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

Update prepared by
Climate Prediction Center / NCEP
June 11, 2012

Outline

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

Overview

- The MJO index signal strengthened during the past week and has propagated eastward.
- The MJO index forecasts from dynamical models forecast the signal to continue moving eastward at its current strength and there is good agreement amongst the models. Both a strong atmospheric Kelvin wave and the MJO are contributing to the MJO index forecast signal and there are likely to be multiple areas of enhanced convection over the period.
- Based on the latest observations and model forecasts, the MJO is forecast to continue during the next 1-2 weeks with the enhanced phase continuing to shift eastward across the Pacific.
- The MJO favors enhanced rainfall across many areas of the Pacific (Weeks 1-2) and Central America over the course of the next two weeks. Drier-than-average conditions are favored across parts of the Indian Ocean and Maritime continent.

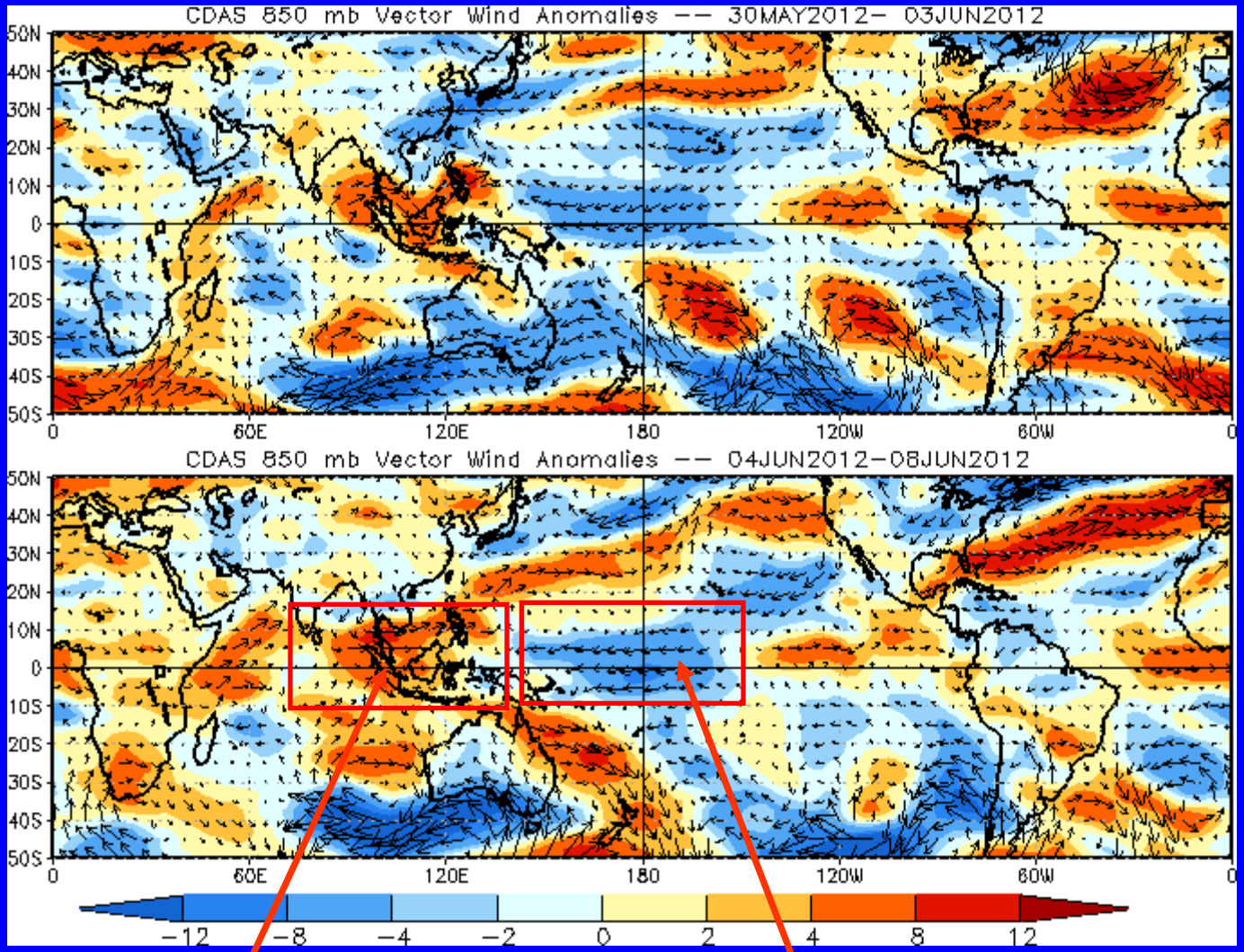
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



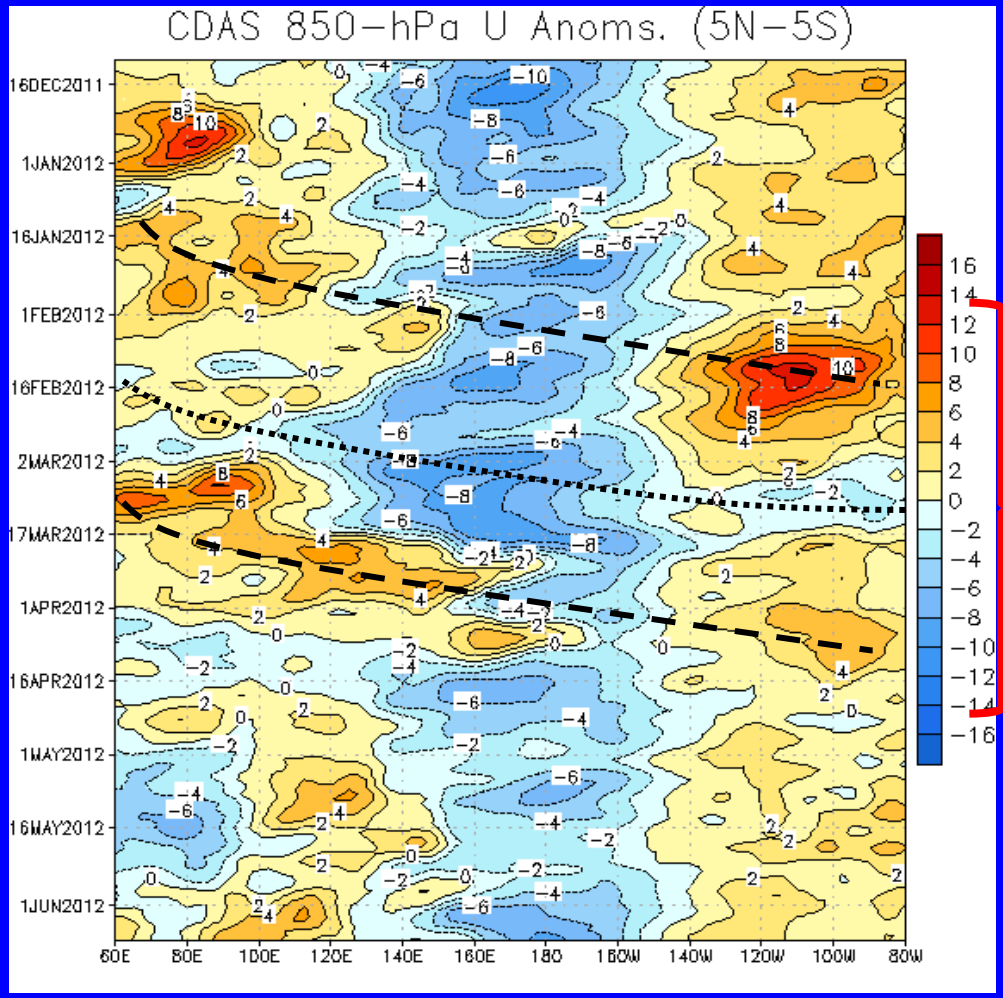
Westerly anomalies continued across parts of the Maritime continent. They also developed across Africa and the Indian Ocean.

Easterly anomalies continued 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

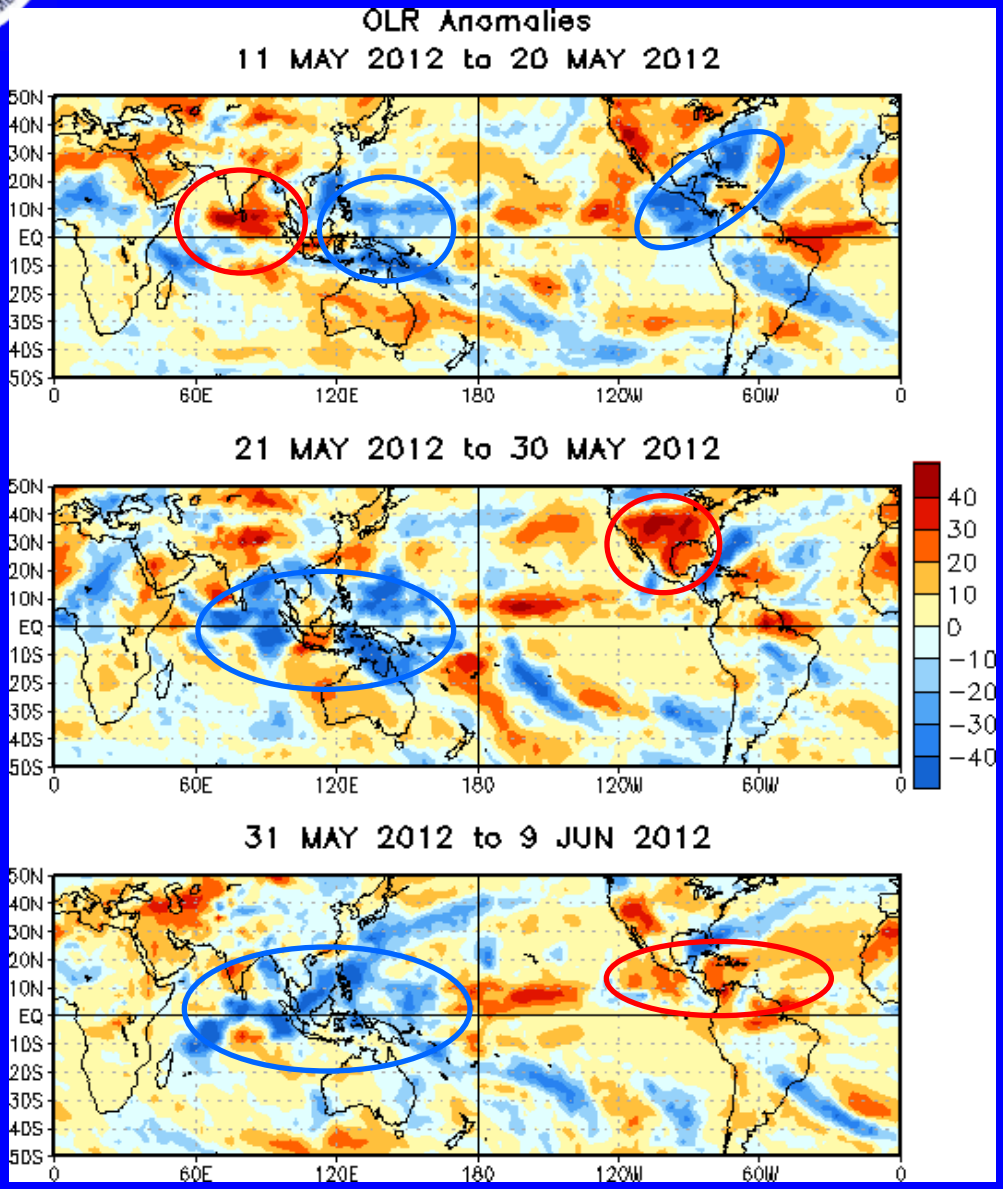
During much of mid-to-late December and the first half of January, on average, westerly (easterly) wind anomalies across the Indian Ocean (western Pacific) became more stationary.

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)

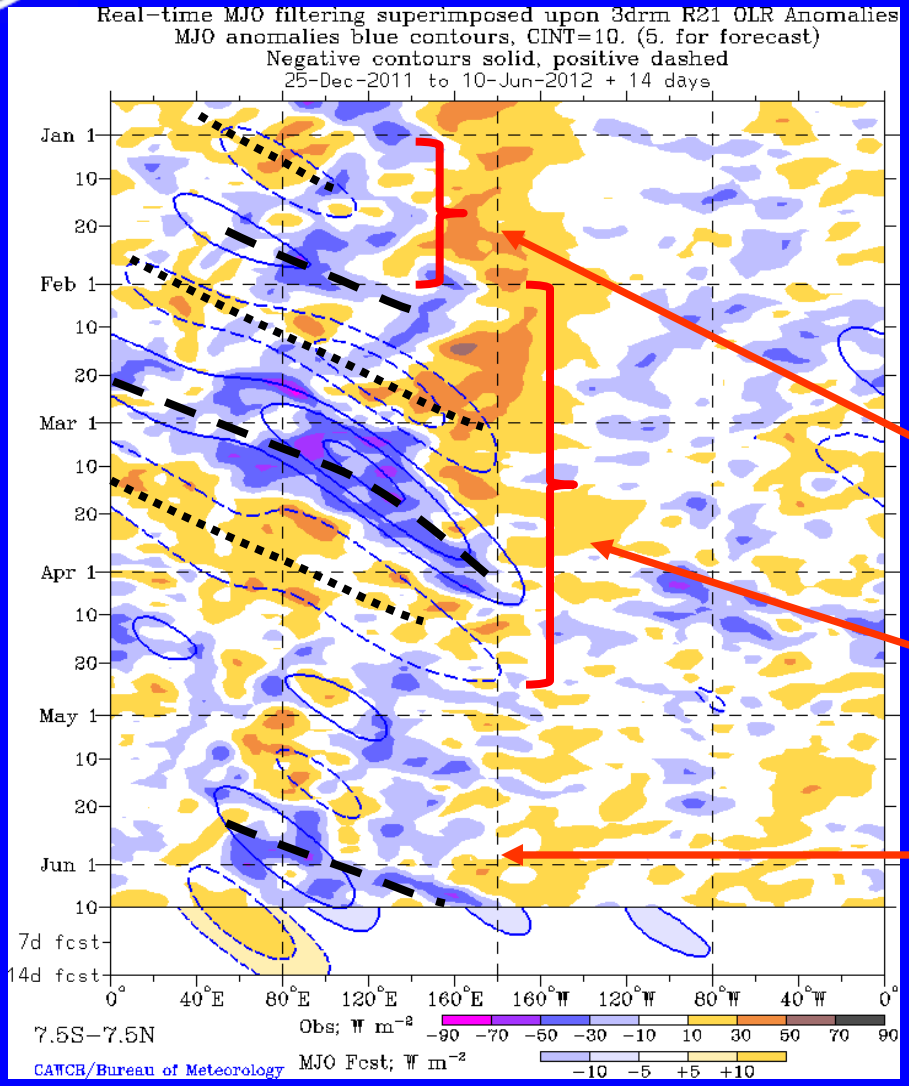
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

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 developed over the Indian Ocean and continued across the eastern Pacific and parts of the Maritime Continent in late May. Drier than average conditions continued across much of the southern U.S. and northern Mexico.

In early June, enhanced convection continued across the Indian Ocean and Maritime Continent region, while suppressed convection strengthened across the western hemisphere.

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.

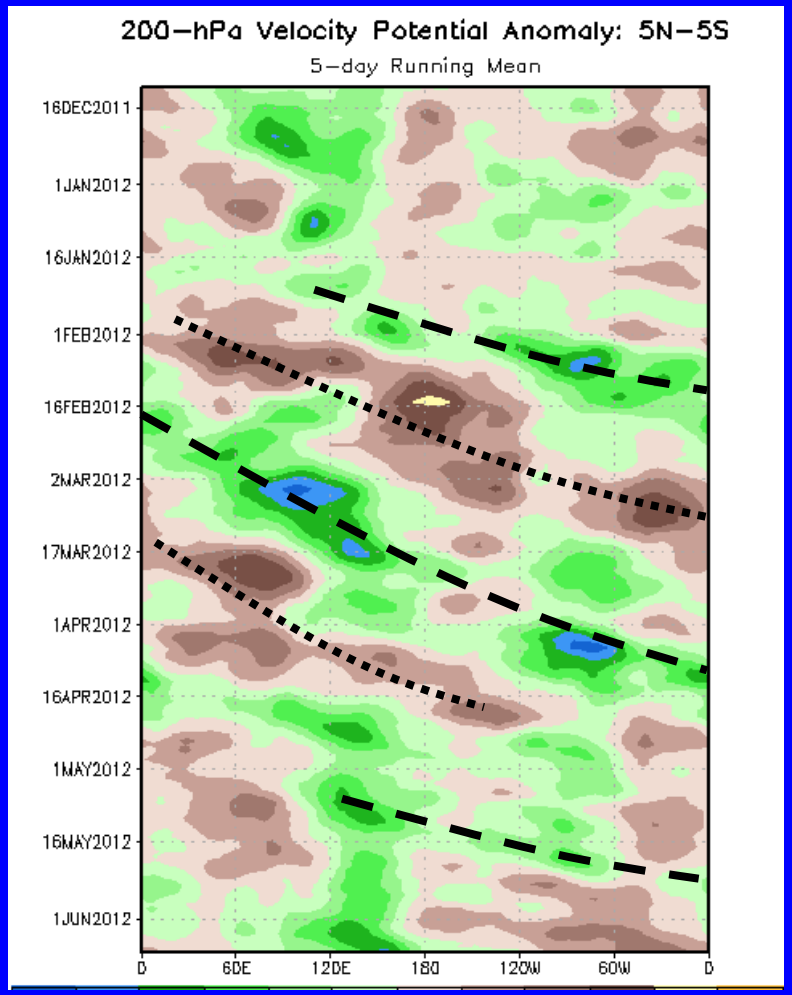
Strong MJO activity once again developed during late January and continued into mid-April. During this same period, other modes of subseasonal variability have also contributed to the observed pattern.

Anomalies became less coherent during the second half of April and much of May. Most recently, some eastward propagation of enhanced convection is evident. The propagation speed is faster than the typical MJO, and may re related to other subseasonal variability like a Kelvin wave.

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.

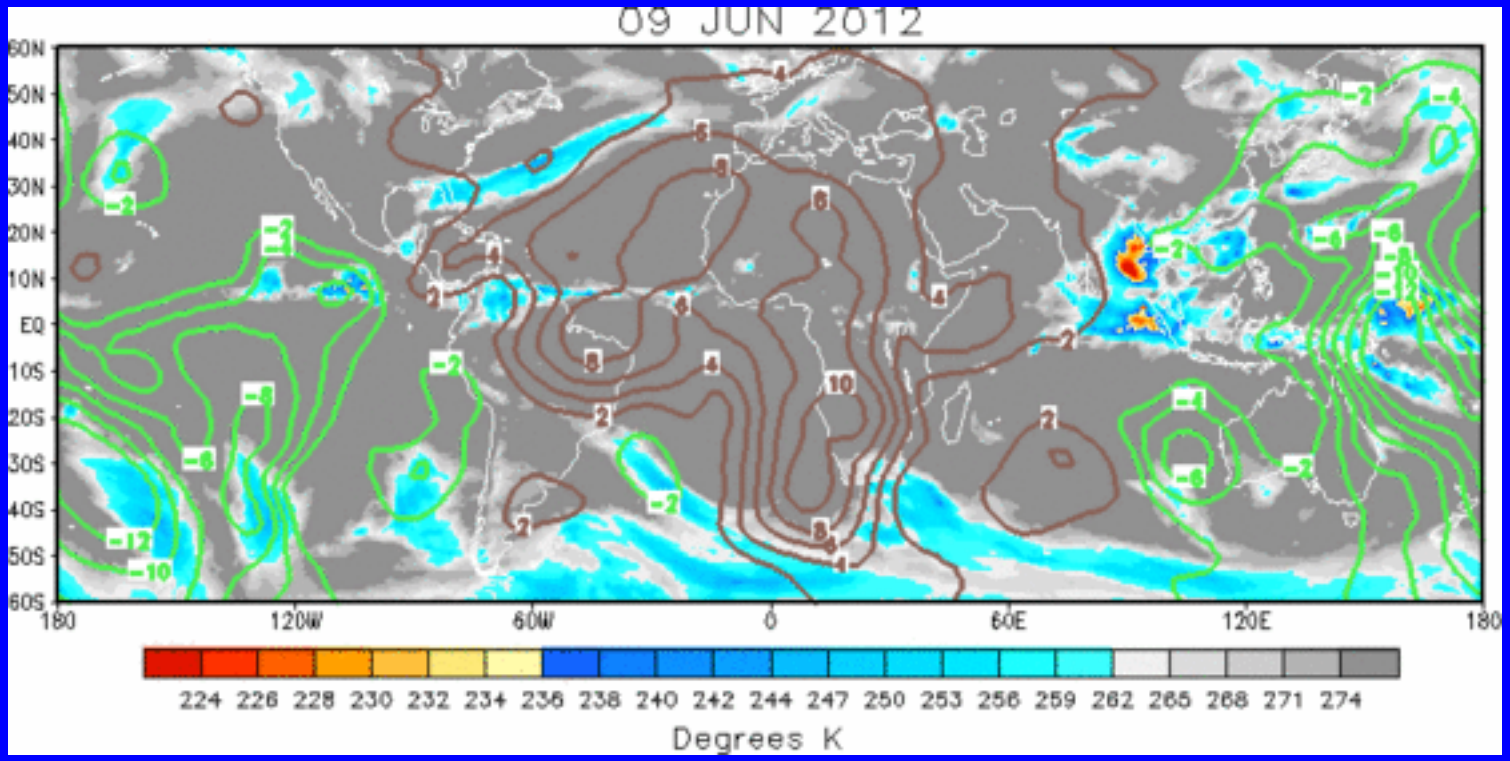
The MJO strengthened in late January as indicated by alternating negative (dashed lines) and positive (dotted lines) anomalies with eastward propagation. The activity continued through mid-April.

Beginning in late April, anomalies became weaker and less coherent than earlier in the year. Some eastward propagation is evident during May, which may be associated with a Kelvin wave.

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

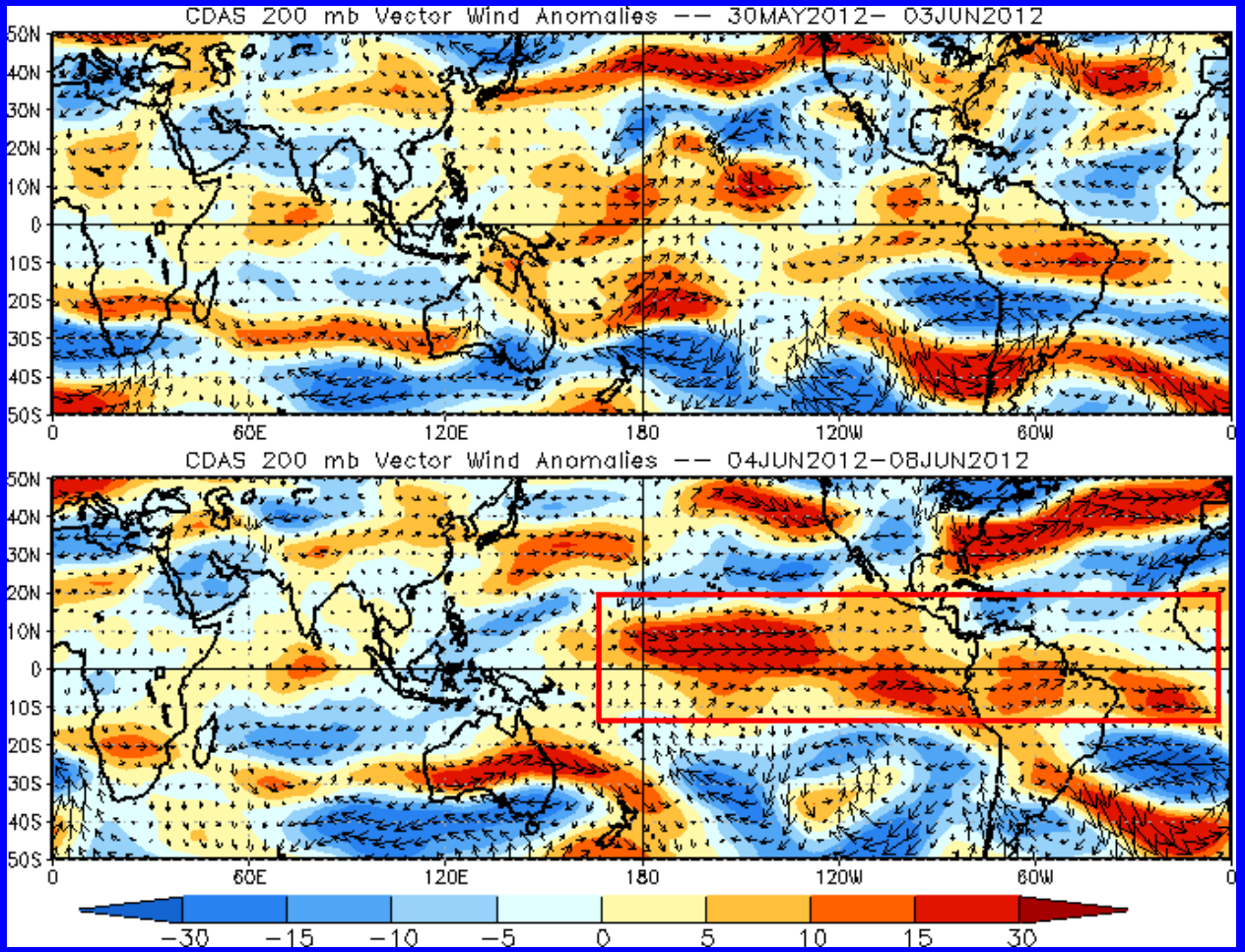
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern reflects upper-level divergence across the Pacific with upper-level convergence located from the Americas to western Indian Ocean. This pattern has been shifting eastward over the past week. The wave-1 structure seen here is consistent with a MJO when it propagates eastward.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

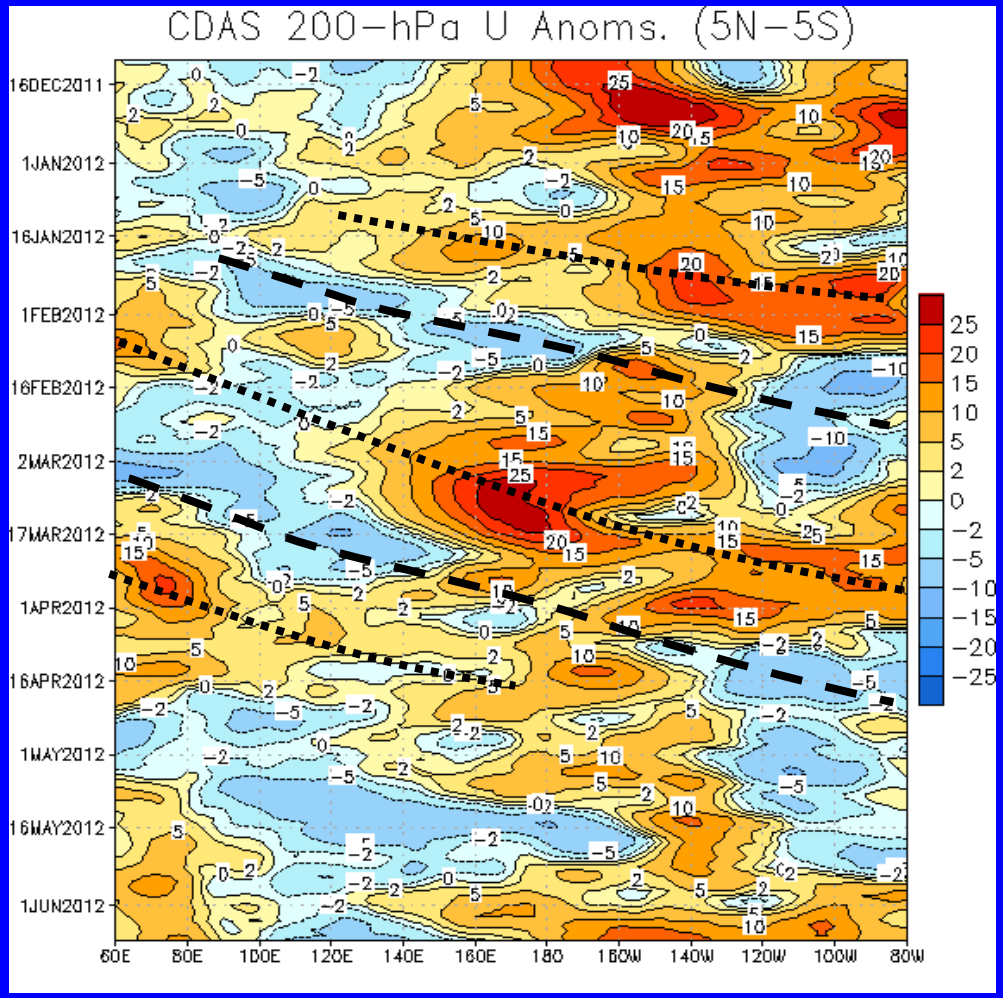
Red shades: Westerly anomalies

Westerly anomalies have strengthened across the central and eastern Pacific and developed across the Atlantic.

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

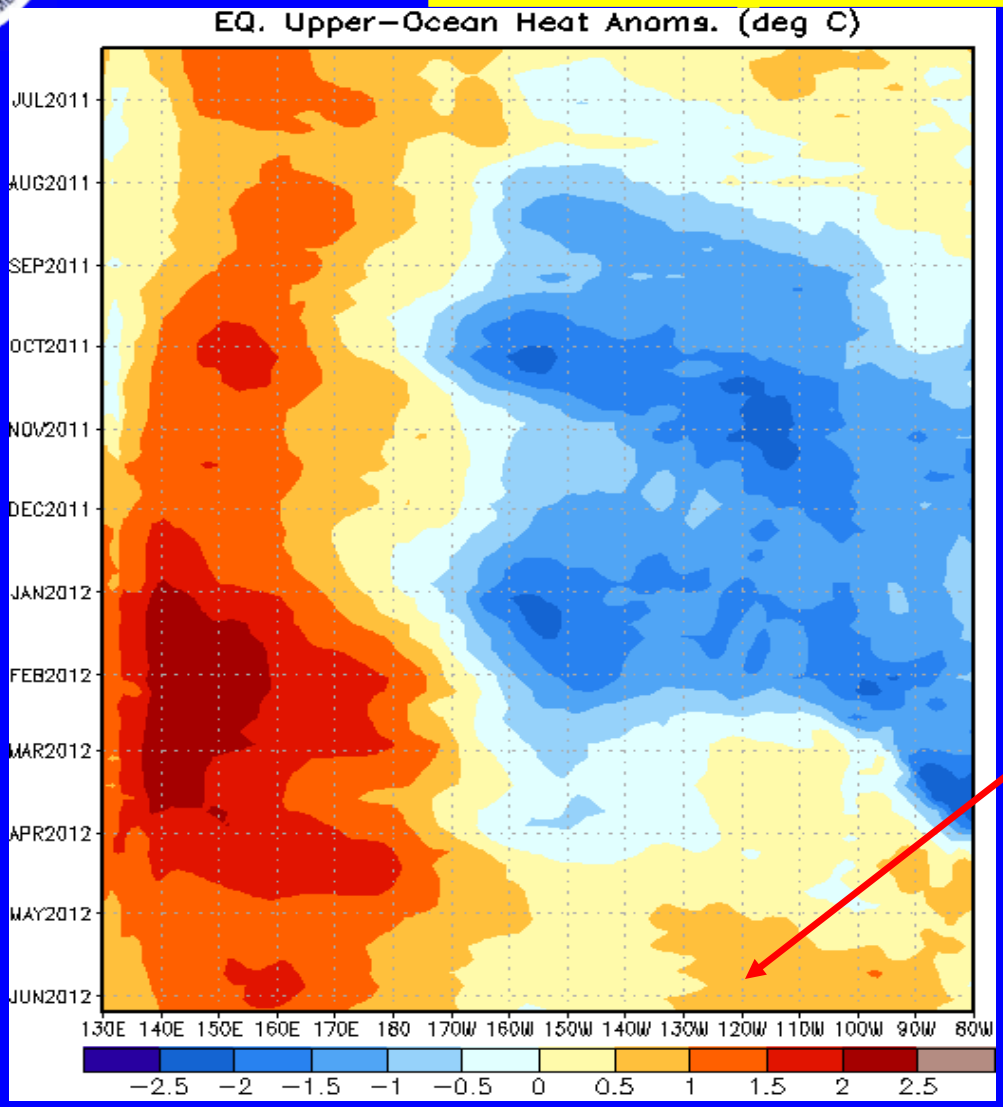
Longitude

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).

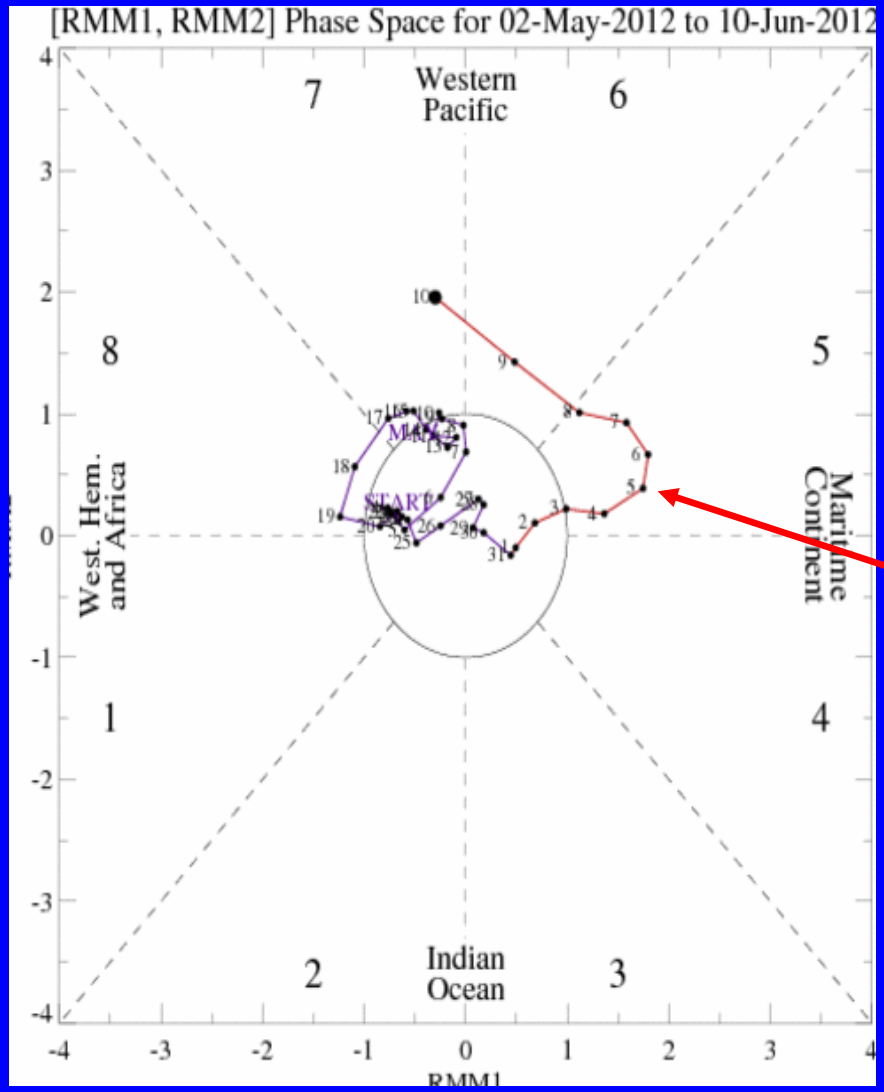
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

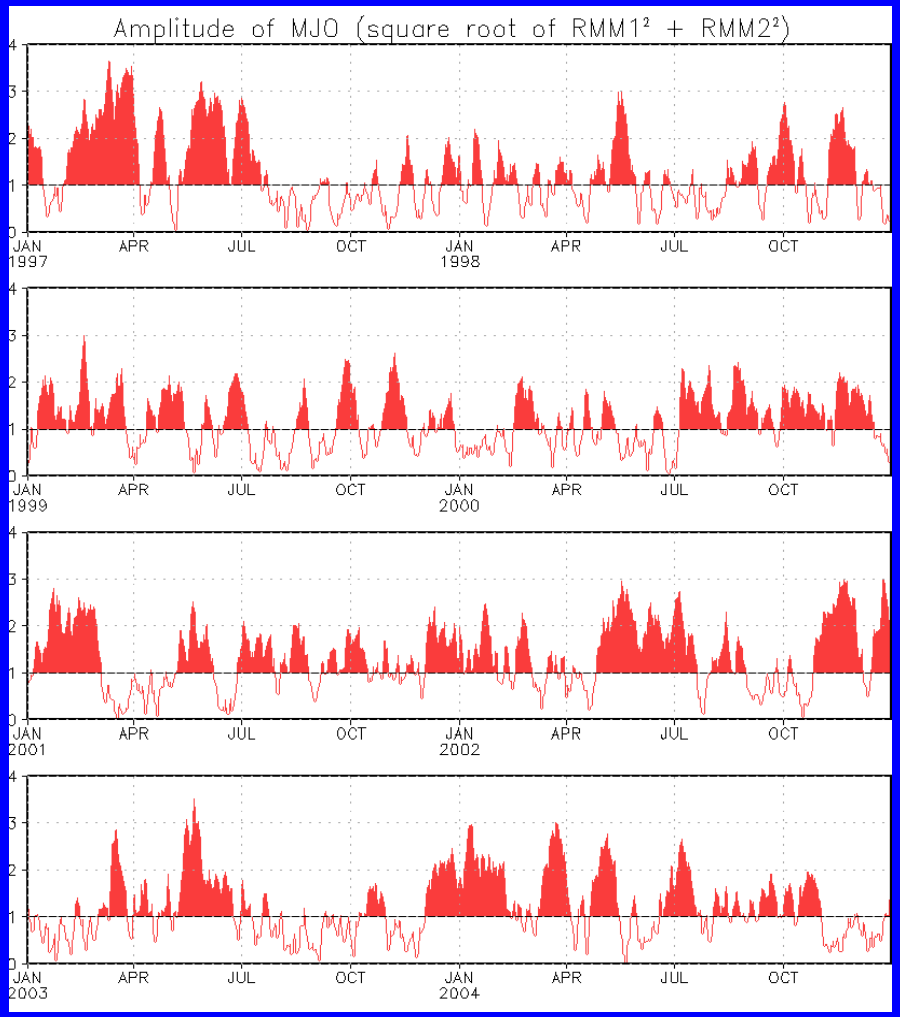
MJO Index -- Recent Evolution

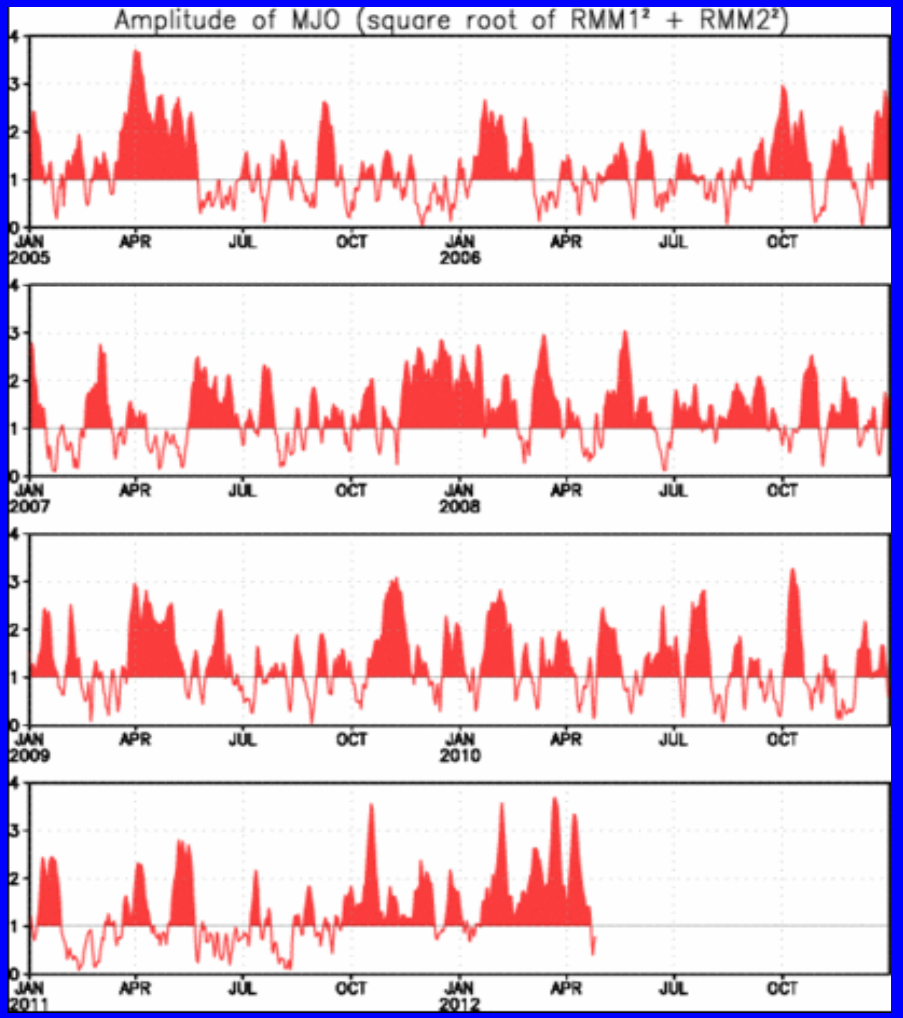


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

In early June, the MJO index strengthened over the Maritime Continent. During the past week, it has propagated eastward across the western Pacific.

MJO Index – Historical Daily Time Series





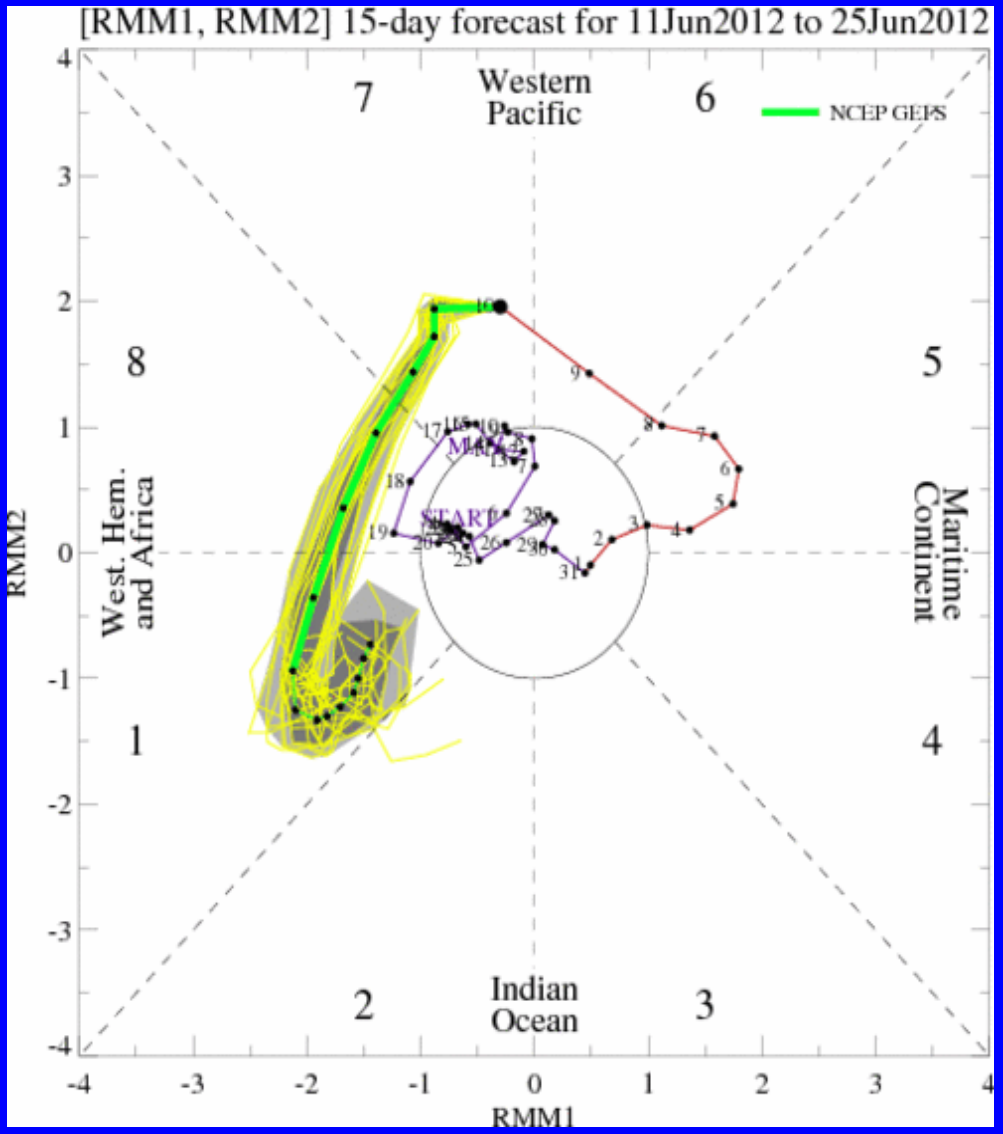
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

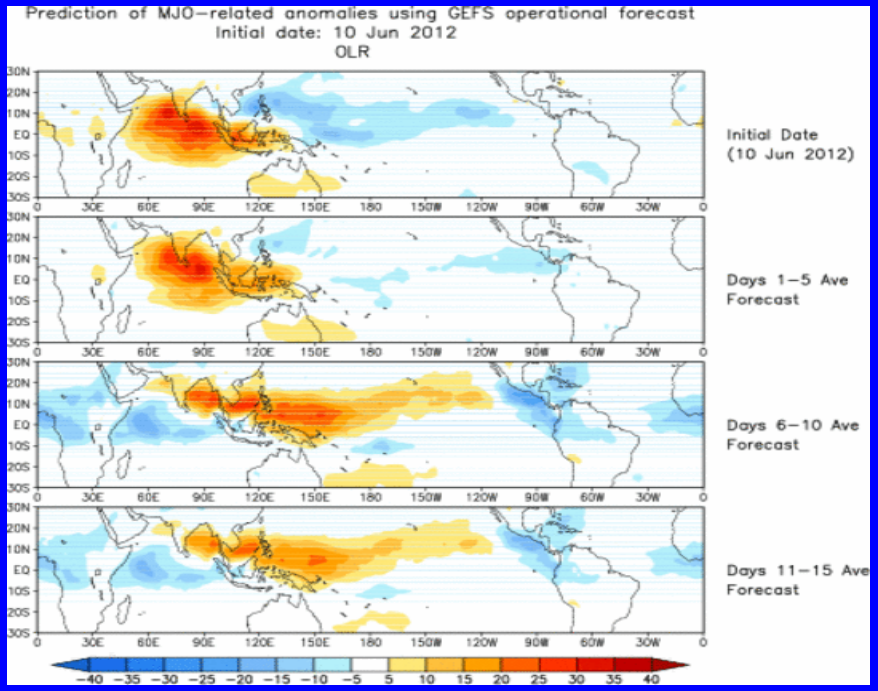


The ensemble GFS forecasts the MJO signal to maintain its strength and continue propagating eastward across the Pacific during week-1 and across the western hemisphere during week-2. Uncertainty is very low with this forecast, as indicated by the tight clustering of the yellow lines.

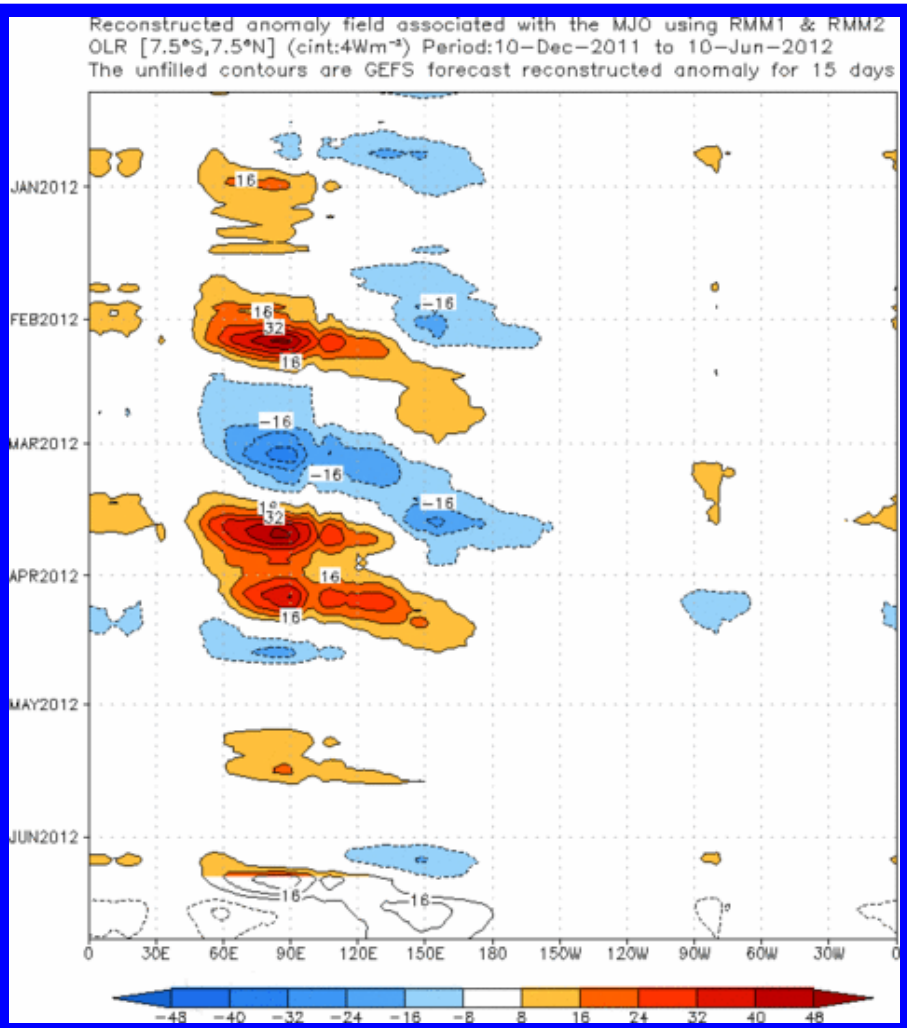
Ensemble Mean GFS MJO Forecast

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

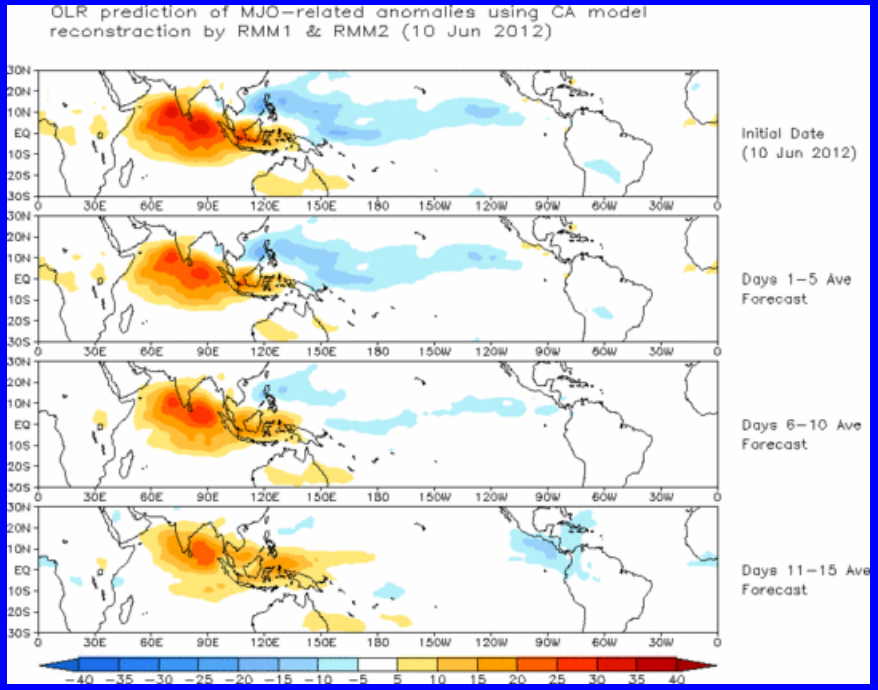


The ensemble mean GFS forecast indicates enhanced convection shifting eastward from the central Pacific into the western hemisphere by week-2. Suppressed convection is forecast for the Indian Ocean during week-1 and the western Pacific during week-2.

Constructed Analog (CA) MJO Forecast

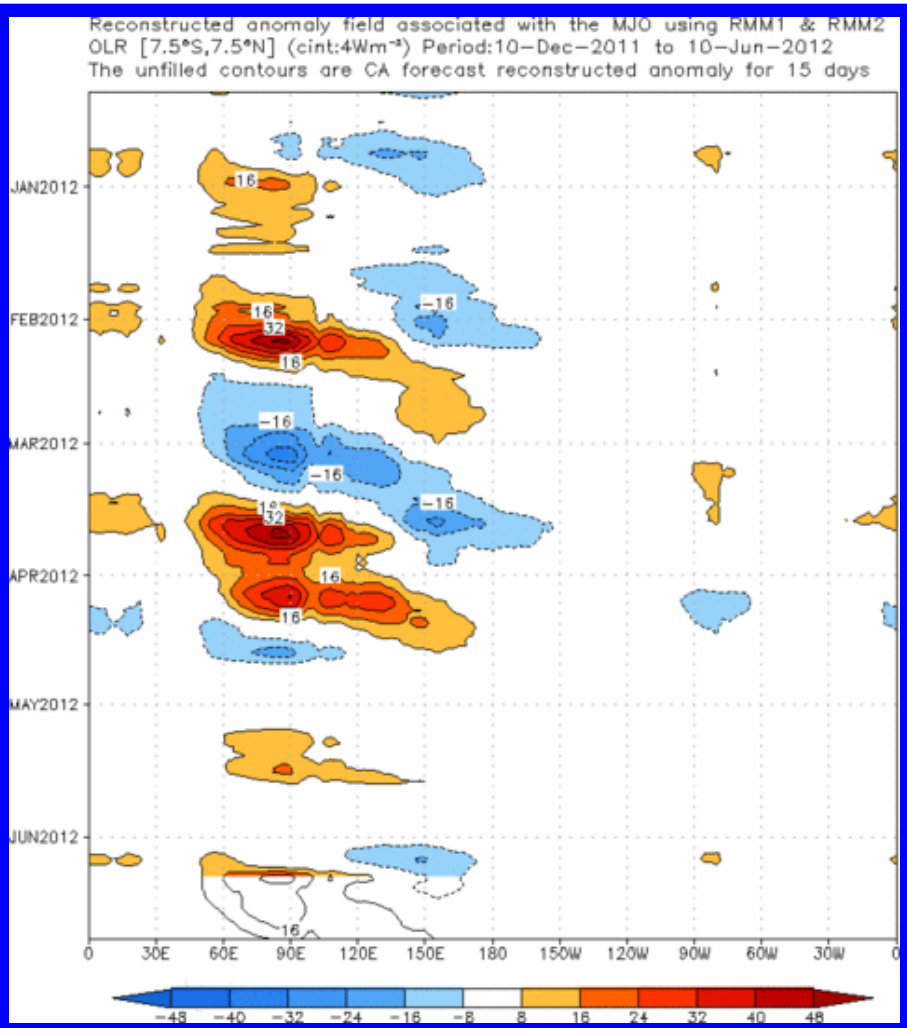
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



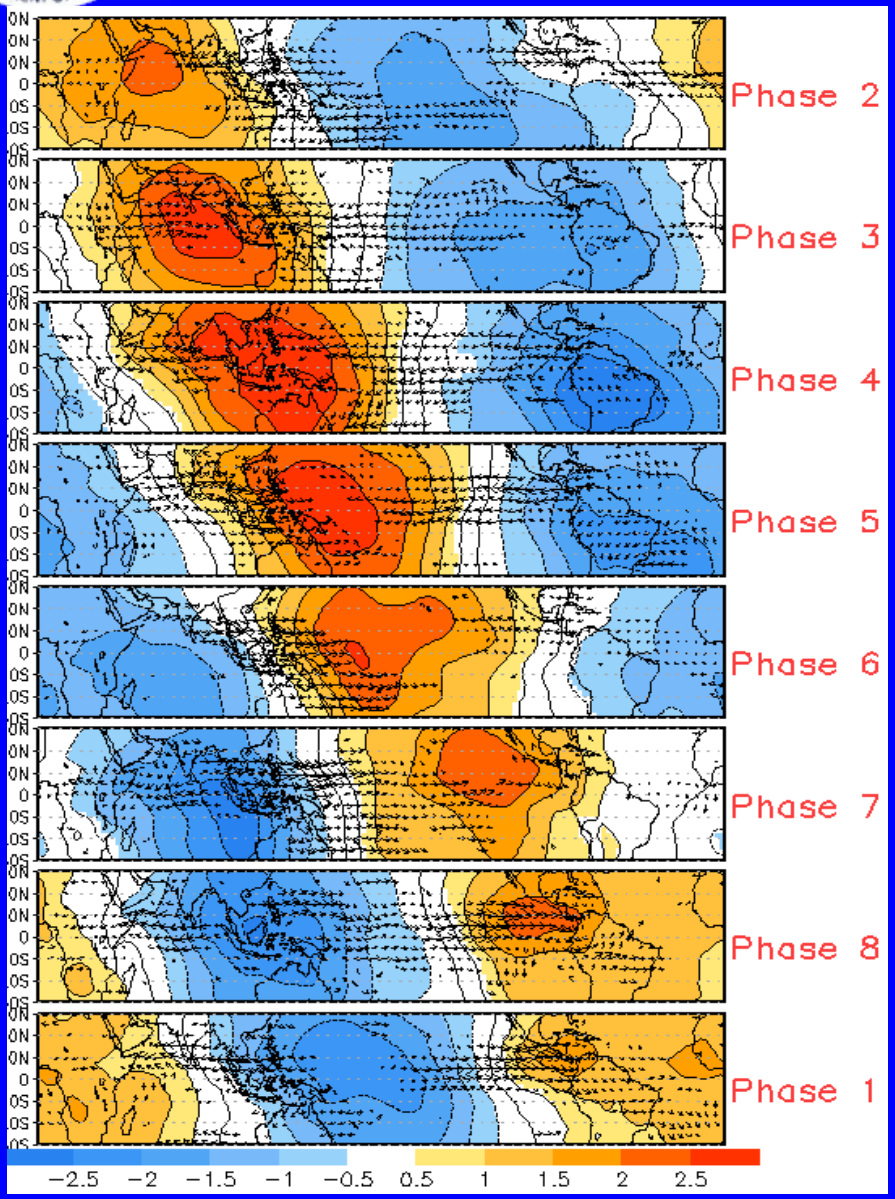
This forecast indicates a slower moving signal with enhanced convection remaining across the western and central Pacific during week-1 and shifting into the eastern pacific during week-2. Suppressed convection is forecast over the Indian Ocean and Maritime Continent.

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

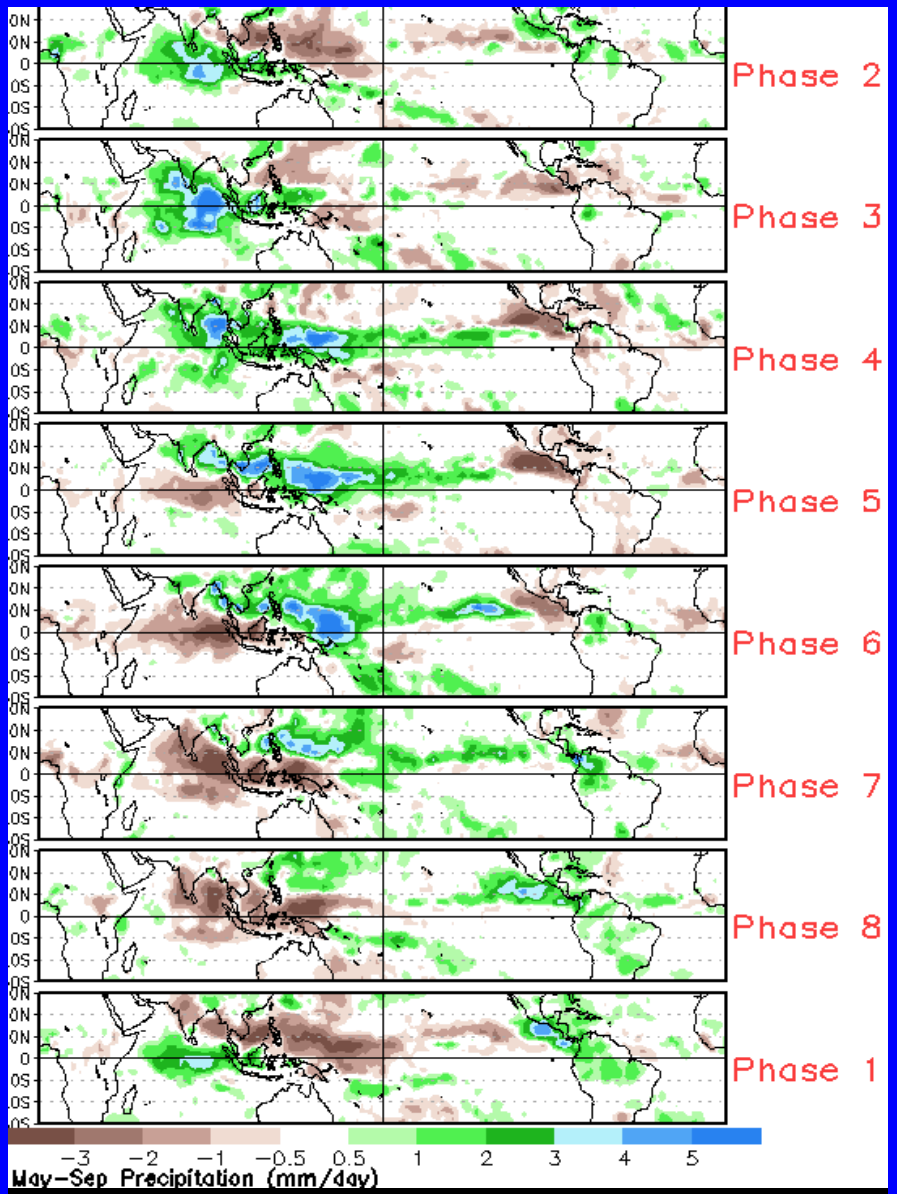


MJO Composites – Global Tropics

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

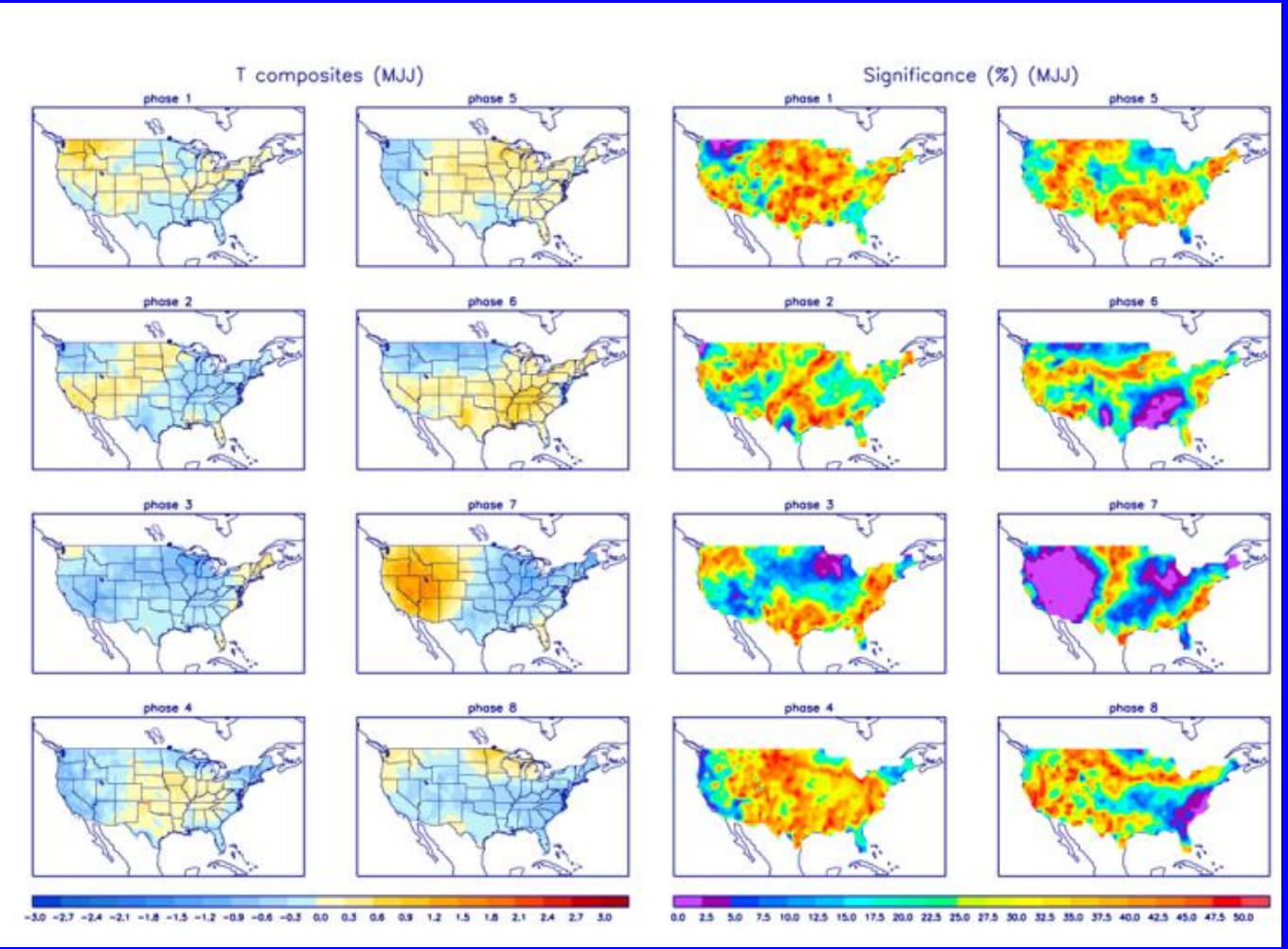


Precipitation Anomalies (May-Sep)



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.**

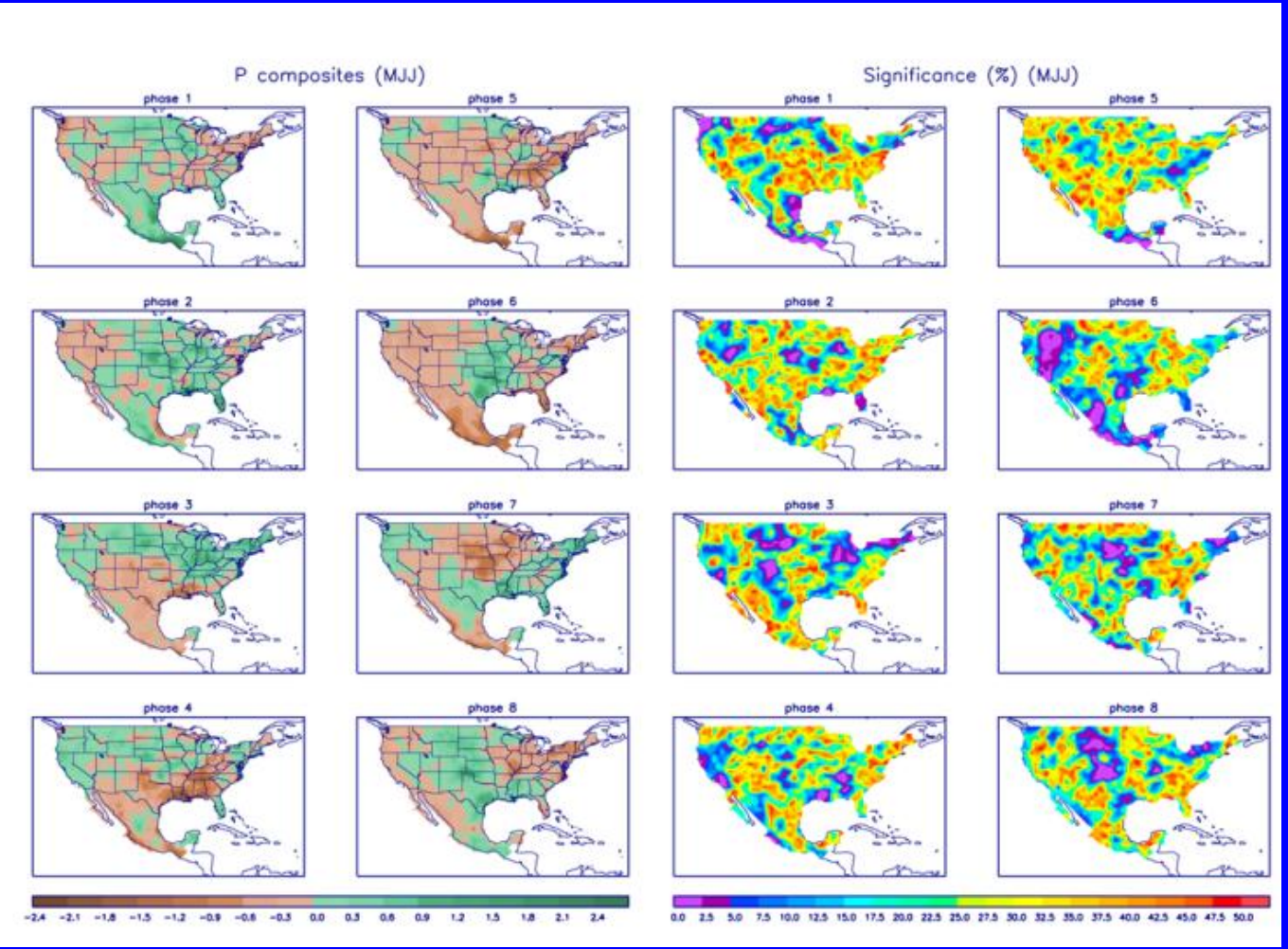


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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