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

Update prepared by
Climate Prediction Center / NCEP
May 13, 2013

Outline

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

Overview

- The MJO was active during the past week after enhanced convection rapidly developed across the Indian Ocean with suppressed convection affecting the east-central Pacific Ocean.

- Dynamical model MJO index forecasts are in good agreement for a continuation of the MJO signal during the early part of Week-1. The models indicate a reduced amplitude as the enhanced phase propagates east of the Maritime Continent later in Week-1. This is most likely related to other tropical subseasonal variability; models typically struggle with propagating the signal east across the Maritime Continent.

- Based on recent observations and model MJO forecasts, the MJO is forecast to remain active during Week-1 but uncertainty on its duration increases during Week-2.

- During Week-1 the MJO favors enhanced rainfall across parts of the Maritime Continent, while other tropical subseasonal variability promotes enhanced rainfall across the western Indian Ocean. Heavy rainfall is expected across Bangladesh, associated with Tropical Cyclone Mahasen. Tropical cyclogenesis is favored across the eastern Pacific Ocean.

- Uncertainty is high during Week-2 with respect to anomalous convection associated with a potentially weaker MJO signal. Enhanced (suppressed) rainfall is expected across Central America and the southwest Caribbean Sea (west-central Indian Ocean).

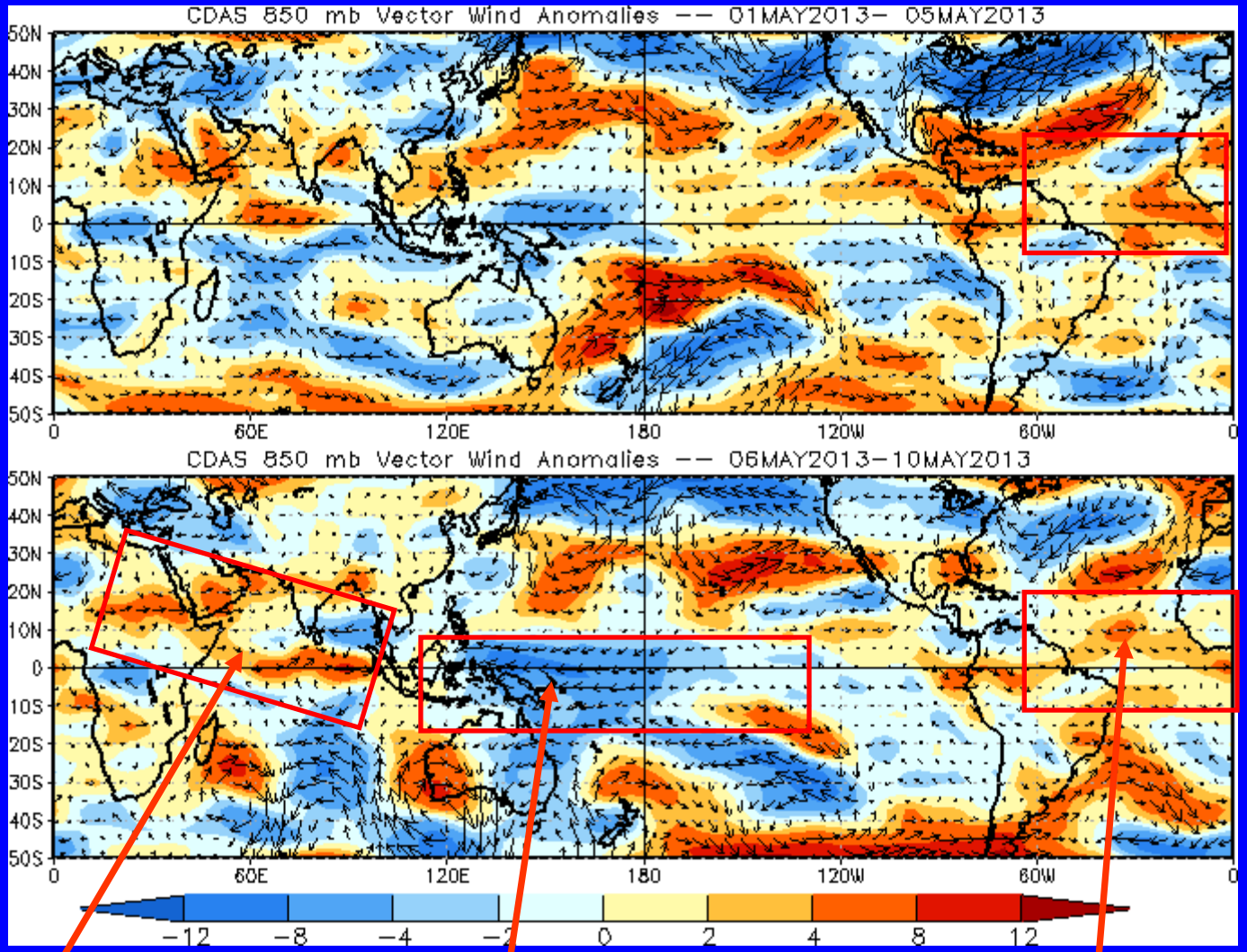
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies continued over Africa and the Indian Ocean.

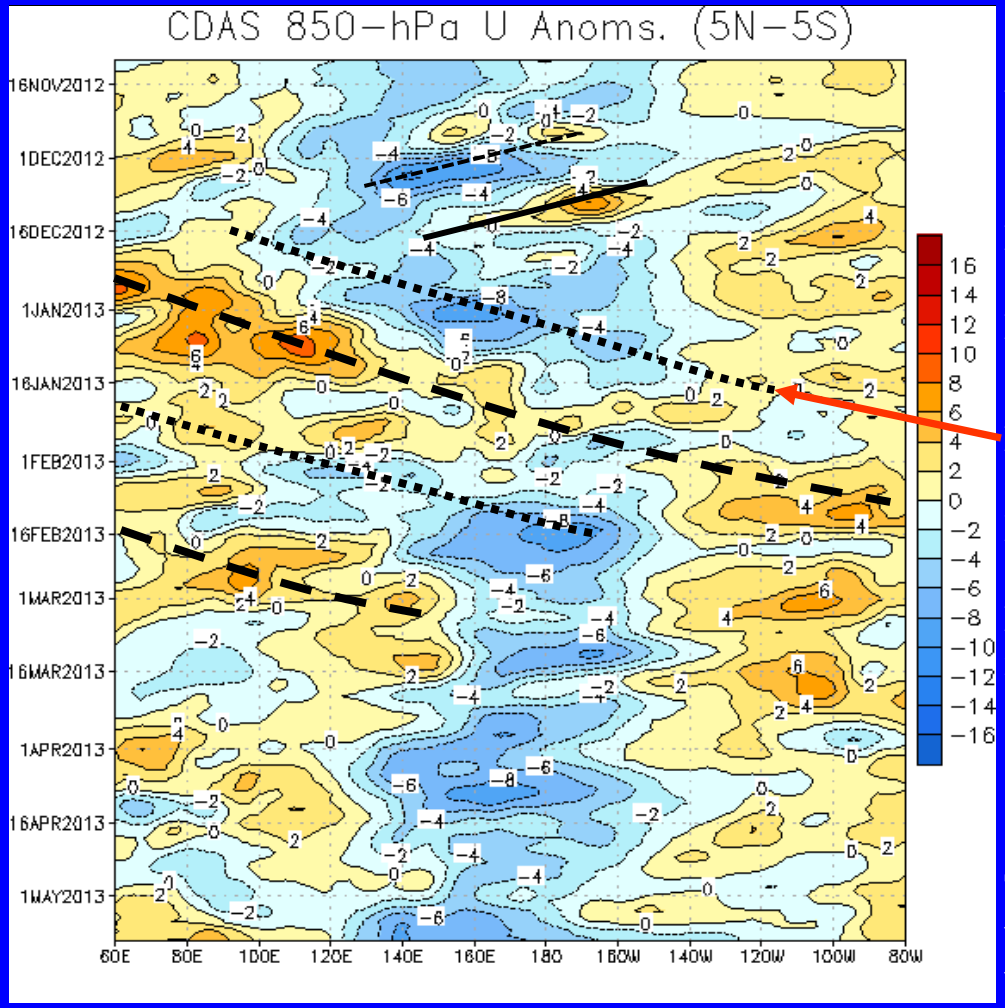
Easterly anomalies continued over the western Pacific and expanded east of the Date Line.

Westerly anomalies were smaller over the tropical Atlantic during the past five days.

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



Time

Longitude

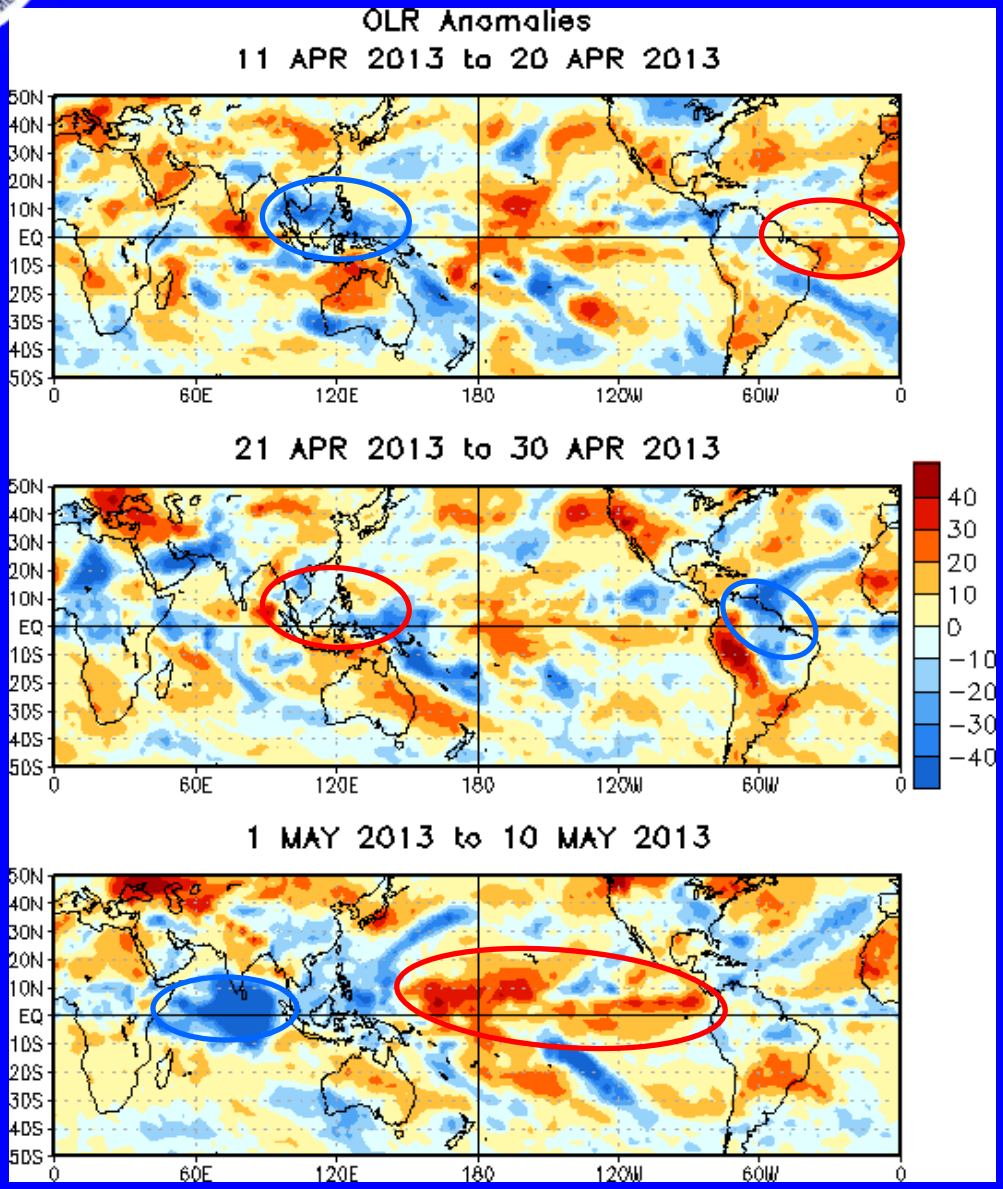
Westward propagation (dashed/solid lines sloping down and to the left) of anomalies during much of November and early December were primarily due to equatorial Rossby wave activity as the MJO was then generally weak.

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.

The MJO strengthened during early May with eastward propagation of low-level wind anomalies noted.

OLR Anomalies – Past 30 days



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

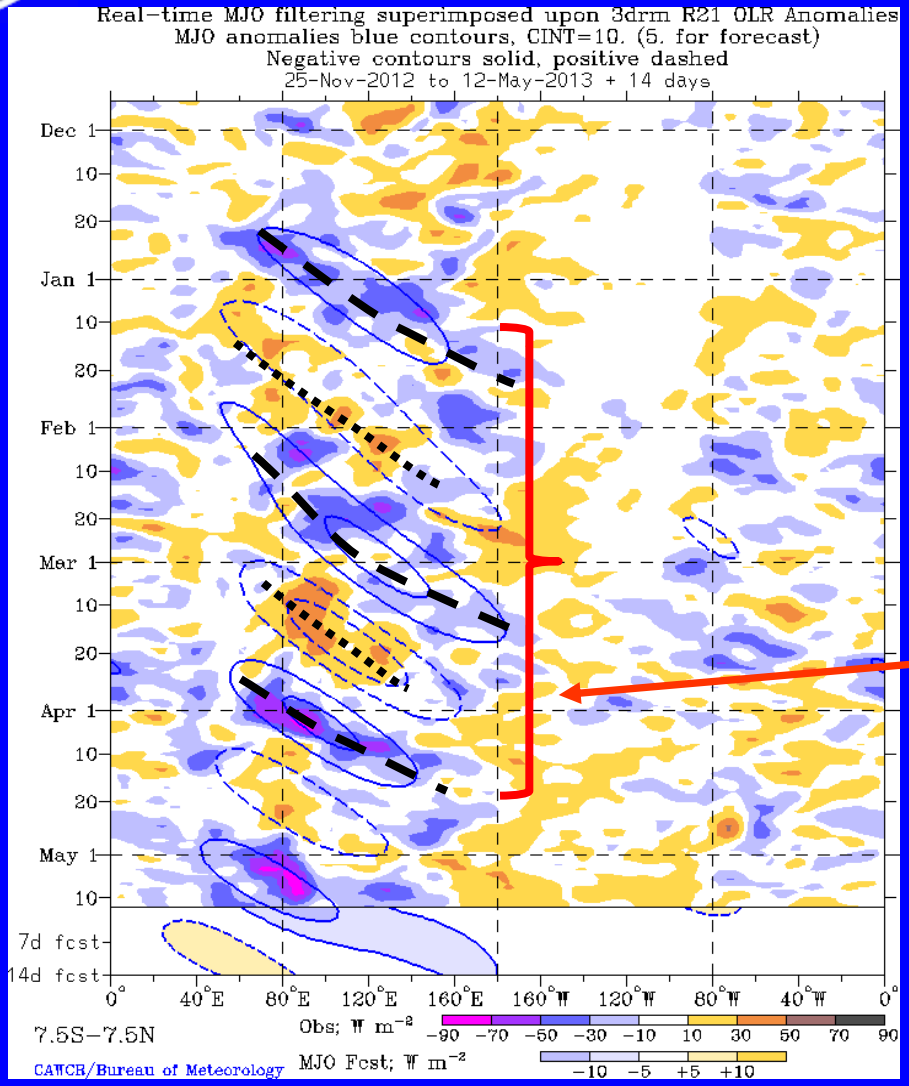
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early to mid-April, suppressed convection was located across northeast South America, while convection remained enhanced across the Maritime Continent.

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

During early May, enhanced (suppressed) convection rapidly developed across the Indian Ocean (central/eastern Pacific Ocean).

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



Time

Longitude

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.

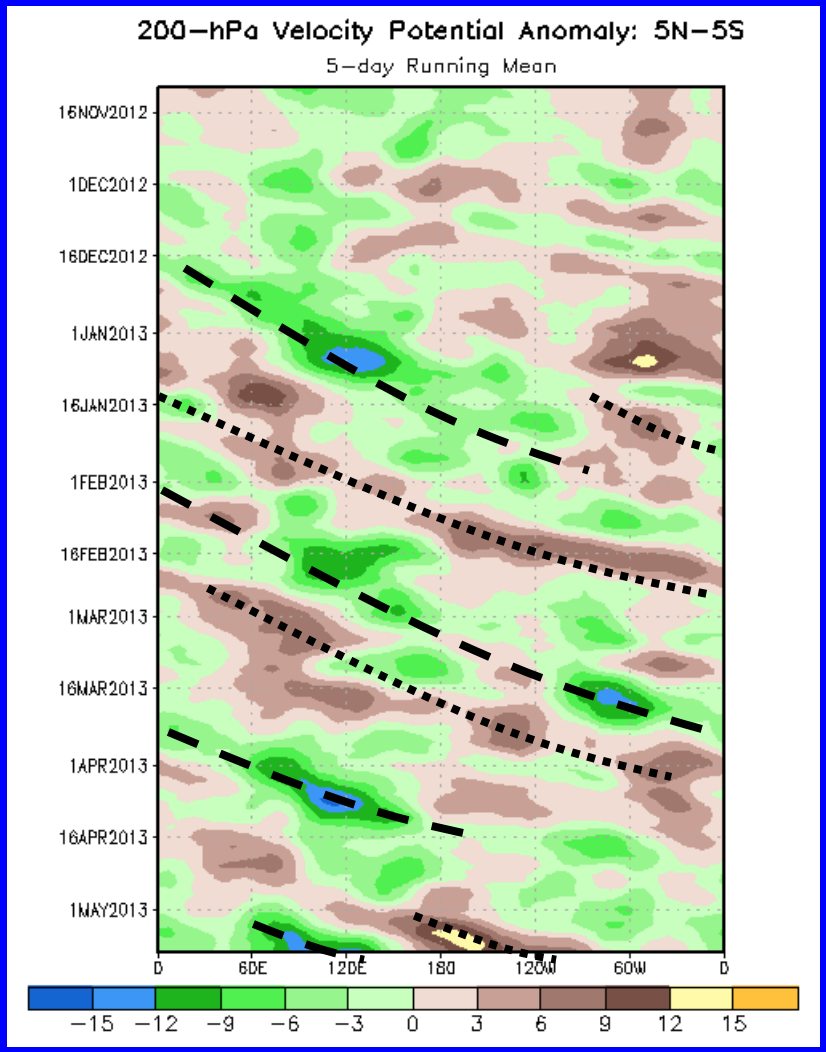
Near the end of March, the anomalies show signs of influence from other modes of tropical variability.

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

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

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.

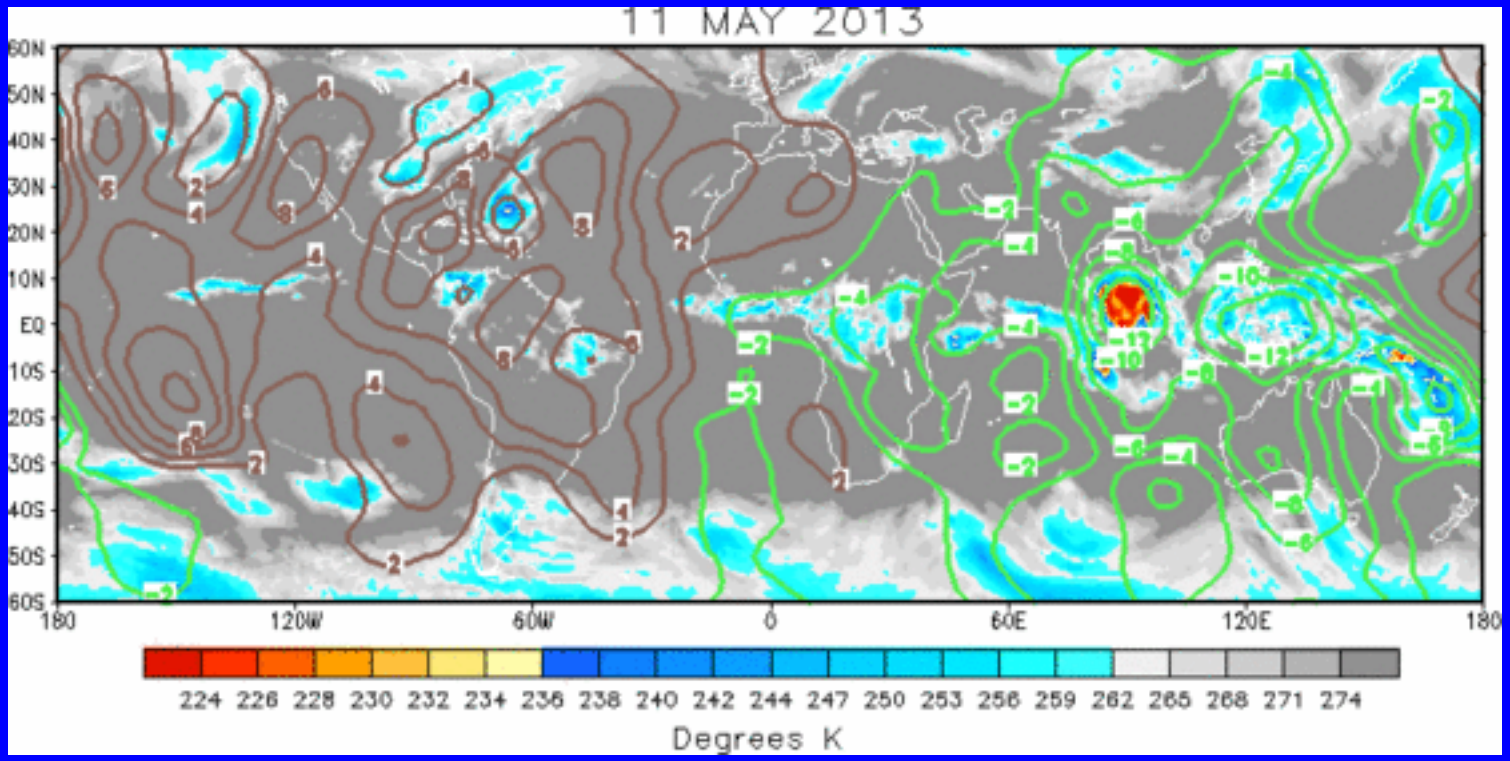
Anomalies became less coherent at times during this period as the influence from other modes of variability are evident in the depicted anomalies, namely during late January into early February, before reorganizing in late February and early March.

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

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

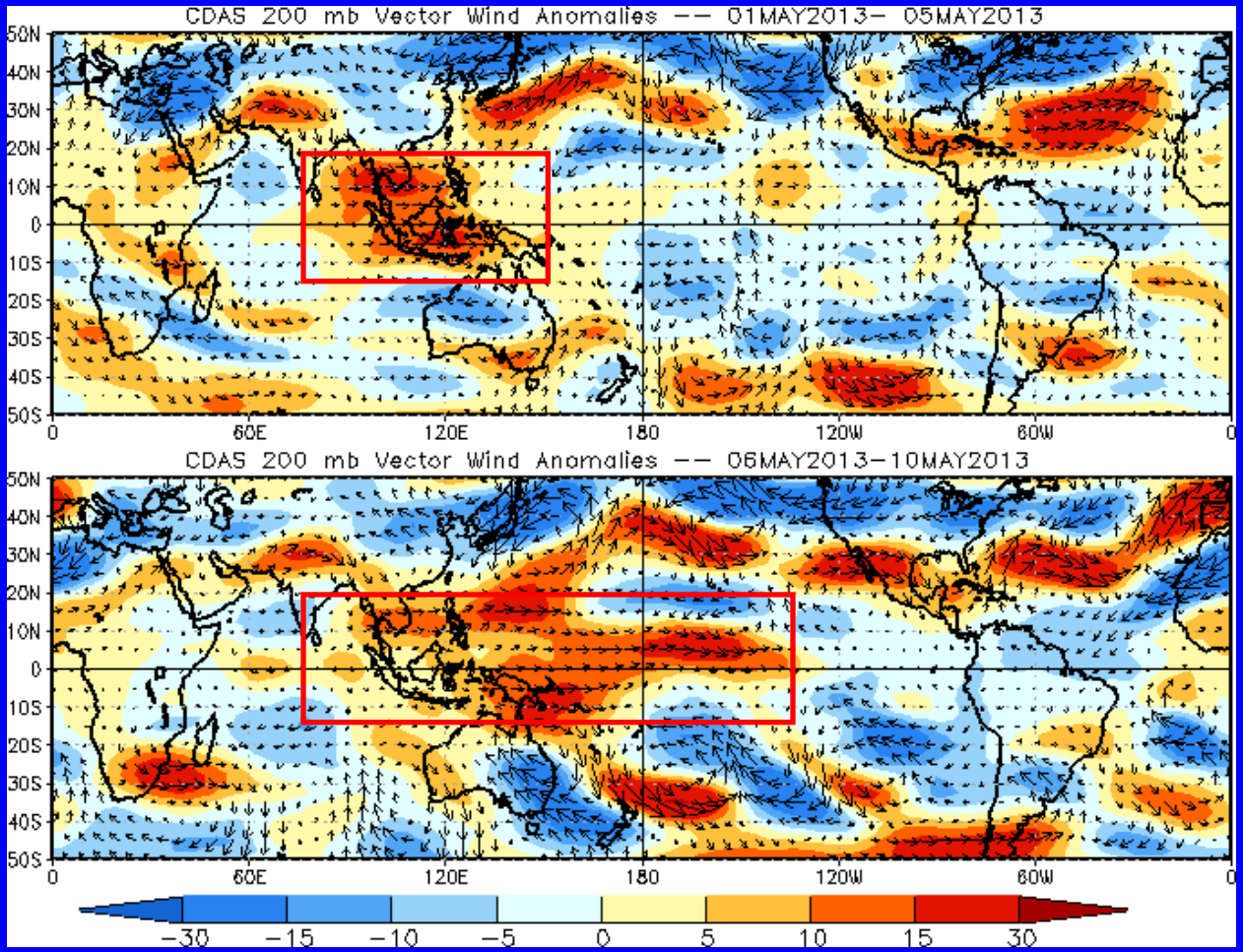
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern indicates a coherent wave-1 pattern. Upper-level divergence is observed across Africa, the Indian Ocean, and Maritime Continent while positive anomalies (upper-level convergence) cover the eastern Pacific and Americas.

200-hPa Vector Wind Anomalies (m s^{-1})



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

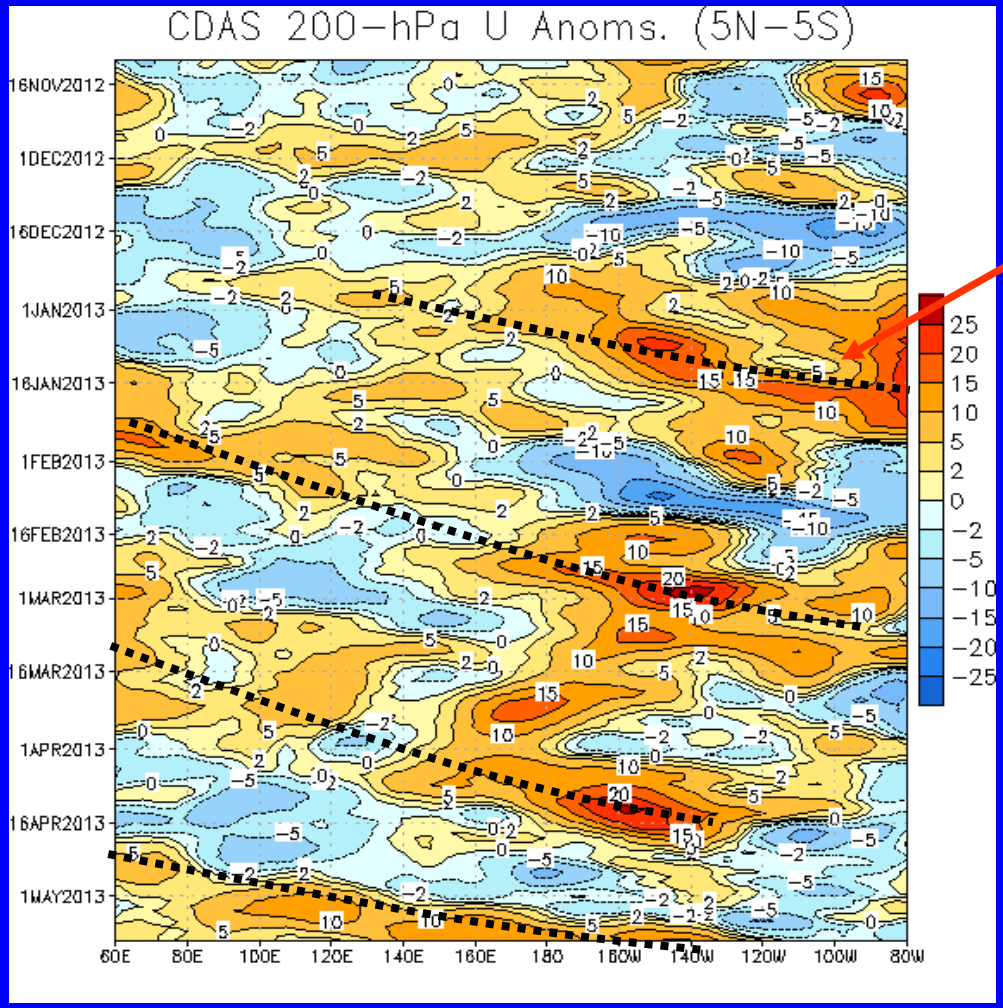
Red shades: Westerly anomalies

Westerly anomalies (red box) expanded east during the past five days along the Equator.

200-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



Time

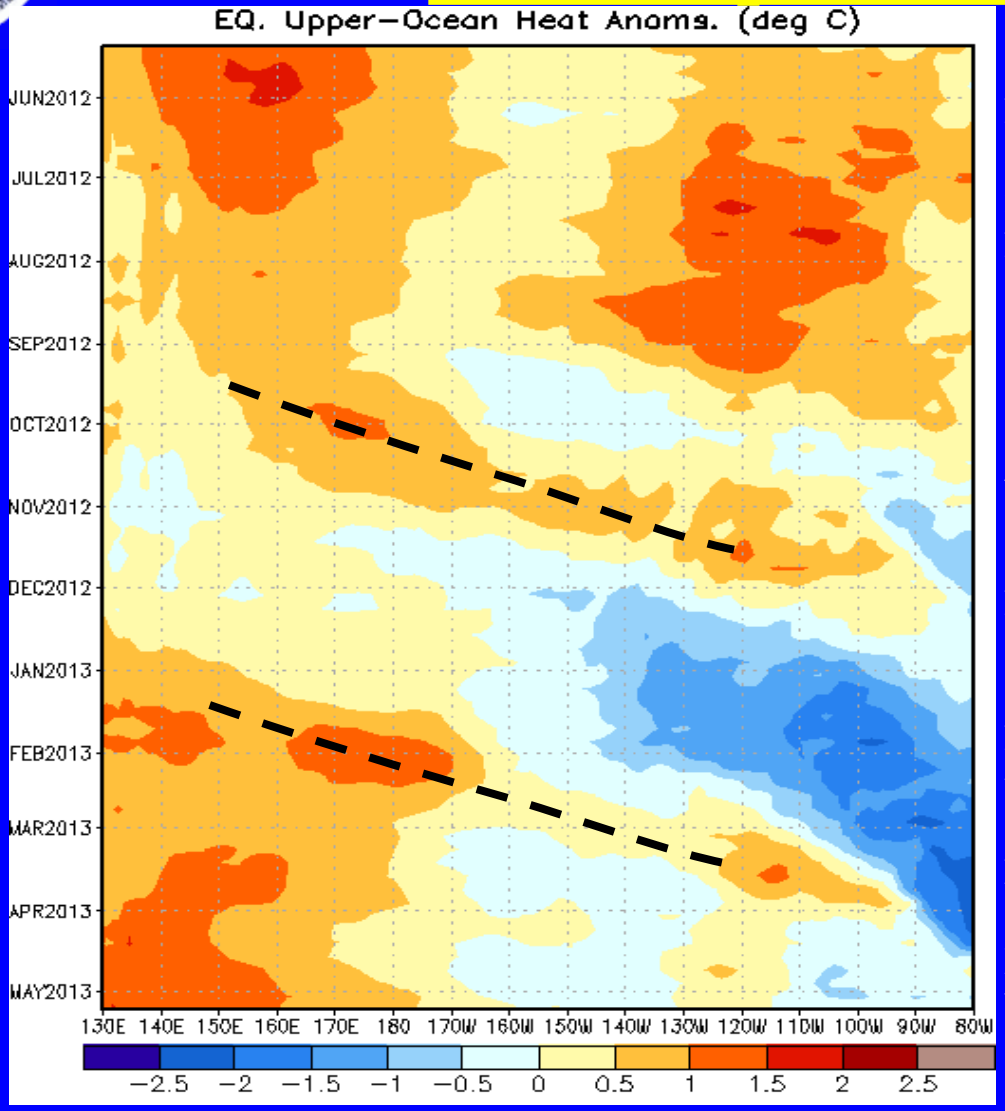
Longitude

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.

Westerly anomalies shifted east of the Date Line recently.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

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).

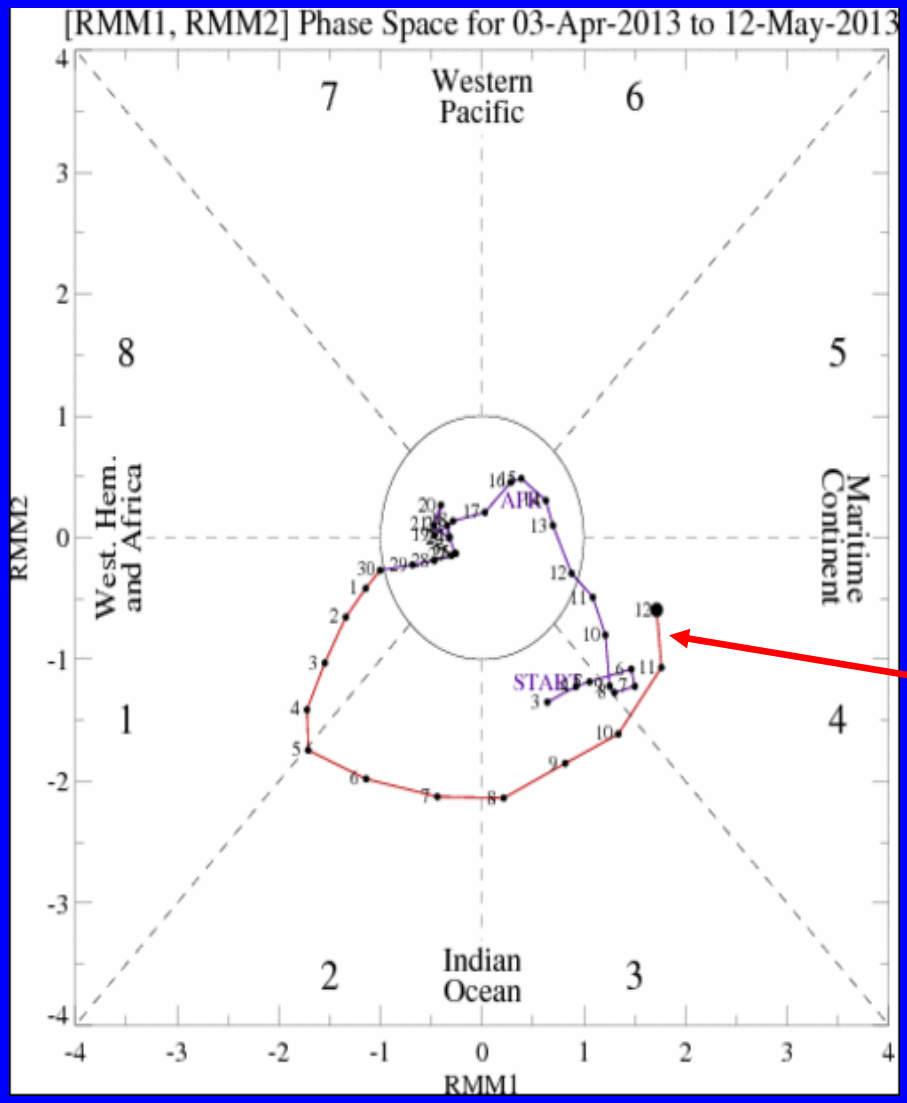
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

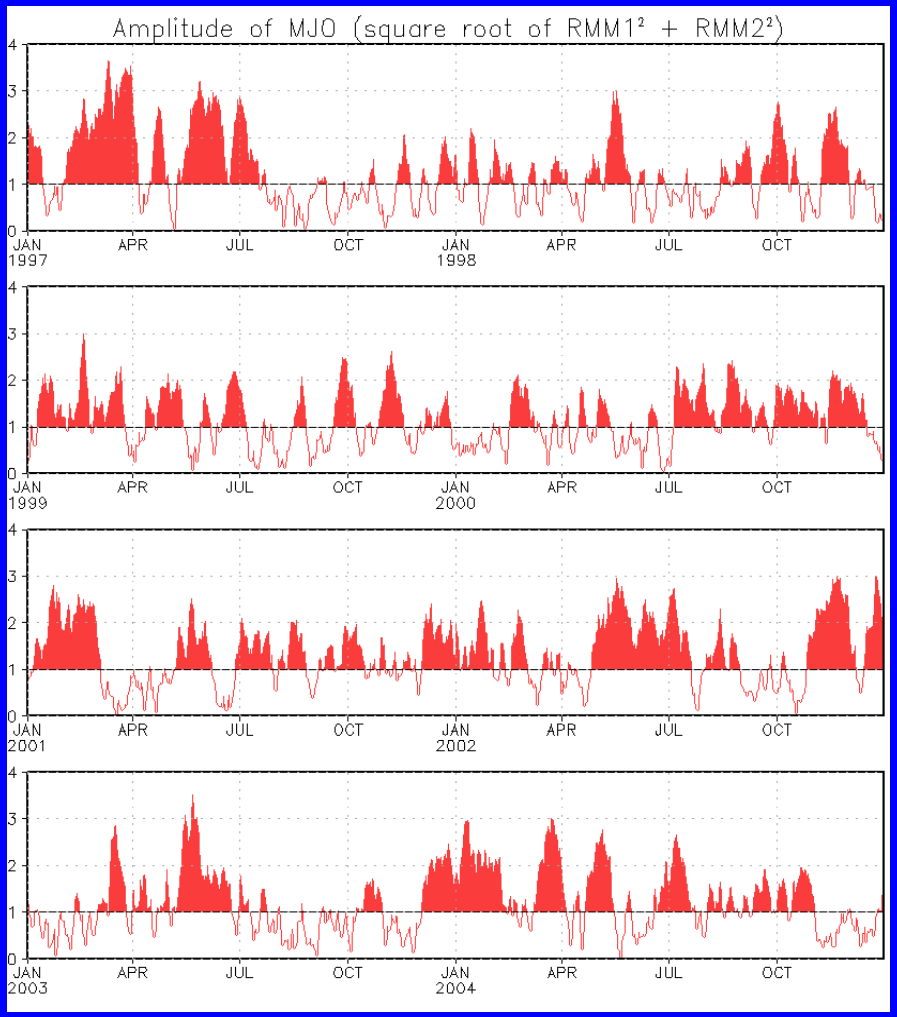
MJO Index -- Recent Evolution

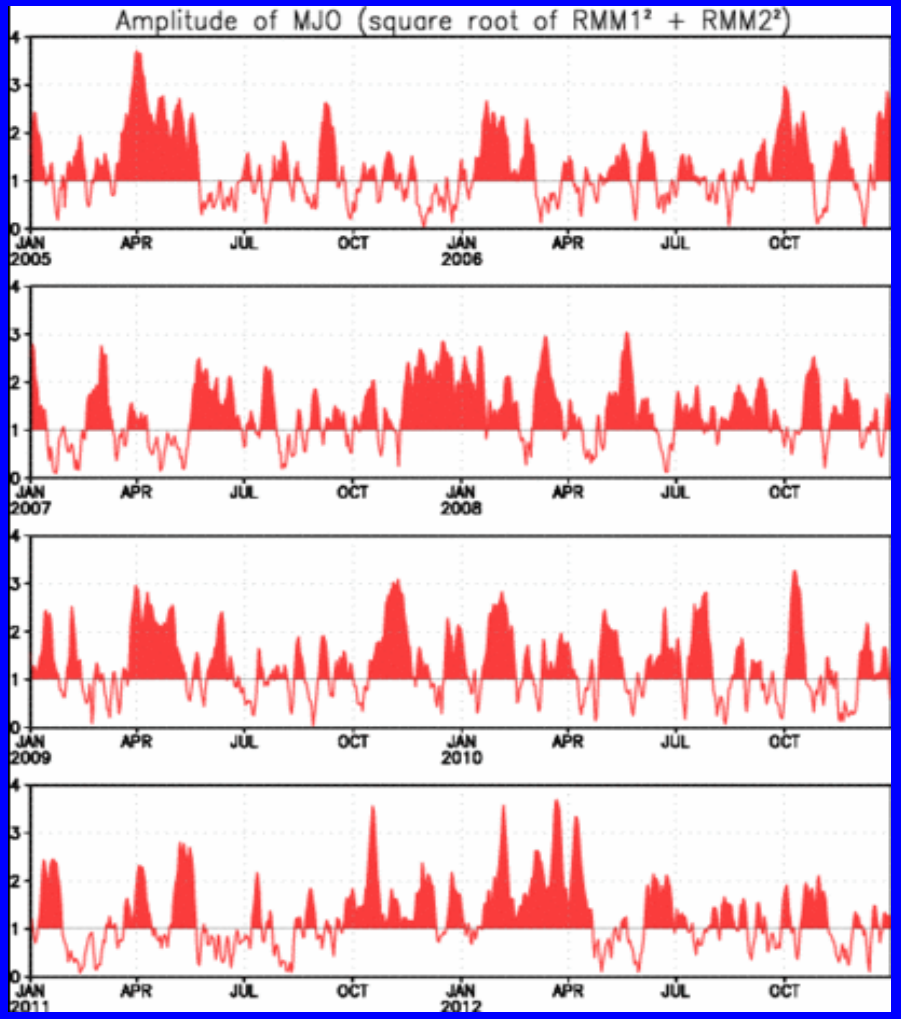


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates an eastward propagation during the past week.

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.

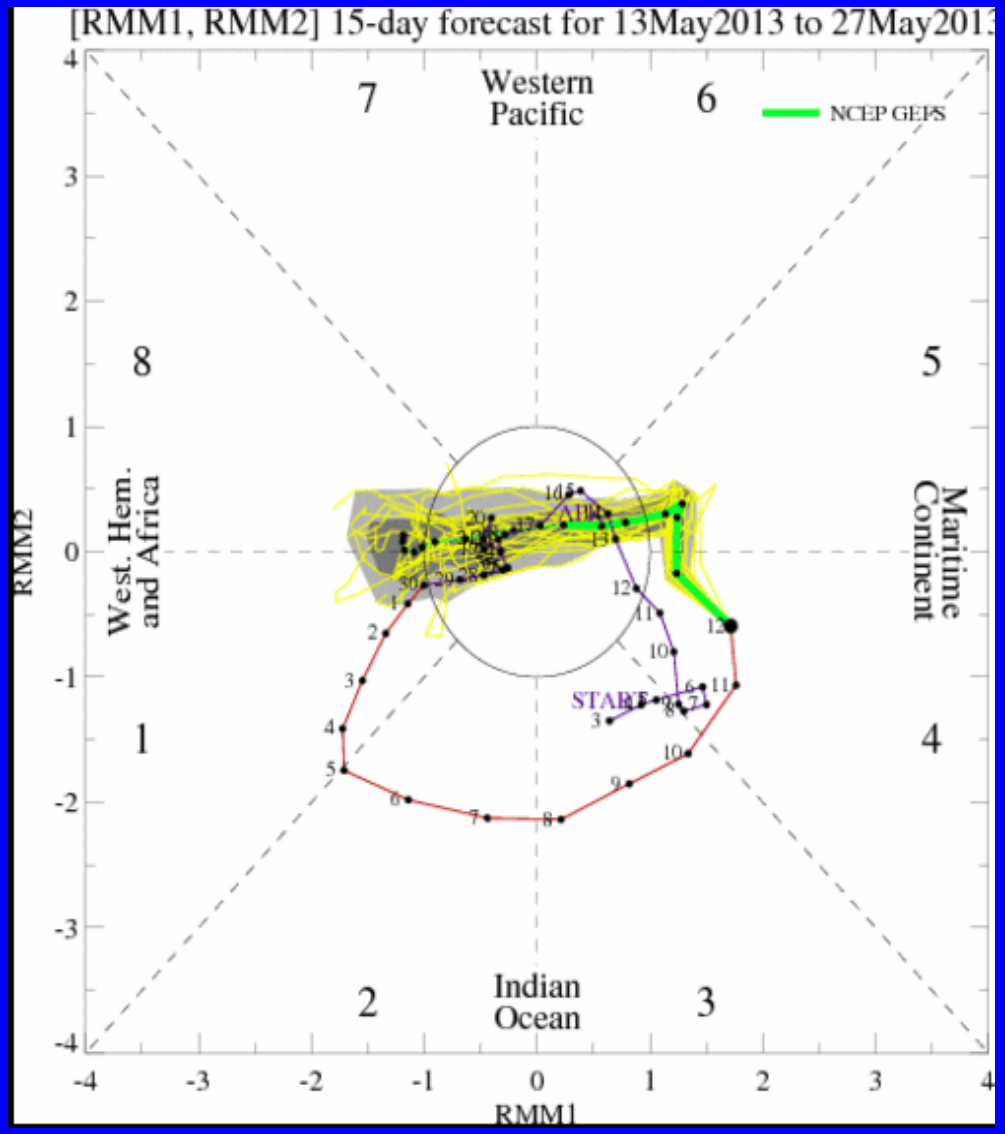
Ensemble GFS (GEFS) MJO Forecast

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

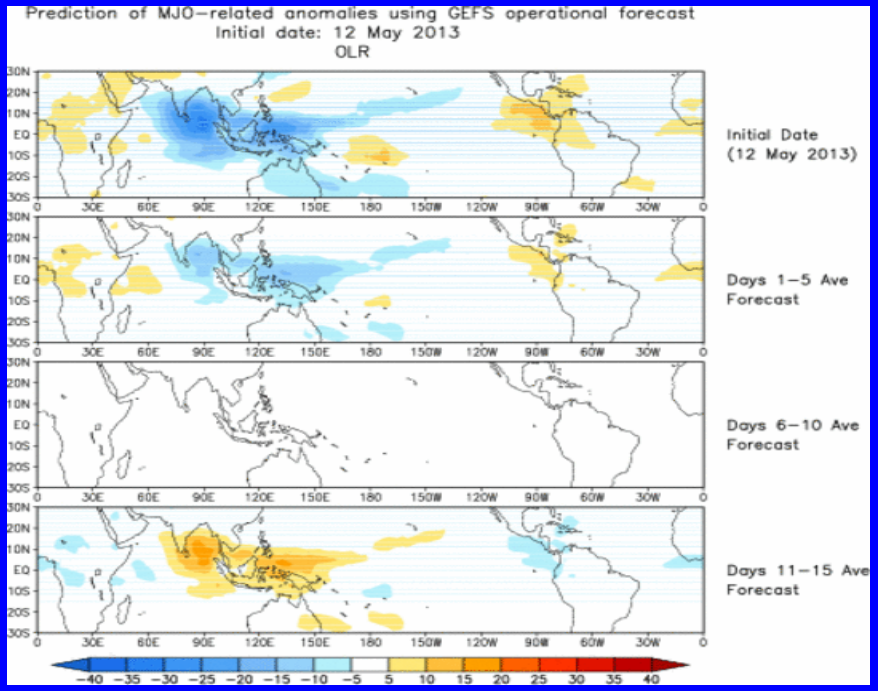
The bias-corrected ensemble GFS indicates a continued MJO signal early in Week-1 before it weakens with a fast eastward propagation.



Ensemble Mean GFS MJO Forecast

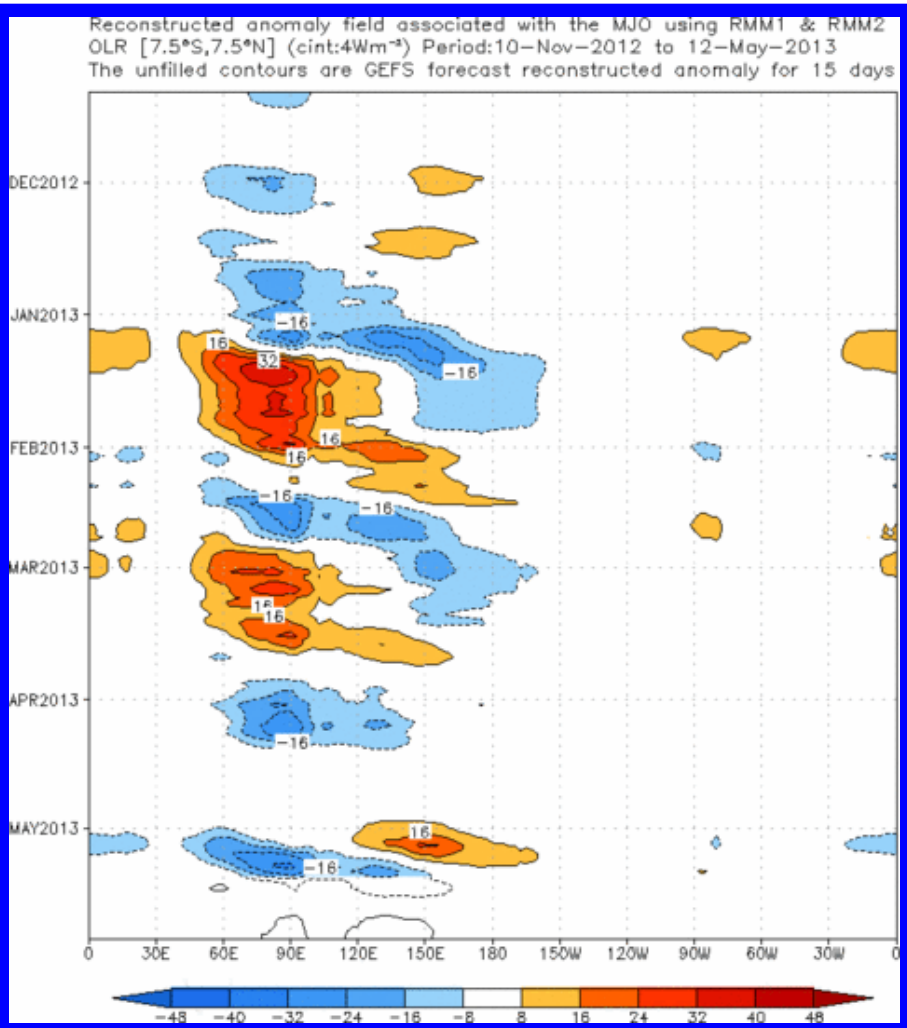
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts enhanced convection diminishing across the Indian Ocean and Maritime Continent where suppressed convection is forecast later in Week-2.

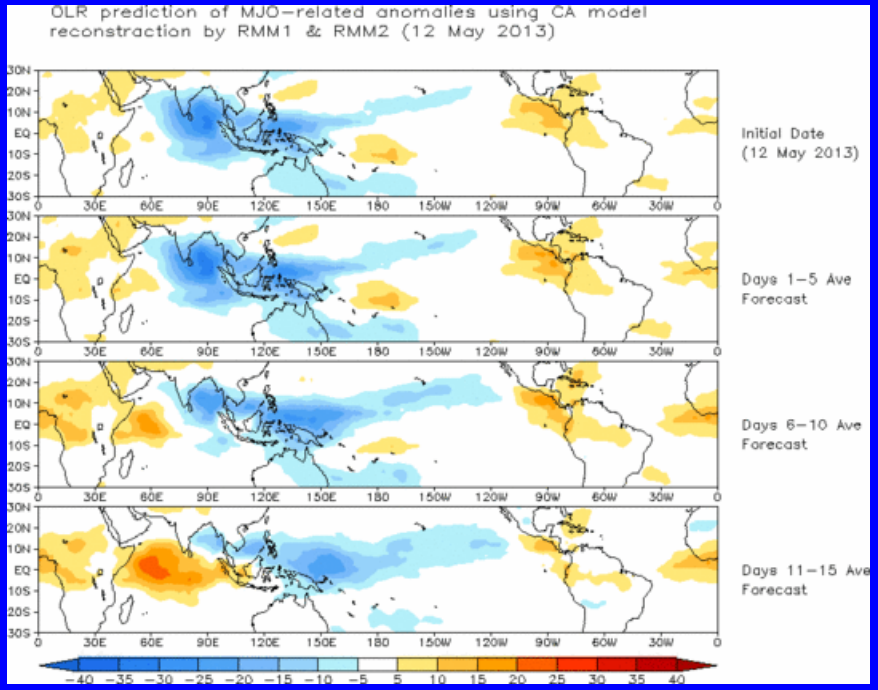
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

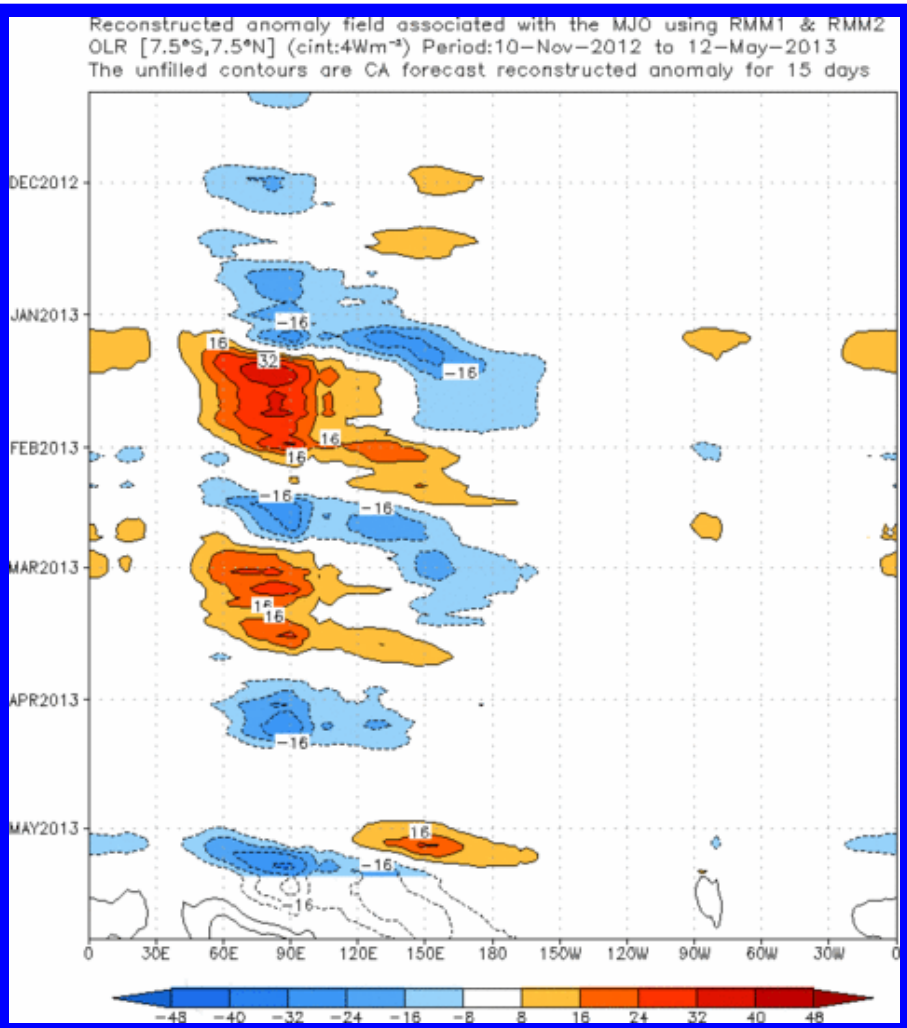
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



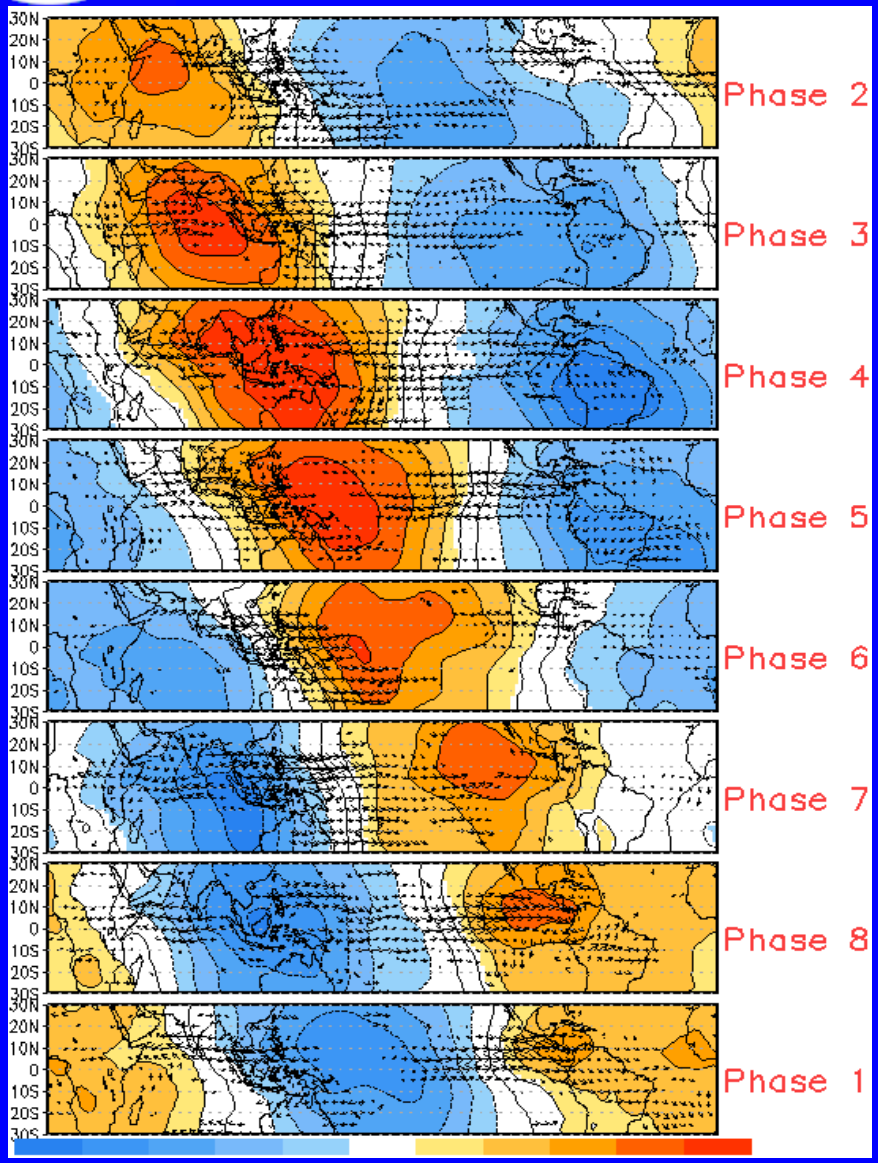
This statistical forecast indicates eastward propagation of anomalous convection across the global tropics.

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

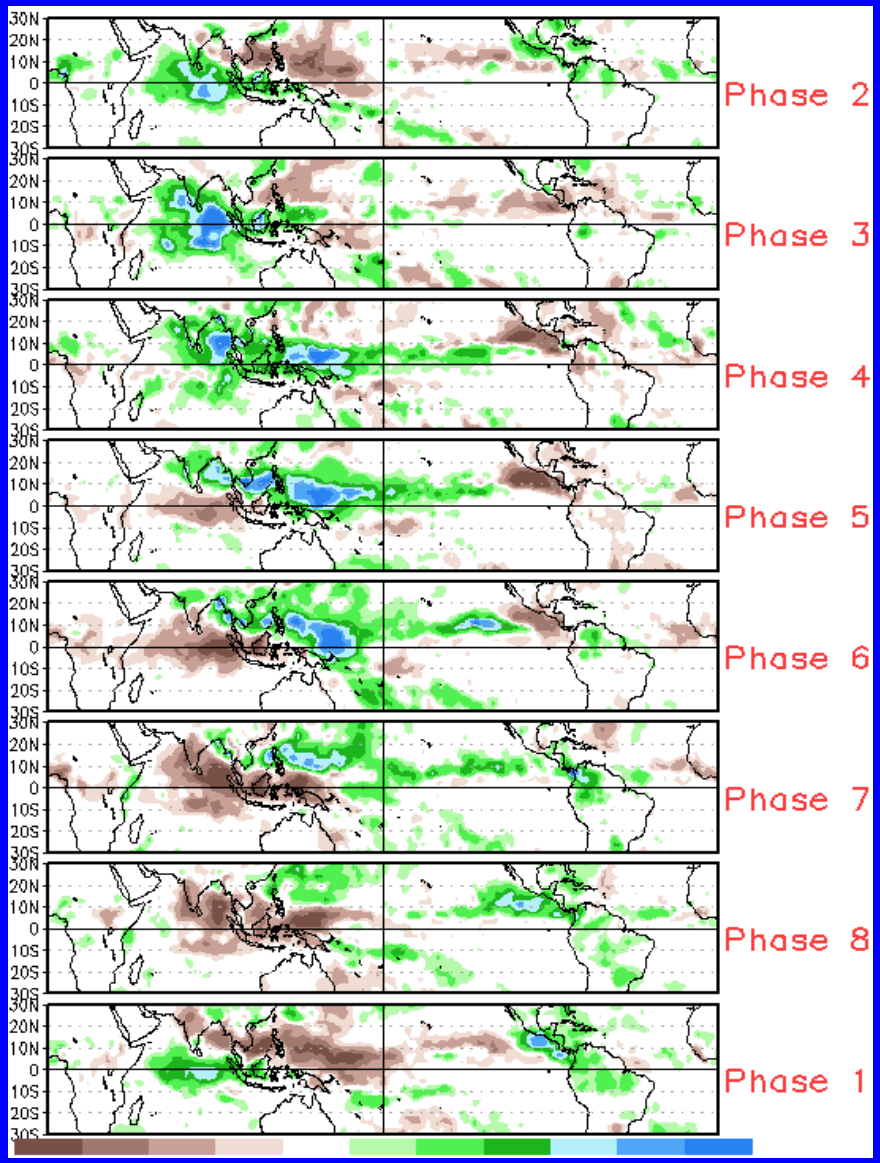


MJO Composites – Global Tropics

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

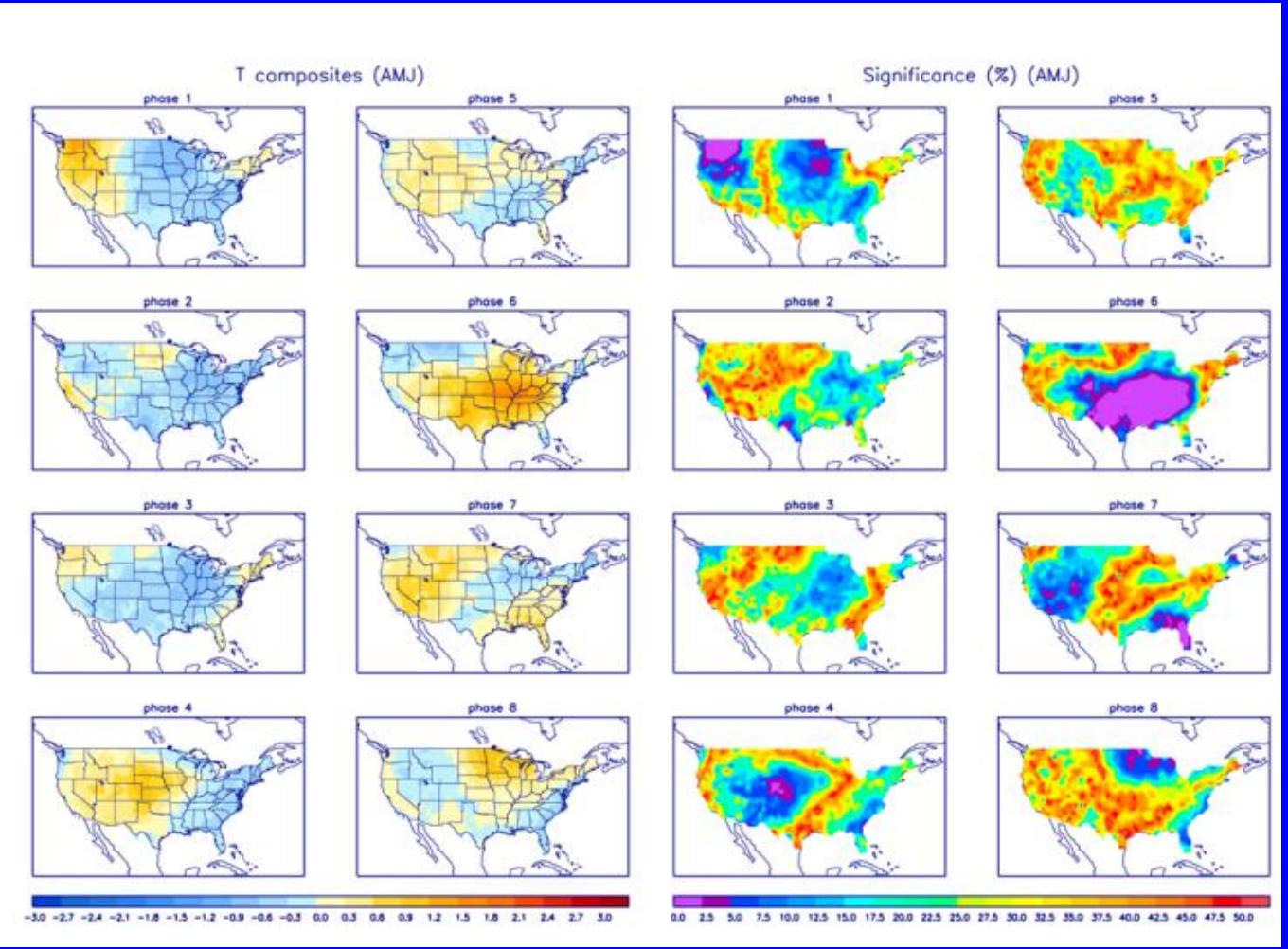


Precipitation Anomalies (May-Sep)



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.**

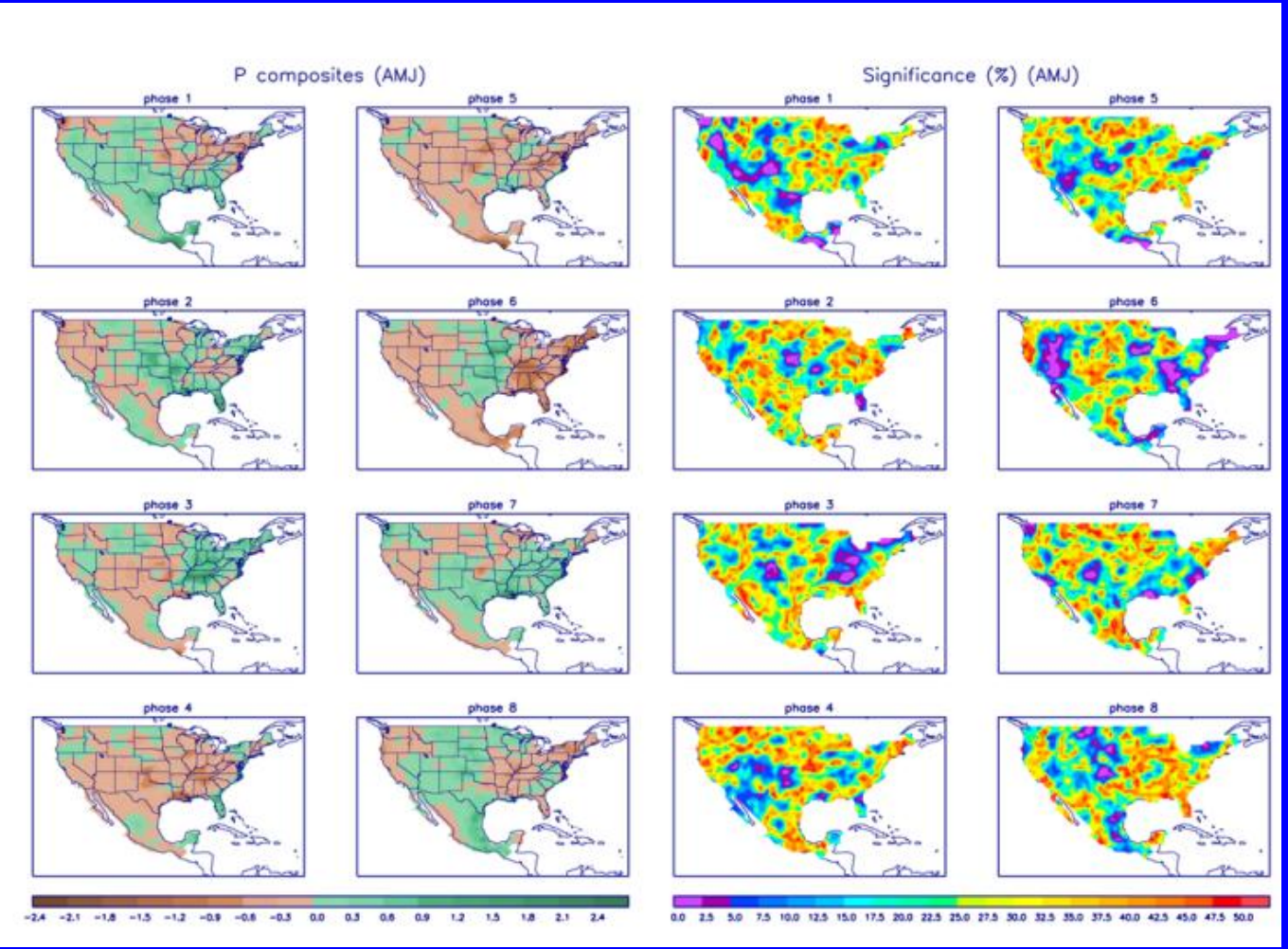


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.**



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