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

Prepared by

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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)

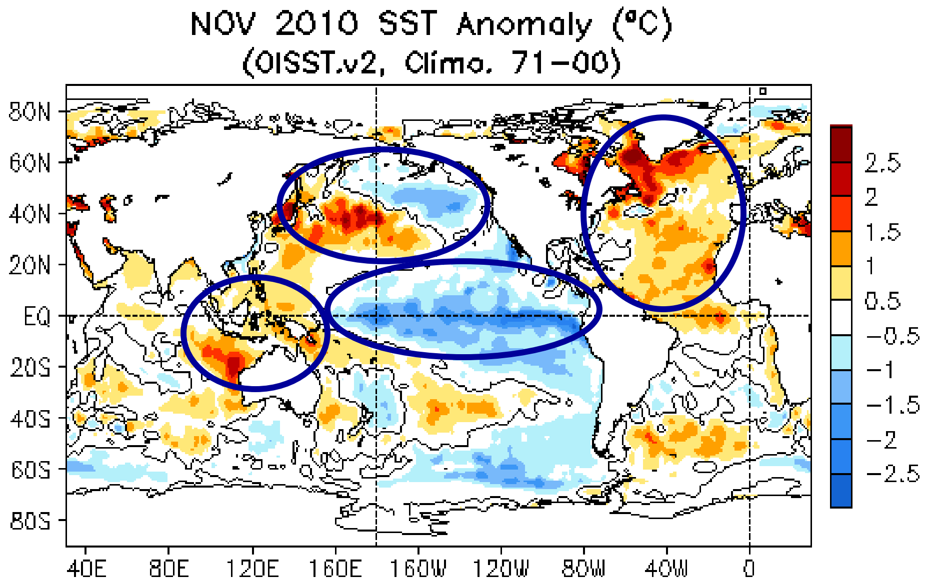
Outline

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

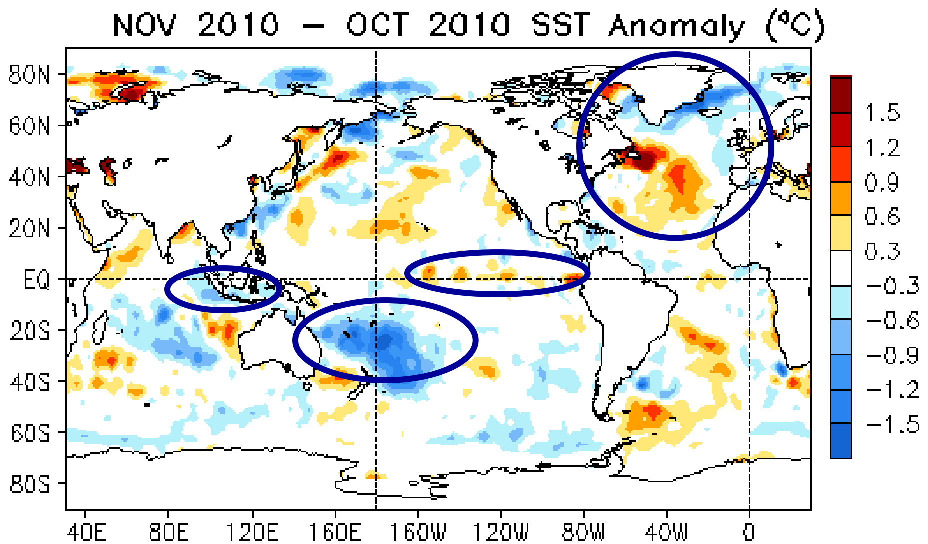
Overview

- **Pacific/Arctic Ocean**
  - ENSO cycle: La Niña conditions persisted with NINO3.4=-1.4°C in Nov 2010.
  - NOAA/NCEP Climate Forecast System (CFS) predicted a strong La Niña, to last through the Northern Hemisphere spring/summer 2011.
  - PDO has been below-normal since Jul 2010, with PDOI=-1.2 in Nov 2010.
  - Upwelling was abnormally strong north of 36°N along the west coast of North America in Nov 2010.
  - Arctic sea ice extent was comparable to the 2007 historical low in Nov 2010.
- **Indian Ocean**
  - Dipole Mode Index has been below-normal since May 2010, strengthened to be about -0.9°C during Sep-Oct 2010, but weakened to be about -0.3°C in Nov 2010.
- **Atlantic Ocean**
  - NAO index has been persistently below-normal since Oct 2009, and it was -1.6 in Nov 2010.
  - Strong positive SSTA (>2.5°C) persisted in the high latitudes since Sep 2010.
  - Positive SSTA in the tropical North Atlantic has been above-normal since Oct 2009, peaked during Mar-May 2010, and slowly weakened since then.
  - The 2010 N. Atlantic was very active hurricane year, which can be attributable to multiple factors such as the strong La Nina conditions, the ongoing active phase of the AMO and persistent negative phase of NAO.
  - The 2010 N. Atlantic hurricane season was successfully predicted by NOAA.

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



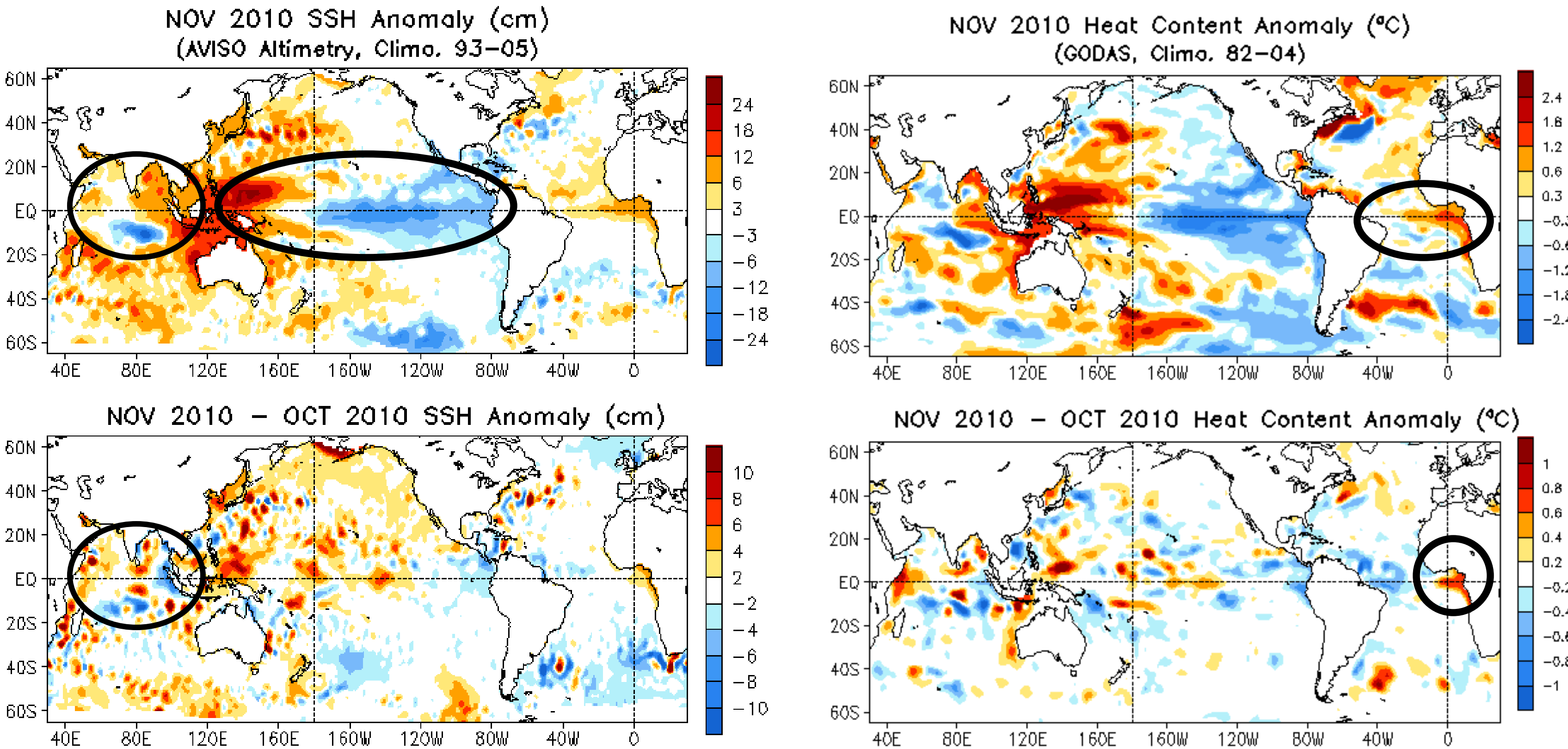
- Negative SSTA presented in the tropical eastern and central Pacific, indicating La Nina conditions.
- Negative PDO pattern continued in N. Pacific.
- Positive SSTA was observed in the southeast Indian Ocean and W. tropical Pacific.
- Positive SSTA presented in the North Atlantic and equatorial Atlantic.



- Positive SSTA tendency was observed in the central and eastern tropical Pacific, indicating weakening of La Nina conditions.
- Negative SST tendency was observed in the southeast Indian Ocean, resulting in a drastic reduction of the negative Dipole Model Index.
- Strong negative SSTA tendency was observed in the southwest Pacific.
- Positive (negative) SSTA tendency was evident in the mid- (high-) latitudes of N. Atlantic.

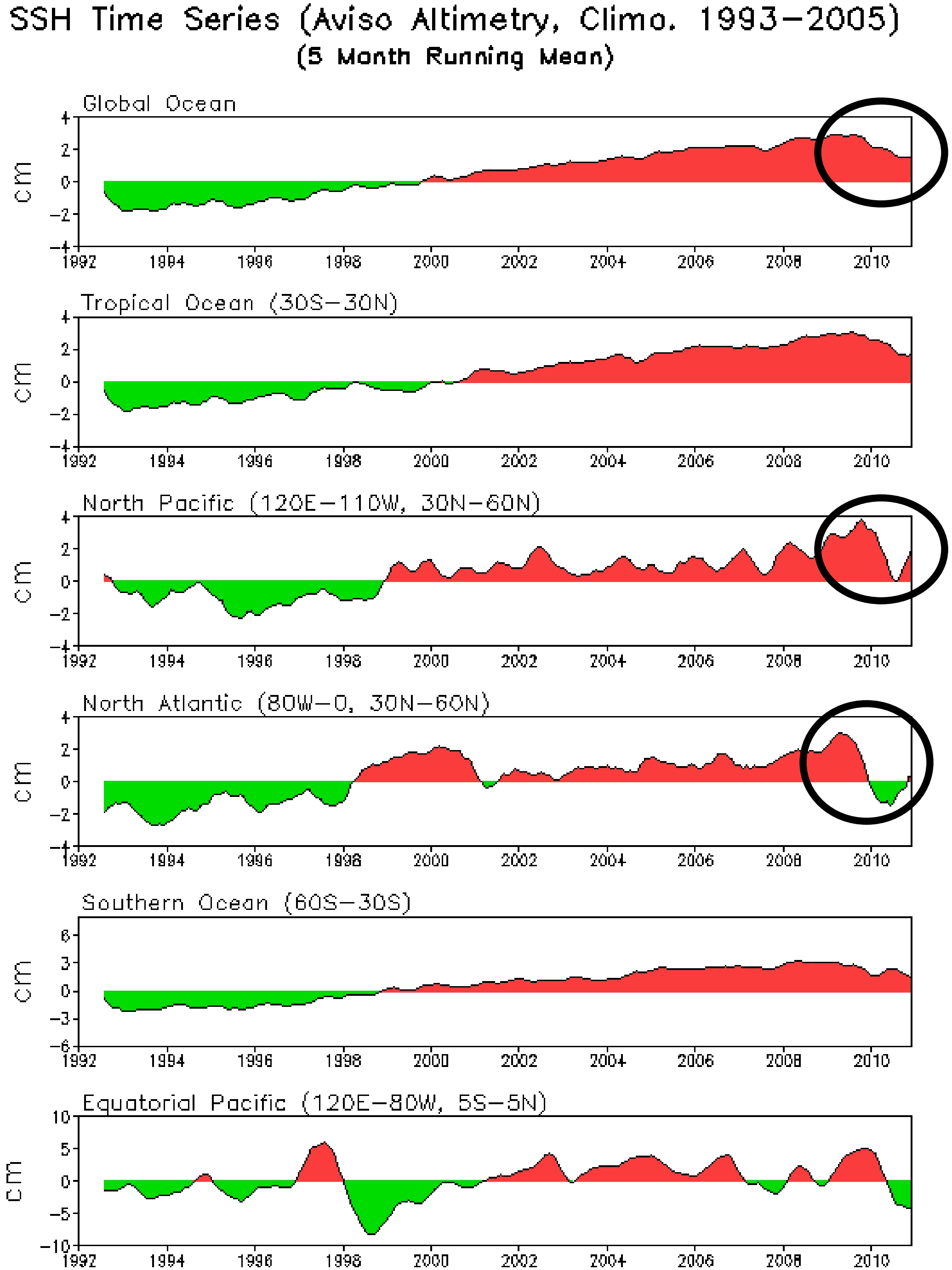
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

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



- **Negative (positive) SSHA and HCA in the central and eastern (western) tropical Pacific are consistent with the La Nina conditions.**
- **In the tropical Indian Ocean, positive (negative) SSHA and HCA weakened in the eastern (central) basin, consistent with weakening of the negative Indian Ocean Dipole (IOD).**
- **Positive SSHA and HCA in the eastern equatorial Atlantic enhanced.**
- **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.



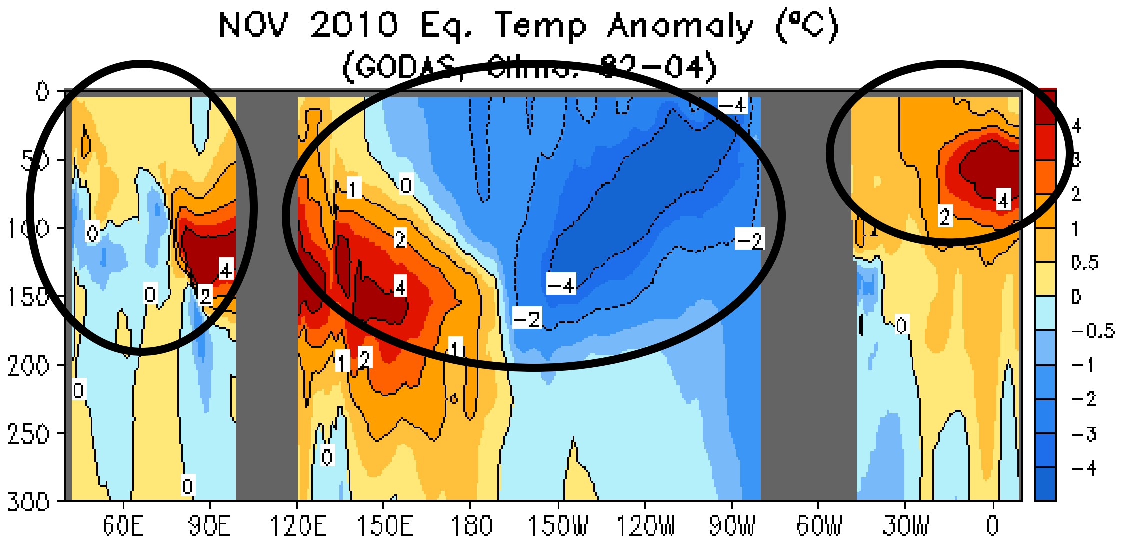
SSH Anomaly (cm)

- The global ocean mean SSHA has an upward trend from 1993 to 2009 and a downward trend since late 2009, which is consistent with the variation in the mean SSHA of the tropical ocean.

- The mean SSHA in North Pacific and North Atlantic has upward trend and prominent interannual variability. The recent cooling since late 2009 is the strongest in both ocean basins over the historical record since 1993.

- The mean SSHA in the equatorial Pacific Ocean has been persistently positive since 2001, but decreased to negative values as low as those in 1999 due to the La Nina cycle.

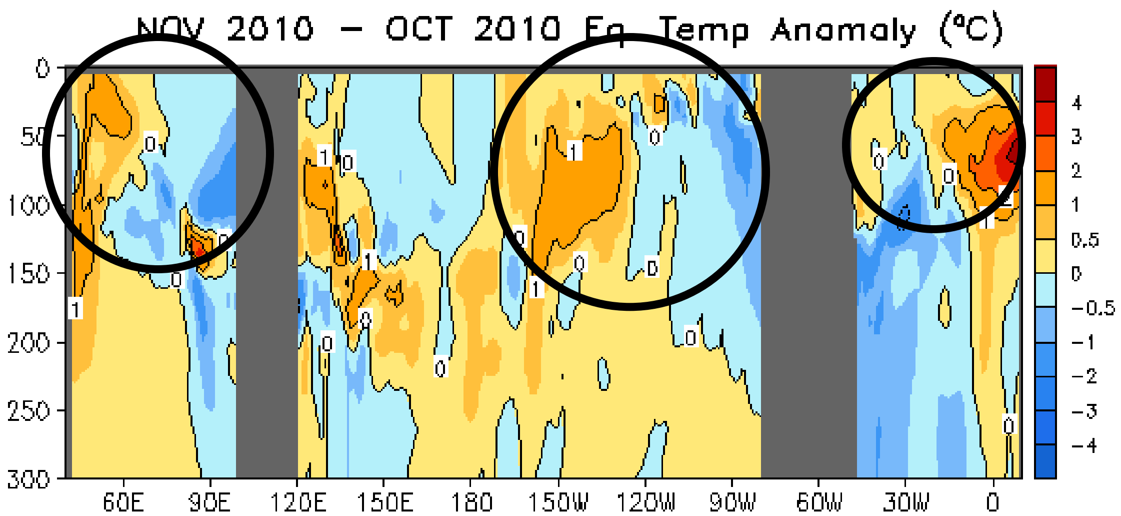
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2^{O}S-2^{O}N



- Negative (positive) temperature anomalies dominated in the equatorial central and eastern (western) Pacific, consistent with the La Niña conditions.

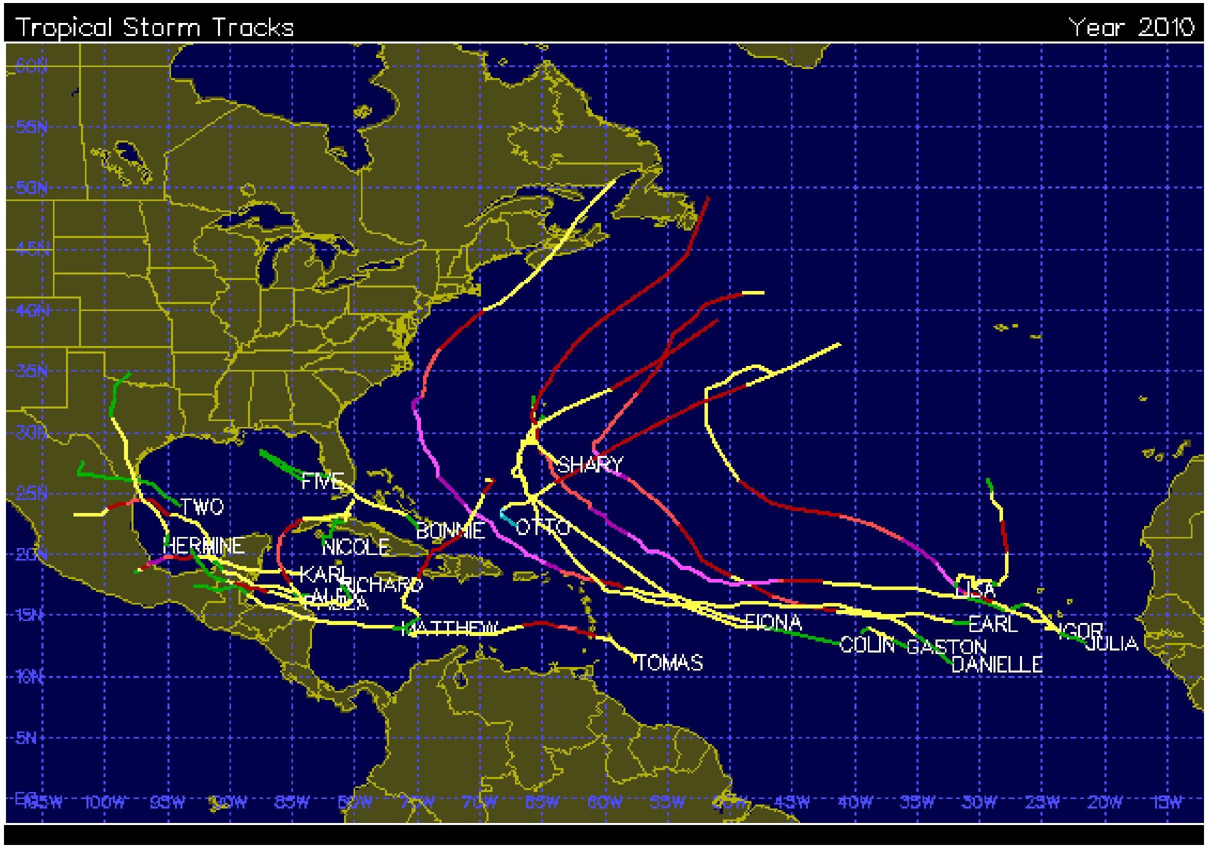
- Positive temperature anomalies covered the upper 75m of the equatorial Indian Ocean, while from 75m to 175m a weak dipole pattern was evident, consistent with the negative IOD event.

- Positive temperature anomalies were strongest near the thermocline in the eastern equatorial Atlantic Ocean.



- Positive (negative) temperature anomaly tendency presented near the thermocline in the central (eastern Pacific).
- Subsurface temperature anomalies associated with the negative IOD event weakened.
- Positive temperature anomaly in the eastern Atlantic Ocean enhanced.

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.



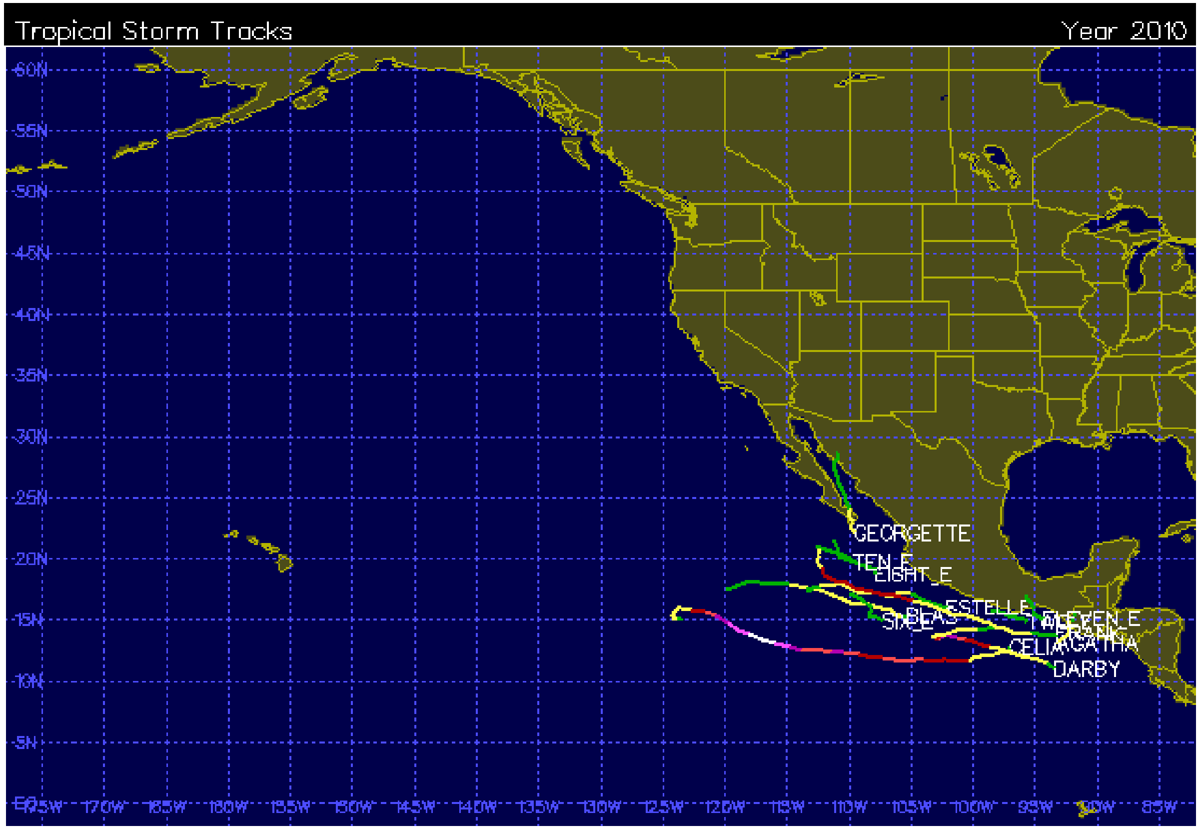
2010 N. Atlantic tropical cyclone activity:

Very active year, well predicted by NOAA and others

In this 2010 season, the La Nina conditions was expected to enhance the N. Atlantic basin's hurricane activity. This combined with the ongoing active phase of the AMO that began in 1995 (may as well as persistent negative phase of NAO) made the 2010 North Atlantic season one of the very active seasons.

Category	Observed Number	NOAA Prediction (Aug 5, 2010)	*Mean (1950-2005)*
Major HR (5+4+3)	5 (0+4+1)	4-6	*2.7*
Total HR	12	8-12	*6.2*
Total Named TS	19	14-20	*10.3*
Accumulated Cyclone Energy	172% (*preliminary)*	170%-260%	*93.2*

From: http://en.wikipedia.org/wiki/2010_Atlantic_hurricane_season



2010 E. N. Pacific tropical cyclone activity:
A less active year

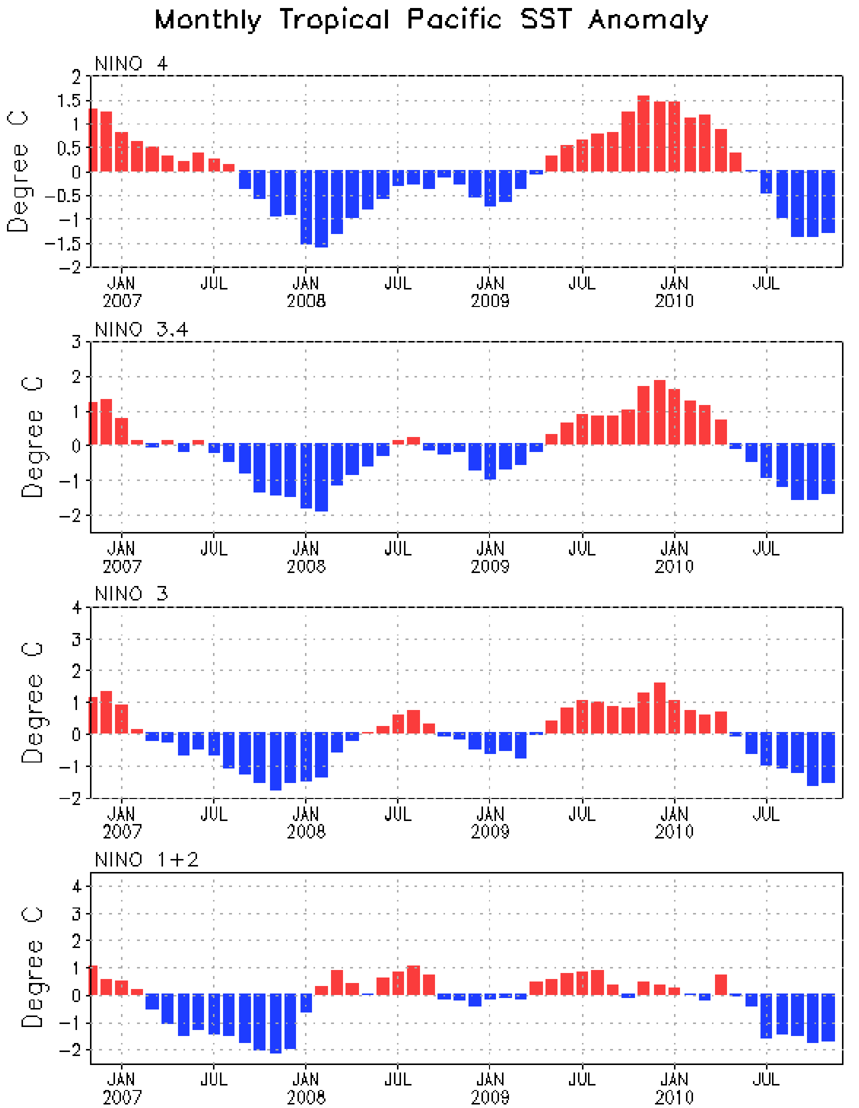
In this 2010 season, the La Nina conditions in the tropical Eq. Pacific was expected to suppress the E. Pacific's hurricane activity.

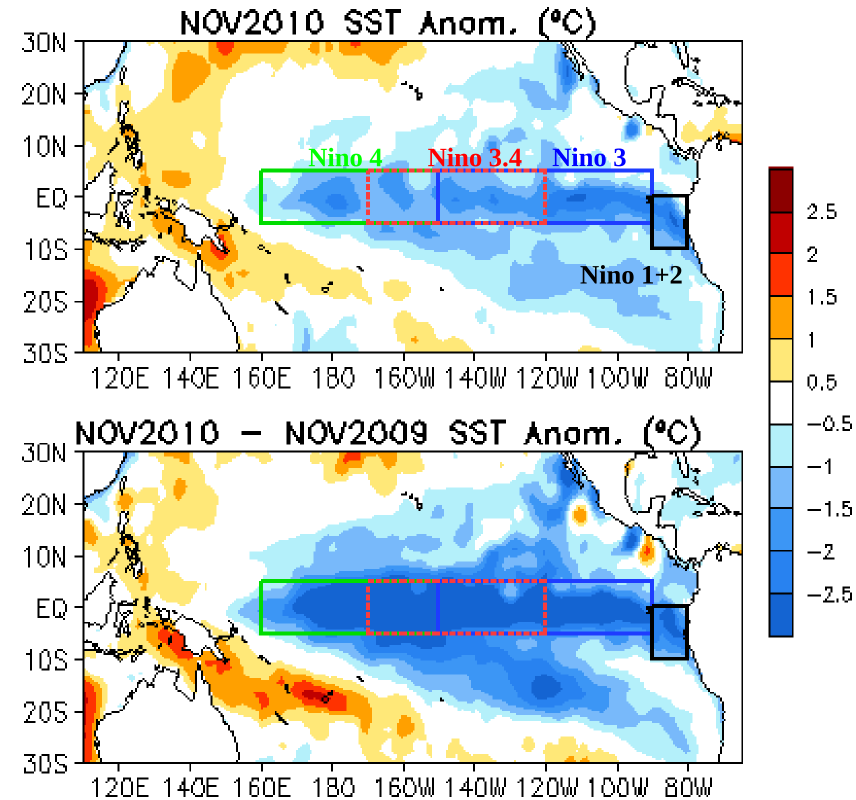
Category	Observed Number	NOAA Prediction (May 27, 2010	*Mean (NOAA 1995-2008)*
Major HR (5+4+3)	2 (1+0+1)	1-3	*3*
Total HR	3	4-8	*7*
Total Named TS	7	9-15	*14*

http://en.wikipedia.org/wiki/2010_Pacific_hurricane_season#cite_note-NOAA_May-3

Tropical Pacific Ocean

Evolution of Pacific NINO SST Indices



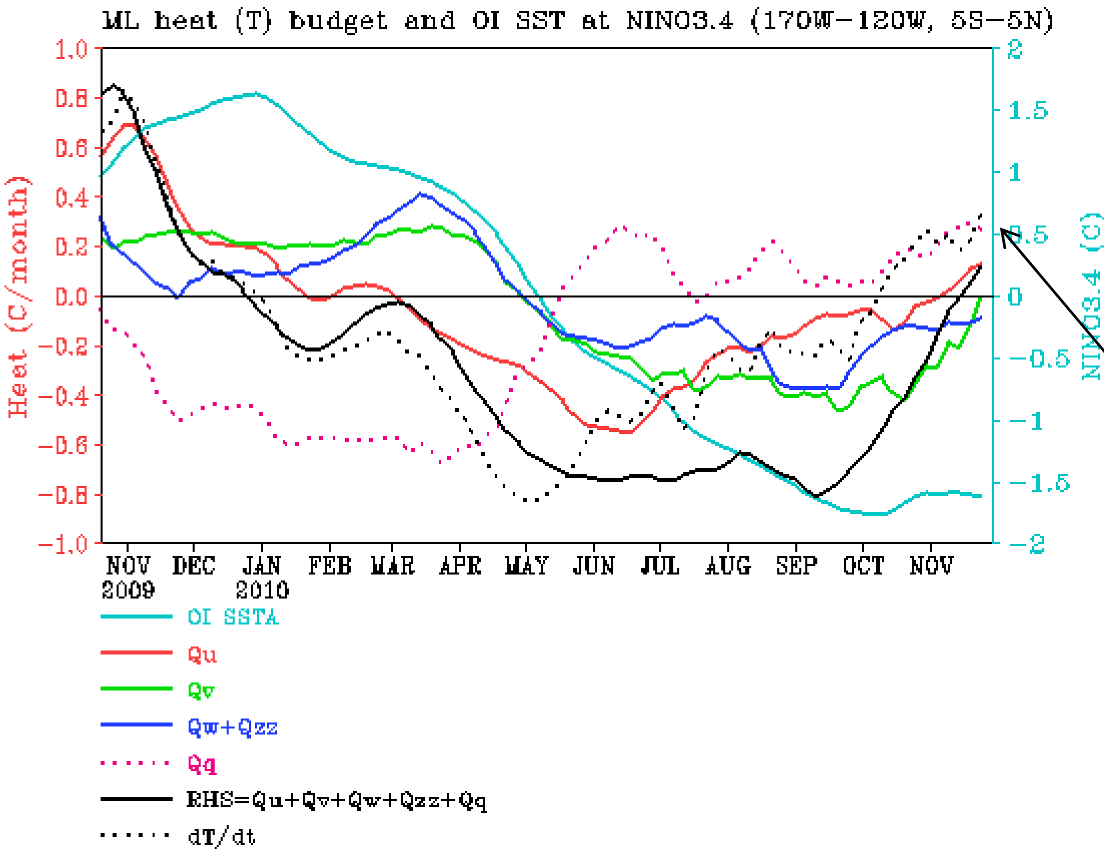


- All indices weakened slightly.

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

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

NINO3.4 Heat Budget



- Tendency (dT/dt) in NINO 3.4 became positive since Oct 2010, indicating weakening of the La Nina conditions.

- Qu switched to positive in Nov 2010, while other dynamical terms (Qv, Qw+Qzz) remained negative.

- The thermodynamic processes (Qq) have been positive since Jun 2010.

- There was a clear difference between the tendency (dT/dt) and the total heat budget term (RHS) since Jun 2010. This may be due to the fact that (1) the cooling from Qu and Qv might be overestimated in the GODAS due to too strong zonal and meridional current, and (2) surface heat flux (Qq) damping was too weak.

Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

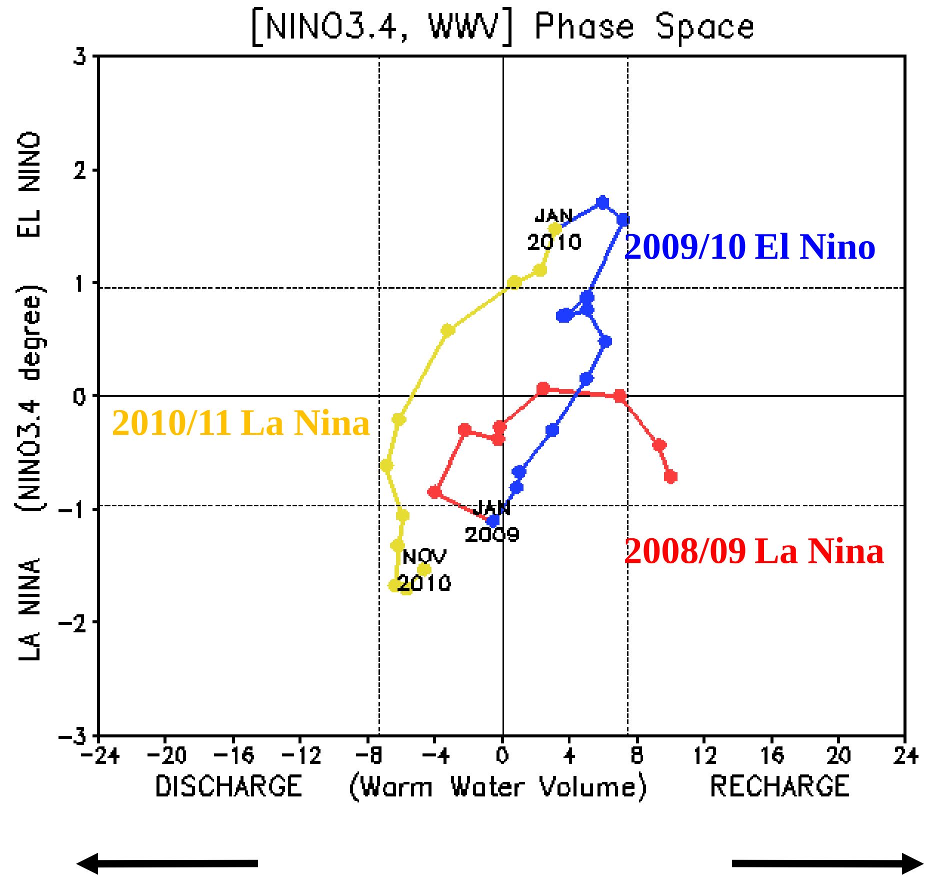
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

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.

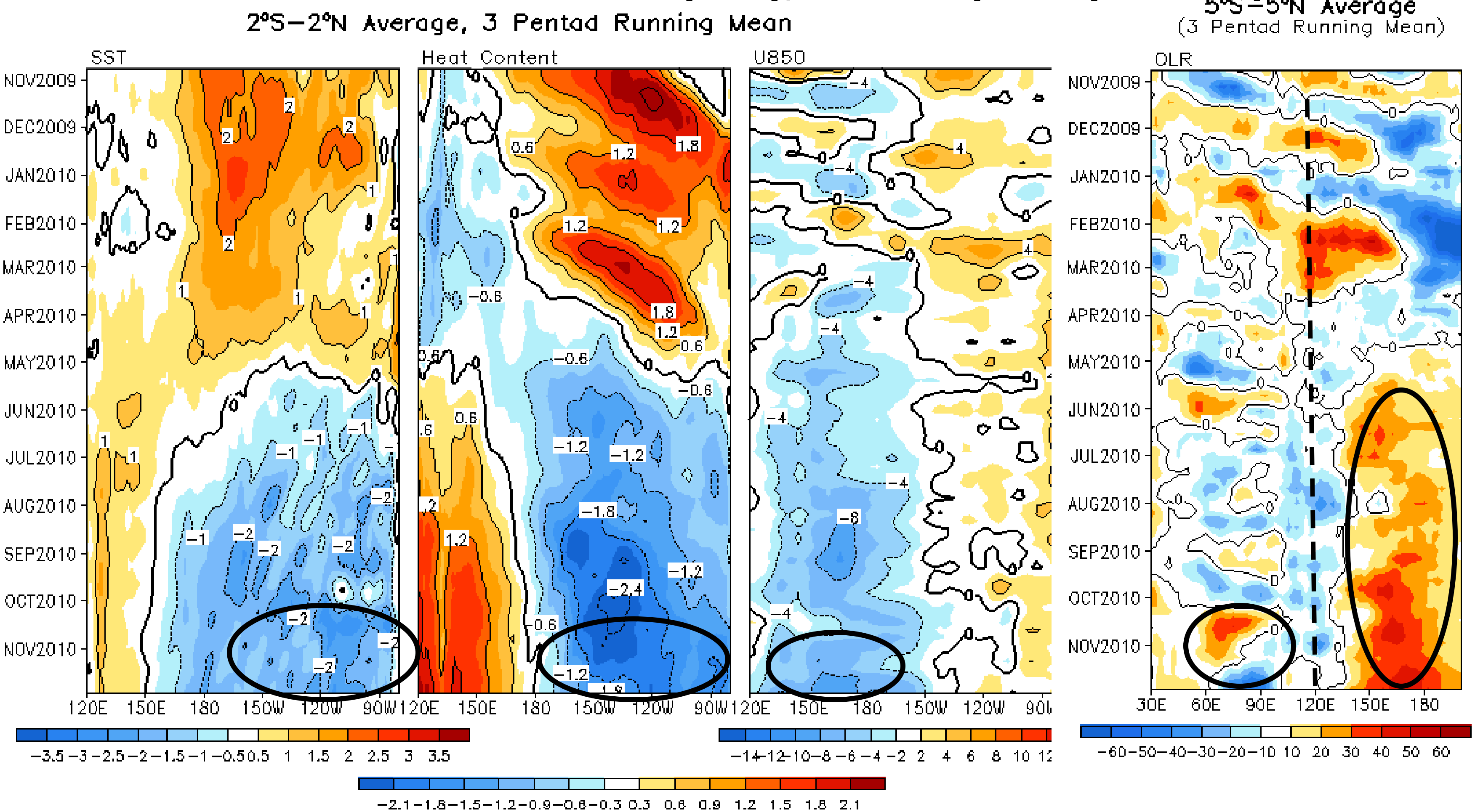


- Nino3.4 became less than -1C since Jul 2010, indicating moderate-strong La Nina conditions.

- Both Nino3.4 and WWV weakened slightly in Nov 2010.

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.

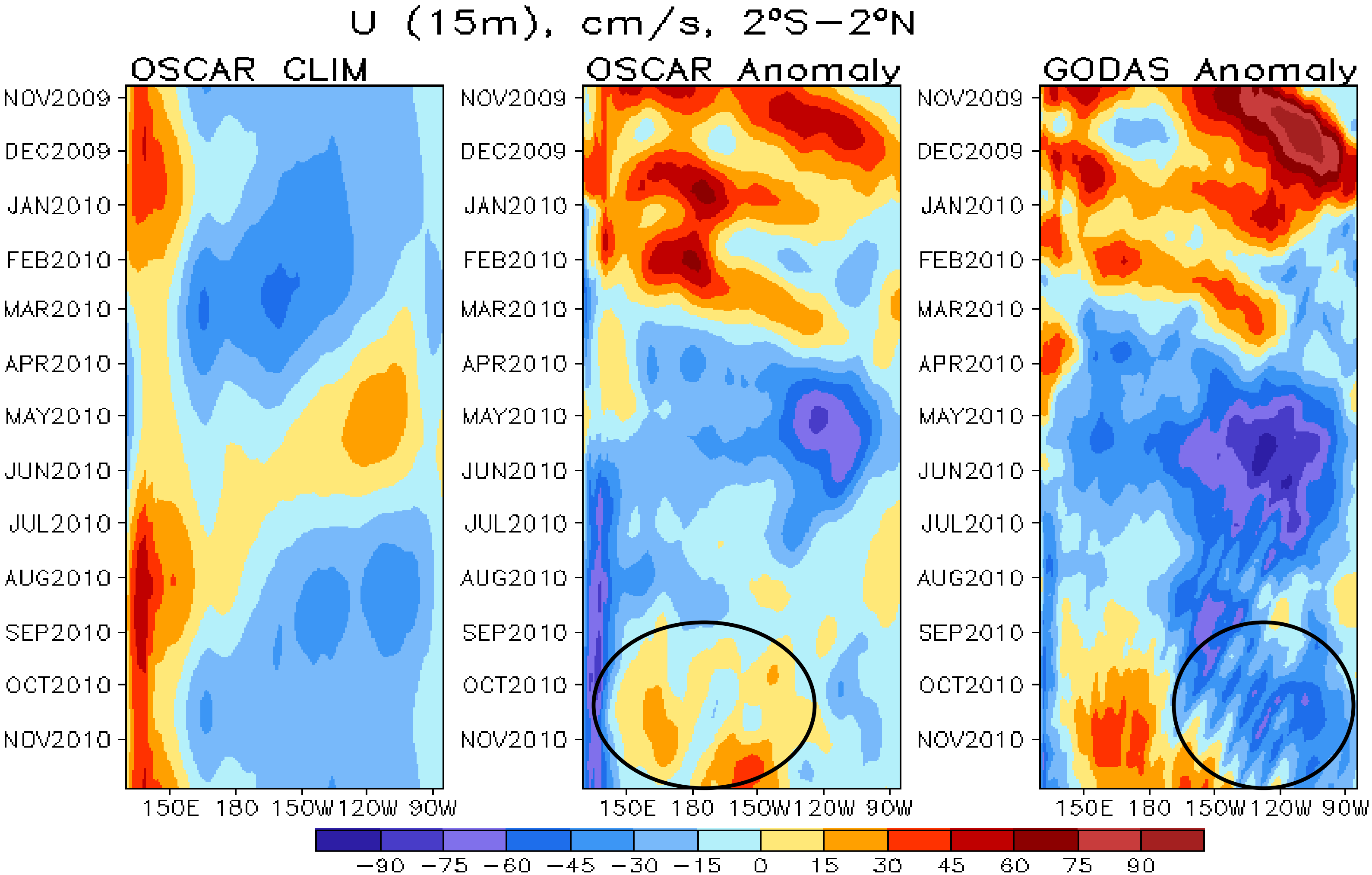
Evolution of Equatorial Pacific SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly



- **Negative SSTA and HC300A weakened slightly, while easterly wind anomalies strengthened in Nov 2010.**
- **Convection has been suppressed (enhanced) in the equatorial central Pacific (over the Maritime Continent) since May 2010, consistent with near surface wind convergence and divergence.**

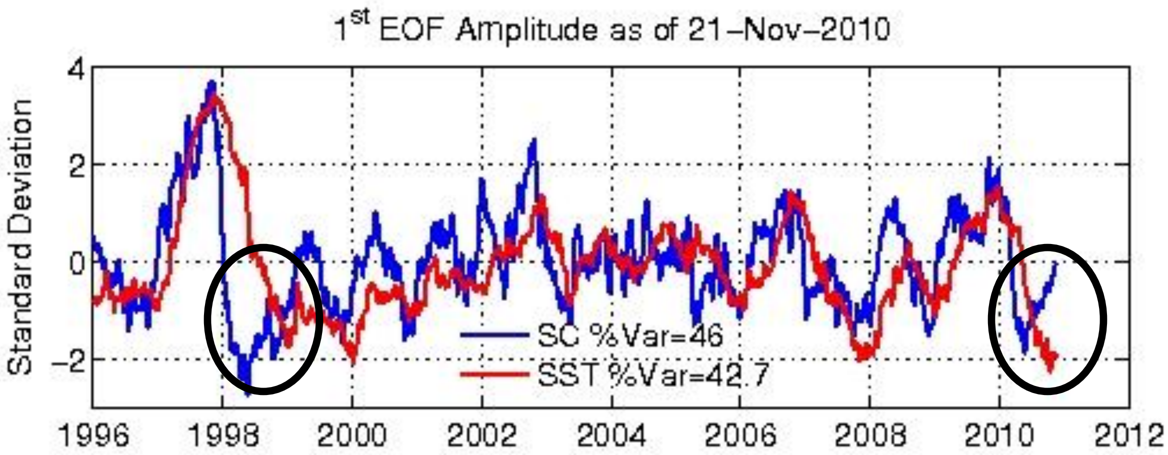
Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST is derived from the NCEP OI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

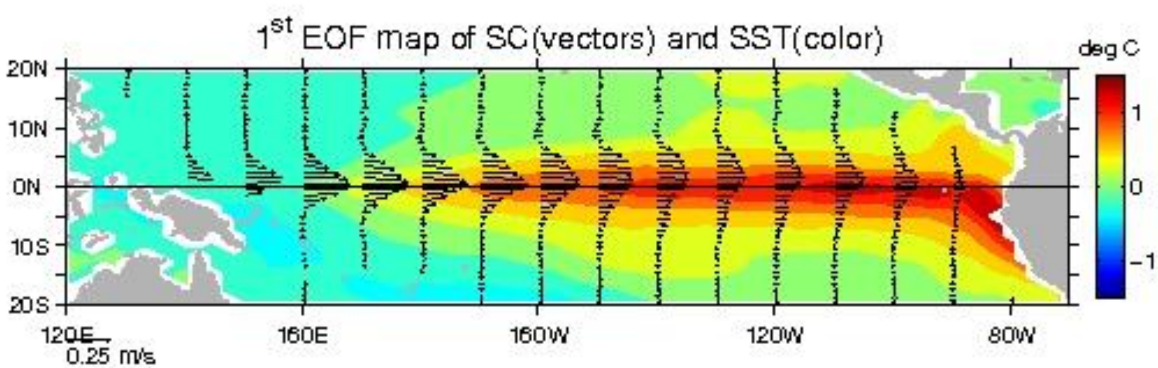
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **Anomalous zonal current in the OSCAR transitioned from negative (westward) to positive (eastward) west of 120W in Sep 2010, implying reduction of the zonal advection contribution to the cooling associated with the La Niña conditions.**
- **However, anomalous zonal current in the GODAS remained strongly negative east of 170W, which contributed to the imbalance of mixed layer heat budget.**

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



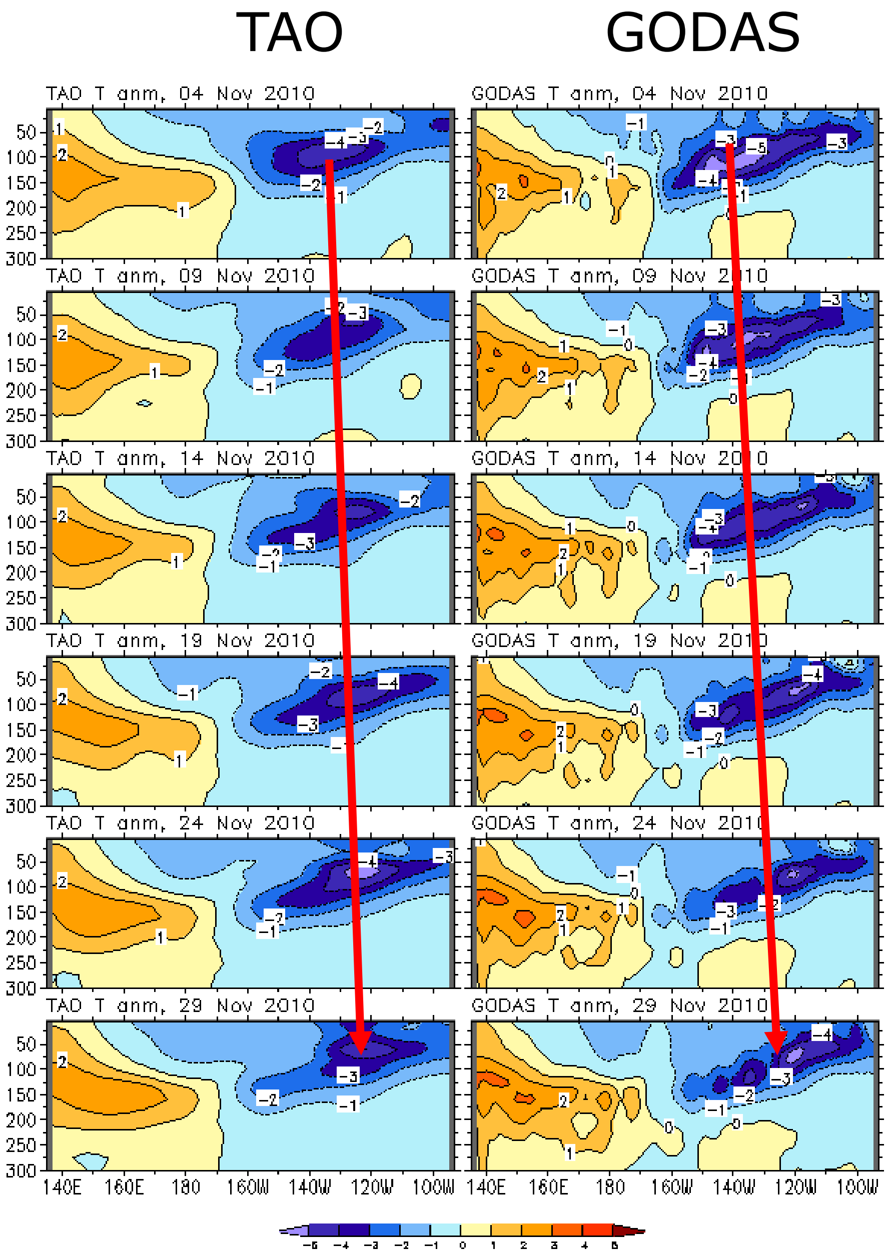


- Negative surface zonal current anomaly has weakened rapidly since Jul 2010, becoming near zero in Nov 2010.

- 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 Ni ño 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

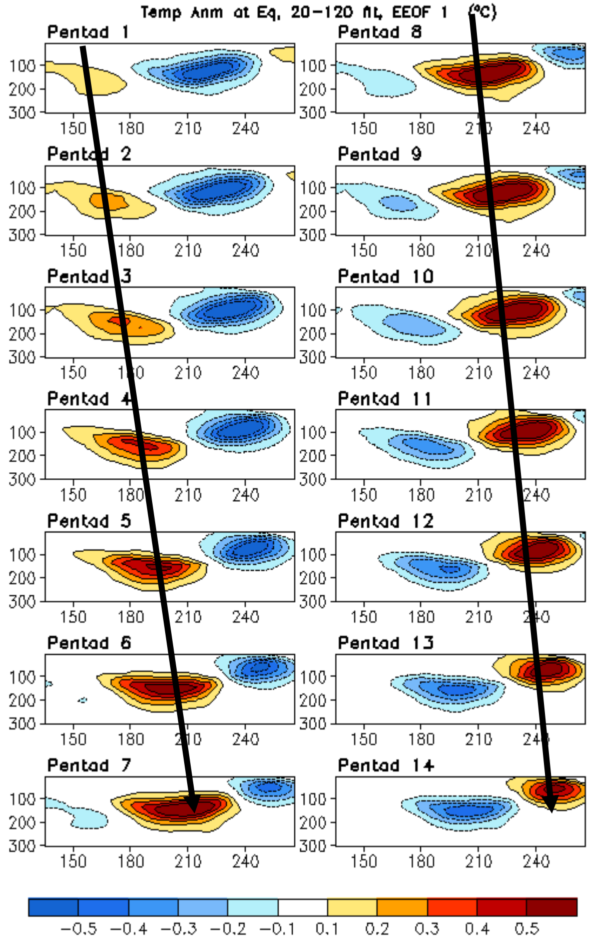


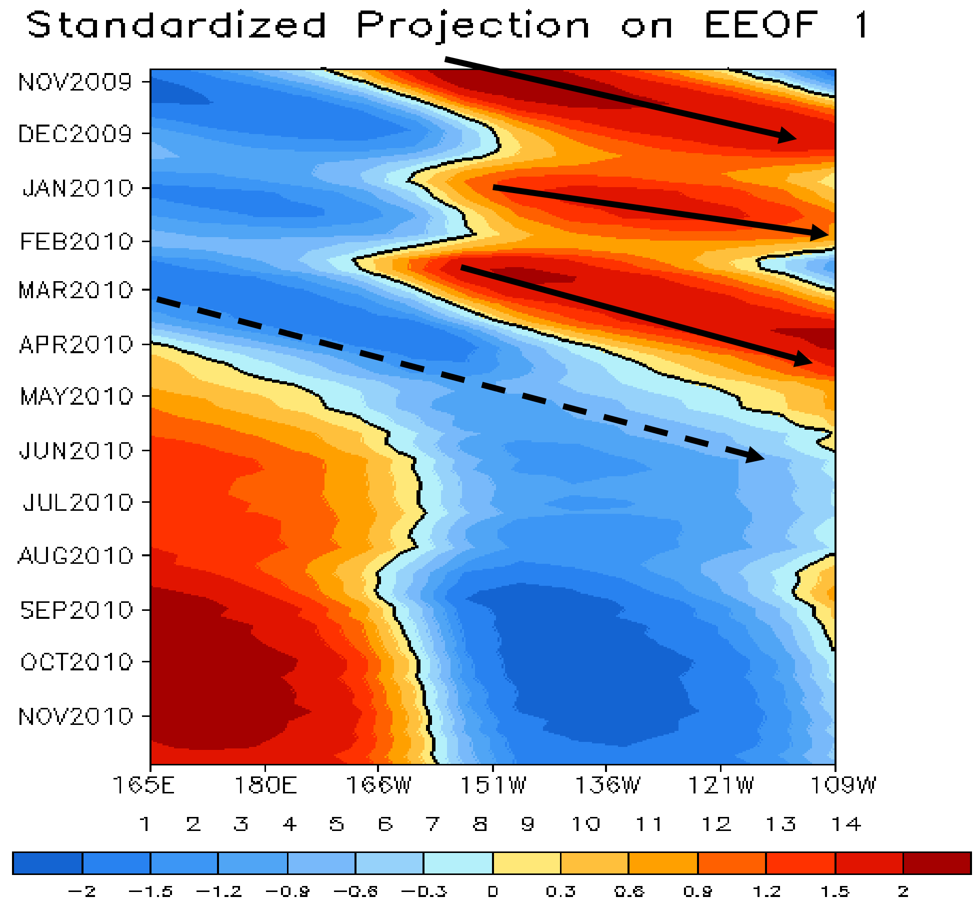
TAO climatology used

- **Negative (positive) temperature anomalies in the equatorial east-central (western) Pacific persisted in Nov 2010, consistent with the La Niña conditions.**

- **Negative temperature anomaly in the equatorial east-central Pacific propagated slowly eastward.**

Oceanic Kelvin Wave Indices

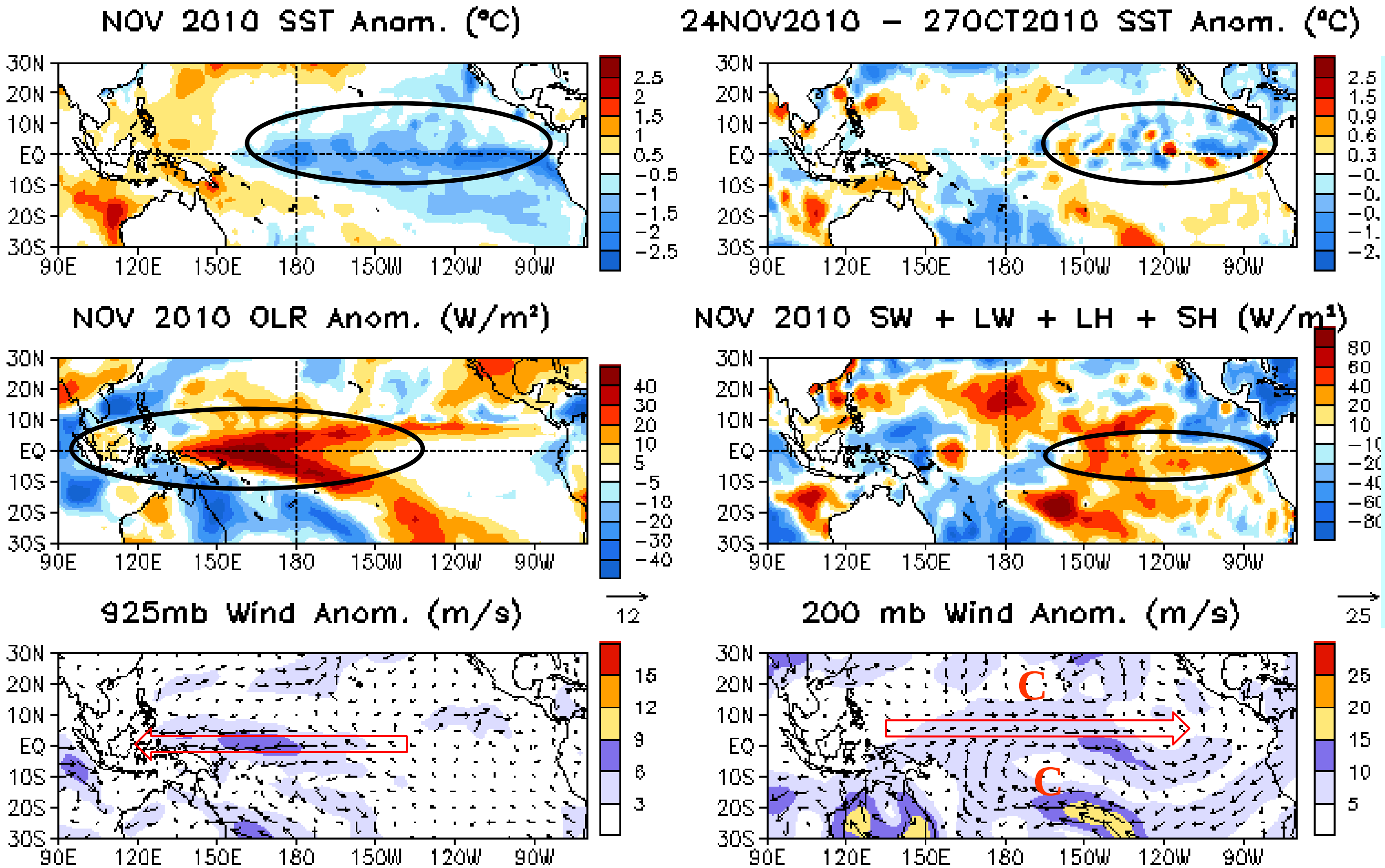




- Upwelling Kelvin wave occurred in late Feb 2010 in the W. Pacific and propagated eastward, which may have contributed to the transition of ENSO cycle from the warm phase to the cold phase.
- There were no Kelvin wave propagations since Jun 2010.

- **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

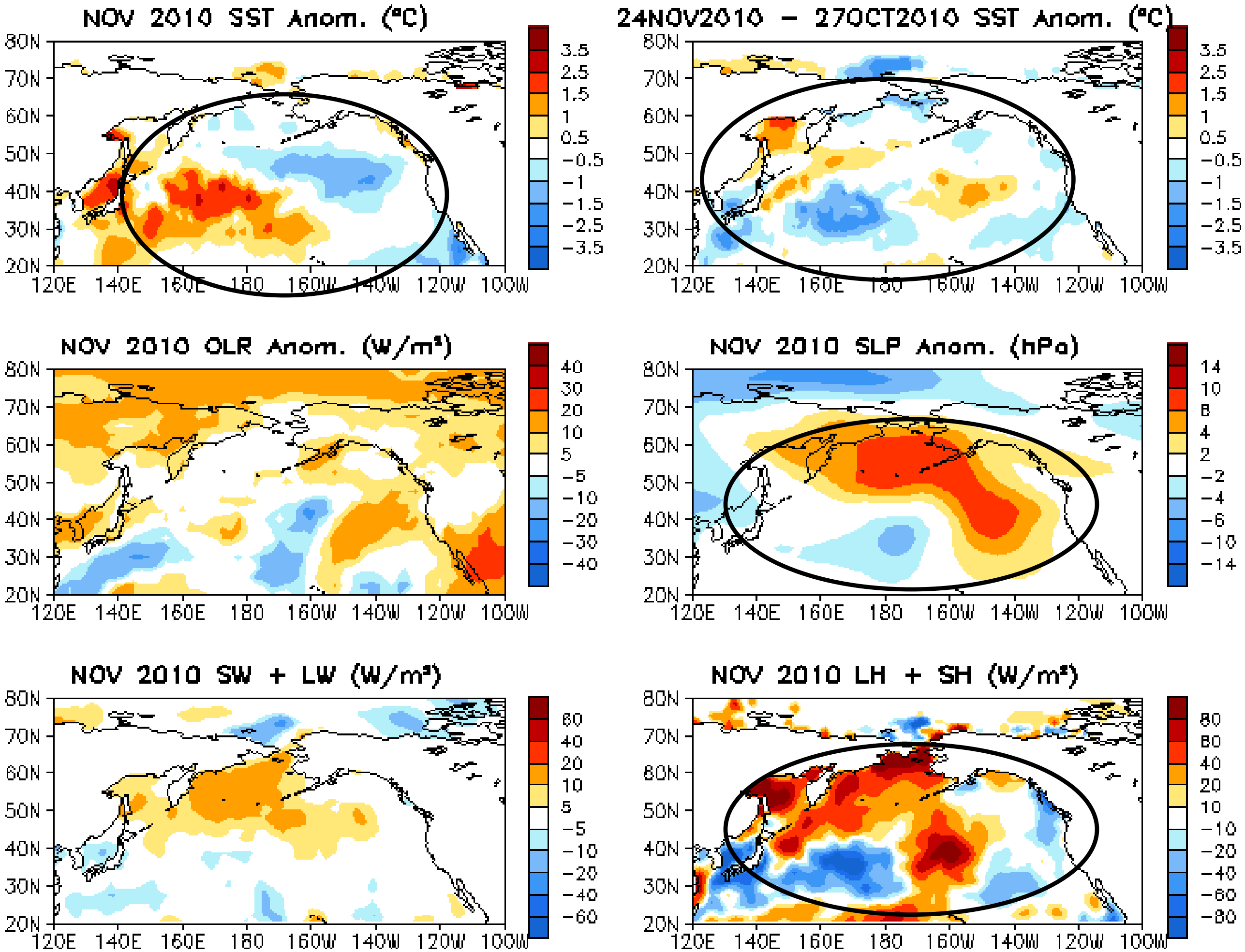


- **Negative SSTA largely persisted in the east-central equatorial Pacific in Nov 2010.**
- **Convection was enhanced (suppressed) over the Maritime Continent (in the west-central tropical Pacific).**
- **Net surface heat flux anomalies damped SSTA between 150W-90W.**
- **Easterly (westerly) wind anomaly in low level (high level) dominated in the western and central tropical Pacific, consistent with the La Nina conditions.**

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



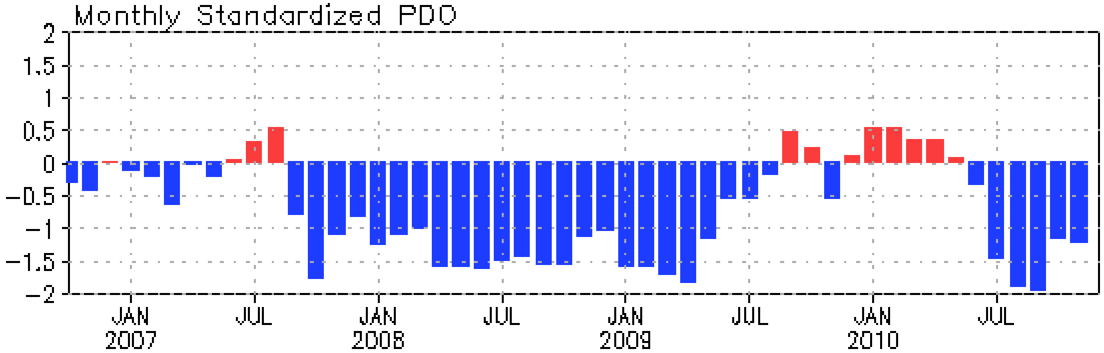
- **Positive (negative) SSTA was observed in the west-central N. Pacific (in the eastern N. Pacific) in Nov 2010, consistent with the negative PDO index (next slide).**

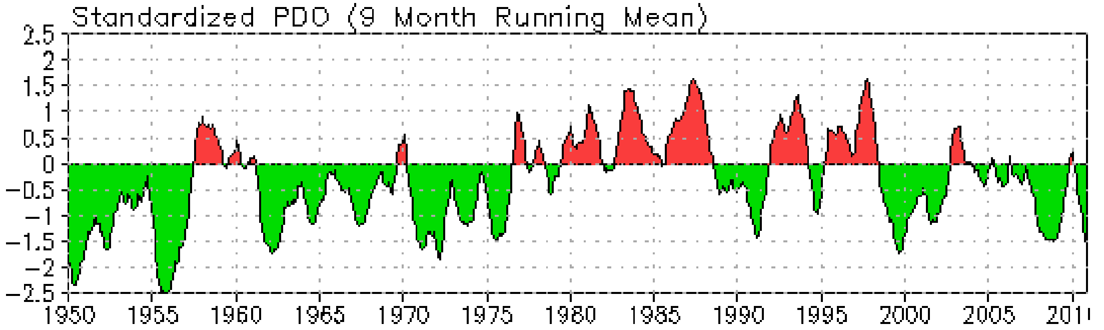
- **SSTA tendency is generally consistent with latent and sensible heat flux anomalies (LH+SH).**

- **Positive (negative) SLP anomaly existed in the northern and eastern N. Pacific (southern and central N. Pacific).**

Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

PDO index

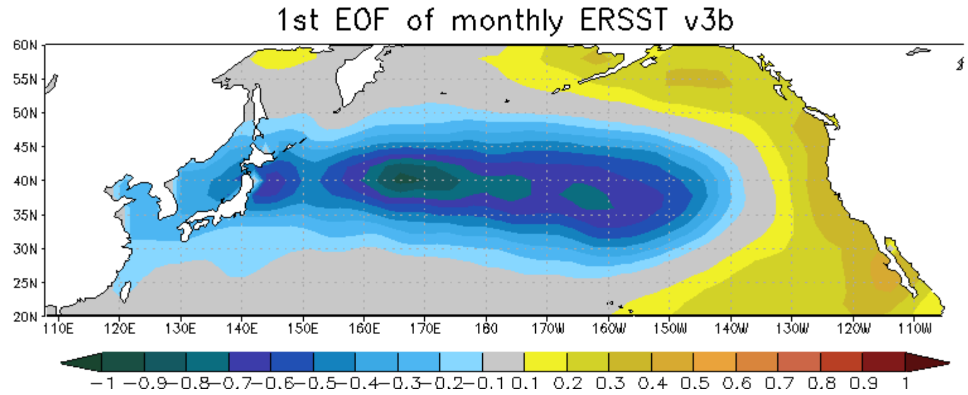




- The PDO index was near -1.2 in Nov 2010.

- The PDO index has been below normal since Jun 2010.

- Negative PDO index was coincident with the La Nina conditions.



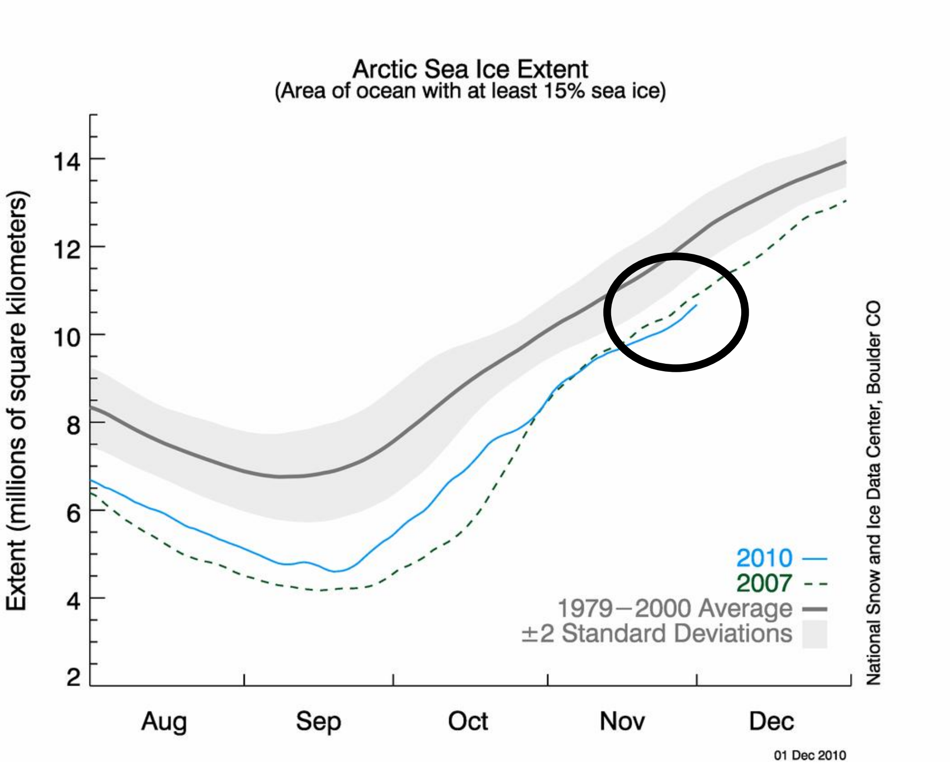
- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

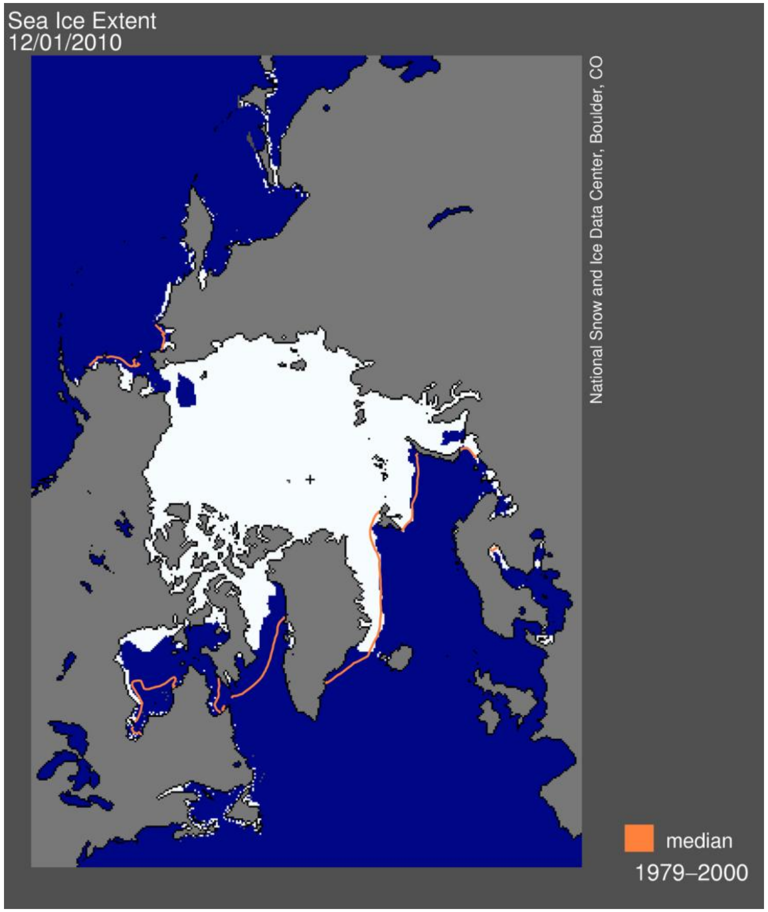
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

Arctic Sea Ice

National Snow and Ice Data Center

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

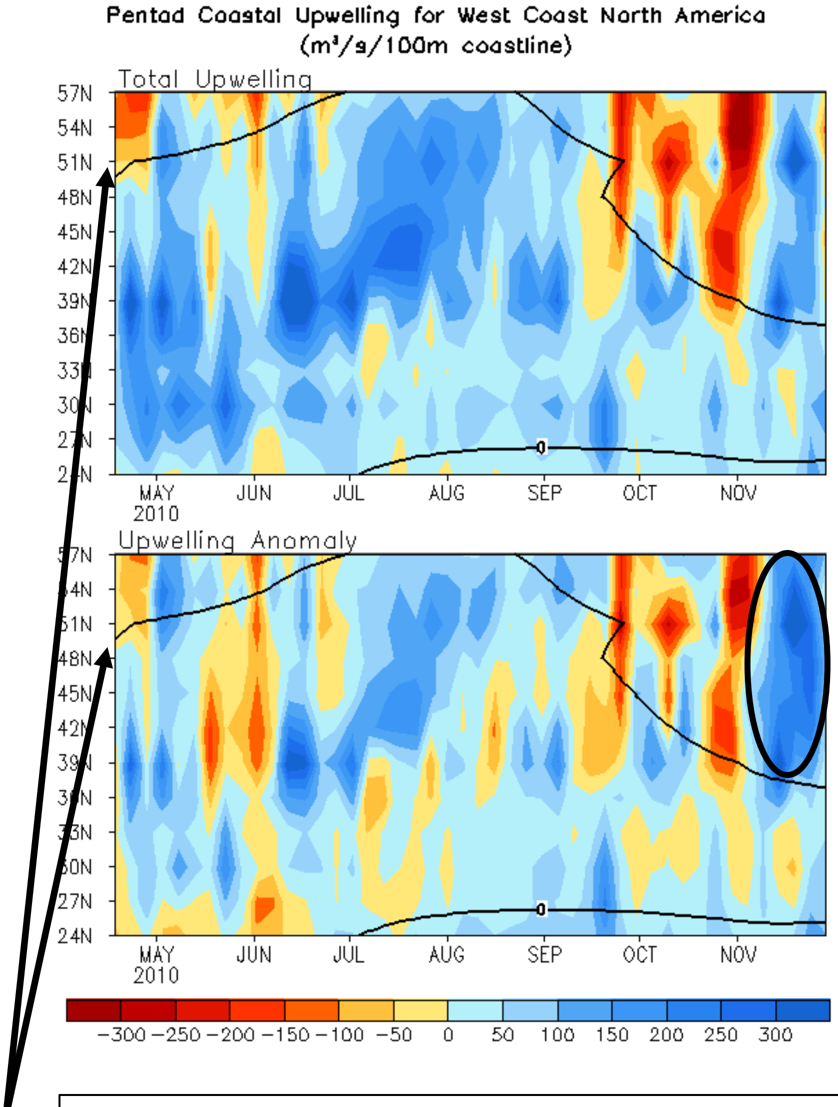


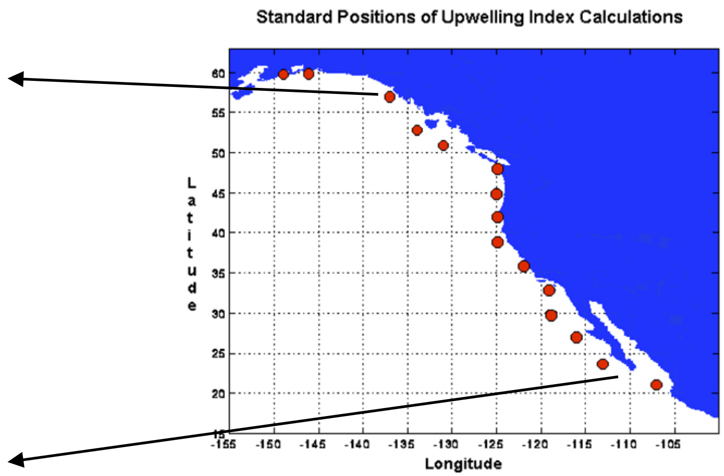


- The Arctic sea ice extent in 2010 was larger than the 2007 value from Jun to Oct 2010 ;

- But it became comparable to the 2007 value in Nov 2010 , and even became slightly smaller than the 2007 value since late Nov.

North America Western Coastal Upwelling



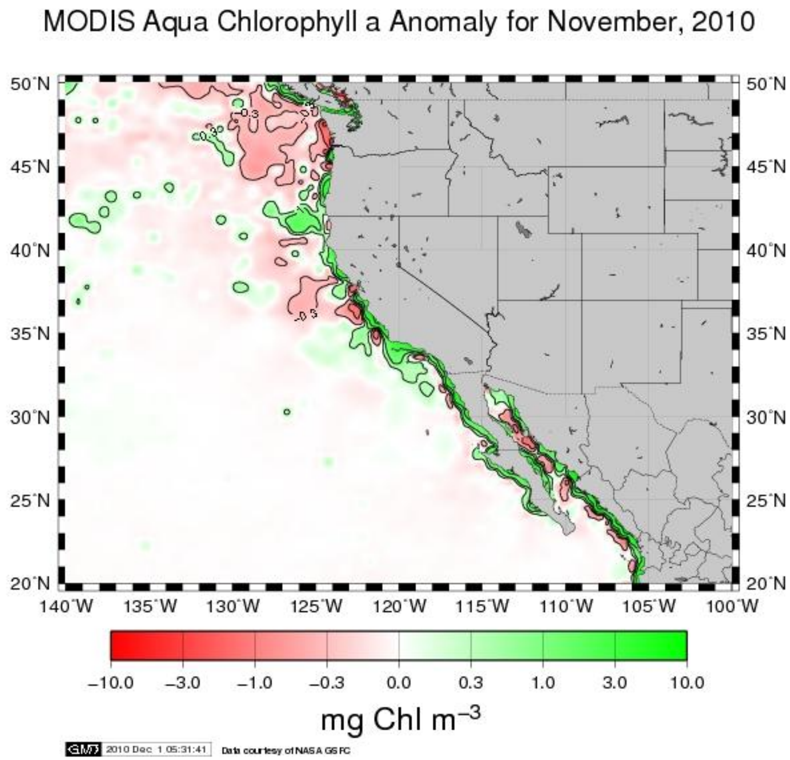


- **Upwelling was well-above normal north of 36N in Nov 2010.**

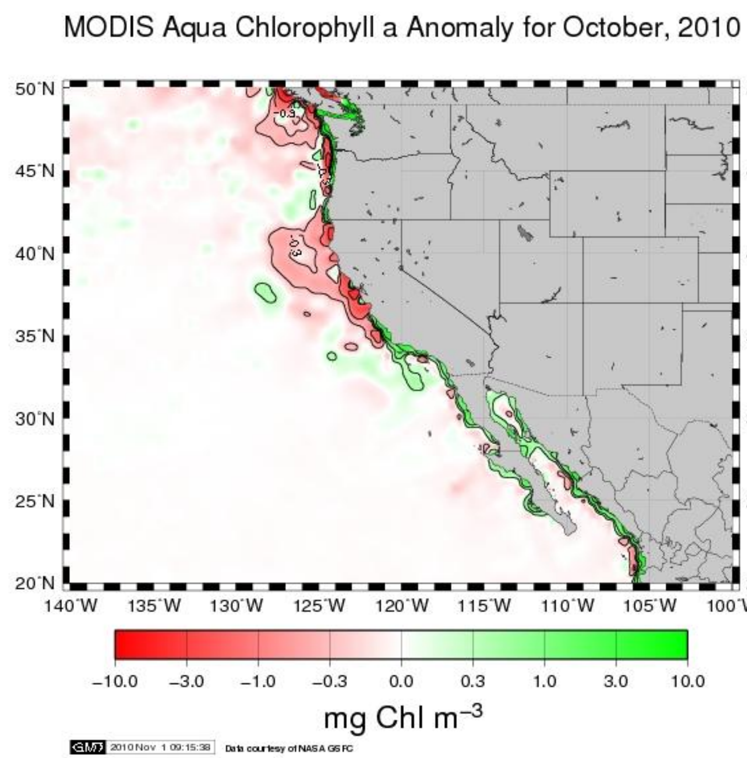
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

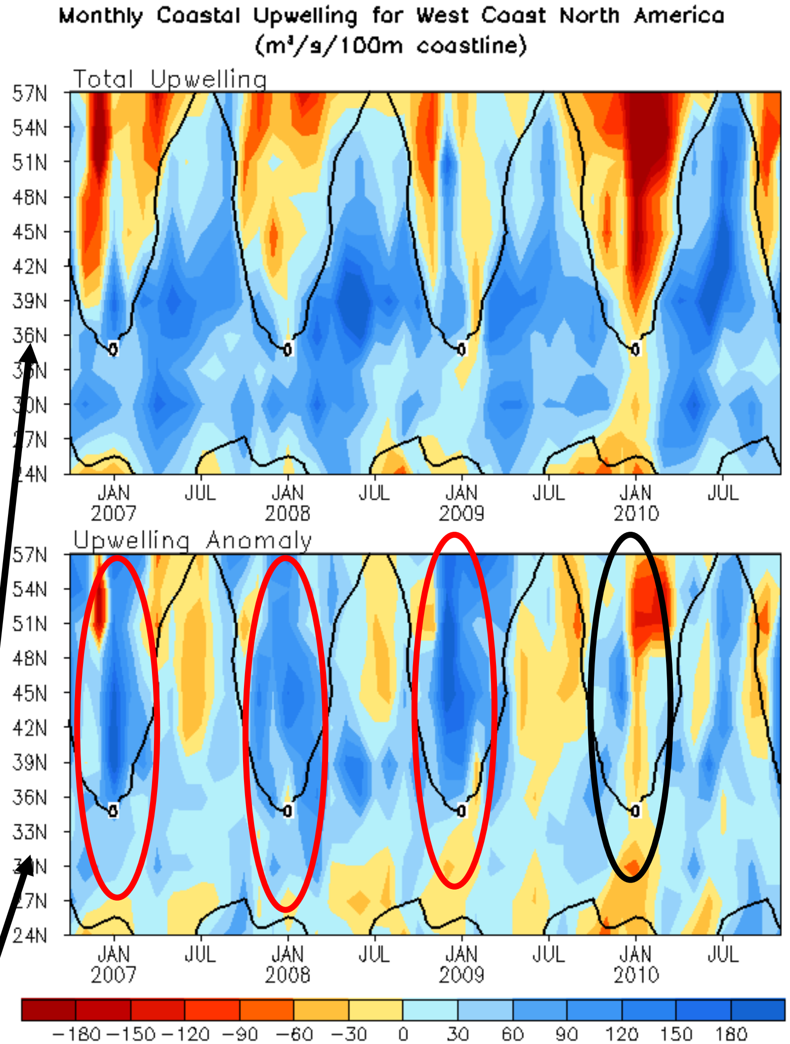


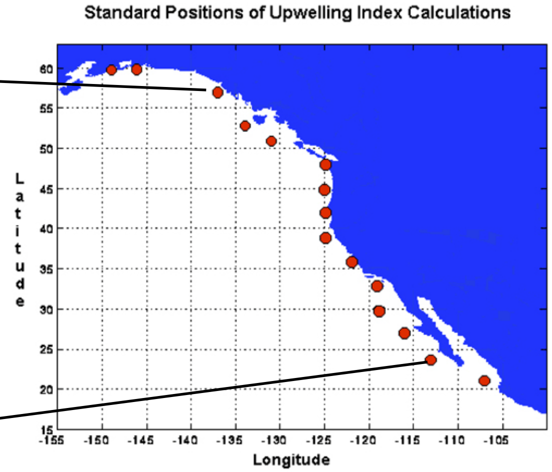
- **Positive (negative) chlorophyll anomaly largely covered the west coast of N. America south (north) of 45N.**
- **Chlorophyll anomalies increased across the west coast from Oct to Nov 2010, generally consistent with enhanced upwelling.**



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.

- Upwelling was relatively strong in spring and summer 2010, relatively weak from mid-Sep to Oct 2010, but became very strong in Nov 2010.

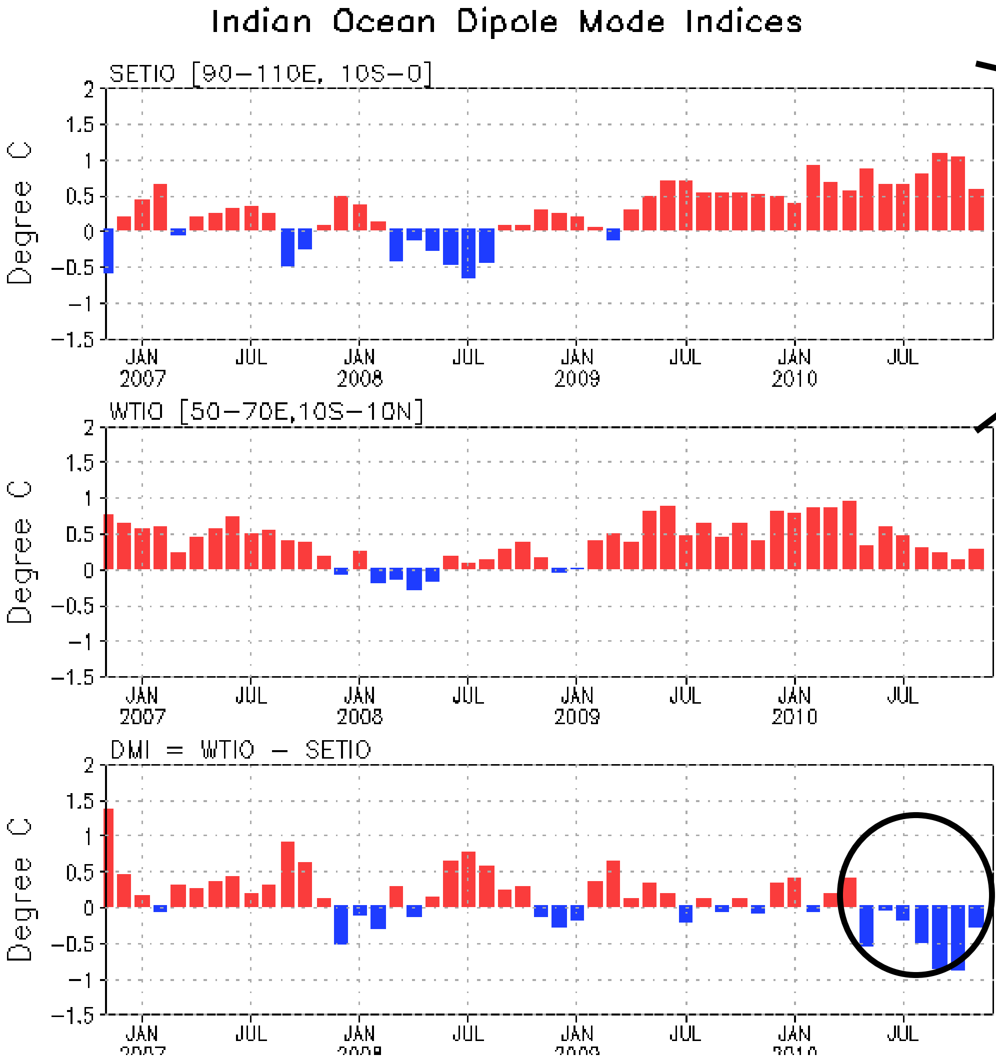
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

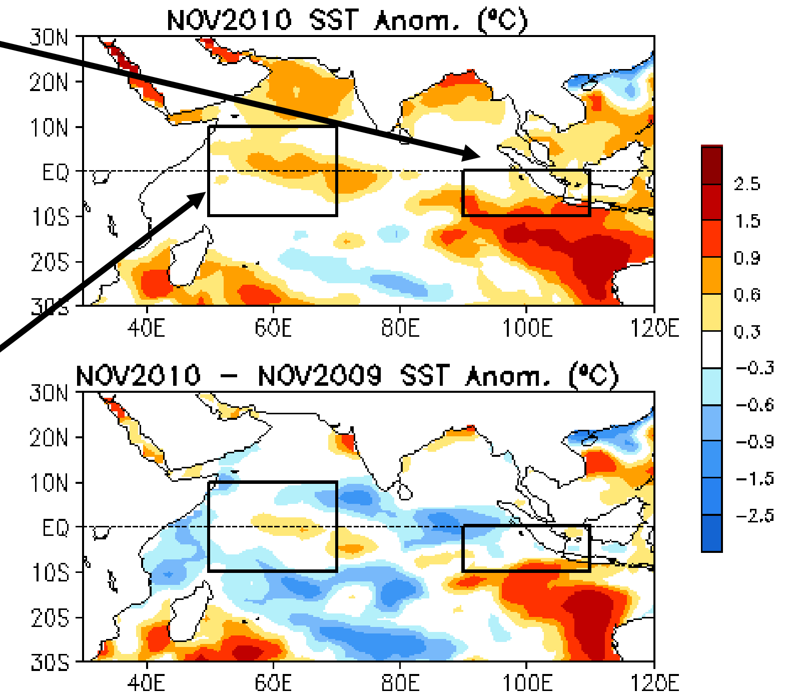
- Area below (above) black line indicates climatological upwelling (downwelling) season.

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

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices



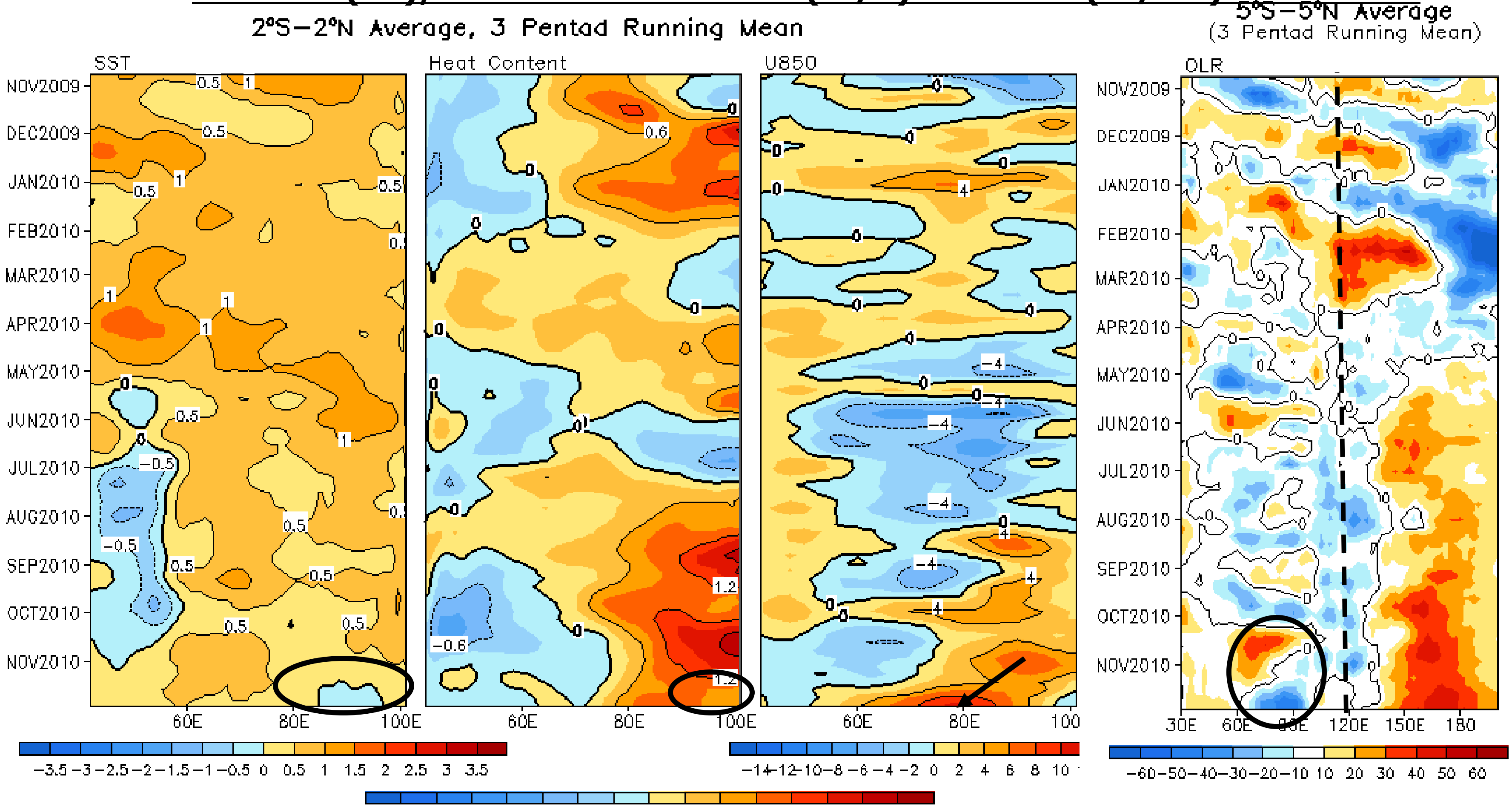


- **Eastern (SETIO) pole SSTA decreased, while western (WTIO) pole SSTA increased slightly, resulting in a drastic reduction of the negative DMI index.**

- **DMI has been below-normal since May 2010, strengthened during Sep-Oct 2010, and returned to weakly below-normal in Nov 2010.**

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

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

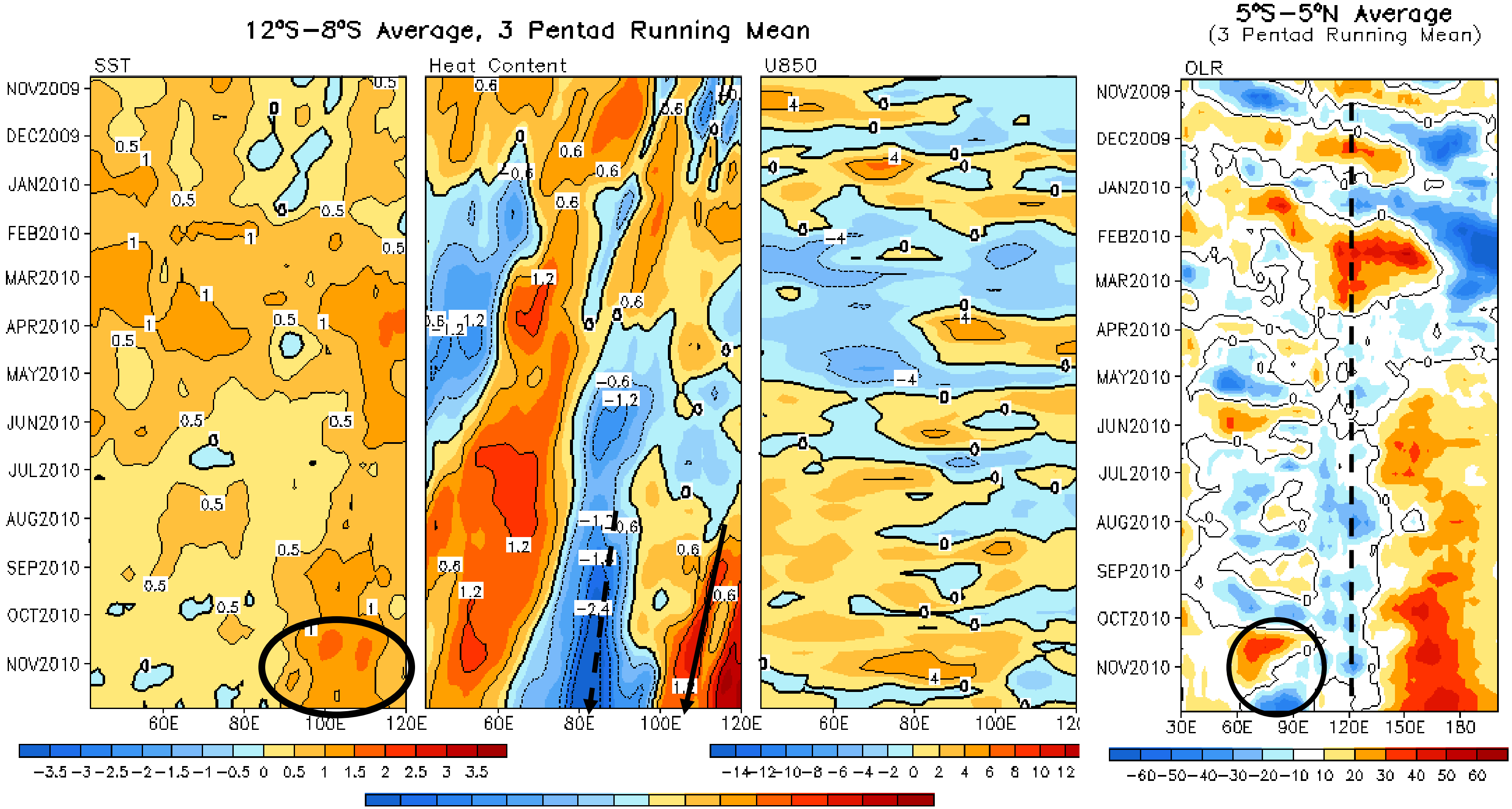


- **The positive SSTA in the eastern Indian Ocean weakened significantly in Nov 2010, resulting a drastic reduction of negative DMI index.**

- **Positive heat content anomaly also weakened in the eastern Indian Ocean, that is probably related to the westward shift of westerly wind anomalies associated with the transition from suppressed to enhanced convection from Oct to Nov 2010.**

Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

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



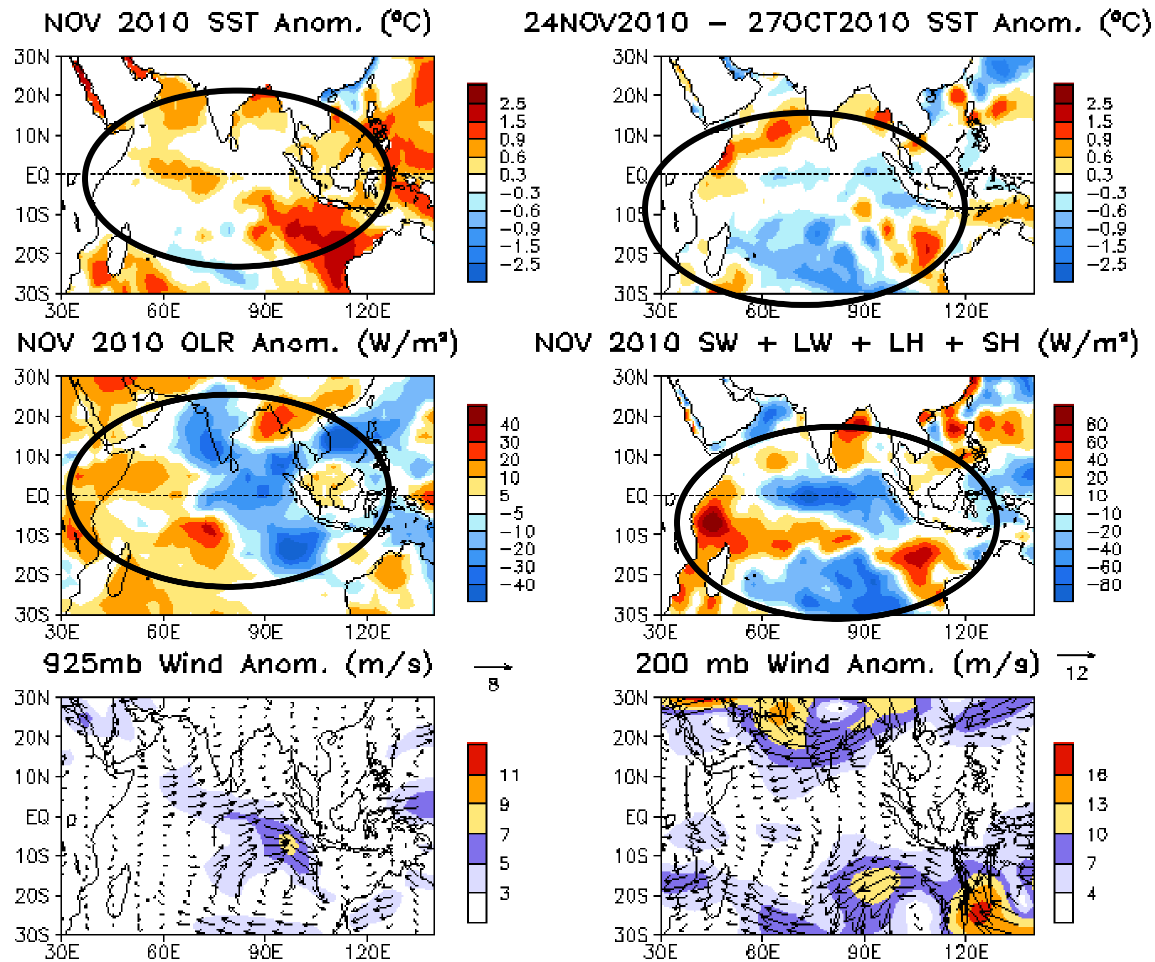
- **Strong positive SSTA in the southeast Indian Ocean persisted.**

- **Westerly wind anomalies that persisted since Jun 2010 weakened significantly in mid-Nov 2010, associated with the onset of enhanced convection near the equator at 80E.**

- **The dipole HC300A, negative near 80E and positive near 110E, is associated with the negative IOD event.**

Fig. I4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 12°S-8°S and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

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

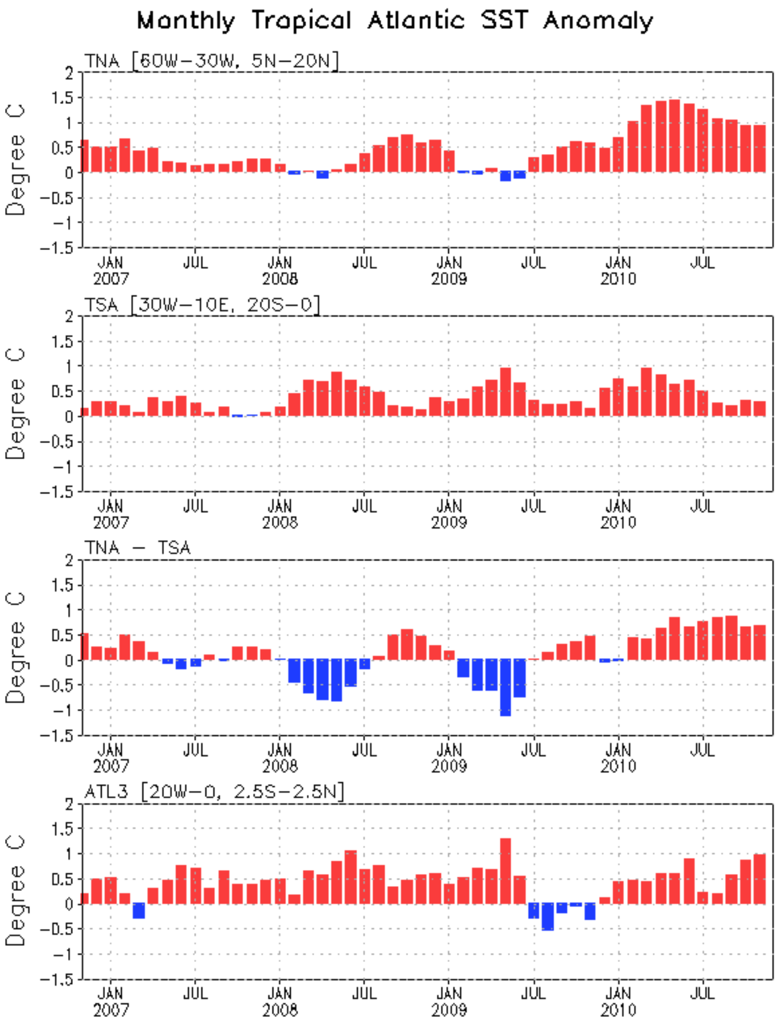


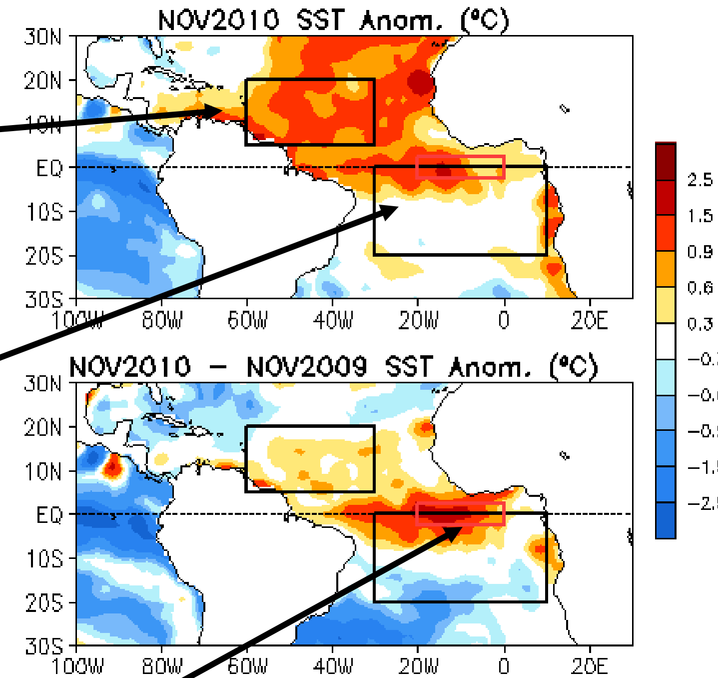
- Positive SSTA weakened in the central and eastern tropical Indian Ocean, and in the south subtropical Indian Ocean in Nov 2010.
- The SSTA tendency is partially consistent with net surface heat flux anomalies, except along 10S in the southwest Indian Ocean, where subsurface temperature likely influenced the warming tendency.
- Convection was enhanced (suppressed) in the eastern (western) tropical Indian Ocean, consistent with the negative IOD conditions.

Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

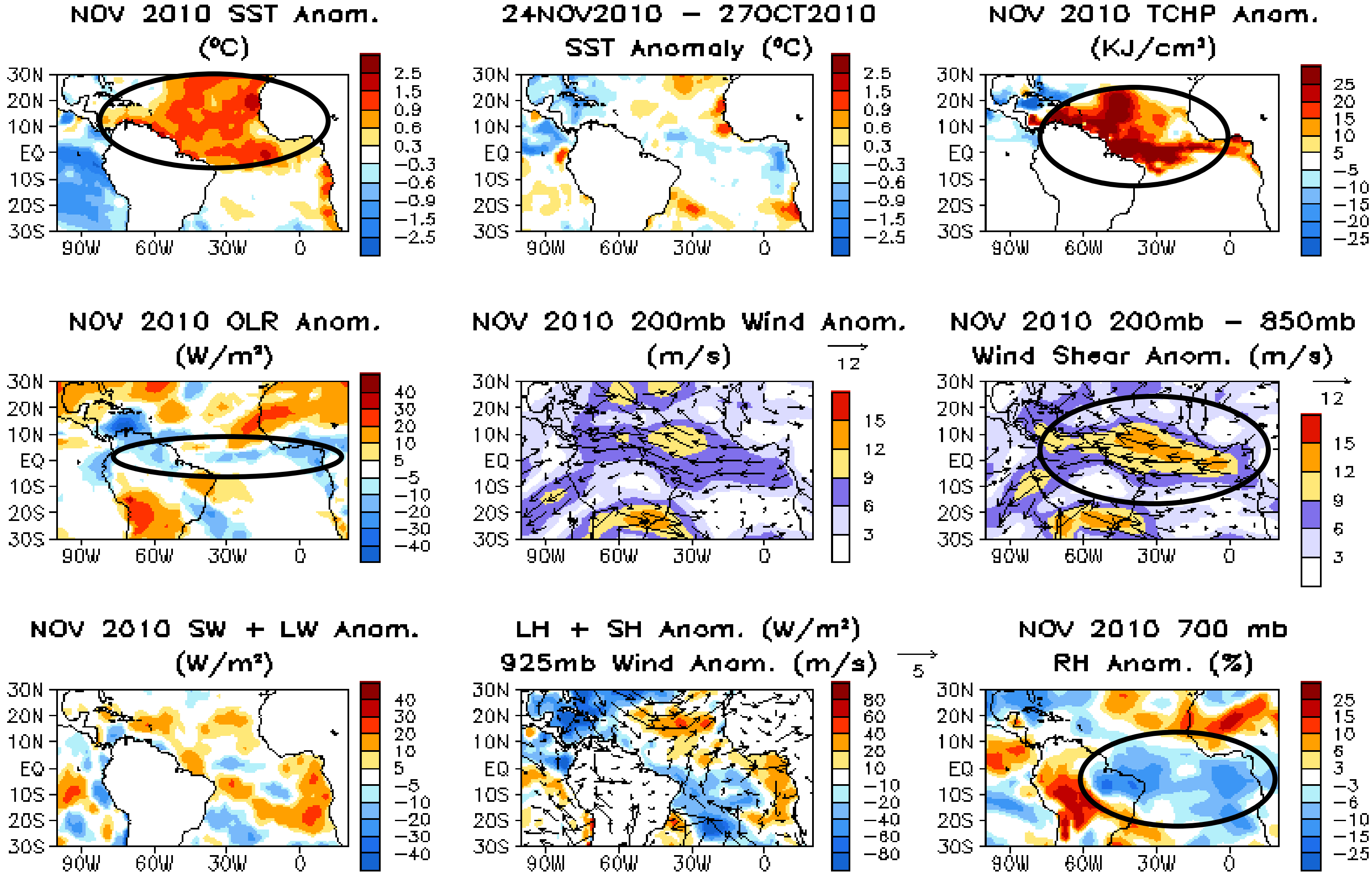




- **Positive SSTA in TNA and TSA persisted in Nov 2010.**
- **Meridional Gradient Mode (TNA-TSA) has been above-normal since Feb 2010.**
- **ATL3 SST has been positive since Dec 2009 and strengthened since Sep 2010.**

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 1971-2000 base period means.

Tropical Atlantic:



- **Positive SSTA in the tropical N. Atlantic persisted.**
- **Convection was enhanced in the Caribbean Sea regions and along the equatorial Atlantic.**
- **Relative humidity was mostly below-normal in the tropical Atlantic.**
- **Easterly wind shear anomaly and above-normal TCHP presented in the tropical Atlantic.**

North Atlantic Ocean

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

- Negative NAO strenghened in Nov 2010 (next slide), consistent with the SLP anomalies.
- SSTA tendency was largely consistent with surface heat flux anomalies (SW+LW+LH+SH).

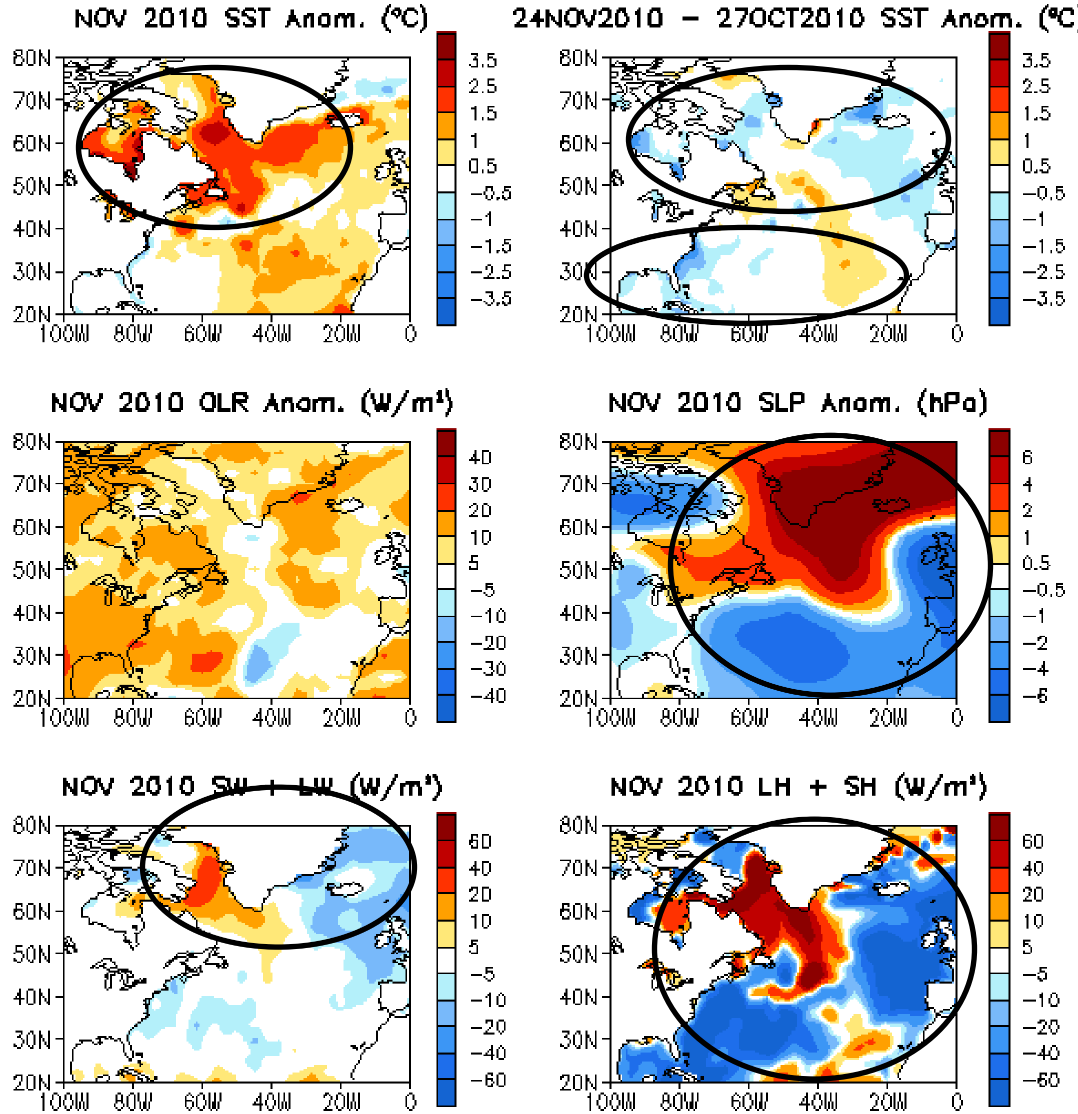
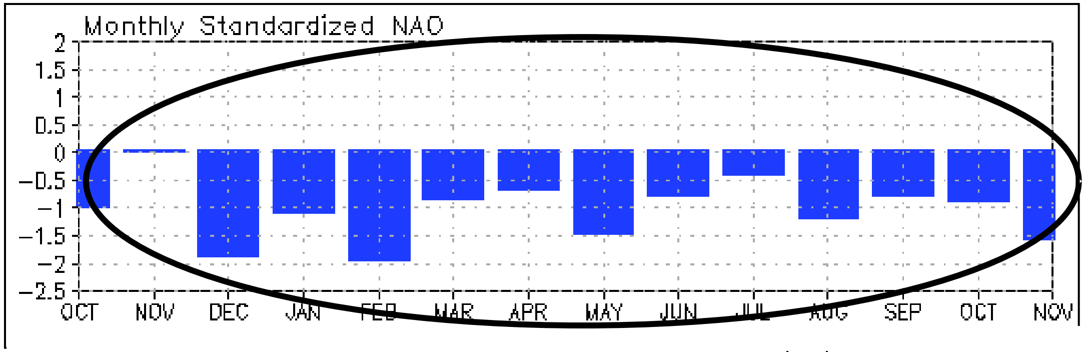
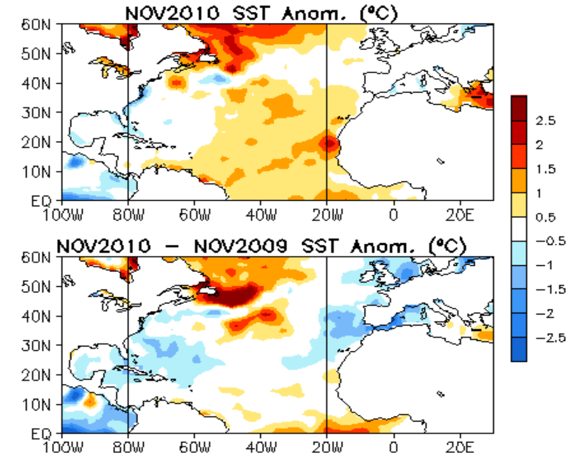
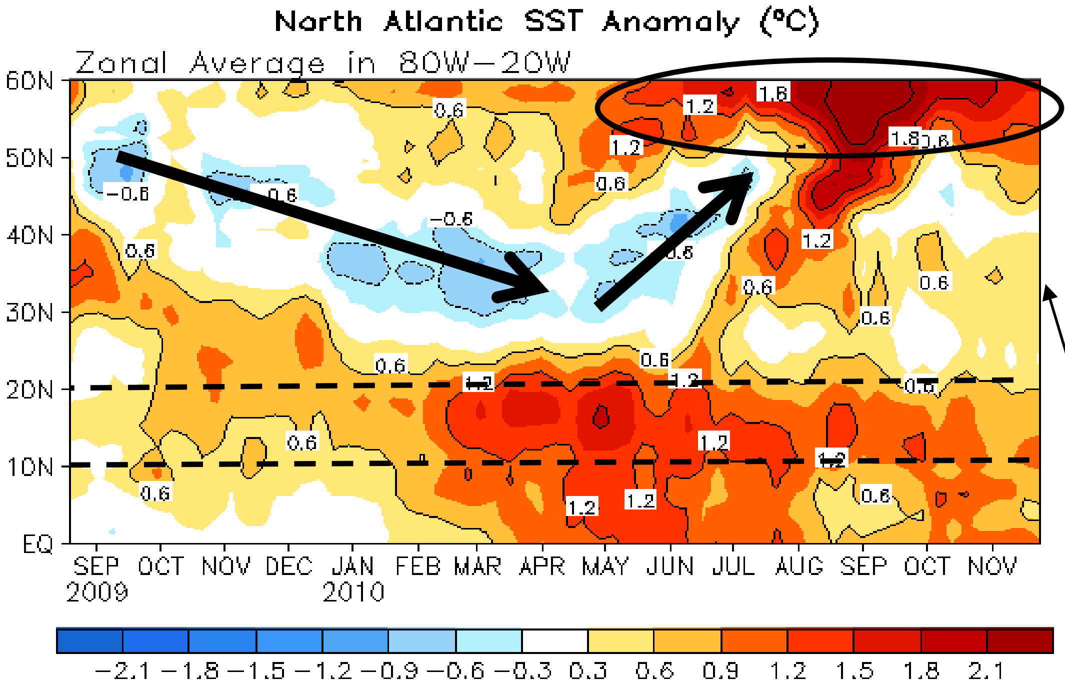


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1971-2000 base period means.

NAO and SST Anomaly in North Atlantic



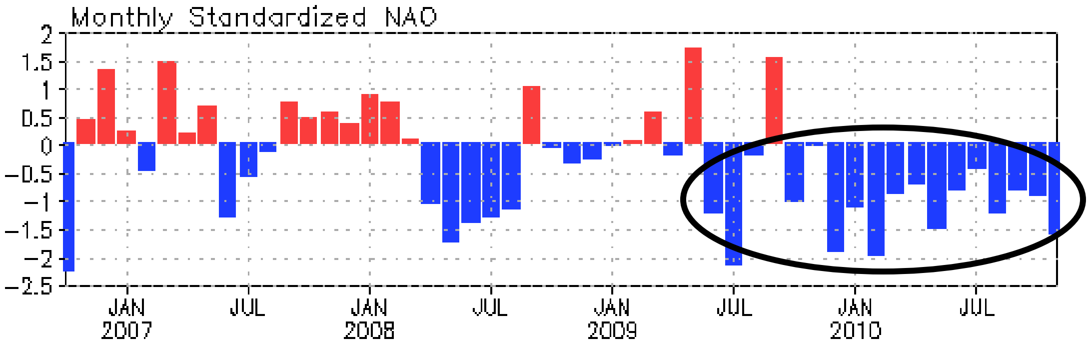


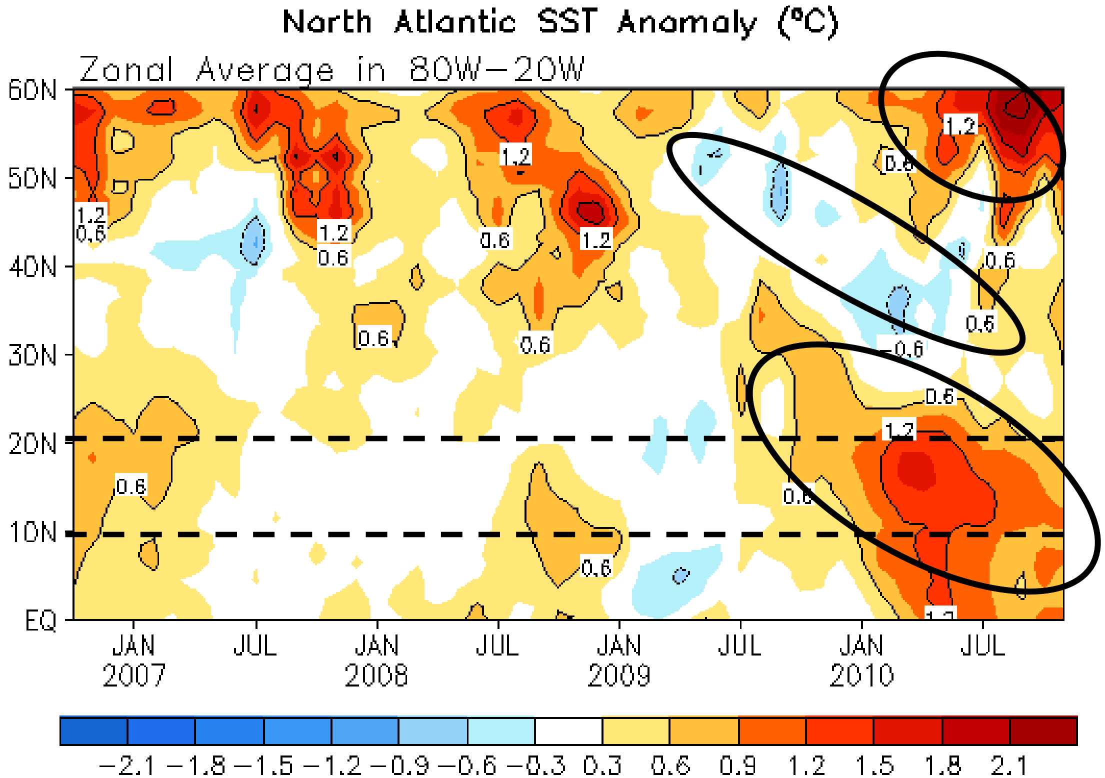


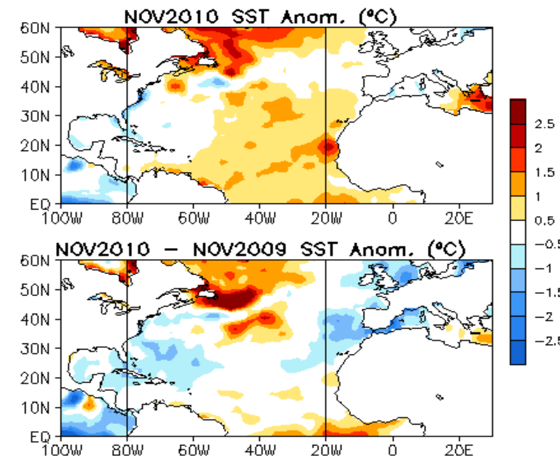
- **NAO Index=-1.6 in Nov 2010.**
- **NAO has been persistently below-normal since Oct 2009, which contributed to the development and maintenance of negative (positive) SSTA in mid-latitude (tropical) North Atlantic.**
- **Strong warming presented in the high latitudes North Atlantic Since May 2010.**
- **Positive SSTA in the Atlantic hurricane MDR has been above-normal since Oct 2009, peaked during Mar-May 2010, and then slowly weakened afterwards.**
- **The combination of persistent negative NAO phase and delayed impact of the 2009/10 El Nino resulted in the strongly positive SSTA in MDR in spring 2010, which is similar to 2005.**

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







- **Strong high-latitude warming since May 2010.**

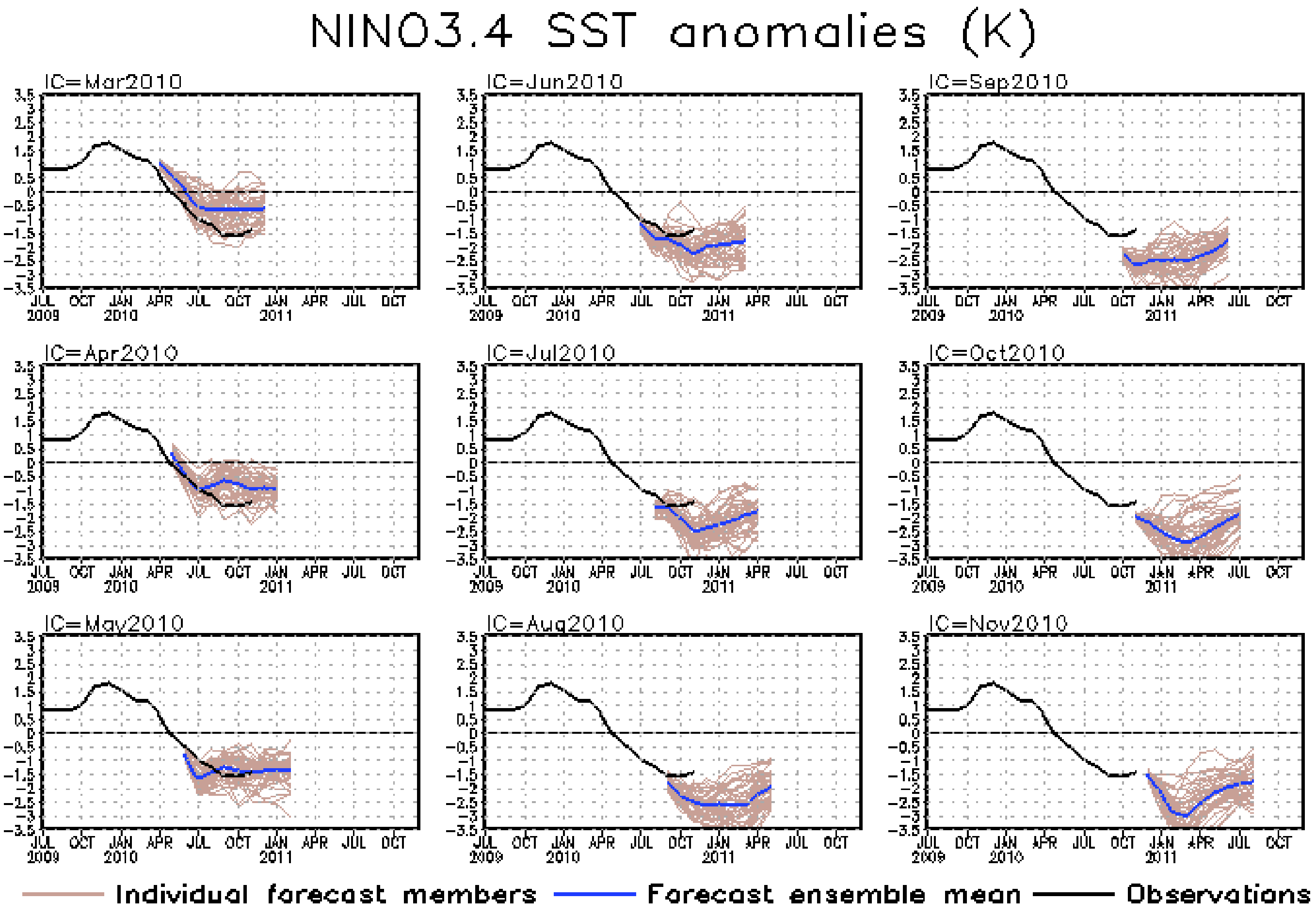
-Mid-latitude North Atlantic SST has been below-normal since May 2009 and became positive since Jul 2010.

- **SST in the Atlantic hurricane MDR has been above-normal since Jul 2009, intensified significantly during Feb-May 2010, and slowly weakened since Jun 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



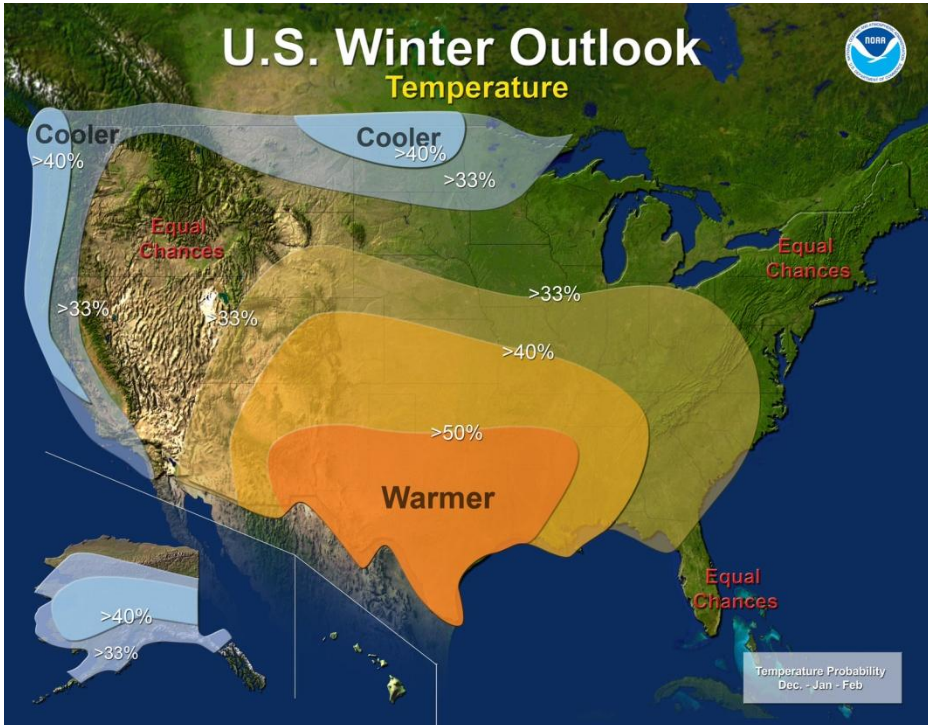
- Forecasts from Feb-Apr I.C. had warm biases, while those from Jun-Sep I.C. had cold biases. The recent cold forecast biases can be alleviated through statistical model corrections
(http://www.cpc.ncep.noaa.gov/products/people/wwang/cfs_fcst).

- The latest forecasts from Nov 2010 I.C. suggest that the current La Niña will reach its peak phase in the early spring of 2011, and last into the summer 2011.

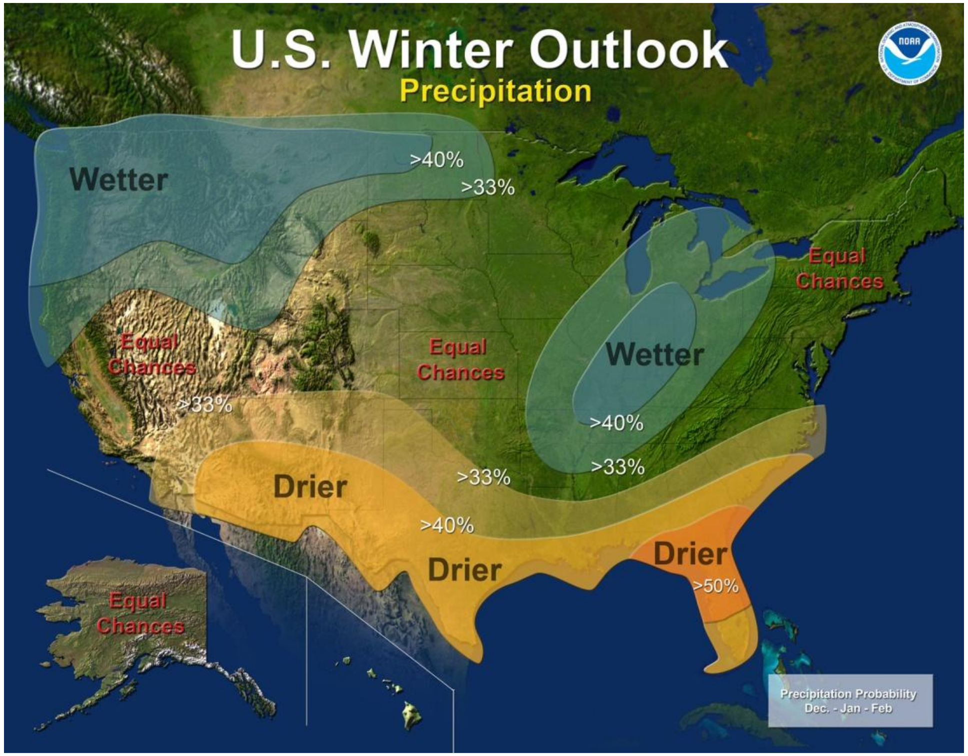
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

U. S. Winter Outlook

(Issued by Climate Prediction Center, NCEP/NWS/NOAA, Oct 21, 2010)



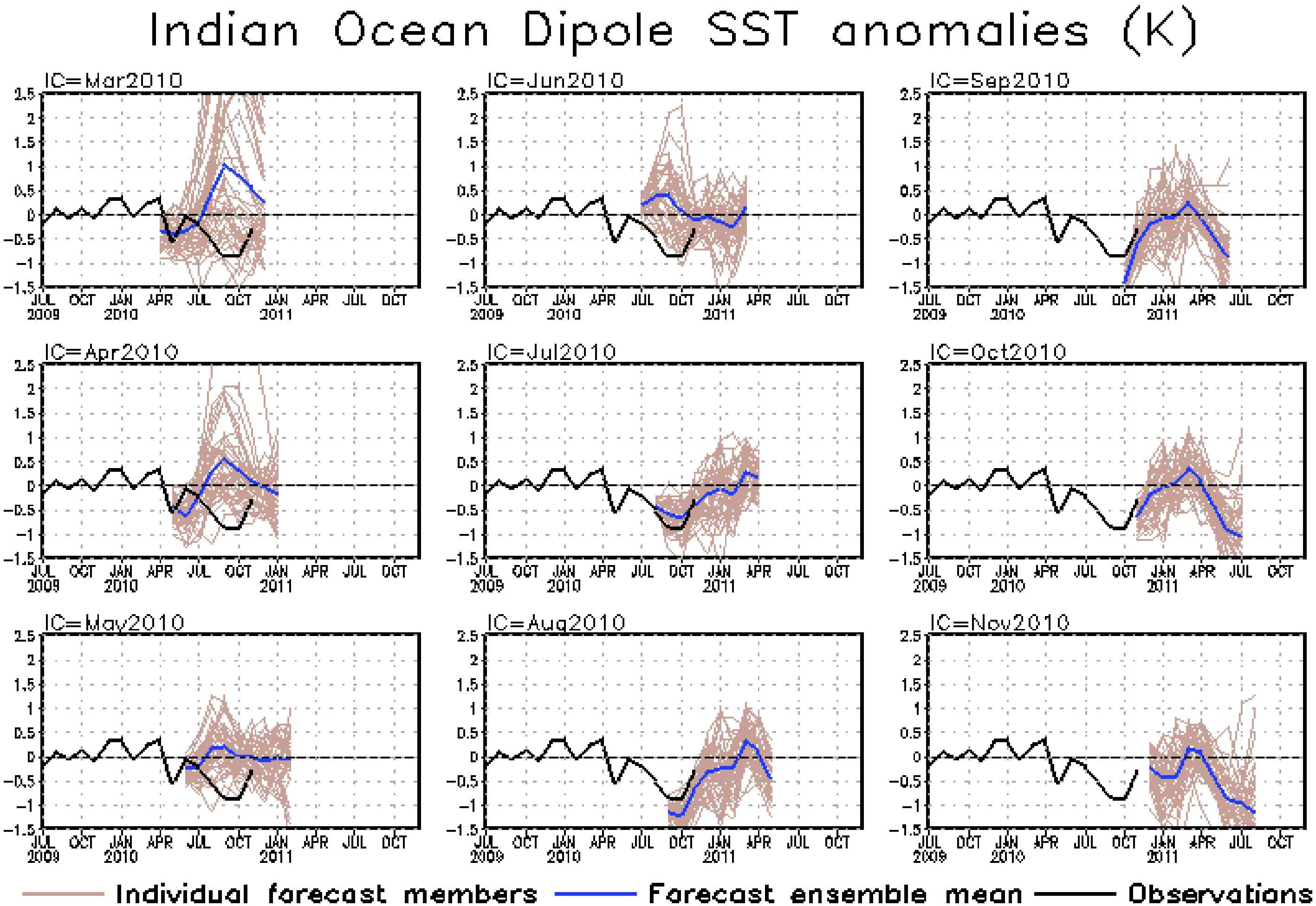
- **Warmer winter in the regions from the east part of SW to west part of SE.**
- **Cooler winter in California, Pacific NW, and Northern Palins.**



- **Drier winter in the regions from SW to SE.**
- **Wetter winter in NW, Lower Great Lakes, Ohio Valley, and north part of Tennessee Valley.**

Details in “http://www.noaanews.noaa.gov/stories2010/20101021_winteroutlook.html”

CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

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

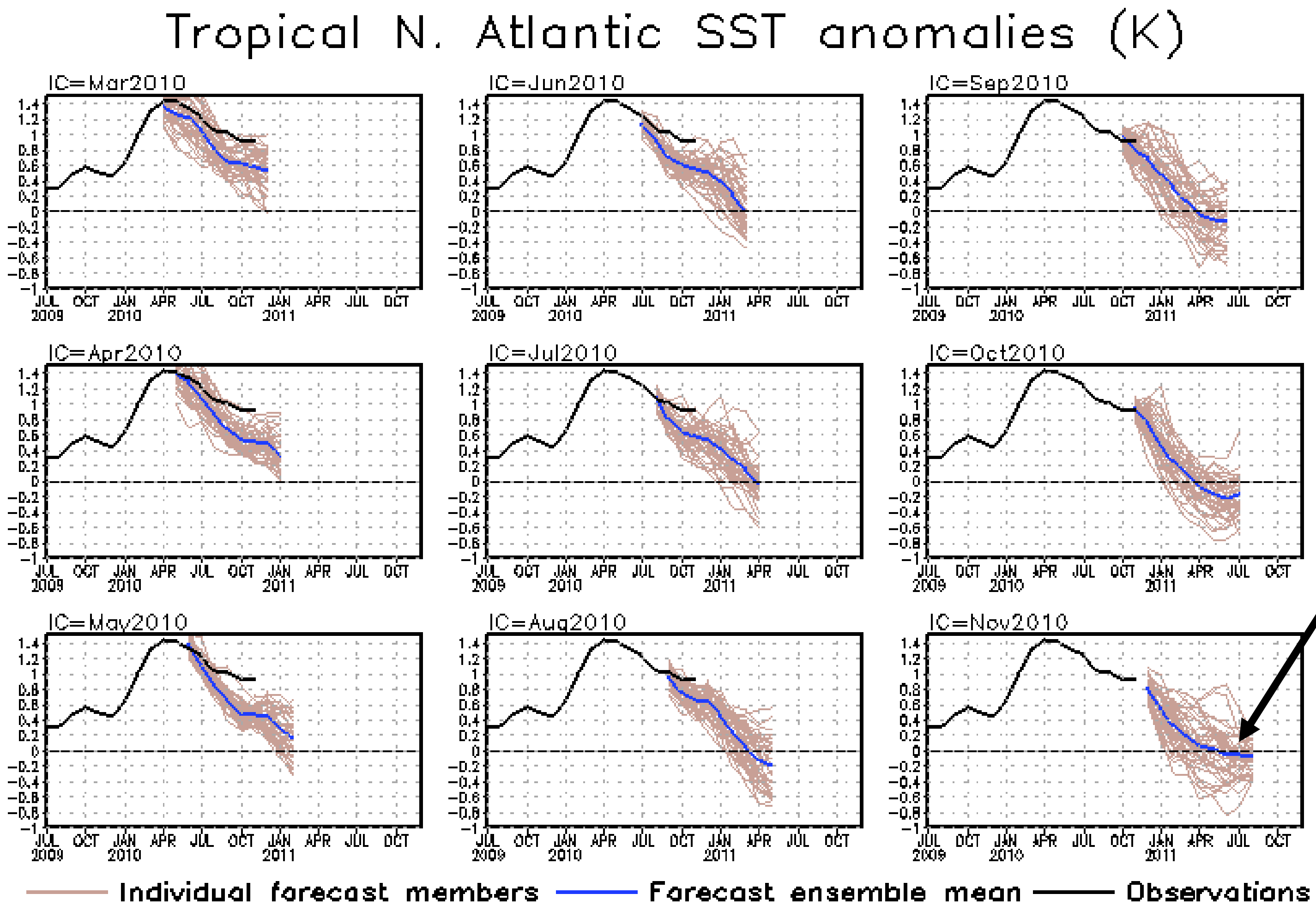
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- Larger inter-ensemble member spread from Feb-Jun 2010 I.C. suggests the forecasts are less reliable.
- The onset phase of the negative IOD event was poorly forecast, but the decay phase was well predicted.
- Forecasts from Nov 2010 I.C. suggest the current negative IOD will return to normal conditions in winter 2010/11, but may regains its strength in summer 2011.

Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

CFS 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].

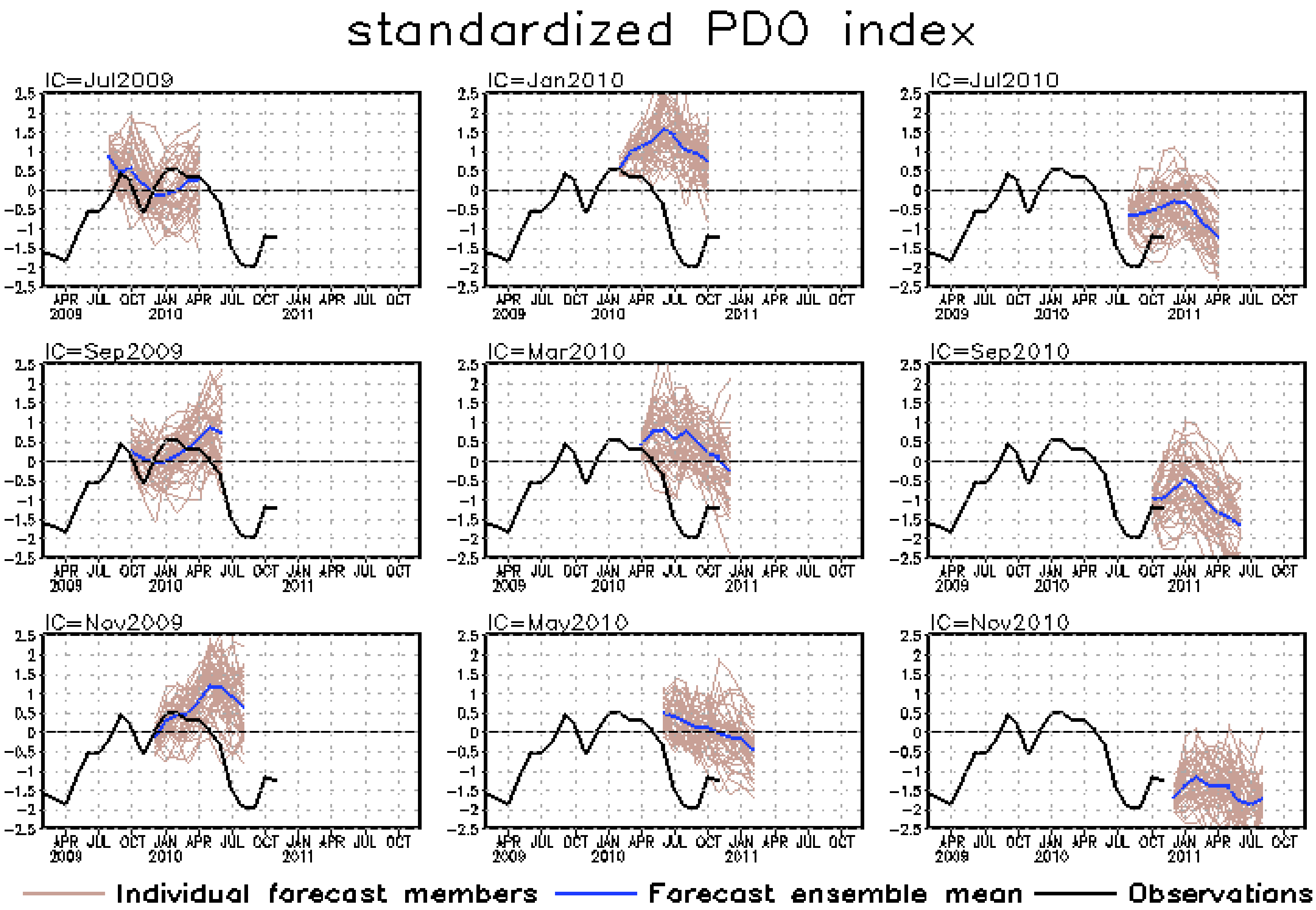


- Cold forecast biases were evident from Feb-Aug I.C.

- Latest forecasts suggest that positive SSTA in the tropical North Atlantic will decay rapidly in next few months, and become near-normal in spring/summer 2011.

Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

CFS 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 onset of the negative PDO phase was poorly forecast.**
- **Latest forecasts suggest that the negative PDO will last into the spring and summer 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.

Overview

- **Pacific/Arctic Ocean**
  - ENSO cycle: La Niña conditions persisted with NINO3.4=-1.4°C in Nov 2010.
  - NOAA/NCEP Climate Forecast System (CFS) predicted a strong La Niña, to last through the Northern Hemisphere spring/summer 2011.
  - PDO has been below-normal since Jul 2010, with PDOI=-1.2 in Nov 2010.
  - Upwelling was abnormally strong north of 36°N along the west coast of North America in Nov 2010.
  - Arctic sea ice extent was comparable to the 2007 historical low in Nov 2010.
- **Indian Ocean**
  - Dipole Mode Index has been below-normal since May 2010, strengthened to be about -0.9°C during Sep-Oct 2010, but weakened to be about -0.3°C in Nov 2010.
- **Atlantic Ocean**
  - NAO index has been persistently below-normal since Oct 2009, and it was -1.6 in Nov 2010.
  - Strong positive SSTA (>2.5°C) persisted in the high latitudes since Sep 2010.
  - Positive SSTA in the tropical North Atlantic has been above-normal since Oct 2009, peaked during Mar-May 2010, and slowly weakened since then.
  - The 2010 N. Atlantic was very active hurricane year, which can be attributable to multiple factors such as the strong La Nina conditions, the ongoing active phase of the AMO and persistent negative phase of NAO.
  - The 2010 N. Atlantic hurricane season was successfully predicted by NOAA.

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!