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

Update prepared by
Climate Prediction Center / NCEP
June 4, 2012

Outline

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

Overview

- The MJO remained weak over the past week, but the latest observations show some signs that the MJO is becoming more organized.

- The latest forecasts of the MJO index from dynamical models indicate a more coherent MJO signal emerging this week and continuing to varying degrees during Week-2. There is considerable spread amongst the models, but there is a greater consensus for a signal than seen in recent weeks.

- Based on the latest observations and model forecasts, the MJO is forecast to strengthen during the next 1-2 weeks with the enhanced phase shifting into the western Pacific. It is unclear at this time whether the signal will persist as a robust MJO.

- The MJO favors enhanced rainfall from parts of Southeast Asia to the western Pacific during Week-1 and for much of the Pacific and Central America during Week-2. Drier-than-average conditions are favored across parts of the Indian Ocean and western Maritime continent.

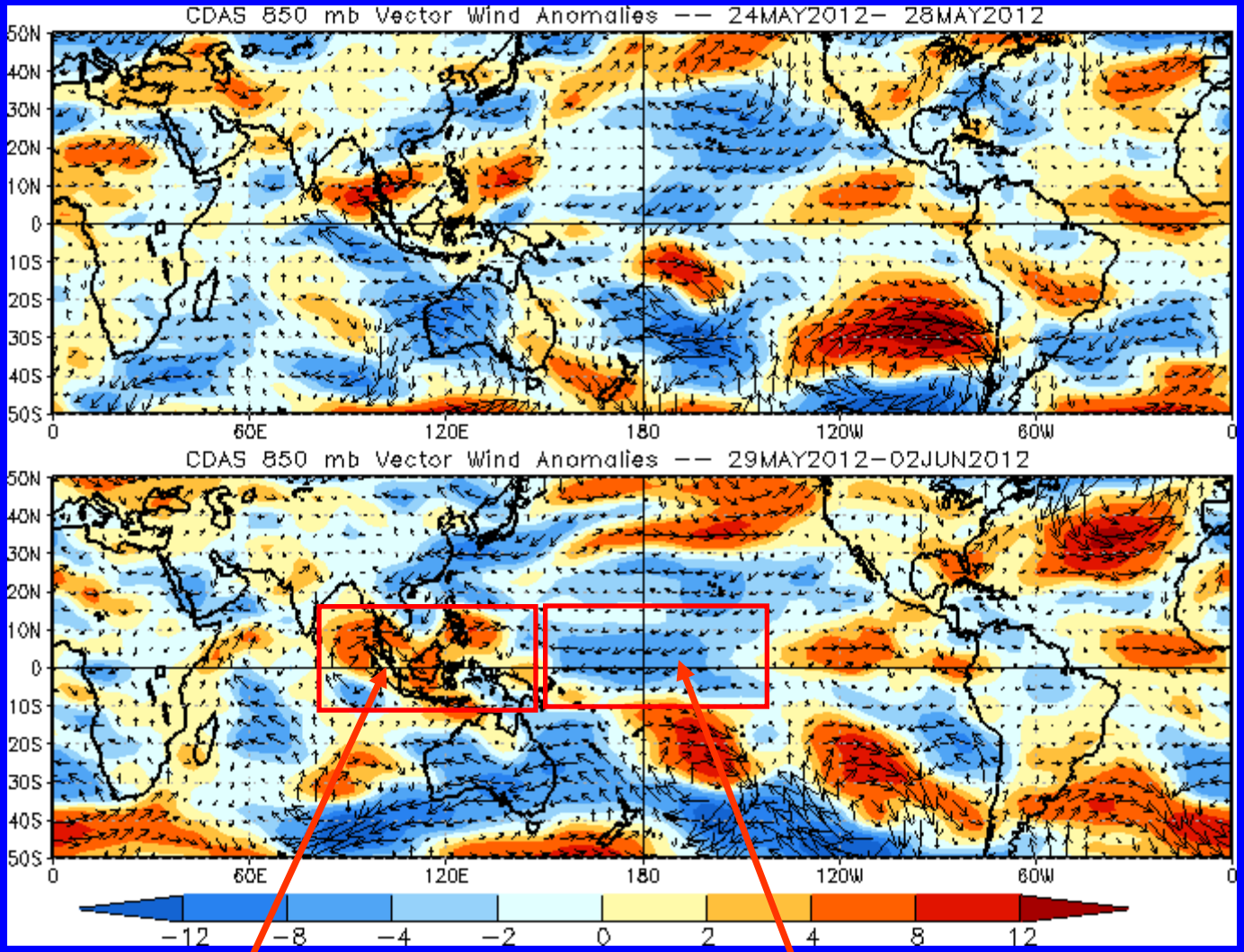
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



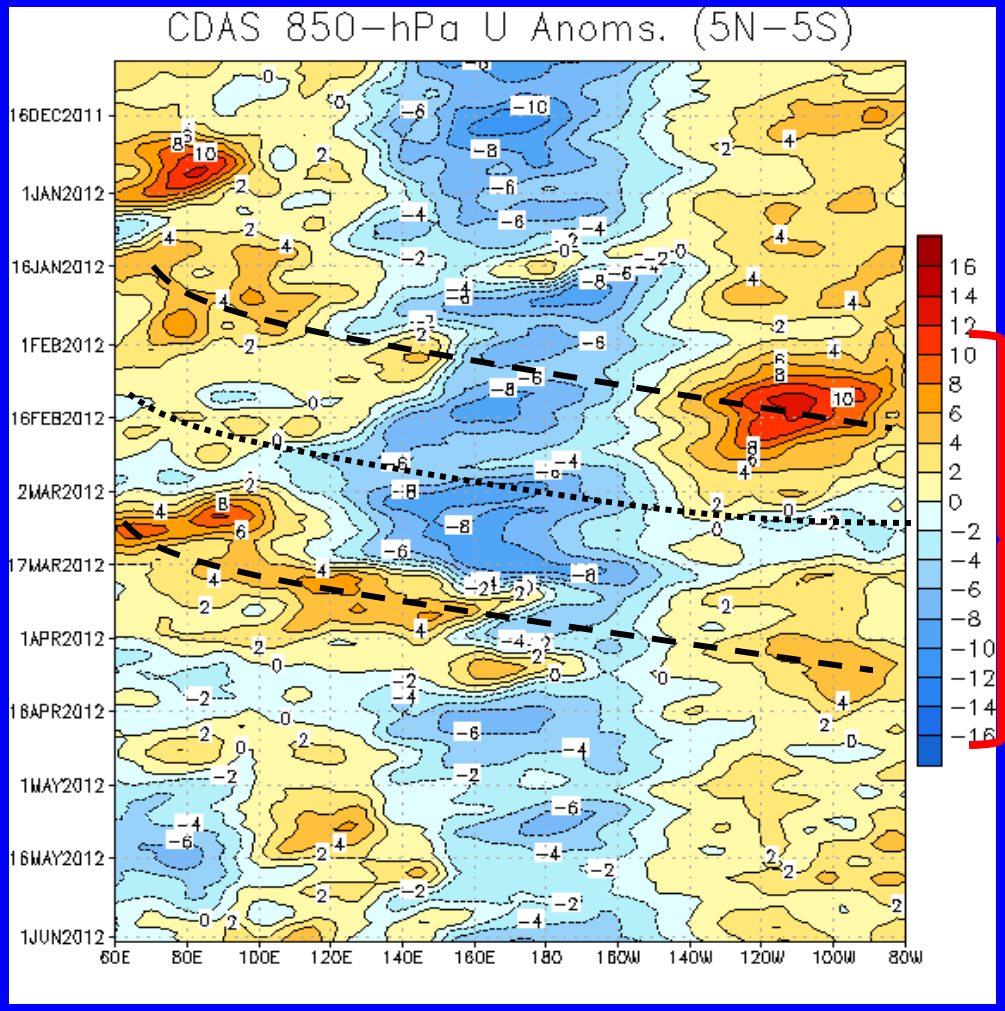
Areas of westerly anomalies continued across parts of the Maritime continent and western Pacific during the last five days.

Easterly anomalies strengthened in the central Pacific during the last 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

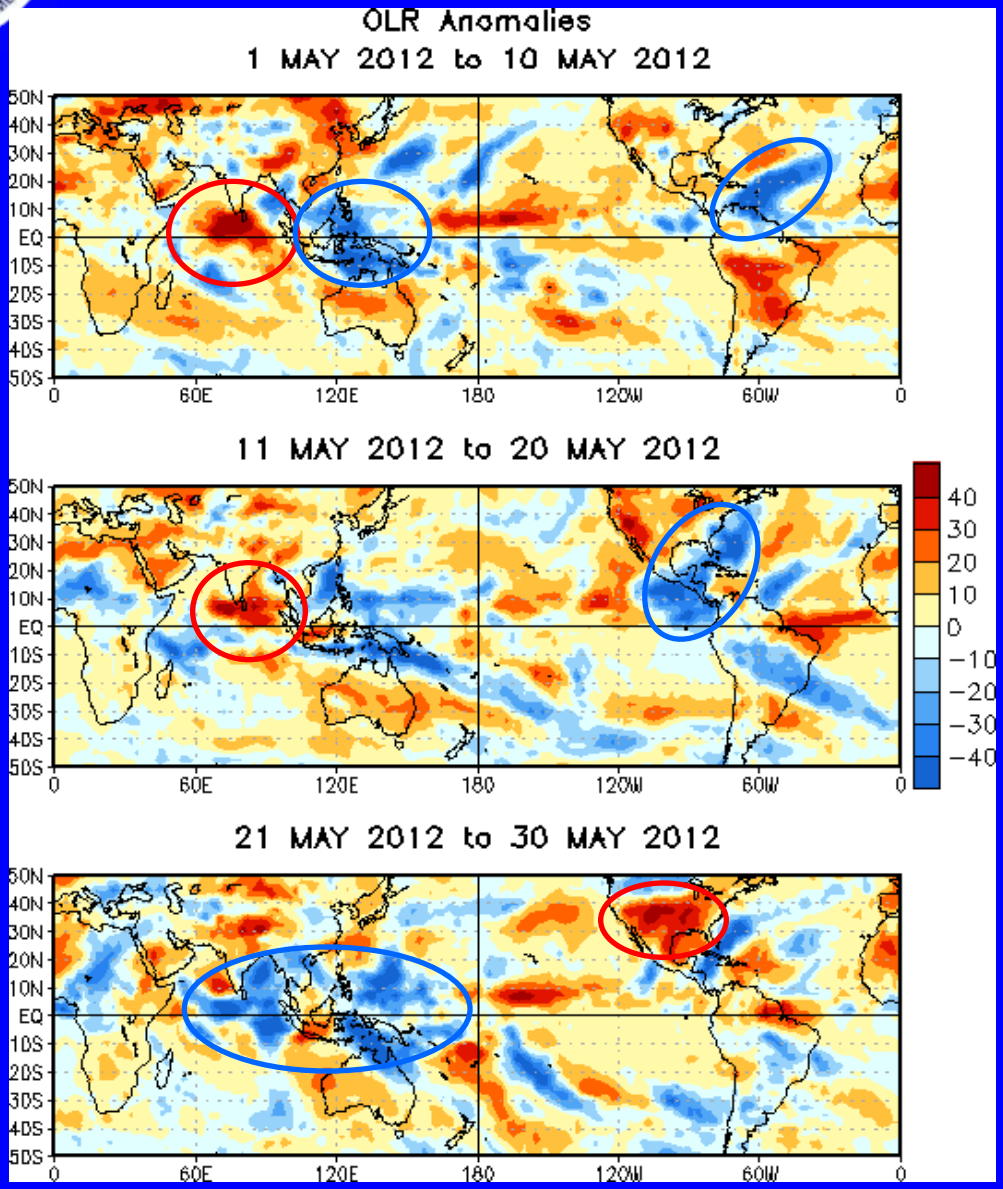
During much of mid-to-late December and the first half of January, on average, westerly (easterly) wind anomalies across the Indian Ocean (western Pacific) became more stationary.

During the first half of February, the MJO contributed to increased westerly anomalies near 140E and across the eastern Pacific while decreasing easterly anomalies in the central Pacific.

MJO activity continued into April, with westerly anomalies associated with the MJO located near the Date Line and western hemisphere early in the month.

On average, anomalies have been somewhat stationary across much of the global tropics since mid-April.

OLR Anomalies – Past 30 days



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

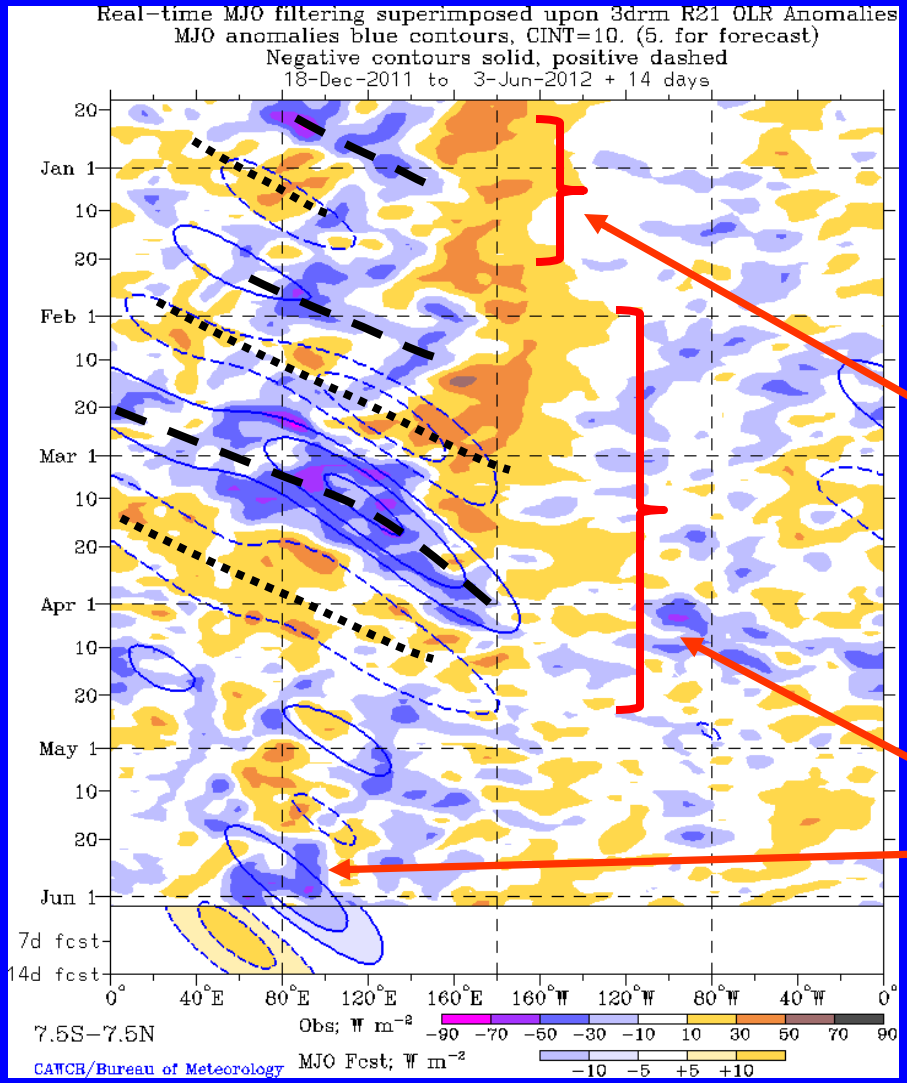
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

In early May, suppressed convection developed across the equatorial Indian Ocean while wet conditions increased across the Maritime continent and across the eastern Caribbean.

During mid May, suppressed convection continued across southern India and the northern Indian Ocean with enhanced convection observed over the eastern Pacific, Central America and near the Bahamas.

Enhanced convection became more prevalent over a region from the central Indian Ocean to Southeast Asia to parts of the Maritime continent and western Pacific. Drier than average conditions continued across much of the southern U.S. and Mexico.

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)

Weak MJO activity was evident in late December and early January as alternating areas of enhanced (dashed lines) and suppressed (dotted lines) convection shifted eastward.

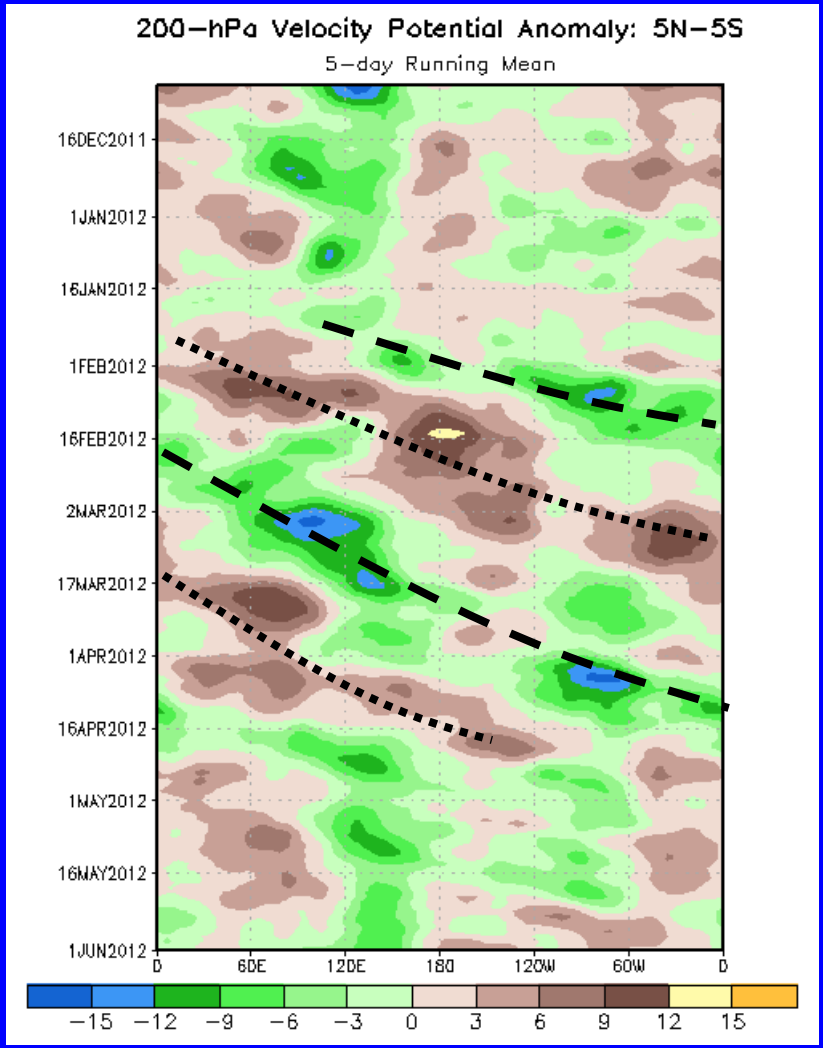
Strong MJO activity once again developed during late January and continued into mid-April. During this same period, other modes of subseasonal variability have also contributed to the observed pattern.

Anomalies became less coherent during the second half of April and much of May. Most recently, the strongest enhanced convection is located across the Indian Ocean region.

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

Anomalies weakened and eastward propagation became less coherent during parts of the second half of December and the first half of January.

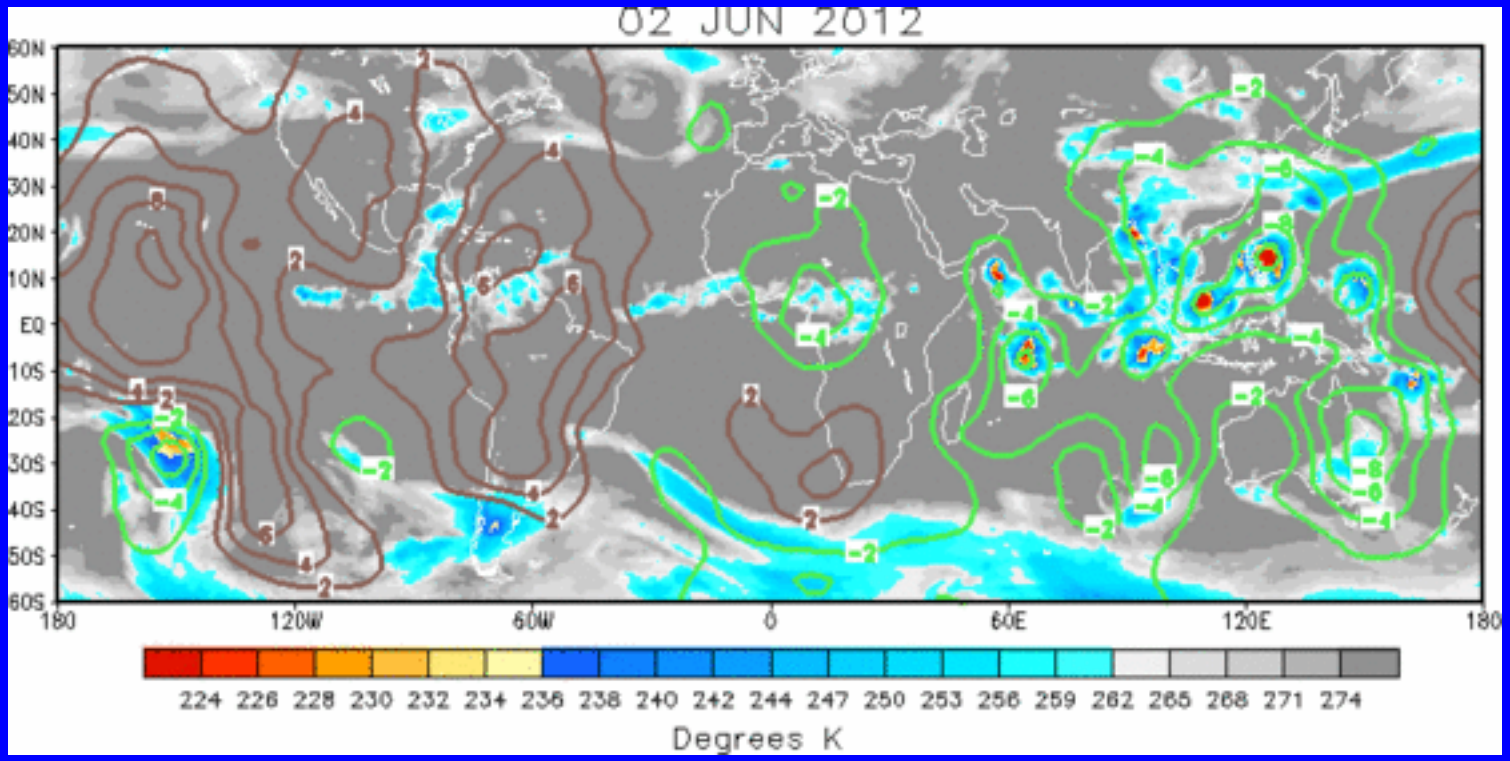
The MJO strengthened in late January as indicated by alternating negative (dashed lines) and positive (dotted lines) anomalies with eastward propagation. The activity continued through mid-April.

Beginning in late April, anomalies became weaker and less coherent than earlier in the year.

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

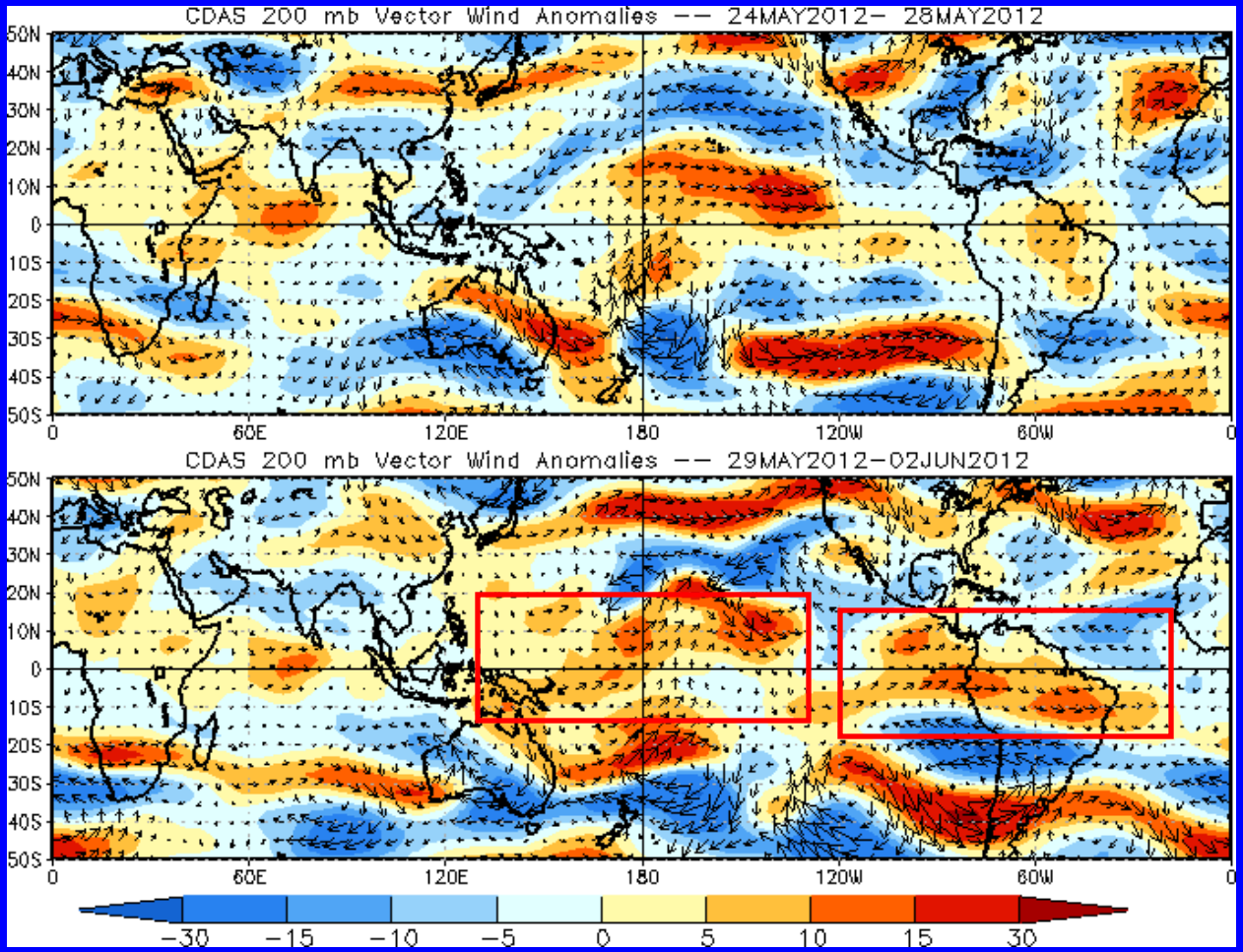
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern reflects upper-level divergence from the Indian Ocean to the western Pacific with upper-level convergence located over 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

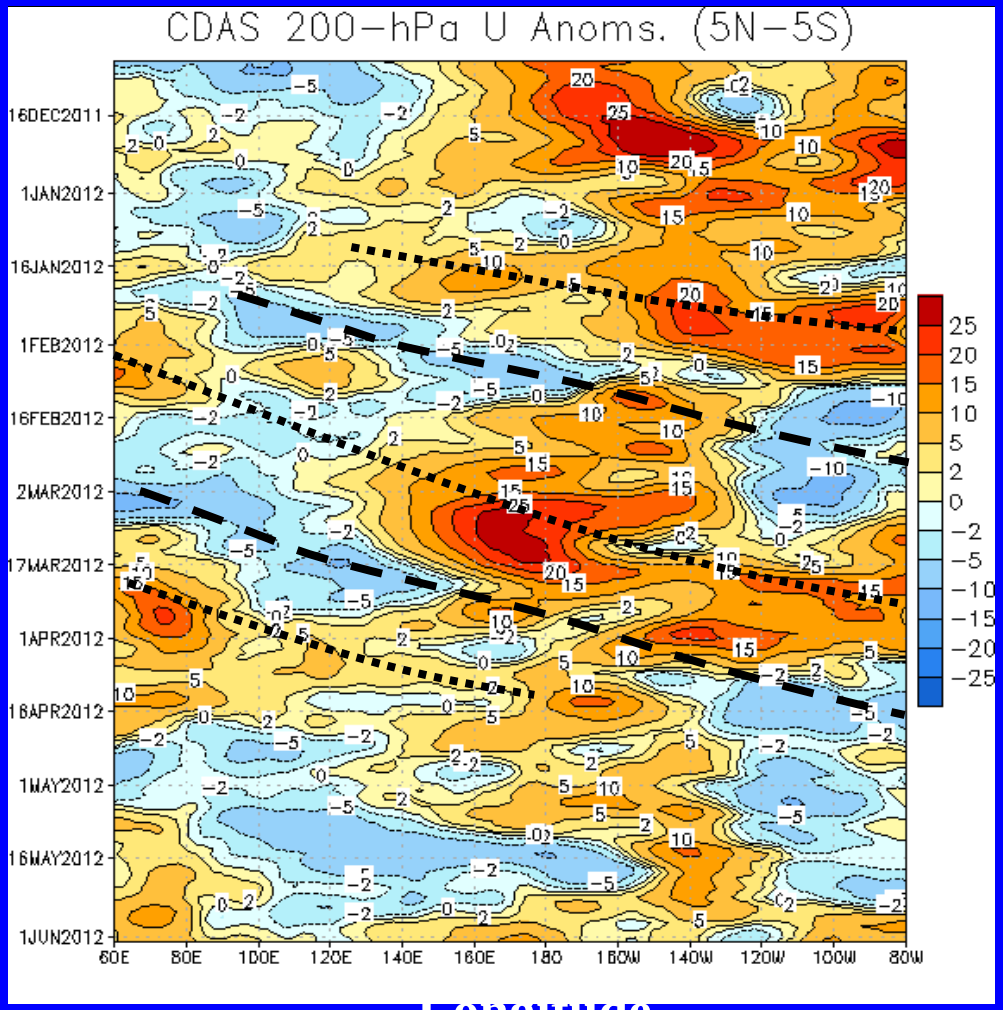
Red shades: Westerly anomalies

Two areas of westerly anomalies (red boxes) are evident in the Tropics during the last five days, one centered near the Date Line and another centered over northern South America.

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

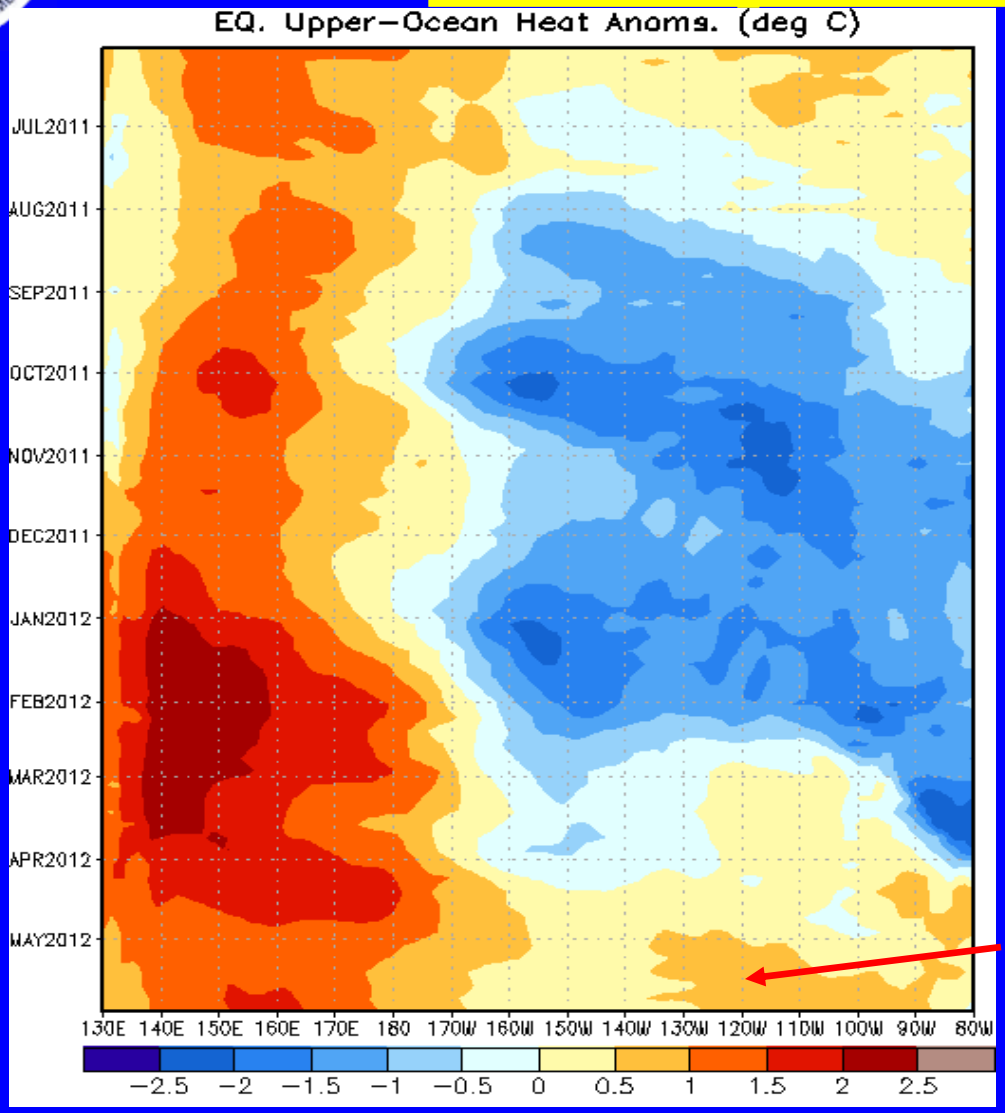
Longitude

In December, westerly anomalies strengthened over the central Pacific.

The MJO strengthened once again in late January as indicated by alternating westerly (dotted lines) and easterly (dashed lines) anomalies. This activity continued to mid-April.

Anomalies have been less coherent during much of late April and May.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From July 2011 through February 2012, heat content was below average in the central and eastern equatorial Pacific.

In April, heat content anomalies returned to near zero across much of the central and eastern Pacific.

Recently, heat content is now 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).

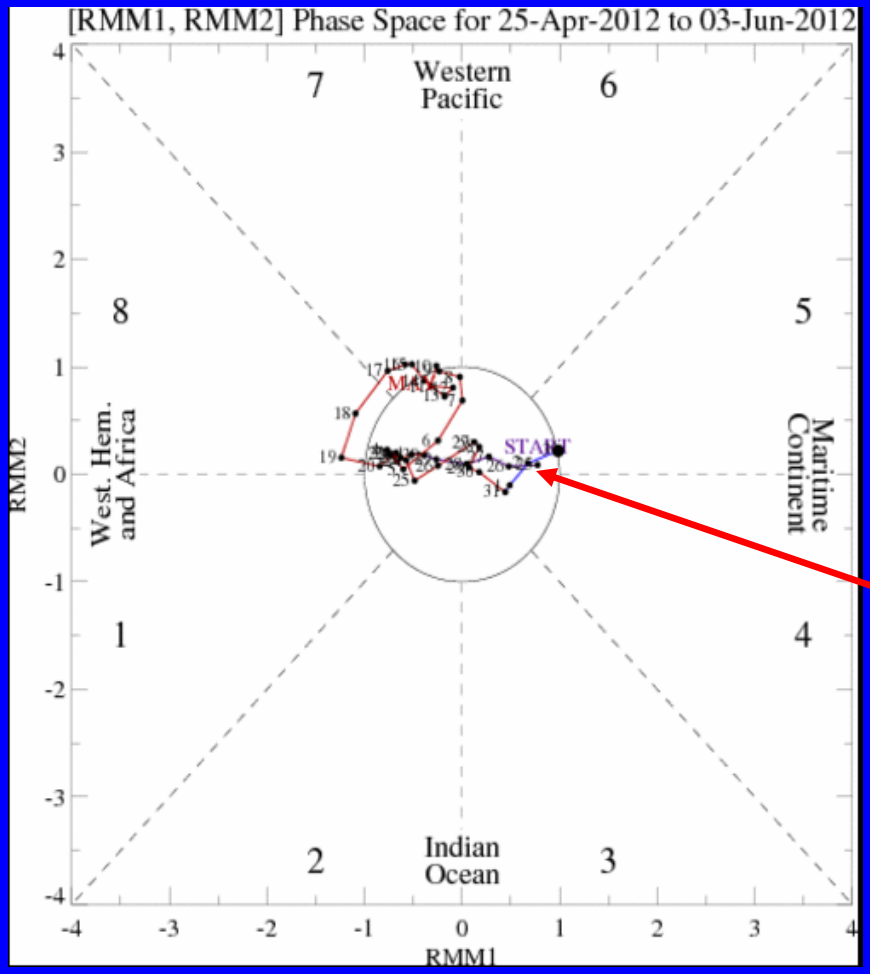
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

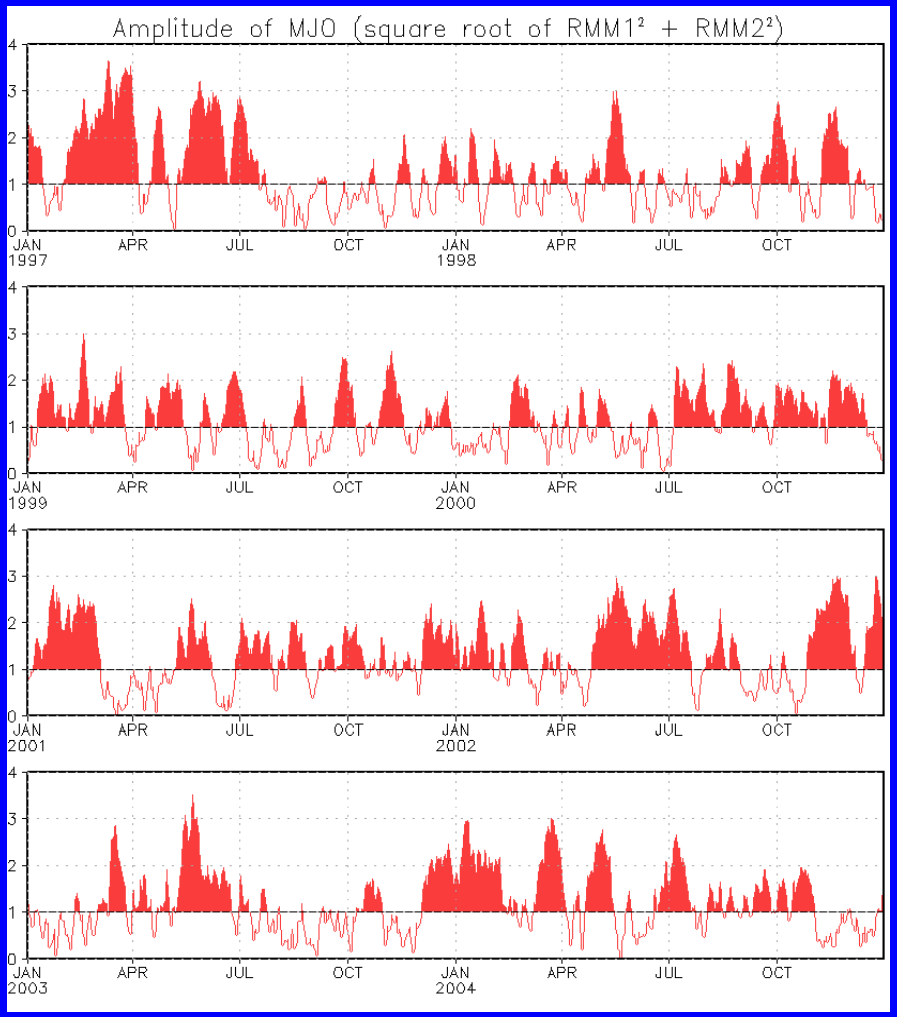
MJO Index -- Recent Evolution

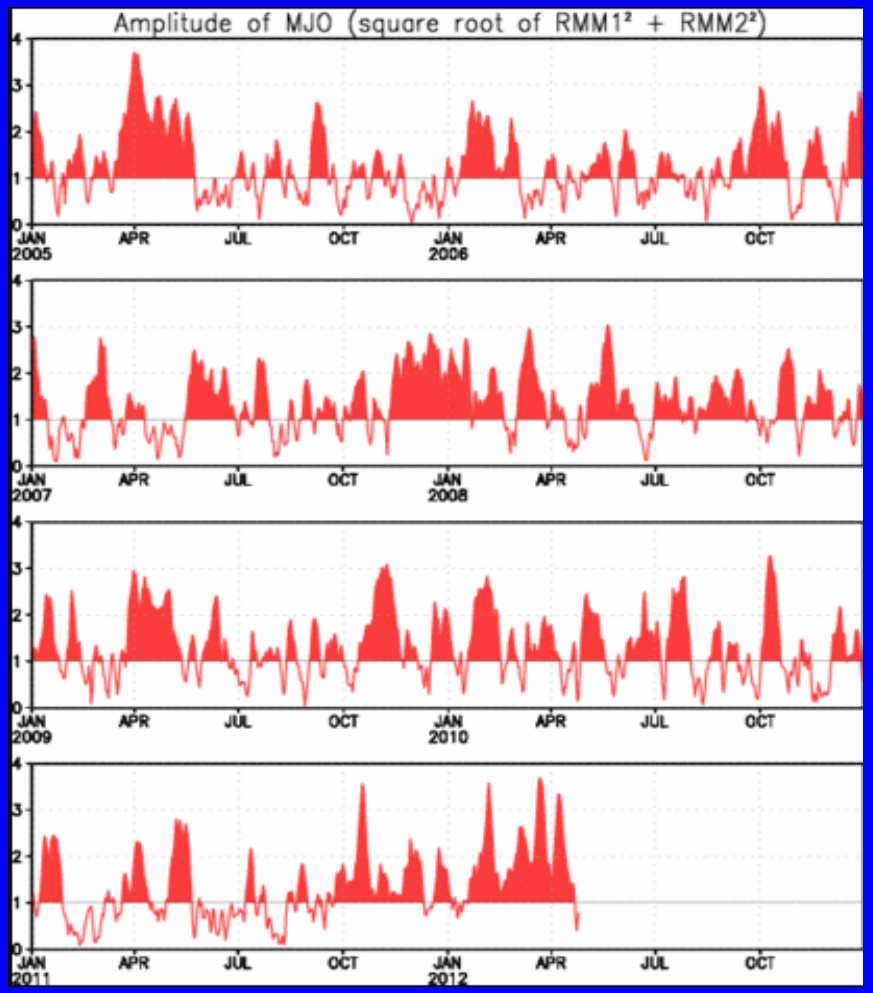


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past week, the MJO index indicated a continued weak signal.

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.

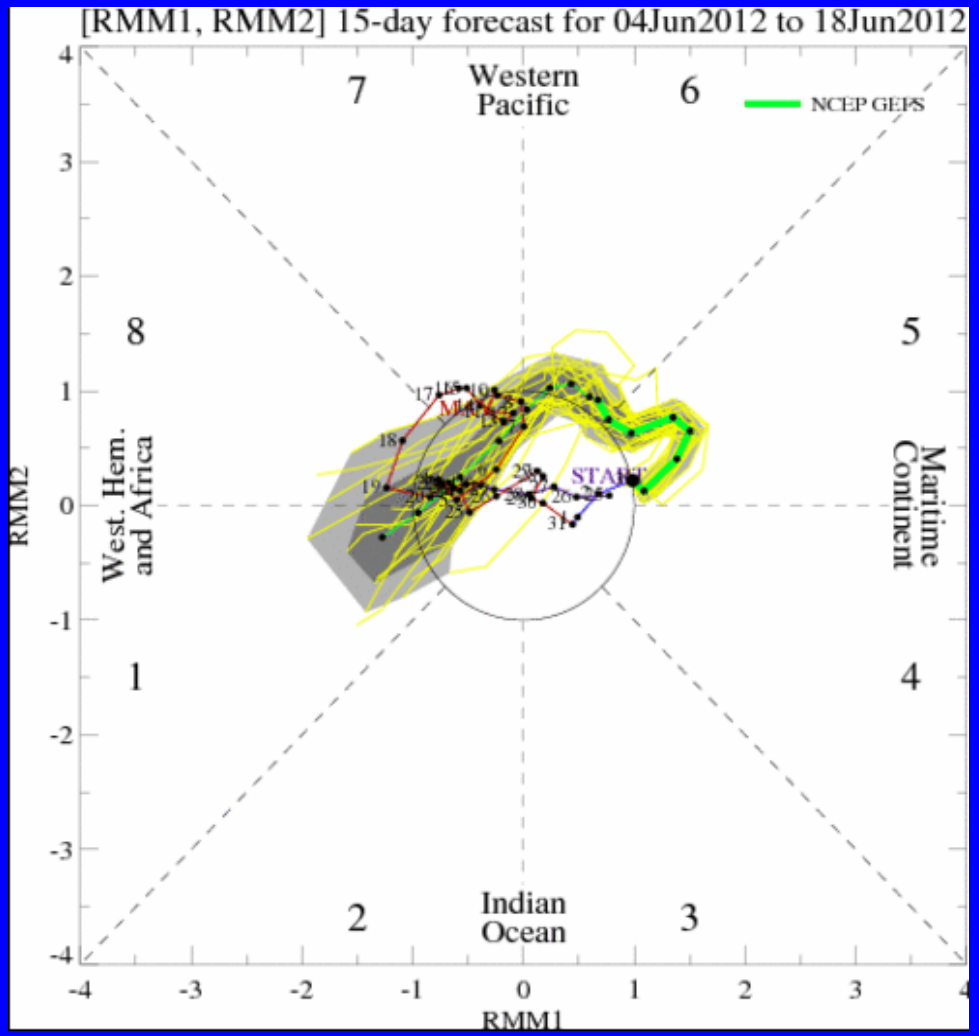
Ensemble GFS (GEFS) MJO Forecast

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

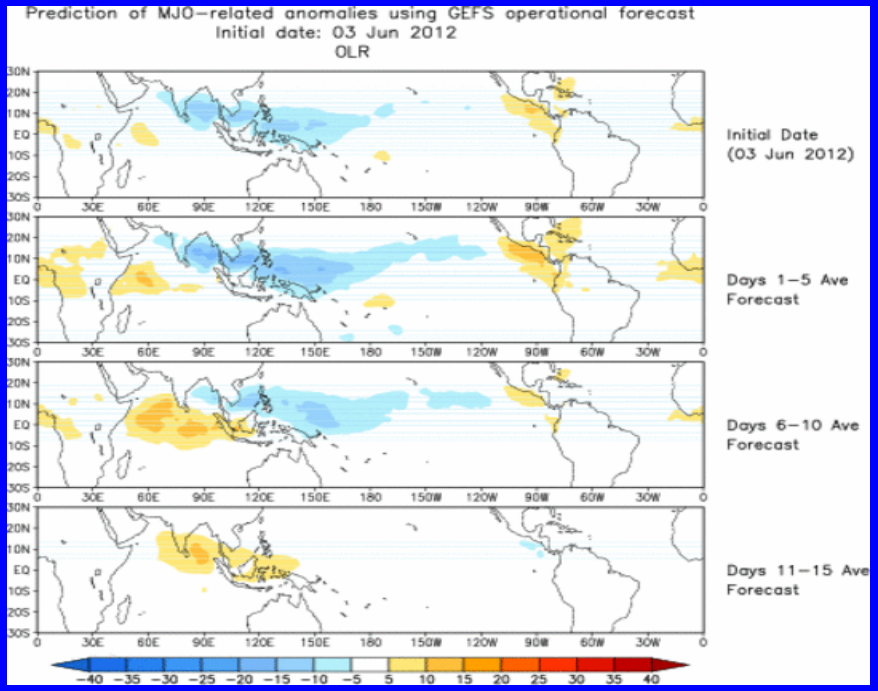
The ensemble GFS MJO index forecasts indicate the potential for a more coherent signal to emerge during the upcoming period than has been seen in recent weeks.



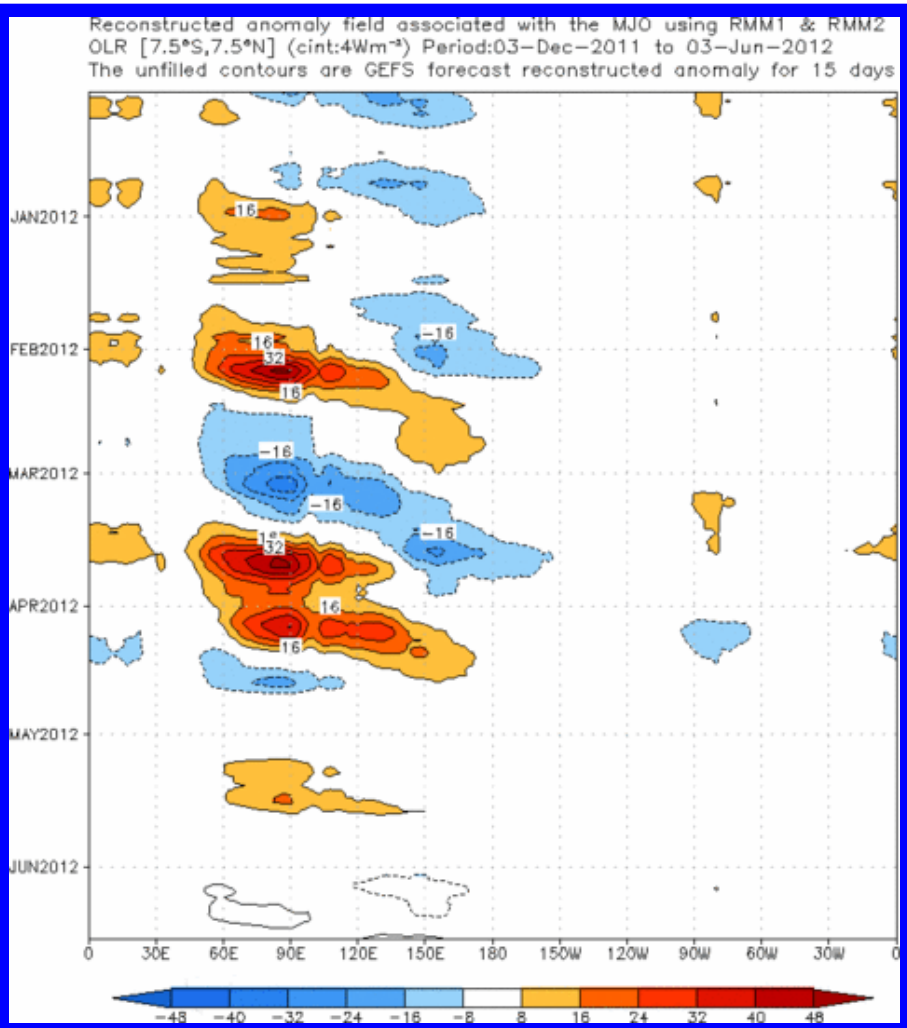
Ensemble Mean GFS MJO Forecast

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

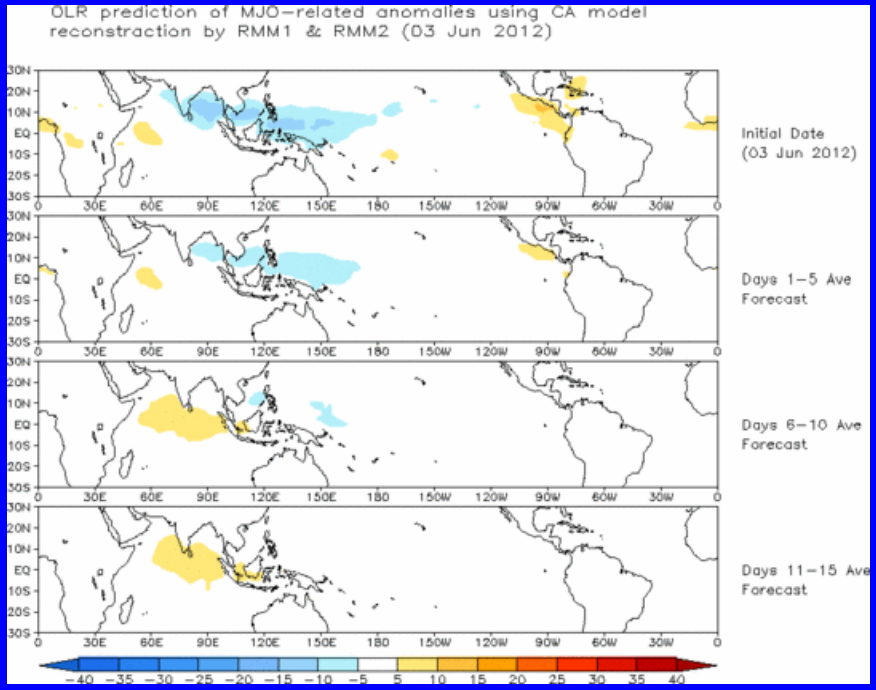


The ensemble mean GFS forecast indicates enhanced convection shifting eastward from parts of Southeast Asia to the western Pacific during the period and suppressed convection across Central America and Africa during Week-1 and developing over the Indian Ocean in Week-2.

Constructed Analog (CA) MJO Forecast

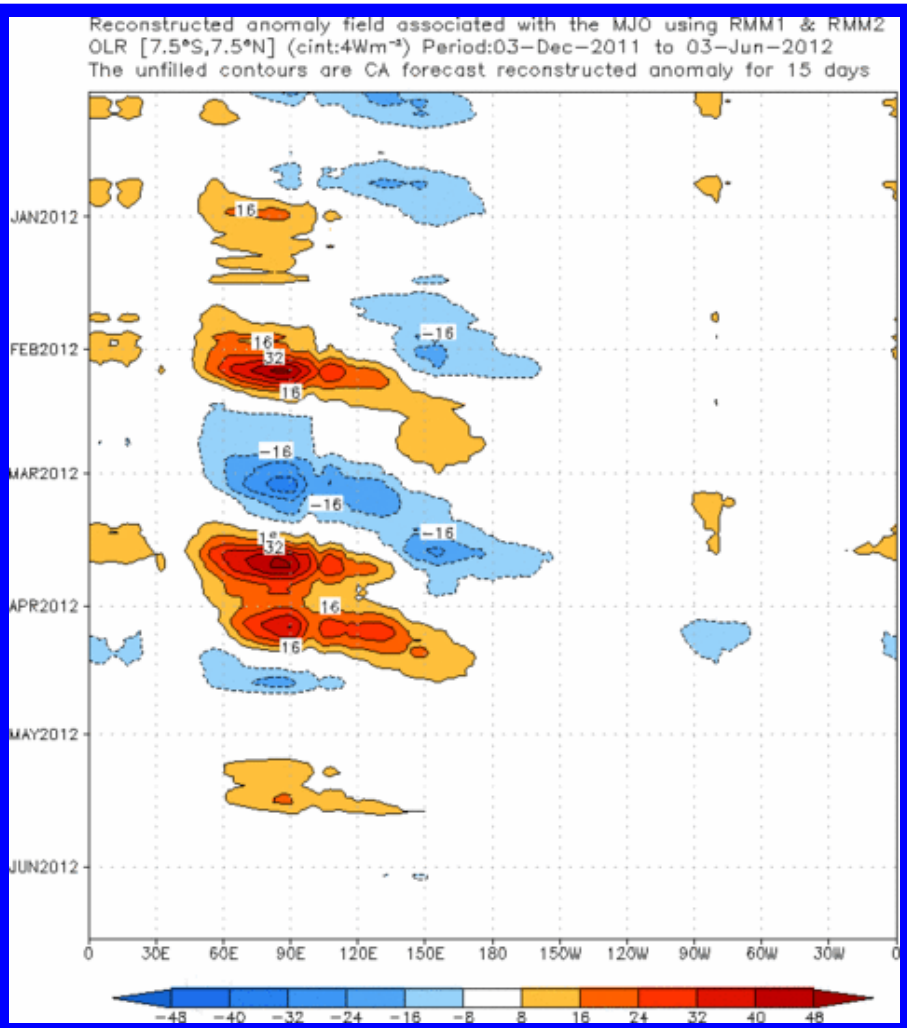
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



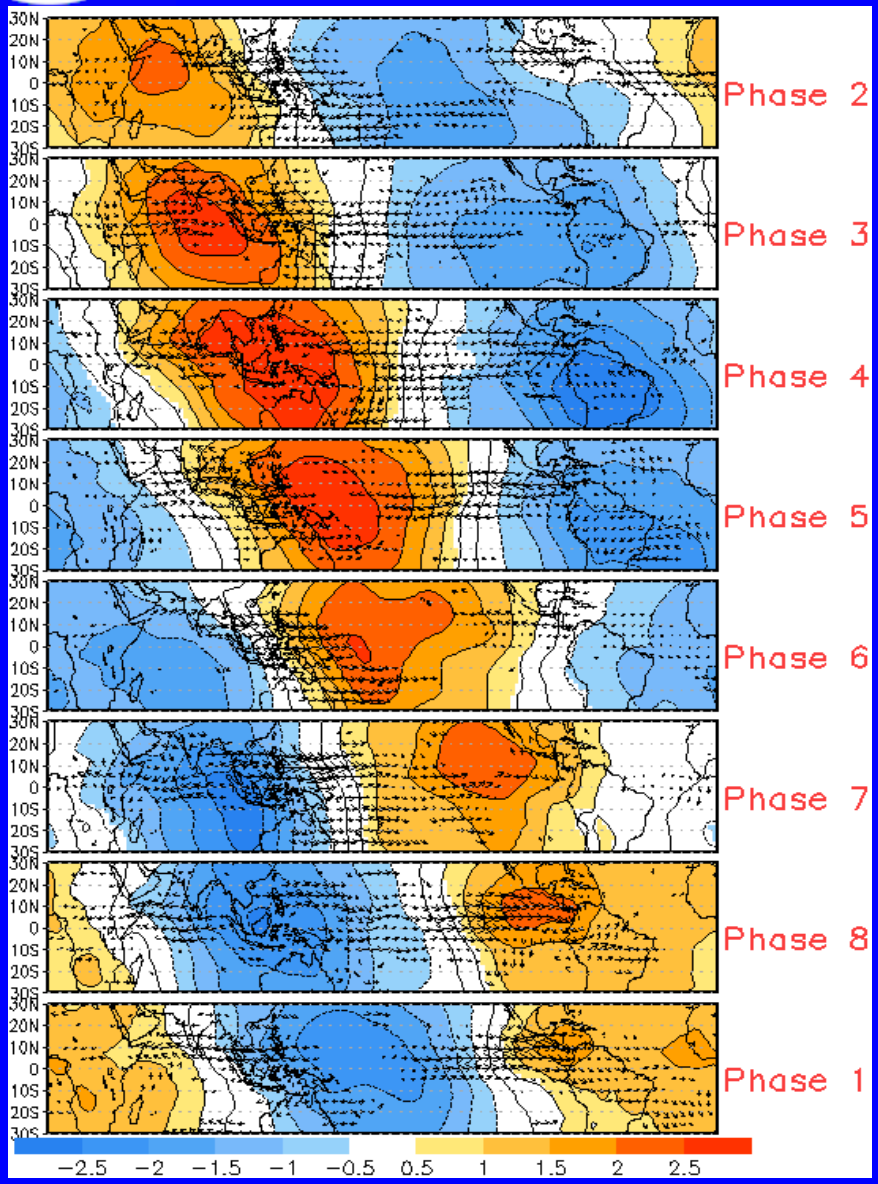
This forecast indicates similar anomalous convection during the period as shown by the GFS, but with considerably weaker signals.

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

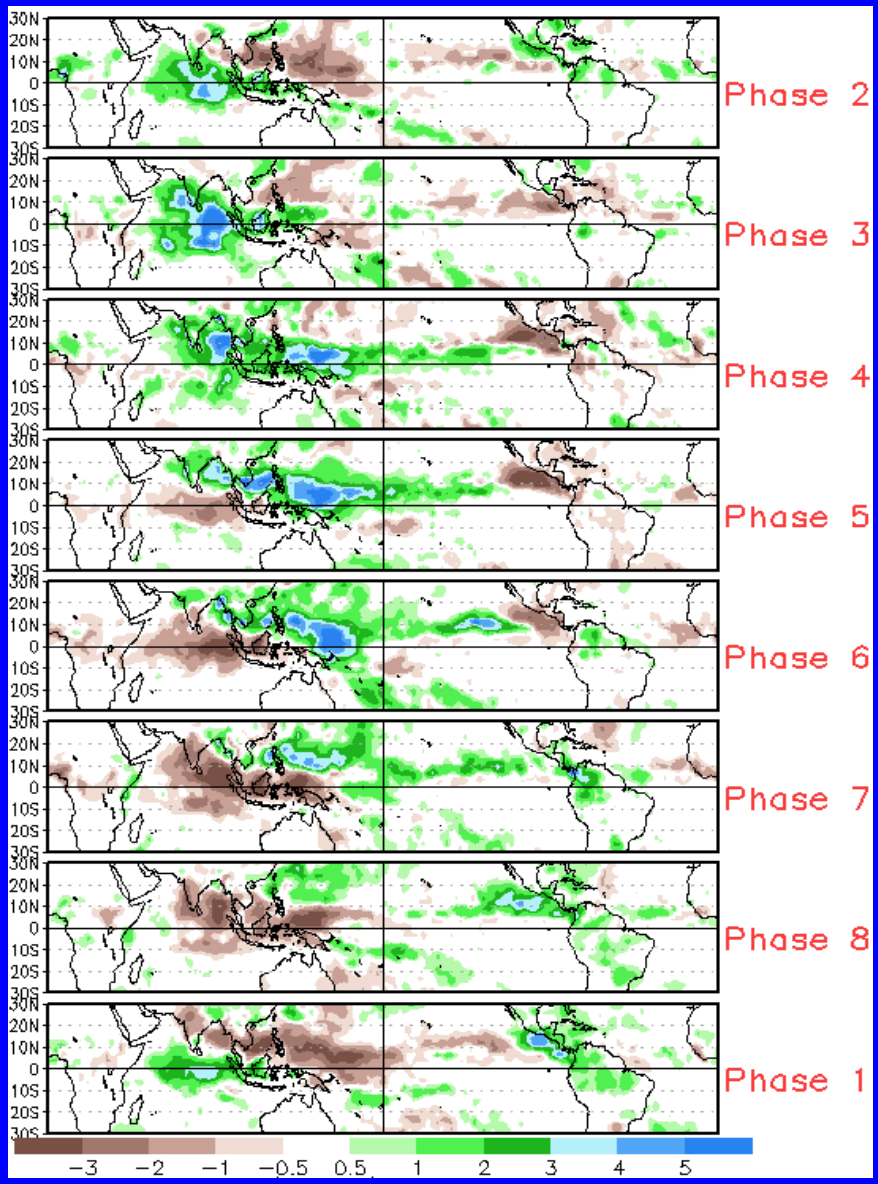


MJO Composites – Global Tropics

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

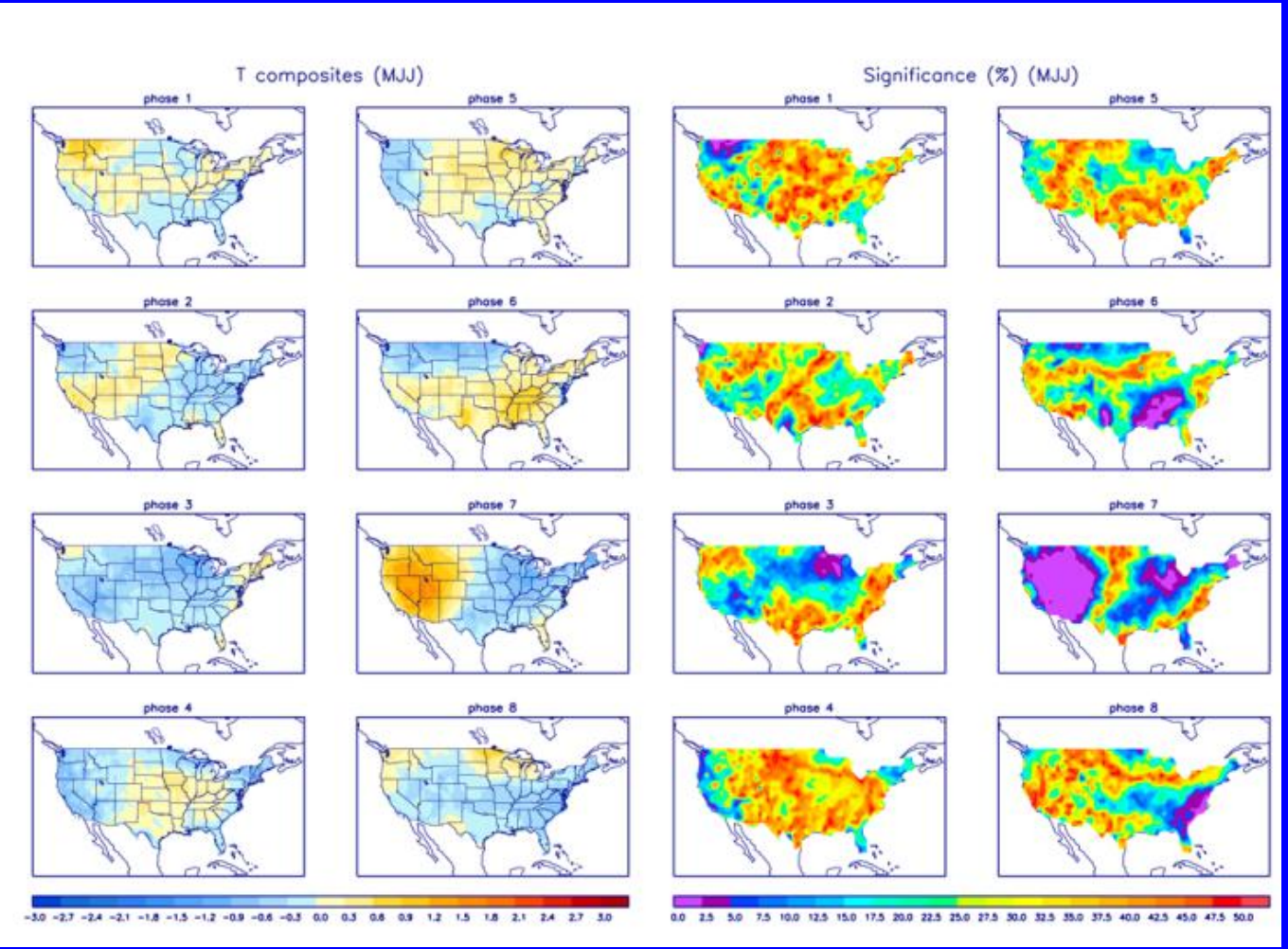


Precipitation Anomalies (May-Sep)



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.**

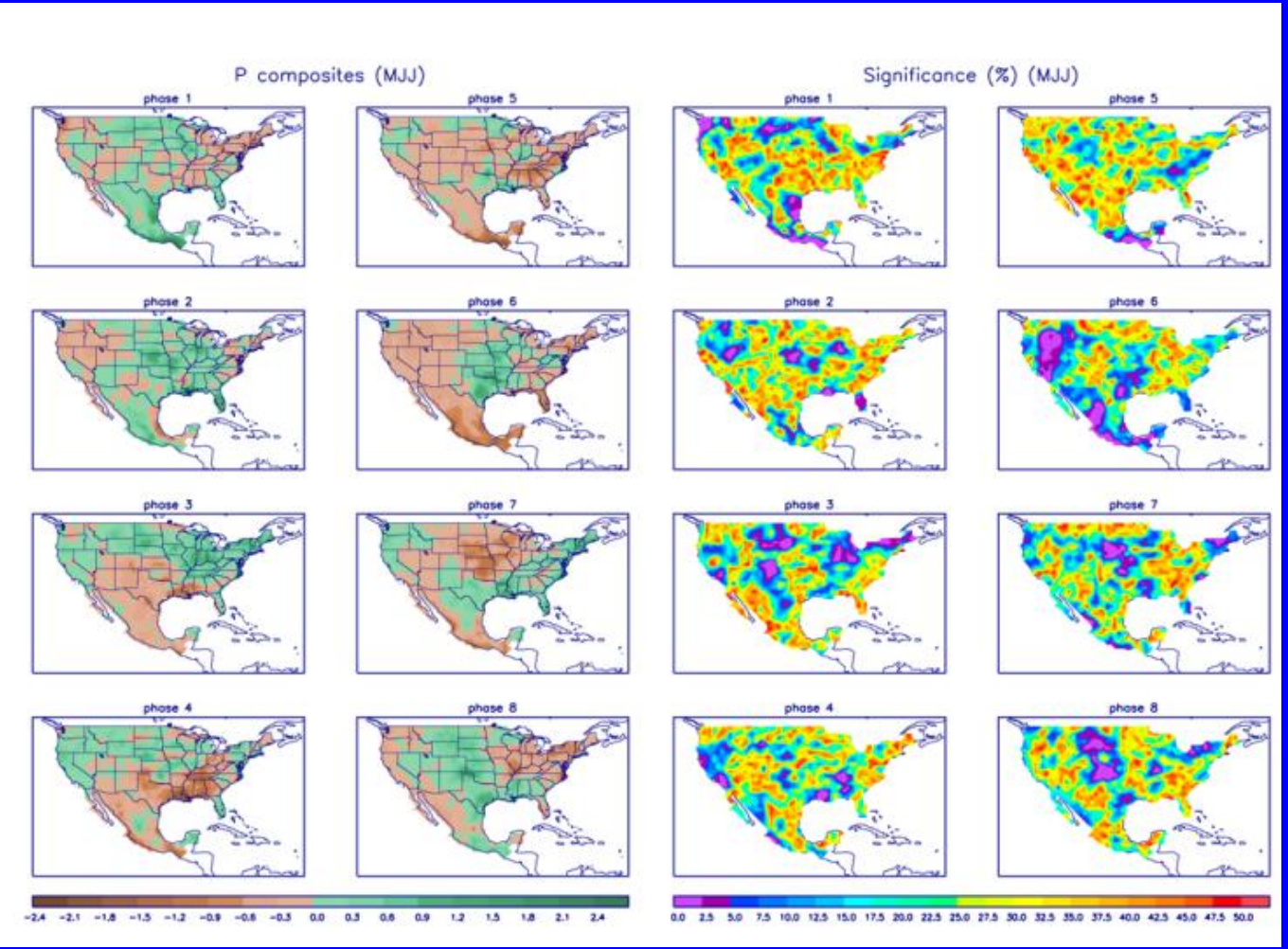


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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