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

Prepared by

Climate Prediction Center, NCEP

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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 Office of Climate Observation (OCO)

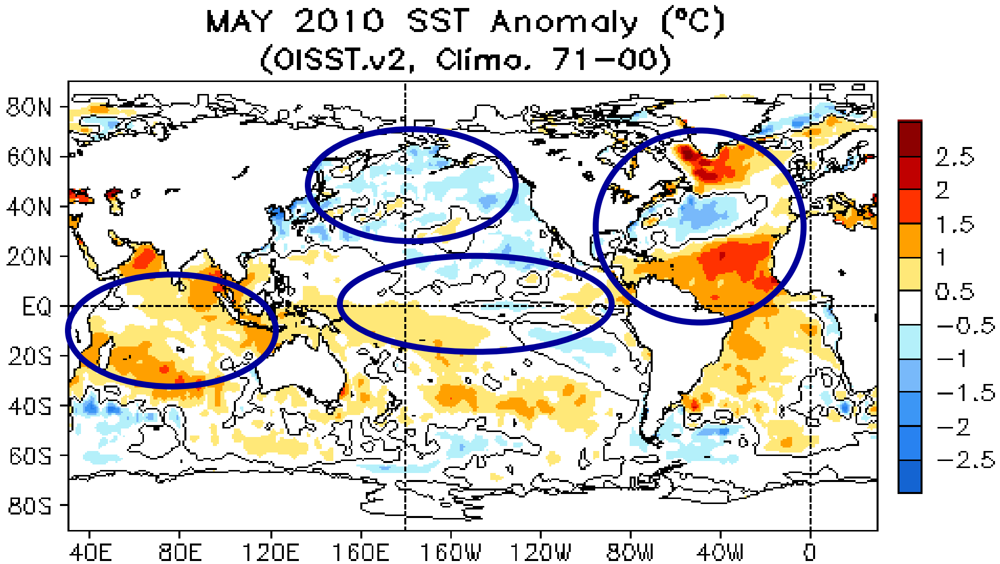
Outline

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

Overview

- **Pacific/Arctic Ocean**
  - ENSO cycle: Transition to neutral conditions in May 2010
  - Upwelling oceanic Kelvin waves forced by persistent low-level easterly wind anomalies during Mar-May2010 pushed negative heat content anomalies eastward to near the American coast and generated strong westward zonal current anomalies.
  - NOAA/NCEP Climate Forecast System (CFS) predicts the onset of La Niña conditions during Jun-Aug2010.
  - PDO was in neutral phase during Mar-May 2010.
  - Arctic sea ice extent decreased significantly from near-normal in Apr 2010 to well below-normal in late May 2010.
- **Indian Ocean**
  - Positive SSTA strengthened (weakened) in the eastern (western) tropical Indian Ocean in May 2010.
  - Indian Dipole index transitioned from positive to negative in May 2010.
- **Atlantic Ocean**
  - NAO remained strong negative in May 2010 with NAOI=-1.5.
  - Tripole SSTA pattern persisted in May 2010, which may be due to the impact of El Nino and negative phase of NAO.
  - SST in the tropical North Atlantic (TNA) increased steadily from Dec 2009 to May 2010, and SSTA exceeded +1.3C during Mar-May 2010.
  - Easterly wind shear anomaly and above-normal tropical cyclone heat potential presented in the hurricane MDR in May 2010.

Global SST Anomaly (^{0}C) and Anomaly Tendency

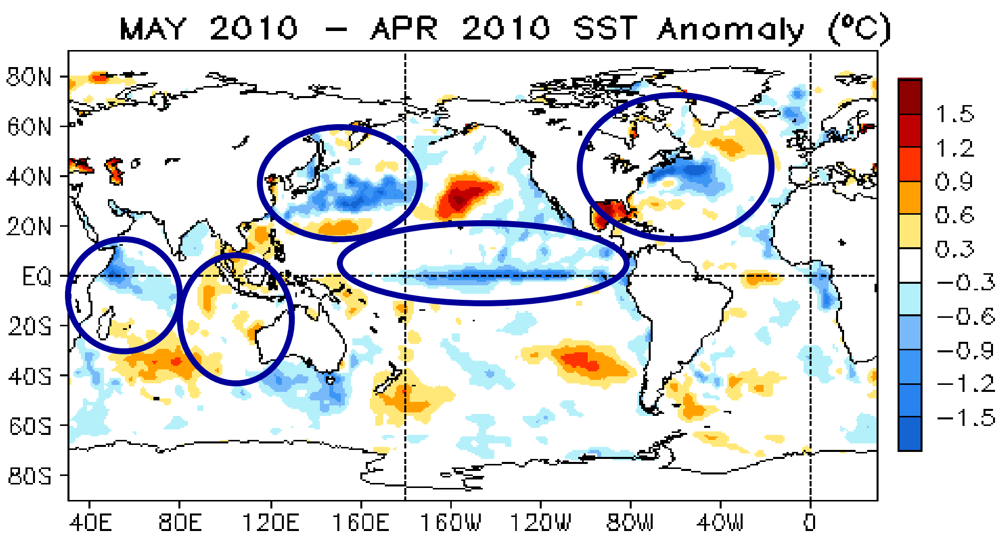


- ENSO in neutral condition

- SST was below normal in N. Pacific.

- SST was above-normal in the tropical Indian Ocean and tropical Atlantic.

-Tripole SST anomaly pattern persisted in North Atlantic, and the SST in the tropical North Atlantic was extremely high during Mar-May 2010.



- SST decreased in the central and eastern tropical Pacific.

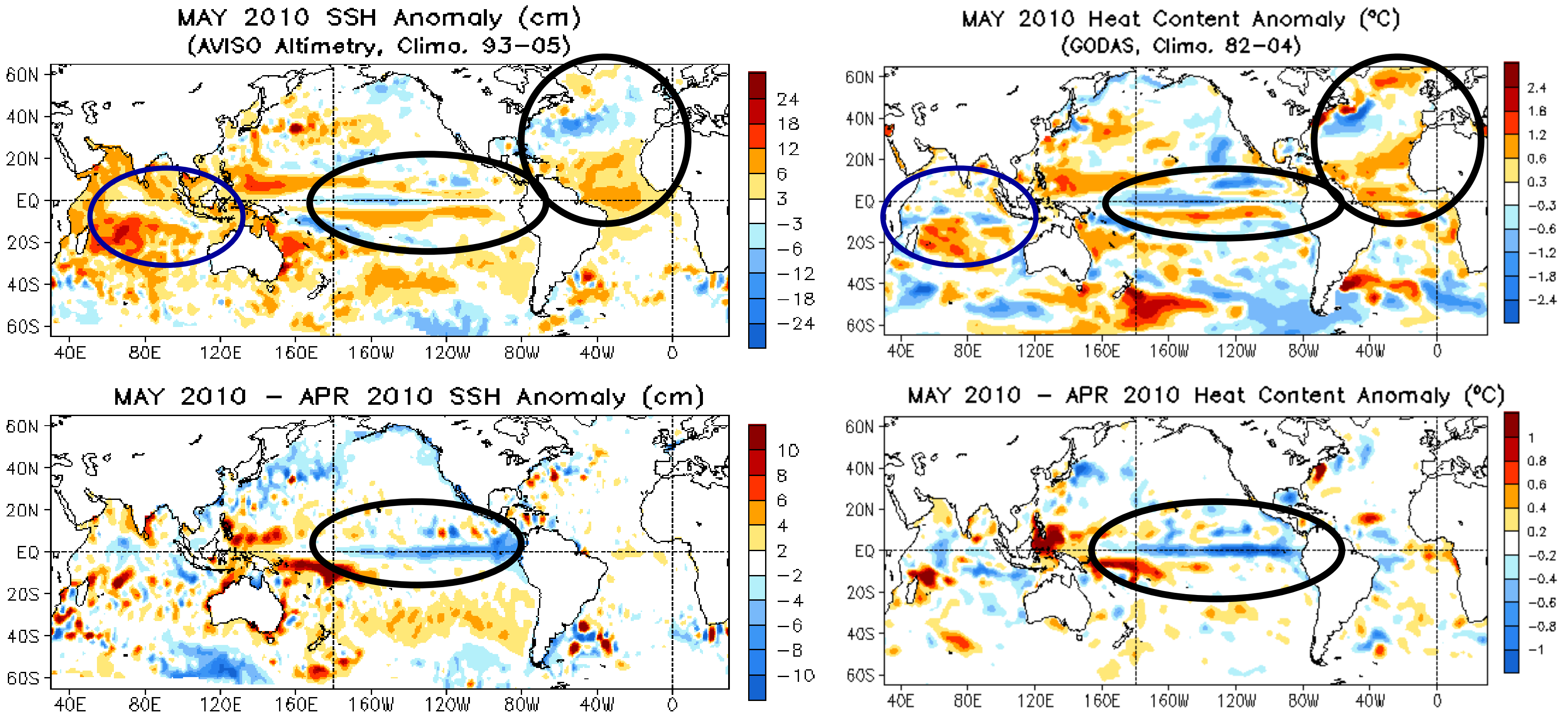
- SST decreased (increased) in the NW Pacific and along the west coast of N. America (central N. Pacific).

- SST increased (decreased) in the eastern (western) tropical Indian Ocean.

-Tripole SSTA pattern intensified in North Atlantic.

Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

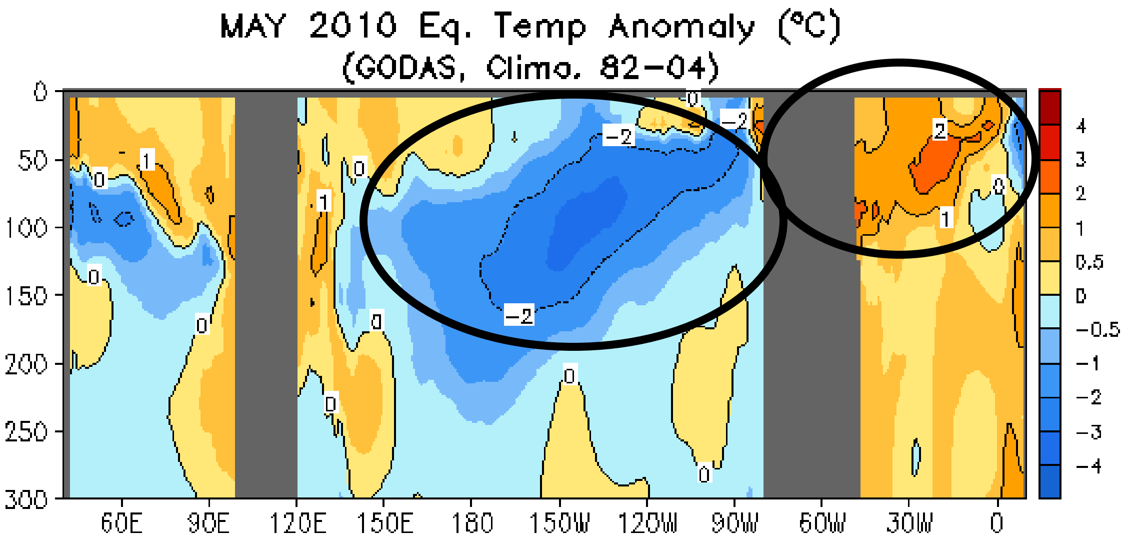
Global SSH/HC Anomaly (cm/°C) and Anomaly Tendency



- Small SSHA and HCA were present in the eastern equatorial Pacific, consistent with the neutral-ENSO conditions.
- Positive HCA and SSHA in the tropical Indian Ocean weakened.
-The tripole SSHA and HCA pattern in North Atlantic are consistent with the tripole SSTA pattern there.
- SSHA and HCA were largely consistent except in the Southern Ocean where biases in GODAS climatology are large (not shown).
- Tendency of SSHA and HCA was largely consistent.

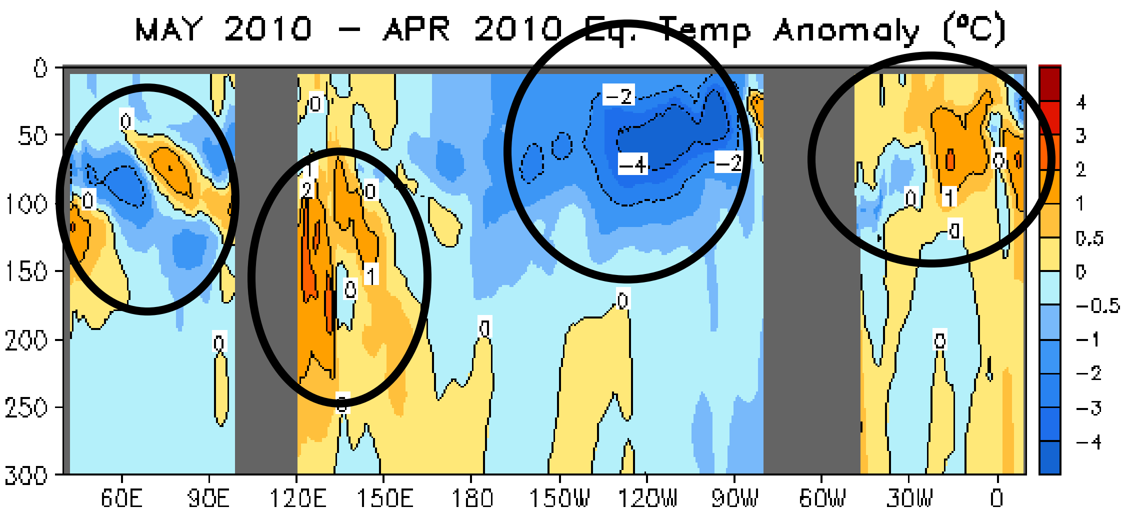
Fig. G2. Sea surface height anomalies (SSHA, top left), SSHA tendency (bottom left), top 300m heat content anomalies (HCA, top right), and HCA tendency (bottom right). SSHA are derived from http://www.aviso.oceanobs.com, and HCA from GODAS.

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



- Negative subsurface ocean temperature anomalies dominated in the equatorial Pacific, implying a tendency for La Nina development.

- Positive ocean temperature anomalies presented in the Atlantic, except the region near the eastern boundary.



-Positive (negative) subsurface temperature anomaly enhanced in the western (eastern) Pacific Ocean.

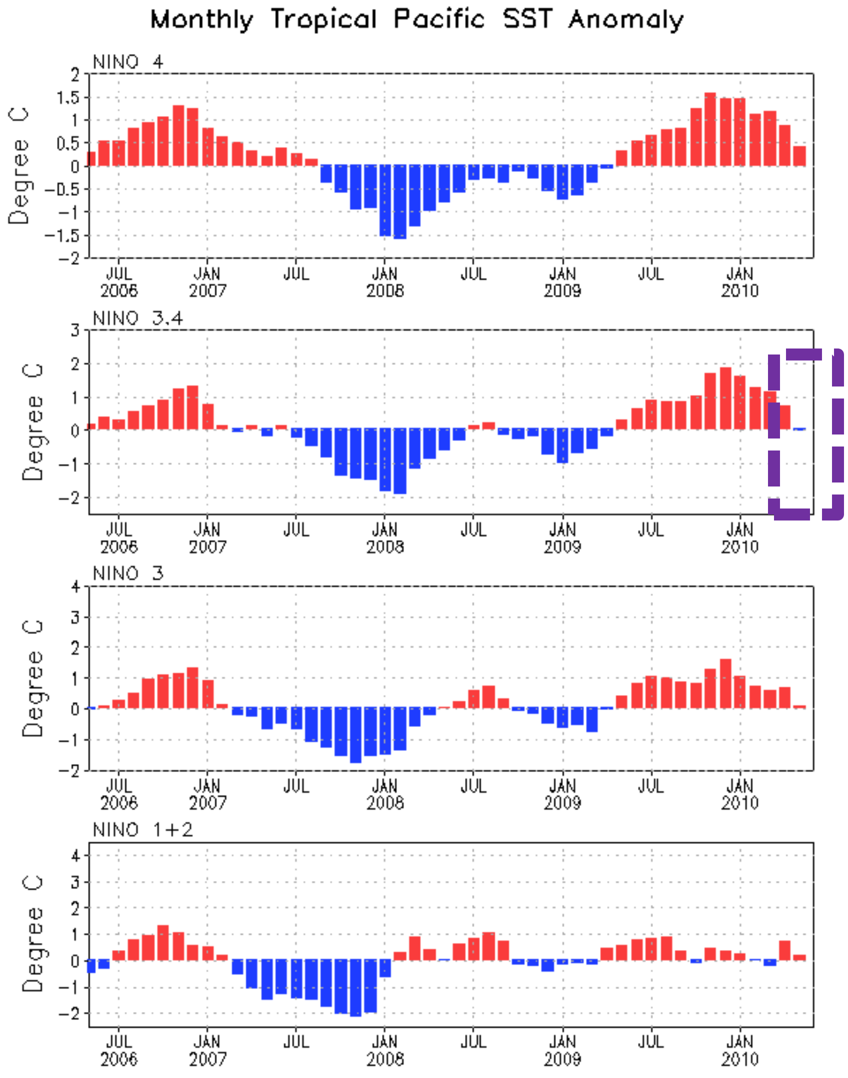
-Positive tendency presented in the Atlantic Ocean.

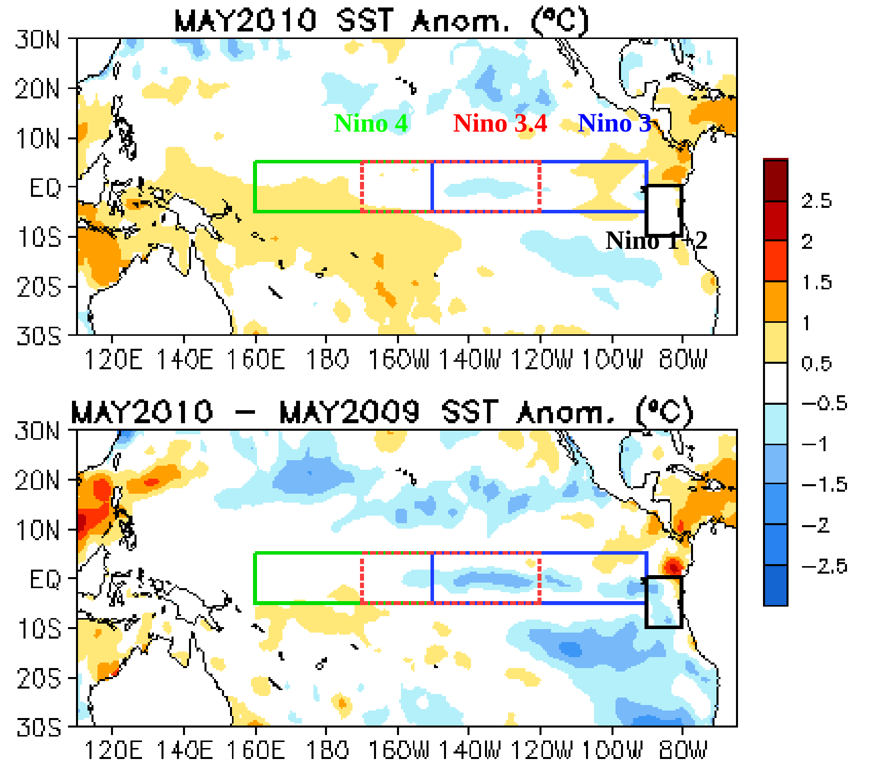
-Both negative and positive tendencies were observed in Indian Ocean.

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.

Tropical Pacific Ocean

Evolution of Pacific NINO SST Indices

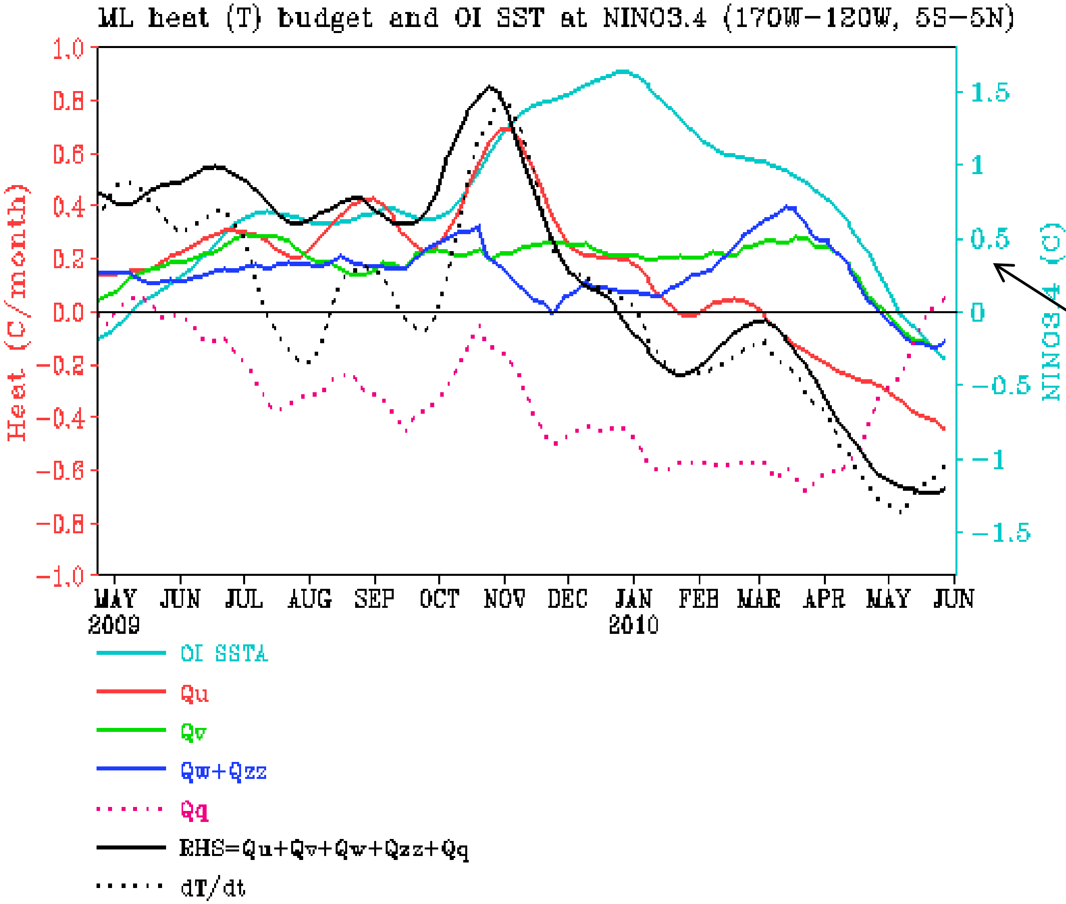




- **All indices were small and decreased.**
- **NINO3.4 index was small negative (-0.0) for OI SST and +0.36 for ERSST.v3b SST.**

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.

NINO3.4 Heat Budget: 09/10 El Nino



-Negative tendency in NINO 3.4 intensified significantly since Mar 2010, largely due to increased cooling from Qu and decreased warming from Qw+Qzz and Qv.

-All components became negative in May 2010 except Qq.

-Qq transitioned from negative to positive in late May.

- Qw+Qzz was negative in May 2010, implying a contribution of vertical circulation to the transition from warm to neutral phase of ENSO.

Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

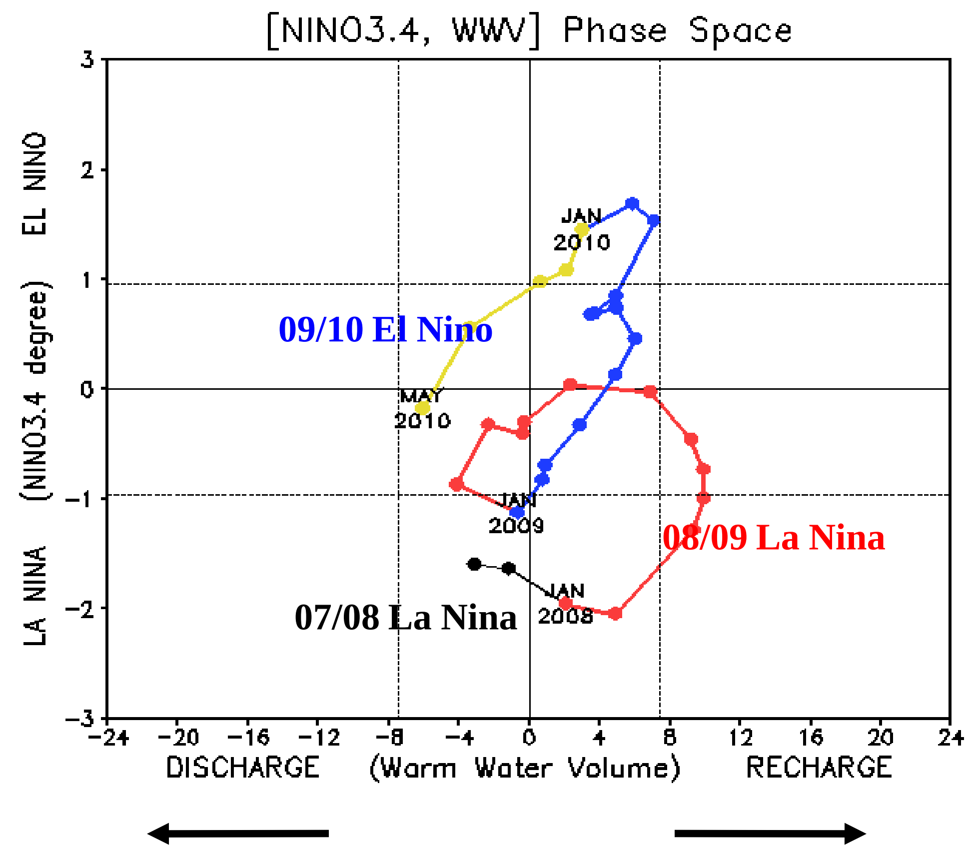
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

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).

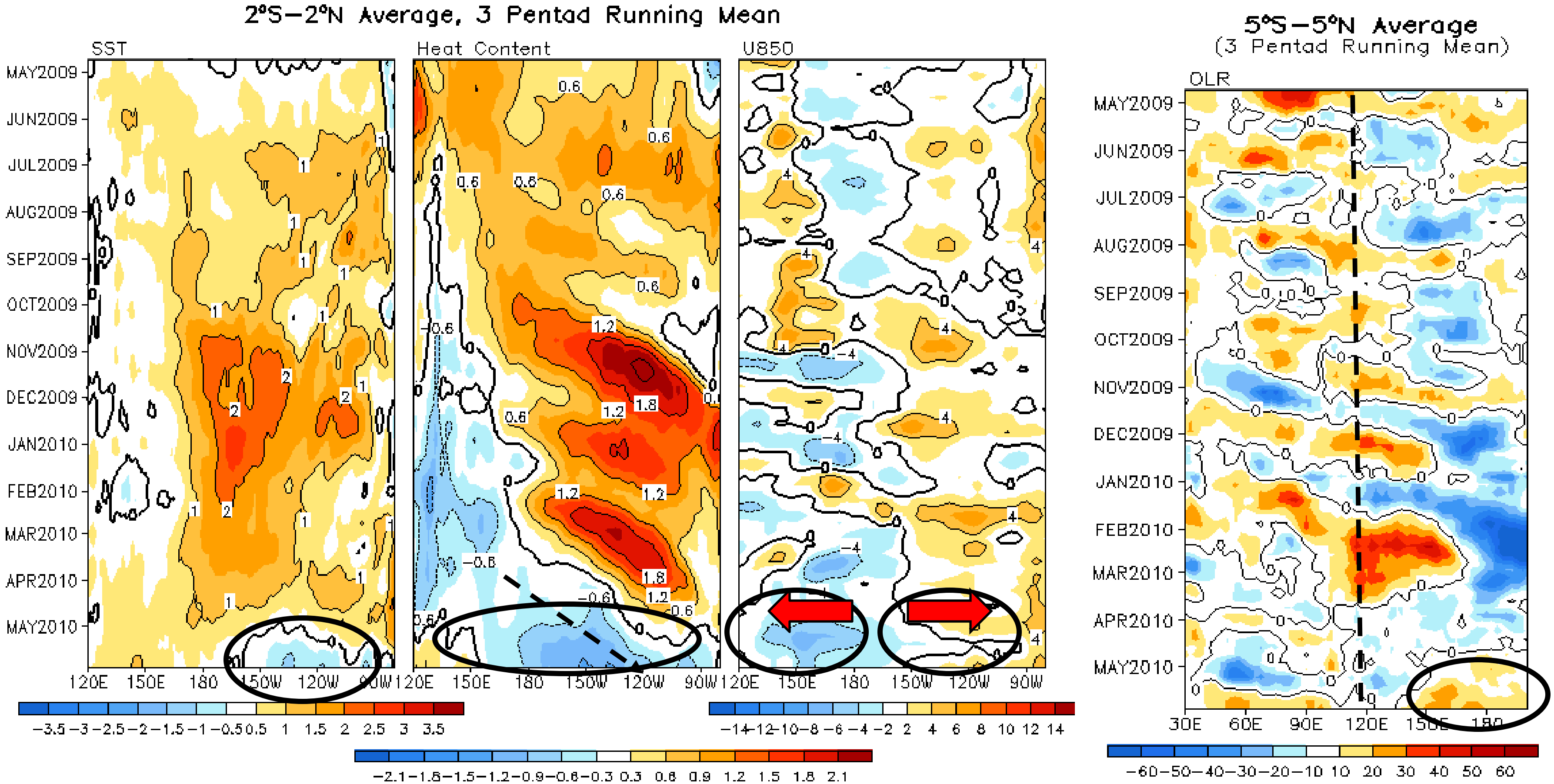
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



- **Nino3.4 and WWV decreased steadily from Dec 2009 to May 2010.**
- **Nino3.4 became slightly negative in May 2010, indicating an ENSO-neutral condition.**

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.

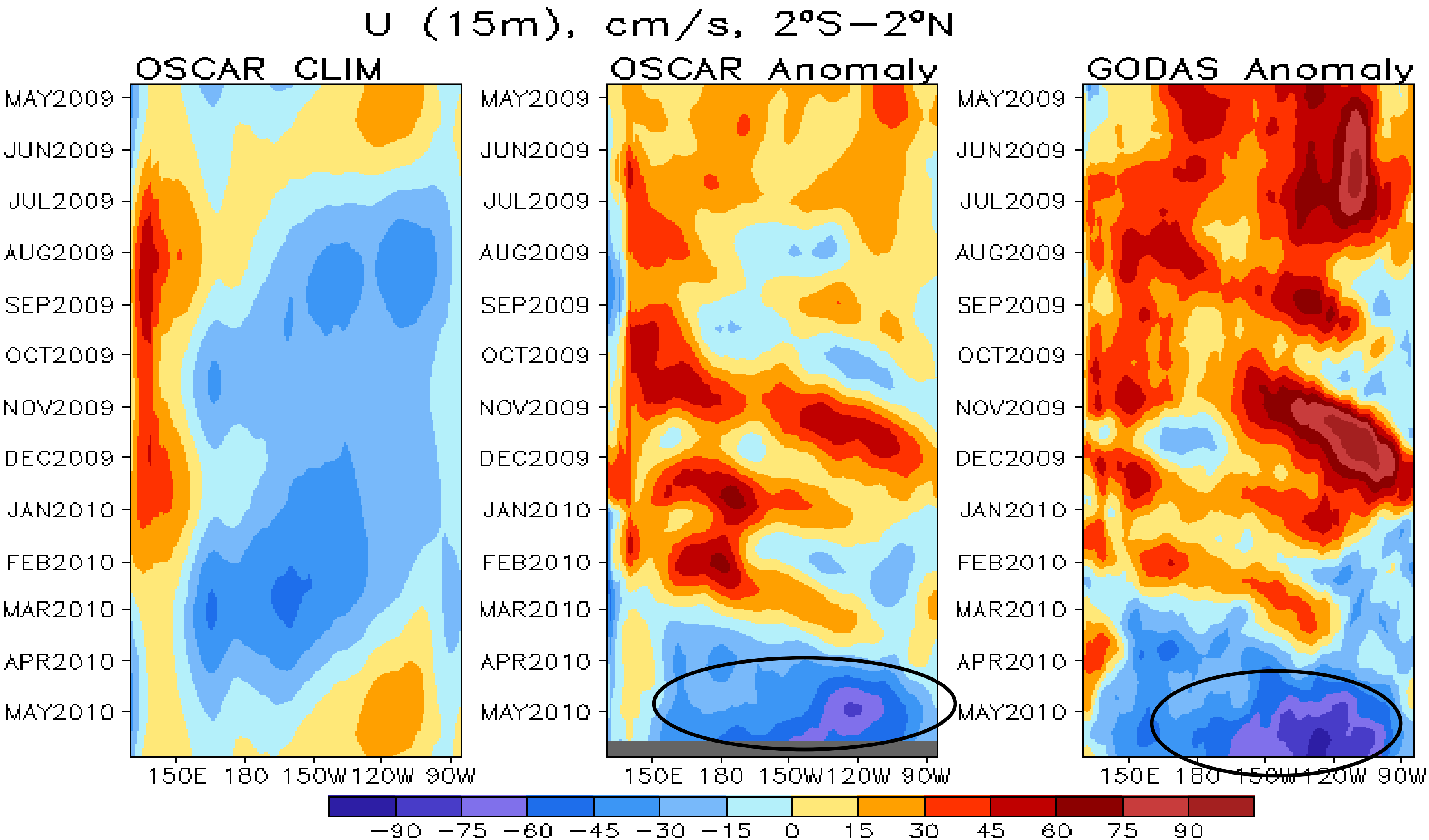
Evolution of Equatorial Pacific SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly



- **SSTA transitioned from positive to negative in the east-central equatorial Pacific in May 2010.**
- **Consistent with the negative SST tendency, negative HCA intensified and moved eastward in Mar-May2010.**
- **Convection weakened in the central equatorial Pacific in May 2010, consistent with the low-level divergence in the tropical Pacific.**

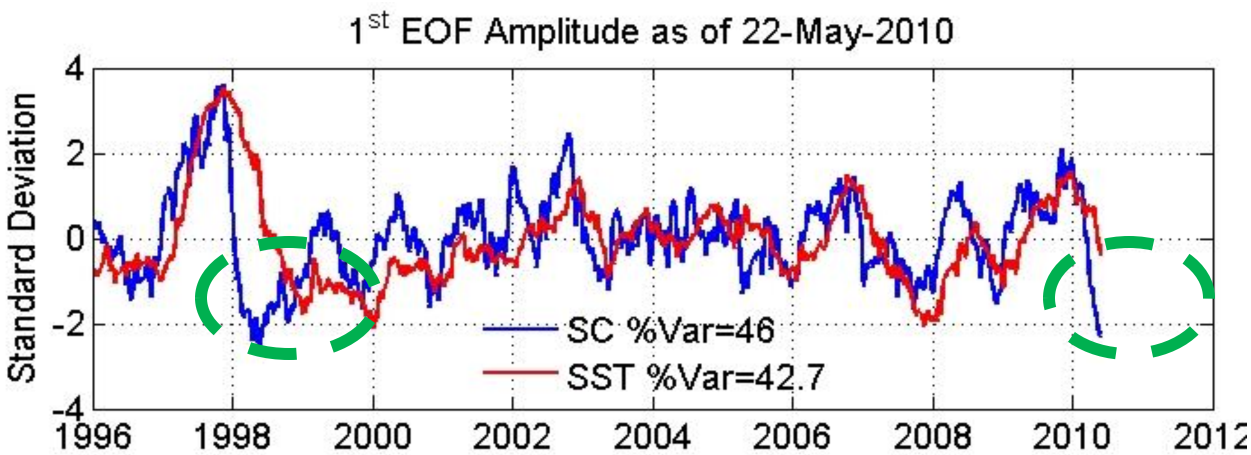
Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST is derived from the NCEP OI 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 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

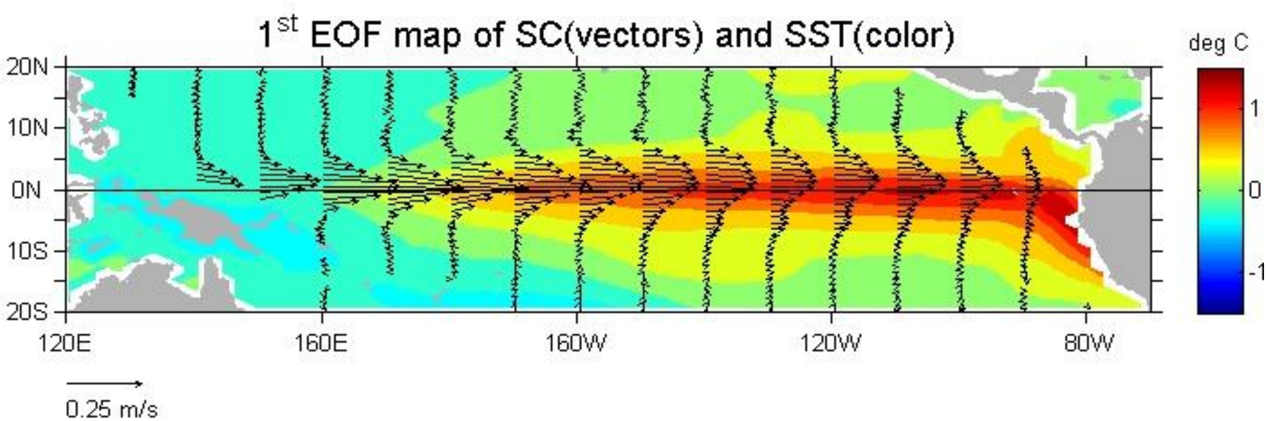
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **Surface zonal current anomaly became negative since Mar 2010, and intensified in Apr-May 2010, consistent with the transition of ENSO from warm to neutral phase.**
- **Surface zonal current anomalies simulated by GODAS were overall too strong compared with those of OSCAR in the equatorial Pacific, but they were comparable in recent months.**

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





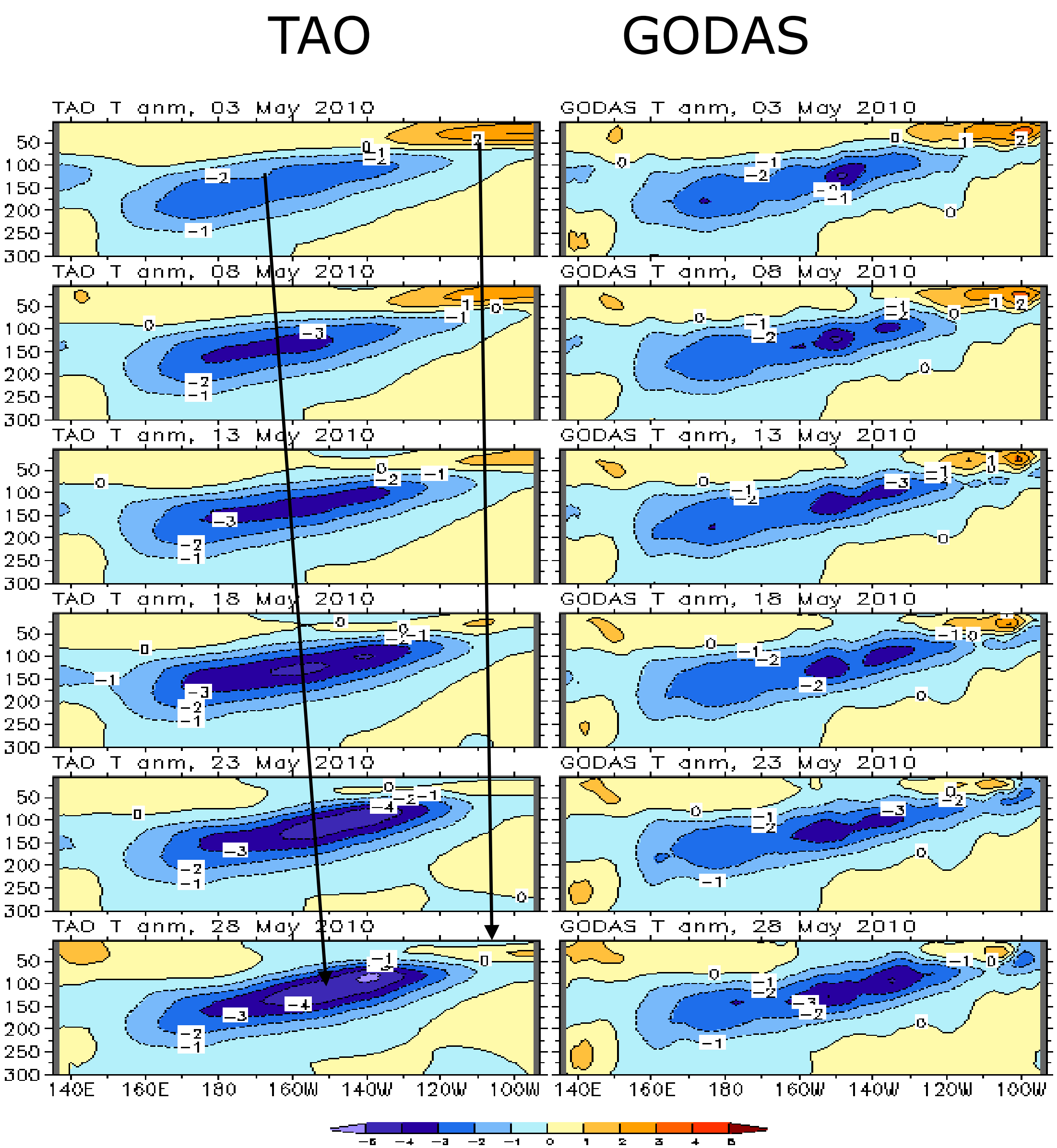
- Surface westward current anomaly intensified in May 2010, comparable with that in 1998.

- 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 Dr. Kathleen Dohan and see "http://www.esr.org/enso_index.html" for details)

Equatorial Pacific Temperature Anomaly

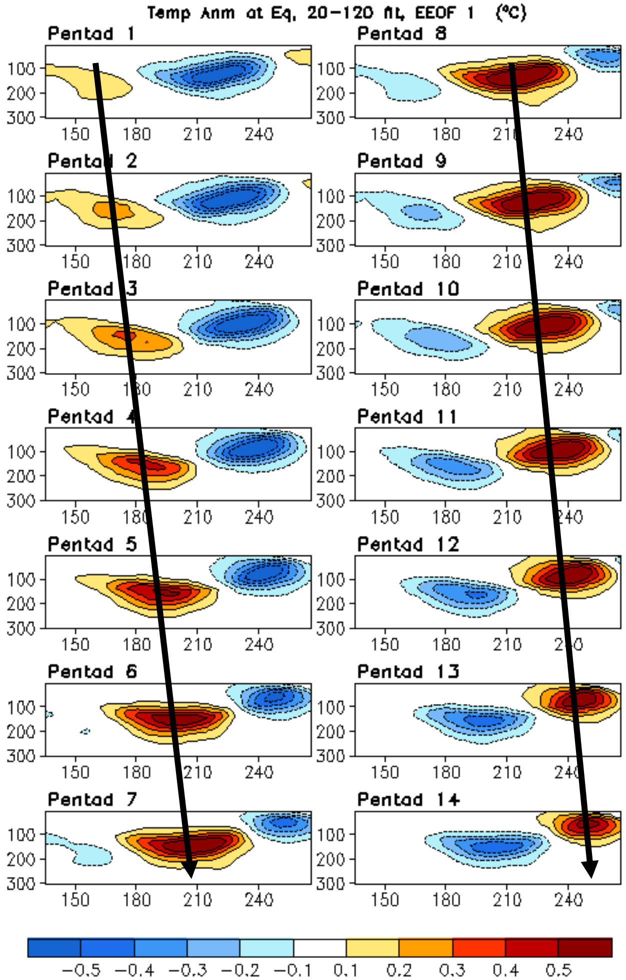


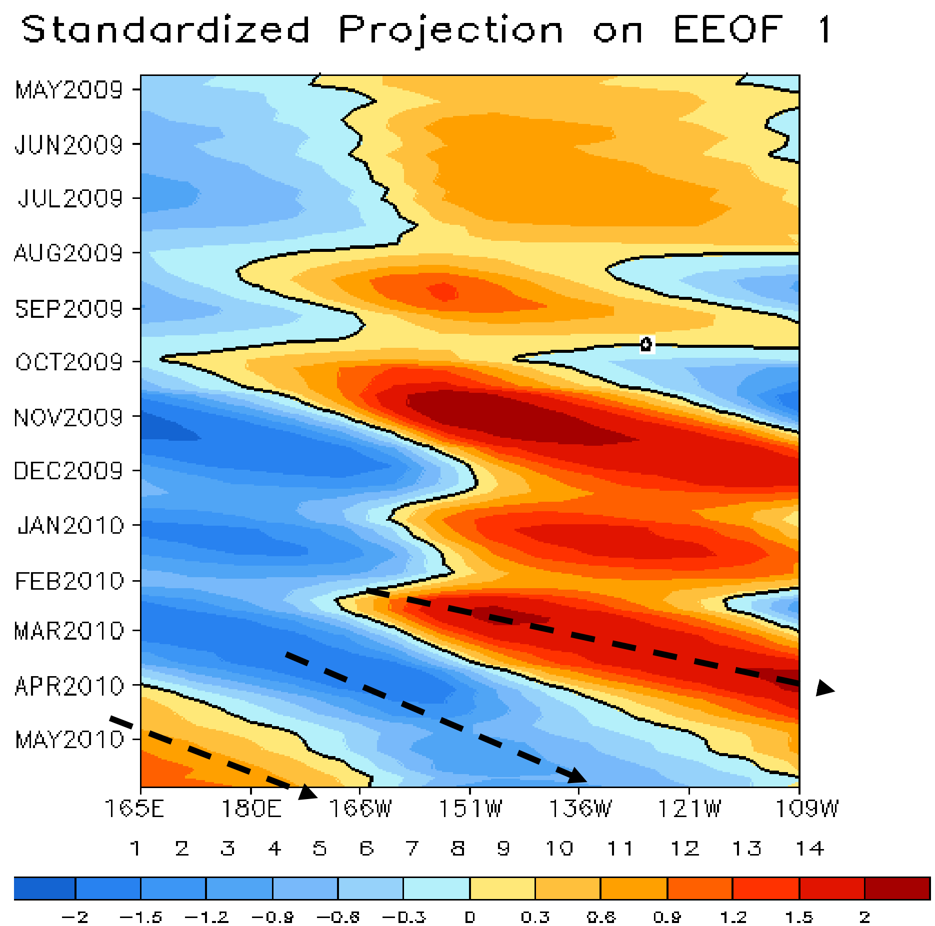
TAO climatology used

- Positive temperature anomaly near the surface in the east-central equatorial Pacific weakened substantially and was replaced by negative anomaly in May 2010.

- Negative temperature anomaly near the thermocline in the central equatorial Pacific propagated eastward and upward in May 2010.

Oceanic Kelvin Wave Indices

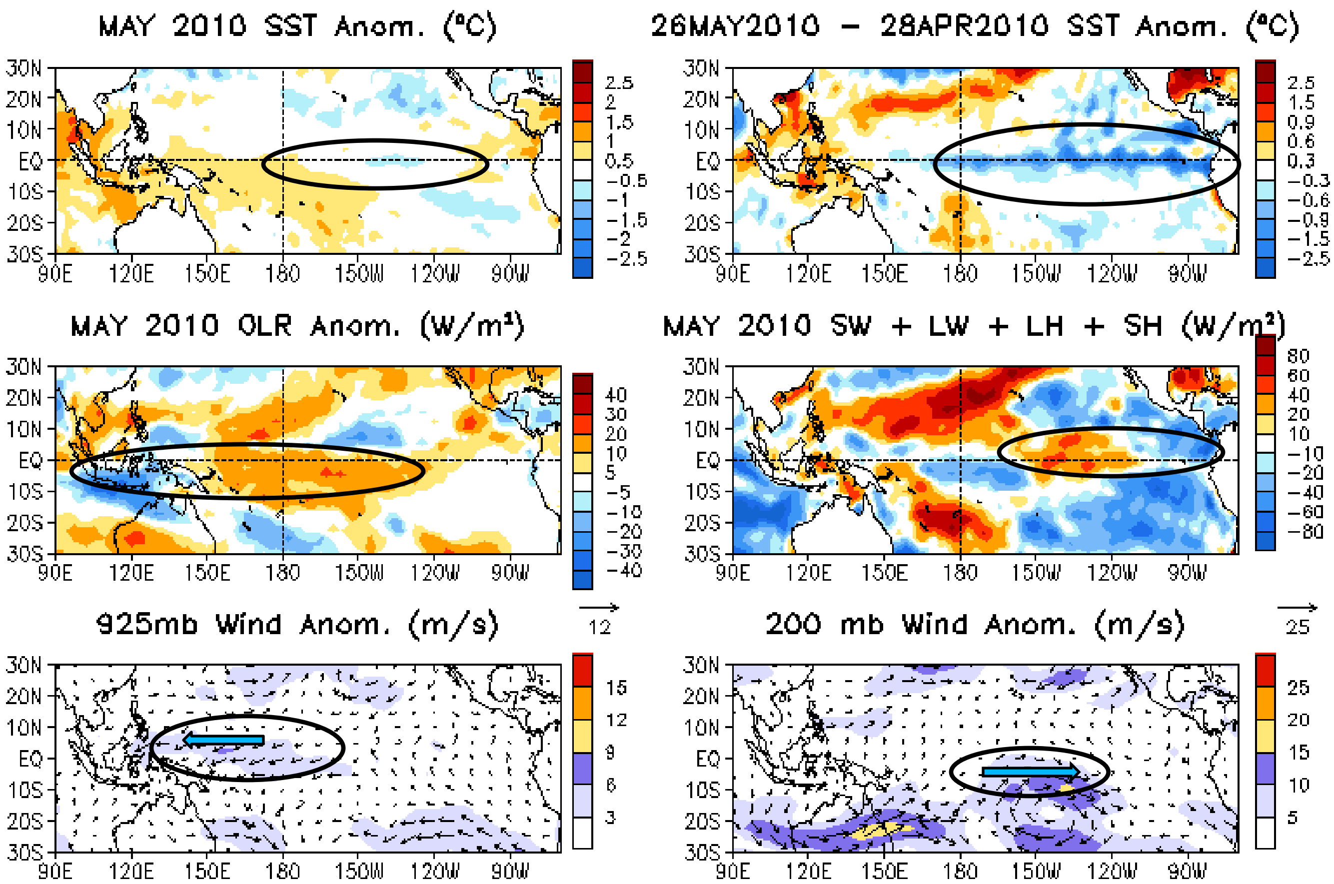




- **Upwelling Kelvin wave occurred in late Feb 2010 in the W. Pacific and propagated eastward, which weakened the positive SSTA and generated the negative SSTA in the central and eastern tropical Pacific.**

- **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



- Positive SSTA was replaced by negative one in the east-central equatorial Pacific.

- Convection was enhanced (suppressed) over the Maritime Continent (equatorial central Pacific).

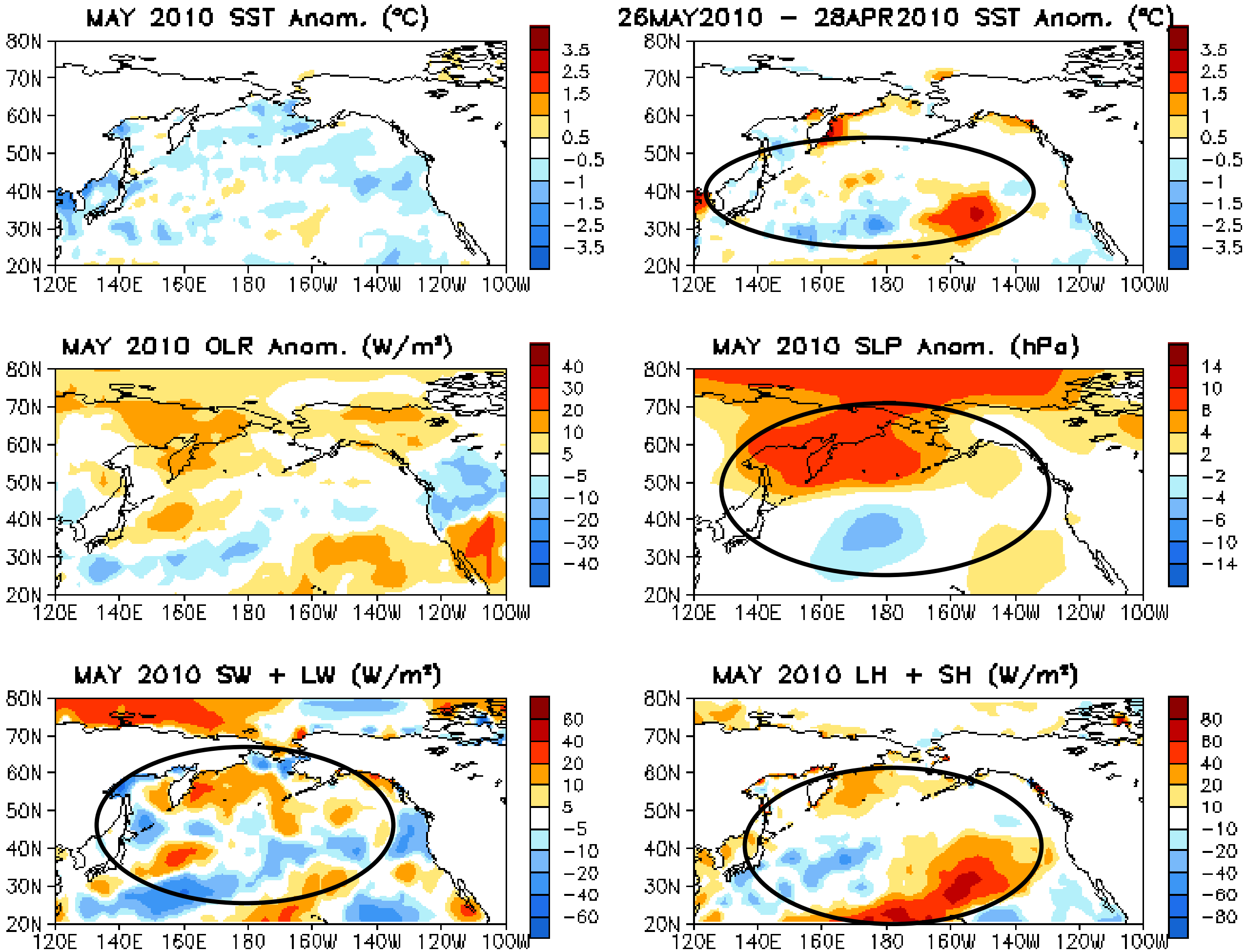
- Negative SSTA tendency presented in the east-central equatorial Pacific is inconsistent with net surface heat flux anomaly, indicating ocean dynamics is important.

- Low-level easterly (upper-level westerly) wind anomaly presented in the central tropical 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.

North Pacific & Arctic Ocean

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



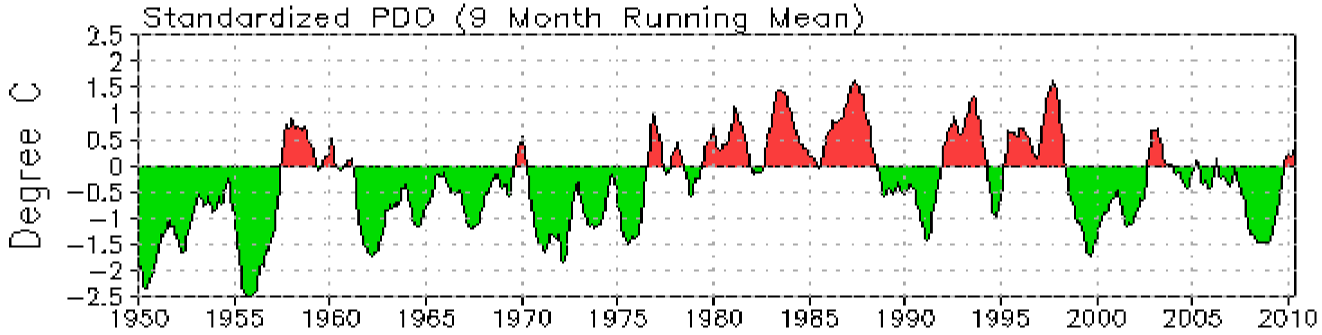
- The SSTA tendency, showing a cooling (warming) in the western (eastern) N. Pacific, is consistent with surface heat flux anomaly.

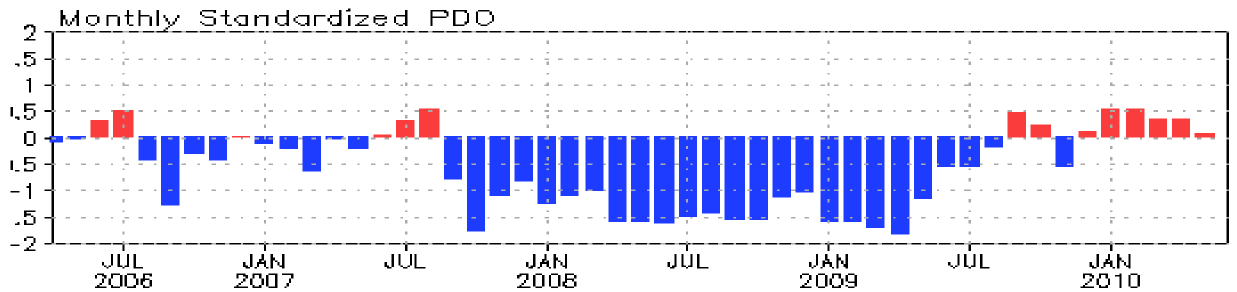
-Positive (negative) SLP anomaly presented in northern (southern) part of North Pacific.

- SLP meridional gradient reversed from Apr to May.

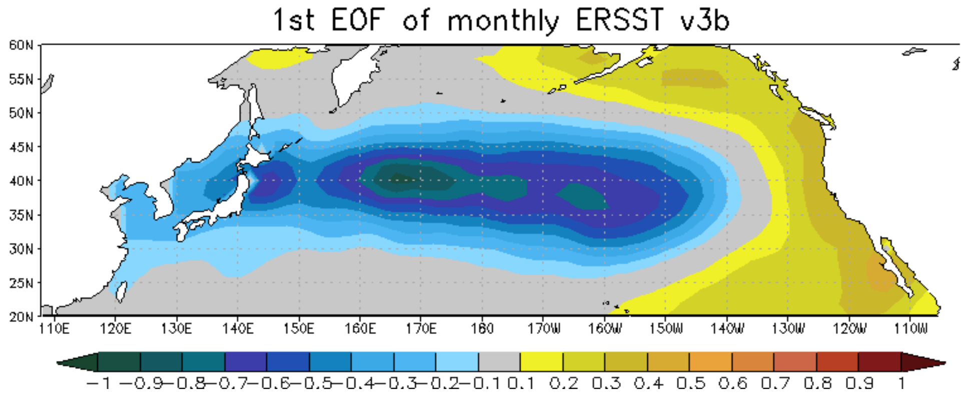
Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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





- **PDO index was near zero in May 2010.**

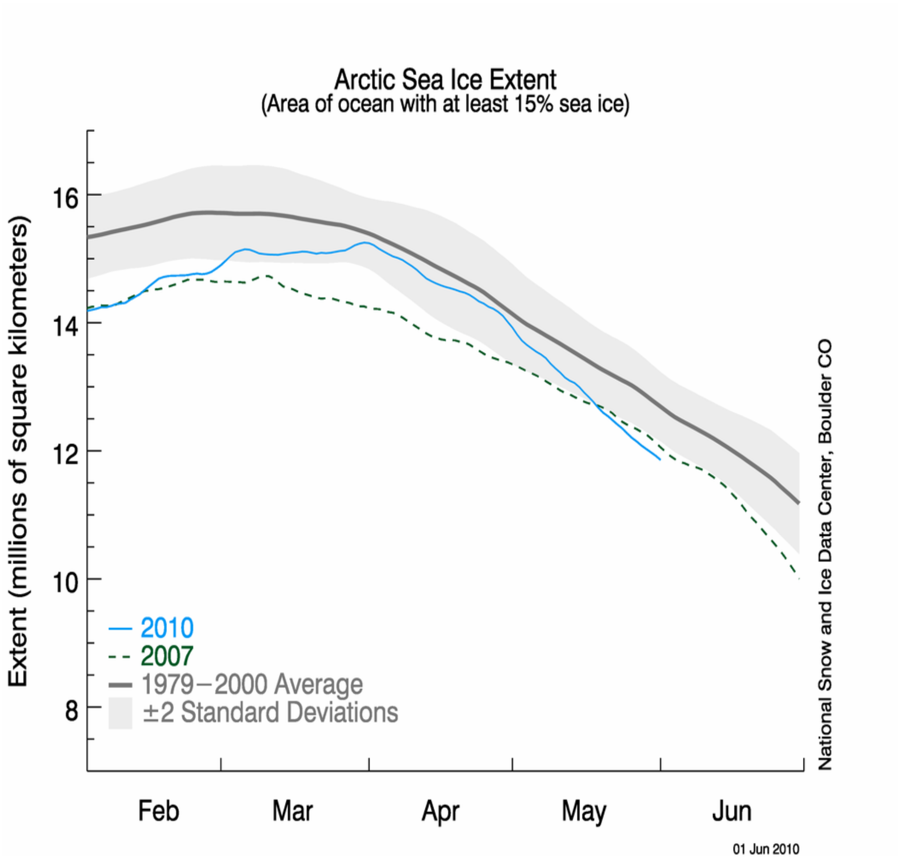


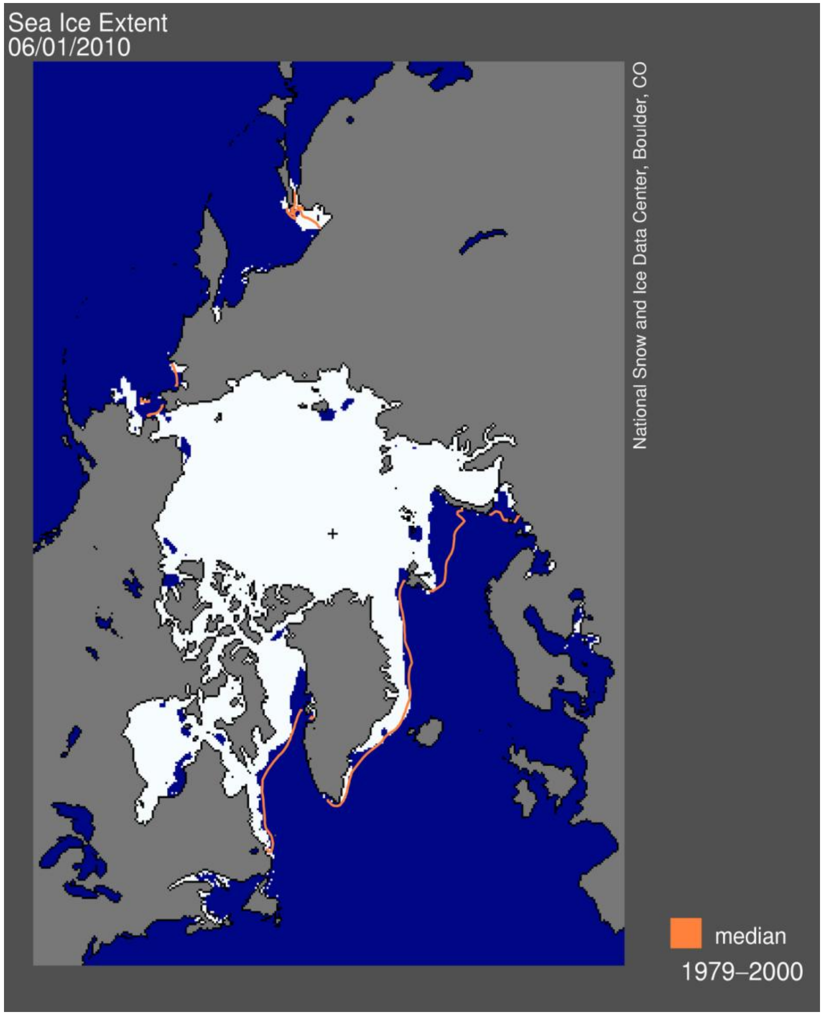
- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**
- **The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.**

Arctic Sea Ice

National Snow and Ice Data Center

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

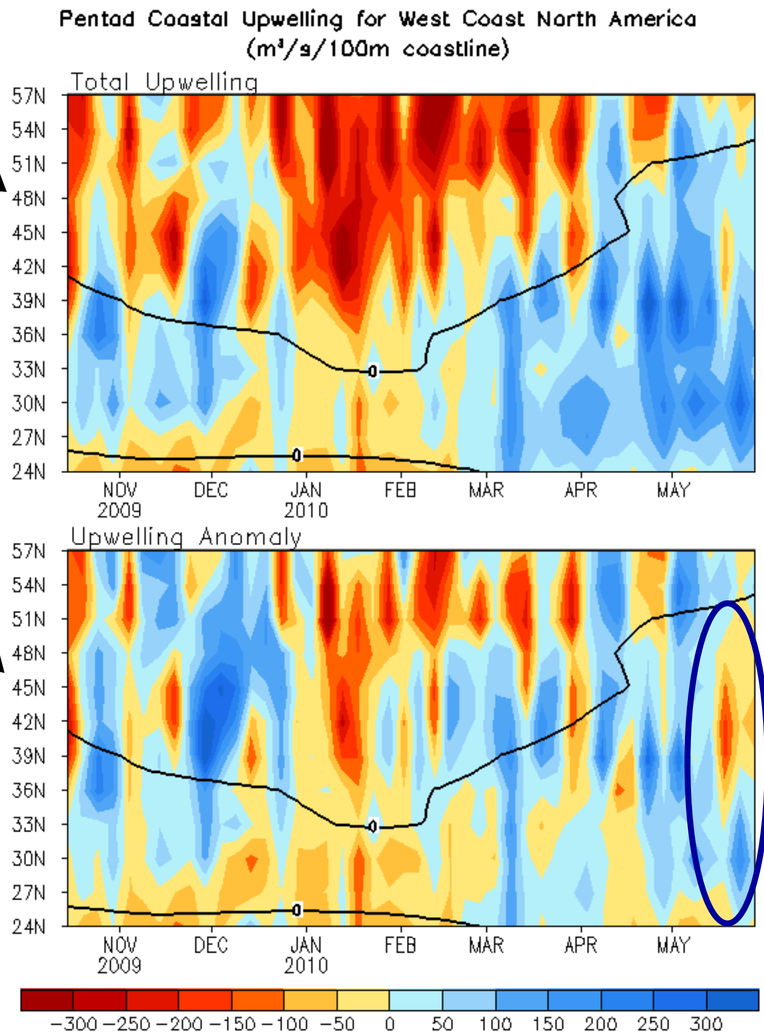


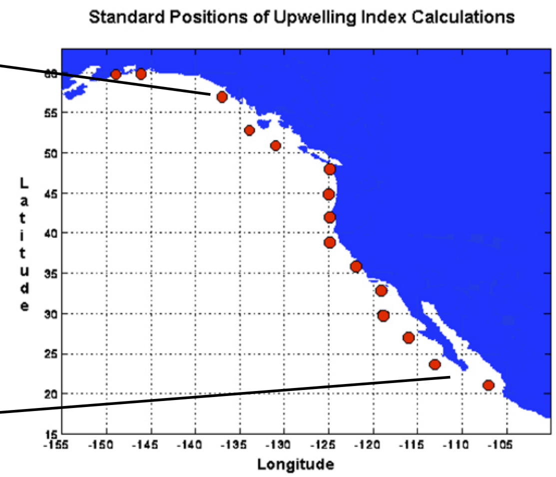


- Sea ice extent decreased significantly from near normal in Apr 2010 to well below normal in late May 2010.

-The sea ice extent in late May 2010 was even smaller than that in 2007.

North America Western Coastal Upwelling





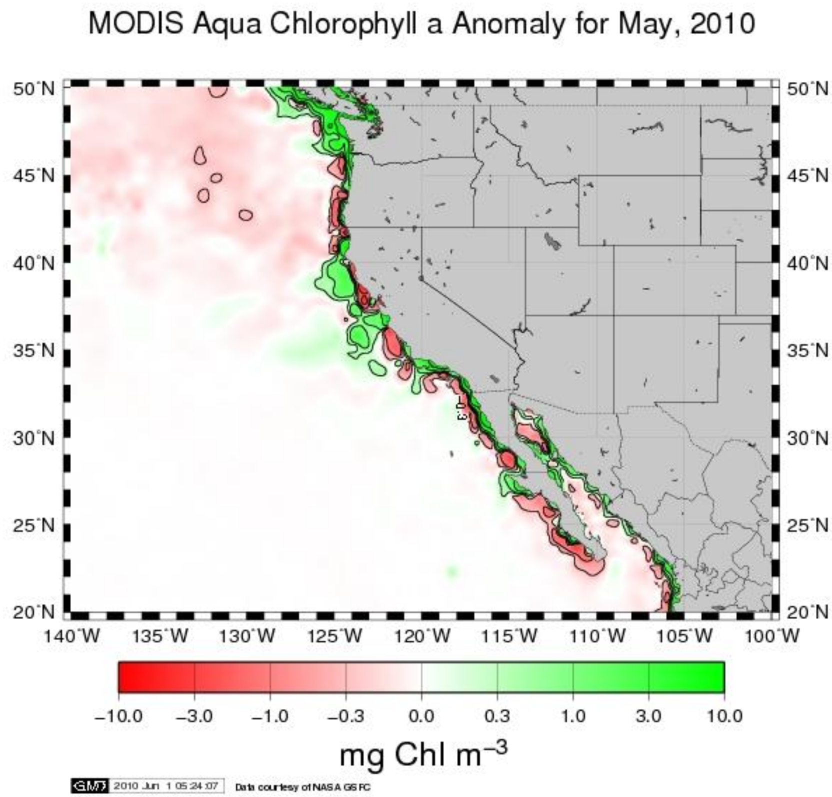
- Upwelling weakened in mid-latitude and intensified in low latitude in May 2010.

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.

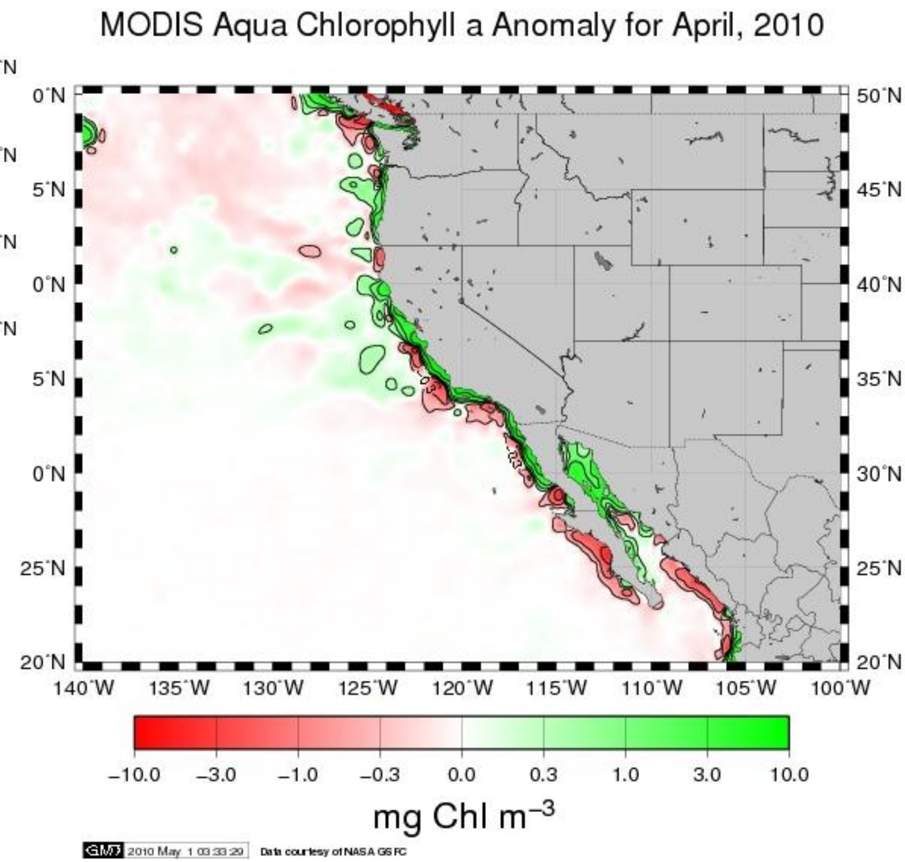
- Area below (above) black line indicates climatological upwelling (downwelling) season.

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

Monthly Chlorophyll Anomaly

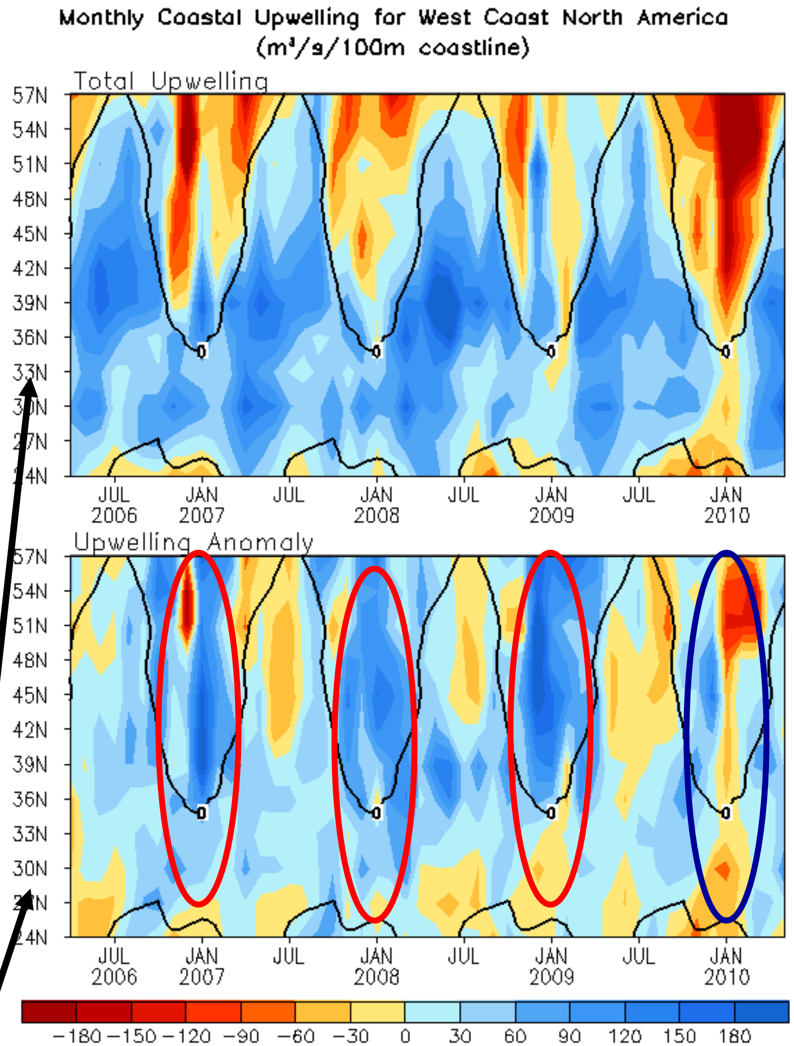


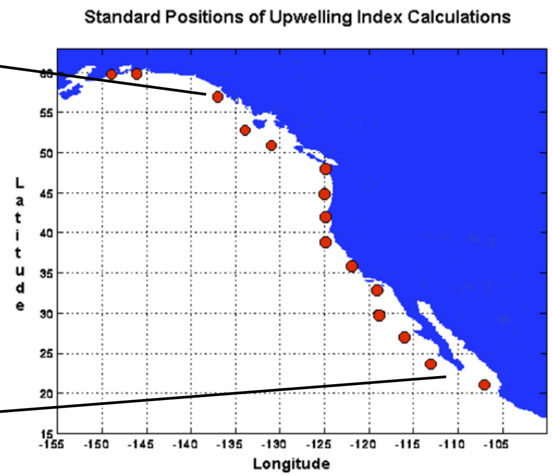
- **Chlorophyll decreased along the coast between 40-45N, consistent with the weakened upwelling in May 2010.**



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

North America Western Coastal Upwelling





- Upwelling had been above-normal during the winter of 2006/07, 2007/08, 2008/09.

-But, upwelling was below-normal during the winter of 2009/10.

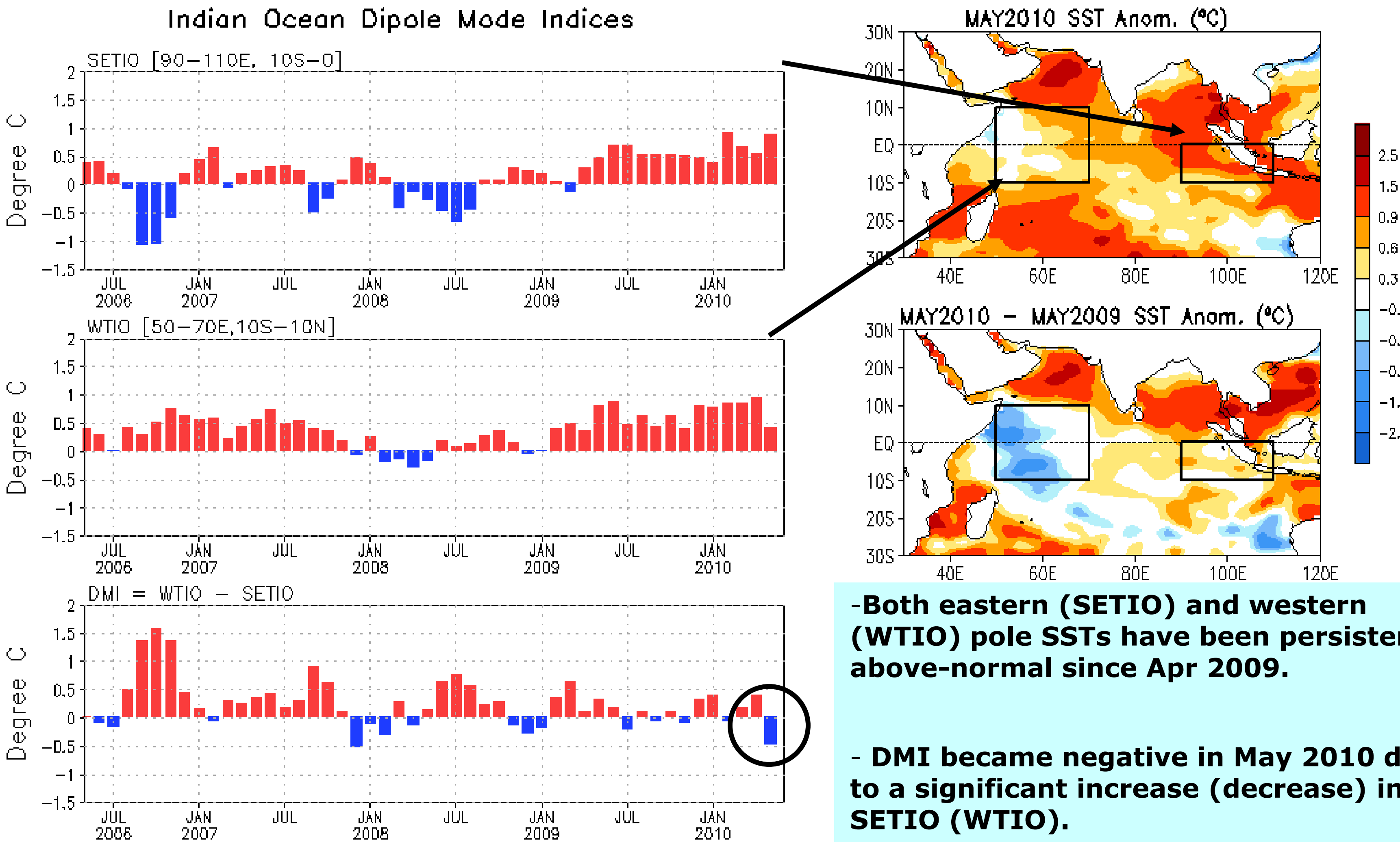
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point (m³/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

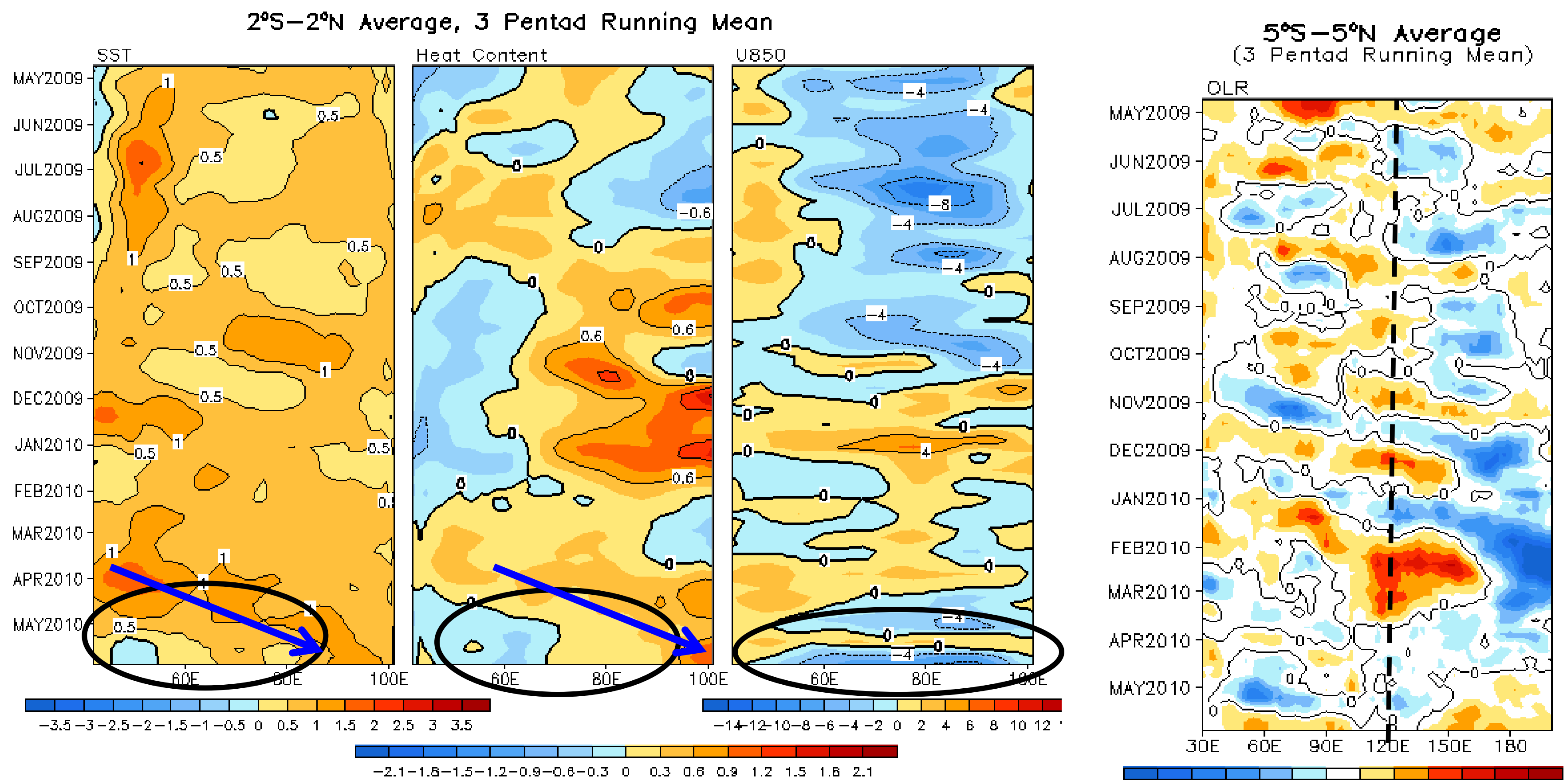


-Both eastern (SETIO) and western (WTIO) pole SSTs have been persistently above-normal since Apr 2009.

- DMI became negative in May 2010 due to a significant increase (decrease) in SETIO (WTIO).

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.

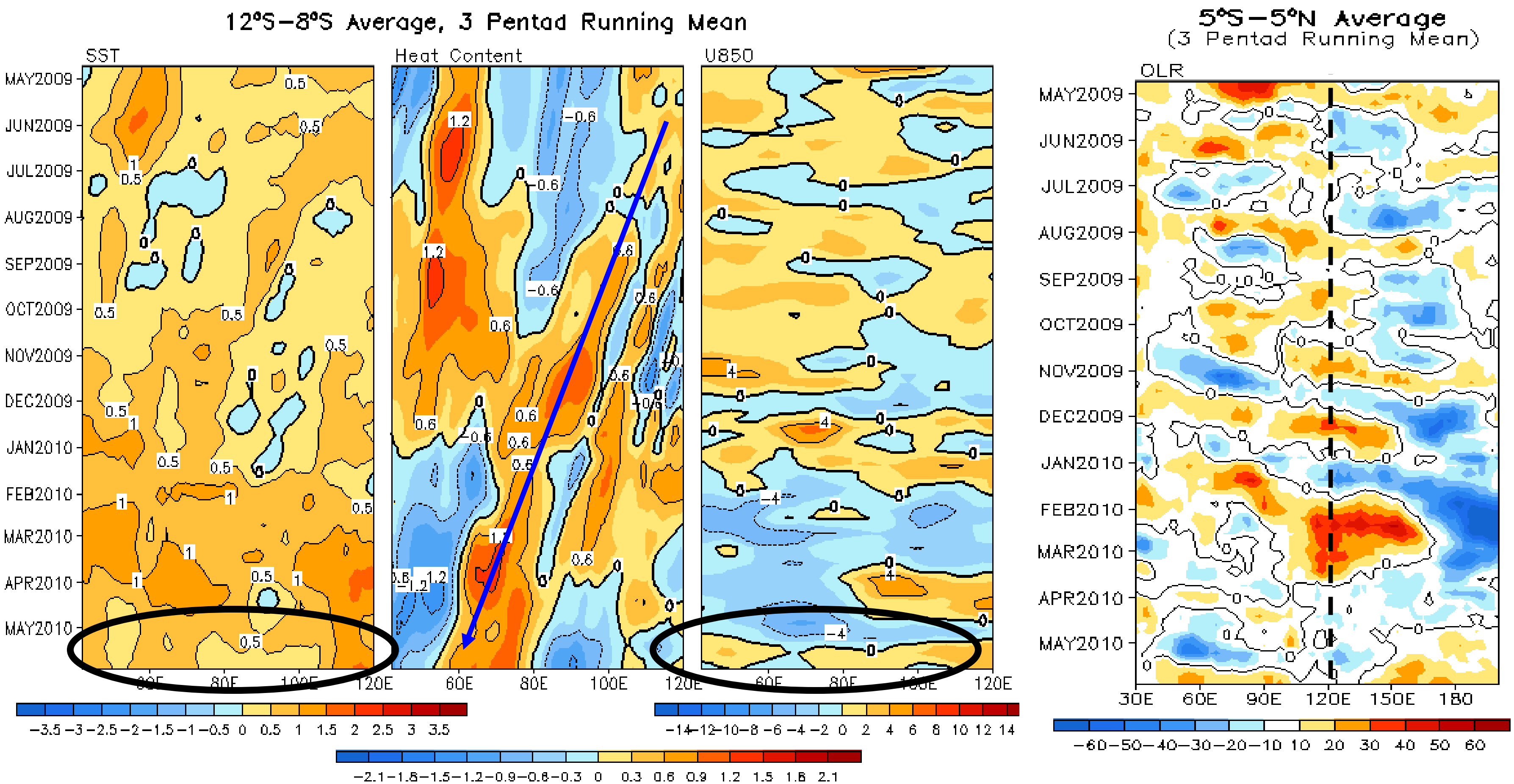
Recent Evolution of Equatorial Indian SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s) and OLR (W/m²) Anomalies



- **Positive SSTA propagated eastward in Apr-May 2010.**
- **Heat content anomaly was positive in the eastern-central tropical Indian Ocean and propagated eastward.**
- **Easterly wind anomalies developed in the tropical Indian Ocean in late May2010.**

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^{o}S Indian SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s)



- **Positive SSTA weakened.**
- **Positive HCA propagated westward in the central-eastern tropical Indian Ocean since Jun 2009.**
- **Low-level wind anomaly was weak.**

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^{O}S-8^{O}S and Outgoing Long-wave Radiation (OLR, right) averaged in 5^{O}S-5^{O}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 presented in the tropical Indian Ocean.

- Negative net surface heat flux anomalies contributed to the negative SSTA tendency.

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- Convection was enhanced over NW Indian Ocean, Bay of Bengal, and the Maritime Continent, and suppressed in northwestern tropical Pacific Ocean.

-Convection was consistent with wind anomalies in the region.

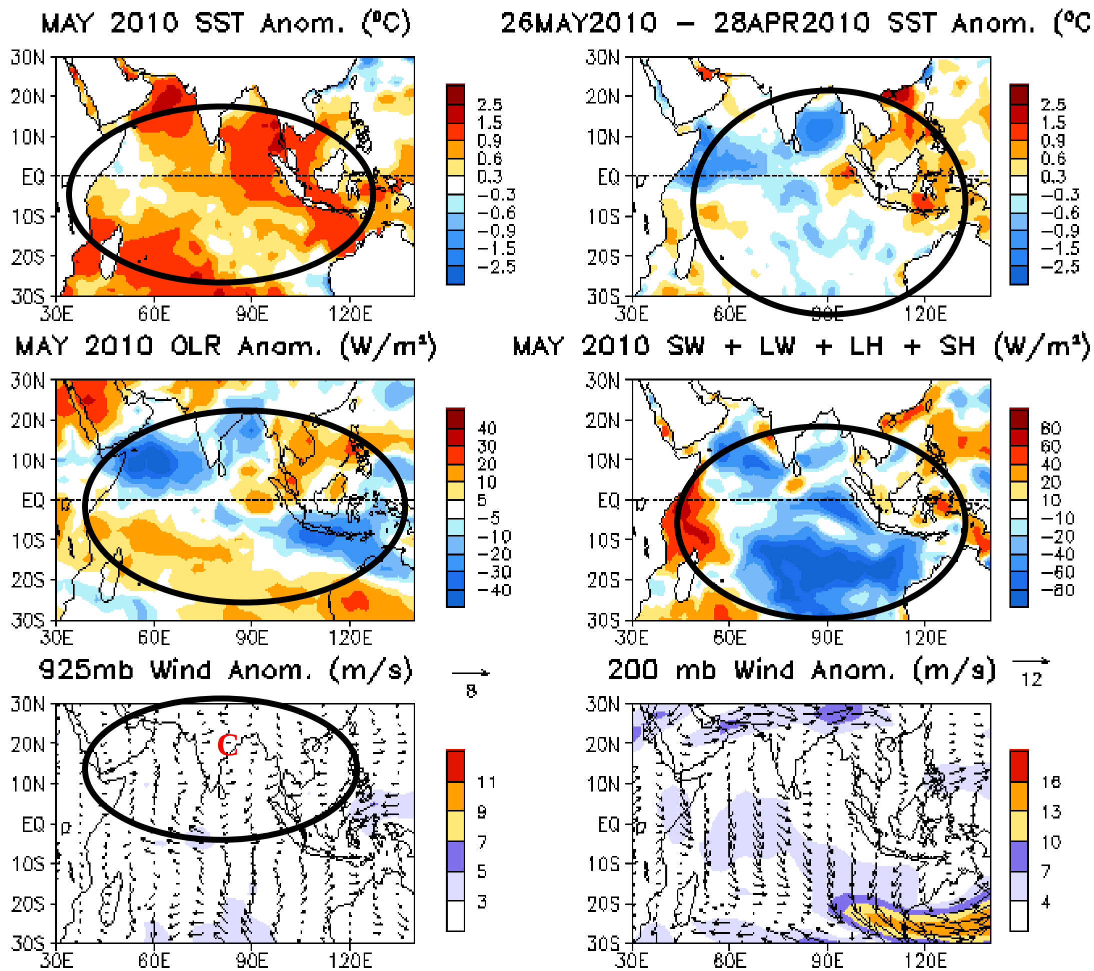
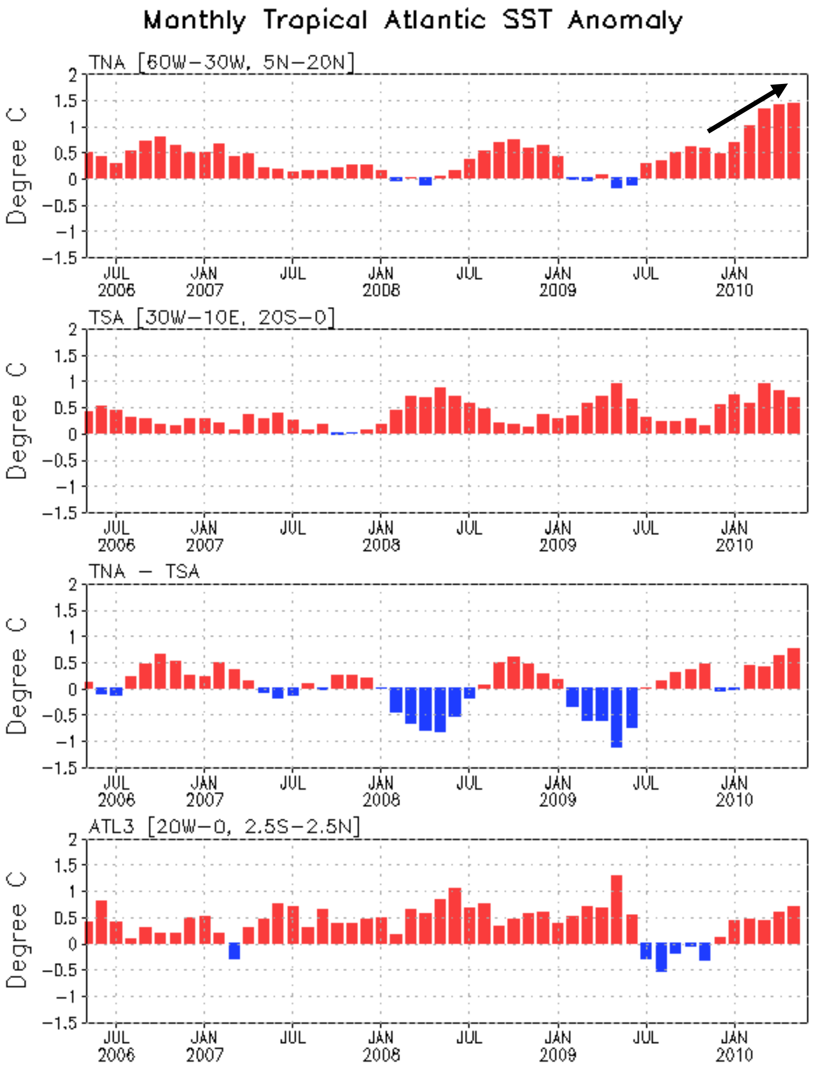
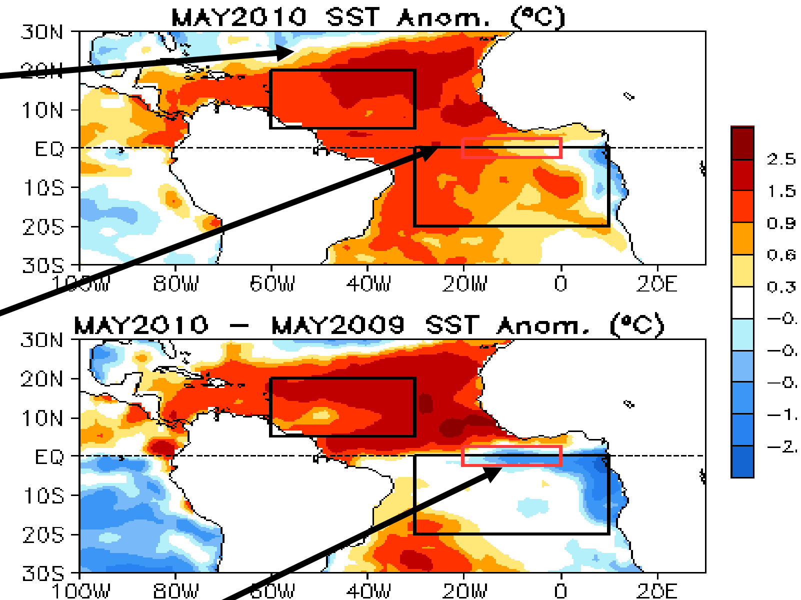


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

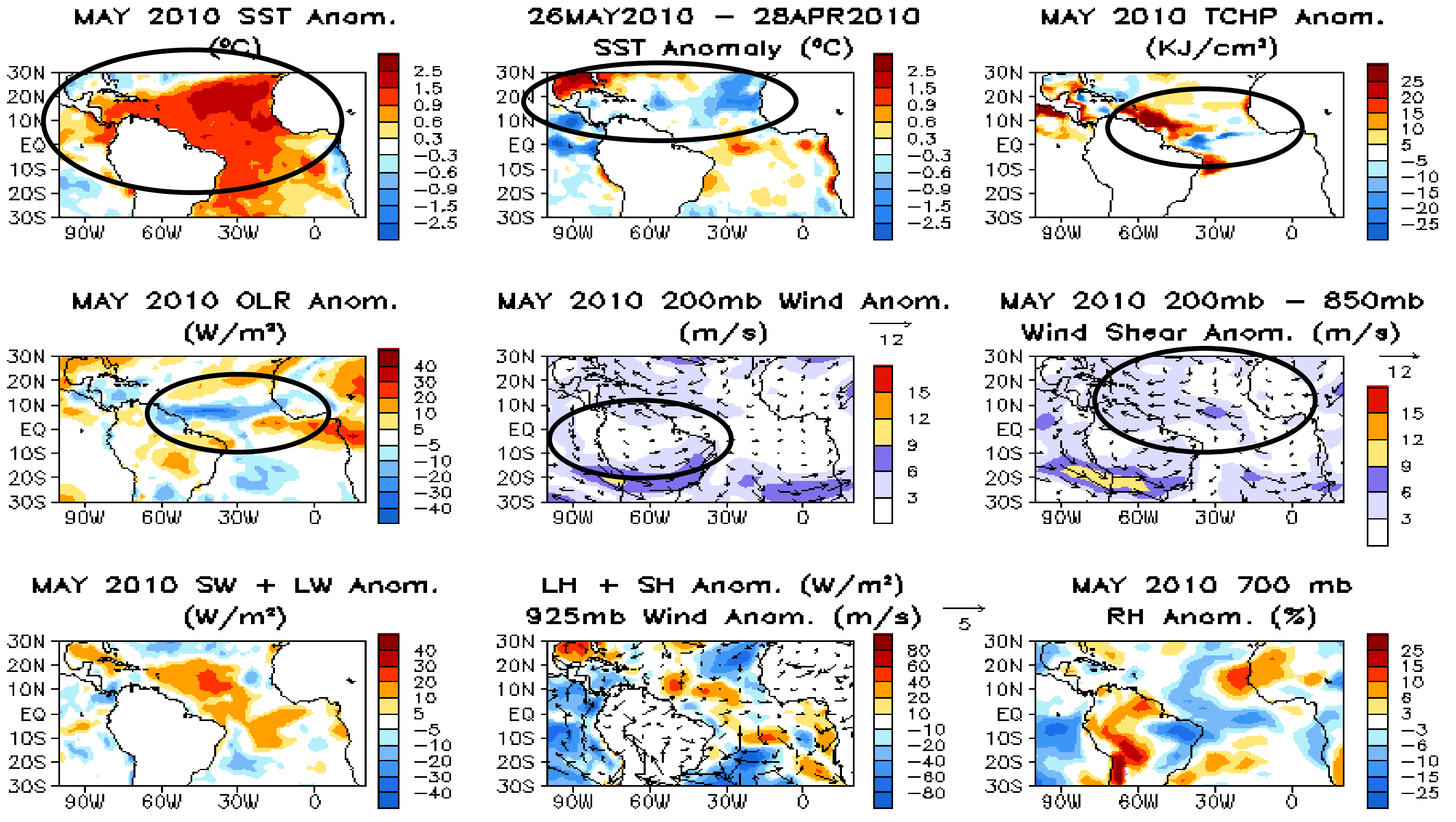




- **SST in the tropical North Atlantic (TNA) increased steadily from Dec 2009 to May 2010, and SSTA exceeded +1.3C during Mar-May 2010.**
- **Tropical South Atlantic SST (TSA) remained above-normal.**
- **Meridional Gradient Mode (TNA-TSA) was above-normal.**
- **Positive ATL3 SST persisted.**

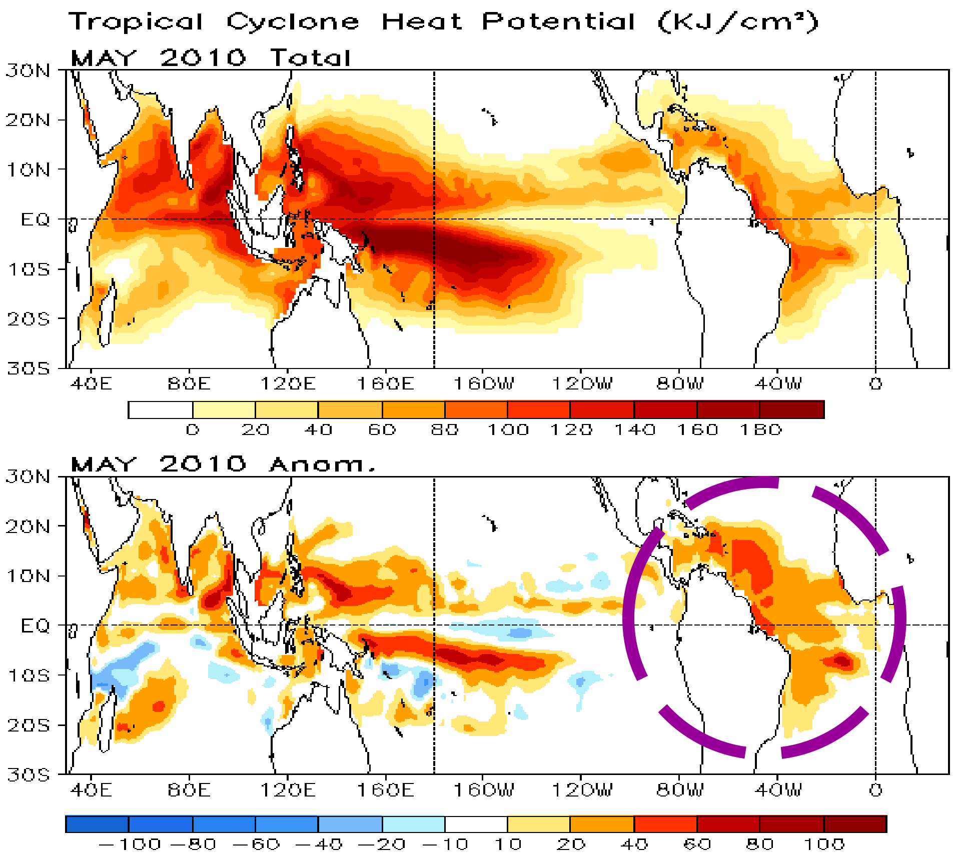
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between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

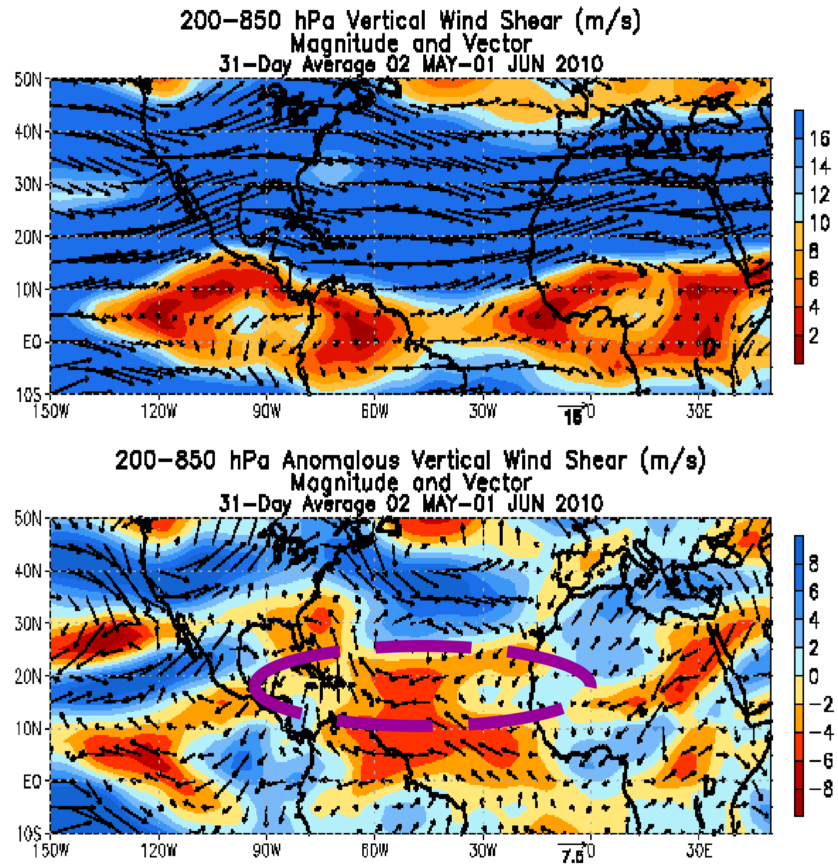
Tropical Atlantic:



- **SST decreased in the eastern tropical N. Atlantic and increased in Gulf of Mexico.**
- **Convection was enhanced (suppressed) in the western (eastern) equatorial Atlantic Ocean.**
- **Easterly wind shear anomaly and above-normal TCHP in hurricane MDR are favourable for hurricane development.**
- **Strong cyclonic wind in the central America at high levels was consistent with the suppressed convection there.**

Tropical Cyclone Heat Potential, wind shear and their Anomaly





- **Positive TCHP anomalies in the tropical Atlantic , North Indian Ocean, and NW Pacific Ocean in May 2010.**
- **Vertical wind shear was below-normal in MDR**

-The positive TCHP anomalies and below-normal wind shear might affect the hurricane activity in the coming months in the Atlantic basin.

The tropical cyclone heat potential (hereafter TCHP), is defined as a measure of the integrated vertical temperature from the sea surface to the depth of the 26°C isotherm.

North Atlantic Ocean

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

- Negative NAO continued in May 2010 (next slide), consistent with SLP anomalies.

- Consistent with the negative NAO are the tripole pattern of SSTA, OLR anomalies, and LH+SH anomalies.

- SSTA tendencies were consistent with surface heat flux anomalies.

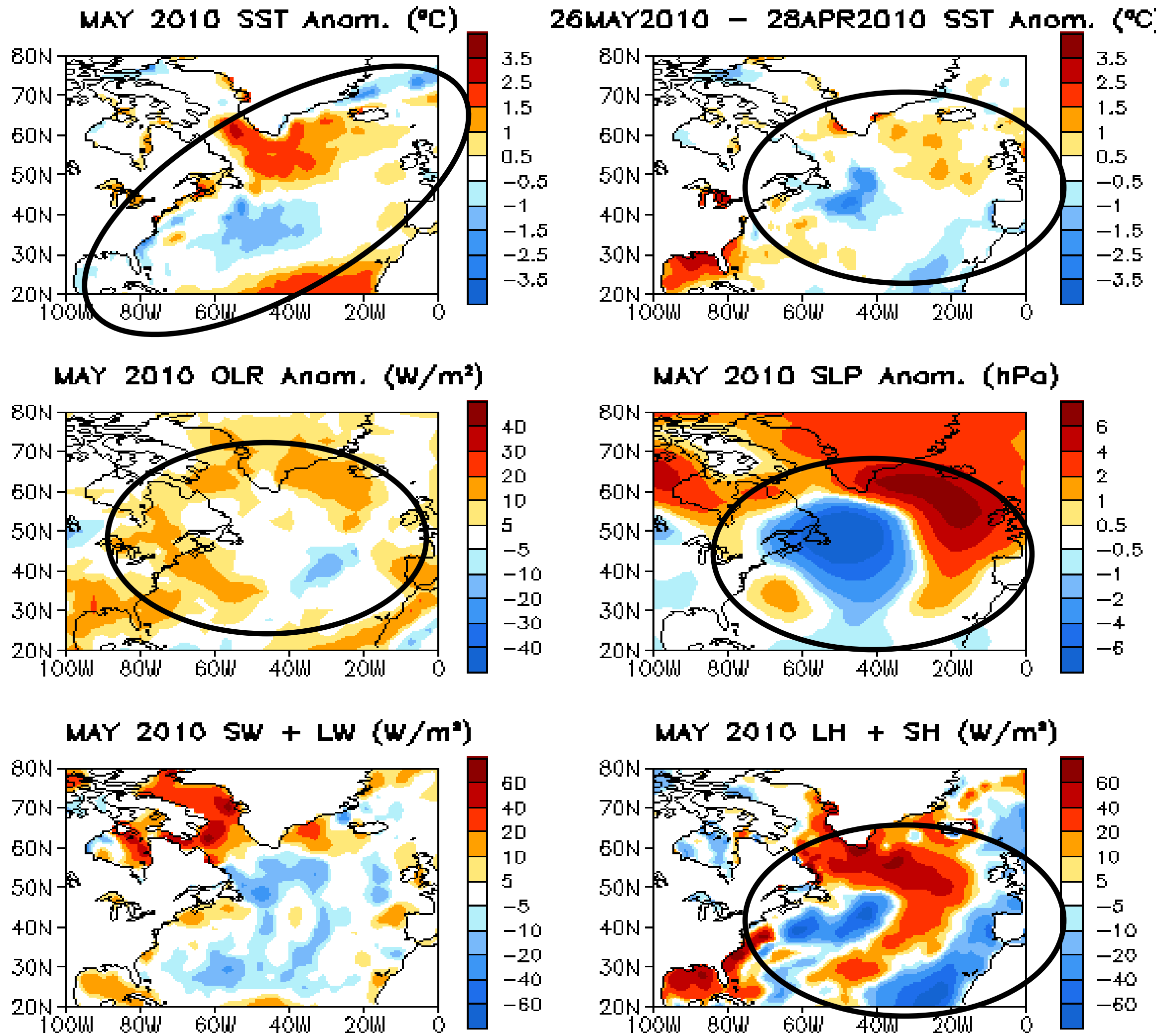
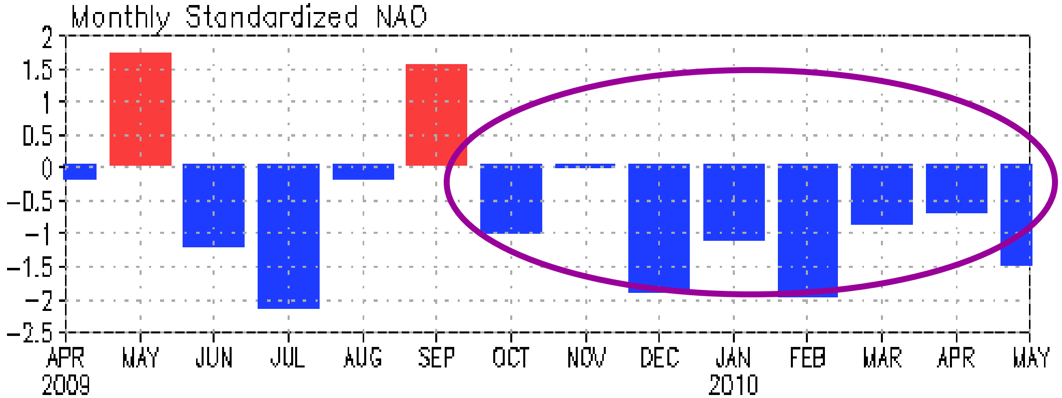
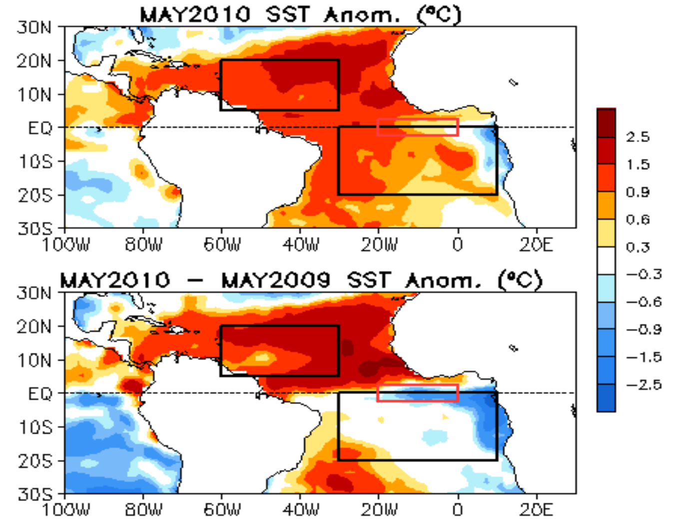
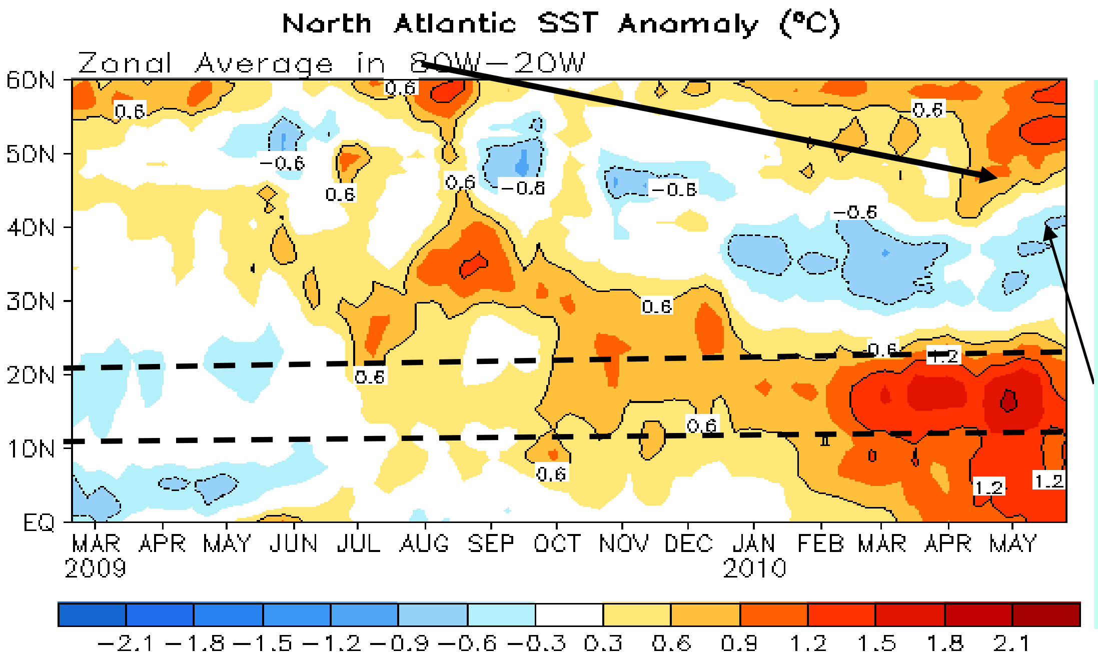


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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







- **NAOI=-1.5.**

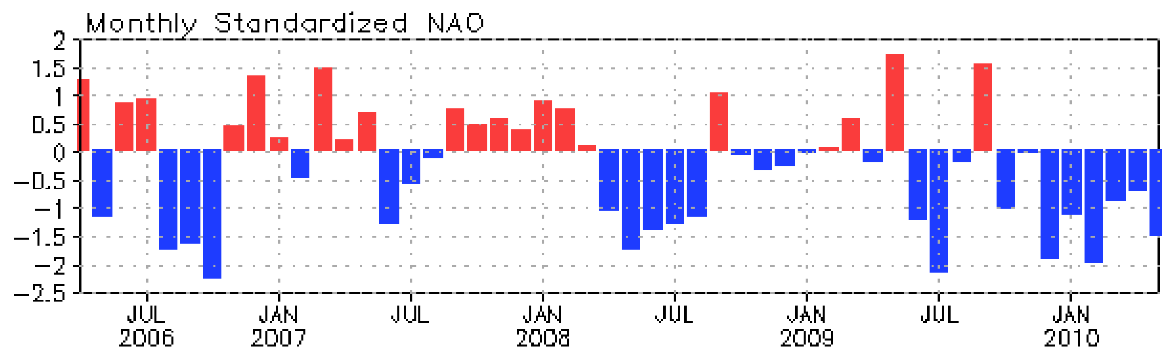
- **Mid-latitude North Atlantic SSTA are closely related to NAO index – negative (positive) NAO leads to SST cooling (warming).**

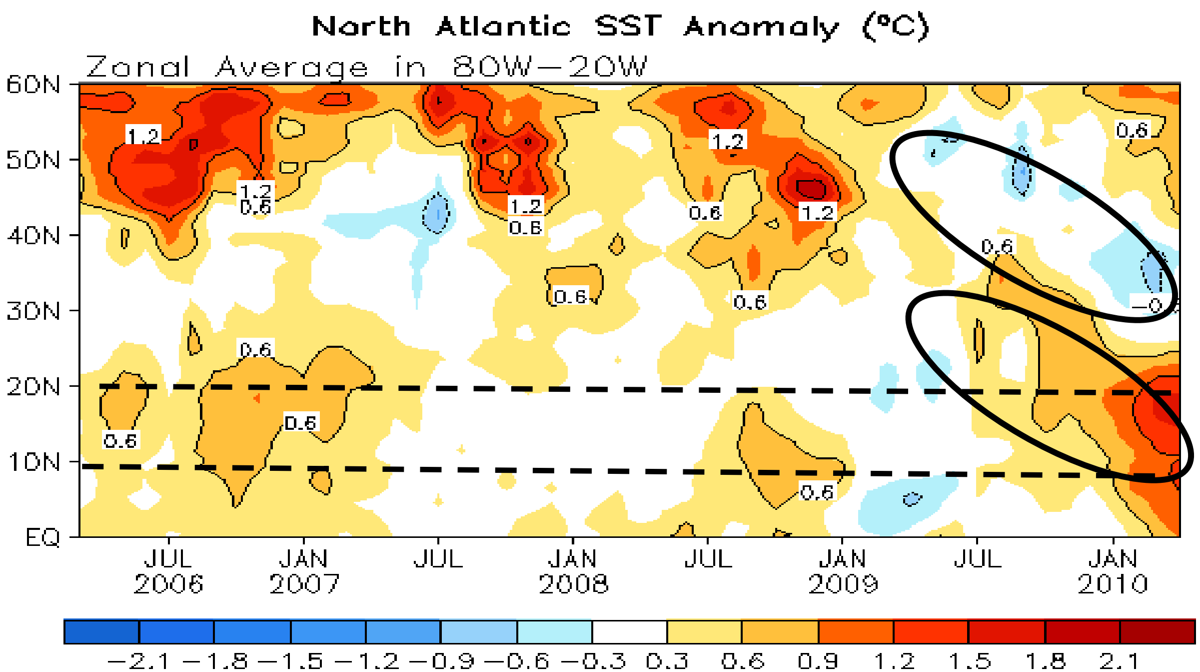
- **NAO has been persistently below-normal since Oct 2009, which contributed to the development and maintenance of negative (positive) SSTA in mid-latitude (tropical) North Atlantic.**

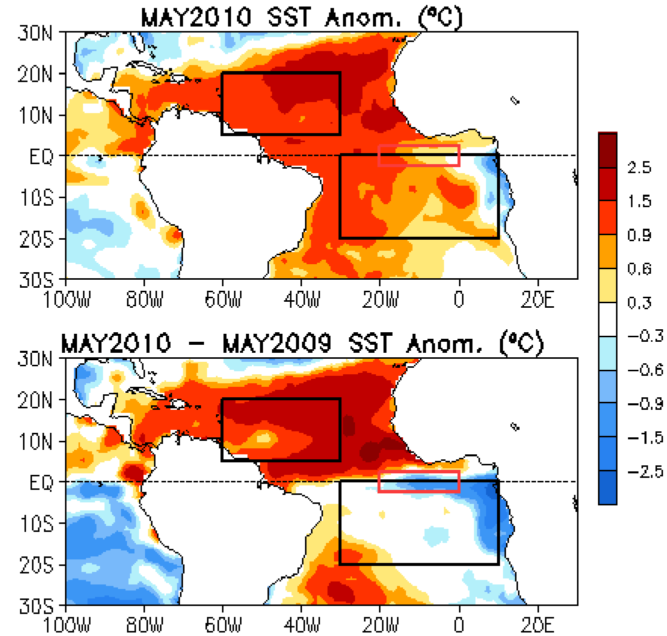
- **Positive SSTA in the Hurricane MDR have been above-normal since Oct 2009 and intensified since Feb 2010, consistent with the impacts of El Nino.**

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

NAO and SST Anomaly in North Atlantic





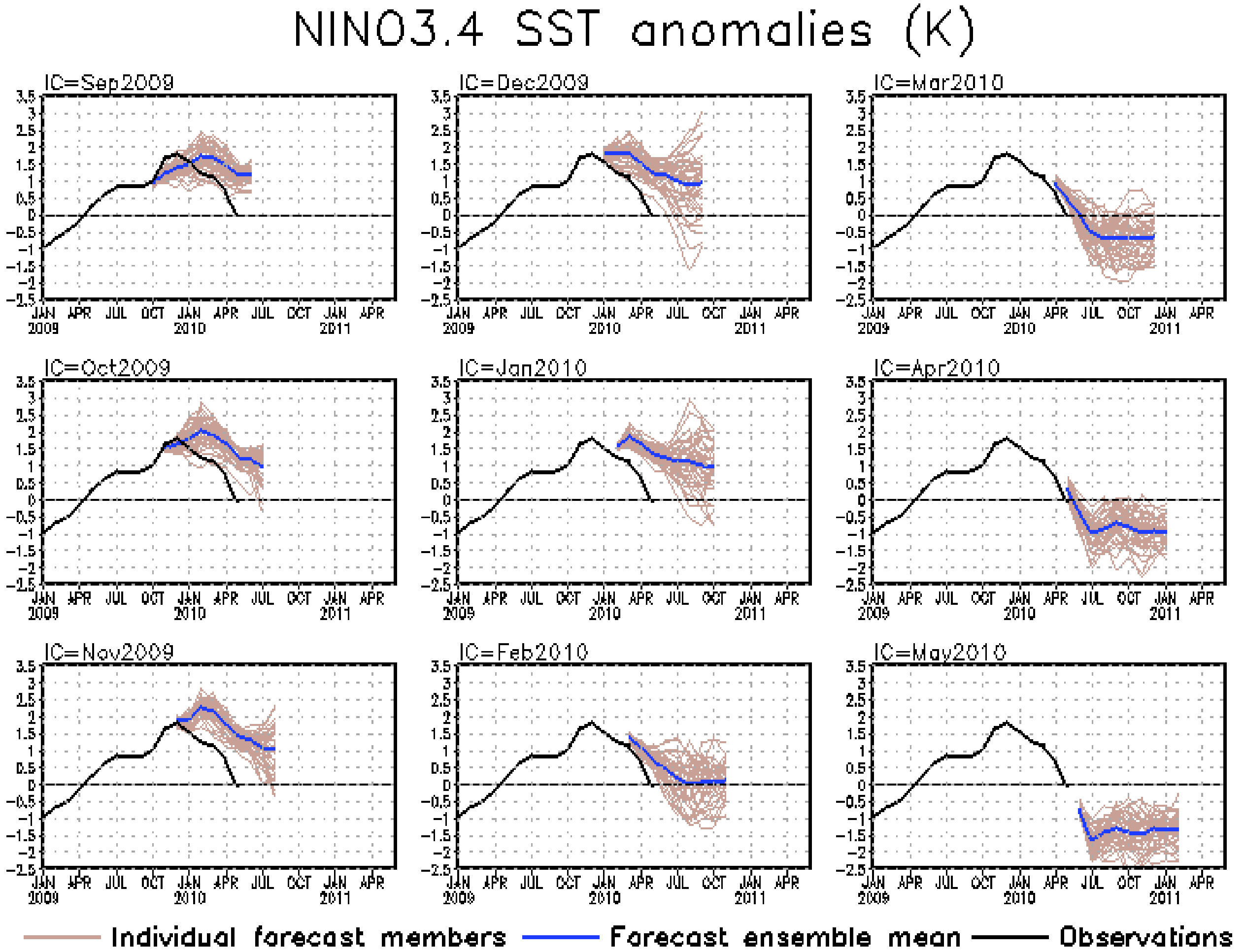


- **Mid-latitude North Atlantic SST has been below-normal since May 2009 .**
- **SST in the Hurricane MDR has been above-normal since Jul 2009, and intensified significantly since Feb 2010.**

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (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

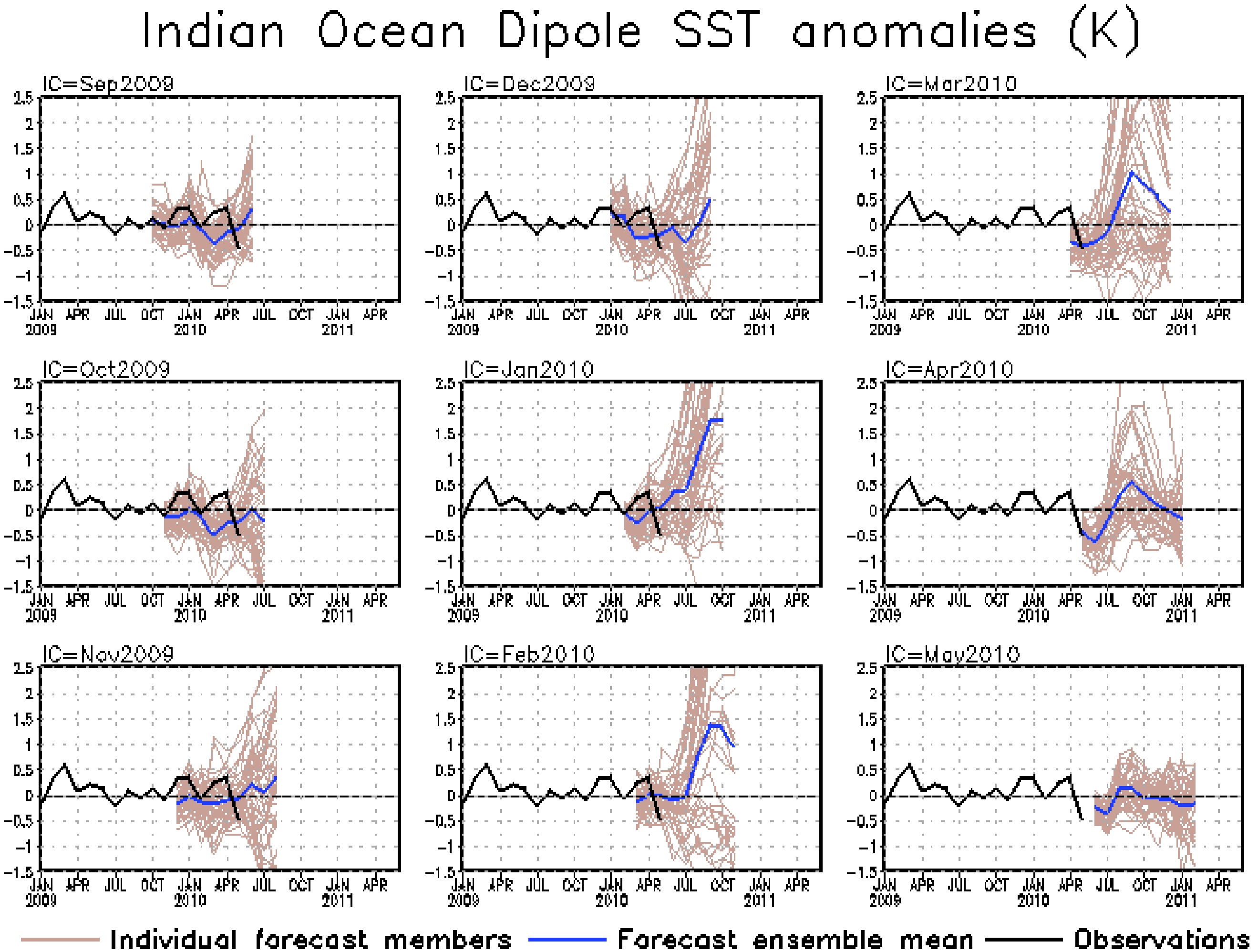


- **Forecasts from Sep-Feb I.C. show warm biases, and delayed the transition to the decay/neutral phase of El Nino in Jan2010/May2010.**

- **The latest forecast from May 2010 I.C. suggests the E. Pacific will transit to La Nina conditions in summer 2010.**

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.

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]

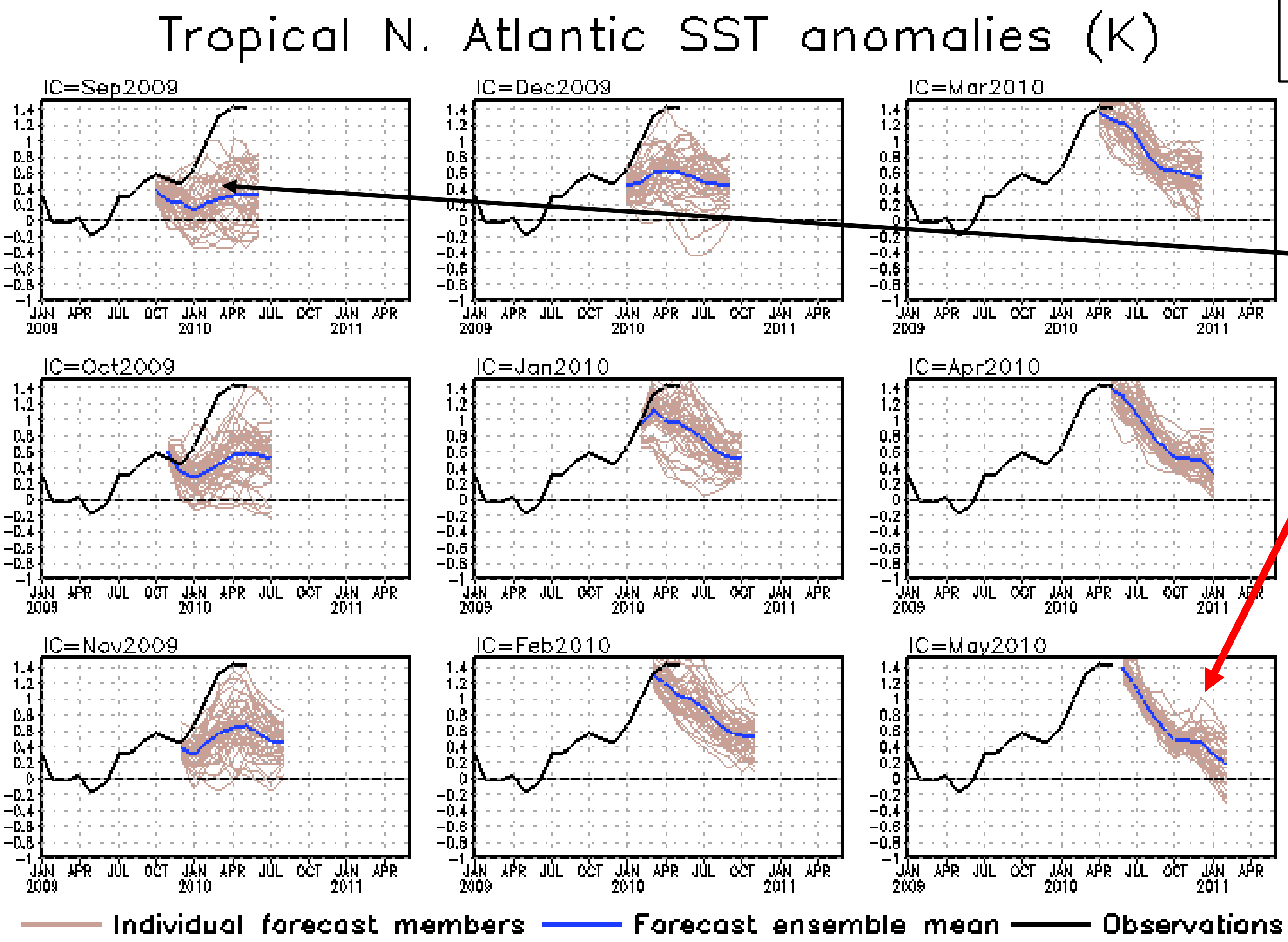
- Latest forecasts called for a near-normal IOD during the following months of 2010.

-Large inter-ensemble member spread in the forecasts from Feb-Apr2010 I.C.

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 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].

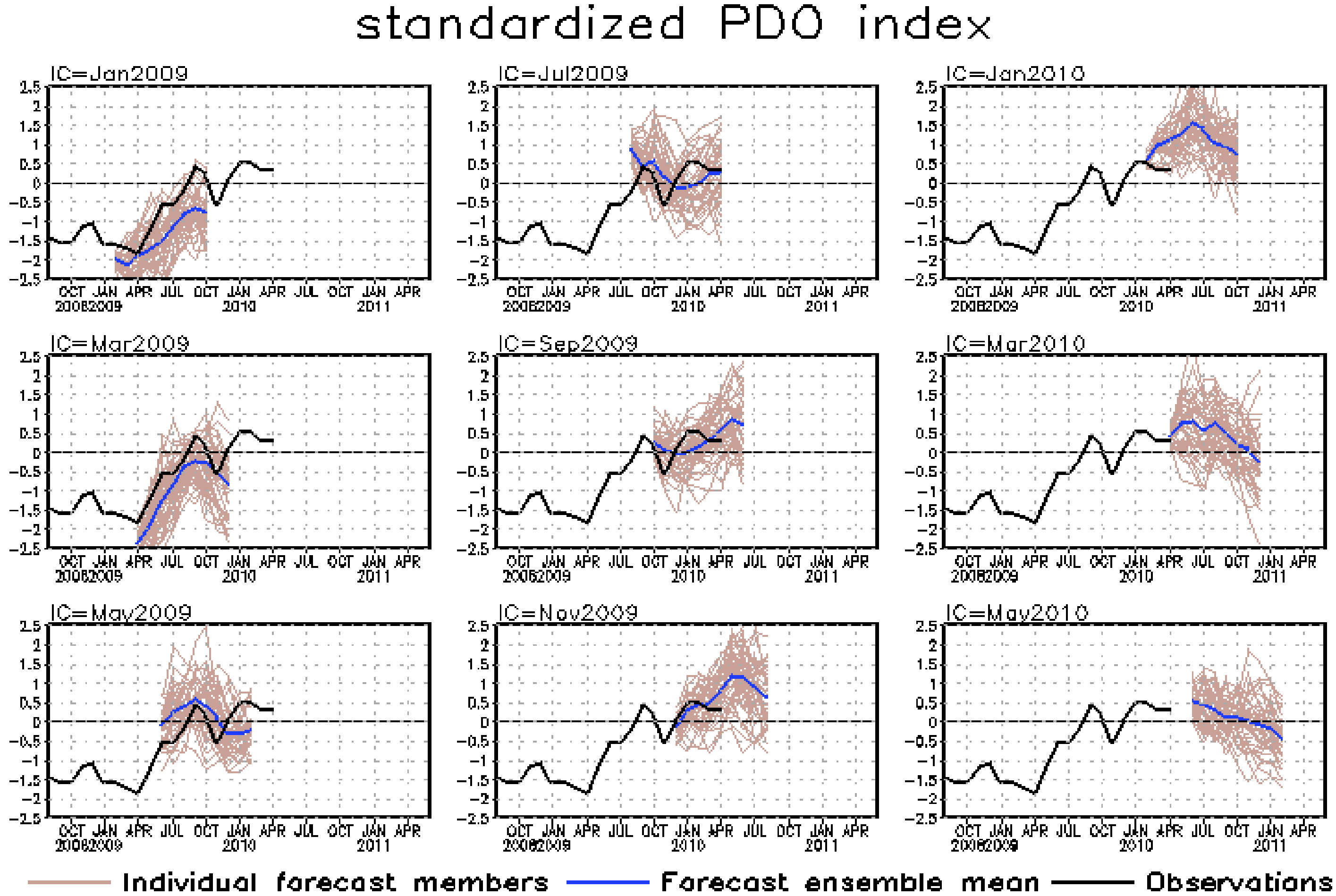


- **Large cold biases from Sep-Mar I.C.**
- **Less spread in the latest forecasts**

- **Latest forecasts suggested that the positive tropical North Atlantic SST anomalies would peak in late spring or early summer of 2010 due to the weakening of the impacts of the 2009/2010 El Nino, and likely remain positive through summer/fall 2010.**

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 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.

- Latest forecasts suggested that the PDO will remain near-normal throughout winter 2010/2011.

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 1971-2000 base period means.

Summary

- **Pacific/Arctic Ocean**
  - **ENSO cycle: Transition to neutral conditions in May 2010**
  - **Upwelling oceanic Kelvin waves forced by persistent low-level easterly wind anomalies during Mar-May2010 pushed negative heat content anomalies eastward to near the American coast and generated strong westward zonal current anomalies.**
  - **NOAA/NCEP Climate Forecast System (CFS) predicts the onset of La Niña conditions during Jun-Aug2010.**
  - **PDO was in neutral phase during Mar-May 2010.**
  - **Arctic sea ice extent decreased significantly from near-normal in Apr 2010 to well below-normal in late May 2010.**
- **Indian Ocean**
  - **Positive SSTA strengthened (weakened) in the eastern (western) tropical Indian Ocean in May 2010.**
  - **Indian Dipole index transitioned from positive to negative in May 2010.**
- **Atlantic Ocean**
  - **NAO remained strong negative in May 2010 with NAOI=-1.5.**
  - **Tripole SSTA pattern persisted in May 2010, which may be due to the impact of El Nino and negative phase of NAO.**
  - **SST in the tropical North Atlantic (TNA) increased steadily from Dec 2009 to May 2010, and SSTA exceeded +1.3C during Mar-May 2010.**
  - **Easterly wind shear anomaly and above-normal tropical cyclone heat potential presented in the hurricane MDR in May 2010.**

Backup Slides

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!