and Ice Data Center

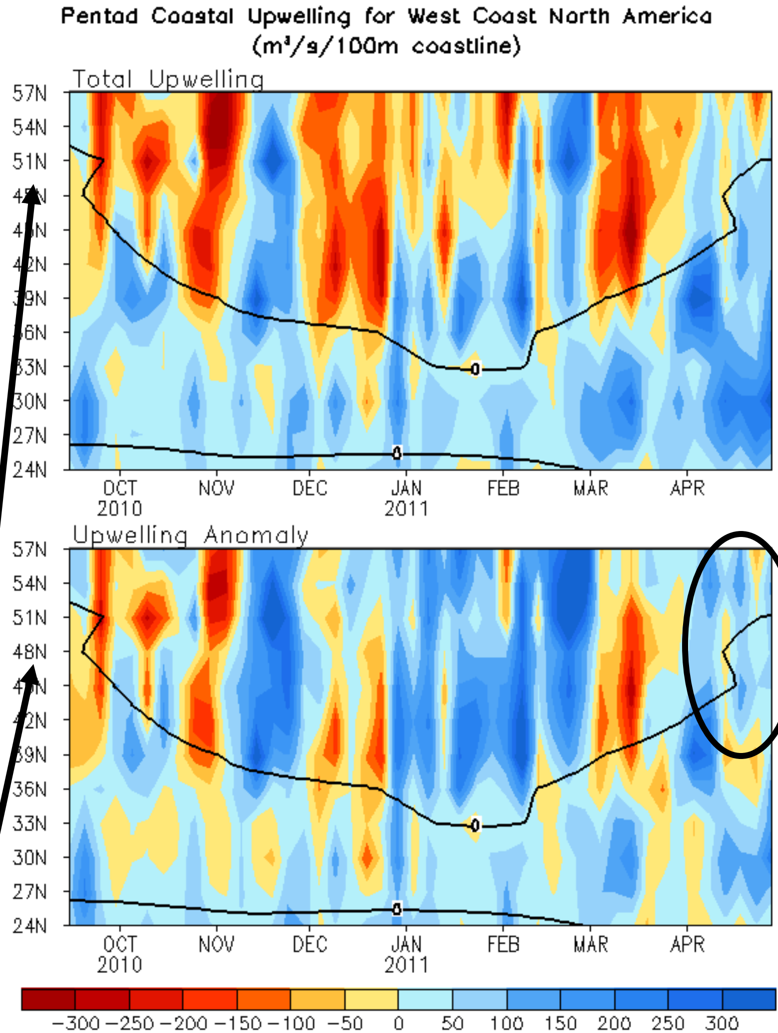
http://nsidc.org/arcticseaicenews/index.html

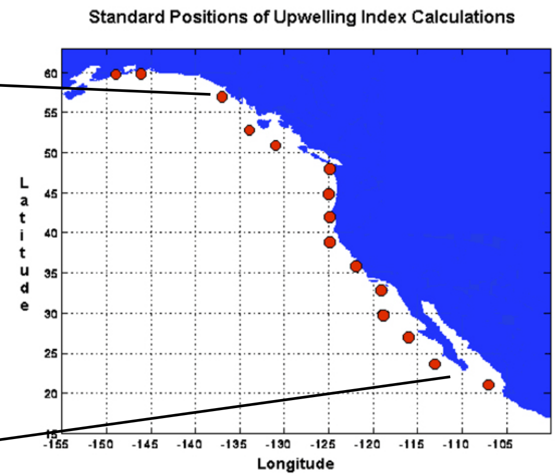




- **The Arctic sea ice extent was well blow normal in Apr 2011.**
- **The sea ice deficit was observed in both the North Atlantic and Pacific sectors.**

North America Western Coastal Upwelling



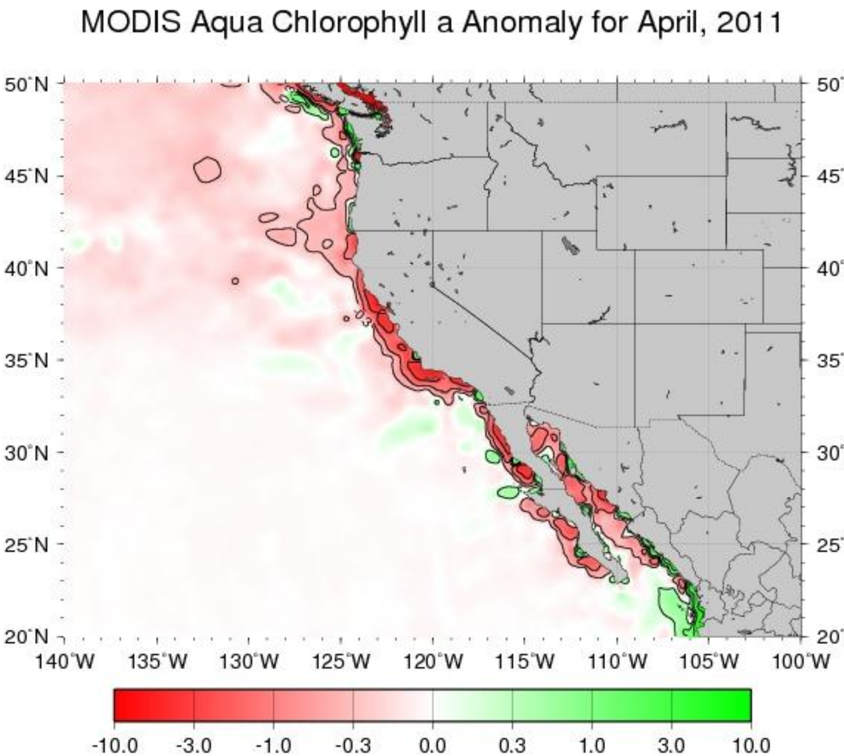


- **Anomalous upwelling observed at 39ºN-57ºN in Apr 2011, consistent with the SLP anomaly pattern along the coast.**

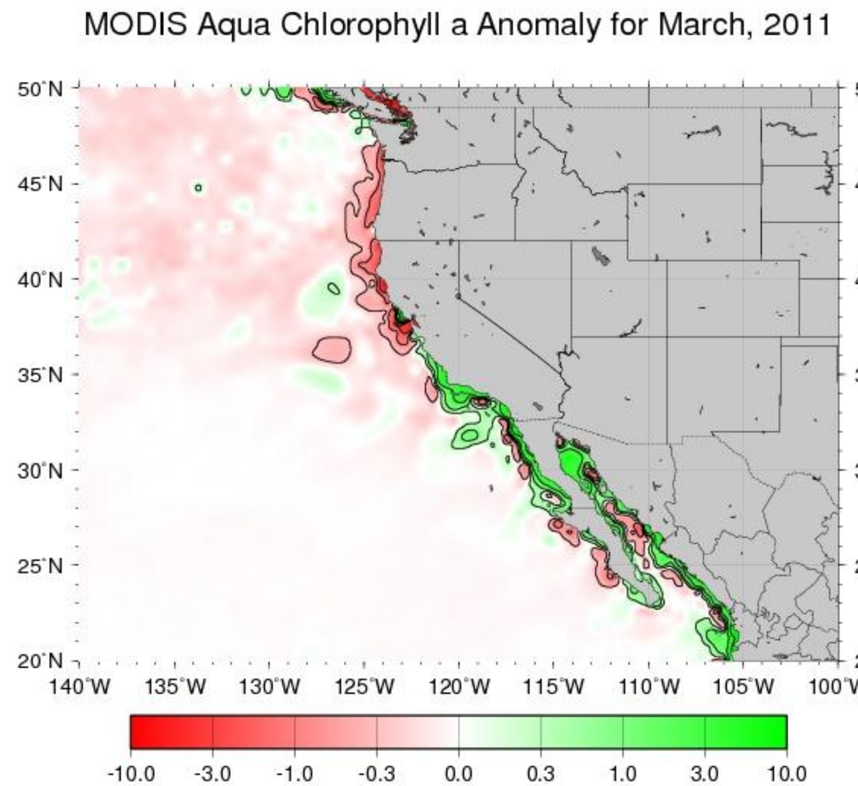
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport 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 36ºN to 57ºN.**

Monthly Chlorophyll Anomaly

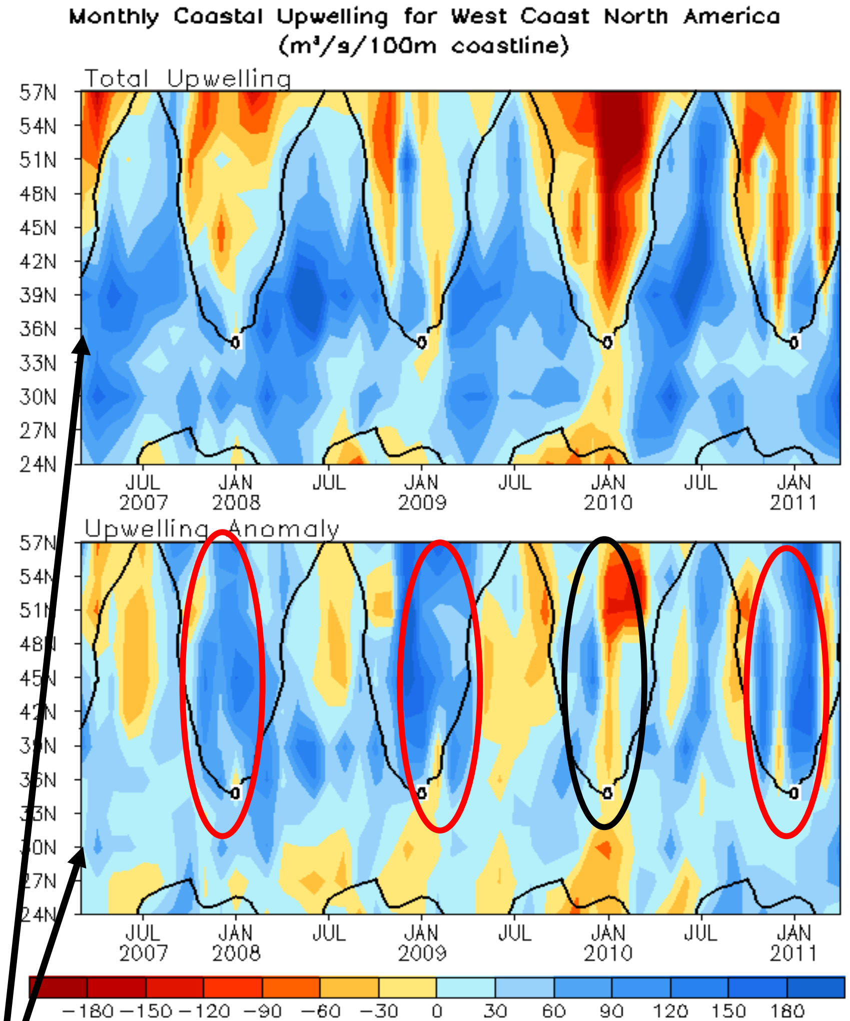


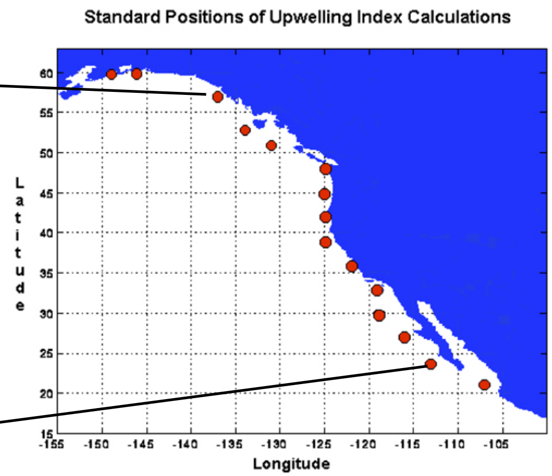
- **Negative chlorophyll anomalies dominated at 23°N-50°N in Apr 2011.**
- **That is not consistent with anomalous upwelling, suggesting that anomalous upwelling may not be the dominant factor causing the chlorophyll anomalies in this month.**



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

North America Western Coastal Upwelling





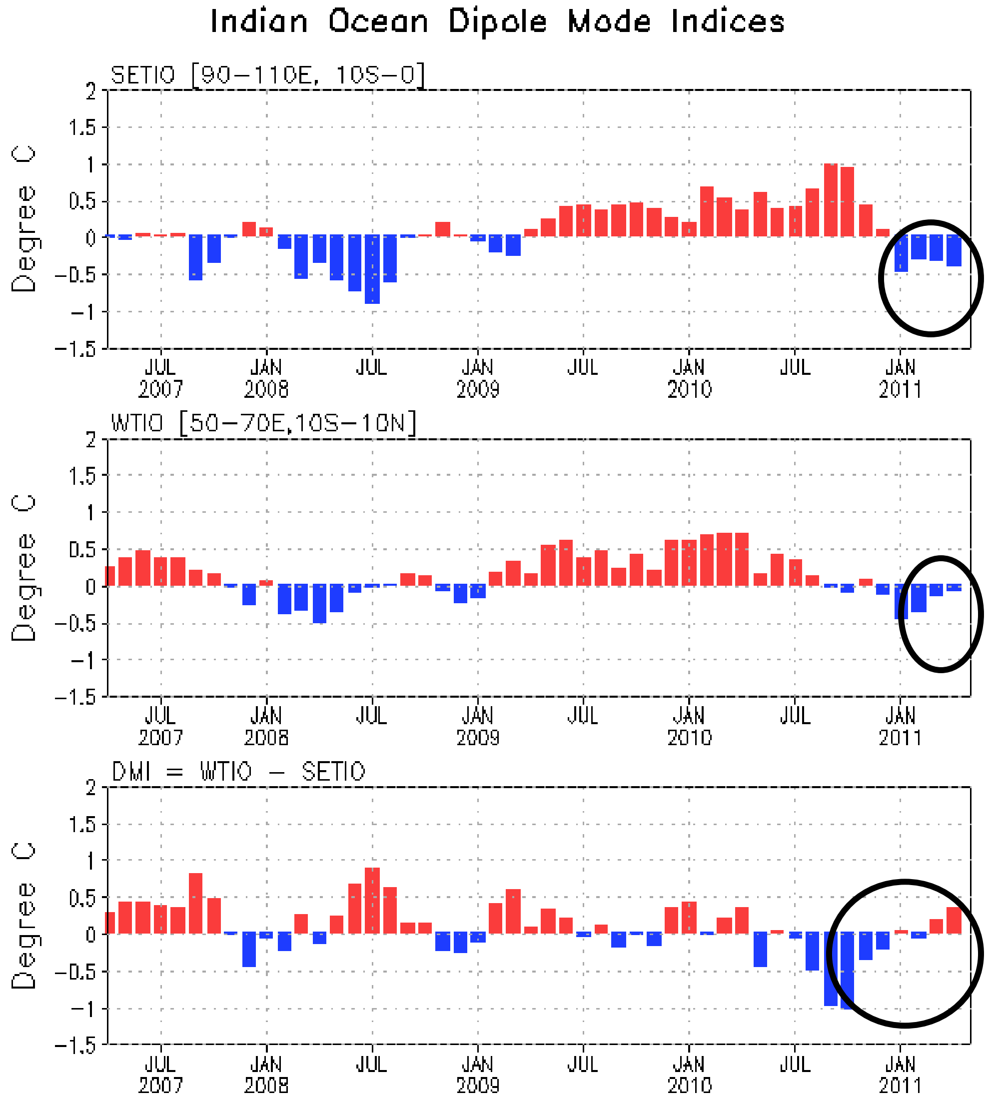
- **Seasonal downwelling was weaker than climatology during the winter of 2006/07, 2007/08, 2008/09, and 2010/11.**
- **But, seasonal downwelling was stronger than climatology during the winter of 2009/10.**

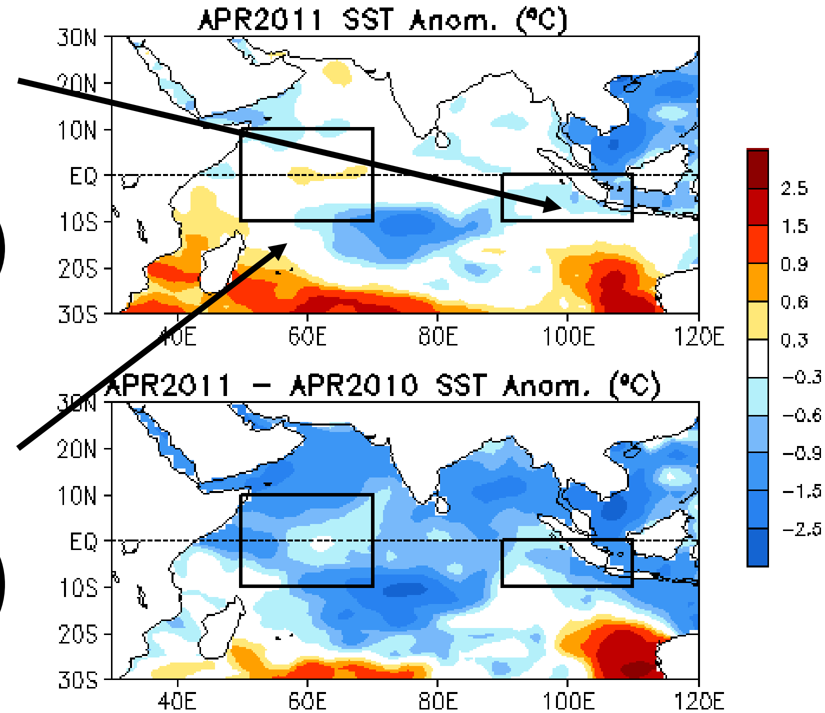
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport 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 36ºN to 57ºN.**

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices





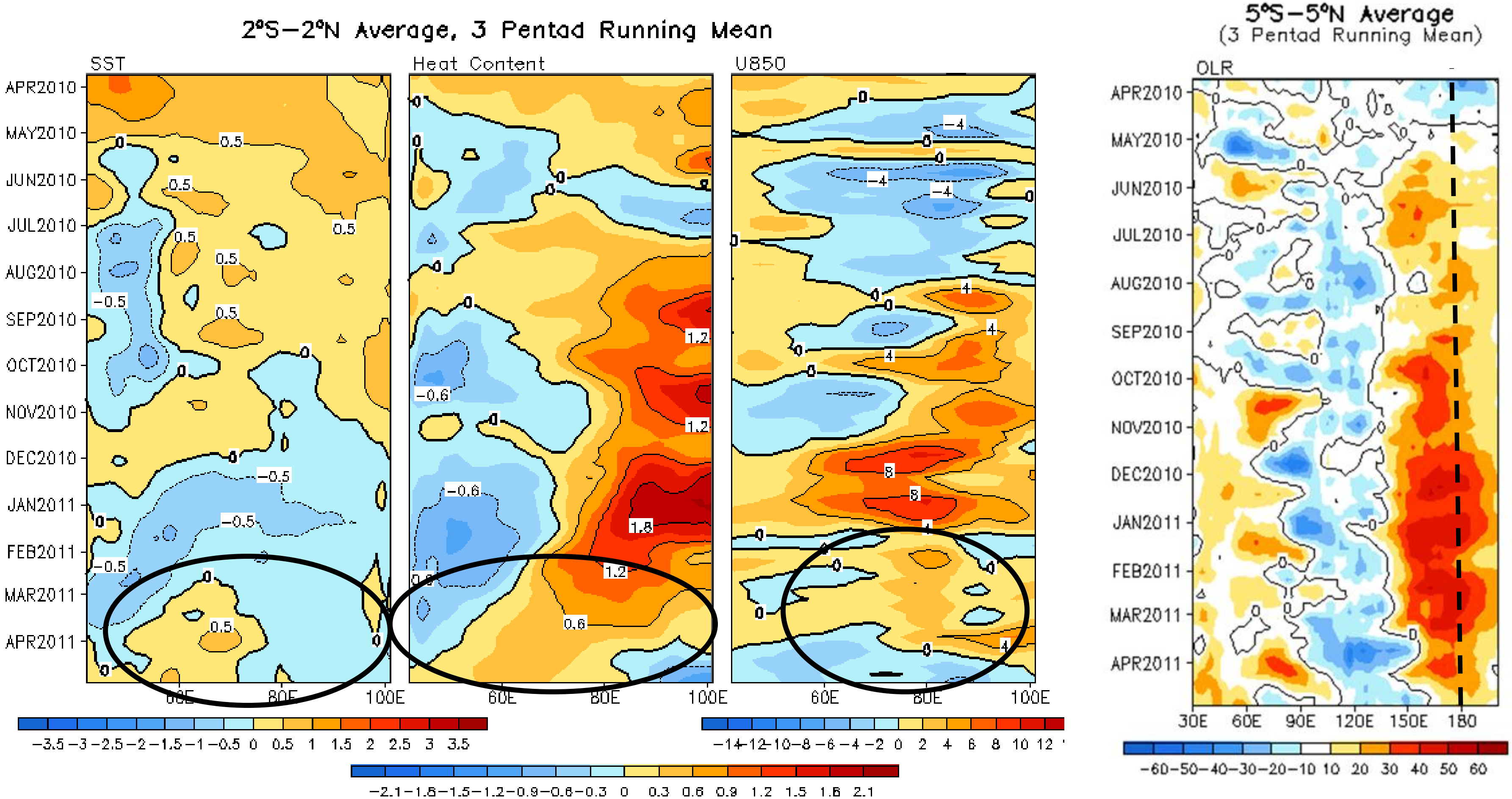
- Both eastern (SETIO) and western (WTIO) pole SSTA was negative since Jan 2011, consistent with basin wide negative SSTA.

- DMI has been above-normal since Mar 2011.

- Compared with Apr 2010, a basin wide cooling of about 1-2ºC was observed in Apr 2011, which is consistent with the contrast impacts of the 2009/10 El Nino and the 2010/2011 La Nina.

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the SETIO [90ºE-110ºE, 10ºS-0] and WTIO [50ºE-70ºE, 10ºS-10ºN] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

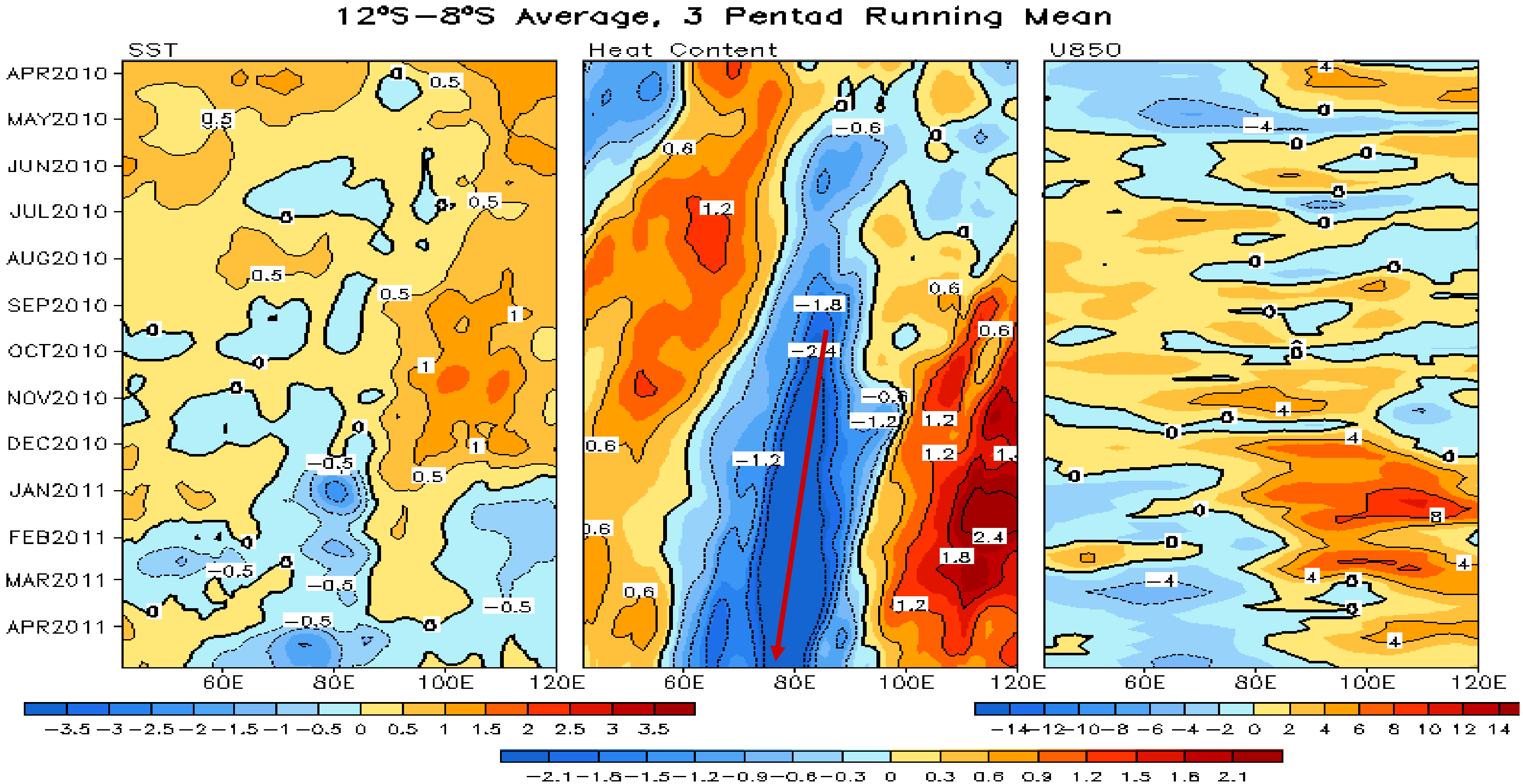
Recent Evolution of Equatorial Indian SST (ºC), 0-300m Heat Content (ºC), 850-mb Zonal Wind (m/s) and OLR (W/m²) Anomalies



- **SSTA switched to negative for the whole basin since mid-Dec 2010, probably due to the delayed impact of the La Nina. But, positive SSTA presented in central Indian Ocean since Apr 2011.**
- **Positive (negative) heat content anomaly presented in the western and 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 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. 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 1981-2010, 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)



- **Both negative and positive SSTA observed in Apr 2011 in the southern Indian Ocean. SST cooled down around 70E in April 2011, which is consistent with the strengthening of negative HC anomalies and low-level divergence.**
- **Westerly (easterly) wind anomalies presented in southeast (southwest) tropical Indian Ocean, which are probably associated with the La Nina conditions.**
- **The tripole HC300A, negative near 80°E and positive to its two sides, persisted, which is consistent with the U850 anomalies.**

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 1981-2010, 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.

- Negative SSTA dominated the whole basin with strong negative SSTA in the tropical-subtropical southern Indian Ocean.

- Negative SSTA tendency was not very consistent with the net surface heat flux anomalies, indicating dominant influence of subsurface temperature anomalies on SST tendency.

- Convection was suppressed in most regions of the tropical Indian Ocean.

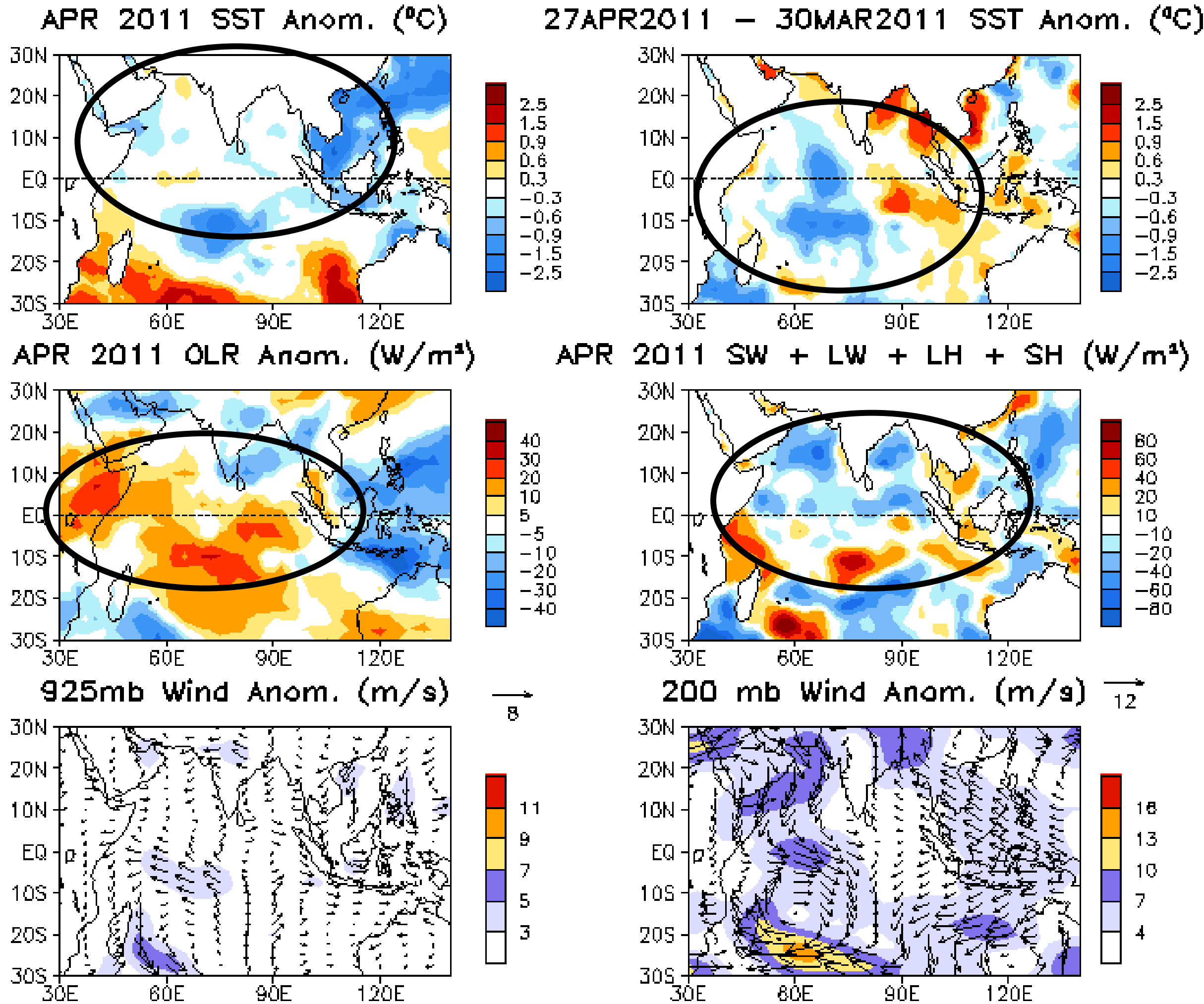
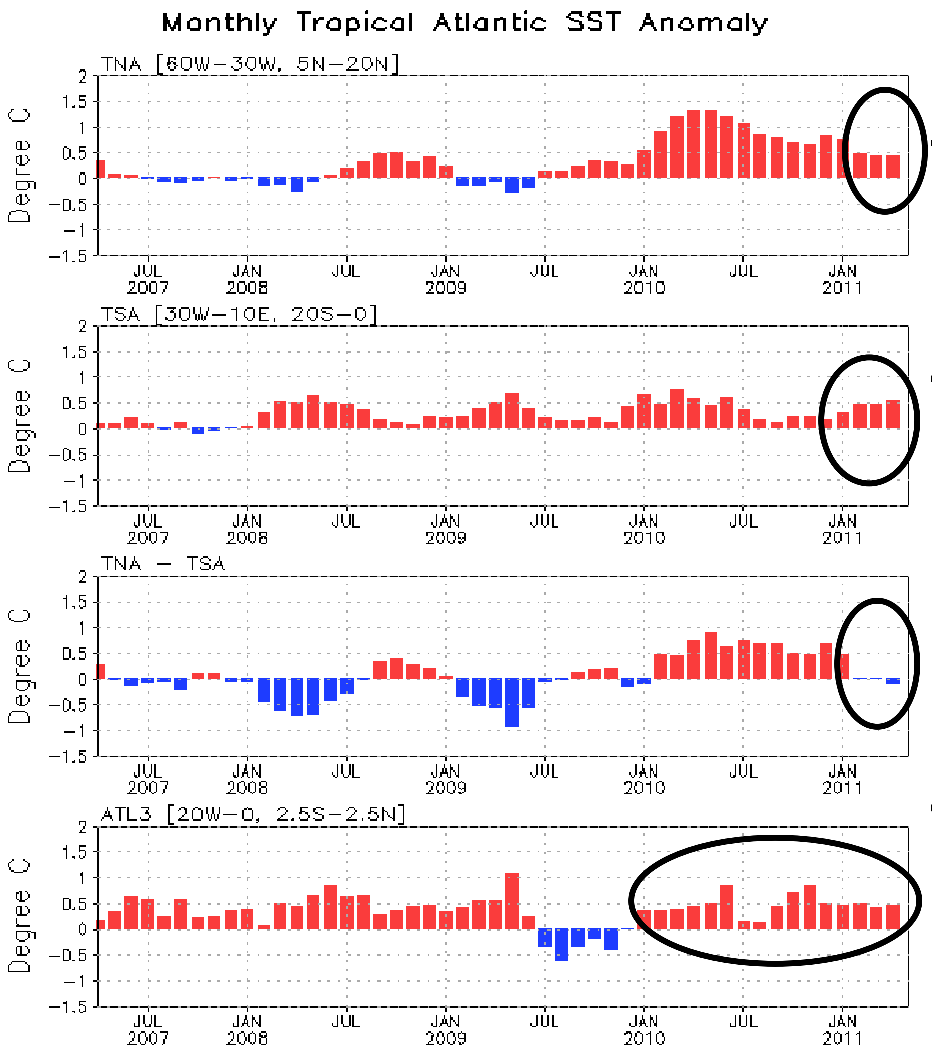
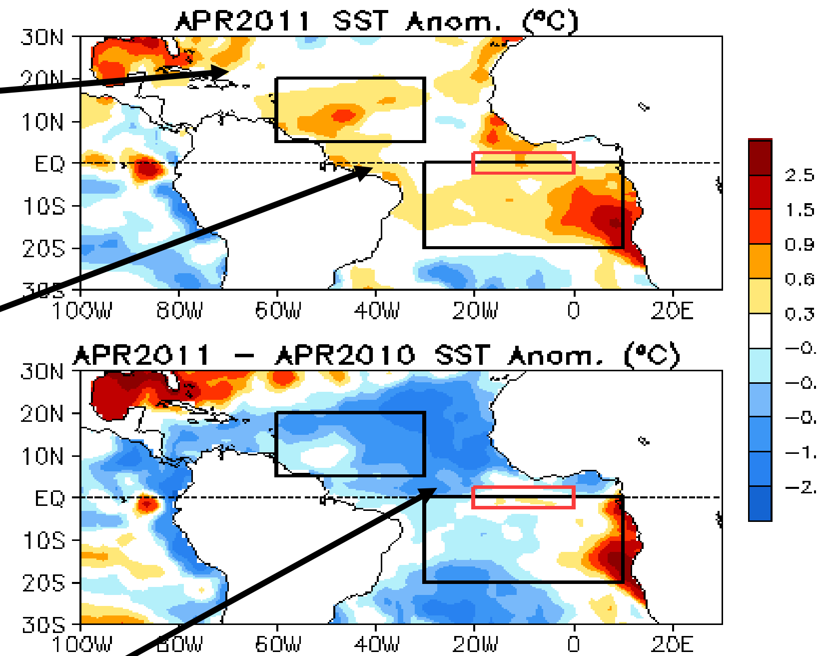


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 1981-2010 base period means.

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

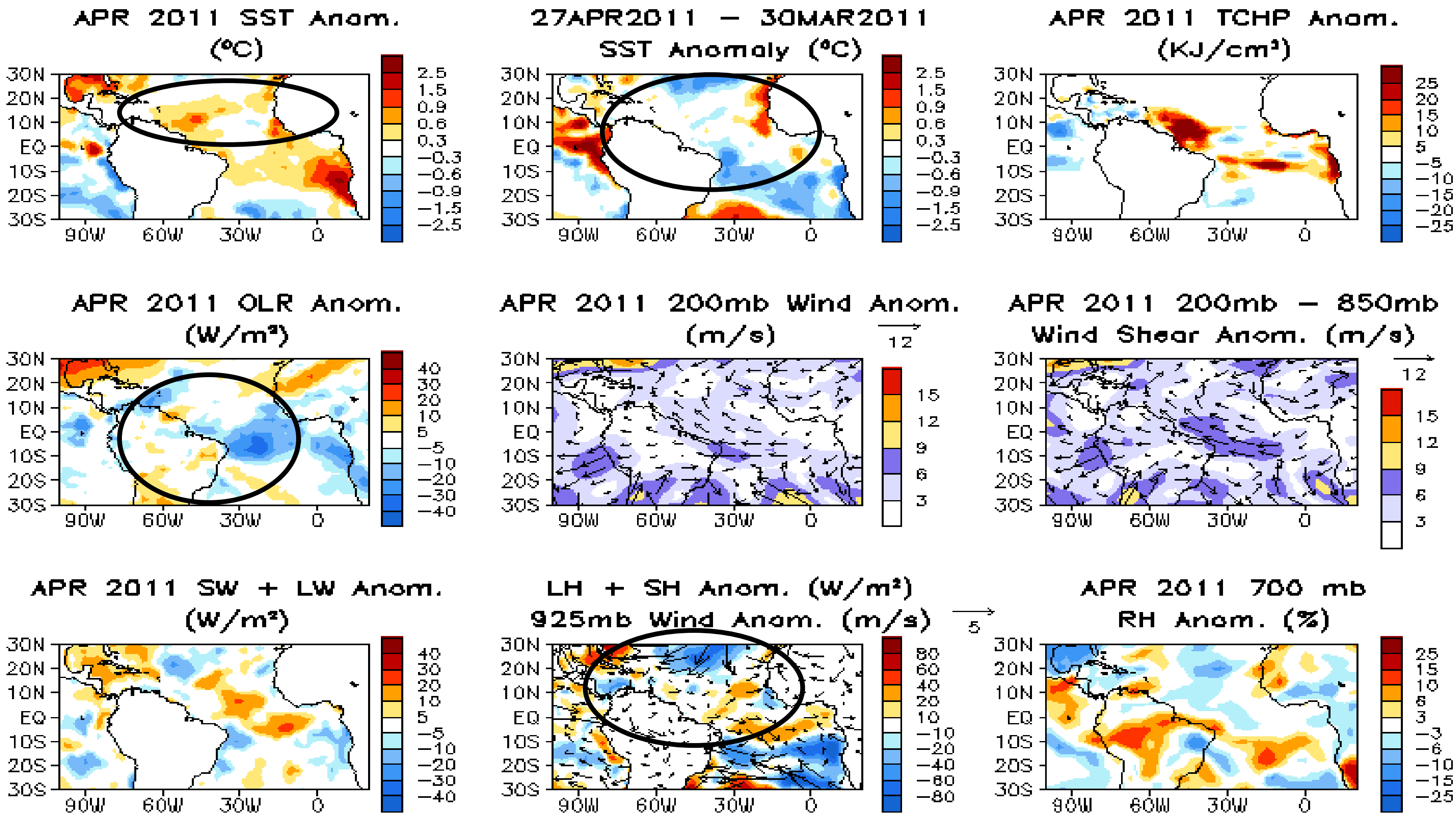




- Positive SSTA persisted for both TNA and TSA since Feb 2011.
- Meridional Gradient Mode (TNA-TSA) was near-zero since Feb 2011.
- Positive ATL3 SST persisted since Jan 2010.

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

Tropical Atlantic:



- **Positive SSTA in the tropical N. Atlantic presented in Apr 2011.**
- **Convection was enhanced over the equatorial Atlantic Ocean.**
- **SSTA tendency was generally consistent with total heat flux, particularly LH+SH.**

North Atlantic Ocean

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

- NAO has switched to positive phase since Feb 2011 (next slide), consistent with the SLP anomaly pattern.
- SSTA tendency was consistent with total HF (SW+LW+LH+SH).

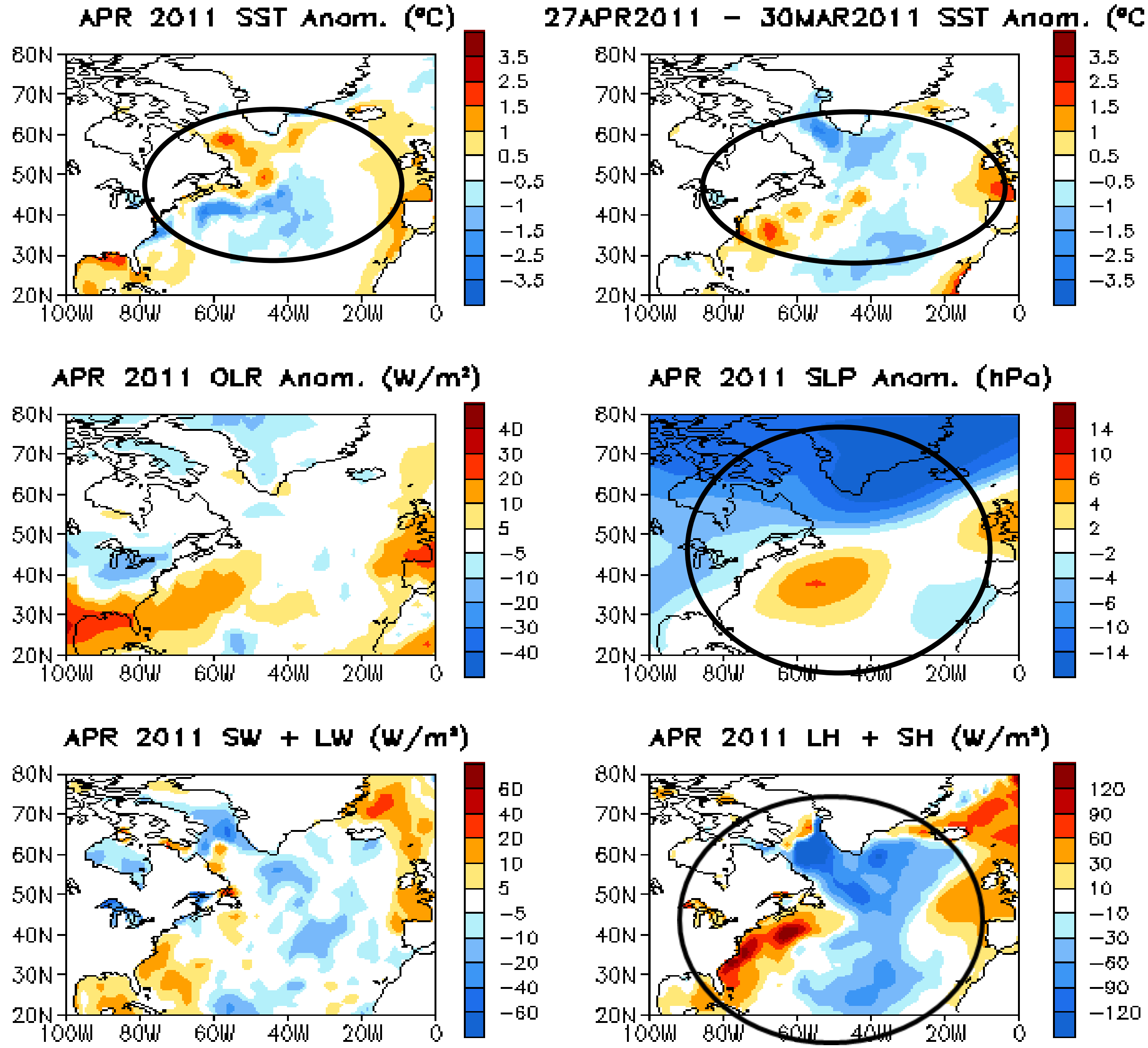
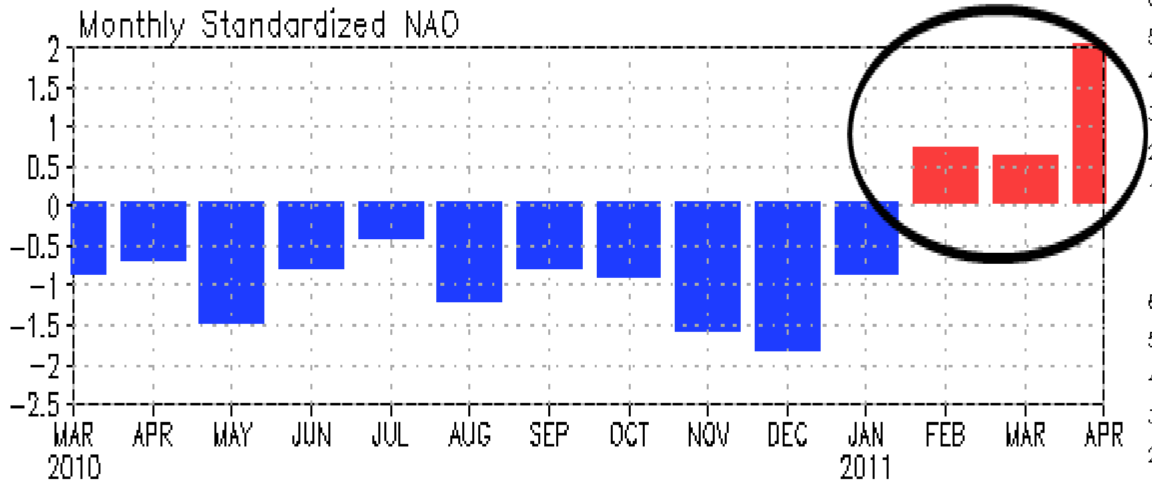
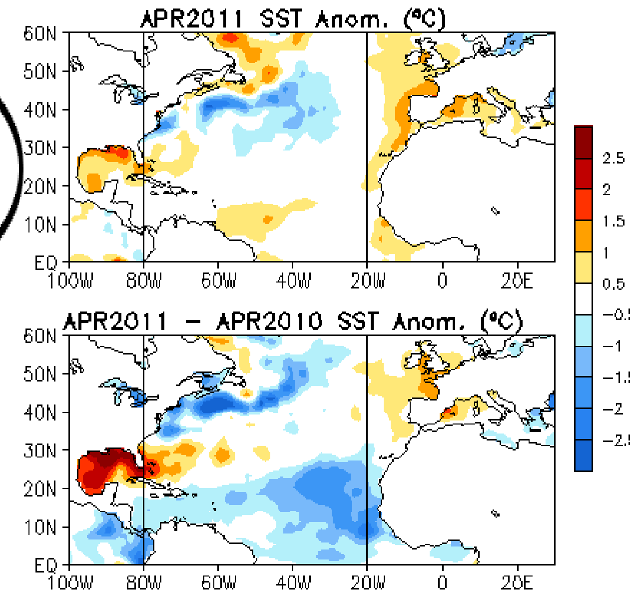
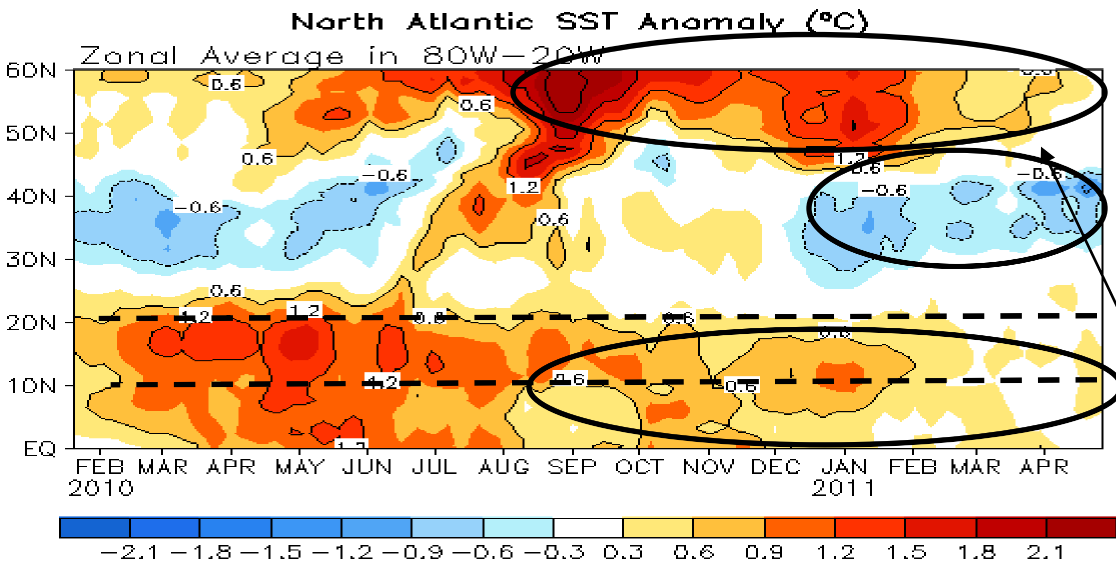


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1981-2010 base period means.

NAO and SST Anomaly in North Atlantic



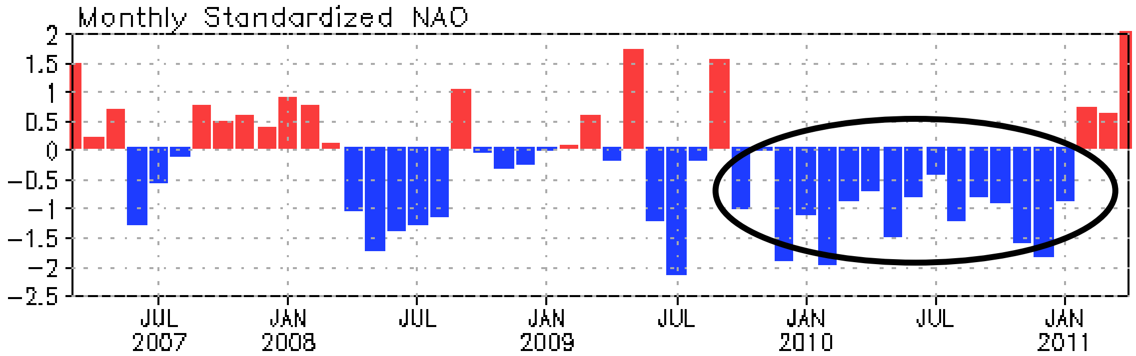


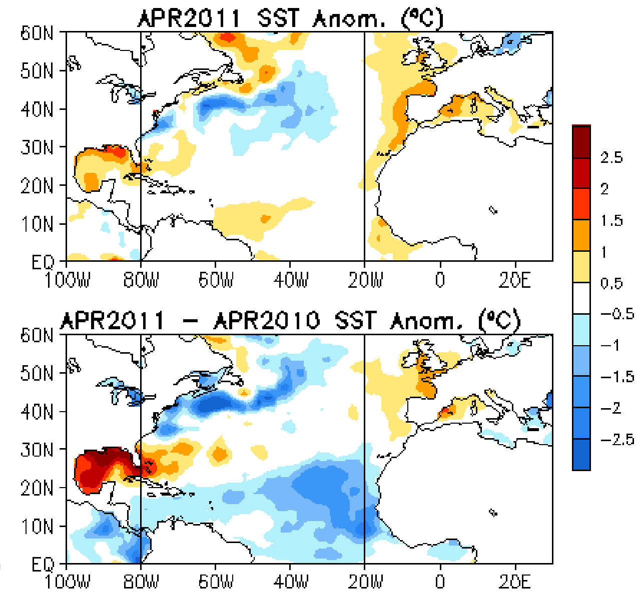


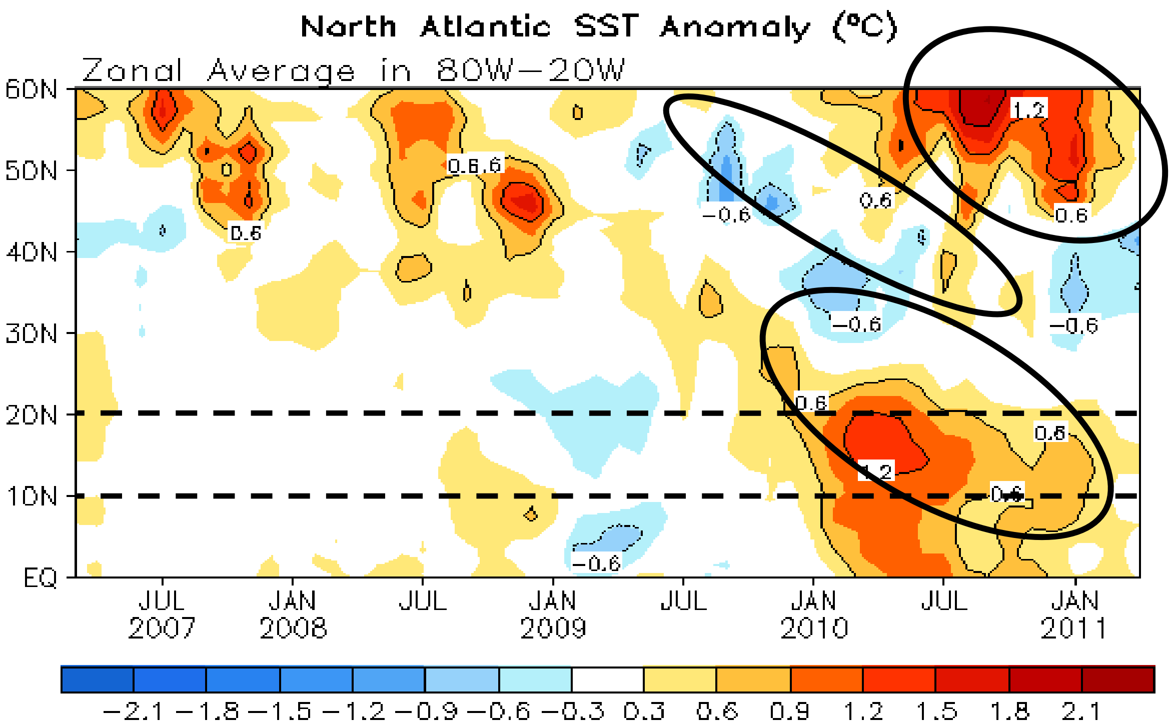
- **NAO has switched from negative to positive phase in Feb 2011 with NAO Index=2.5 in Apr 2011.**
- **Negative SSTA still appeared in mid-latitude, and warming in the low and high latitudes of North Atlantic weakened.**
- **Overall amplitudes of the SSTA associated with tripole pattern have weakened since Feb 2011, consistent with the phase switching of the NAO.**
- **Compared with Apr 2010, there was a strong cooling in tropical N. Atlantic in Apr 2011. That might affect hurricane activity .**

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.

NAO and SST Anomaly in North Atlantic



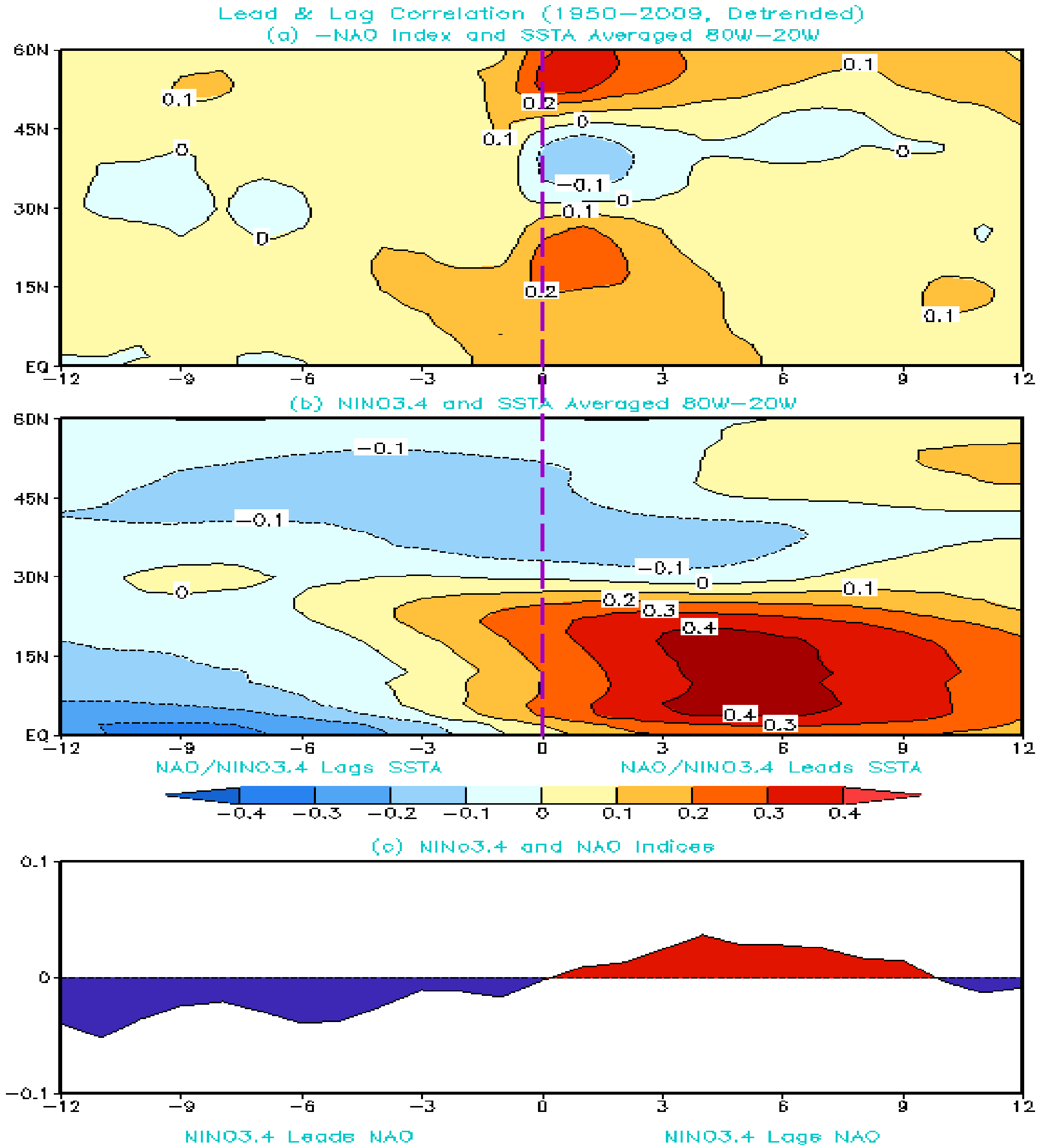




- NAO was persistently below-normal during Oct 2009-Jan 2011, which contributed to the development and maintenance of negative (positive) SSTA in mid-latitude (tropical and high latitude) North Atlantic.
- The tripole or horseshoe pattern of SSTA in 2009-2011 was largely associated with the influence of NAO and ENSO cycle, as well as long-term trend and SST feedback (next slide).

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.

Historical Connection of SST with Nino3.4 & NAO



NAO's impact on SST is mainly with 0-3 month lag. The NAO correlation is weaker than that of ENSO.

The tripole or horseshoe pattern is consisted with the observed SSTA in 2009-2011.

ENSO signals propagate into the tropical N. Atlantic in 3-8 months late.

ENSO affects the trade wind through atmosphere (PNA), then changes the SST through WES mechanism.

Preceding El Nino may slightly favor to negative phase of NAO.

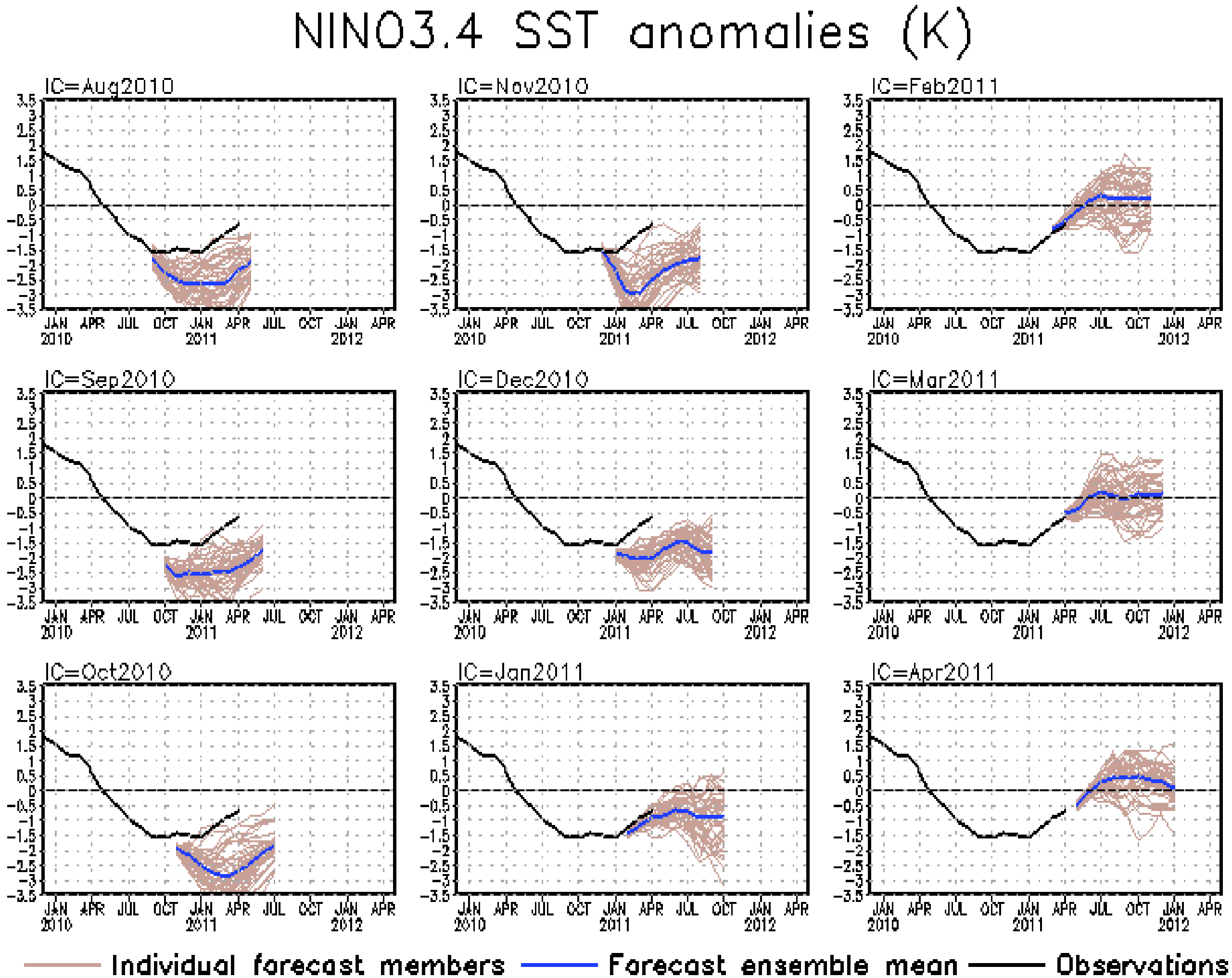
Based on the statistical relations and current observed evidences (La Nina decay phase and positive NAO), it might suggest a unfavorable environment for the hurricane generation in the coming summer and fall.

From:

Hu, Z.-Z., A. Kumar, B. Huang, Y. Xue, W. Wang, and B. Jha, 2010: Persistent atmospheric and oceanic anomalies in the North Atlantic from Summer 2009 to Summer 2010. J. Climate (accepted).

CFS SST Predictions and Ocean Initial Conditions

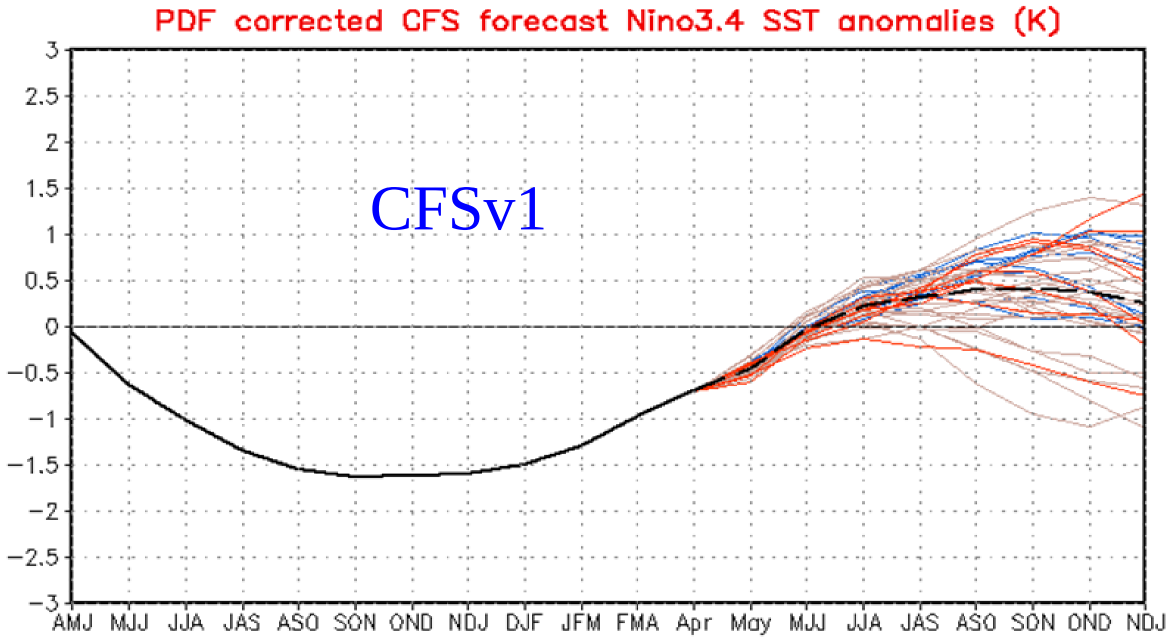
CFS Niño3.4 SST Predictions from Different Initial Months

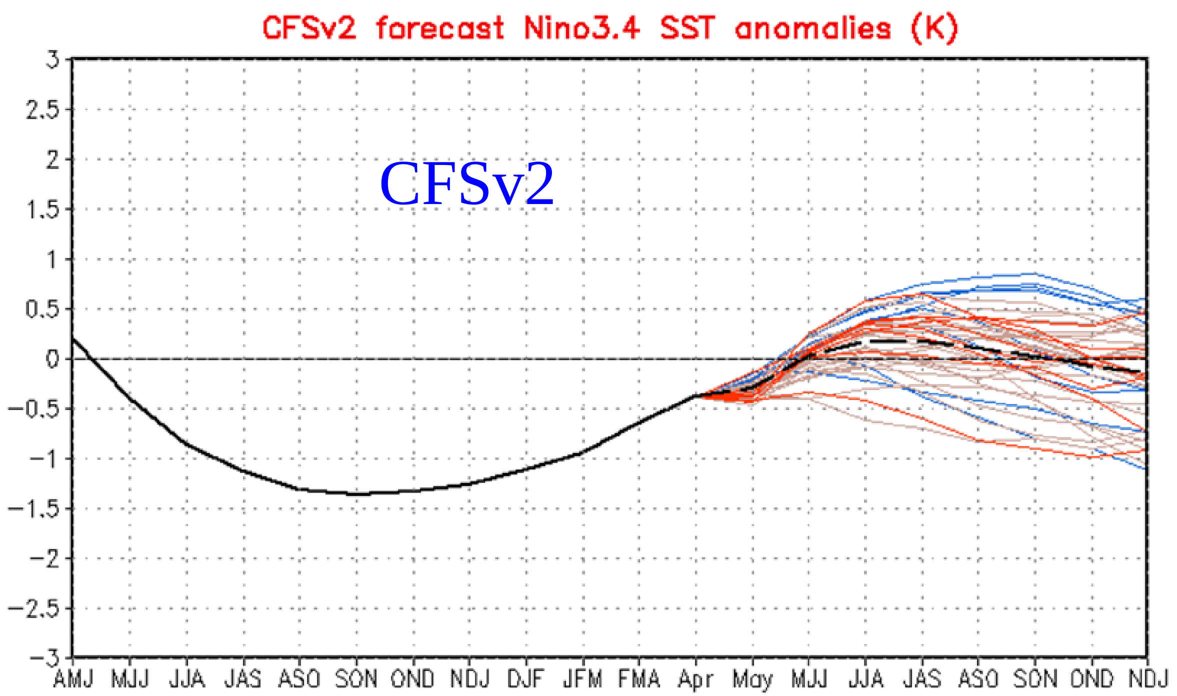


- **Forecasts from Aug 2010-Jan 2011 I.C. had cold biases. The recent cold forecast biases can be alleviated through statistical model corrections (*http://www.cpc.ncep.noaa.gov/products/people/wwang/cfs_fcst*).**

- **The latest forecasts from Apr 2011 I.C. suggest that the current La Niña is in decay phase, and ENSO will be near neutral by May-Jun 2011.**

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 1981-2010 base period means.



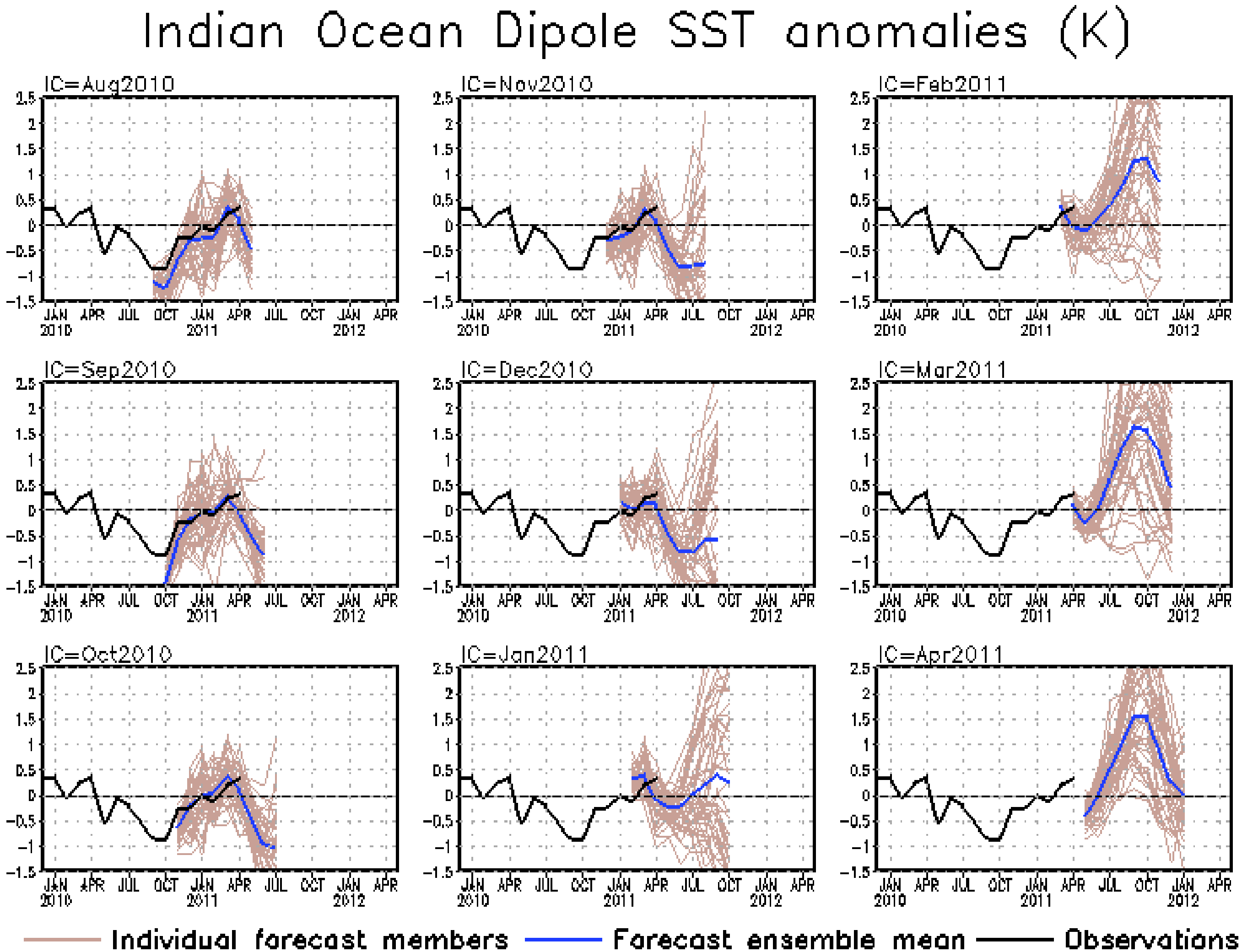


NCEP CFSv1 and v2 ENSO Forecasts:

- Both predicted an ENSO neutral condition by May 2011.

- IC was warmer in CFSv2 than in CFSv1.

CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

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

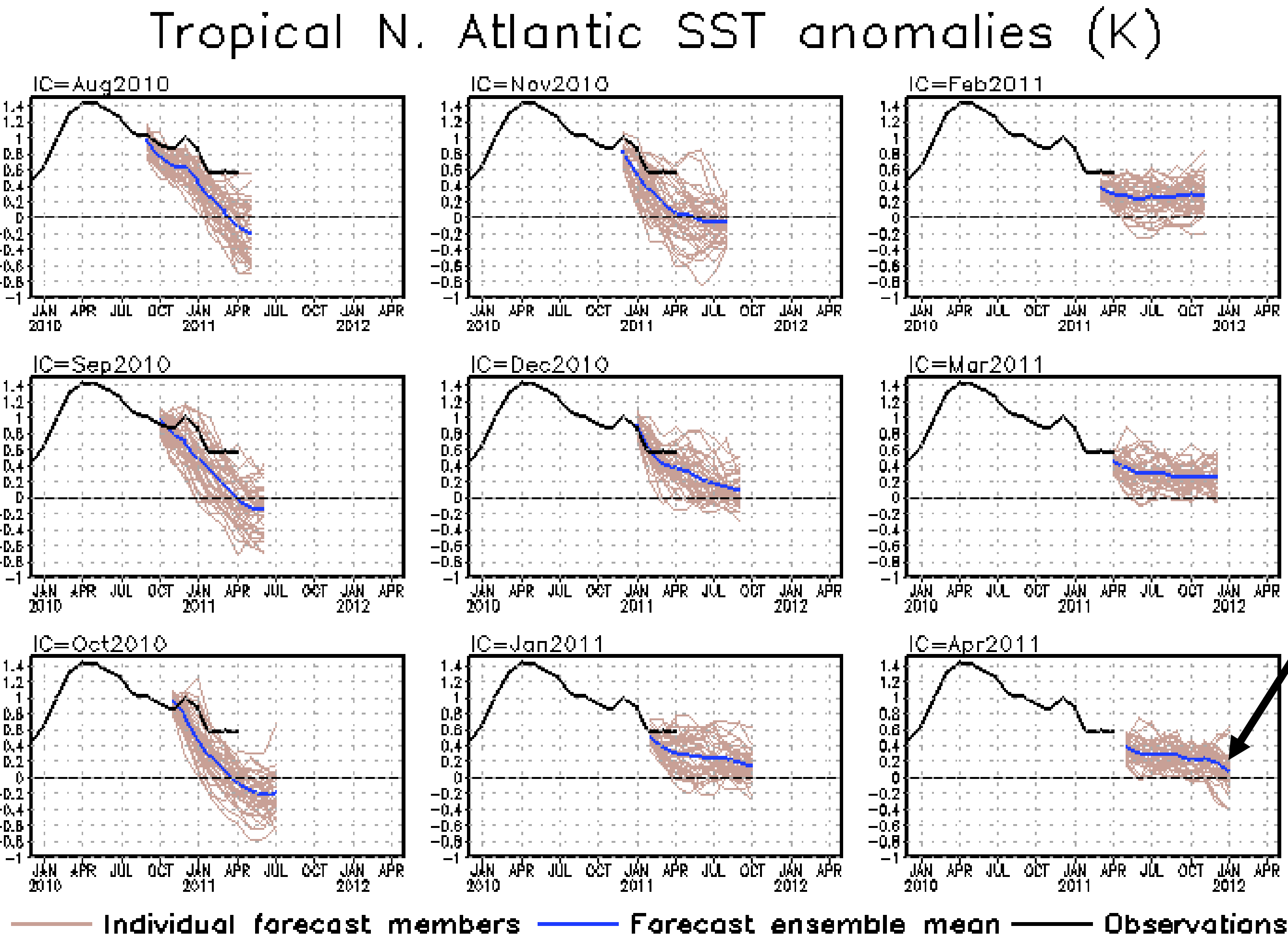
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- **The spread between individual members was large, implying the uncertainty of the IOD forecasts.**
- **Forecasts from Apr 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 1981-2010 base period means.

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].

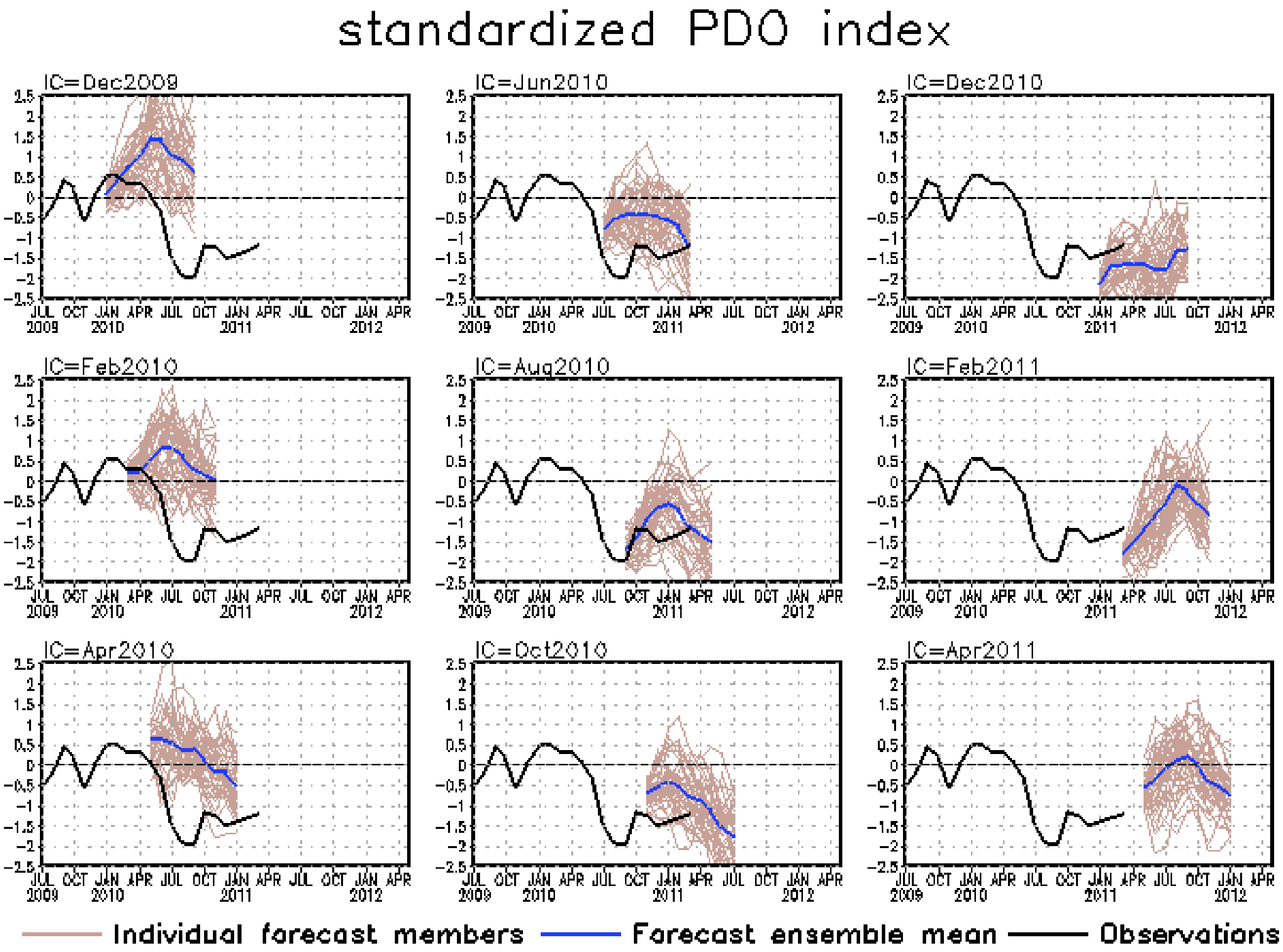


- Cold forecast biases were evident, may due to the fact that the NAO and its impact were poorly predicted.

- Latest forecasts suggest that positive SSTA in the tropical North Atlantic will decay slowly in next few months.

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 1981-2010 base period means.

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



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

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

- The forecast of the onset of the negative phase of the PDO was failed.

- Latest forecasts suggest that the negative phase of the PDO will weaken in next few months and return to near-normal condition in summer/fall 2011.

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 1981-2010 base period means.

Overview

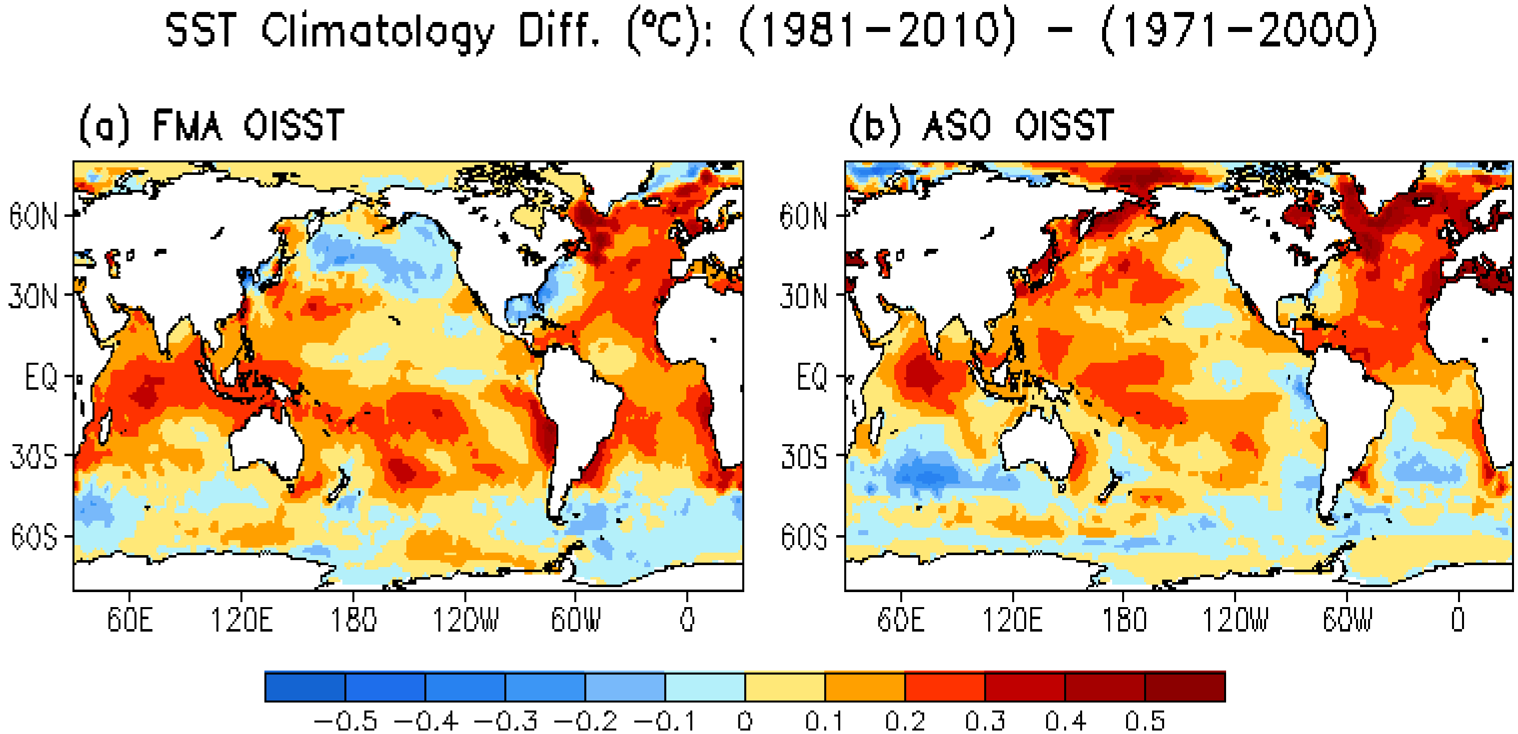
- **Pacific and Arctic Oceans**
  - ENSO cycle: La Niña conditions continuously weakened with OISST NINO3.4=-0.77°C in Apr 2011.
  - NOAA/NCEP Climate Forecast System (CFS) suggests that the current La Niña is in a decay phase, and ENSO will be near neutral by May 2011.
  - PDO has been negative since Jun 2010, and weakened slightly since Jan 2011 with PDO index=-1.04 in Apr 2011, consistent with La Nina evolution.
  - Anomalous upwelling observed along the west coast of North America in Apr 2011, which might not be the dominant factor contributing to the below-normal nutrient supply in this month.
  - Artic sea ice extent was still well below normal in Apr 2011.
- **Indian Ocean**
  - Negative SSTA was dominated.
- **Atlantic Ocean**
  - After 16 month persistent negative phase (Oct 2009-Jan2011), NAO has switched to positive phase since Feb 2011 with NAO index = 2.5 in Apr 2011.
  - Tripole SSTA pattern has weakened since Feb 2011.

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!