



# **Madden-Julian Oscillation: Recent Evolution, Current Status and Predictions**

**Update prepared by  
Climate Prediction Center / NCEP  
July 28, 2014**



# Outline

- **Overview**
- **Recent Evolution and Current Conditions**
- **MJO Index Information**
- **MJO Index Forecasts**
- **MJO Composites**



# Overview

- **MJO indices increased in amplitude during the past several days with enhanced (suppressed) convection over the Pacific (Indian) Ocean. Little eastward propagation was observed.**
- **Other modes of tropical variability, including Kelvin Waves, tropical cyclones, and the low-frequency state, continue to strongly influence the convective pattern.**
- **There is considerable spread among dynamical model MJO forecasts, with some models indicating increasing MJO activity over the Indian Ocean or Maritime Continent during Week-2.**
- **Based on recent observations and dynamical model guidance, the future evolution of the MJO remains uncertain.**
- **The MJO may contribute to enhanced convection over parts of the northwestern and central Pacific during the upcoming week.**

**Additional potential impacts across the global tropics and a discussion for the U.S. are available at:**  
**<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>**

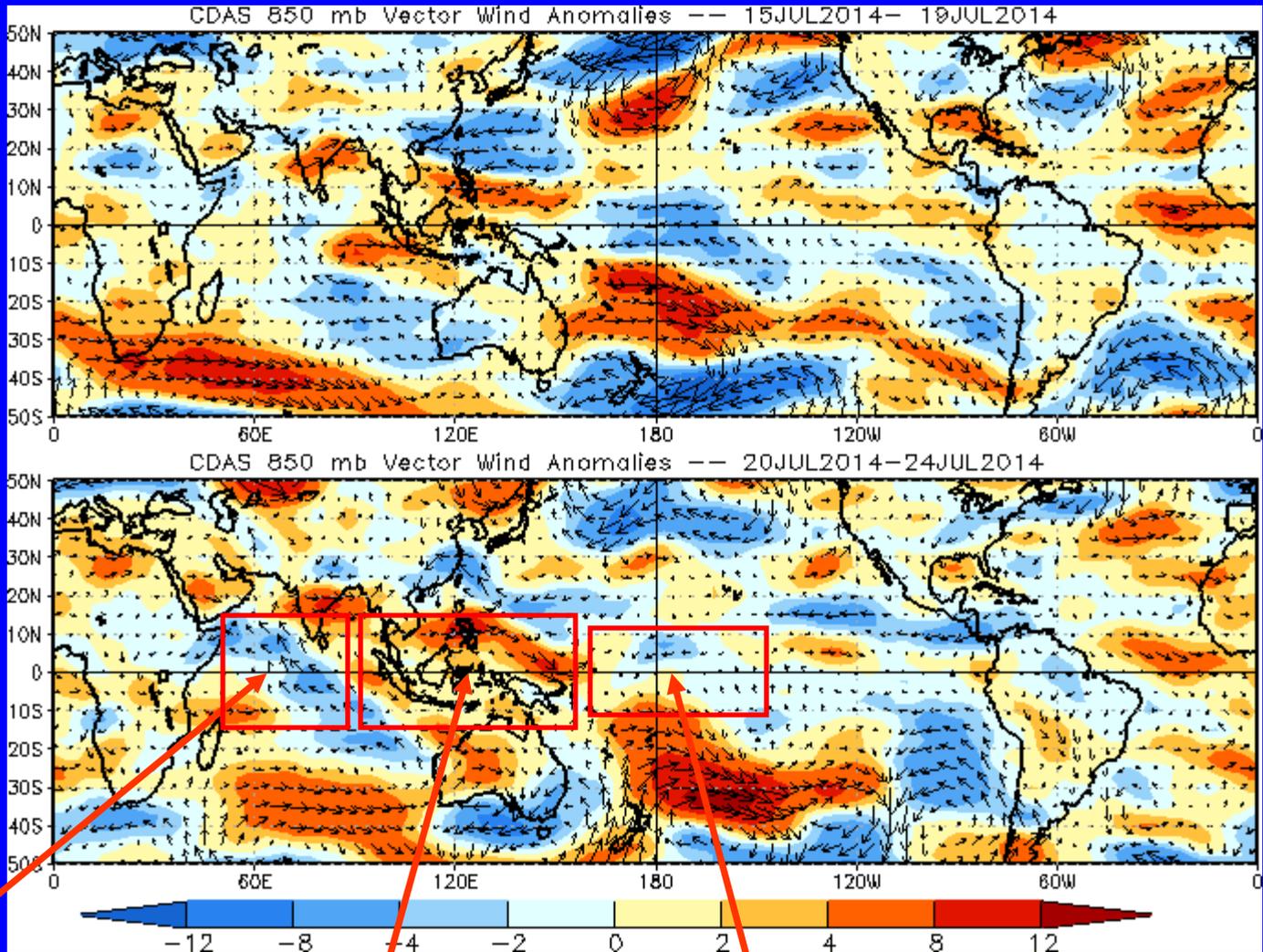


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies strengthened over the central Indian Ocean.

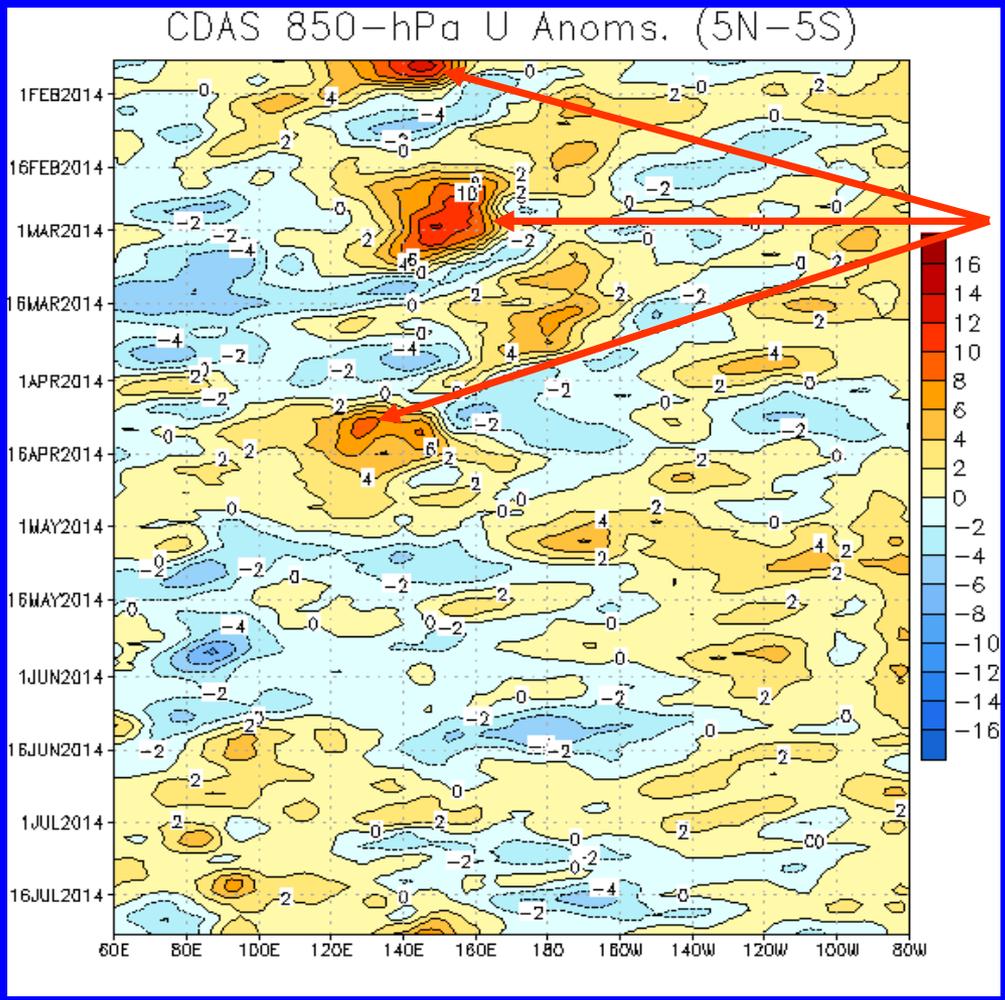
Westerly anomalies persisted over the Maritime Continent.

Easterly anomalies weakened near the Date Line.



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

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow  
Easterly anomalies (blue shading) represent anomalous east-to-west flow



Time  
↓

Longitude

Multiple westerly wind bursts were observed across the western Pacific between January and mid-April.

During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May and June, westerly anomalies were observed over the eastern Pacific.

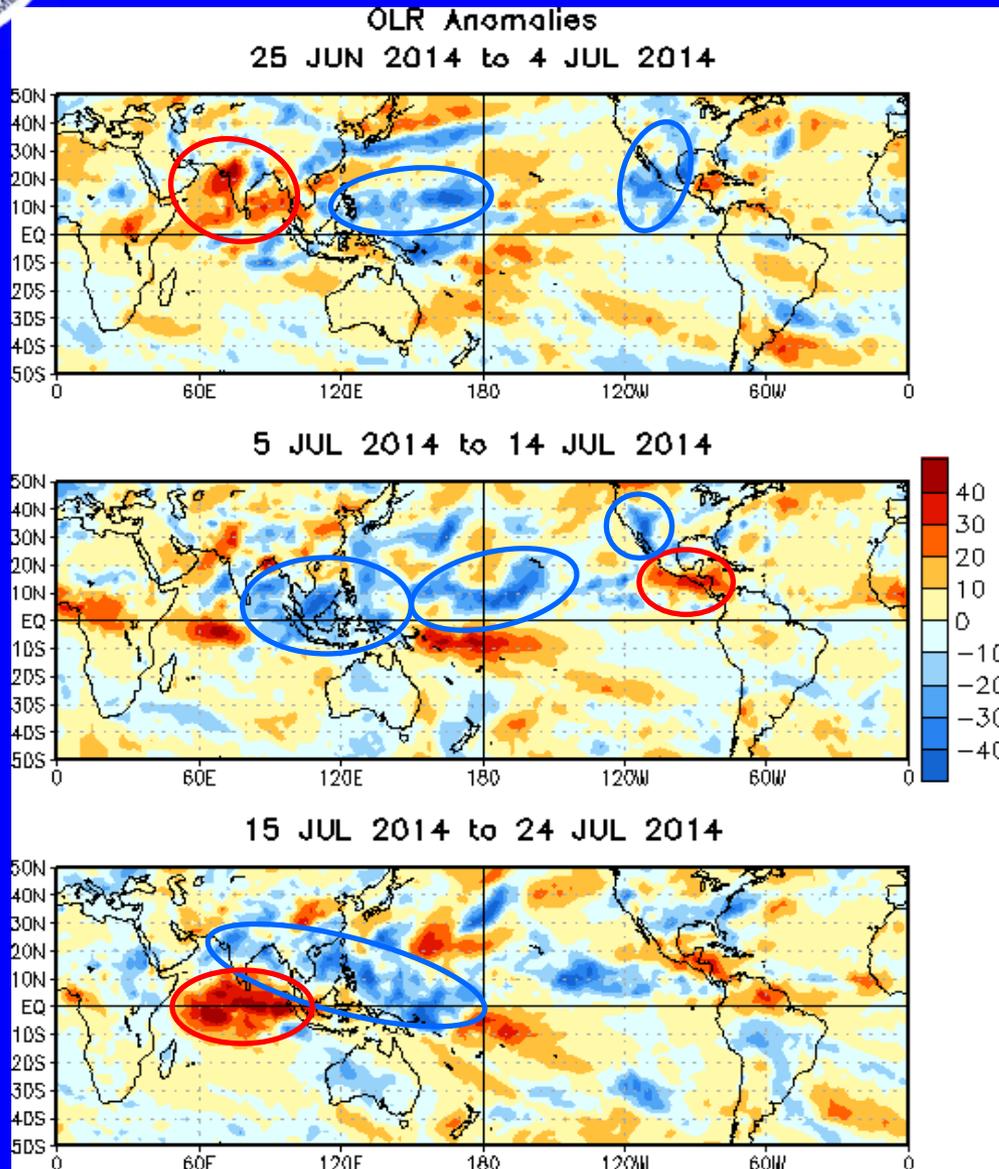
Westerly anomalies associated with an enhanced Southeast Asian monsoon circulation are evident from 80E to 120E during much of June and July.

Since early June, anomalies have been alternating sign and fairly low magnitude across much of the equatorial Pacific.



# OLR Anomalies – Past 30 days

**Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)**  
**Wetter-than-normal conditions, negative OLR anomalies (blue shading)**



During late June and early July, enhanced (suppressed) convection was observed over both the western and eastern Pacific (northern Indian Ocean and parts of South Asia).

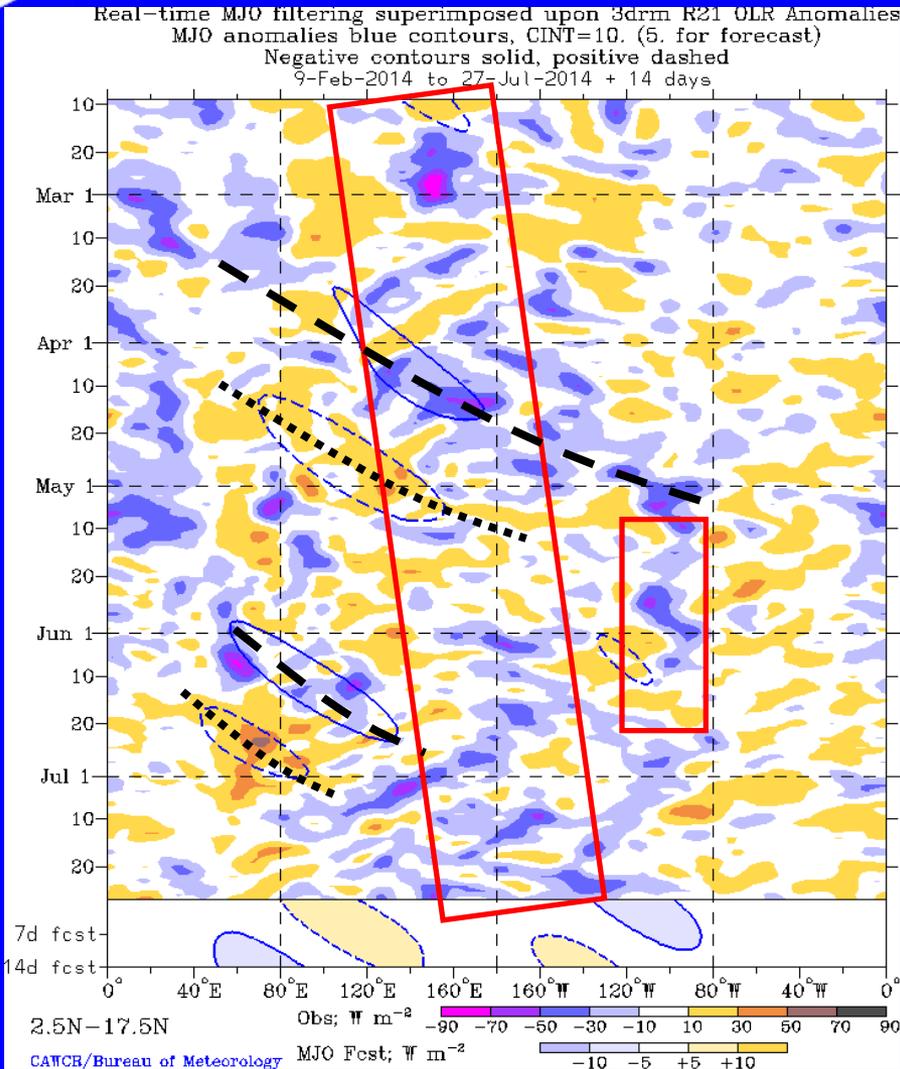
During early to mid-July, enhanced convection developed over the Maritime Continent and central Pacific. The North American Monsoon remained enhanced, while suppressed convection was observed over the western Caribbean and far eastern Pacific.

Areas of enhanced convection were observed over India, Southeast Asia and the western Pacific during mid-July while suppressed convection intensified across the equatorial Indian Ocean.



# Outgoing Longwave Radiation (OLR)

## Anomalies (2.5°N-17.5°N)



Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

Wetter-than-normal conditions, negative OLR anomalies (blue shading)

(Courtesy of CAWCR Australia Bureau of Meteorology)

Since January, enhanced convection has propagated slowly eastward from the Maritime Continent to the central Pacific (red box), interrupted periodically by subseasonal variability.

The MJO became more coherent during April, with the subseasonal envelopes of enhanced and suppressed convection modulating the strength of the low frequency signal. The anomalous tropical convection pattern became largely incoherent during mid-May, with enhanced convection more clear over the eastern Pacific (red box).

During June, the MJO became more organized as eastward propagation was observed primarily over the Indian Ocean, but in July the pattern has become less coherent.

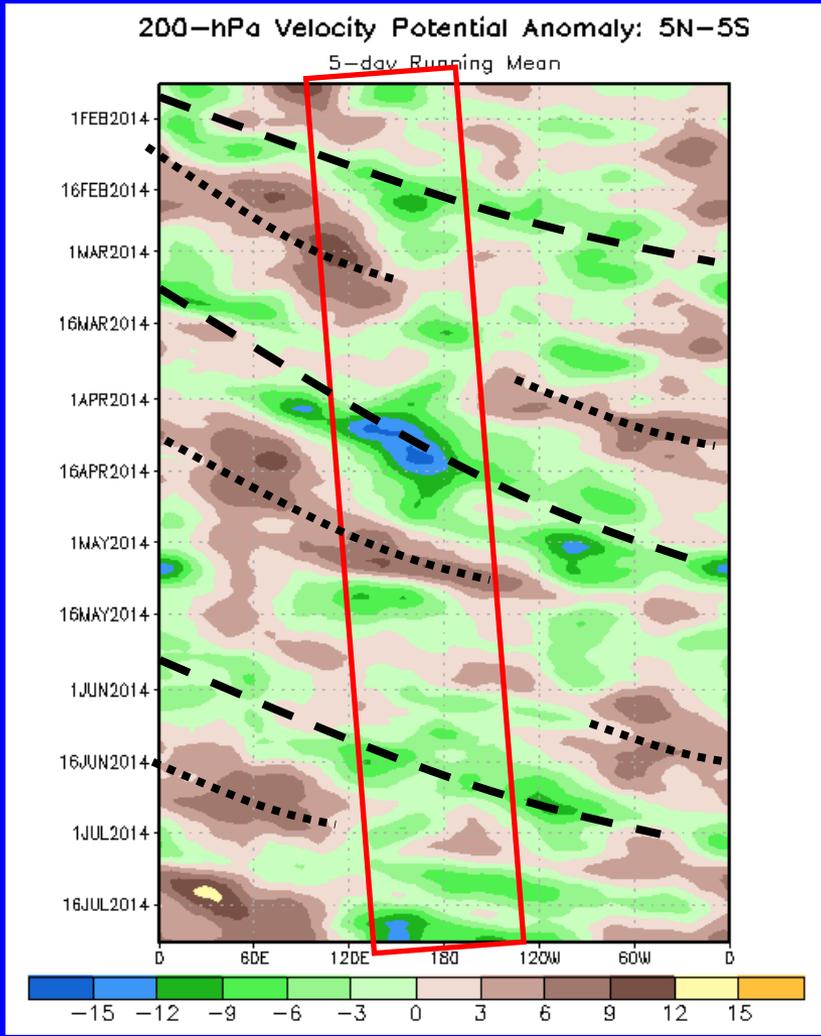


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time  
↓



Longitude

A slow eastward progression of negative anomalies was observed from January to present across the Indo-Pacific warm pool and central Pacific (red box).

During February through April, anomalies propagated eastward with time associated with the MJO before weakening for much of May.

The pattern became more organized during June with a more coherent wave-1 MJO like structure with eastward propagation.

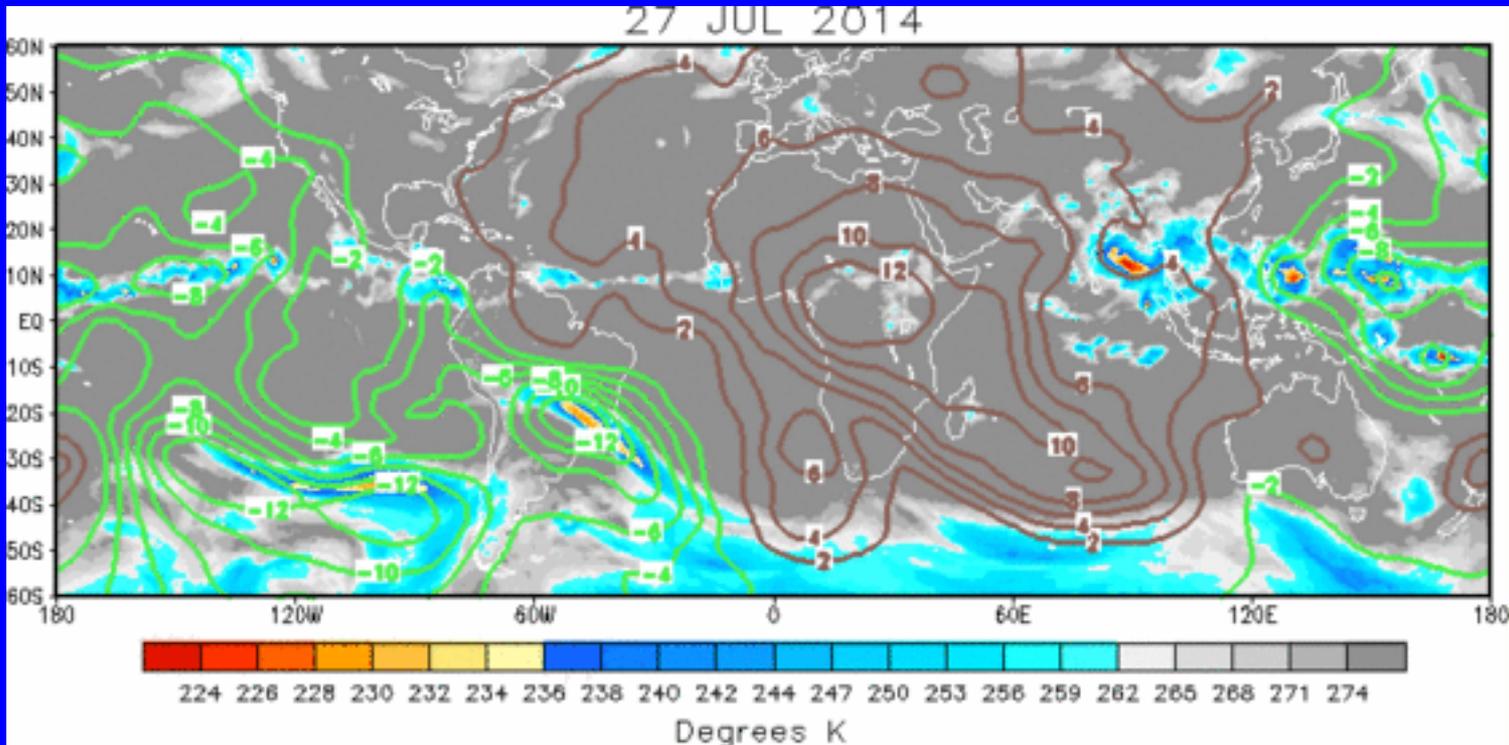
More recently, the pattern became less coherent as other modes of subseasonal tropical variability (e.g., equatorial Rossby and Kelvin wave activity) appear to have become the more dominant signals.



# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern indicates strong anomalous descent across Africa and the western Indian ocean and strong anomalous ascent over most of the Pacific Ocean.

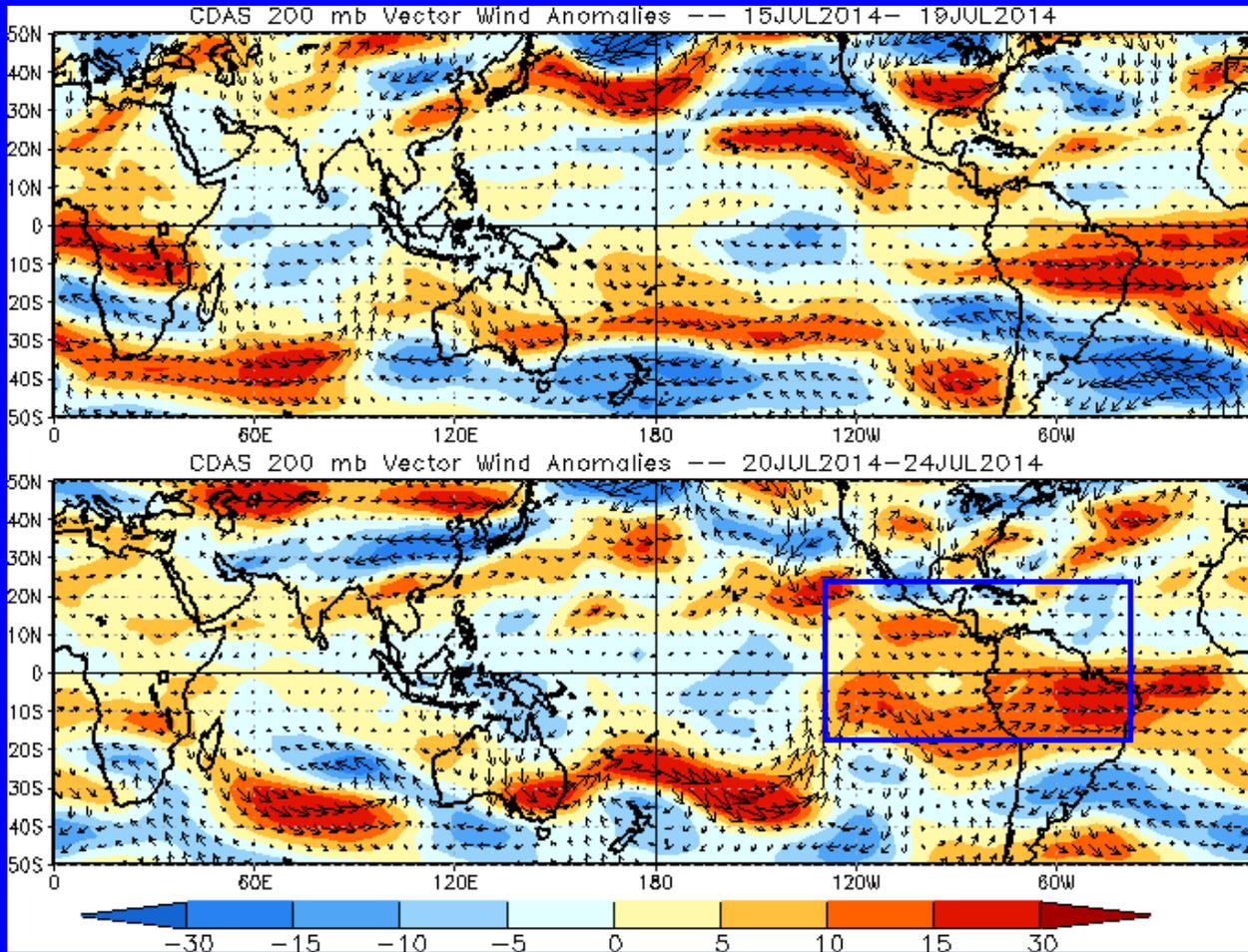


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



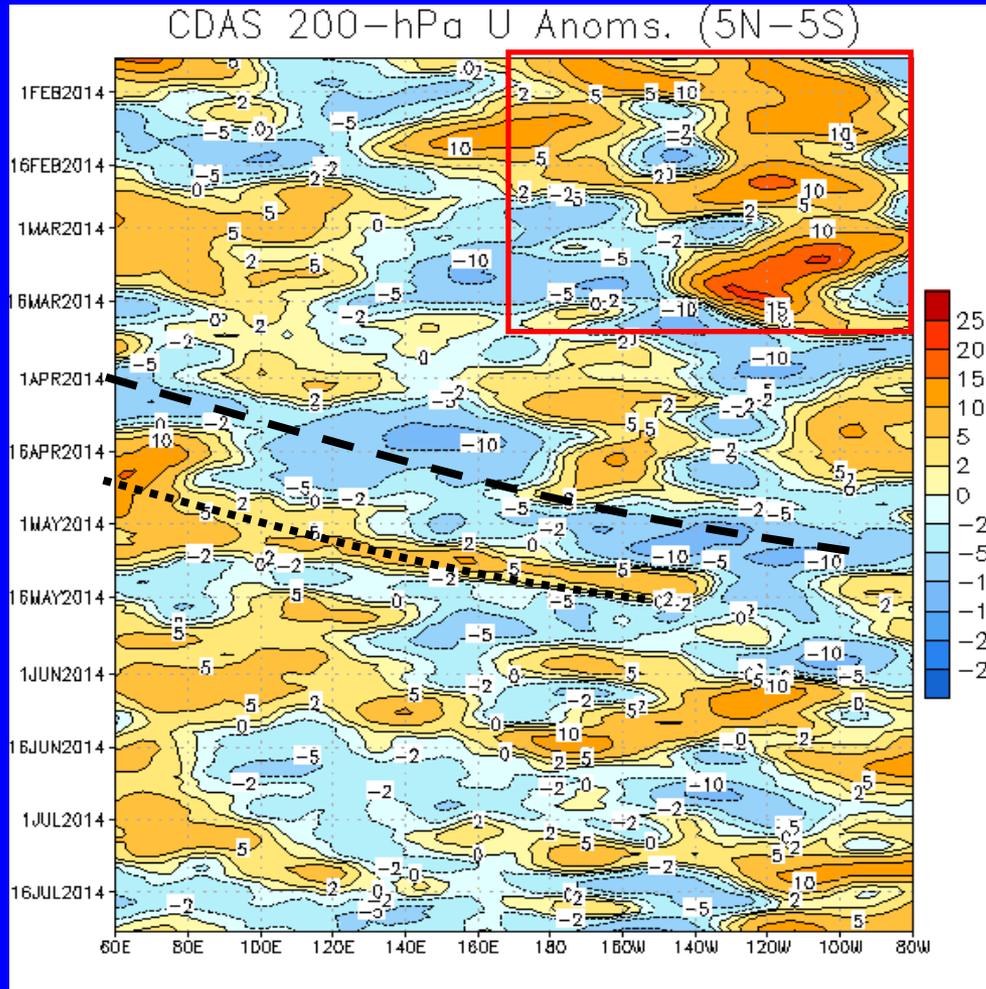
Upper-level westerly wind anomalies (blue box) increased over the eastern Pacific.



# 200-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow



Time  
↓

Longitude

From January into March, westerly anomalies were most prevalent across the western Hemisphere (red box).

During mid-April, the slowly evolving background state contributed to easterly anomalies expanding to the Date Line.

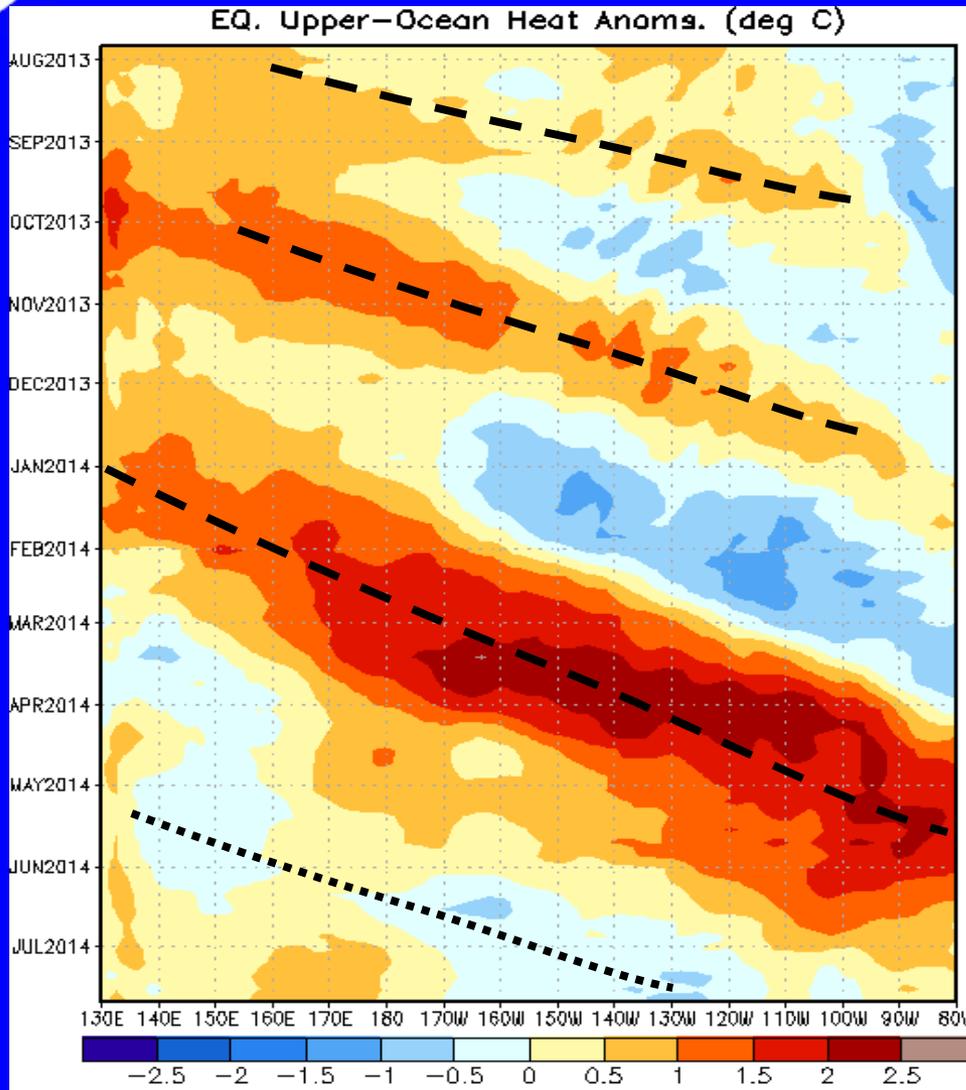
MJO activity is evident in the eastward propagation of both easterly and westerly anomalies during April and early May. This signal weakened during late May.

Westward propagation of westerly anomalies is evident over the east central Pacific during June.

More recently, easterly anomalies were observed across most of the Pacific.



# Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident in late August 2013 and once again during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

Warm anomalies persisted over much of the Pacific during April and May, though basin-averaged anomalies decreased during June associated with upwelling Kelvin wave activity.



# MJO Index -- Information

- The MJO index illustrated on the next several slides is the CPC version of the Wheeler and Hendon index (2004, hereafter WH2004).

**Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review*, 132, 1917-1932.**

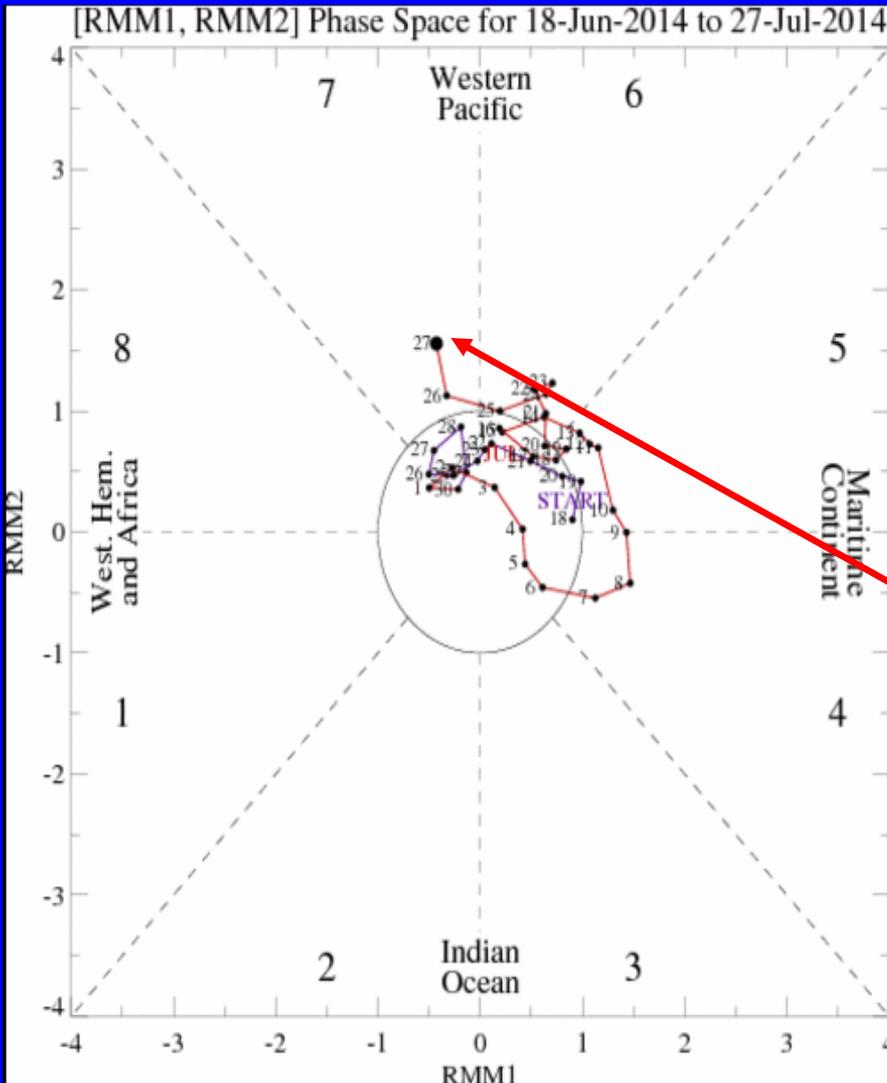
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.**

- The index is based on a combined Empirical Orthogonal Function (EOF) analysis using fields of near-equatorially-averaged 850-hPa and 200-hPa zonal wind and outgoing longwave radiation (OLR).



# MJO Index -- Recent Evolution

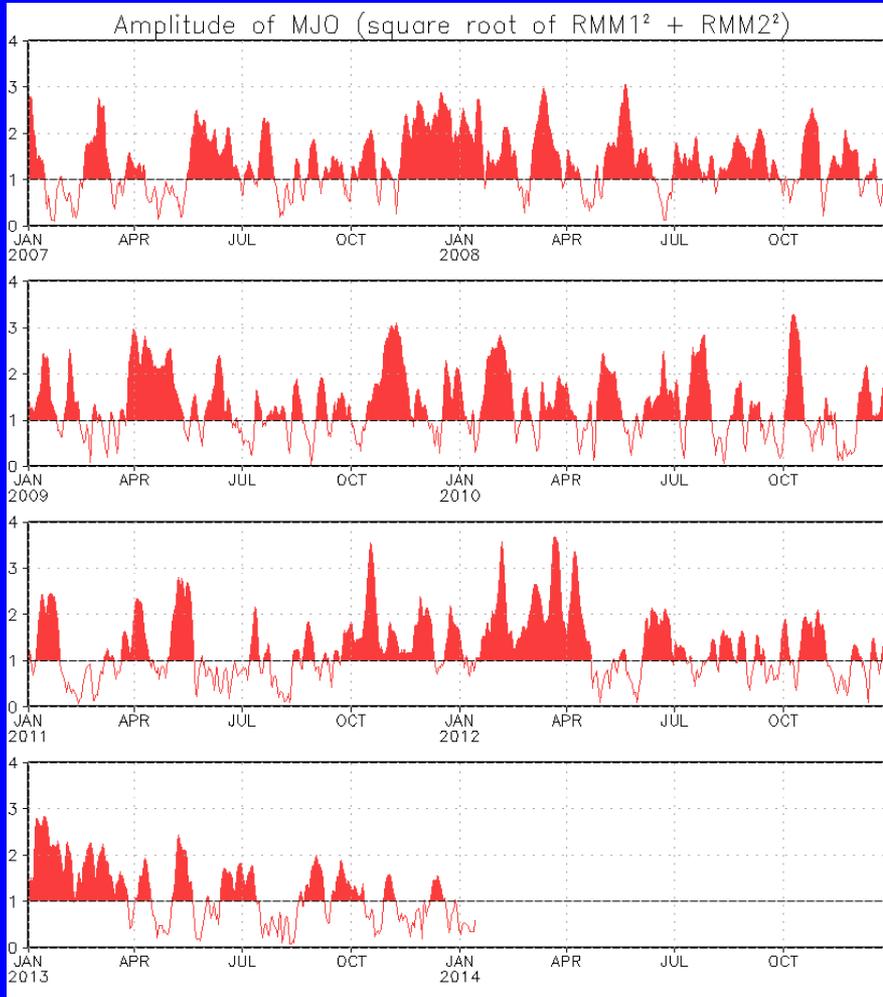


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the origin is proportional to MJO strength
- Line colors distinguish different months

The MJO index indicated little coherent MJO activity during the past week, although there is a strong projection over the west-central Pacific.



# MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

Plot puts current MJO activity in recent historical context.



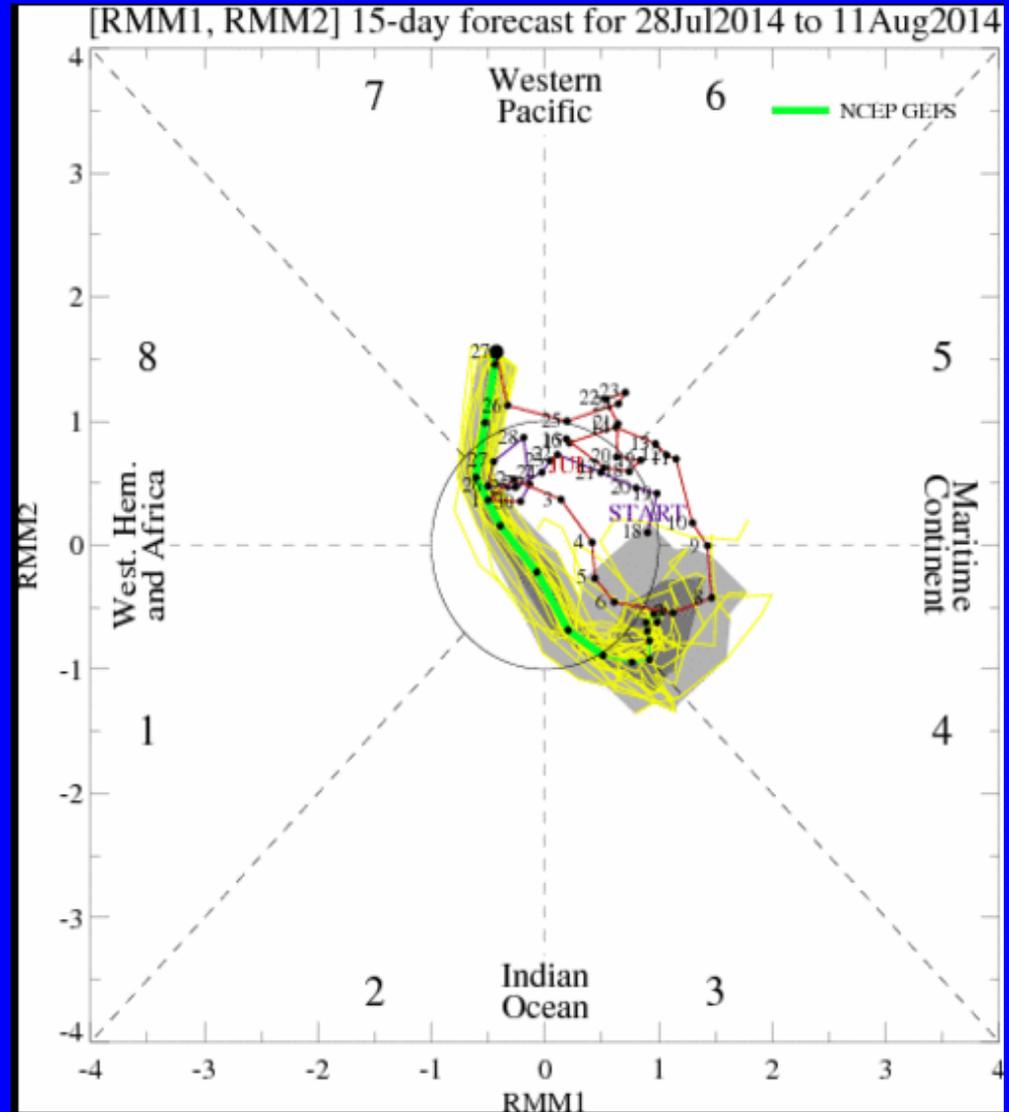
# Ensemble GFS (GEFS) MJO Forecast

Yellow Lines – 20 Individual Members  
Green Line – Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts  
dark gray shading: 50% of forecasts

The ensemble GFS forecast indicates an incoherent MJO signal over the next two weeks.

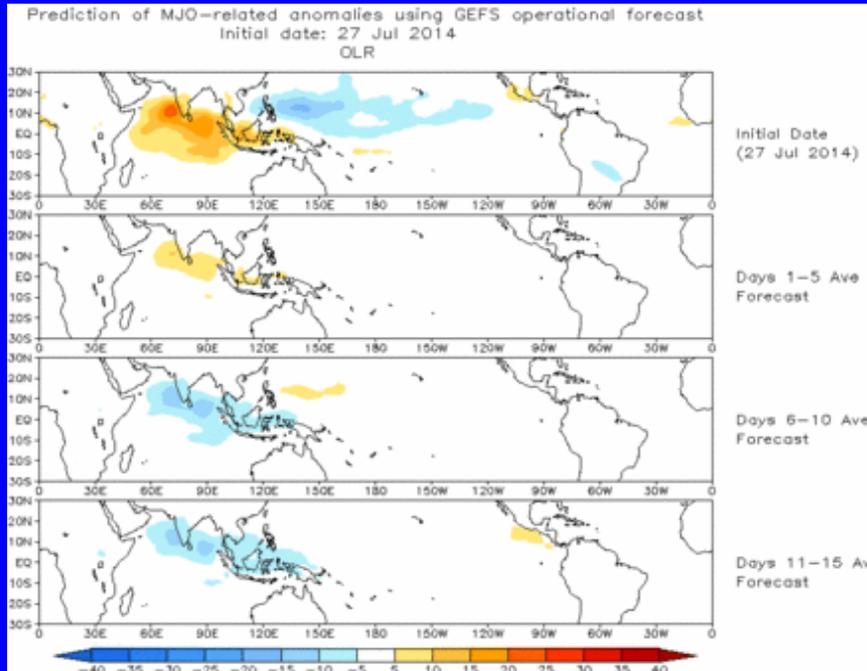




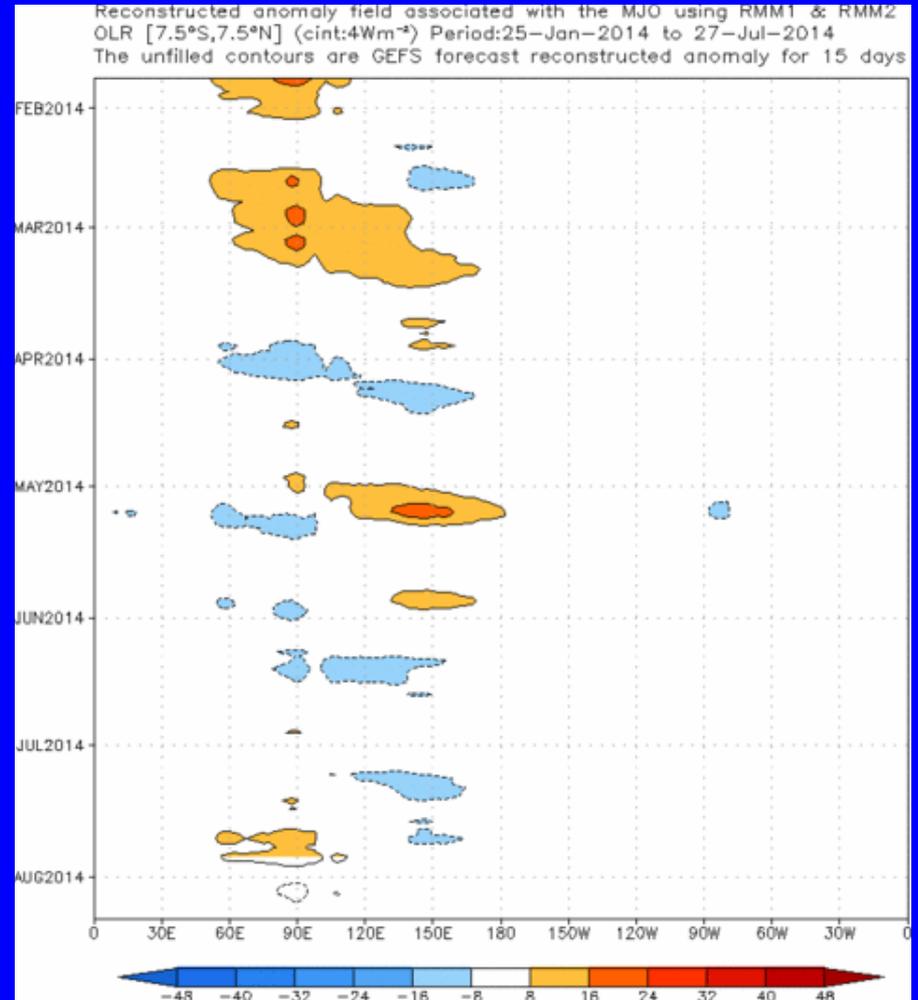
# Ensemble Mean GFS MJO Forecast

Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



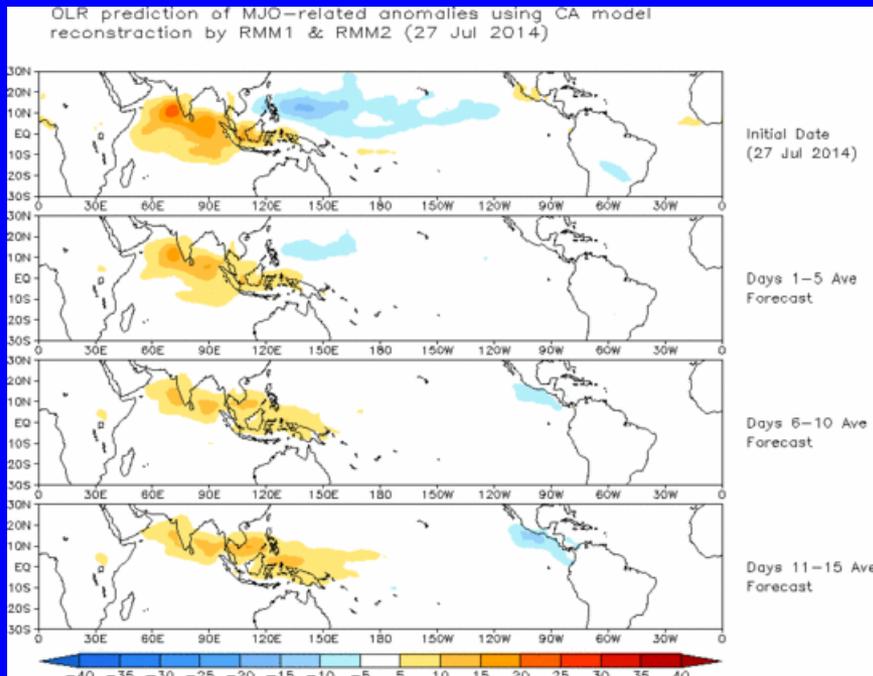
The ensemble mean GFS forecasts generally weak anomalies over the next two weeks.



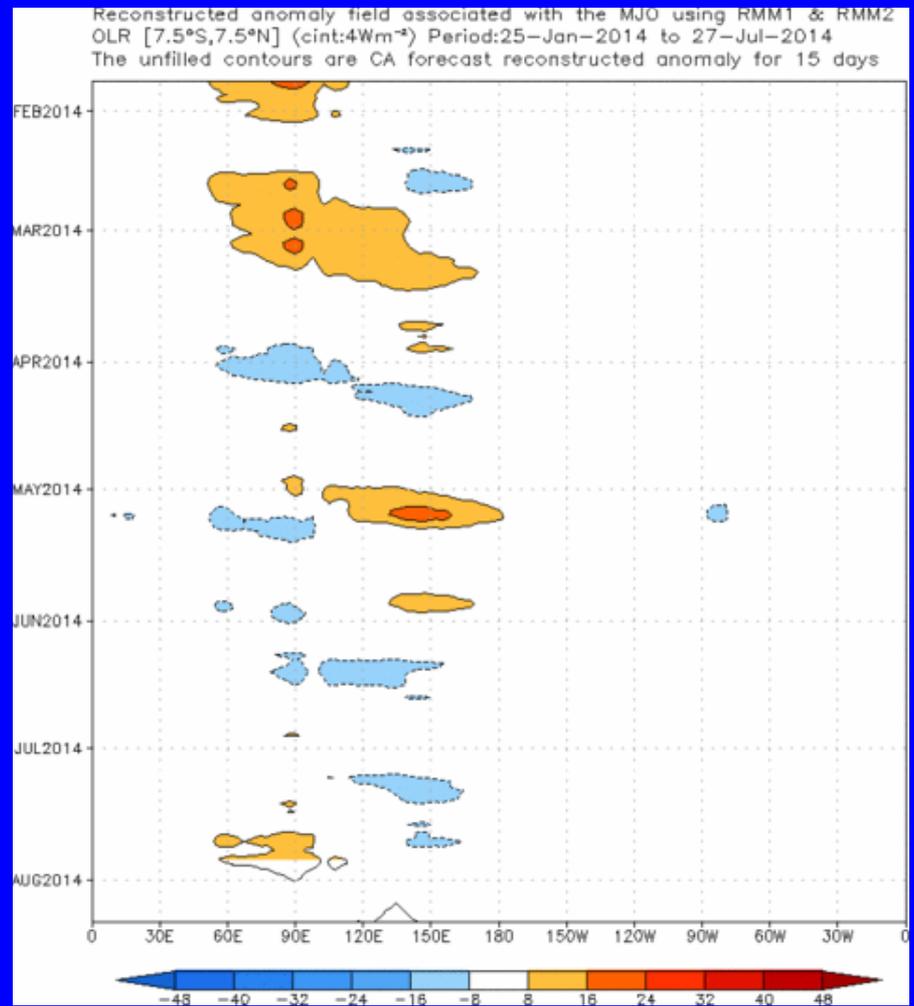
# Constructed Analog (CA) MJO Forecast

Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



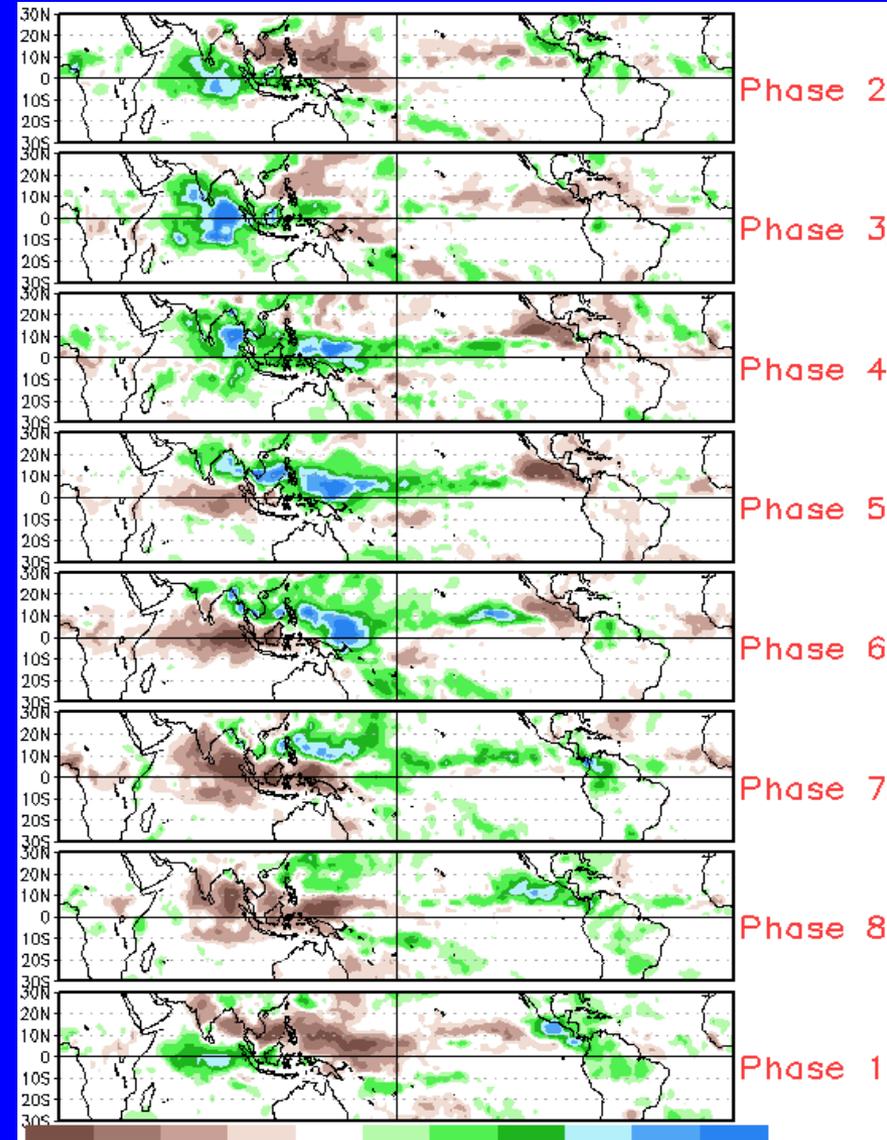
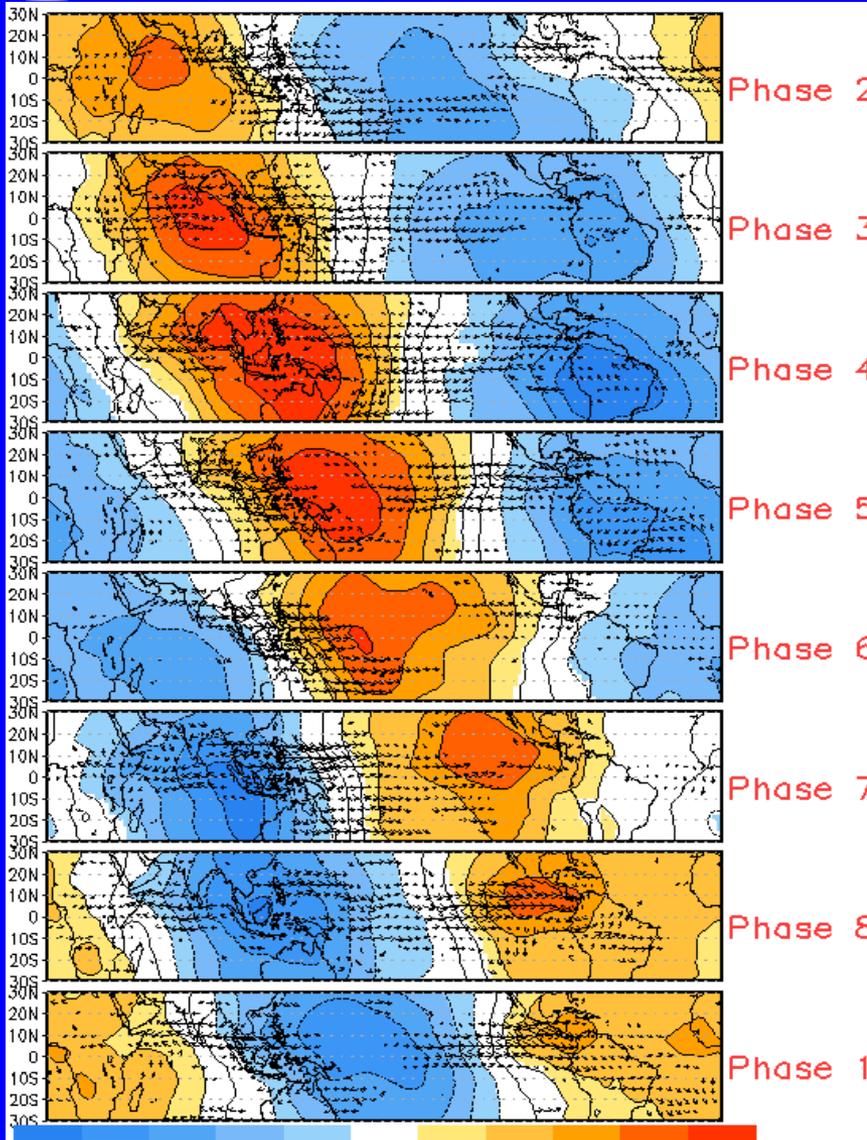
The constructed analog forecast depicts anomalous convection more consistent with MJO activity over the next two weeks.



# MJO Composites – Global Tropics

850-hPa Velocity Potential and  
Wind Anomalies (May-Sep)

Precipitation Anomalies (May-Sep)

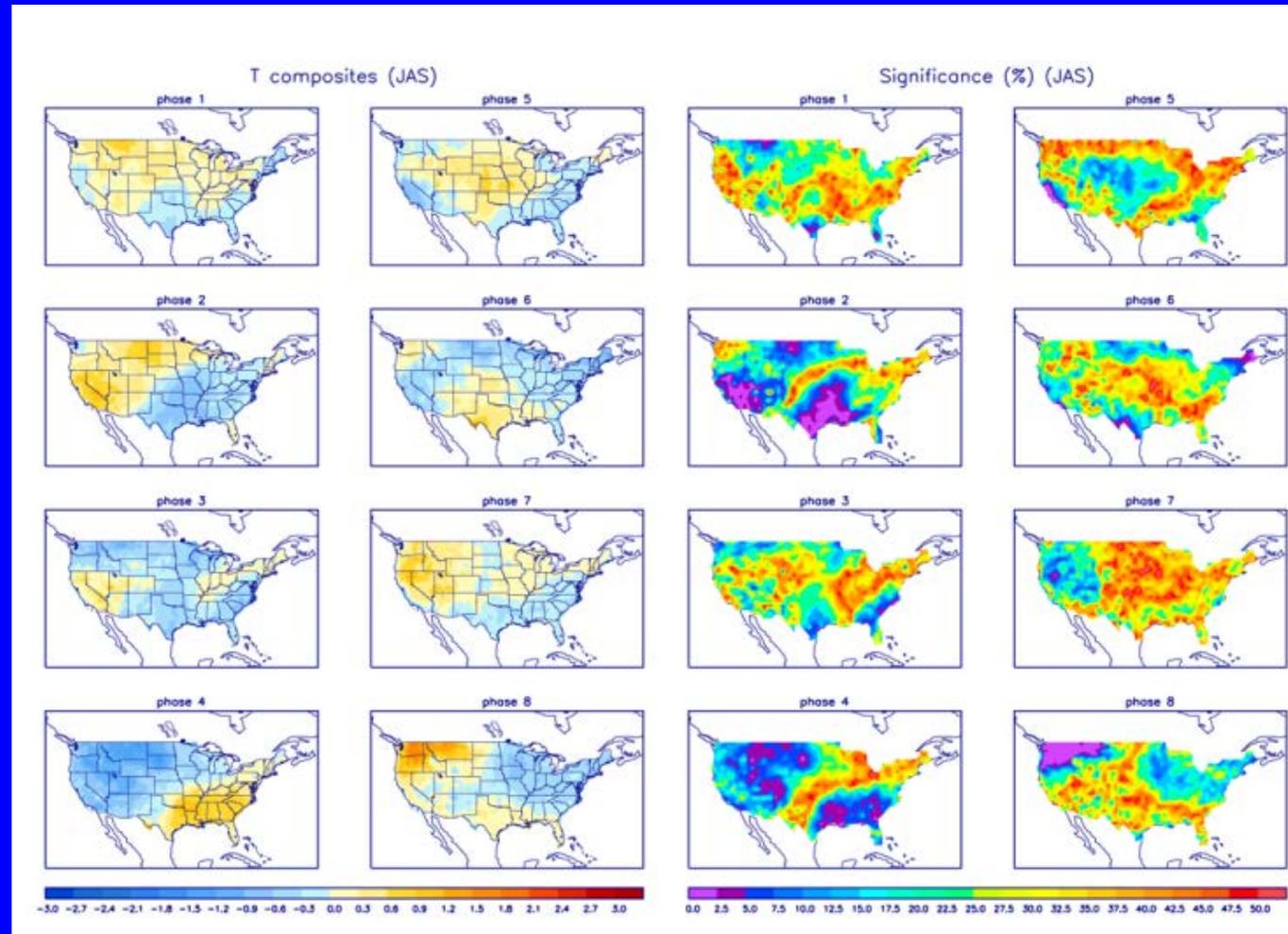




# U.S. MJO Composites – Temperature

Left hand side plots show temperature anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Blue (orange) shades show negative (positive) anomalies respectively.

Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



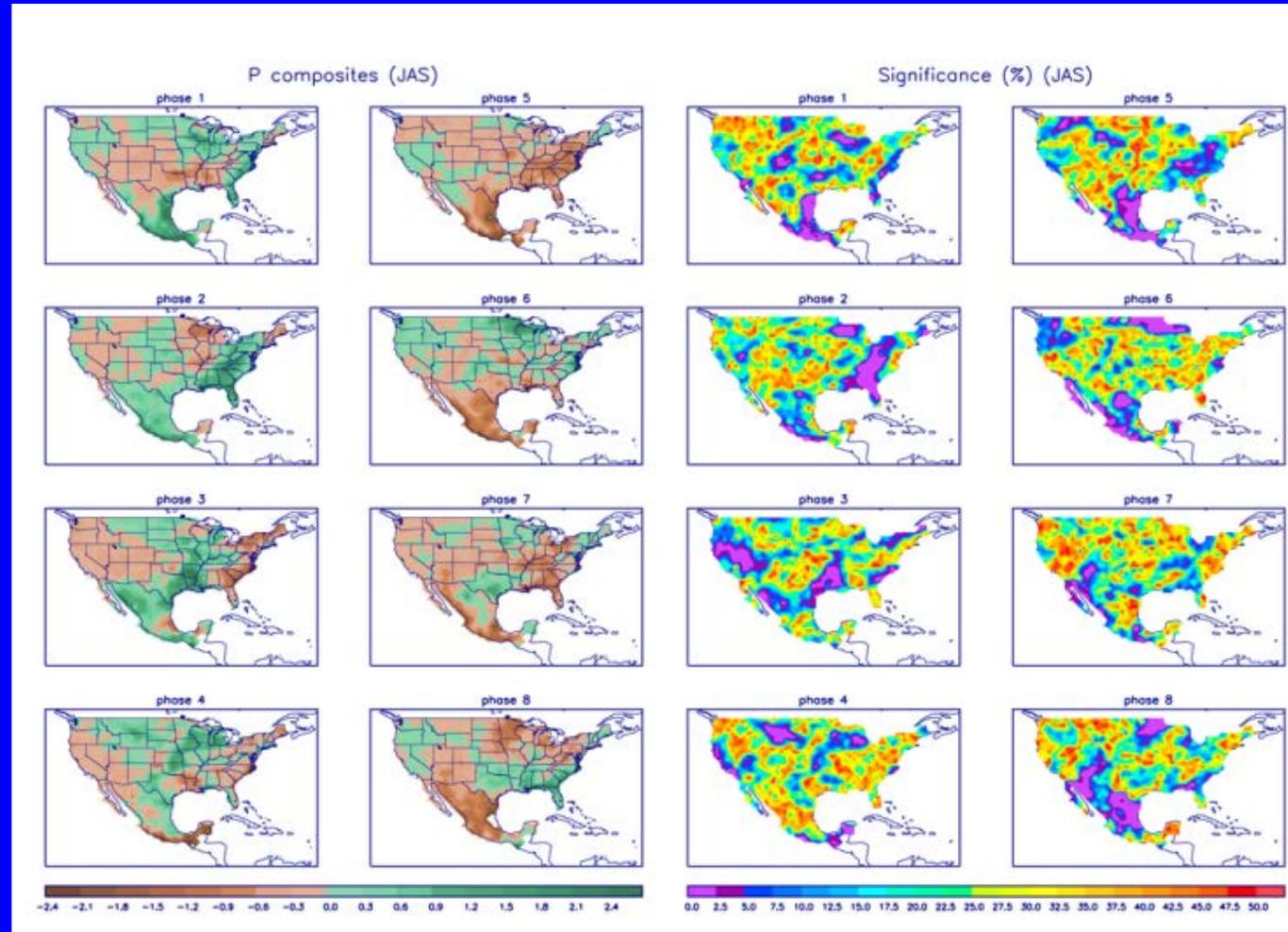
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>



# U.S. MJO Composites – Precipitation

- Left hand side plots show precipitation anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Brown (green) shades show negative (positive) anomalies respectively.
- Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.



Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>