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

Prepared by
Climate Prediction Center, NCEP/NOAA

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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**

    (Continued uncertainty in equatorial sub-surface temperature anomalies)
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SST Predictions**

Overview

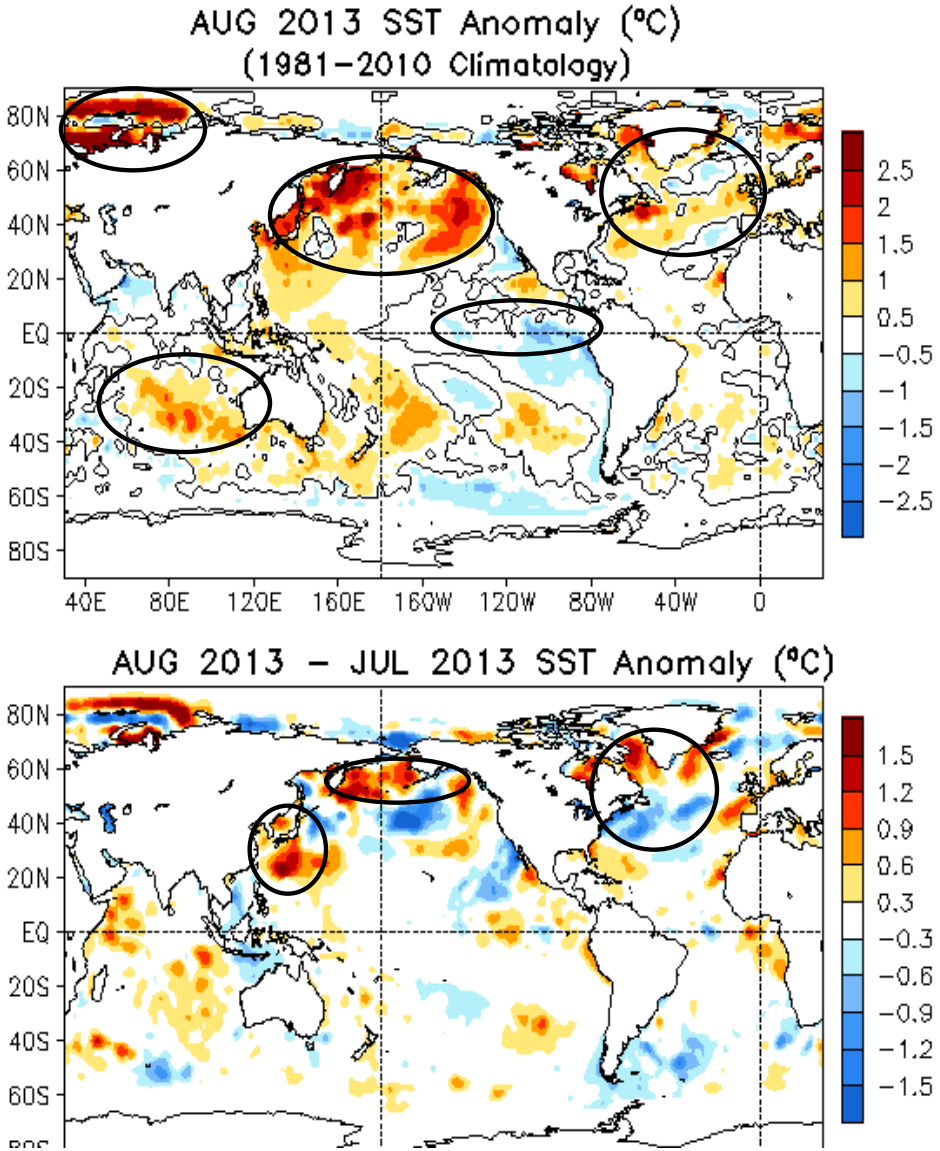
- **Pacific and Arctic Oceans**
  - **ENSO-neutral conditions persisted during August 2013.**
  - **The consensus forecast favors ENSO-neutral conditions to continue into the Northern Hemisphere Spring 2014.**
  - **Negative PDO phase persisted with PDO=-1.5 in August 2013, and NCEP CFSv2 predicted negative PDO phase would continue into next spring.**
  - **SSTA in the north Pacific Ocean reached the historical high since 1982.**

- **Indian Ocean**
  - **SSTs were above-normal in the east and in the west, and negative Indian Ocean Dipole index continued in August 2013.**

- **Atlantic Ocean**
  - **Above-normal SST continued in the hurricane main development region.**
  - **NCEP CFSv2 forecast suggest above-normal SST in the tropical N. Atlantic will continue into the northern hemisphere spring 2014.**
  - **Positive NAO index persisted in the past five months.**

Global Oceans

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

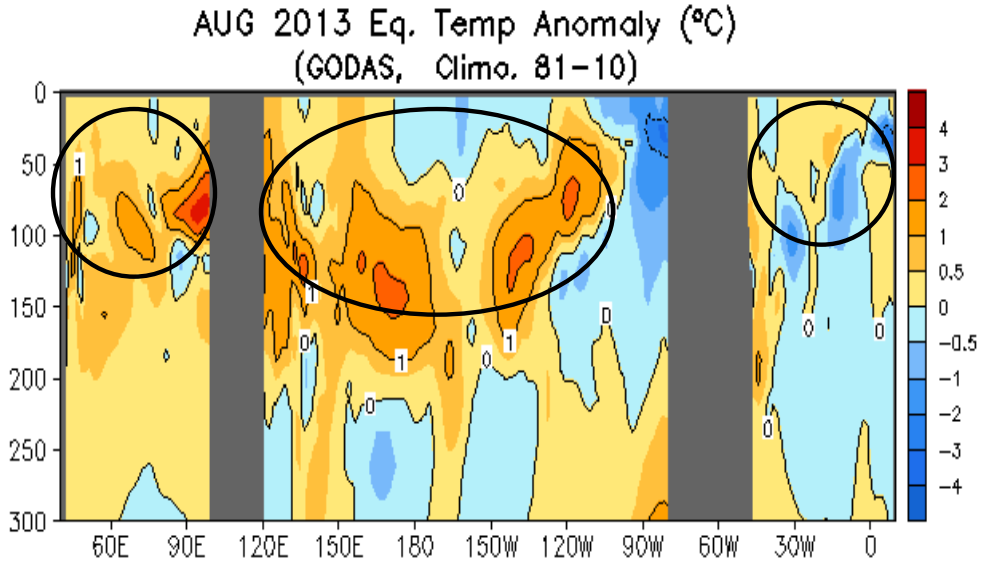


- **SST was near-normal across the western-central tropical Pacific and below normal across the eastern Pacific.**
- **Strong SST warming continued in the high latitudes of North Pacific and Arctic Oceans in Aug. 2013.**
- **Positive SSTA dominated the North Atlantic Ocean.**

- **A strong warming tendency was observed near the Bering Sea and East China Sea and subpolor North Atlantic.**
- **Positive SSTA near the Gulf Stream extension weakened in Aug.2013.**

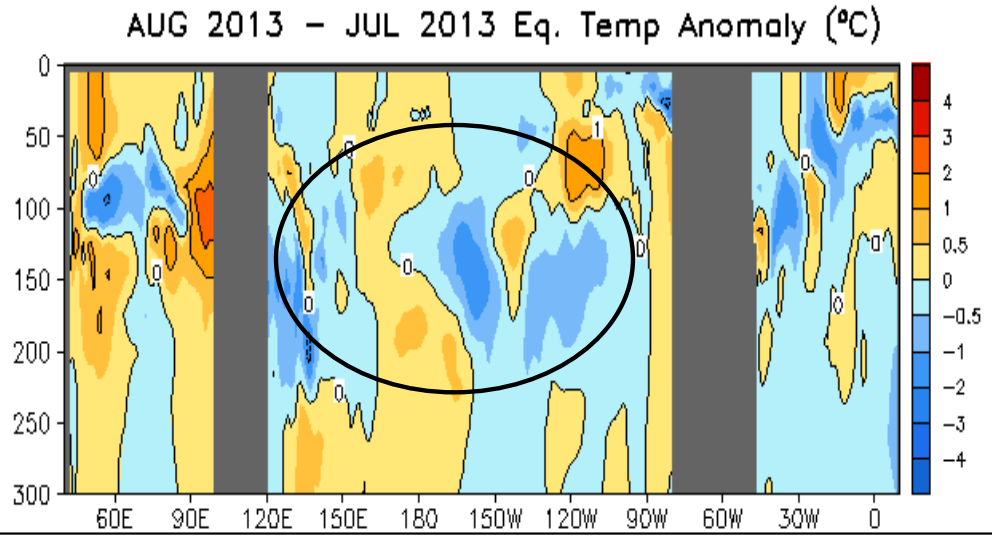
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

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



- **Positive temperature anomalies continued to occupy near the thermocline in the western-central equatorial Pacific Ocean.**

- **Positive anomalies continued to dominate at the upper 100m of equatorial Indian Ocean.**

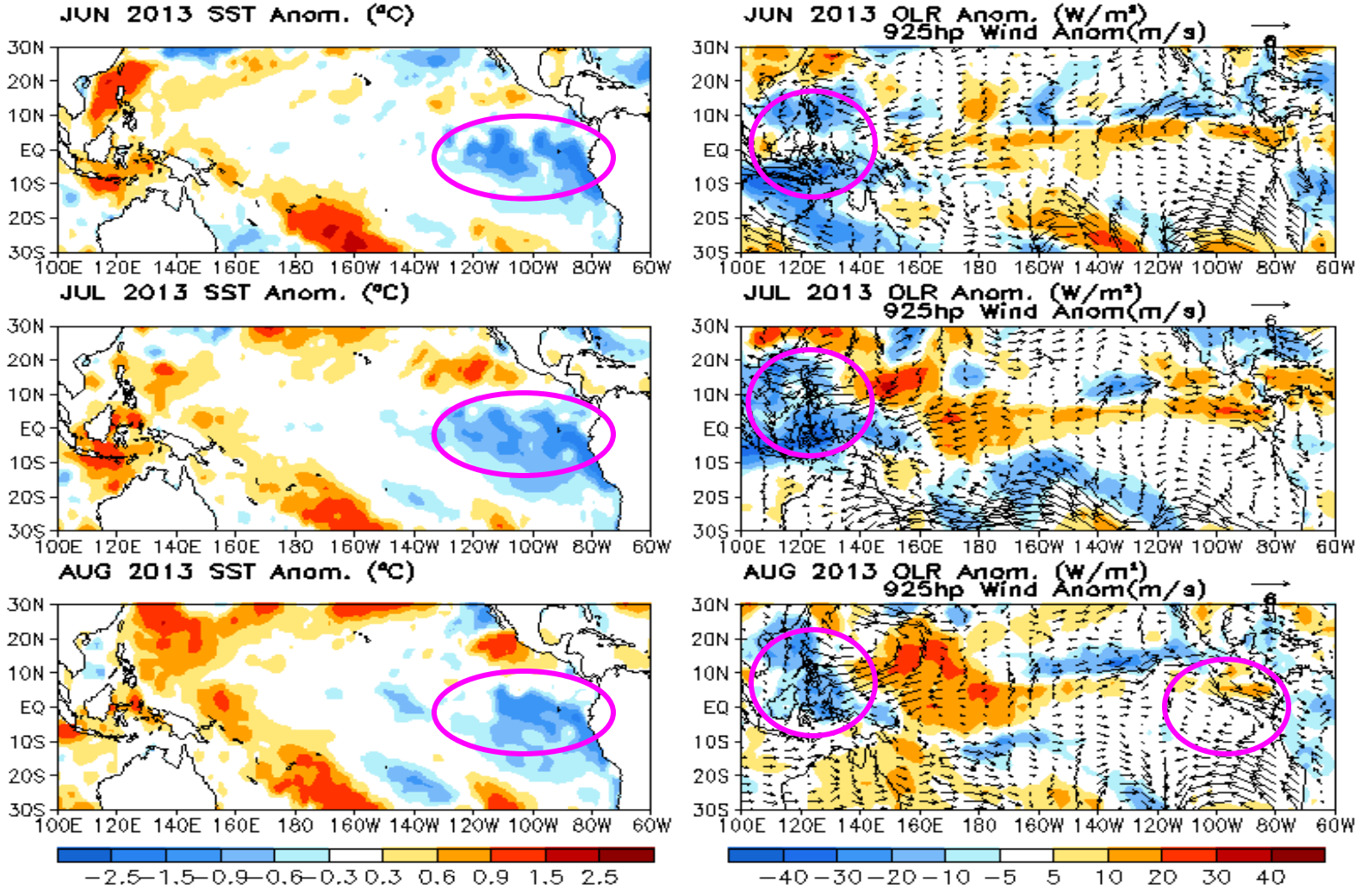


- **Both warming and cooling tendencies were observed in the upper ocean of Pacific.**

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.

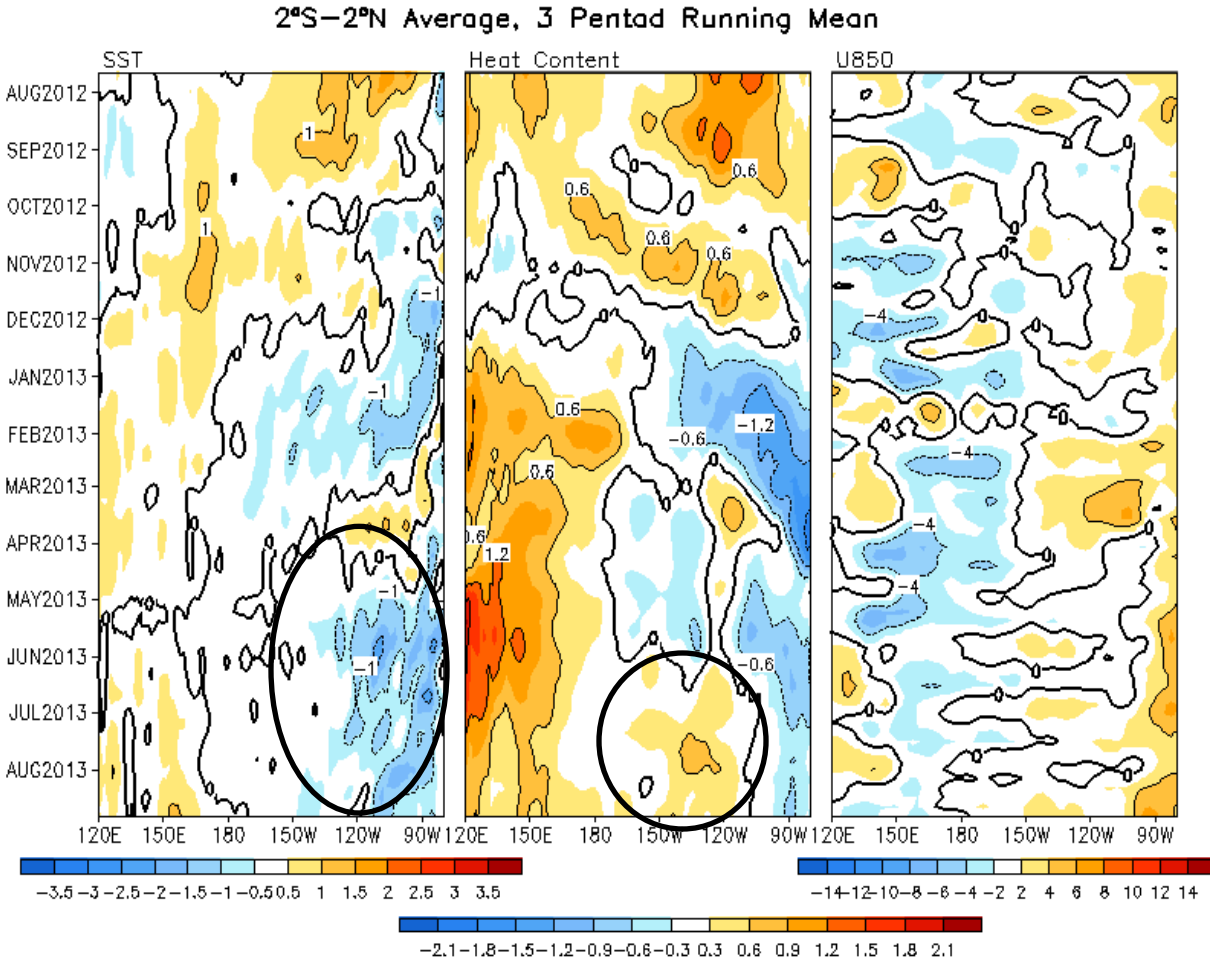
Tropical Pacific Ocean and ENSO Conditions

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

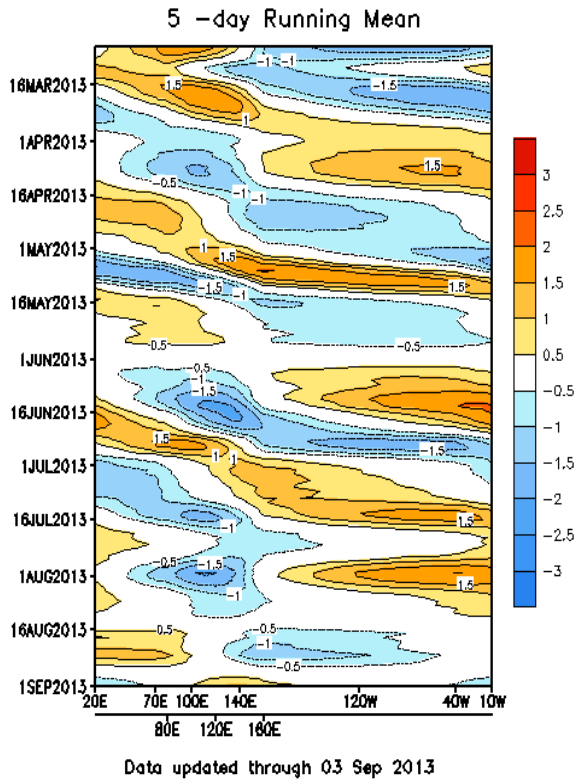


- **Negative (positive) SST anomalies persist in the eastern (western) Pacific during the past three months.**
- **Equatorial cooling weakened in Aug. 2013.**
- **During the last three months, negative OLR anomalies(enhanced convection) persisted over Indonesia and Malaysia.**
- **Westerly (easterly) wind anomalies were observed in the far eastern Pacific (western Pacific).**

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



CPC MJO Indices

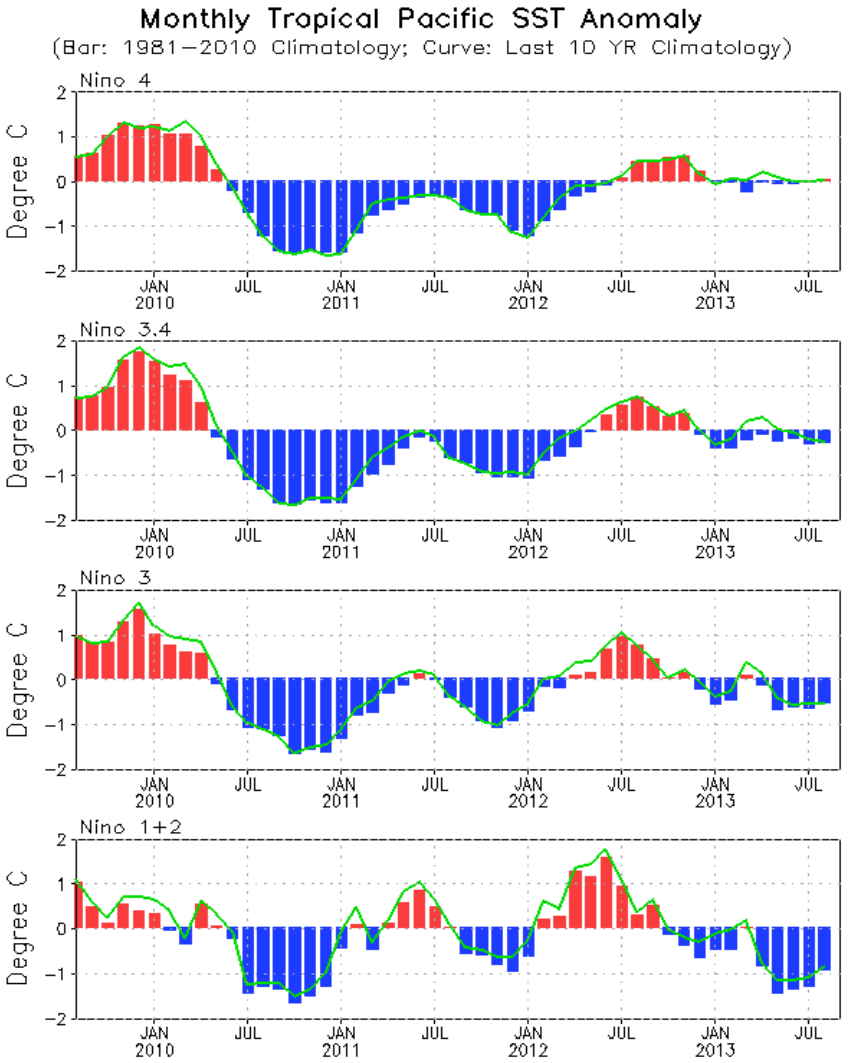


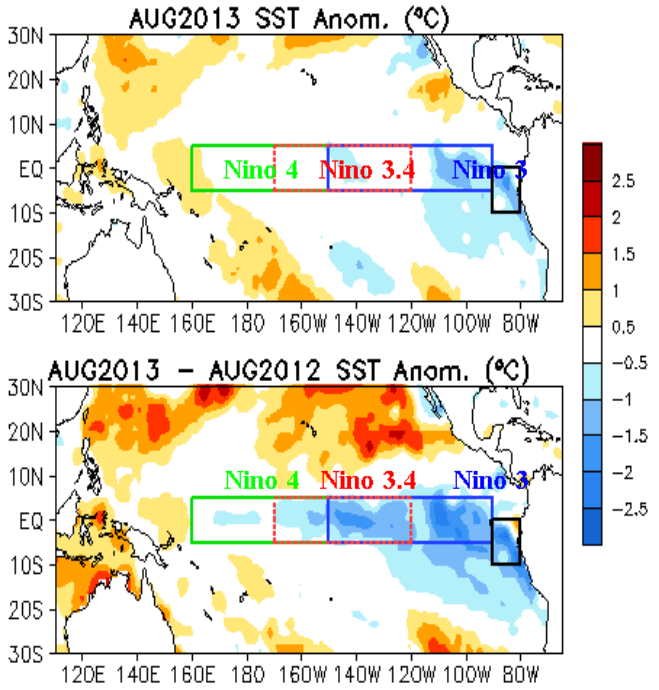
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

- **Below average SSTs were observed in the eastern Pacific since May 2013.**
- **Positive HC300 anomalies have persisted in the east-central Pacific since early June 2013..**
- **Westerly low-level zonal wind anomalies prevailed over central-eastern Pacific since mid-August 2013.**

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

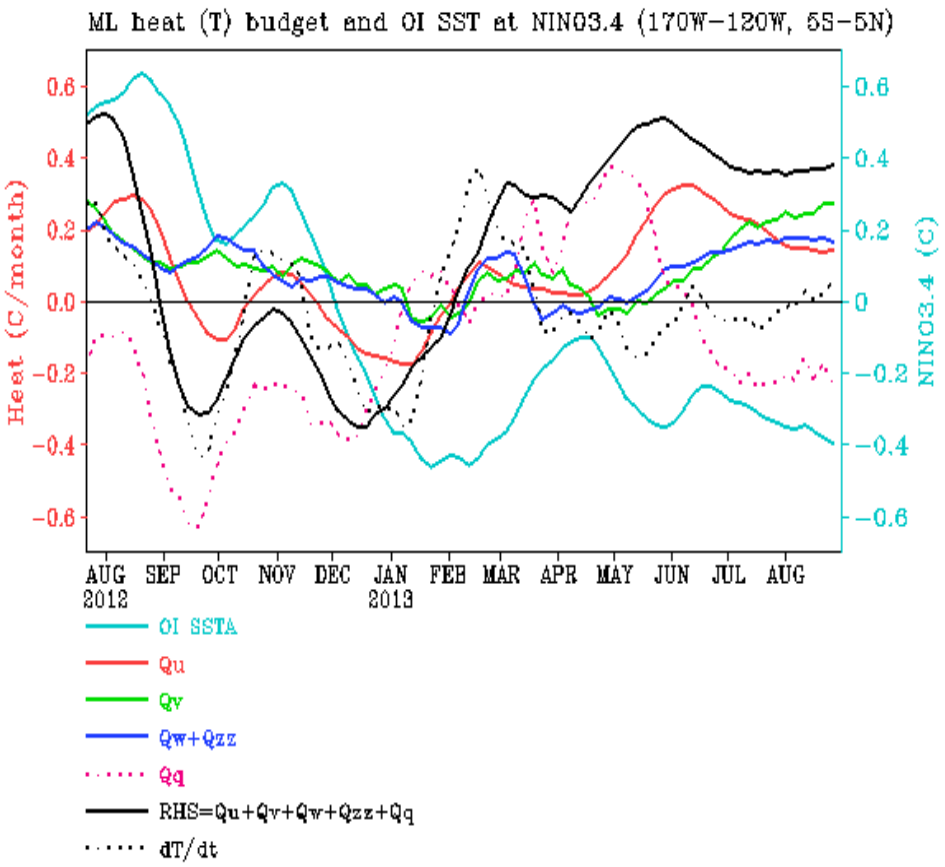




- **Negative Nino indice weakened in Aug. 2013.**
- **Nino 3.4 = -0.3.**
- **ENSO-neutral conditions continued.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.**

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.

NINO3.4 Heat Budget



- SSTA tendency (dT/dt) in NINO3.4 region (dotted black line) was near zero in Aug 2013, indicating a persistence in NINO3.4.

- All the dynamical terms were positive, while the thermodynamical term (Qq) was negative.

-The RHS and dT/dt had large differences since March 2013. This indicates the heat budget analysis based on GODAS is limited during the period.

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;

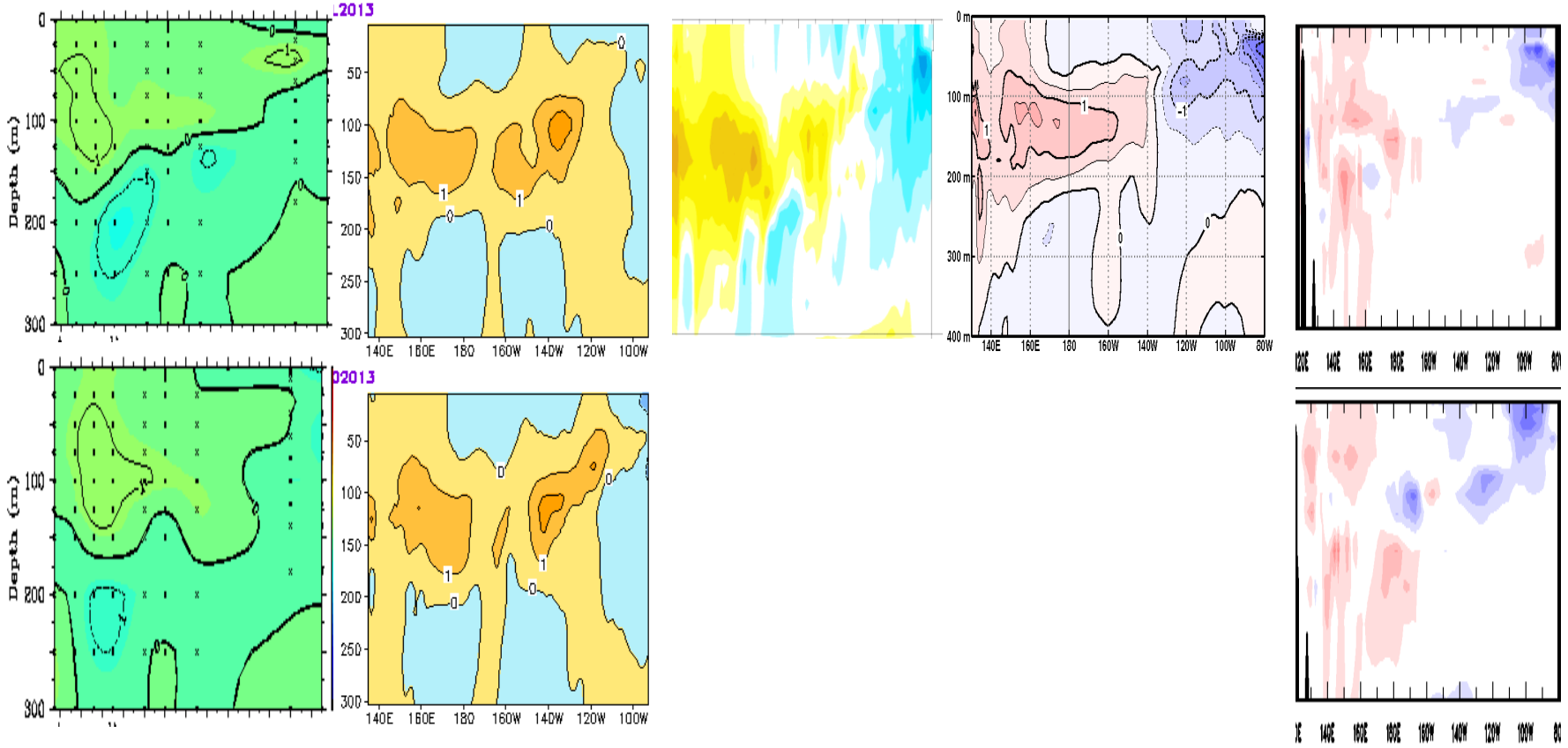
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

Subsurface Temperature Anomalies along Equator

TAO GODAS ECMWF S4 JMA BOM

July

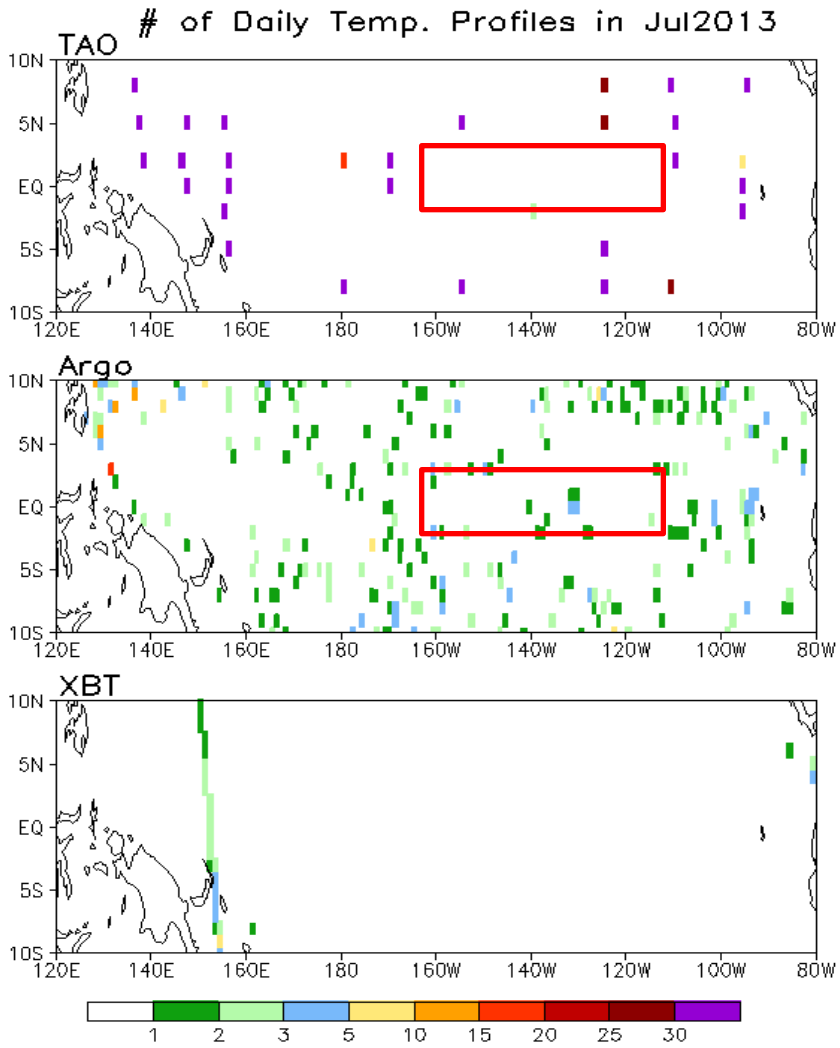
August



- **Subsurface temperature distribution in the last two months exhibited large uncertainty among ocean reanalysis products.**
- **Discrepancies between GODAS and TAO temperature anomalies near 150W-110W were as large as 2C.**
- **There were no TAO mooring data near 155W-115W since mid-June 2013.**

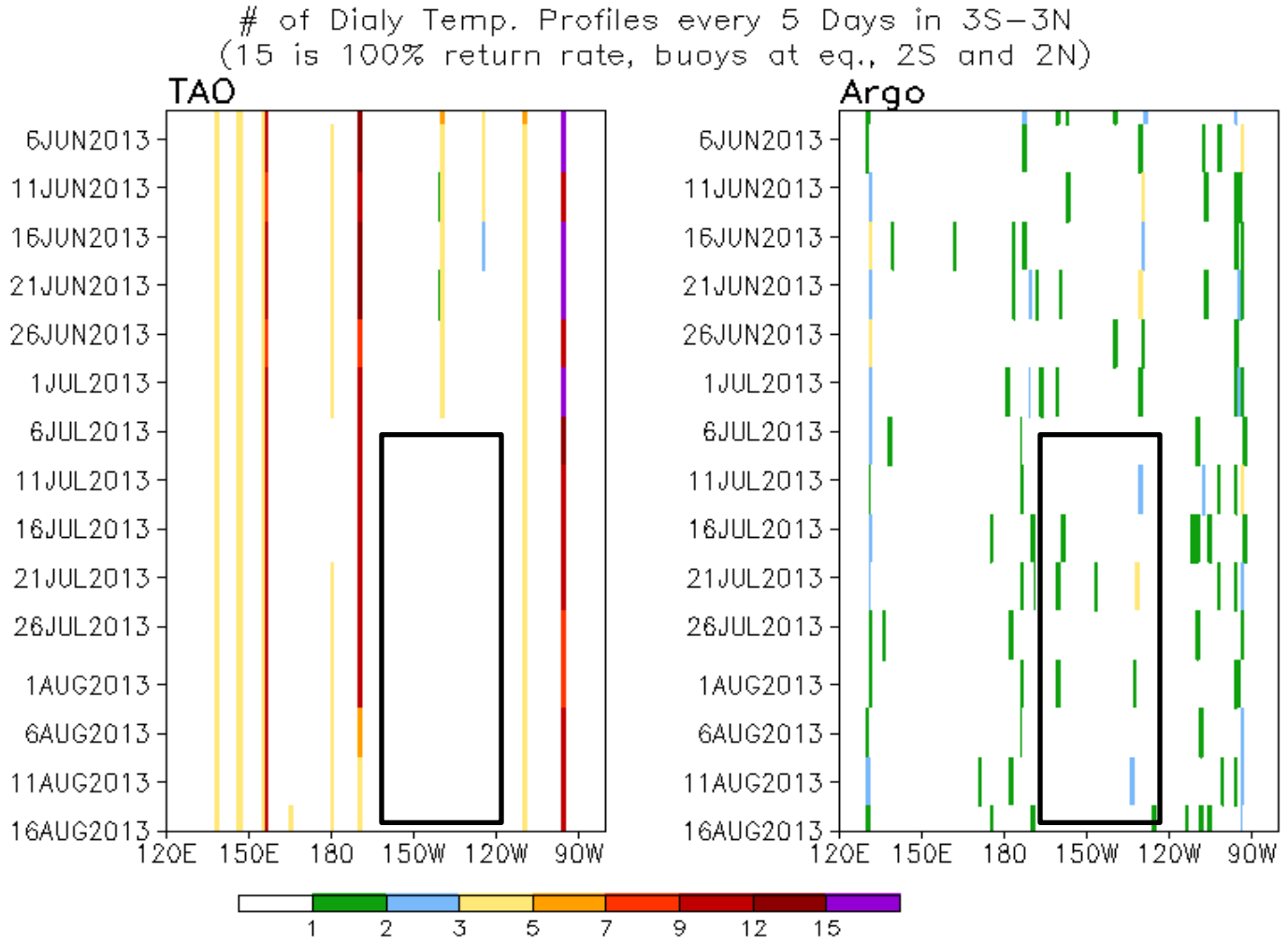
TAO: http://www.pmel.noaa.gov/tao/jsdisplay/
ECMWF S4: http://www.ecmwf.int/products/forecasts/d/charts/oras4/reanalysis/sections/xzmaps/1m!1m!201306!Anomaly!Temperature!/
JMA :http://ds.data.jma.go.jp/tcc/tcc/products/elnino/outlook.html
BOM:http://www.bom.gov.au/climate/enso/

Number of Daily Temperature Profiles Assimilated into GODAS



- **Number of daily temperature profiles were gridded into one degree box.**
- **Number of daily temperature profiles from TAO buoys should be around 30 in each month if data return rate is 100%.**
- **There were no TAO profile assimilated/available near the equator between 160W-110W.**
- **Argo floats usually return less then 3 profiles each month in one degree box which is much less than that of TAO buoys normally return.**

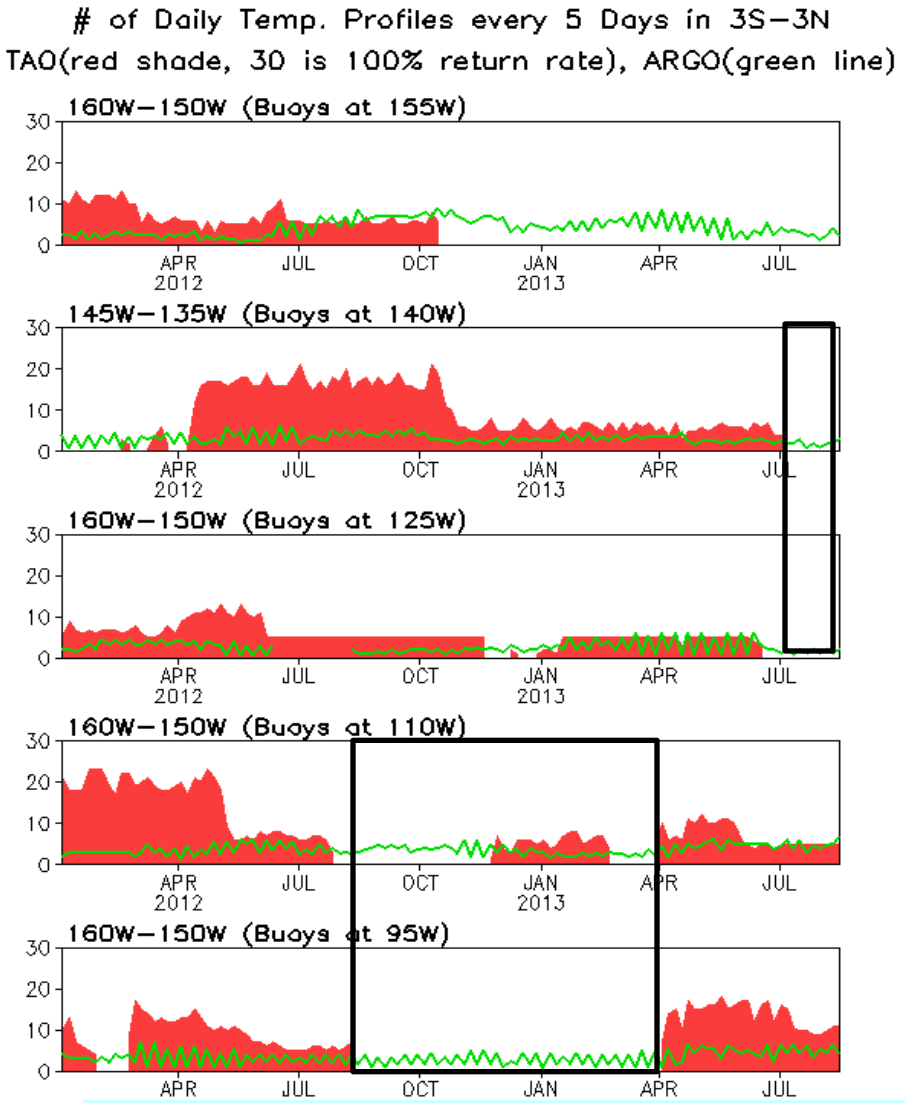
Number of Daily Temperature Profiles Assimilated into GODAS

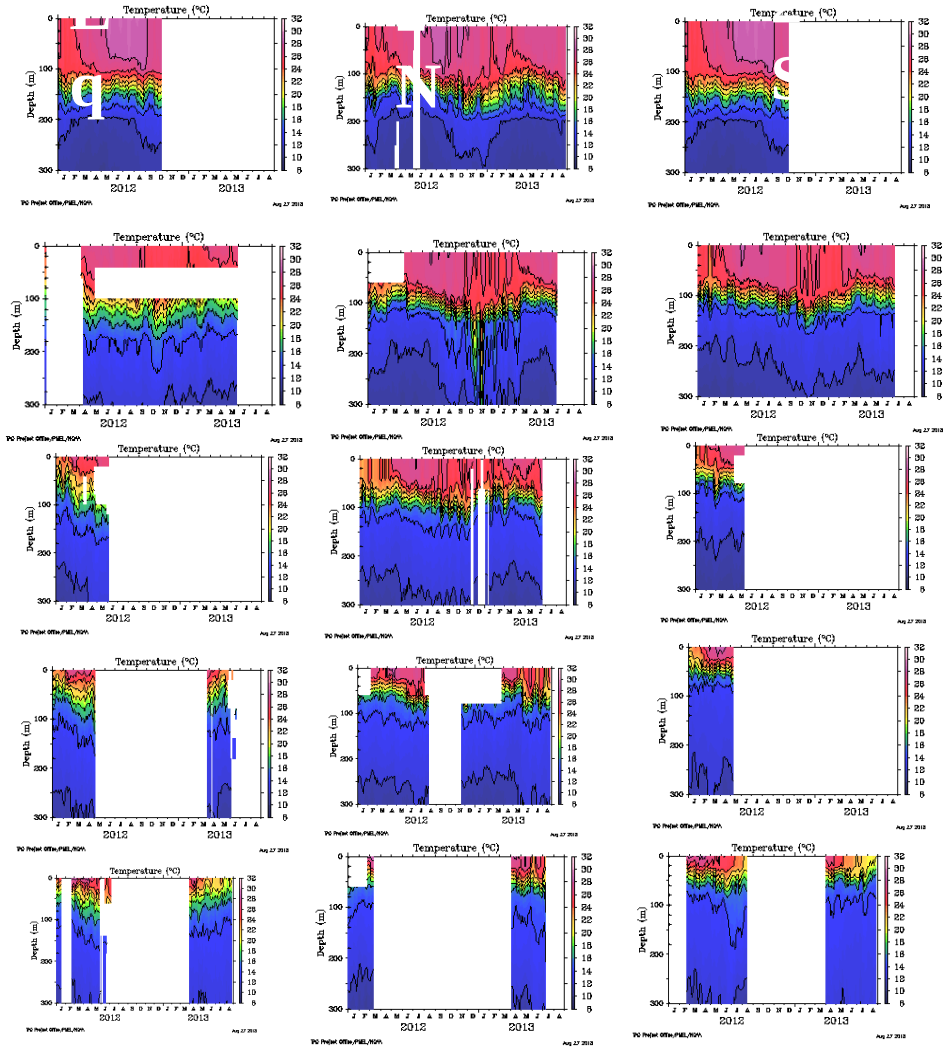


-**There were no TAO profile assimilated near the equator between 160W-110W since Jul.6 2013.**

- **Argo only provided 1-2 profiles every 5 days in the box of 3S-3N and one degree longitude.**

Number of Profiles Assimilated into GODAS



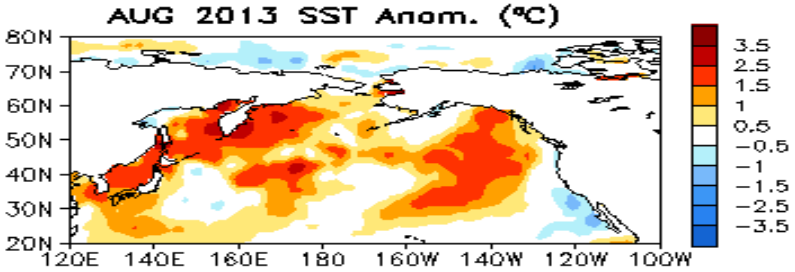


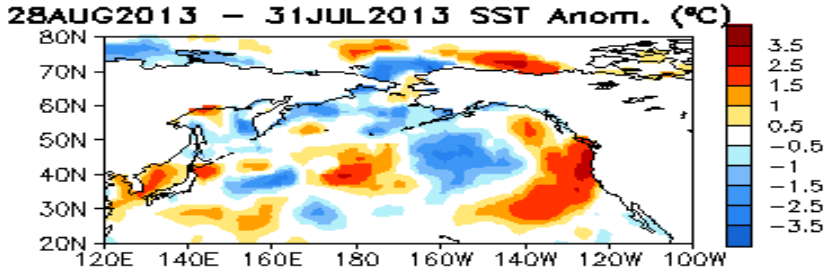
- **There were significant data loss at central-east equatorial Pacific since Oct.2012 and no data available since Jul. 2013.**

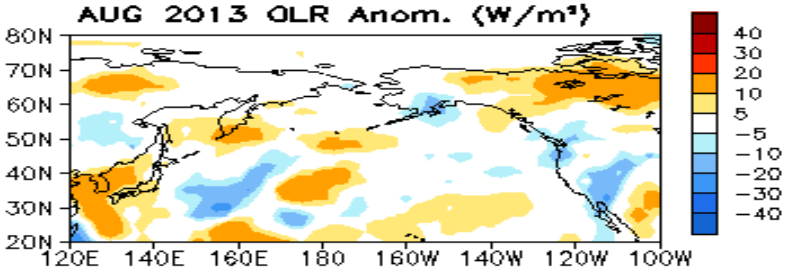
- **The TAO date return rate in the far eastern Pacific have improved since Apr. 2013 .**

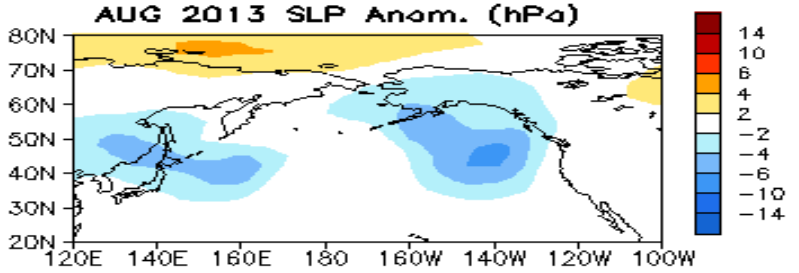
North Pacific & Arctic Oceans

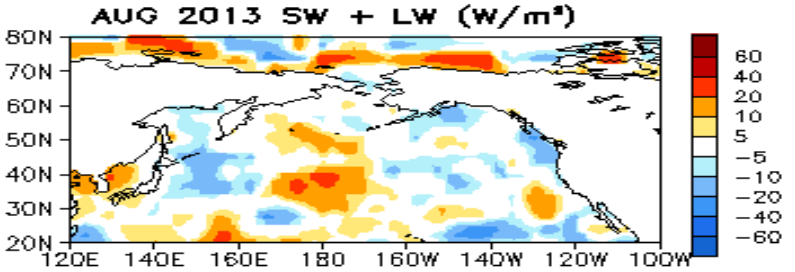
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tendency, OLR, SLP, Sfc Rad, Sfc Flx

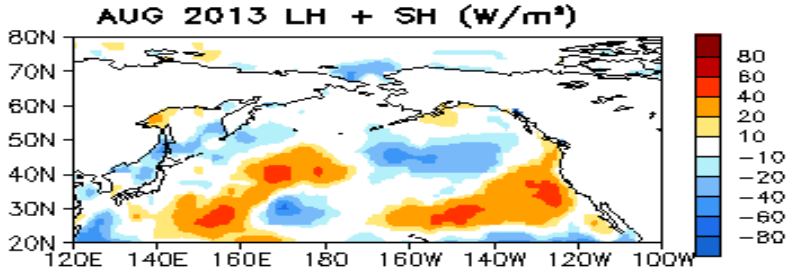






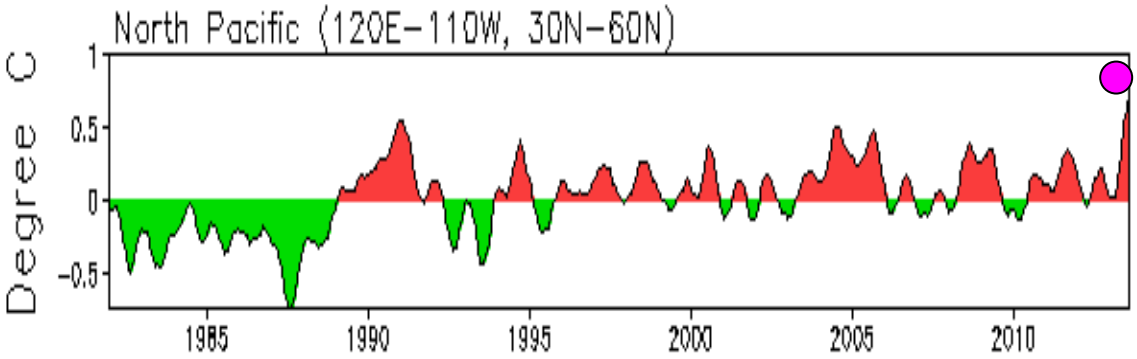




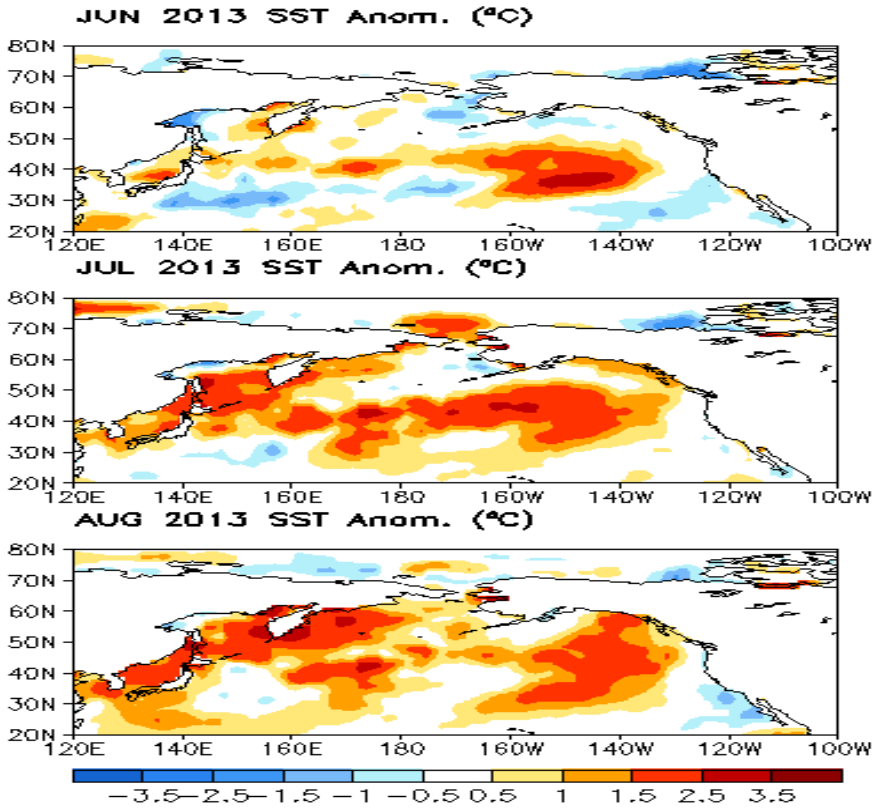


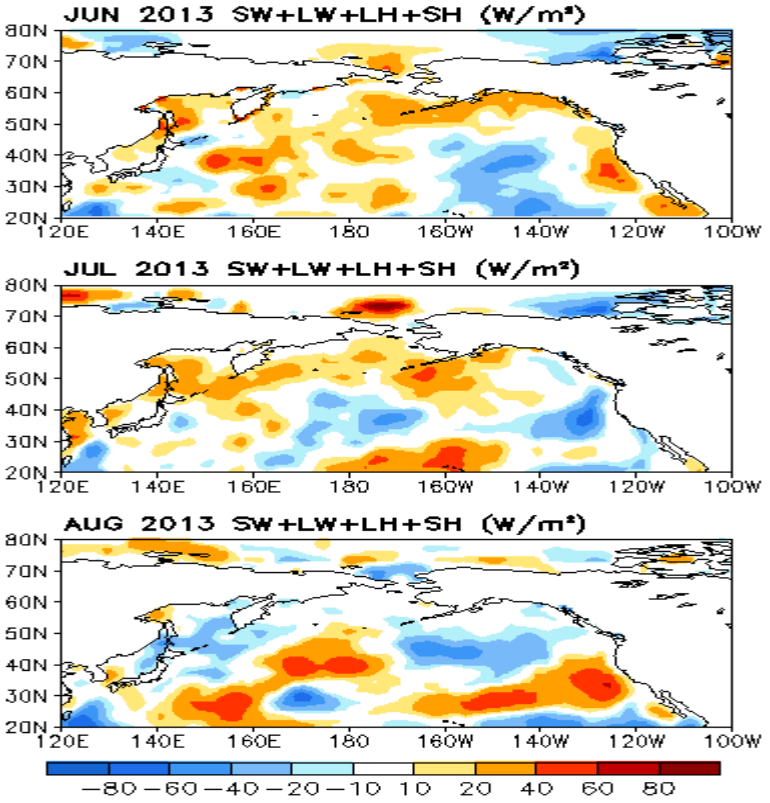
- **Significant warming continued in the North Pacific.**
- **SSTA tendency was largely consistent with surface heat flux anomalies.**
- **Negative SLP anomalies were observed over Gulf of Alaska, and anomalous cyclonic winds associated with the negative SLPA center were unfavorable for coastal upwelling.**

North Pacific SST

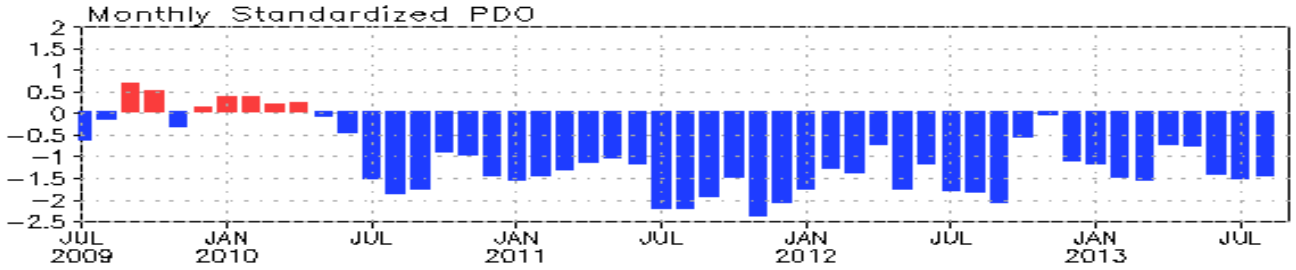


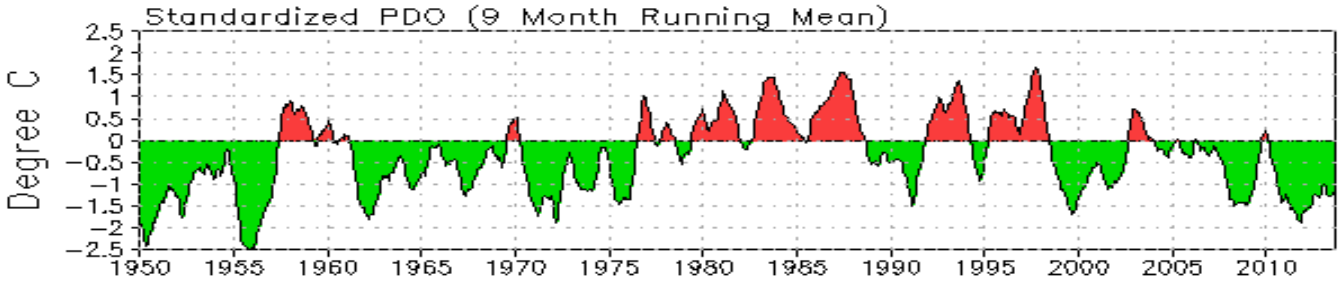
SSTA in the north Pacific Ocean reached the historical high since 1982

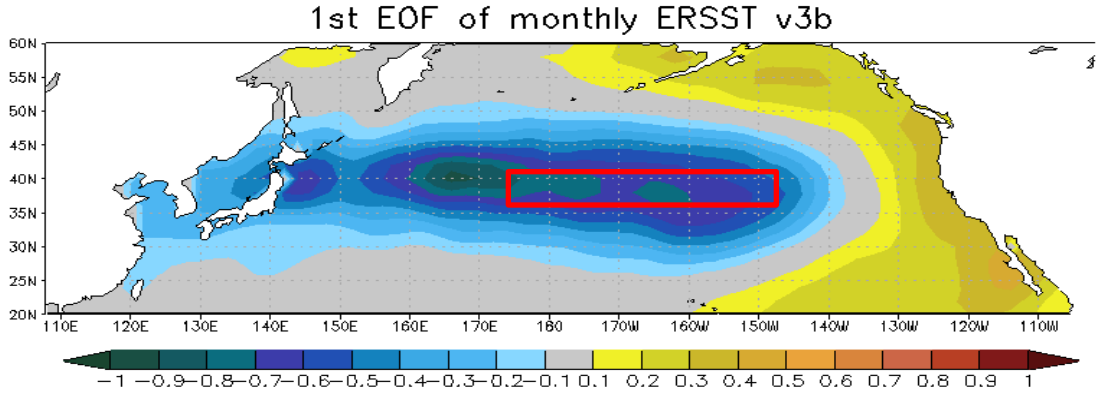




Pacific Decadal Oscillation Index







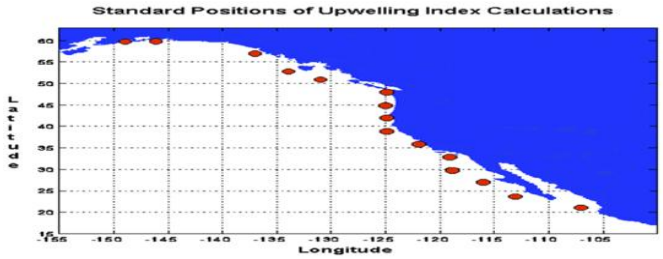
- **PDO index in Aug. 2013 =-1.5**

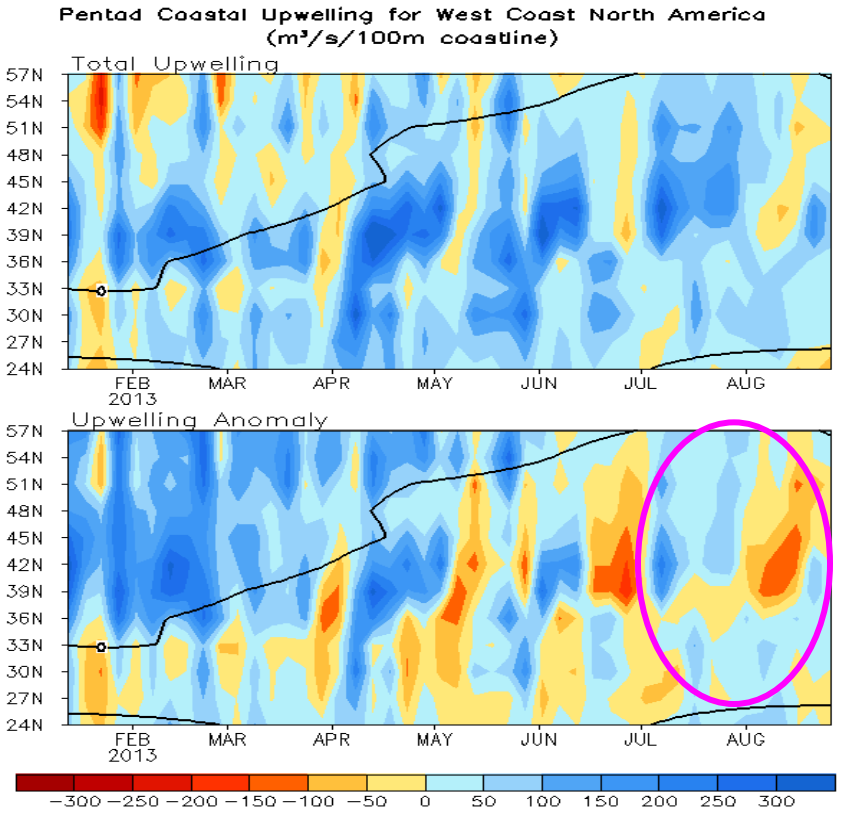
-**Negative PDO phase since May 2010 has persisted more than 3 years (40 months) now.**

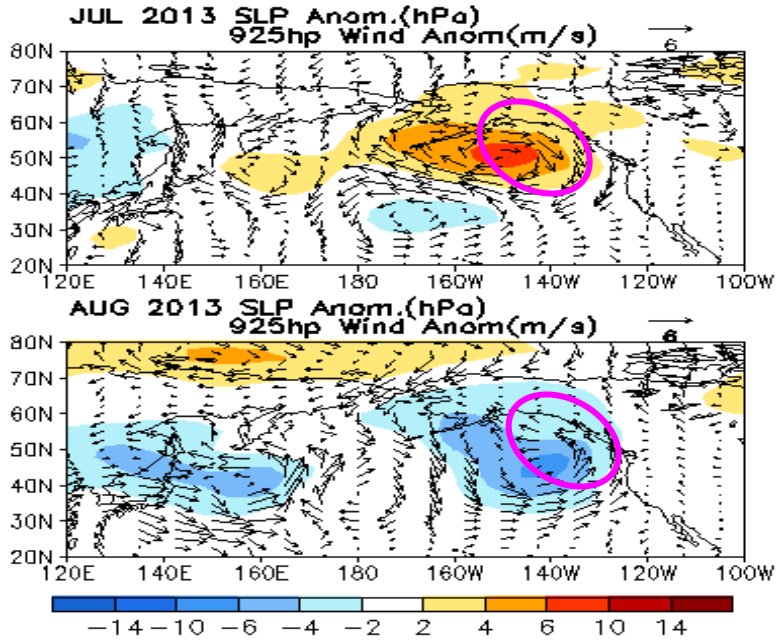
- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**

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

North America Western Coastal Upwelling





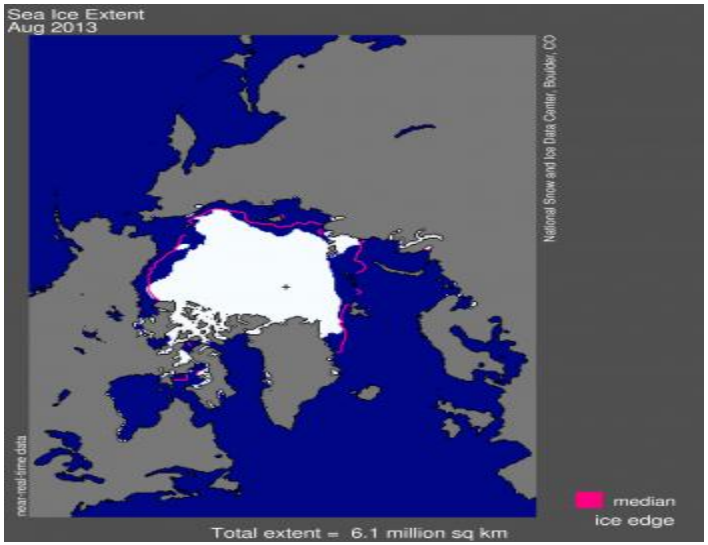


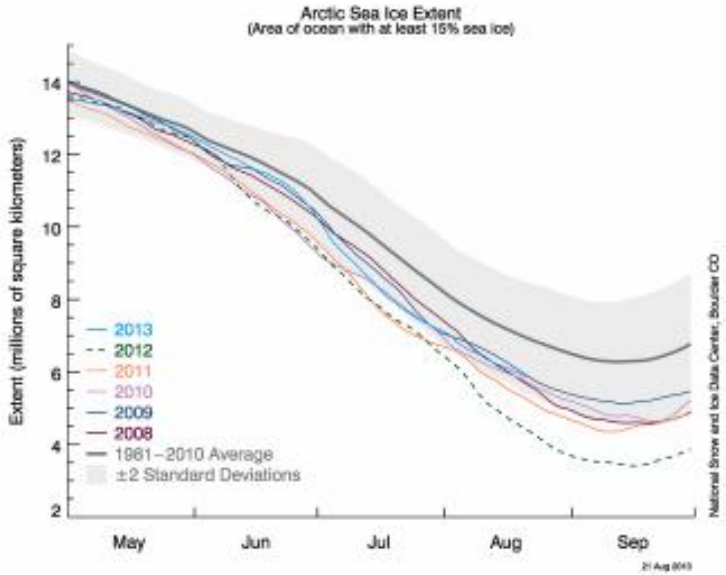
- Upwelling north of 36N weakened in Aug. 2013, consistent with anomalous southerly winds.

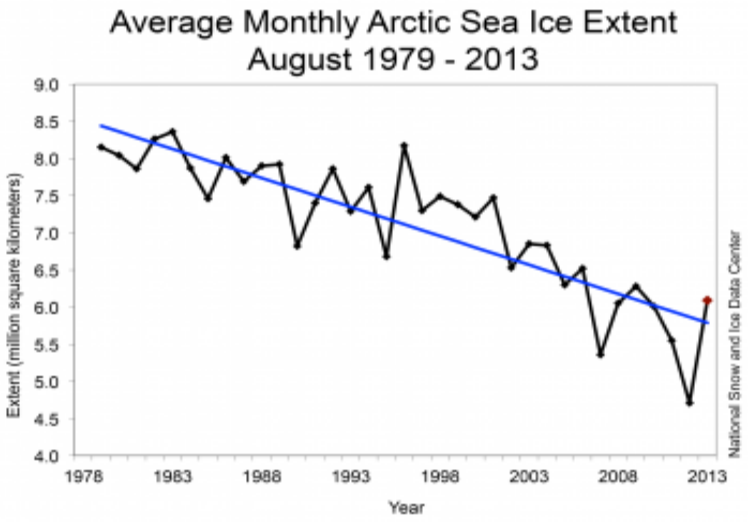
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1981-2010 base period pentad means.
-Area below (above) black line indicates climatological upwelling (downwelling) season.
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

Arctic Sea Ice

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





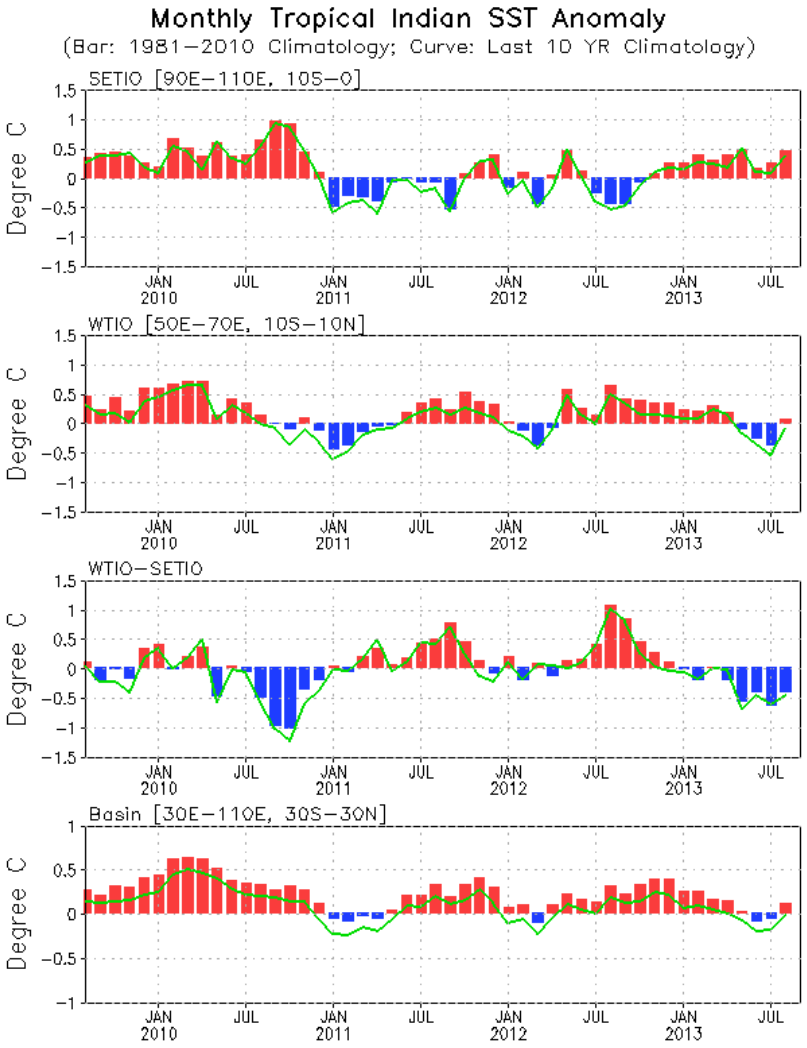


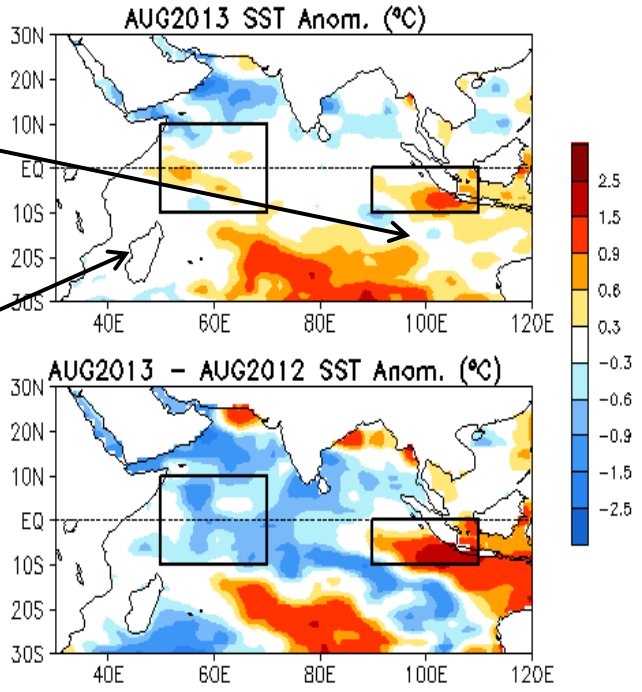
- **Ice extent remained below average in Aug. 2013, but well above the level recorded last year.**

- **August 2013 was the sixth lowest in the 1979-2013 satellite record.**

Indian Ocean

Evolution of Indian Ocean SST Indices



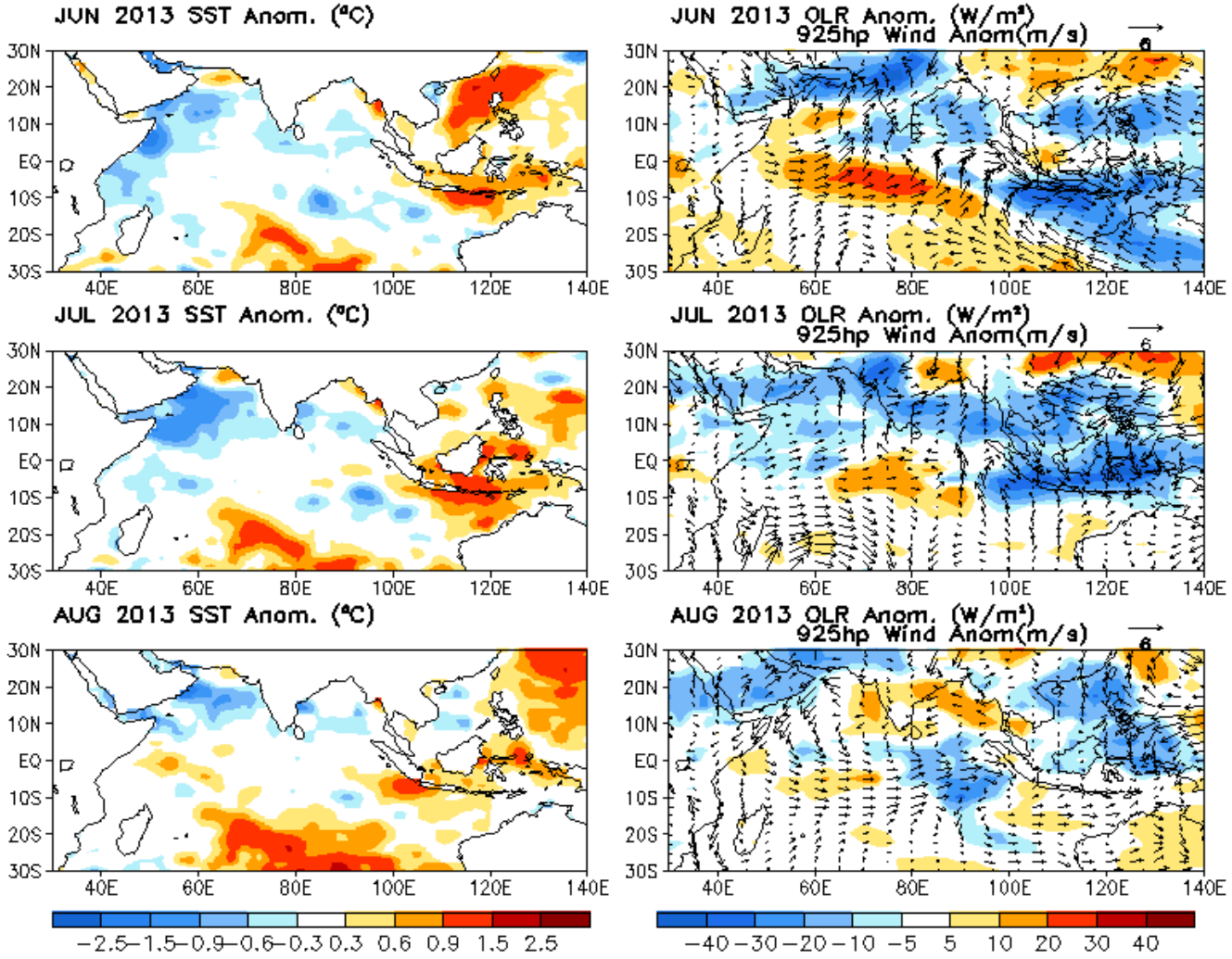


- DMI has been below normal since Jan. 2013.

- The basin mean SST was above-normal in Aug.2013.

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.

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

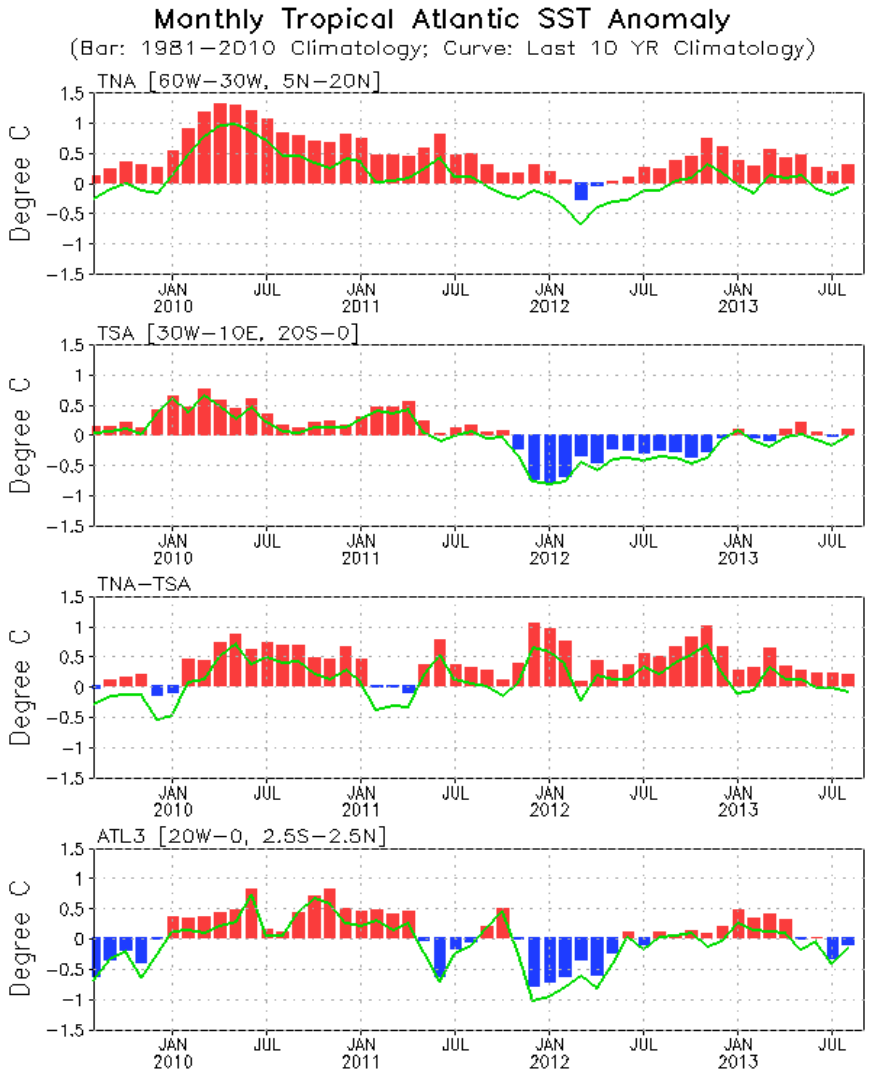


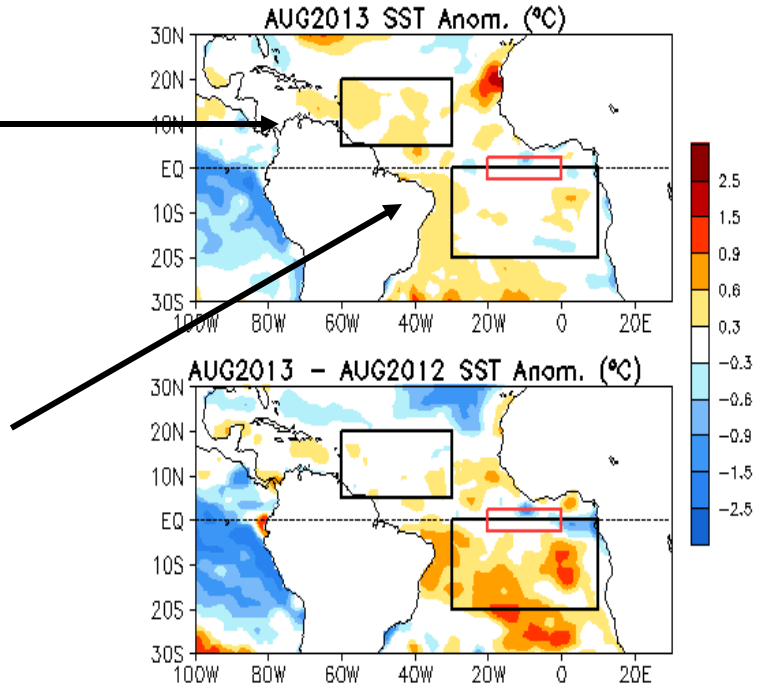
-**SST cooling near Arabian Sea weakened in Aug. 2013.**

- **Negative OLR anomalies (enhanced convection) over the tropical North Indian Ocean weakened.**

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices



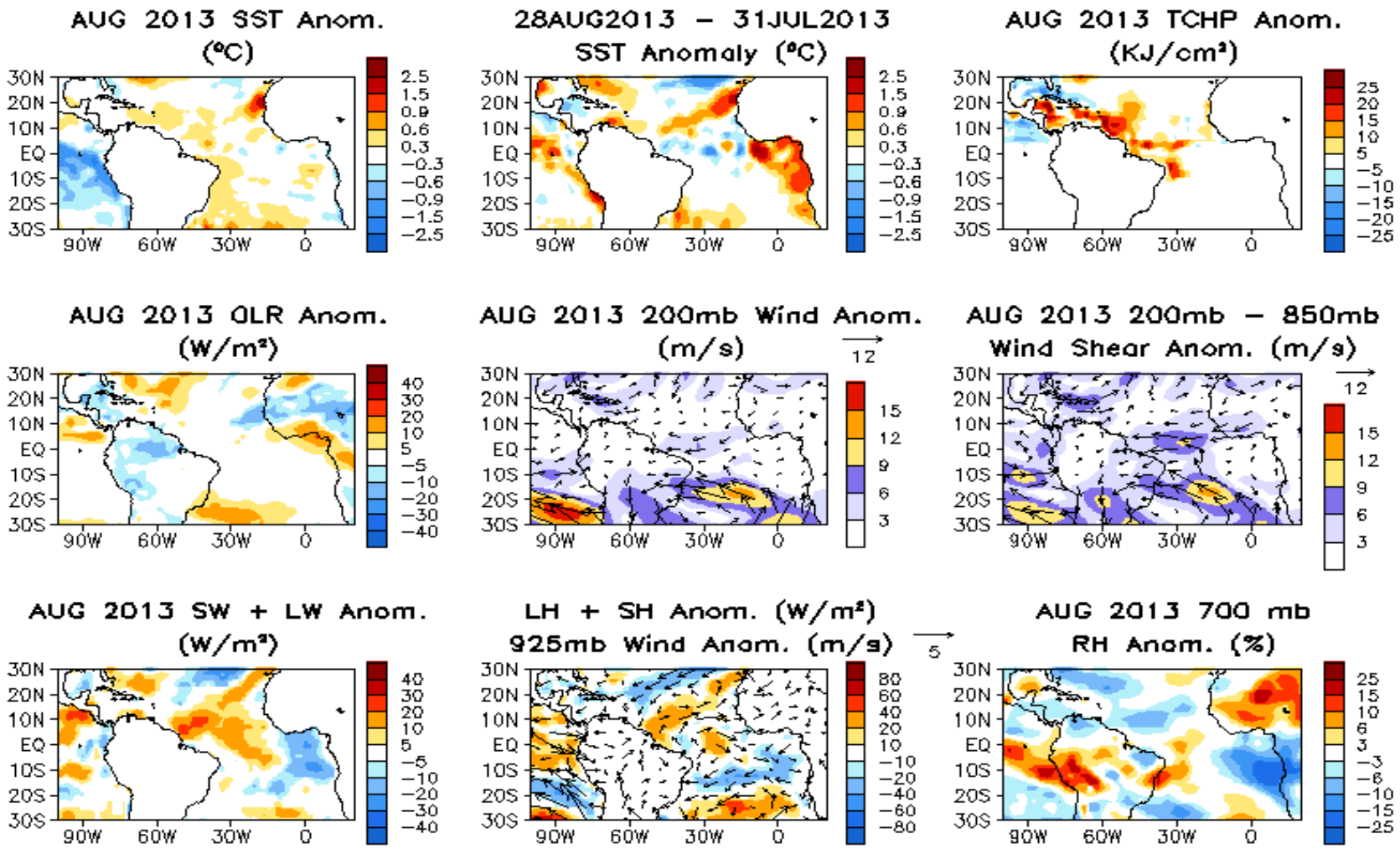


- **Positive TNA persisted Aug. 2013.**
- **Meridional Gradient Mode index (TNA-TSA) was above-normal since May 2011.**

Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and departures from the 1981-2010 base period means and the recent 10 year means are shown in bars and green lines.

Tropical Atlantic:

SST Anom., SST Anom. Tend., TCHP OLR, Sfc Flx, 925-mb/200-mb Winds and RH



- **Above-normal SSTA and TCHP persisted in the hurricane Main Development Region (MDR) .**
- **Below-normal vertical wind shear continured in MDR.**

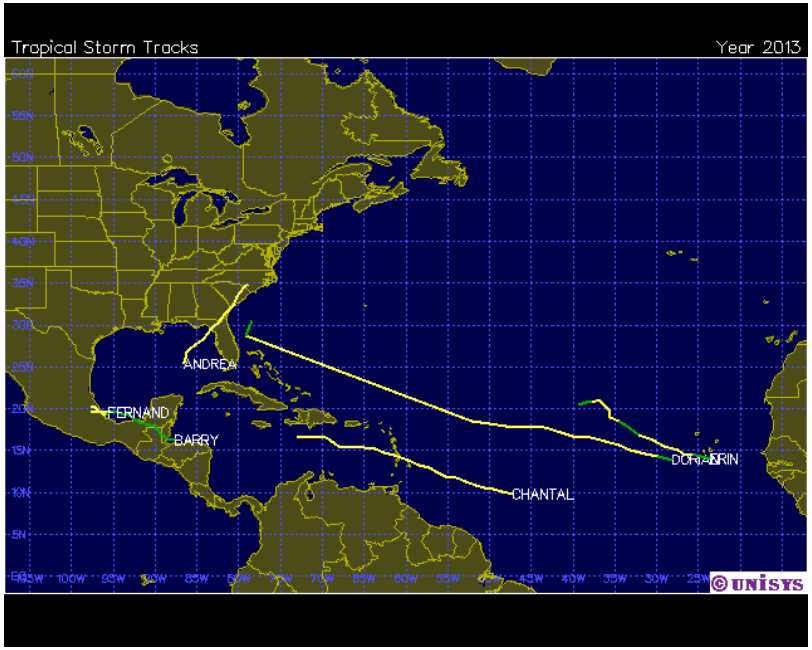
NOAA Predict an Above-Normal Atlantic Hurricane Season in 2013

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml
http://weather.unisys.com/hurricane/atlantic/2013/index.html)

NOAA 2013 Atlantic Hurricane Season Outlooks

Activity Type	August Update	May 23 Outlook	NHC 1981-2010 Normals
Chance Above Normal	70%	70%	
Chance Near Normal	25%	25%	
Chance Below Normal	5%	5%	
Named Storms*	13-19	13-20	12
Hurricanes*	6-9	7-11	6
Major Hurricanes	3-5	3-6	3
ACE (% Median)	120-190	120-205	71-120**

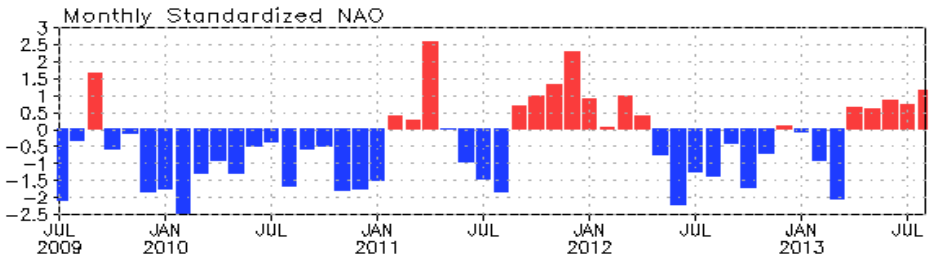
The outlooks indicate a 70% probability for each range of activity.
* Includes all such storms regardless of strength
**A near-normal season has ACE values of 71%-120% of the median.

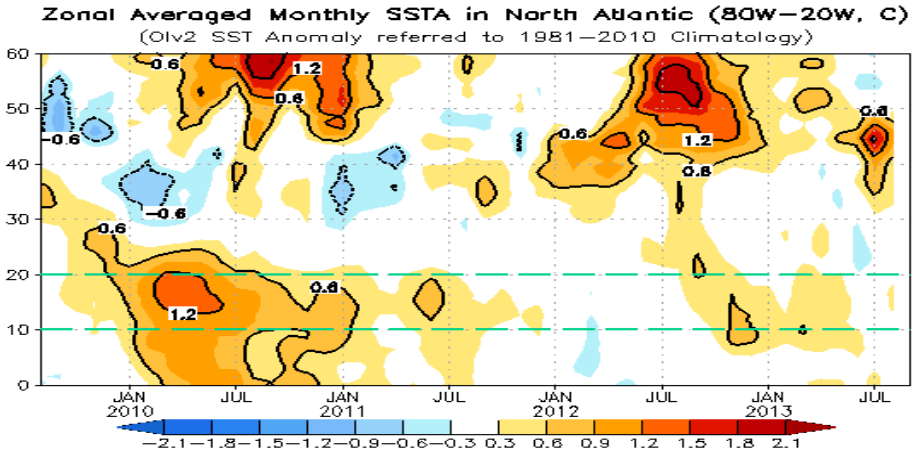


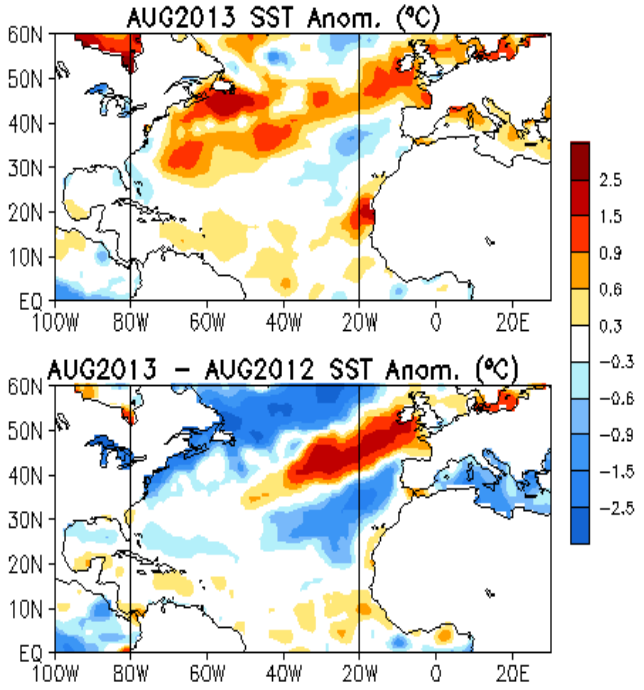
- NOAA's updated Atlantic hurricane outlook continued to call for an above-normal season, while the predicted ranges of activity are slightly lower and narrower than the May outlook.

- Six tropical storms were formed in North Atlantic by September 5.

NAO and SST Anomaly in North Atlantic







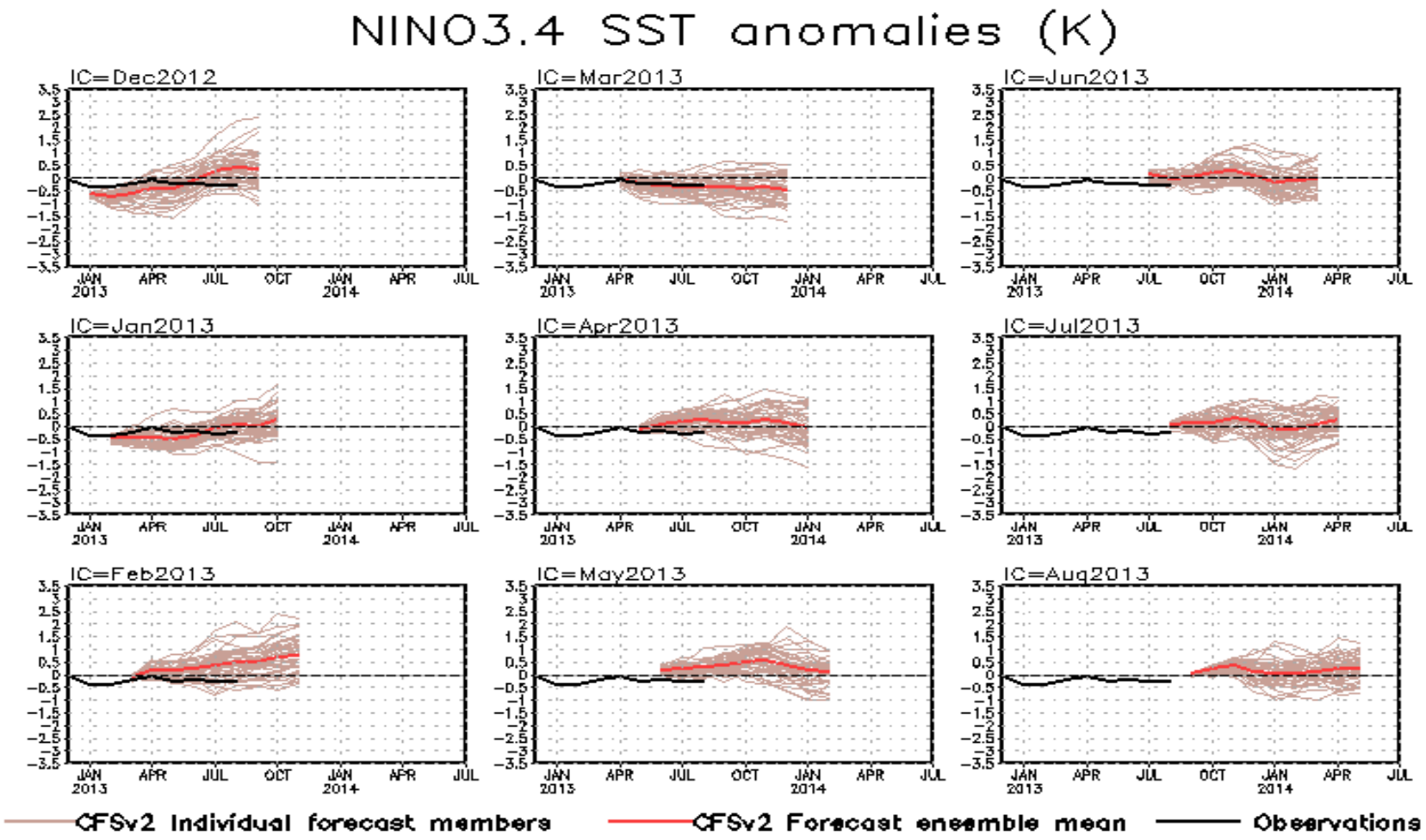
- **High-latitude North Atlantic SSTA is generally closely related to NAO index (negative NAO leads to SST warming and positive NAO leads to SST cooling).**

- **NAO has been above-normal since Apr. 2013.**

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.

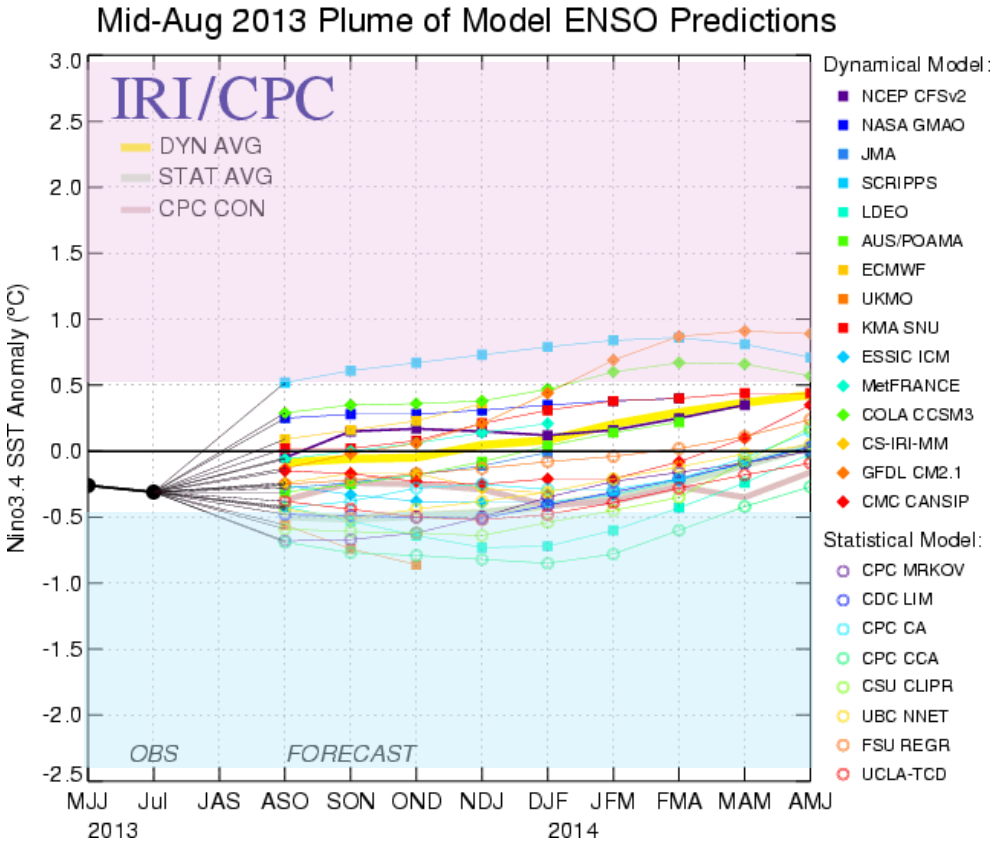
Global SST Predictions

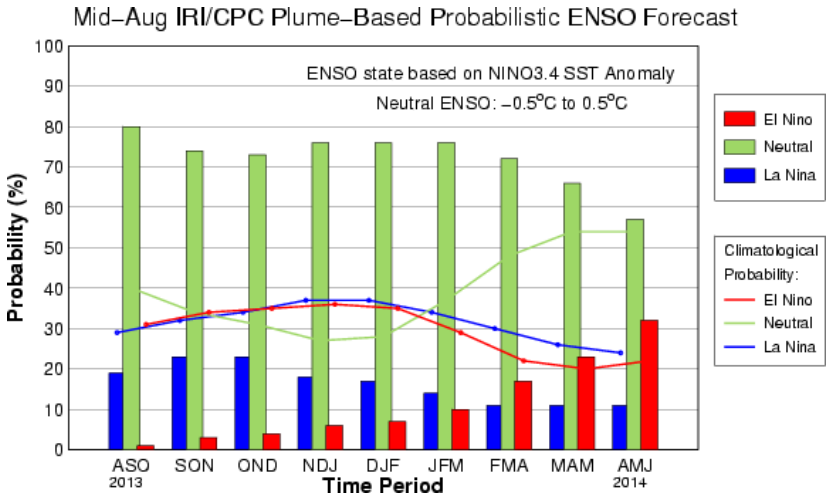
NCEP CFSv2 NINO3.4 Forecast

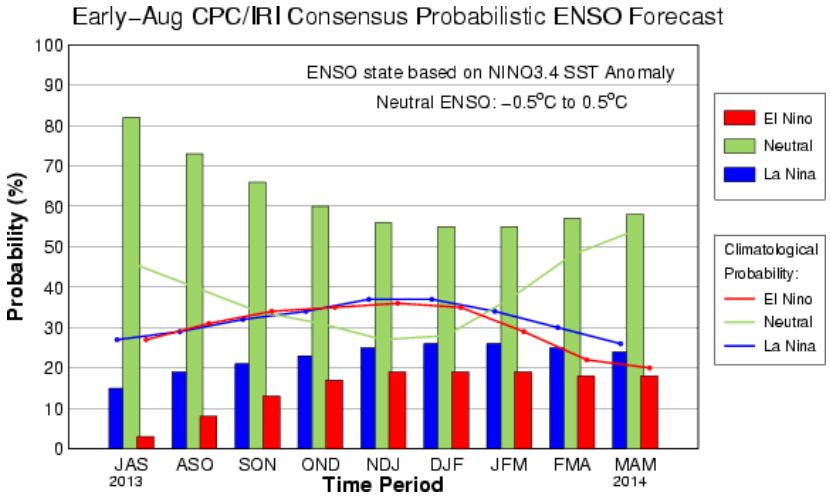


- Latest CFSv2 prediction suggests ENSO-neutral condition into spring 2014.

IRI/CPC NINO3.4 Forecast Plume

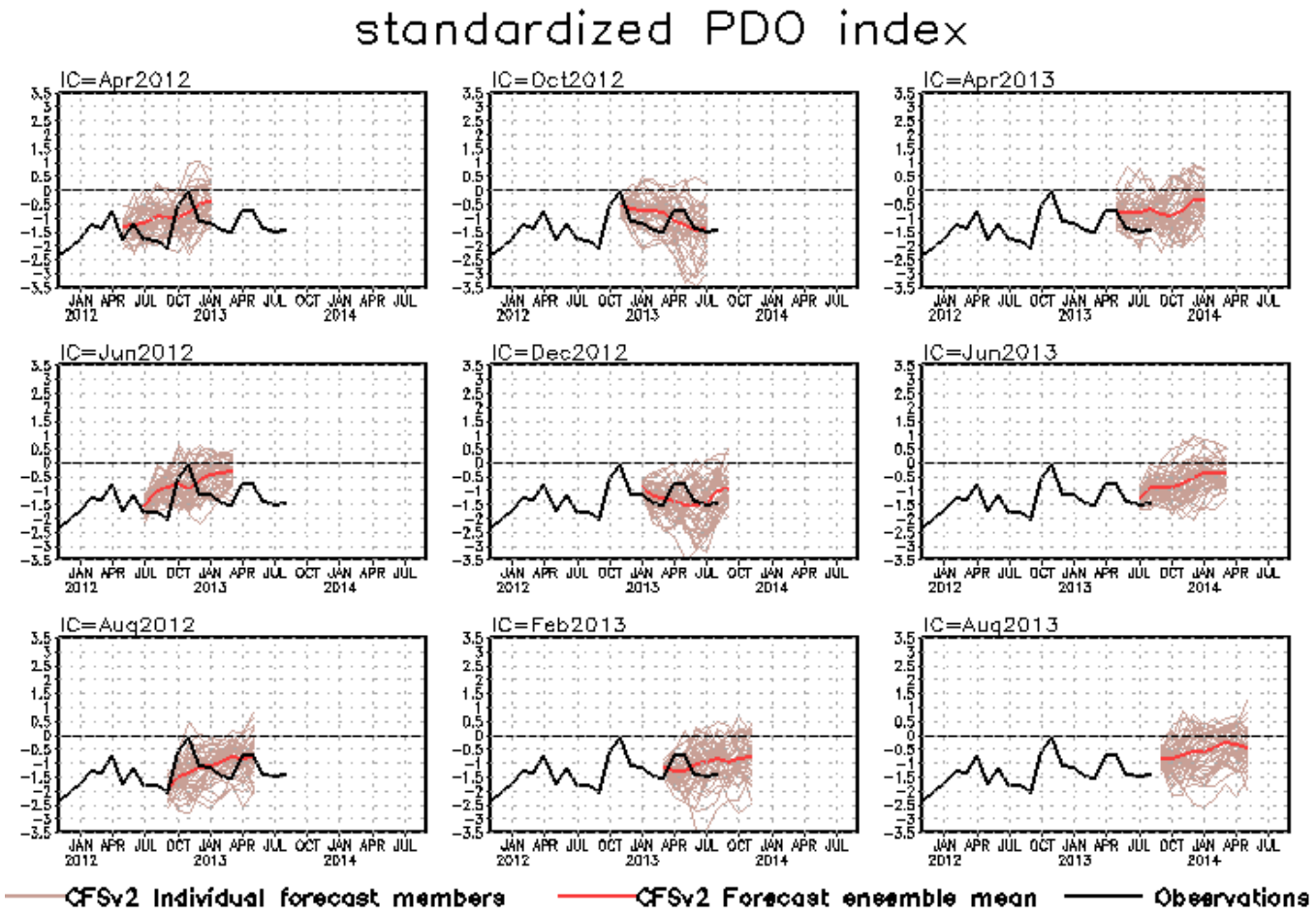






- **Most of the models predicted ENSO-neutral in the coming Northern Hemisphere winter and spring.**
- **The consensus forecast favors ENSO-neutral conditions into Northern Hemisphere spring 2014.**

NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

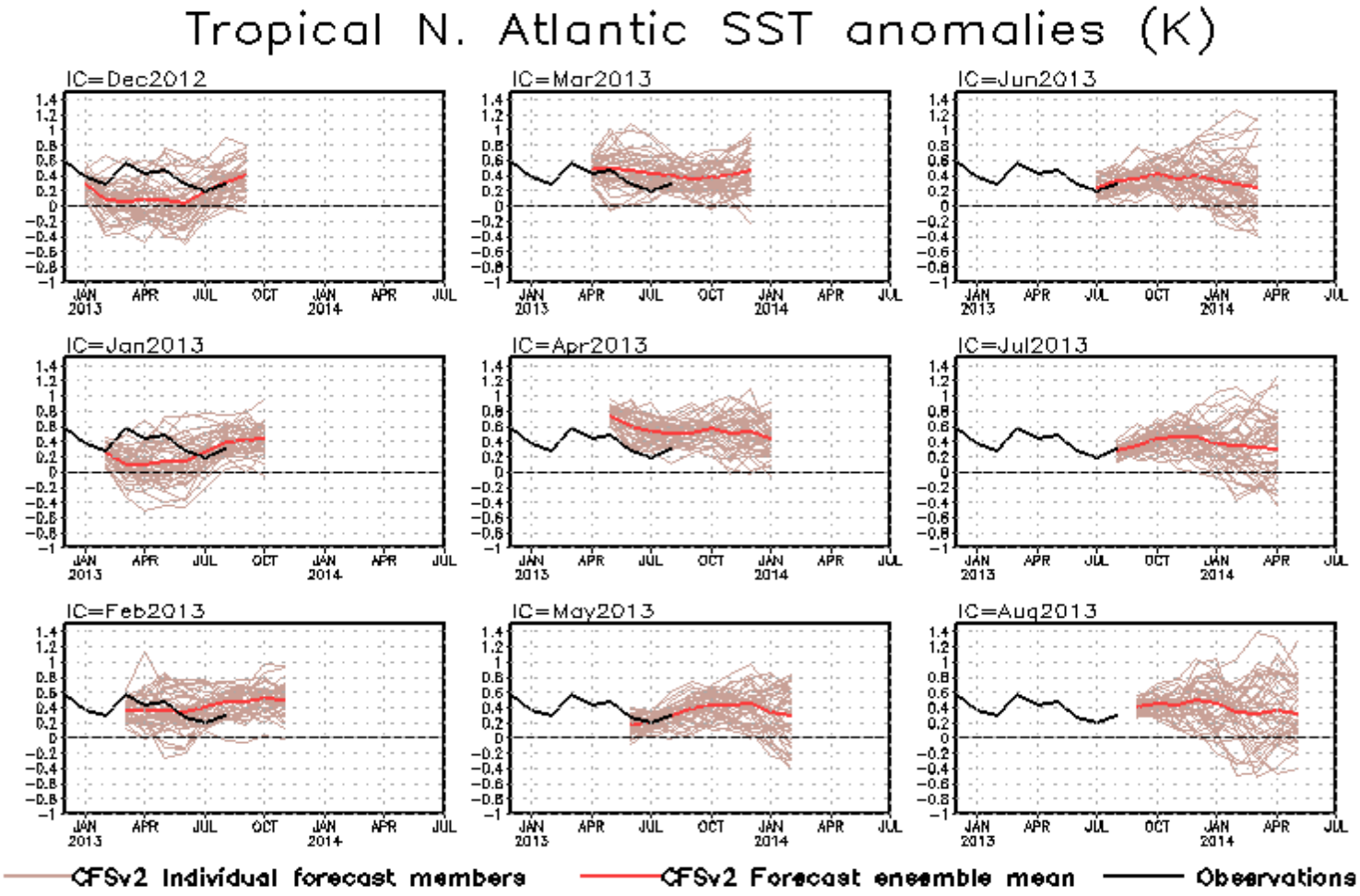


PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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

- Latest CFSv2 prediction suggests negative PDO phase will likely continue into the northern hemisphere spring 2014.

NCEP CFSv2 Tropical North Atlantic SST Forecast



- **Latest CFSv2 prediction suggests that above-normal SST in the tropical N. Atlantic will continue into the northern hemisphere spring 2014.**

Overview

- **Pacific and Arctic Oceans**
  - **ENSO-neutral conditions persisted during August 2013.**
  - **The consensus forecast favors ENSO-neutral conditions to continue into the Northern Hemisphere Spring 2014.**
  - **Negative PDO phase persisted with PDO=-1.5 in August 2013, and NCEP CFSv2 predicted negative PDO phase would continue into next spring.**
  - **SSTA in the north Pacific Ocean reached the historical high since 1982**

- **Indian Ocean**
  - **SSTs were above-normal in the east and in the west, and negative Indian Ocean Dipole index continued in August 2013.**

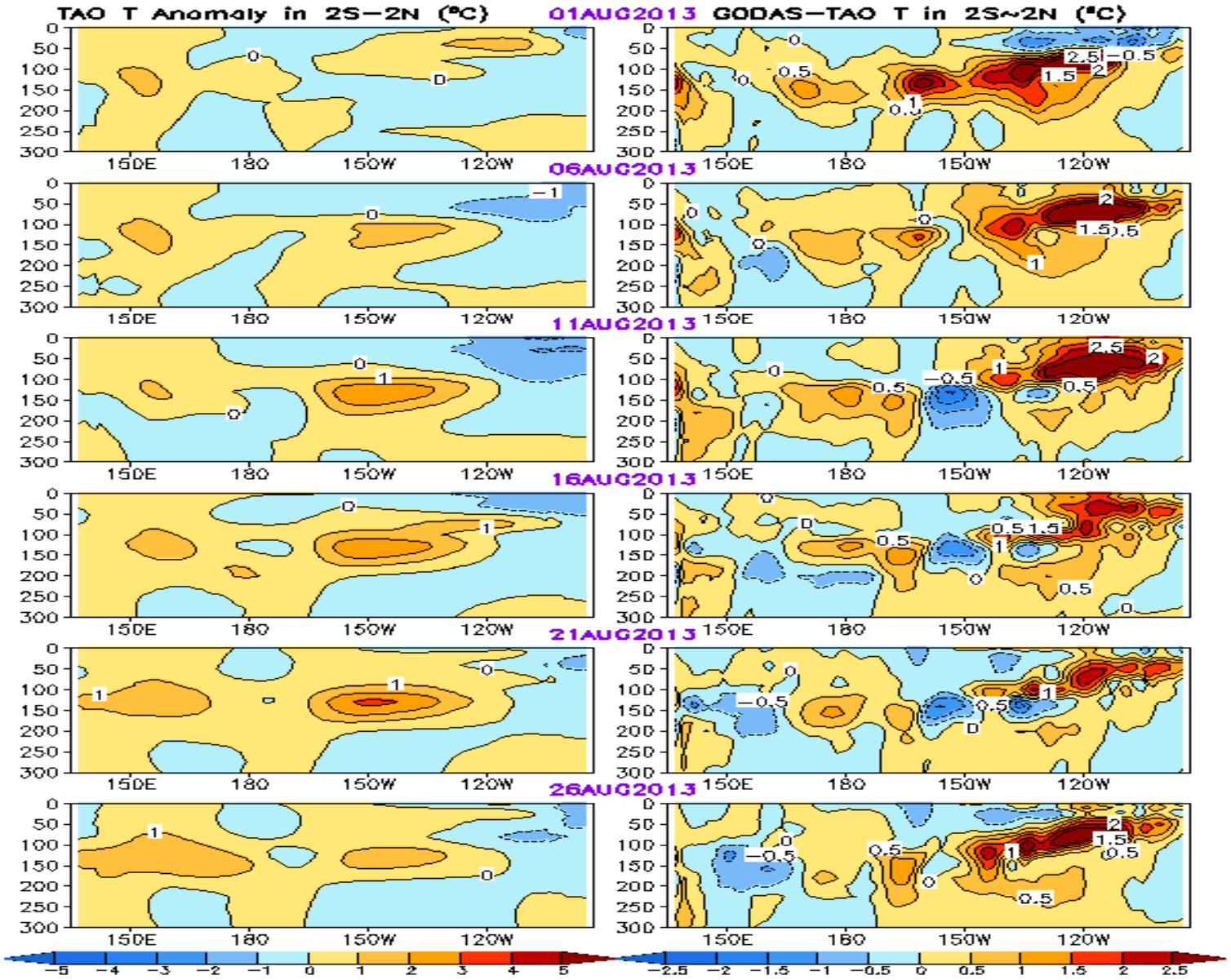
- **Atlantic Ocean**
  - **Above-normal SST continued in the hurricane main development region.**
  - **NCEP CFSv2 forecast suggest above-normal SST in the tropical N. Atlantic will continue into the northern hemisphere spring 2014.**
  - **Positive NAO index persisted in the past five months.**

Backup Slides

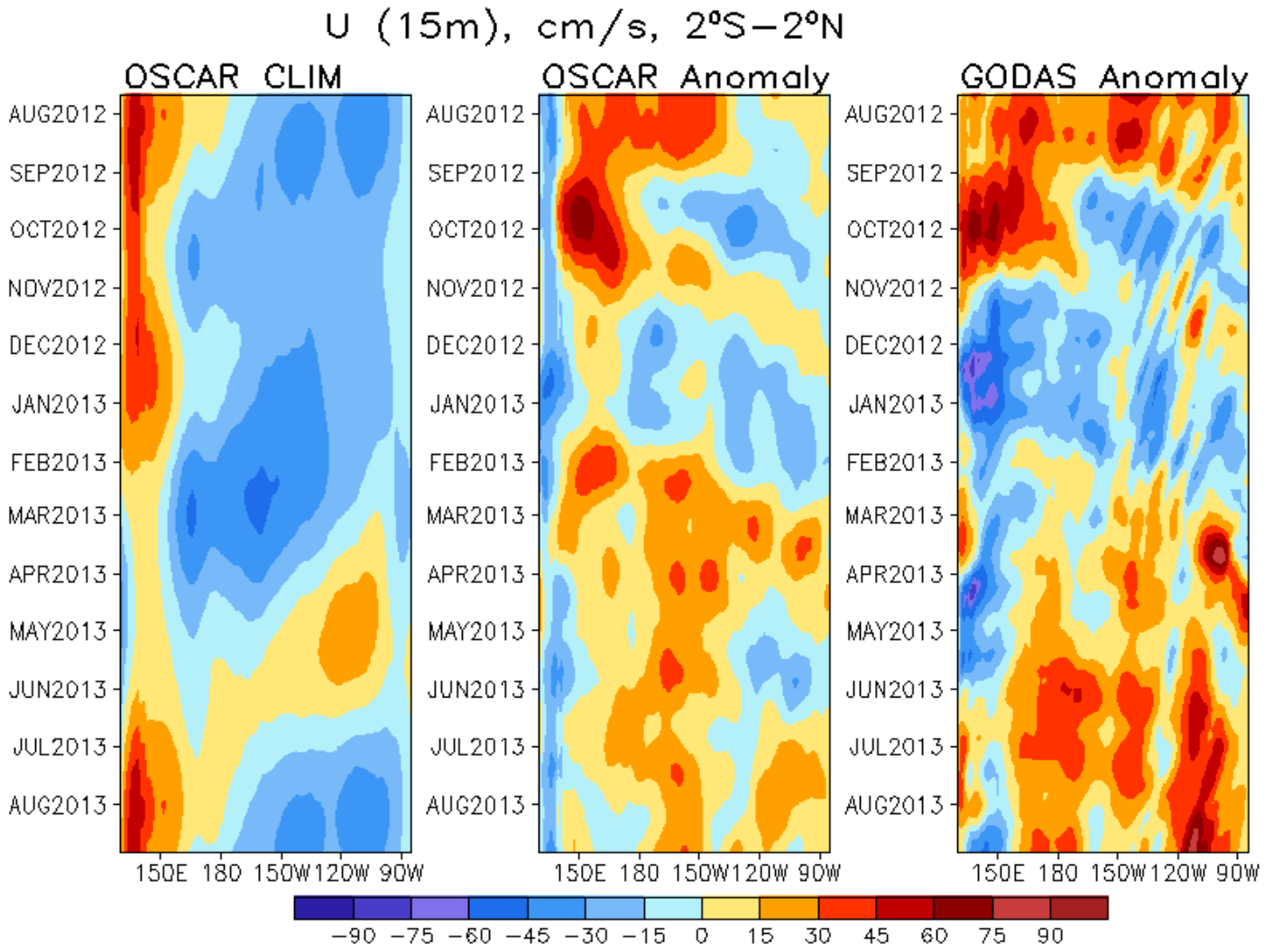
Equatorial Pacific Temperature Anomaly

TAO

GODAS-TAO



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



- **Positive zonal current anomalies have dominated in the central-eastern Pacific since June 2013.**
- **Westerly zonal current anomalies from GODAS were stronger than those from OSCAR.**

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

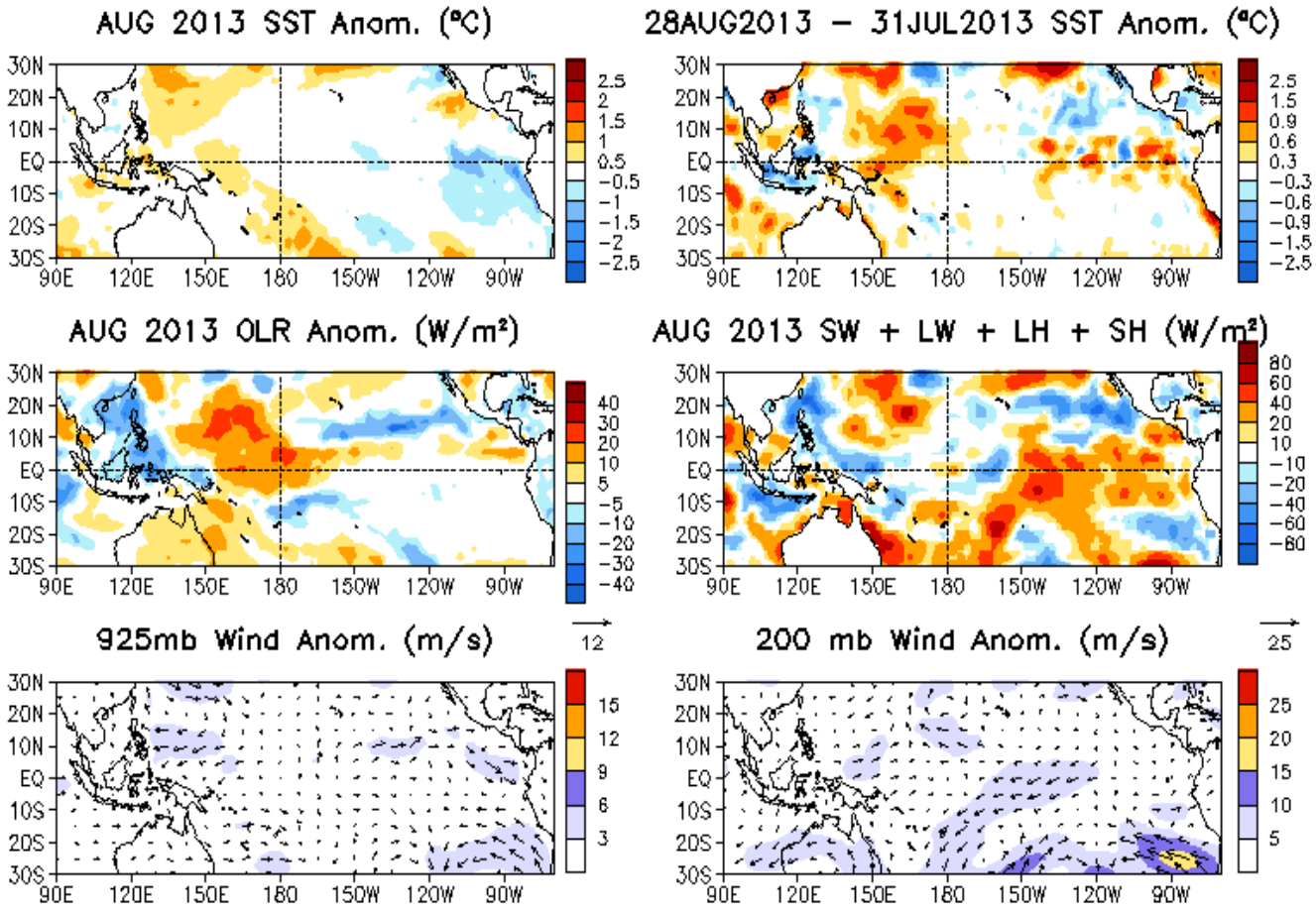


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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

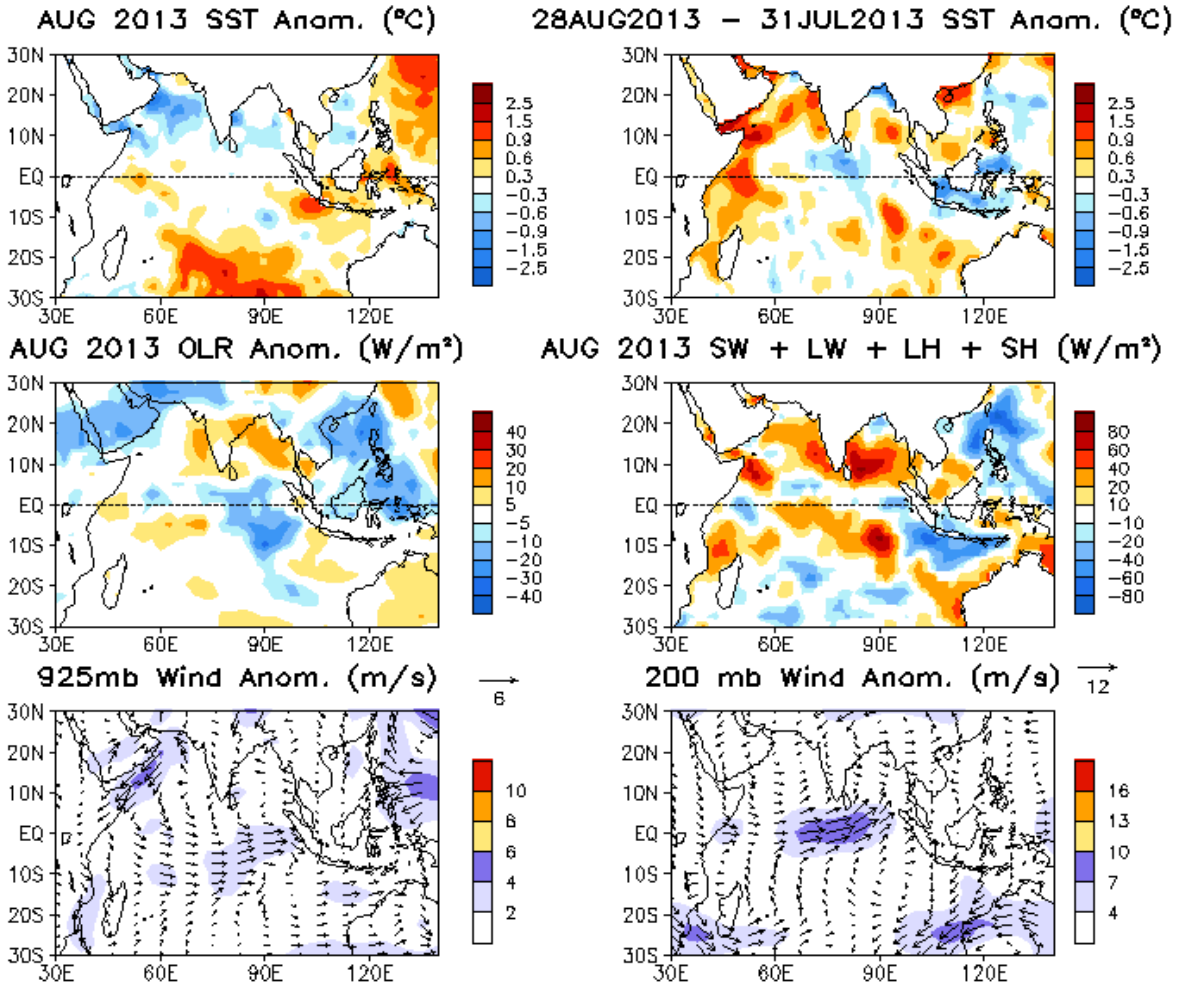
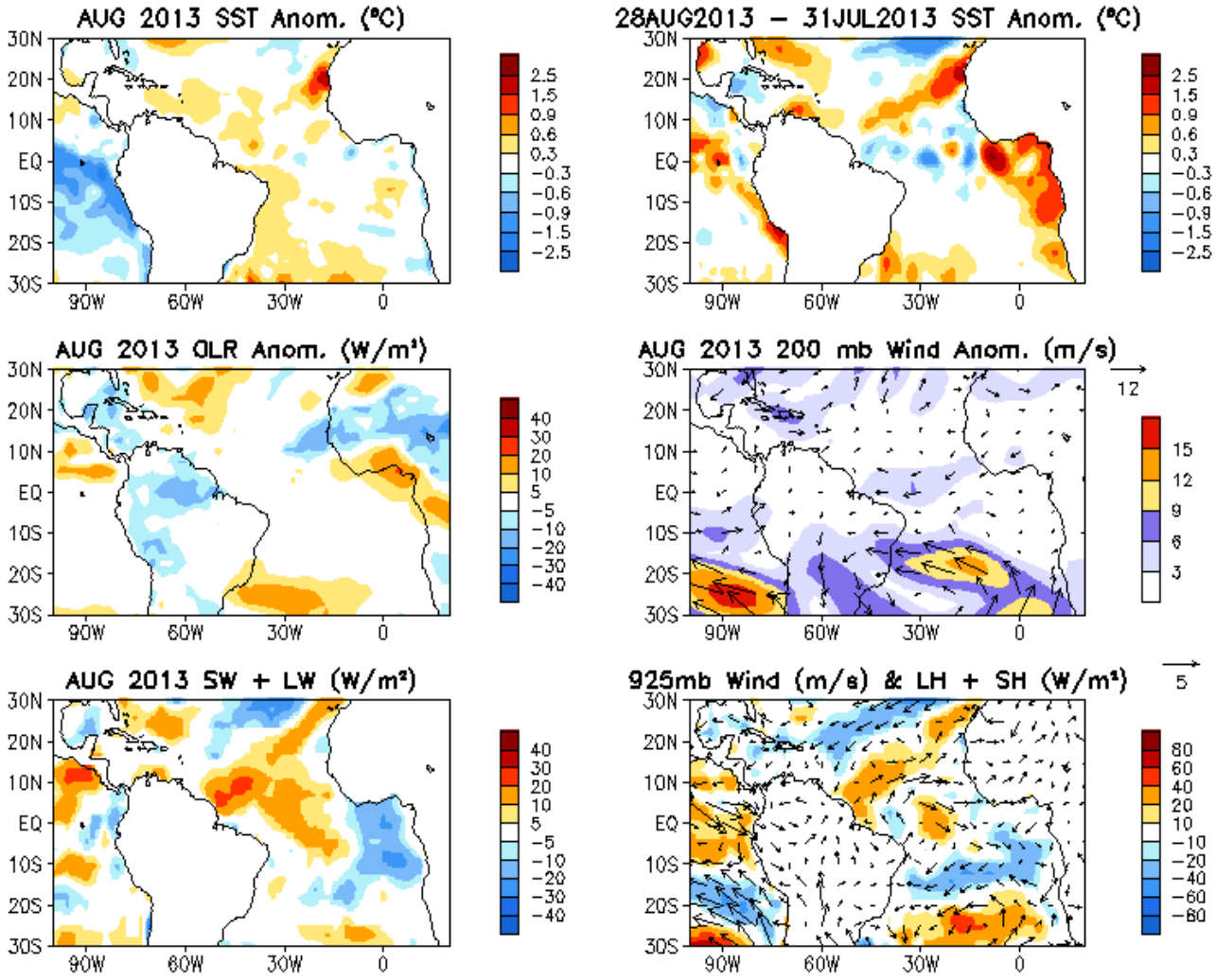


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

Tropical Atlantic:

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



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

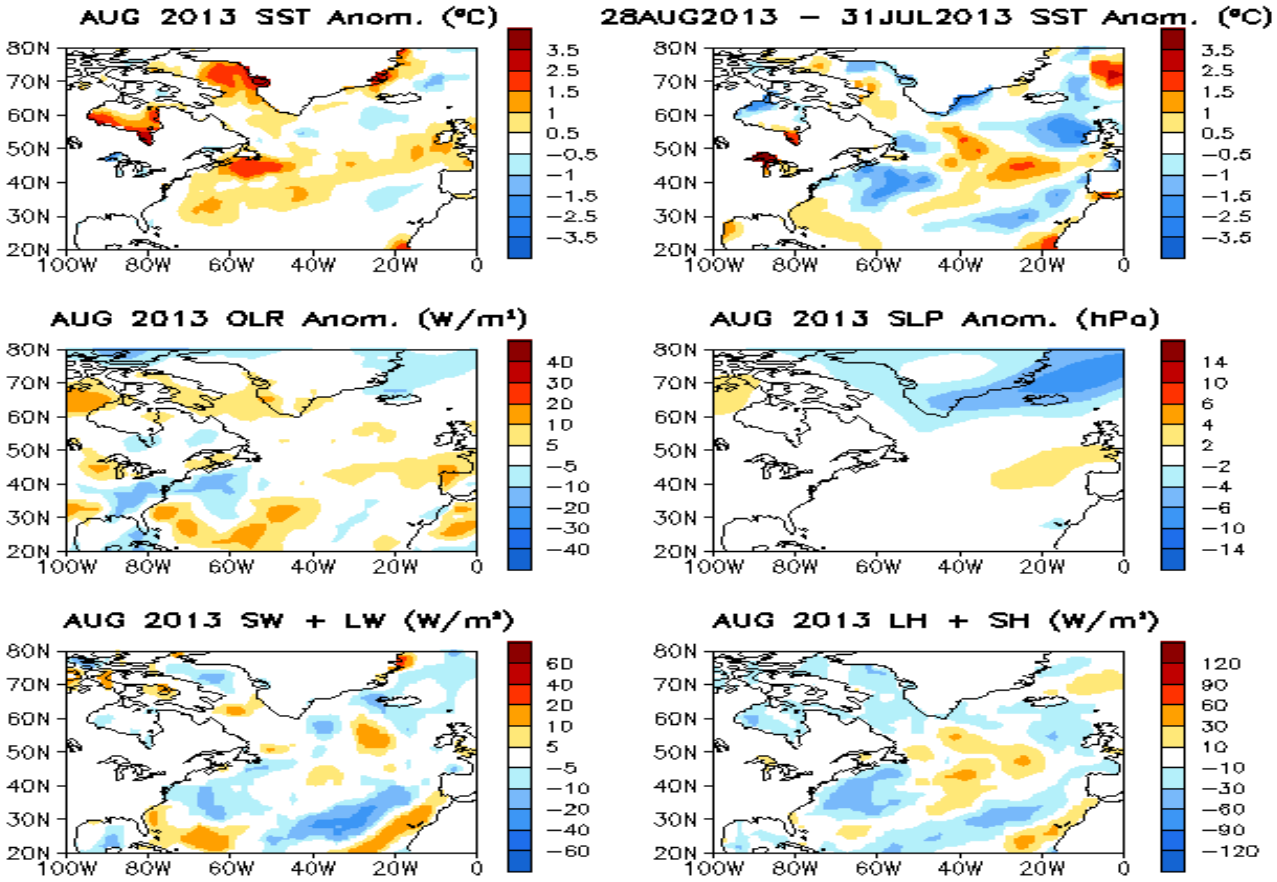
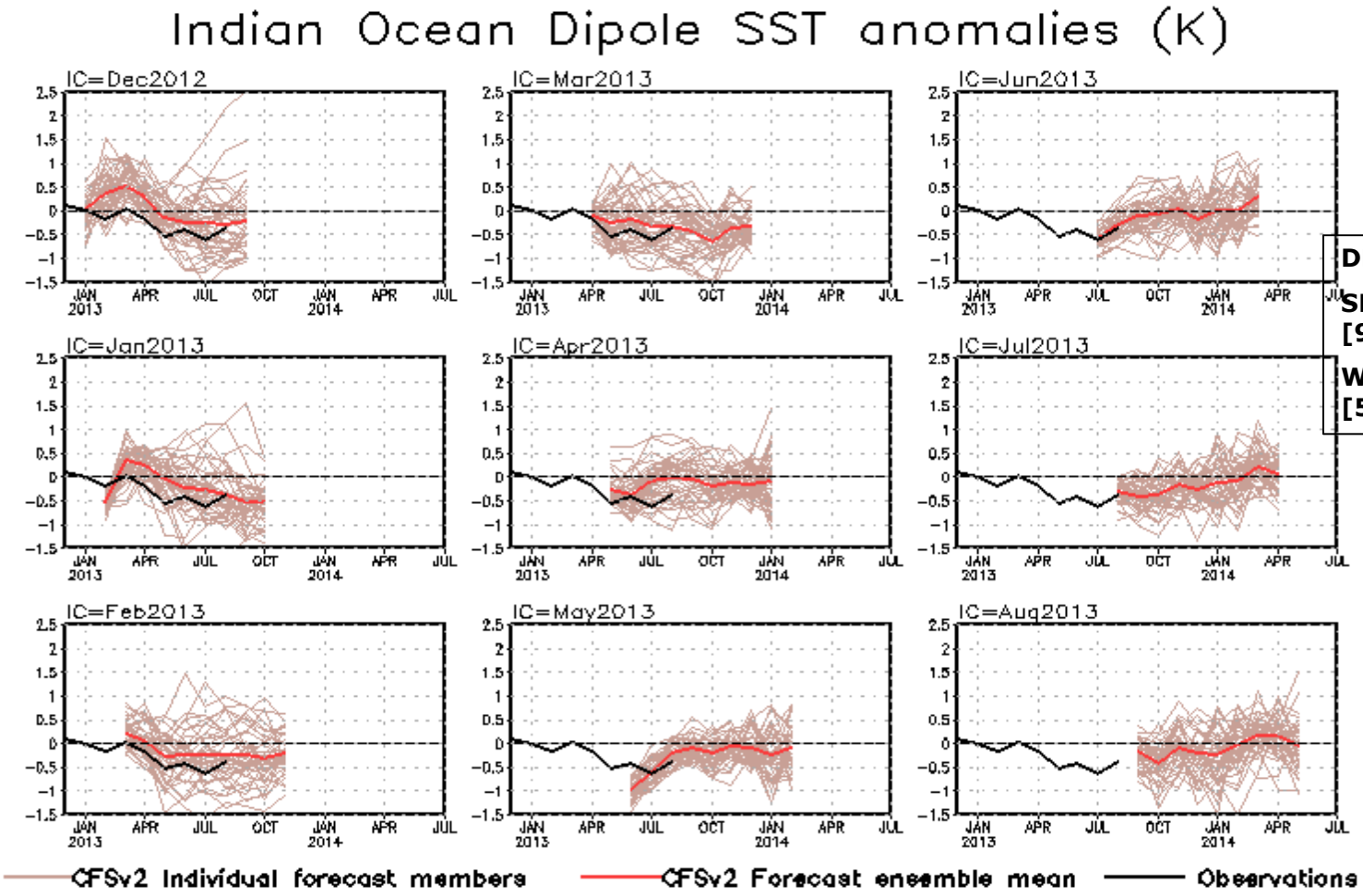


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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



DMI = WTIO- SETIO

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

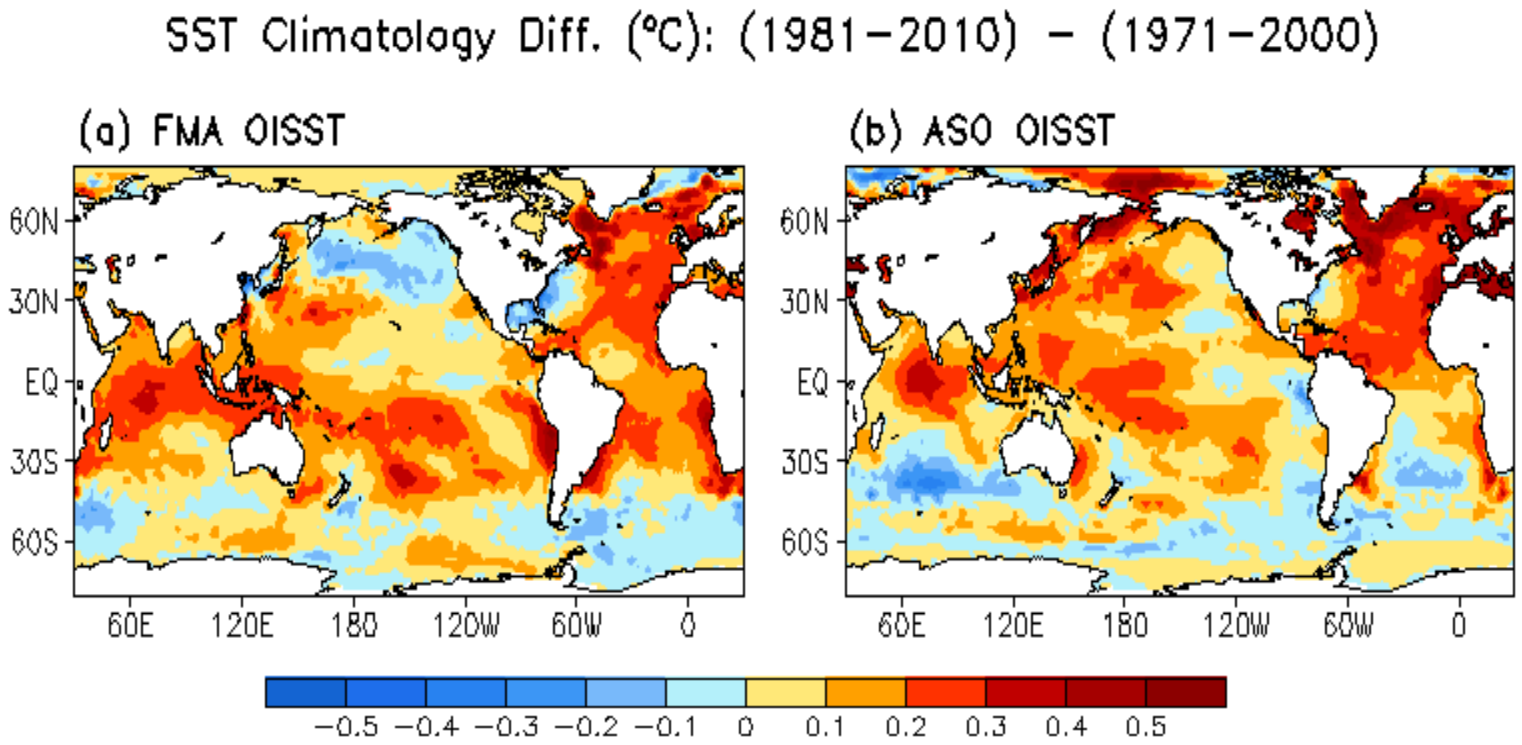
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

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



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!