

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

Prepared by
Climate Prediction Center, NCEP/NOAA
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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 Ocean Climate Observation Program (OCO)

Outline

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

Overview

▪ Pacific and Arctic Oceans

- ENSO-neutral conditions continued during Dec 2012.
- A strong cooling tendency was observed in the central-eastern tropical Pacific near the thermocline due to propagation of upwelling oceanic Kelvin waves.
- The consensus forecast favors ENSO-neutral conditions to continue into the Northern Hemisphere spring 2013.
- Negative PDO phase persisted with $\text{PDO} = -1.1$ in Dec 2012, and NCEP CFSv2 predicted negative PDO phase would continue into next spring.
- Arctic sea ice extent in Dec 2012 was below-normal and similar to that in Dec 2011.

▪ Indian Ocean

- Indian Ocean Dipole was near-normal in Dec 2012.

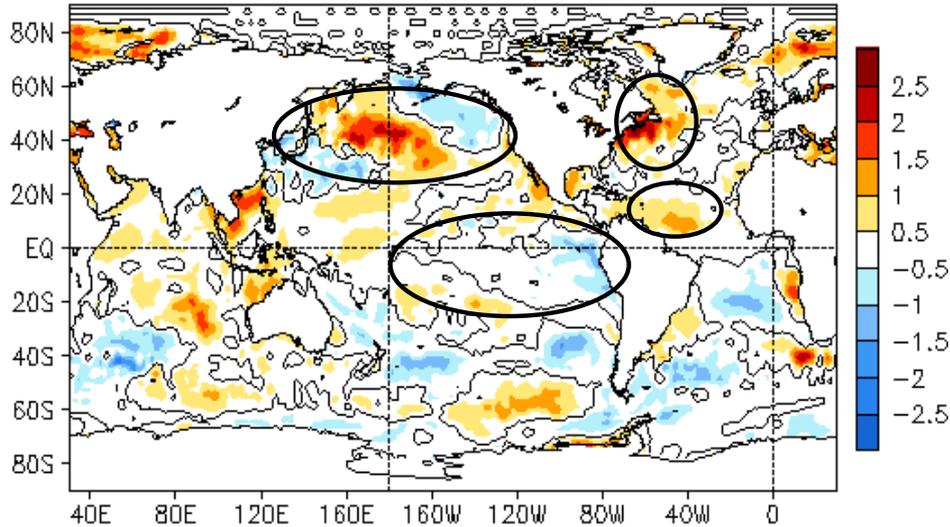
▪ Atlantic Ocean

- Negative NAO phase that has persisted from May to Nov 2012 returned to near-normal in Dec 2012.
- Positive SSTA in high-latitude N. Atlantic weakened, while positive SSTA in tropical N. Atlantic persisted.

Global Oceans

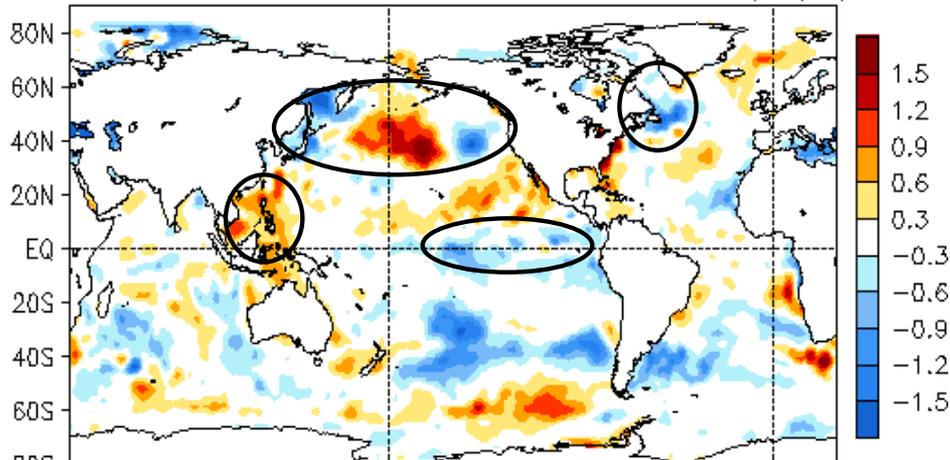
Global SST Anomaly ($^{\circ}\text{C}$) and Anomaly Tendency

DEC 2012 SST Anomaly ($^{\circ}\text{C}$)
(1981–2010 Climatology)



- SST was near-normal in the central-eastern tropical Pacific.
- Positive SST anomalies presented in central N. Pacific, along the Gulf Stream, and in the subtropical North Atlantic.
- Negative SST anomalies presented in southeast Pacific and Gulf of Alaska.

DEC 2012 – NOV 2012 SST Anomaly ($^{\circ}\text{C}$)

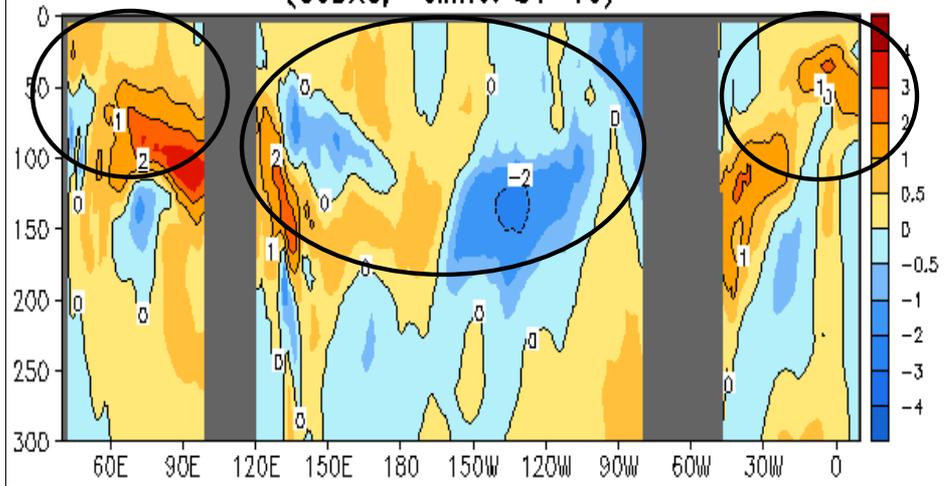


- A cooling tendency presented in central-eastern tropical Pacific, north of Japan and along the Gulf Stream.
- A warming tendency was observed in South China Sea and central N. Pacific.

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.

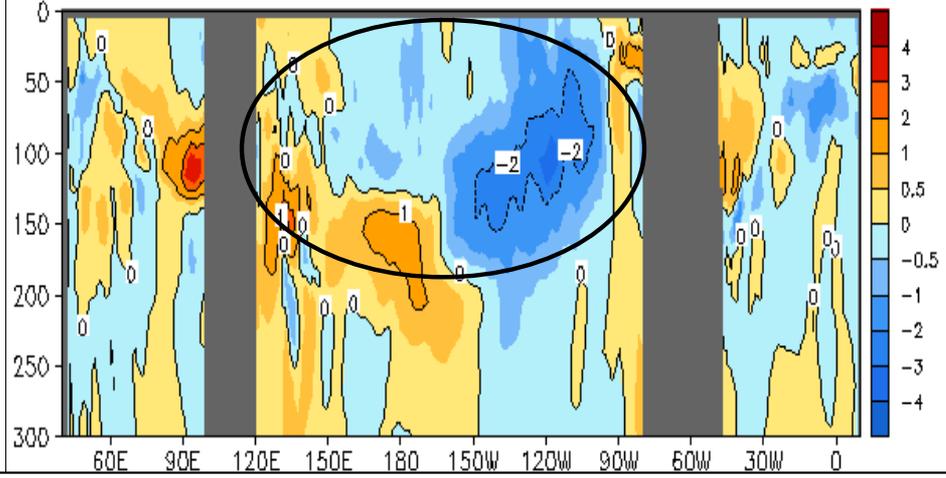
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

DEC 2012 Eq. Temp Anomaly (°C)
(GODAS, Climo. 81-10)



- Positive (negative) temperature anomalies dominated in western (eastern) equatorial Pacific Ocean.
- Positive anomalies dominated at the upper 100m of equatorial Indian and Atlantic Ocean.

DEC 2012 – NOV 2012 Eq. Temp Anomaly (°C)

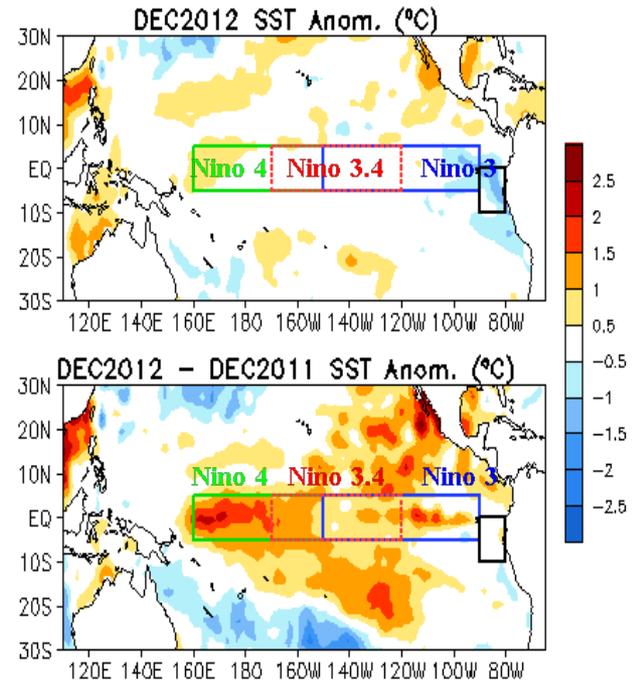
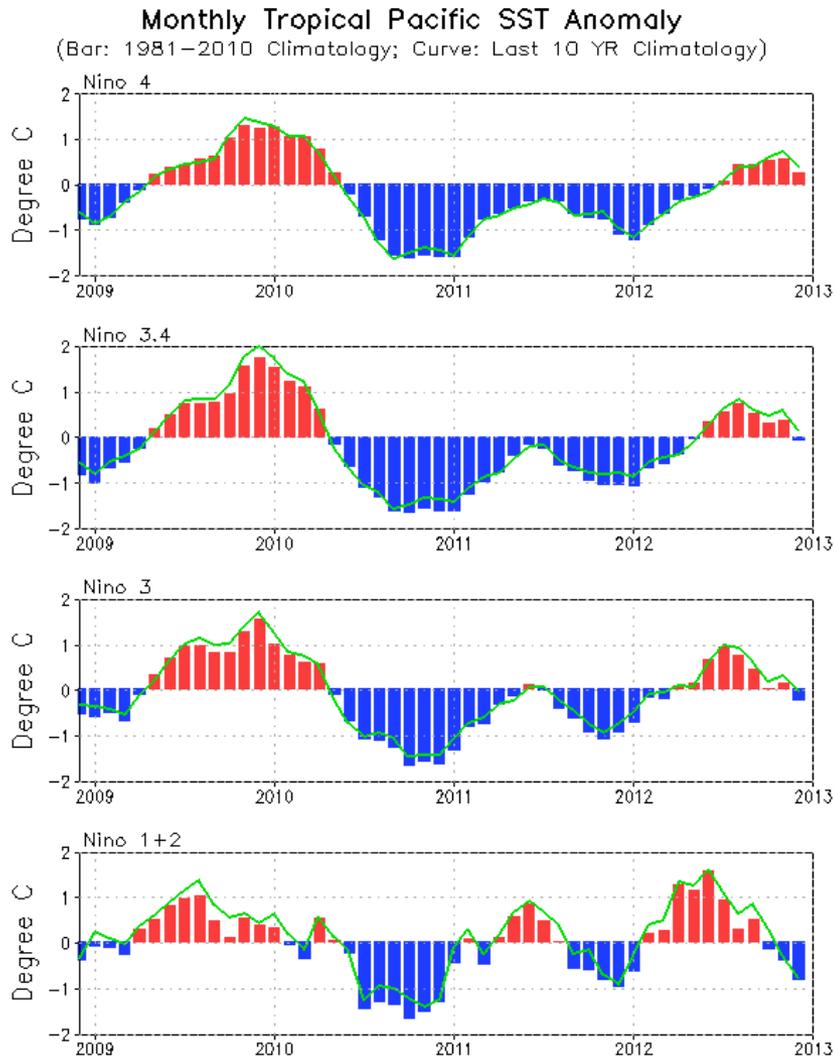


- A cooling (warming) tendency was observed in the central-eastern (western) Pacific Ocean near the thermocline, largely due to propagation of upwelling oceanic Kelvin waves.

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 1981-2010 base period means.

Tropical Pacific Ocean and ENSO Conditions

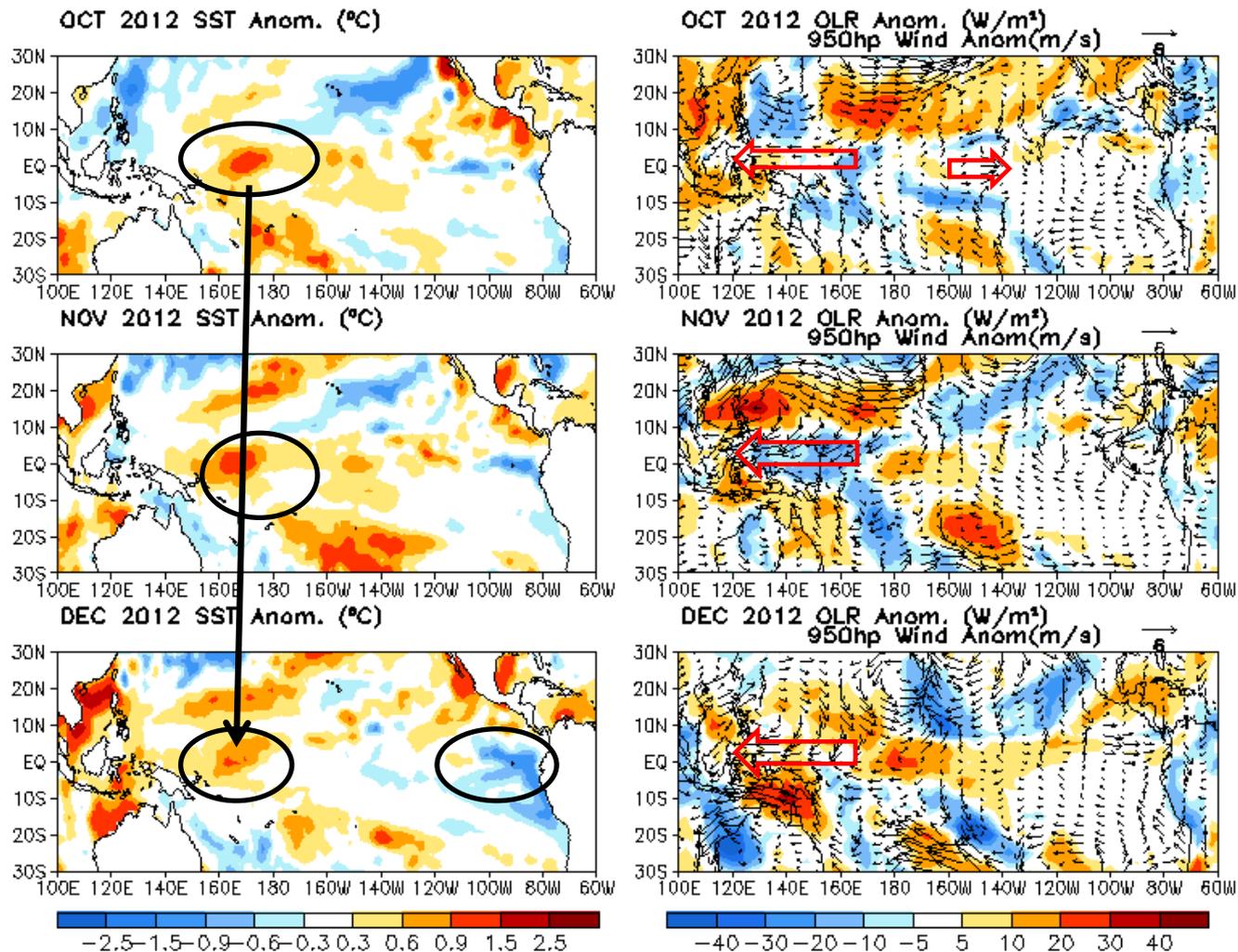
Evolution of Pacific NINO SST Indices



- All Niño indices were near-normal except NINO1.2 = -0.7°C .
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.

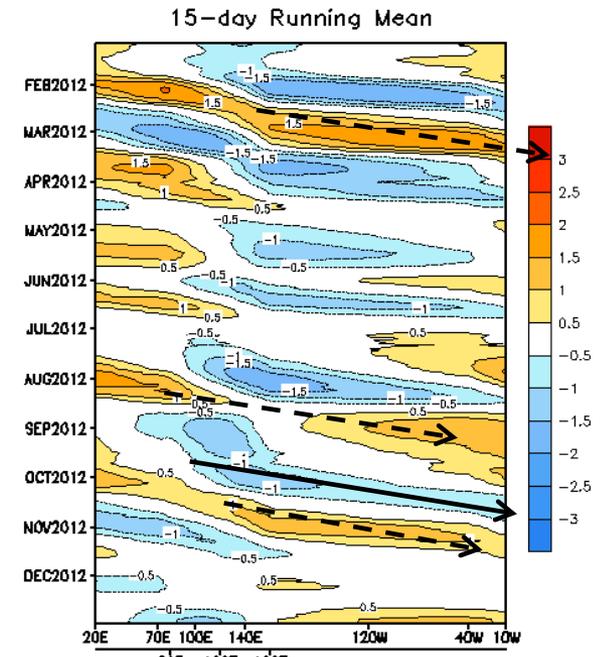
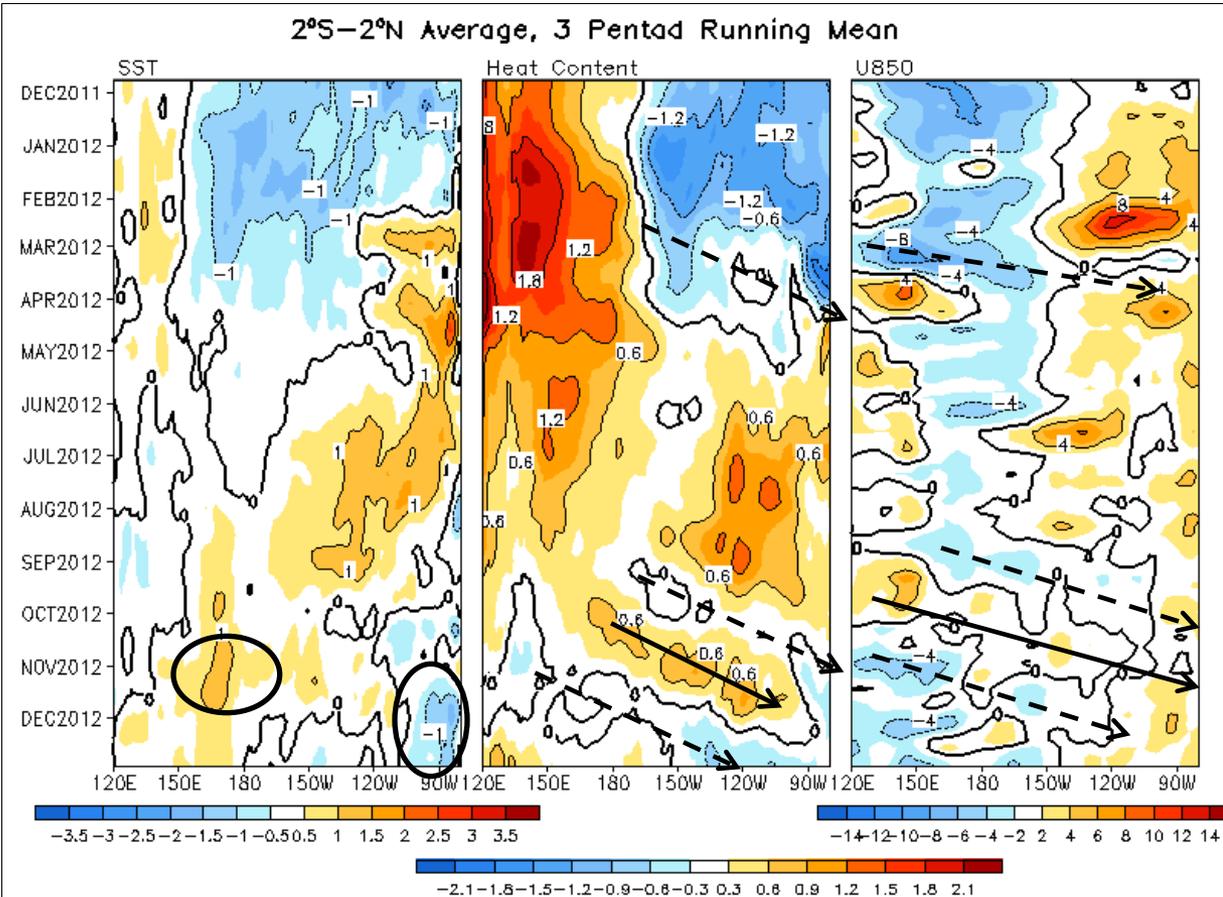
Fig. P1a. Niño region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies ($^{\circ}\text{C}$) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981–2010 (bar) and last ten year (green line) means.

Last Three Month SST, OLR and 925hp Wind Anom.



- The center of positive SSTA shifted westward, and below-normal SST expanded in the far E. Pacific, which enhances the east-west SST gradient.
- Easterly wind anomalies persisted in the western tropical Pacific during Oct-Dec 2012.

Equatorial Pacific SST ($^{\circ}\text{C}$), HC300 ($^{\circ}\text{C}$), u850 (m/s) and OLR(W/m^2) Anomalies

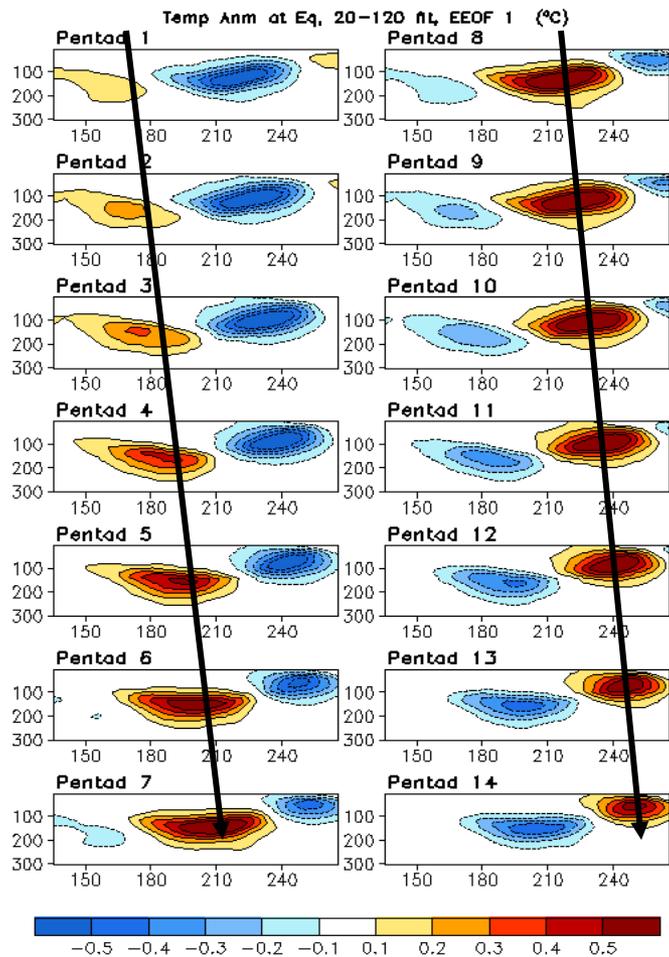


http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

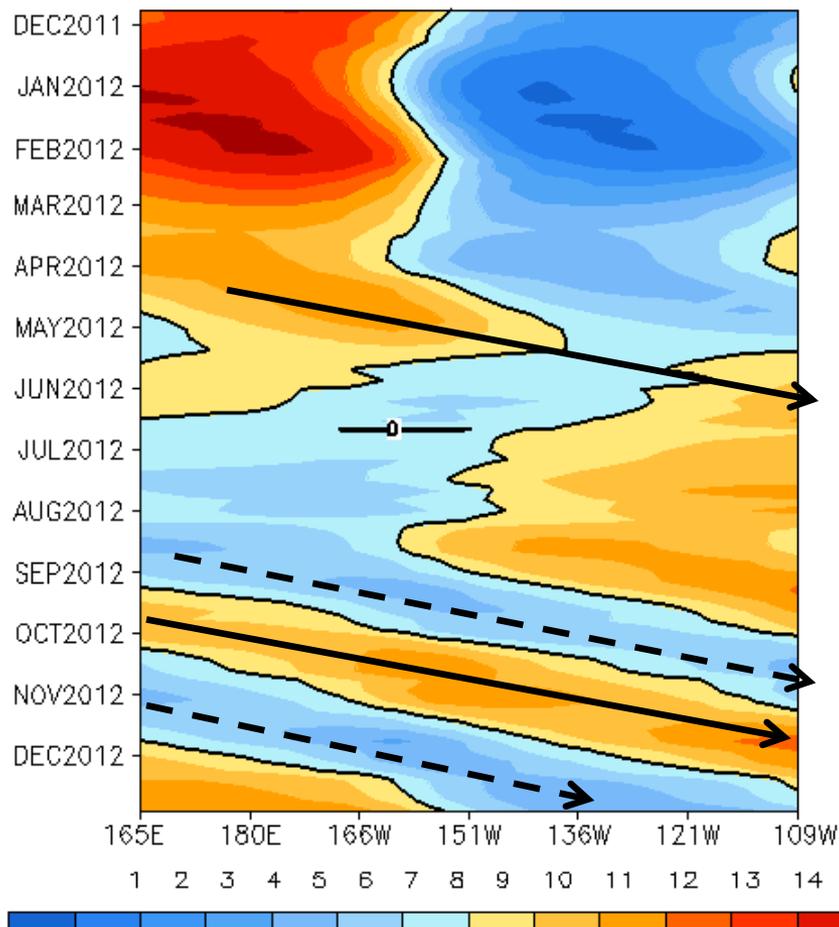
- Positive SSTA near 170E weakened, while negative SSTA persisted east of 110W.
- Negative HC300 anomalies propagated eastward and reached 120W, due to upwelling (dash lines) oceanic Kelvin waves.
- Upwelling (downwelling) oceanic Kelvin waves were forced by MJO-related easterly (westerly) surface wind 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 base period pentad means respectively.

Oceanic Kelvin Wave Indices

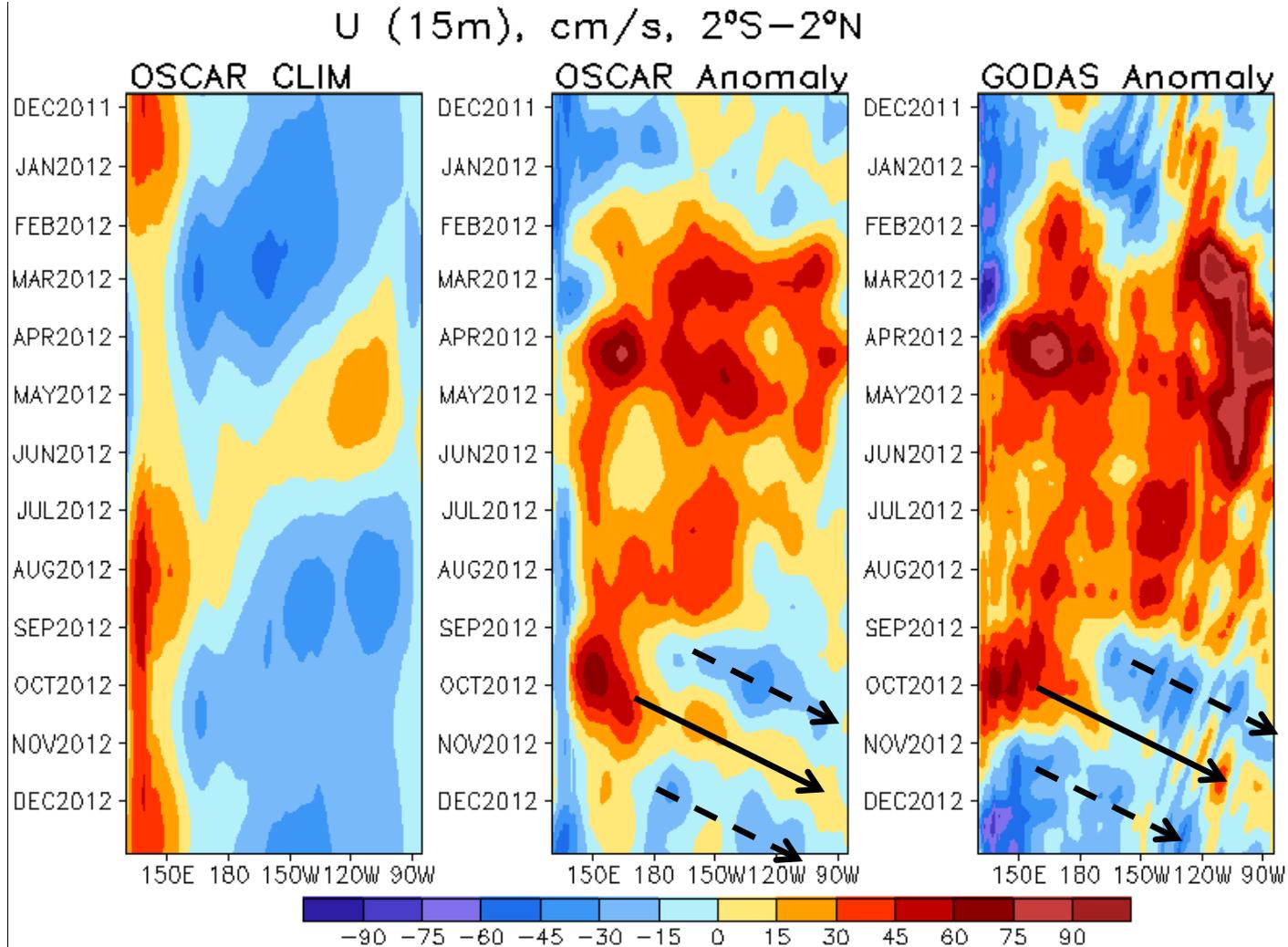


Standardized Projection on EEOF 1



- Upwelling oceanic Kelvin wave (OKW, dash line) emerged in early Nov in the W. Pacific and propagated eastward associated with the negative phase of MJO.
- Downwelling OKW (solid line) emerged in mid-Sep in the W. Pacific was associated with the positive phase of MJO, while upwelling OKW initiated in mid-Aug in the W. Pacific was associated with the negative phase of MJO.
- Oceanic Kelvin wave indices are defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF 1 of equatorial temperature anomalies (Seo and Xue, GRL, 2005).

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

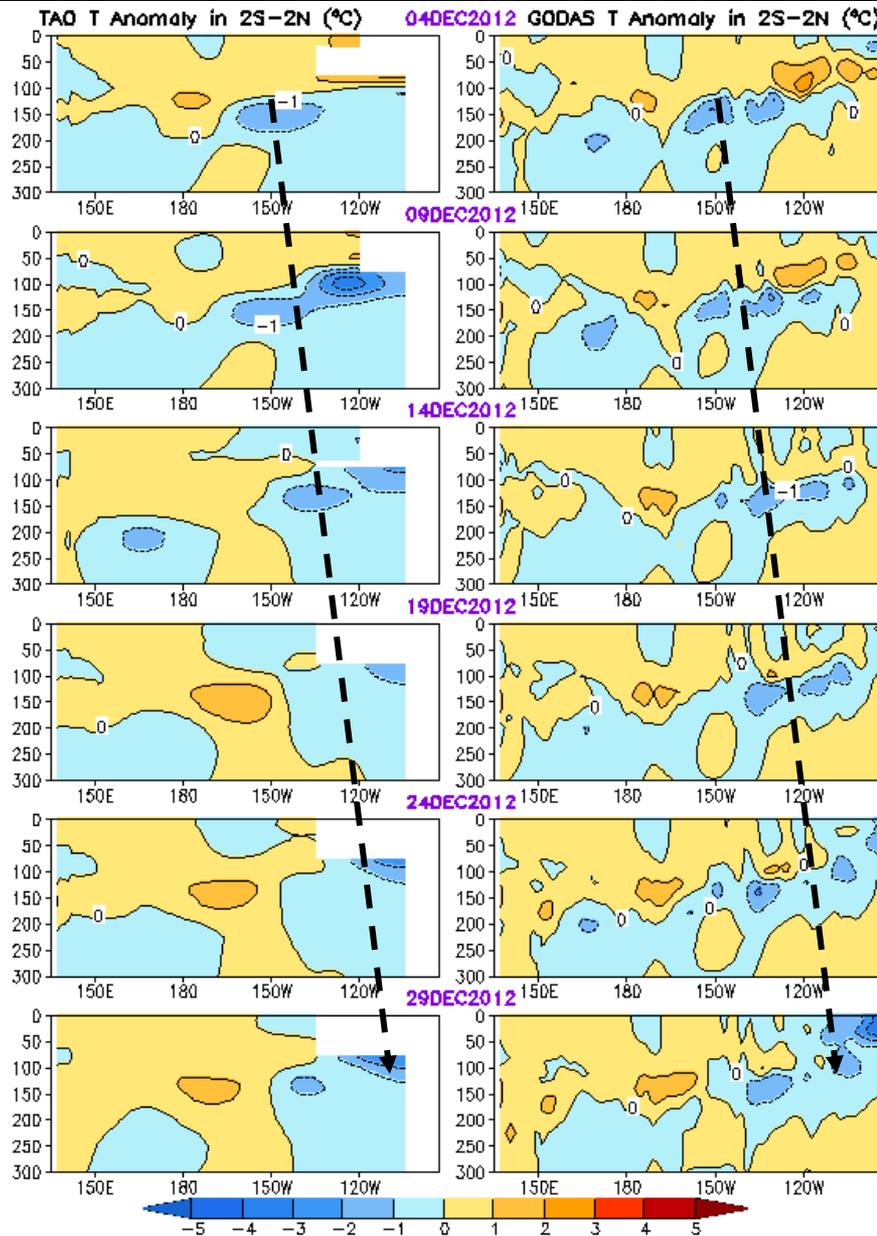


- Positive (negative) zonal current anomalies were associated with downwelling (upwelling) oceanic Kelvin waves.

TAO

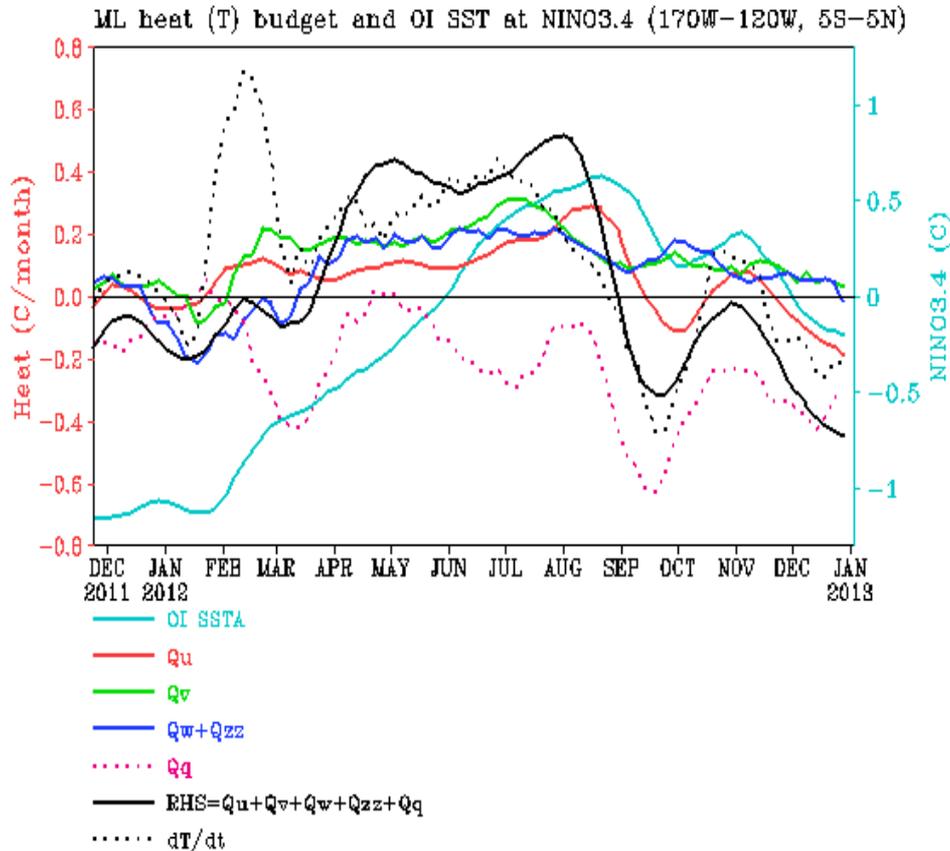
GODAS

Equatorial Pacific Temperature Anomaly



- Negative temperature anomalies near the thermocline propagated eastward, associated with upwelling oceanic Kelvin waves.

NINO3.4 Heat Budget



- SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was negative in Dec 2012, indicating a cooling tendency in NINO3.4.
- The cooling tendency was dominated by surface heat fluxes (Q_q) and zonal advection (Q_u).

Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, *J. Climate.*, 23, 4901-4925.

Q_u : Zonal advection; Q_v : Meridional advection;

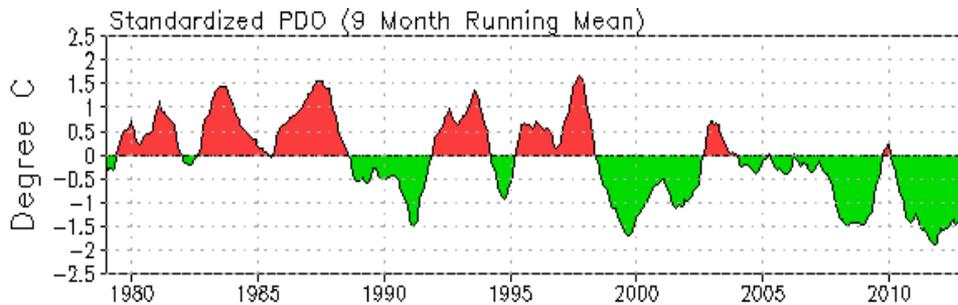
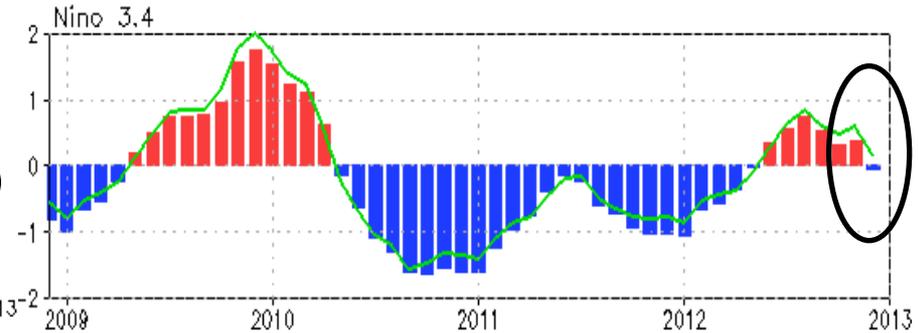
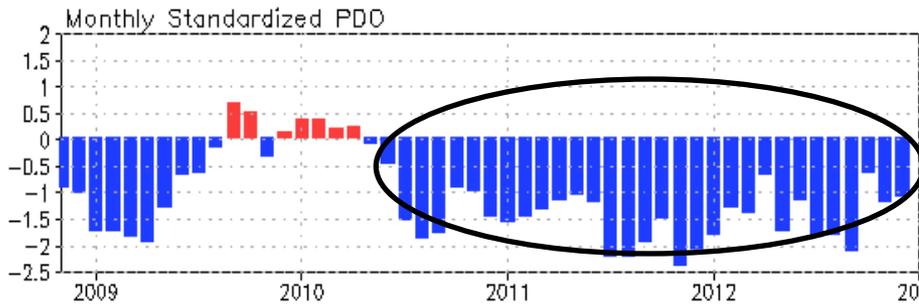
Q_w : Vertical entrainment; Q_{zz} : Vertical diffusion

Q_q : $(Q_{net} - Q_{open} + Q_{corr})/pcph$; $Q_{net} = SW + LW + LH + SH$;

Q_{open} : SW penetration; Q_{corr} : Flux correction due to relaxation to OI SST

North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index

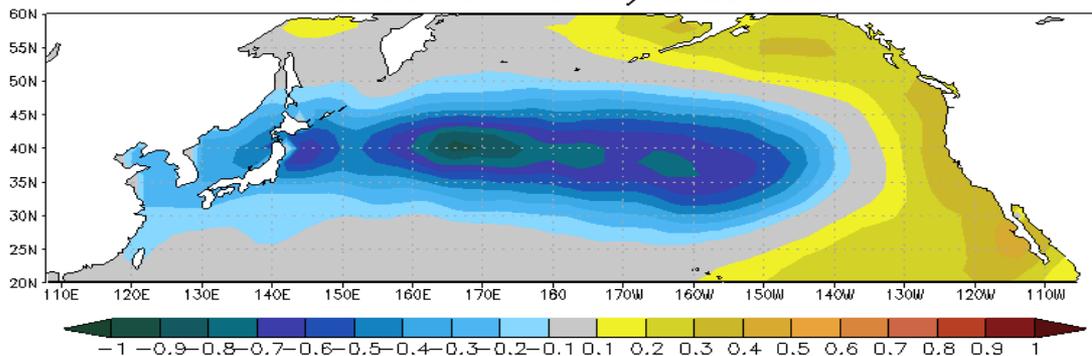


- Negative PDO phase since May 2010 has persisted for 32 months now, and the PDO index weakened slightly in Dec 2012 with PDO index = -1.1

- The apparent connection between NINO3.4 and PDO index suggest connections between tropics and extratropics.

- However, the negative phase of PDO since Jun 2012 seems not connected with the positive Nino3.4 SSTA.

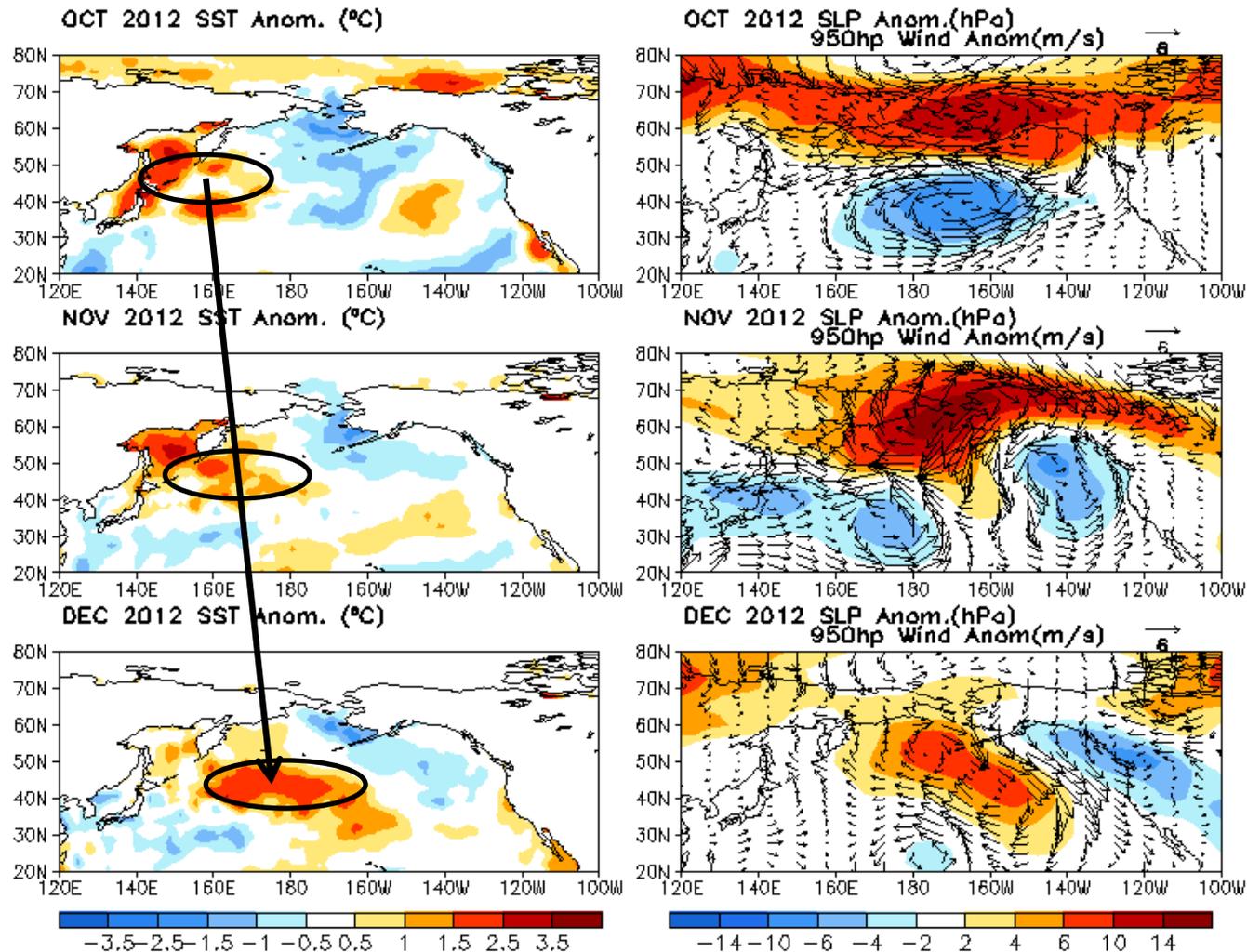
1st EOF of monthly ERSST v3b



- 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.

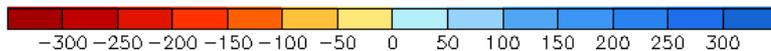
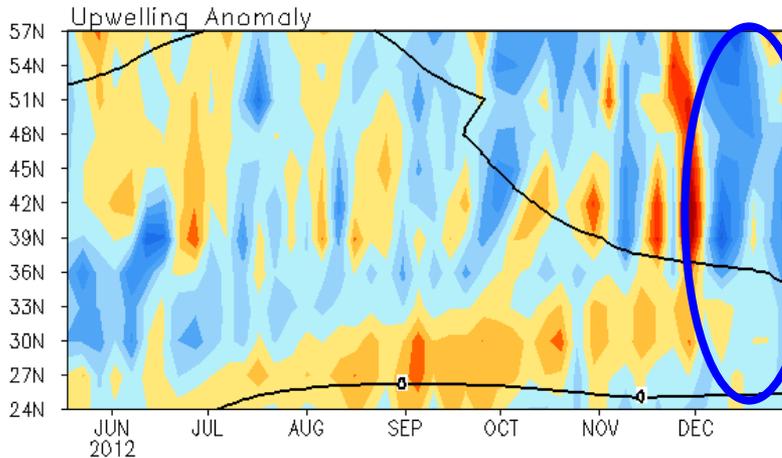
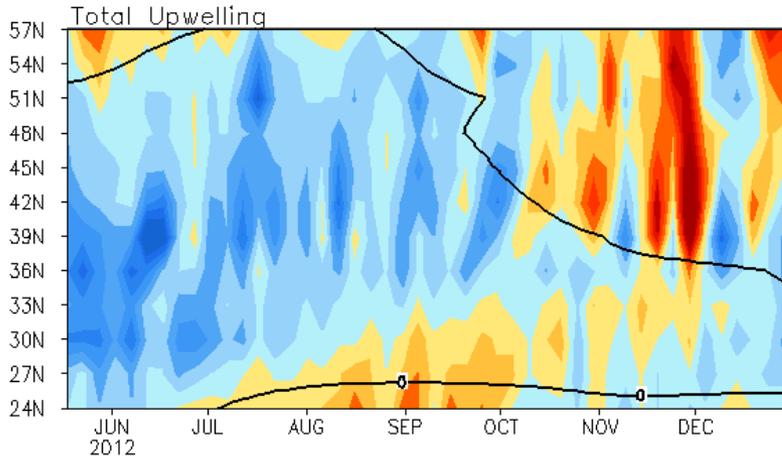
Last Three Month SST, SLP and 925hp Wind Anom.



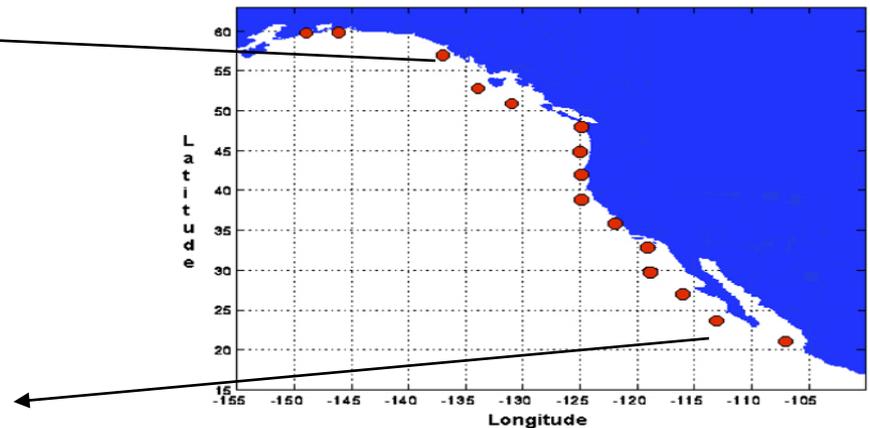
- Positive SSTA shifted eastward, and strengthened in the central N. Pacific.
- Anomalous anticyclone was observed near the west coast of North America, favorable for upwelling.

North America Western Coastal Upwelling

Pentad Coastal Upwelling for West Coast North America
($m^3/s/100m$ coastline)



Standard Positions of Upwelling Index Calculations



- Seasonal upwelling (downwelling) was enhanced (weakened) south (north) of 36N.

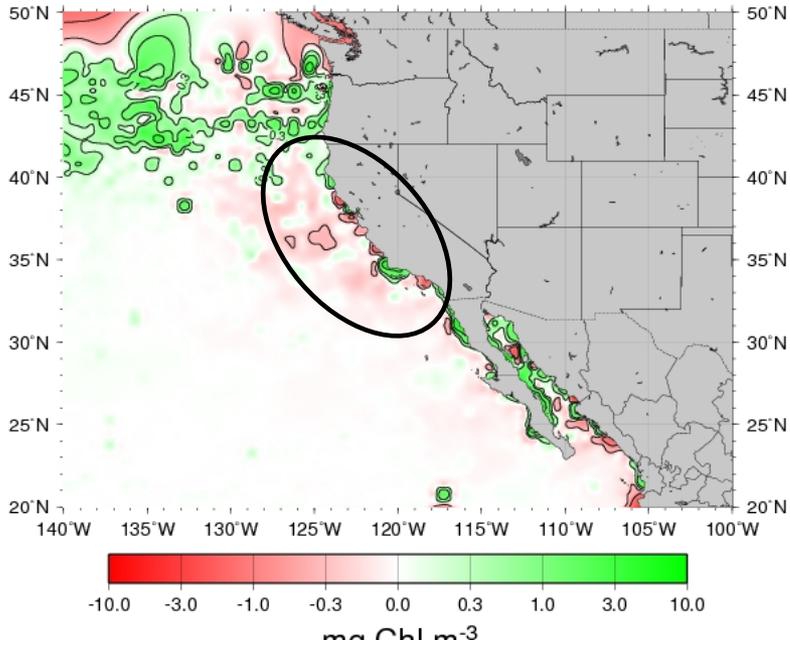
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1981-2010 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

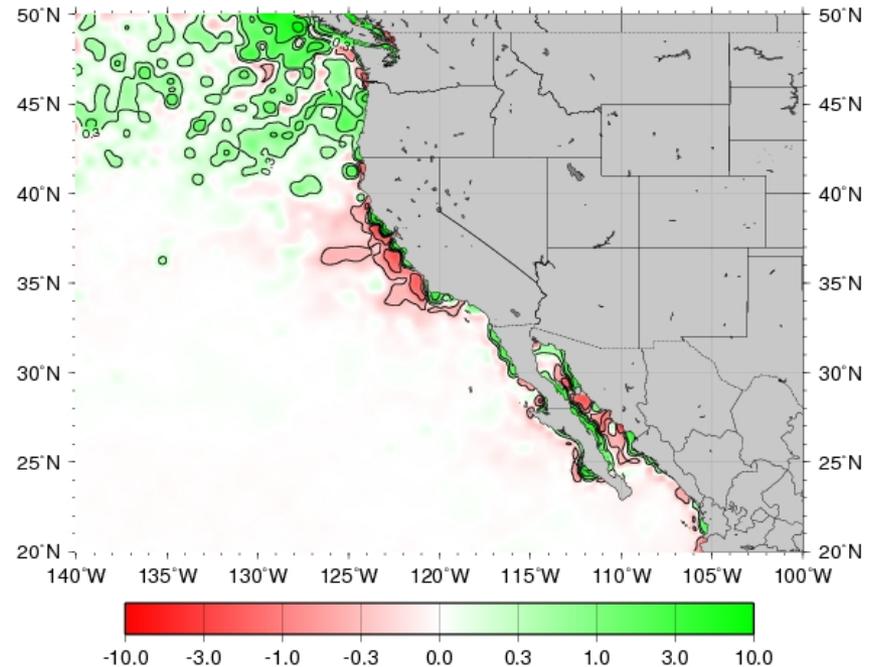
<http://coastwatch.pfel.noaa.gov/FAST>

MODIS Aqua Chlorophyll a Anomaly for December, 2012



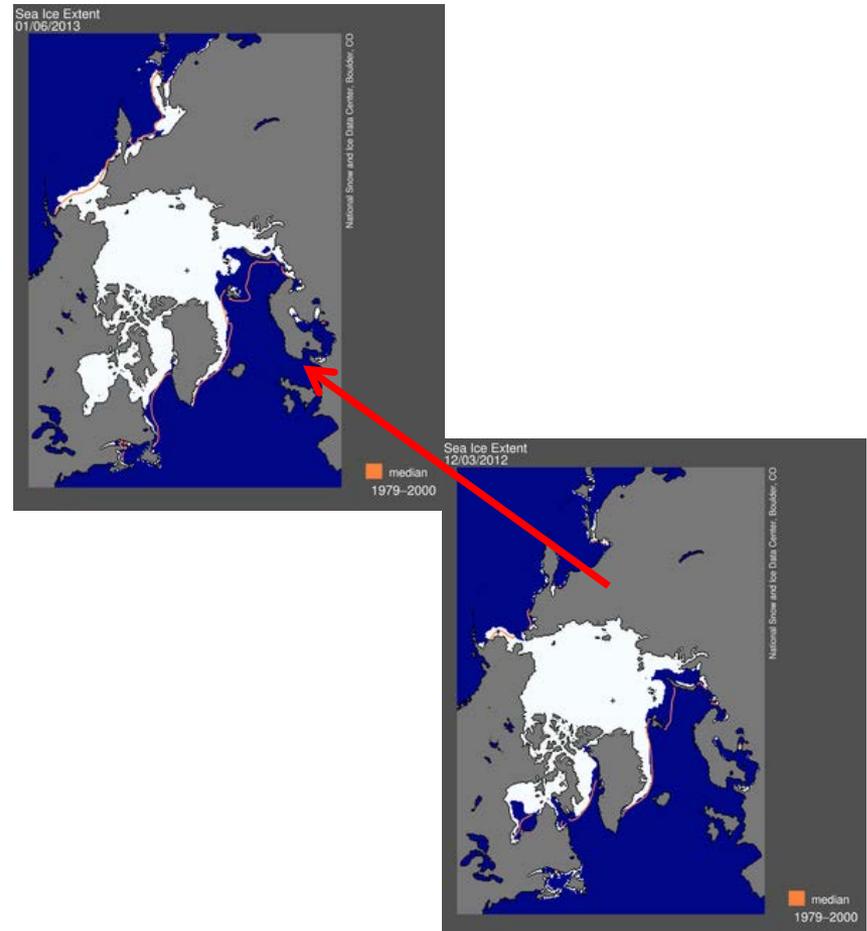
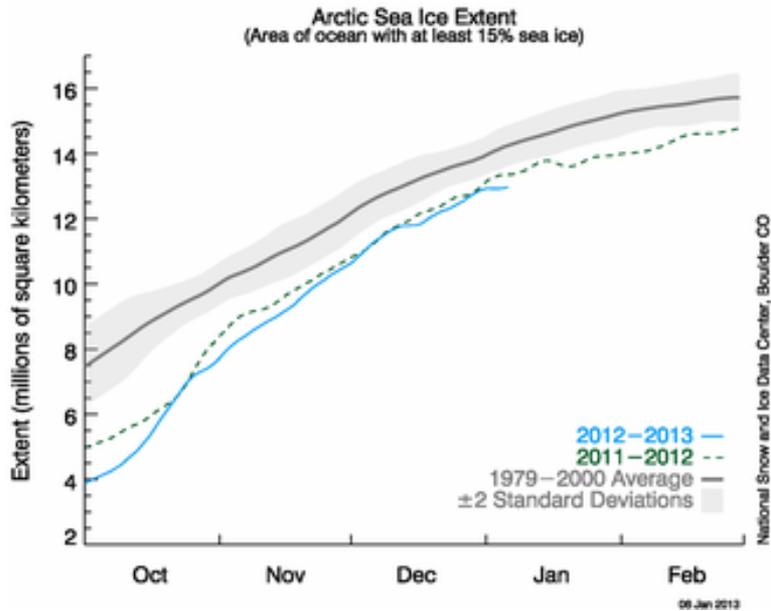
- Negative Chlorophyll anomaly weakened south of 40N.

MODIS Aqua Chlorophyll a Anomaly for November, 2012



Arctic Sea Ice

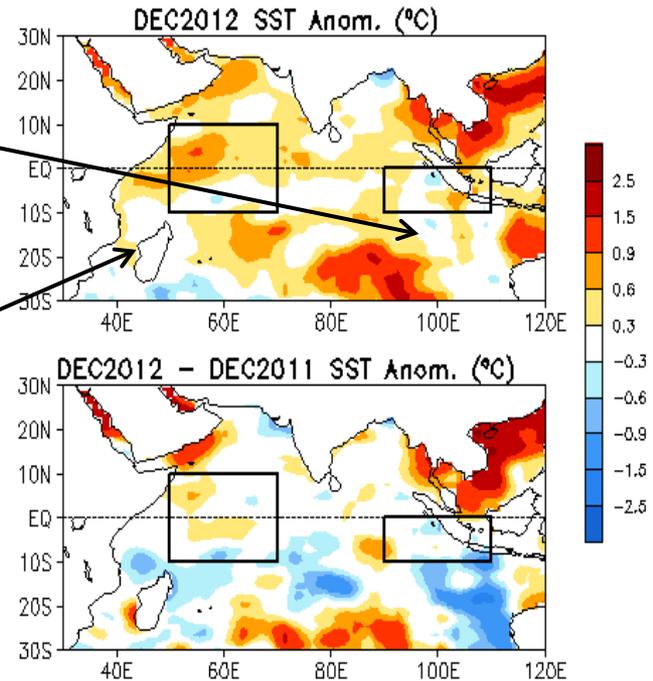
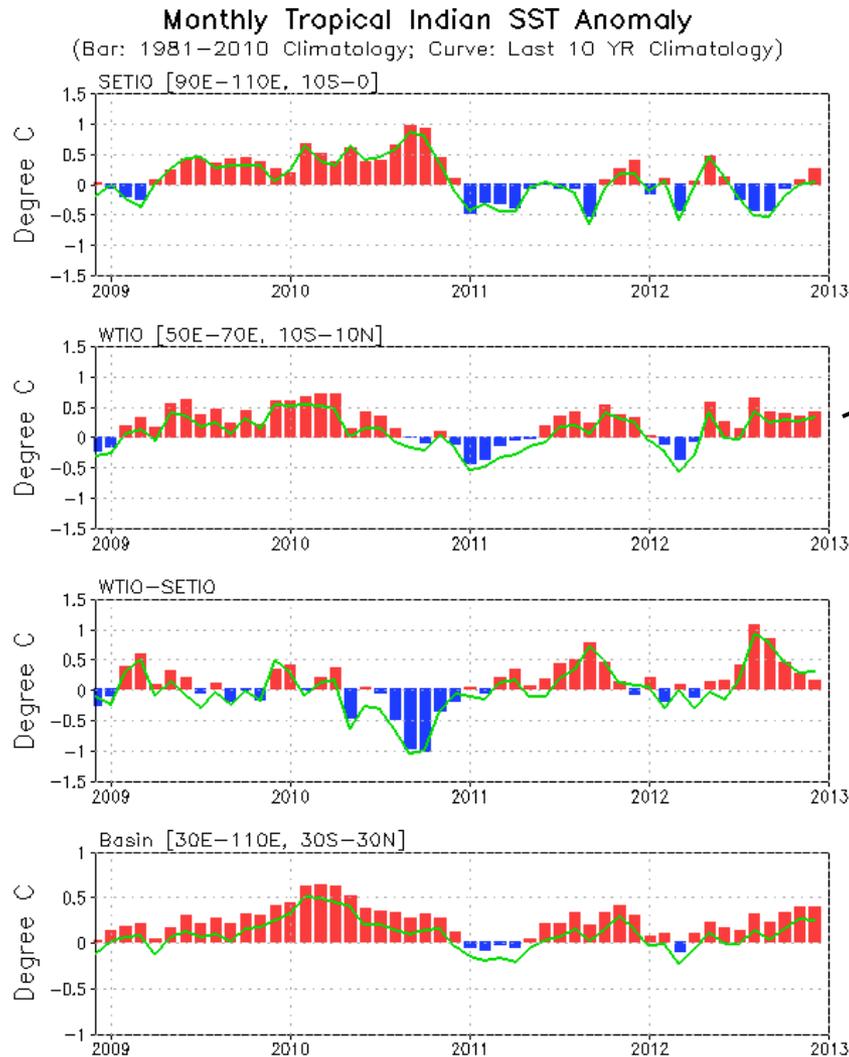
<http://nsidc.org/arcticseaicenews/index.html>.



- Average sea ice extent for Dec 2012 was similar to Dec 2011.

Indian Ocean

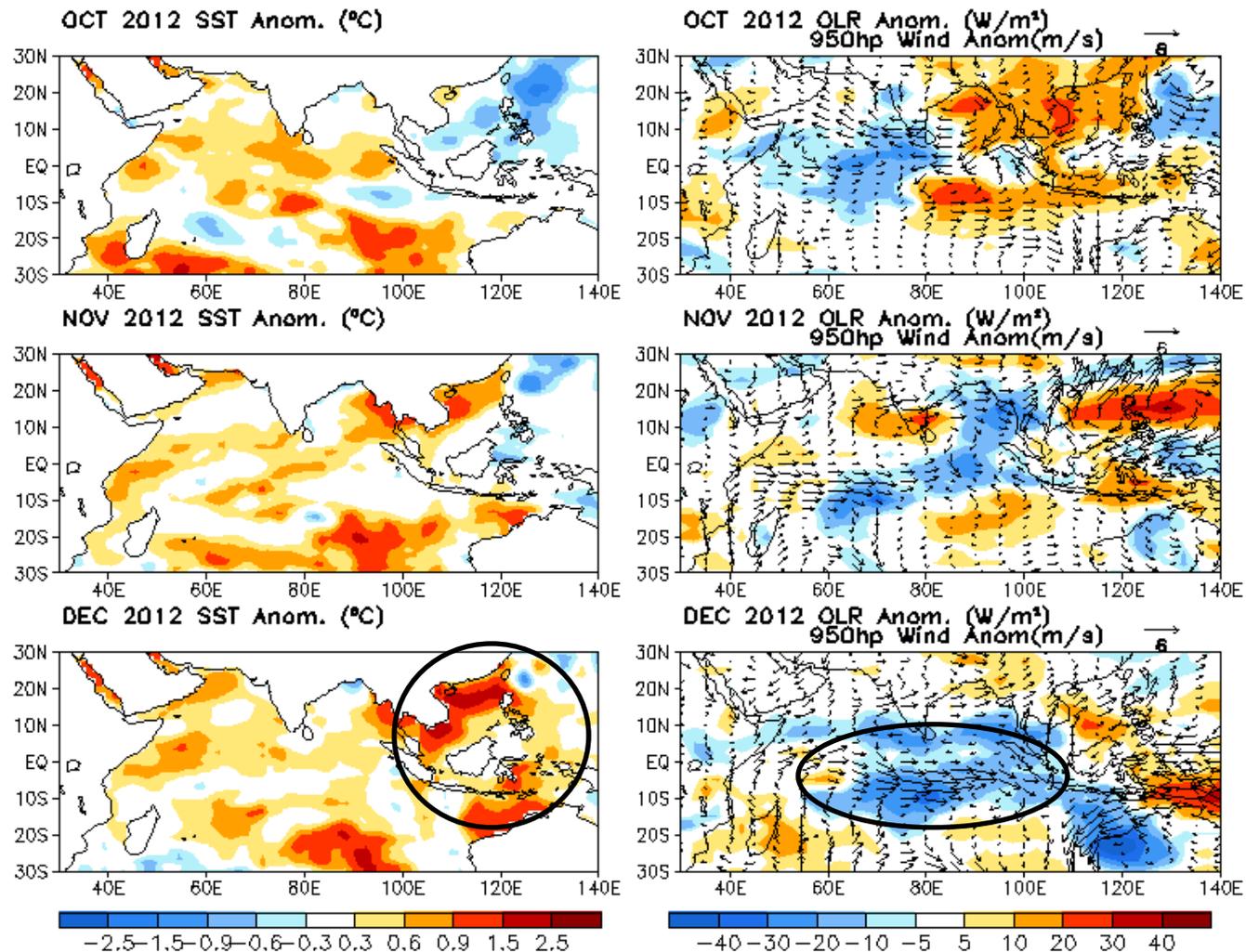
Evolution of Indian Ocean SST Indices



- DMI was near normal.
- The basin mean SSTA was above-normal.

Fig. 11a. 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 departures from the 1981–2010 base period means and the recent 10 year means are shown in bars and green lines.

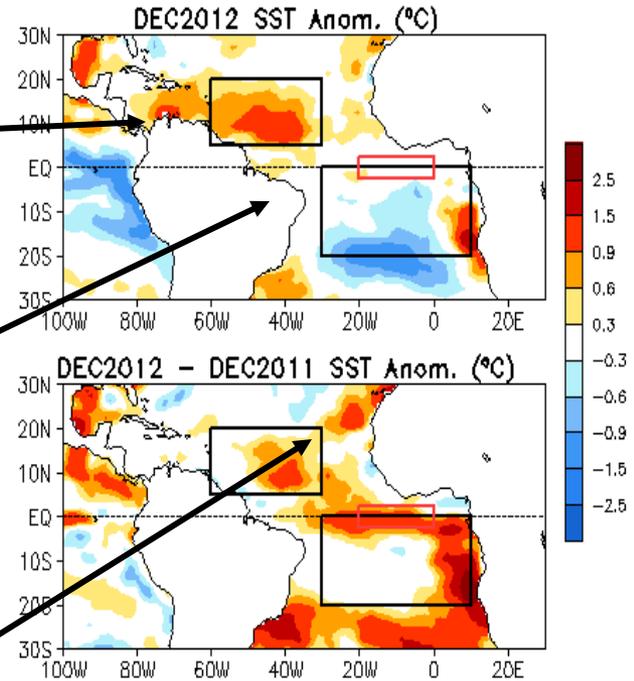
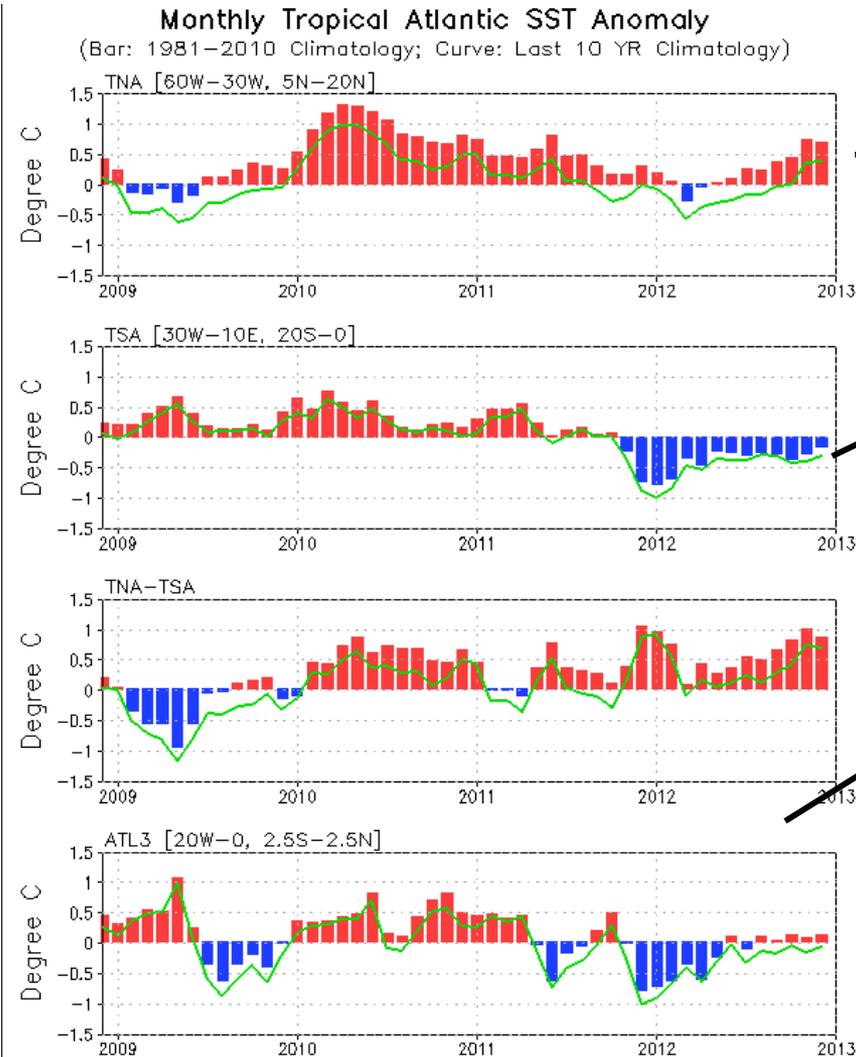
Last Three Month SST, SLP and 925hp Wind Anom.



- Positive SSTA strengthened in South China Sea and north of Australia.
- Convection was enhanced in the central tropical Indian Ocean and northwestern Australia.

Tropical and North Atlantic Ocean

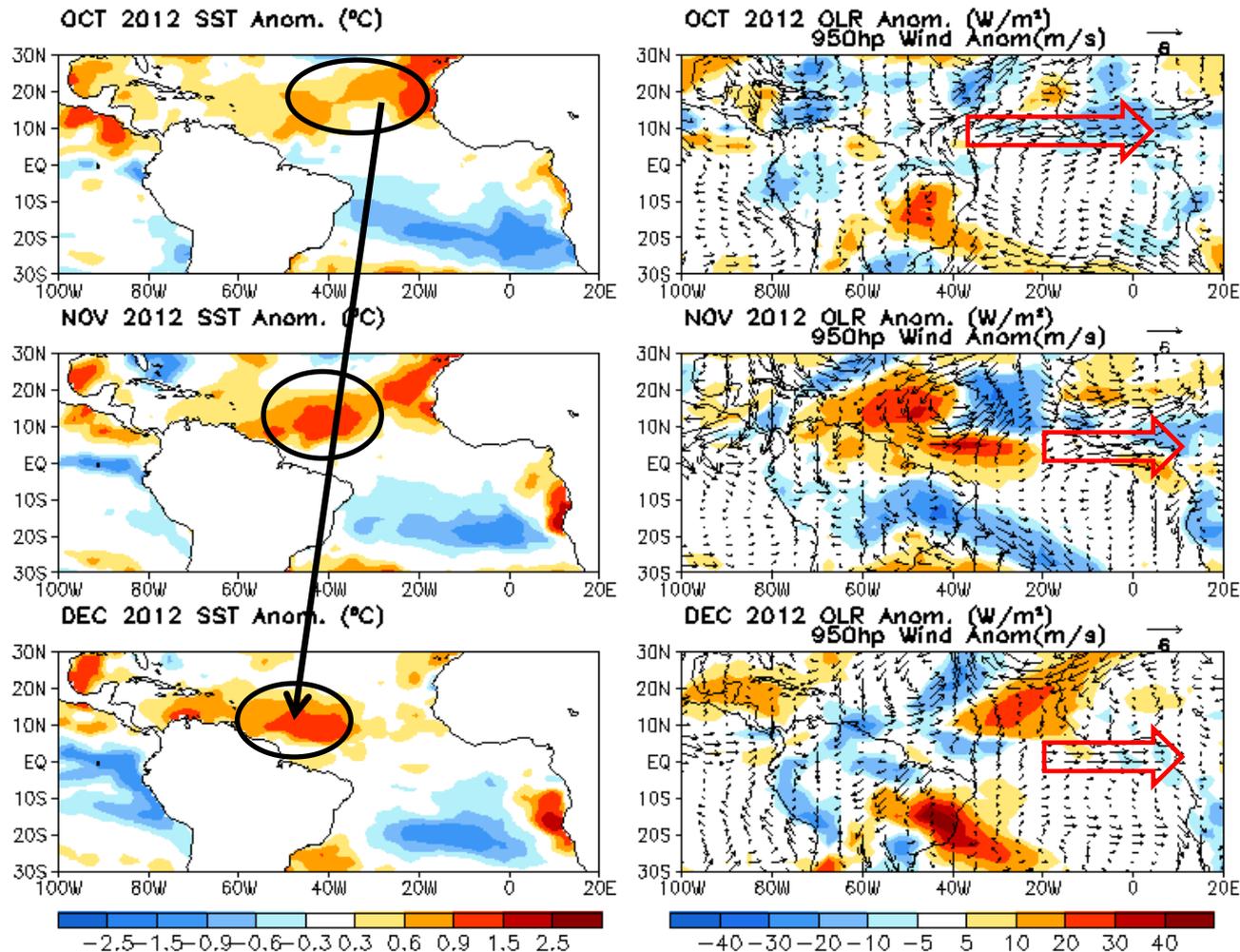
Evolution of Tropical Atlantic SST Indices



- Positive SSTA in the tropical North Atlantic (TNA) persisted.
- Positive Meridional Gradient Mode index (TNA-TSA) also persisted.
- ATL3 SSTA was near-normal since Jun 2012.

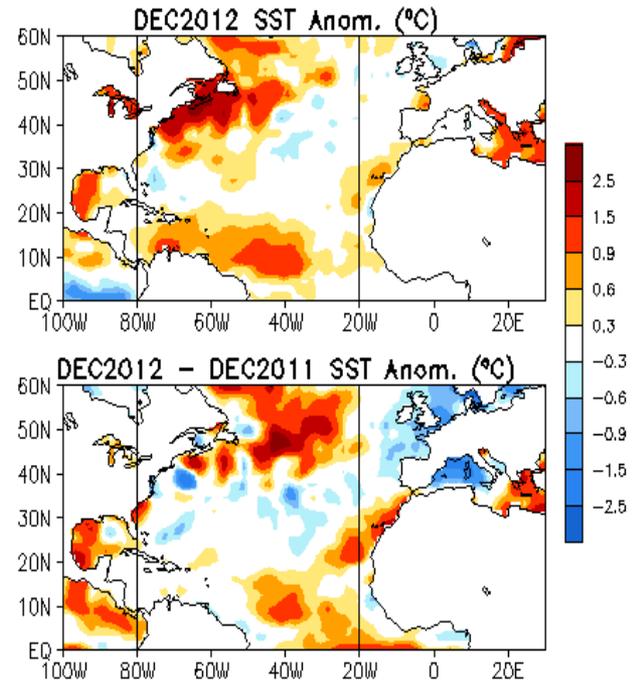
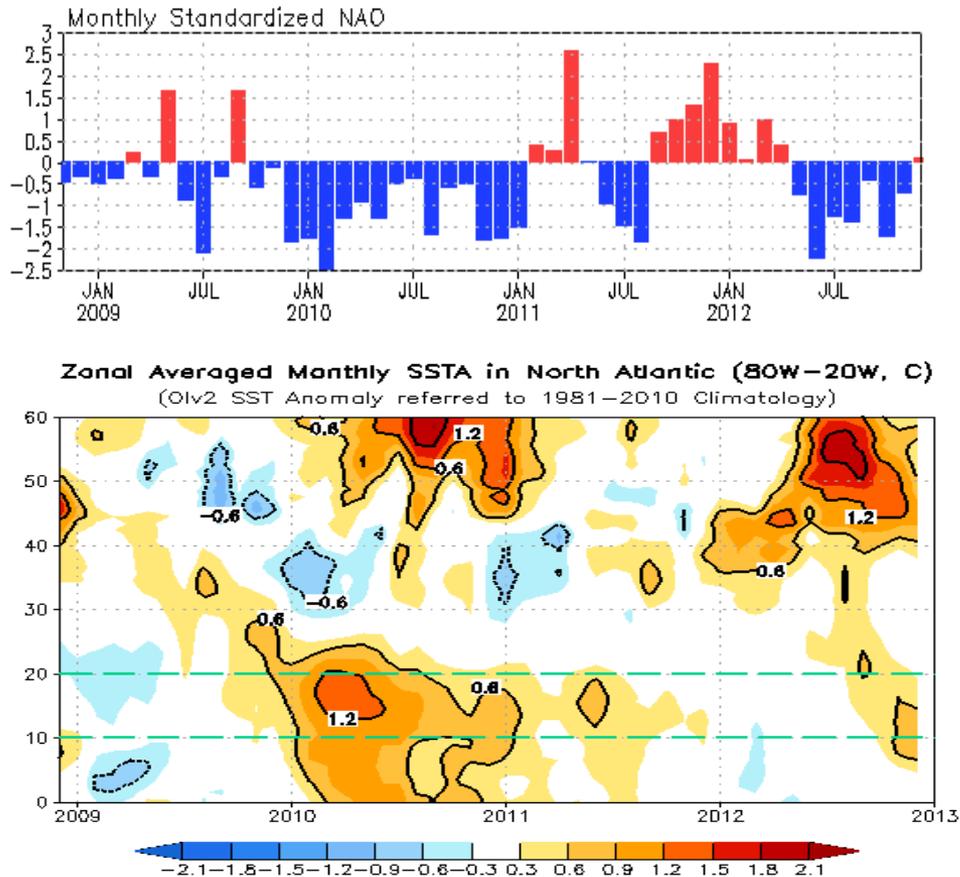
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between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

Last Three Month SST, SLP and 925hp Wind Anom.



- Positive SSTA persisted and shifted westward.
- Low-level westerly wind anomalies that blew toward North Africa have persisted from Oct to Dec 2012.

NAO and SST Anomaly in North Atlantic



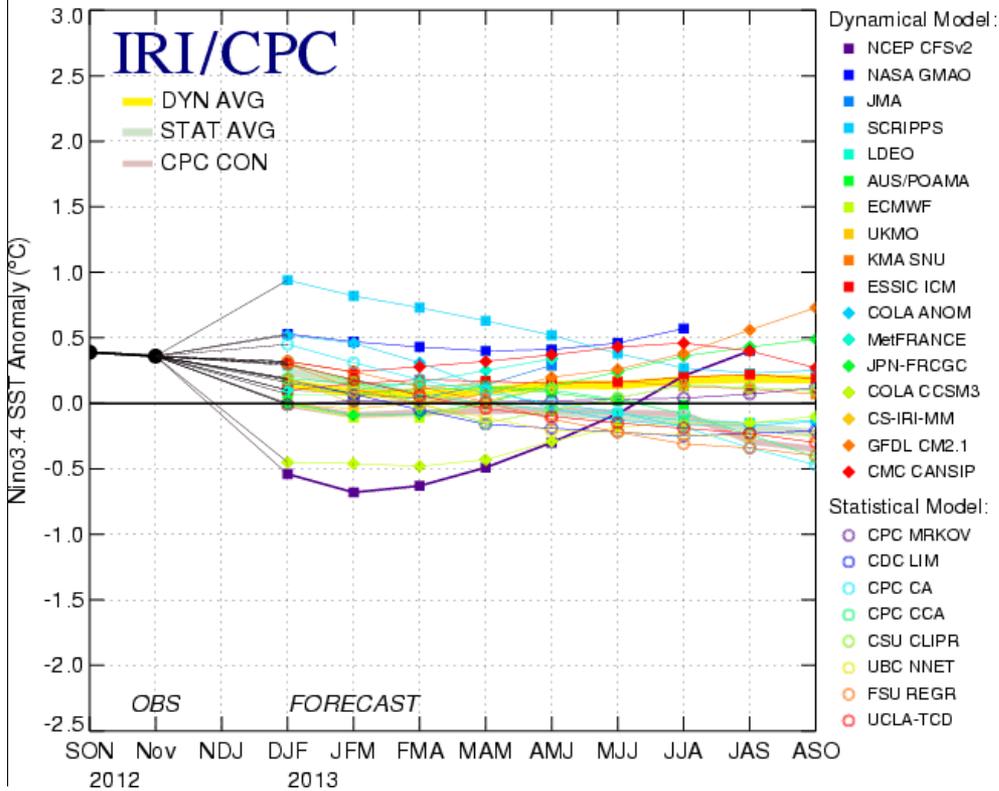
- Negative NAO index that has persisted for 7 months returned to near-normal in Dec 2012.
- Positive SSTA in high-latitude N. Atlantic weakened, probably due to weakening of negative NAO.

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (<http://www.cpc.ncep.noaa.gov>). Time-Latitude section of SST anomalies averaged between 80°W and 20°W (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

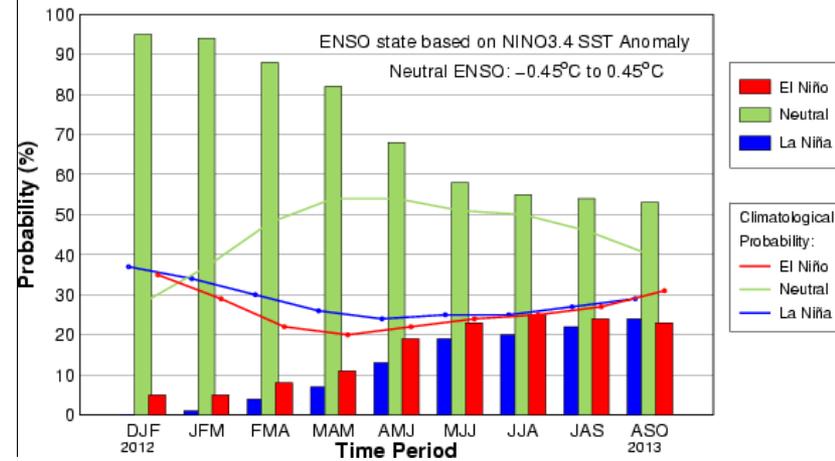
Global SST Predictions

IRI/CPC NINO3.4 Forecast Plume

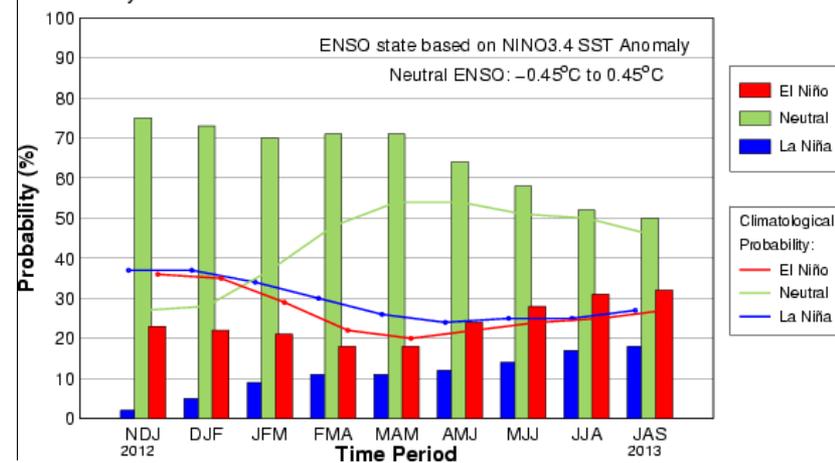
Mid-Dec 2012 Plume of Model ENSO Predictions



Mid-Dec IRI/CPC Plume-Based Probabilistic ENSO Forecast



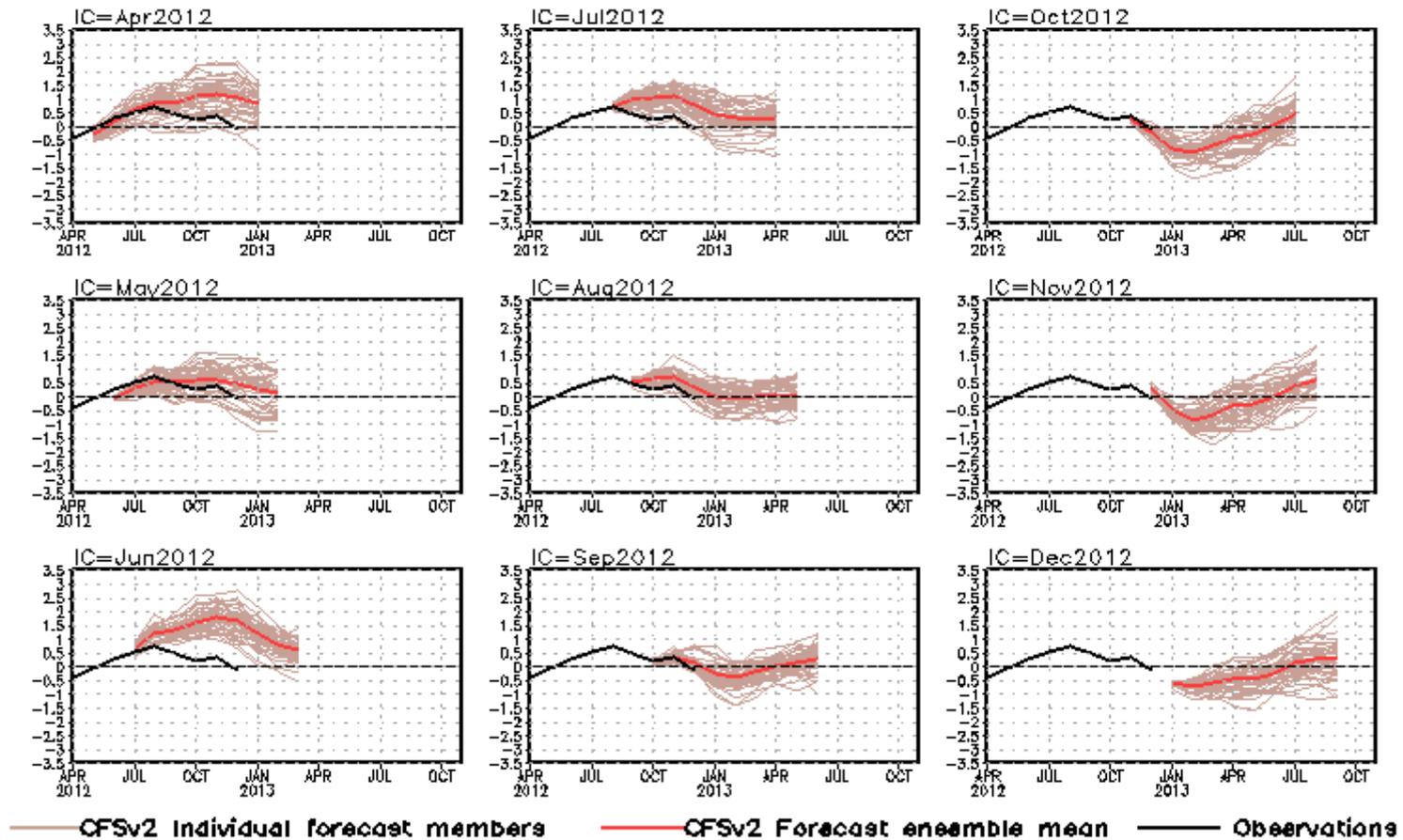
Early-Dec CPC/IRI Consensus Probabilistic ENSO Forecast



- Most of the models predicted ENSO-neutral in the coming Northern Hemisphere winter and spring.
- The consensus forecast favors ENSO-neutral conditions in the winter and next spring.

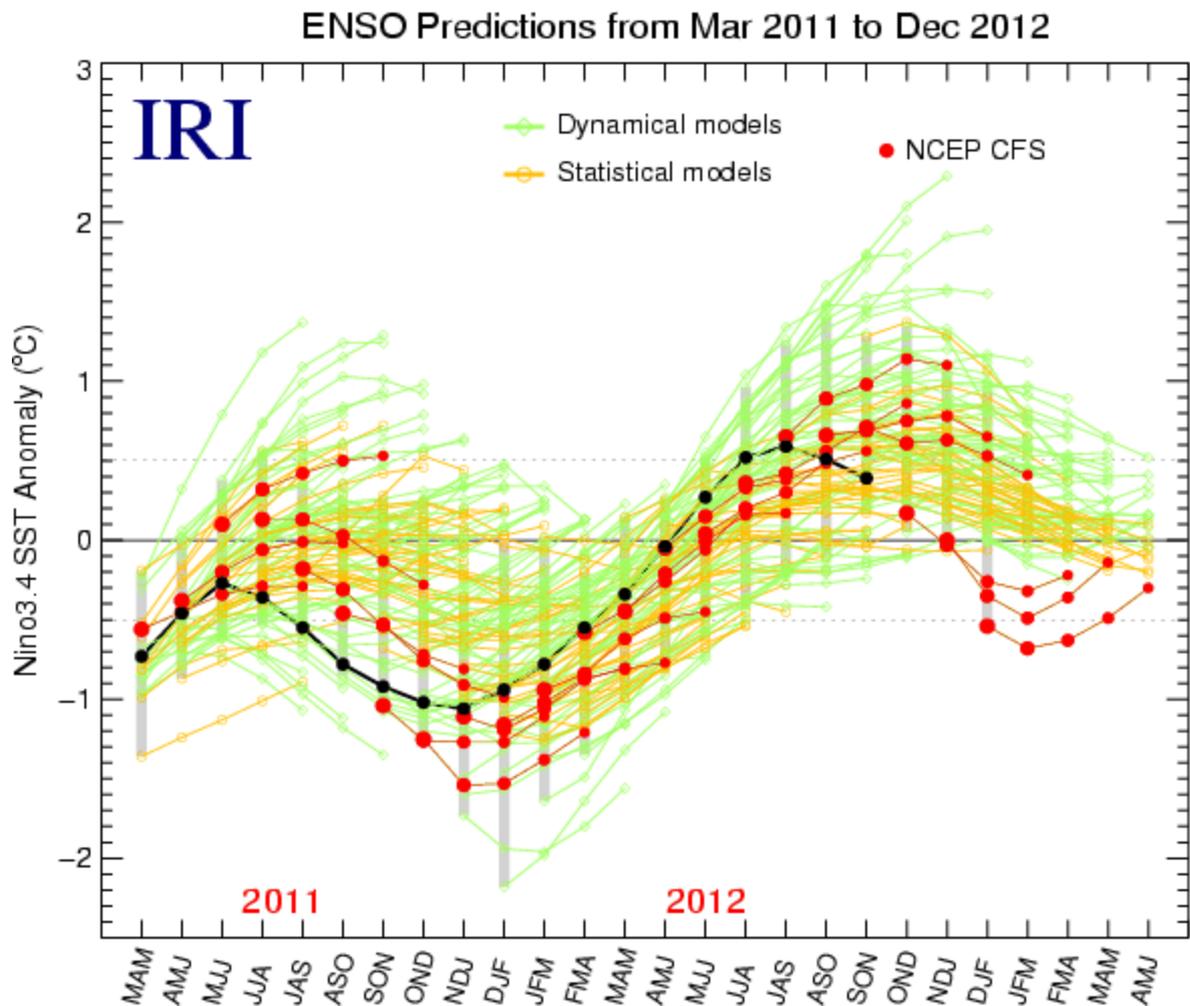
NCEP CFSv2 NINO3.4 Forecast

NINO3.4 SST anomalies (K)



- CFSv2 has persistently forecast cold anomalies for the Northern Hemisphere winter 2012/13 and spring 2013 from Oct to Dec initial conditions.

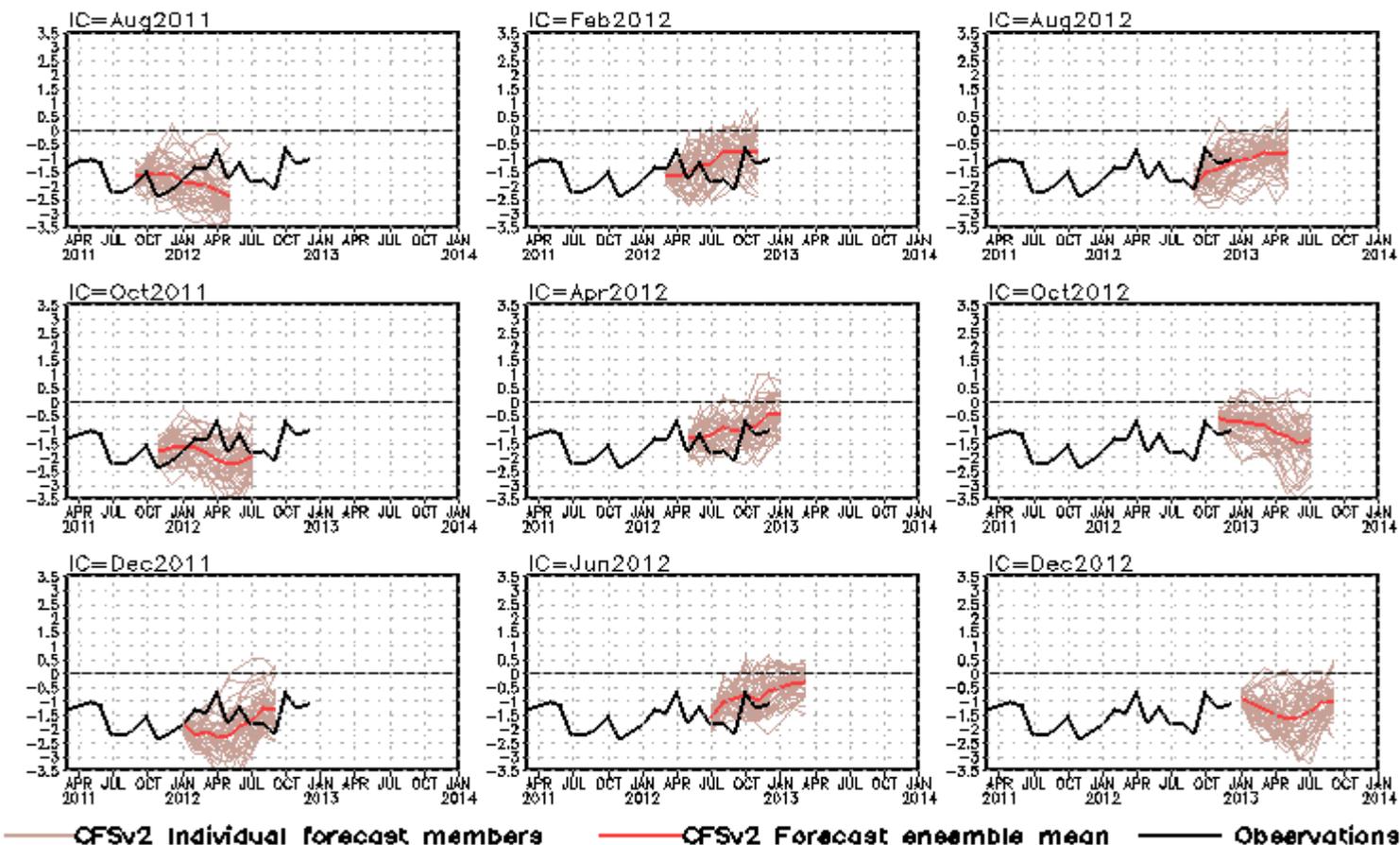
CFSv2 Forecasts over Last 22 Months



- CFSv2 forecasts are much colder than other model forecasts.

NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

standardized PDO index



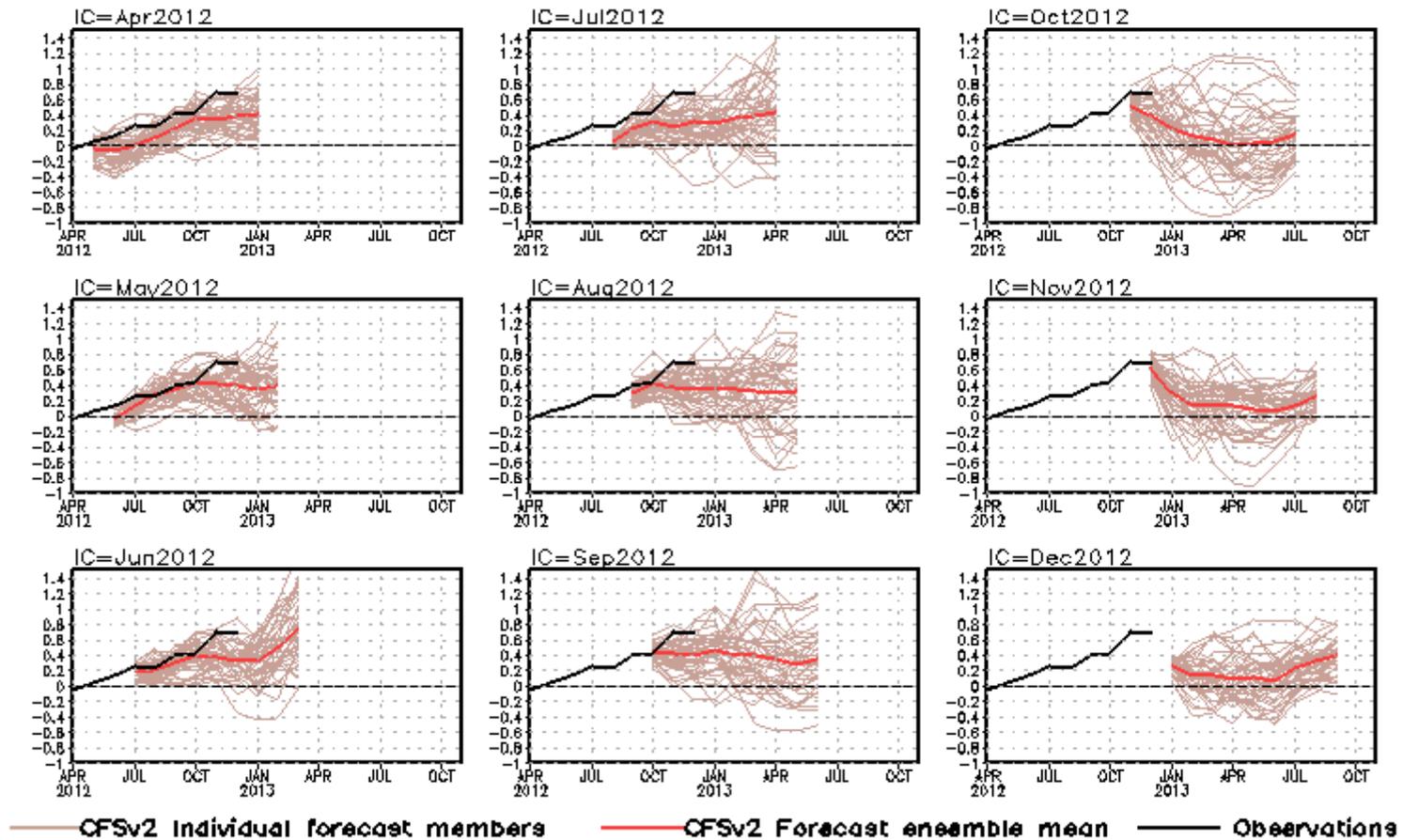
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- Latest CFSv2 prediction suggests negative PDO will strengthen in next spring and summer.

NCEP CFSv2 Tropical North Atlantic SST Forecast

Tropical N. Atlantic SST anomalies (K)



- Latest CFSv2 prediction suggests tropical North Atlantic SST will cool down and return to near-normal in late winter and next spring.
- The CFSv2 underestimated the warming tendency since spring 2012.

Overview

▪ Pacific and Arctic Oceans

- ENSO-neutral conditions continued during Dec 2012.
- A strong cooling tendency was observed in the central-eastern tropical Pacific near the thermocline due to propagation of upwelling oceanic Kelvin waves.
- The consensus forecast favors ENSO-neutral conditions to continue into the Northern Hemisphere spring 2013.
- Negative PDO phase persisted with $\text{PDO} = -1.1$ in Dec 2012, and NCEP CFSv2 predicted negative PDO phase would continue into next spring.
- Arctic sea ice extent in Dec 2012 was below-normal and similar to that in Dec 2011.

▪ Indian Ocean

- Indian Ocean Dipole was near-normal in Dec 2012.

▪ Atlantic Ocean

- Negative NAO phase that has persisted from May to Nov 2012 returned to near-normal in Dec 2012.
- Positive SSTA in high-latitude N. Atlantic weakened, while positive SSTA in tropical N. Atlantic persisted.

Backup Slides

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

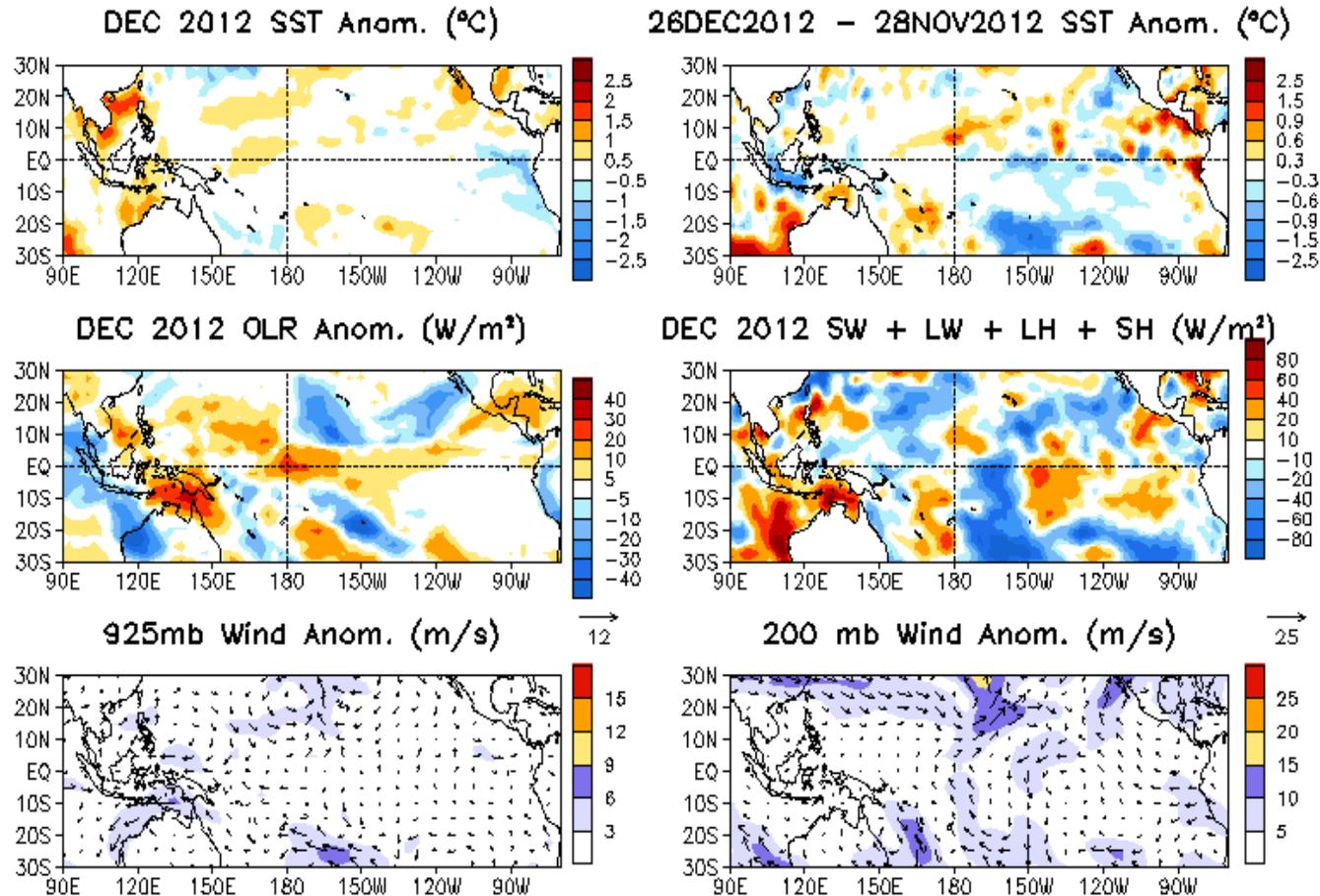


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 1981-2010 base period means.

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

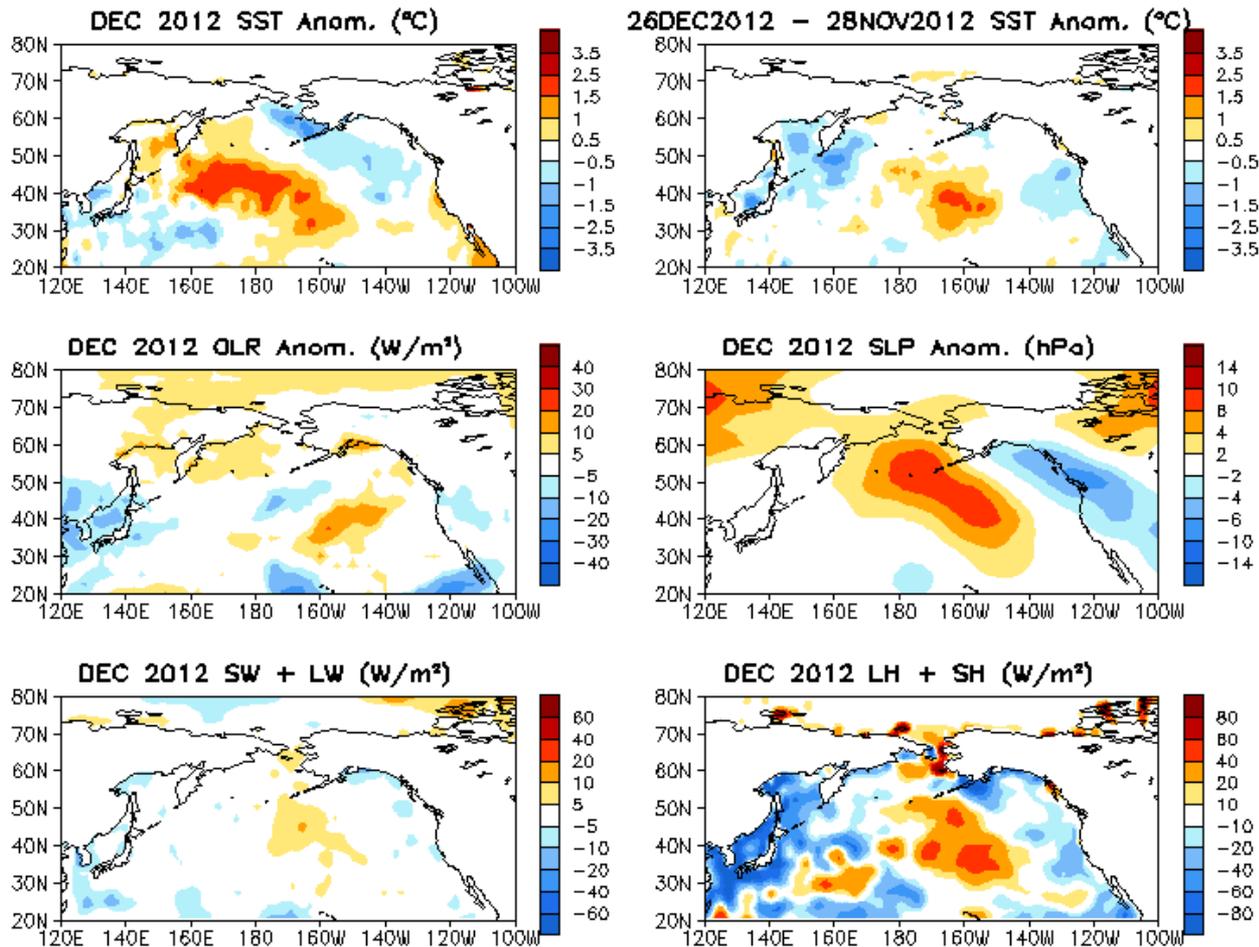


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1981-2010 base period means.

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

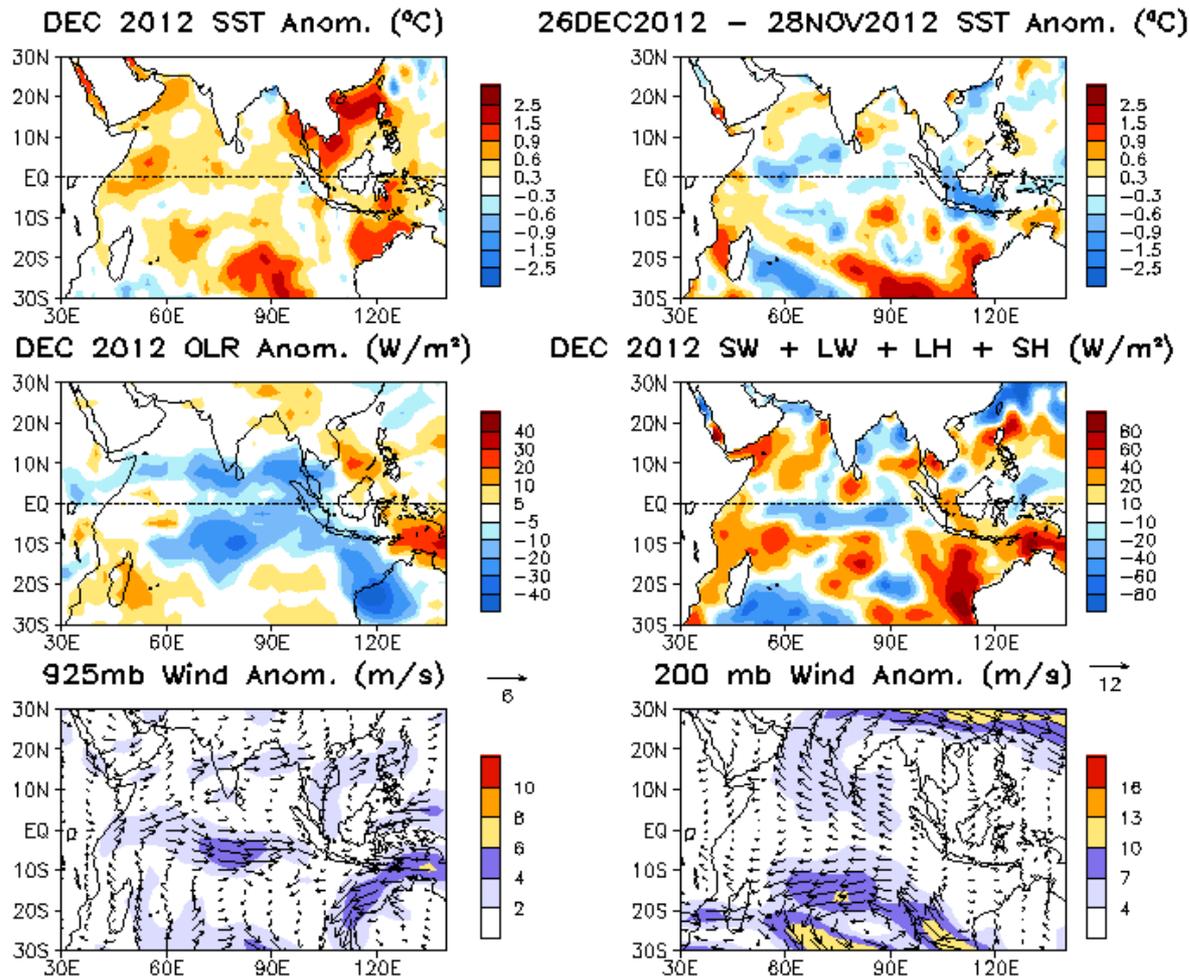
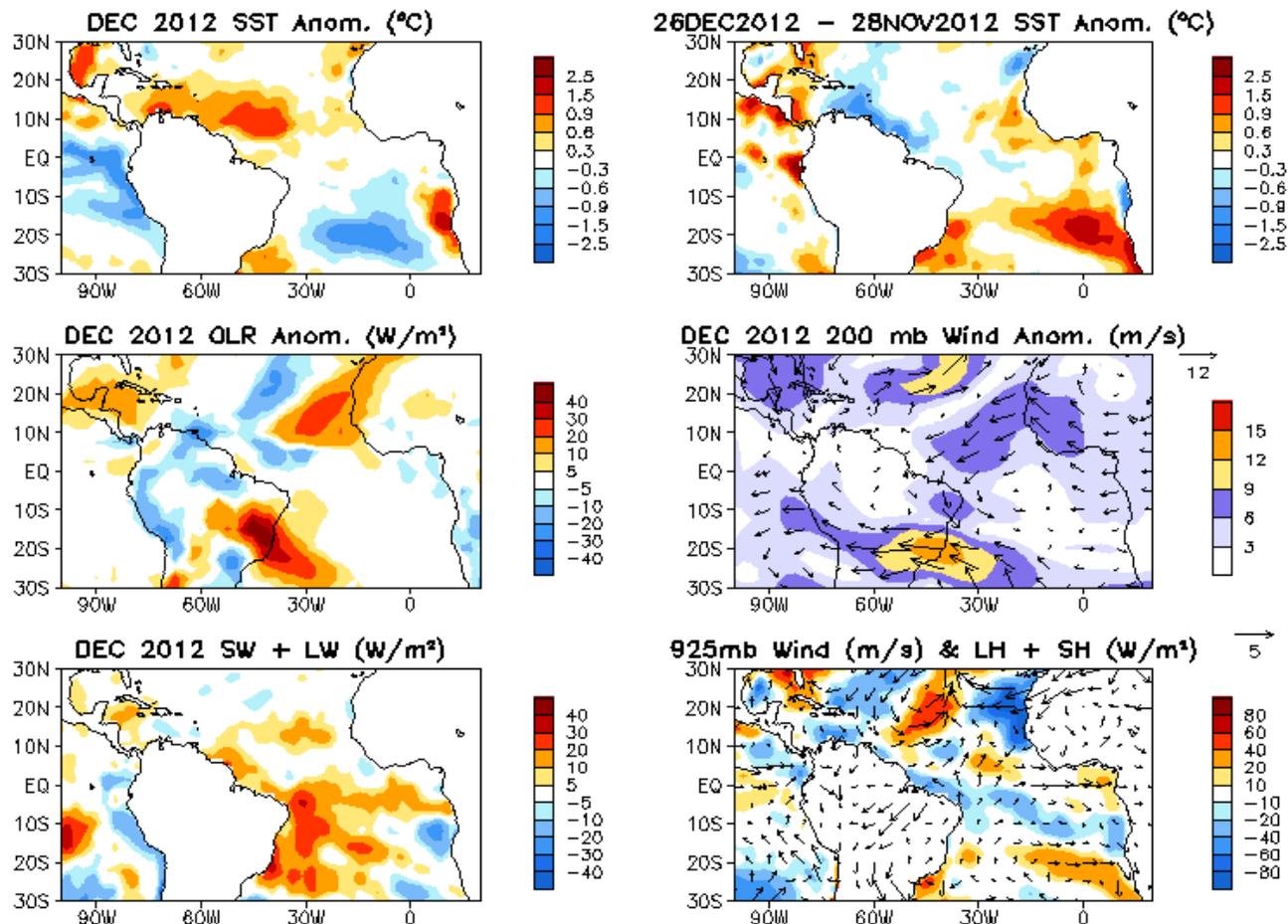


Fig. 12. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 1981-2010 base period means.

Tropical Atlantic:

SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb/200-mb Winds



- Above-normal SSTA persisted in the hurricane Main Development Region (MDR) .
- Below-normal vertical wind shear presented in MDR.
- Convection was suppressed (enhanced) in the western (eastern) tropical North Atlantic.
- Westerly low-level wind blew towards the western Africa, indicating enhanced west African monsoon.

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

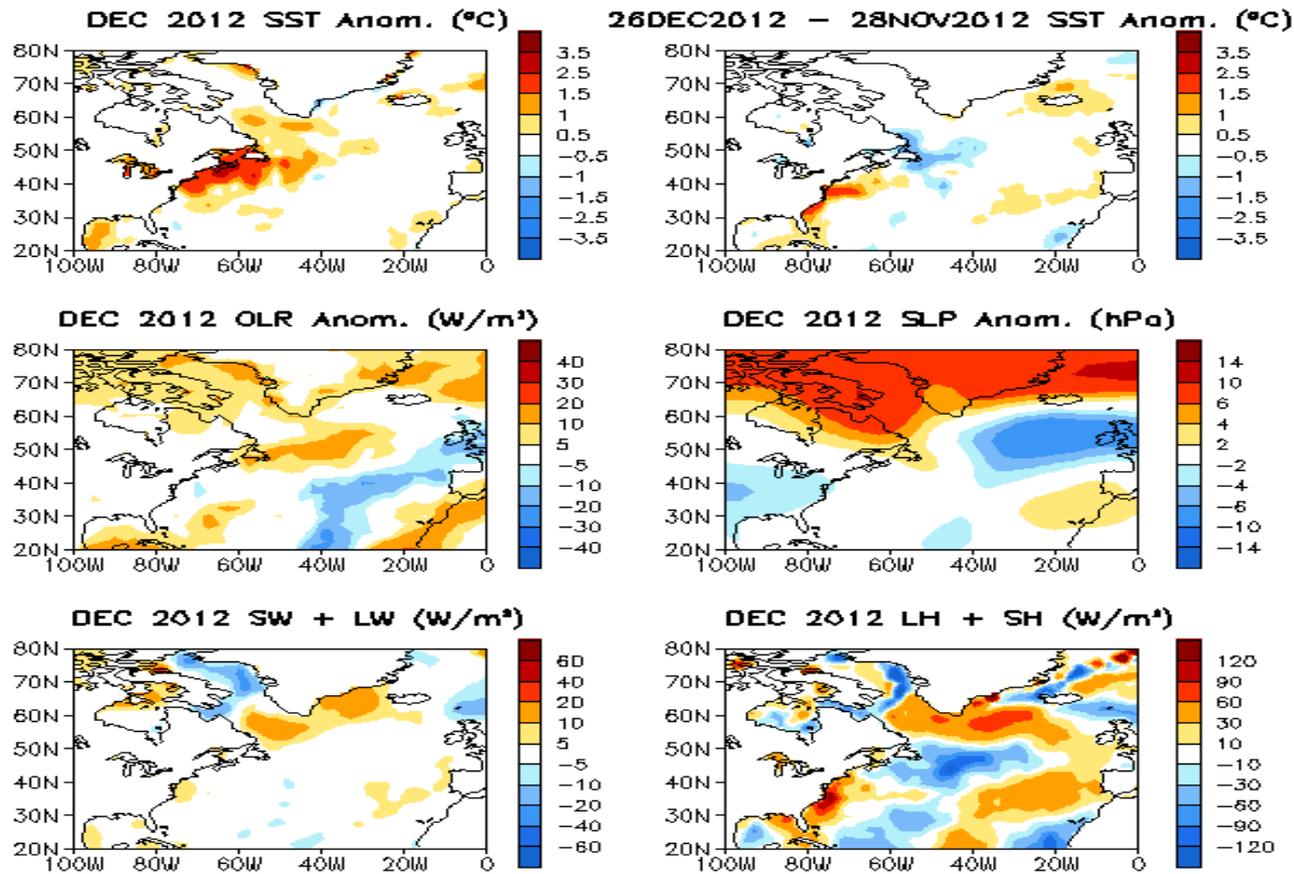


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

NCEP CFS DMI SST Predictions from Different Initial Months

Indian Ocean Dipole SST anomalies (K)

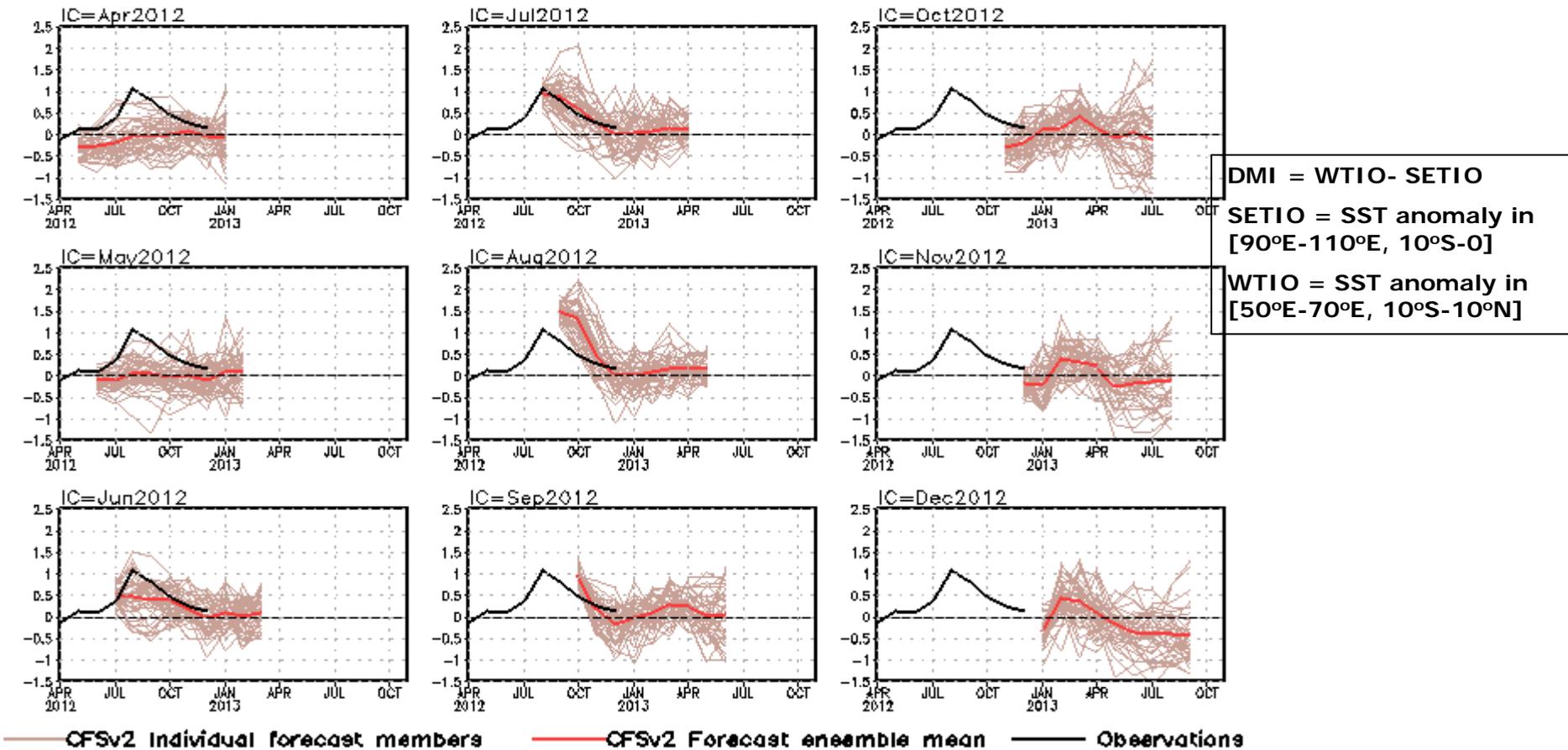


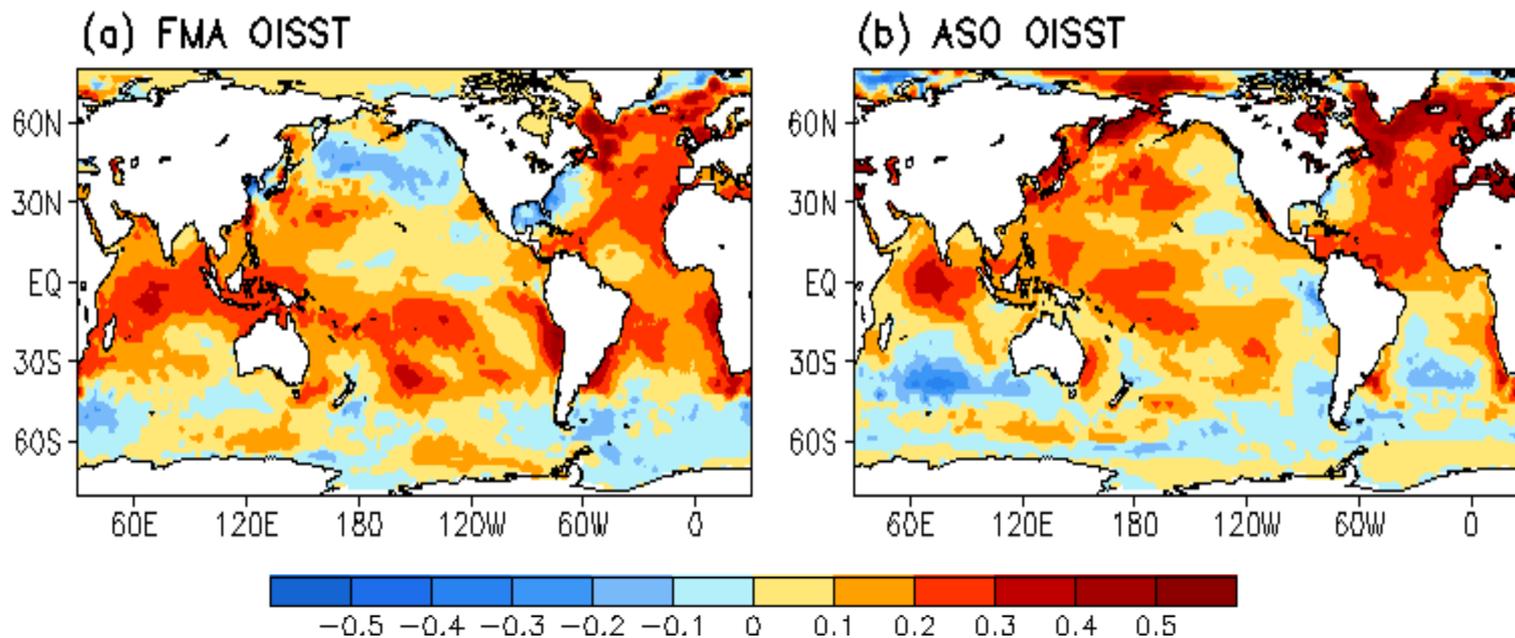
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1981-2010 base period means.

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°C, sea surface height, mixed layer depth, tropical cyclone heat potential, surface currents, upwelling
- **Satellite data climatology 1993-2005 unchanged**
 - Aviso Altimetry Sea Surface Height
 - Ocean Surface Current Analyses – Realtime (OSCAR)

Be aware that new climatology (1981-2010) was applied since Jan 2011

SST Climatology Diff. ($^{\circ}\text{C}$): (1981–2010) – (1971–2000)



1971-2000 SST Climatology (Xue et al. 2003):

http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst_clim.htm

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

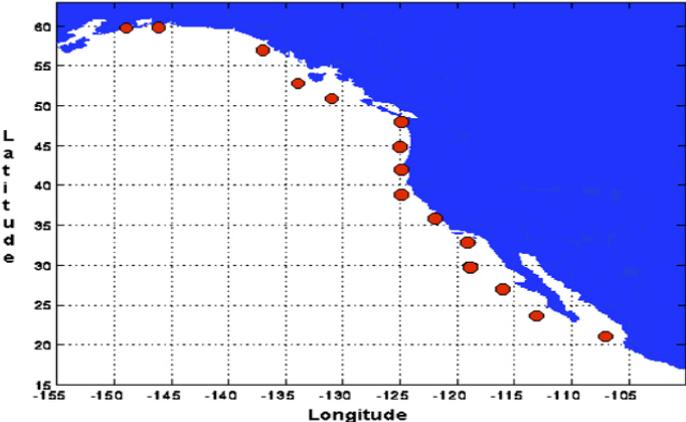
- The seasonal mean SST in February-April (FMA) increased by more than 0.2°C over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2°C in high-latitude N. Pacific, Gulf of Mexico and along the east coast of U.S.
- Compared to FMA, the seasonal mean SST in August-October (ASO) has a stronger warming in the tropical N. Atlantic, N. Pacific and Arctic Ocean, and a weaker cooling in Gulf of Mexico and along the east coast of U.S.

Data Sources and References

- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **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!

Standard Positions of Upwelling Index Calculations



1st EOF of monthly ERSST v3b

