



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

**Update prepared by  
Climate Prediction Center / NCEP  
January 6, 2014**



# Outline

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



# Overview

- The MJO remained generally weak and not well defined by some of the diagnostic tools typically used to monitor the MJO. Any enhanced convective phase is currently centered across the western Pacific.
- MJO index dynamical model forecasts do not indicate strengthening of the MJO during the upcoming two week period at the current time. Statistical tools also do not indicate MJO activity moving forward.
- Based on the latest observations and most model forecasts, the MJO is forecast to remain weak but may, in part, contribute to enhanced convection across parts of the western South Pacific and suppressed convection across parts of the Indian Ocean and Brazil.
- Enhanced convection along and south of the equator in the West Pacific may contribute to long wave amplification across the Pacific/North America sector enhancing the likelihood of cold air outbreaks across the central U.S. during and beyond Week-2.

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>

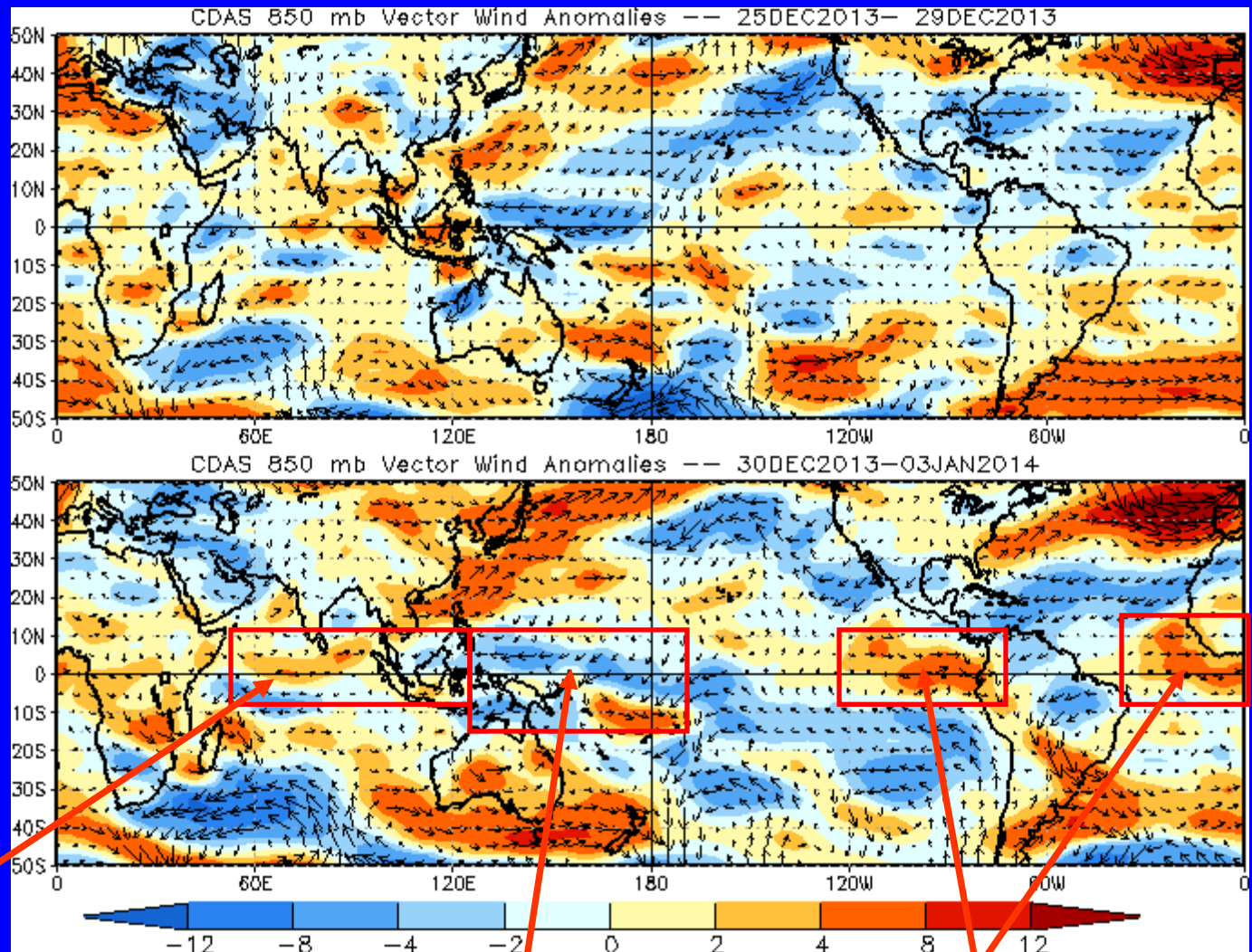


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Weak westerly anomalies continued over the equatorial Indian Ocean and western Maritime continent during the past five days.

Weak easterly anomalies persisted over the equatorial western Pacific.

Westerly anomalies increased west of South America and over portions of Africa during the past five days.

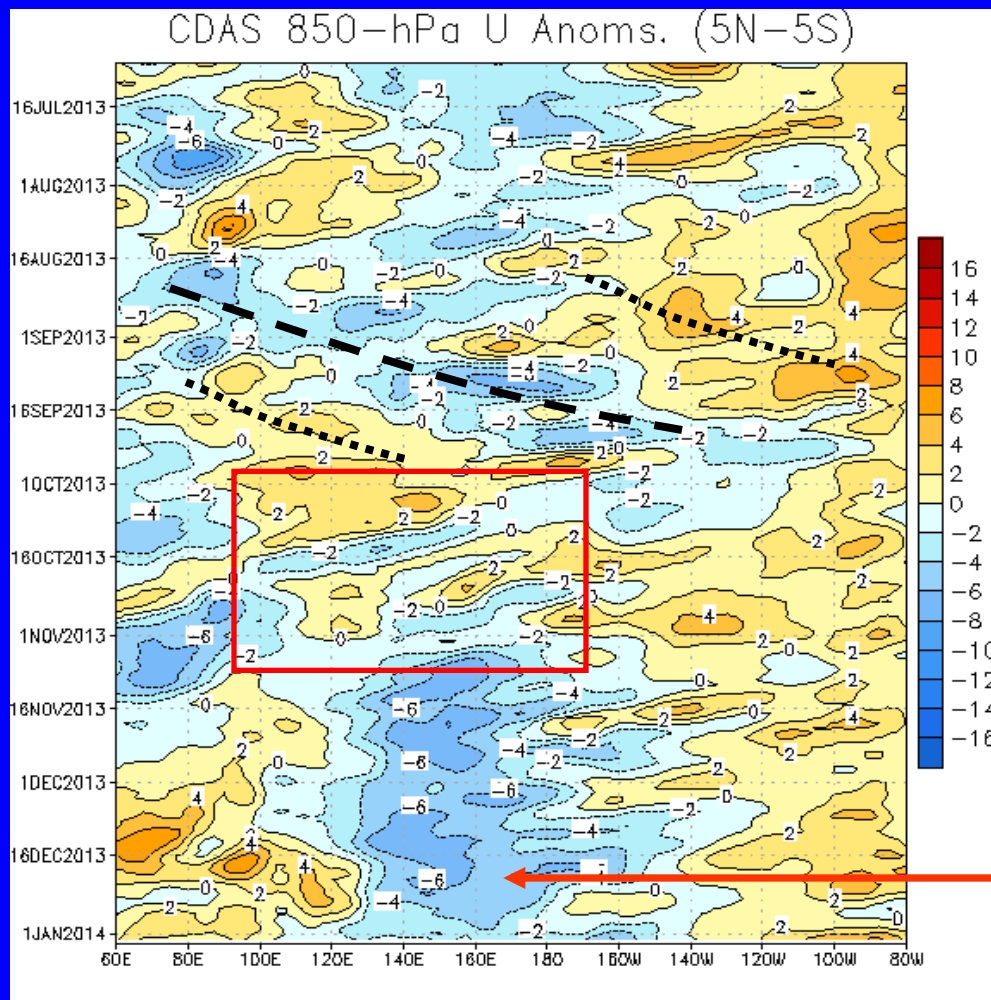


# 850-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

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

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

Time



Longitude

During late July through mid-August, the MJO was weak.

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.

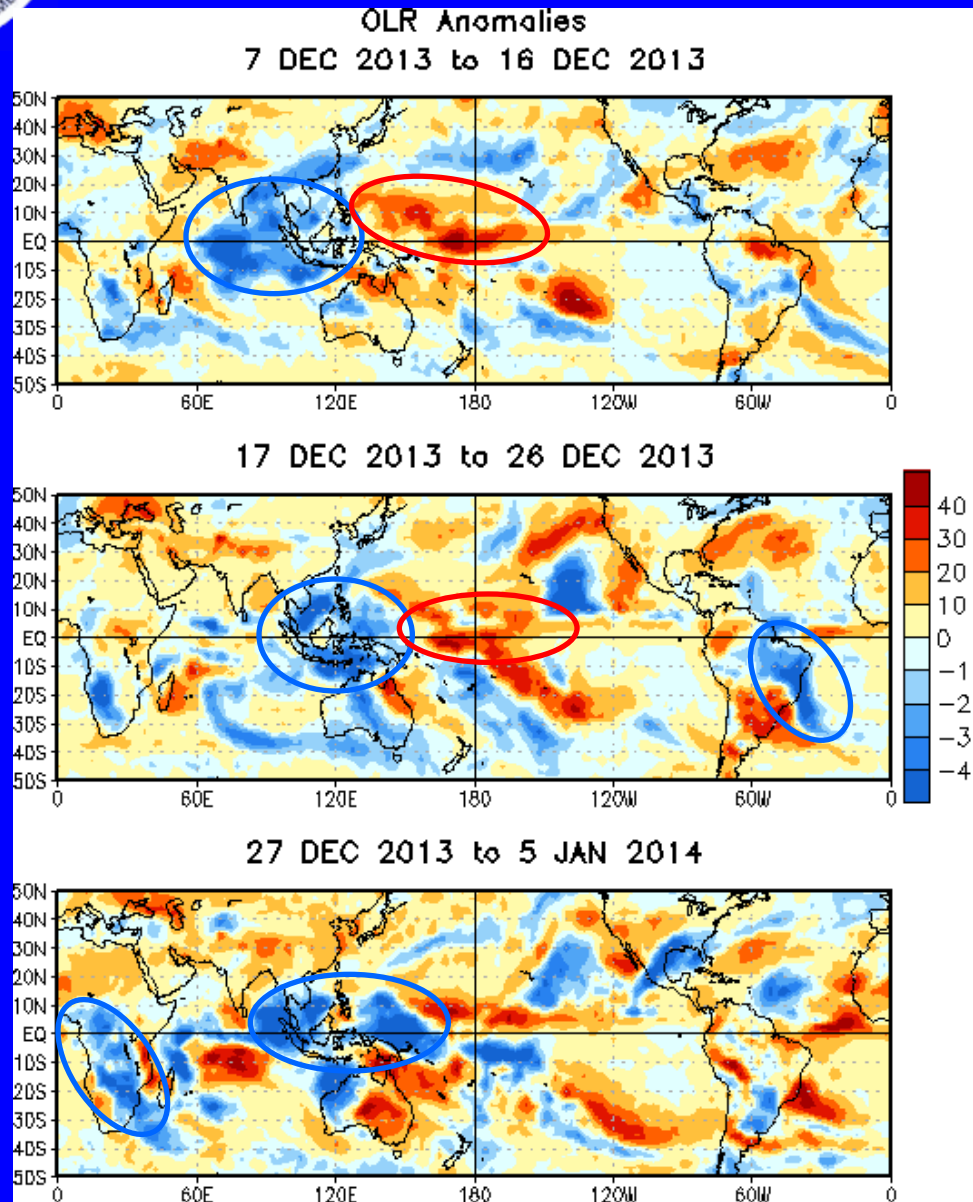
During November and December, easterly anomalies were persistent from 120E to near the Date Line. Westerly anomalies were also evident across the Indian Ocean during this period. These anomalies have decreased some during late December.



# 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 to mid-December, enhanced convection persisted across the Indian Ocean, while suppressed convection continued over much of the equatorial western and central Pacific.

During mid to late December, enhanced convection shifted east to the Maritime Continent with suppressed convection persisting at the Date Line. Enhanced convection intensified across Brazil with suppressed convection indicated over parts of south-central South America.

By early January, enhanced convection persisted across parts of the Indian ocean and western Pacific and increased in coverage over parts of central and southern Africa.





# Outgoing Longwave Radiation (OLR)

## Anomalies (7.5°N-7.5°S)

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

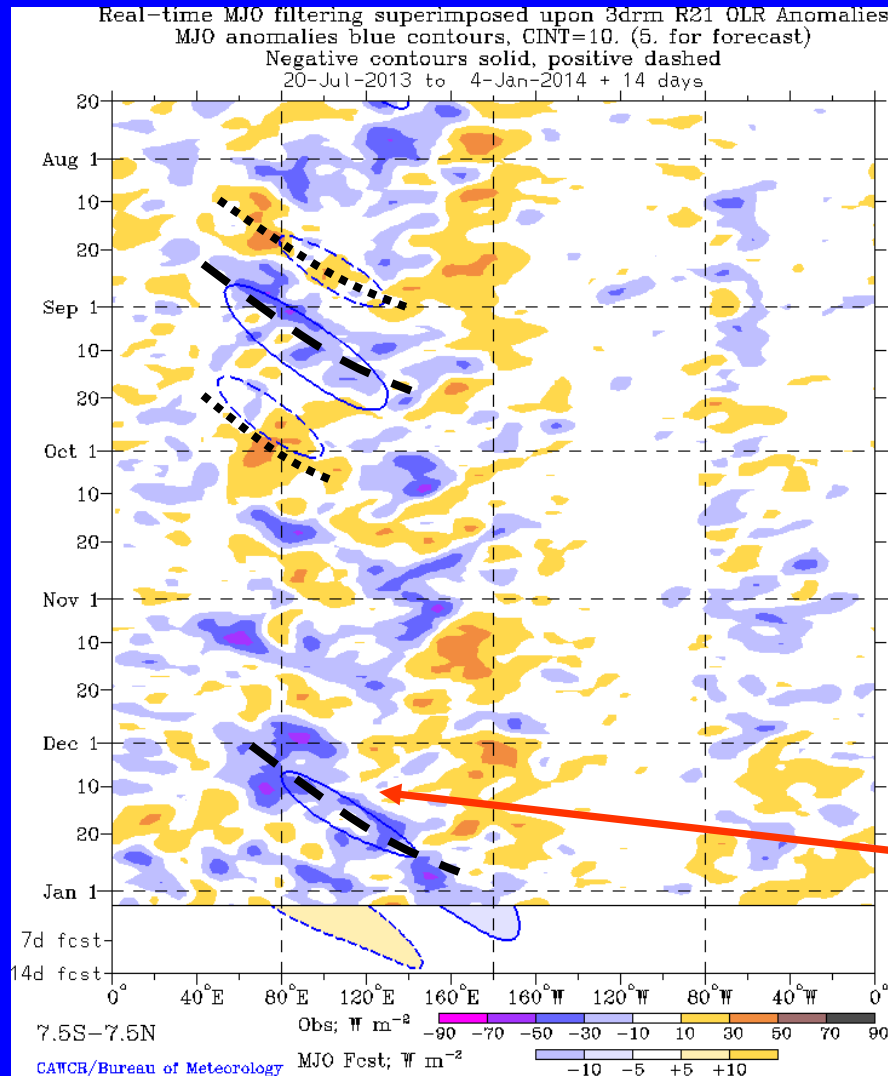
**Wetter-than-normal conditions, negative OLR anomalies (blue shading)**

**(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 in the Indian Ocean and recently propagated eastward to the west Pacific Ocean.



**Longitude**

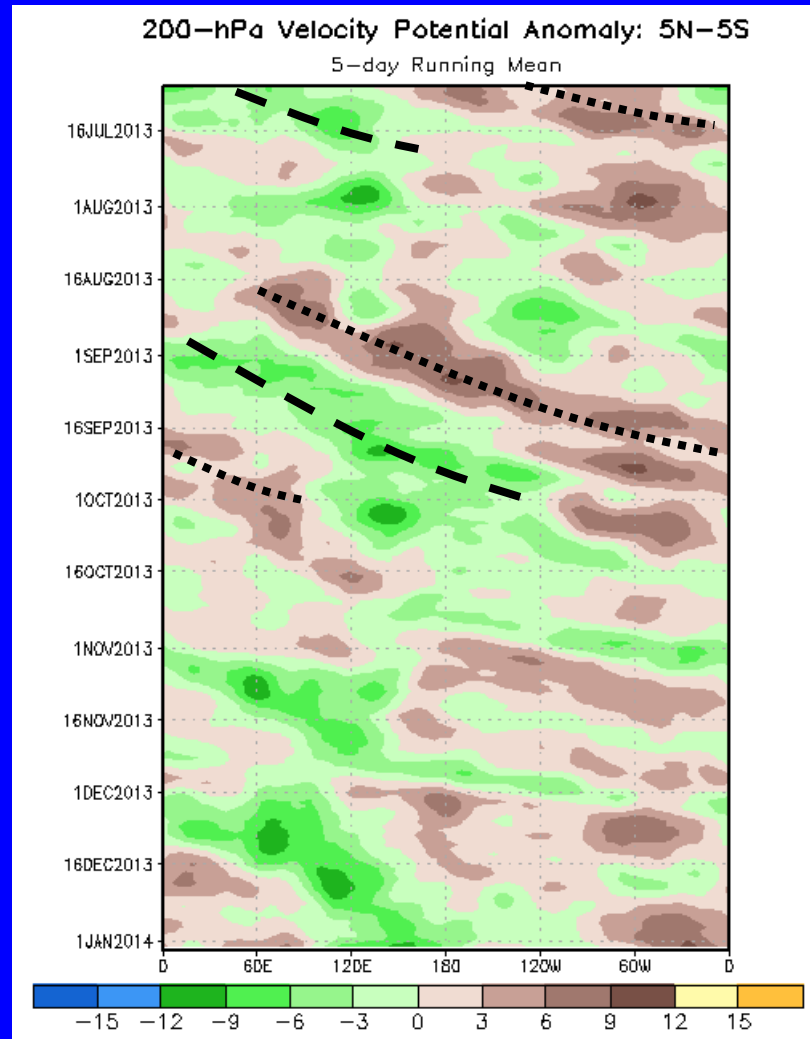


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



Longitude

The MJO was active (alternating dashed and dotted lines) during June and early July before weakening at the end of the month.

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. 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 during mid-December.

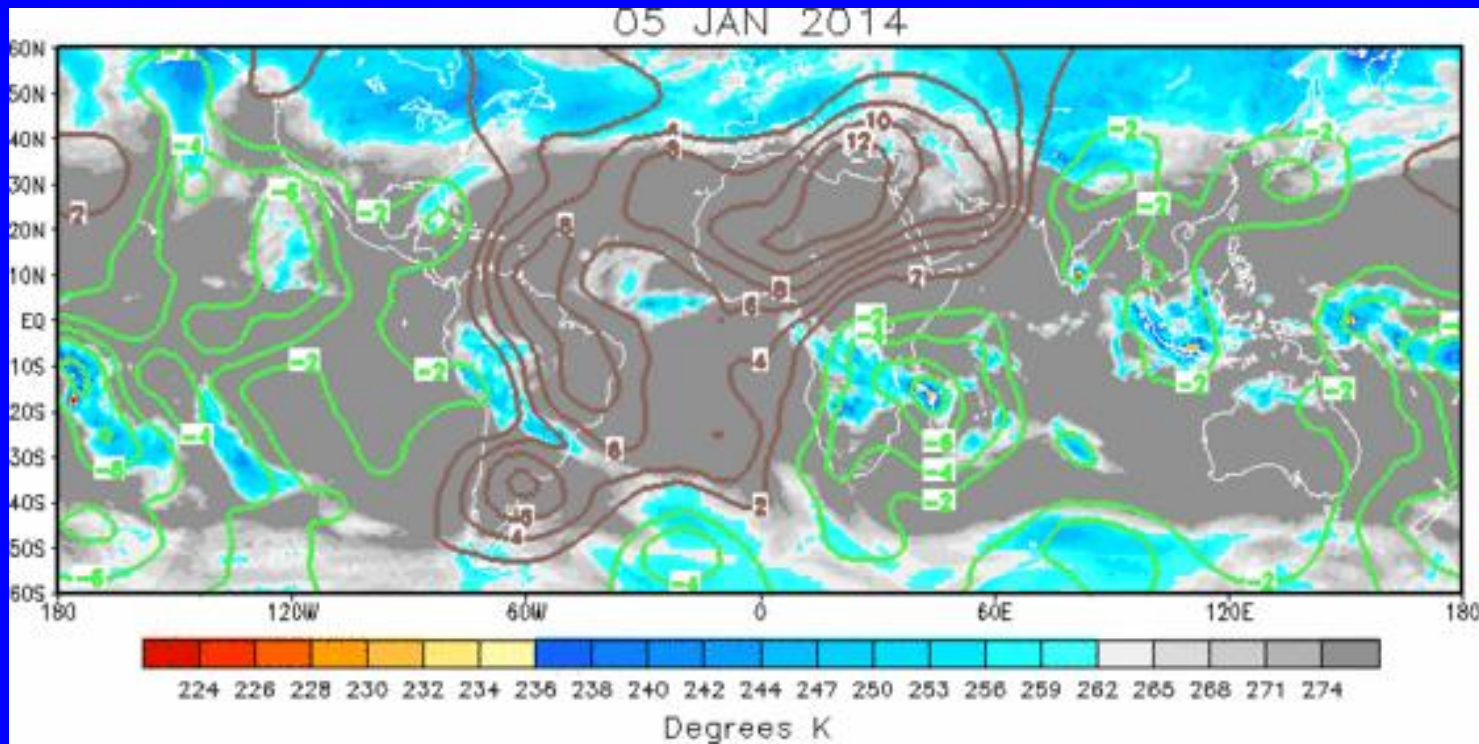




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The current velocity potential anomalies indicate a coherent pattern of large scale upper-level divergence (convergence) primarily over the Maritime Continent and Pacific Ocean (South America, Atlantic Ocean, and Africa).

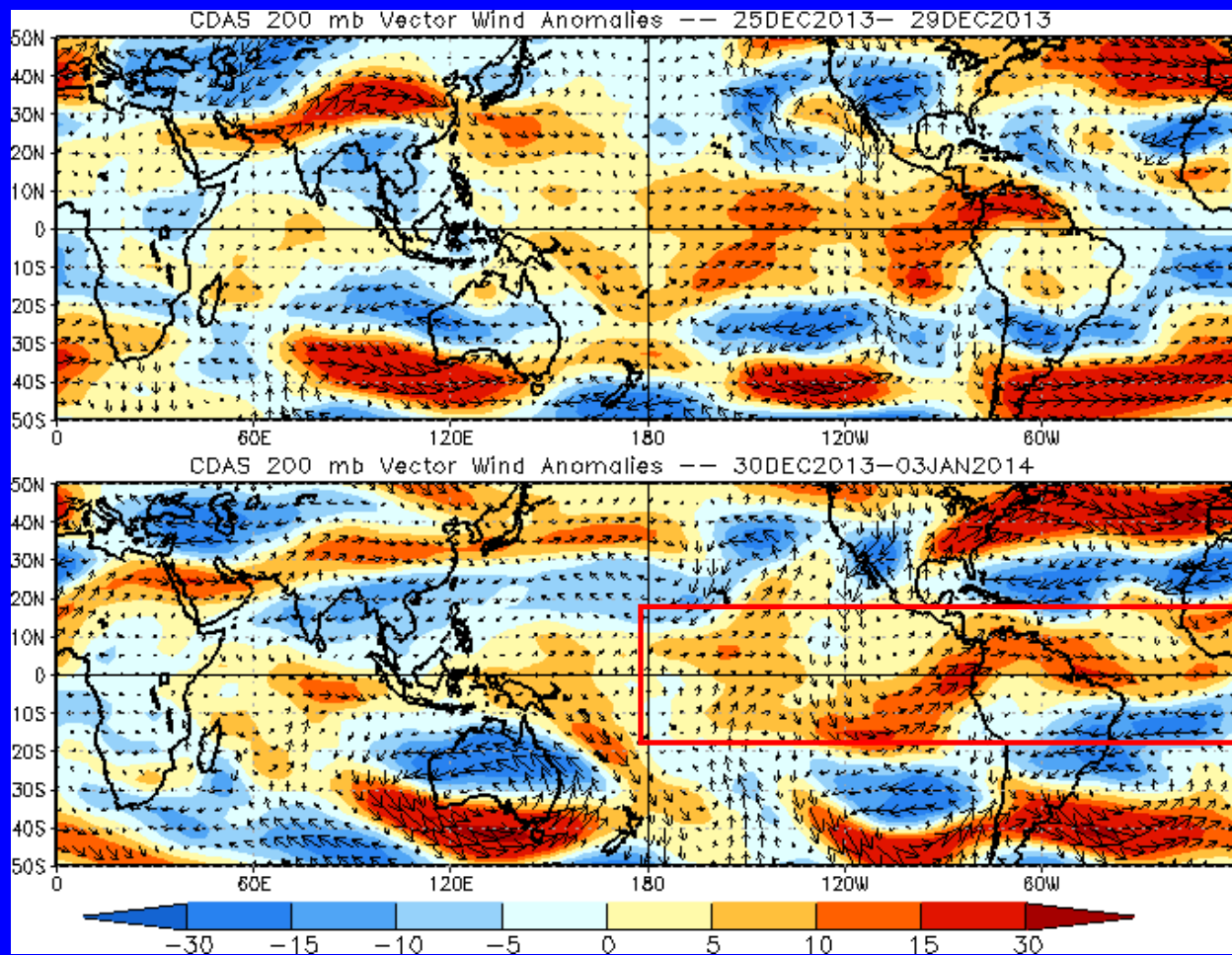


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



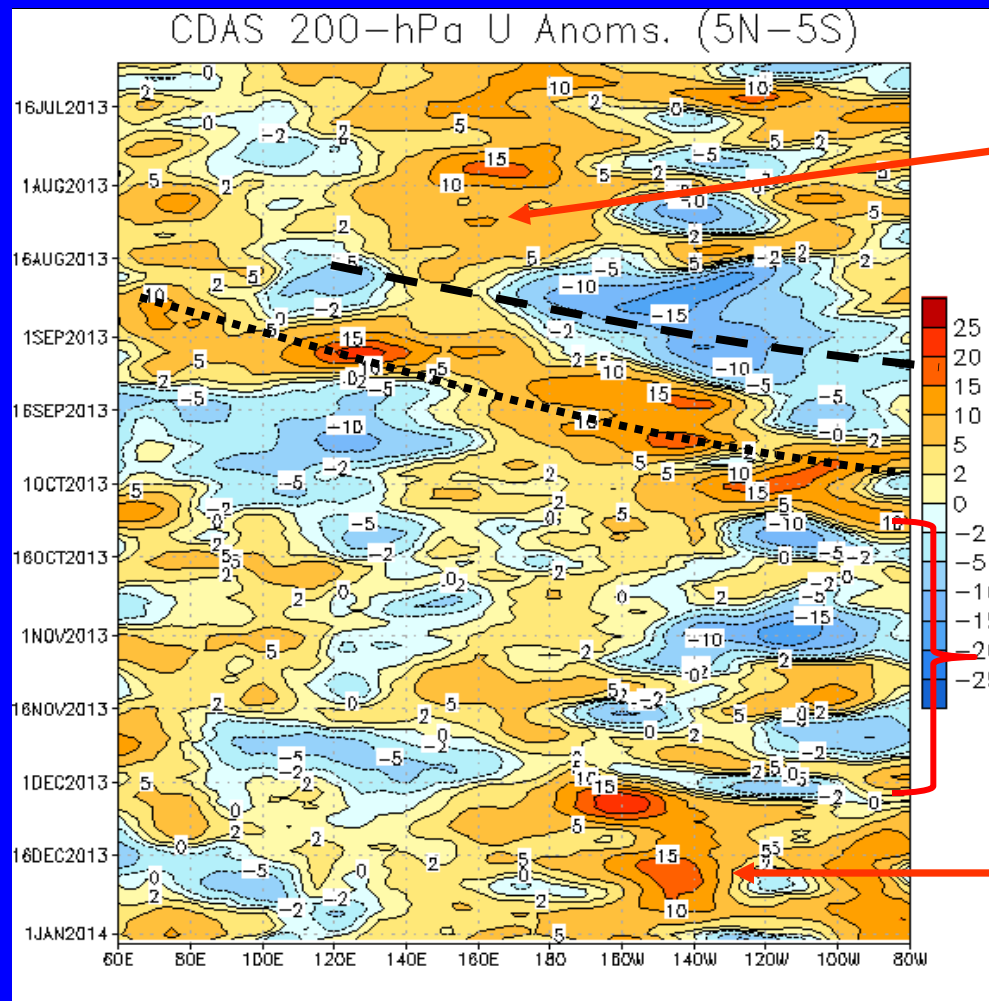
Westerly anomalies continued to spread eastward from the Pacific Ocean to the Atlantic Ocean during the previous five days (red box).



# 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.

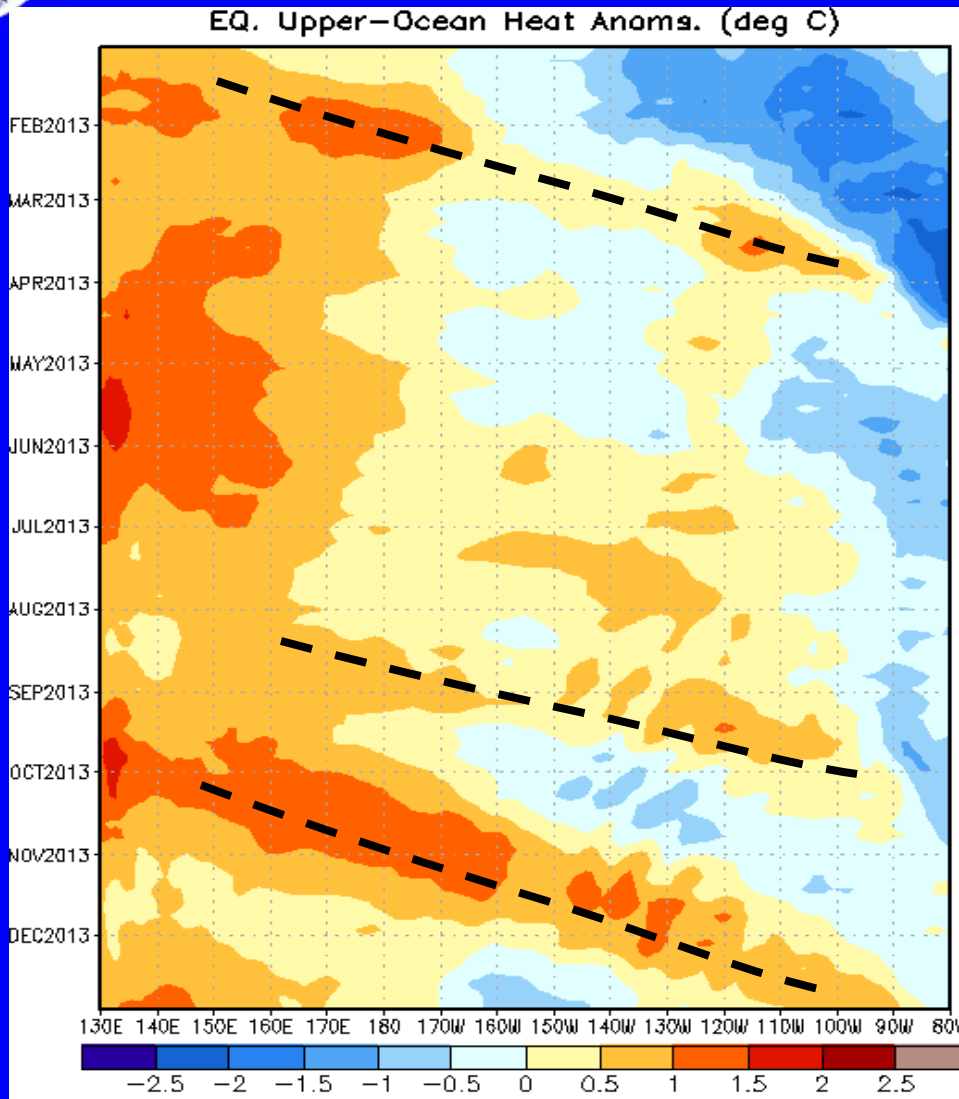
Anomalies of alternating sign are evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

Also, westerly anomalies increased in December just east of the Date Line and have generally persisted.



# Weekly Heat Content Evolution in the Equatorial Pacific

Time



Longitude

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.





# **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.**

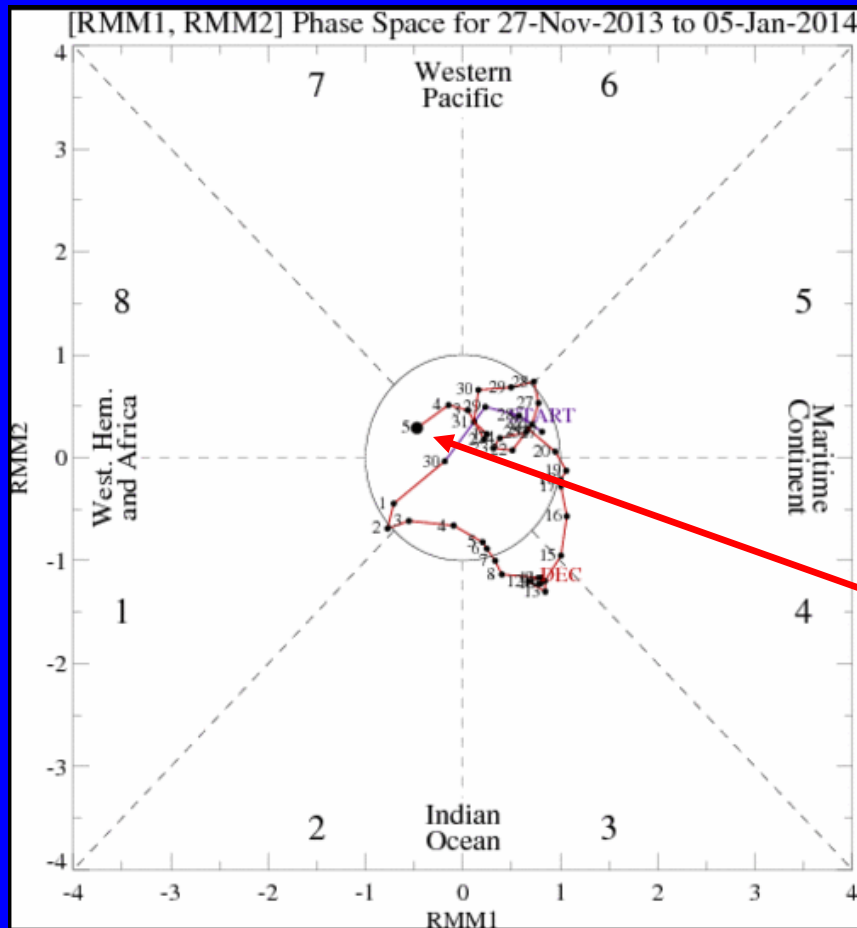
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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



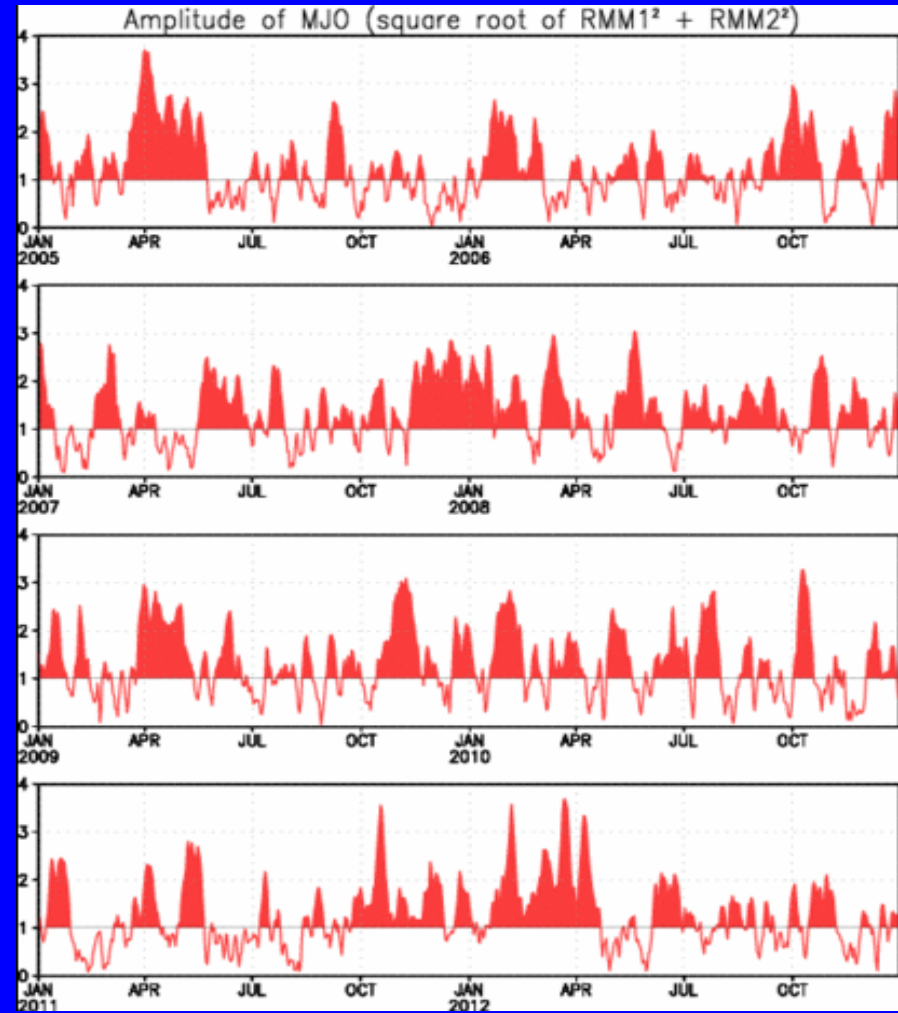
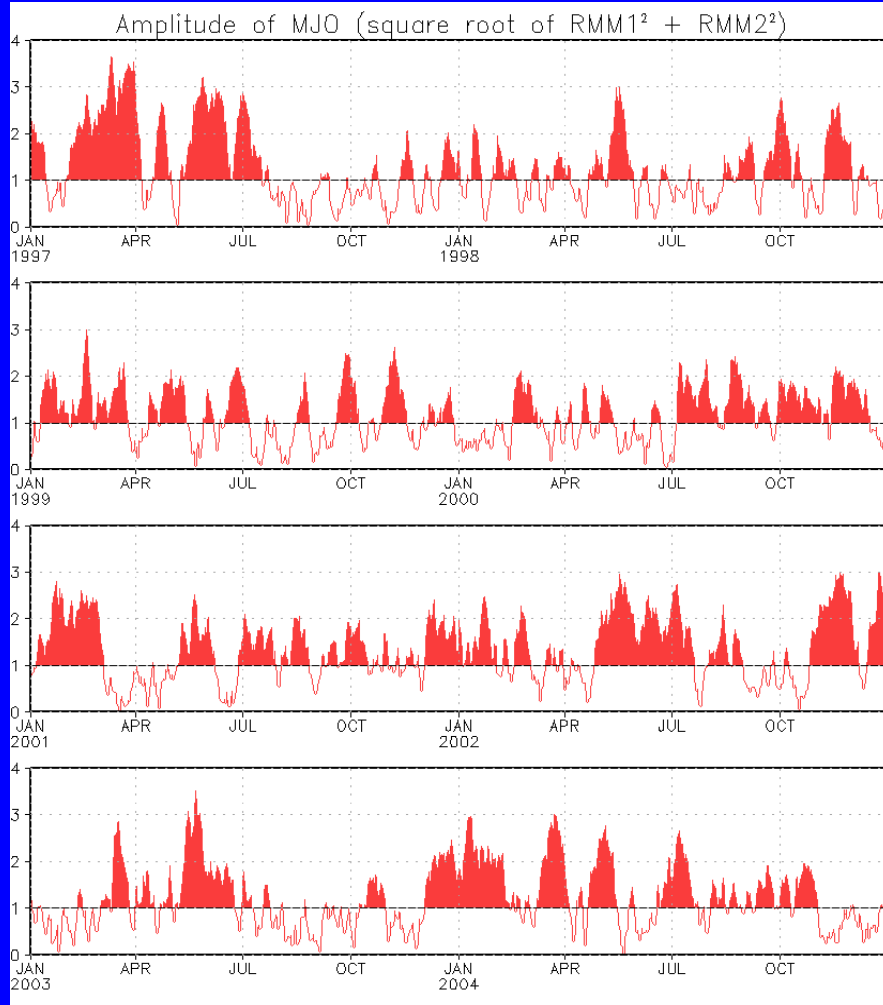
- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index continues to indicate a very gradual eastward propagation of a weak signal during the past several weeks.





# MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 1997 to present.  
Plots put current MJO activity in historical context.



# Ensemble GFS (GEFS) MJO Forecast

Yellow Lines – 20 Individual Members

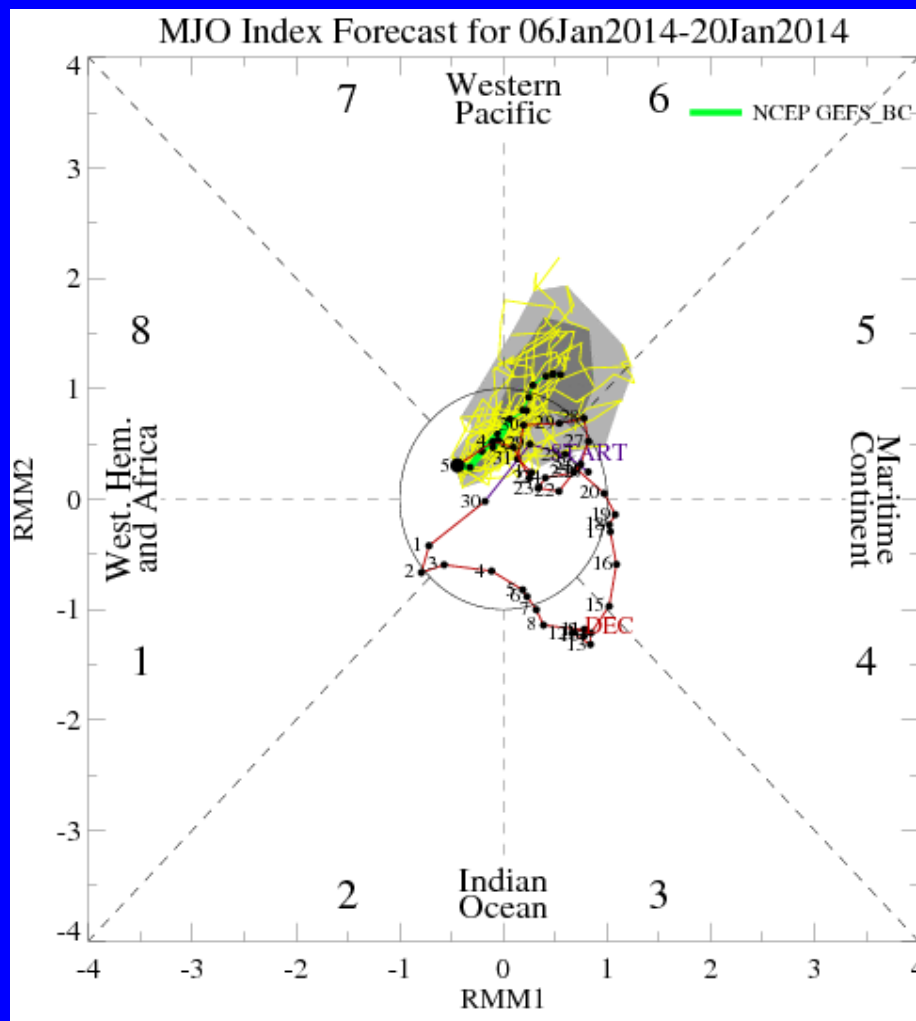
Green Line – Ensemble Mean

**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 signal, non-coherent signal during the period.

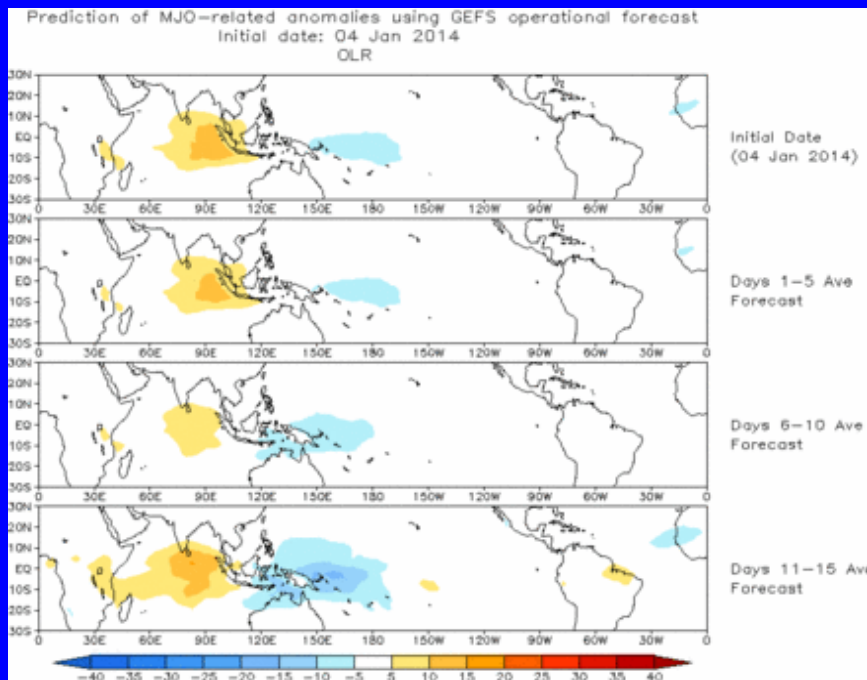




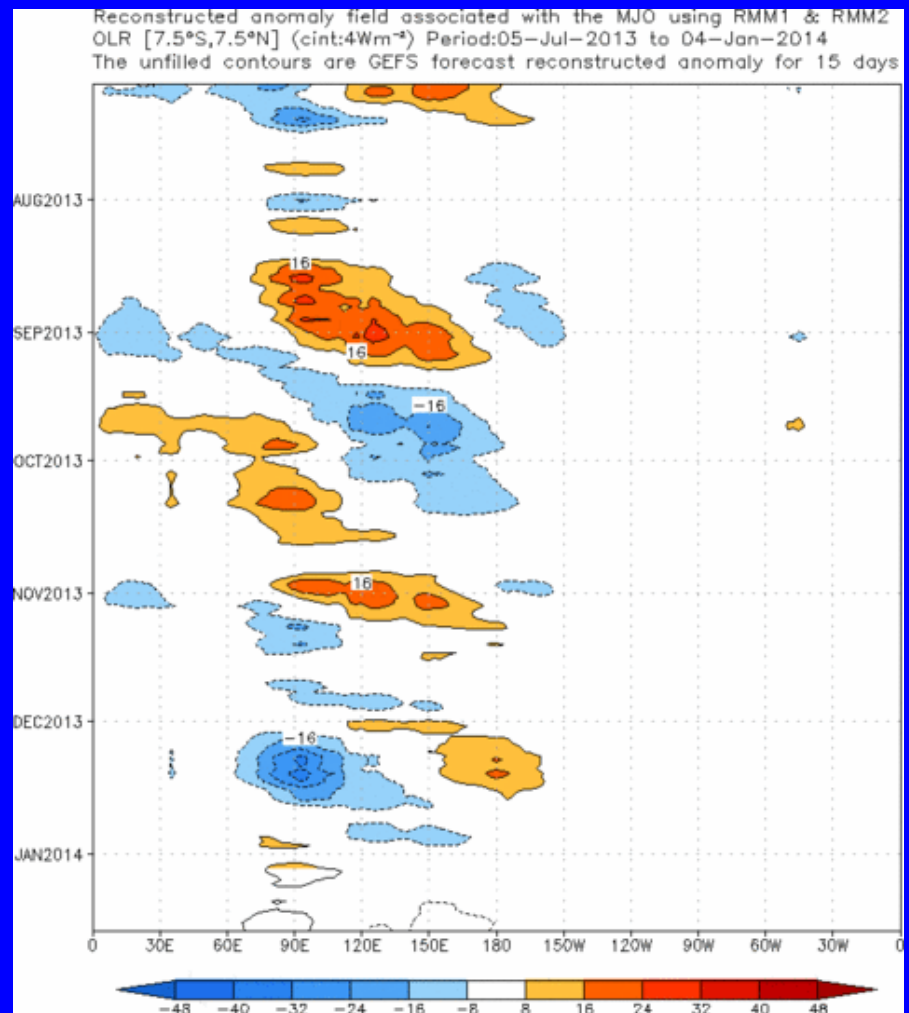
# Ensemble Mean GFS MJO Forecast

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



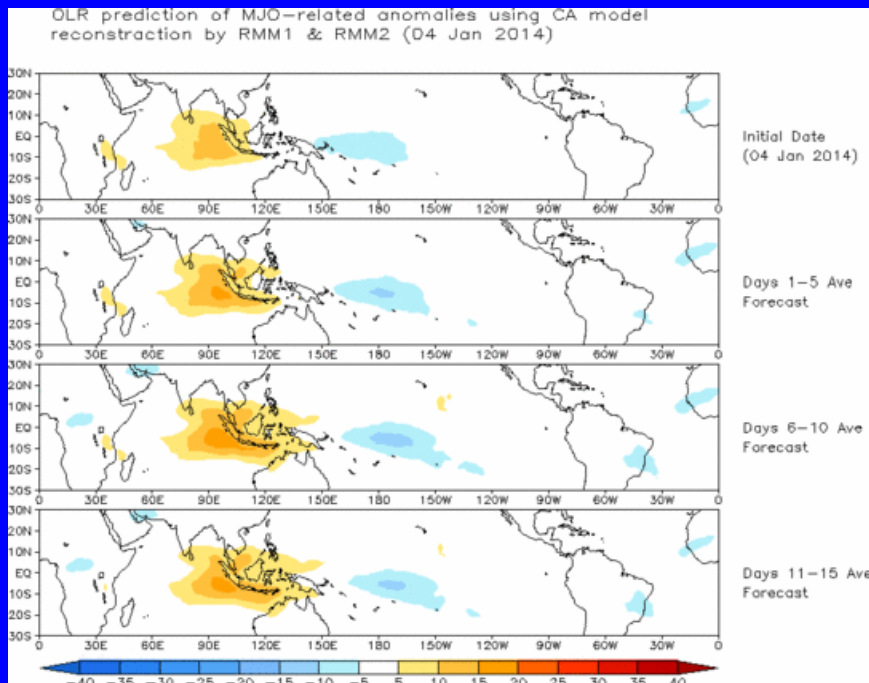
The ensemble mean GFS forecasts generally persistent weak enhanced (suppressed) convection across the western Pacific (Indian) oceans during the next two weeks.



# Constructed Analog (CA) MJO Forecast

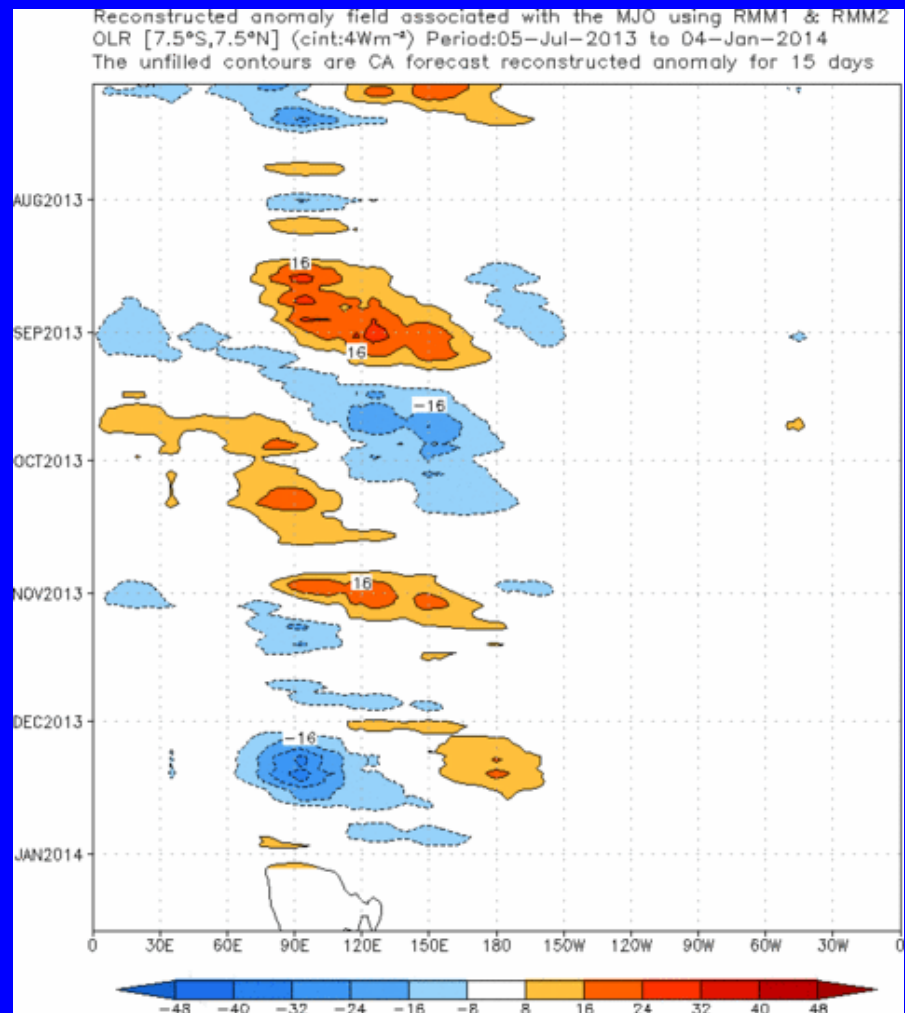
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

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



The constructed analog MJO forecasts generally persistent enhanced (suppressed) convection across the west-central Pacific (eastern Indian/western Maritime continent) areas during the next two weeks.

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

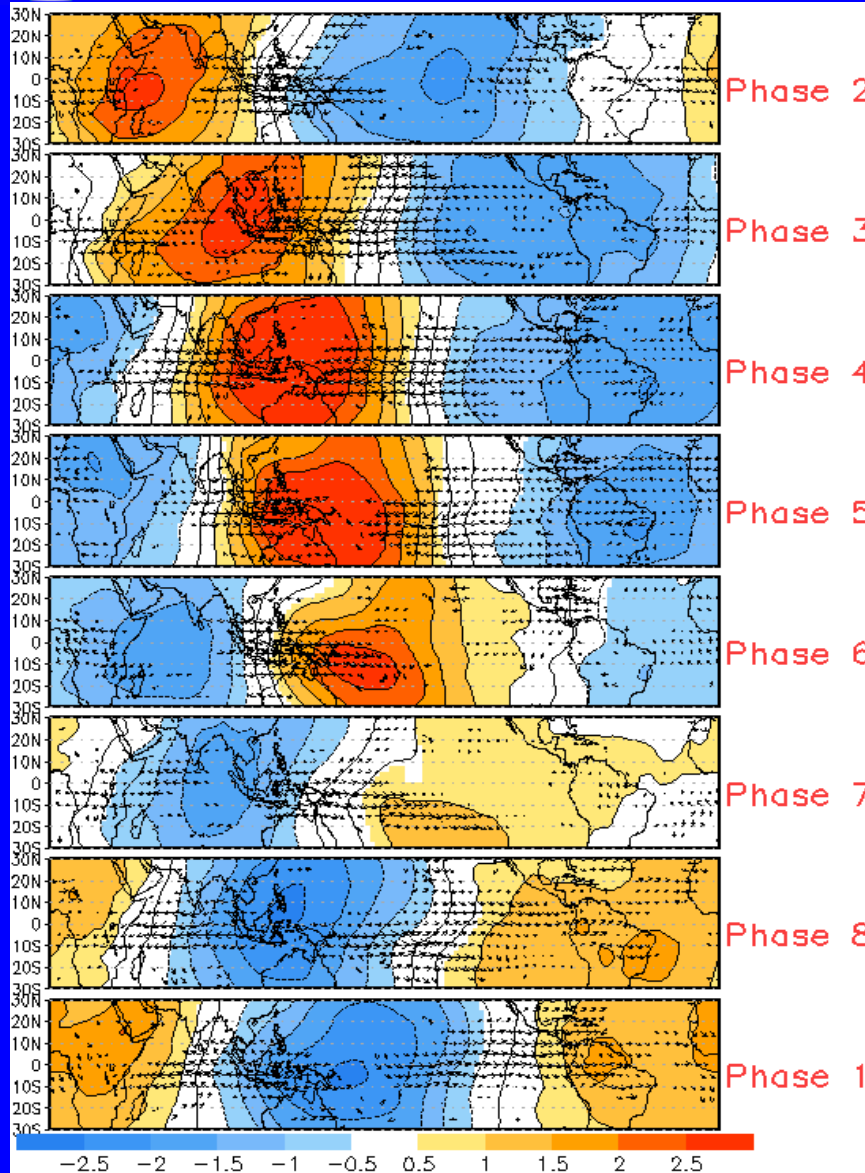




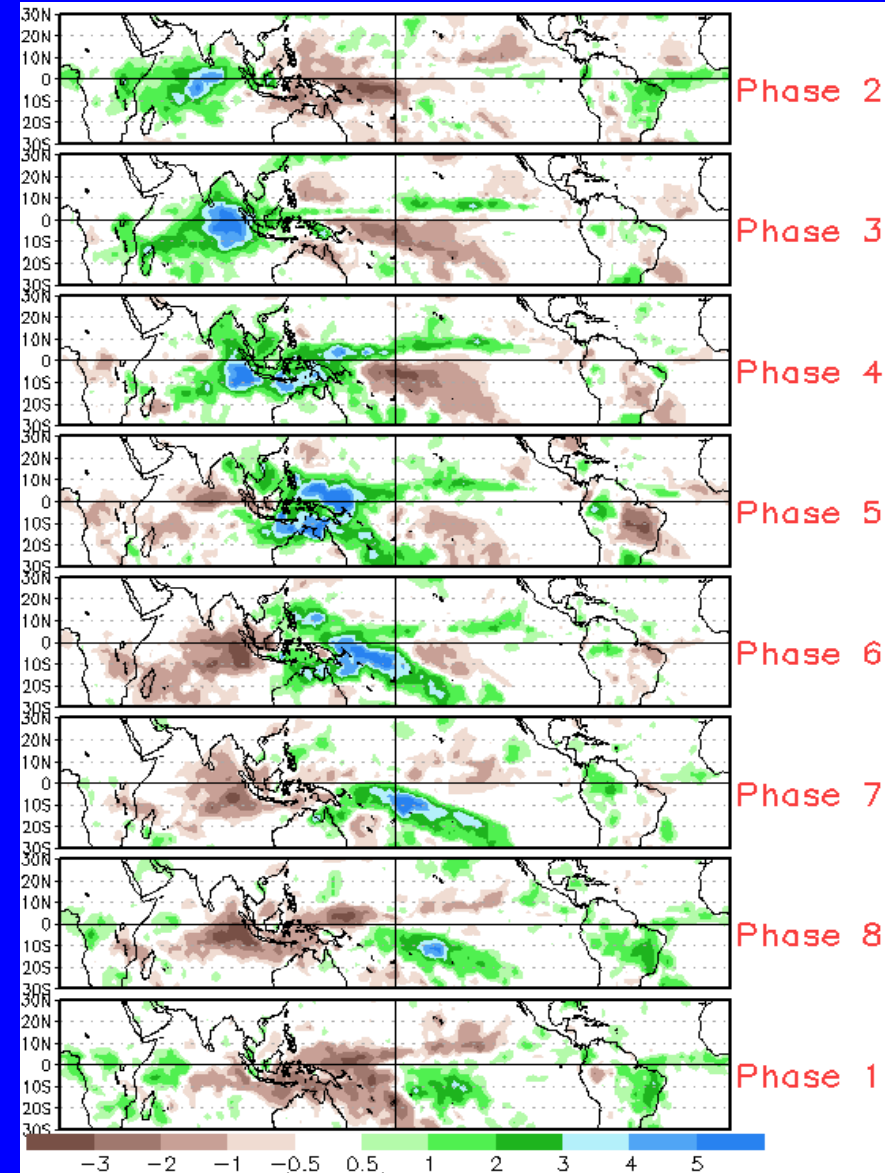


# MJO Composites – Global Tropics

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



Precipitation Anomalies (Nov-Mar)

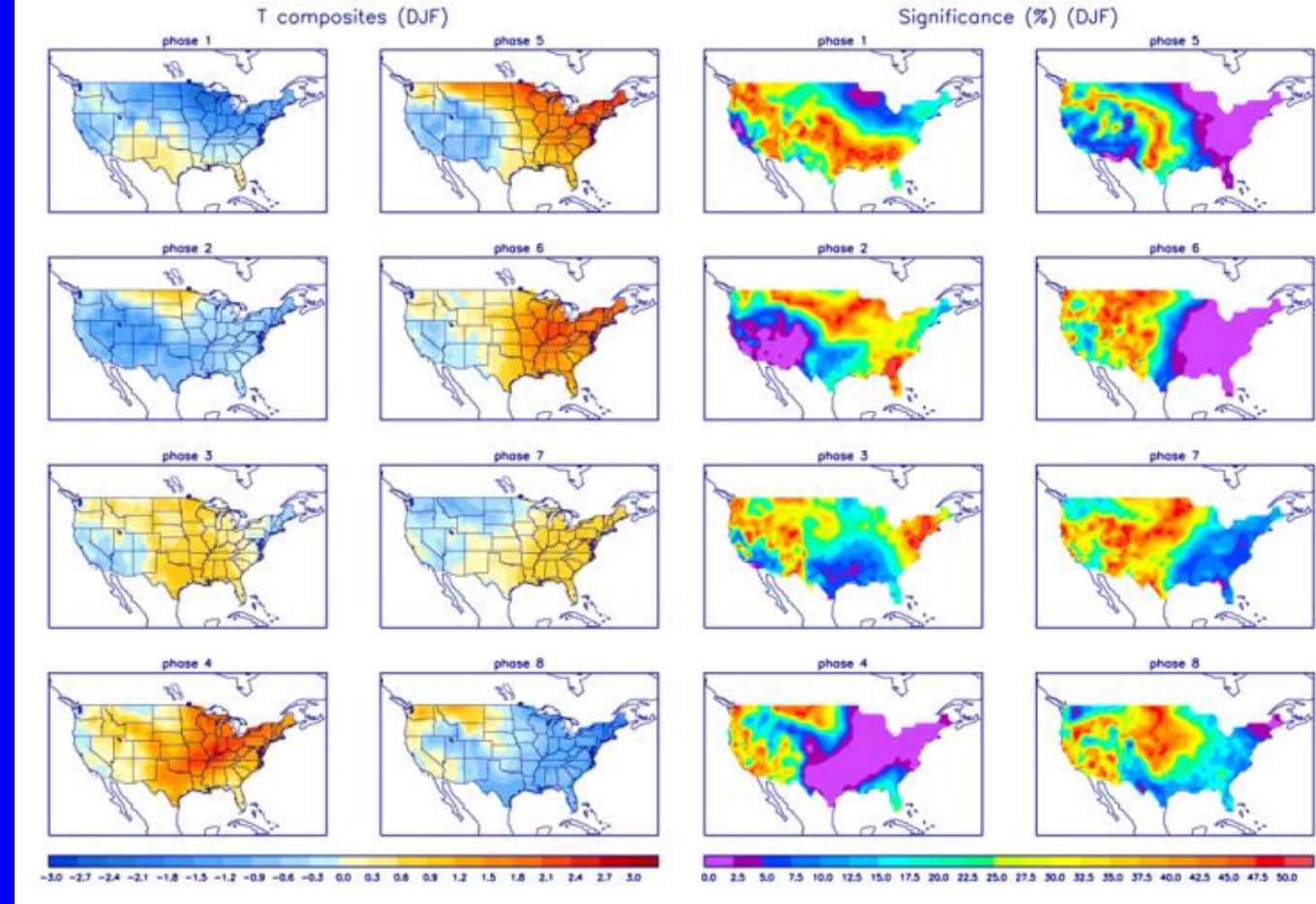




# U.S. MJO Composites – Temperature

- 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

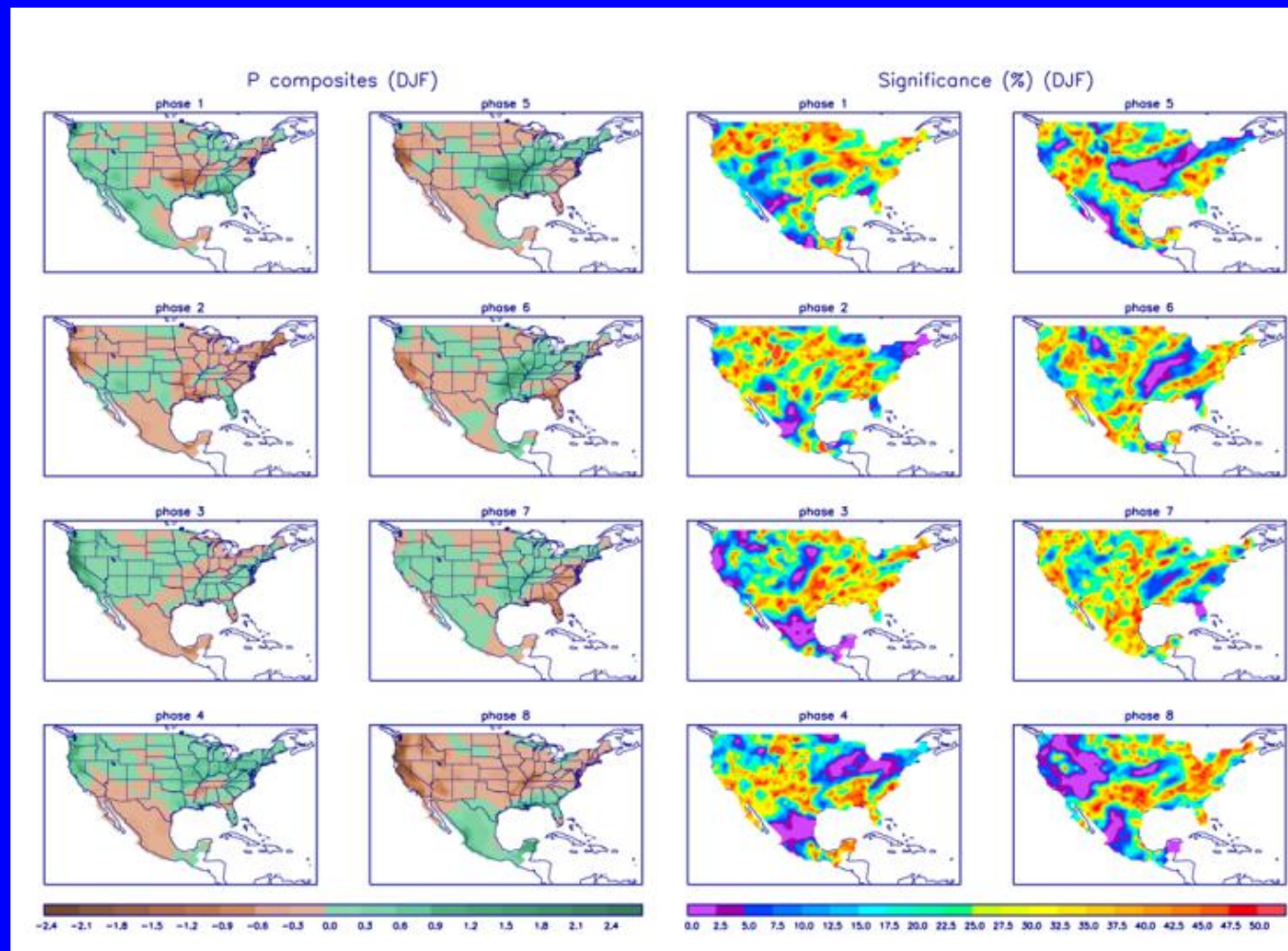
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>





# 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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