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's Climate Observation Division (COD)

Outline

- **Overview**
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SST Predictions**

Overview

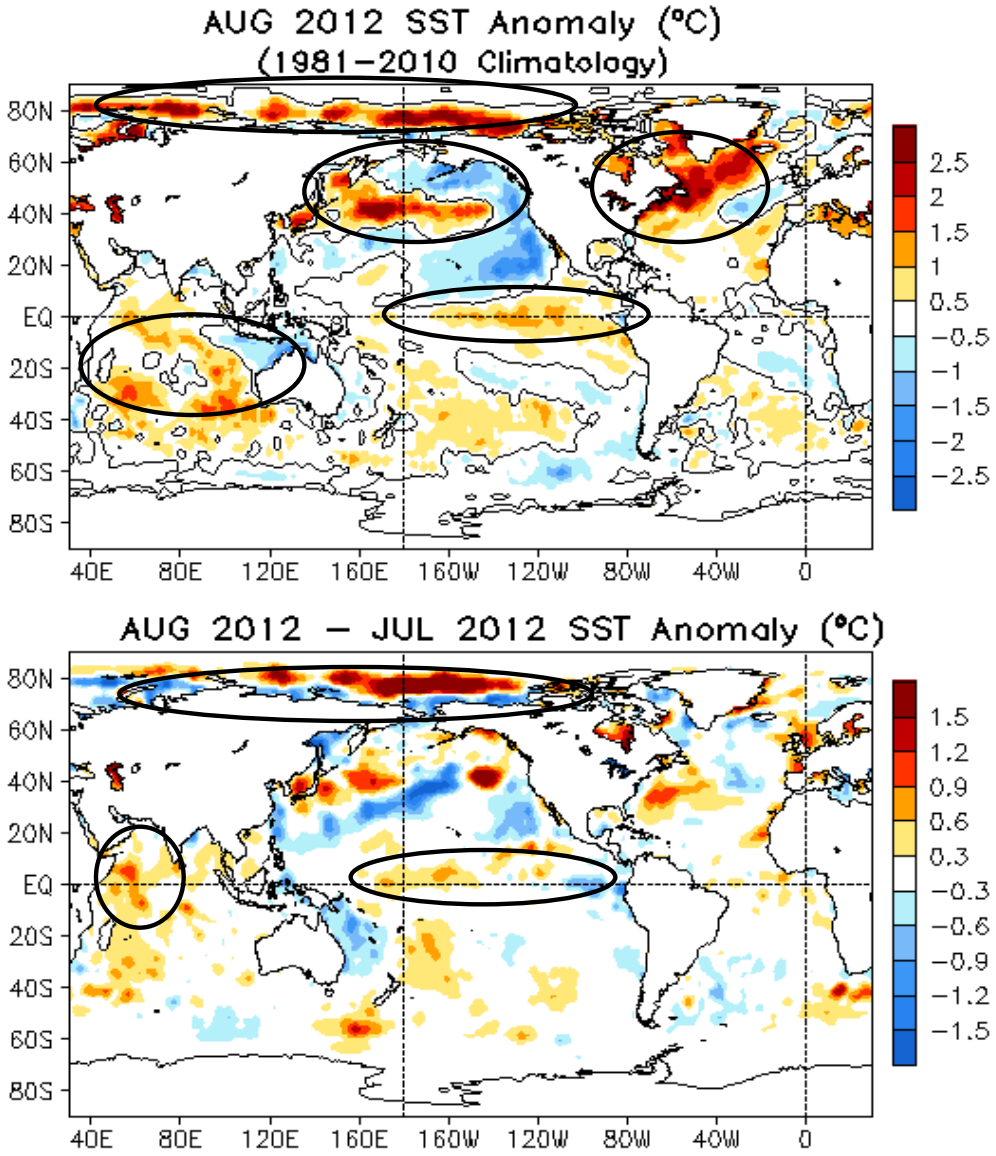
- **Pacific and Arctic Oceans**
  - **ENSO-neutral conditions continued during August 2012.**
  - **NOAA "ENSO Diagnostic Discussion" in September 2012 suggests an El Nino most likely develops during August-October, and persists through December-February 2012/2013.**
  - **Negative PDO phase continued in August 2012, with PDO=-1.8, and has last for 28 months since May 2010.**
  - **Arctic sea ice extent reached the historical low in the satellite record.**

- **Indian Ocean**
  - **Above-normal Indian Ocean Dipole condition emerged in Aug 2012, with DMI = 1.2^{o} C.**

- **Atlantic Ocean**
  - **Weak above-normal SSTA presented in the hurricane Main Development Region(MDR).**
  - **NOAA predicted a high likelihood of near- or above-normal hurricane season in 2012.**
  - **Negative NAO index persisted in the past four months, contributing to a strong warming in the high-latitude N. Atlantic.**

Global Oceans

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

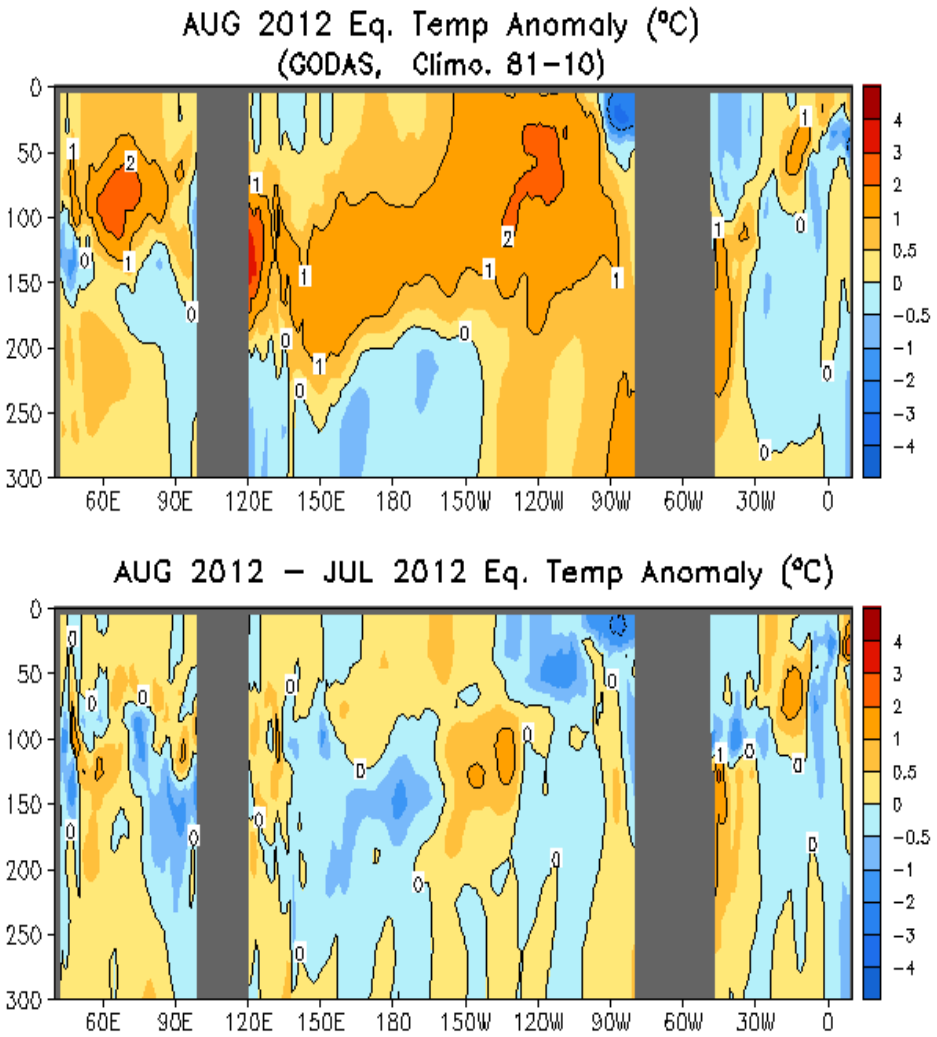


- **Positive SST anomalies presented in the central-eastern equatorial Pacific.**
- **Large positive SST anomalies presented in the Artic Ocean, subpolar North Atlantic, and along the Gulf Stream.**
- **Negative PDO-like pattern continued in North Pacific.**
- **Negative(positive) SST anomalies presented north of Australia (in the central tropical and subtropical southern Indian Ocean).**

- **A weak warming(cooling) tendency presented in the central (far eastern) equatorial Pacific.**
- **A warming tendency presented in the western tropical Indian Ocean.**
- **A strong warming tendency presented in the Artic Ocean.**

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

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



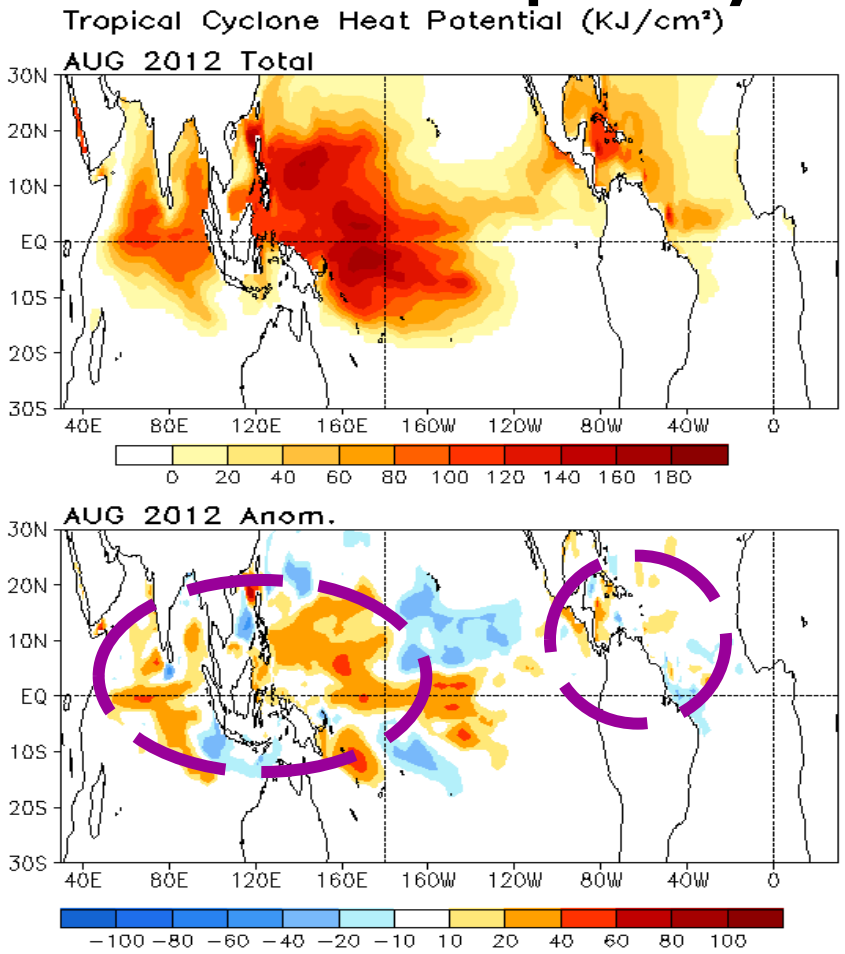
- **Positive temperature anomalies continued to occupy near the thermocline in the equatorial Pacific Ocean.**

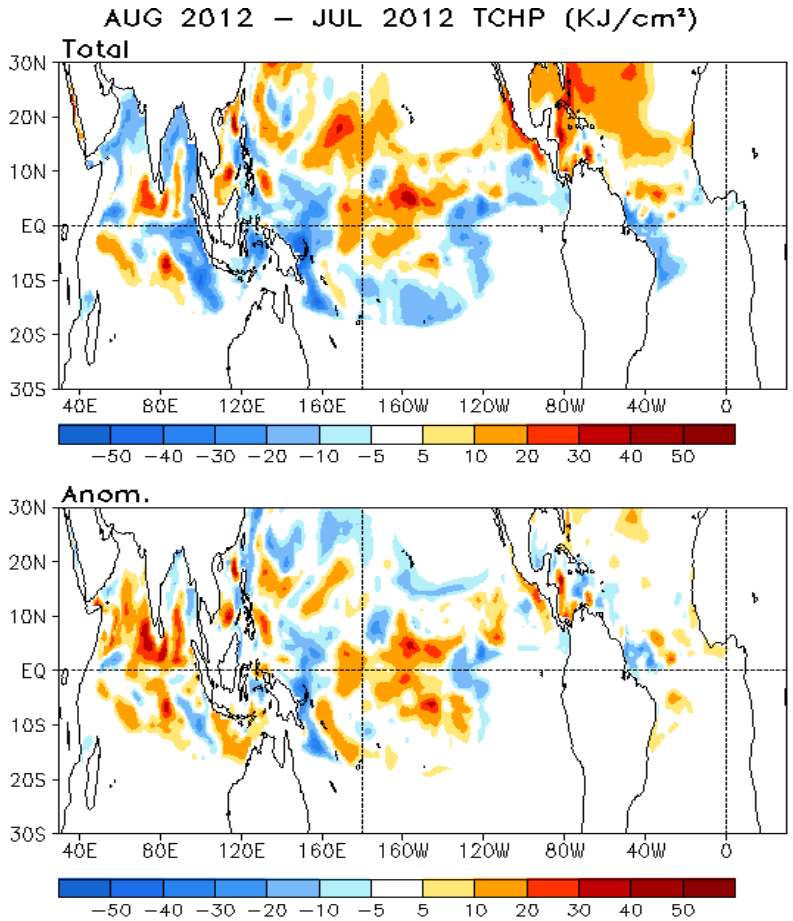
- **Positive anomalies were dominated at the upper 150m of equatorial Indian Ocean.**

- **Cooling tendency was observed near the thermocline in the western and eastern Pacific 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





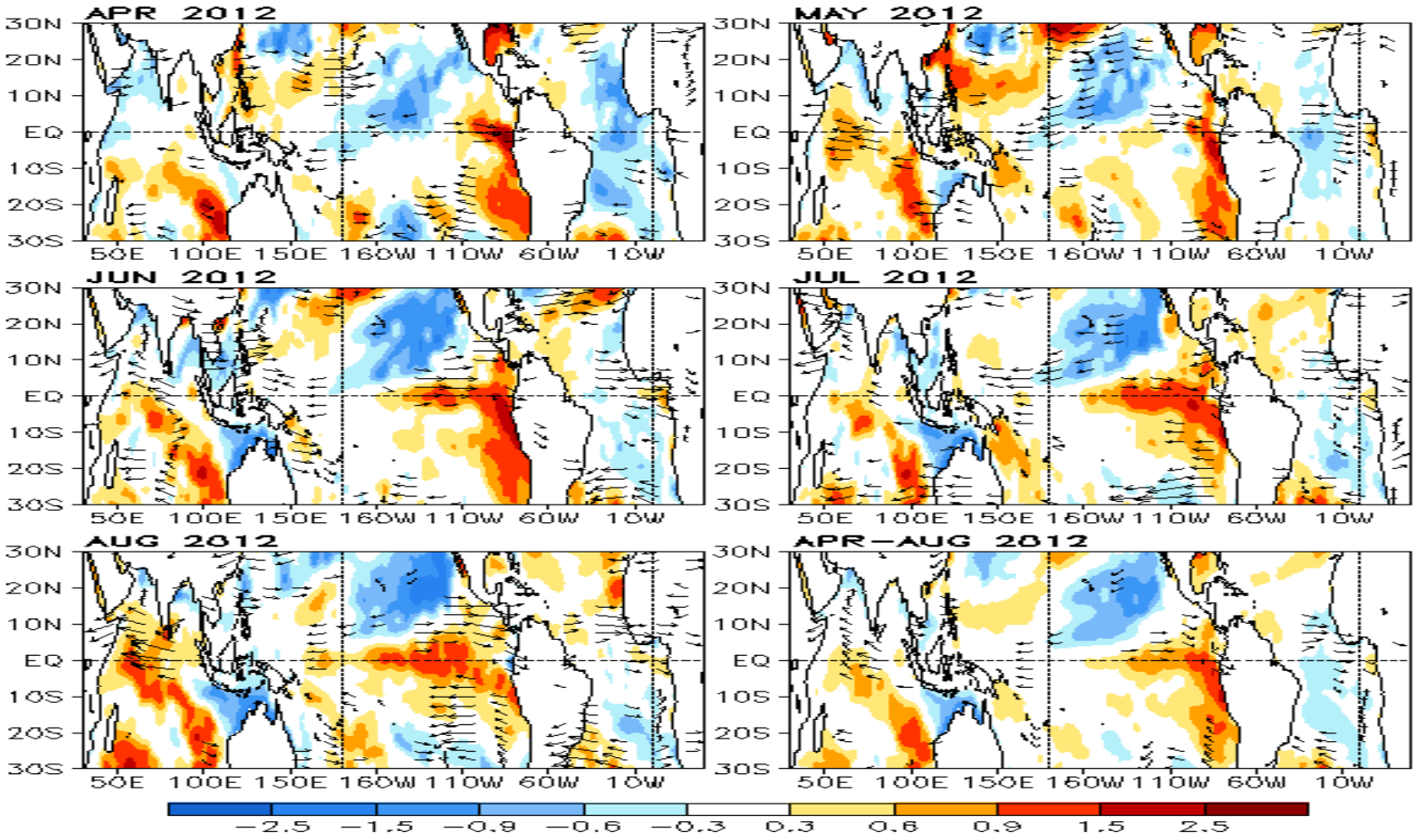
- Large positive TCHP anomalies presented in the western tropical Pacific ocean and Indian Ocean in Aug 2012.

- Both TCHP anomaly and anomaly tendency were small over the tropical Atlantic Ocean.

The tropical cyclone heat potential (hereafter TCHP), is defined as a measure of the integrated vertical temperature from the sea surface to the depth of the 26°C isotherm.

Tropical Pacific Ocean and ENSO Conditions

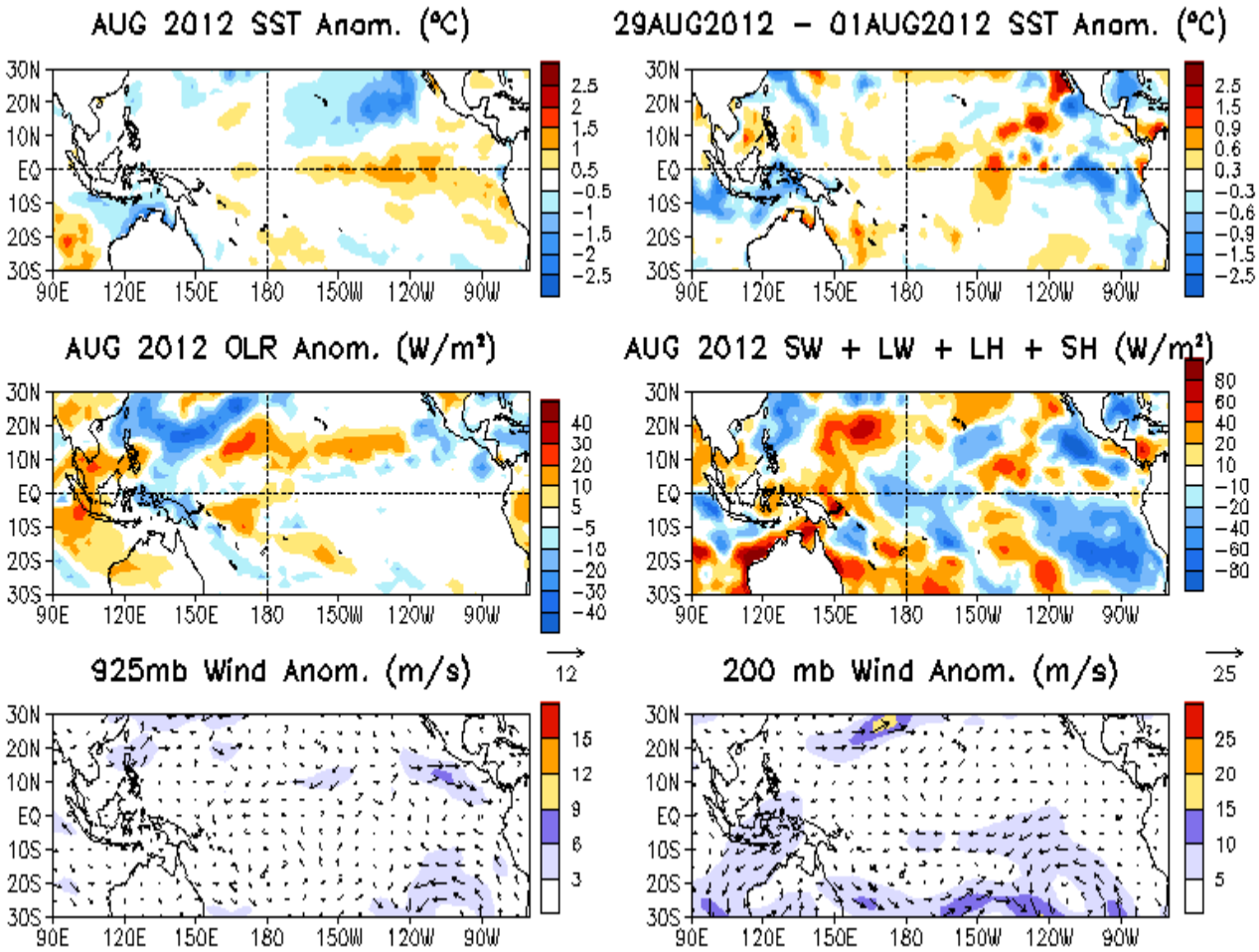
Recent Evolution of SST and 850mb Wind Anom.



- **Easterly wind anomalies persisted near Dateline in the equatorial Pacific from Mar to Aug 2012.**

- **Accompanying the persistent easterly wind anomalies were persistent westerly wind anomalies in the eastern equatorial Pacific, indicating a persistent low-level divergence in the central-eastern Pacific.**

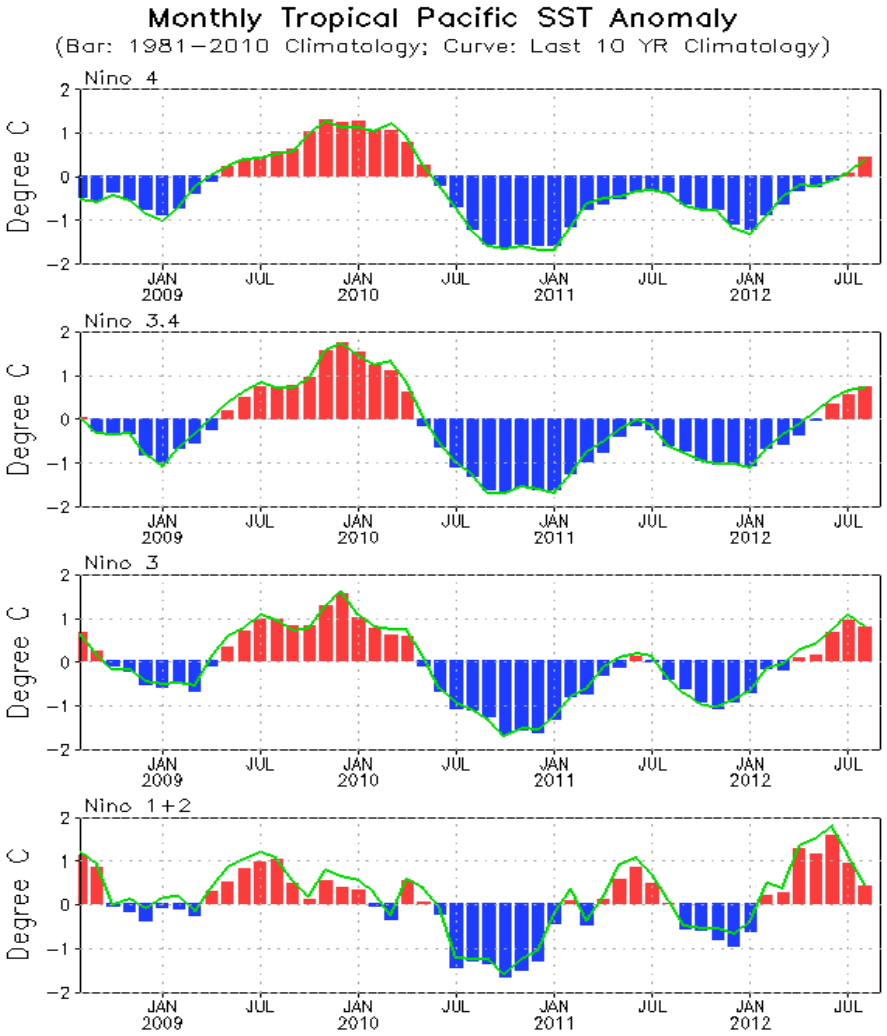
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

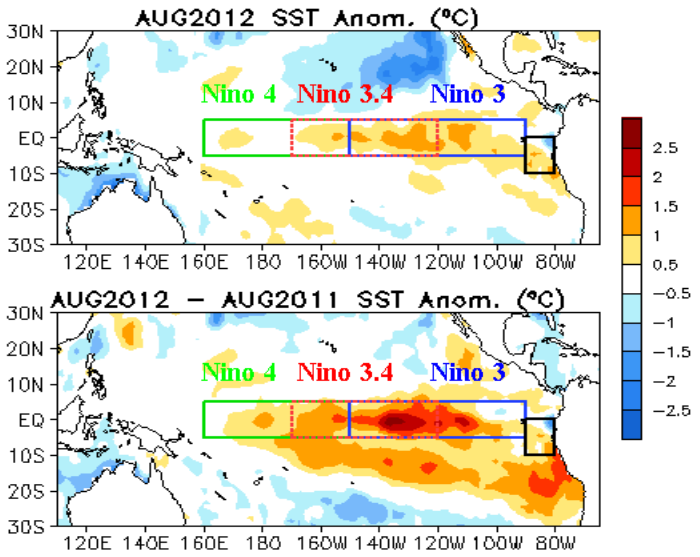


- **Positive SSTA (>0.5C°) extended west of Dateline near the equator.**
- **Warm temperature strengthened (weakened) in the central (eastern) equatorial Pacific Ocean.**
- **Atmosphere circulation continued to be near-normal in August.**

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

Evolution of Pacific NINO SST Indices





- Positive Nino 1+2 and Nino 3 indices decreased in Aug 2012.

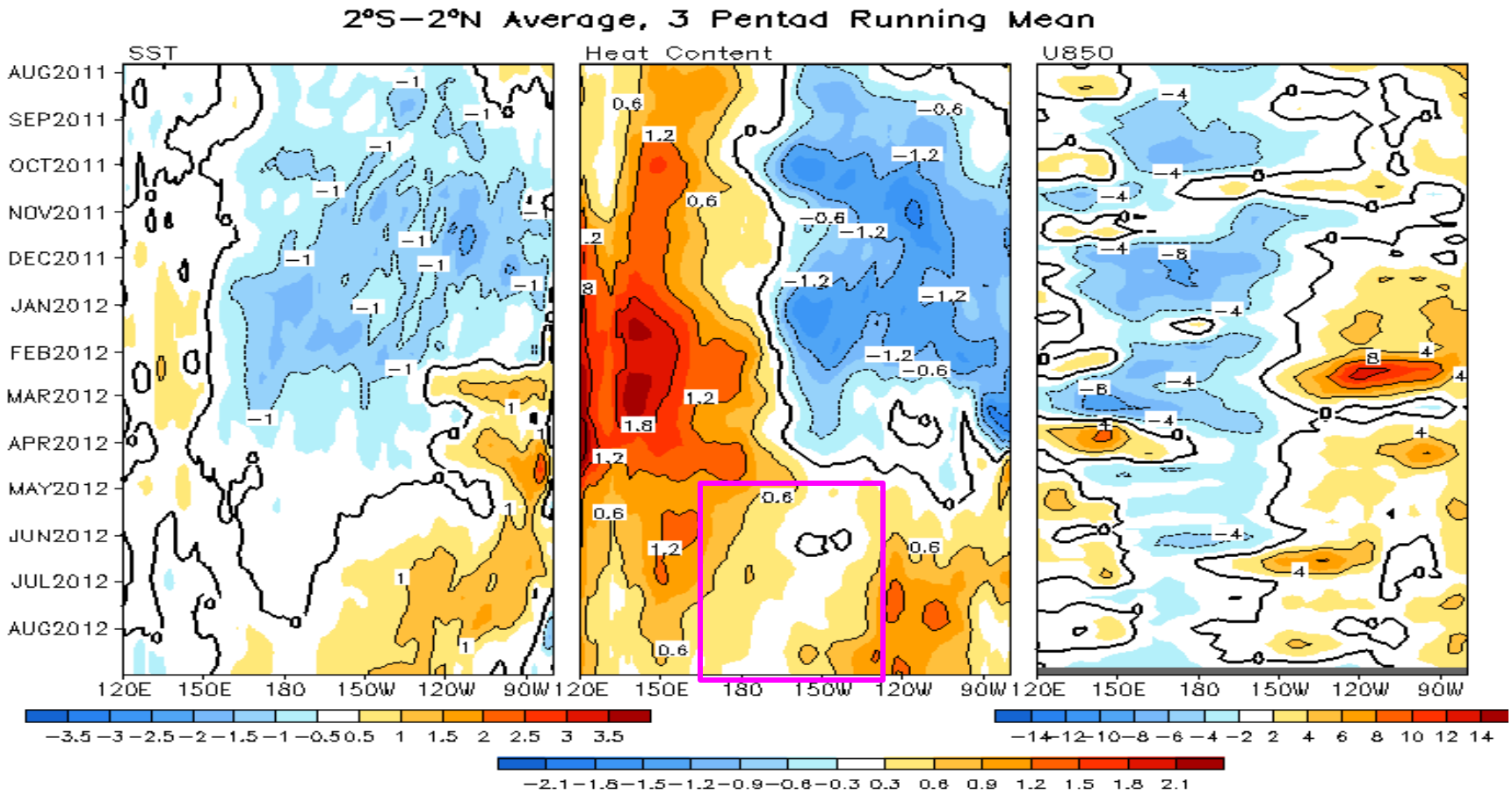
- Nino 3.4 and Nino 4 indices further increased in Aug, with Nino 3.4 index = 0.7°C .

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

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

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

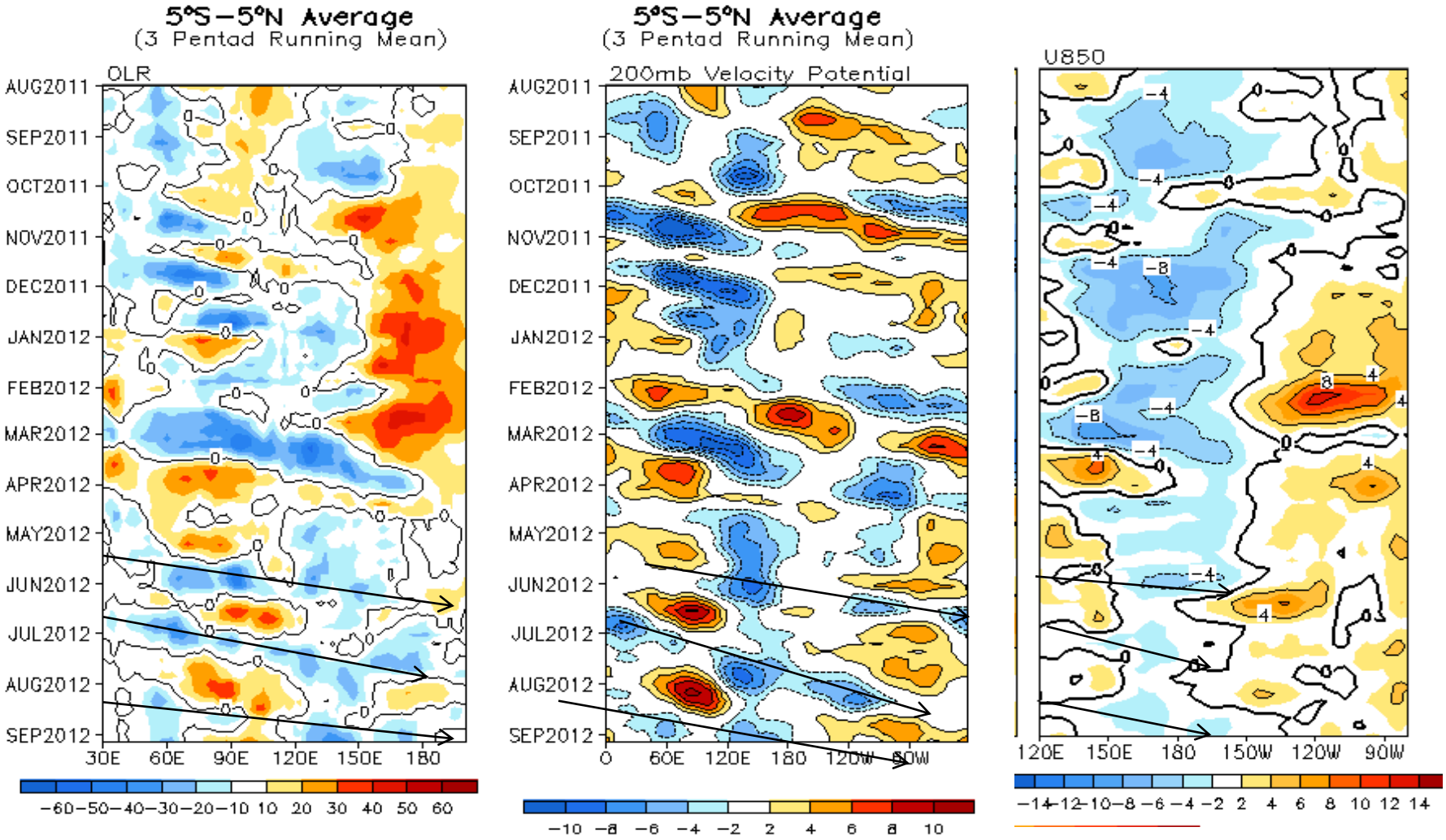
Equatorial Pacific SST (ºC), HC300 (ºC), u850 (m/s) Anomalies



- **Positive SSTA developed in the E. Pacific since Feb 2012 and gradually extended to the W. equatorial Pacific Ocean.**
- **Westerly wind anomalies in the eastern equatorial Pacific weakened in the late August.**
- **HC300 anomalies in the central equatorial Pacific experienced near-average condition since May 2012.**

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.

Equatorial Pacific OLR, 200mb Velocity Potential and U850 Anomalies



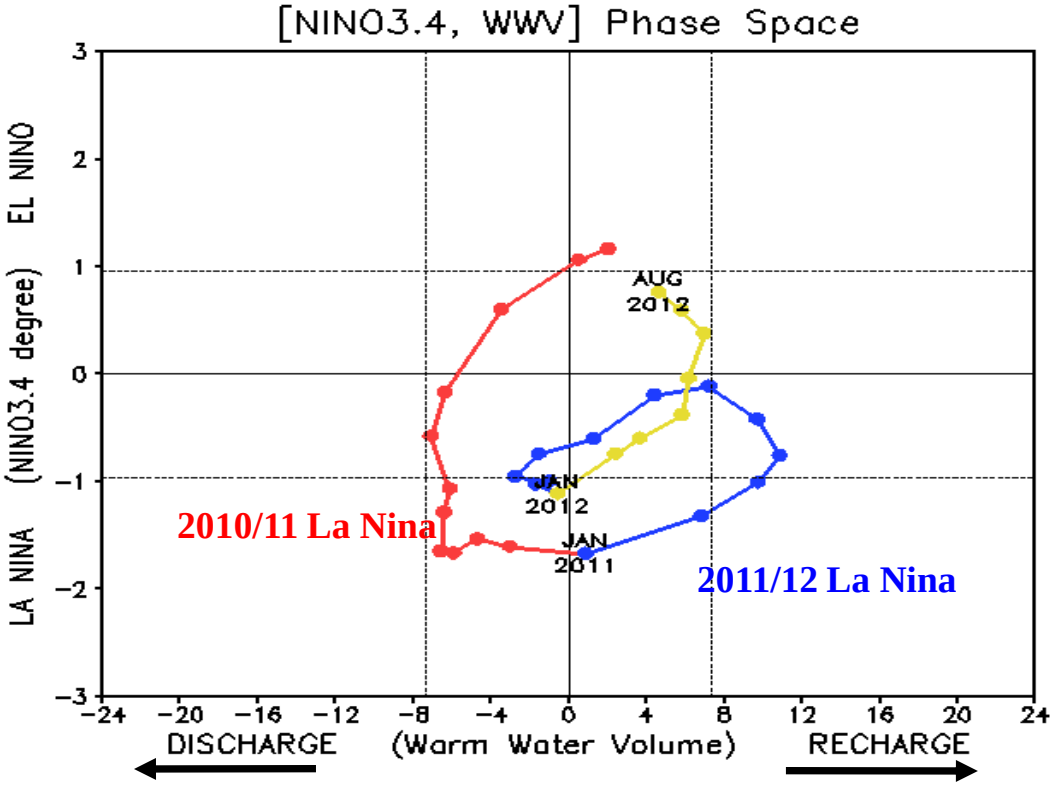
- **Eastward propagation associated with MJO was observed from late May into September , modulating low-level wind anomalies at the western-central equatorial Pacific ocean.**

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).

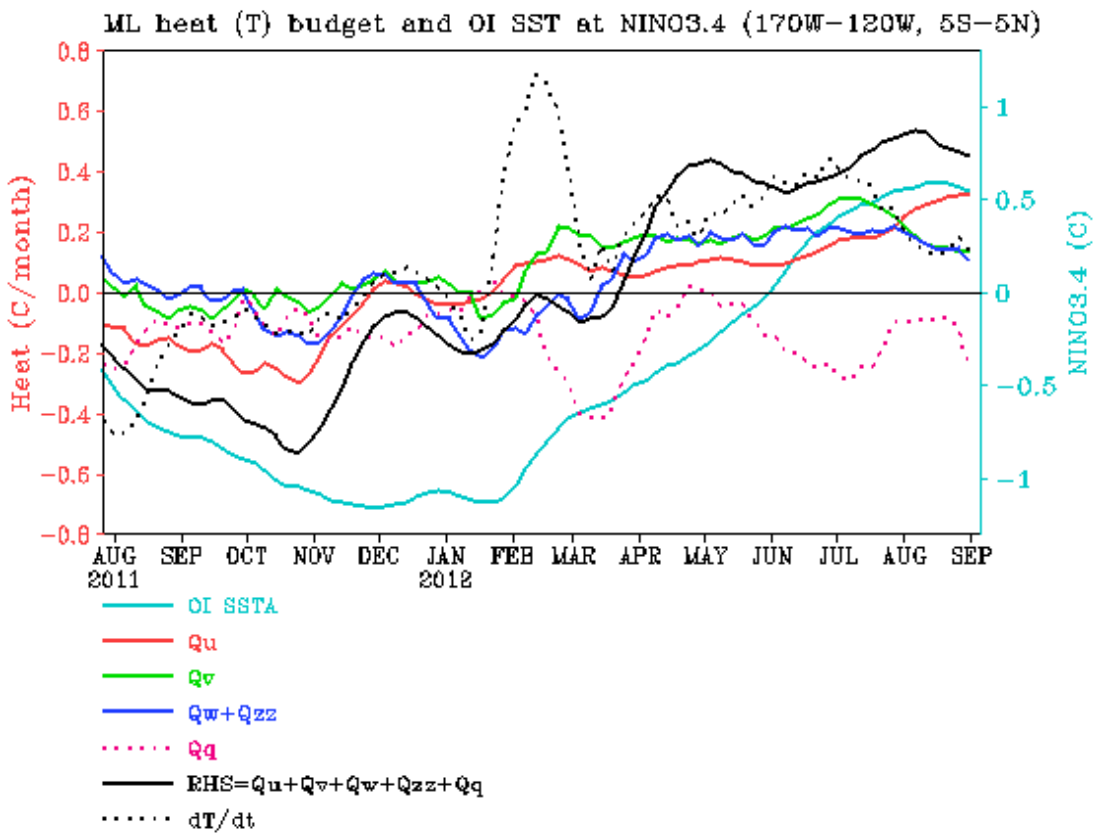
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



- Positive Nino 3.4 further increased in August, while above–normal WWV decreased since July.

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.

NINO3.4 Heat Budget



- **SSTA tendency (dT/dt) in NINO3.4 region (dotted line) was positive since mid-Jan 2012.**

- **All dynamical terms (Qu, Qv, Qw+Qzz) were positive since Mar 2012, contributing to the warming tendency.**

- **Large discrepancy between the total heat budget term (RHS) and the observed tendency (dT/dt) was observed in Aug 2012.**

Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

Qu: Zonal advection; Qv: Meridional advection;

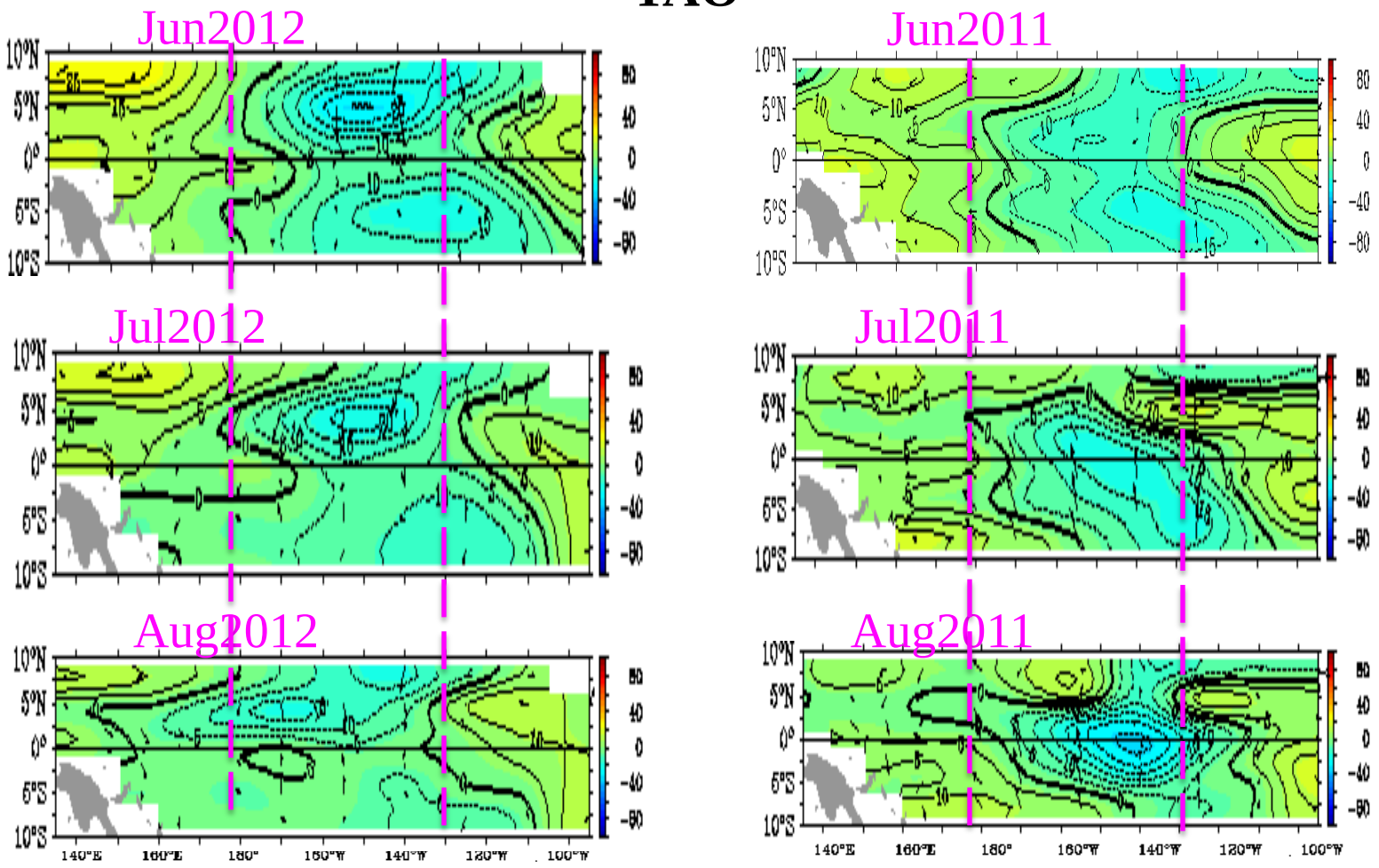
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

Recent Evolution of Depth of 20C Isotherm Anomaly (m)

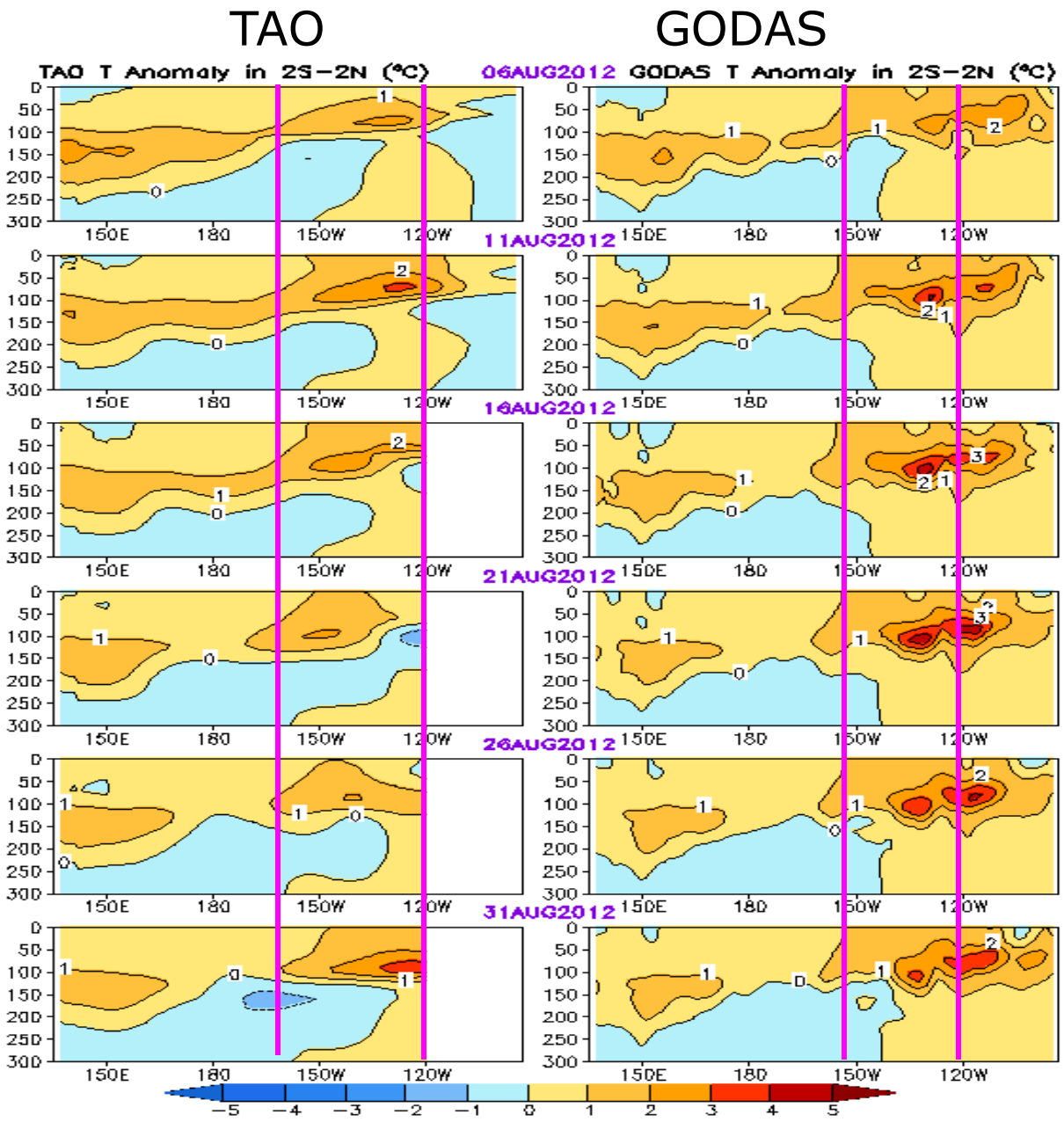
TAO



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

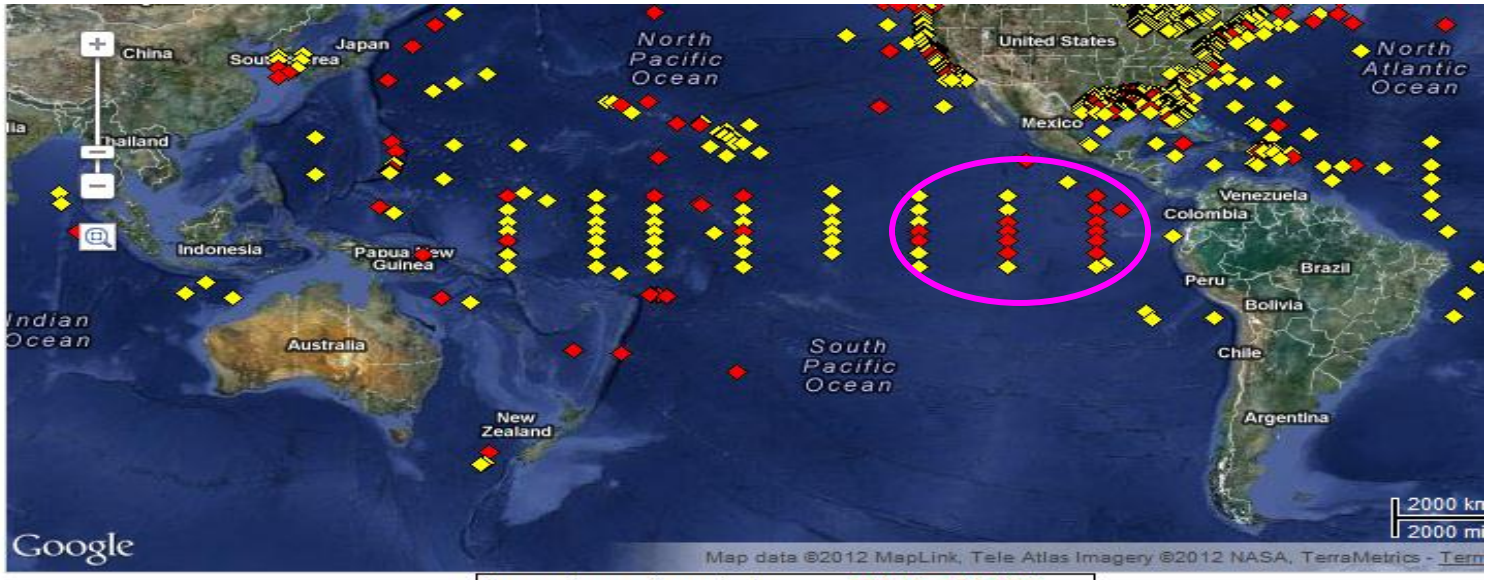
- **Negative d20 anomaly dominated in the central tropical Pacific Ocean since May 2012.**
- **Negative D20 patterns in the central tropical Pacific weakened in August 2012, which may be associated with the recent MJO activities.**

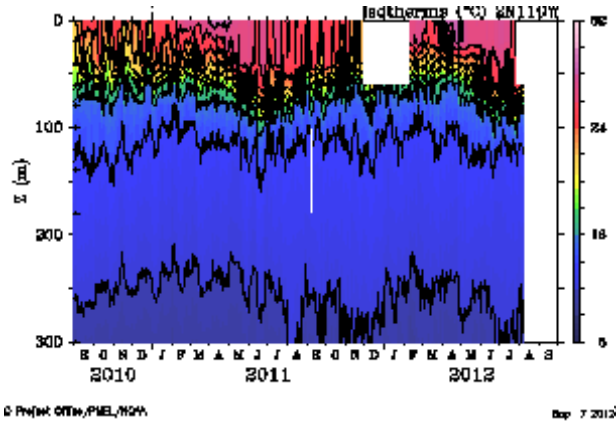
Equatorial Pacific Temperature Anomaly



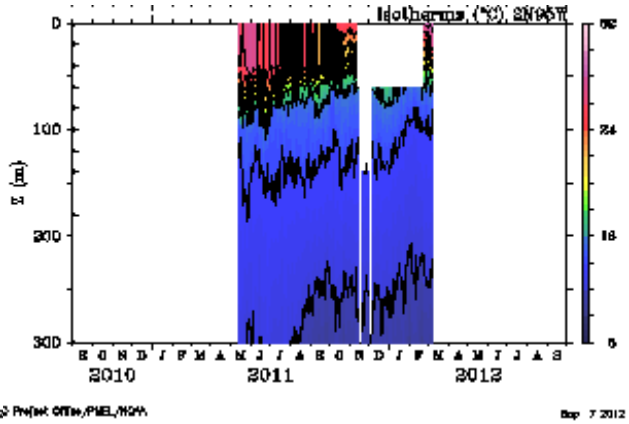
- **Warm temperature anomalies near the central thermocline decreased in late August.**
- **Compared to TAO, GODAS was too warm at 100-250m depth between 160W-120W.**

Some TAO moorings have failed to delivery data in the past few months

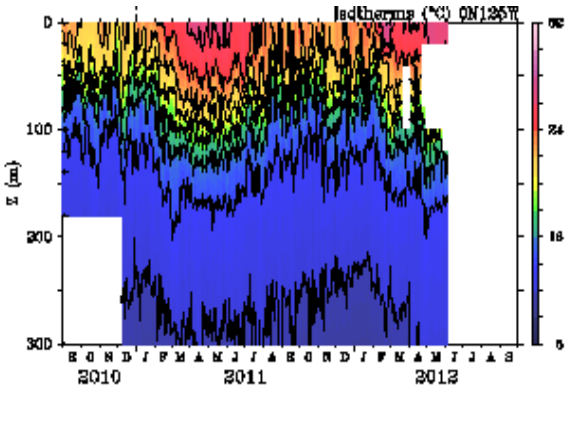




(2ºN, 110ºW)



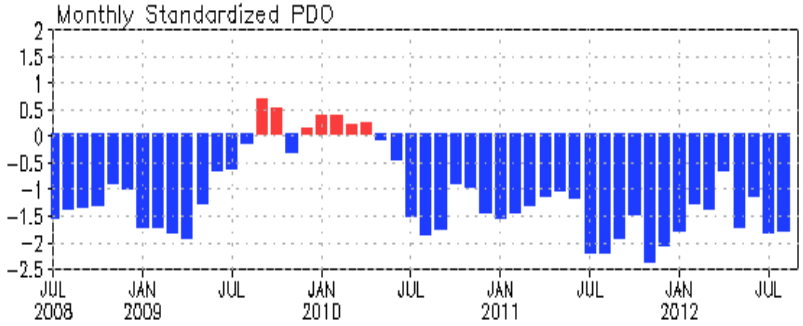
(2ºN, 95ºW)

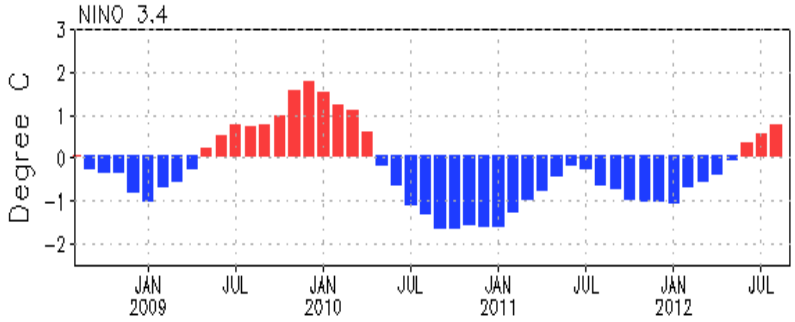


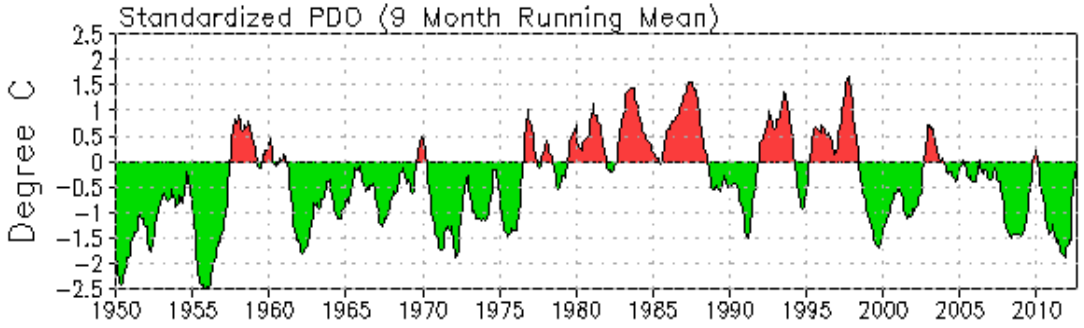
(0ºN, 125ºW)

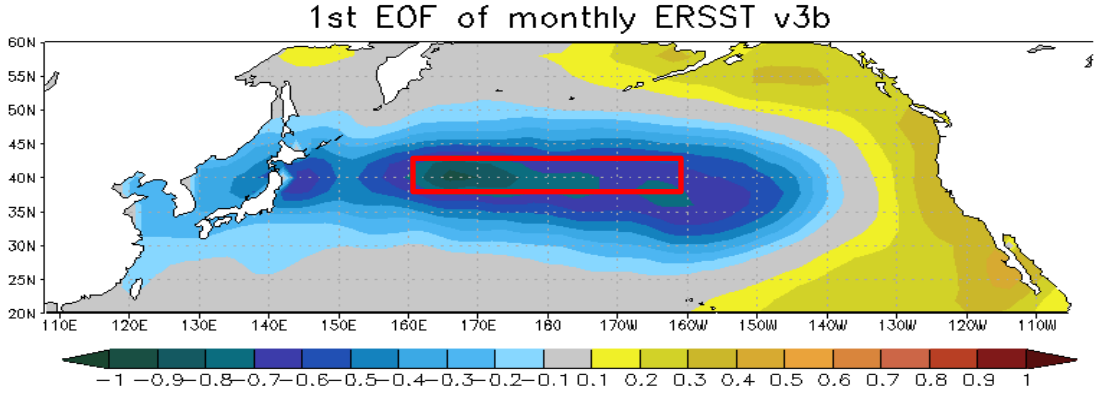
North Pacific & Arctic Oceans

PDO index









- Negative PDO phase since May 2010 has persisted for 28 months now, and the large PDO index continued in Aug 2012 with PDO index = -1.8

- The apparent connection between NINO3.4 and PDO index suggest connections between tropics and extratropics.

- However, the strengthening of negative phase of PDO in Aug 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.

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

- PDO-like pattern presented in the North Pacific.
- Positive SSTA in the Artic ocean further strengthened in August.
- Large positive SW+LW anomalies were observed in the Artic ocean and the western North Pacific, leading to significant warming in these regions.

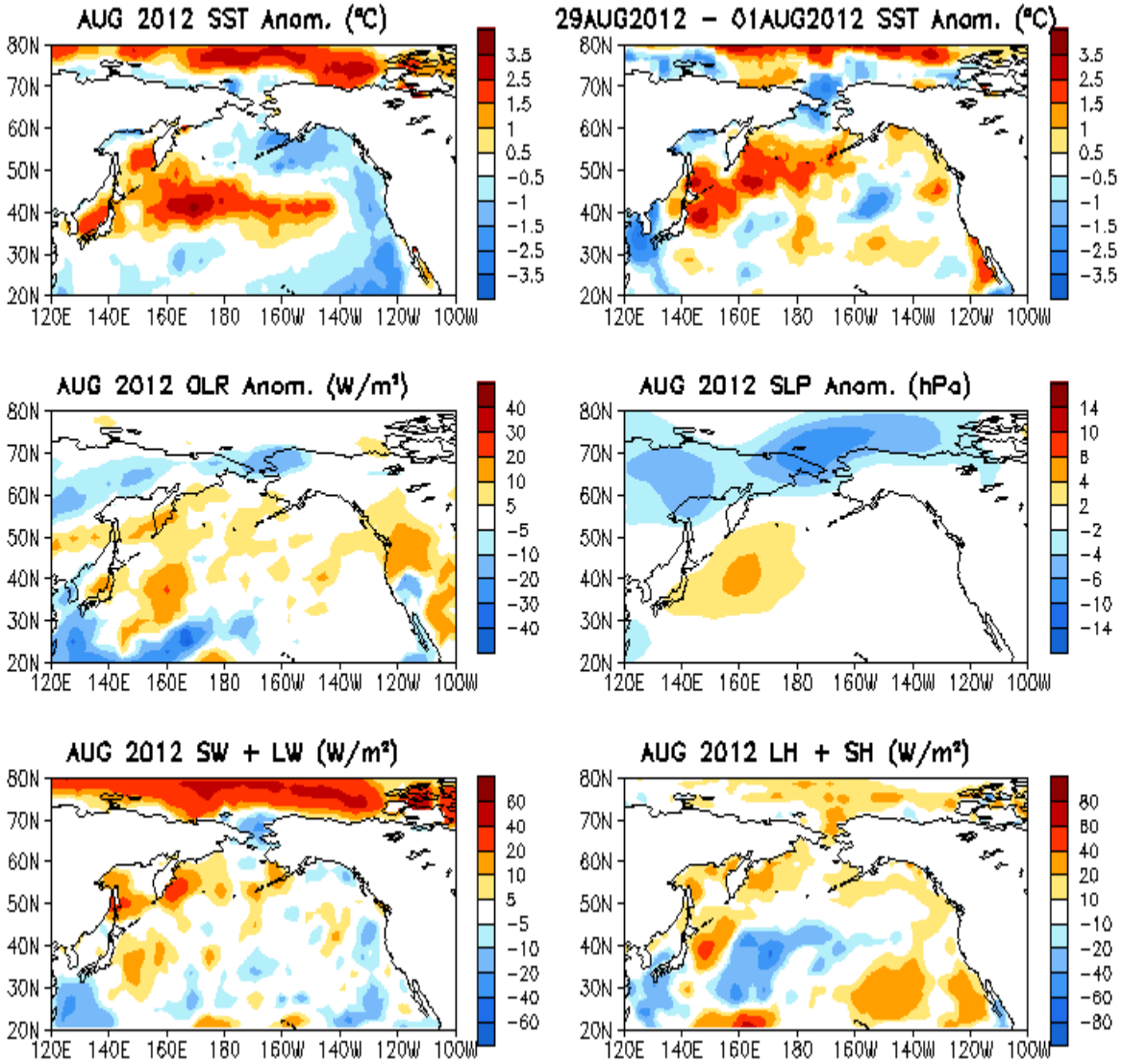
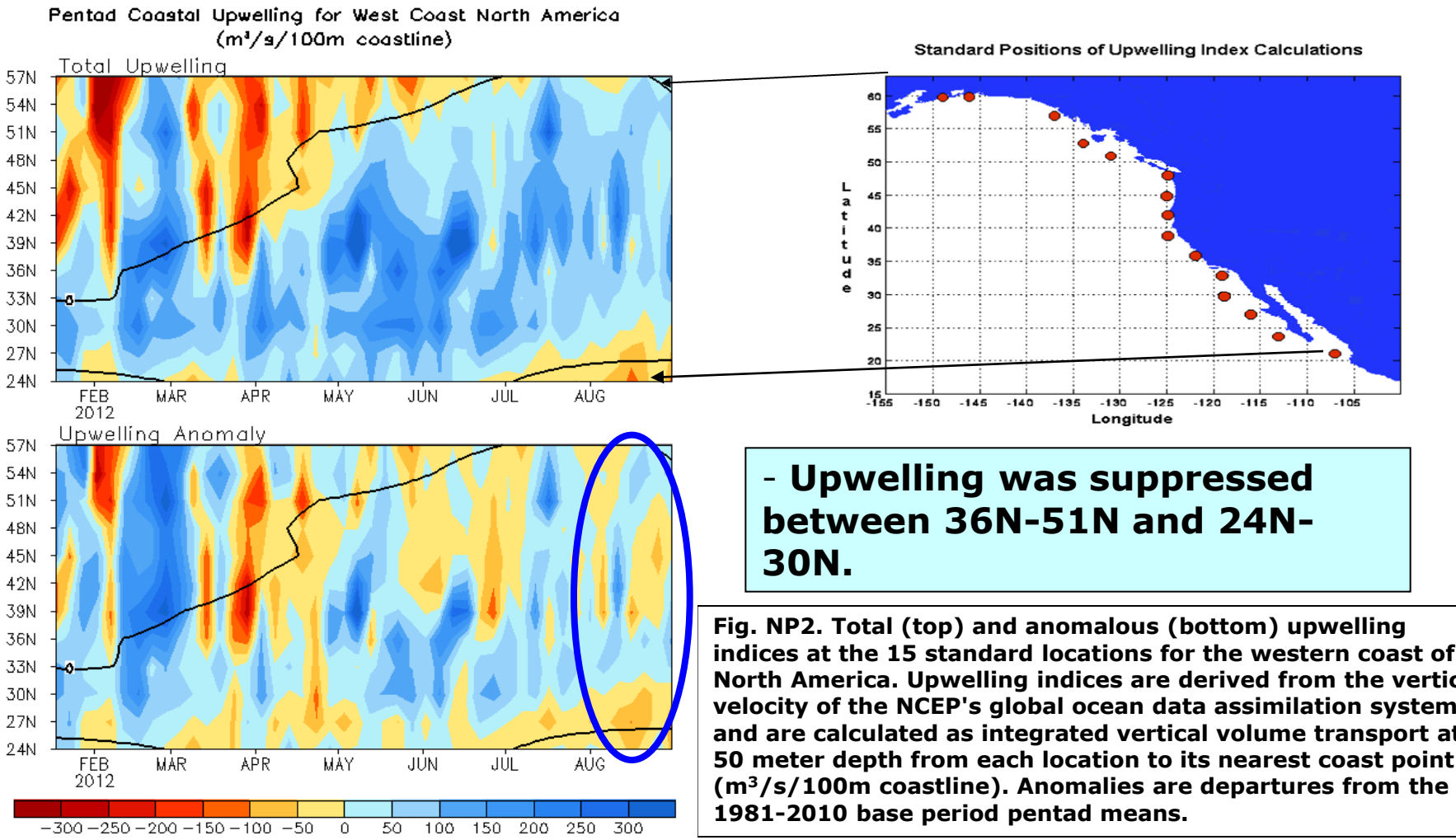


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

North America Western Coastal Upwelling



- Upwelling was suppressed between 36N-51N and 24N-30N.

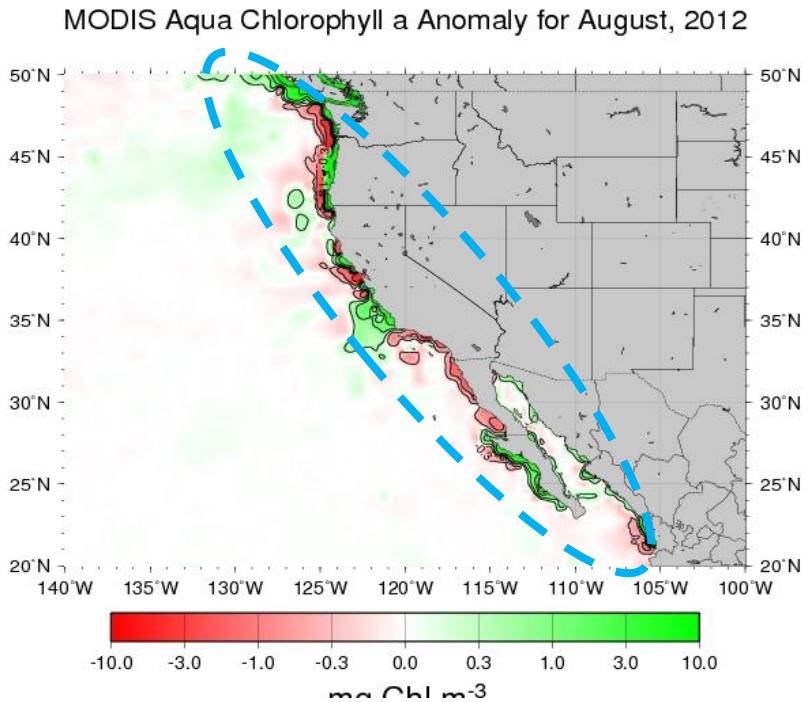
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

- Area below (above) black line indicates climatological upwelling (downwelling) season.

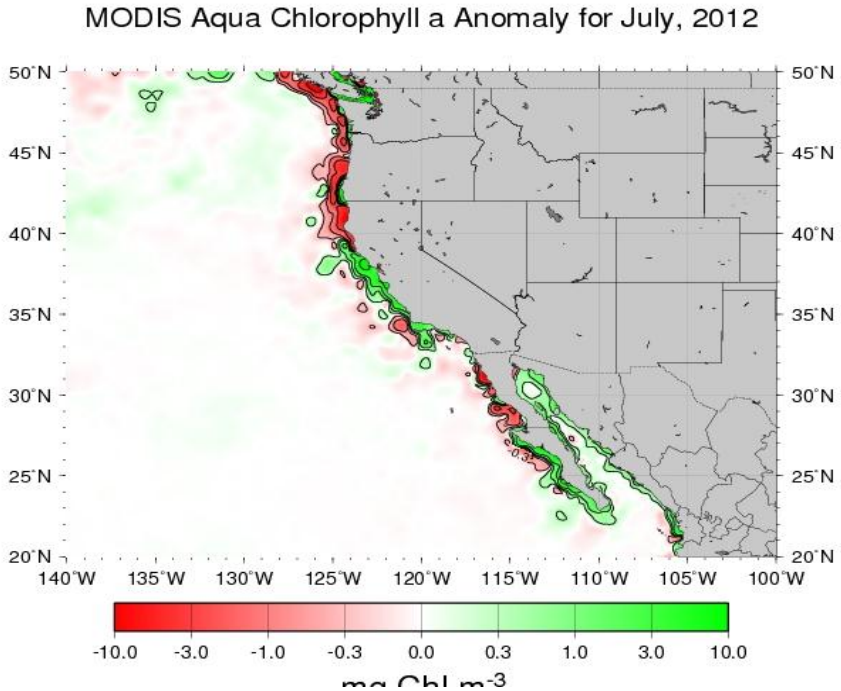
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

Monthly Chlorophyll Anomaly

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

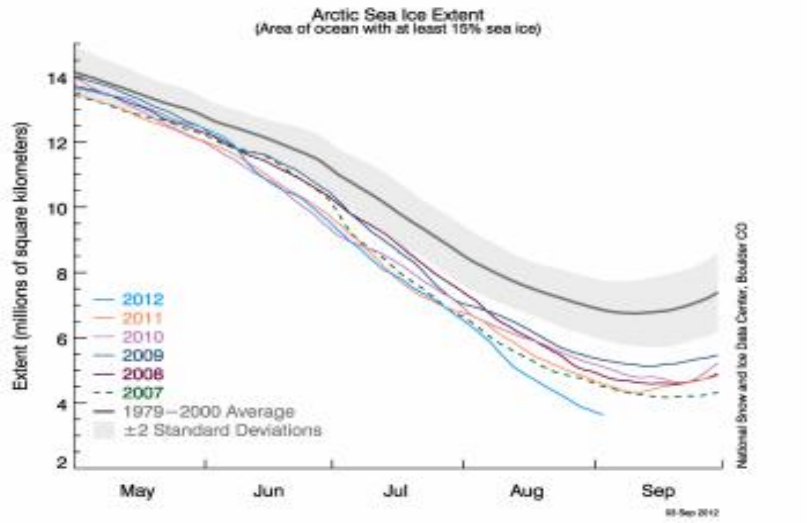


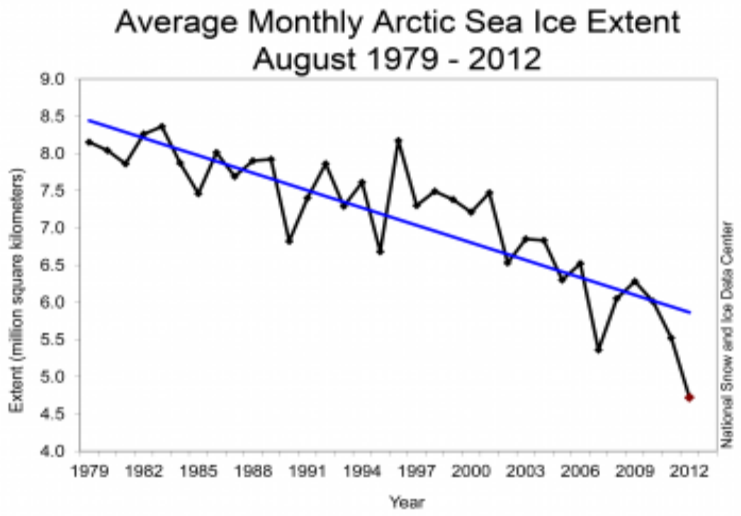
- **Negative Chlorophyll anomaly along the coast was consistent with the weakened upwelling .**

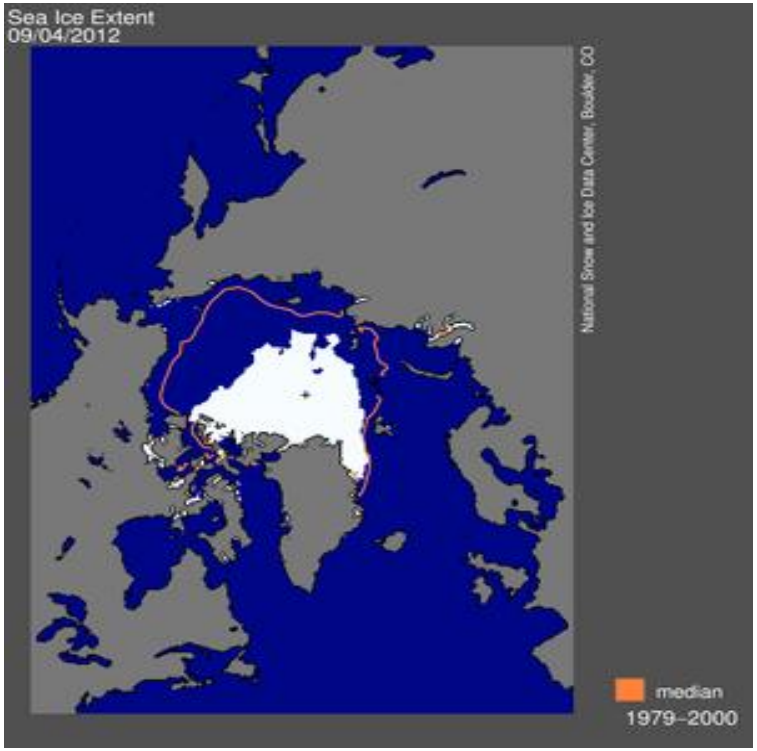


Arctic Sea Ice

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



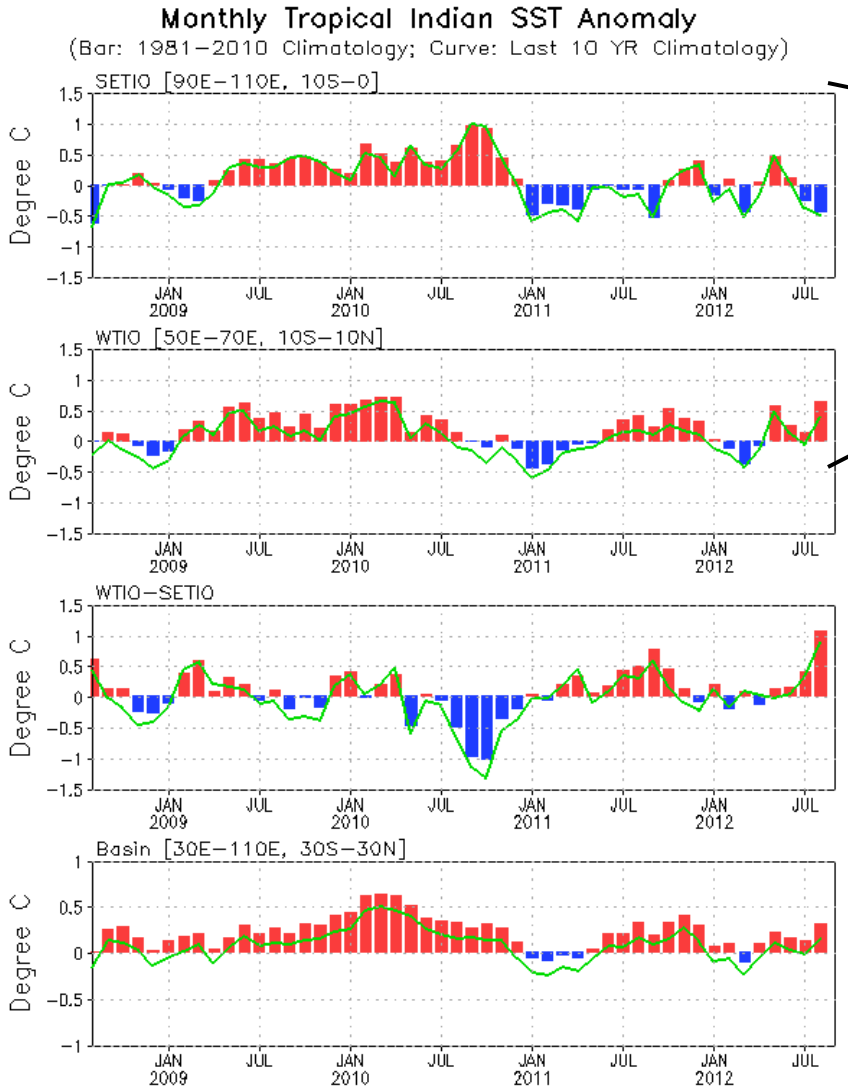


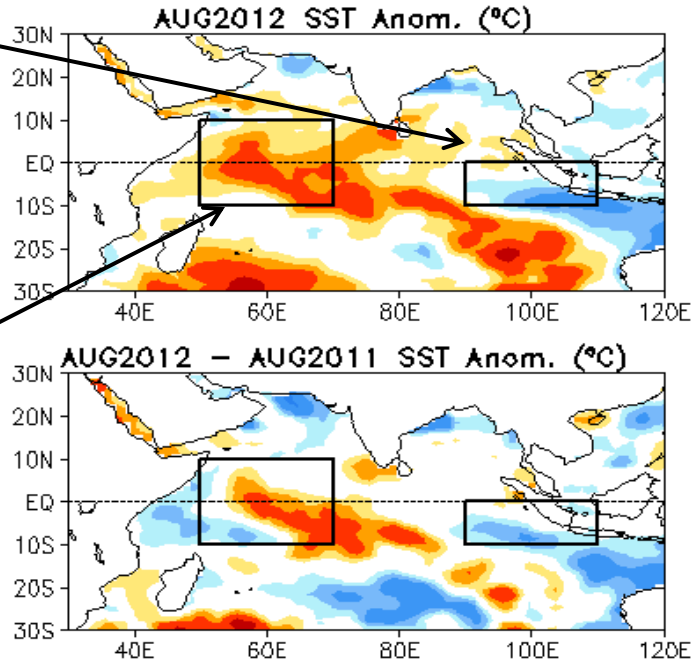


- **The Arctic sea ice extent in August 2012 reached the historical low in the satellite record.**

Indian Ocean

Evolution of Indian Ocean SST Indices





-Warm (cold) temperature anomalies in the western (eastern) tropical Indian Ocean strengthened in Aug 2012.

- DMI was near 1.2° C in Aug.

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

- Convection was enhanced (suppressed) in the western (eastern) of the tropical Indian Ocean.

- Southerly wind anomalies blew towards the India island.

- SSTA tendency was largely consistent with surface heat flux anomalies.

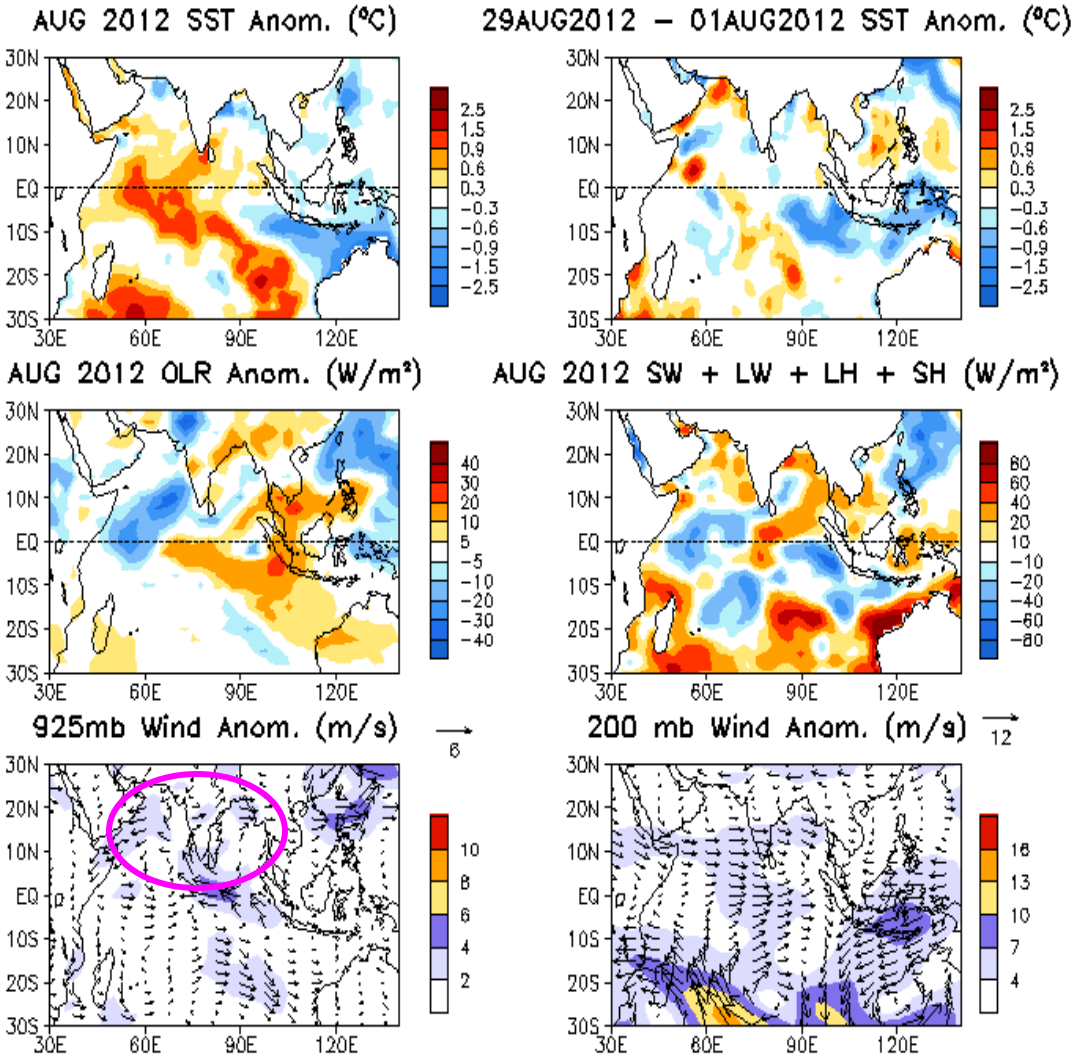
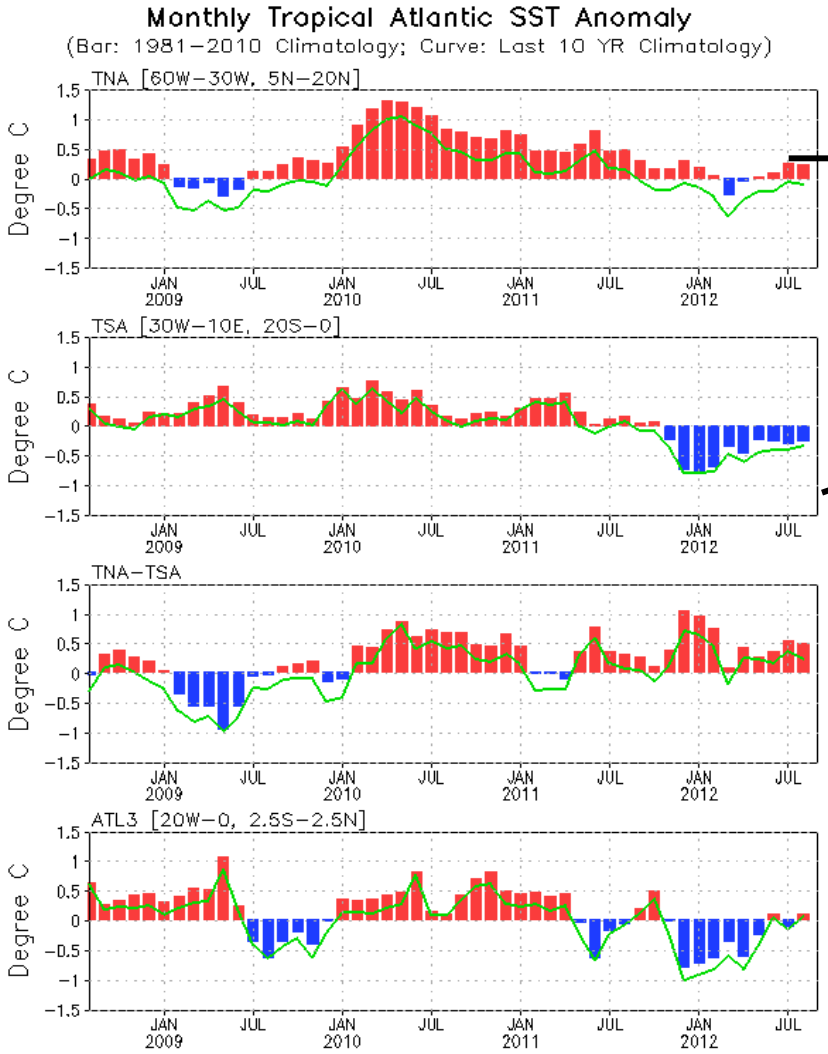
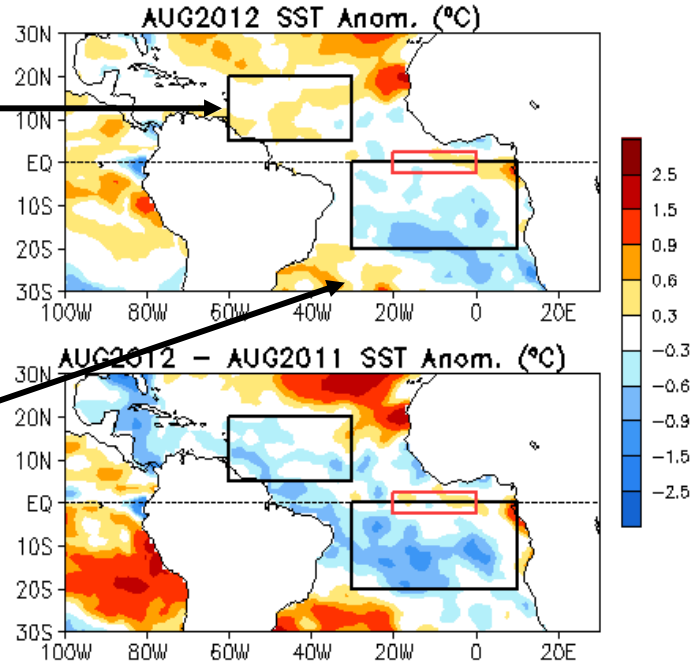


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices





- **SSTA in the tropical North Atlantic (TNA) and the tropical South Atlantic (TSA) were near-normal in August.**

- **Meridional Gradient Mode index (TNA-TSA) continued to be above-average in August 2012.**

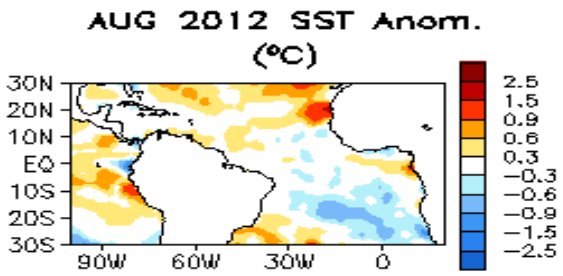
- **ATL3 SSTA was near-normal since June.**

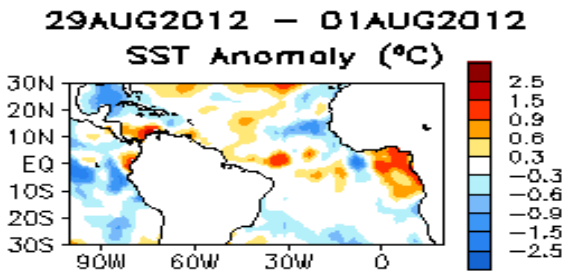
- **Tropical Atlantic in August was cooler in 2012 than in 2011, except for eastern equatorial region.**

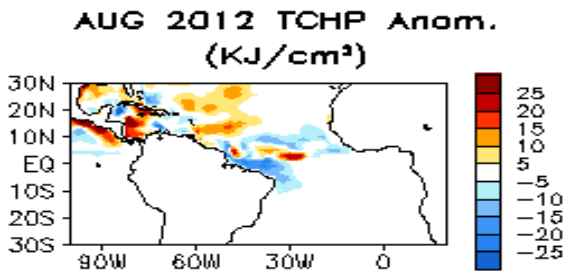
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between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

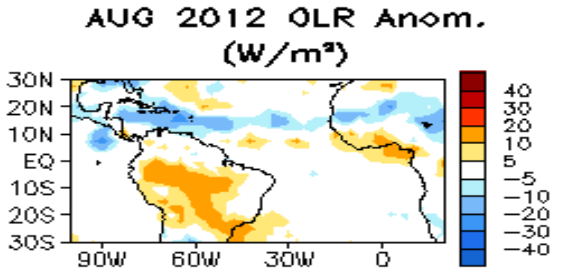
Tropical Atlantic:

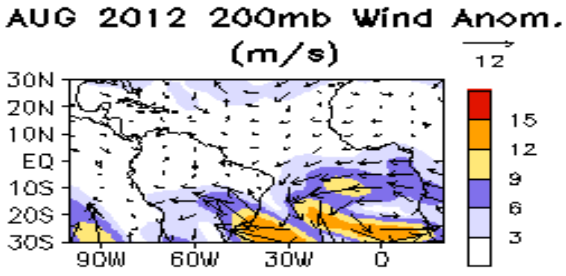
SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb/200-mb Winds

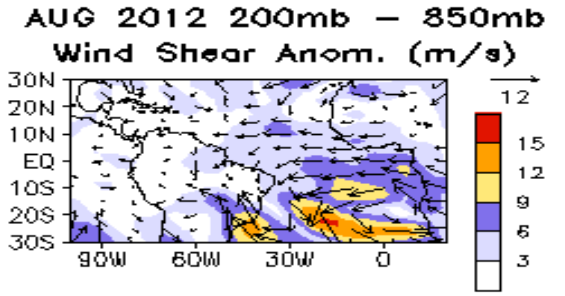


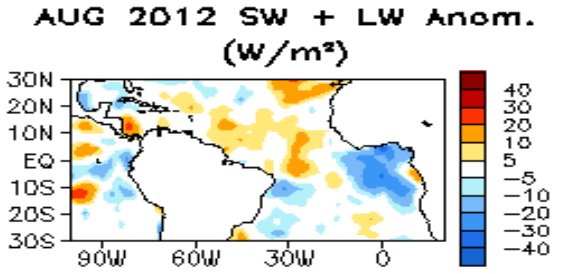


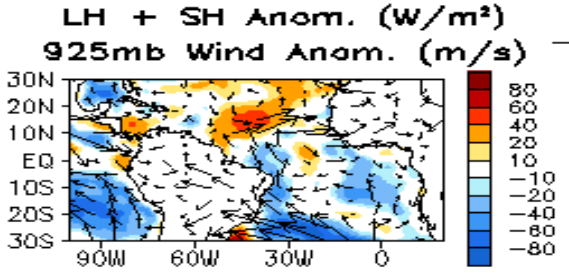


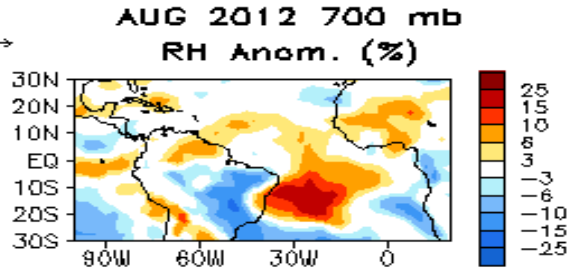












- **Above-normal SSTA continued in the hurricane Main Development Region(MDR) .**
- **Convection enhanced near the Caribbean Sea.**
- **Westerly Low-level wind blew towards the western Africa, indicating the enhanced west African Monsoon.**

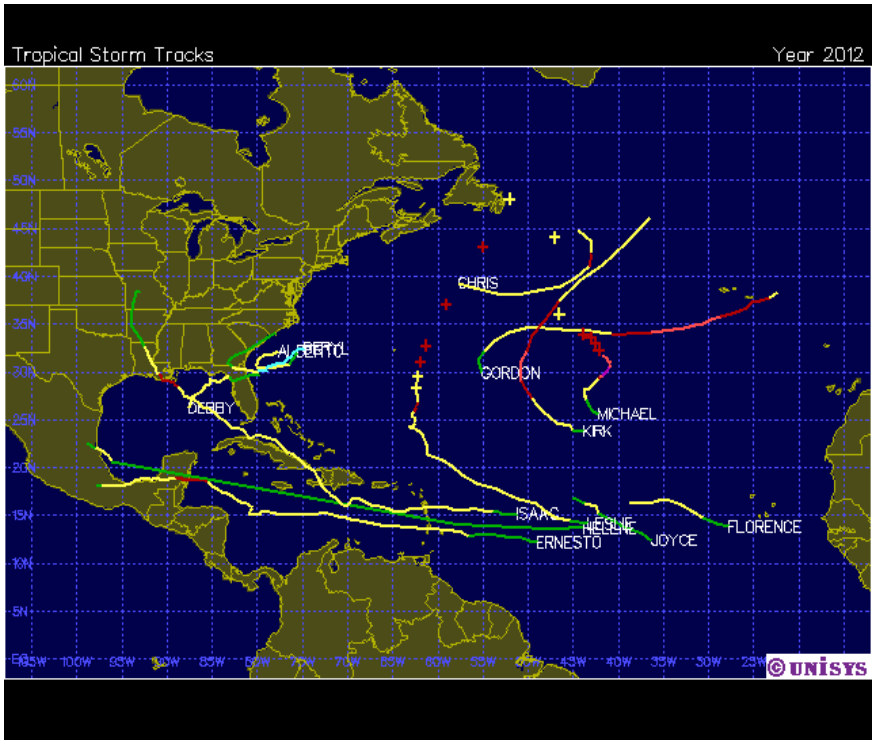
NOAA Predict a near-Normal Atlantic Hurricane Season in 2012

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml
http://weather.unisys.com/hurricane/atlantic/2012/index.php)

NOAA 2012 Atlantic Hurricane Season Outlooks

Activity Type	August Update	May 19 Outlook	NHC 1981-2010 Normals
Chance Above Normal	35%	25%	
Chance Near Normal	50%	50%	
Chance Below Normal	15%	25%	
Named Storms*	12-17	9-15	12
Hurricanes*	5-8	4-8	6
Major Hurricanes	2-3	1-3	3
ACE (% Median)	75-135	65-140	71-111**

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%-111% of the median.



- **NOAA 2012 Hurricane seasonal outlook issued in August called for high likelihood of near- or above-normal Hurricane activities in 2012.**

-6 tropical storms and 7 hurricane were formed in the North Atlantic by Sep 08.

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

- **Large SSTA continued in the high-latitudes of North Atlantic Ocean.**

- **SST tendency was roughly consistent with surface heat flux anomalies.**

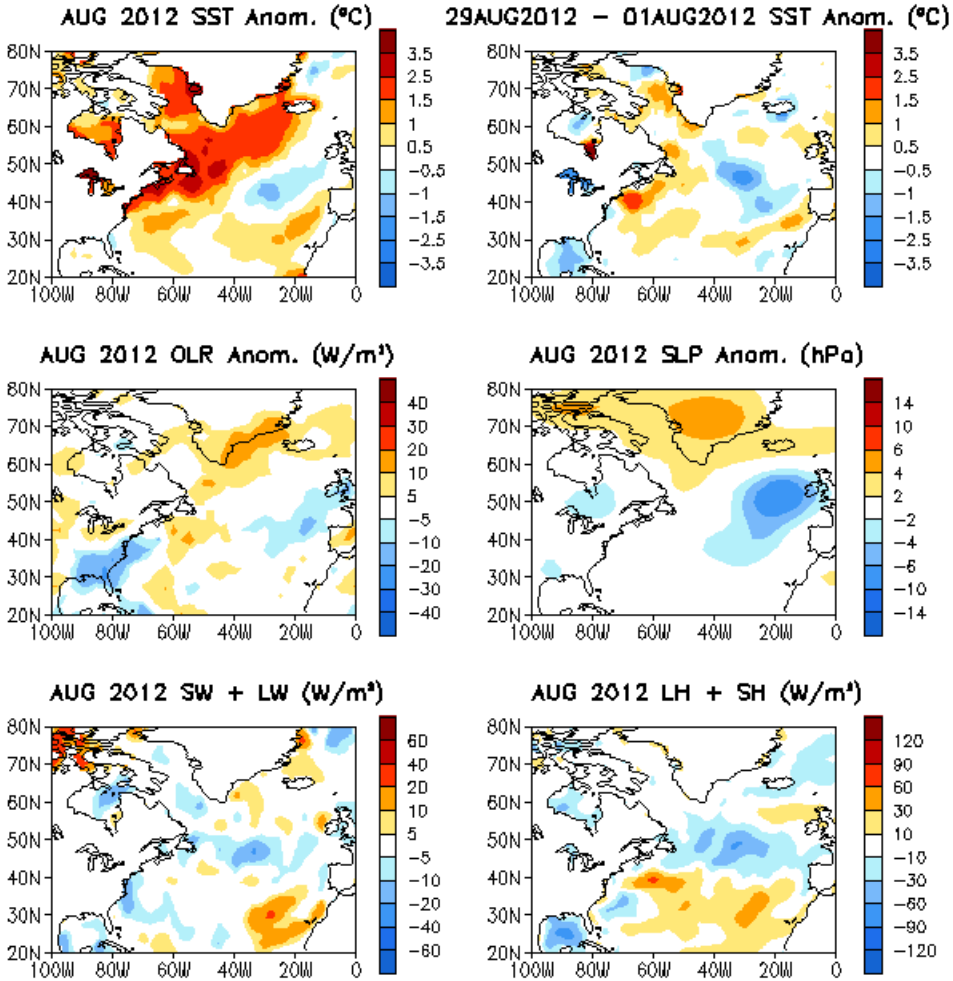
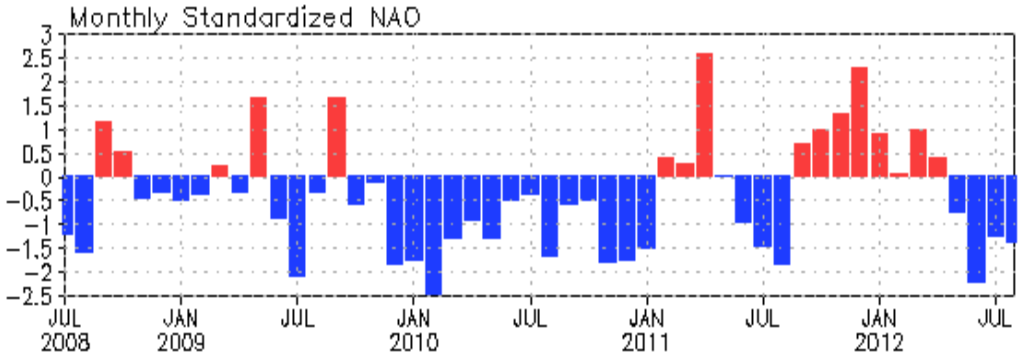
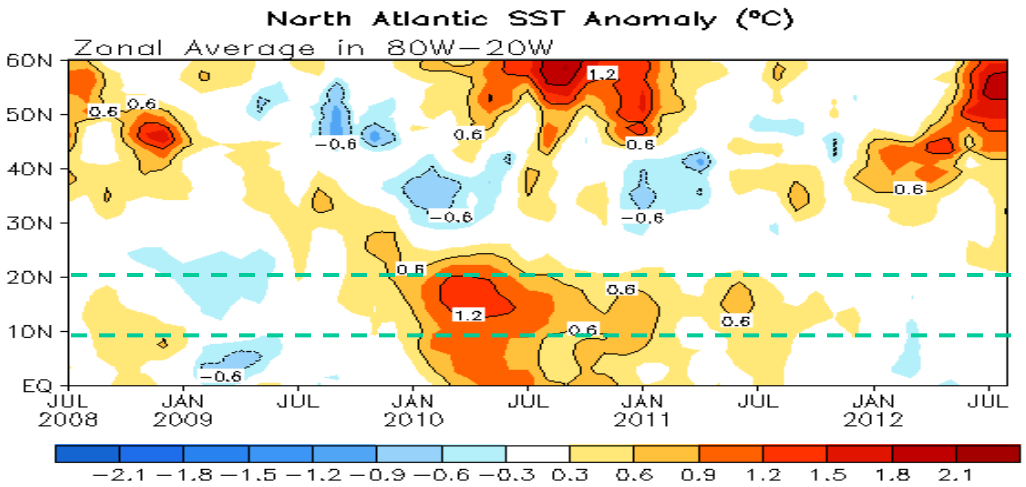
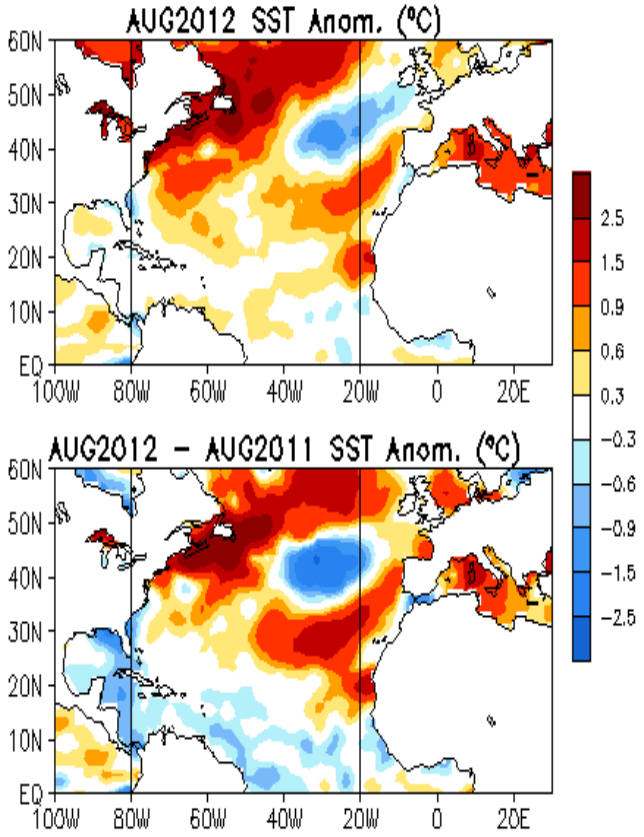


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

NAO and SST Anomaly in North Atlantic







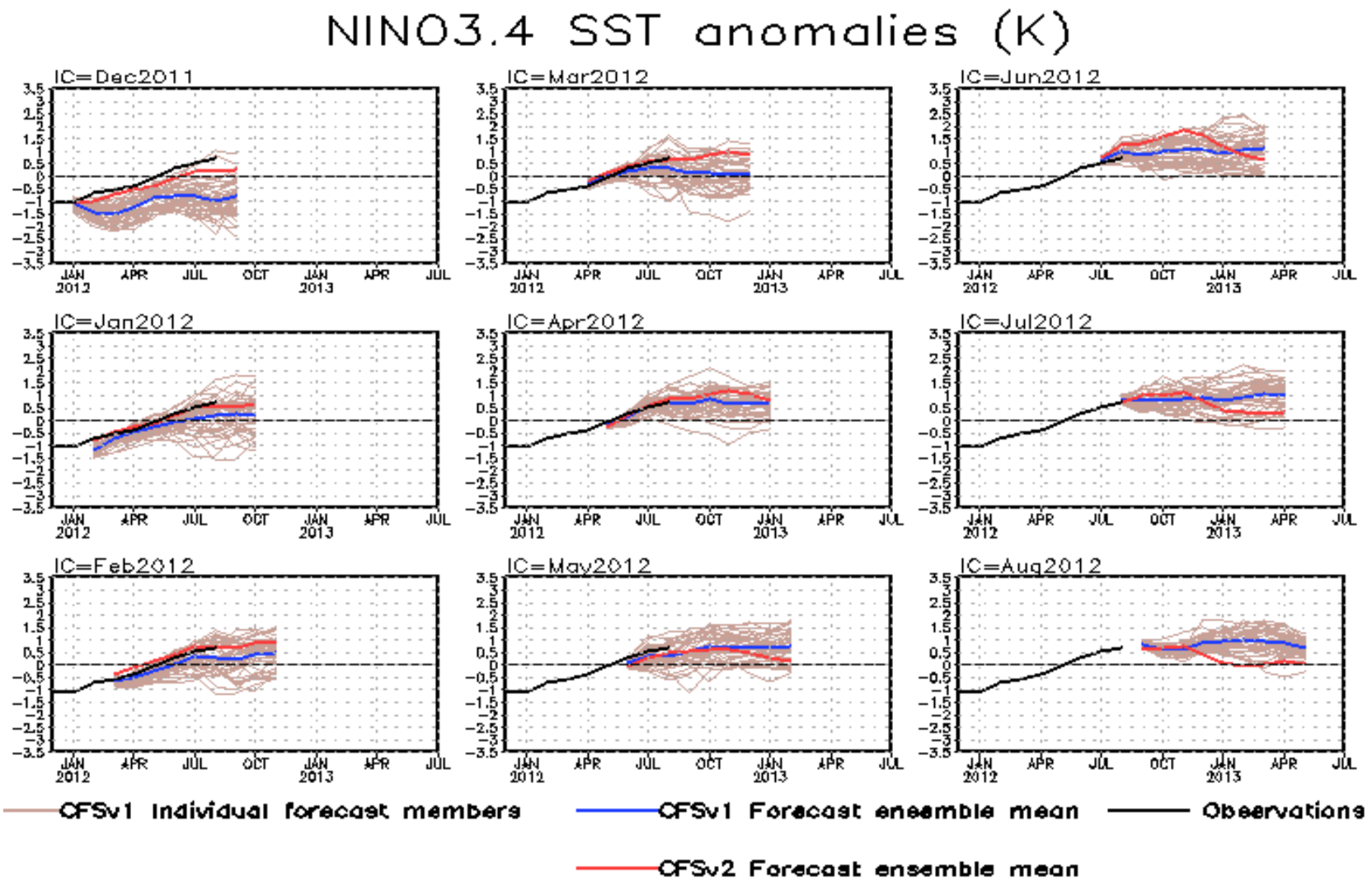
- **High-latitude North Atlantic SSTA are closely related to NAO index (negative NAO leads to SST warming and positive NAO leads to SST cooling).**

-**Large negative NAO index persisted over four months, contributing to the strong warming in the high-latitude N. Atlantic.**

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

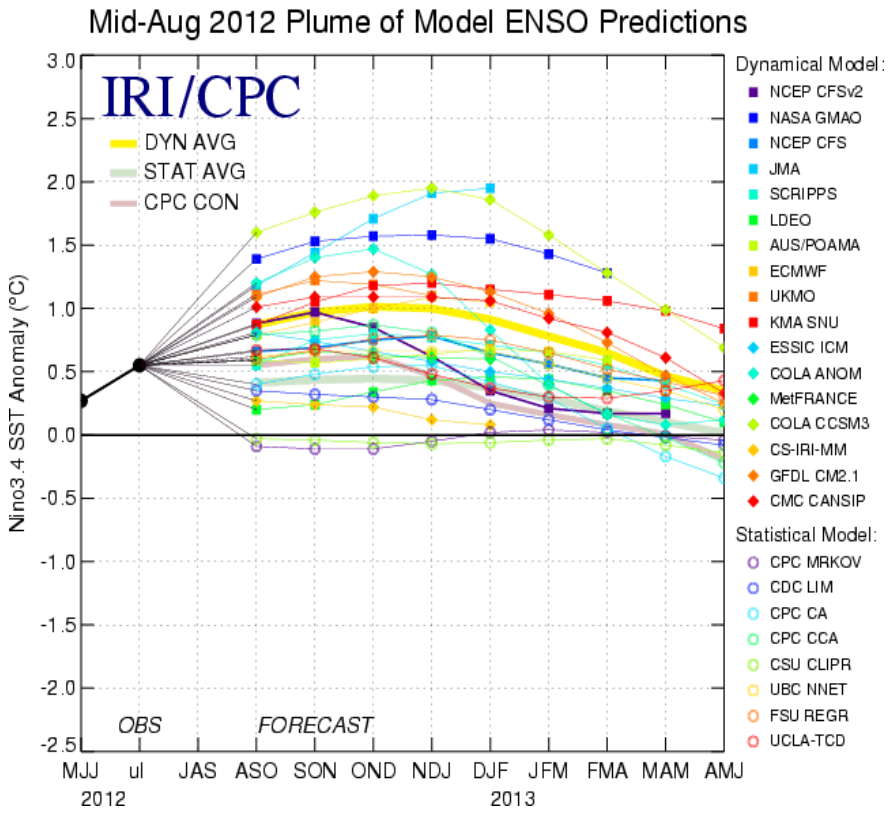
Global SST Predictions

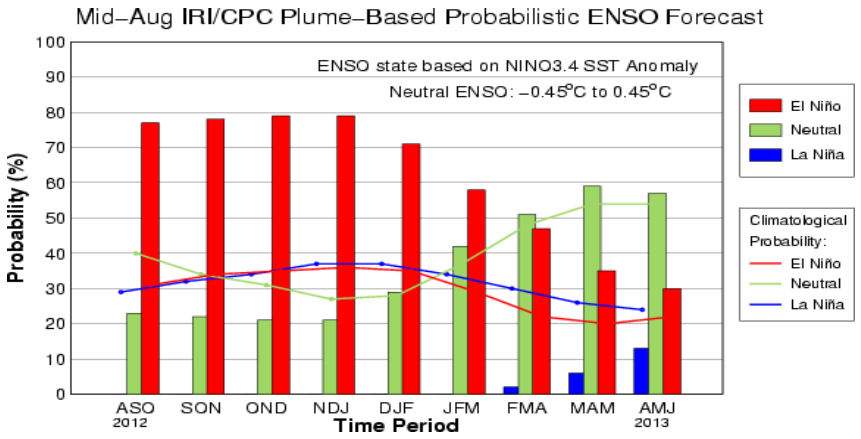
NCEP CFSv1 and CFSv2 NINO3.4 Forecast

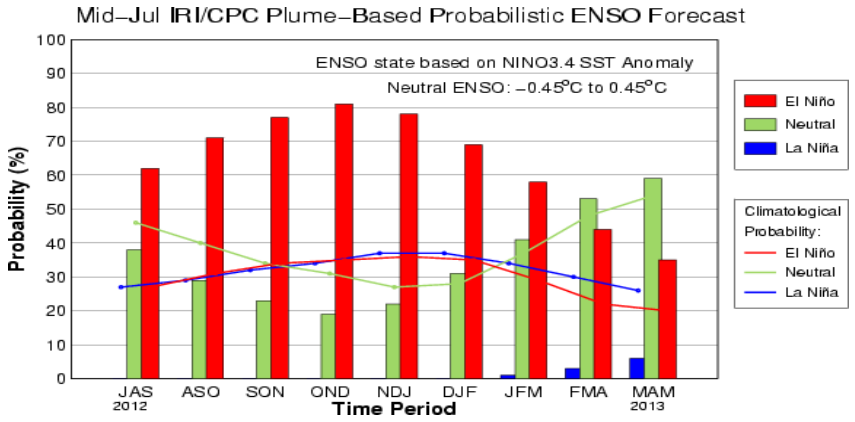


- **The latest CFSv1 forecasts an moderate El Nino development during September, persisting through the boreal winter 2012/2013.**
- **The latest CFSv2 predicts a weak El Nino event during Sep-Nov and decay to neutral condition through Dec-Feb 2012-2013.**

IRI NINO3.4 Forecast Plum

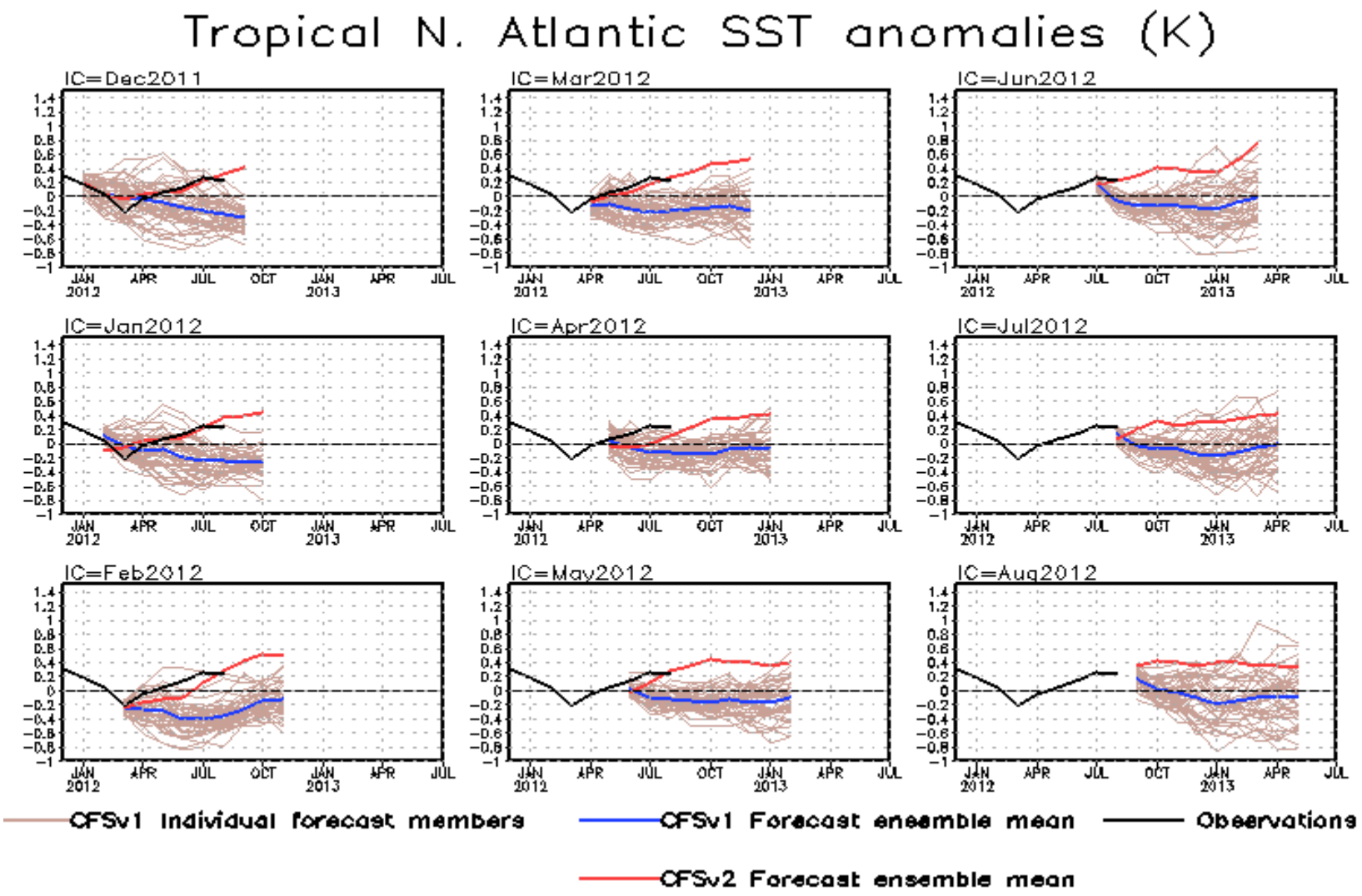






- **A majority of dynamical models predicted an moderate El Nino would develop in the coming seasons.**
- **One-half statistical models predict the onset of weak El Nino beginning Aug-Oct.**
- **NOAA "ENSO Diagnostic Discussion" in September suggests a weak El nino will most likely develop during Sep 2012 and persistent through Dec-Feb 2012-13.**

NCEP CFSv1 and CFSv2 Tropical North Atlantic SST Forecast



CFSv1 predicted near-normal SST in the tropical N. Atlantic while CFSv2 predicted above-normal through the remainder of the year.

Overview

- **Pacific and Arctic Oceans**

- **ENSO-neutral conditions continued during August 2012.**
- **NOAA "ENSO Diagnostic Discussion" in September 2012 suggests an El Nino most likely develops during August-October, and persists through December-February 2012/2013.**
- **Negative PDO phase continued in August 2012, with PDO=-1.8, and has last for 28 months since May 2010.**
- **Arctic sea ice extent reached the historical low in the satellite record.**

- **Indian Ocean**

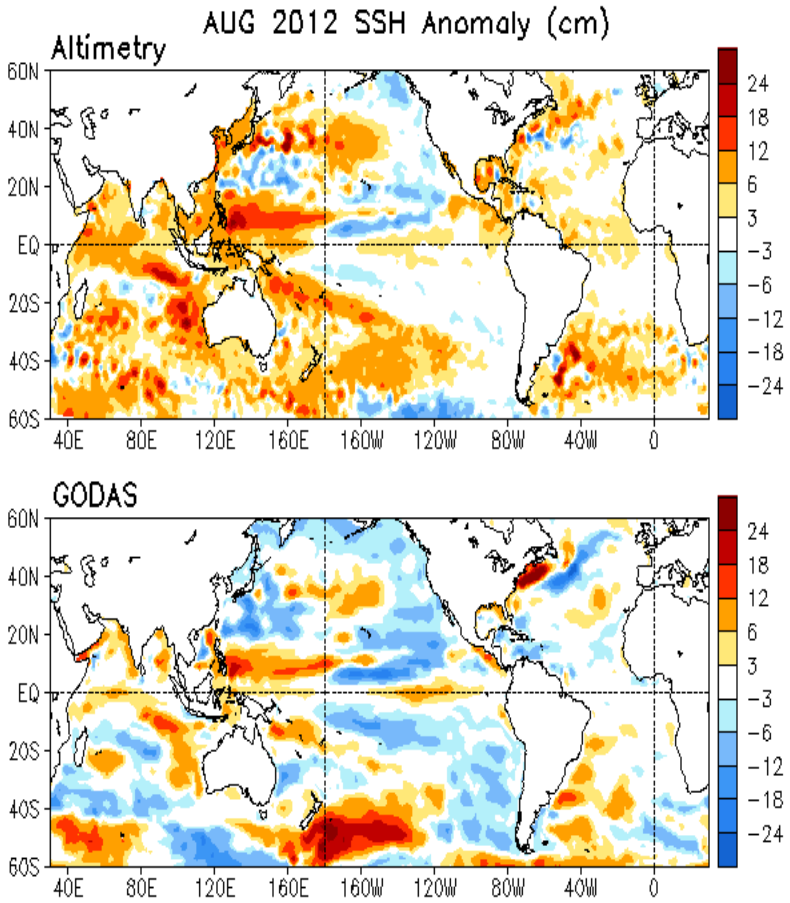
- **Above-normal Indian Ocean Dipole condition emerged in Aug 2012, with DMI = 1.2^{o} C.**

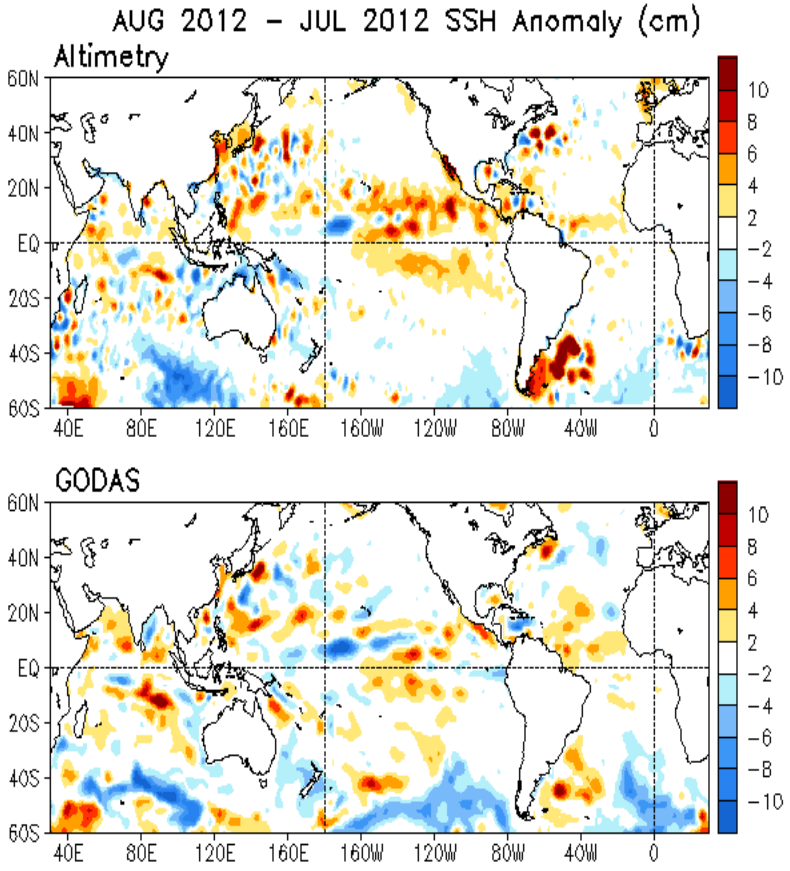
- **Atlantic Ocean**

- **Weak above-normal SSTA presented in the hurricane Main Development Region(MDR).**
- **NOAA predicted a high likelihood of near- or above-normal hurricane season in 2012.**
- **Negative NAO index persisted in the past four months, contributing to a strong warming in the high-latitude N. Atlantic.**

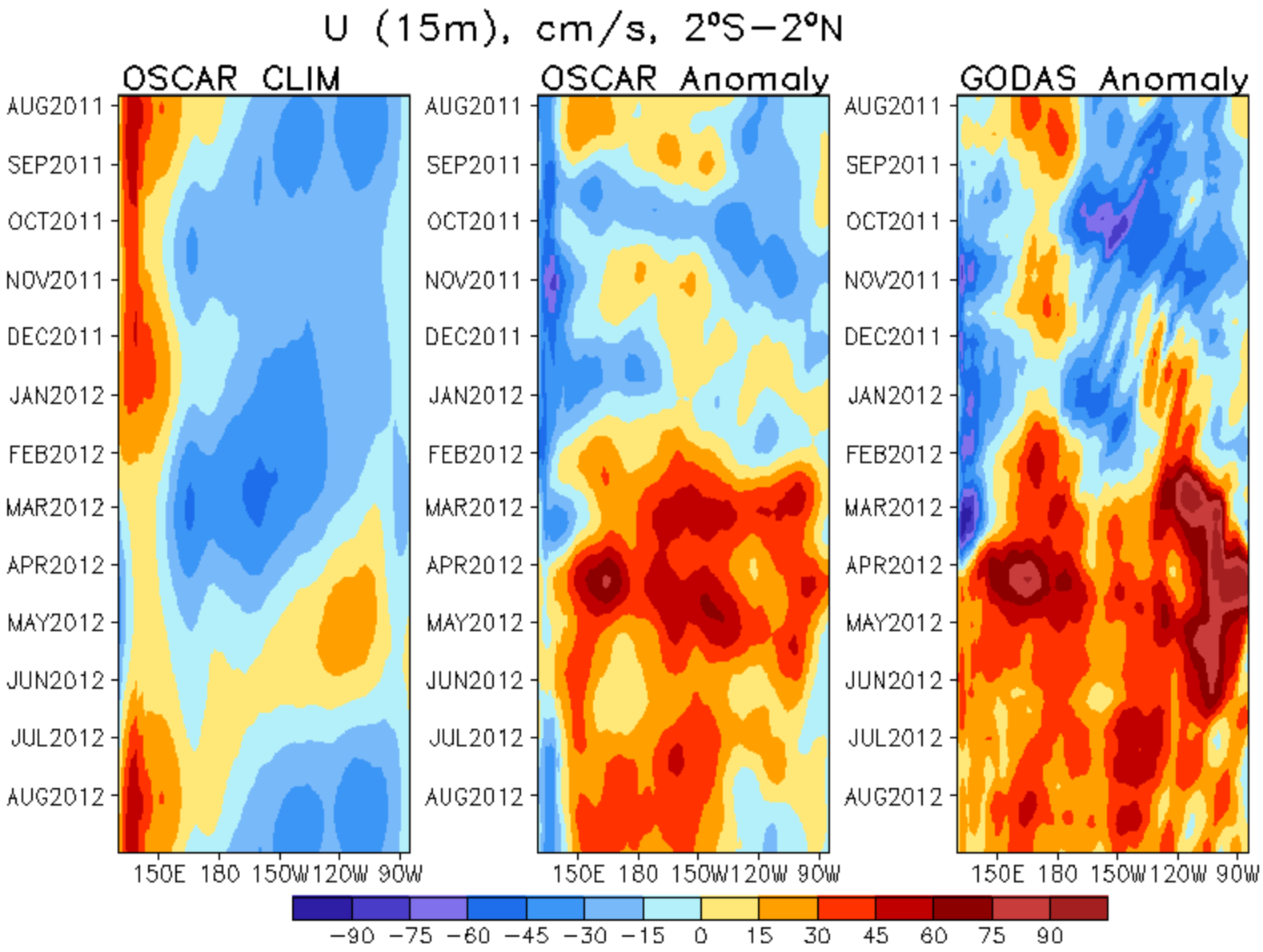
Backup Slides

Global SSH Anomaly and Anomaly Tendency





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



Recent Evolution of 10°S Indian SST (°C), 0-300m Heat Content (°C), and 850-mb Zonal Wind (m/s) Anomalies

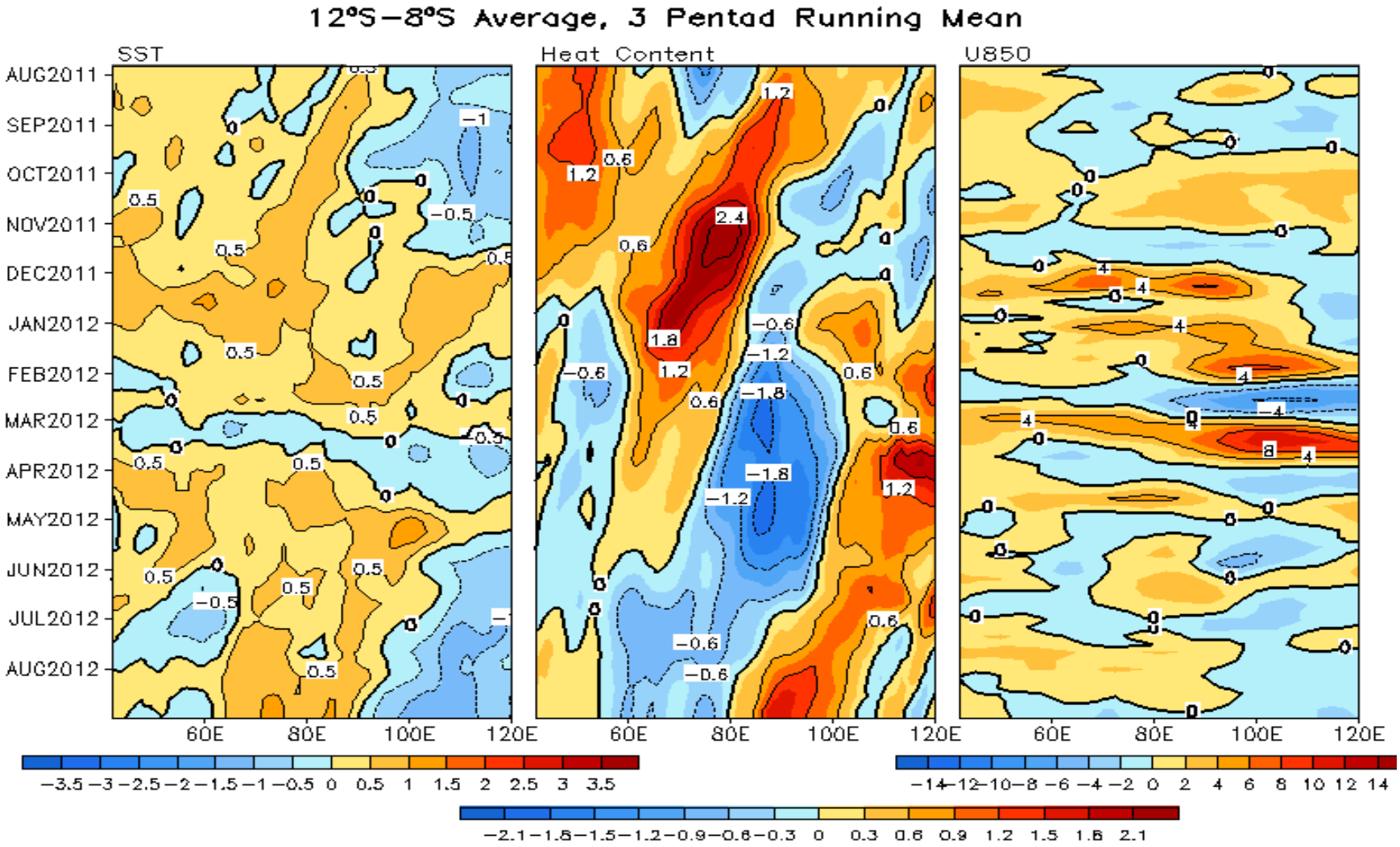
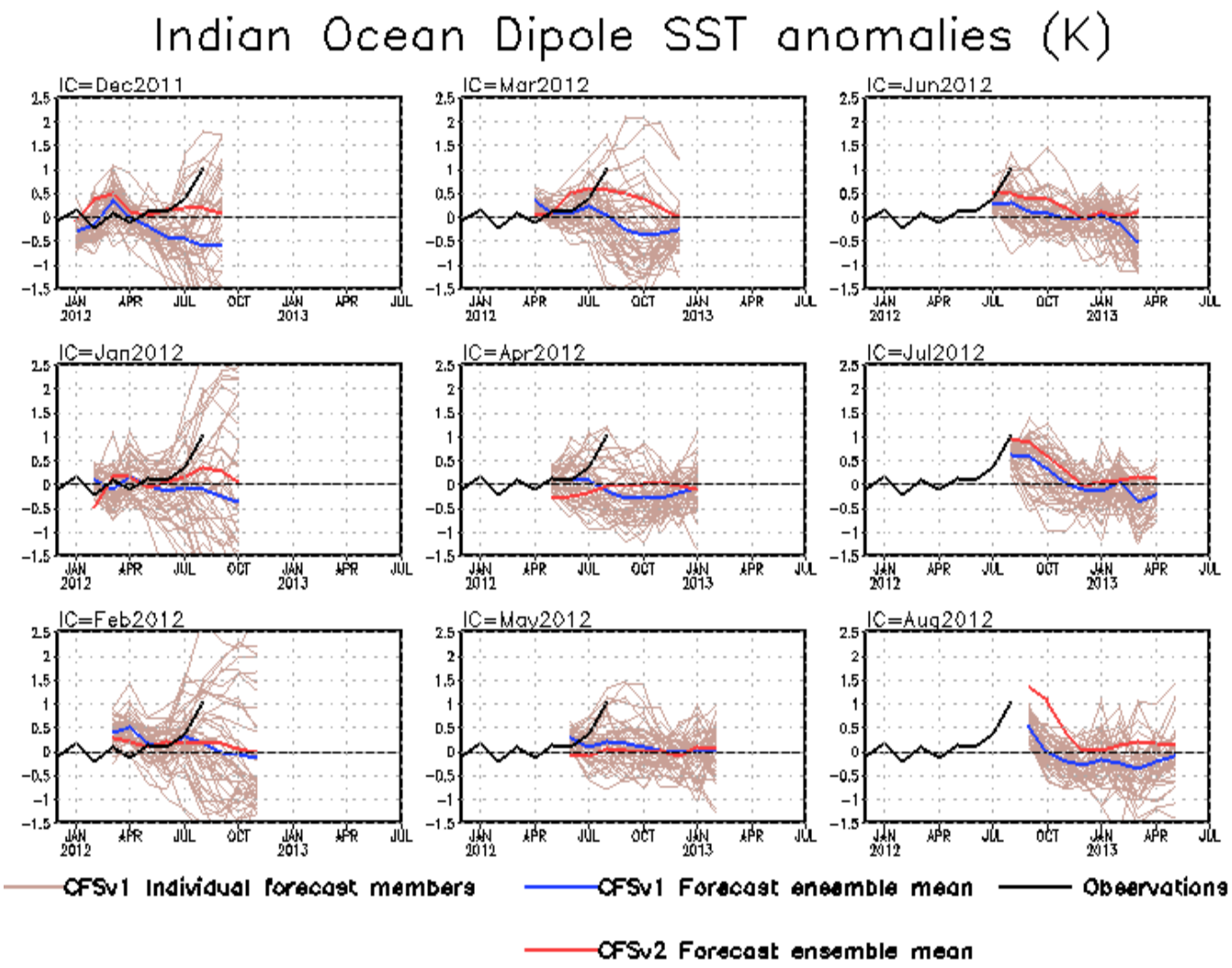


Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period pentad means.

NCEP CFS DMI SST Predictions from Different Initial Months



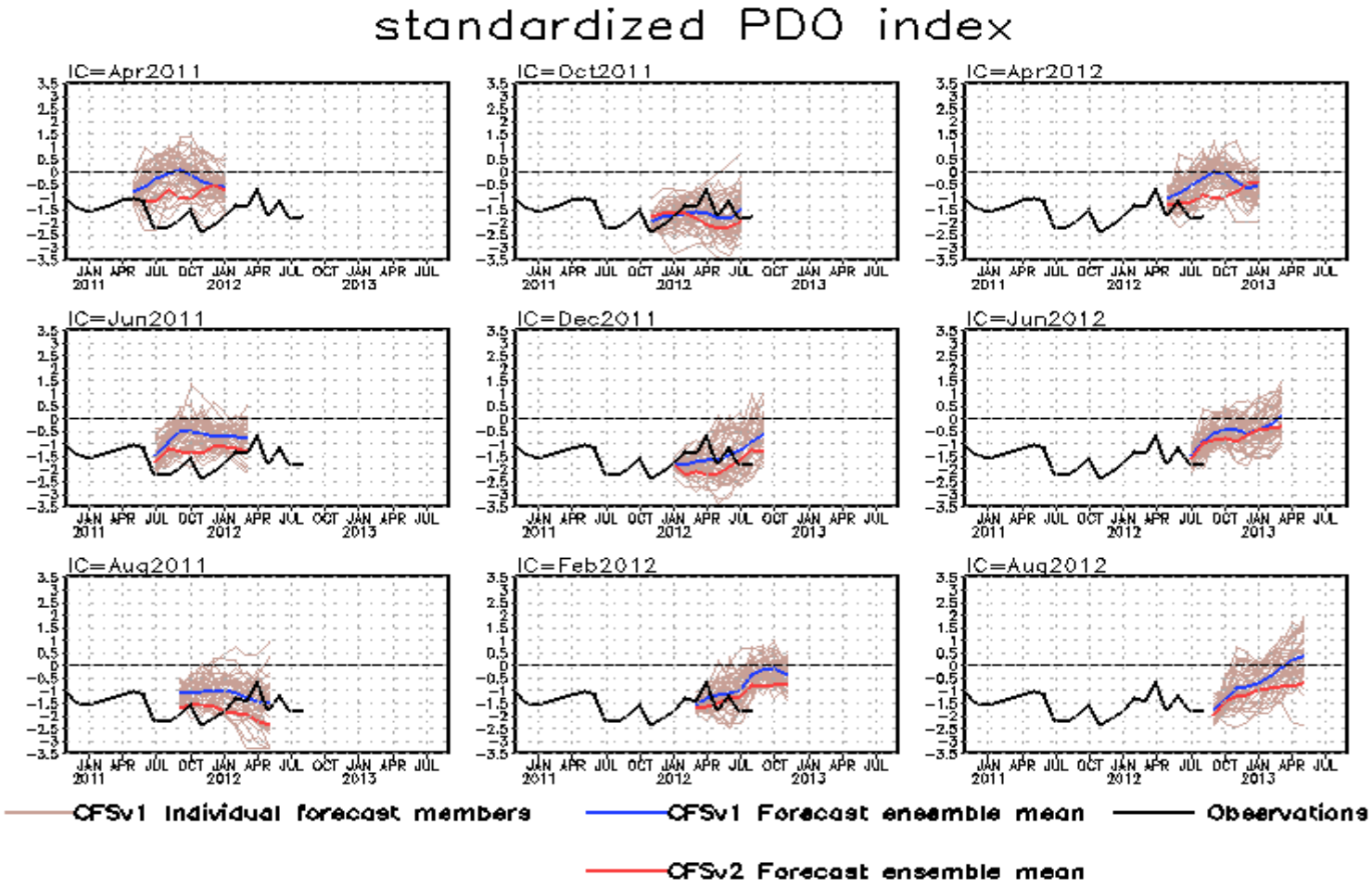
DMI = WTIO- SETIO

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.

CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



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

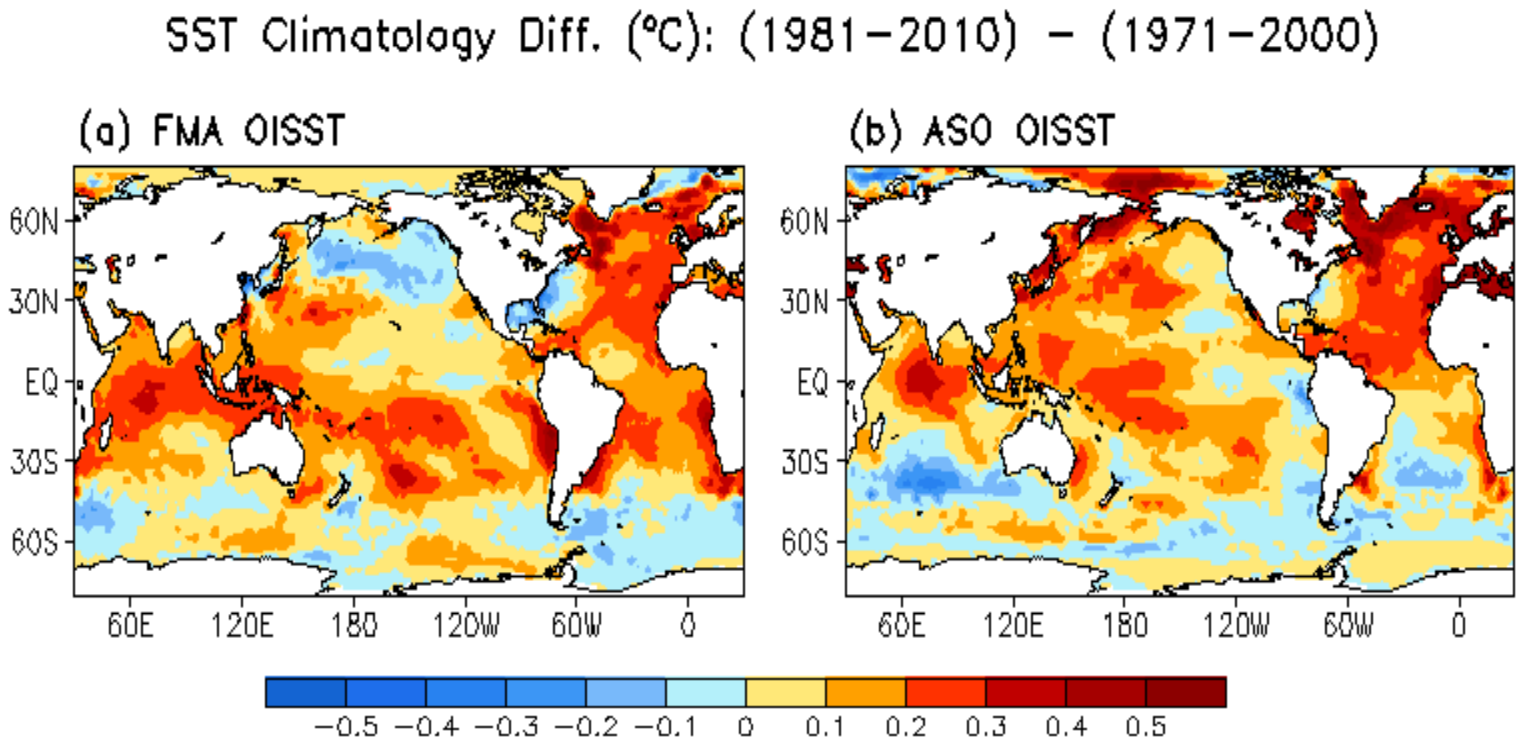
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). 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 1971-2000 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!