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

Update prepared by
Climate Prediction Center / NCEP
April 11, 2011

Outline

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

Overview

- The MJO signal weakened during the last seven days as it propagated eastward.
- The majority of dynamical model MJO index forecasts indicate continued weakening over the next two weeks.
- This signal favors a reduced role of the MJO to patterns of anomalous tropical rainfall during the period.

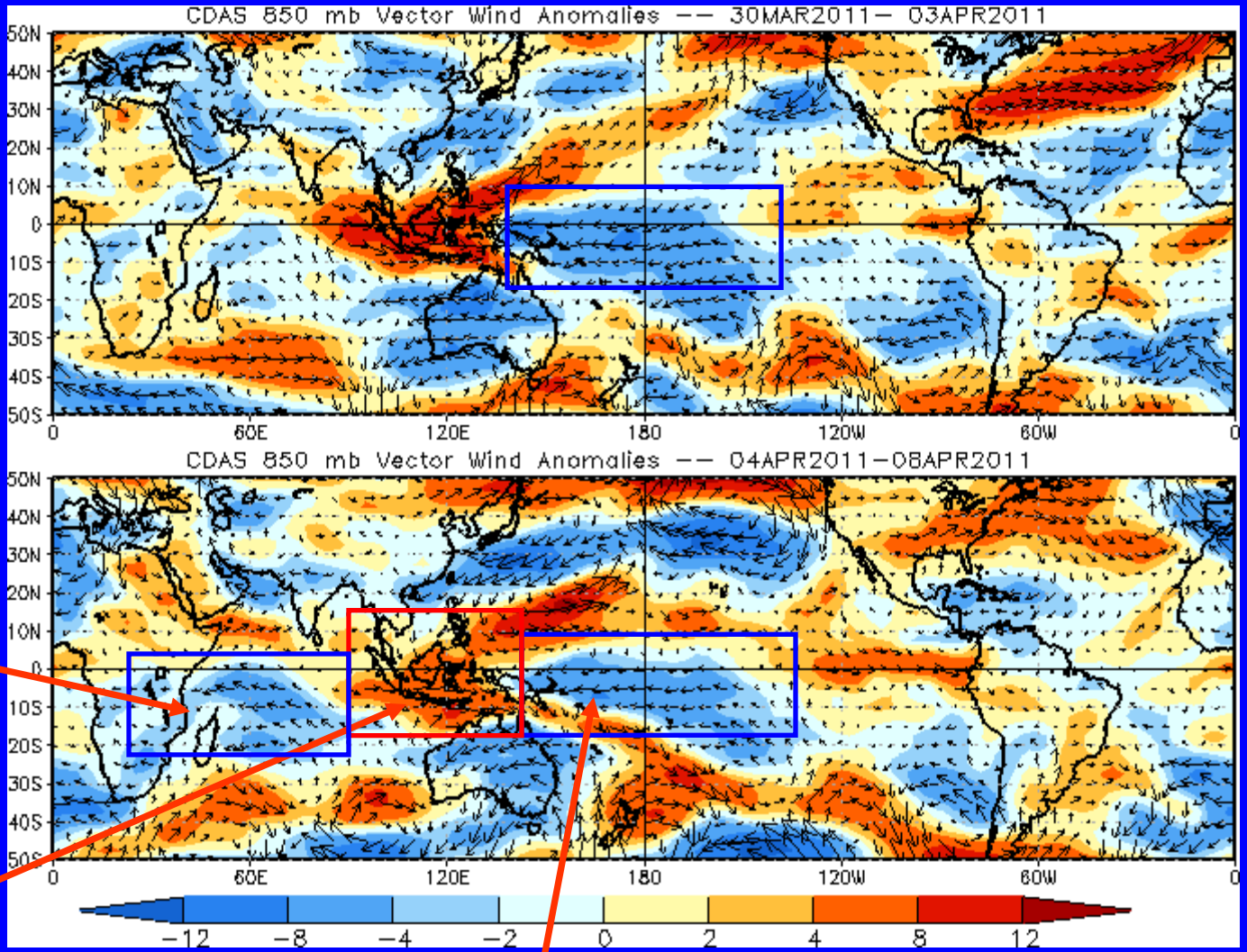
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies strengthened across the Indian Ocean during the last five days.

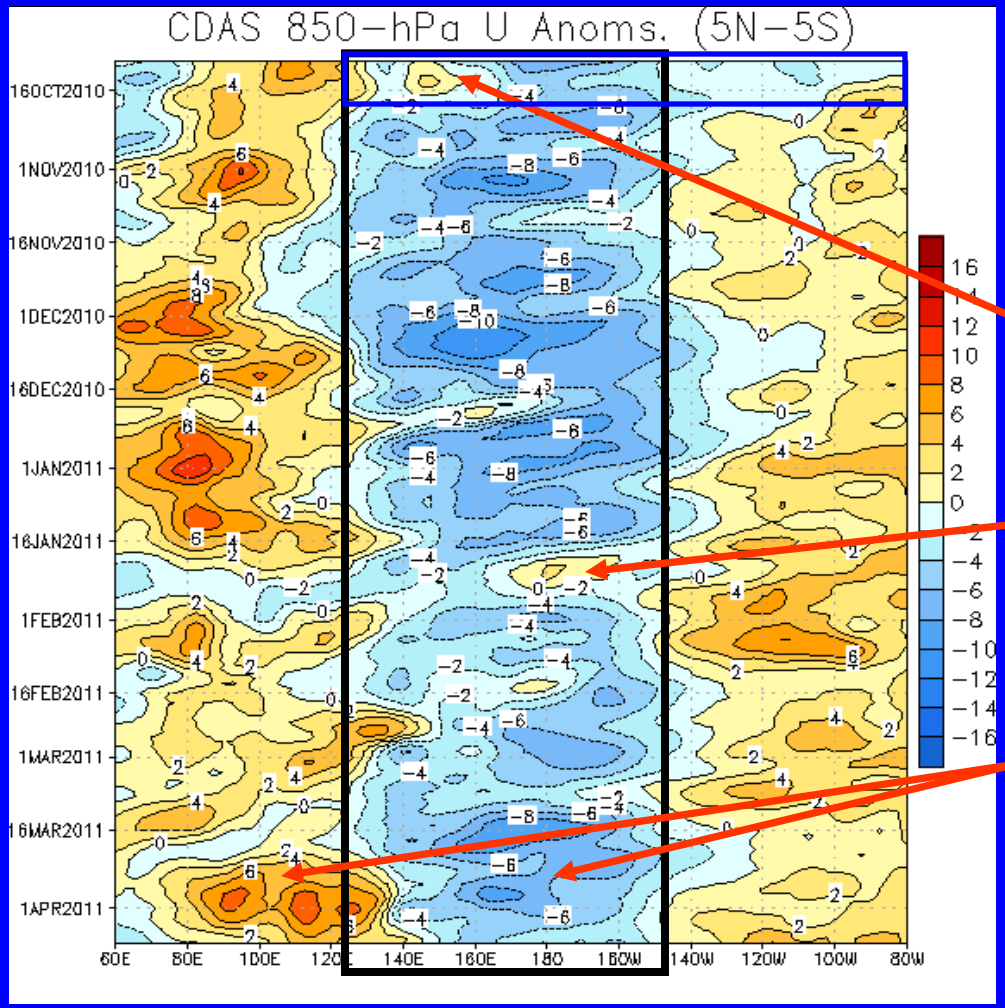
Westerly anomalies persisted and expanded across the SPCZ during the last five days.

Easterly anomalies persisted but weakened somewhat across the western 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

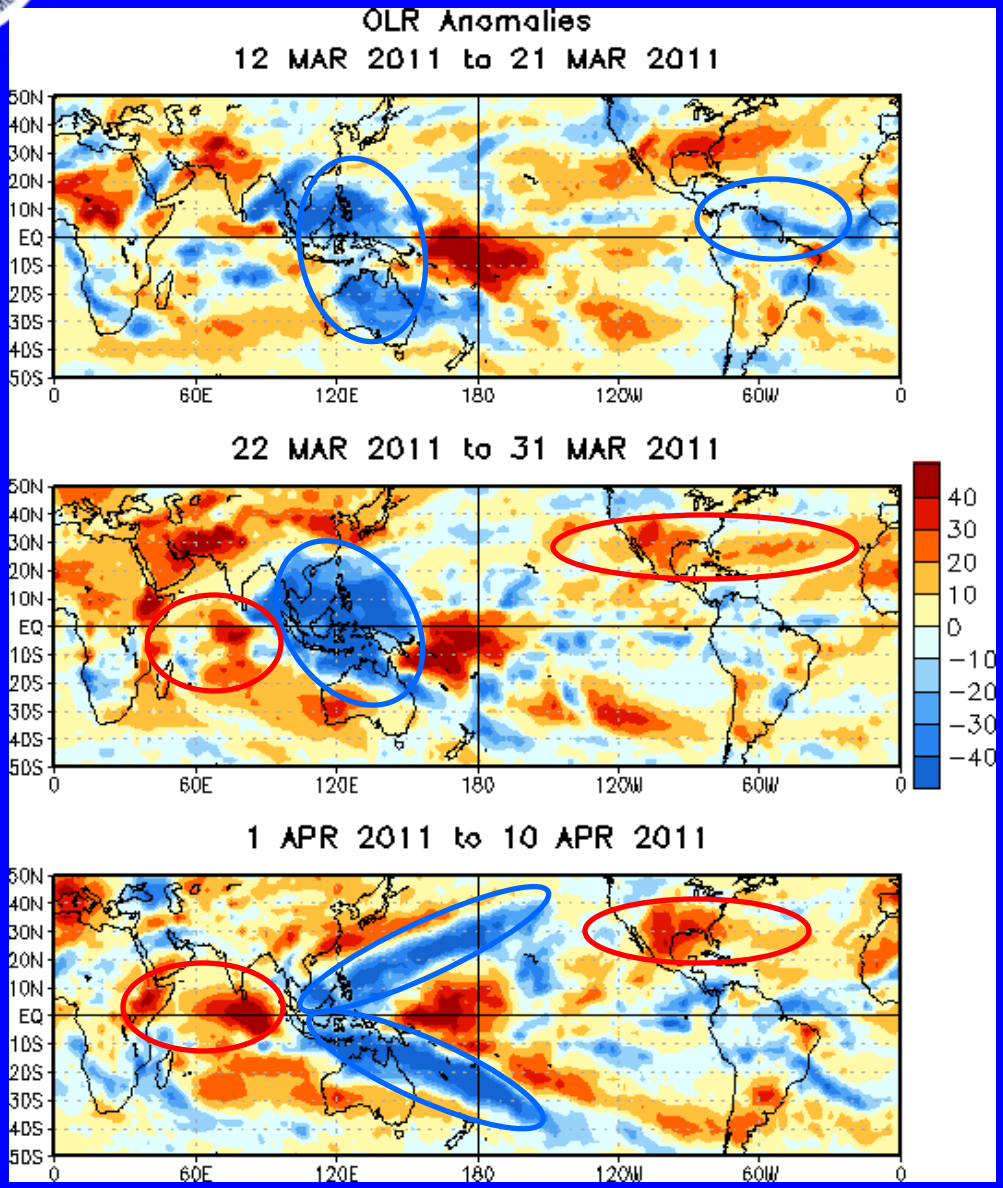
Easterly anomalies have persisted in the west-central Pacific since October (black box) consistent with La Nina conditions.

The MJO strengthened in October as evidenced by weak westerly anomalies and a weakening of the easterlies across the central Pacific during mid-October. (blue box).

In late January, easterly winds weakened and westerly anomalies developed near the Date Line due to MJO activity.

During March, easterlies strengthened near the Date Line, while westerly wind anomalies increased dramatically in strength at the end of the month.

OLR Anomalies – Past 30 days



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

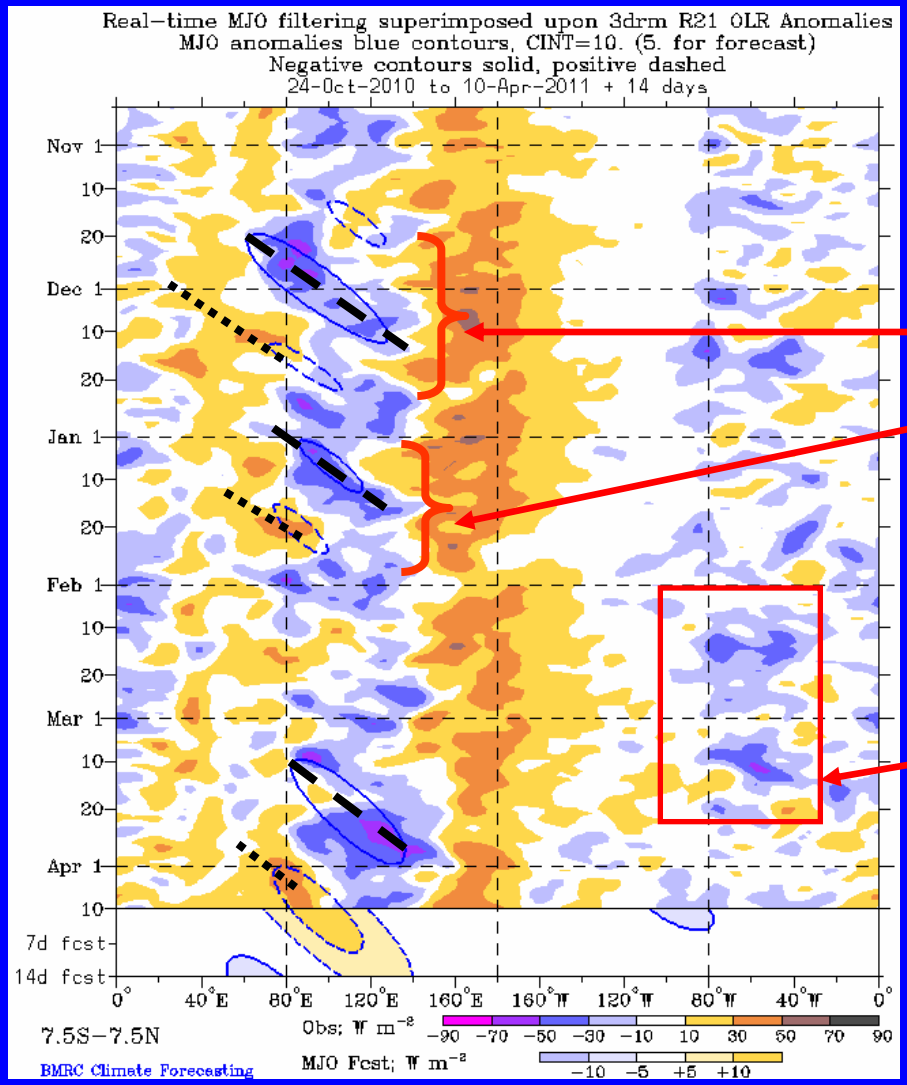
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-March, enhanced convection (blue circle) continued over northern South America and from Australia to the Philippines.

During late March, enhanced convection continued over the Maritime Continent, Australia and parts of Southeast Asia with suppressed convection observed across the southern tier of the U.S.. Suppressed convection also emerged across the Indian Ocean.

During early April, enhanced convection continued across Australia, the Maritime continent and the Philippines, spreading poleward into the Northern and Southern Hemispheres. Suppressed convection continued across the Indian Ocean and southern tier of the U.S.

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 the Bureau of Meteorology (BOM) - Australia)

MJO activity was experienced during late November into December and once again during January. During both periods, enhanced convection developed near 80E and shifted to the Maritime continent followed by an area of suppressed convection.

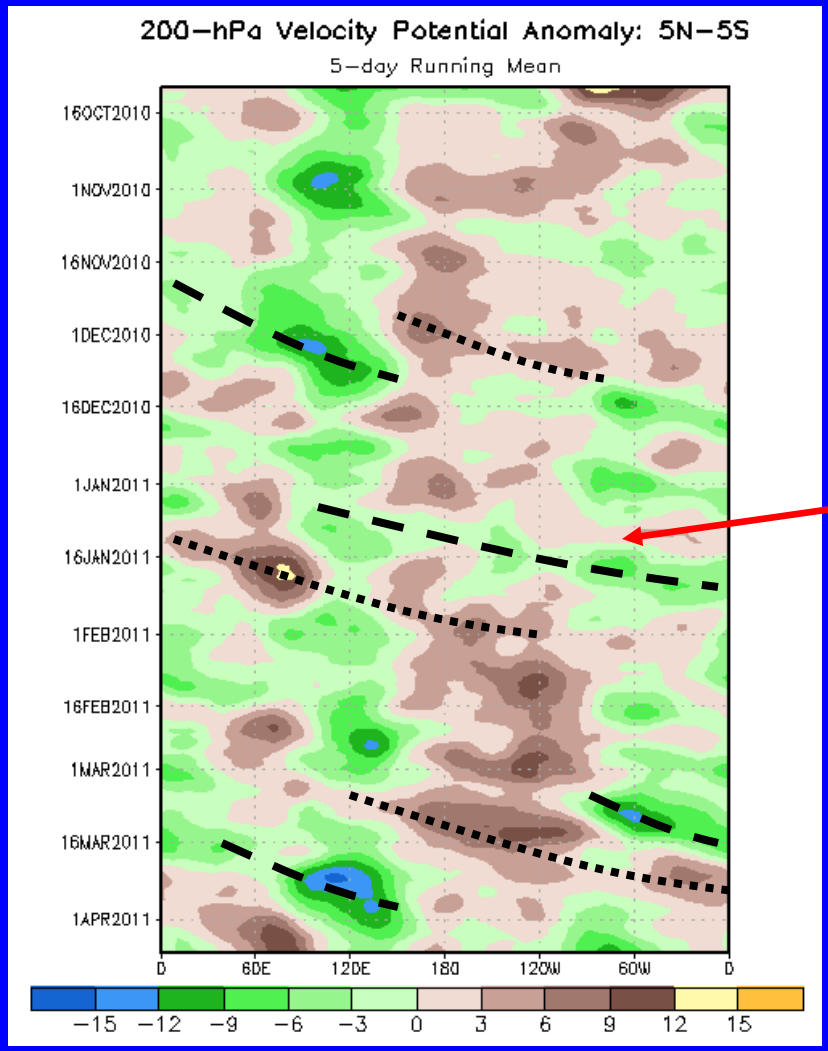
Enhanced convection was evident across northern South America during much of February and March.

During late March, a large area of strongly enhanced convection developed between 80E to 140E and shifted eastward.

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

During late November and early December, some eastward propagation associated with the MJO is evident in velocity potential anomalies.

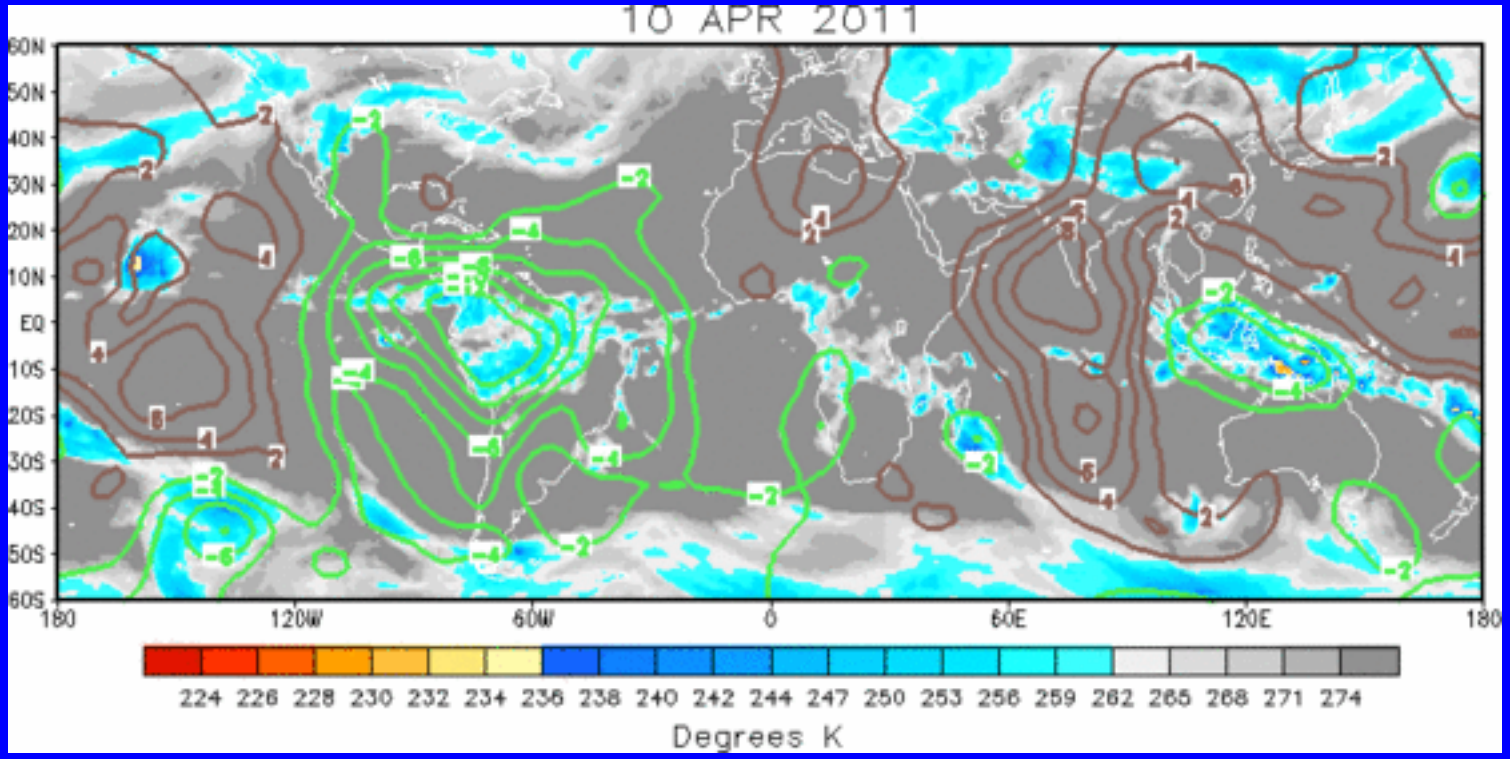
During mid-to-late January, the MJO strengthened and upper-level divergence shifted eastward from 120E and upper-level convergence shifted from Africa to near the Date Line.

Eastward propagation of anomalies was observed during March associated with weak MJO activity.

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

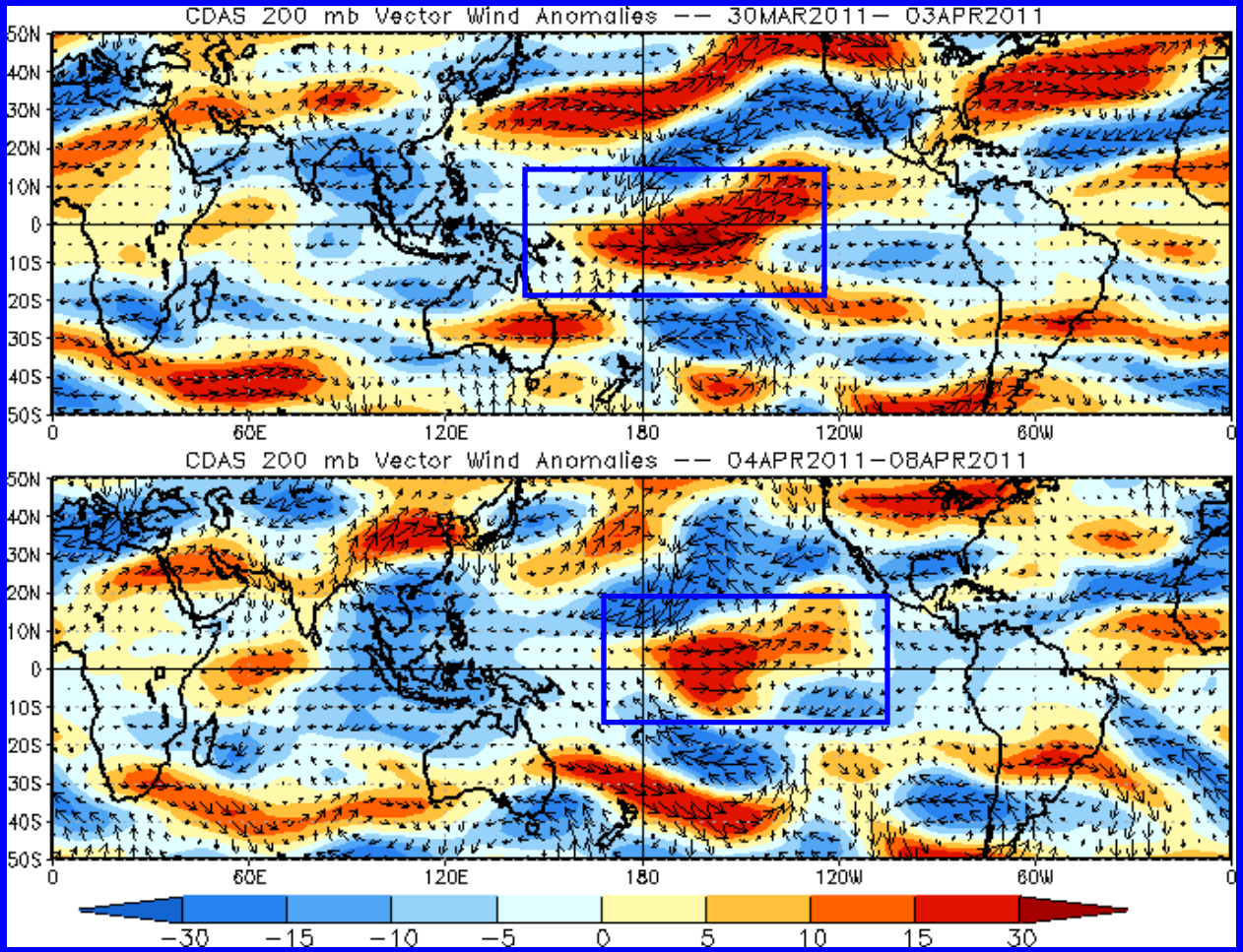
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern shows anomalous upper-level convergence over the eastern hemisphere save the Maritime Continent. Anomalous upper-level divergence is evident over portions of the western hemisphere and especially strong over northern South America.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

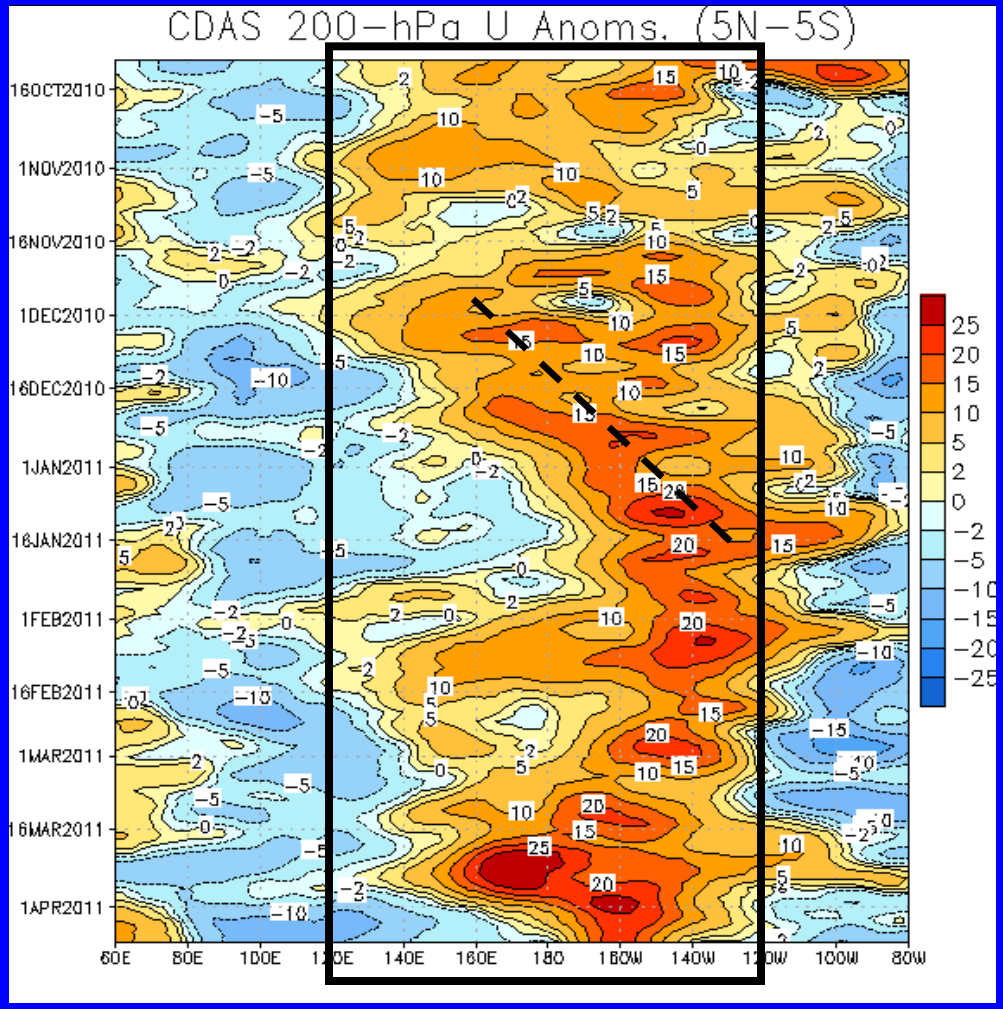
Red shades: Westerly anomalies

Westerly anomalies weakened and shifted eastward across the equatorial central Pacific during the last five to ten days (blue boxes).

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

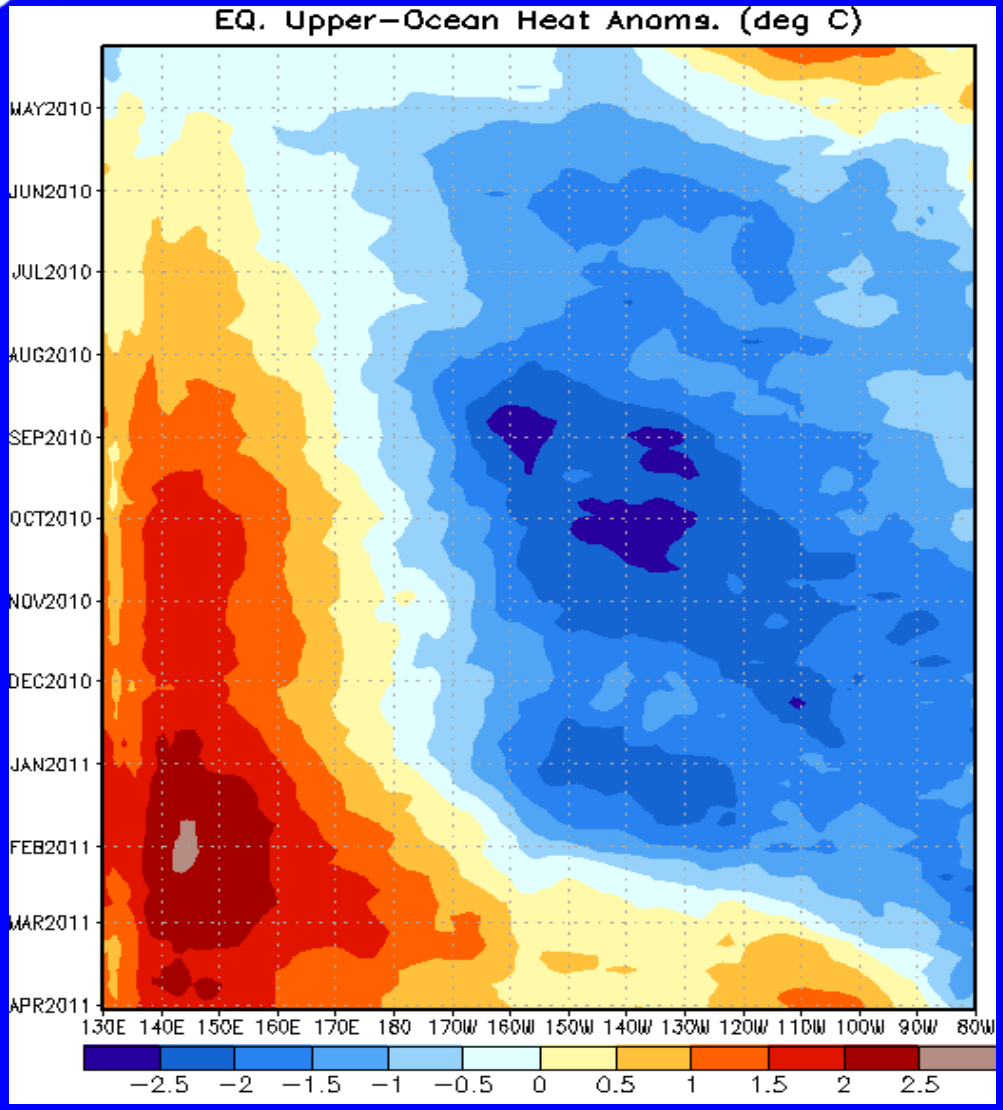
Westerly anomalies persisted across a large area from the Maritime Continent to the central Pacific (black solid box) since October.

There was a gradual eastward shift in the core of the westerly anomalies across the Pacific during December and January (dashed line).

In February, westerly anomalies shifted back to the west across the central Pacific similar to where they were during much of the September to December period.

Some strengthening and eastward propagation of these westerly anomalies is evident in the most recent observations.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

During April 2010 heat content anomalies decreased across the Pacific in association with the upwelling phase of a Kelvin wave and later during the early summer due to the development of La Nina.

Since the beginning of January 2011, positive heat content anomalies have shifted eastward, while negative heat content anomalies weakened and then became positive across much of the Pacific basin.

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).

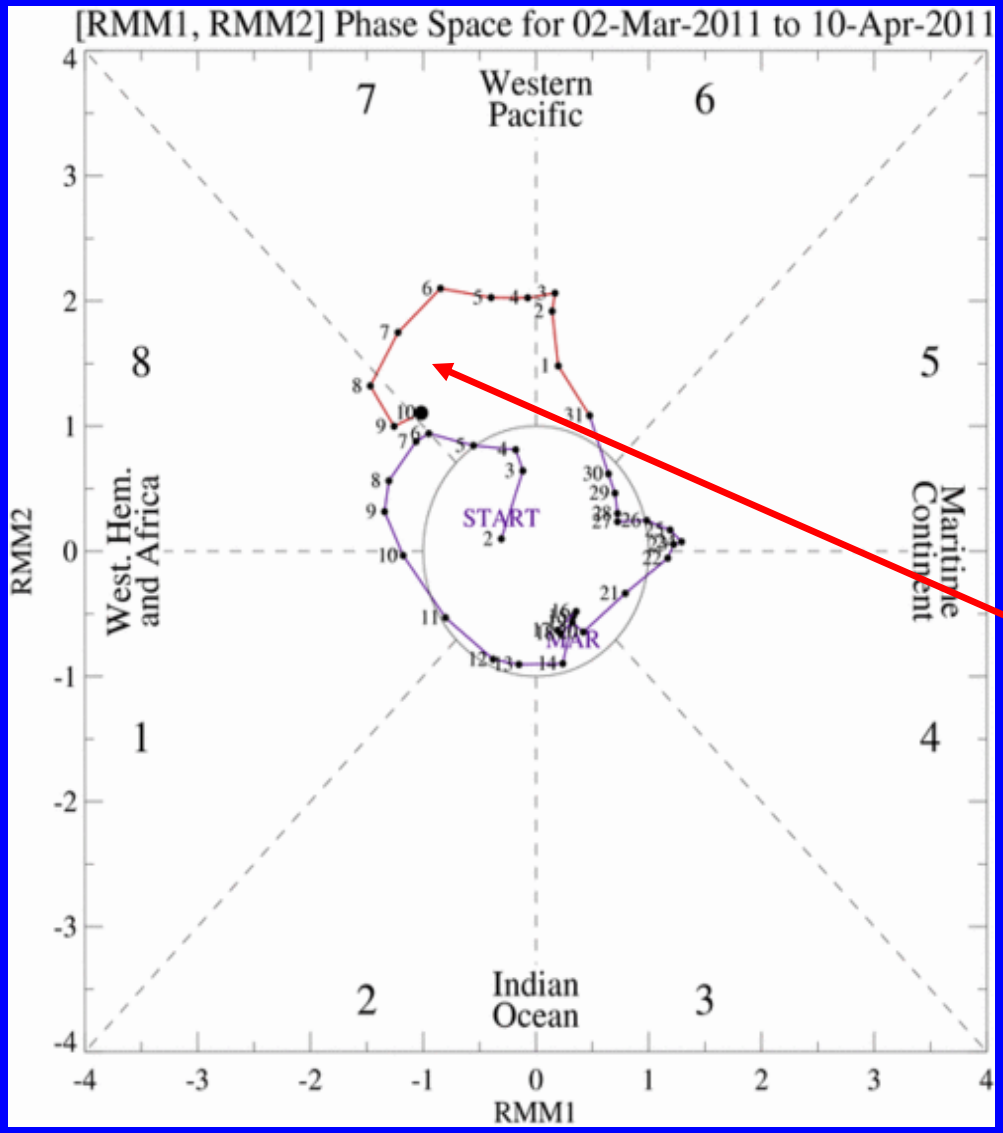
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

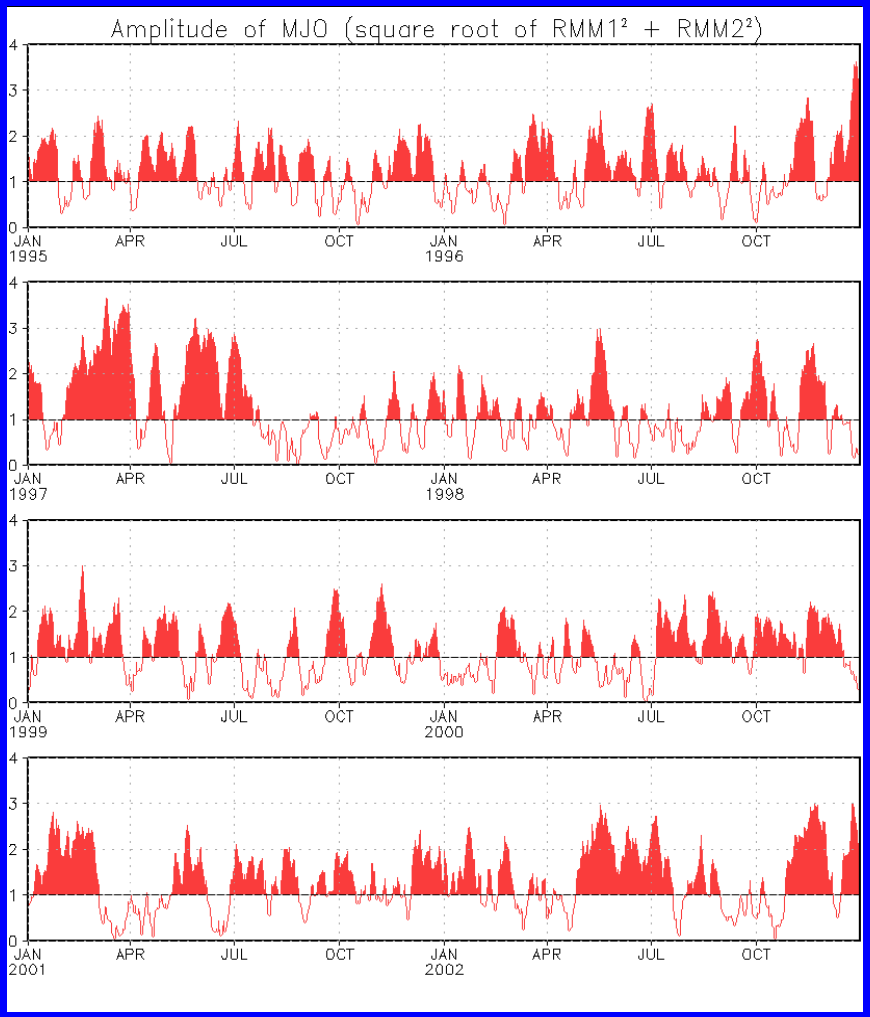
MJO Index -- Recent Evolution

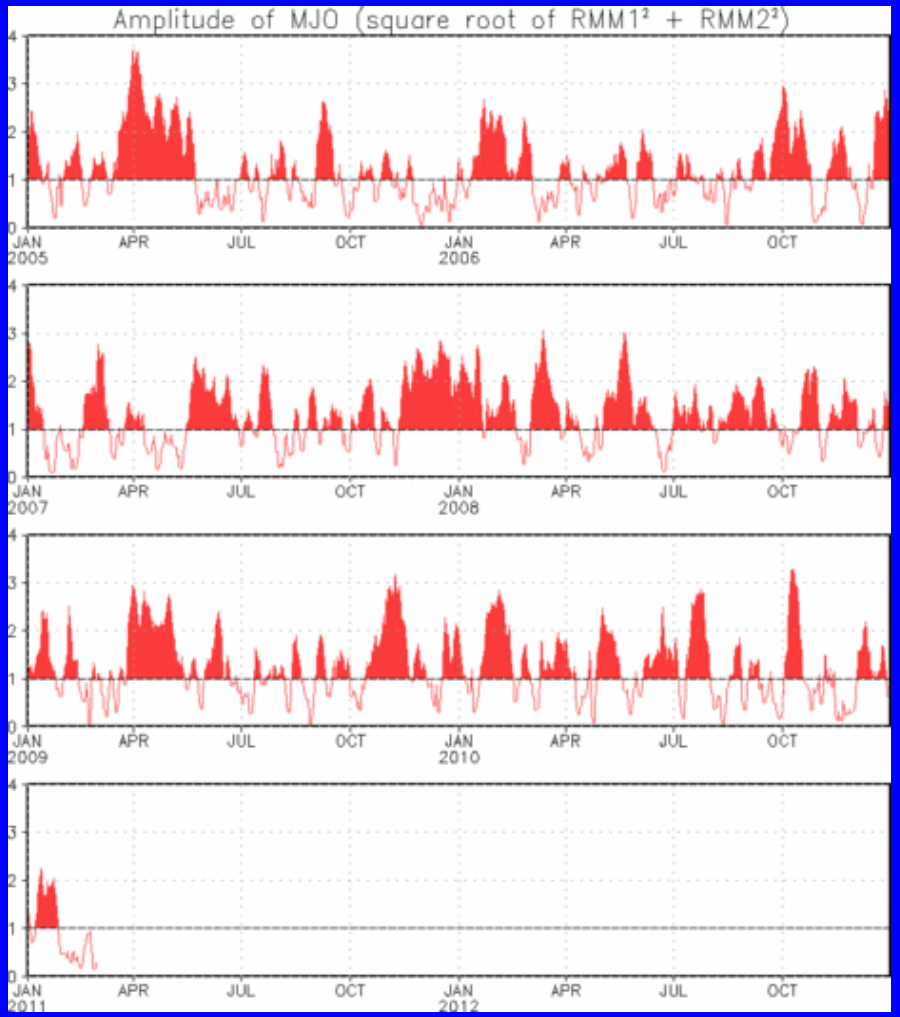


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicated eastward propagation but weakened during the past seven days.

MJO Index – Historical Daily Time Series





Time series of daily MJO index amplitude from 1995 to present.
Plots put current MJO activity in historical context.

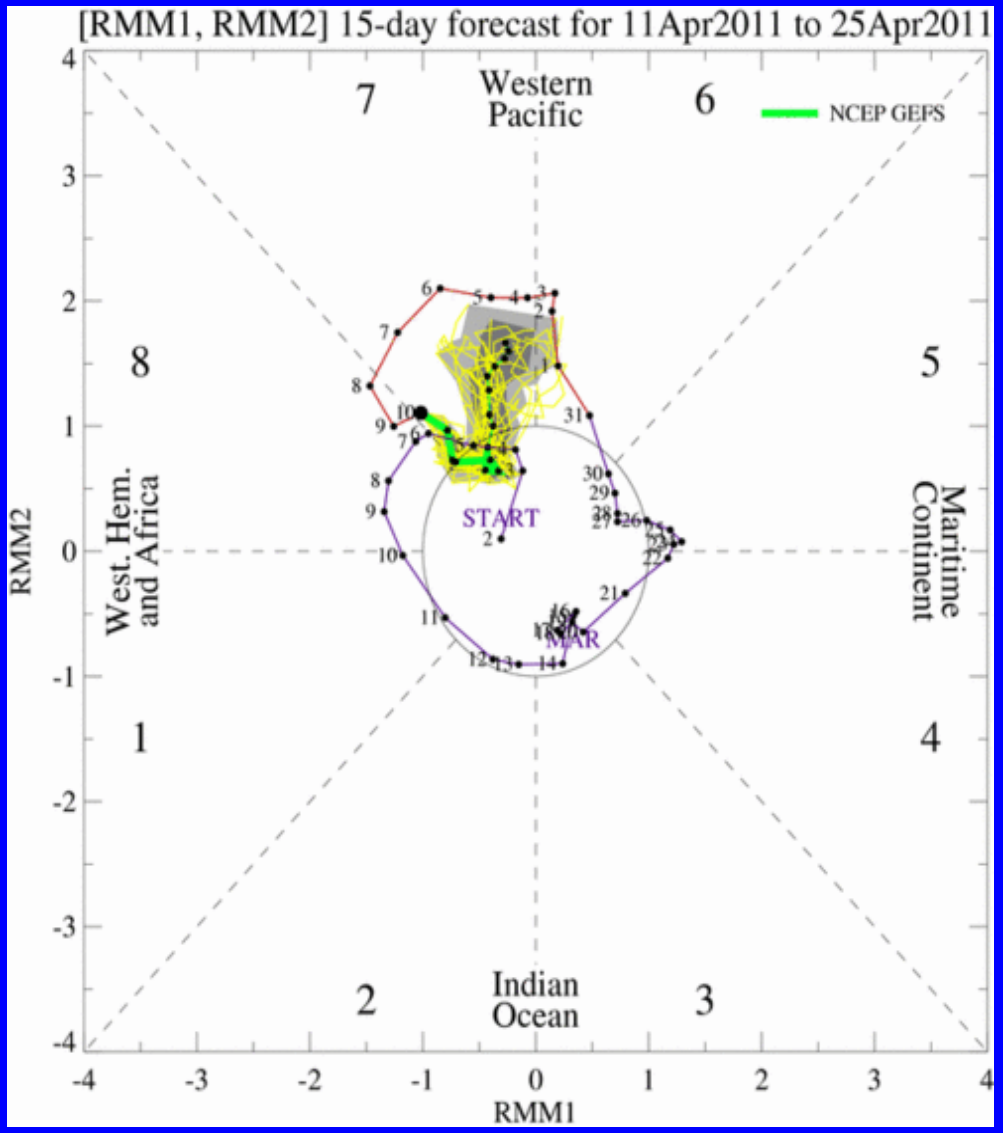
Ensemble GFS (GEFS) MJO Forecast

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

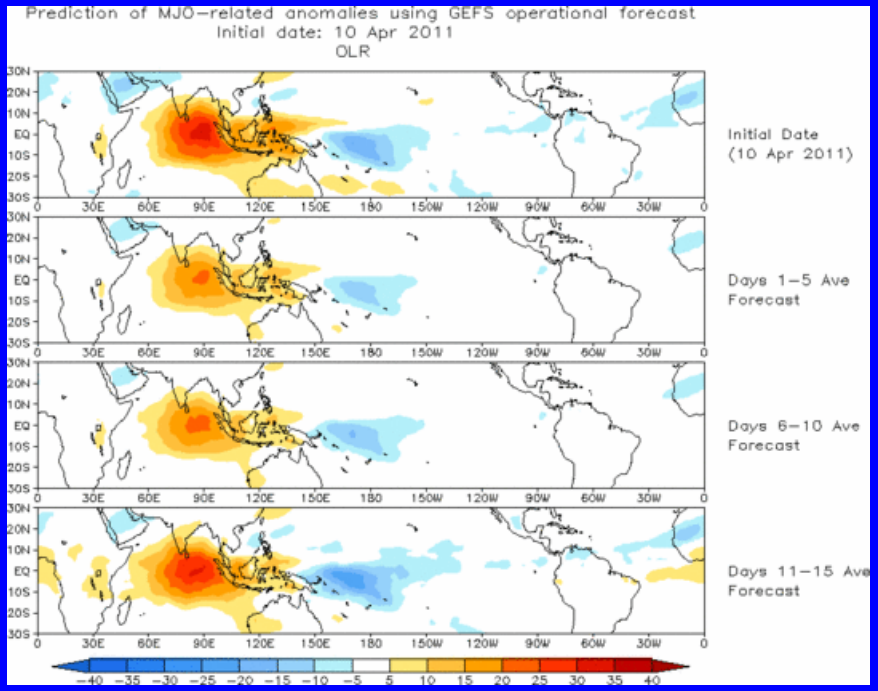
The ensemble GFS forecasts a continued weakening signal during the next two weeks.



Ensemble Mean GFS MJO Forecast

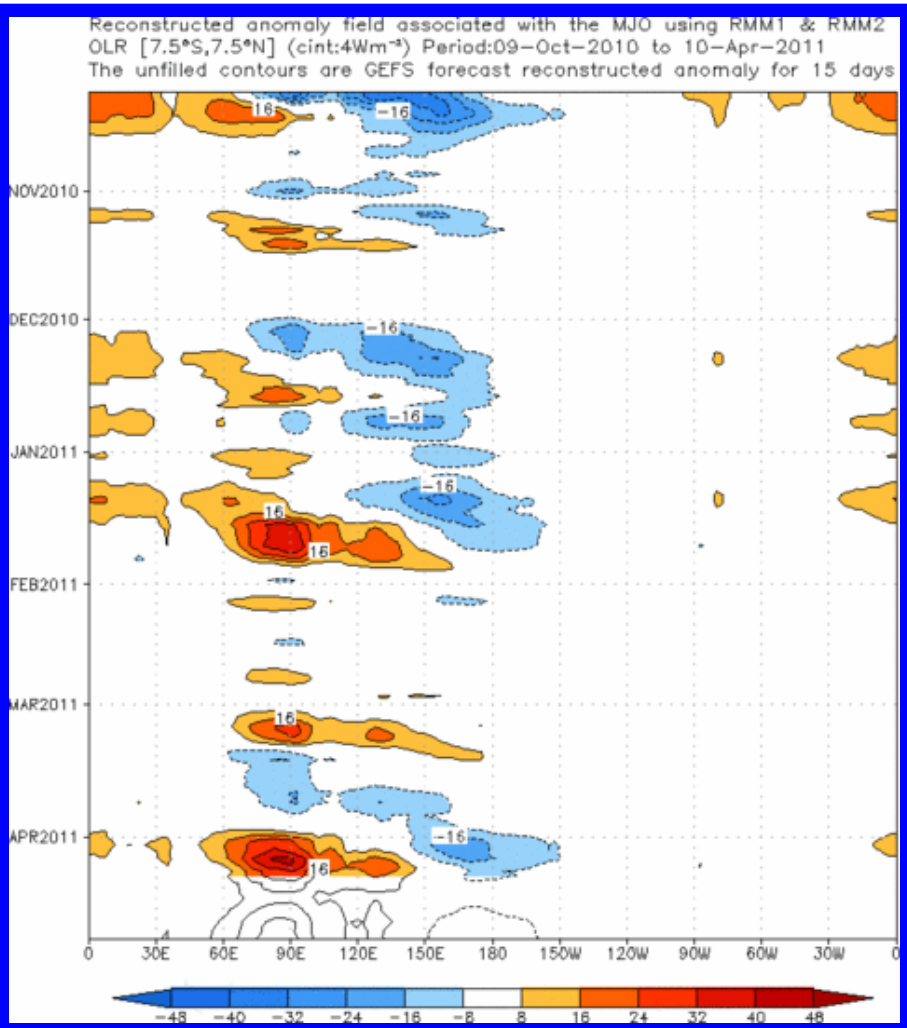
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons)

Spatial map of OLR anomalies for the next 15 days



The GEFS ensemble mean forecast indicates suppressed convection persisting across the Indian Ocean during the forecast period.

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



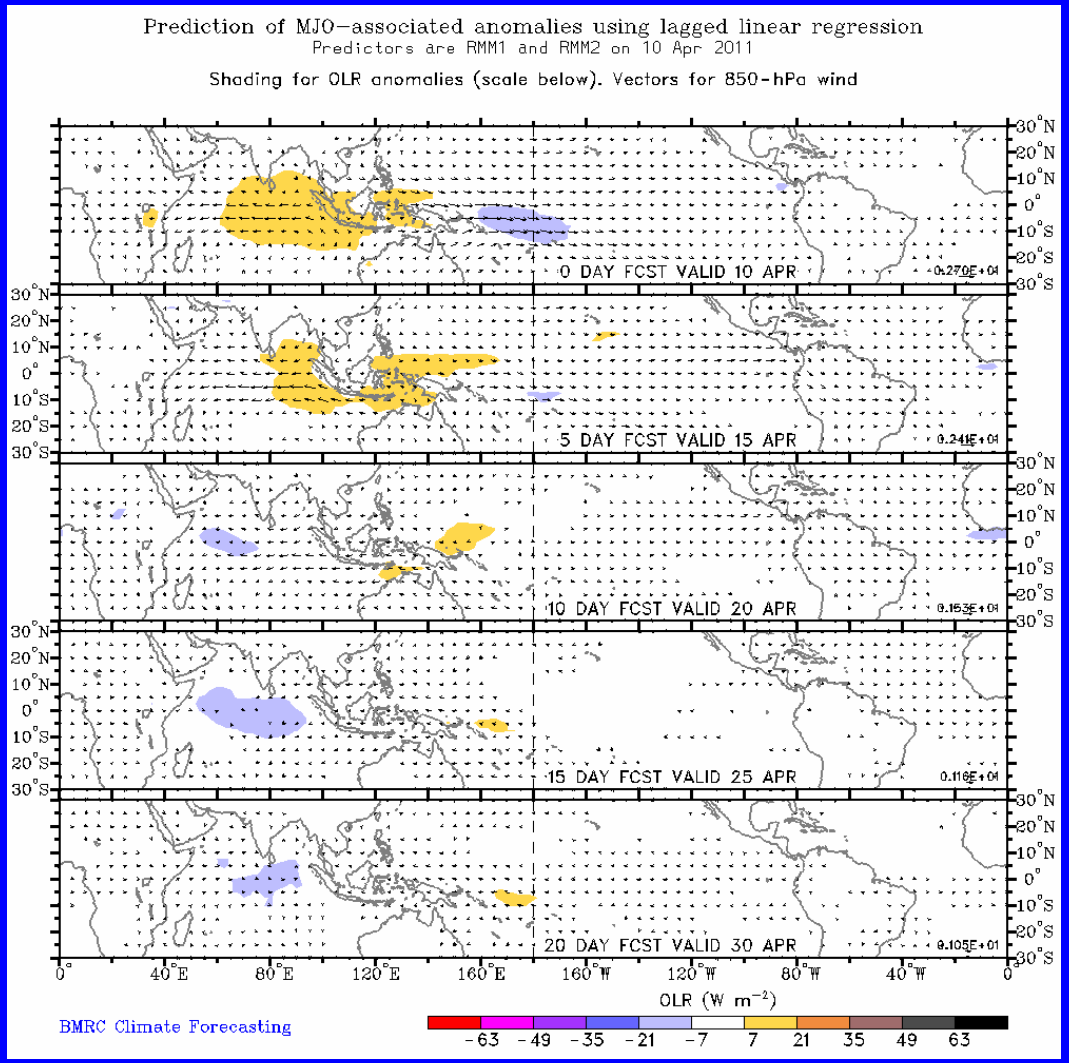
Statistical MJO Forecast

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)

Spatial map of OLR anomalies and 850-hPa vectors for the next 20 days

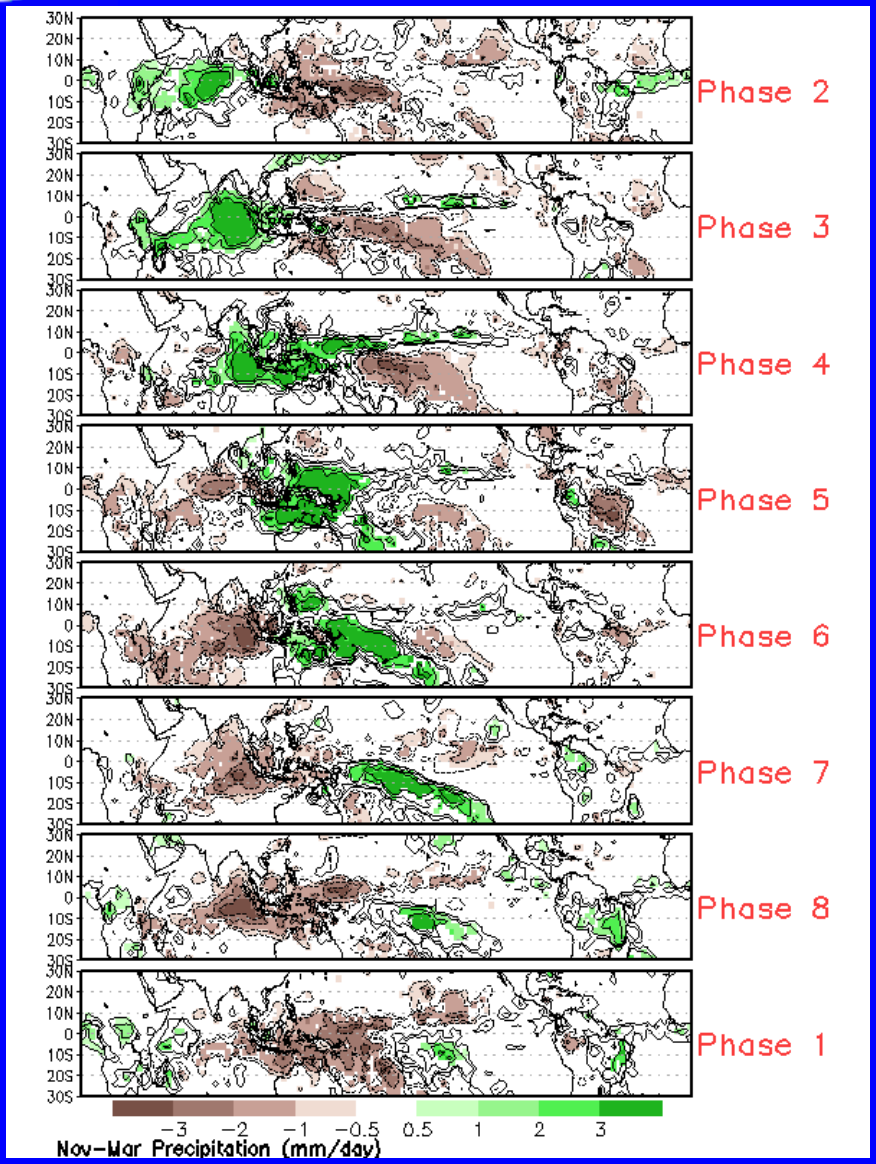
(Courtesy of the Bureau of Meteorology Research Centre - Australia)

The forecast calls for weakening MJO activity during the period.

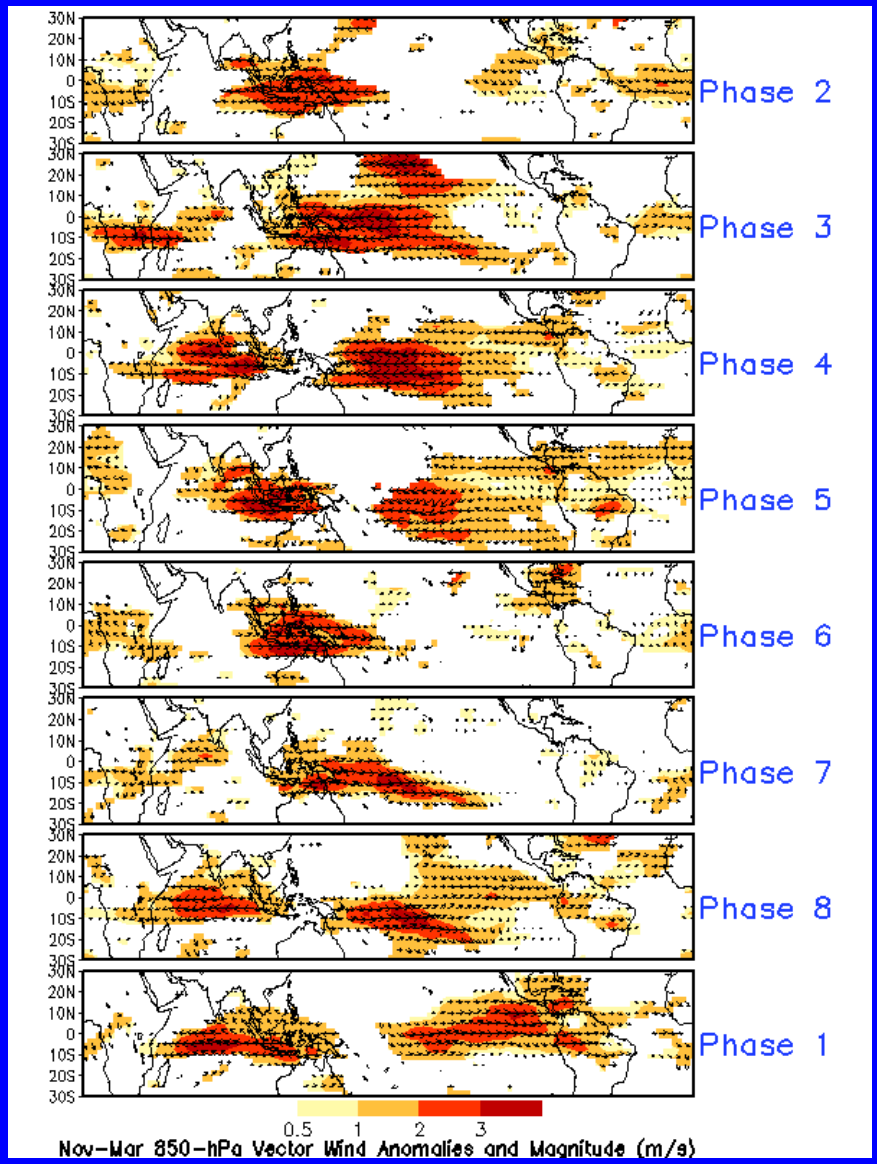


MJO Composites – Global Tropics

Precipitation Anomalies (Nov-Mar)

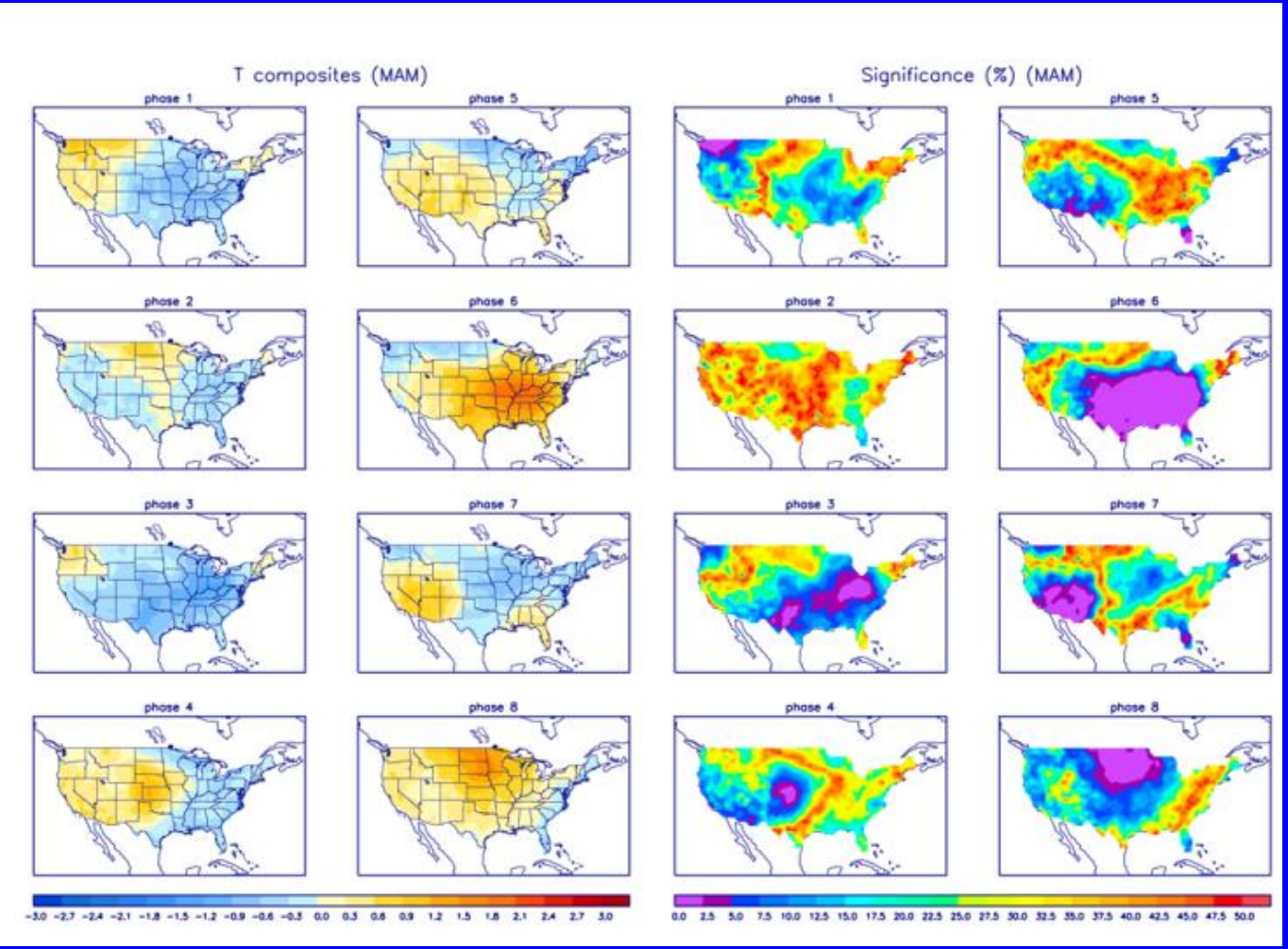


850-hPa Wind Anomalies (Nov-Mar)



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. Dark blue and purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**

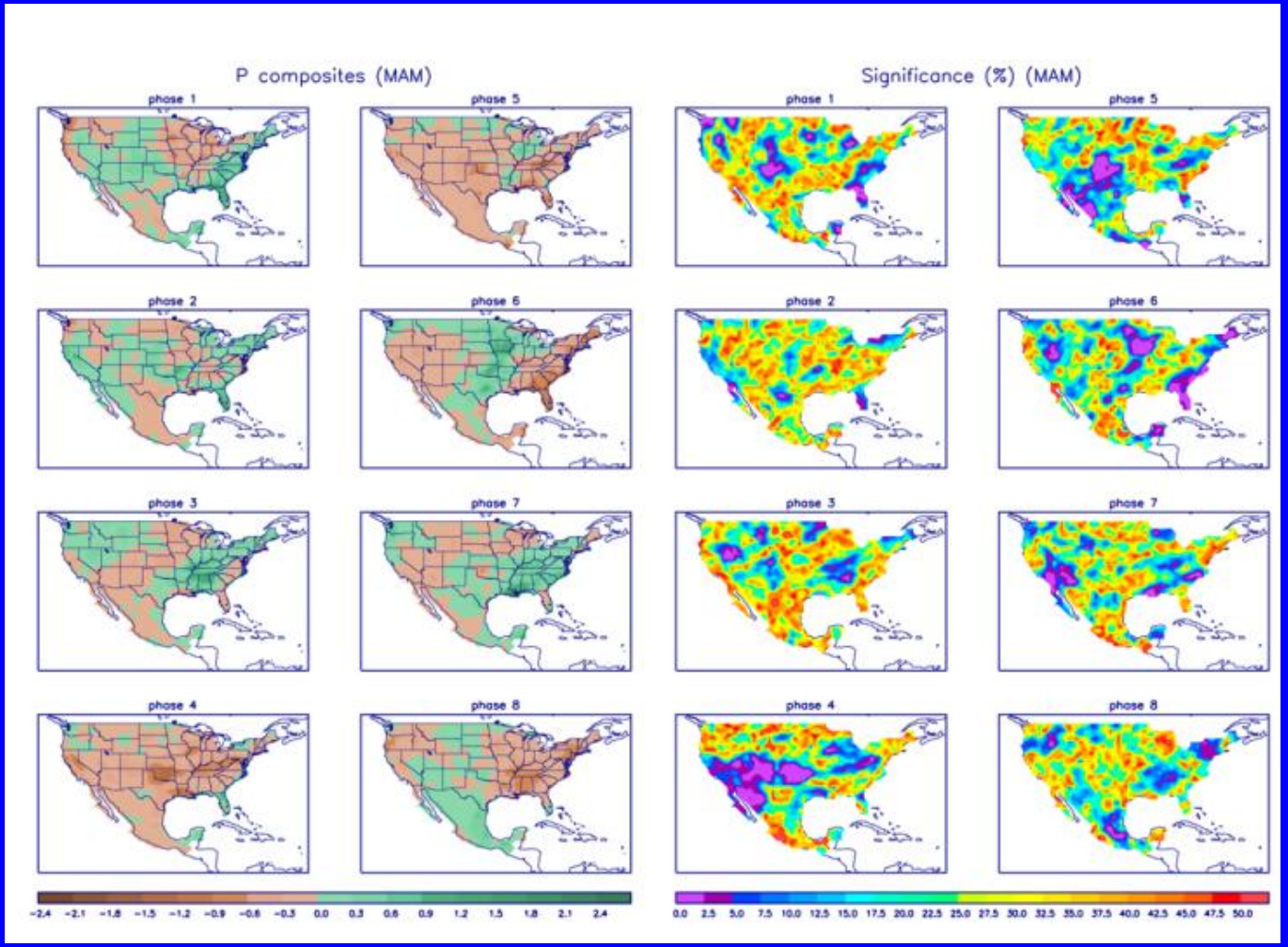


Zhou et al. (2010): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, Submitted.

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. Dark blue and purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**



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