



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

**Update prepared by  
Climate Prediction Center / NCEP  
February 3, 2014**



# Outline

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



# Overview

- The MJO remained incoherent during the past week.
- Though statistical tools suggest renewed MJO activity during the next two weeks, most reliable dynamical tools suggest that the pattern of tropical convection will be dominated by low frequency variability.
- Based on the latest observations and most model forecasts, the MJO is forecast to remain weak during the next 1-2 weeks.

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>

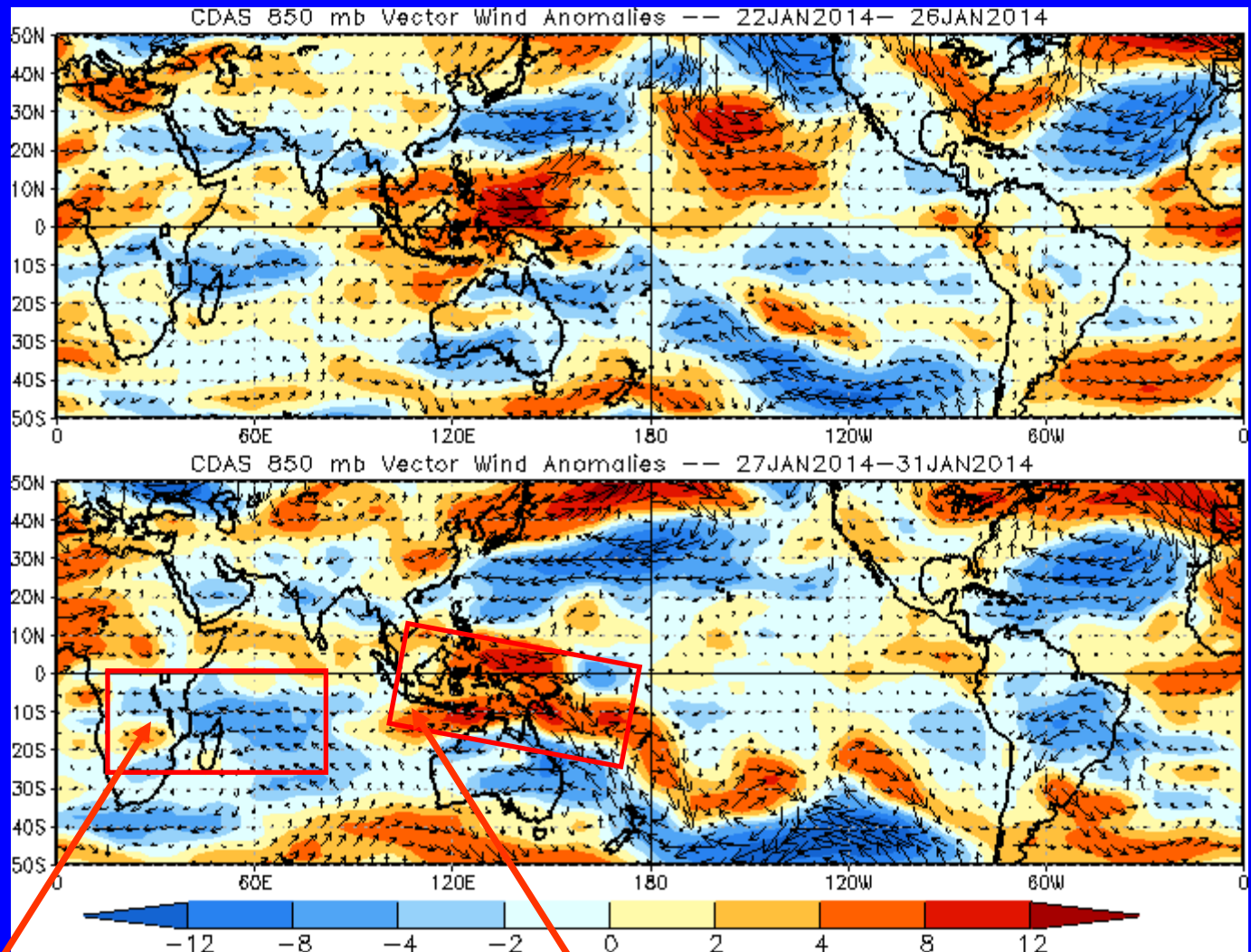


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted across southern Africa and the southwest Indian Ocean during the past five days.

Anomalous westerlies continued across the Maritime Continent, West Pacific and north of Australia.



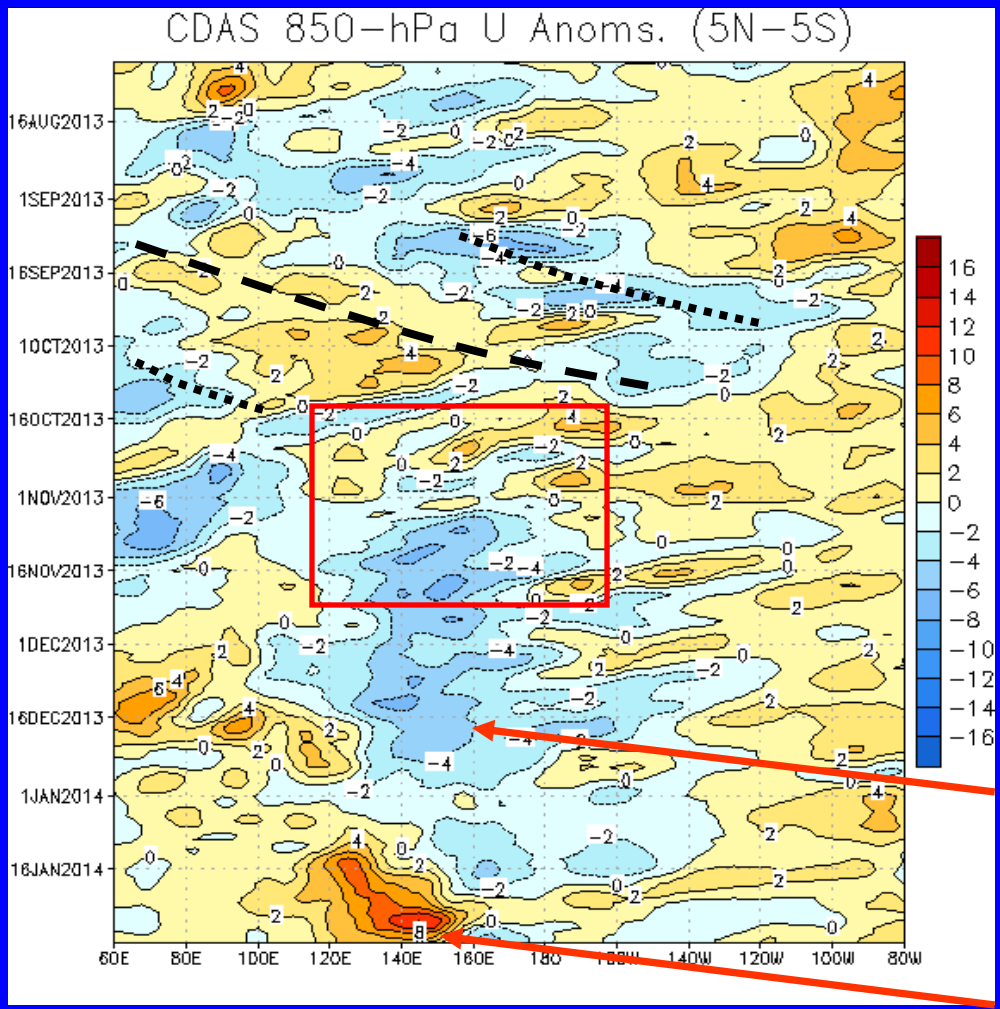
# 850-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

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

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

Time

↓



Longitude

In late August and early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.

During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

During November and December, easterly anomalies were persistent from 120E to near the Date Line. Westerly anomalies were also evident across the Indian Ocean during this period.

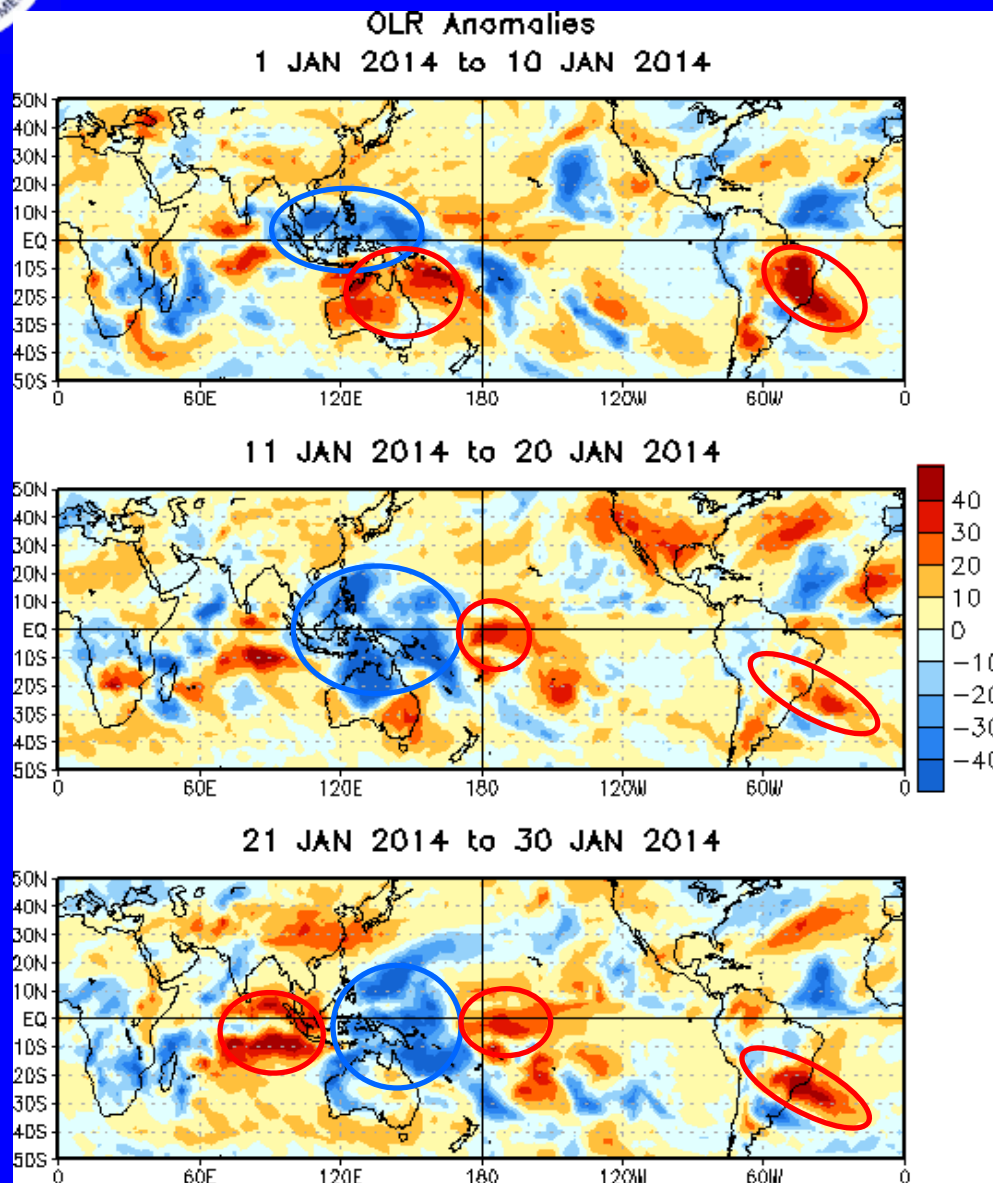
During January westerly anomalies intensified and shifted east to the Maritime Continent and West Pacific, but have remained nearly stationary recently.



# 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 early January, enhanced (suppressed) convection developed across parts of the Maritime Continent and West Pacific (parts of Brazil, Australia, and the southwestern Pacific).

During mid-January, enhanced convection expanded from the Maritime Continent to the west Pacific and northern Australia. Suppressed convection developed near the Date Line and persisted in parts of South America and southern Atlantic.

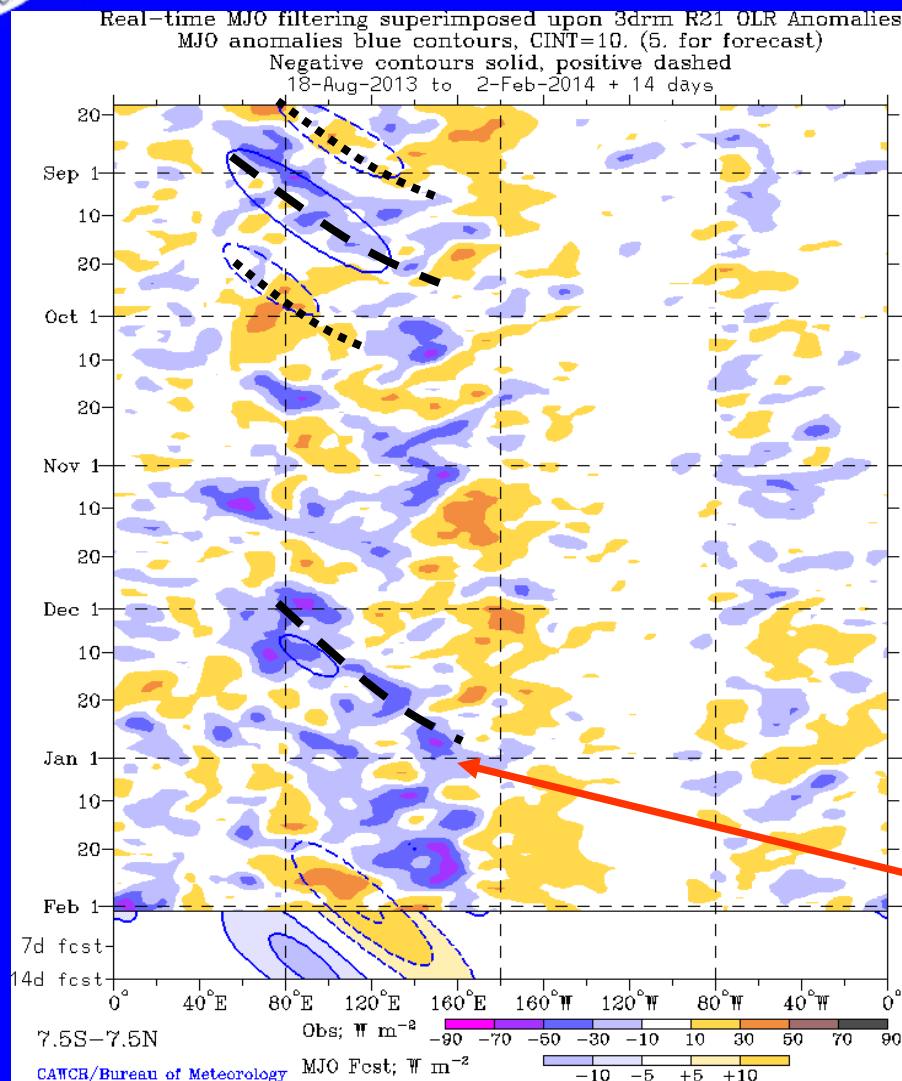
Enhanced convection persisted across the Maritime Continent, west Pacific, and northern Australia during late January, while suppressed convection prevailed across parts of the Indian Ocean, central Pacific, and South America.





# Outgoing Longwave Radiation (OLR)

## Anomalies (7.5°N-7.5°S)



**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)**

The MJO was active from late August through early October with the enhanced phase propagating eastward from the Indian Ocean to the western Pacific Ocean over this period.

The MJO was generally weak or incoherent for much of November and other types of coherent tropical subseasonal variability were very active.

During late November, a large area of enhanced convection developed over the Indian Ocean and propagated eastward to the west Pacific Ocean. Enhanced convection has persisted between 120E and 140E, most recently shifting eastward toward 160E.

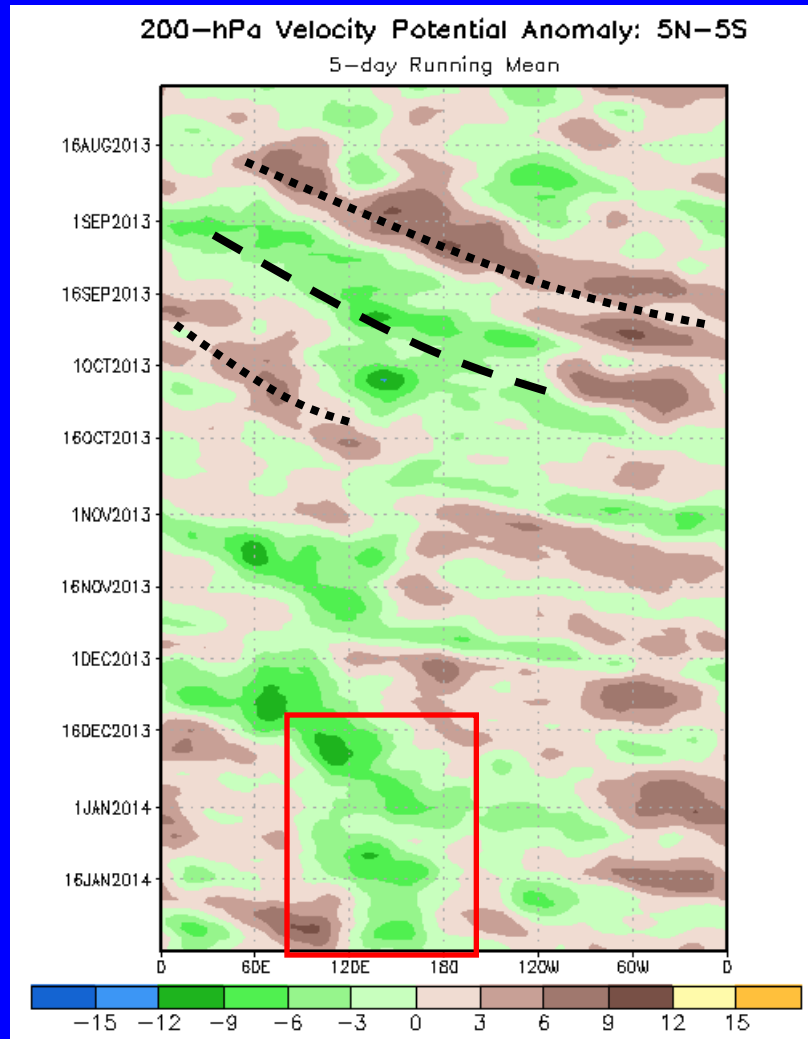


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



Longitude

The MJO was not active during late July and much of August, but strengthened during late August and September, with eastward propagation of robust upper-level velocity potential anomalies (alternating dashed and dotted lines). Other modes of tropical intraseasonal variability are also evident.

From late October to early December, the MJO was not very strong or coherent. There was evidence of coherent eastward propagation at times during this period, but much of this activity exhibited fast propagation speeds more consistent with atmospheric Kelvin waves.

A slower eastward propagation of 200-hPa velocity potential anomalies was observed from mid-December to mid-January across the Indo-Pacific warm pool region (red box). Anomalies have recently become more stationary.

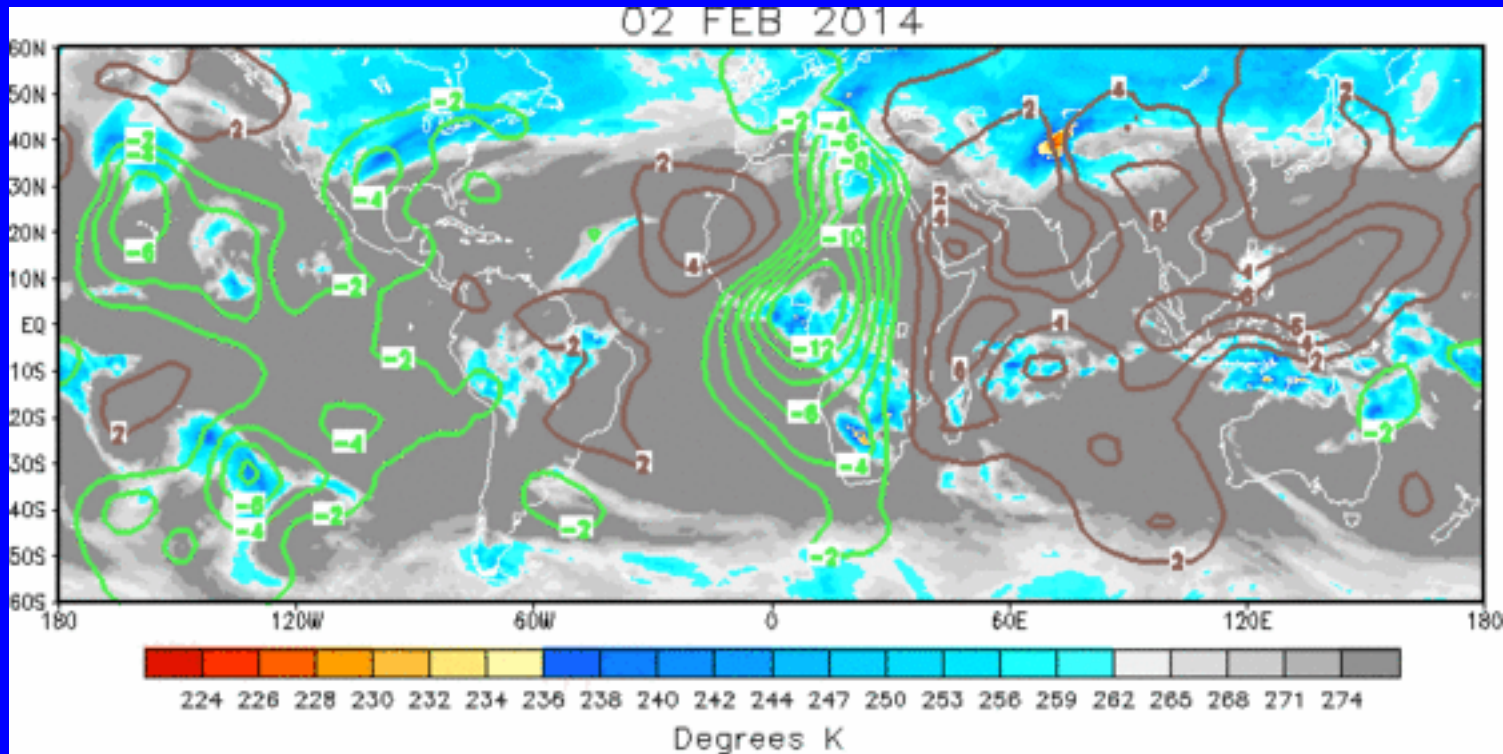




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



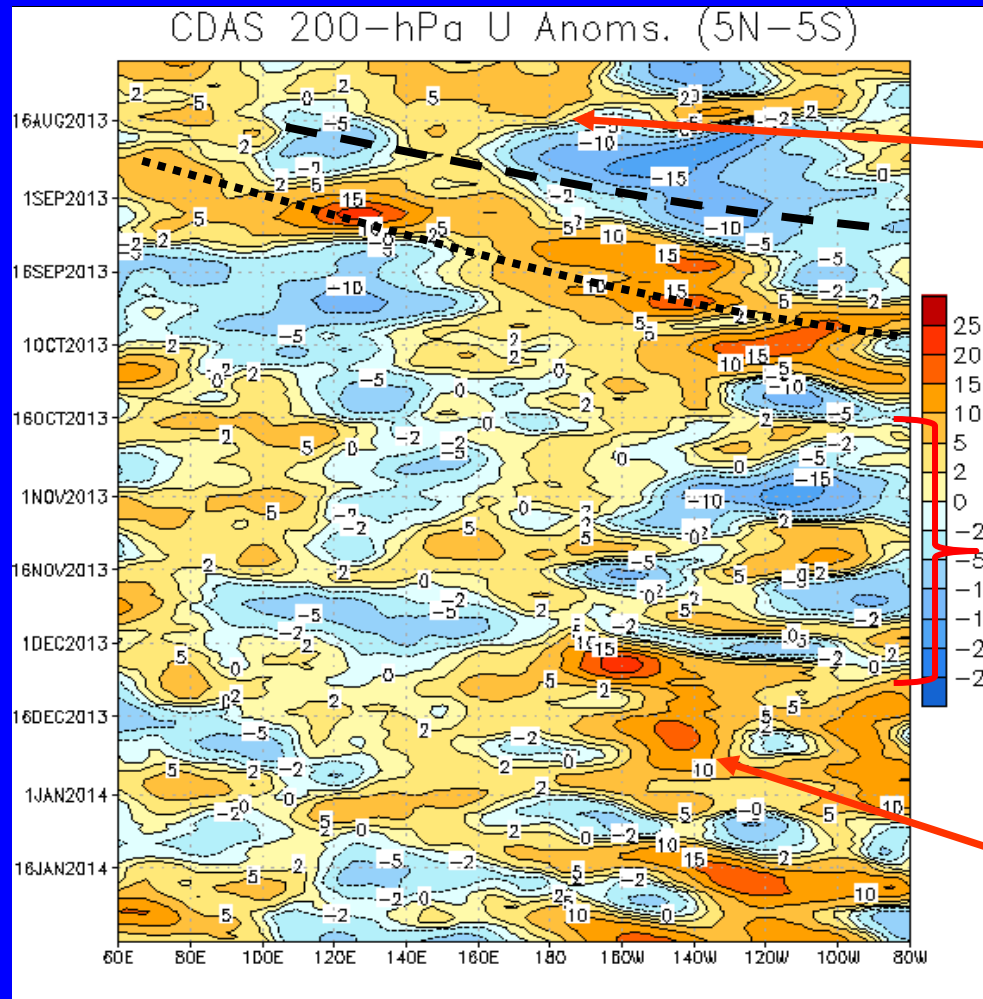
The current velocity potential data does not indicate a coherent wave-1 pattern of large scale anomalies of upper-level divergence or convergence. However, upper-level divergence persists across central and eastern Pacific with an intensifying area of upper-level convergence across parts of the Indian Ocean and Maritime Continent. Other subseasonal variability is contributing to large convective anomalies over parts of Africa.



# 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



During August, westerly wind anomalies were generally persistent just west of the Date Line.

Renewed MJO activity (alternating dotted and dashed lines) occurred during late August and September with westerly wind anomalies shifting east to the eastern Pacific.

Anomalies of alternating sign are evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

Westerly anomalies increased in December across the western Hemisphere and persisted into early January. Recently, anomalies have been dominated by Kelvin wave activity and interaction with the extratropics over the Western Hemisphere.

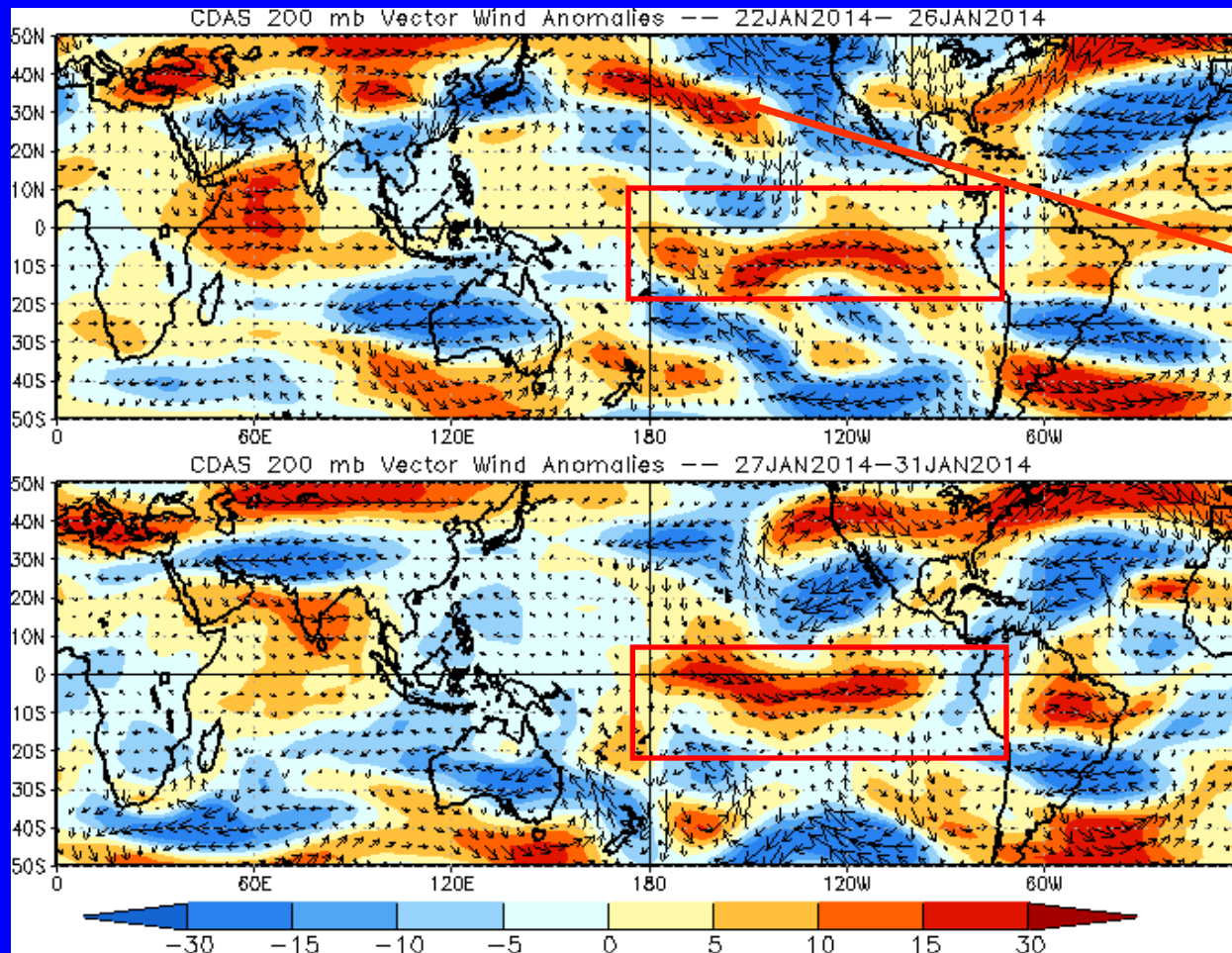


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

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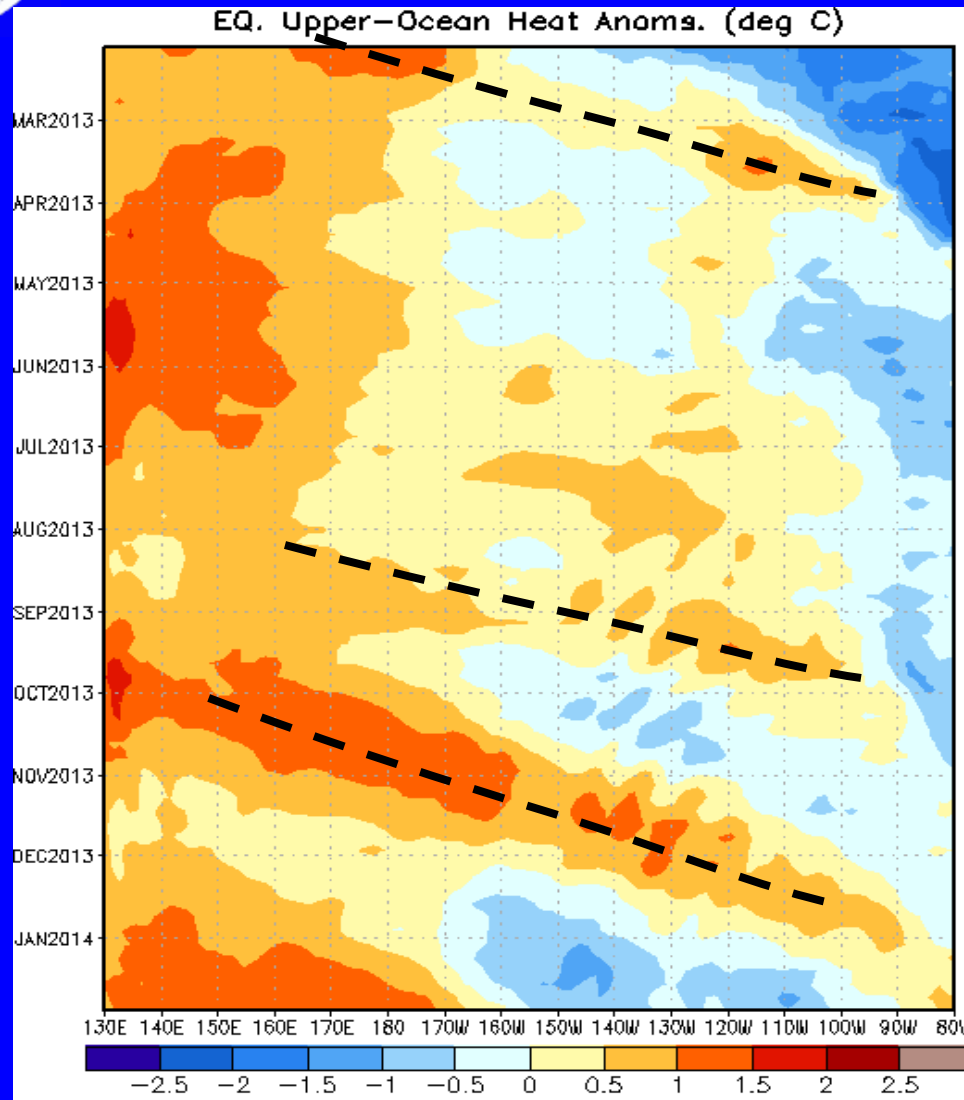


A prominent extension of the East Asian jet stream is observed. This signal is consistent with previously observed convection over the tropical West Pacific.

Westerly anomalies intensified and persisted across the east Pacific during the past ten days (red boxes).



# Weekly Heat Content Evolution in the Equatorial Pacific



Positive (negative) anomalies developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave (dashed line) can be seen during late February and March as anomalies became positive in the east-central Pacific.

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

There is some evidence that another downwelling event is beginning in the West Pacific.





# 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.**

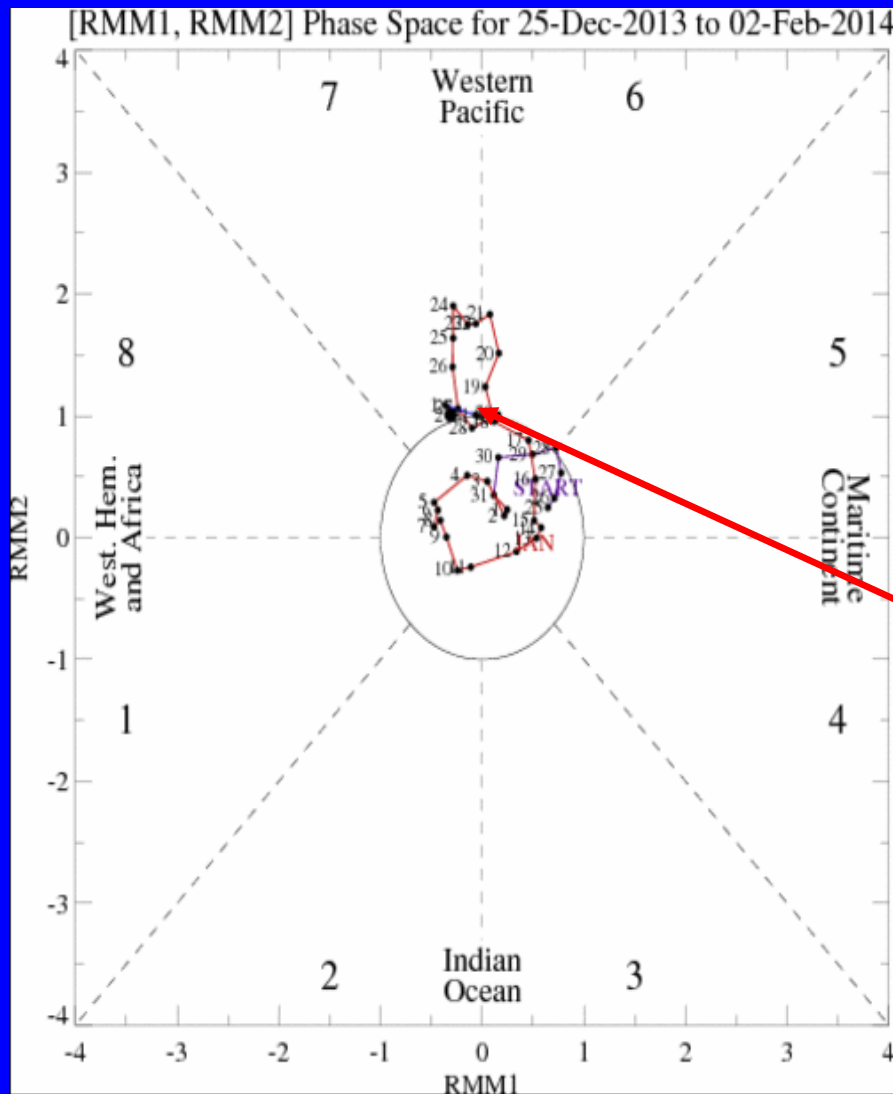
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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



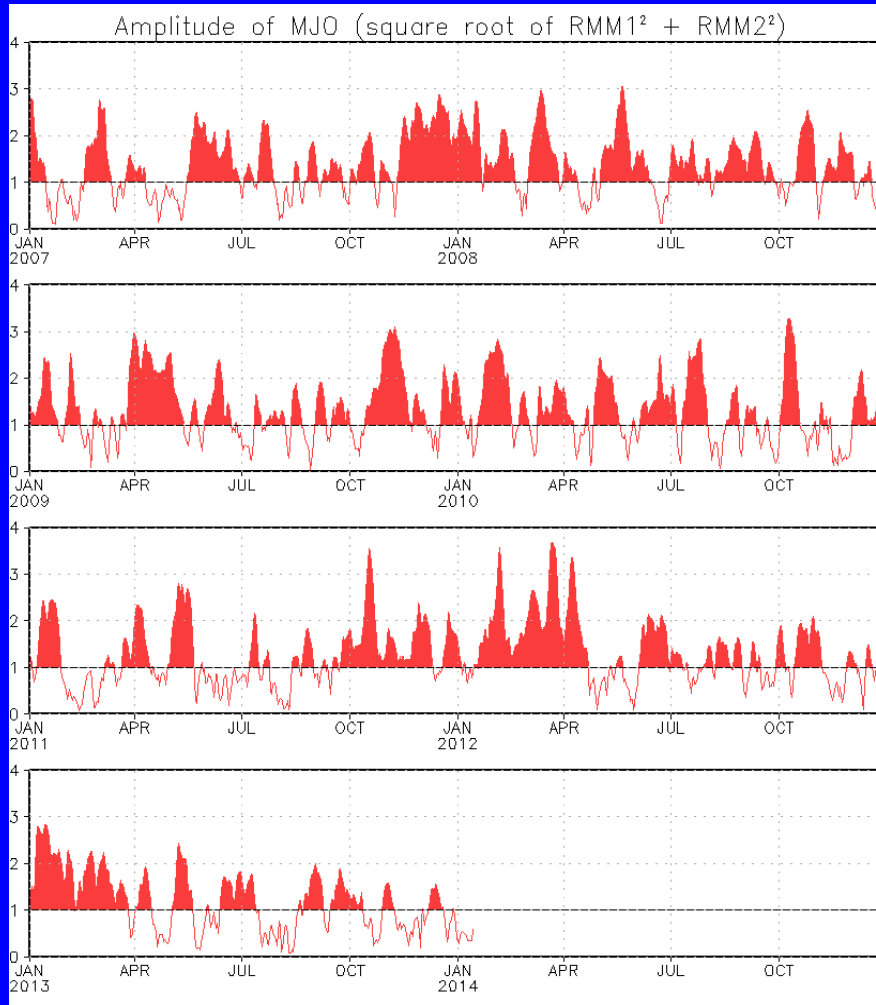
- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index remains weakly in phases 6 and 7, with no observed eastward propagation.





# 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

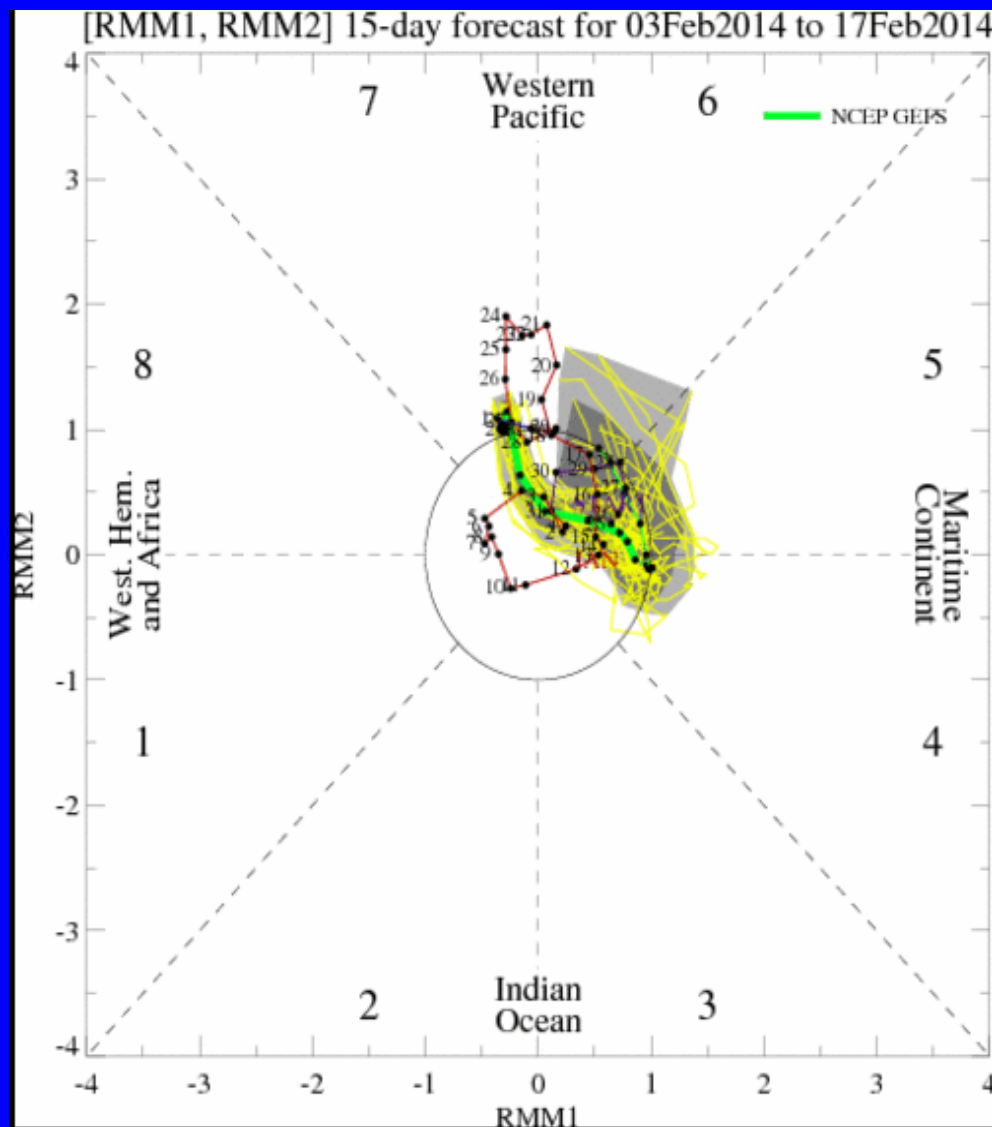
Green Line – Ensemble Mean

**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 a weak MJO signal, with convection reemerging over the Maritime Continent and western Pacific during Week-2. This is likely due to the eastward propagation of a strong Kelvin wave during Week-1, eventually amplifying the low-frequency signal in Week-2.

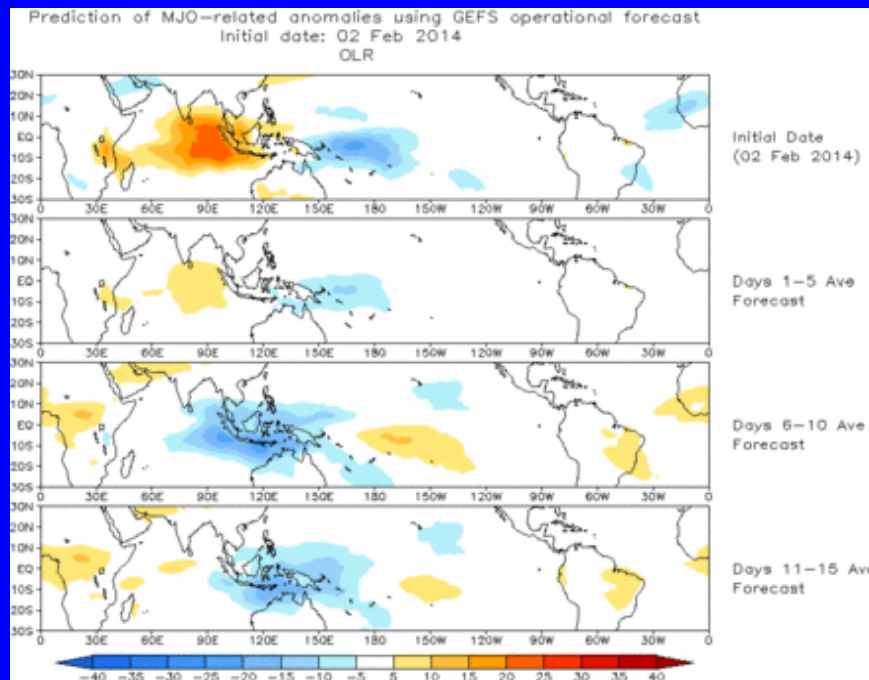




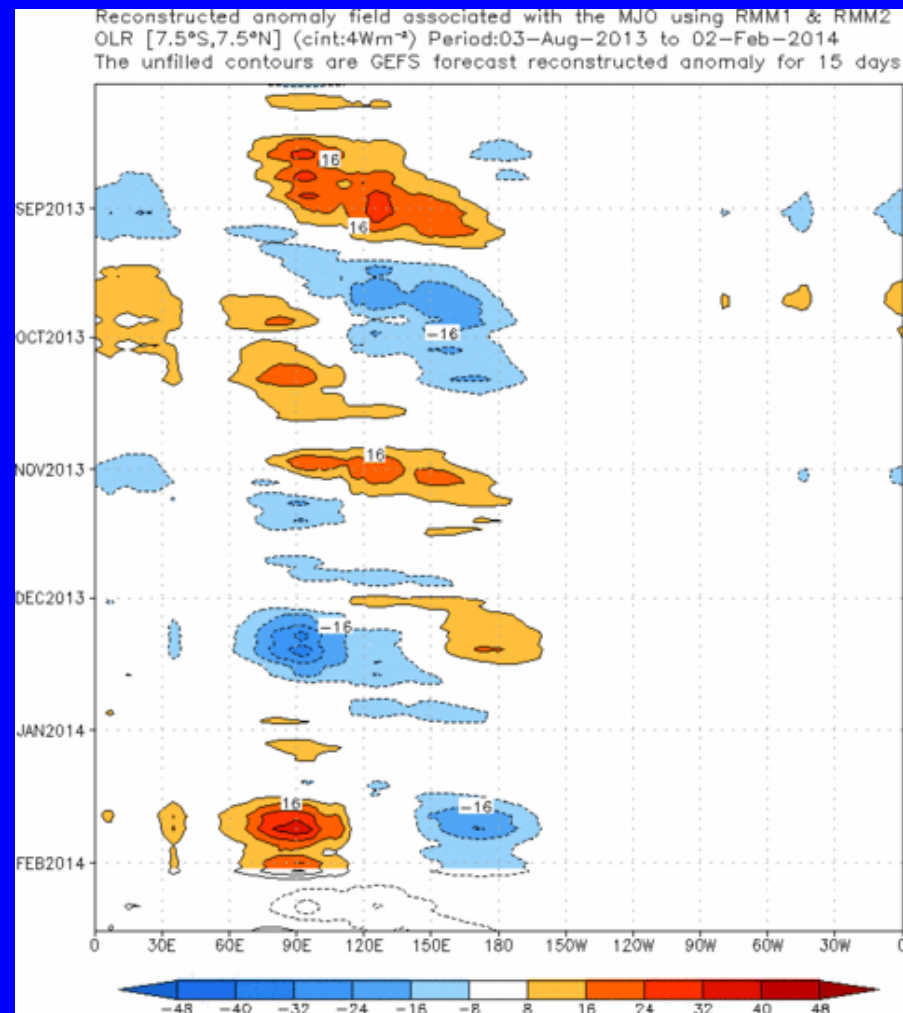
# Ensemble Mean GFS MJO Forecast

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**



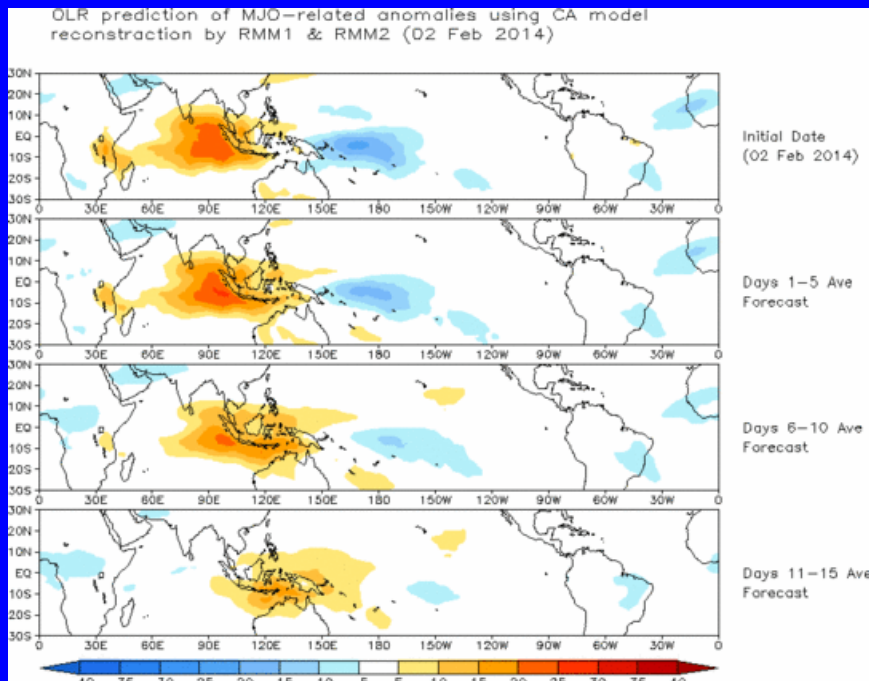
The ensemble mean GFS forecasts a rapid propagation of convective anomalies to the Maritime Continent during Week-2, not consistent with coherent MJO activity.



# Constructed Analog (CA) MJO Forecast

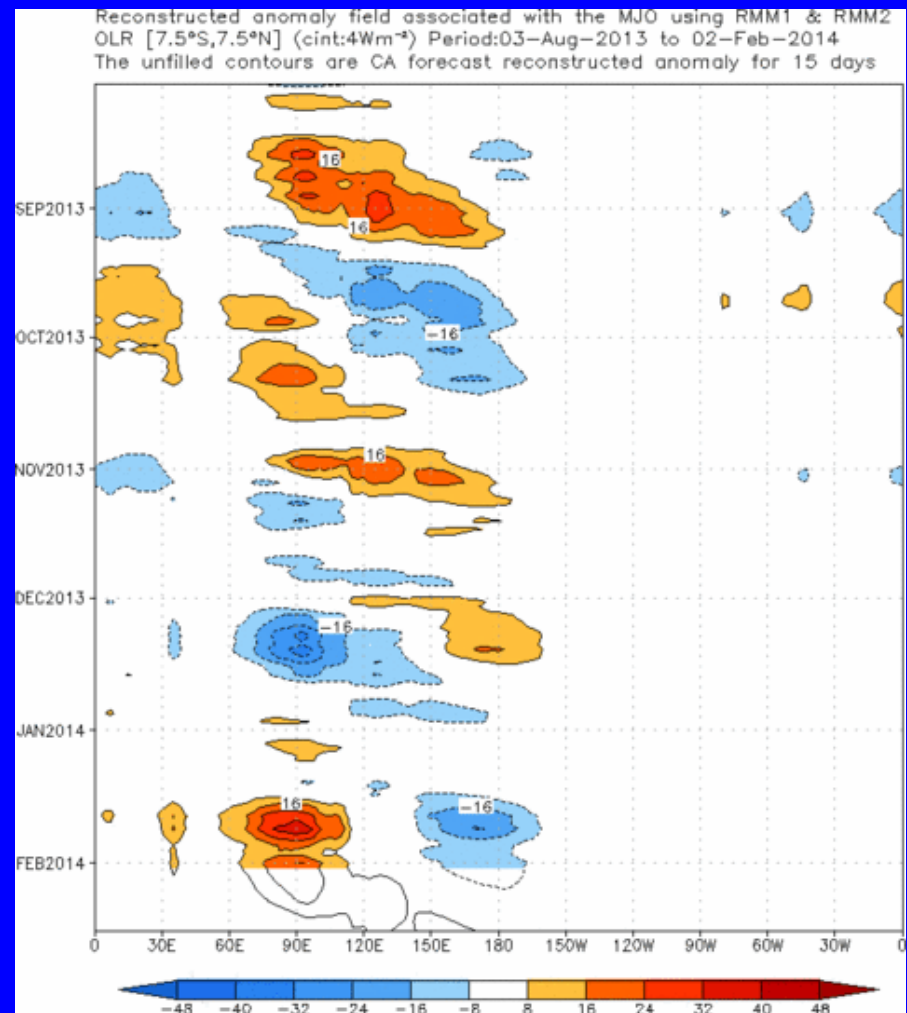
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

**Spatial map of OLR anomalies for the next 15 days**



The constructed analog MJO forecast indicates eastward propagation of enhanced convection to the Western Hemisphere as suppressed convection shifts to the Maritime Continent.

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

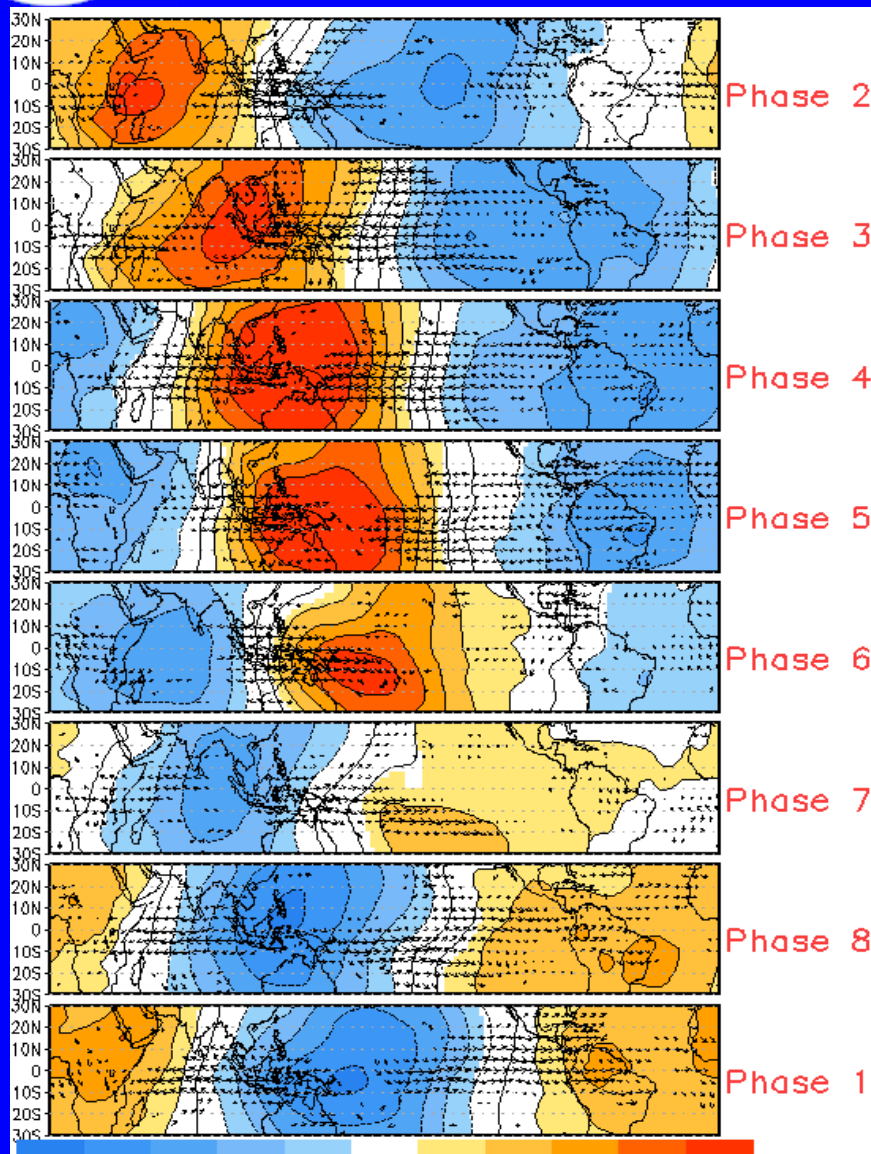




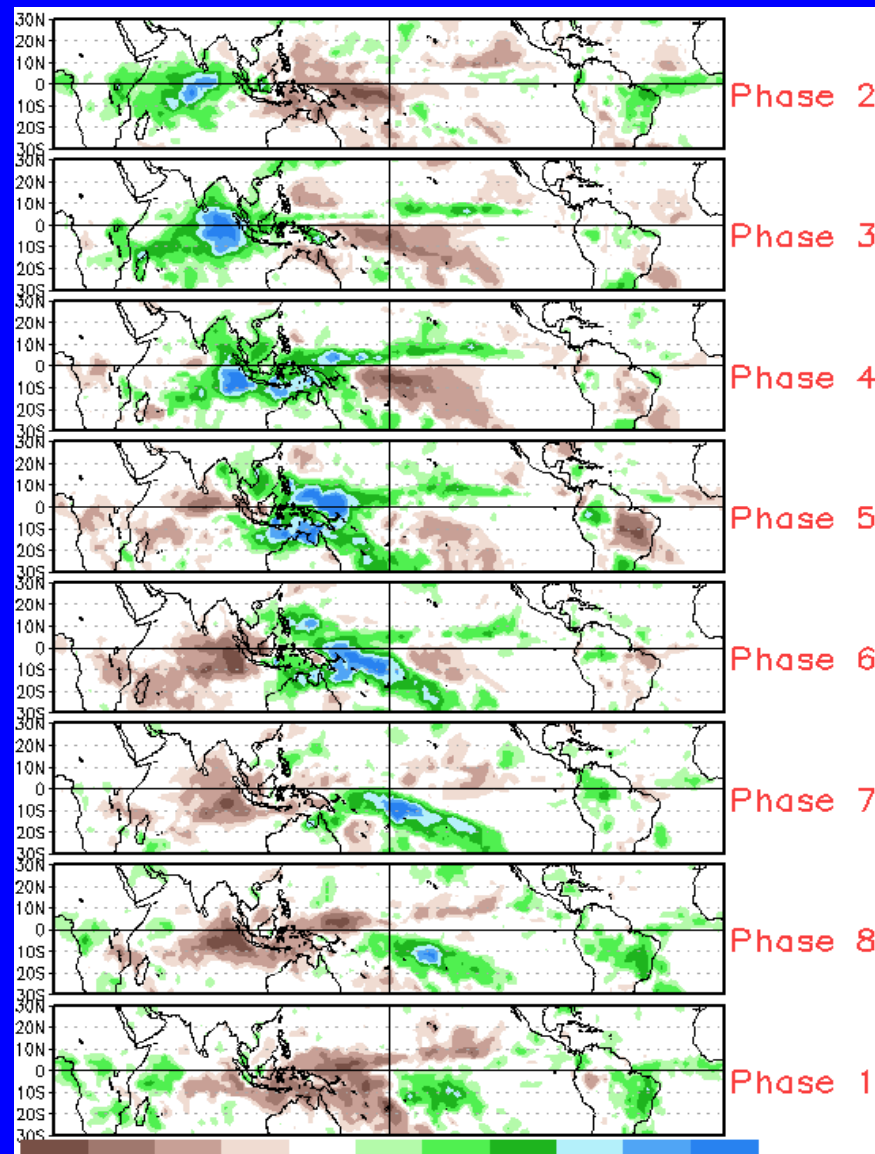


# MJO Composites – Global Tropics

850-hPa Velocity Potential and  
Wind Anomalies (Nov-Mar)



Precipitation Anomalies (Nov-Mar)

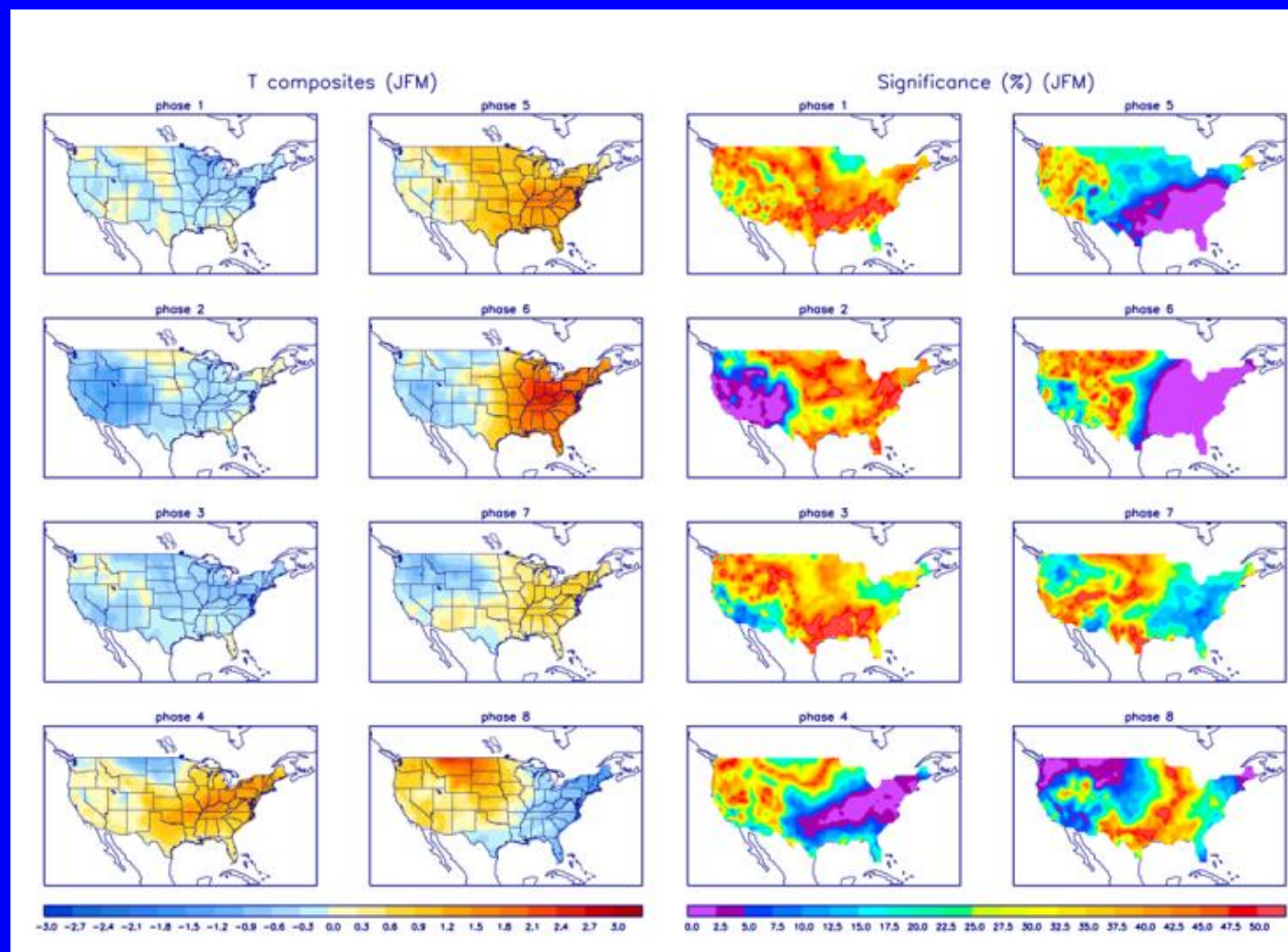




# U.S. MJO Composites – Temperature

- 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

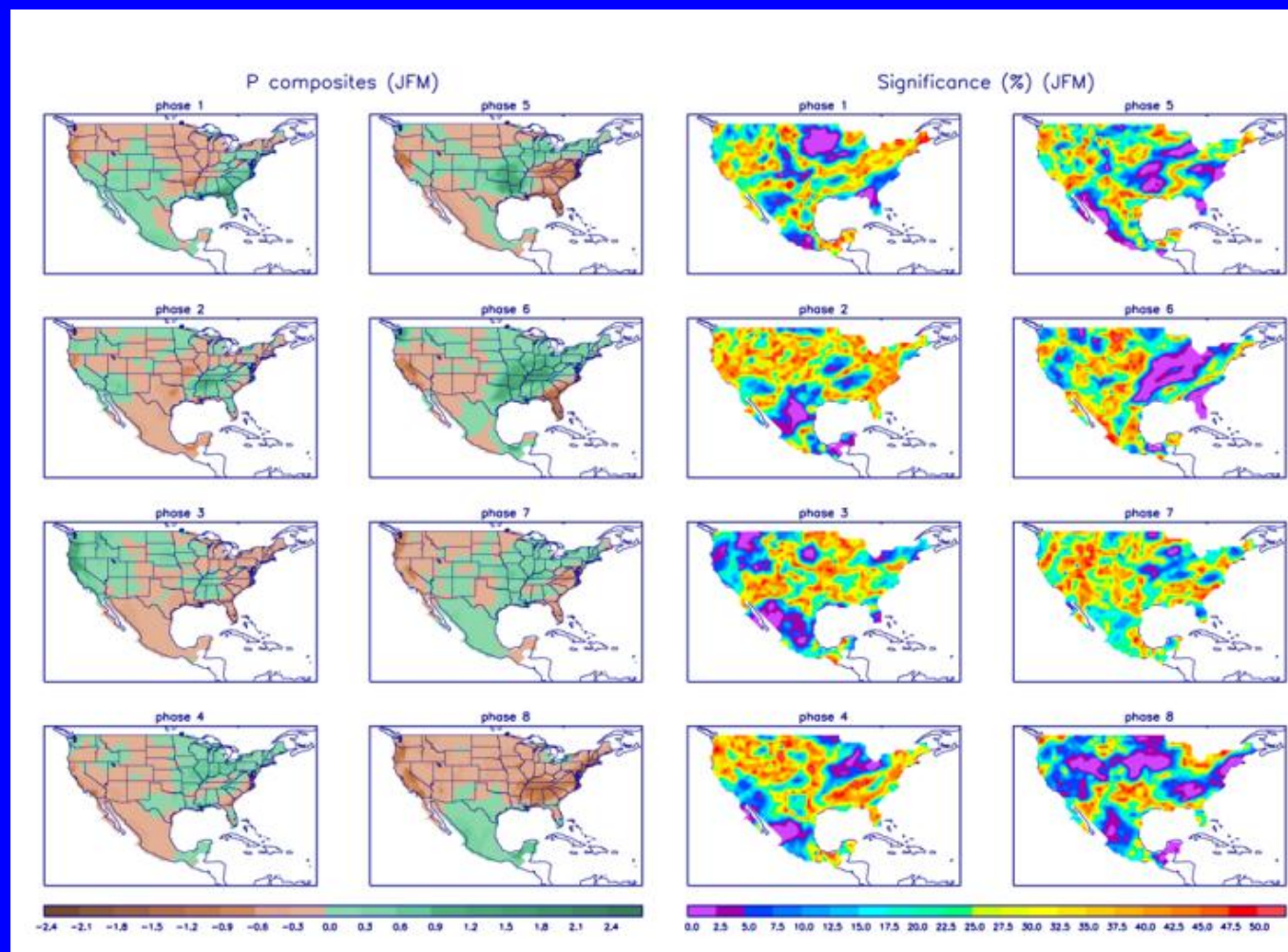
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>





# 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.



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