Challenges in Monitoring and Prediction for Current ENSO Conditions

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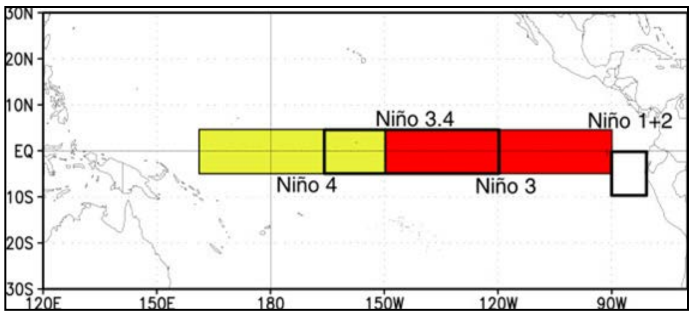
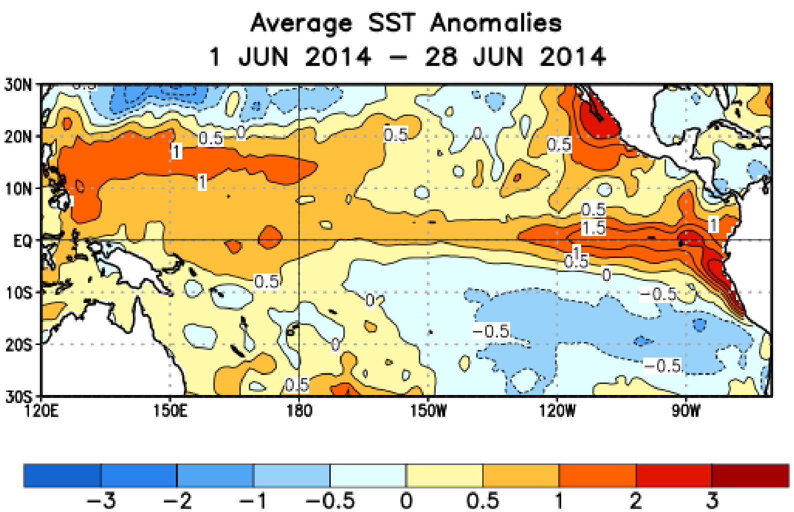
Climate Prediction Center, NCEP/NOAA

Acknowledgement: CPC/IRI ENSO Forecast Team, CPC Ocean Briefing Team, Real-Time Ocean Reanalysis Intercomparison Team

US CLIVAR Summit, Denver, July 8-11, 2014

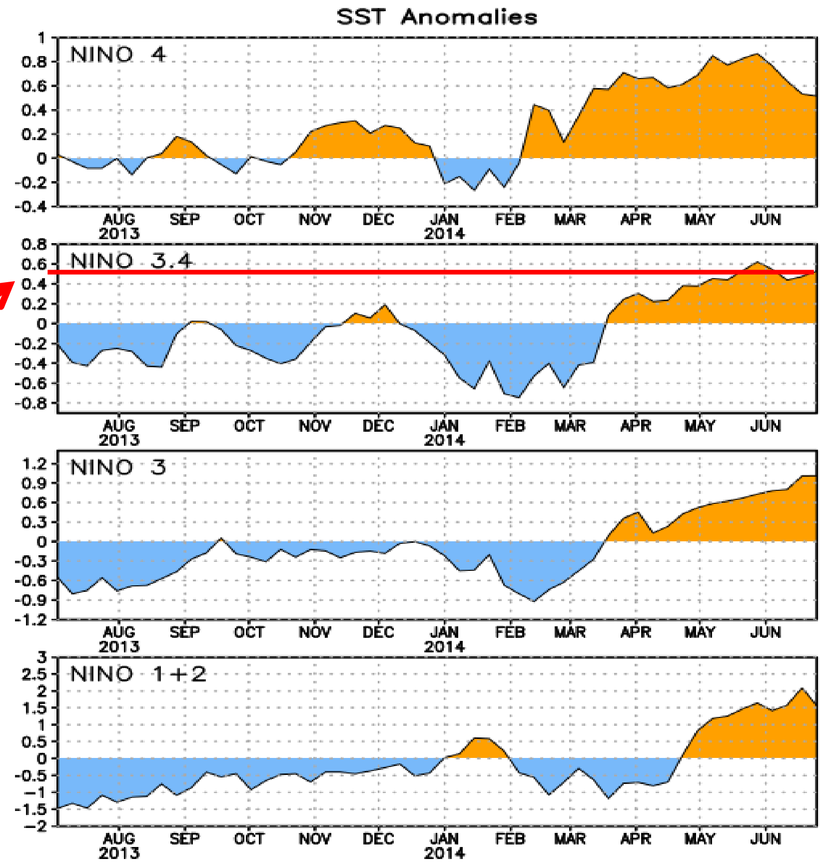
Weekly ENSO Update





http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml

Weekly OI.v2 SST



June NINO3.4=+0.5

NOAA considers El Niño or La Niña conditions to occur when the monthly Niño3.4 OISST departures meet or exceed + / - 0.5°C along with consistent atmospheric features. These anomalies must also be forecasted to persist for 3 consecutive months.

Oceanic Nino Index (ONI) Derived from ERSST.v3b

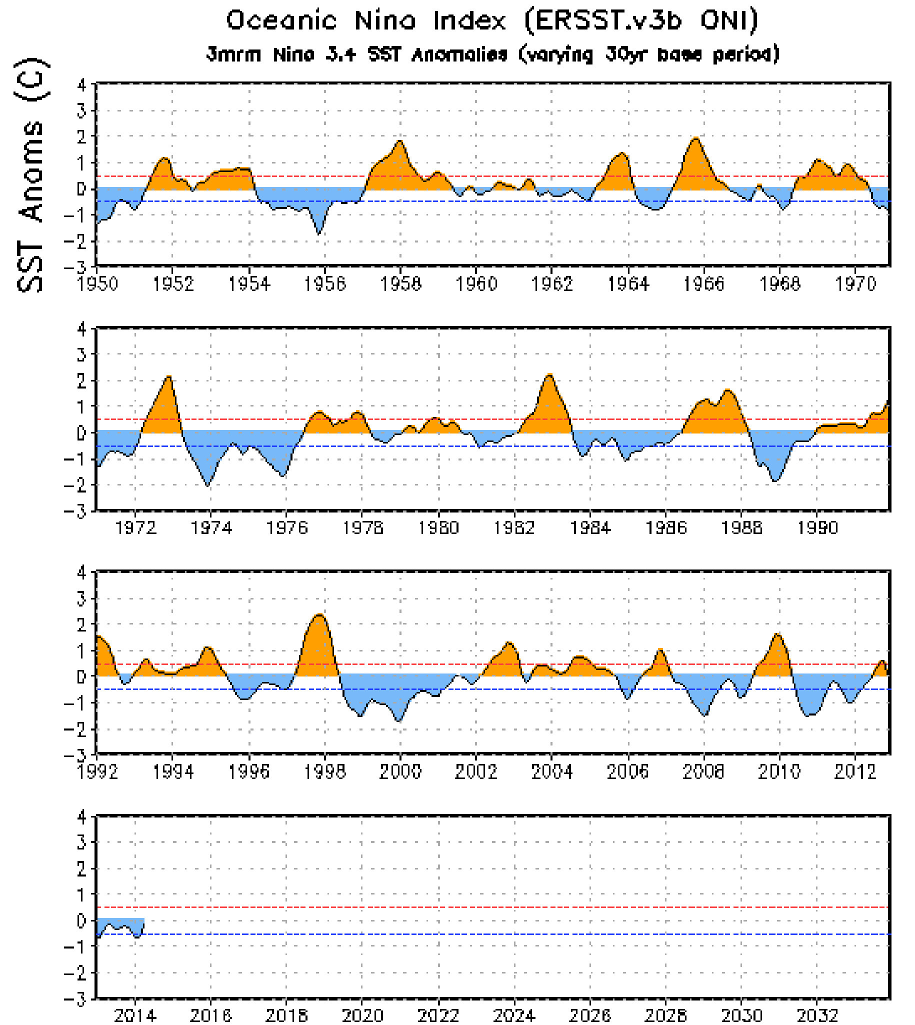
- **NOAA's operational definitions of El Niño and La Niña are keyed to the ONI index**
- **The ONI is defined as three-month running-mean Niño3.4 SST Anomalies**
- **El Niño (La Niña) is characterized by a ONI greater (less) than or equal to +0.5°C (-0.5°C).**
- **To be classified as a full-fledged episode, these thresholds must be exceeded for a period of at least 5 consecutive overlapping 3-month seasons.**

The most recent ONI value (April – June 2014) is 0.19°C.

El Niño

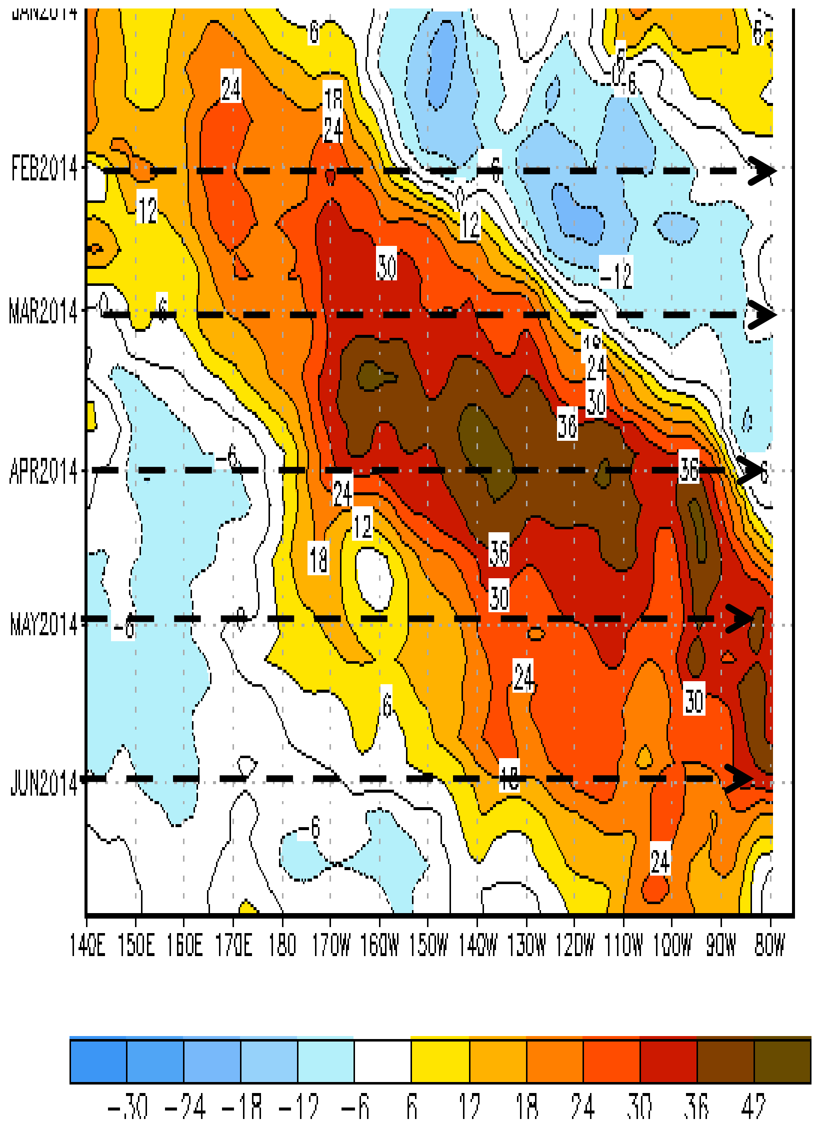
Neutral

La Niña

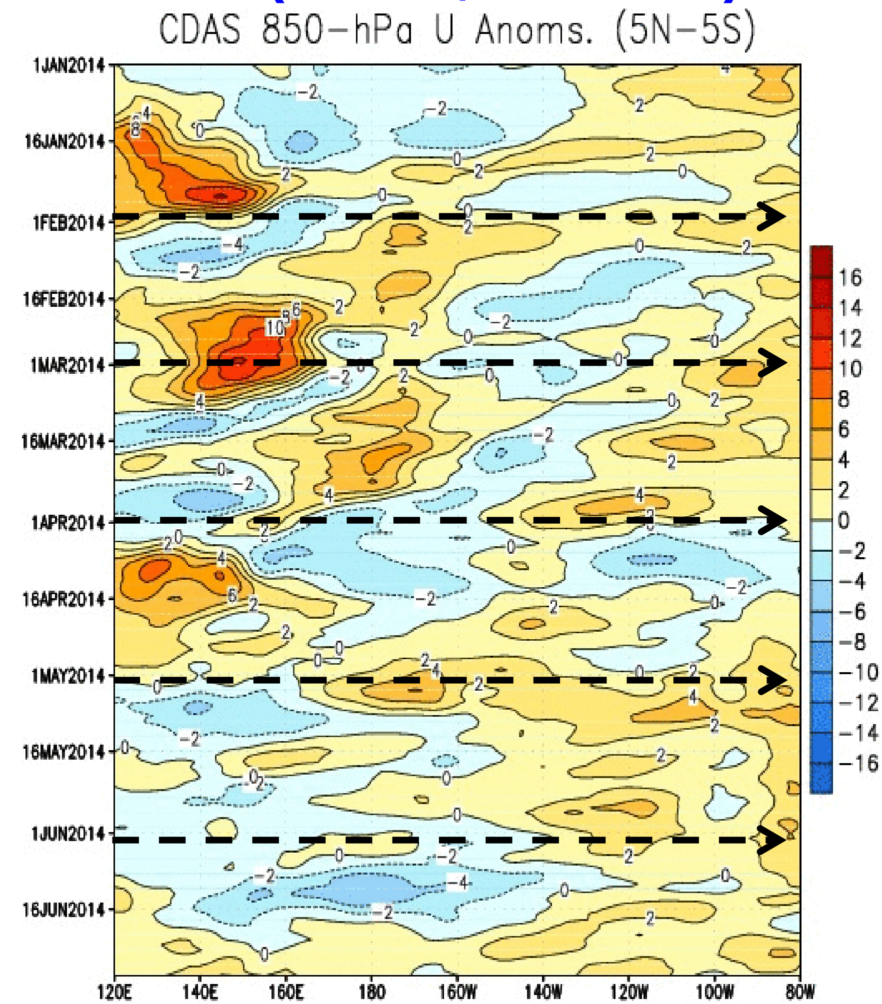


http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Depth of 20C Isotherm Anomaly (2S-2N, GODAS)



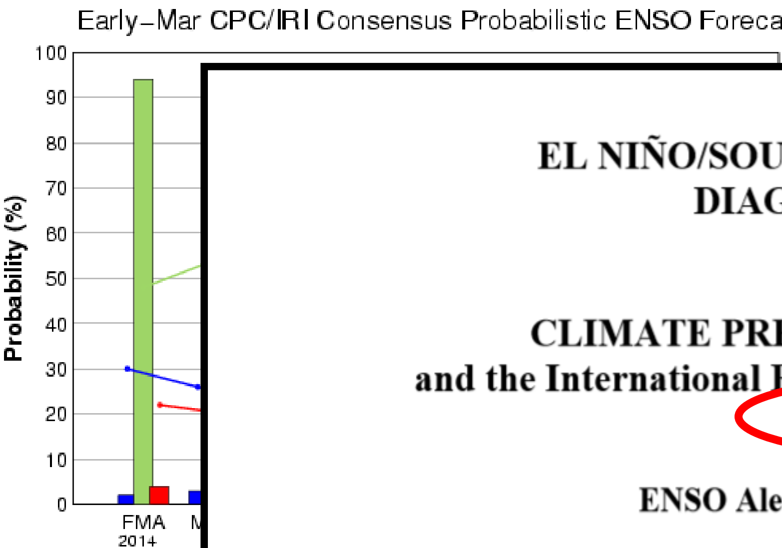
850mb Zonal Wind Anomaly (5S-5N, NCEP R1)

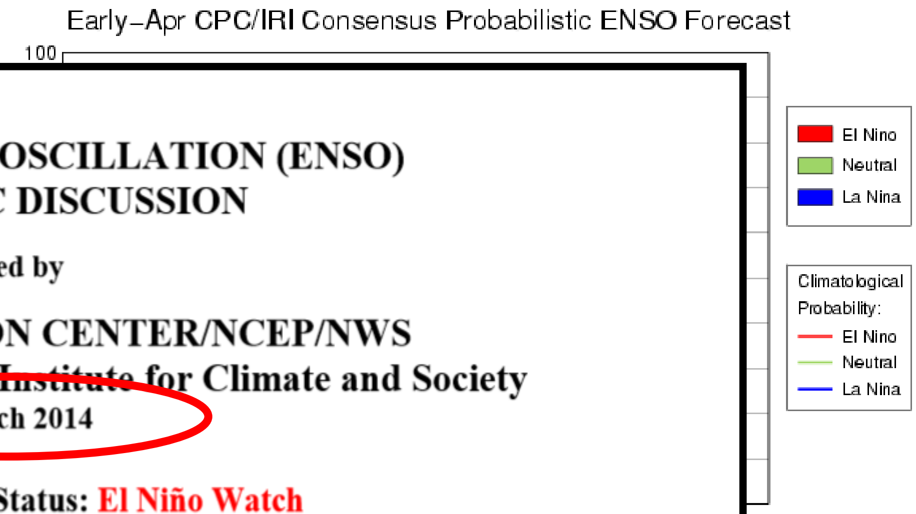


http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml

Consensus Forecast by CPC/IRI Forecasters

50% in summer/fall | **50-65% in summer/fall/winter**





EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by

CLIMATE PREDICTION CENTER/NCEP/NWS and the International Research Institute for Climate and Society

6 March 2014

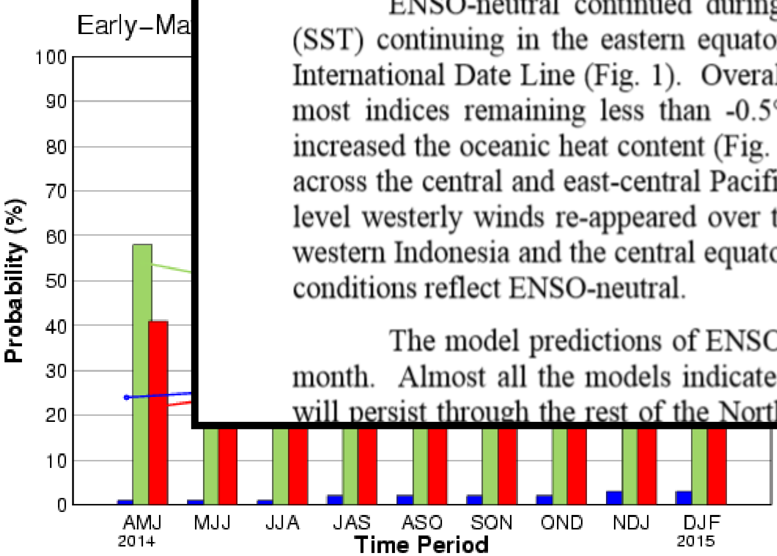
ENSO Alert System Status: El Niño Watch

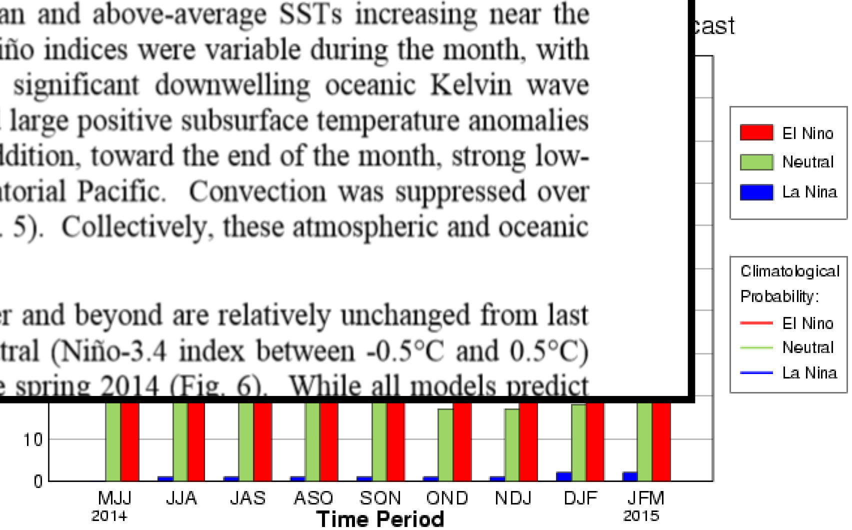
Synopsis: ENSO-neutral is expected to continue through the Northern Hemisphere spring 2014, with about a 50% chance of El Niño developing during the summer or fall.

ENSO-neutral continued during February 2014, with below-average sea surface temperatures (SST) continuing in the eastern equatorial Pacific Ocean and above-average SSTs increasing near the International Date Line (Fig. 1). Overall, the weekly Niño indices were variable during the month, with most indices remaining less than -0.5°C (Fig. 2). A significant downwelling oceanic Kelvin wave increased the oceanic heat content (Fig. 3) and produced large positive subsurface temperature anomalies across the central and east-central Pacific (Fig. 4). In addition, toward the end of the month, strong low-level westerly winds re-appeared over the western equatorial Pacific. Convection was suppressed over western Indonesia and the central equatorial Pacific (Fig. 5). Collectively, these atmospheric and oceanic conditions reflect ENSO-neutral.

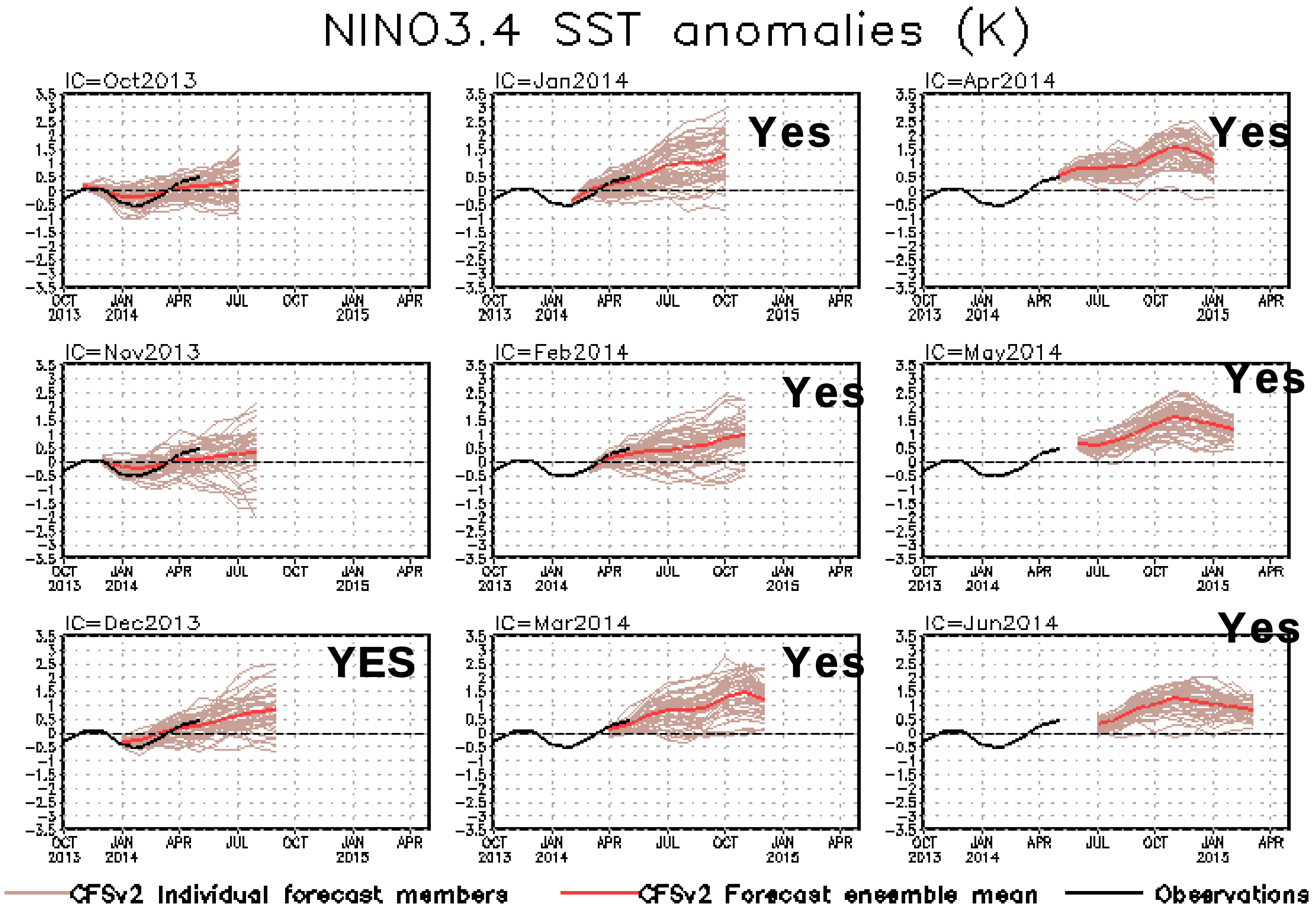
The model predictions of ENSO for this summer and beyond are relatively unchanged from last month. Almost all the models indicate that ENSO-neutral (Niño-3.4 index between -0.5°C and 0.5°C) will persist through the rest of the Northern Hemisphere spring 2014 (Fig. 6). While all models predict

65-75 … **nter**

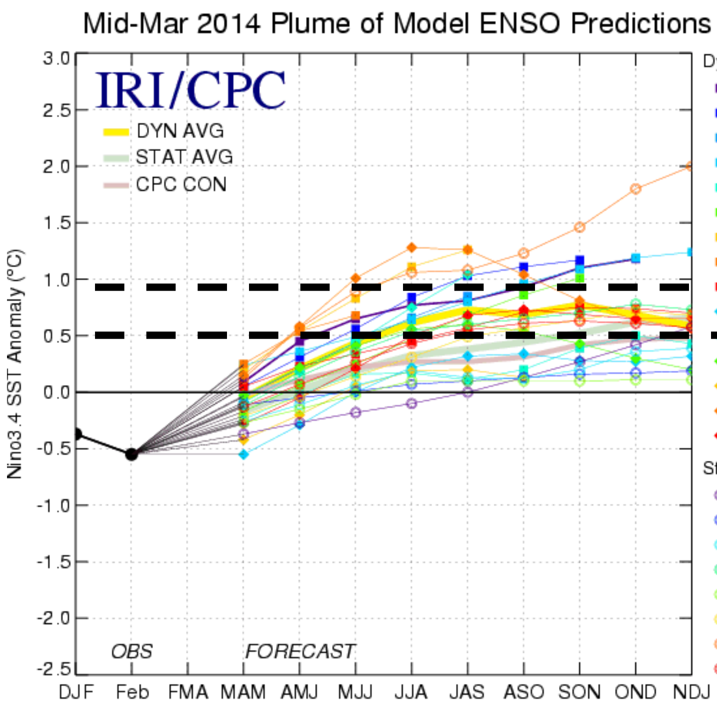
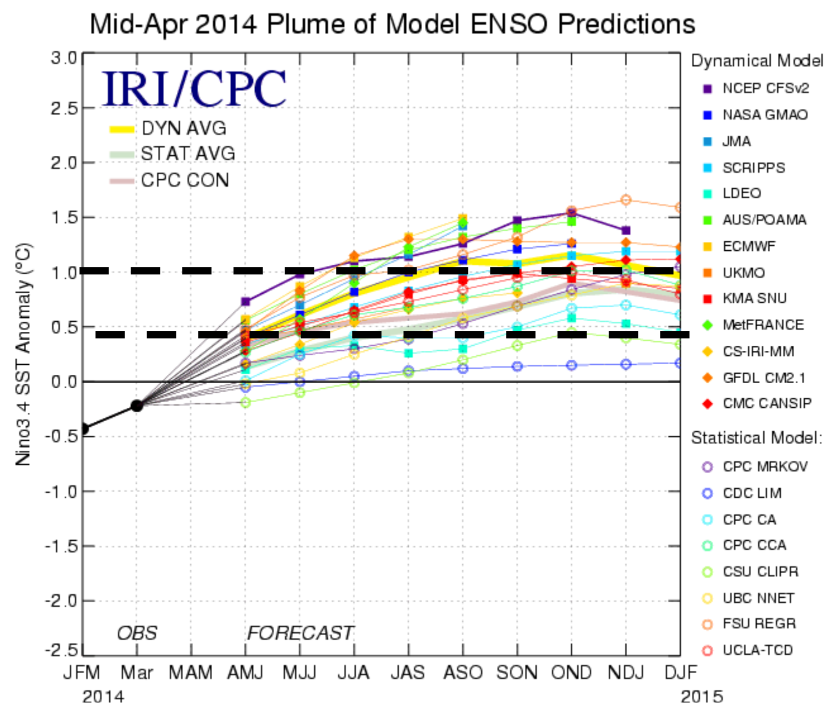




NCEP CFSv2 NINO3.4 Forecast



CFS Nino3.4 SST prediction 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). Anomalies were computed with respect to the 1981-2010 base period means.


Mid-Mar 2014 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
Nino3.4 SST Anomaly (°C)
OBS
FORECAST
DJF Feb FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
Dynamical Model:
NCEP CFSv2
NASA GMAO
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
COLA CCSM3
MetFRANCE
SINTEX-F
CS-IRI-MM
GFDL CM2.1
CMC CANSIP
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD

Mid-Apr 2014 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
Nino3.4 SST Anomaly (°C)
OBS
FORECAST
JFM Mar MAM AMJ MJJ JJA JAS ASO SON OND NDJ DJF
2014
2015
Dynamical Model:
NCEP CFSv2
NASA GMAO
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
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CPC MRKOV
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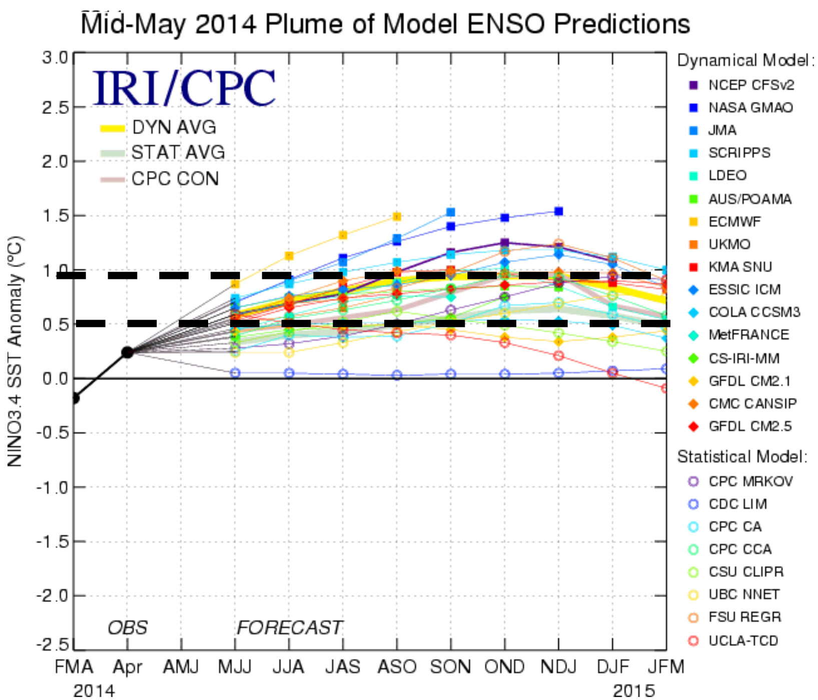
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD

Mid-May 2014 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
NINO3.4 SST Anomaly (°C)
OBS
FORECAST
FMA Apr AMJ MJJ JJA JAS ASO SON OND NDJ DJF JFM
2014
2015
Dynamical Model:
NCEP CFSv2
NASA GMAO
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
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CMC CANSIP
GFDL CM2.5
Statistical Model:
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CDC LIM
CPC CA
CPC CCA
CSU CLIPR
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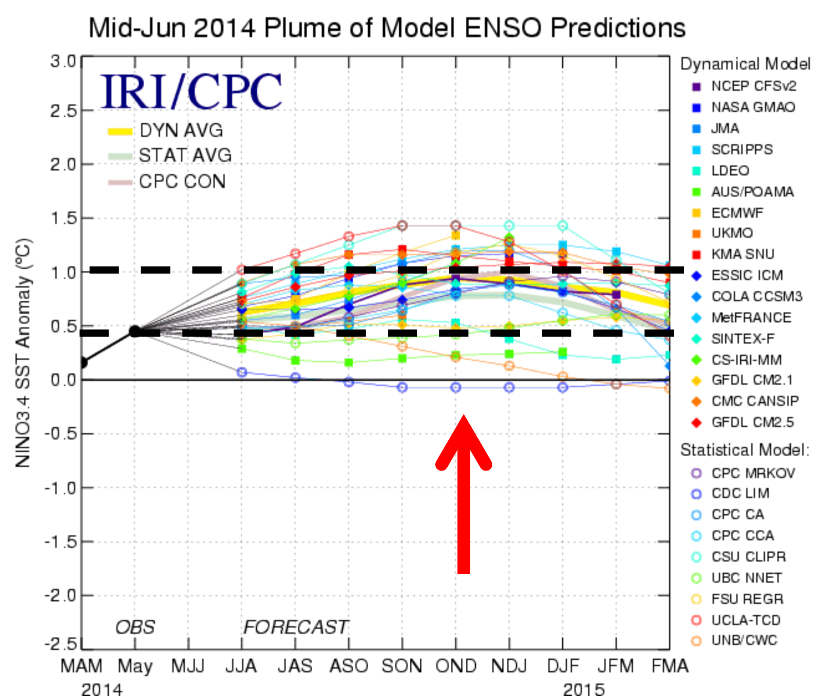
UCLA-TCD

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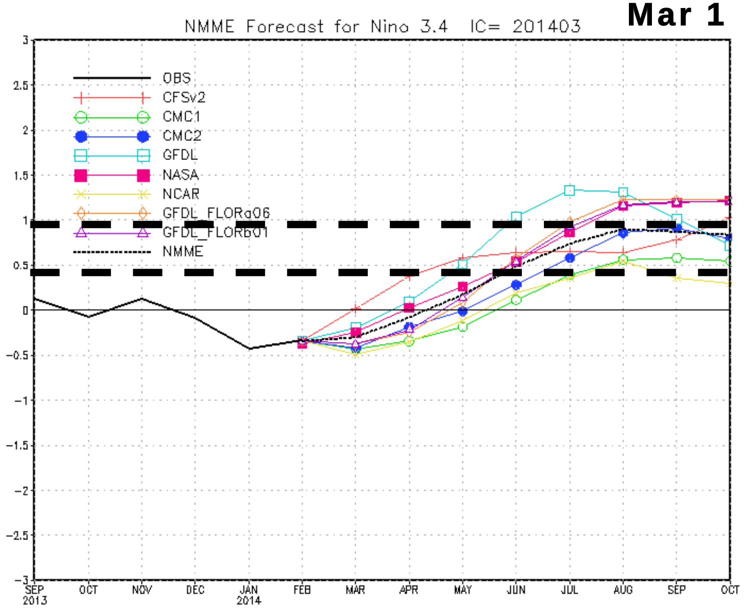
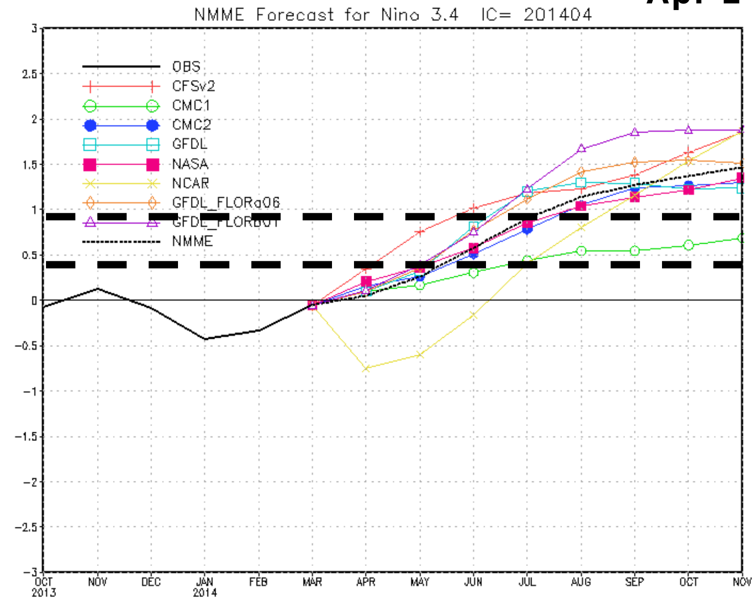
CMC CANSIP
GFDL CM2.5
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD
UNB/CWC

National Multi-Model Ensemble

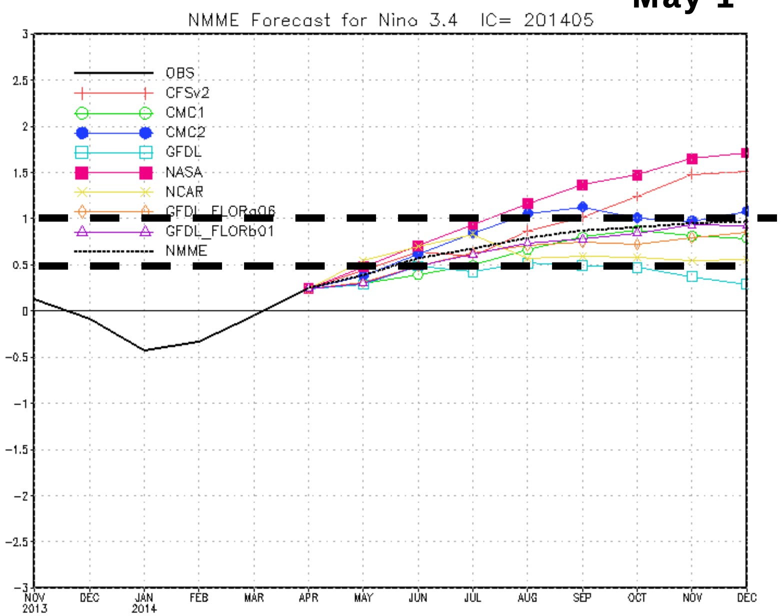
Mar 1



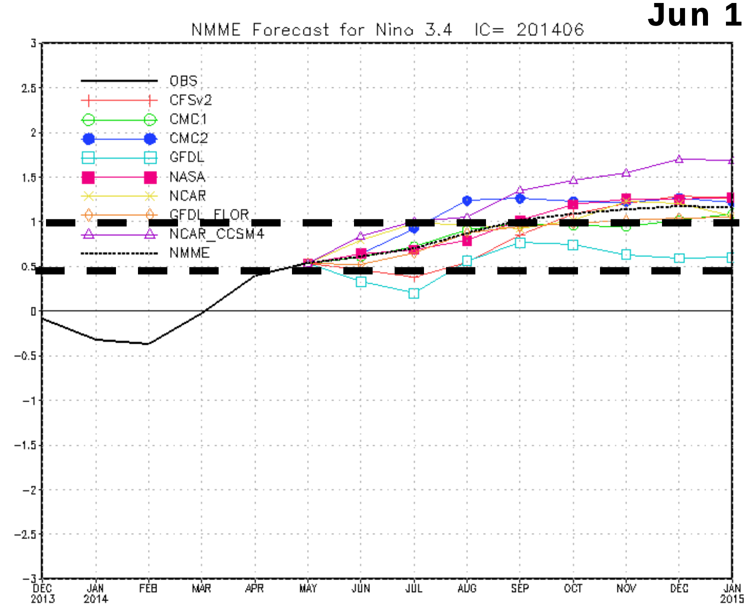
Apr 1



May 1

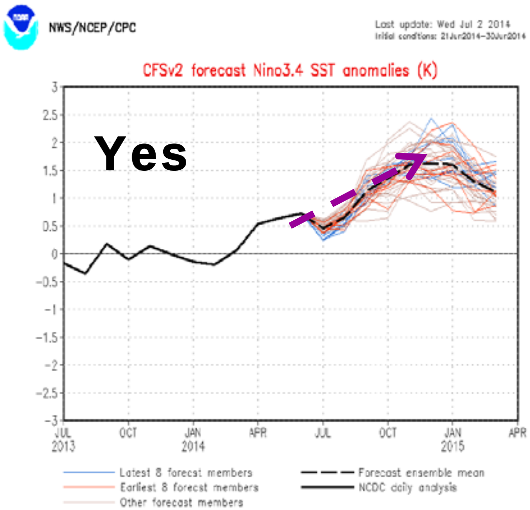


Jun 1

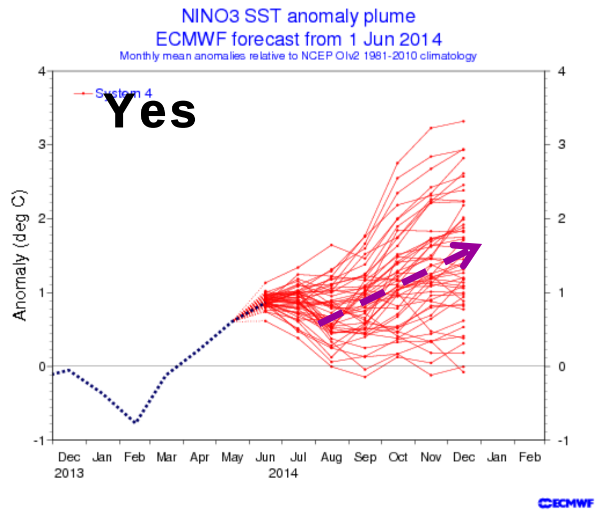


Individual Model Forecasts

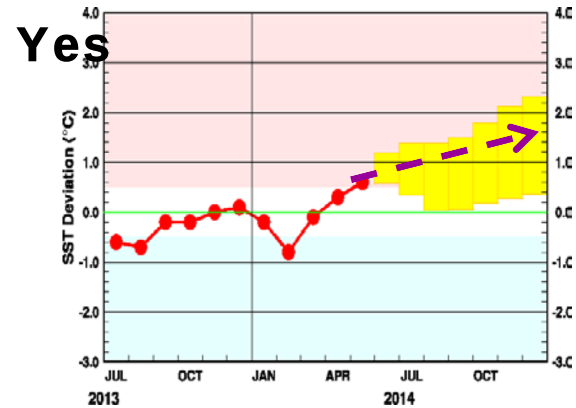
NCEP/CFSv2



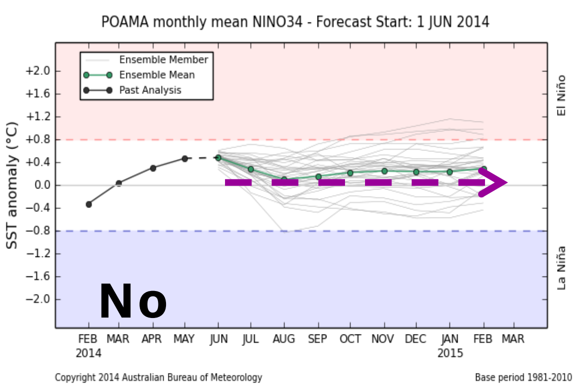
ECMWF



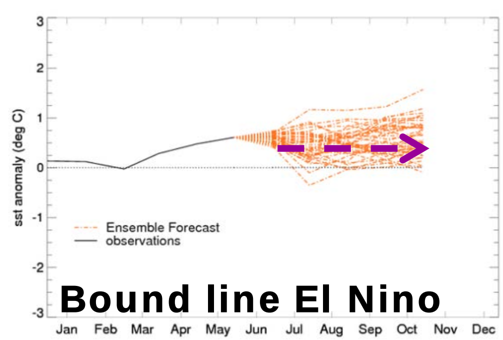
JMA



AUS/POAMA

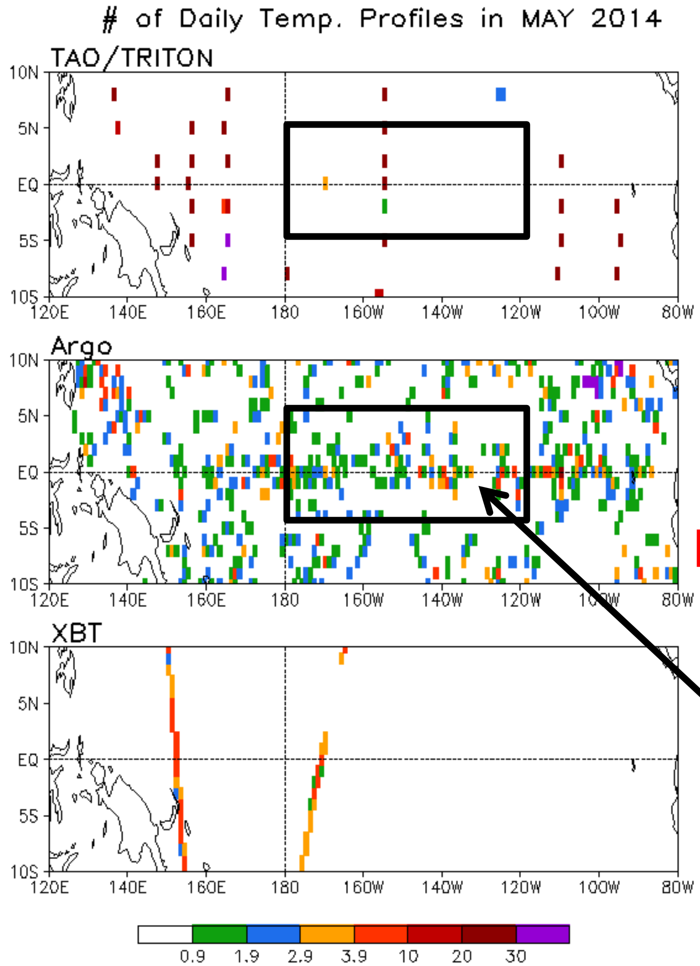


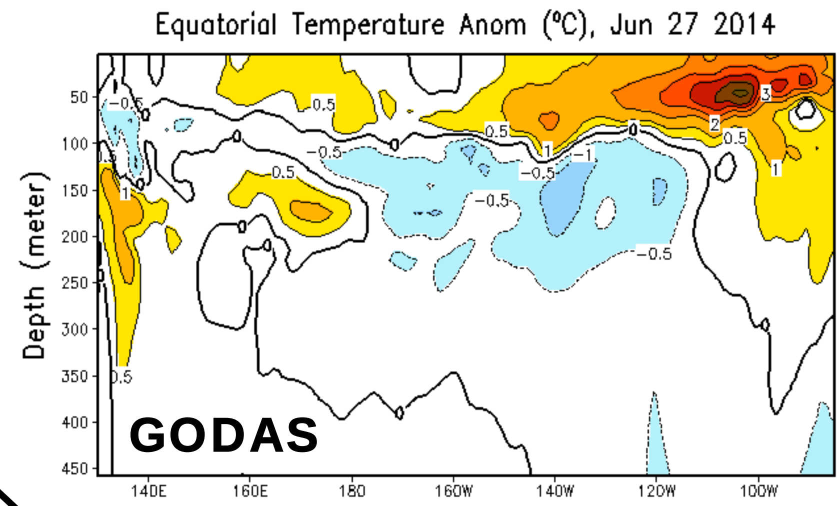
UKMO



- **Is El Nino coming?**
- **How strong is the El Nino?**
- **When will El Nino peak?**

Ocean Observations and Ocean Reanalyses

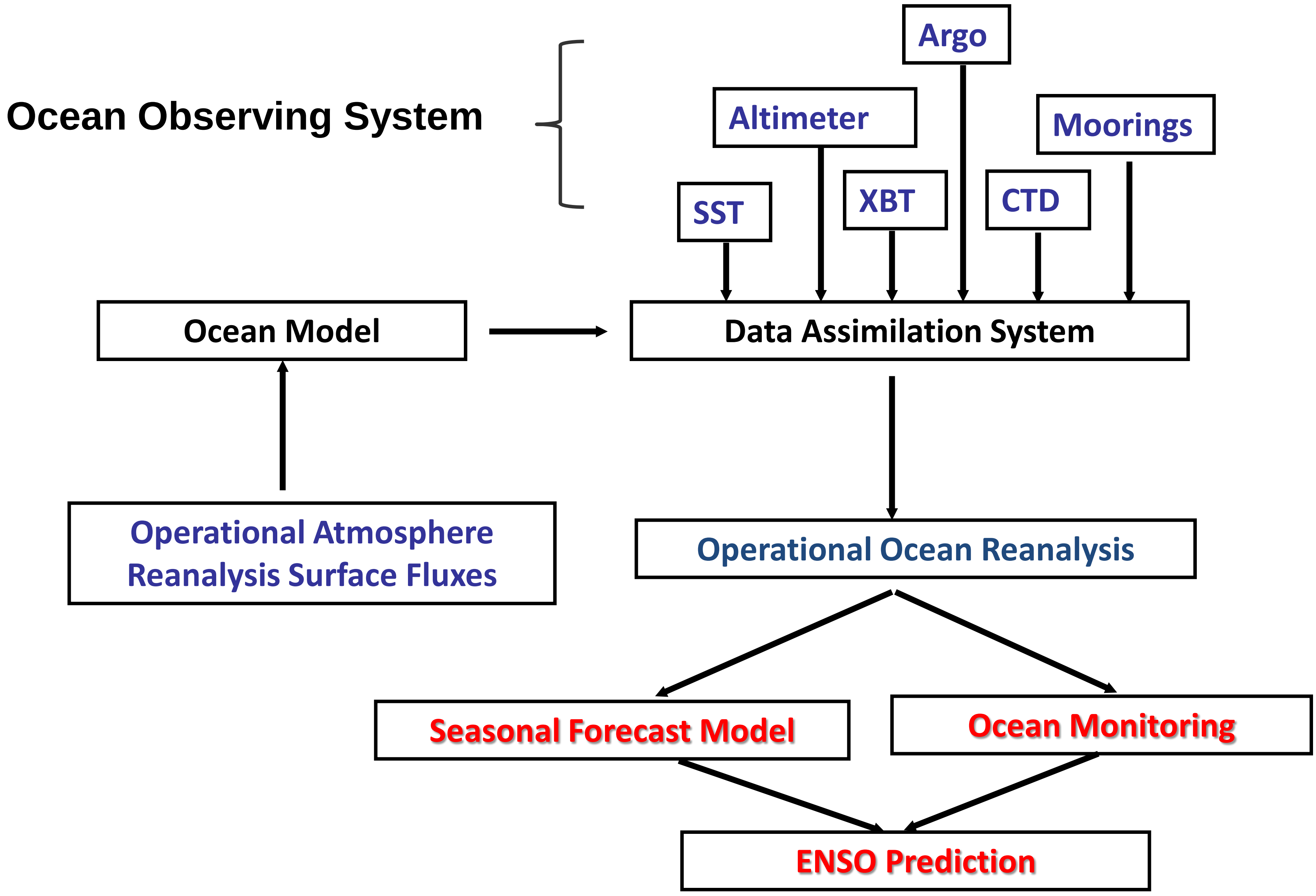




1-3 profiles per month from Argo

- **Real time ENSO monitoring**
- **Ocean initialization for seasonal predictions**
  - Behringer et al. 1998; Alves et al. 2003; Balmaseda et al. 2007; Balmaseda and Anderson 2009; Stockdale et al. 2011; Xue et al. 2013

Operational Ocean Reanalysis

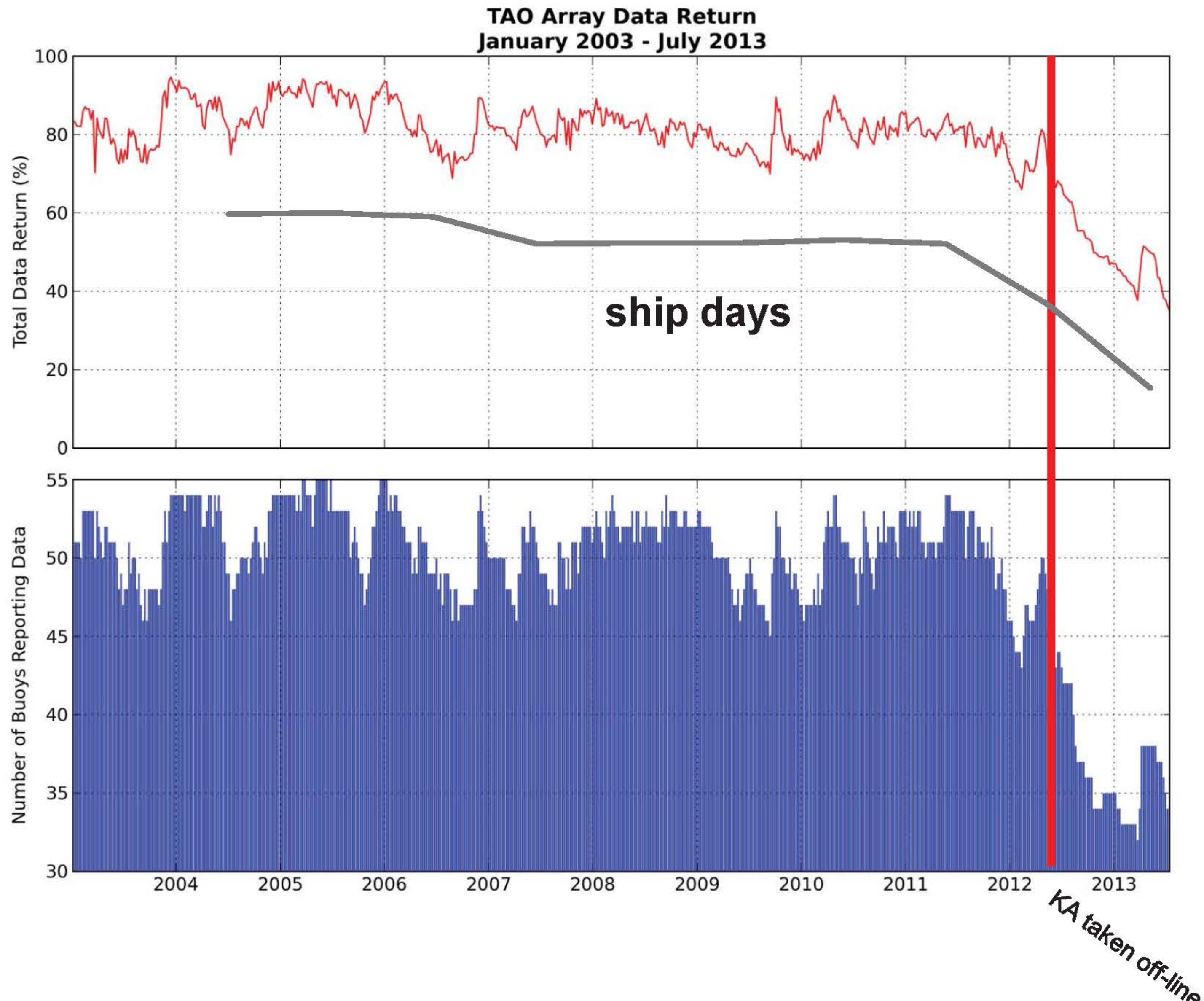


Operational Ocean Reanalyses

Name	Method & Forcings	In Situ Data	Altimetry Data	Resolution	Period	Vintage	Reference
EN3.v2a	Analysis Correction Scheme	No XBT corrections	No	1° x 1°, 42 Levels Monthly Temp.	1950-present	2009	Ingleby and Huddleston (2007)
NODC	Objective Analysis	No XBT corrections	No	1° x 1°, 16 Levels, 0 to 700m Seasonal Temp.	1955-present	2010	Levitus et al. (2009)
GODAS	3D-VAR	No XBT corrections	NO (Yes in real time)	1° x 1° (1/3° near Eq), 40 Levels Pentad, Monthly	1979-present	2003	Behringer and Xue (2004
ECMWF (S3)	OI	No XBT corrections	Yes	1° x1° (1/3° near Eq), 29 Levels Daily, Monthly	1959-present	2007	Balmaseda et al. (2008)
JMA	3D-VAR	No XBT corrections	Yes	1° x1° (1/3° near Eq), 50 Levels Pentad, Monthly	1979-present	2009	Usui et al. (2006)
CFSR	3D-VAR Partially coupled	No XBT corrections	No (Yes in real time)	1/2° x 1/2° (1/4° near Eq), 40 Levels Daily, Pentad, Monthly	1979-present	2010	Xue et al. (2010)
GFDL	EnKF Fully coupled	XBT corrections	Yes	1° x 1° (1/3° near Eq), 50 Levels Daily, Pentad, Monthly	1970-present	2010	Zhang et al. (2009)
GMAO	EnOI Fully coupled	XBT corrections	No	1/2° x 1/2° (1/4° near Eq), 40 Levels Daily, Monthly	1980-present	2011	Rienecker at al. (2011)
MERCATOR (PSY2G2)	KF-SEEK	No XBT corrections	Yes	2° x 2° (1/2° near Eq), 31 Levels Daily, Pentad, Monthly	1979-present	2007	Drévillon et al. (2008)
BOM (PEODAS)	EnKF	No XBT corretions	No	2° x 1.5 ° (1/2° near Eq.), 25 Levels Daily, Monthly	1980-present	2009	Yin et al. (2010)

Xue et al. 2012, J. Climate

Climate Observation Division
Historical TAO reporting + ship resourcing



Tropical Pacific Observing System (TPOS) 2020 Workshop

(January 27-30, 2014, La Jolla, CA)

- **Highlight the impacts** of the tropical Pacific observing system on information/services of societal relevance – **ENSO monitoring and prediction**
- **Evaluate existing and potential requirements** for sustained observations of ocean variables in tropical Pacific Ocean – **uncertainties in ocean estimation in tropical Pacific**
- **Evaluate the adequacy of existing observing strategies**
- **Recommend revisions and/or adjustments** to enhance resilience, efficiency, integration.
- **Evaluate logistical requirements** for implementation of the recommended Tropical Pacific Observing System.
- **Assess readiness of new technologies**, their potential impact and feasibility in addressing requirements, and/or lowering costs per observation.

Courtesy of David Legler

Real-Time Ocean Renalyses Intercomparison

- **Extend CLIVAR-GSOP/GODAE OceanView Ocean Reanalyses Intercomparison Project (ORA-IP) into real time**
- **Assess uncertainties in temperature analysis of tropical Pacific in support of ENSO monitoring and prediction**
- **Explore any connections between gaps in ocean observations and spreads among ensemble ORAs**
- **Articulate needs for sustained ocean observing systems in support of TPOS2020**
- **Monitor signal-to-noise ratio in the global ocean temperature, 300m heat content, depth of 20C isotherm**

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

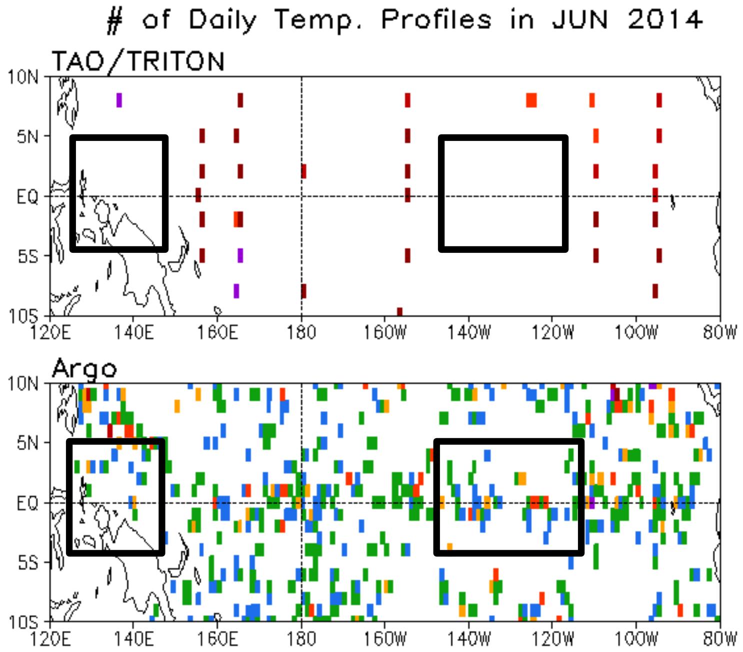
Real Time Multiple Ocean Reanalysis Intercomparison

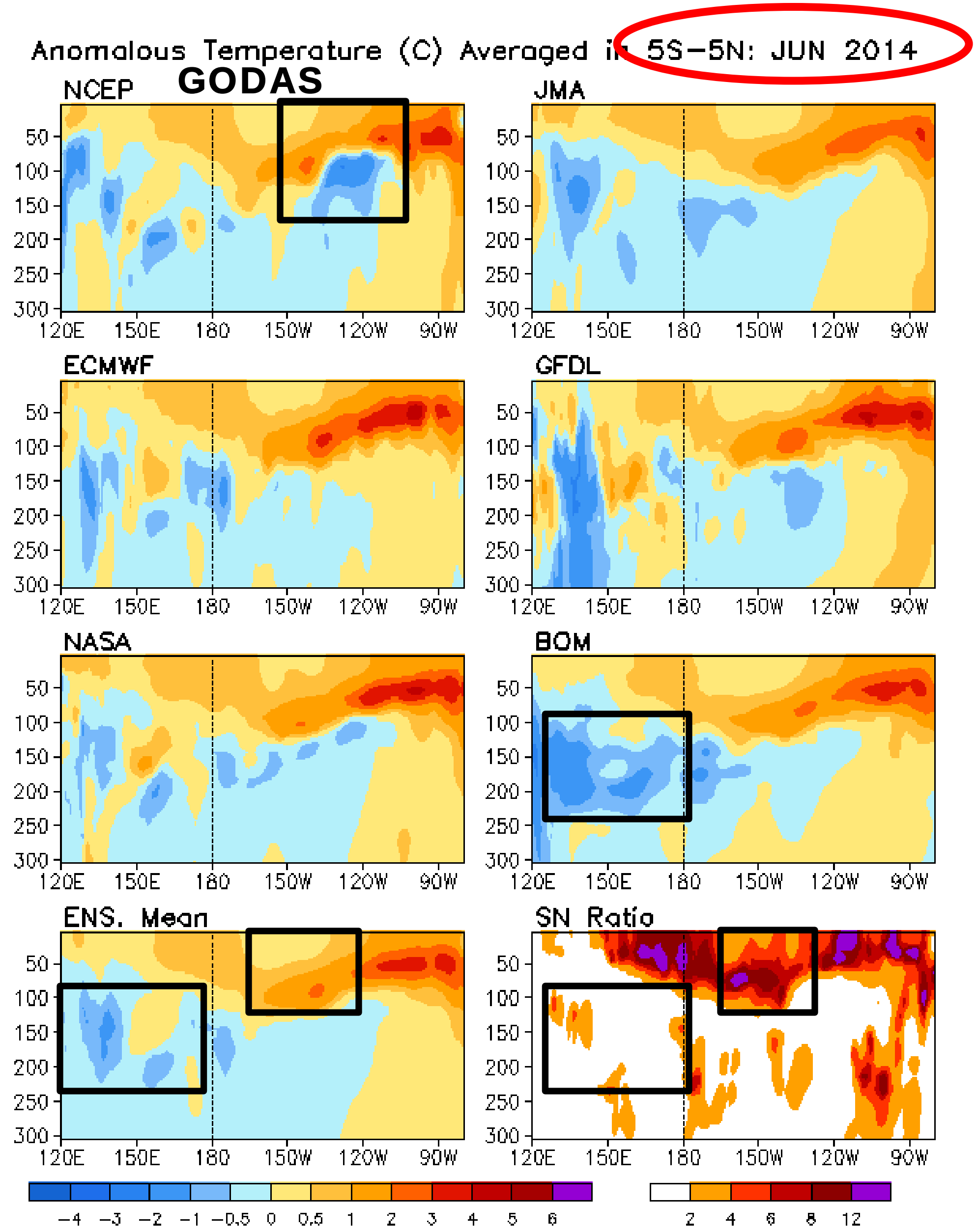
(with contributions from NCEP, ECMWF, JMA, GFDL, NASA, BOM based on 1981-2010 Climatology)

(Background Information)

Tropical Pacific Ocean

- **Climate Indices**
  - Depth of 20C isotherm anomaly in NINO3: last 4 years last 15 years 1979-present
  - Depth of 20C isotherm anomaly in NINO4: last 4 years last 15 years 1979-present
  - Upper 300m heat content anomaly in NINO3: last 4 years last 15 years 1979-present
  - Upper 300m heat content anomaly in NINO4: last 4 years last 15 years 1979-present
  - Warm Water Volume: last 4 years last 15 years 1979-present
  - Warm Water Volume average in last two months ending in: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
- **Spatial Maps**
  - Temperature anom. at z=5m (X-Y section): last month month before last month 1979-present
  - Temperature anom. at z=15m (X-Y section): last month month before last month 1979-present
  - Temperature anom. at z=35m (X-Y section): last month month before last month 1979-present
  - Temperature anom. at z=55m (X-Y section): last month month before last month 1979-present
  - Temperature anom. at z=75m (X-Y section): last month month before last month 1979-present
  - Temperature anom. at z=100m (X-Y section): last month month before last month 1979-present
  - Temperature anom. at z=150m (X-Y section): last month month before last month 1979-present
  - Temperature anom. in 1S-1N (X-Z section): last month month before last month 1979-present
  - Temperature anom. in 5N-10N (X-Z section): last month month before last month 1979-present
  - Temperature anom. in 10S-5S (X-Z section): last month month before last month 1979-present
  - Temperature anom. in 120W-90W (Y-Z section): last month month before last month 1979-present
  - Temperature anom. in 150W-120W (Y-Z section): last month month before last month 1979-present
  - Temperature anom. in 160E-150W (Y-Z section): last month month before last month 1979-present
  - Temperature anom. in 130E-160E (Y-Z section): last month month before last month 1979-present
  - Depth of 20C isotherm anomaly: last month month before last month 1979-present
  - Upper 300m heat content anomaly: last month month before last month 1979-present





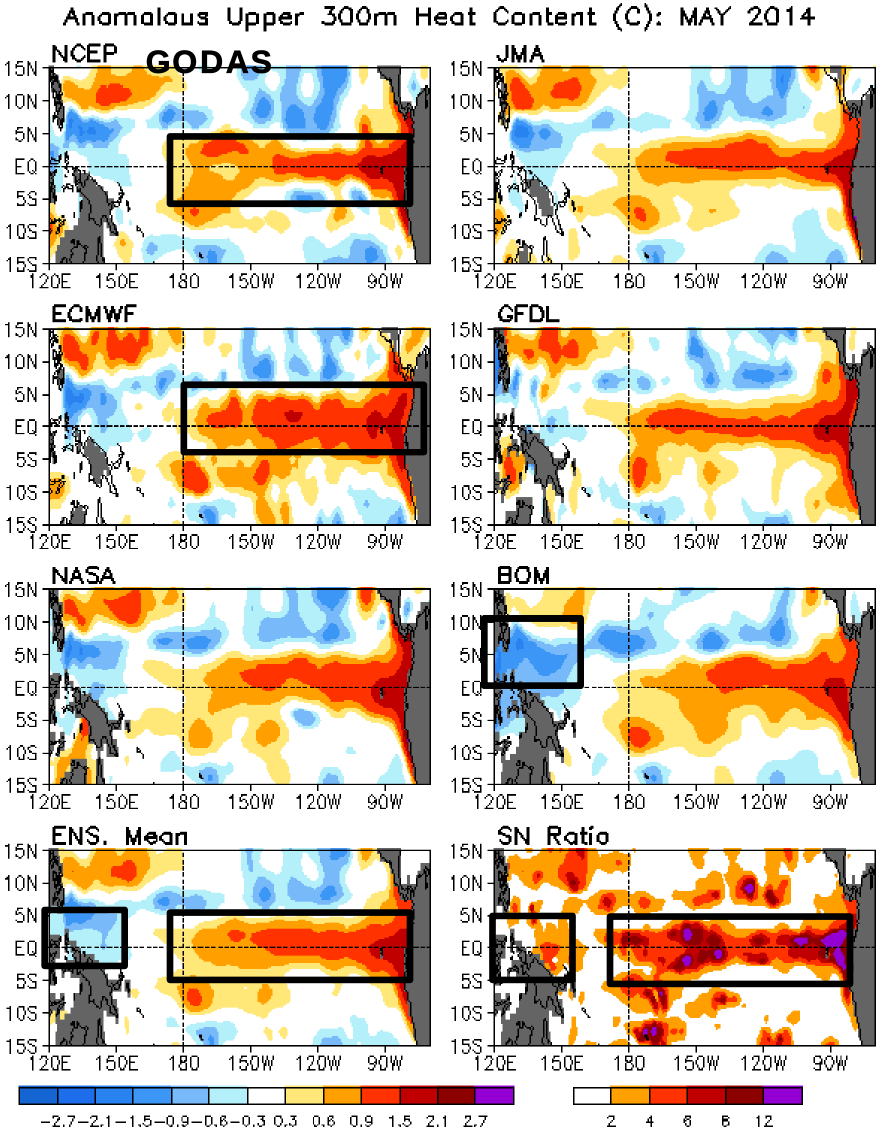
-The ensemble mean (ensemble spread) can be used to measure signal (noise).

- The signal-to-noise (SN) ratio is relatively low in the western (central-eastern) Pacific where negative (positive) anomalies presented.

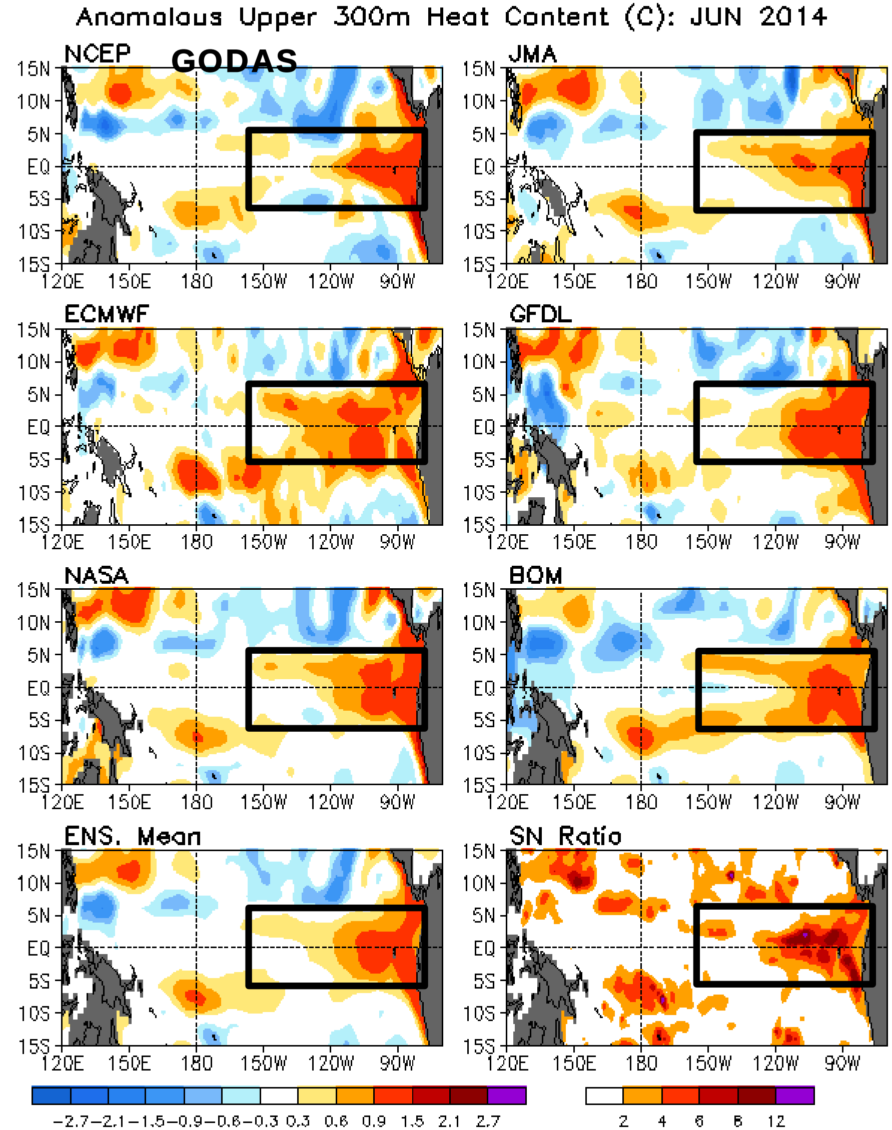
- The low signal-to-noise ratio may be partially attributed to the sparse observations in those regions.

Upper 300m Heat Content Anomaly

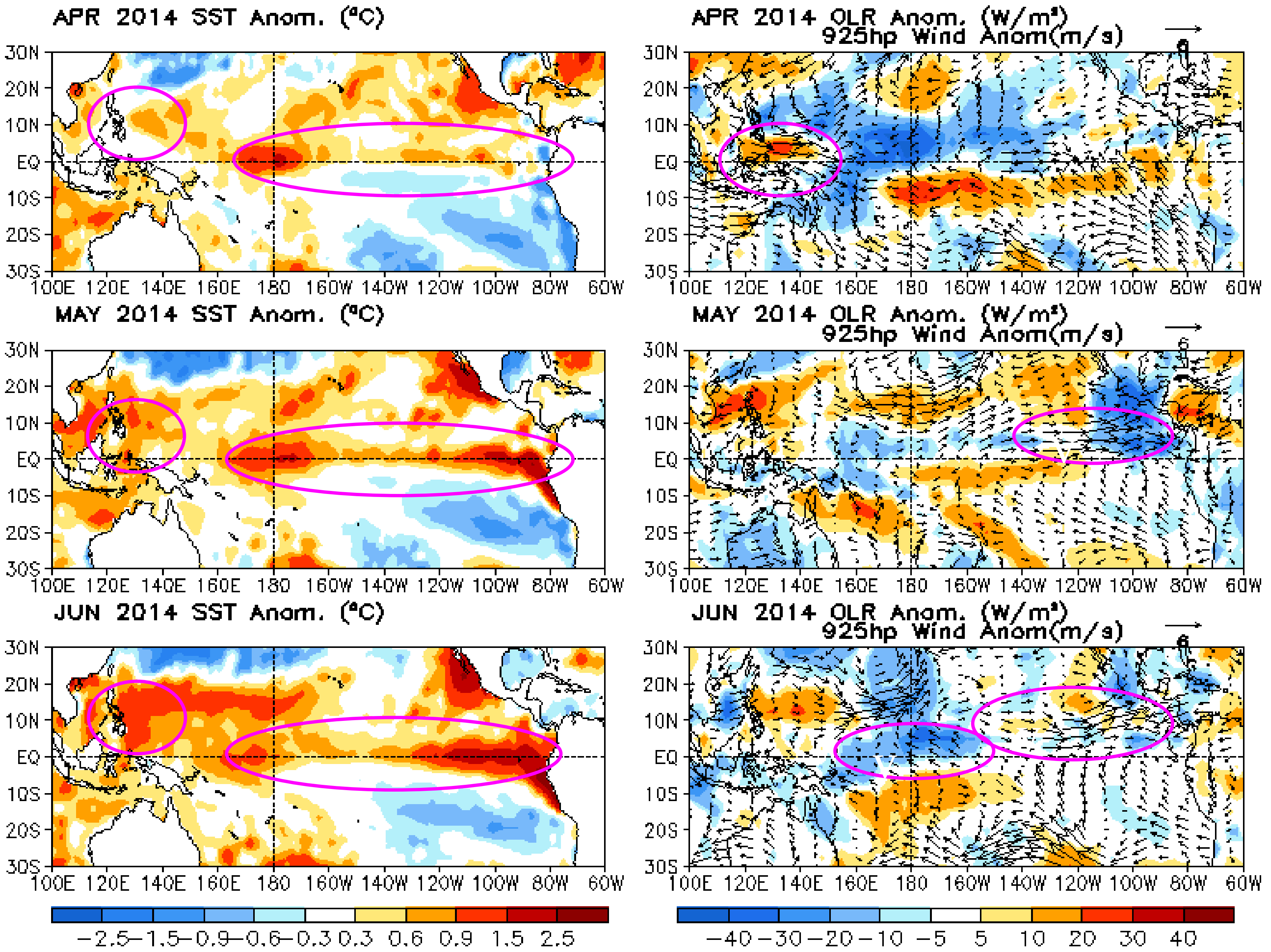
May



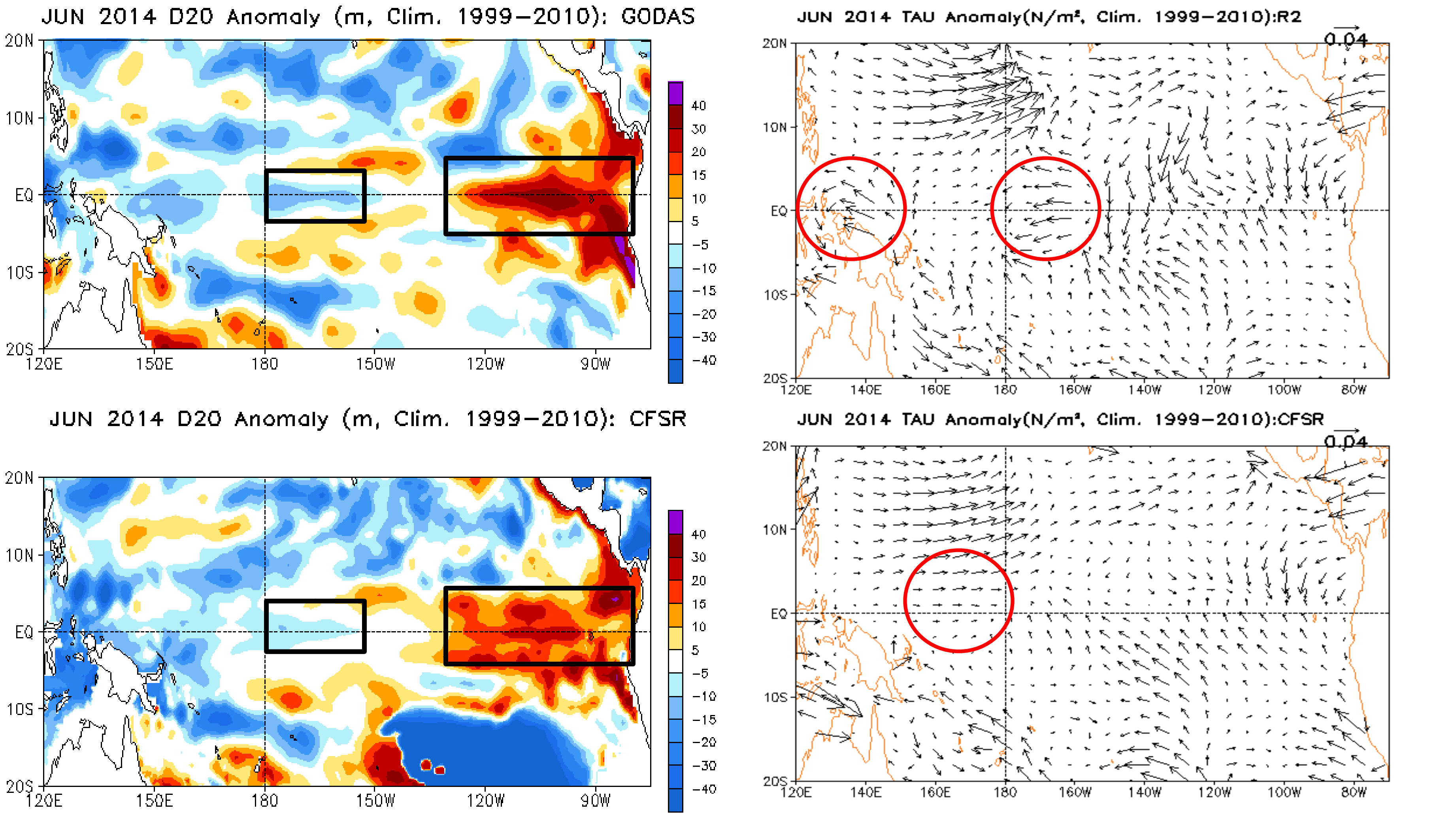
June



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



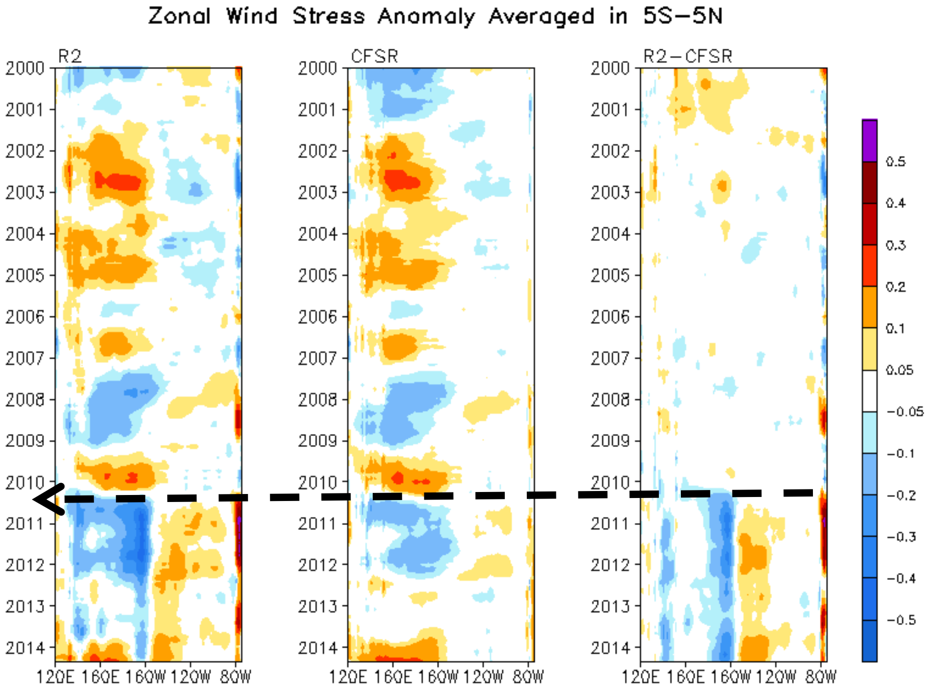
Difference between GODAS and CFSR (1999-2010 Clim.)



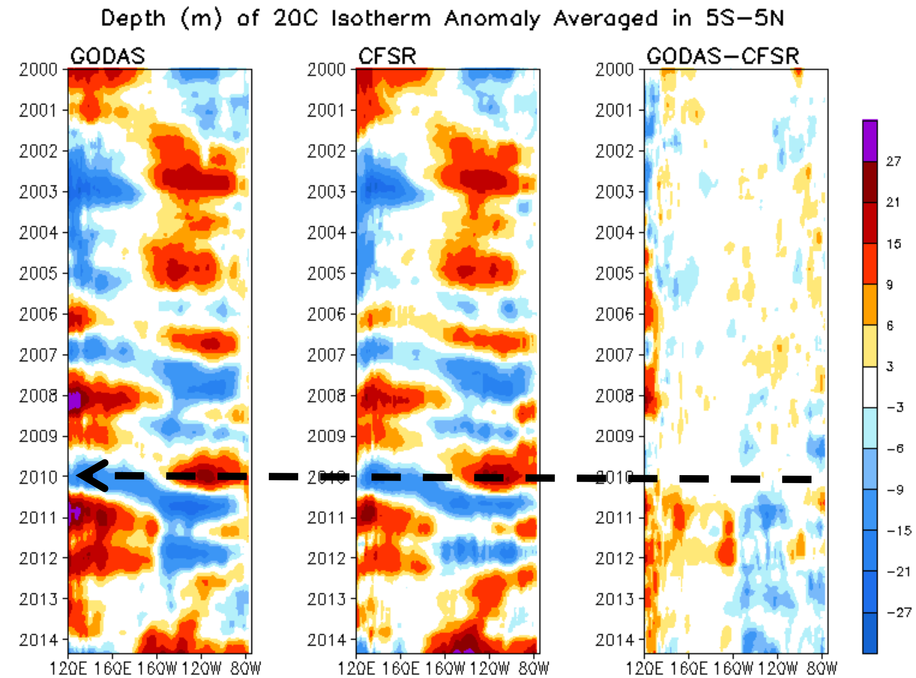
- **Positive D20 anomaly in GODAS has much narrower meridional extend than CFSR between 130W-100W, and negative D20 anomaly near Dateline was stronger than that in CFSR.**
- **Easterly wind anomaly was stronger in R2 than that in CFSR.**

Difference between GODAS and CFSR

Zonal Wind Stress Anomaly

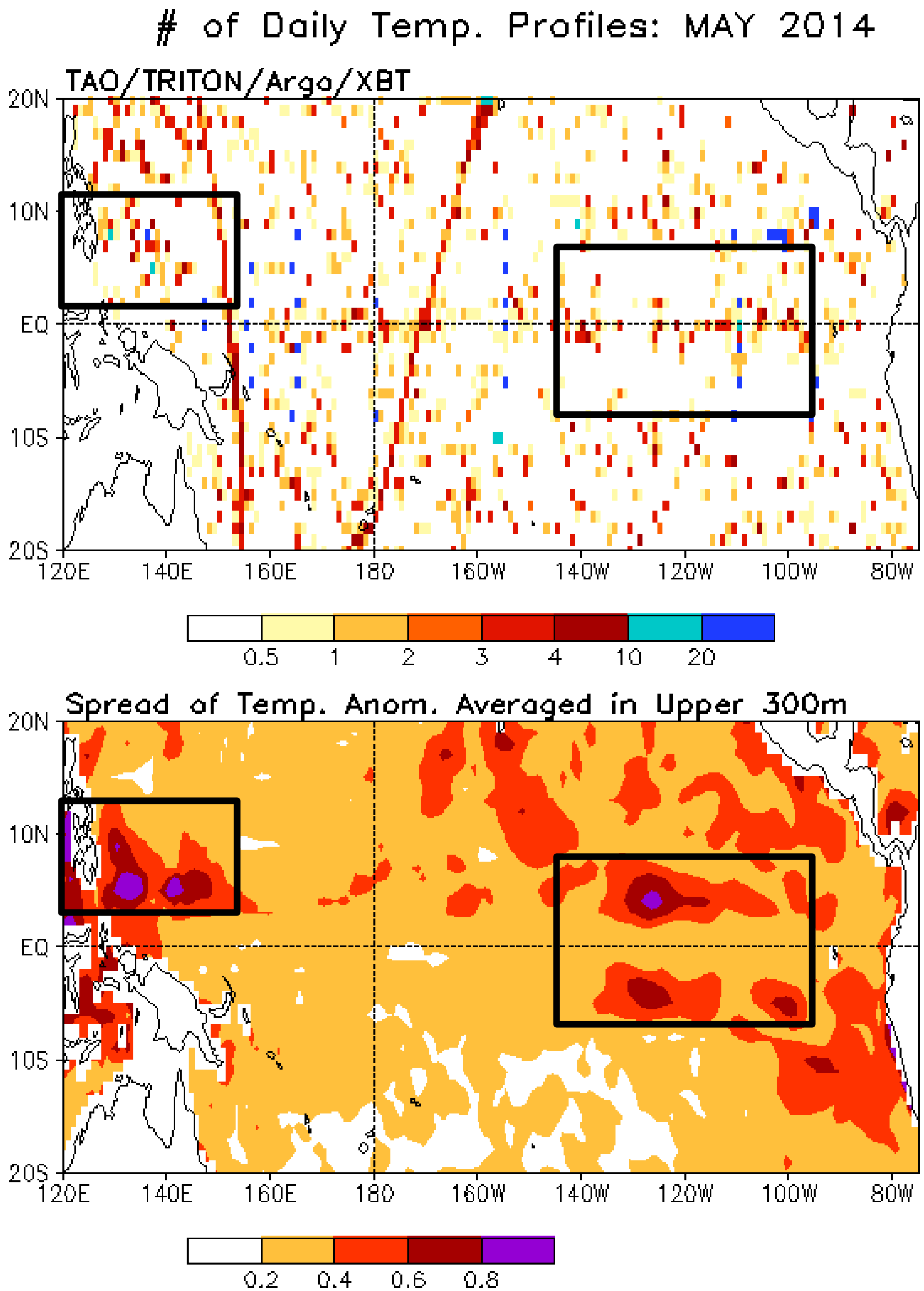


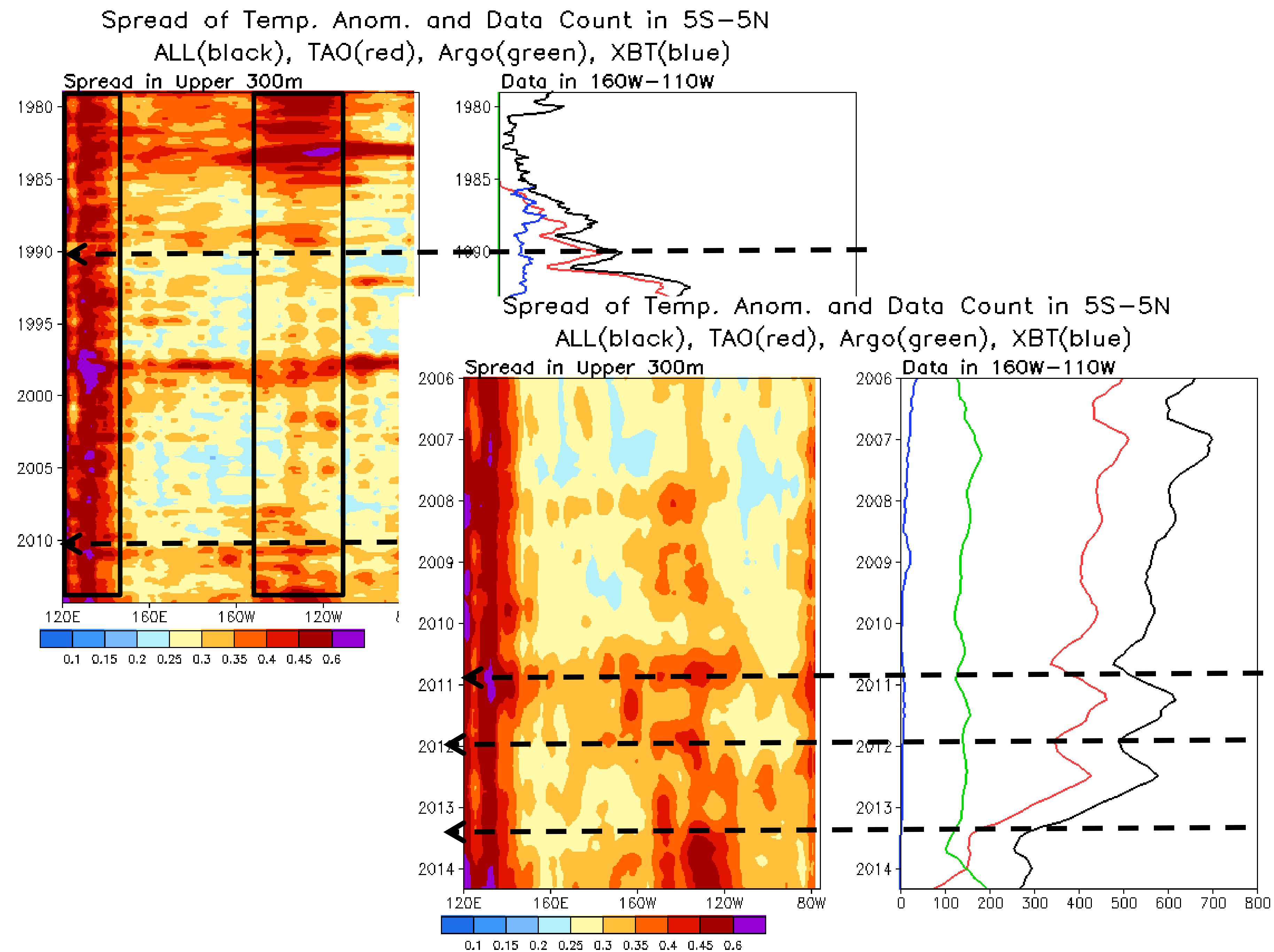
Depth of 20C Isotherm Anomaly



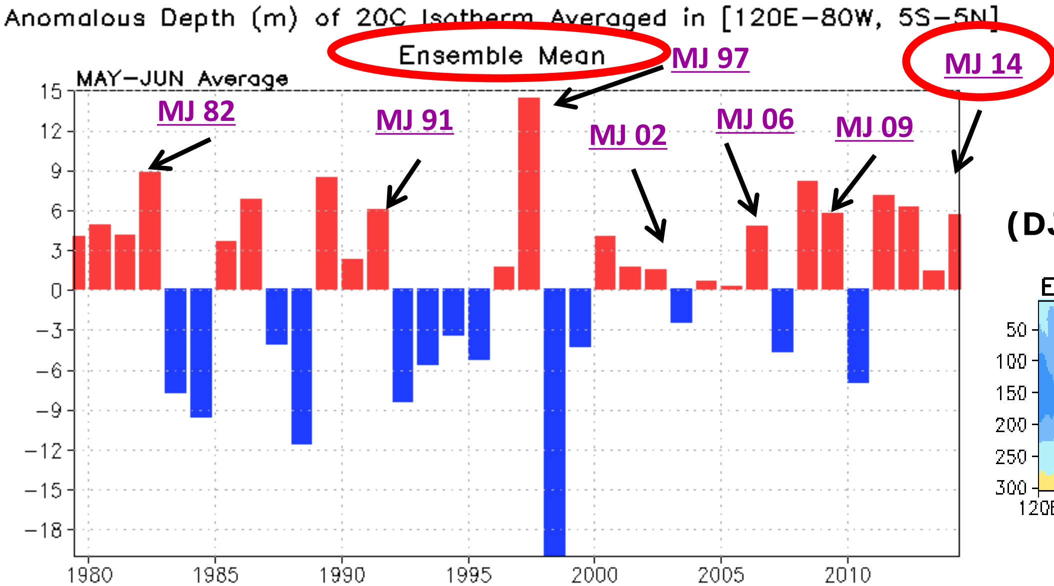
- Trade winds in R2 are much stronger than those in CFSR near 170W since 2010.
- Consistent to the stronger trade winds in R2, D20 anomaly in GODAS is about 3-6m lower than that in CFSR east of 150W since 2010.

Influences of ocean observations on spread among ocean reanalyses

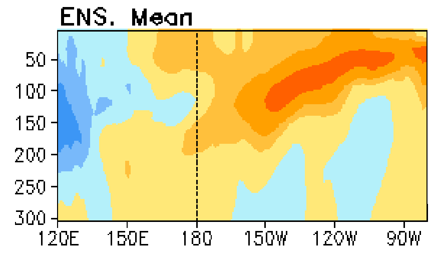



Spread of Temp. Anom. and Data Count in 5S–5N
ALL(black), TAO(red), Argo(green), XBT(blue)
Spread in Upper 300m
Data in 160W–110W
1980
1985
1990
1995
2000
2005
2010
120E
160E
160W
120W
0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.6
Spread of Temp. Anom. and Data Count in 5S–5N
ALL(black), TAO(red), Argo(green), XBT(blue)
Spread in Upper 300m
Data in 160W–110W
2006
2007
2008
2009
2010
2011
2012
2013
2014
120E
160E
160W
120W
80W
0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.6
0
100
200
300
400
500
600
700
800

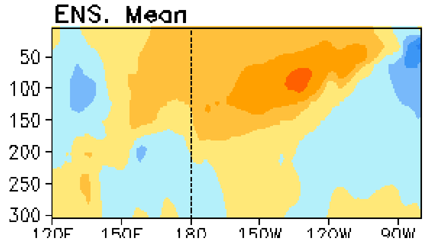
Warm Water Volume Index Derived From Ensemble Mean of Ocean Reanalyses



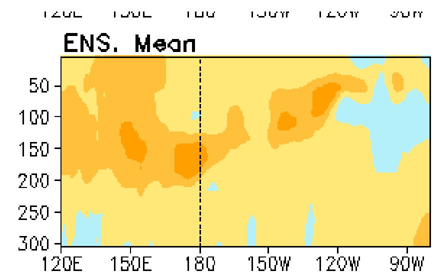
Jun 1991
(DJF NINO3.4=+1.6)



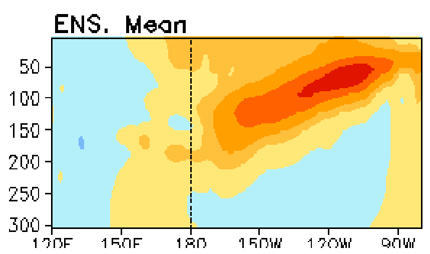
Jun 2002
(DJF NINO3.4=+1.1)



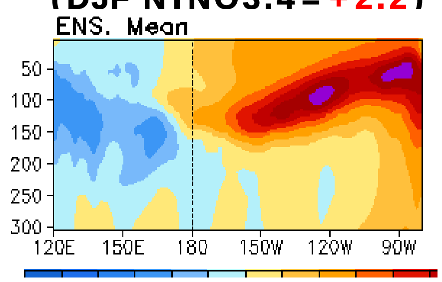
Jun 2006
(DJF NINO3.4=+0.7)



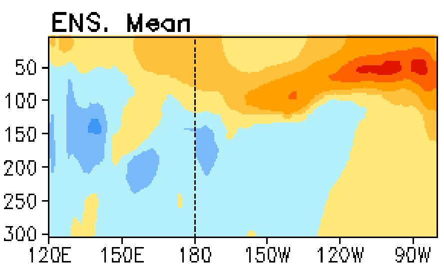
Jun 1982
(DJF NINO3.4=+2.2)



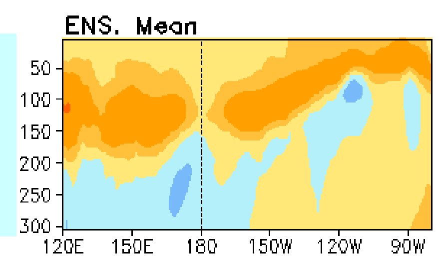
Jun 1997
(DJF NINO3.4=+2.2)



Jun 2014

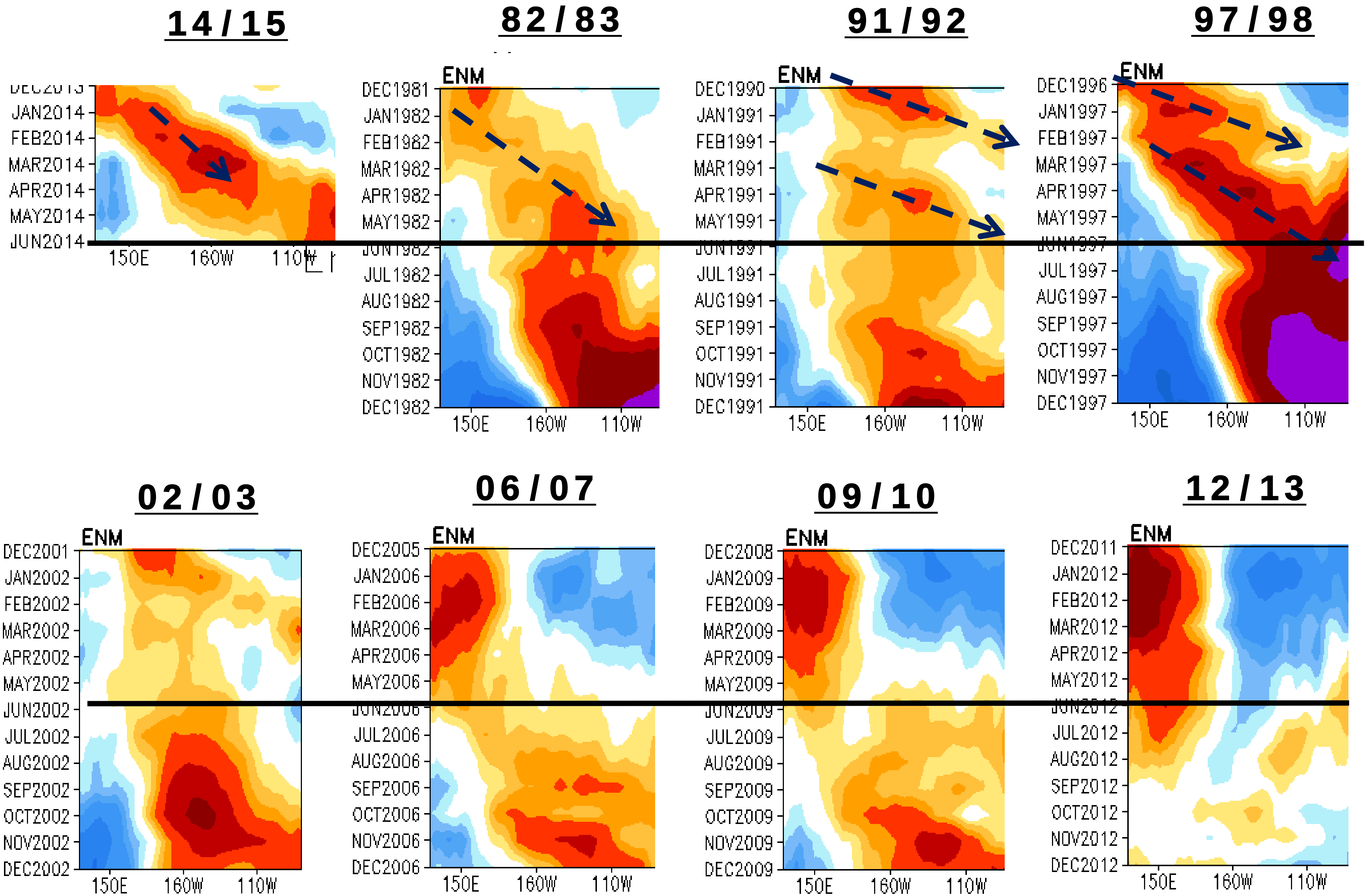


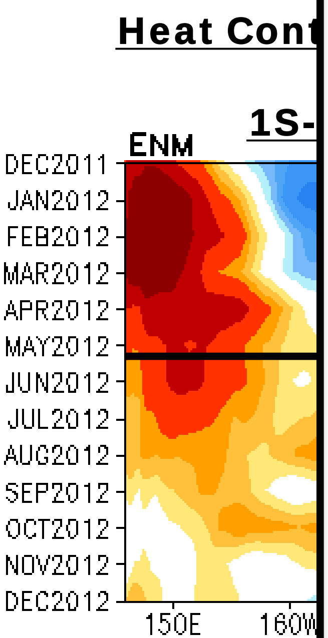
Jun 2009
(DJF NINO3.4=+1.6)

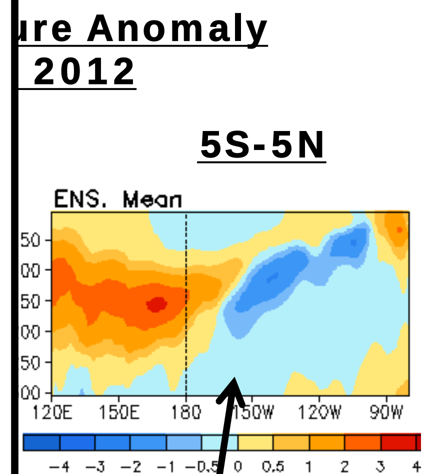


- **Warm Water Volume averaged in May-June 2014 is similar to that in May-June of 2009, 2006 and 1991. However, the pattern of subsurface temperature anomaly averaged in 5S-5N in Jun 2014 is mostly similar to Jun 1991.**

Upper 300m Heat Content Anomaly Averaged in 5S-5N







EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

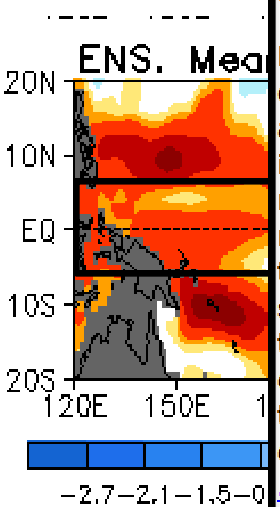
issued by
CLIMATE PREDICTION CENTER/NCEP
and the International Research Institute for Climate and Society

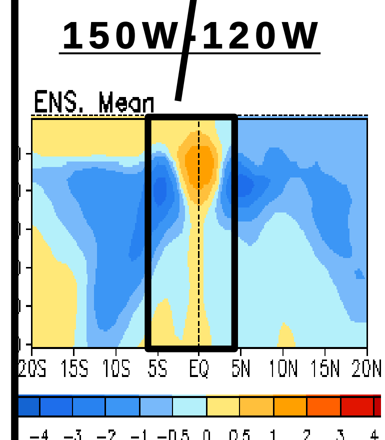
7 June 2012

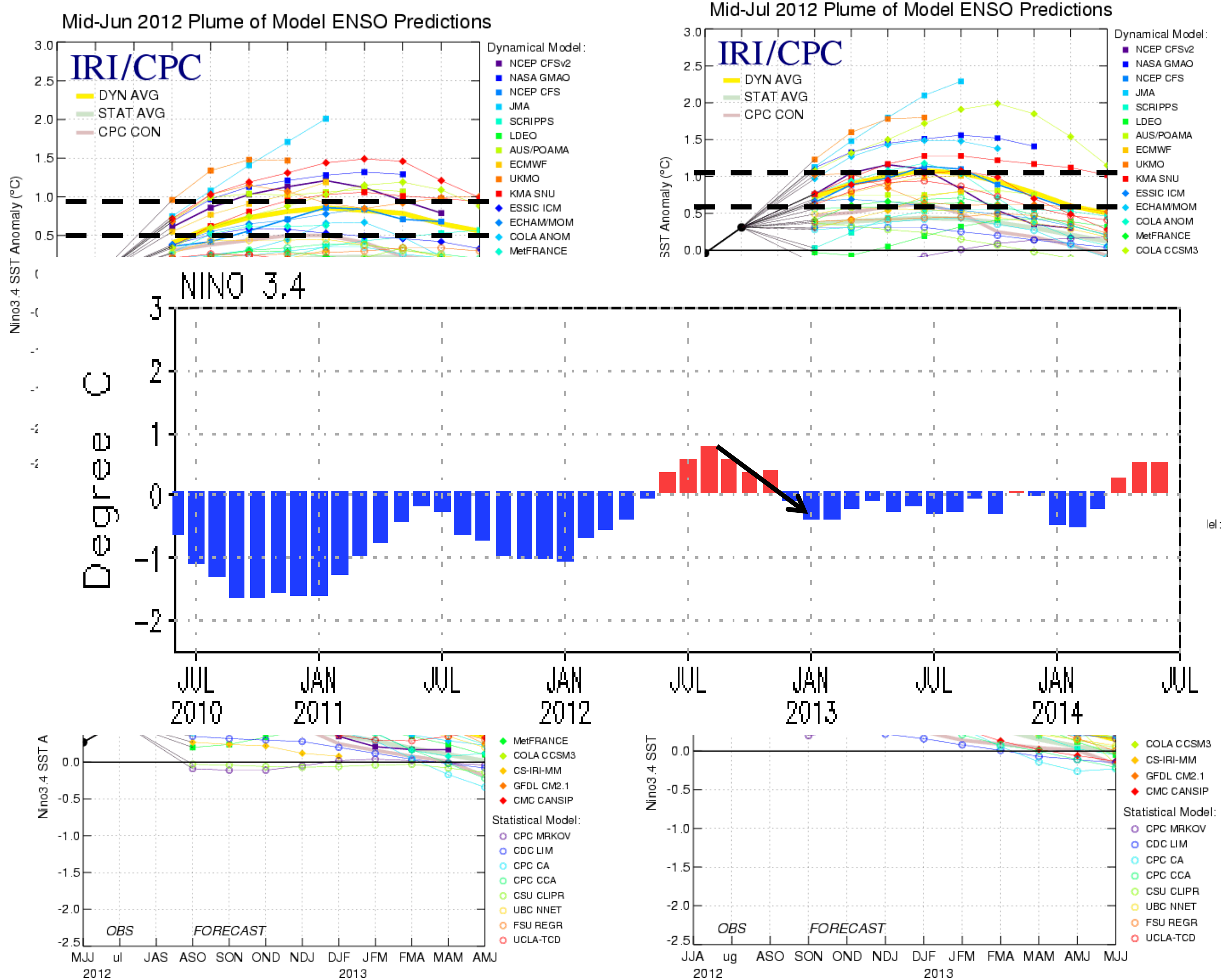
ENSO Alert System Status: **El Niño Watch**

Synopsis: **There is a 50% chance that El Niño conditions will develop during the second half of 2012.**

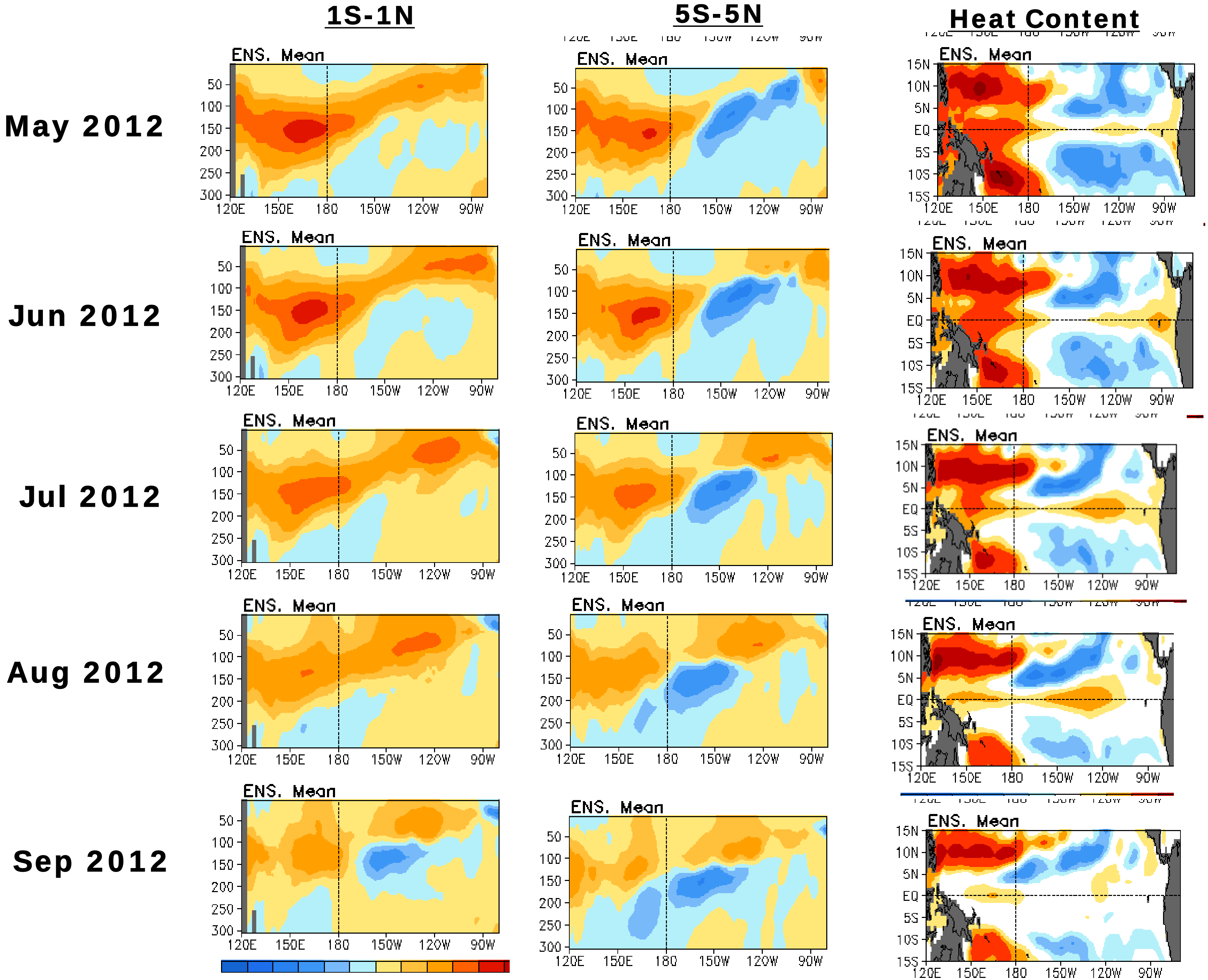
ENSO-neutral conditions prevailed in May 2012, following the dissipation of La Niña in April. Sea surface temperatures (SSTs) are currently near average across most of the equatorial Pacific Ocean, and above-average in the far eastern Pacific (Fig. 1). The Niño 4 and Niño 3.4 indices were near zero during most of May, while the Niño 3 and Niño 1+2 indices remained positive (Fig. 2). The oceanic heat content (average temperature in the upper 300m of the ocean) anomalies became more strongly positive in May (Fig. 3), as above-average sub-surface temperatures became established across most of the central and eastern equatorial Pacific (Fig. 4). The low-level trade winds and convection over the central equatorial Pacific were near average during May, although convection remained enhanced over portions of the western Pacific (Fig. 5). Collectively, these oceanic and atmospheric patterns indicate ENSO-neutral conditions.







Mid-Jun 2012 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
Dynamical Model:
NCEP CFSv2
NASA GMAO
NCEP CFS
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
ESSIC ICM
ECHAM/MOM
COLA ANOM
MetFRANCE
Nino3.4 SST Anomaly (°C)
Mid-Jul 2012 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
Dynamical Model:
NCEP CFSv2
NASA GMAO
NCEP CFS
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
ESSIC ICM
ECHAM/MOM
COLA ANOM
MetFRANCE
COLA CCSM3
NINO 3.4
Degree C
JUL 2010
JAN 2011
JUL
JAN 2012
JUL
JAN 2013
JUL
JAN 2014
JUL
MetFRANCE
COLA CCSM3
CS-IRI-MM
GFDL CM2.1
CMC CANSIP
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD
OBS
FORECAST
MJJ 2012
JAS
ASO
SON
OND
NDJ
DJF 2013
JFM
FMA
MAM
AMJ
COLA CCSM3
CS-IRI-MM
GFDL CM2.1
CMC CANSIP
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD
OBS
FORECAST
JJA 2012
ASO
SON
OND
NDJ
DJF 2013
JFM
FMA
MAM
AMJ
MJJ


1S-1N
5S-5N
Heat Content
May 2012
Jun 2012
Jul 2012
Aug 2012
Sep 2012
ENS. Mean
50
100
150
200
250
300
120E
150E
180
150W
120W
90W
15N
10N
5N
EQ
5S
10S
15S
-4
-3
-2
-1
-0.5
0
0.5
1
2
3
4

Summary

- NOAA's official ENSO predictions are made by a group of forecasters who make probabilistic forecast for El Nino, ENSO-neutral and La Nina by synthesizing subjectively ensemble model ENSO forecasts and recent evolution of atmospheric and oceanic conditions.

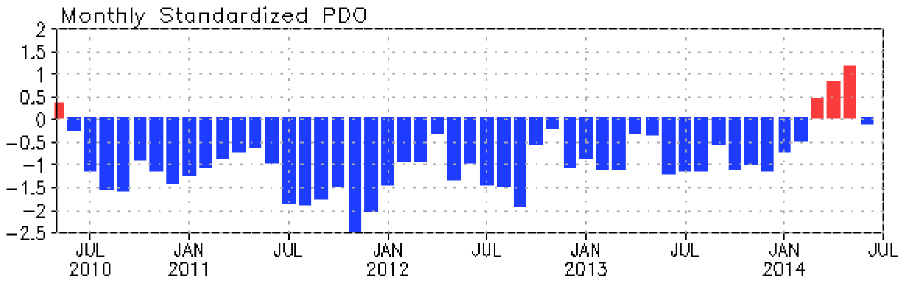
- Uncertainties in ocean reanalyses seem partially attributed to the declining TAO array, and whether they have attributed to differences in the ensemble ENSO forecast of different coupled models are unknown.

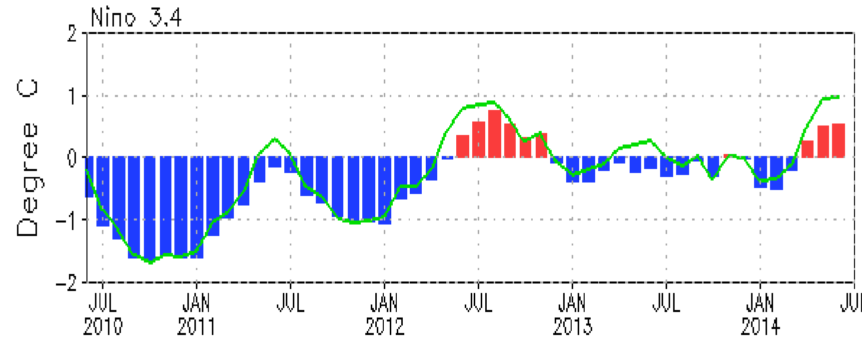
- Although there are uncertainties in ocean reanalysis products, the ensemble mean of multiple ocean reanalyses likely provides the best estimation of the state of ocean. The ensemble spread provides uncertainties in ocean estimation.

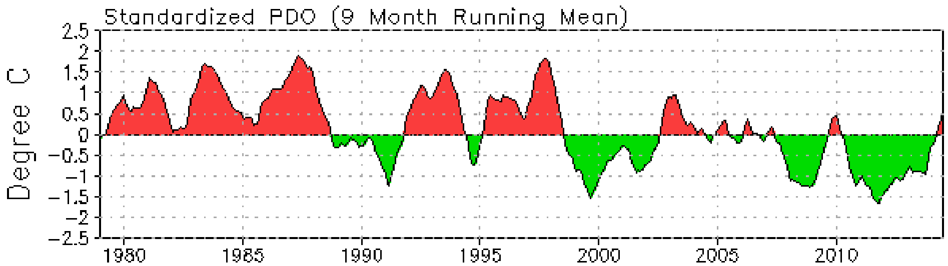
- Subsurface temperature anomalies off equator can have significant impacts on ENSO evolutions, and coupled models appear underestimate the off-equatorial influences.

- Atmospheric high-frequency variability can have large impacts on ENSO evolution even after the typical spring predictability barrier. Predictability after 2000 appears much lower than that in 1980s and 1990s.

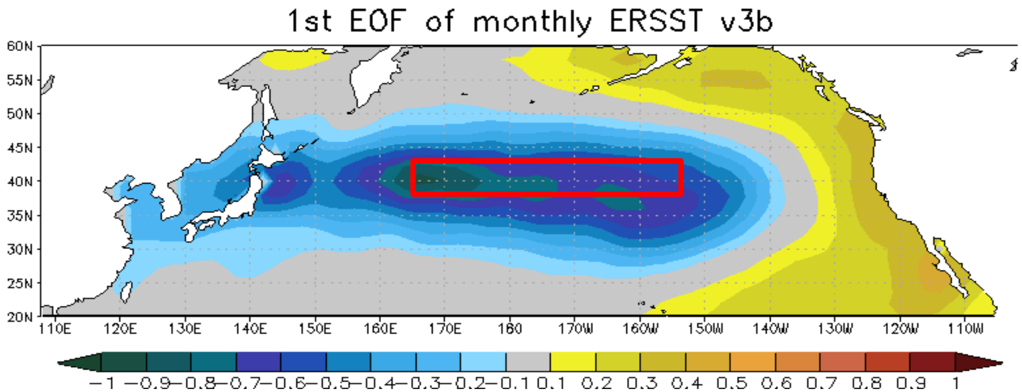
PDO index





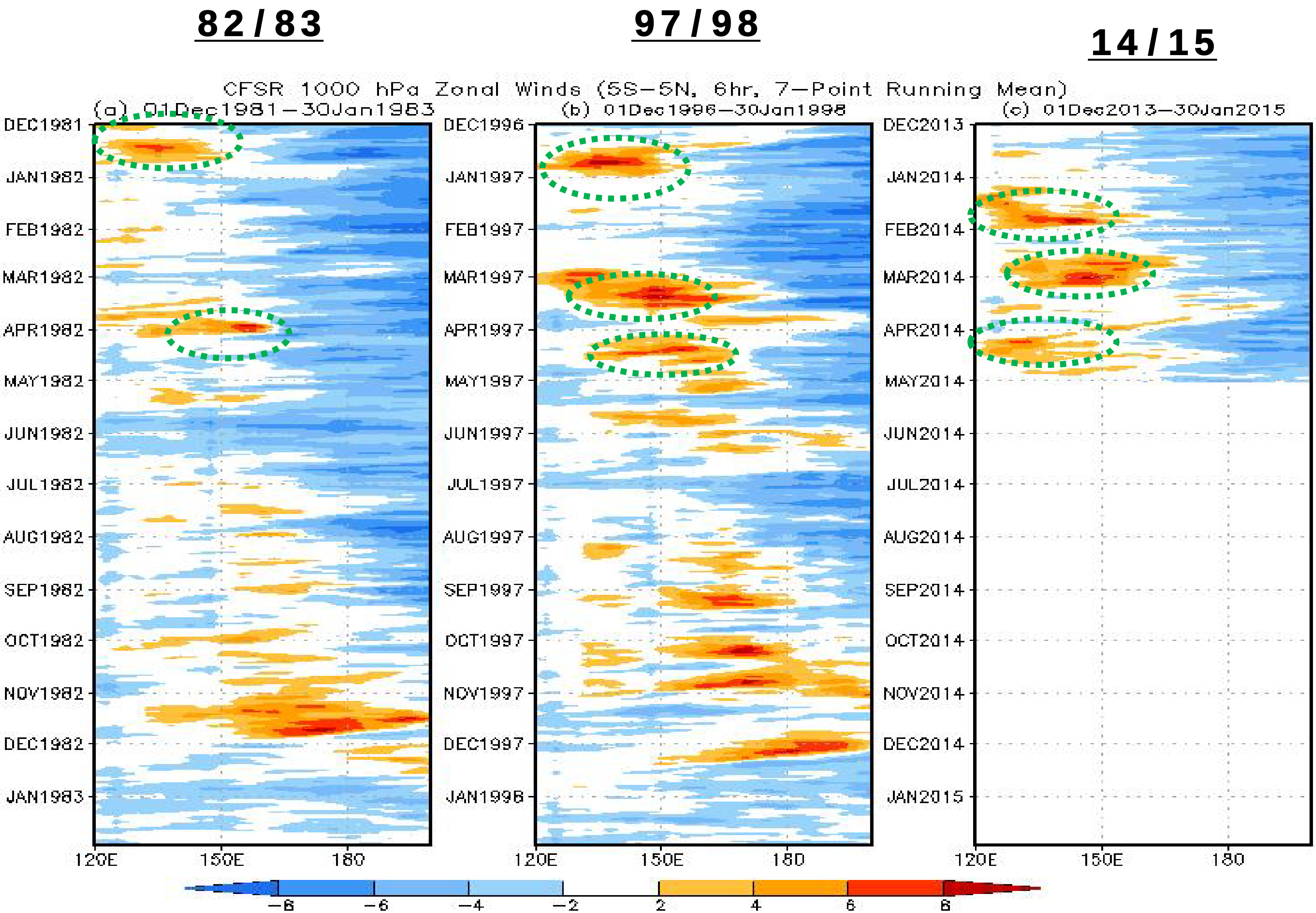


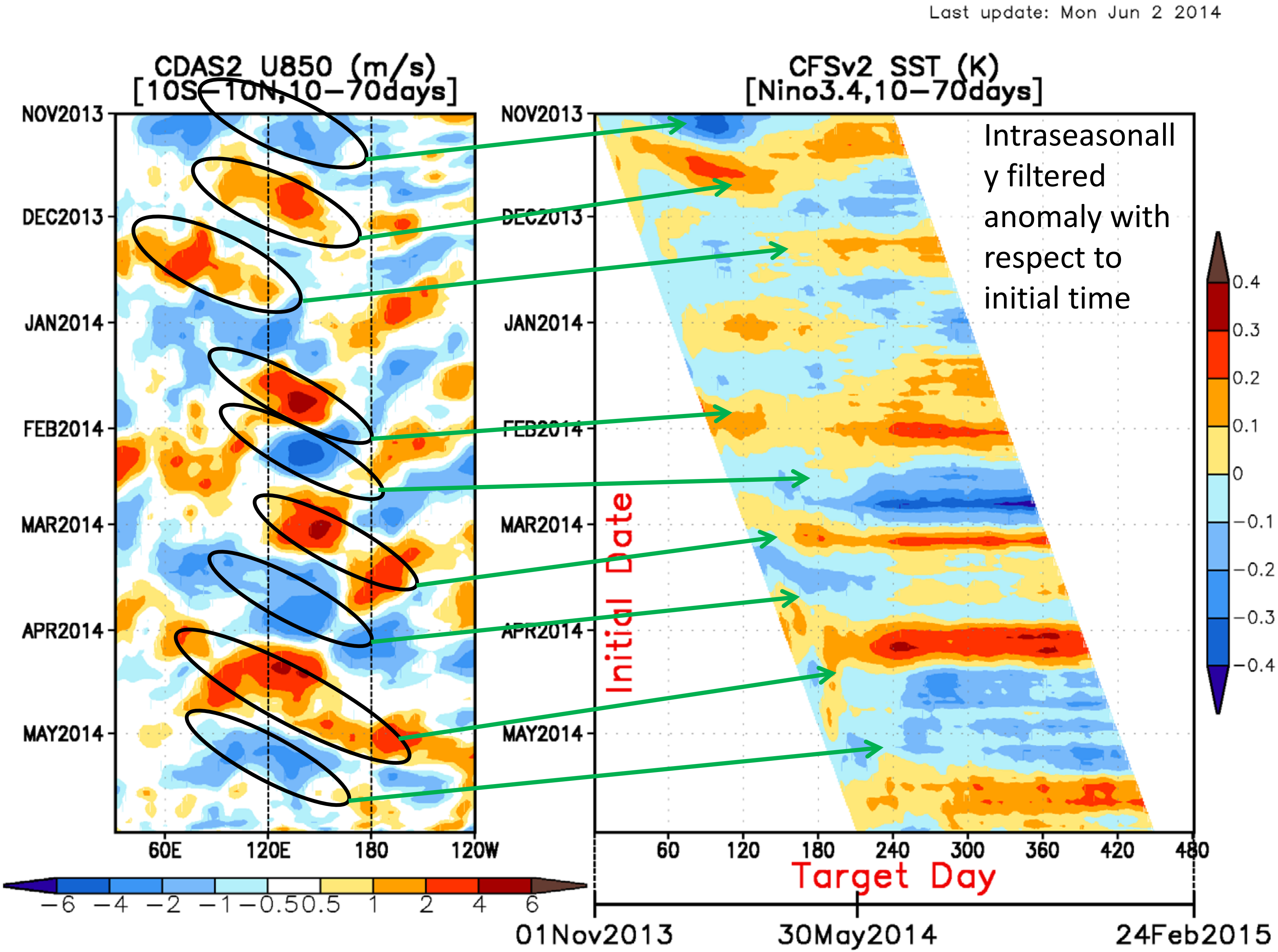
- **PDO switched to positive phase in Mar-May 2014, but returned to negative phase in Jun with PDO index =-0.13.**

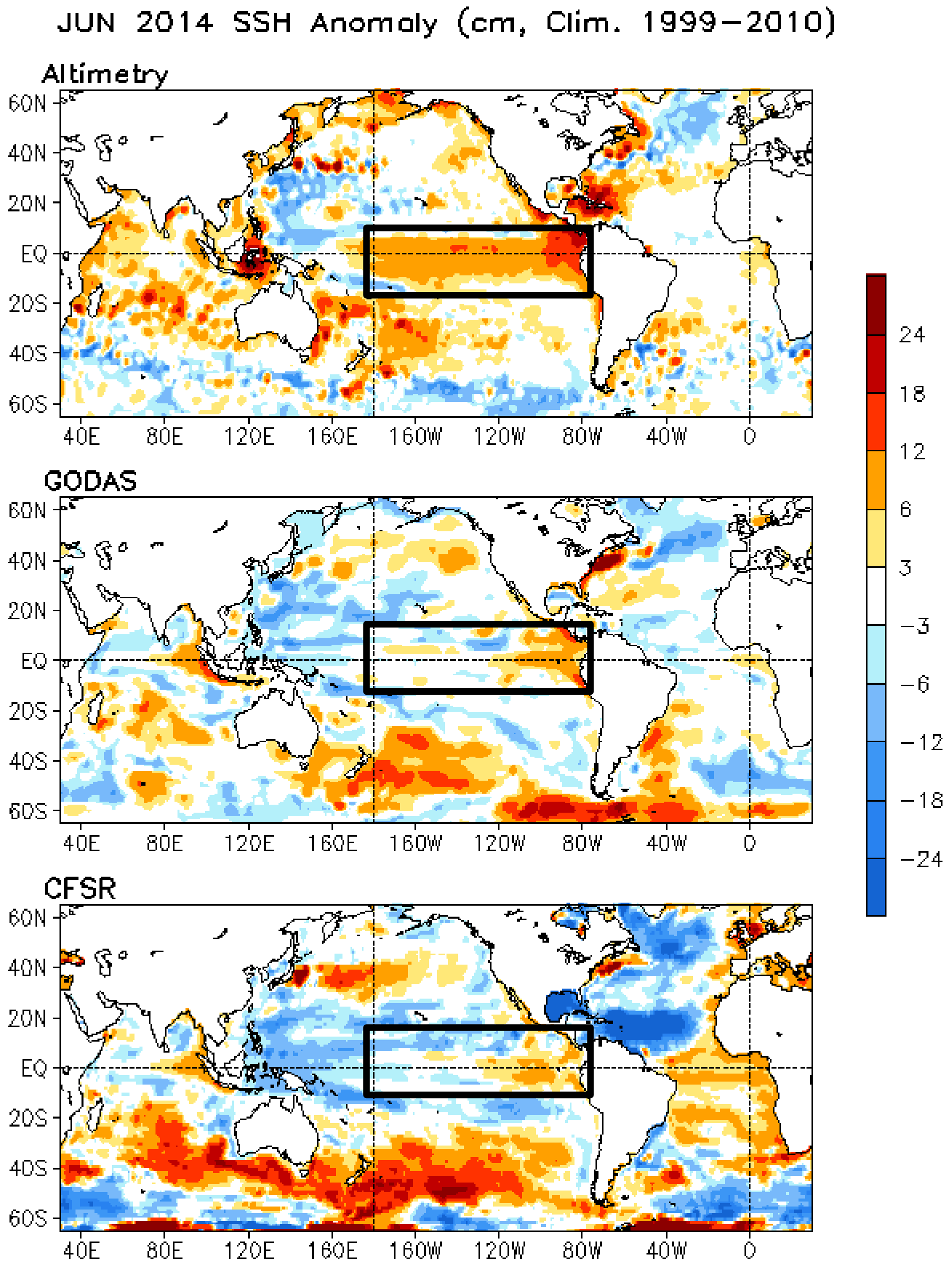


- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**
- **The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.**

Westerly Wind Burst (WWB) Events




Last update: Mon Jun 2 2014
CDAS2 U850 (m/s)
[10S–10N,10–70days]
NOV2013
DEC2013
JAN2014
FEB2014
MAR2014
APR2014
MAY2014
60E
120E
180
120W
−6 −4 −2 −1 −0.5 0.5 1 2 4 6
CFSv2 SST (K)
[Nino3.4,10–70days]
Intraseasonally filtered anomaly with respect to initial time
Initial Date
60
120
180
240
300
360
420
480
Target Day
01Nov2013
30May2014
24Feb2015
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4

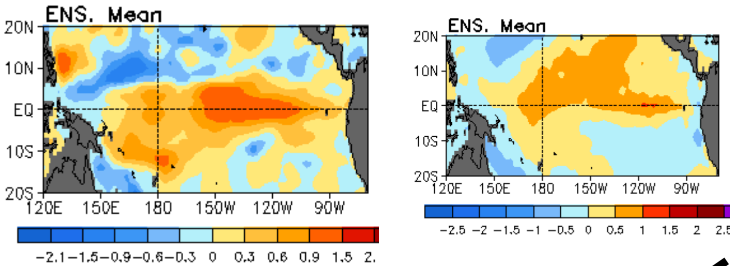


- Both GODAS and CFSR underestimate positive SSH anomaly in the central-eastern Pacific.

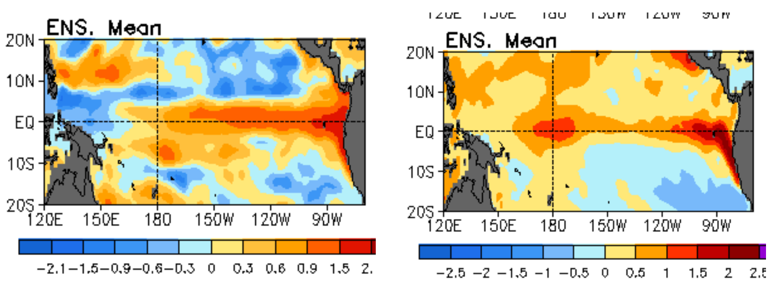
300m Heat Content Anom.

SST Anom.

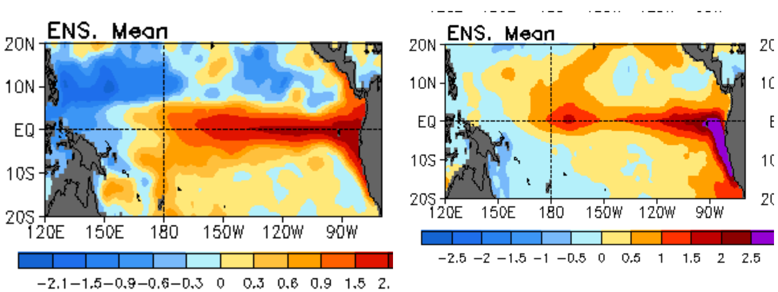
May 1982 (DJF NINO3.4=2.2)



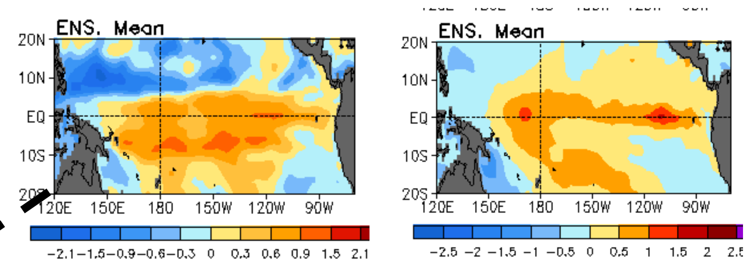
May 2014



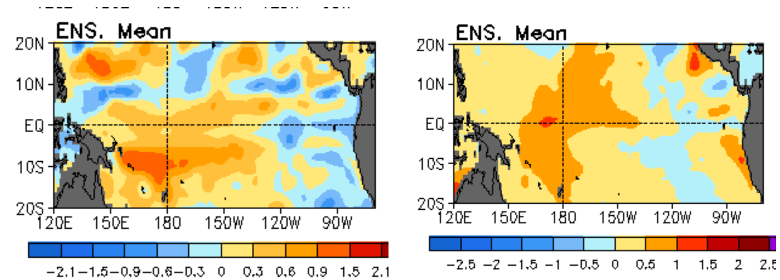
May 1997 (DJF NINO3.4=2.2)



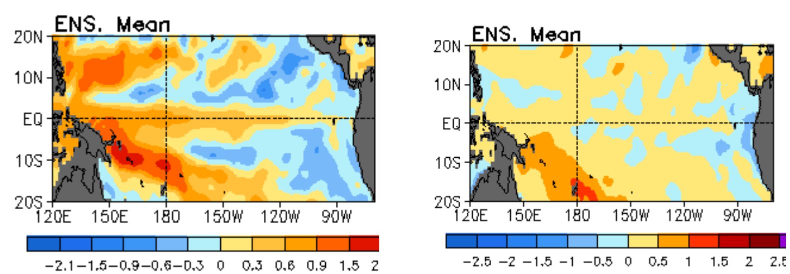
May 1991 (DJF NINO3.4=1.6)



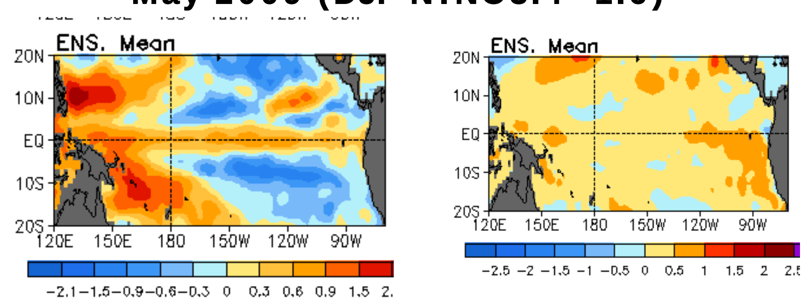
May 2002 (DJF NINO3.4=1.1)



May 2006 (DJF NINO3.4=0.7)

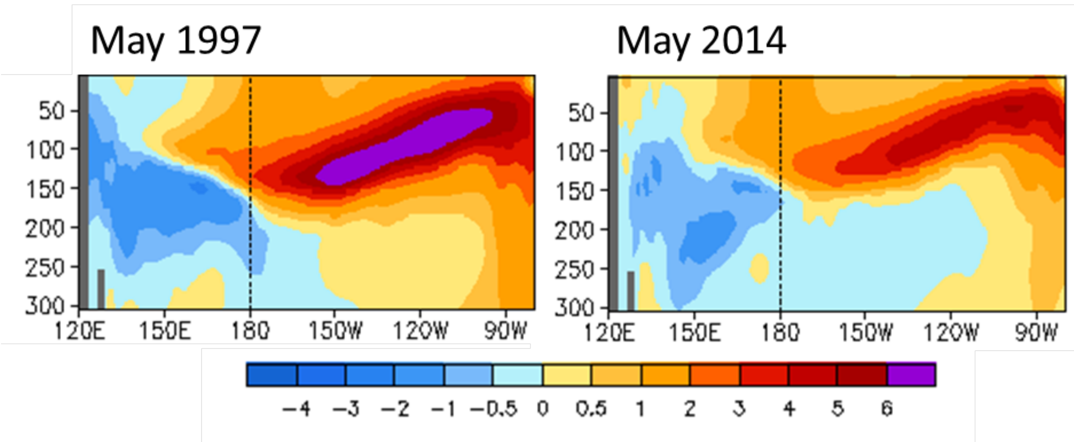


May 2009 (DJF NINO3.4=1.6)



Public Use of Ensemble Ocean Reanalysis Products

NOAA ENSO blog issued on June 6 introduced the real-time multiple ocean reanalysis intercomparison products

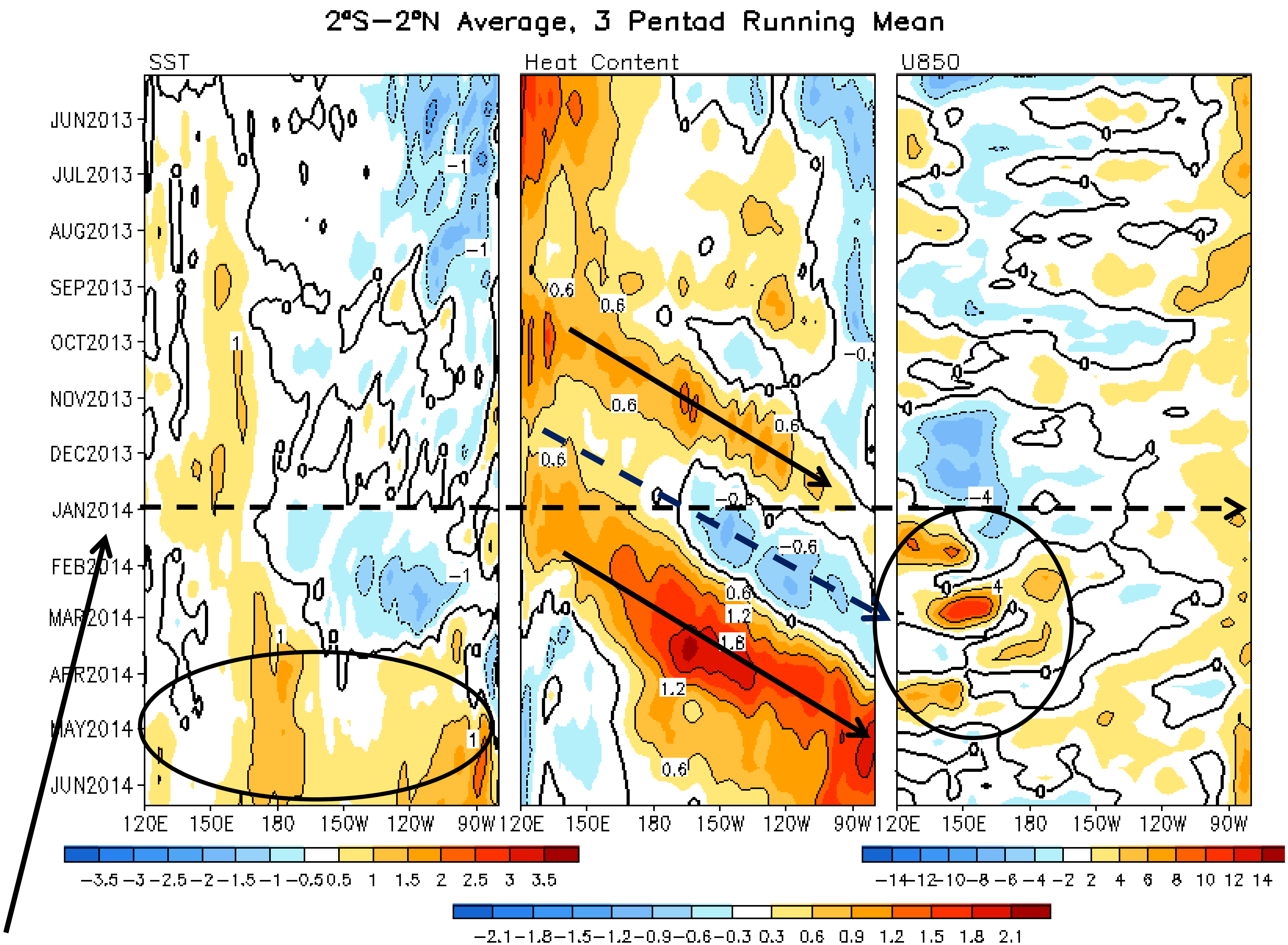


http://www.climate.gov/news-features/blogs/enso/details-june-2014-enso-discussion

ENSO Blog by Watts Up With That also used many plots from real-time multiple ocean reanalysis intercomparison web site

http://wattsupwiththat.com/2014/06/10/noaa-reaches-out-to-the-blogosphere/#more-111157

Equatorial Pacific SST (°C), HC300 (°C), and u850 (m/s) Anomalies



El Nino was forecast starting from Dec I.C. (last 10 days in Dec).

Recent Evolution of Ocean Heat Content Anomaly