



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

**Update prepared by
Climate Prediction Center / NCEP
May 16, 2011**



Outline

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



Overview

- **The MJO signal remained strong with continued eastward propagation during the last week. The enhanced convective phase is now located across the Western Hemisphere.**
- **The dynamical model MJO index forecasts indicate continued eastward propagation, but a significant weakening of the signal during Week-1. Uncertainty increases during Week-2 as some models indicate a re-strengthening of the signal while others suggest continued weak activity.**
- **Based on the latest observations and majority of model forecasts, the MJO is expected to contribute to suppressed rainfall across the Maritime Continent and southeast Asia. The enhanced convective phase of the MJO favors wetter than average conditions across northern South America and portions of Africa.**

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

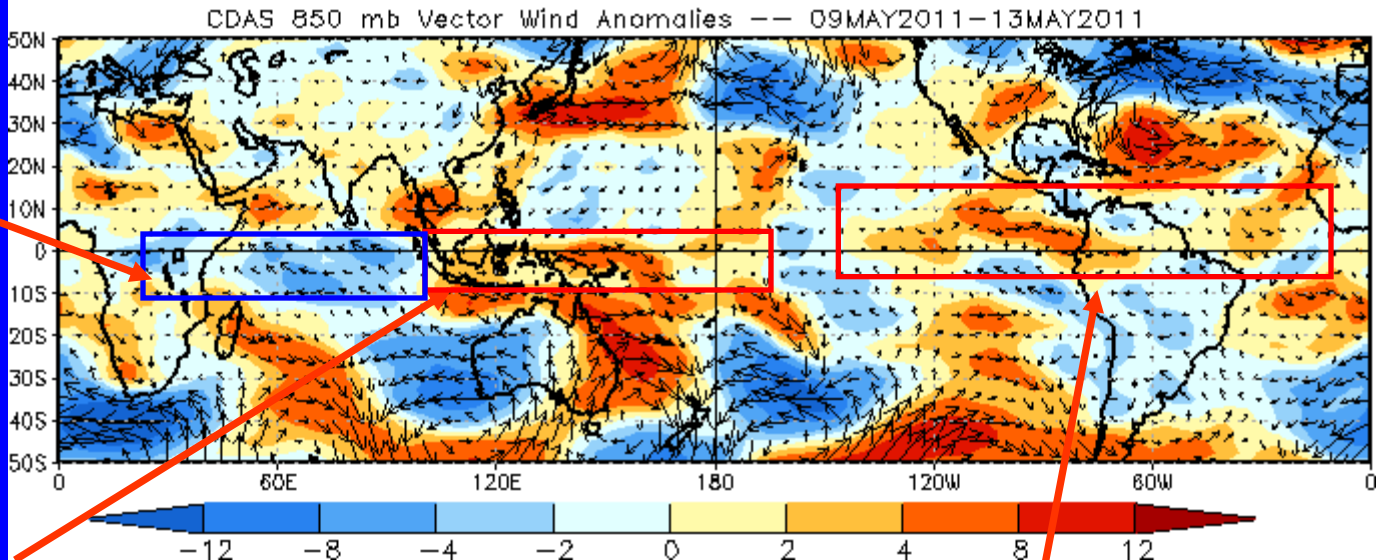
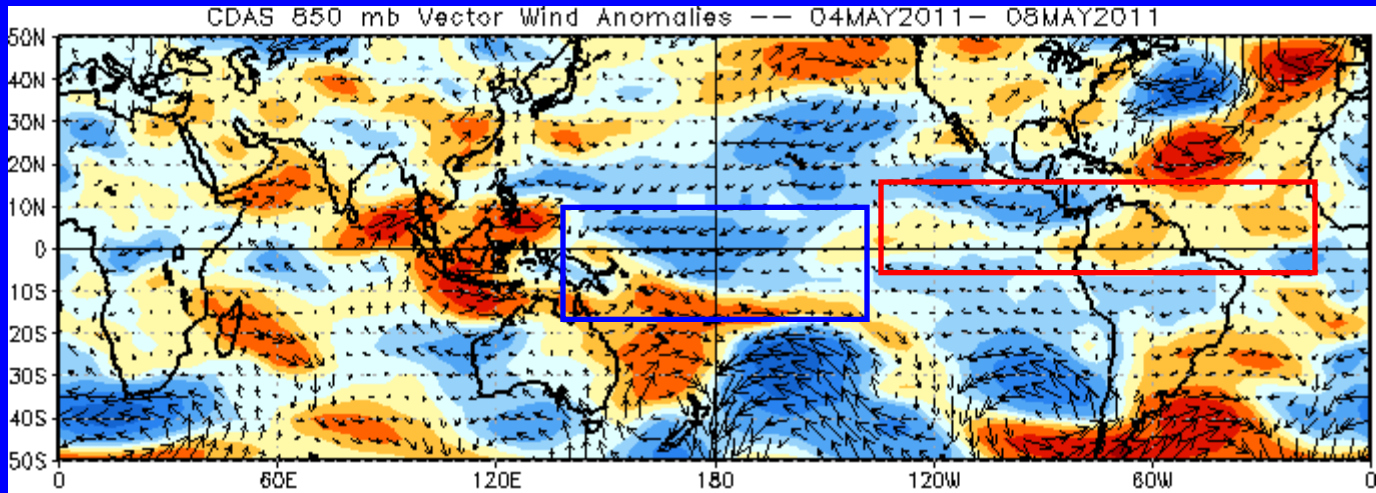


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted across eastern equatorial Africa and the Indian Ocean during the last five days.

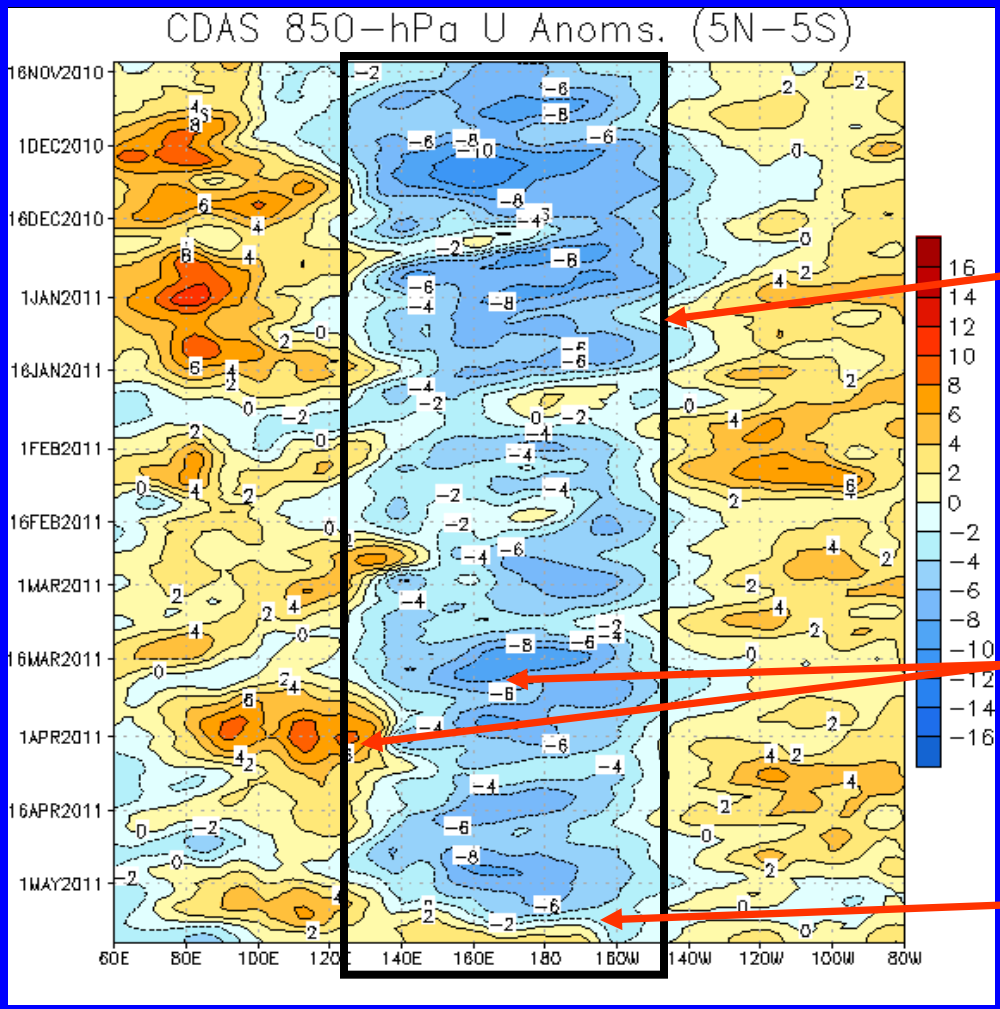
Westerly anomalies spread eastward across the entire western Pacific while easterly anomalies are confined to east of the Date Line.

Westerly developed across the eastern Pacific Ocean and most of the tropical Atlantic Basin.



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.

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

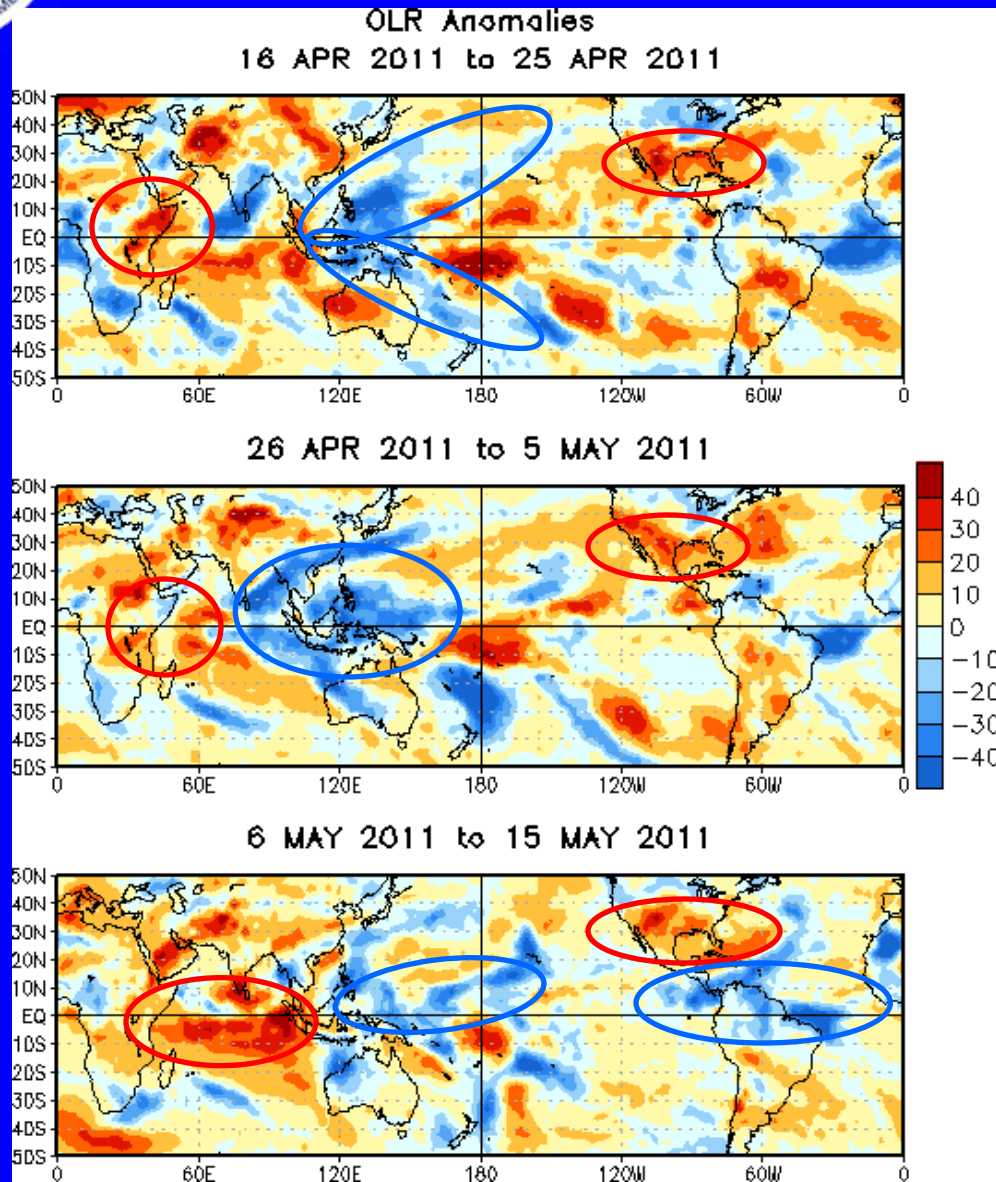
During March, easterlies strengthened near the Date Line, while westerly wind anomalies increased dramatically in strength at the end of the month.

More recently, in a significant change from the past few months, westerly anomalies spread across most of the tropical Pacific basin.



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-April, enhanced convection continued across the Maritime Continent, northern Australia, the Philippines, and eastern India. Suppressed convection continued across the western Indian Ocean, east Africa, the southern tier of the U.S., and the central Pacific Ocean.

The enhanced convection pattern over parts of the Eastern Hemisphere strengthened during late-April and early May. Suppressed convection persisted across Africa and the western Indian Ocean.

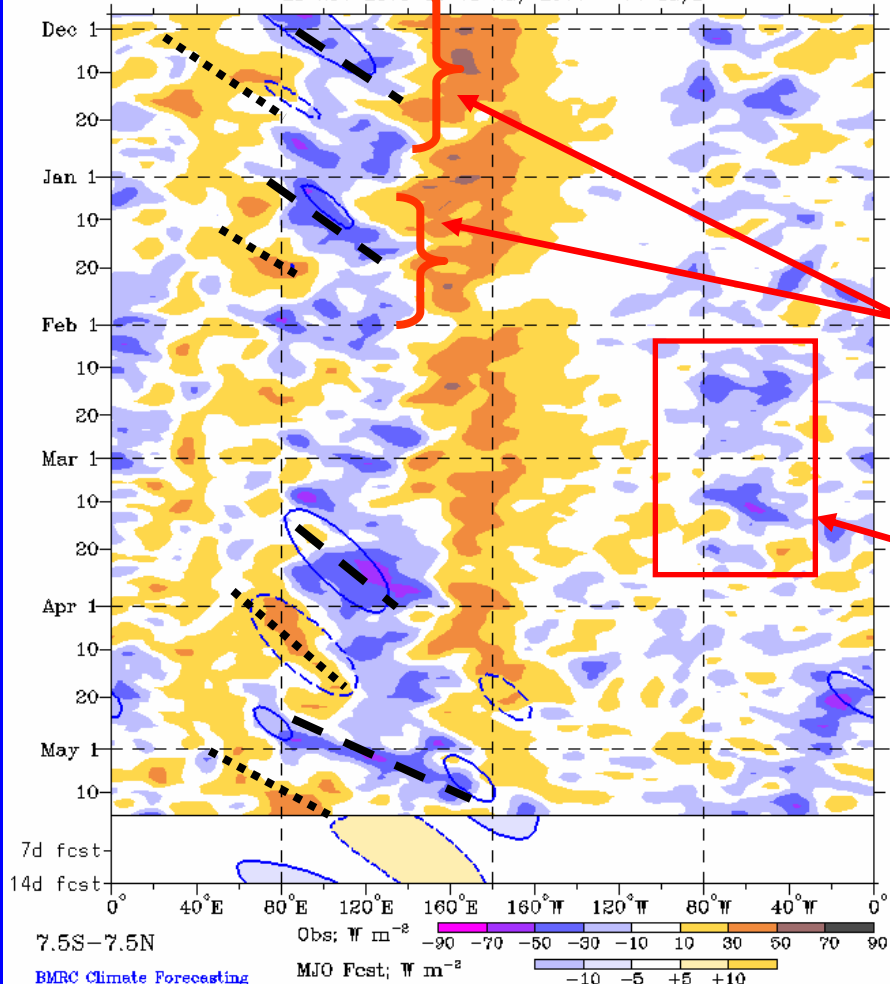
During early to mid-May enhanced convection developed across much of the tropical Pacific Basin and from Central America to northern South American. The area of suppressed convection extended eastward from Africa to cover the entire Indian Ocean.



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
28-Nov-2010 to 15-May-2011 + 14 days

Time
↓



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.

More recently, convection developed near 80E and moved rapidly eastward with an area of suppressed convection developing across the Indian Ocean.

Longitude

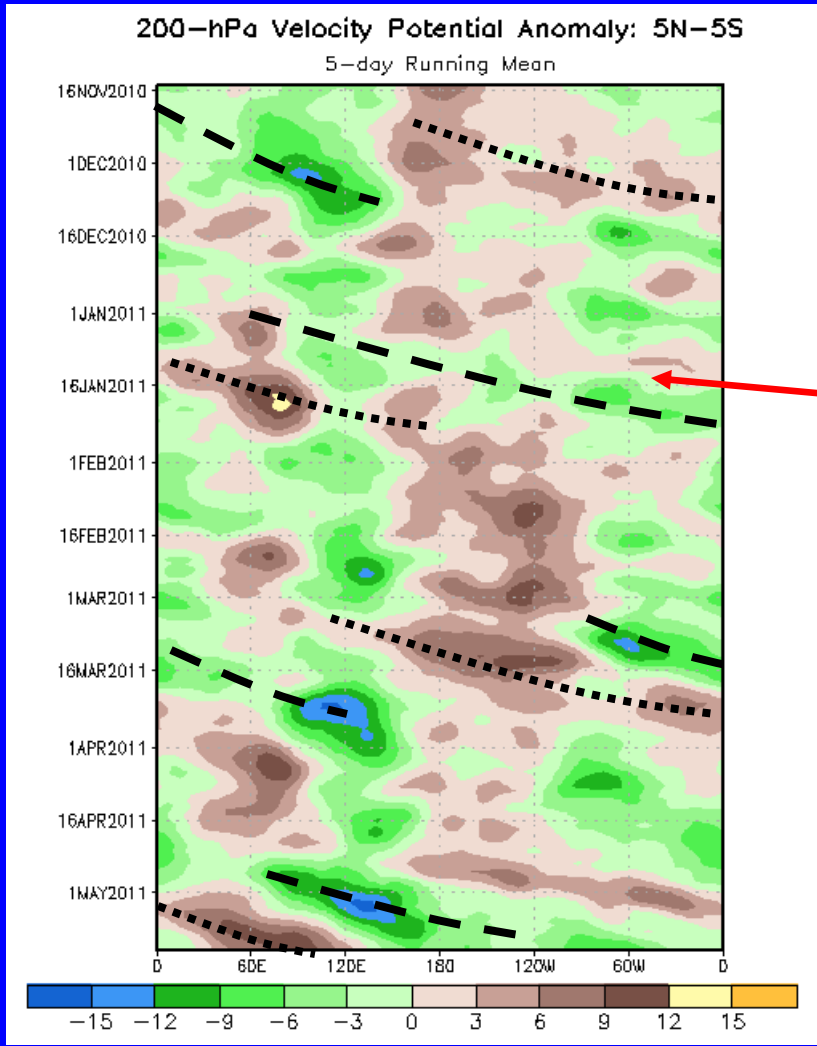


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



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.

Most recently, an area of enhanced upper-level divergence spread eastward from the Indian Ocean, and now covers the western Hemisphere. Strong convergent flow is evident across much of the eastern Hemisphere.

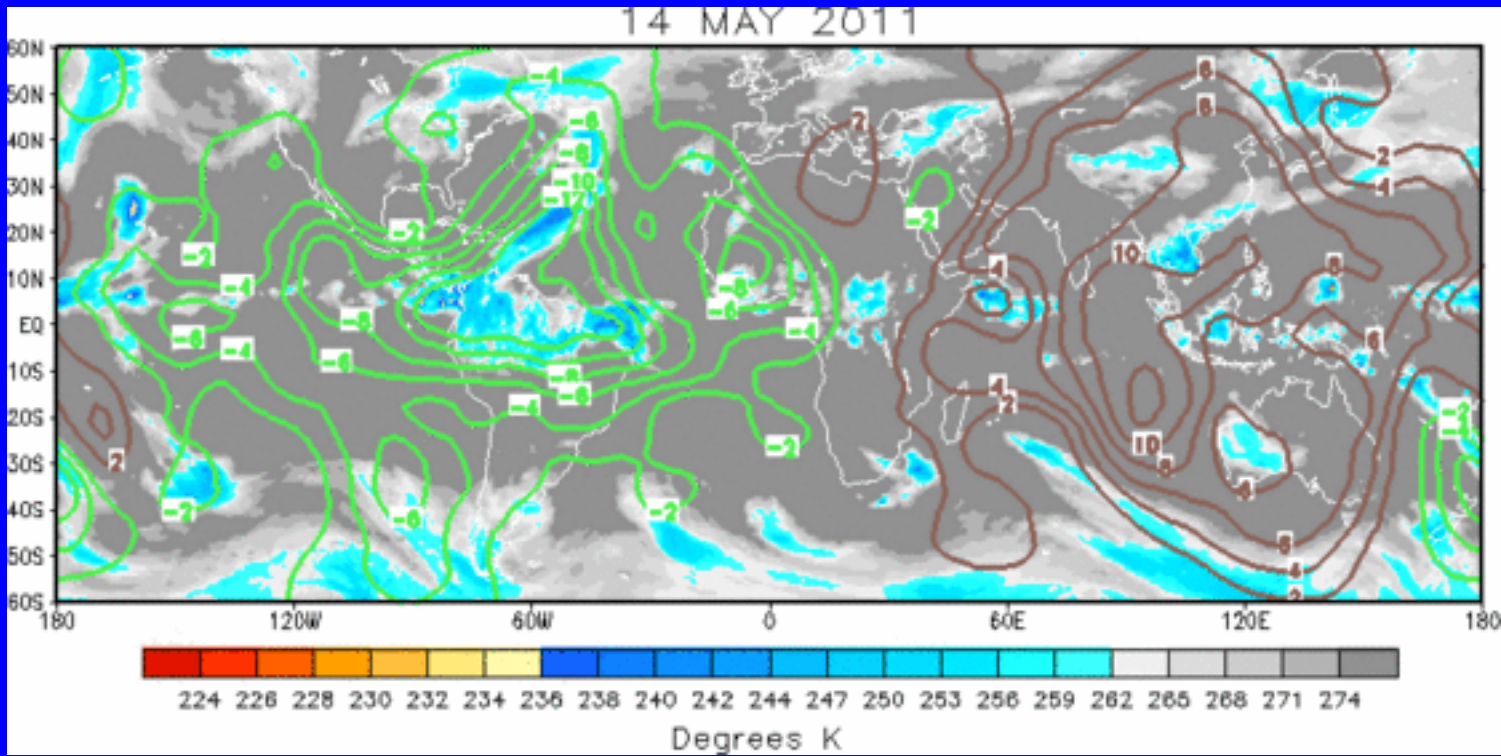
Longitude



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 portions of the eastern Pacific Ocean, the Americas, the Atlantic Ocean, and Africa. Anomalous upper-level convergence is evident from eastern Africa to the western Pacific Ocean.

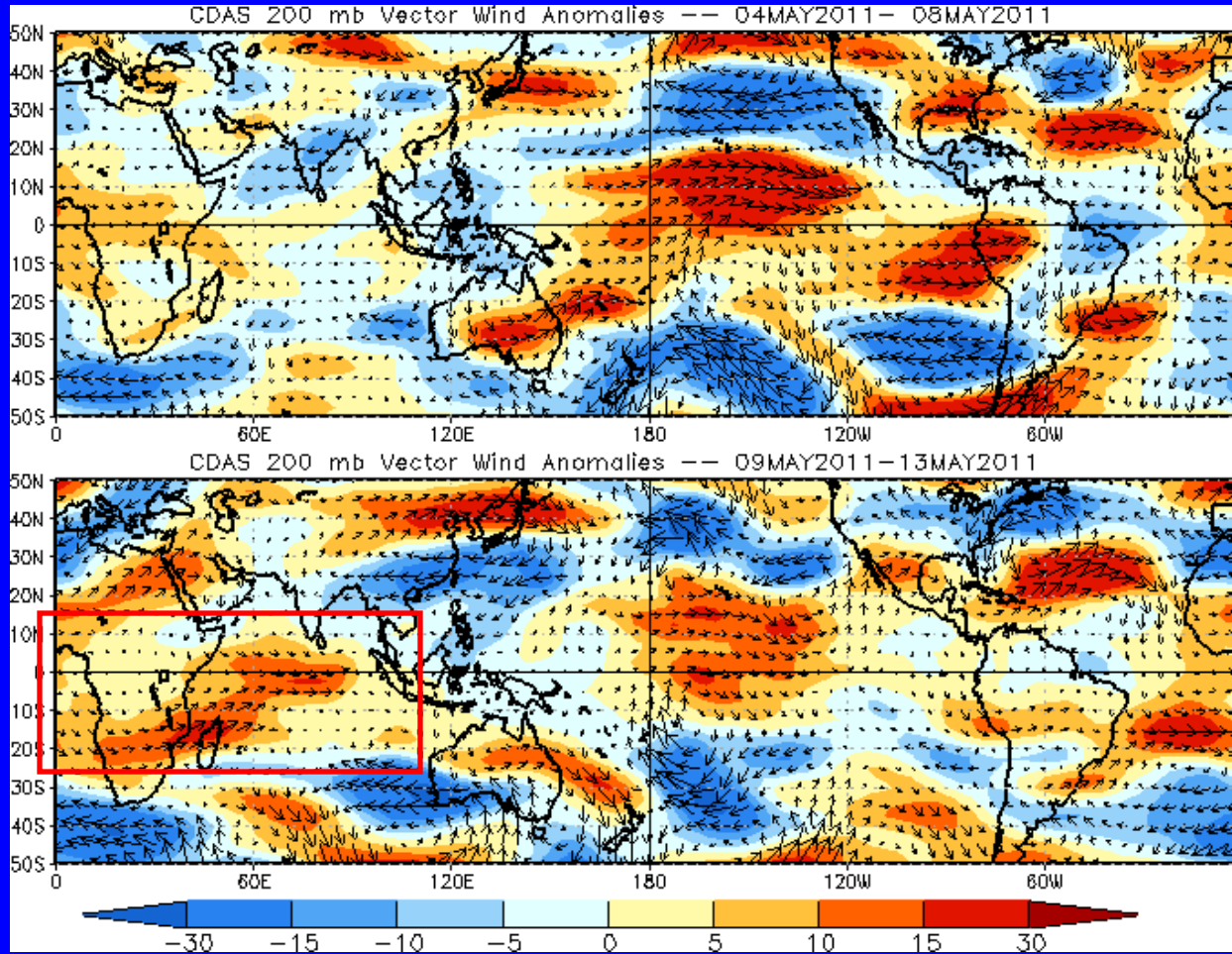


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



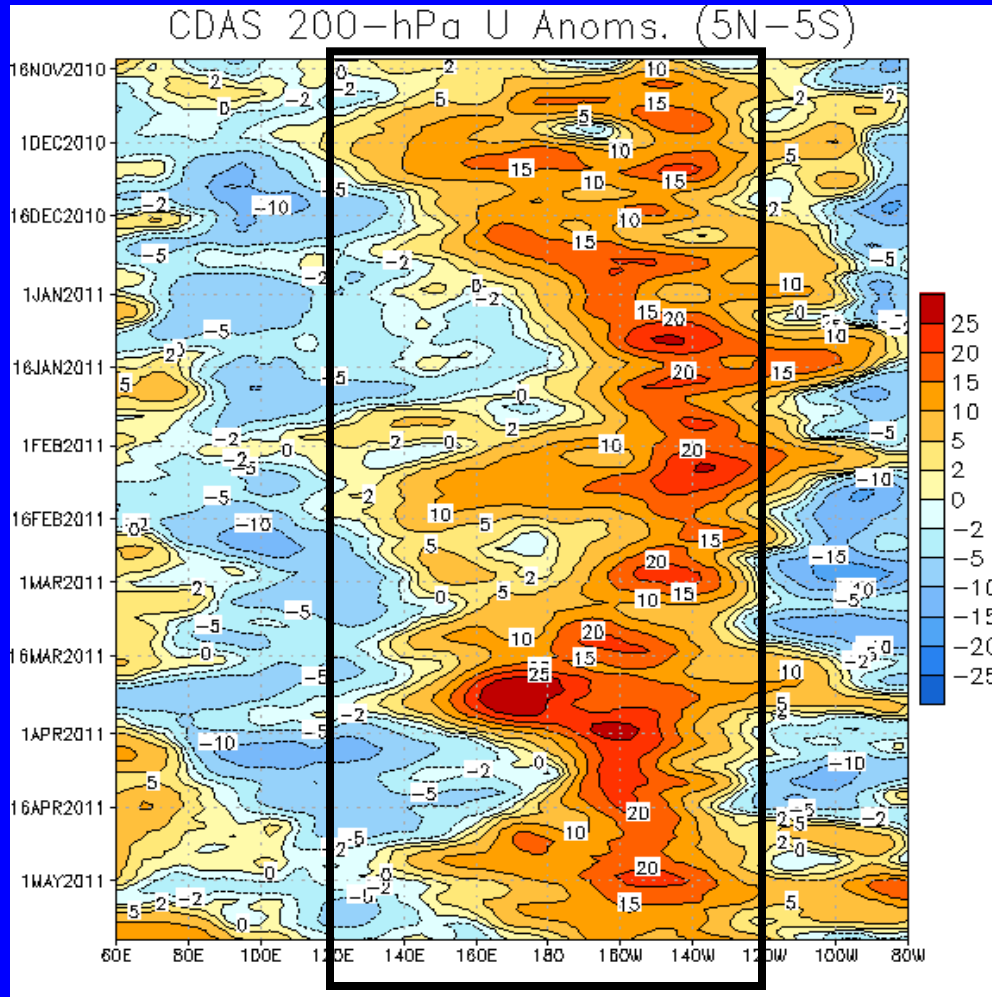
Westerly anomalies persisted across the equatorial central Pacific during the last five to ten days. Also, a noticeable change is the development of westerly anomalies across the Indian Ocean associated with the MJO (red box).



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



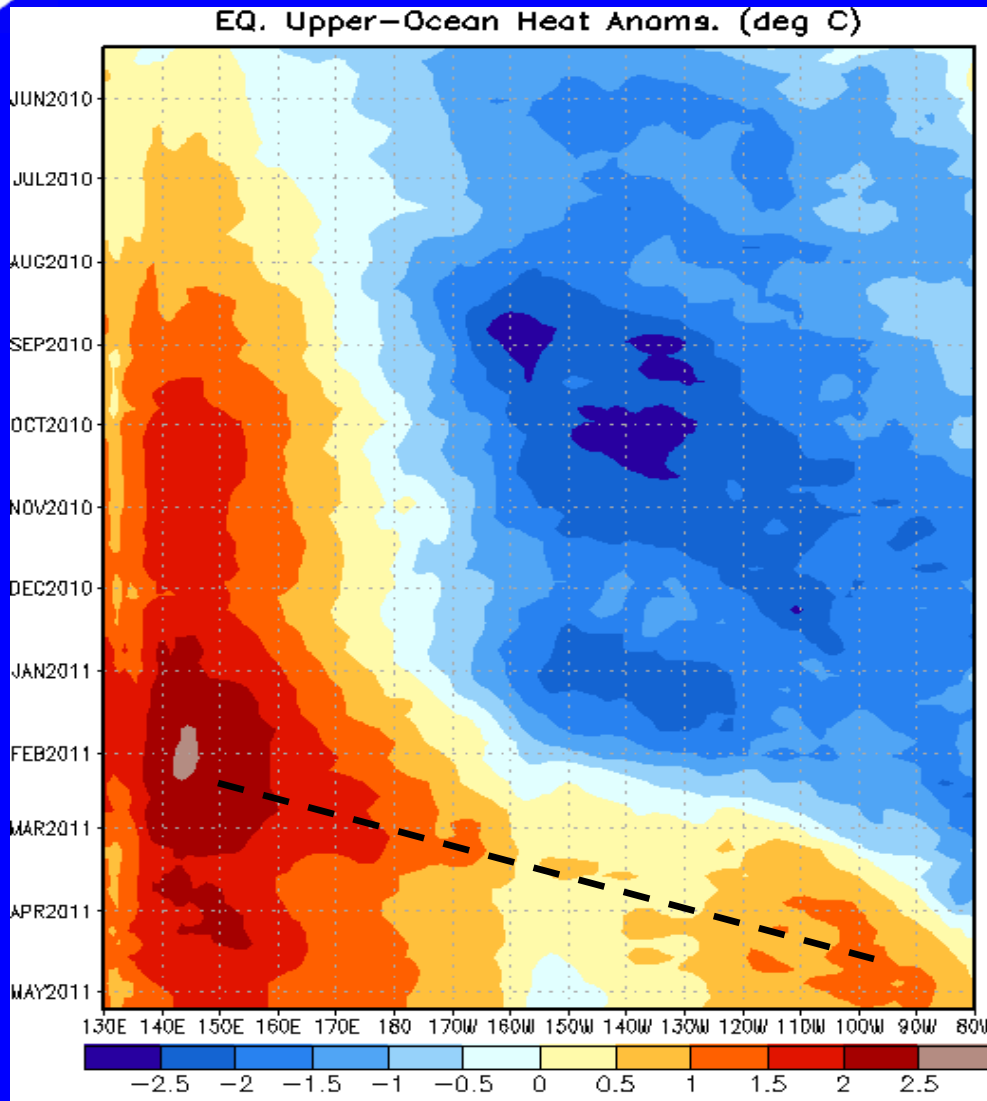
Westerly anomalies persisted across a large area from the Maritime Continent to the central Pacific (black solid box) since October.

Some strengthening and eastward propagation of westerly anomalies was evident in late March. In early April there was some eastward propagation of an easterly/westerly anomaly couplet over the eastern Hemisphere.

Significant eastward propagation of the upper-level pattern is evident during the last 5-10 days.



Weekly Heat Content Evolution in the Equatorial Pacific



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.

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



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.

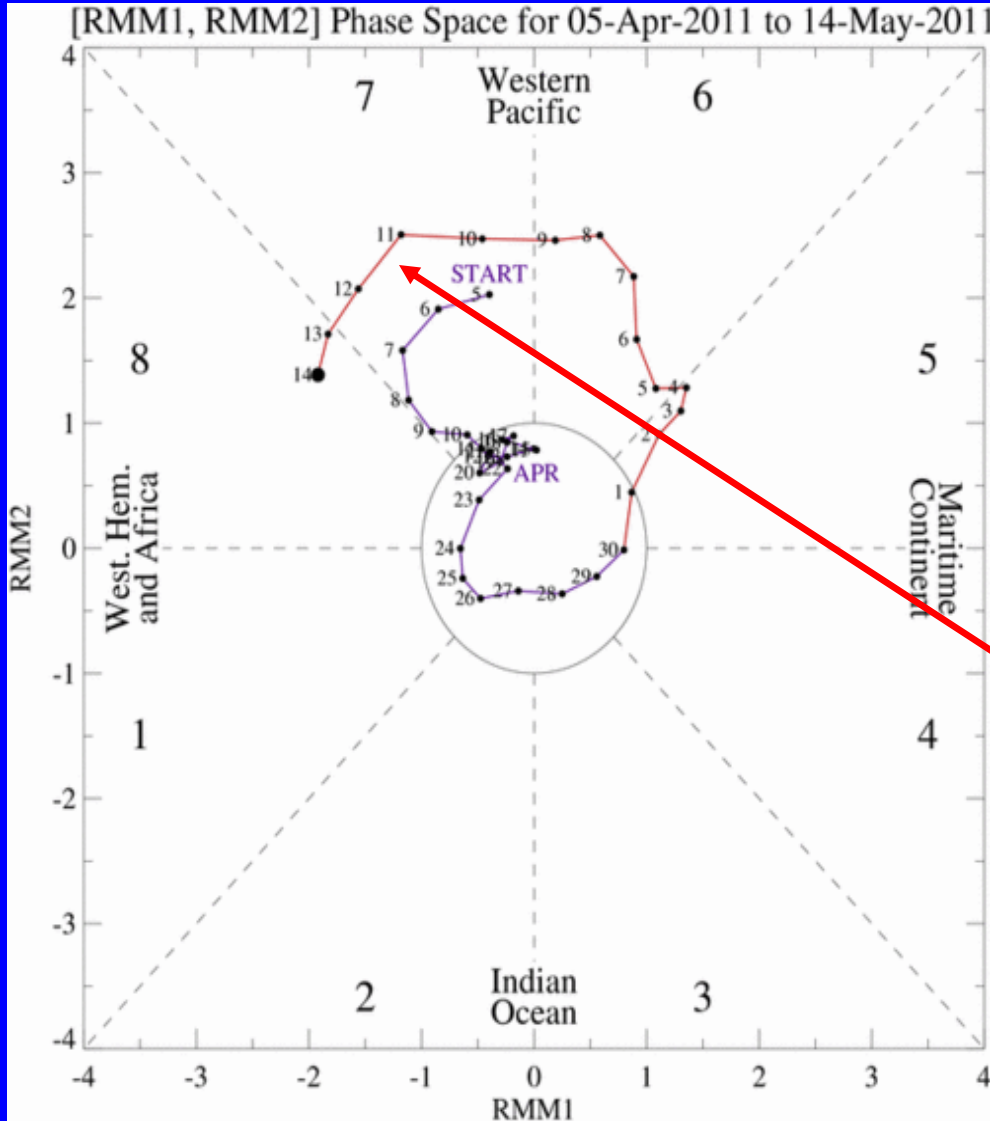
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

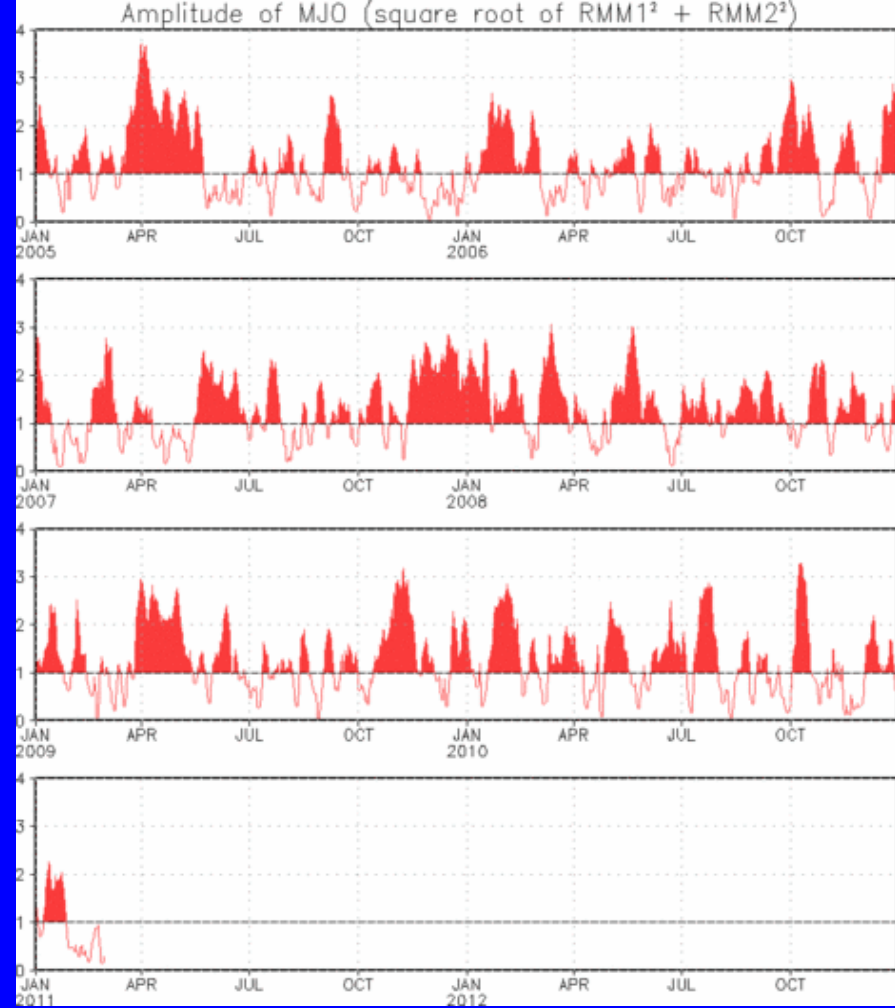
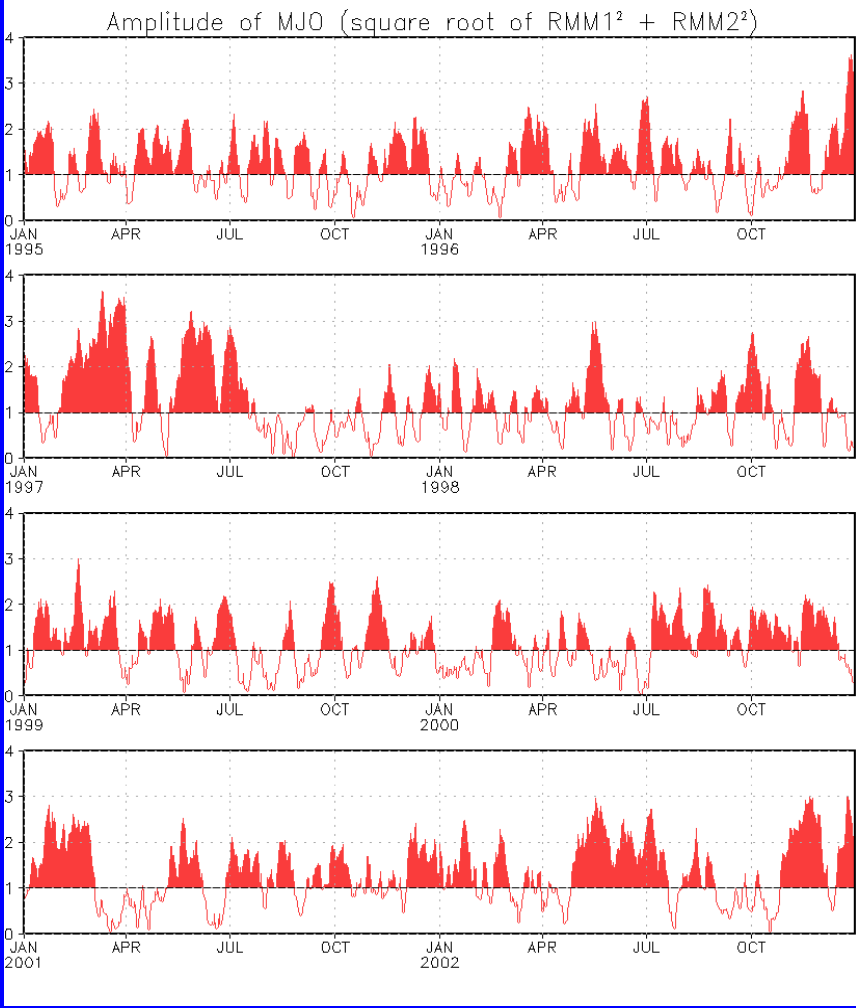


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates the continued progression of the MJO signal with a propagation speed at the faster end of the MJO envelope.



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.



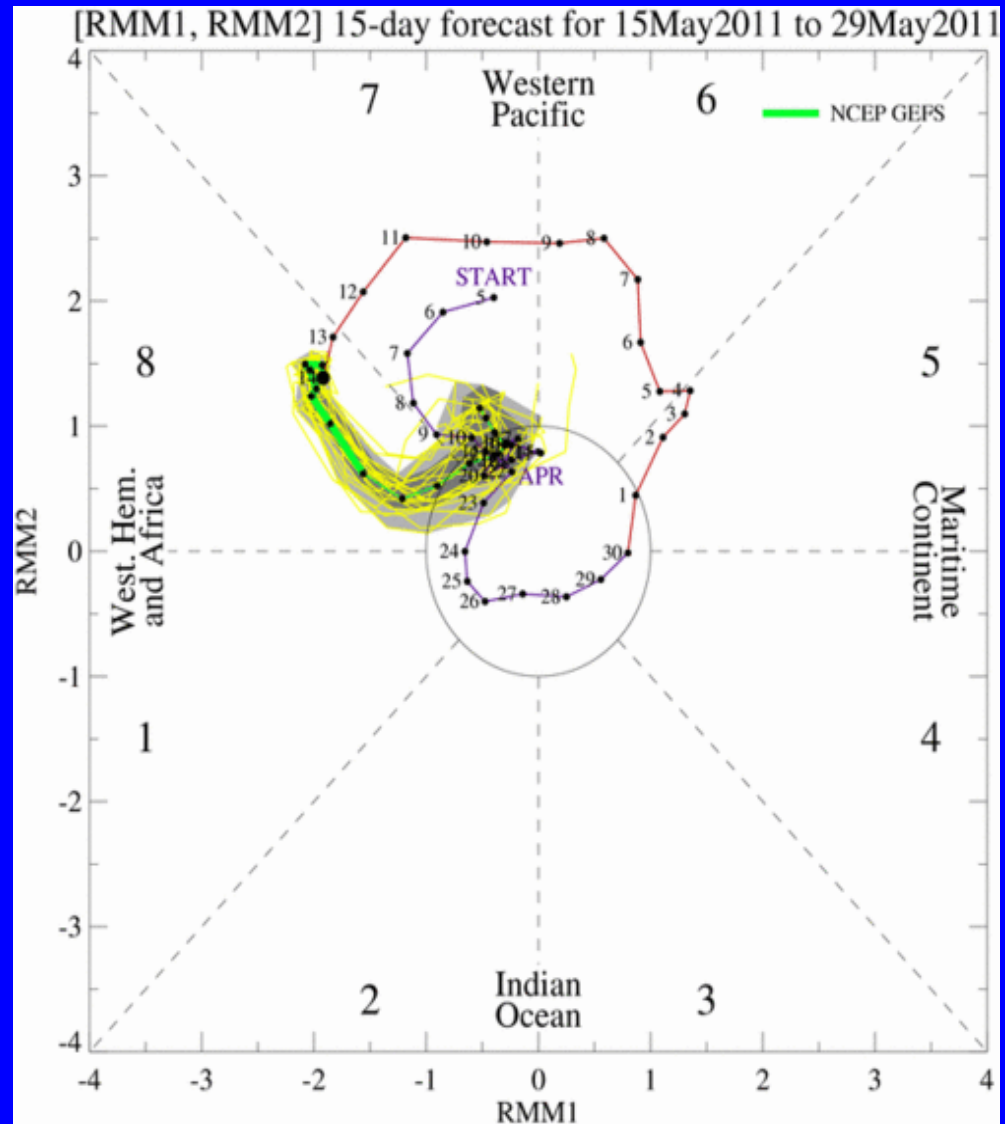
Ensemble GFS (GEFS) MJO Forecast

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 much slower propagation of the signal during Week-1, with significant weakening of the signal through Week-2.



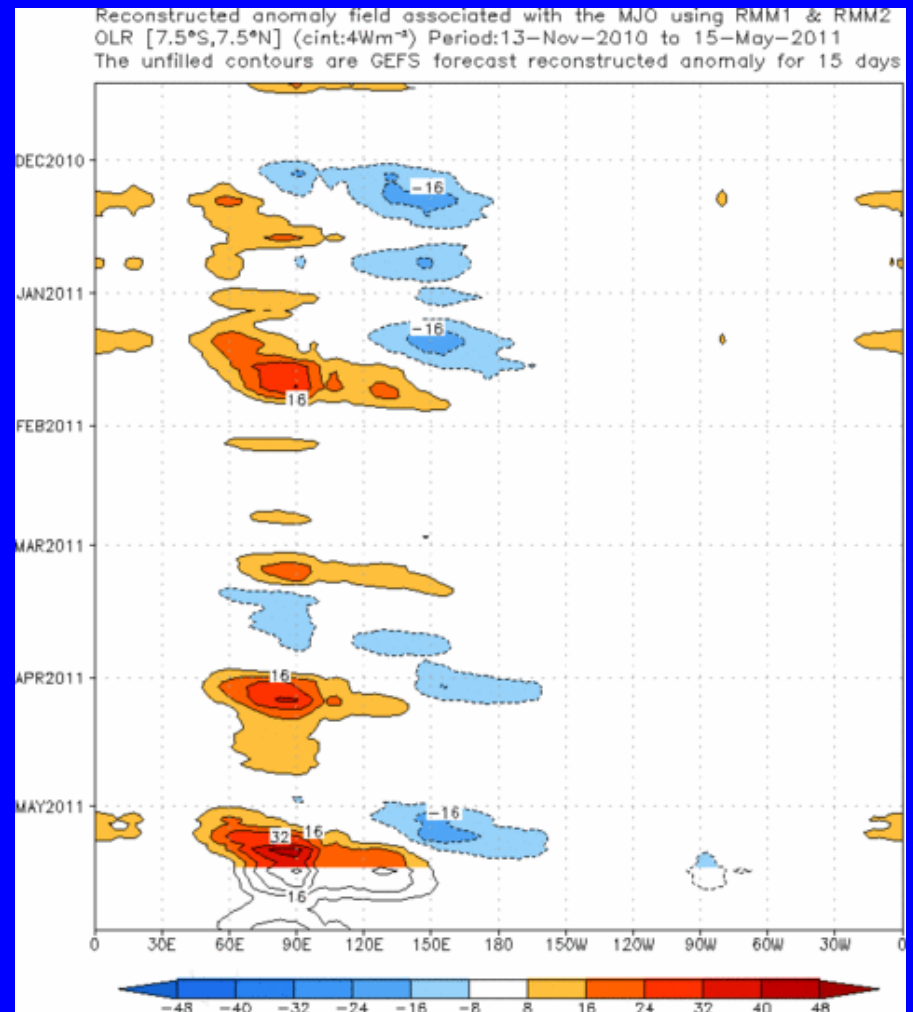
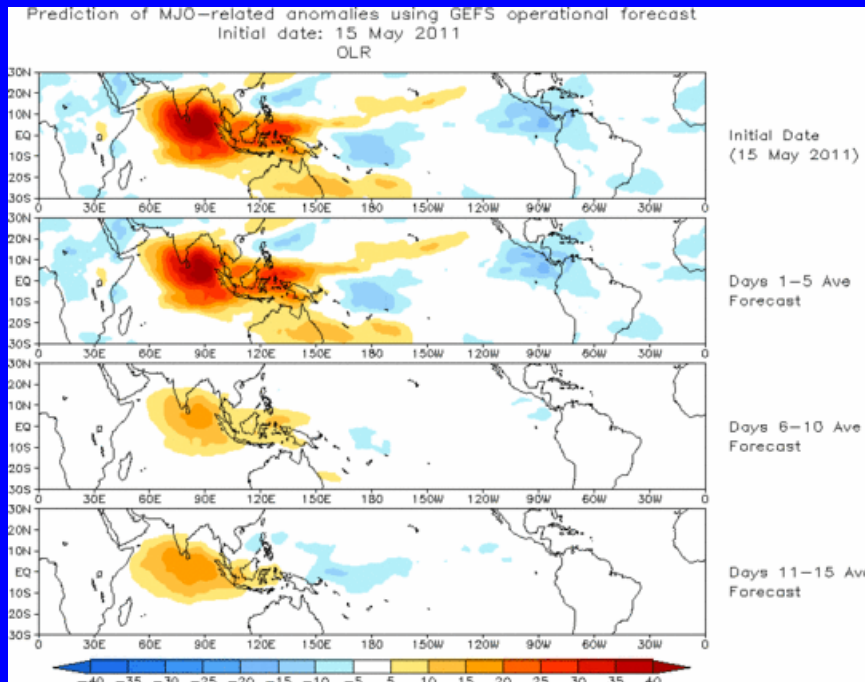


Ensemble Mean GFS MJO Forecast

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)

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 some propagation of the signal during Week-1 with suppressed convection forecast across the eastern Indian Ocean and Maritime continent and enhanced convection across portions of the Western Hemisphere.



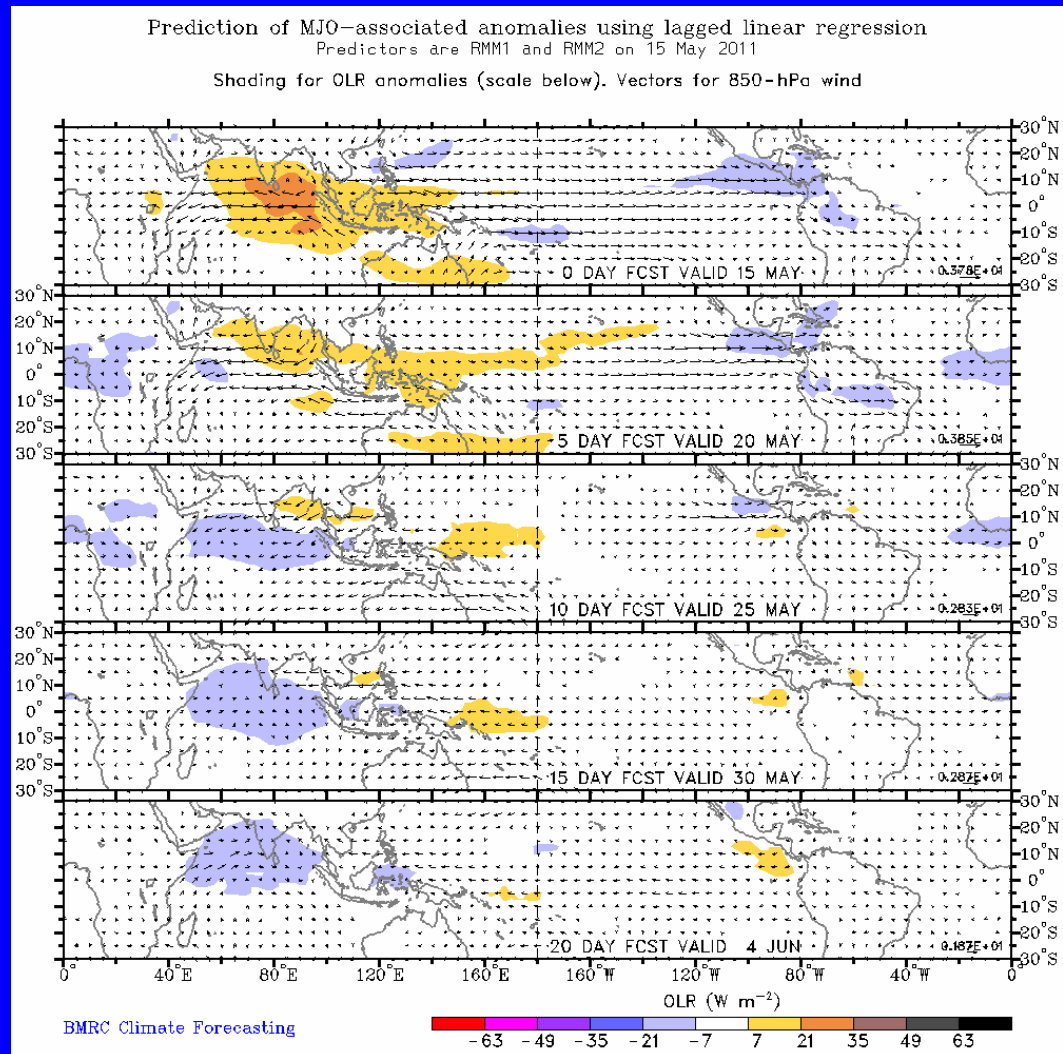
Statistical MJO Forecast

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)

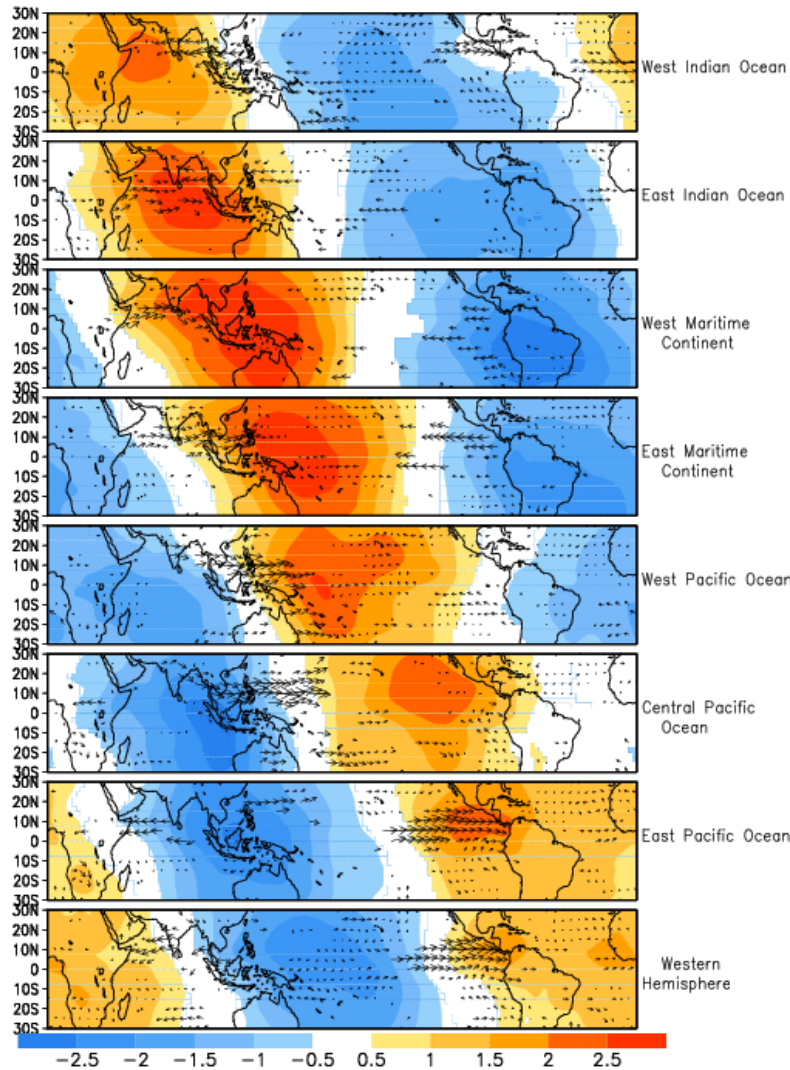
The forecast calls for MJO activity during the period, similar to the dynamic models, but with faster eastward propagation.



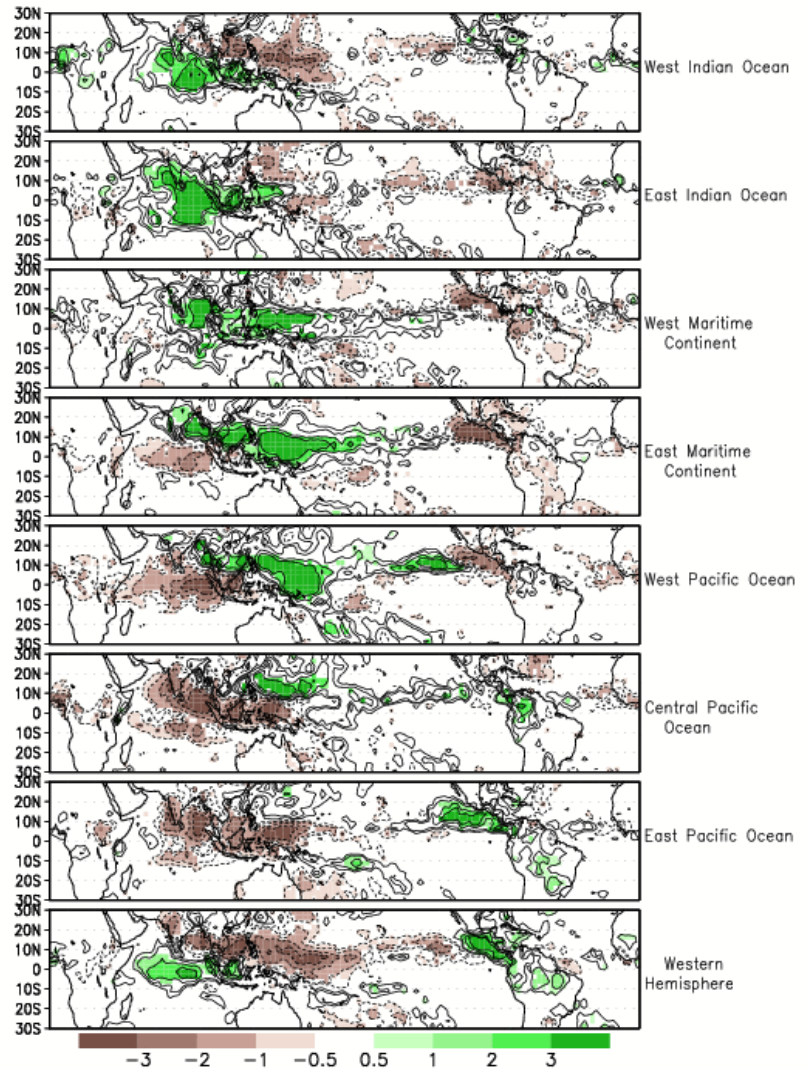


MJO Composites – Global Tropics

Precipitation Anomalies (Nov-Mar)



850-hPa Wind Anomalies (Nov-Mar)

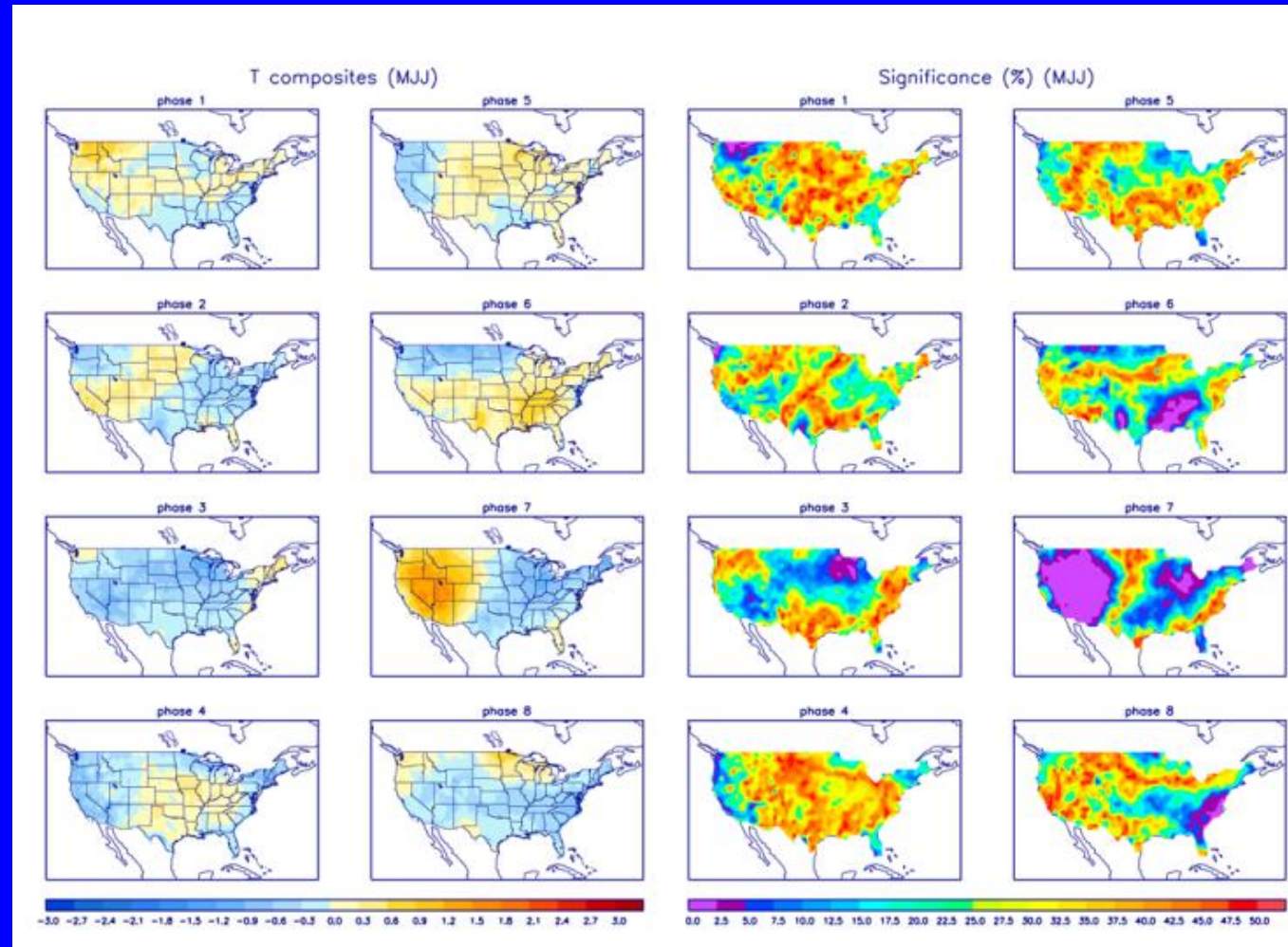




U.S. MJO Composites – Temperature

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.



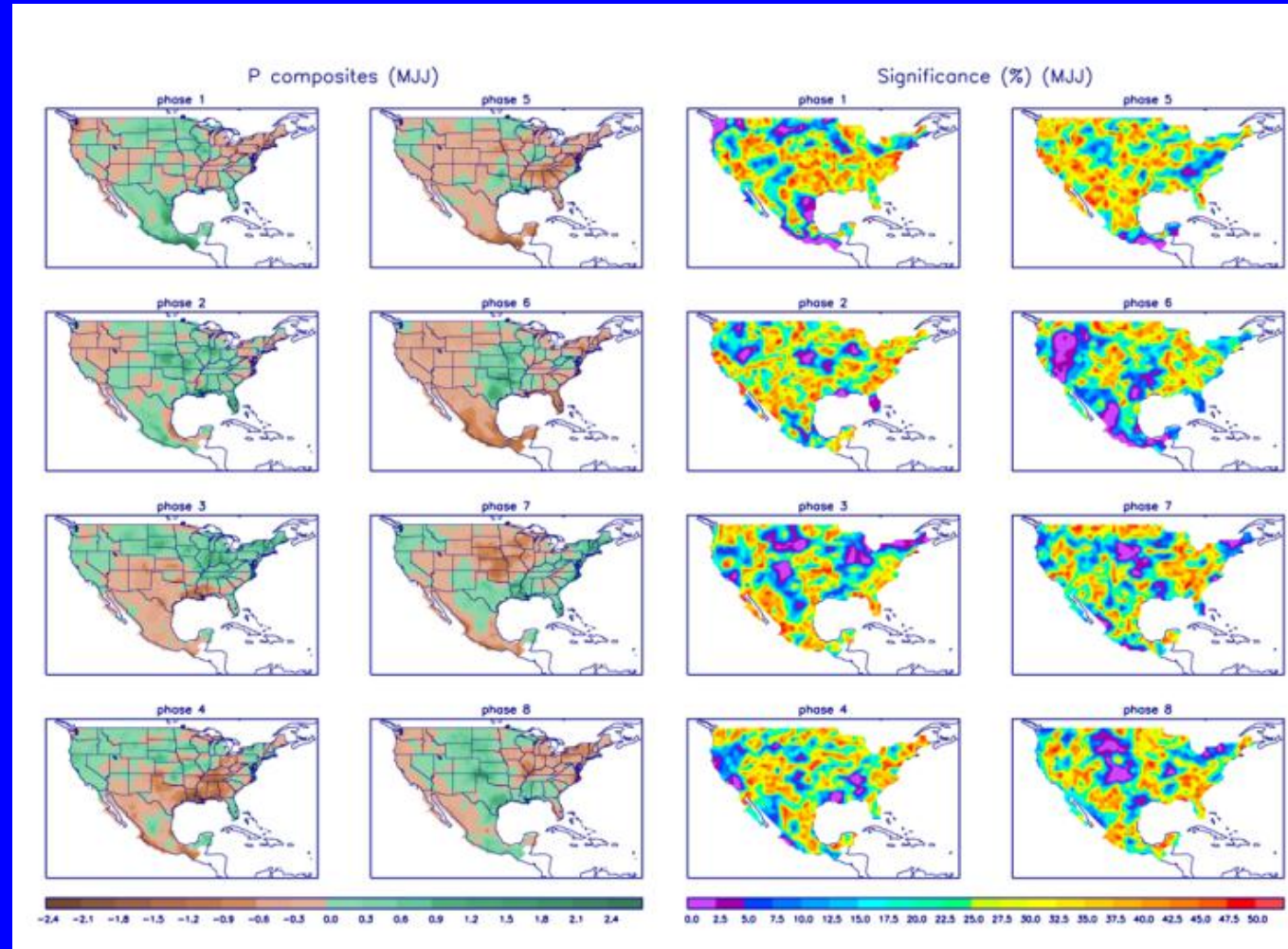
Zhou et al. (2010): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, Submitted.

<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.



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>