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

Update prepared by
Climate Prediction Center / NCEP
March 19, 2012

Outline

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

Overview

- The MJO remained active during the past week with the enhanced phase entering the Western Pacific.
- Dynamical model MJO index forecasts show the MJO remaining active through the period. Statistical models indicate much more eastward propagation than the dynamical models.
- Based on the latest observations and forecast models, the MJO is forecast to remain active and shift further into the Pacific during the upcoming 1-2 weeks.
- The MJO is forecast to contribute to enhanced convection across parts of the western Pacific during the next two weeks, with potential connections of enhanced rainfall over the Americas. Suppressed convection is favored for parts of Africa and the Indian Ocean during the period.
- MJO composites for current and upcoming forecast enhanced phases favor above-average temperatures for portions of the eastern U.S., and enhanced odds for above-average precipitation for parts of the northern tier of the U.S. and for areas across the center portion of the country.

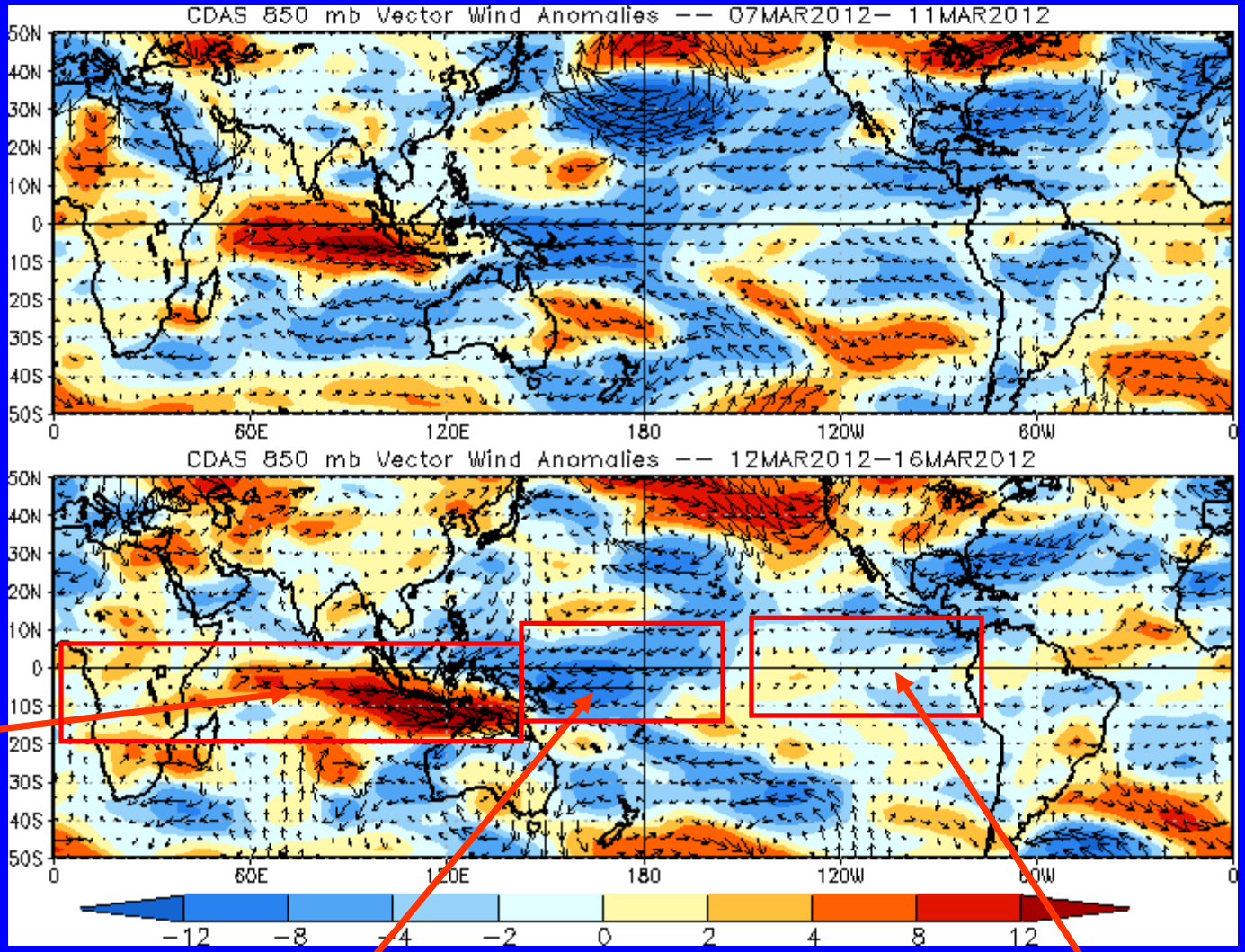
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 expanded eastward over the southern Maritime Continent and northern Australia during the past five days with an increase in magnitude.

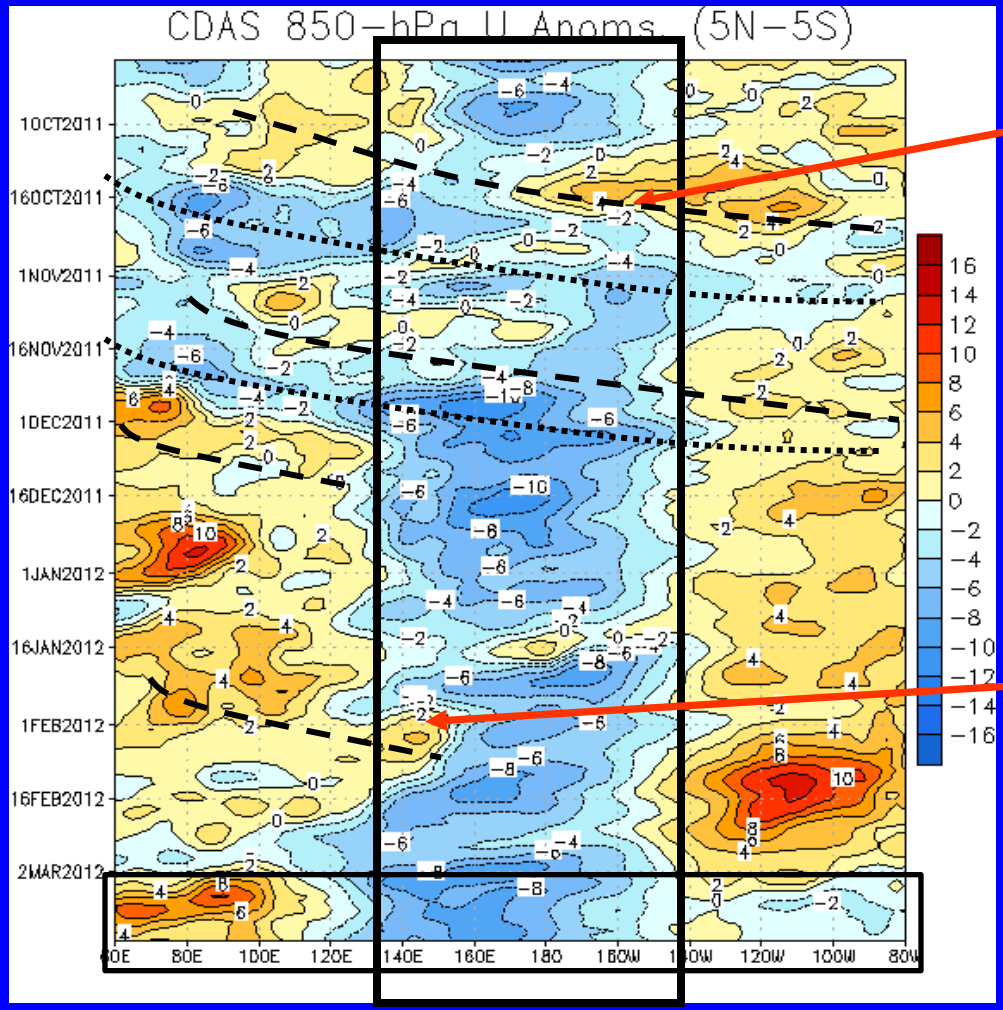
Easterly anomalies persisted over the Western and Central Pacific during the past five days but decreased in coverage.

Winds over the eastern Pacific Ocean were generally close to average 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

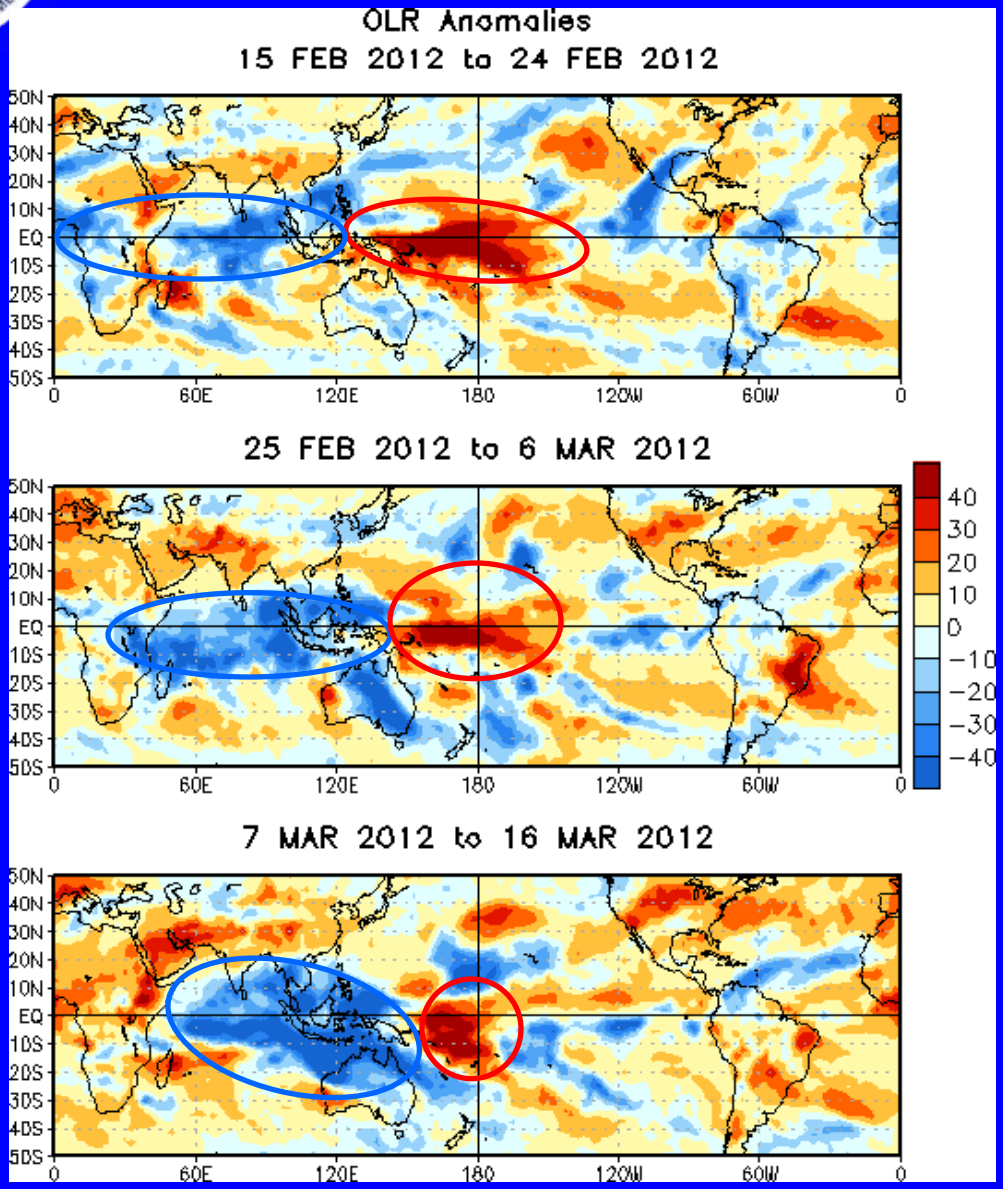
In early October, MJO activity weakened the persistent easterly anomalies across the central Pacific (first dashed line).

MJO activity continued into December (altering dashed and dotted lines), but then westerly (easterly) wind anomalies across the Indian Ocean (western Pacific) became more stationary.

In early February, westerly anomalies extended to 140E and were associated with MJO activity.

During early March, the MJO, along with other modes of variability, combined to enhance westerly anomalies across the Indian Ocean and Maritime Continent, while enhancing easterly anomalies in the central Pacific.

OLR Anomalies – Past 30 days



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

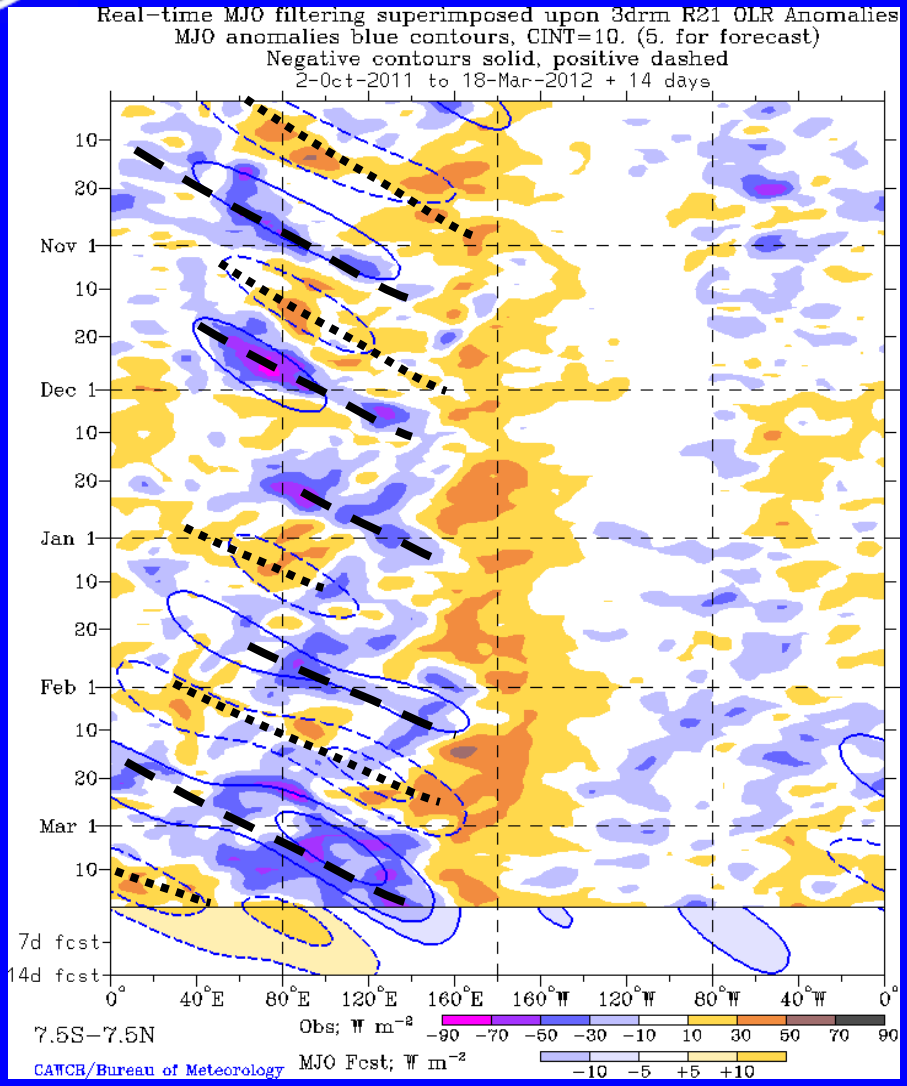
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid to late February, suppressed convection was observed over the central and Western Pacific. Enhanced convection was observed across Mexico, Africa, and the Indian Ocean.

Enhanced convection was evident from Africa to the Maritime Continent during late February and early March. Suppressed convection was observed for the western and Central Pacific, and parts of the Americas.

During early to mid-March, the MJO contributed to enhanced (suppressed) convection across the Indian Ocean and Maritime Continent (western Pacific, Americas and Africa).

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)

MJO activity was evident during October, November and early December as alternating areas of enhanced (dashed lines) and suppressed (dotted lines) convection shifted eastward.

The MJO once again strengthened during late January as enhanced convection shifted eastward across the Maritime continent.

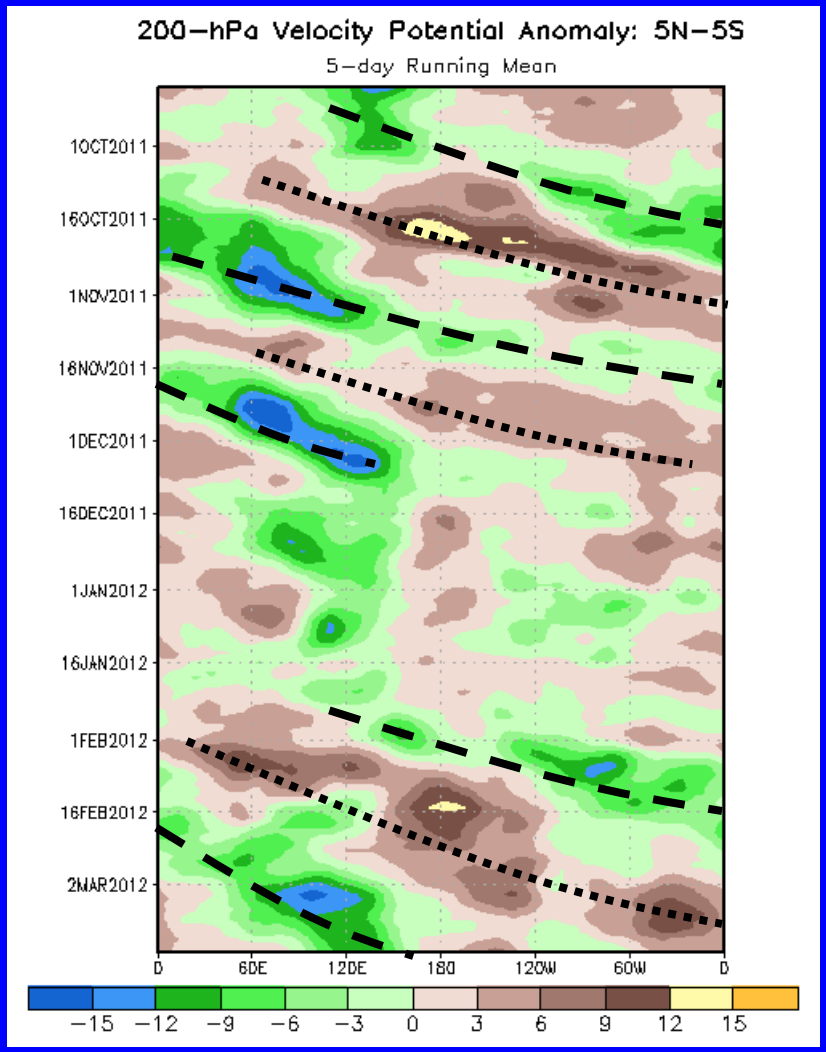
The MJO activity has continued into March, with enhanced convection now centered over the eastern Maritime Continent.

Other modes of coherent subseasonal tropical variability (Equatorial Rossby Wave) were also evident during February between 90E and 150E.

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

Beginning in the second half of September and lasting until December, alternating negative (dashed lines) and positive (dotted lines) anomalies were evident and associated with MJO activity during the period.

Eastward propagation of anomalies became less coherent during late December and early January and anomalies weakened.

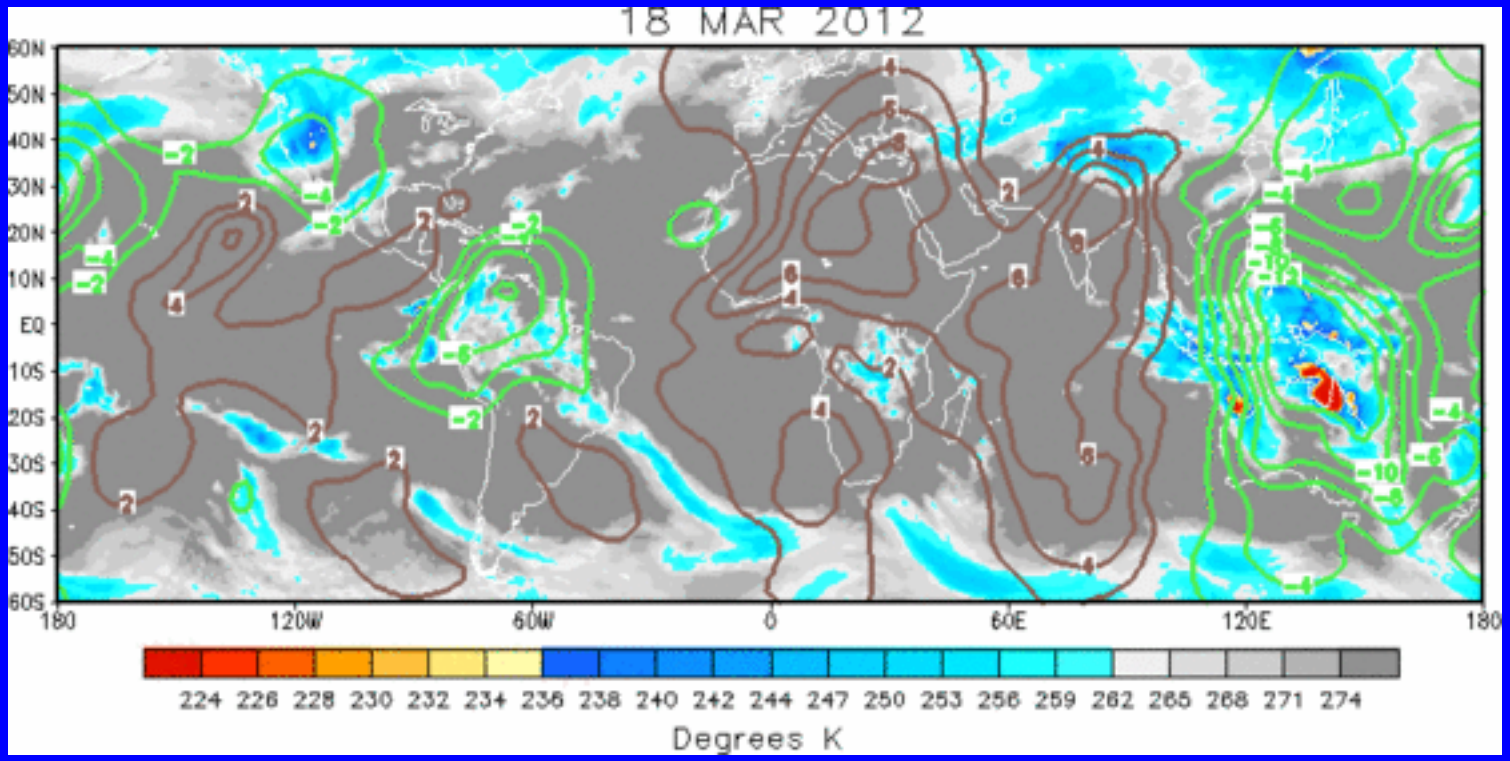
Eastward propagation again became evident in late January and continued through mid-February, during which time, anomalies became more stationary. By early March, eastward propagation continued with enhanced divergence (convergence) centered over the western Maritime Continent (Atlantic Ocean-Africa).

Faster modes of variability are also evident during recent days in the Pacific.

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 generally exhibits a wave-2 structure with the strongest upper-level divergence across Maritime Continent and western Pacific, and upper-level convergence mainly over Africa and the Indian Ocean.

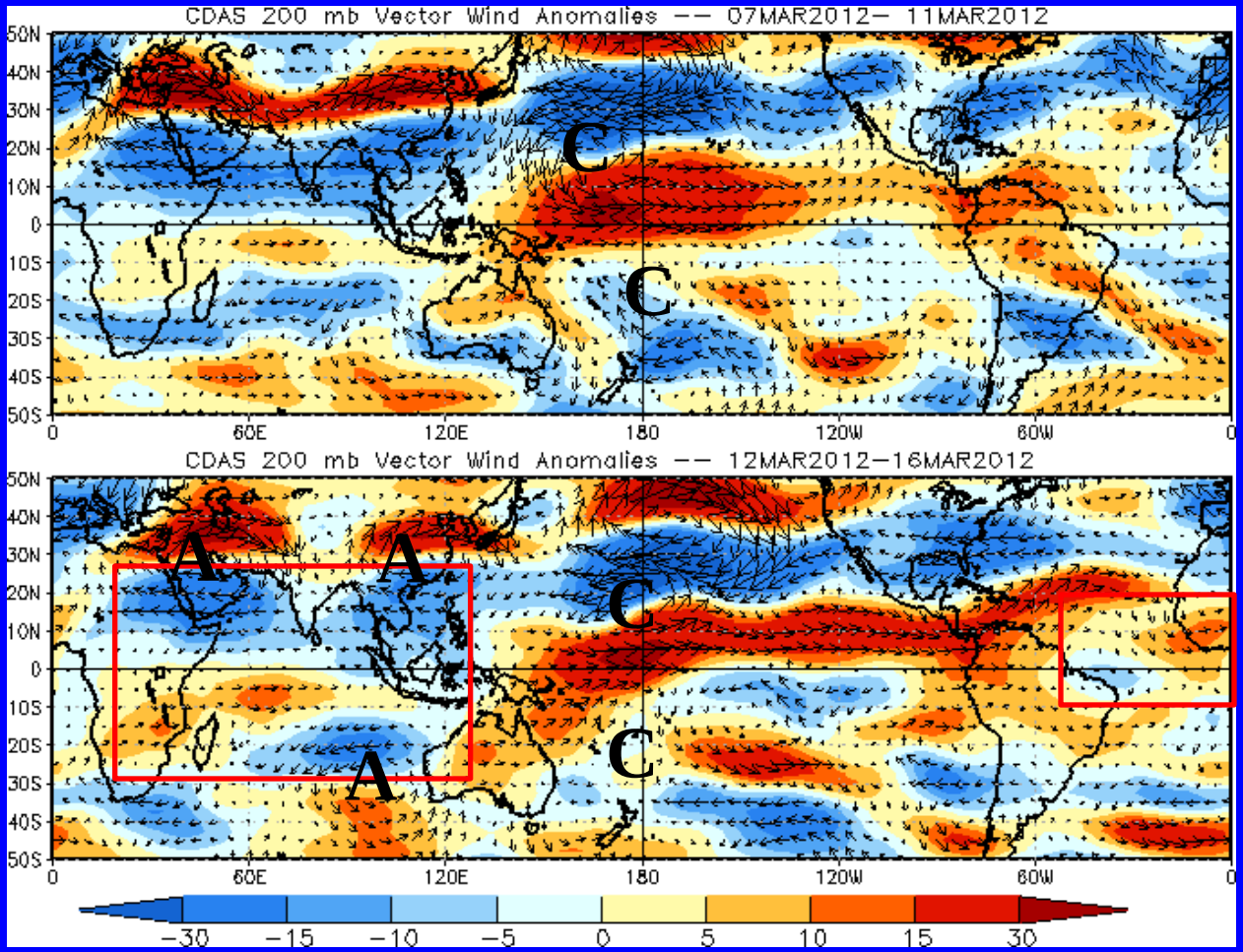
Other modes of subseasonal tropical variability and mid-latitude influences are also affecting the pattern.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



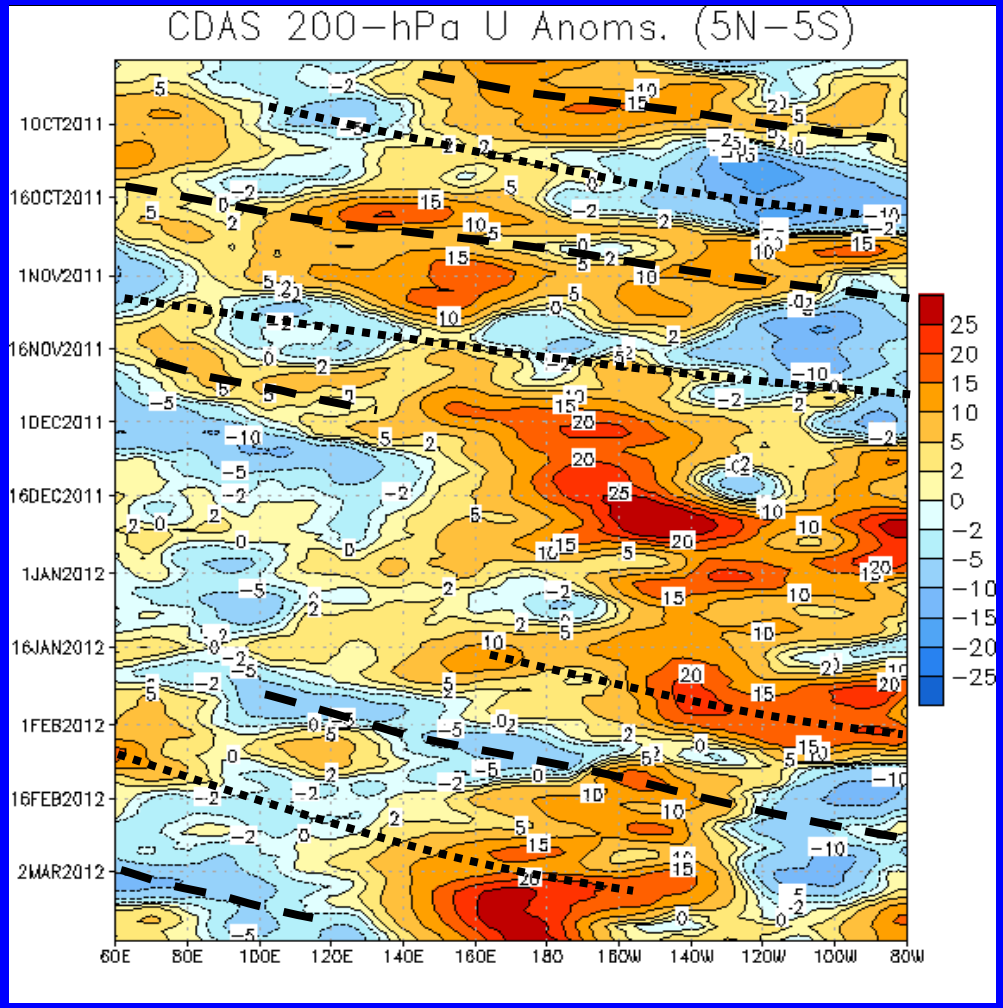
During the most recent five days, westerly anomalies over the western and central Pacific have shifted slightly eastward, as have the anomalous cyclonic circulation features poleward of those westerlies.

Easterly anomalies and anomalous anticyclones are evident over parts of southern Asia and the southern Indian Ocean. Anticyclonic circulations are less coherent in the most recent five days.

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

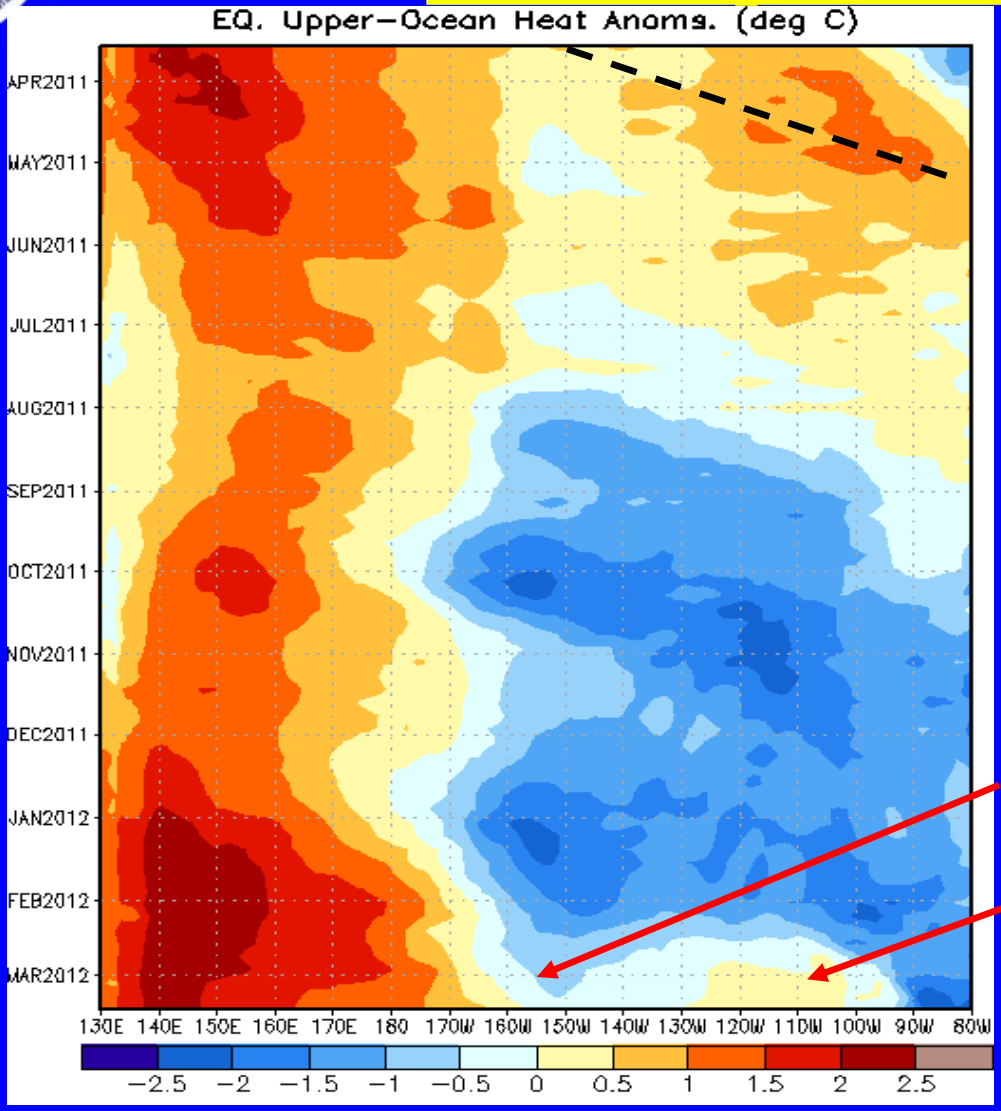
Longitude

Alternating westerly (dashed lines) and easterly (dotted lines) anomalies are evident from mid-September into December associated with the MJO.

In December, westerly anomalies strengthened over the Pacific.

Eastward propagation was again more clearly evident during late January and February. Strong westerly anomalies now stretch from 140E to 80W, with easterly anomalies from 10E to 120E.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

An oceanic Kelvin wave (dashed line) shifted eastward during March and April 2011.

Since late July, negative heat content anomalies are evident across the equatorial central and eastern Pacific.

In February and March 2012, negative heat content anomalies weakened in the central and eastern equatorial 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).

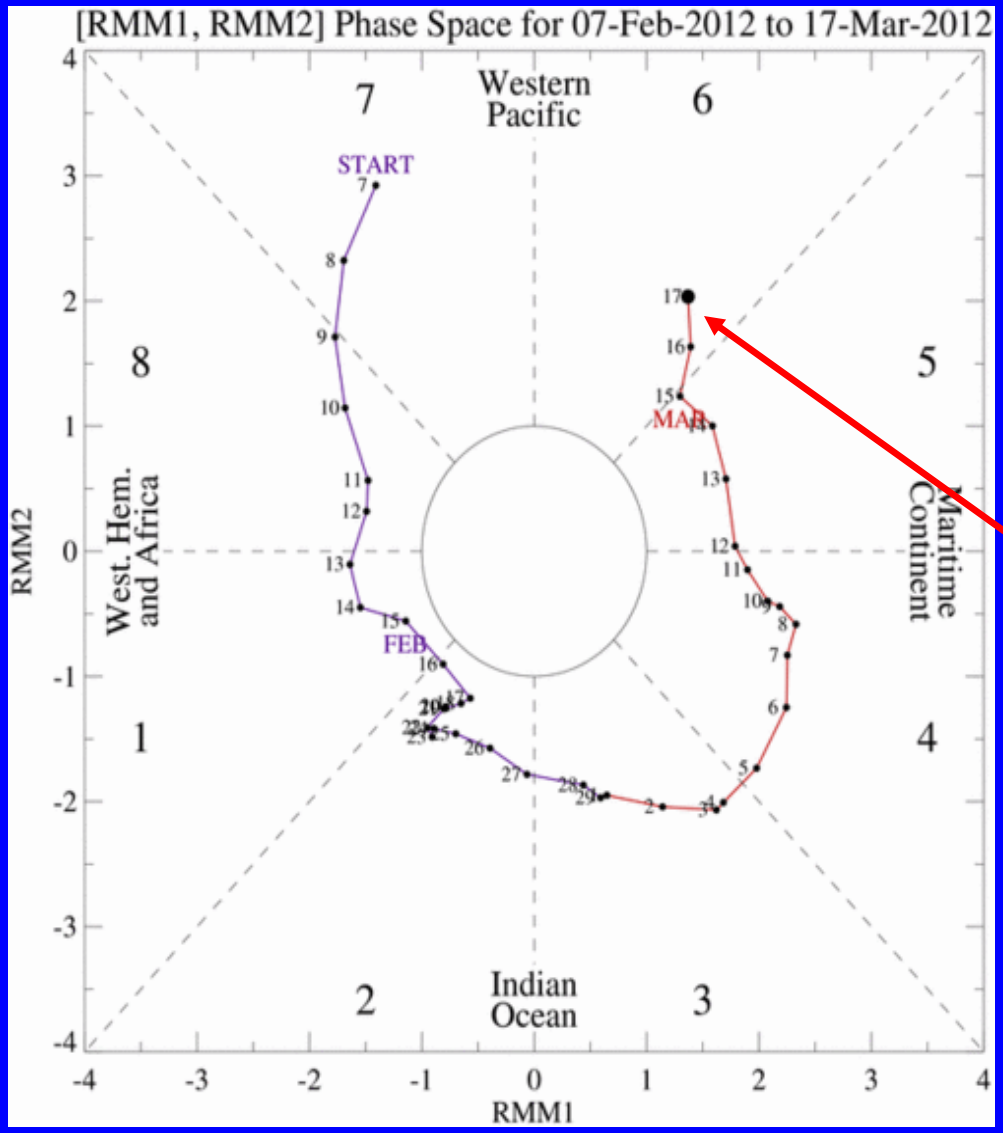
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

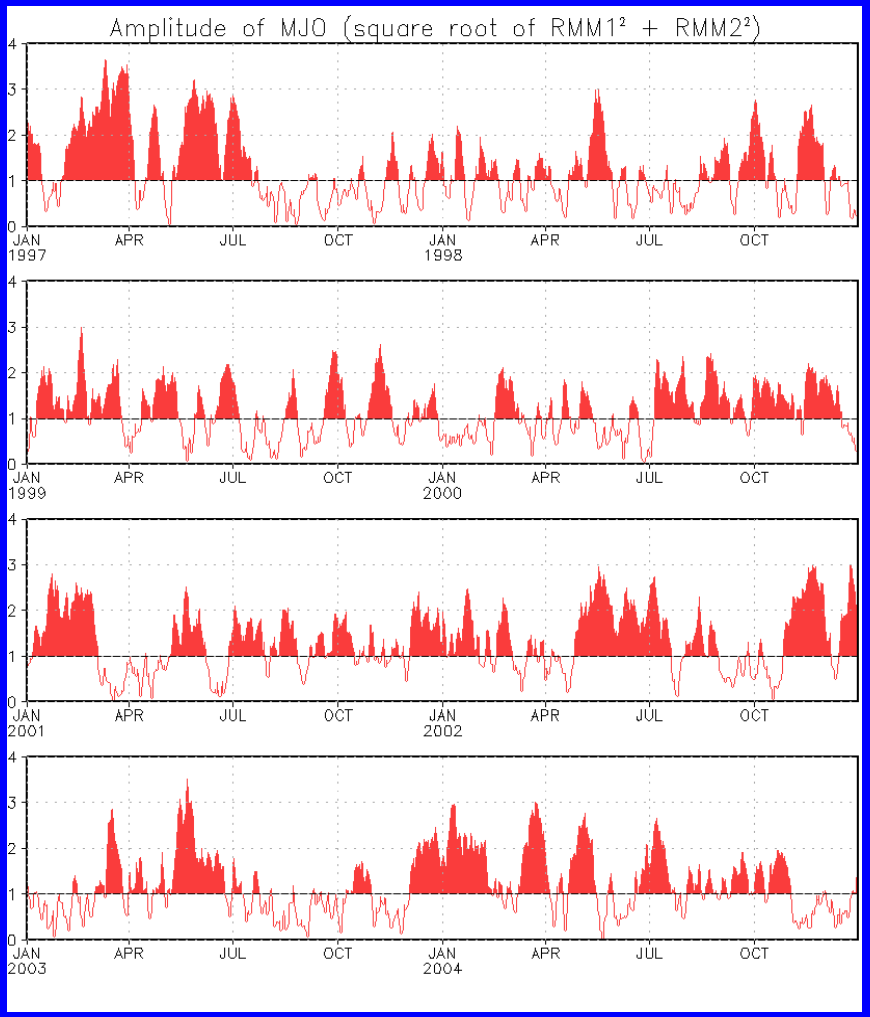
MJO Index -- Recent Evolution

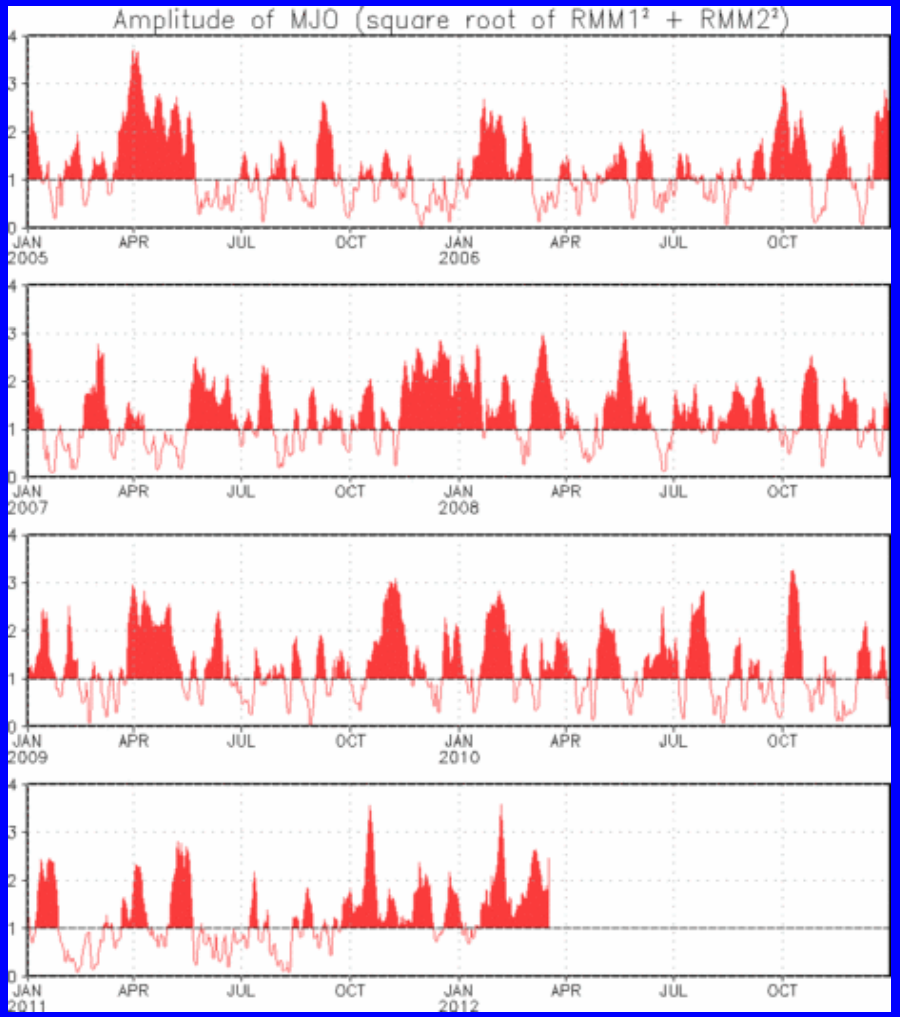


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index shows continued MJO activity during the past week. The eastward propagation speed is consistent with coherent MJO activity.

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.

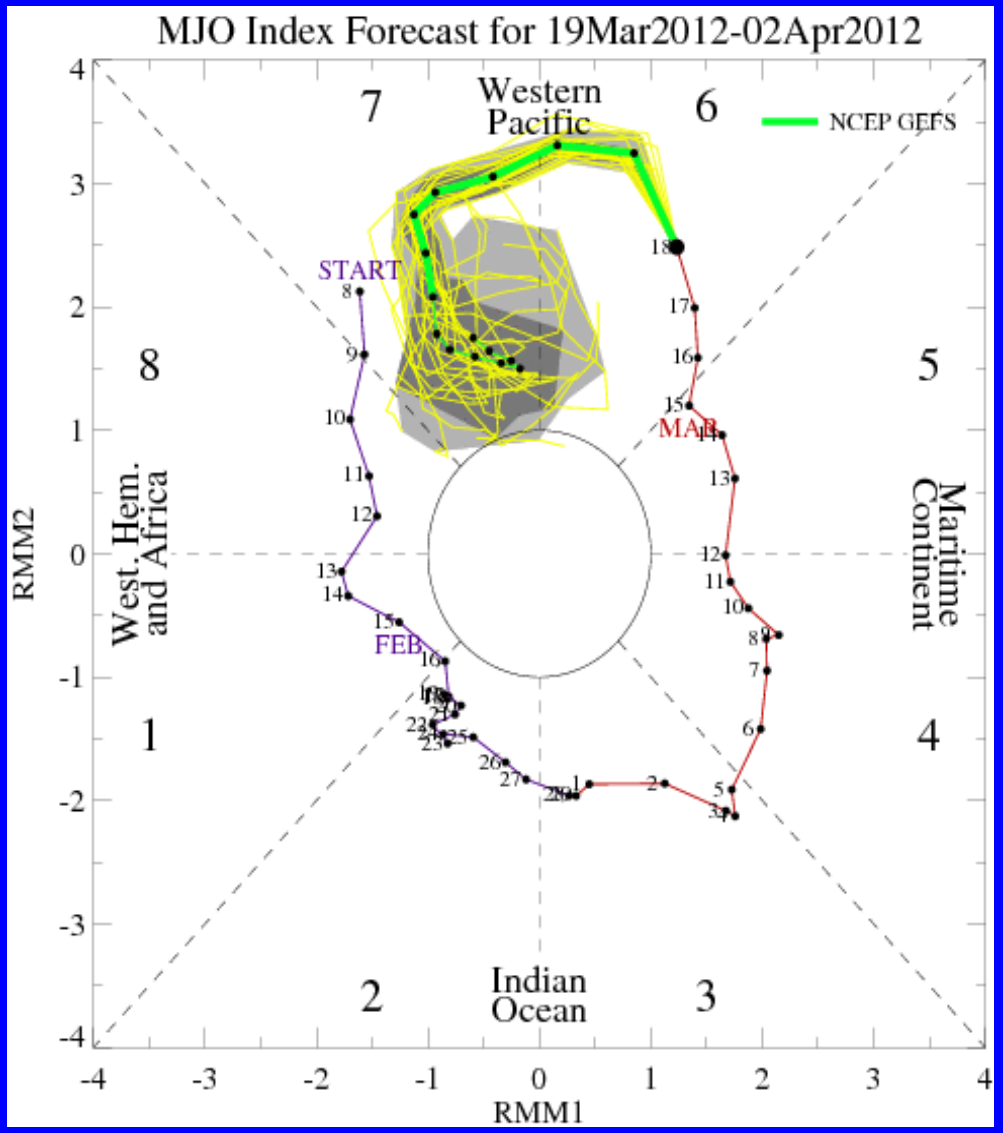
Ensemble GFS (GEFS) MJO Forecast

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

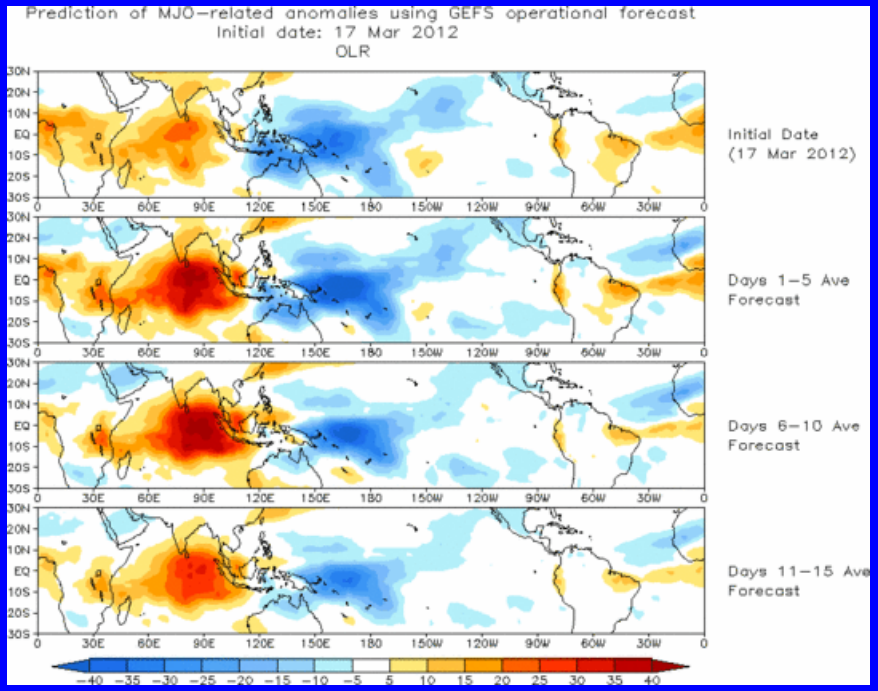
The ensemble GFS forecasts the MJO signal to continue propagating eastward over the next two weeks with the enhanced phase over the Western Pacific during Week-1. Eastward propagation slows during Week-2.



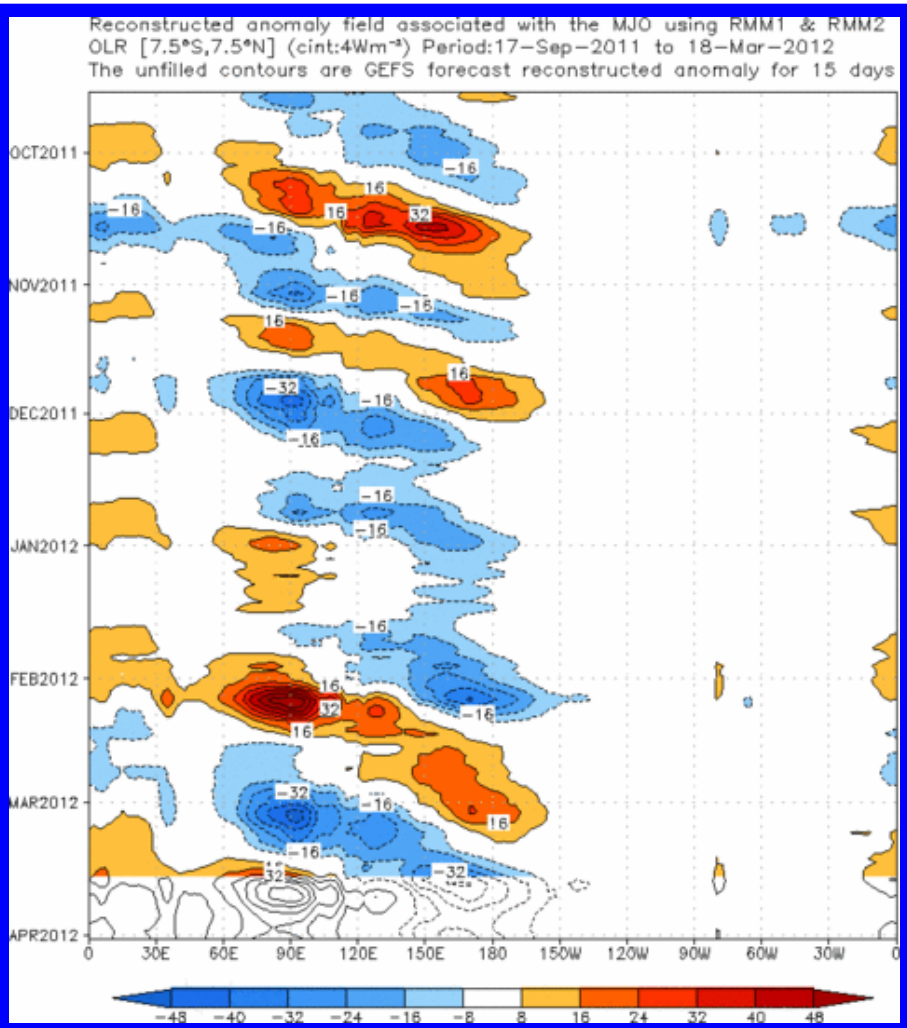
Ensemble Mean GFS MJO Forecast

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

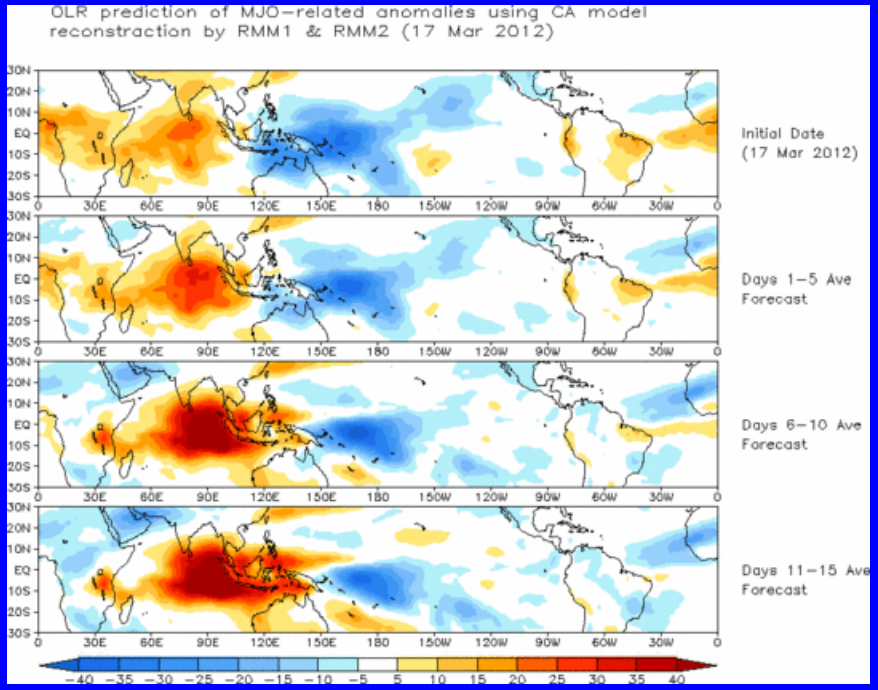


The ensemble mean GFS forecast indicates enhanced convection across the western Pacific during Week-1. Little to no eastward propagation is forecast by Week-2. Suppressed convection is forecast across the Indian Ocean during the period with some potential for wet conditions to return to Africa later in Week-2.

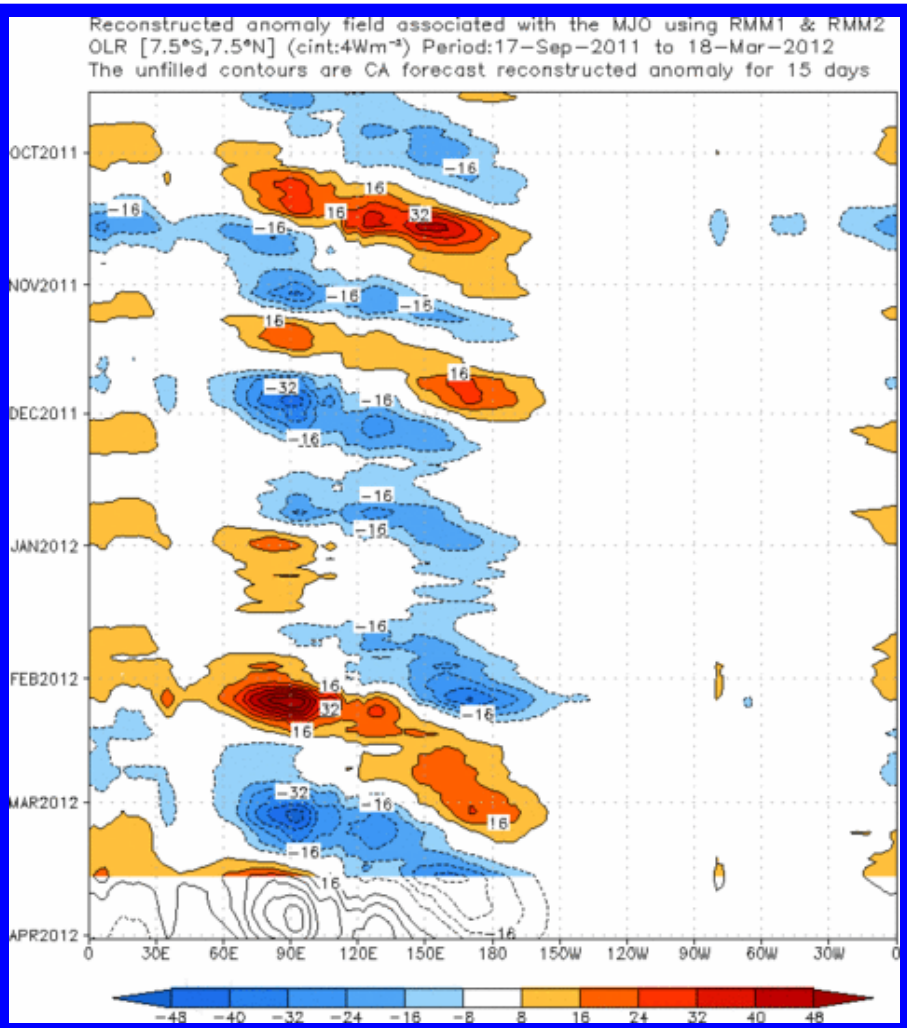
Constructed Analog (CA) MJO Forecast

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



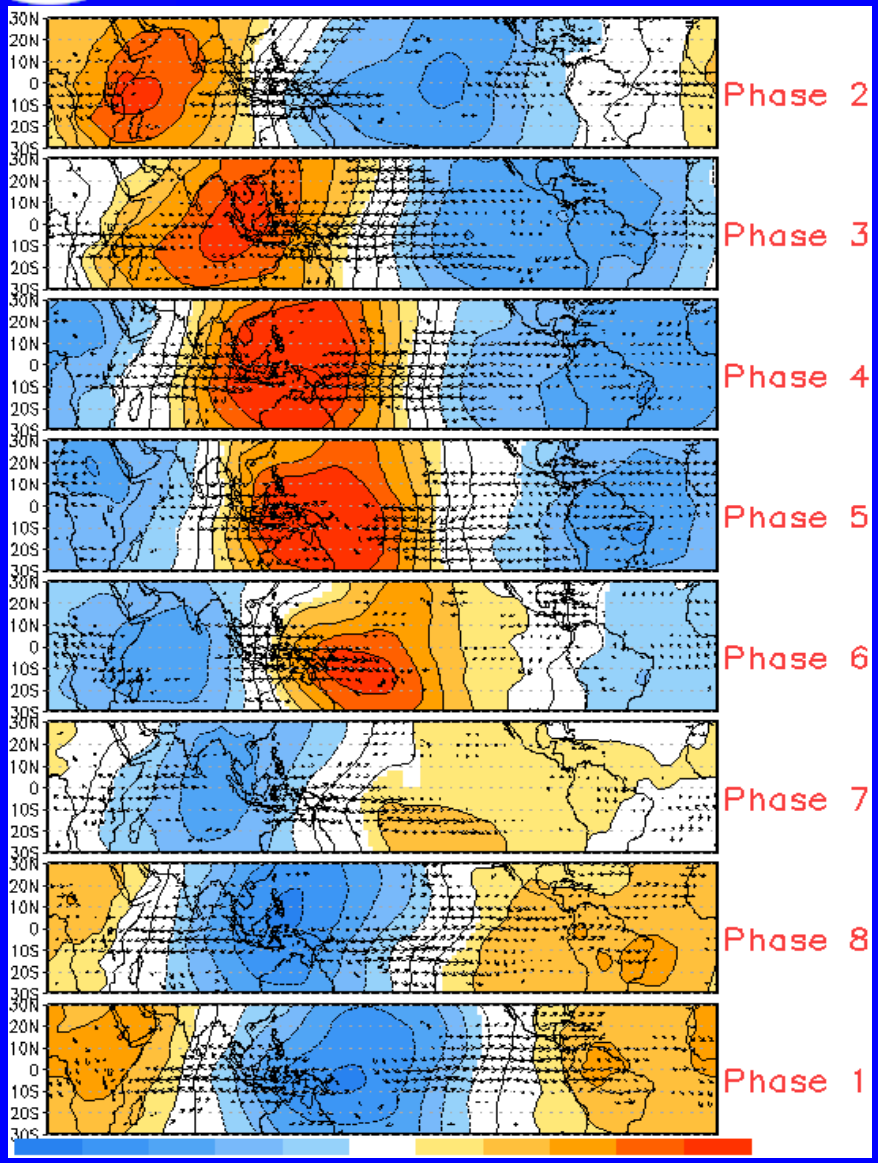
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



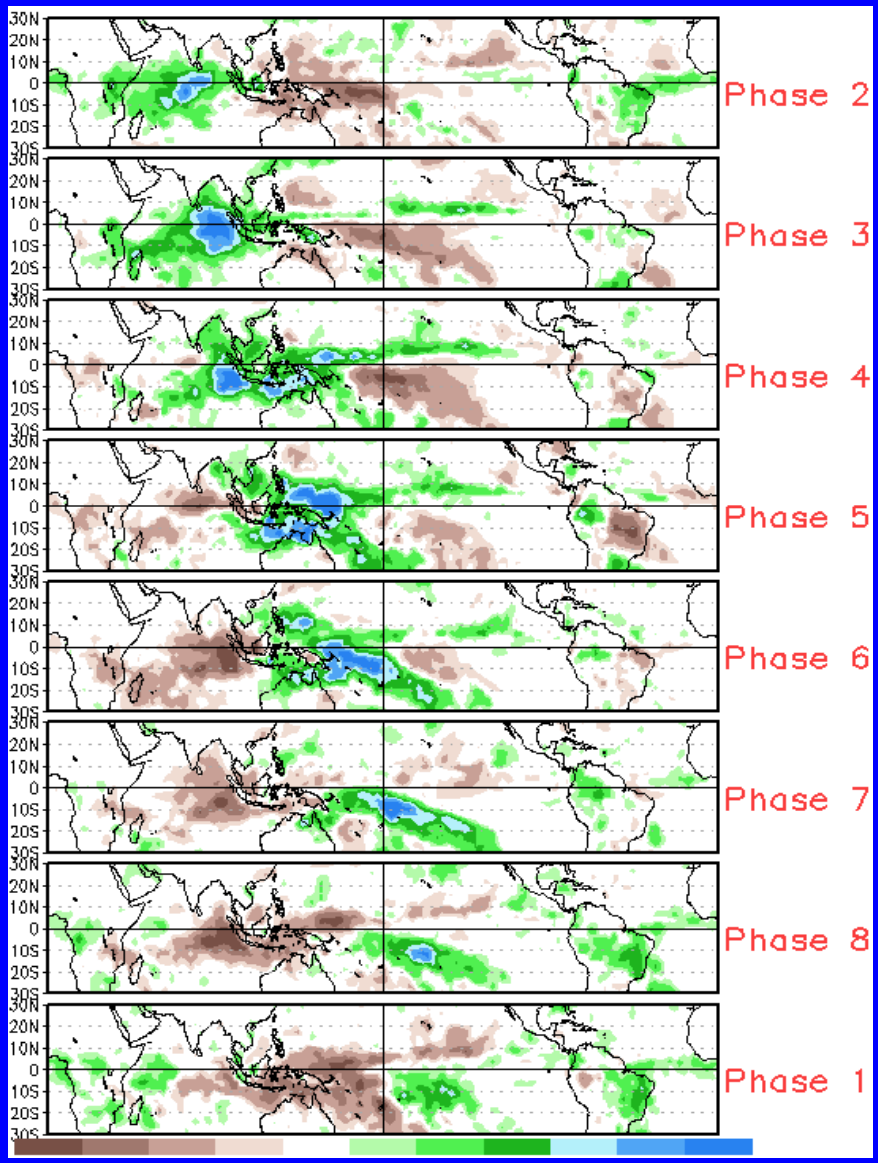
The CA forecast shows enhanced (suppressed) convection stretching across the Western Pacific (Africa and Indian Ocean) during Week-1, with eastward propagation during Week-2. Drier than average conditions are forecast for the Indian Ocean during much of the period with significant drying moving across the Maritime Continent for Week-2.

MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

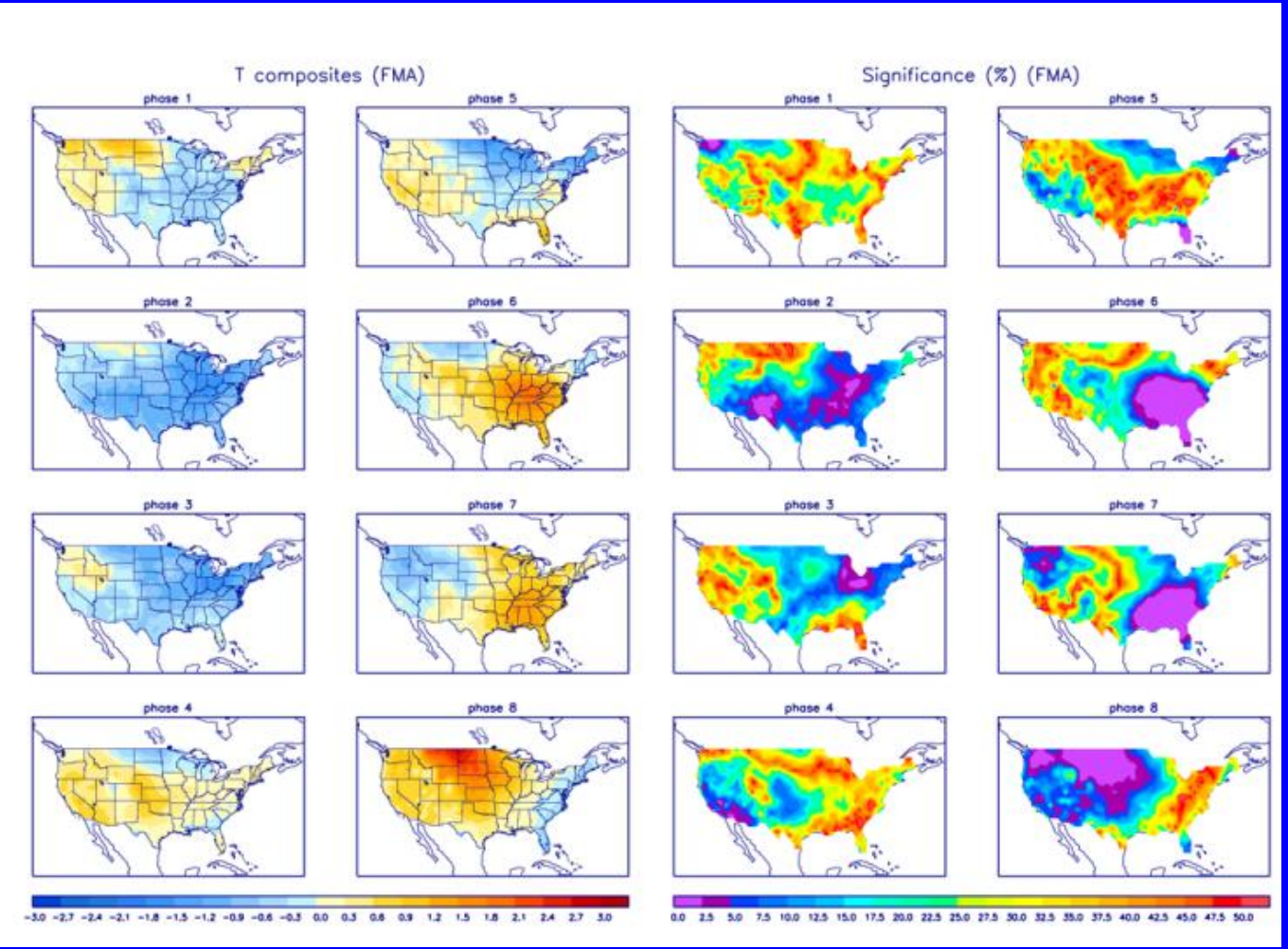


Precipitation Anomalies (Nov-Mar)



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.**

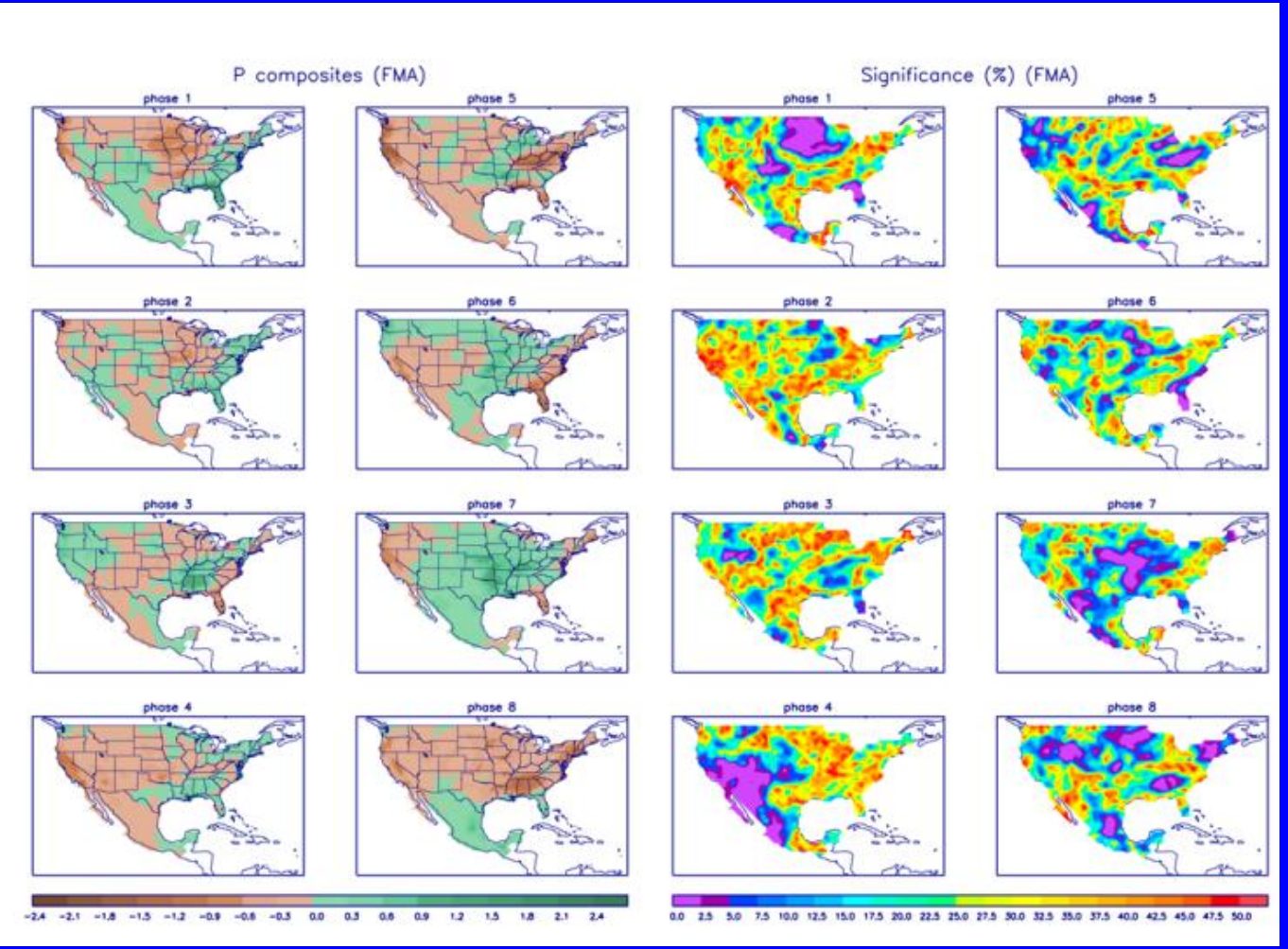


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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