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

Update prepared by
Climate Prediction Center / NCEP
June 18, 2012

Outline

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

Overview

- The MJO signal continued to propagate eastward during the past week with little change in strength.

- The MJO index forecasts from dynamical models show continued activity over the next 1-2 weeks, but vary considerably in their forecast strength and eastward propagation, in part due to contributions from other forms of tropical variability. Statistical models indicate faster and more consistent, eastward propagation.

- 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 to Africa.

- The MJO favors enhanced rainfall across many areas of Africa and the Americas during the course of the next two weeks as well as an increase threat for tropical cyclogenesis for areas of the eastern Pacific and western Atlantic basins. Drier-than-average conditions are favored across parts of the eastern Indian Ocean and Maritime continent as well.

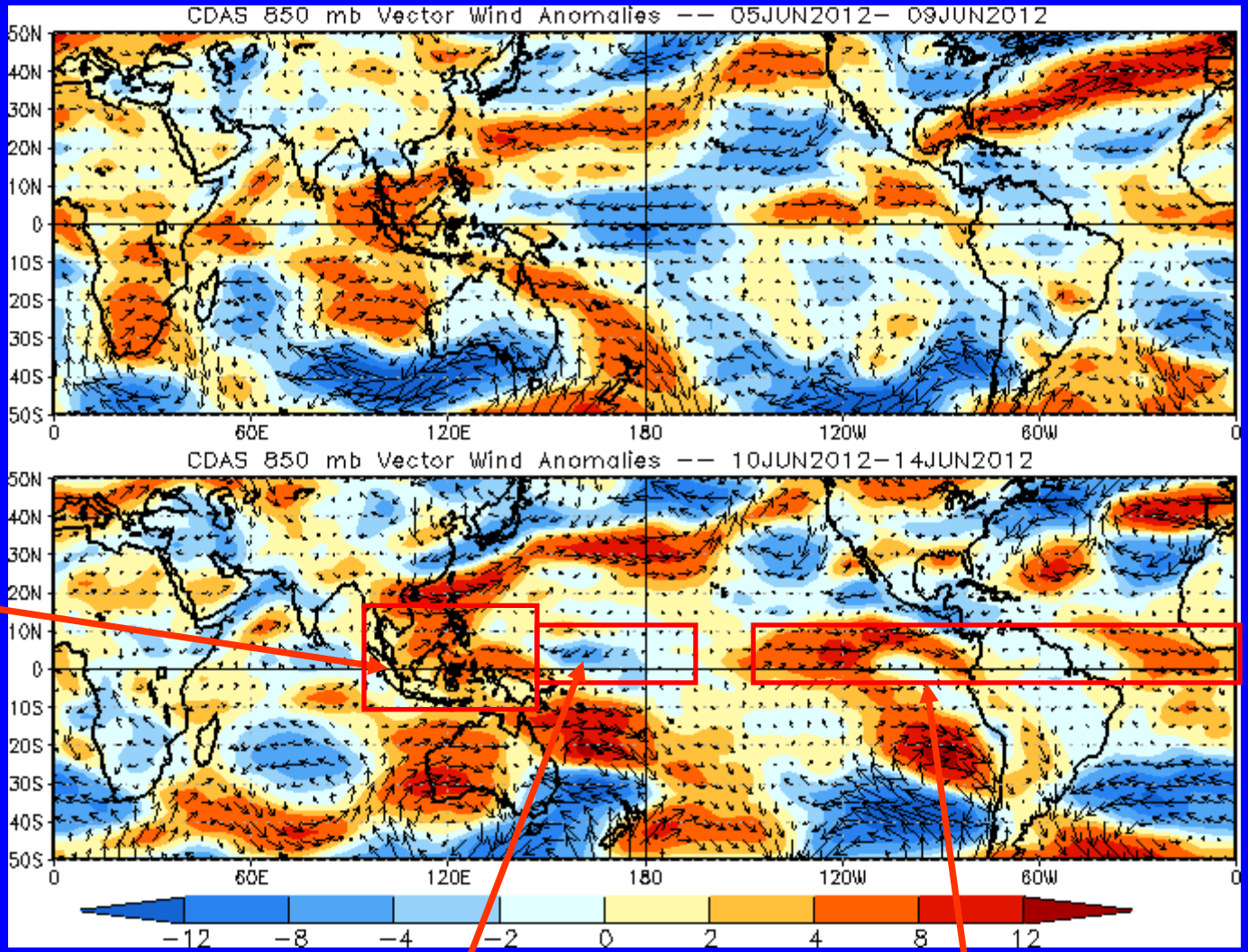
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 and western North Pacific.

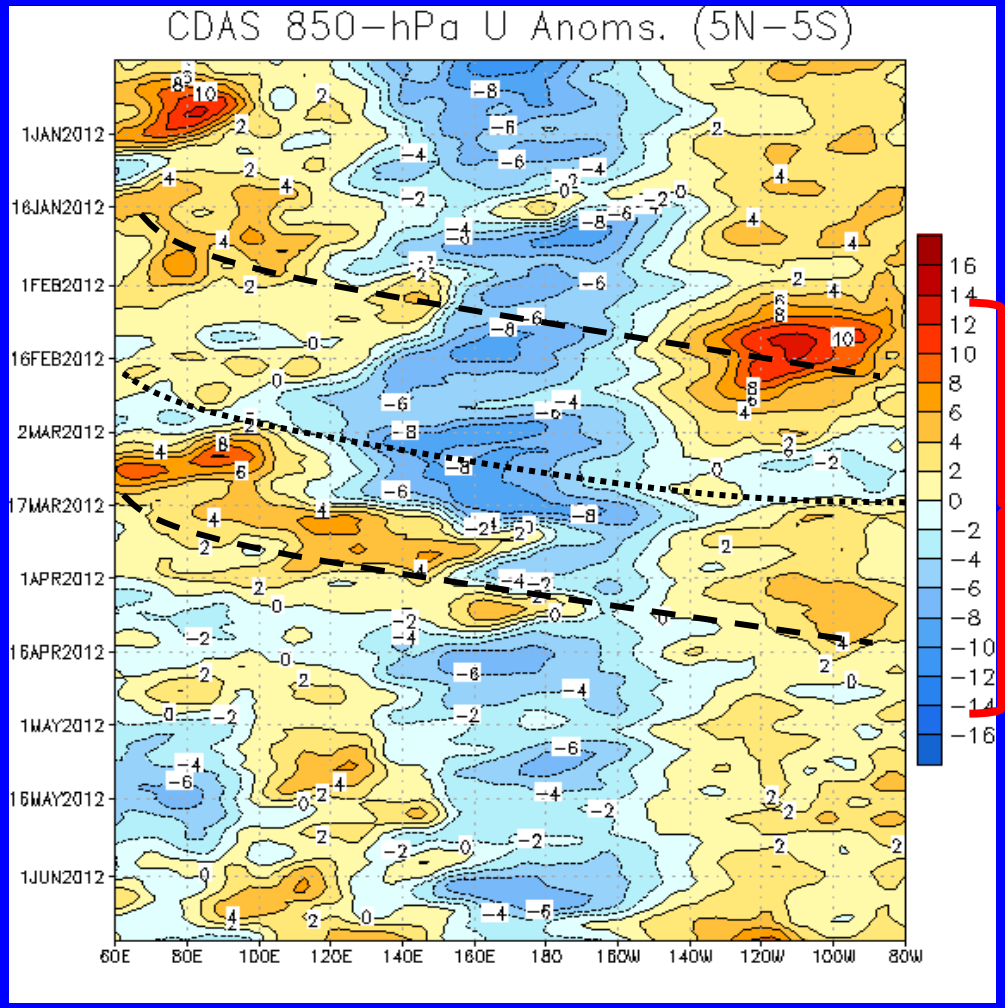
Easterly anomalies diminished over the central Pacific during the last five days.

Westerly wind anomalies increased across the eastern Pacific and 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

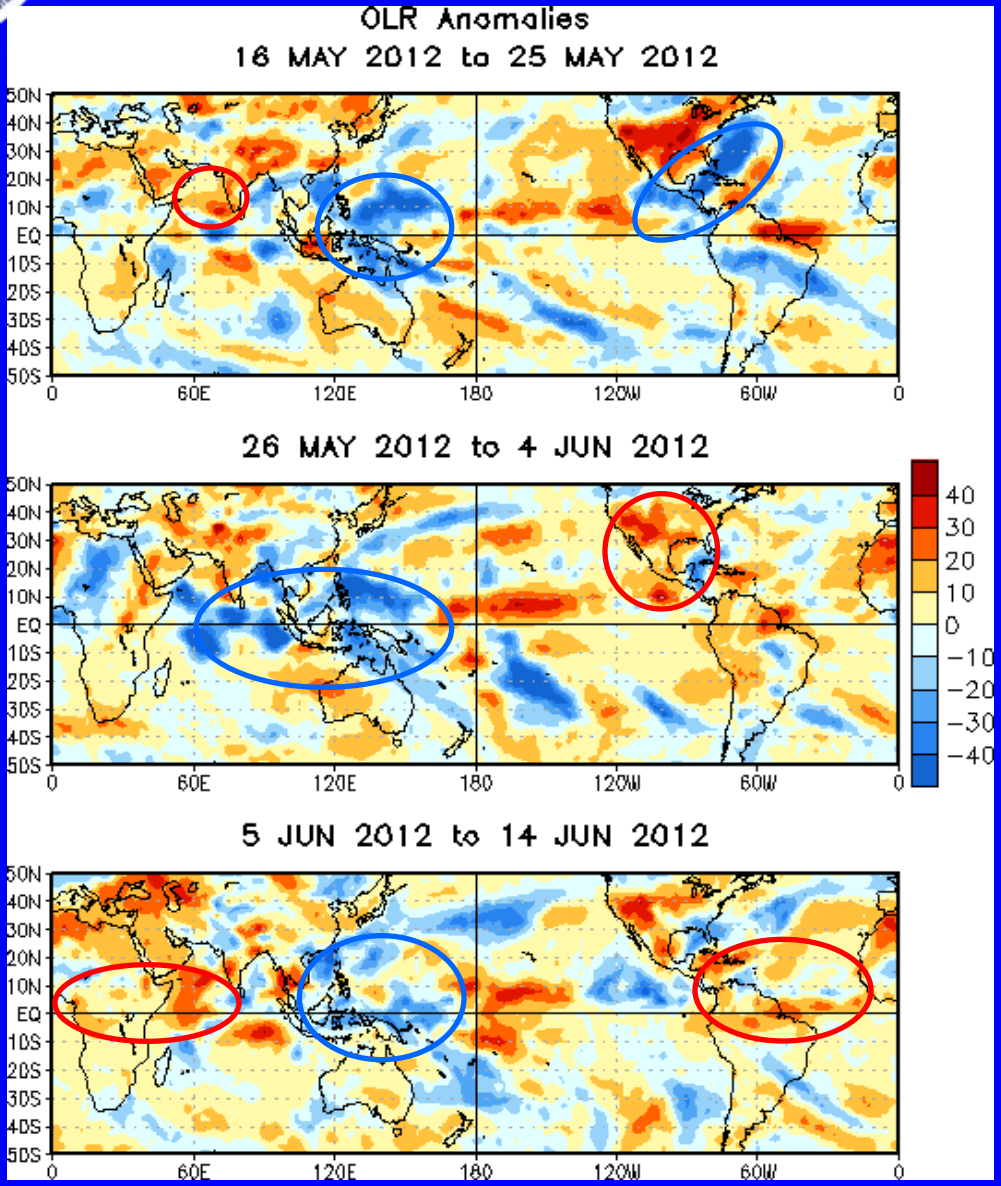
During much of mid-to-late December and the first half of January, on average, westerly (easterly) wind anomalies across the Indian Ocean (western Pacific) became more stationary.

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. Westerly anomalies have increased across the eastern Pacific in the last several days.

OLR Anomalies – Past 30 days



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

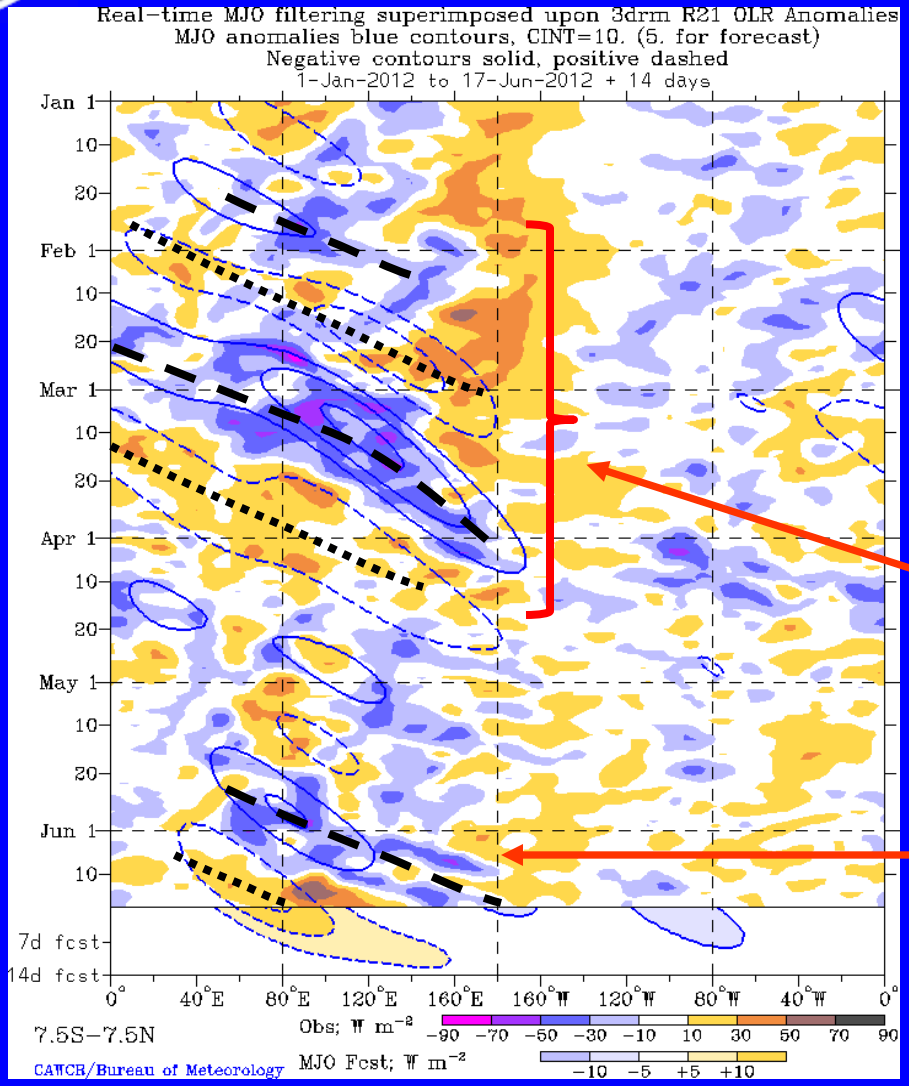
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-to-late May, suppressed convection continued across southern India with enhanced convection observed over the western Pacific, South China Sea, and from the eastern Pacific to the Bahamas.

Enhanced convection developed over the Indian Ocean and parts of the Maritime Continent in late May and early June. Drier than average conditions continued across much of the southern U.S. and northern Mexico, while also spreading across the eastern Pacific.

In early to mid-June, enhanced convection continued across the western North Pacific and once again developed over the eastern Pacific. Suppressed convection strengthened from northern South America, across Africa to the western Indian 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)

Strong MJO activity (alternating dashed and dotted lines) 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.

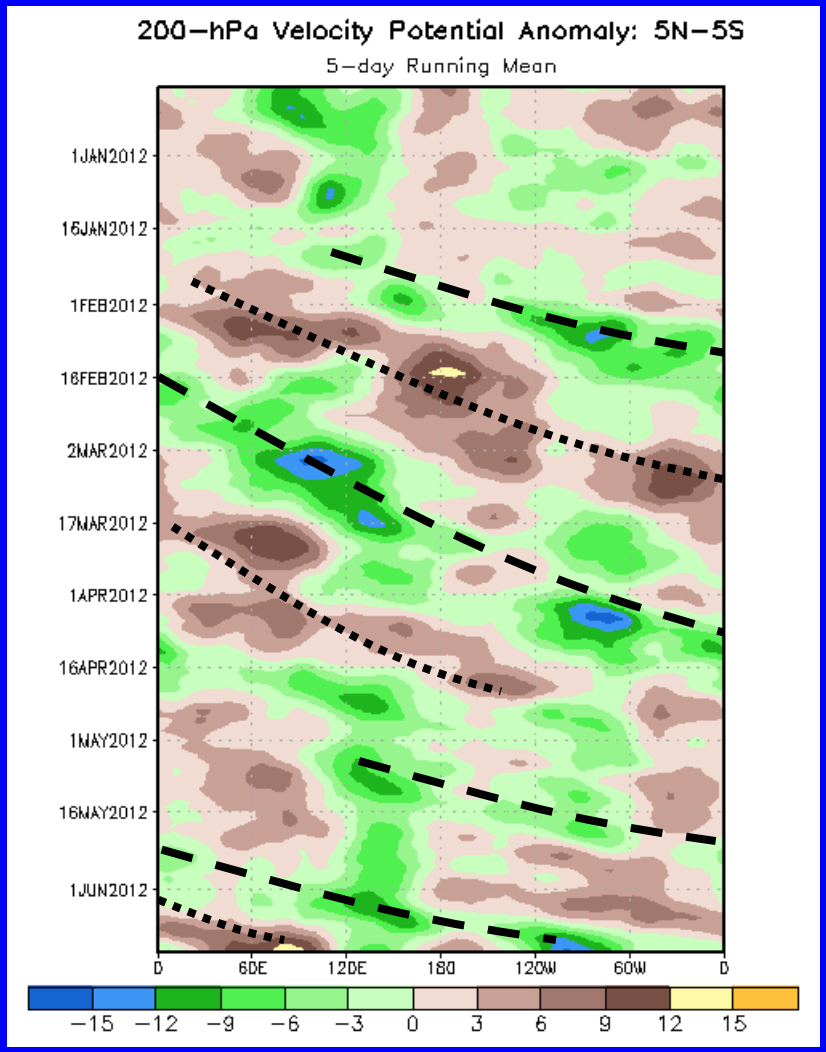
Anomalies became less coherent during most of April and May.

Most recently, eastward propagation of an enhanced/suppressed convection couplet is evident. Atmospheric Kelvin wave activity is playing a large role in the pattern of anomalous convection across the Pacific and the western Hemisphere as seen by the two separate, more horizontal lines of blue shades during June.

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.

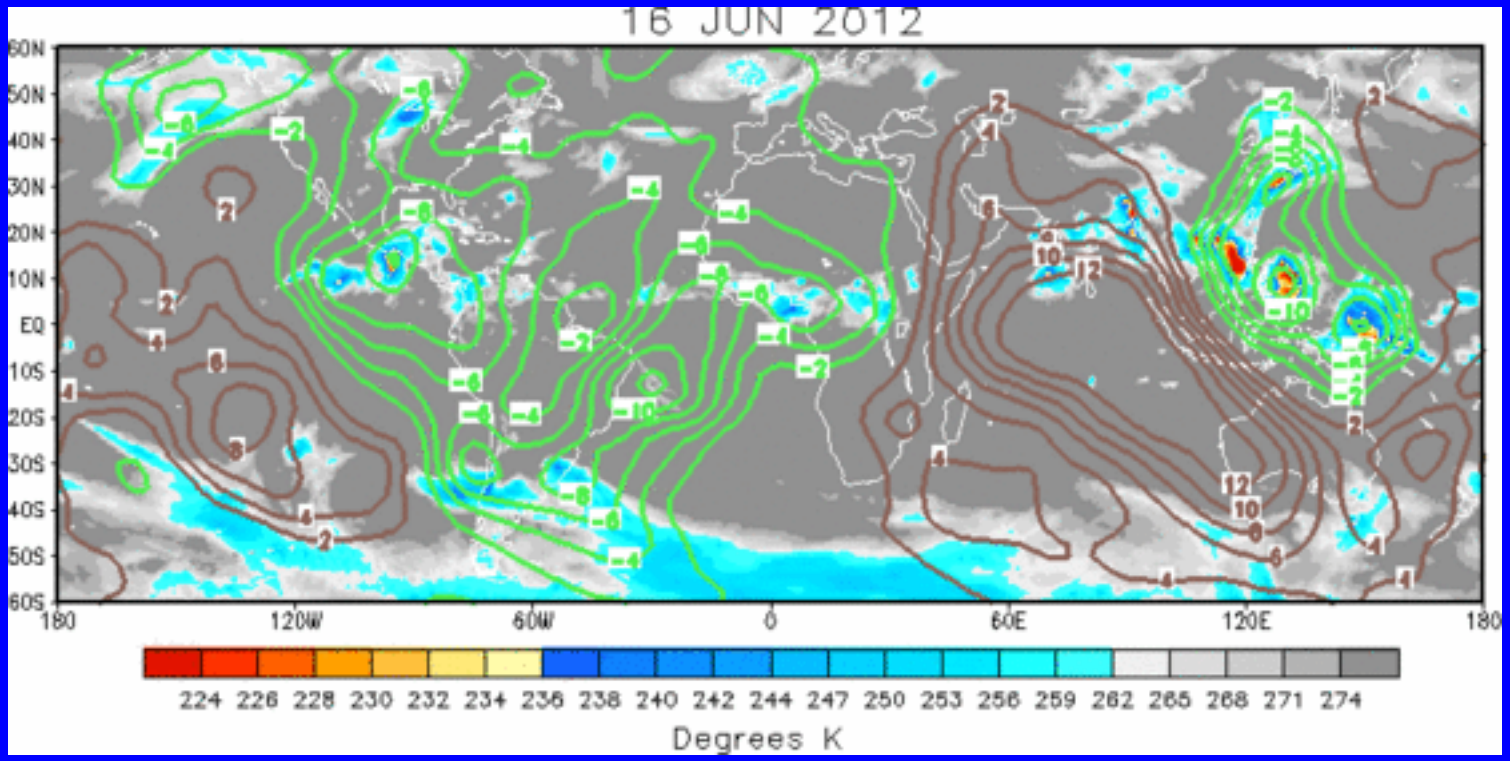
The MJO strengthened in late January as indicated by alternating negative (dashed lines) and positive (dotted lines) anomalies with eastward propagation. The activity continued through mid-April.

Beginning in late April, anomalies became weaker and less coherent than earlier in the year. Eastward propagation is evident from late May to the present, in which atmospheric Kelvin wave activity is playing a role as indicated by the fast propagation.

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



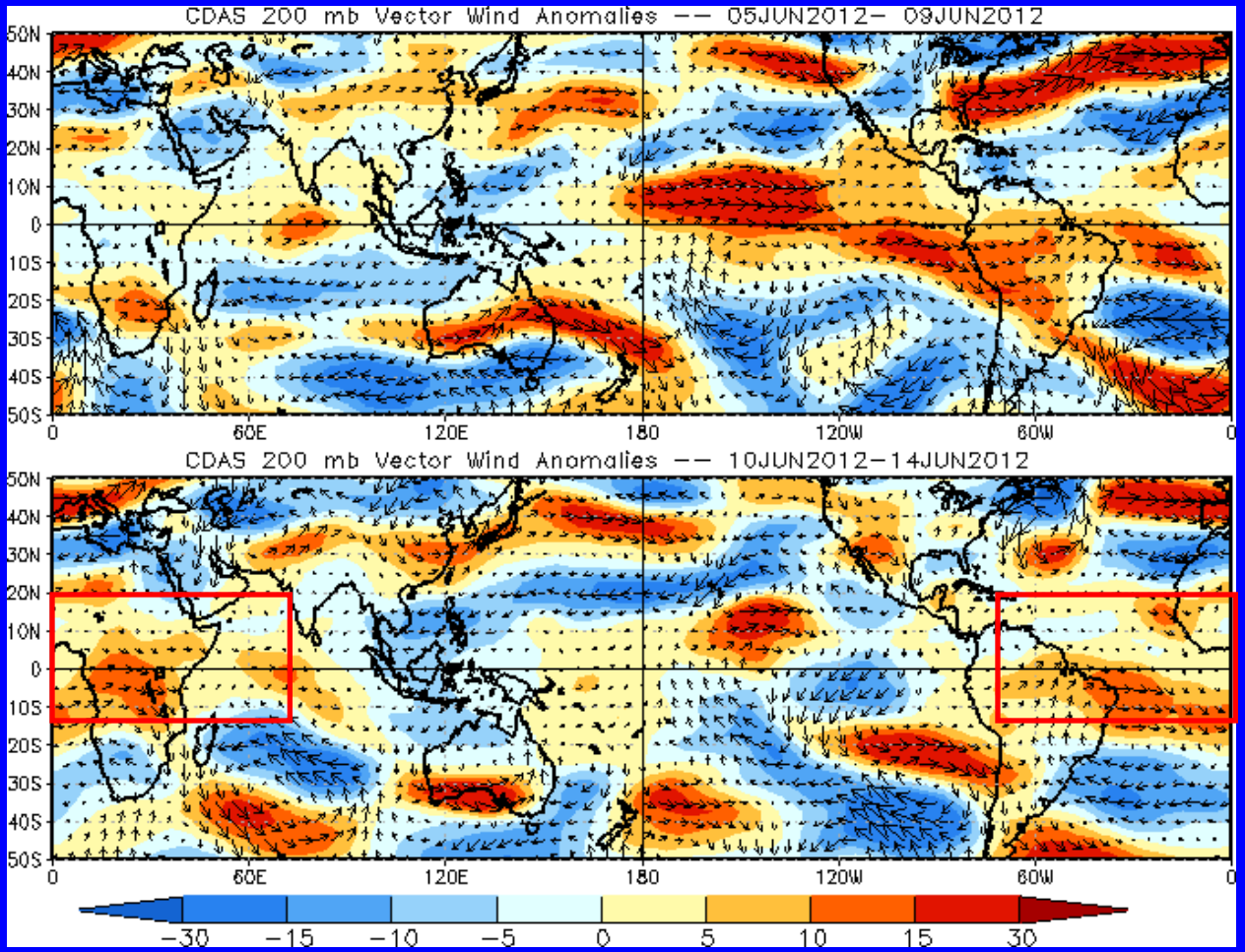
The large scale velocity potential pattern reflects anomalous upper-level divergence across the western Pacific, Americas and Atlantic and upper-level convergence over the Indian Ocean and central Pacific. This pattern has been shifting eastward over the past week. The wave-2 structure seen here is consistent with the presence of the MJO and other subseasonal variability.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

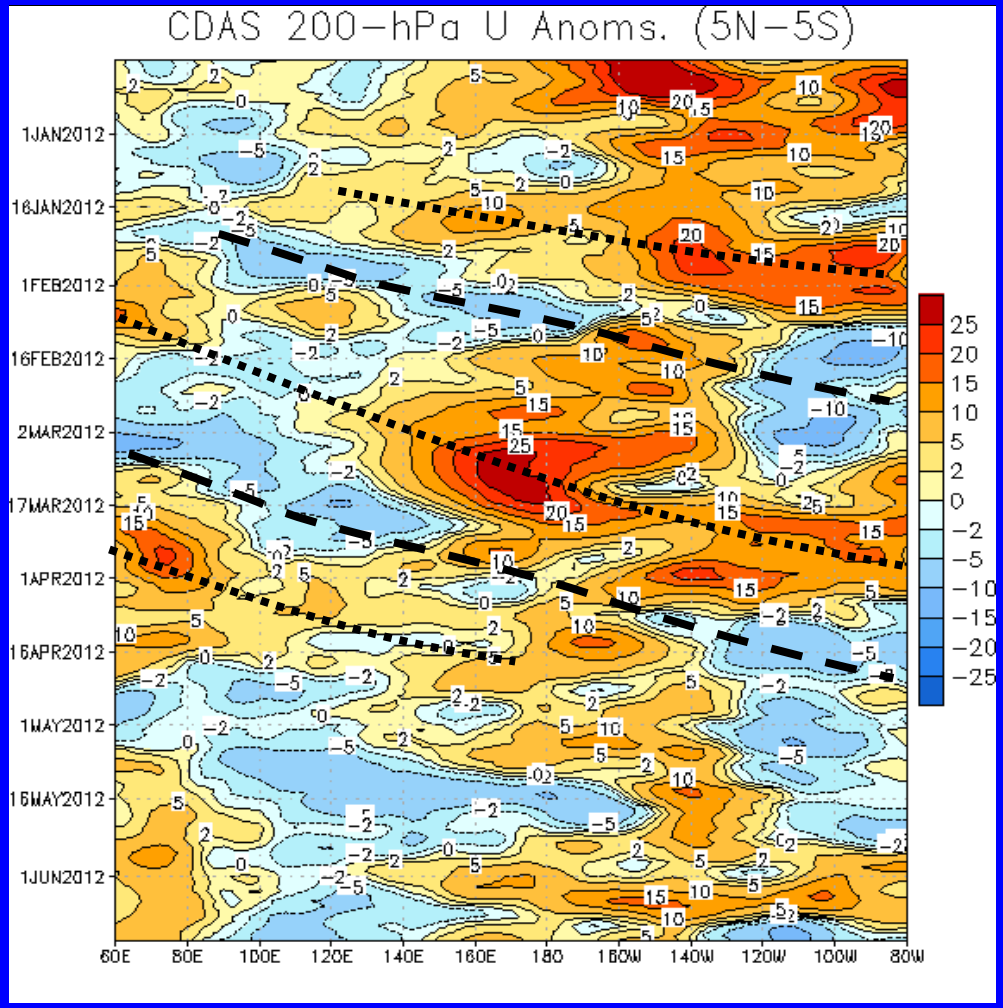


The area of the most intense westerly wind anomalies shifted eastward, with anomalous easterlies building over the western North Pacific.

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

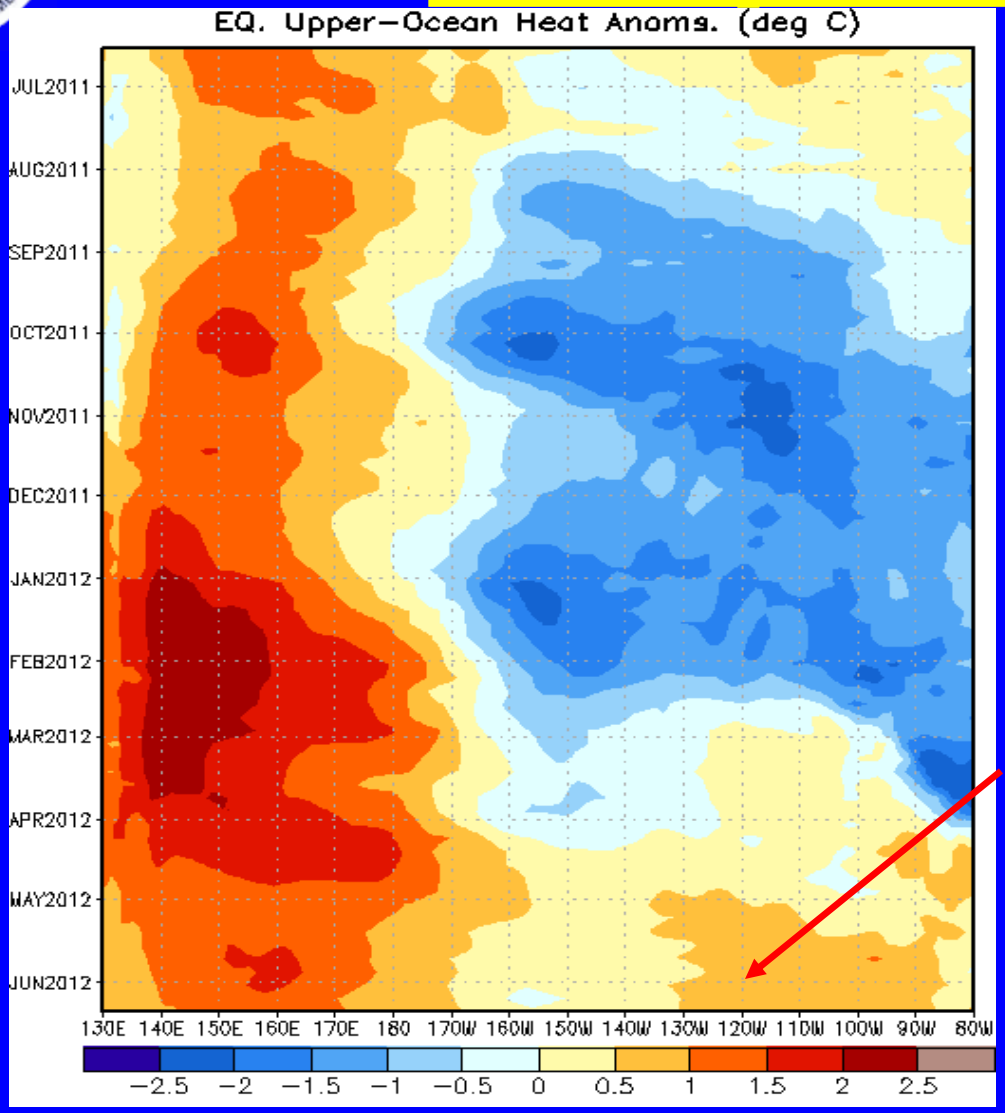
Longitude

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. Some evidence of faster moving, subseasonal variability can be seen during June.

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).

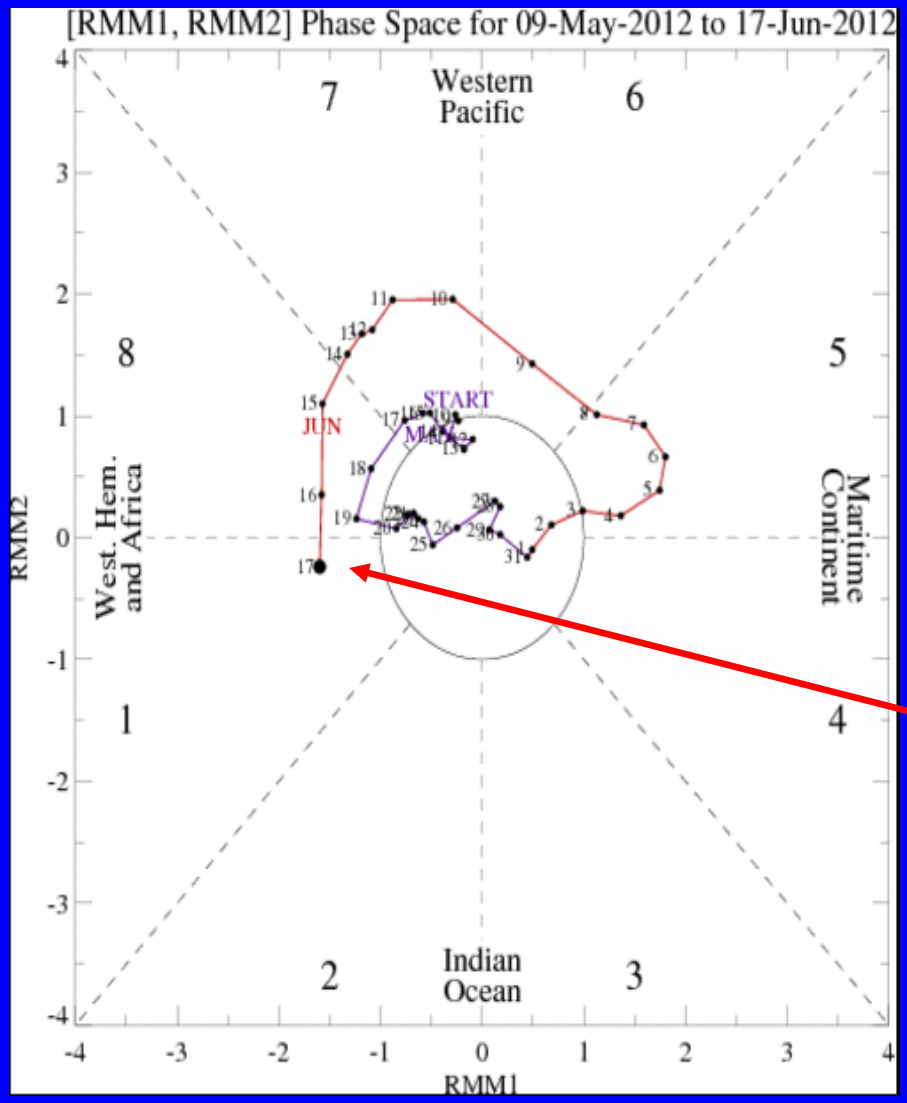
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

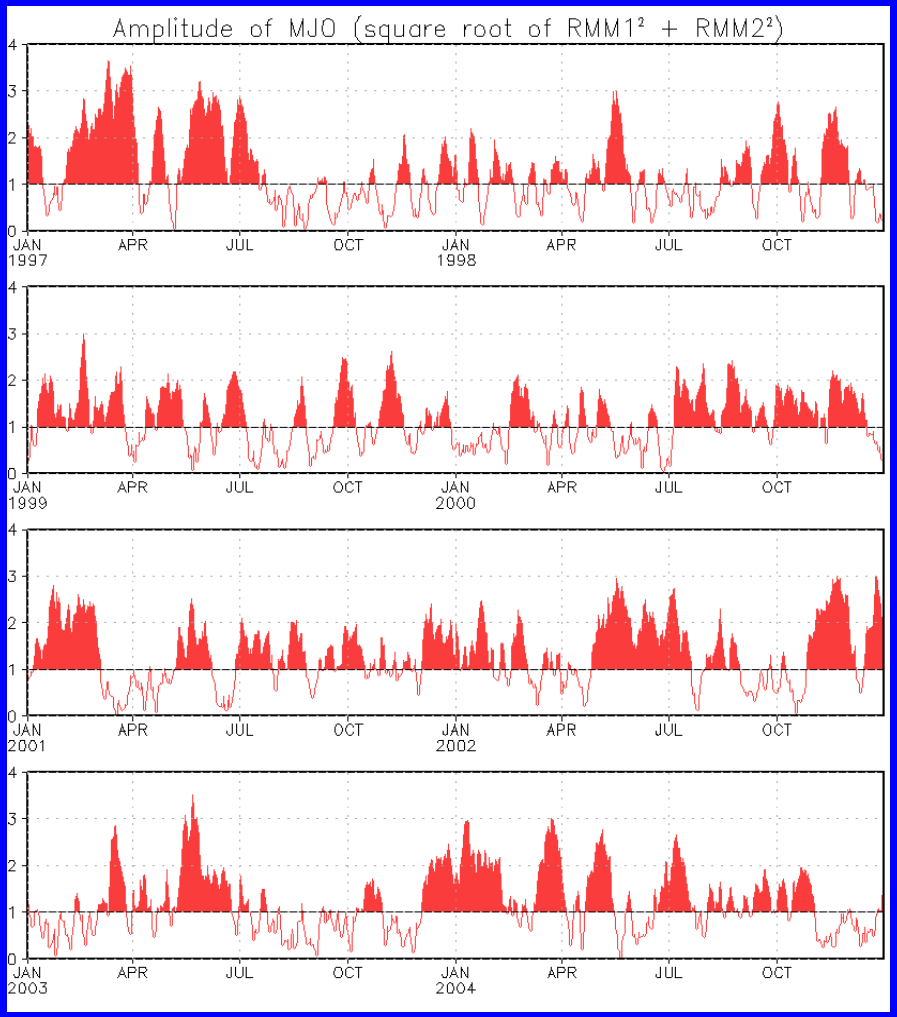
MJO Index -- Recent Evolution

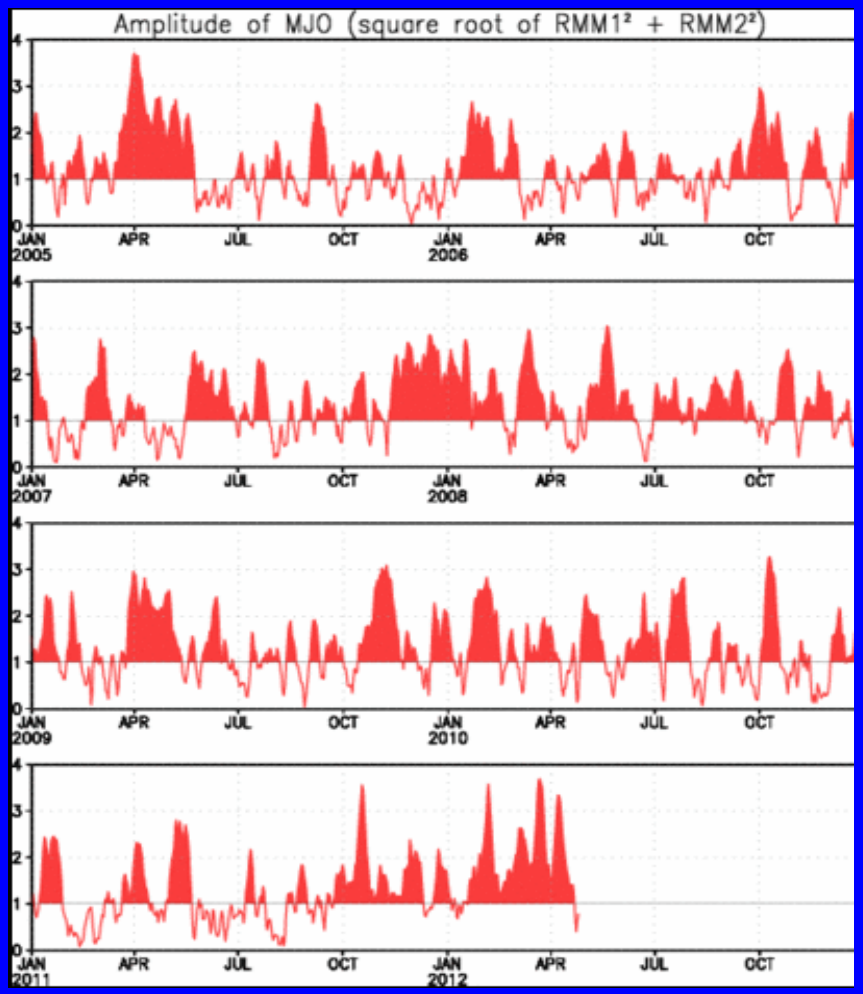


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

In early June, the MJO index strengthened over the Maritime Continent and during the past ten days it has shifted eastward to the western Hemisphere. At times, the propagation speed has been faster than typical MJO speeds.

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.

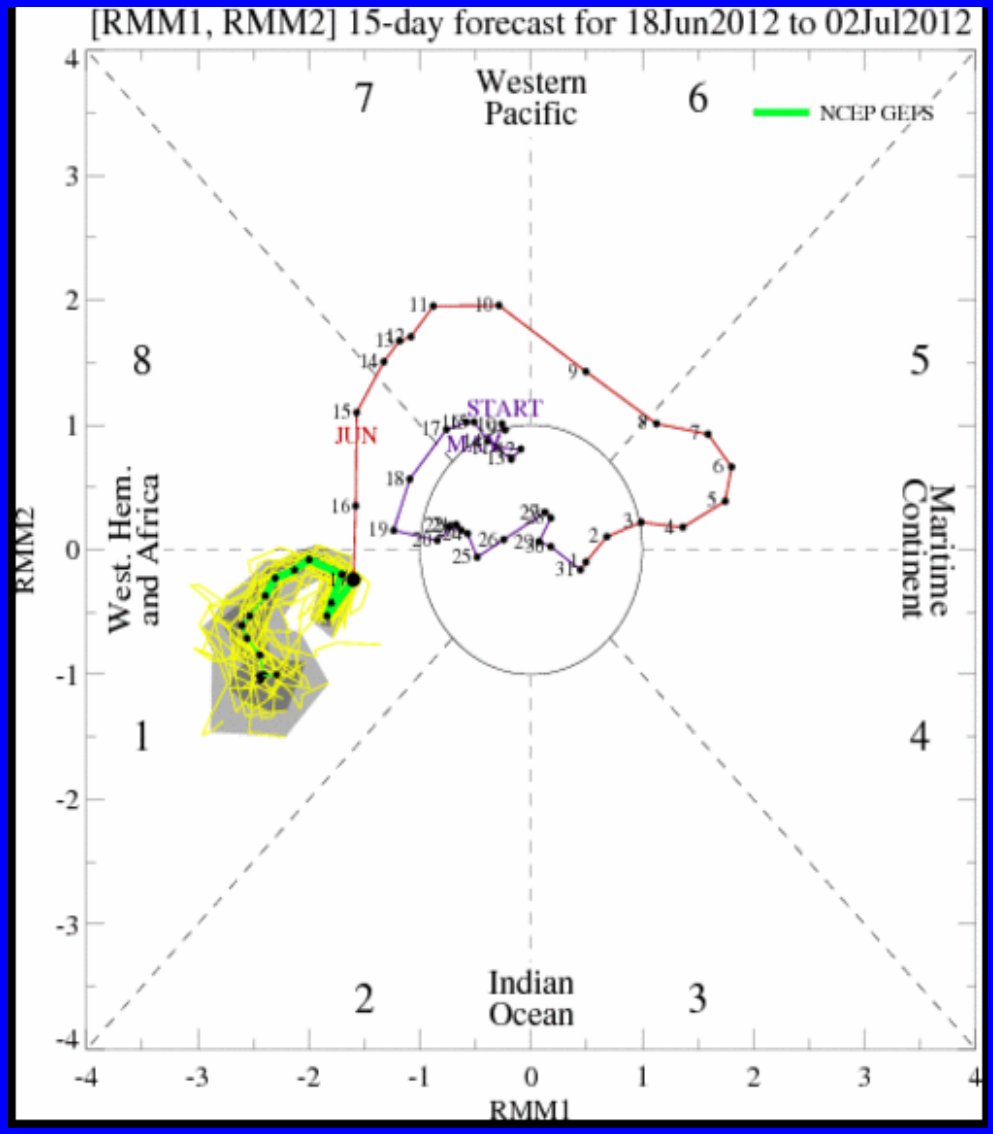
Ensemble GFS (GEFS) MJO Forecast

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

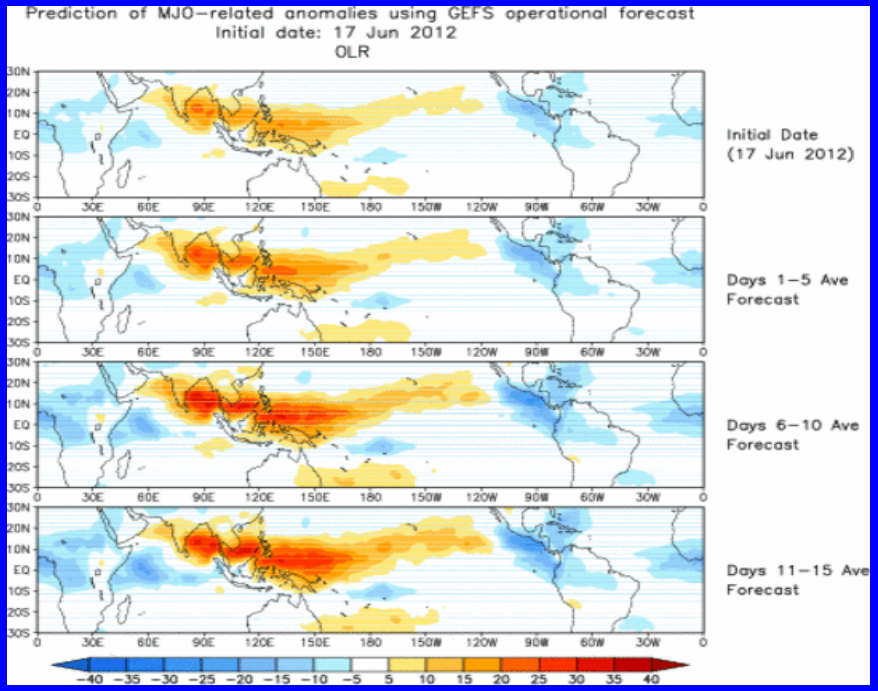
The ensemble GFS forecasts little eastward propagation of the MJO signal during the next two weeks.



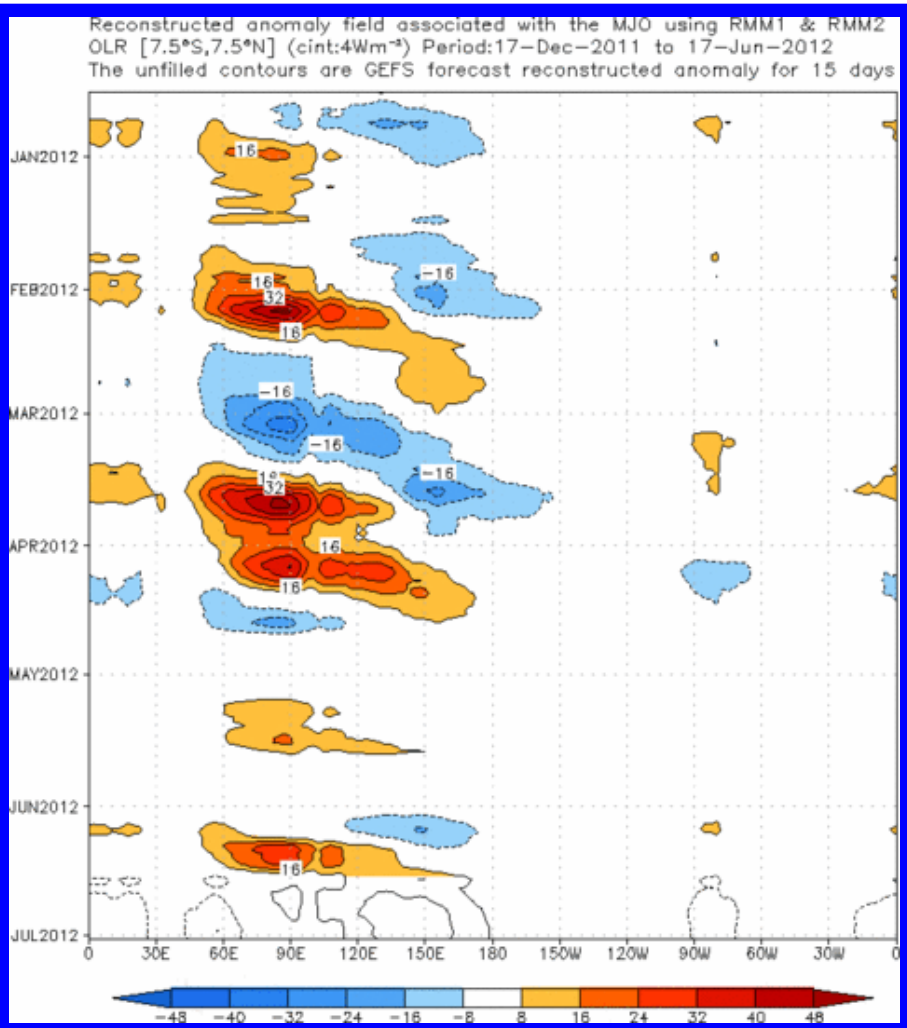
Ensemble Mean GFS MJO Forecast

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

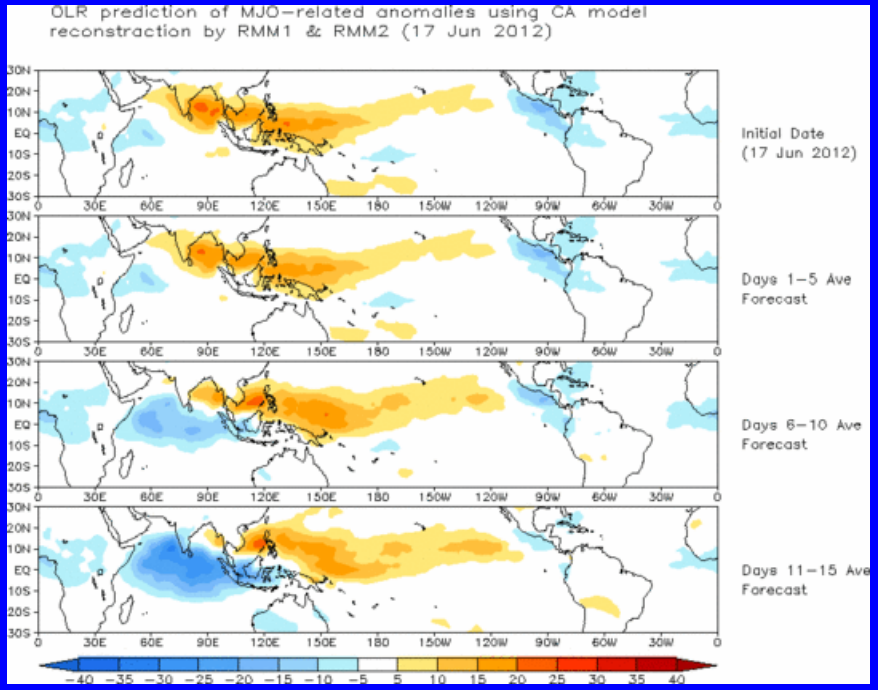


The ensemble mean GFS forecast indicates enhanced convection over the Americas and Africa during most of the period, as the signal is nearly stationary.

Constructed Analog (CA) MJO Forecast

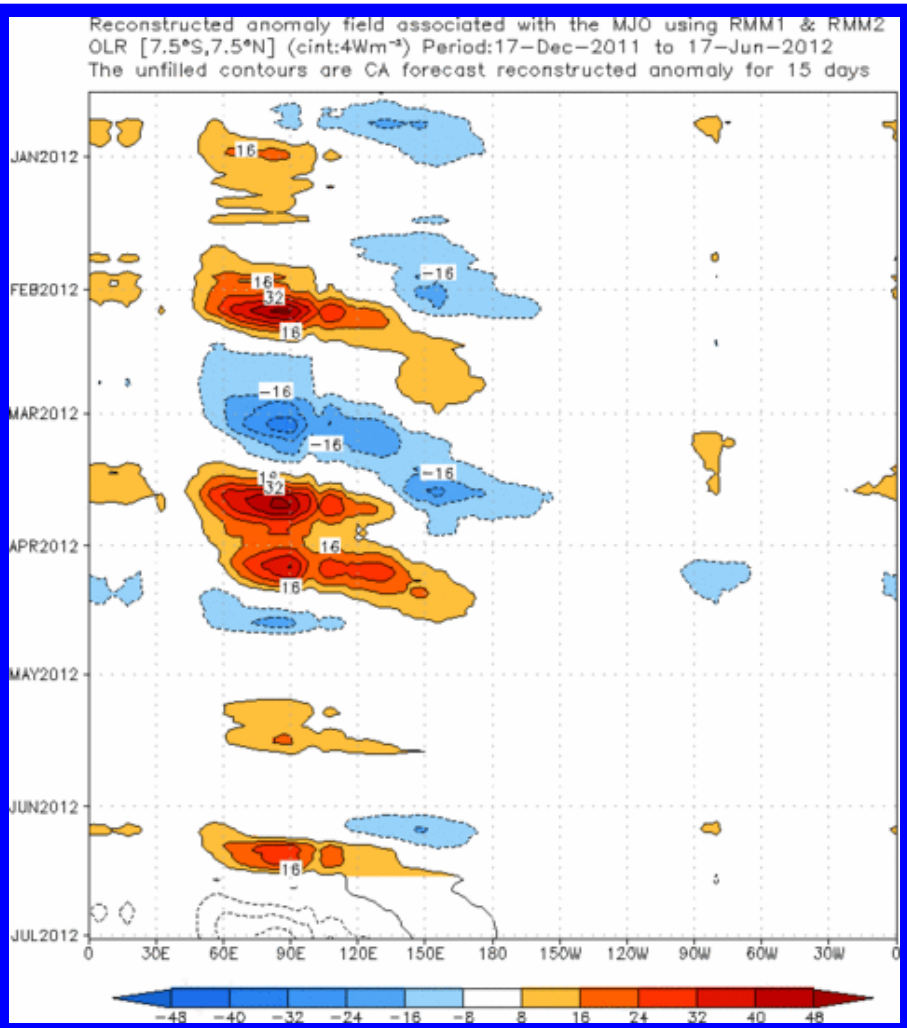
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



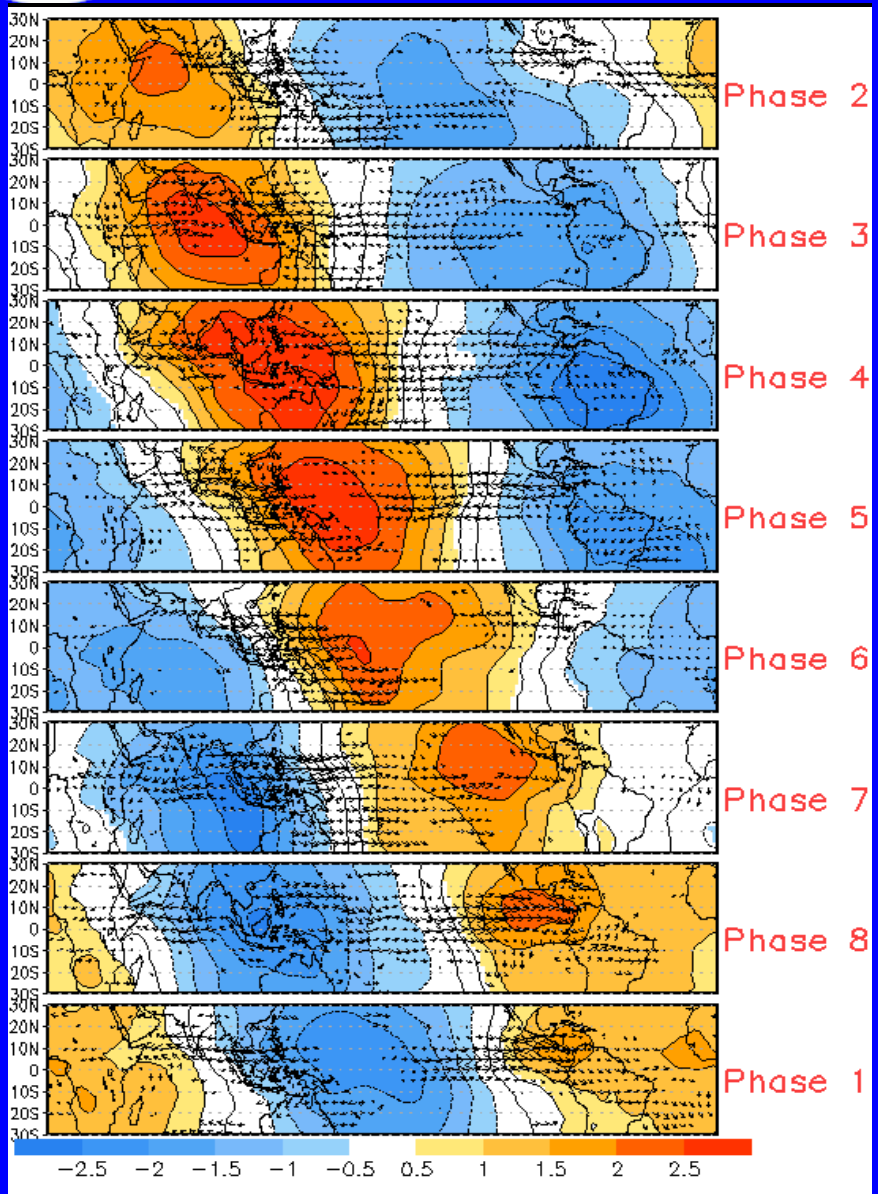
This forecast indicates enhanced convection across the Americas and Africa during week-1 with the area of enhanced convection forecast to shift over the Indian Ocean during week-2. Suppressed convection is forecast over the Maritime Continent and Western North Pacific.

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

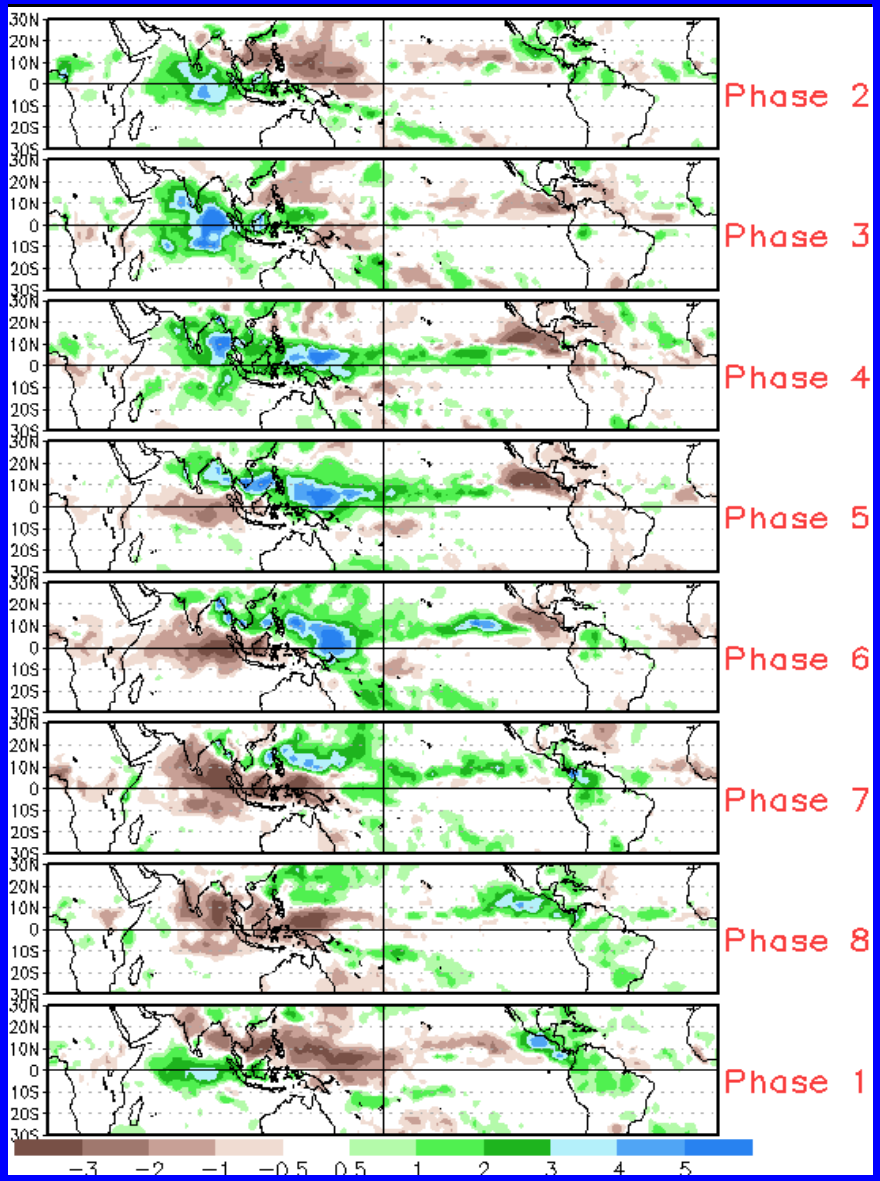


MJO Composites – Global Tropics

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

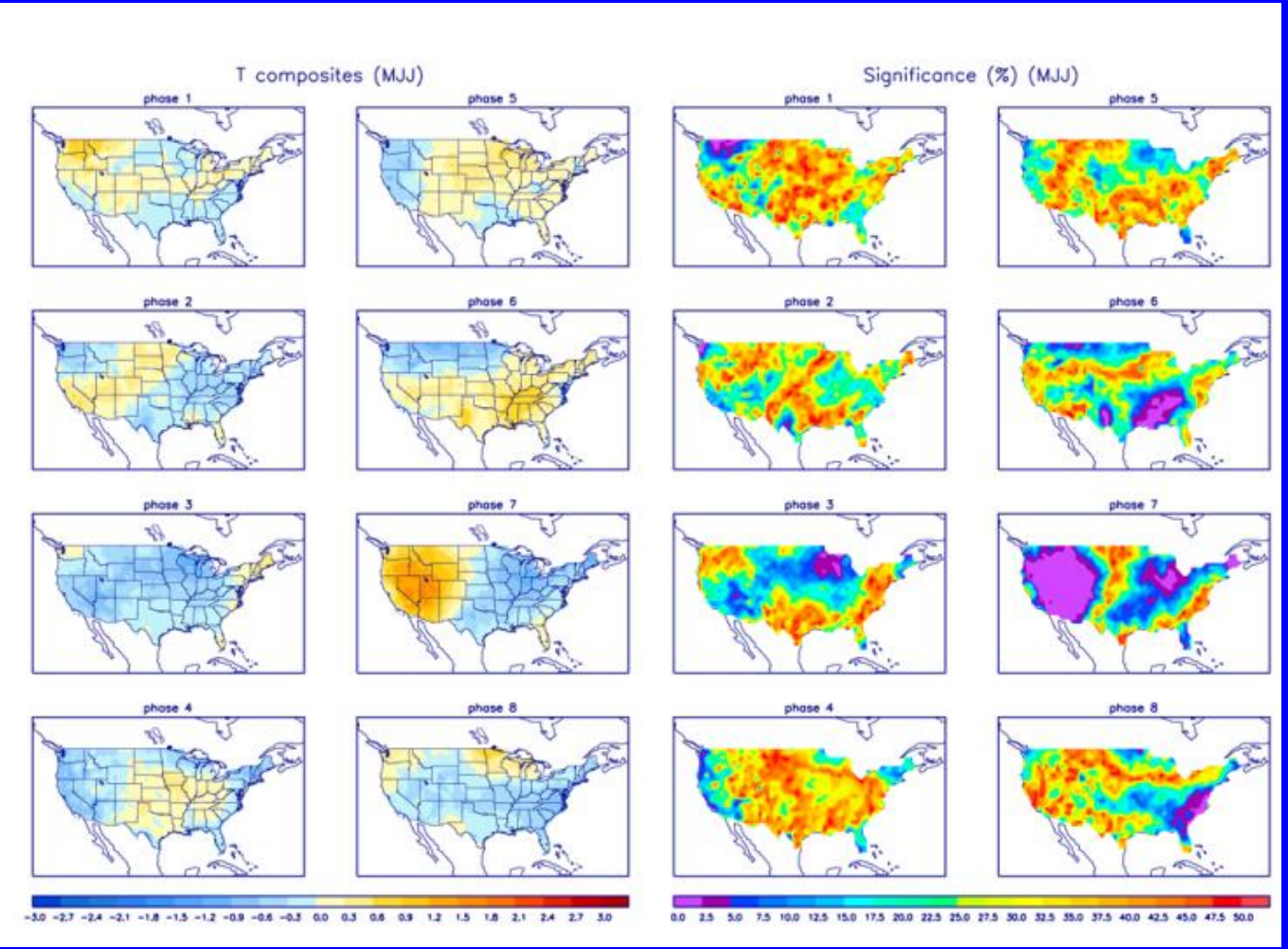


Precipitation Anomalies (May-Sep)



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.**

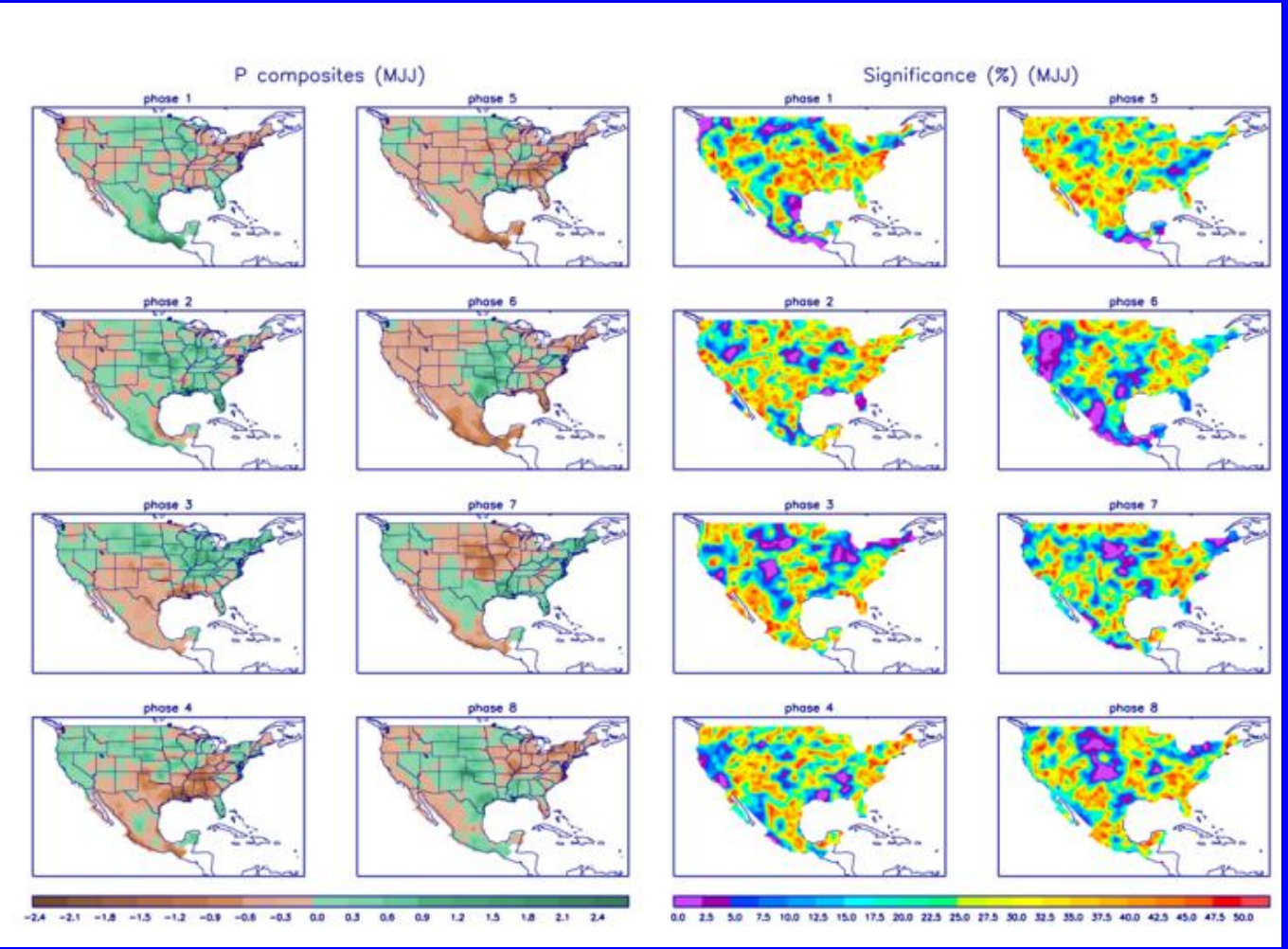


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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