



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

**Update prepared by
Climate Prediction Center / NCEP
January 10, 2011**



Outline

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



Overview

- The MJO remained weak during the last seven days, but has showed signs of strengthening in recent days.
- Dynamical model MJO forecasts indicate a strengthening MJO signal during the upcoming week with eastward propagation through Week-2. The enhanced convective phase is forecast to be entering the western hemisphere near the end of Week-2.
- The MJO is expected to contribute to enhanced rainfall across parts of Australia (Week-1), SPCZ (Week-1 and 2) and parts of northern South America (Week-2). Drier conditions are forecast to benefit areas across Indonesia and Australia during Week-2.
- For the U.S., potential impacts (focusing on Week-2/3), include increased chances of below-normal temperatures across the north central and eastern U.S. and extending and strengthening of the Pacific jet stream. At the current time, uncertainty is high and forecast confidence low for these potential circulation changes across North America given background La Nina conditions and current strength and phase of high-latitude variability (*i.e.*, Arctic Oscillation).

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



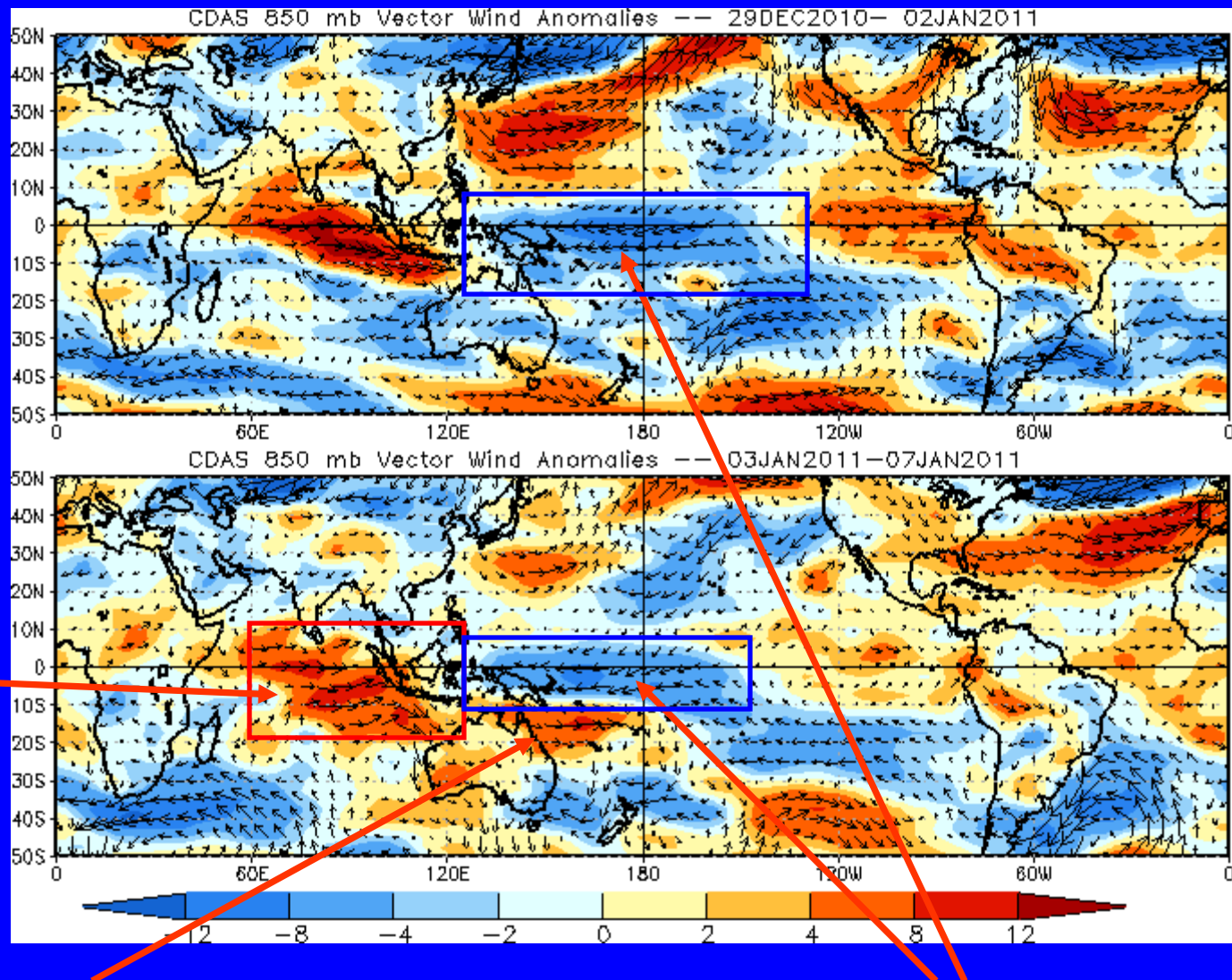
850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies continued across the Indian Ocean, but weakened some across the western Maritime Continent.



Westerly anomalies also developed northeast of Australia during the last five days.

Easterly anomalies continued across the western and central equatorial Pacific (primarily along the equator) and shifted slightly to the west.

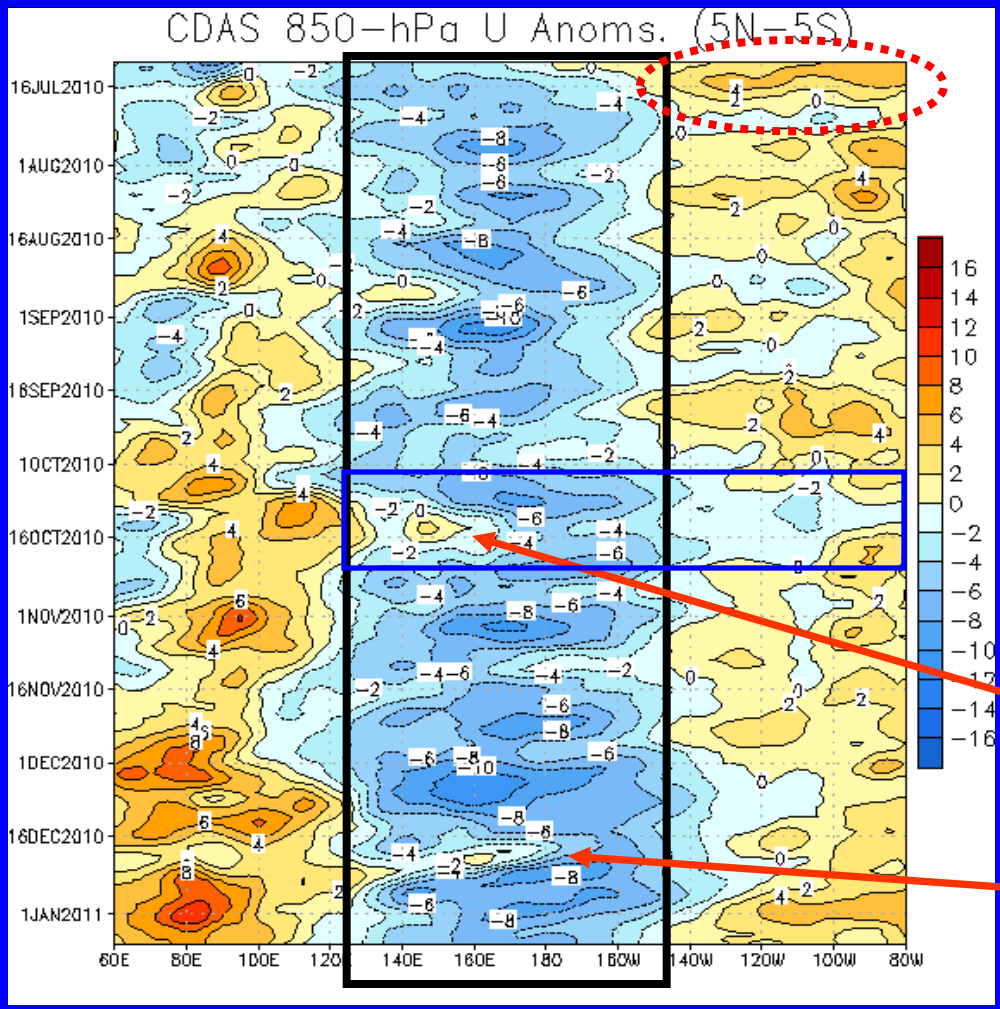


850-hPa Zonal Wind Anomalies (m s^{-1})

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, partly 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).

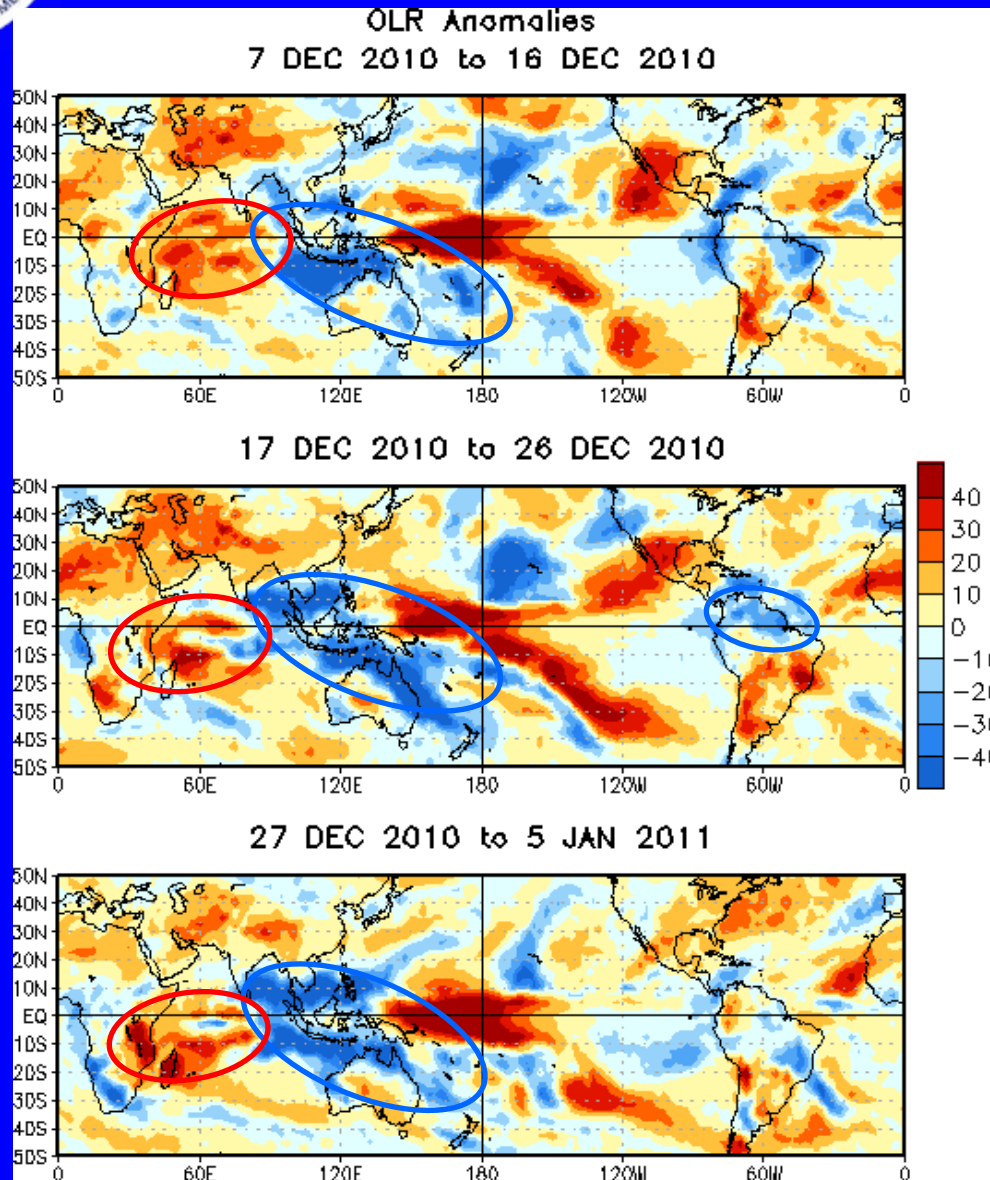
In mid-December, easterly anomalies weakened just west of the Date Line due to a combination of weak MJO activity and extratropical interactions.



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 early-to-mid December, enhanced convection (blue circle) continued over parts of the eastern Indian Ocean, Australia and along the SPCZ while suppressed convection (red circle) strengthened across the western Indian Ocean.

Enhanced convection continued over the Maritime continent and Australia during mid-to-late December.

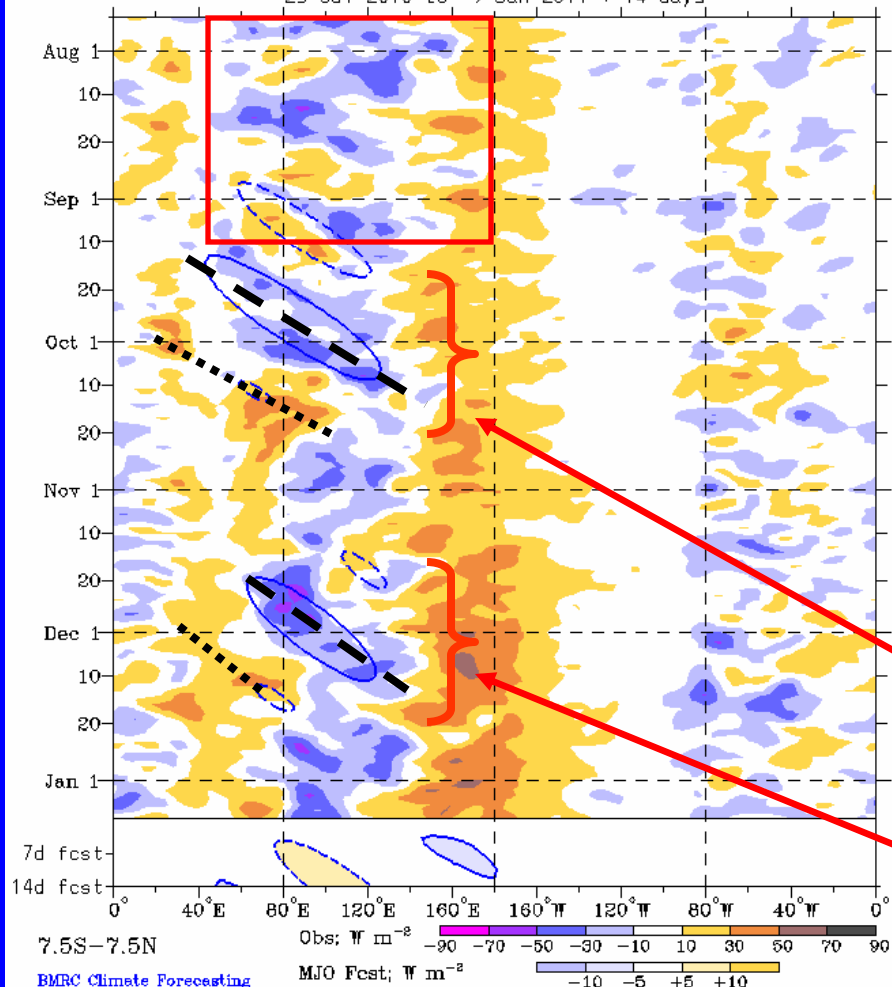
During late December and early January, enhanced convection over the Maritime continent and Australia shifted slightly westward. Drier-than-average conditions continued across parts of the Indian Ocean and southeast Africa.



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
25-Jul-2010 to 9-Jan-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)

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 but the MJO did not play a large role.

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.

Weak MJO activity was again experienced during late November into December. An area of enhanced convection propagated eastward from the Indian Ocean to the Maritime continent followed by suppressed convection thereafter.

Time



Longitude

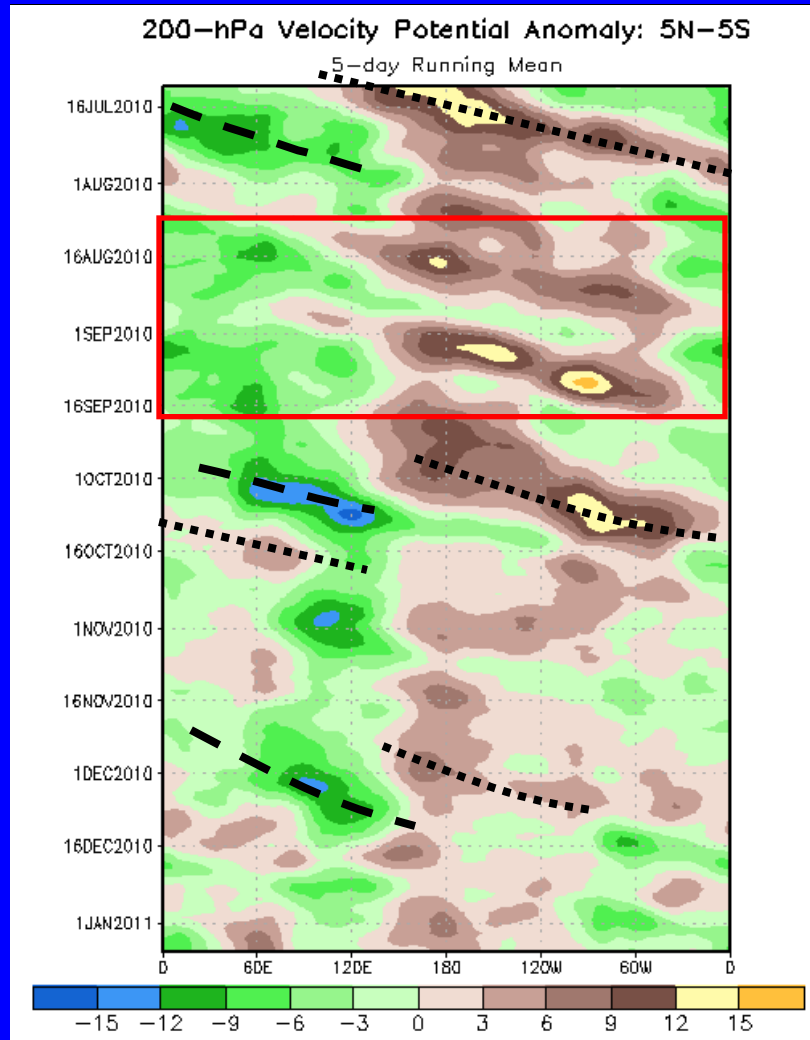


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



Longitude

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.

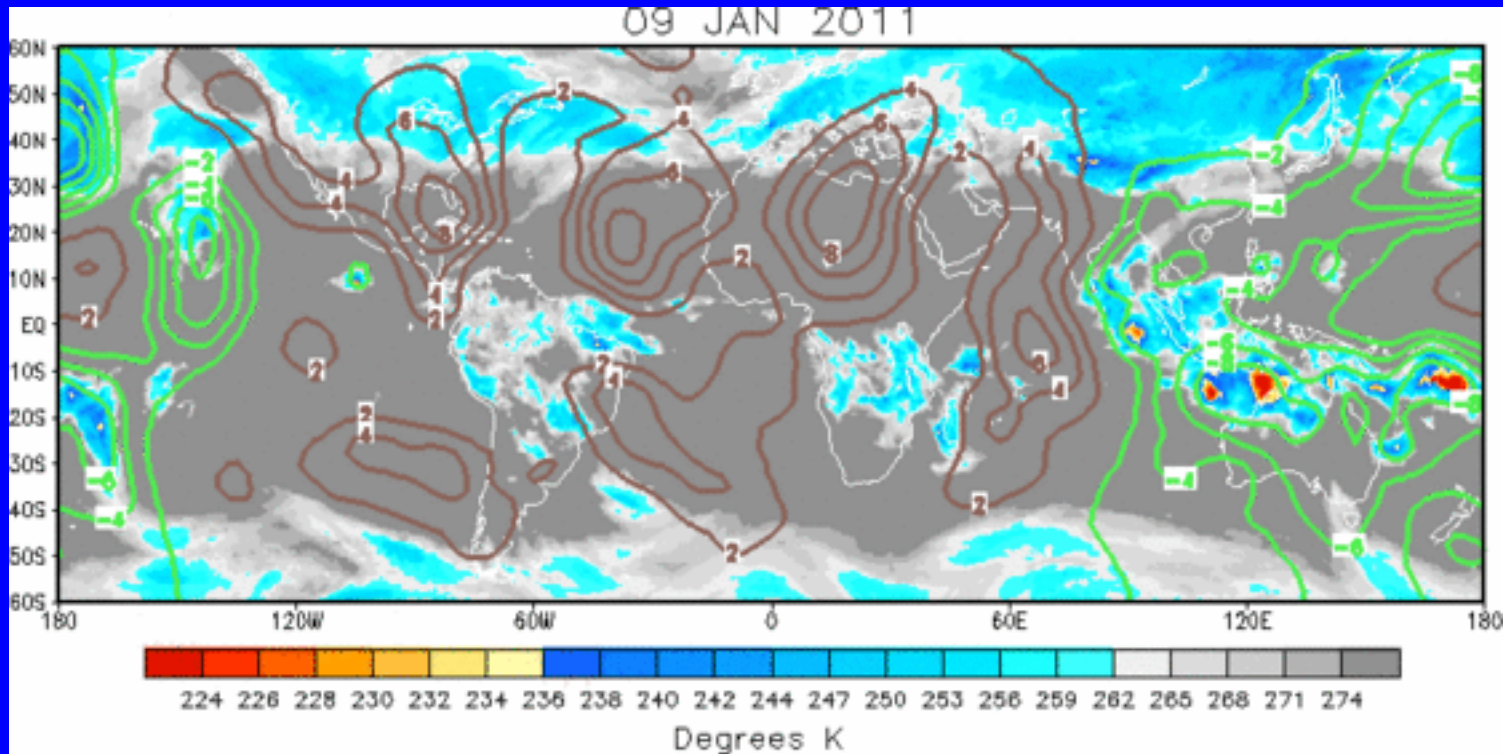
During late November and early December, some eastward propagation associated with the MJO is evident in velocity potential anomalies.



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 shows anomalous upper-level divergence over the Maritime continent while anomalous convergence has recently become more organized across parts of Americas, Atlantic Ocean, and Africa.

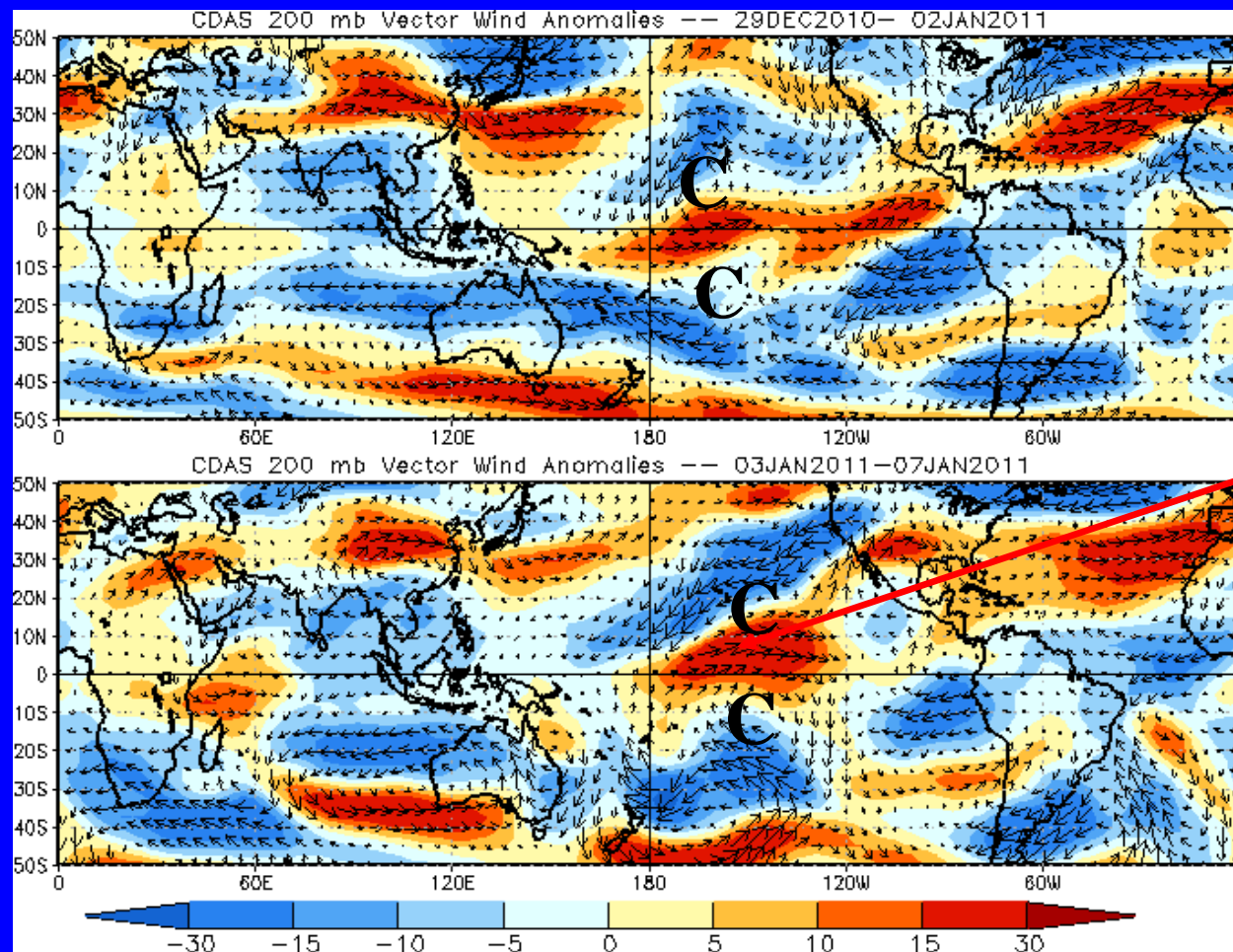


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies continued across most of the equatorial central Pacific with easterly anomalies in the Indian Ocean shifting slightly eastward across

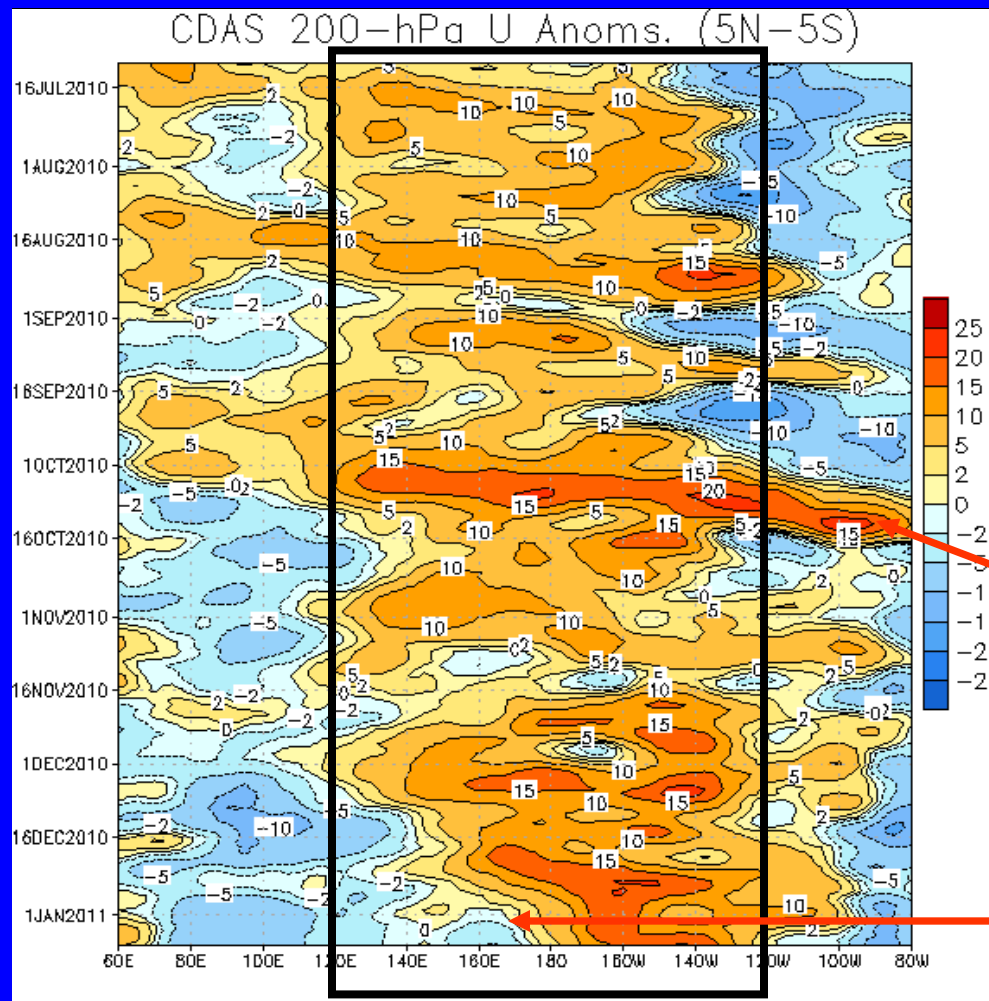
The off-equatorial cyclones (C) have shifted slightly eastward during the last five days.



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



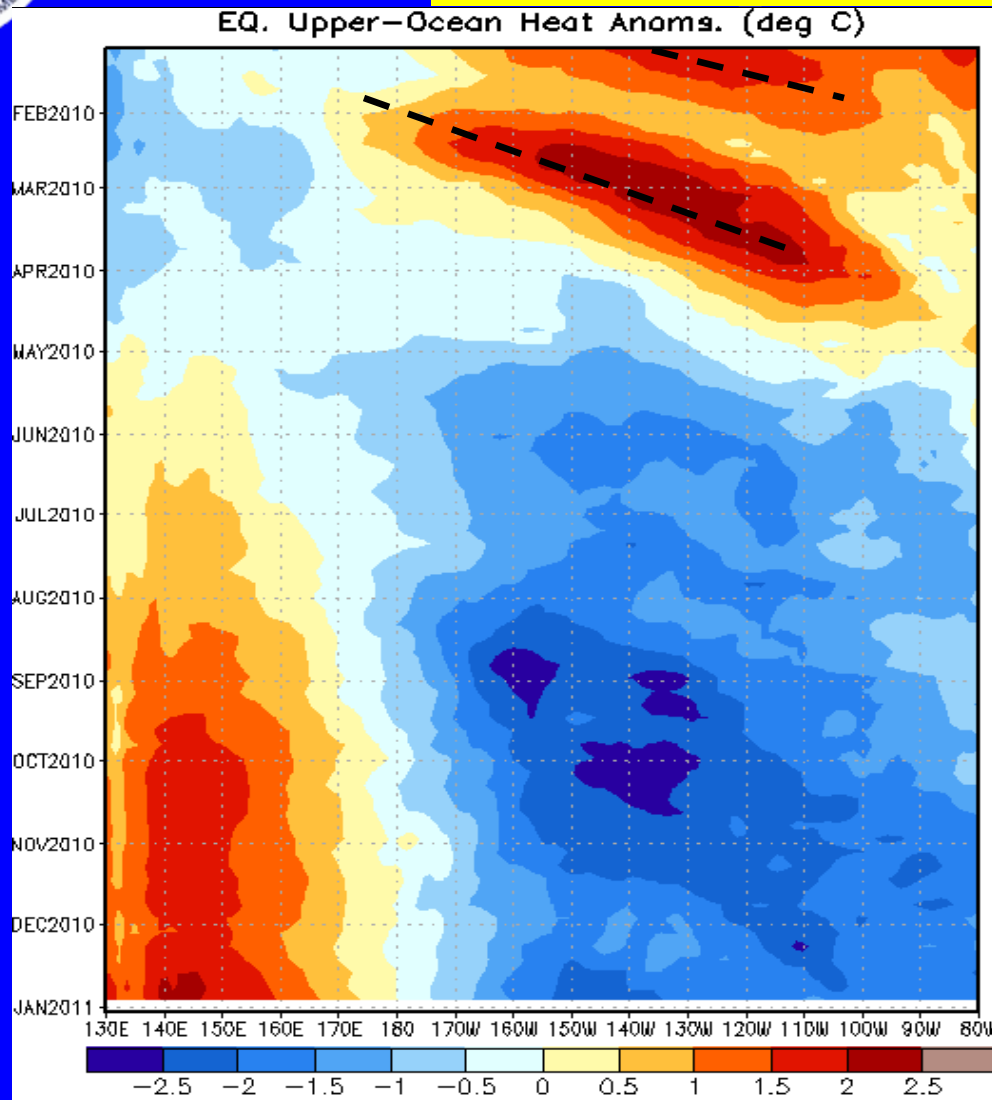
Westerly anomalies persisted across a large area from the Maritime Continent to the central Pacific (black solid box) since early July. Eastward propagation of westerly anomalies in August and September were not associated with the MJO.

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

Most recently, easterly anomalies have shifted east towards the Date Line .



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.

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.

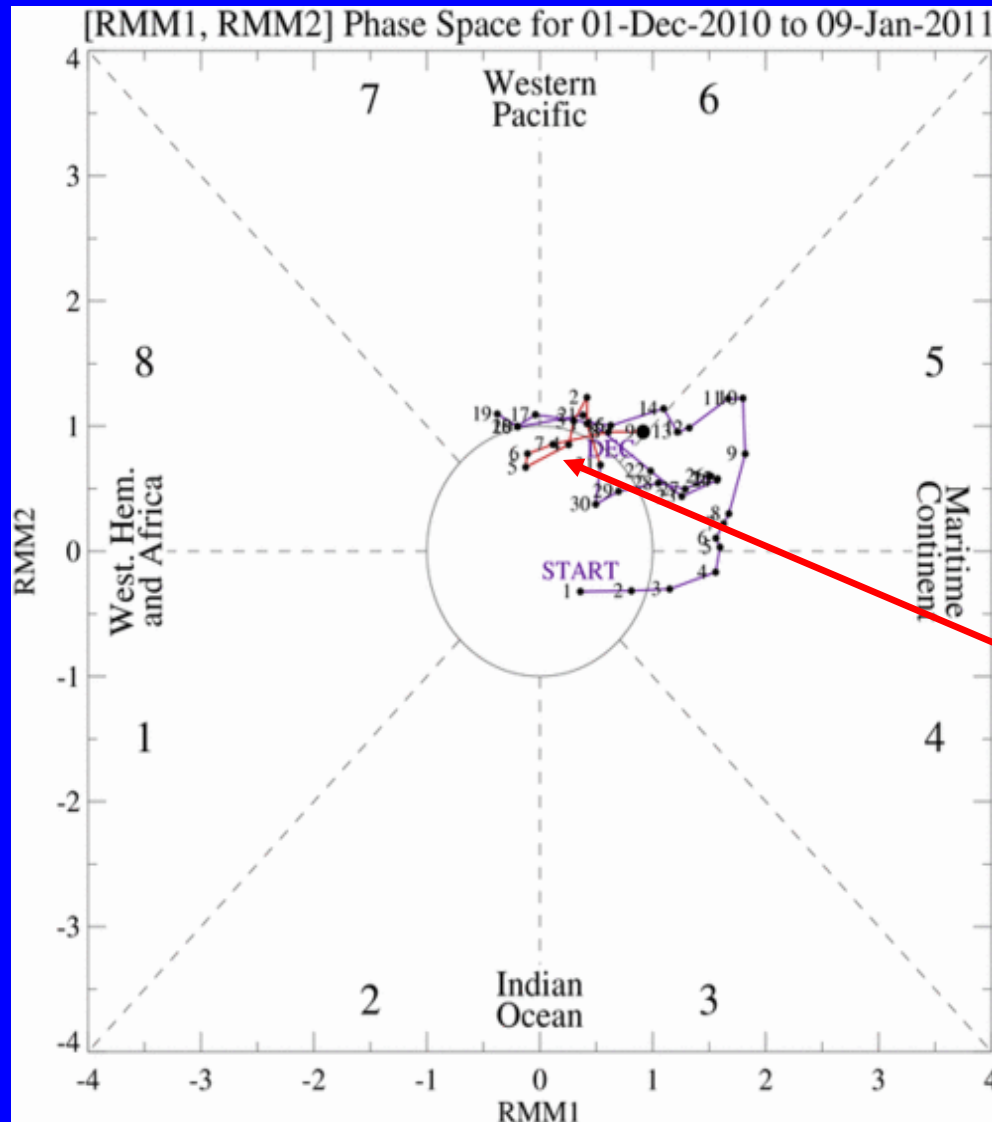
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

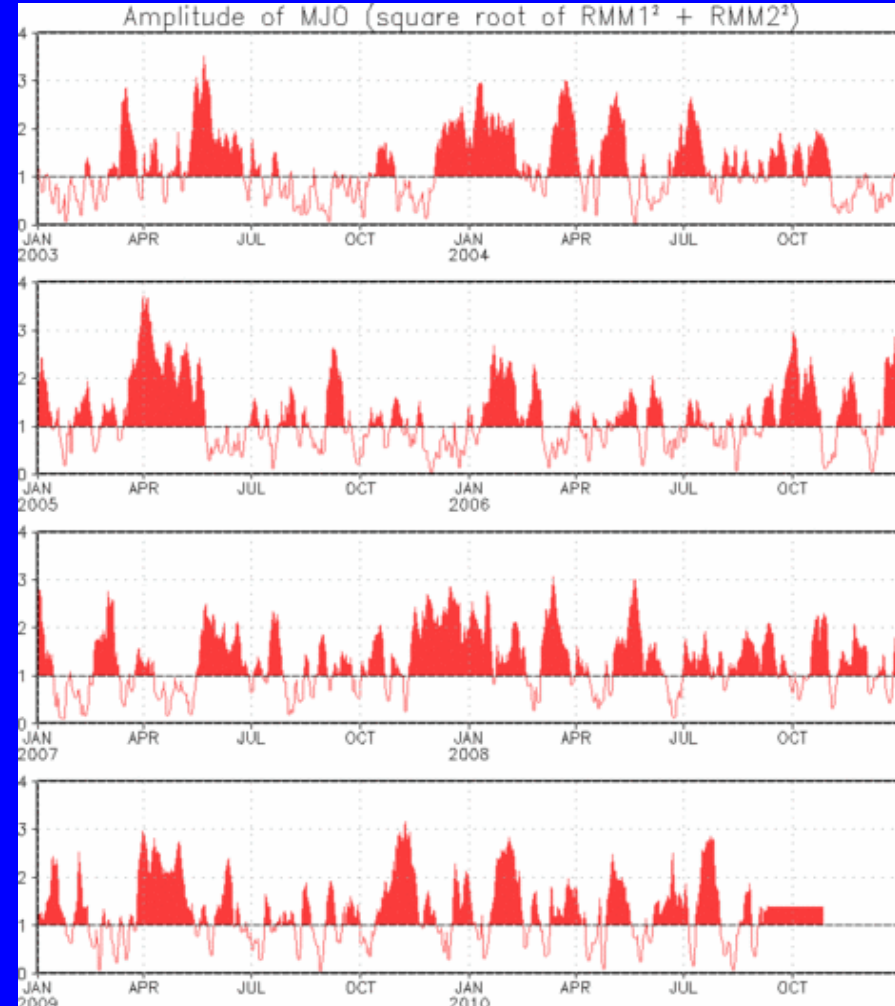
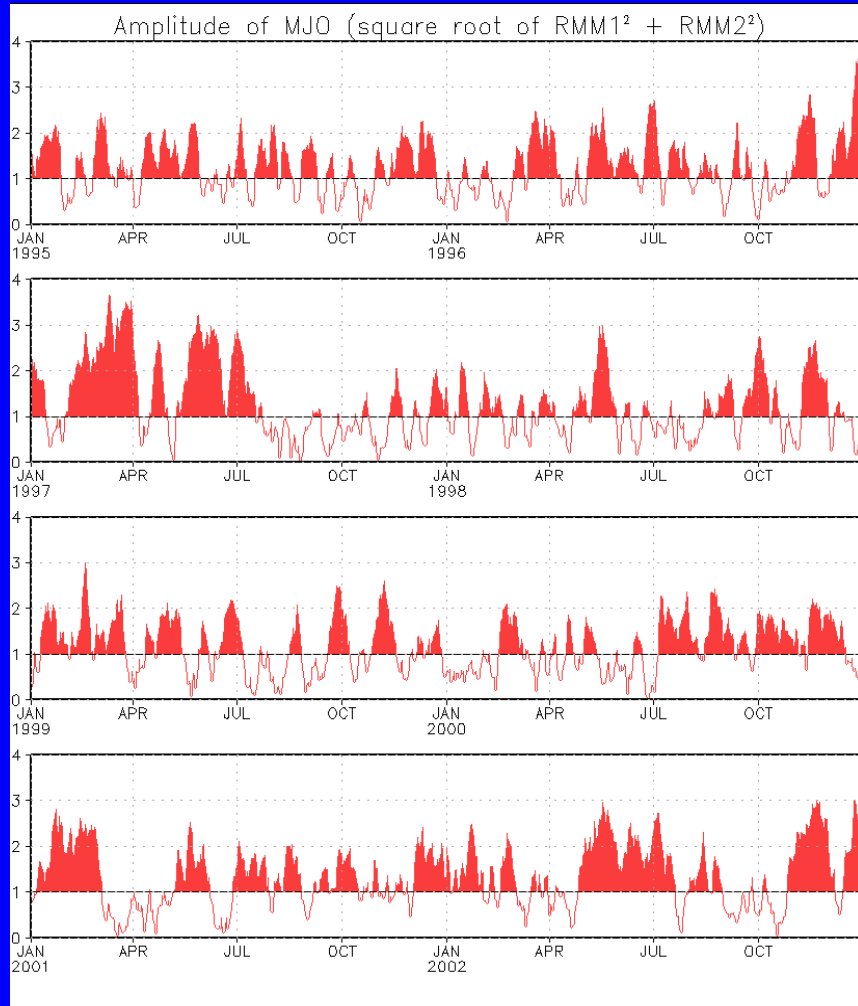


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index did not indicate significant MJO activity 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

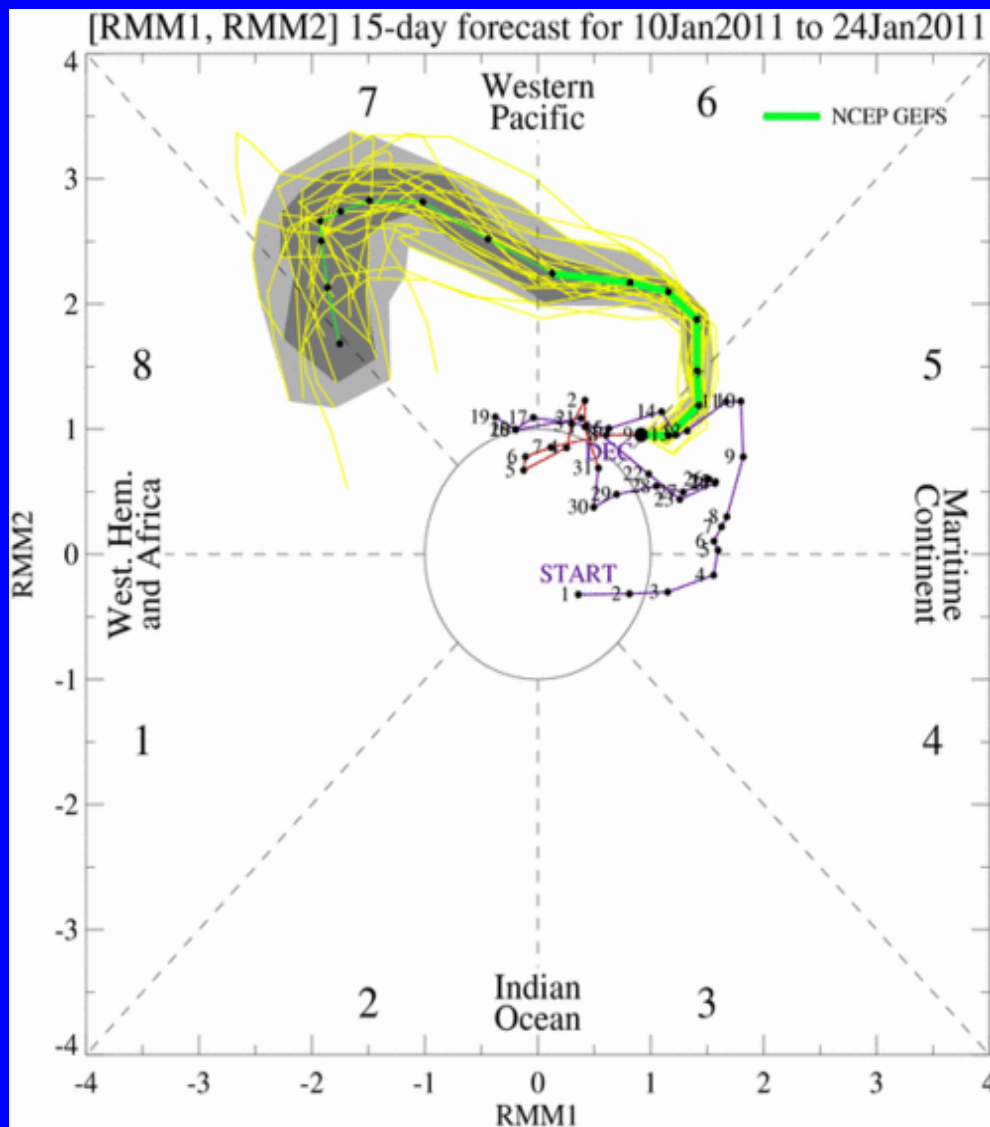
Green Line – Ensemble Mean

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 a strengthening and continuation of an MJO signal over the next two weeks.

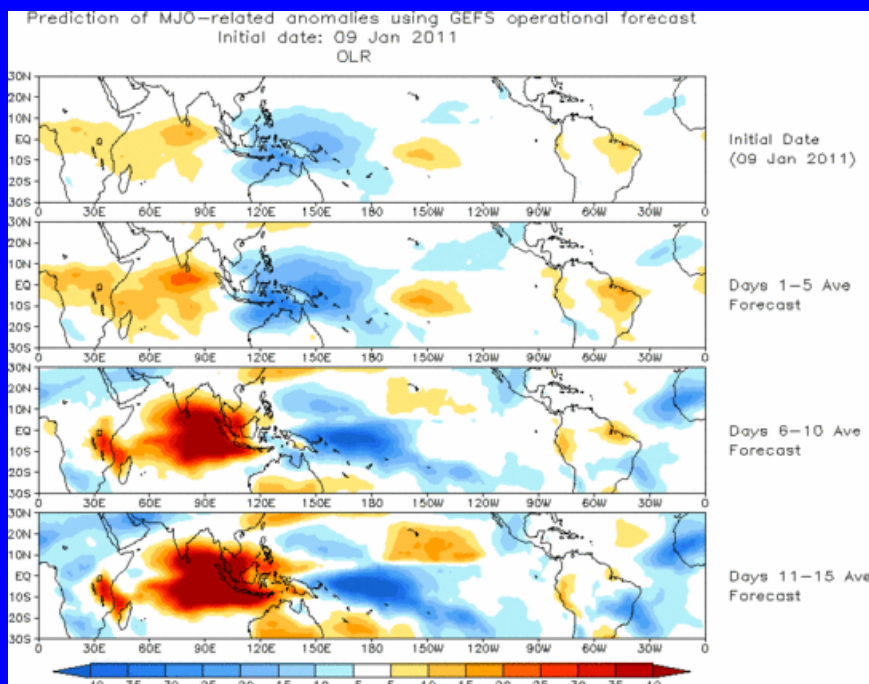




Ensemble Mean GFS MJO Forecast

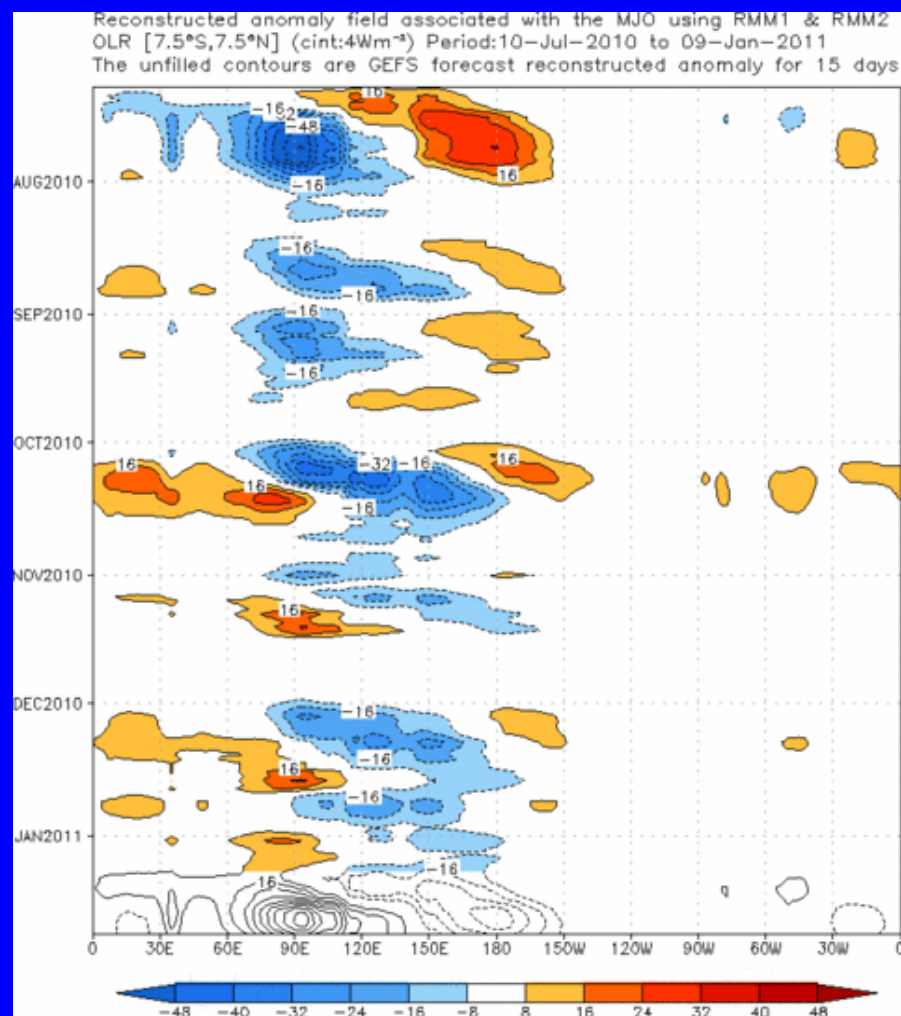
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons)

Spatial map of OLR anomalies for the next 15 days



The GEFS ensemble mean forecast indicates enhanced convection persisting in the southwest Pacific Ocean. Suppressed convection is forecast to shift east across the Indian Ocean to the Maritime continent associated with a strengthening MJO signal.

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





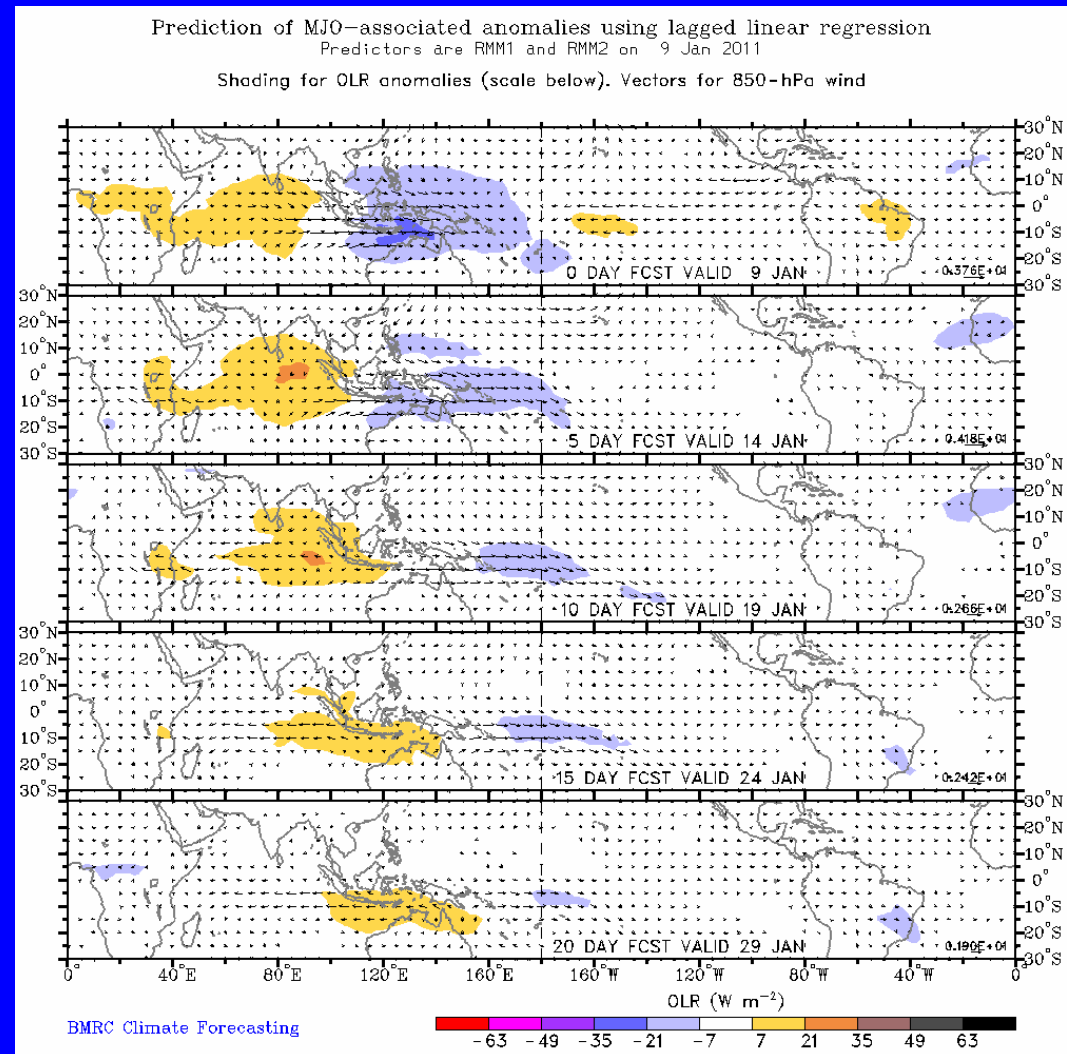
Statistical MJO Forecast

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)

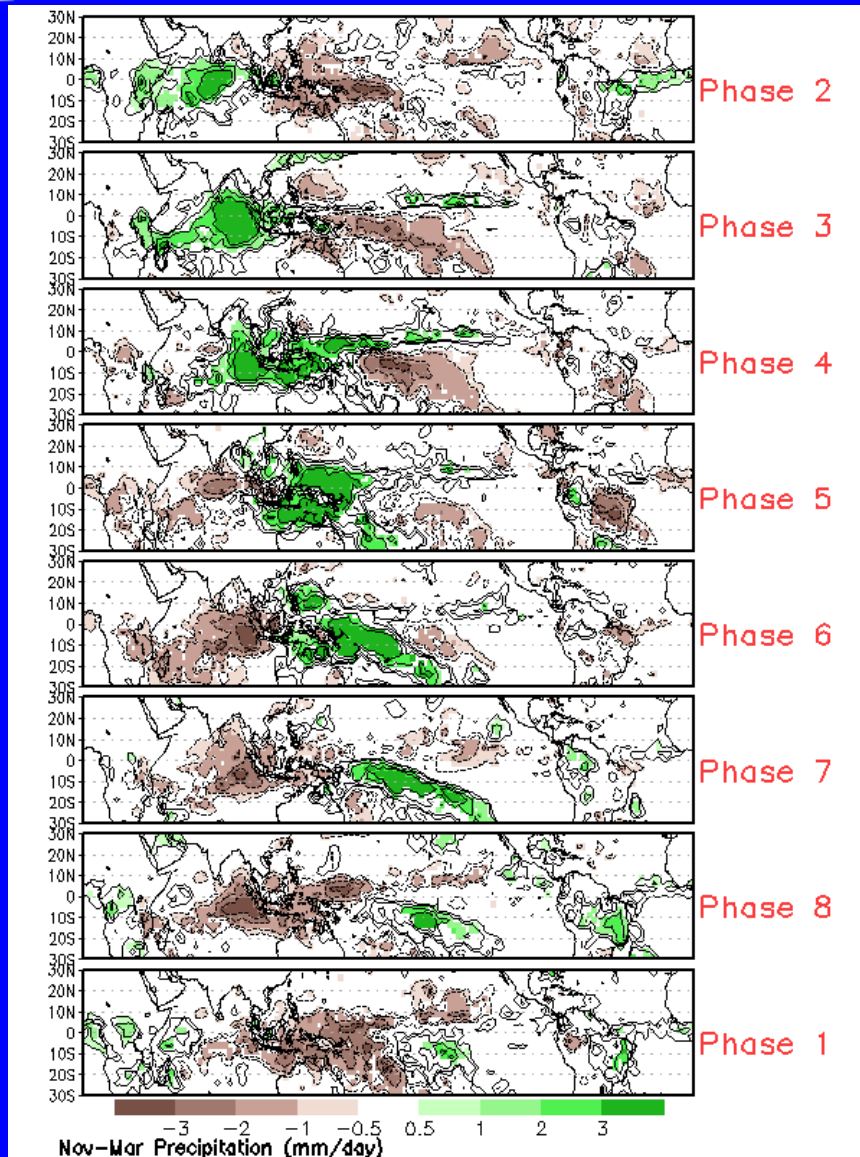
MJO activity is forecast to increase
during the next two weeks with a drying
trend forecast across the Maritime
Continent.



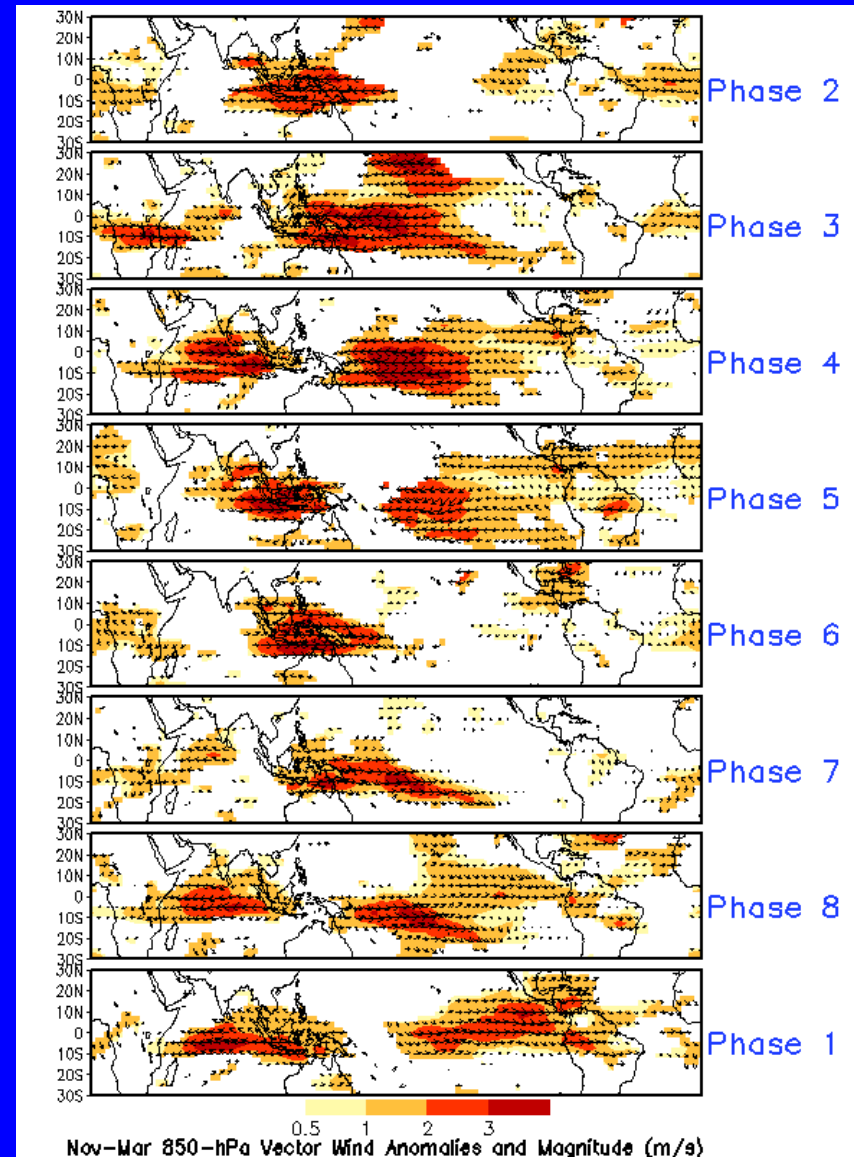


MJO Composites – Global Tropics

Precipitation Anomalies (Nov-Mar)



850-hPa Wind Anomalies (Nov-Mar)

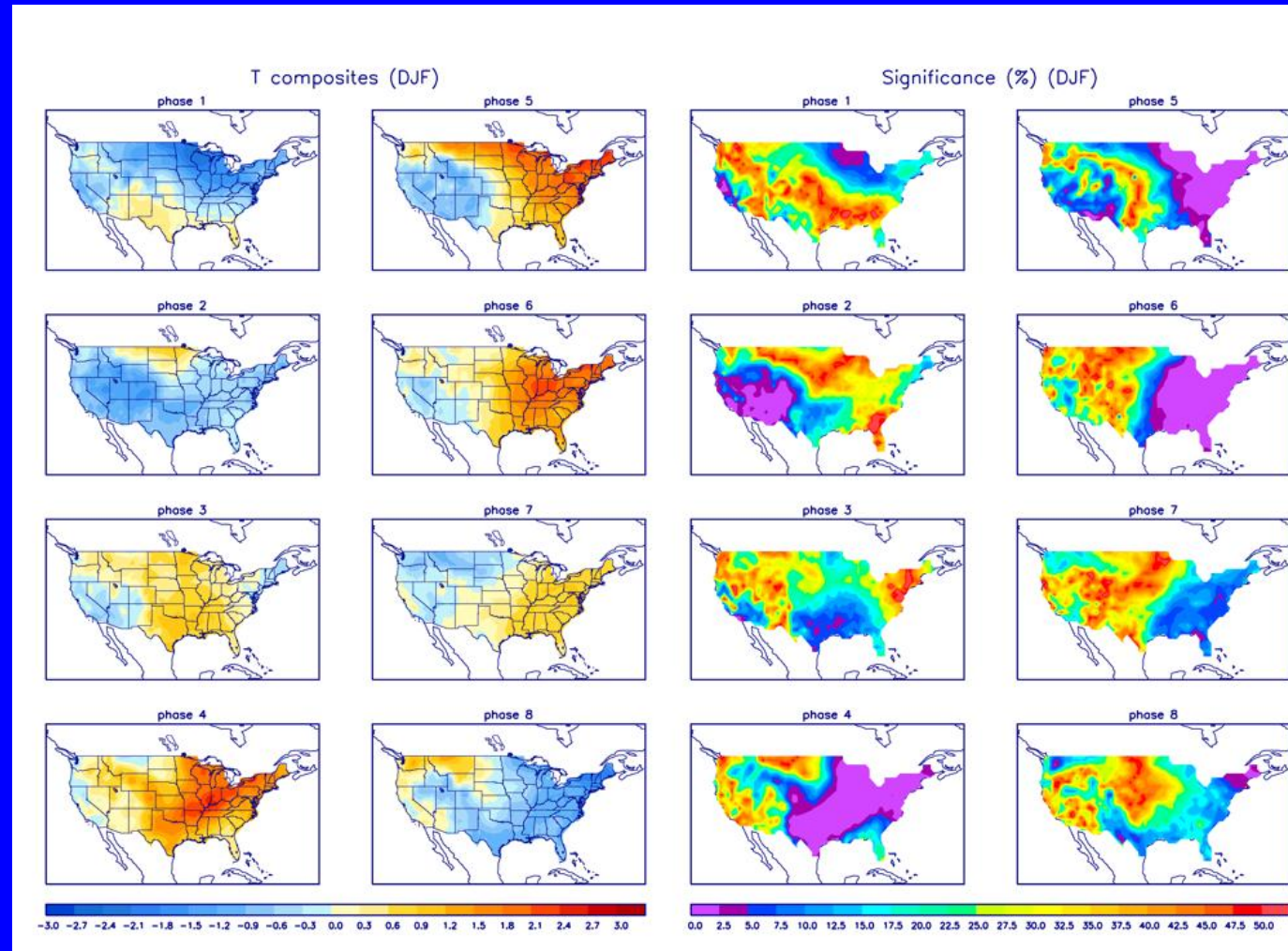




U.S. MJO Composites – Temperature

- 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.



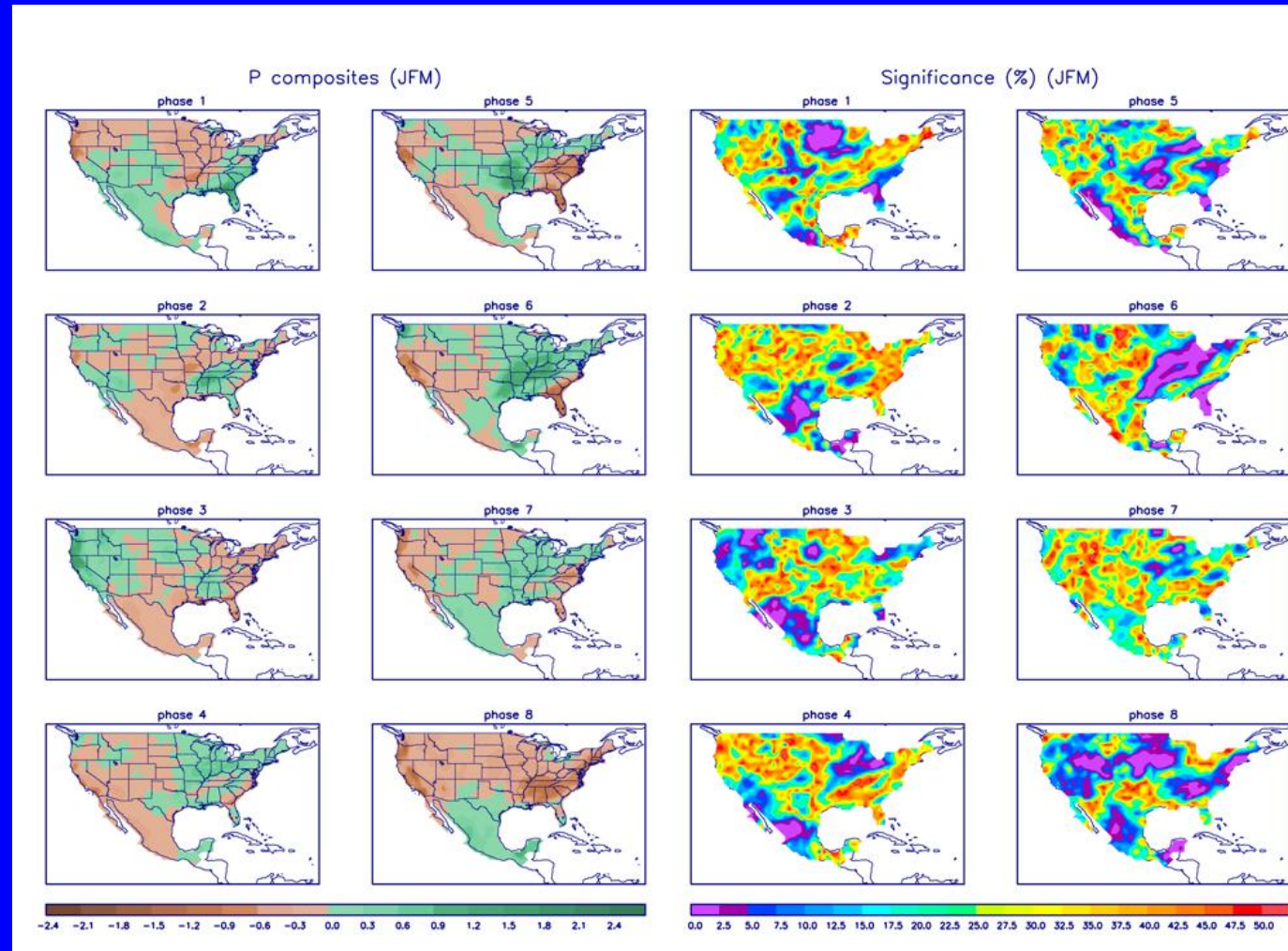
Zhou et al. (2010): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, Submitted.

<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>