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

Update prepared by
Climate Prediction Center / NCEP
April 2, 2012

Outline

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

Overview

- The MJO showed some signs of weakening during the past week as a few indicators became less coherent. The strongest enhanced convection in the Tropics is currently located across the southwest Pacific Ocean.

- Dynamical model MJO index forecasts indicate the MJO signal continuing with an increase in amplitude and renewed eastward propagation by Week-2.

- Based on the latest forecast models, the MJO is forecast to remain active and shift across the Western Hemisphere over the next 1-2 weeks.

- The MJO is forecast to contribute to enhanced convection across parts of the southwest Pacific, South America and Africa during the period. Suppressed convection remains favored for the eastern Indian Ocean (Week-1), northern Australia and the Maritime Continent (Weeks 1 and 2).

- Upcoming phases of the MJO favor and are consistent with an increase in chances of colder air entering the central and eastern continental U.S. during the period. MJO composites favor below-normal temperatures for parts of the central and southeast U.S. and above-average precipitation for parts of the southeast U.S. during Week-2.

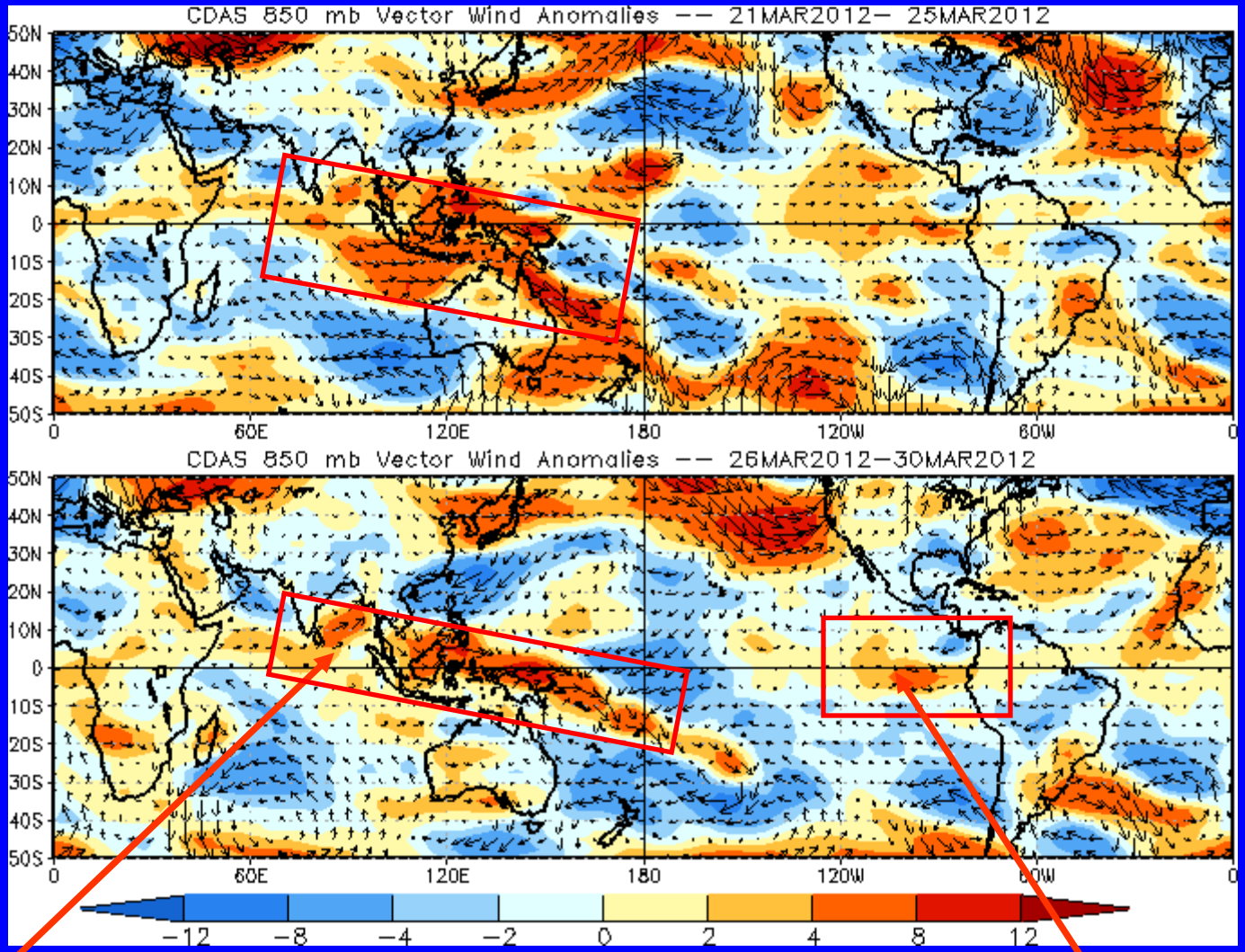
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



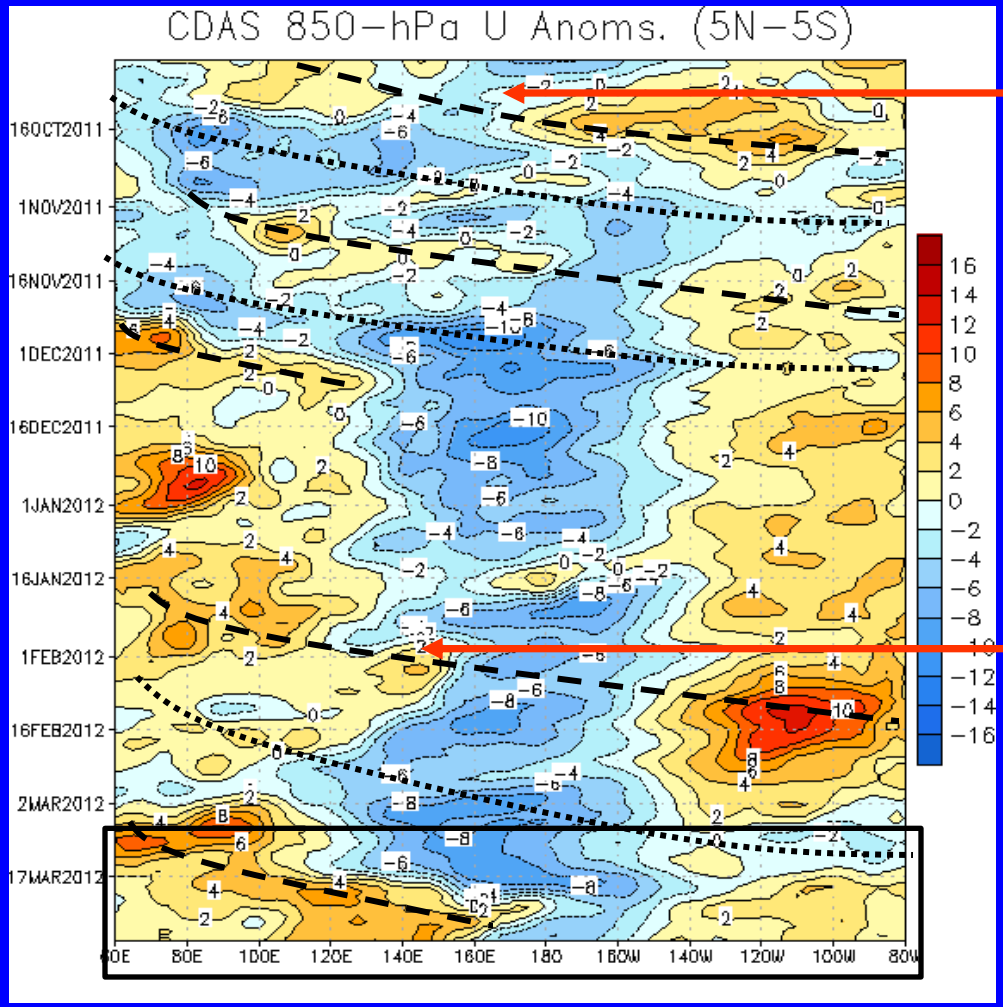
Westerly anomalies shifted slightly eastward over the western Pacific during the last five days, but also decreased in area and magnitude across the Maritime continent.

Westerly wind anomalies decreased in magnitude over the eastern Pacific 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

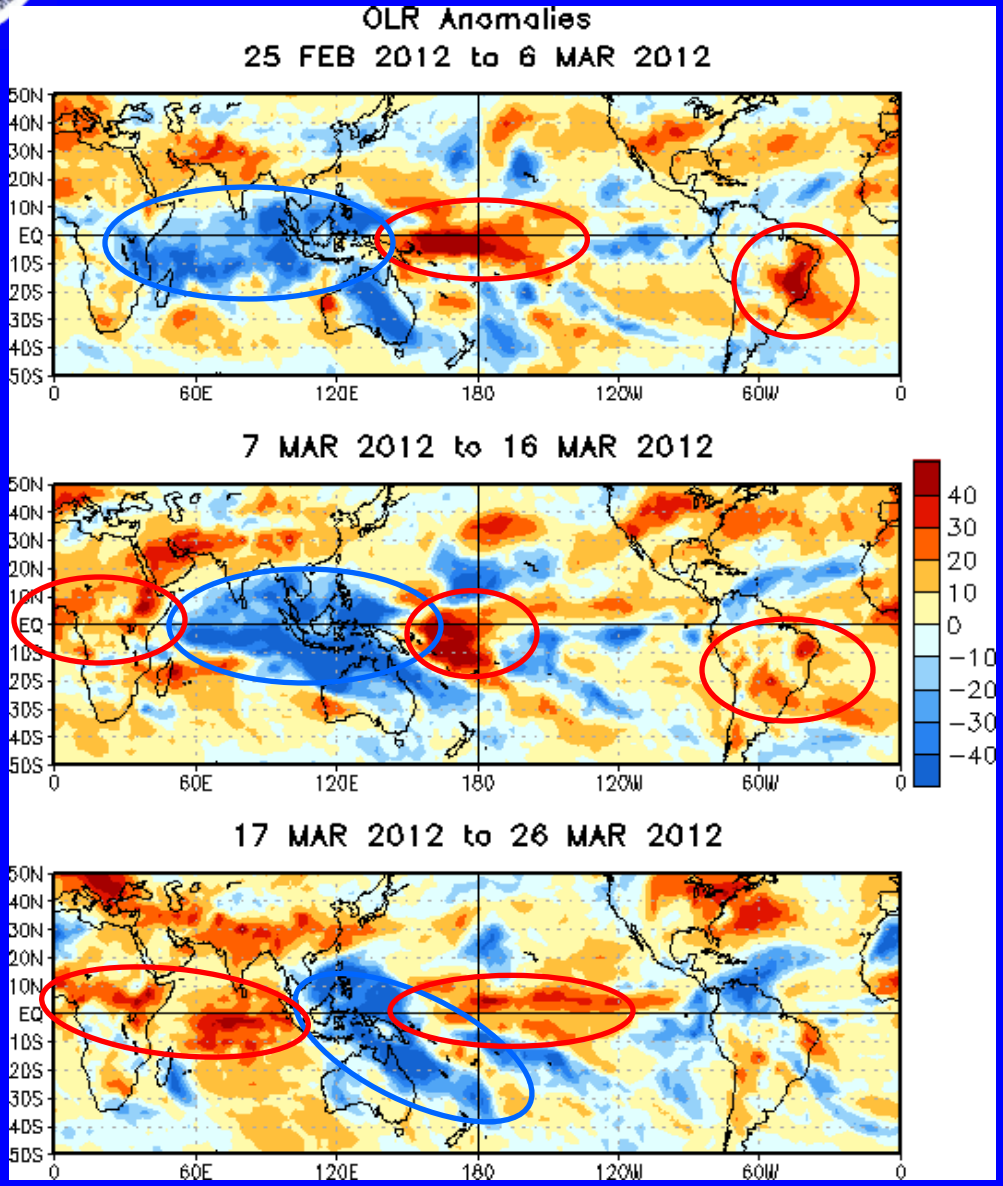
In early October, MJO activity weakened the persistent easterly anomalies across the central Pacific (first dashed line).

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 late March, westerly anomalies associated with the MJO propagated to the western Pacific, near the Date Line (black box).

OLR Anomalies – Past 30 days



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

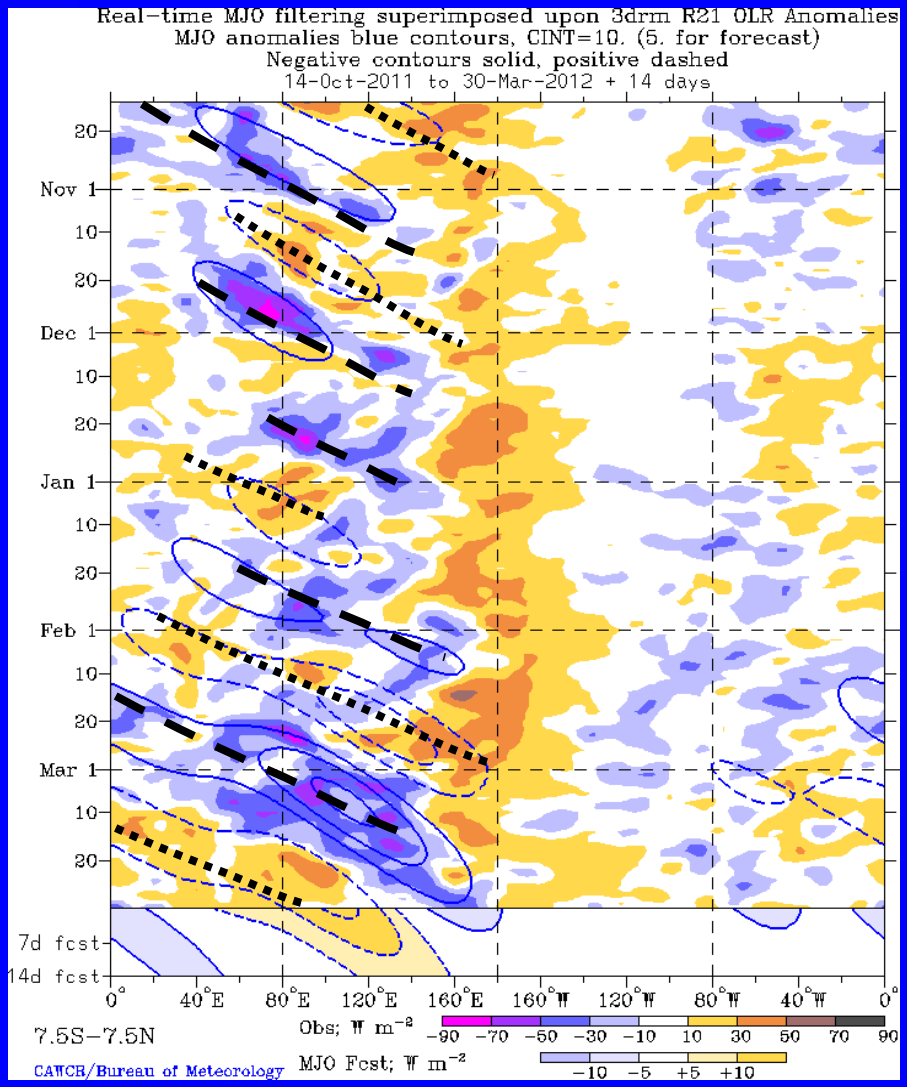
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During late February into early March, enhanced convection was evident from Africa to the Maritime Continent while suppressed convection was observed for the west-central Pacific and parts of the South America.

During early to mid-March, the MJO contributed to enhanced (suppressed) convection across the Maritime Continent and Western Pacific (central Pacific, South America and Africa).

Late in March, enhanced convection shifted eastward into the western Pacific and suppressed convection continued over Africa and developed across the 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)

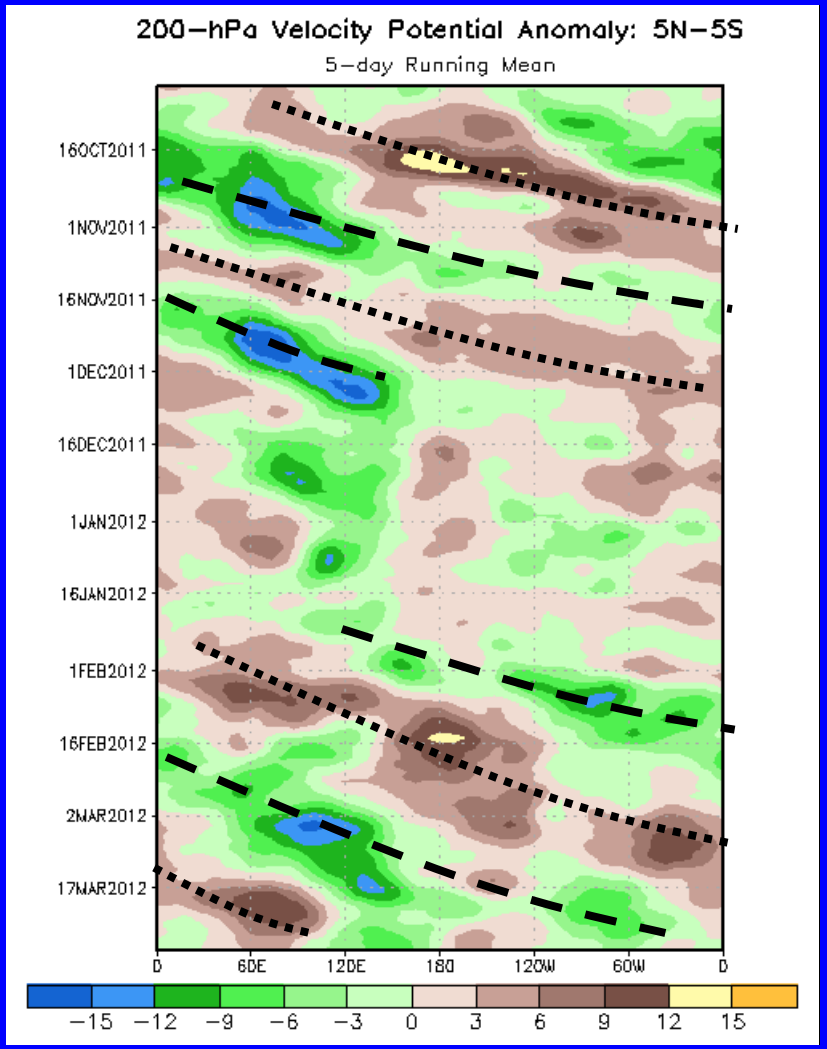
MJO activity was evident during October, November and early December as alternating areas of enhanced (dashed lines) and suppressed (dotted lines) convection shifted eastward.

The MJO once again strengthened during late January as enhanced convection shifted eastward across the Maritime continent. The MJO has continued into March, with enhanced convection beginning across the Western hemisphere and suppressed convection building across the Indian Ocean.

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.

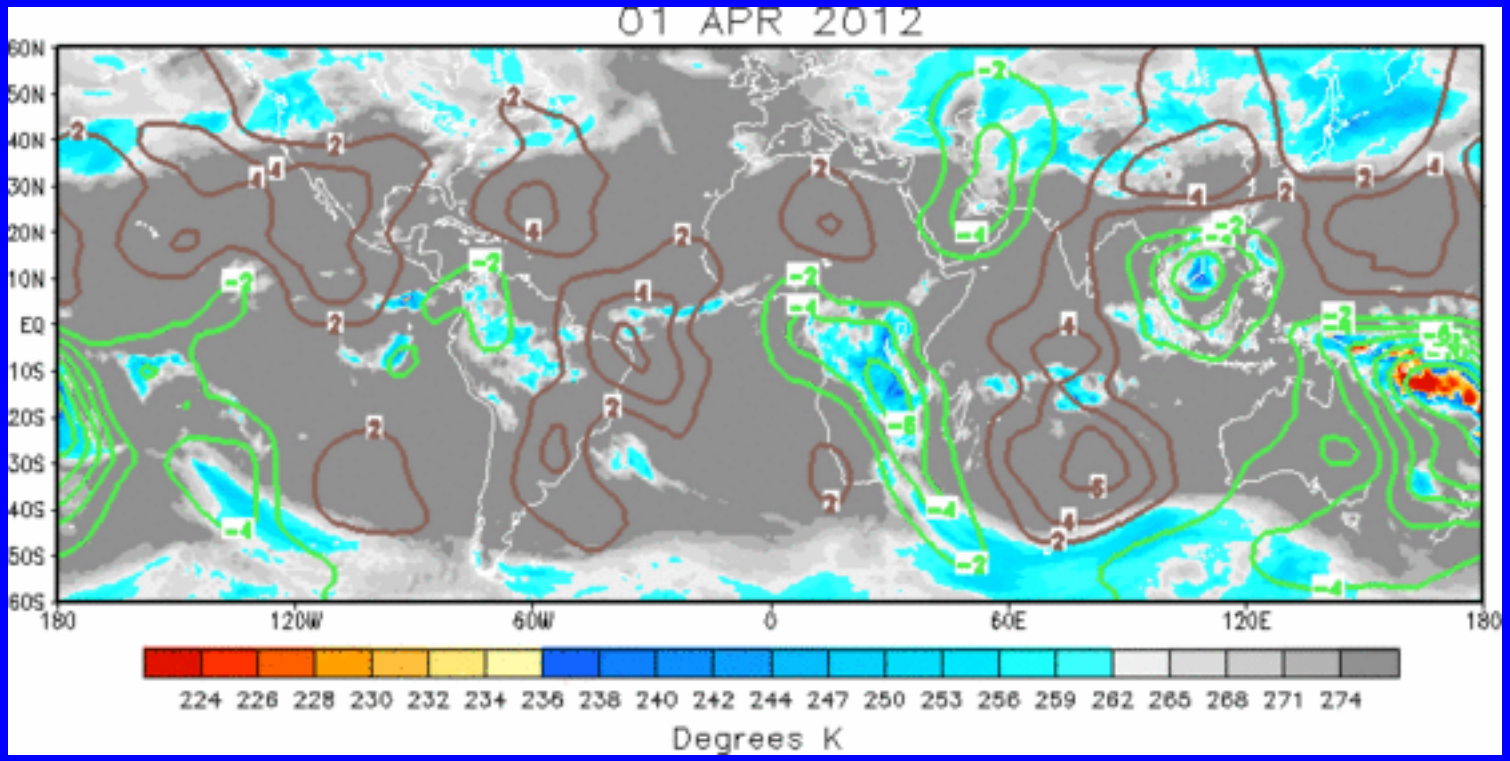
Eastward propagation of anomalies became less coherent during late December and early January and anomalies weakened.

The MJO strengthened in late January and eastward propagation has been evident through late March.

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

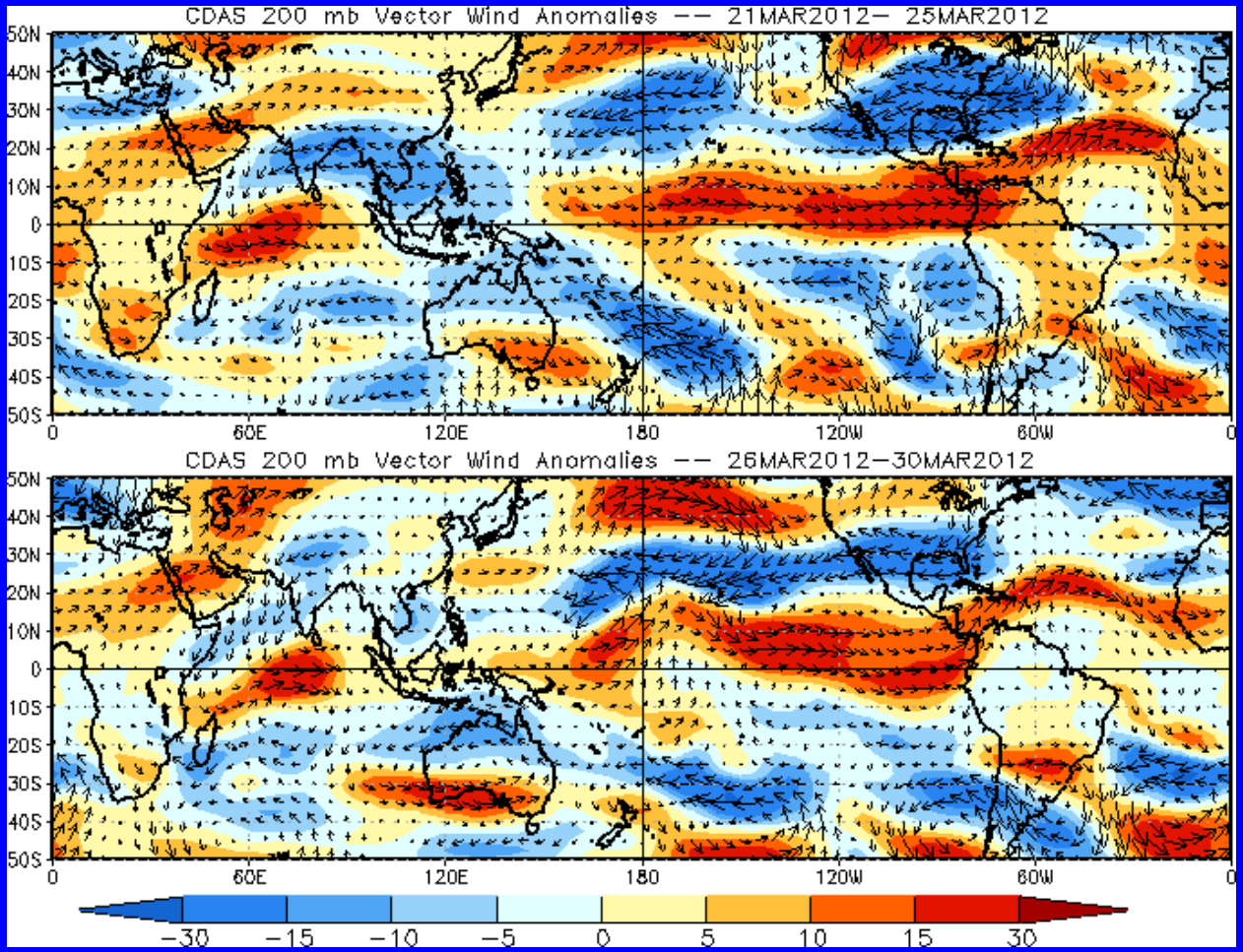
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern has become less coherent during the past week. The strongest current anomalies are for enhanced divergence across the southwest Pacific Ocean.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

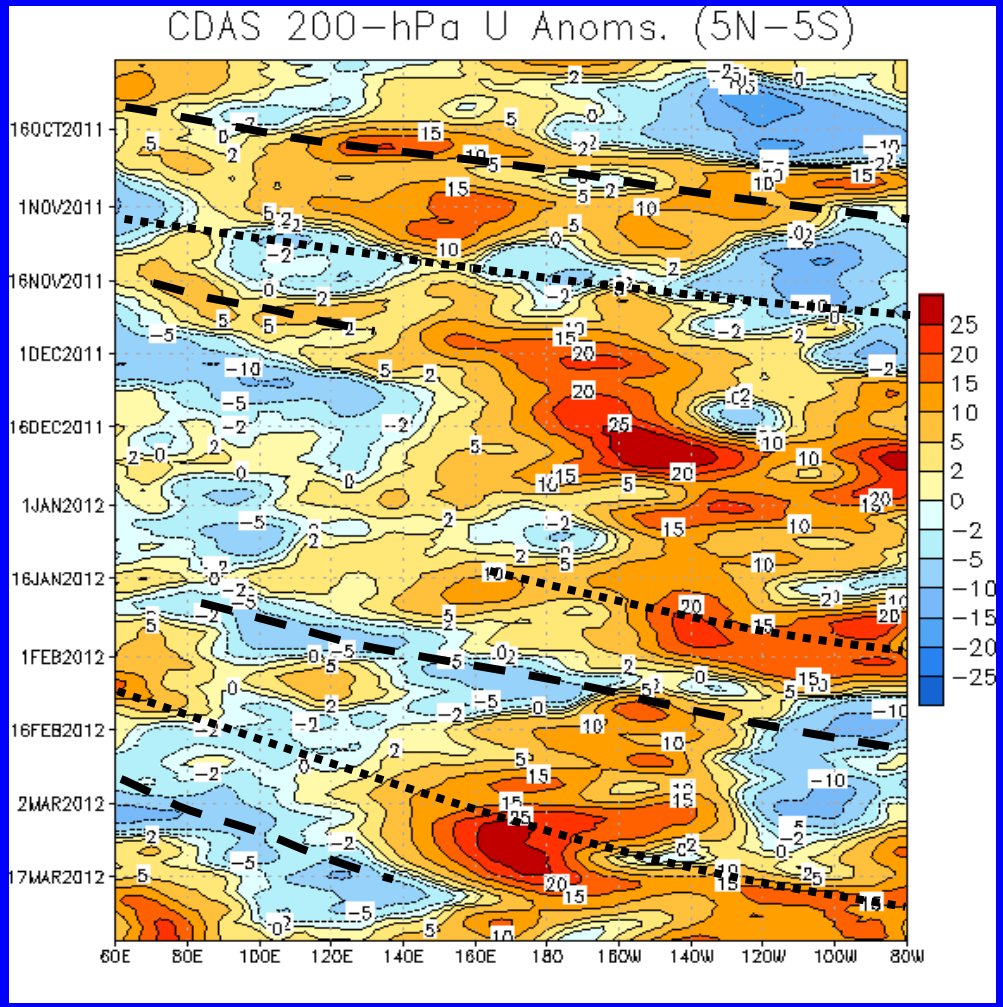
Red shades: Westerly anomalies

Westerly anomalies continued over the central and eastern Pacific during the past five days, but have decreased in coverage and magnitude across parts of Africa and the 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

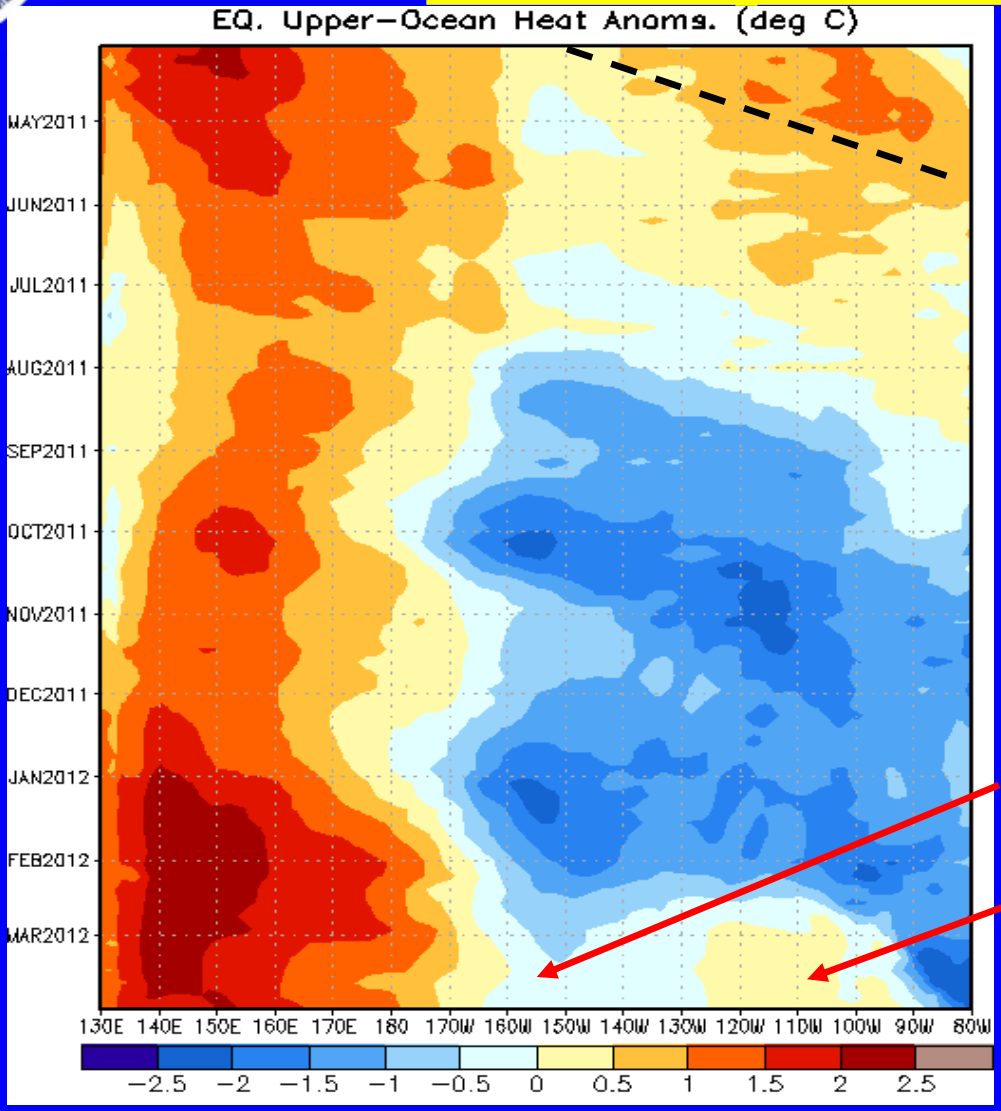
Longitude

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.

Eastward propagation was again more clearly evident during late January and February, continuing until mid-to-late March when easterly anomalies were evident near 140E and westerly anomalies shifted eastward, over the Americas, Africa and western Indian Ocean.

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).

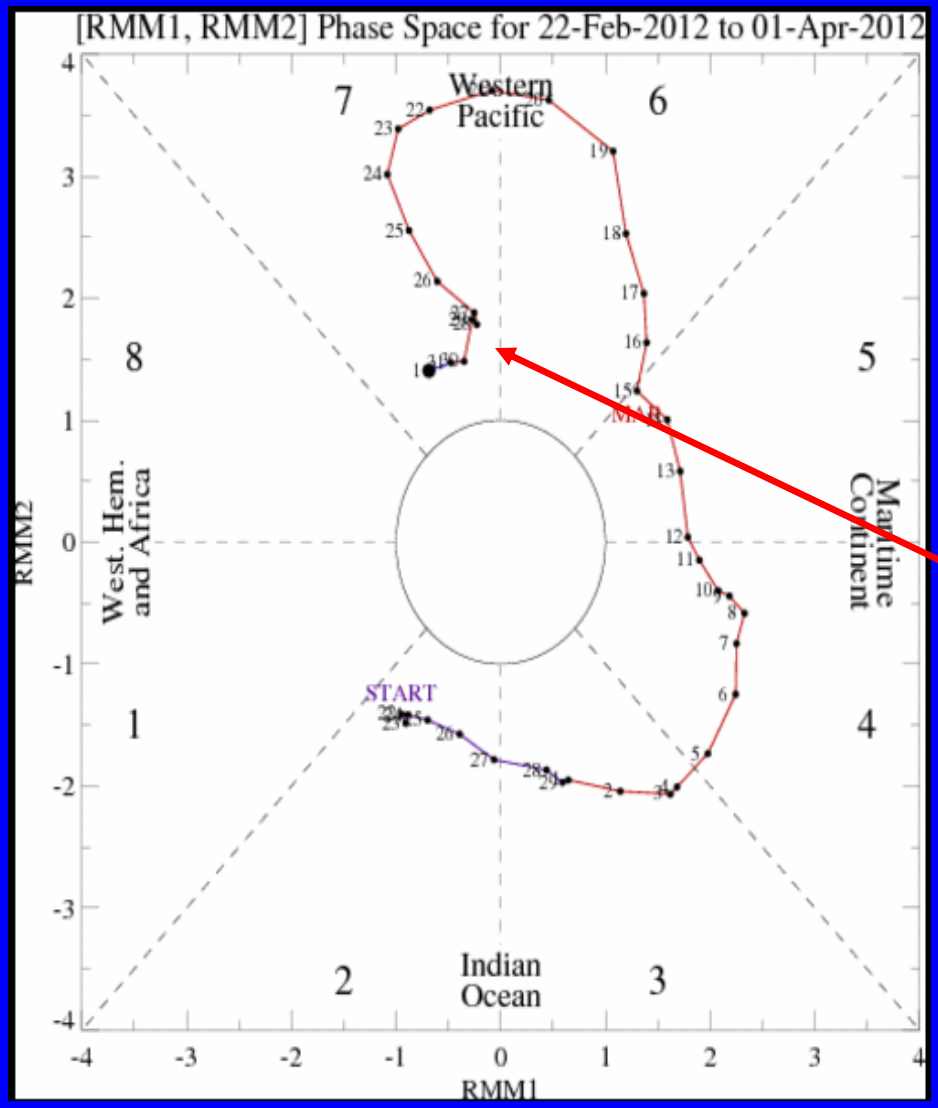
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

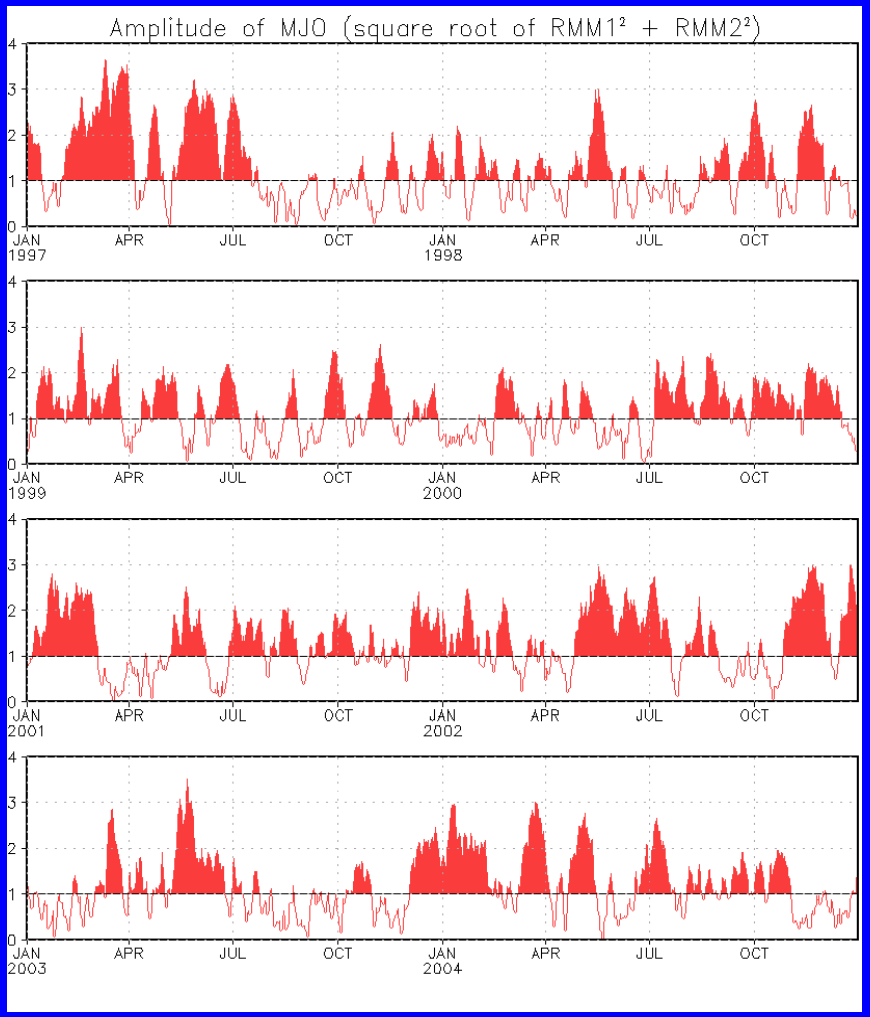
MJO Index -- Recent Evolution

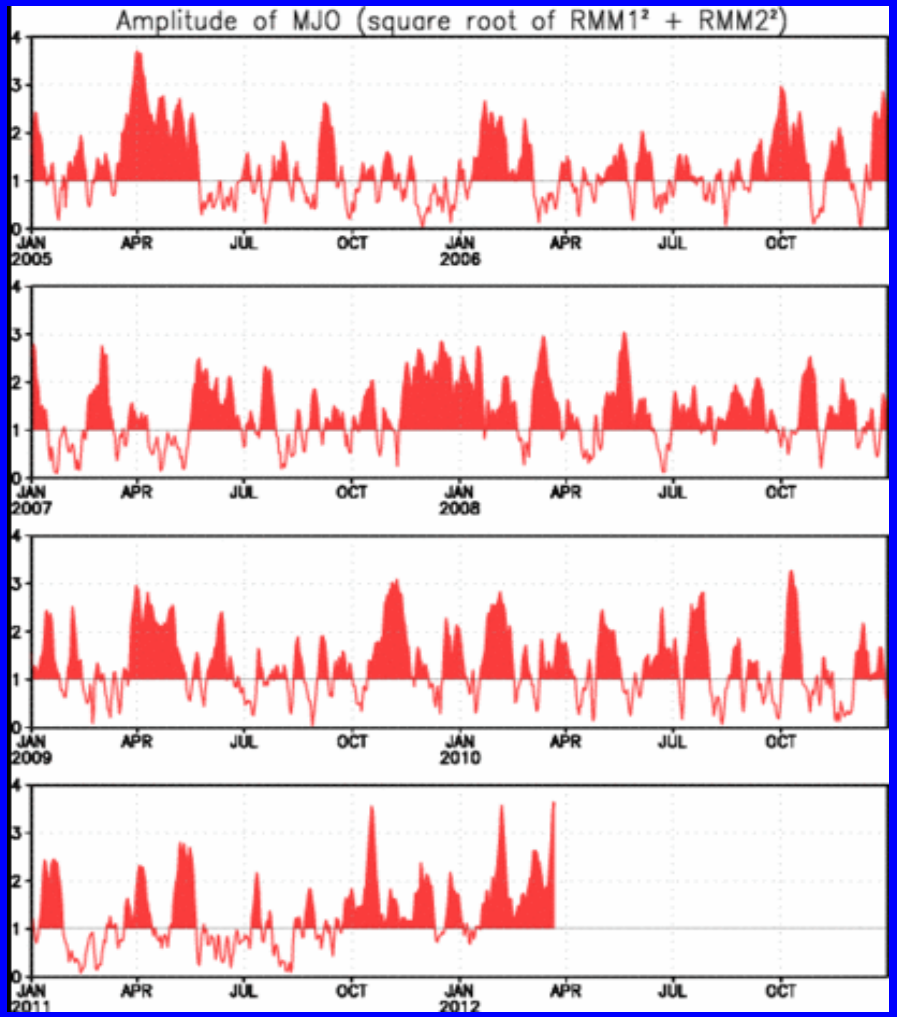


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index amplitude decreased markedly during the past week with also a decrease in eastward propagation.

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.

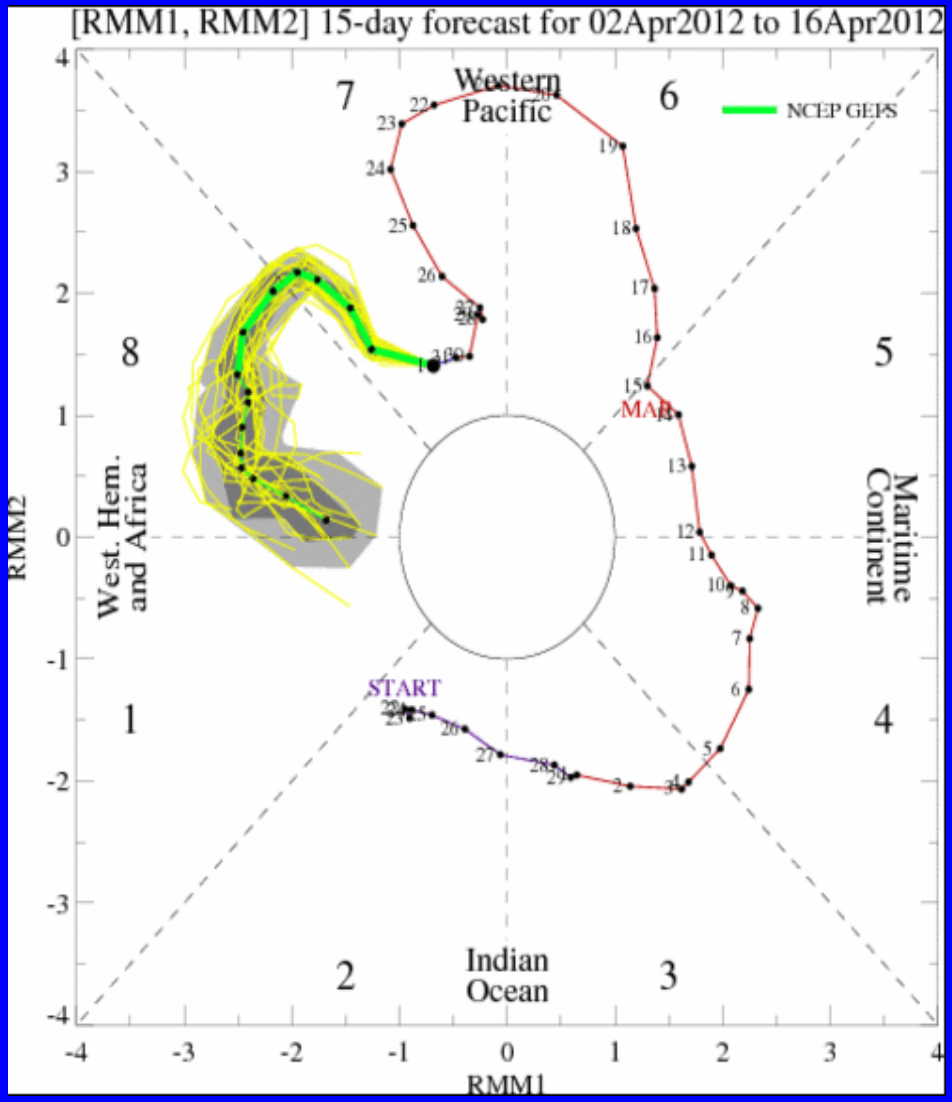
Ensemble GFS (GEFS) MJO Forecast

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

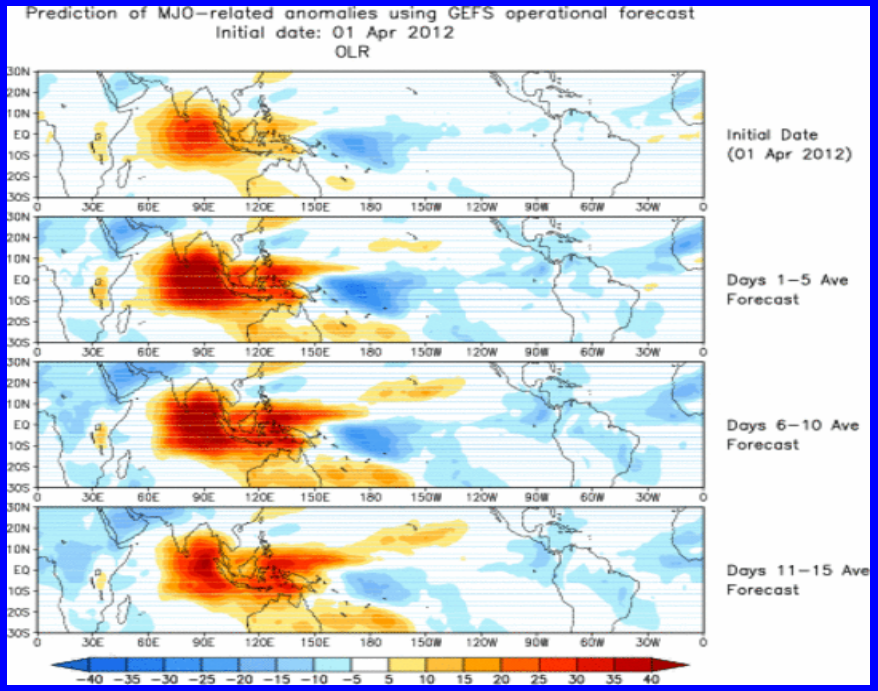
The ensemble GFS forecasts MJO activity to continue during the next two weeks, although eastward propagation early in the period is slow.



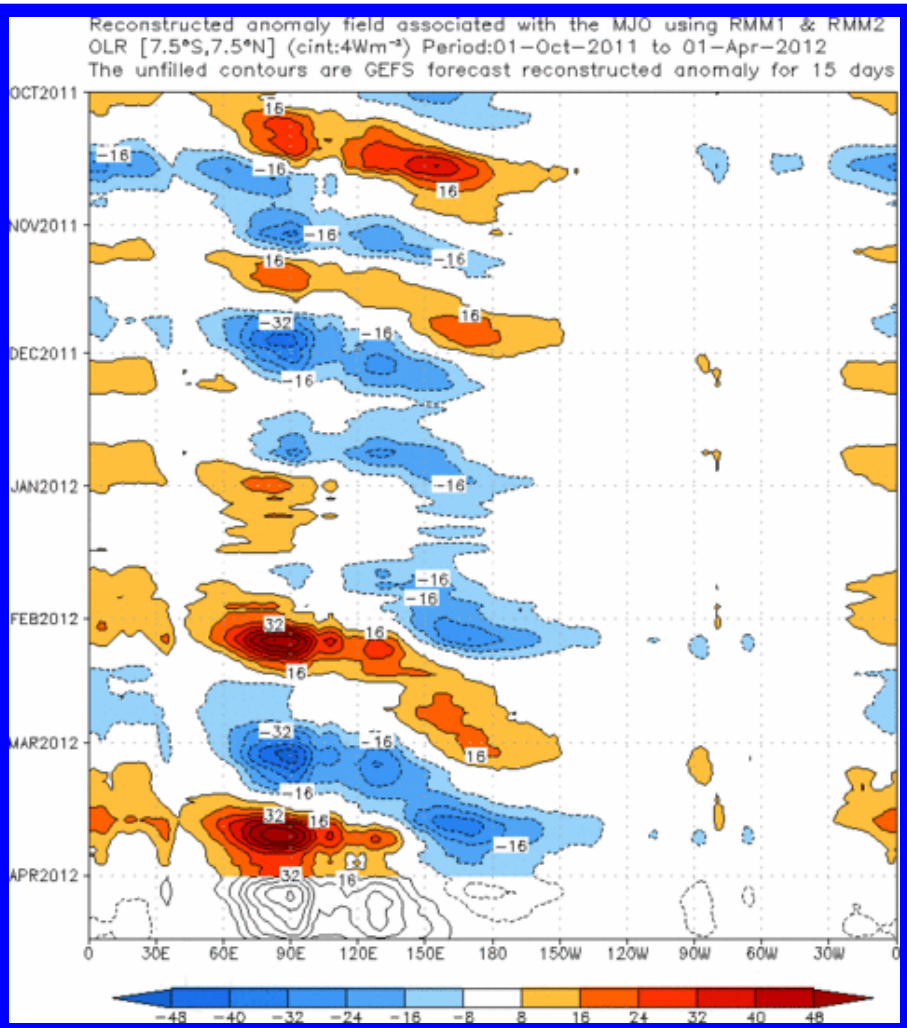
Ensemble Mean GFS MJO Forecast

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

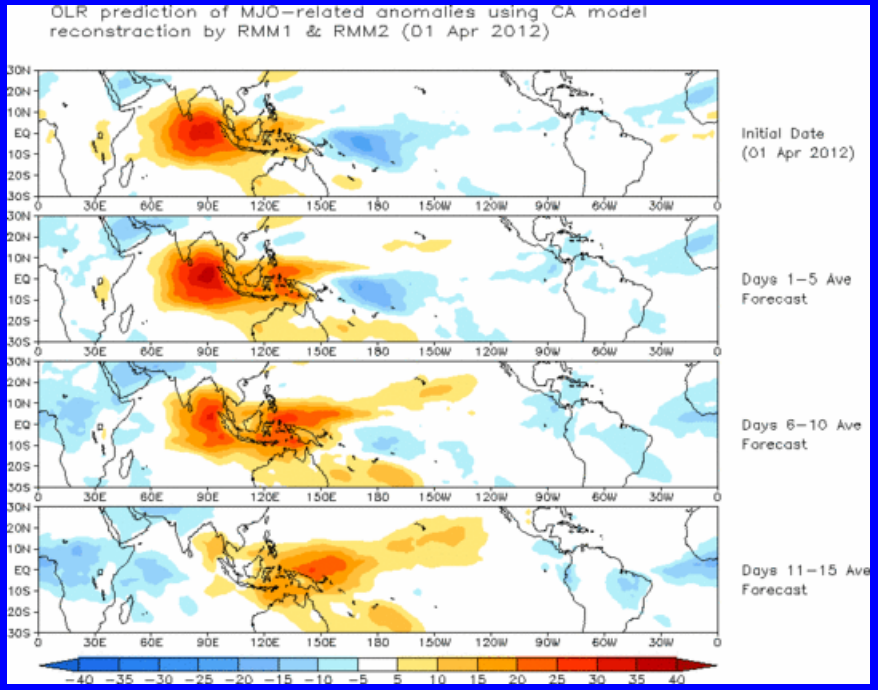


The ensemble mean GFS forecast indicates enhanced convection across parts of the Pacific Ocean, South America and Africa during the period, with suppressed convection for the eastern Indian Ocean and Maritime continent.

Constructed Analog (CA) MJO Forecast

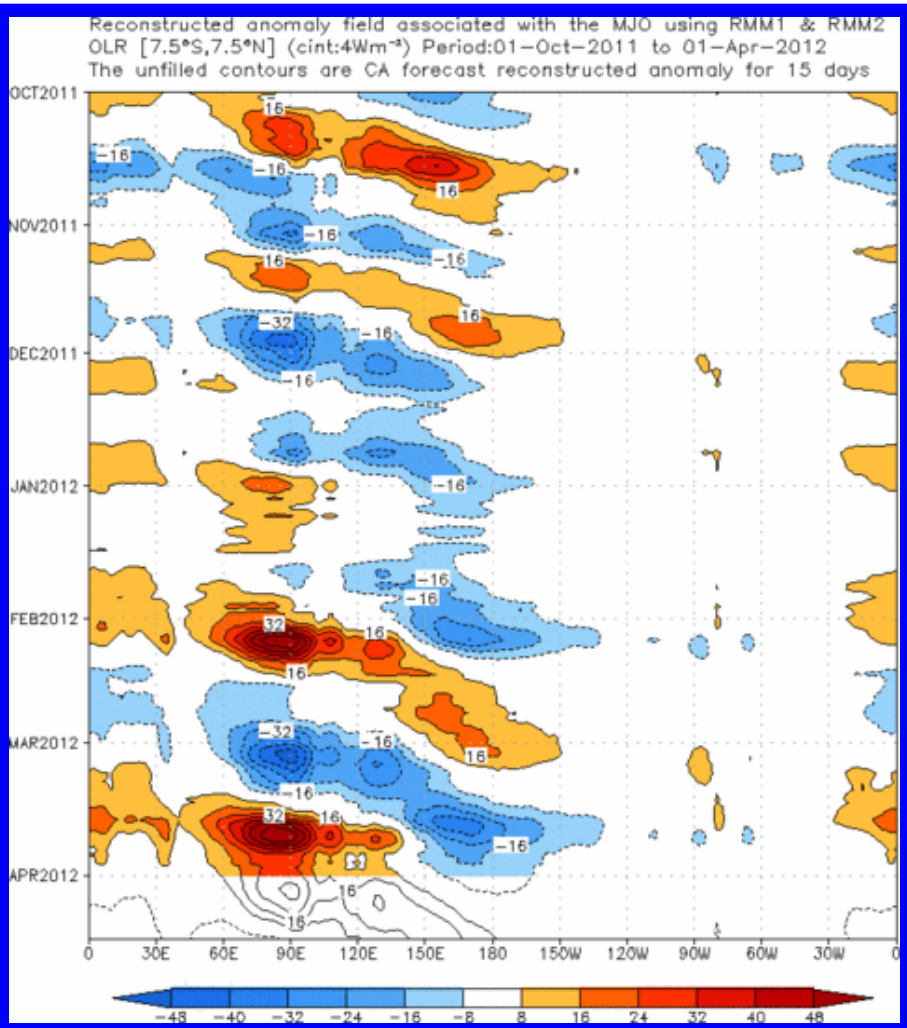
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



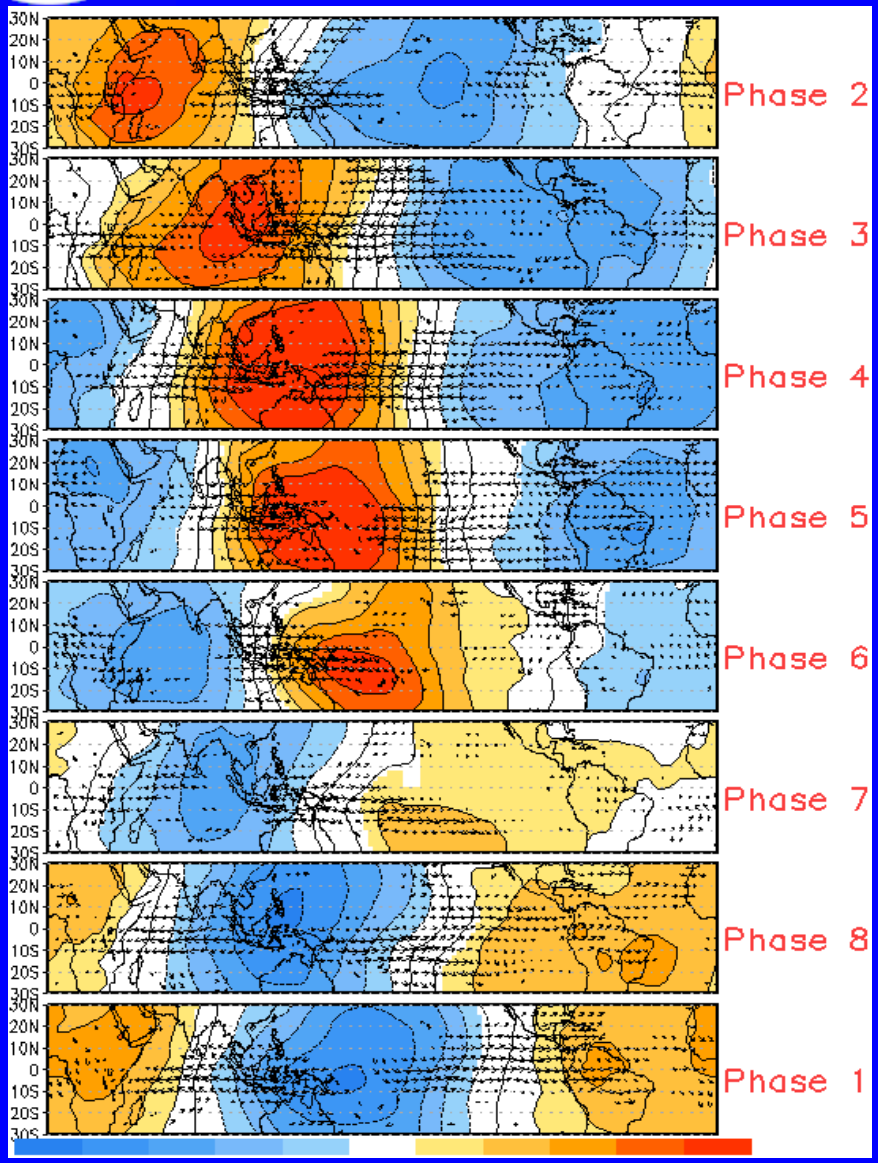
The CA forecast shows suppressed convection shifting from the eastern Indian Ocean across the Maritime Continent to the western Pacific during the period with enhanced convection impacting the Americas and Africa.

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

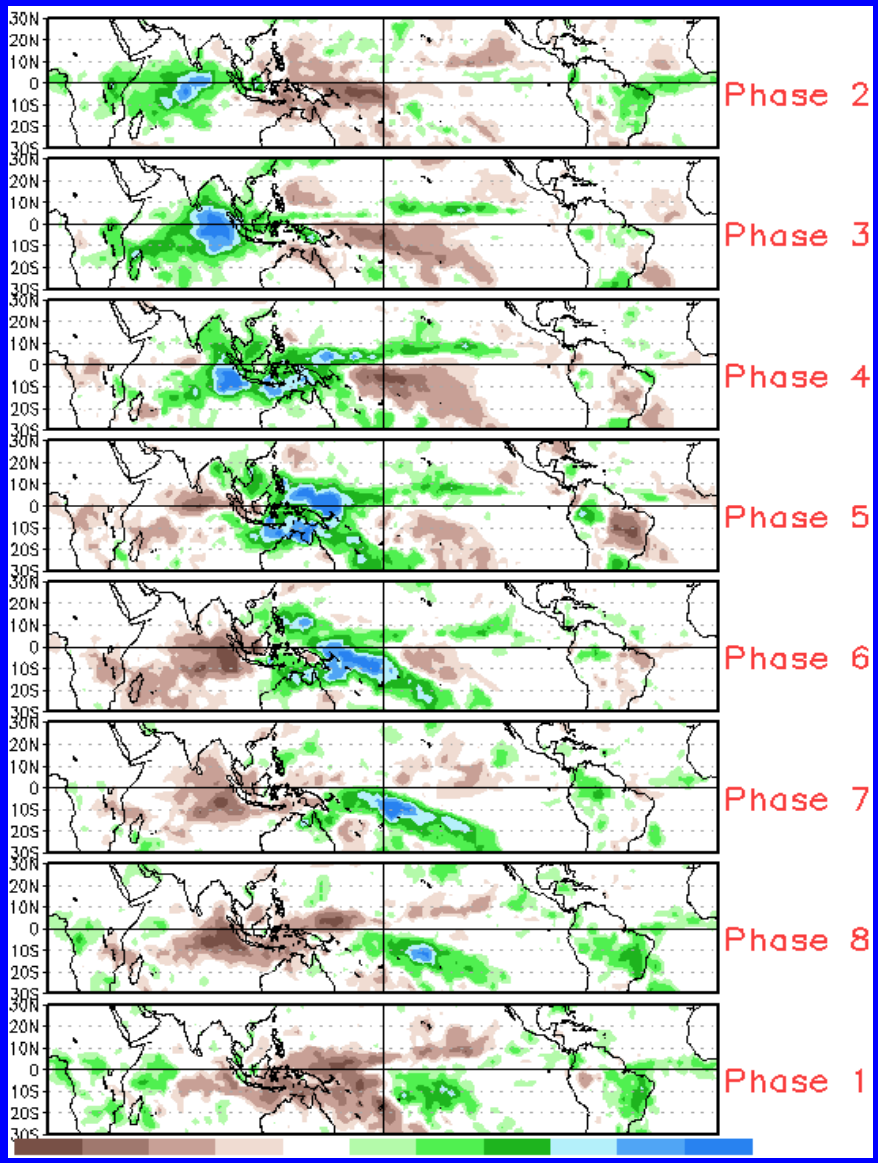


MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

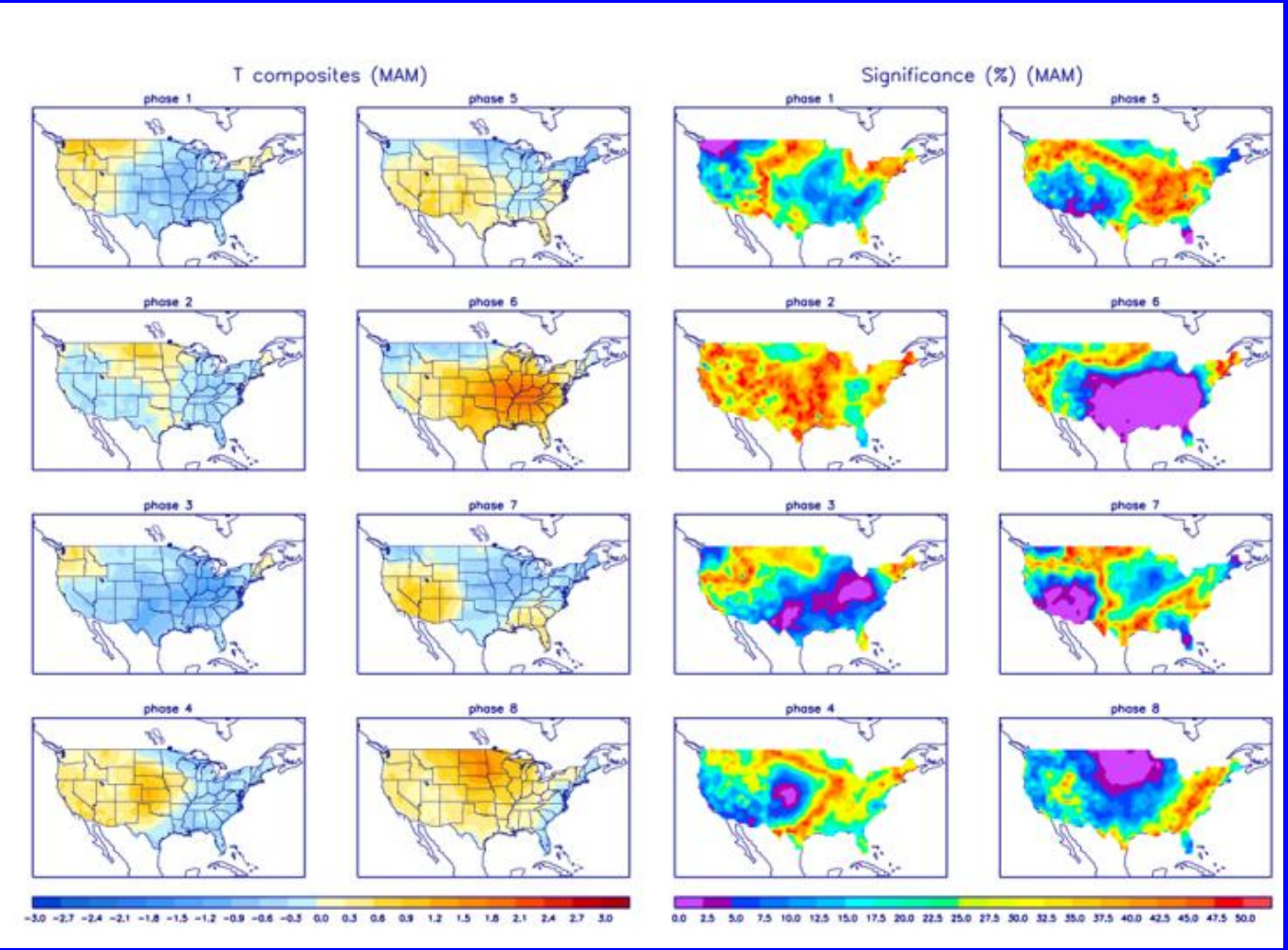


Precipitation Anomalies (Nov-Mar)



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.**

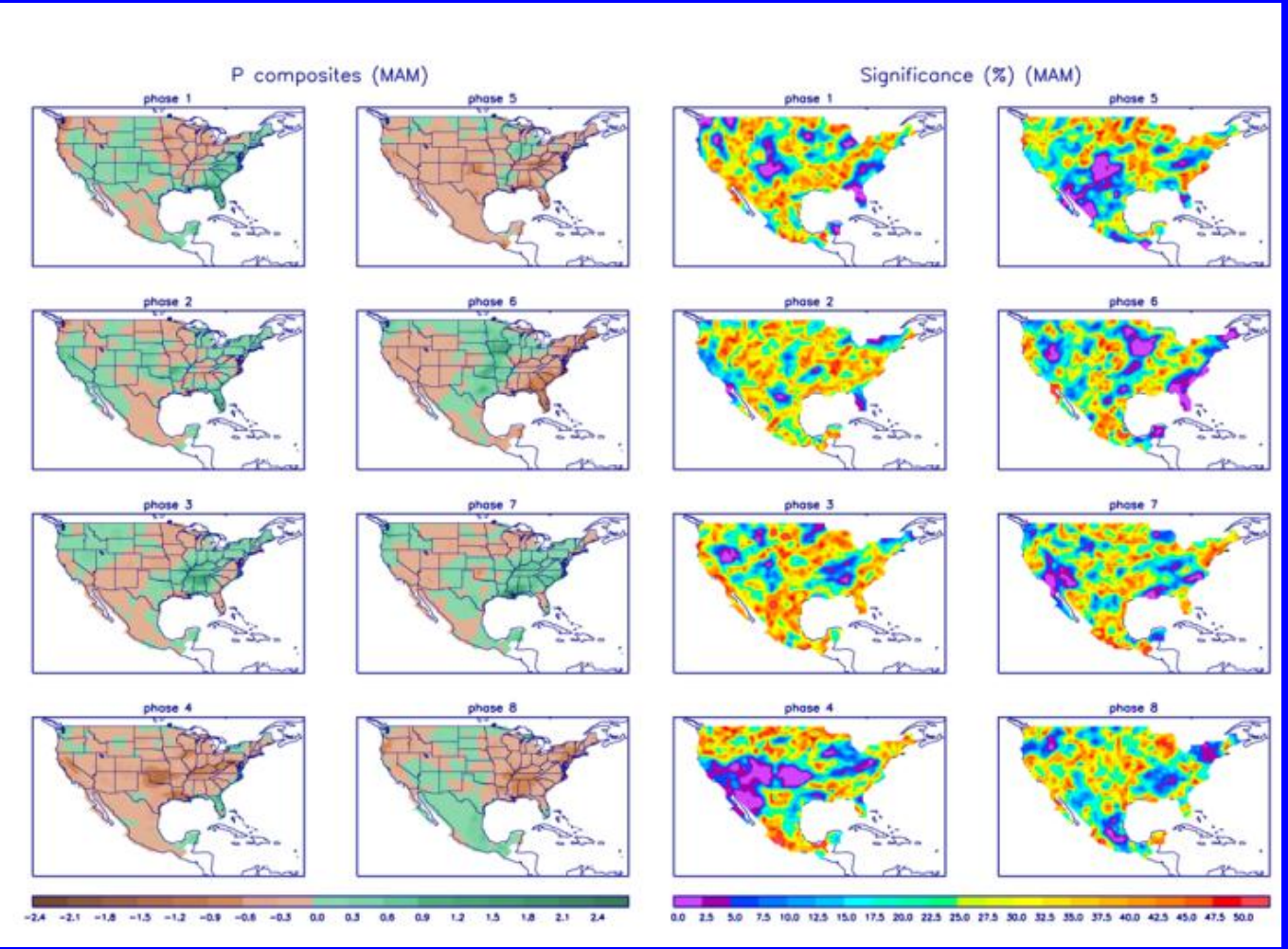


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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