



# Recent Evolution and Outlook of ENSO Cycle

Xianjun Xiao, Lijuan Chen,

Yanjiao Wang, Fei Zheng

Beijing Climate Center, CMA





# Outline

- ◆ Overview
- ◆ Recent Evolution and Current Conditions
- ◆ Outlook of ENSO
- ◆ Summary





# Overview

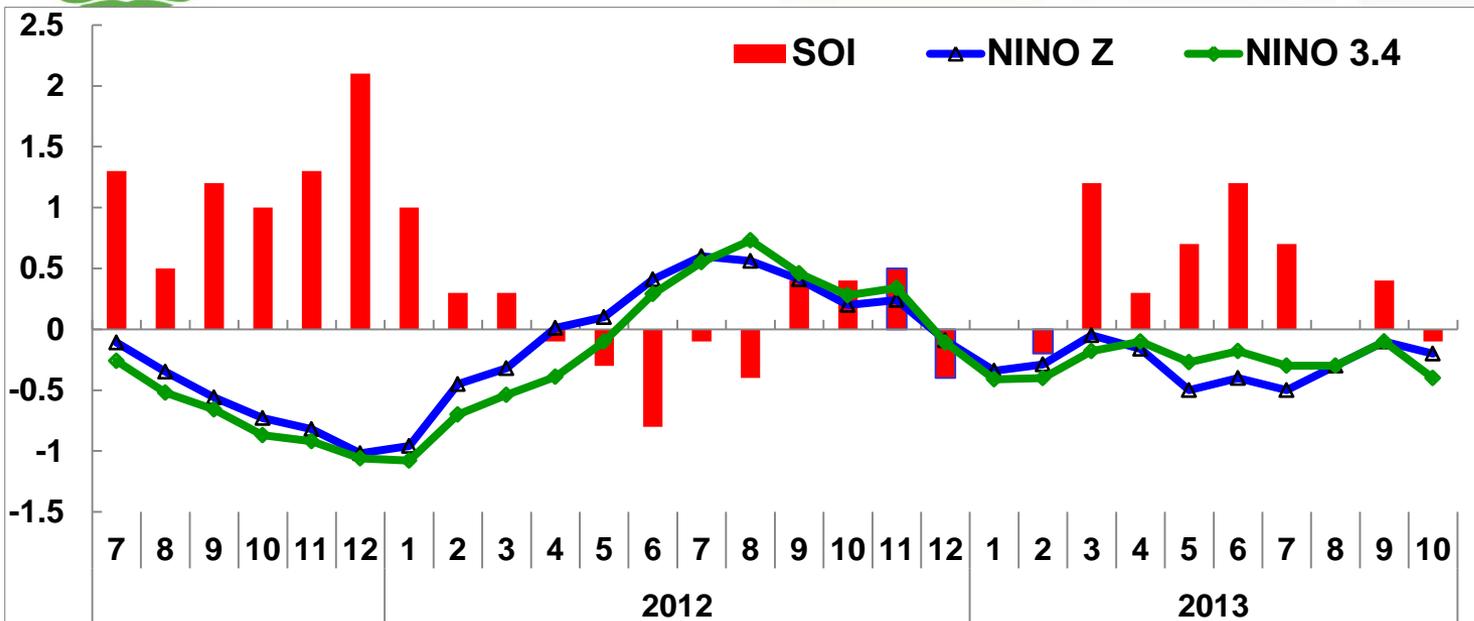
- **ENSO-neutral conditions continue.**
- **Equatorial sea surface temperatures (SST) are near average across much of the equatorial Pacific Ocean.**
- **The status of atmosphere and ocean associated with ENSO are expected remain neutral through the winter of 2013-2014.**





# Recent Evolution and Current Conditions





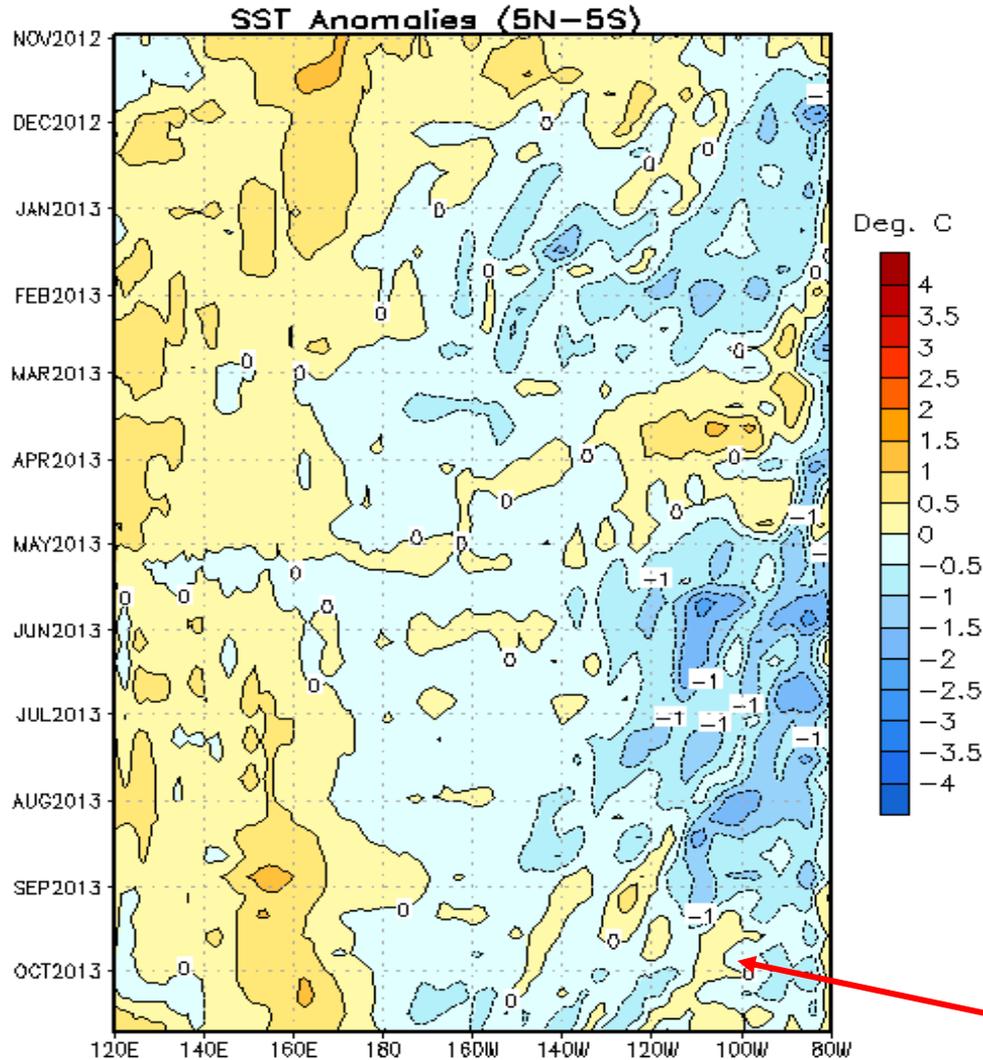
Index of Nino Z  
in Oct. 2013:  
-0.2

- Nino Z index (Nino1+2+3+4) has continued negative value since December 2012.
- Southern Oscillation Index has also taken on the similar La Nina feature since March 2013.





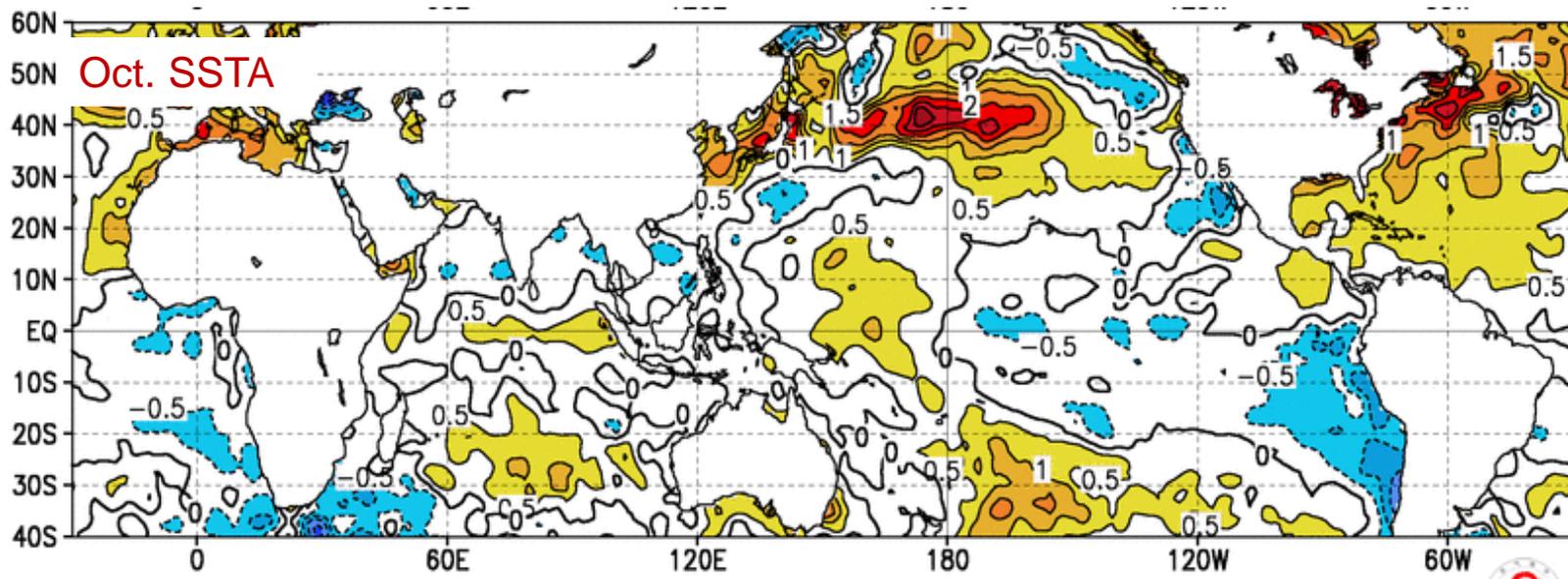
# Recent Evolution of Equatorial Pacific SST Departures (°C)



**During May-September 2013, below-average SSTs were observed over the eastern half of the Pacific.**

**Recently, SSTs have been near-average across much of the equatorial Pacific.**

# SST Departures ( $^{\circ}\text{C}$ ) in the Tropical Pacific



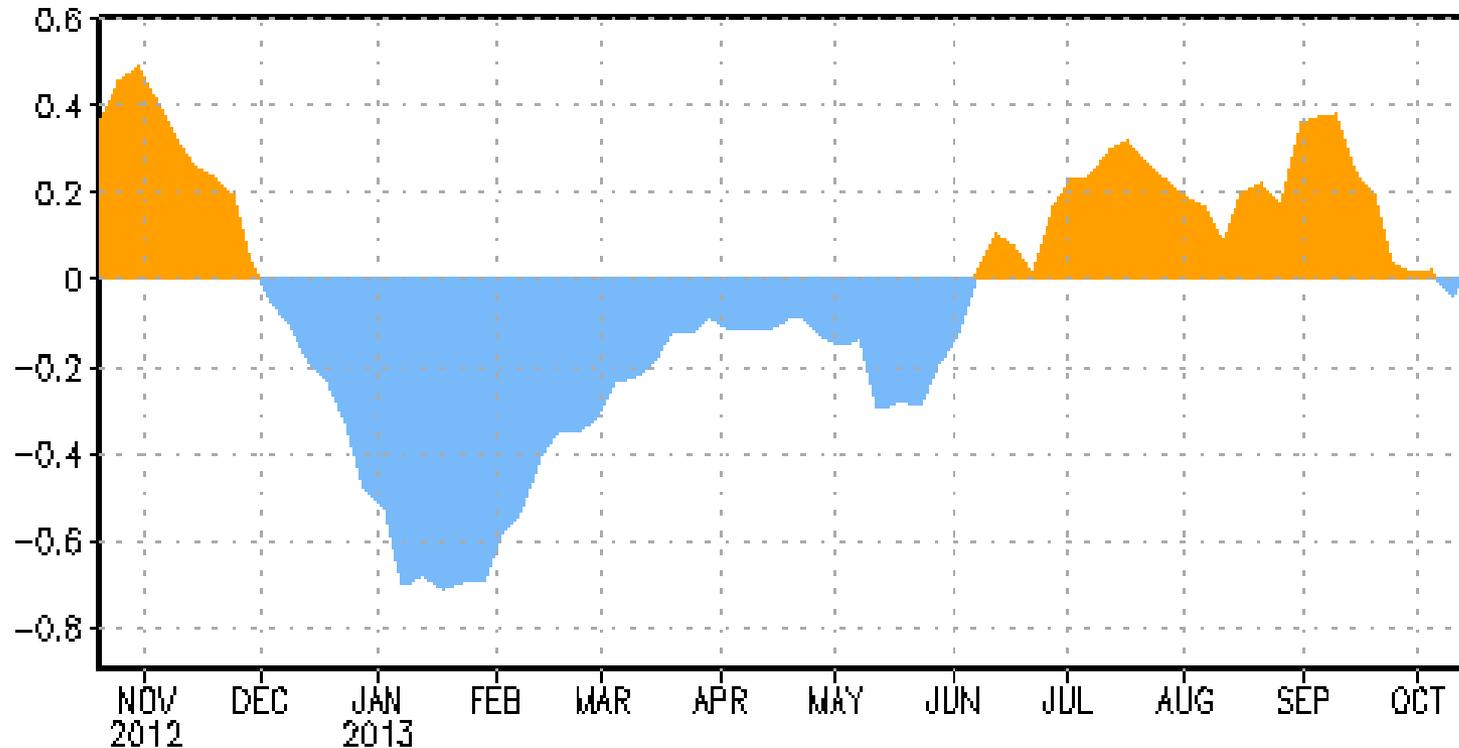
Recently, equatorial SSTA were above average in the western Pacific, and near or slightly below average between 180W and the South American coast.



# Weekly Central & Eastern Pacific Upper-Ocean (0-300 m) Average Temperature Anomalies



EQ. Upper-Ocean Heat Anoms. (deg C) for 180-100W



**Subsurface temperatures were below average during December 2012 – May 2013. From June – September 2013, subsurface temperature anomalies were positive. Currently, subsurface temperature anomalies are near zero.**



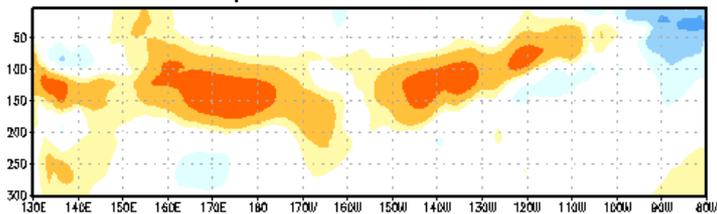


# Sub-Surface Temperature Departures (°C) in the Equatorial Pacific

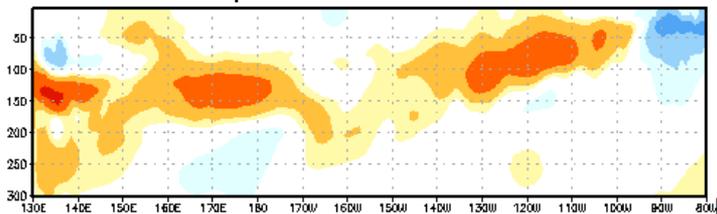


EQ. Subsurface Temperature Anomalies (deg C)

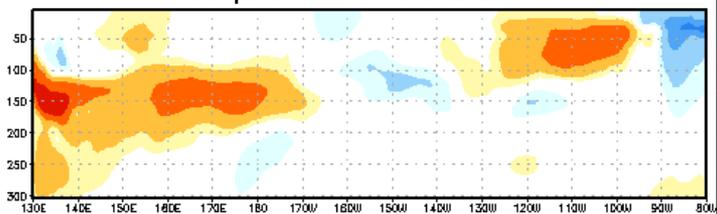
Three-pentad ave. centered on 28 AUG 2013



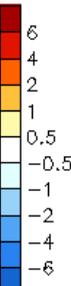
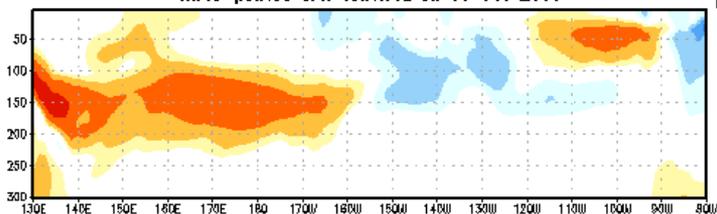
Three-pentad ave. centered on 10 SEP 2013



Three-pentad ave. centered on 25 SEP 2013



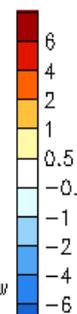
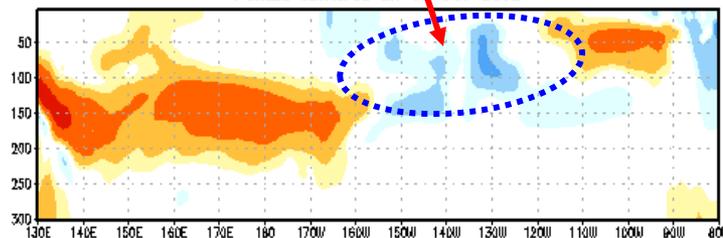
Three-pentad ave. centered on 10 OCT 2013



- During the last two months, above-average subsurface temperatures persisted over the western equatorial Pacific Ocean, while below-average temperatures continued in the far eastern Pacific. In late September, below-average temperatures emerged in the east-central Pacific.
- Recently, negative subsurface anomalies persisted in the east-central Pacific Ocean.

EQ. Subsurface Temperature Anomalies (deg C)

Pentad centered on 13 OCT 2013



Most recent pentad analysis

Time

Depth (meters)

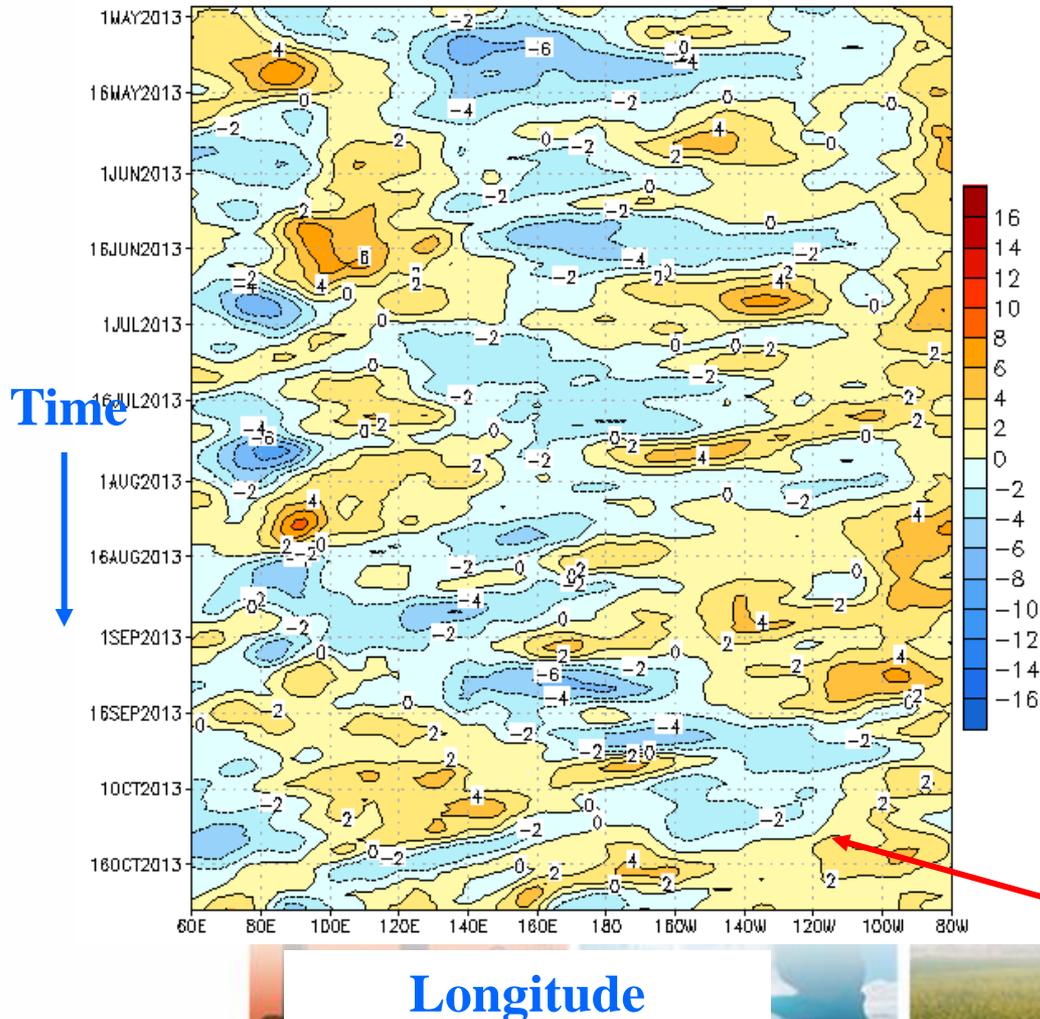
Longitude





# Low-level (850-hPa) Zonal (east-west) Wind Anomalies ( $\text{m s}^{-1}$ )

CDAS 850-hPa U Anoms. (5N-5S)

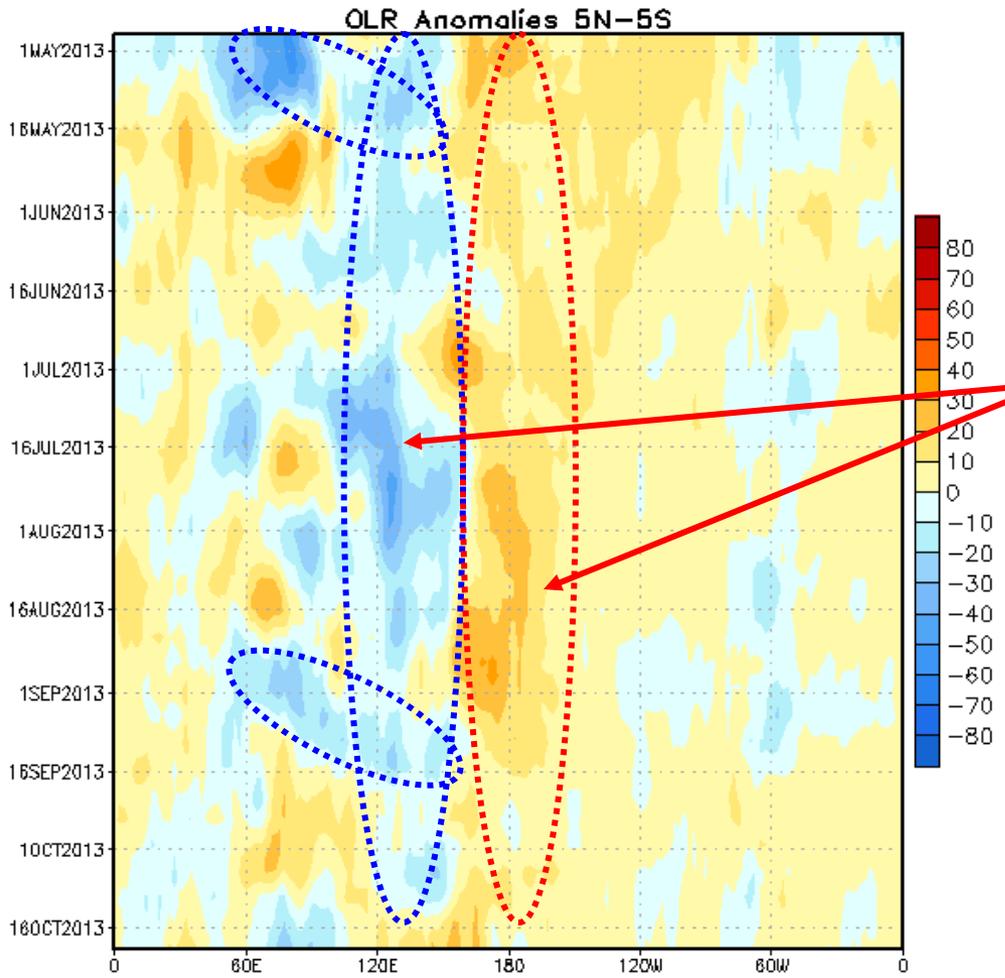


Over the last week, westerly wind anomalies have predominated over most of the equatorial Pacific Ocean.





# Outgoing Longwave Radiation (OLR) Anomalies



Since April 2013, below-average OLR has been evident over the western Pacific, while above-average OLR has persisted near the Date Line.



Longitude





# Summary



- ENSO-neutral conditions continue.
- Equatorial sea surface temperatures (SST) are near average across much of the equatorial Pacific Ocean.



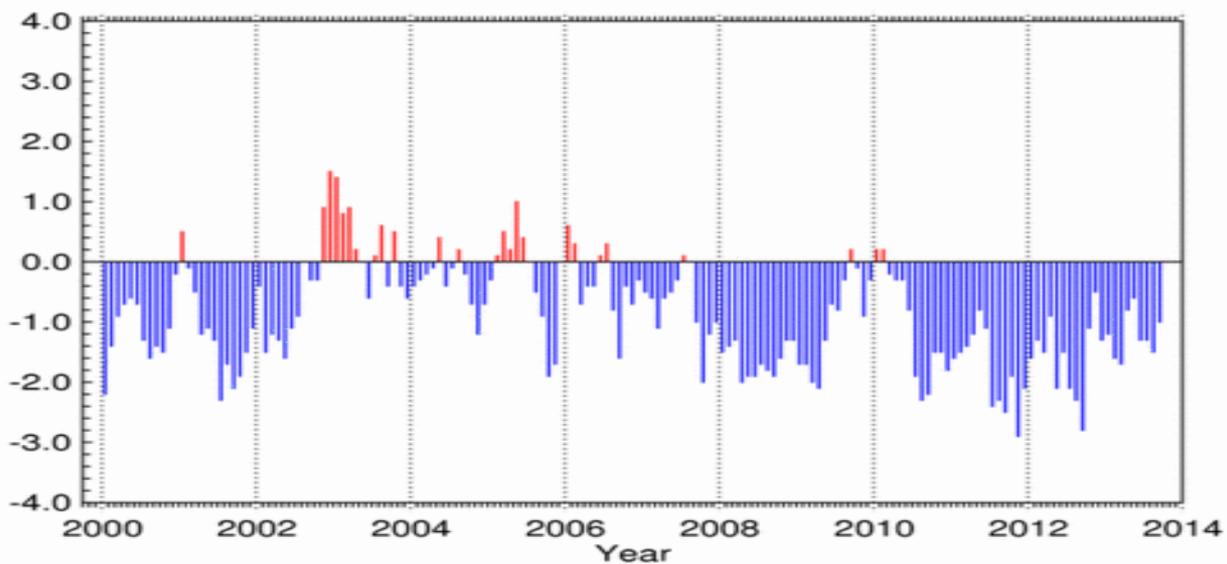


# Outlook of ENSO



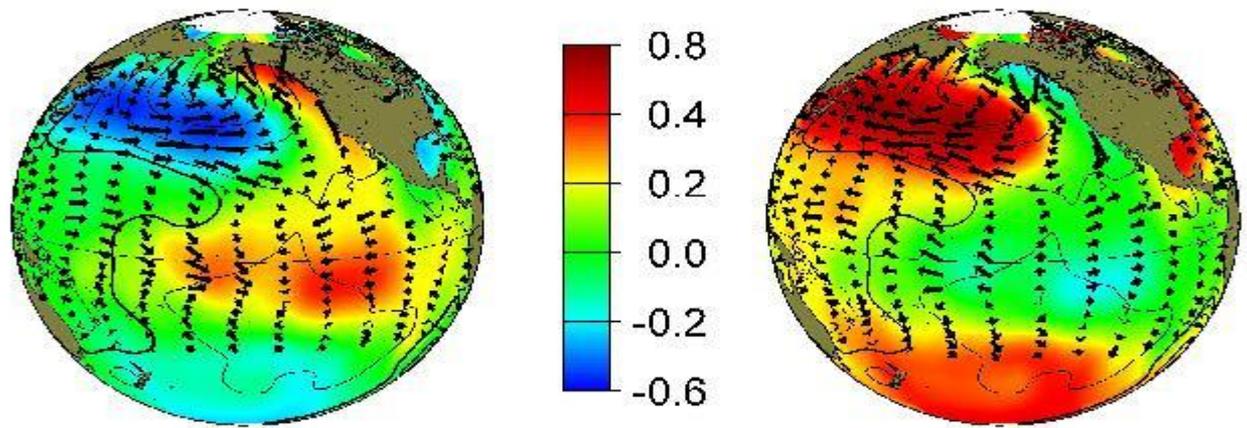


# Pacific Decadal Oscillation (PDO)



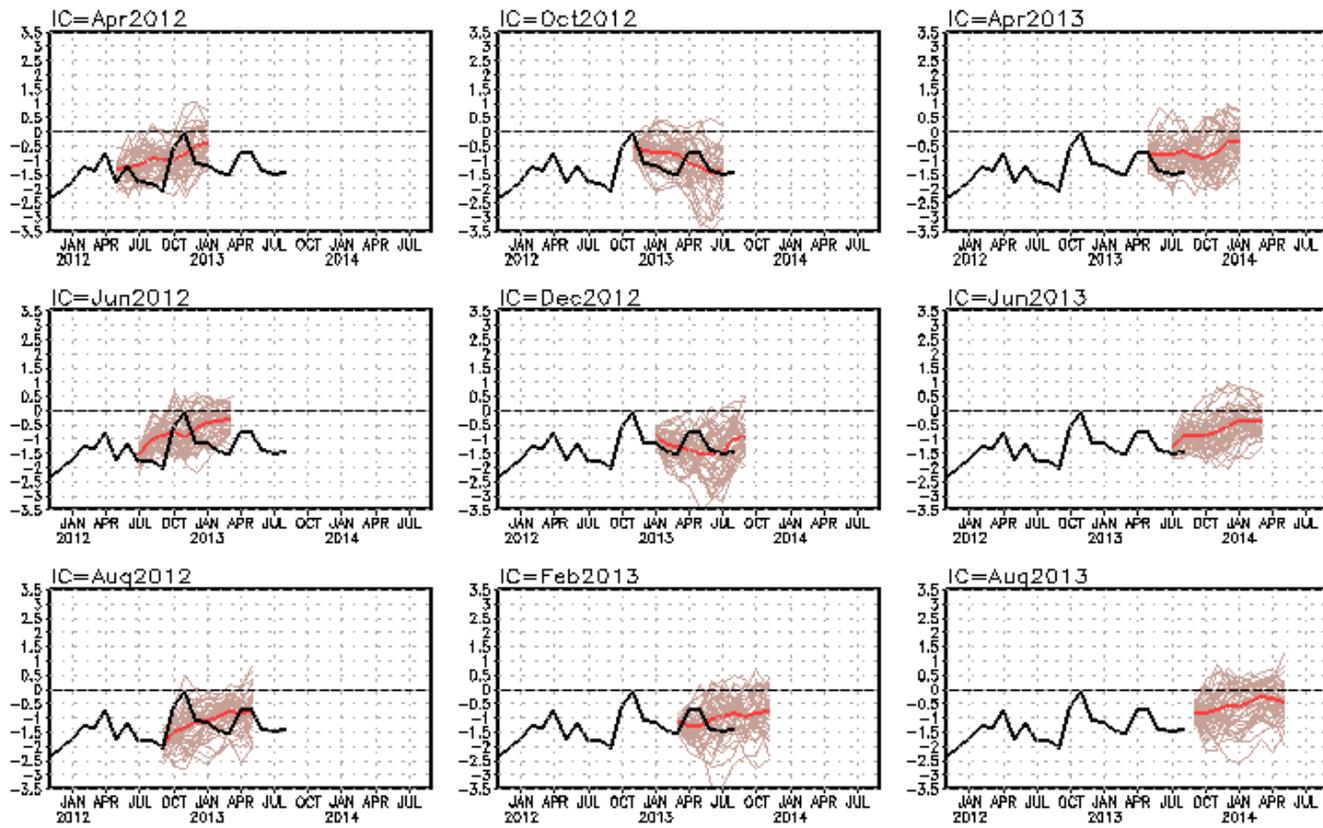
National Climatic Data Center / NESDIS / NOAA

**negative PDO  
phase suggests  
a cold tropic  
pacific of  
decadal period**



# NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

## standardized PDO index



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

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

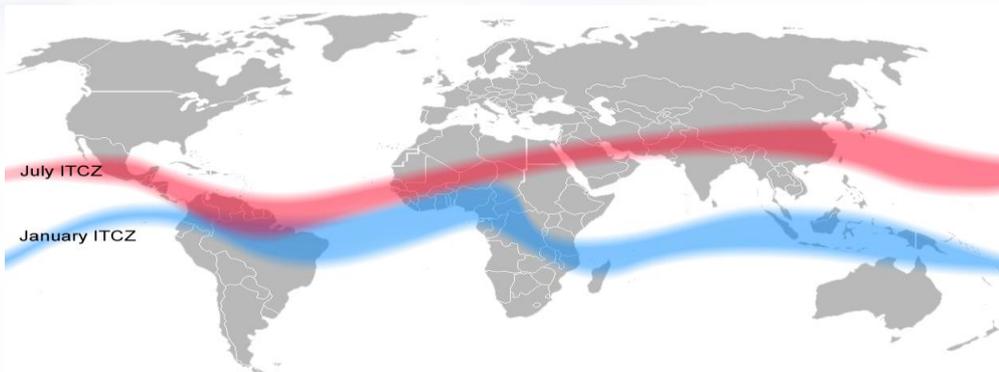
— CFSv2 Individual forecast members    — CFSv2 Forecast ensemble mean    — Observations

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

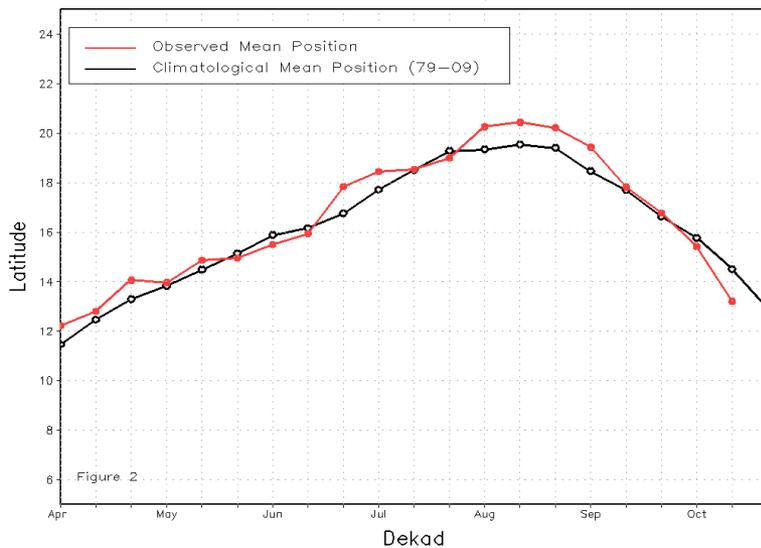




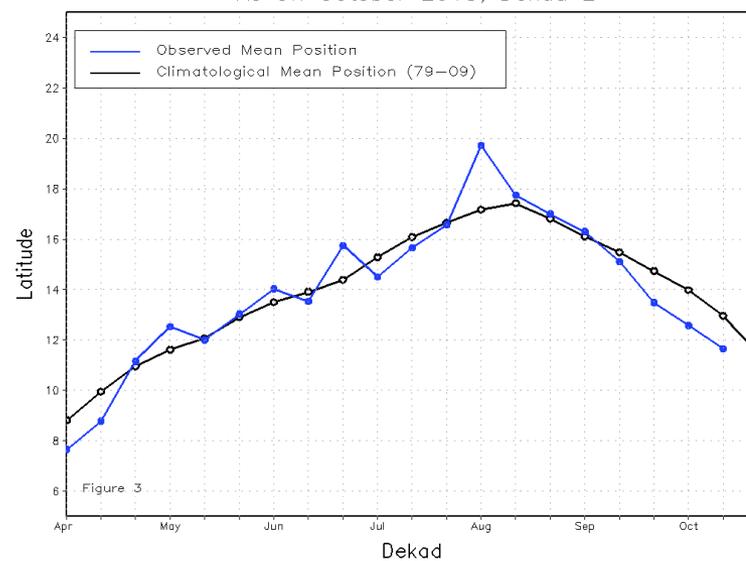
# ITCZ Monitoring



Mean Western Portion of the ITF: Averaged 10W to 10E  
As of: October 2013, Dekad 2

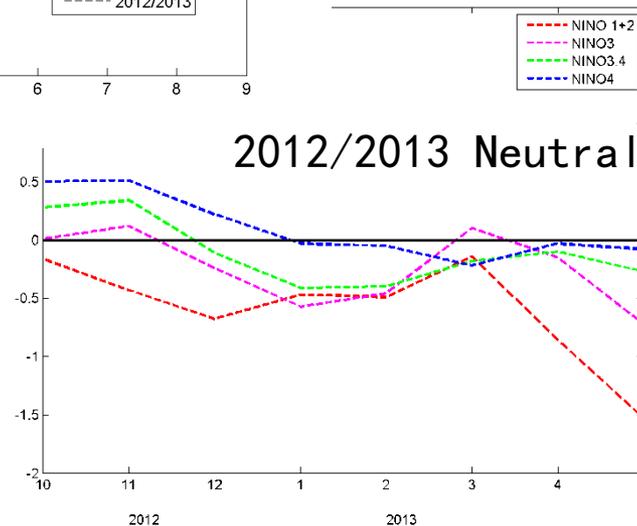
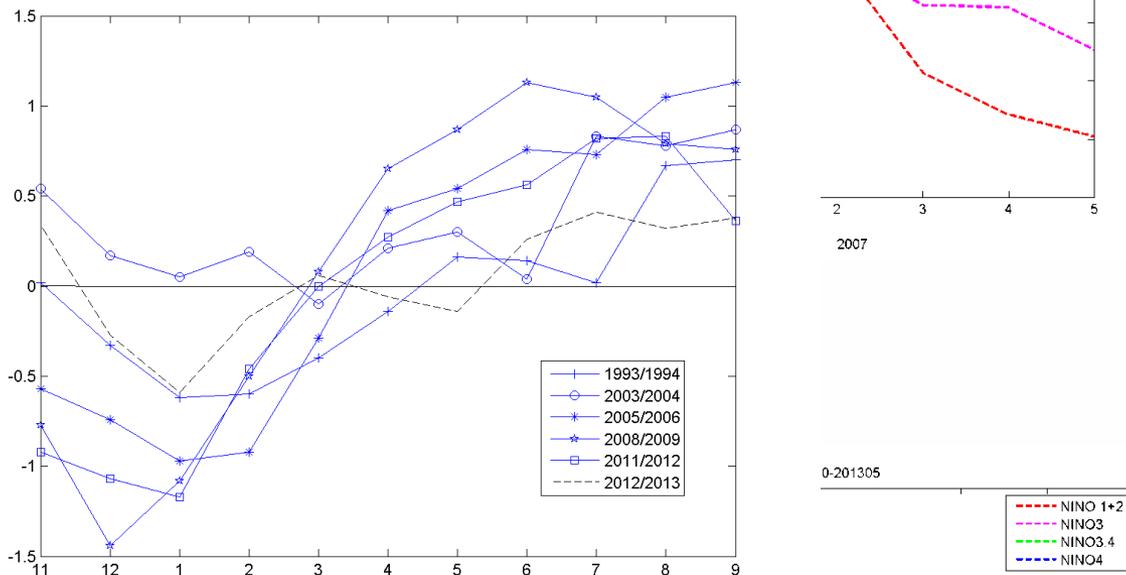
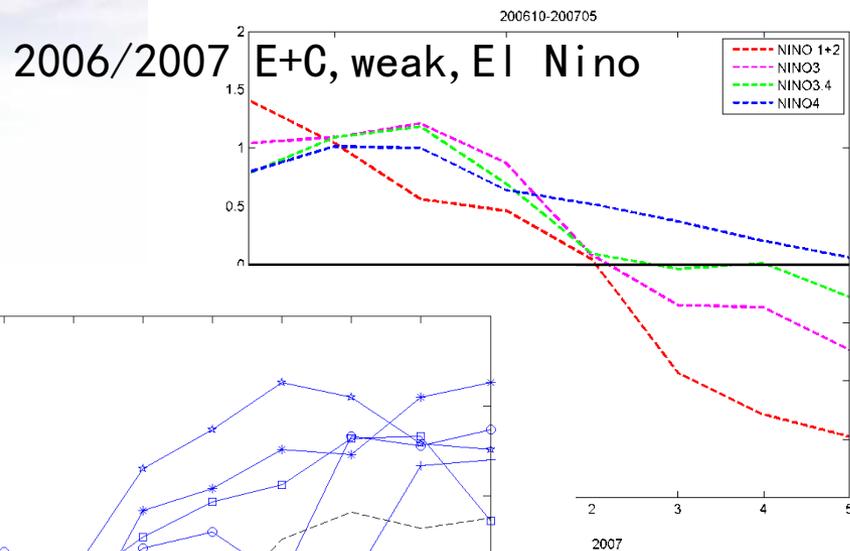
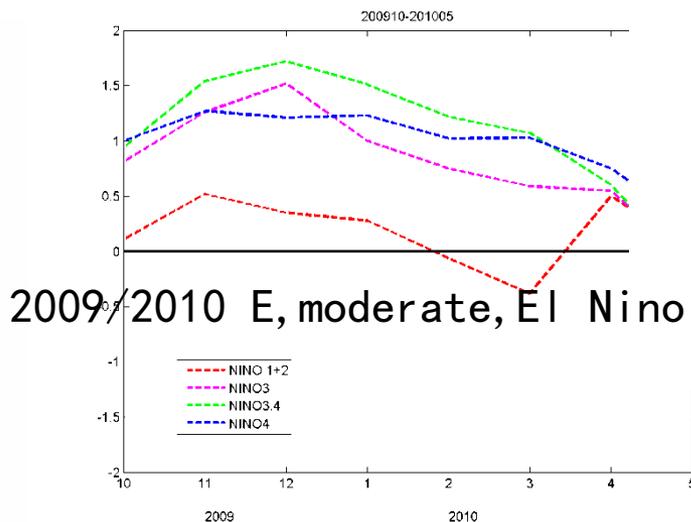
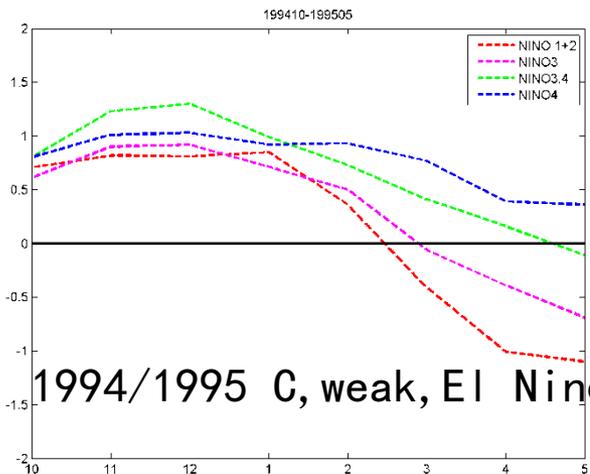
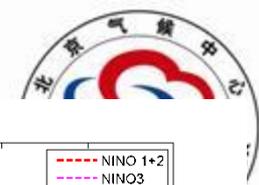


Mean Eastern Portion of the ITF: Averaged 20E to 35E  
As of: October 2013, Dekad 2





# Similarity analysis of heat content



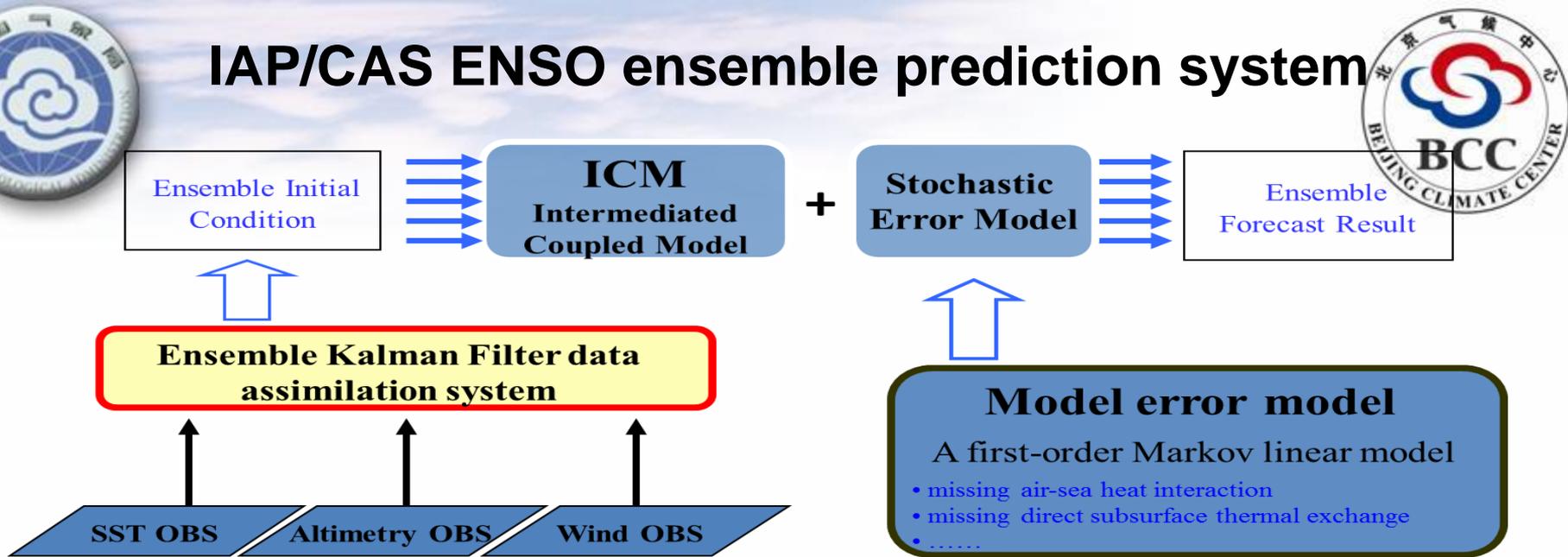
The evolution of heat content of last year in favor of a weakly El Nino or ENSO-Neutral condition in the coming winter



# ENSO Prediction by the Ensemble Prediction System



# IAP/CAS ENSO ensemble prediction system



## Ensemble Data Assimilation:

**SST+Altimetry:** providing the surface and subsurface initial thermal states

**Wind stress:** coupled improving the accuracy of the ocean currents at the initial time

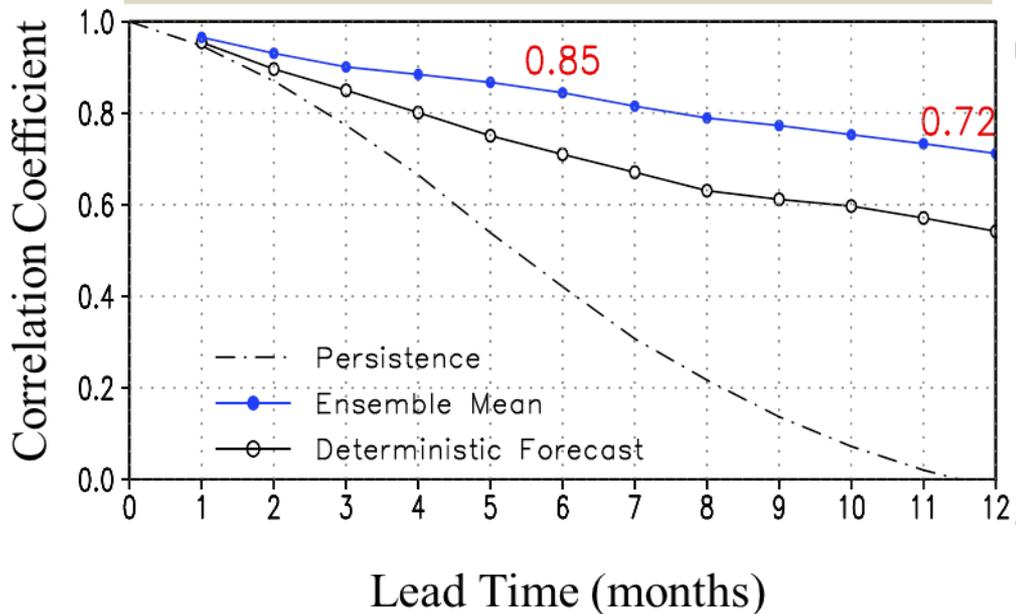
Zheng, F., and J. Zhu, 2010: Coupled assimilation for an intermediated coupled ENSO prediction model. *Ocean Dyn.*, 60, 1061-1073, doi: 10.1007/s10236-010-0307-1.

Zheng, F., and J. Zhu, 2013: Improved ensemble-mean forecast skills of ENSO events by a zero-mean stochastic error model of an intermediate coupled model. Submitted to *Mon. Wea. Rev.*

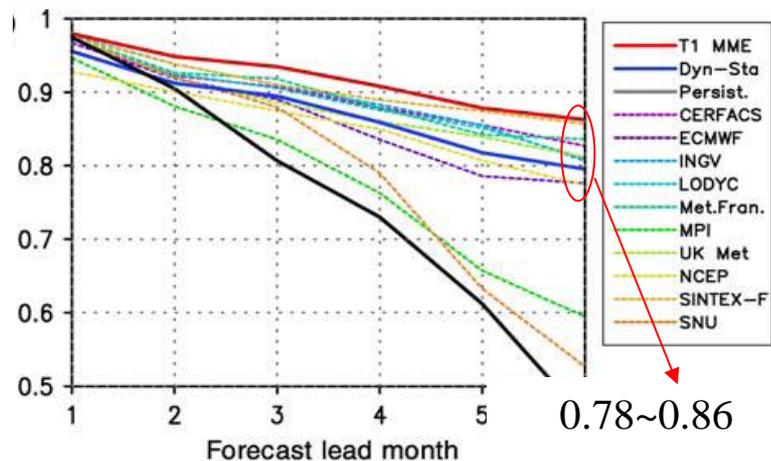


# Prediction skill

### Prediction Skill of ENSO EPS (1993-2010)



### Most ENSO models



Jin et al., (2008)

Prediction skills (anomaly correlation) of the Niño3.4 index for the ensemble-mean forecast, the deterministic forecast, and the persistence forecast. These are shown as functions of lead time, and these results are obtained from the ensemble/deterministic predictions made during the period from 1993 to 2009 regardless of their starting month.



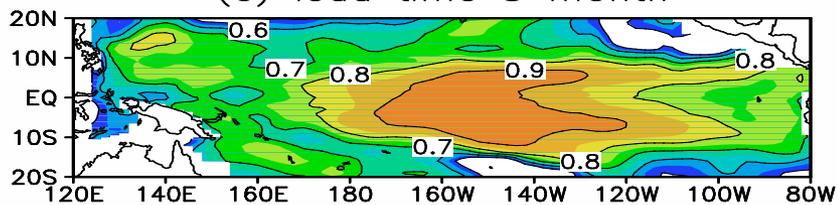


# Prediction skill

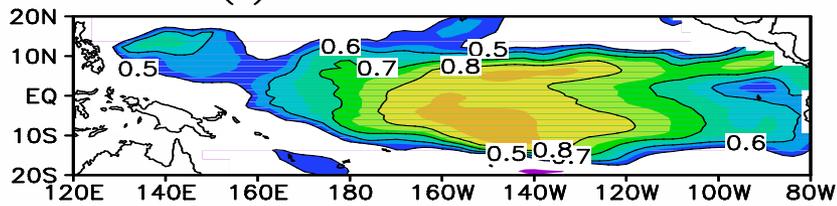


## Anomaly Correlation

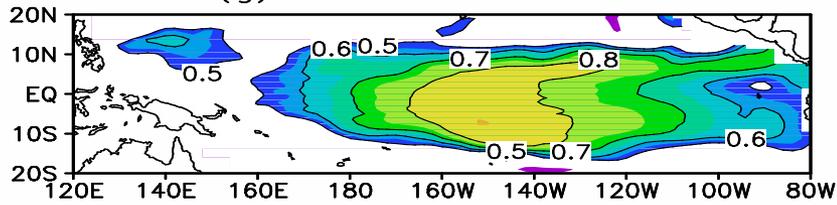
(e) lead time 3 month



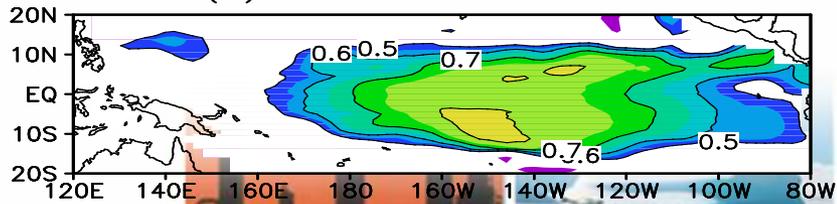
(f) lead time 6 month



(g) lead time 9 month

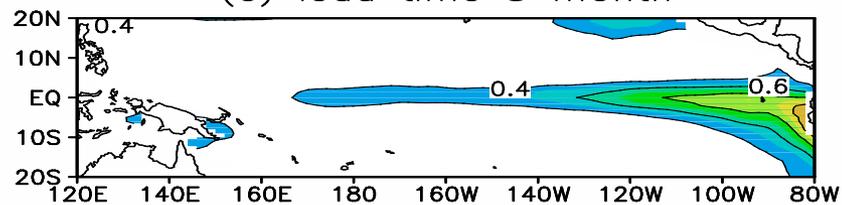


(h) lead time 12 month

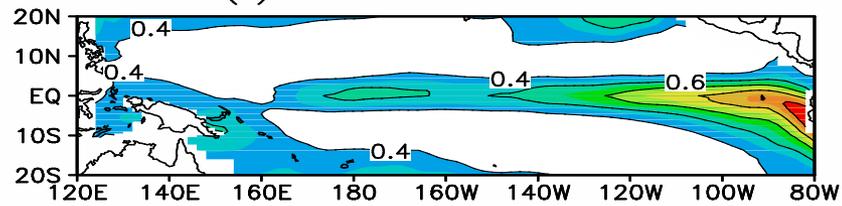


## RMS error

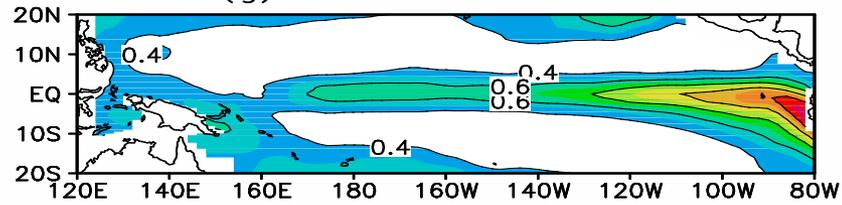
(e) lead time 3 month



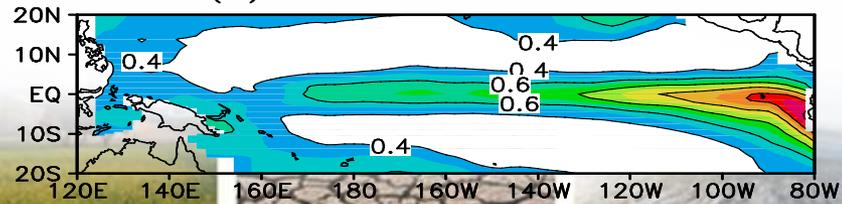
(f) lead time 6 month



(g) lead time 9 month



(h) lead time 12 month





# Experimental design for 2013-14 ensemble prediction



- A 12-month forecast **started from Oct. 2013**
- **100** ensemble members
- **Initial condition** is provided by the **coupled data assimilation** system through assimilating SST, Altimetry and wind stress observations into the model
- Considering the impacts of **model errors** during the forecast process

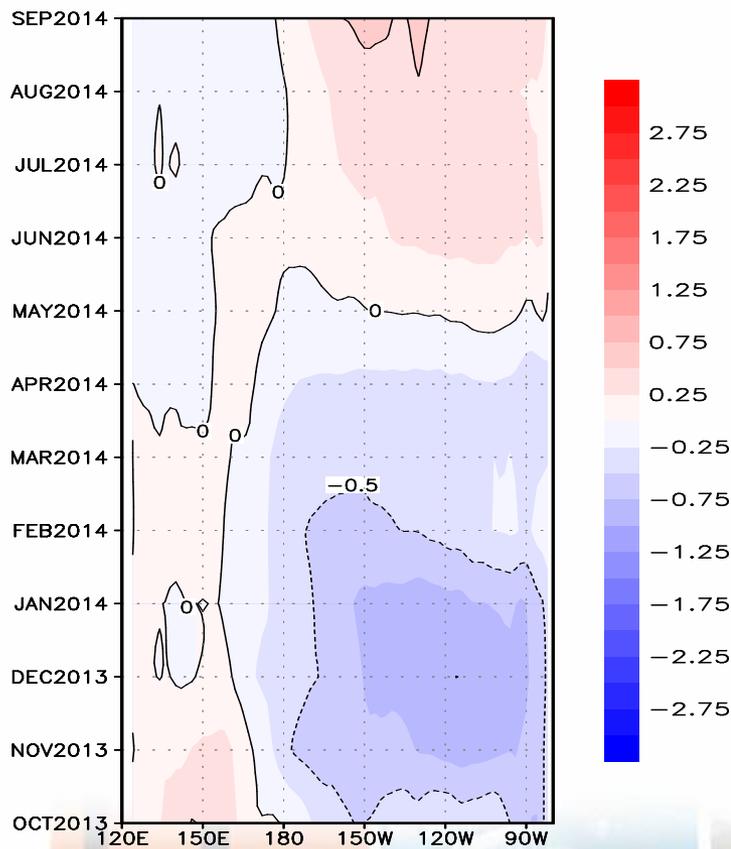




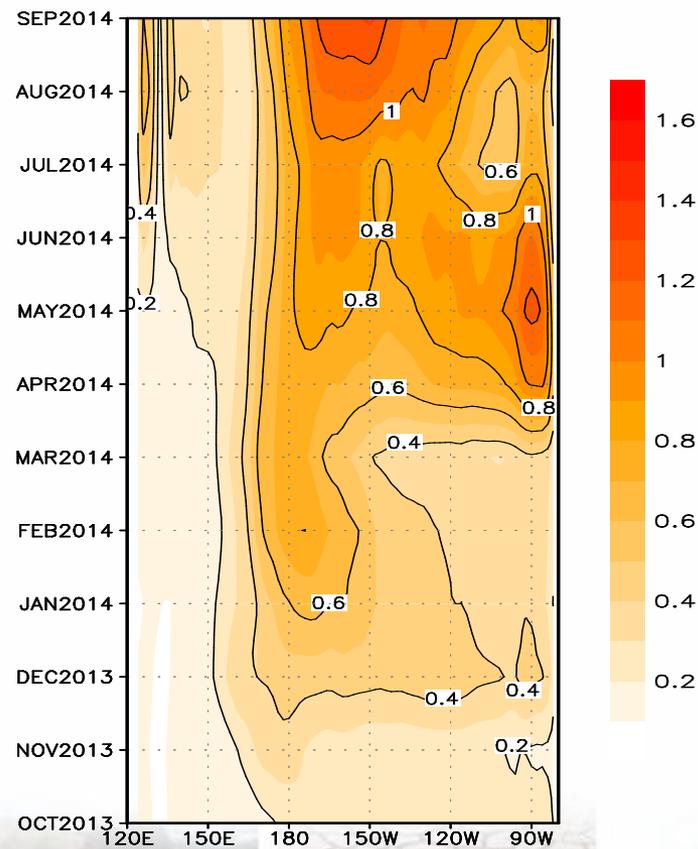
# Predicted SST along the equator

## SSTA Forecast Along the Equator

Ensemble Mean Forecast



Forecast Uncertainty



Ensemble-mean Forecast

Forecast Uncertainty

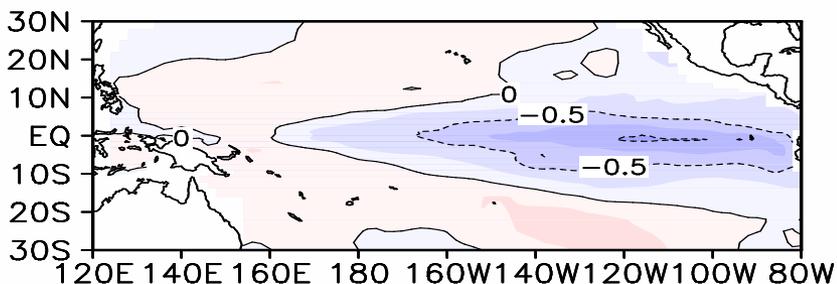




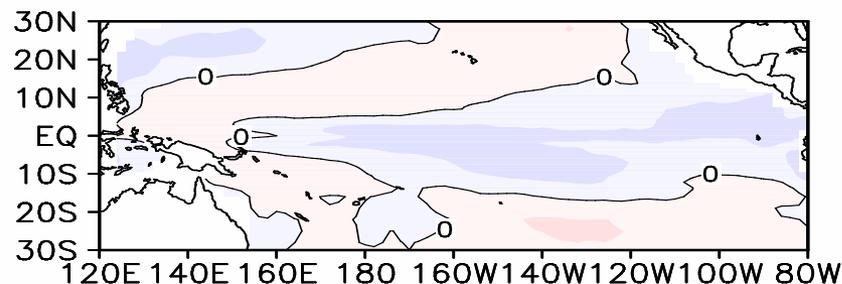
# Predicted SST over the tropical Pacific

SSTA Ensemble Mean Forecast (Start from Oct 01 2013)

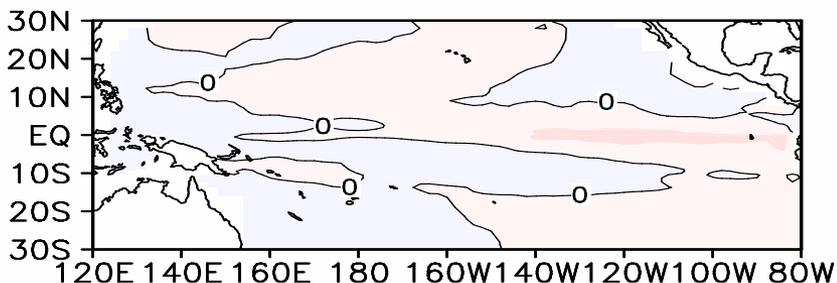
(a) Dec 2013 (lead time 3 month)



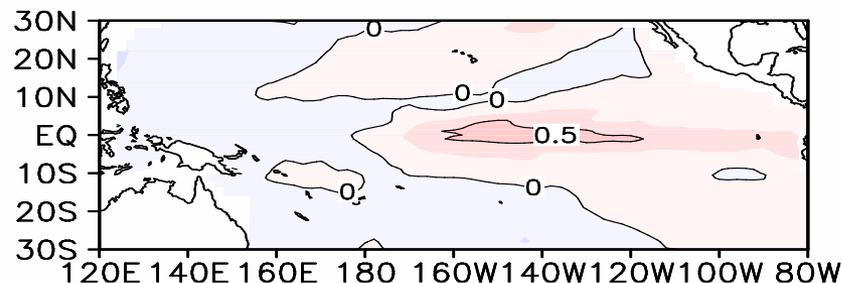
(b) Mar 2014 (lead time 6 month)



(c) Jun 2014 (lead time 9 month)



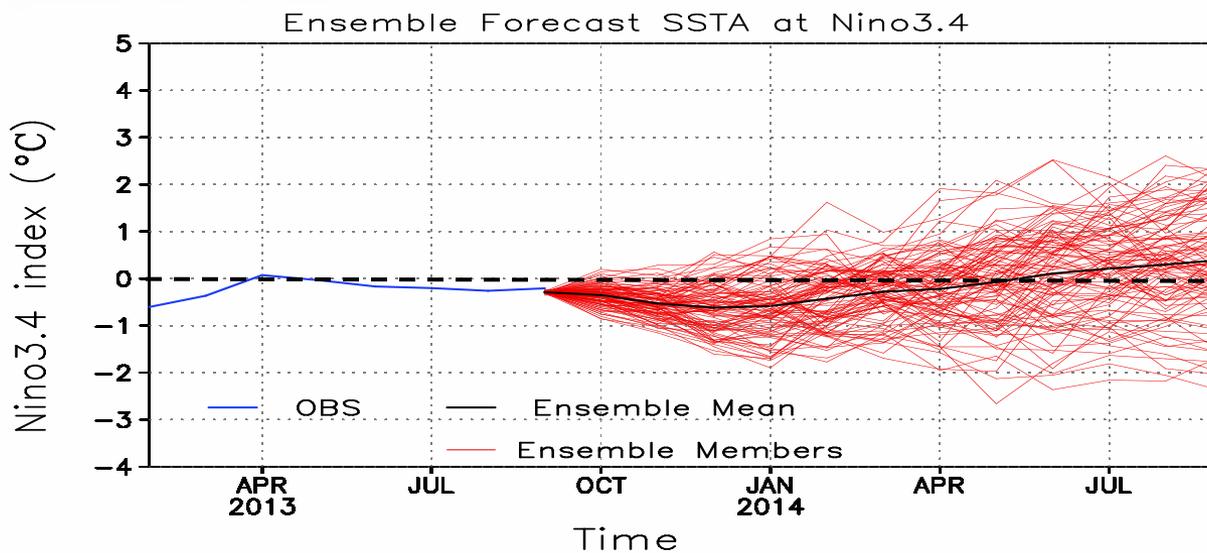
(d) Sep 2014 (lead time 12 month)



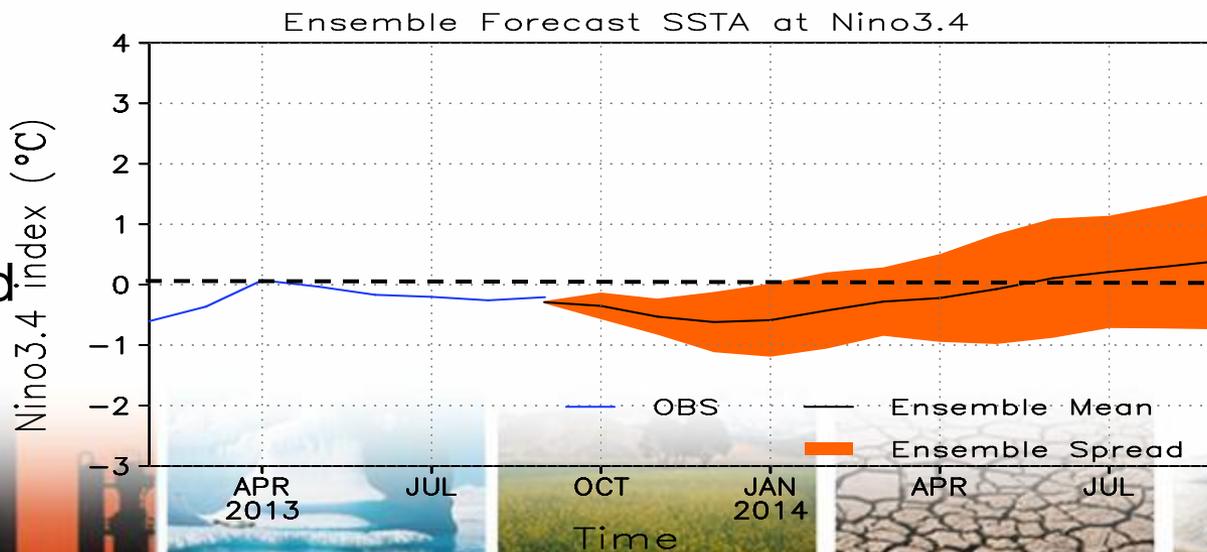


# Ensemble predicted Nino3.4 index

100 Ensemble Members



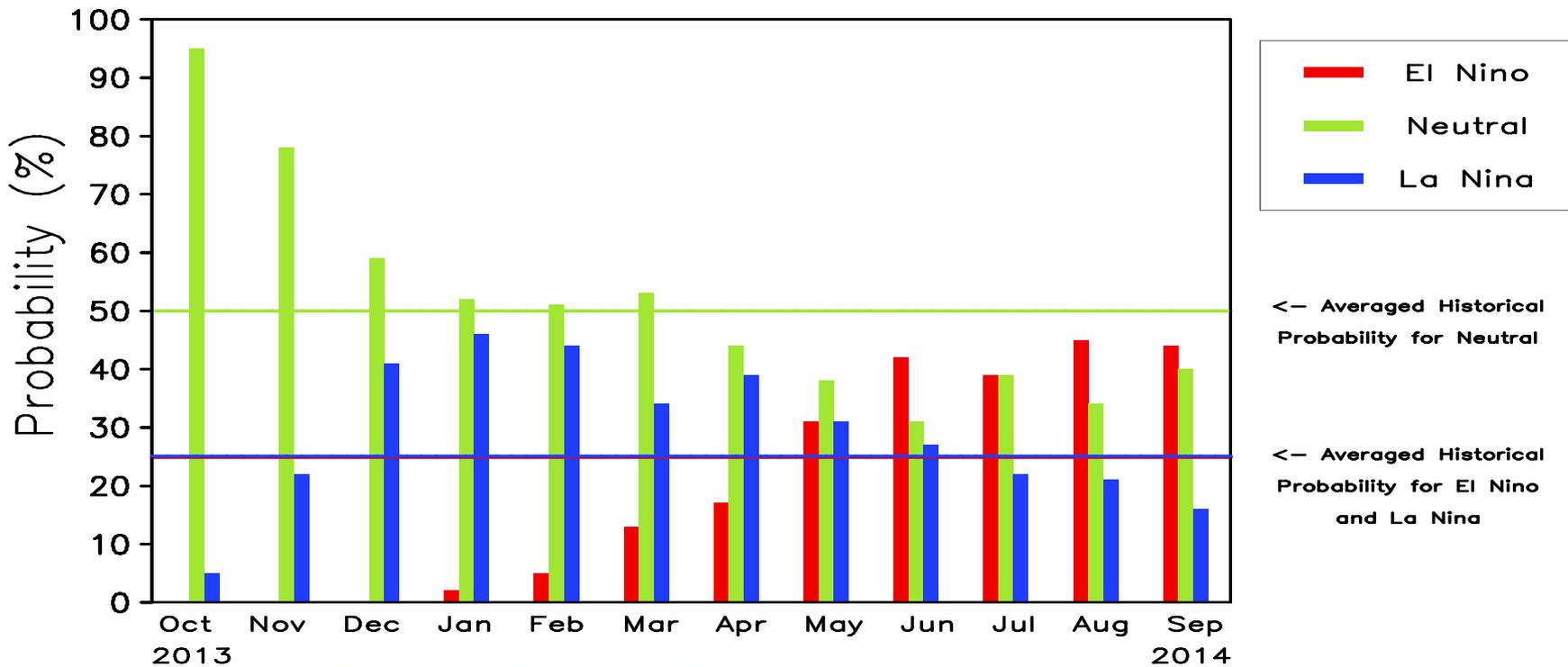
Ensemble Spread





# Probabilistic forecast for Nino3.4 index

## Probabilistic ENSO Forecast for Nino3.4 region





# Summary

- **ENSO-neutral conditions continue since the boreal spring of 2012.**
- **During the boreal spring and autumn, equatorial SSTs were below averages in the eastern half of the Pacific, above averages in the far western Pacific and near-average elsewhere.**
- **Equatorial sea surface temperatures (SST) are near average across much of the equatorial Pacific Ocean recently.**
- **According to the ensemble prediction and diagnostic, the ENSO-neutral conditions are expected remain through the winter of 2013-2014.**
- **There is a little more uncertainty about the prediction of boreal spring of 2014, but the El-nino condition is likely appearance. Keep an eye on the Following development is necessary.**





*Thanks*

