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

Update prepared by
Climate Prediction Center / NCEP
December 20, 2010

Outline

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

Overview

- The MJO weakened over the past week, but eastward propagation continued.
- Dynamical model MJO forecasts indicate further weakening during the upcoming week and background La Nina conditions are expected to continue to dominate much of the pattern of tropical convection.
- The remaining MJO signal likely will contribute to continued enhanced convection across Australia and the South Pacific Convergence Zone during the period.

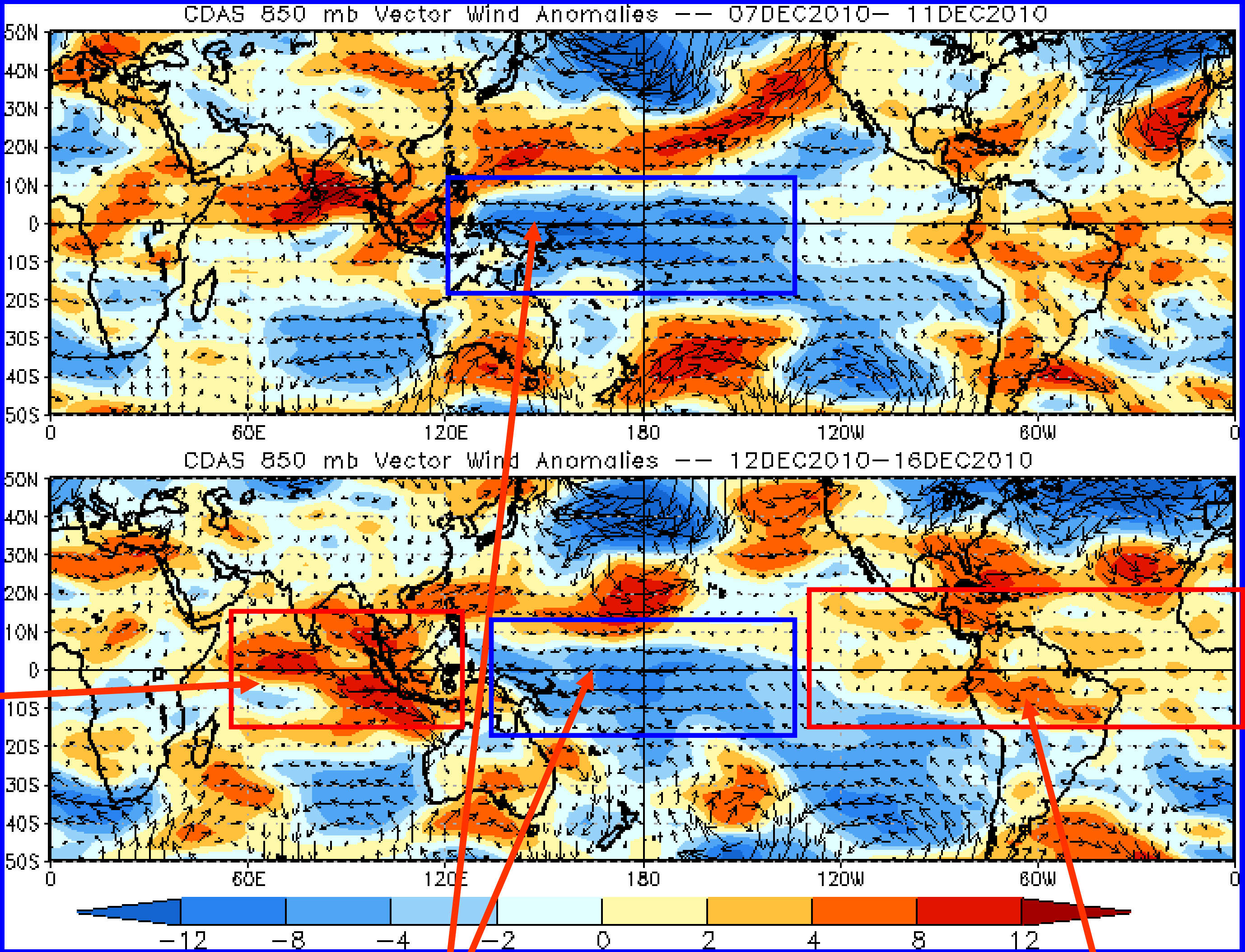
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/ghaz.shtml

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 parts of the Indian Ocean with a slight strengthening of the anomalies near the Maritime Continent.

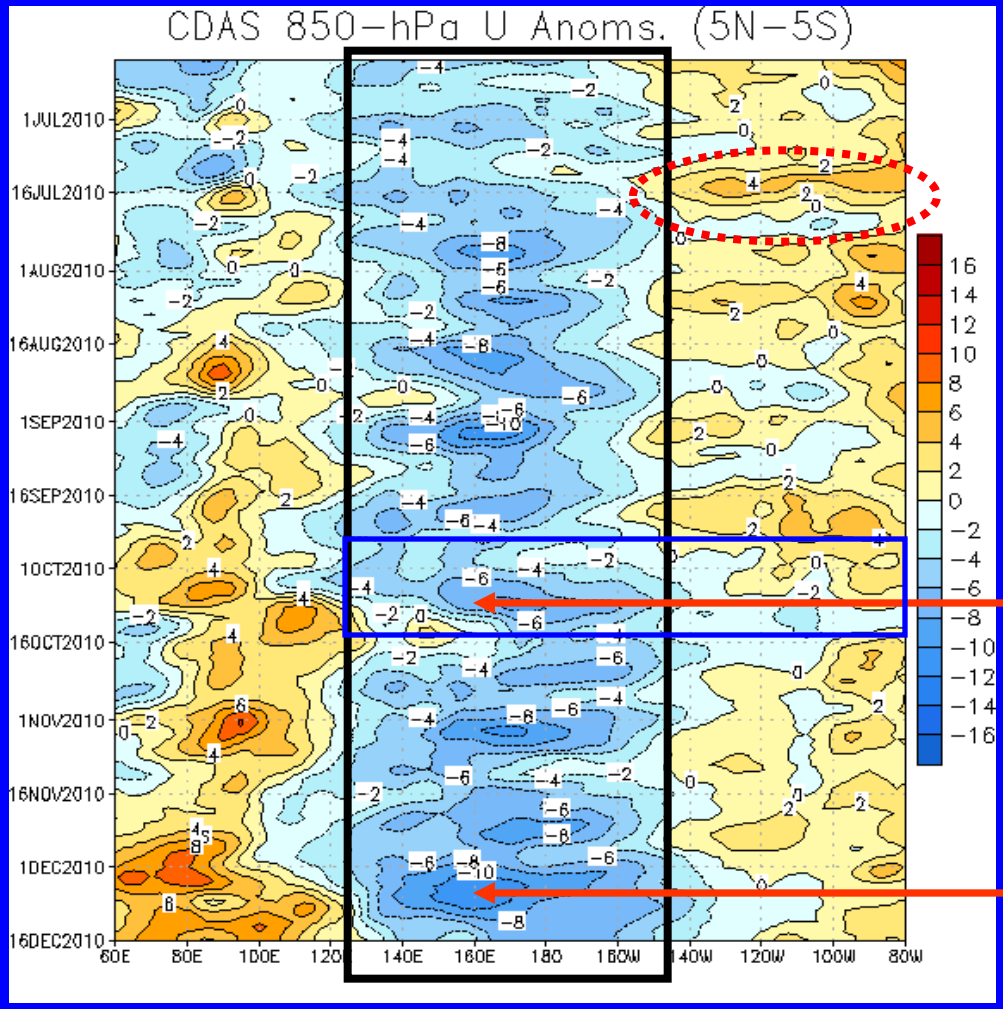
Easterly anomalies continued across the western and central equatorial Pacific with some weakening during the last five days.

Westerly anomalies continued across South America and 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

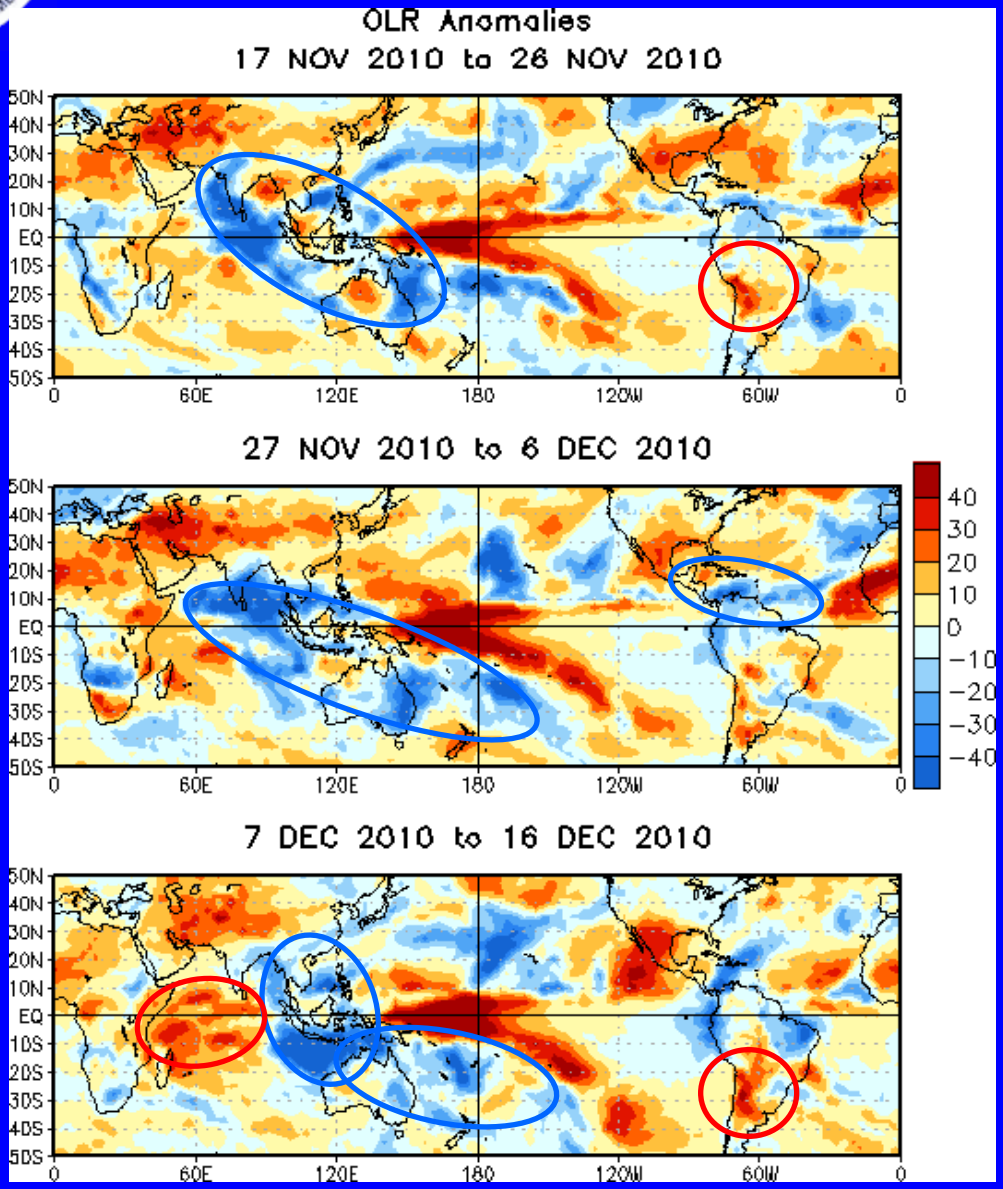
Easterly anomalies have persisted in the west-central Pacific since June (black box) consistent with the development of La Nina conditions.

Enhanced westerly anomalies (red dotted oval) occurred across the eastern Pacific during early-to-mid July and these were in part associated with MJO activity.

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 early December, easterly (westerly) anomalies strengthened just west of the Date Line (Indian Ocean).

OLR Anomalies – Past 30 days



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

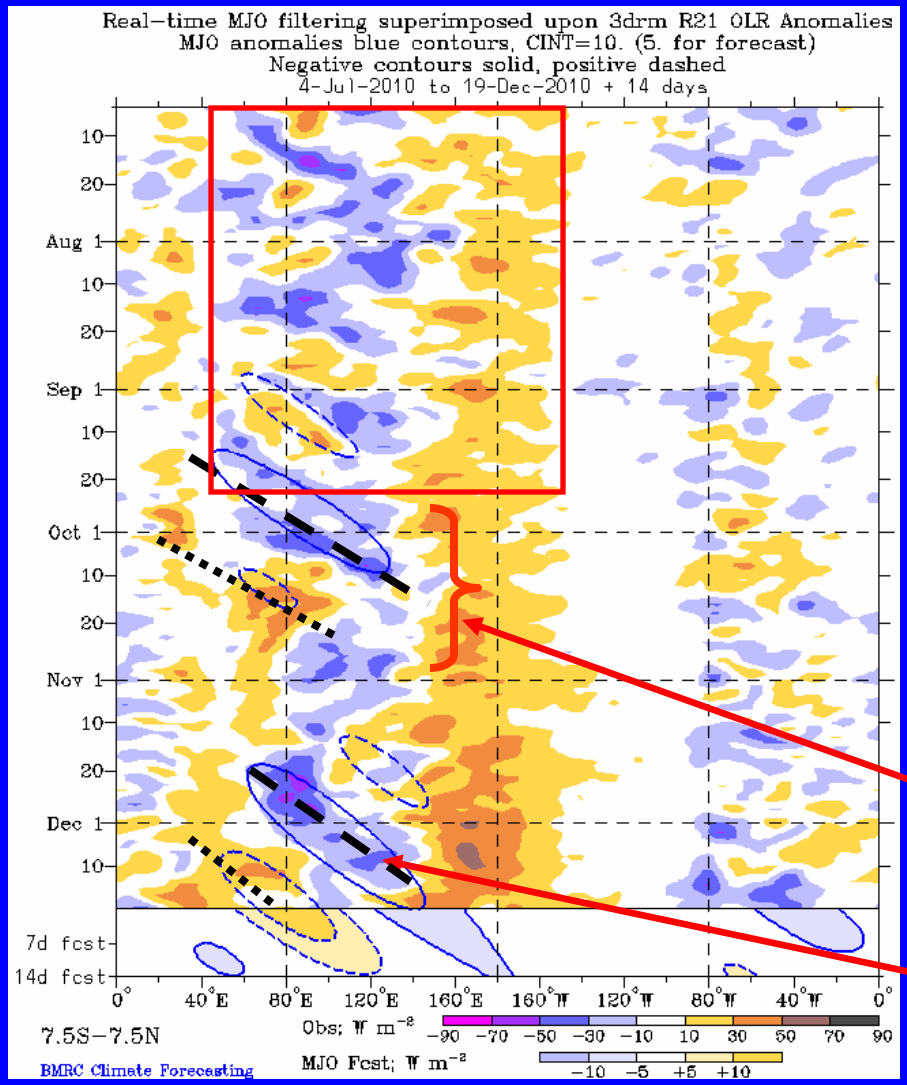
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Drier-than-average conditions (red circle) continued across central South America during mid November, while an area of broken enhanced convection (blue circle) remained over parts of the eastern Indian Ocean, Maritime continent and Australia.

From late-November to early December, enhanced convection continued over parts of the eastern Indian Ocean and along the SPCZ. Wetter-than-average conditions continued over northern South America.

Enhanced convection continued over the eastern Indian Ocean, the Maritime continent, and Australia during early December. Suppressed convection returned to central South America and the western 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 the Bureau of Meteorology (BOM) - Australia)

From late-July into September, generally enhanced (suppressed) convection prevailed across the western Maritime continent (Date Line) (red box). Considerable intraseasonal variability was evident during the period as enhanced convection shifted both eastward and westward in this area, but this was not related to the MJO.

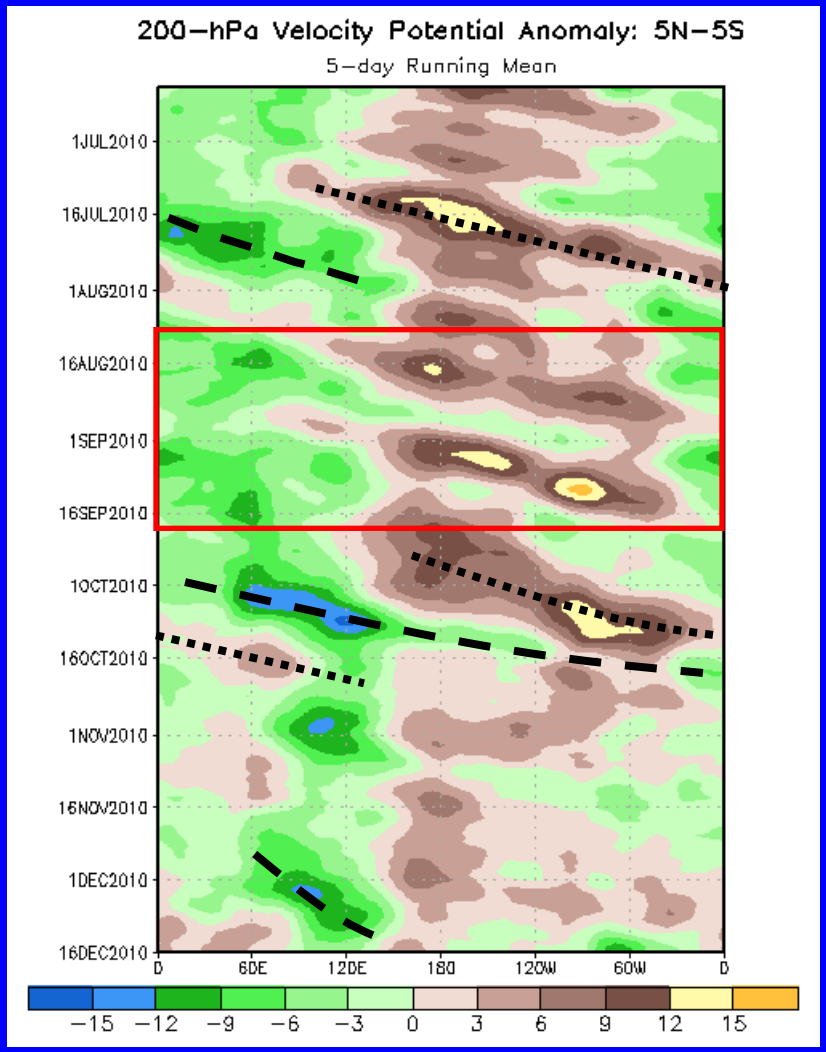
As the MJO strengthened in late September into October, enhanced convection developed near 60E and shifted eastward followed by suppressed convection near 20E during early-mid October.

Most recently, an area of enhanced convection propagated eastward from the Indian Ocean to the Maritime continent. Suppressed convection has followed.

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

Eastward propagation was evident during mid-July associated with the MJO.

Eastward propagation in August and September was mainly associated with higher frequency coherent tropical variability rather than the MJO (red box).

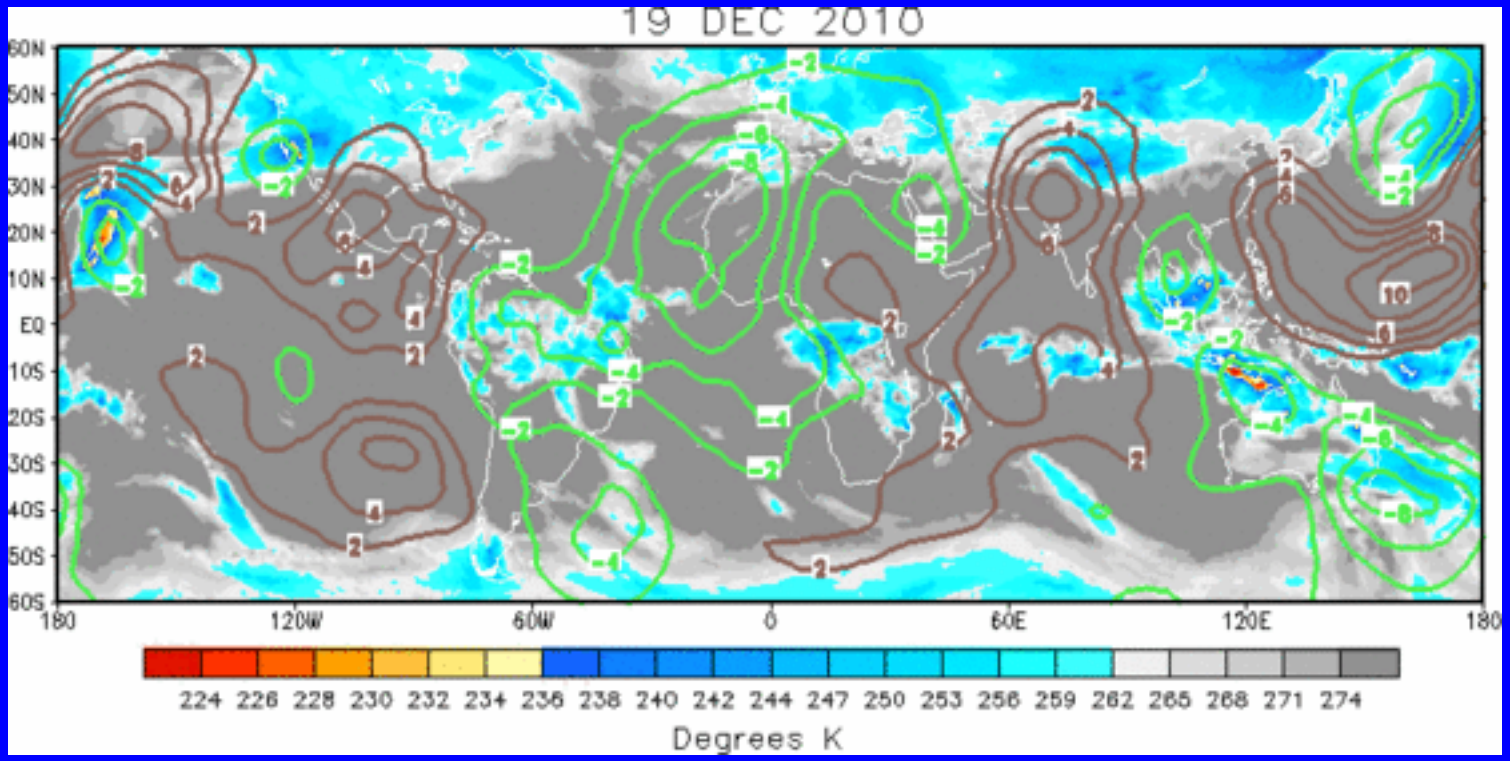
The MJO strengthened during late September as anomalies increased and eastward propagation was seen through mid-October.

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

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

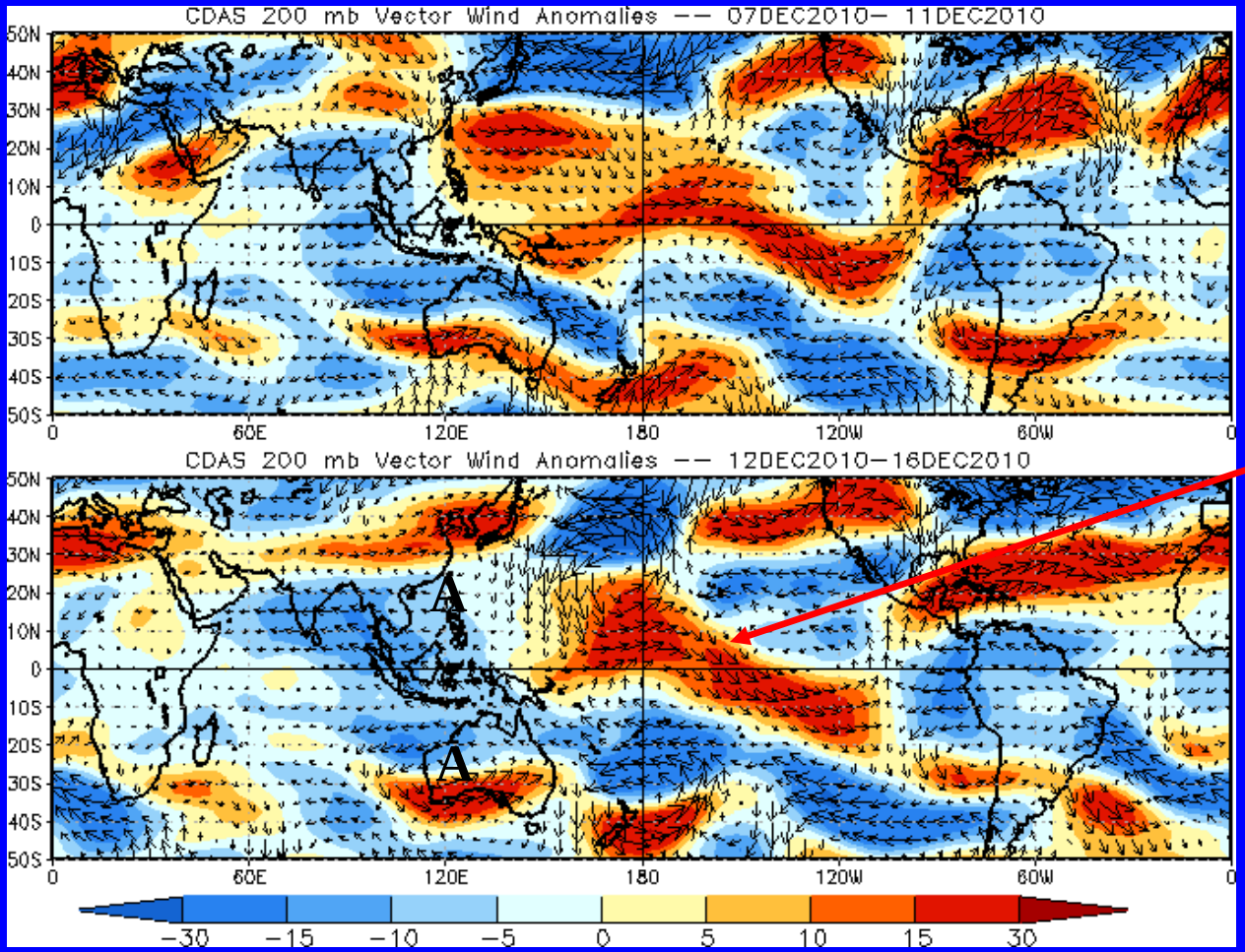
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern is less coherent than the previous week and shows anomalous upper-level convergence over parts of the Pacific Ocean, North America, and Indian Ocean with upper-level divergence across northern South America, western Africa, and northern Australia.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

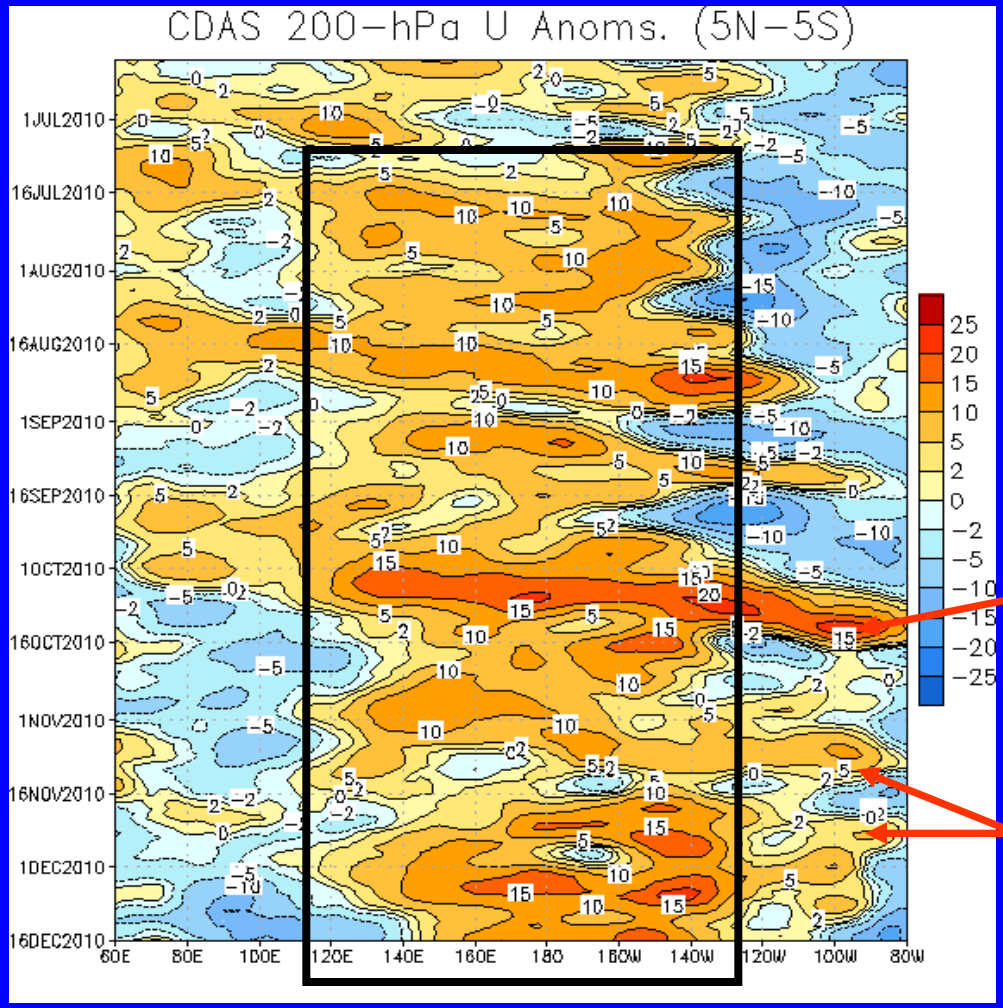
During the last five to ten days, westerly anomalies continued across the central Pacific with easterly anomalies across the Maritime Continent and Indian Ocean.

Off-equatorial anticyclones (A) are present over southeast Asia and western Australia.

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

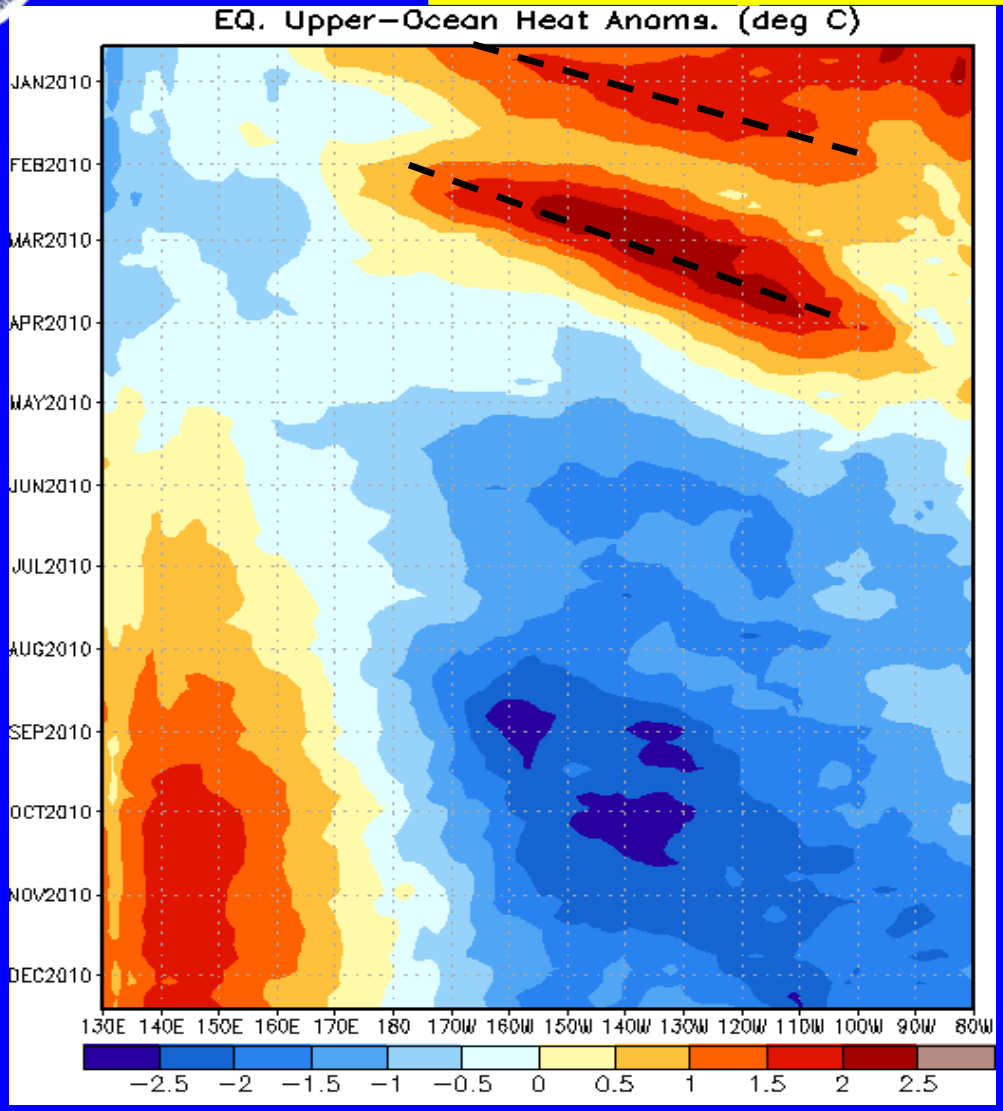
Westerly anomalies persisted across a large area from the Maritime Continent to the central Pacific (black solid box) since early July. Eastward propagation of westerly anomalies in August and September were not associated with the MJO.

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

During November, westerly anomalies increased episodically from 140W to 80W.

Most recently, easterly anomalies have spread across the Indian Ocean.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From December 2009 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.

Currently, negative heat content anomalies extend across the central and eastern Pacific with positive anomalies in the western 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).

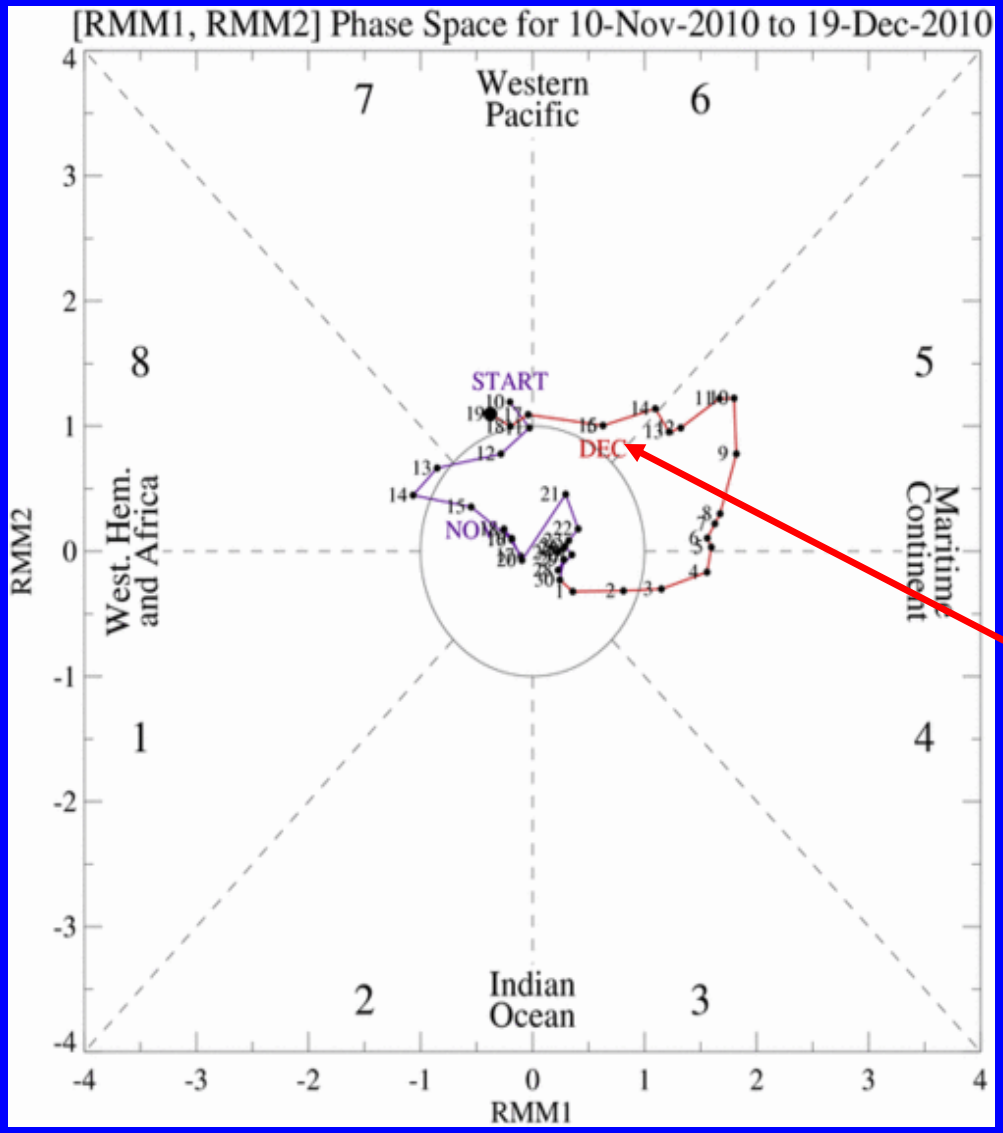
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

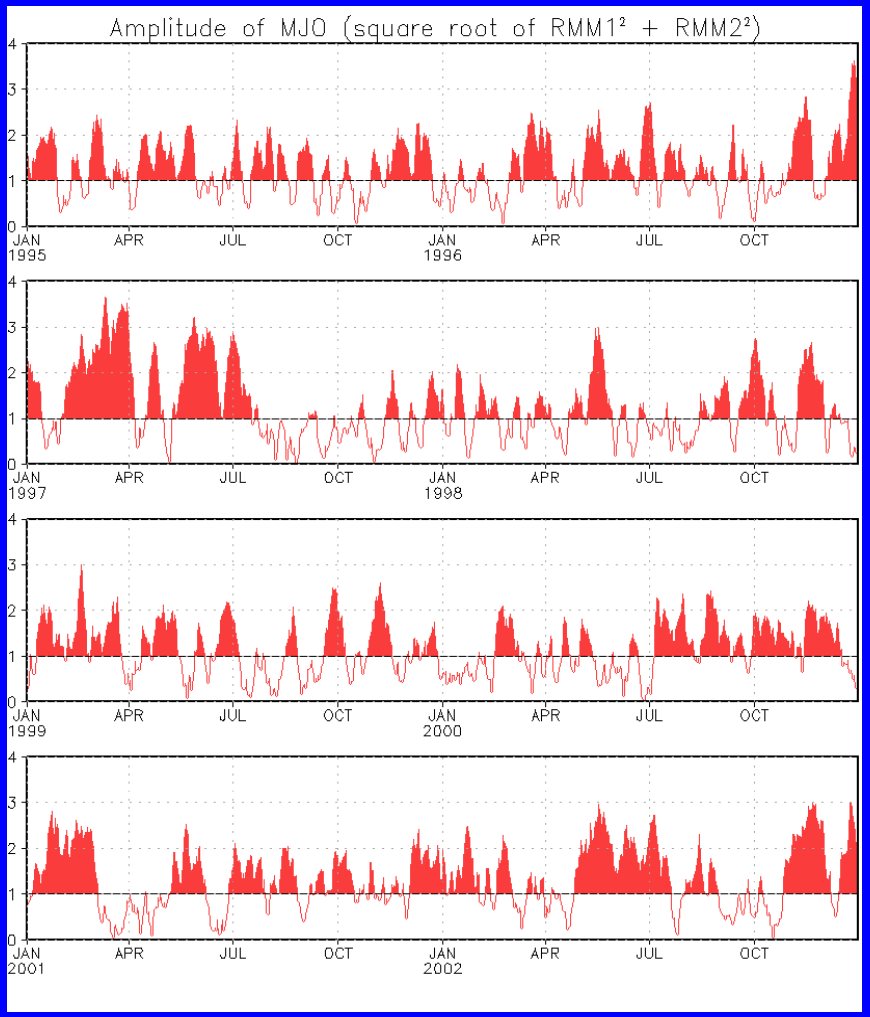
MJO Index -- Recent Evolution

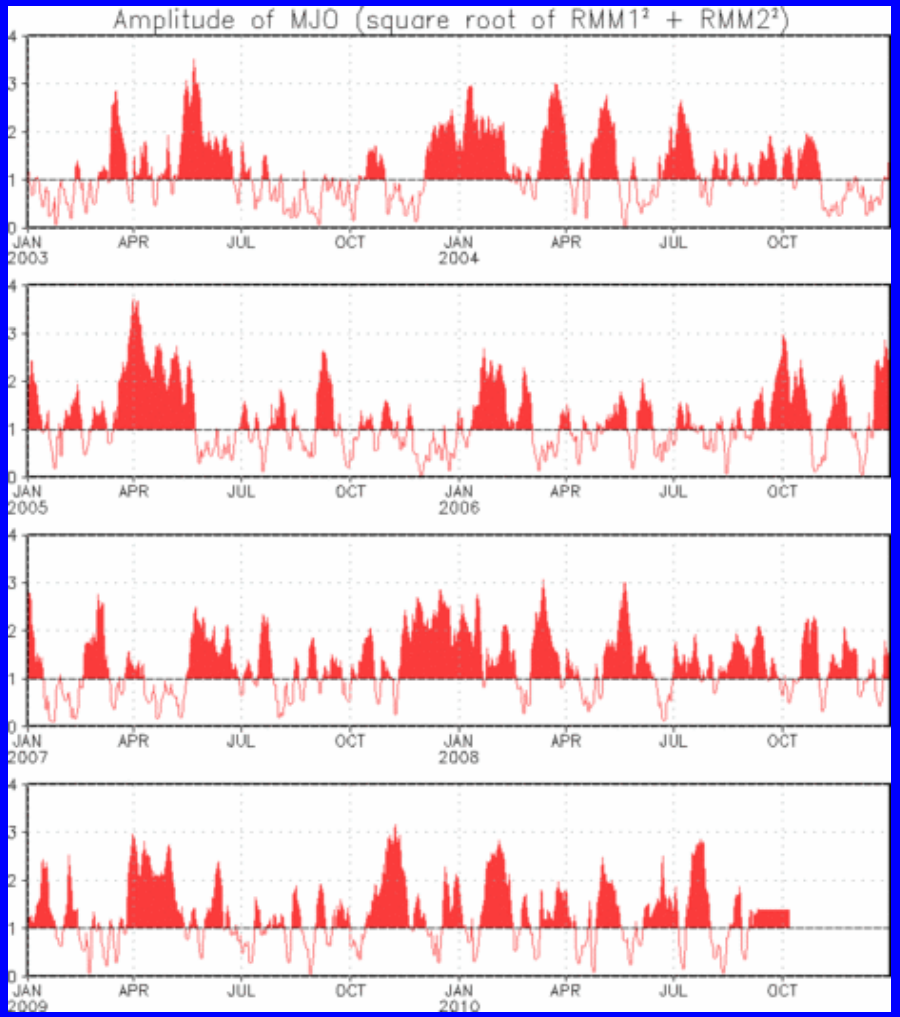


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates continued activity during the past week, albeit a weakening signal.

MJO Index – Historical Daily Time Series





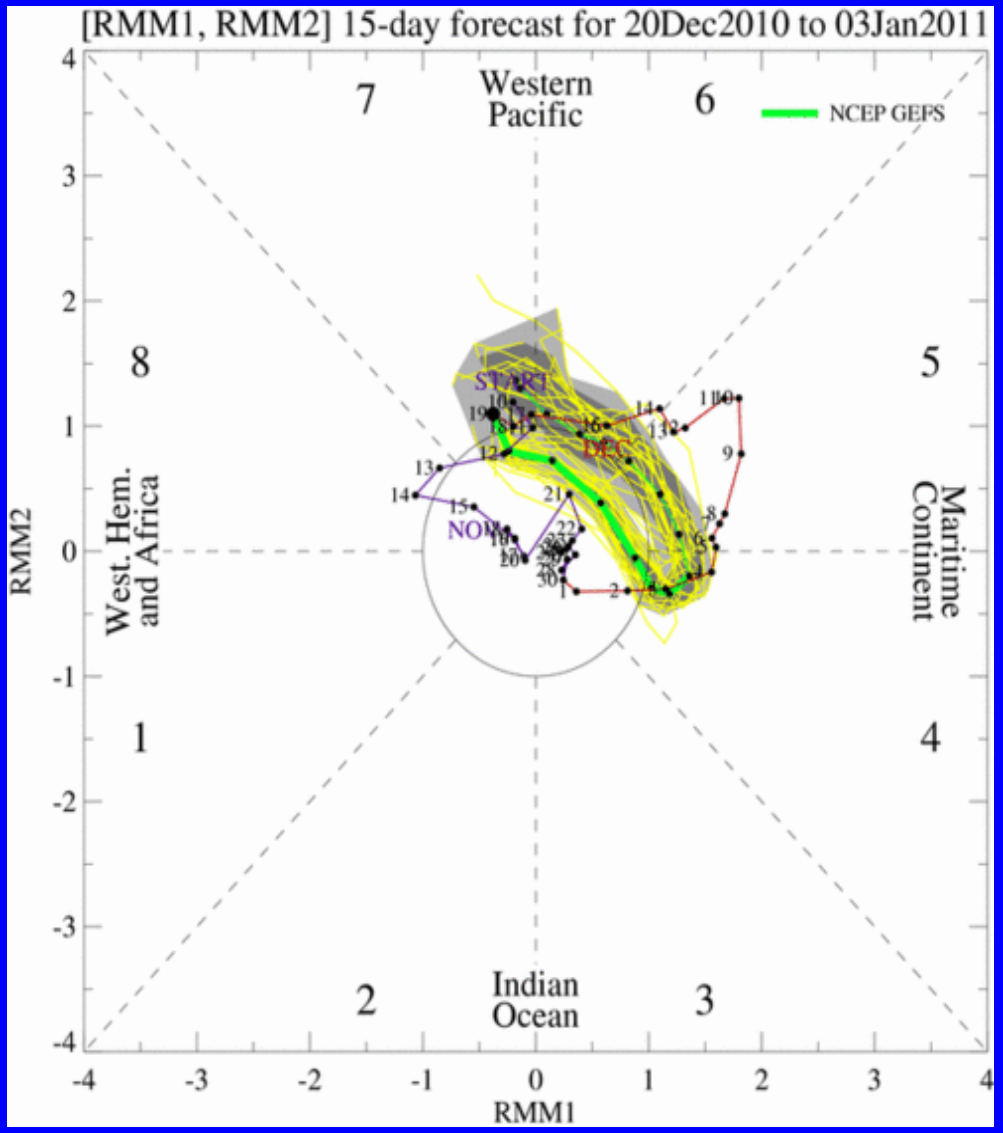
Time series of daily MJO index amplitude from 1995 to present.
Plots put current MJO activity in historical context.

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

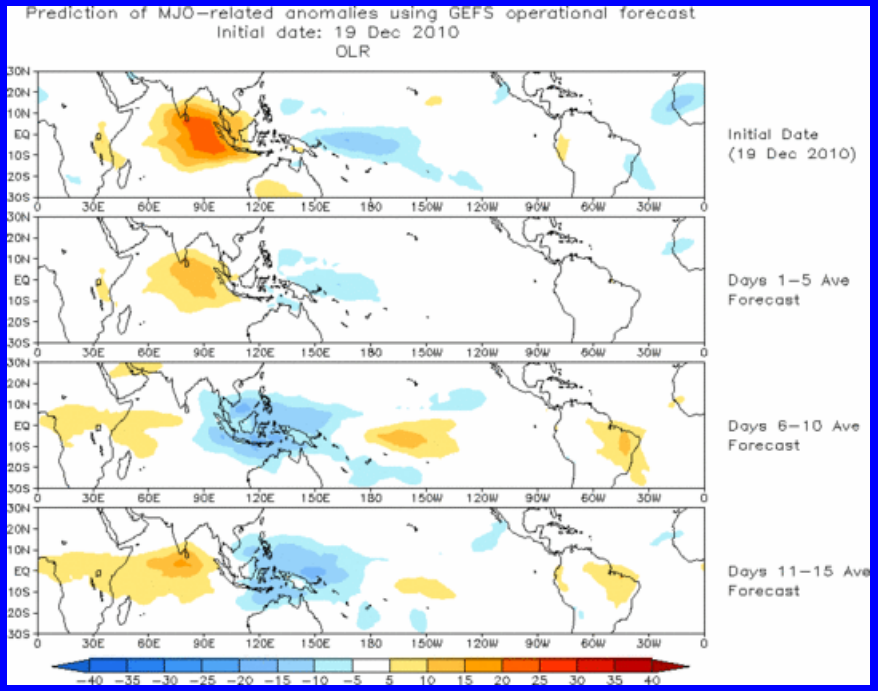


The GFS forecasts indicate a weakening of the signal during Week-1, with a re-emergence during Week-2. The signal during Week-2 is consistent with background La Nina conditions and other faster modes of subseasonal tropical variability.

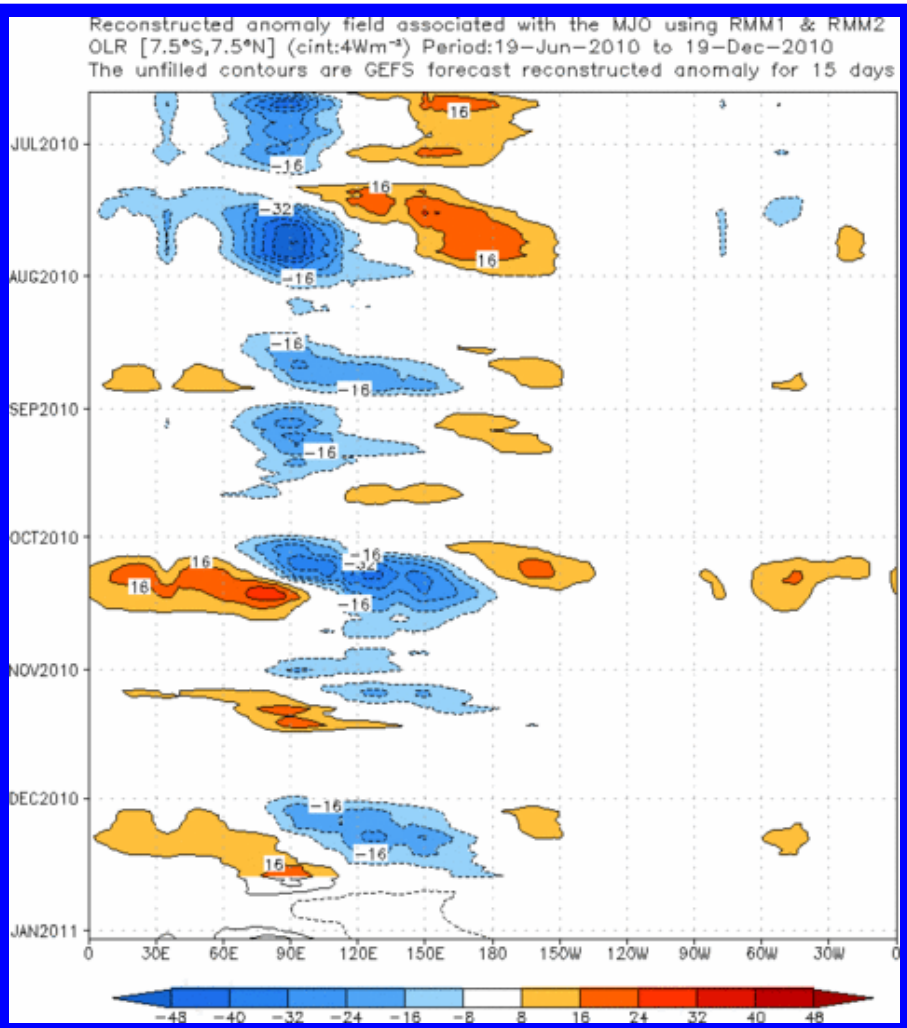
Ensemble Mean GFS MJO Forecast

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 moderate anomalies, but may be more related to a combination of La Nina and other modes of subseasonal tropical variability.

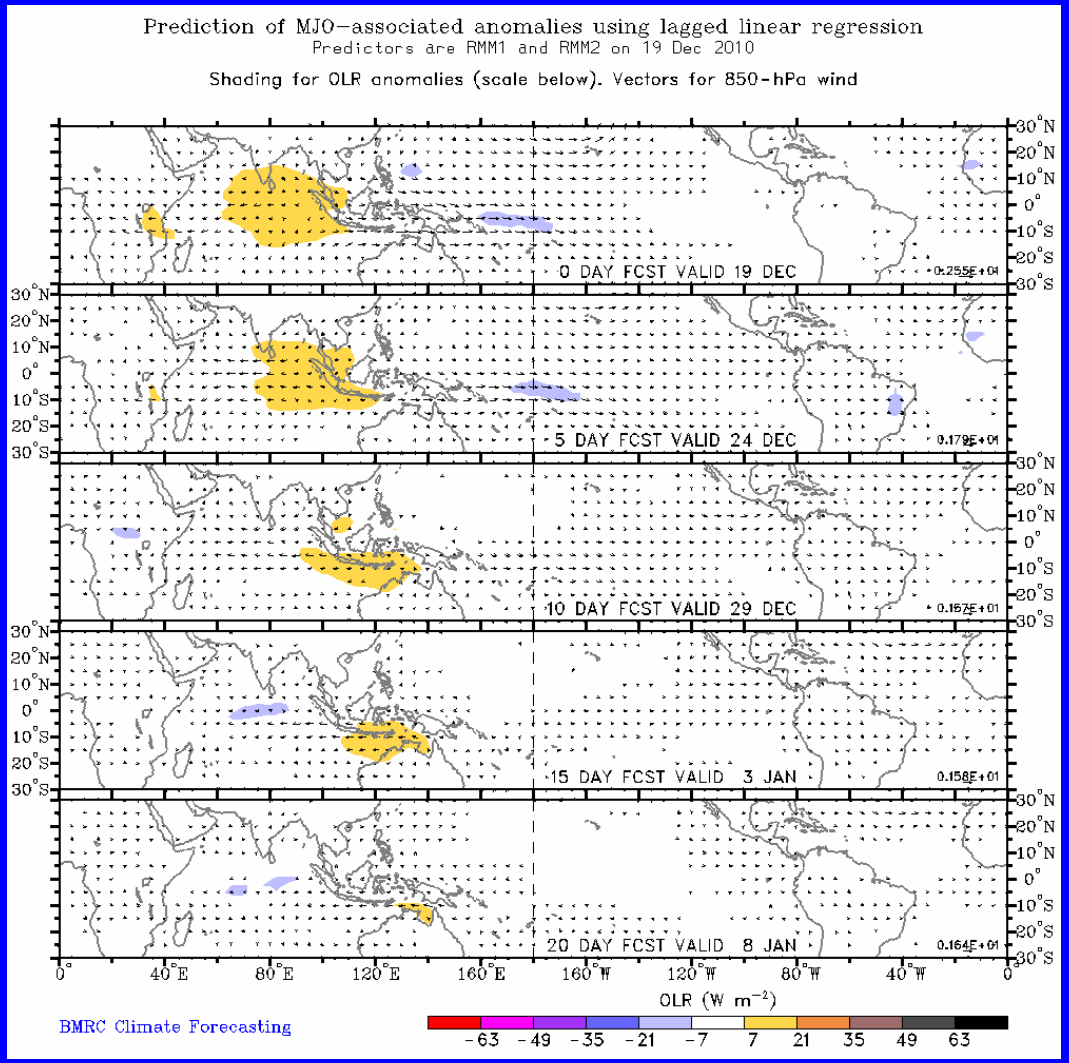
Statistical MJO Forecast

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

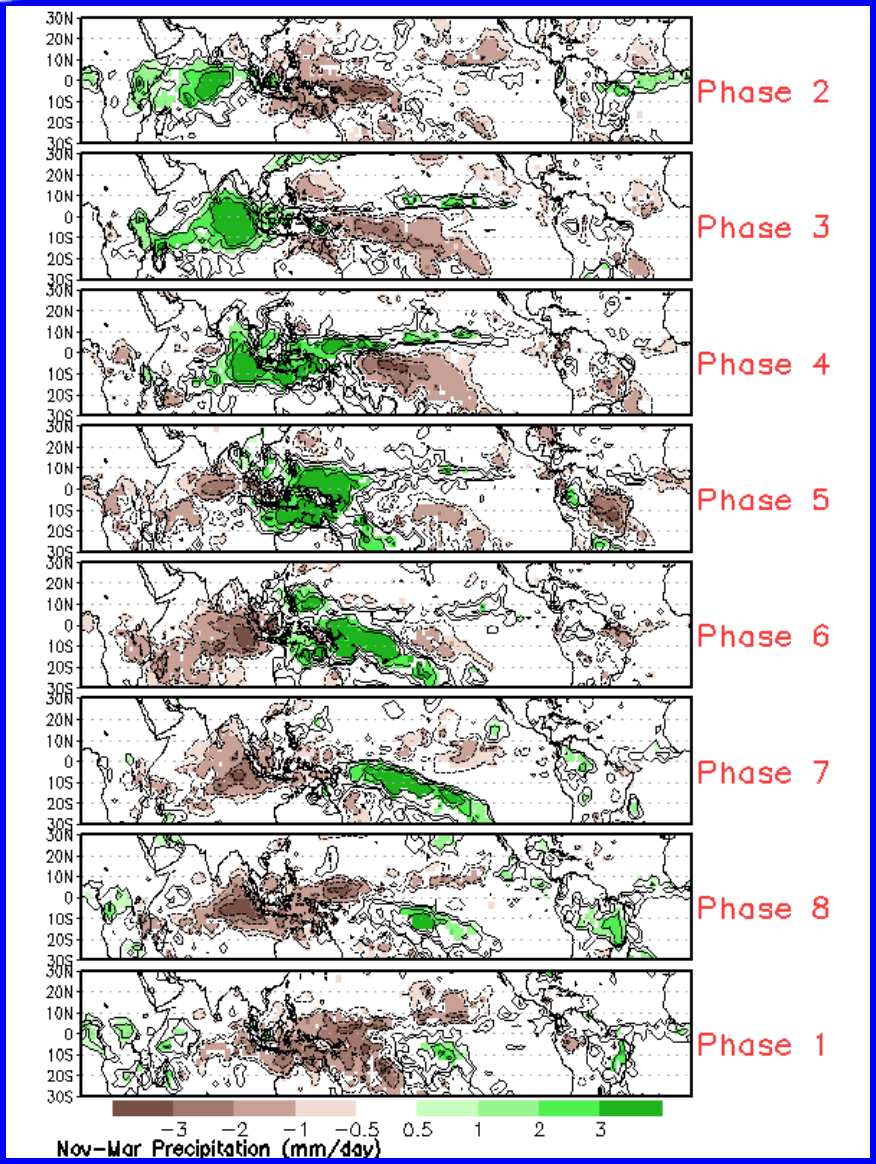
(Courtesy of the Bureau of Meteorology Research Centre - Australia)

Weak MJO activity is forecast during the period with suppressed convection shifting eastward from the Indian ocean to Indonesia while weakening.

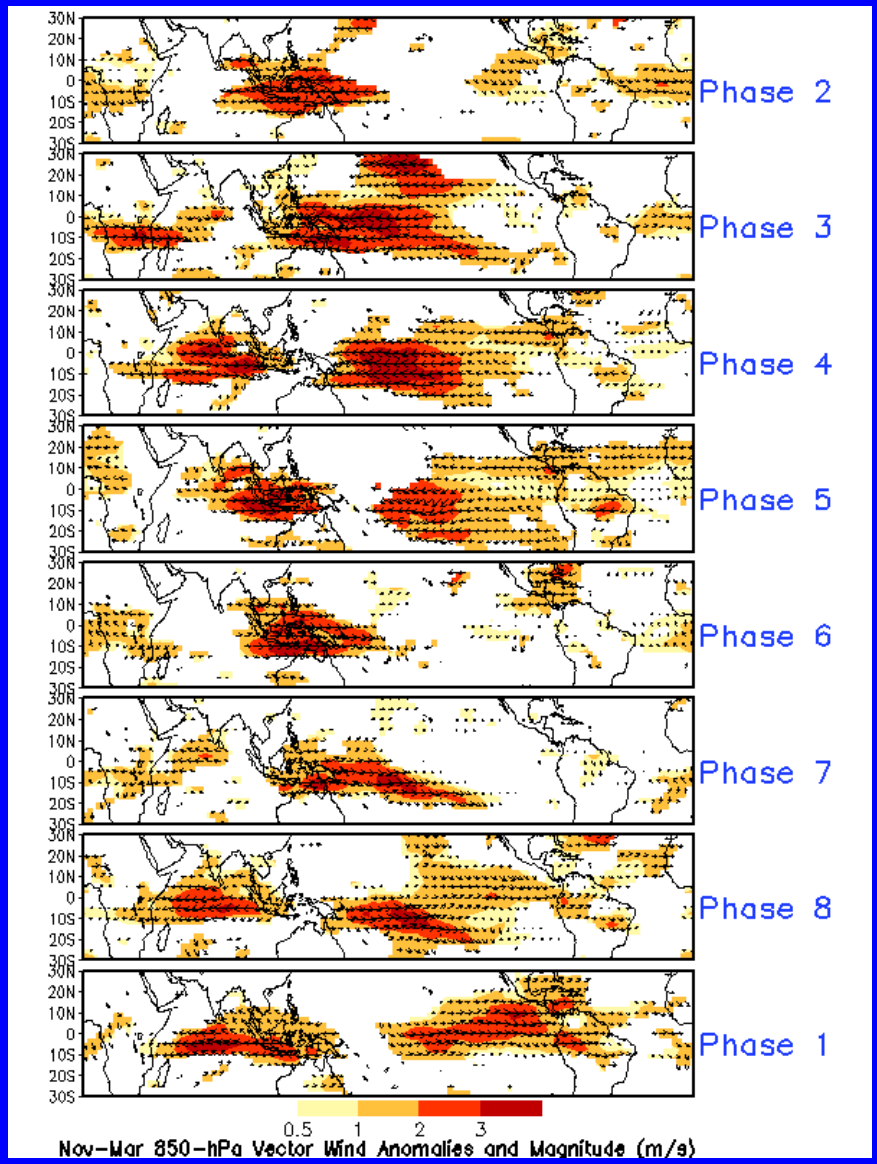


MJO Composites – Global Tropics

Precipitation Anomalies (Nov-Mar)

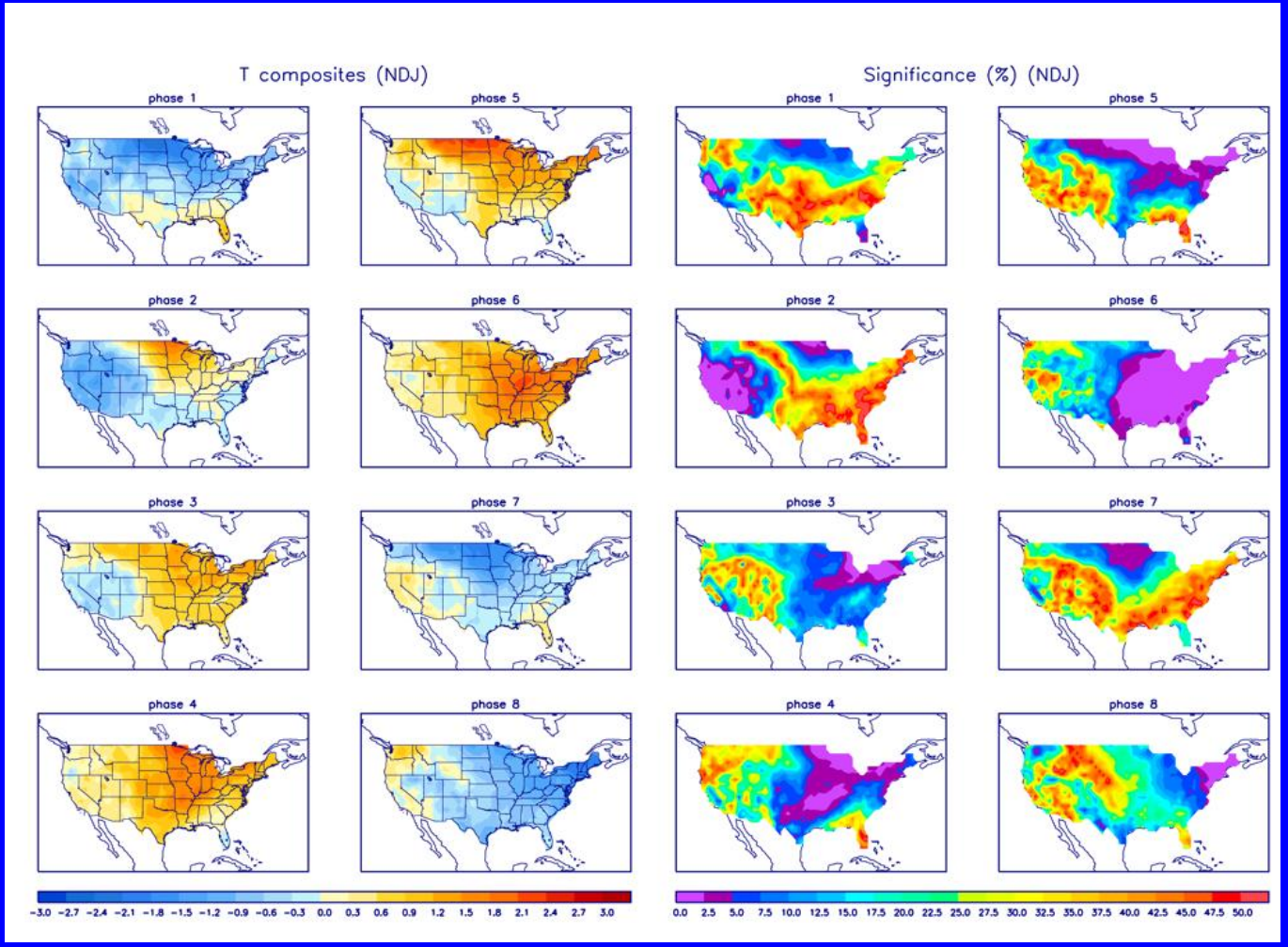


850-hPa Wind Anomalies (Nov-Mar)



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.**

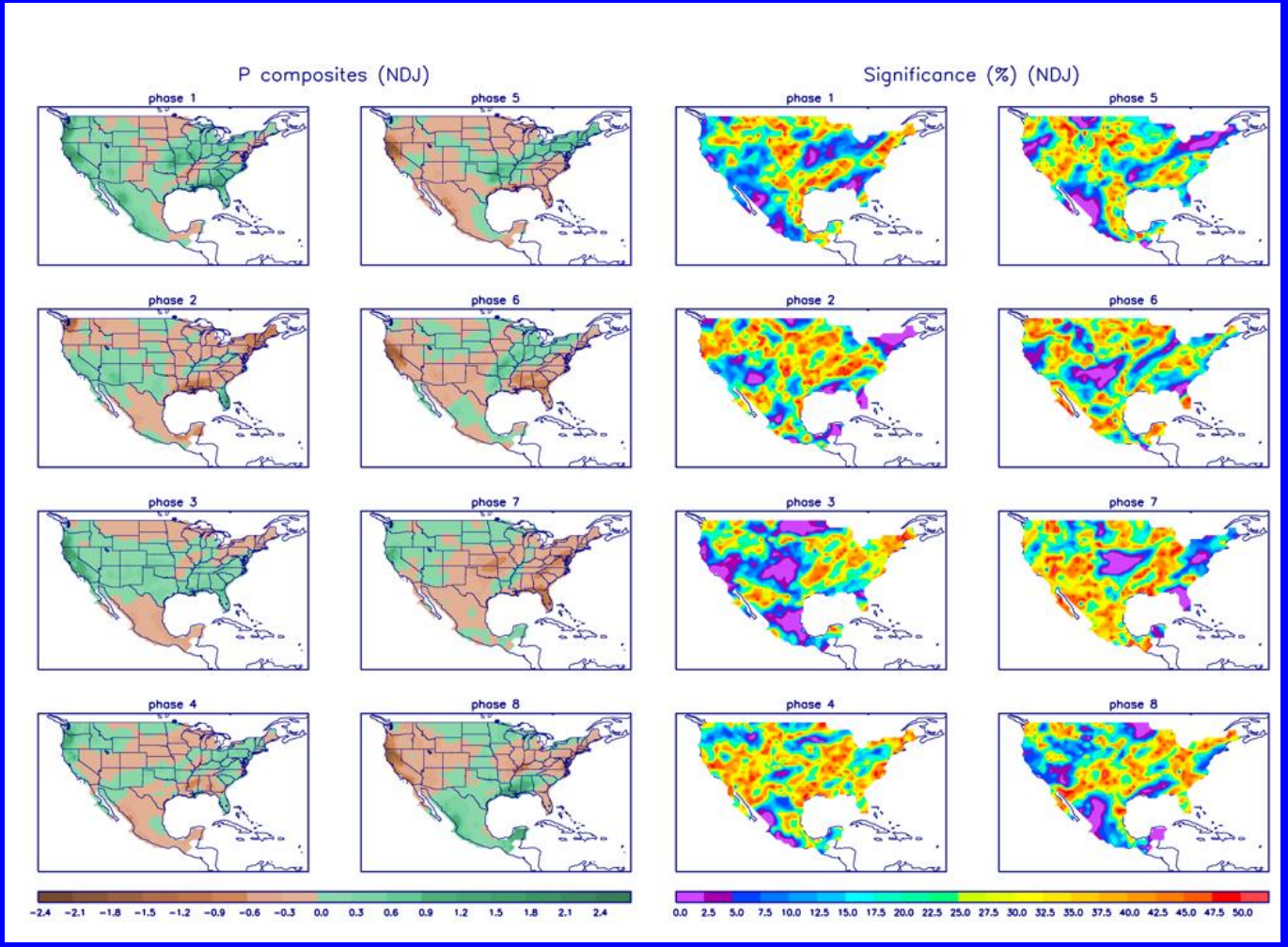


Zhou et al. (2010): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, Submitted.

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