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 Climate Observation Division (COD)

Outline

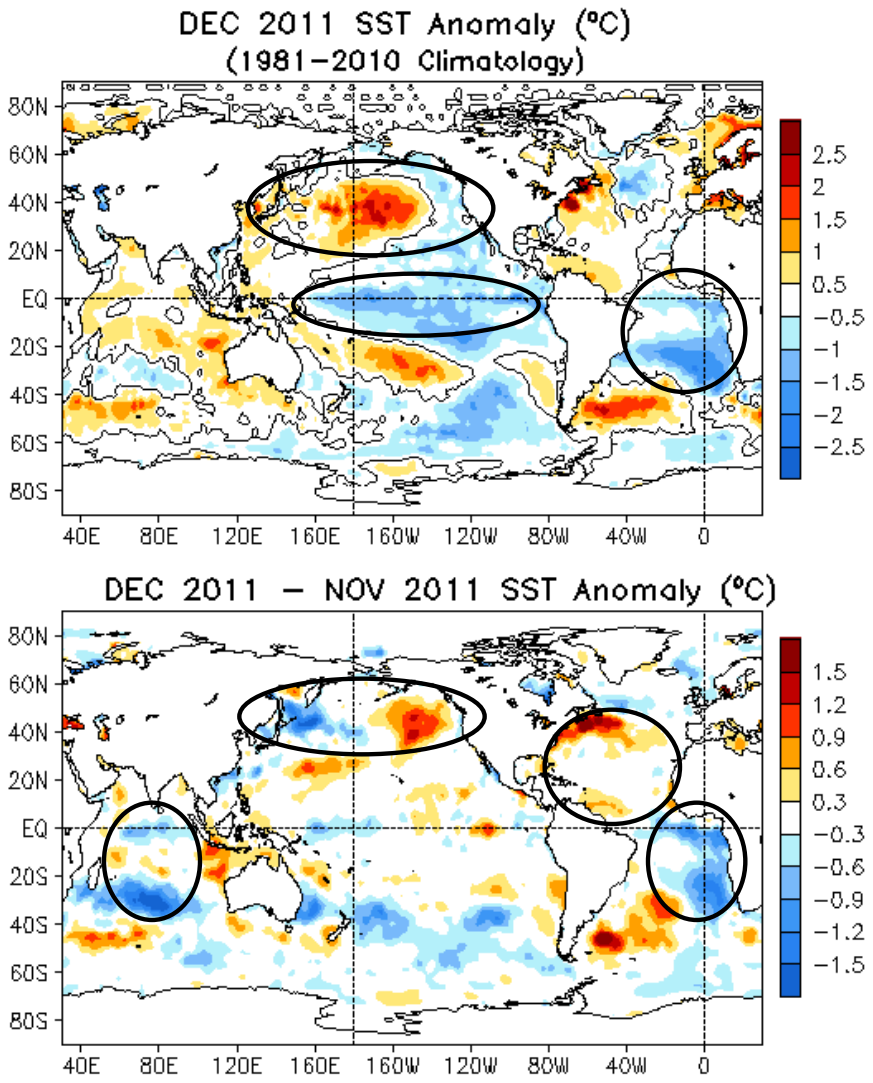
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- CFS SST Predictions

Overview

- **Pacific Ocean**
  - La Nina conditions persisted with NINO3.4=-1.0°C in Dec 2011.
  - NOAA "ENSO Diagnostic Discussion" suggests La Niña is expected to continue into the Northern spring 2012.
  - The atmospheric components of La Niña became more well-defined after MJO activities and positive IOD dissipated by the end of Nov.
  - Negative PDO persisted, with PDOI=-2.1 in Dec 2011.
  - National Multi-Model Ensemble (NMME) predicted negative PDO to last through the Northern winter and continue into the Northern spring/summer 2012.
- **Indian Ocean**
  - Westerly wind anomalies were consistent with enhanced convection in eastern tropical Indian Ocean and over Indonesia, which reflected influences of La Niña.
- **Atlantic Ocean**
  - Positive NAO strengthened with NAO=2.5 in Dec 2011.
  - Meridional SSTA gradient strengthened with value 1.2°C in Dec 2011.
  - Consistent with meridional SSTA gradient, convection was enhanced (weakened) in subtropical N. Atlantic (along the equatorial Atlantic)

Global Ocean

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

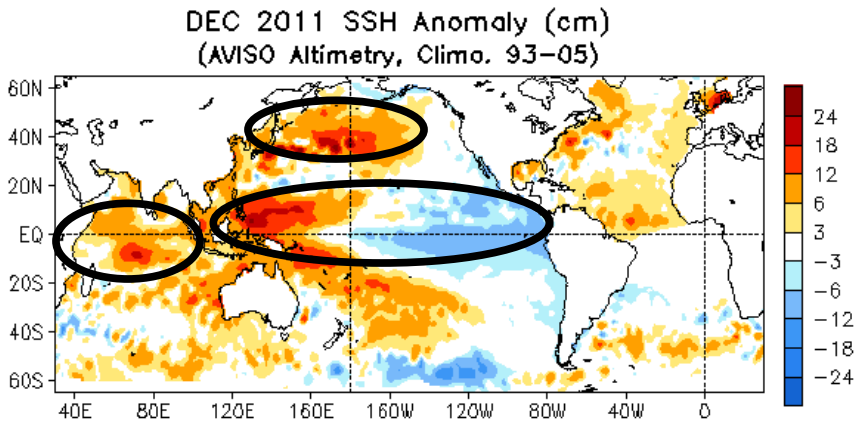


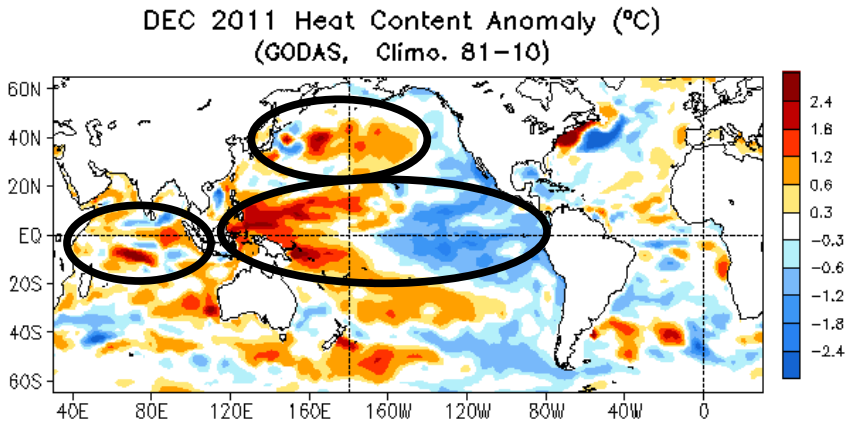
- La Nina conditions prevailed in the tropical Pacific.
- Negative PDO pattern dominated in the North Pacific.
- Negative SST anomalies were observed in the equatorial Atlantic and southern Atlantic.

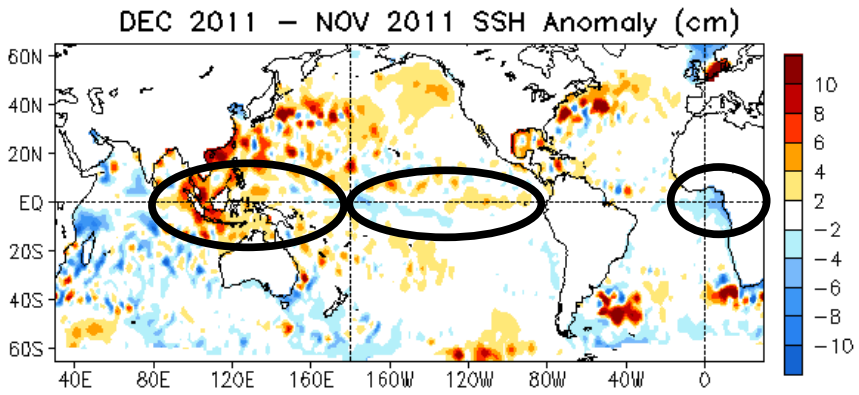
- SST increased (decreased) in the eastern (western) N. Pacific.
- SST increased near Gulf Stream and in subtropical N. Atlantic.
- SST decreased in the eq. Atlantic and south-eastern Atlantic.
- SST decreased in the eq. Indian Ocean and southern Indian Ocean.

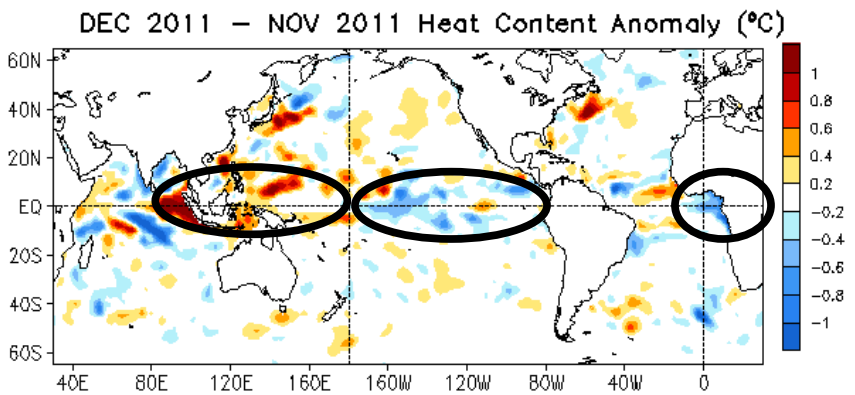
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Global SSH / HC Anomaly (cm / ºC) and Anomaly Tendency





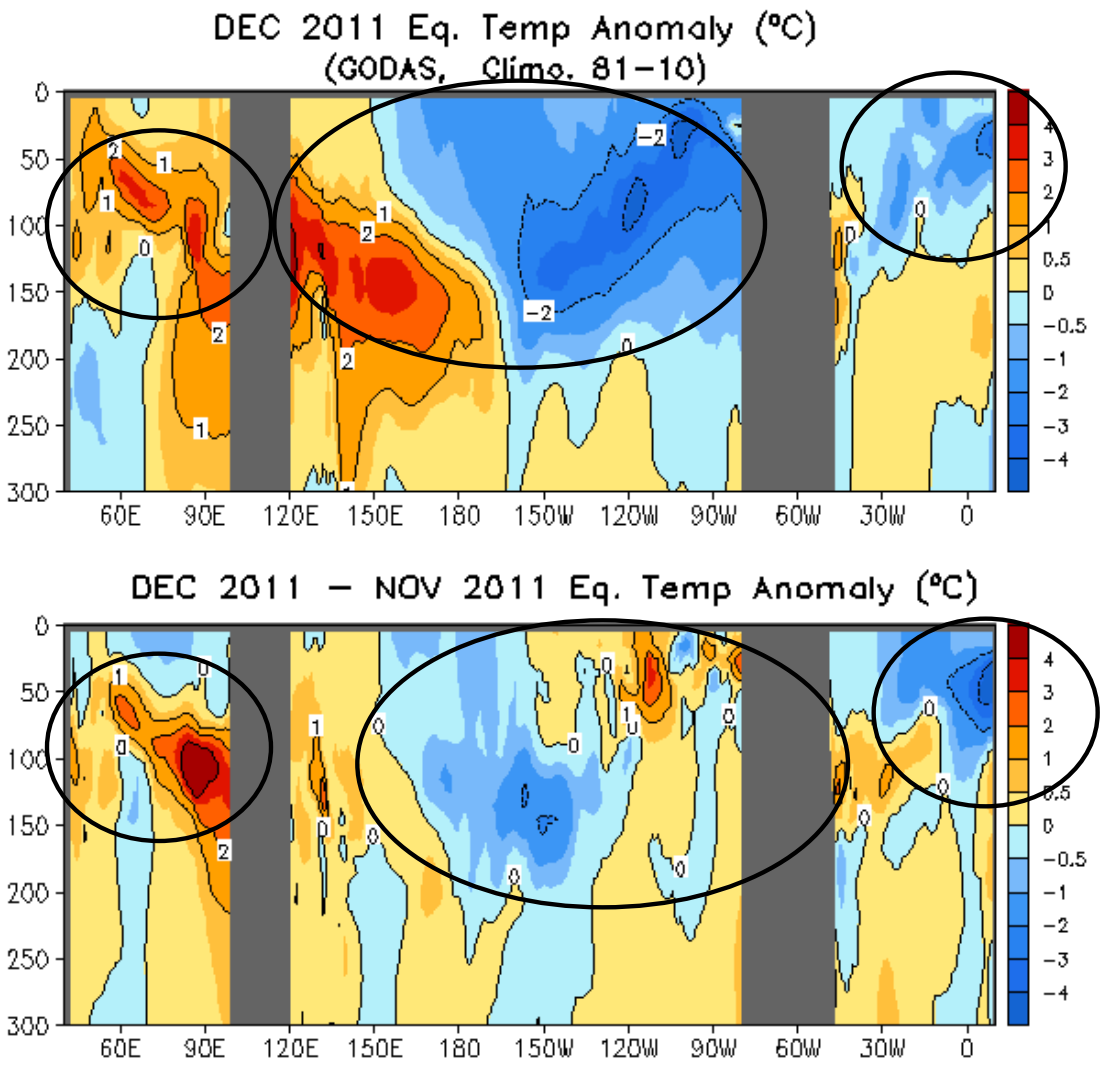




- **Dipole SSH and HC anomalies in the tropical Pacific resemble the mature phase of La Nina, and strengthened slightly.**
- **SSH and HC anomalies in the North Pacific have a negative PDO pattern, consistent with that of SST anomalies.**
- **Negative SSH and HC anomaly tendency was observed in the eastern equatorial Atlantic.**
- **SSH and HC anomalies as well as their tendencies were largely consistent except in N. Atlantic and Southern Oceans.**

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

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



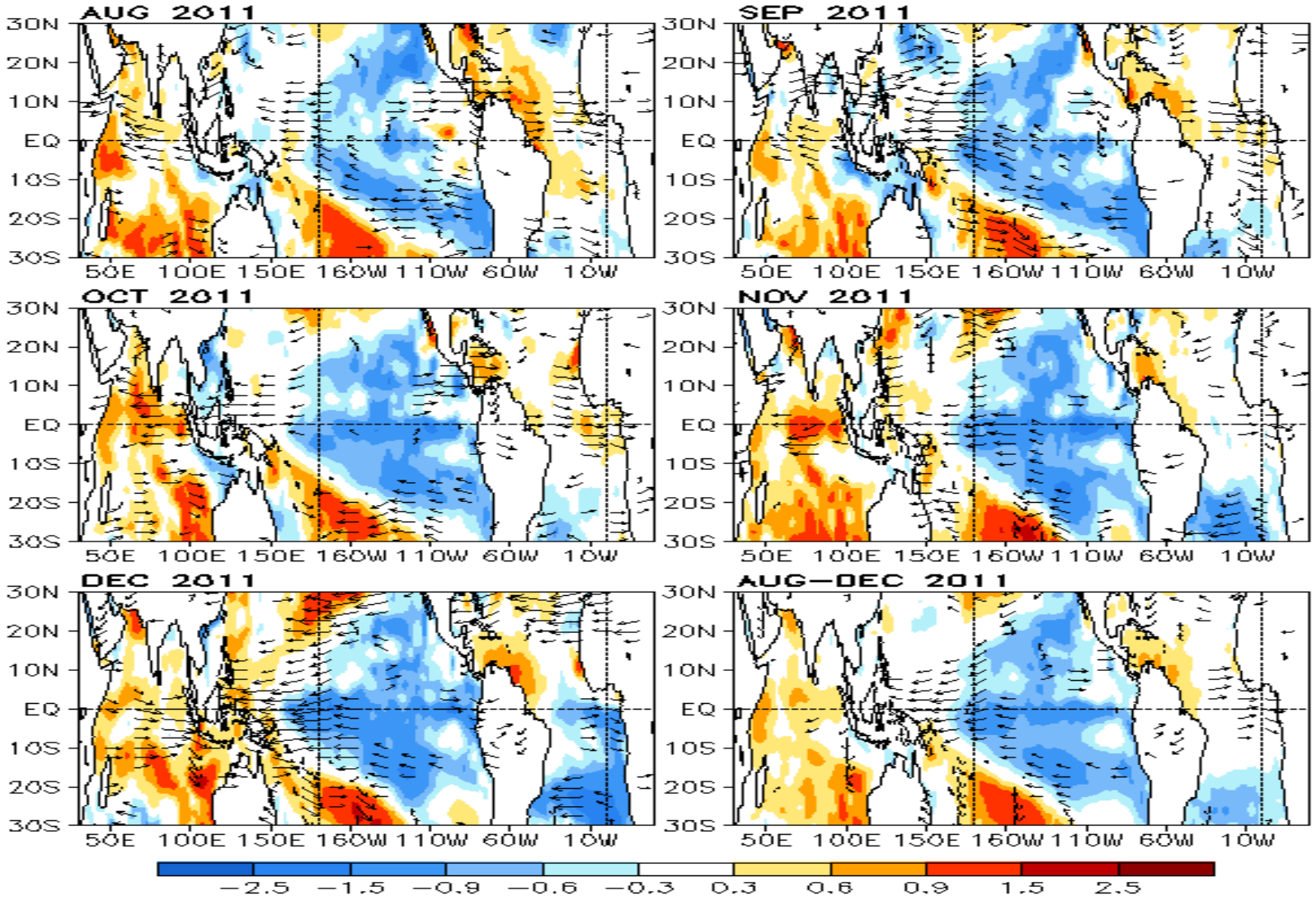
- Dipole temperature anomalies, warm (cold) in the west (east), are consistent with La Nina conditions.
- Positive temperature anomalies covered most of the top 300m equatorial Indian Ocean.
- Negative temperature anomalies dominated the top 100m equatorial Atlantic Ocean.

- Temperature increased slightly (decreased) in the eastern (central) tropical Pacific in Dec 2011.
- Temperature decreased (increased) near the surface (100m depth) in the equatorial Indian Ocean.
- Temperature decreased by more than 2C in the top 100m equatorial Atlantic Ocean.

Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

Global Tropical Ocean

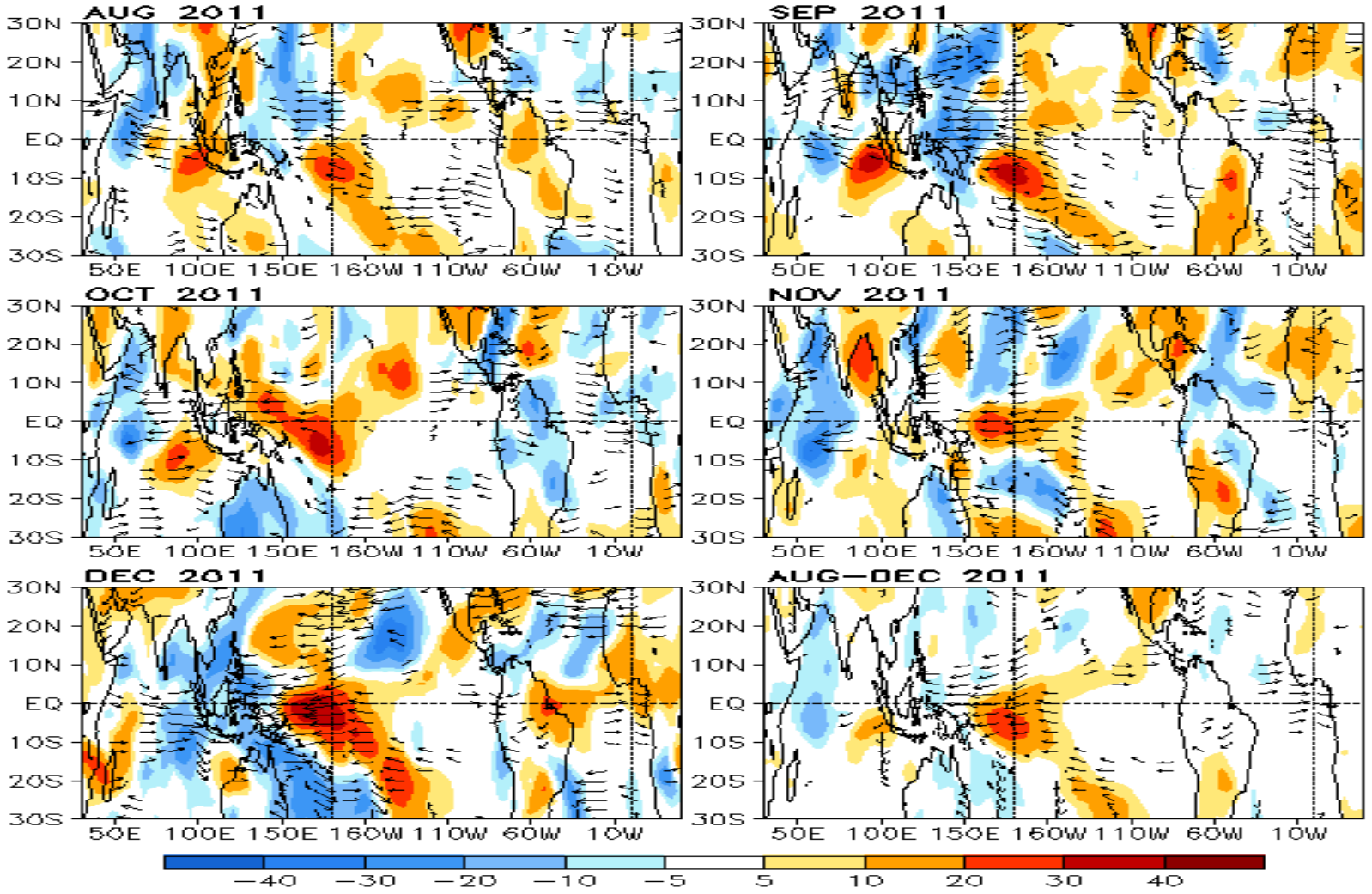
Evolution of SST and 850mb Wind Anom.



- **Persistent SST anom. (SSTA): Negative SSTA in trop. Pacific, positive SSTA in trop. N. Atlantic, positive SSTA in trop. Indian Ocean.**

- **Persistent surface wind anom.: easterly in W. and C. trop. Pacific, westerly in tropical Atlantic, easterly in the tropical Indian Ocean, that switched to westerly in Dec 2011.**

Evolution of OLR and 850mb Wind Anom.

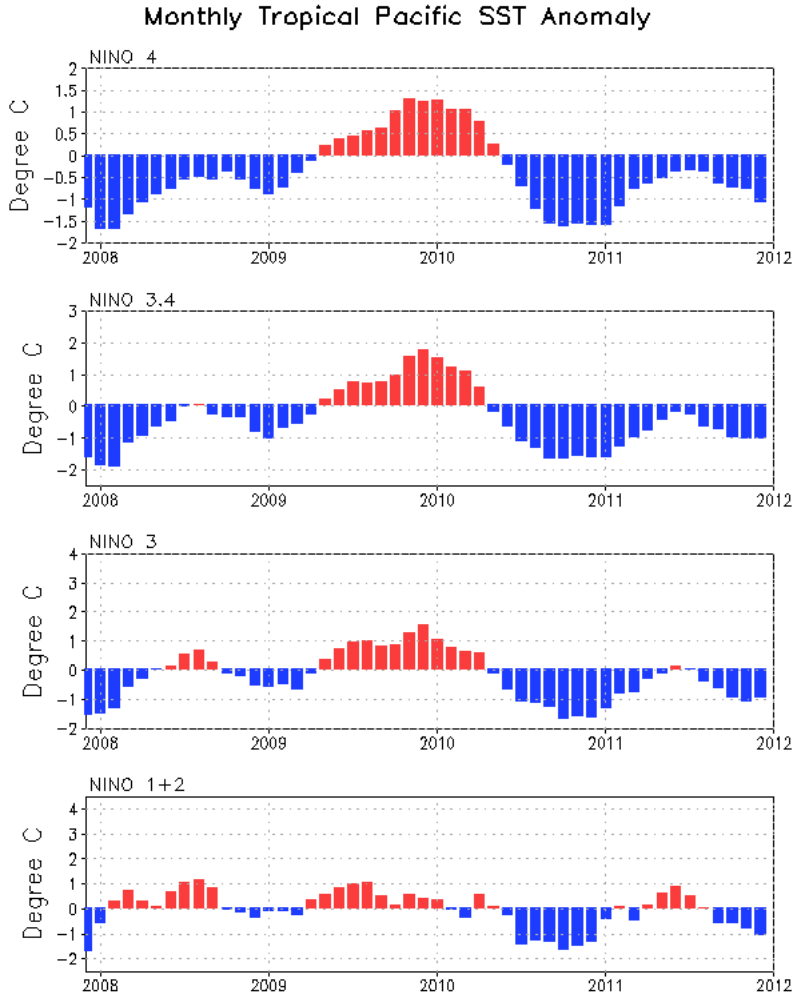


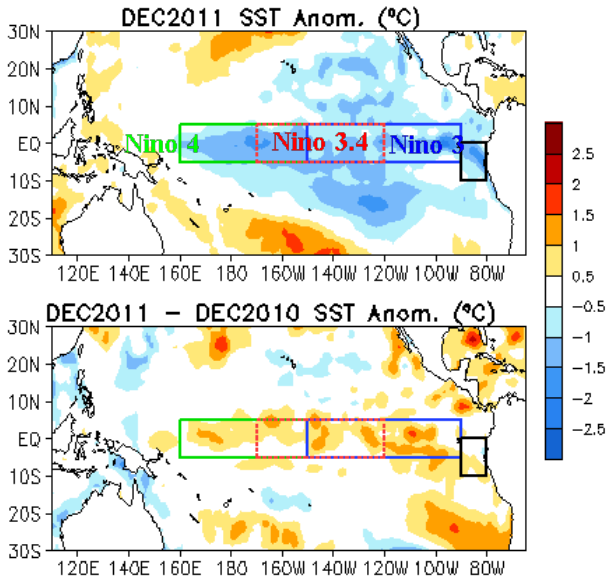
- Persistent OLR anom.: Suppressed (enhanced) convection in C. trop. Pacific and S.E. Indian Ocean (W. trop. Indian Ocean and northwest trop. Pacific). Convection modulated by MJO activities in Oct-Nov 2011, and became more La Nina-like pattern in the Indo-Pacific region in Dec 2011 when MJO and positive IOD event dissipated in Nov 2011.

- Surface wind anomalies converged to (diverged from) the center of enhanced (suppressed) convection.

ENSO Conditions

Evolution of Pacific NINO SST Indices





- **All NINO indices were negative and persisted.**
- **Nino3.4 = -1.0°C in Dec 2011.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

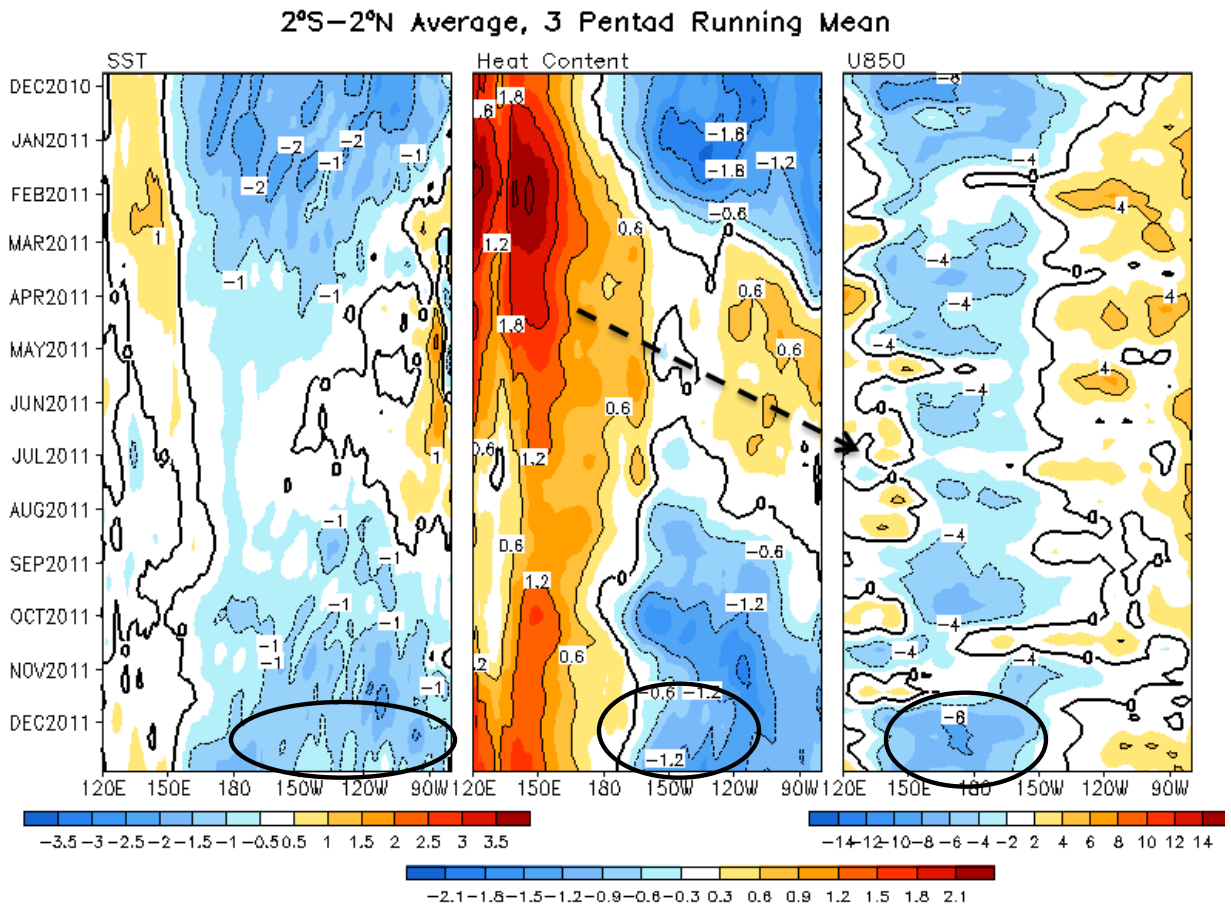
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

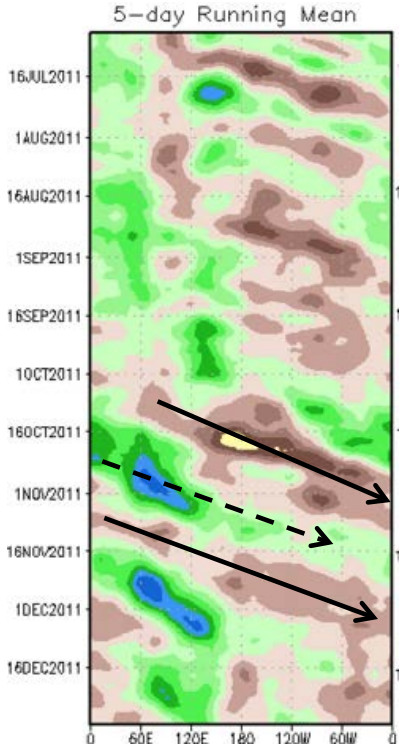
Evolution of Equatorial Pacific SST (°C), 0-300m

Heat Content (°C), 850-mb Zonal Wind (m/s) Anomaly

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

200-mb Velocity Potential





- Negative SST anomalies strengthened (weakened) in the central (eastern) equatorial Pacific in Dec 2011.
- Negative HC anomalies strengthened in the central and eastern Pacific forced by persistent easterly wind anomalies.
- 200mb velocity potential shows continuous MJO activities from early Oct to the end of Nov.

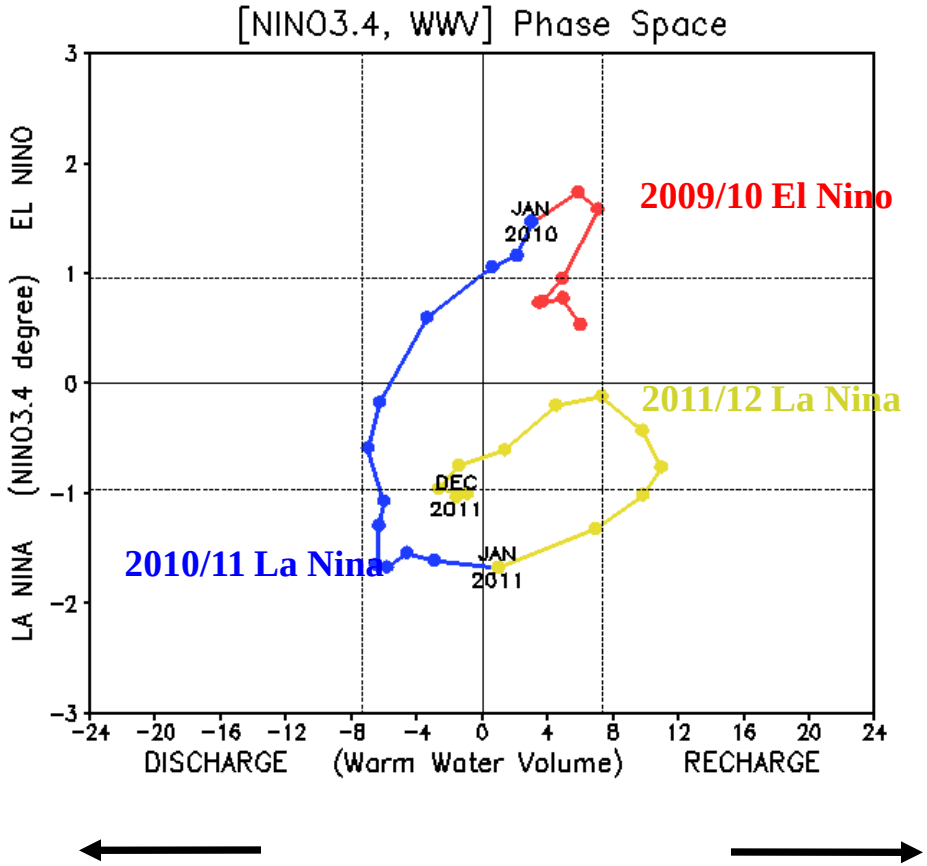
Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST is derived from the NCEP OI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

Warm Water Volume (WWV) and NINO3.4 Anomalies

- WWV is defined as average of depth of 20°C in [120°E-80°W, 5°S-5°N]. Statistically, peak correlation of Nino3 with WWV occurs at 7 month lag (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.



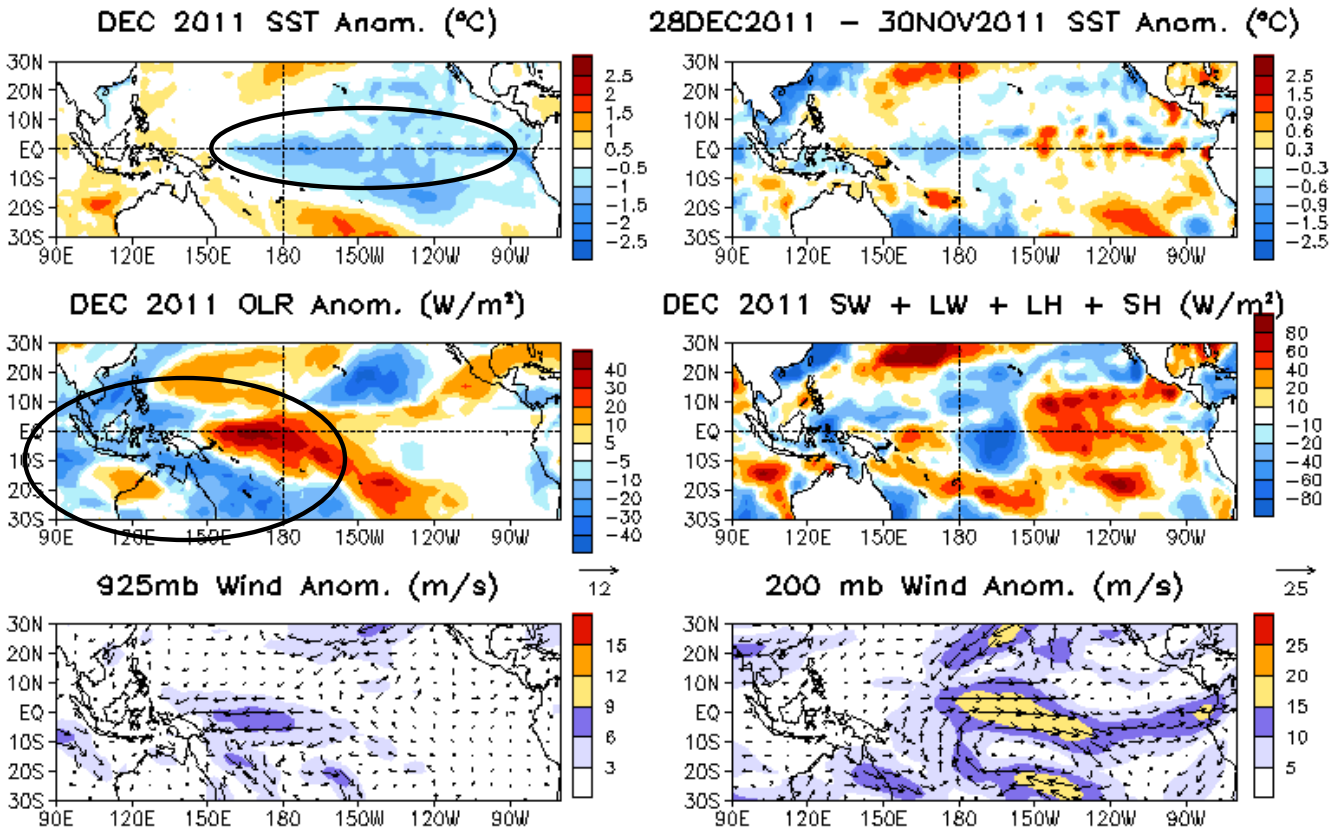
- La Nina conditions (NINO3.4 < -0.5C) were established in Aug 2011.

- WWV discharged steadily from Apr to Oct 2011, and then started to recharge slowly from Oct to Dec 2011.

- NINO3.4 decreased steadily from Jun to Oct 2011, and then became stationary during Oct-Dec 2011.

Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

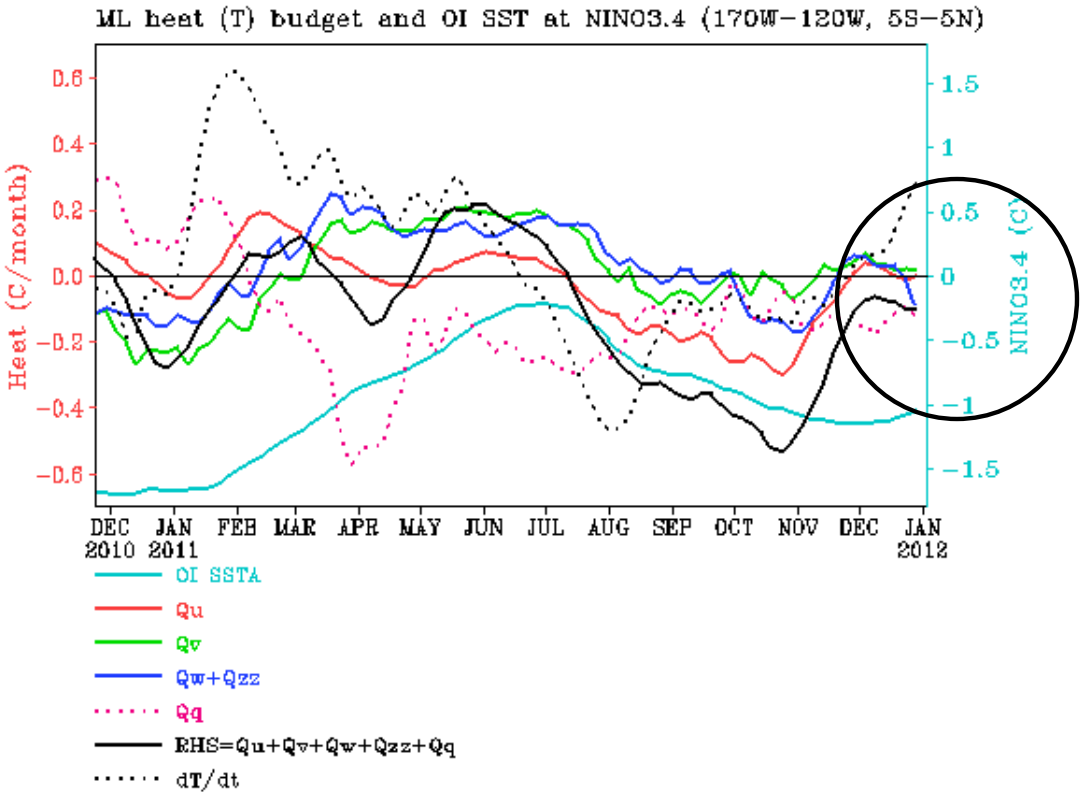
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds



- Negative SSTA prevailed in the tropical Pacific.
- Convection was suppressed (enhanced) near the Dateline (over Indonesia).
- Low- (upper-) level easterly (westerly) wind anomalies strengthened in Dec 2011.

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.

NINO3.4 Heat Budget



- **SSTA tendency (dT/dt) in NINO 3.4 (dotted line) switched from negative to positive in Dec, indicating weakening of La Nina conditions.**

- **Both Qu and Qw+Qzz reached minimum in late Oct and started to increase rapidly and reached near zero by the end of Nov.**

- **The total heat budget term (RHS) has large cold biases compared with the tendency (dT/dt) since early Sep 2011.**

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.

Qu: Zonal advection; Qv: Meridional advection;

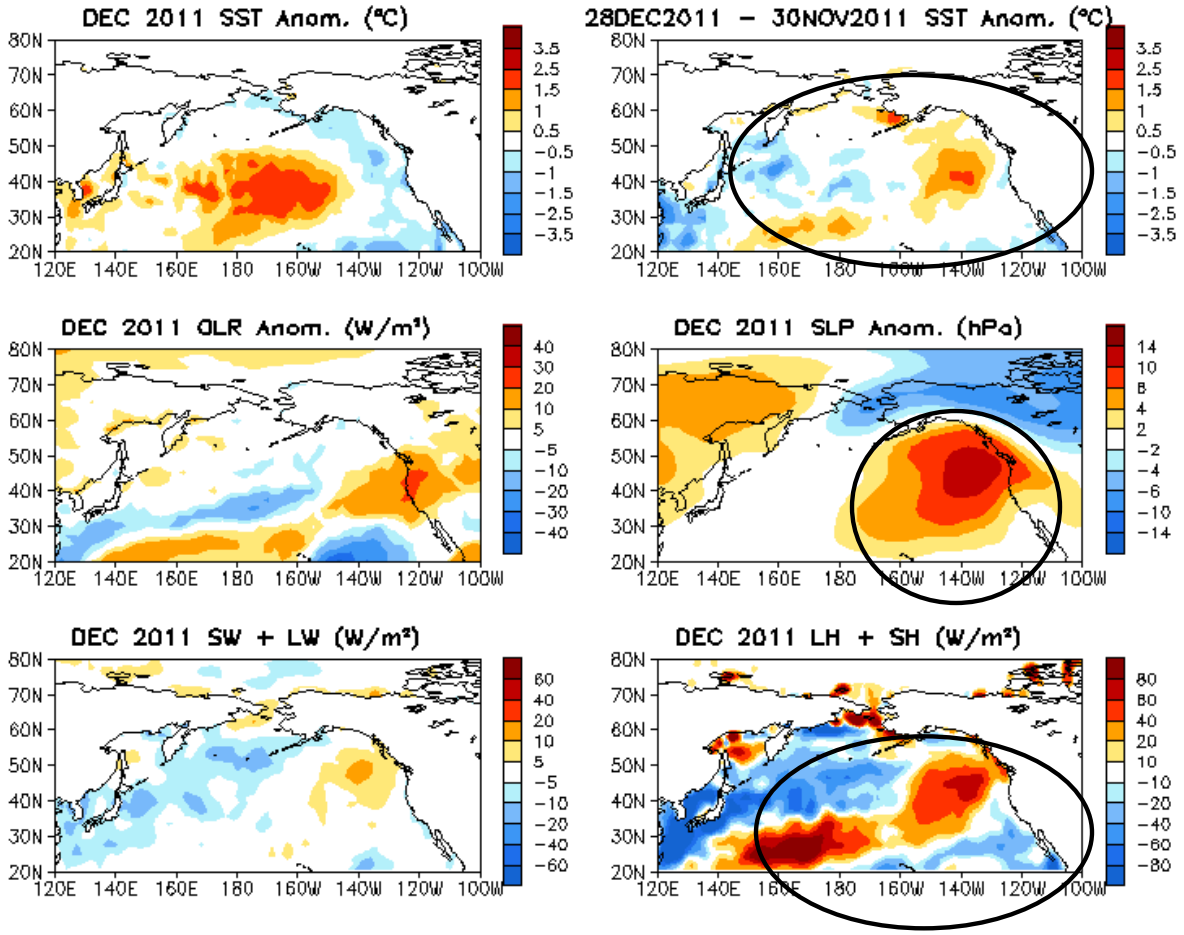
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

North Pacific & Arctic Ocean

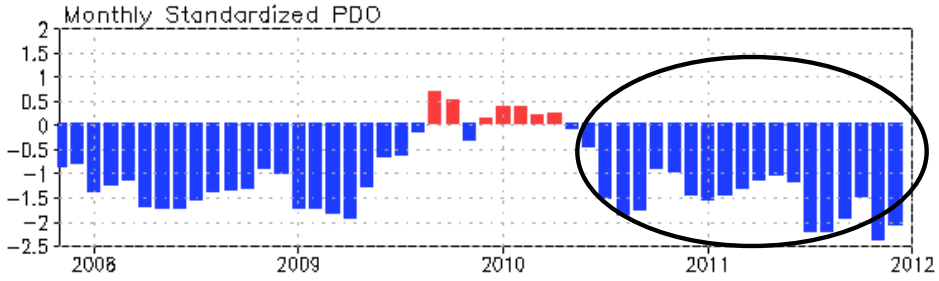
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

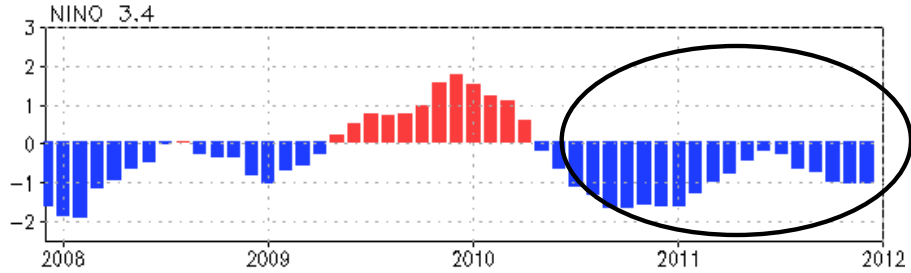


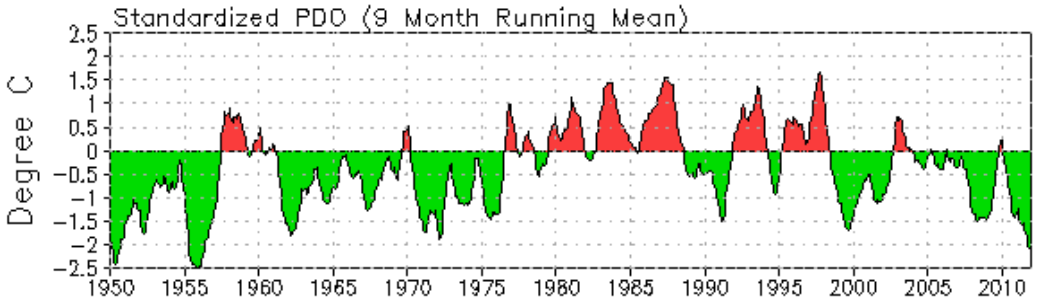
- Positive (negative) SSTA presented in the western and central (eastern) North Pacific, consistent with the negative PDO index (next slide).
- Net surface heat flux anomalies contributed to the SST tendency in the North Pacific.
- Above-normal sea level pressure and associated northerly wind anomalies along the coast were favourable for upwelling.

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.

PDO index

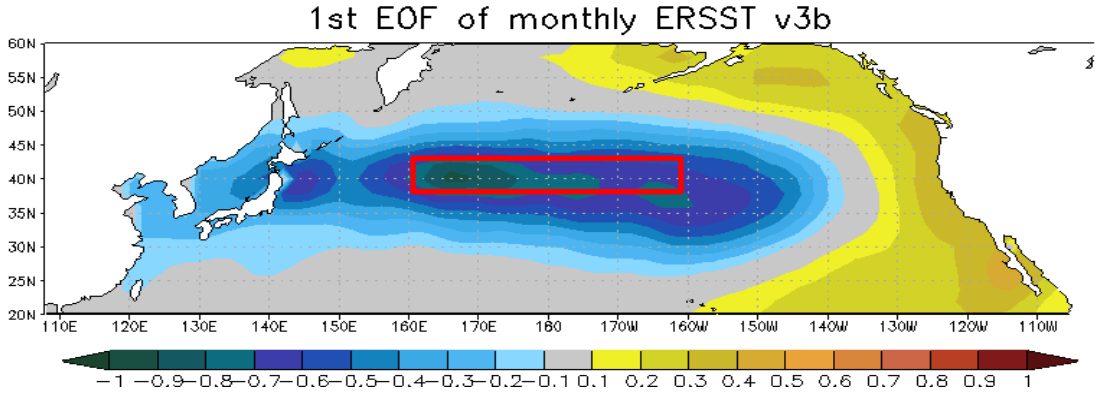






- **The negative PDO index persisted in Dec with PDO =-2.1.**

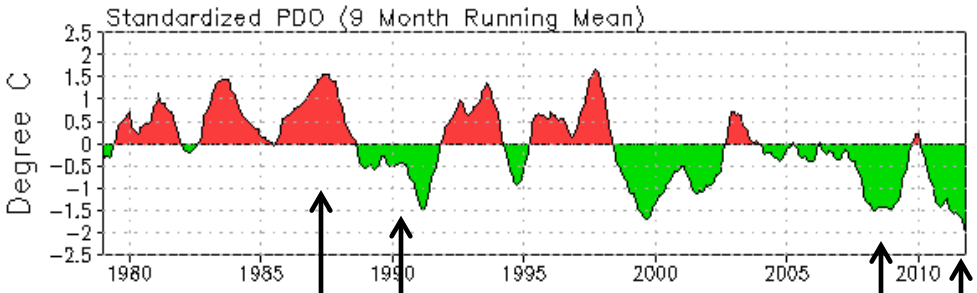
- **The apparent positive correlation between NINO3.4 and PDO index suggests strong influences of the La Nina on the North Pacific SST variability through atmospheric bridge.**

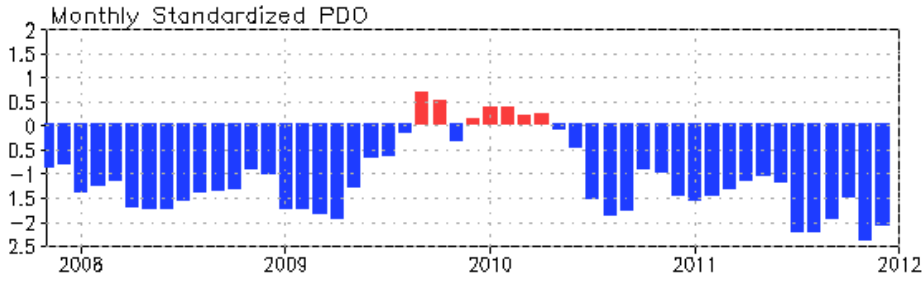


- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**

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

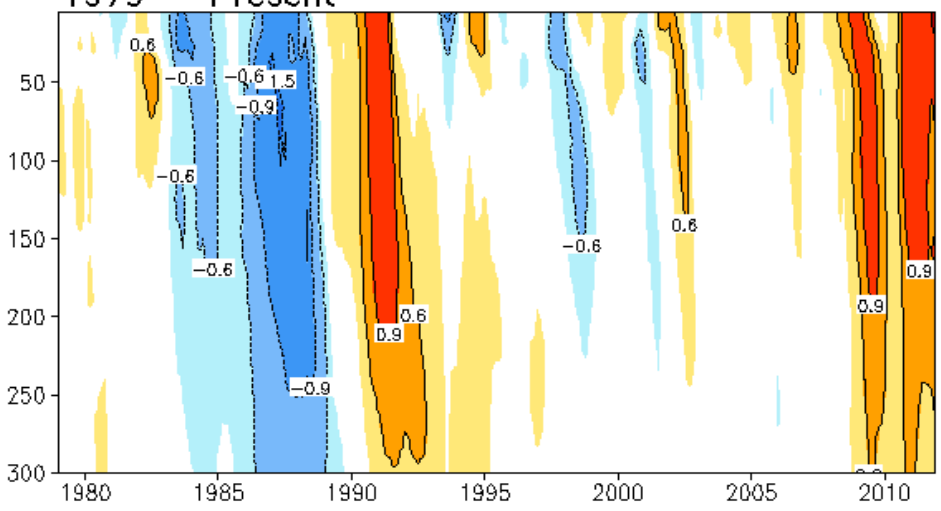
Subsurface Temperature Anom. in Central North Pacific



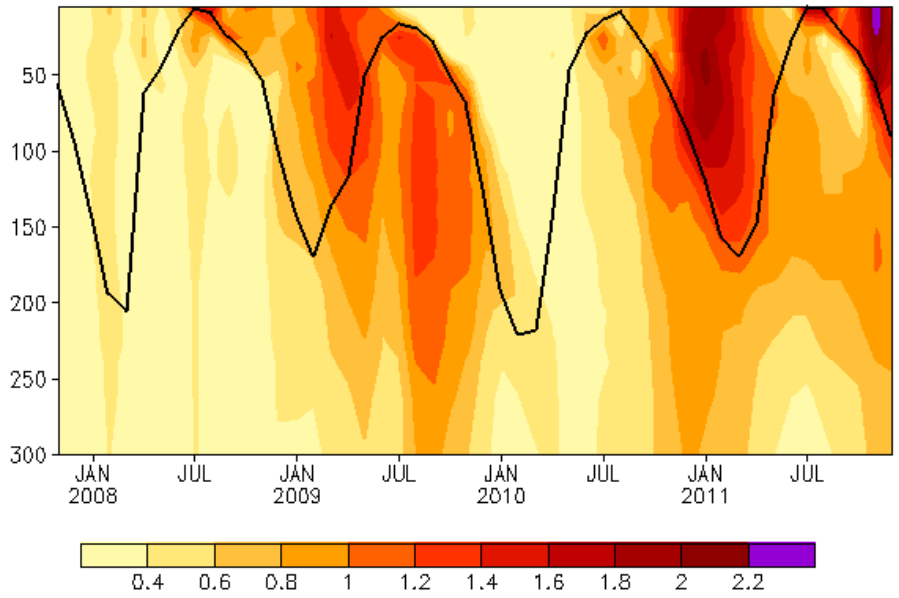


Central North Pacific Temp. Anomaly
Average in [160E−160W, 38N−42N] (°C)

1979 − Present



Temperature Anomaly & Mixed Layer Depth
Average in [160E−160W, 38N−42N] (°C)

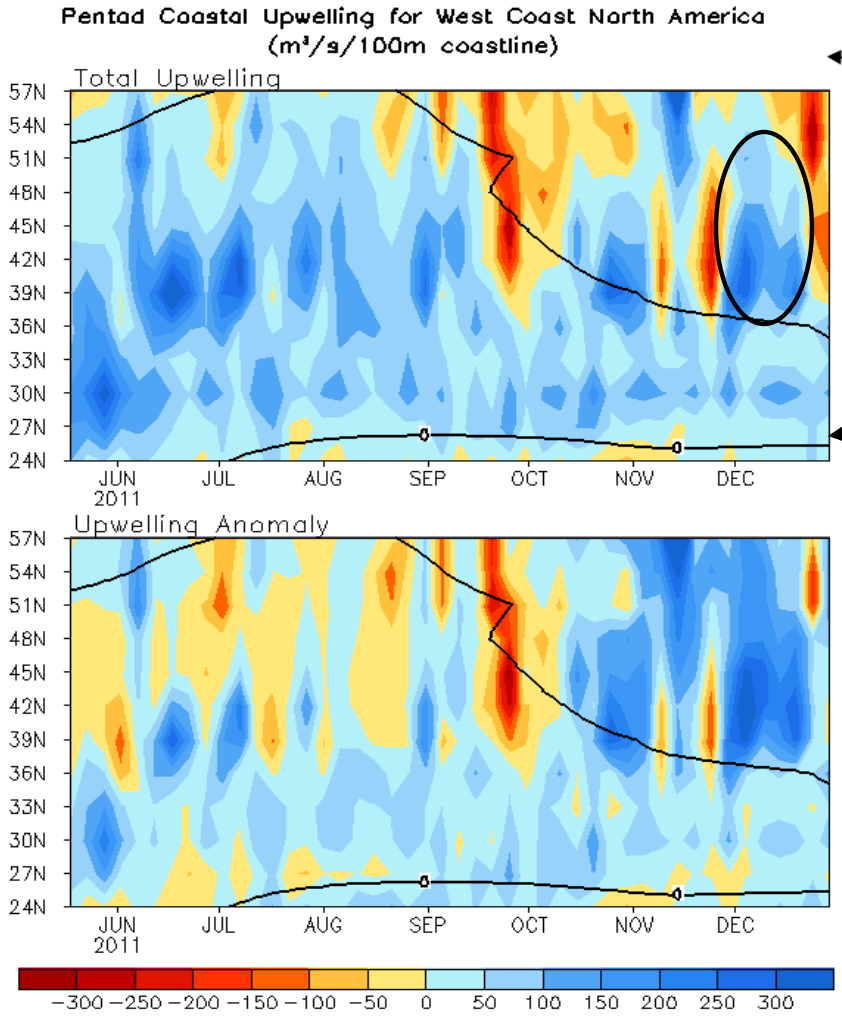


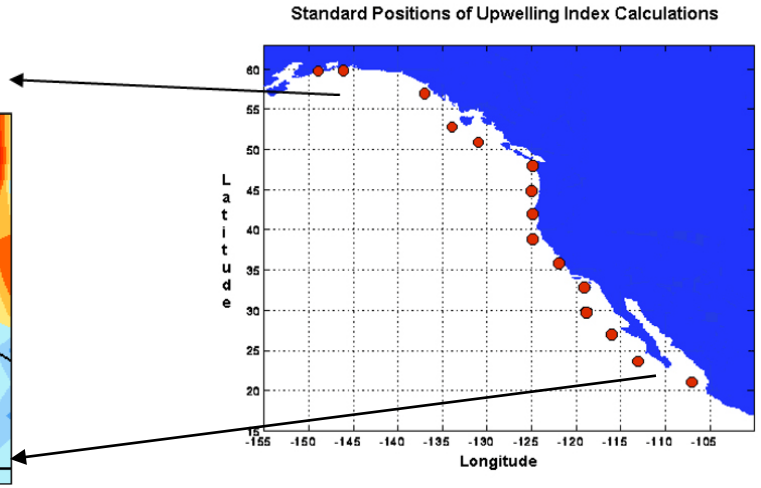
- **PDO has strong signature of subsurface temperature anomalies that can penetrate to below 300m.**

- **Deep ocean warming in the central N. Pacific (160E-160W, 38N-42N) was particularly strong during the negative phases of PDO in 2009, 2010 and 2011.**

- **Positive temperature anomalies greater than 1C were confined within mixed layer, which has gradually deepened since July and reached to about 100m depth by the end of Dec 2011.**

North America Western Coastal Upwelling





- Seasonal downwelling between 36N-54N switched to upwelling due to strong upwelling favorable winds along the coast.

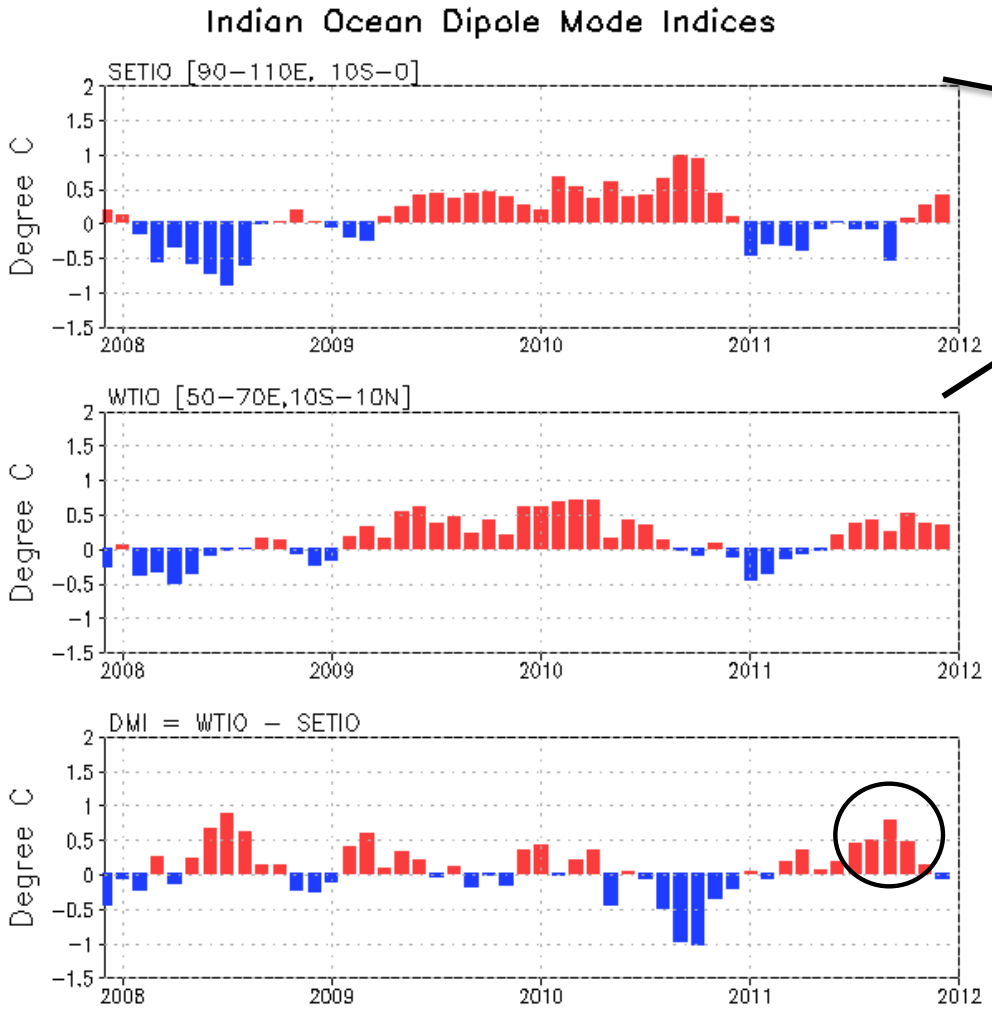
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point (m³/s/100m coastline). Anomalies are departures from the 1981-2010 base period pentad means.

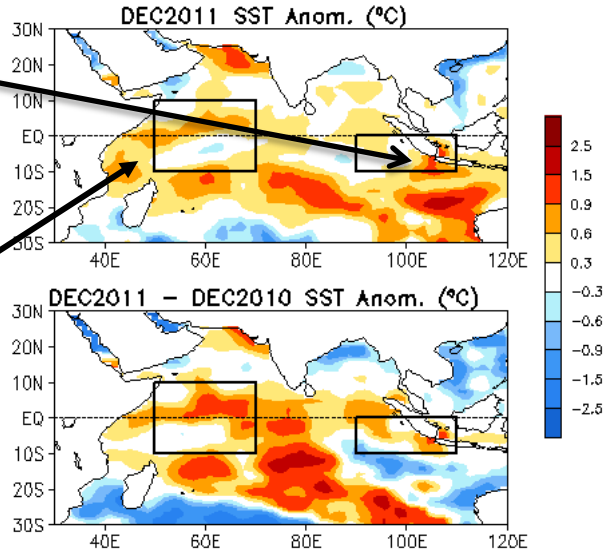
- Area below (above) black line indicates climatological upwelling (downwelling) season.

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

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices

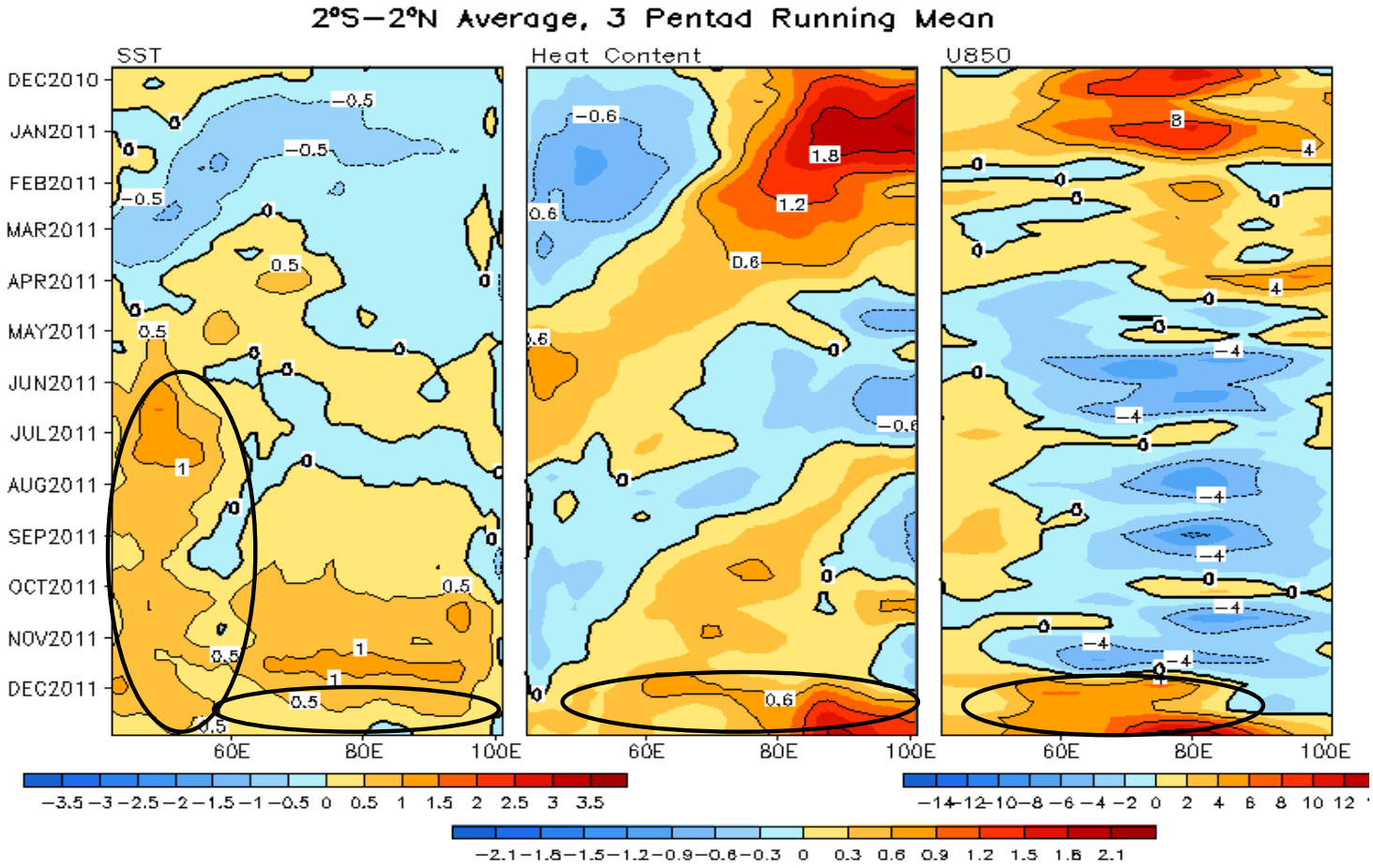




- **SETIO switched to positive in Oct-Dec 2011.**
- **DMI=0.56ºC in Aug-Oct 2011, indicating positive IOD conditions.**
- **DMI was near-normal in Nov-Dec 2011.**

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) 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), and 850-mb Zonal Wind (m/s) Anomalies



- **Positive SSTA has persisted in the western tropical Indian Ocean from May 2011 to Dec 2011.**
- **Positive SSTA weakened in the central-eastern tropical Indian Ocean in Dec 2011.**
- **Westerly wind anomalies dominated in the eq. Indian ocean, consistent with positive heat content 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 are departures from the 1981-2010 base period pentad means.

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

- Positive SSTA was observed over much of the tropical Indian Ocean.
- Convection was enhanced over Indonesia and eastern Indian Ocean.
- Low-level westerly wind anomalies located to west of enhanced convection.

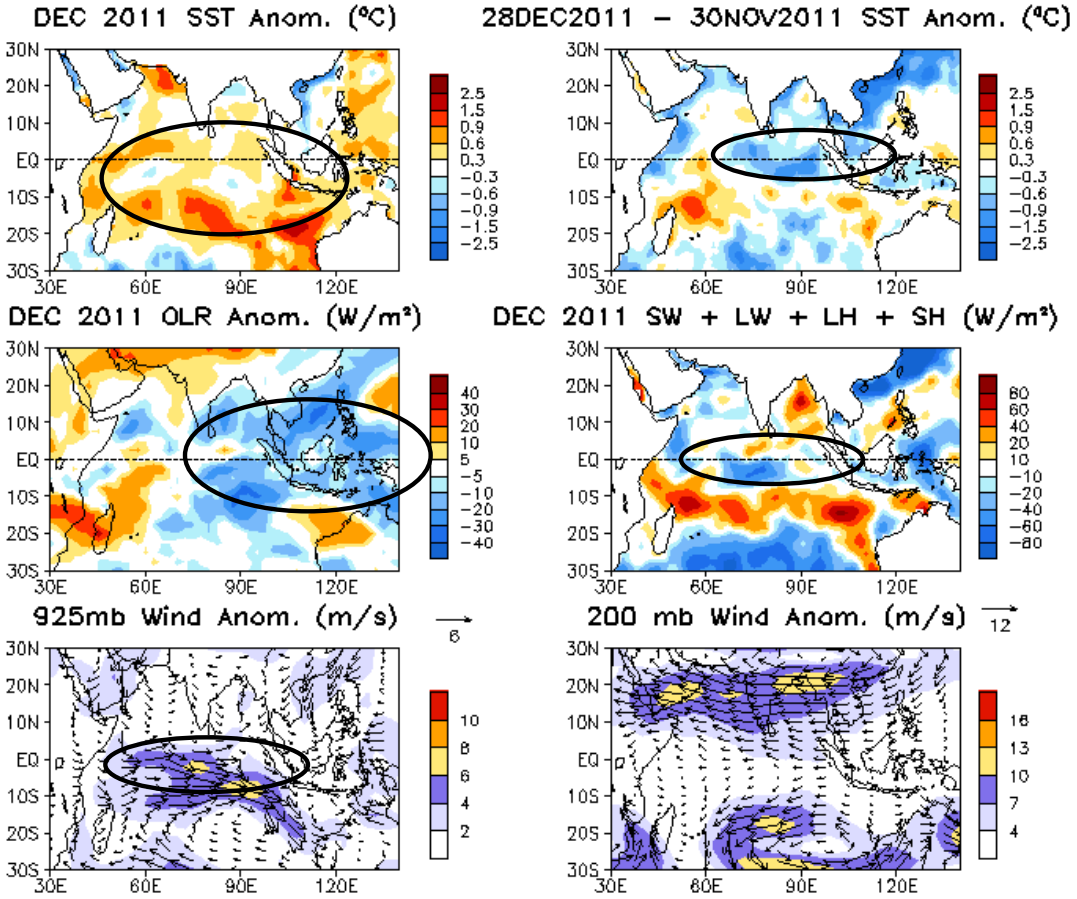
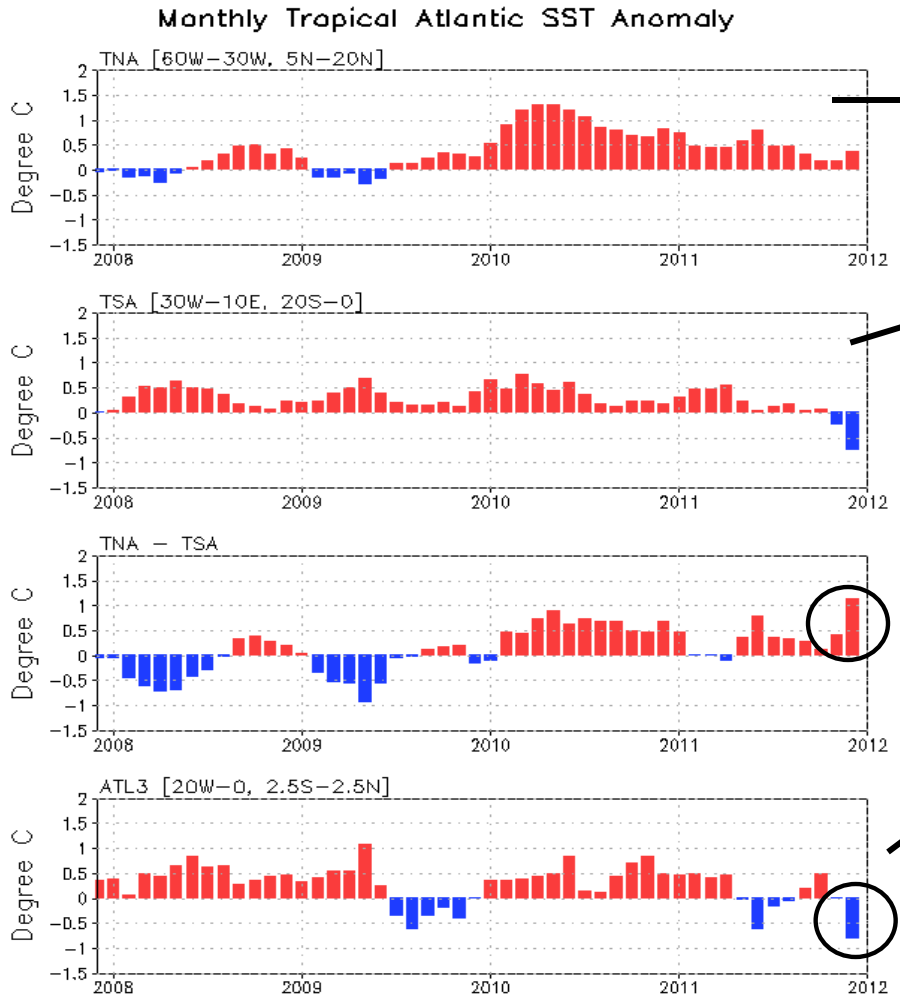
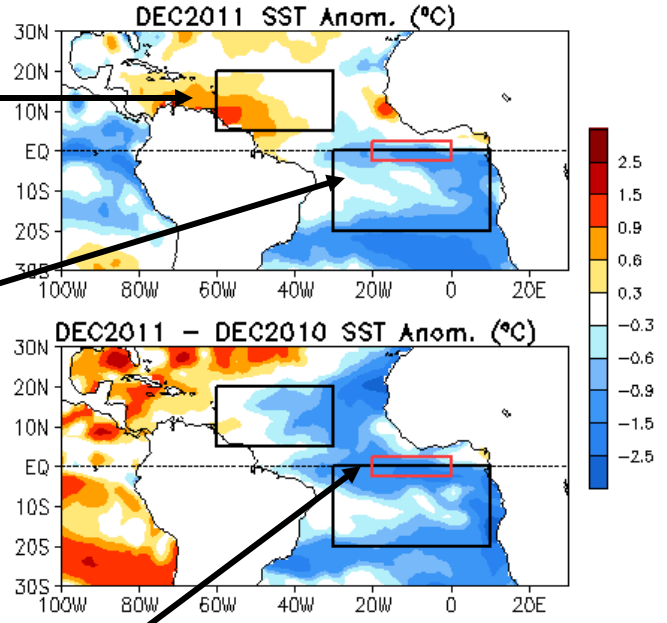


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

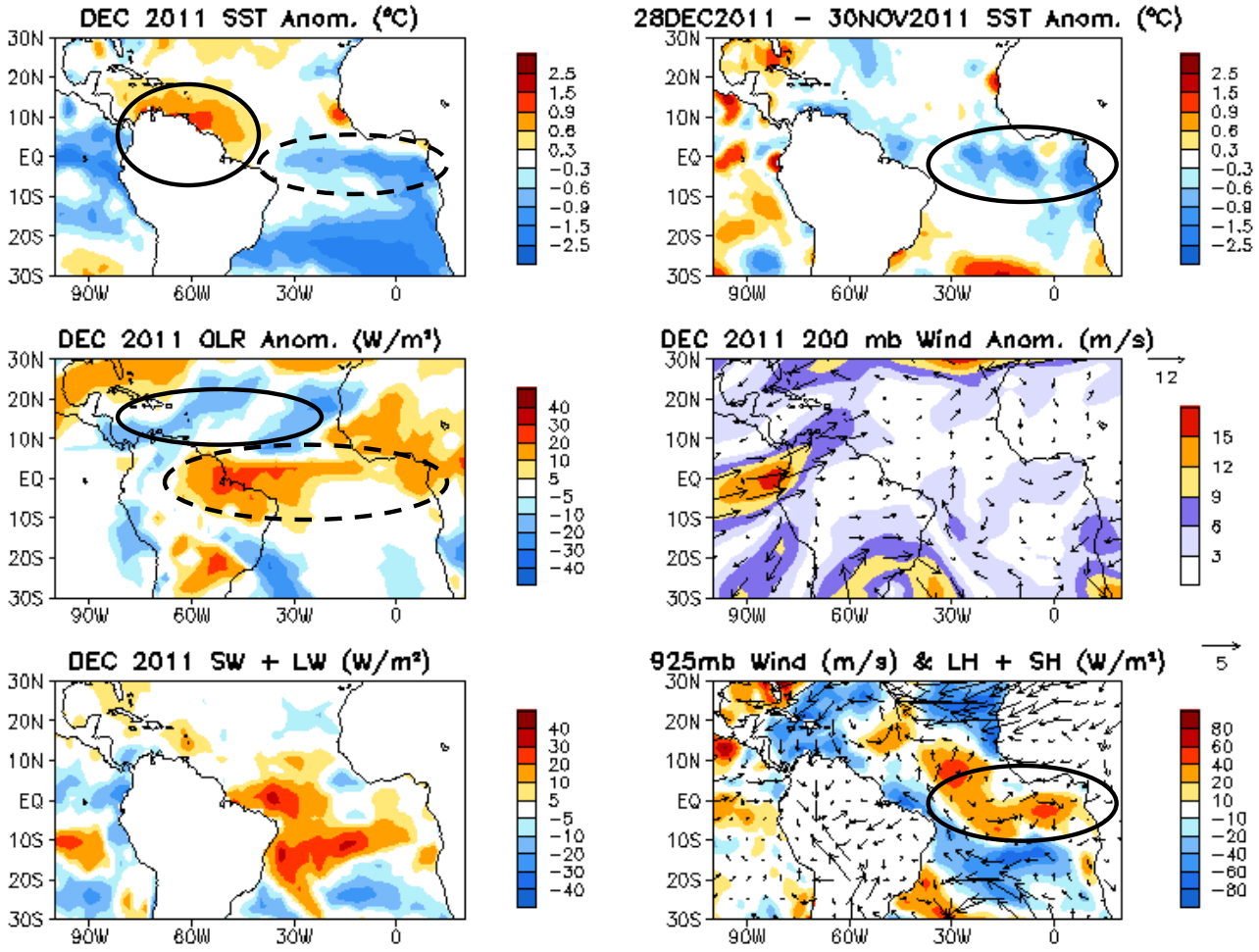




- Tropical North Atlantic (TNA) increased slightly.
- Tropical South Atlantic (TSA) decreased substantially.
- Meridional Gradient Mode (TNA-TSA) increased substantially reaching a value of 1.2C in Dec 2011.
- ATL3 SSTA decreased a lot with a value of -0.8C in Dec 2011.

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 1981-2010 base period means.

Tropical Atlantic:



- **SST was above-normal (below-normal) in Caribbean Sea (equatorial Atlantic).**

- **Consistent with the meridional SSTA gradient, convection enhanced (weakened) in Caribbean Sea and subtropical N. Atlantic (equatorial Atlantic and surrounding land regions).**

- **Negative tendency of SSTA in the eastern equatorial Atlantic seems associated with negative subsurface temperature anomalies, which, however, seems inconsistent with westerly wind anomalies.**

North Atlantic

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

- Positive (negative) SSTA was observed near Gulf Stream (central N. Atlantic).
- Sea level pressure (SLP) was below-normal (above-normal) north (south) of 50N, consistent with positive NAO index (next slide).

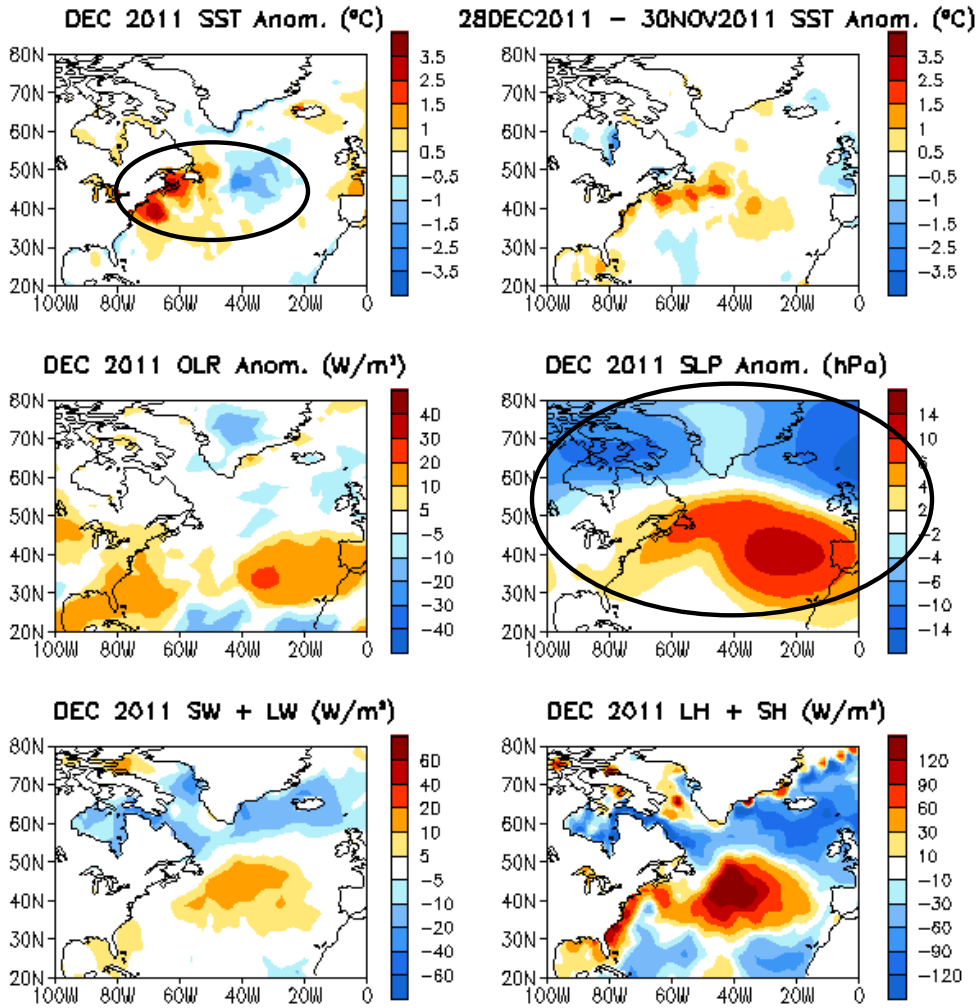
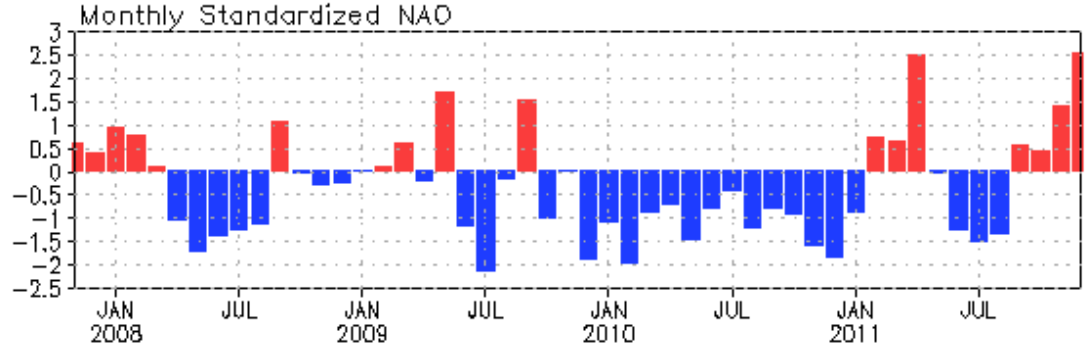
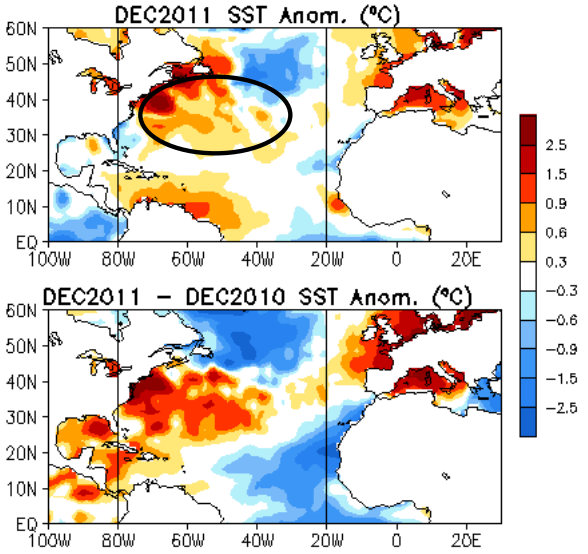
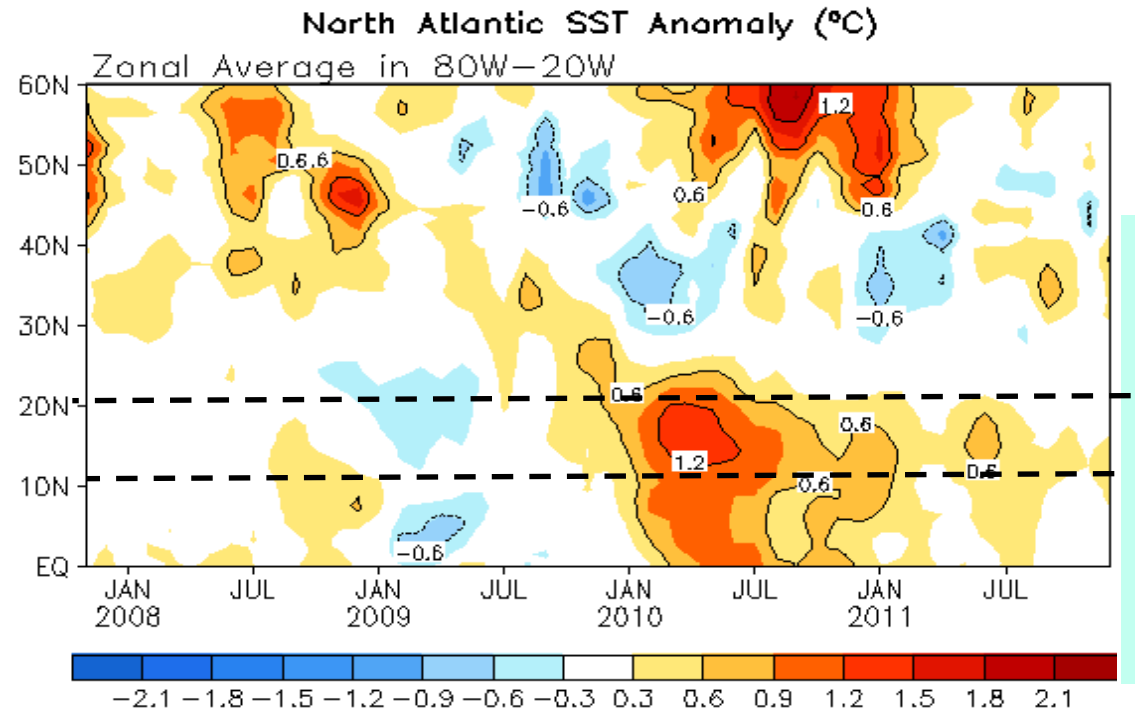


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1981-2010 base period means.

NAO and SST Anomaly in North Atlantic







- **Positive NAO enhanced with NAO=2.5 in Dec 2011.**

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

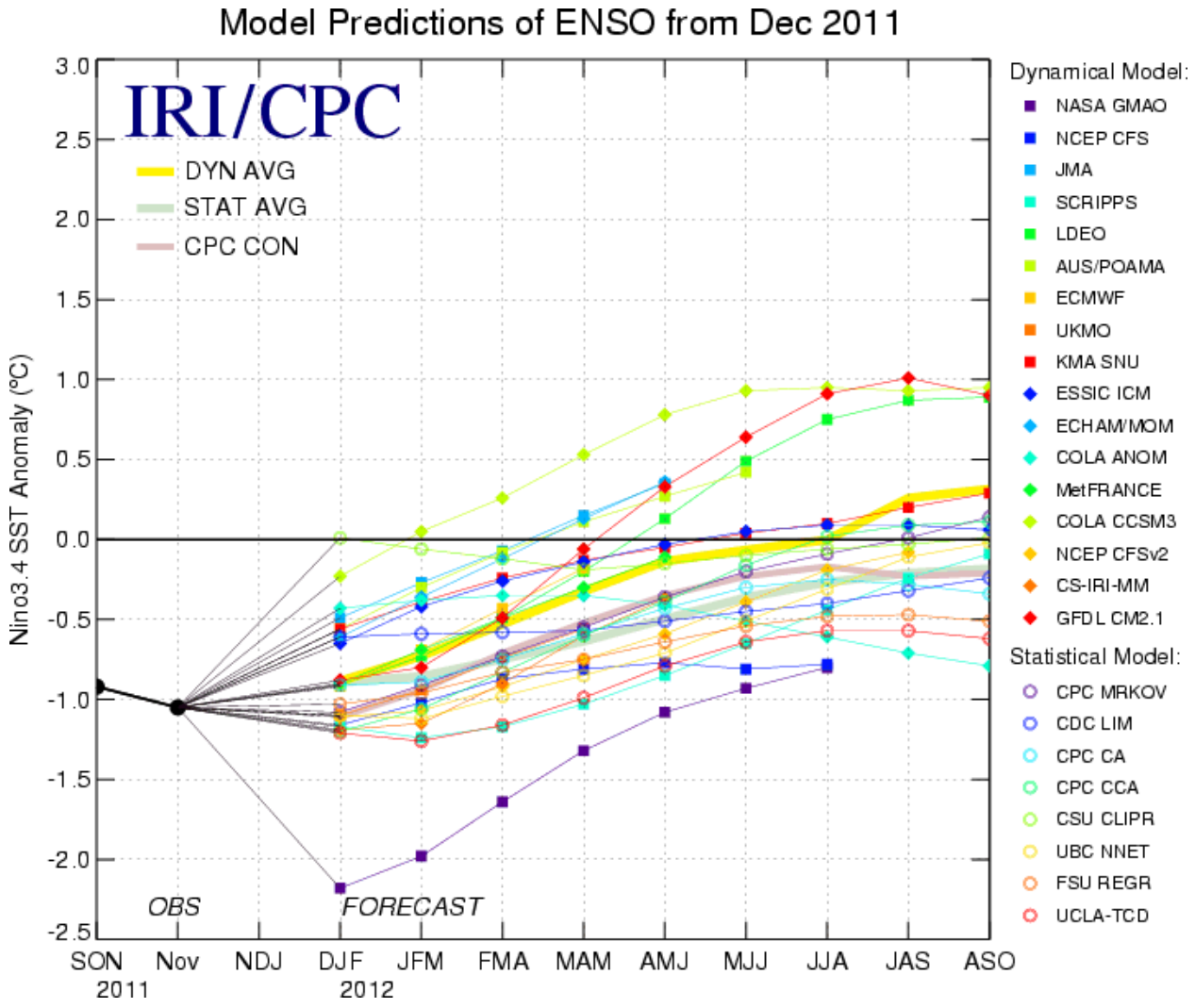
- **Persistent positive NAO during Sep-Dec 2011 are expected to contribute to development of positive SSTA in mid-latitude in next few months.**

- **Tropical North Atlantic SST was weakly above-normal, much cooler than that in last Dec.**

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.

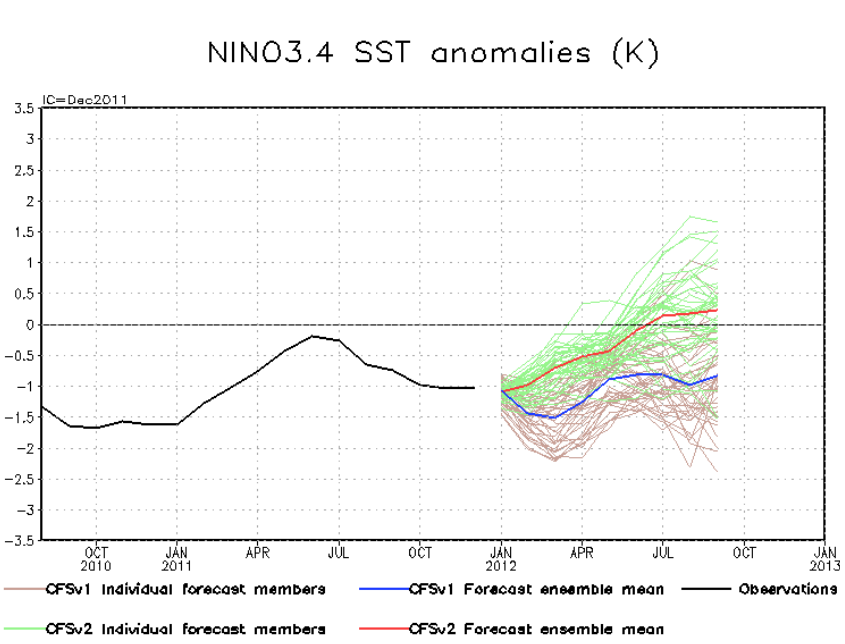
SST Predictions

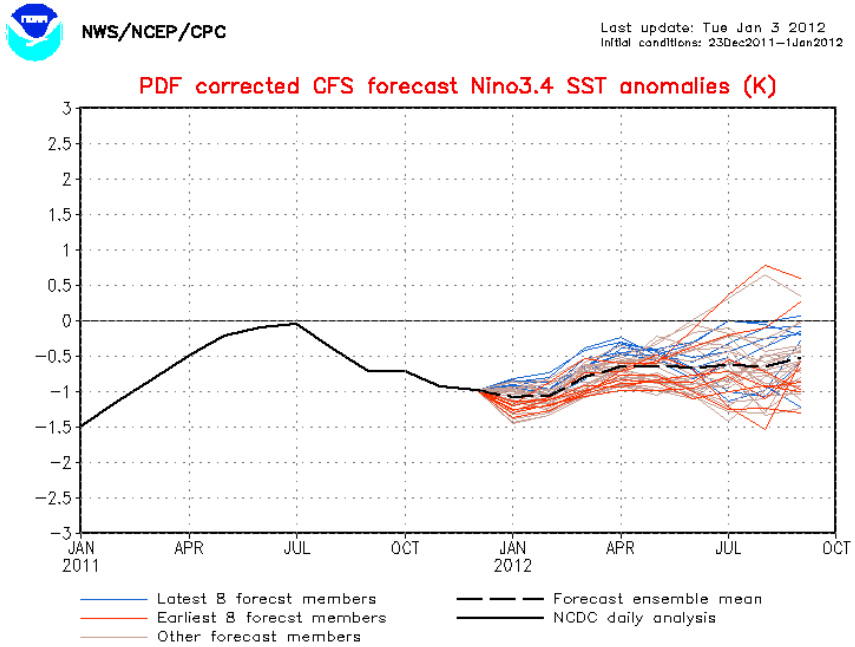
IRI NINO3.4 Forecast Plum



- The majority of models predicted that weak to moderate La Nina peaks in the winter 2011/12, dissipate in spring 2012 and return to normal-conditions by early summer 2012.

NCEP CFSv1 and CFSv2 NINO3.4 Forecast

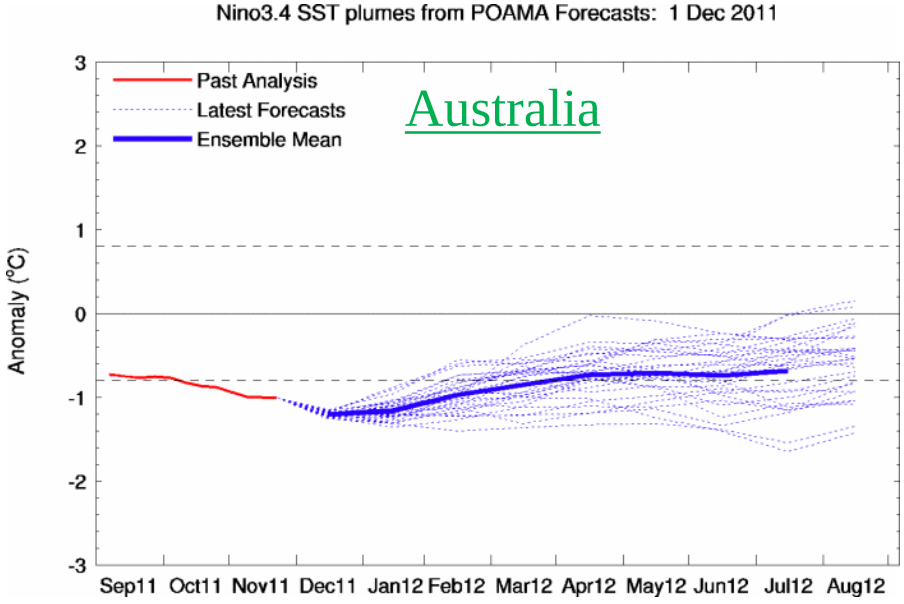




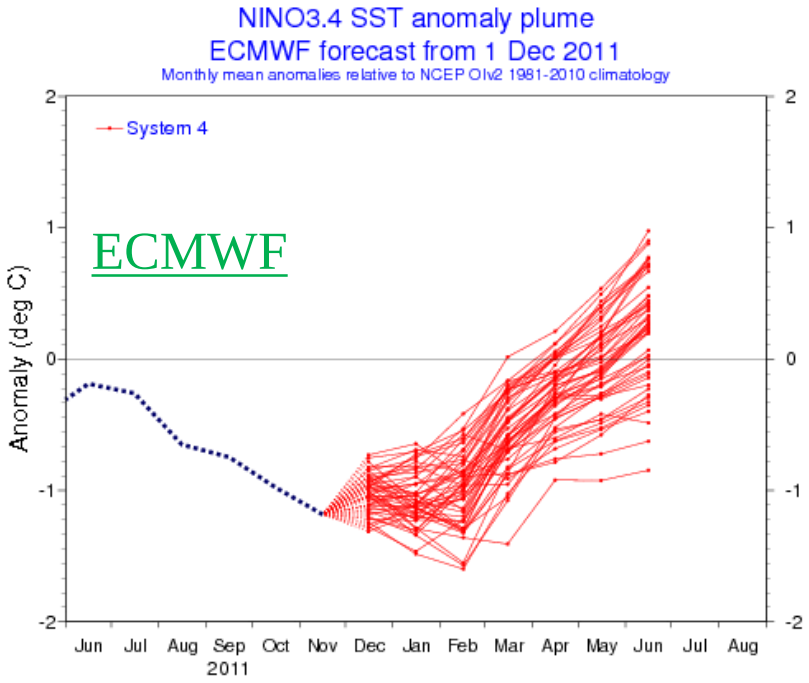
- CFSv2 predicted La Nina would peak in Jan 2012 and gradually weaken towards normal-conditions in late spring, while CFSv1 predicted La Nina would peak in Mar 2012, and then weaken slightly in spring, continuing through the Northern summer.

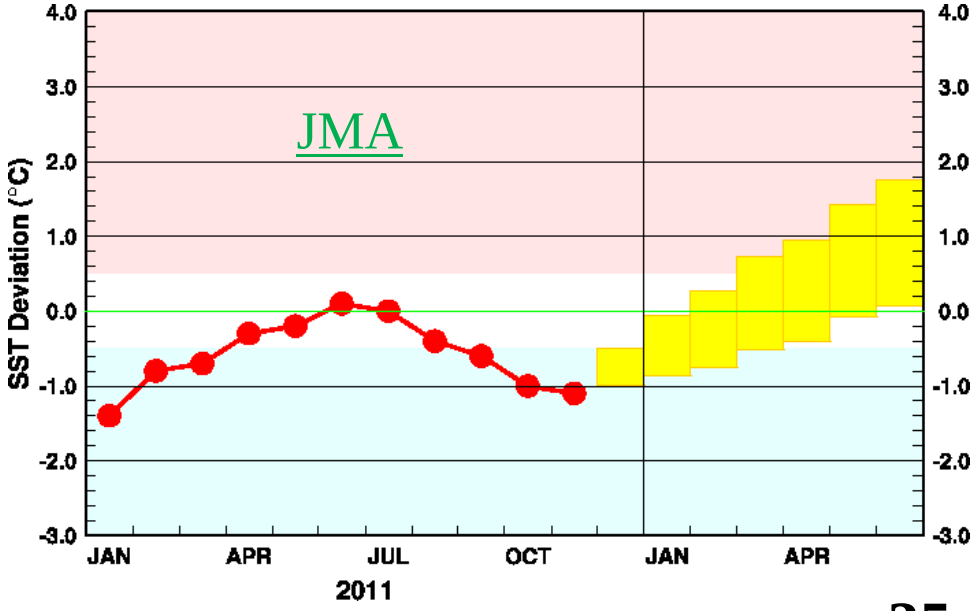
- PDF corrected CFSv1 forecast favors moderate La Nina conditions to last through the Northern summer 2012.

- NOAA "ENSO Diagnostic Discussion" suggests La Niña is expected to continue into the Northern spring 2012.

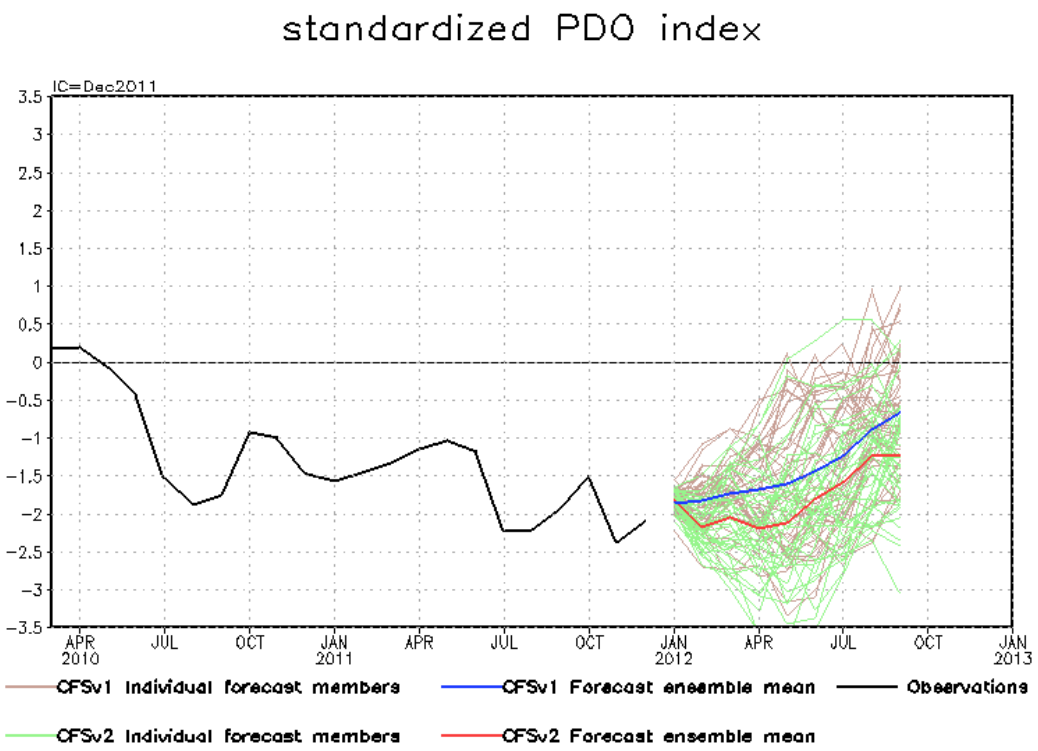


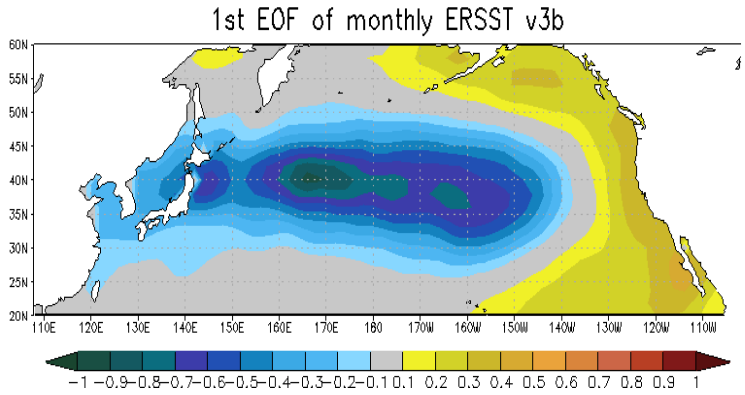
- **Large spread in NINO3.4 forecast was evident among models: some examples here.**





NCEP CFSv1 and CFSv2 PDO Forecast

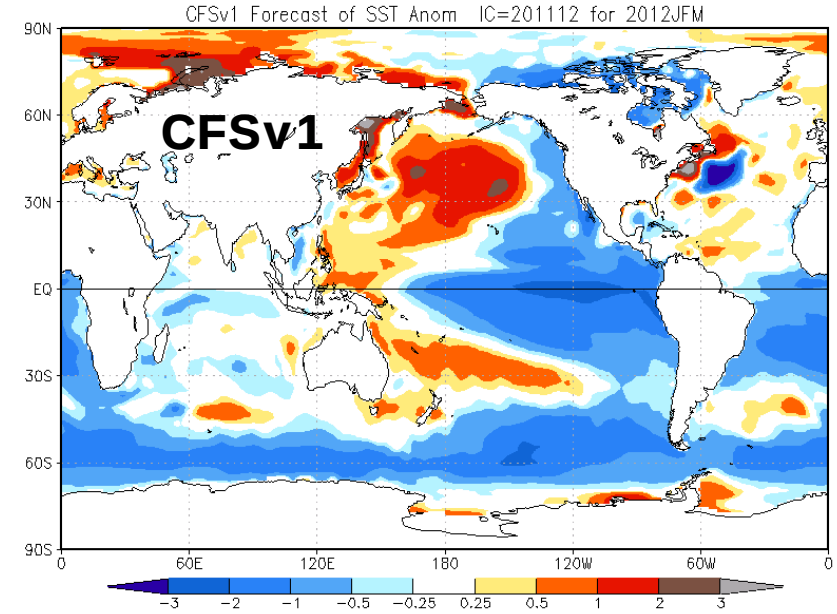


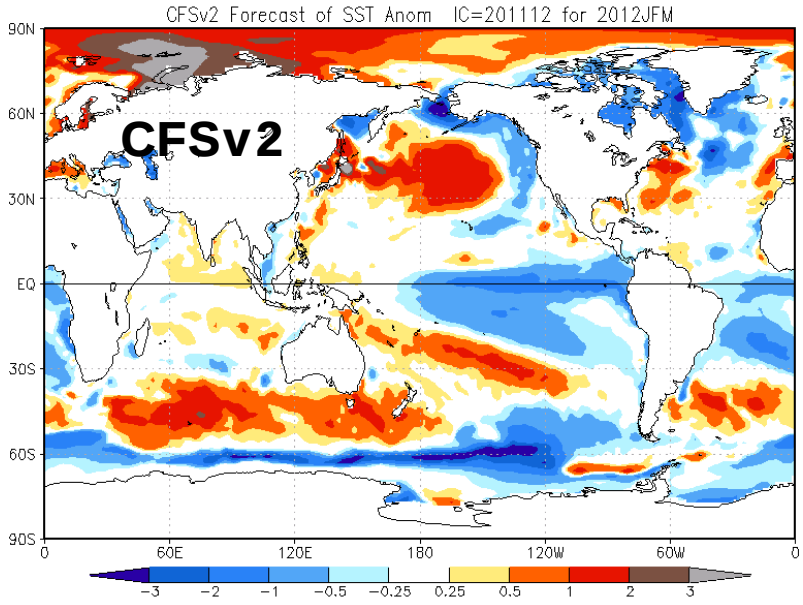


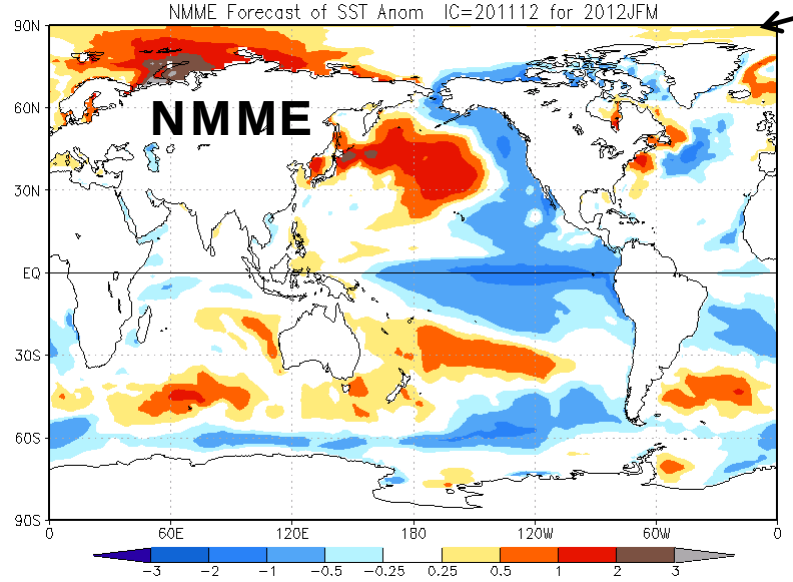
- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSSTv3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**

- **Both CFSv1 and CFSv2 predicted negative PDO to last through the Northern winter 2011/12, and continue into spring and summer 2012.**

National Multi-Model Ensemble (NMME) SST Forecast for JFM 2011 (Nov 2011 I.C.)







Ensemble Mean of 7 Models
(CFSv1, CFSv2, ECHAMA, ECHAMF, GFDL, NCAR, NASA)

http://www.cpc.ncep.noaa.gov/products/people/wd51yf/NMME
experimental product

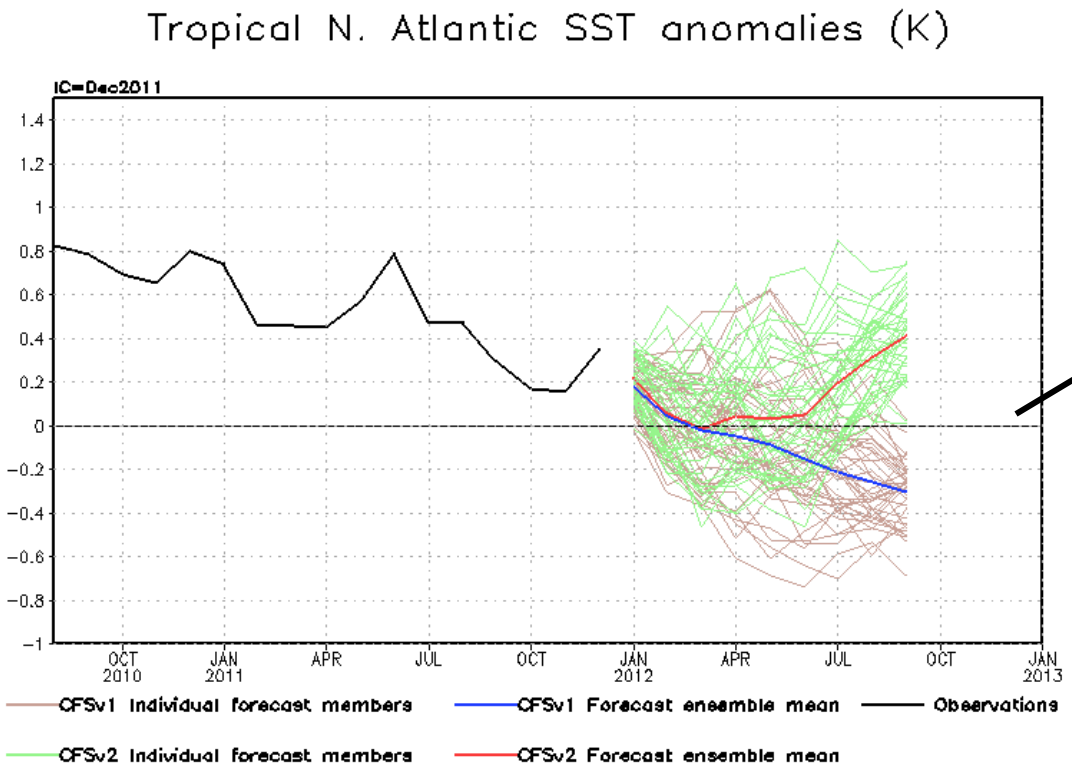
Thanks Qin Zhang, Huug van den Dool, Suru Saha, Malaquias Pena Mendez, Patrick Tripp, Peitao Peng and Emily Becker plus the originators at NASA, NCAR, GFDL, IRI (all coupled models)

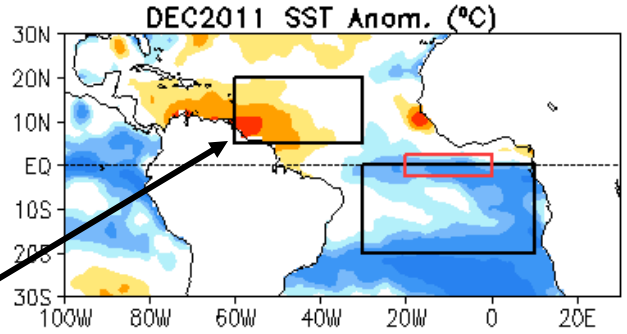
- National Multi-Model Ensemble (NMME) forecast favors La Nina conditions and negative PDO in JFM.

- CFSv2 forecast agrees well with NMME forecast.

- Compared to NMME forecast, CFSv1 forecast SST is too cold and has too broad meridional extent in the tropical Pacific, too cold in the tropical Indian and tropical Atlantic Ocean.

NCEP CFSv1 and CFSv2 Tropical North Atlantic SST Forecast



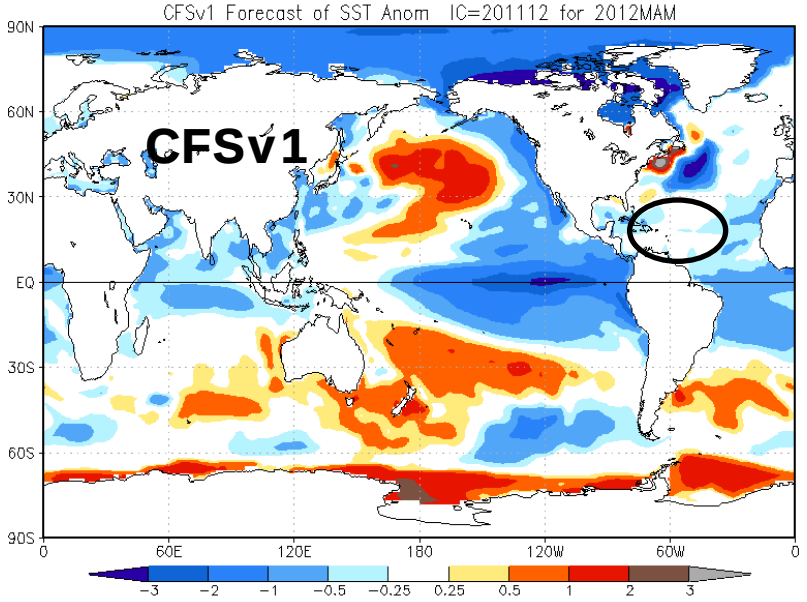


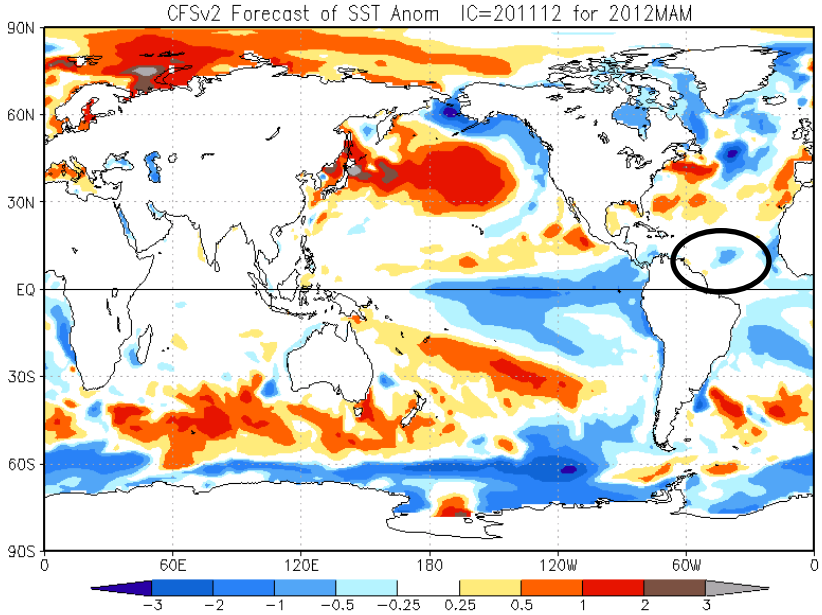
- CFSv1 predicted positive TNA would weaken rapidly, switch to negative in early spring, and continue to cool in spring/summer 2012.

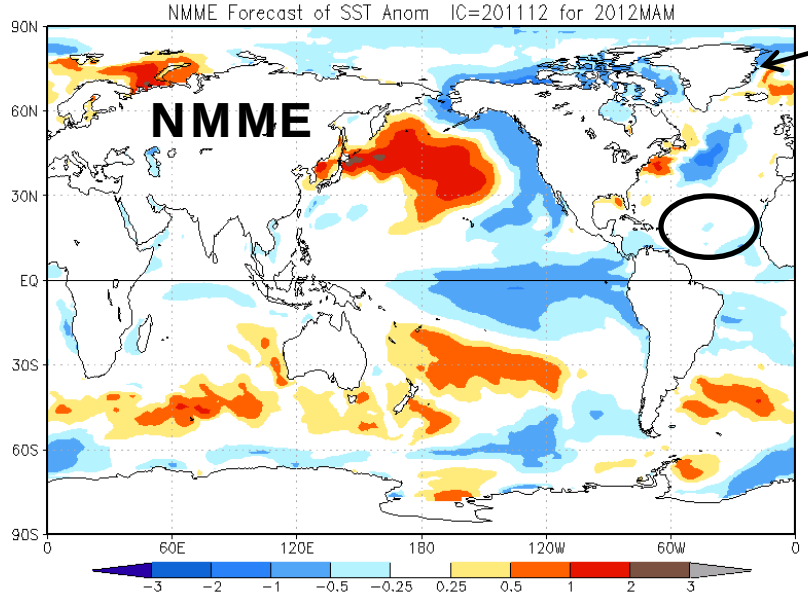
- However, CFSv2 predicted positive TNA to return to near-normal in spring 2012, and then increase rapidly in summer 2012.

National Multi-Model Ensemble (NMME) SST Forecast for MAM 2012

(Nov 2011 I.C.)







Ensemble Mean of 7 Models
(CFSv1, CFSv2, ECHAMA, ECHAMF, GFDL, NCAR, NASA)

http://www.cpc.ncep.noaa.gov/products/people/wd51yf/NMME
experimental product

Thanks Qin Zhang, Huug van den Dool, Suru Saha, Malaquias Pena Mendez, Patrick Tripp, Peitao Peng and Emily Becker plus the originators at NASA, NCAR, GFDL, IRI (all coupled models)

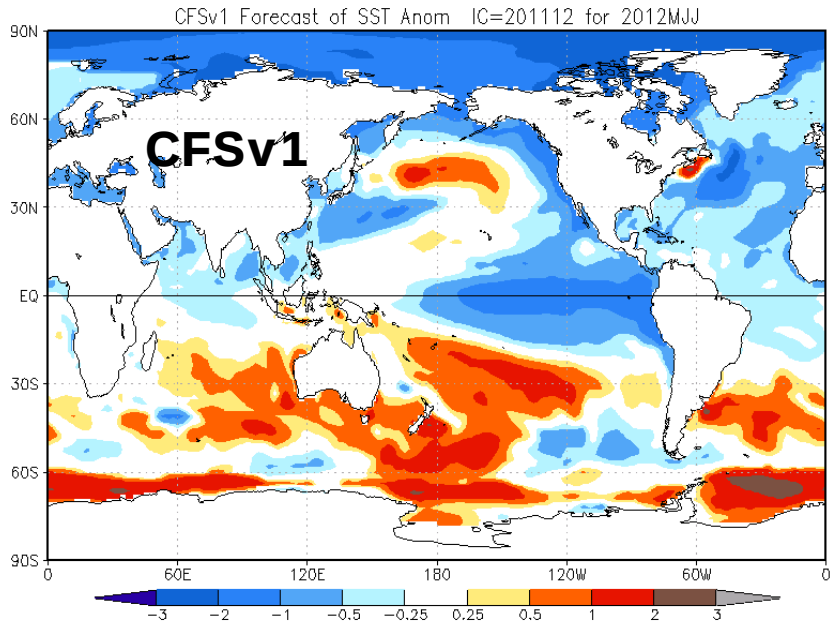
- National Multi-Model Ensemble (NMME) forecast favors La Nina conditions and negative PDO in MAM 2012.

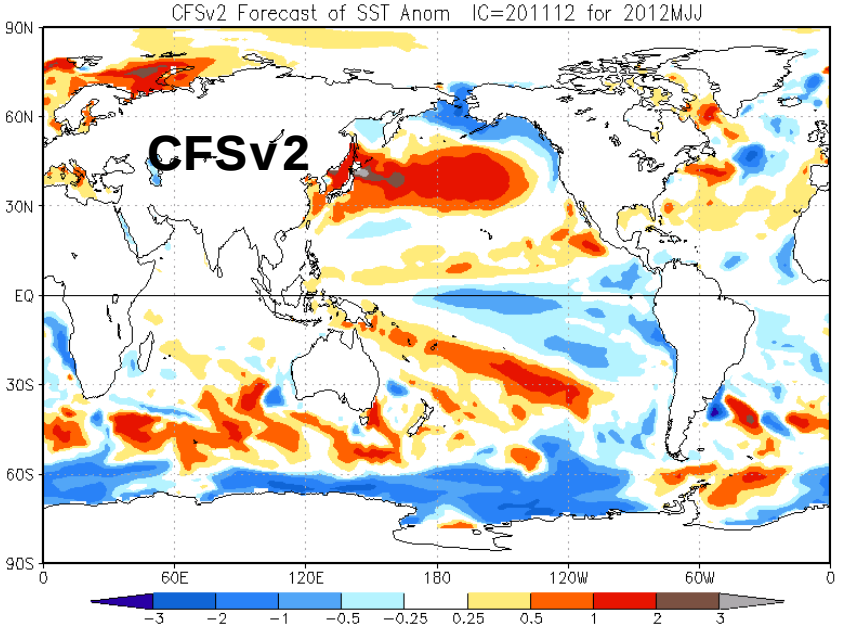
- CFSv2 forecast agrees with NMME forecast better than CFSv1 does.

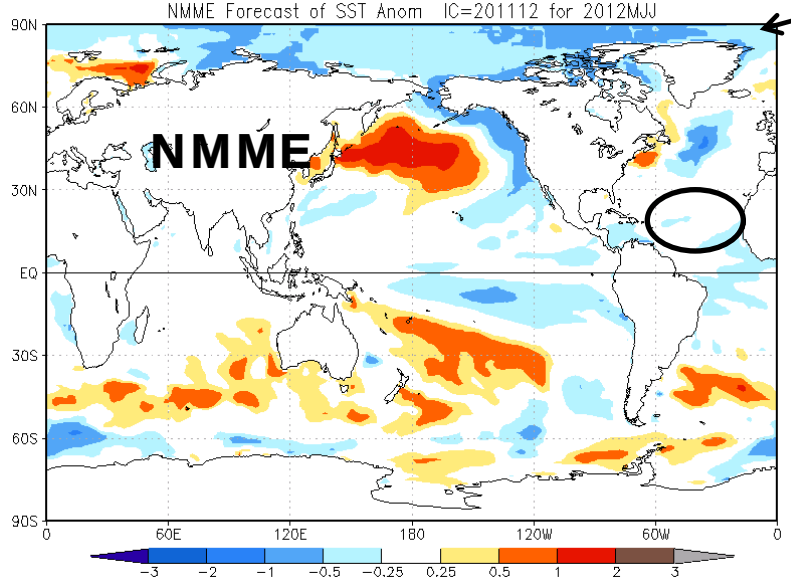
- All models predicted near-normal tropical North Atlantic SST in MAM 2012.

National Multi-Model Ensemble (NMME) SST Forecast for MJJ 2012

(Nov 2011 I.C.)







Ensemble Mean of 7 Models
(CFSv1, CFSv2, ECHAMA, ECHAMF, GFDL, NCAR, NASA)

http://www.cpc.ncep.noaa.gov/products/people/wd51yf/NMME
experimental product

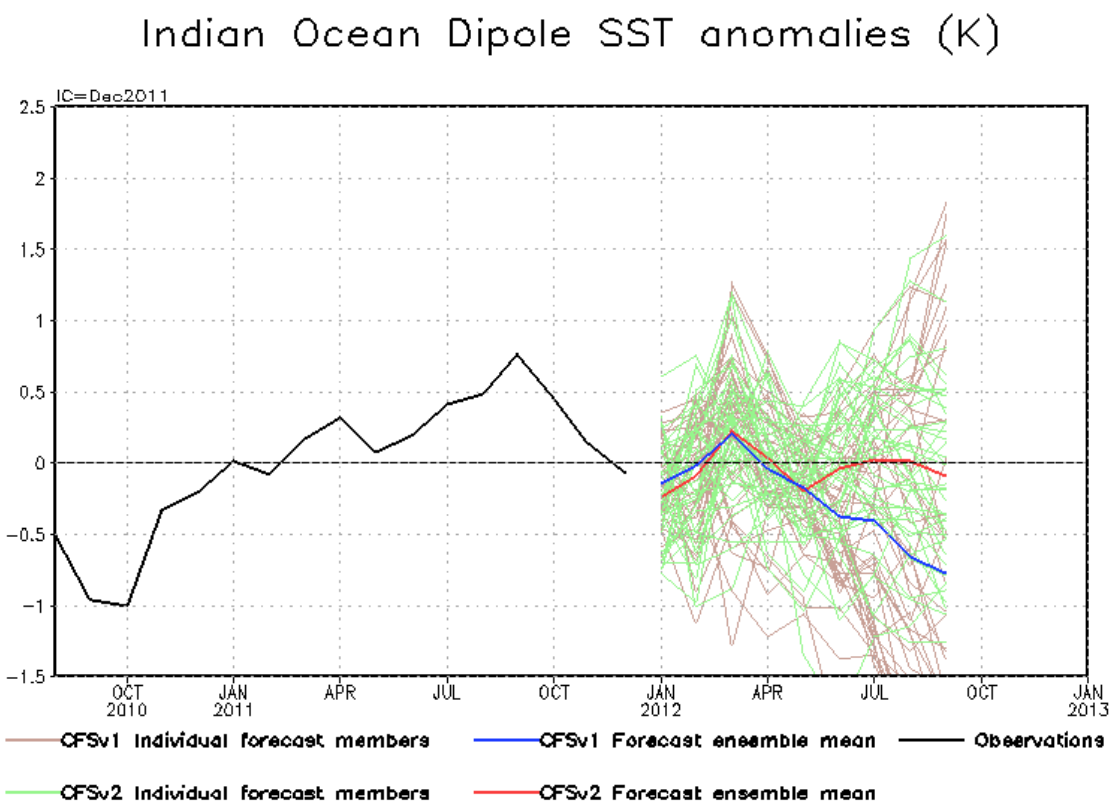
Thanks Qin Zhang, Huug van den Dool, Suru Saha, Malaquias Pena Mendez, Patrick Tripp, Peitao Peng and Emily Becker plus the originators at NASA, NCAR, GFDL, IRI (all coupled models)

- National Multi-Model Ensemble (NMME) forecast favors ENSO-neutral conditions, negative PDO, near-normal tropical North Atlantic SST in MJJ 2012.

- CFSv2 forecast agrees well with NMME forecast.

- However, CFSv1 forecast La Nina conditions in the tropical Pacific and excessive cooling in N. Atlantic.

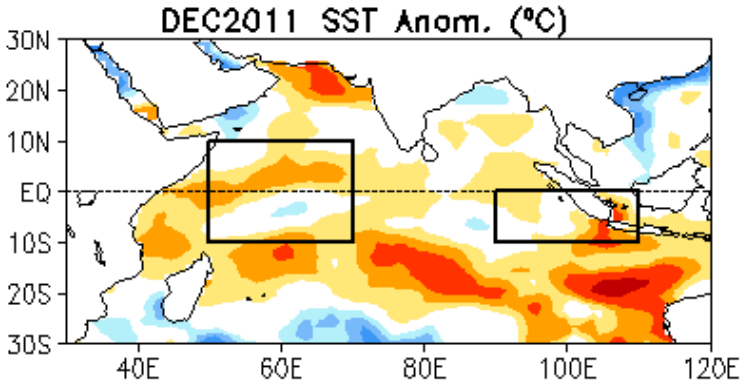
NCEP CFSv1 and CFSv2 Dipole Model Index Forecast



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]



- **CFSv1 predicted negative IOD conditions to develop in summer/fall 2012.**
- **However, CFSv2 predicted neutral IOD conditions would prevail in next 9 months.**

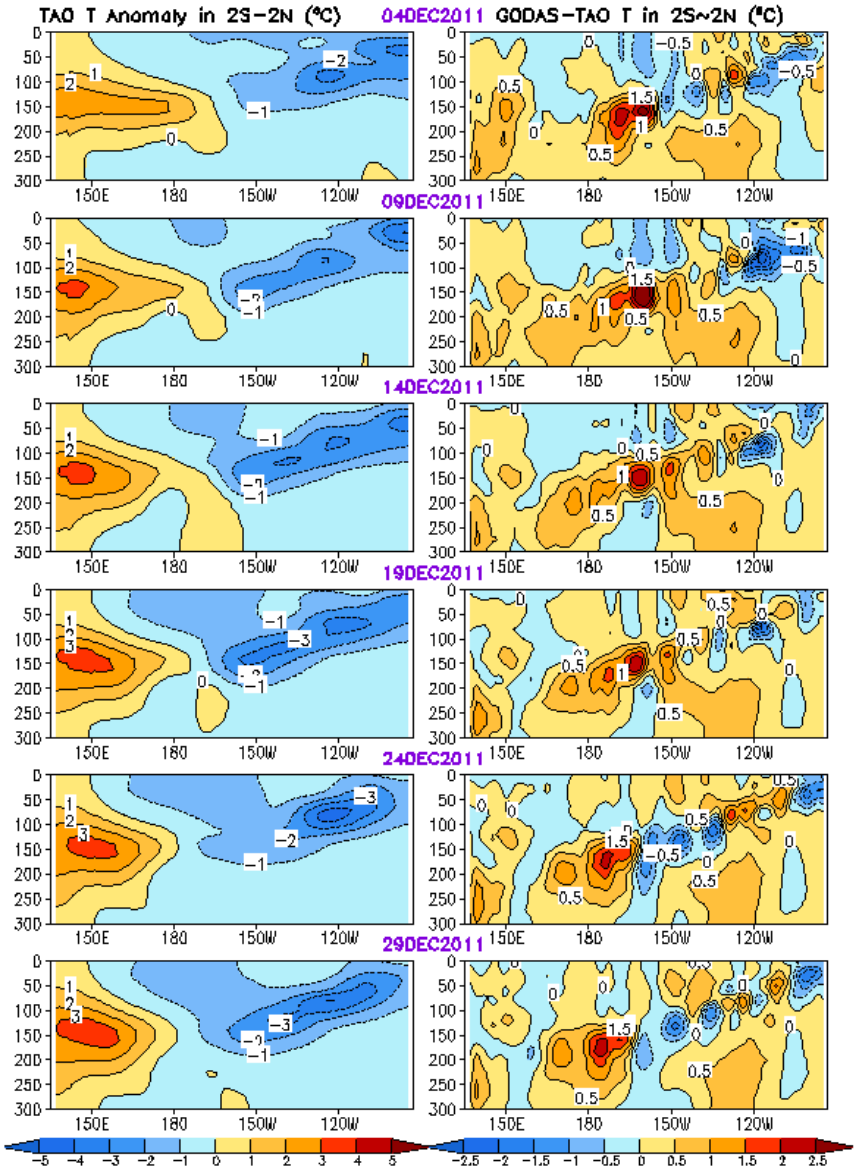
Overview

- **Pacific Ocean**
  - La Nina conditions persisted with NINO3.4=-1.0°C in Dec 2011.
  - NOAA "ENSO Diagnostic Discussion" suggests La Niña is expected to continue into the Northern spring 2012.
  - The atmospheric components of La Niña became more well-defined after MJO activities and positive IOD dissipated by the end of Nov.
  - Negative PDO persisted, with PDOI=-2.1 in Dec 2011.
  - National Multi-Model Ensemble (NMME) predicted negative PDO to last through the Northern winter and continue into the Northern spring/summer 2012.
- **Indian Ocean**
  - Westerly wind anomalies were consistent with enhanced convection in eastern tropical Indian Ocean and over Indonesia, which reflected influences of La Niña.
- **Atlantic Ocean**
  - Positive NAO strengthened with NAO=2.5 in Dec 2011.
  - Meridional SSTA gradient strengthened with value 1.2°C in Dec 2011.
  - Consistent with meridional SSTA gradient, convection was enhanced (weakened) in subtropical N. Atlantic (along the equatorial Atlantic)

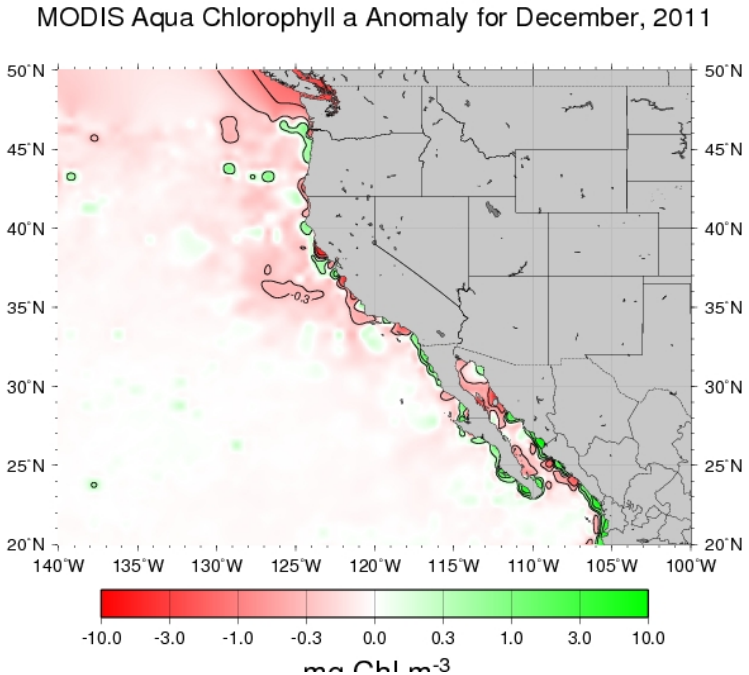
Backup Slides

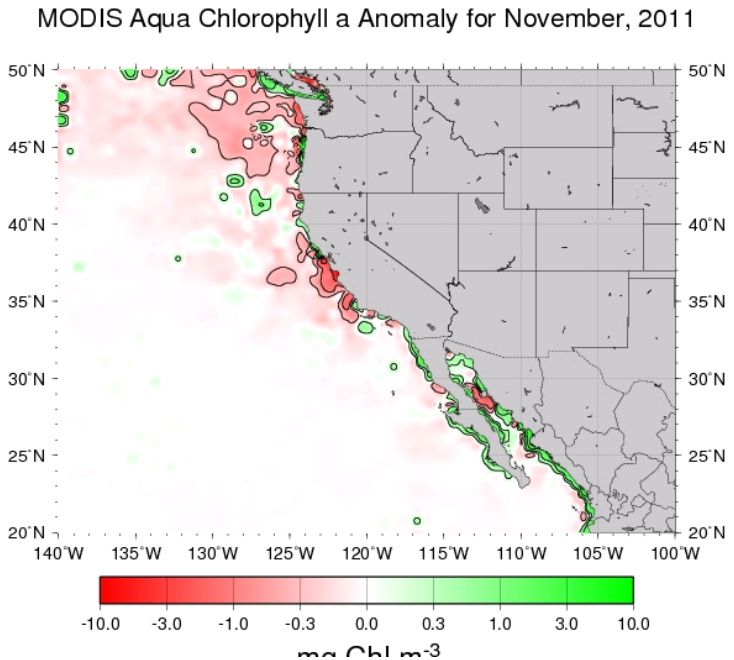
Equatorial Pacific Temperature Anomaly

TAO GODAS-TAO



Monthly Chlorophyll Anomaly



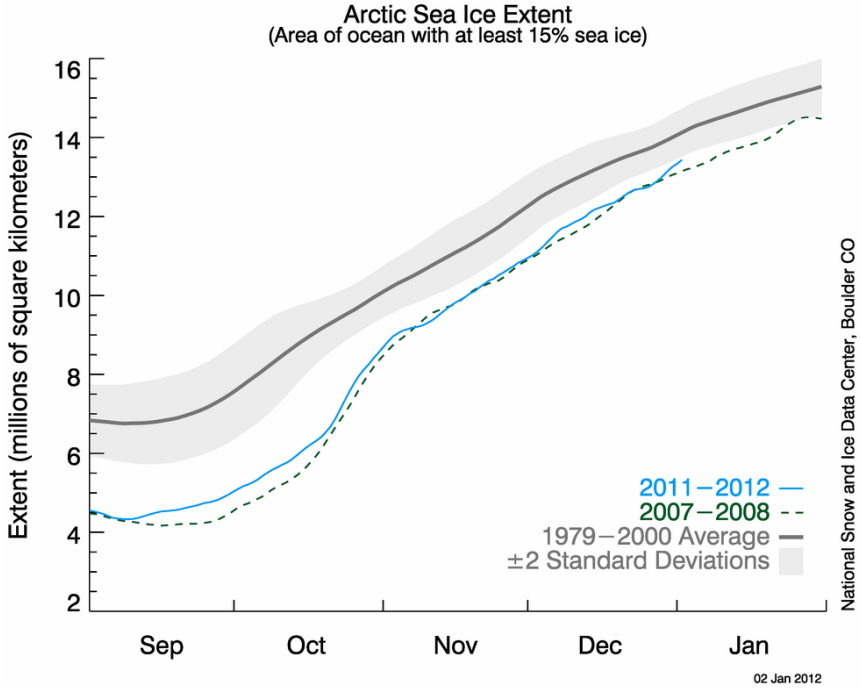


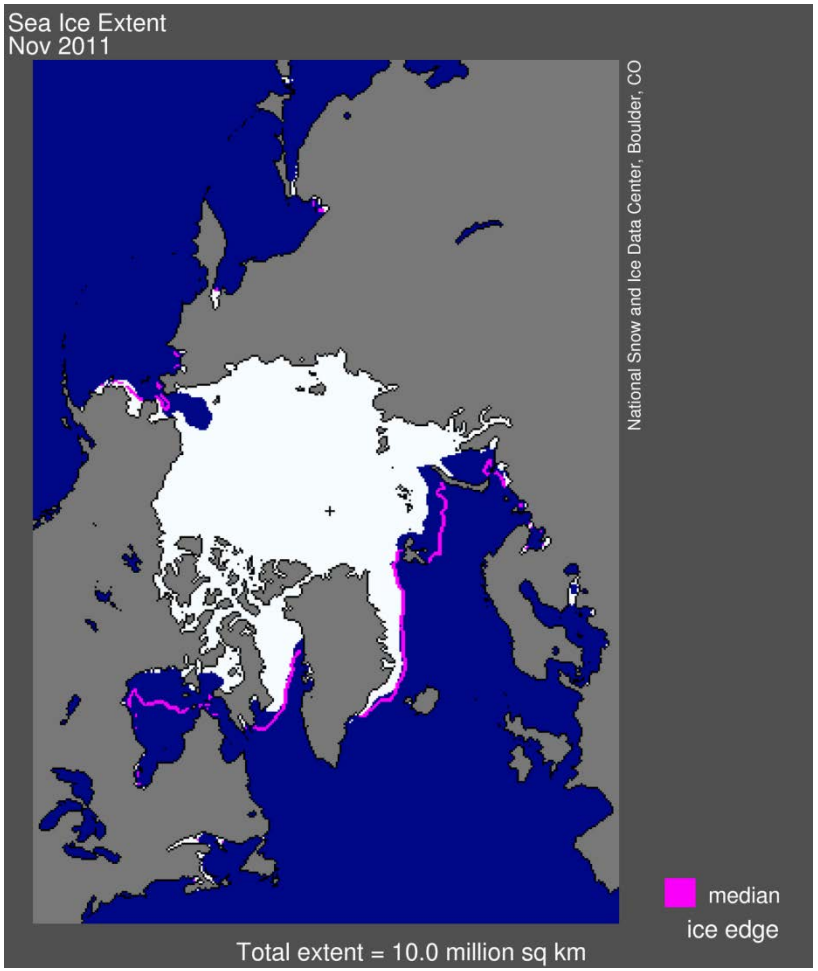
http://coastwatch.pfel.noaa.gov/FAST

Arctic Sea Ice

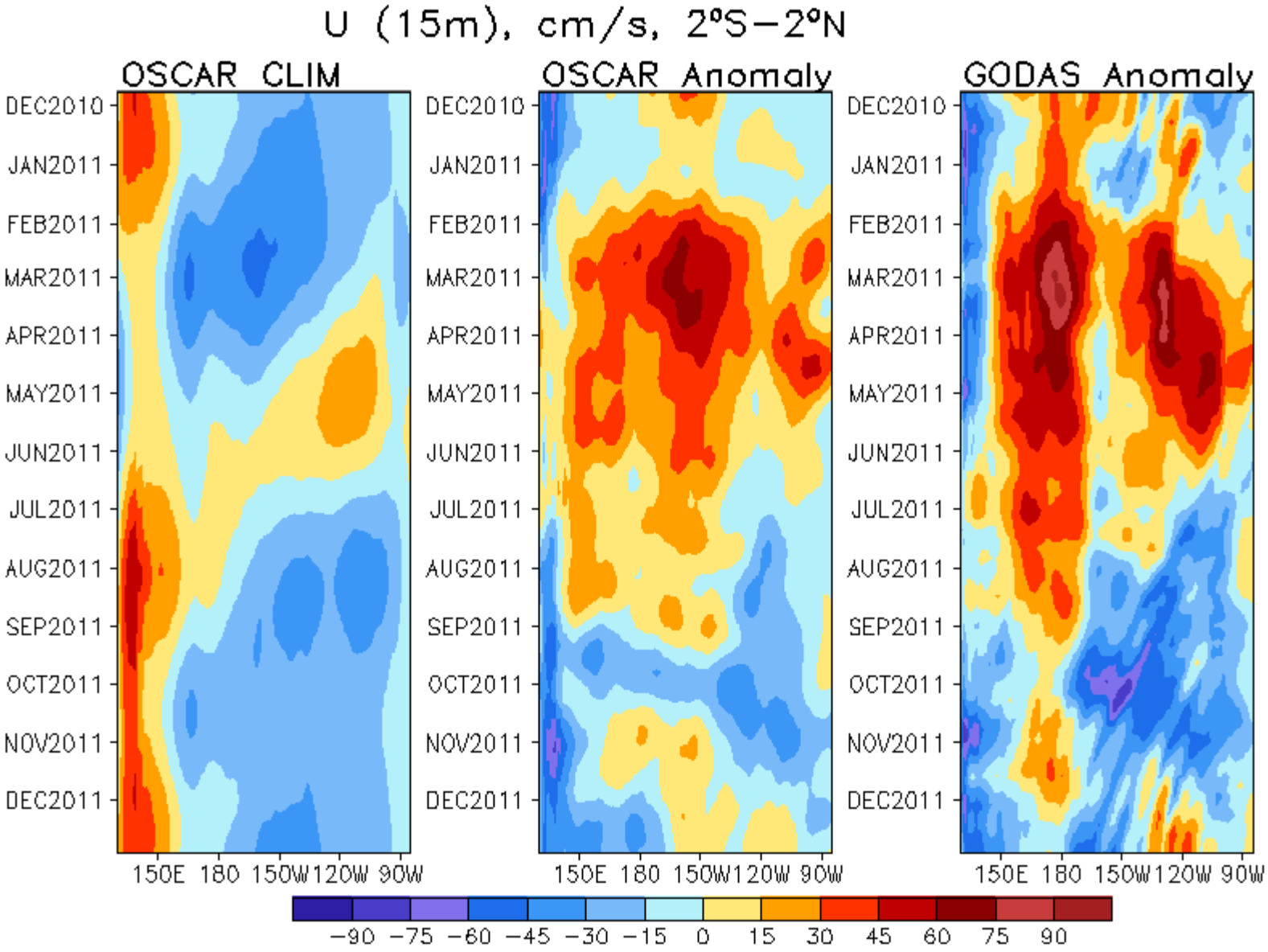
National Snow and Ice Data Center

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





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



CFS Niño3.4 SST Predictions from Different Initial Months

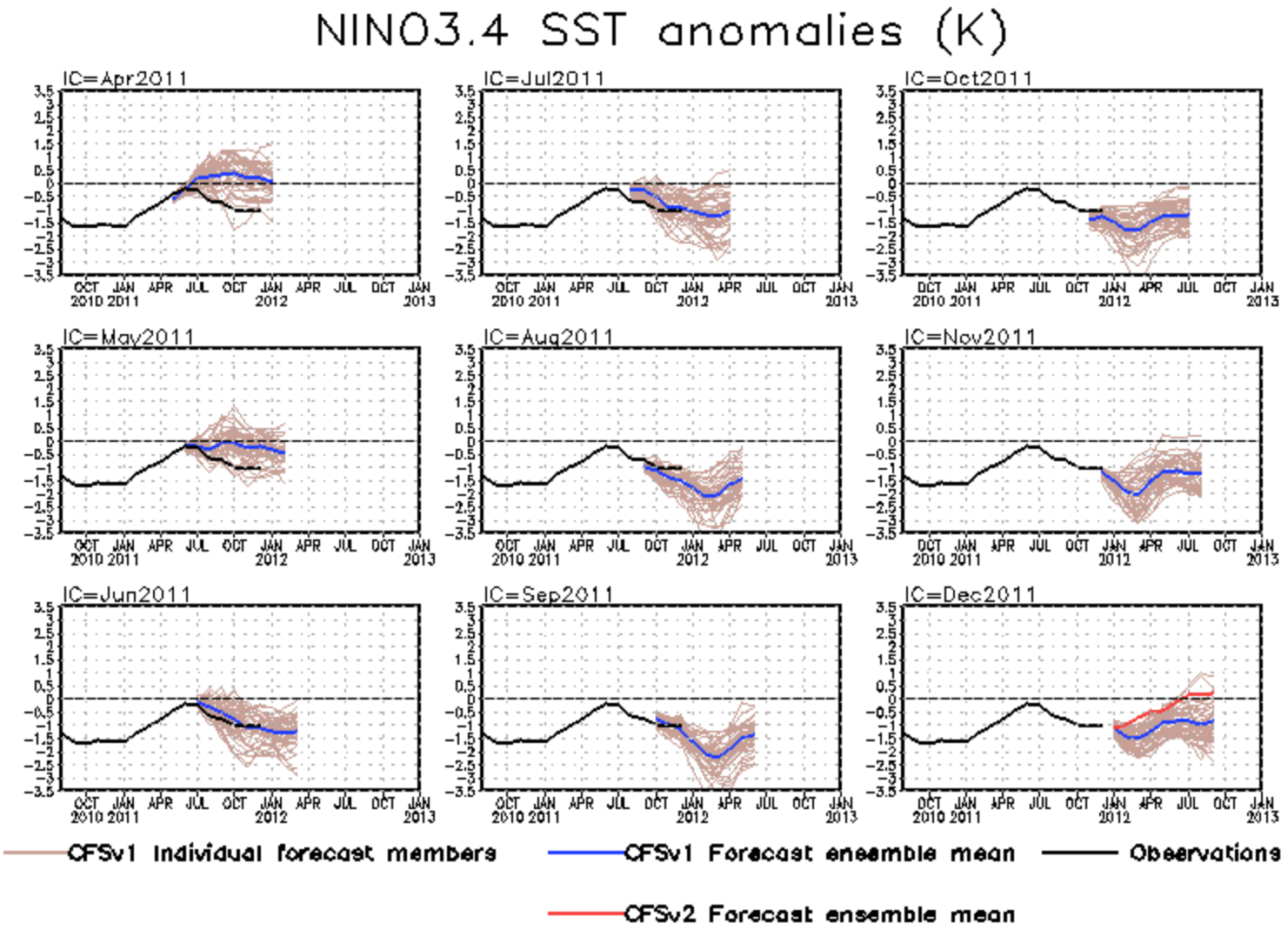
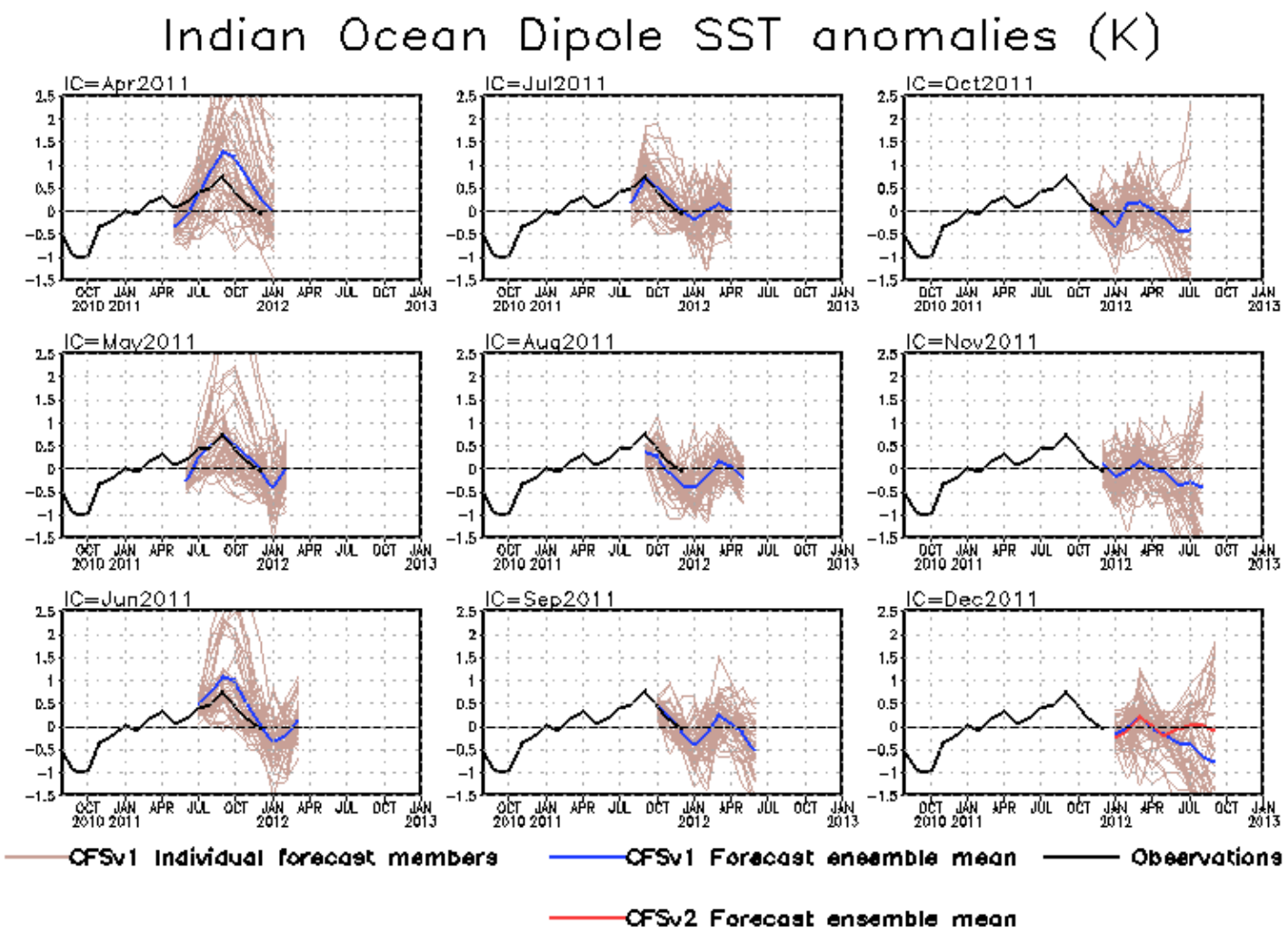


Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

NCEP 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 of positive IOD in fall 2011 was forecast well by CFSv1 since Feb 2011.

- However, the spread among ensemble members is quite large.

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.

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].

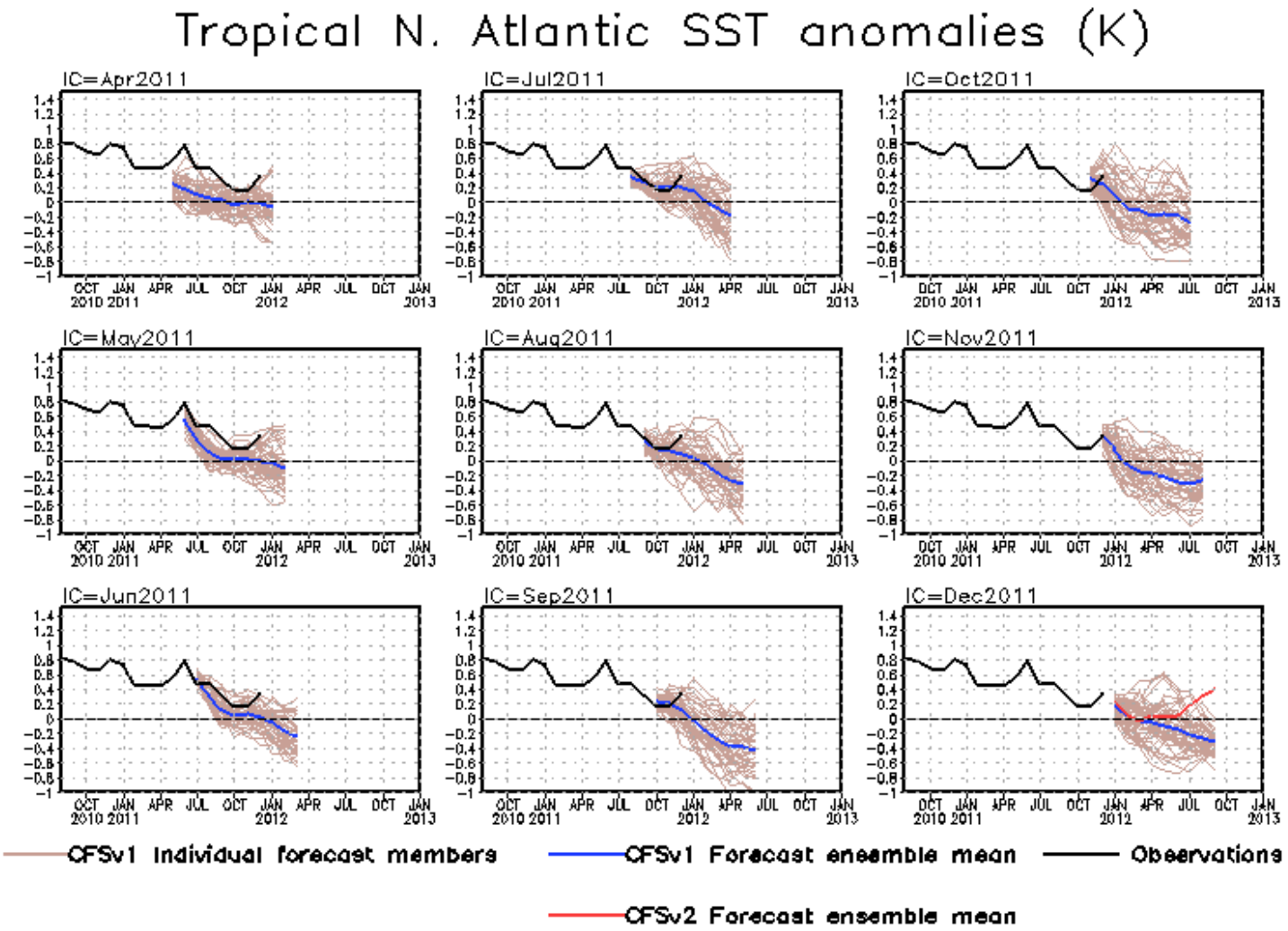
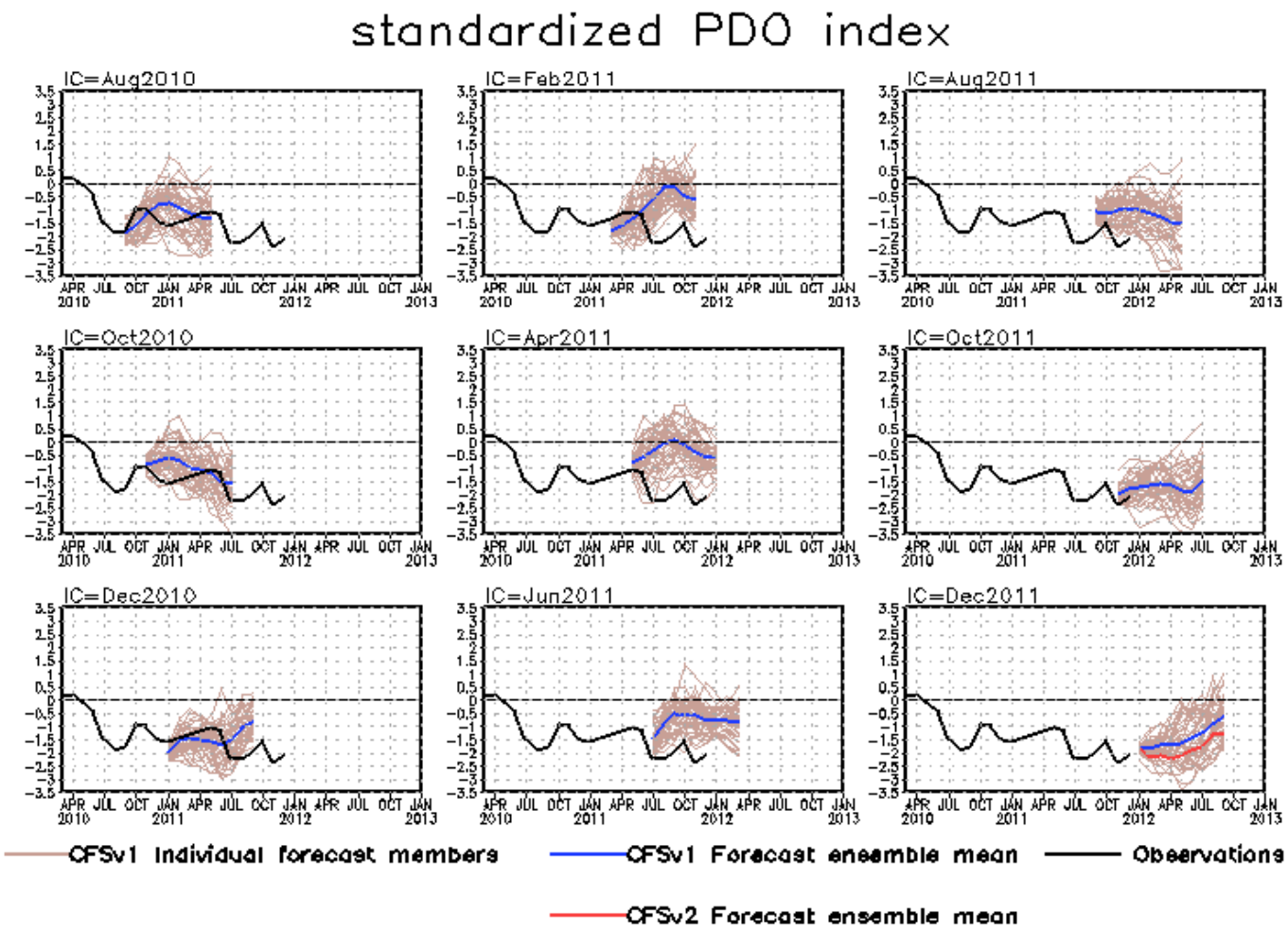


Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 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].

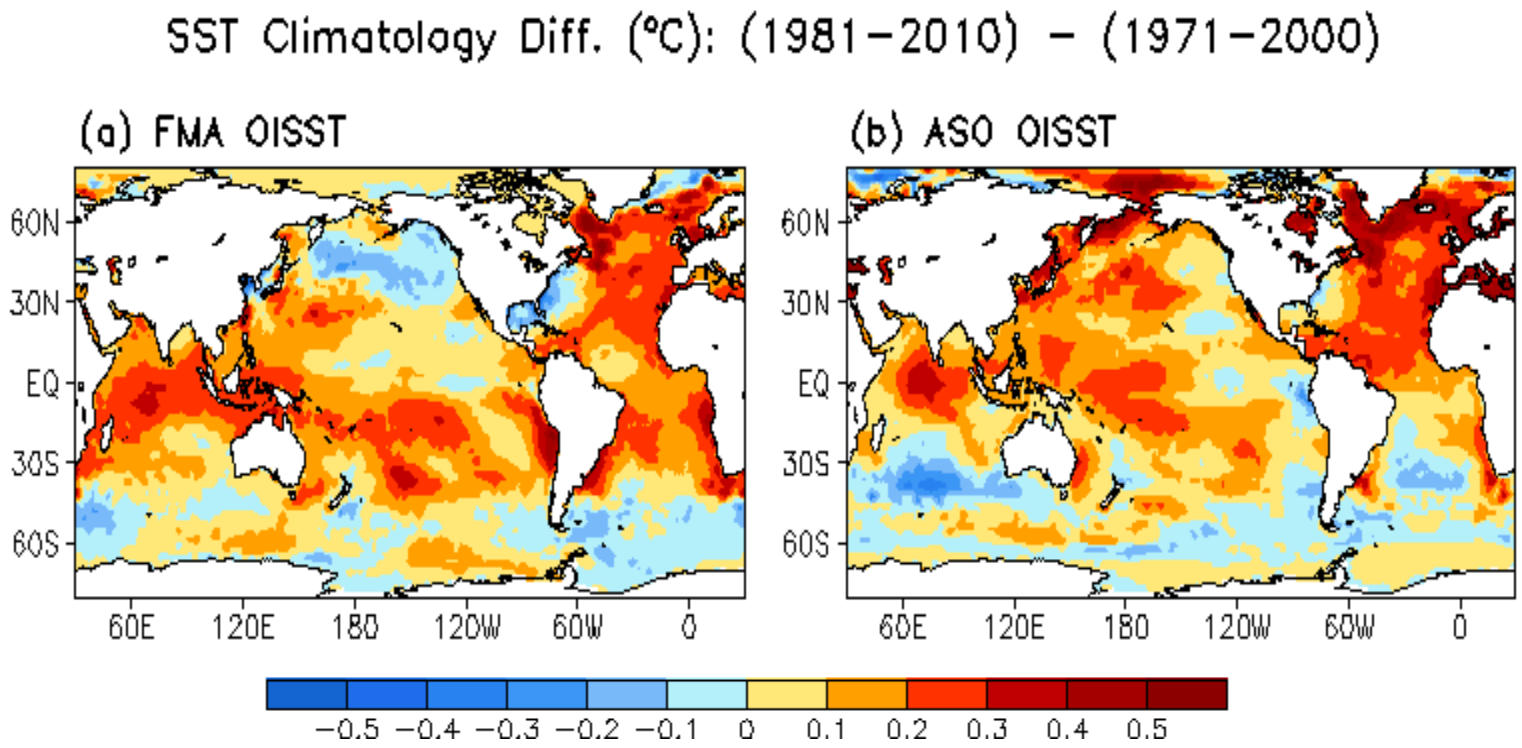
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

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). 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



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!