

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 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 condition continued during Feb 2013 with Nino3.4=-0.4C.
- NOAA officially forecast ENSO-neutral condition to continue in the Northern Hemisphere spring-summer 2013.
- Negative PDO phase slightly strengthened with PDO index =-1.5 in Feb 2013, and NCEP CFSv2 predicted negative phase of PDO would continue.
- Arctic sea ice extent in Feb 2013 was well below-normal and similar to that in Feb 2012.

▪ Indian Ocean

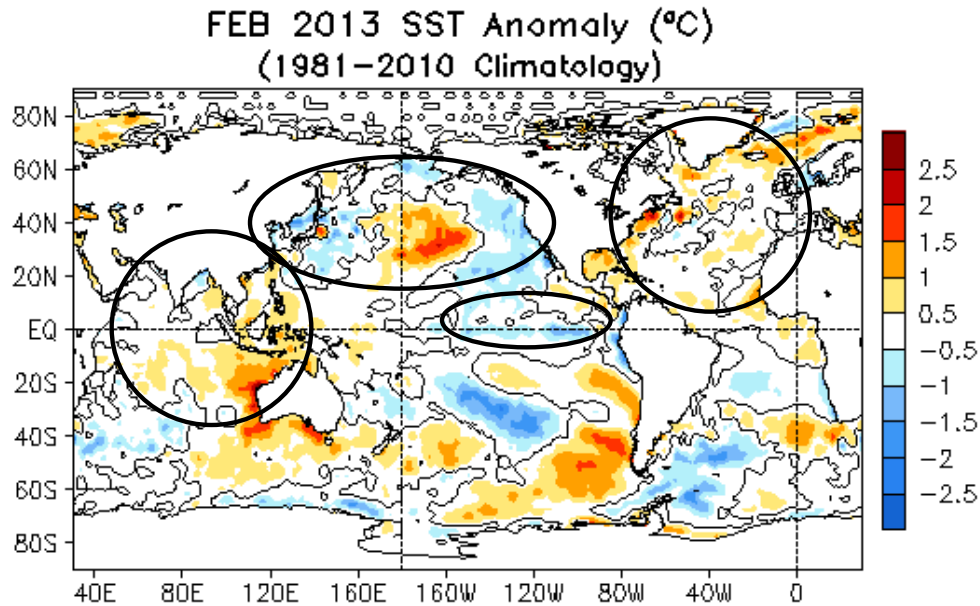
- SSTs in Indian Ocean were above or near-normal in Feb 2013.

▪ Atlantic Ocean

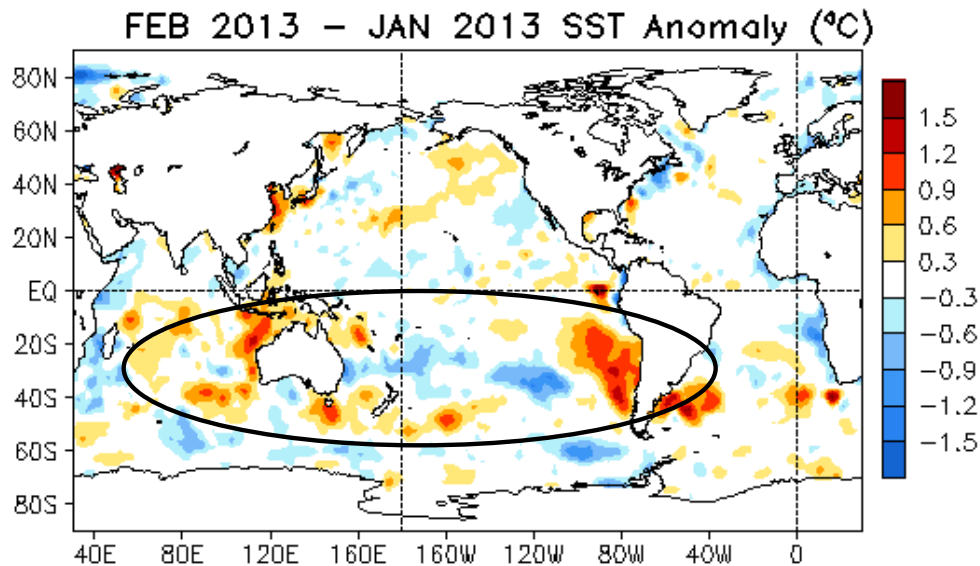
- Negative phase of NAO strengthened significantly with NAO index =-0.96 in Feb 2013.
- Positive SSTA in high-latitude N. Atlantic significantly weakened, while positive SSTA in tropical N. Atlantic also weakened.

Global Oceans

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



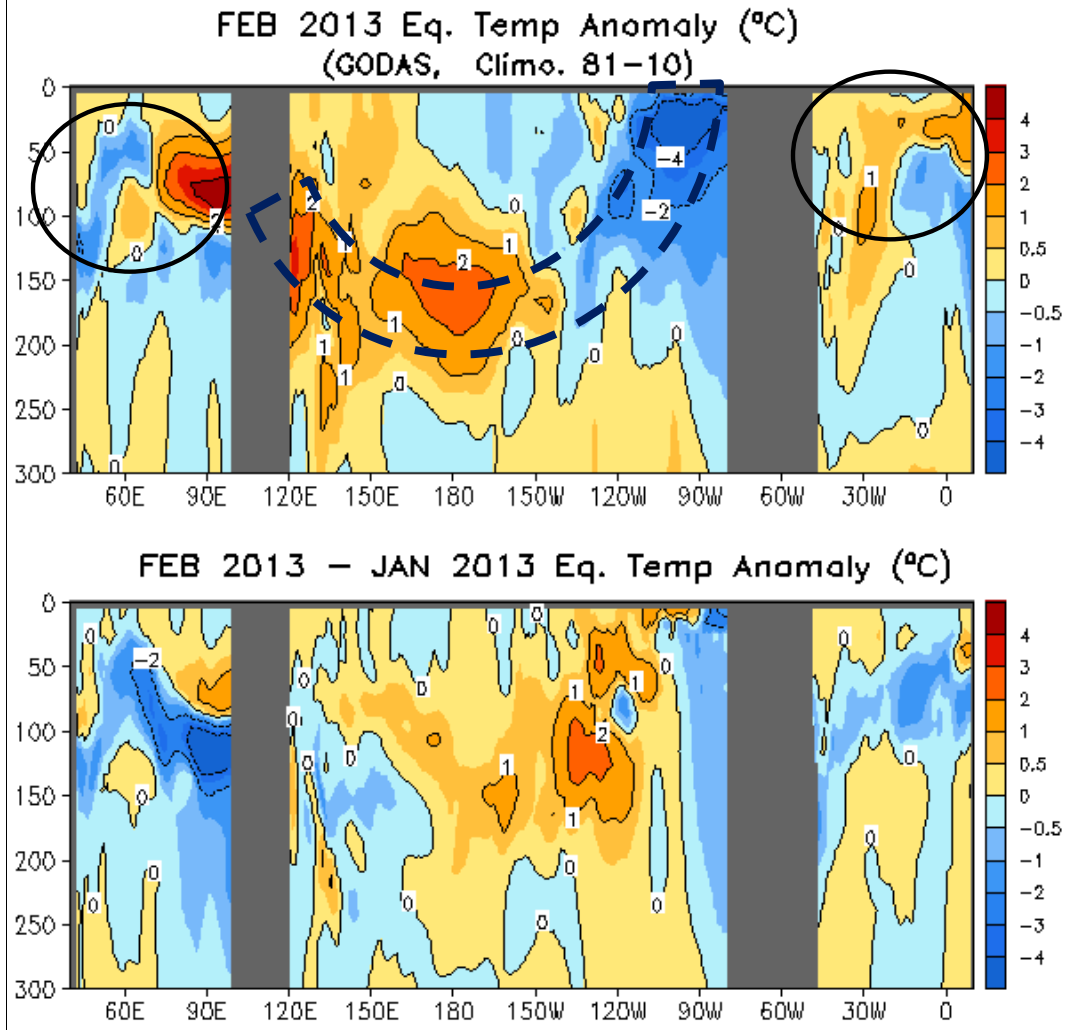
- SST was below-normal in the central-eastern tropical Pacific.
- Negative phase PDO associated SSTA presented in North Pacific.
- Positive SSTA was observed in the Indian Ocean and western Pacific.
- Above-normal SSTA occurred in the North Atlantic.
- Large SST anomalies were observed in the South Ocean.



- Small tendency in Northern Hemisphere and large tendency in the mid-latitudes of the Southern Hemisphere.

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



- Positive (negative) temperature anomalies continued to occupy along the thermocline in the equatorial western (eastern) Pacific Ocean.
- Positive anomalies presented at the upper 100m of equatorial Indian and Atlantic Oceans.

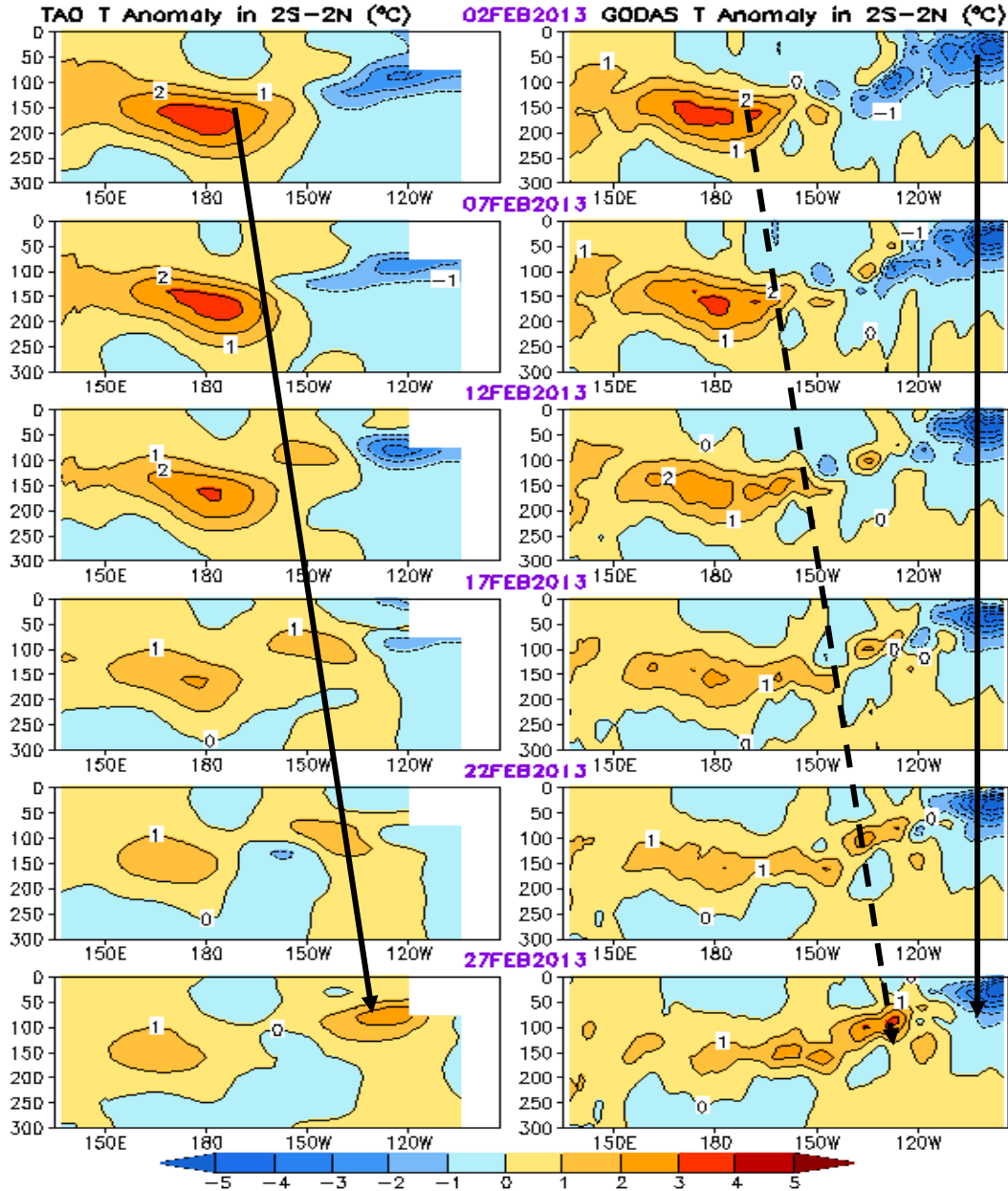
- A cooling (warming) tendency was observed in the western (eastern and central) Pacific Ocean along the thermocline, largely due to propagation of oceanic Kelvin waves (slide 13).

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

TAO

GODAS



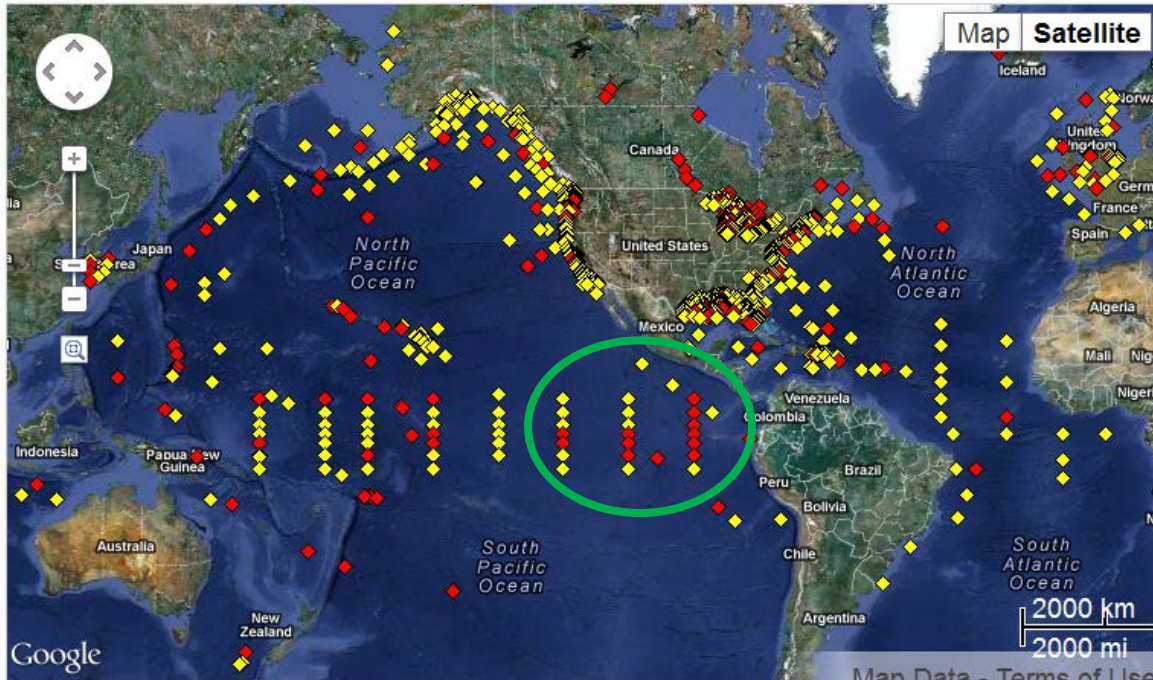
Pentad Mean Equatorial Pacific Temperature Anomaly

- Positive temperature anomalies along the thermocline propagated eastward, associated with downwelling ocean Kelvin waves.
- However, the differences between TAO and GODAS were large in the eastern Pacific. **What causes the differences?**

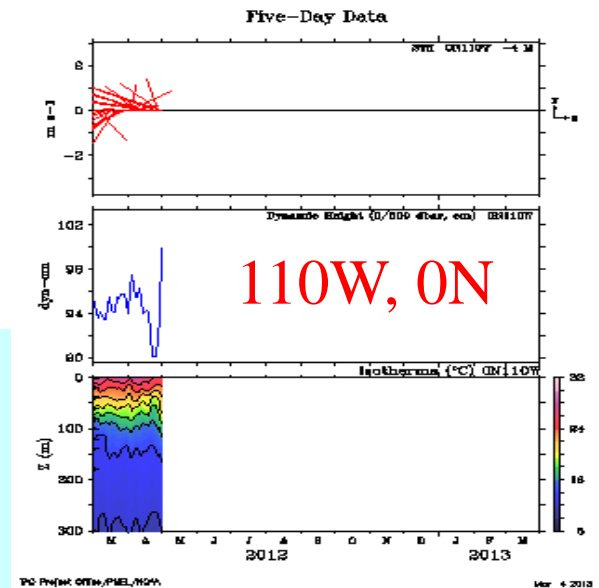
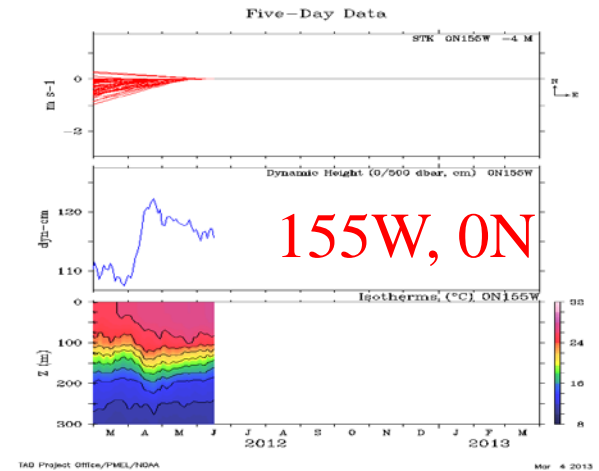
Status of TAO/TRITON Data Delivery

<http://www.ndbc.noaa.gov>

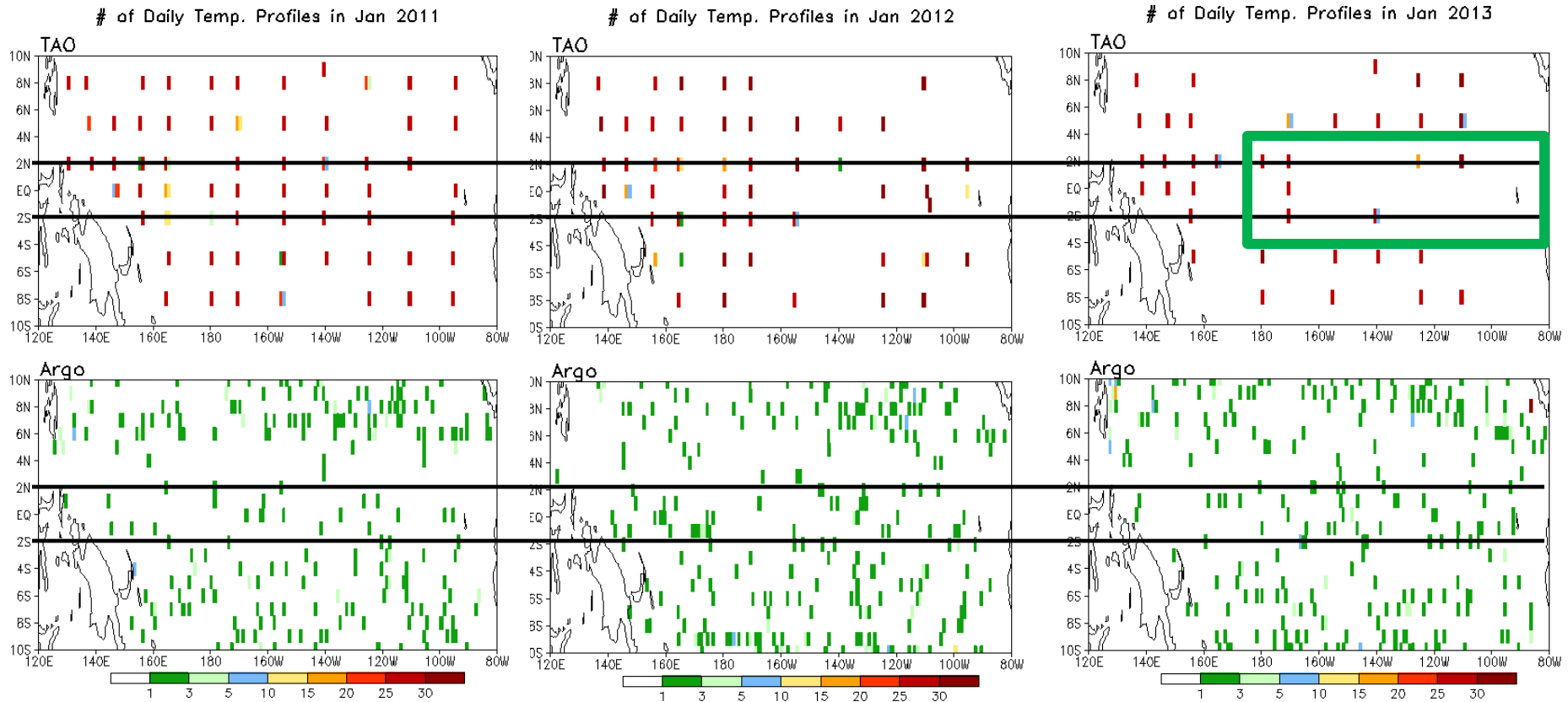
<http://www.pmel.noaa.gov/tao/jsdisplay/>



- The TAO/TRITON array has encountered significant outages, particularly in the eastern part of the array.
- For example, the mooring at (155W, 0N) has been down since July 2012, and the mooring at (110W, 0N) went down since May 2012.

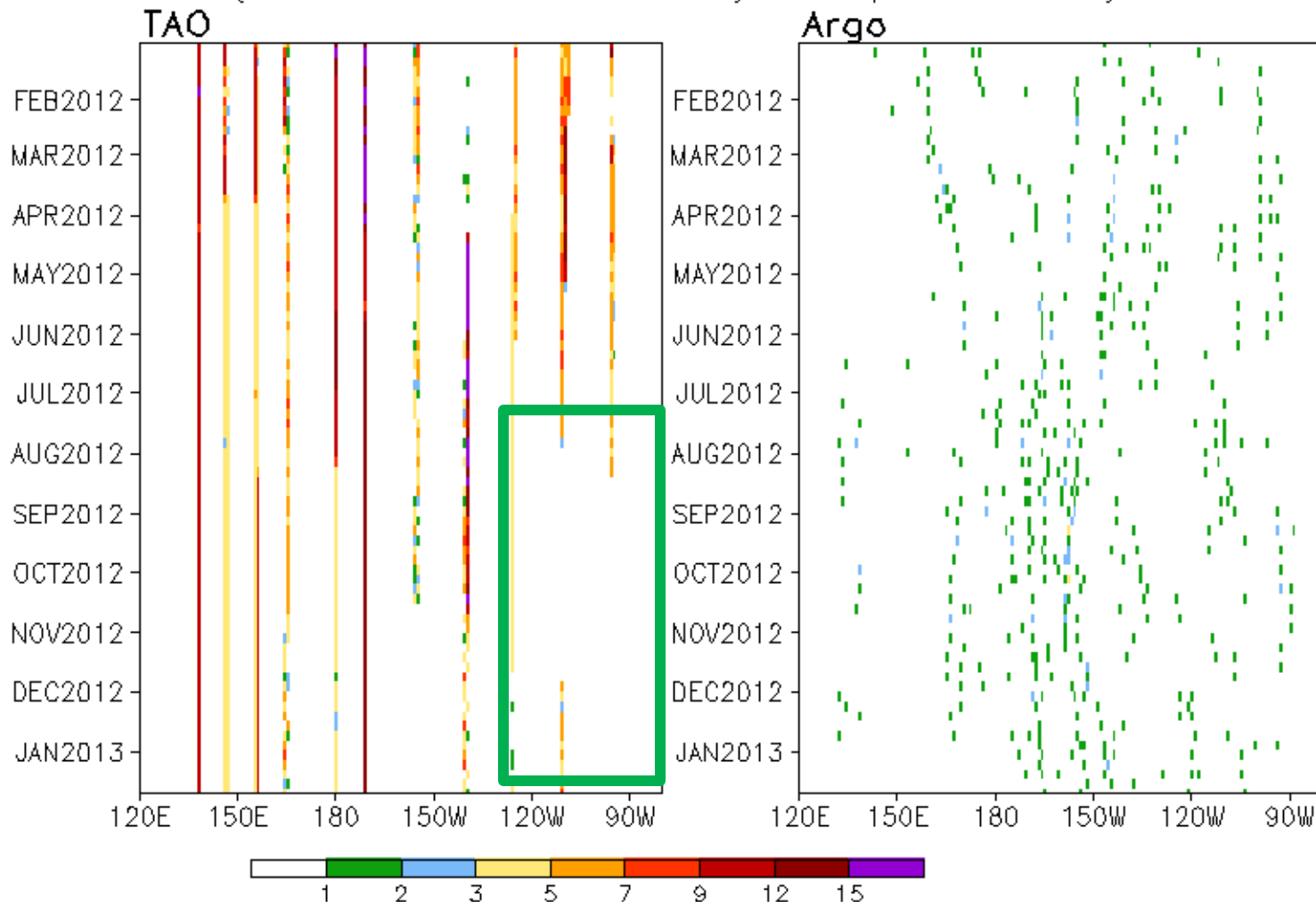


Number of Daily Temperature Profiles Assimilated into GODAS



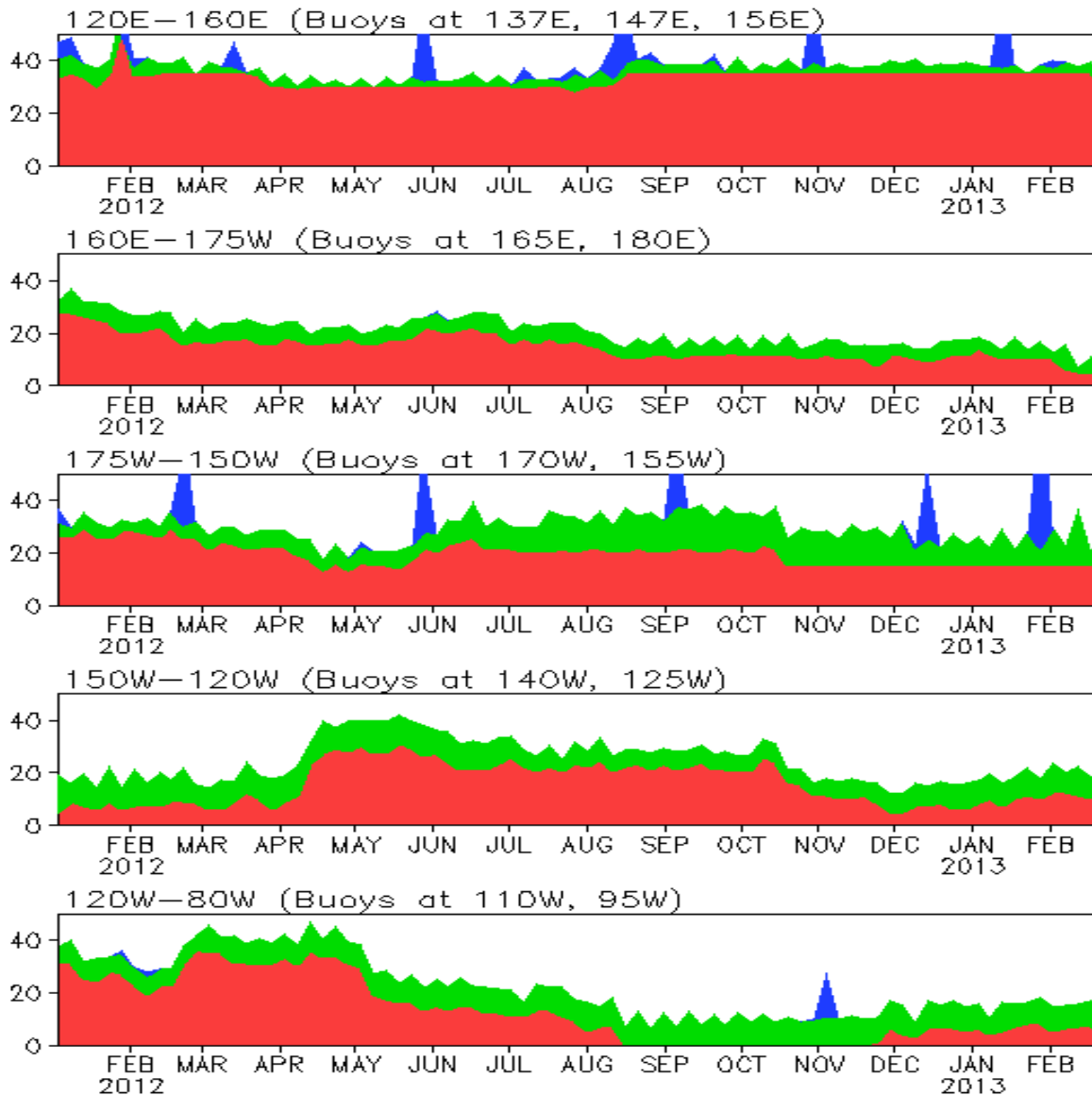
- Number of daily temperature profiles were gridded into one degree grid.
- Number of daily temperature profiles from TAO buoys should be around 30 in each month if data return rate is 100%.
- There were declining data return rate in TAO buoys. In fact, almost all the buoys east of 160W near the equator failed to return data in Jan 2013.
- Argo floats usually return **less than 3 profiles each month** in one degree box which is much less than that of TAO buoys normally return.

of Daily Temp. Profiles every 5 Days in 3S–3N
 (15 is 100% return rate, buoys at eq., 2S and 2N)



- The data return rate is lower than 50% (< 7 profiles) at all equatorial TAO buoys except at 137E and 170W since Nov 2012.
- Argo only provided 1-2 profiles every 5 days in the box of 3S-3N and one degree longitude.

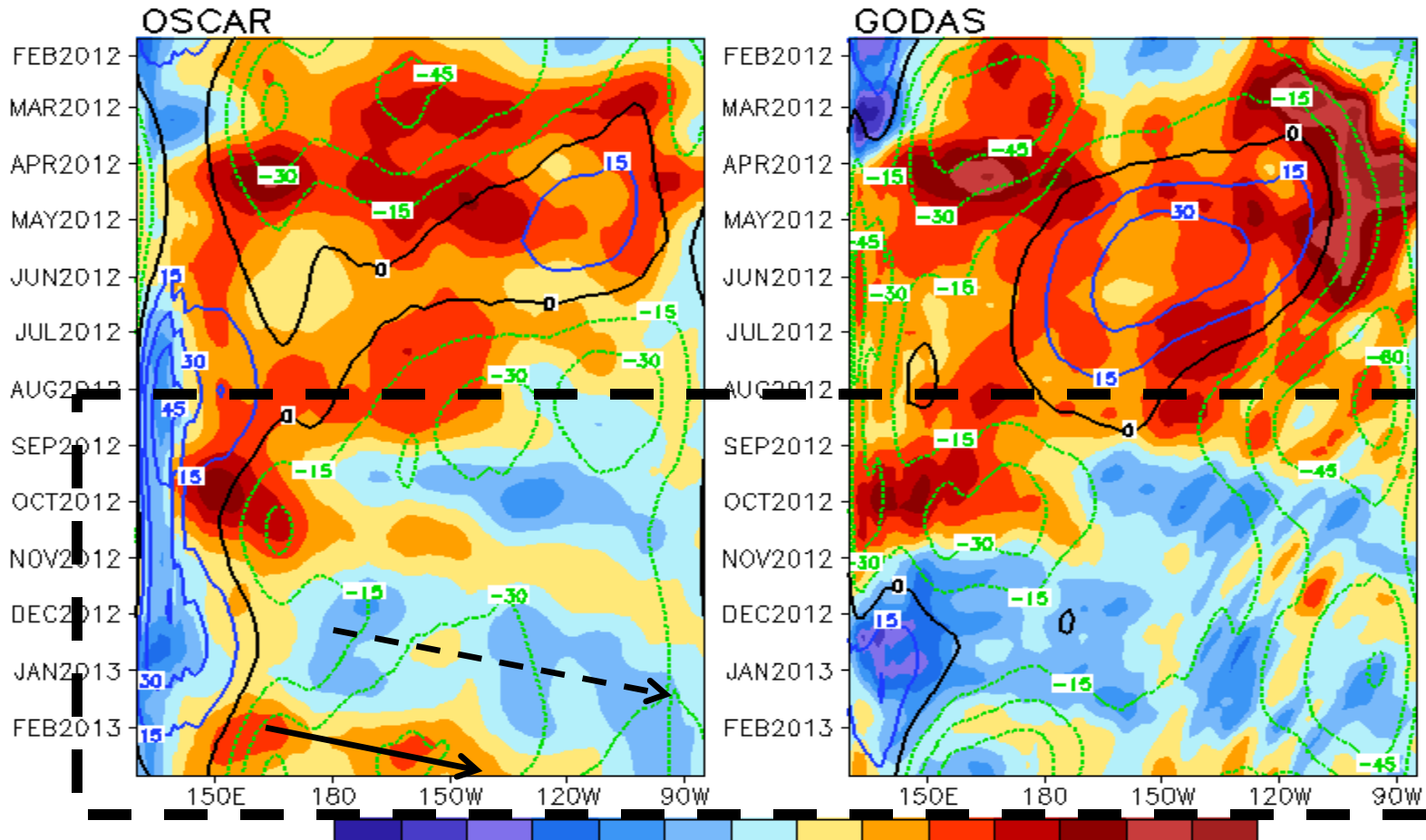
of Daily Temp. Profiles every 5 Days in 3S-3N
TAO(red, 30 is 100% return rate), ARGO(green), XBT(blue)



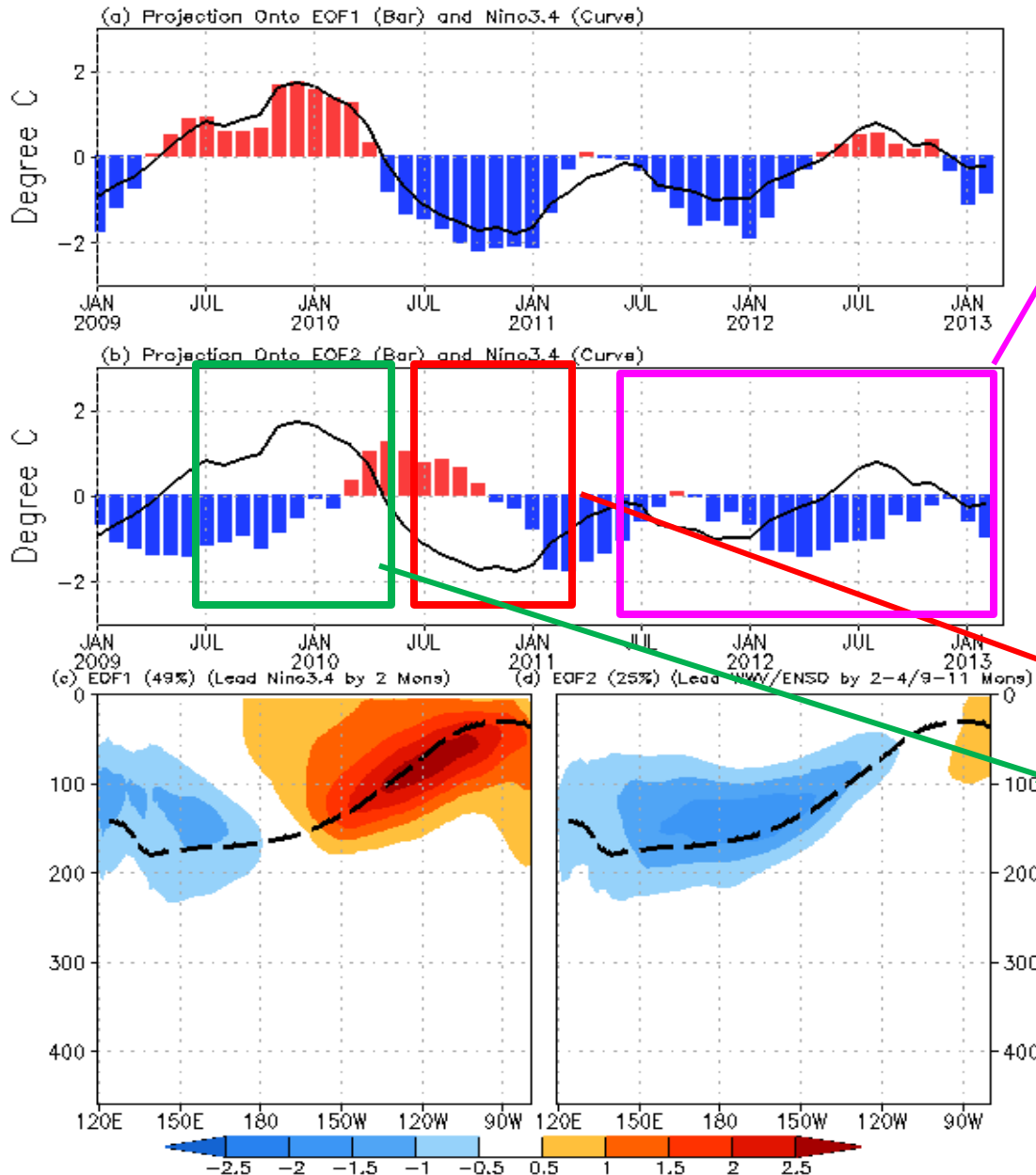
- Number of profiles accumulated in each longitude band that covers 2-3 TAO buoys and 3S-3N every 5 days are shown.
- There were significant data loss at 160E-175W in Feb 2013.
- There were significant data loss at 150W-120W since Nov 2013.
- The TAO data return rate at 120W-80W was the poorest among all buoy sites since **June 2012**, and it went to zero during Sep-Nov 2012.

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

U (15m), cm/s, 2°S–2°N (Shading=Anomaly; Contour=Climatology)



- Positive (negative) zonal current anomalies were associated with downwelling (upwelling) oceanic Kelvin waves.
- Profound differences noted for both anomaly and climatology between OSCAR and GODAS.
- Is the difference of the anomaly since Oct 2012 due to observational data (TAO...) missing in GODAS?



Equatorial subsurface ocean temperature monitoring: Right now, in recharge phase; recharge/discharge were weak in last 2 years.

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

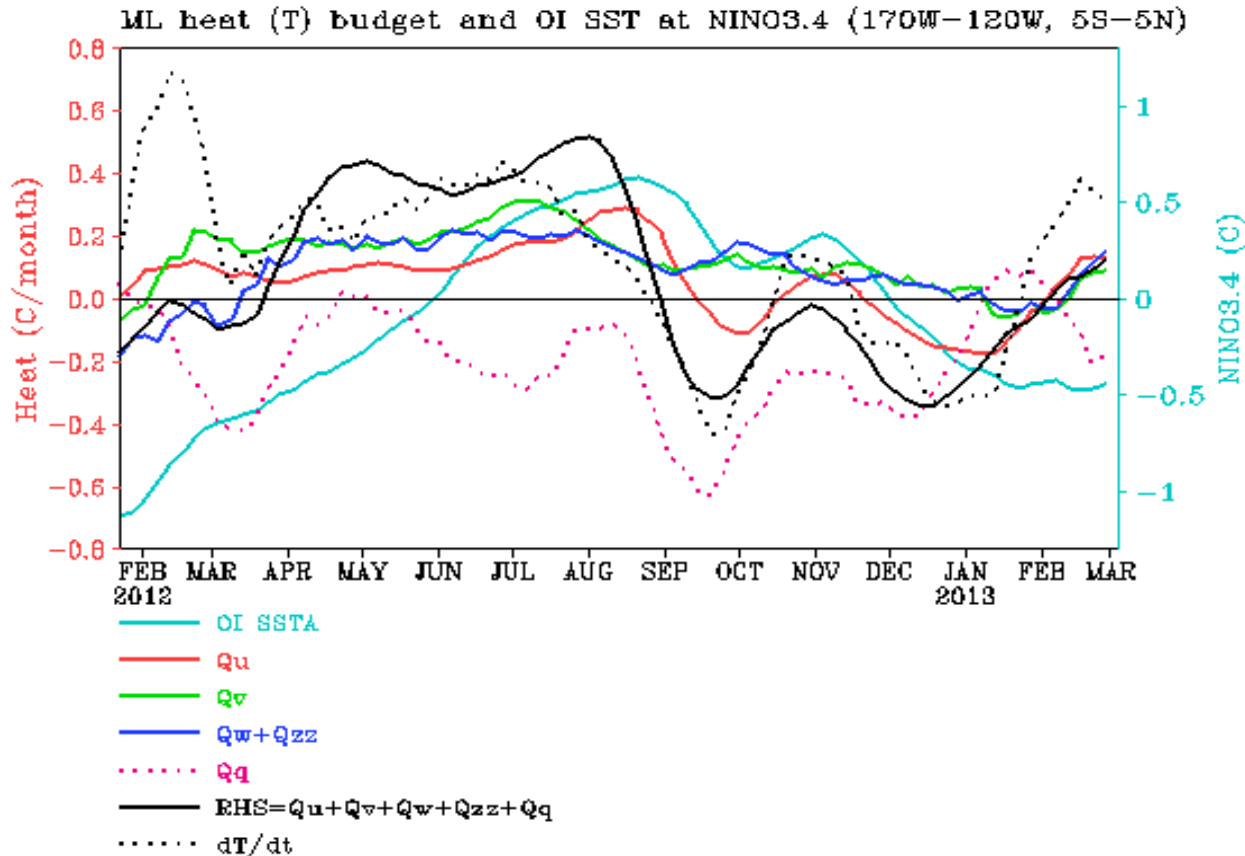
EOF1: Tilt mode (ENSO peak phase);
EOF2: WWV mode, Recharge/discharge oscillation (ENSO transition phase).

Recharge process: heat transport from outside of equator to equator -> La Nina

Discharge process: heat transport from equator to outside of equator -> El Niño

For details, see:
 Kumar, A. and Z.-Z. Hu, 2013: Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. *Clim. Dyn.* DOI: 10.1007/s00382-013-1721-0 (in press).

NINO3.4 Heat Budget



- SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was positive since Feb 2013, indicating a warming tendency in NINO3.4.

- The warming tendency was due to dynamical processes (Q_u , Q_v , Q_w+Q_{zz}).

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.

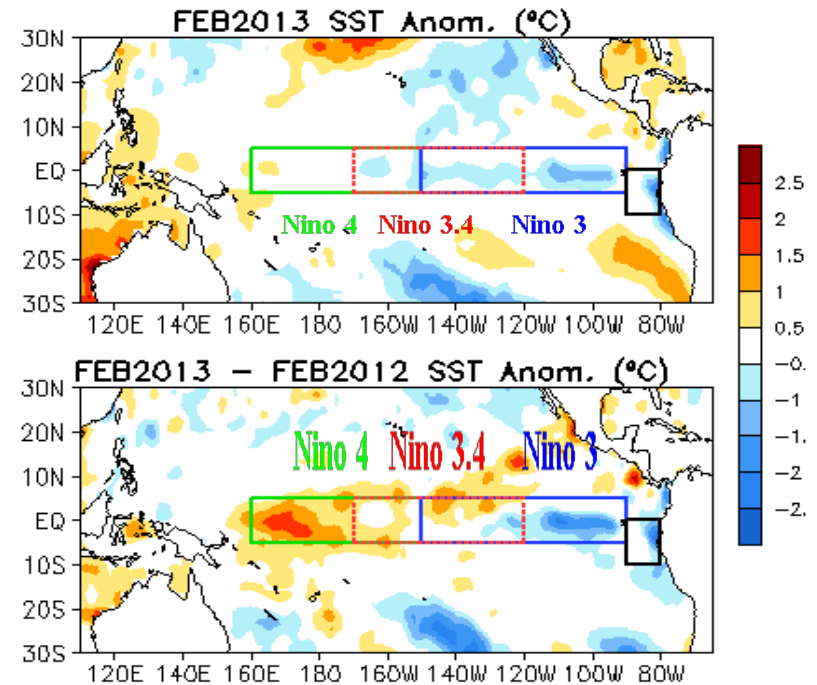
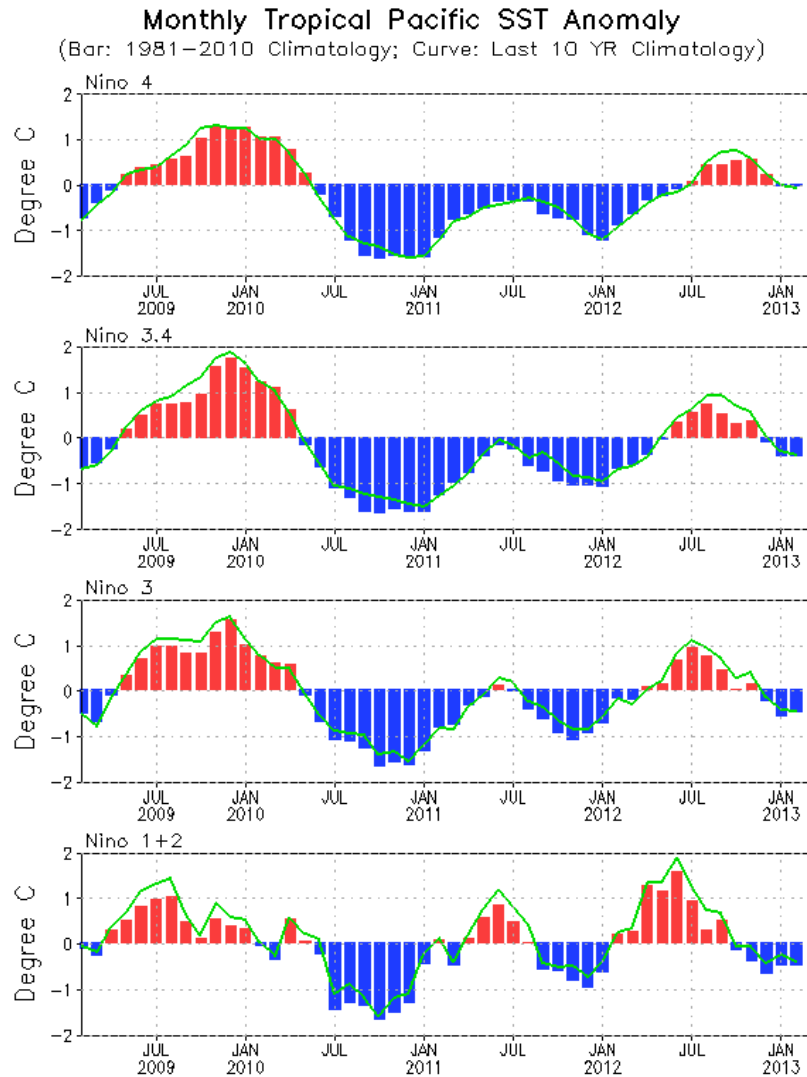
Q_u : Zonal advection; Q_v : Meridional advection;

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

Evolution of Pacific NINO SST Indices



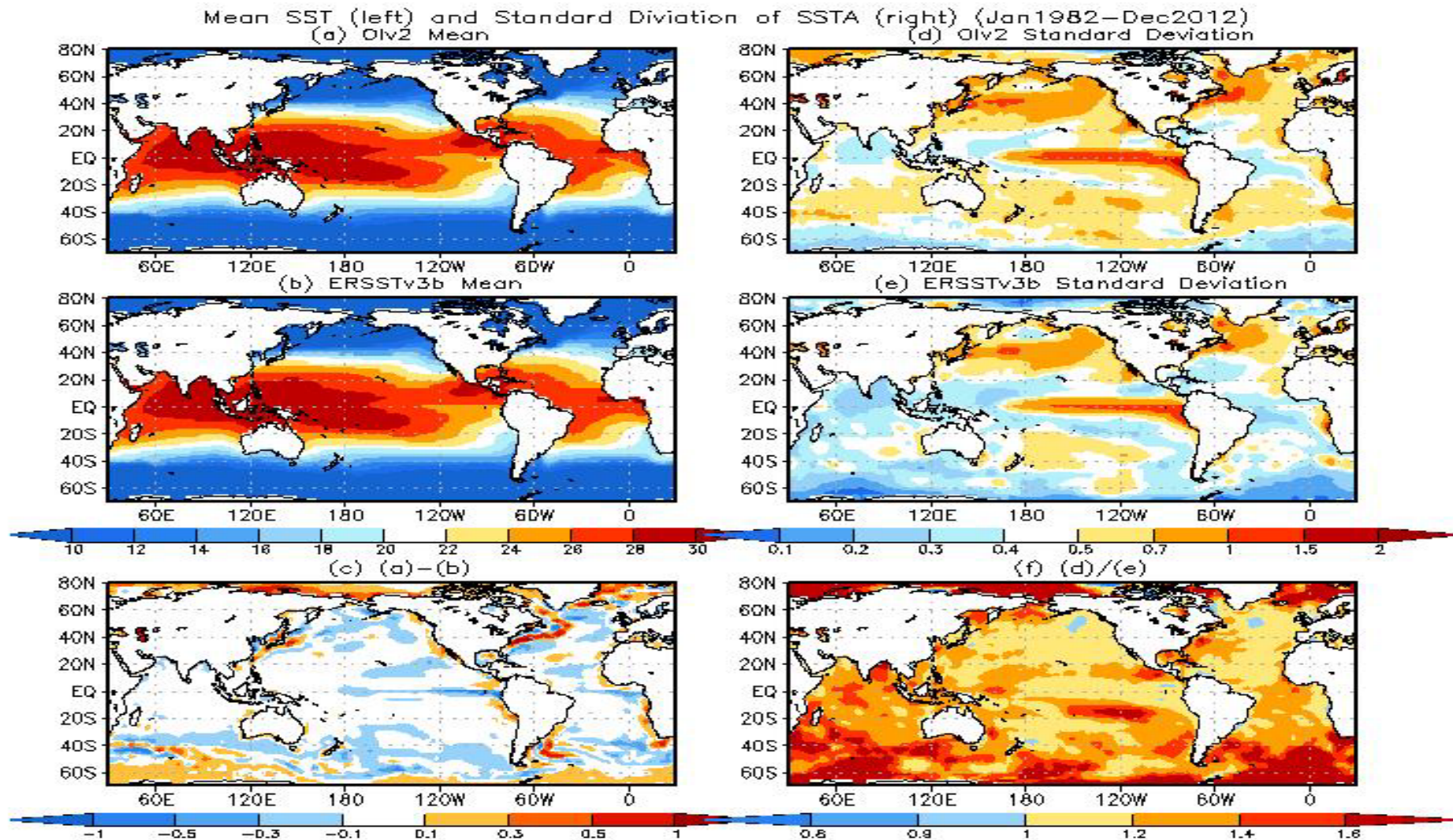
- All Nino indices were below or near-normal with NINO3.4 = -0.4°C.
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b (see next slides).

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 (bar) and last ten year (green line) means.

Mean difference: OIv2 SST is slightly cooler and has larger variability than ERSSTv3.

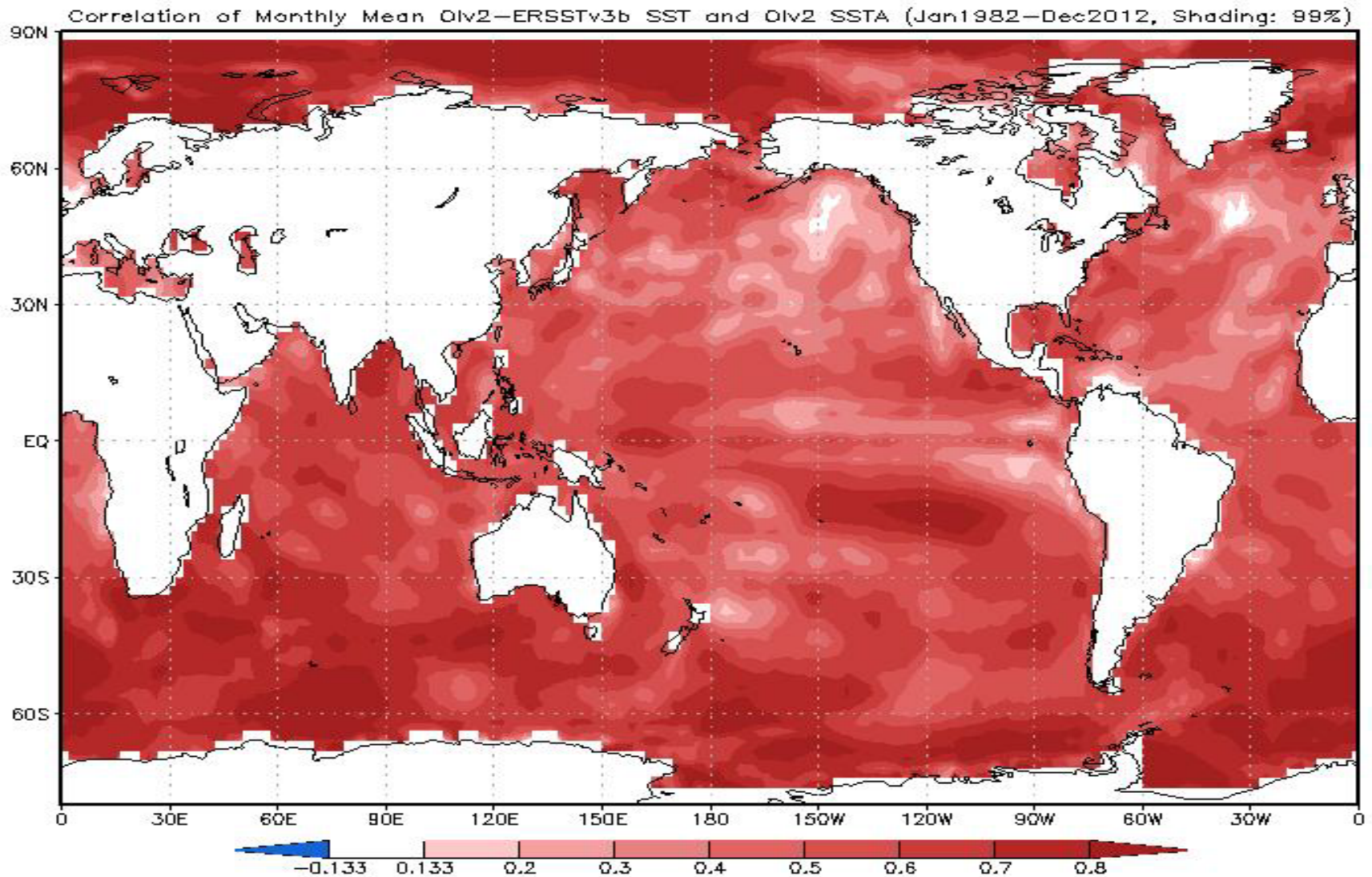
Large differences along Gulfstream extension and Kuroshio current, equatorial Pacific and SH high latitudes.

The standard deviation differences are especially large in the regions having large mean differences. In South Ocean, OIv2 standard deviation is larger than ERSSTv3b by 40% in some regions.




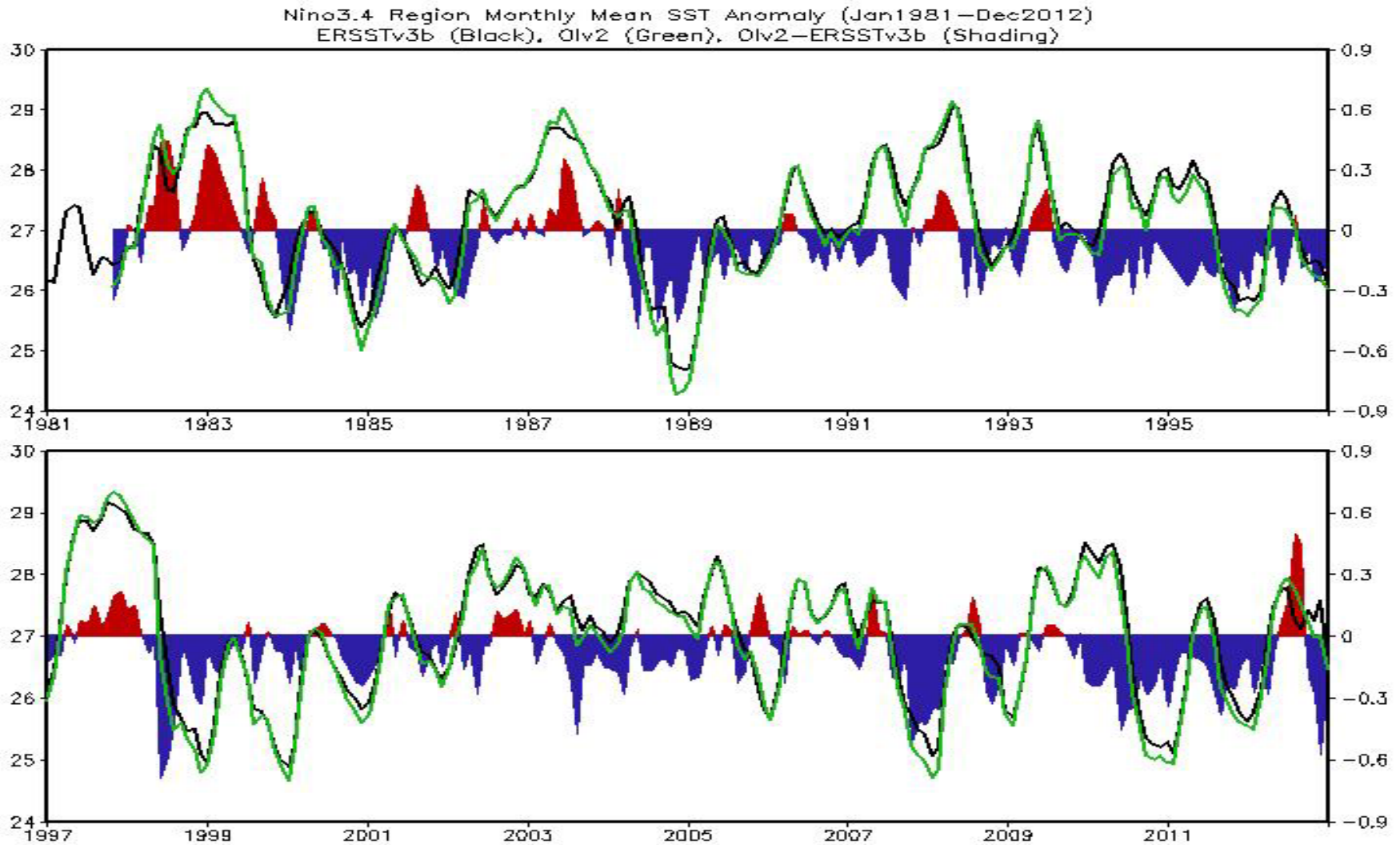
Correlation between OIv2-ERSSTv3b SST and OIv2 SSTA:

- (a) All positive suggests that OIv2 SSTA amplitude is larger than that of ERSSTv3 everywhere.
- (b) Correlations are larger in high latitudes, and relatively smaller in mid-latitudes of N Pacific and N. Atlantic.
- (c) Correlations are relatively larger along the equator than to its north/south sides.



Nino3.4: Olv2-ERSSTv3b SST (shading) and Olv2/ERSSTv3b SSTA (curves) (unit: °C)

Large positive/negative Olv2-ERSSTv3b SST (shading) corresponding to large positive/negative Olv2 or ERSSTv3b SSTA (curves)  Olv2 variability is larger than ERSSTv3 variability



SST differences between OI and ERSSTv3b:

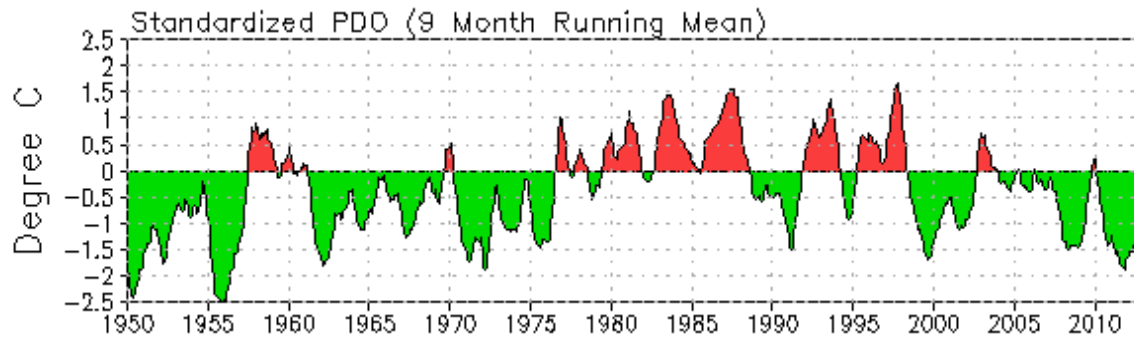
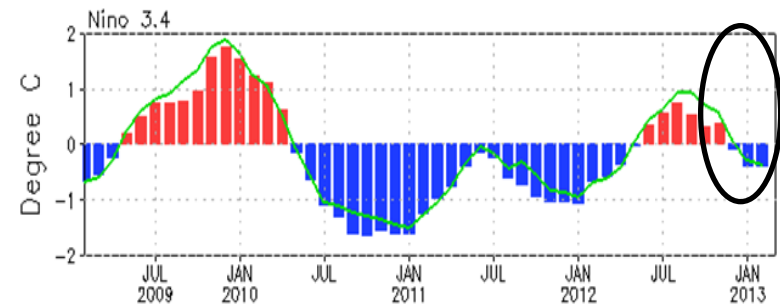
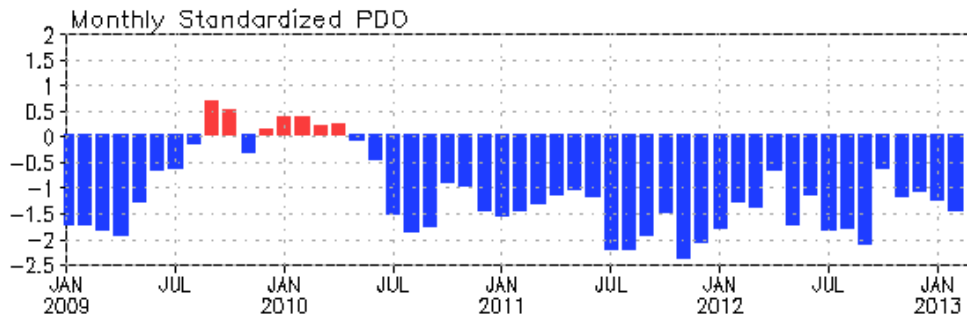
Jan1982-Dec2012

OIv2 is slightly cooler and has higher variability than ERSSTv3

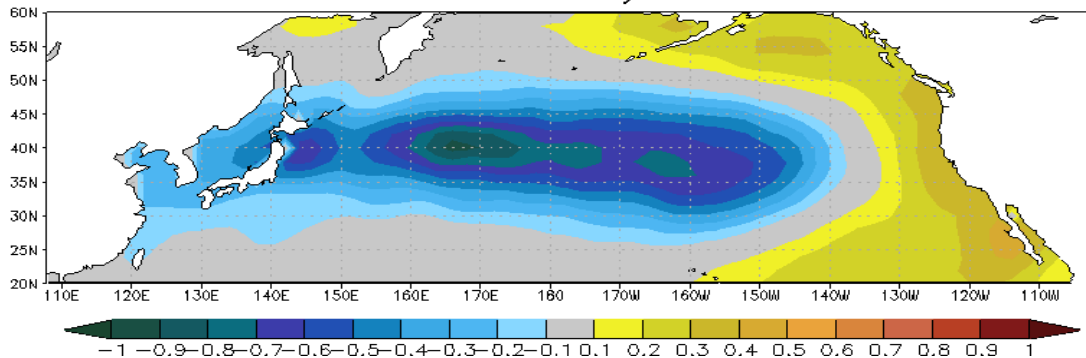
	OIv2	ERSSTv3b	OIv2-ERSSTv3b (OIv2/ERSSTv3b)
30°S-30°N Mean	26.17	26.20	-0.03
30°S-30°N Standard Deviation	0.160	0.156	102.5%
Nino3.4 Mean	27.02	27.11	-0.09
Nino3.4 Standard Deviation	0.956	0.878	108.9%

North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index



1st EOF of monthly ERSST v3b



- Negative PDO phase since May 2010 has persisted for 34 months now, and the PDO index strengthened slightly in Feb 2013 with PDO index = -1.5

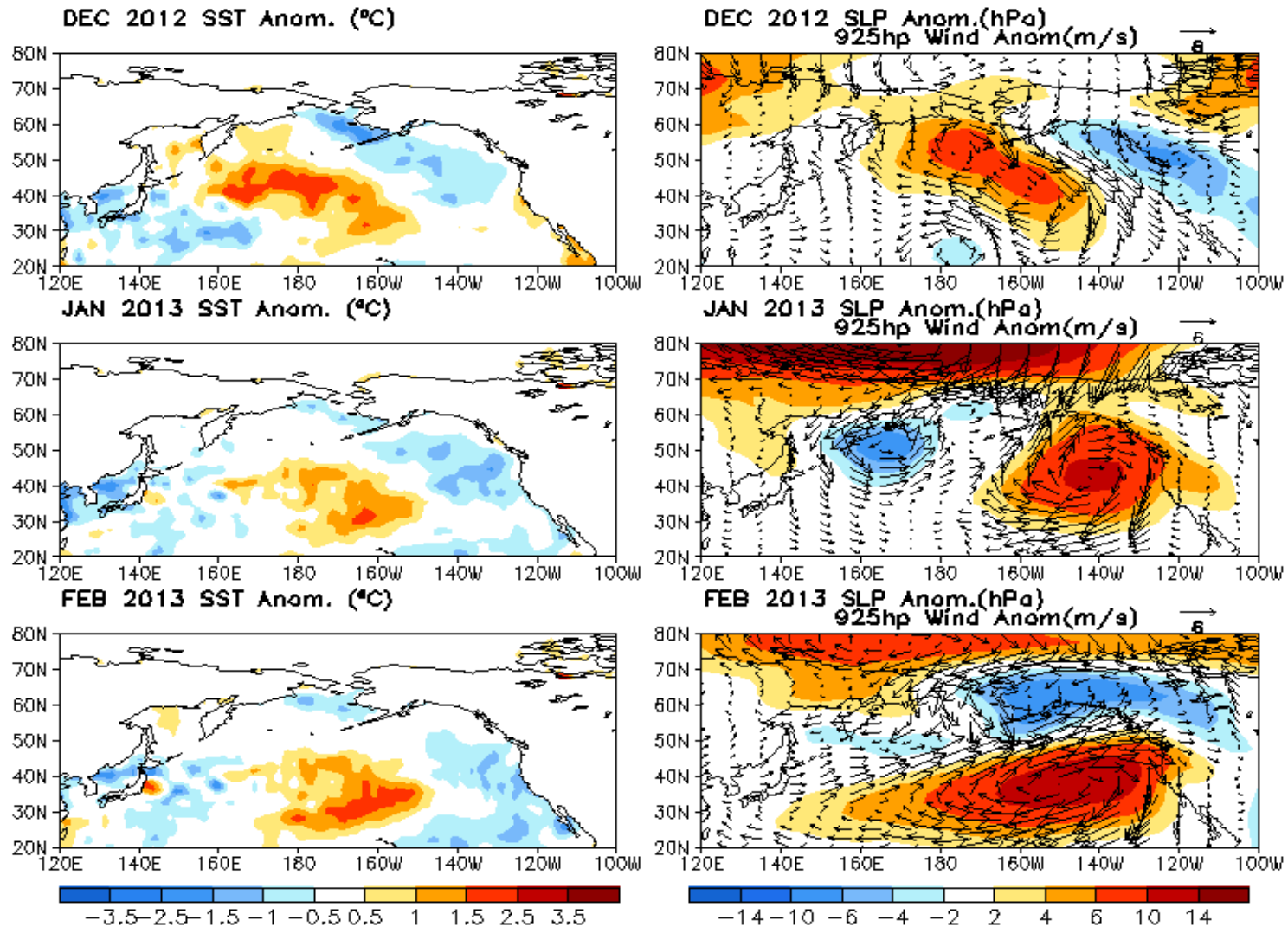
- The apparent connection between Nino3.4 and PDO indices suggest connections between tropics and extratropics.

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

- 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.

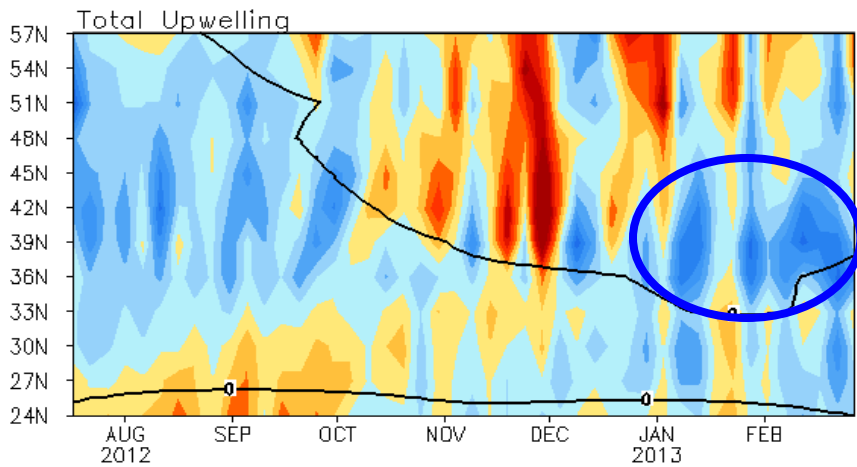
Last Three Month SST, SLP and 925hp Wind Anom.



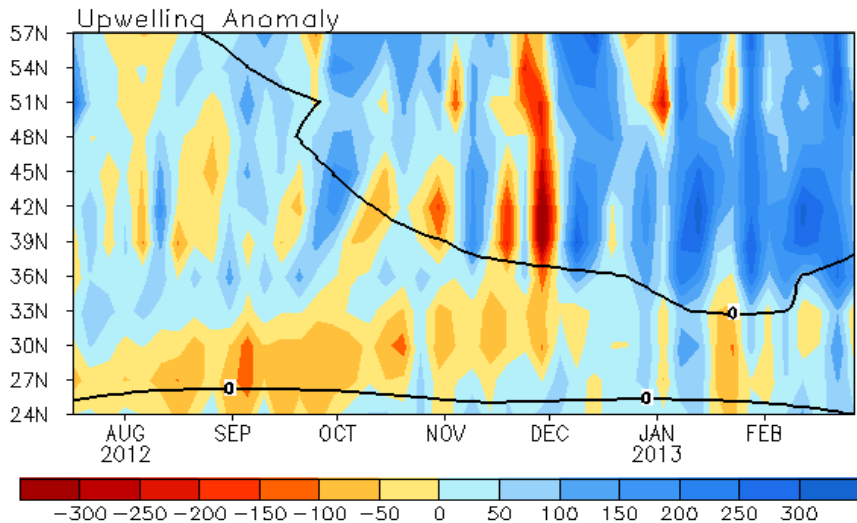
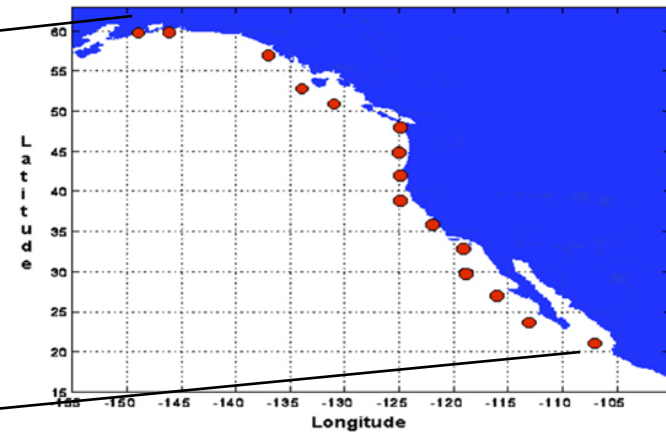
- Negative phase of PDO-like pattern persisted in the North Pacific.
- Anomalous anti-cyclone was observed in the northwest of N. Pacific.
- The northerly wind anomaly favors the anomalous upwelling along the Pacific coast.

North America Western Coastal Upwelling

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



Standard Positions of Upwelling Index Calculations



- Consisted with the anomalous northerly wind, downwelling in 36-45N was suppressed.

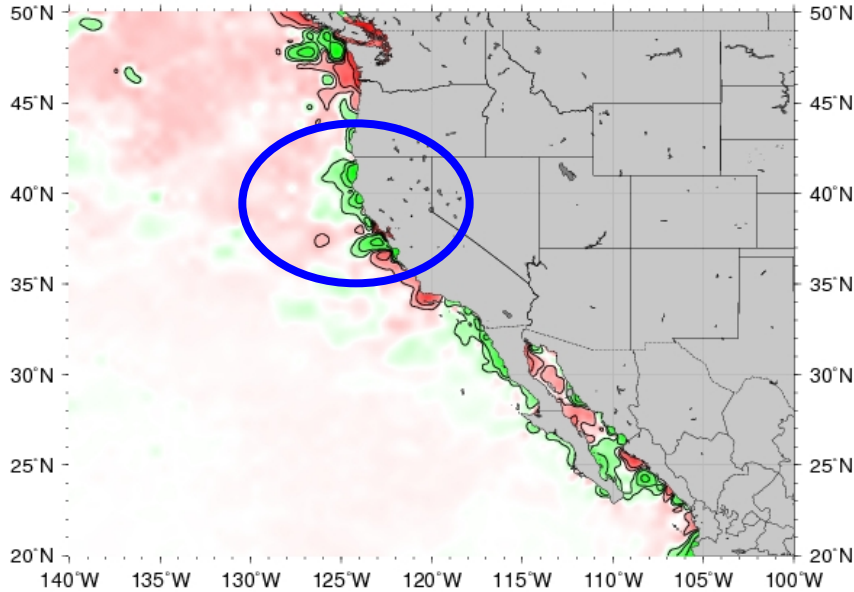
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

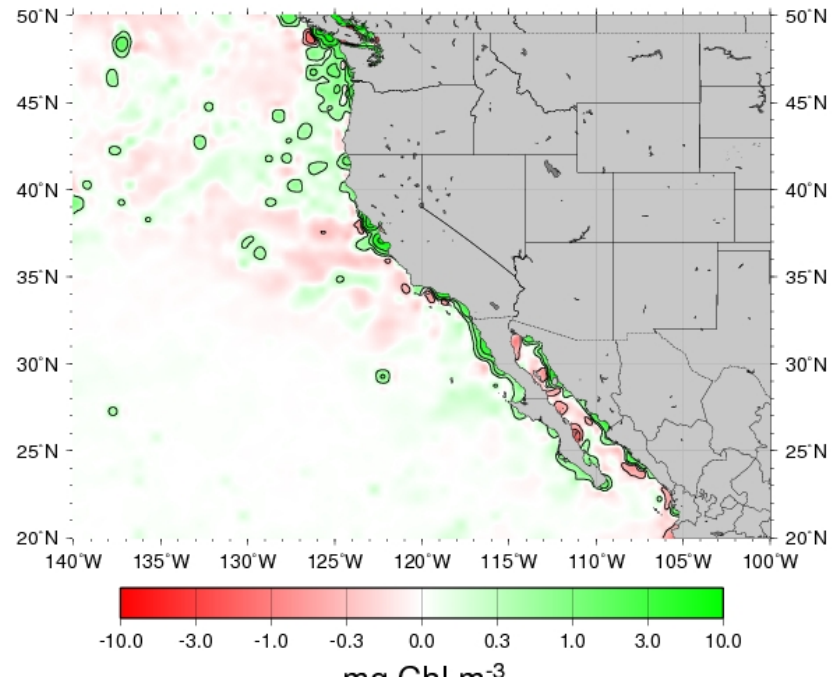
<http://coastwatch.pfel.noaa.gov/FAST>

MODIS Aqua Chlorophyll a Anomaly for February, 2013



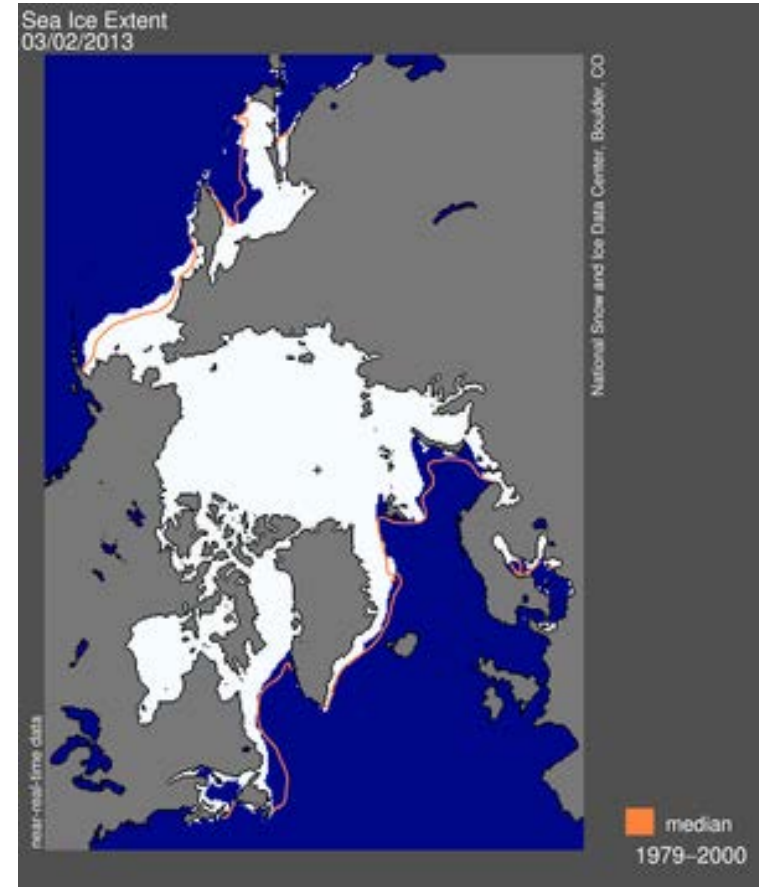
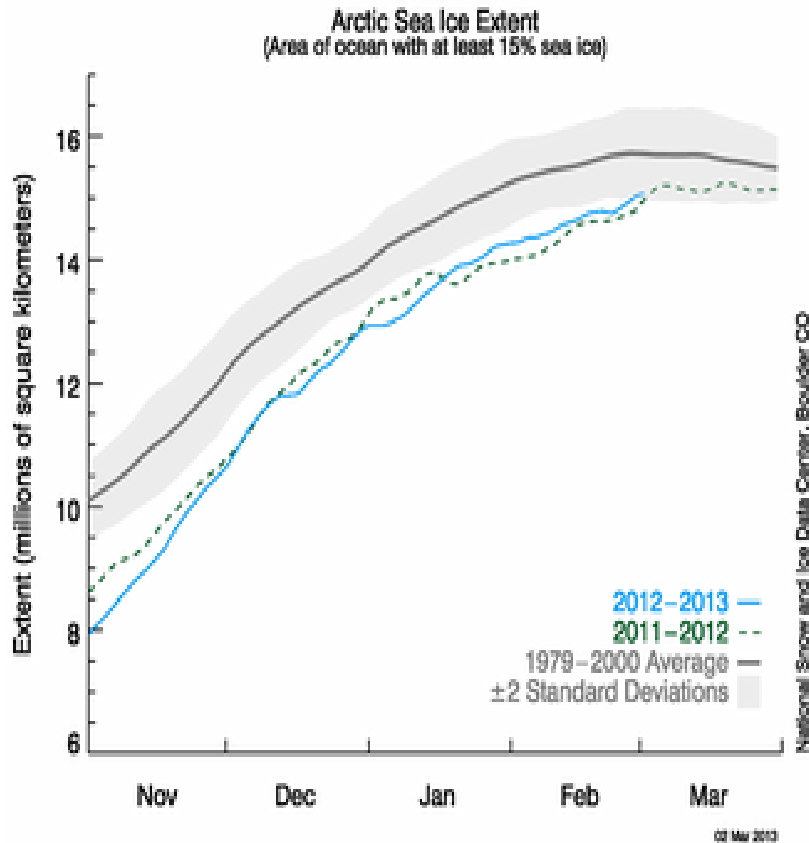
- Positive chlorophyll anomaly in 35-45N increased in Feb 2013, consistent with suppressed downwelling.

MODIS Aqua Chlorophyll a Anomaly for January, 2013



Arctic Sea Ice

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



- Average sea ice extent for Feb 2013 was well below-normal and similar to Feb 2012.
- This is probably partially due to the impact of negative phase of NAO.

Indian Ocean

Evolution of Indian Ocean SST Indices

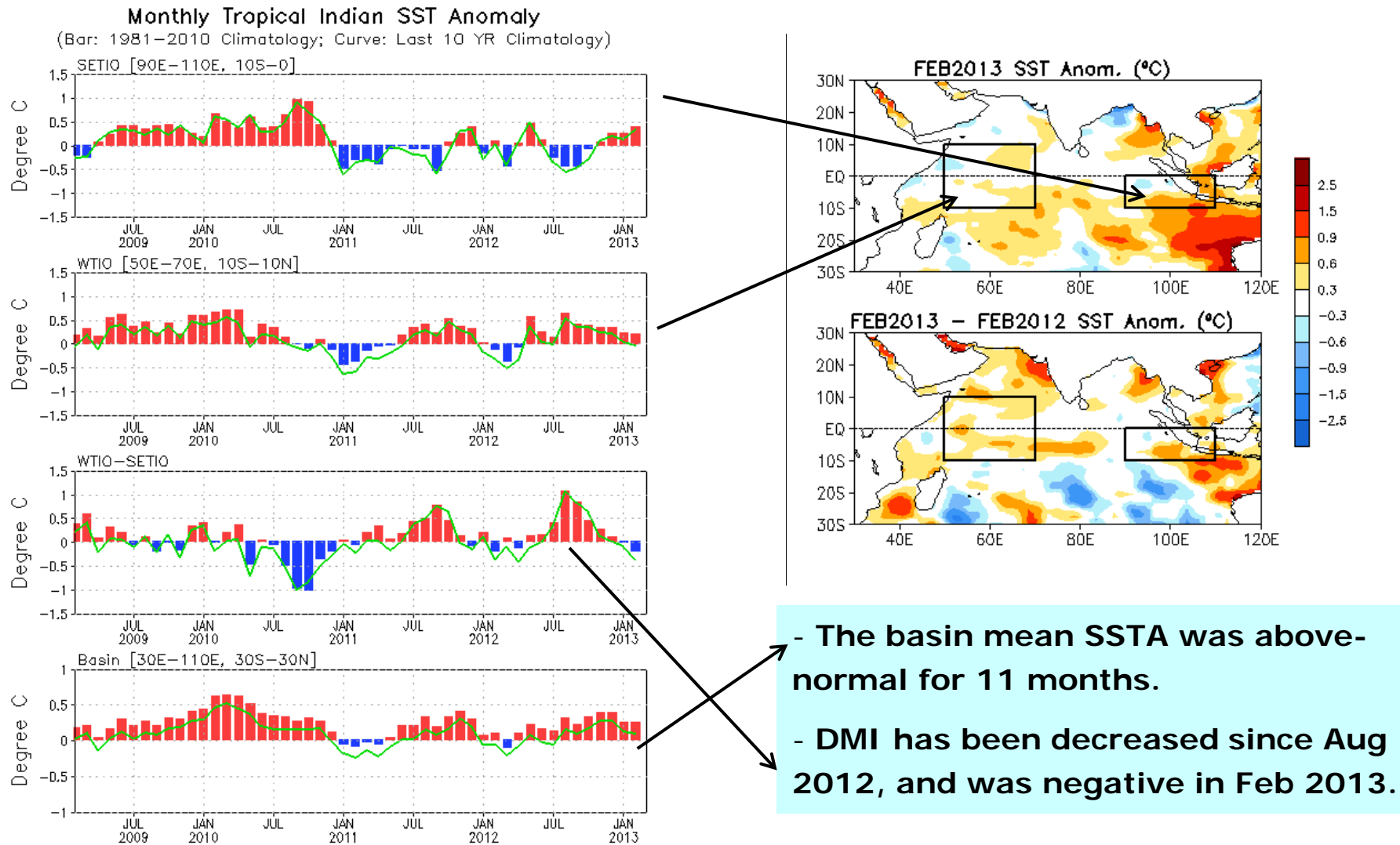
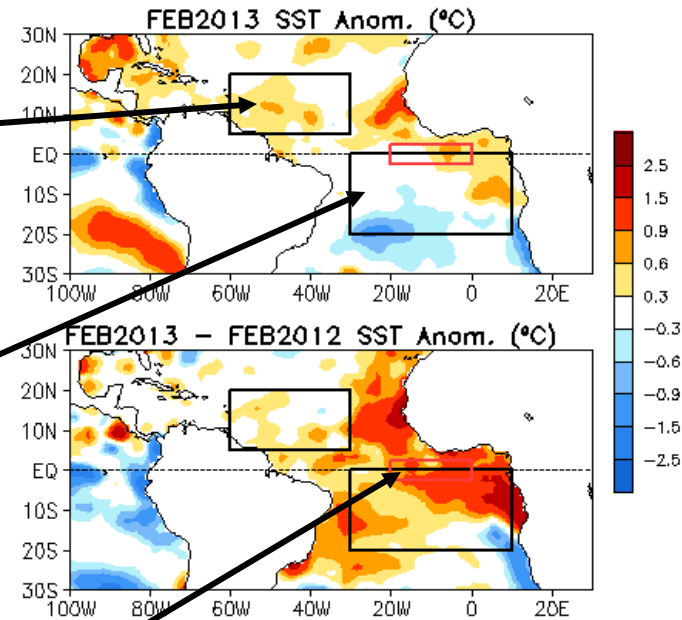
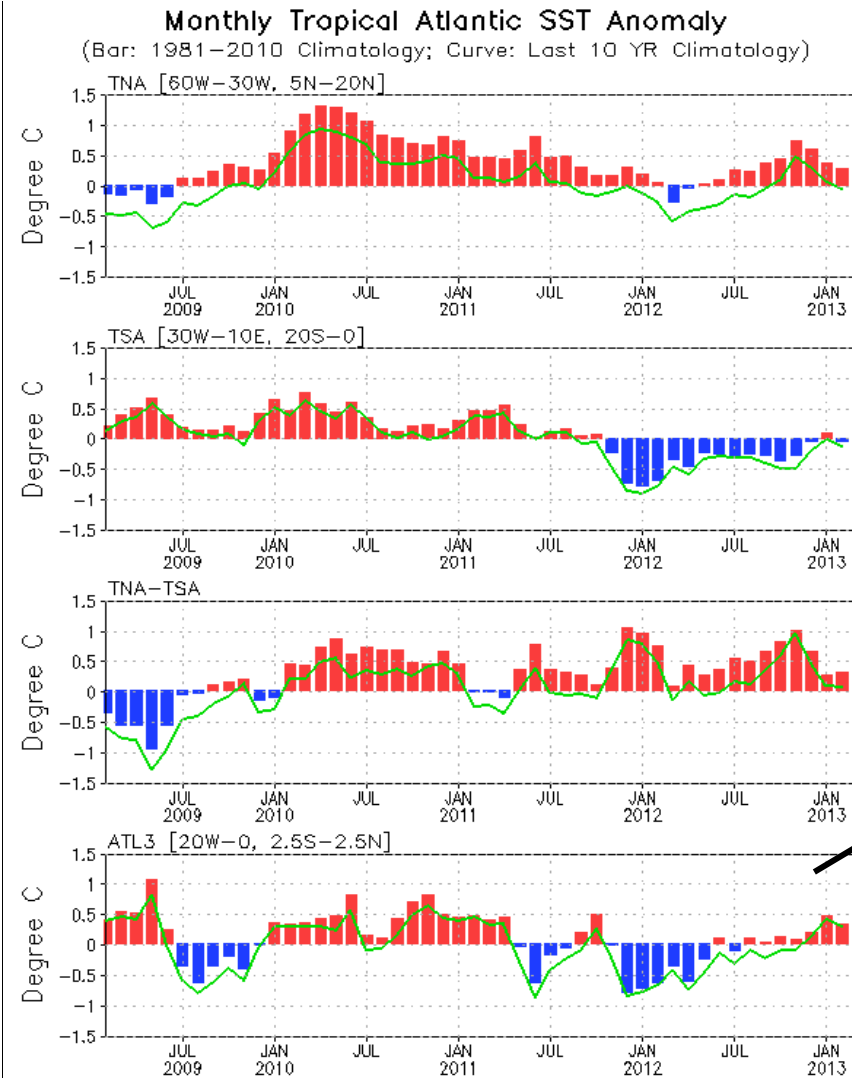


Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E–110°E, 10°S–0] and WTIO [50°E–70°E, 10°S–10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and departures from the 1981–2010 base period means and the recent 10 year means are shown in bars and green lines.

Tropical and North Atlantic Ocean

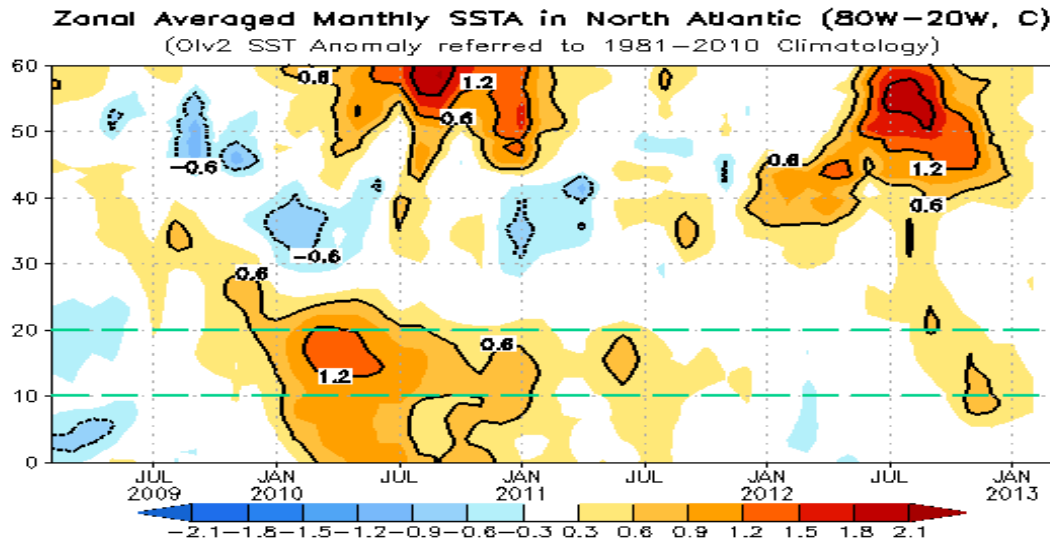
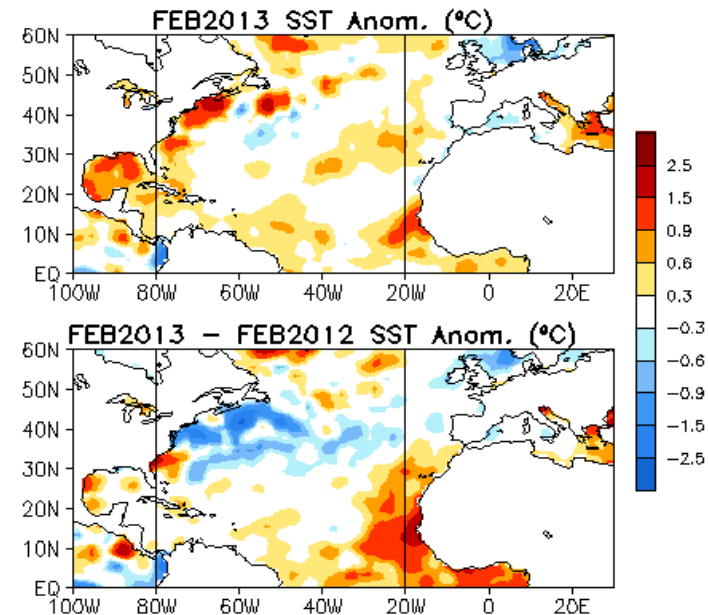
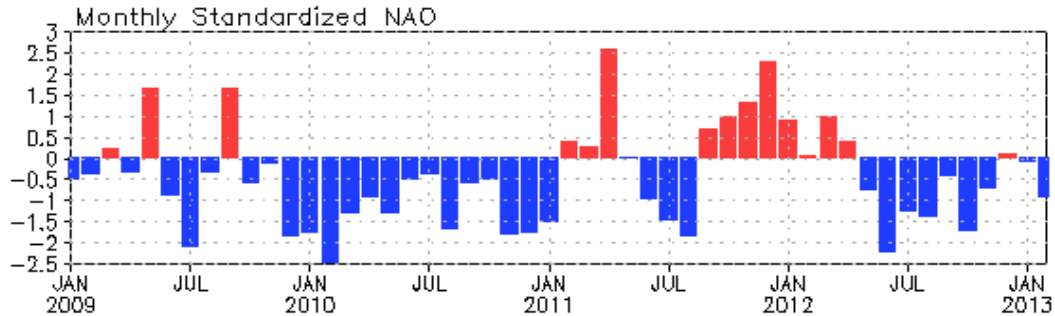
Evolution of Tropical Atlantic SST Indices



- SSTA in the tropical North Atlantic (TNA) has been above-normal since May 2012, and weakened since Nov 2012.
- Meridional Gradient Mode index (TNA-TSA) was positive for 22 months (since May 2011).
- ATL3 SSTA was above- or near-normal since Aug 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.

NAO and SST Anomaly in North Atlantic

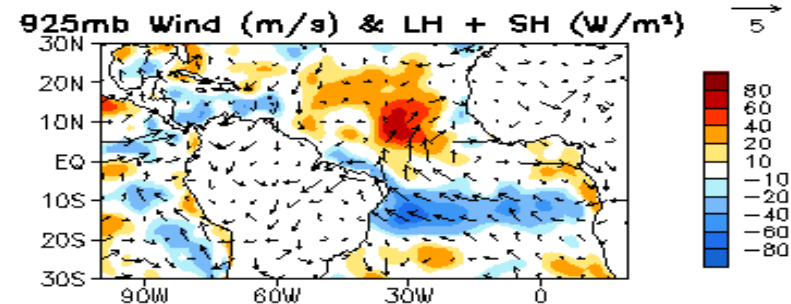
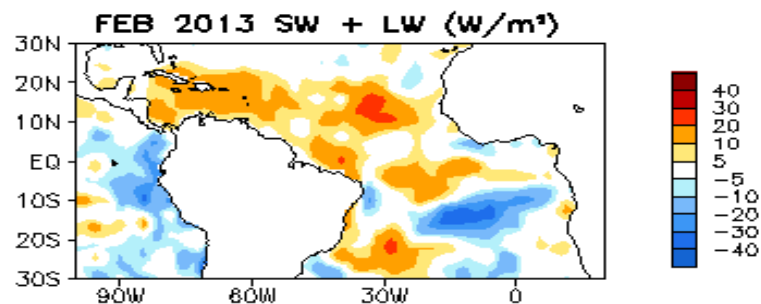
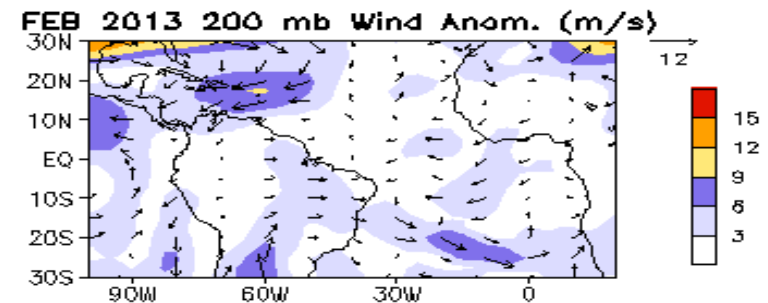
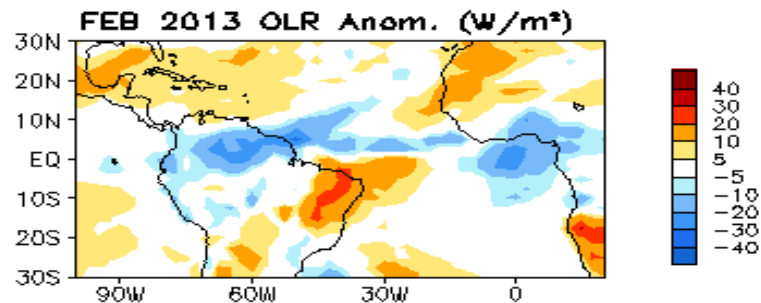
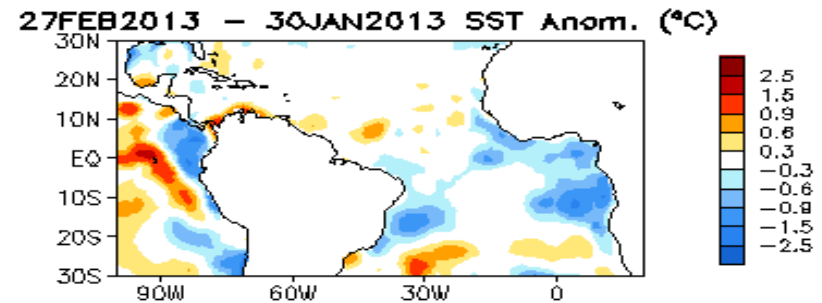
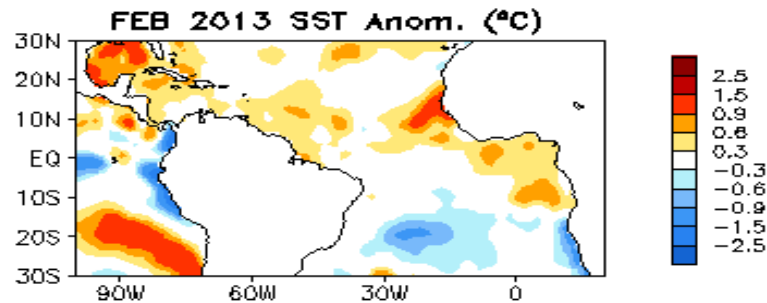


- Strong positive SSTA in high-latitude N. Atlantic has been weakened significantly in past 2 months.
- Negative phase of NAO strengthened with NAO index = -0.96 in Feb 2013.
- The SSTA evolution was generally related to NAO index: negative NAO leads to SST warming and positive NAO leads to SST cooling in high latitudes and tropics.

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.

Tropical Atlantic:

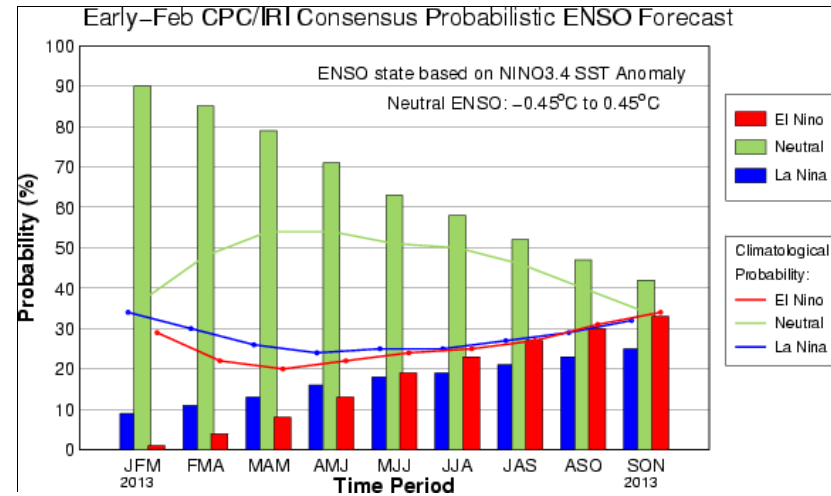
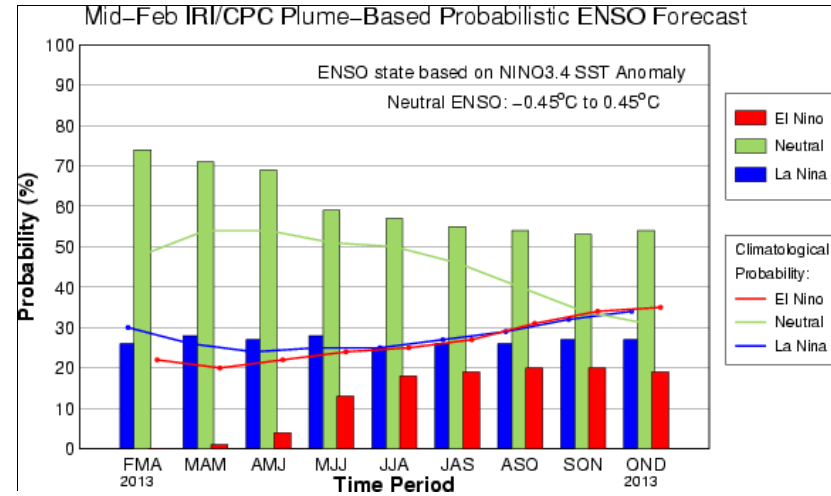
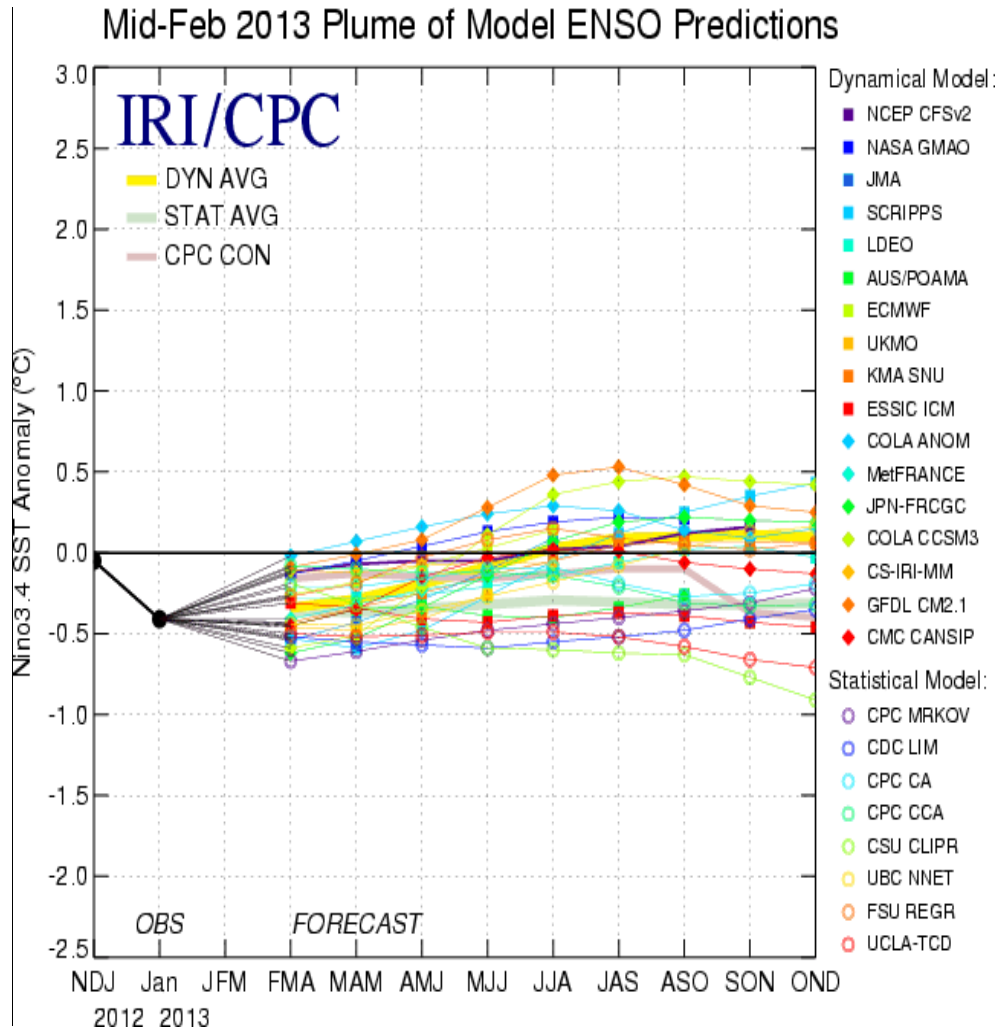
SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb/200-mb Winds



- Above-normal SSTA and small tendency presented in the tropical N. Atlantic
- Convection was enhanced (suppressed) along the equator (in the tropical North Atlantic).

Global SST Predictions

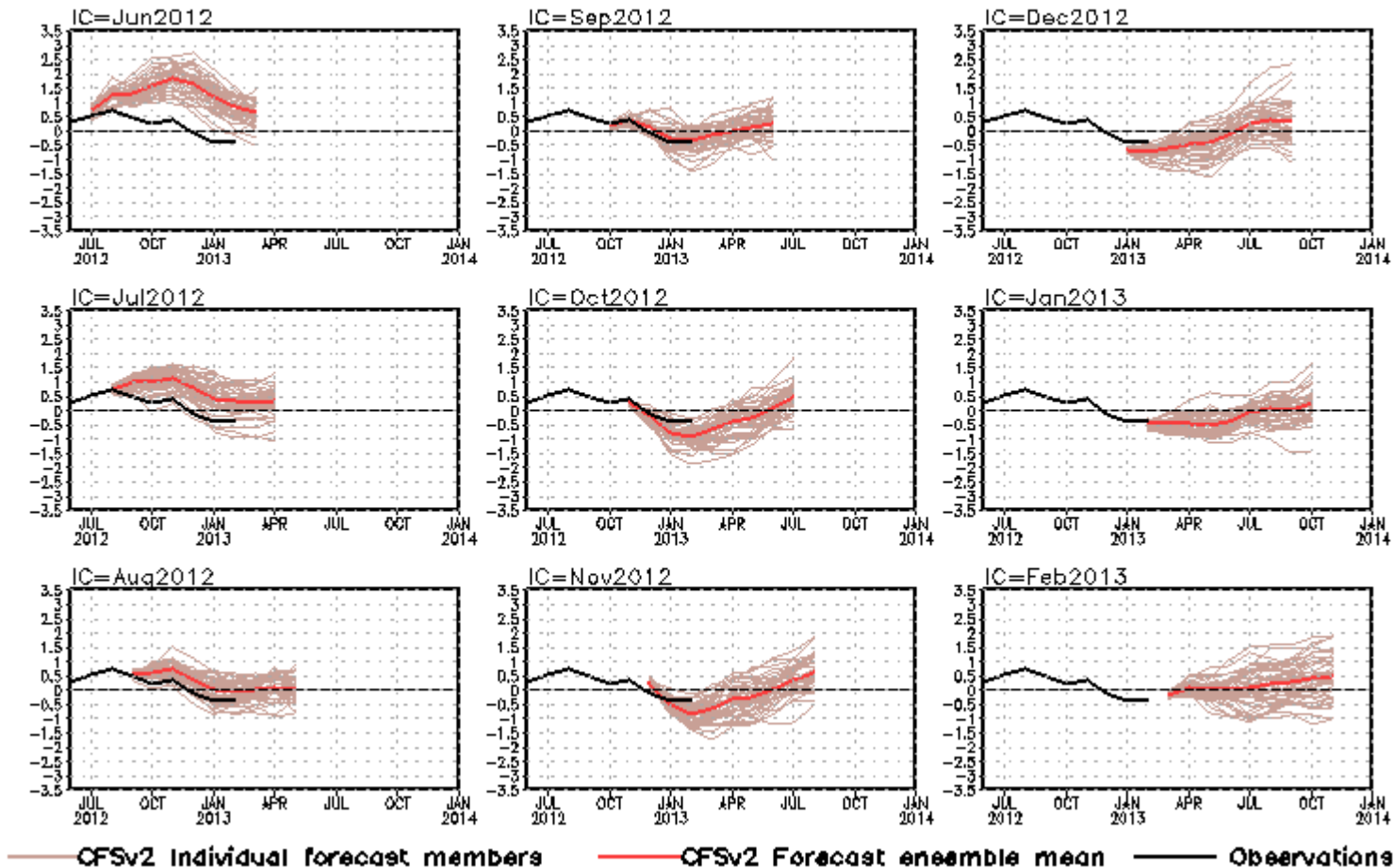
IRI/CPC NINO3.4 Forecast Plume



- Majority of the models predicted ENSO-neutral in the coming NH spring-autumn.
- NOAA officially forecast ENSO-neutral conditions in the coming spring-summer.

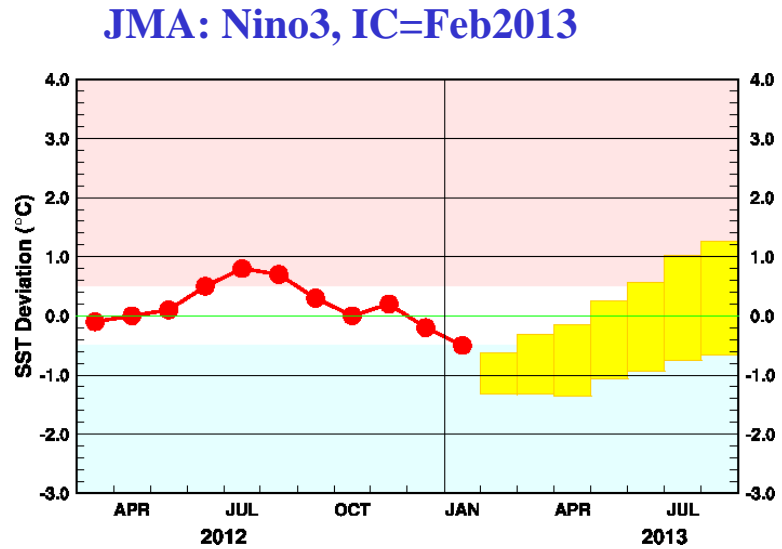
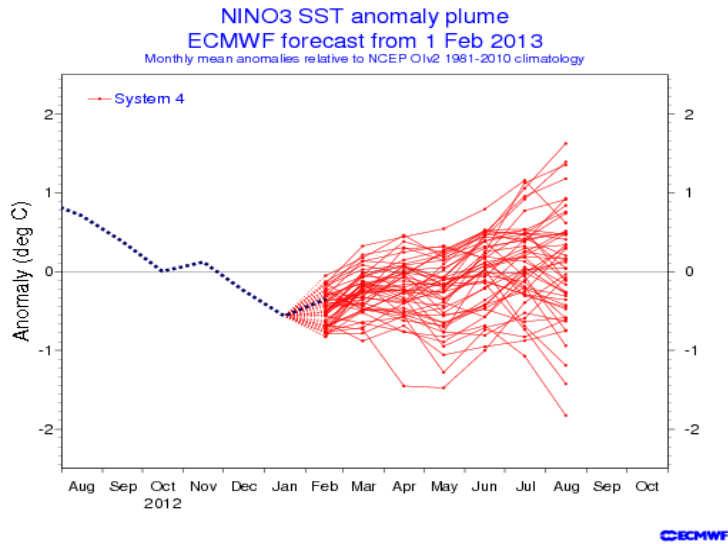
NCEP CFSv2 NINO3.4 Forecast

NINO3.4 SST anomalies (K)

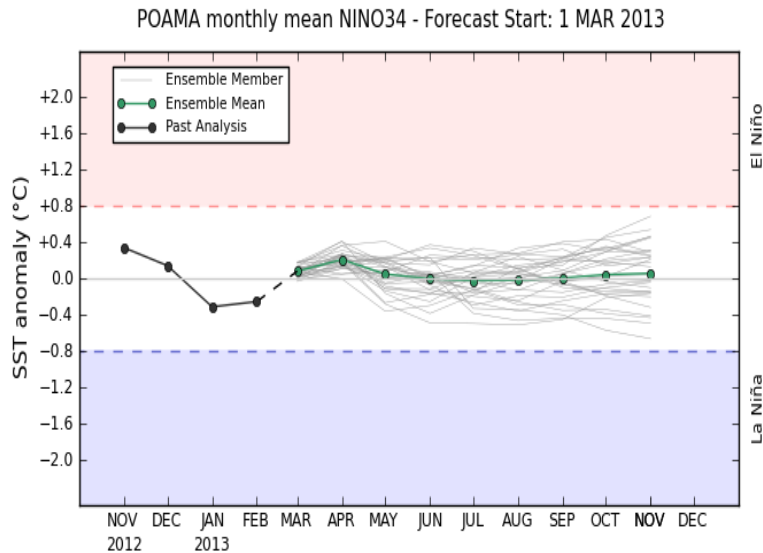


- CFSv2 predictions had large warm biases with IC in Jun-Aug 2012; some cold biases with IC in Oct-Dec 2012.
- Latest forecast suggests that neutral condition continues in the NH spring-autumn 2013.

Individual Model Forecasts: Slightly warming tendency

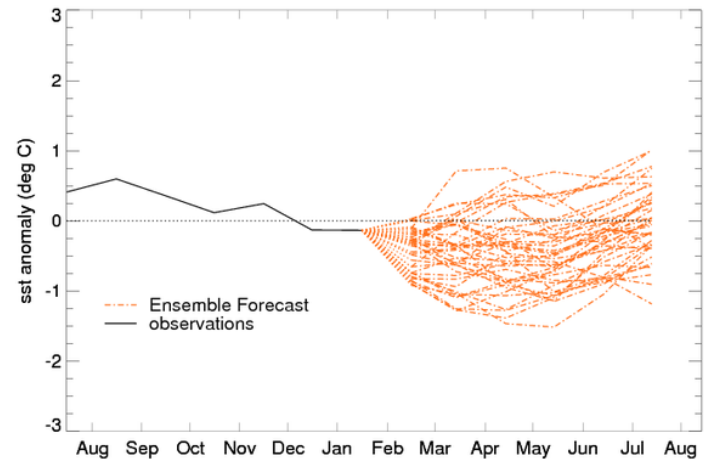


Australia: Nino3.4, IC=01Mar2013

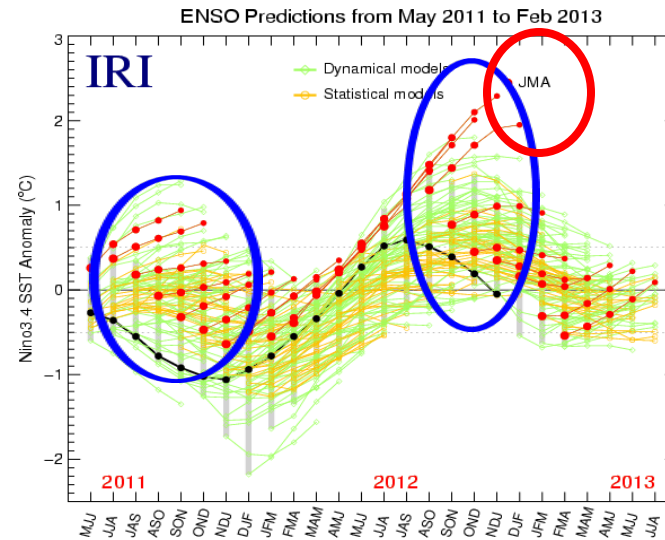
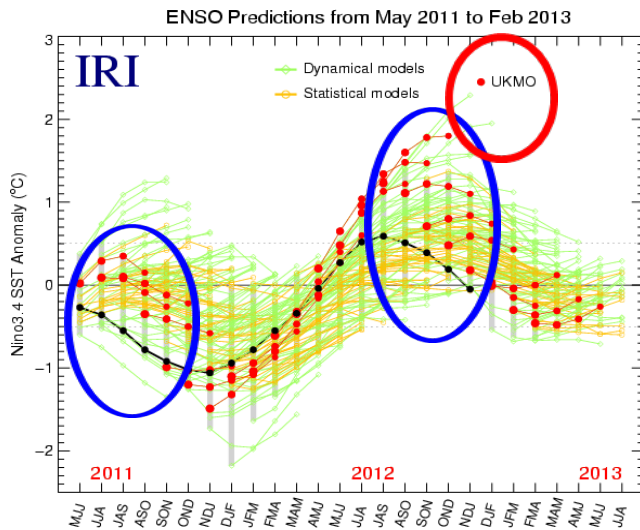
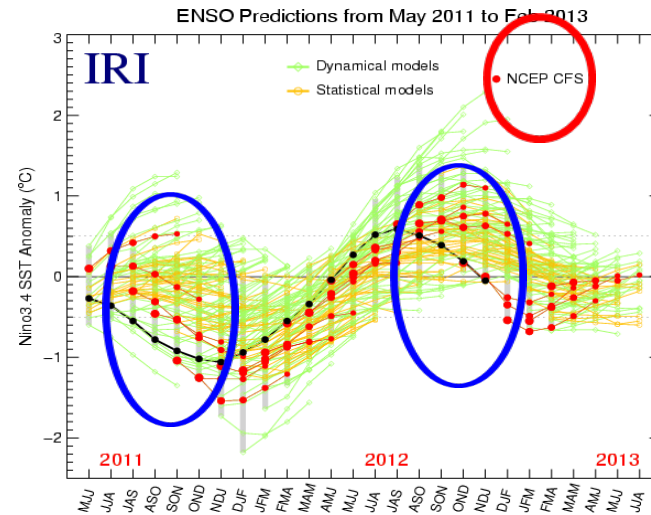
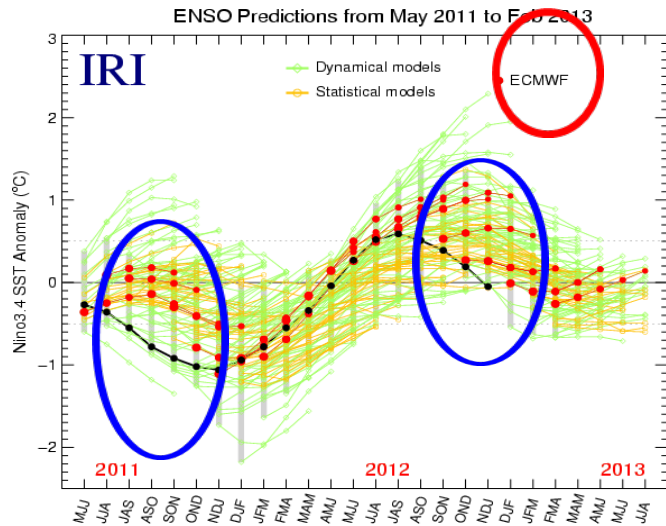


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UKMO: Nino3.4, IC=Feb2013

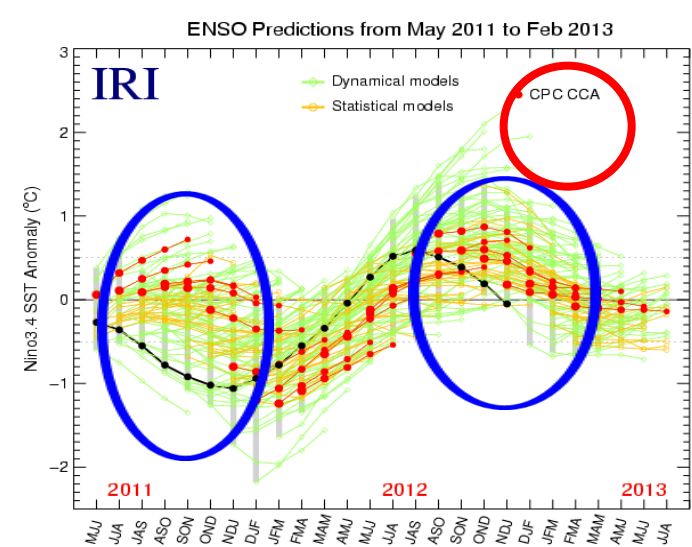
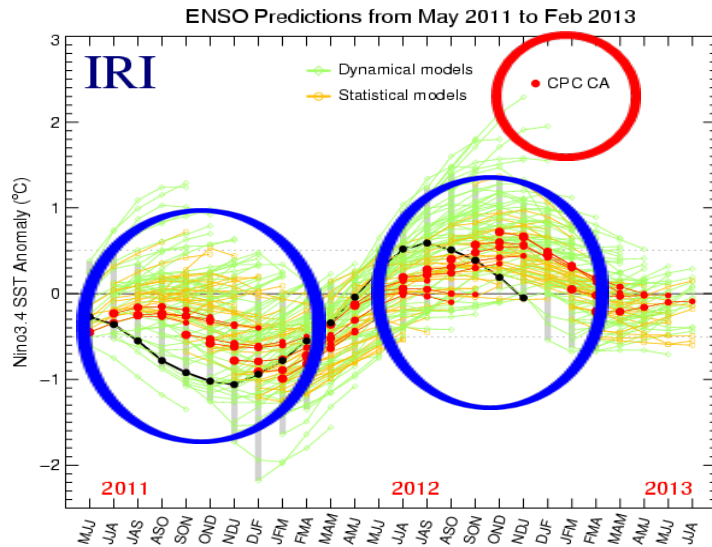
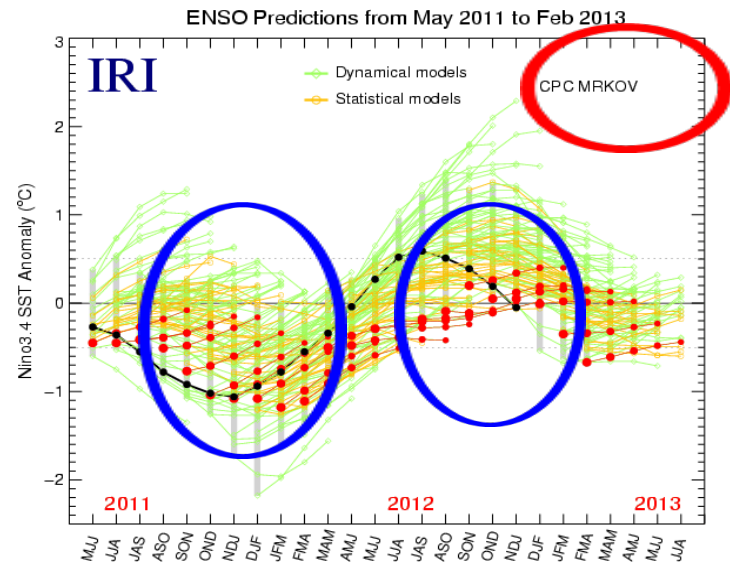
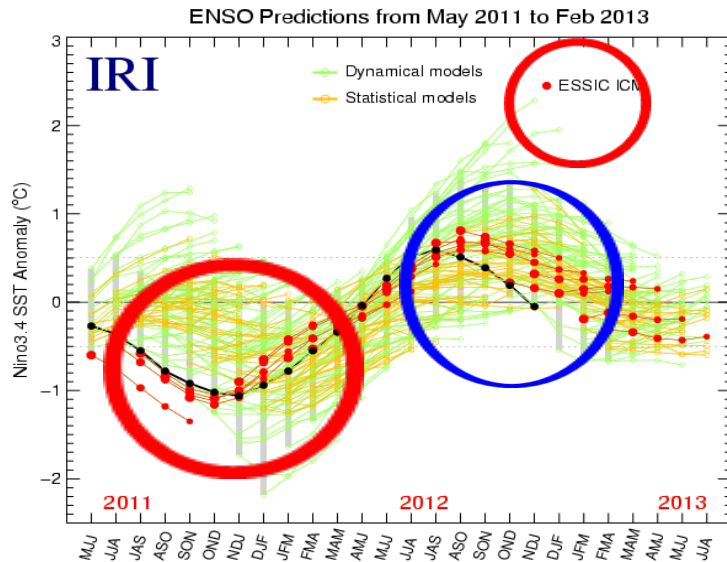


Some Model Forecasts over Last 22 Months



- Models face challenges to predict ENSO cycle in the last 2 years.
- Is this due to the observational data (TAO...) missing?

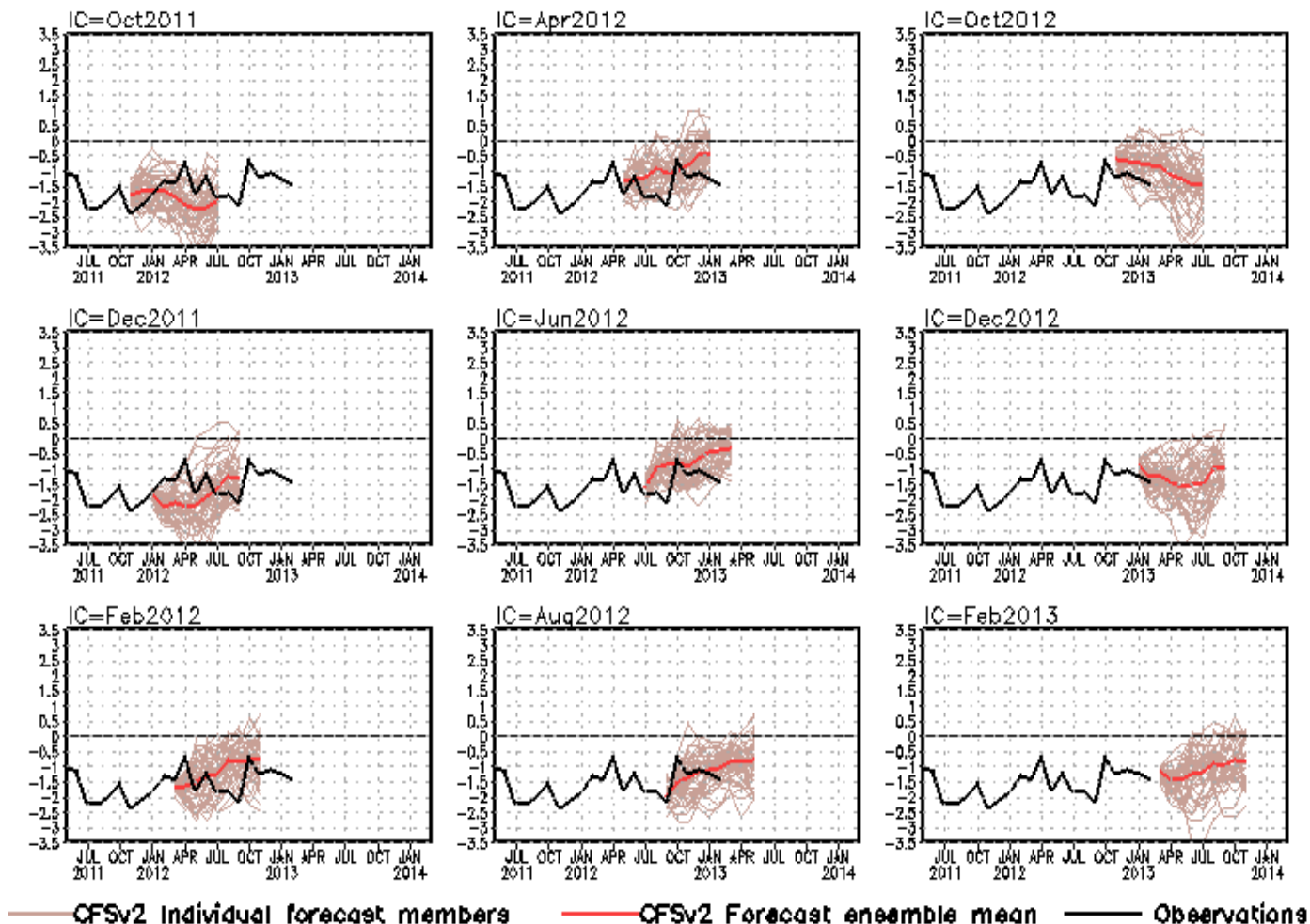
Some Model Forecasts over Last 22 Months



- Models face challenges to predict ENSO cycle in the last 2 years.
- Is this due to the observational data (TAO...) missing?

NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

standardized PDO index



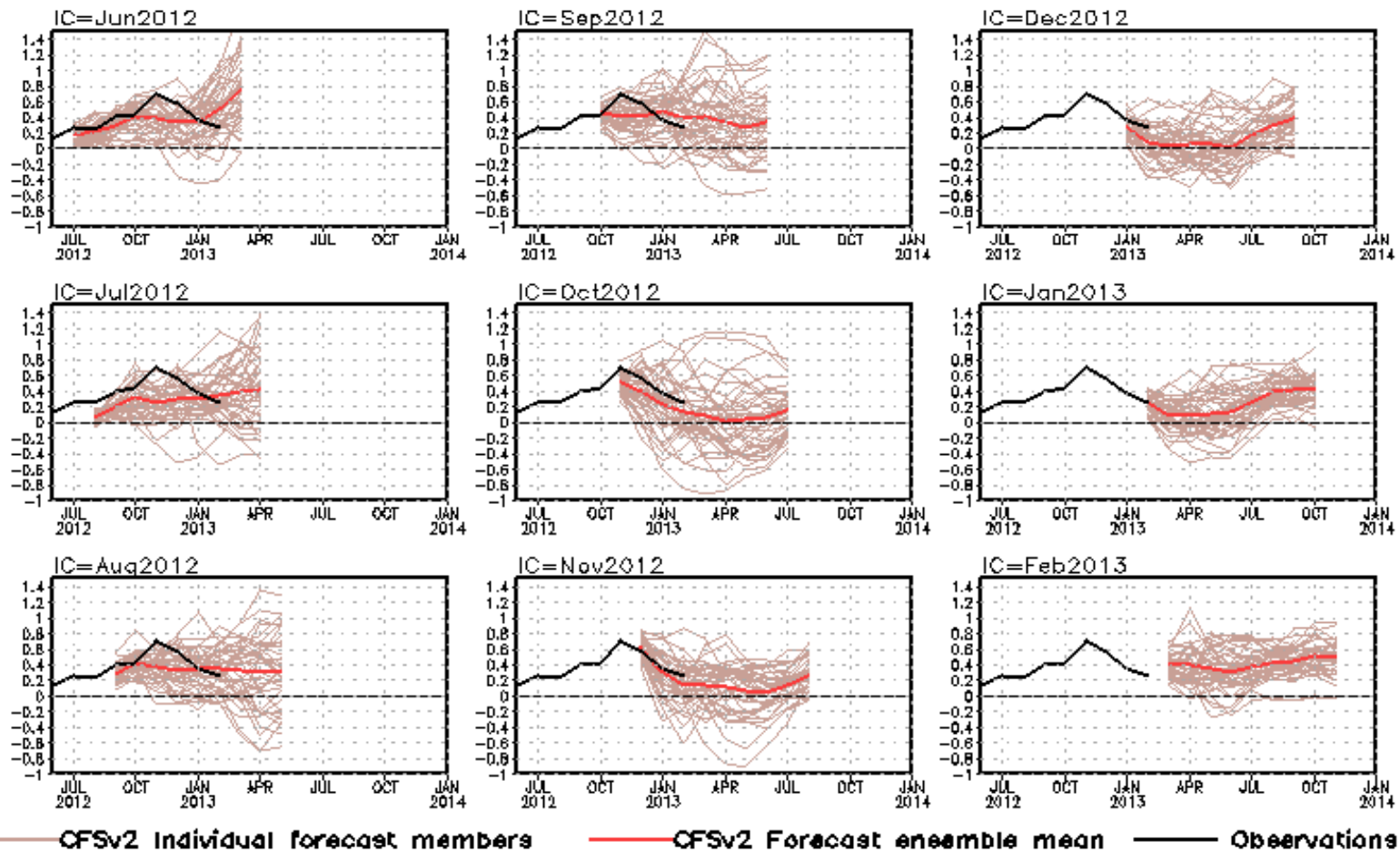
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- Latest CFSv2 prediction suggests that negative phase of PDO will continue in spring-automn 2013.

NCEP CFSv2 Tropical North Atlantic SST Forecast

Tropical N. Atlantic SST anomalies (K)



- Latest CFSv2 prediction suggests that above-normal SST in the tropical North Atlantic will continue in spring-autumn 2013 (hurricane season).

Overview

▪ Pacific and Arctic Oceans

- ENSO-neutral condition continued during Feb 2013 with Nino3.4=-0.4C.
- NOAA officially forecast ENSO-neutral condition to continue in the Northern Hemisphere spring-summer 2013.
- Negative PDO phase slightly strengthened with PDO index =-1.5 in Feb 2013, and NCEP CFSv2 predicted negative phase of PDO would continue.
- Arctic sea ice extent in Feb 2013 was well below-normal and similar to that in Feb 2012.

▪ Indian Ocean

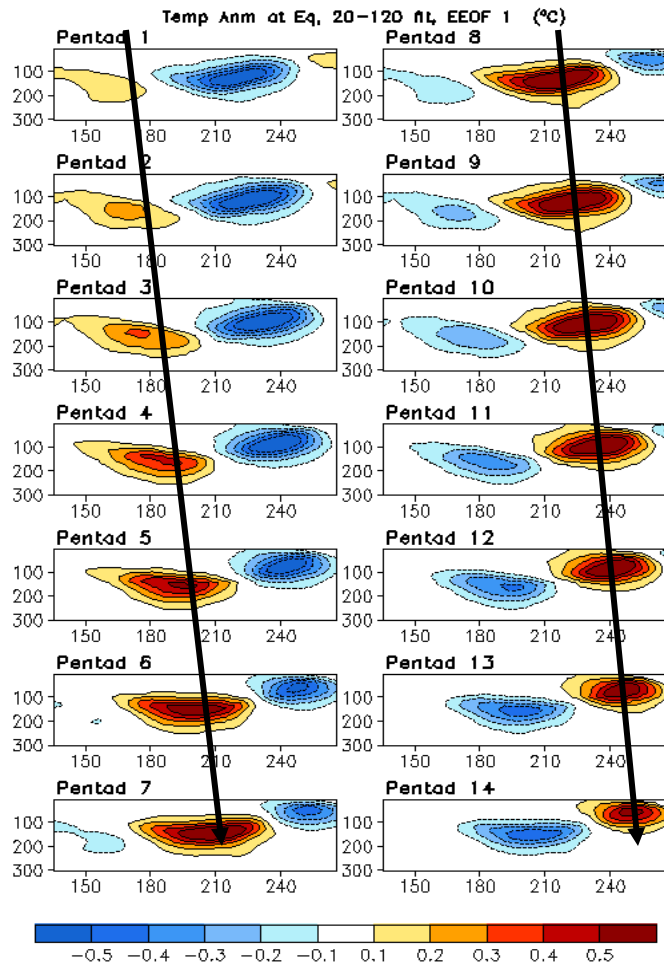
- SSTs in Indian Ocean were above or near-normal in Feb 2013.

▪ Atlantic Ocean

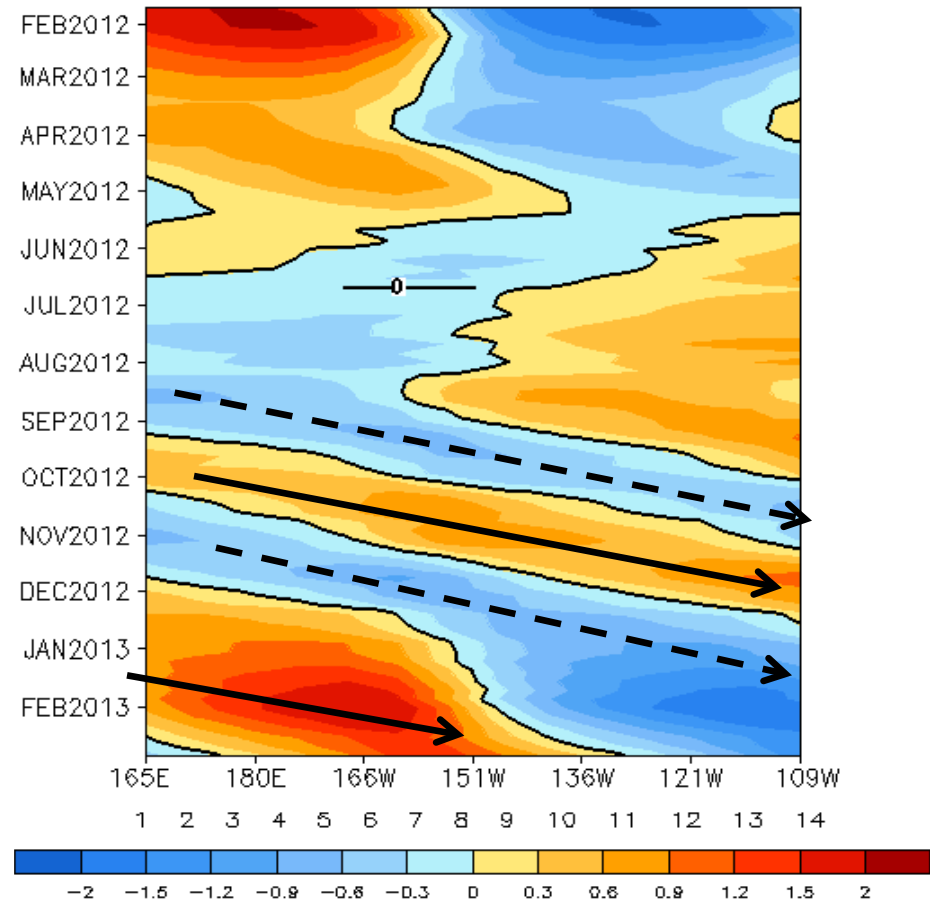
- Negative phase of NAO strengthened significantly with NAO index =-0.96 in Feb 2013.
- Positive SSTA in high-latitude N. Atlantic significantly weakened, while positive SSTA in tropical N. Atlantic also weakened.

Backup Slides

Oceanic Kelvin Wave Indices



Standardized Projection on EEOF 1

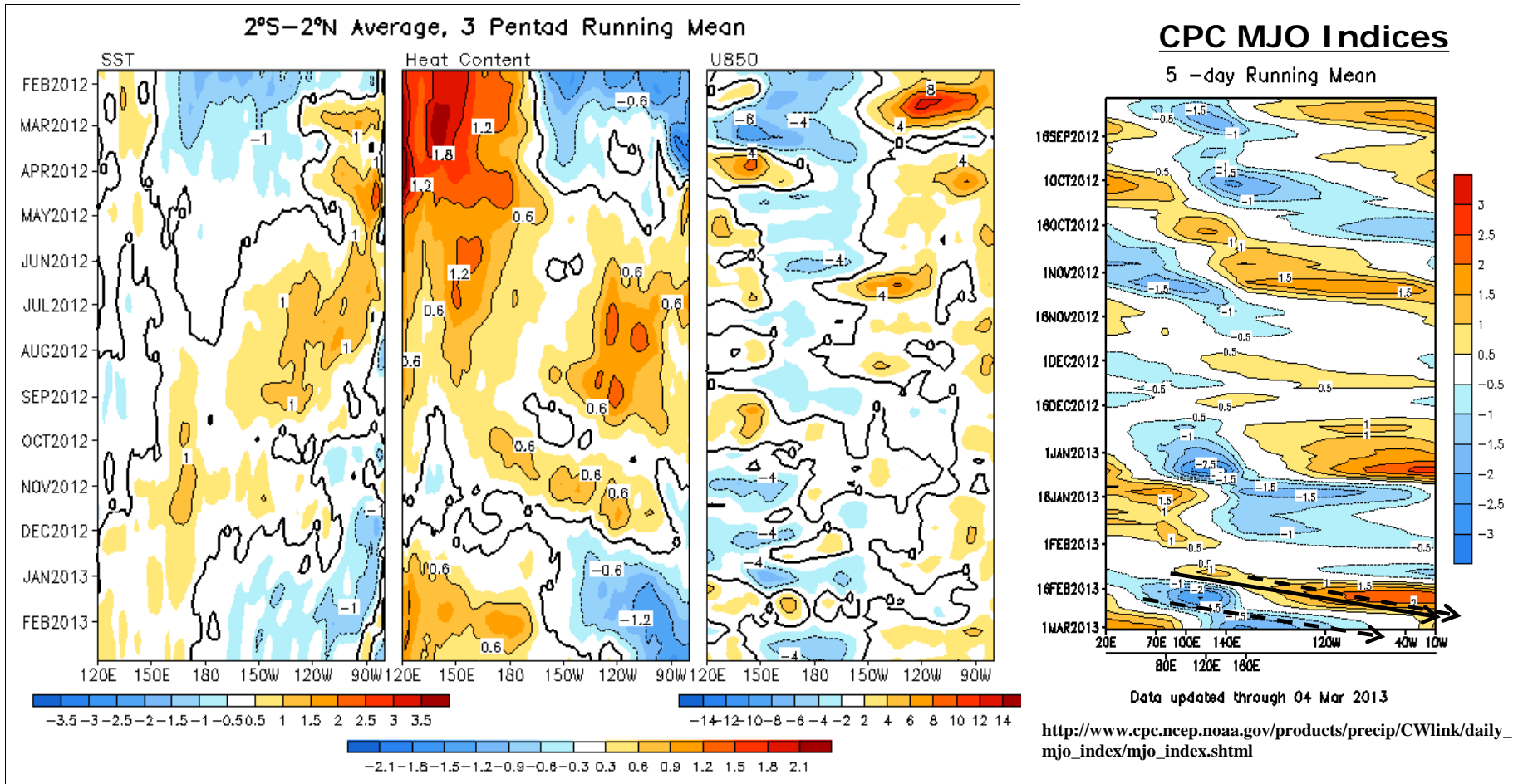


- Downwelling oceanic Kelvin wave (solid line) emerged in Sep 1012 in the W. Pacific was associated with the positive phase of MJO.

- Upwelling oceanic Kelvin wave (dash line) emerged in Nov 2012 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).

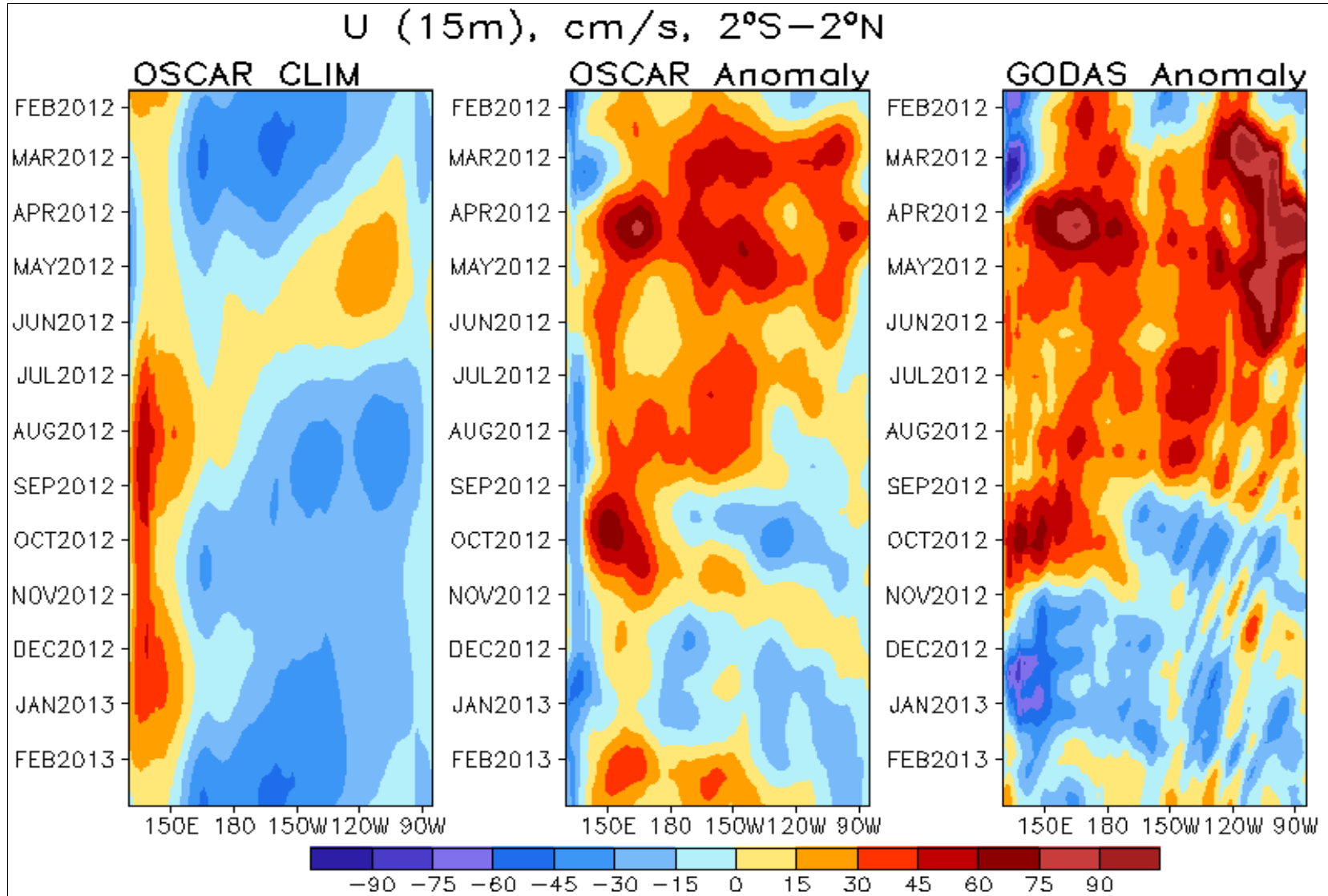
Equatorial Pacific SST ($^{\circ}\text{C}$), HC300 ($^{\circ}\text{C}$), u850 (m/s) and OLR(W/m^2) Anomalies



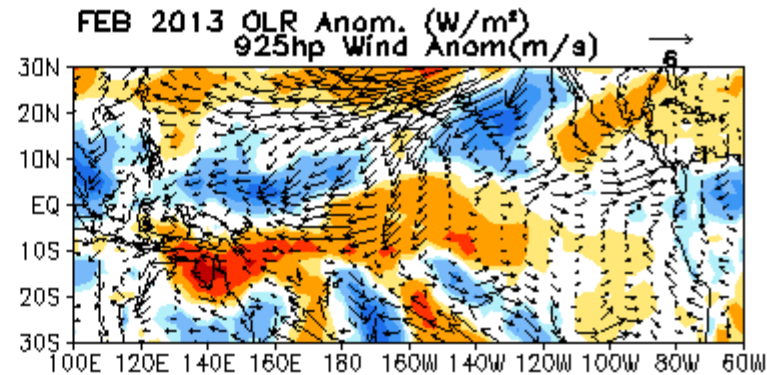
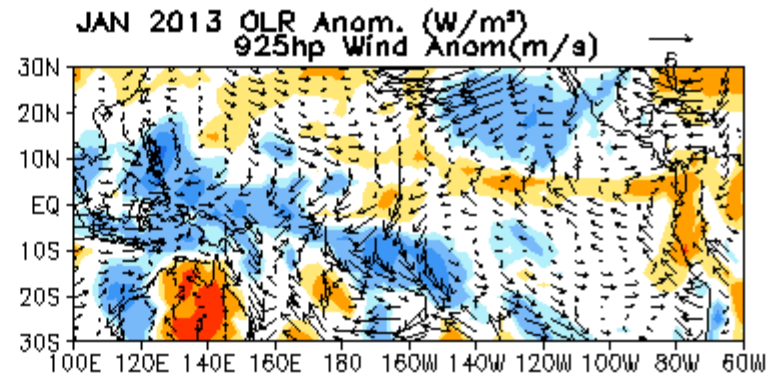
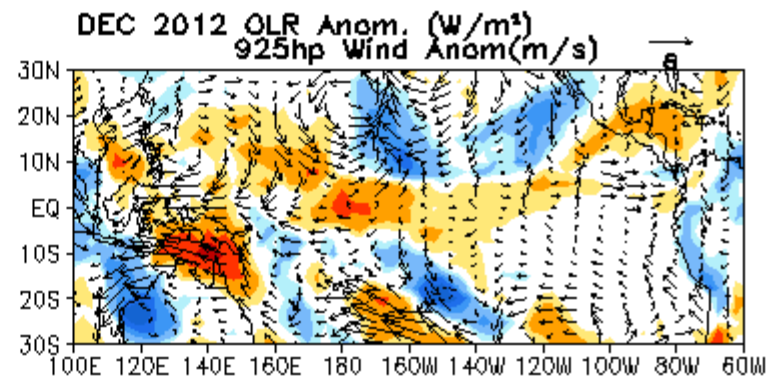
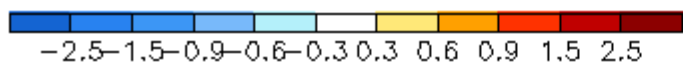
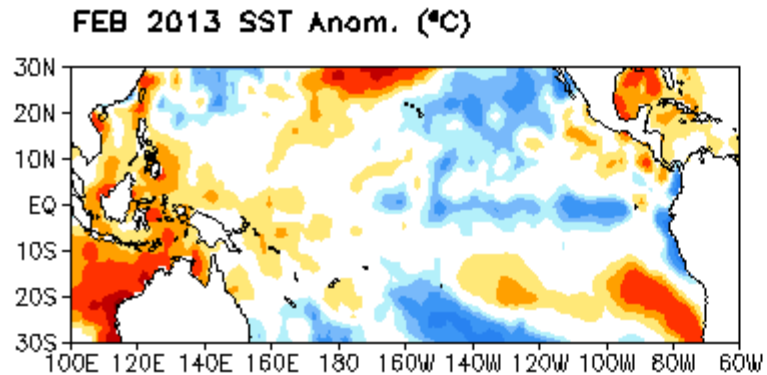
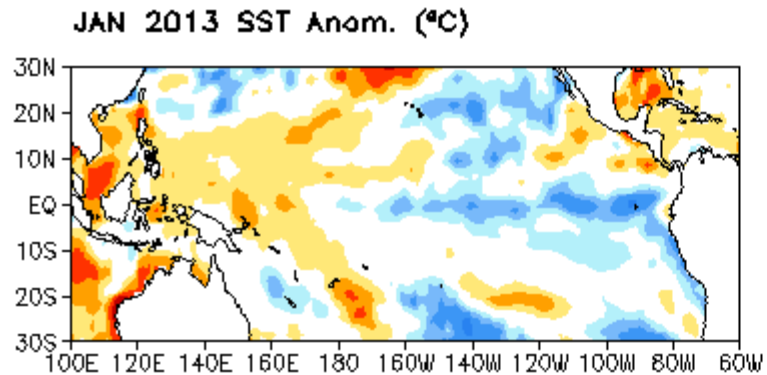
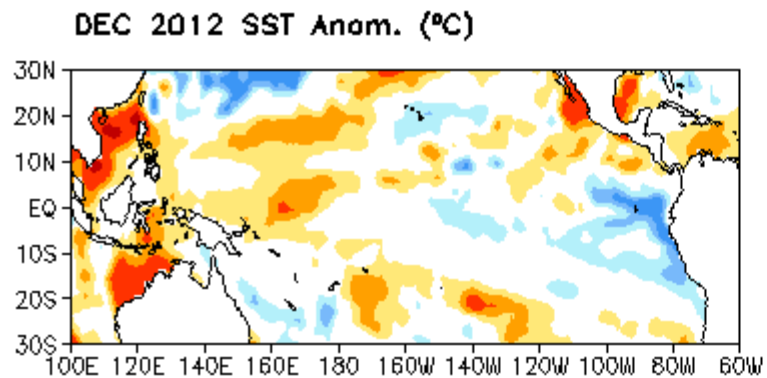
- Slightly positive SSTA in the west, while negative in the east in Feb 2013, consisted with the H300 anomaly pattern.
- Easterly wind anomalies near Dateline since mid-Feb were probably related to MJO activity, which might force upwelling oceanic Kelvin waves and lead to a cooling SST in the eastern Pacific in next 2 months.

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.

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



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



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

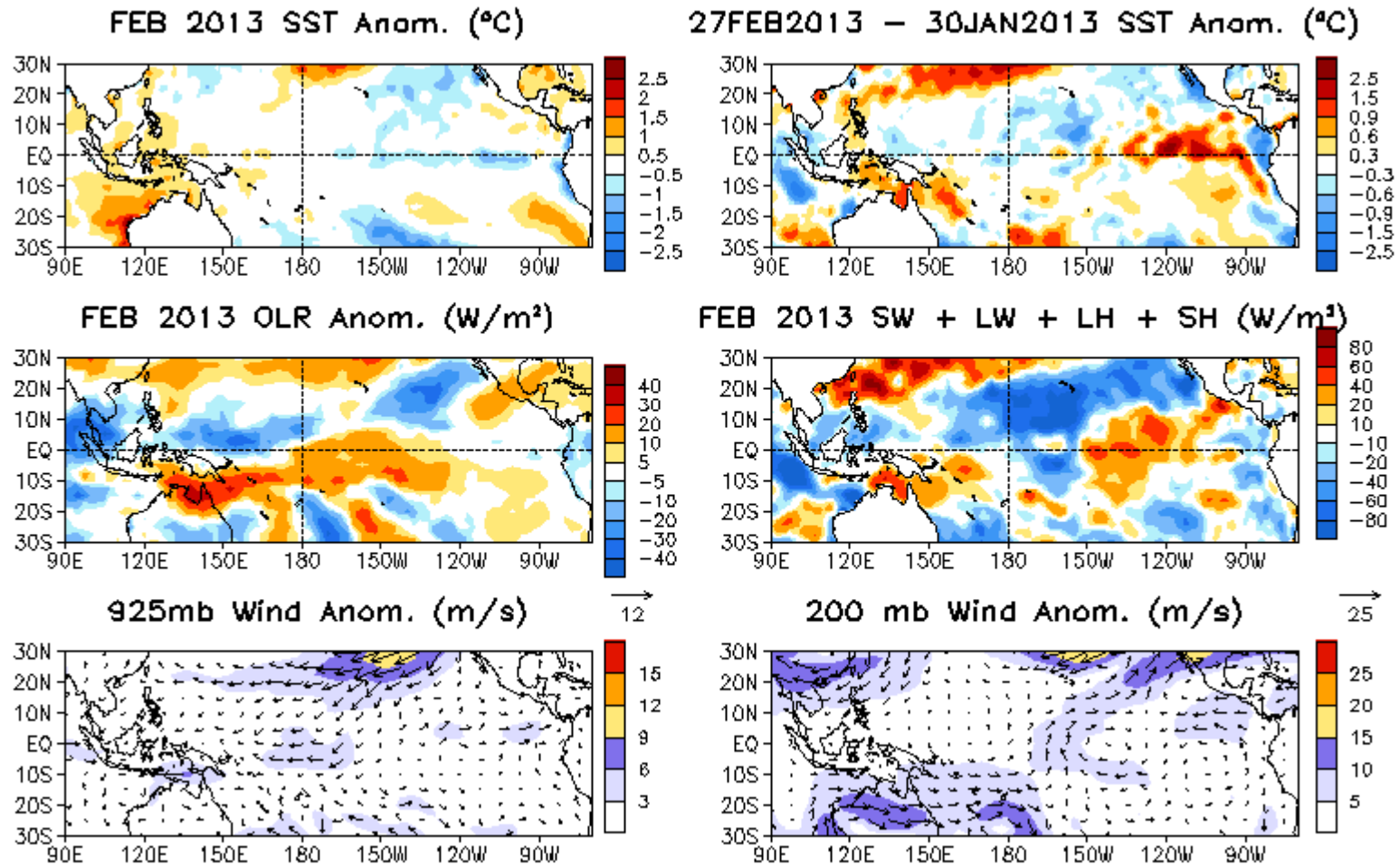


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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 (Wyrтки 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.

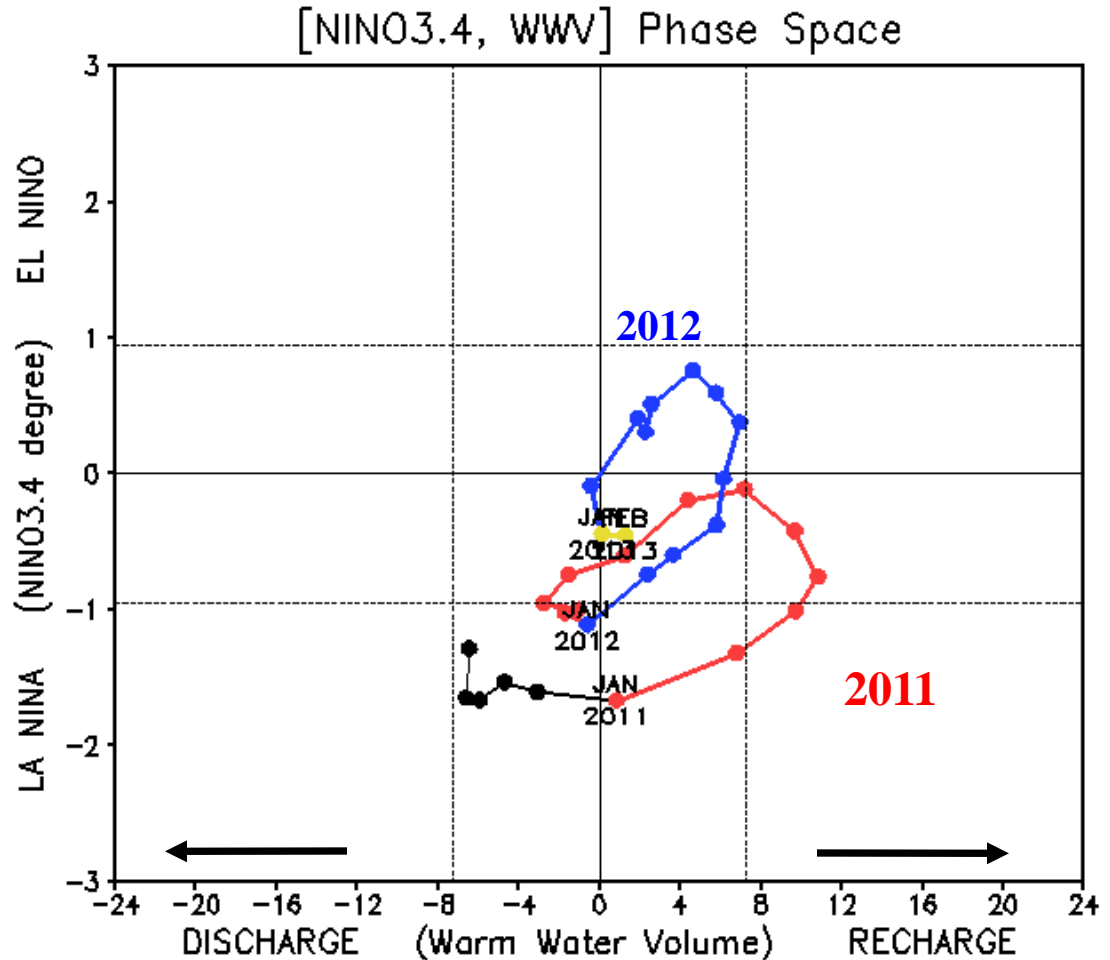


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

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

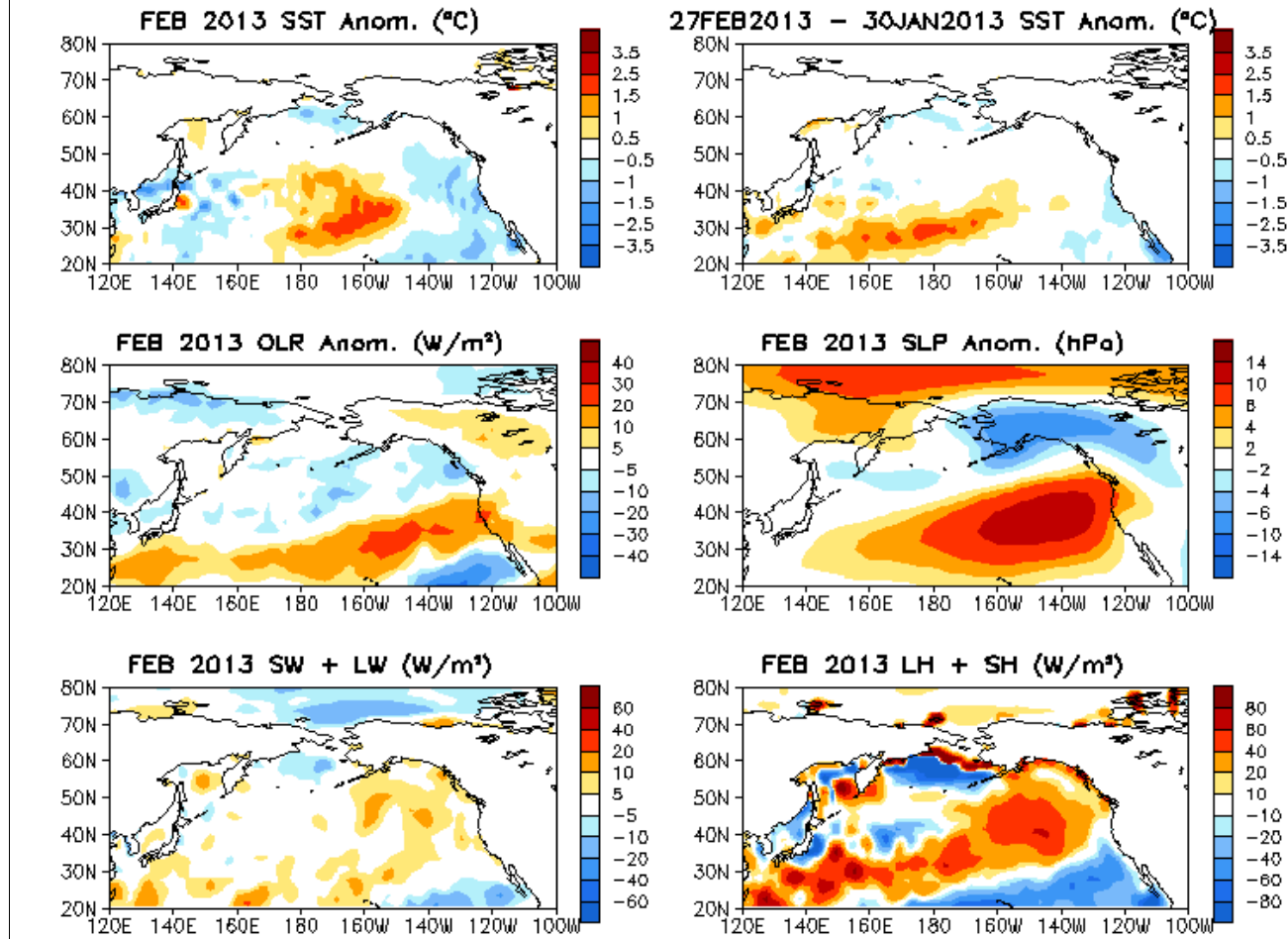
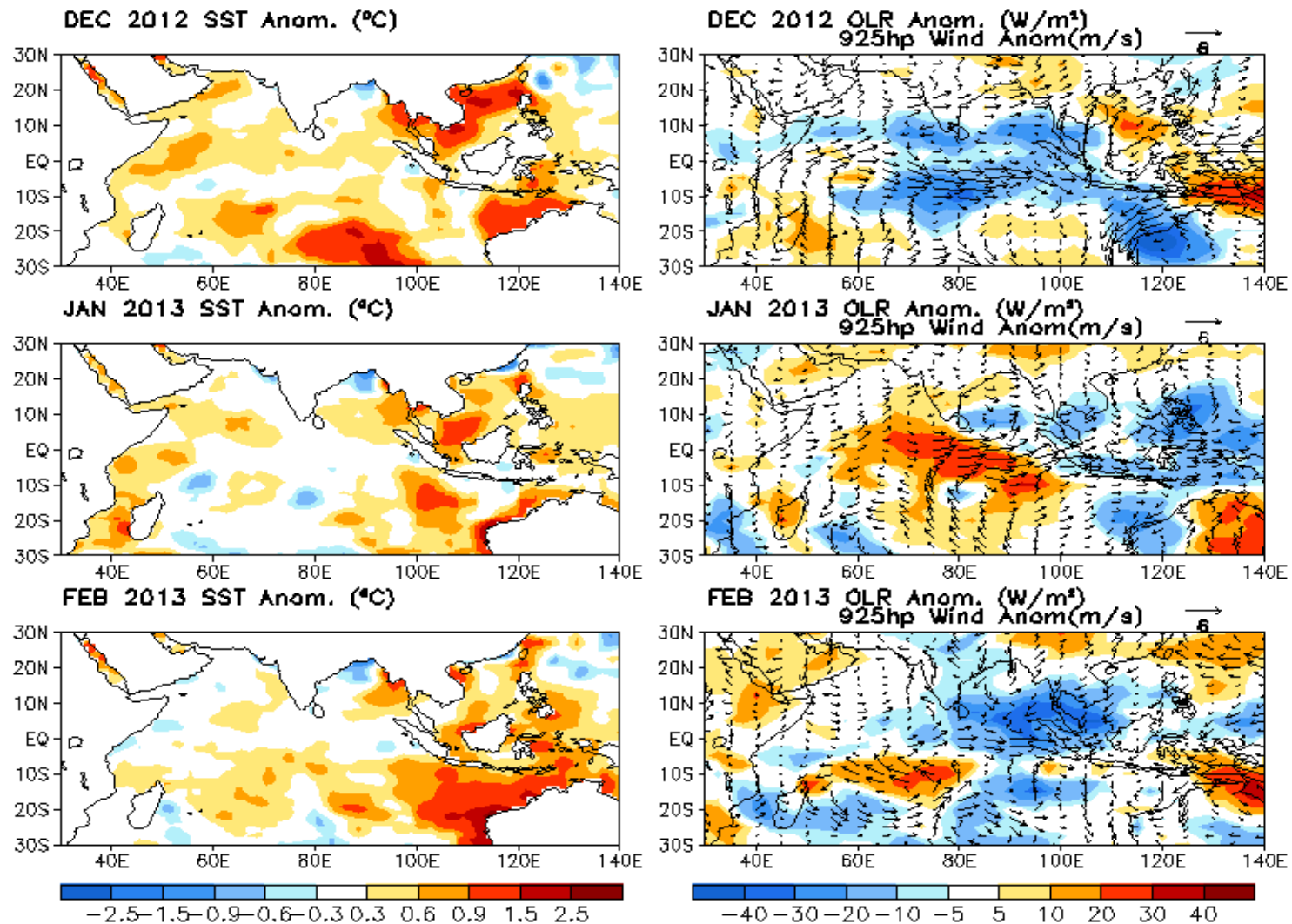


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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



- Positive SSTA in the eastern and westerly wind anomalies in the tropical Indian Ocean were observed .
- Convection was enhanced in the central and eastern tropical Indian Ocean in Feb 2013.

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

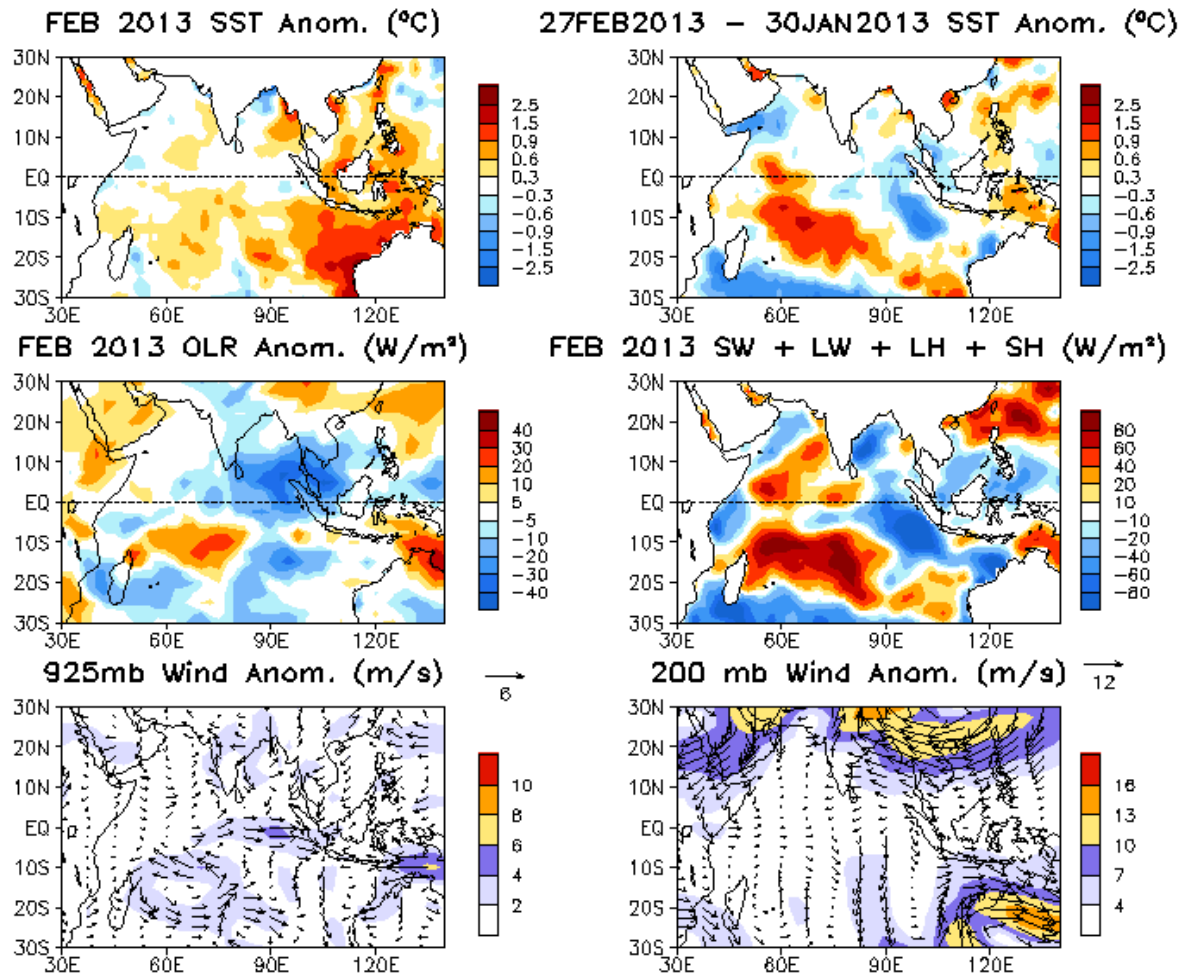
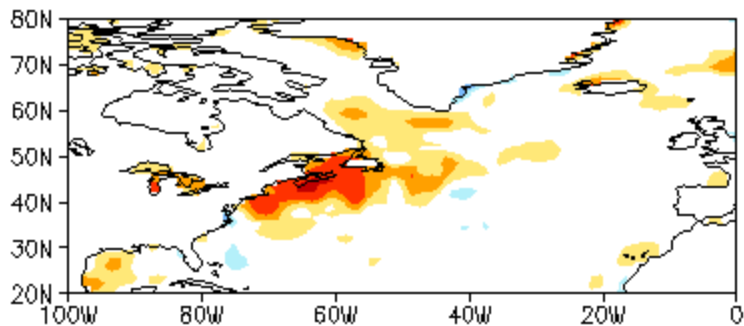
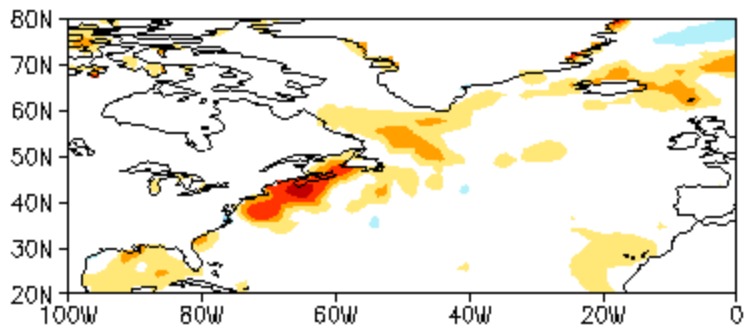


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

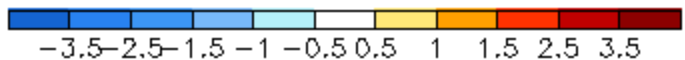
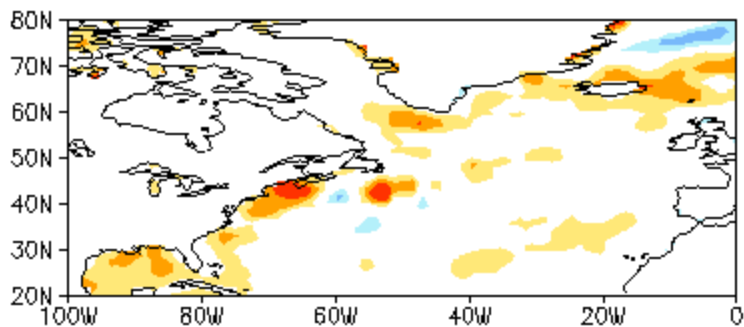
DEC 2012 SST Anom. (°C)



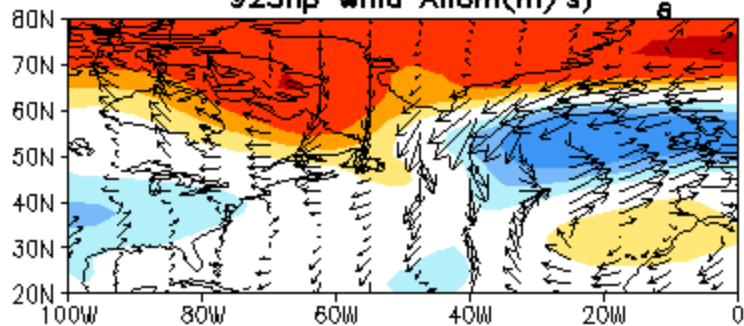
JAN 2013 SST Anom. (°C)



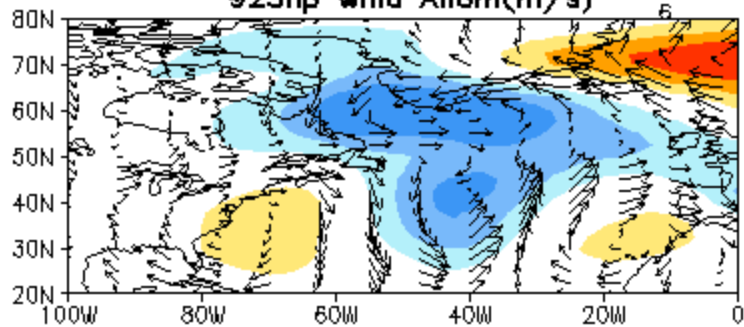
FEB 2013 SST Anom. (°C)



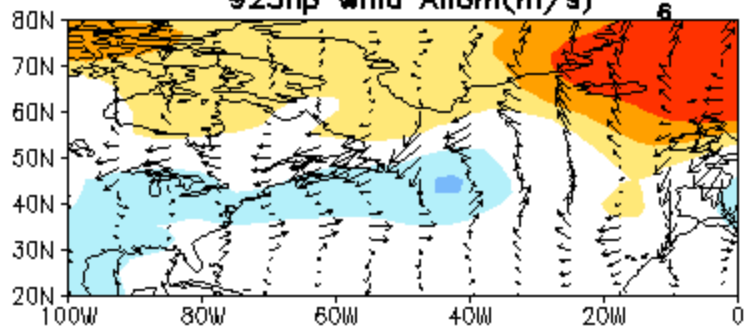
DEC 2012 SLP Anom.(hPa)
925hp Wind Anom(m/s)



JAN 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)



FEB 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)



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

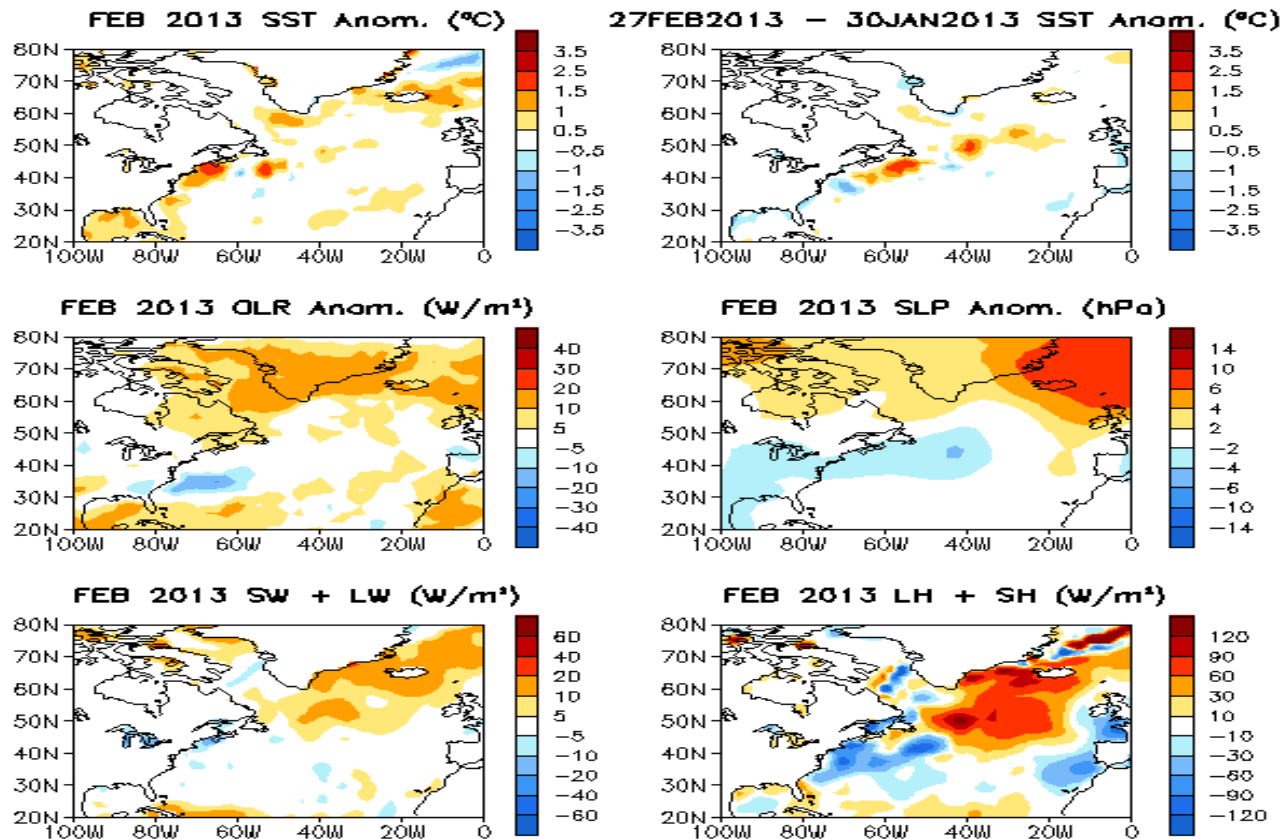
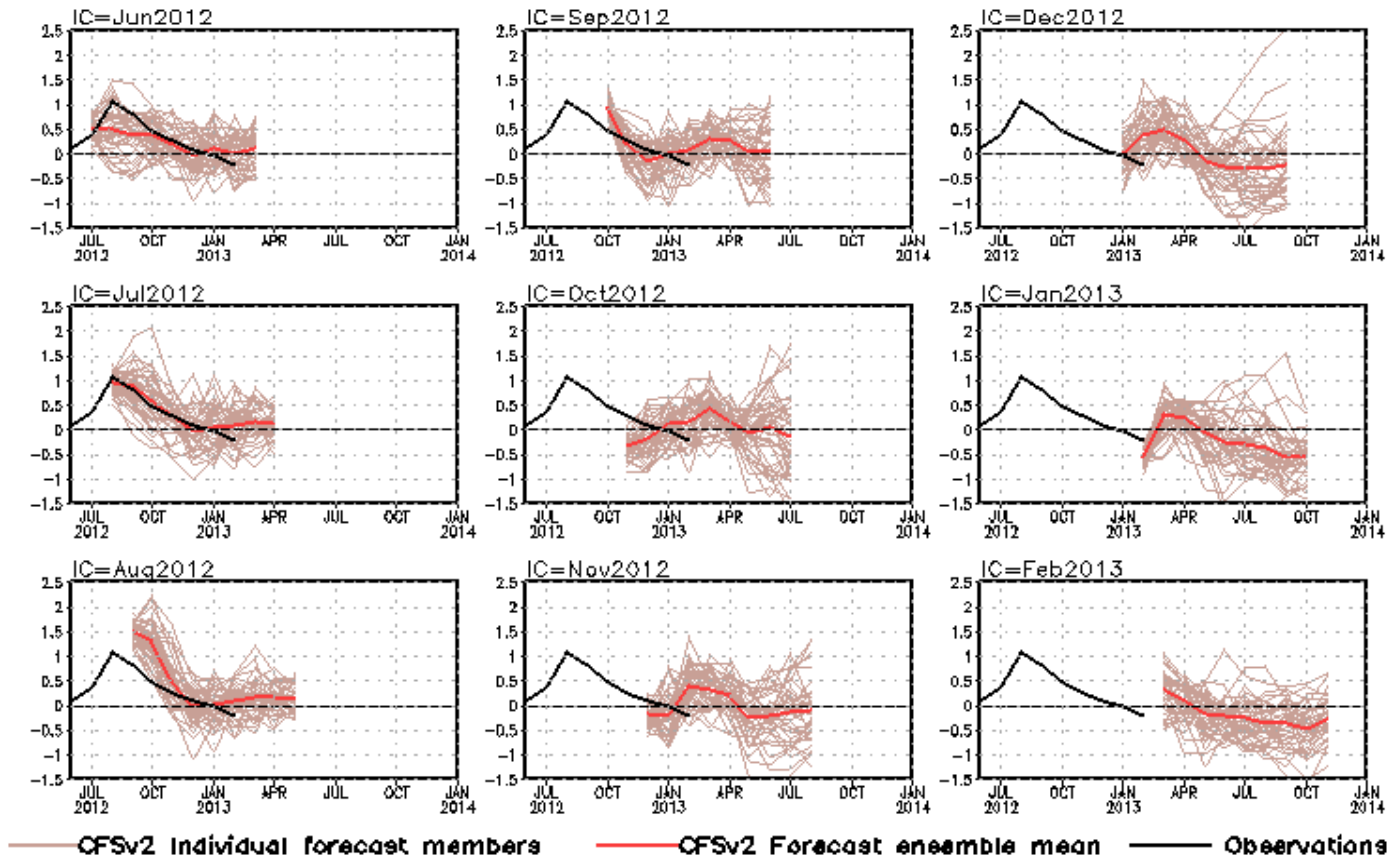


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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



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]

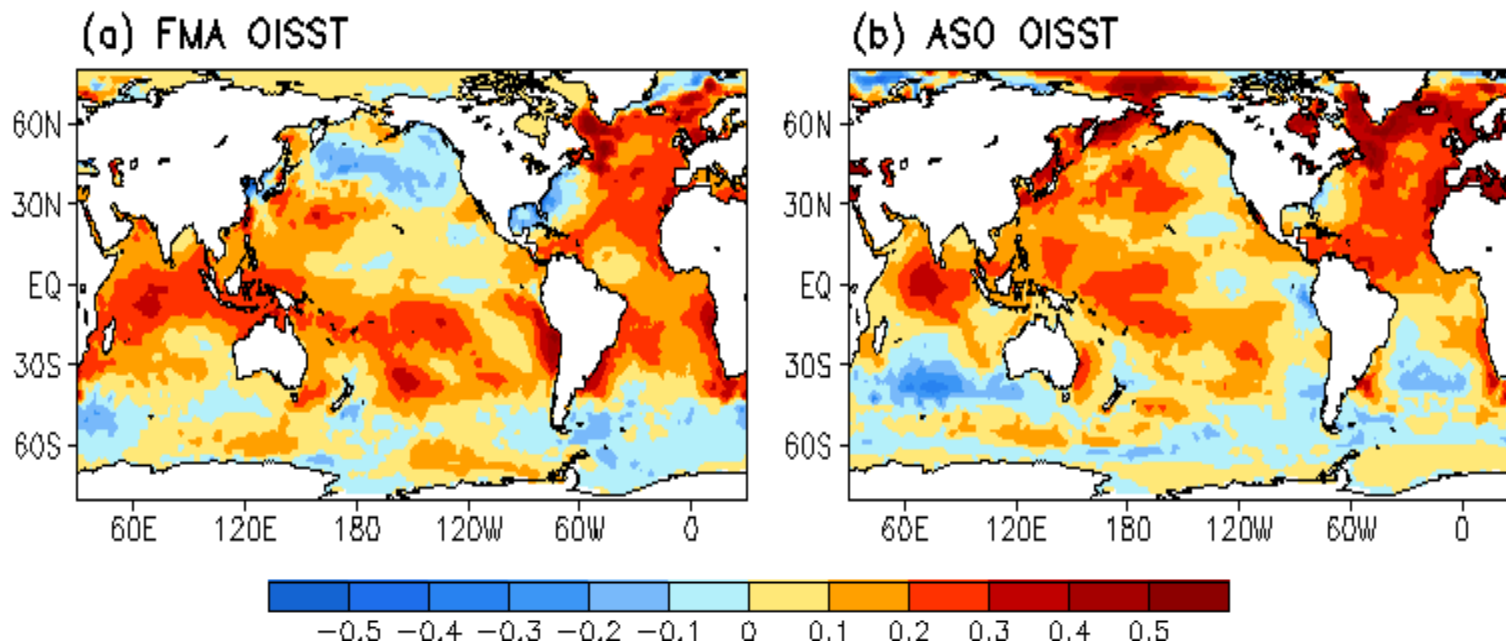
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast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

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!