



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

**Update prepared by  
Climate Prediction Center / NCEP  
March 21, 2011**



# Outline

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



# Overview

- **The MJO signal remained weak during the last seven days.**
- **The majority of dynamical model MJO index forecasts indicate an increase in amplitude of a signal followed by eastward propagation over the next two weeks.**
- **It is still uncertain whether this signal will become a coherent MJO event and this signal may be more related to higher frequency coherent subseasonal variability interacting with La Nina background conditions.**
- **Over the next 1-2 weeks, this signal favors enhanced rainfall for the Maritime continent, northern Australia, the western Pacific and the South Pacific Convergence Zone. Drier-than-average conditions are favored across the Indian Ocean 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>**

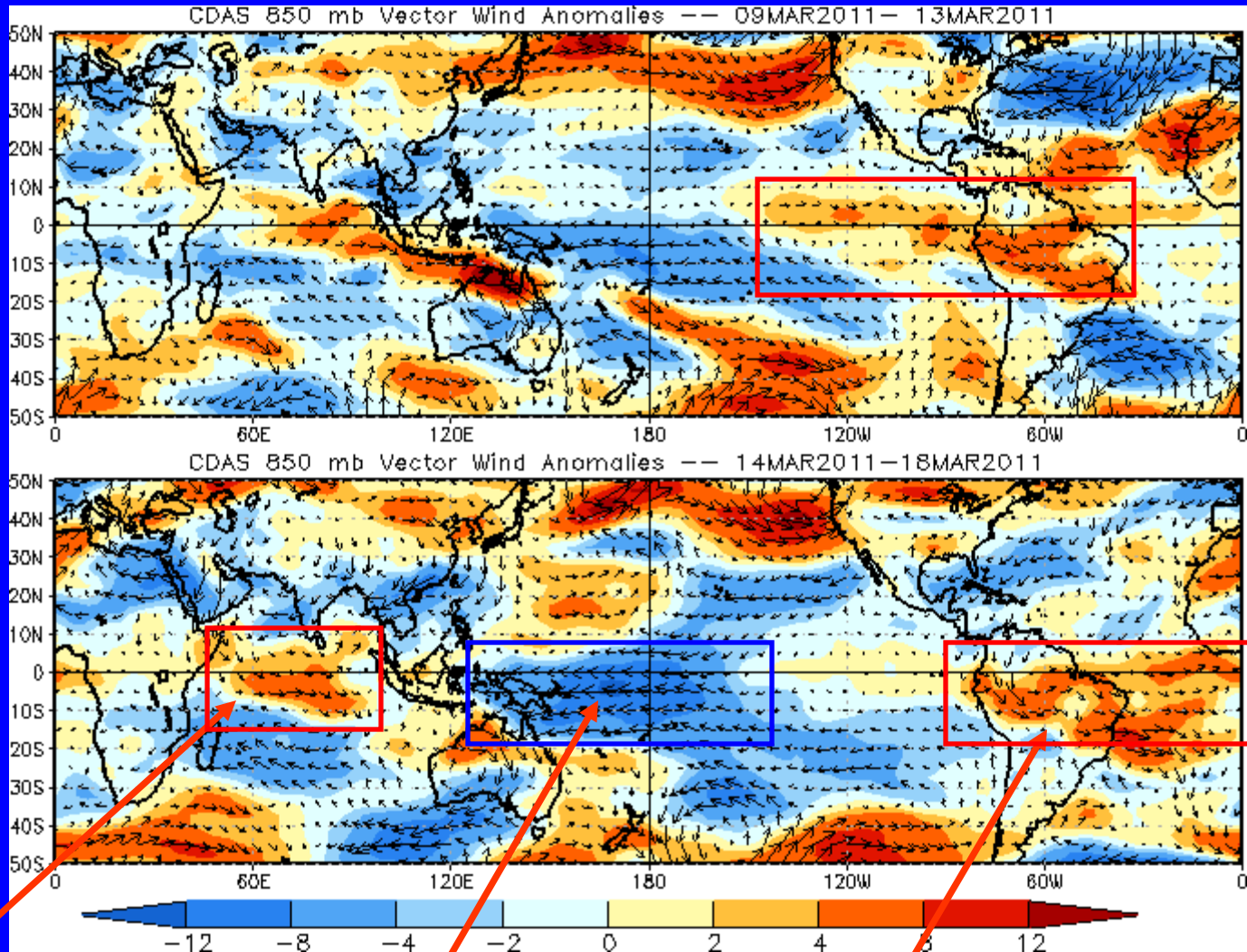


# 850-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies ended across the western Maritime Continent but continued over the Indian Ocean.

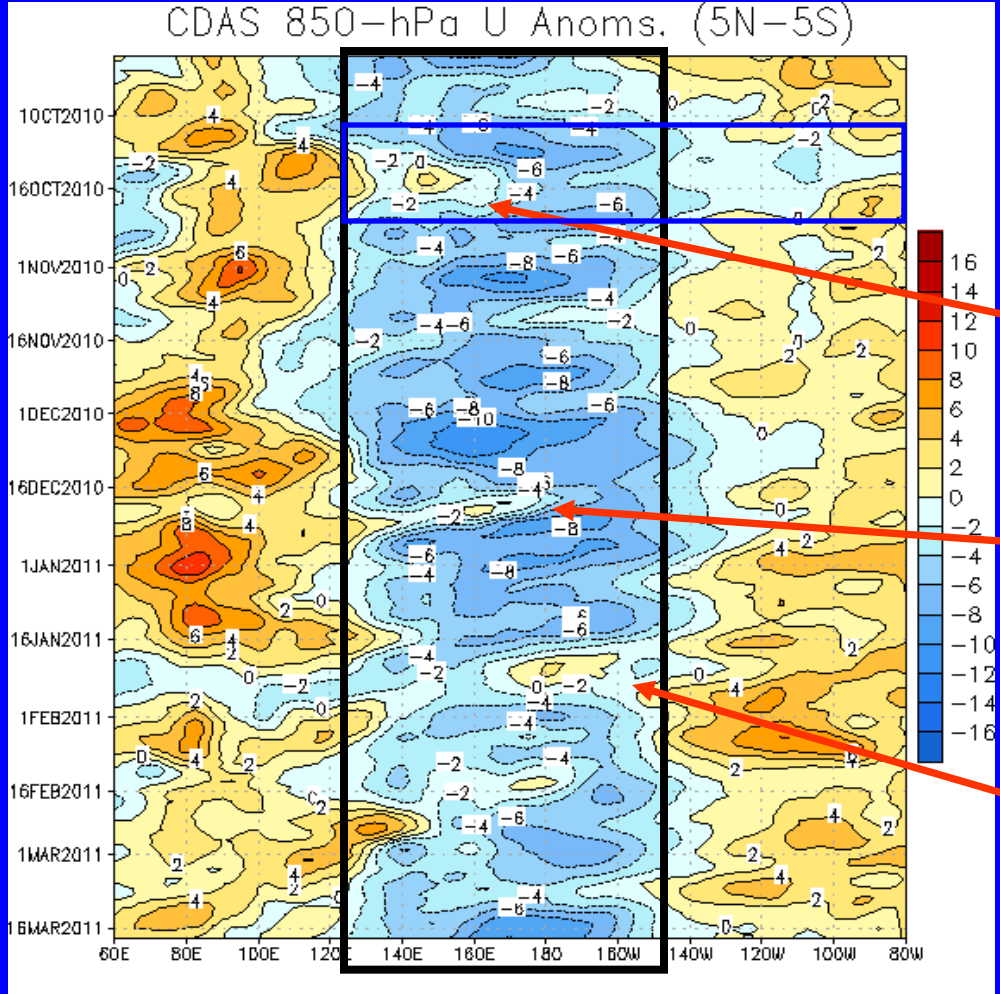
Easterly anomalies strengthened across the western Pacific during the last five days.

Westerly anomalies shifted eastward and strengthened during the last five days in the western hemisphere.



# 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 September (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).

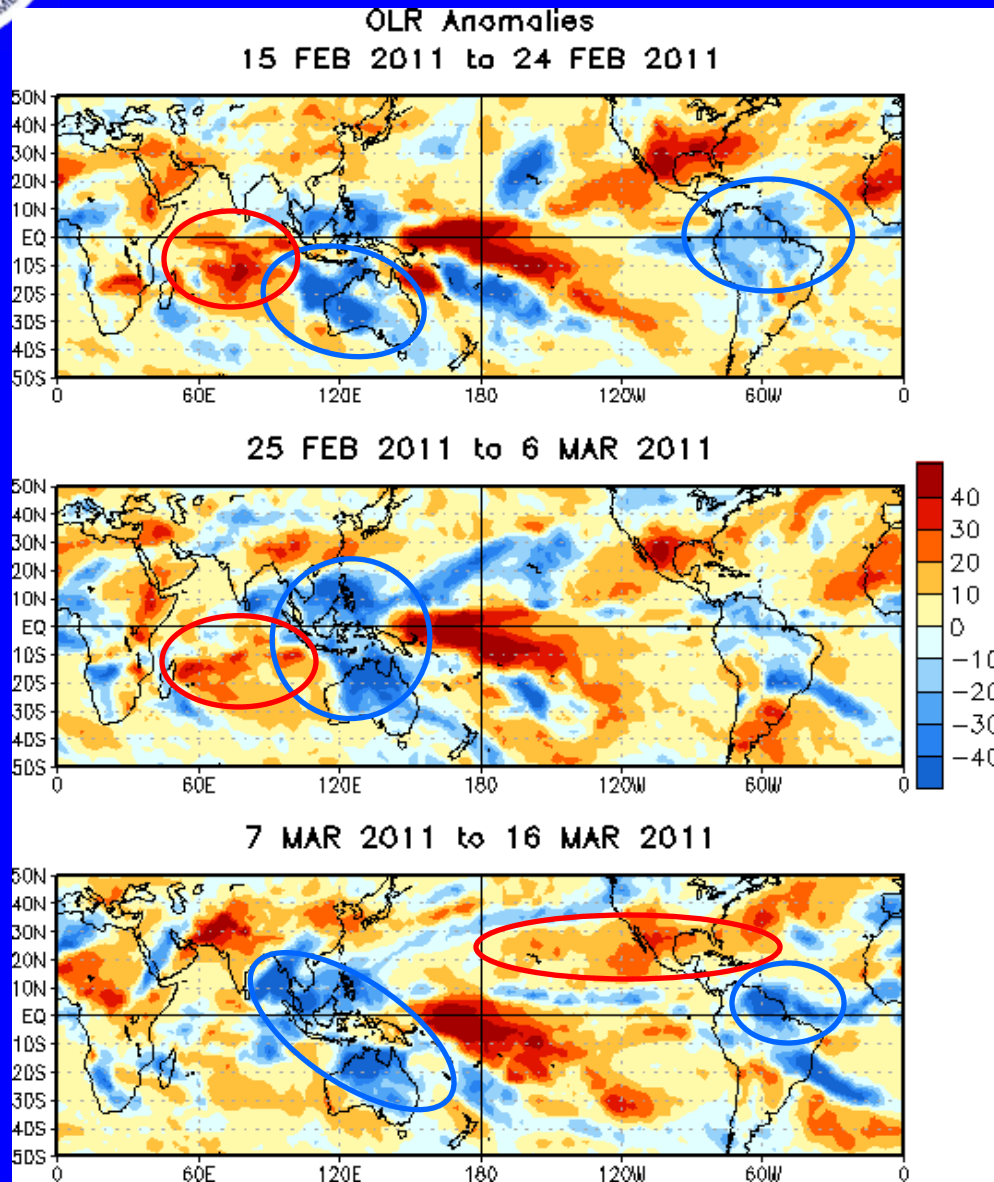
In mid-December, easterly anomalies weakened just west of the Date Line due to a combination of weak MJO activity and extratropical interactions.

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



# OLR Anomalies – Past 30 days

**Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)**  
**Wetter-than-normal conditions, negative OLR anomalies (blue shading)**



Enhanced convection (blue circle) continued over northern Southern America and in close proximity to Hawaii during mid-to-late February. Wetter-than-average conditions also developed across Australia. Suppressed convection (red circle) also continued across the Indian Ocean.

During late February into early March, enhanced convection became more widespread over the Maritime continent, Australia and the Philippines while suppressed convection continued across the southern Indian Ocean.

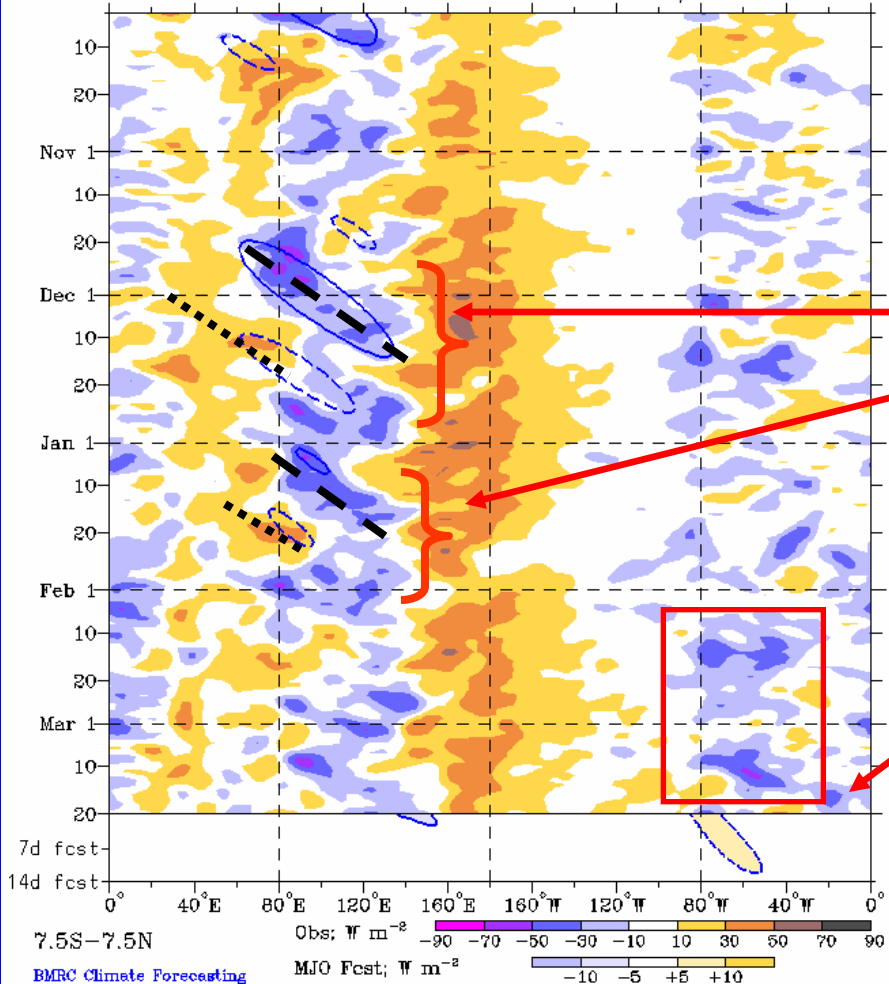
Into early-to-mid March, enhanced convection continued across Australia, the Maritime continent, the Philippines and northern South America. Suppressed convection was observed over Hawaii and across the southern tier of the U.S..





# Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°N)

Real-time MJO filtering superimposed upon 3drn R21 OLR Anomalies  
MJO anomalies blue contours, CINT=10. (5. for forecast)  
Negative contours solid, positive dashed  
3-Oct-2010 to 20-Mar-2011 + 14 days



**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 but shifted eastward during the last several days.

**Longitude**

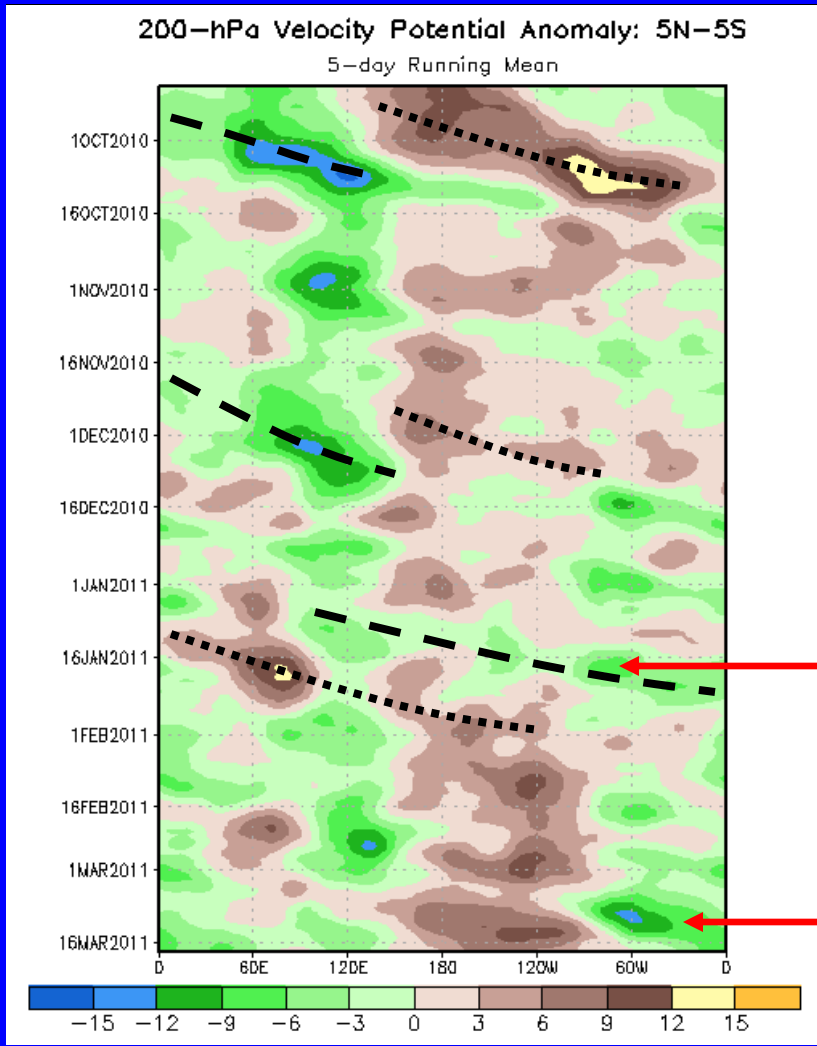


# 200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time  
↓



The MJO strengthened during late September as anomalies increased and eastward propagation was seen through mid-October.

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.

In mid-March, negative anomalies increased in magnitude near 60W and shifted eastward very quickly.

Longitude

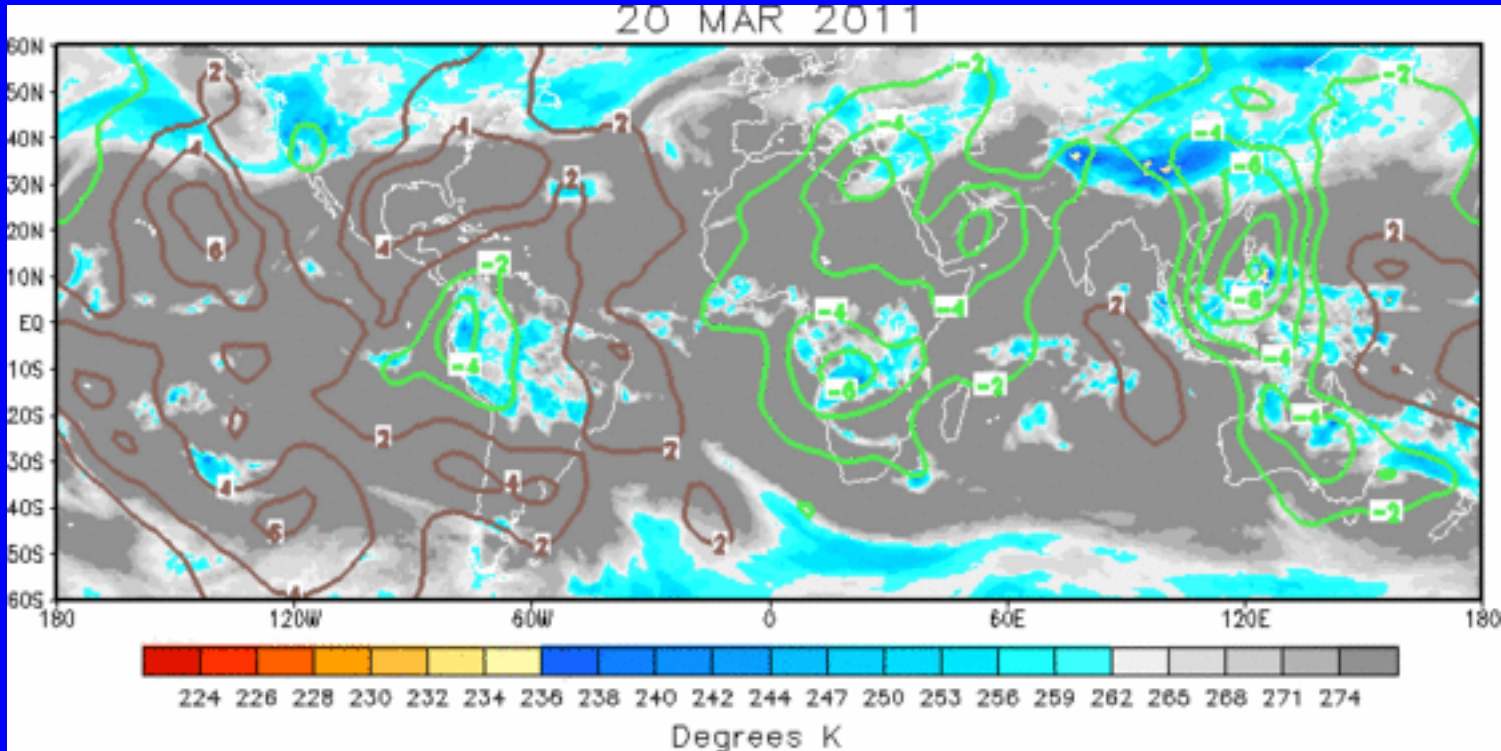




# IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

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 divergence over Africa, the western Indian Ocean and parts of the Maritime continent. Anomalous upper-level convergence decreased during the past week and shifted eastward, entering the Americas.

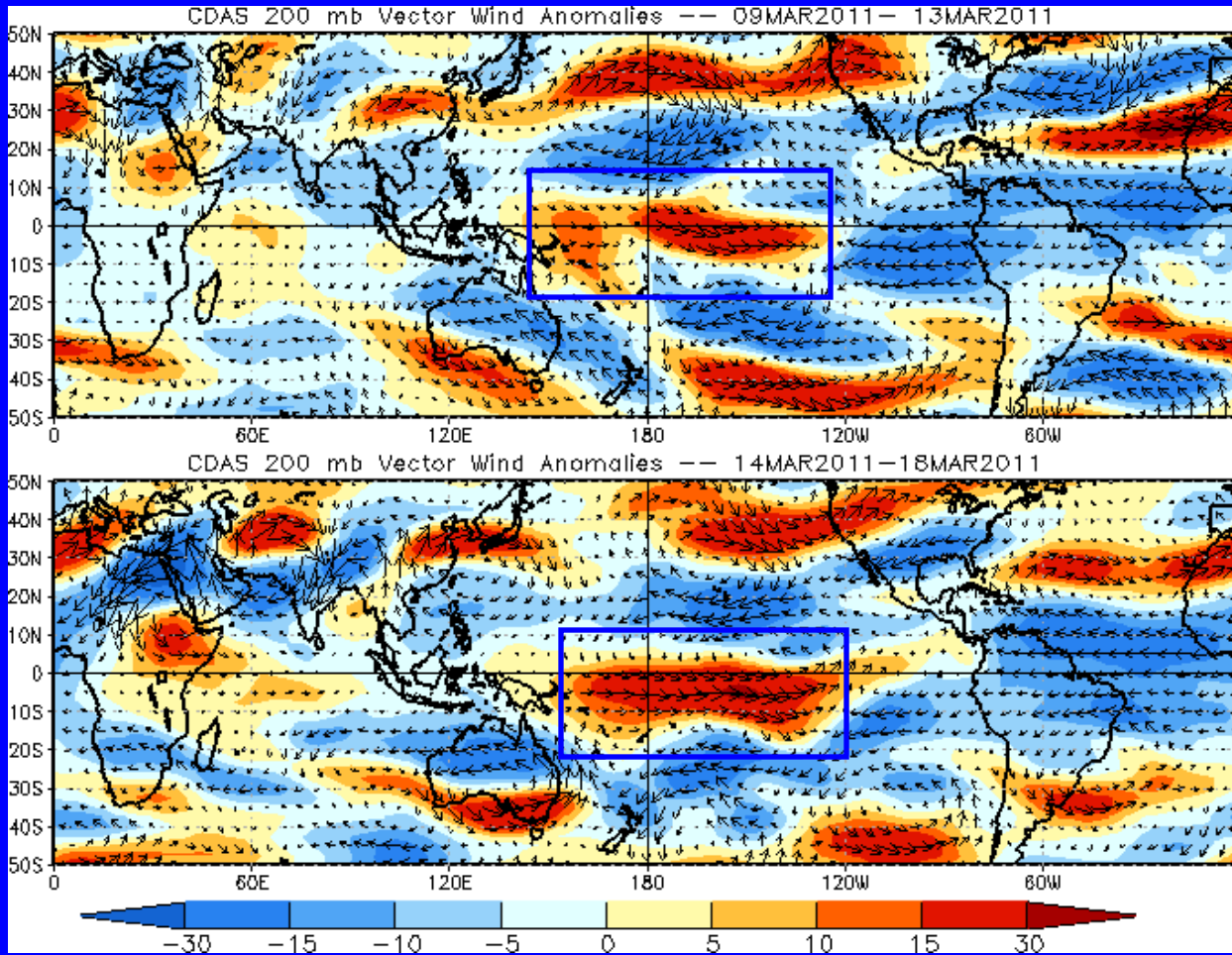


# 200-hPa Vector Wind Anomalies ( $\text{m s}^{-1}$ )

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



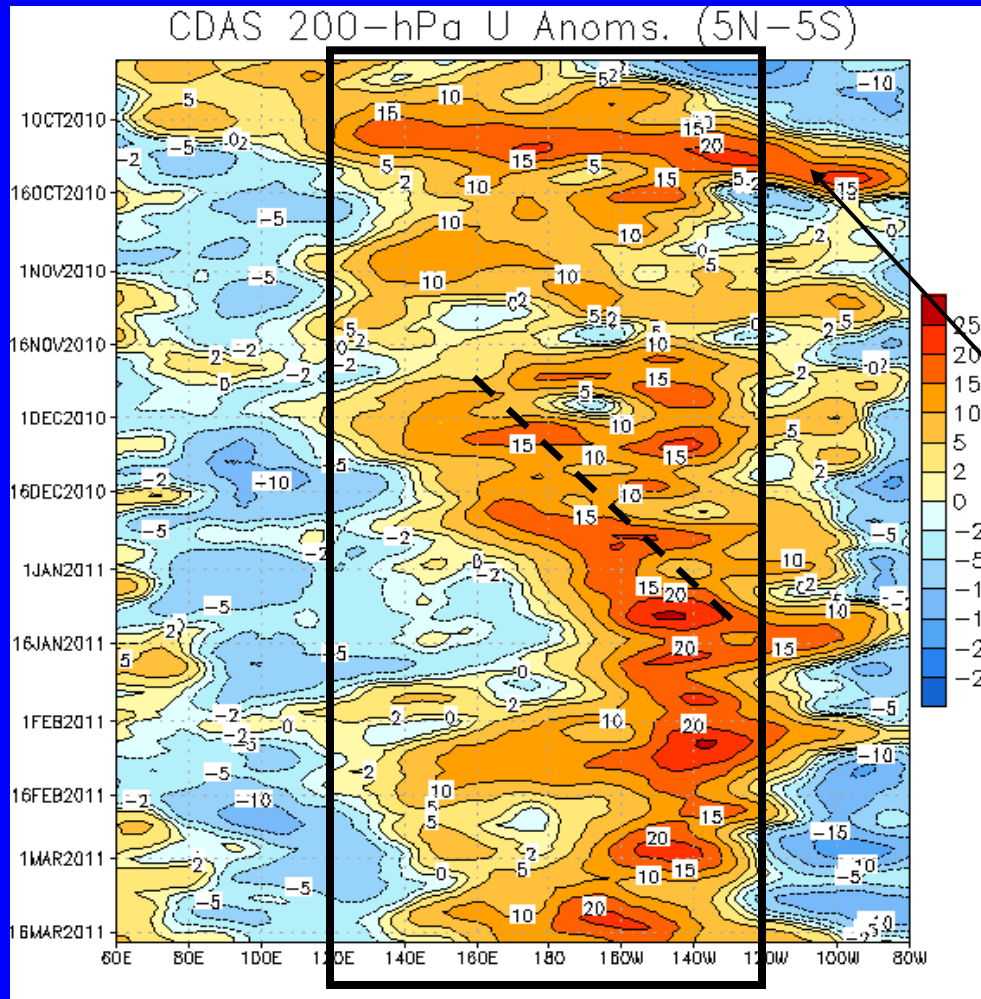
Westerly anomalies continued across the equatorial central Pacific during the last five to ten days (blue boxes).



# 200-hPa Zonal Wind Anomalies ( $\text{m s}^{-1}$ )

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 September.

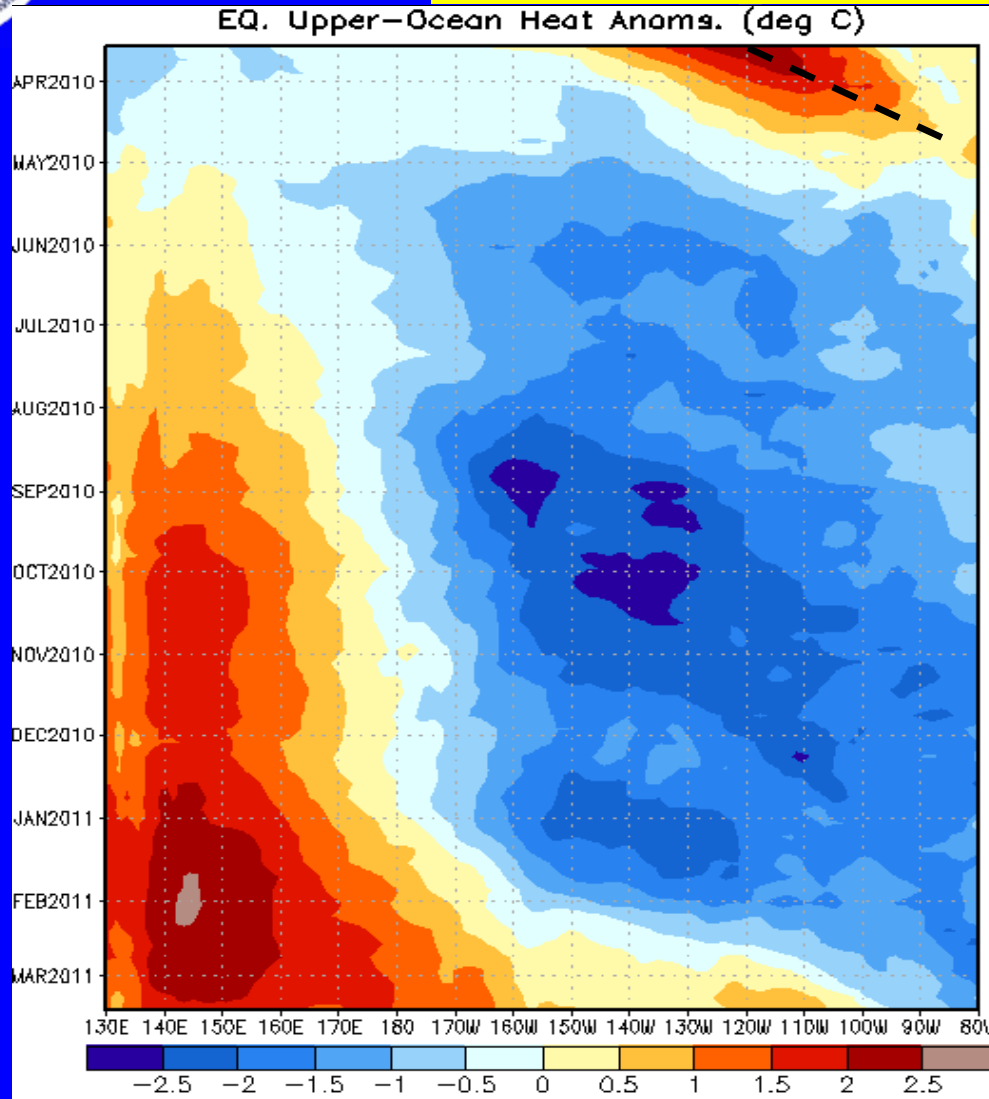
In early October, westerly anomalies strengthened considerably associated with MJO activity and an eastward extension of these anomalies is evident.

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.



# Weekly Heat Content Evolution in the Equatorial Pacific



From January through March 2010, heat content anomalies remained above-average for much of the period.

From December 2009 – February 2010 two ocean Kelvin waves contributed to the change in heat content across the eastern Pacific (last two dashed black lines).

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 become 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.

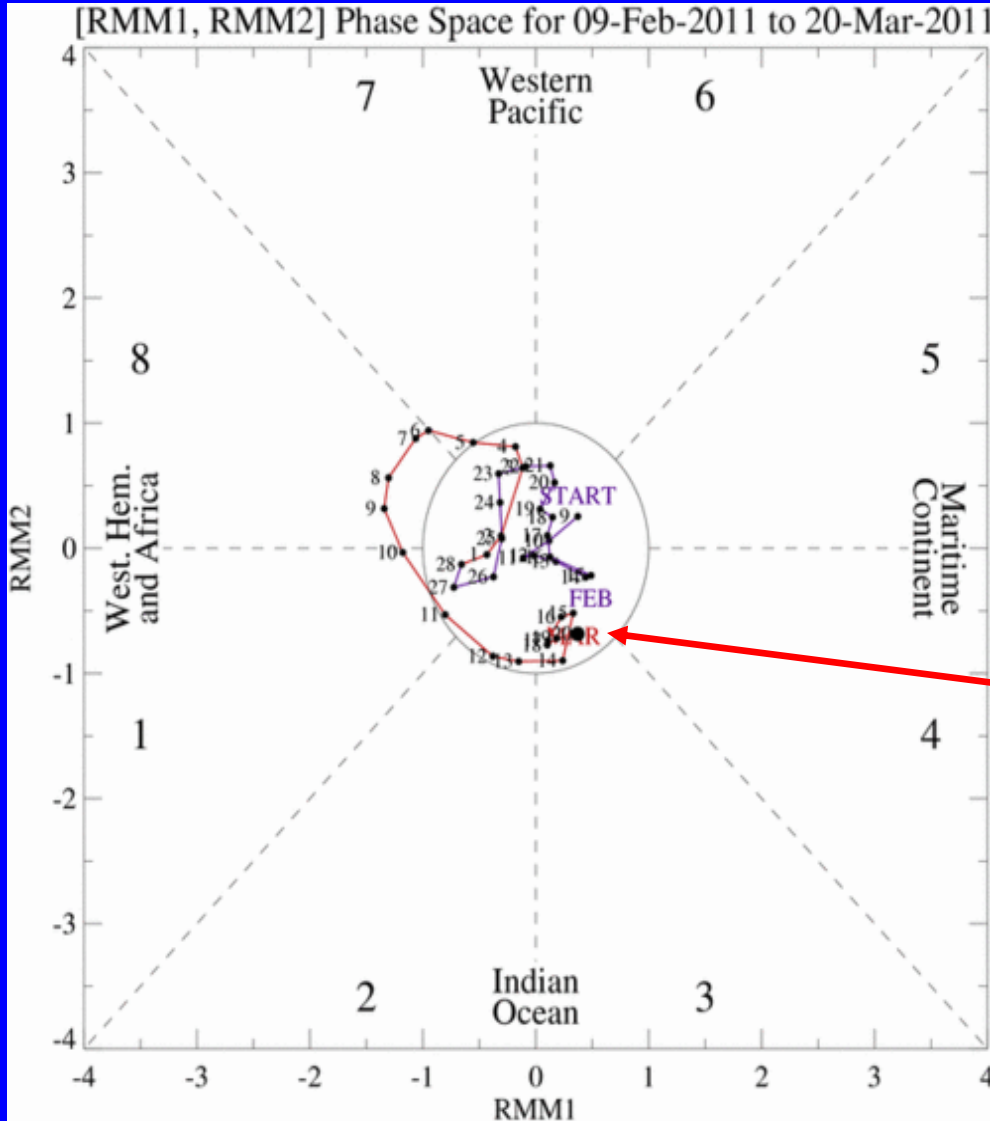
**Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.**

- 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

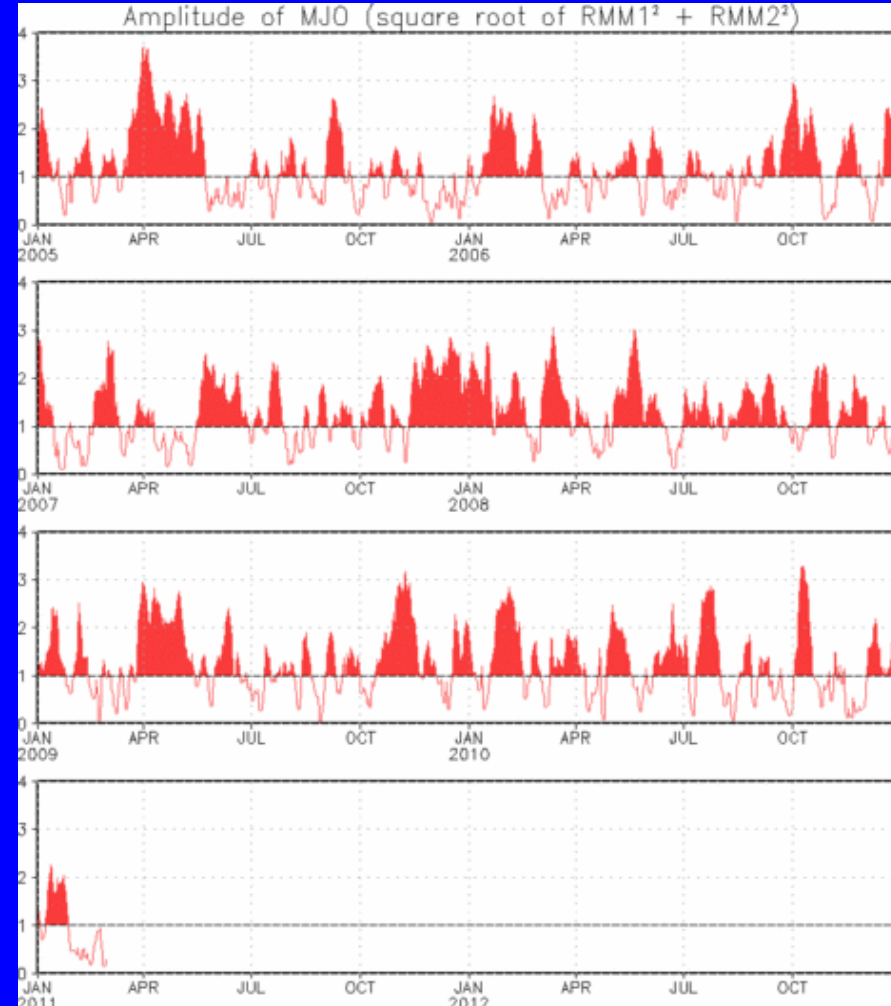
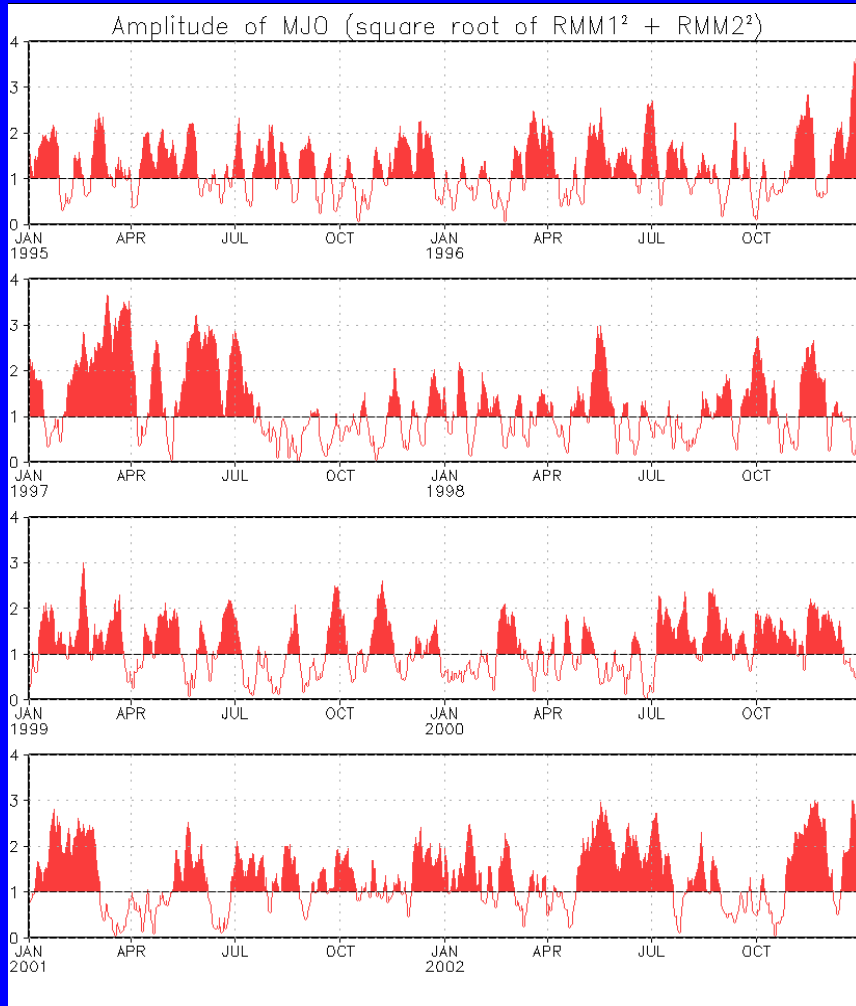


The MJO index indicated a pause in eastward propagation of the weak signal during the past week.





# 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.



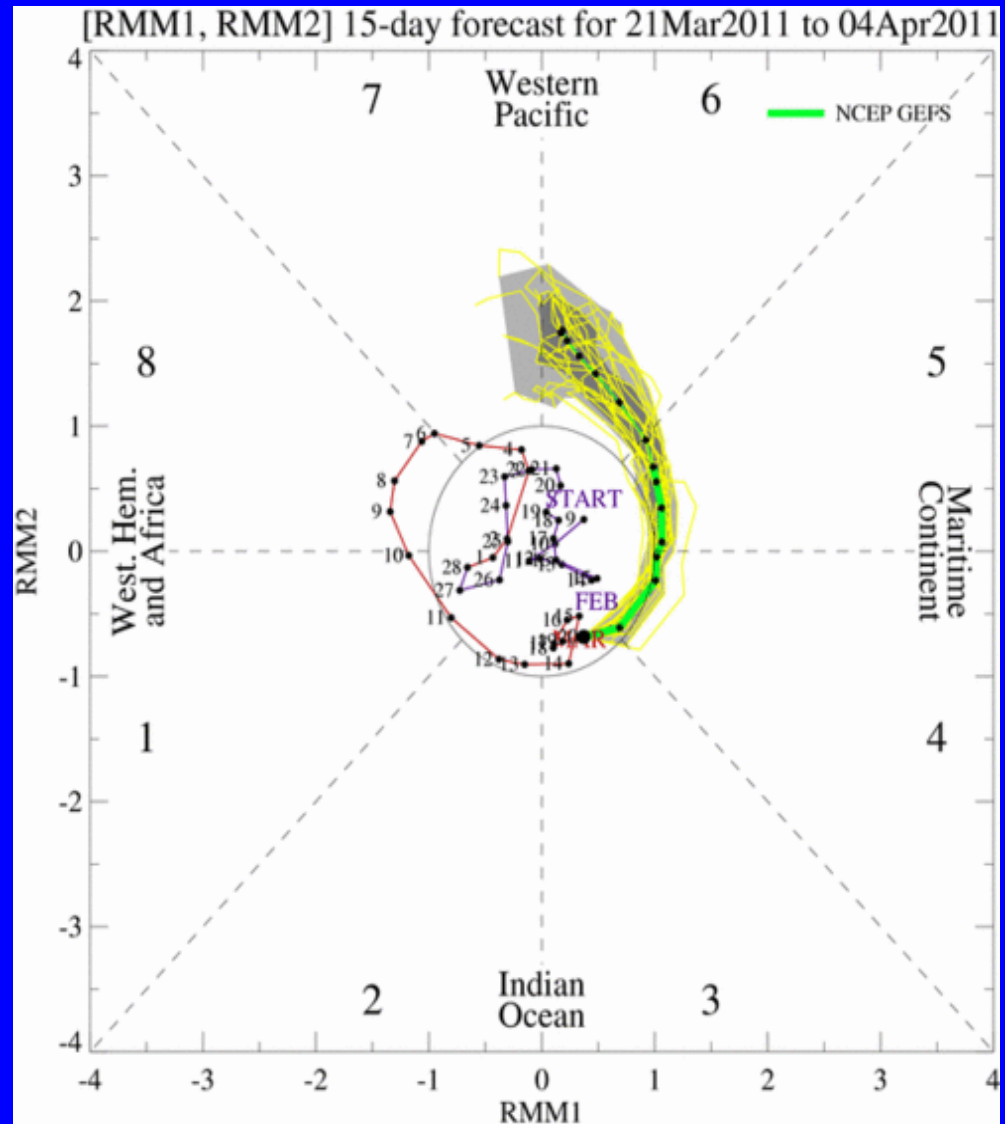
# Ensemble GFS (GEFS) MJO Forecast

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 re-initiation of an eastward propagating signal during the next two weeks towards the western Pacific.



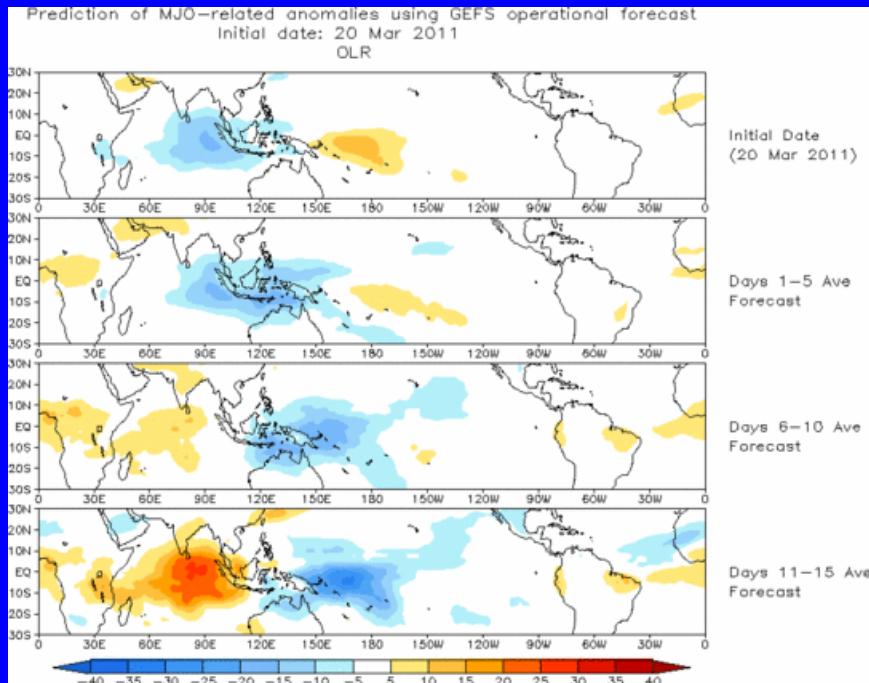


# Ensemble Mean GFS MJO Forecast

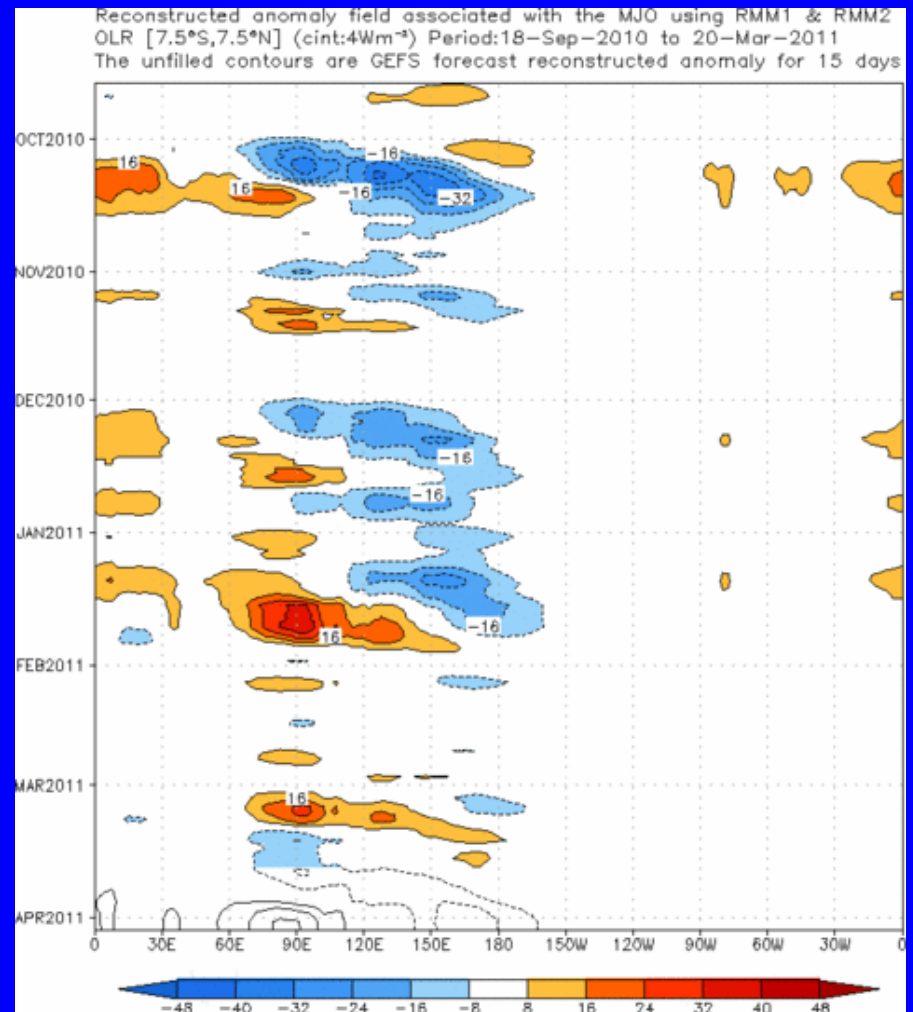
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons)

Spatial map of OLR anomalies for the next 15 days

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



The GEFS ensemble mean forecast indicates enhanced convection shifting eastward to the Maritime continent during Week-1 and the western Pacific in Week-2. Drier-than-average conditions are forecast across the Indian Ocean by the end of Week-2.





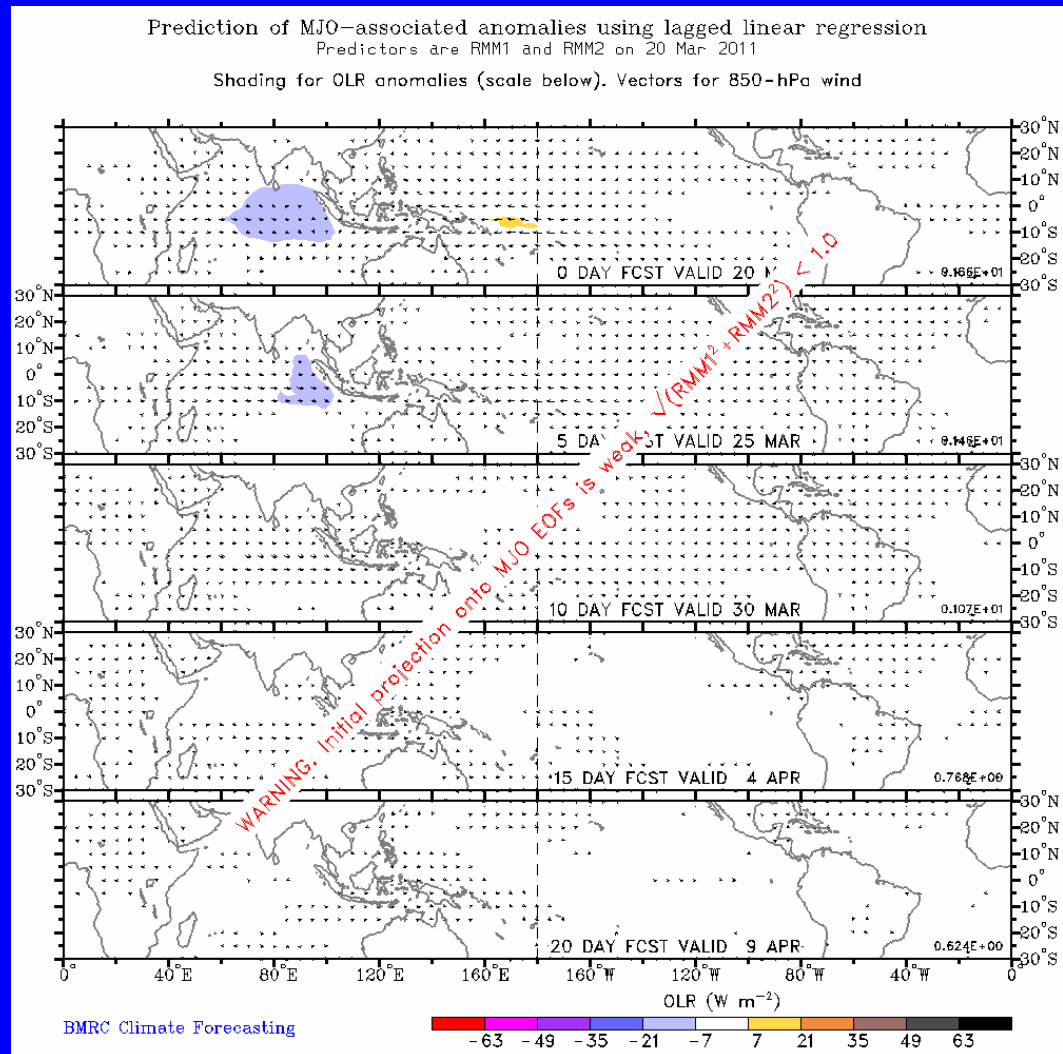
# Statistical MJO Forecast

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 is for weak MJO activity during the period.

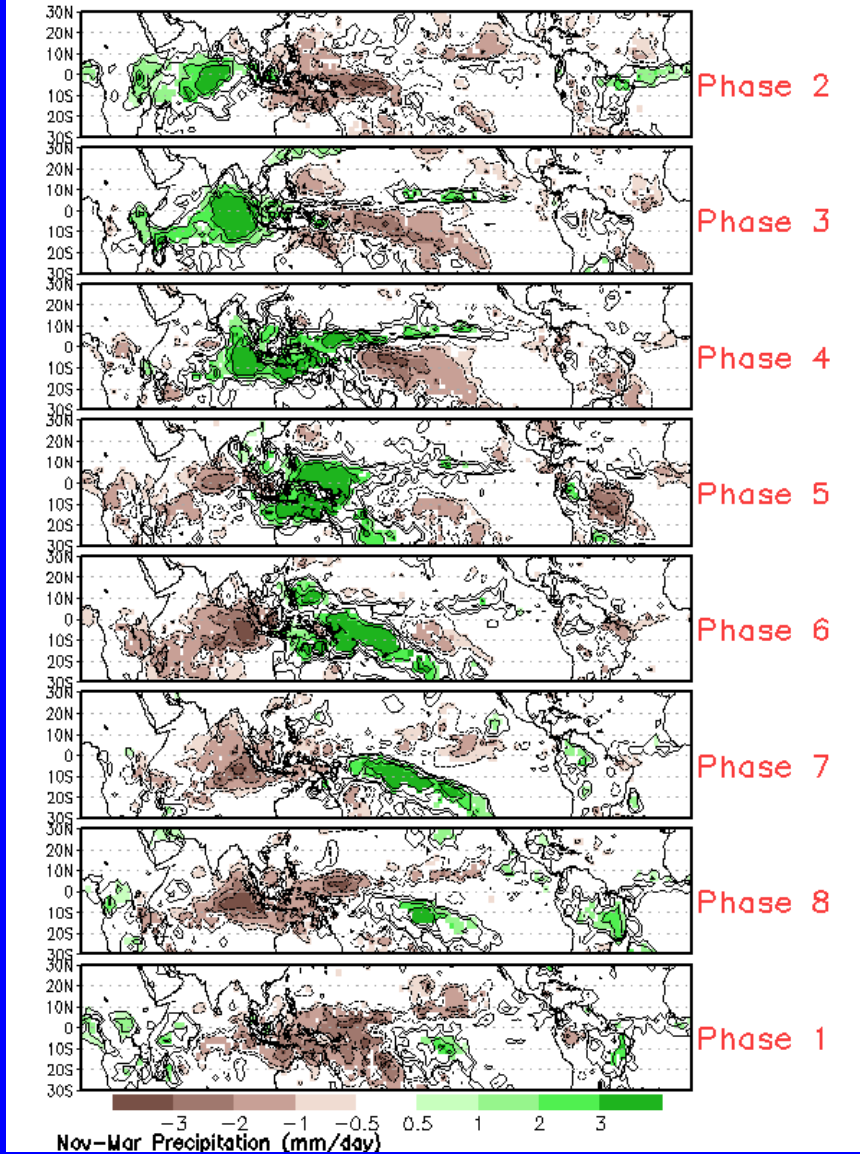




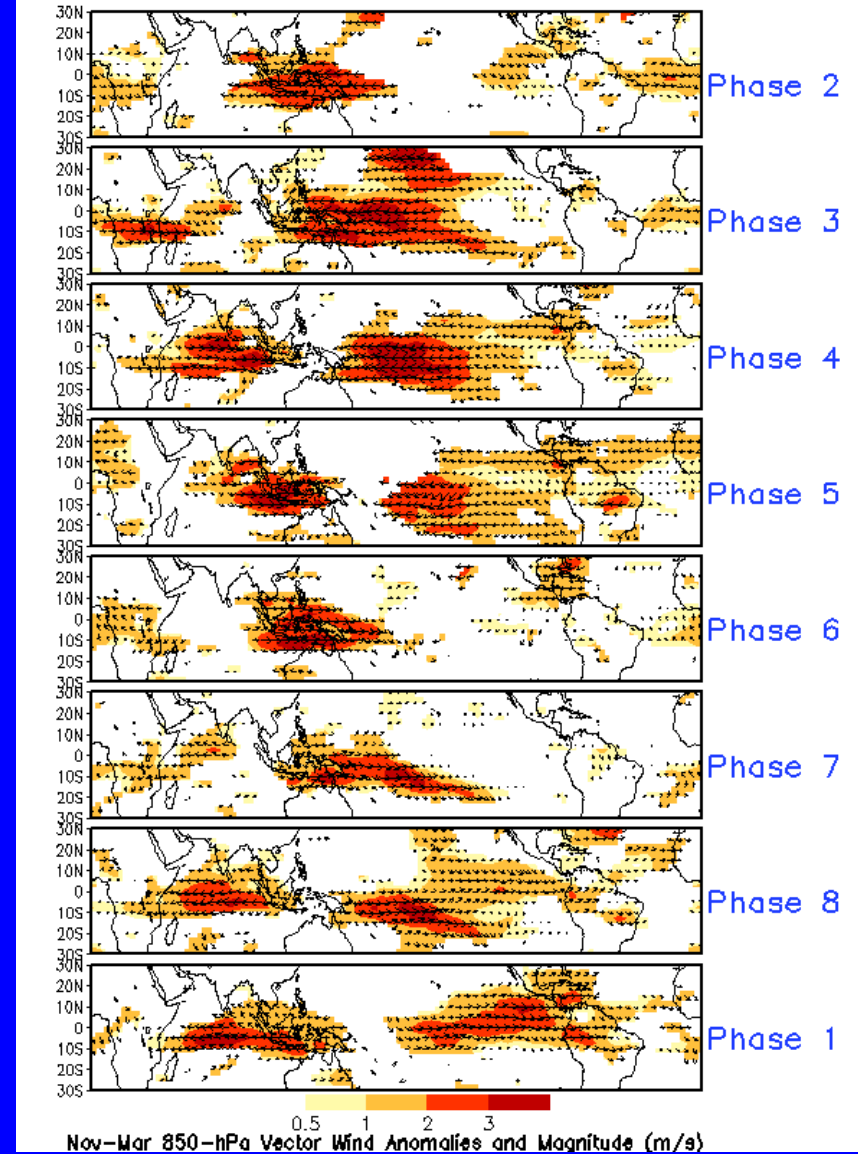


# MJO Composites – Global Tropics

## Precipitation Anomalies (Nov-Mar)



## 850-hPa Wind Anomalies (Nov-Mar)

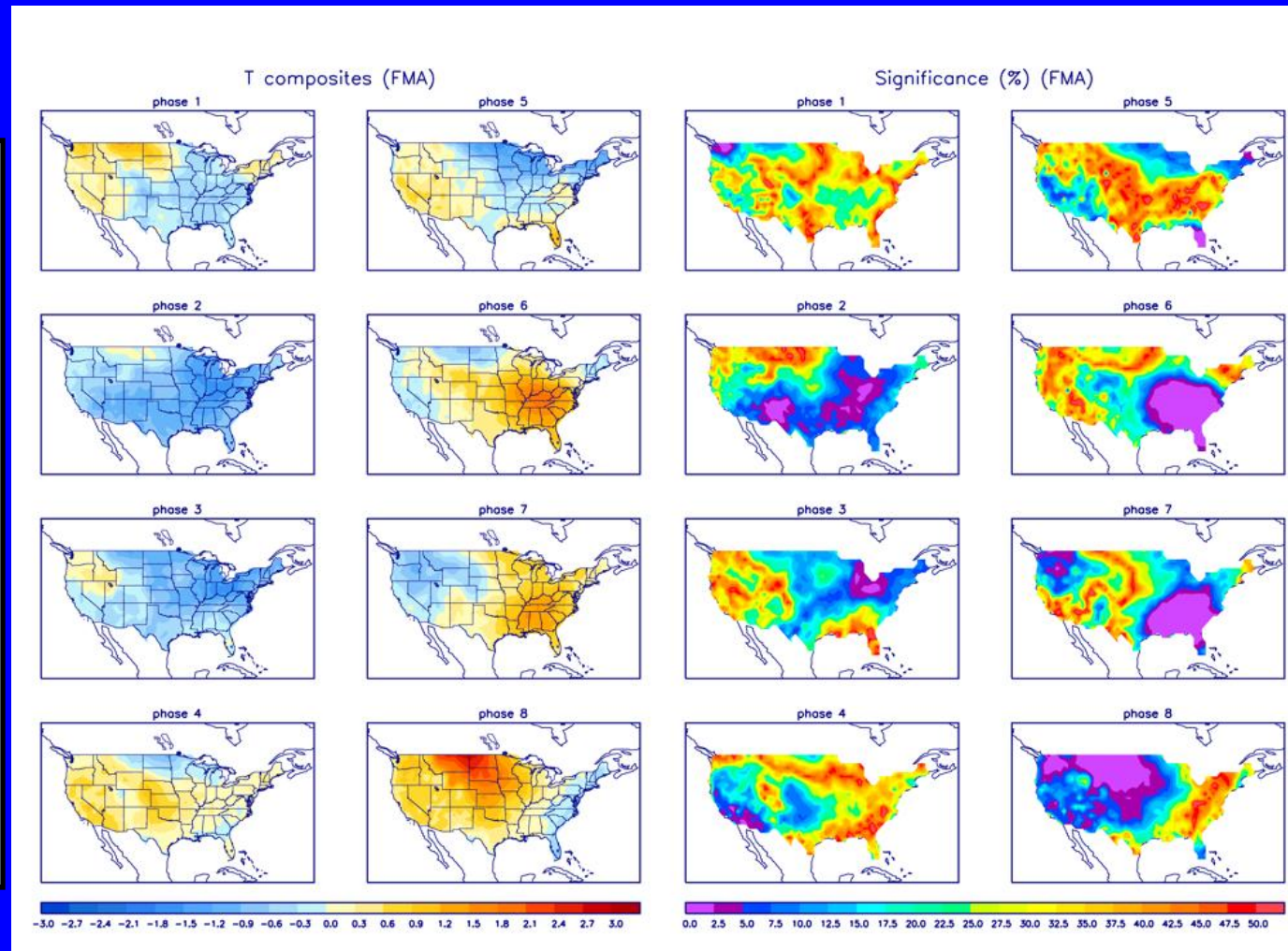




# U.S. MJO Composites – Temperature

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.

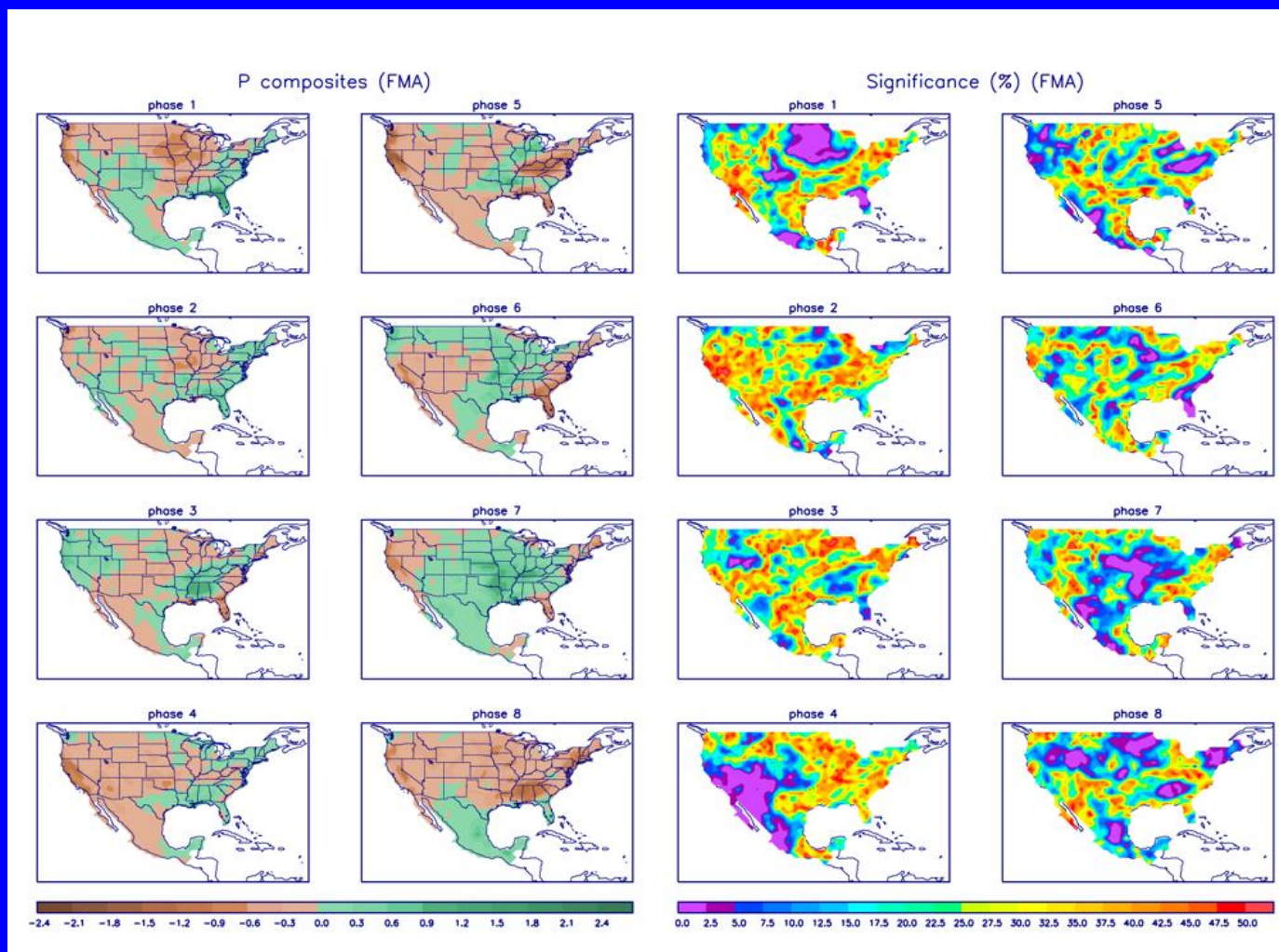
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml>





# 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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