

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

Prepared by
Climate Prediction Center, NCEP/NOAA
June 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**
(NOAA 2013 E. Pacific hurricane prediction)
 - **Indian Ocean**
 - **Atlantic Ocean**
(NOAA 2013 Atlantic hurricane prediction)
- **Global SST Predictions**

Overview

▪ Pacific and Arctic Oceans

- ENSO-neutral condition continued during May 2013 and cooling tendency was strengthened in the eastern Pacific with Nino3.4=-0.3C.
- NOAA officially forecast ENSO-neutral condition to continue in the Northern Hemisphere summer 2013.
- Negative PDO phase weakened since Apr 2013 and PDO index =-0.6 in May 2013, and NCEP CFSv2 predicted negative phase of PDO will continue.
- Arctic sea ice extent in May 2013 was below-normal.

▪ Indian Ocean

- SSTs were above in the east and slightly below-normal in the west, and negative dipole index was strengthened in May 2013.

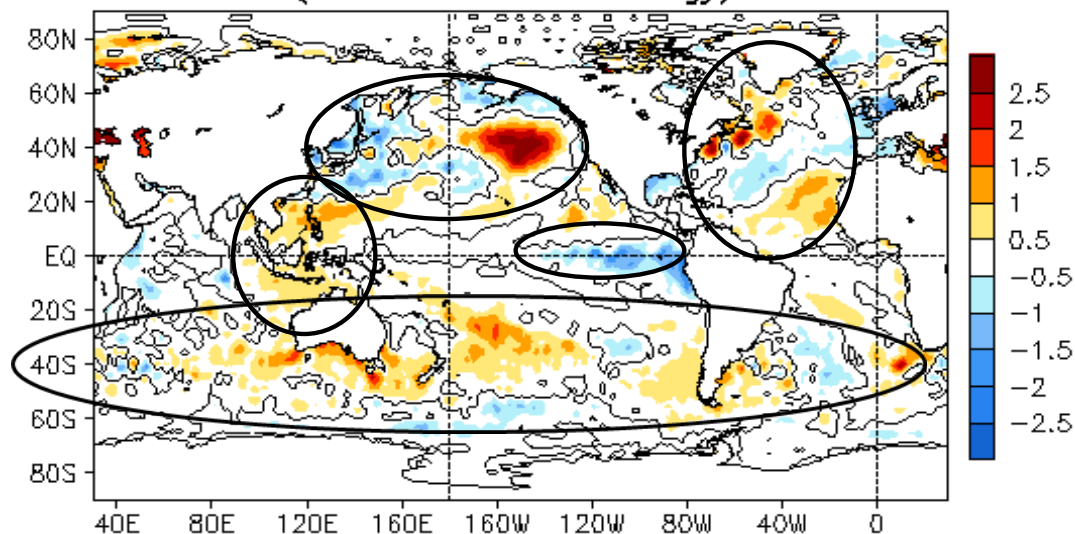
▪ Atlantic Ocean

- NAO switched from negative to positive phase in Apr 2013 and NAO index =0.6 in May 2013.
- SSTs were above-normal in the tropical North Atlantic main hurricane development region in May 2013.

Global Oceans

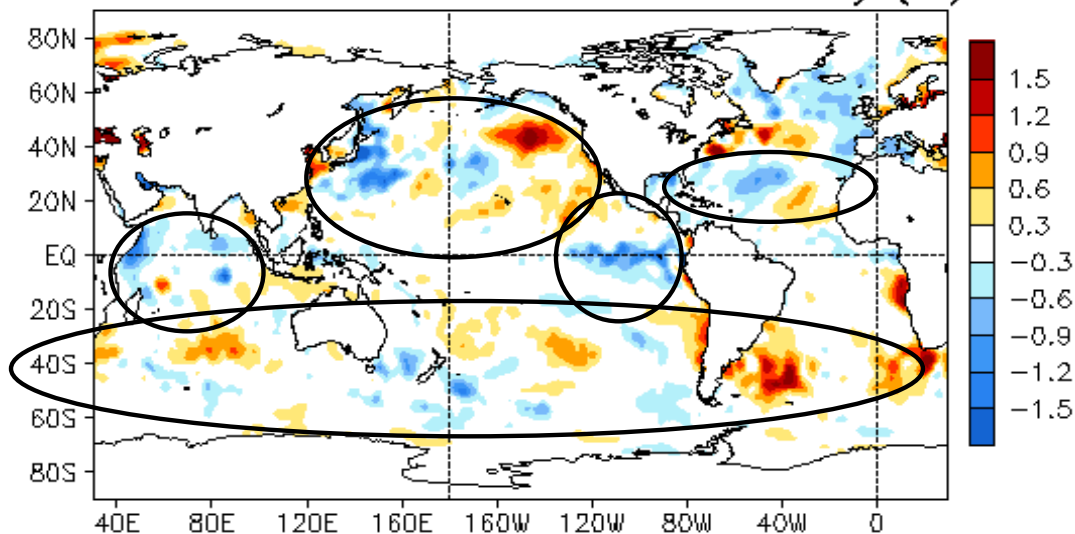
Global SST Anomaly ($^{\circ}\text{C}$) and Anomaly Tendency

MAY 2013 SST Anomaly ($^{\circ}\text{C}$)
(1981–2010 Climatology)



- Negative SSTA presented in the e. Pacific.
- Negative phase PDO associated SSTA pattern continued in N. Pacific.
- Positive SSTA was observed in the e. Indian and w. Pacific Oceans.
- Tripolar SSTA presented in N. Atlantic.

MAY 2013 – APR 2013 SST Anomaly ($^{\circ}\text{C}$)

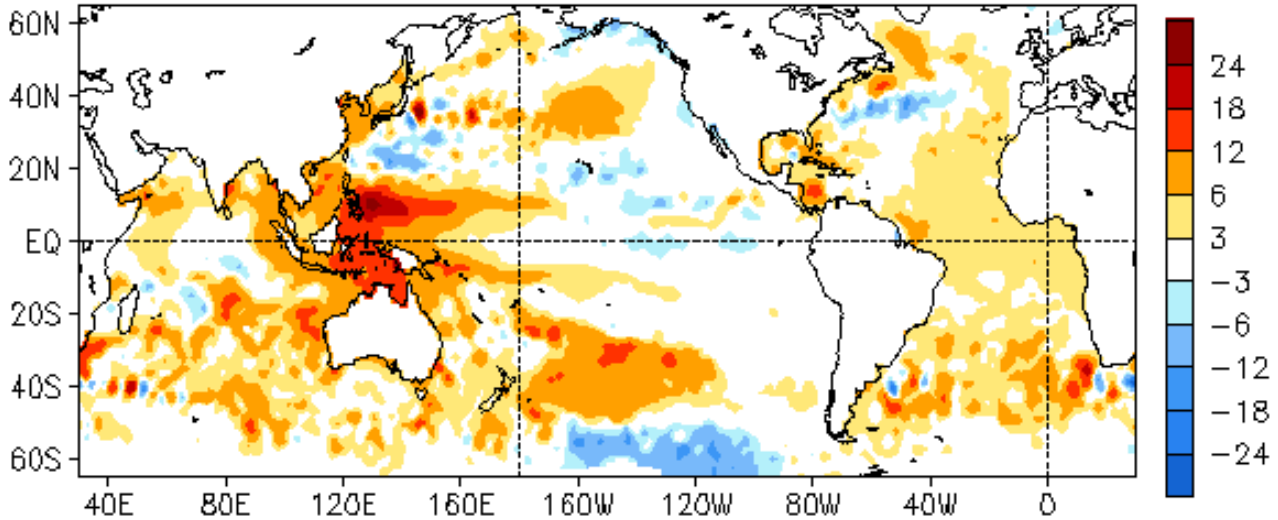


- Cooling tendency presented in the equatorial e. Pacific.
- Weakening tendency of negative phase of PDO associated SSTA was observed in N. Pacific.
- Cooling (warming) tendency was seen in the w. (e.) tropical N. Atlantic.
- An overall cooling tendency was observed in the tropical Indian Ocean.

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

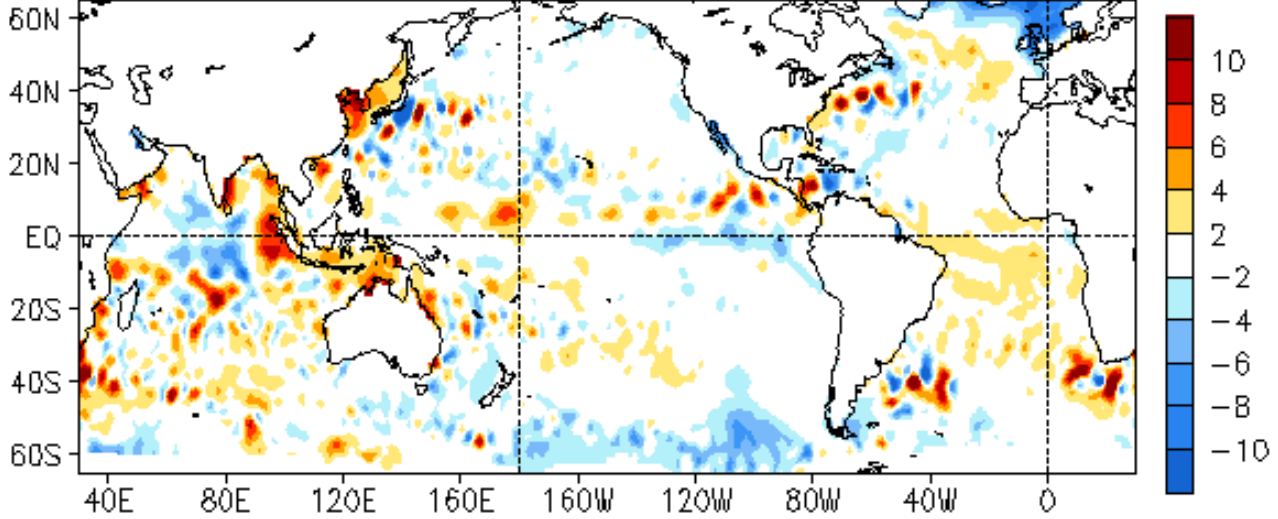
Global SSH Anomaly (cm) and Anomaly Tendency

MAY 2013 SSH Anomaly (cm)
(AVISO Altimetry, Climo. 93-05)



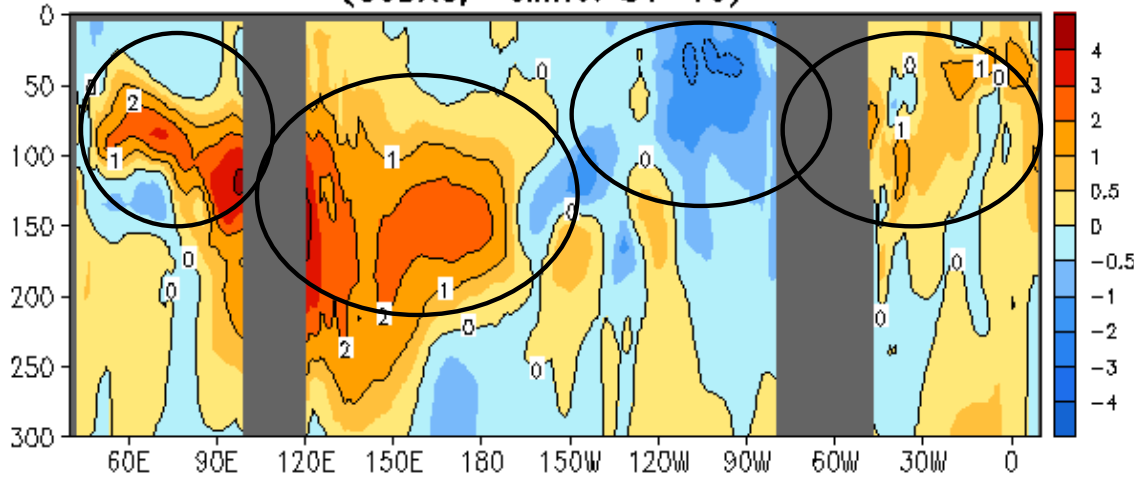
- The SSH anomalies were overall consistent with SSTA for large-scale pattern: Positive (negative) SSTA is tied up with positive (negative) SSH anomaly.

MAY 2013 - APR 2013 SSH Anomaly (cm)

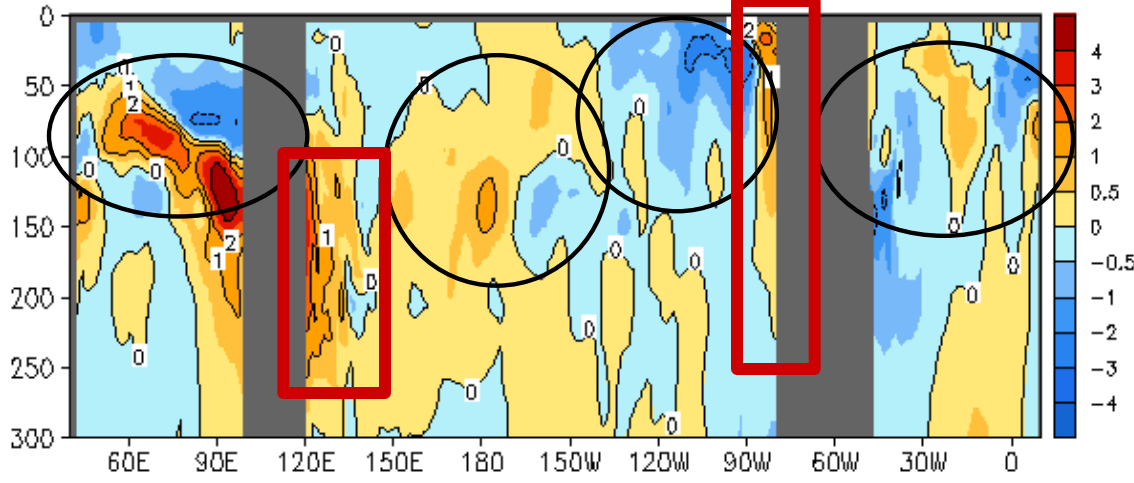


Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

MAY 2013 Eq. Temp Anomaly (°C)
(GODAS, Climo. 81-10)



MAY 2013 - APR 2013 Eq. Temp Anomaly (°C)

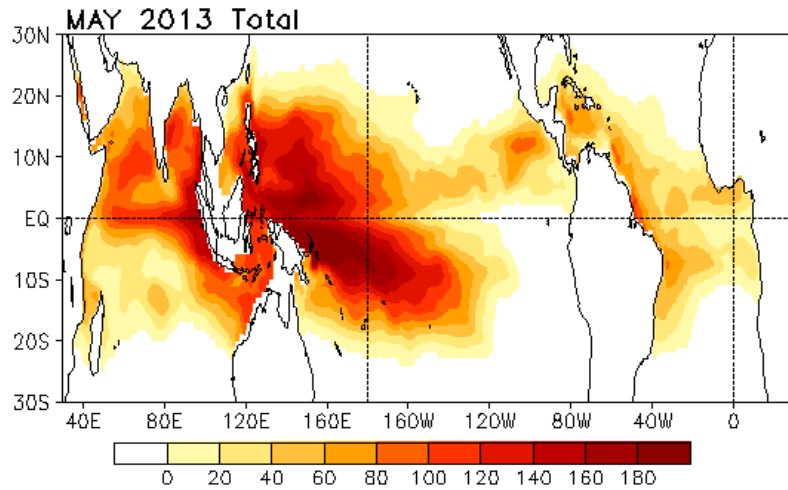


- Positive (negative) temperature anomalies occupied around the thermocline in the w. (e.) Pacific Ocean, suggesting an intensified w-e contrast.
- Positive anomalies around the thermocline occurred in the Atlantic and Indian Oceans.

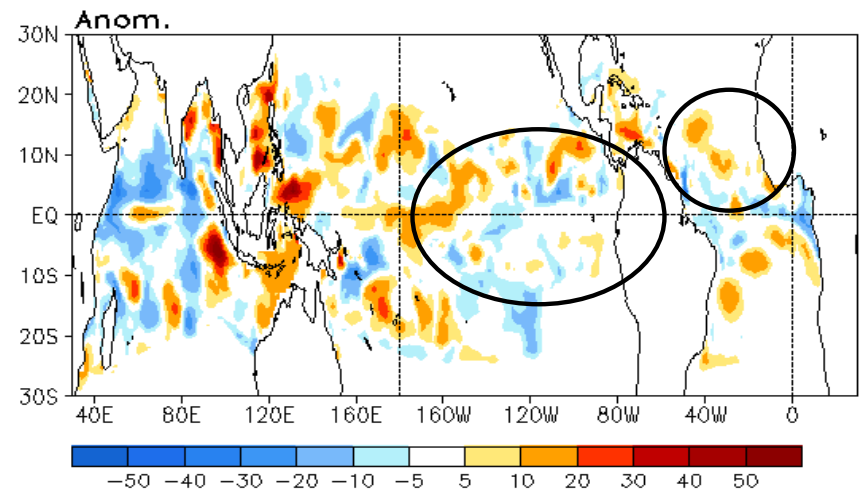
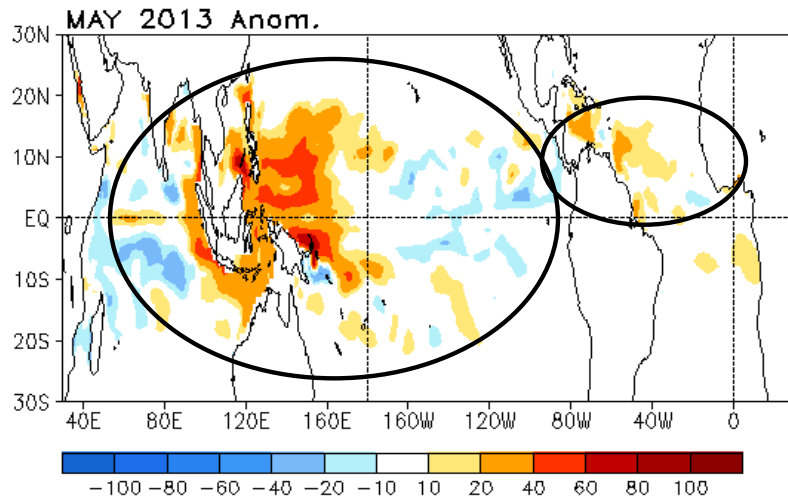
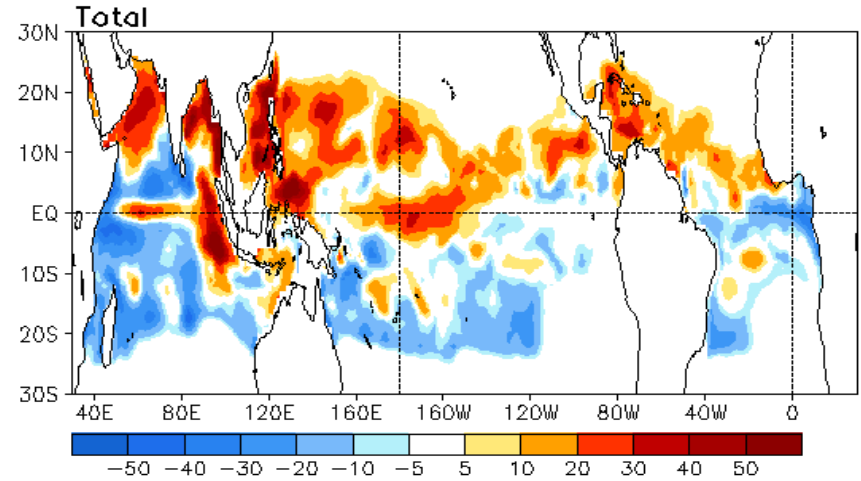
- Warming (cooling) tendency was observed in the w. (e.) Pacific around the thermocline, and warming tendency was seen in both e. and w. coasts.
- Obvious warming tendency around the thermocline was noted the Indian Ocean.
- Both positive and negative tendency presented in Atlantic Ocean.

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

Tropical Cyclone Heat Potential (KJ/cm²)



MAY 2013 – APR 2013 TCHP (KJ/cm²)



- Positive TCHP anomalies presented in the w. Pacific and negative ones in the c. and e. Pacific.
- Positive anomalies were observed over the w. Atlantic Ocean.
- The tendency was small in both the tropical N. Atlantic and E. tropical Pacific.

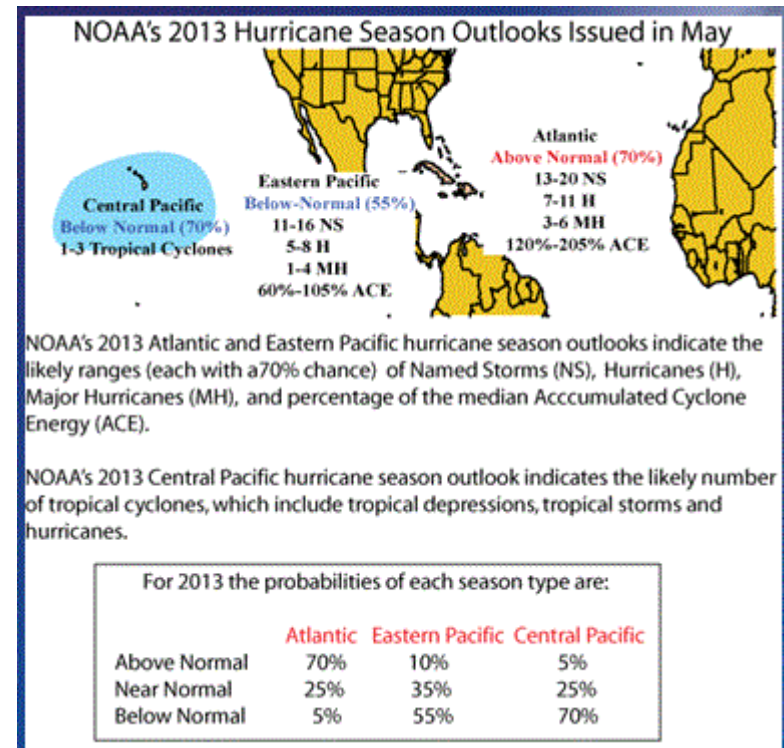
TCHP field is the anomalous heat storage associated with temperatures larger than 26 °C.

NOAA Predict an Above-Normal Atlantic Hurricane Season in 2013

(<http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml>)

http://en.wikipedia.org/wiki/Accumulated_cyclone_energy)

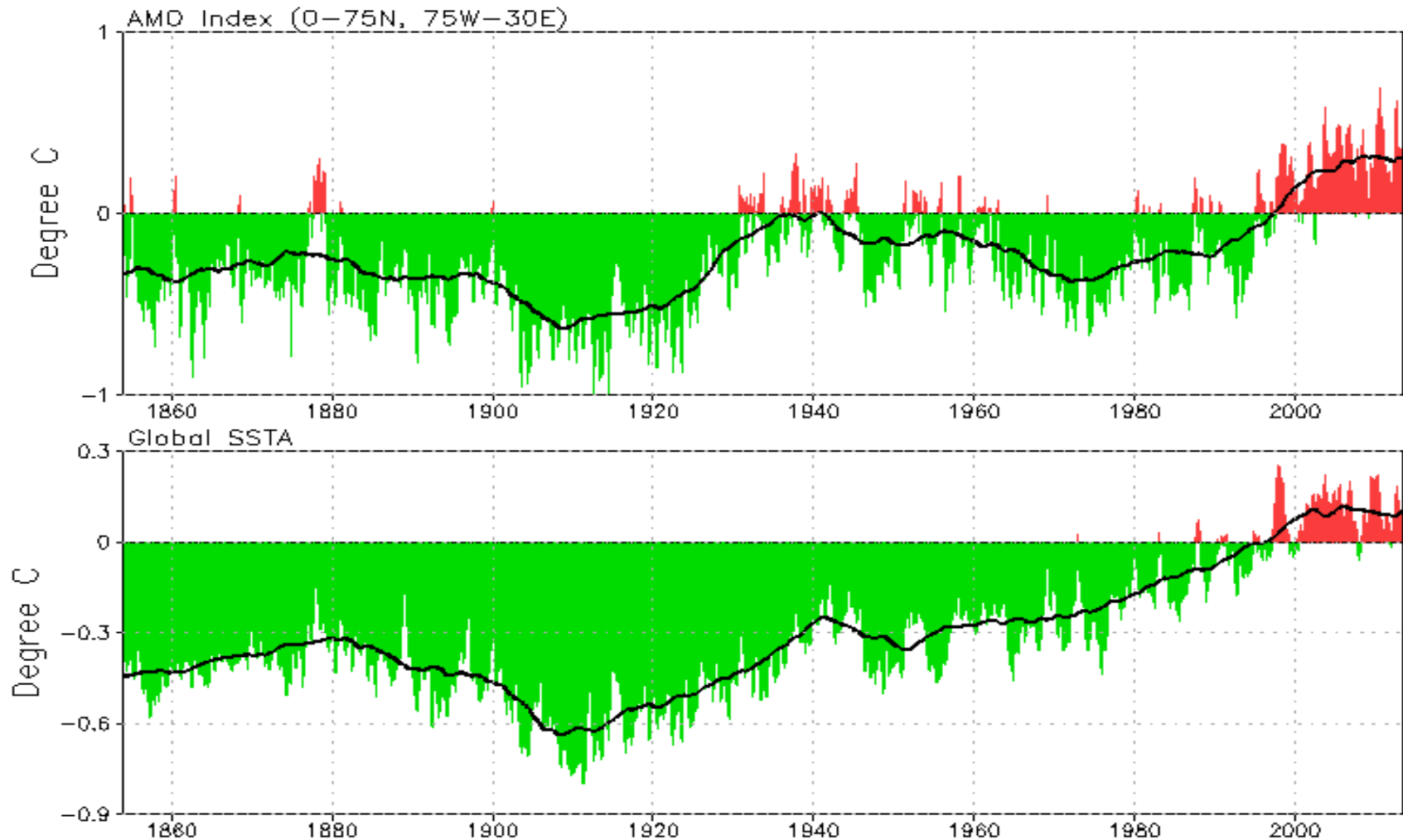
	2013 prediction (issued on May 23) (1981-2010)
Named storms	13-20 (12.1)
Hurricanes	7-11 (6.4)
Major hurricanes	3-6 (2.7)
ACE %	120-205



- The ongoing set of atmospheric and oceanic conditions include:
- An expected continuation of above-average sea surface temperatures (SSTs) across the tropical Atlantic Ocean and Caribbean Sea, that have been producing increased Atlantic hurricane activity since 1995;
- A likely continuation of ENSO-neutral conditions in 2013 (i.e., no El Niño or La Niña); meaning El Niño is not expected to develop and suppress the hurricane season.

AMO is a major factors for Atlantic hurricane Forecast

ERSST.v3b SST Anomaly (1854–Current; 1981–2010 Climatology)
(Shading: Monthly; Curve: 10 Year–Running–Mean, C)



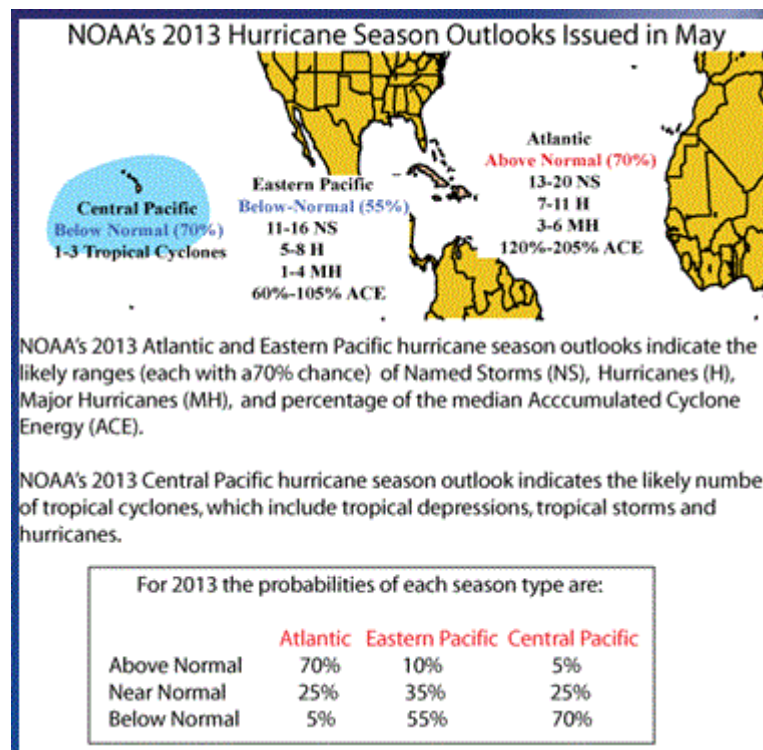
- AMO was above normal since around 1995.

NOAA Predict a Below-Normal E. Pacific Hurricane Season in 2013

(http://en.wikipedia.org/wiki/2013_Pacific_hurricane_season)

(http://en.wikipedia.org/wiki/Accumulated_cyclone_energy)

	2013 prediction (issued on May 23) (1971-2006)
Named storms	11-16 (15.3)
Hurricanes	5-8 (8.8)
Major hurricanes	1-4 (4.2)
ACE %	60-105

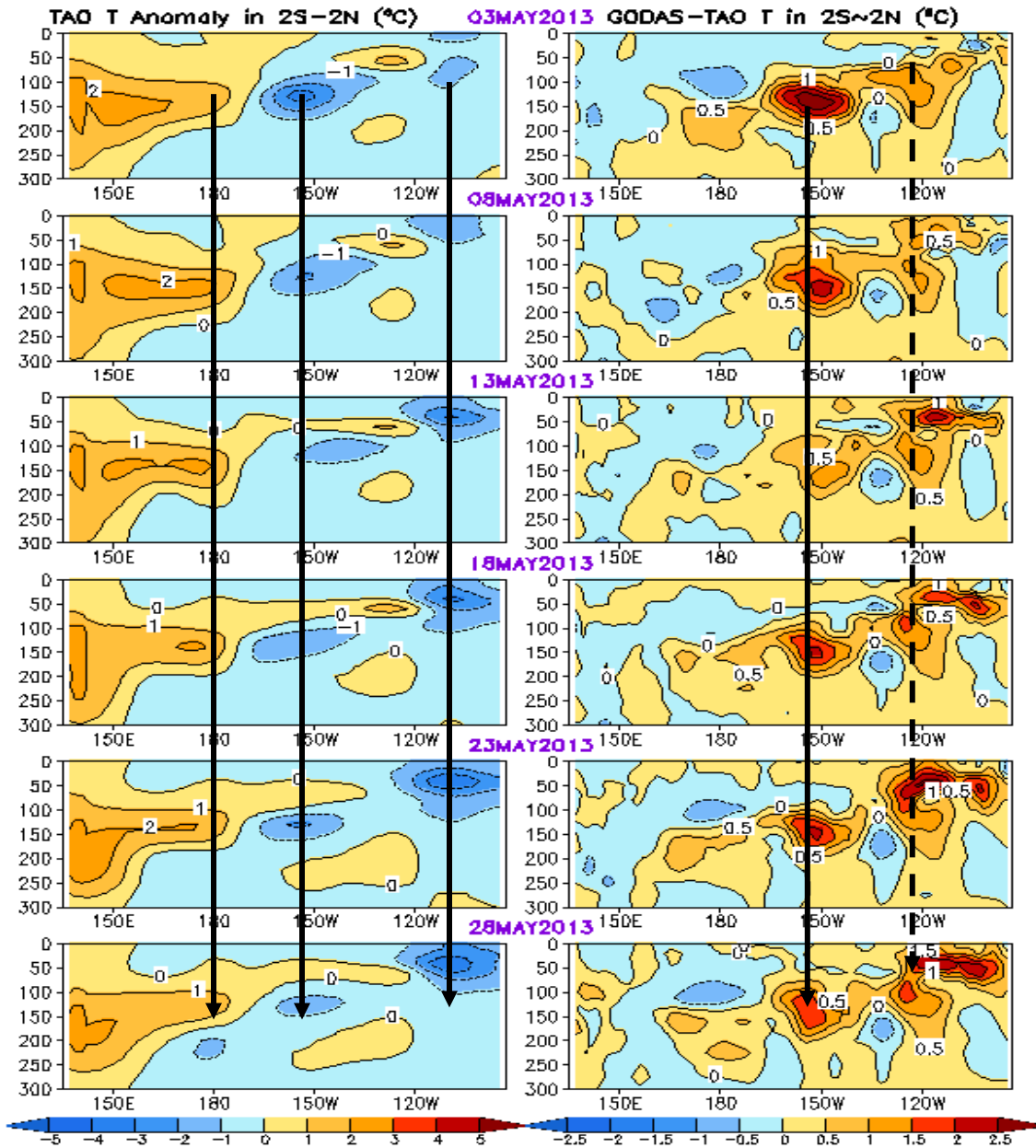


- The ongoing climate conditions include:
- Expected ENSO-neutral conditions in 2013, meaning El Niño is not expected to develop and strengthen the seasonal activity;
- Expected near-average or below-average sea-surface temperatures in the eastern equatorial Pacific Ocean.

Tropical Pacific Ocean and ENSO Conditions

TAO

GODAS-TAO



Pentad Mean Equatorial Pacific Temperature Anomaly

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

TAO

GODAS

CFSR

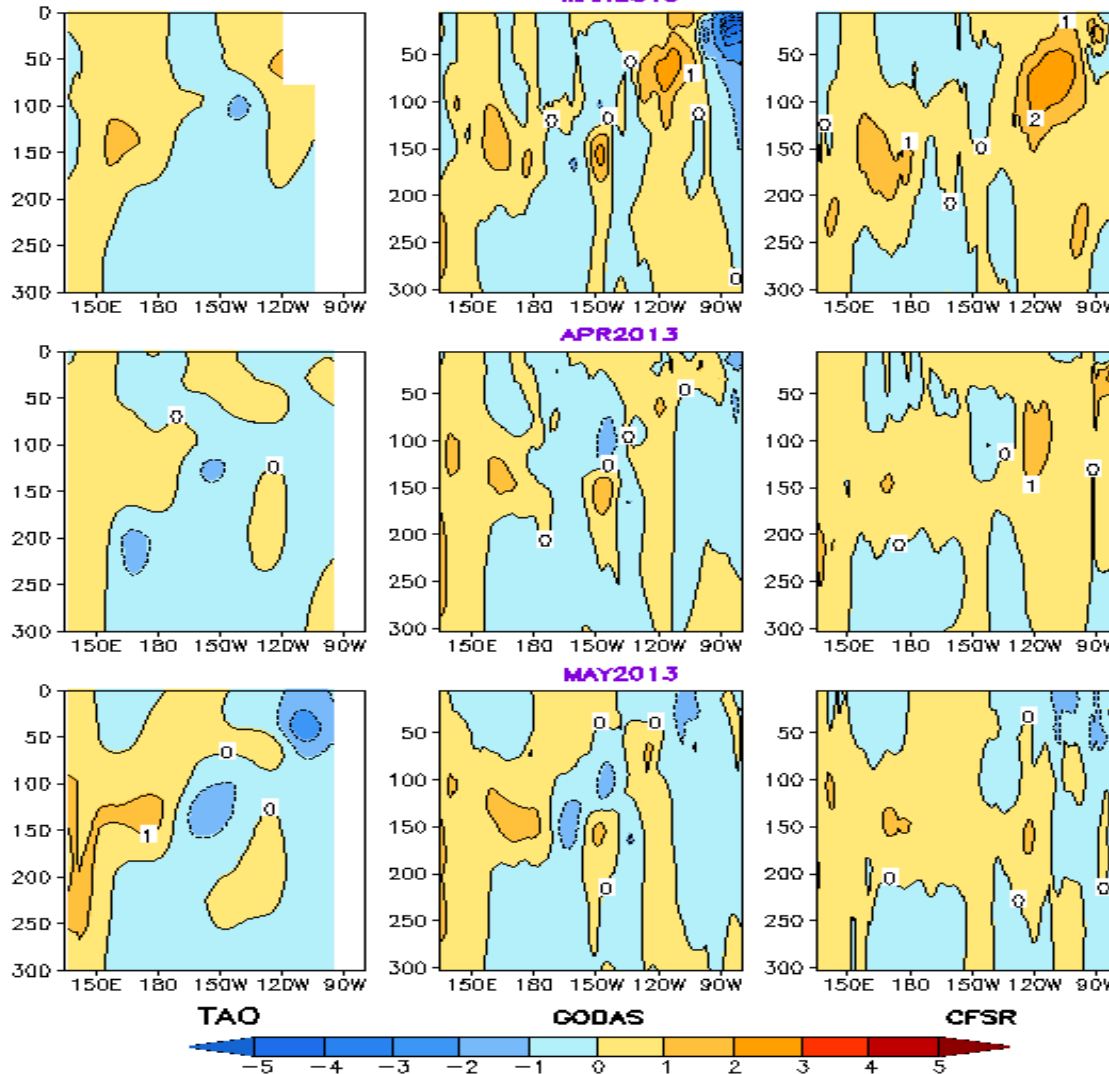
Last 3-Month Mean Equatorial Pacific Temperature Anomaly

Ocean Temperature Anomaly in 2S–2N ($^{\circ}\text{C}$, 1999–2010 Climatology)

MAR2013

APR2013

MAY2013

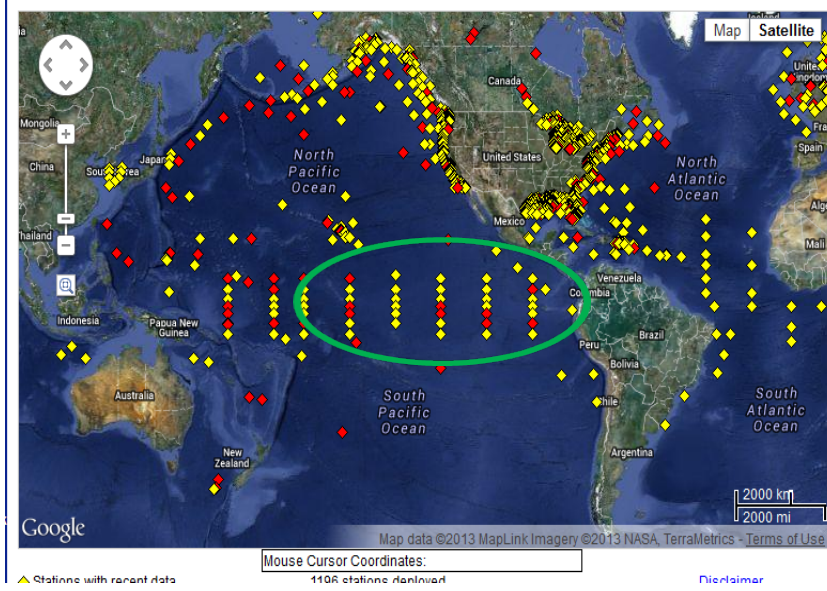


- The monthly mean differences between TAO and GODAS, and between TAO and CFSR were also large in the c. and e. Pacific.
- **What causes the differences?**

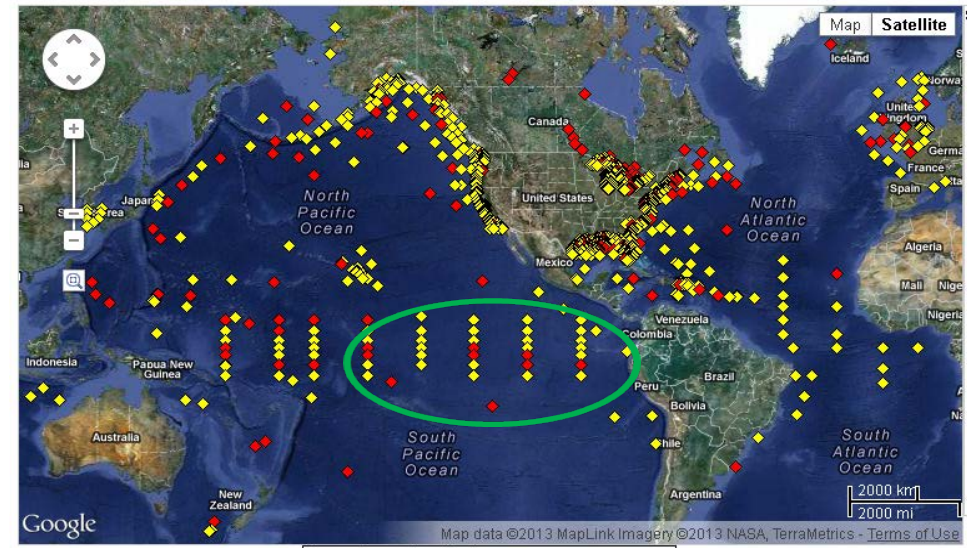
Status of TAO/TRITON Data Delivery

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

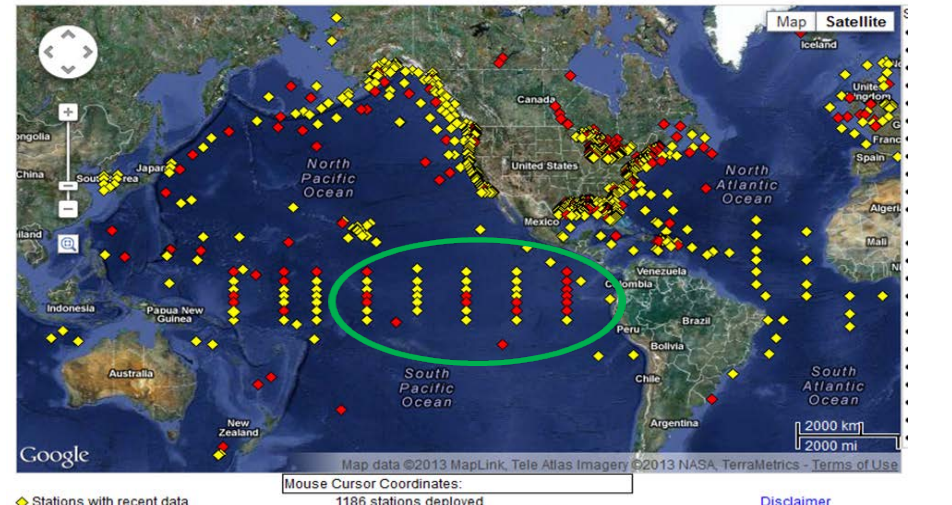
Beginning of June 2013



Beginning of May 2013



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



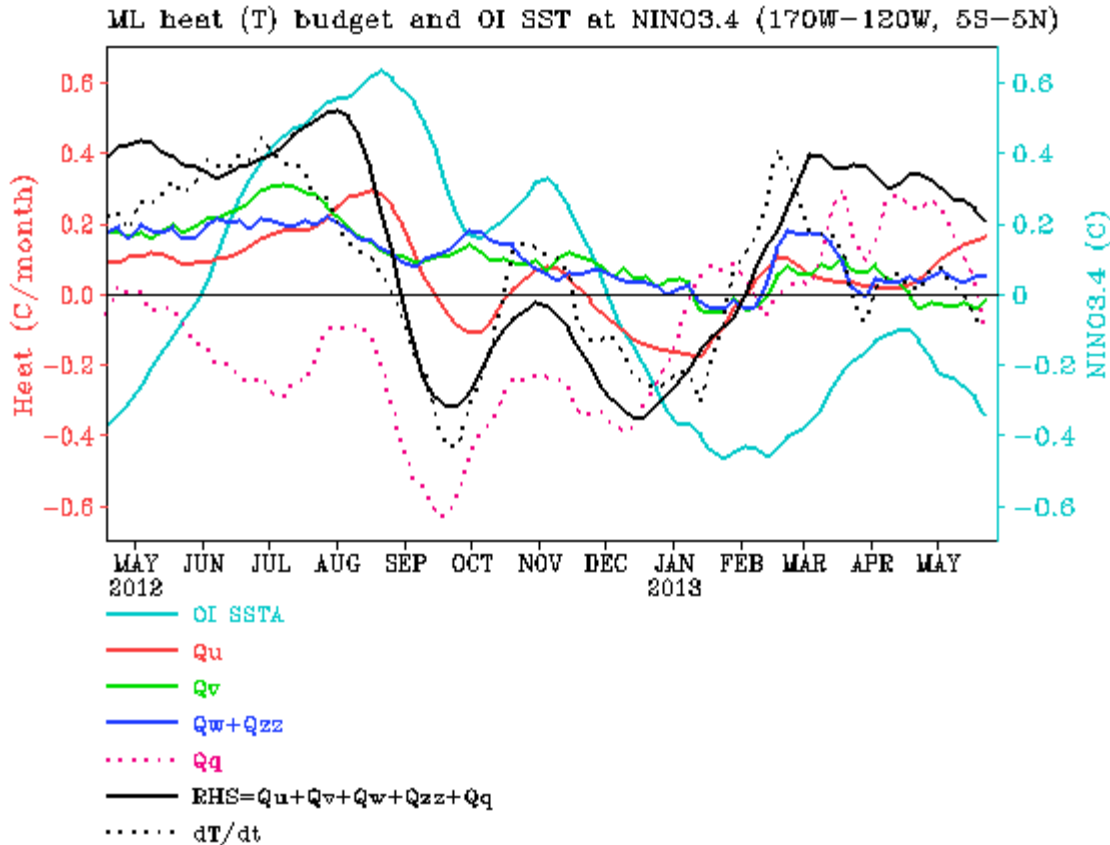
◆ Stations with recent data
◆ Stations with historical data only
◆ Stations with no data in last 8 hours (24 hours for tsunami stations)
◆ Tsunami station in event mode (within previous 24 hours)

1186 stations deployed
 896 have reported in the past 8 hours

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[How do I use KM](#)

Beginning of Apr 2013

NINO3.4 Heat Budget



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

- All the advection terms were small since mid-Jan 2013.

- The thermodynamical term (Q_q) were positive most time in May 2013.

- The RHS and dT/dt had large differences during Mar-May 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.

Q_u : Zonal advection; Q_v : Meridional advection;

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

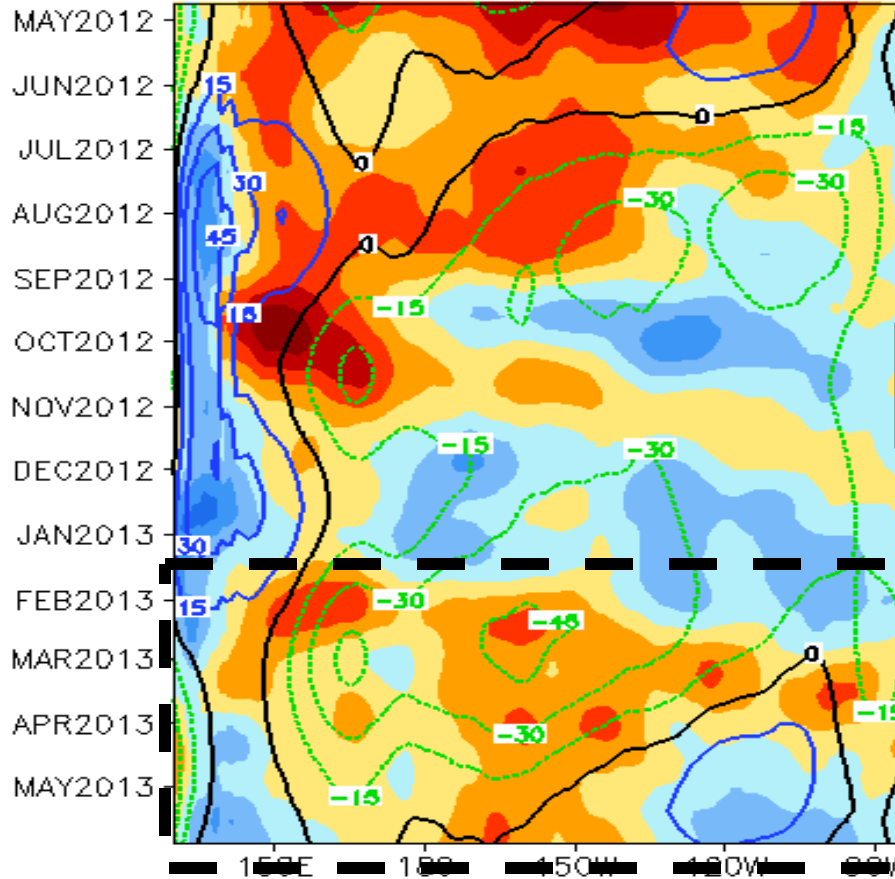
Q_q : $(Q_{net} - Q_{open} + Q_{corr})/pcph$; $Q_{net} = SW + LW + LH + SH$;

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

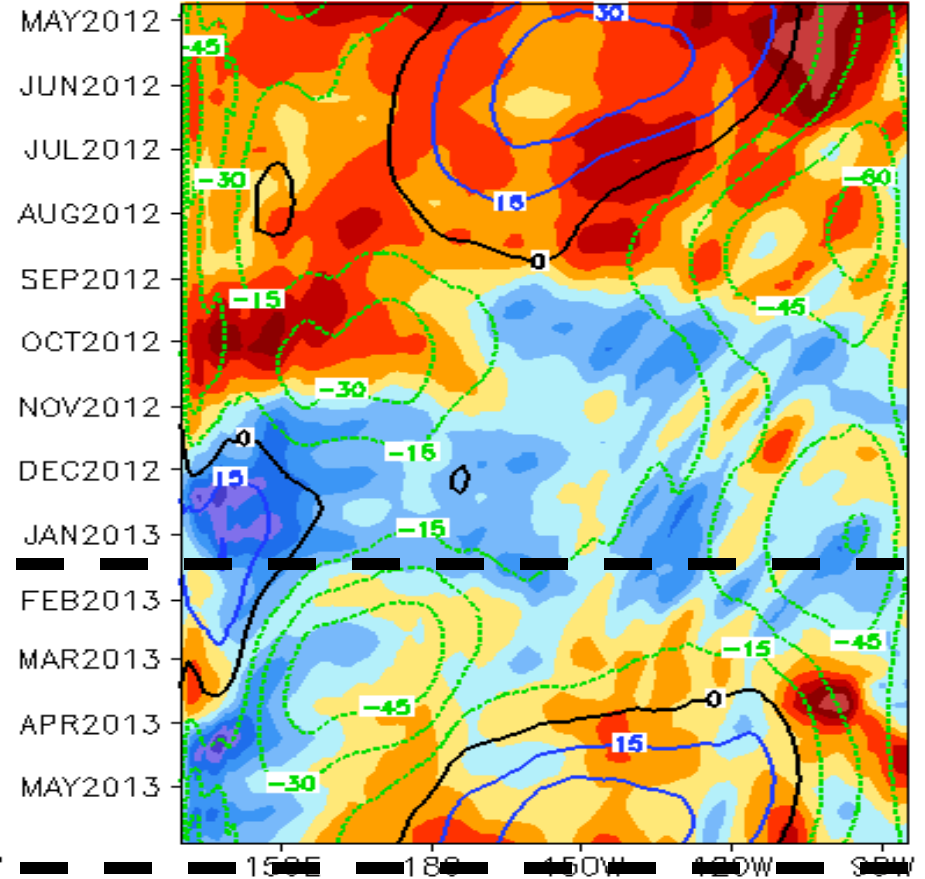
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)

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

OSCAR

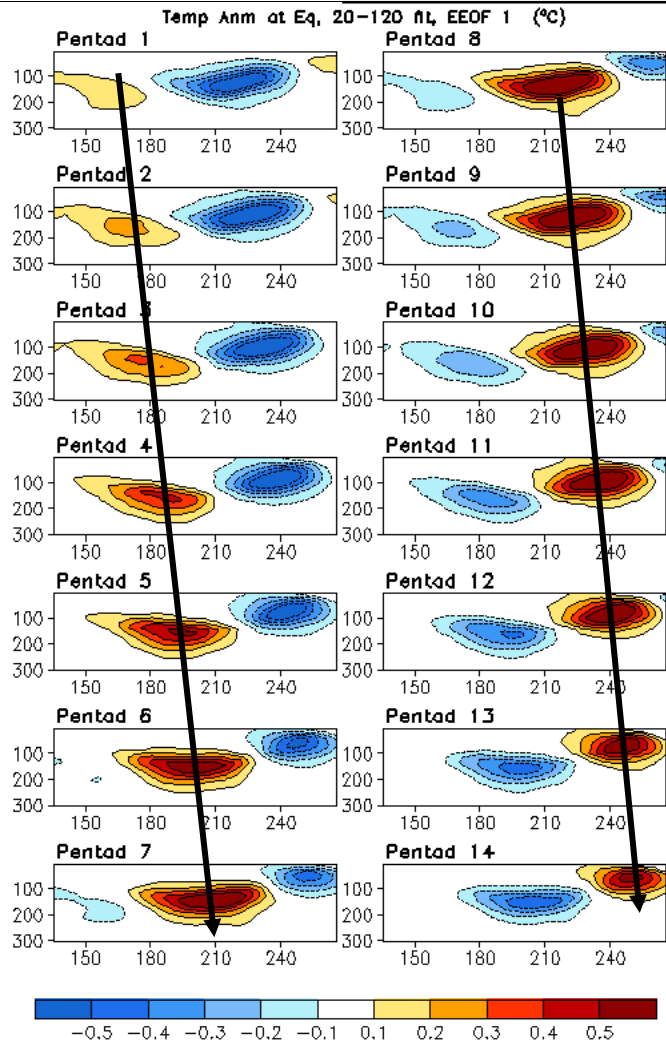


GODAS

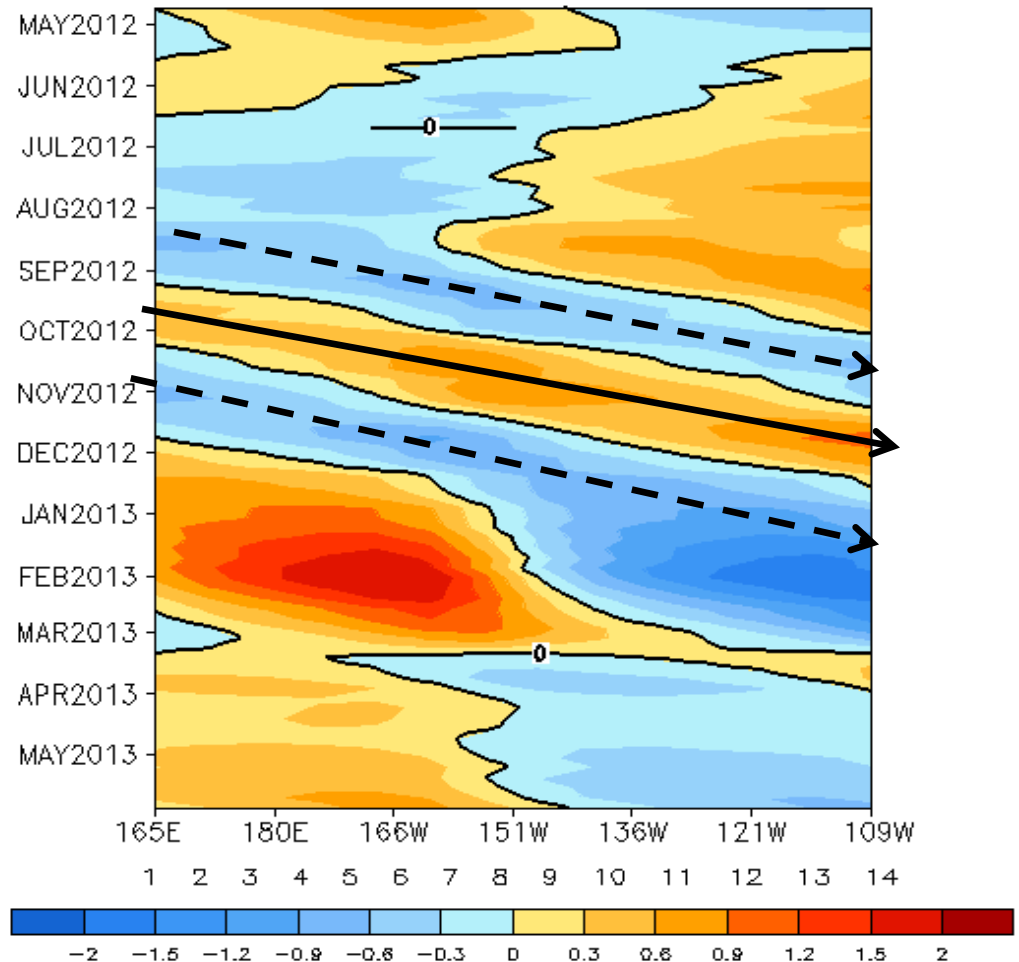


- Since Feb 2013, eastward anomaly current was observed, and weakened since Apr 2013.
- Some detailed differences were noted for both anomaly and climatology between OSCAR and GODAS.

Oceanic Kelvin Wave Indices



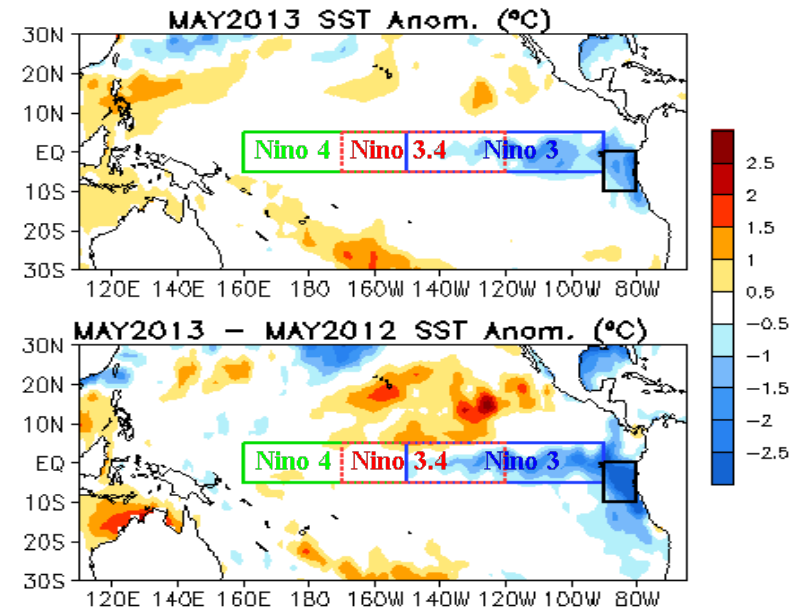
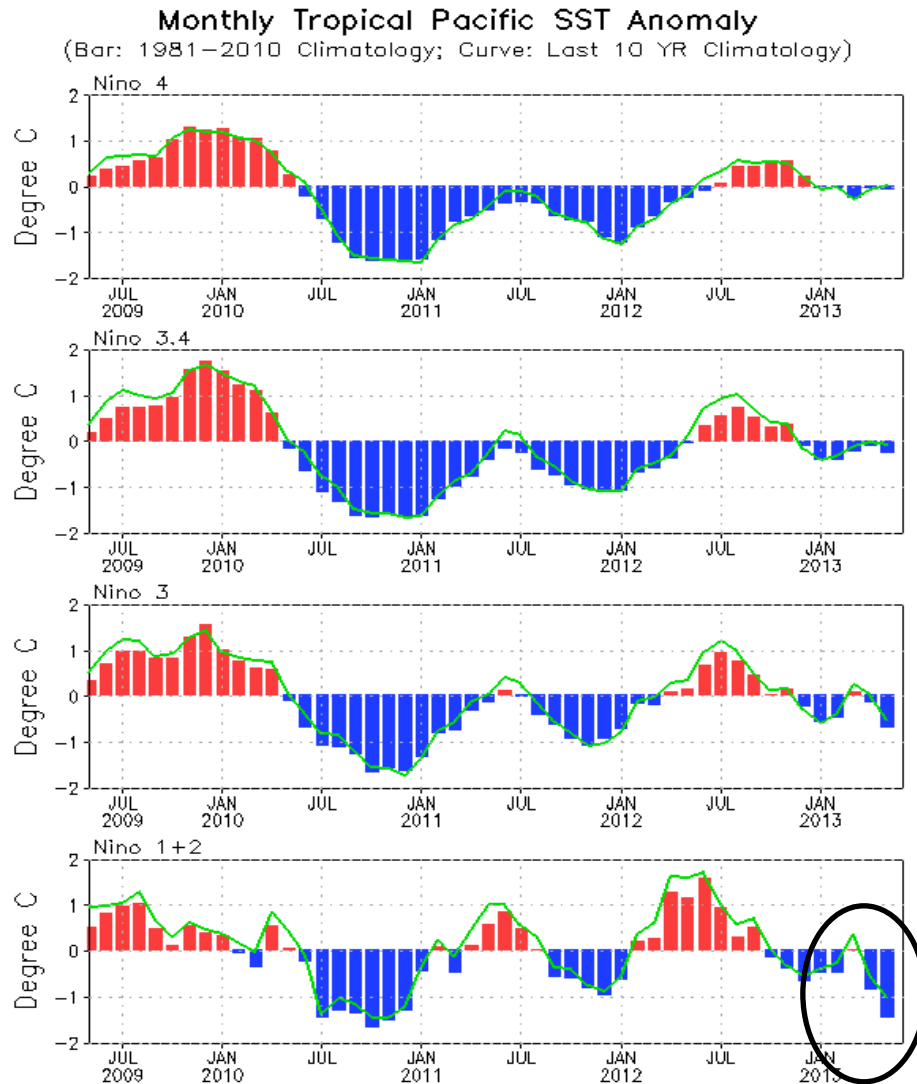
Standardized Projection on EEOF 1



- Since Mar 2013, Kelvin wave –like propagation was less evident, and almost stationary variation is consistent with the pentad ocean temperature anomaly shown in slide 12.

- 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

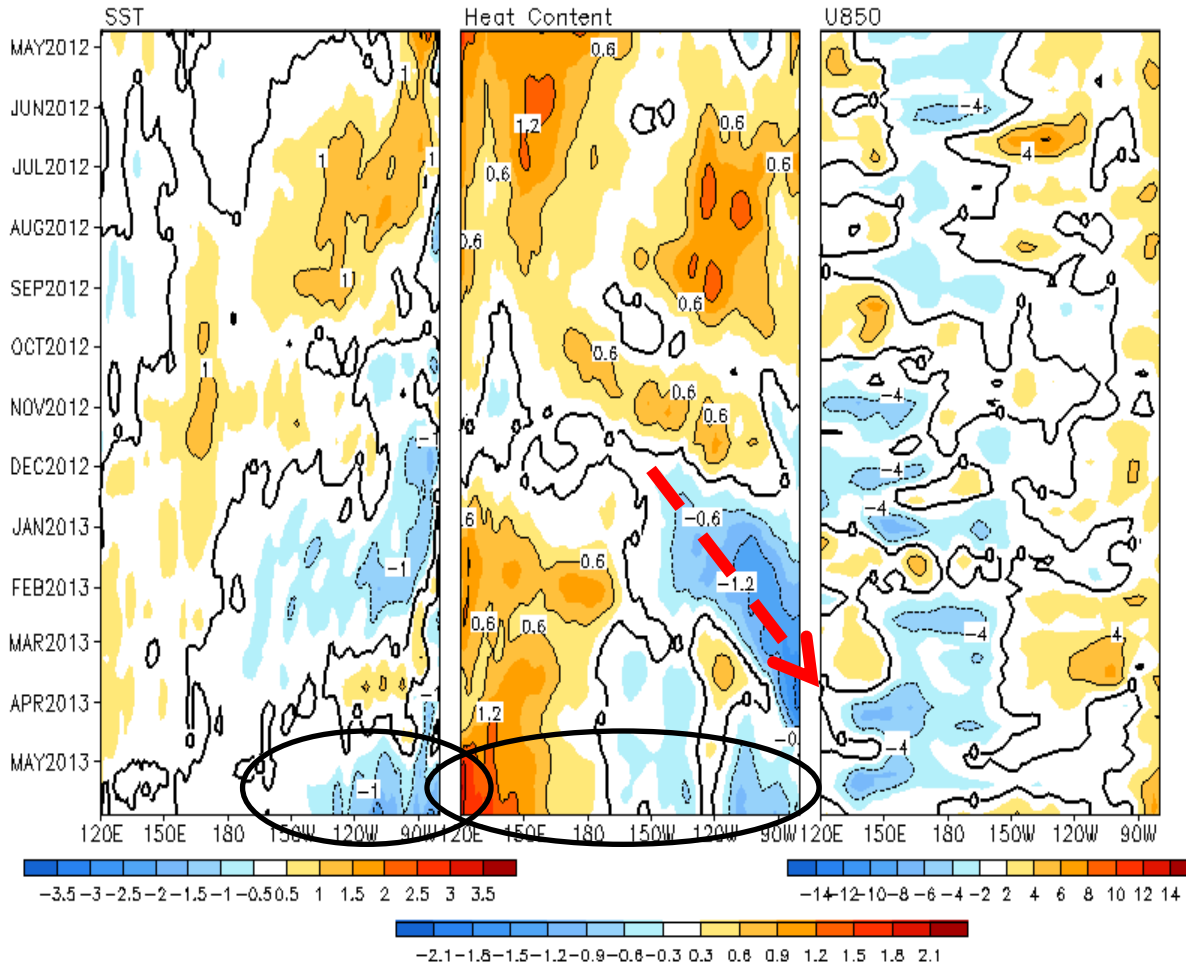


- All Nino indices were negative: Nino1+2=-1.4C, Nino3=-0.7C, NINO 3.4=-0.3°C.
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.

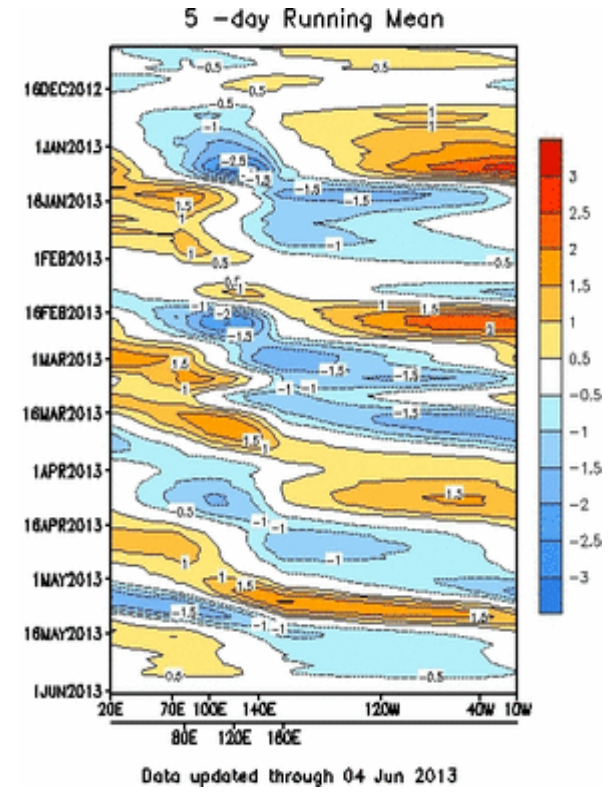
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 (bar) and last ten year (green line) means.

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

2°S–2°N Average, 3 Pentad Running Mean



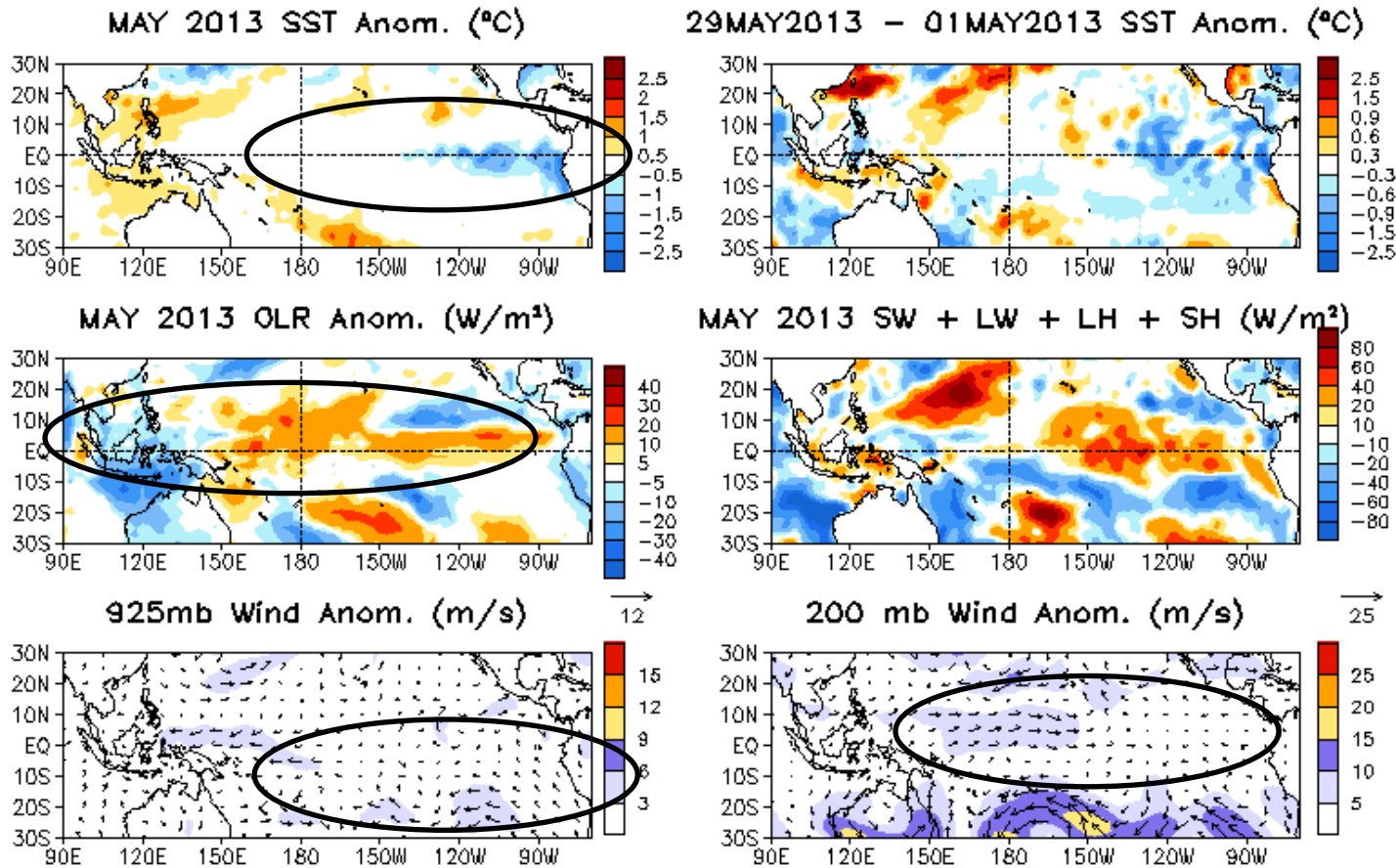
CPC MJO Indices



Data updated through 04 Jun 2013
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 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.

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

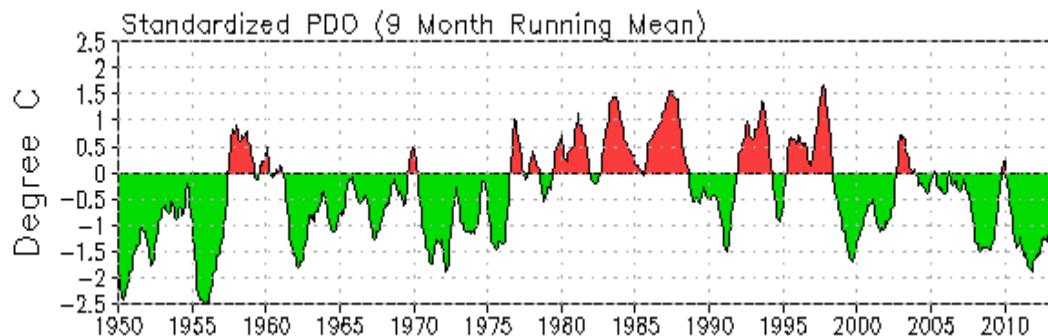
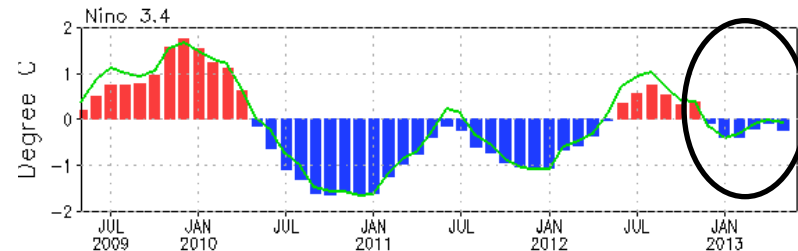
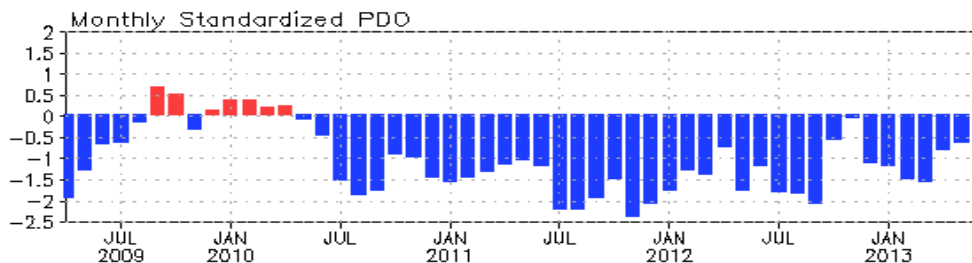


- The suppressed (enhanced) convection near the Dateline (over the Maritime Continent), low level (upper level) easterly (westerly) wind anomalies in the western-central Pacific are consistent with La Nina-like conditions.

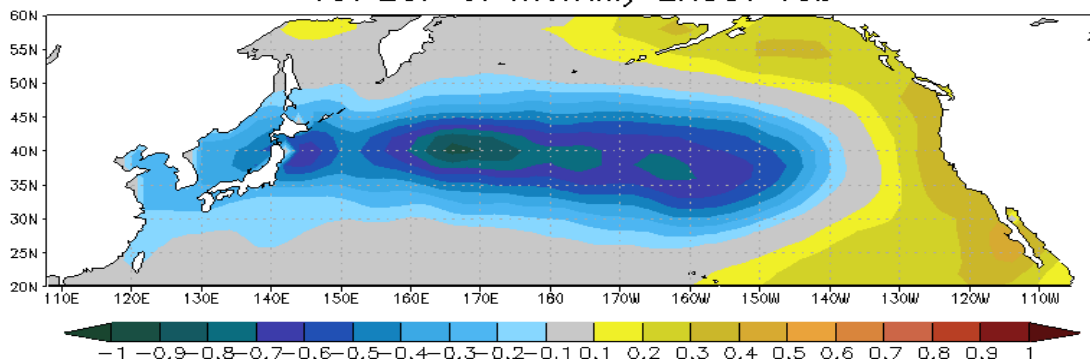
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

North Pacific & Arctic Oceans

Pacific Decadal Oscillation Index



1st EOF of monthly ERSST v3b



- Negative PDO phase since May 2010 has persisted for more than 3 years (37 months) now, and the PDO index weakened since Apr 2013 and PDO index = -0.6 in May 2013.

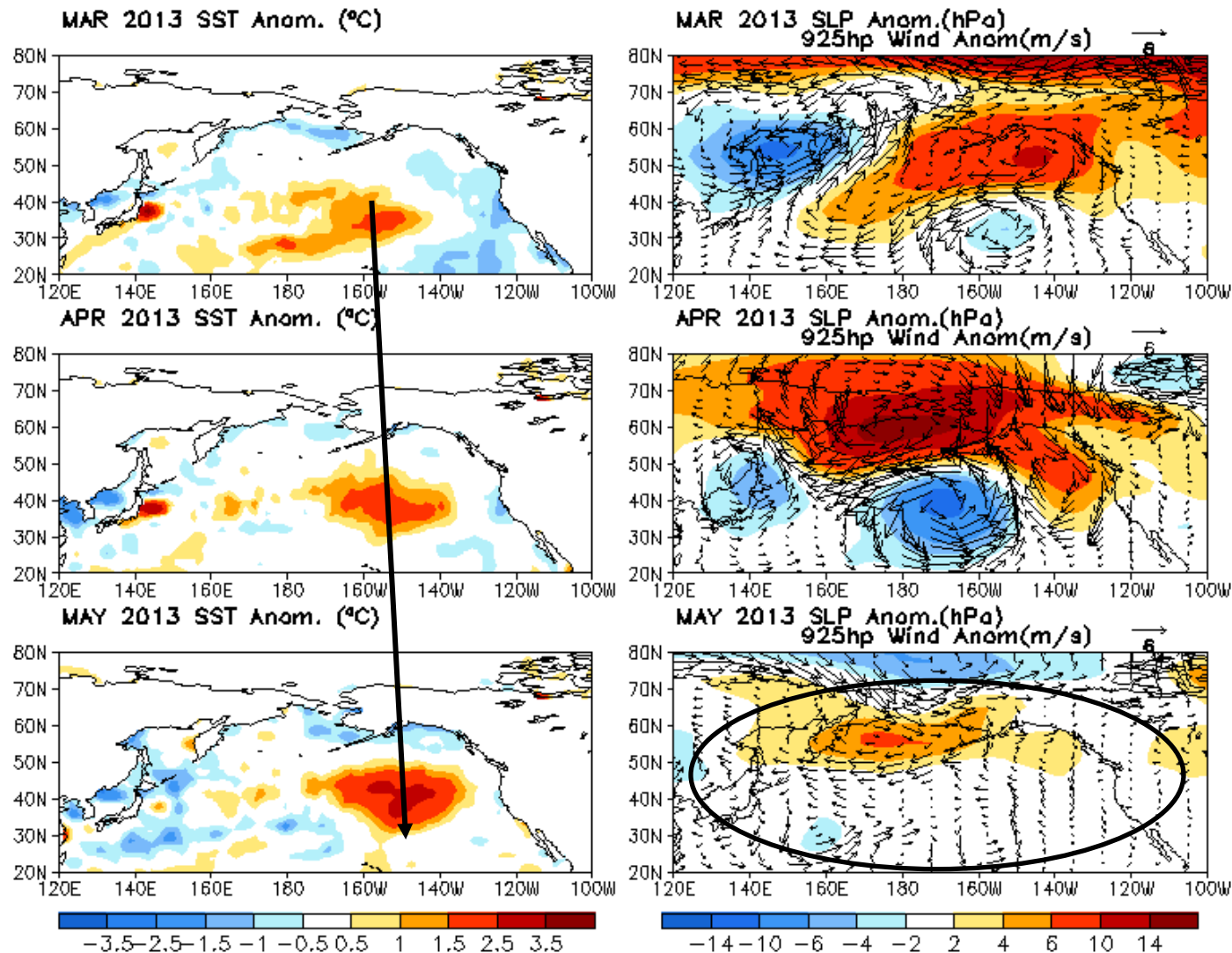
- The apparent connection between Niño3.4 and PDO indices suggests connections between tropics and extra-tropics.

- However, the negative phase of PDO during Jun-Nov 2012 seems not connected with the positive Niño3.4 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.

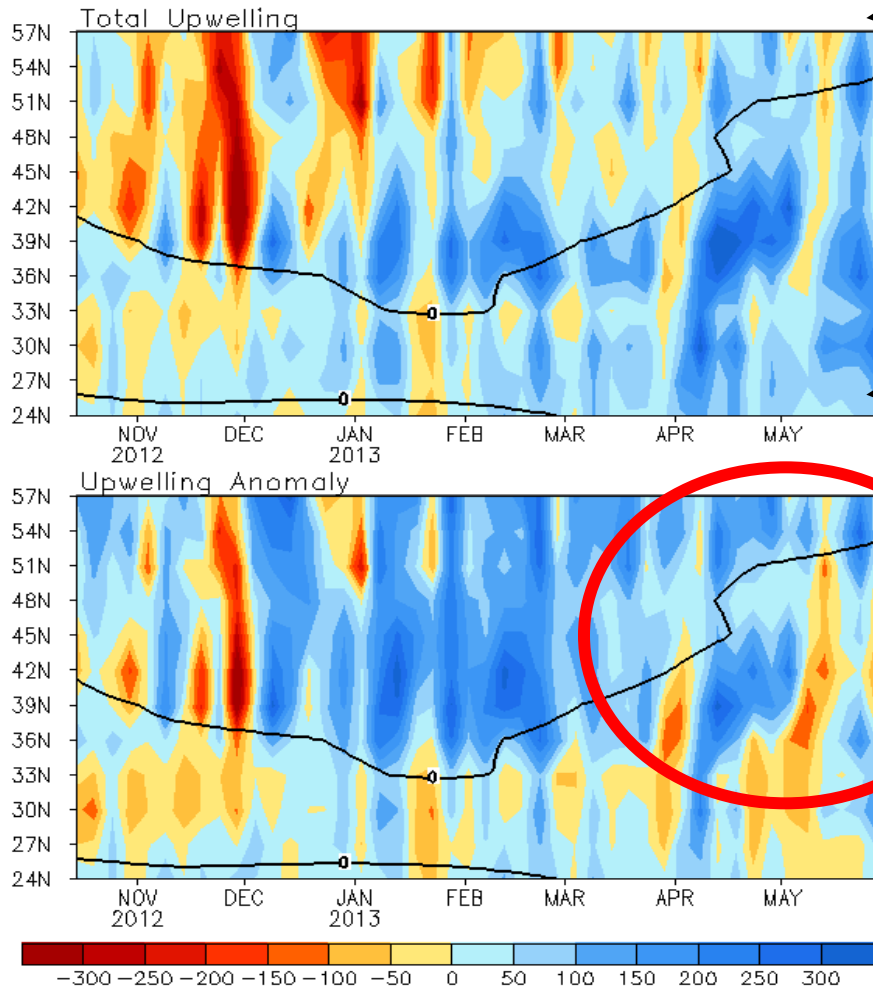
Last Three Month SST, SLP and 925hp Wind Anom.



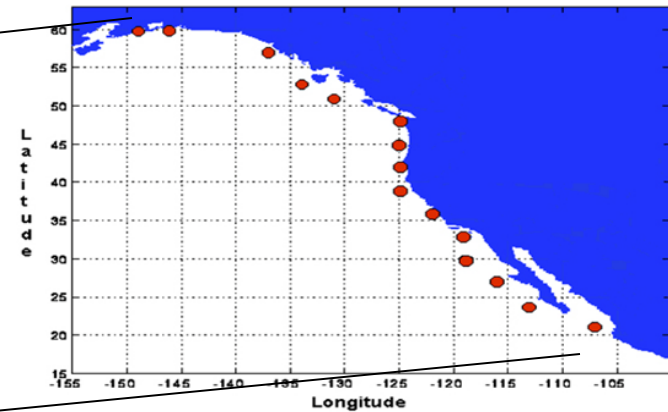
- Negative phase of PDO associated SSTA persisted and the positive SSTA propagated eastward.
- Both wind and SLP anomalies were small in N. Pacific in May 2013.

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



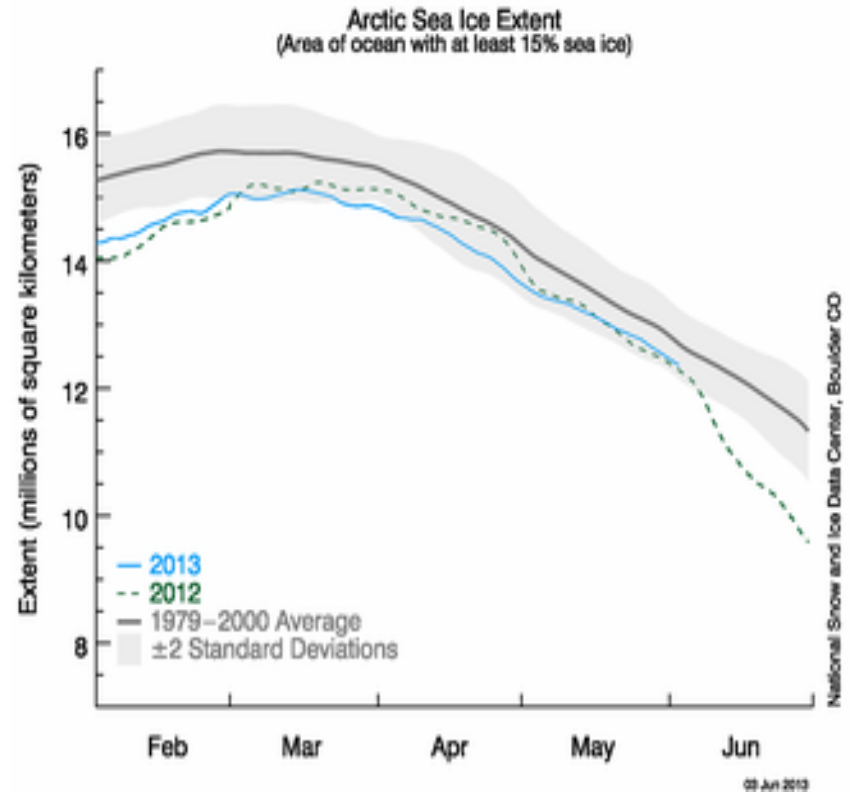
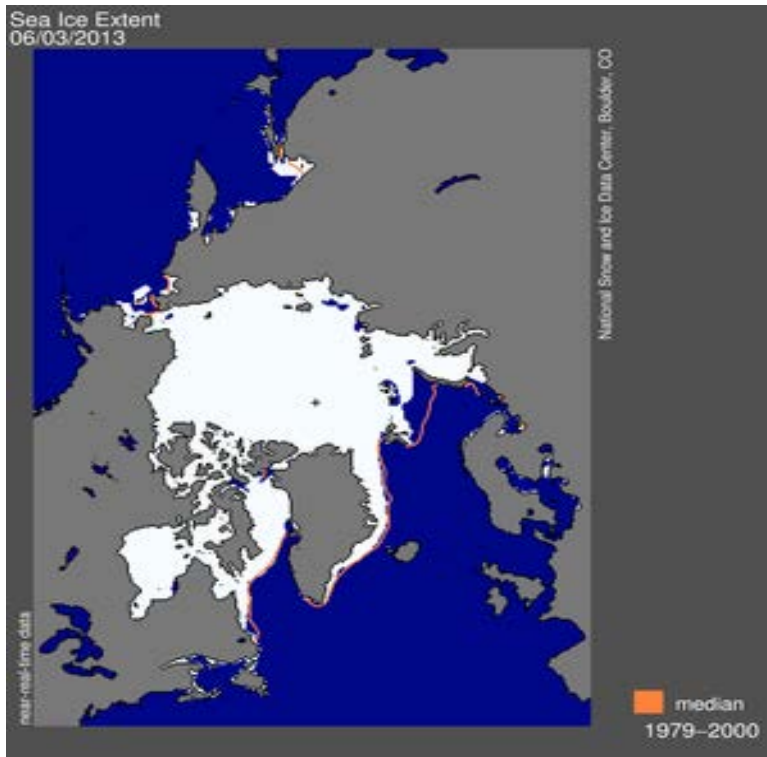
- Both downwelling in high latitudes (50-57N) and upwelling in low latitudes (24-48N) were suppressed in May 2013.

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.

Arctic Sea Ice

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



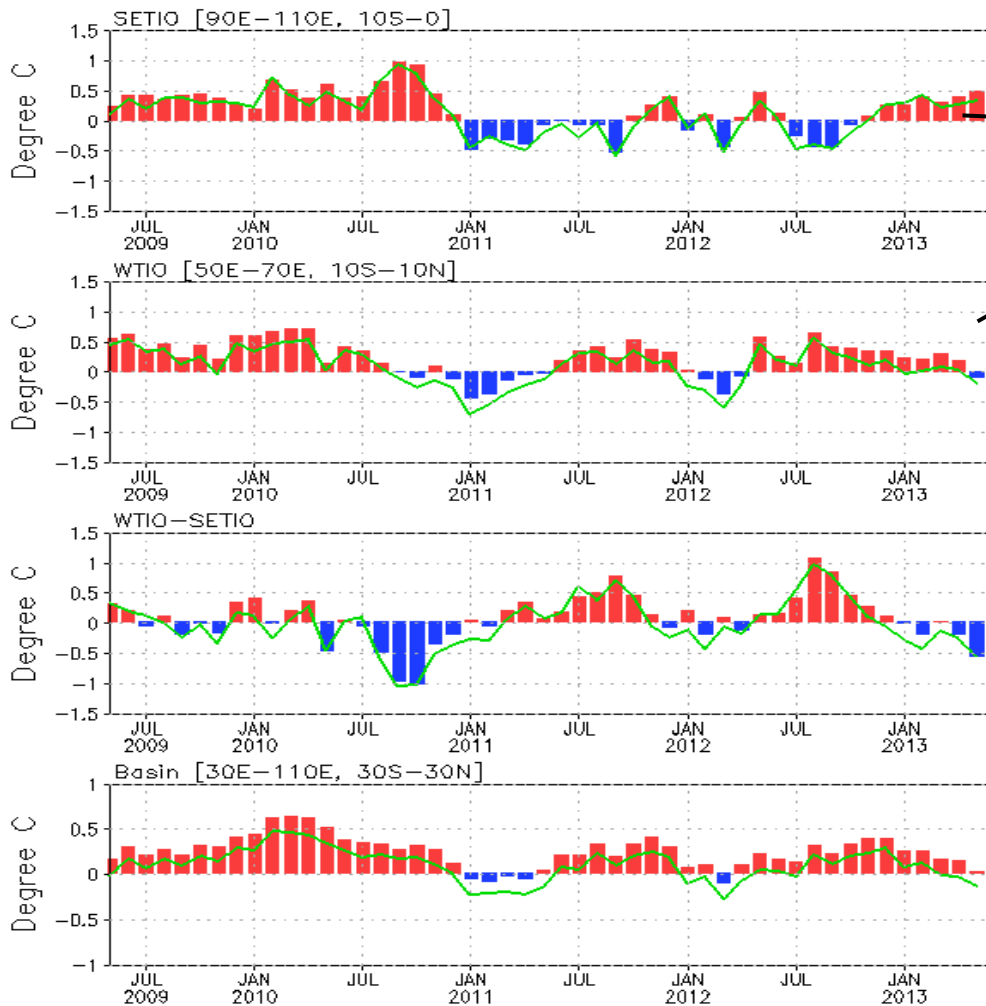
- Averaged sea ice extent for May 2013 was still below-normal, and it is similar to May 2012.

Indian Ocean

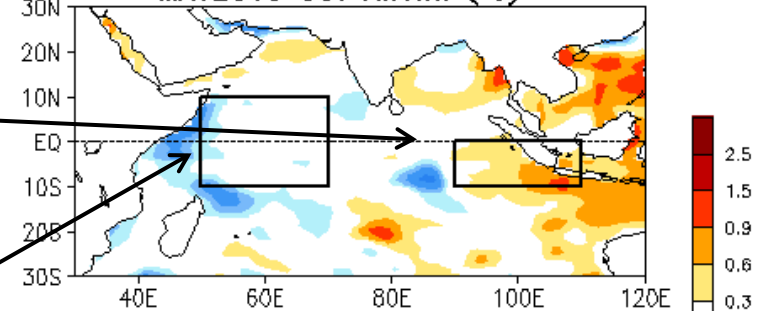
Evolution of Indian Ocean SST Indices

Monthly Tropical Indian SST Anomaly

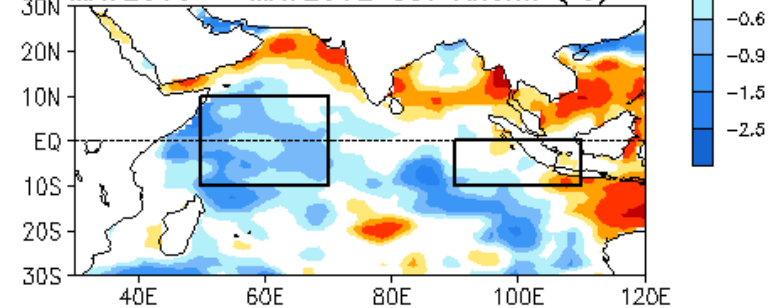
(Bar: 1981–2010 Climatology; Curve: Last 10 YR Climatology)



MAY2013 SST Anom. (°C)



MAY2013 - MAY2012 SST Anom. (°C)



- DMI was negative since Apr 2013, consistent with above (below) normal in the e. (w.) Indian Ocean.
- Negative DMI was intensified in May 2013.

Fig. 11a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and departures from the 1981-2010 base period means and the recent 10 year means are shown in bars and green lines.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

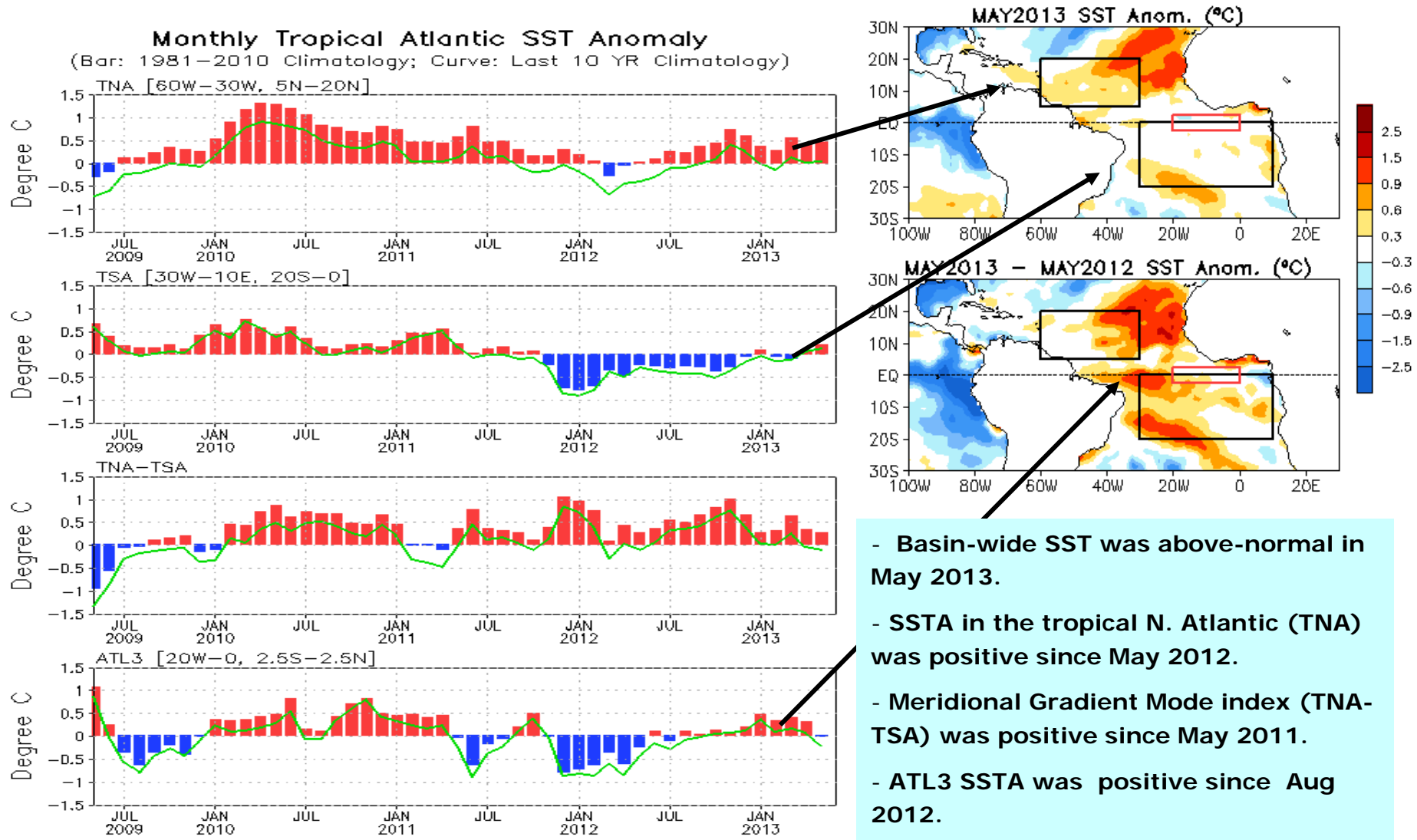
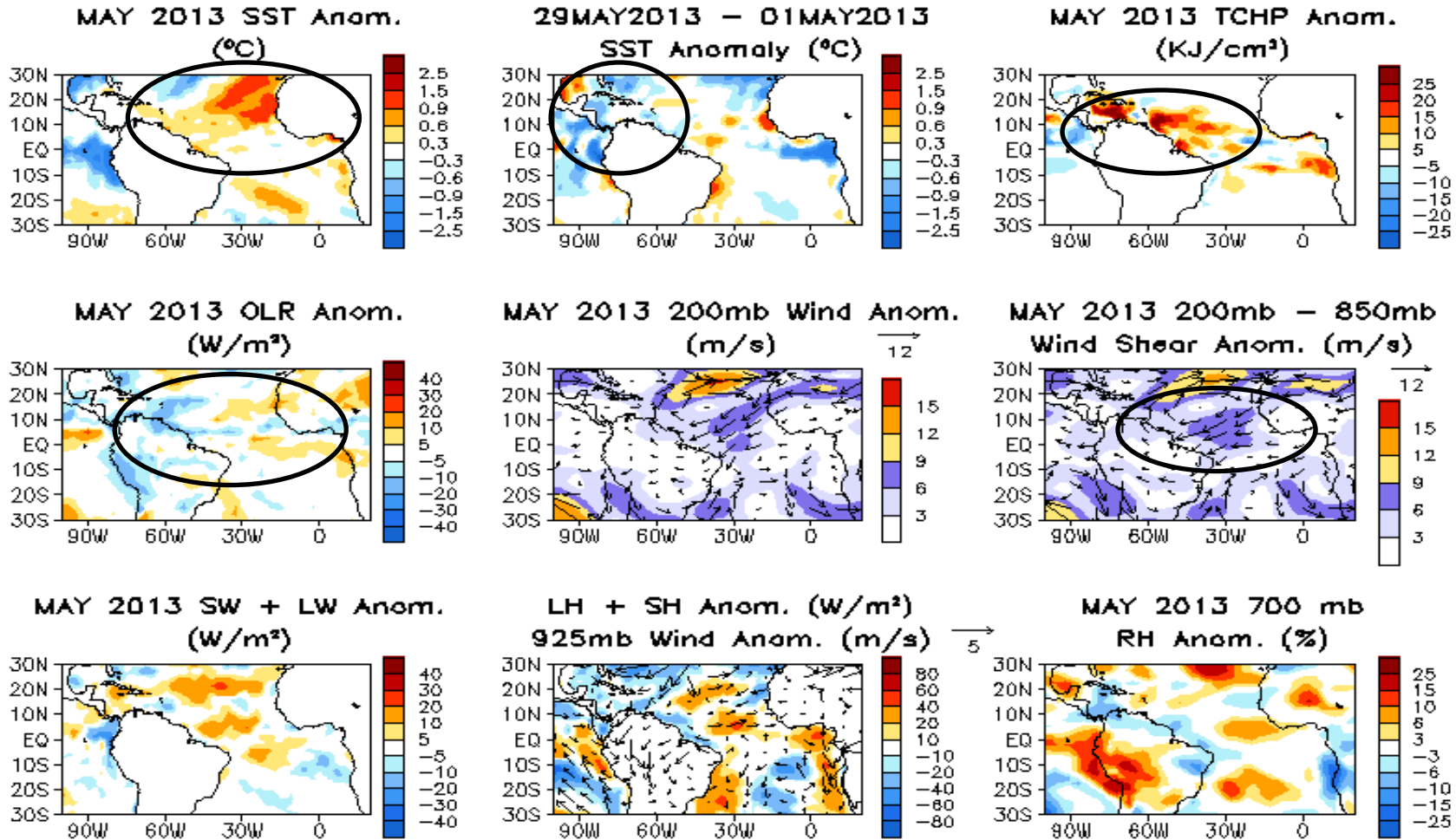


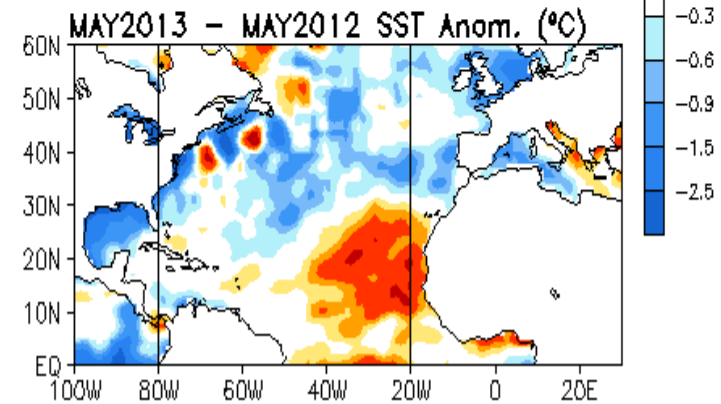
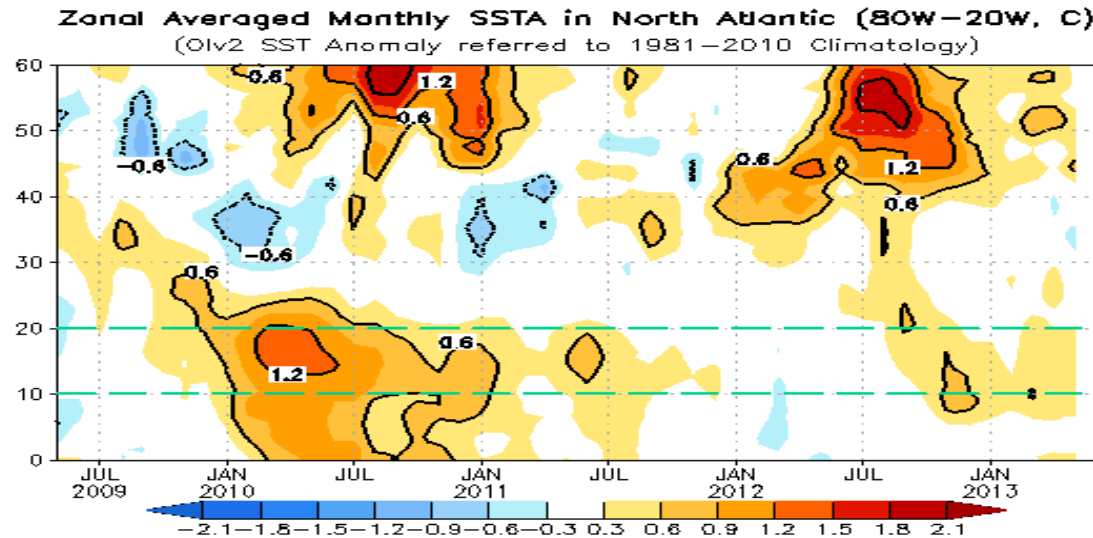
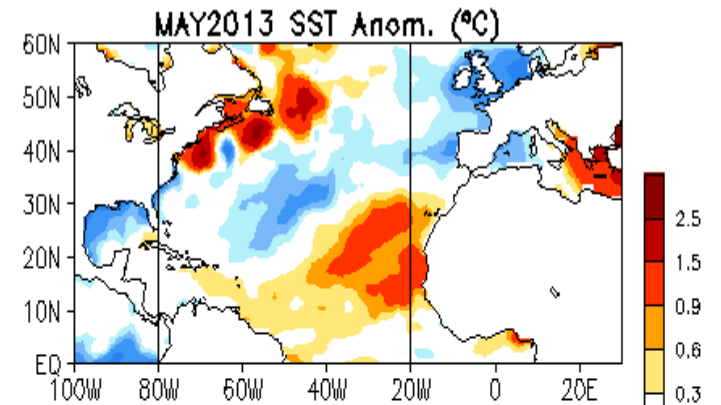
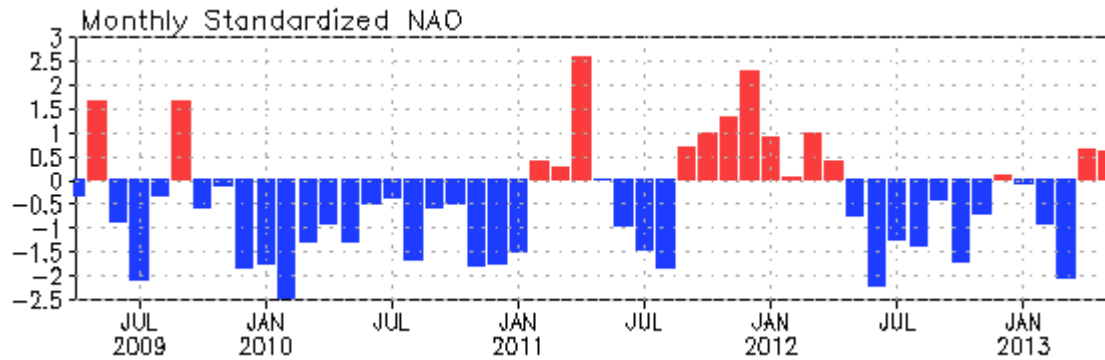
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W–30°W, 5°N–20°N], TSA [30°W–10°E, 20°S–0] and ATL3 [20°W–0, 2.5°S–2.5°N] regions, and Meridional Gradient Index, defined as differences between 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 presented in the hurricane Main Development Region (MDR).
- The vertical wind shear was below-normal in the hurricane Main Development Region, favorable for hurricane activities.
- Cooling tendency was observed in the western Atlantic and Gulf of Mexico.
- Both suppressed and enhanced convection was observed in the tropical N. Atlantic.
- TCHP was positive and mainly in the NW Atlantic Ocean.

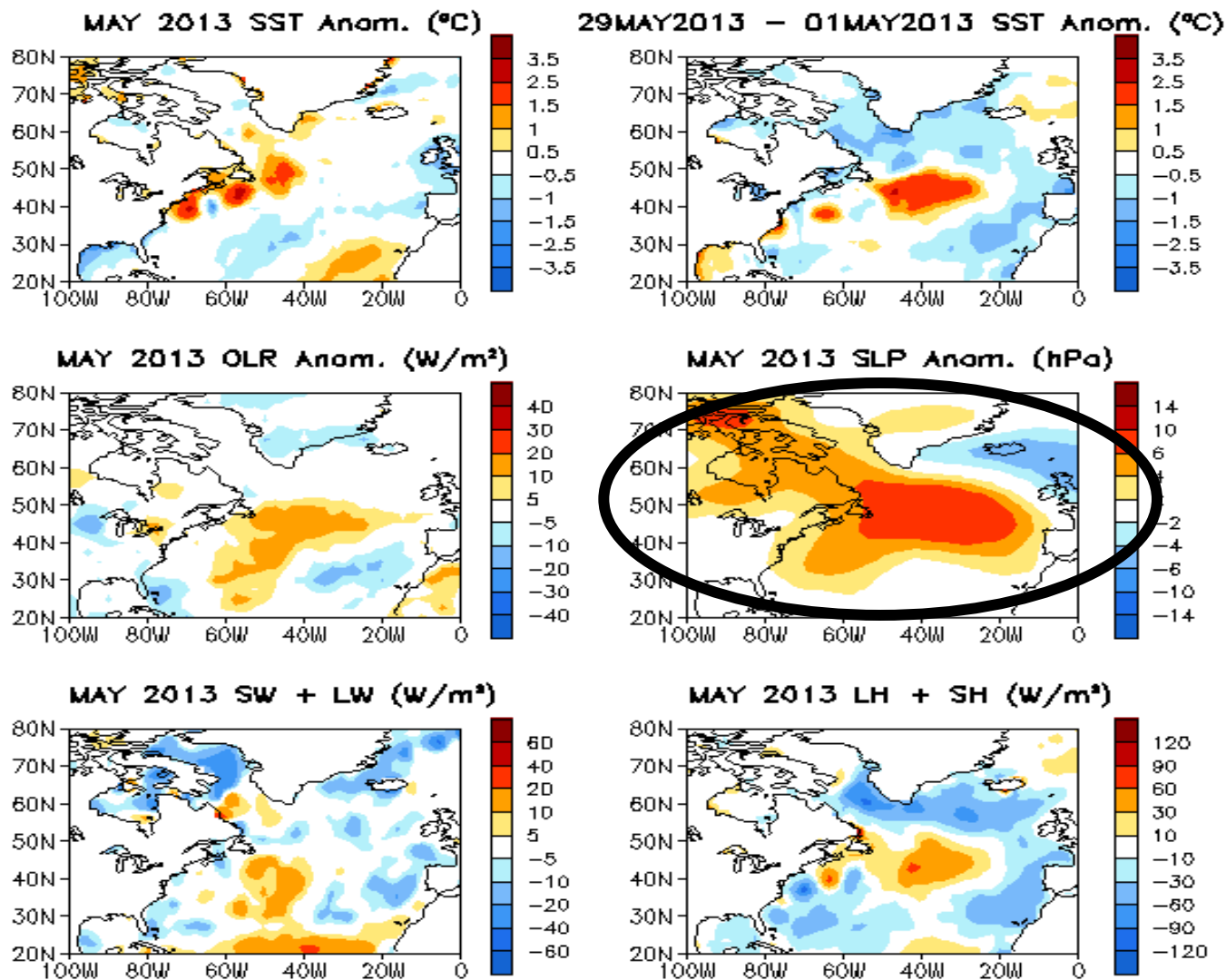
NAO and SST Anomaly in North Atlantic



-NAO switched from negative to positive phase in Apr 2013, with NAO index = 0.6 in May 2013. That may not favor the positive SSTA in the tropical N. Atlantic.

- The zonal mean SSTA in North Atlantic is generally related to NAO and ENSO impact (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

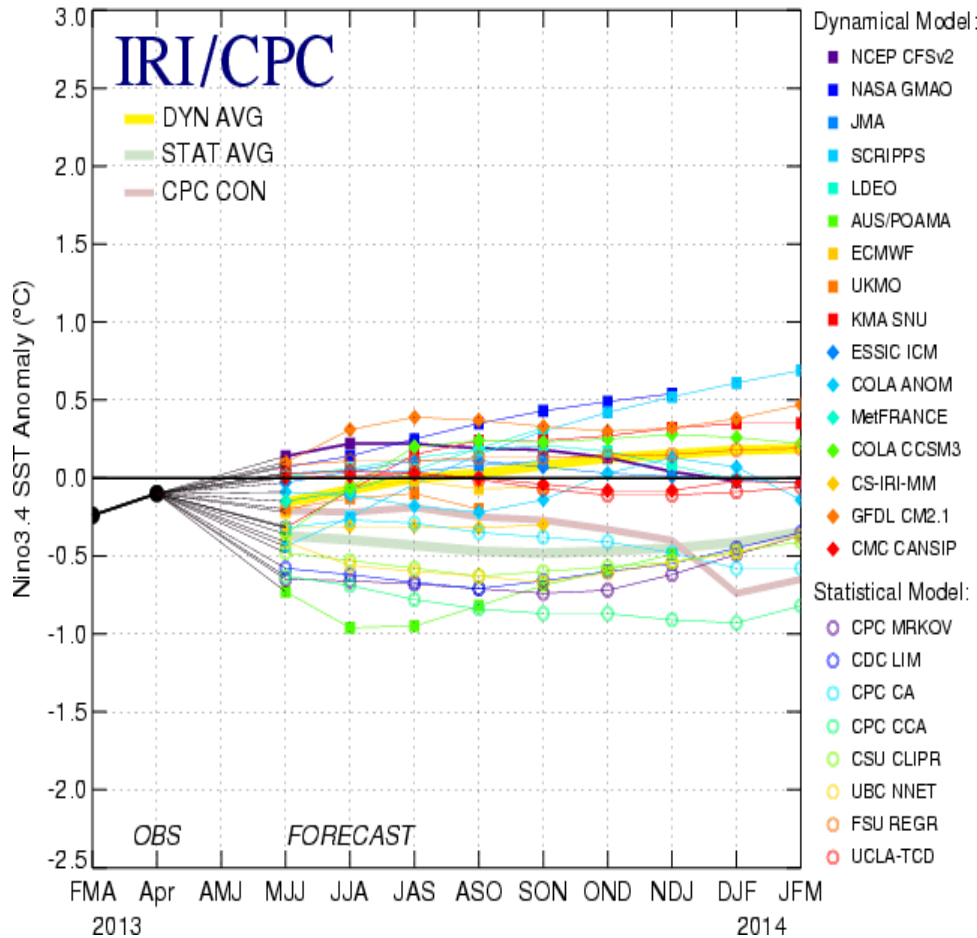
- Positive SLP anomaly in the south and negative in the northeast was consistent with the positive NAO index in May 2013.

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.

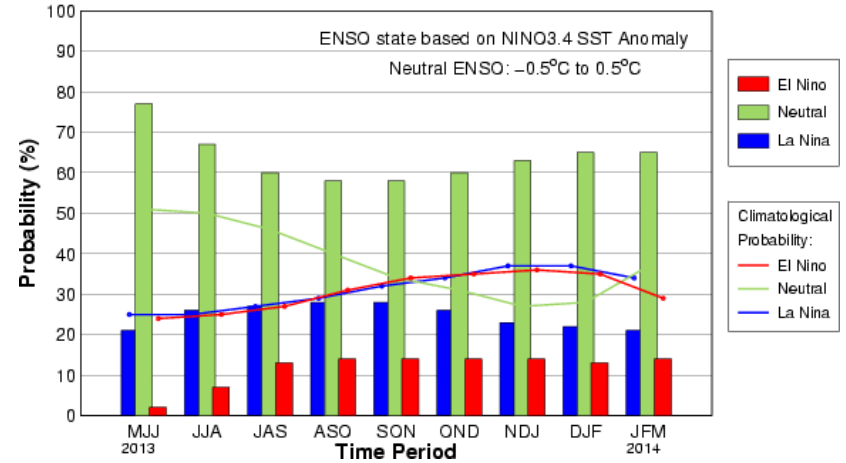
Global SST Predictions

IRI/CPC NINO3.4 Forecast Plume

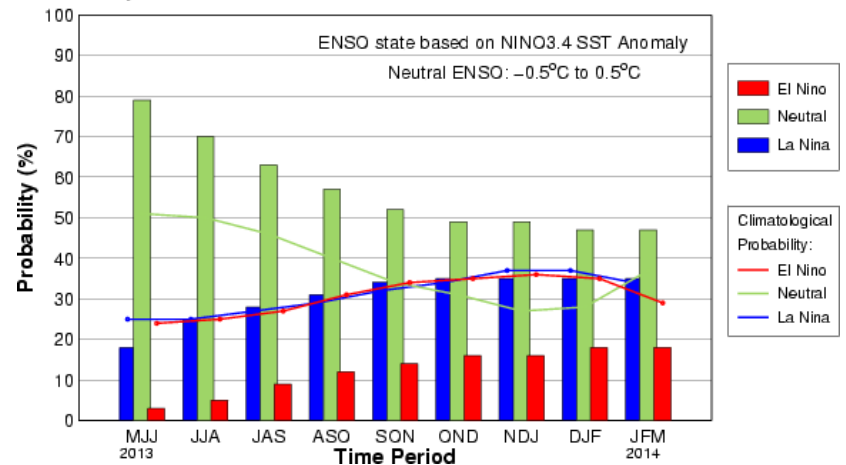
Mid-May 2013 Plume of Model ENSO Predictions



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



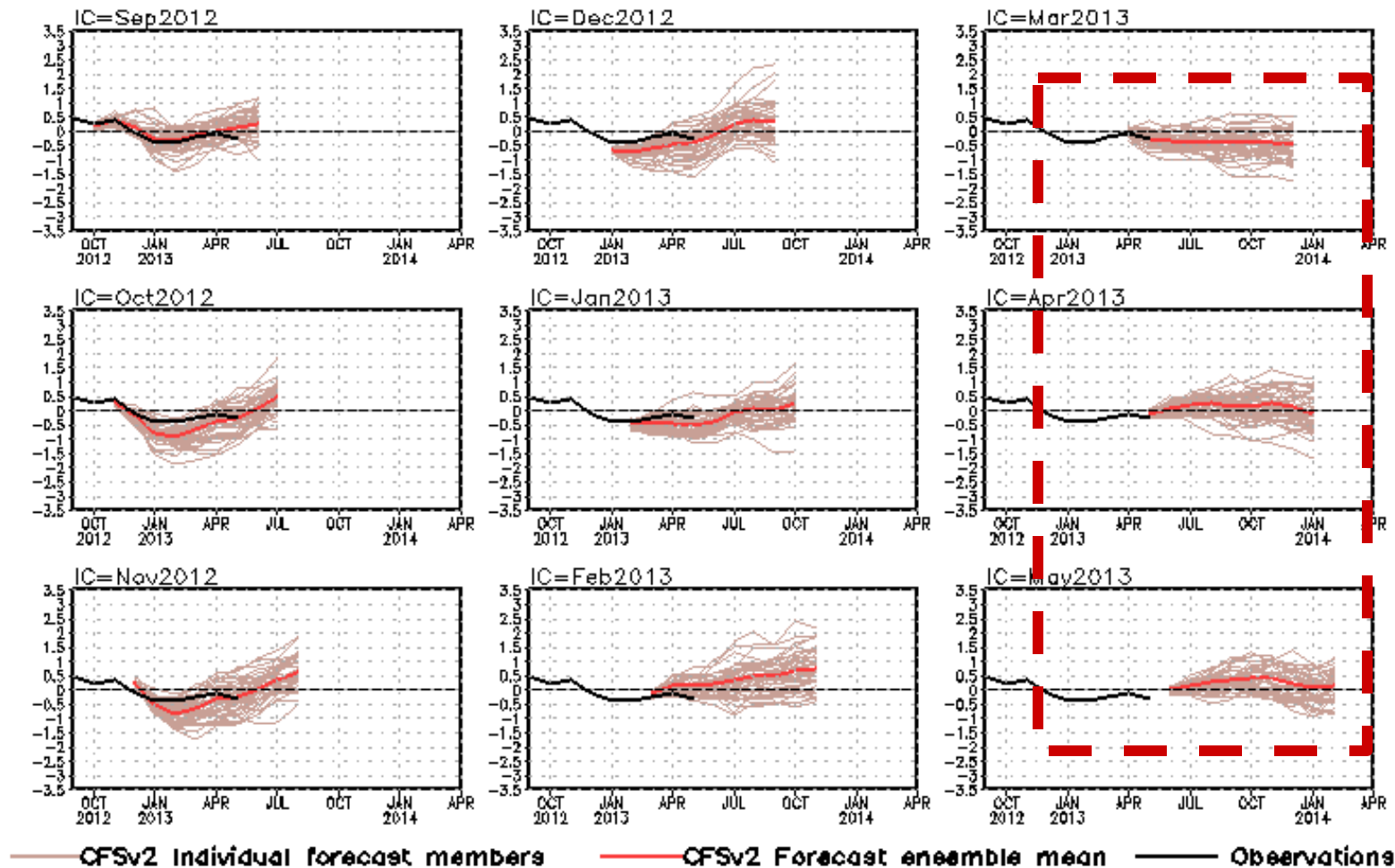
Early-Jun CPC/IRI Consensus Probabilistic ENSO Forecast



- Majority of the models predicted ENSO-neutral in the Northern Hemisphere summer-winter.
- Average of forecast Nino3.4 of dynamical models were warmer than that of statistical models.
- The consensus forecast favors ENSO-neutral conditions in the summer-autumn 2013.

NCEP CFSv2 NINO3.4 Forecast

NINO3.4 SST anomalies (K)

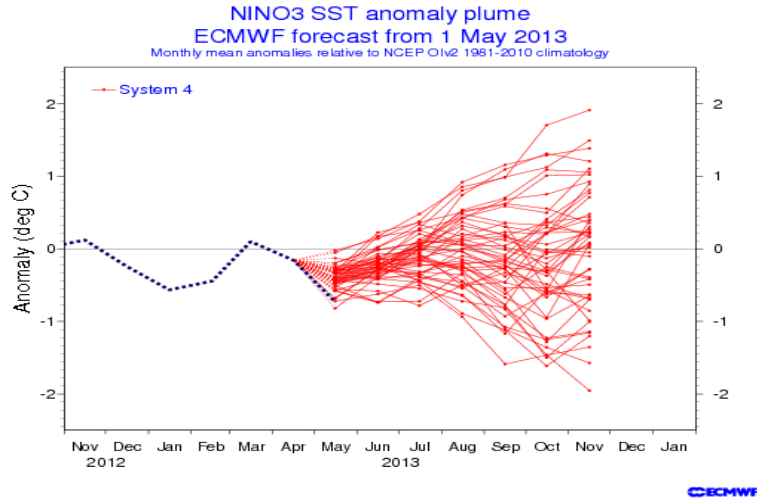


- The Nino3.4 predictions of CFSv2 shifted from positive SSTA in summer-autumn with IC in Feb 2013 to negative with IC in Mar 2013, near normal with IC in Apr 2013, then positive again with IC in May 2013, may imply the impact of short-term fluctuation and challenge of ENSO prediction with IC in spring.

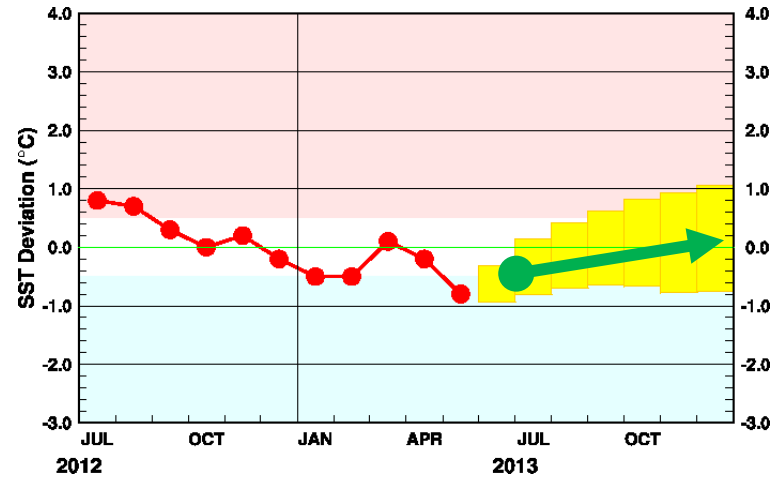
(Wang, W., M. Chen, A. Kumar, and Y. Xue, 2011: How important is intraseasonal surface wind variability to real-time ENSO prediction? Geophys. Res. Lett., 38, L13705. DOI: 10.1029/2011GL047684.)

Individual Models: diverged results

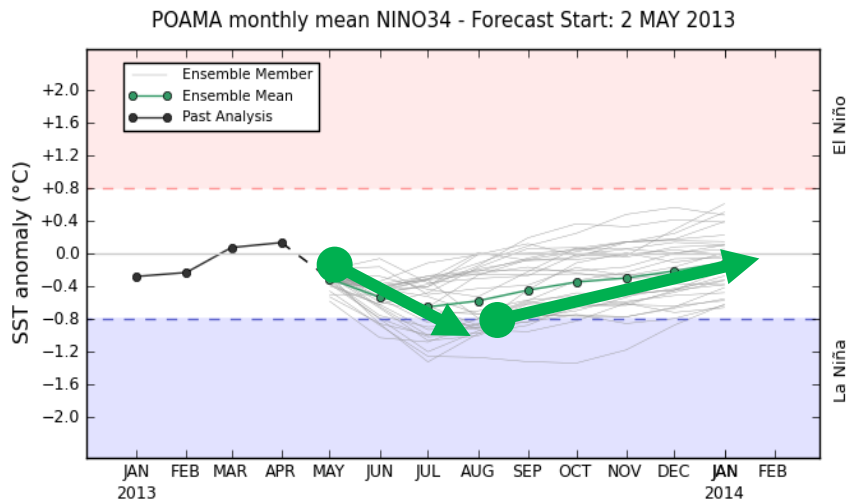
ECMWF: Nino3, IC=01May2013 (large spread)



JMA: Nino3, IC=May2013 (near normal)

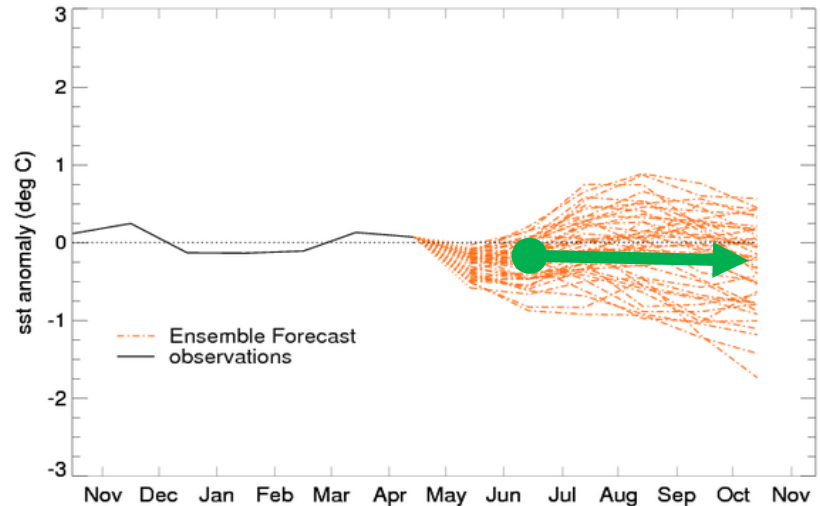


Australia: Nino3.4, IC=02May2013 (u-type)



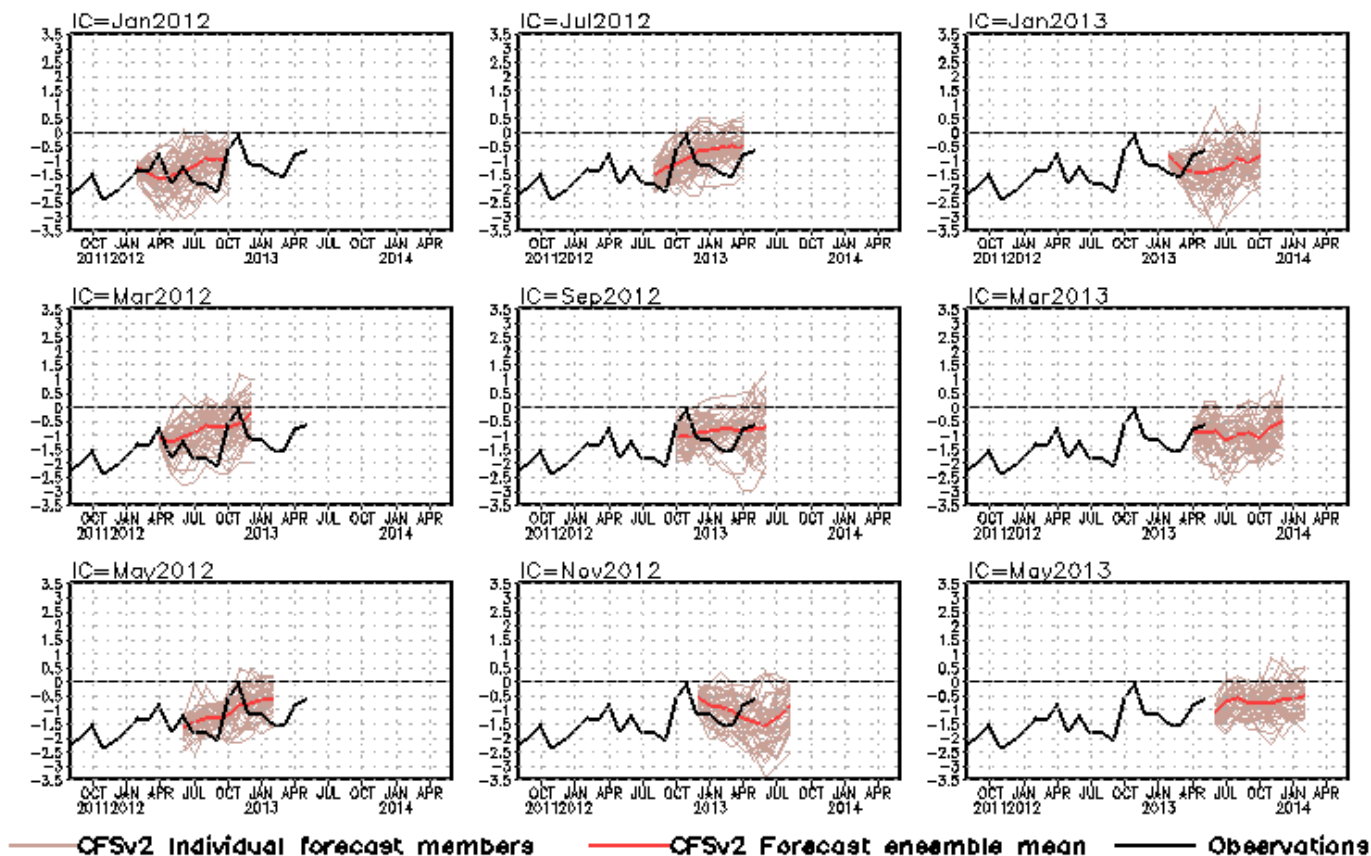
Copyright 2013 Australian Bureau of Meteorology

UKMO: Nino3.4, IC=15May2013 (near normal)



NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

standardized PDO index



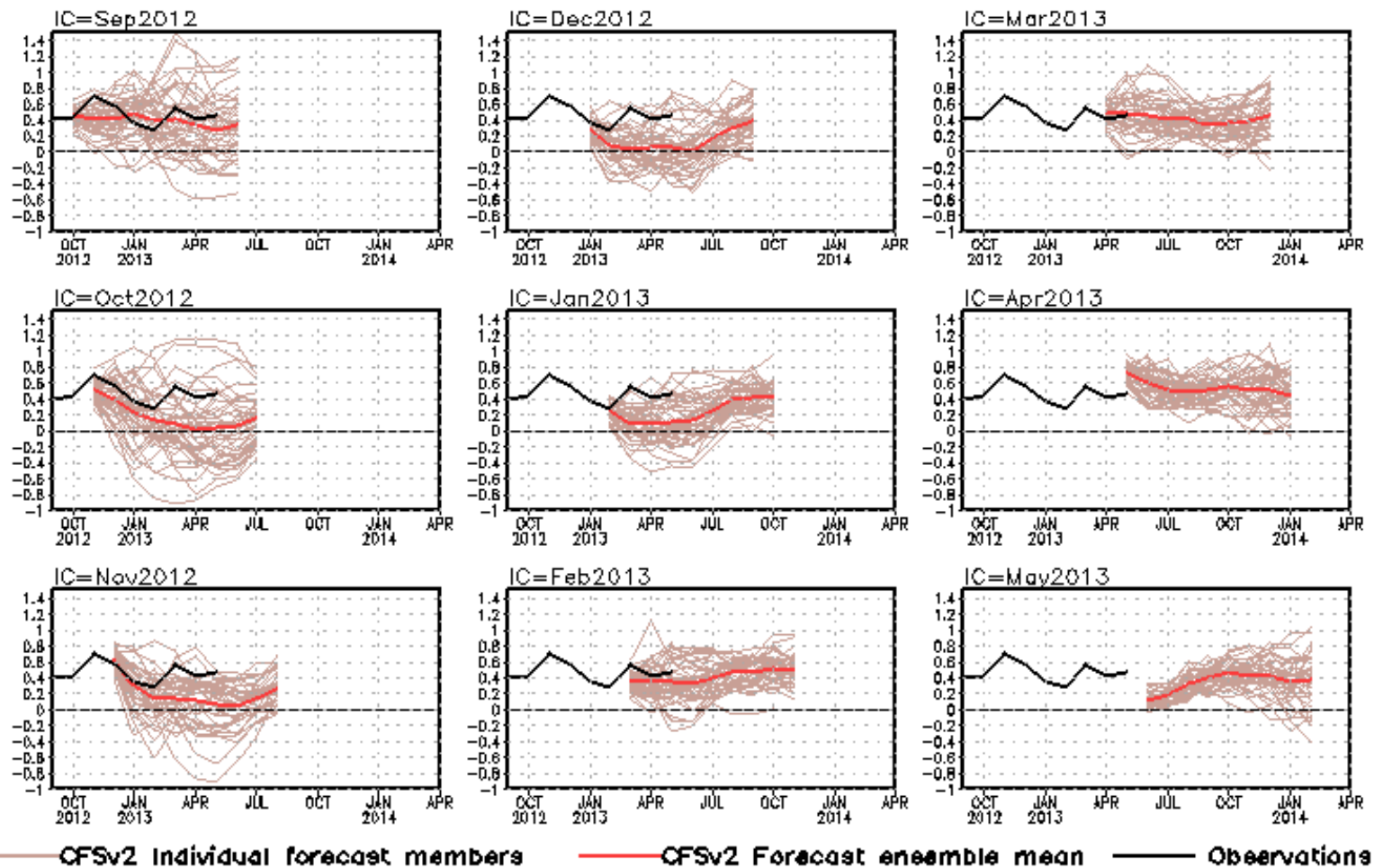
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

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

NCEP CFSv2 Tropical North Atlantic SST Forecast

Tropical N. Atlantic SST anomalies (K)

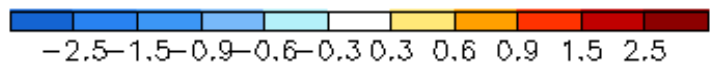
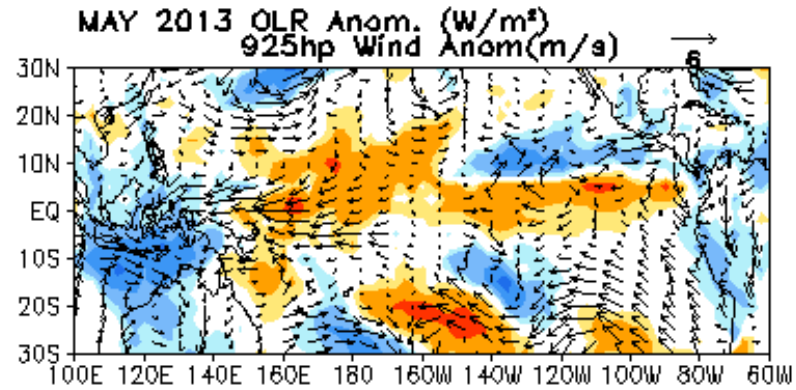
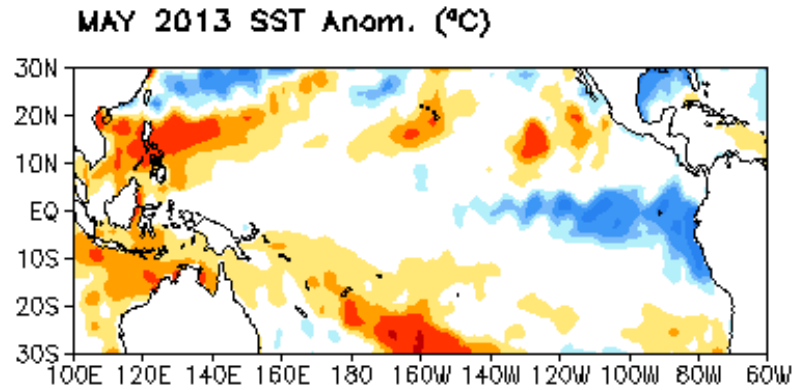
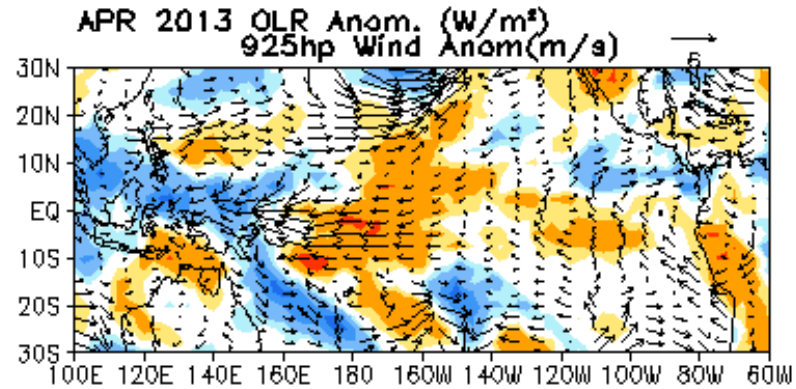
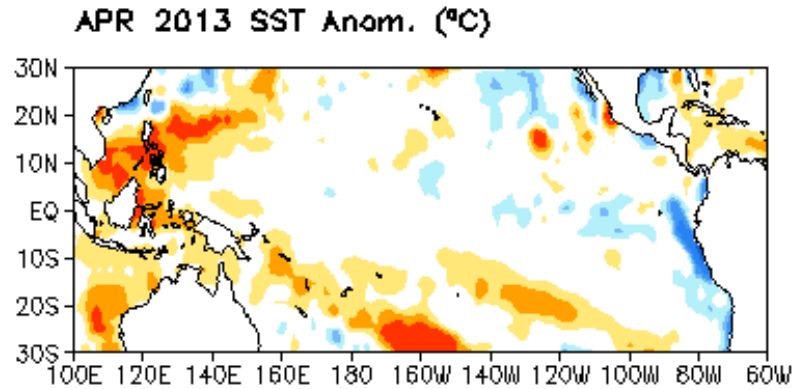
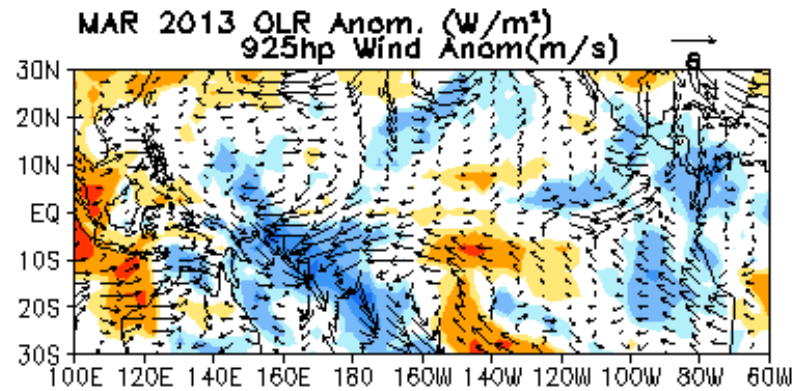
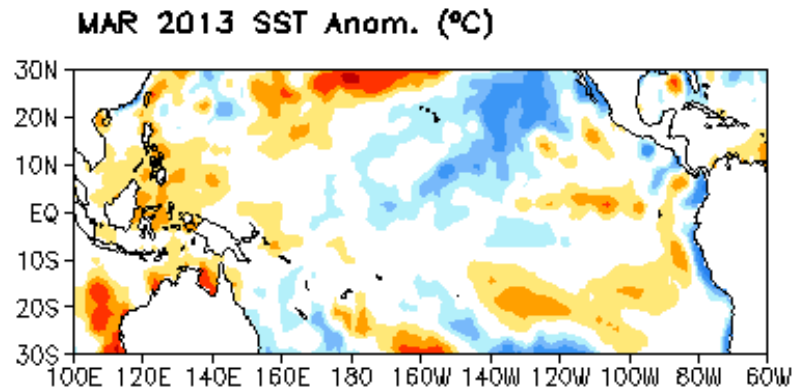


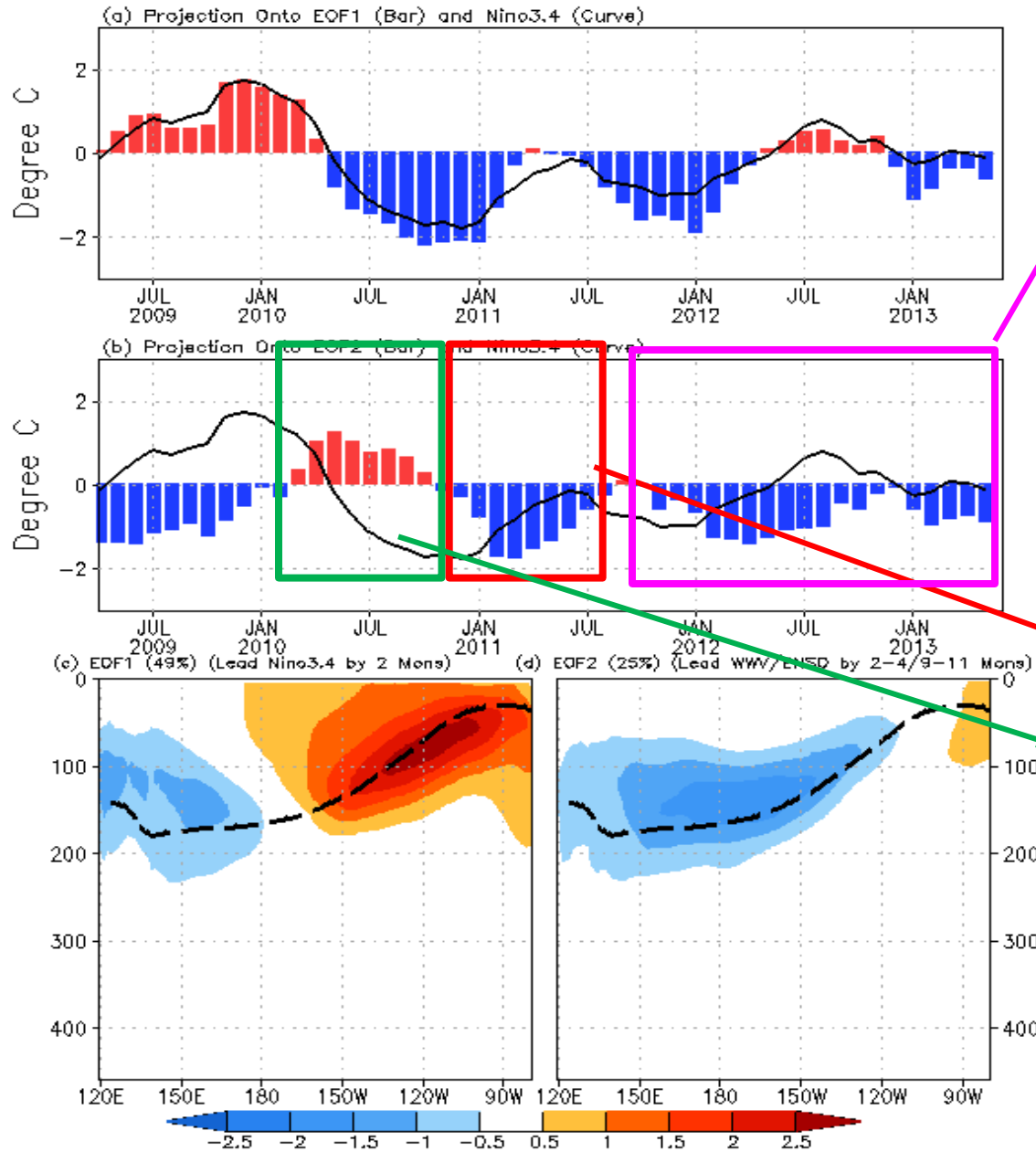
- Latest CFSv2 prediction suggests that above-normal SST in the tropical N. Atlantic will continue in summer-automn 2013 (hurricane season).

Backup Slides

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

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





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 (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.

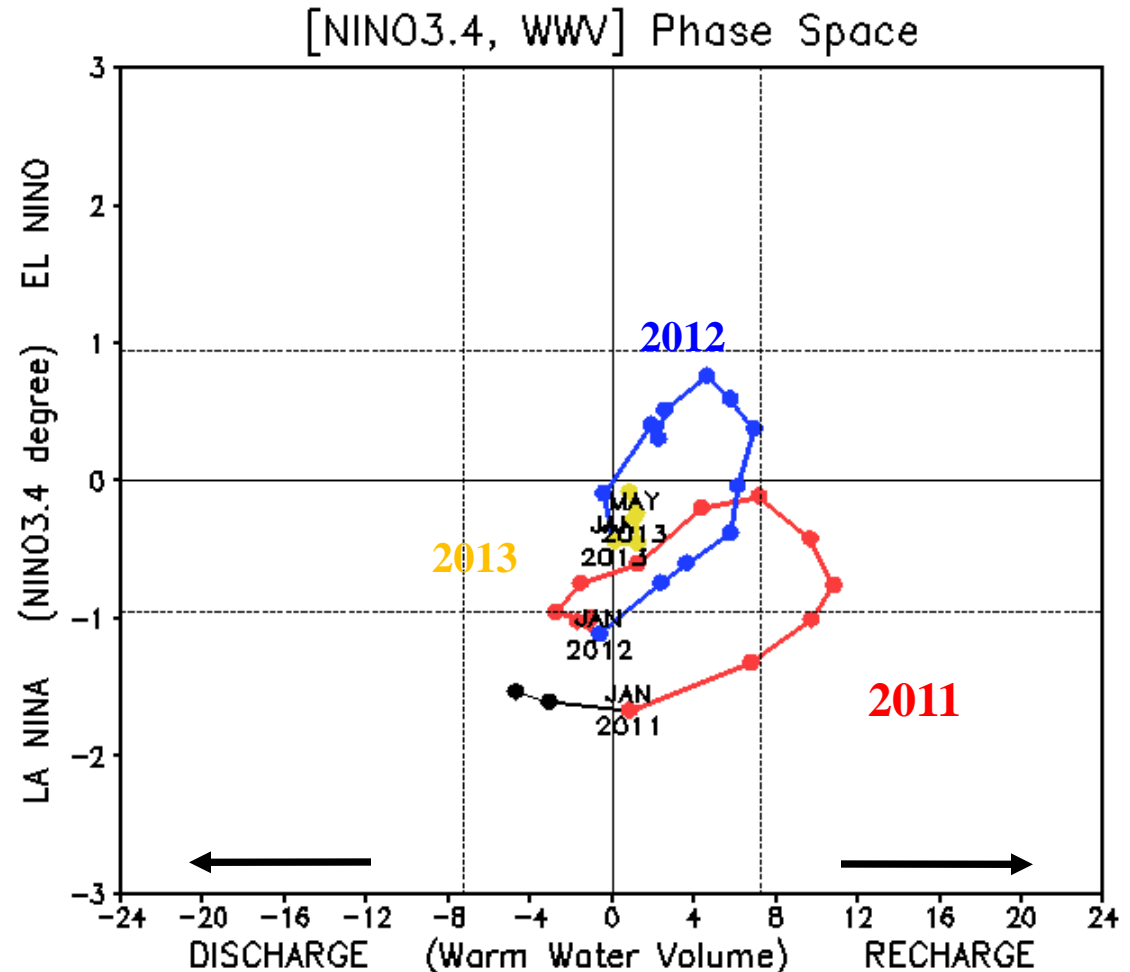


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.

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

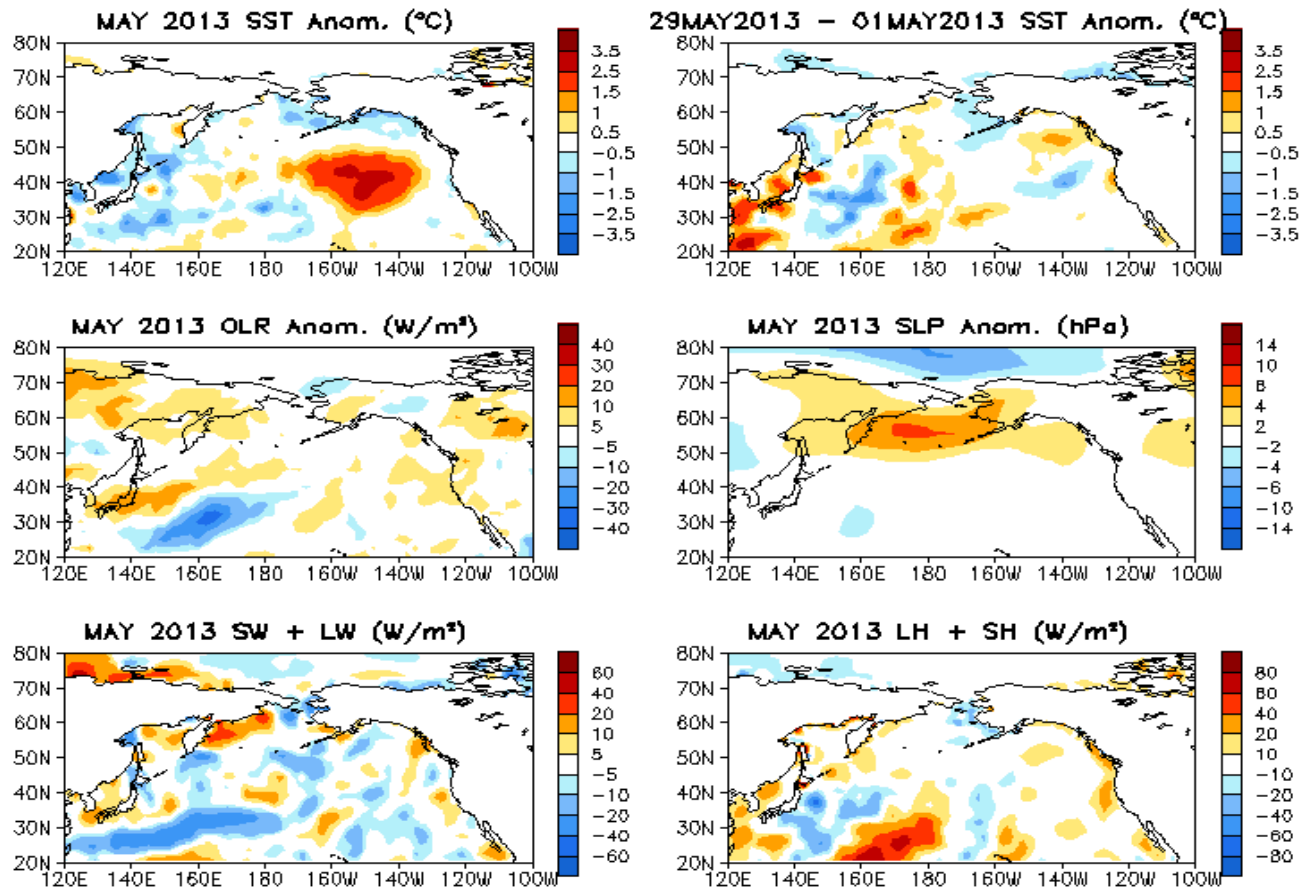
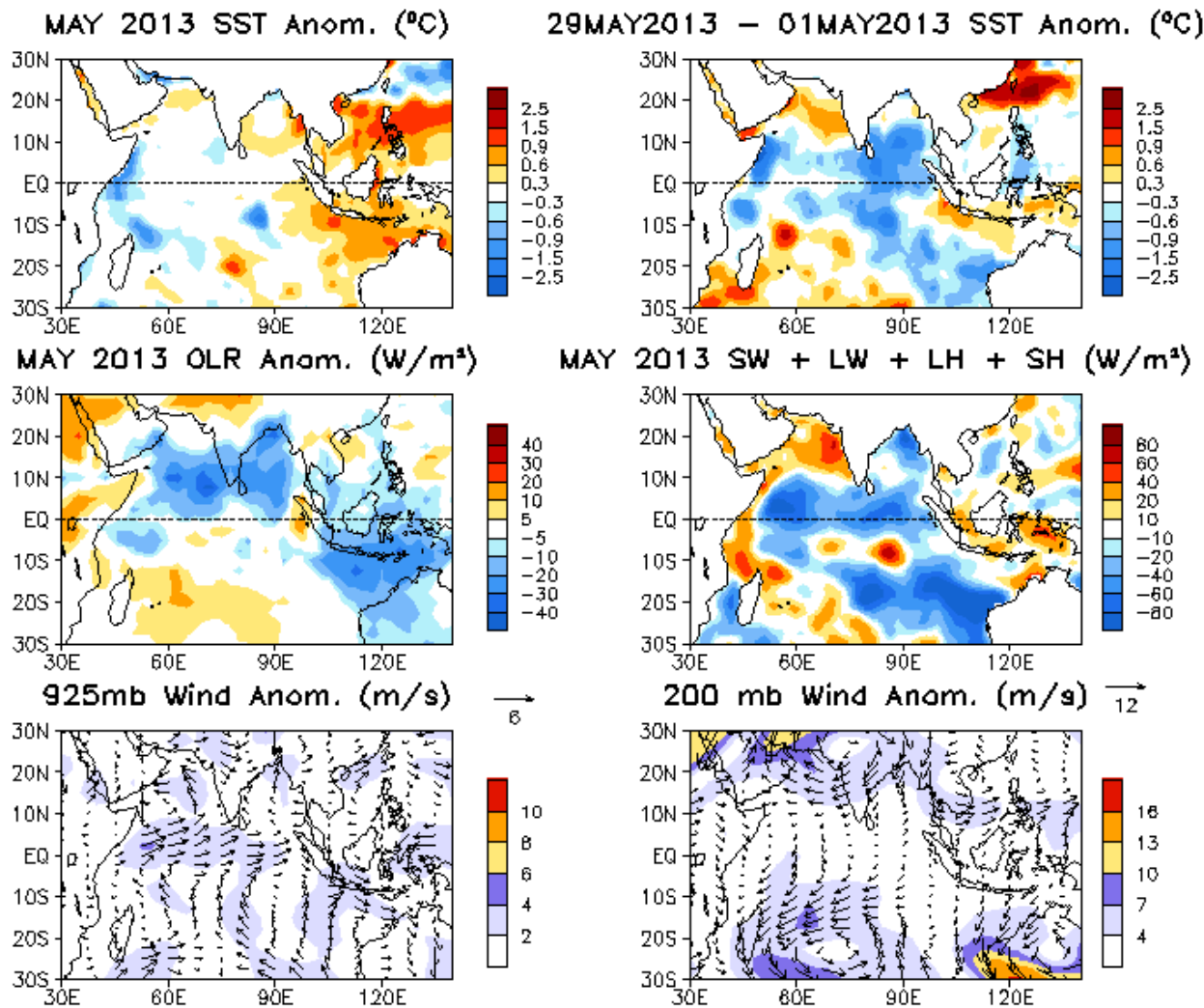


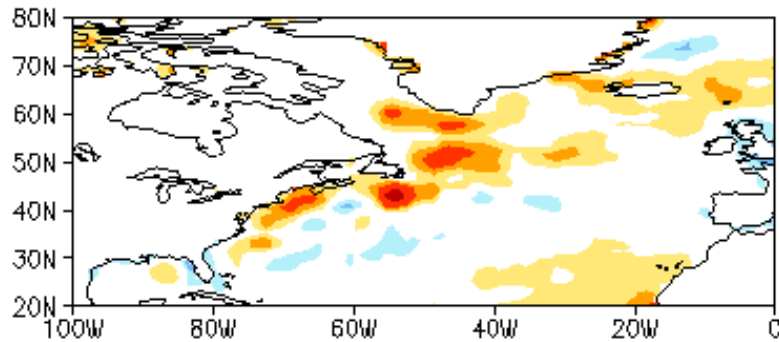
Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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



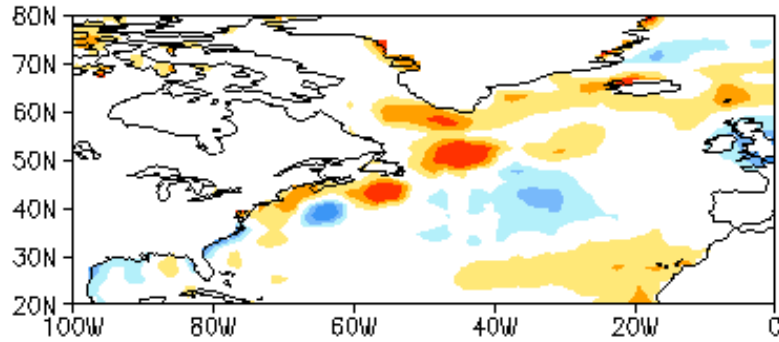
Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

Fig. 12. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

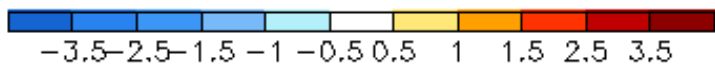
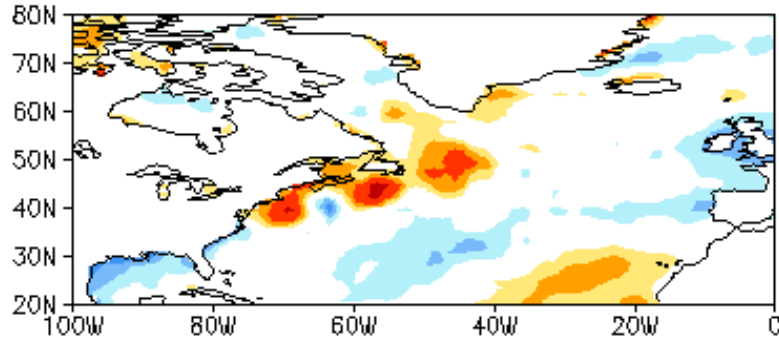
MAR 2013 SST Anom. (°C)



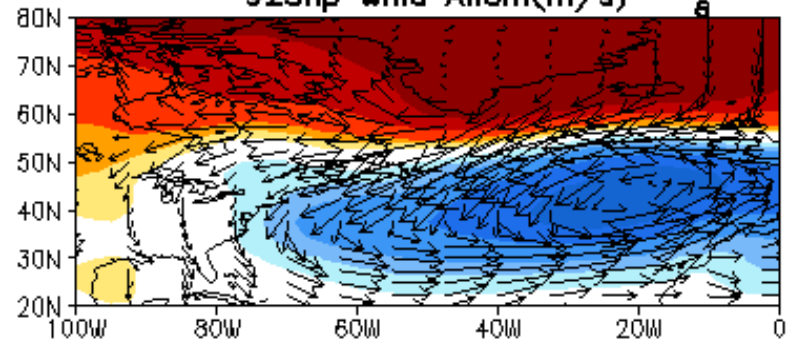
APR 2013 SST Anom. (°C)



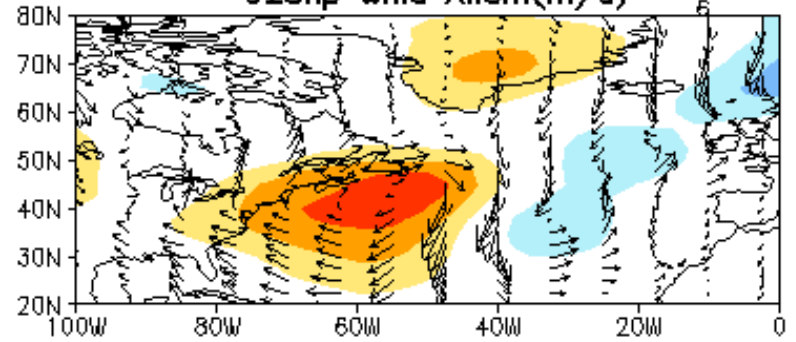
MAY 2013 SST Anom. (°C)



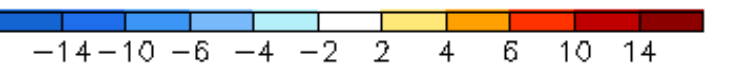
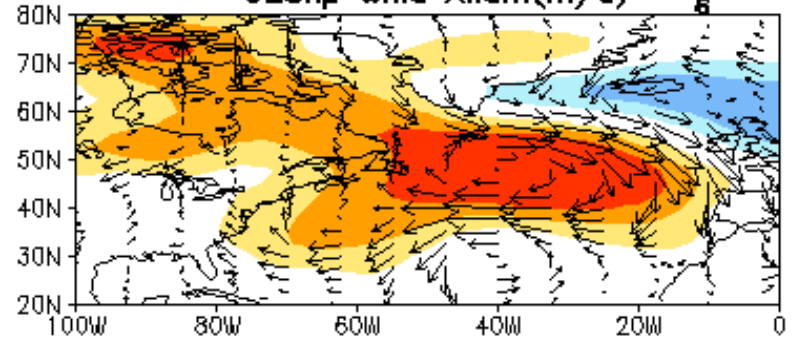
MAR 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)



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

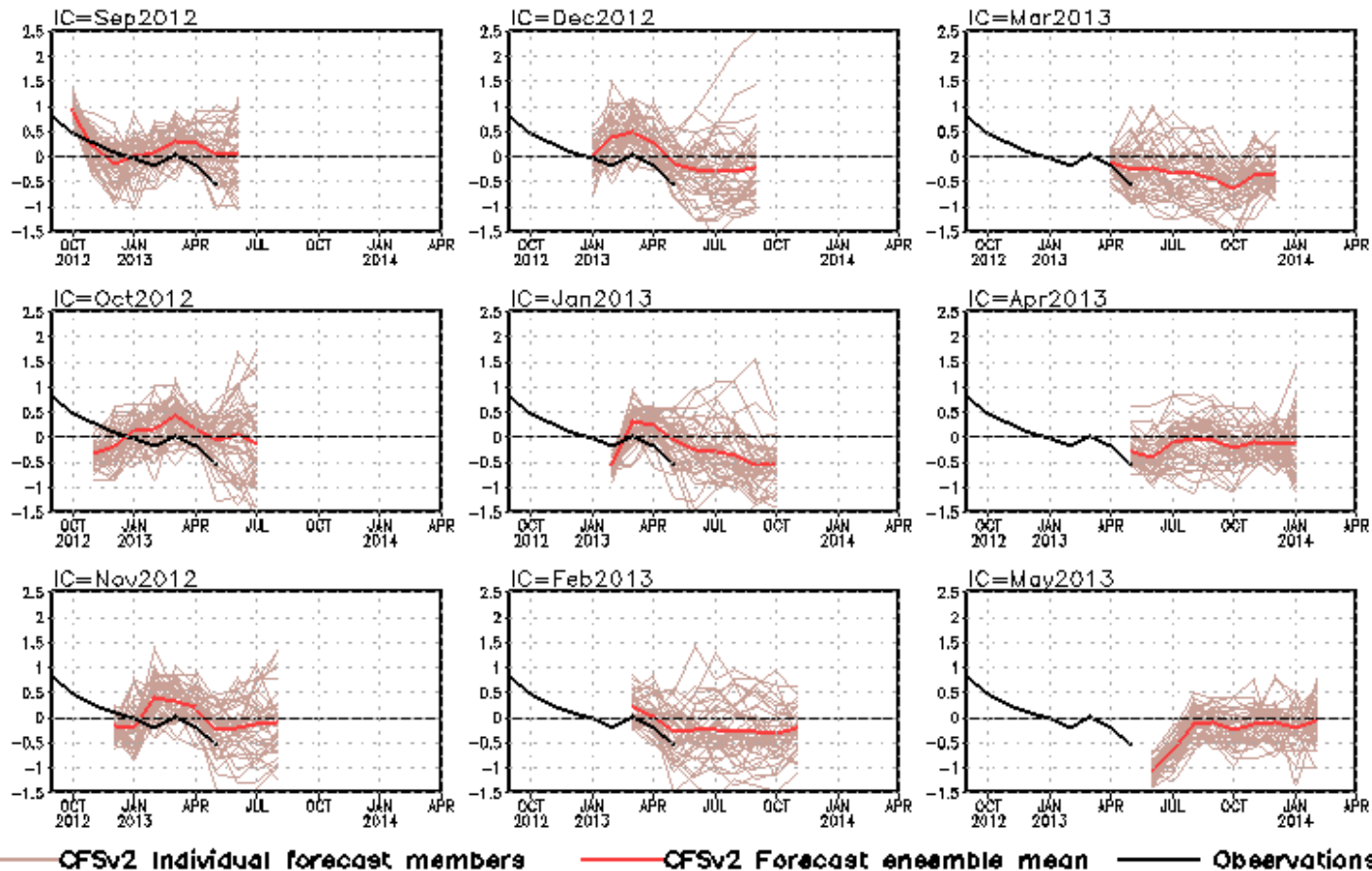


MAY 2013 SLP Anom.(hPa)
925hp Wind Anom(m/s)



NCEP CFS DMI SST Predictions from Different Initial Months

Indian Ocean Dipole SST anomalies (K)

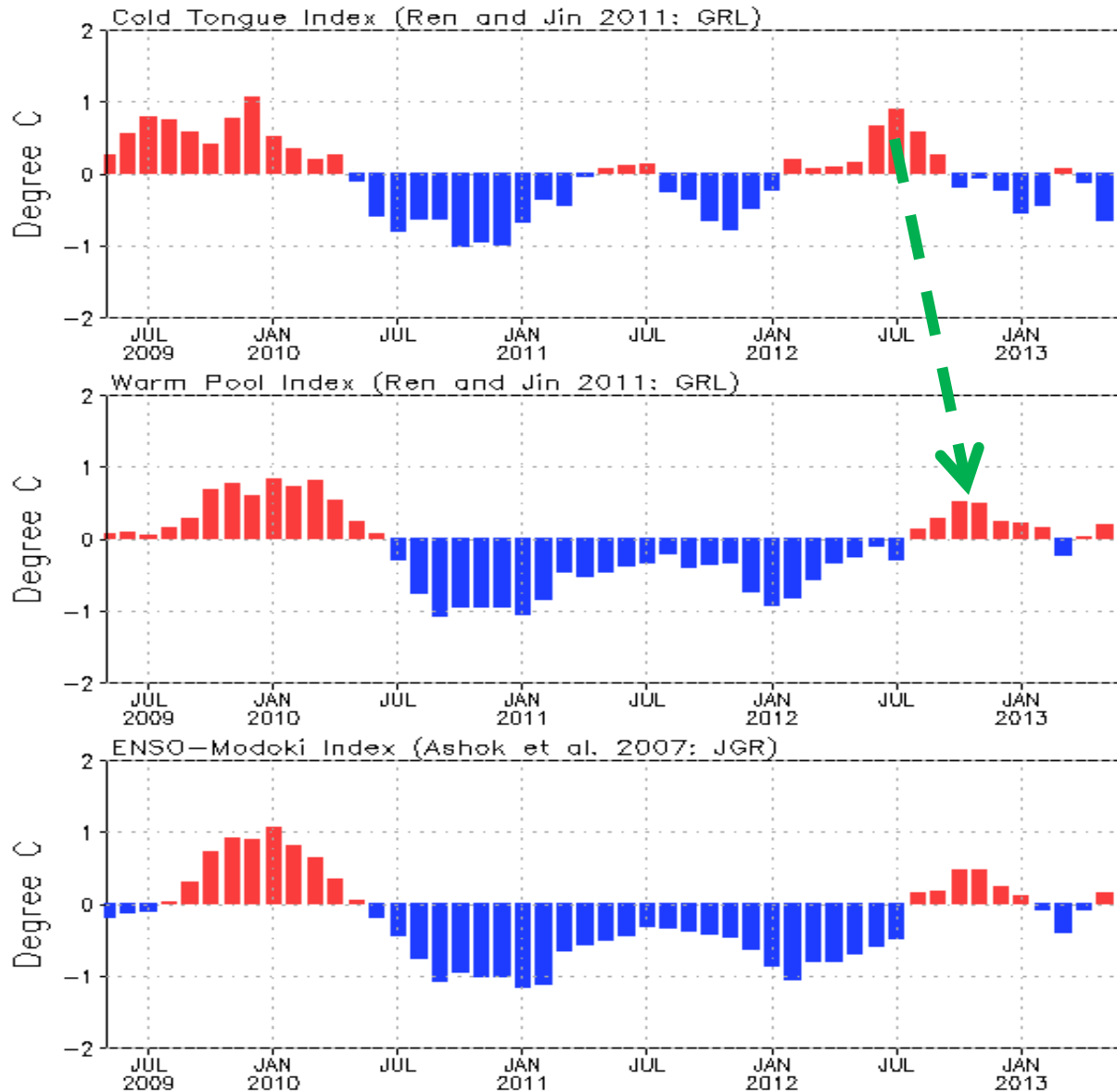


DMI = WTIO - SETIO
 SETIO = SST anomaly in [90°E-110°E, 10°S-0]
 WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

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.

Evolution of Pacific NINO SST Indices

Monthly Tropical Pacific SST Anomaly



- Positive SSTA in 2012 propagated from the eastern 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.

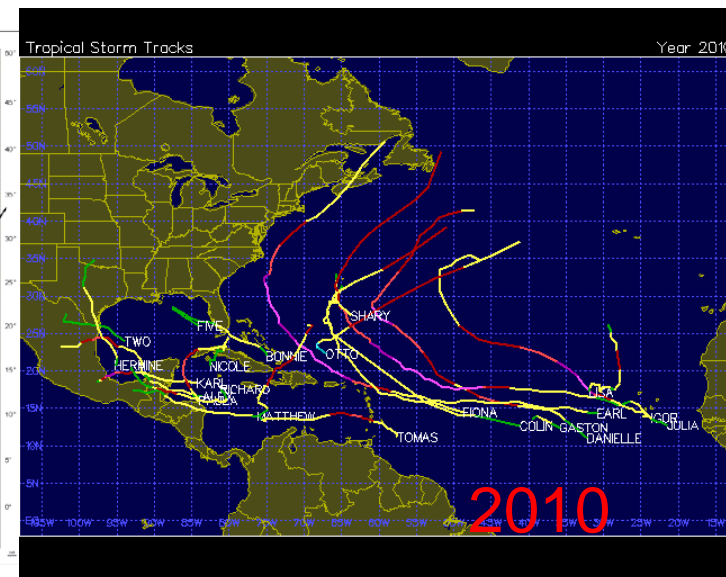
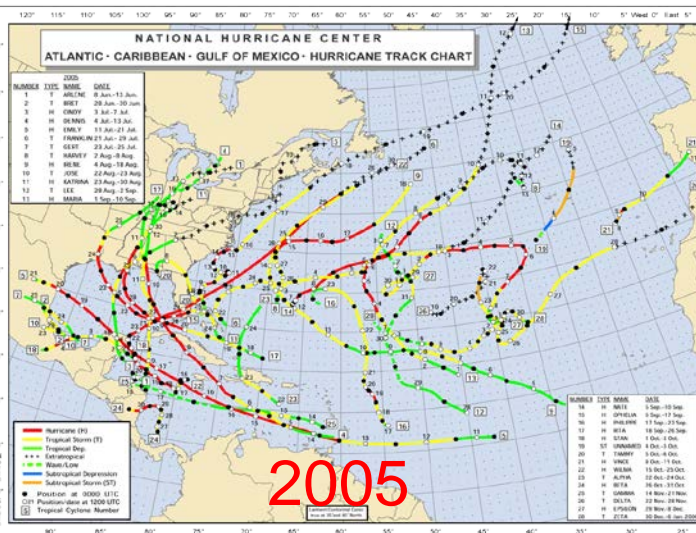
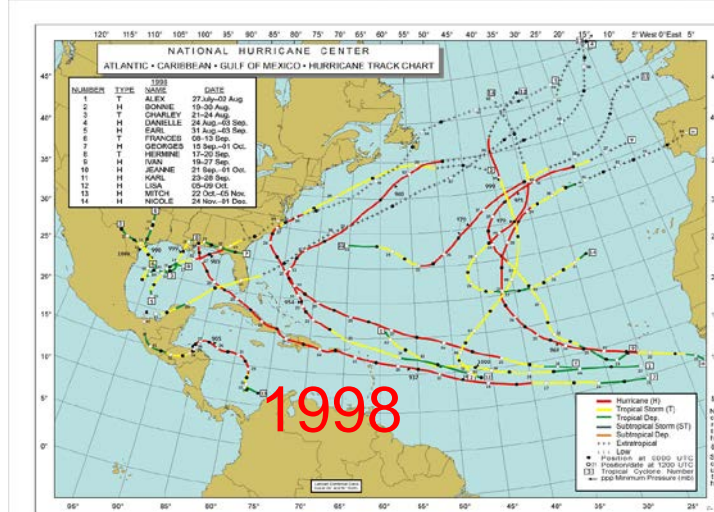
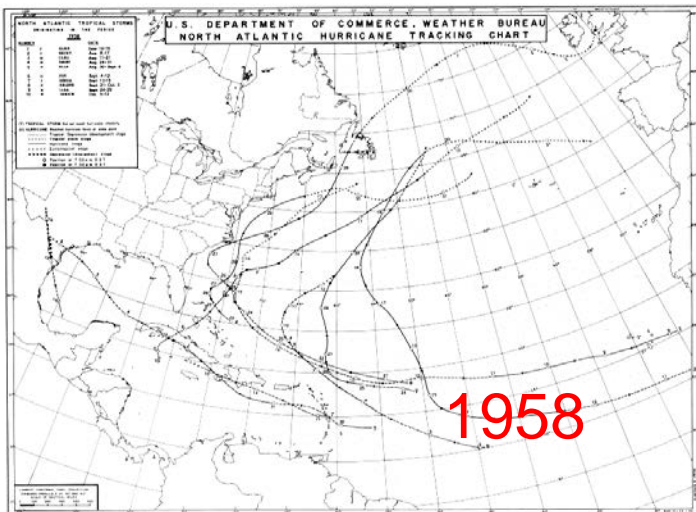
Atlantic Hurricane Activity in 1958, 1998, 2005, 2010

<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.>

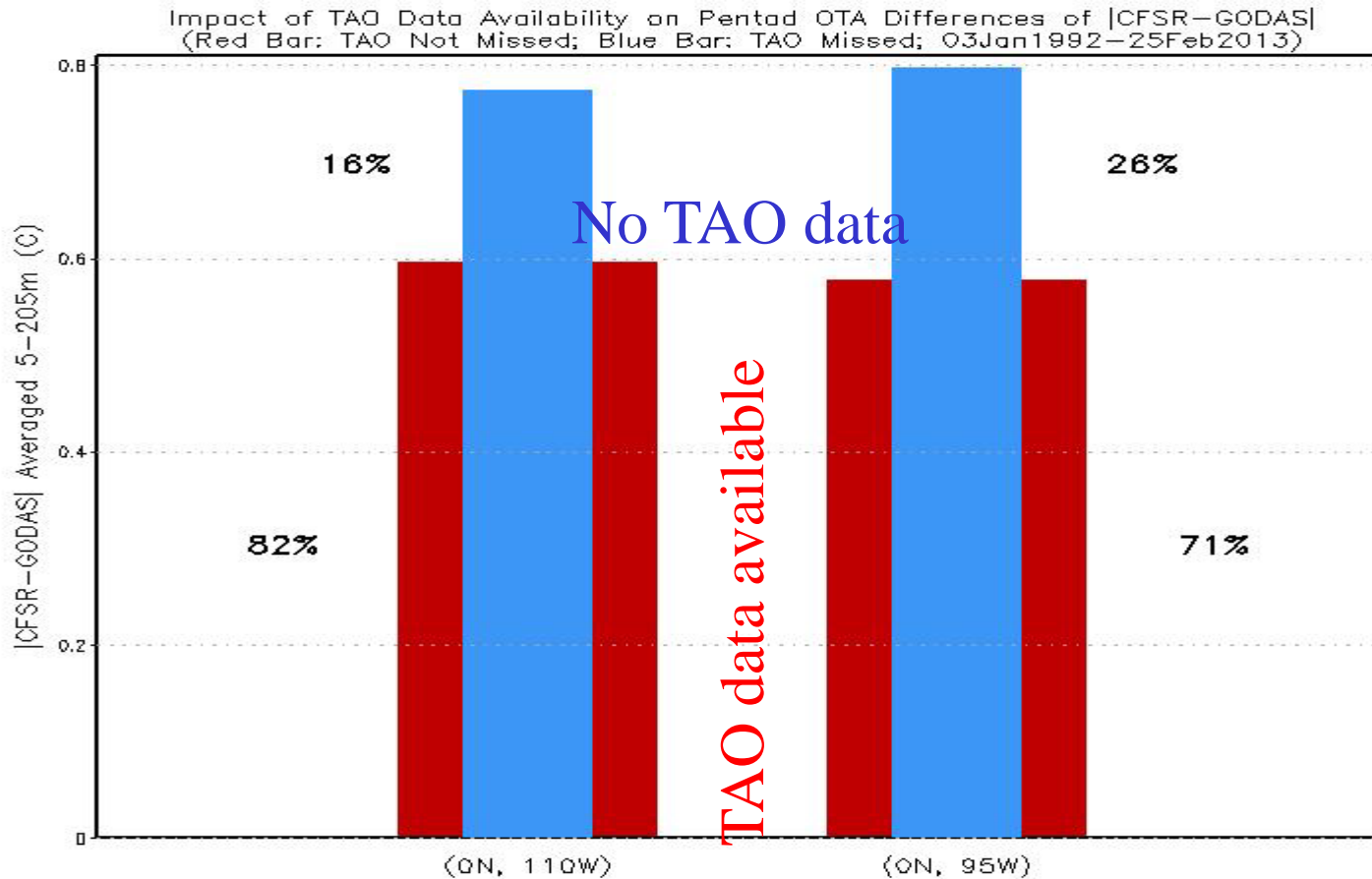
The 4 years that had a similar juxtaposition of a warm ENSO (decay phase) and negative phase of the NAO, i.e., 1958, 1998, 2005, and 2010 had above normal Atlantic hurricane seasons.

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.



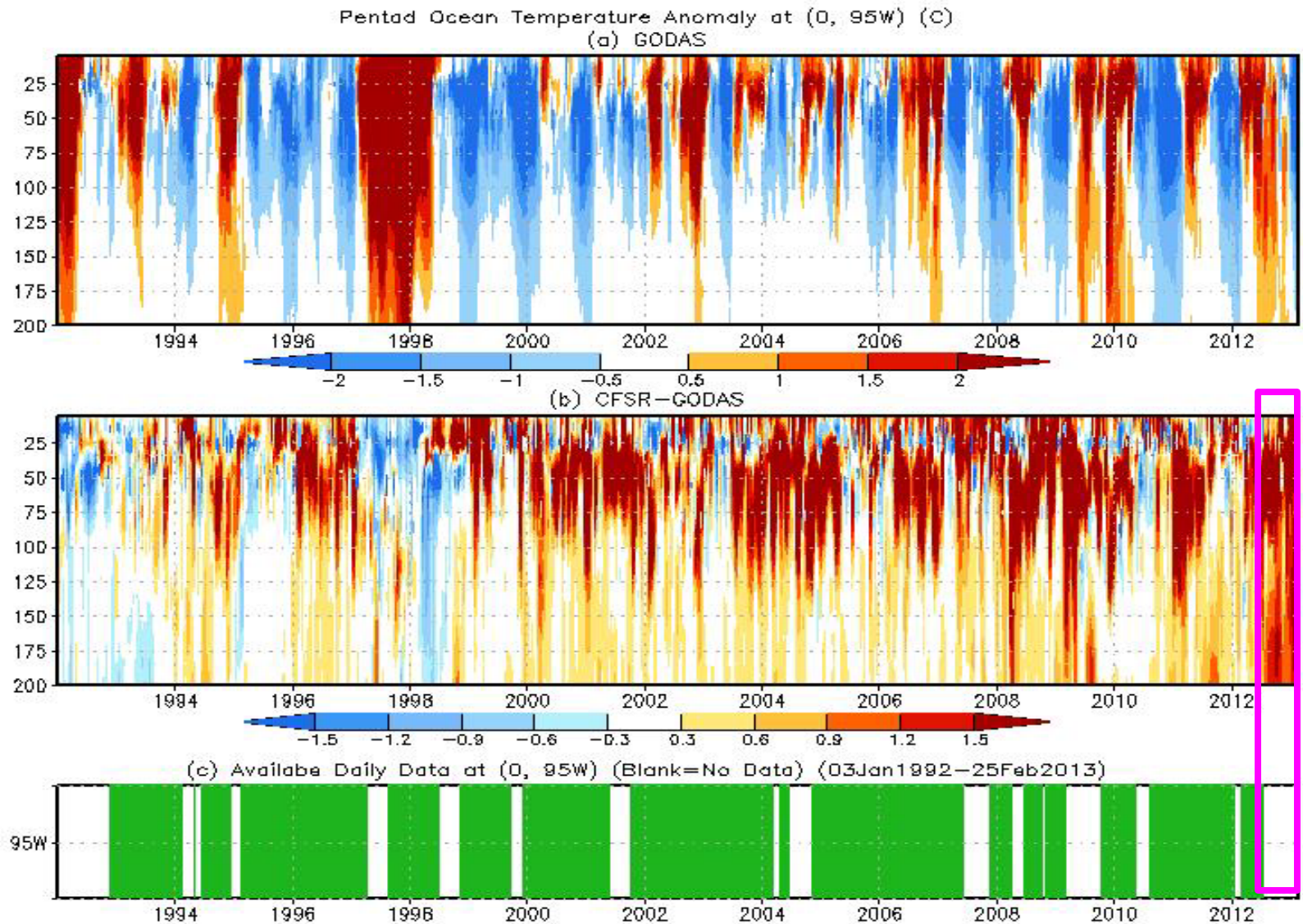
Possible Impact of TAO Data Missing on NCEP Data Assimilations ($\sum_{5m}^{205m} |\text{CFSR-GODAS}|$)



- 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.

Possible Impact of TAO Data Missing on NCEP Data Assimilations

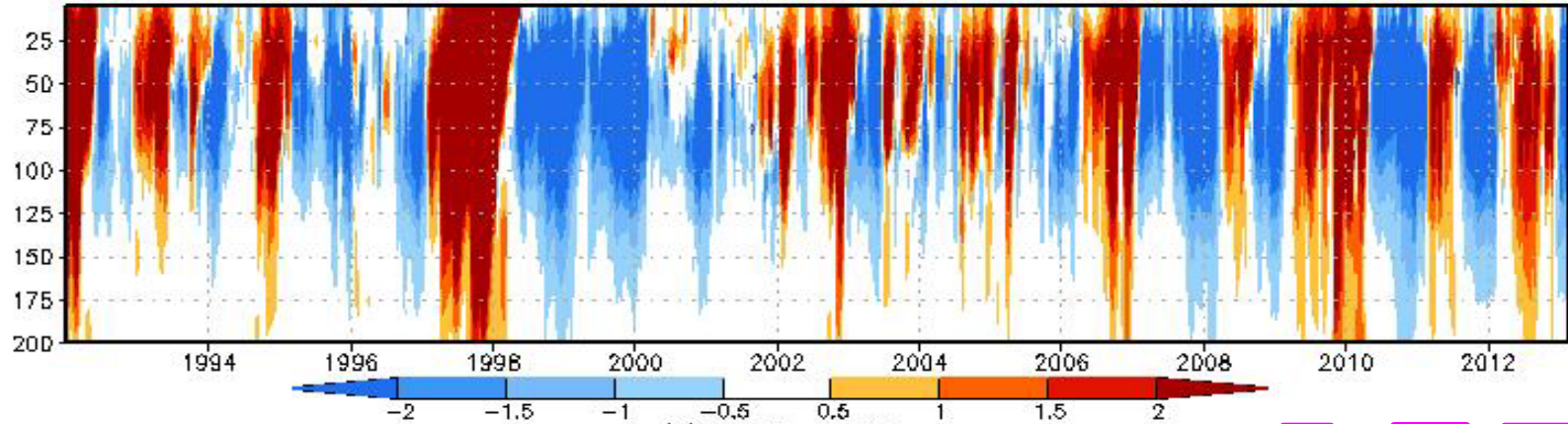
(CFSR and GODAS; 1981-2010 Climatology) at (0, 95W)



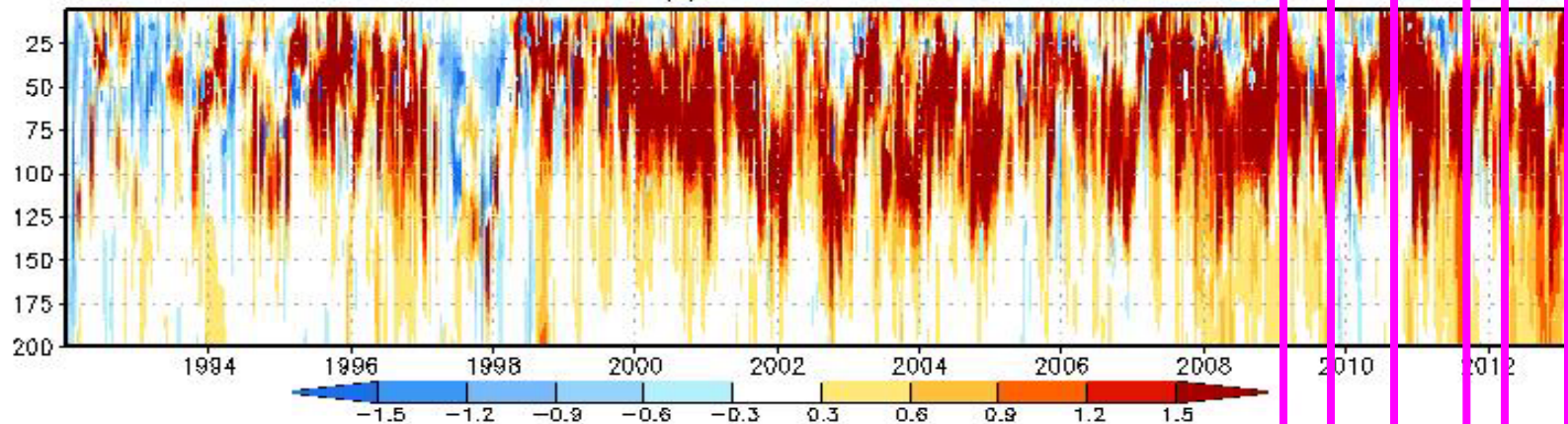
Possible Impact of TAO Data Missing on NCEP Data Assimilations

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

Pentad Ocean Temperature Anomaly at (0, 110W) (C)
(a) GODAS



(b) CFSR-GODAS



(c) Available Daily Data at (0, 110W) (Blank=No Data) (03Jan1992-25Feb2013)

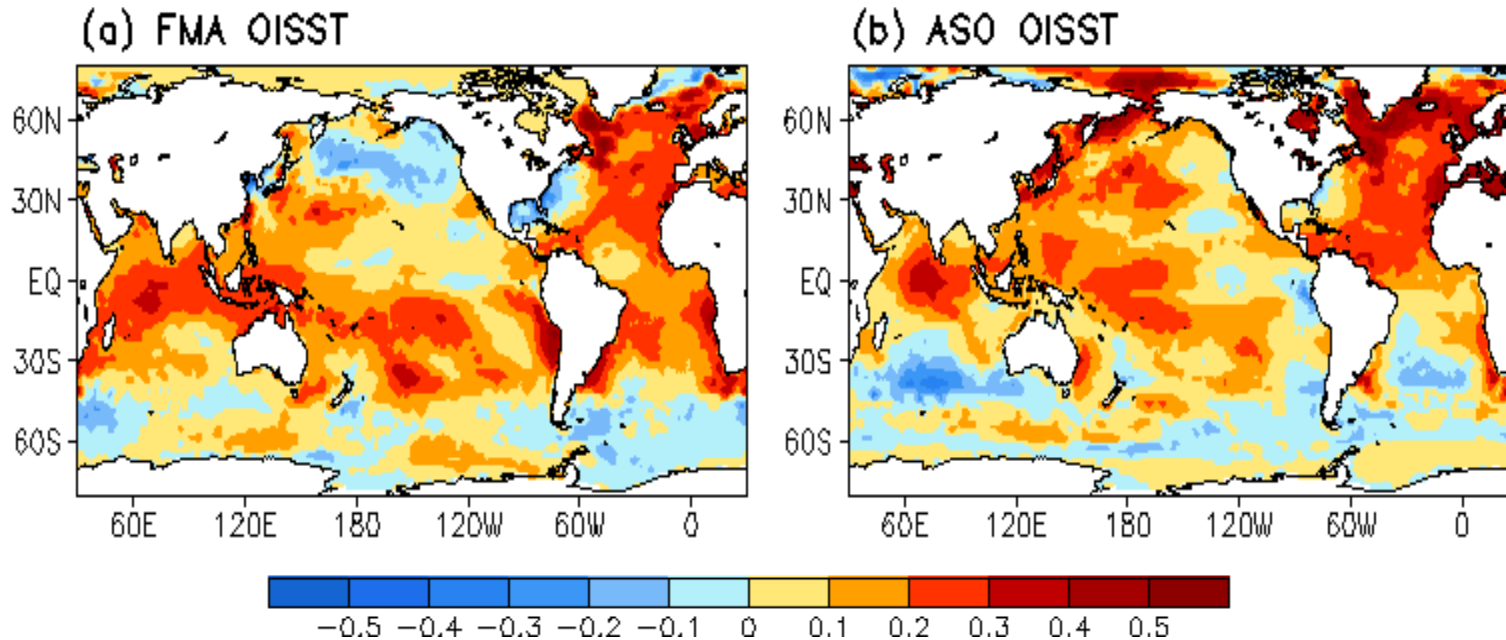


Switch to 1981-2010 Climatology

- **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!