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

Prepared by
Climate Prediction Center, NCEP/NOAA

May 7, 2013

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**

    (Show possible impact of TAO missing on NCEP data assimilation)
  - **Indian Ocean**
  - **Atlantic Ocean**

    (check the evolution of some factors which might affect the hurricane activity)
- **Global SST Predictions**

Overview

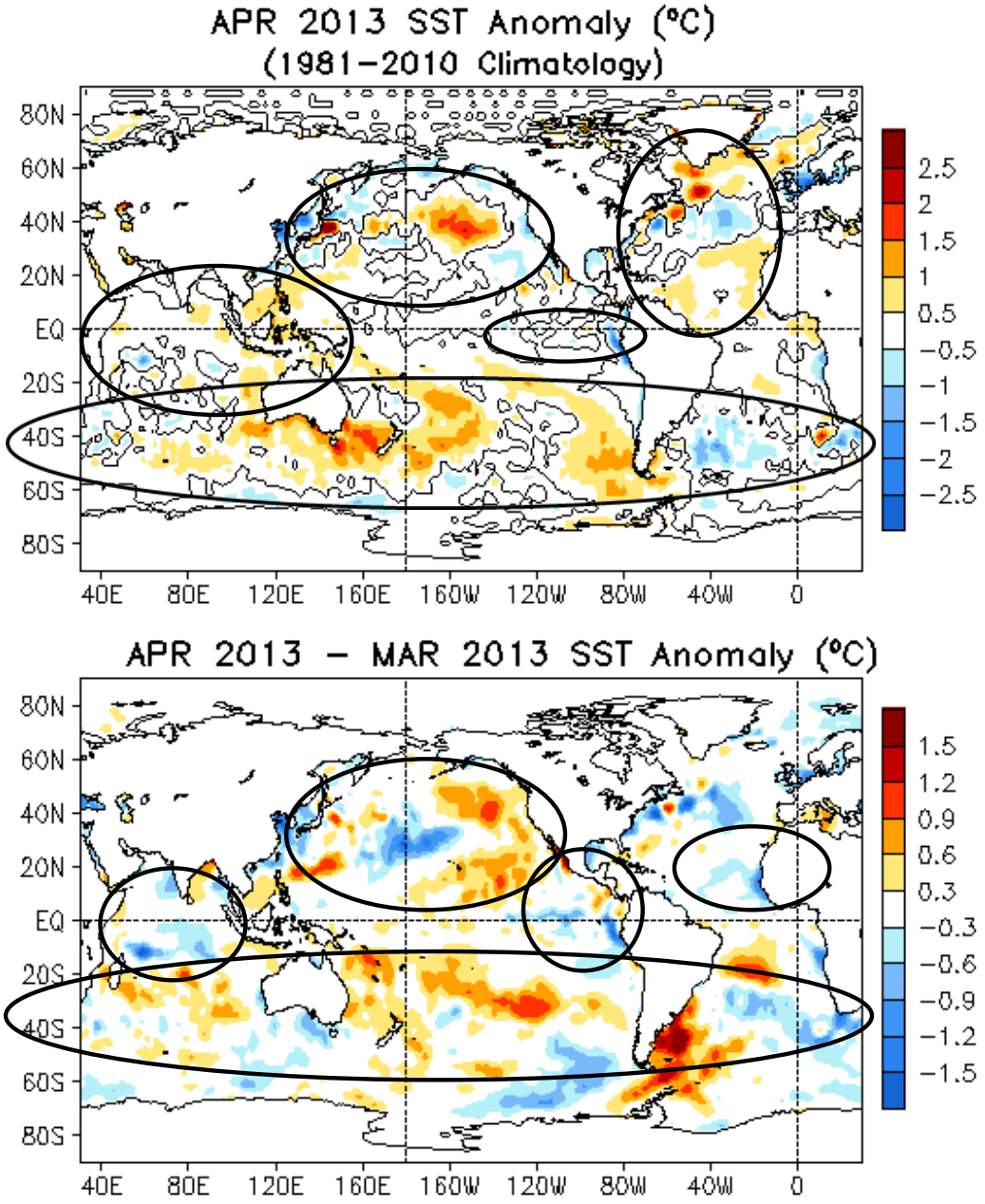
- **Pacific and Arctic Oceans**
  - **ENSO-neutral condition continued during Apr 2013 with Nino3.4=-0.15C.**
  - **NOAA officially forecast ENSO-neutral condition to continue in the Northern Hemisphere spring-summer 2013.**
  - **Negative PDO phase weakened with PDO index =-0.8 in Apr 2013, and NCEP CFSv2 predicted negative phase of PDO would continue.**
  - **Arctic sea ice extent in Apr 2013 was well below-normal.**

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

- **Atlantic Ocean**
  - **NAO switched from negative to positive phase with NAO index =0.6 in Apr 2013.**
  - **Tripolar SSTA in N. Atlantic enhanced in Apr 2013, may due to the impact of persistent negative phase of NAO in Jan-Mar 2013.**

Global Oceans

Global SST Anomaly (°C) and Anomaly Tendency

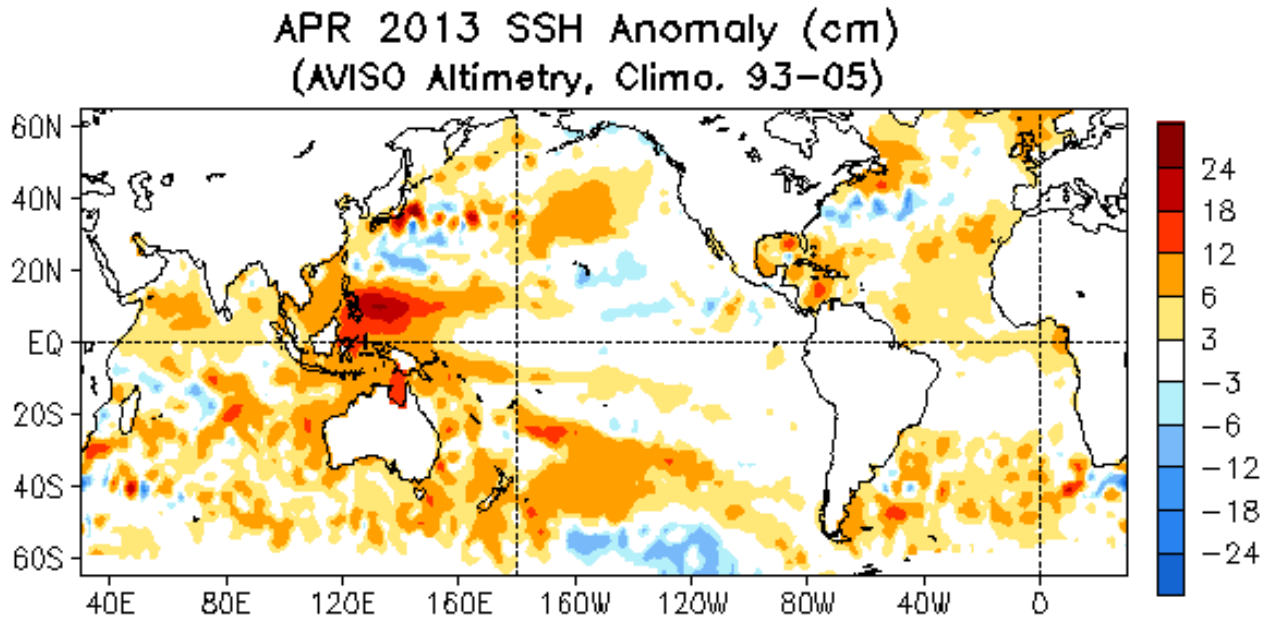


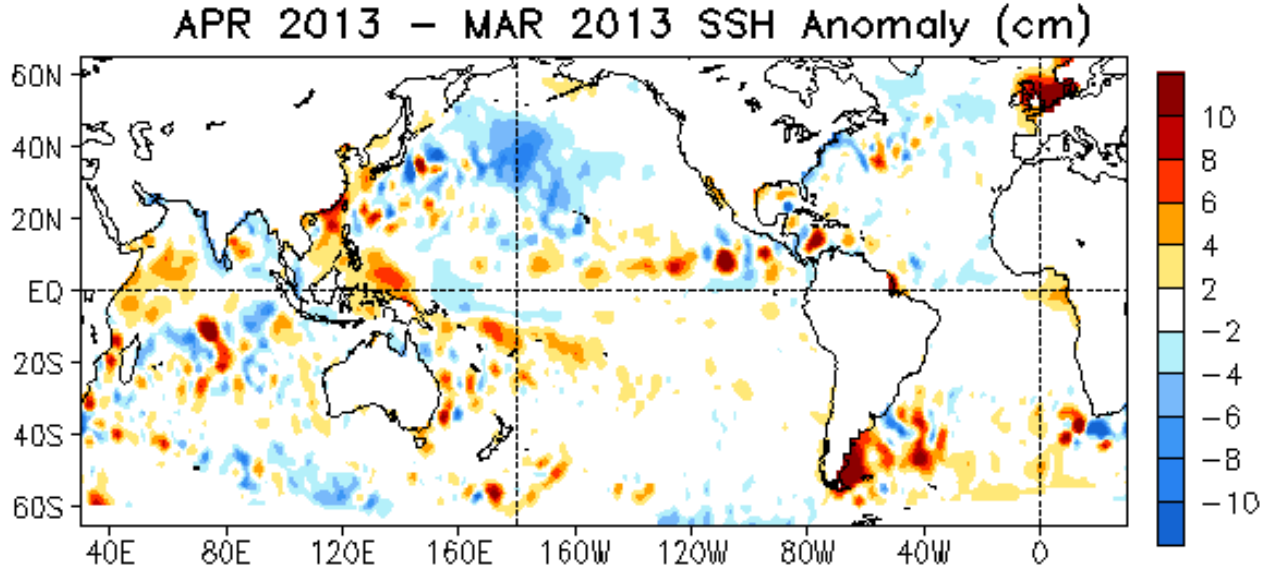
- **SSTA was small in the tropical Pacific.**
- **Negative phase PDO associated SSTA presented in N. Pacific.**
- **Positive SSTA was observed in the Indian and w. Pacific Oceans.**
- **Tripolar SSTA occurred in N. Atlantic.**
- **Large SST anomalies were observed in the South Ocean.**

- **A slightly warming (cooling) tendency presented in the equatorial central (eastern) Pacific.**
- **Weakening tendency of negative phase of PDO associated SSTA presented in N. Pacific.**
- **An overall cooling tendency was observed in the mid-latitude and tropical N. Atlantic, and central Indian Ocean.**
- **Large tendencies were observed in the mid-latitudes of 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.

Global SSH Anomaly (cm) and Anomaly Tendency

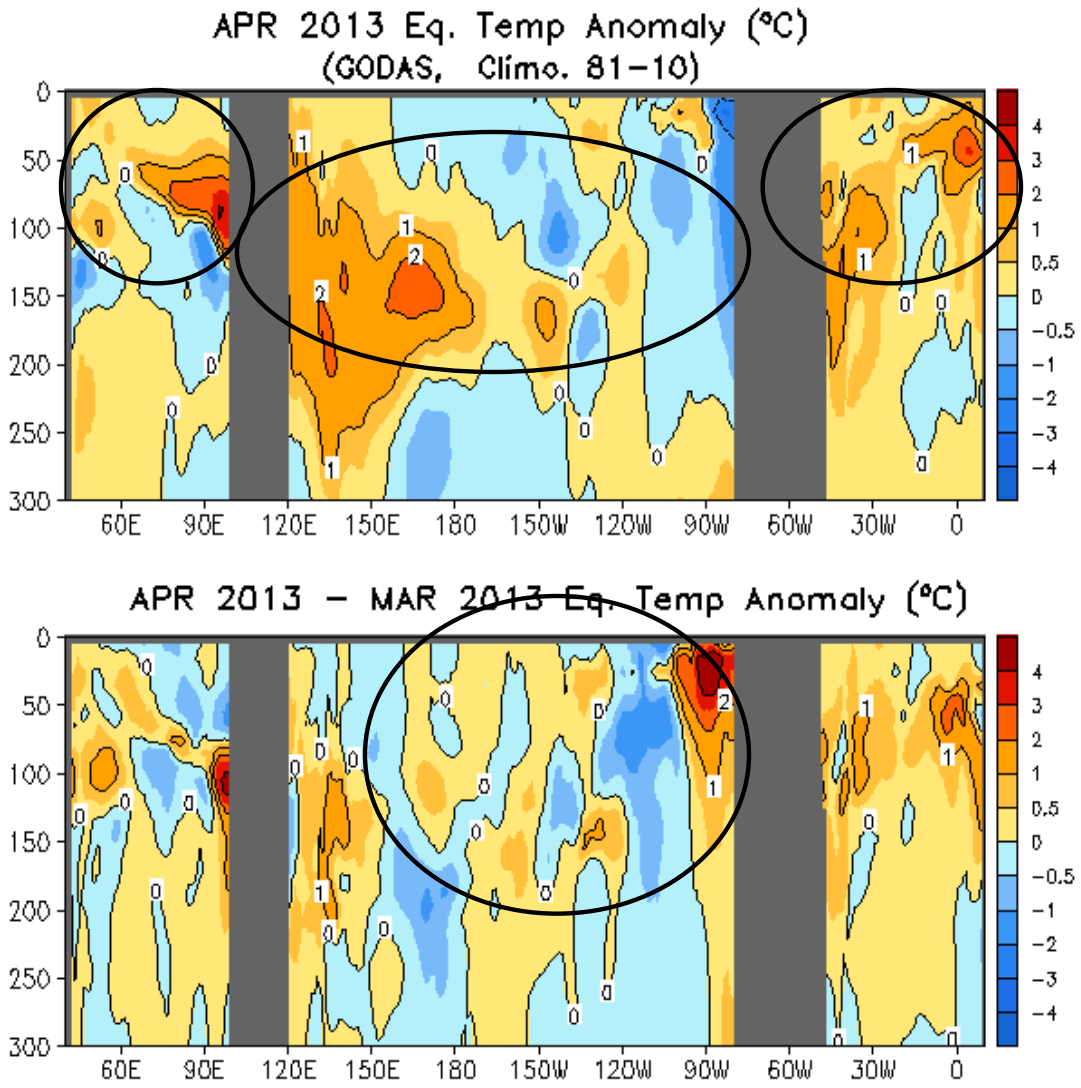




- The SSH anomalies were overall consistent with SSTA:

Positive (negative) SSTA is tied up with positive (negative) SSH anomaly.

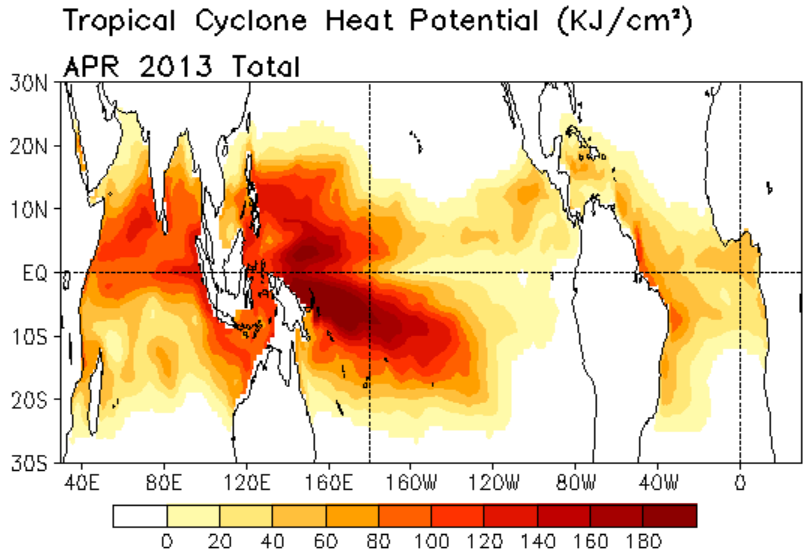
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

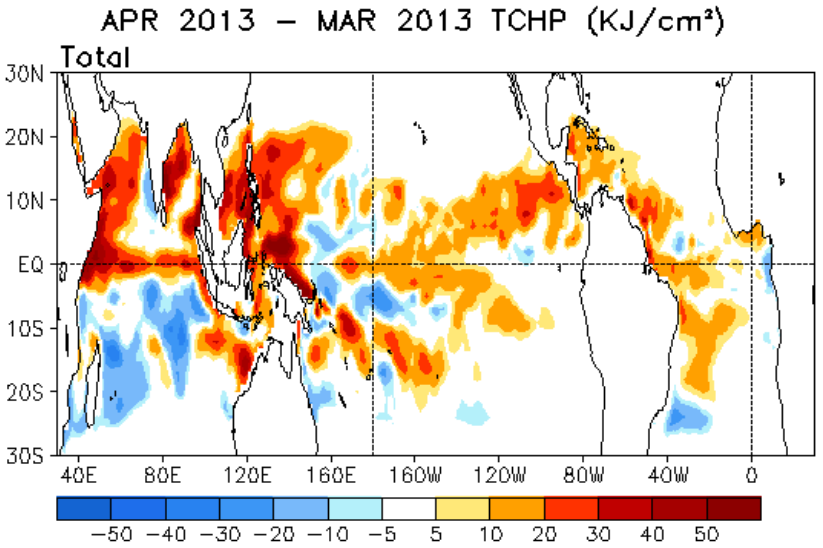


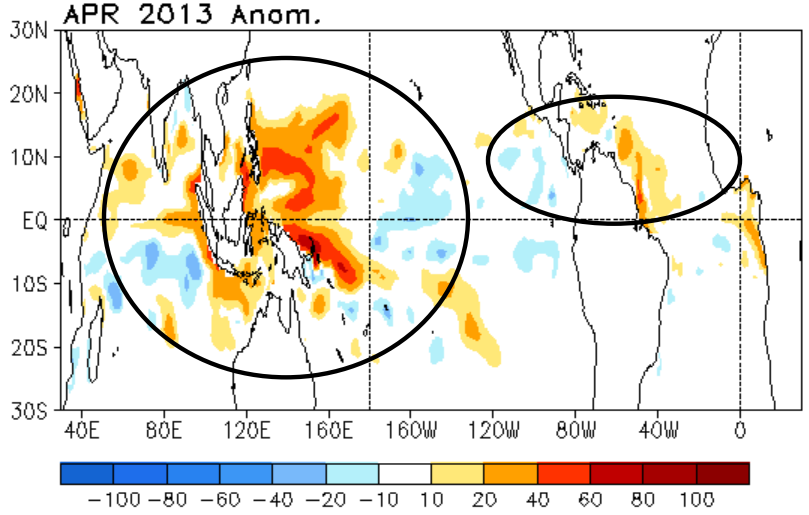
- **Positive temperature anomalies occupied around the thermocline in the equatorial c. and w. Pacific Ocean, and negative ones near the American coast and in the c. and e. Pacific.**
- **Positive anomalies dominated in Atlantic Ocean and at the upper 100m of equatorial eastern Indian Ocean.**

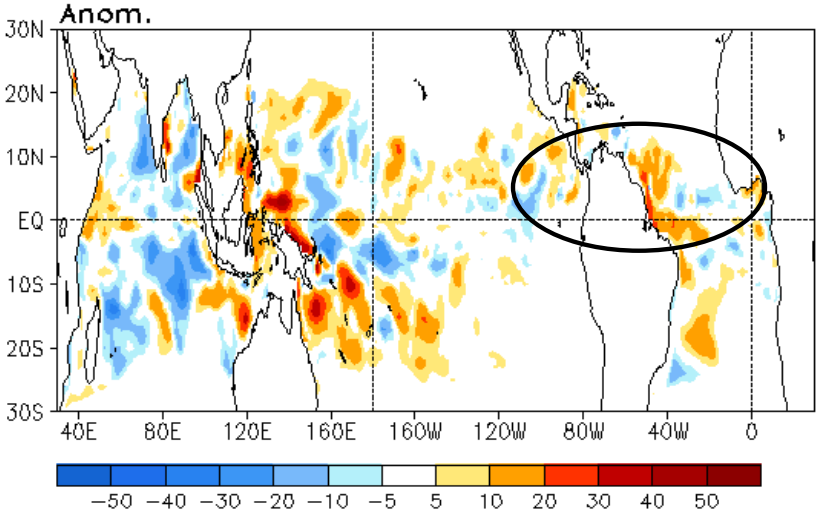
- **Both warming and cooling tendency was observed in the central Pacific around the thermocline, and warming tendency in both e. and w. coast.**
- **No obvious propagation was seen.**

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.





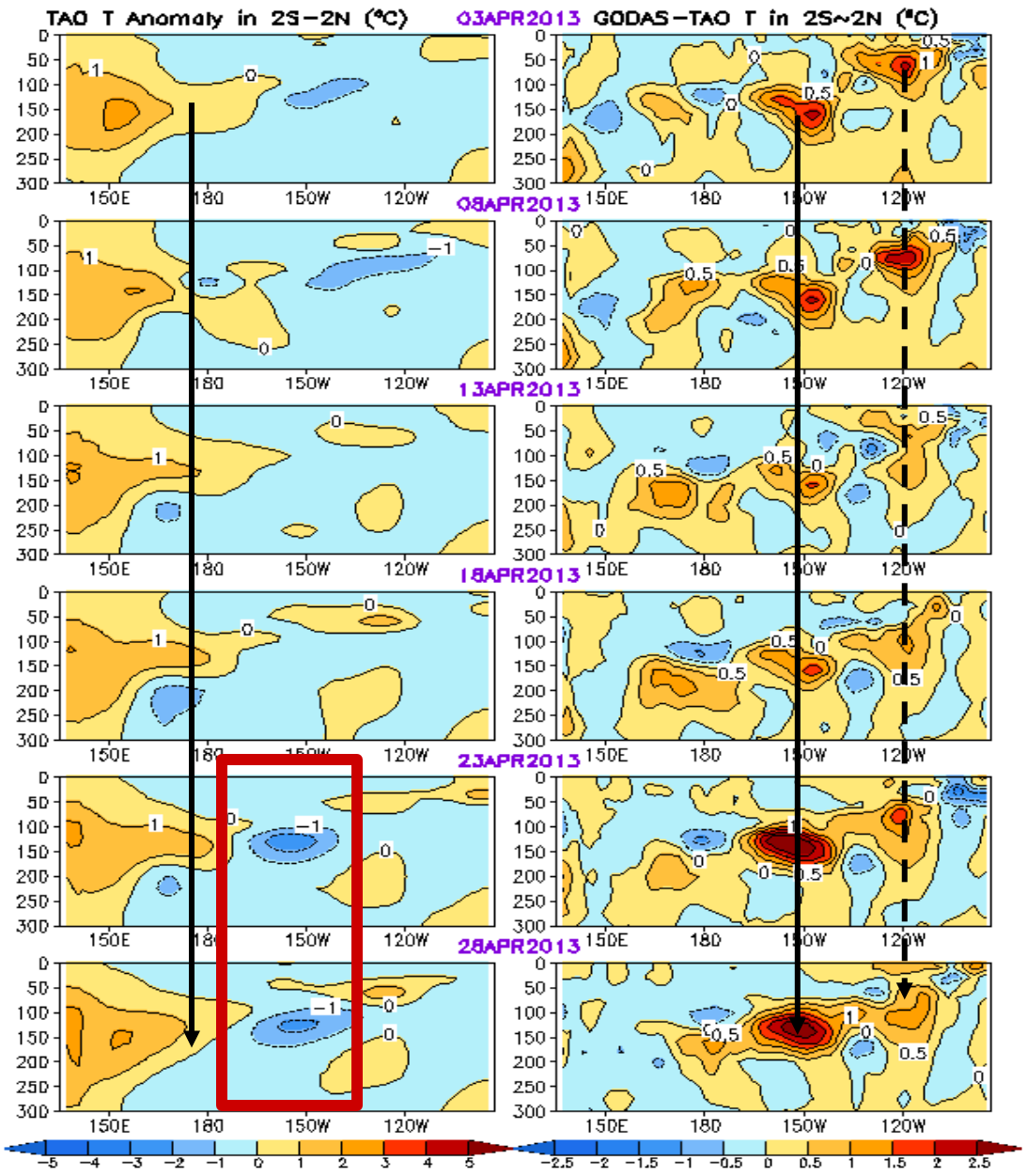




- **Positive TCHP anomalies presented in the w. Pacific and negative ones in the c. and e. Pacific.**
- **Both the anomalies and the tendencies over the w. Atlantic Ocean were small positive.**

TCHP field is the anomalous heat storage associated with temperatures larger than 26℃.

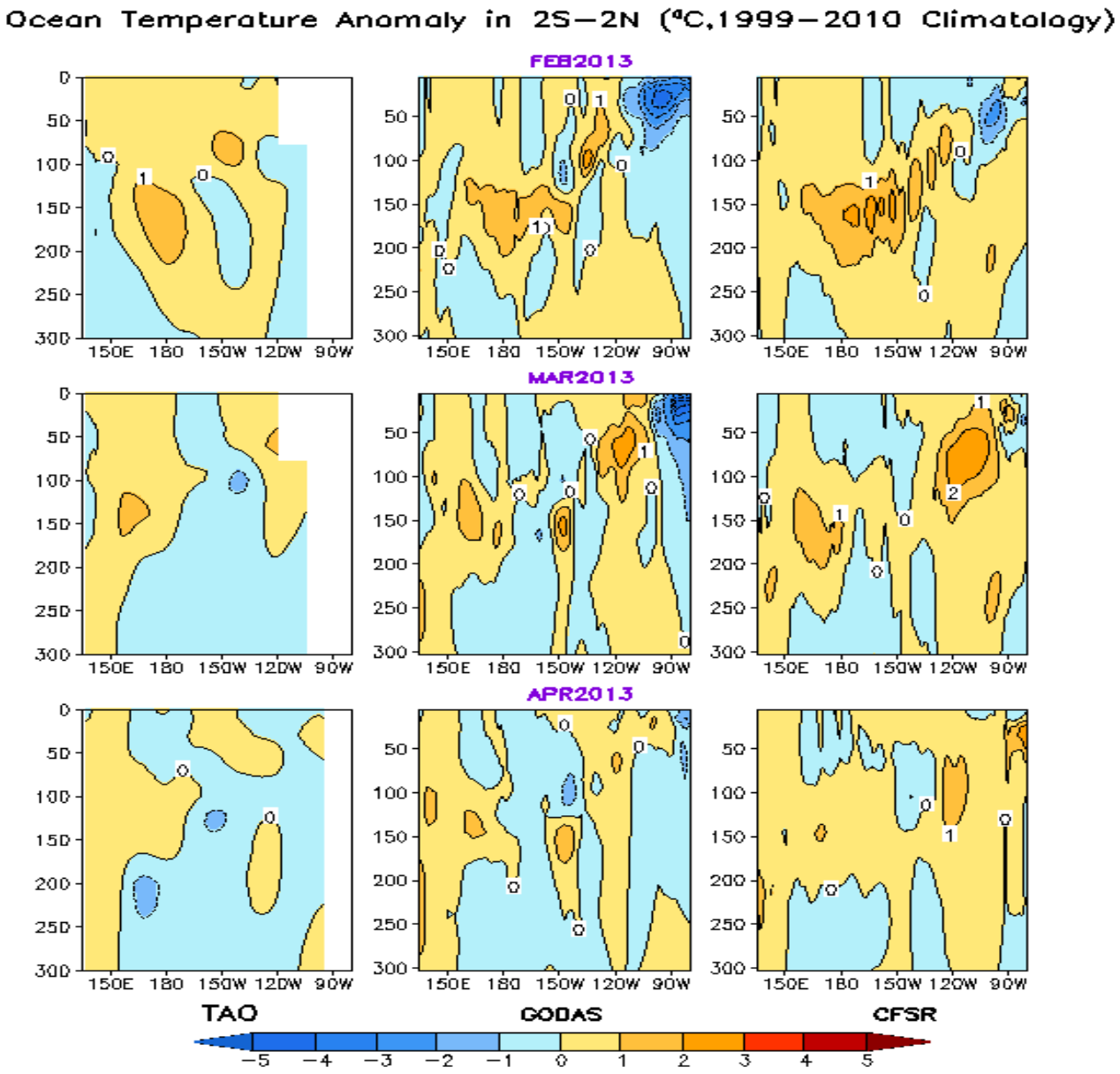
Tropical Pacific Ocean and ENSO Conditions



Pentad Mean Equatorial Pacific Temperature Anomaly

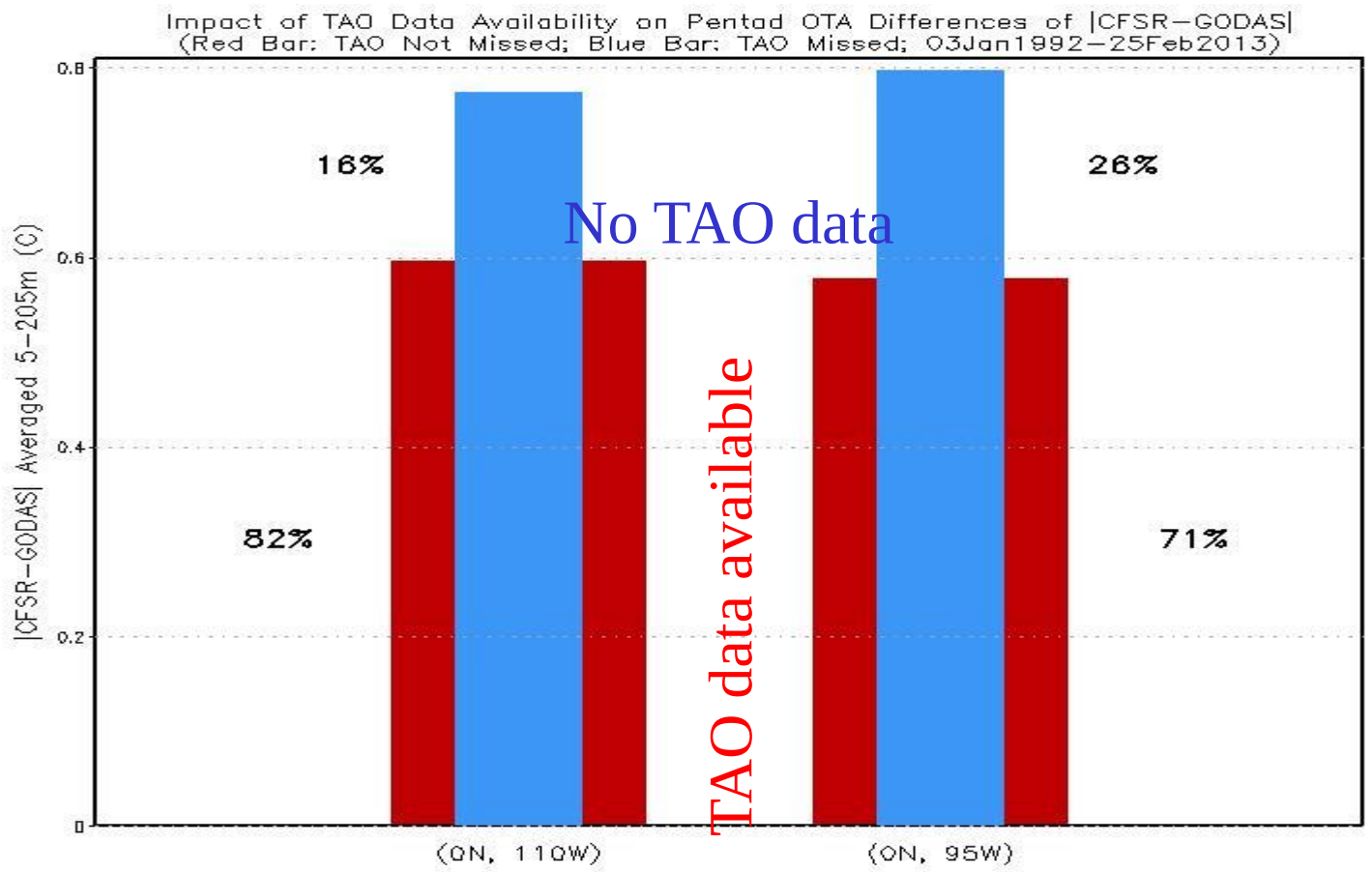
- **Positive temperature anomalies in the c. and w. Pacific did not have clear propagation.**
- **Negative temperature anomalies in the c. and e. Pacific were intensified in recent 2 pentads.**
- **However, the differences between TAO and GODAS were large in the c. and e. Pacific (150W, 120W). What causes the differences?**

Last 3-Month Mean Equatorial Pacific Temperature Anomaly



- **The differences between TAO and GODAS, and between TAO and CFSR were large in the c. and e. Pacific.**
- **What causes the differences?**

Possible Impact of TAO Data Missing on NCEP Data Assimilations ($\sum_{5m}^{205m}$|CFSR-GODAS|)



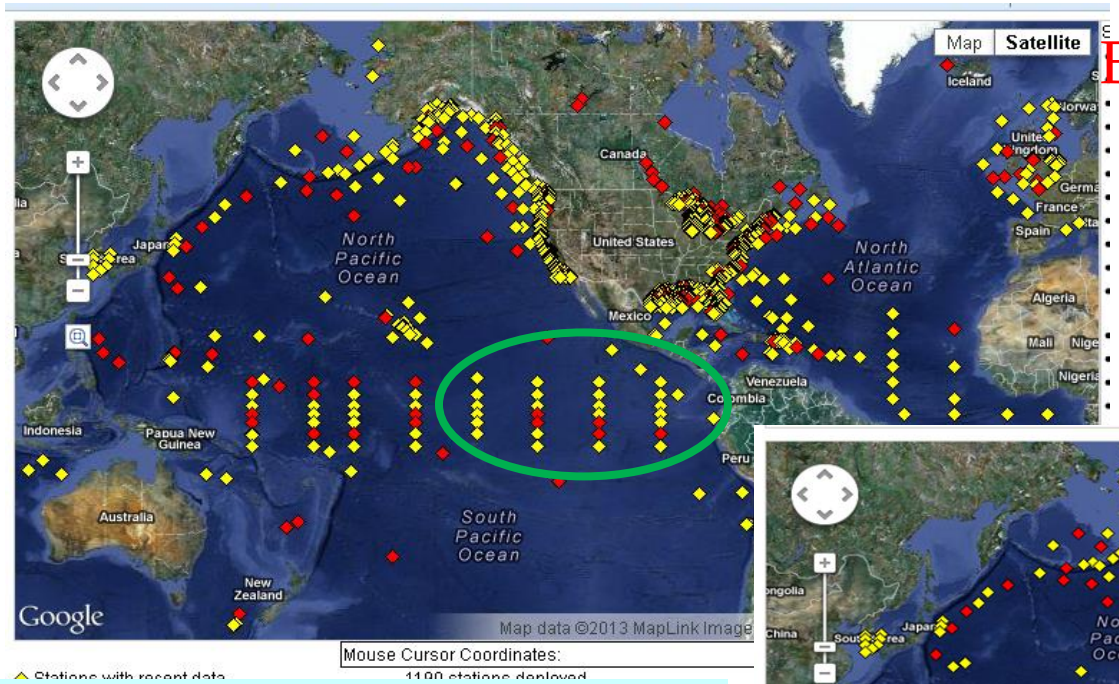
- **The ocean temperature anomaly differences between CFSR and GODAS are larger when TAO data are missed compared with that they are not missed.**

- **Statistically, it seems to suggest that without constraint of TAO data, the differences become larger between GODAS and CFSR.**

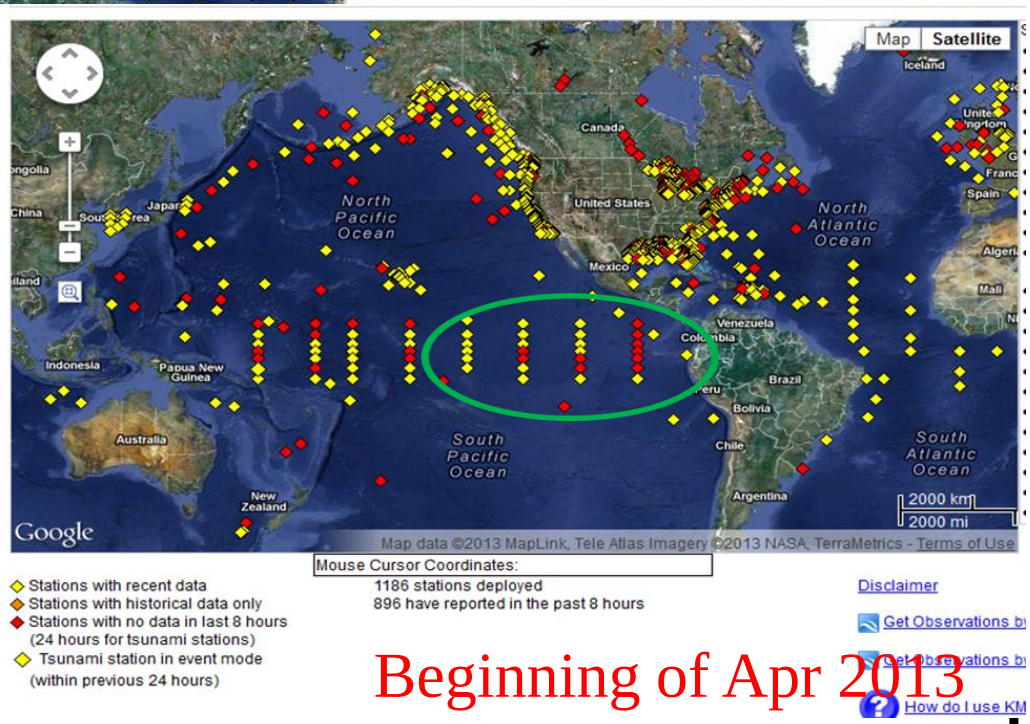
- **It seems that both the data assimilation system and data inputs may cause biases in the reanalysis data.**

Status of TAO/TRITON Data Delivery

http://www.ndbc.noaa.gov
http://www.pmel.noaa.gov/tao/jsdisplay/



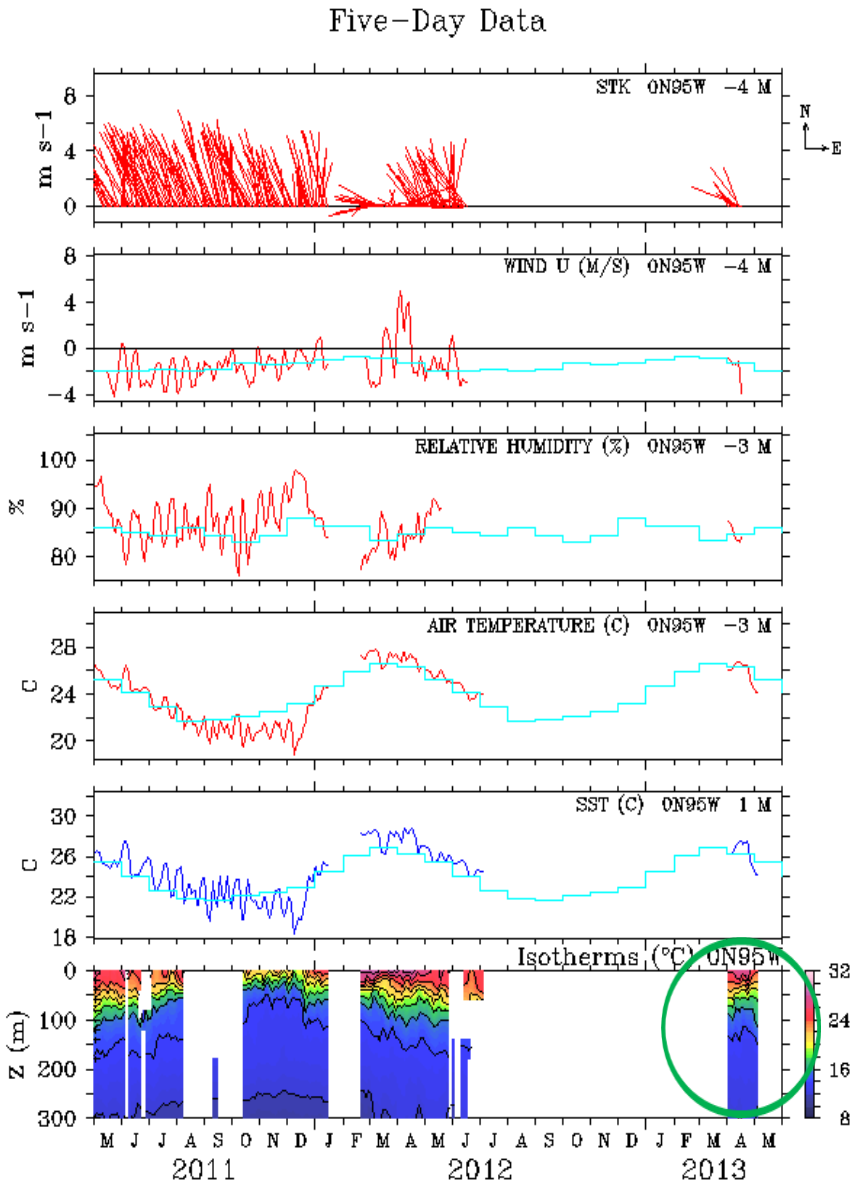
Beginning of May 2013

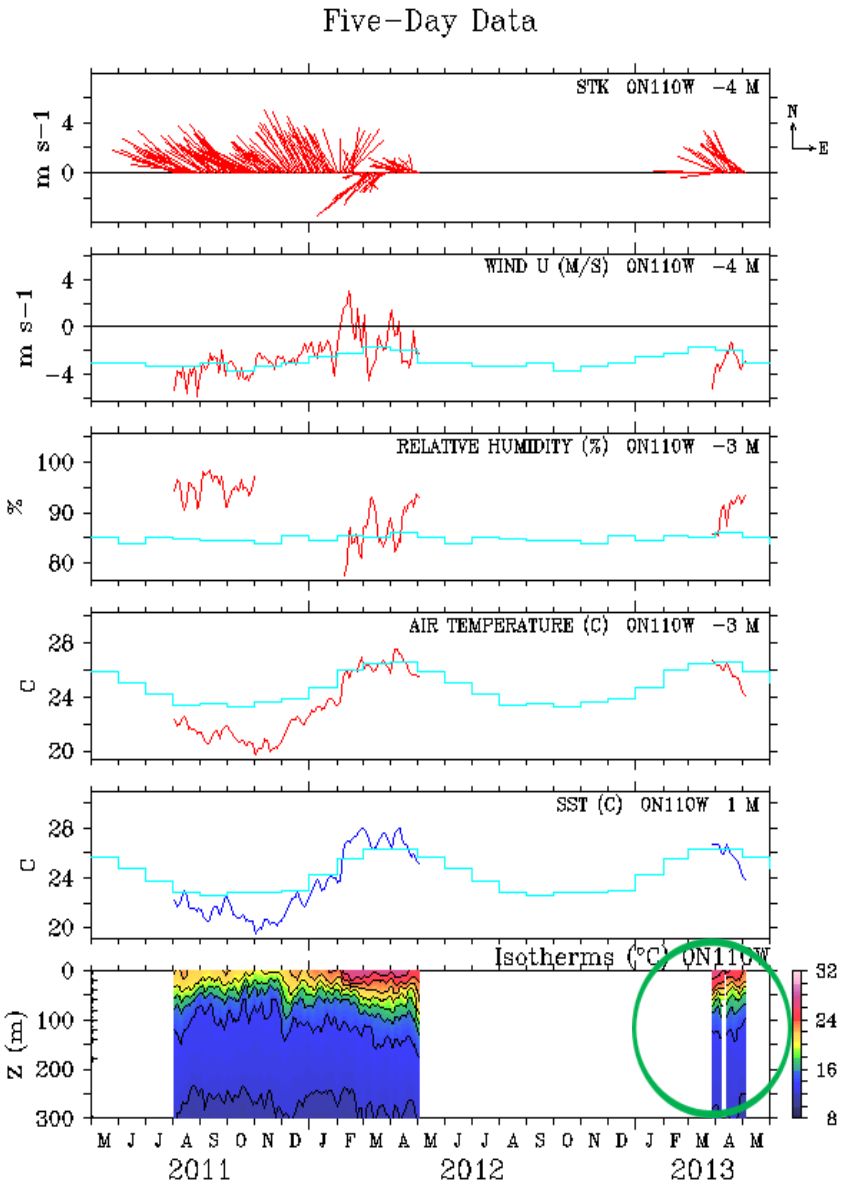


Beginning of Apr 2013

- **The TAO/TRITON array has encountered significant outages in the past year, particularly in the eastern part of the array.**
- **However, some of the arrays were repaired and the data were available since Apr 2013.**

Good News: Data are available at (0N, 95W) and (0, 110W) since Apr 2013



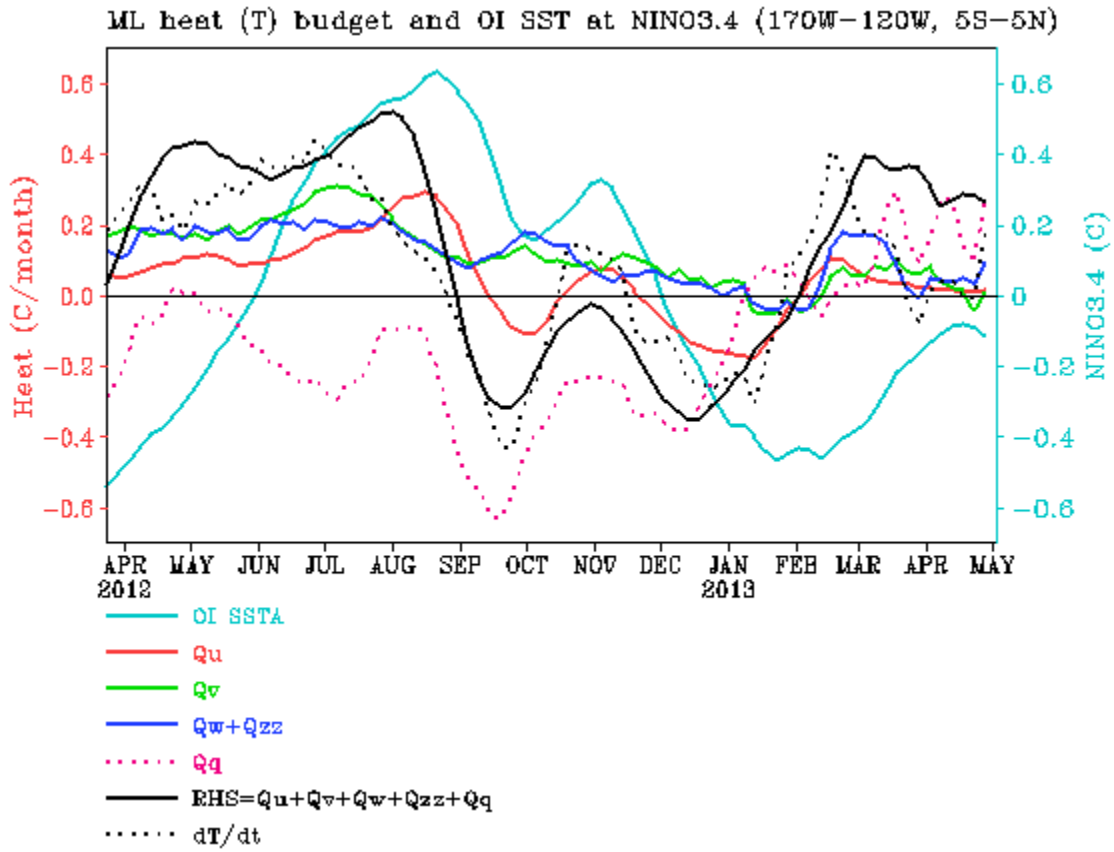


Subject: Re: [ncep.list.CPC-OceanBriefing] CPC's Monthly Ocean Briefing: 1-2pm on May 7, 2013, Tuesday
Date: Wed, 1 May 2013 15:32:22 -0500
From: Dawn Petraitis - NOAA Federal <dawn.petraitis@noaa.gov>
To: yan.xue <yan.xue@noaa.gov>

Hi Yan,
I have an update on the TAO service cruises. The ship went completely dark en route to Panama for fuel before departing on the second cruise. They encountered more problems after arrival in Panama. **The bottom line is that the ship had a major engine casualty and will be in dry dock for at least one month. Not good news for restoring the rest of the 95w and 110w lines in a timely manner.** Hopefully I'll have more info before the briefing next week.

Thanks,
Dawn

NINO3.4 Heat Budget



- **SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was near zero in Apr 2013.**

- **All the advection terms, as well as thermodynamical term (Qq) were positive.**

- **The RHS and dT/dt had large differences in Apr 2013.**

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.

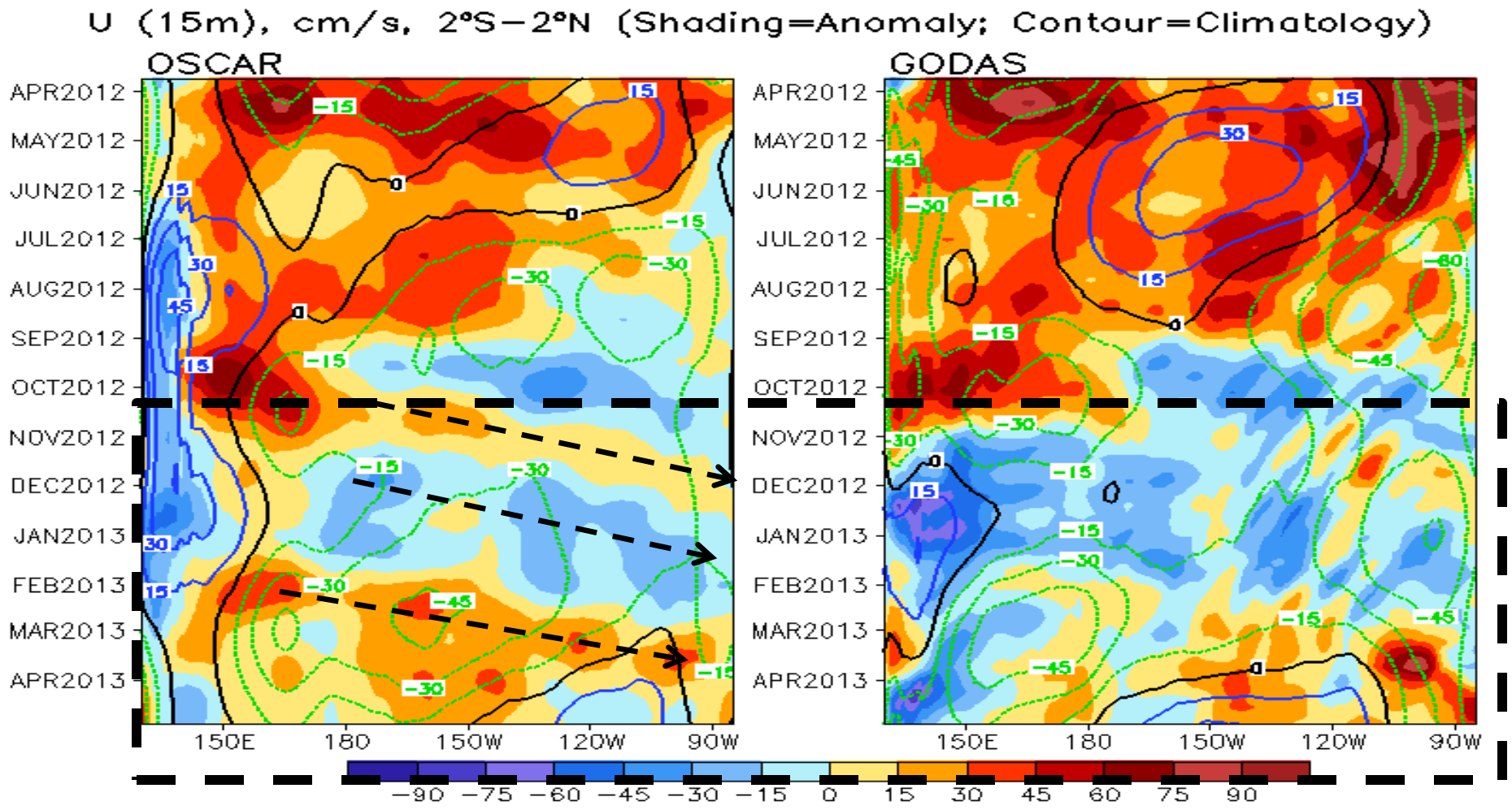
Qu: Zonal advection; Qv: Meridional advection;

Qw: Vertical entrainment; Qzz: Vertical diffusion

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

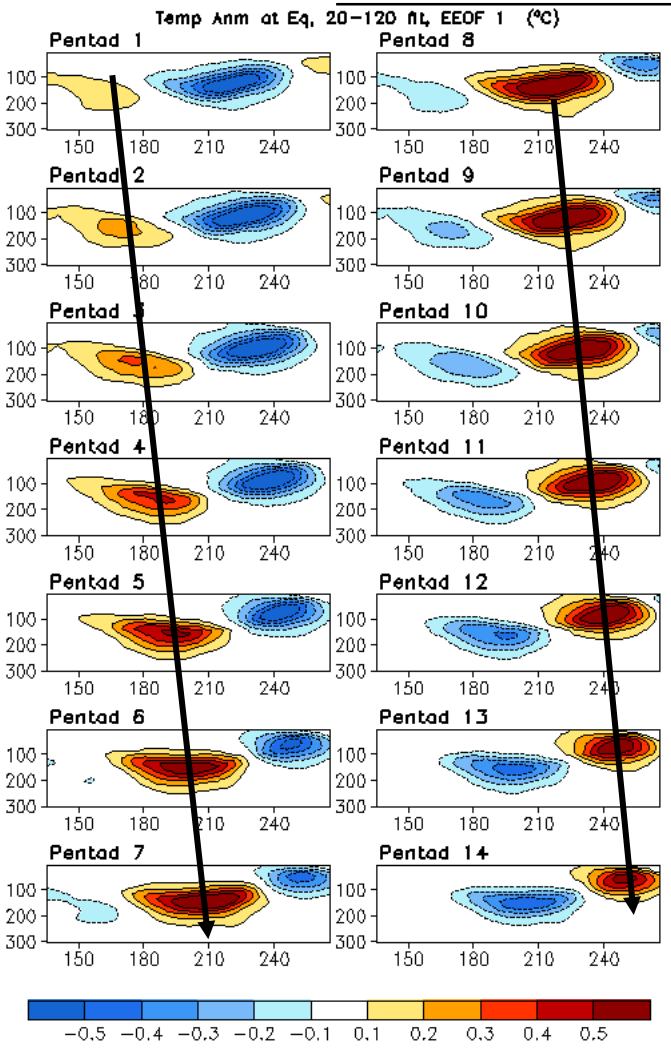
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

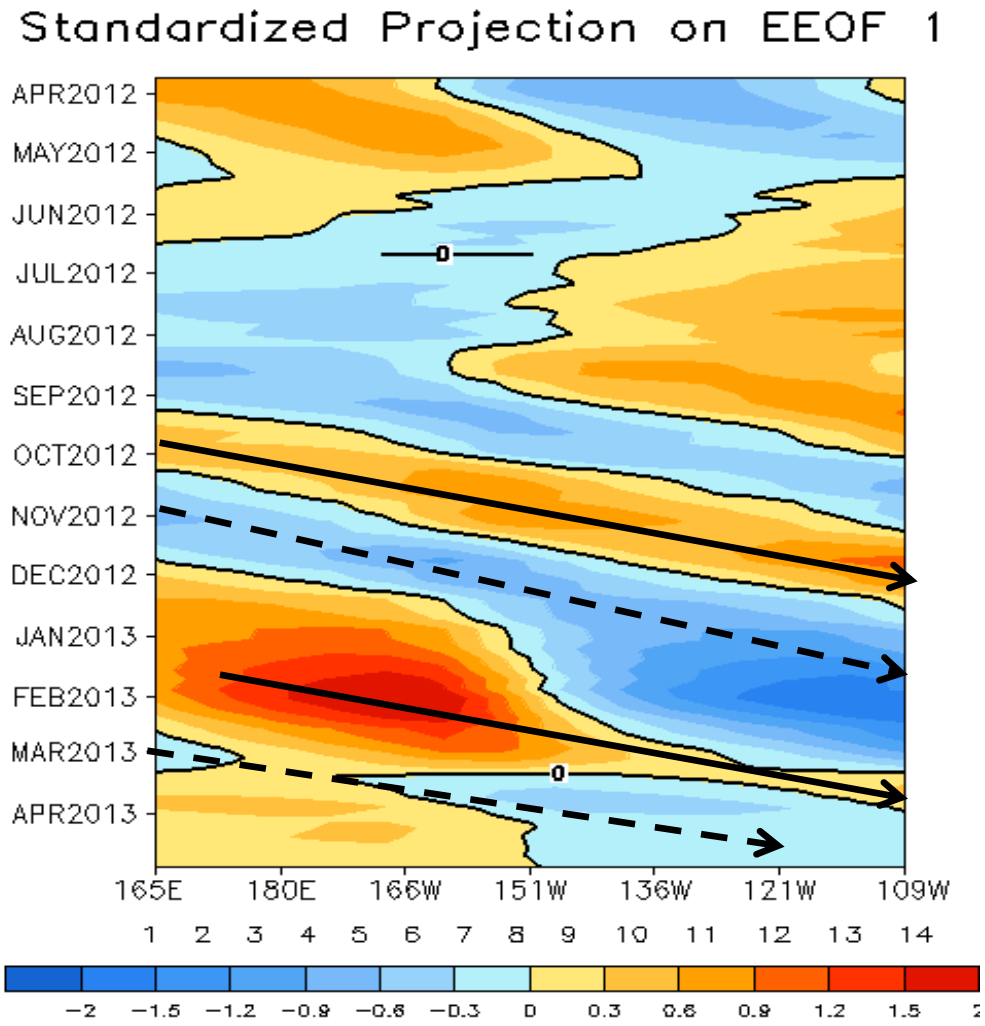
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **In the last three months, eastward anomaly current was observed, and weakened in Apr 2013. That seems consistent with the Kelvin wave activities (next slide).**
- **Some differences were noted for both anomaly and climatology between OSCAR and GODAS.**

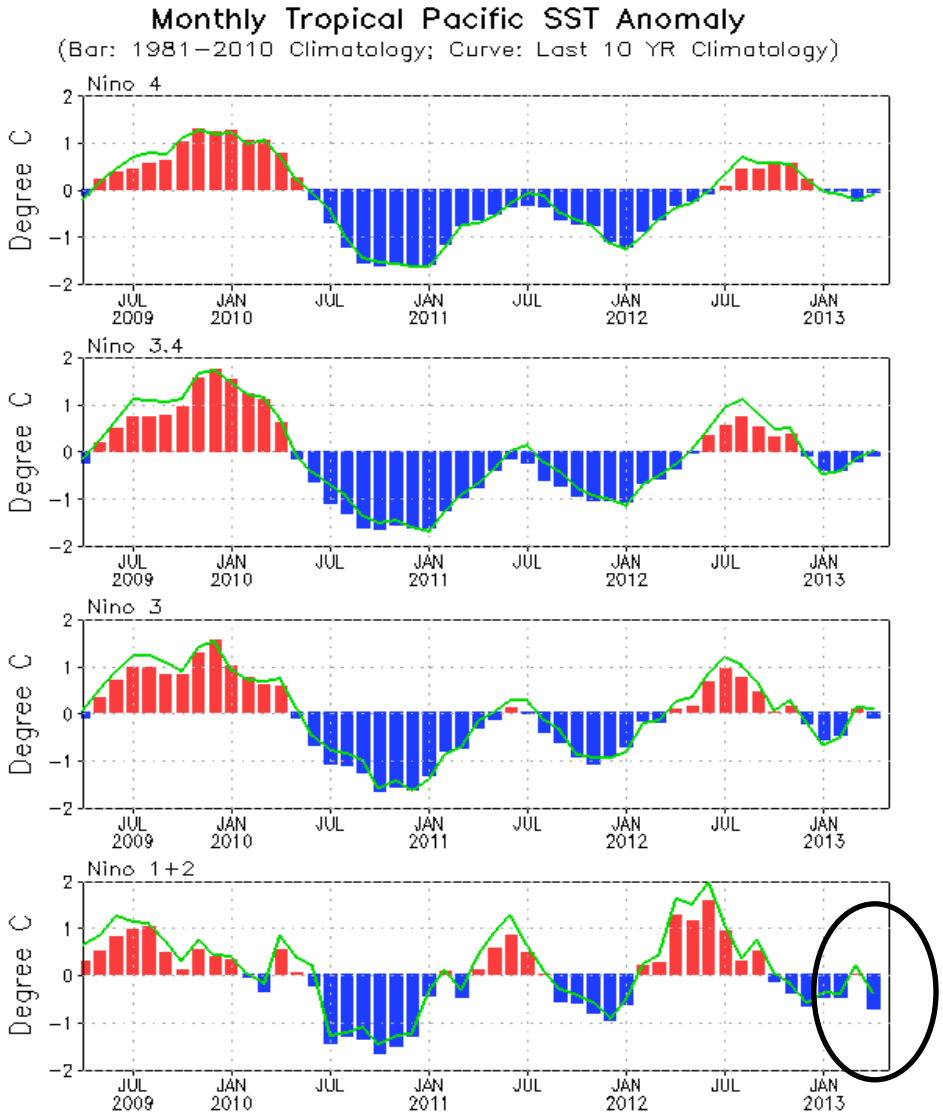
Oceanic Kelvin Wave Indices

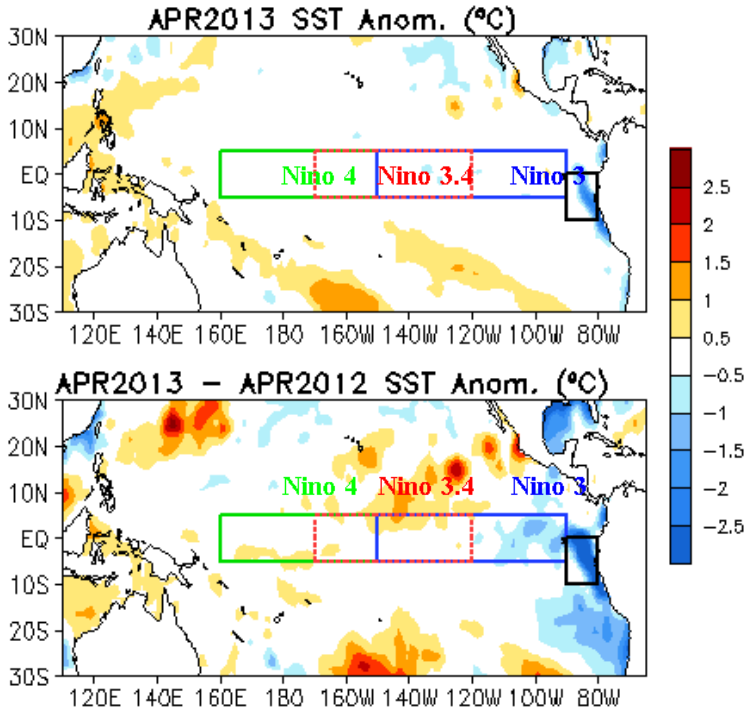




- Oceanic Kelvin wave indices are defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF 1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).

Evolution of Pacific NINO SST Indices

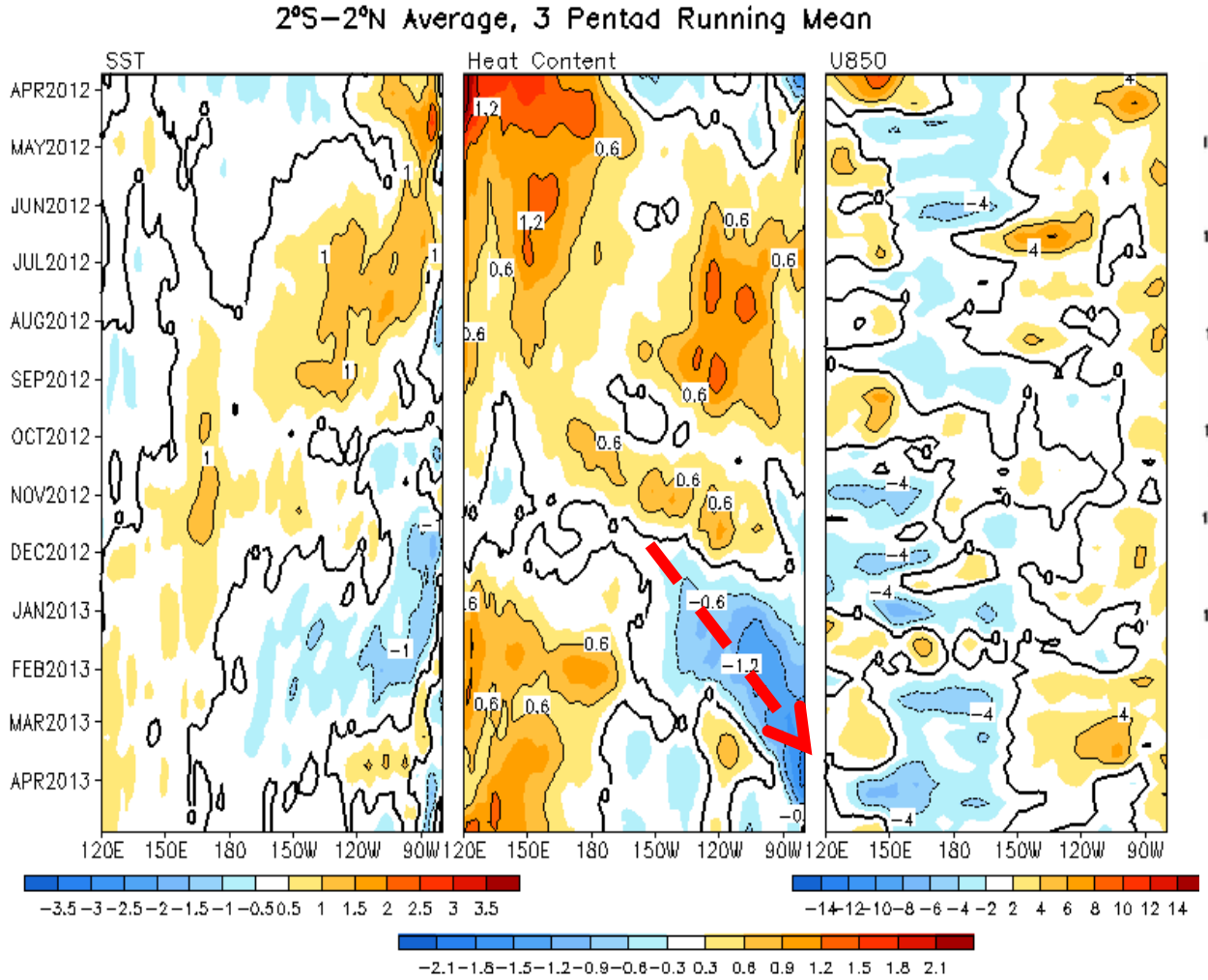




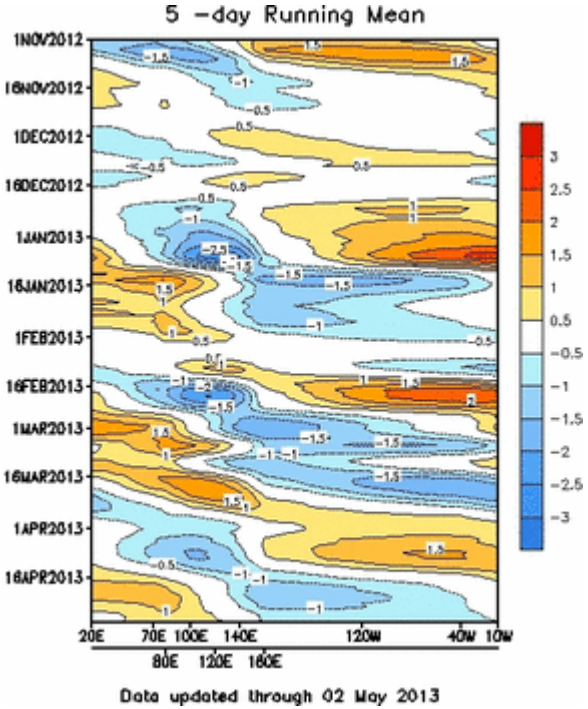
- **All Nino indices were negative and NINO 3.4 = -0.15°C.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

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

Equatorial Pacific SST (ºC), HC300 (ºC), u850 (m/s) and OLR(W/m²)Anomalies



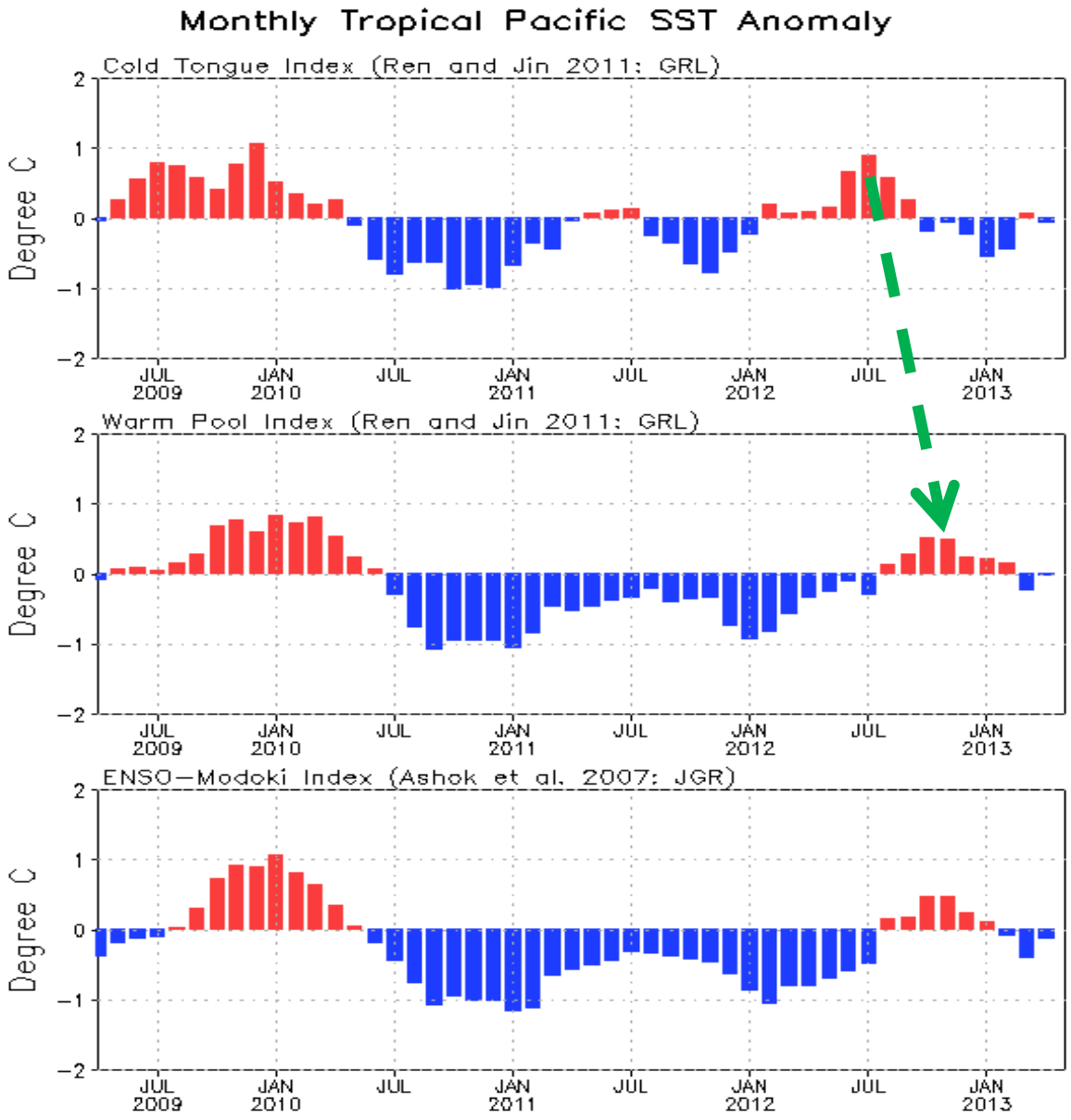
CPC MJO Indices



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

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.

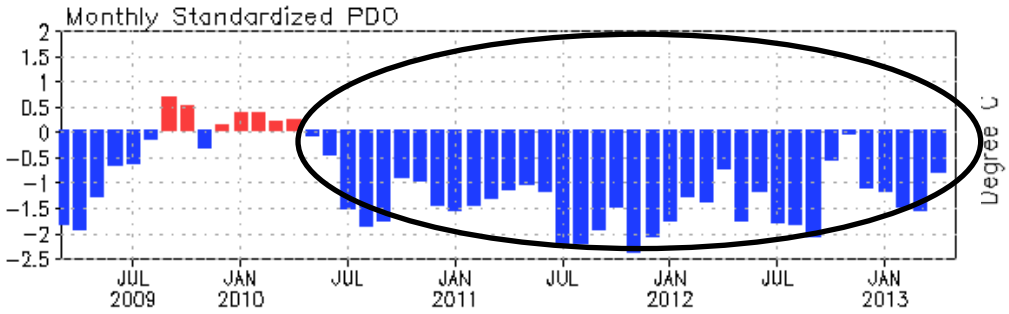
Evolution of Pacific NINO SST Indices

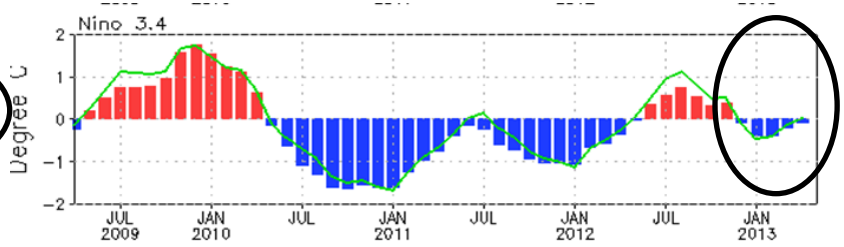


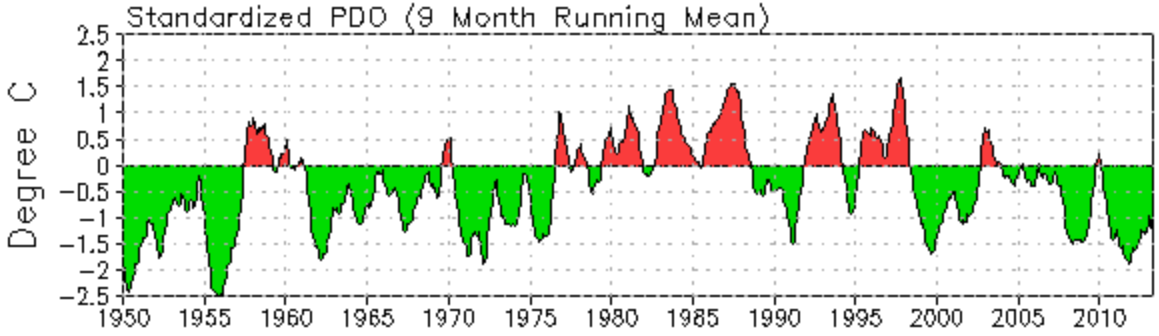
- **Positive SSTA in 2012 propagated from east to western Pacific.**
- **Both Cold Tongue, Warm Pool, and ENSO-Modoki indices were slightly negative, consistent with overall small SSTA in the equatorial Pacific.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

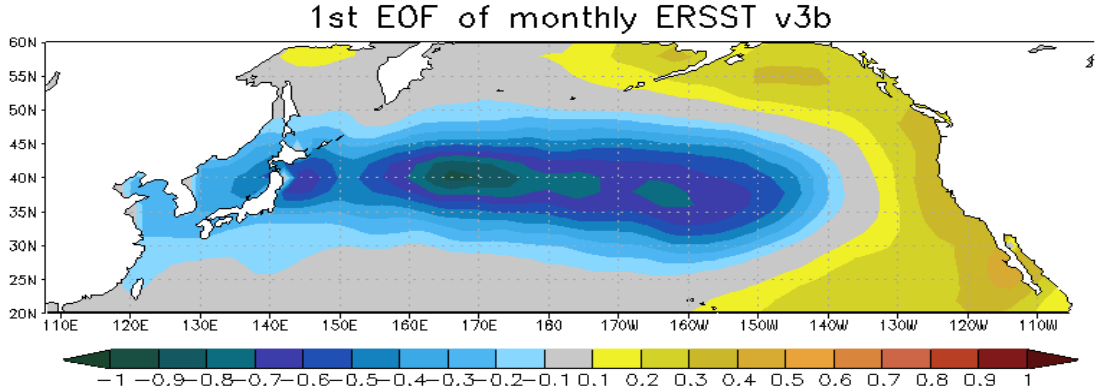
North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index









- Negative PDO phase since May 2010 has persisted for 3 years (36 months) now, and the PDO index weakened in Apr 2013 with PDO index=-0.8.

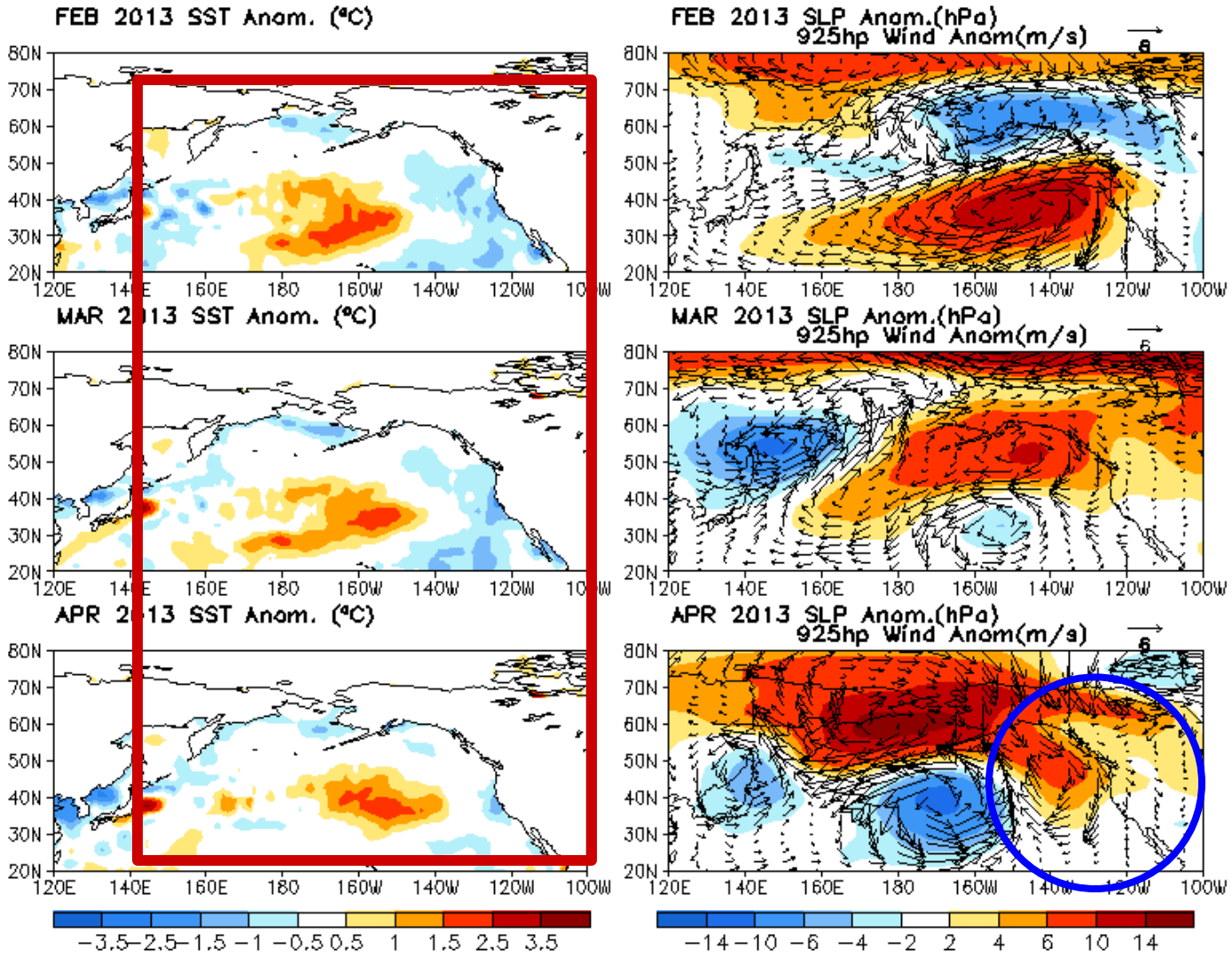
- The apparent connection between Nino3.4 and PDO indices suggest connections between tropics and extra-tropics.

- 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.

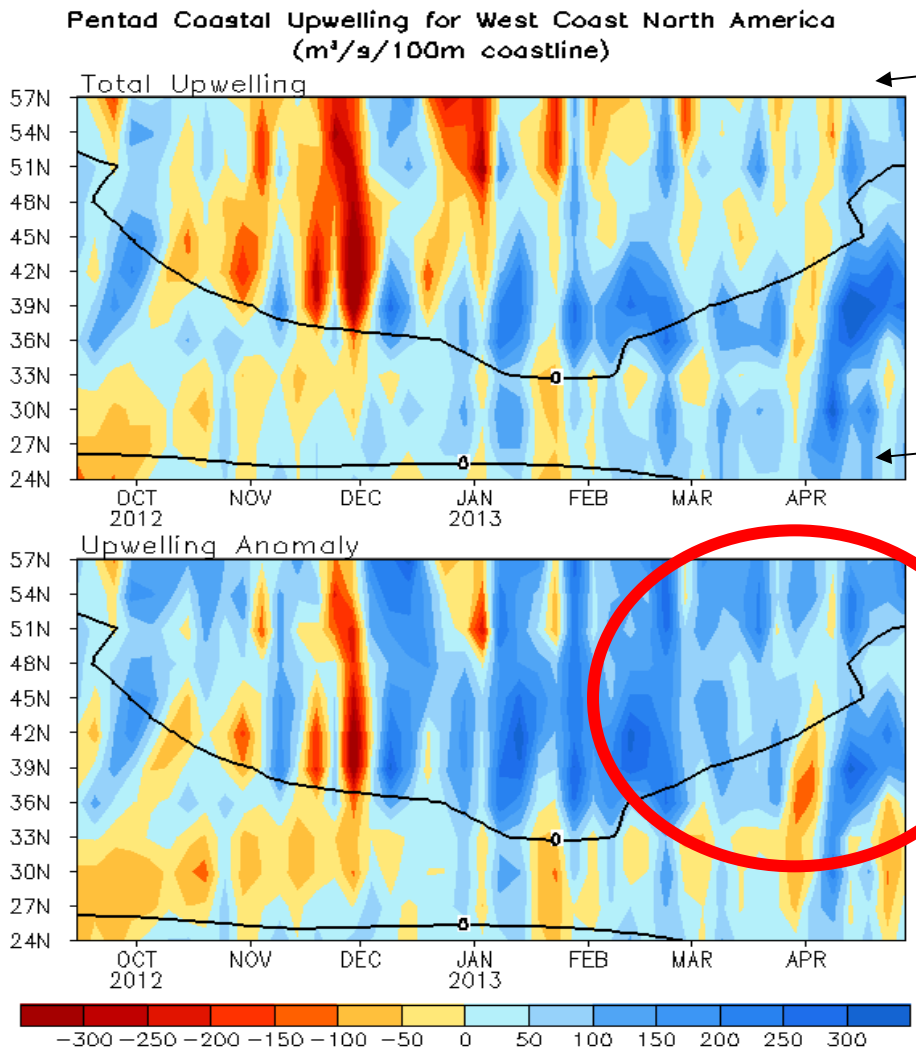
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

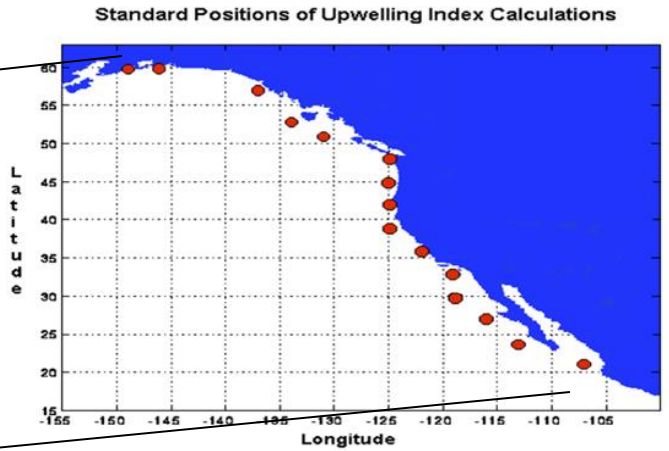
Last Three Month SST, SLP and 925hp Wind Anom.



- **Negative phase of PDO associated SSTA persisted.**
- **Anomalous anti-cyclone was observed near the high-latitudes of N. Pacific in Apr 2013.**

North America Western Coastal Upwelling





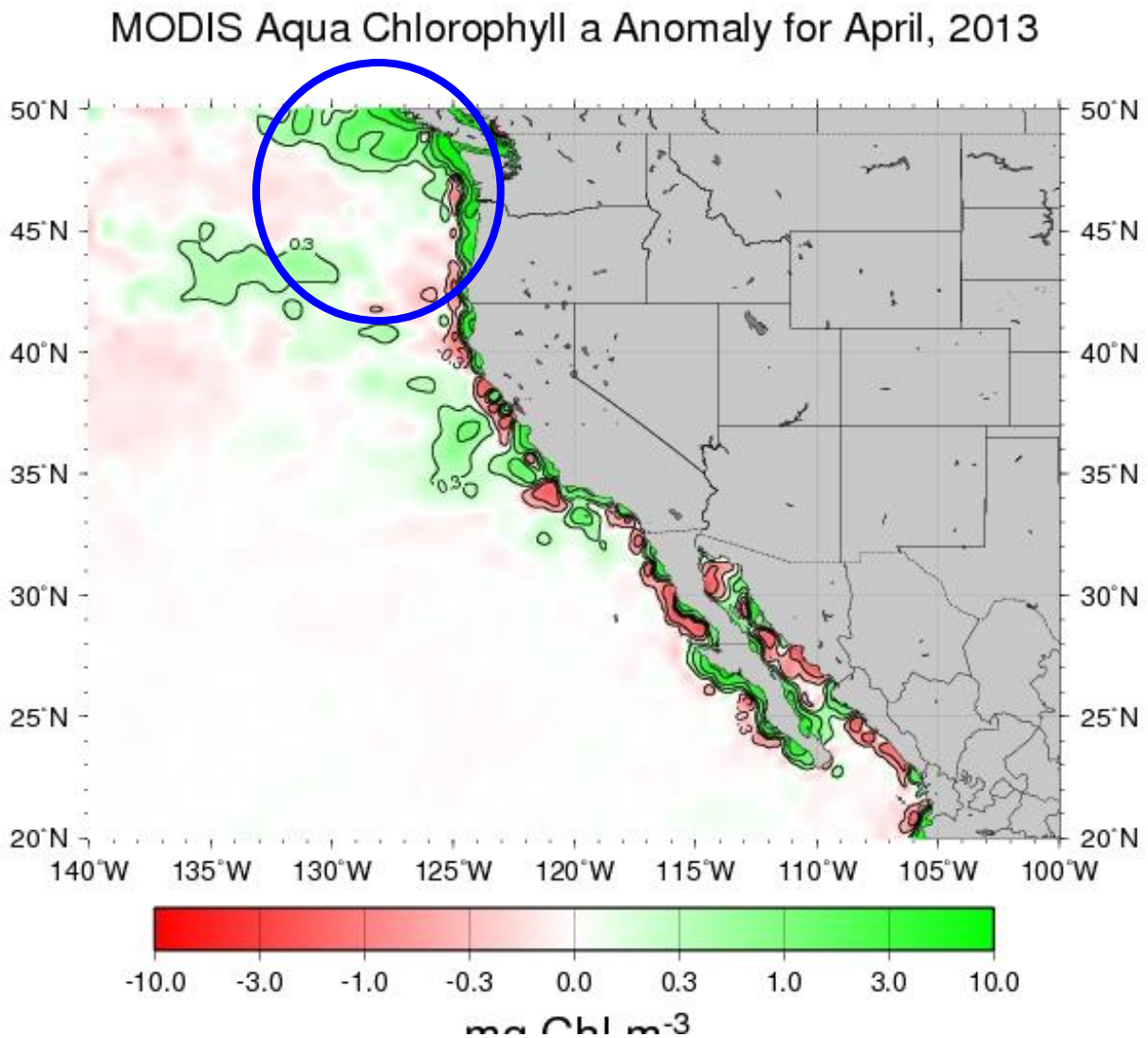
- **Consisted with the anomalous northerly wind, upwelling was enhanced in low latitudes and downwelling was suppressed in 48-57N.**

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

- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

Monthly Chlorophyll Anomaly

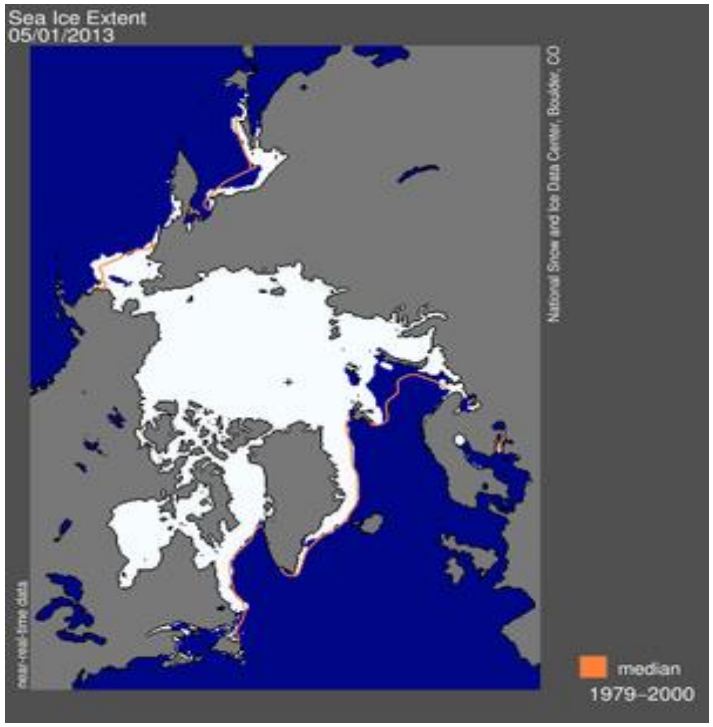
http://coastwatch.pfel.noaa.gov/FAST

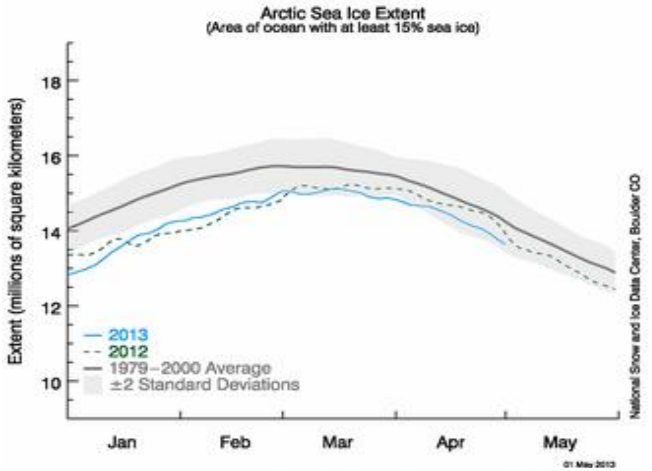


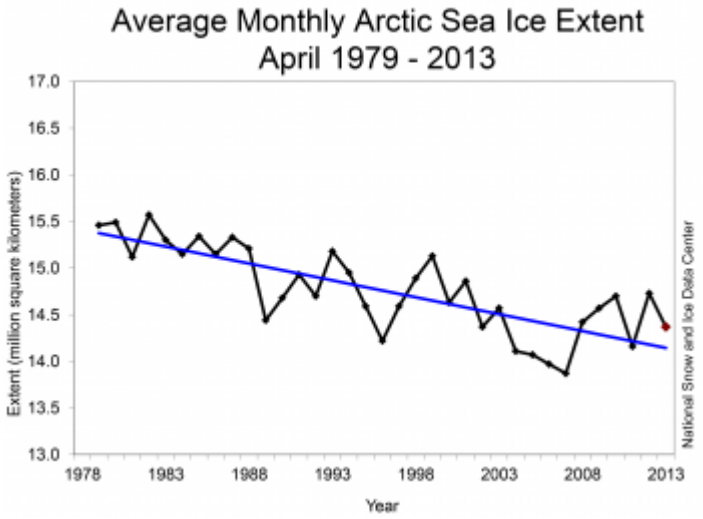
- **Positive chlorophyll anomaly in 45-50N increased in Apr 2013, consistent with suppressed downwelling.**

Arctic Sea Ice

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



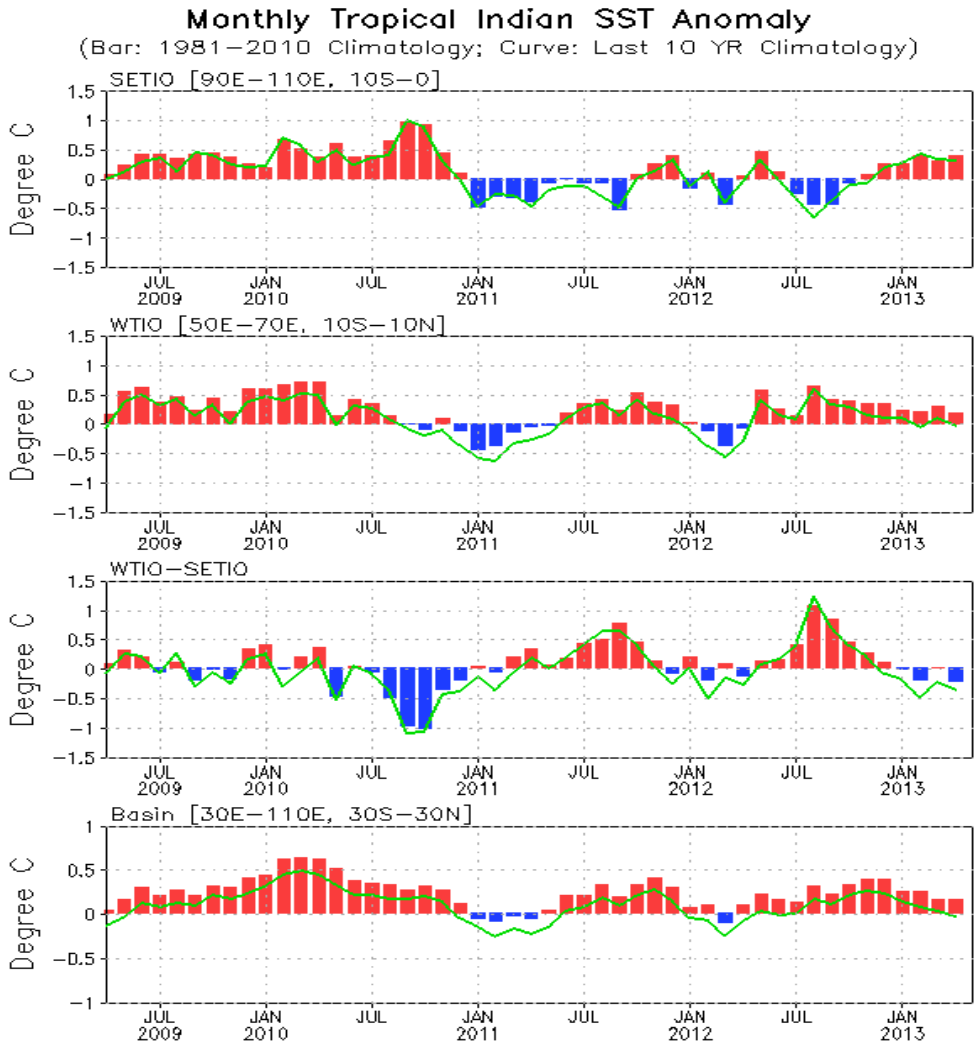


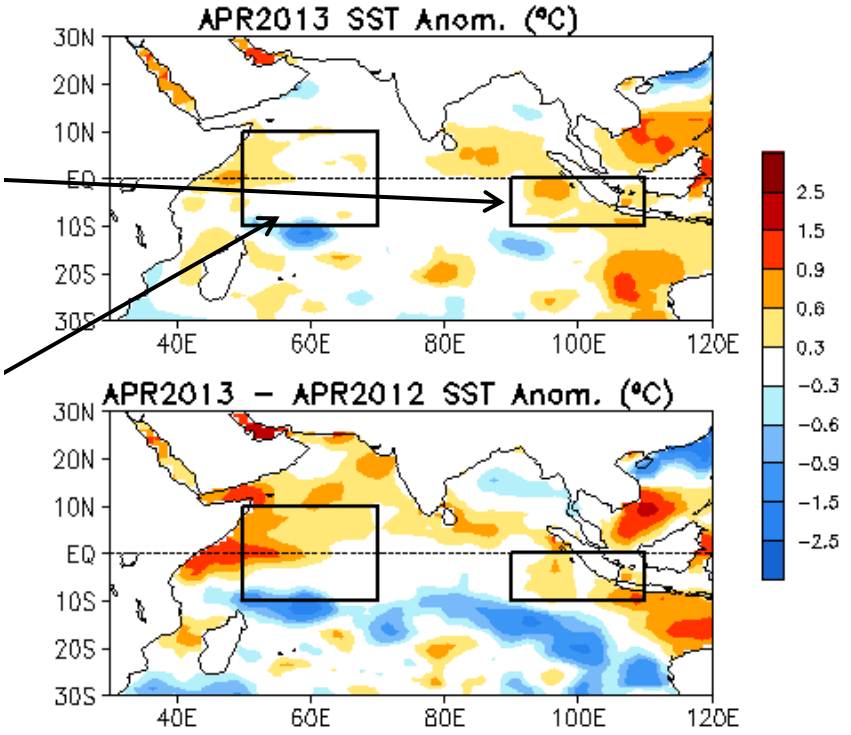


- **Averaged sea ice extent for Apr 2013 was well below-normal (near -2 standard deviations).**
- **Averaged Arctic sea ice extent for April 2013 was the seventh lowest for the month in the satellite record.**
- **Through 2013, the linear rate of decline for April ice extent is -2.3% per decade relative to the 1979 to 2000 average.**

Indian Ocean

Evolution of Indian Ocean SST Indices





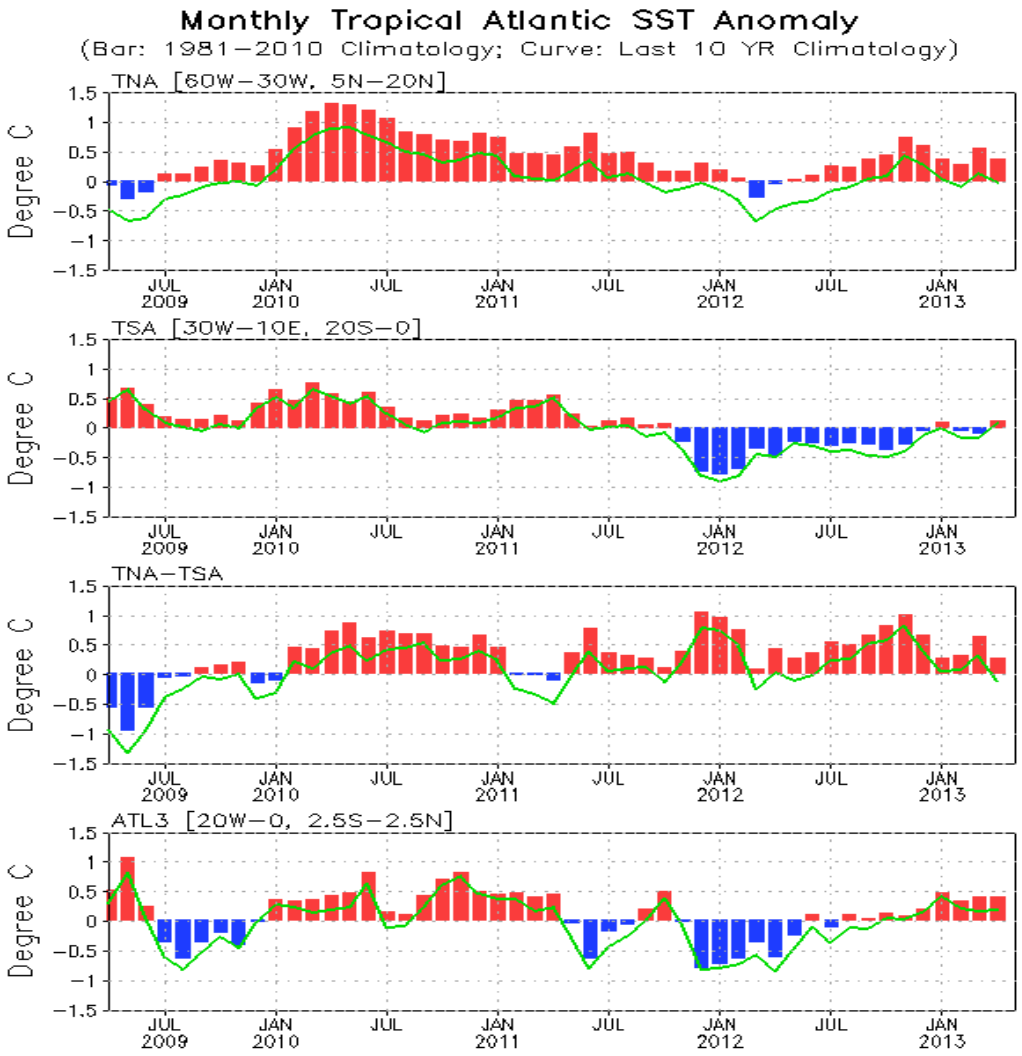
- DMI was small negative in Apr 2013.

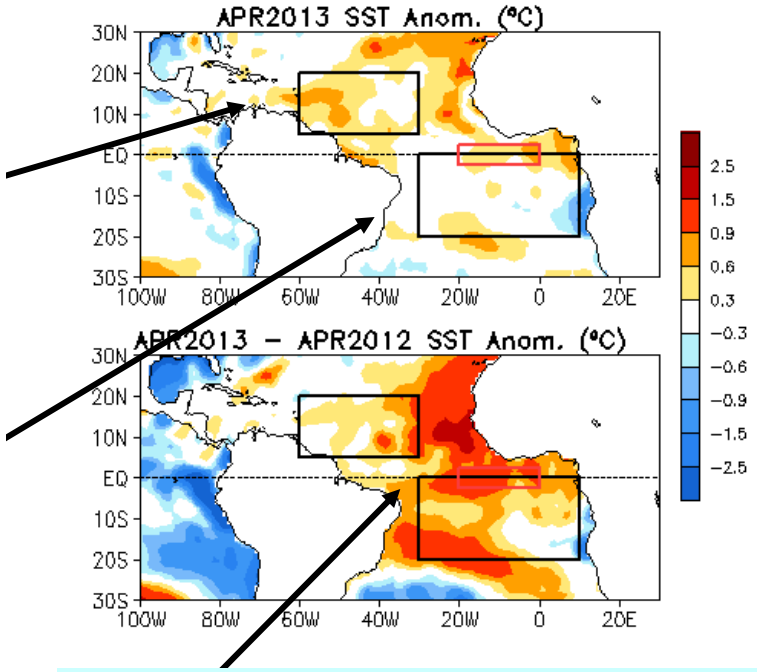
- The basin mean SST was above-normal.

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

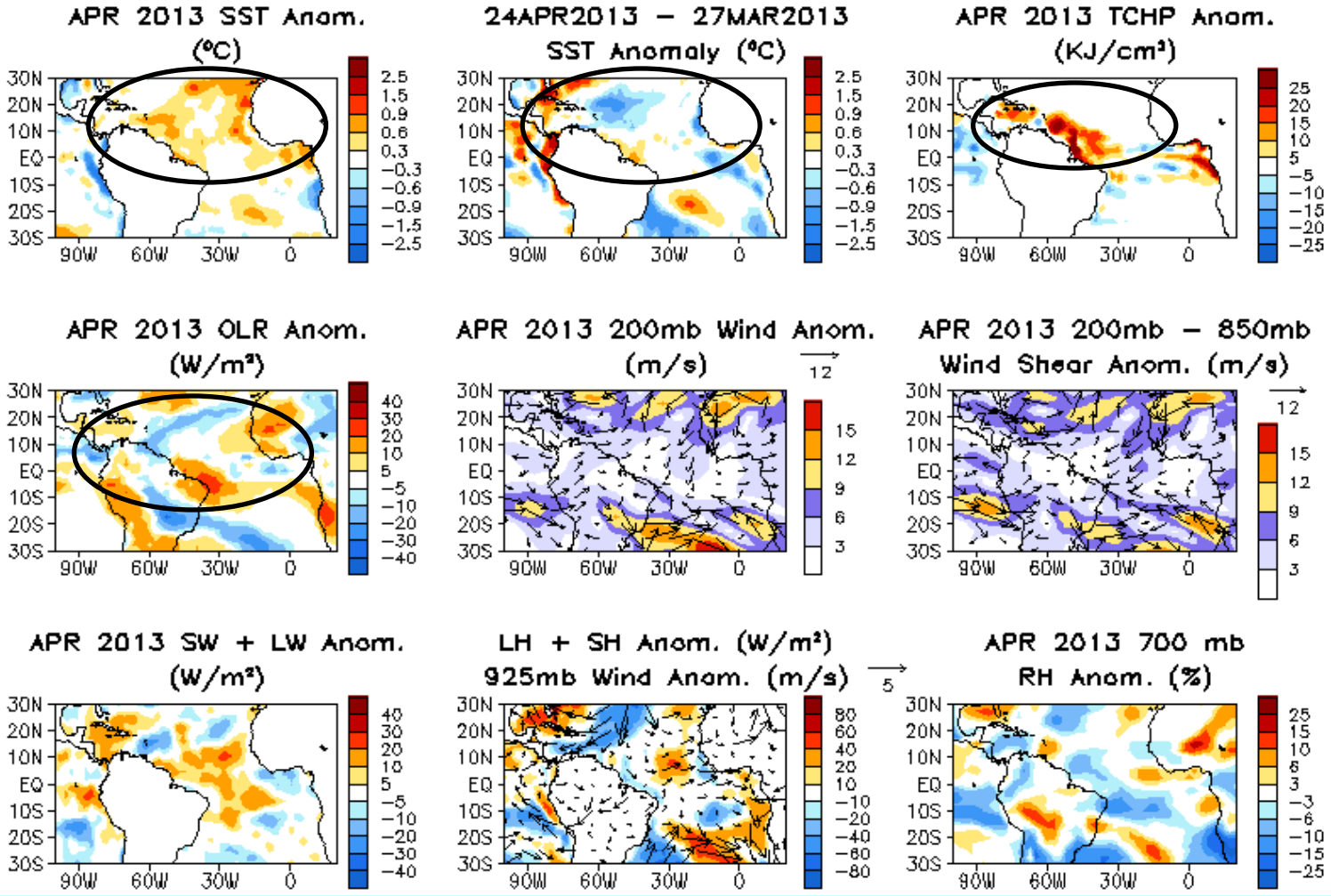




- **Basin-wide SST was above-normal in Apr 2013.**
- **SSTA in the tropical N. Atlantic (TNA) was positive since May 2012.**
- **Meridional Gradient Mode index (TNA-TSA) was positive since May 2011.**
- **ATL3 SSTA was positive since Aug 2012.**

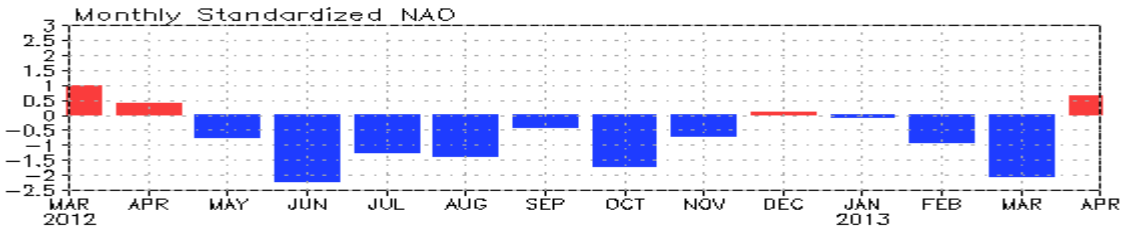
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between 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.

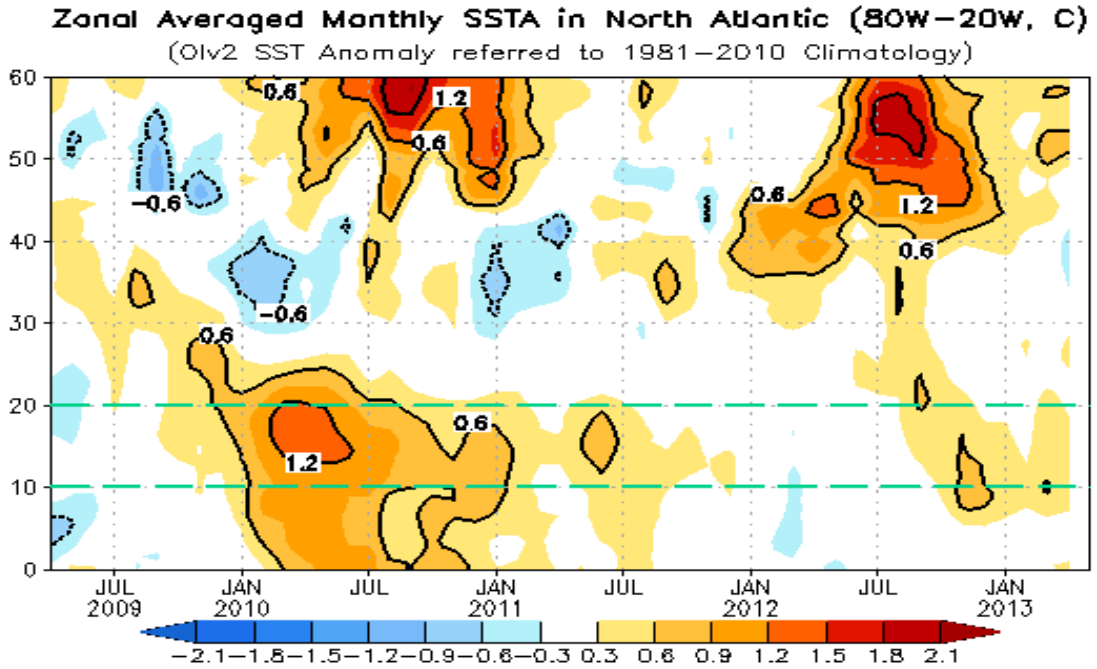
Tropical Atlantic:

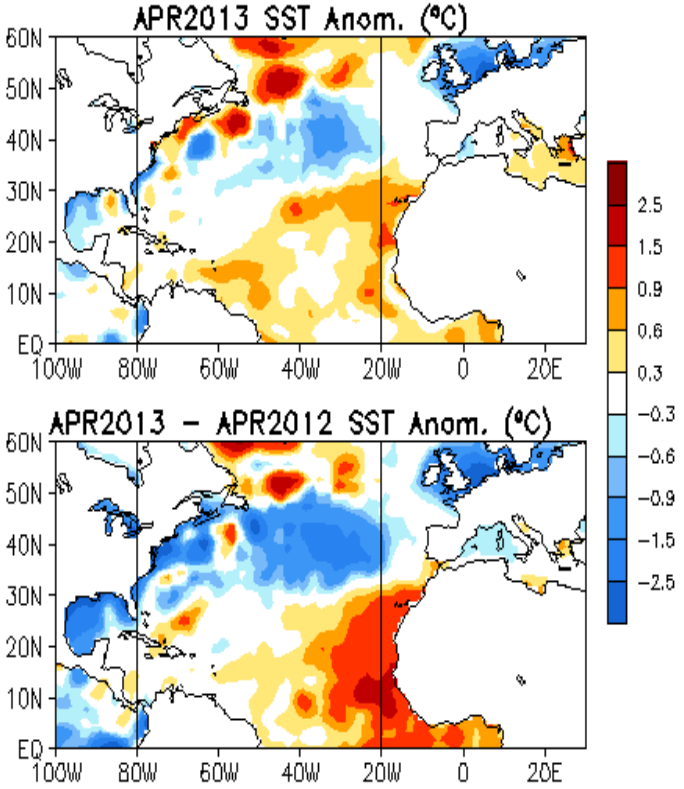


- **Above-normal SST weakened in the hurricane Main Development Region (MDR).**
- **Both suppressed and enhanced convection was presented in the tropical N. Atlantic.**
- **TCHP was positive and mainly in the NW Atlantic Ocean.**

NAO and SST Anomaly in North Atlantic



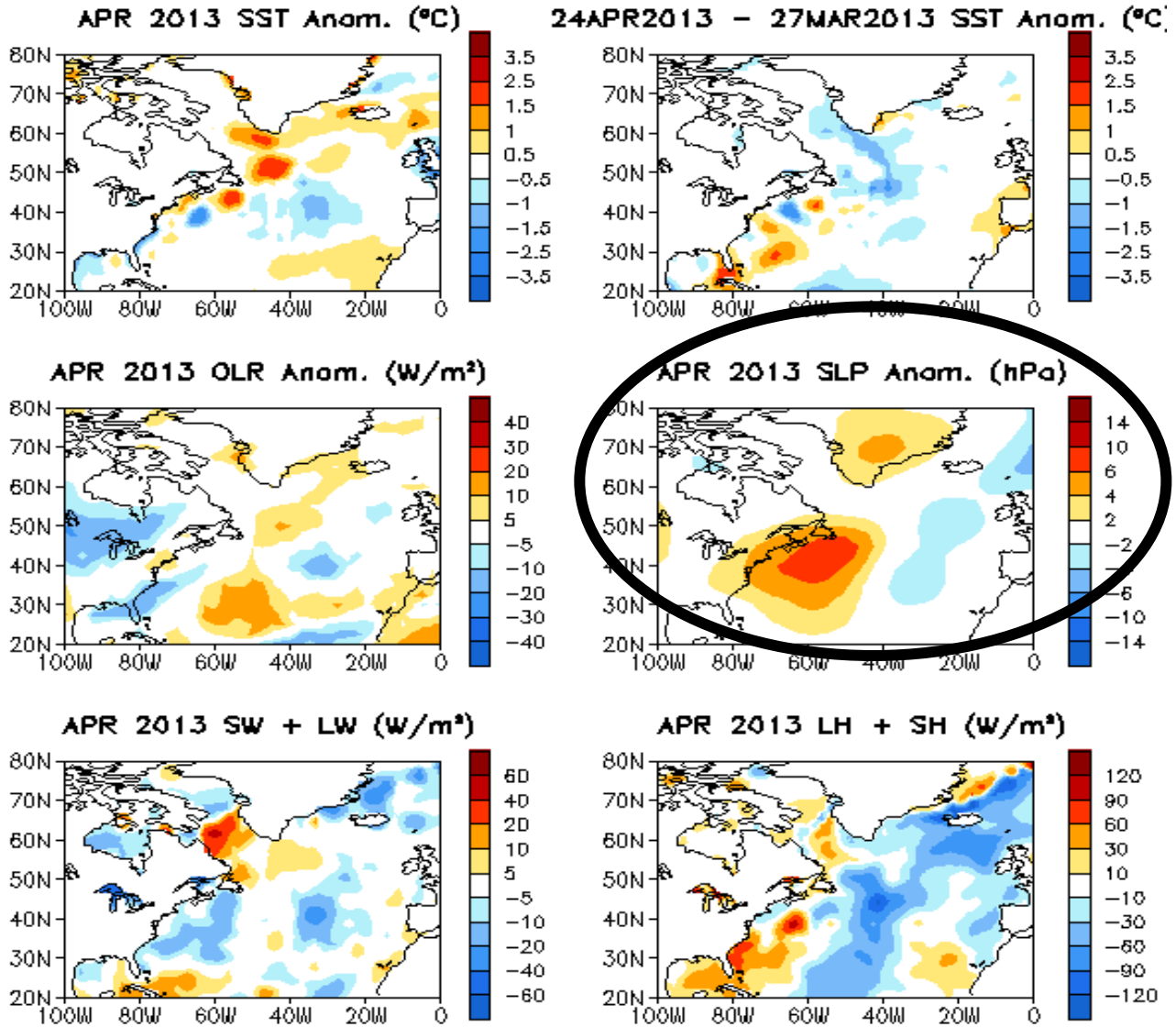




-NAO switched from negative to positive phase in Apr 2013, with NAO index = 0.6.

- High-latitude North Atlantic SSTA is generally related to NAO index (negative NAO results in SST warming and positive NAO leads to SST cooling) (Hu et al. 2011: *J. Climate*, 24(22)).

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.



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

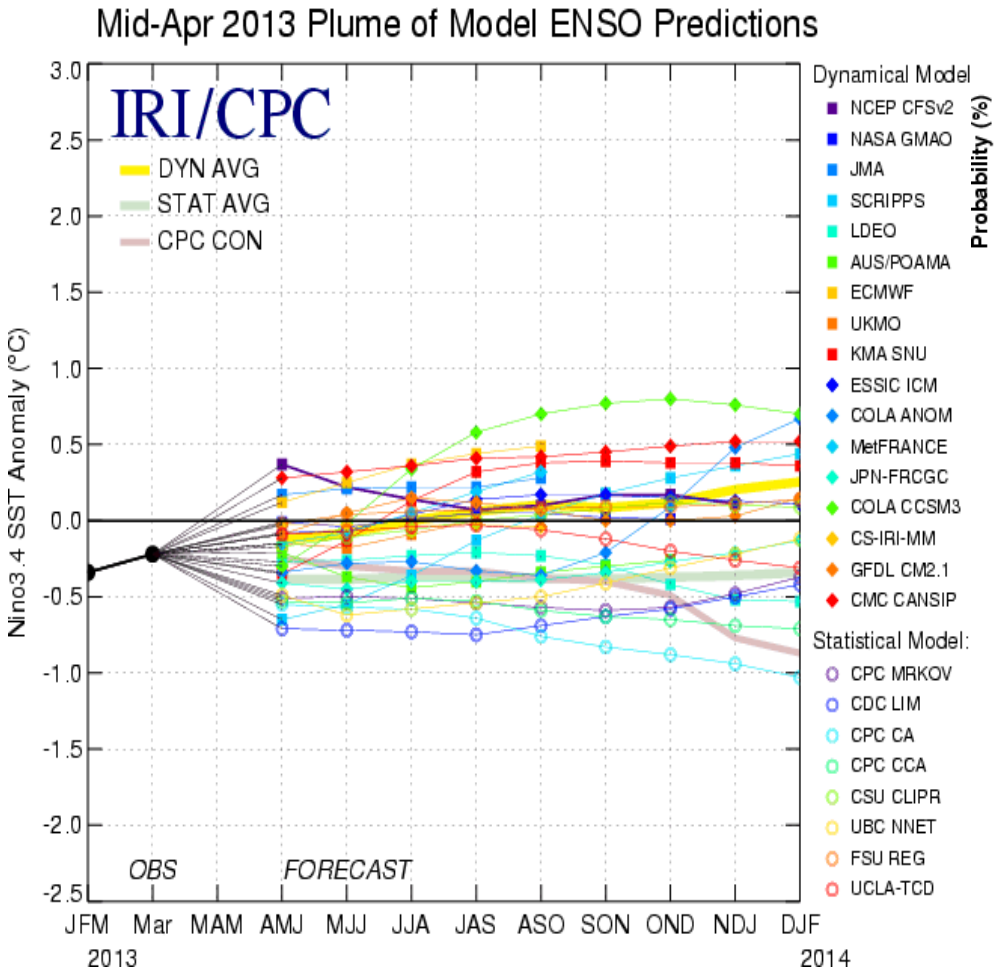
- **N-S SLP gradient in Apr 2013 reduced significantly, compared with Mar 2013, consistent with weakening of negative phase of NAO.**

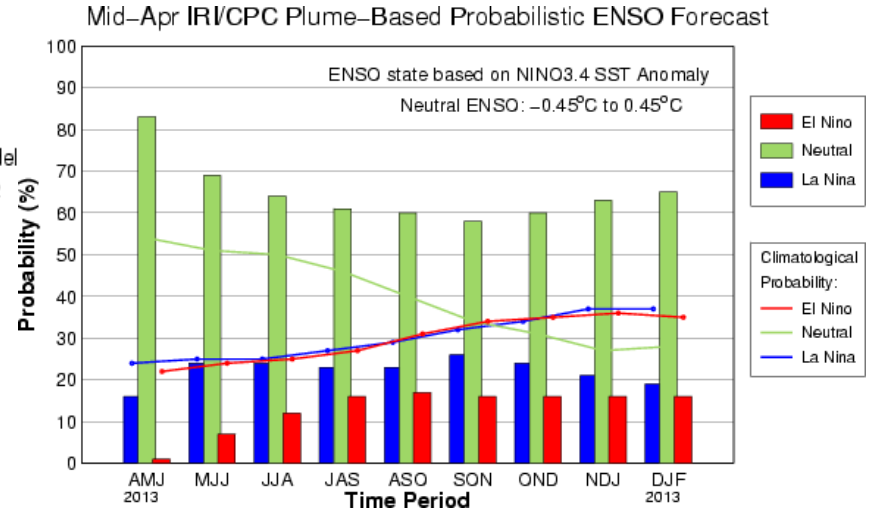
- **E-W SLP gradient presented in Apr 2013.**

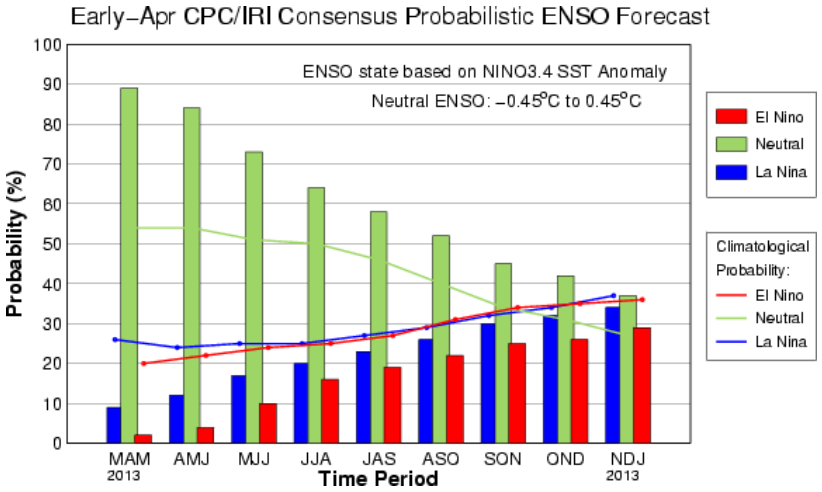
Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

Global SST Predictions

IRI/CPC NINO3.4 Forecast Plume

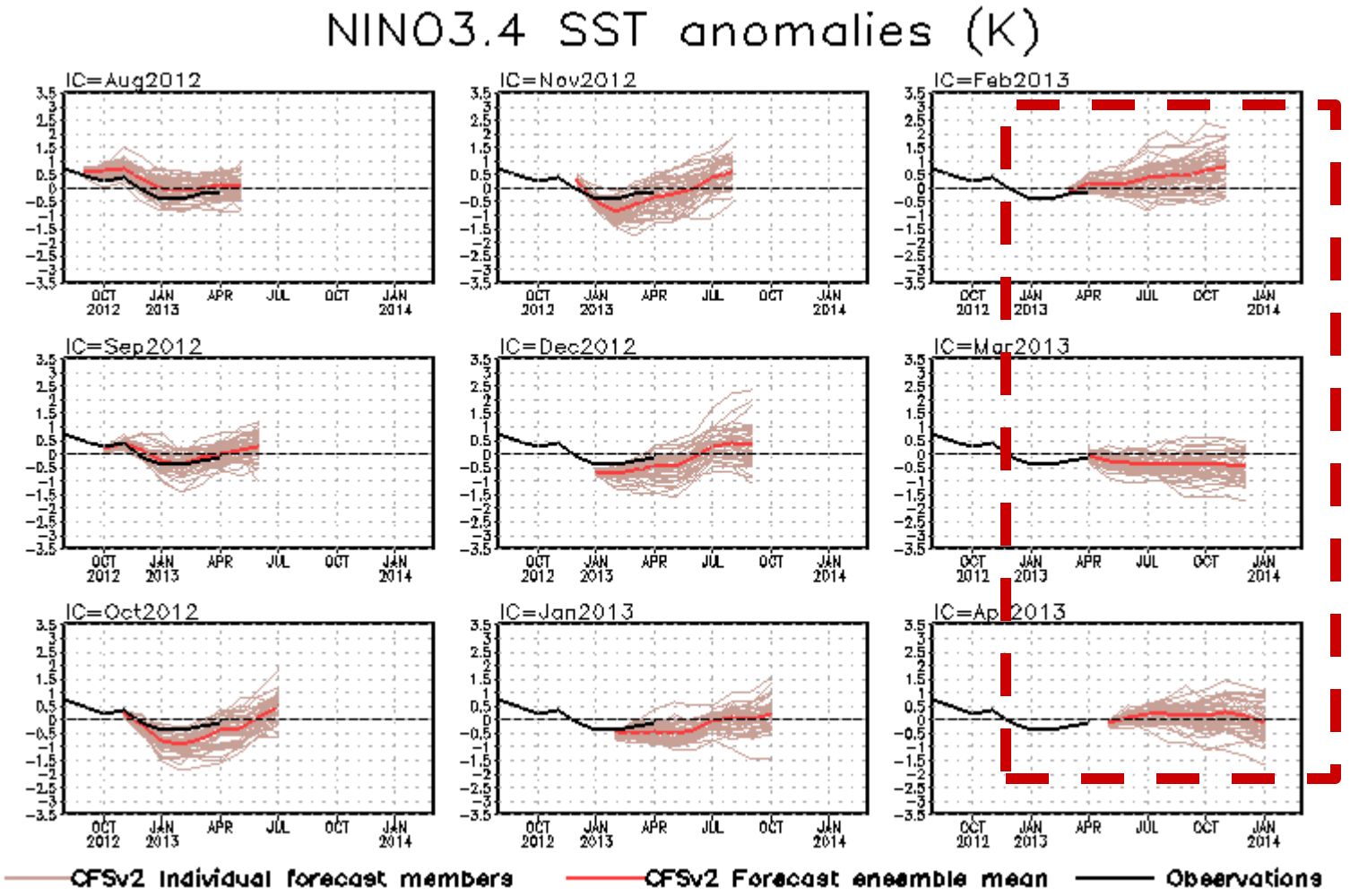






- **Majority of the models predicted ENSO-neutral in the Northern Hemisphere spring-summer.**
- **The consensus forecast favors ENSO-neutral conditions in the spring and summer.**

NCEP CFSv2 NINO3.4 Forecast

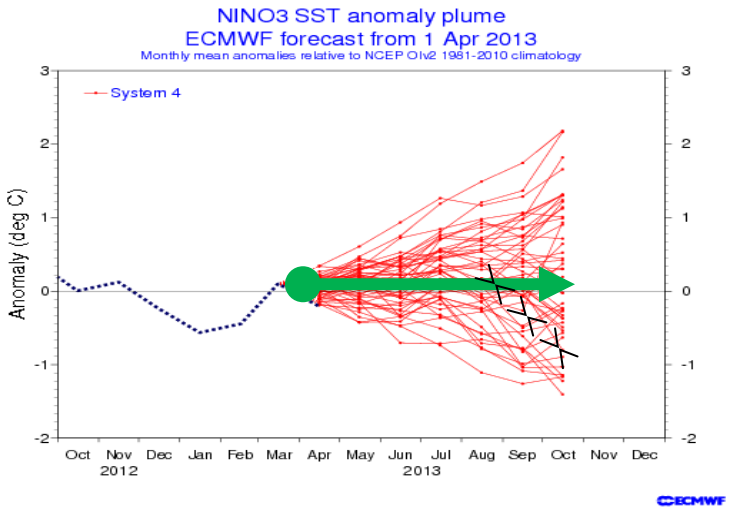


- **The Nino3.4 predictions of CFSv2 shifted from positive SSTA in summer-autumn with IC in Feb 2013 to negative with IC in Mar 2013, then near normal with IC in Apr 2013, may imply the impact of short-term fluctuation and challenge of ENSO prediction with IC in spring.**

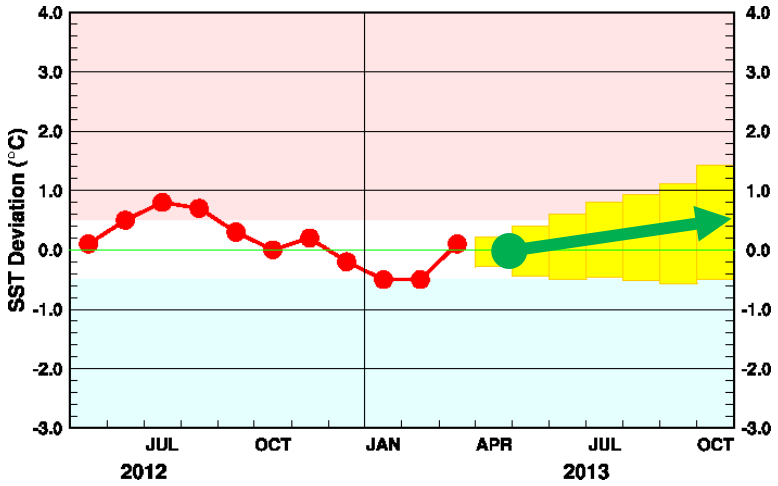
(Wang, W., M. Chen, A. Kumar, and Y. Xue, 2011: How important is intraseasonal surface wind variability to real-time ENSO prediction? Geophys. Res. Lett., 38, L13705. DOI: 10.1029/2011GL047684.)

Individual Models: divided results

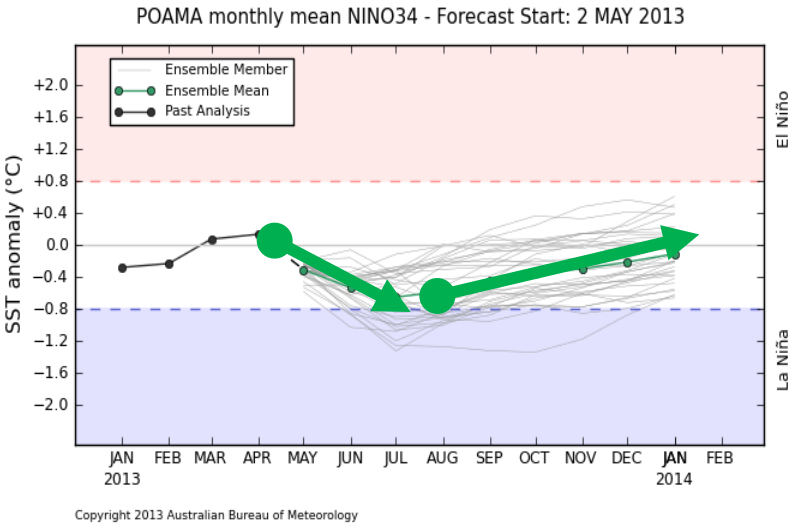
ECMWF: Nino3, IC=01Apr2013



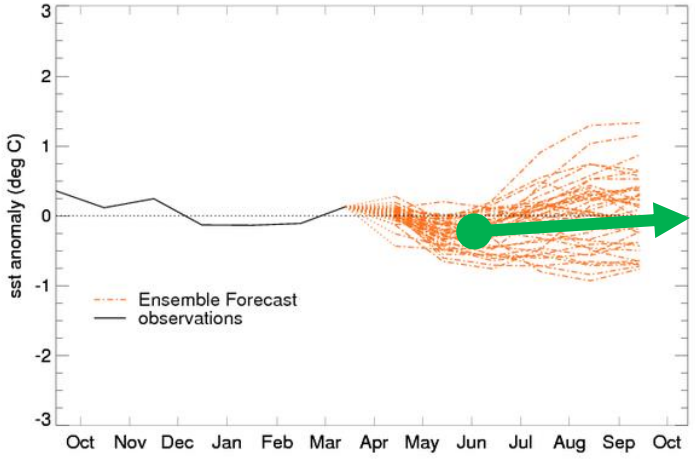
JMA: Nino3, IC=Apr2013



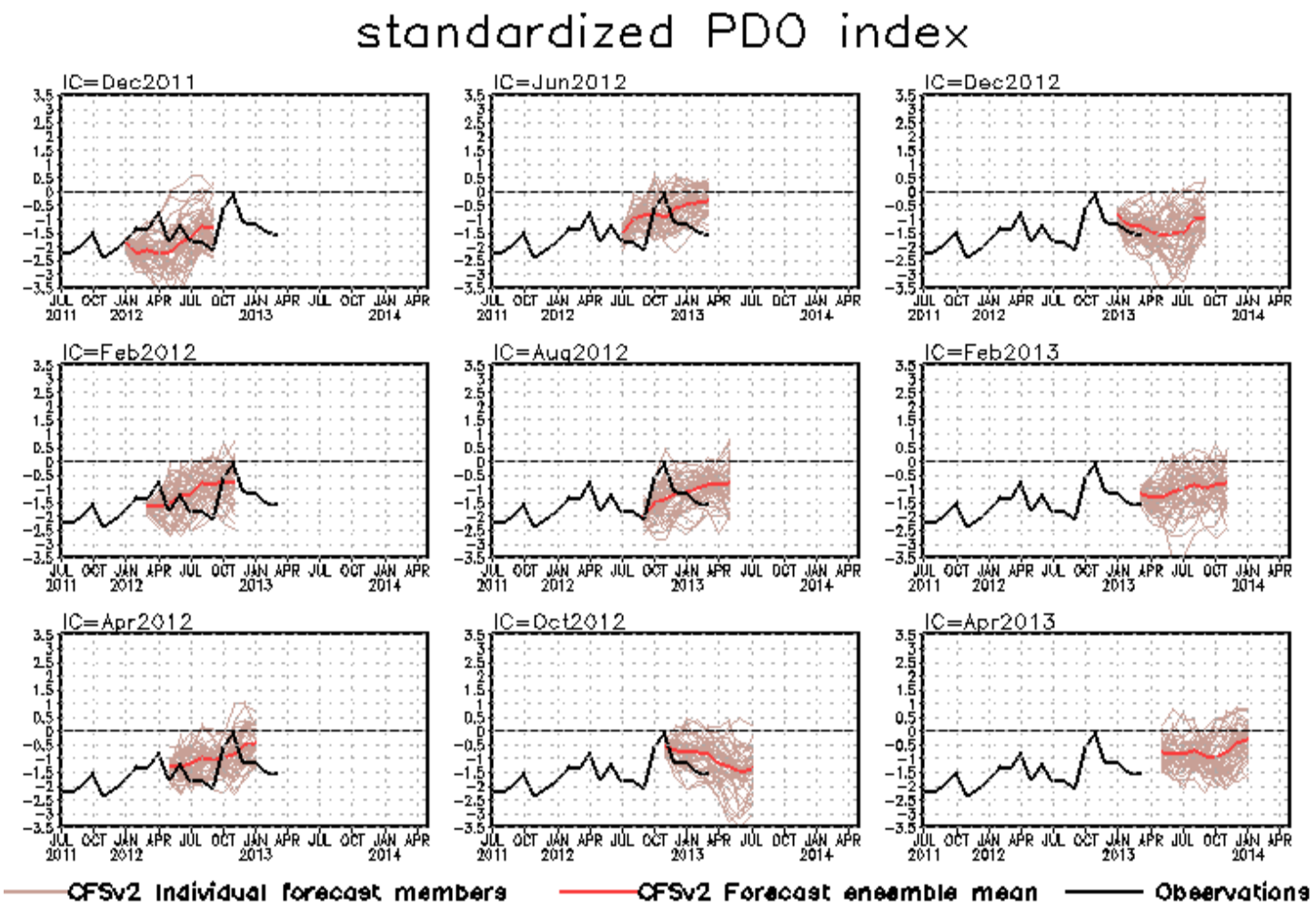
Australia: Nino3.4, IC=02May2013



UKMO: Nino3.4, IC=16Apr2013



NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

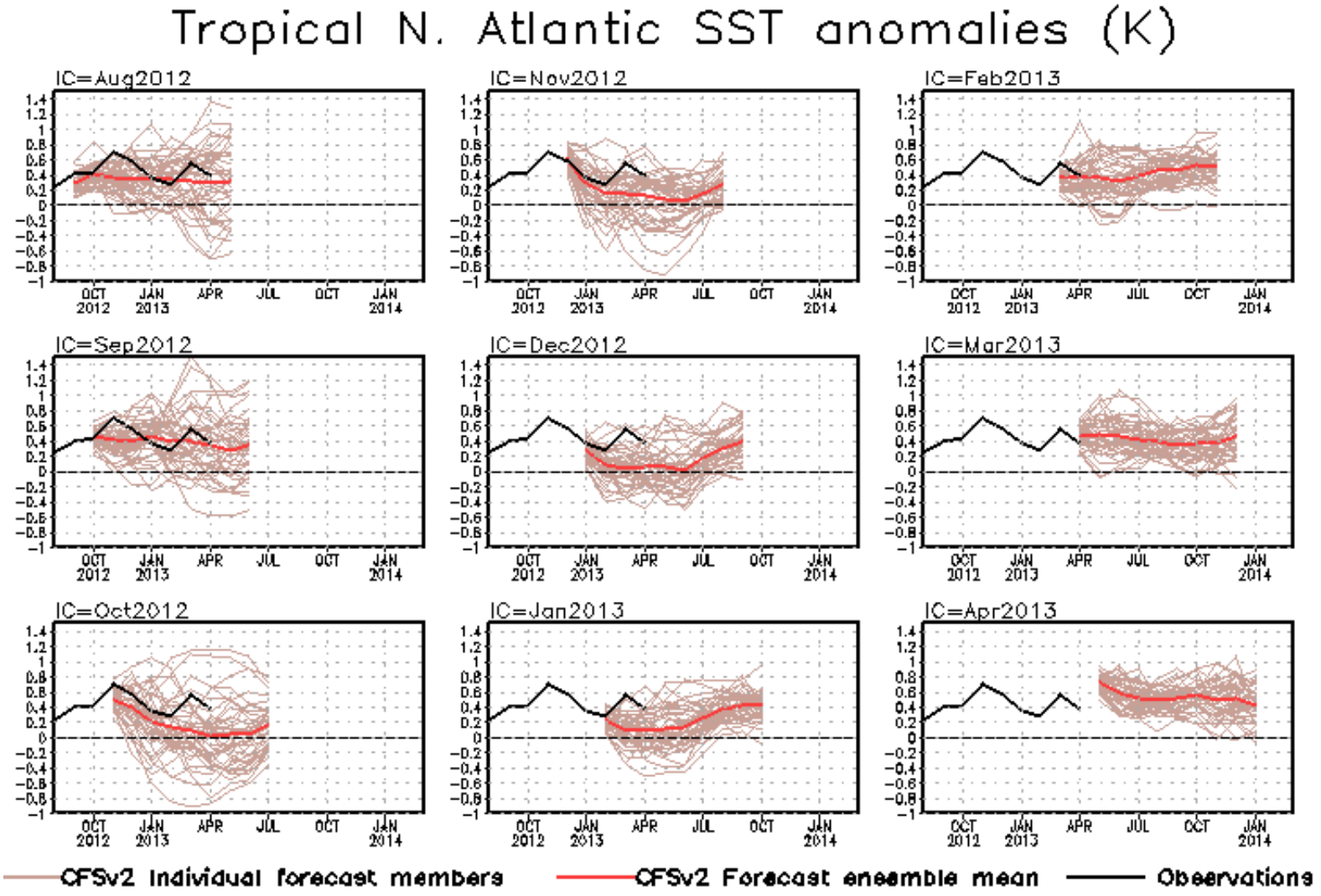


PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- Latest CFSv2 prediction suggests negative phase of PDO will persist through the coming summer and autumn.

NCEP CFSv2 Tropical North Atlantic SST Forecast

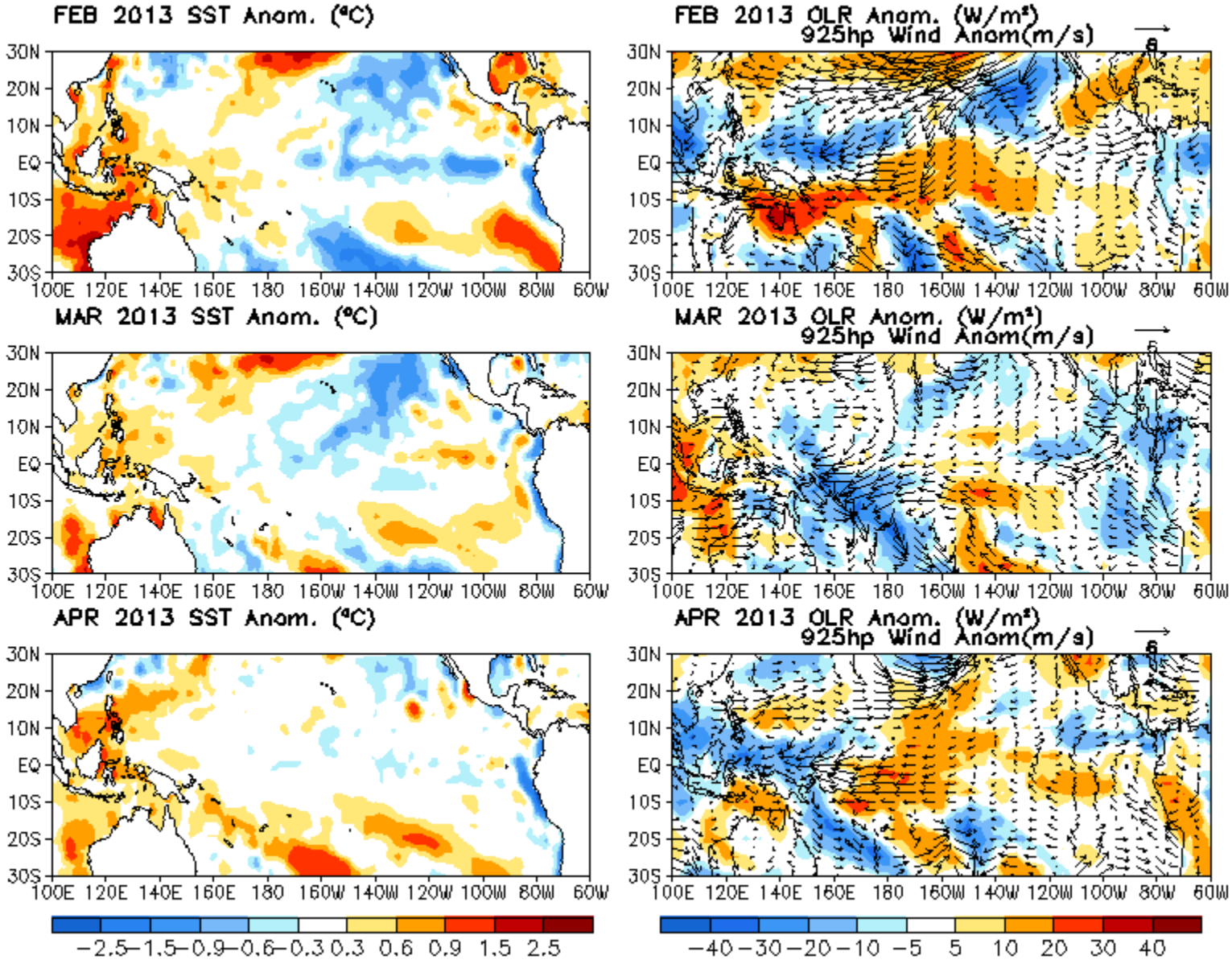


- **Latest CFSv2 prediction suggests that above-normal SST in the tropical N. Atlantic will continue in spring-autumn 2013 (hurricane season).**

Backup Slides

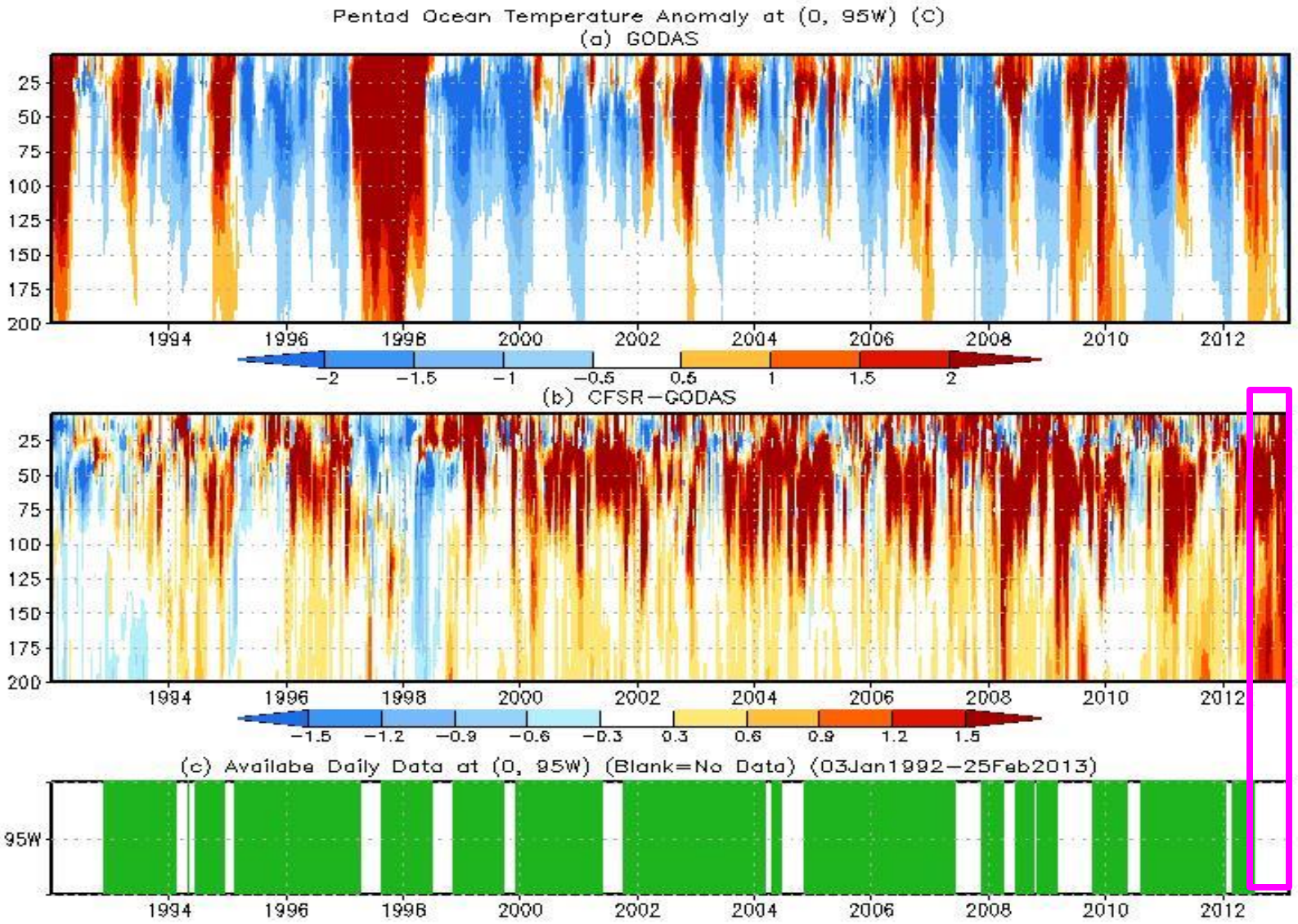
http://www.cpc.ncep.noaa.gov/products/GODAS/

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



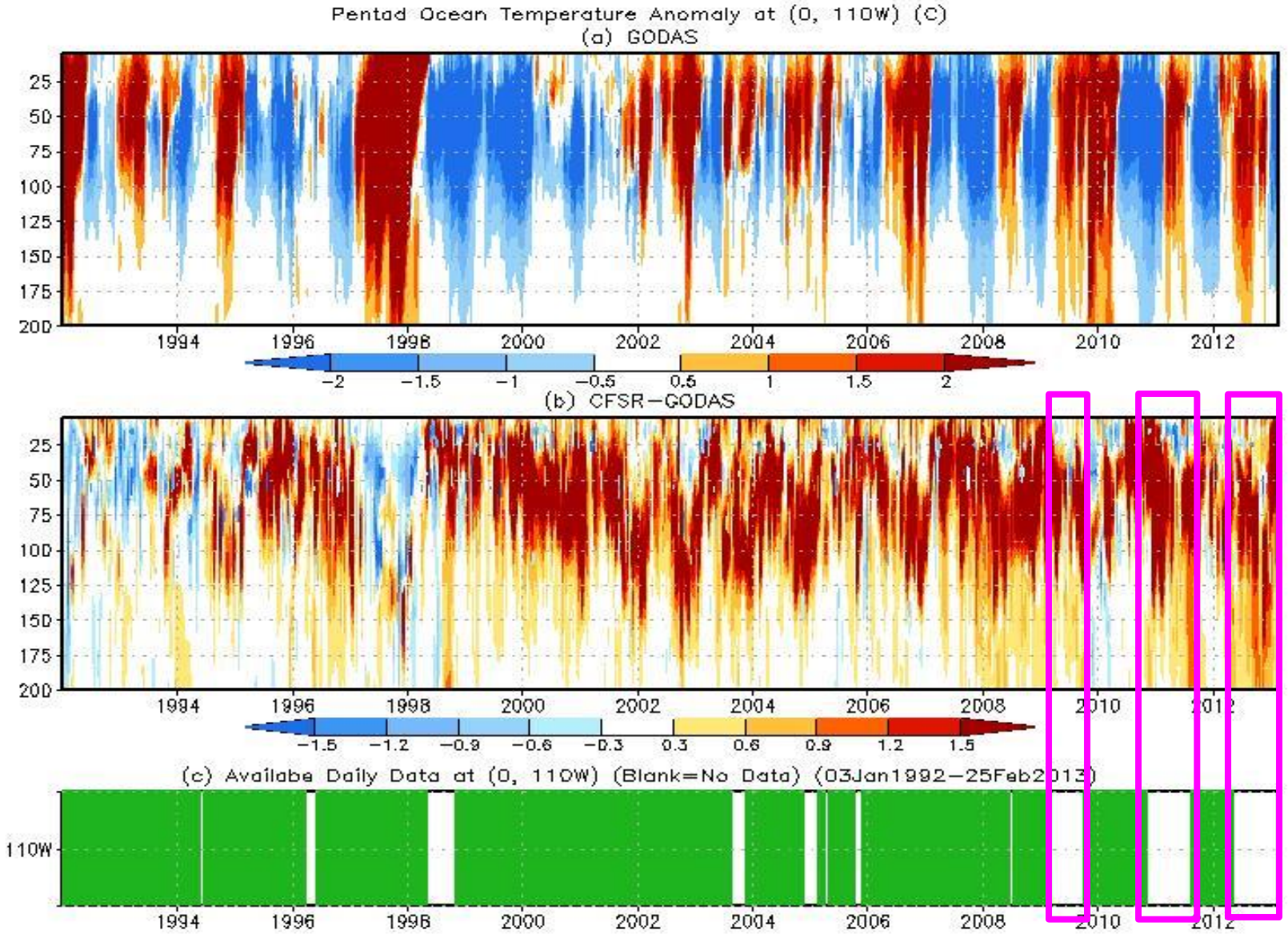
Possible Impact of TAO Data Missing on NCEP Data Assimilations

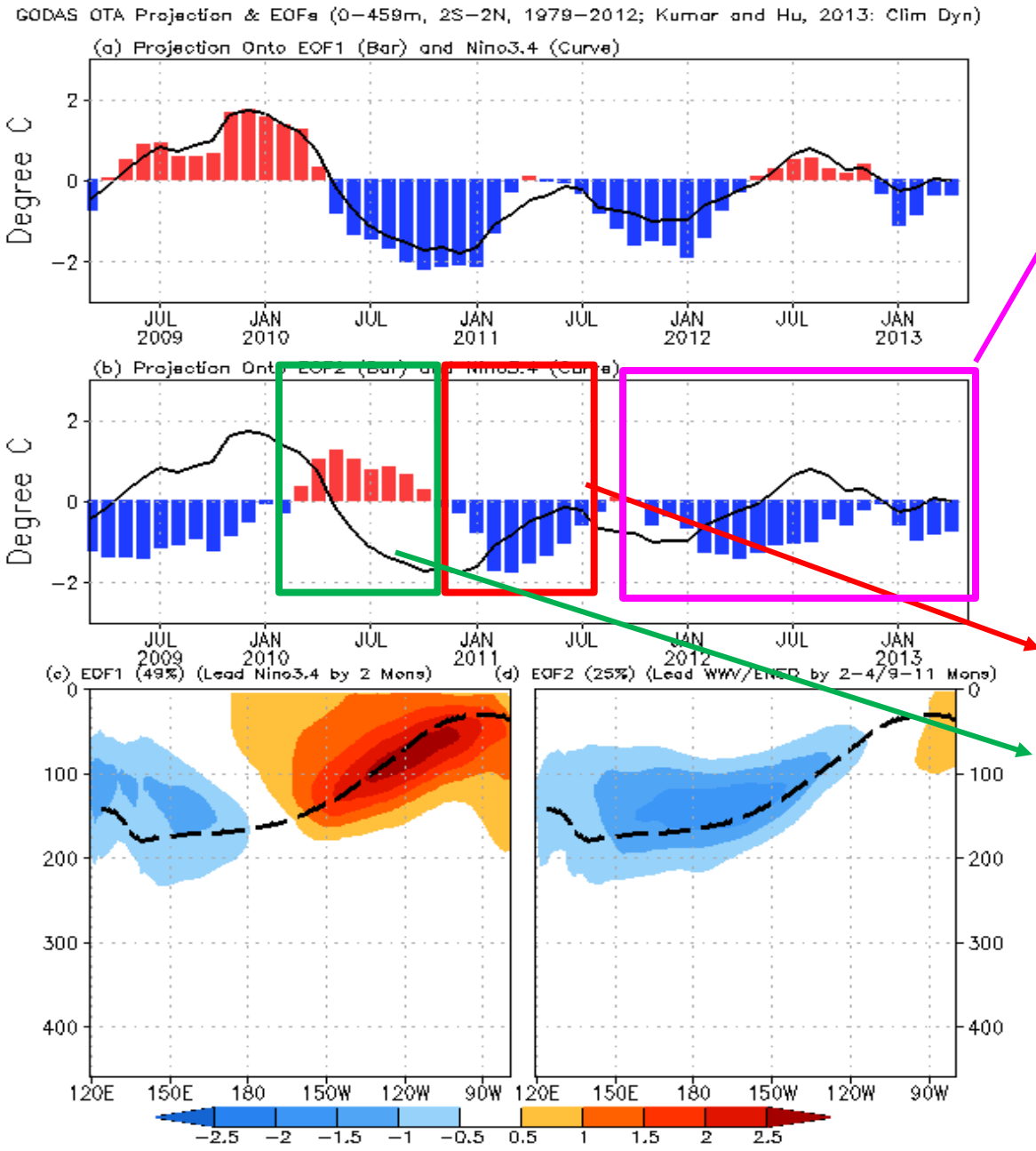
(CFSR and GODAS; 1981-2010 Climatology) at (0, 95W)



Possible Impact of TAO Data Missing on NCEP Data Assimilations

(CFSR and GODAS; 1981-2010 Climatology) (0, 110W)





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 : Negative -> positive phase of ENSO

Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

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 (published online).

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.

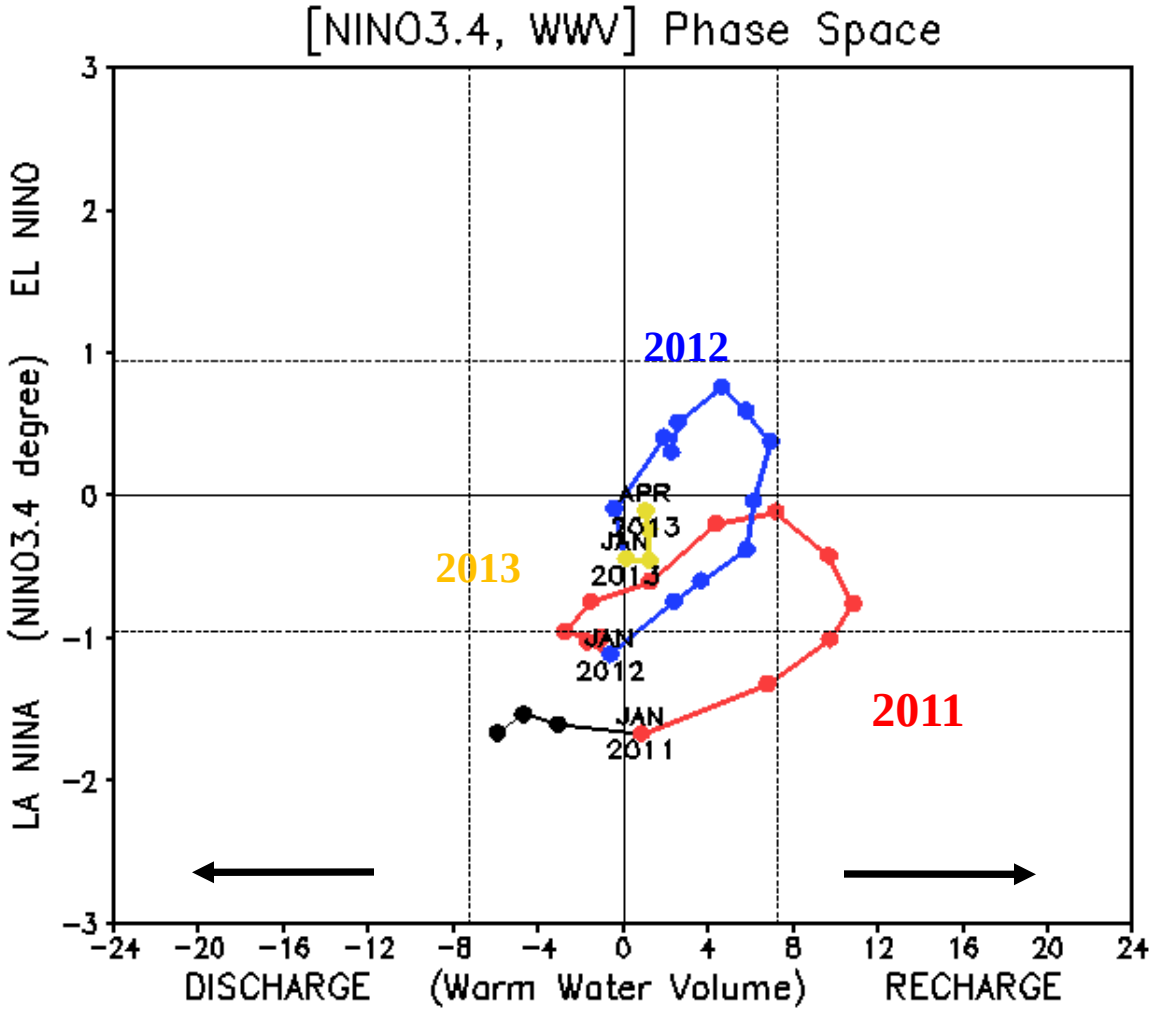


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

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

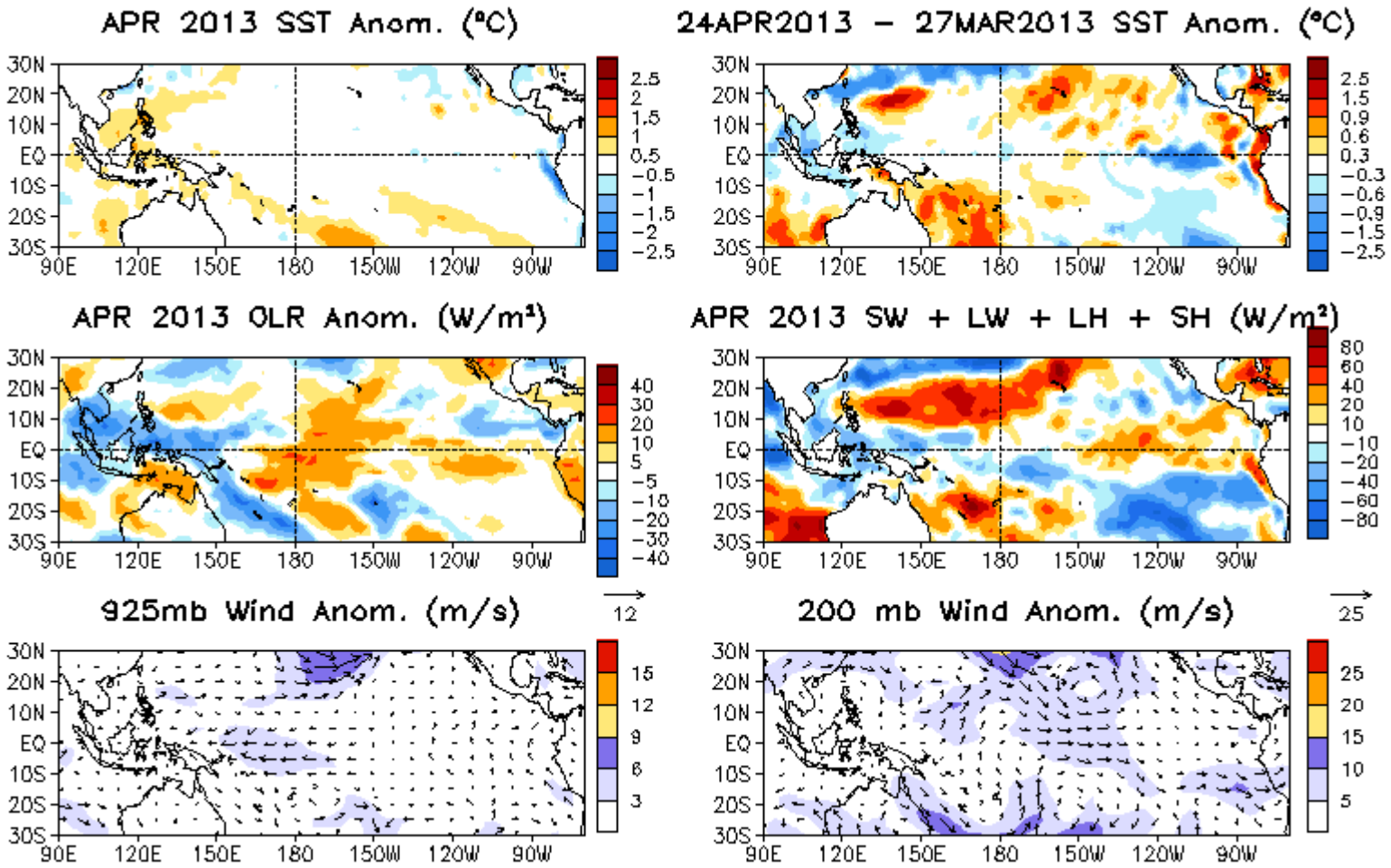


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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

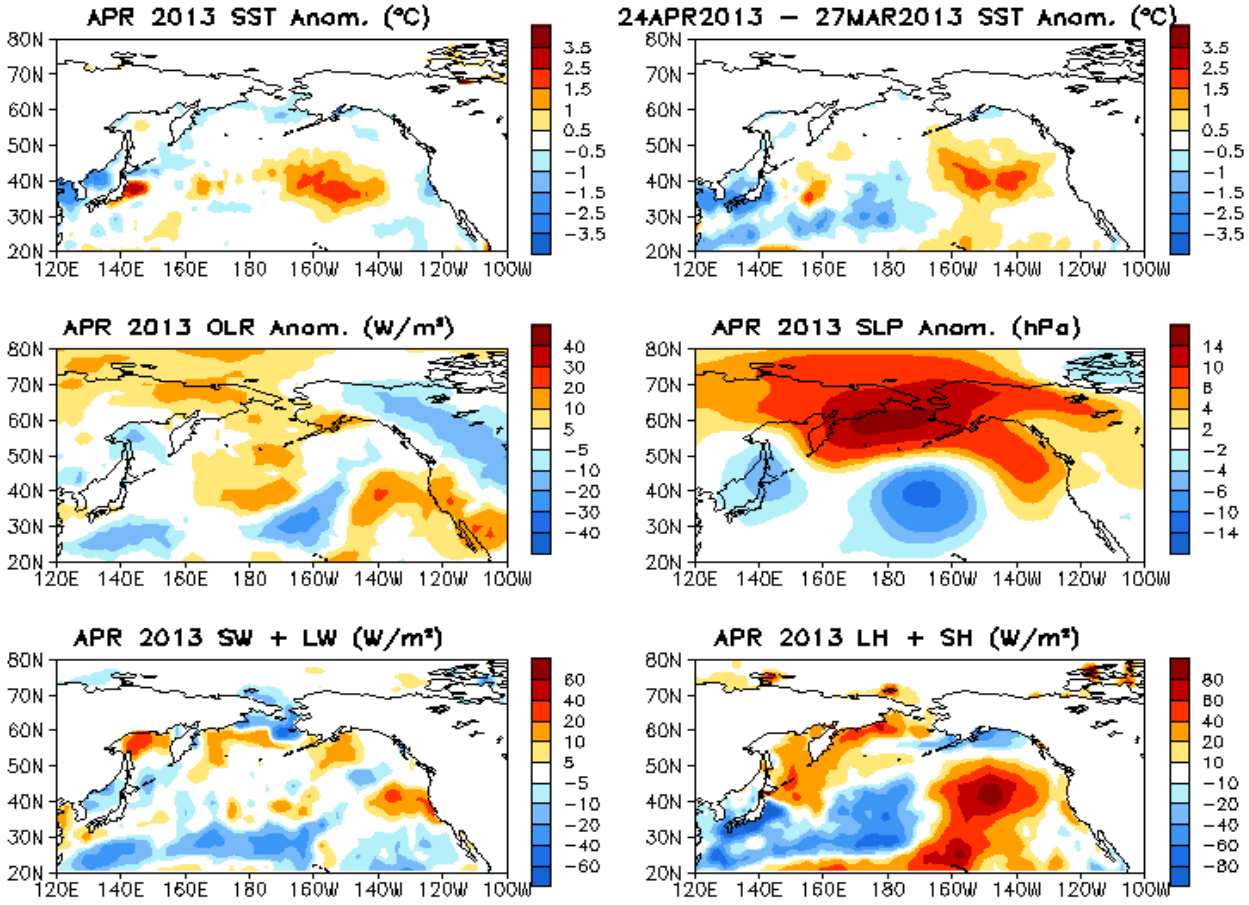
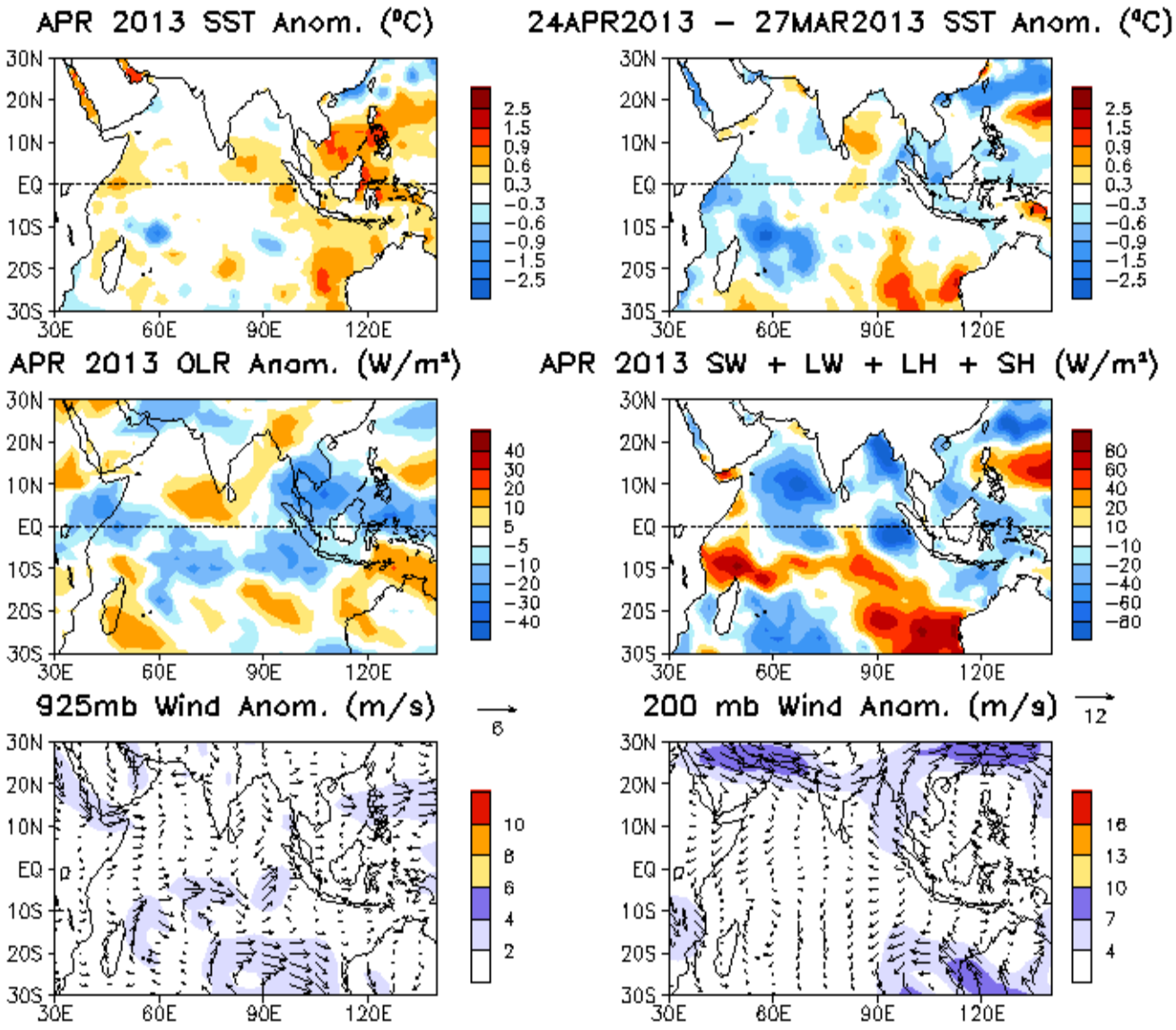
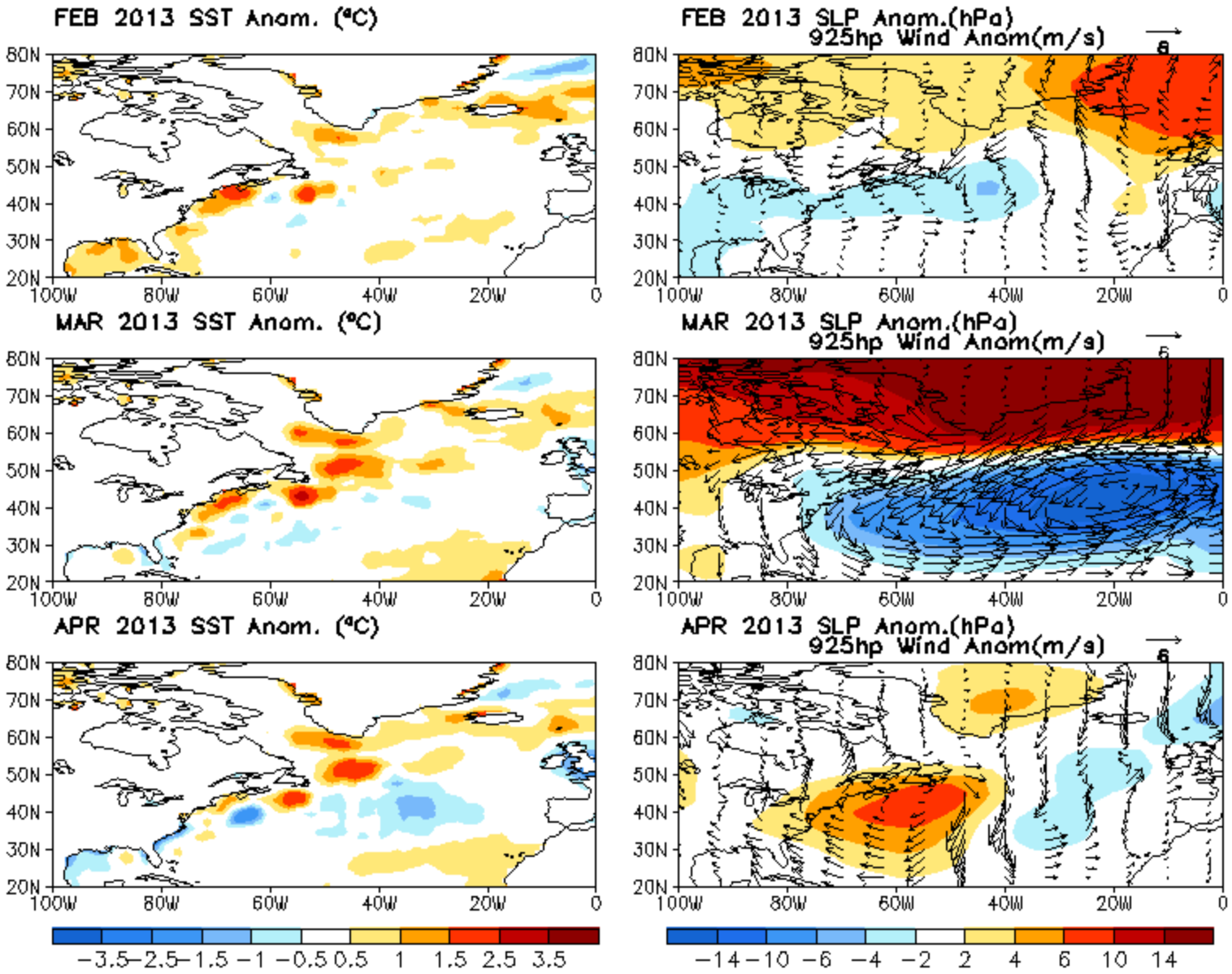


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

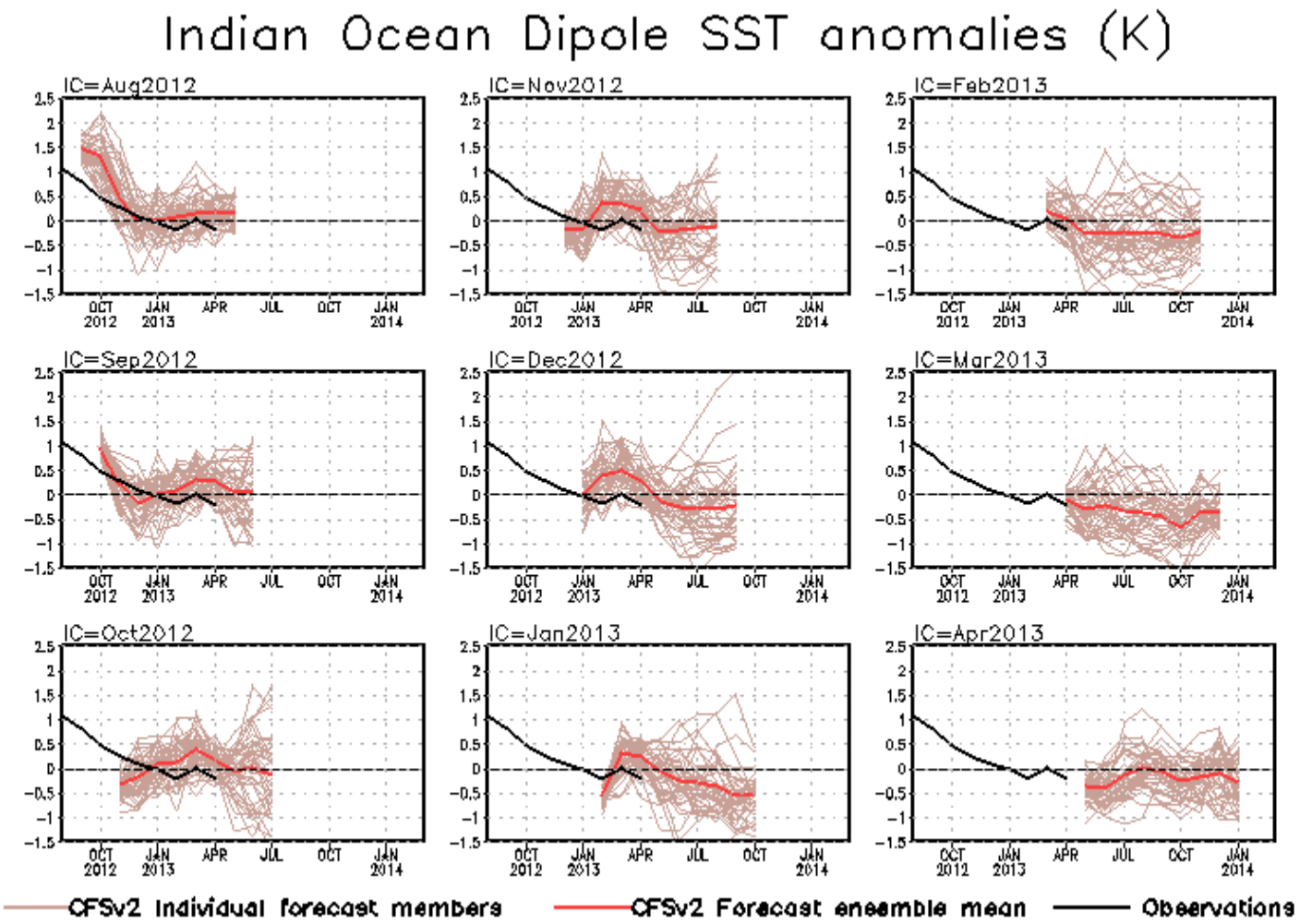


Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

Fig. 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.


FEB 2013 SST Anom. (°C)
FEB 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)
MAR 2013 SST Anom. (°C)
MAR 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)
APR 2013 SST Anom. (°C)
APR 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)
80N
70N
60N
50N
40N
30N
20N
100W
80W
60W
40W
20W
0
−3.5 −2.5 −1.5 −1 −0.5 0.5 1 1.5 2.5 3.5
−14 −10 −6 −4 −2 2 4 6 10 14

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

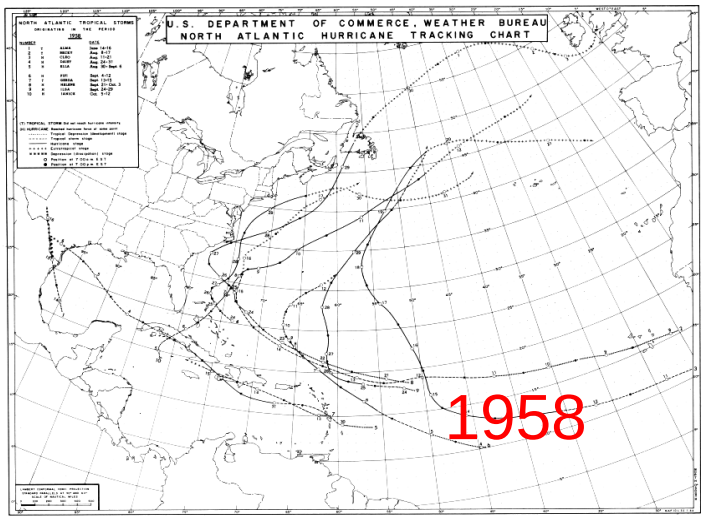
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

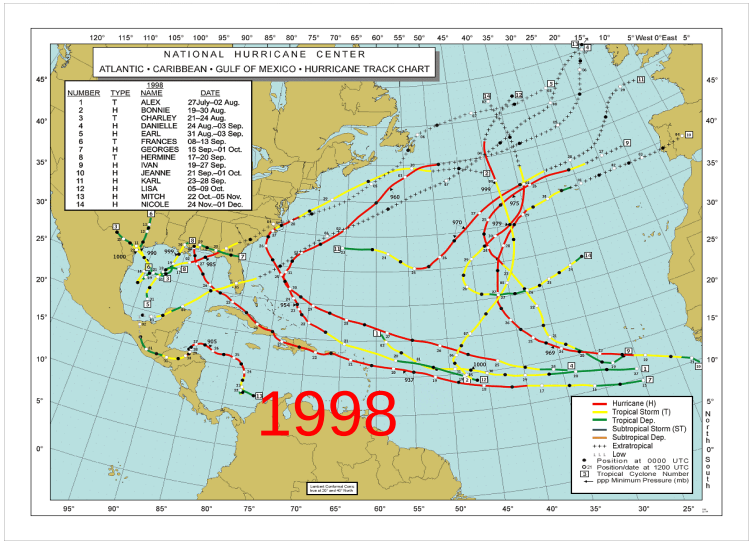
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

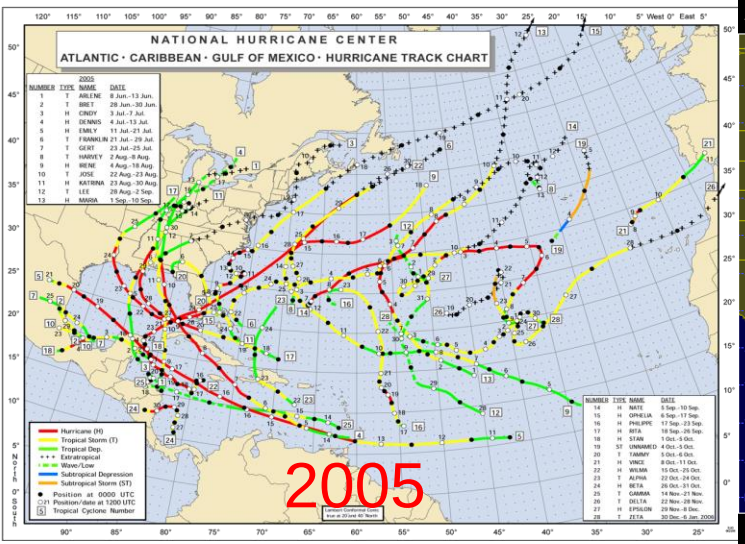
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast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

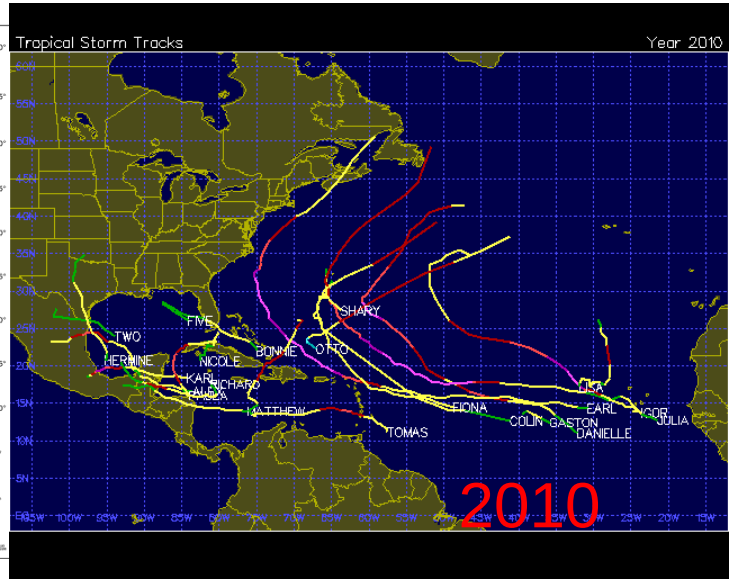
Atlantic Hurricane Activity in 1958, 1998, 2005, 2010

<Hu, Z.-Z., A. Kumar, B. Huang, Y. Xue, W. Wang, and B. Jha, 2011: Persistent atmospheric and oceanic anomalies in the North Atlantic from Summer 2009 to Summer 2010. *J. Climate,* **24(22)**, 5812-5830.>









The 4 years that had a similar juxtaposition of a warm ENSO (decay phase) and negative phase of the NAO, i.e., 1958, 1998, 2005, and 2010 had above normal Atlantic hurricane seasons.

The Atlantic Accumulated Cyclone Energy (ACE) index value in the North Atlantic (http://en.wikipedia.org/wiki/Accumulated_cyclone_energy) is 121 in 1958, 182 in 1998, 248 in 2005, **and 165 in 2010.**

For 1950-2009, the mean of ACE is 101 and the median is 88.0.

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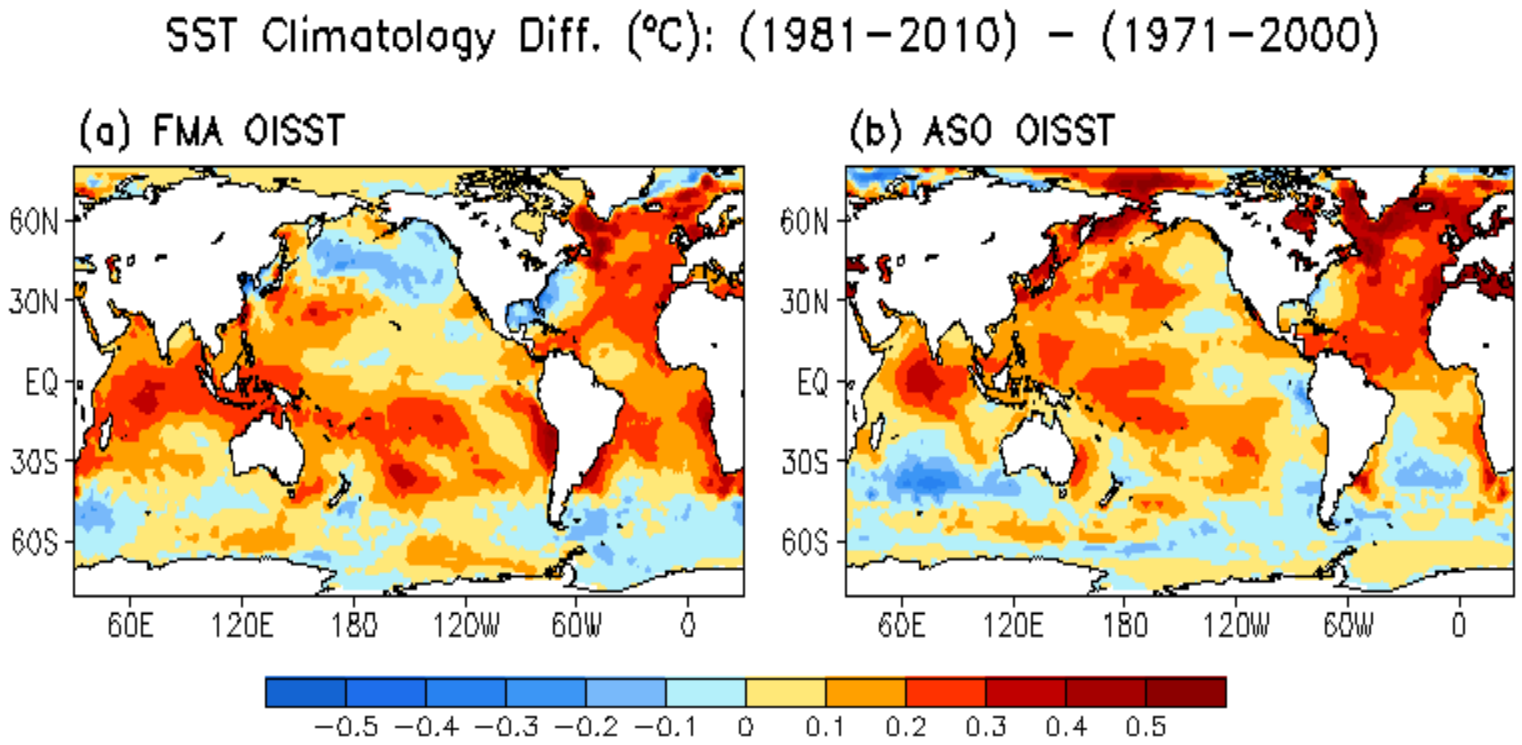
Switch to 1981-2010 Climatology

- **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!