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

Update prepared by
Climate Prediction Center / NCEP
March 12, 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 shifting to the Maritime Continent.

- Dynamical model MJO index forecasts show the MJO remaining active through the period, although there is some spread amongst the models about the phase by the end of the period. The MJO is forecast to remain active and shift to the western Pacific during the upcoming 1-2 weeks.

- The MJO is forecast to contribute to enhanced convection across the Maritime Continent and parts of the western Pacific during the next two weeks. Suppressed convection is favored for the parts of Brazil (Week-1), Africa, and the Indian Ocean (Weeks 1-2) during the period.

- The current phase of the MJO favors constructive interference with La Nina as enhanced convection related to the MJO continues over the Maritime continent. As the MJO continues to shift eastward later in Week-2, this will decrease.

- Looking ahead, as the MJO enhanced phase shifts to the western Pacific (Week-2), composites favor above-average temperatures for much of the eastern U.S. and enhanced odds for above-average precipitation for parts of the Pacific Northwest, the northern tier of the contiguous U.S, Great Lakes and Ohio Valley.

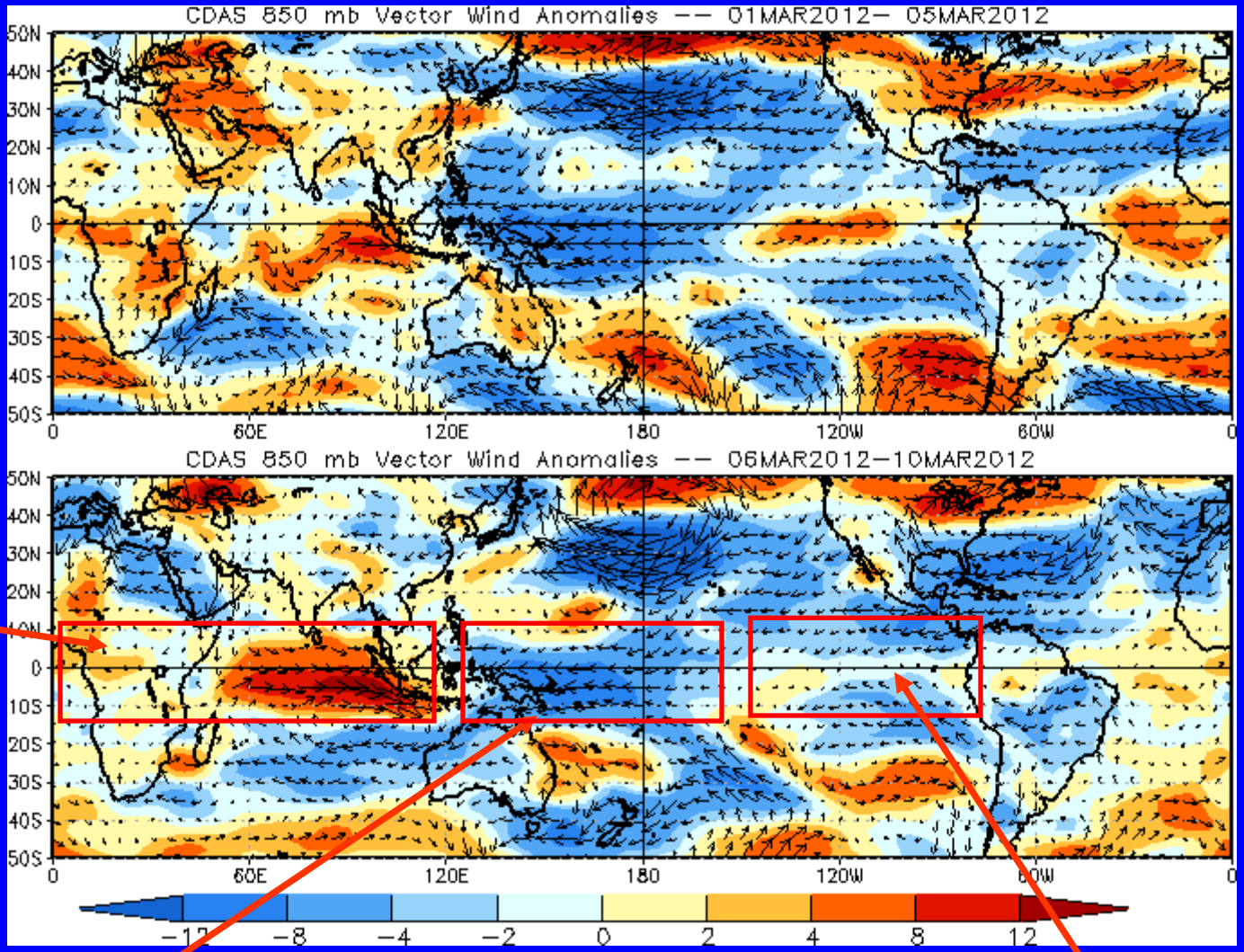
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 over Africa shifted eastward across the Indian Ocean and increased in intensity the past five days.

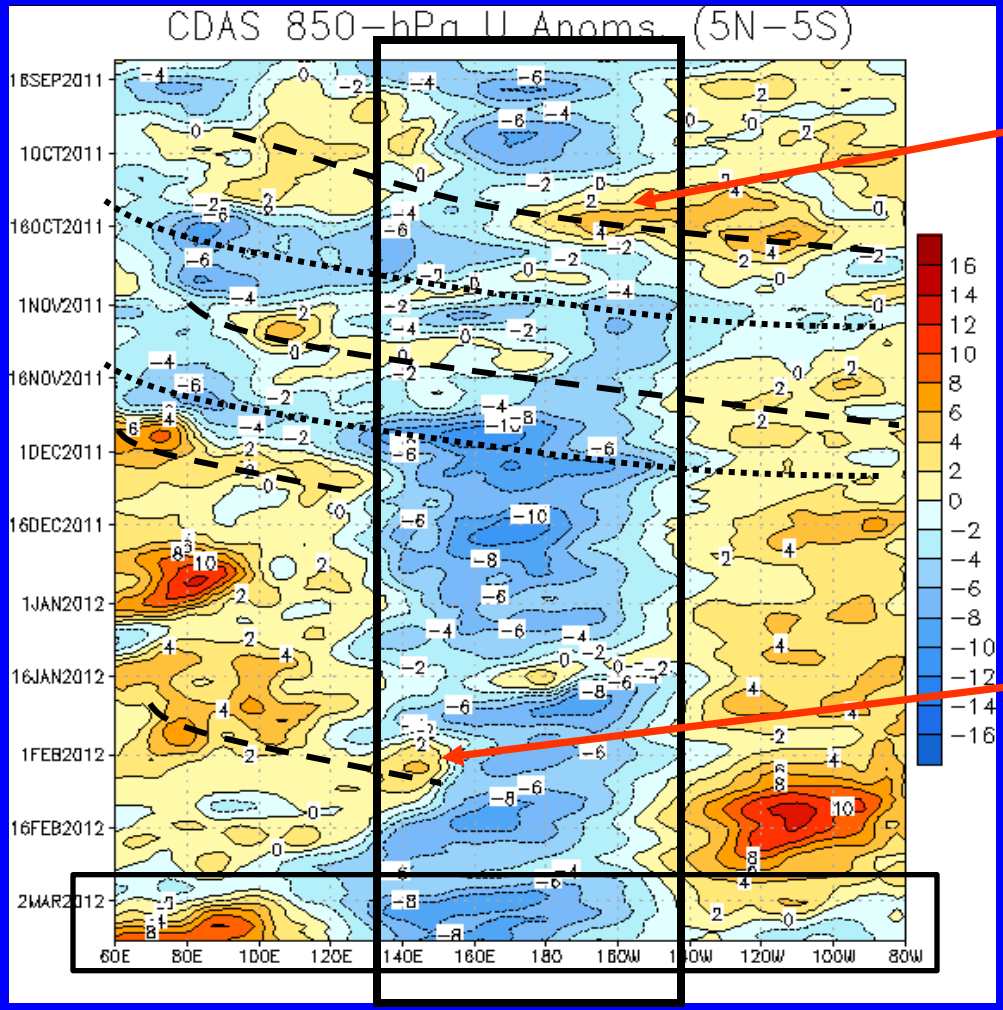
Easterly anomalies persisted over the Western and Central Pacific during the past five days but retreated from the bulk of the Maritime Continent.

Westerly wind anomalies over the eastern Pacific Ocean diminished significantly 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

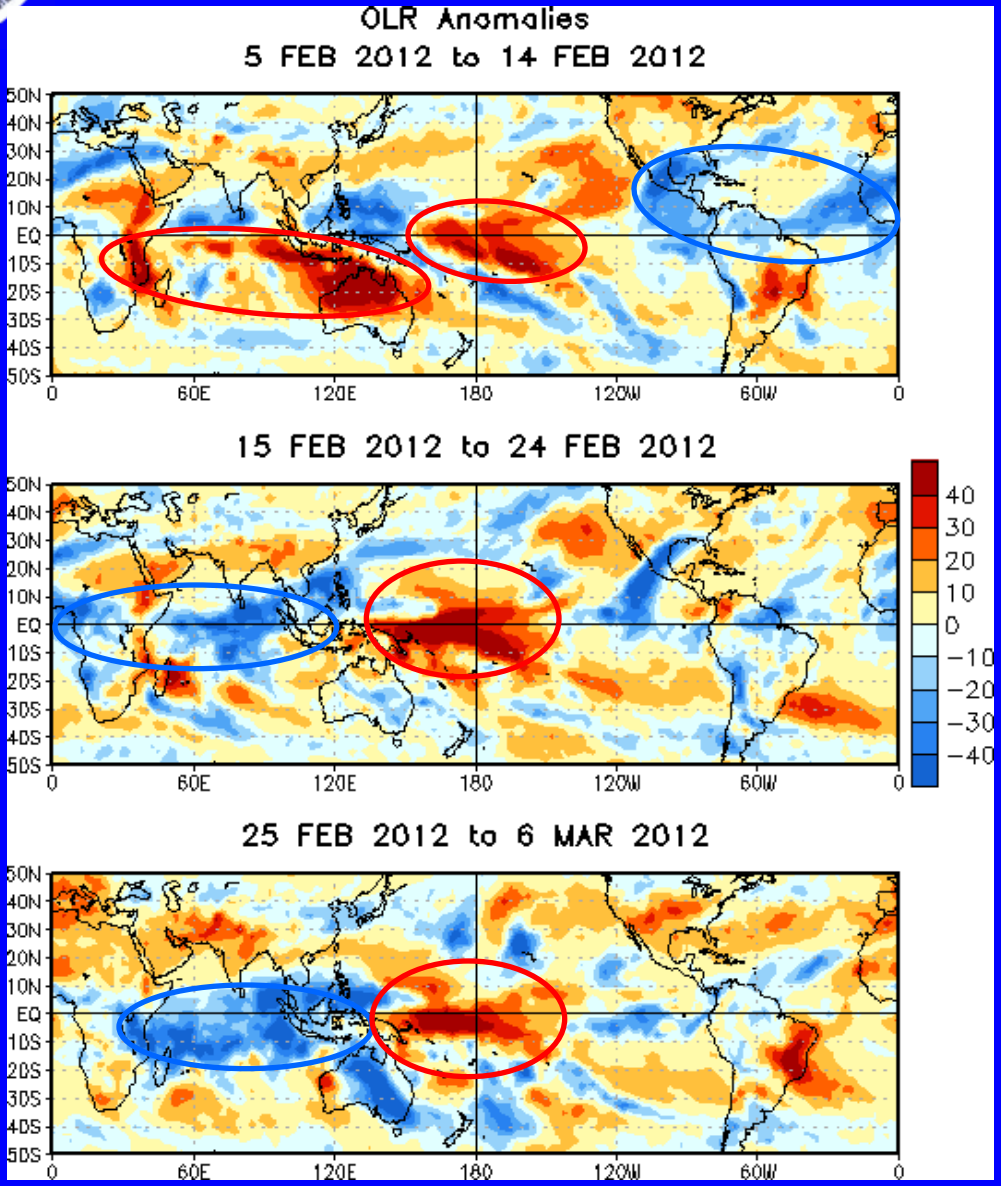
In early October, MJO activity weakened the persistent easterly anomalies across the central Pacific (first dashed line).

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 the current MJO activity.

During early March, the MJO along with other modes of variability have combined to enhanced westerly anomalies across the Indian Ocean, while producing easterly anomalies in the eastern Pacific.

OLR Anomalies – Past 30 days



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

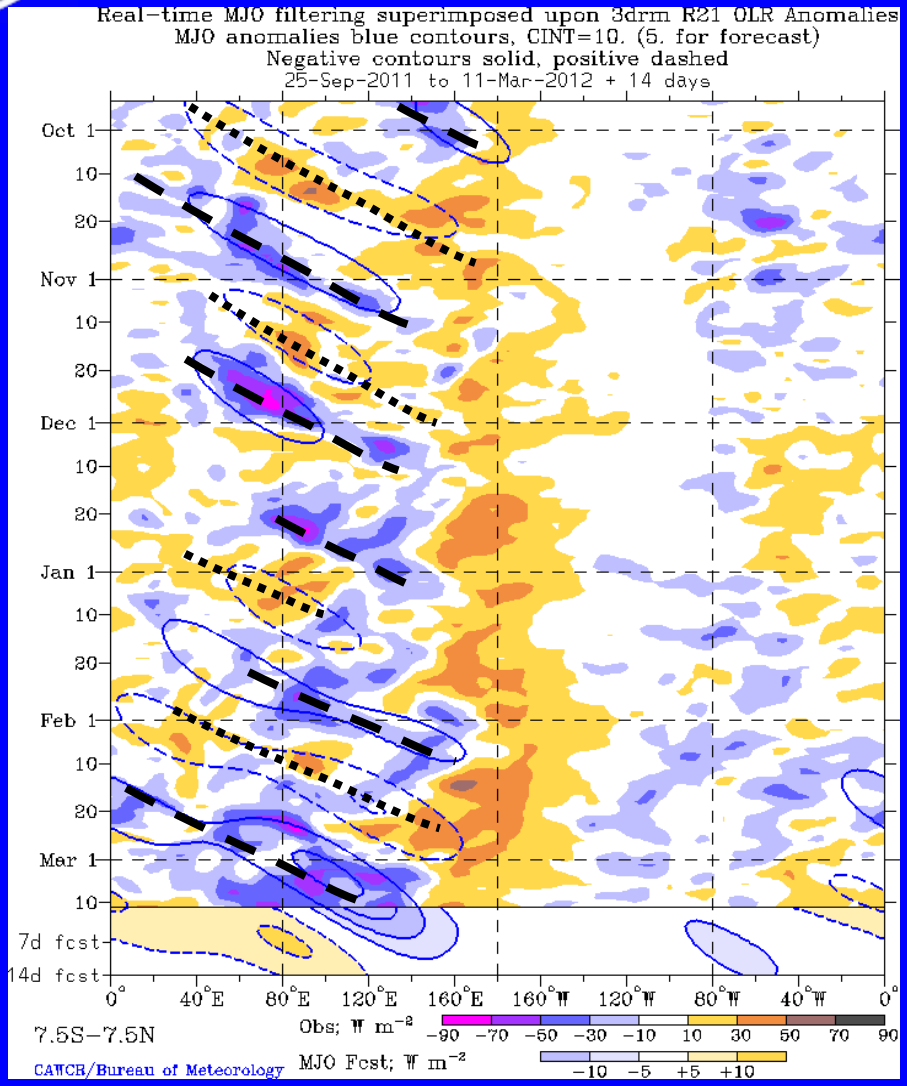
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early to mid-February, suppressed convection was observed over the central Pacific, Africa, most of the Indian Ocean, and northern Australia. Enhanced convection was observed across the Americas, the tropical Atlantic and Africa.

Enhanced convection was evident across Africa and the Indian Ocean during mid-February. Suppressed convection was observed for the western and Central Pacific.

During late February and early March, the MJO contributed to enhanced (suppressed) convection across Africa, the Indian Ocean, and the Maritime Continent (western Pacific and south America).

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.

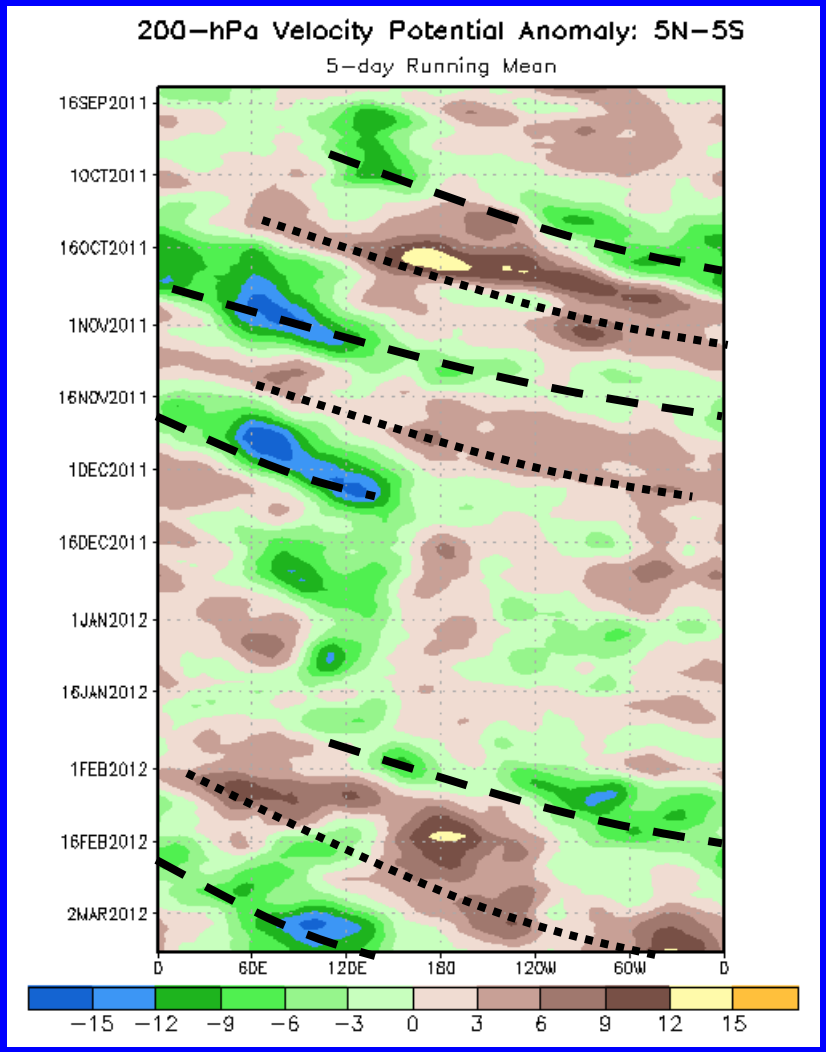
The MJO once again strengthened during late January enhanced convection shifted eastward across the Maritime continent.

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

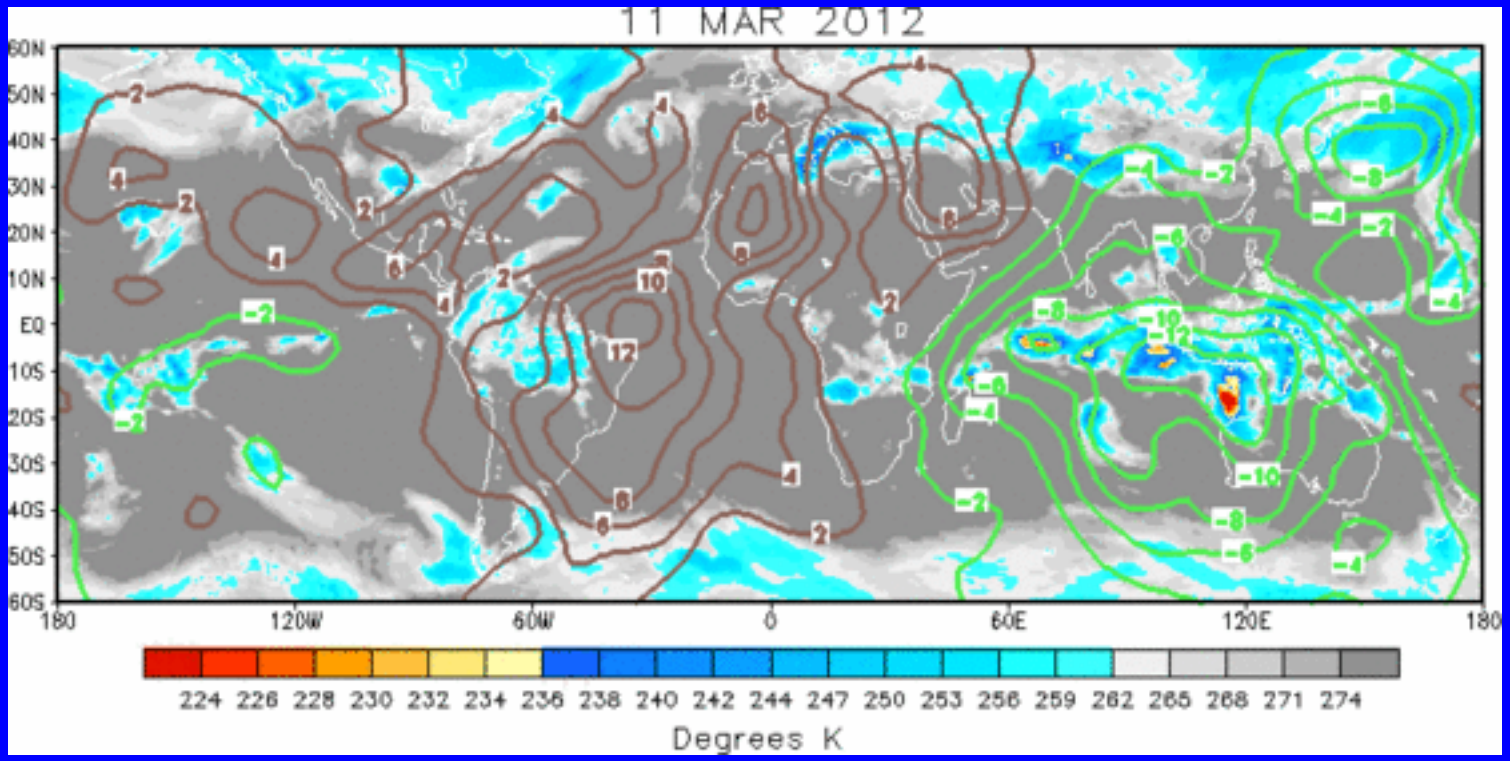
Eastward propagation of anomalies became less coherent during late December and early January and anomalies weakened.

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 once again is evident with enhanced divergence centered over the western Maritime Continent.

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

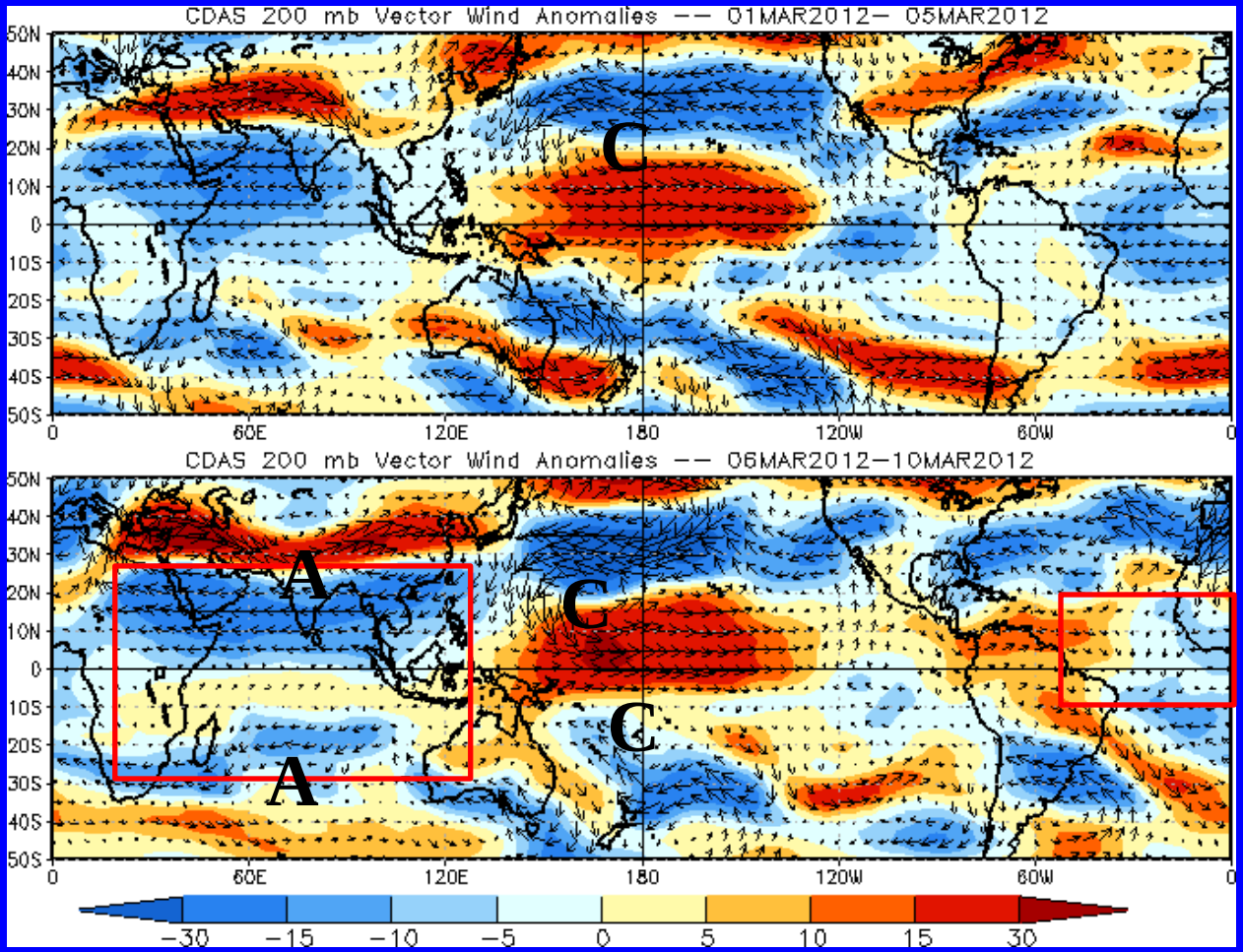
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern generally exhibits a wave-1 structure with upper-level divergence across the Indian Ocean and Maritime Continent, with upper-level convergence mainly over the Americas and Africa. 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

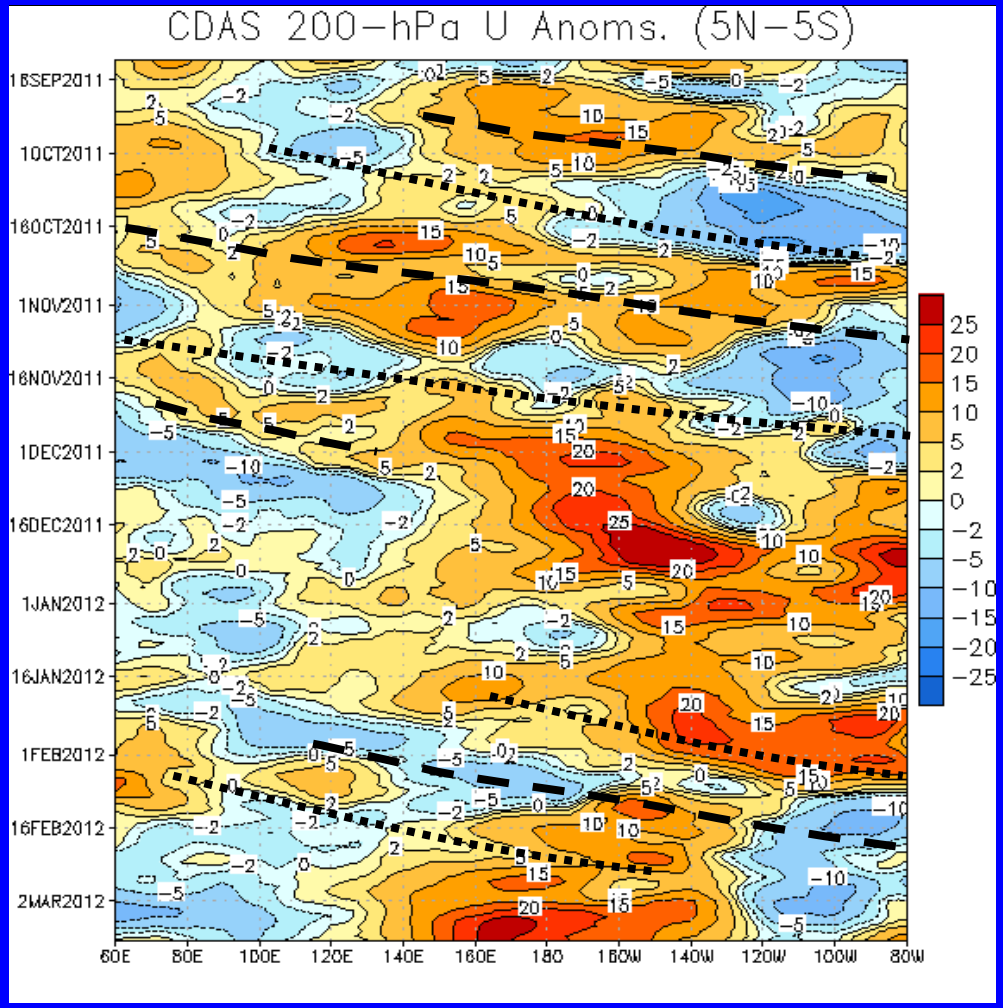
Red shades: Westerly anomalies

During the most recent five days, westerly anomalies over the western and central Pacific have increased in coverage and magnitude. Easterly anomalies and anomalous anticyclones are evident over southern Asia and the southern Indian Ocean.

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

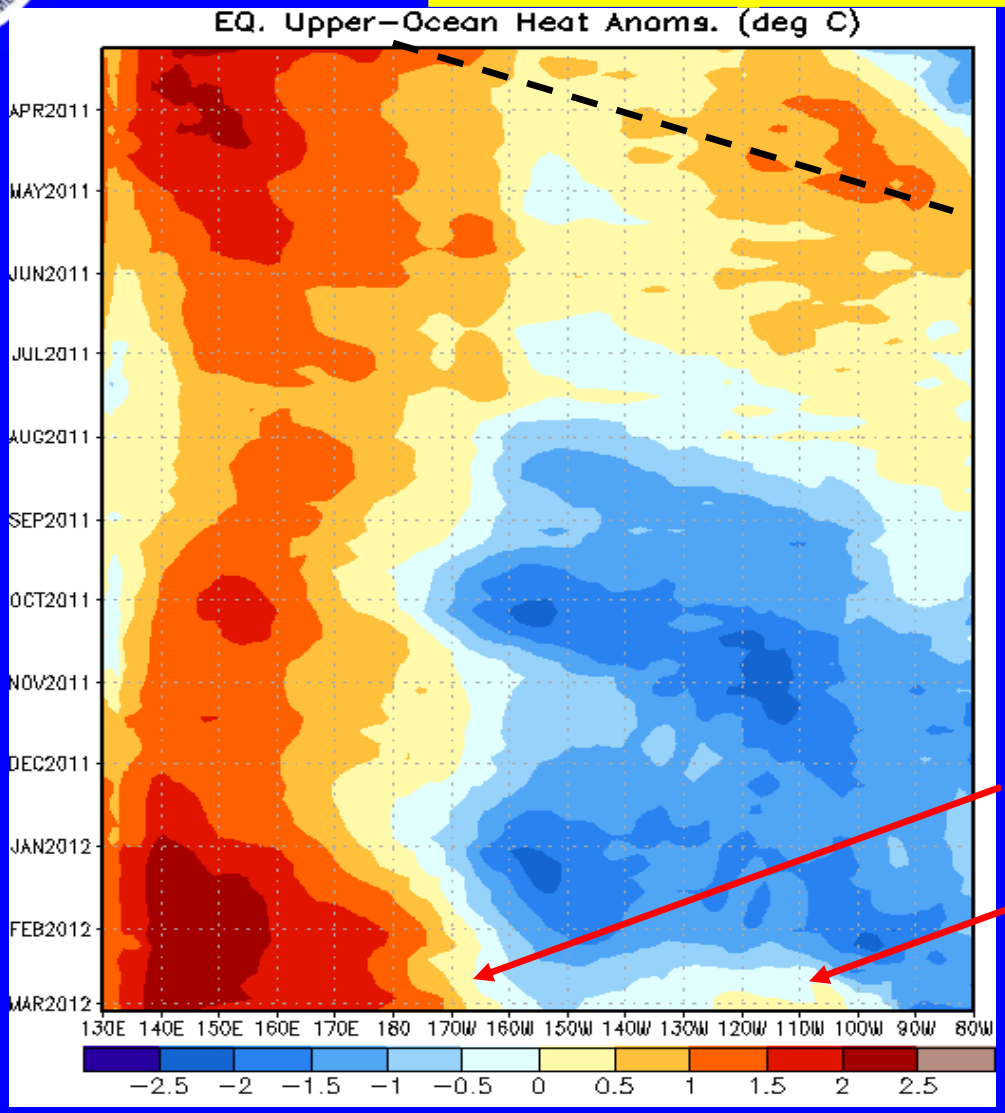
Alternating westerly (dashed lines) and easterly (dotted lines) anomalies are evident from mid-September into December associated with the MJO.

In December, westerly anomalies strengthened over the Pacific. In January these westerly anomalies showed some eastward propagation, and easterly anomalies have also shifted over the Pacific.

During February, westerly anomalies have moved slowly westward and are now located over the Maritime Continent and the Western Pacific.

Strong westerly anomalies now stretch from 120E to 120W, with easterly anomalies from 60E to 120E.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

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

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

In January and February 2012, negative heat content anomalies have 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).

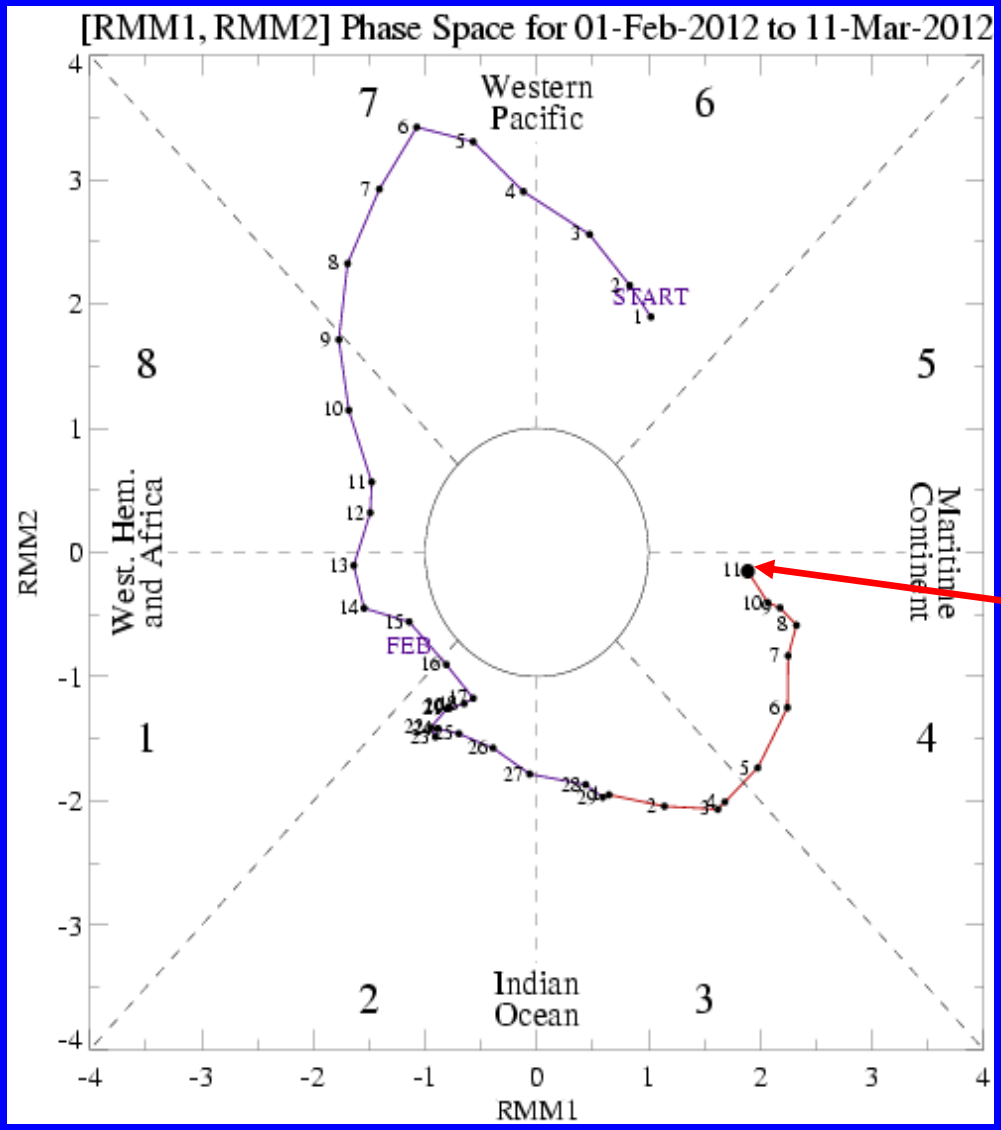
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

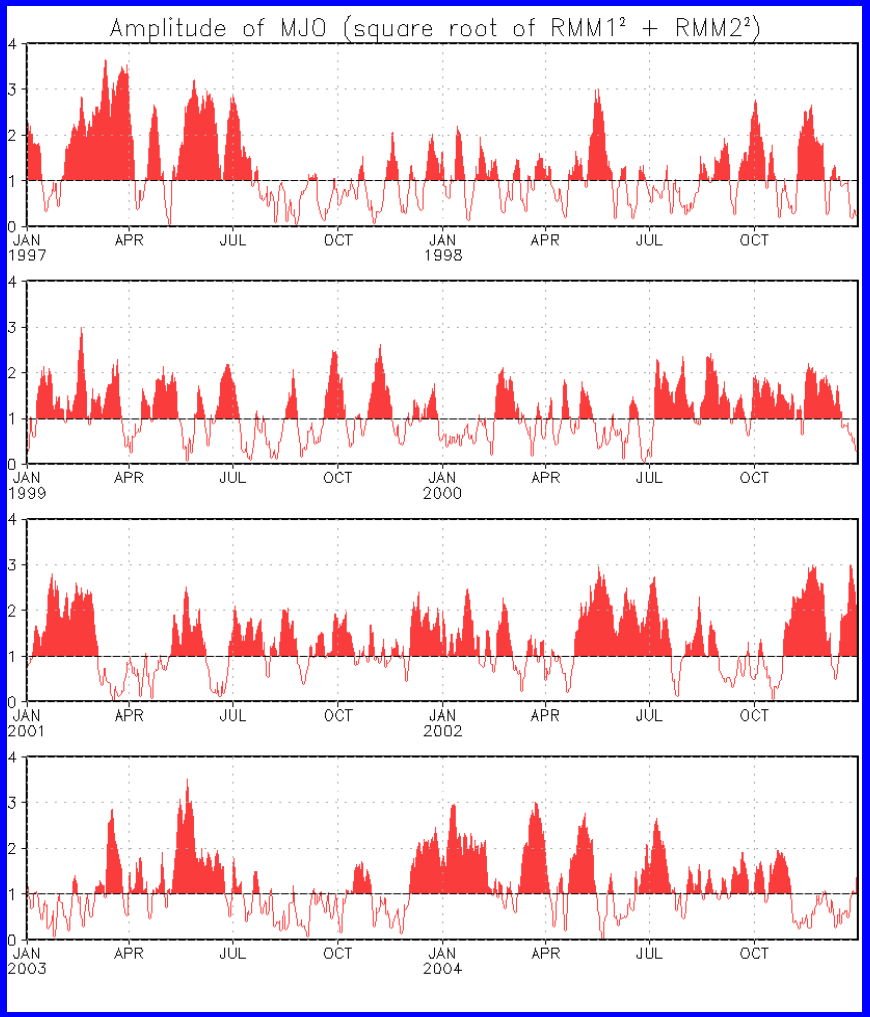
MJO Index -- Recent Evolution

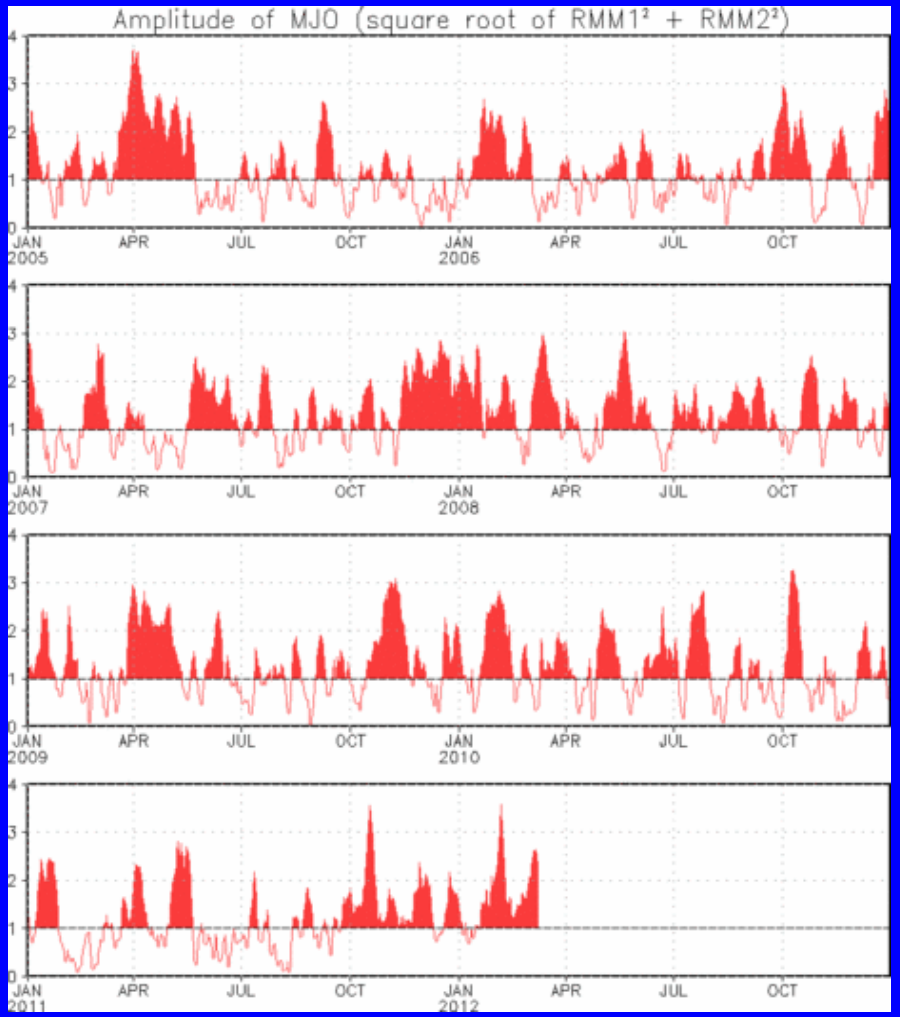


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

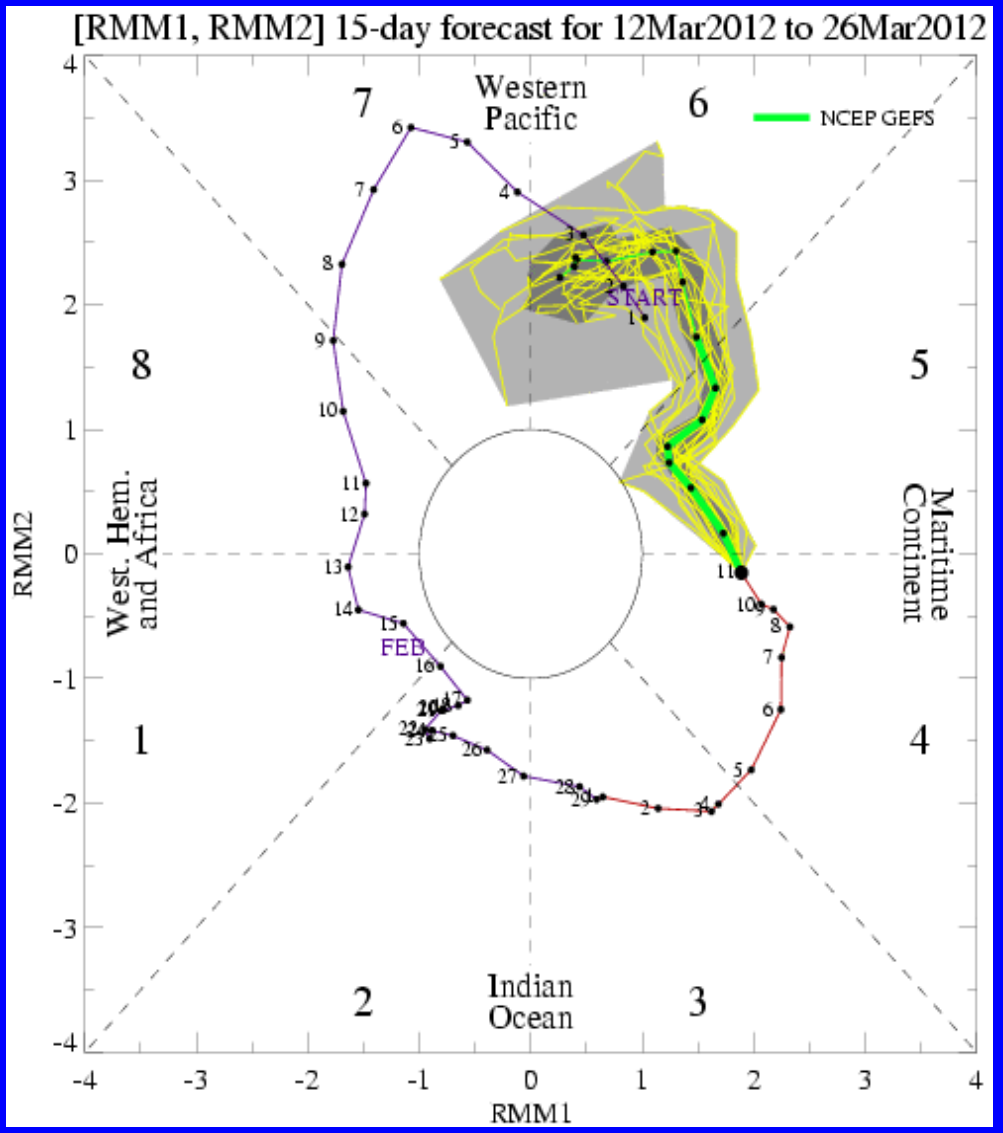
Ensemble GFS (GEFS) MJO Forecast

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

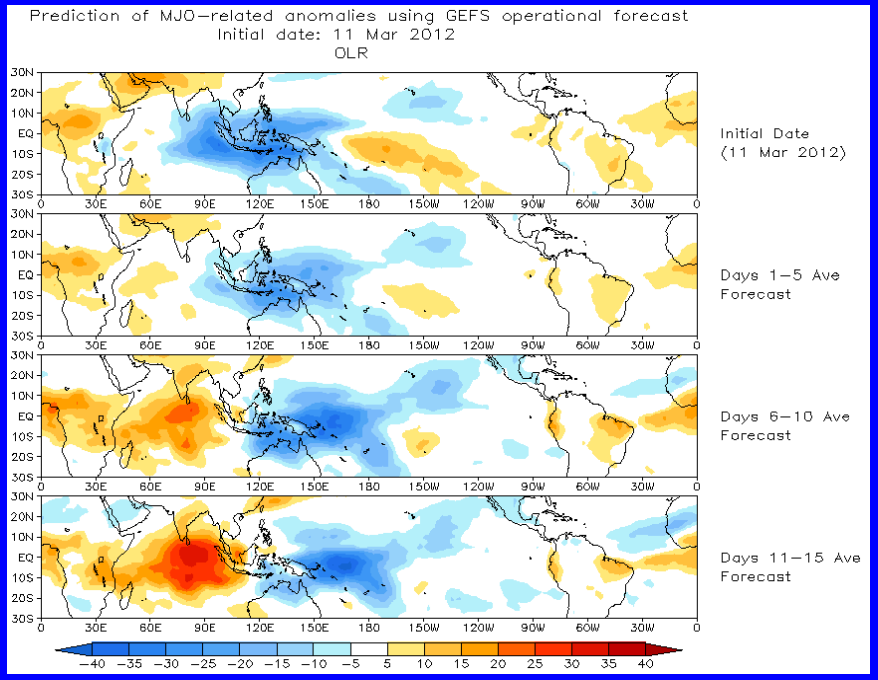
The ensemble GFS forecasts the MJO signal to continue propagating eastward over the next two weeks with the enhanced phase over the eastern Maritime Continent during Week-1 and entering the Western Pacific during Week-2.



Ensemble Mean GFS MJO Forecast

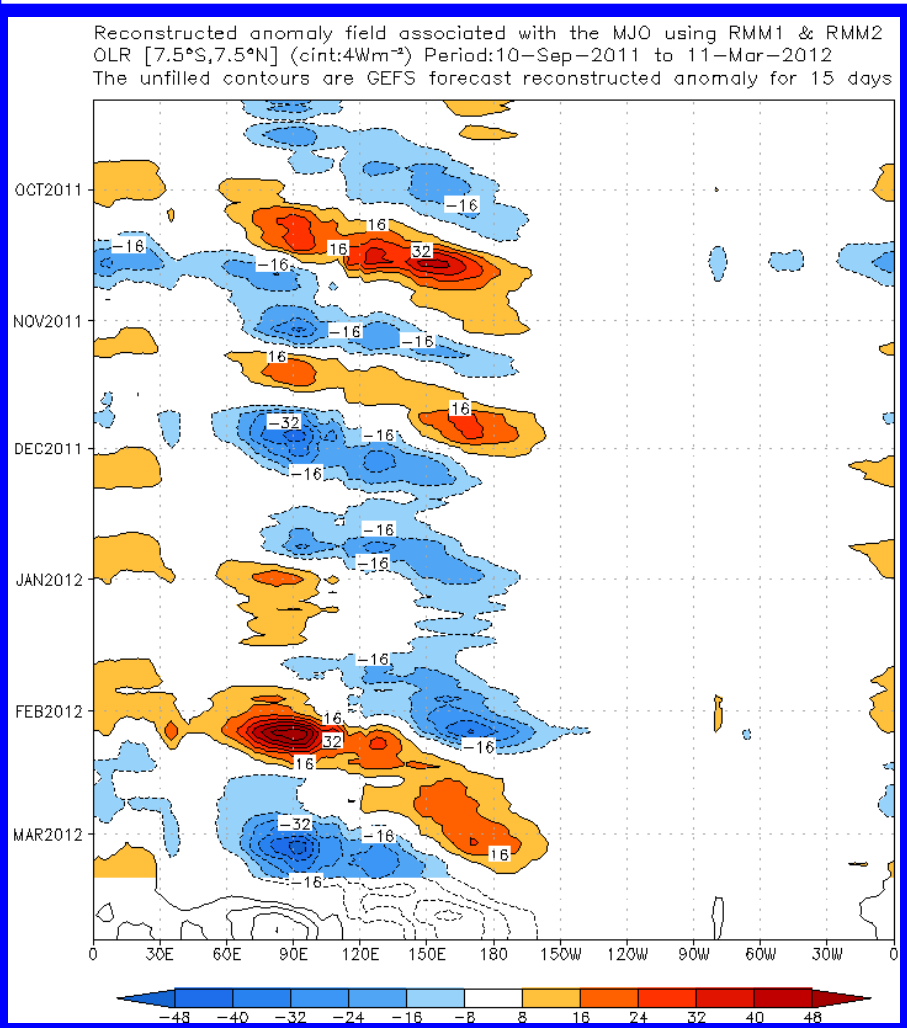
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecast indicates enhanced convection across the Maritime Continent during Week-1 with eastward propagation into the western Pacific by Week-2. Suppressed convection is forecast across Africa and the Indian Ocean during the period.

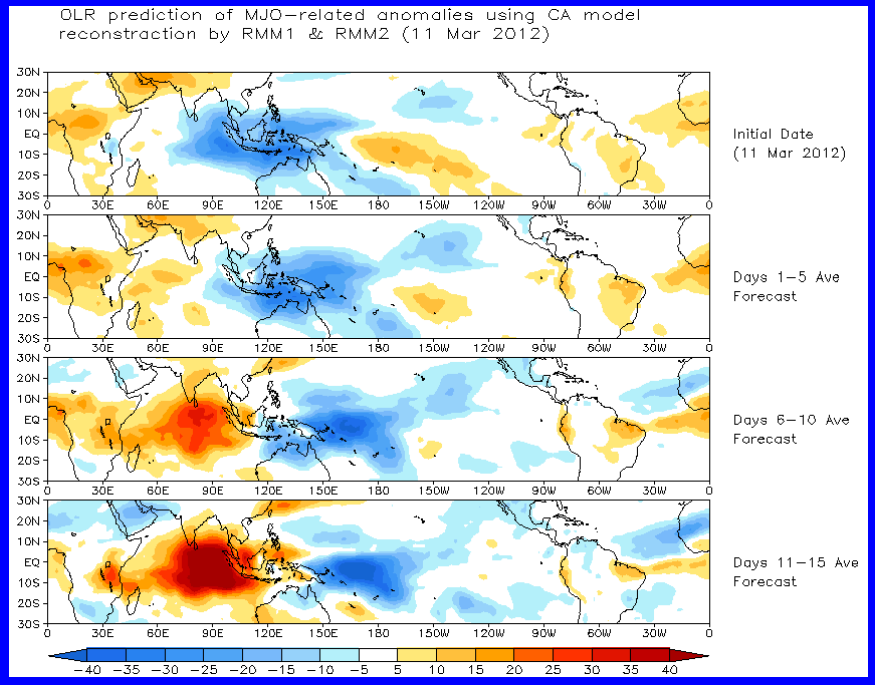
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

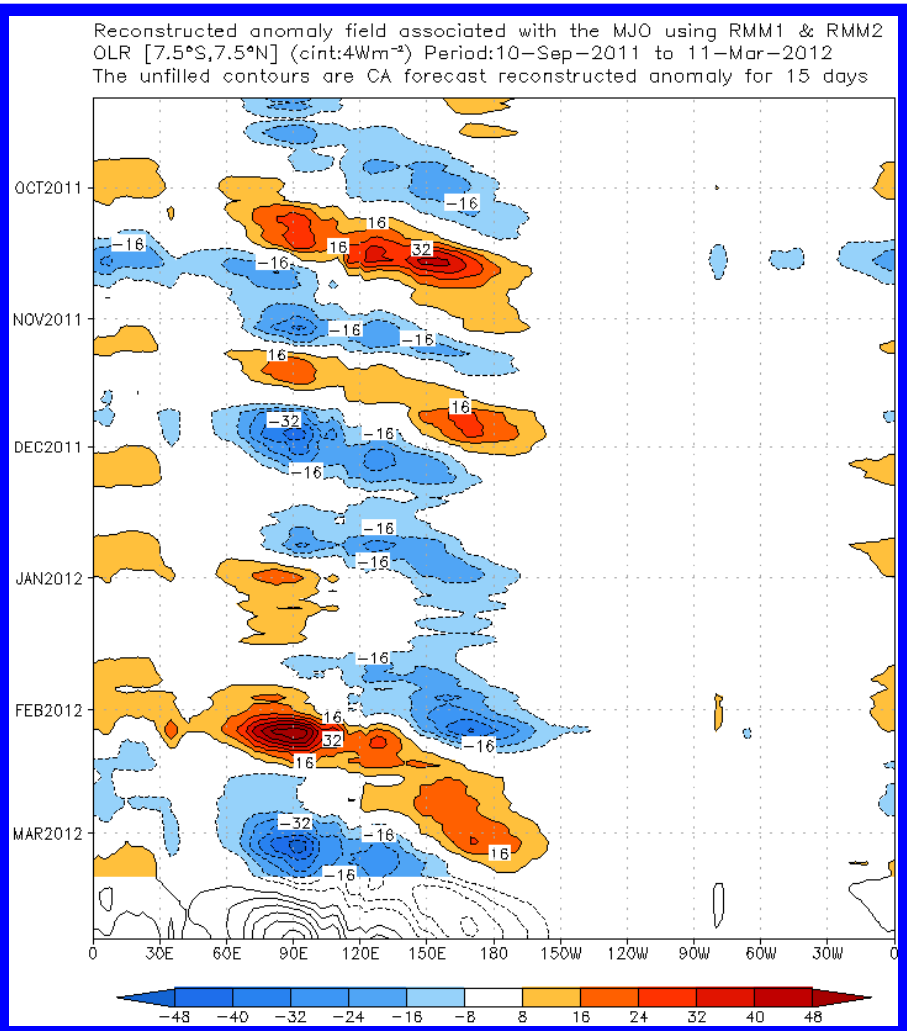
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



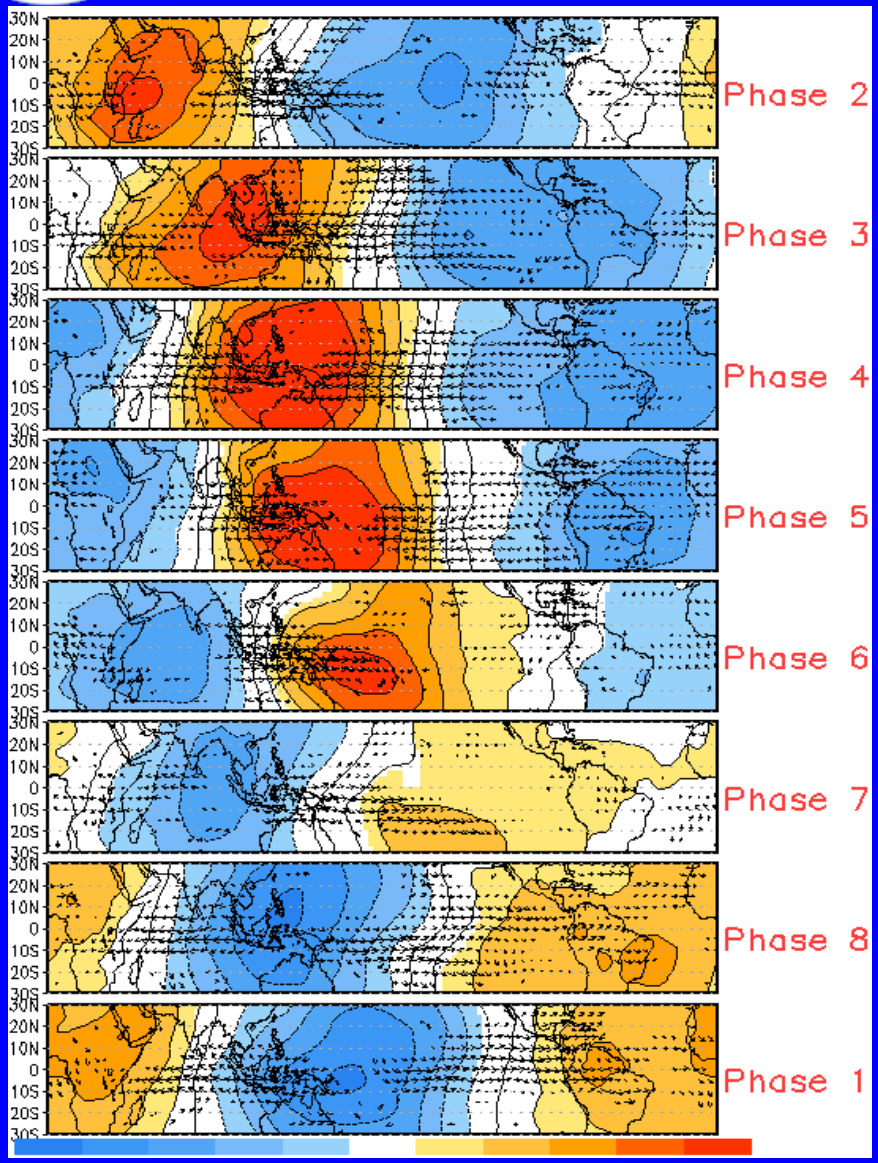
The CA forecast shows enhanced convection stretching from the Indian Ocean to the Western Pacific during Week-1, with additional eastward propagation during Week-2. Drier than average conditions are forecast for Africa and the Indian Ocean is forecast during much of the period.

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

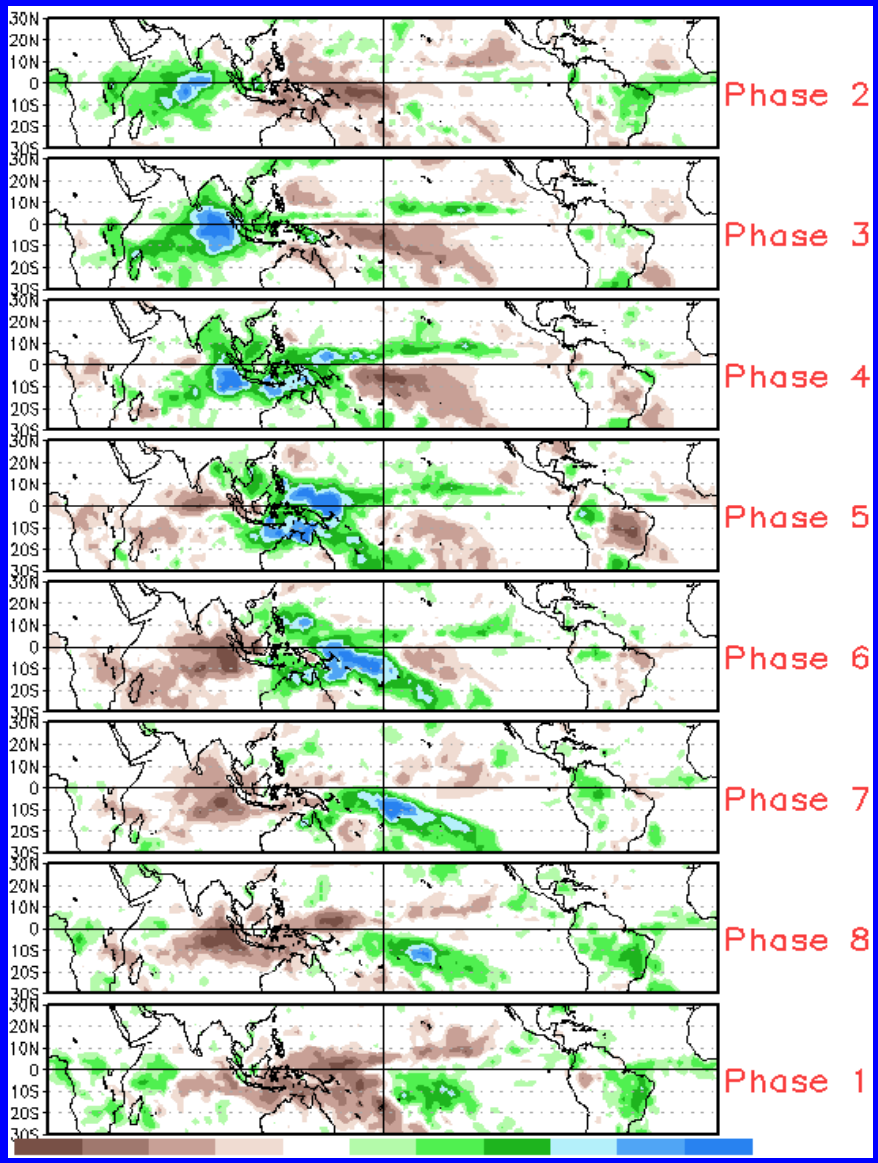


MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

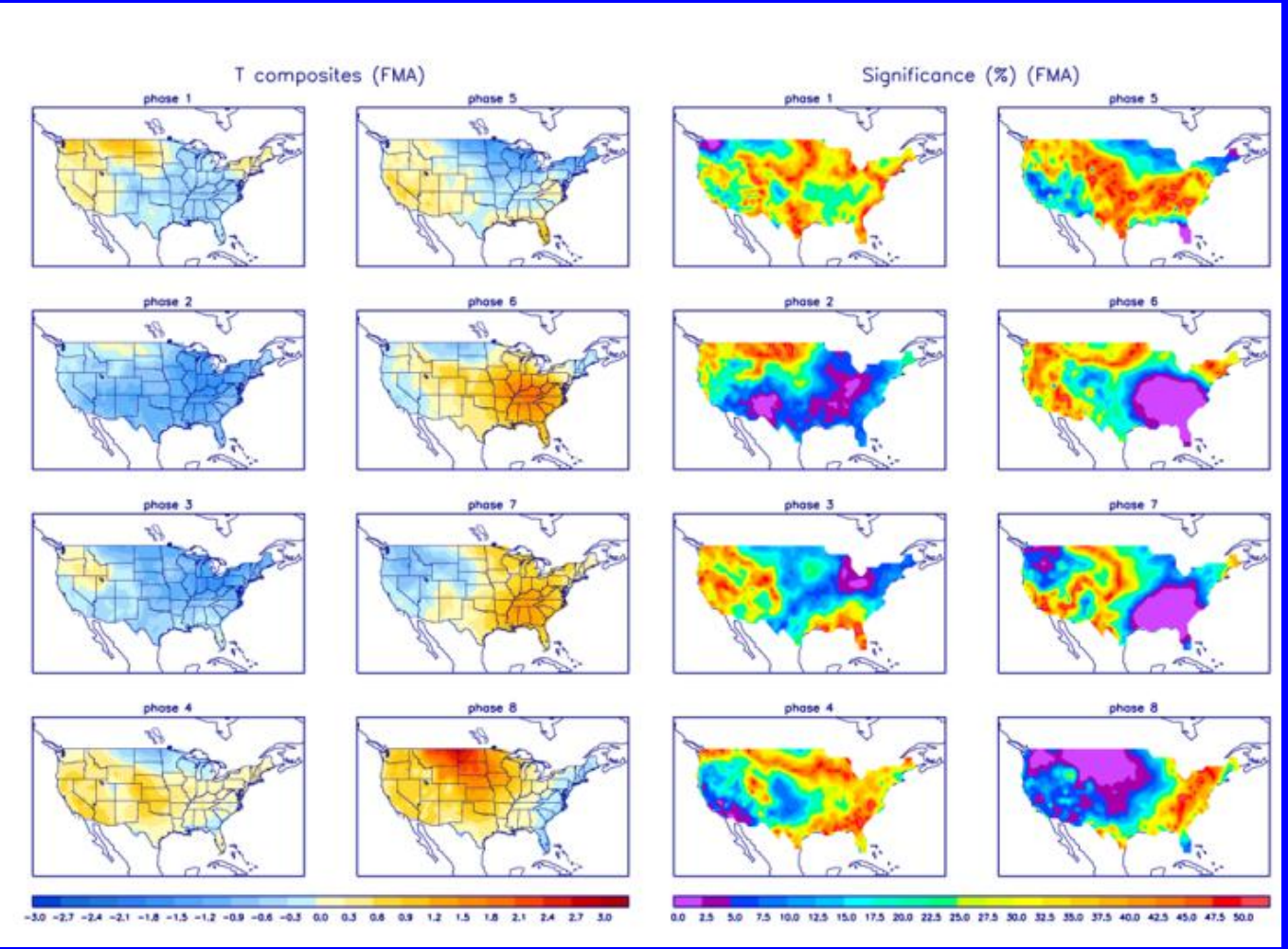


Precipitation Anomalies (Nov-Mar)



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.**

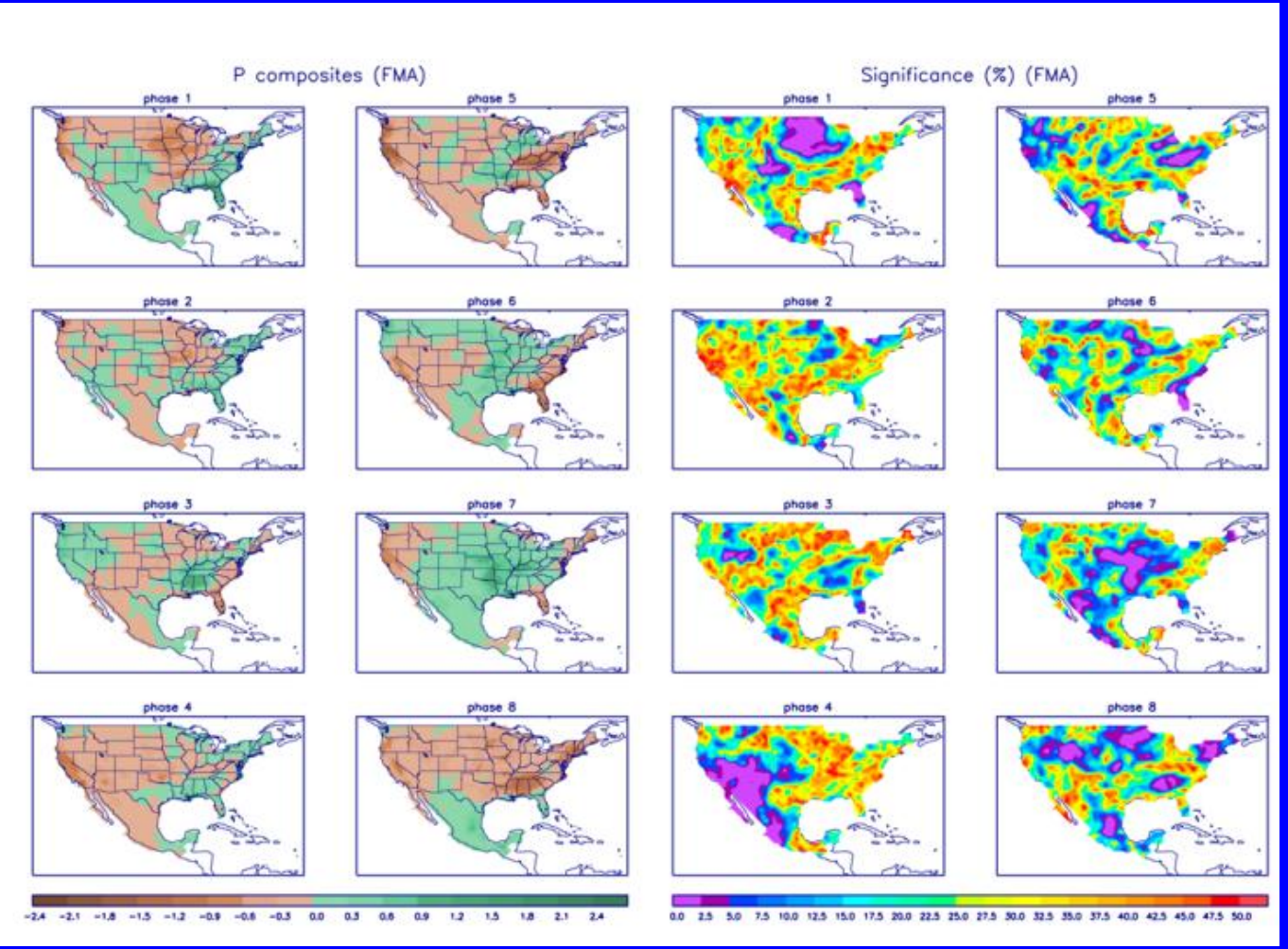


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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