2014 Annual Ocean Review

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)

Main Features of SST Anomaly in 2014

- The annual mean SSTA in the tropical Pacific was characterized by two positive centers, one west of the Dateline and another east of 120°W, and one negative center in the southeastern Pacific.

- The SSTA gradient index, defined as difference of SSTA averaged in the northeastern and southeastern Pacific, exceeded +2 STD during March-July and September-December 2014, which may have strong impacts on local climate.

- The SSTA pattern in the North Pacific resembled the positive phase of the PDO and the normalized monthly PDO index was predominantly positive with an average value of 0.6 in 2014.

- In the Atlantic Ocean, SSTA was characterized by a tripole pattern with mostly positive anomalies in the North Atlantic, neutral conditions in the tropical Atlantic, and positive anomalies in the southwestern Atlantic.

- The SSTA in the tropical Indian Ocean was generally positive with a maximum near 30°S.

2014 Yearly Mean SST Anomaly and Tendency

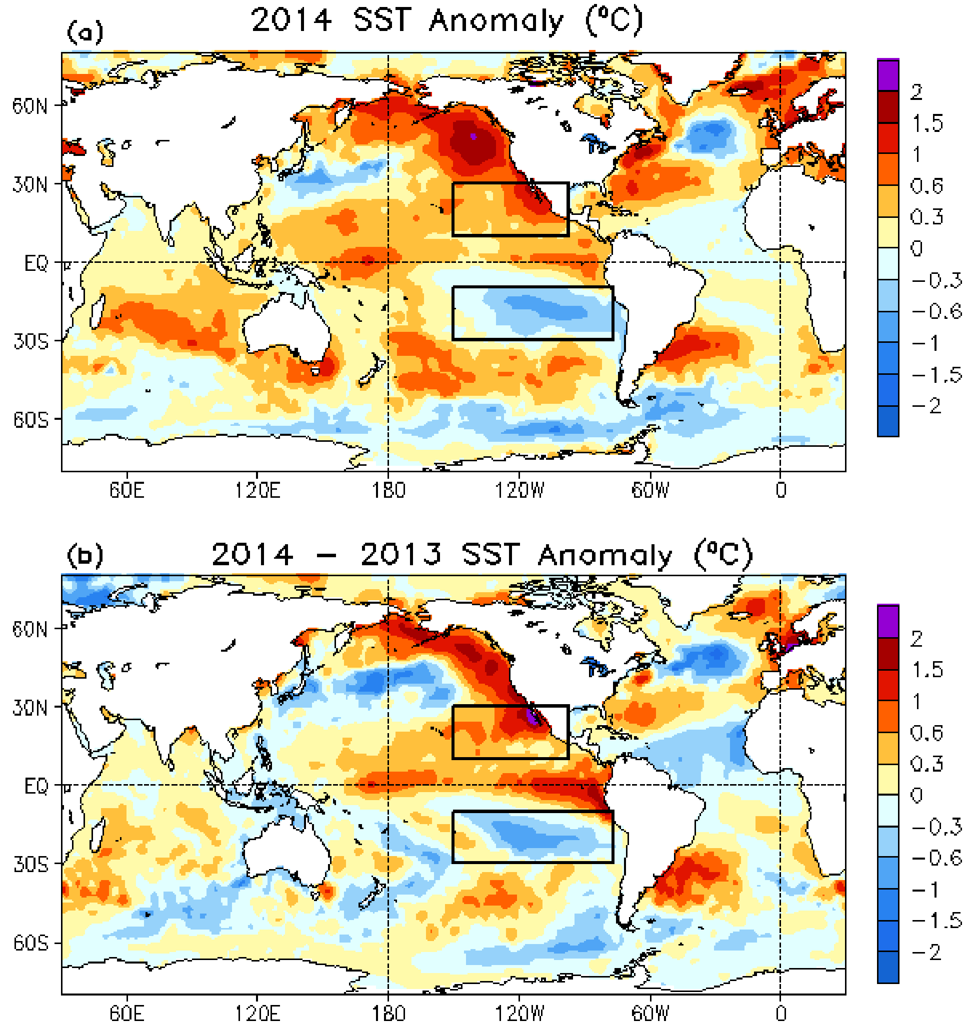


Fig. 3.1. (a) Yearly mean OISST anomaly (°C, relative to 1981-2010 average) in 2014, (b) 2014 minus 2013 OISST anomaly.

Global SST Section in the BAMS State of the Climate in 2014 by Xue et al.

Seasonal Mean SST Anomaly in 2014

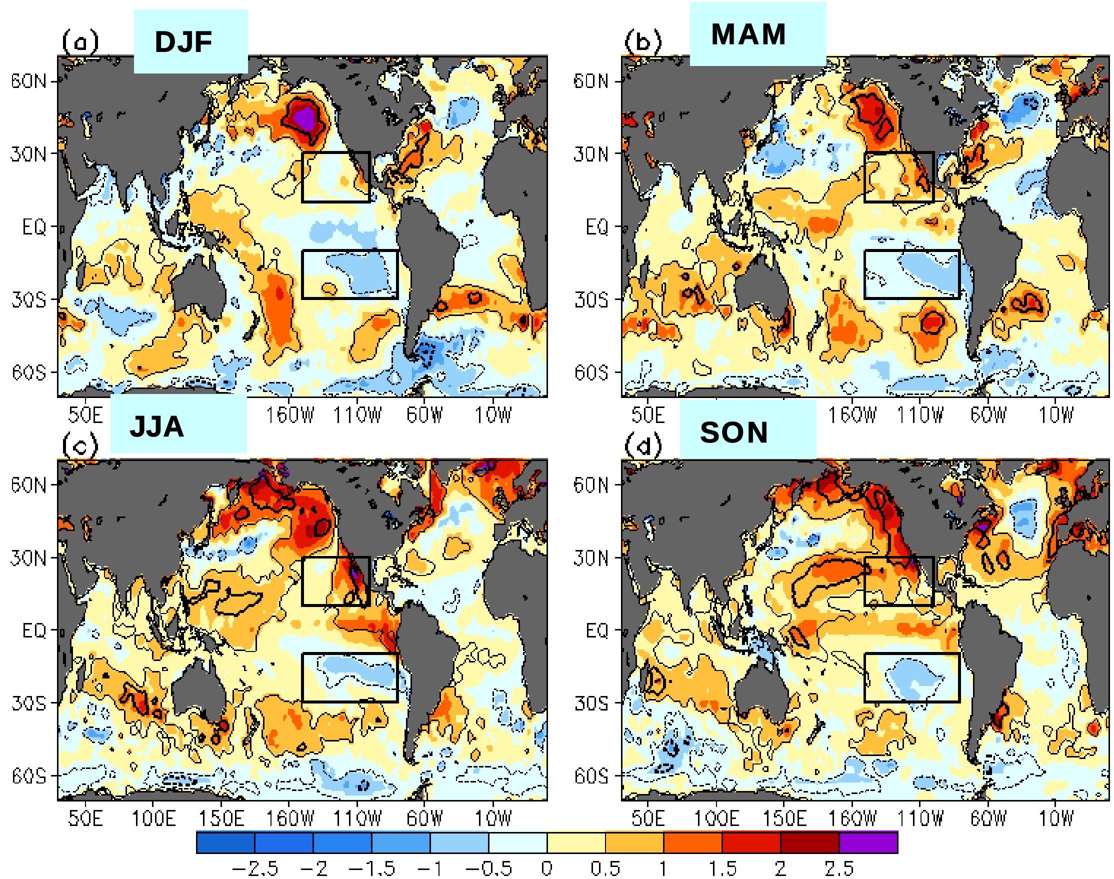


Fig. 3.2. Seasonal mean SSTA from OISST (shading, oC, relative to 1981-2010 average) for (a) December 2013 to February 2014, (b) March to May 2014, (c) June to August 2014 and (d) September to November 2014. The thin contours are +1 and -1 and the thick contours are +2.5 and -2.5 normalized seasonal mean SSTA based on seasonal mean standard deviation over 1981-2010.

Global SST Section in the BAMS State of the Climate in 2014 by Xue et al.

- **Winter 2013/2014: a weak negative phase of the PDO, and ENSO-neutral conditions**

- **Spring 2014: Positive SSTA in W. Pacific shifted eastward and positive SSTAs developed along the west coast of North America.**

- **Summer 2014: Positive SSTAs both west of the Philippines and near Baja California intensified and exceeded +2.5 STD.**

- **Fall 2014: Positive SSTA in N.W. Pacific shifted northeastward and intensified with an amplitude exceeding +2.5 STD. Positive SSTA near the Dateline increased and exceeded +2.5 STD.**

- **Negative SSTA exceeding -1 STD persisted throughout the year.**

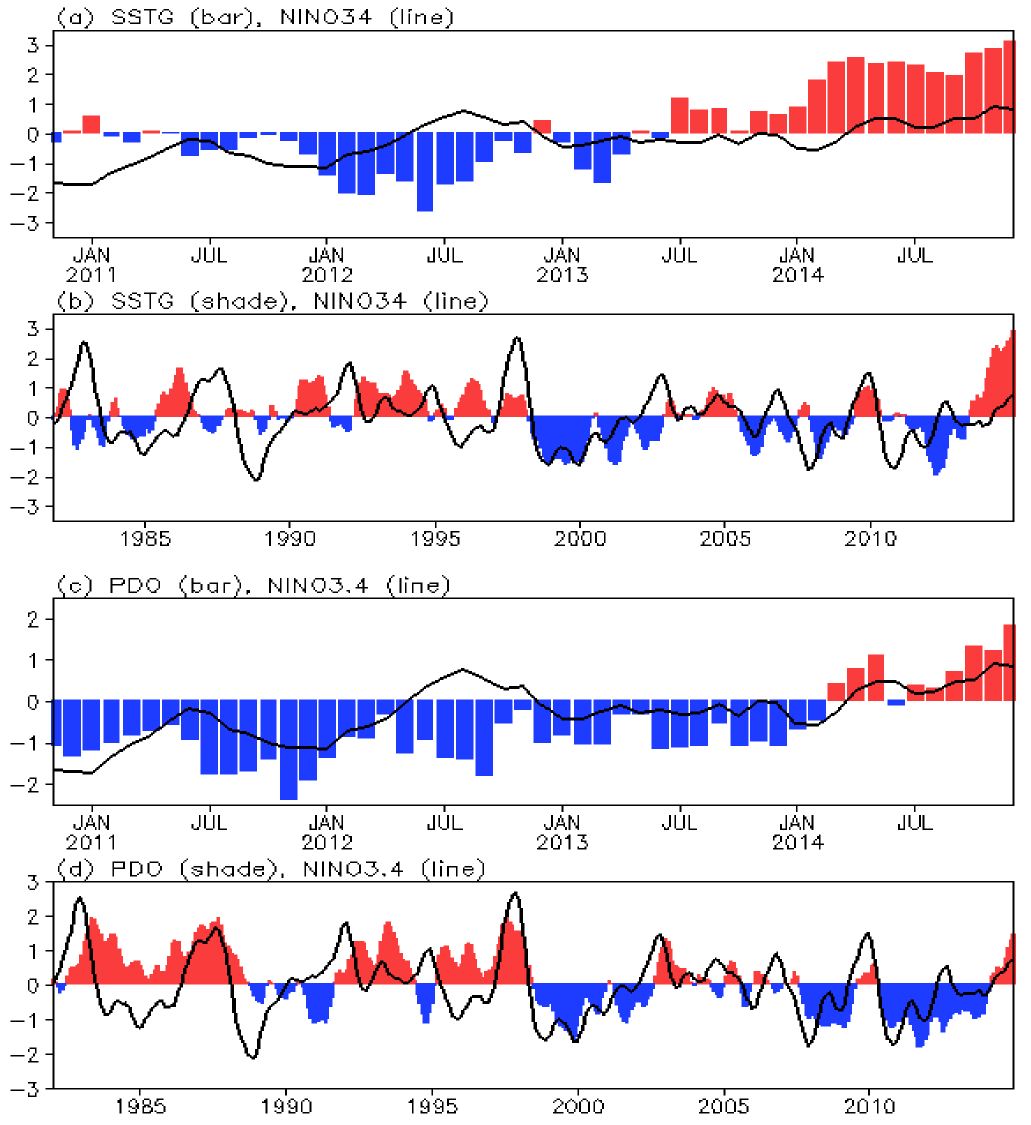


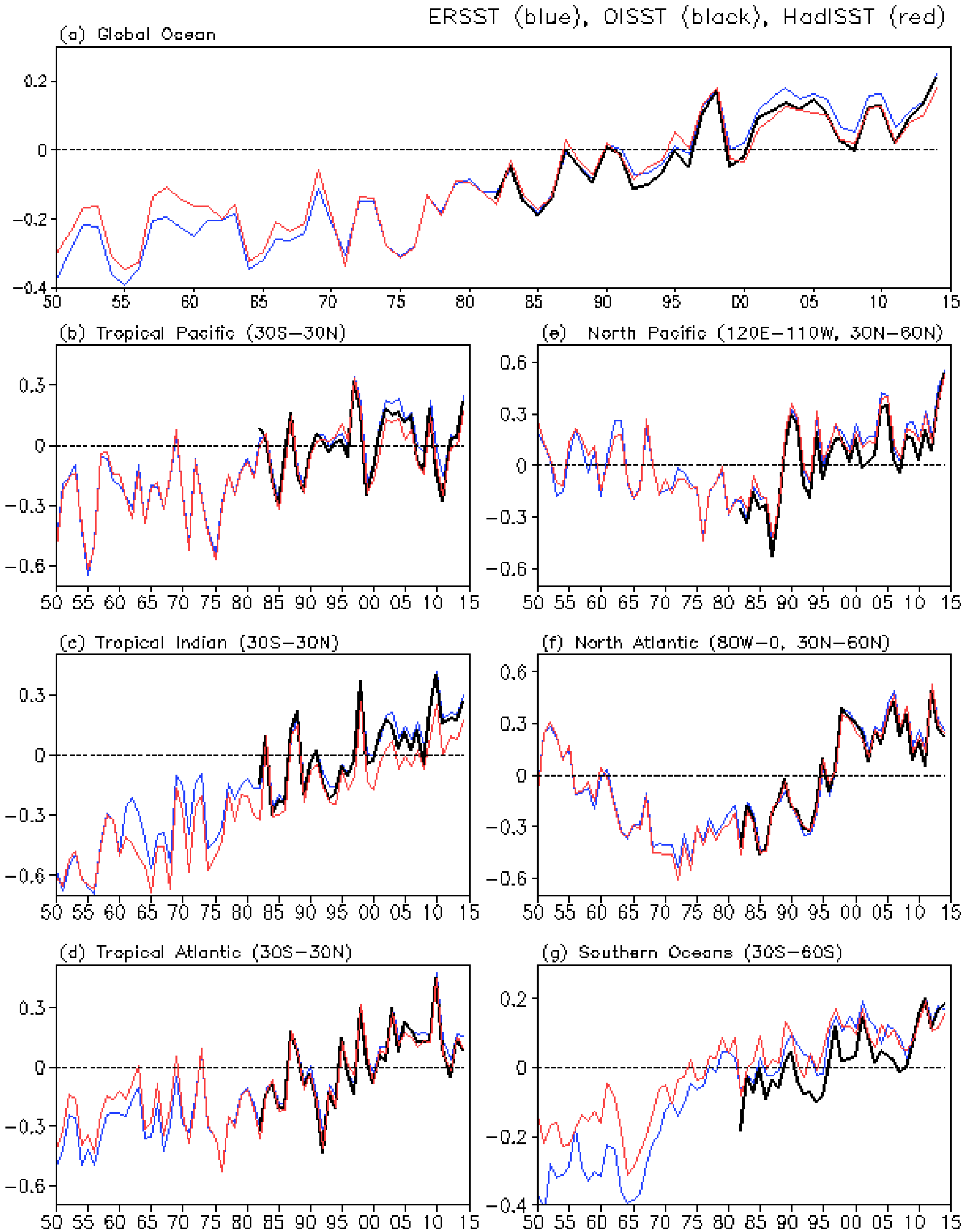
Fig. 3.3. (a) Monthly normalized differences between SSTA averaged in the northern and southern boxes shown in Figs. 3.1 and 3.2, labeled as SSTG (bar), and monthly normalized Niño3.4 index (average SSTA in 170ºW-120ºW, 5ºS-5ºN) (line) in 2011-2014 and; (b) 5-month running mean of SSTA indices in 1982-2014; (c) monthly normalized PDO index (bar) and Niño3.4 index (line) in 2011-2014; (d) 5-month running mean of PDO and Niño3.4 index in 1982-2014. SSTA is relative to 1981-2010 average (°C).

Global SST Section in the BAMS State of the Climate in 2014 by Xue et al.

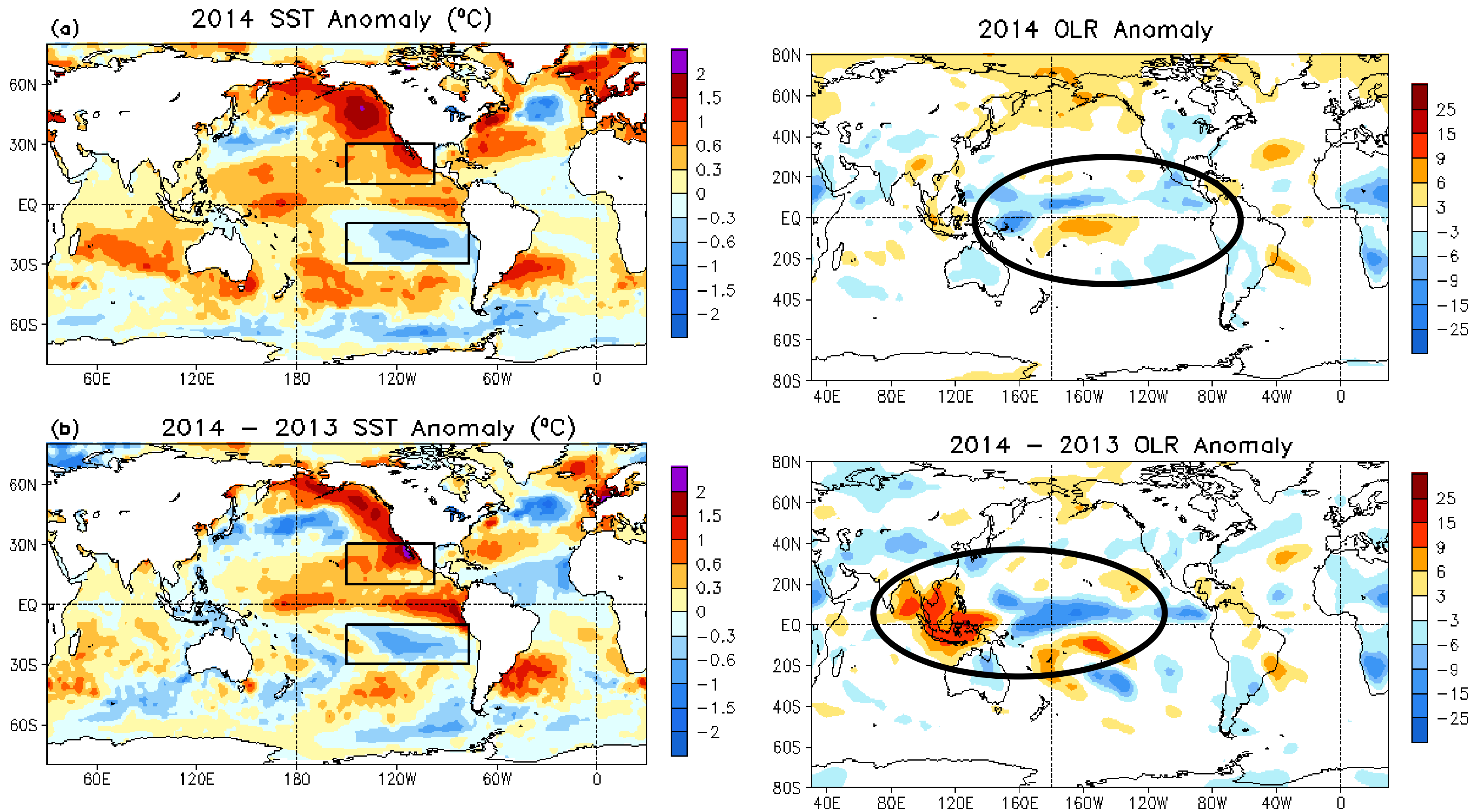
- **SSTG exceeded +2 STD during March-July and September-December 2014.**

- **There was a switch from negative to positive PDO around March 2014, which preceded by one month the transition of Niño3.4 from negative to positive anomalies.**

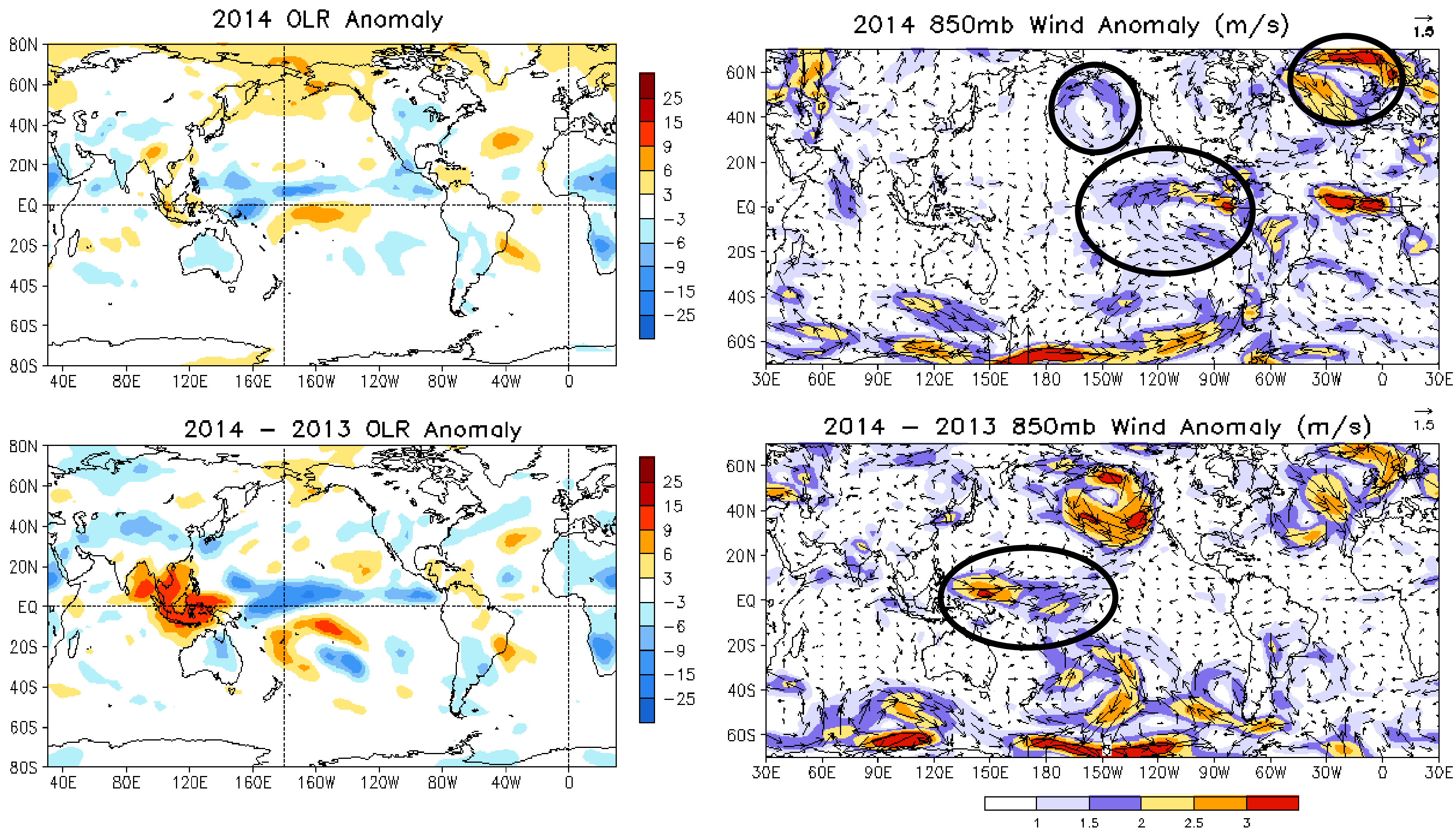
Yearly Mean SST Anomaly Indices



- The global ocean SST increased by +0.07ºC from 2013, becoming **the warmest year** since 1982.
- The mean SST in the tropical Pacific increased substantially (+0.18ºC) from 2013, becoming the 2nd warmest year (behind 1997) since 1982.
- The mean SST in the tropical Indian Ocean increased modestly (+0.1ºC) from 2013, becoming the 3rd warmest year since 1982.
- The mean SST in the tropical Atlantic decreased from 2013, ranking the 13th warmest year since 1982.
- The mean SST in the North Pacific increased substantially (+0.17ºC) from 2013, becoming **the warmest year** since 1982.
- The mean SST in the North Atlantic continued to decrease from the 2012 historical high, becoming the 11th warmest year since 1982.
- There is a convergence in the southern Ocean SSTA since 2009.



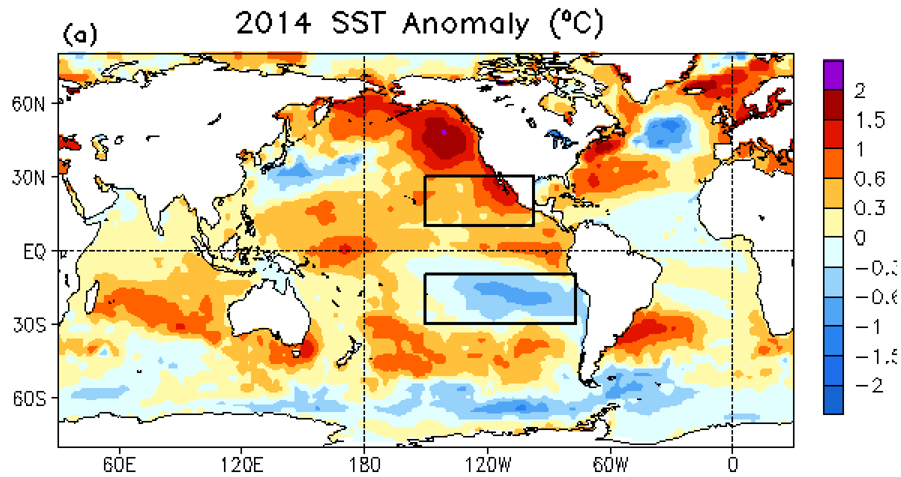
- In 2014 the OLR anomaly pattern was characterized by enhanced (suppressed) convection in the western Pacific and ITCZ (south of equator near Dateline).
- In 2014, the northward shift of ITCZ seems associated with the south-north SSTA gradient, and the enhanced convection in the western Pacific associated with positive SSTA in that region.
- The 2014 minus 2013 OLR anomaly was dominated by a dipole pattern in the Indo-Pacific and enhancement of ITCZ.

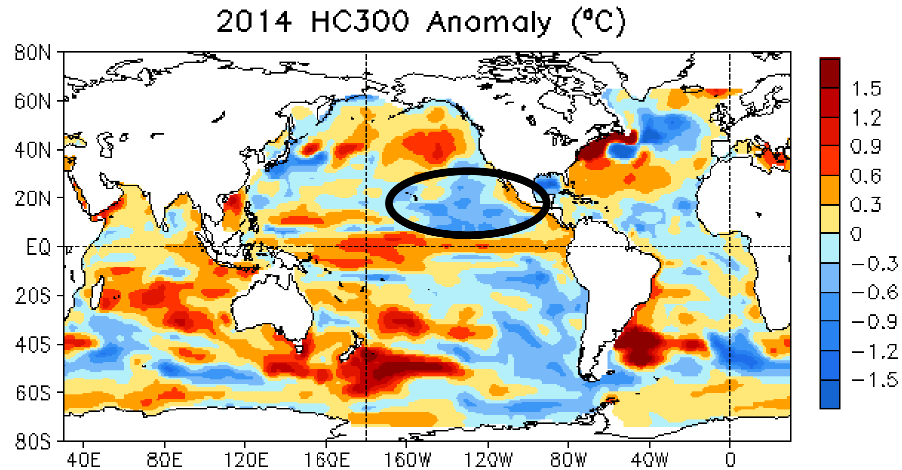


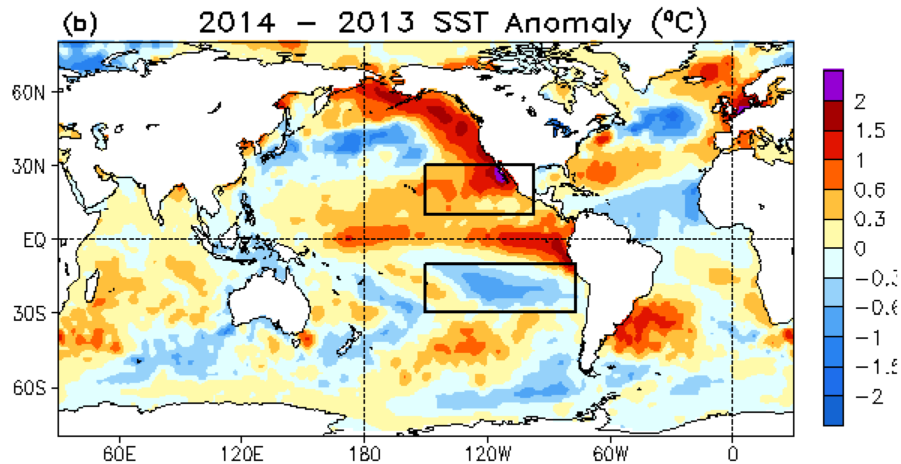
- In 2014, the enhanced ITCZ was associated with cross-equatorial wind anomalies in the eastern Pacific.
- The 2014 minus 2013 dipole OLR anomaly was associated with strong westerly wind anomalies in the western Pacific.
- Cyclonic anomaly circulations were observed near Gulf of Alaska and subpolar N. Atlantic.

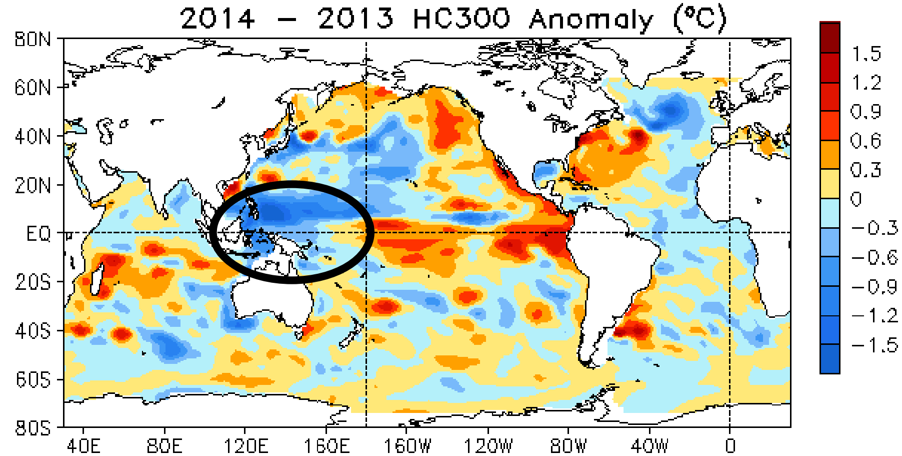
OI SST

GODAS HC300





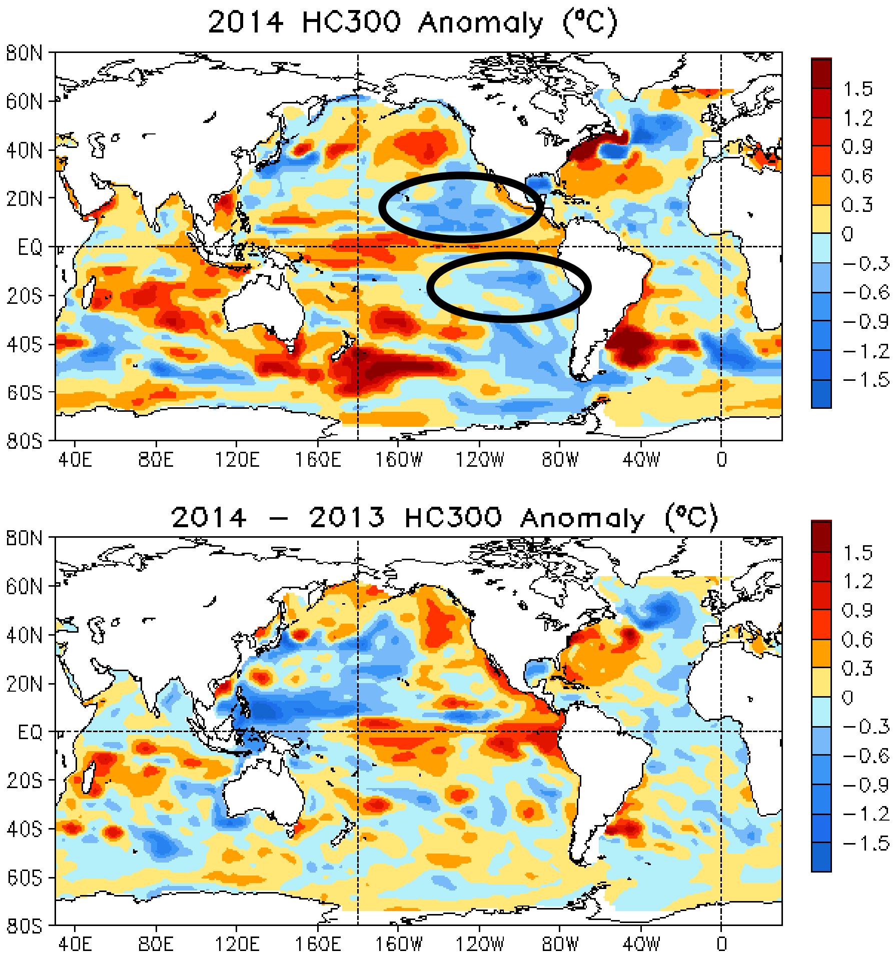




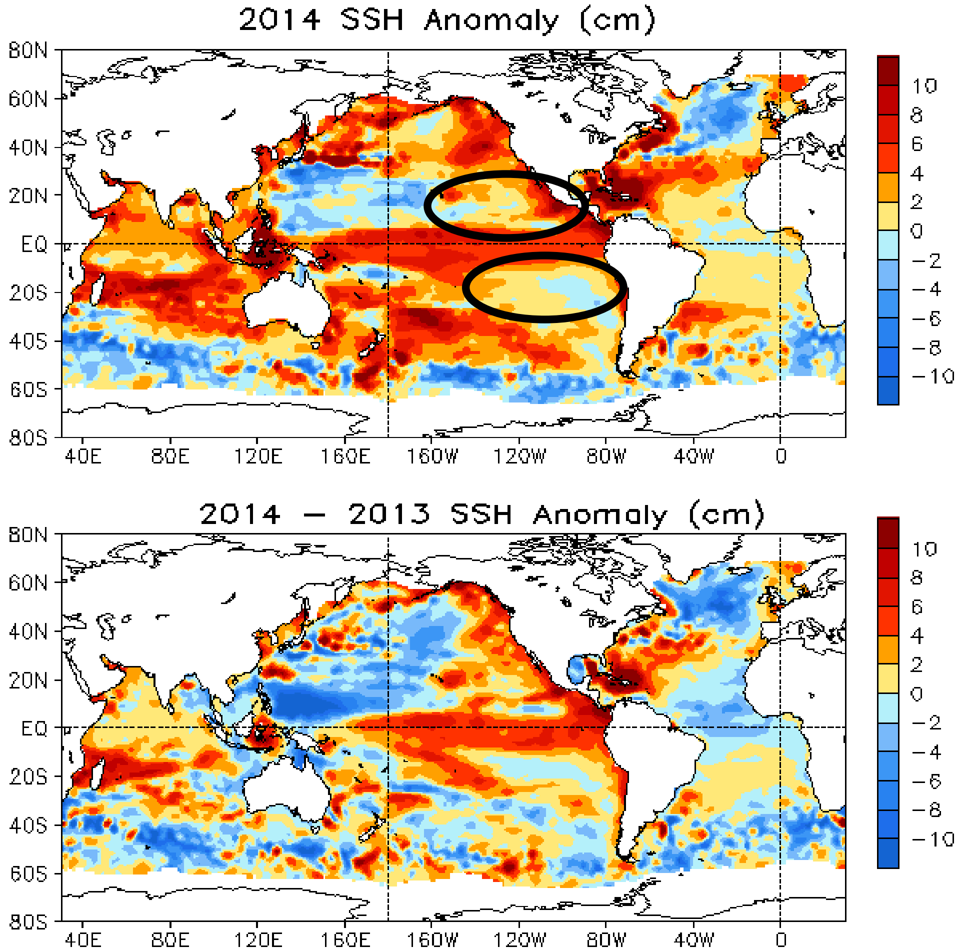
- **Pattern of SST and HC300 anomalies were consistent except in the northeastern Pacific.**

- **The tendency of SST and HC300 anomalies were also consistent except in the western tropical Pacific.**

GODAS HC300

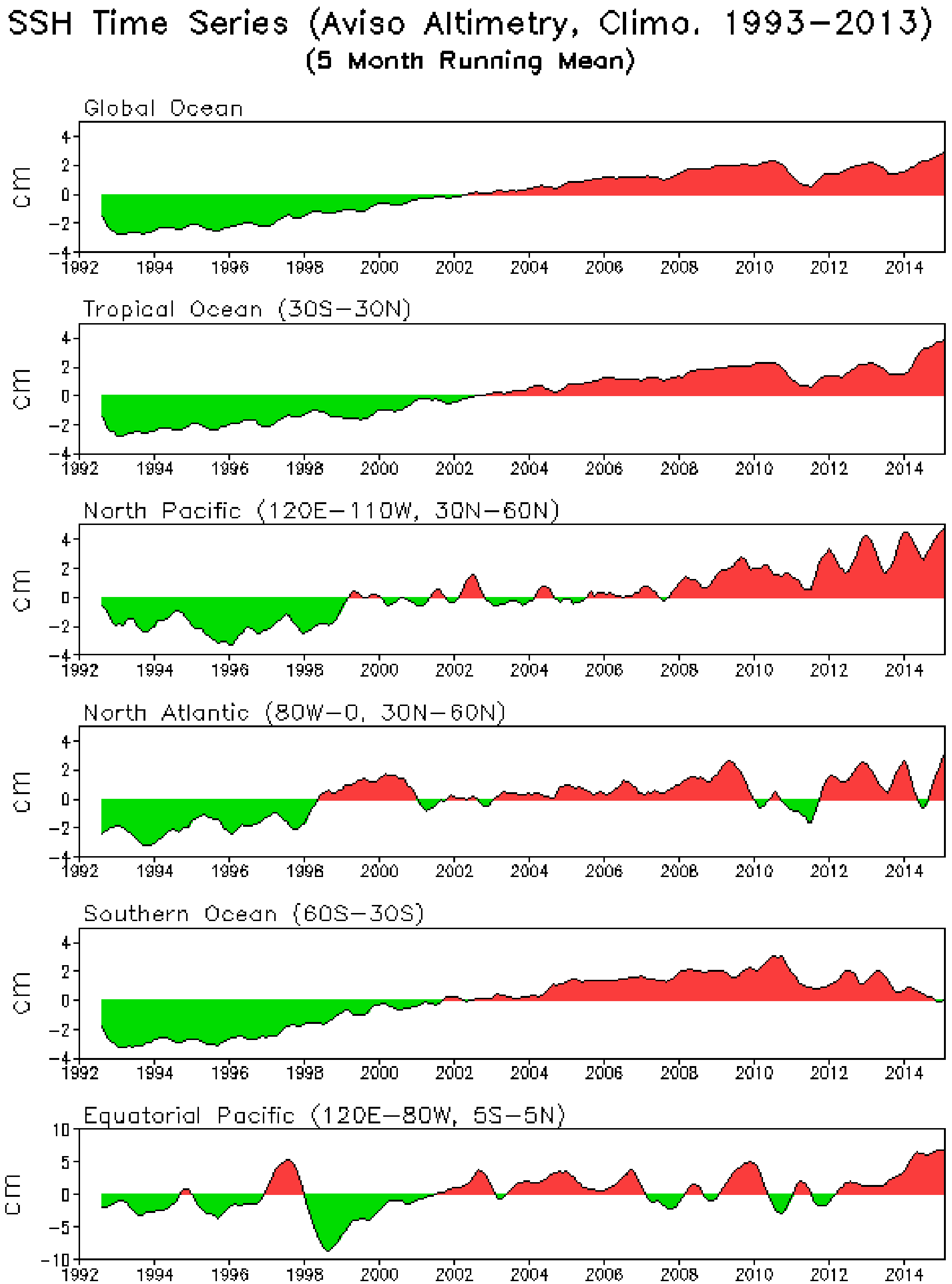


AVISO SSH



- Pattern of HC300 and SSH anomalies were largely consistent except in the northeastern and southeastern Pacific and tropical Atlantic Ocean.

- The tendency of HC300 and SSH anomalies were largely consistent.



- **The mean SSH anomaly in the global ocean increased in 2014, reaching the historical high since 1992.**

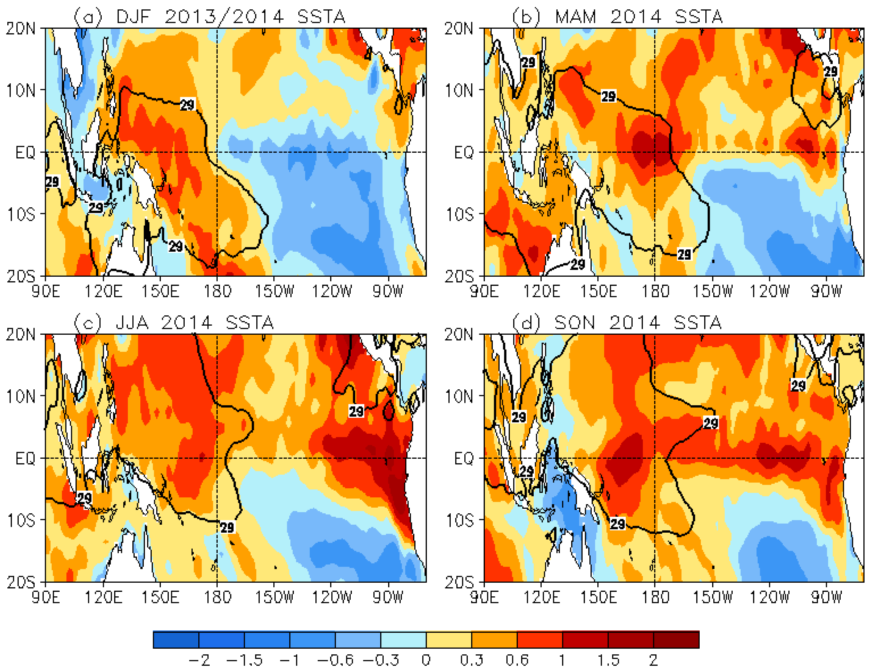
- **The mean SSH anomaly in the tropical Ocean increased in 2014, reaching the historical high since 1992.**

- **The mean SSH anomaly in North Pacific has pronounced annual variability since 2011, reaching the historical high since 1992..**

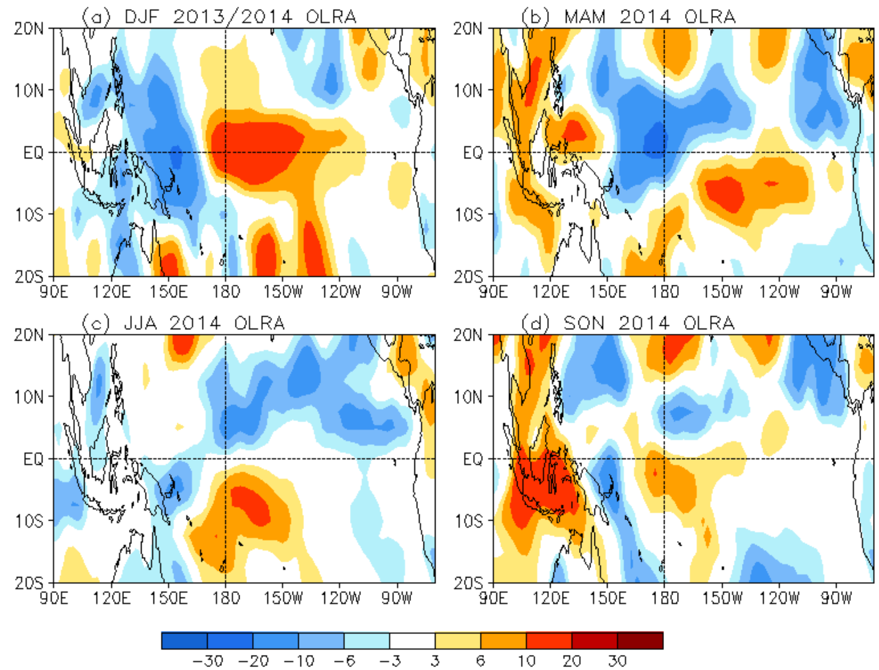
- **The mean SSH anomaly in Southern Ocean has been trending downward since 2010.**

- **The mean SSH anomaly in the equatorial Pacific reached a historical high since 1992.**

Seasonal Mean SST Anomaly

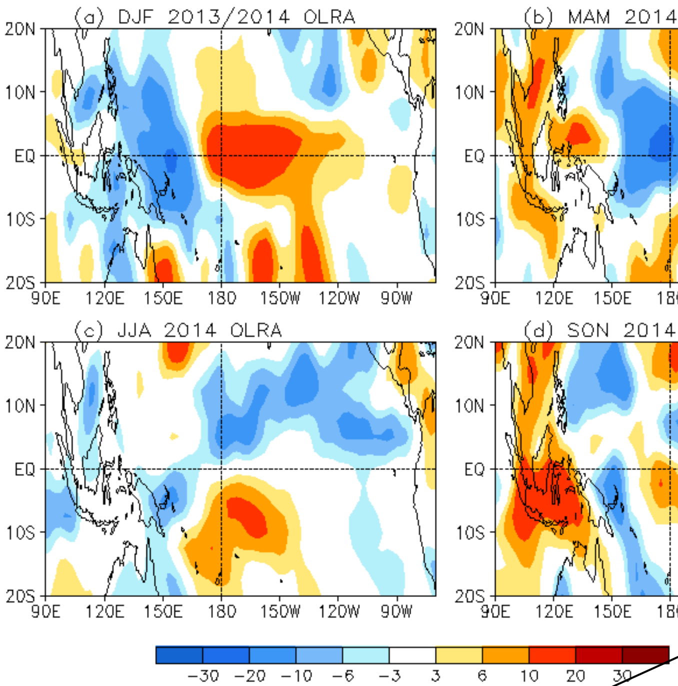


Seasonal Mean OLR Anomaly

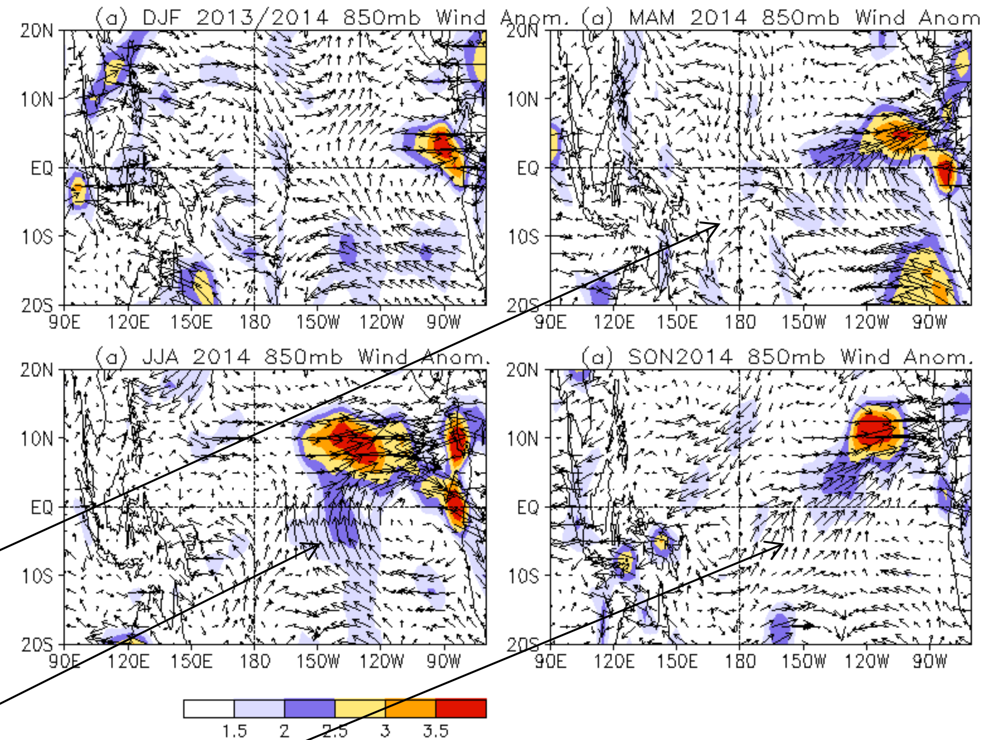


- **Positive (negative) SSTA has persisted in the western tropical Pacific (southeastern Pacific).**
- **Enhanced convection moved to Dateline in spring 2014 when positive SSTA moved the central Pacific.**
- **Enhanced convection shifted to north of equator during summer.**
- **Suppressed convection persisted south of equator near Dateline during summer and fall.**

Seasonal Mean OLR Anomaly



Seasonal Mean 850mb Wind Anomaly

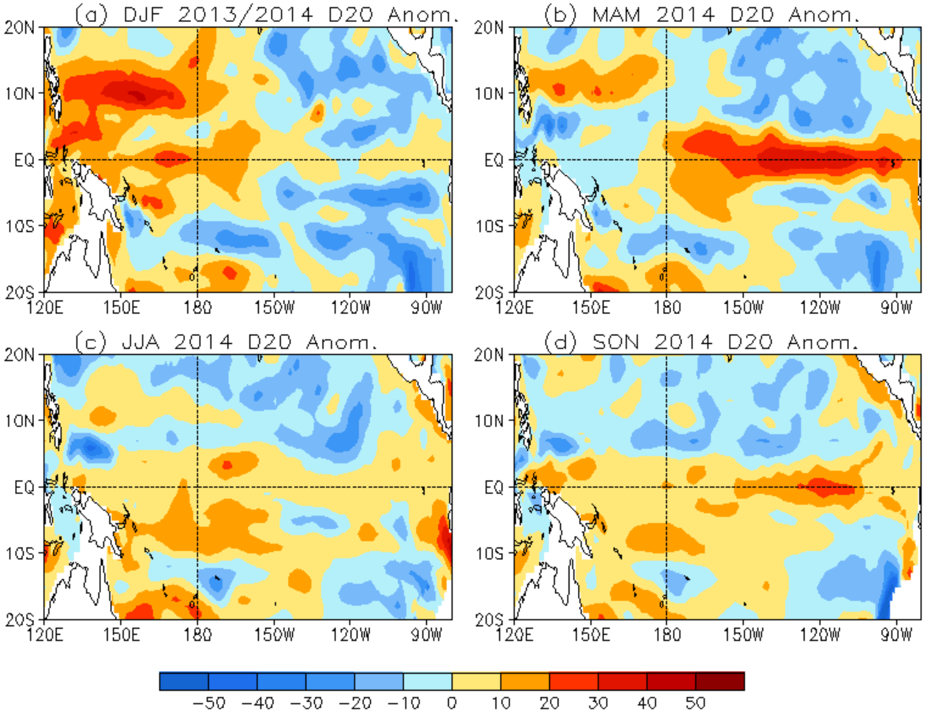


- During spring, westerly wind anomalies presented in the west-central Pacific and cross-equatorial wind anomalies in the eastern Pacific, consistent with OLR anomaly pattern.

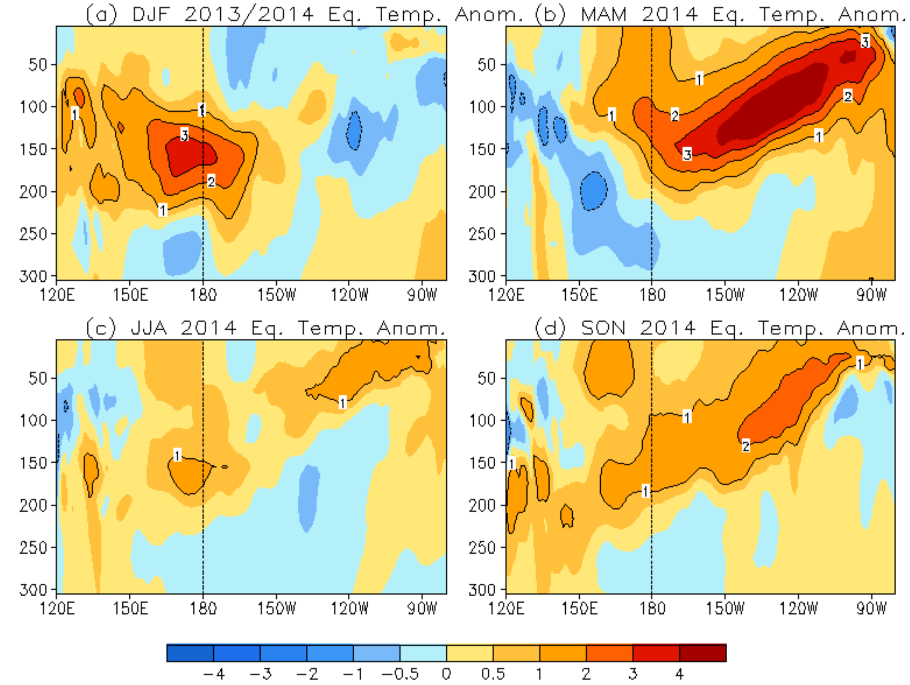
- During summer, cross-equatorial wind anomalies presented in the central-eastern Pacific, consistent with northward shift of ITCZ.

- During fall, easterly wind anomalies presented in the western Pacific and cross-equatorial wind anomalies in the central-eastern Pacific.

Seasonal Mean Depth of 20C Anomaly



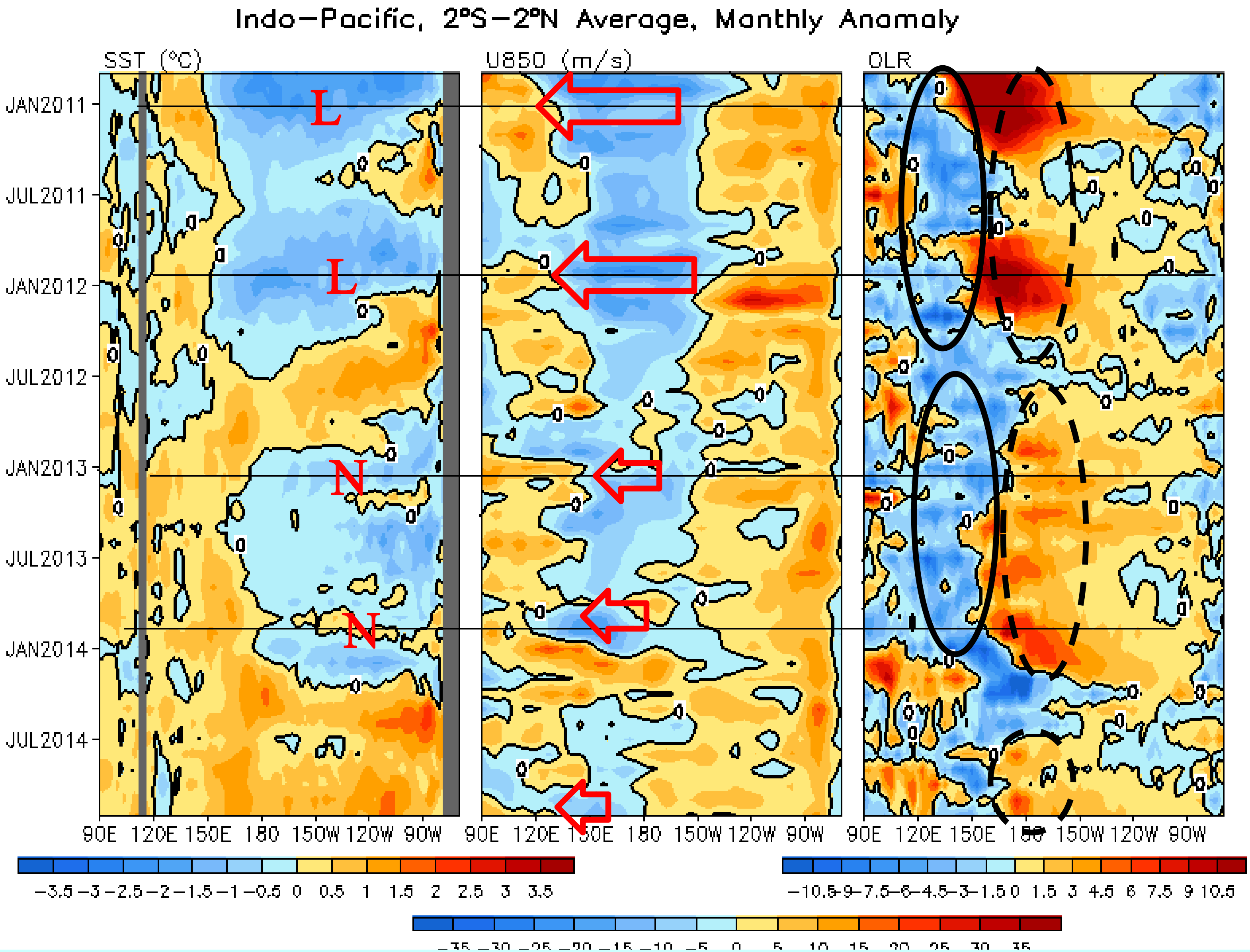
Seasonal Mean Eq. Temp. Anomaly



- **Positive subsurface temperature anomalies quickly grew and moved to the central-eastern Pacific during spring 2014.**

- **The positive temperature anomalies dissipated quickly during summer 2014, which may be associated the northward shift of ITCZ and enhancement of cross-equatorial wind anomalies.**

- **Positive temperature anomalies enhanced in the eastern Pacific during fall due to enhancement of westerly wind anomalies in the eastern Pacific.**

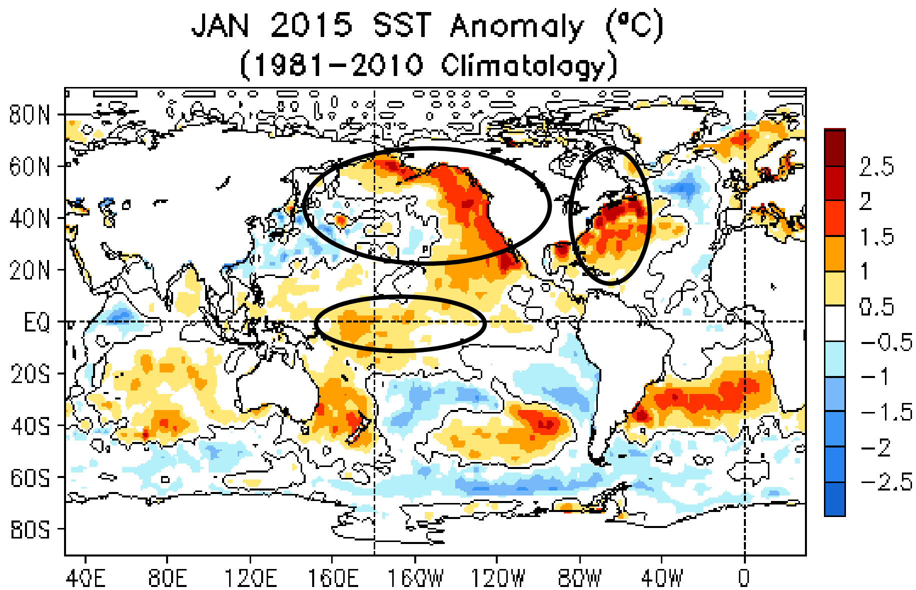


- **Easterly wind anomalies persisted in the central Pacific during ENSO-neutral year of 2012 and 2013, resembling those during La Nina year of 2010 and 2011.**

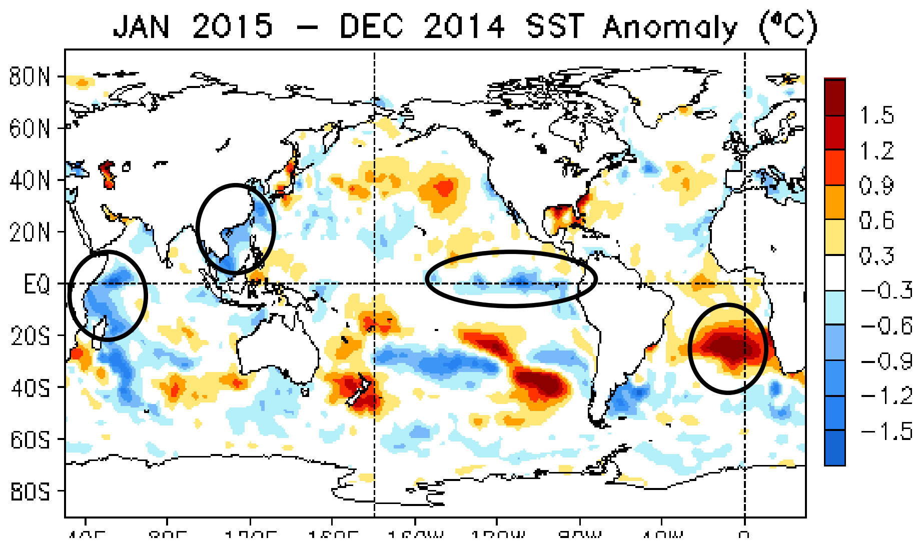
- **Despite of positive SSTA, easterly wind anomalies (suppressed convection) persisted west of Dateline (near Dateline) since summer 2014.**

Highlights in January 2015

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



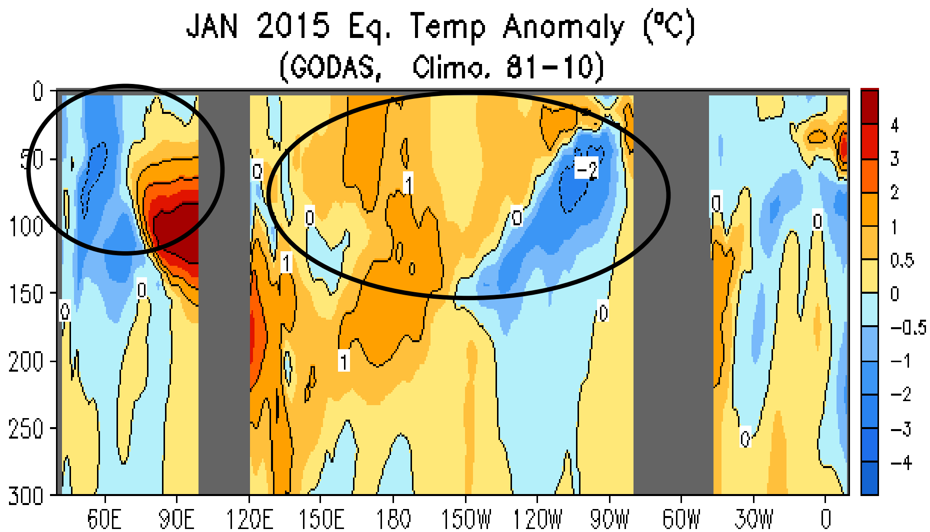
- SST was above-normal in the central equatorial Pacific.
- A positive PDO pattern presented in N. Pacific.
- Positive SST anomalies were observed near the east coast of US.



- A cooling tendency presented in the eastern equatorial Pacific, east coast of China and western Indian Ocean.
- A warming tendency was observed in South Atlantic.

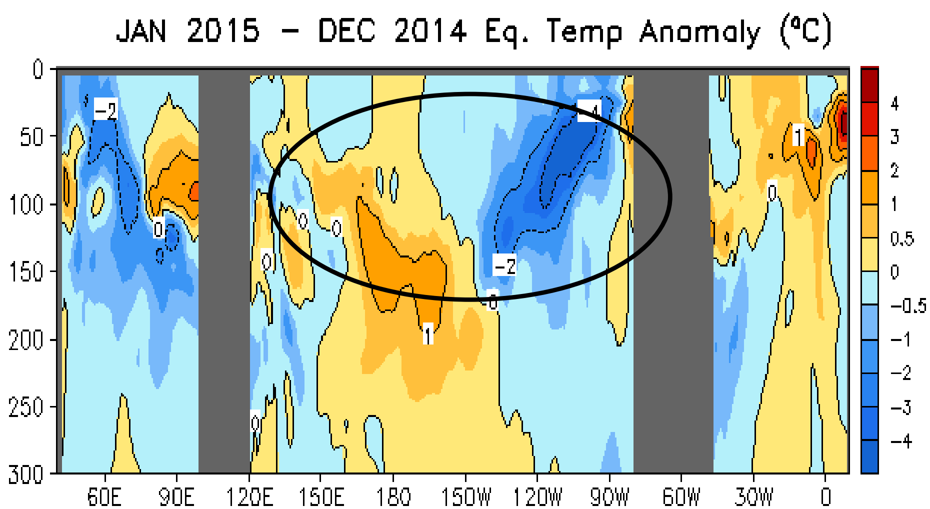
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2^{O}S-2^{O}N



- Positive temperature anomalies occupied most of the equatorial Pacific except in the eastern Pacific near the thermocline.

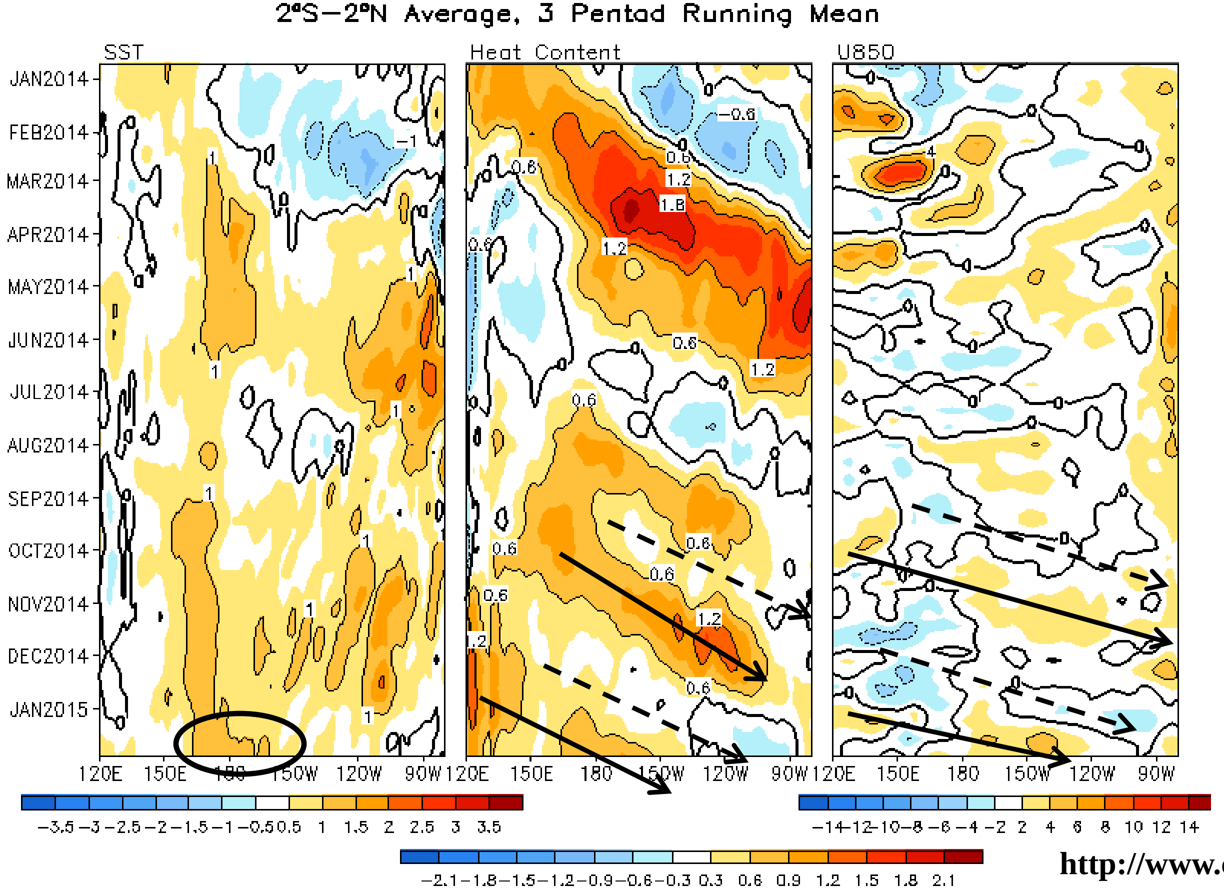
- A dipole anomaly pattern presented in the equatorial Indian Ocean.

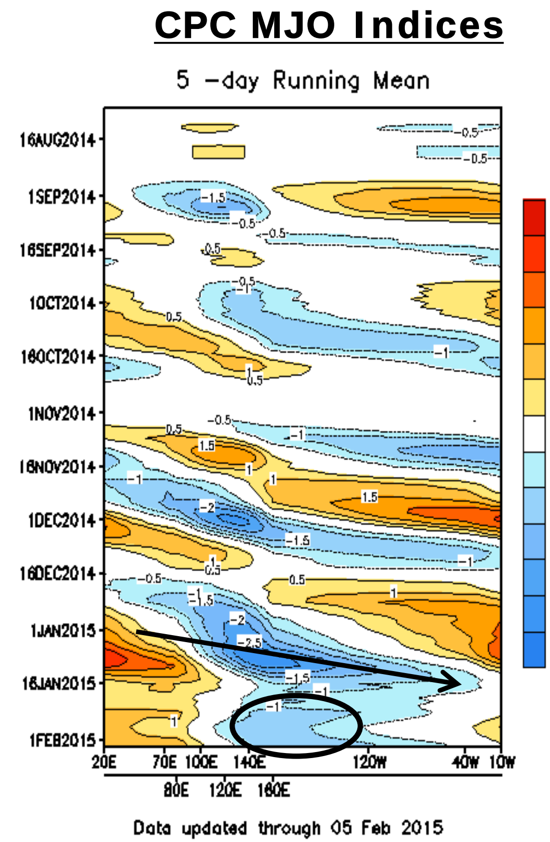


- A cooling (warming) tendency was observed in the eastern (western) Pacific near the thermocline, largely due to eastward propagation of upwelling oceanic Kelvin waves.

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.

Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) and OLR(W/m^2) Anomalies



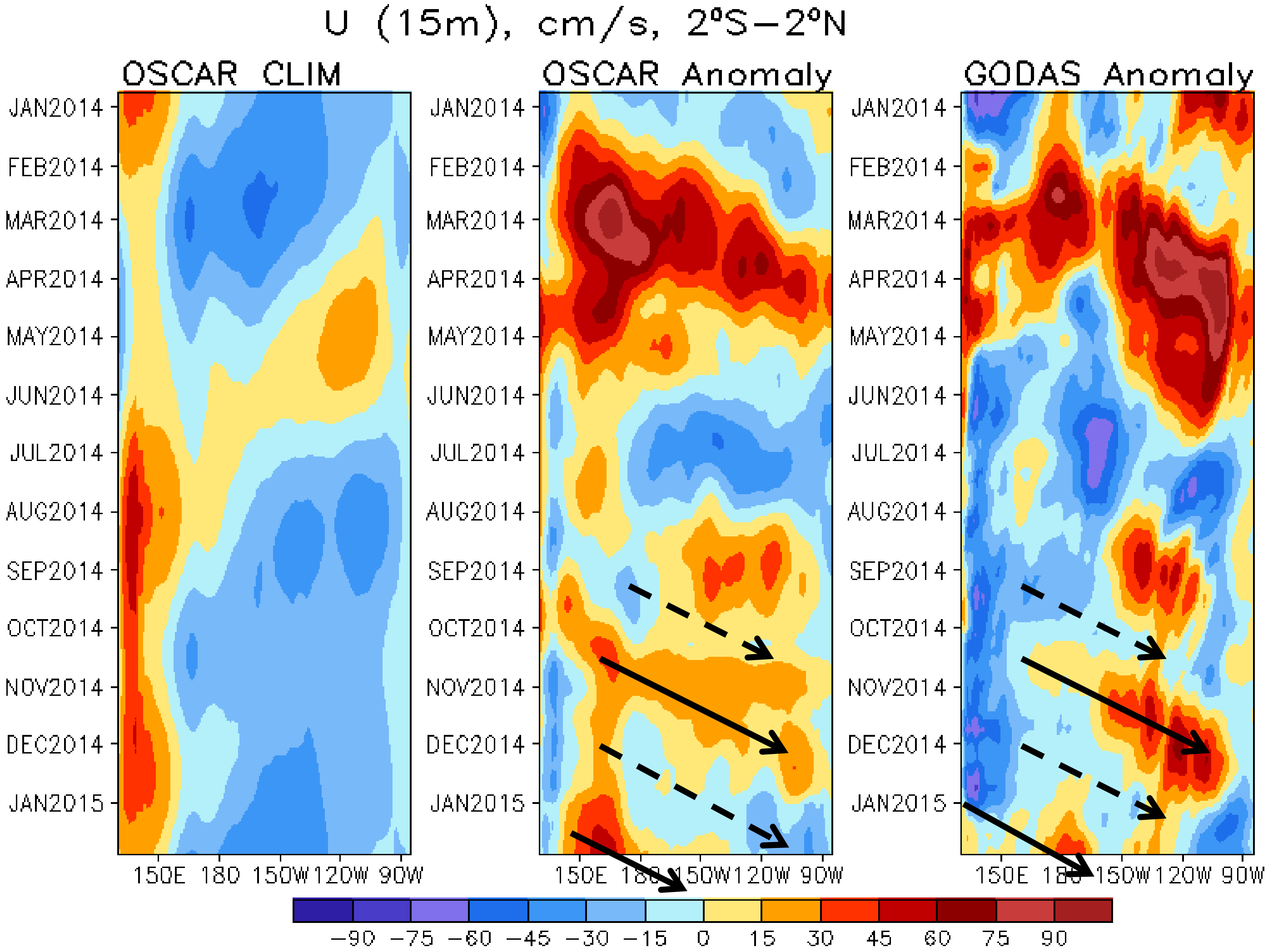


http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.shtml

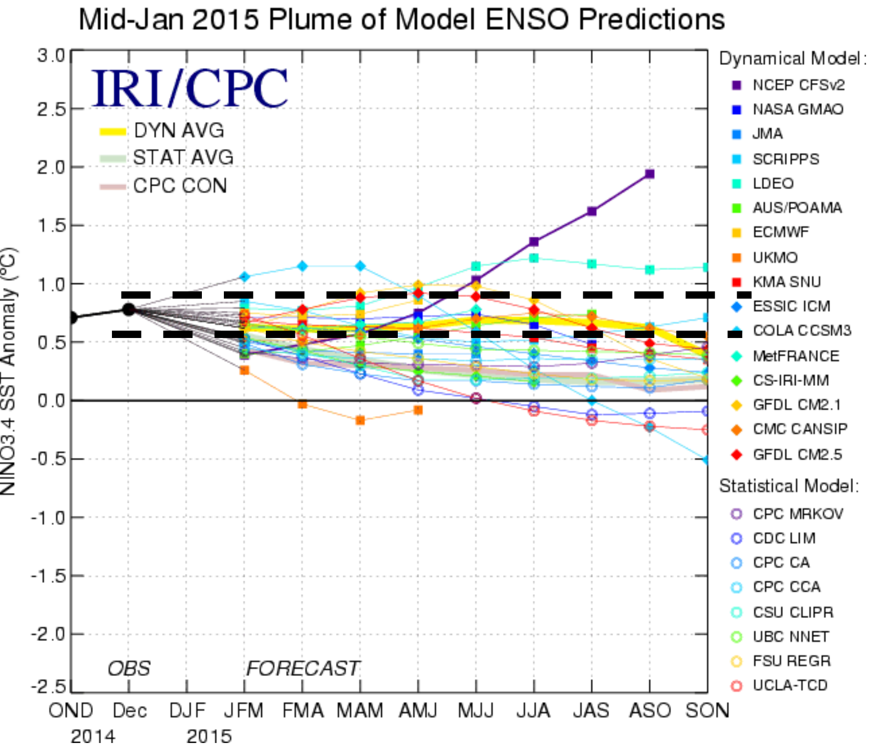
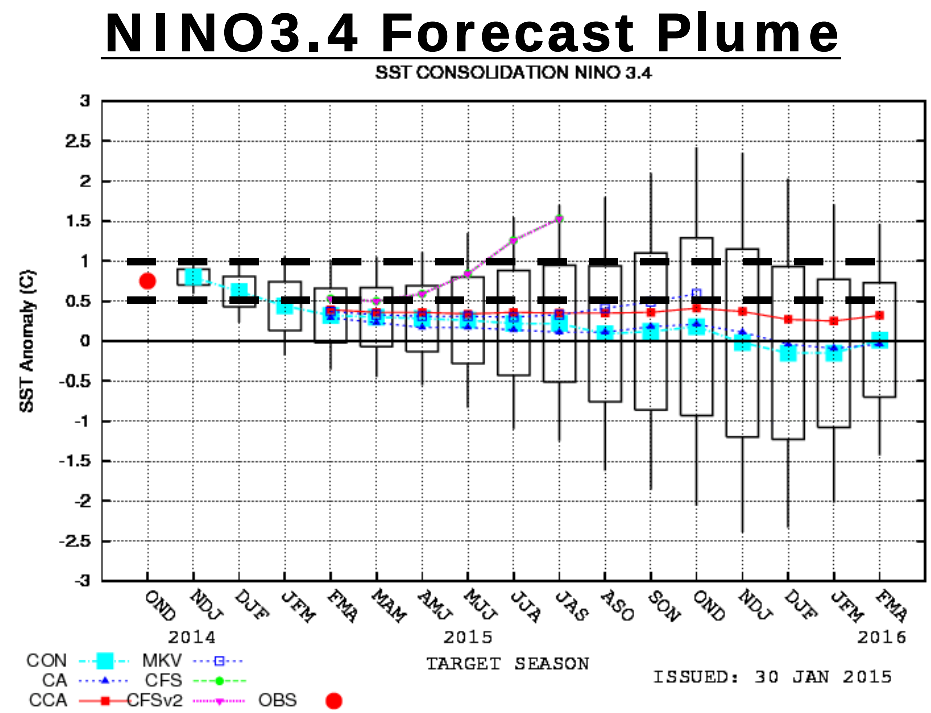
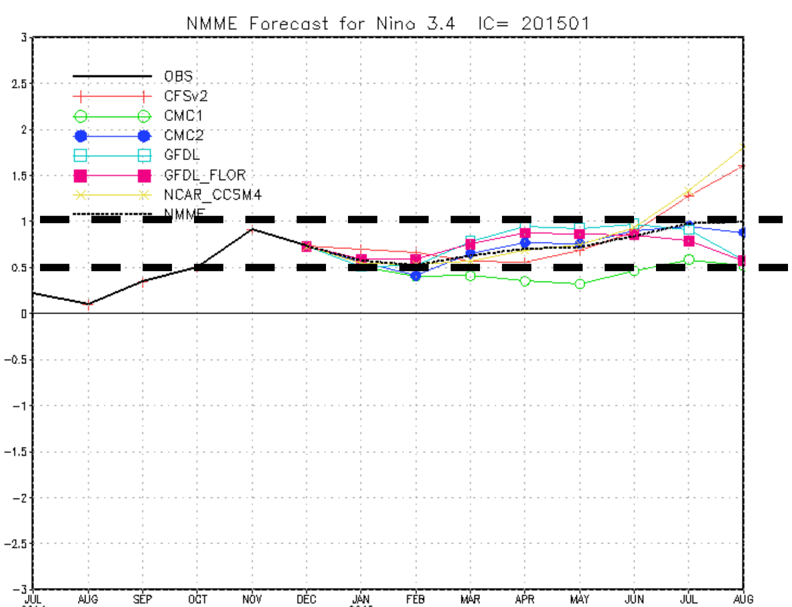
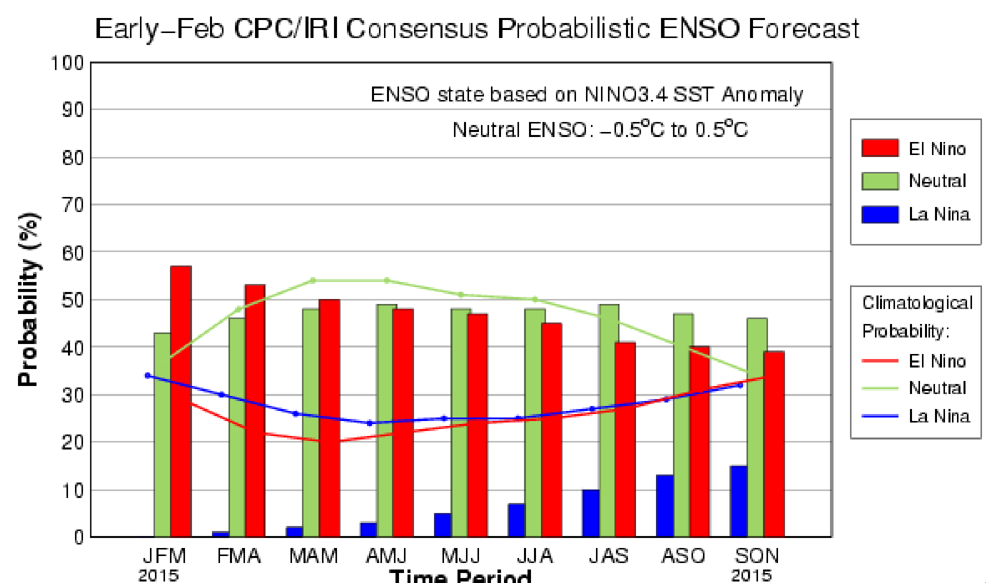
- **Positive SSTA more than +1°C persisted near Dateline.**
- **Positive HC300 anomalies propagated eastward and reached 150W, due to downwelling oceanic Kelvin waves.**
- **Westerly wind anomalies emerged in the far western equatorial Pacific in early Jan 2014 and reached the eastern Pacific in late Jan associated with the positive phase of MJO (blue color in CPC MJO indices).**

Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST is derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1981-2010 base period pentad means respectively.

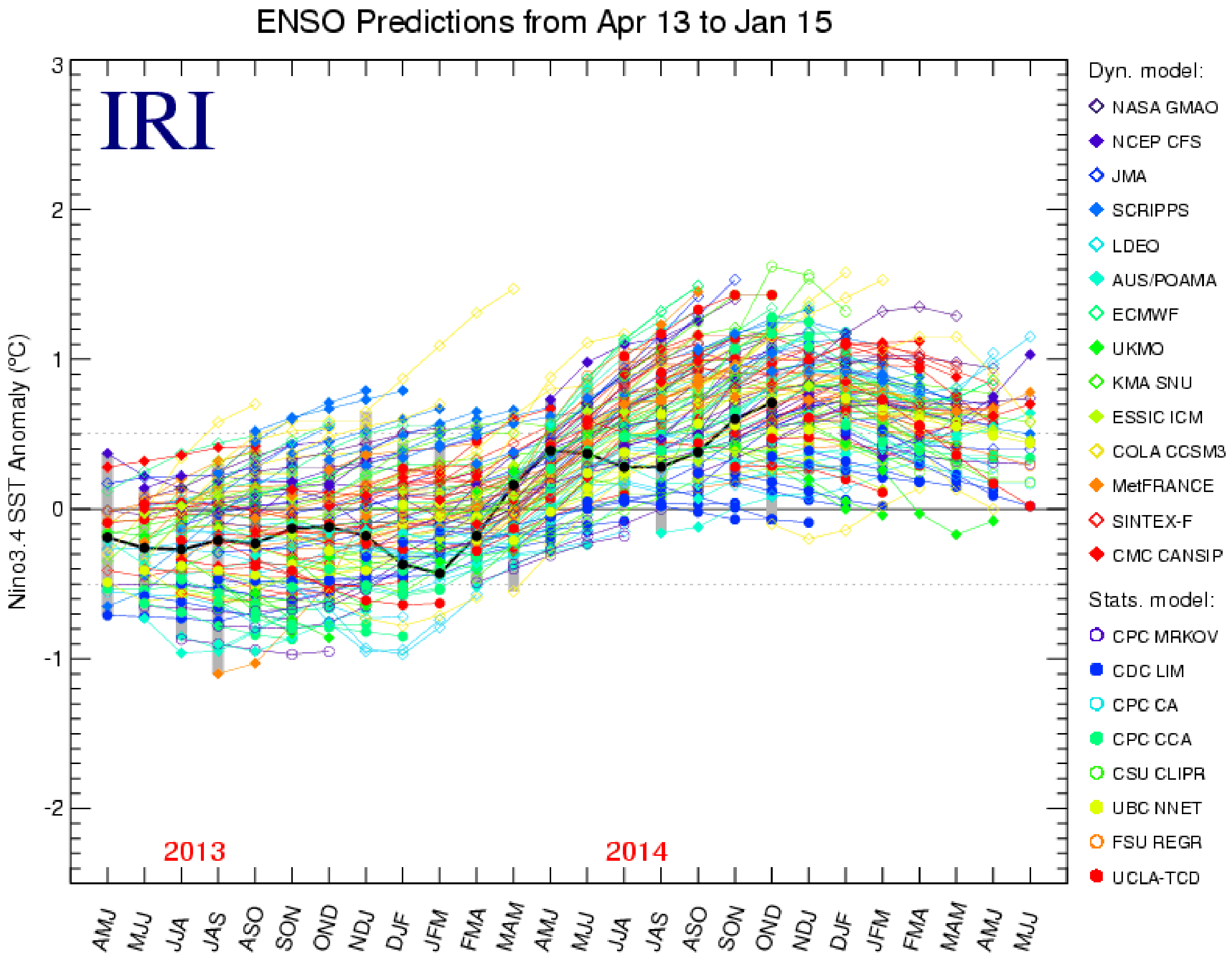
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- **Positive (negative) zonal current anomalies were associated with downwelling (upwelling) oceanic Kelvin waves.**


Mid-Jan 2015 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
Dynamical Model:
NCEP CFSv2
NASA GMAO
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
ESSIC ICM
COLA CCSM3
MetFRANCE
CS-IRI-MM
GFDL CM2.1
CMC CANSIP
GFDL CM2.5
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD
NINO3.4 SST Anomaly (°C)
OBS
FORECAST
OND Dec DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON
2014
2015

NINO3.4 Forecast Plume
SST CONSOLIDATION NINO 3.4
SST Anomaly (C)
OND NDJ DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ DJF JFM FMA
2014
2015
2016
TARGET SEASON
ISSUED: 30 JAN 2015
CON
MKV
CA
CFS
CCA
CFSv2
OBS

NMME Forecast for Nino 3.4 IC= 201501
OBS
CFSv2
CMC1
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NMME
JUL 2014
AUG
SEP
OCT
NOV
DEC
JAN 2015
FEB
MAR
APR
MAY
JUN
JUL
AUG

Early–Feb CPC/IRI Consensus Probabilistic ENSO Forecast
ENSO state based on NINO3.4 SST Anomaly
Neutral ENSO: –0.5°C to 0.5°C
El Nino
Neutral
La Nina
Climatological Probability:
El Nino
Neutral
La Nina
Probability (%)
JFM 2015
FMA
MAM
AMJ
MJJ
JJA
JAS
ASO
SON 2015
Time Period

Challenges in Forecasting this Event



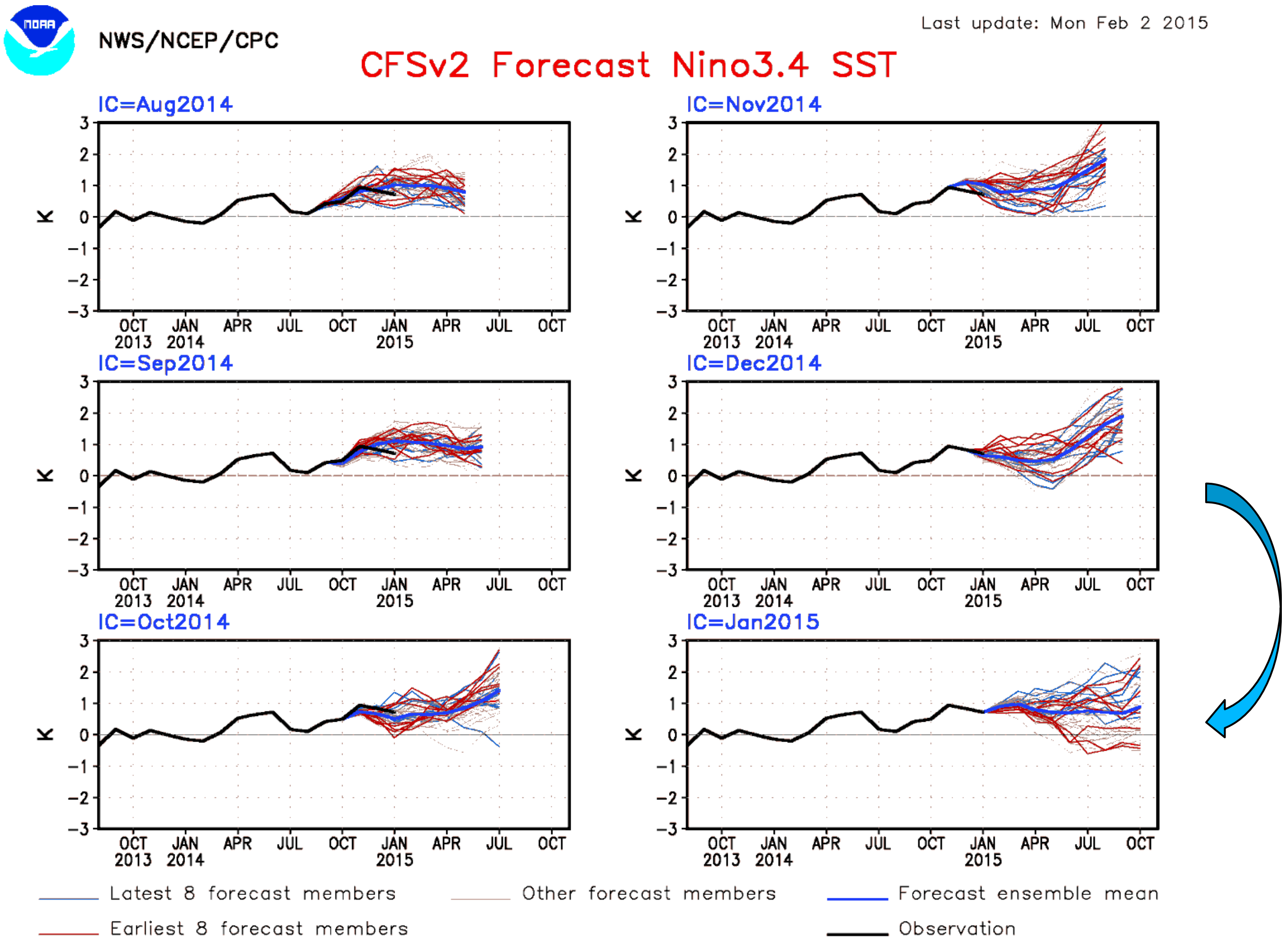
NOAA ENSO Blog

http://www.climate.gov/news-features/department/8443/all

US CLIVAR Variations on ENSO

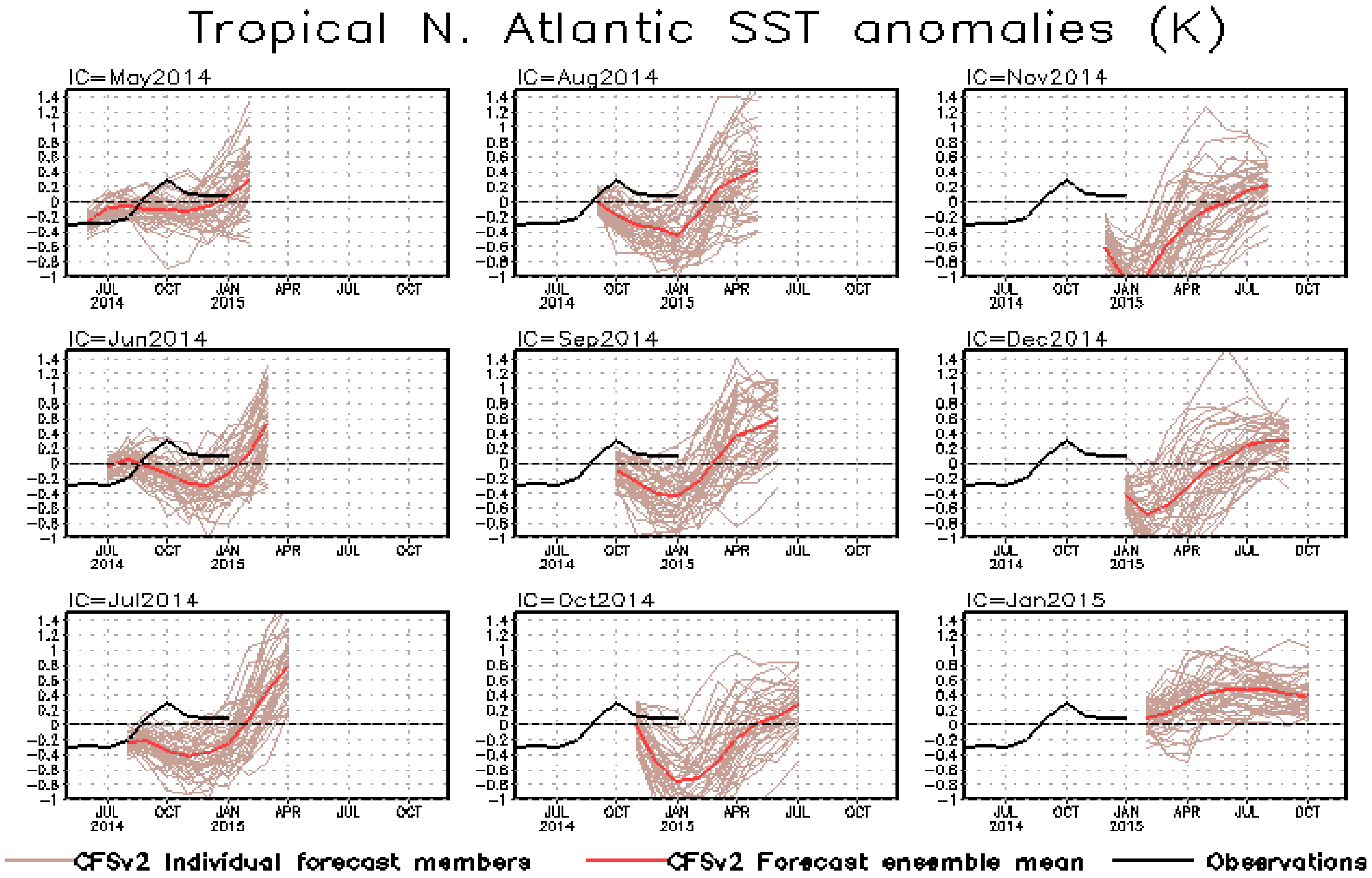
http://www.usclivar.org/sites/default/files/documents/2015/Variations2015Winter_0.pdf

NCEP CFSv2 NINO3.4 Forecast



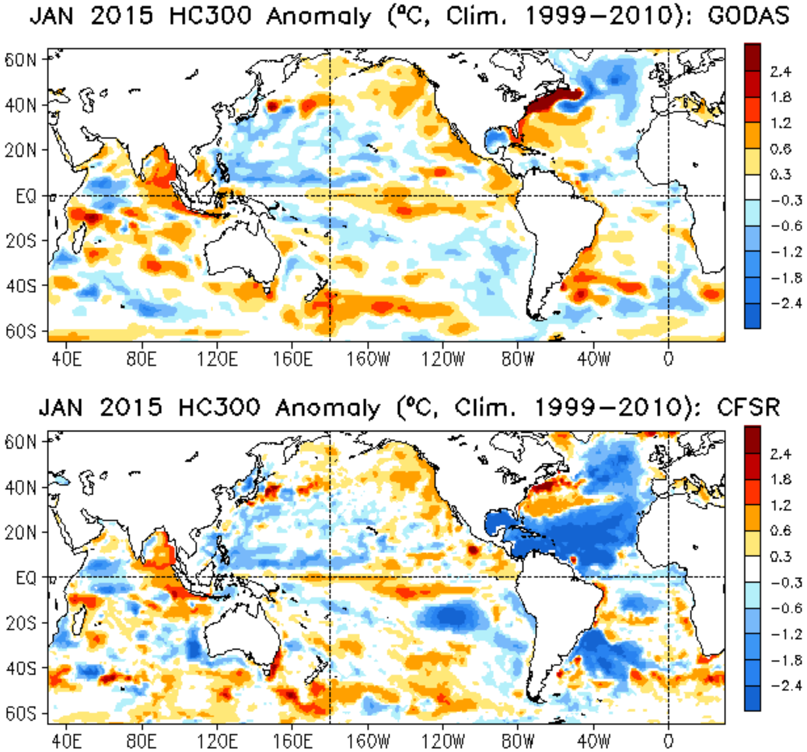
- The CFSv2 prediction from Jan I.C. suggests that the current weak warm conditions will not amplify after spring as suggested in the previous forecasts, rather it suggests the current warm conditions will persist from spring to fall.
- The spread among forecast members is larger than that in the previous forecasts.

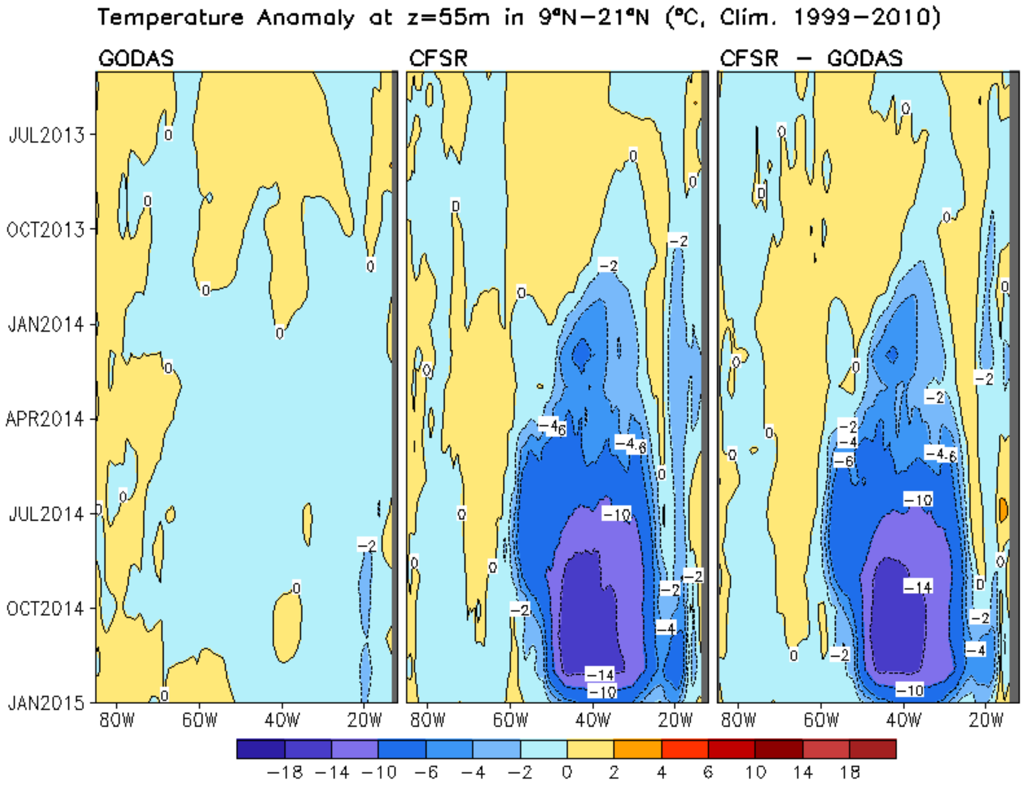
NCEP CFSv2 Tropical North Atlantic SST Forecast



- The forecasts have large cold biases starting from Jun to Dec I.C..
- However, the cold forecast biases seem gone starting from Jan I.C..
- This is probably related to the upgrade of CFSR on Jan. 14 that fixed the large cold biases in the tropical North Atlantic in CFSR (see next slide).

Impacts of CFSR on Tropical N. Atlantic SSTA Forecast





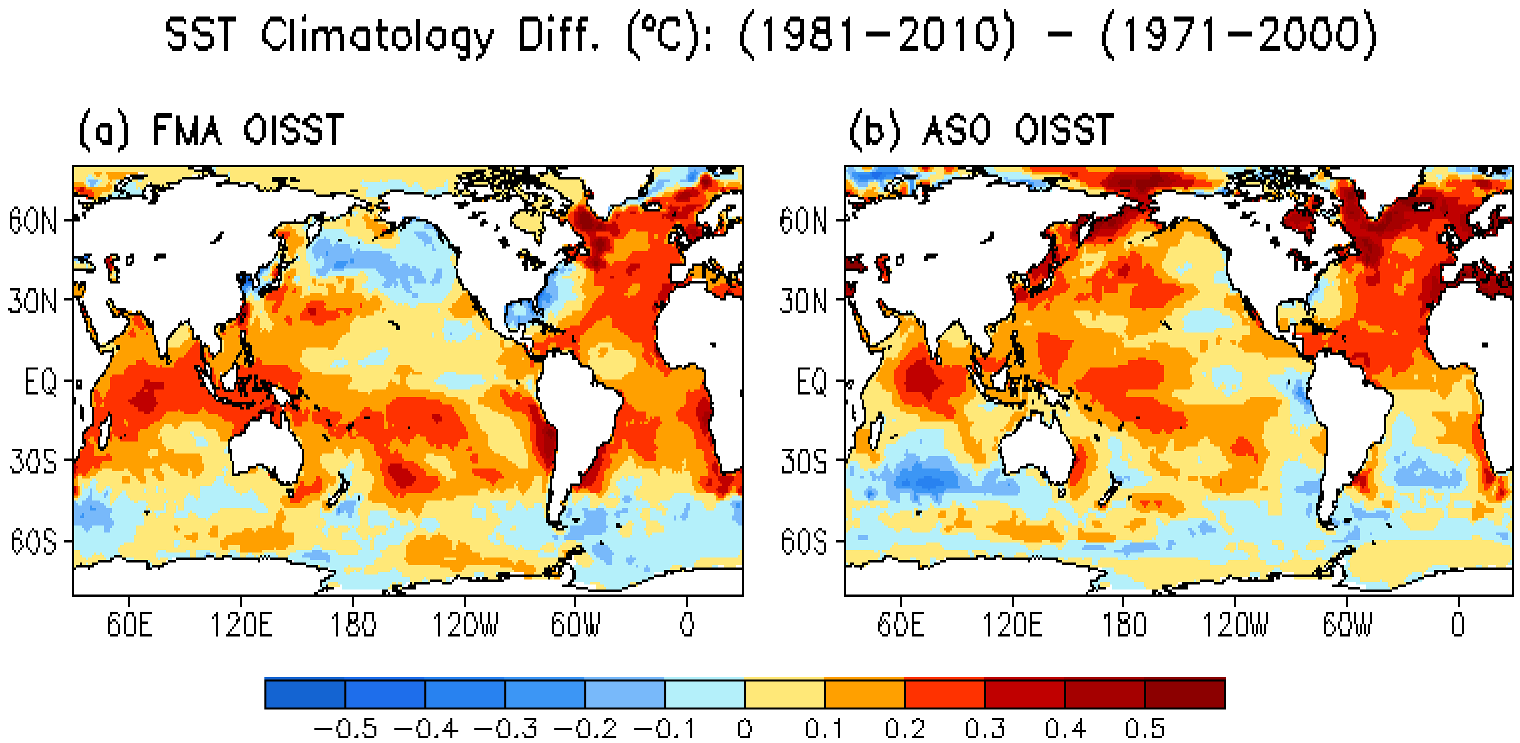
- Compared to GODAS, CFSR - initial conditions for CFSv2 - had large cold biases in North Atlantic, middle-latitude South Atlantic and some parts of South Pacific.
- The cold biases in the Atlantic Hurricane Main Development Region (MDR) emerged around **October 2013** and enhanced quickly with time. For example, the departure of temperature in MDR at 55m depth from GODAS grew to be **-10°C by Jul 2014**.
- The large cold biases in CFSR seem have been significantly alleviated by **the update of CFSR on Jan. 14 2015.**

Backup Slides

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**
  - **Aviso Altimetry Sea Surface Height (1993-2013)**
  - **Ocean Surface Current Analyses – Realtime (OSCAR) (1993-2005)**

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!