# 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)**

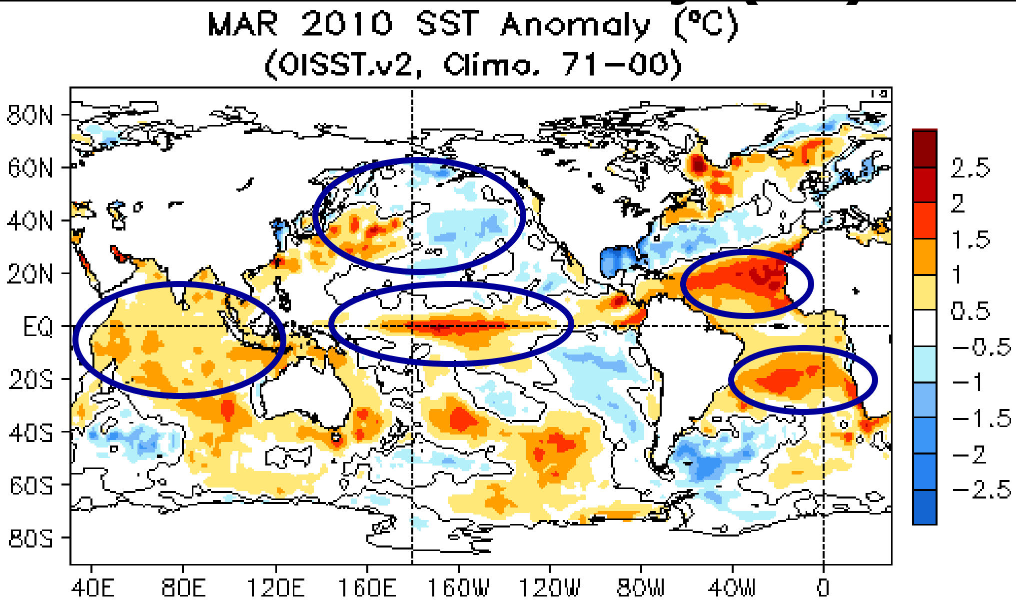
# Outline

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

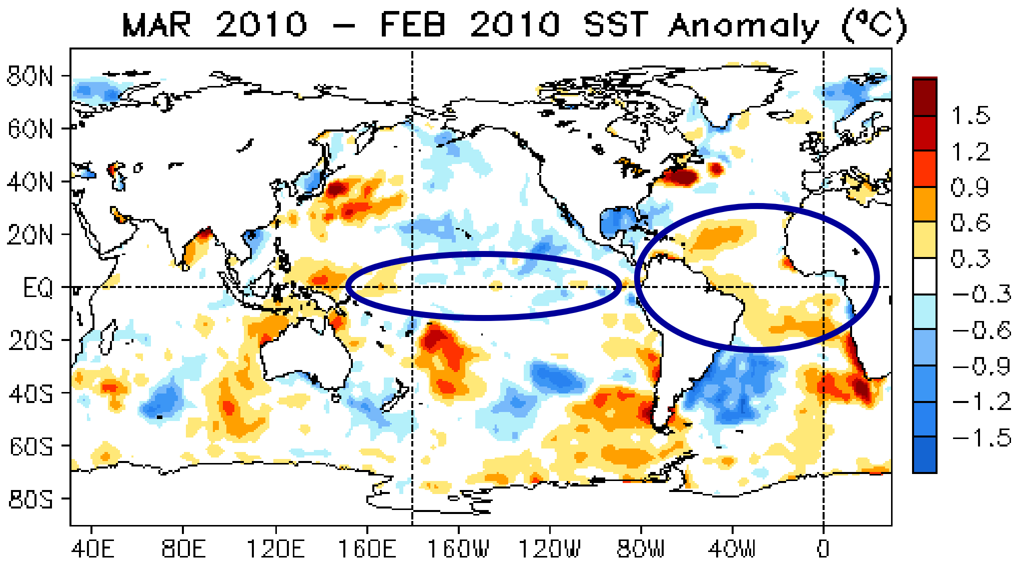
# Overview

- **Pacific / Arctic Ocean**
  - El Niño conditions (NINO 3.4 > 0.5 ºC) peaked in Dec 09, and weakened steadily during Jan-Mar 2010, and are expected to transition to ENSO-neutral conditions by summer 2010;
  - Westerly wind bursts events, which have been very active from July 2009 to Mar 2010, contributed to the strengthening and maintenance of the 2009/10 El Niño;
  - PDO was near-normal in Aug-Dec 2009, and became weakly above-normal in Jan-Mar 2010;
  - Upwelling along west coast of North America was mostly above-normal in March 2010, consistent with above-normal Chlorophyll.
  - Arctic sea ice content increased dramatically and became near-normal in Mar 2010, the first time since 2001.
- **Indian Ocean**
  - Positive SSTA persisted in the tropical Indian Ocean in Mar 2010, and Dipole Mode Index was near-normal.
- **Atlantic Ocean**
  - Positive SSTA enhanced in the tropical North and South Atlantic in Mar 2010, probably due to the impacts from the Pacific El Nino;
  - Convection was mostly suppressed in the tropical North Atlantic;
  - NAO remained negative in Mar 2010;
  - Mid-latitude North Atlantic SSTs have been unusually below-normal since May 2009, and SSTs in hurricane main development region reached a historic high in Mar 2010.

# Global SST Anomaly ($^0$C) and Anomaly Tendency



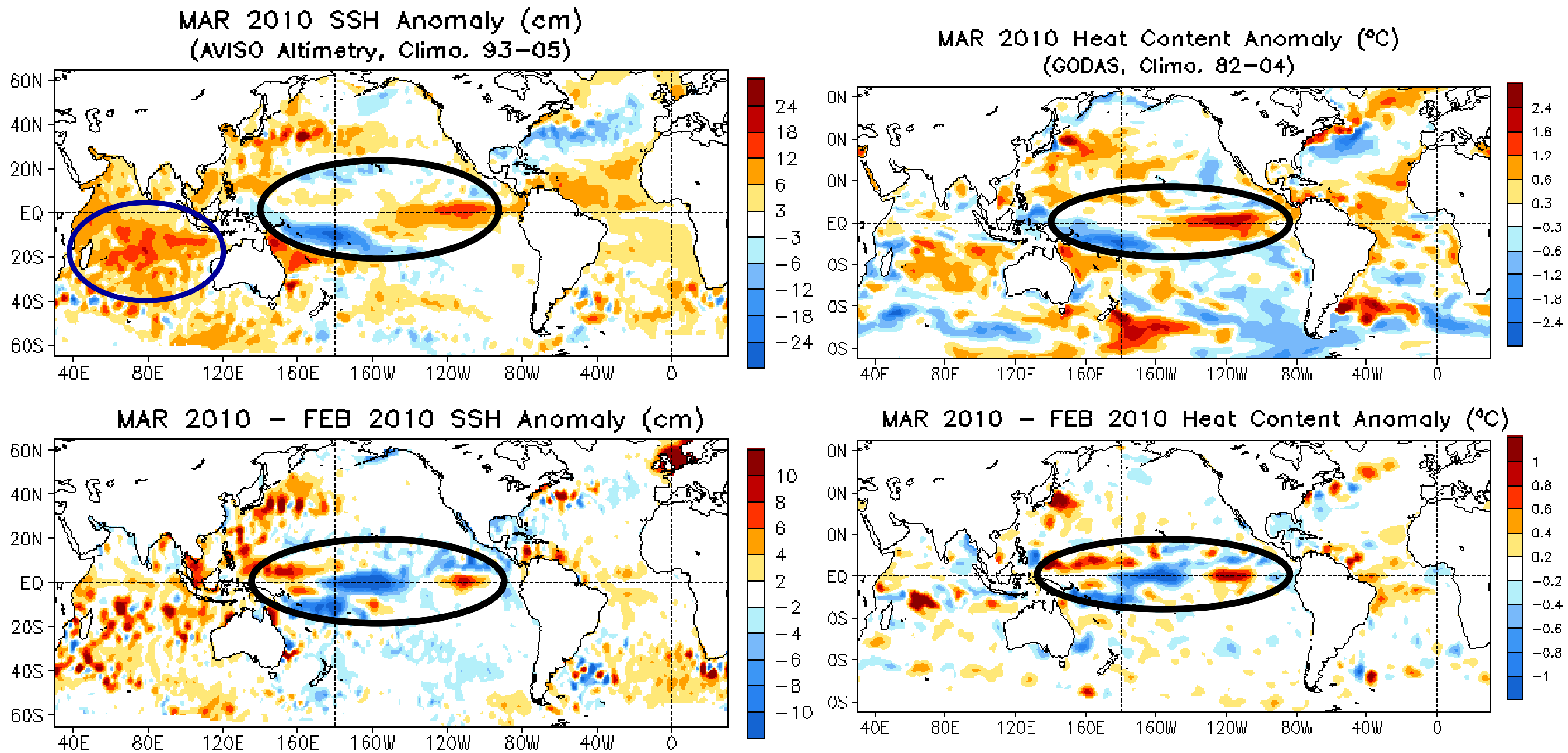

- El Nino condition (NINO 3.4 > 0.5ºC) weakened slightly in the tropical Pacific;
- PDO was in positive phase (slide 19);
- SST was above-normal in the tropical Indian Ocean and tropical North and South Atlantic;
- Large SST anomalies in the subtropical South Pacific, and North Atlantic




- SST decreased slightly in the eastern tropical Pacific;
- SST tendency was large in the Southern Ocean
- SST increased in tropical North and South Atlantic.
- SST tendency was small in the Indian 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.

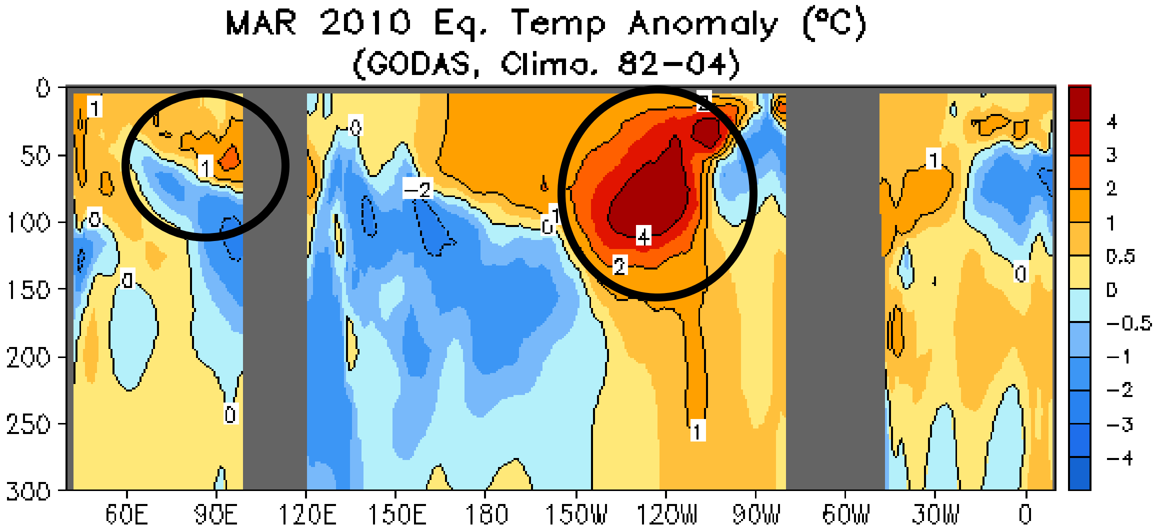
# Global SSH / HC Anomaly (cm / $^oC$ ) and Anomaly Tendency




- **Negative PDO-like pattern in HCA and SSH in the North Pacific persisted.**
- **Positive SSHA and HCA were present in the east-central equatorial Pacific, negative ones in the western Pacific, consistent with the El Nino conditions.**
- **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 in the tropical and northwest Pacific Oceans.**

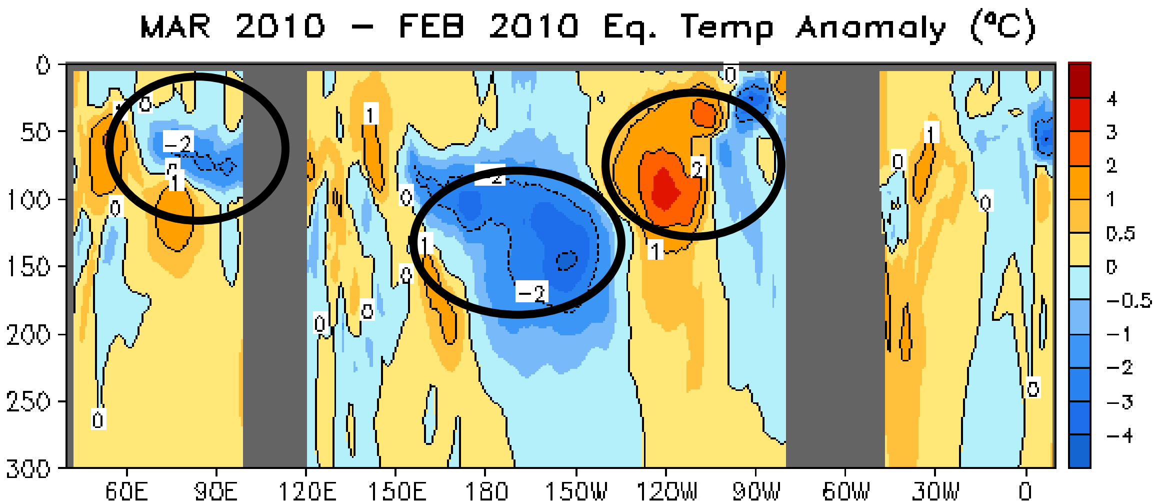
**Fig. G2. Sea surface height anomalies (SSHA, top left), SSHA tendency (bottom left), top 300m heat content anomalies (HCA, top right), and HCA tendency (bottom right). SSHA are derived from http://www.aviso.oceanobs.com, and HCA from GODAS.**

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




- Positive subsurface temperature anomalies above 4°C were present in the thermocline in the east-central equatorial Pacific, consistent with the El Nino conditions.

- Positive anomalies are weakened in the eastern Indian Ocean

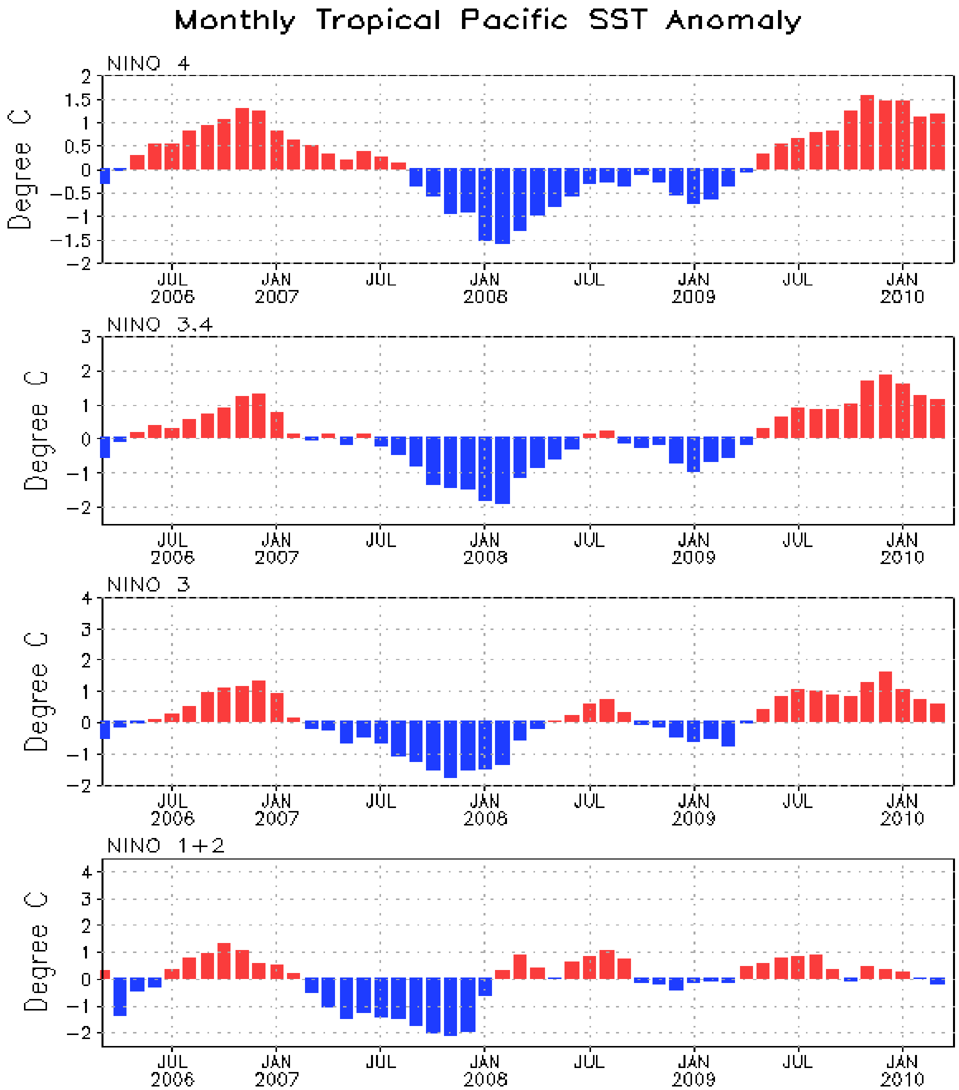


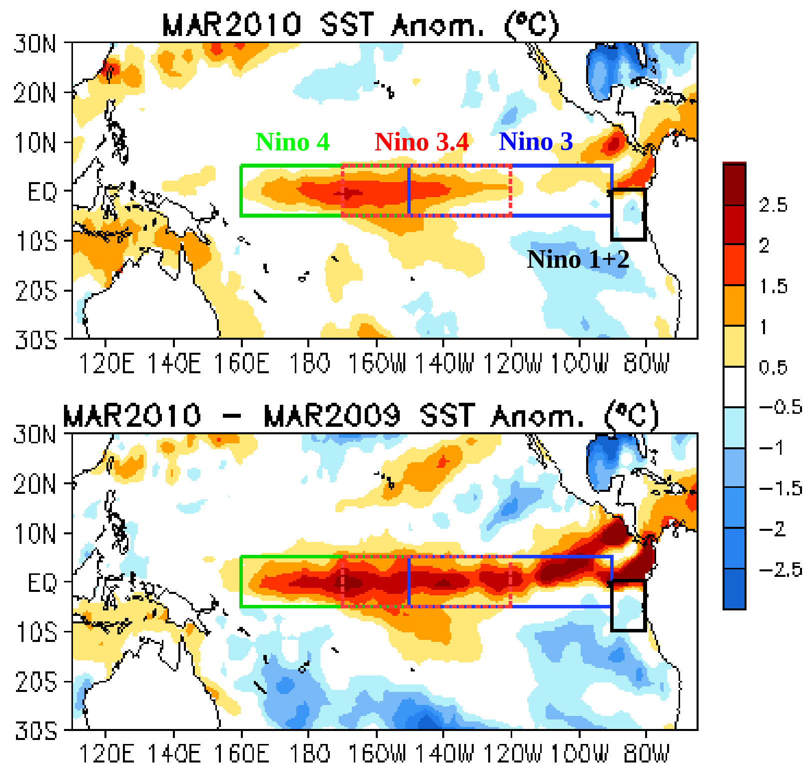

- Subsurface temperature anomalies decreased (increased ) by 2-3°C near 180-150°W (120-90°W) along the thermocline of the equatorial Pacific.
- Negative anomalies intensified in the west Pacific Ocean at 80-200 m.

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

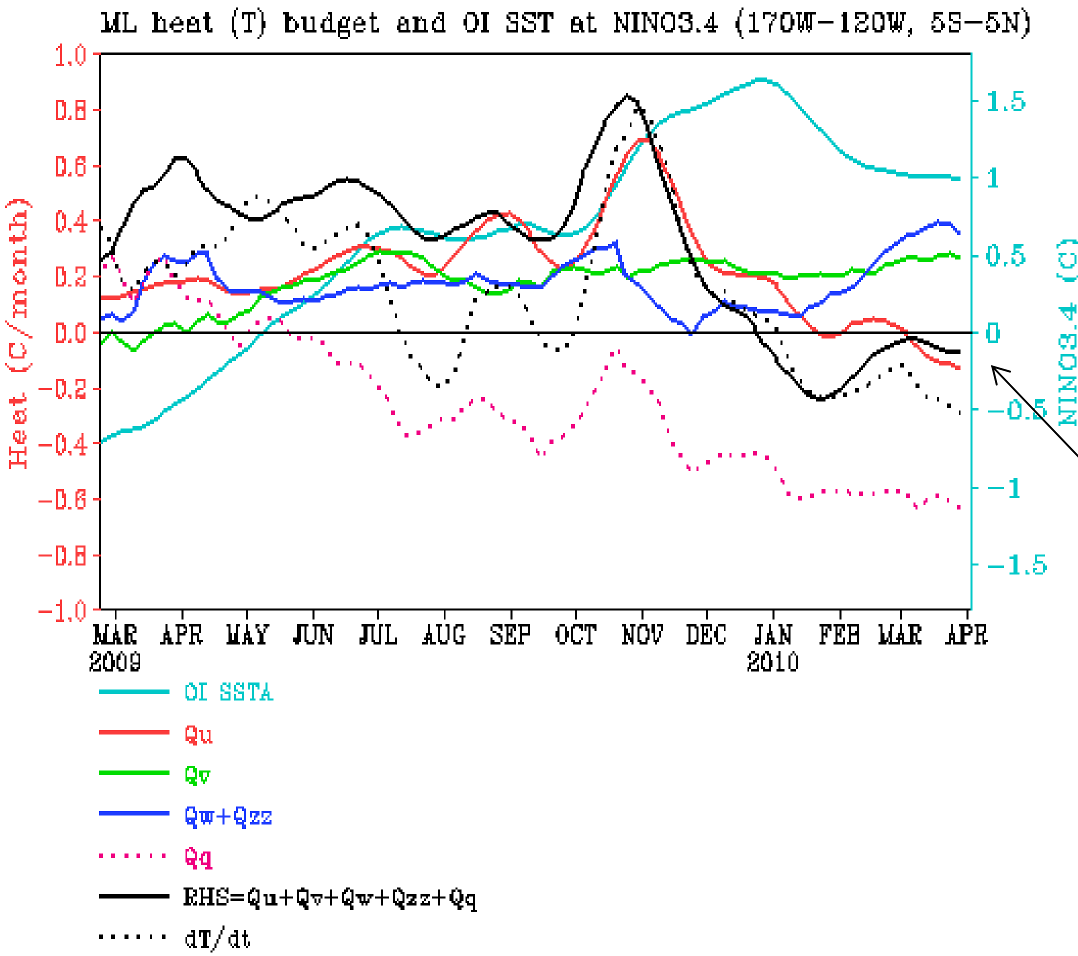



- All NINO indices decreased, except NINO4 with slight increase.

**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




**The negative tendency since Jan2010 suggests that the El Nino is in its decay phase.**

**Negative tendency is caused by reduced warming from Qu and strengthened cooling from Qq.**

**The decay due to Qu and Qq, suggesting that influences of subsurface temperature anomalies on the recent SSTA changes are small.**

**Qw+Qzz is positive, implying a contribution to the persistent positive SSTA.**

**Qu: Zonal advection; Qv: Meridional advection;**

**Qw: Vertical entrainment; Qzz: Vertical diffusion**

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

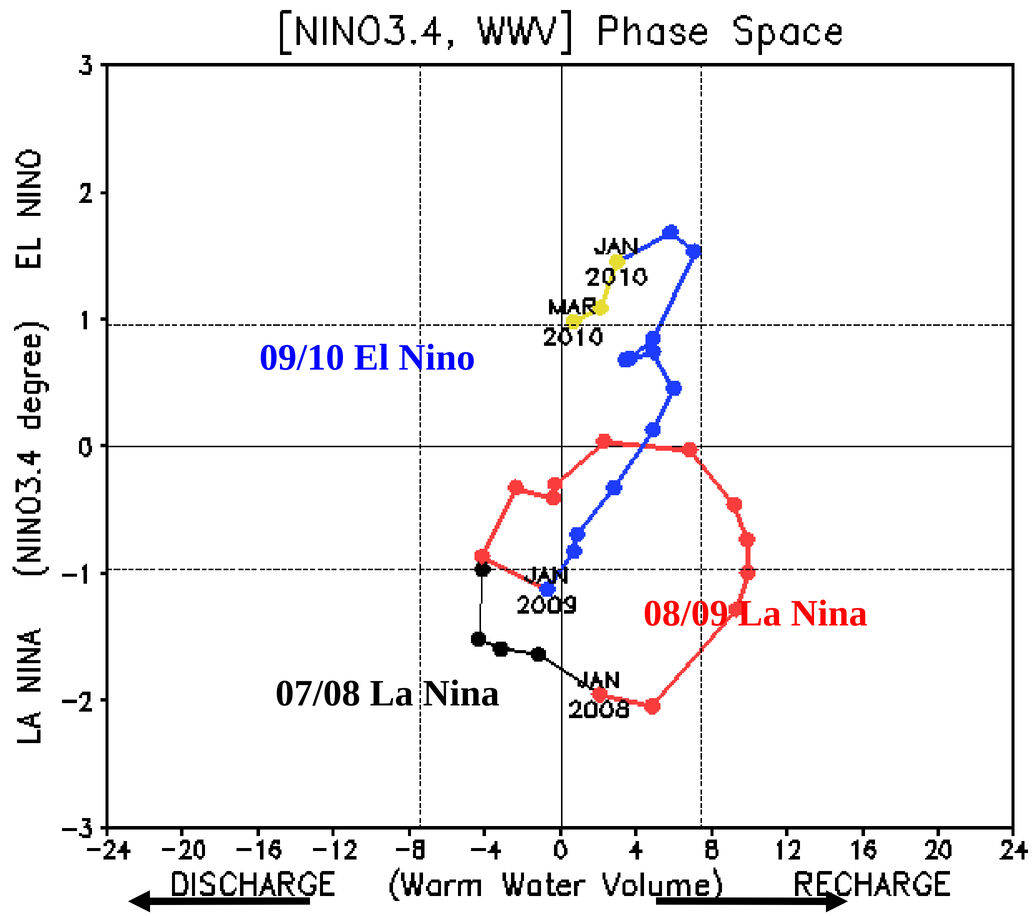
**Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST**

# Warm Water Volume (WWV) and NINO3.4 Anomalies

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

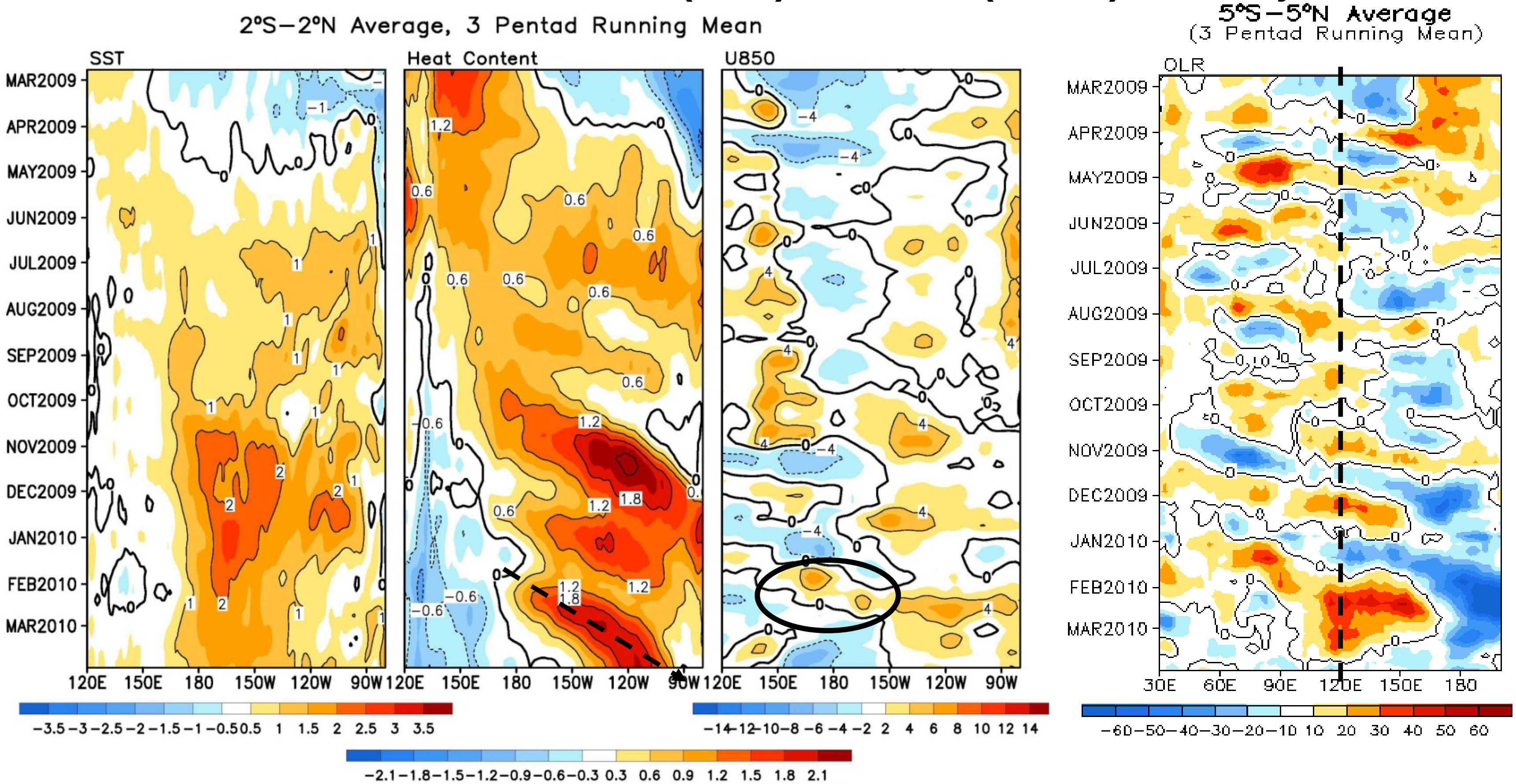



- NINO3.4 and WWV increased steadily during Jan-Jun 2009, persisted during Jul-Oct 2009, and increased dramatically in Nov 2009; NINO3.4 (WWV) increased (decreased) slightly during Dec 09; Nino3.4 and WWV decreased from Dec 2009 to Mar 2010;

- The phase trajectory became similar to the typical anti-clockwise rotation during El Nino events since Dec 2009.

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

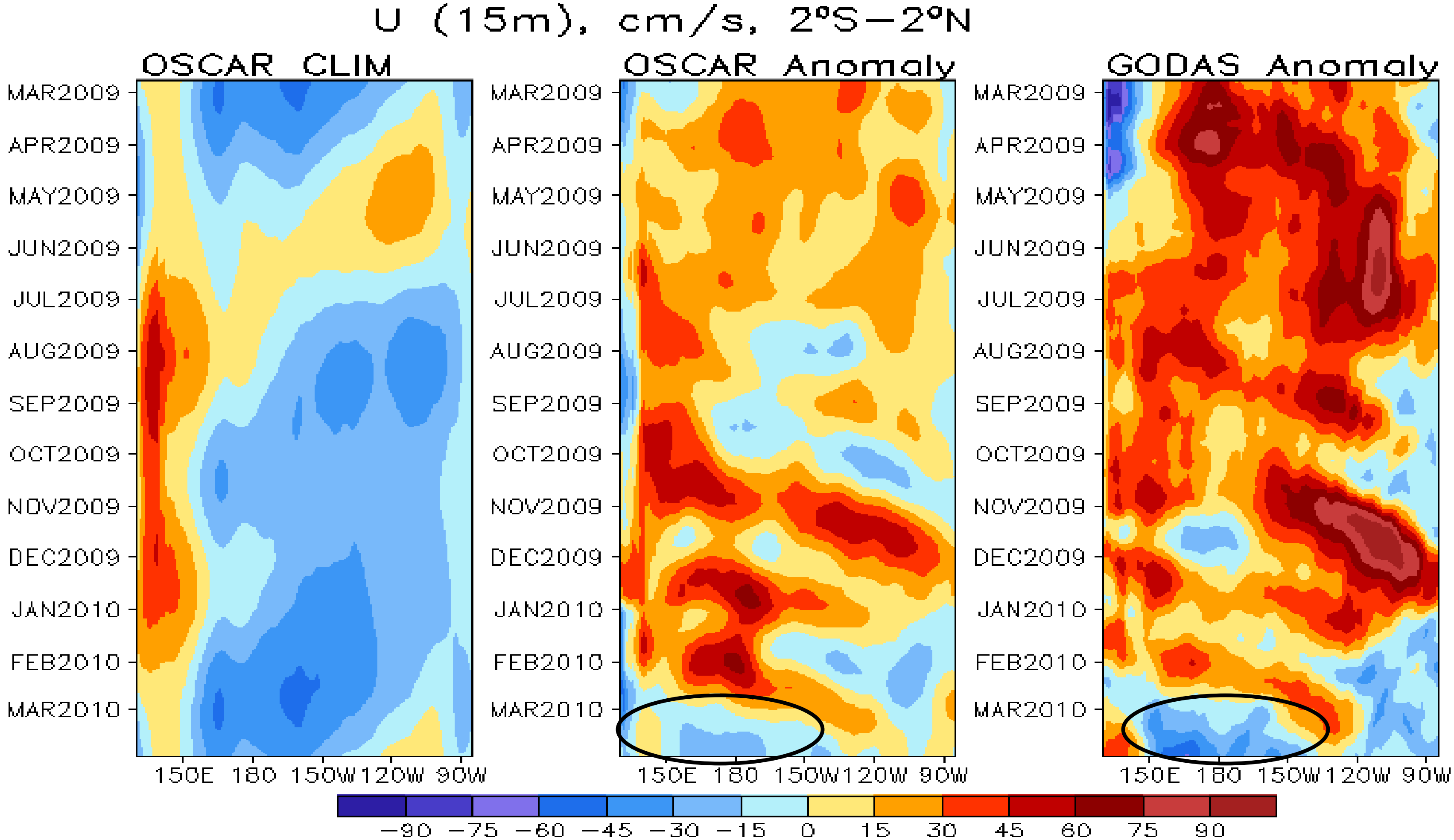
## Evolution of Equatorial Pacific SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly




- Positive SST anomalies in the central and eastern equatorial Pacific persisted in Mar 2010.
- Positive heat content anomalies (HCA) developed in the central and eastern Pacific and negative ones in the western Pacific since Feb. 2010, in response to the westerly wind anomalies occurred in the western and central Pacific between later Jan and earlier Feb 2010.

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.

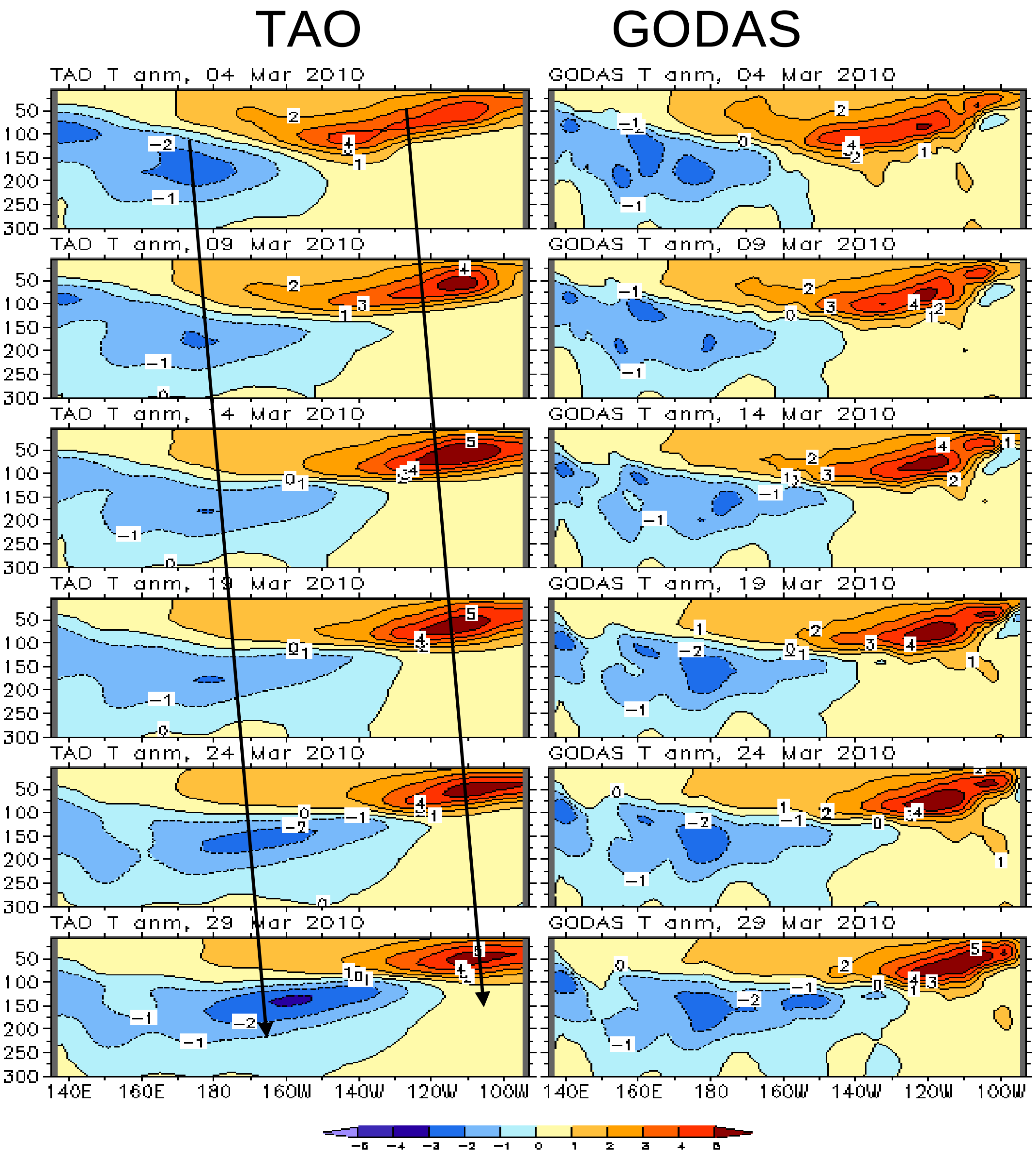
## Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)




- Surface zonal current anomaly became negative since Mar 2010, consistent with the decay of the El Nino conditions.

- 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.

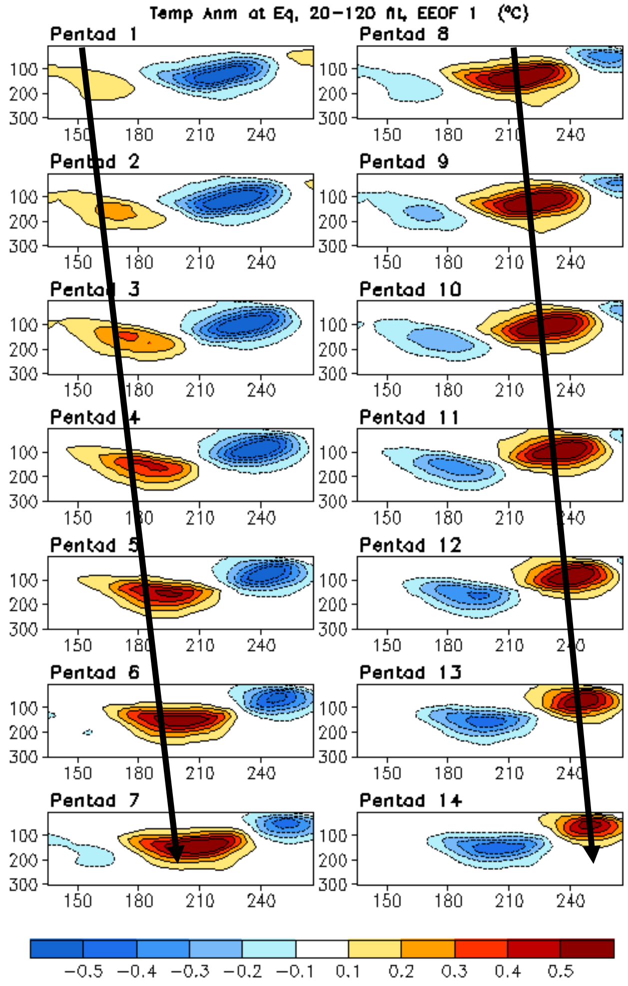
# Equatorial Pacific Temperature Anomaly

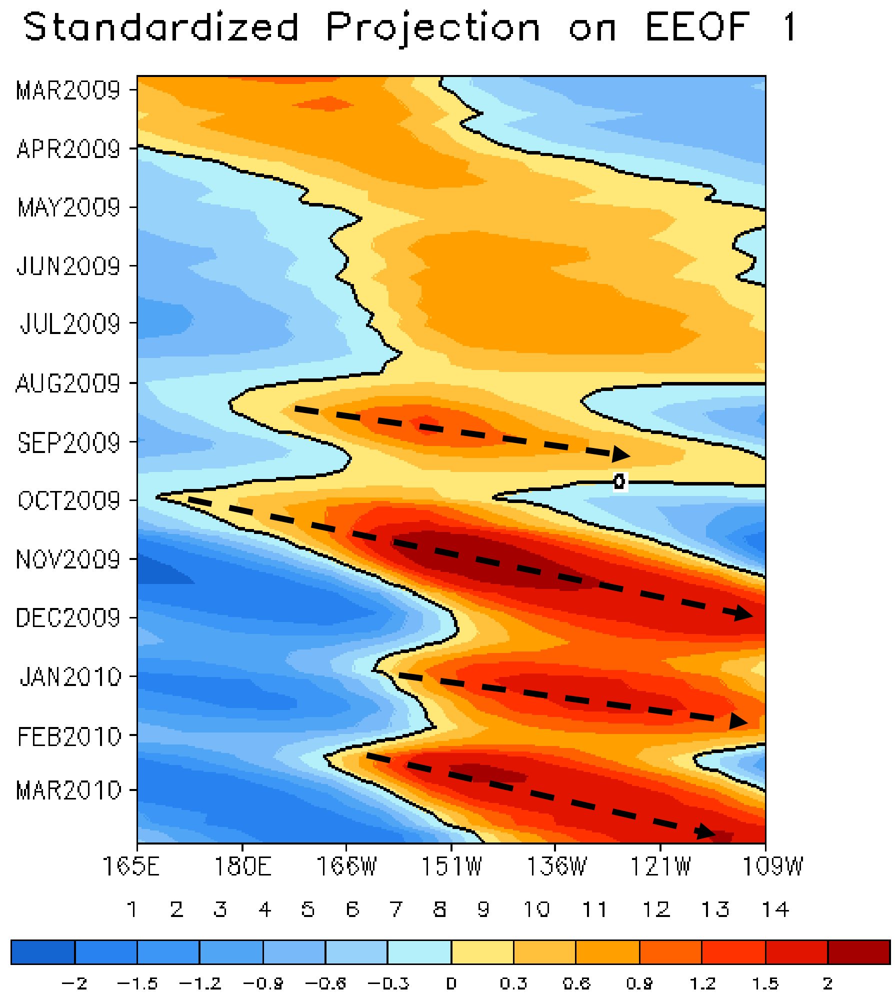



**TAO climatology used**

- **Positive (negative) temperature anomaly in the east-central (western) equatorial Pacific strengthened and propagated eastward in Mar 2010.**

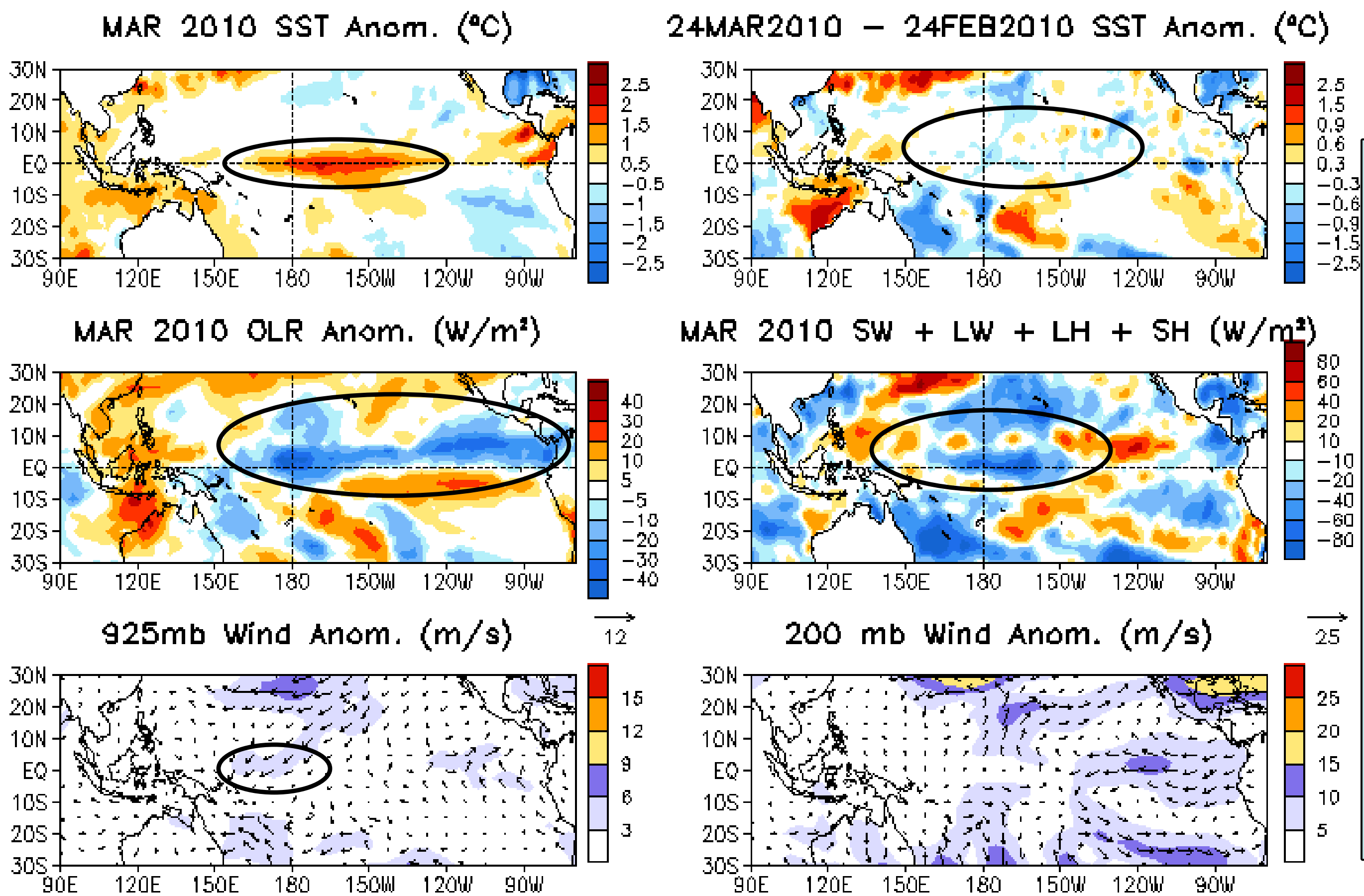
# Oceanic Kelvin Wave Indices




- 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

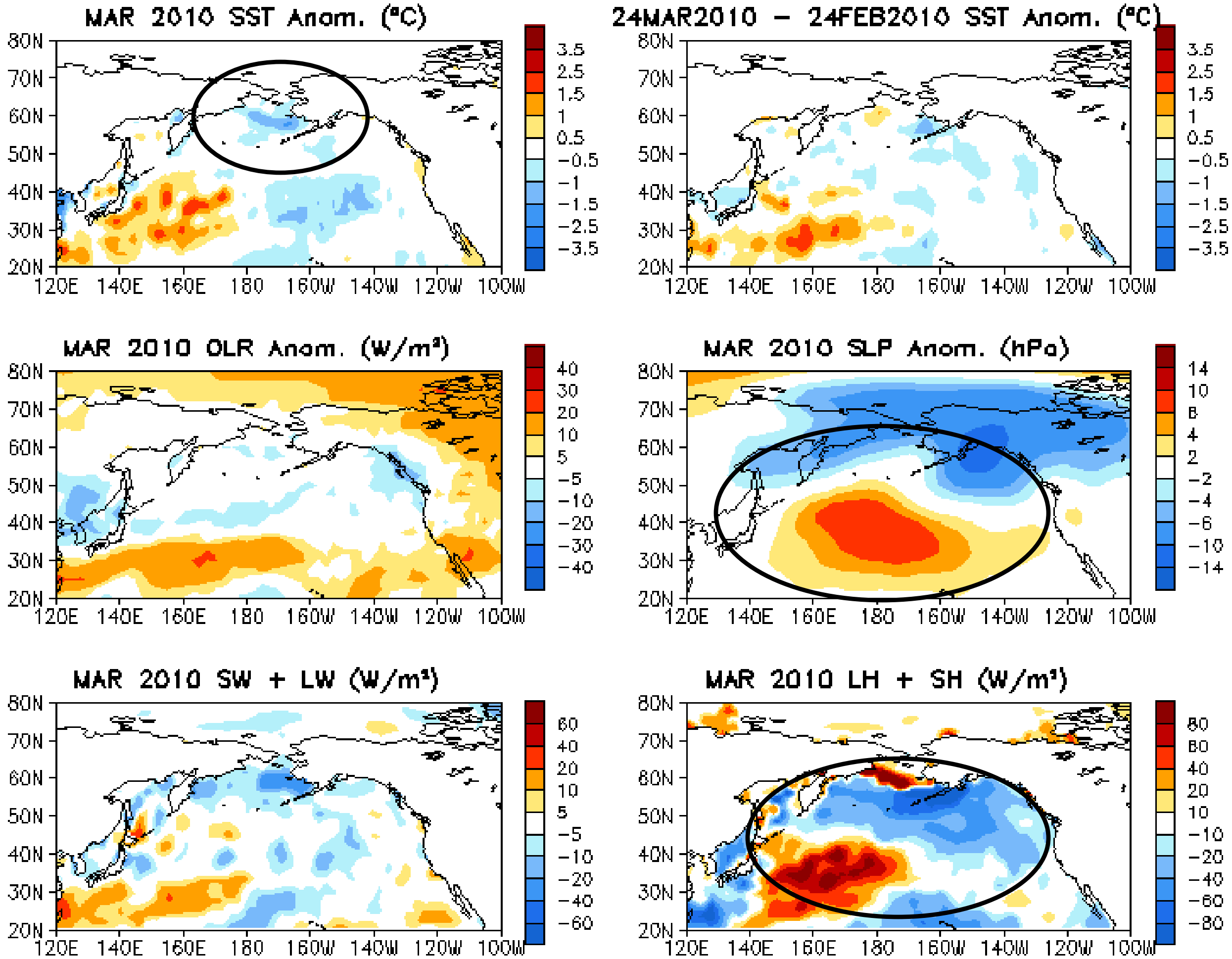



- Positive SSTA persisted in the central equatorial Pacific.
- Convection was suppressed over the Maritime Continent and western Pacific, and enhanced in the central tropical Pacific.
- SSTA tendency in the tropical Pacific was small, not consistent with net surface heat flux anomaly.
- Easterly wind anomaly was present at low level in the western tropical Pacific, and at the higher-level in the eastern 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 was positive in the west and negative in the east.

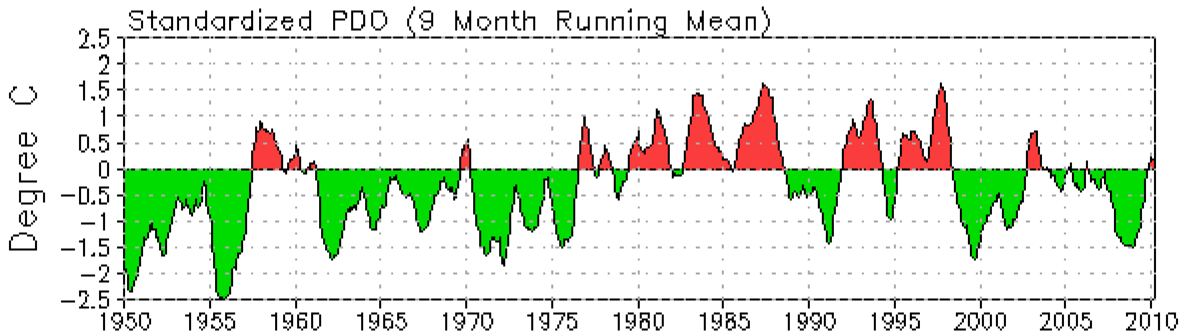
- Heat flux does not favour the positive phase of PDO (next slide)

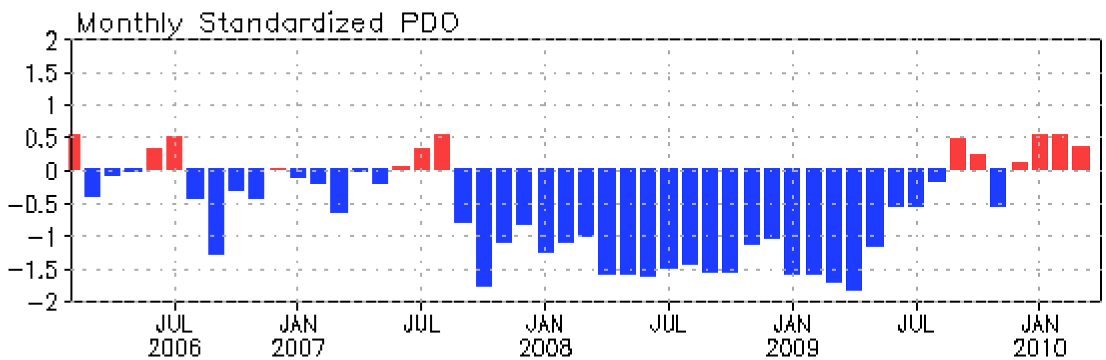
- Negative (positive) SLP anomaly in northern (southern) part of North Pacific.

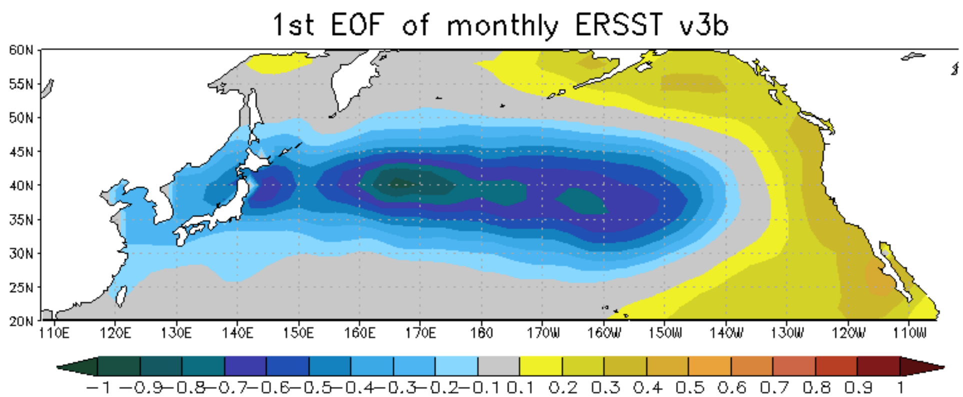
- Negative SSTA near Bering Sea favoured increased sea-ice in Mar 2010 (slide 20)

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



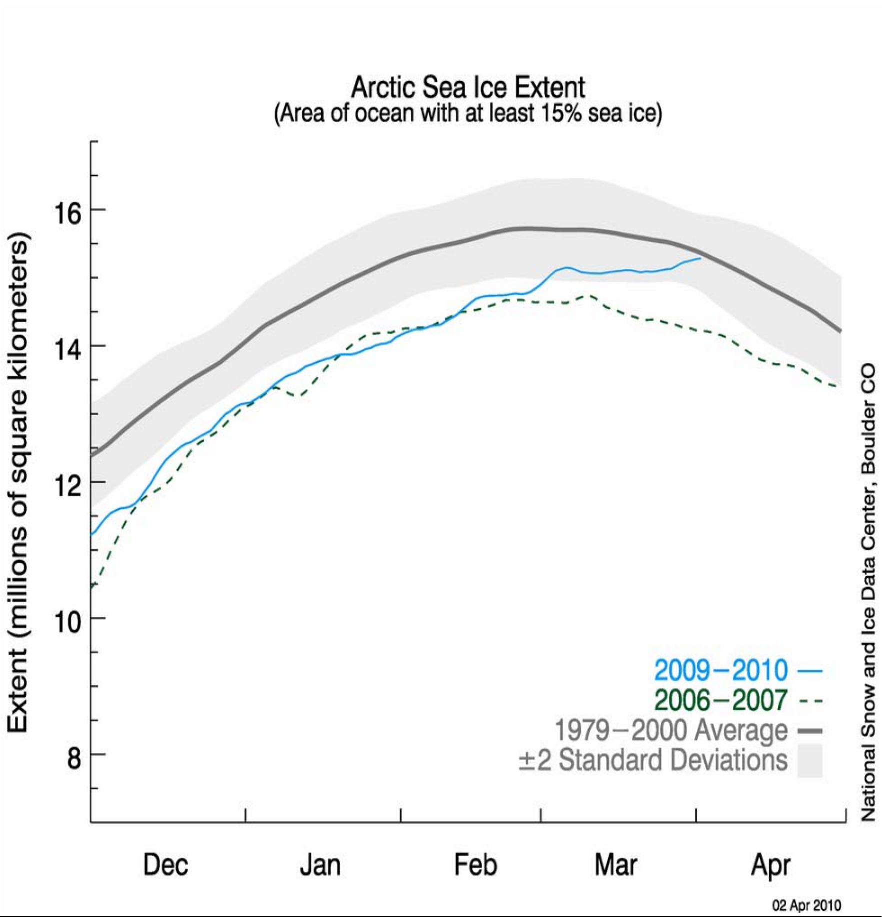

- **Positive PDO index persisted in Mar 2010.**

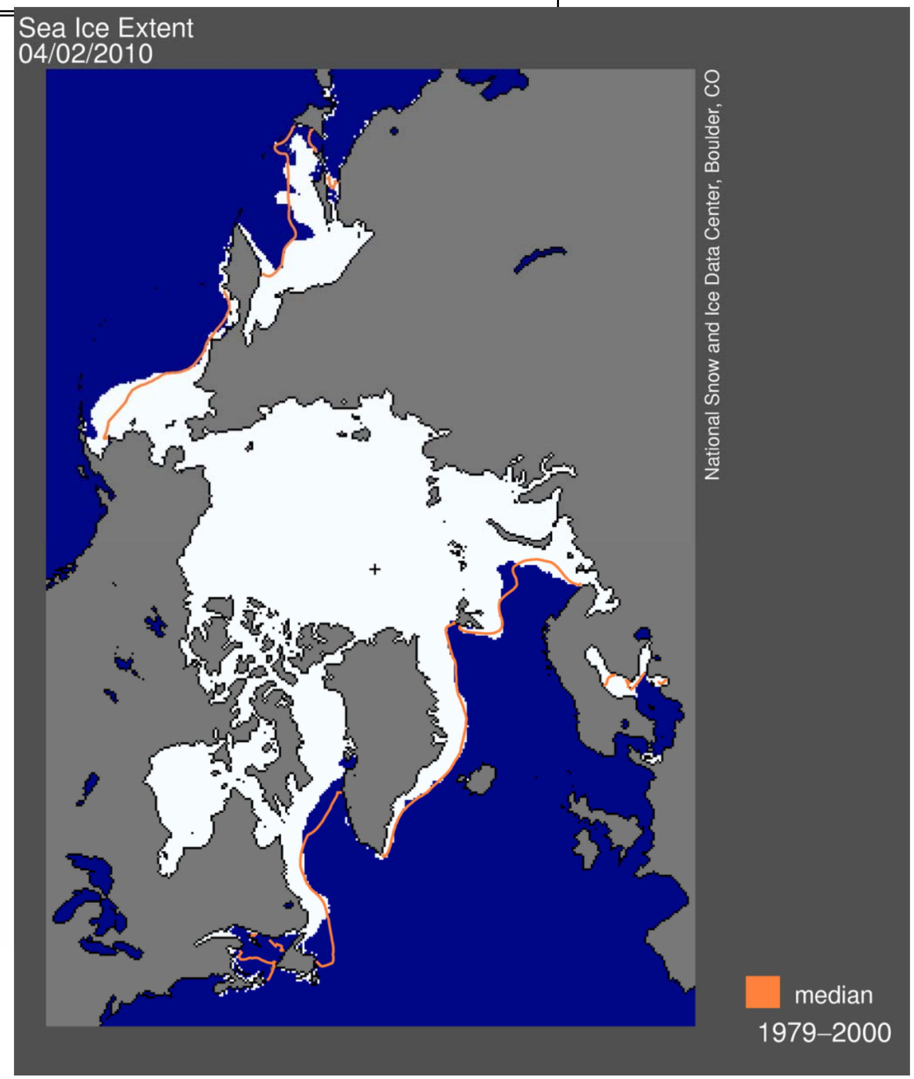
- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**
- **The PDO index differs slightly from that of JISAO, which uses a blend of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

# Arctic Sea Ice

**National Snow and Ice Data Center**

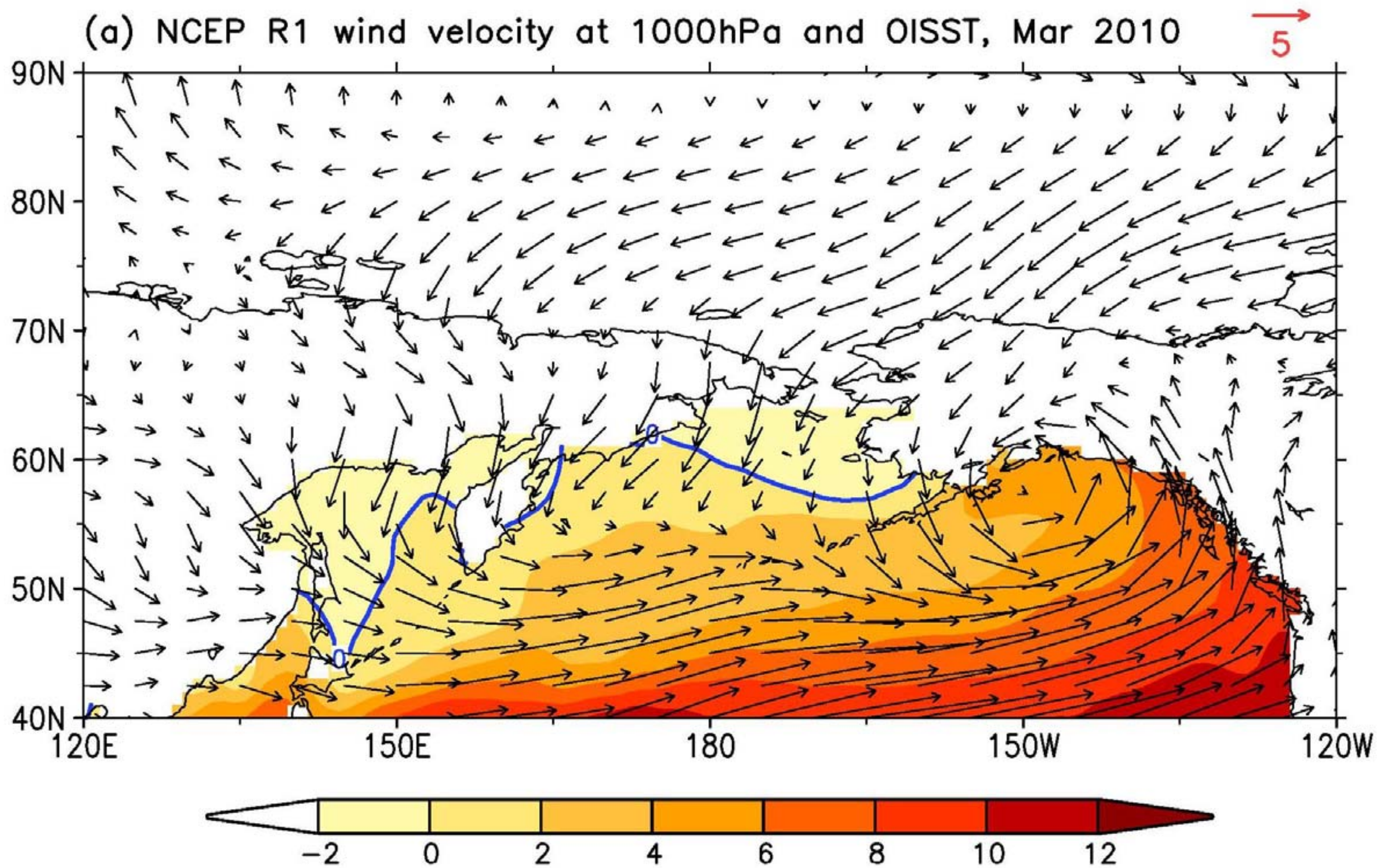
**http://nsidc.org/arcticseaicenews/index.html**



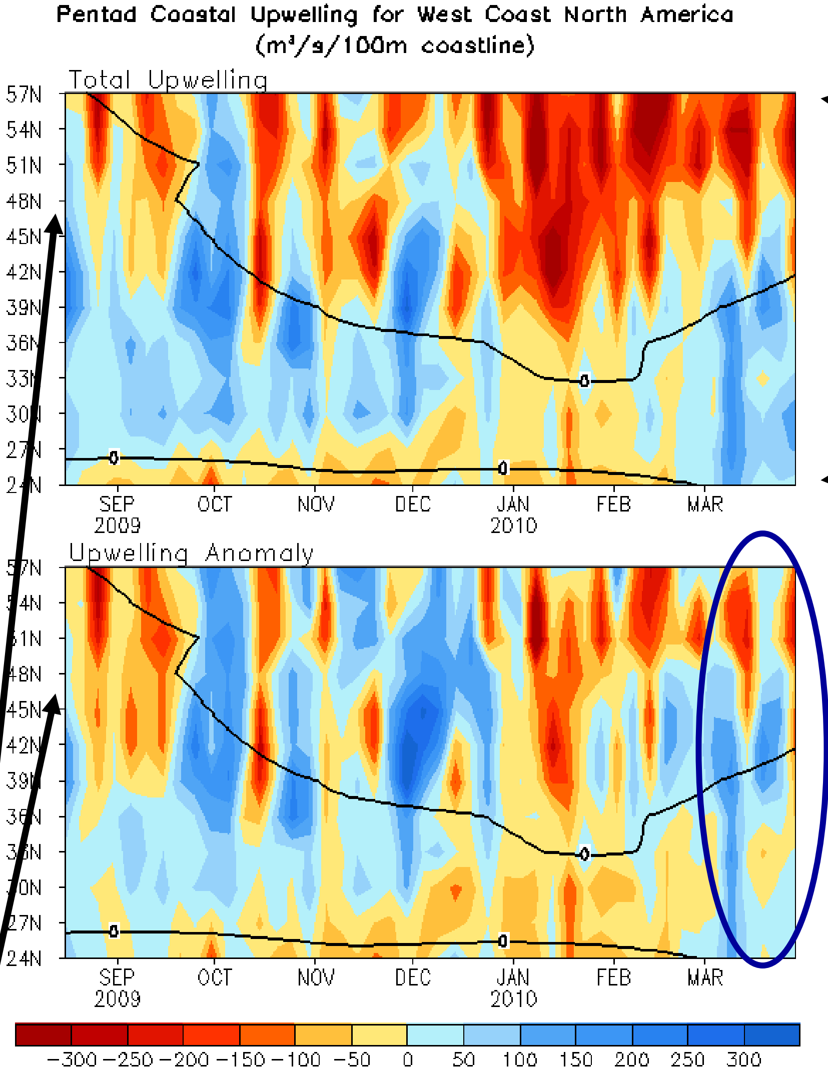

**- Sea ice extent increased dramatically in March 2010, and closed to the climatology, which is the first time since 2001.**

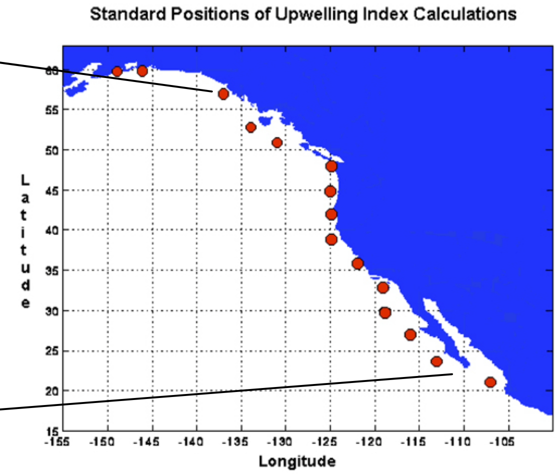
# R1 Wind Velocity at 1000 hPa and OISST, Mar 2010




- SST in Bering Sea was below 0C, and northerly wind favoured sea ice drifting southward.

# North America Western Coastal Upwelling



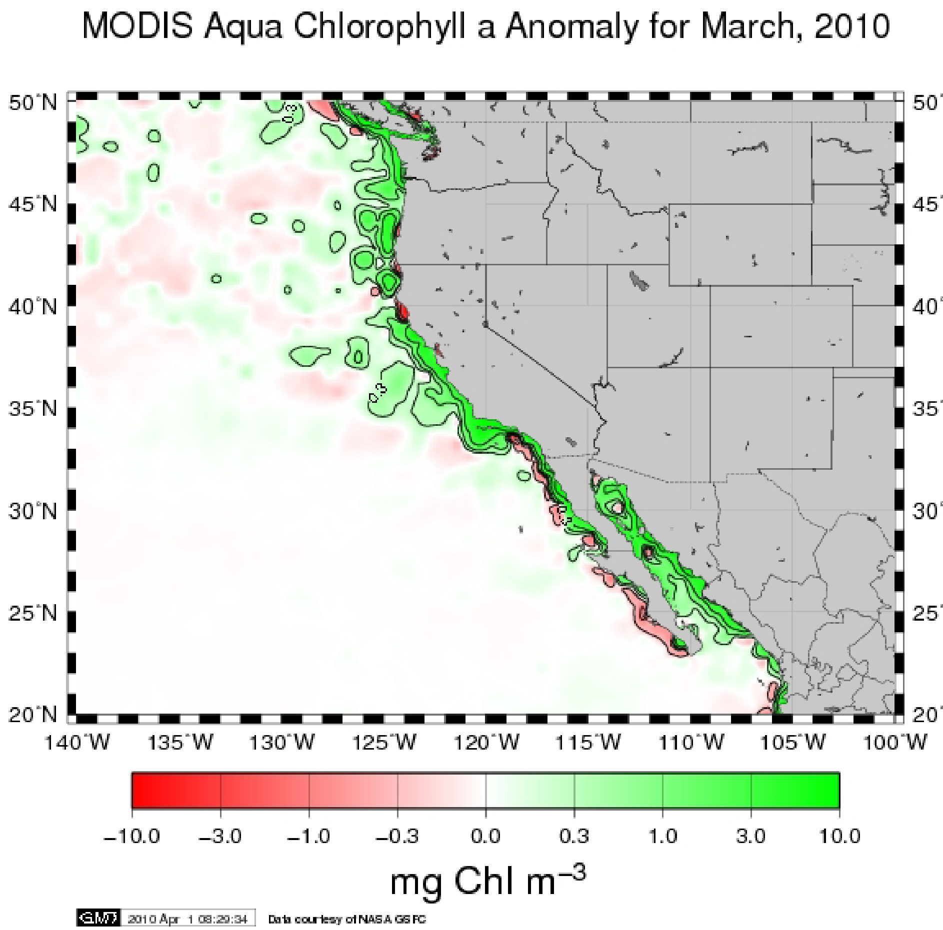




- The upwelling was below-normal (above-normal) north (south) of 48N in Mar 2010.

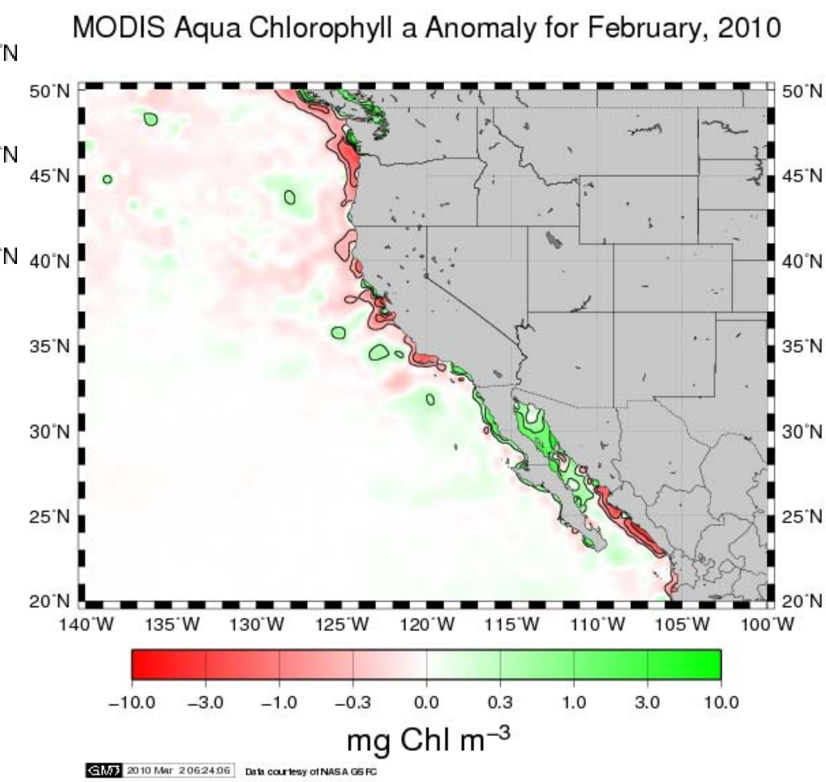
**Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

# Monthly Chlorophyll Anomaly

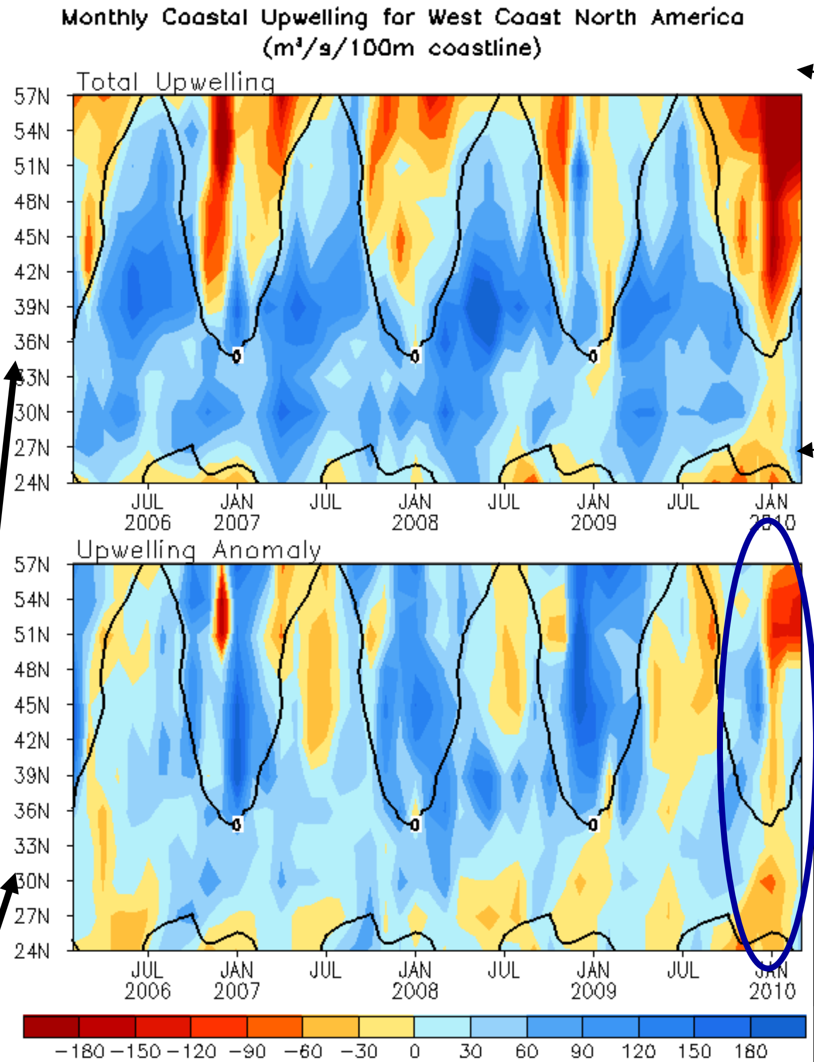


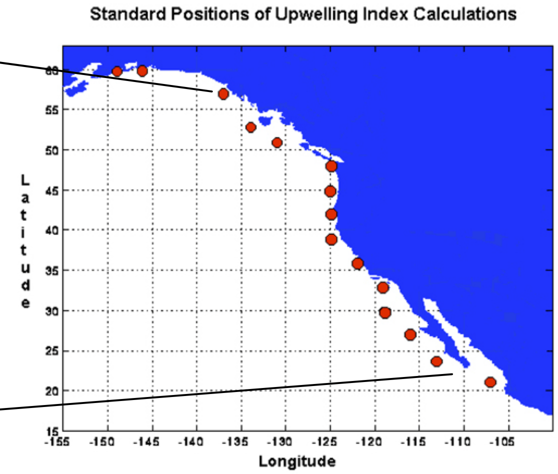

- Chlorophyll was mostly above-normal in Mar 2010, which is consistent with above-normal upwelling south of 48N.




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

# North America Western Coastal Upwelling




- Upwelling had been above-normal during the winter of 2006/07, 2007/08, and 2009

- Upwelling was mostly below-normal during the winter of 2009/10.

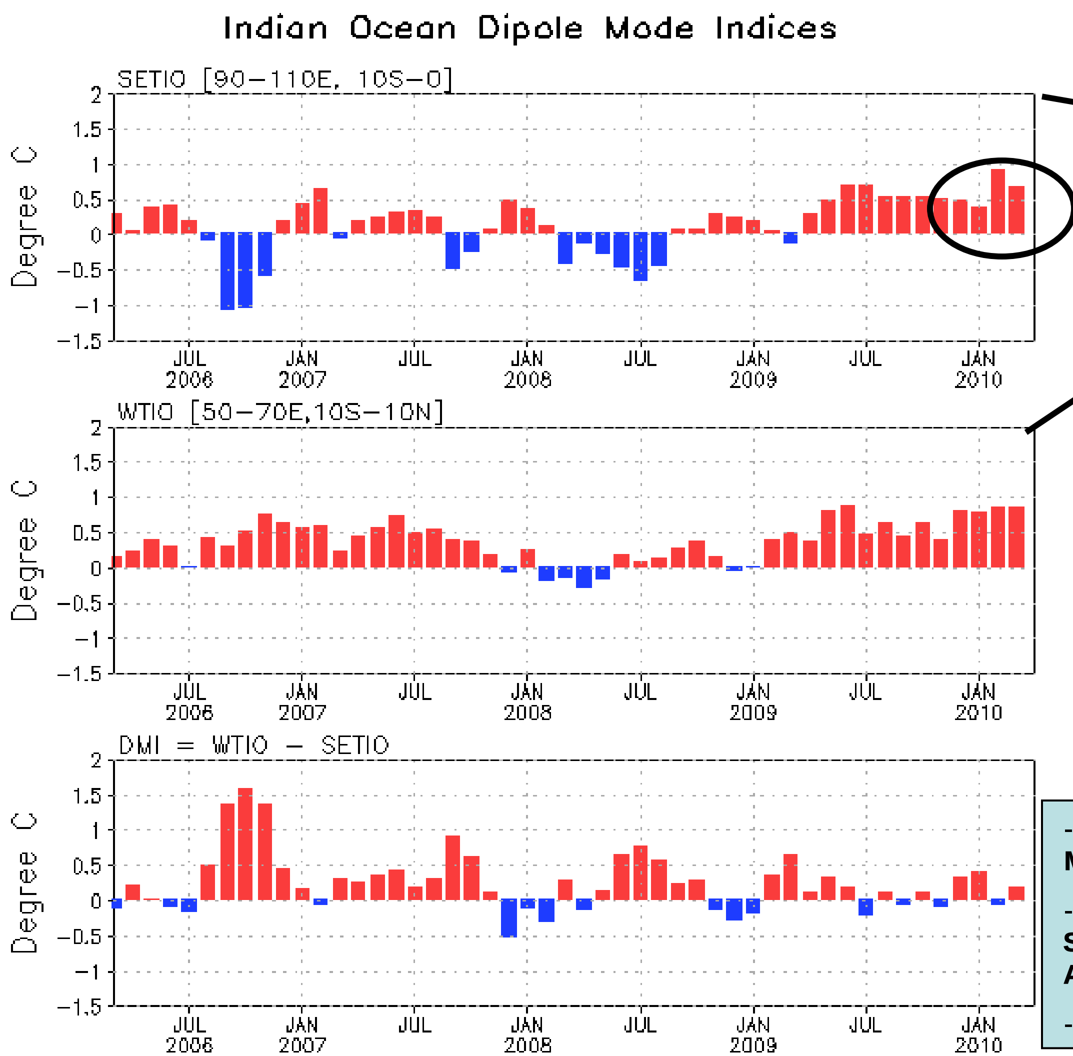
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

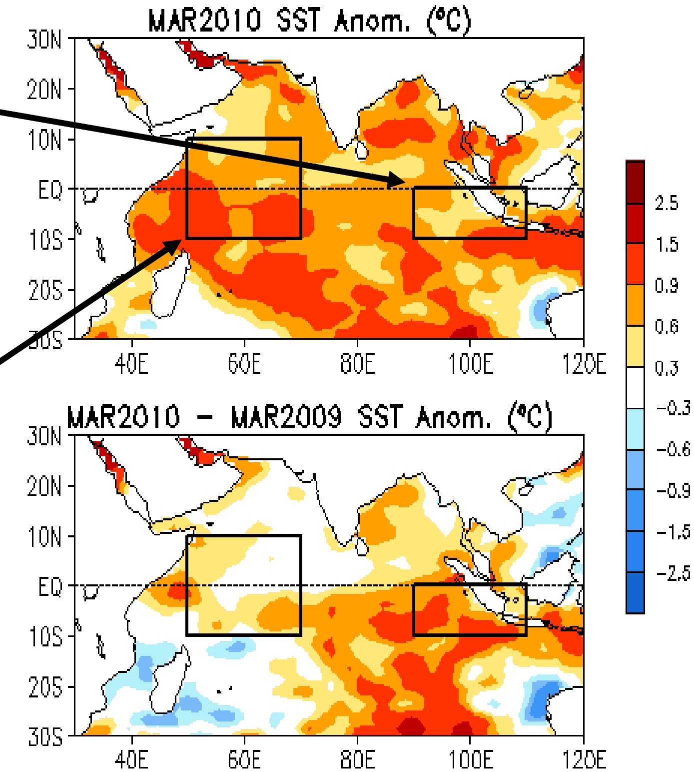
- Area below (above) black line indicates climatological upwelling (downwelling) season.

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

# Tropical Indian Ocean

# Evolution of Indian Ocean SST Indices

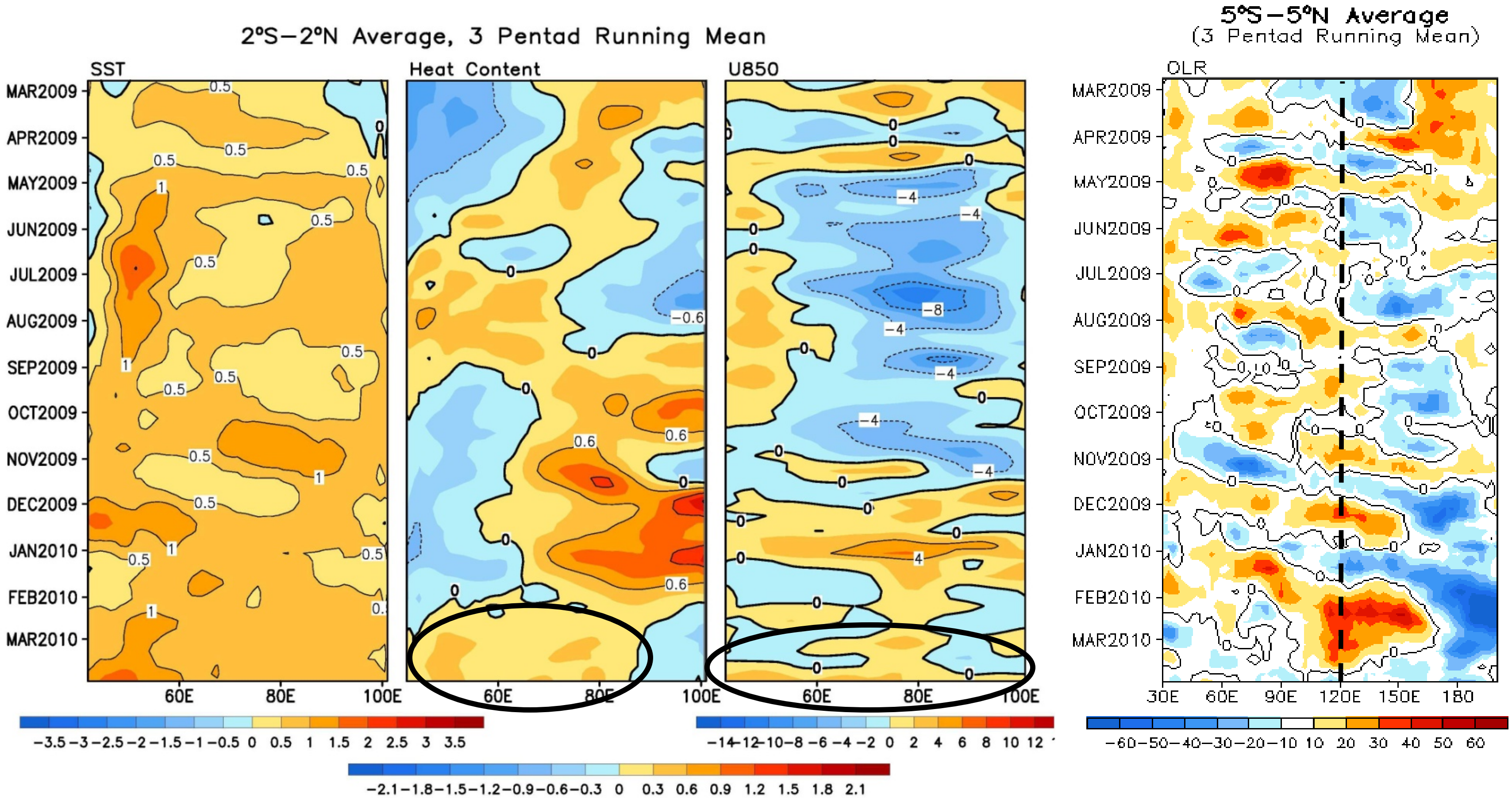



- **Positive eastern (SETIO) pole SSTA persisted in Mar 2010.**
- **Both eastern (SETIO) and western (WTIO) pole SST have been persistently above-normal since April 09.**
- **DMI became above-normal in Mar 2010.**

**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.**

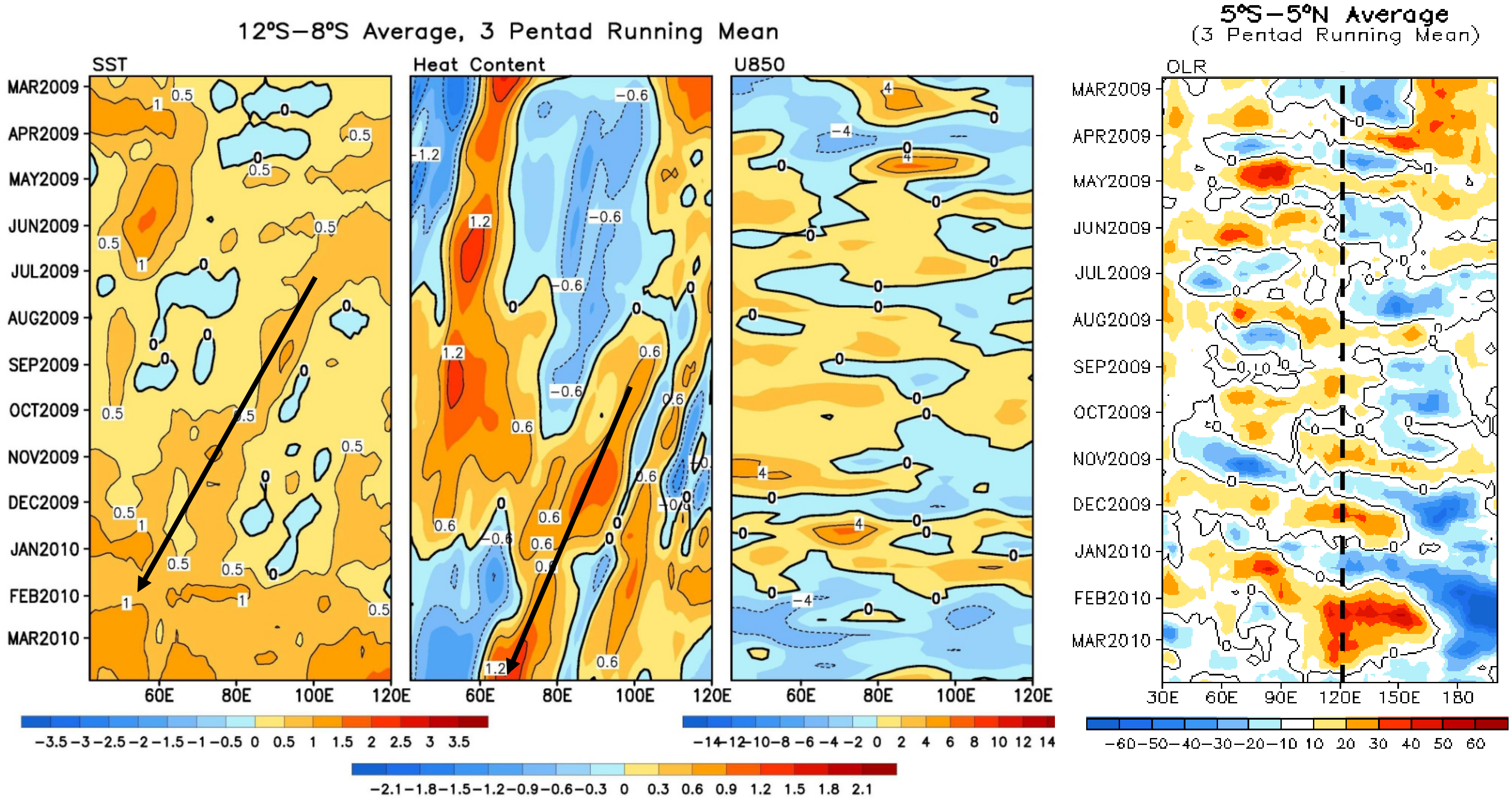
# Recent Evolution of Equatorial Indian SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s) and OLR (W/m²) Anomalies




- Positive SSTA persisted in Mar 2010.
- Heat content anomaly was positive in the west-central tropical Indian Ocean.
- Westerly wind anomalies were weak in the tropical Indian Ocean since Jan 2010.

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




- SST increased and became more than 0.5C above-normal cross the basin.
- positive HCA propagated westward in the central-eastern tropical Indian since Jun 2009.

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.

- SSTA exceeding +1C presented in the tropical Indian Ocean.
- Net surface heat flux anomalies contributed to the positive (negative) SSTA tendency in the North (South) Indian Ocean.
- Convection was suppressed over the Maritime Continent, and intensified in southeastern Indian Ocean
- Consistent with the suppressed convection was low-level divergence (up-level convergence) wind anomalies in the Maritime Continent

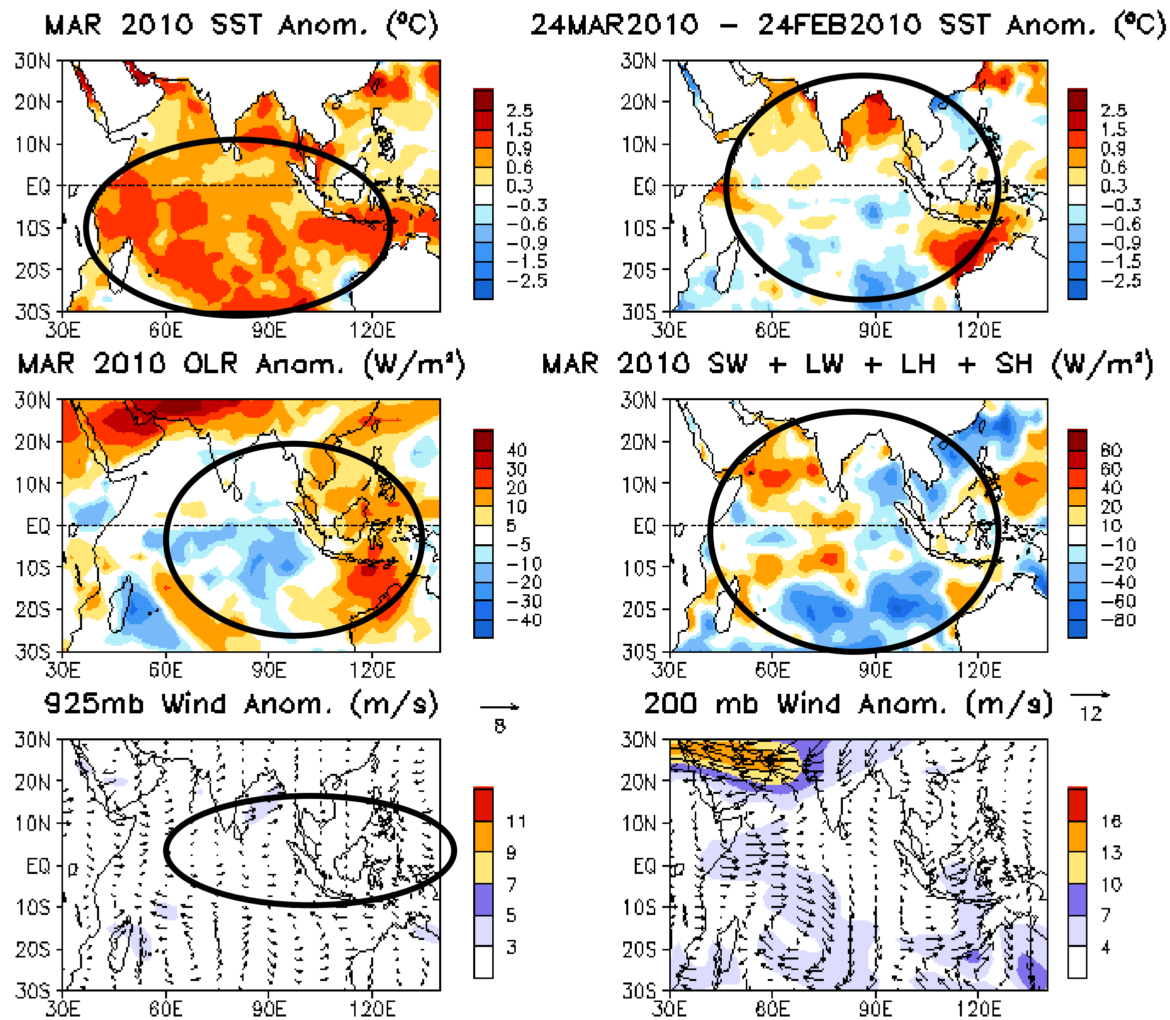
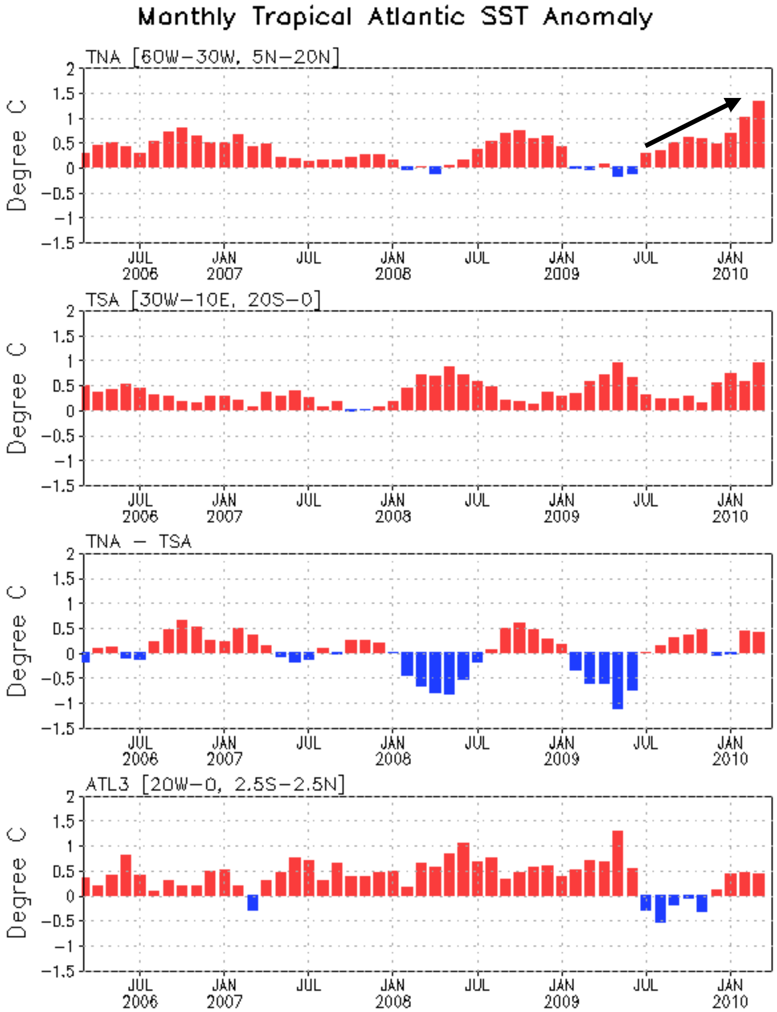
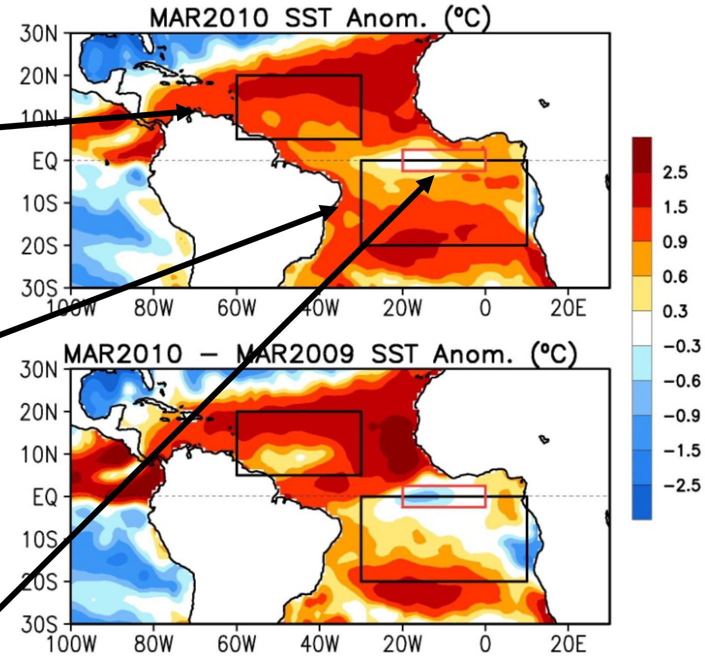



Fig. 12. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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




- Tropical North Atlantic SST (TNA) was above-normal from Jul 09 to Jan 10, and strengthened significantly in Mar 2010.

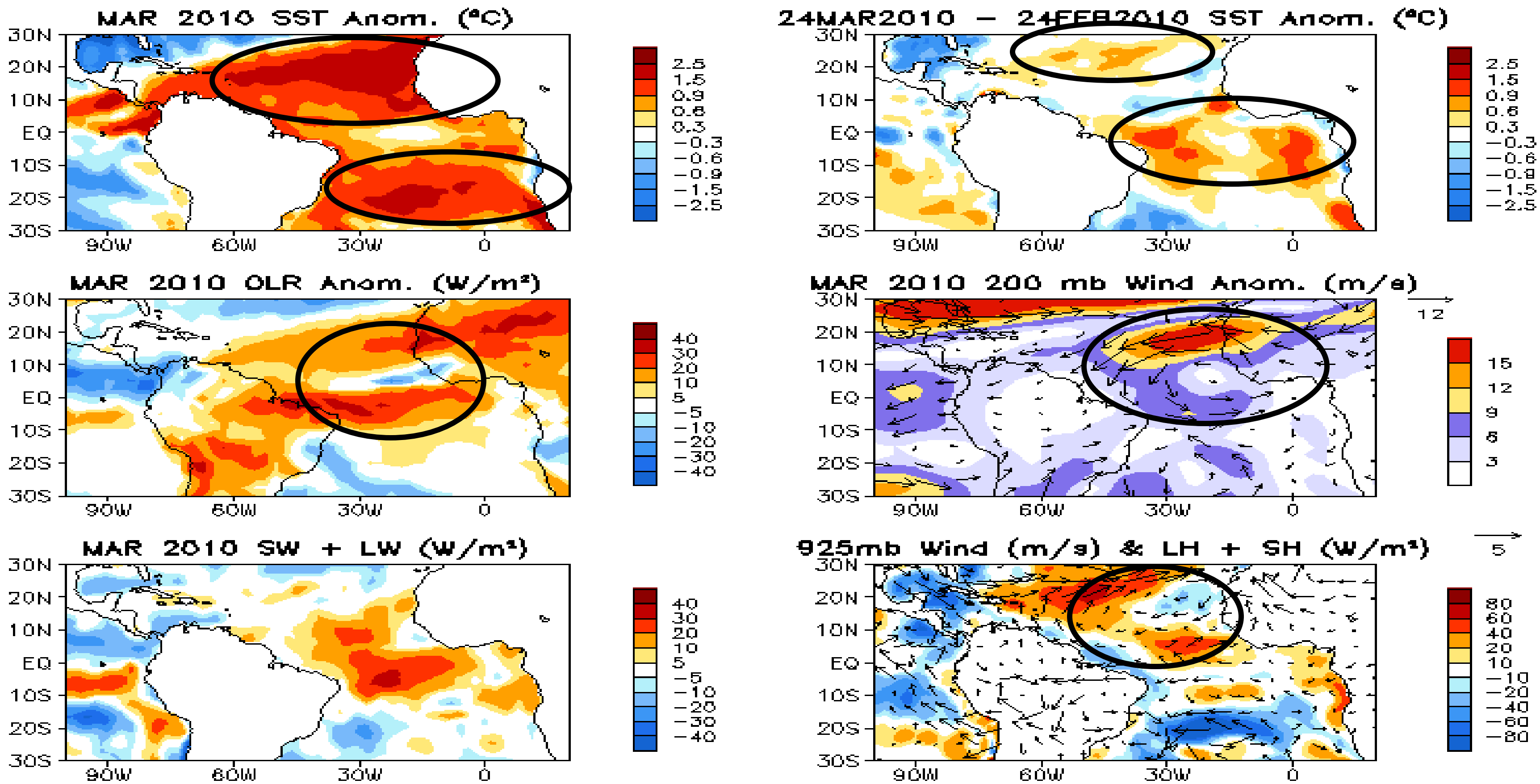
- Tropical South Atlantic SST (TSA) remained above-normal.

- Meridional Gradient Mode (TNA-TSA) remained above-normal.

- Positive ATL3 SST persisted.

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 intensified in the tropical North and South Atlantic.
- Convection was suppressed in the tropical North Atlantic and northern Africa.
- Strong cyclonic (anti-cyclonic) anomalous wind in the tropical North Atlantic at high (low) levels, which may be associated with the suppressed convection there.

# North Atlantic Ocean

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

- Negative NAO continue in Mar 2010 (next slide).

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

- However, SSTA tendencies were small, probably due to the deep mixed layer during winter.

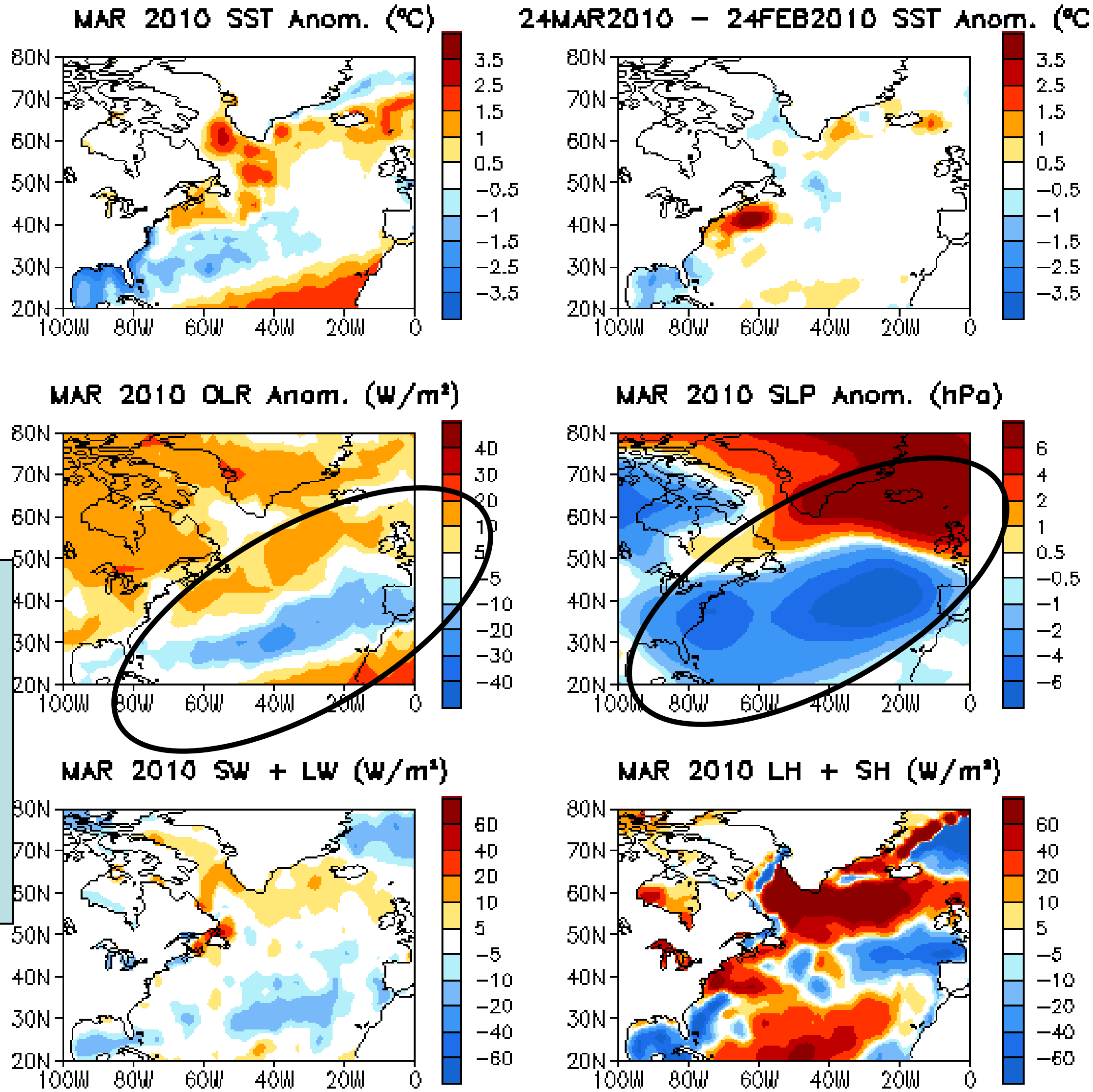
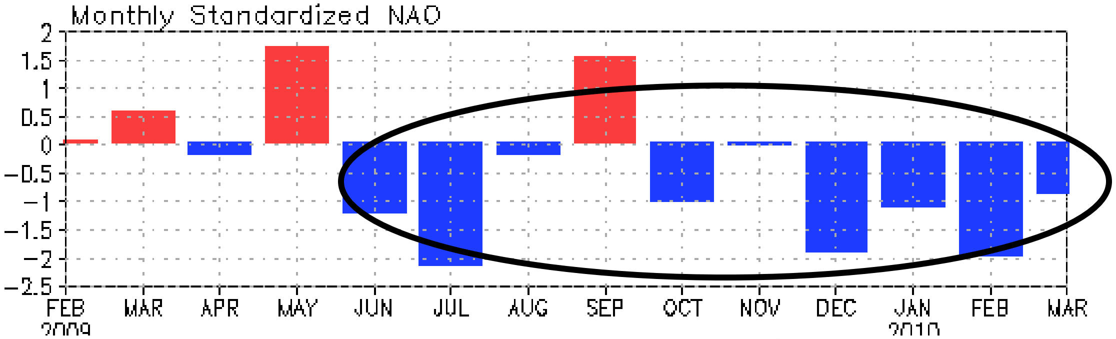
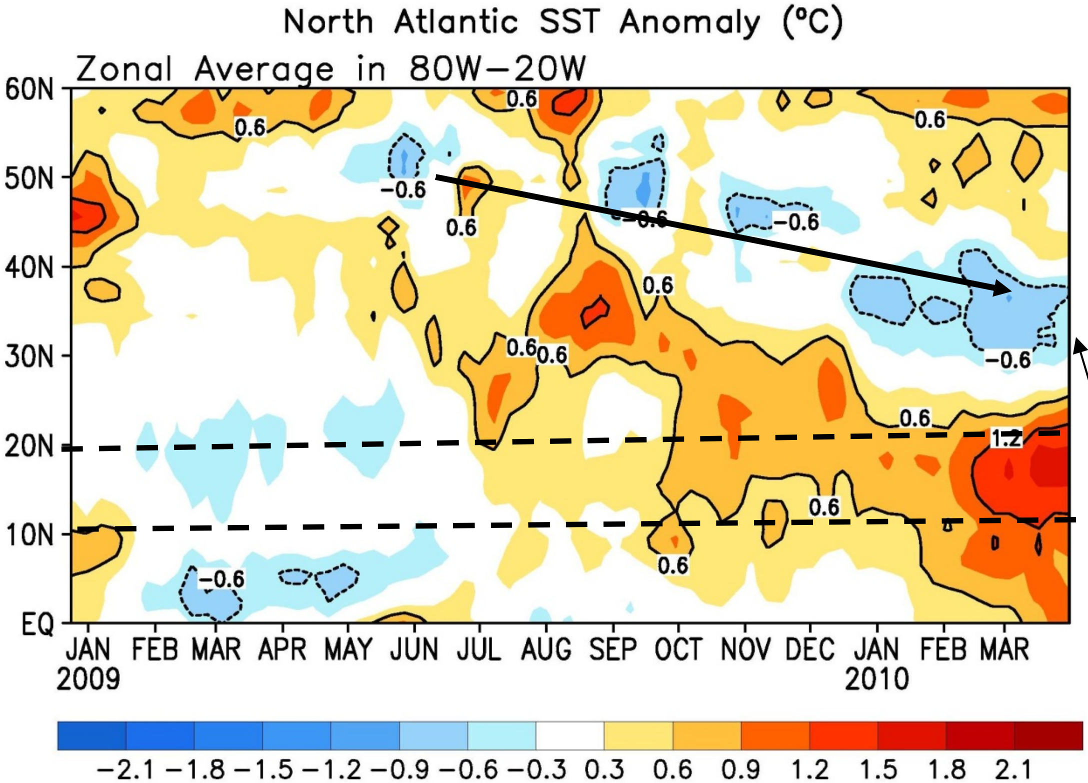
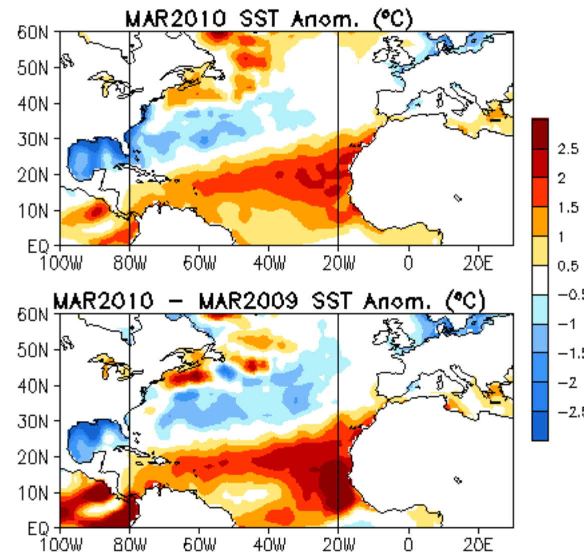



Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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



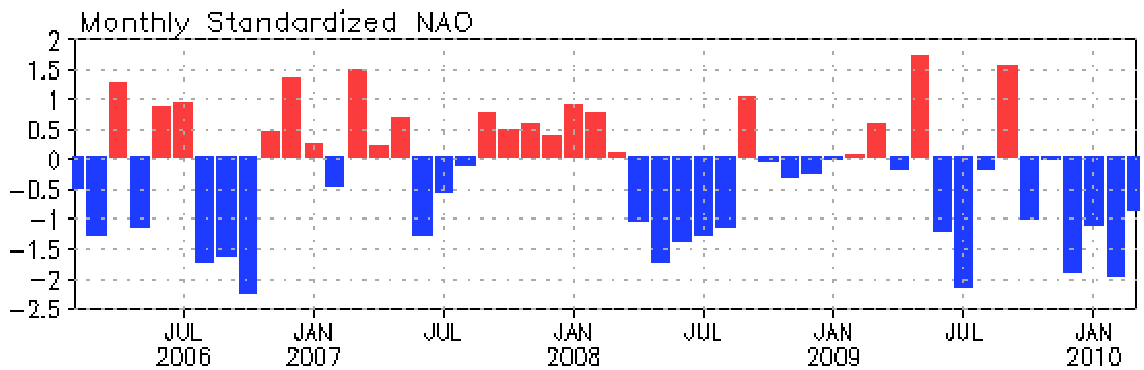



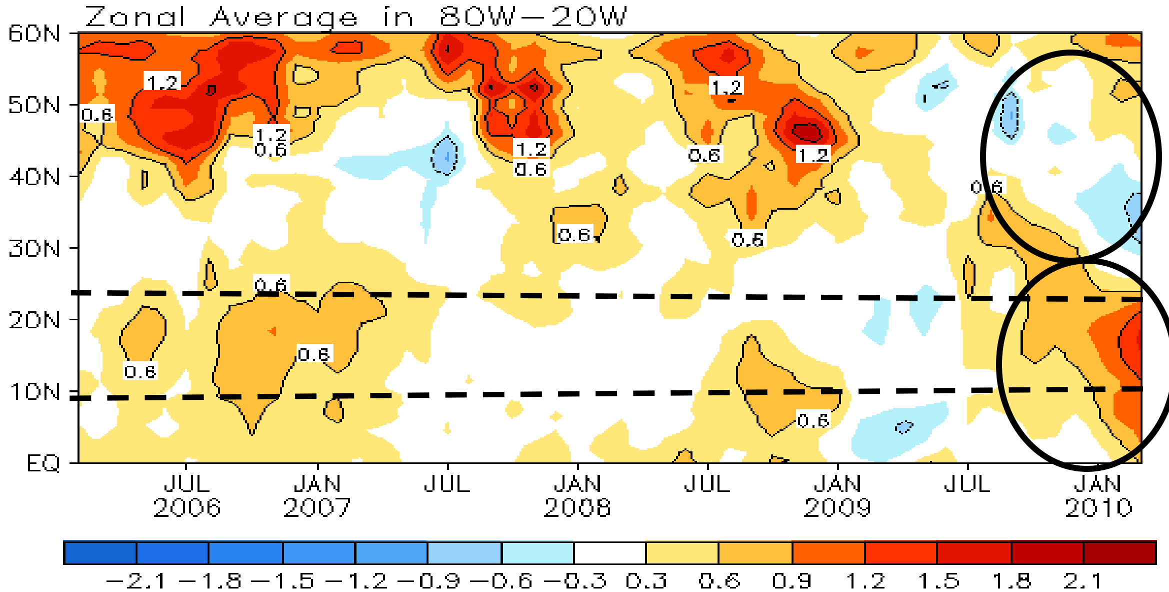



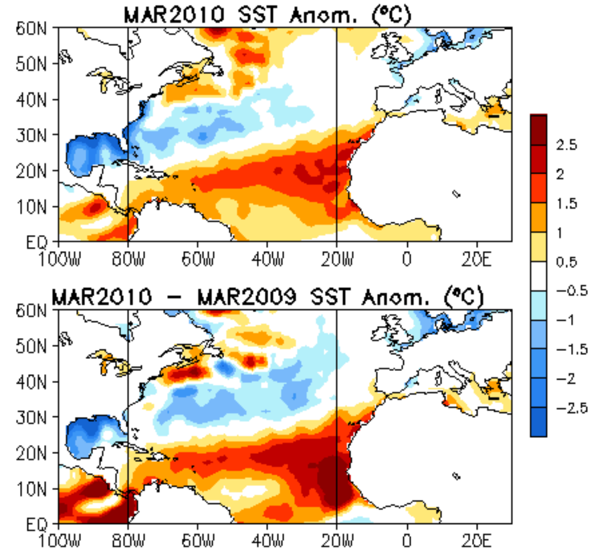

- Mid-latitude North Atlantic SSTA are closely related to NAO index – negative (positive) NAO leads to SST cooling (warming).
- NAO has been persistently below-normal since Jun 09, which contributed to the development and maintenance of negative SSTA in mid-latitude
- Positive SSTA in the Hurricane Main Development Region enhanced in Mar 10, consistent with the ENSO impact pattern.

**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.**

# NAO and SST Anomaly in North Atlantic



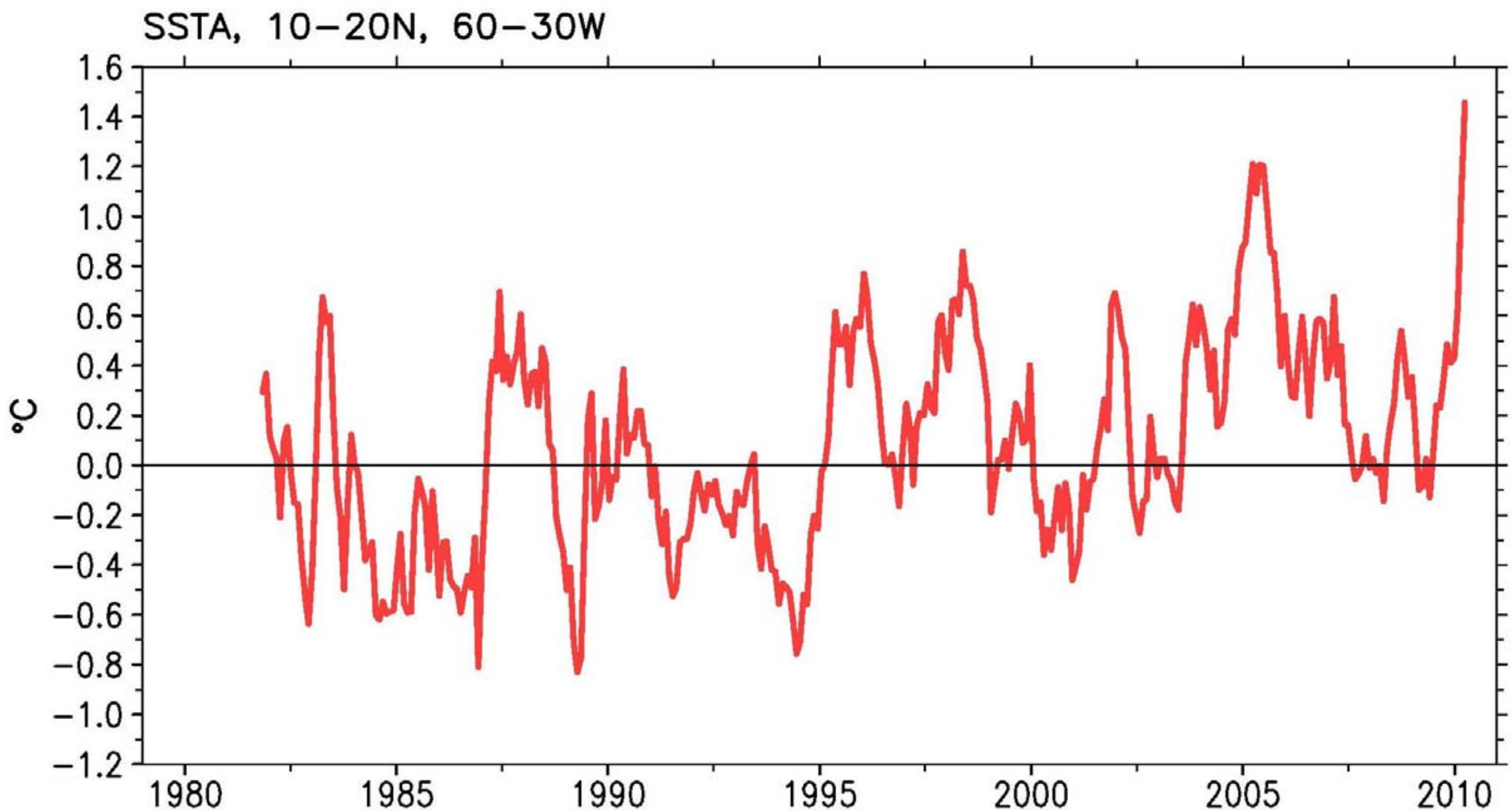




- **Mid-latitude North Atlantic SSTs cooled down and became slightly below-normal since May 09.**

- **SST in the Hurricane Main Development Region was weakly above-normal in summer/fall 09, 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 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.**

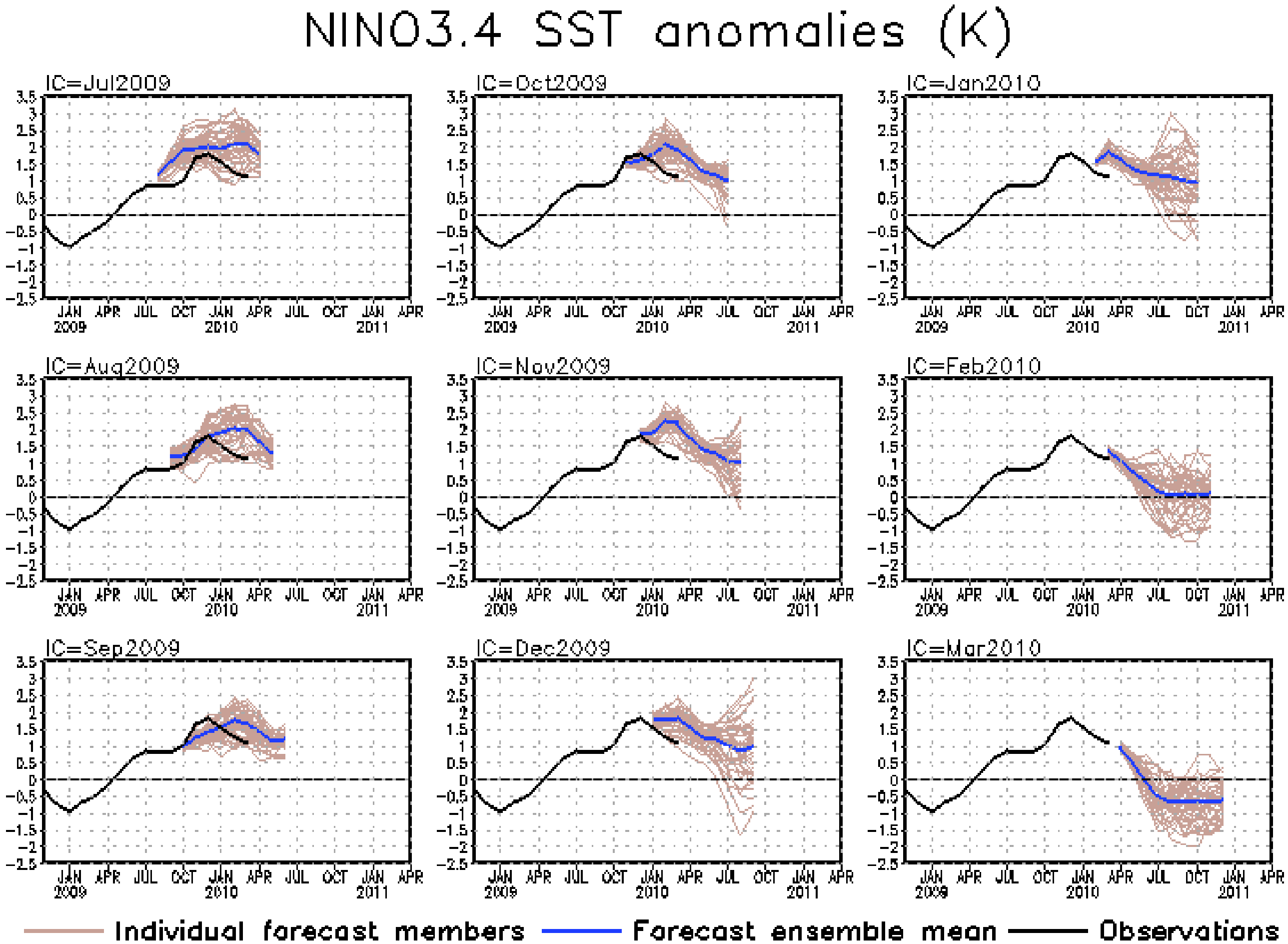
# Monthly OI SSTA at Hurricane Main Development Region 10-20N, 30-60W




- SSTA in HMDR reached 1.4C, the highest in record.

# CFS SST Predictions and Ocean Initial Conditions

# CFS Niño3.4 SST Predictions from Different Initial Months

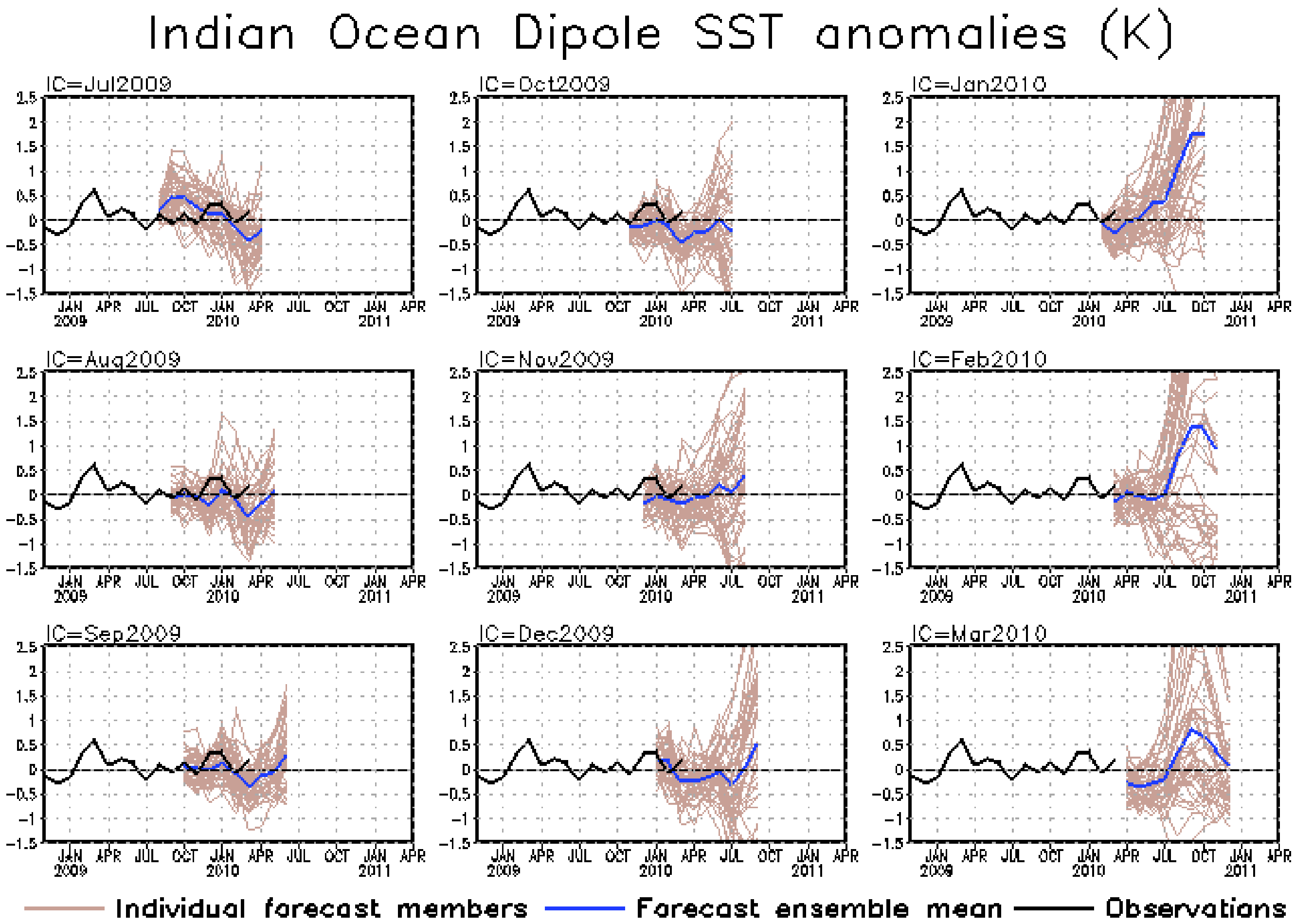



- Forecasts from Jul-Jan I.C. overshoot the peak phase, and delayed the transition to the decay phase in Jan-Feb 2010.

- The latest forecast from Mar 2010 I.C. suggests the current El Nino will decay rapidly in spring, returning to near-normal or below-normal 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

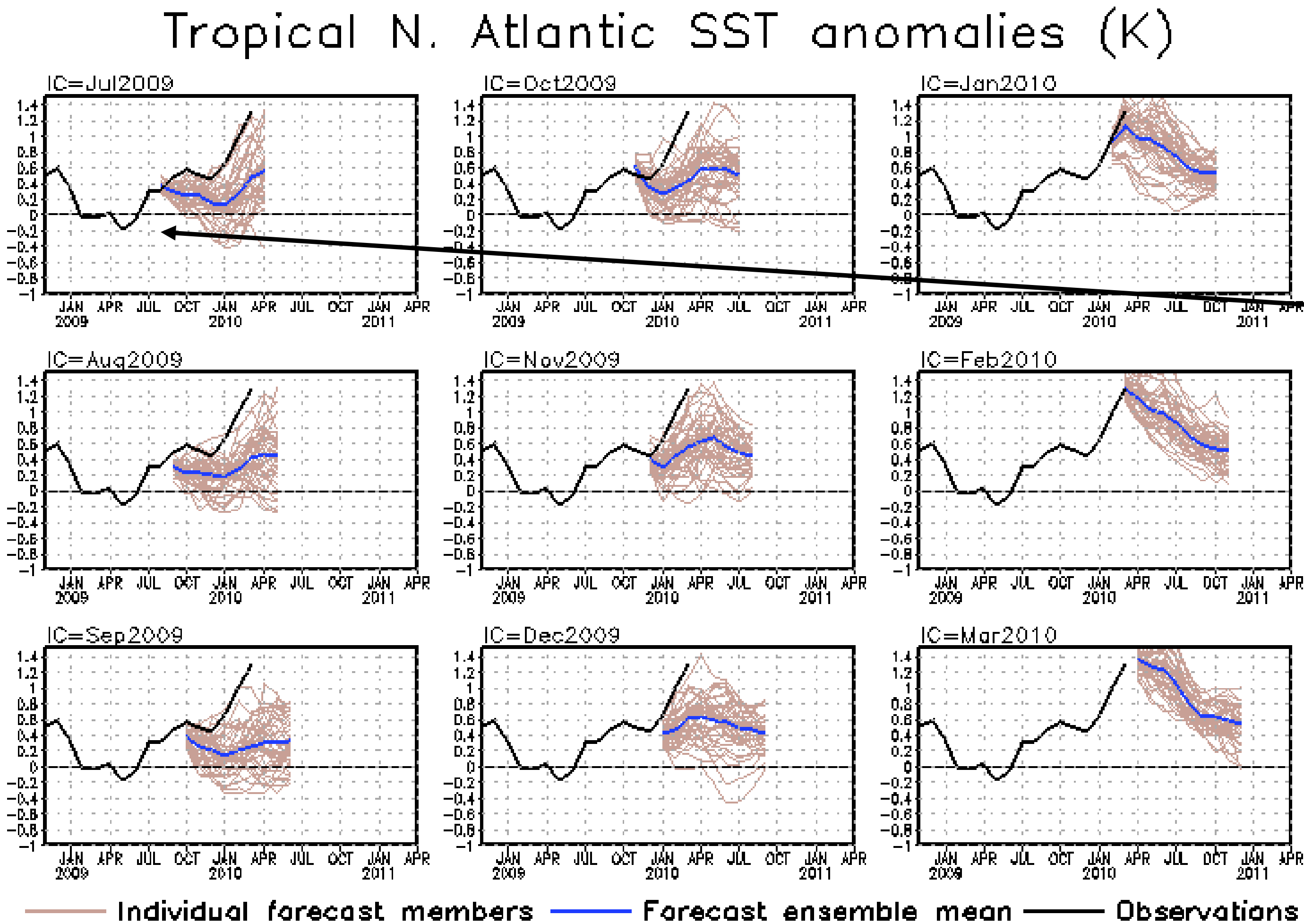
SETIO = SST anomaly in [90ºE-110ºE, 10ºS-0]

WTIO = SST anomaly in [50ºE-70ºE, 10ºS-10ºN]

- Latest forecasts called for weak positive Indian Ocean Dipole (IOD) in fall 2010.

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



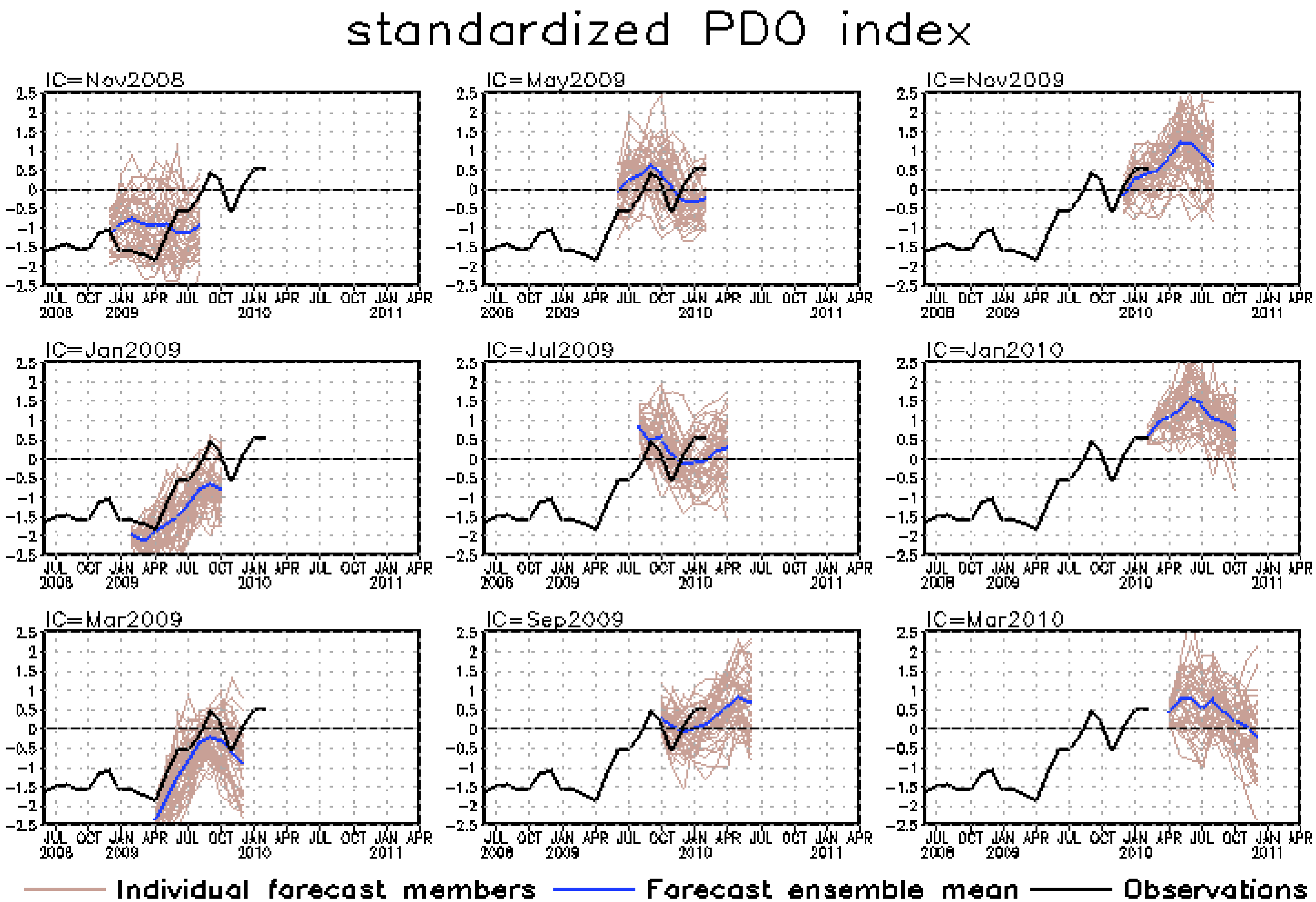

**TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].**

**- Cold biases from Jul-Jan I.C.**

**- Latest forecasts suggested that the positive tropical North Atlantic SST anomalies would peak in early spring 2010 due to the impacts of the 09/10 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.**

**- Nice forecasts from Jan-Nov 09 I.C.**

**Latest forecasts suggested that the PDO will be weakly above-normal in spring/summer 2010.**

**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**
  - El Niño conditions (NINO 3.4 > 0.5 ºC) peaked in Dec 09, and weakened steadily during Jan-Mar 2010, and are expected to transition to ENSO-neutral conditions by summer 2010;
  - Westerly wind bursts events, which have been very active from July 2009 to Mar 2010, contributed to the strengthening and maintenance of the 2009/10 El Niño;
  - PDO was near-normal in Aug-Dec 2009, and became weakly above-normal in Jan-Mar 2010;
  - Upwelling along west coast of North America was mostly above-normal in March 2010, consistent with above-normal Chlorophyll.
  - Arctic sea ice content increased dramatically and became near-normal in Mar 2010, the first time since 2001.
- **Indian Ocean**
  - Positive SSTA persisted in the tropical Indian Ocean in Mar 2010, and Dipole Mode Index was near-normal.
- **Atlantic Ocean**
  - Positive SSTA enhanced in the tropical North and South Atlantic in Mar 2010, probably due to the impacts from the Pacific El Nino;
  - Convection was mostly suppressed in the tropical North Atlantic;
  - NAO remained negative in Mar 2010;
  - Mid-latitude North Atlantic SSTs have been unusually below-normal since May 2009, and SSTs in hurricane main development region reached a historic high in Mar 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!