



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

**Update prepared by  
Climate Prediction Center / NCEP  
November 10, 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 week, with any enhanced convective phase near the Western Hemisphere. To date, eastward propagation of this signal has been limited.**
- **Other types of tropical variability, including the low frequency background state, favor enhanced convection across the central Pacific and continue to influence the pattern of anomalous convection.**
- **Several dynamical model MJO index forecasts depict eastward propagation of a more coherent, subseasonal signal from the Western Hemisphere to the Indian Ocean during the next two weeks, but it is unclear whether this signal will emerge as a more robust, longer lived MJO signal.**
- **Based on recent observations and model guidance, the MJO may contribute to enhanced (suppressed) convection over parts of South America, Africa, and the Indian Ocean basin (the Maritime Continent and western Pacific) during the period.**

**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>**

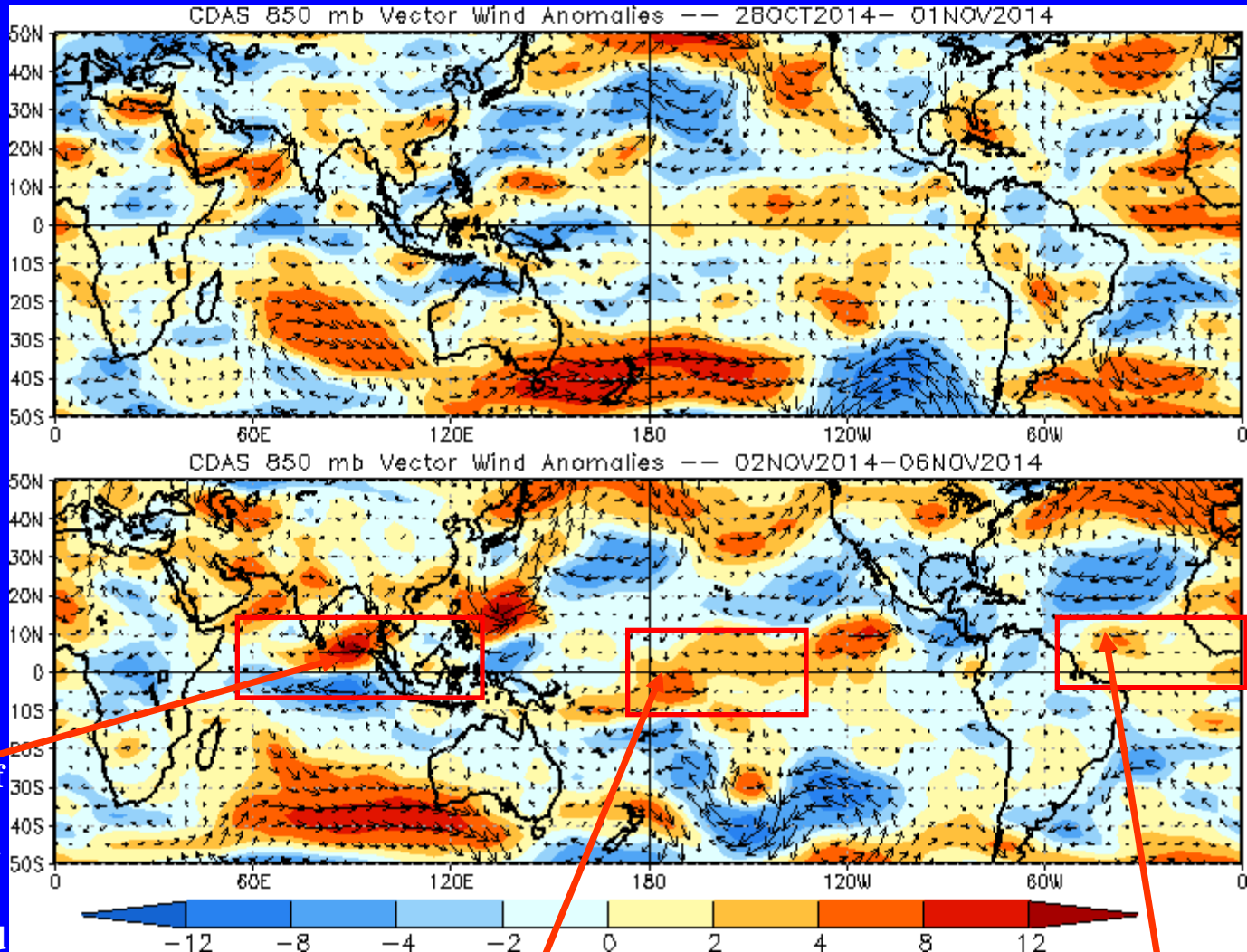


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies over the Indian Ocean south of the equator, while westerly anomalies partly associated with tropical cyclone activity developed over the northeastern Indian Ocean.

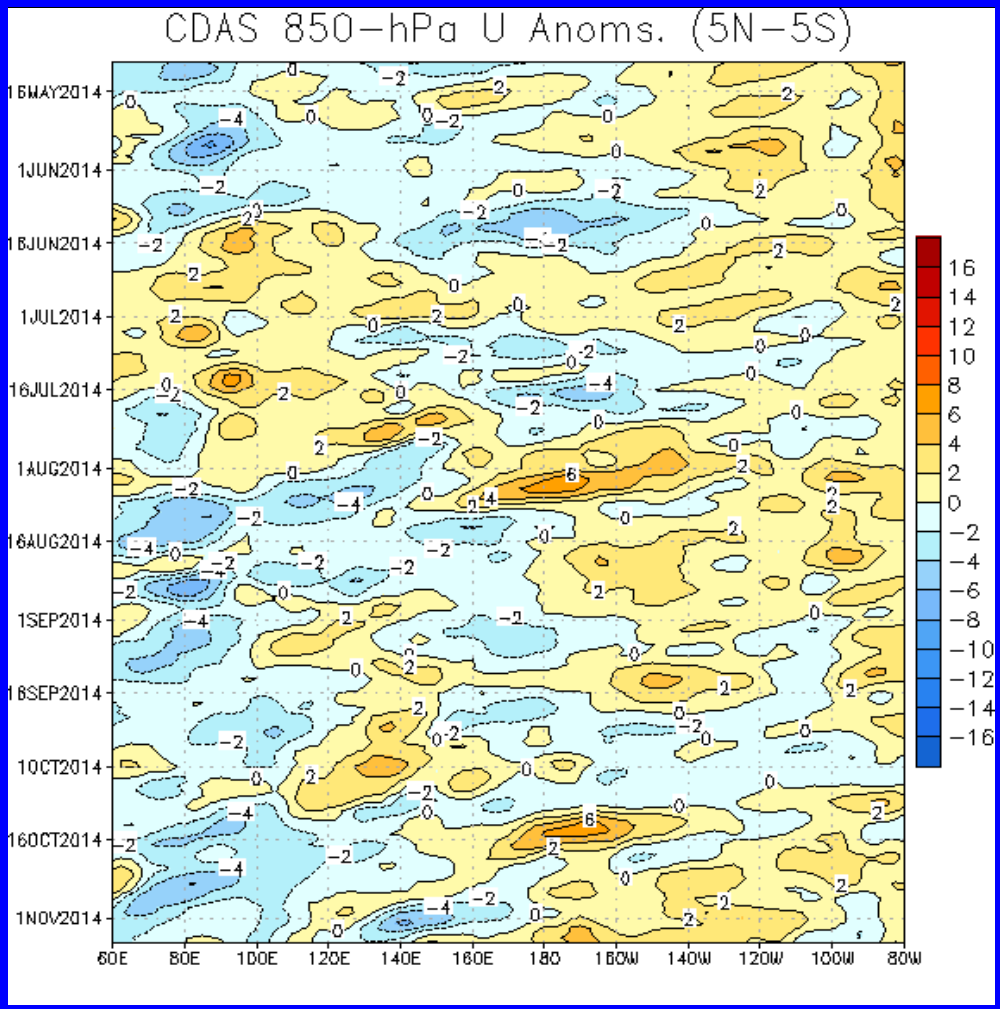
Westerly anomalies strengthened along the equator just east of the Date Line, and persisted north of the equator through the eastern Pacific.

Westerly anomalies persisted but weakened slightly over the tropical Atlantic.



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

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



During much of May and June, westerly anomalies were observed over the eastern Pacific. An enhanced South Asian monsoon circulation developed during much of June and July.

From late July to August, westerly (easterly) anomalies shifted westward over the eastern and central Pacific (western Pacific, Maritime Continent, and Indian Ocean).

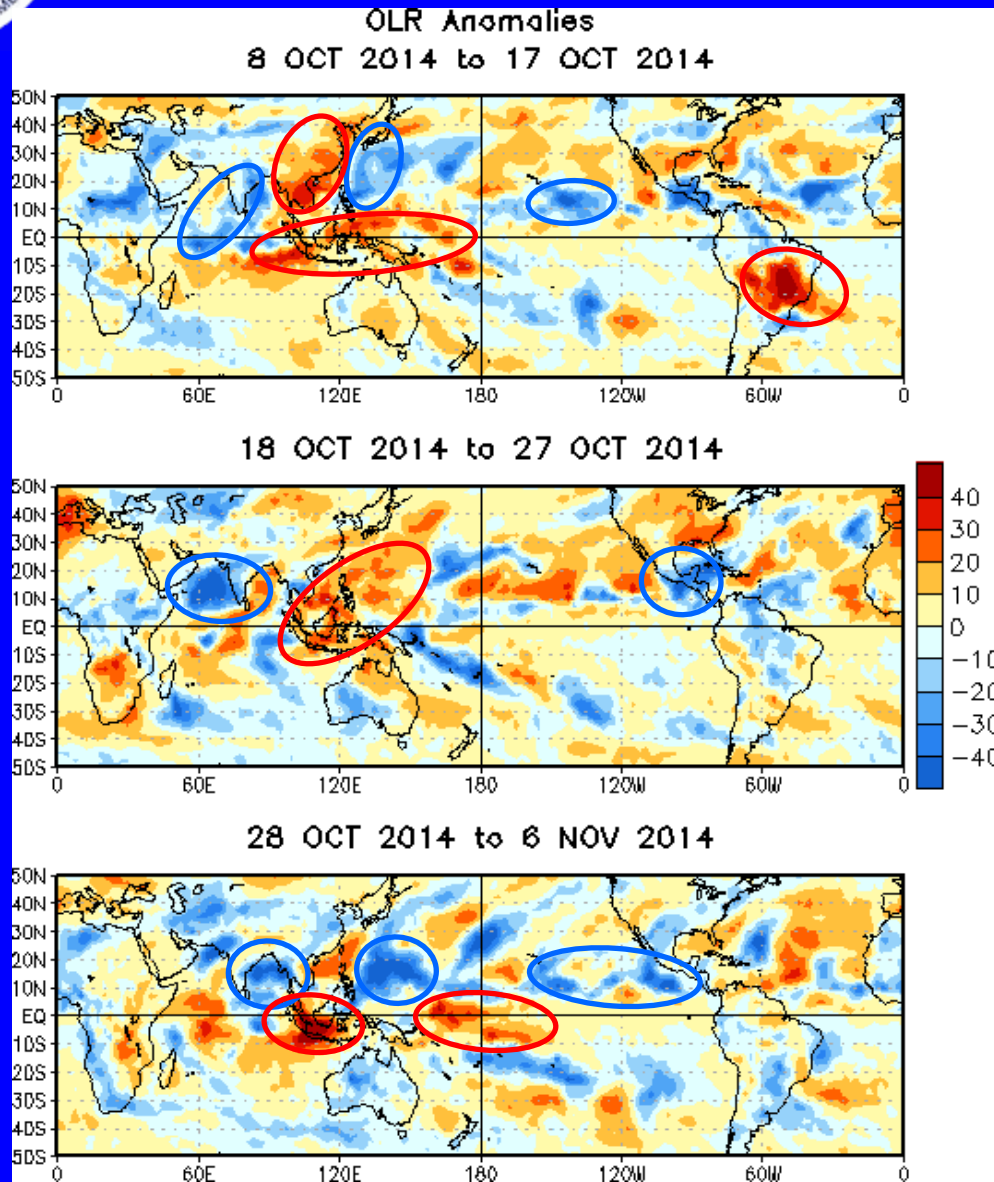
A westerly wind burst was observed near the Date Line during mid-October

More recently, westerly anomalies were observed over much of the Pacific basin, with a weaker and more incoherent anomaly field prevailing across the Indian Ocean and Maritime Continent.



# OLR Anomalies – Past 30 days

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



Suppressed (enhanced) convection was observed across East and Southeast Asia, the Maritime Continent, the equatorial western Pacific, and eastern Brazil (parts of the Indian Ocean, and along the east-central Pacific ITCZ) during mid-October.

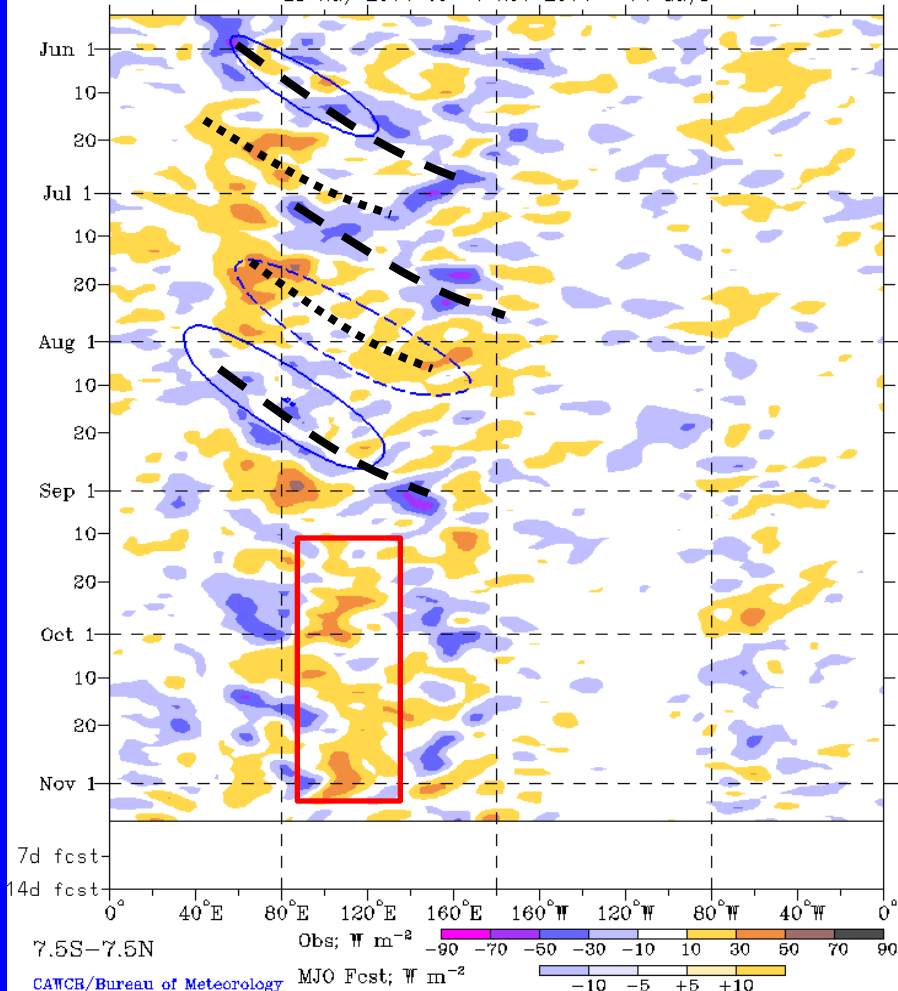
During late October, suppressed convection persisted from the western Maritime Continent through the northwestern Pacific, while enhanced convection associated with tropical cyclone activity was observed over the Arabian Sea and the Caribbean.

During late October and early November, suppressed convection persisted over the western Maritime Continent and developed over the central Pacific, while tropical cyclone related enhanced convection was observed over the Bay of Bengal, northwestern Pacific, and east Pacific.



# Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°N)

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies  
MJO anomalies blue contours, CINT=10. (5. for forecast)  
Negative contours solid, positive dashed  
25-May-2014 to 9-Nov-2014 + 14 days



**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 became more organized during June and July, primarily over the Indian Ocean, but the pattern became less coherent with respect to canonical MJO activity by September.

Since mid-August, the pattern was dominated by interactions between westward moving features and eastward moving features that were more transient than canonical MJO-related activity.

An area of persistent suppressed convection was observed over the western Maritime Continent since mid-September (red box), with pulses of enhanced convection observed both over the Indian Ocean and western Pacific. More recently, large scale convective anomalies have weakened.

**Longitude**

**Time**



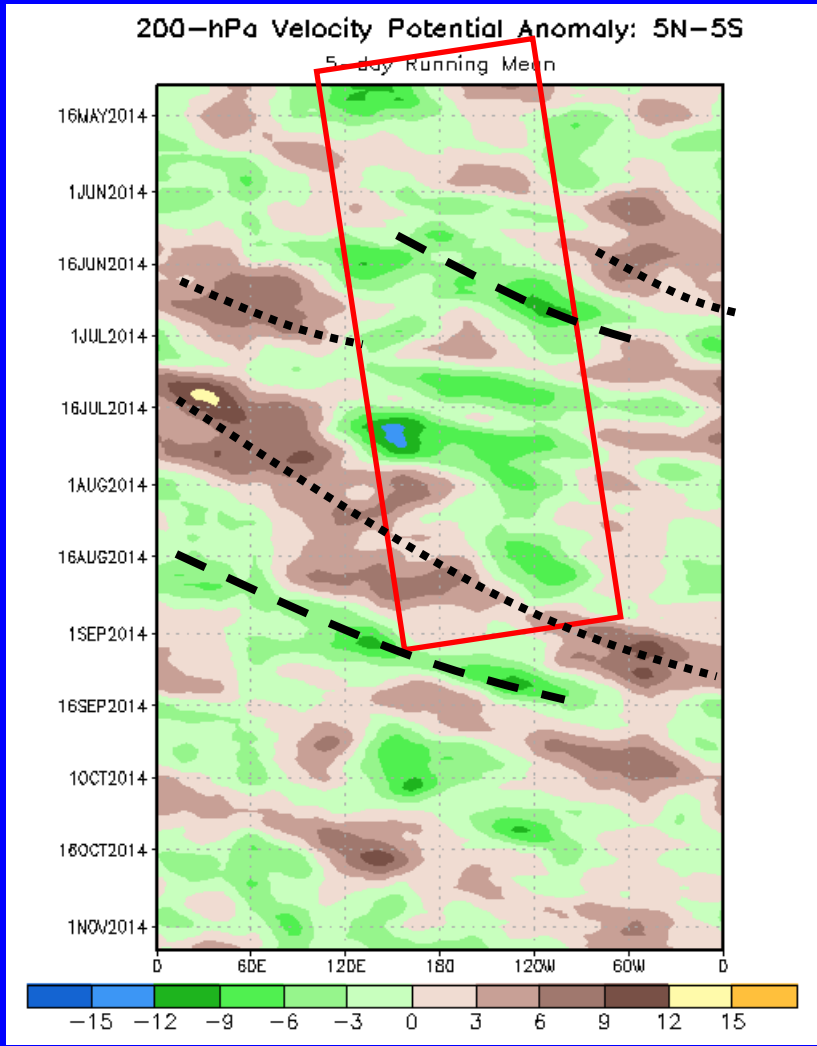


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

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 during the late spring and summer across the Indo-Pacific warm pool and central-eastern Pacific (red box).

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

The pattern became less coherent during early July, but then organized again in late July and August, with a wide area of suppressed convection moving around the planet.

During early September, anomalies were consistent with rapid eastward propagation, before becoming stationary for the second half of the month.

During October and early November, some eastward propagation is evident, although other signals are interfering with the overall pattern.

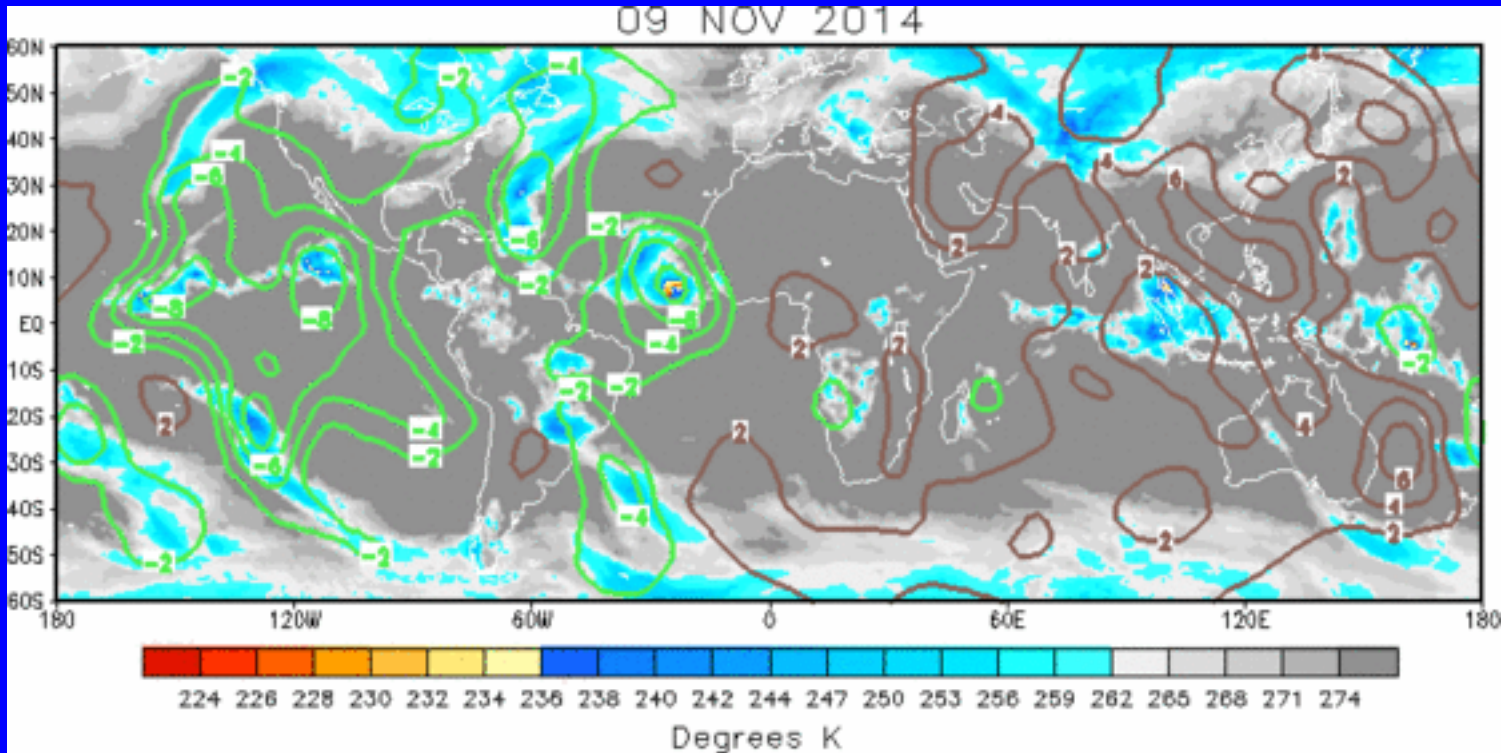




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

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 has become more coherent, with negative (generally positive) anomalies observed over the central and eastern Pacific (the Indian Ocean, and the Maritime Continent). A less coherent pattern remains over the Western Hemisphere.

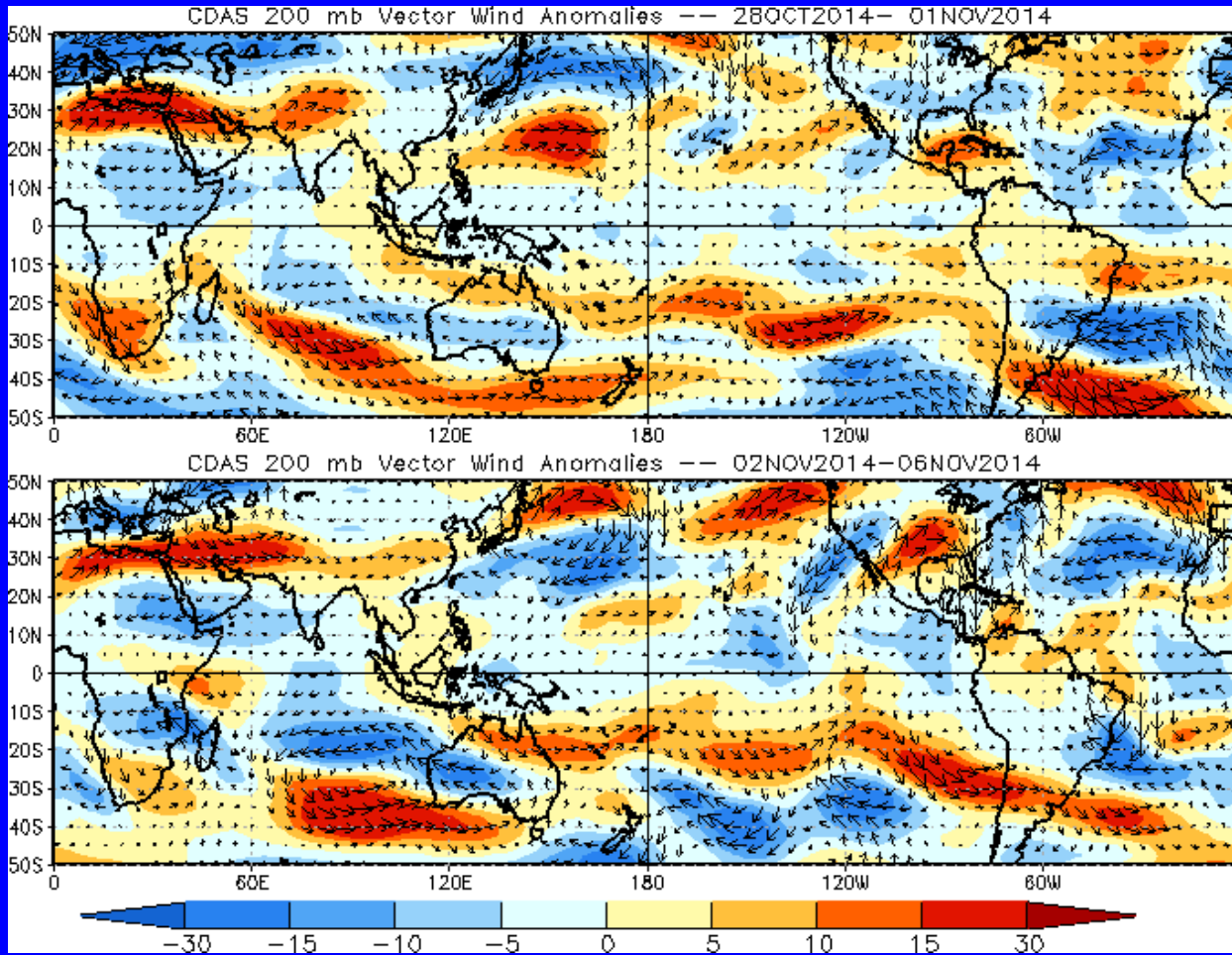


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



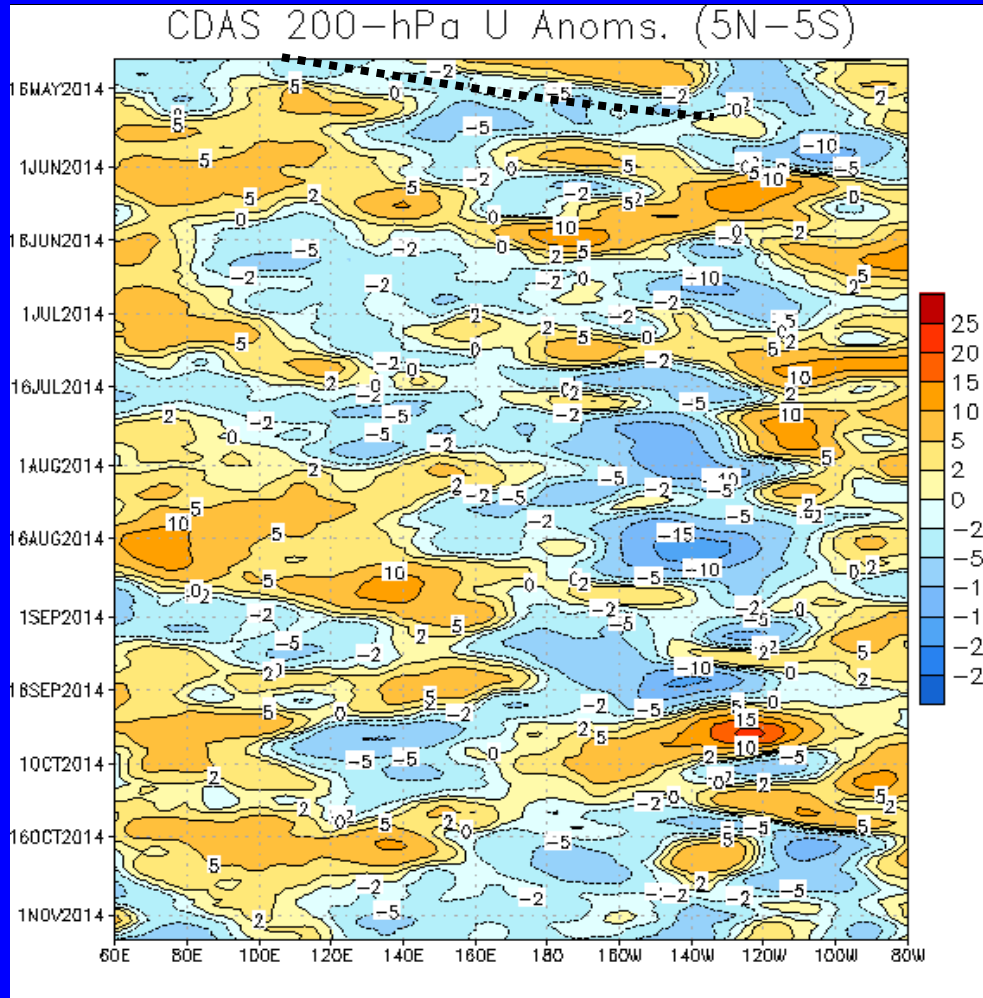
Generally weak easterly 200-hPa zonal wind anomalies were observed during the recent pentad over most of the global Tropics.



# 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



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.

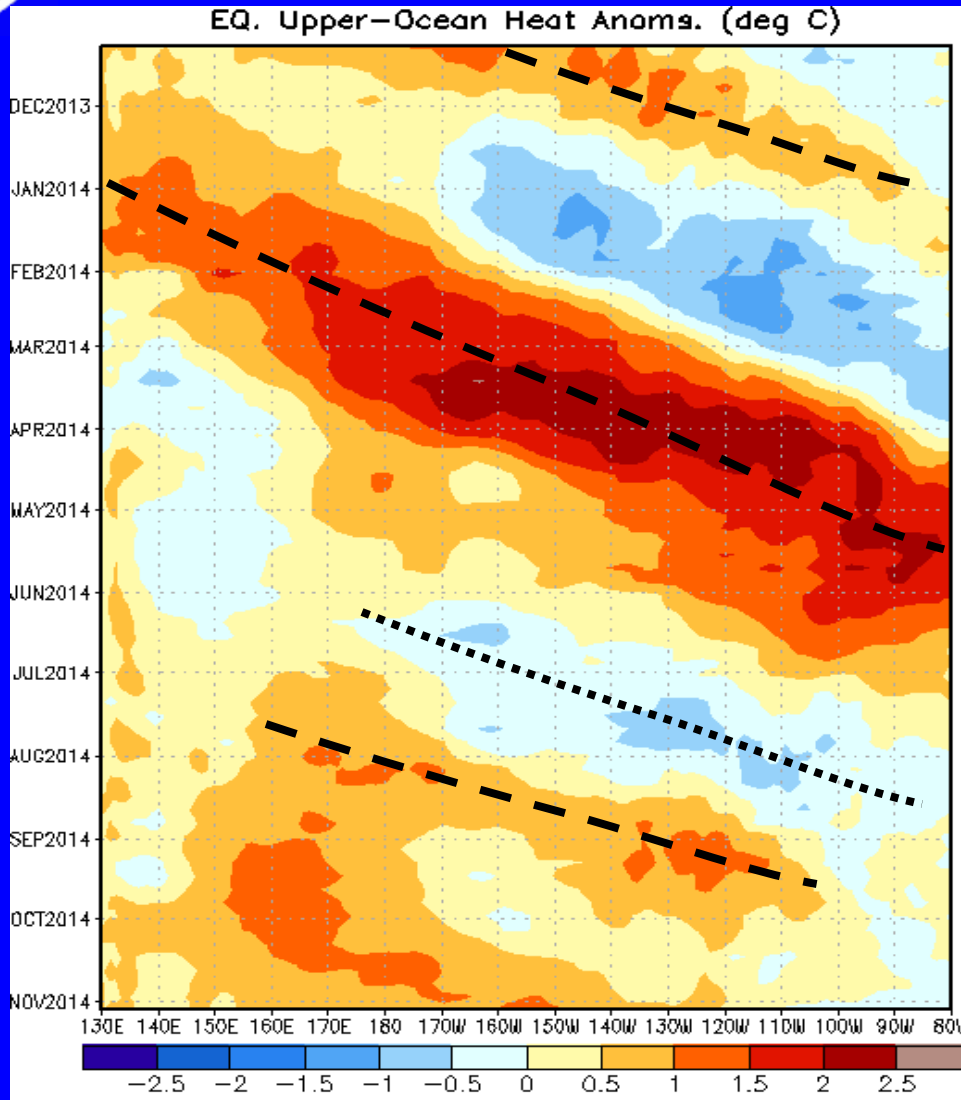
Westward propagation of westerly anomalies is evident over the east-central Pacific during June. In July, easterly anomalies intensified over the central and eastern Pacific.

A slow, eastward progression of westerly anomalies is evident over the Maritime Continent and western Pacific during August. Some westward propagation is noticeable during September and early October.

More recently, weak easterly anomalies developed across much of the tropical Pacific.



# Weekly Heat Content Evolution in the Equatorial Pacific



Oceanic downwelling Kelvin wave activity is evident 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 (dotted line).

Warm anomalies are again evident across much of the Pacific due to another downwelling Kelvin wave.



# 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.**

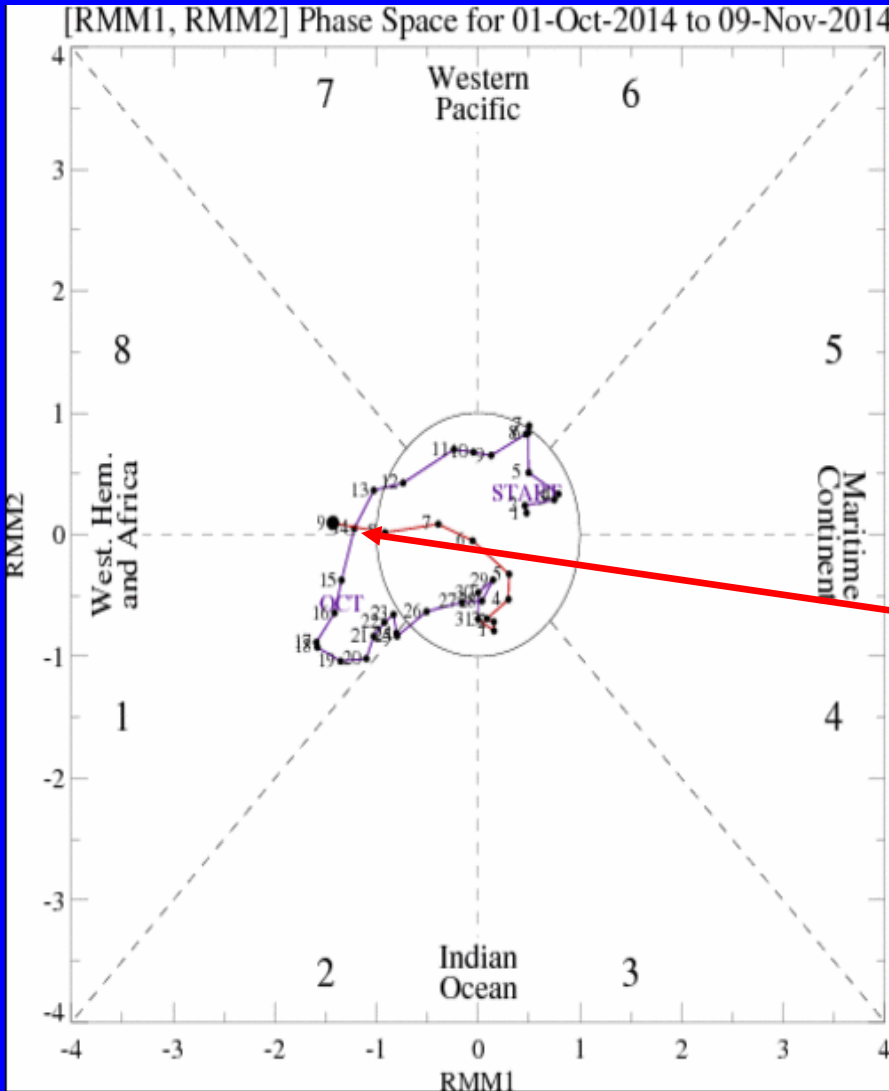
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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

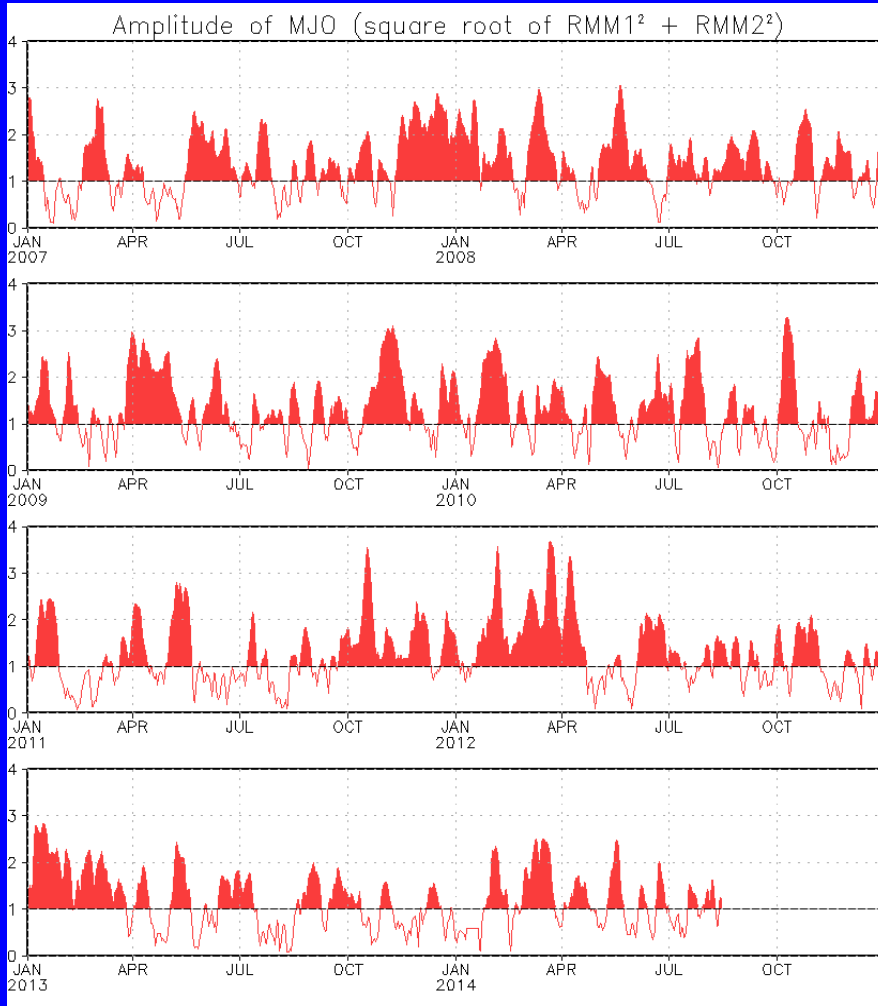


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The RMM MJO index depicts an increase in amplitude over the Western Hemisphere, although there is no evident eastward propagation of the signal.



# 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.



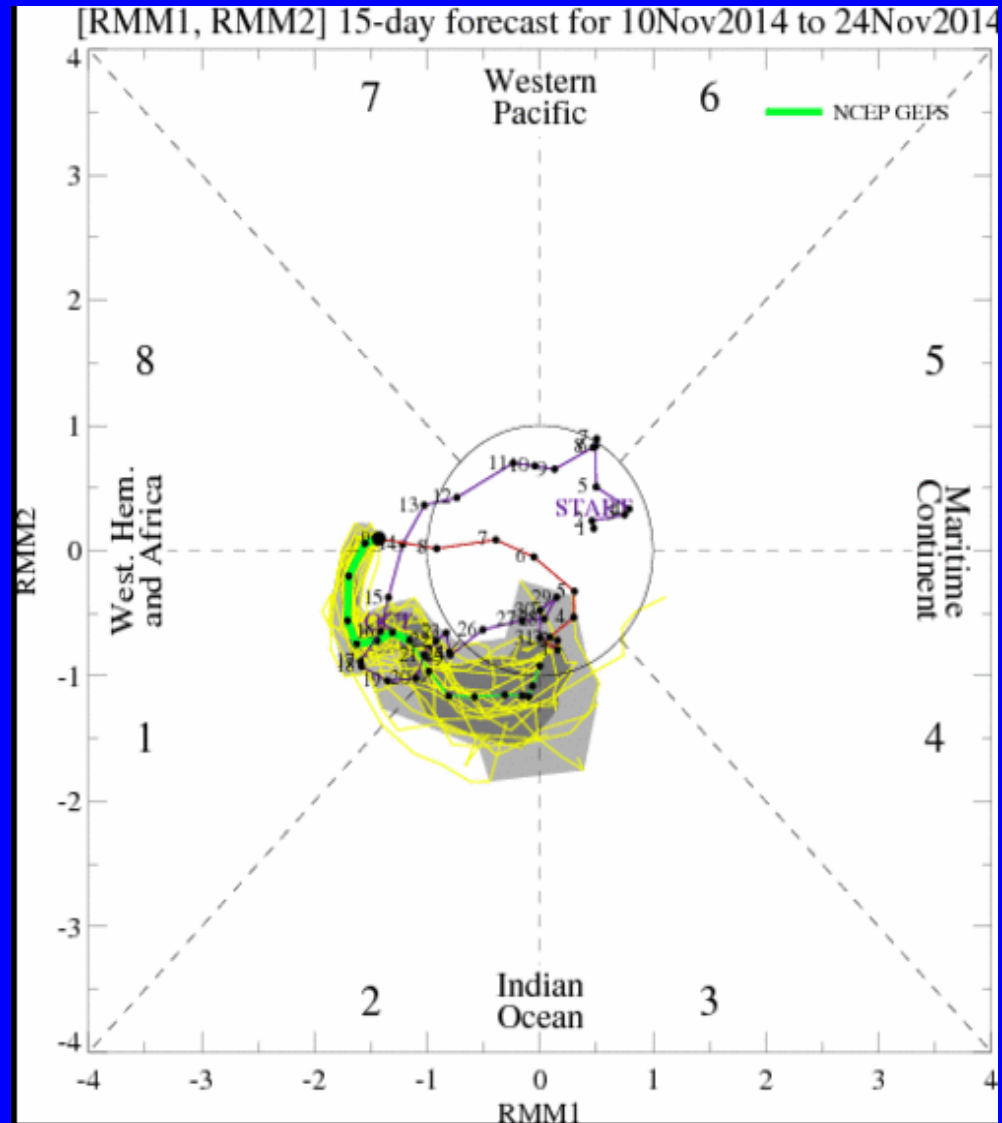
# Ensemble GFS (GEFS) MJO Forecast

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 the eastward propagation of an MJO signal during the next two weeks, with the enhanced phase entering the Indian Ocean basin.



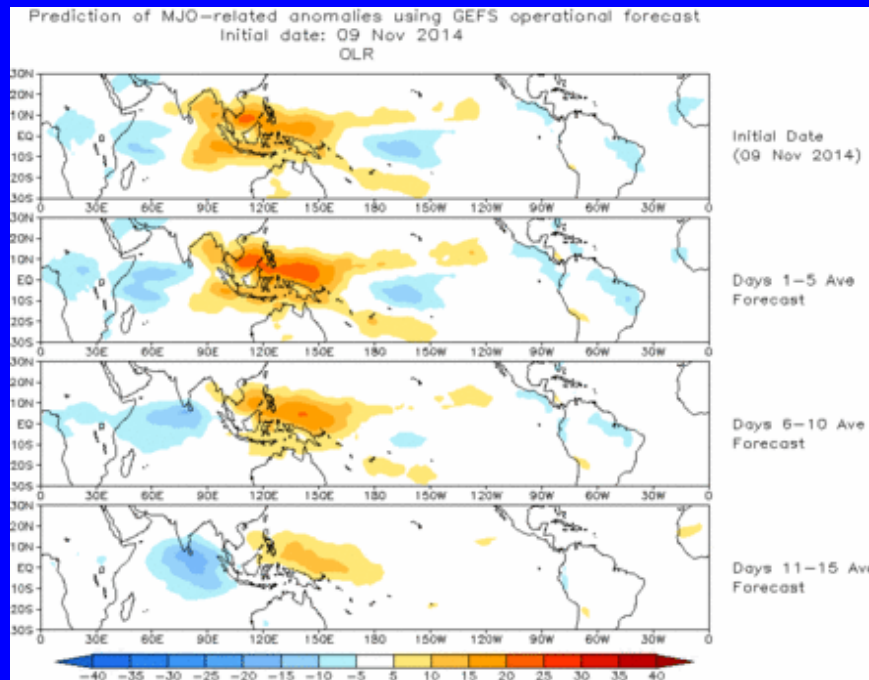




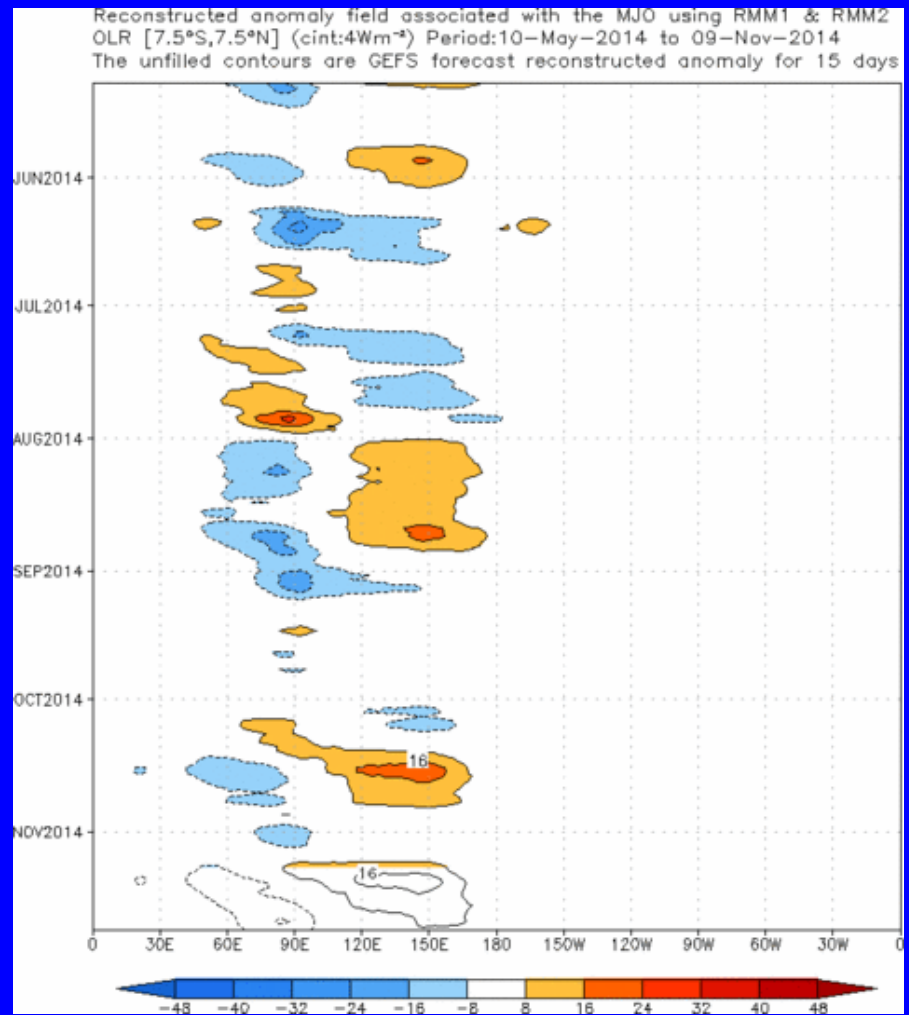
# Ensemble Mean GFS MJO Forecast

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



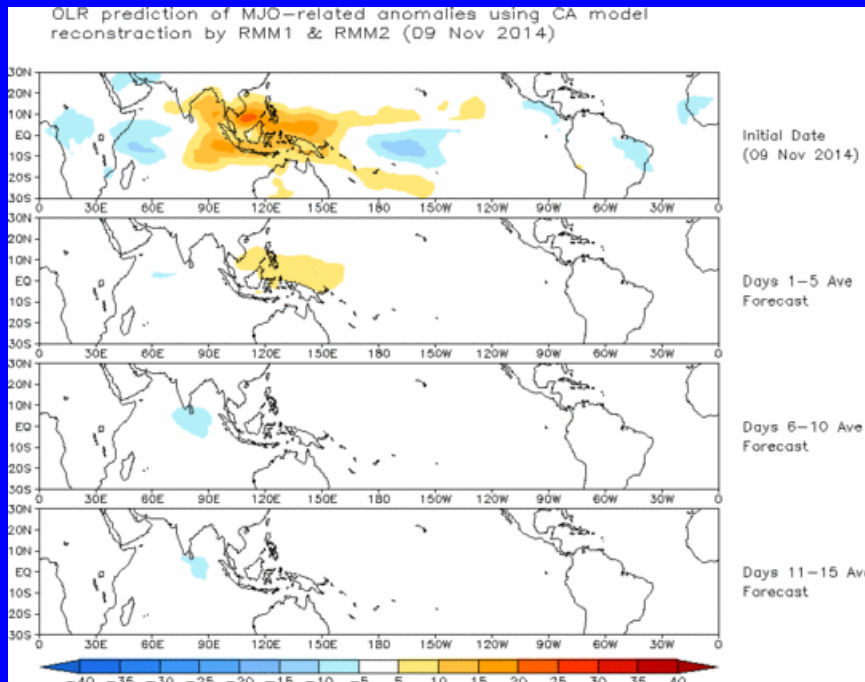
The ensemble mean GFS forecasts eastward propagation of enhanced convective anomalies from the Western Hemisphere to the east-central Indian Ocean during the next two weeks.



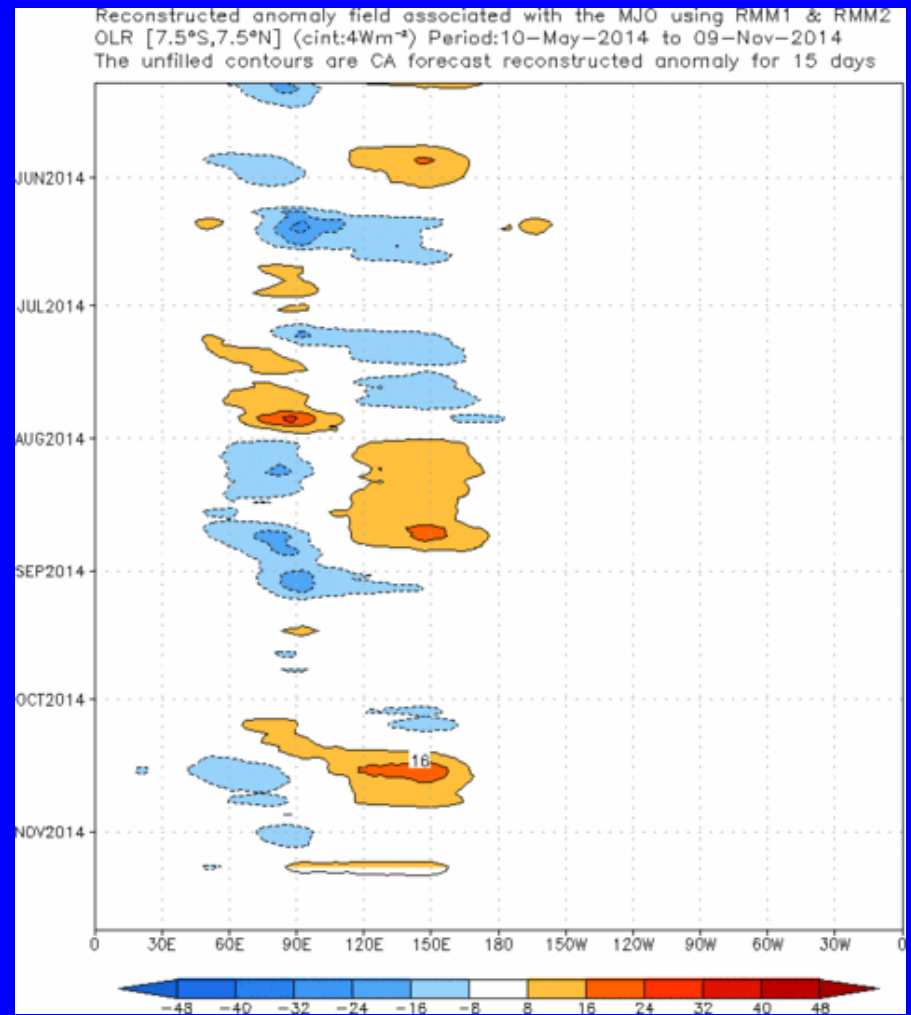
# Constructed Analog (CA) MJO Forecast

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



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



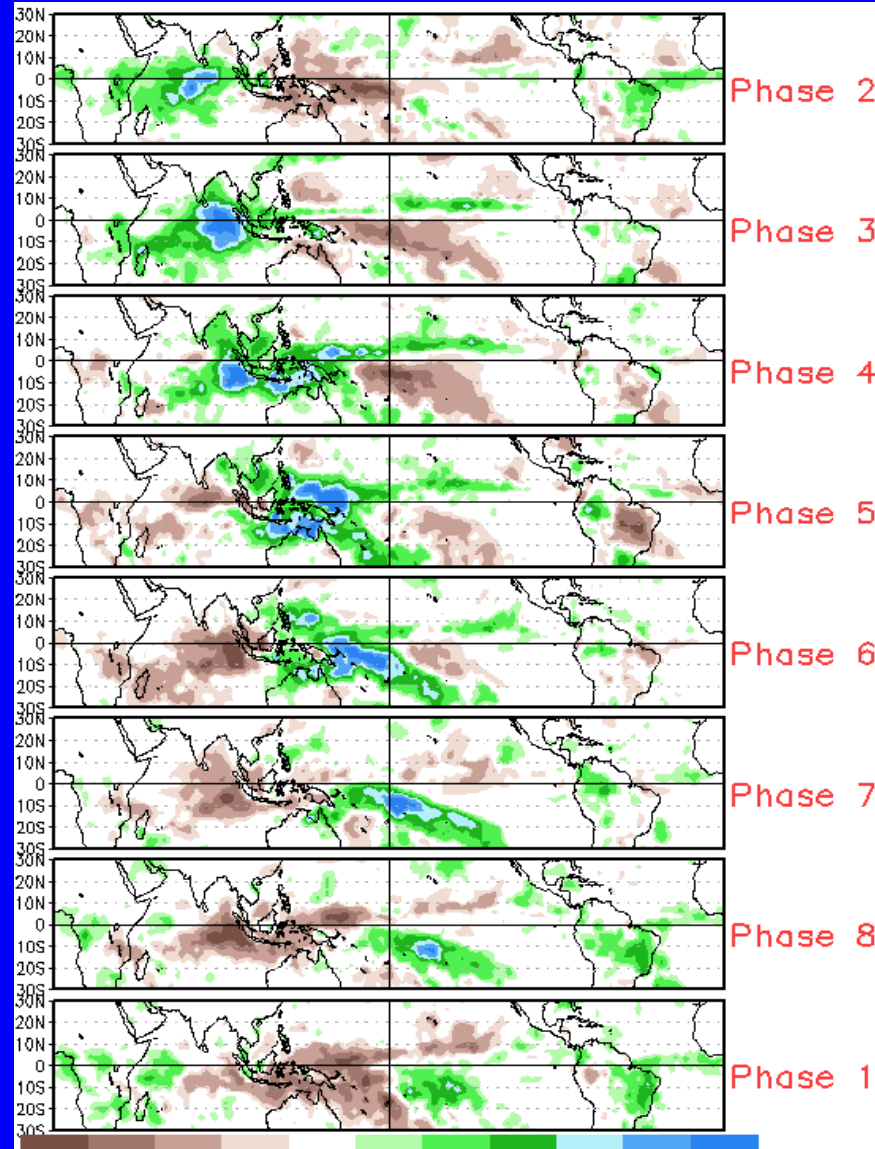
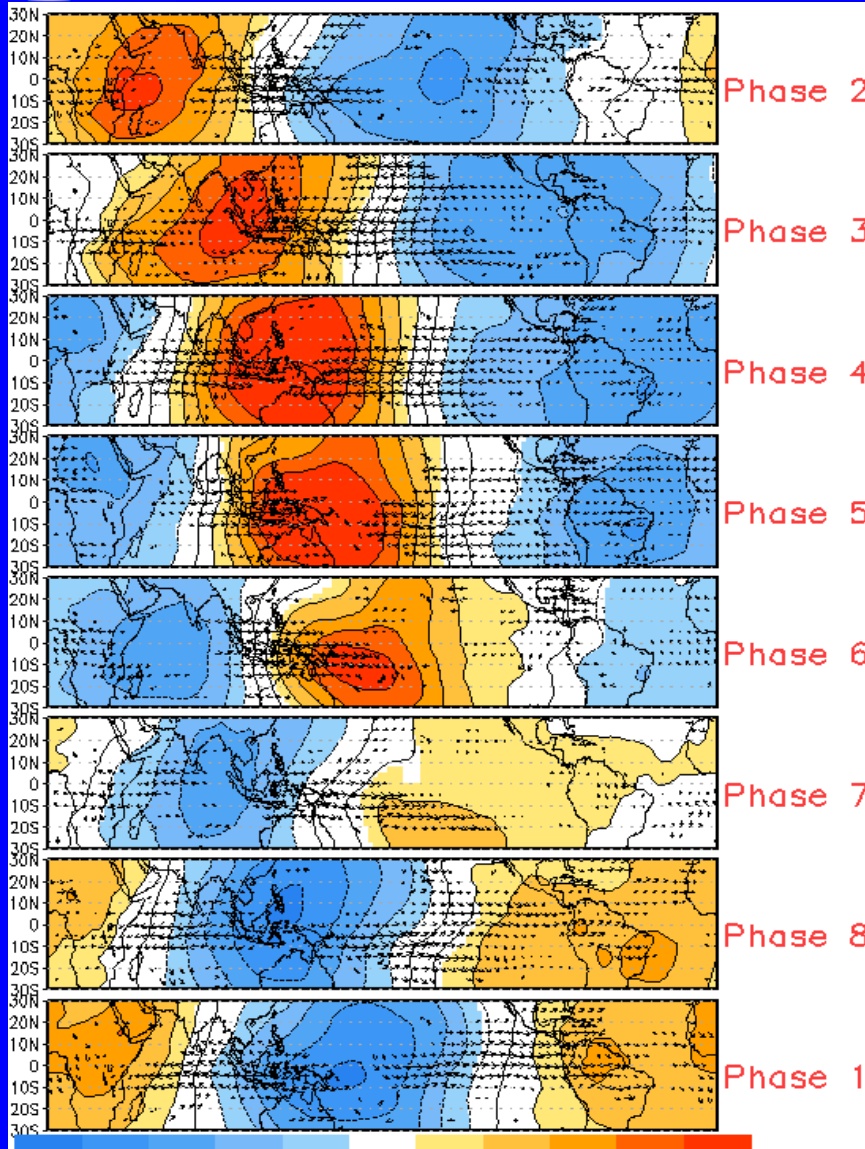
The constructed analog forecast also depicts no significant large-scale convective anomalies.



# MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

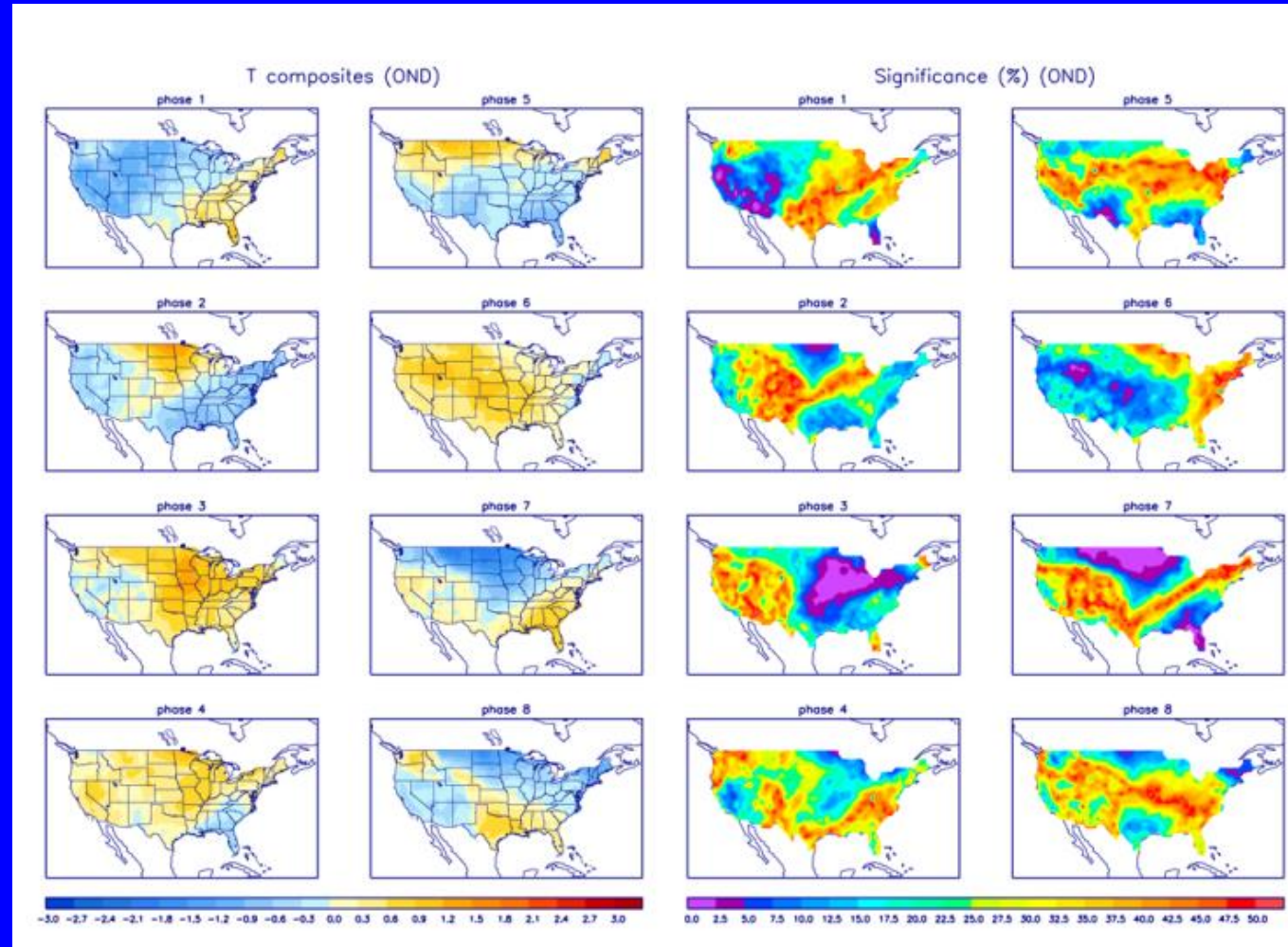




# U.S. MJO Composites – Temperature

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.



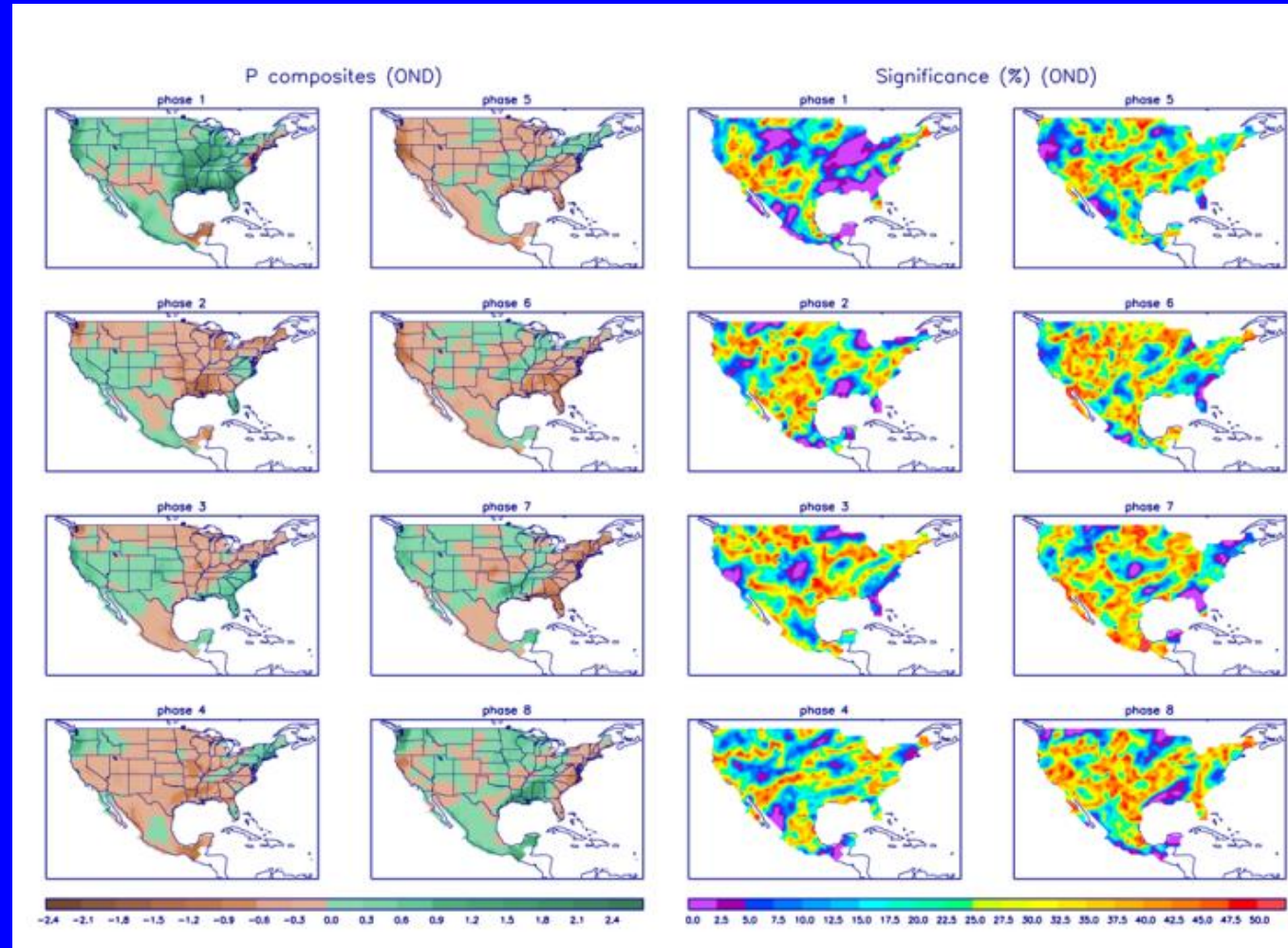
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>