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

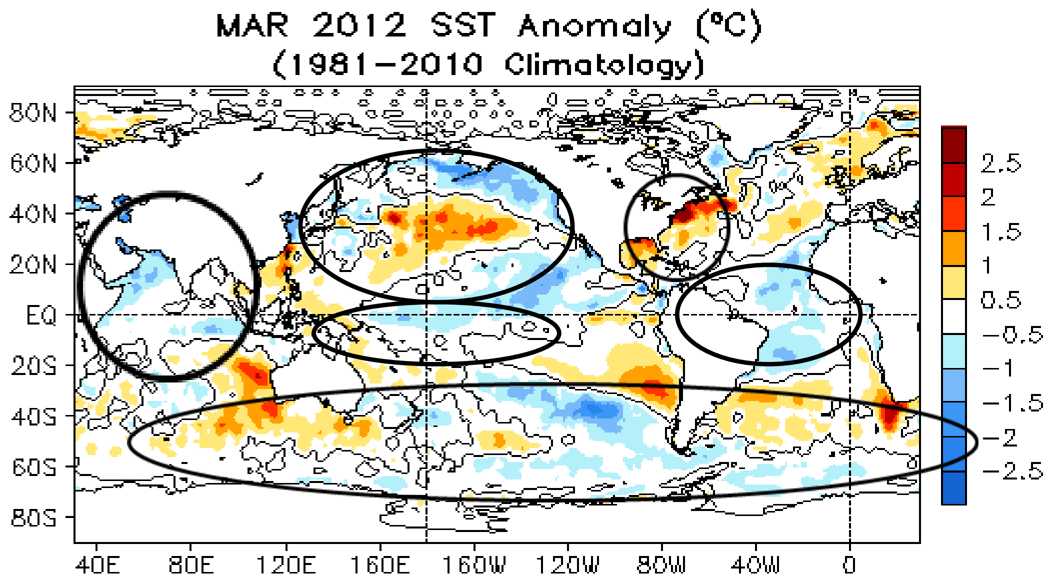
- **Overview**
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Potential New Indices to Monitor Pacific Ocean**
- **Global SST Predictions**

Overview

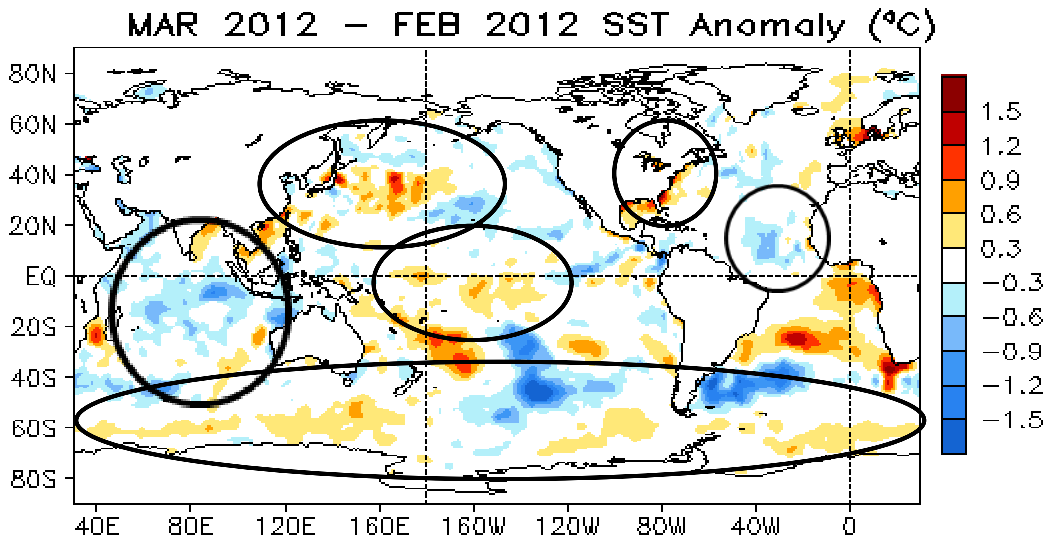
- **Pacific Ocean**
  - **La Nina conditions weakened with NINO3.4=-0.6^{o}C in Mar 2012.**
  - **NOAA "ENSO Diagnostic Discussion" in Apr suggests La Niña is expected to return to ENSO-neutral conditions during April 2012. A majority of ENSO models predict ENSO-neutral to continue through the NH summer 2012. Some models in the US National Multi-Model Ensemble (NMME) predict an El Nino since summer 2012.**
  - **Negative phase of PDO persisted, with PDOI=-1.4 in Mar 2012. NMME predicts the negative phase to last through the NH spring-autumn 2012.**
- **Indian Ocean**
  - **Negative SSTA developed in the tropical Indian Ocean, may be caused by the impact of La Nina.**
- **Atlantic Ocean**
  - **Positive NAO strengthened with NAOI=1.27 in Mar 2012.**
  - **Tropical North Atlantic cooled down, probably due to the impact of La Nina and positive phase of NAO.**
  - **Tropical South Atlantic has cooled down substantially since Dec 2011, which was the coolest period since 1998. NMME predicts the cooling to last until early autumn 2012.**

Global Oceans

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



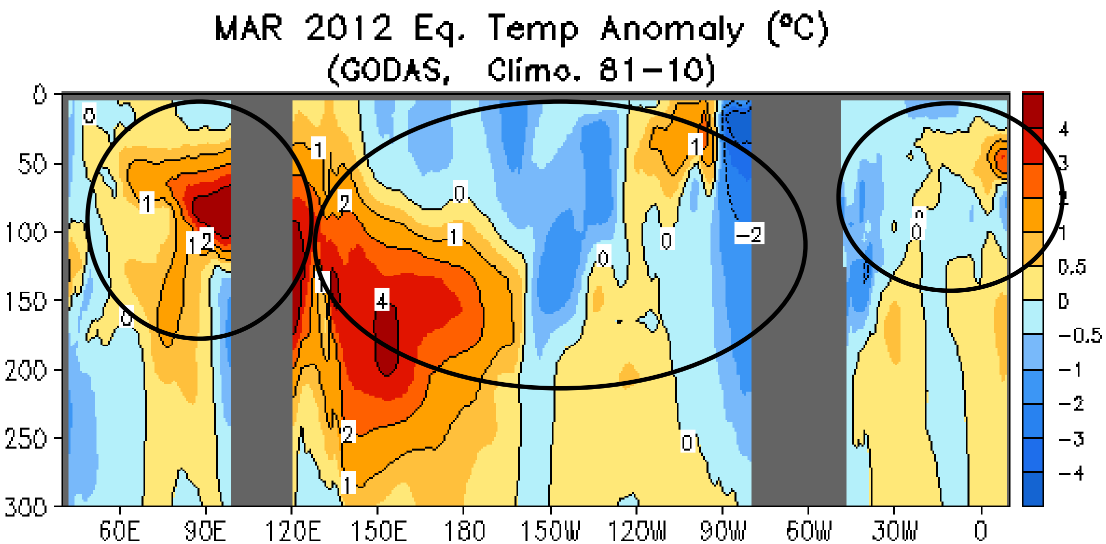
- La Nina associated negative SSTA weakened continuously in the central and eastern equatorial Pacific.
- Negative PDO pattern dominated and persisted in the N. Pacific.
- Negative SSTA developed in Indian Ocean
- Negative SSTA presented in the tropical Atlantic. Warming along American Atlantic coast was observed.
- Large anomalies emerged in the South Ocean.



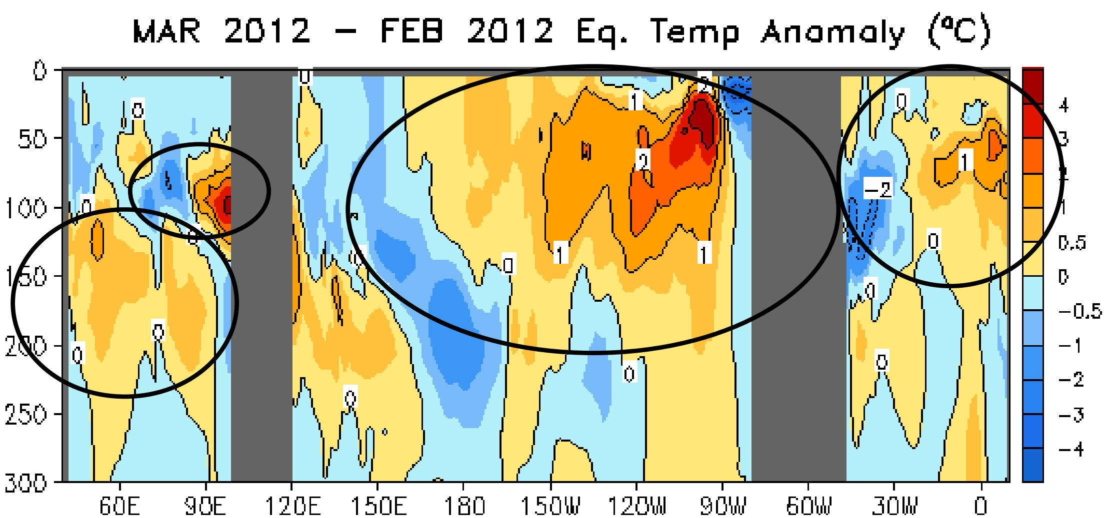
- SST increased in the central and eastern tropical Pacific, as well as in the mid-latitudes of N. Pacific.
- Cooling tendency observed in Indian Ocean, probably due the lagged impact of La Nina.
- Both the warming along American Atlantic coast and cooling in the tropical N. Atlantic strengthened.
- Large tendencies in the South 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.

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



- Ocean temperature anomaly pattern along the equatorial Pacific is consistent with the decay phase of La Nina conditions.
- Positive ocean temperature anomalies covered most of the top 200m in the equatorial Indian Ocean.
- Both positive and negative ocean temperature anomalies presented at top 150m of the equatorial Atlantic.

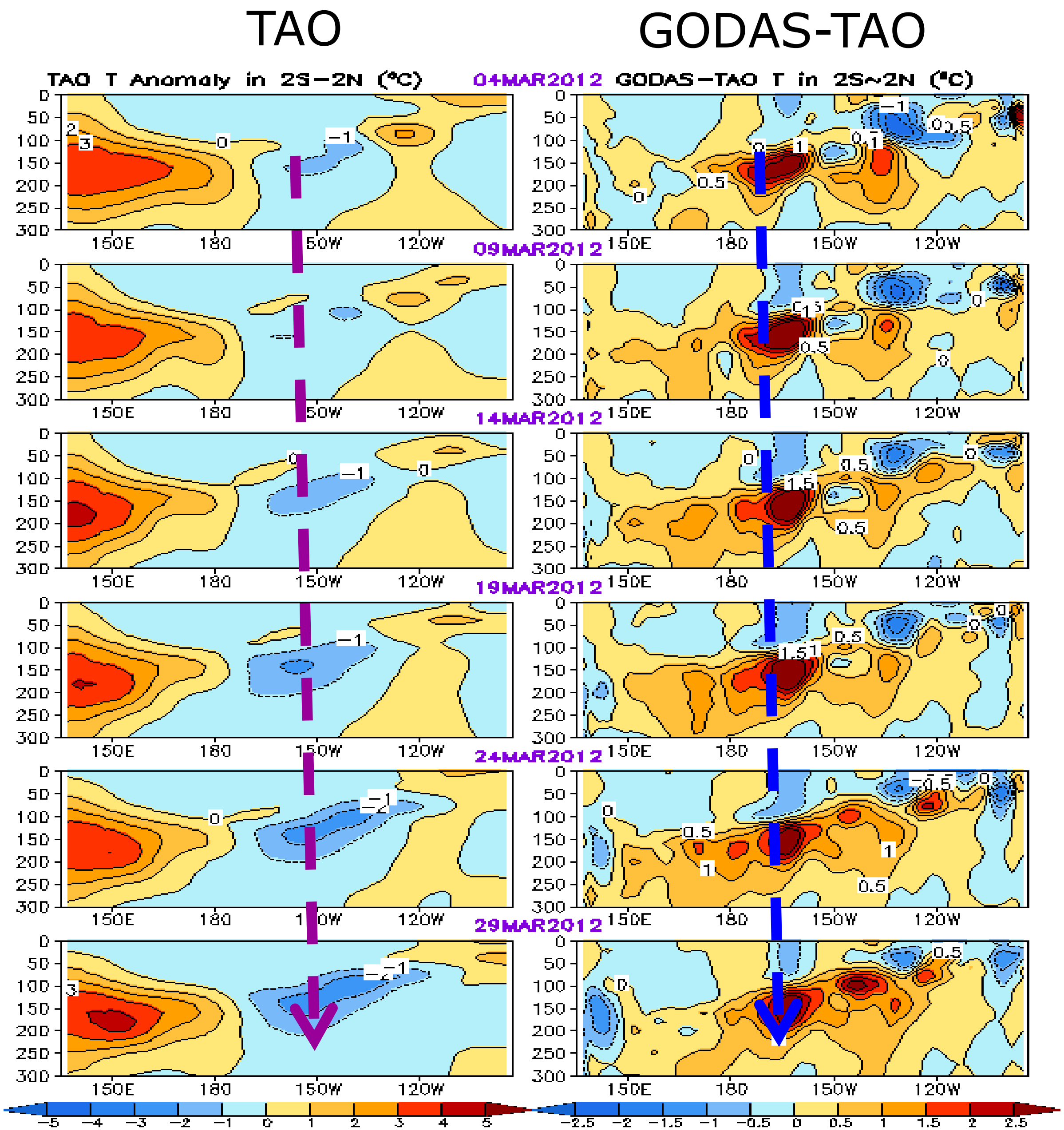


- Ocean temperature warmed up in almost the whole equatorial Pacific, particularly in the eastern Pacific.
- Ocean temperature increased mainly around 100-200 m in the equatorial Indian Ocean and also around 100 m along the eastern boundary.
- Positive (negative) tendency was observed along the thermocline of the eastern (western) equatorial Atlantic, suggesting flattening of the thermocline.

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

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



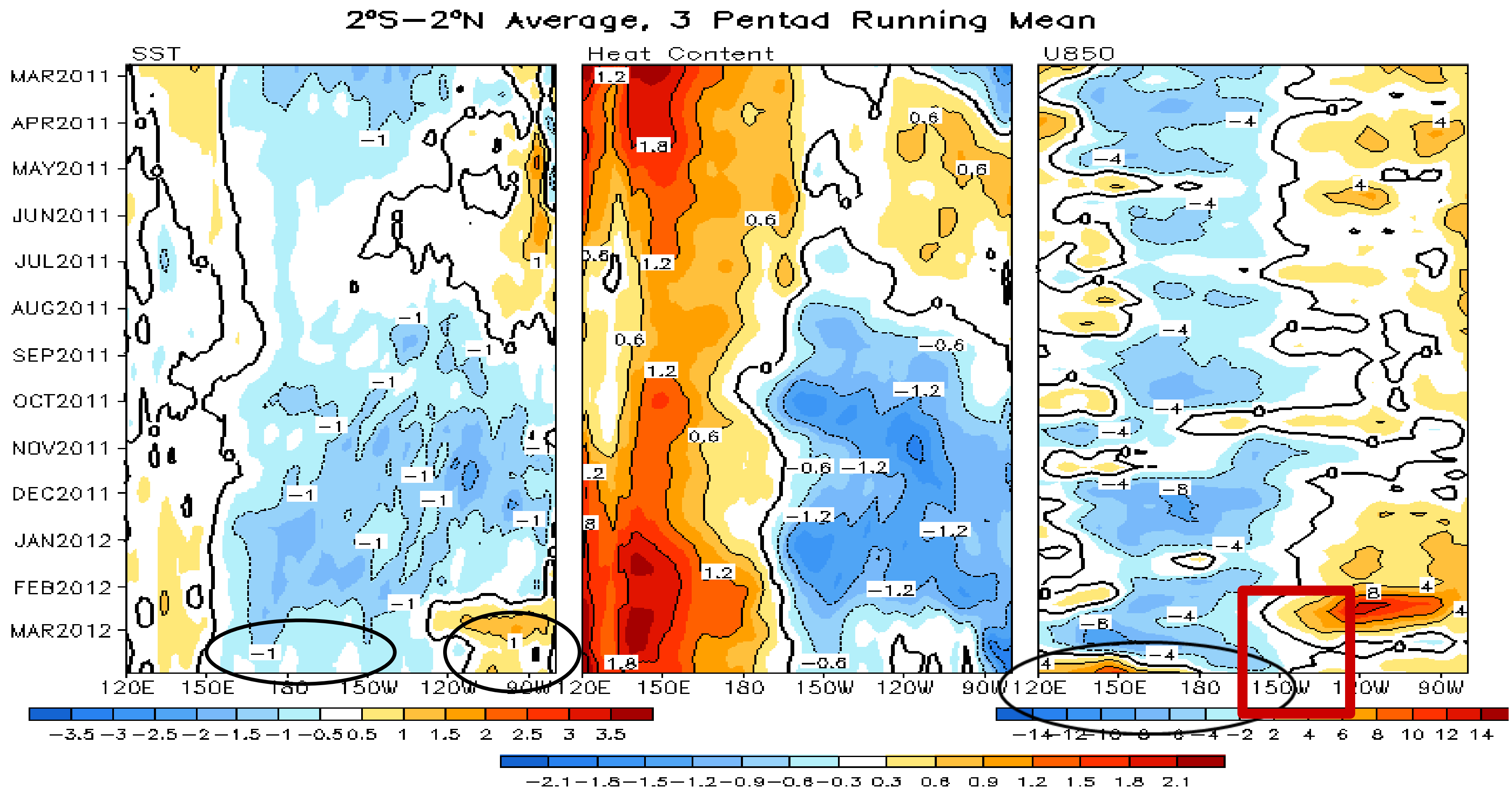
- Large positive anomaly in west and small positive in the east, some negative anomalies mainly around 150W.

- No obvious propagation of the anomalies.

- Slightly strengthening tendency of the cooling around 150W, which may be caused by low-level divergence (next slide).

- Compared with TAO, GODAS is too warm at 100-250 m depth.

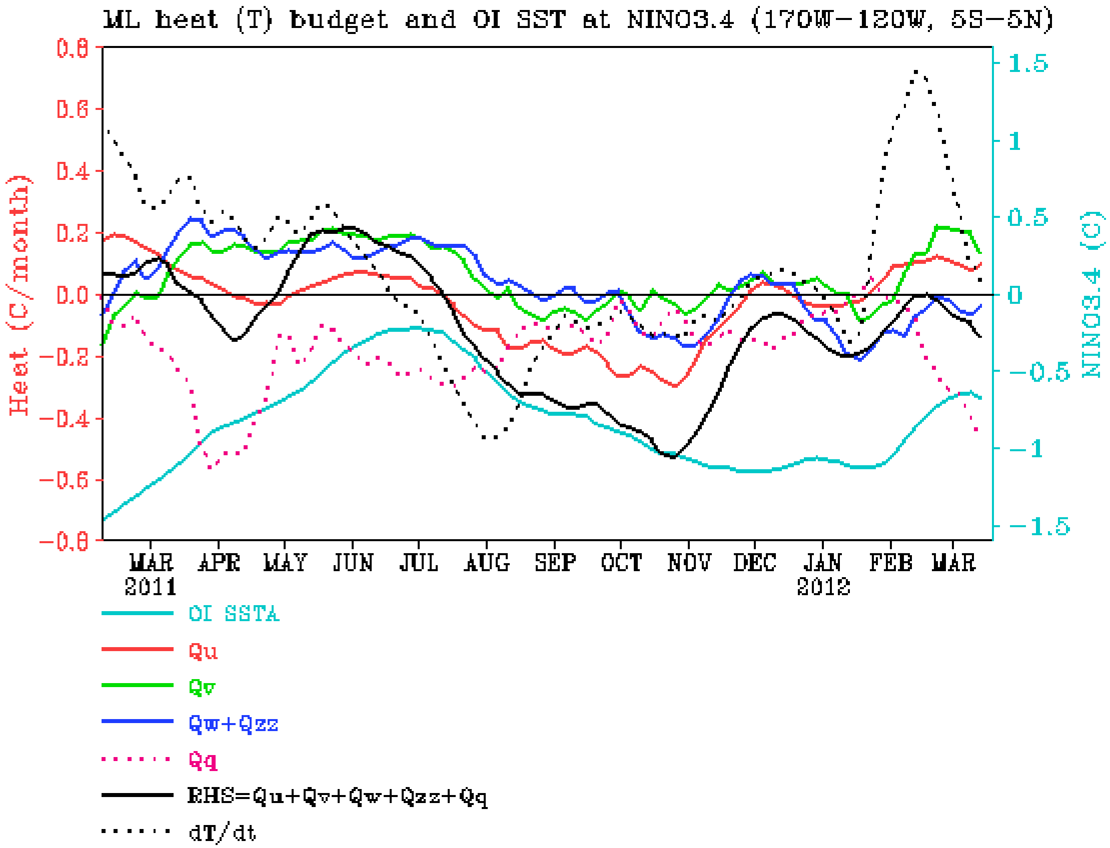
Equatorial Pacific SST (ºC), HC300 (ºC), u850 (m/s) Anomalies



- Negative SSTA weakened in the central (eastern) equatorial Pacific since Feb 2012 (Dec 2011), and positive SSTA developed in the east since Feb 2012.
- HC300 anomalies are consistent with SSTA.
- Westerly wind anomalies presented in the W. Pacific since mid-Mar 2012. The low-level divergence since early-Mar may be a reason causing the strengthened cooling of ocean temperature shown in slide 8.

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 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. 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.

NINO3.4 Heat Budget



- SSTA tendency (dT/dt) in NINO3.4 (dotted line) was positive during mid-Jan-Mar 2012, indicating weakening of La Nina conditions.

- Qu, and Qv were positive, while Qw+Qzz negative in Mar 2012.

- The total heat budget term (RHS) had large cold biases compared with the tendency (dT/dt) in Jan-Mar 2012.

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.

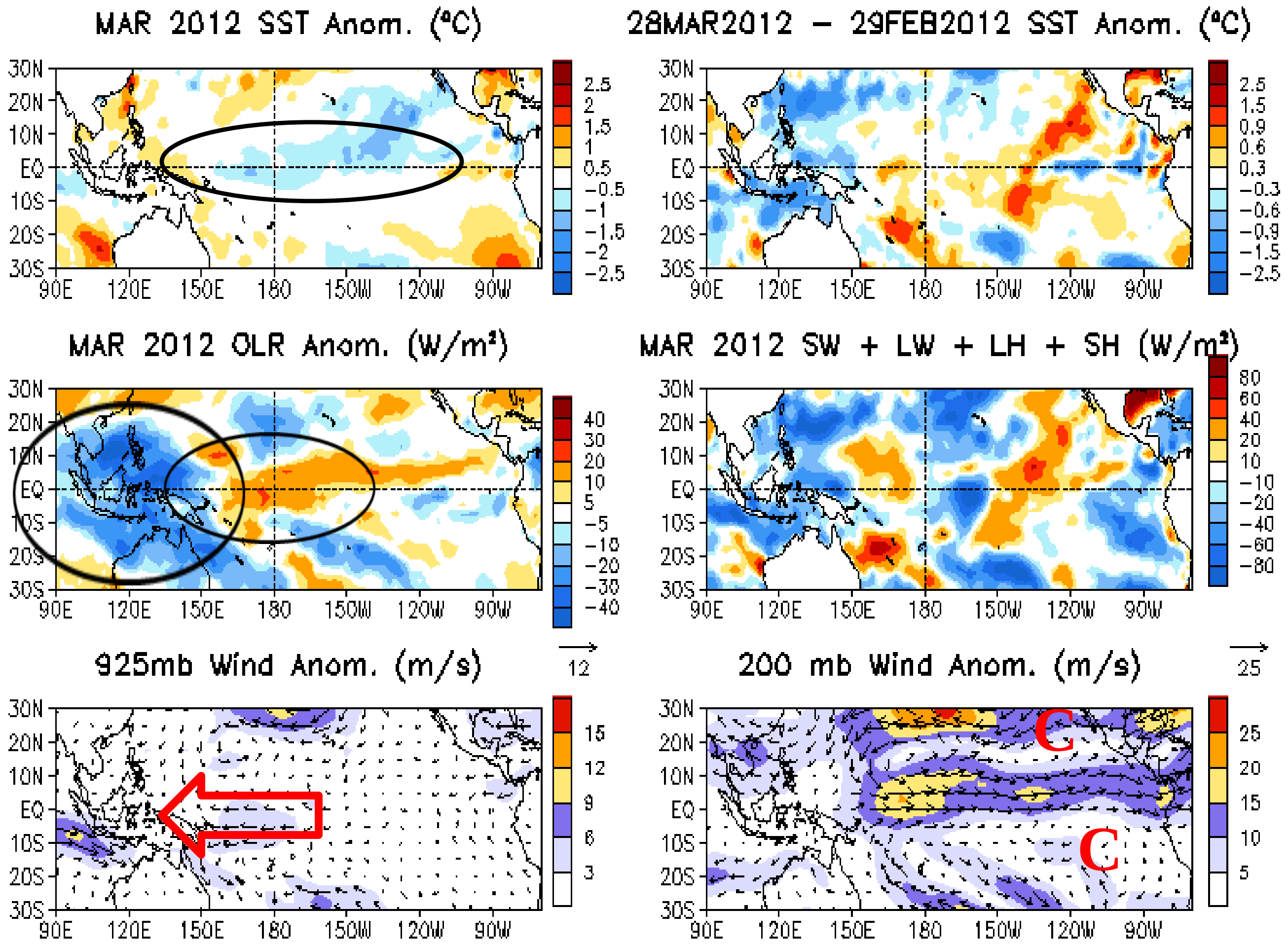
Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

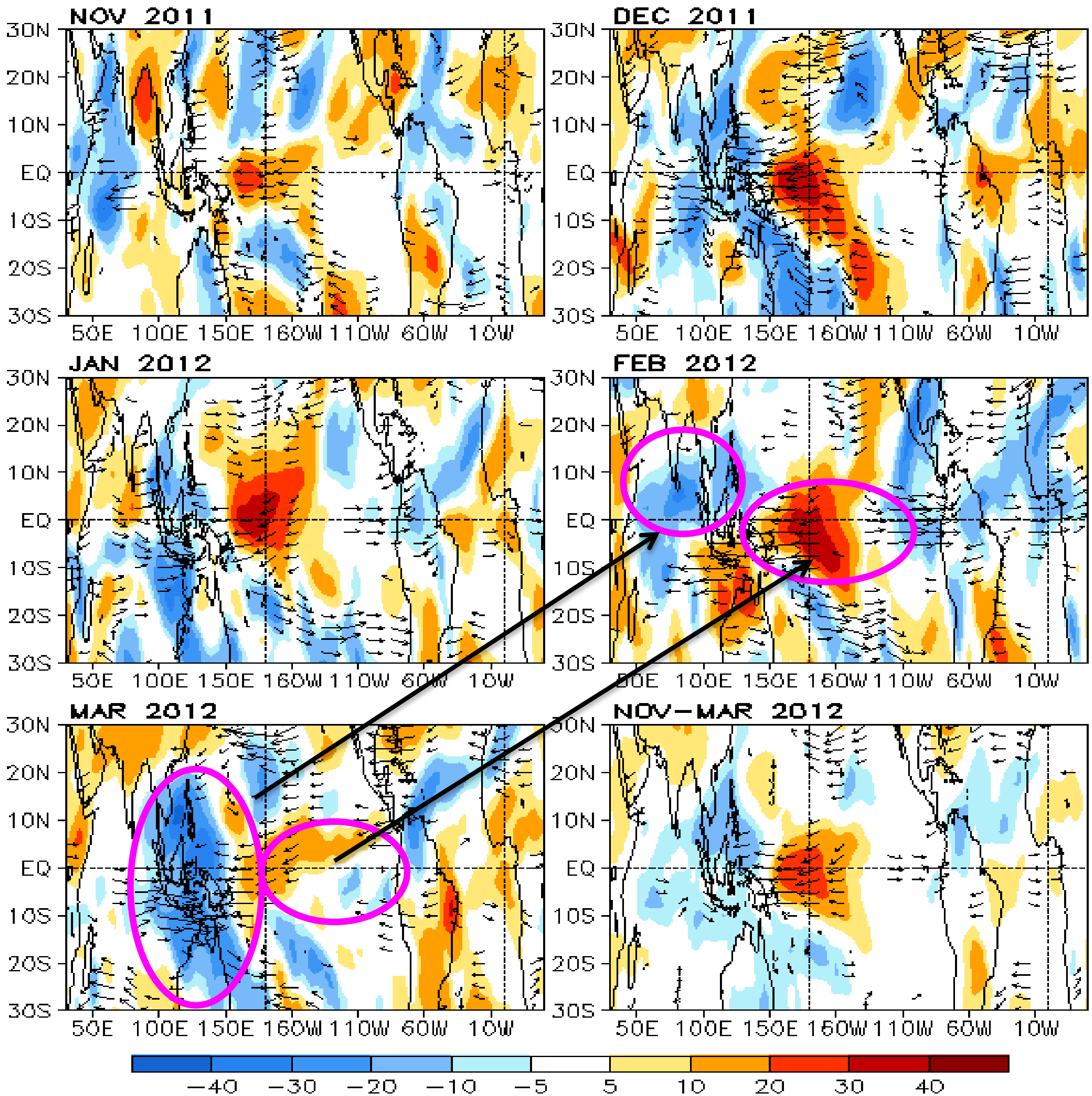
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

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



- **Negative SSTA presented in the central tropical Pacific.**
- **Convection was suppressed (enhanced) near the Dateline (over western Pacific).**
- **Easterly anomaly observed over the western and central Pacific Ocean at low level and westerly anomalies dominated over high level.**
- **Cyclonic anomalous circulation in 200 hPa in tropical N.&S. Pacific, consistent with La Nina conditions.**

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

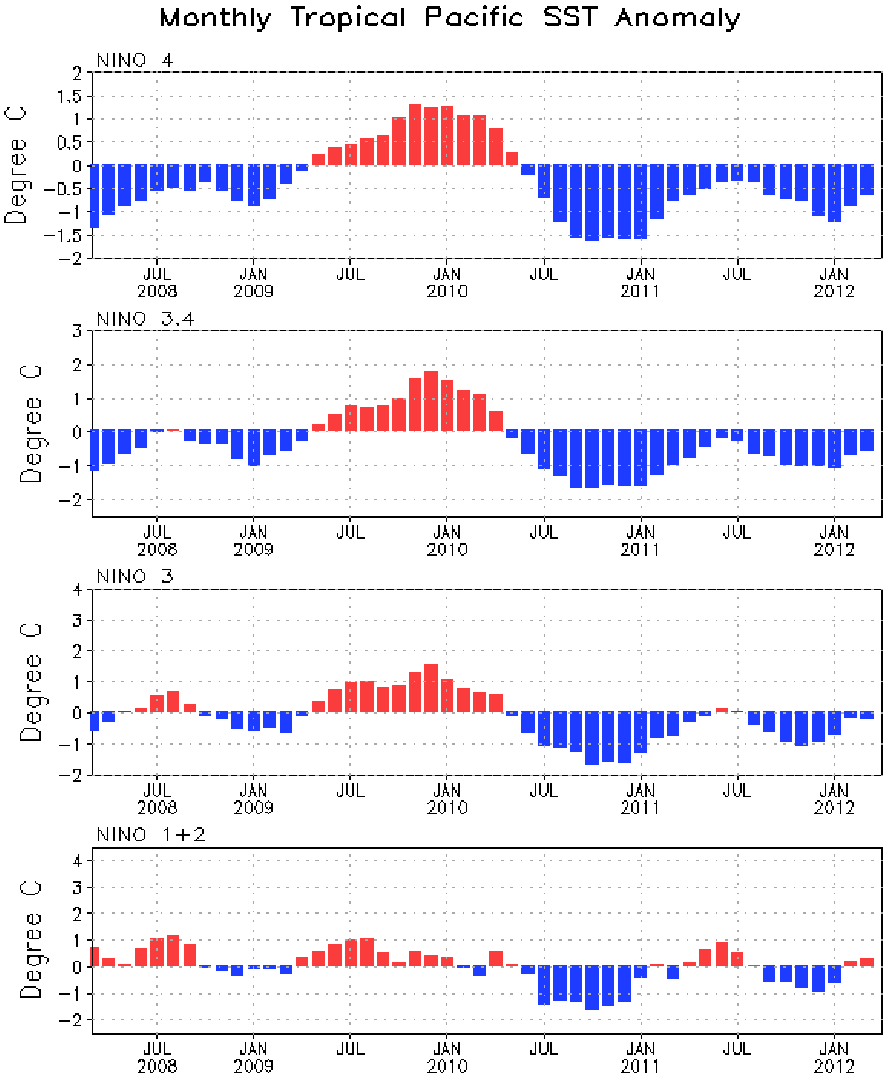


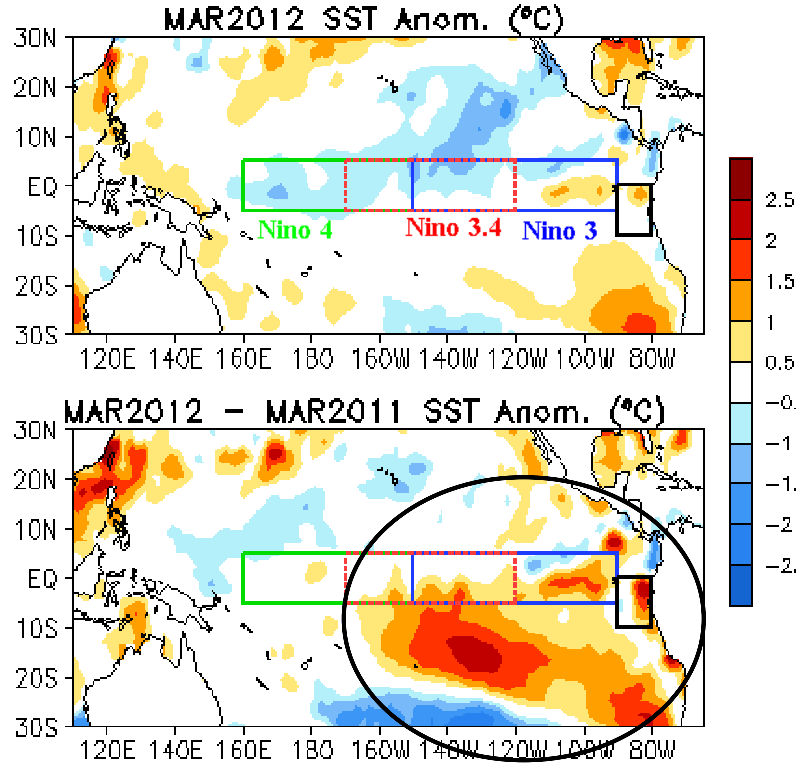
Evolution of OLR and 850mb Wind Anomalies

- Compared with Feb, the convection over the western Pacific further enhanced and extended southward in Mar 2012.

- The suppression of the convection around the dateline weakened in Mar 2012.

Evolution of Pacific NINO SST Indices





- All NINO indices, except Nino1+2, remained negative, but weakened.

- Nino3.4 = -0.6°C in Mar 2012.

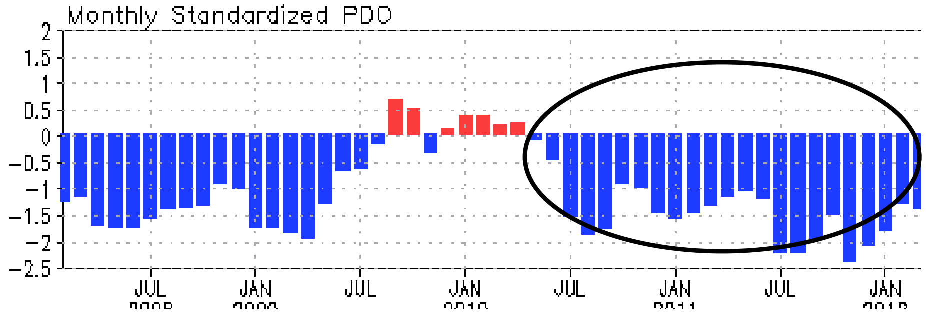
- The distribution of SSTA was asymmetric between the north and south Pacific. Compared with last Mar, SST was much warmer in the tropical-subtropical S. Pacific in Mar 2012.

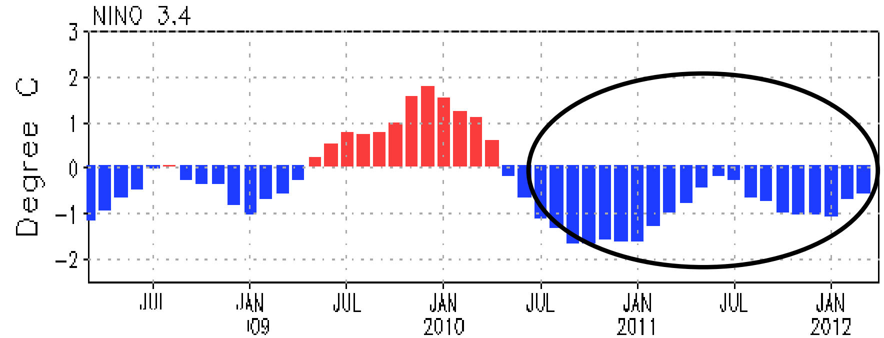
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.

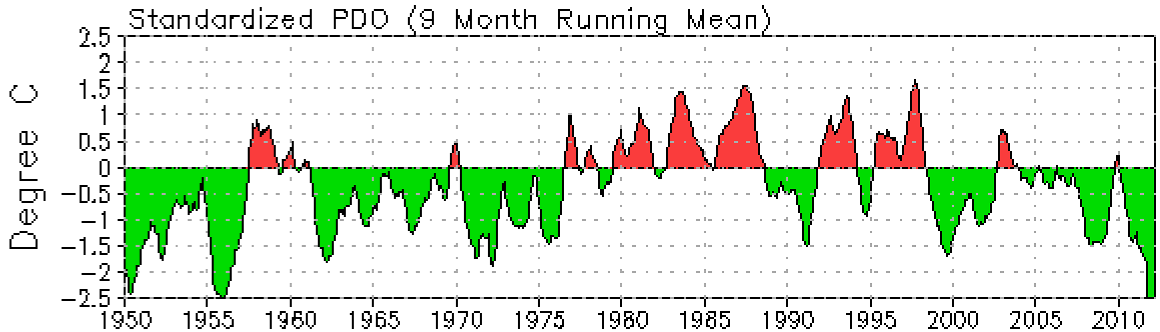
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

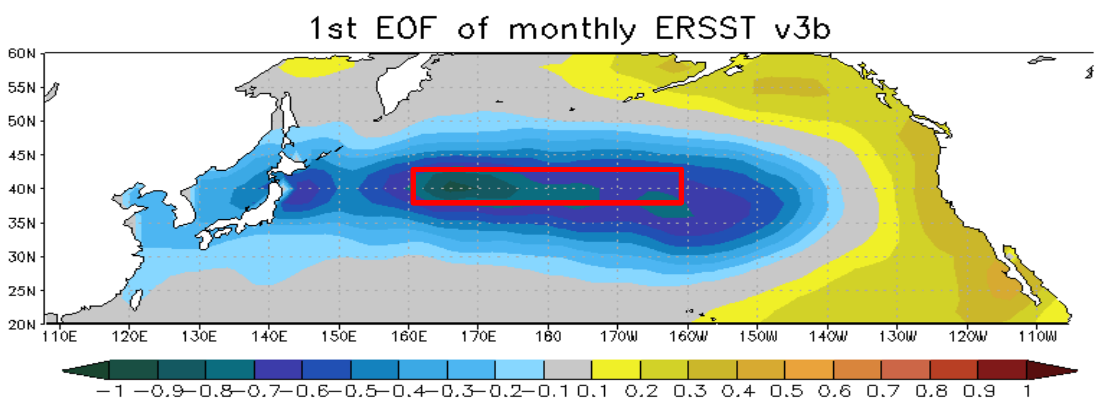
North Pacific & Arctic Oceans

PDO index









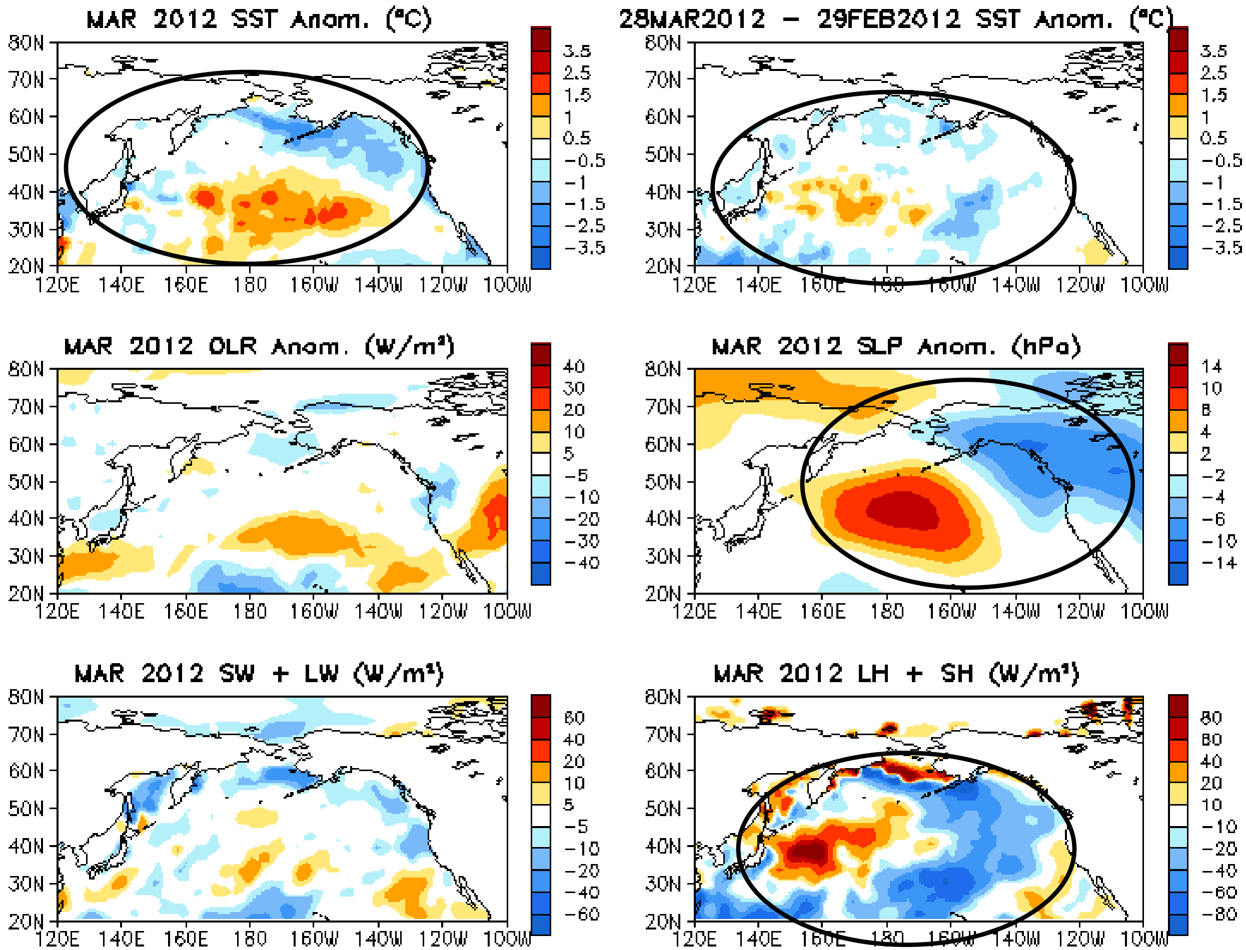
- The negative PDO index persisted in Mar 2012 with PDO =-1.4.

- The apparent connection between NINO3.4 and PDO index may suggest impact 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.

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



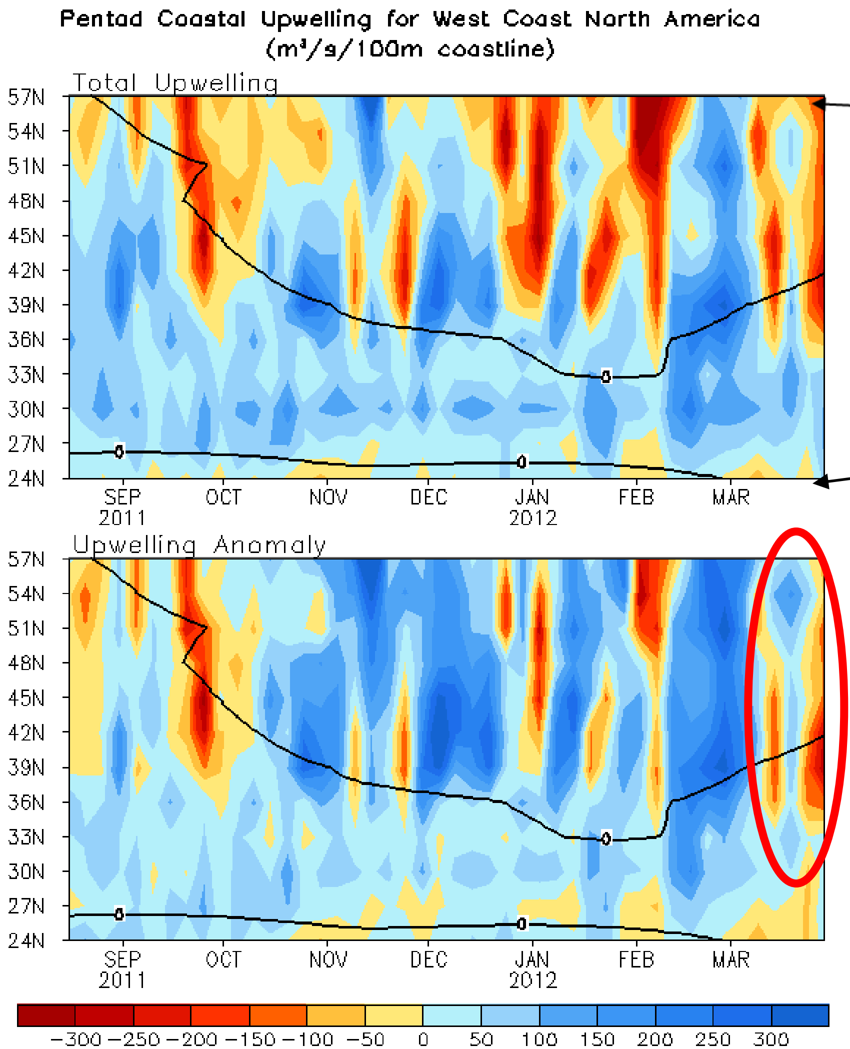
- Positive (negative) SSTA presented in the central (eastern& northern) N. Pacific, consistent with the negative PDO index (previous slide).

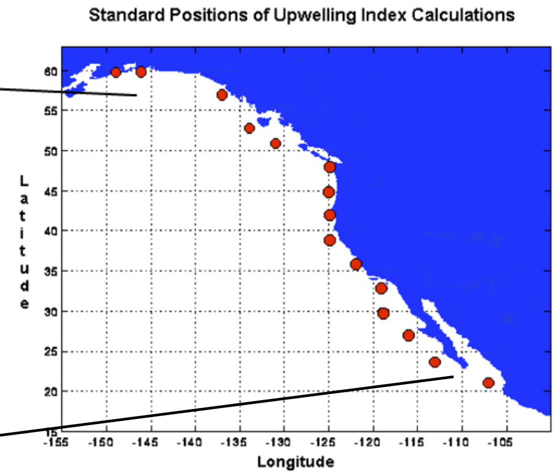
- Net surface heat flux anomalies contributed to the SST tendency in the N. Pacific.

- The sea level pressure gradient between the land and ocean may cause northerly wind anomalies along the coast.

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.

North America Western Coastal Upwelling





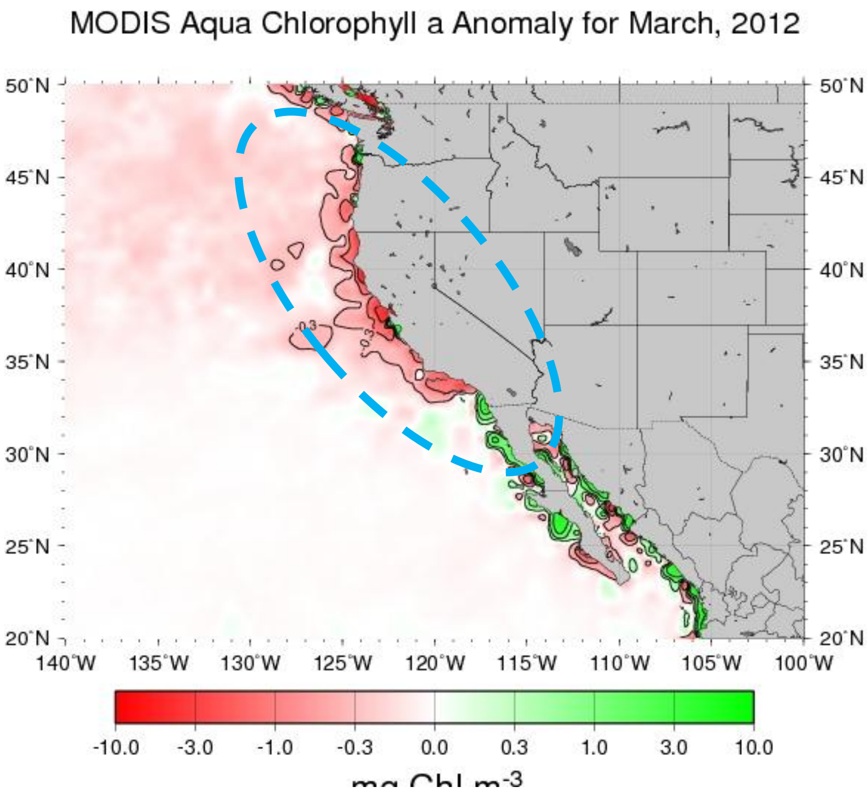
- Seasonal downwelling between 39N-57N strengthened and seasonal upwelling weakened between 33N-36N.

- This is not consistent with strong northerly wind anomalies along the coast.

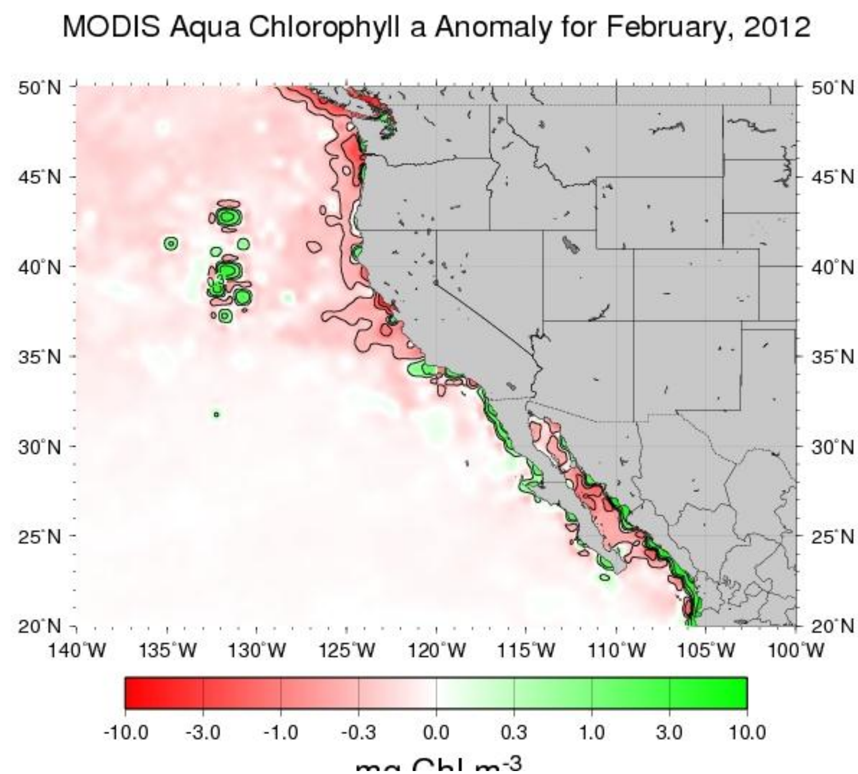
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ 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 36ºN to 57ºN.**

Monthly Chlorophyll Anomaly



- **Chlorophyll anomaly was negative 35N northward.**
- **It is consistent with strengthening of anomalous downwelling 35N northward along the coast.**

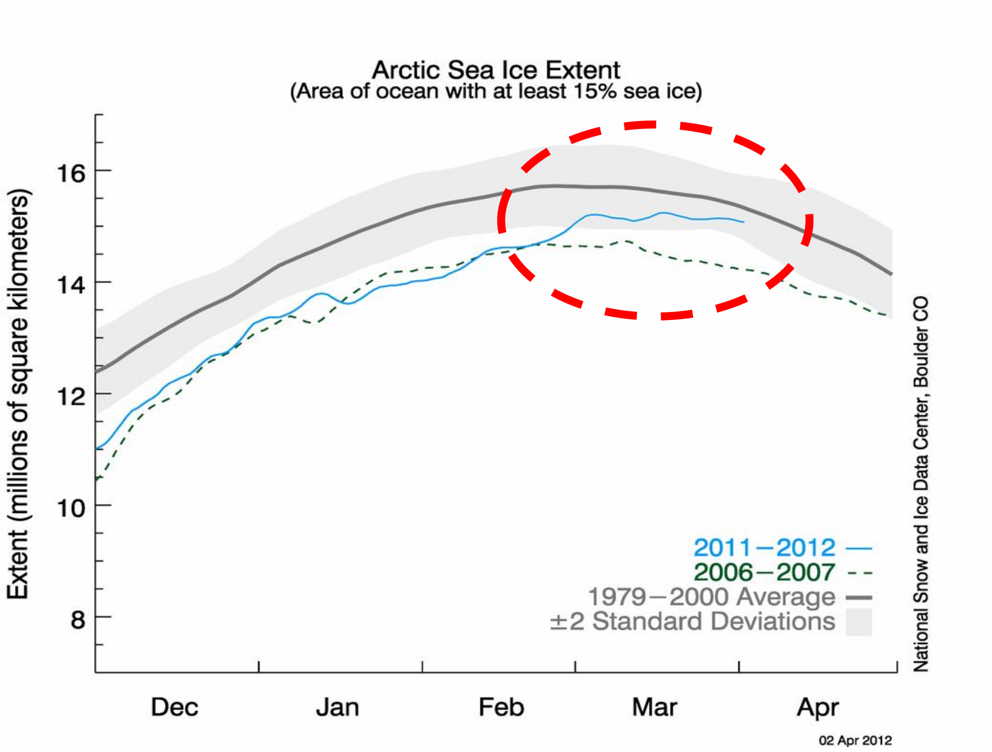


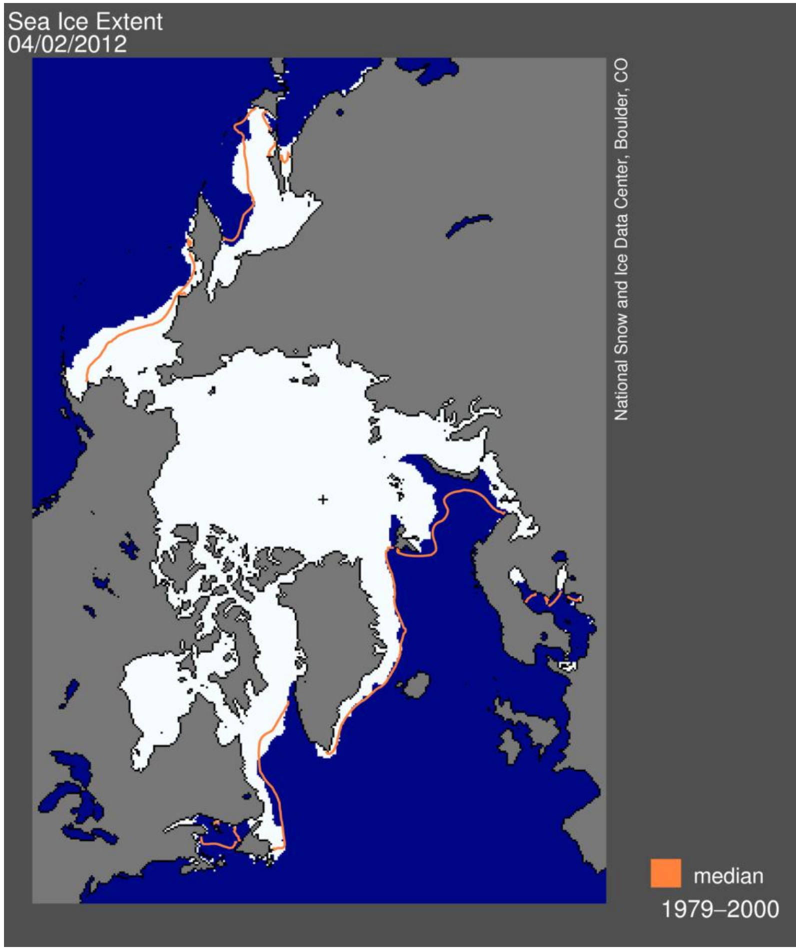
http://coastwatch.pfel.noaa.gov/FAST

Arctic Sea Ice

National Snow and Ice Data Center

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

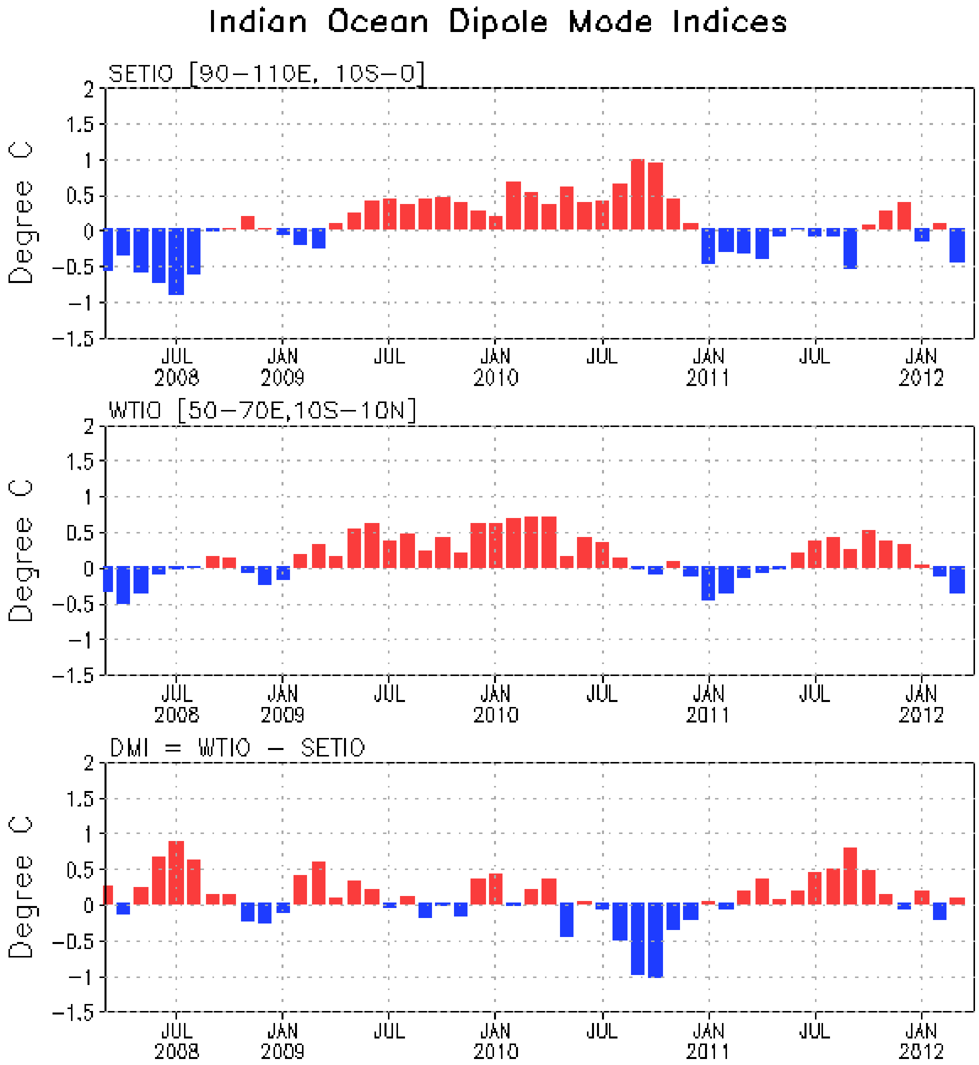


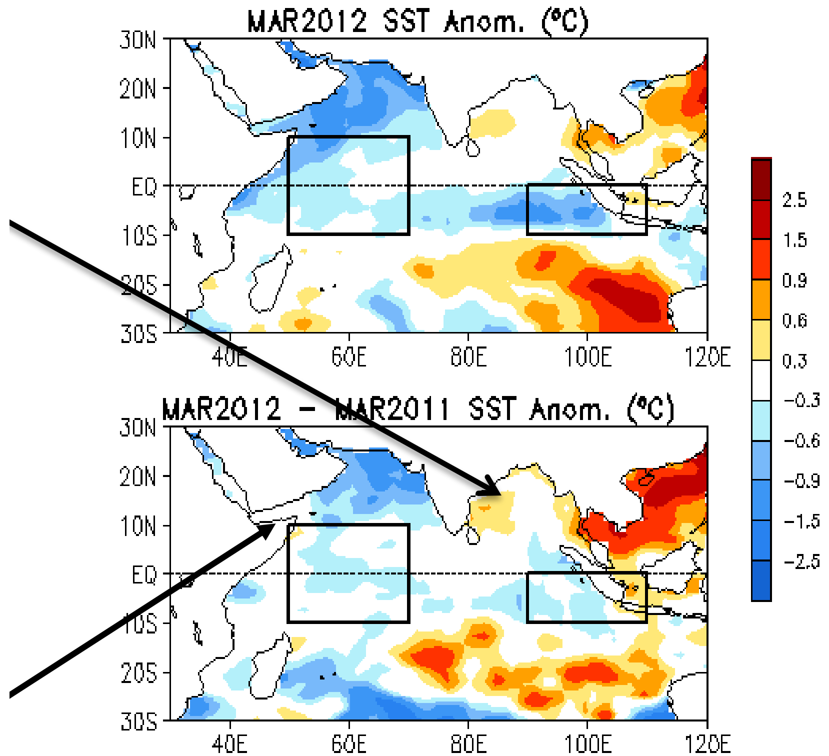


- **Since late-Feb 2012, Arctic sea ice extent almost persisted.**
- **The anomaly is close to one negative standard deviation in early Apr 2012.**

Indian Ocean

Evolution of Indian Ocean SST Indices





- **Negative SSTA developed, probably due to the lagged impact of La Nina.**
- **DMI was close to neutral since Nov 2011.**

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.

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

- **Negative SSTA developed.**
- **Convections were enhanced over the western Pacific and eastern Indian Oceans.**
- **SSTA tendencies over the western Pacific and eastern Indian Oceans were consistent with total heat flux.**

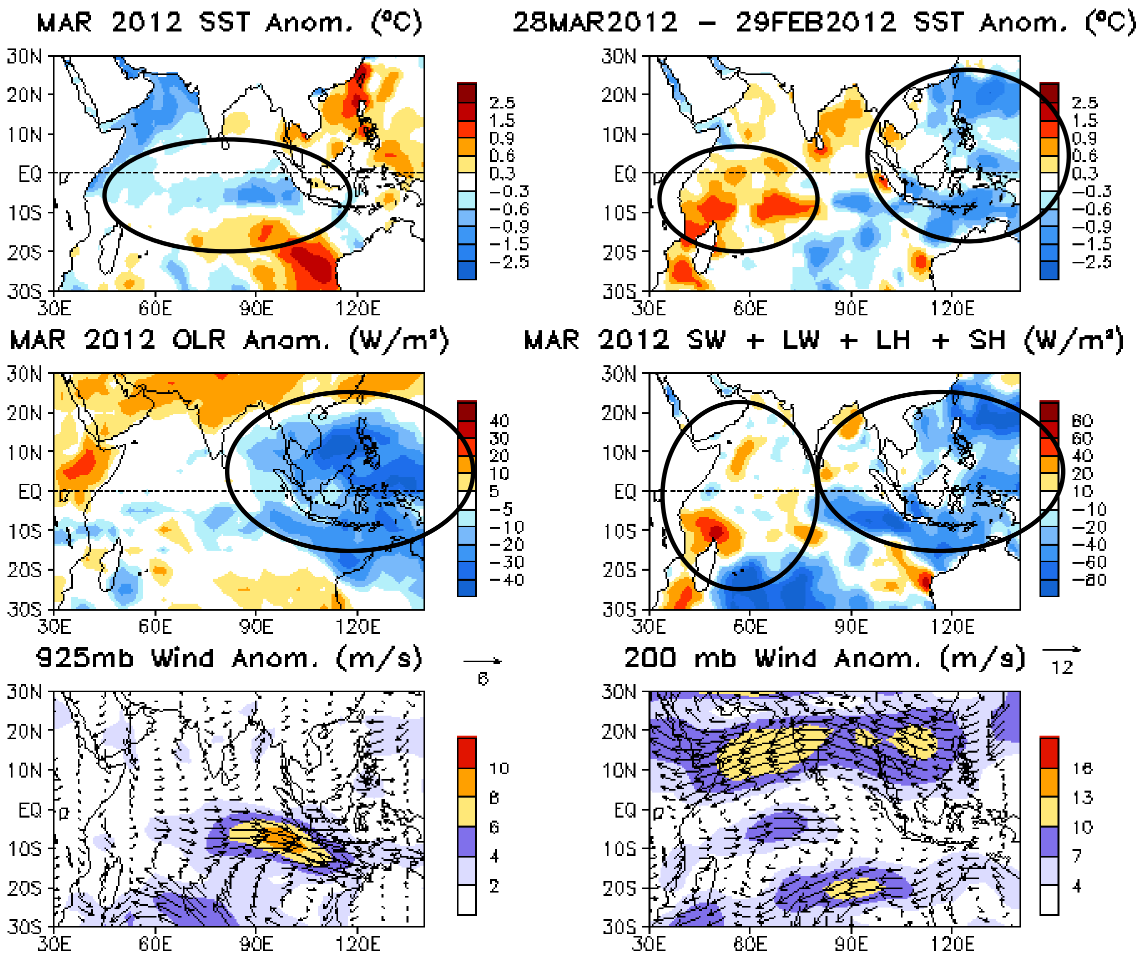
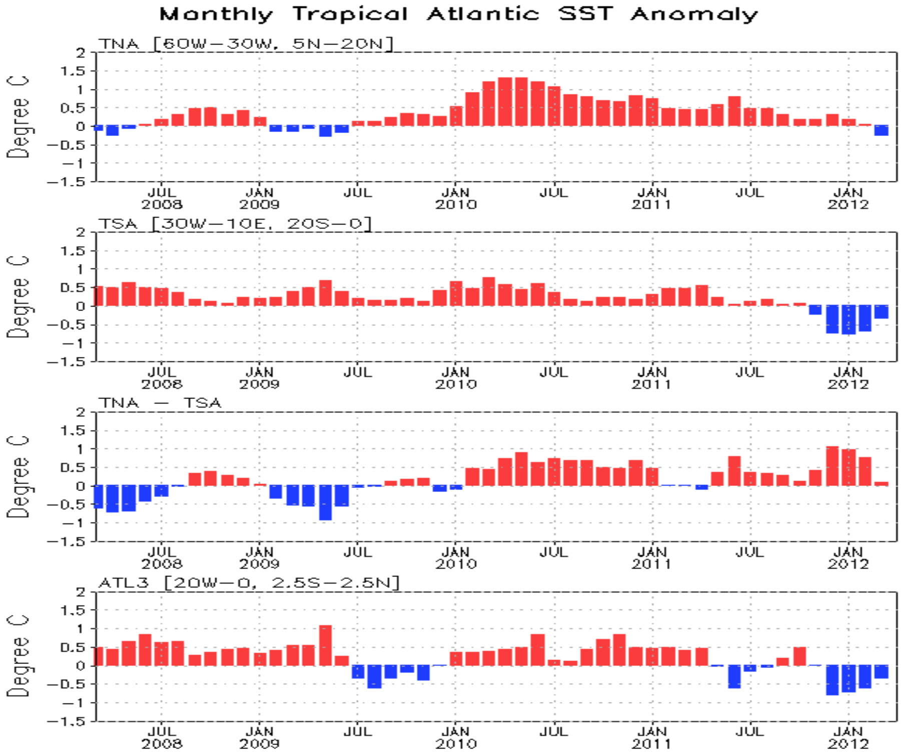
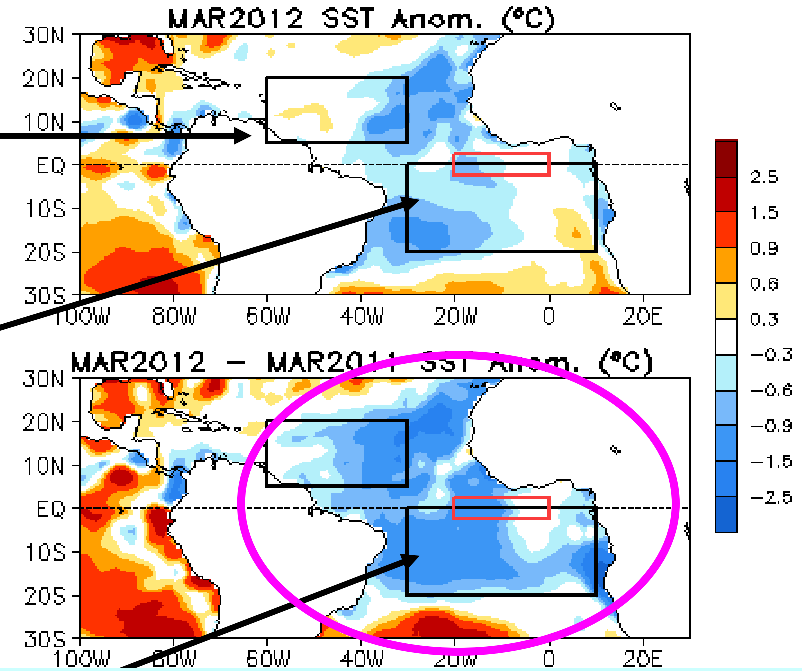


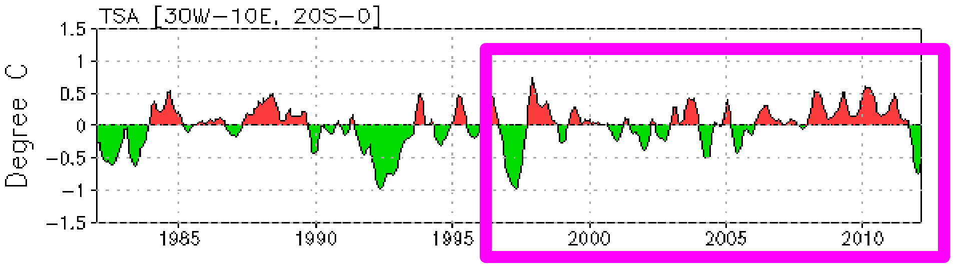
Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Evolution of Tropical Atlantic SST Indices







- Tropical North Atlantic (TNA) was negative, might due to the impact of La Nina and positive phase of NAO.

- Tropical South Atlantic (TSA) has cooled down substantially since Dec 2011, and the cooling weakened in Mar 2012. The past few months were the coolest period since 1998

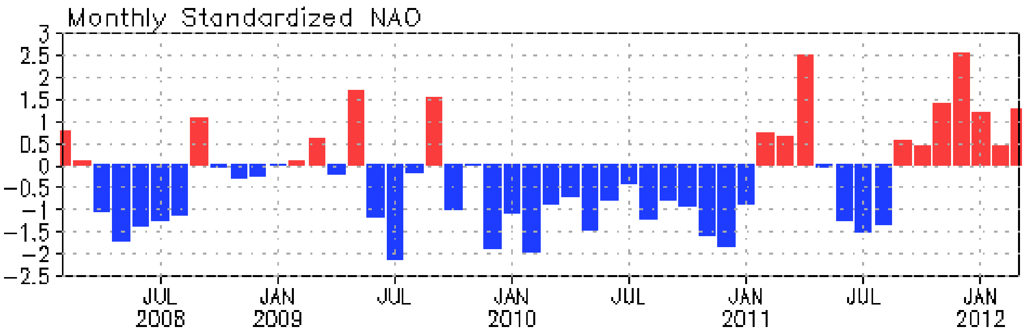
- Meridional Gradient Mode (TNA-TSA) has decreased substantially, and close to neutral in Mar 2012.

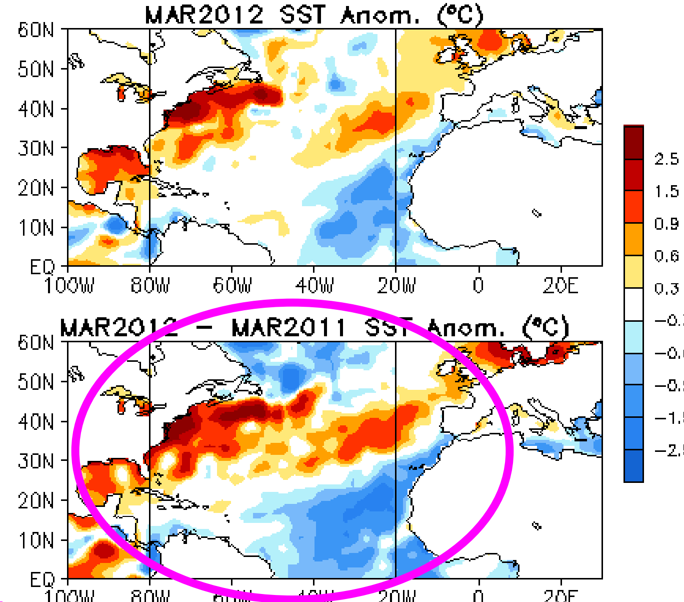
- ATL3 SSTA has been negative since Dec 2011 and weakened in Mar 2012.

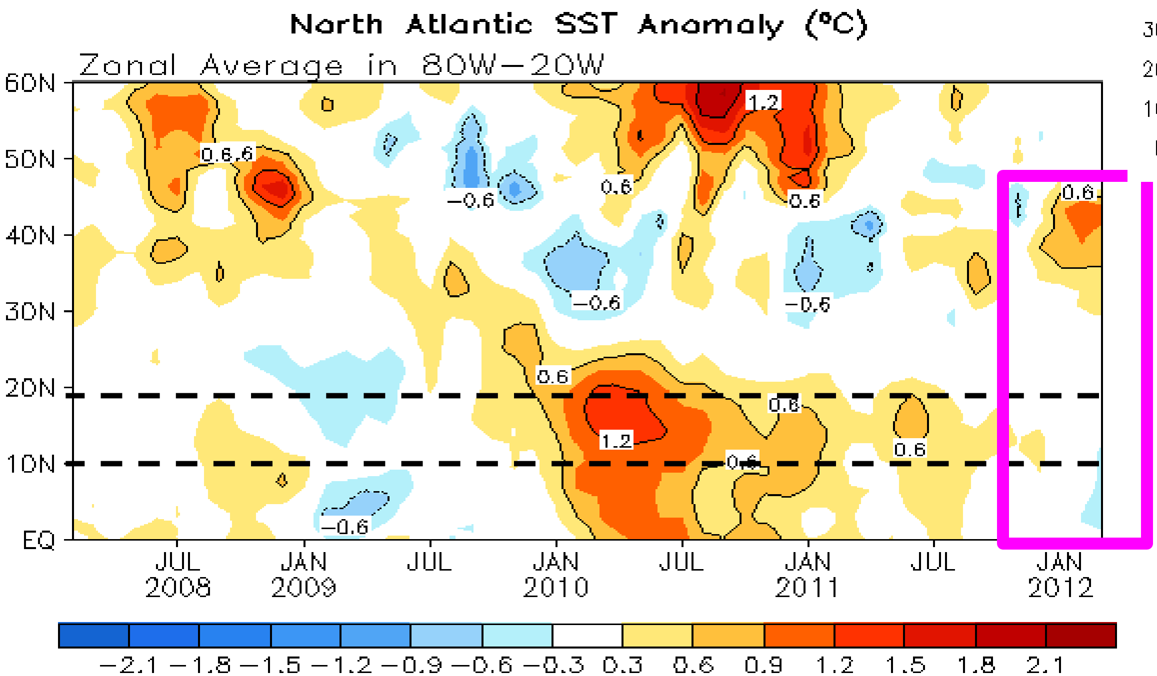
- Tropical Atlantic in Mar was much cooler in 2012 than in 2011.

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.

NAO and SST Anomaly in North Atlantic







- **Positive NAO strengthened in Mar 2012, with NAOI=1.27.**

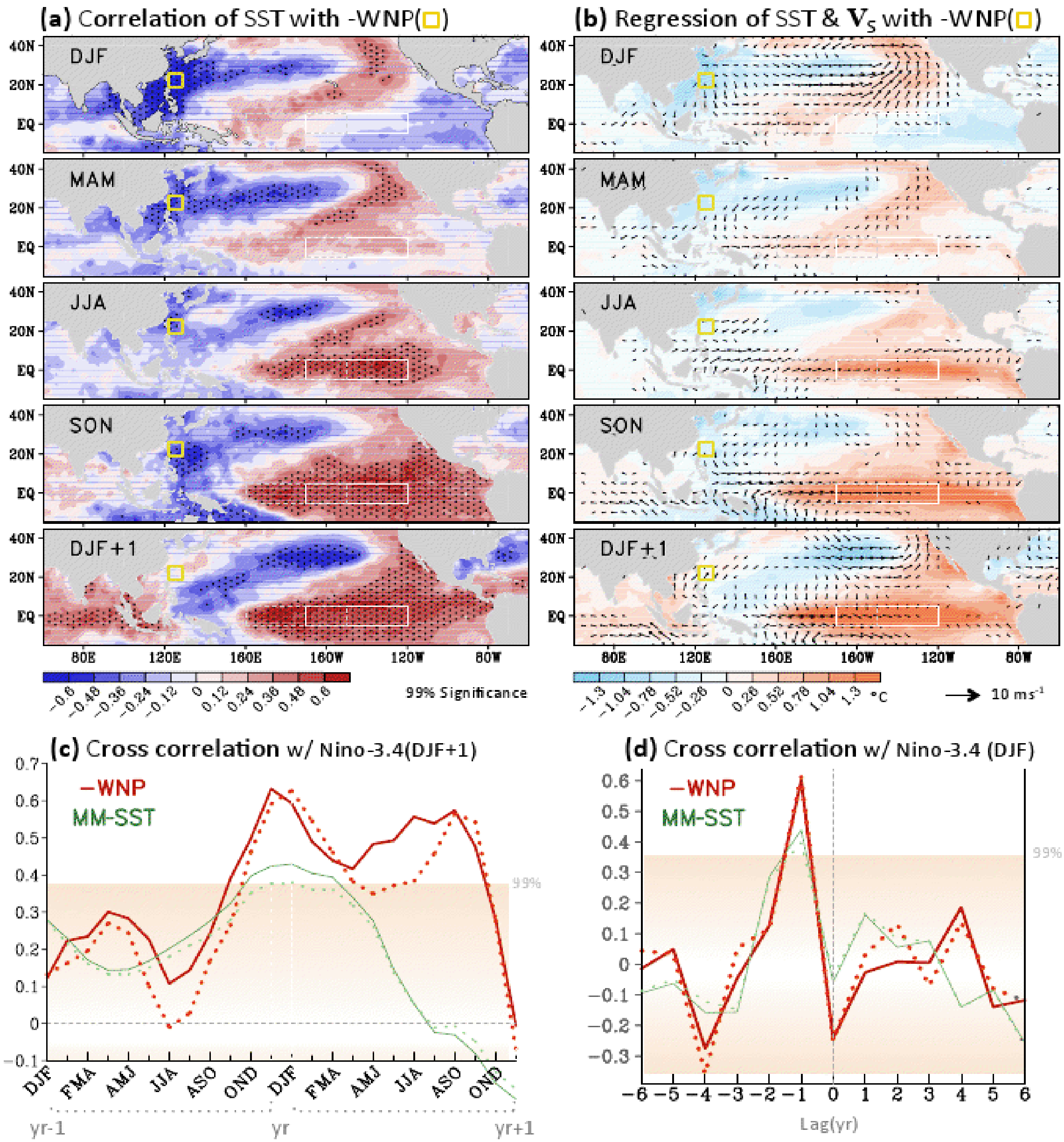
- **Since Jan 2012, positive (negative) SSTA developed in the mid-latitude (tropical) North Atlantic SSTA , probably due to the impact of La Nina and positive phase of NAO.**

- **Warming SST along the American Atlantic coast was observed in Mar 2012.**

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.

Potential New Indices to Monitor Pacific Ocean

Western North Pacific Variability and ENSO



(a) DJF cooling over the WNP is followed by a warming in the equatorial Pacific in next winter.

(b) The correlation between WNP and ENSO is higher than that between meridional mode and ENSO.

(c) The frequency of WNP variability is higher than ENSO.

From Wang, S.-Y., M. L'Heureux, and H.-H. Chia, 2012: ENSO Prediction One Year in Advance Using Western North Pacific Sea Surface Temperatures. GRL ,39, L05702, doi:10.1029/2012GL050909.

Using DJF WNP index to hindcast DJF(+1) ENSO during 1958-2011 *(From Michelle, L'Heureux)*

	Cold WNP	**Warm WNP**
El Nino	48%	17%
Neutral	26%	26%
La Nina	26%	57%

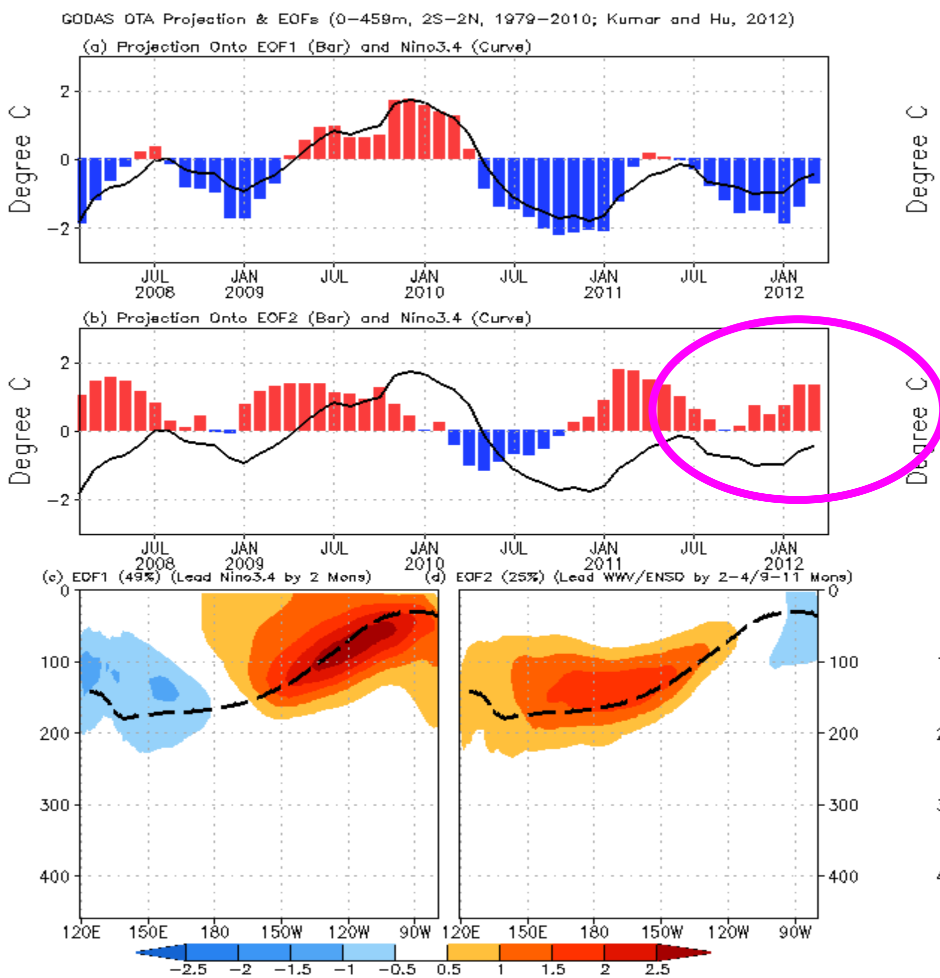
Projection of OTA onto EOF1 and EOF2 (2S-2N, 0-459m, 1979-2010)

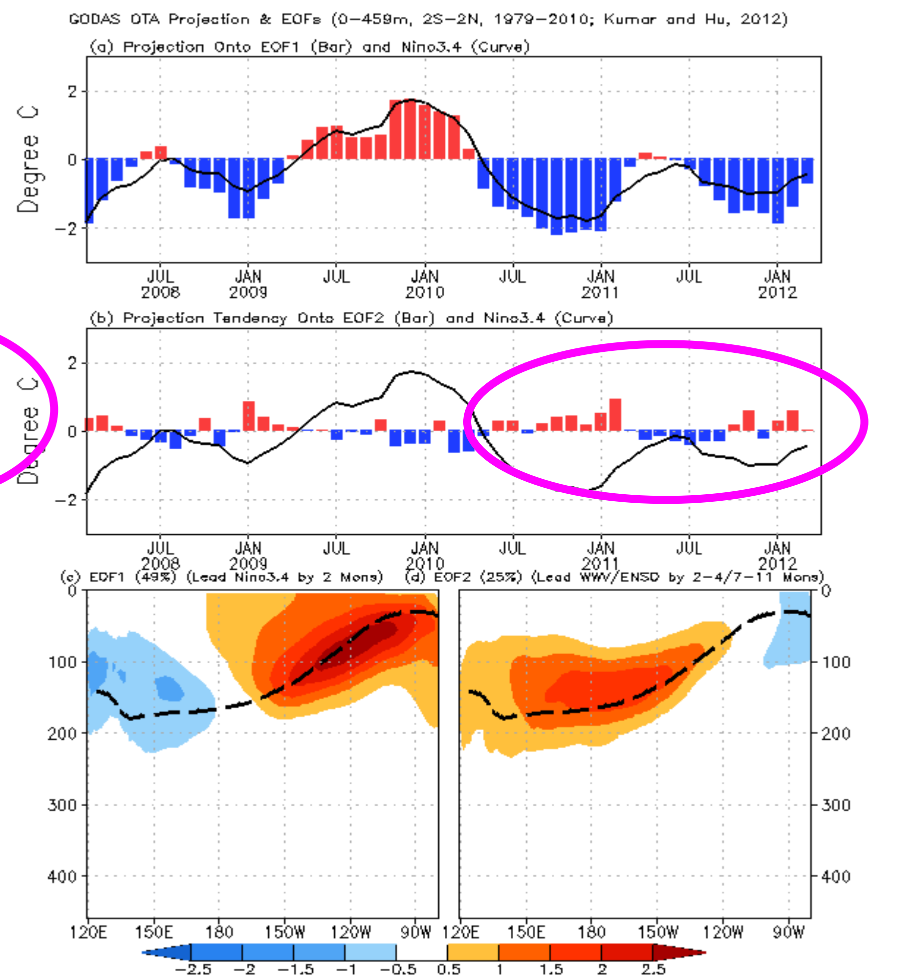
***EOF1: Tilt mode, driven mainly by zonal wind stress, almost in phase with ENSO**

***EOF2: WWV mode, associated with recharge & discharge oscillator; driven by wind curl off the equator**

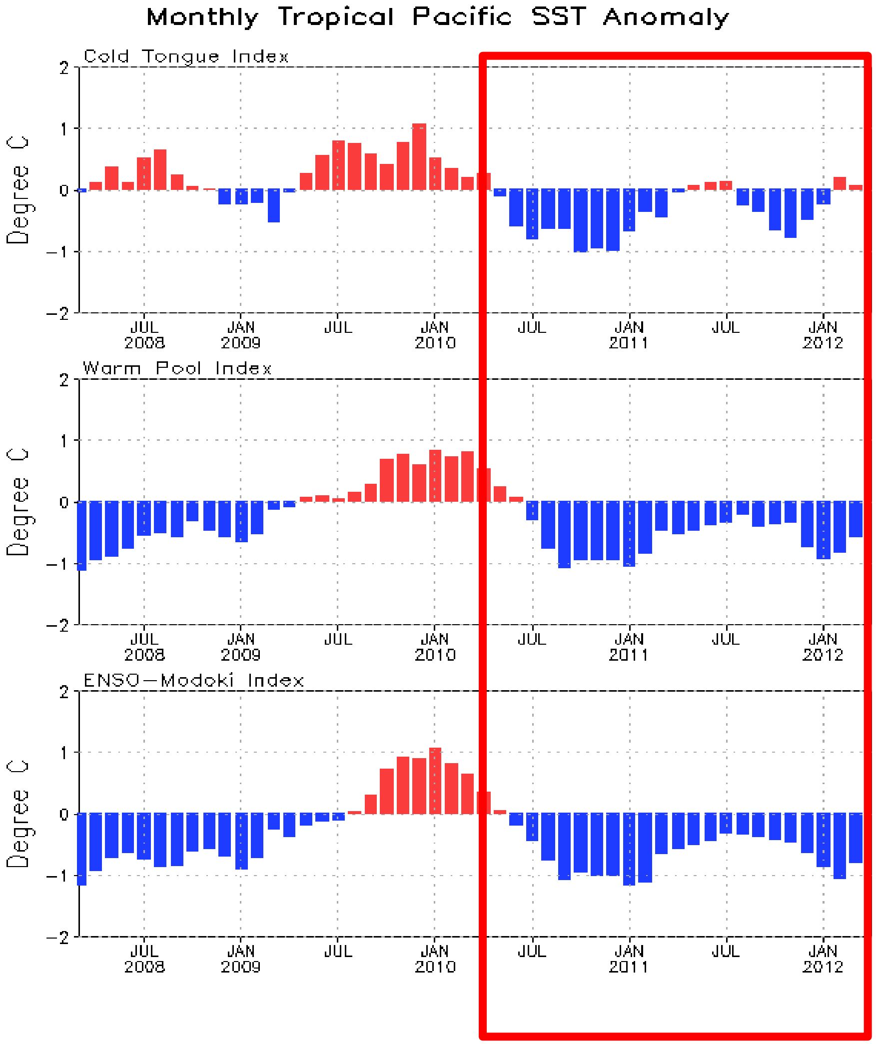
***Tendency of WWV/EOF2 is in proportion to tilt/EOF1; EOF1 and 2 are in quadrature (*Clarke et al. 2007*)**

****Right now, it is in recharge phase***

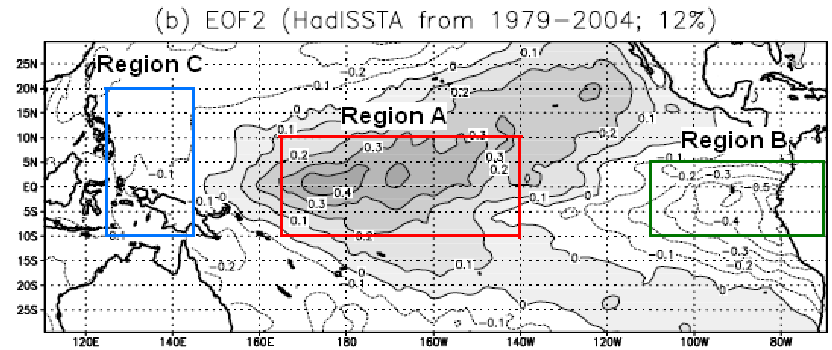




Evolution of Cold Tongue, Warm Pool, and ENSO-Modoki SST Indices



Modoki Index = A-0.5(B+C)*
A (165E-140W, 10S-10N), B (110W-70W, 15S-5N), and C (125E-145E, 10S-20N)
(*Ashok et al. 2007: JGR*, ***112,*** C11007, doi: 10.1029/2006JC003798).

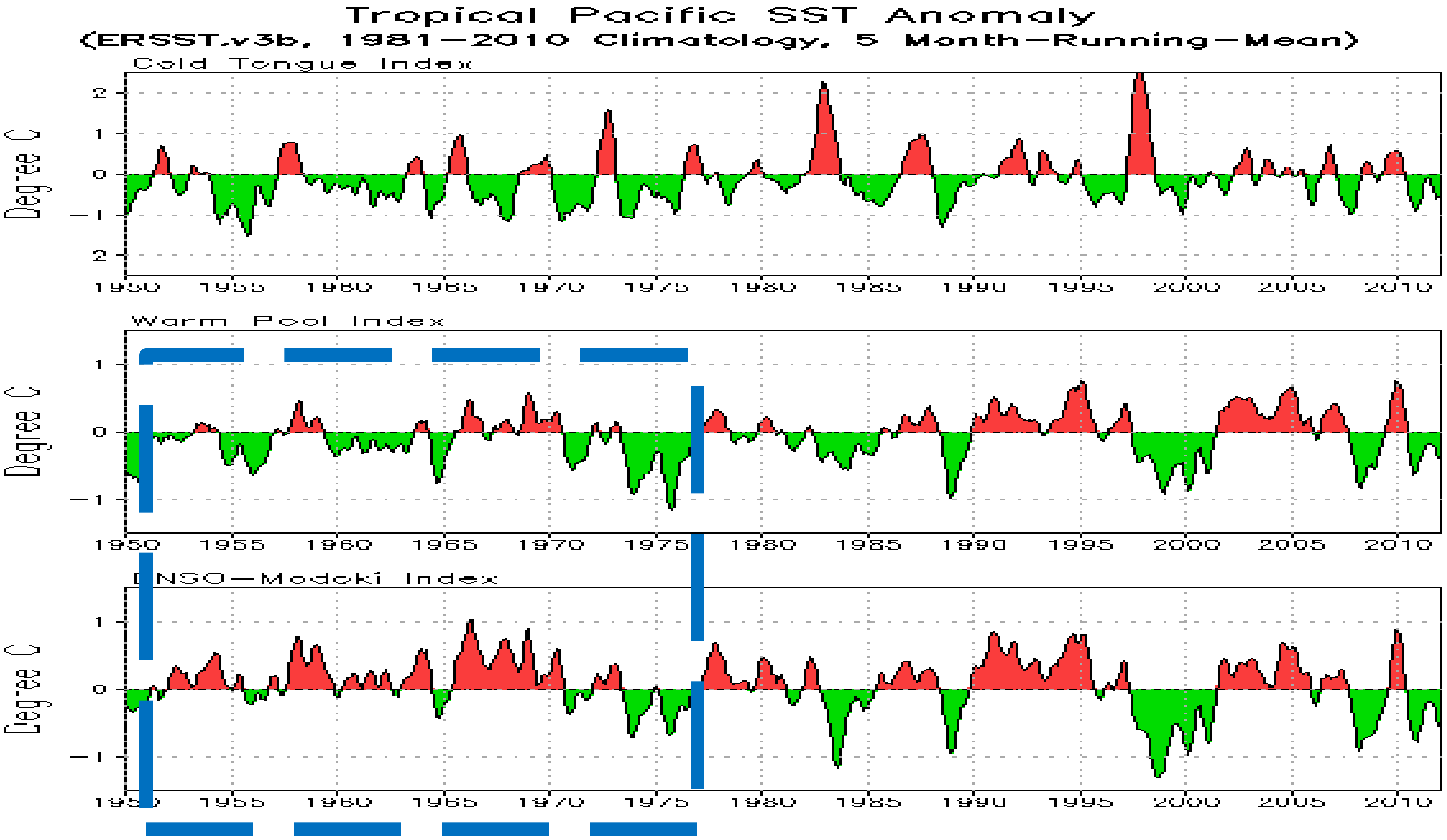


- **Since Nov 2011, SSTA have large projection onto Warm Pool and ENSO-Modoki indices than on Cold Tongue index. That was similar to Jan-Feb 2011.**
- **Cold Tongue index has shorter time scales compared with Warm Pool and ENSO-Modoki indices, consisting with recent work of Kumar and Hu (2012).**
- **The evolution of Warm Pool and ENSO-Modoki indices are similar.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

Cold Tongue Index: Nino3-alpha*Nino4; Warm Pool Index: Nino4-alpha*Nino3; alpha=0.4 when Nino3*Nino4 >0.0 and alpha=0.0 when Nino3*Nino4 $\leq$ 0.0 (Ren and Jin, 2011: *GRL*, **38,** L04704, doi: 10.1029/2010GL046031)

Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Relationship between these indices has decadal variation?



Cold Tongue Index: Nino3-alpha*Nino4; Warm Pool Index: Nino4-alpha*Nino3; alpha=0.4 when Nino3*Nino4 >0.0 and alpha=0.0 when Nino3*Nino4 ≤ 0.0 (Ren and Jin, 2011: *GRL*, **38,** L04704, doi: 10.1029/2010GL046031)

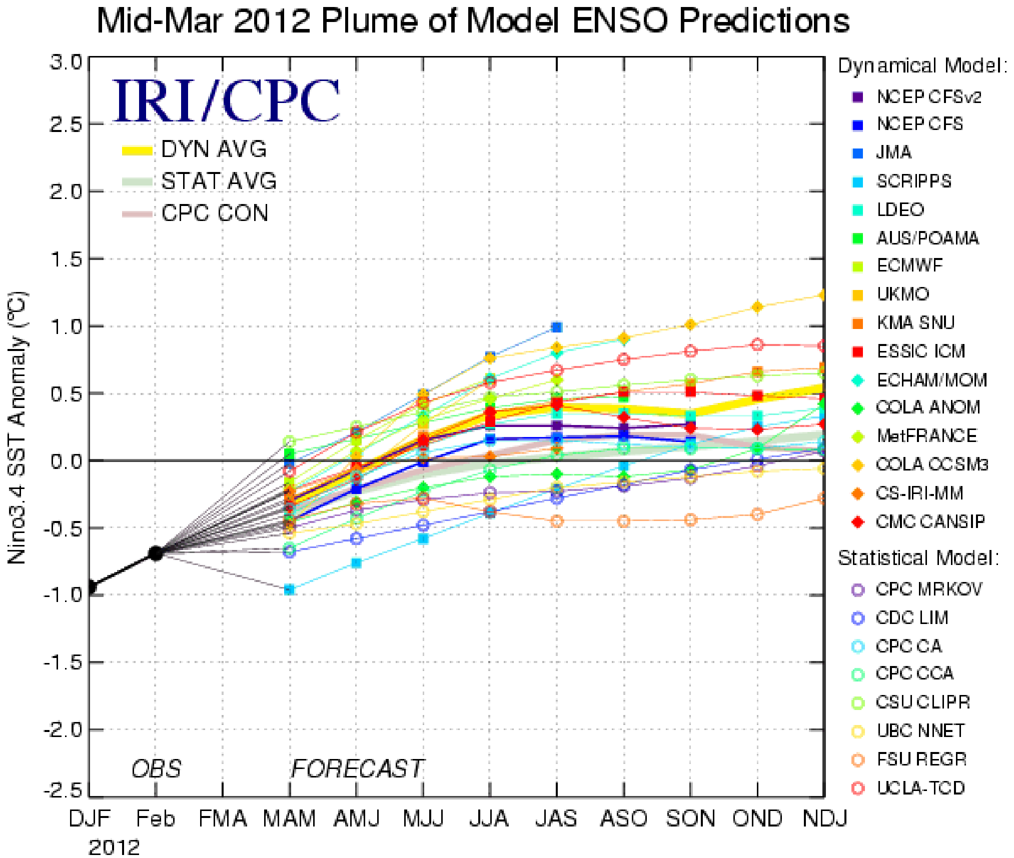
Modoki Index = A-0.5*(B+C)

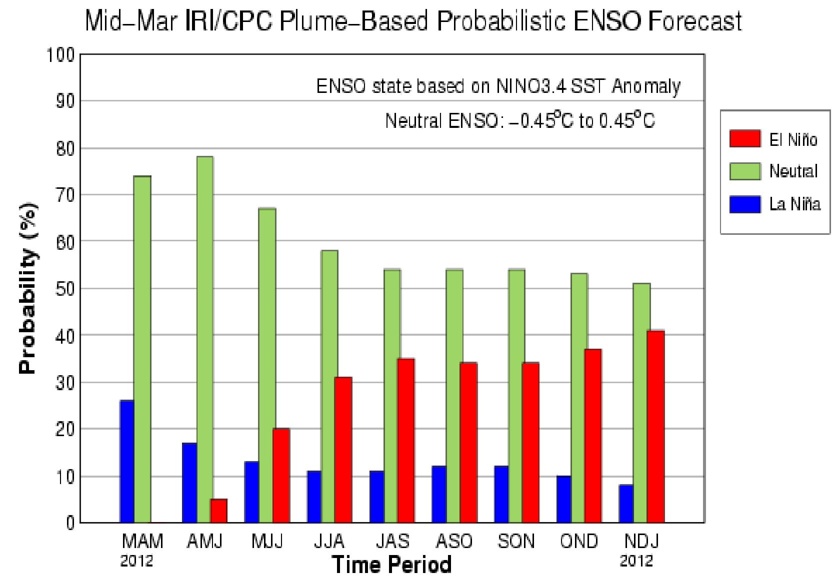
A (165E-140W, 10S-10N), B (110W-70W, 15S-5N), and C (125E-145E, 10S-20N)

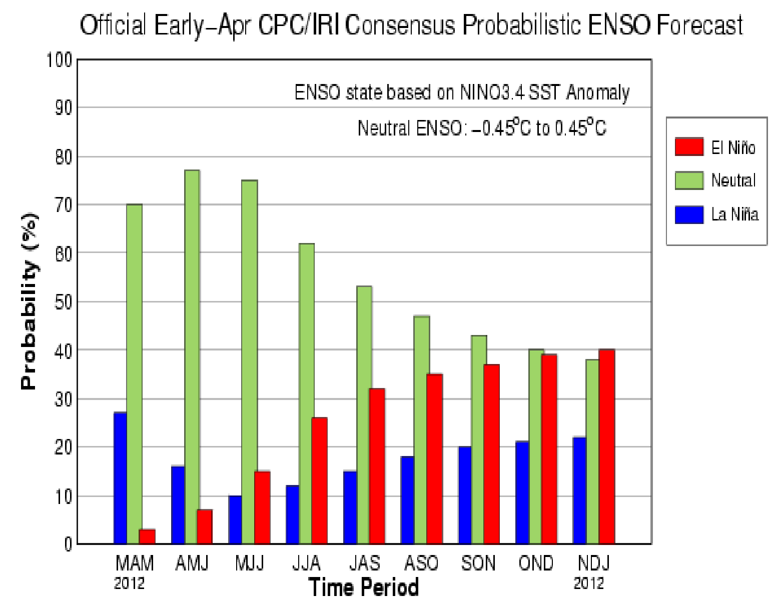
(Ashok et al. 2007: JGR, ***112,*** C11007, doi: 10.1029/2006JC003798*).*

Global SST Predictions

IRI NINO3.4 Forecast Plum

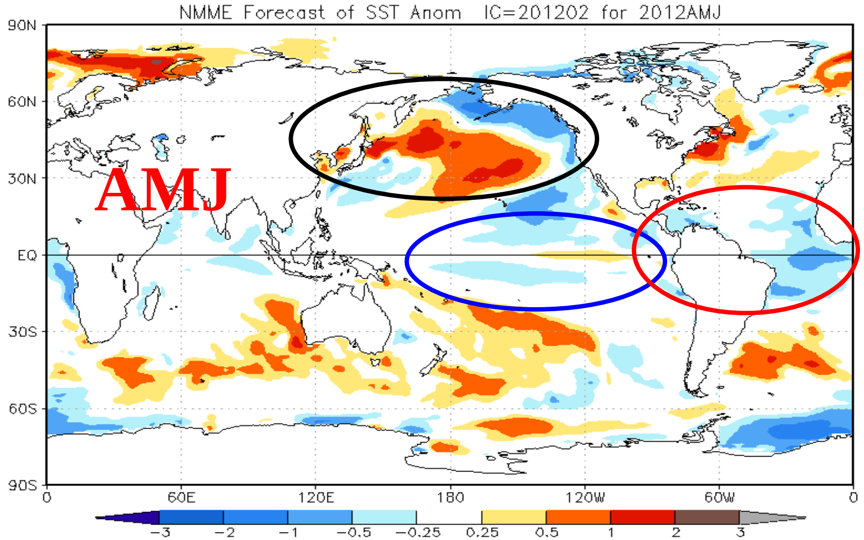


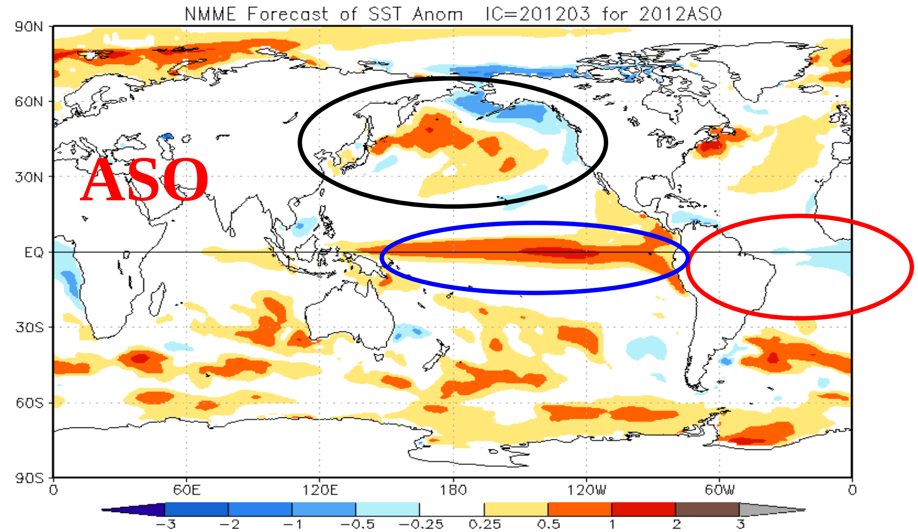


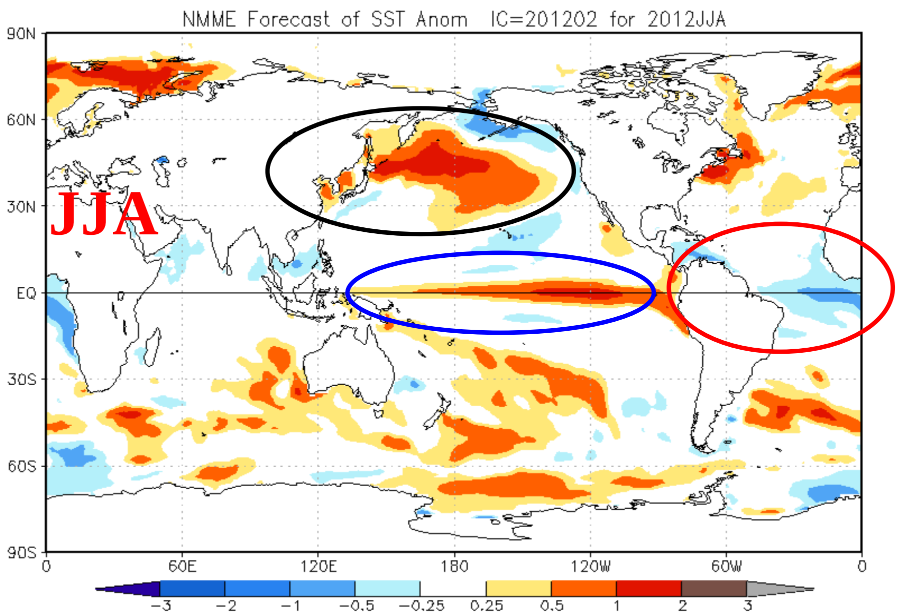


- **A majority of models predicted that ENSO returns to neutral phase in MAM 2012.**
- **After spring 2012, model predictions have large spread.**
- **Human and no-human probabilistic forecasts favor a neutral phase in 2012.**
- **NOAA "ENSO Diagnostic Discussion" in Apr suggests La Niña is expected to return to ENSO-neutral conditions during Apr 2012.**

NMME (CFSv1, CFSv2, ECHAMA, ECHAMF, GFDL, NCAR, NASA) SST Forecast (IC=201203)



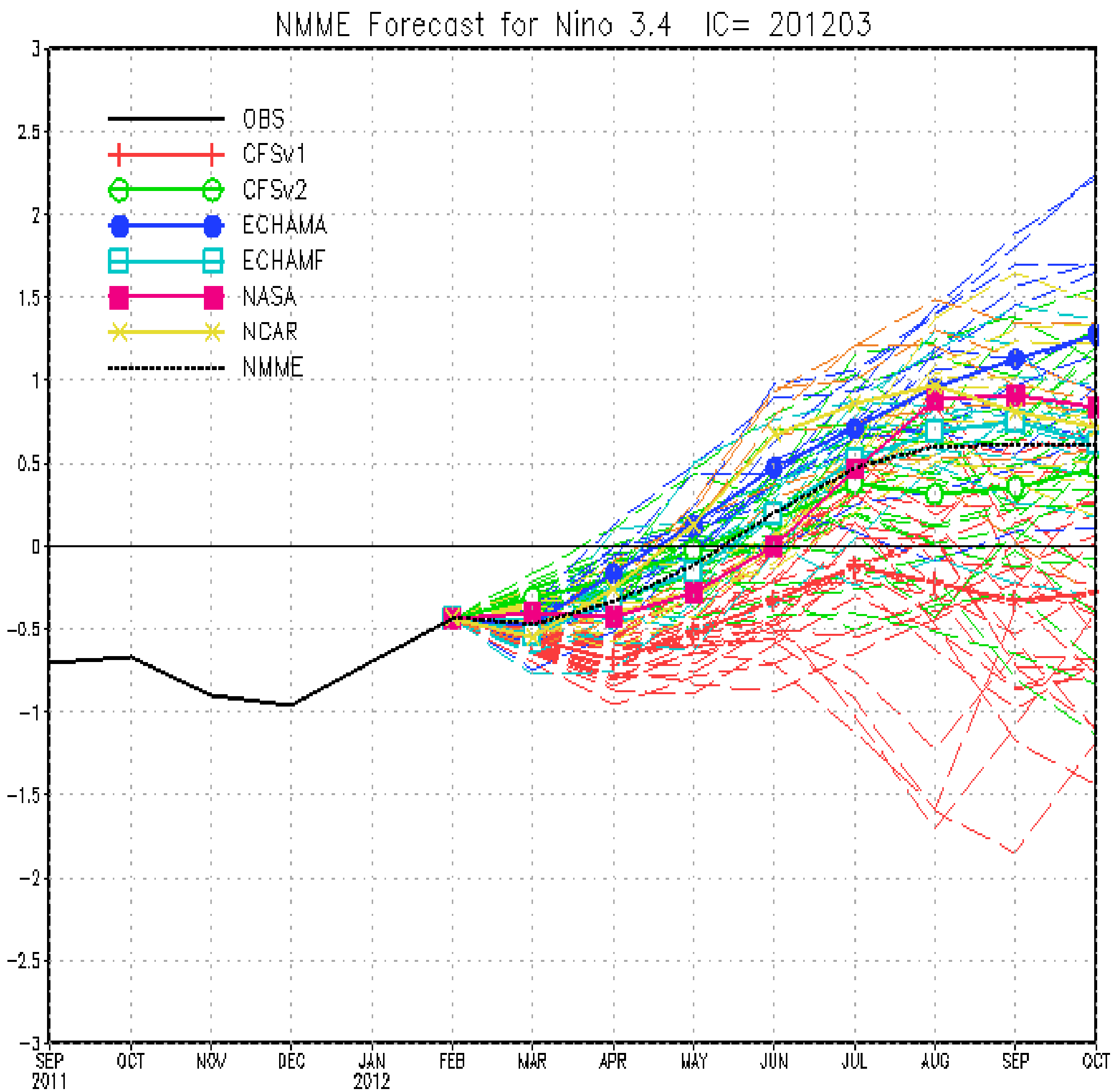




- **A warming event is expected since summer 2012.**
- **The warming in N. Pacific (negative PDO) will be persistent until at least early autumn 2012.**
- **The cooling along the equatorial Atlantic will last at least until early autumn 2012.**

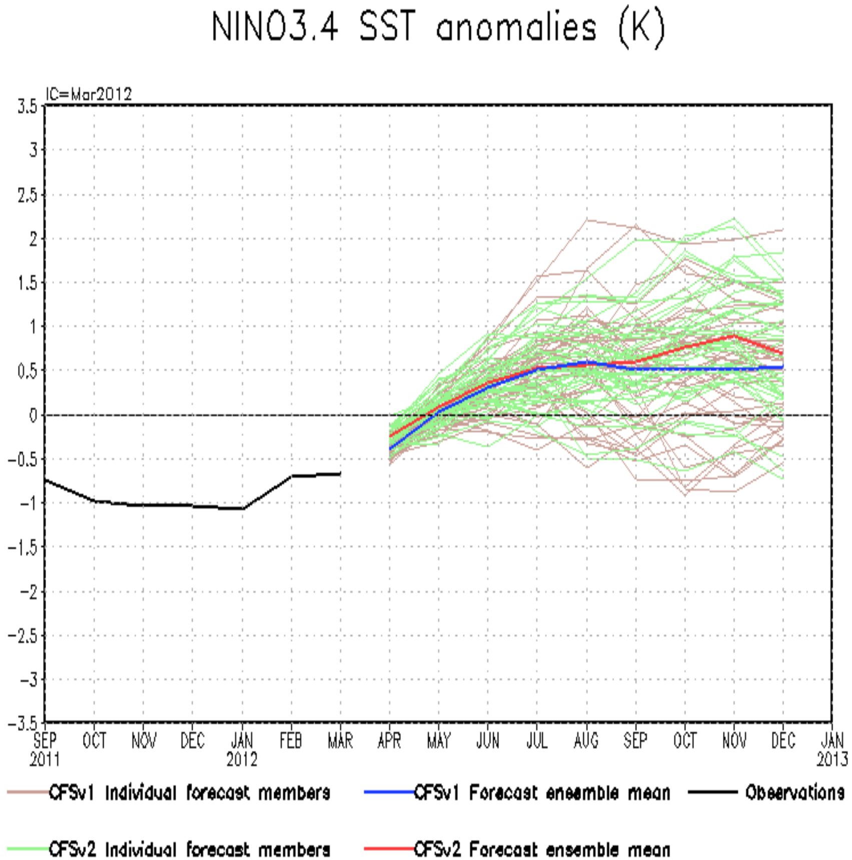
http://www.cpc.ncep.noaa.gov/products/people/wd51yf/
NMME ***experimental product***
Thanks Qin Zhang, Huug van den Dool, Suru Saha, Malaquias Pena Mendez, Patrick Tripp, Peitao Peng and Emily Becker plus the originators at NASA, NCAR, GFDL, IRI (all coupled models)

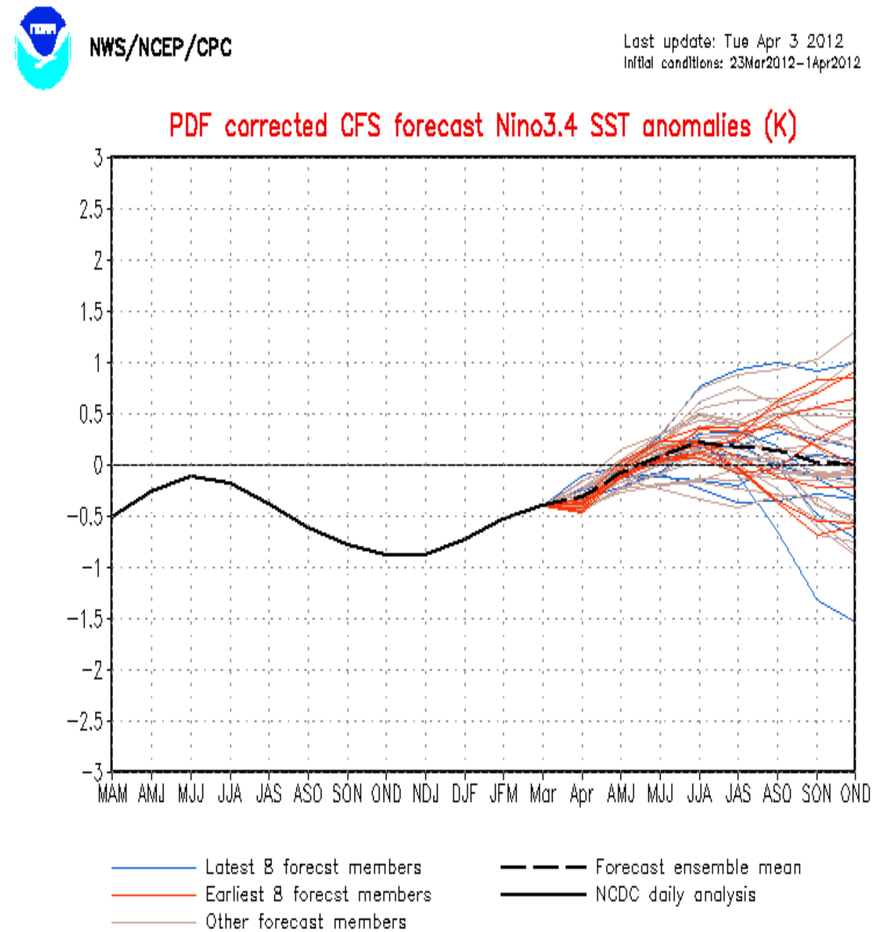
NMME NINO3.4 Forecast (6-models, IC=*201203*)



- ***NMME* forecasts a warming since summer 2012.**
- **Occurrence of El Nino (Nino3.4 >0.5) is expected since around Jun-Jul 2012 for *ECHAMA, ECHAMF*, and *NCAR,* since Jul-Aug for *NASA* models*.***
- ***CFSv1 and CFSv2* predict neutral condition until autumn 2012.**

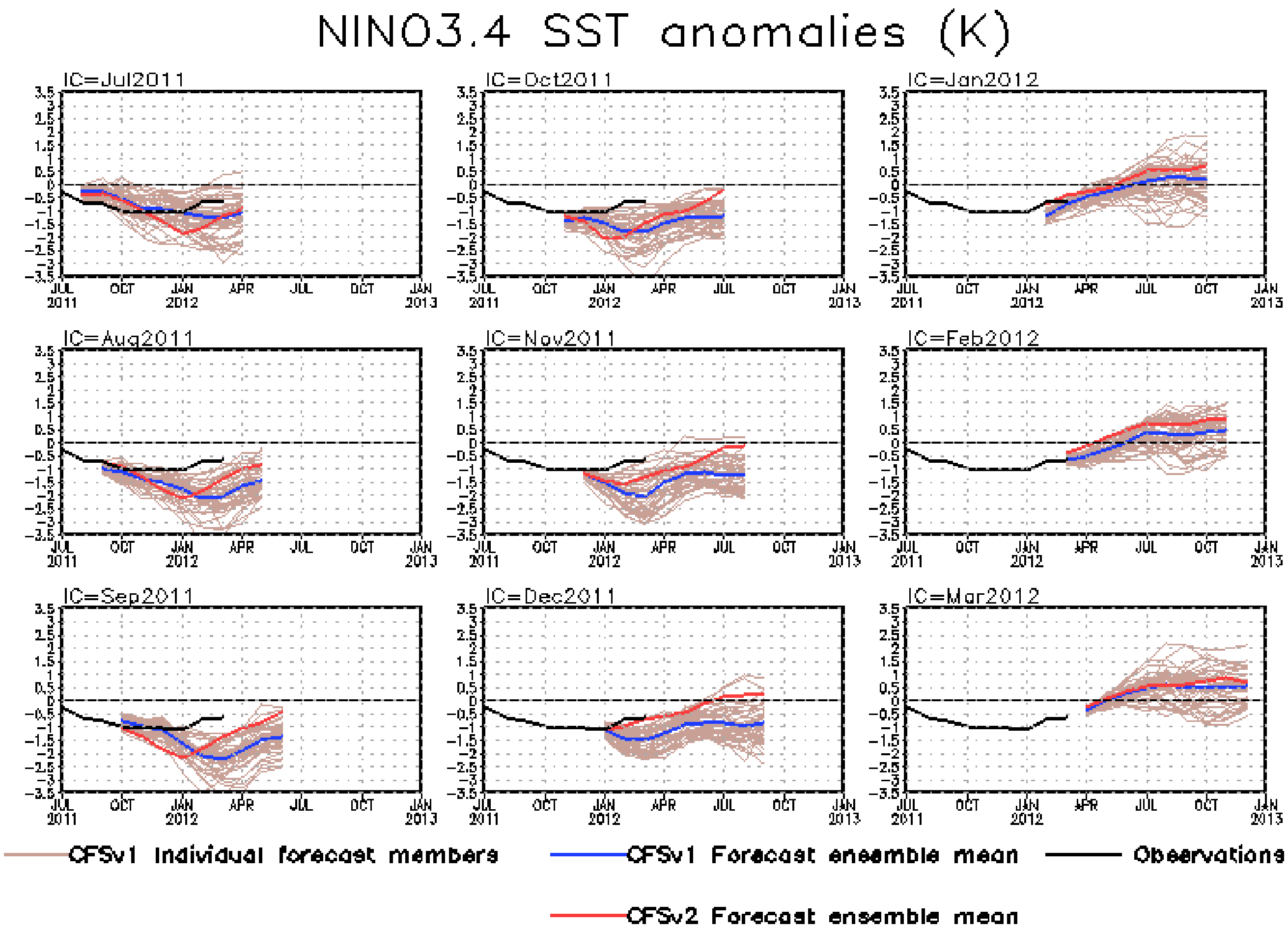
NCEP CFSv1 and CFSv2 NINO3.4 Forecast (IC=*201204*)





- **Both CFSv1 and CFSv2 predicted ENSO neutral-conditions in spring and early summer, while CFSv2 prediction is warmer than that of CFSv1 after summer 2012.**
- **PDF corrected CFSv1 forecast ENSO neutral conditions by autumn 2012.**

CFS Niño3.4 SST Predictions from Different Initial Months



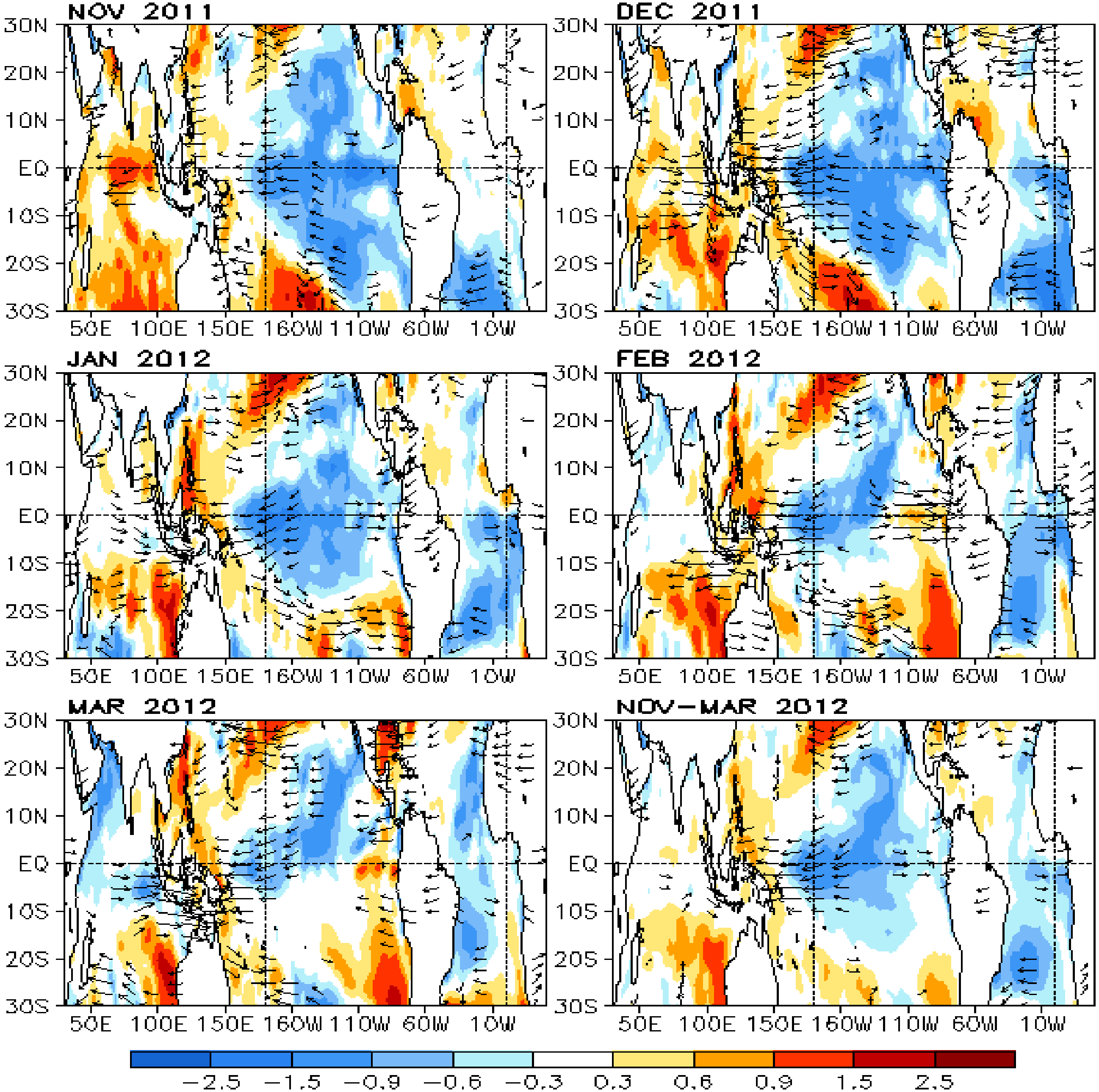
- Both CFSv1 and CFSv2 predict La Nina would weaken towards neutral-conditions in spring 2012.
- CFSv2 prediction is warmer than that of CFSv1 with ICs since Nov 2011.
- It is interesting that CFSv1 and CFSv2 converge for the predictions with IC in Mar 2012.

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.

Overview

- **Pacific Ocean**
  - **La Nina conditions weakened with NINO3.4=-0.6°C in Mar 2012.**
  - **NOAA “ENSO Diagnostic Discussion” in Apr suggests La Niña is expected to return to ENSO-neutral conditions during Apr 2012. A majority of ENSO models predict ENSO-neutral to continue through the NH summer 2012. Some models in the US National Multi-Model Ensemble (NMME) predict an El Nino since summer 2012.**
  - **Negative phase of PDO persisted, with PDOI=-1.4 in Mar 2012. NMME predicts the negative phase to last through the NH spring-autumn 2012.**
- **Indian Ocean**
  - **Negative SSTA developed in the tropical Indian Ocean, may be caused by the impact of La Nina.**
- **Atlantic Ocean**
  - **Positive NAO strengthened with NAOI=1.27 in Mar 2012.**
  - **Tropical North Atlantic cooled down, probably due to the impact of La Nina and positive phase of NAO.**
  - **Tropical South Atlantic has cooled down substantially since Dec 2011, which was the coolest period since 1998. NMME predicts the cooling to last until early autumn 2012.**

Backup Slides



Evolution of SST and 850mb Wind Anomalies

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

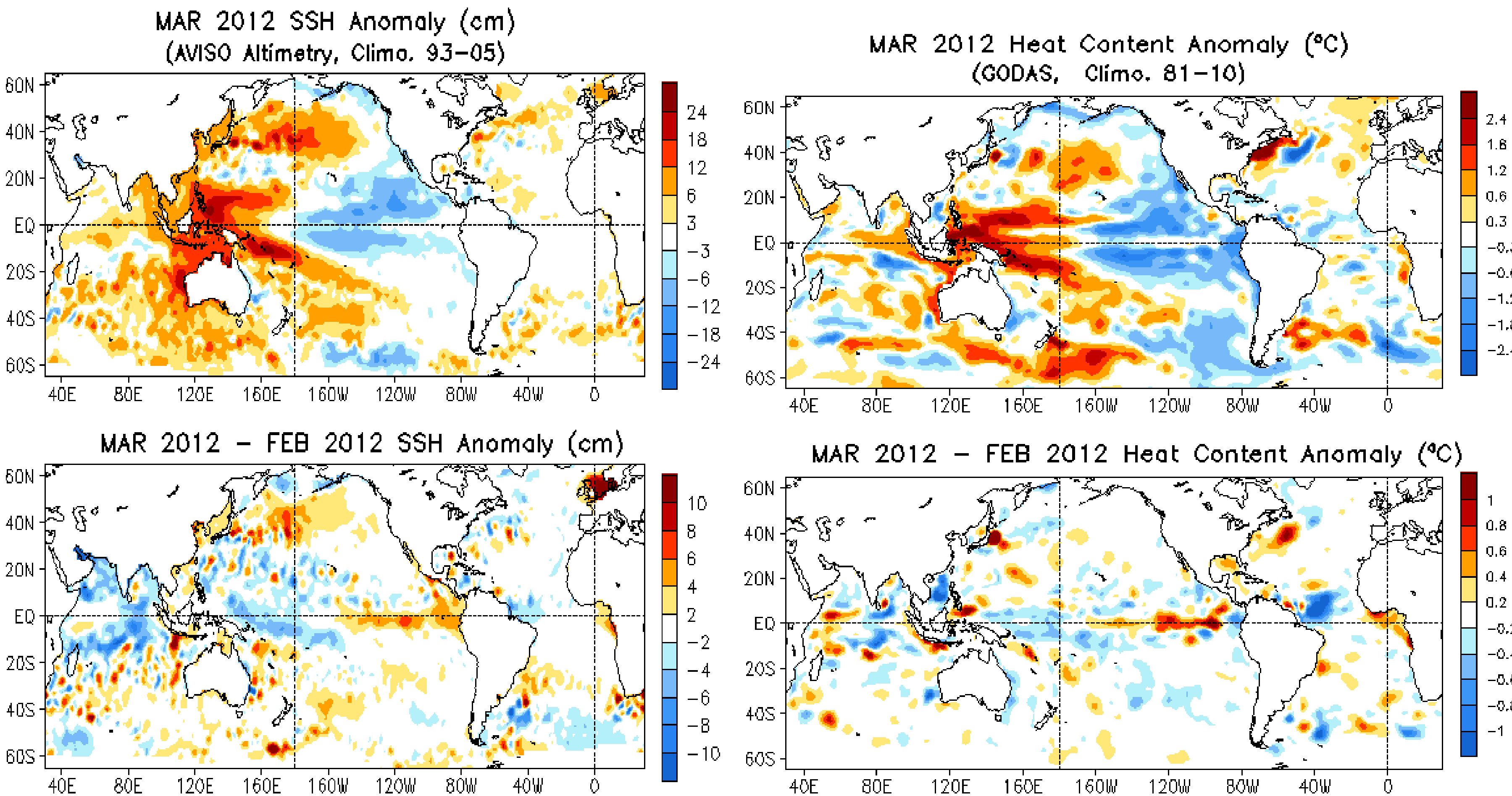


Fig. G2. Sea surface height anomalies (SSHA, top left), SSHA tendency (bottom left), top 300m heat content anomalies (HCA, top right), and HCA tendency (bottom right). SSHA are derived from http://www.aviso.oceanobs.com, and HCA from GODAS.

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.

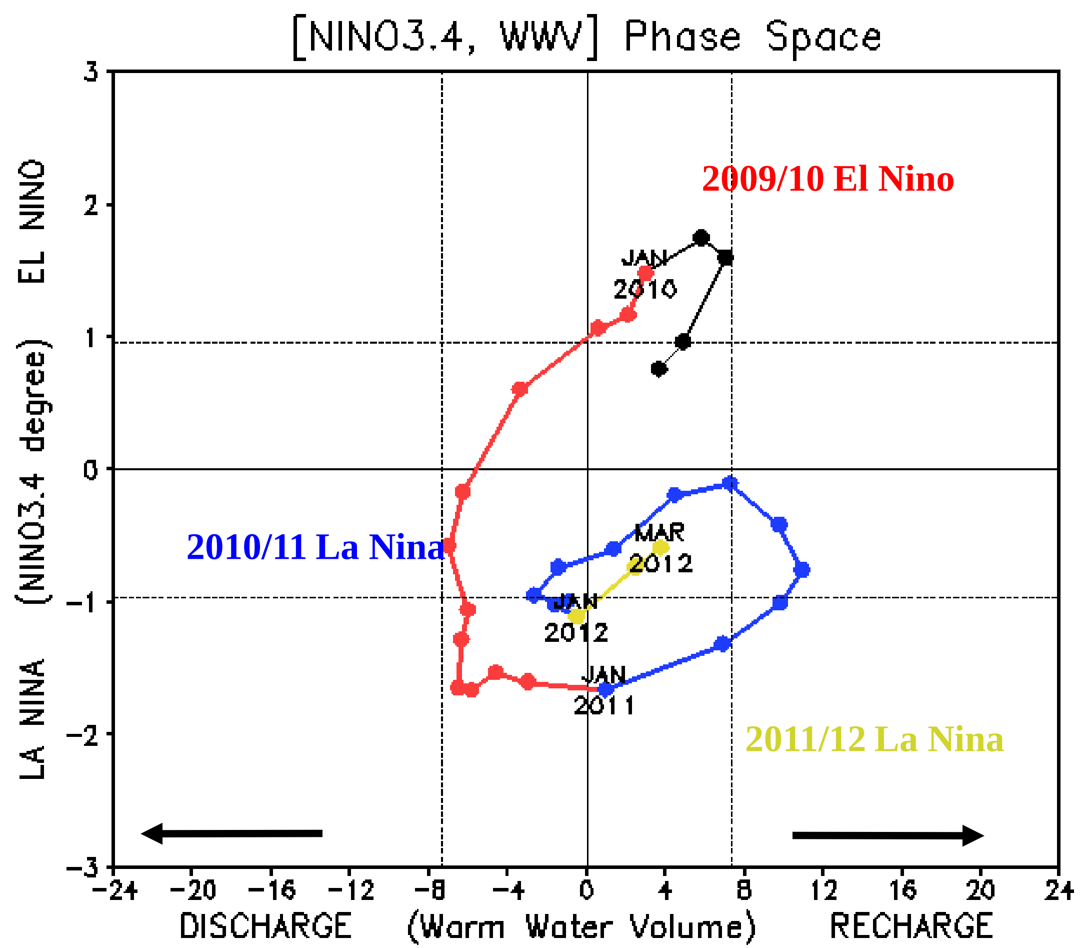
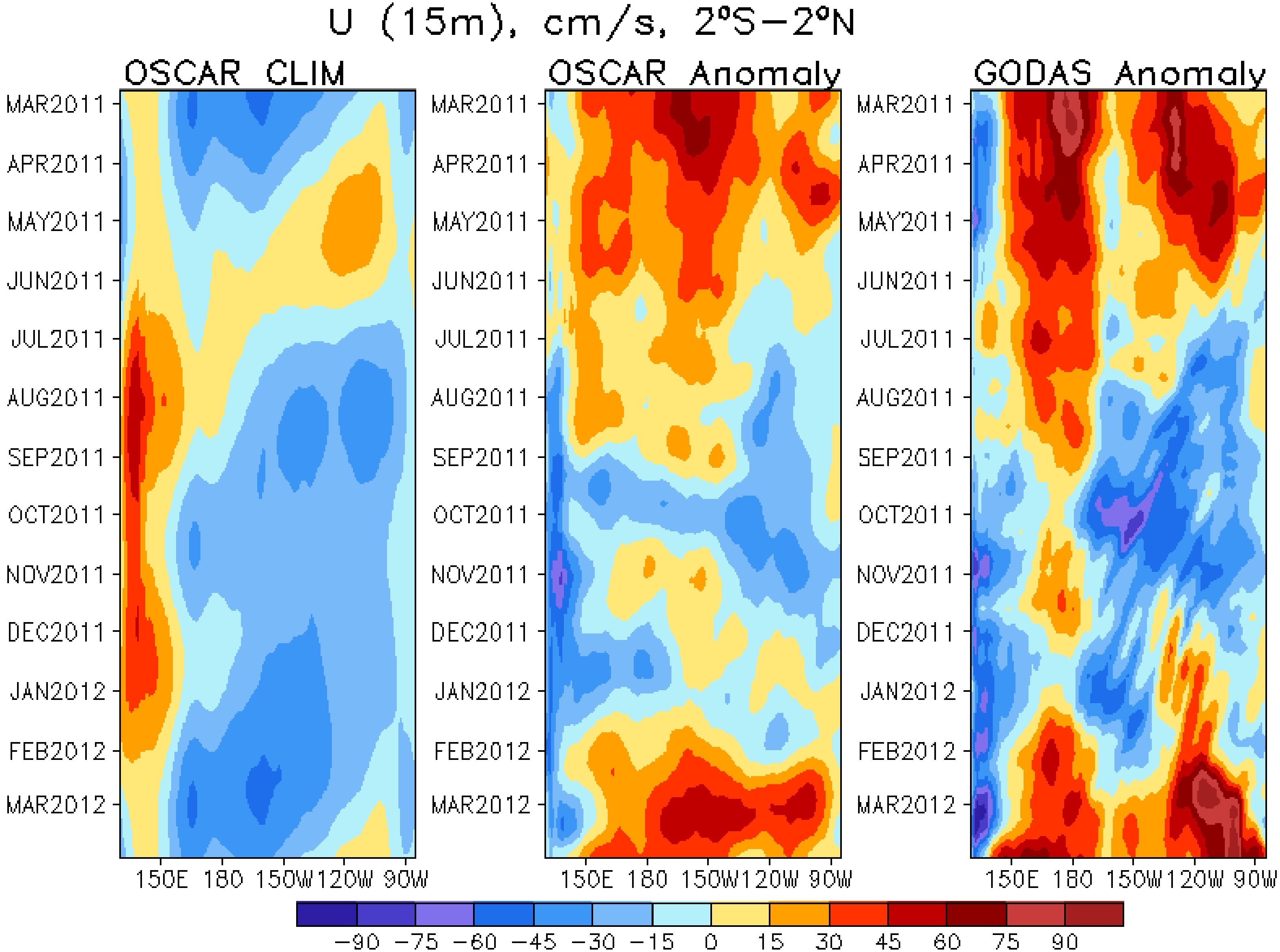


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

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



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

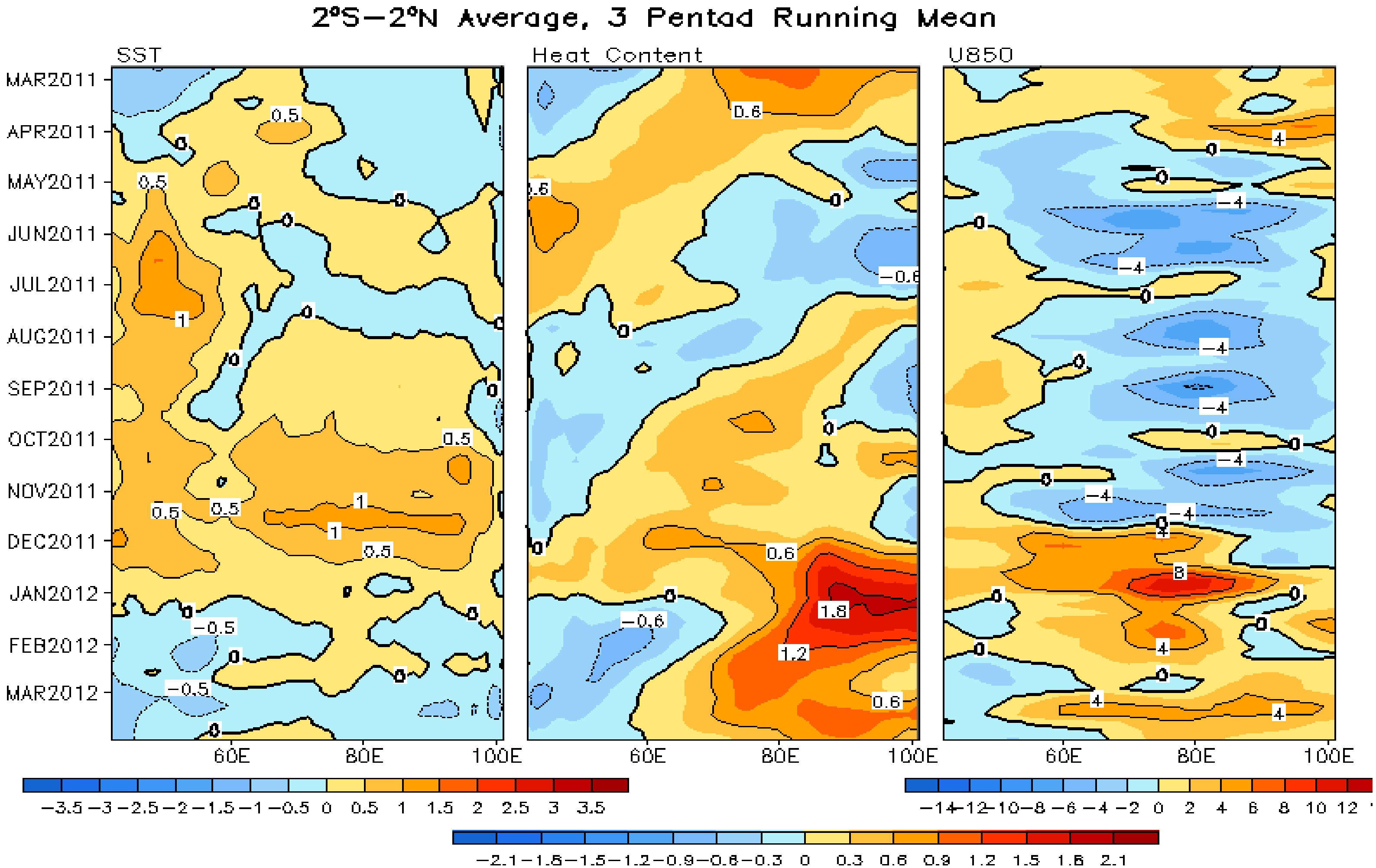
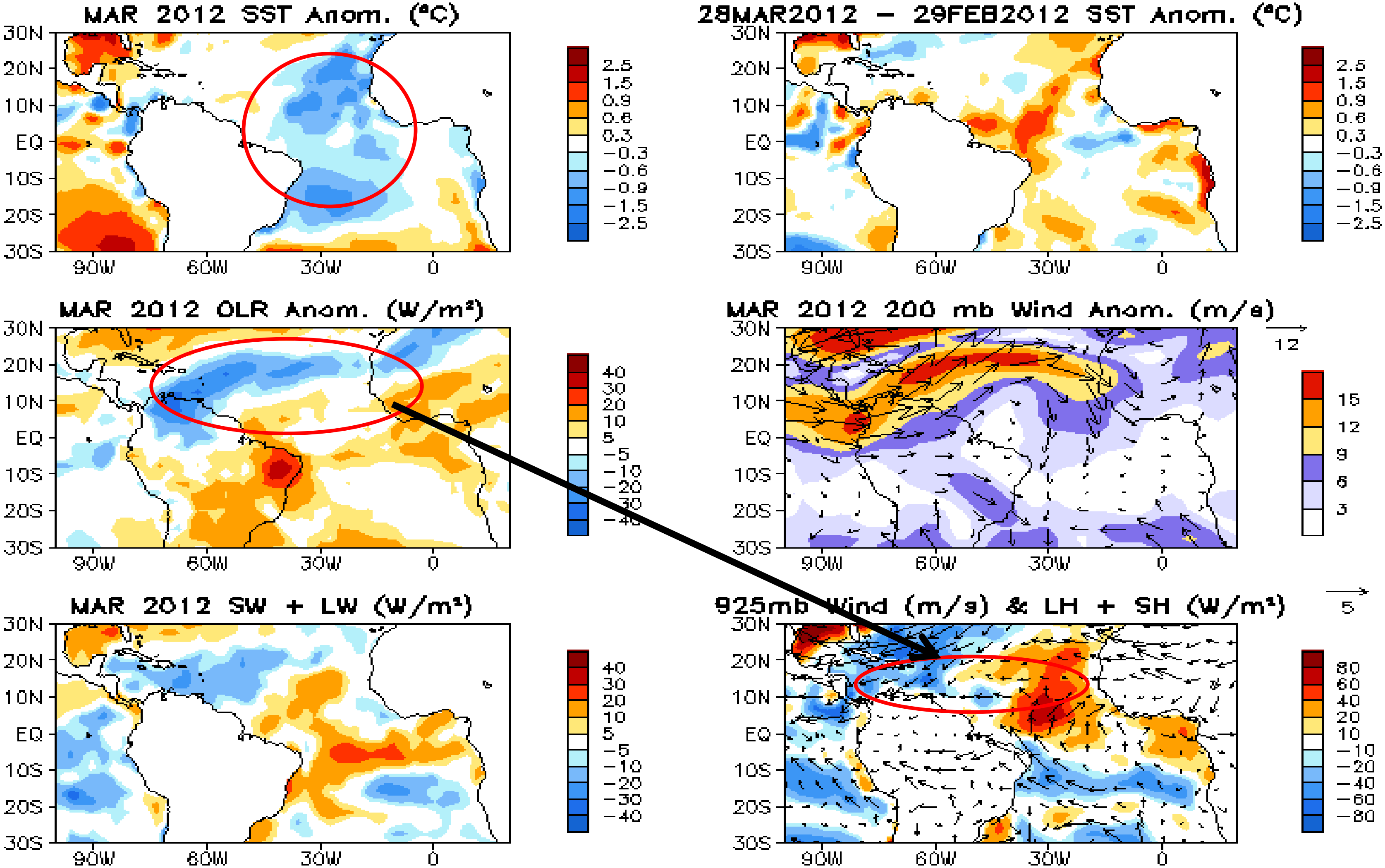


Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. SST are derived from the NCEP OI 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 Atlantic:



- Negative SSTA presented in the Tropical Atlantic, probably due to the lagged impact of La Nina .
- Negative OLR anomalies are consistent with low-level wind convergence.

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

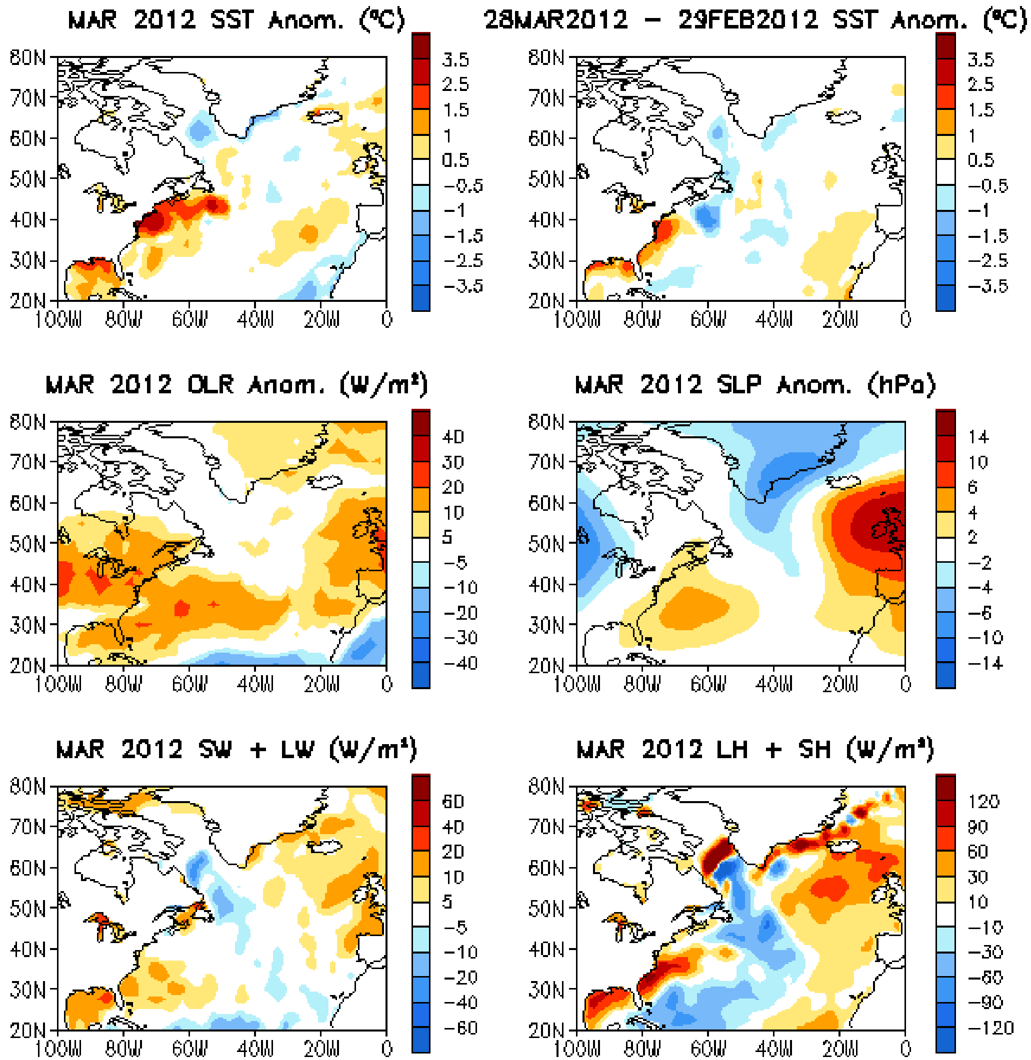
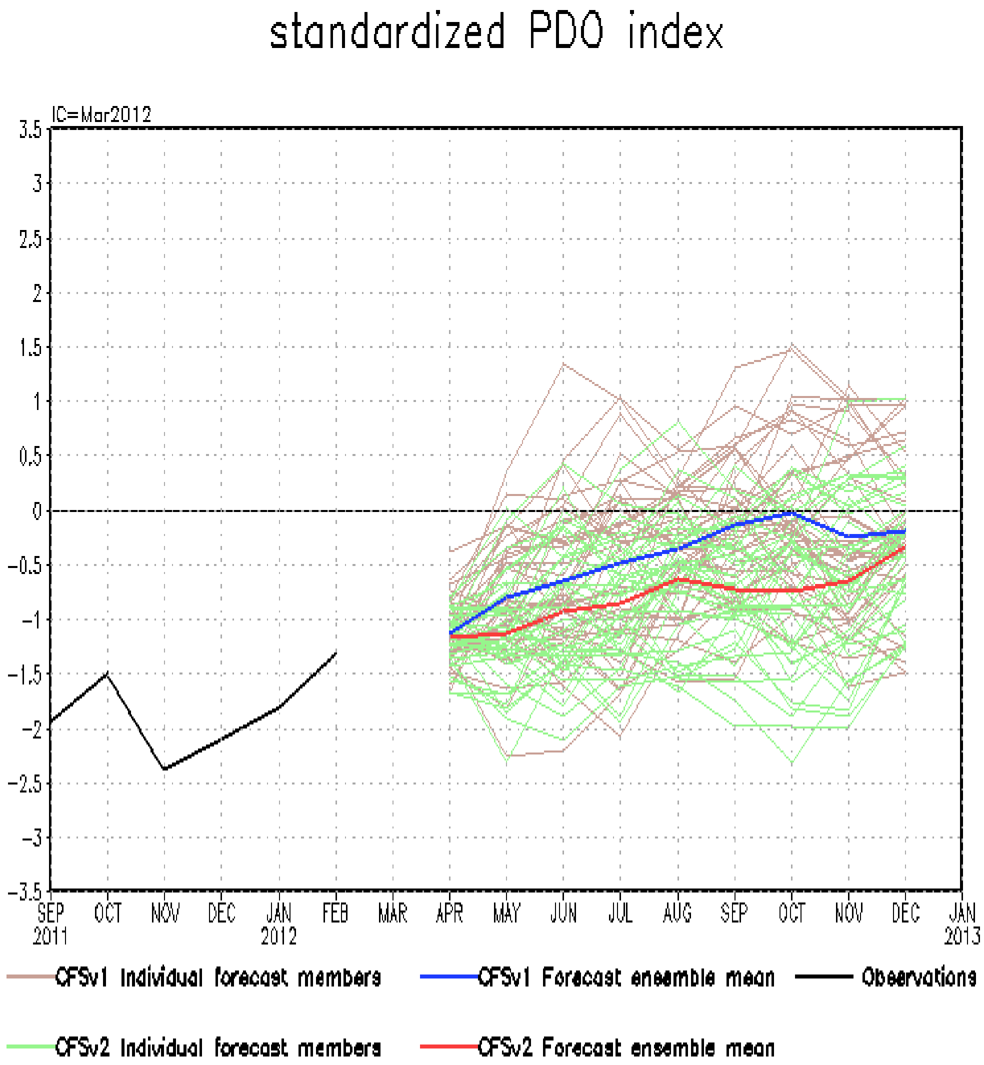
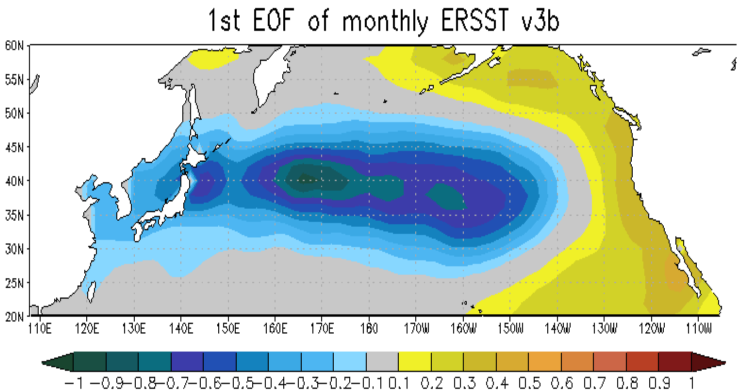


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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.**

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.

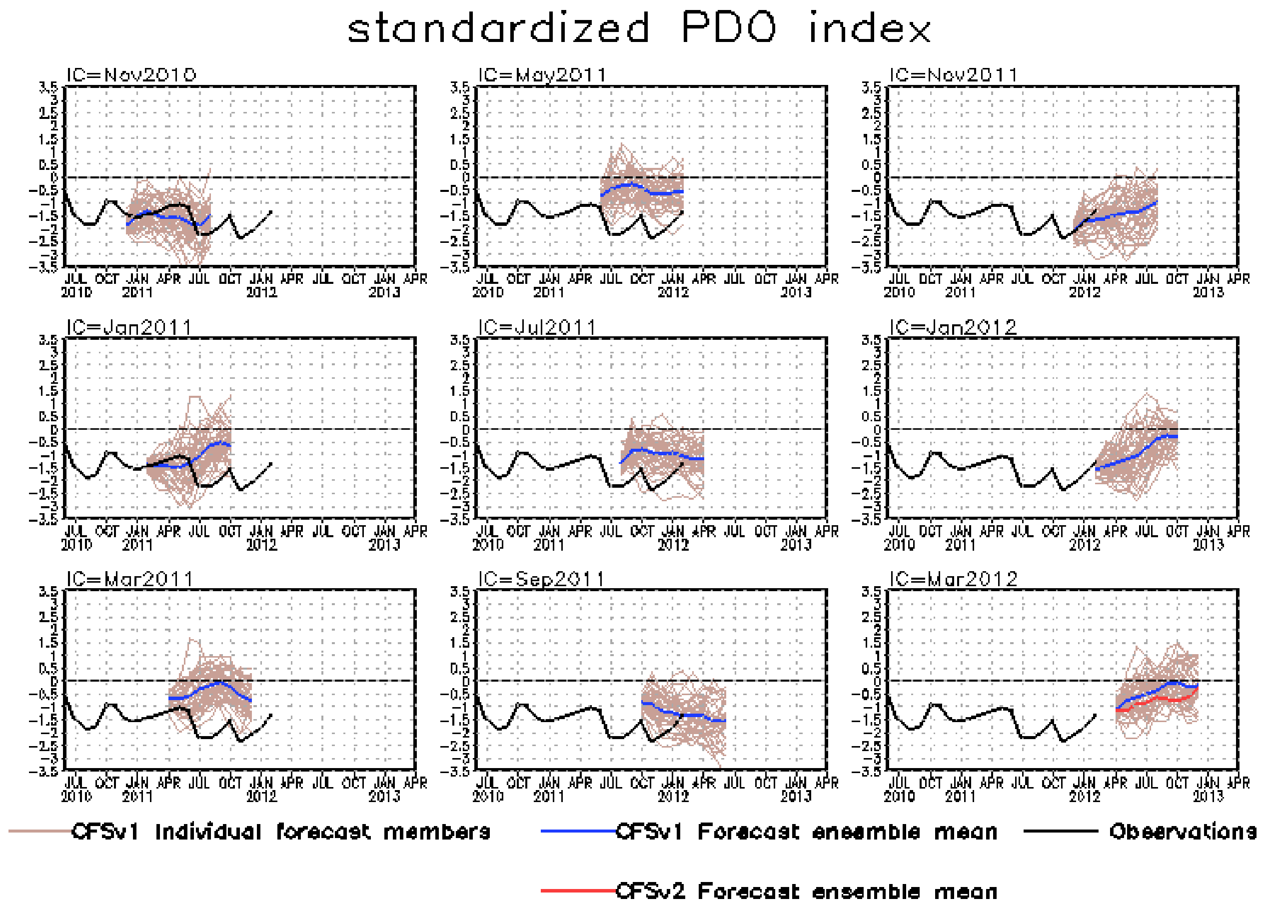


Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

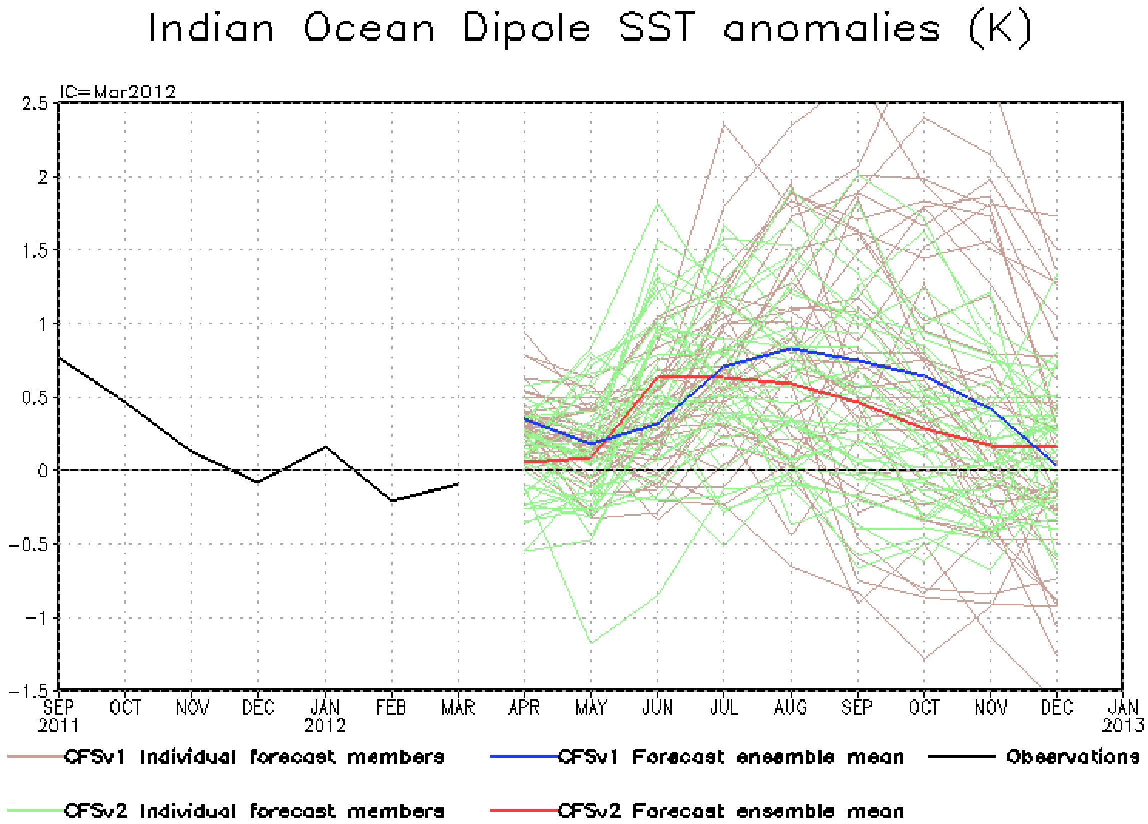
NCEP CFSv1 and CFSv2 Indian Ocean Dipole Model Index

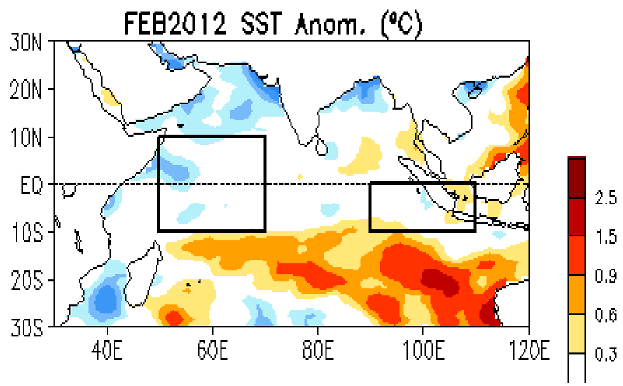
Forecast

DMI = WTIO- SETIO

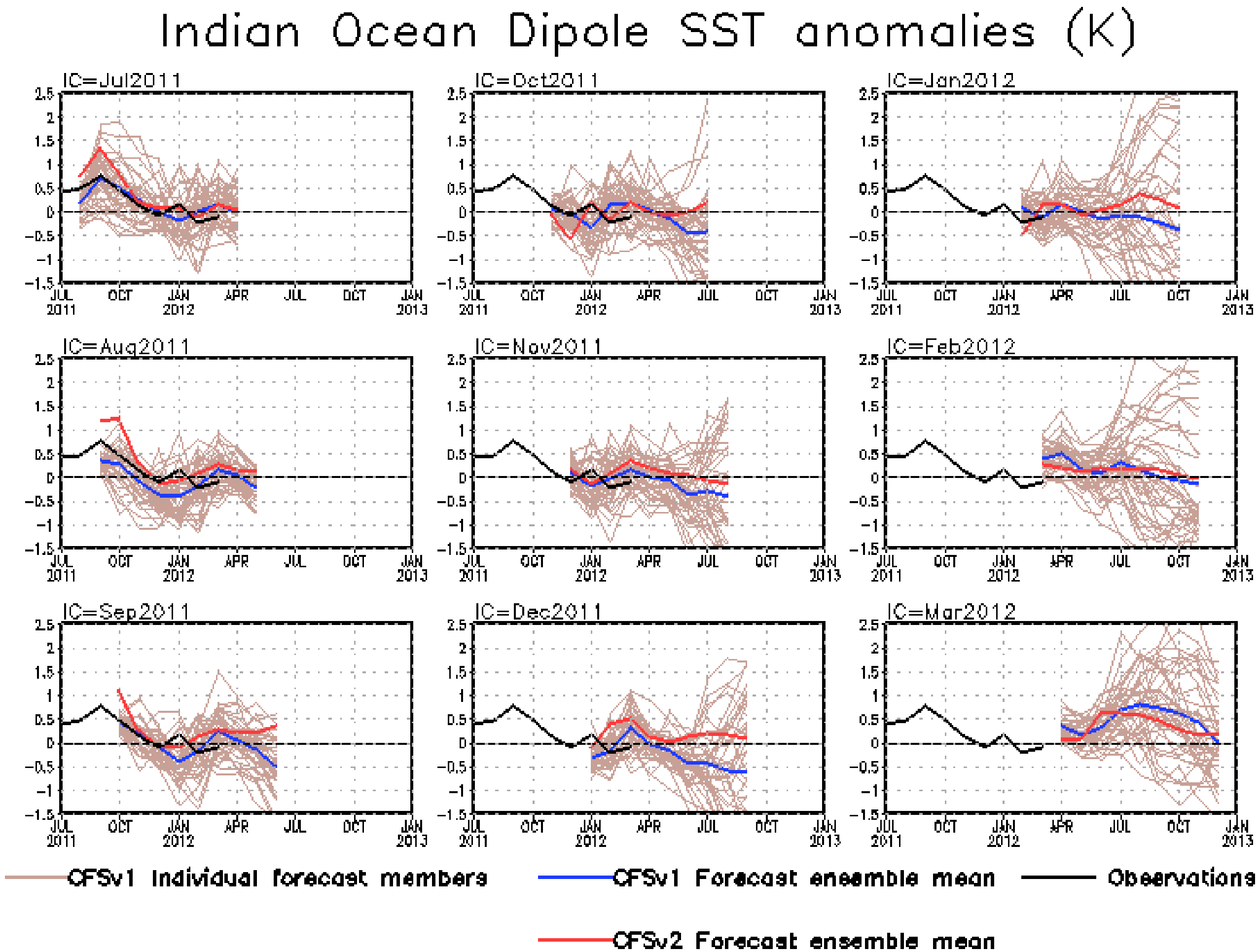
SETIO = SST anomaly in [90ºE-110ºE, 10ºS-0]

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





NCEP CFS DMI SST Predictions from Different Initial Months



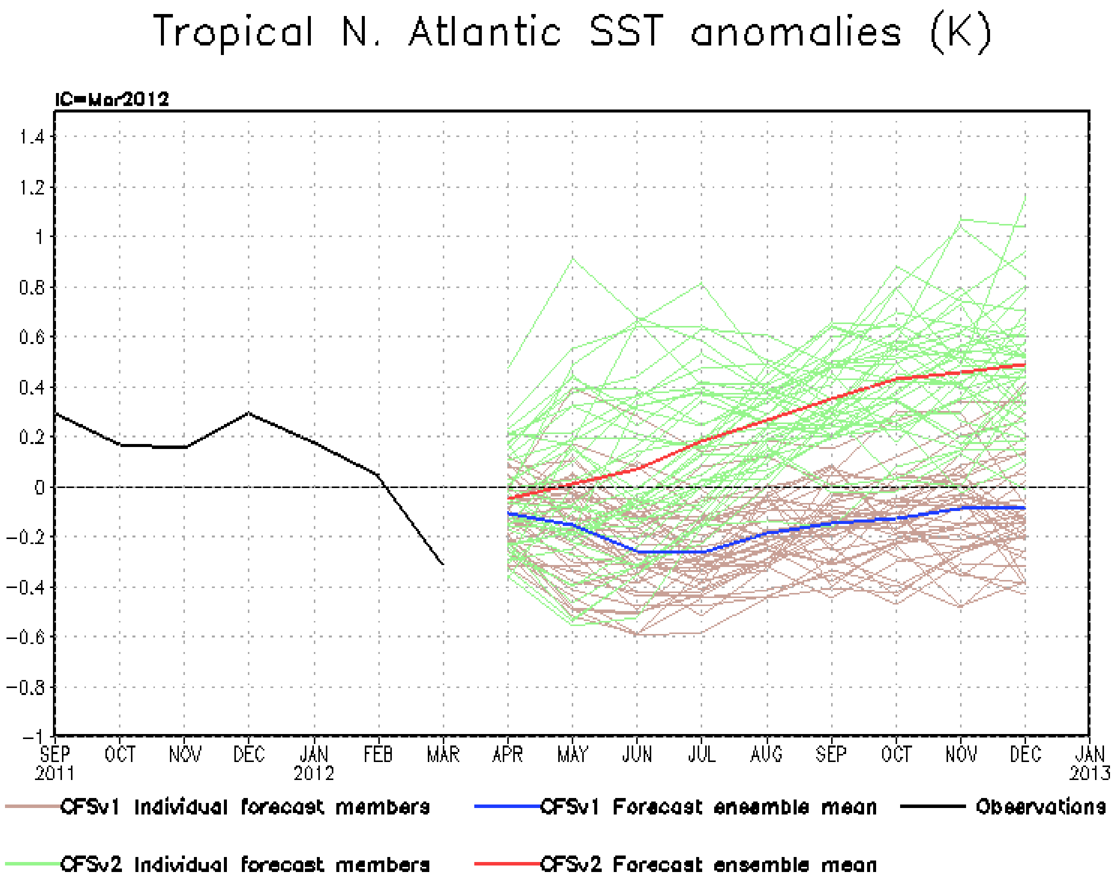
DMI = WTIO- SETIO

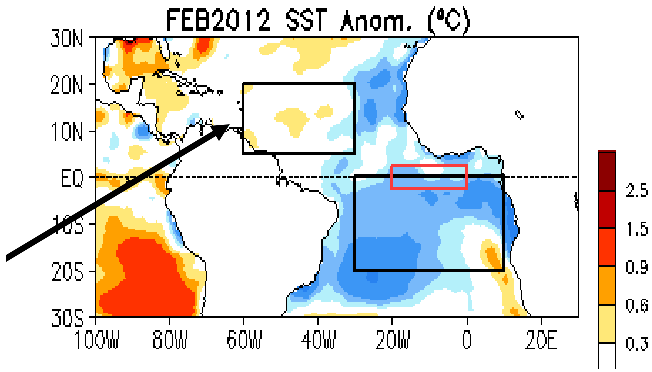
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

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

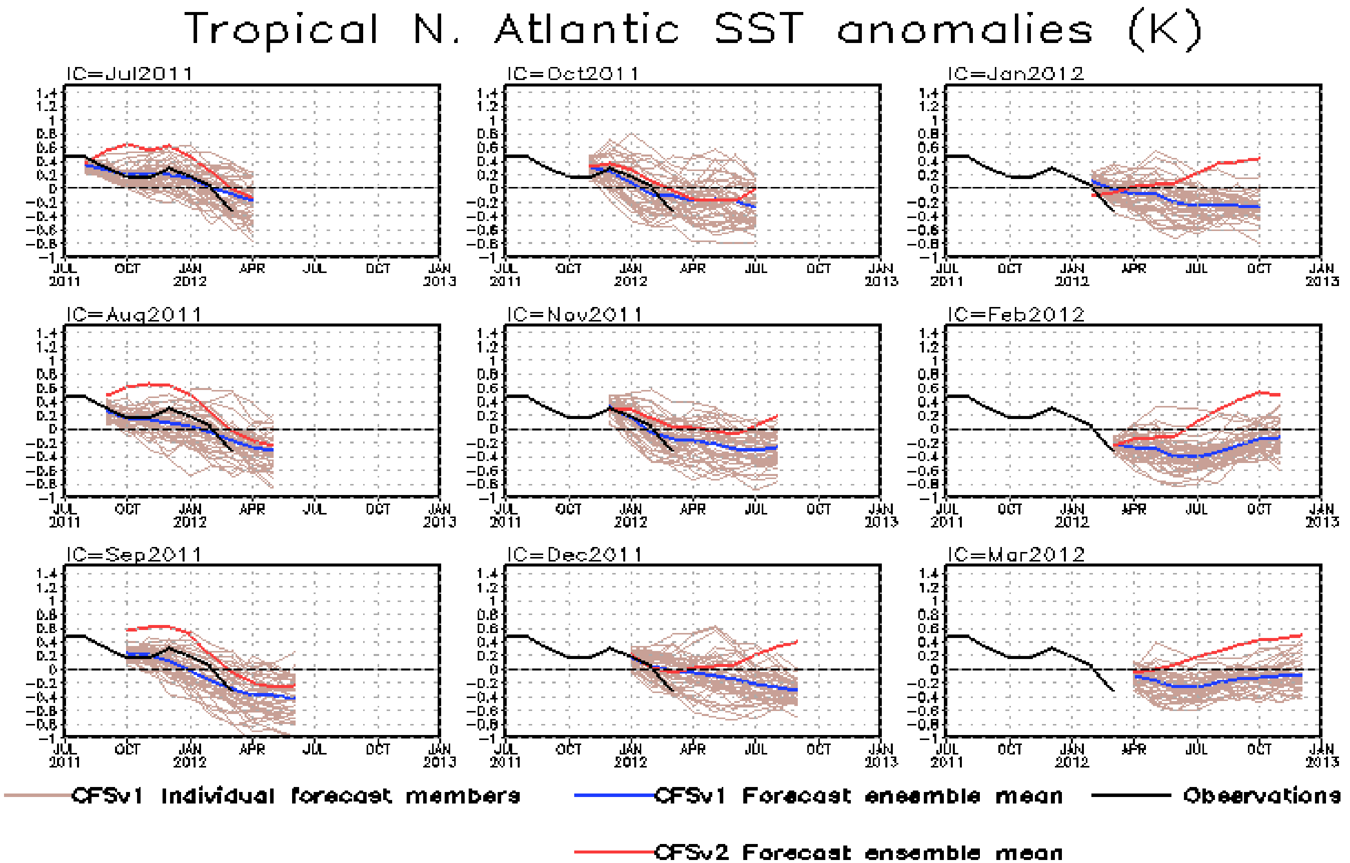
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast 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.

NCEP CFSv1 and CFSv2 Tropical North Atlantic SST Forecast





CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



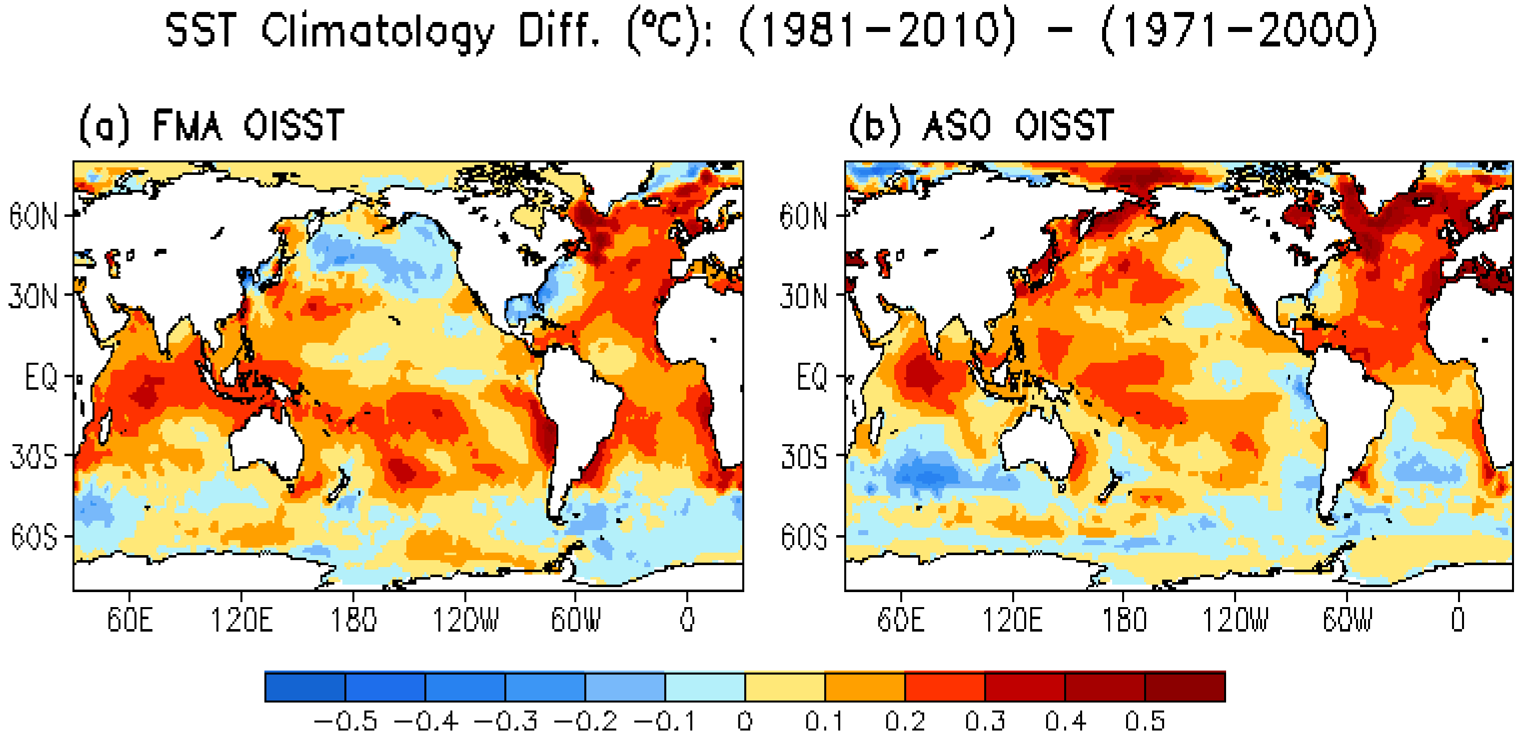
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].

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.

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)**

<u>Be aware that new climatology (1981-2010) was applied since Jan 2011</u>



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!