



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

**Update prepared by
Climate Prediction Center / NCEP
March 7, 2011**



Outline

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



Overview

- **The MJO signal remained weak during the past week.**
- **There is good agreement amongst several dynamical model MJO index forecasts for a strengthening signal during Week-1, with fast eastward propagation to and in some cases across the Indian Ocean by the end of Week-2.**
- **The fast propagation speed of this signal favors other higher frequency coherent subseasonal variability as the primary source, but this activity will need to be monitored to see if a more longer-lived MJO event is developing.**
- **Over the next 1-2 weeks, this signal favors enhanced rainfall for areas across northeast South America, central Africa and the Indian Ocean, with drier conditions, as compared to recent weeks, for parts of the Maritime continent.**

Additional potential impacts across the global tropics are available at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/ghaz.shtml>

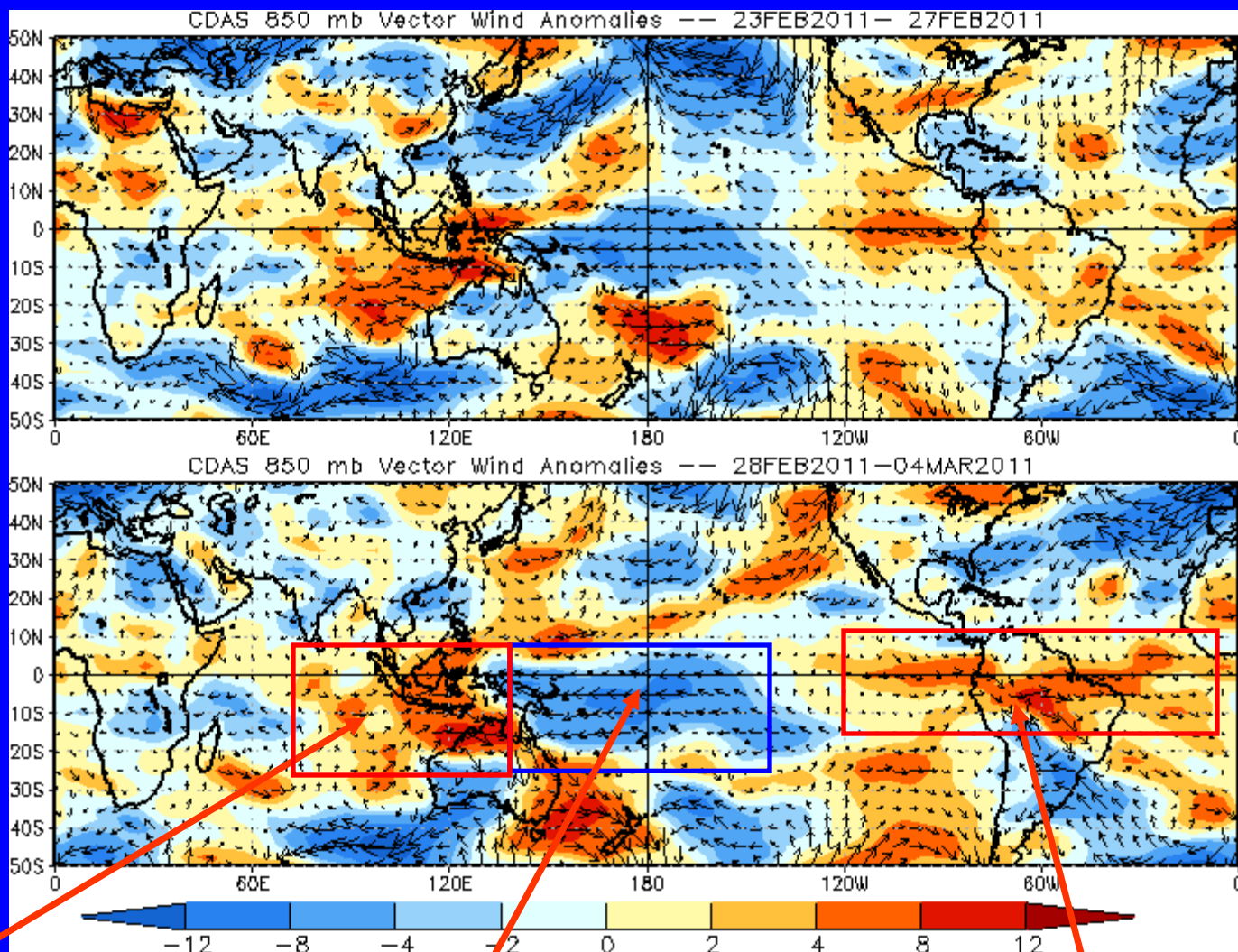


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies continued across the western Maritime Continent, eastern Indian Ocean and Australia.

Easterly anomalies continued across the western Pacific mainly south of the equator.

Westerly anomalies strengthened across northern South America and the Atlantic during the last five days.

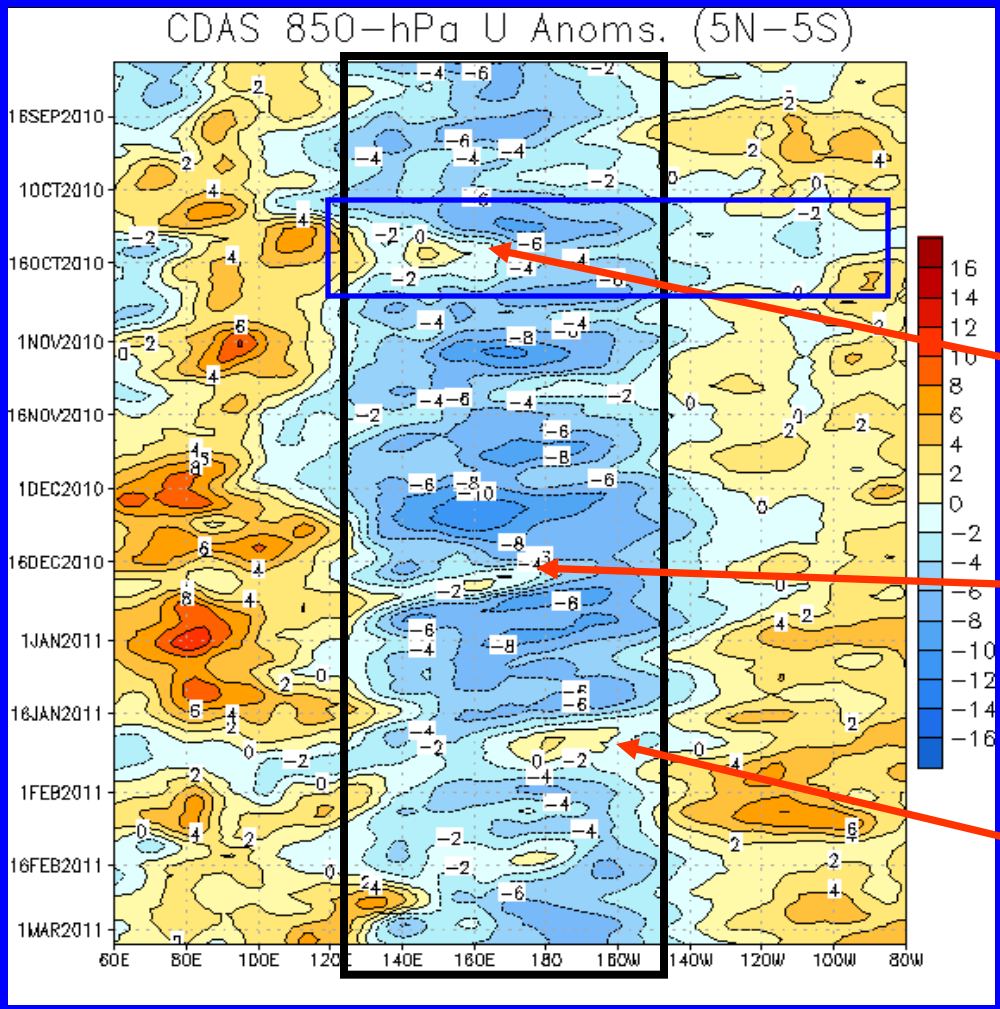


850-hPa Zonal Wind Anomalies (m s^{-1})

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 August (black box) consistent with the development of 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.

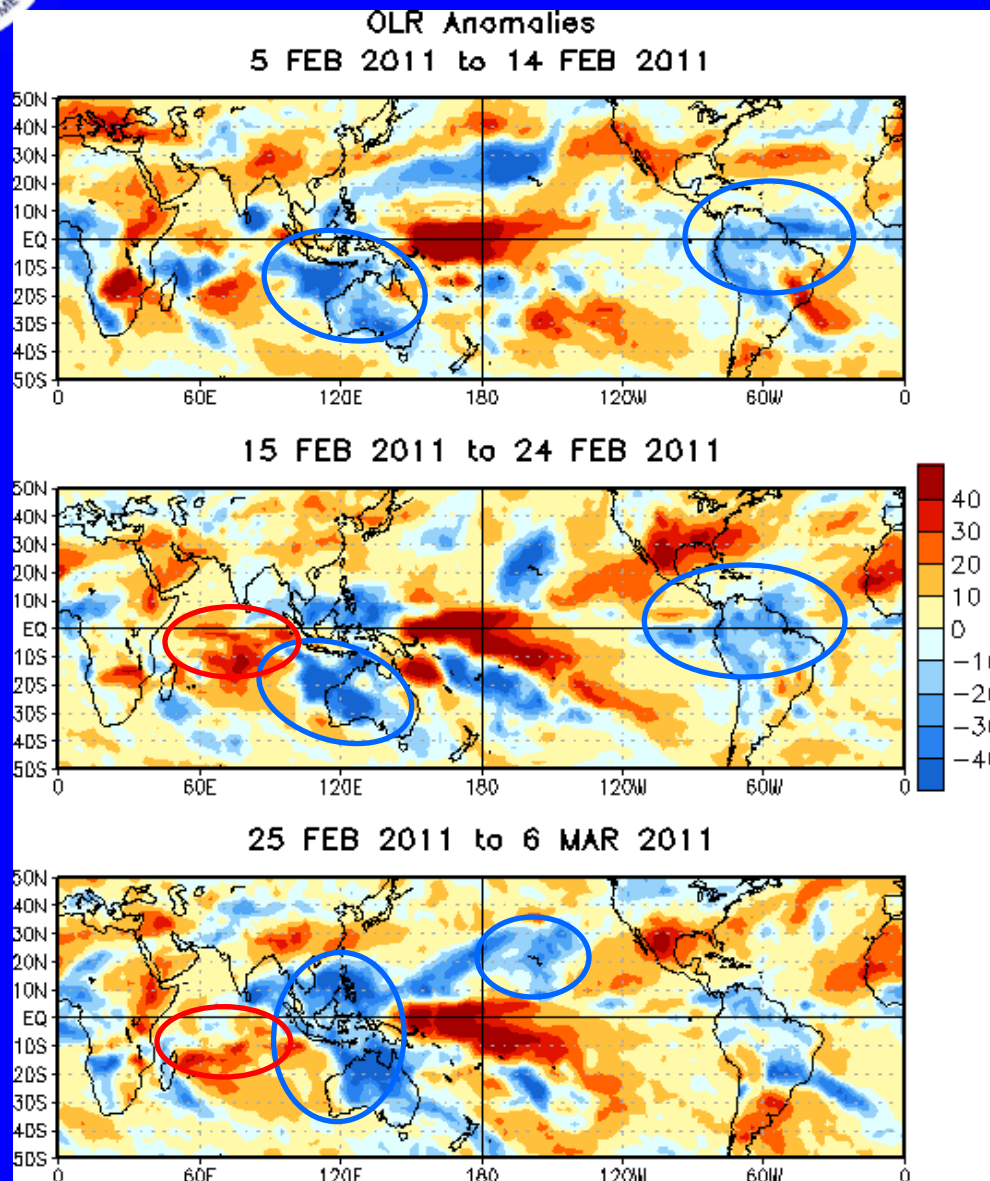
In late January, easterly winds weakened and westerly anomalies developed in some areas near the Date Line due to MJO activity.



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) developed over northern Southern America and in close proximity to Hawaii during early-to-mid February. Wetter-than-average conditions also developed across Australia.

During late February, suppressed convection (red circle) developed across the Indian Ocean, while enhanced convection continued across Australia, the Philippines, Hawaii, and northern South America.

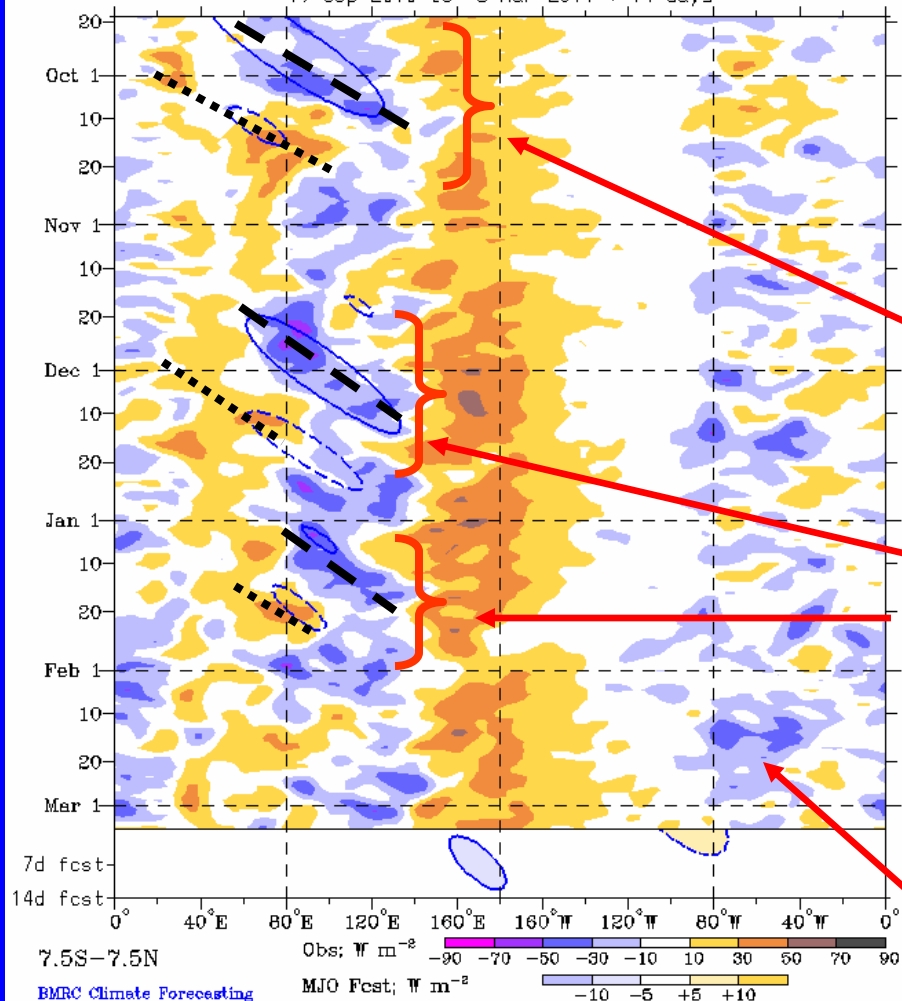
Into early March, enhanced convection continued across Australia, the Maritime continent, the Philippines and Hawaii.



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
19-Sep-2010 to 6-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)

As the MJO strengthened in late September into October, enhanced convection developed near 60°E and shifted eastward followed by suppressed convection near 20°E during early-mid October.

MJO activity was experienced during late November into December and once again during January. During both periods, enhanced convection developed near 80°E 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.

Time
↓

Longitude

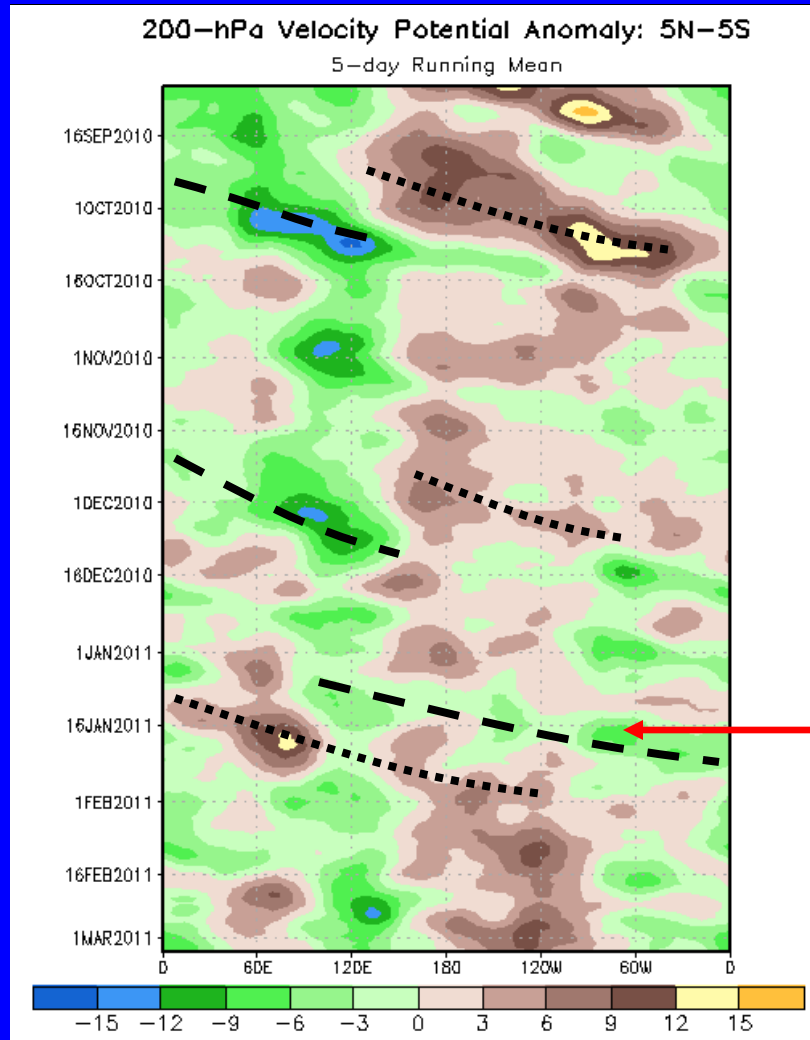


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



Longitude

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.

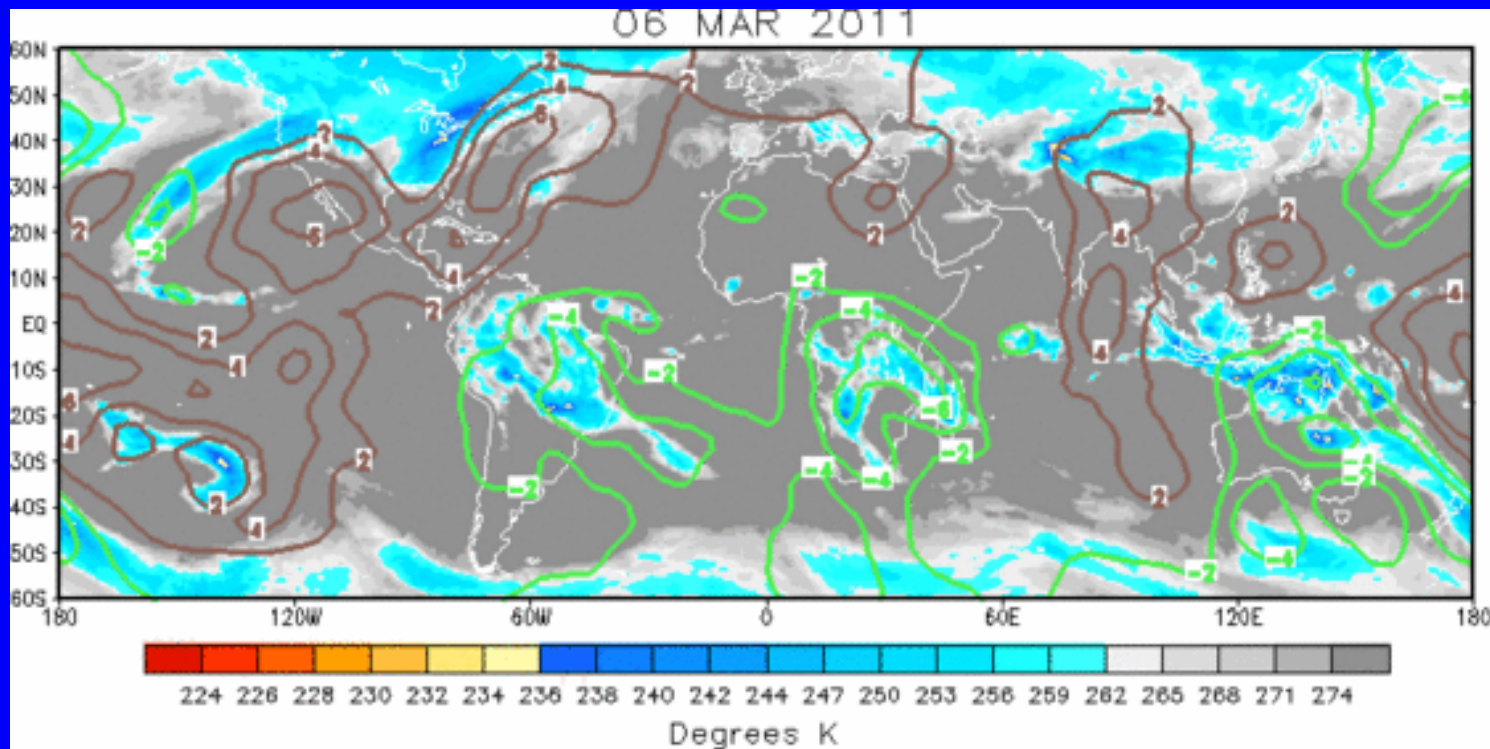
During mid-to-late January, the MJO strengthened and upper-level divergence shifted eastward from 120E and upper-level convergence shifted from Africa to near the Date Line.



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 central Africa, the Maritime continent and Australia, while anomalous upper-level convergence is indicated across the eastern Pacific Ocean.

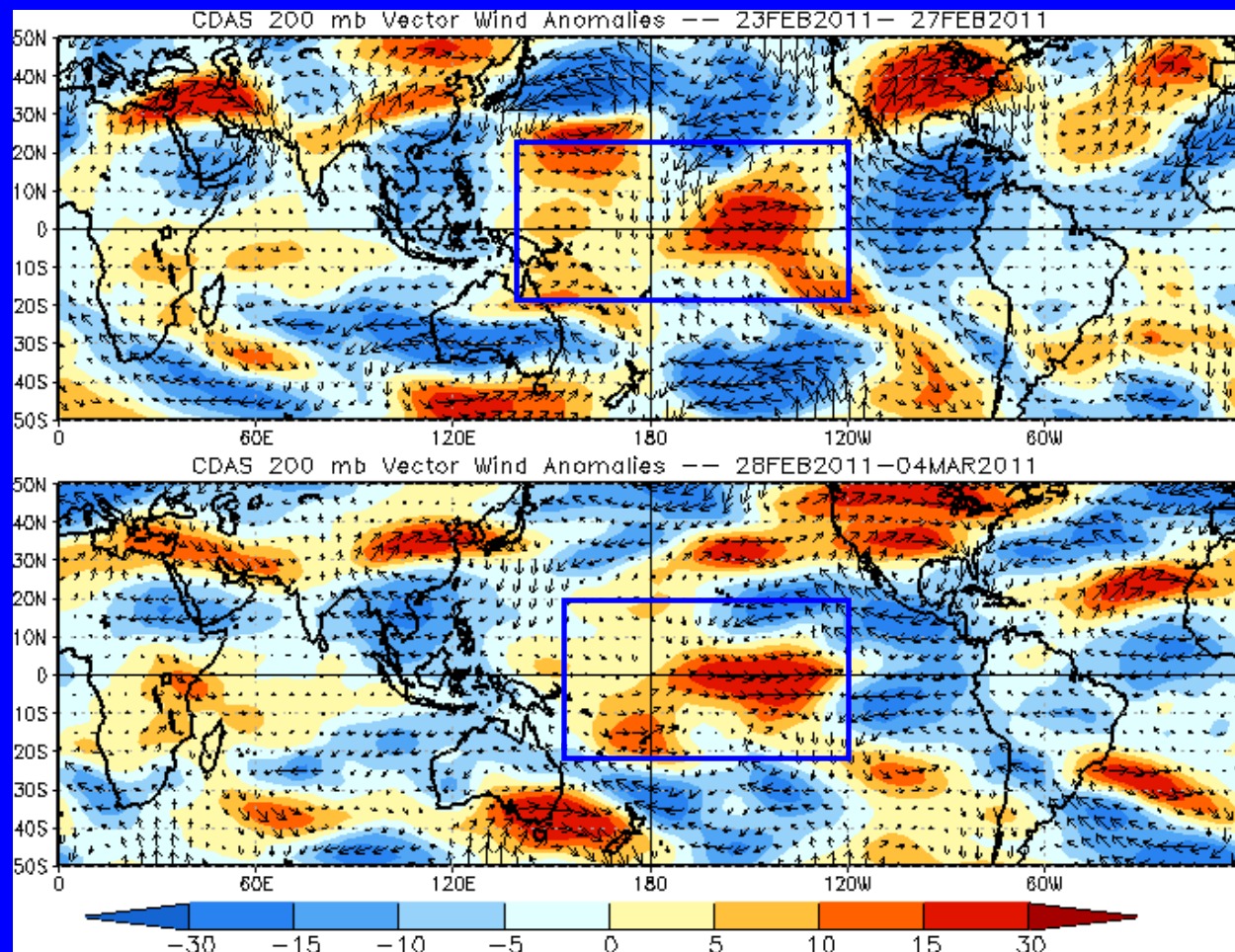


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

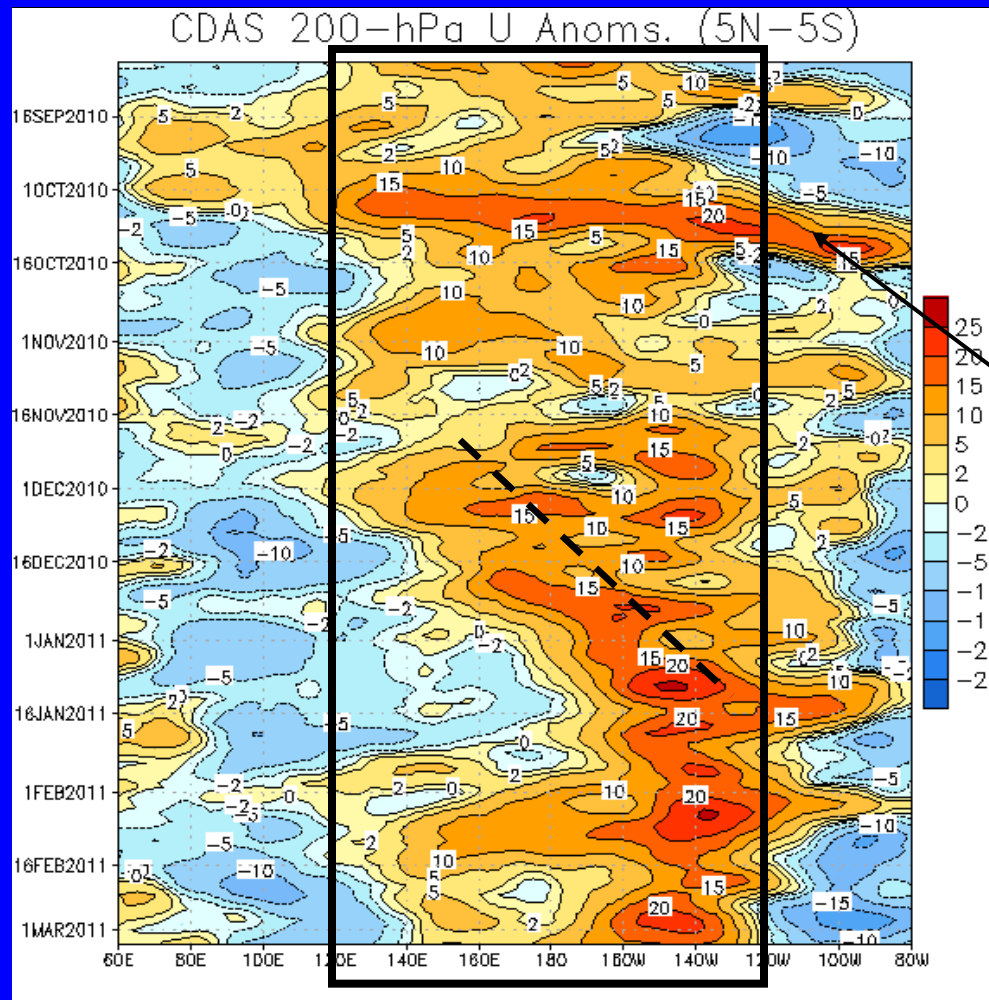


Westerly anomalies continued across the central Pacific during the last five to ten days (blue boxes).



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

Time
↓



Longitude

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

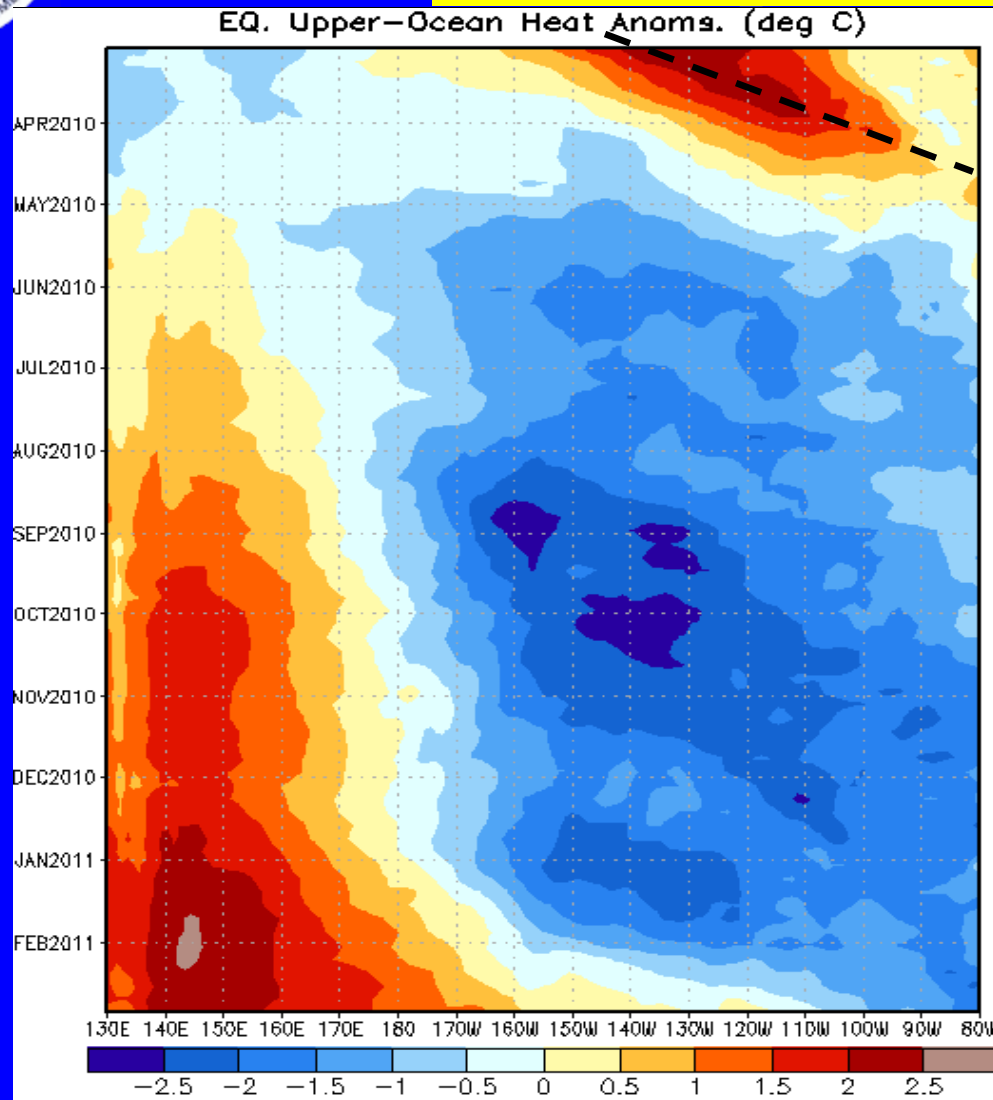
In early October, westerly anomalies strengthened considerably associated with MJO activity and an eastward extension of these anomalies is evident.

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 expanded back to the west across the central Pacific similar to where they were during much of the August to November 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 have weakened 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.

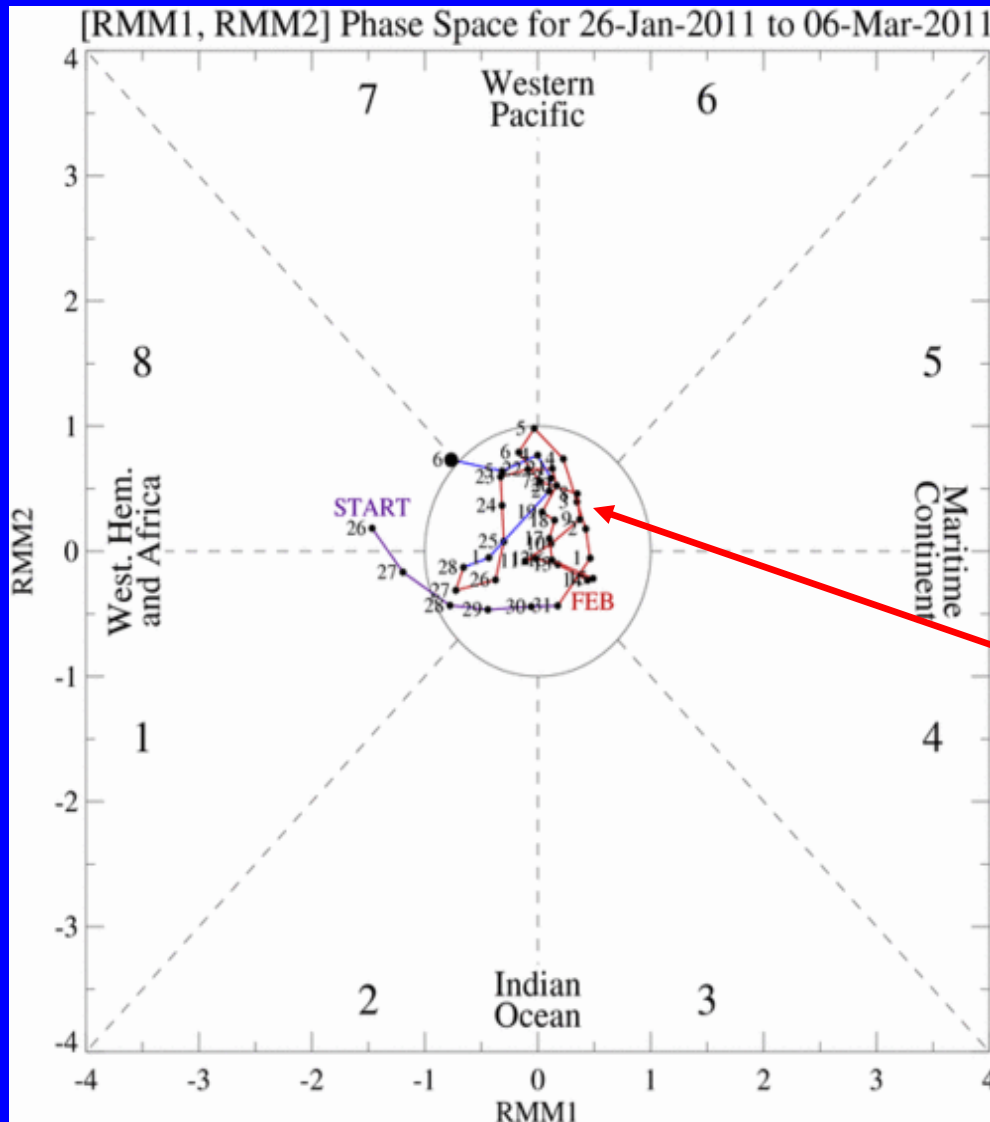
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

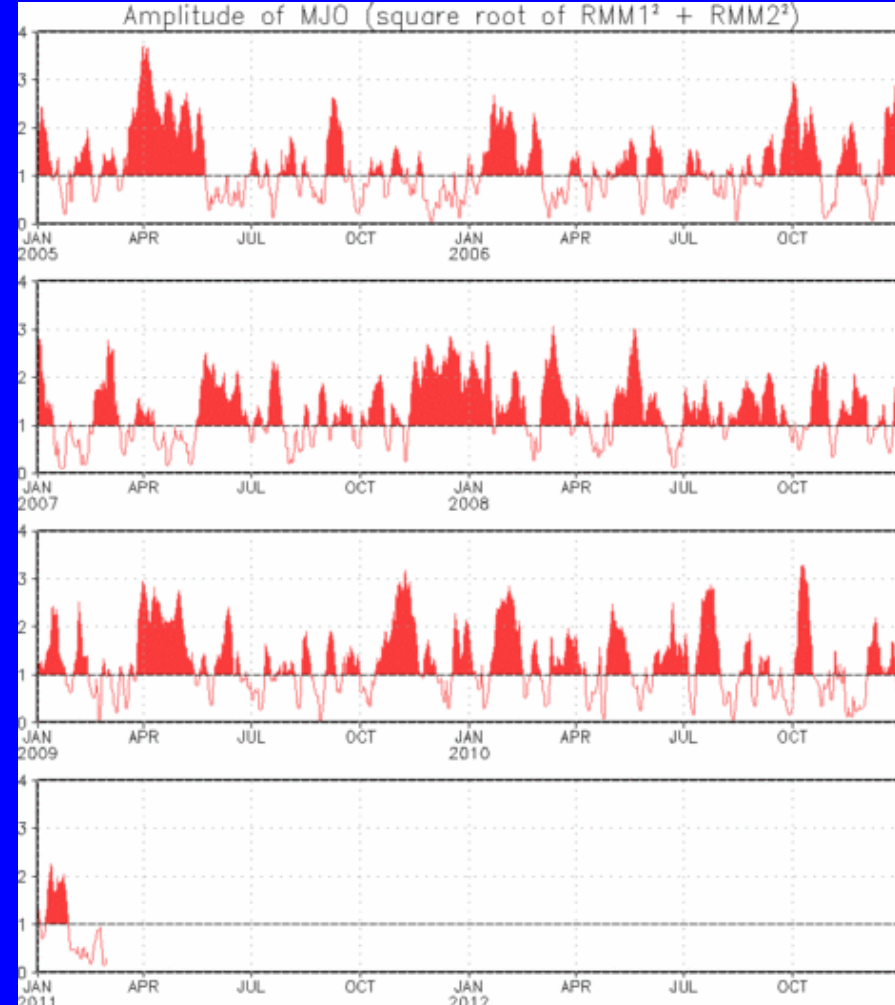
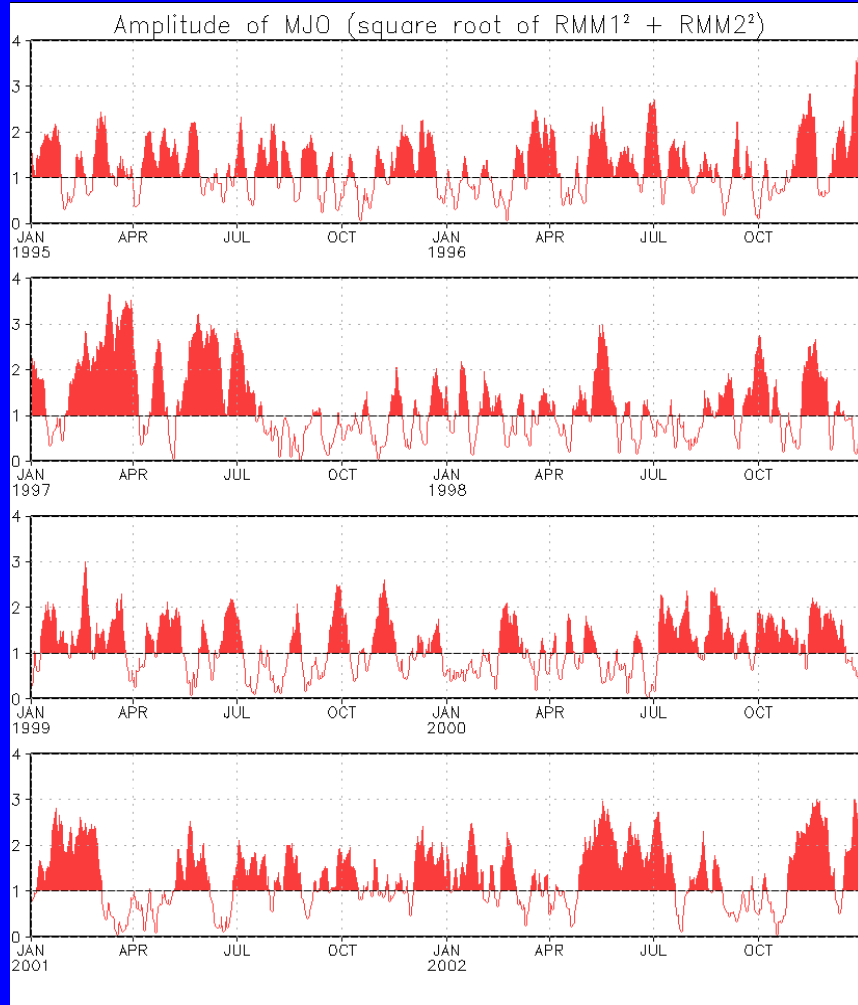


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO remained weak during the past week as indicated by the MJO index. The amplitude has increased in recent 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

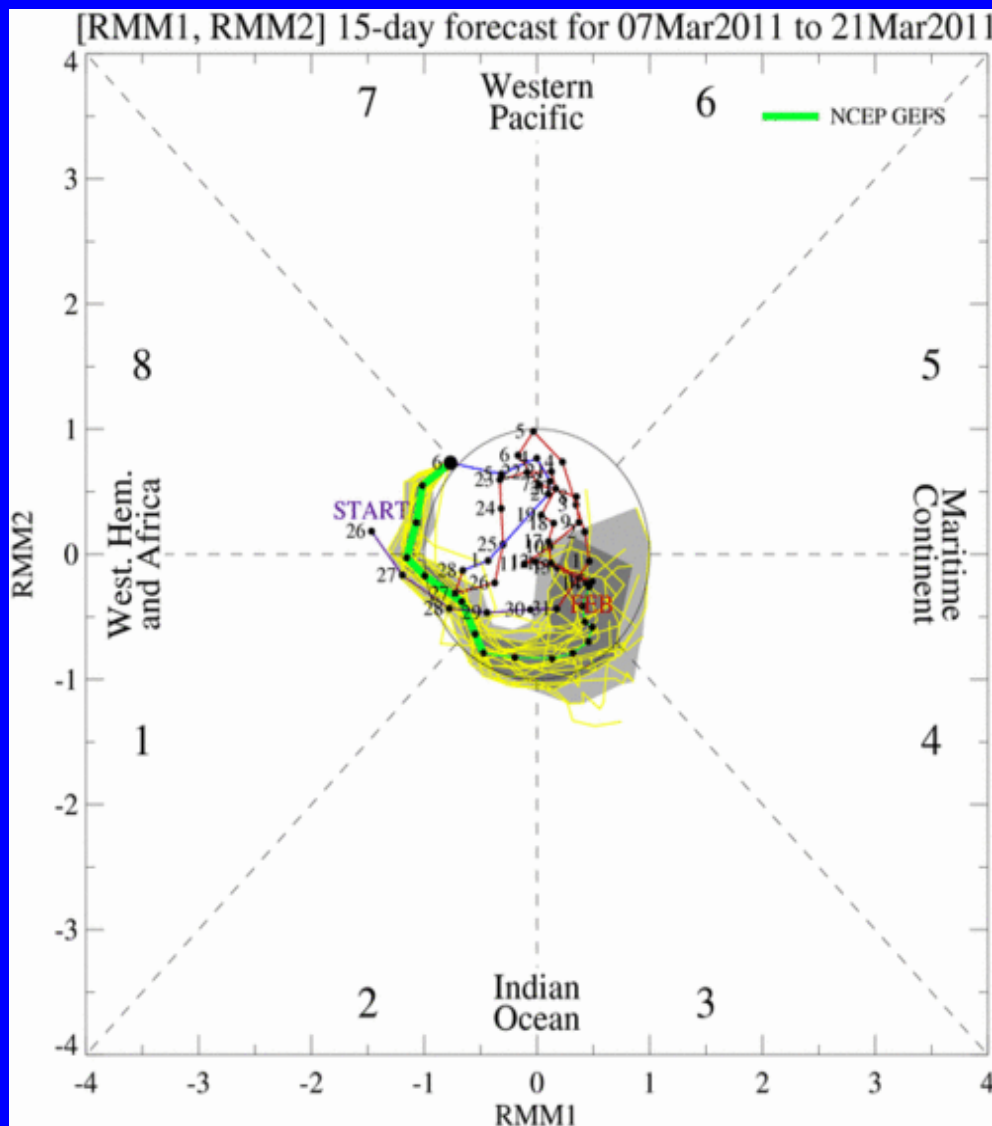
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The ensemble GFS forecasts a weak eastward propagating signal during the next two weeks.

The fast propagation over the two week period indicates that the forcing for this signal may be associated with other higher frequency coherent subseasonal variability rather than a long-lived MJO event developing.

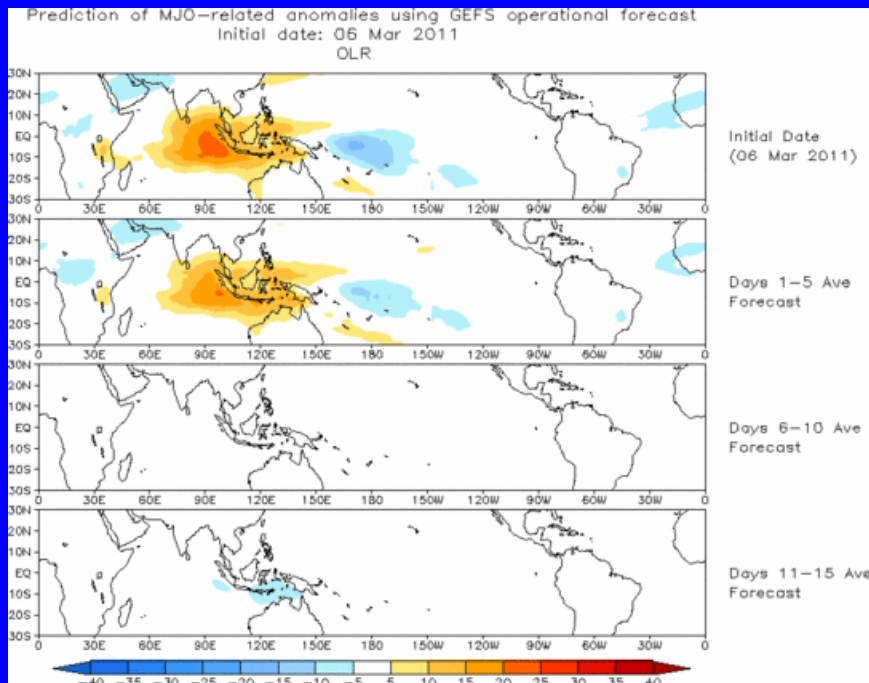




Ensemble Mean GFS MJO Forecast

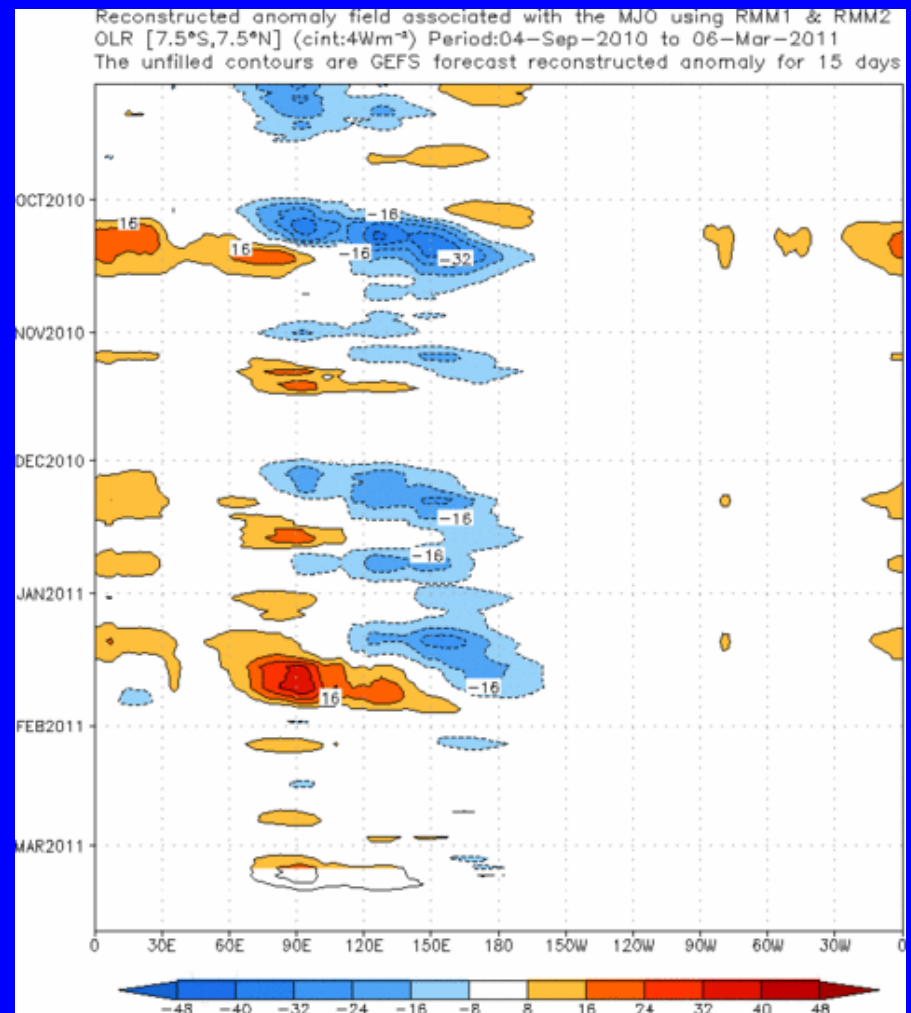
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons)

Spatial map of OLR anomalies for the next 15 days



The GEFS ensemble mean forecast indicates suppressed convection across the Indian Ocean and western Maritime Continent early in the period with weakening signals during Week-2.

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





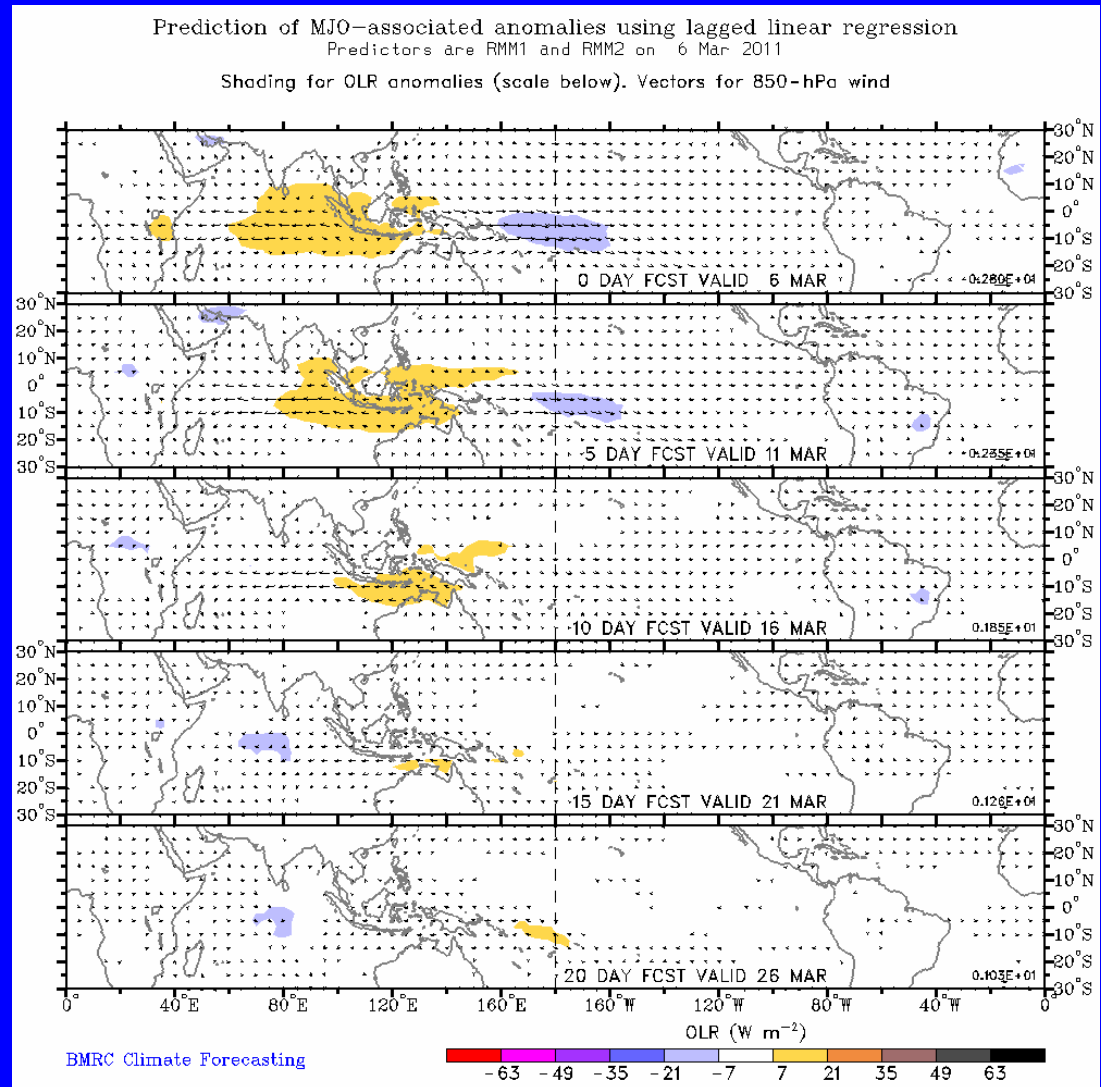
Statistical MJO Forecast

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)

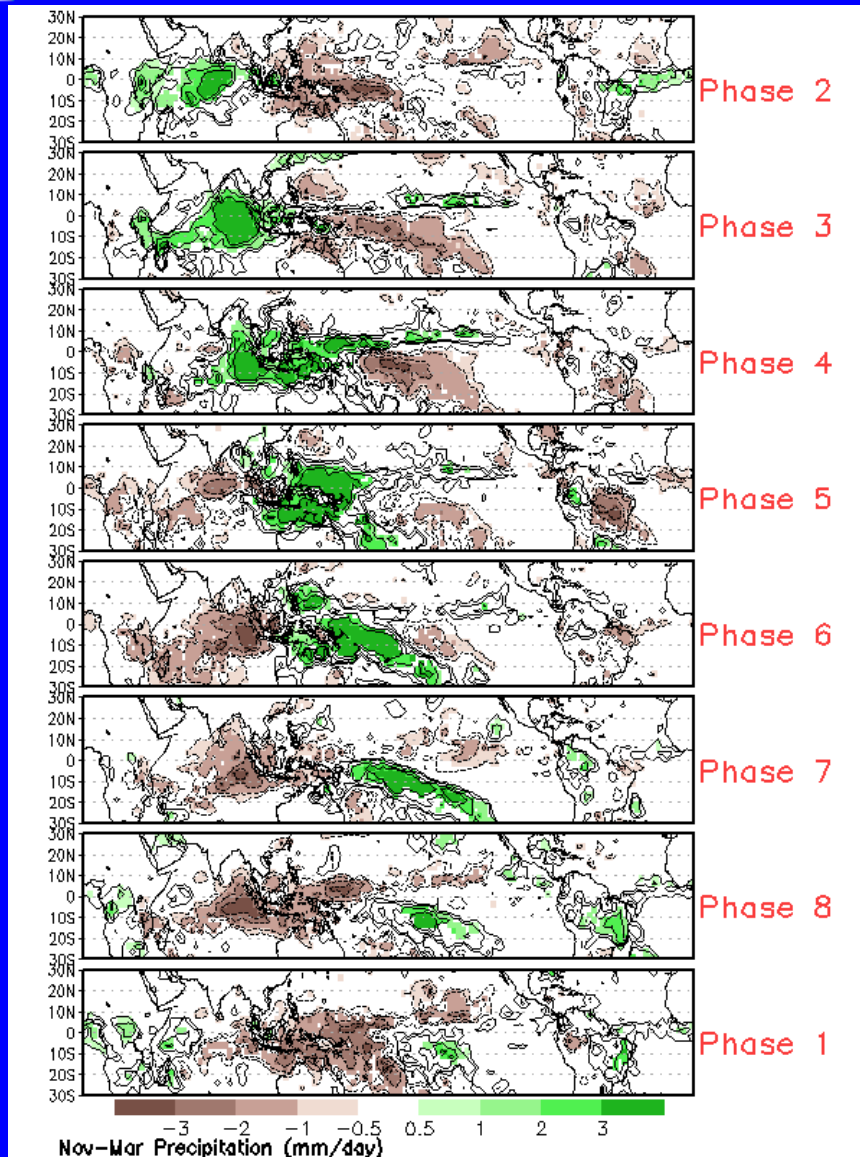
The forecast is for weak suppressed convection to shift eastward to the Maritime continent by Week-2.



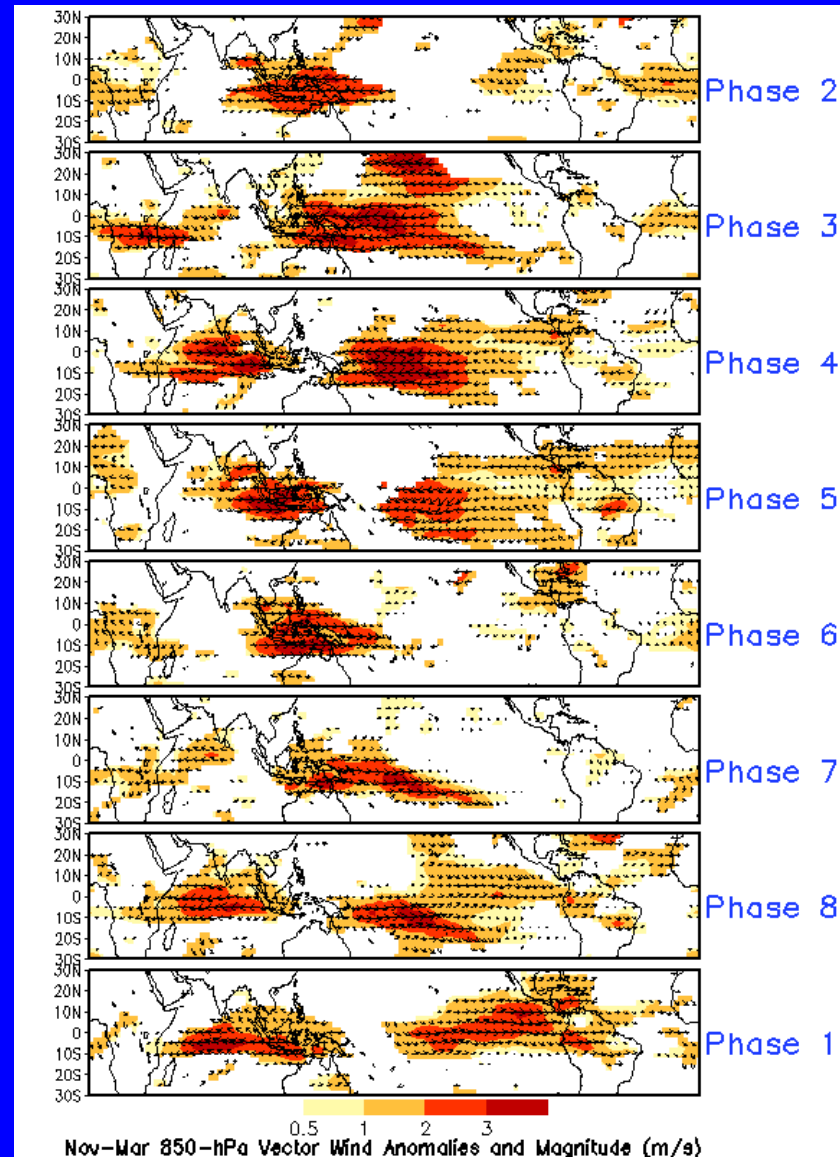


MJO Composites – Global Tropics

Precipitation Anomalies (Nov-Mar)



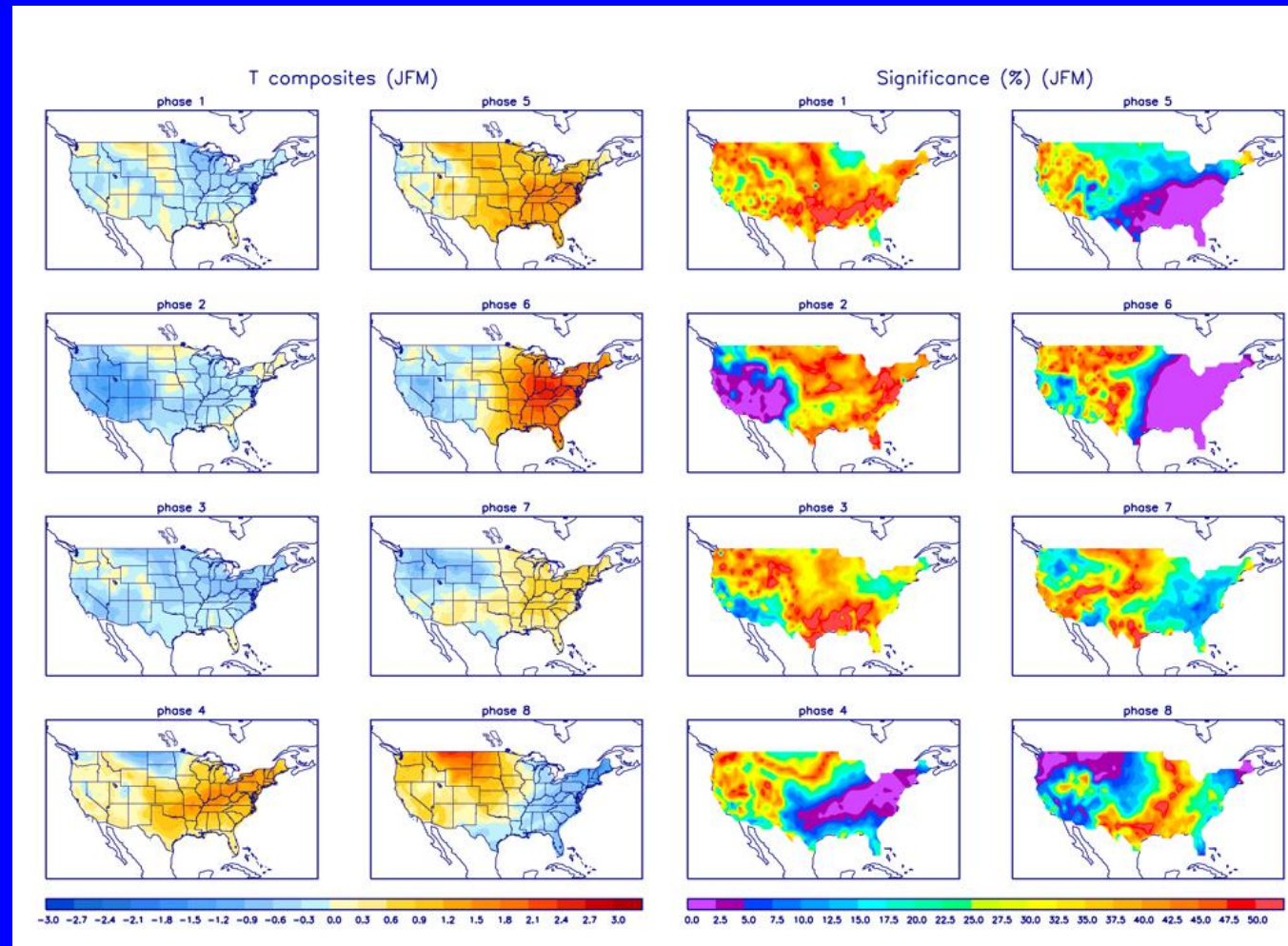
850-hPa Wind Anomalies (Nov-Mar)





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.



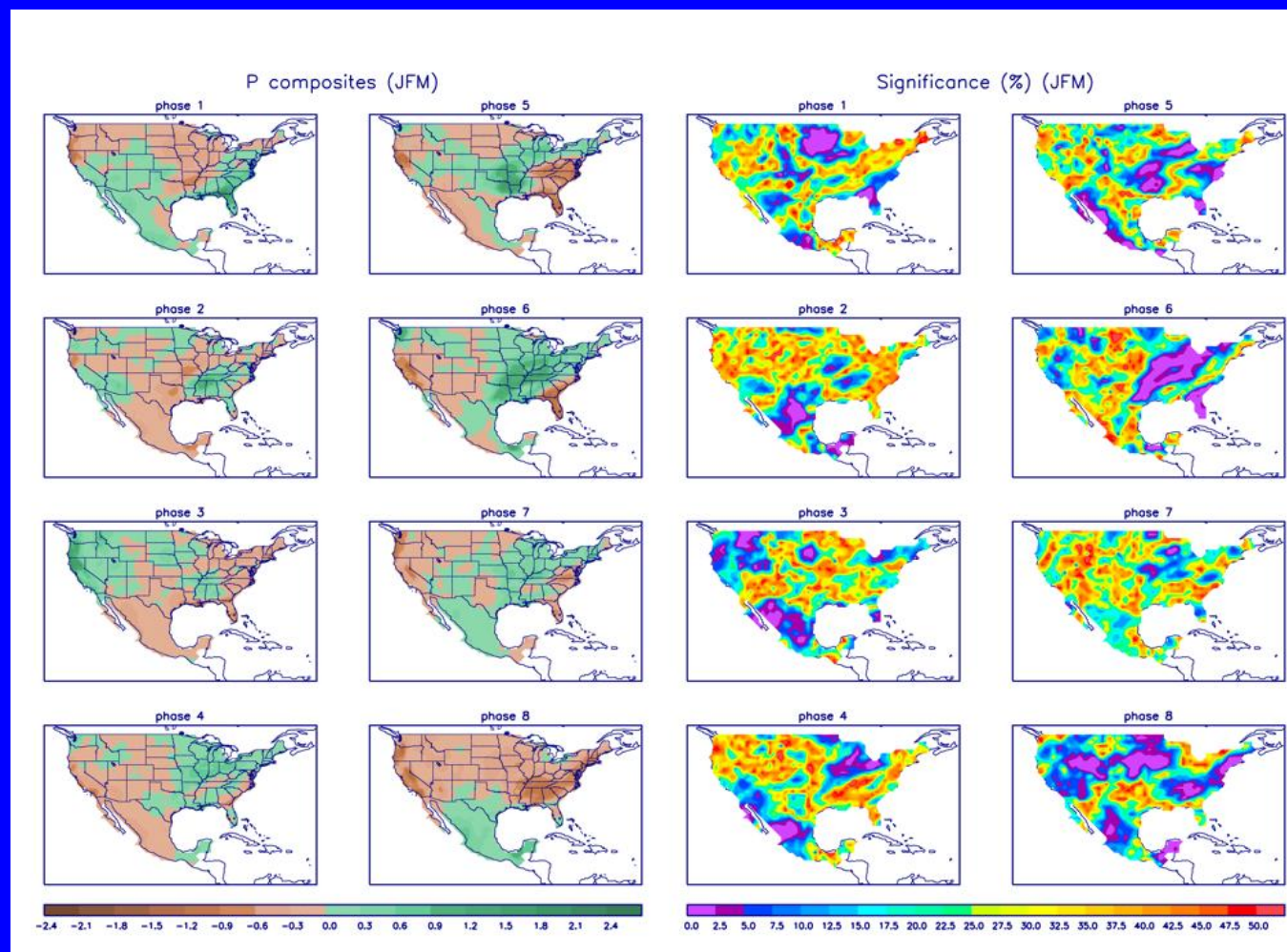
Zhou et al. (2010): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, Submitted.

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