



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

**Update prepared by  
Climate Prediction Center / NCEP  
May 6, 2013**



# Outline

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



# Overview

- **The MJO strengthened over the past several days, as many observational indicators are more coherent than during late April.**
- **Dynamical model MJO index forecasts indicate a continued strong signal with an eastward propagation of the enhanced phase from the Indian Ocean to the Maritime Continent during the next two weeks.**
- **Based on recent observations and model MJO forecasts, the MJO is forecast to remain active.**
- **During Week-1 the MJO favors enhanced rainfall across parts of east Africa, the Indian Ocean, Bay of Bengal, and the Maritime Continent, with suppressed rainfall favored for Central America. Tropical cyclogenesis is expected across the south Indian Ocean and Bay of Bengal.**
- **During Week-2 the MJO is expected to result in enhanced (suppressed) rainfall across the Maritime Continent (Central America, northern South America, and Horn of Africa).**

**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>**

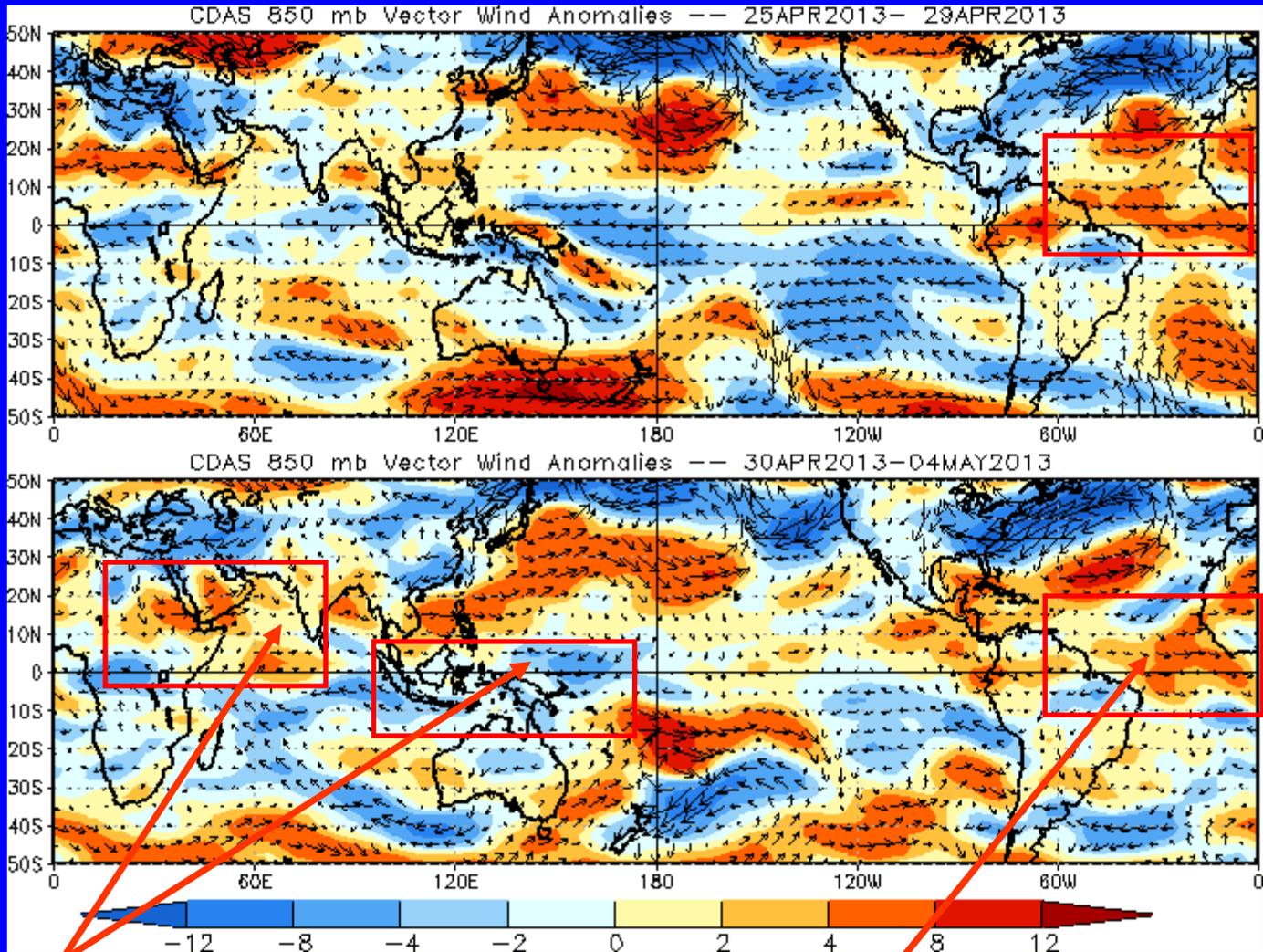


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies shifted east to the Indian Ocean during the past five days, while easterly anomalies developed across the Maritime Continent and equatorial western Pacific Ocean.

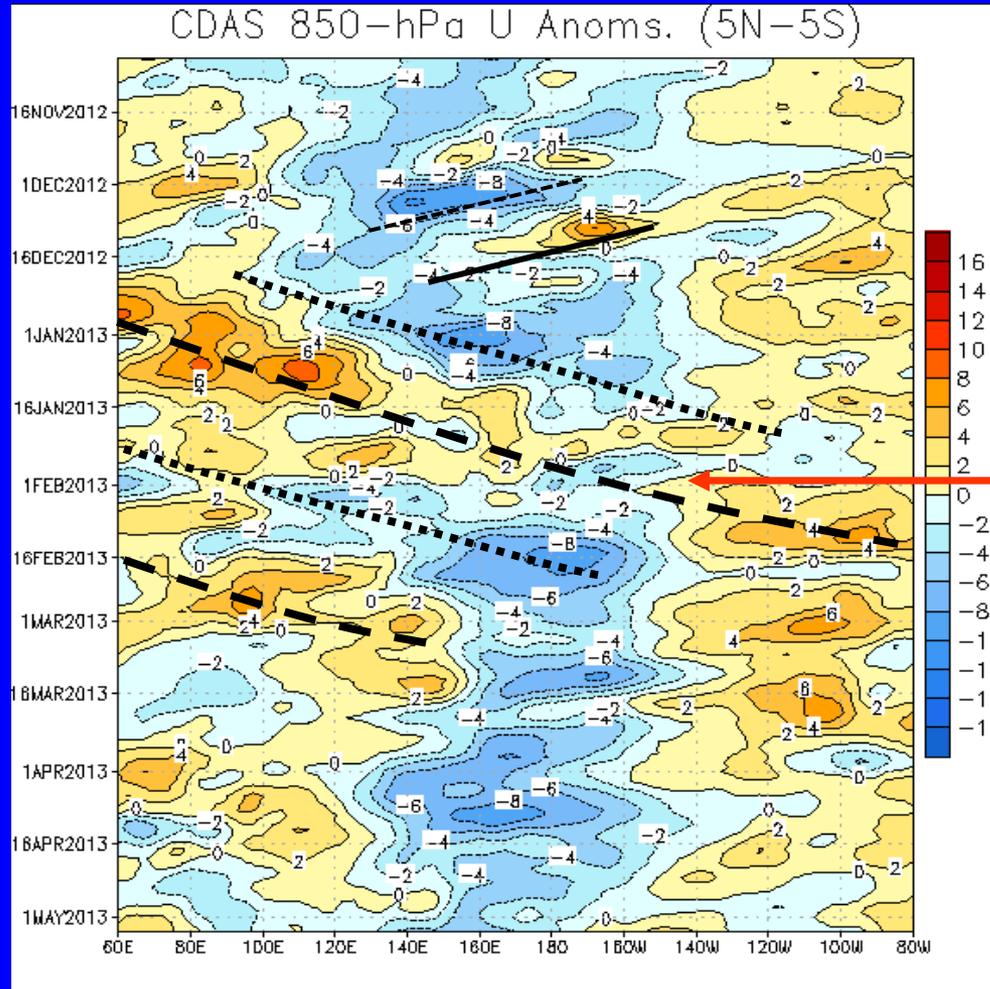
Westerly anomalies continued over the tropical Atlantic during the past ten days.



# 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



Westward propagation (dashed/solid lines sloping down and to the left) of anomalies during much of November and early December were primarily due to equatorial Rossby wave activity as the MJO was then generally weak.

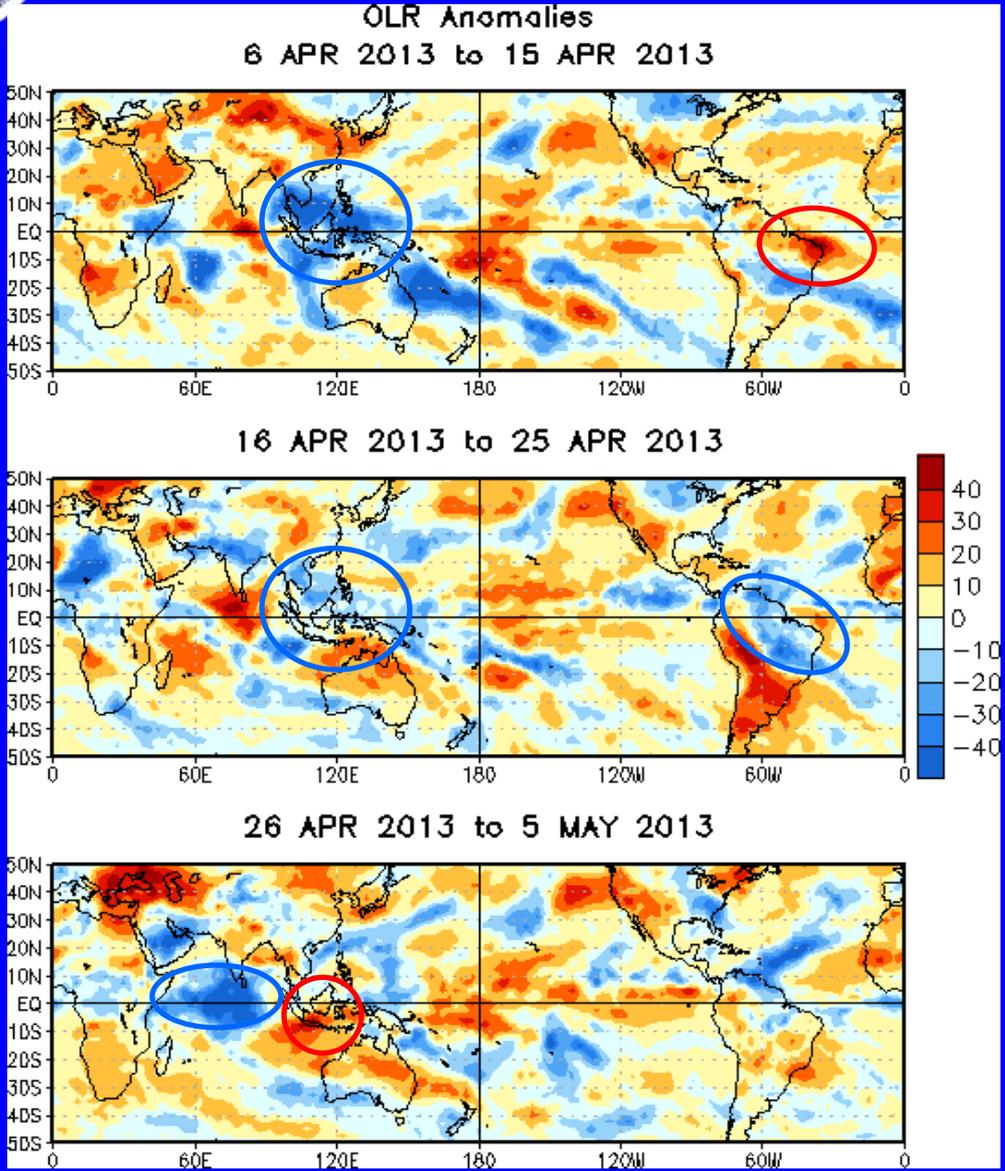
During late December the MJO strengthened (alternating dotted/dashed lines).

During March and early April, anomalies indicate signs of being influenced by equatorial Rossby wave activity with less eastward propagation evident.



# 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-April, suppressed convection was located across northeast South America, while convection strongly increased across the Maritime Continent.**

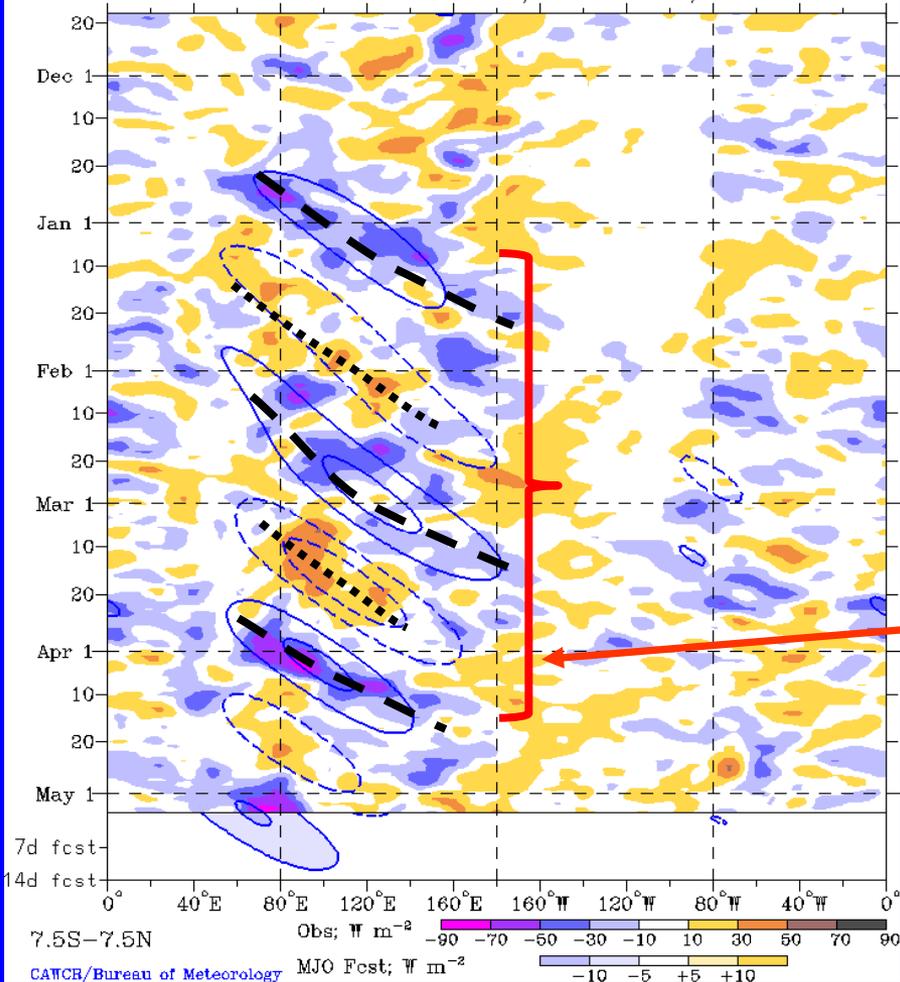
**During mid to late April, enhanced convection diminished across the Maritime Continent, while northeast South America experienced an increase in convection.**

**During late April and early May, enhanced (suppressed) convection developed across the Indian Ocean (Maritime Continent).**



# 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  
18-Nov-2012 to 5-May-2013 + 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)**

**During late November and much of December, convective anomalies were disorganized.**

**The MJO was again a dominant mode of variability across the Tropics from January into March as indicated by the alternating dashed and dotted lines.**

**Near the end of March, the anomalies show signs of influence from other modes of tropical variability.**

**During early May, anomalous OLR increased significantly across the Indian Ocean.**

**Longitude**

**Time**  
↓



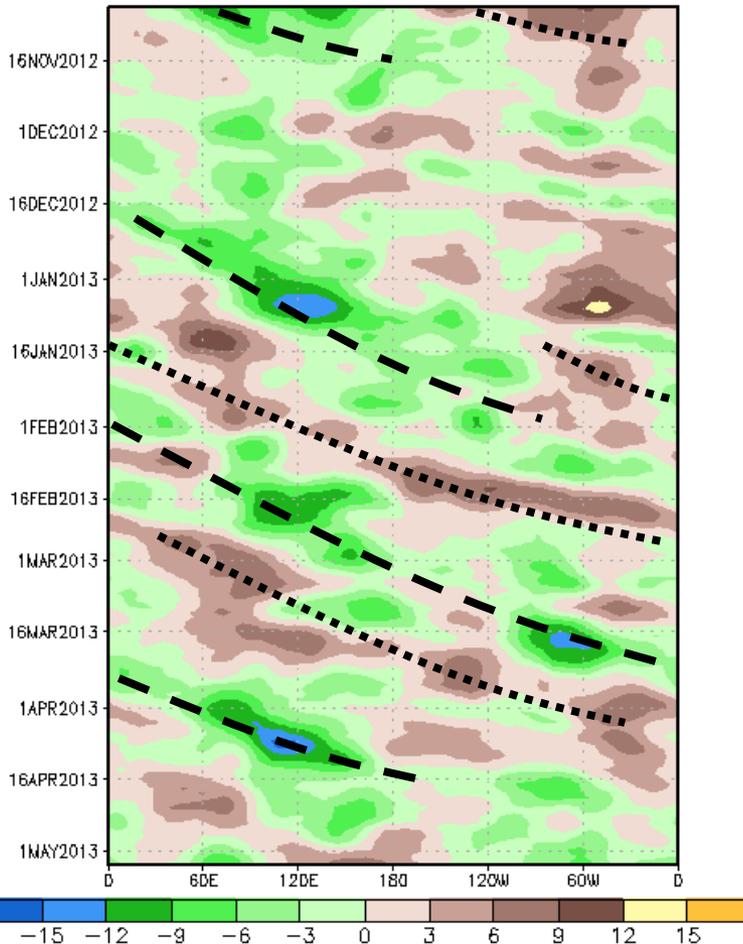
# 200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

200-hPa Velocity Potential Anomaly: 5N-5S

5-day Running Mean



Time



Longitude

After some MJO activity at the start of November, anomalies decreased with less coherent eastward propagation during most of November and December. Other modes of subseasonal variability were more prevalent during this period.

As the MJO strengthened in late December, (alternating dashed and dotted lines), anomalies increased in magnitude with more robust eastward propagation indicated during late 2012 to April 2013.

Anomalies became less coherent at times during this period as the influence from other modes of variability are evident in the depicted anomalies, namely during late January into early February, before reorganizing in late February and early March.

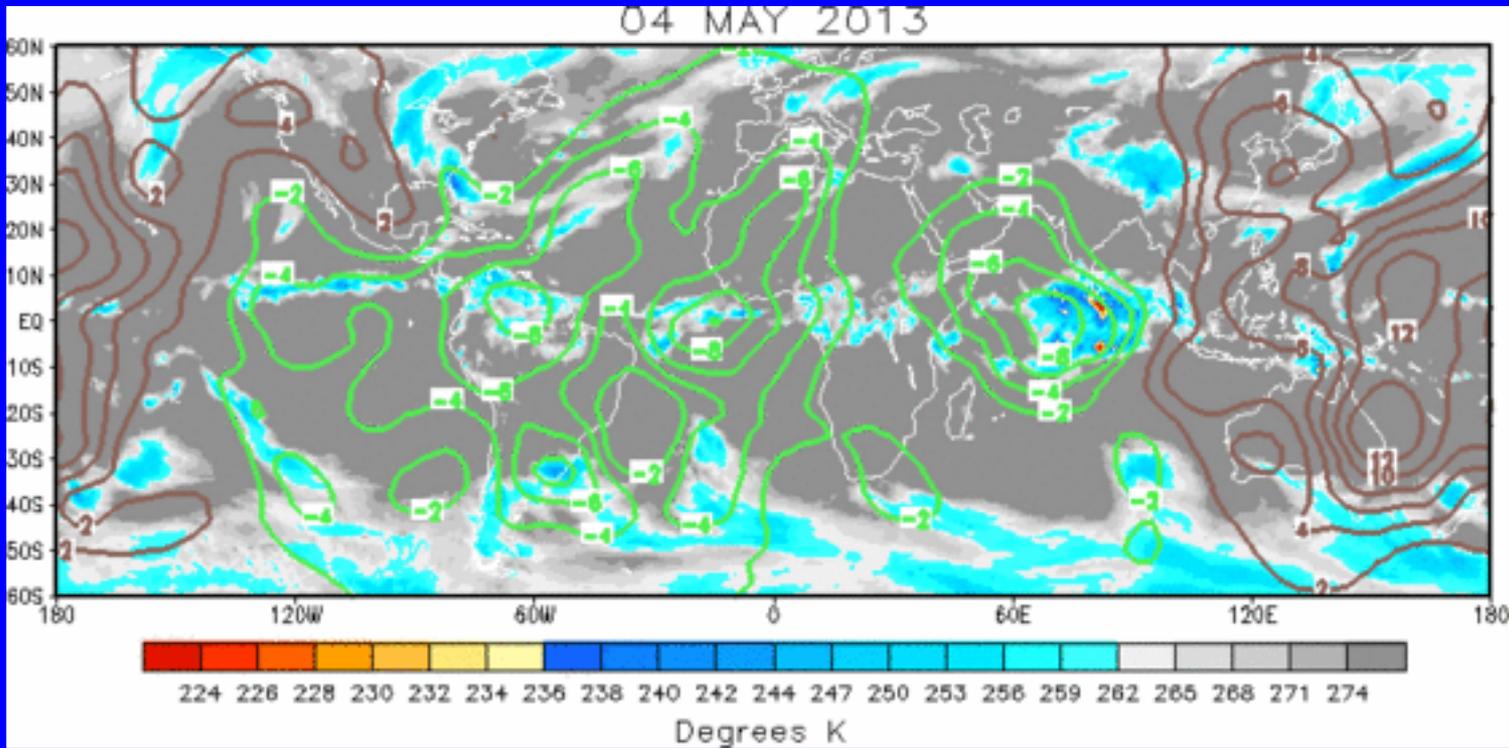
Most recently, the velocity potential anomalies have increased as the MJO becomes more coherent.



# 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 velocity potential pattern indicates a more coherent pattern compared to the previous week. Upper-level divergence is observed across the Atlantic, Africa, and the Indian Ocean while positive anomalies (upper-level convergence) cover the Maritime Continent and west-central Pacific Ocean.

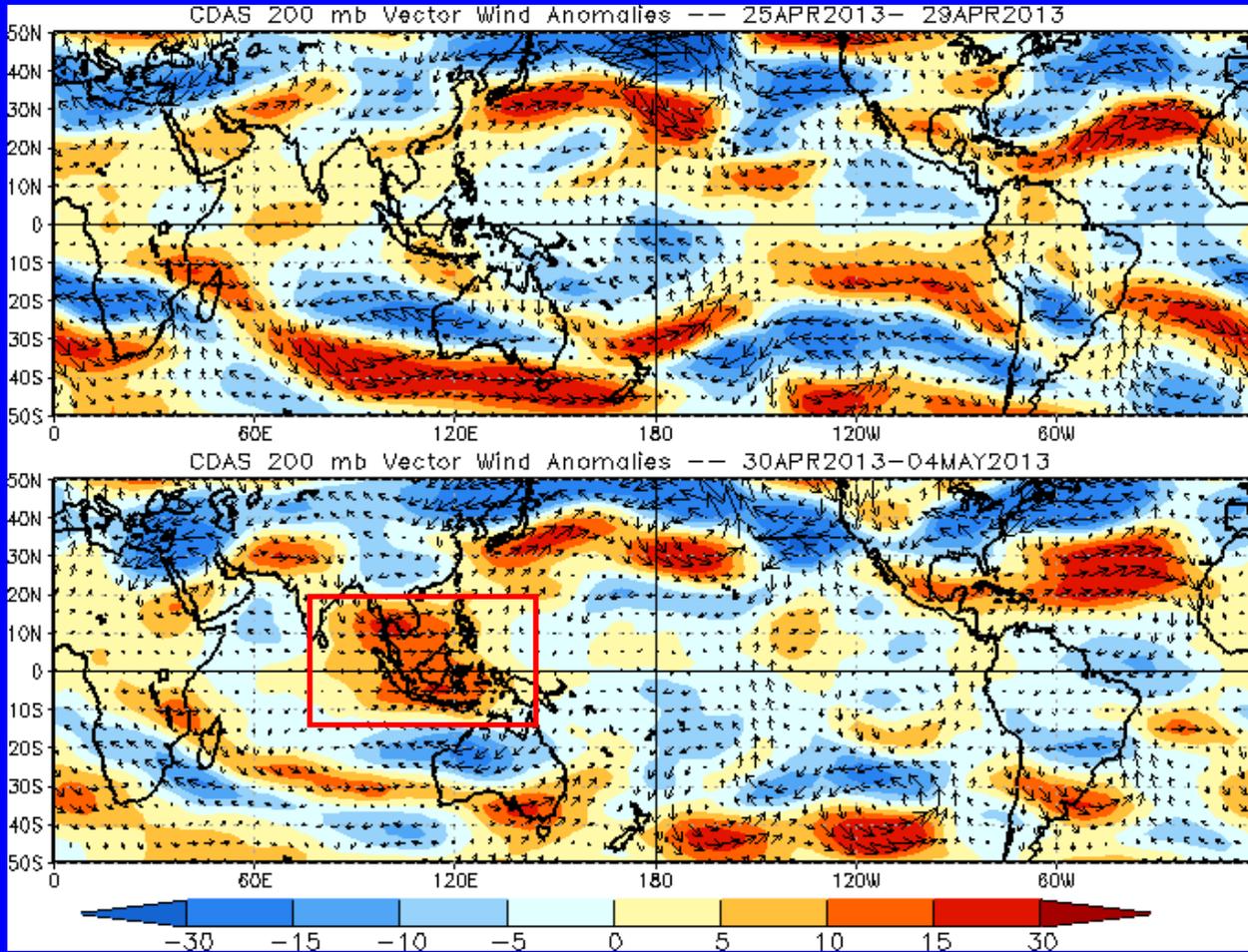


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



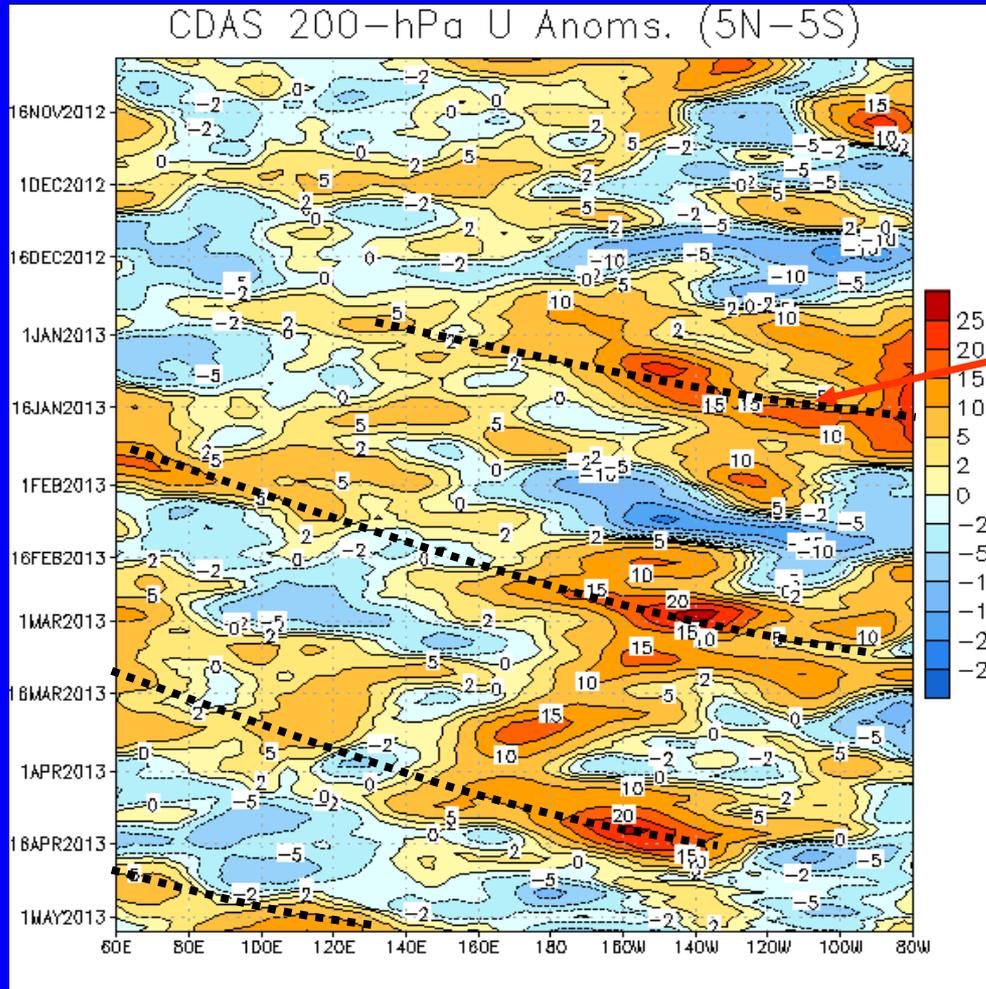
Westerly anomalies (red box) increased over the Maritime Continent during the past five days.



# 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



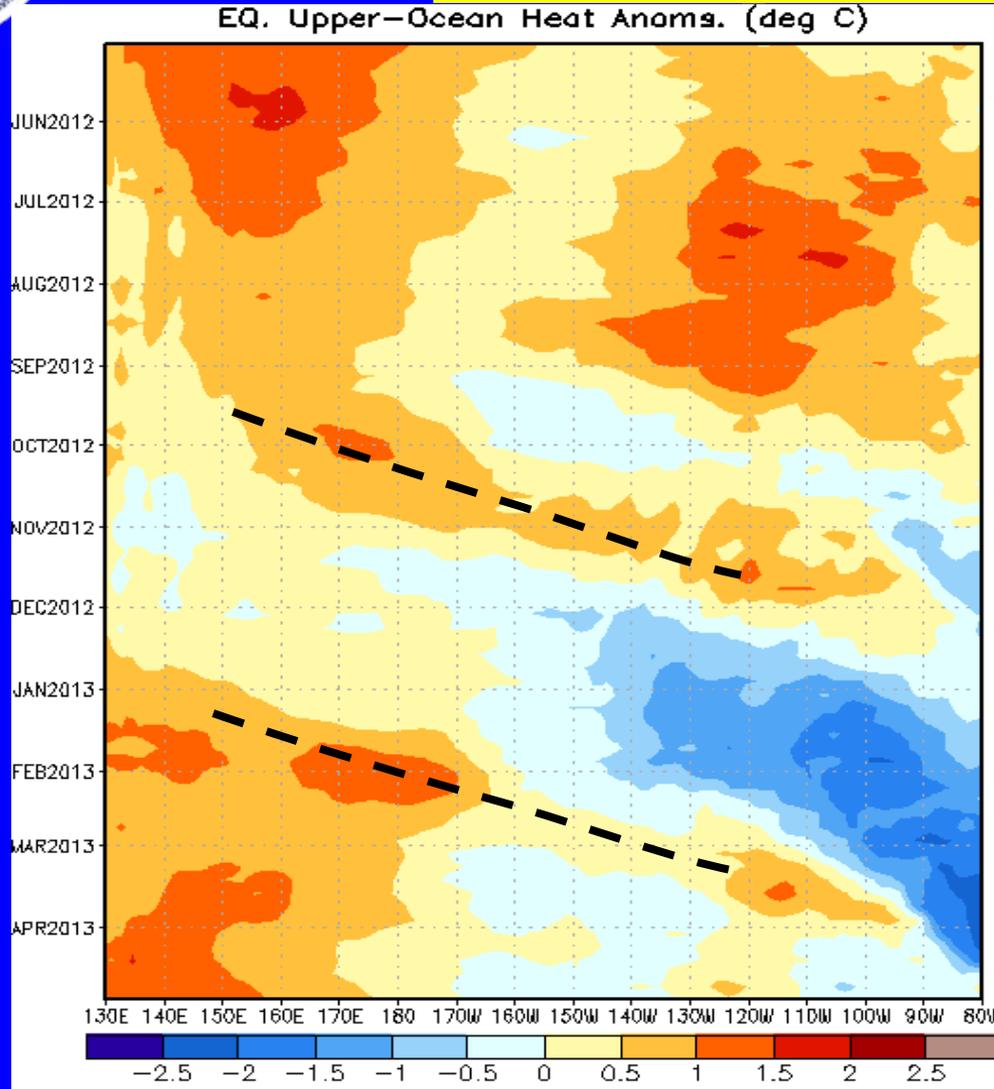
Eastward propagation of westerly wind anomalies associated with the MJO is evident beginning in late December and continuing into April 2013. Some propagation of easterly anomalies is evident during late January and early February.

During March and early April, anomalies were influenced by westward moving features over the central and western Pacific.

Easterly anomalies shifted east of the Date Line recently with westerly anomalies shifting east to 160E.



# Weekly Heat Content Evolution in the Equatorial Pacific



From March into August 2012, heat content anomalies became positive and increased in magnitude across the eastern equatorial Pacific, partly in association with a downwelling Kelvin wave.

An oceanic Kelvin wave was initiated at the end of September and increased heat content across the central and eastern Pacific during October and November.

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 can be seen during late February and March as anomalies became positive in the east-central 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.**

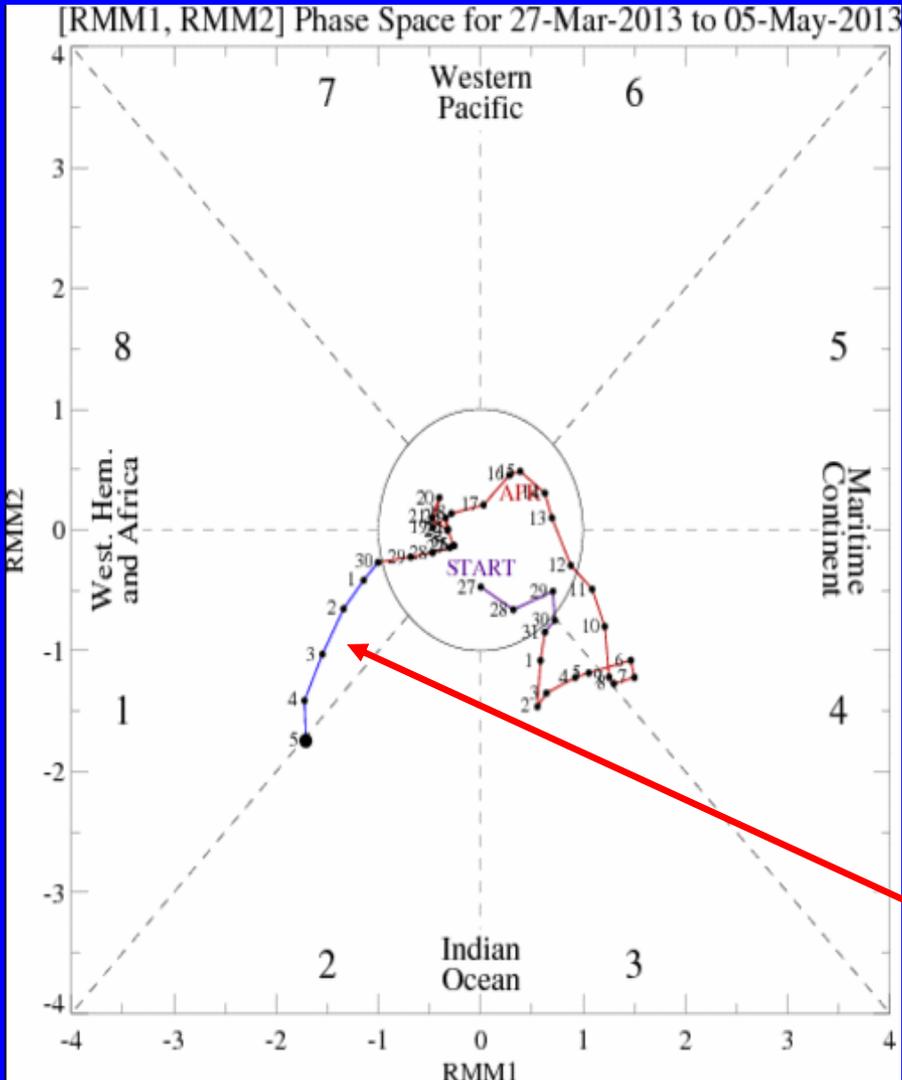
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

**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

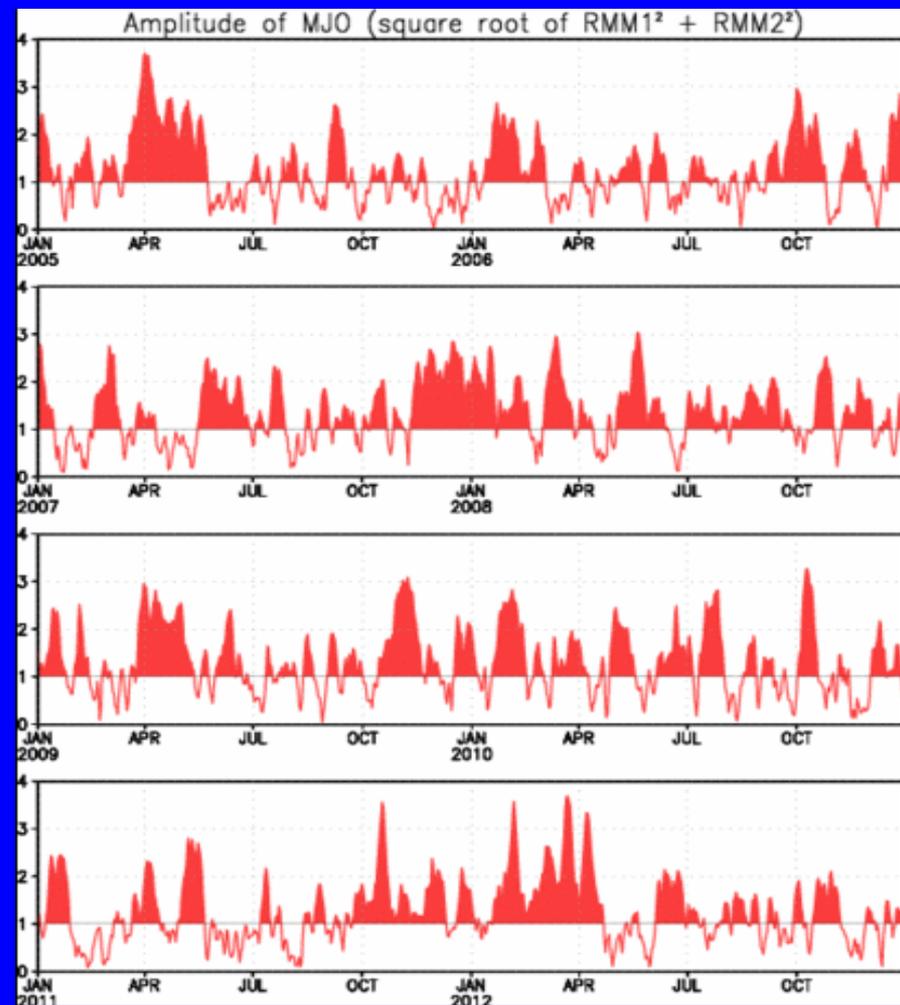
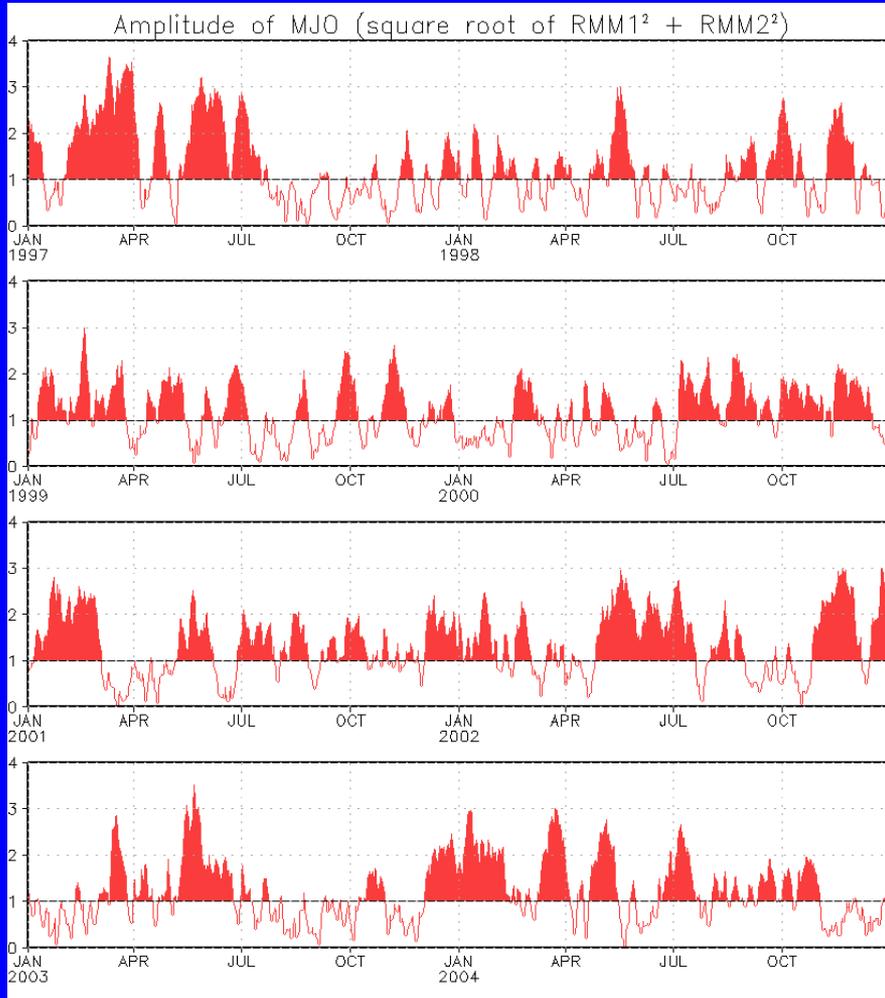


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates a strengthening signal during early May.



# 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.



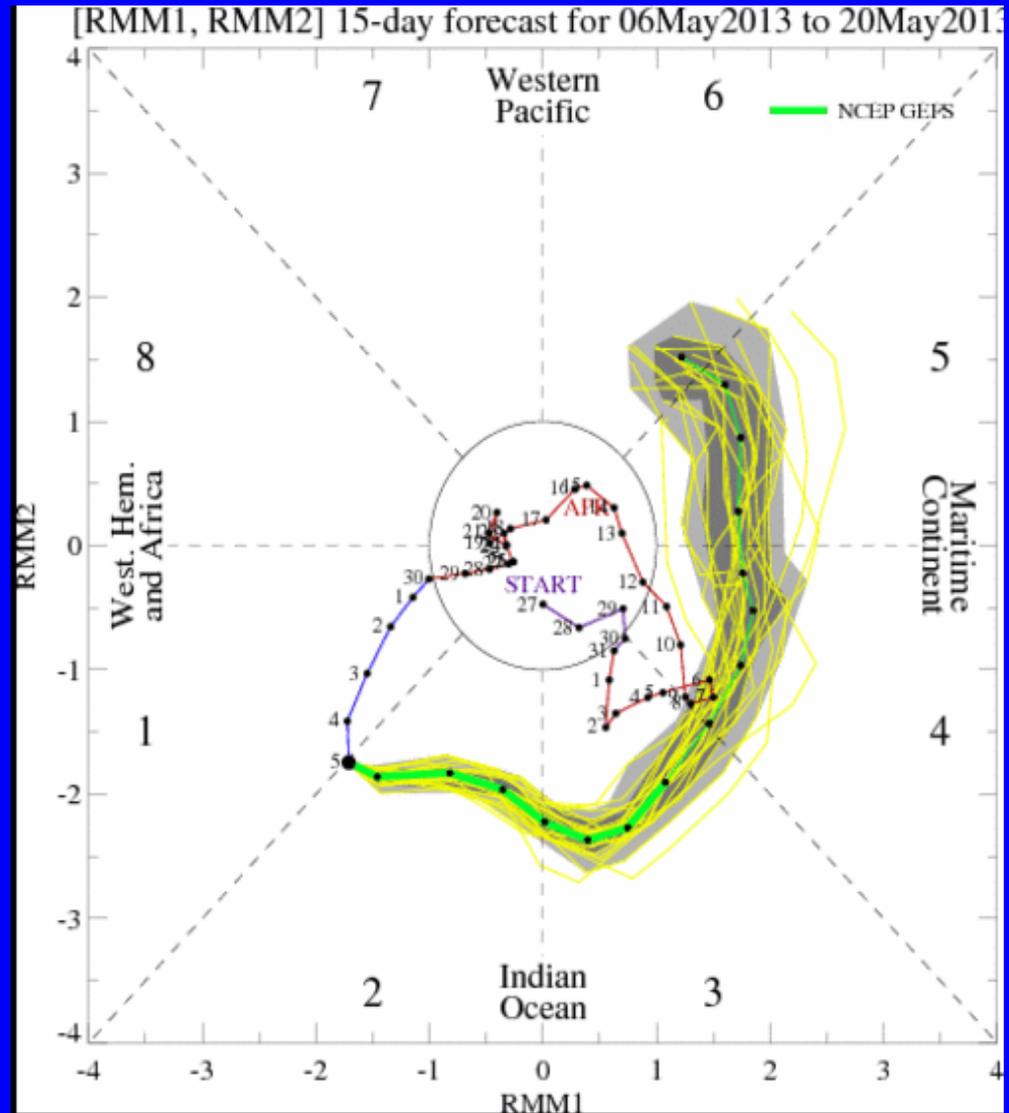
# Ensemble GFS (GEFS) MJO Forecast

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 bias-corrected ensemble GFS indicates a strong MJO signal that propagates east across from the Indian Ocean to the Maritime Continent during the next two weeks.



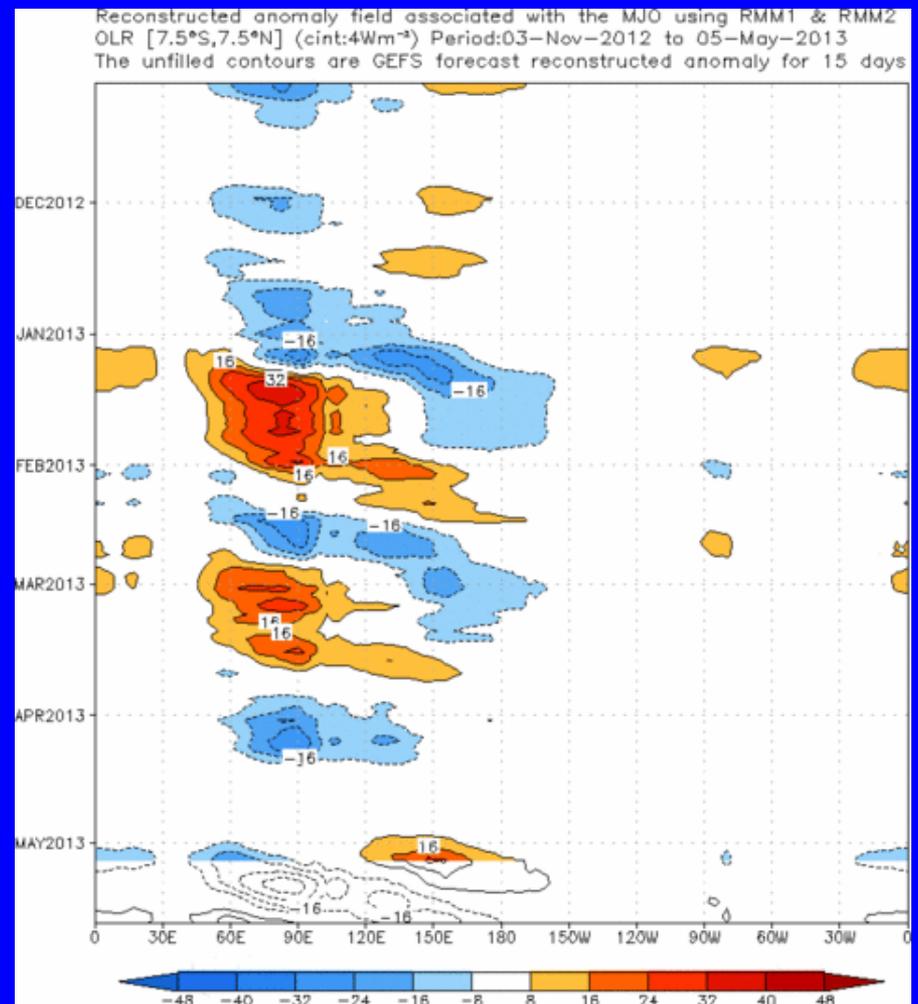
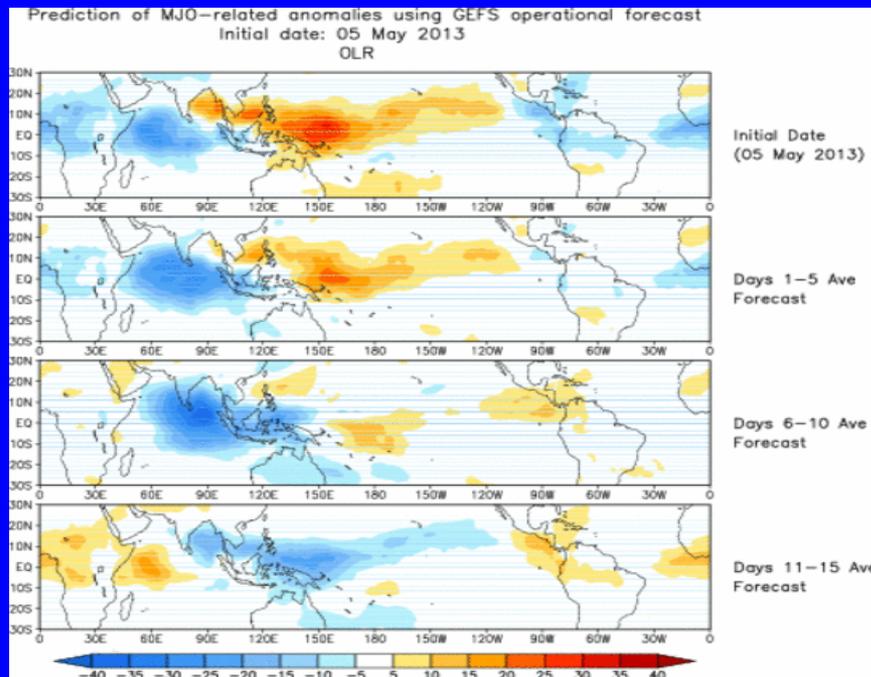


# Ensemble Mean GFS MJO Forecast

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



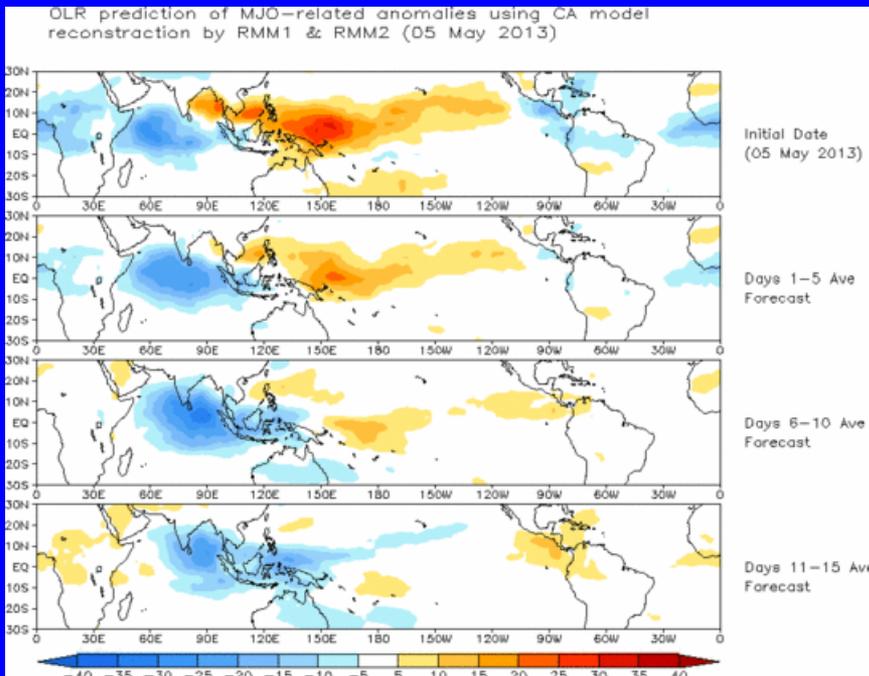
The ensemble mean GFS forecasts enhanced convection shifting east from the Indian Ocean to the Maritime Continent during the next two weeks with suppressed convection spreading east across the Pacific Ocean to the Americas.



# Constructed Analog (CA) MJO Forecast

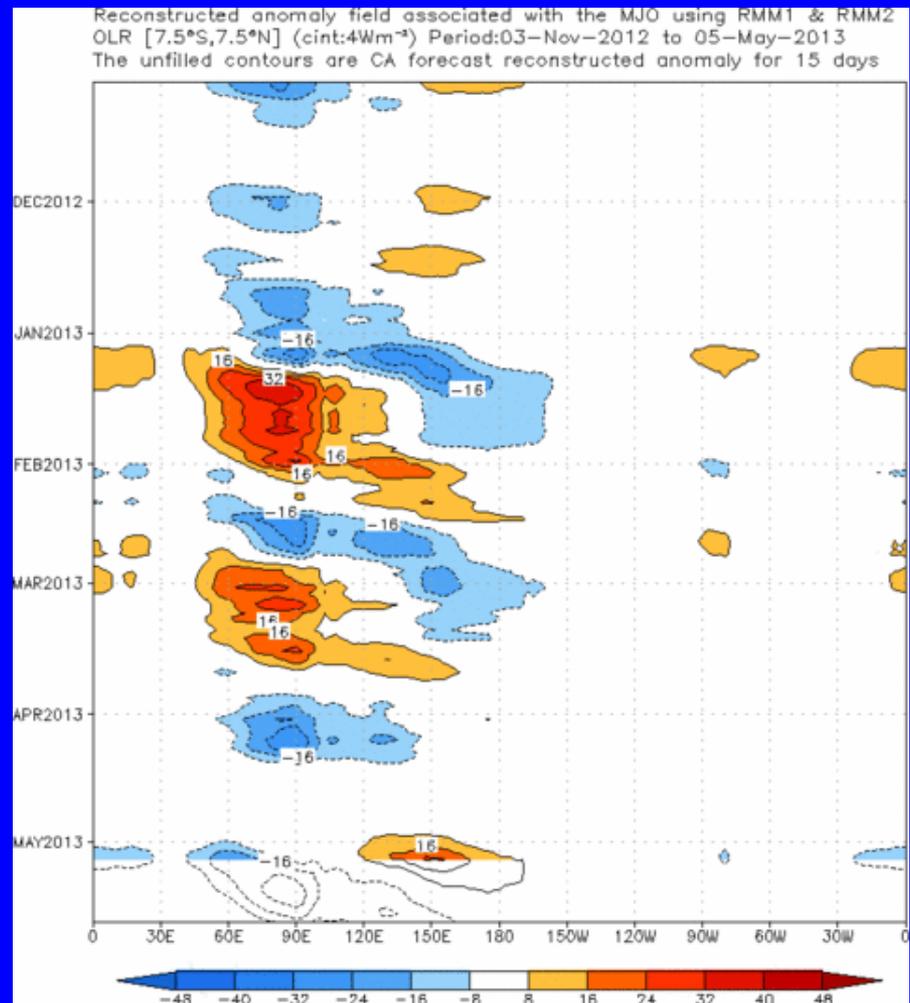
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



This statistical forecast also indicates eastward propagation of anomalous convection across the global tropics.

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

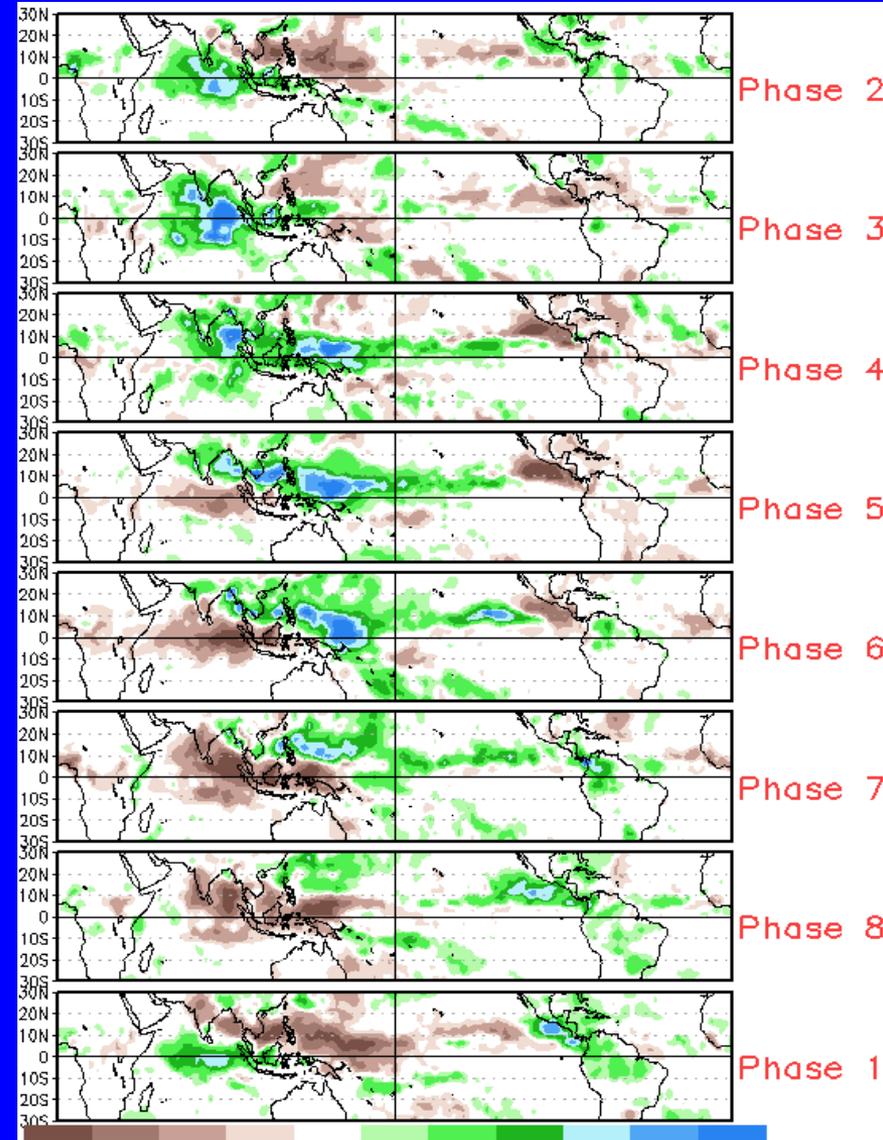
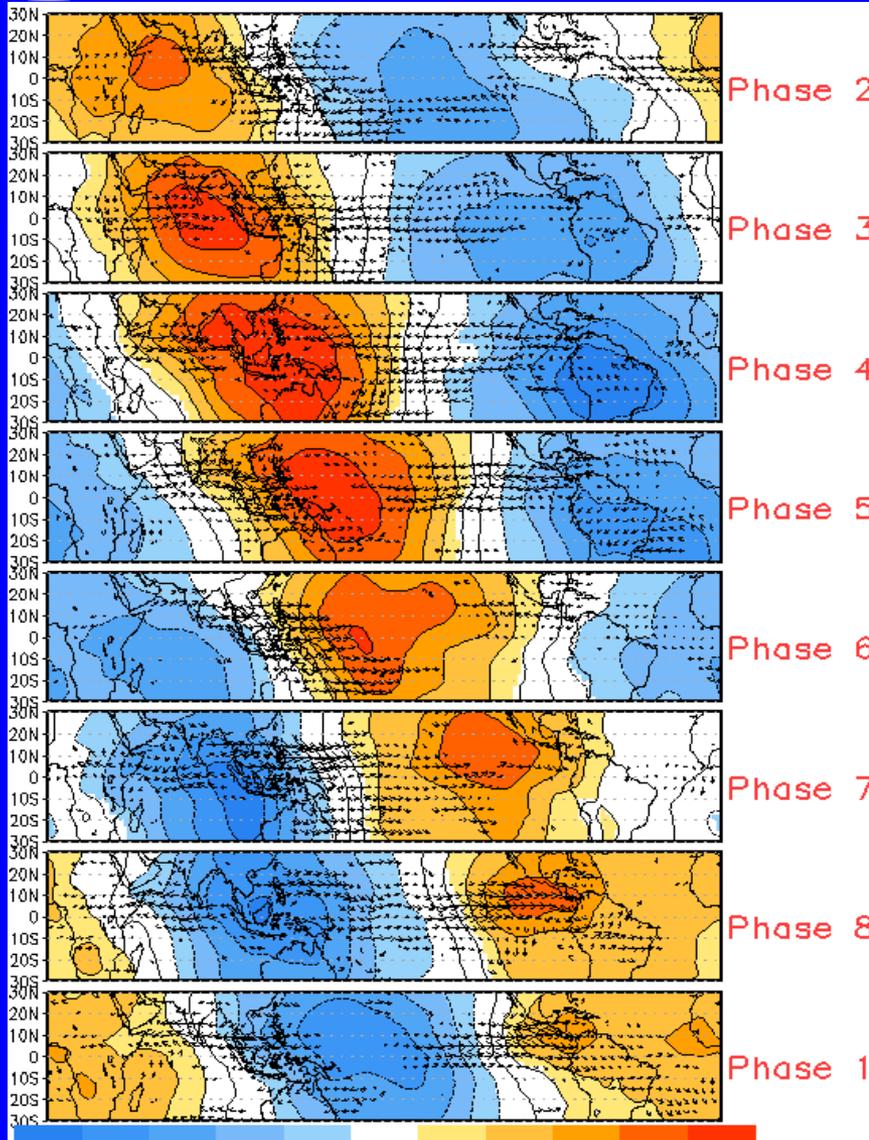




# MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

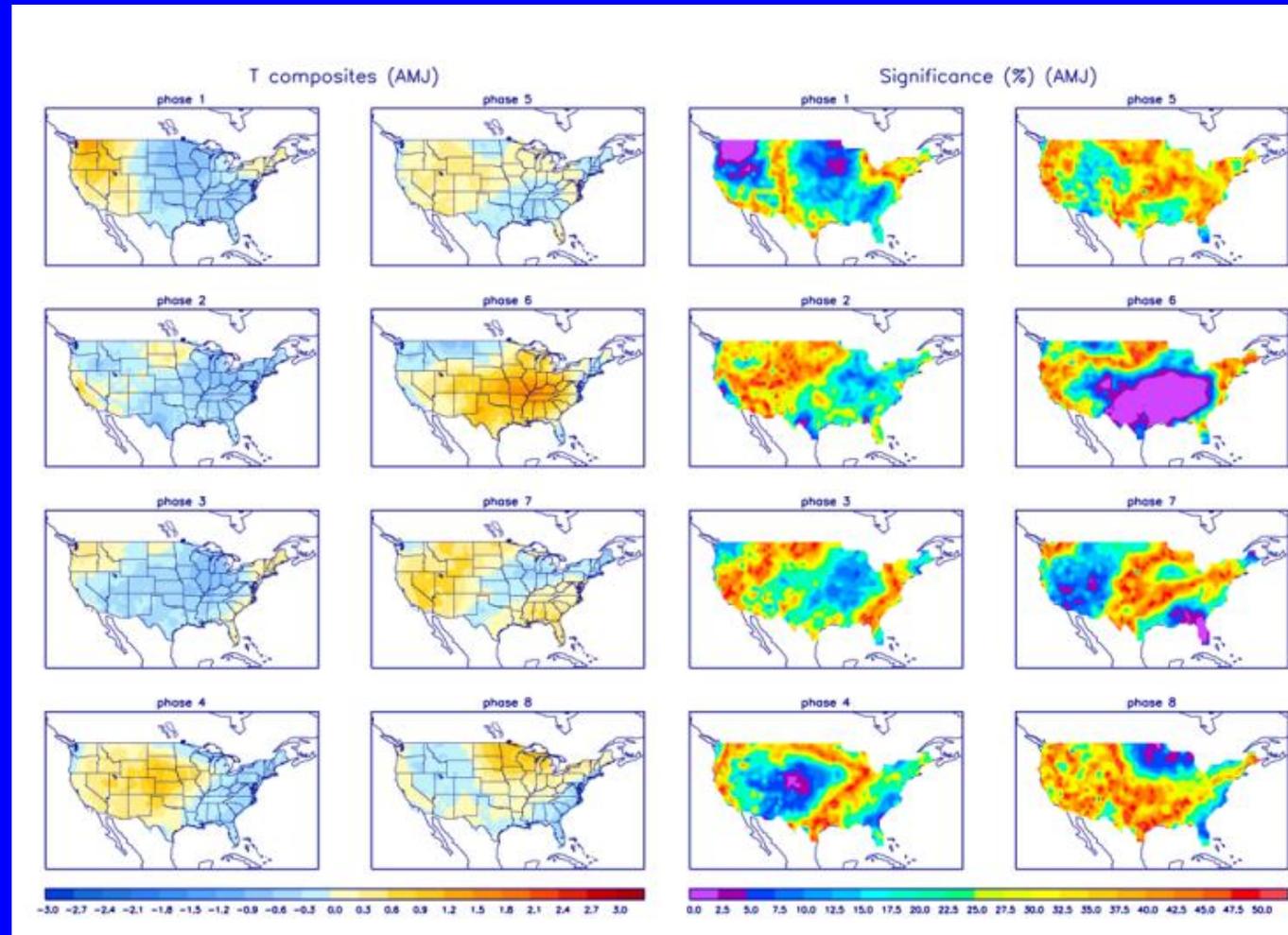




# U.S. MJO Composites – Temperature

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.



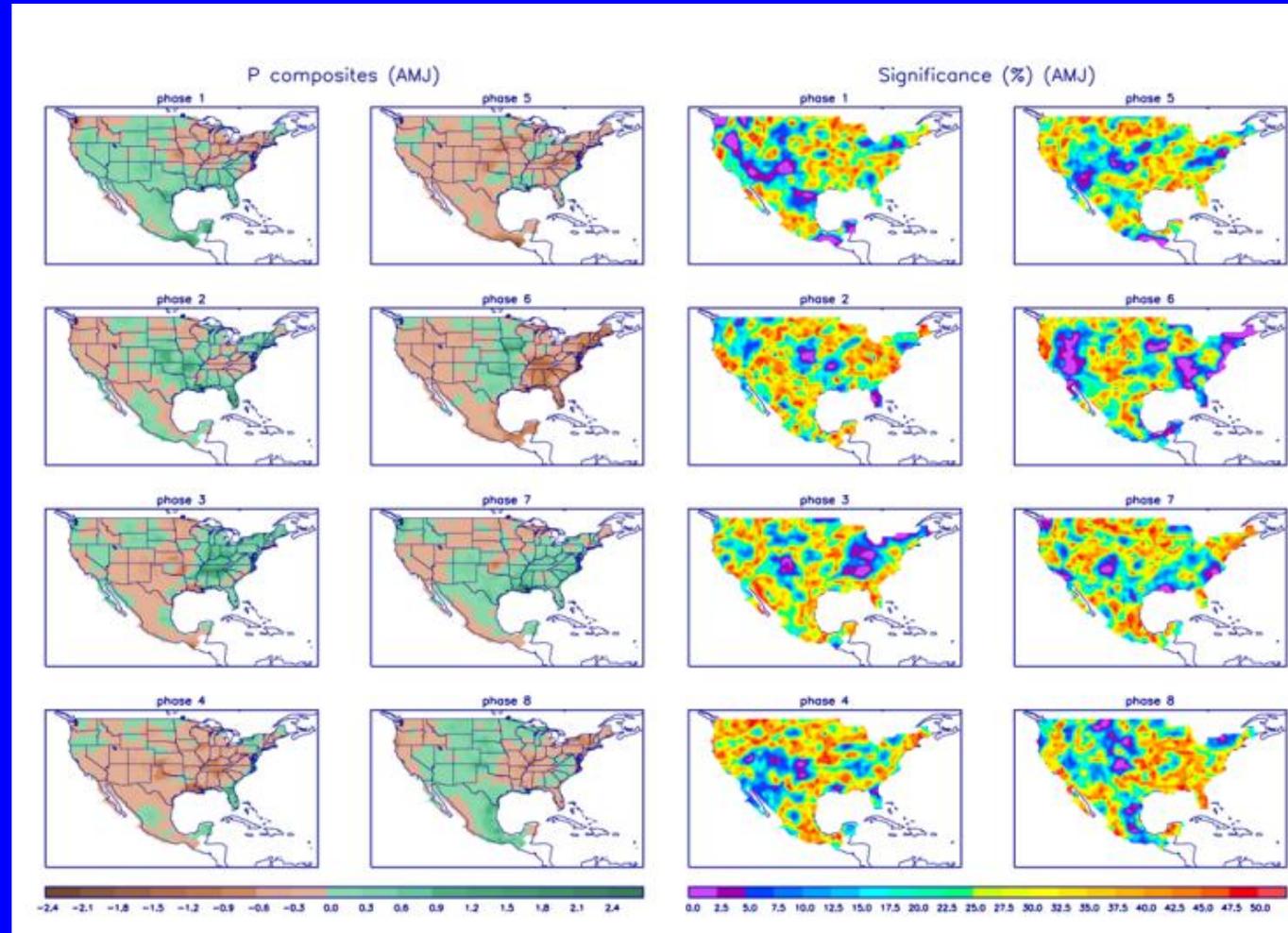
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>