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

Prepared by

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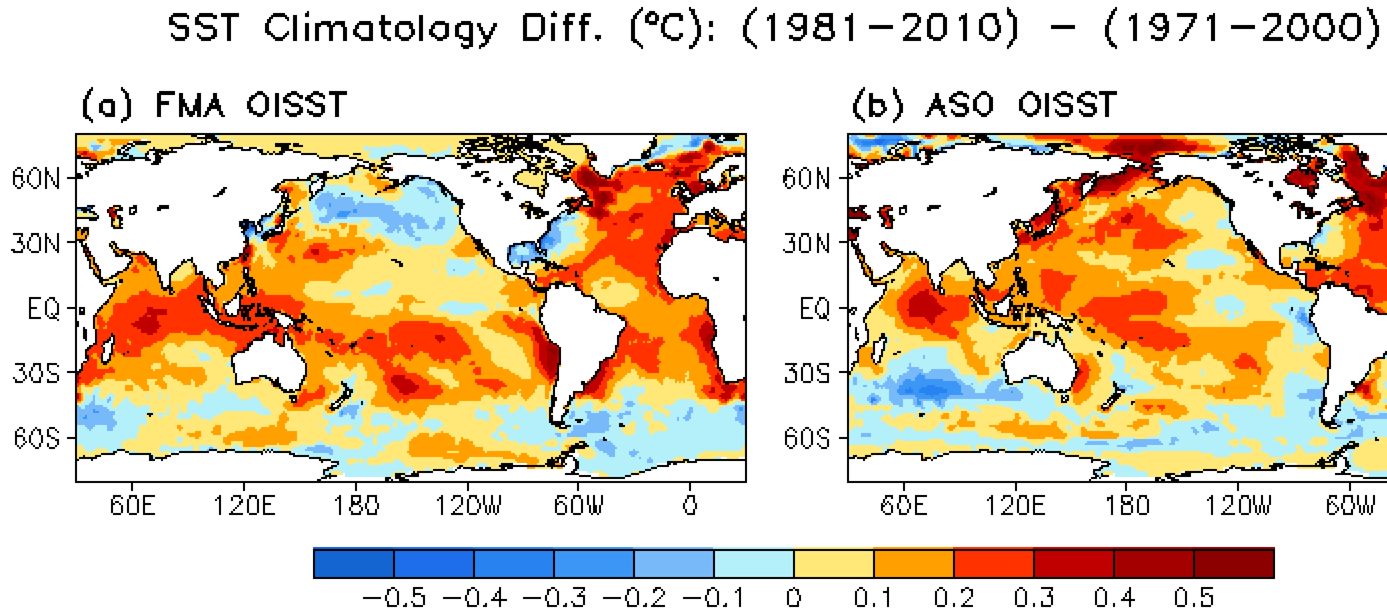
http://www.cpc.ncep.noaa.gov/products/GODAS/

This project to deliver real-time ocean monitoring products is implemented by CPC in cooperation with NOAA's Office of Climate Observation (OCO)

Switch to 1981-2010 Climatology

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

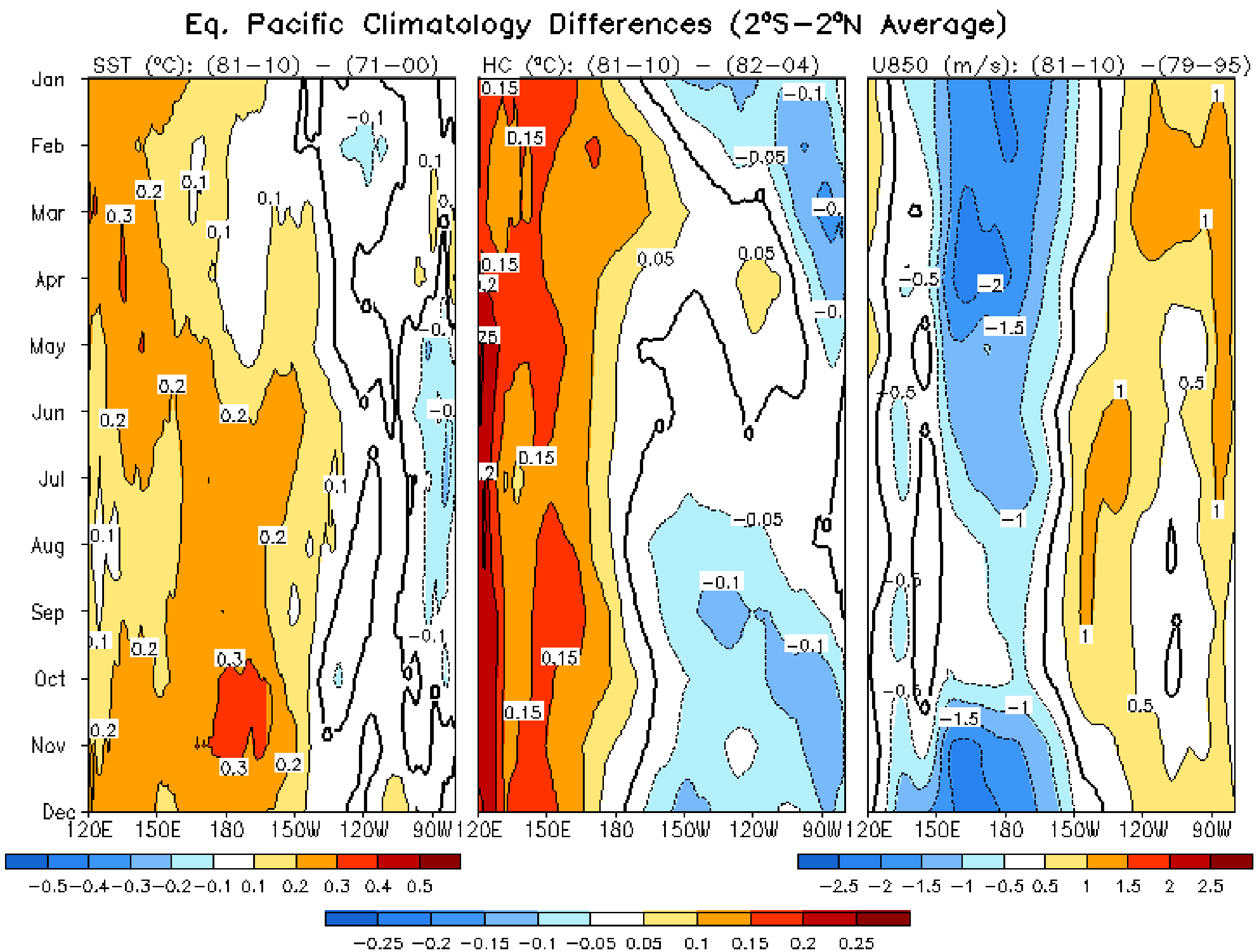


1971-2000 SST Climatology (Xue et al. 2003):
http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst_clim.htm

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

- The seasonal mean SST in February-April (FMA) increased by more than 0.2°C over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2°C in high-latitude N. Pacific, Gulf of Mexico and along the east coast of U.S.

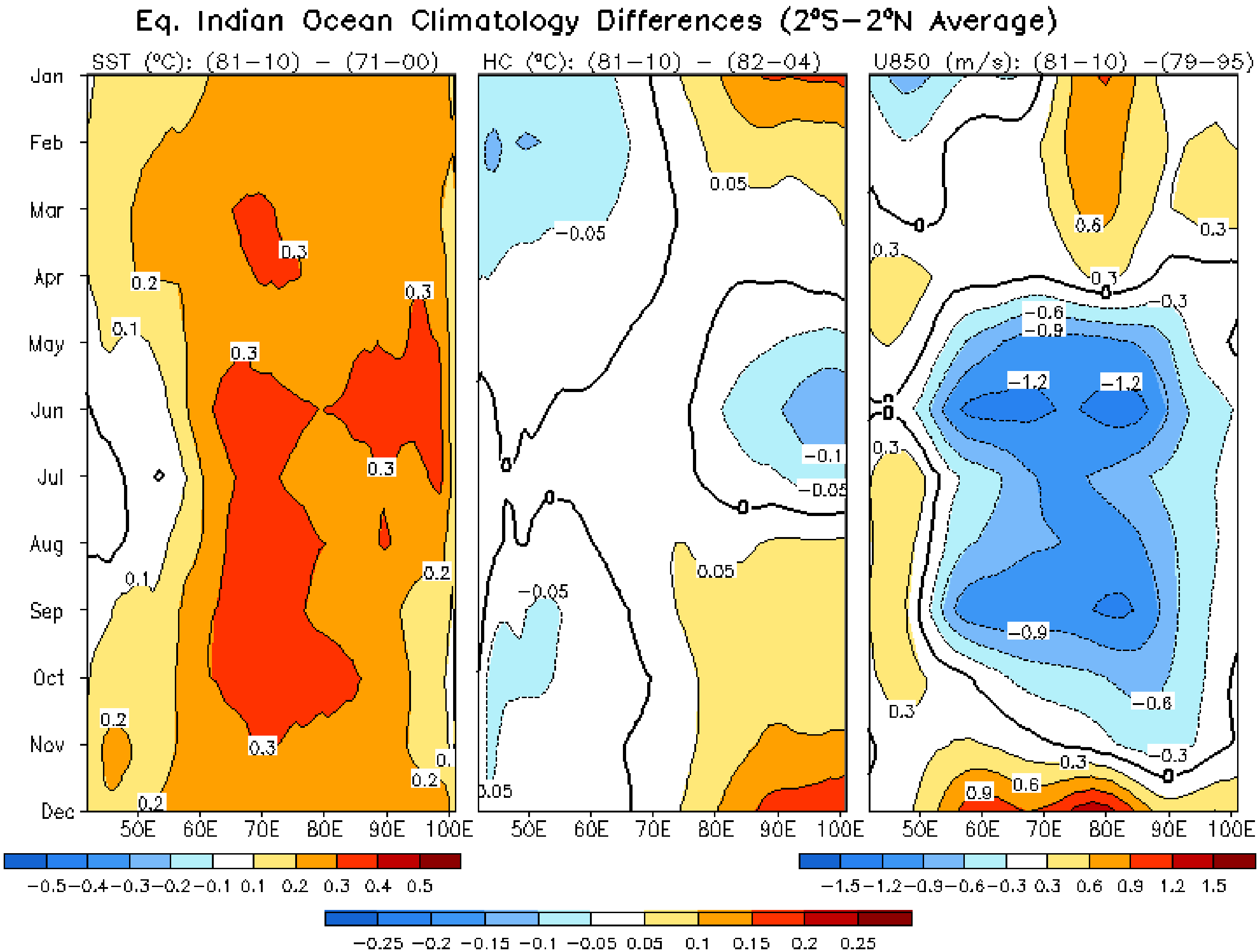
- Compared to FMA, the seasonal mean SST in August-October (ASO) has a stronger warming in the tropical N. Atlantic, N. Pacific and Arctic Ocean, and a weaker cooling in Gulf of Mexico and along the east coast of U.S.



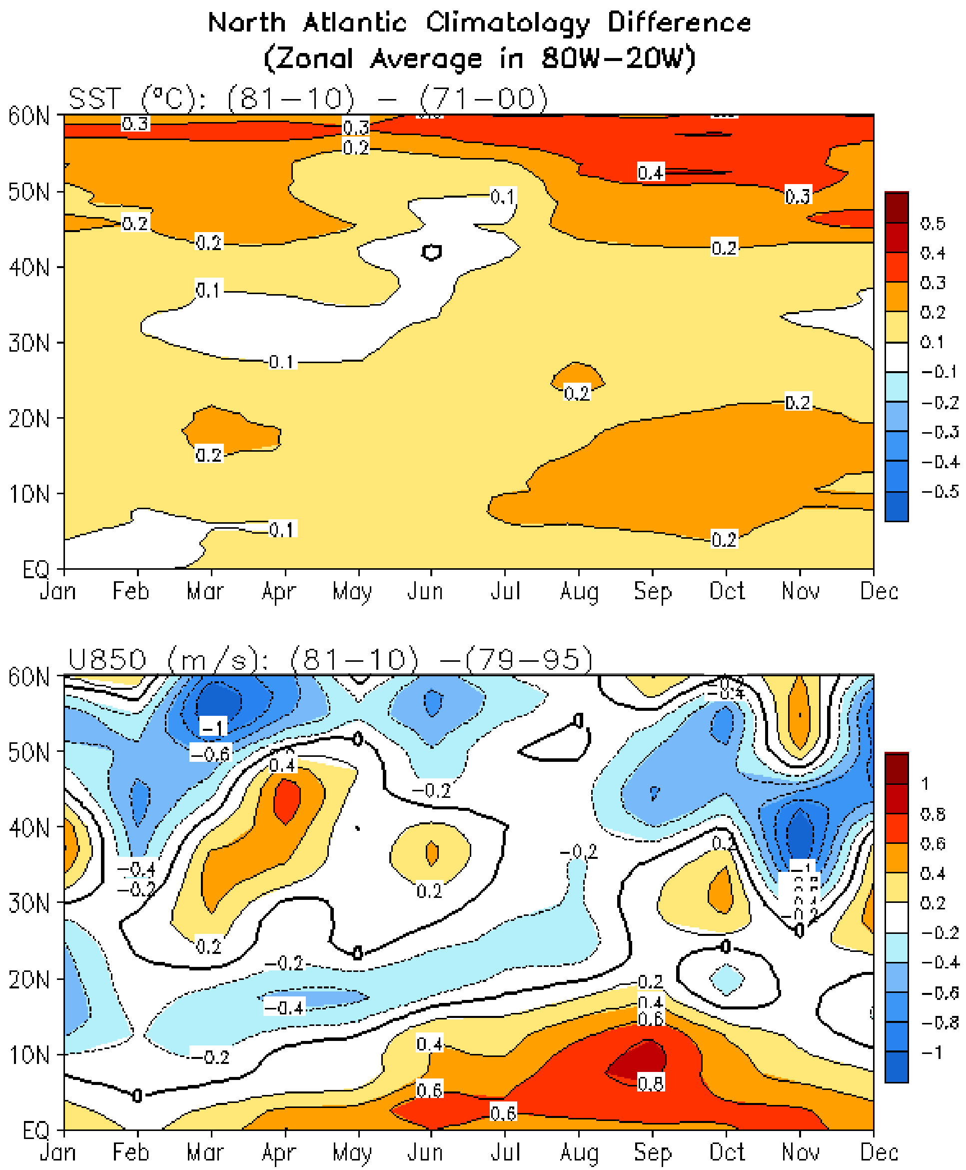
- SST increased by 0.2-0.3°C in the equatorial western Pacific, and changed little east of 150 ° W from 1971-2000 to 1981-2010.

- Upper ocean 300m temperature average (HC) increased (decreased) slightly (0.15 ° C) in the equatorial western (eastern) Pacific from 1982-2004 to 1981-2010.

- Zonal winds at 850mb decreased by about 1.5-2 m/s near the Dateline, and increased by about 1 m/s east of 140 ° W from 1979-1995 to 1981-2010, which is largely consistent with HC changes.



- **SST increased by 0.3°C in the equatorial central and eastern Indian Ocean from 1971-2000 to 1981-2010.**
- **Upper ocean 300m temperature average changed little from 1982-2004 to 1981-2010.**
- **Zonal winds at 850mb decreased by about 1 m/s in the equatorial central Indian Ocean during the boreal summer and fall from 1979-1995 to 1981-2010.**



- SST increased by about 0.3ºC (0.2ºC) in the high-latitude (tropical) N. Atlantic with the most warming during the boreal summer and fall from 1971-2000 to 1981-2010.

- Zonal winds at 850mb decreased (increased) by about 1 m/s in the high-latitude (tropical) N. Atlantic from 1979-1995 to 1981-2010.

2010 SST Anomaly

- **The 2010 SST anomaly (SSTA) is characterized by the transition from El Nino to La Nina conditions in the tropical Pacific, the development of a negative PDO in N. Pacific, the persistence of a tripole SSTA in N. Atlantic and positive SSTA in the tropical Indian Ocean.**

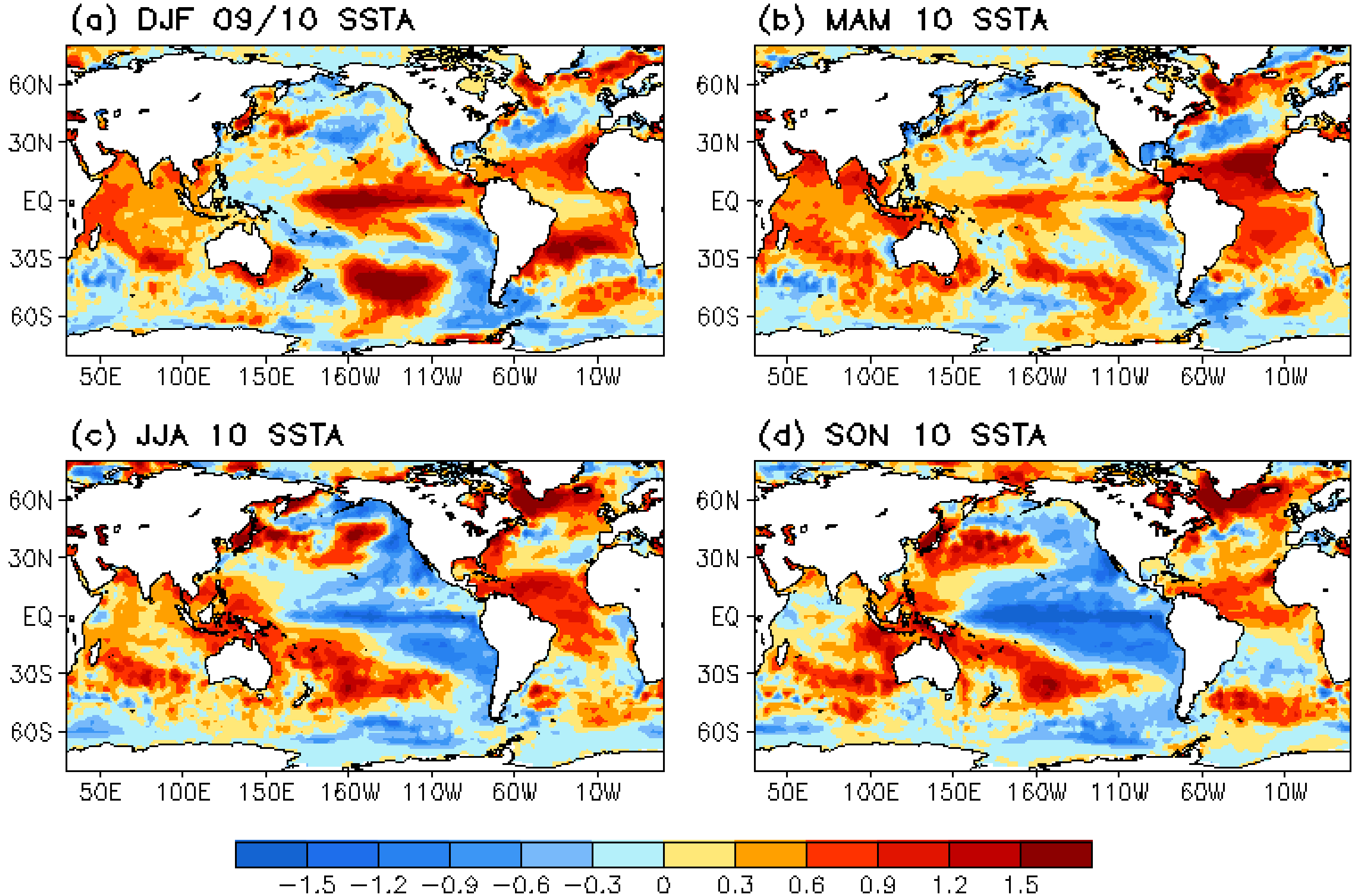
- **The 2010 minus 2009 SSTA indicates a substantial cooling in the tropical Pacific, a significant warming in the high-latitude and tropical N. Atlantic. Weak cooling (warming) is observed in mid-latitude N. Pacific and N. Atlantic (midlatitude Indian Ocean and western S. Pacific).**

- **The 2010/11 La Nina developed in June 2010, and coincided with the development of the negative PDO.**

- **A tripole SSTA in N. Atlantic strengthened significantly during early spring 2010, probably due to the influences of the 2009/10 El Nino and negative NAO. The tropical Atlantic SST increased by 0.33°C from 2009 to 2010 and reached a historical high, 0.2°C higher than the previous high in 1998.**

- **The tropical Indian Ocean (TIO) SST has been above-normal in early 2010, and cooled down substantially in late 2010, probably due to the influences of the 2010/11 La Nina. The TIO SST reached a historical high in 2010, slightly higher than the value in 1998.**

2010 Seasonal Mean SST Anomaly



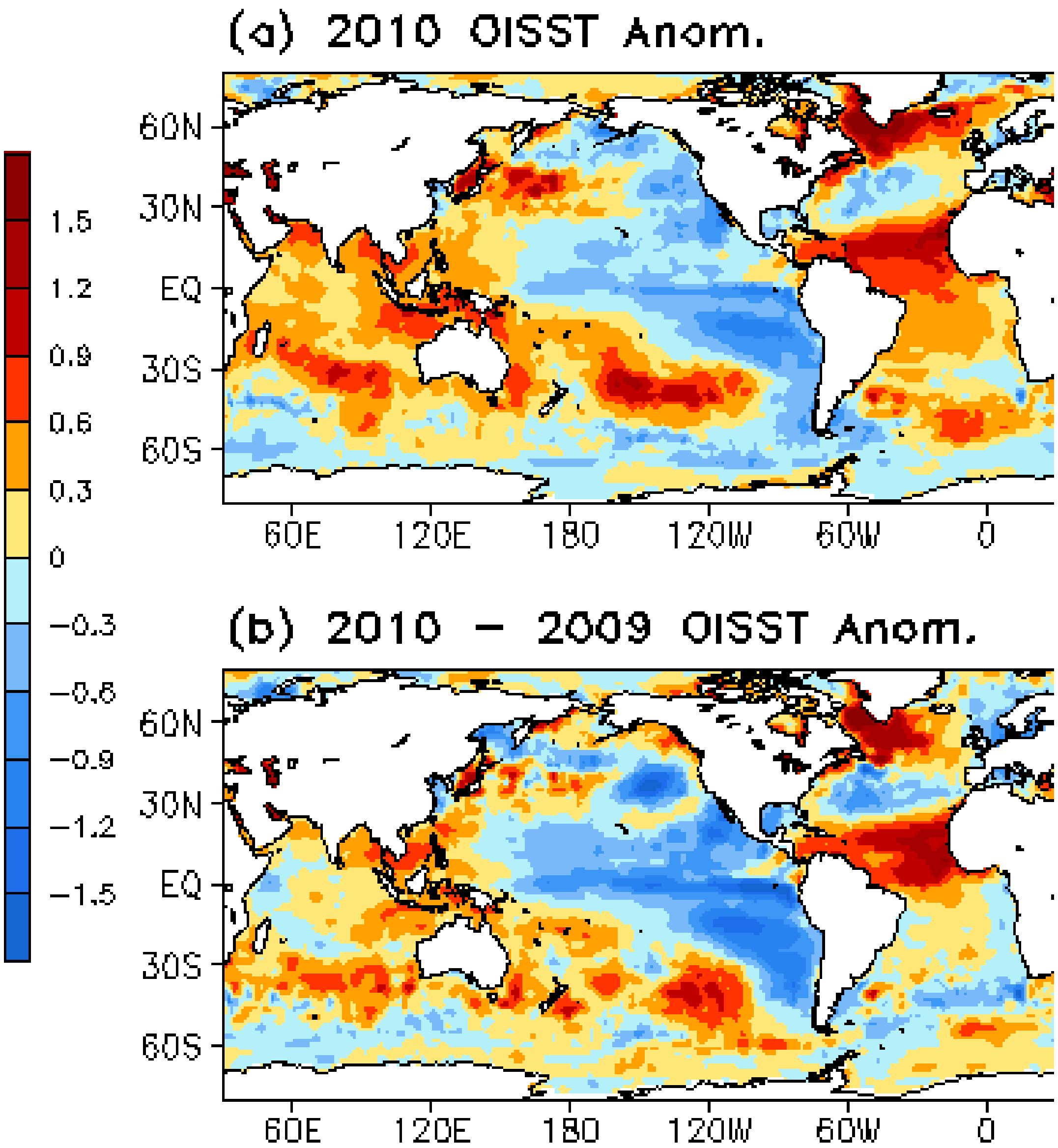
- In DJF 09/10, El Nino conditions dominated in the tropical Pacific, above-normal SST presented in the tropical Indian and Atlantic Ocean.

- In MAM 10, El Nino weakened, positive SSTA in the tropical Indian and Atlantic Ocean strengthened due to influences of the El Nino.

- In JJA 10, La Nina developed in the tropical Pacific, and negative PDO pattern established in N. Pacific.

- SST in the subpolar N. Atlantic increased significantly in JJA, and remained well above-normal throughout the end of 2010. A negative IOD presented during Sep-Oct 10.

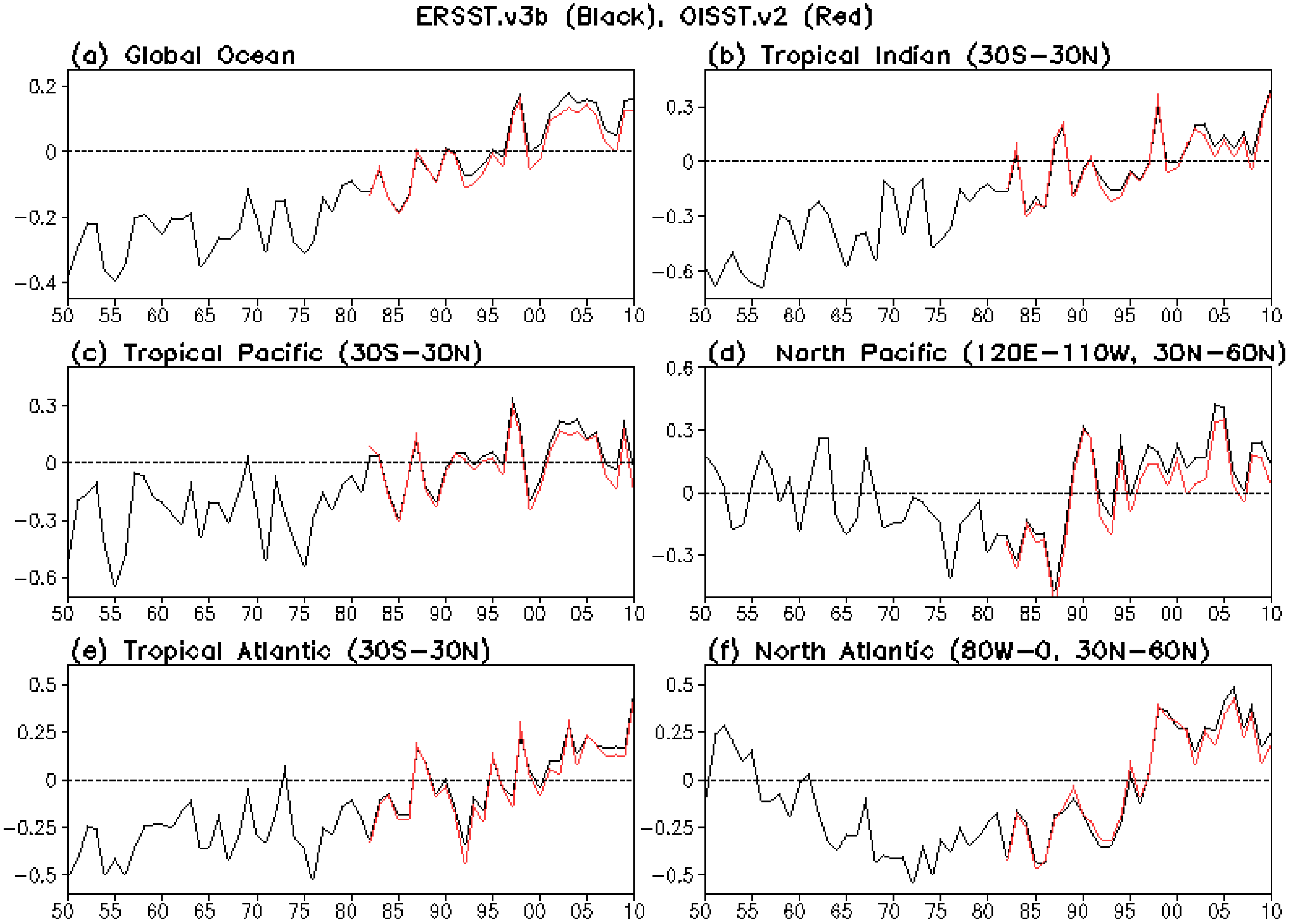
2010 SST Anomaly & 2010 minus 2009 SST Anomaly



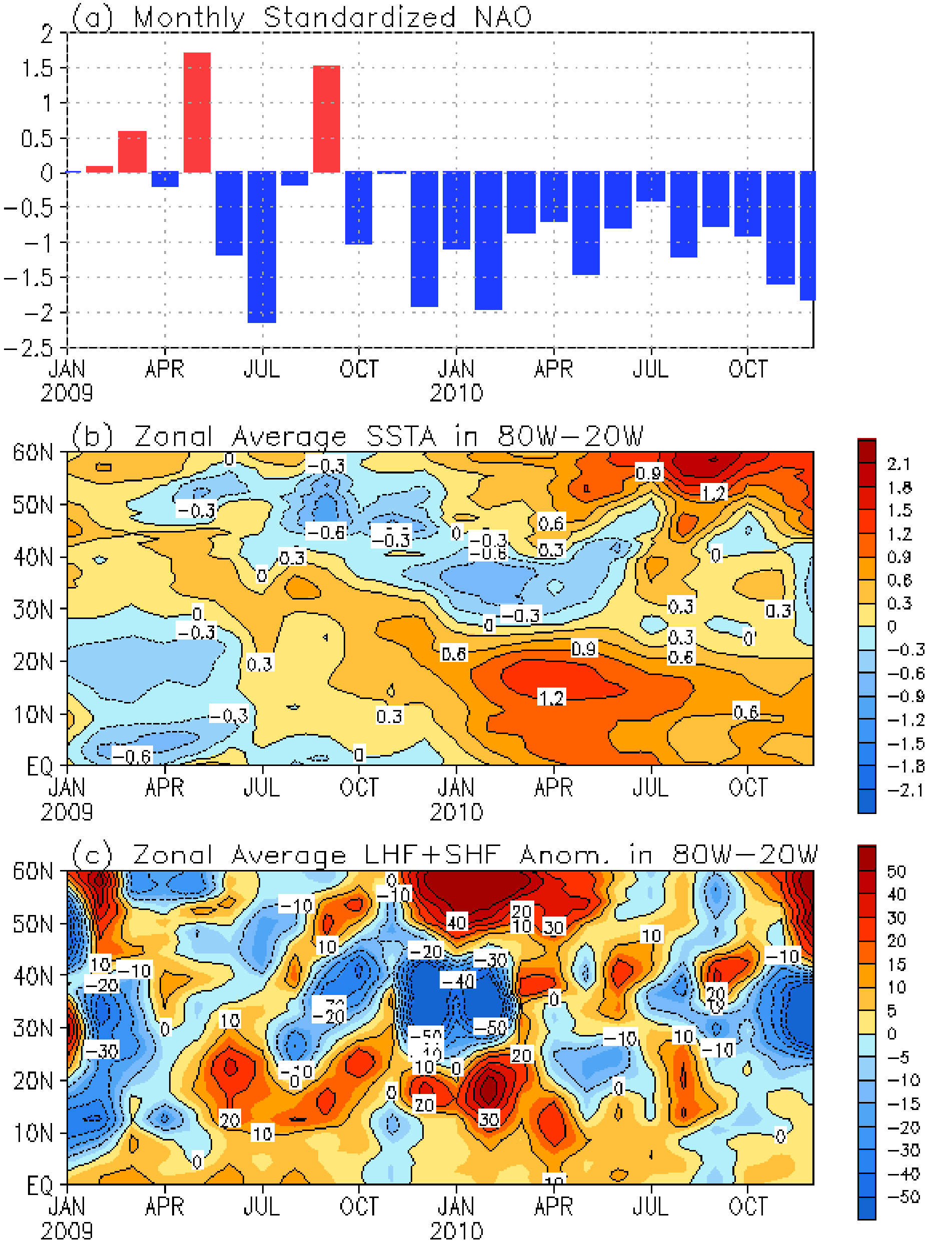
- The 2010 SSTA is characterized by transition from El Nino to La Nina conditions in the tropical Pacific, a negative PDO, a tripole SSTA in N. Atlantic and above-normal SST in the tropical Indian Ocean.

- The 2010 minus 2009 SSTA indicates a substantial cooling in the tropical Pacific, a significant warming in the high-latitude and tropical N. Atlantic. Weak cooling (warming) is observed in midlatitude N. Pacific and N. Atlantic (midlatitude Indian Ocean and western S. Pacific).

Yearly Mean SST Anomaly Indices



- **The global SST changed little from 2009 to 2010, and is near the peak value in 1998.**
- **The tropical Indian Ocean SST increased slightly and reached a historical high in 2010.**
- **The tropical Atlantic SST increased by 0.33°C from 2009 to 2010, and reached a historical high.**
- **The OISST.v2 is slightly cooler than the ERSST.v3b in N. Pacific.**

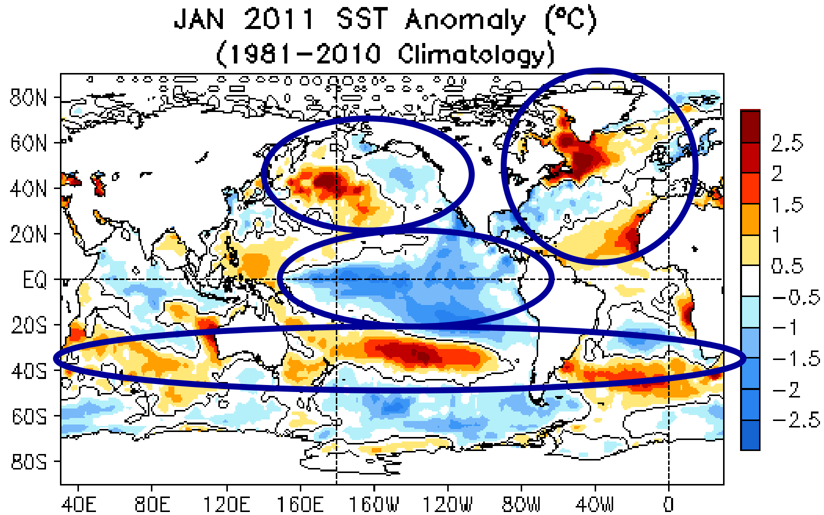


- NAO has been persistently in a negative phase since Oct 2009.
- Positive SSTA in the tropical N. Atlantic increased substantially in early spring 2010, probably due to both the influences of the El Nino and negative NAO phase.
- SST in the high-latitude (mid-latitude) N. Atlantic increased (decreased) substantially in early spring 2010.
- SSTA tendency corresponds well with the net surface heat flux anomalies, which are dominated by latent and sensible heat fluxes.

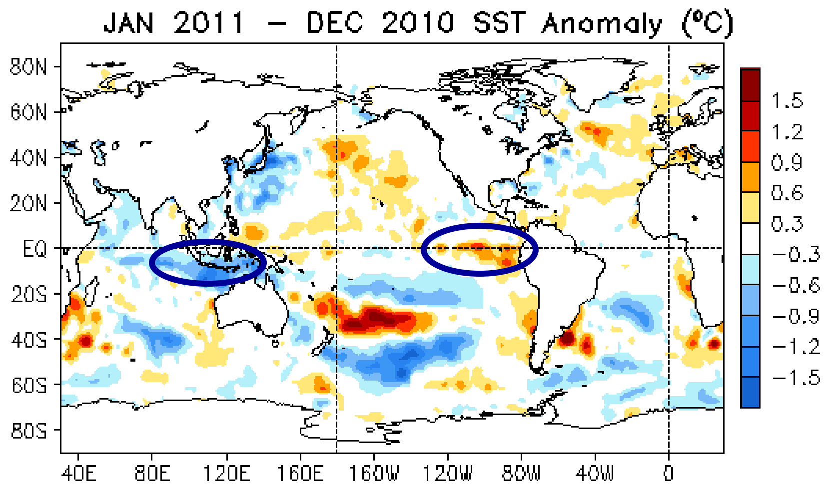
Jan 2011 Overview

- **Pacific Ocean**
  - ENSO cycle: La Niña conditions persisted with NINO3.4=-1.7°C in Jan 2011.
  - However, some weakening was evident: surface westerly wind anomalies covered the tropical Pacific east of the Dateline, positive zonal current anomalies appeared in the central tropical Pacific, Warm Water Volume index switched to positive.
  - NOAA/NCEP Climate Forecast System (CFS) predicted the La Niña will continue well into the Northern Hemisphere summer/fall 2011.
  - PDO has been negative since Jul 2010, and weakened slightly in Jan 2011.
  - Seasonal downwelling was suppressed north of 33°N along the west coast of North America in Jan 2011, leading to above-normal nutrient supply.
- **Indian Ocean**
  - SST was more than 0.5°C below-normal across much of the equatorial Indian Ocean.
- **Atlantic Ocean**
  - NAO index has been persistently below-normal since Oct 2009, and it was -0.88 in Jan 2011.
  - 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.

Global SST Anomaly (^0C) and Anomaly Tendency



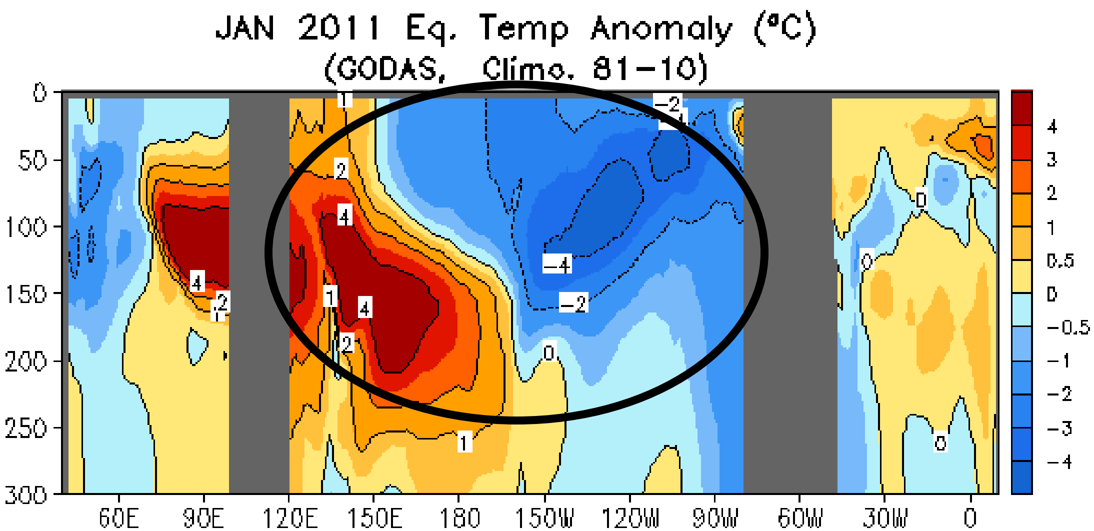
- La Nina conditions presented in the tropical central and eastern Pacific.
- Negative PDO pattern presented in N. Pacific.
- A tripole SSTA pattern presented in N. Atlantic.
- Positive SSTA was observed in mid-latitude southern oceans.



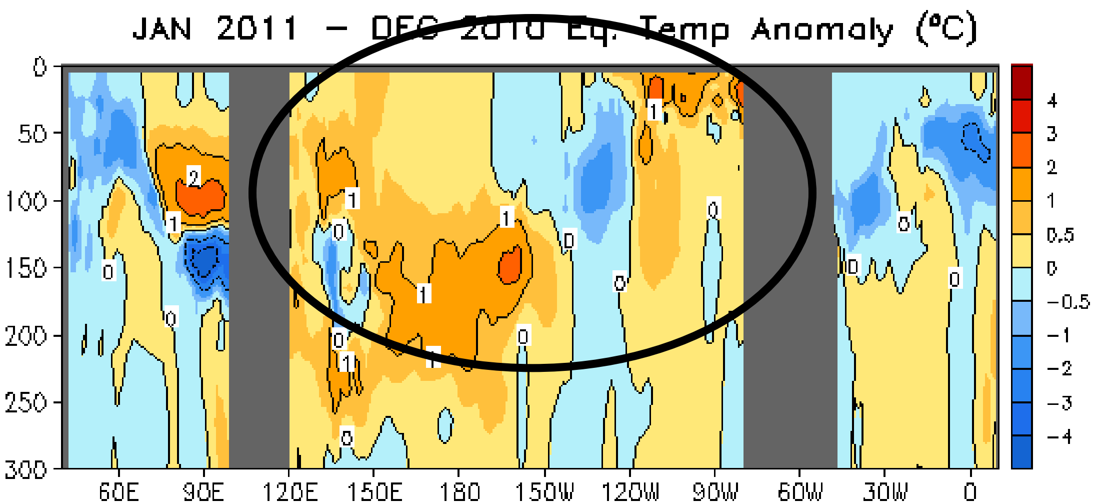
- La Nina conditions weakened slightly.
- Negative SSTA tendency was observed in the S.E. tropical Indian Ocean.
- Large SSTA tendency was observed in the midlatitude S. Pacific.

Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

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.**
- **Negative (positive) temperature anomalies presented near the thermocline in the equatorial western (eastern) Indian Ocean.**
- **Positive temperature anomalies presented near the thermocline cross the equatorial Atlantic Ocean.**

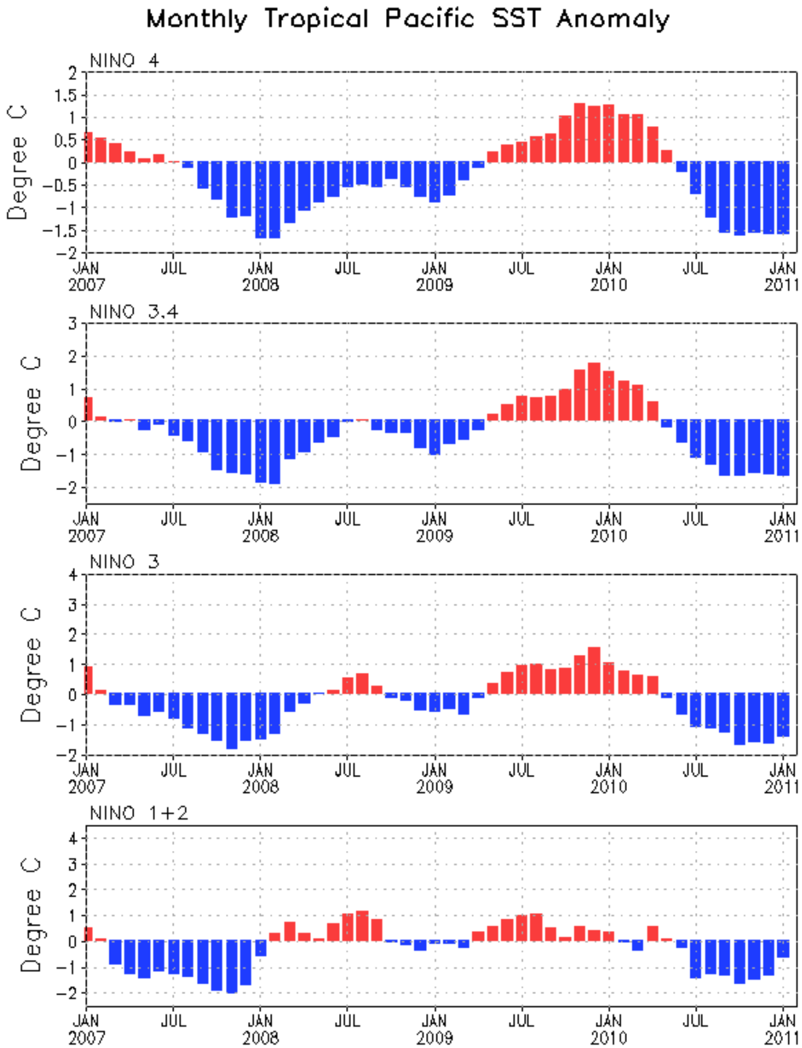


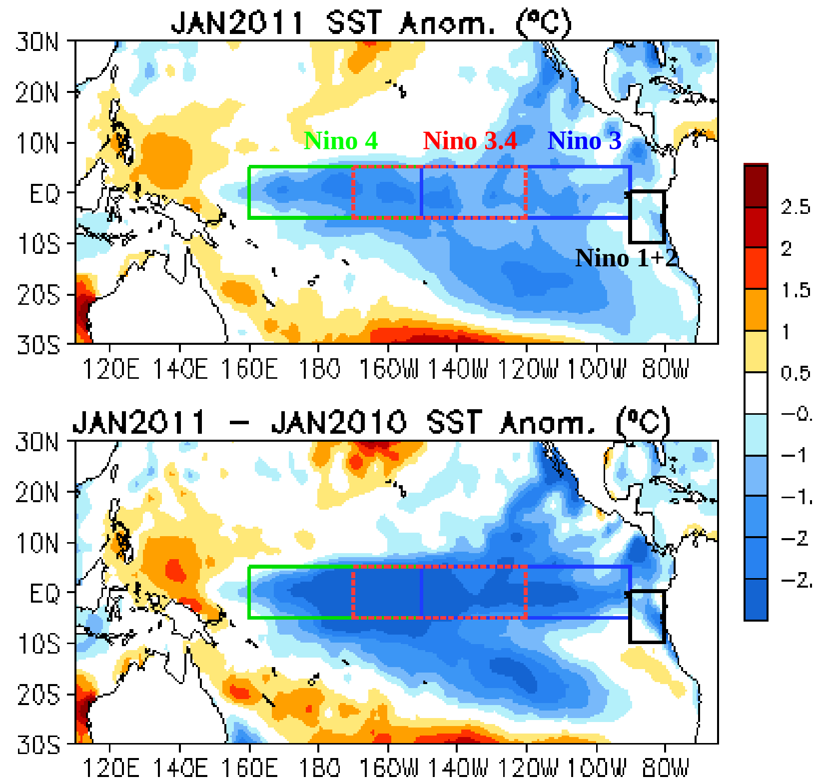
- **Temperature increased across much of the equatorial Pacific.**
- **Positive temperature anomaly in the eastern equatorial Atlantic Ocean weakened.**

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





- **NINO 4 and NINO 3.4 persisted, while NINO 3 and NINO 1+2 weakened.**

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

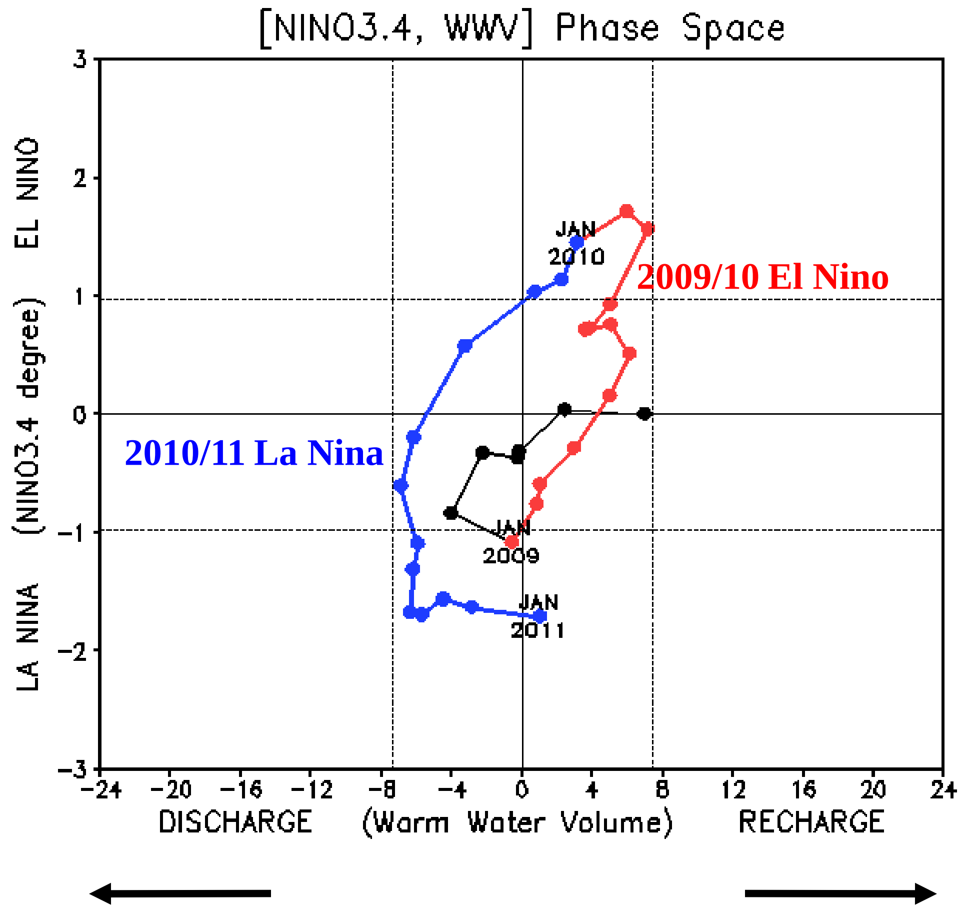
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Warm Water Volume (WWV) and NINO3.4 Anomalies

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

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

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

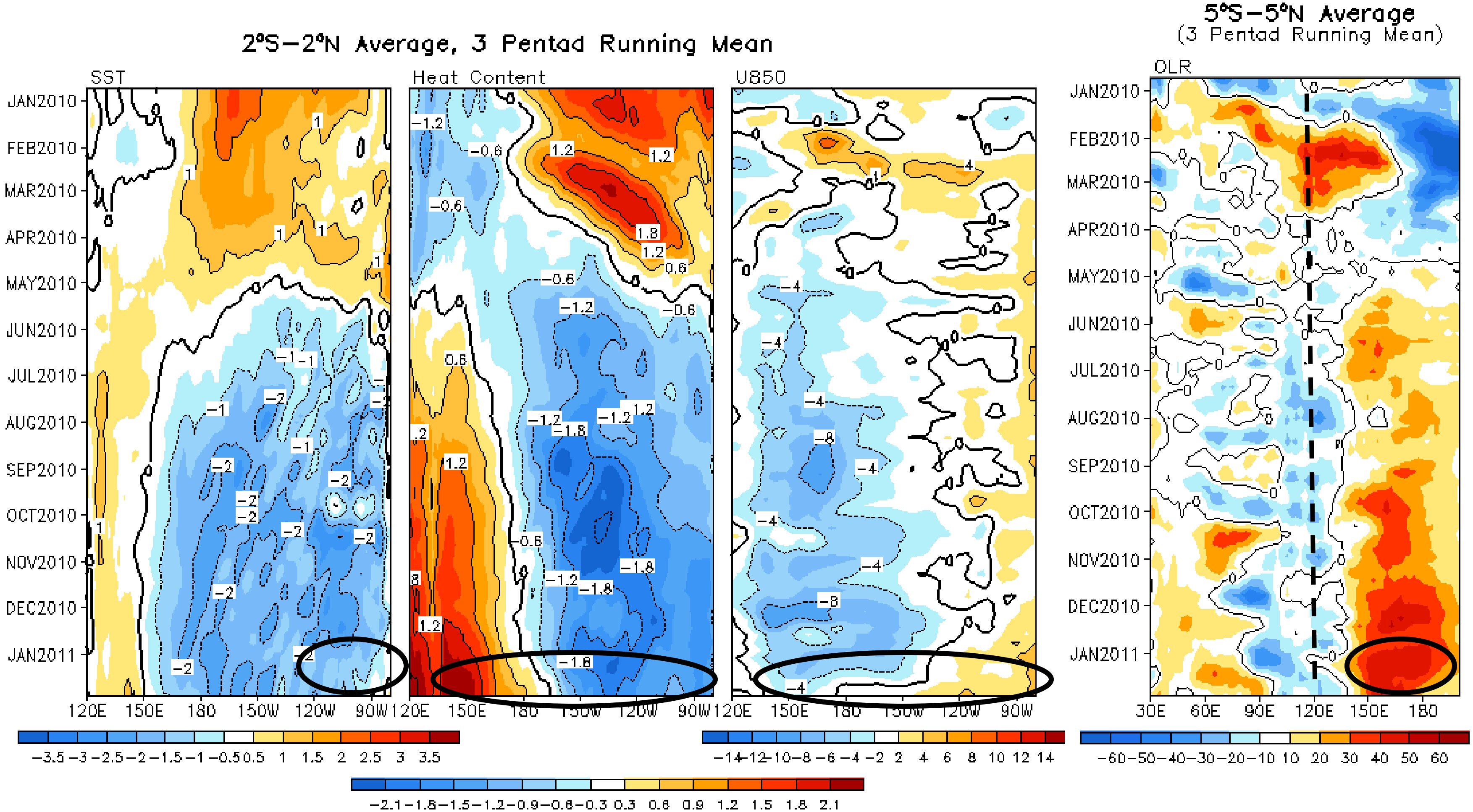


- Nino3.4 became less than -1ºC since Jul 2010, indicating moderate-strong La Nina conditions.

- Nino3.4 has persisted from Dec 2010 to Jan 2011, while WWV weakened substantially and became positive in Jan 2011.

Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies for WWV (NINO 3.4) are departures from the 1982-2004 (1981-2010) base period means.

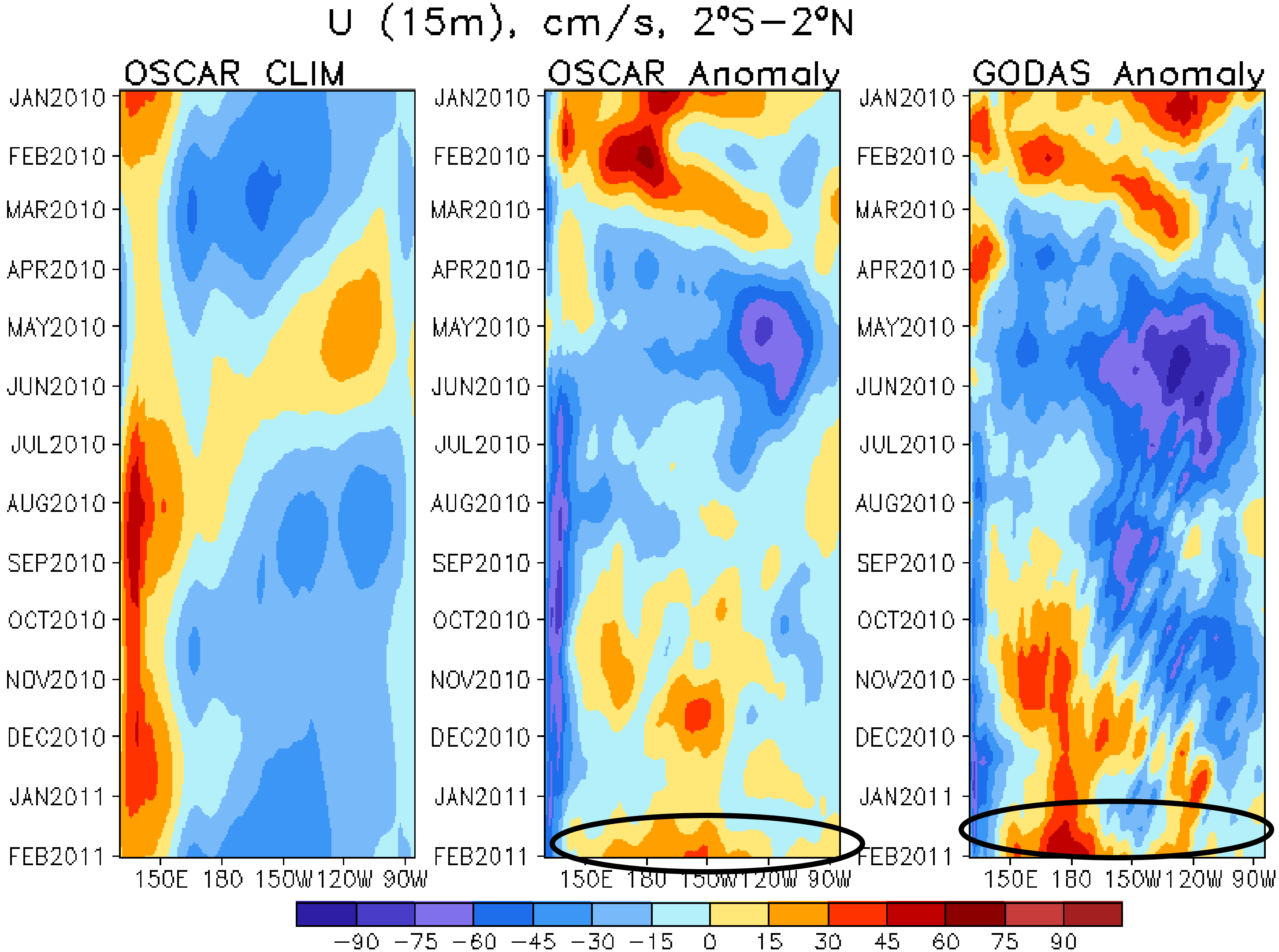
Evolution of Equatorial Pacific SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly



- **Positive heat content anomalies (HCA) shifted eastward, and negative HCA in the far E. Pacific weakened in response to westerly wind anomalies.**
- **Negative SSTA weakened in the far E. Tropical Pacific in response to strengthening westerly wind anomalies.**

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 1981-2010, 1982-2004, 1979-1995 base period pentad means respectively.

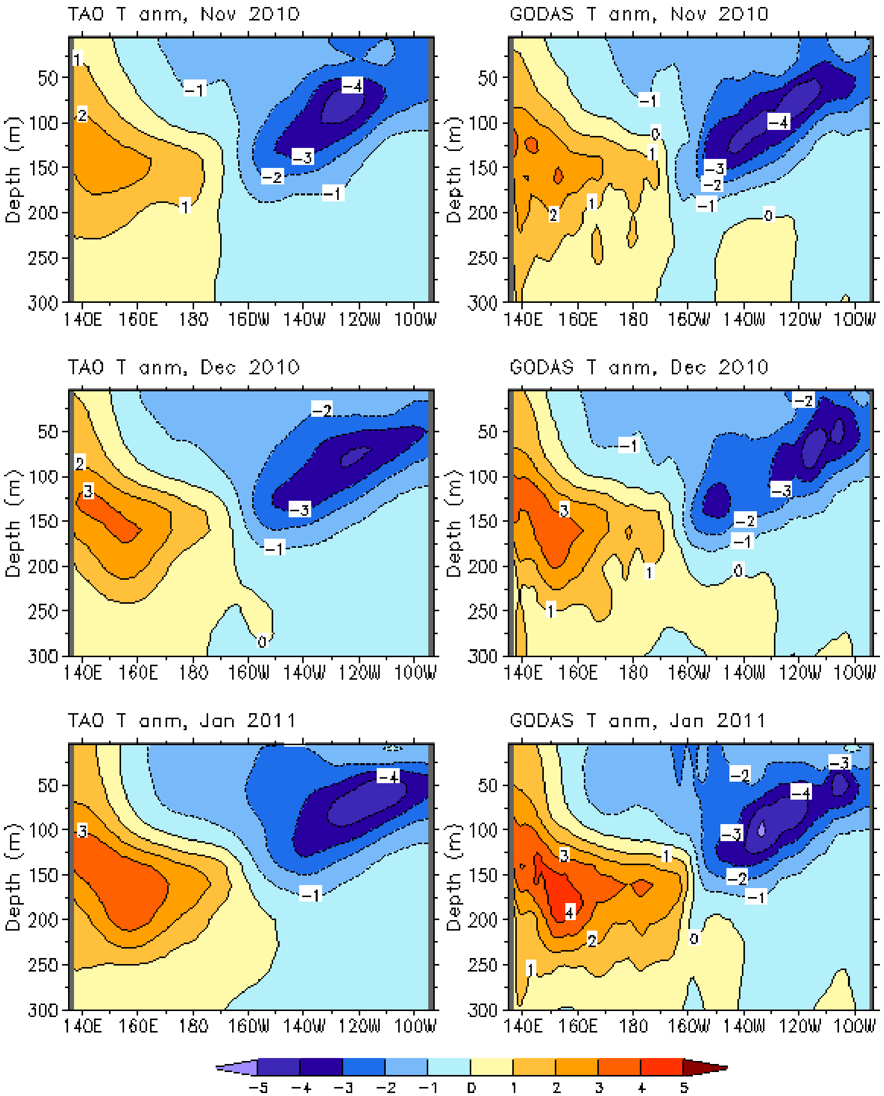
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Eastward zonal current anomalies presented in the central equatorial Pacific in Jan 2011, which is consistent with the eastward shift of positive subsurface temperature anomalies and the development of westerly wind anomalies east of the Dateline.

Equatorial Pacific Temperature Anomaly

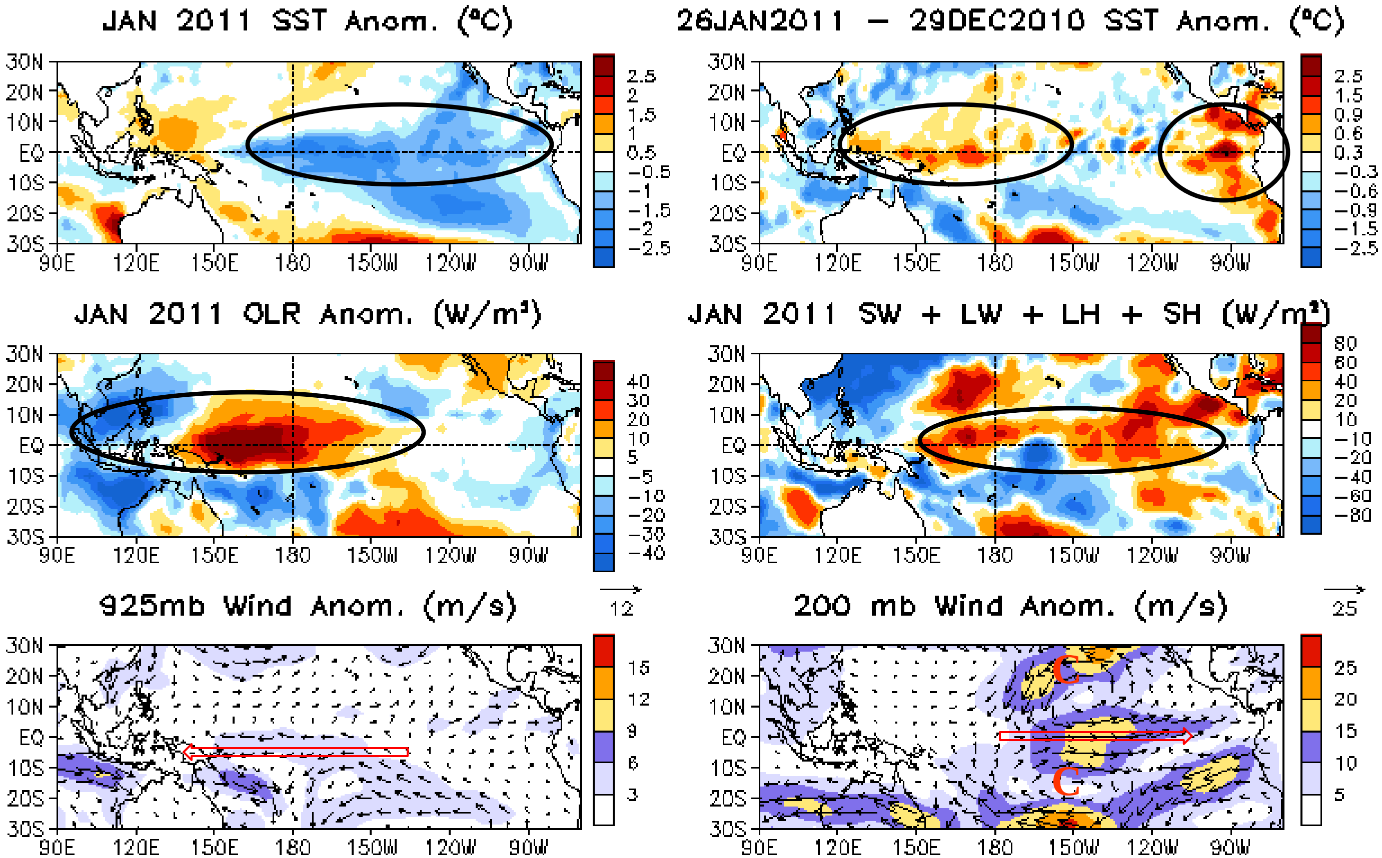
TAO GODAS



TAO climatology used

- Positive temperature anomalies in the equatorial western Pacific strengthened and shifted slightly eastward from Nov 2010 to Jan 2011, while negative temperature anomalies in the E. Pacific changed little.

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

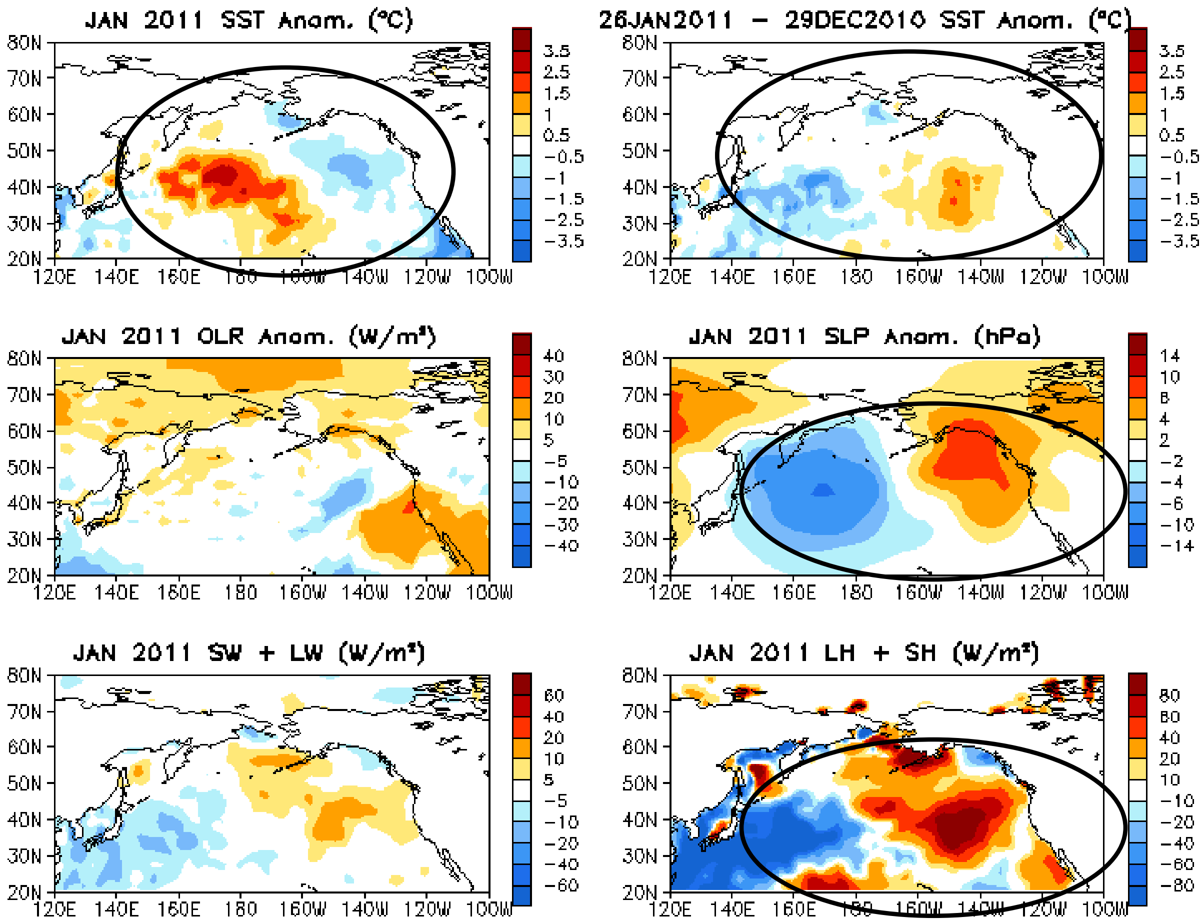


- Negative SSTA weakened in the far E. equatorial Pacific in Jan 2011.
- Convection was enhanced (suppressed) over the Maritime Continents (in the west-central tropical Pacific).
- Net surface heat flux anomalies damped negative SSTA.
- Easterly (westerly) wind anomaly in low (high) level was much weaker in Jan 2011 than in Dec 2010.

Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1981-2010 base period means.

North Pacific & Arctic Ocean

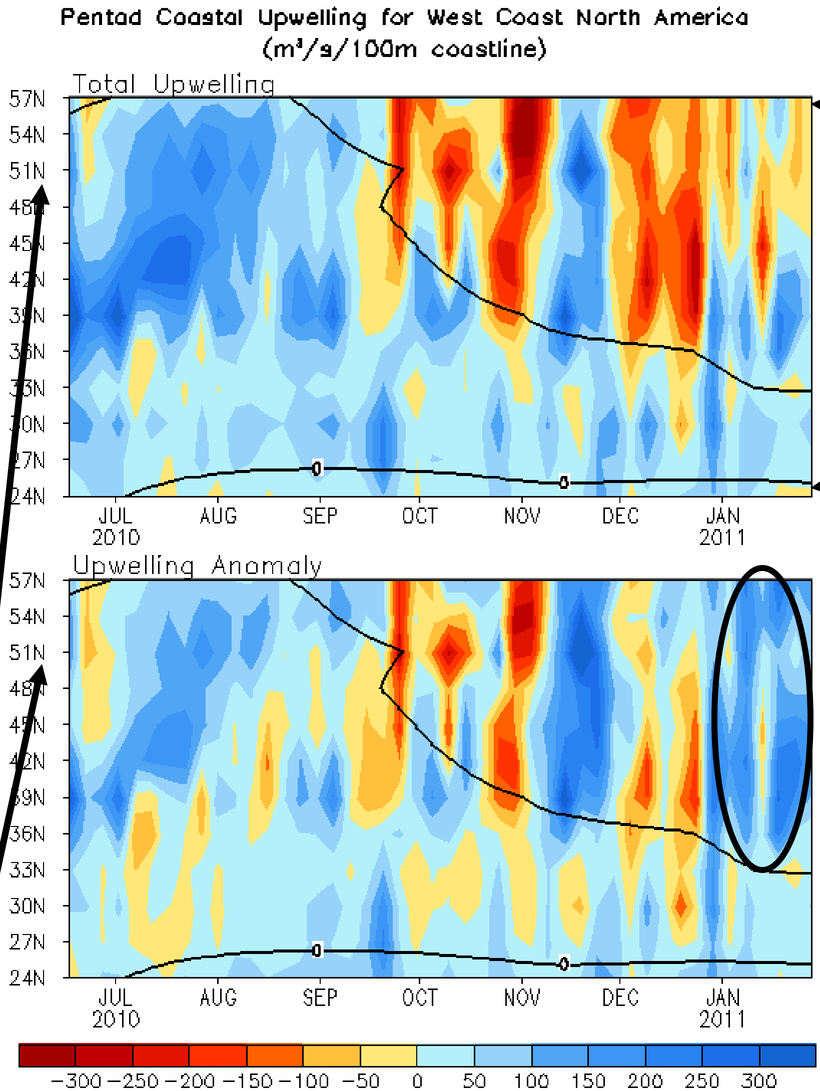
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

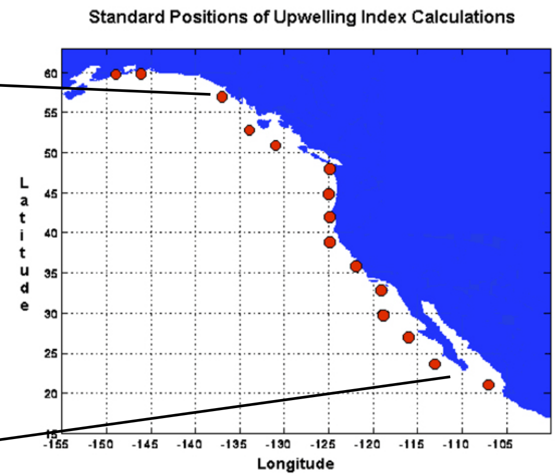


- Negative PDO pattern weakened.
- SSTA tendency is generally consistent with total heat flux anomalies (LH+SH+SW+LW).
- Positive (negative) SLP anomaly presented in Gulf of Alaska and near the west coast N. America (western N. Pacific).

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 1981-2010 base period means.

North America Western Coastal Upwelling





- Seasonal downwelling weakened substantially north of 33ºN in Jan 2011, and became upwelling between 33ºN-45ºN.

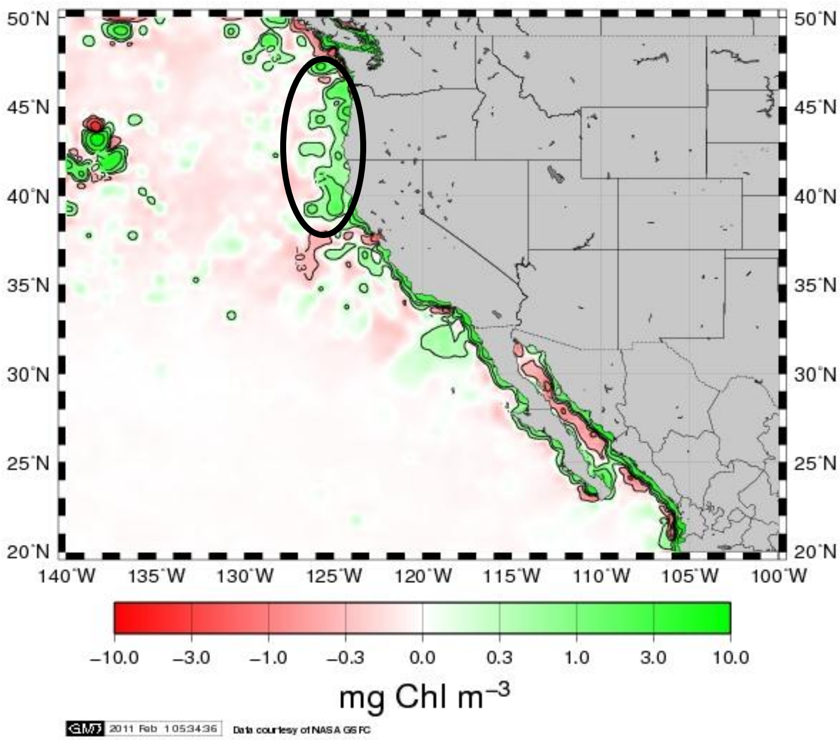
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

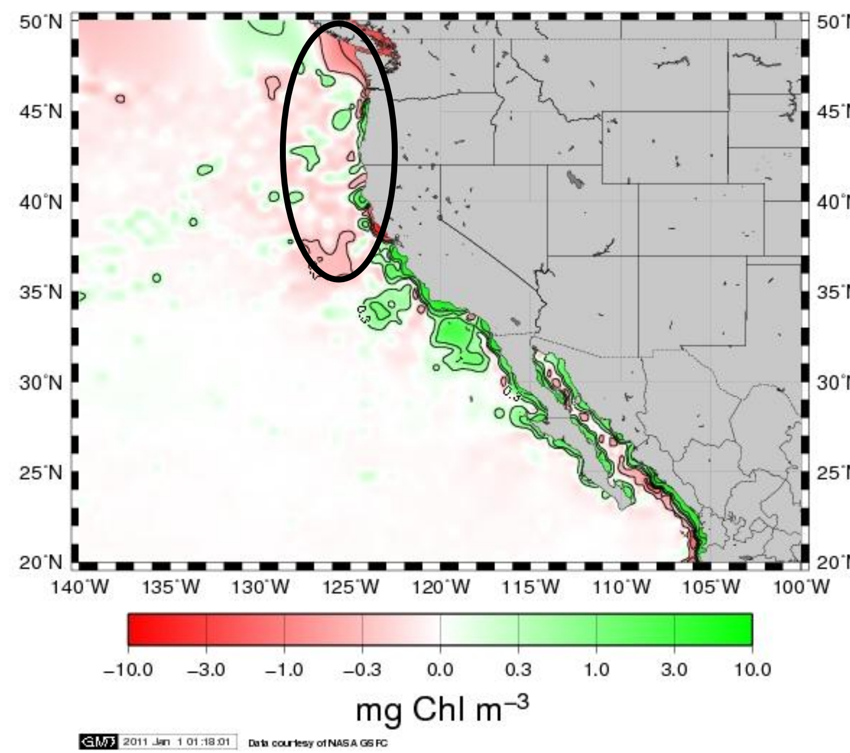
Monthly Chlorophyll Anomaly

MODIS Aqua Chlorophyll a Anomaly for January, 2011



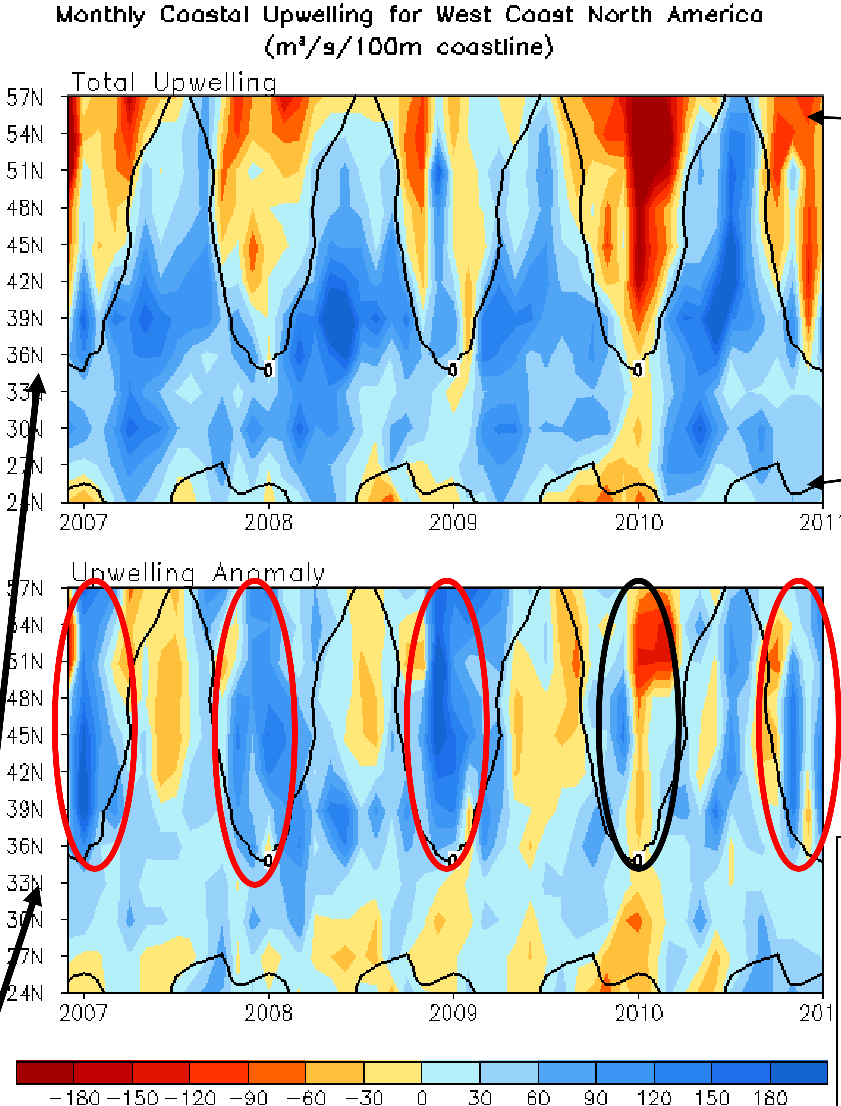
- **Positive chlorophyll anomalies increased north of 37°N from Dec 2010 to Jan 2011, generally consistent with weakened downwelling.**

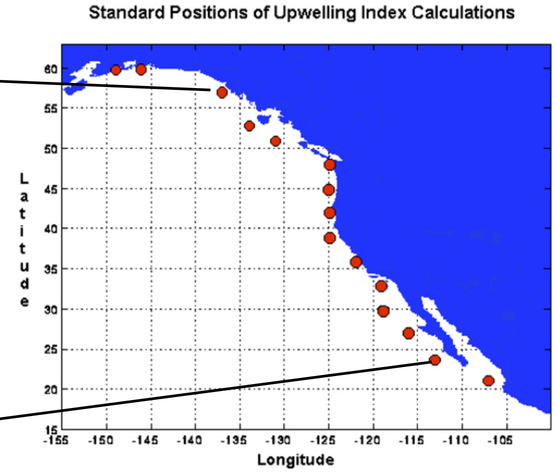
MODIS Aqua Chlorophyll a Anomaly for December, 2010



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.

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

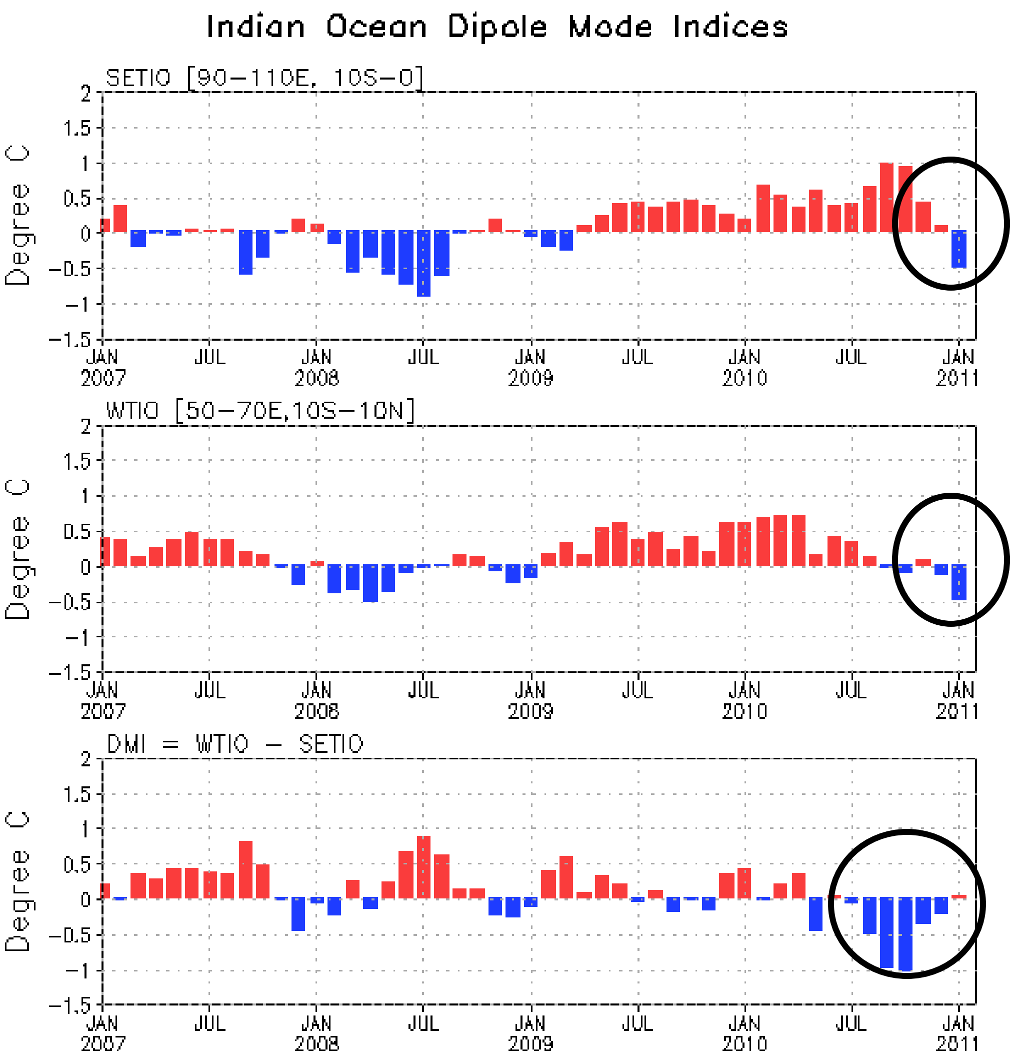
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

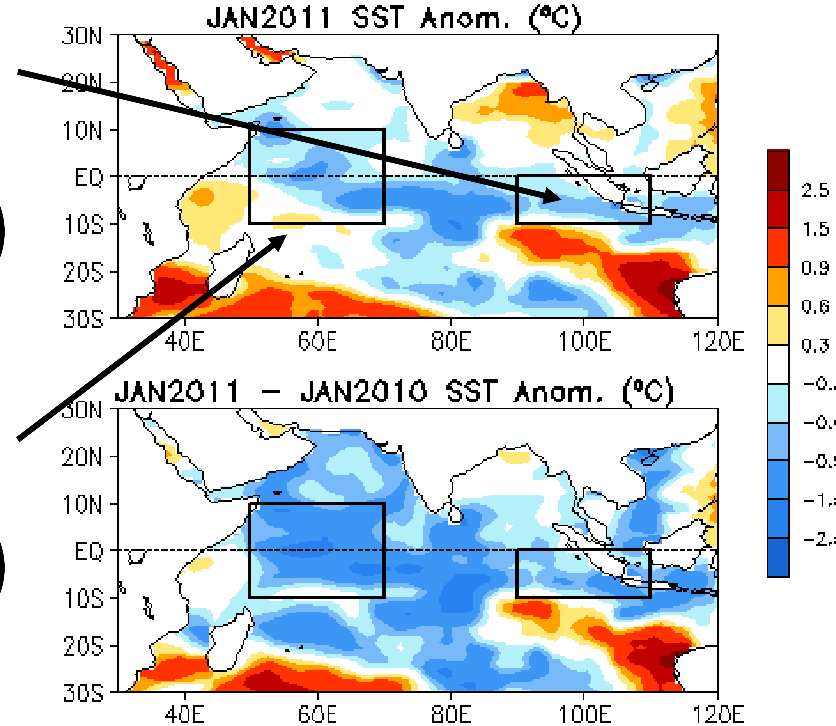
- Area below (above) black line indicates climatological upwelling (downwelling) season.

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

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices

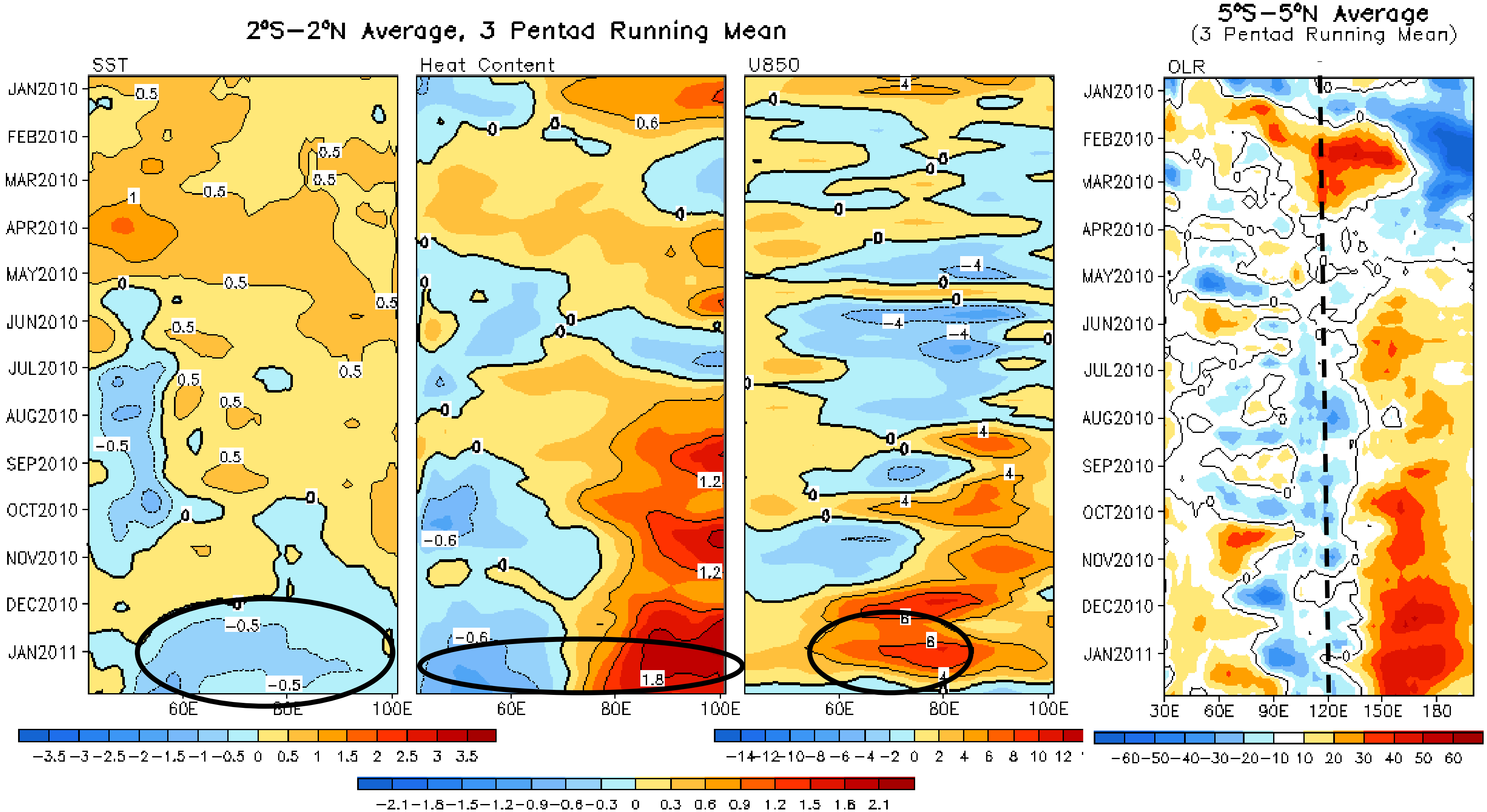




- **Both eastern (SETIO) and western (WTIO) pole SSTA decreased substantially and became negative in Jan 2011.**
- **DMI has been below-normal since May 2010, strengthened to be about -0.9 during Sep-Oct 2010, but returned to near-normal since Dec 2010.**

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 1981-2010 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



- **SST in the tropical Indian Ocean cooled down substantially in Dec 2010, and was about 0.5°C below-normal in Jan 2011.**
- **Positive (negative) heat content anomaly strengthened in the eastern (western) Indian Ocean in response to westerly wind anomalies.**

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 1981-2010, 1982-2004, 1979-1995 base period pentad means respectively.

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

- SST was below-normal across much of the equatorial Indian Ocean.

- SSTA tendency is mostly consistent with net surface heat flux anomalies.

- Convection was enhanced (suppressed) in the eastern (central) tropical Indian Ocean, which is probably associated with the La Nina conditions.

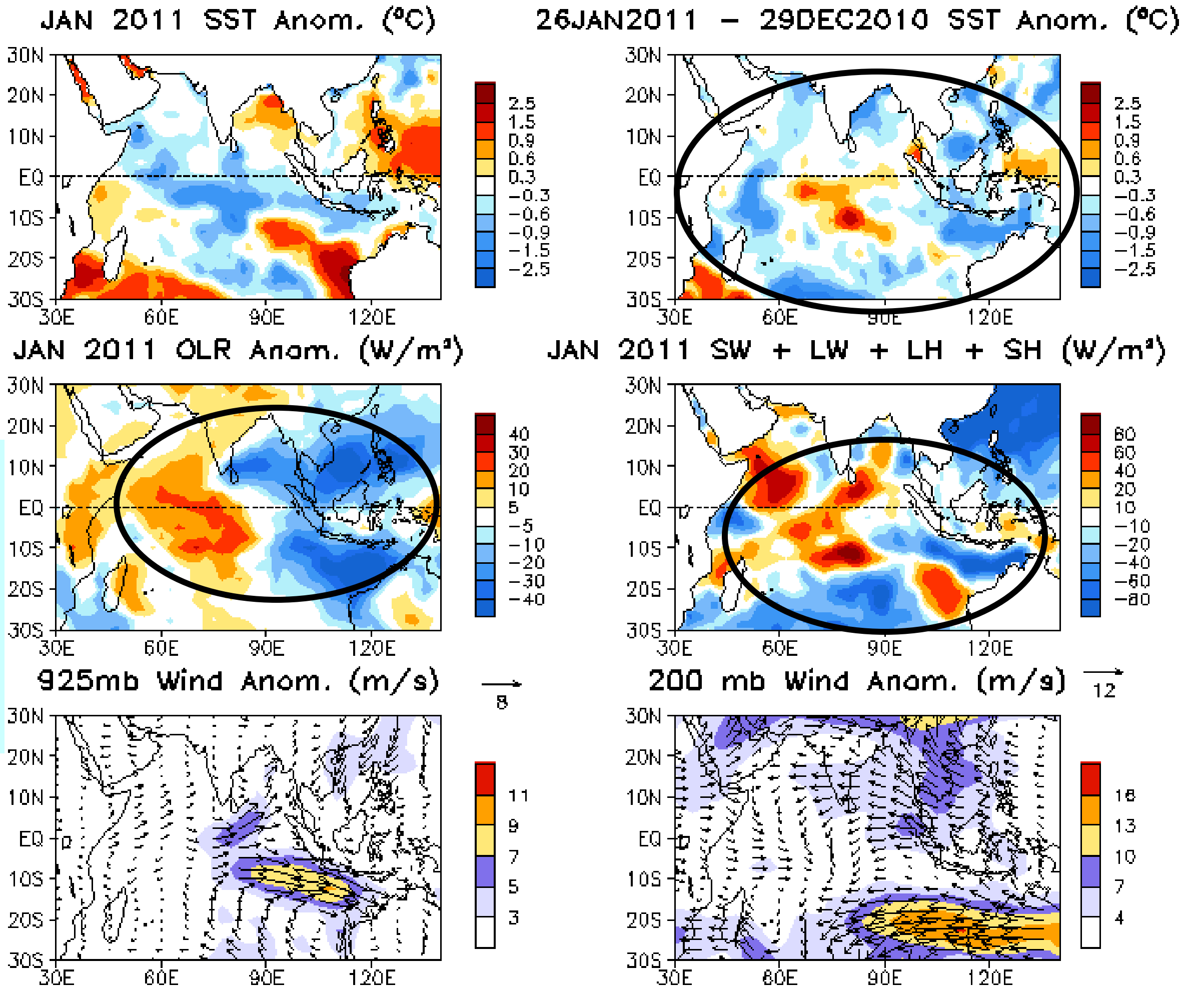
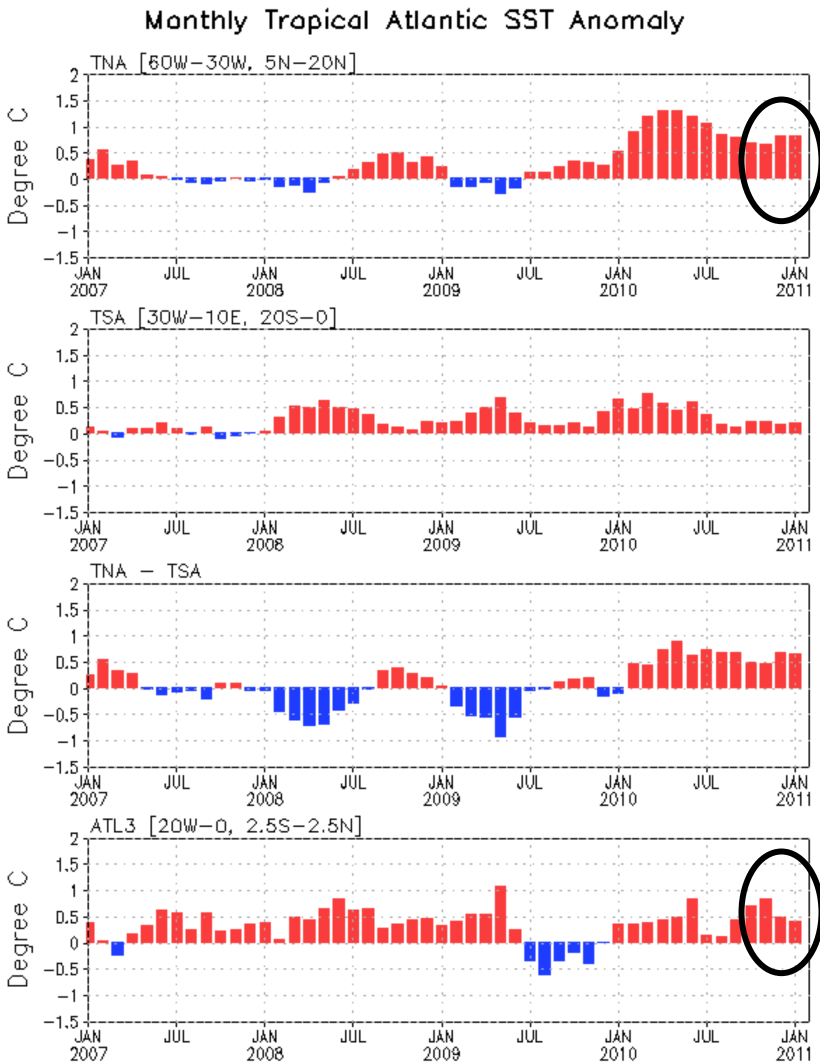
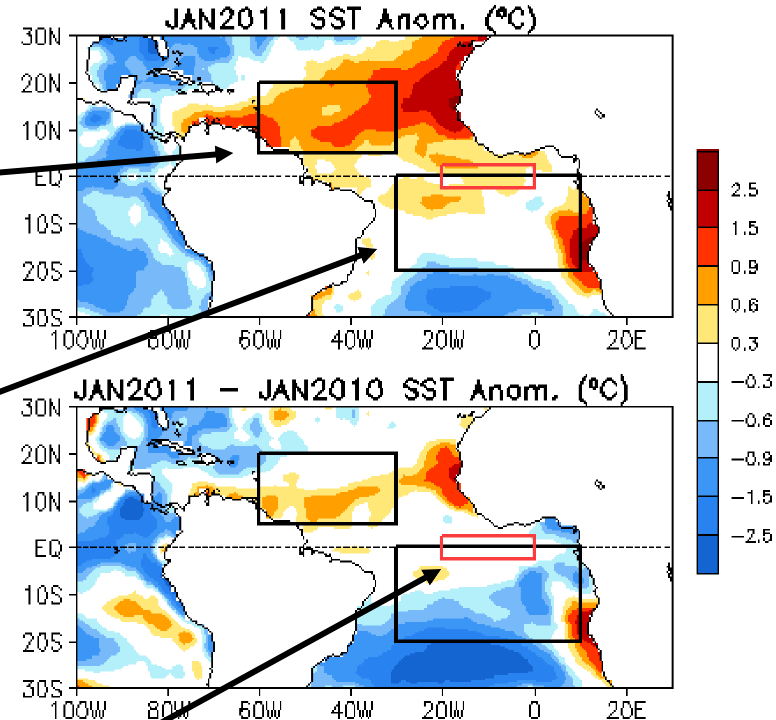


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

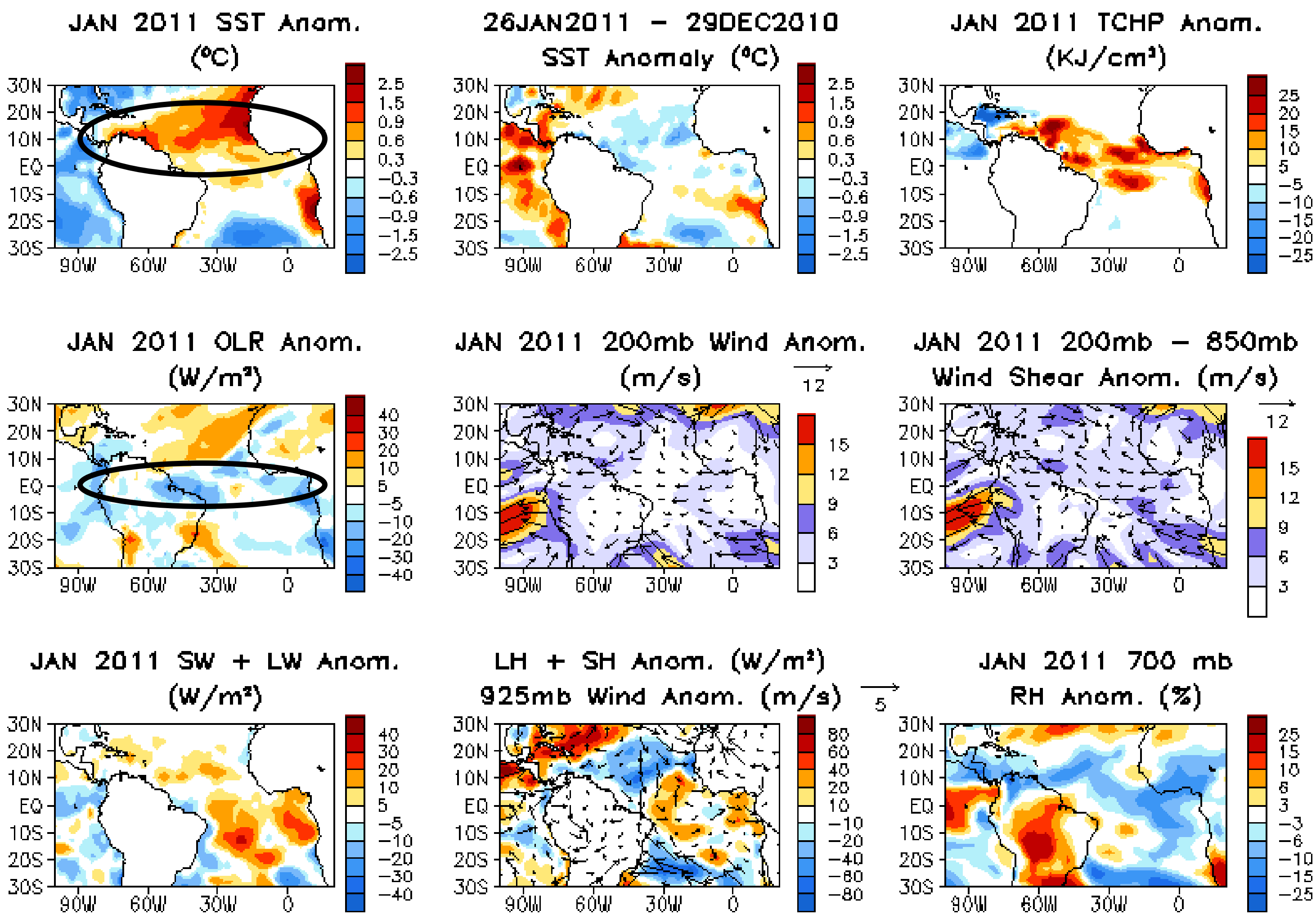




- Positive SSTA in TNA persisted in Jan 2011.
- Meridional Gradient Mode (TNA-TSA) has been above-normal since Feb 2010.
- Positive ATL3 SSTA weakened slightly in Jan 2011.

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 1981-2010 base period means.

Tropical Atlantic:



- **Positive SSTA in the tropical N. Atlantic weakened slightly.**

- **Convection was enhanced over the northern S. America, the eastern tropical Atlantic and Pacific, consistent with the La Nina conditions.**

North Atlantic Ocean

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

- **Negative NAO persisted in Jan 2011 (next slide), consistent with the SLP anomaly pattern.**
- **SSTA changed little.**

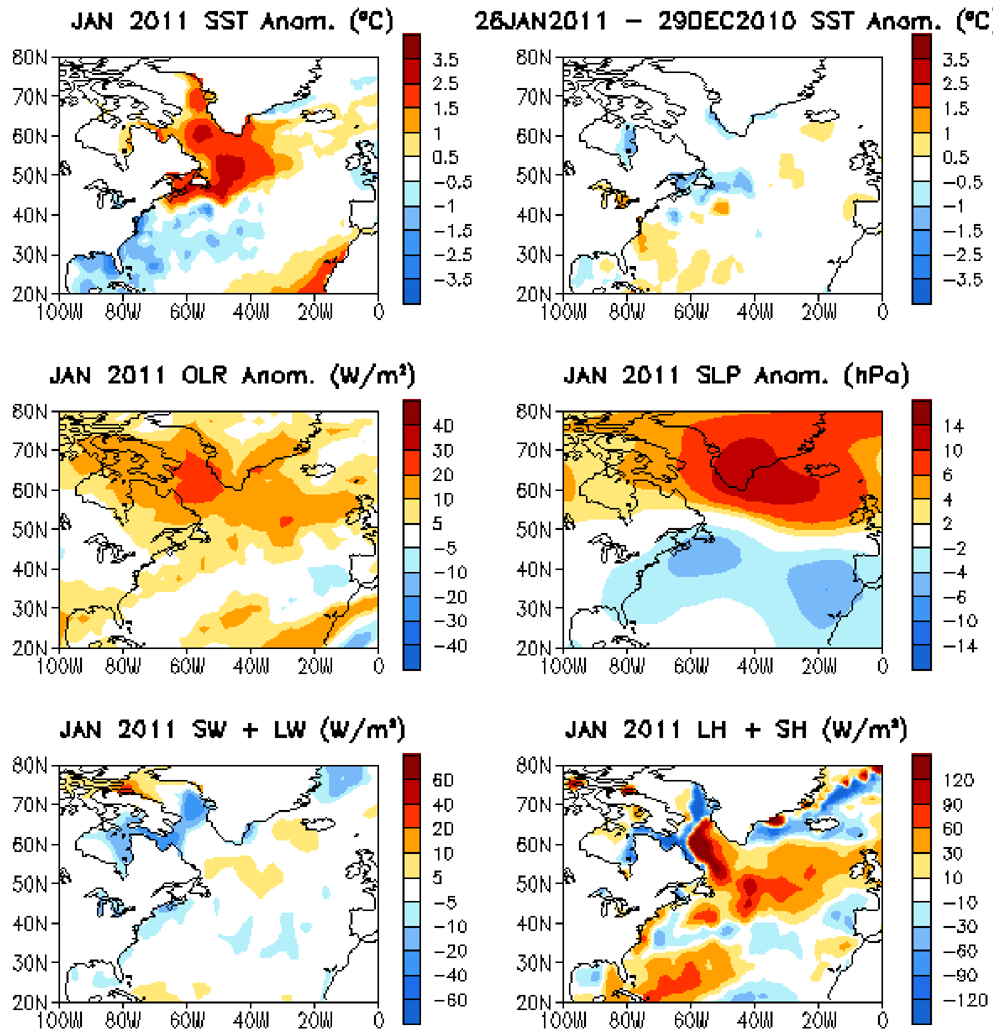
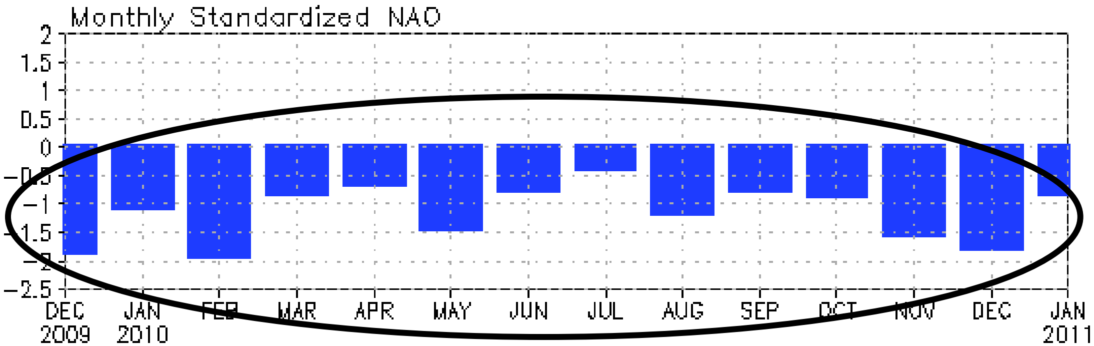
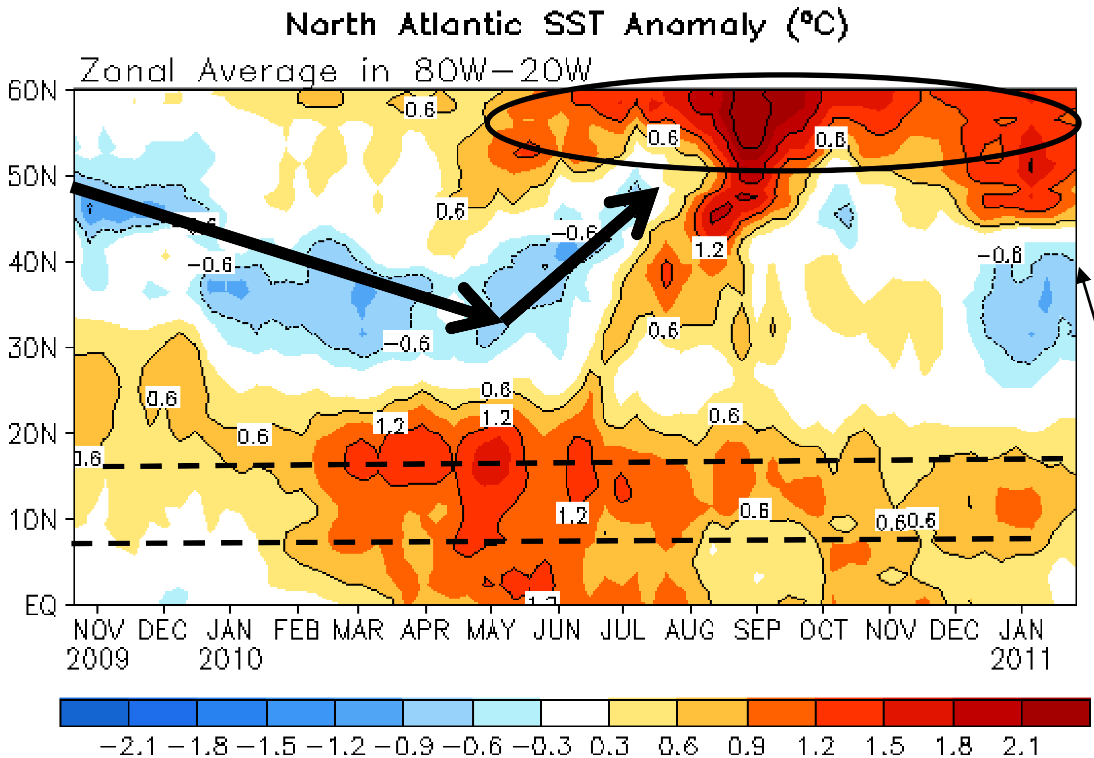
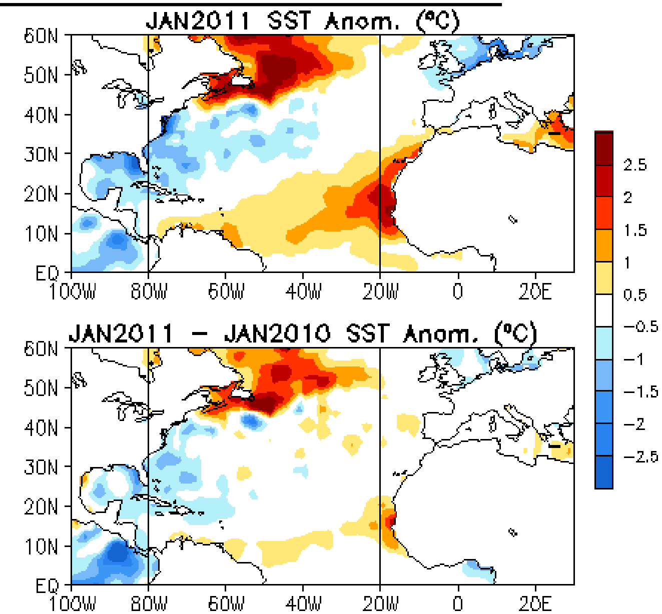


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1981-2010 base period means.

NAO and SST Anomaly in North Atlantic







- NAO Index=-0.88 in Jan 2011.

- 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. Negative SSTA appeared in mid-latitude since Dec 2010.

- Strong warming presented in the high-latitudes North Atlantic since May 2010.

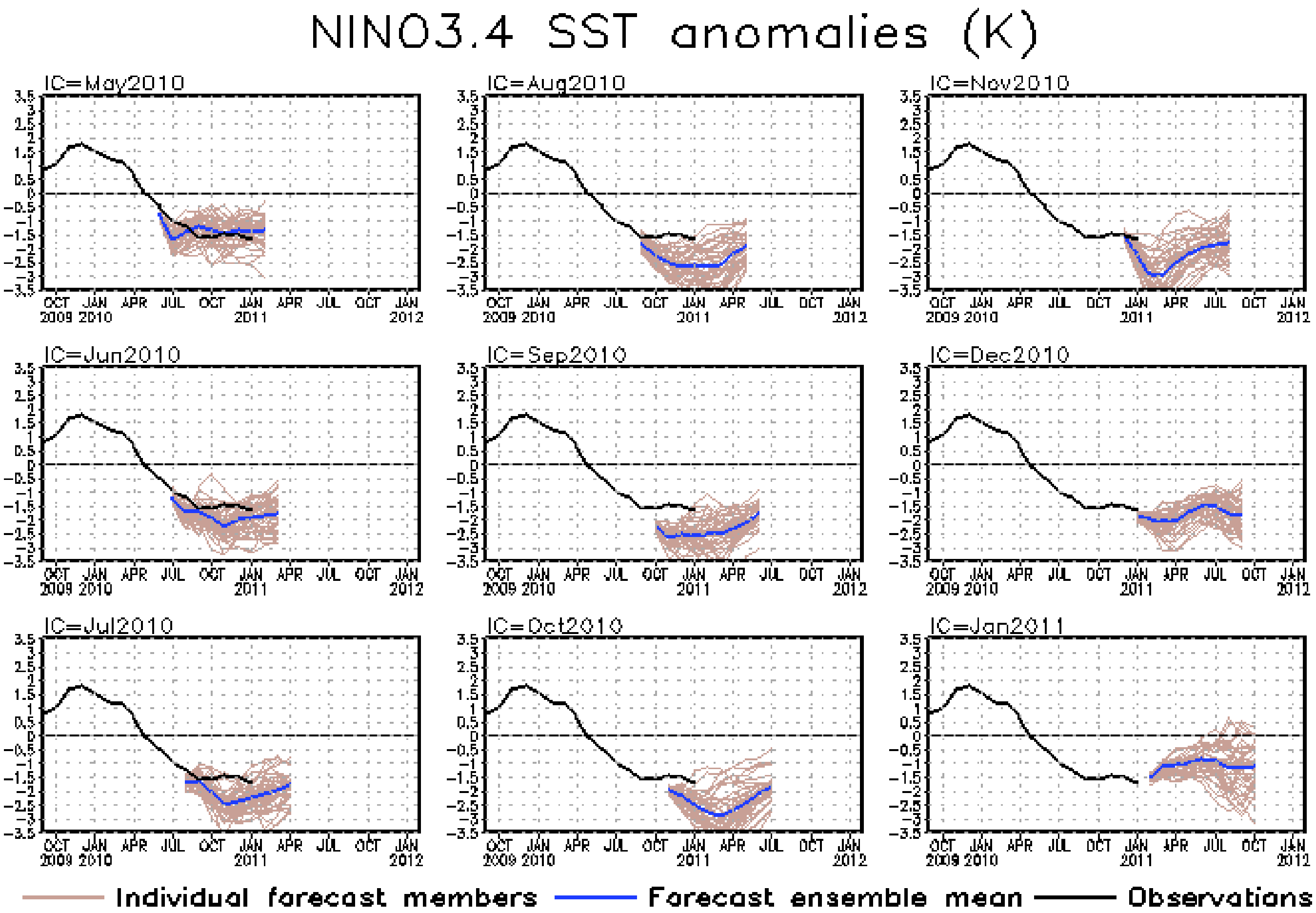
- Positive SSTA in the Atlantic hurricane MDR has been above-normal since Oct 2009, peaked during Mar-May 2010, and then slowly weakened afterwards.

- 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 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 1981-2010 base period means.

CFS SST Predictions and Ocean Initial Conditions

CFS Niño3.4 SST Predictions from Different Initial Months

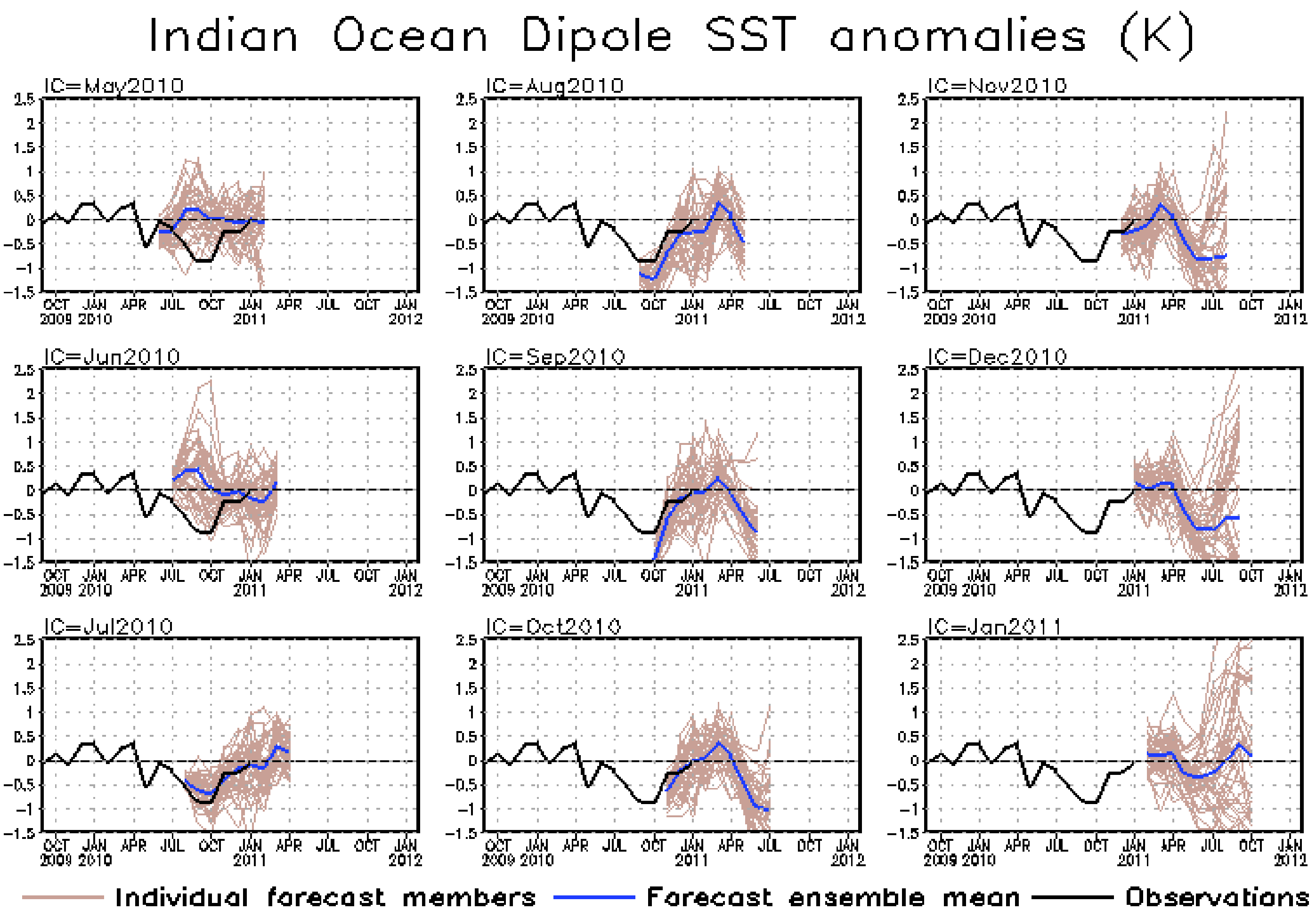


- Forecasts from Jun-Sep I.C. had cold biases. The recent cold forecast biases can be alleviated through statistical model corrections (http://www.cpc.ncep.noaa.gov/products/people/wwang/cfs_fcst).

- The latest forecasts from Jan 2011 I.C. suggest that the current La Niña will weaken slightly in the spring of 2011, and last into the summer/fall 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.

CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

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

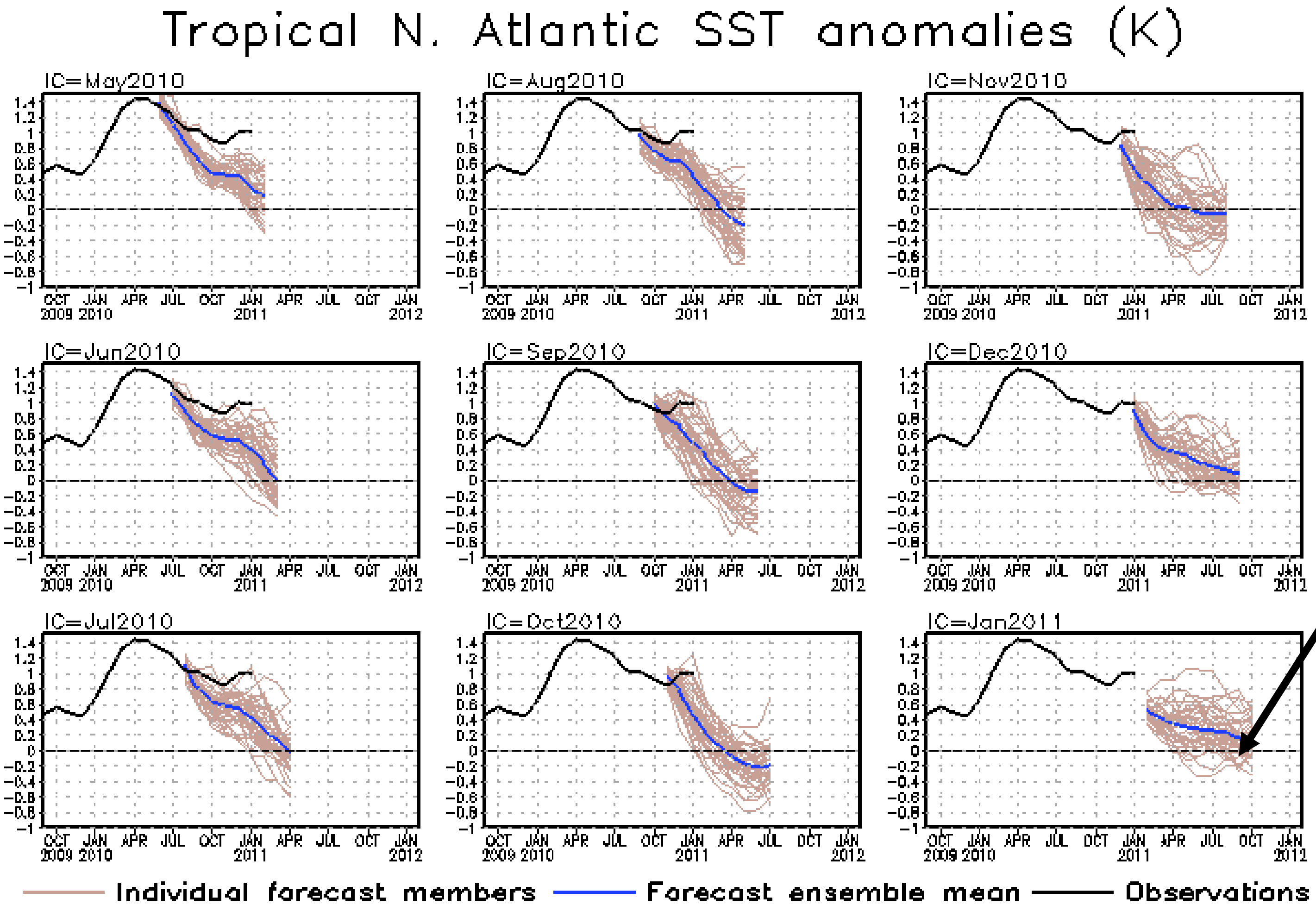
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- **The onset phase of the negative IOD event was poorly forecast, but its decay phase was well predicted.**
- **Forecasts from Jan 2011 I.C. suggest IOD-neutral conditions in the fall 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].

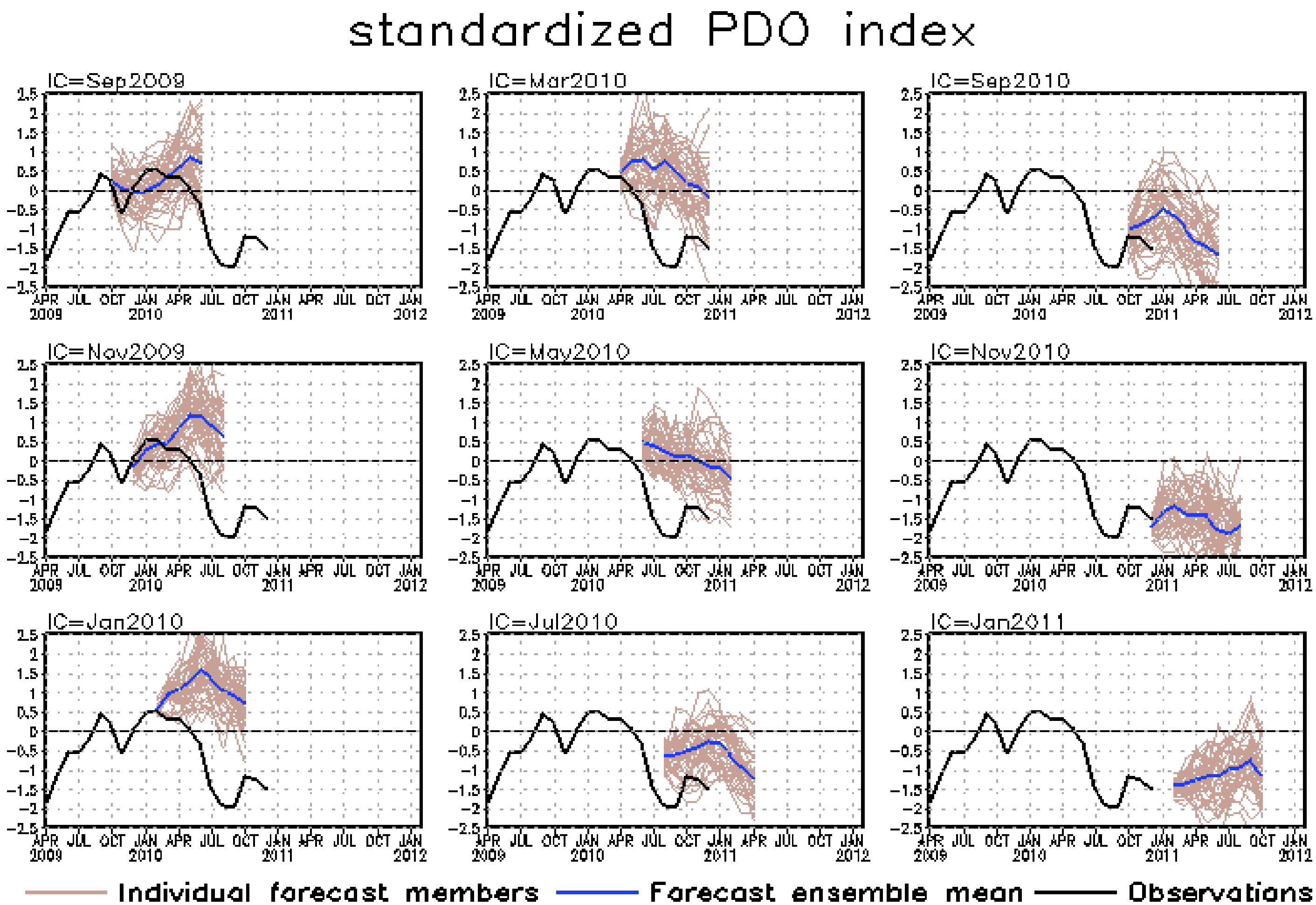


- Cold forecast biases were evident, which might be attributable to unpredictable influences from NAO.

- Latest forecasts suggest that positive SSTA in the tropical North Atlantic will decay rapidly, 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 weaken gradually in next few months, and the negative phase will last through the 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.