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

Update prepared by
Climate Prediction Center / NCEP
December 5, 2011

Outline

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

Overview

- The MJO remained active during the past week with the enhanced convective phase centered across the Maritime continent.
- The majority of dynamical model MJO index forecasts substantially weaken the MJO signal during the period. Model forecasts often struggle in this region and the assessment favors continued MJO activity.
- Based on the latest observations and some MJO forecasts, the MJO is forecast to remain active during the period with the enhanced phase shifting across the Maritime continent to the western Pacific Ocean.
- The MJO is expected to contribute to enhanced rainfall across the Maritime Continent, while suppressed rainfall is favored for Africa (Week-1) and the Indian Ocean (Weeks 1-2).
- MJO composites keyed to the current and forecast phases of the MJO, if it remains coherent, favor above-normal temperatures for much of the east and below- (above) average precipitation for the central west coast (east central U.S.).
- If enhanced convection shifts to and persists in the western Pacific, the East Asian-Pacific jet is likely to become stronger and extend farther east across the Pacific than recently, most likely toward the end of Week-2 and during Week-3.

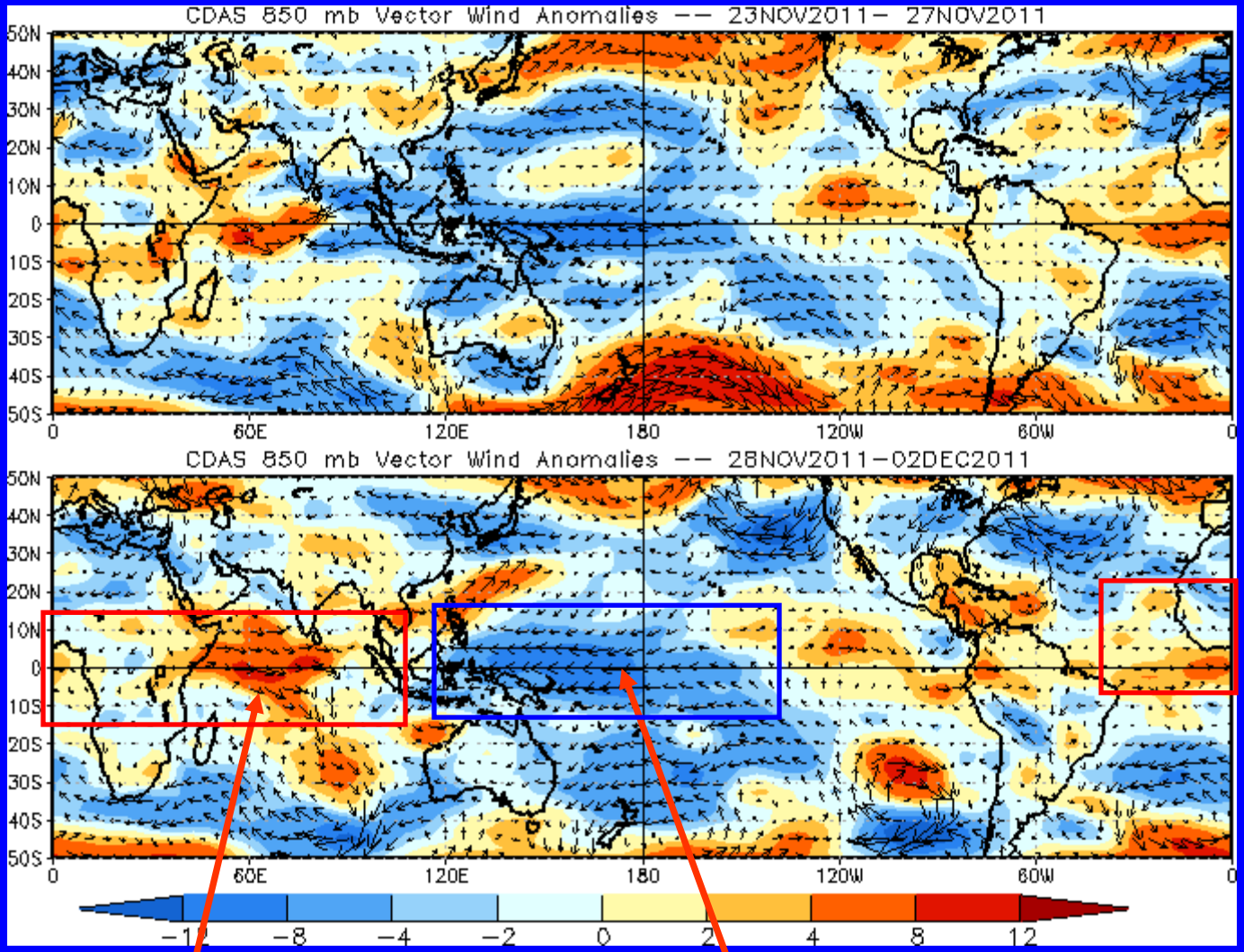
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



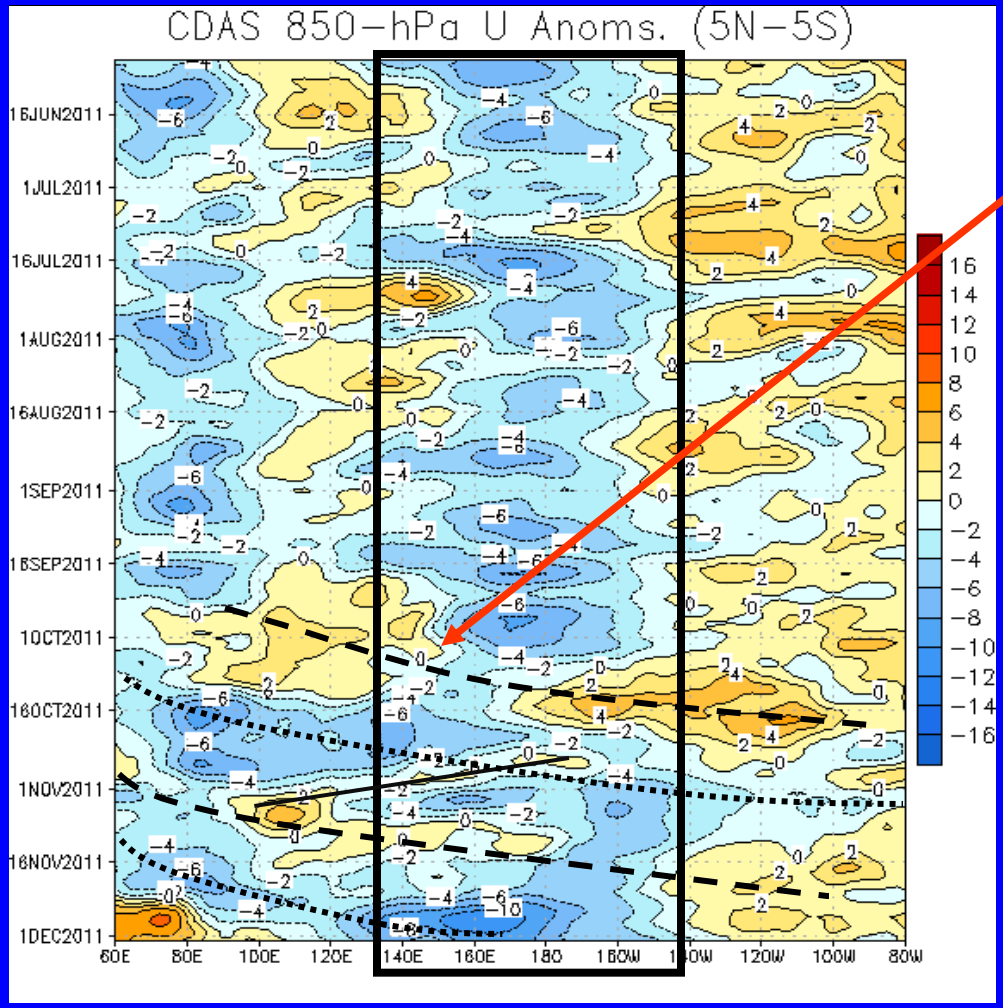
Westerly wind anomalies have strengthened over the Indian Ocean.

Easterly anomalies have shifted from the eastern Indian Ocean into the west Pacific.

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

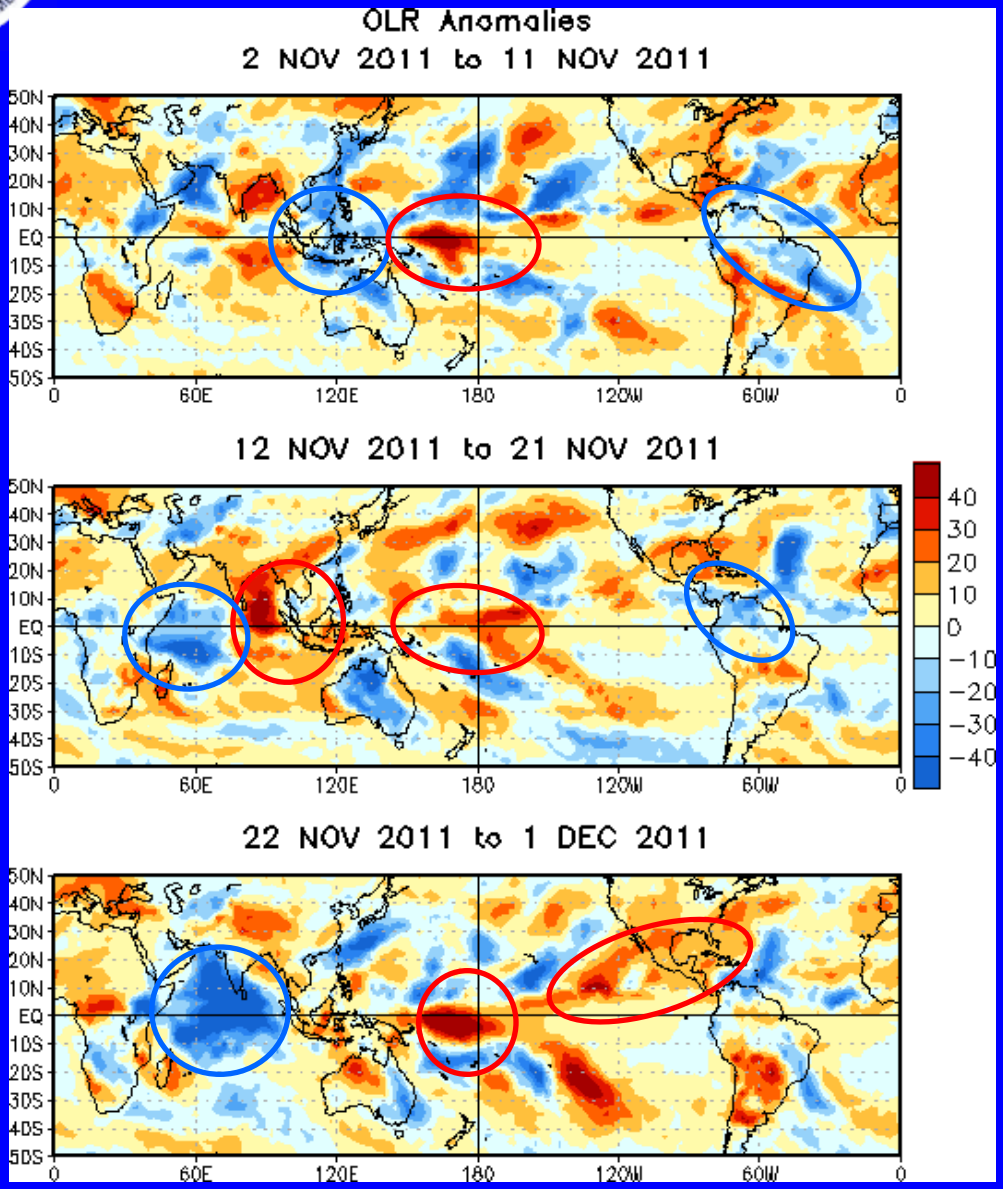
Longitude

In early October, MJO activity weakened the persistent easterly anomalies across the central Pacific (first dashed line).

An equatorial Rossby wave imparted westerly anomalies across parts of the western Pacific and Maritime continent during late October and early November (thin solid line).

MJO activity has continued into December (altering dashed and dotted lines) and most recently westerly anomalies across the Indian Ocean and easterly anomalies across the Maritime Continent and Pacific Ocean are evident.

OLR Anomalies – Past 30 days



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

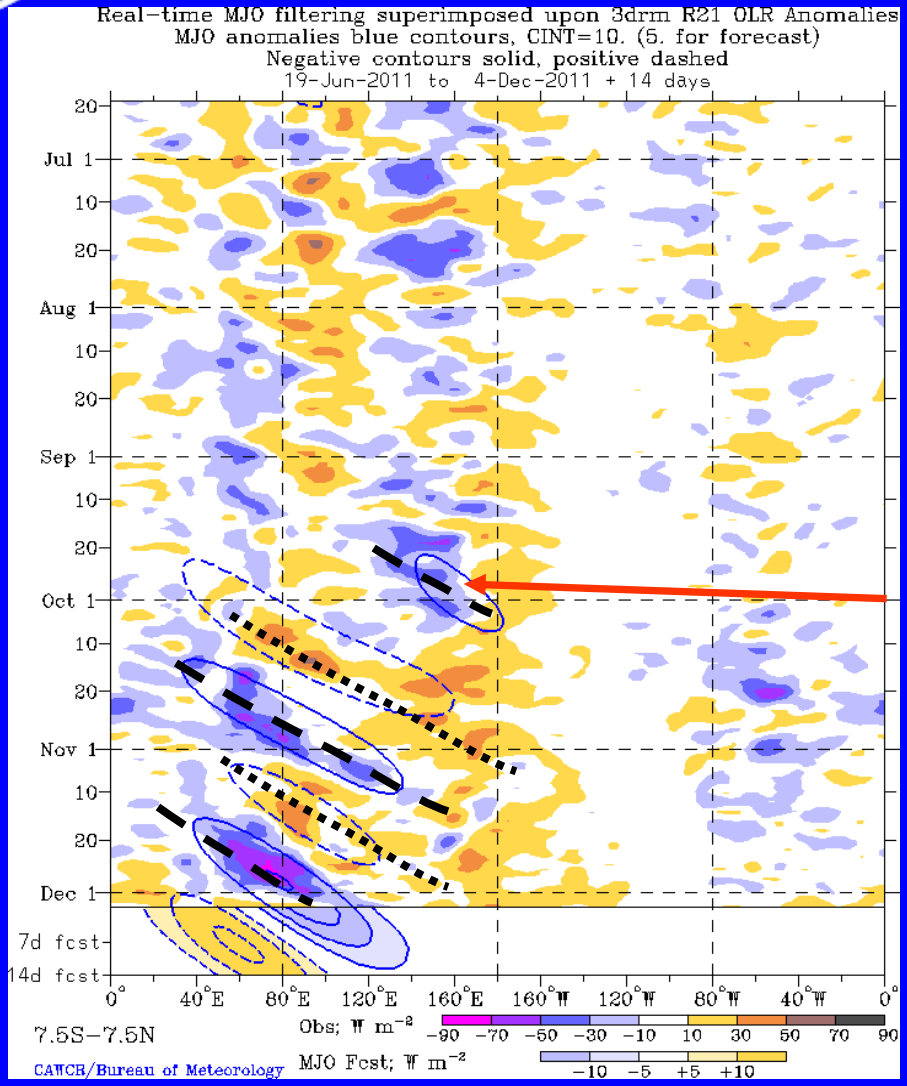
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early November suppressed convection (red circle) was observed across the Western Pacific, while enhanced convection (blue circle) covered portions of the Americas and Maritime Continent.

During mid November enhanced convection persisted over northern South America, developed over the western Indian Ocean, with suppressed convection shifting to the Maritime Continent, consistent with MJO activity at that time. Suppressed convection continued over the Western Pacific near the Date Line.

During late November, suppressed convection developed over parts of the eastern Pacific and Central America while enhanced convection strengthened and spread over most of the 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 CAWCR Australia Bureau of Meteorology)

Little MJO activity was observed during June, July and August.

Beginning in mid-September, enhanced convection shifted from southern Asia to the western Pacific while suppressed convection developed during late September across India and also shifted eastward to the western Pacific.

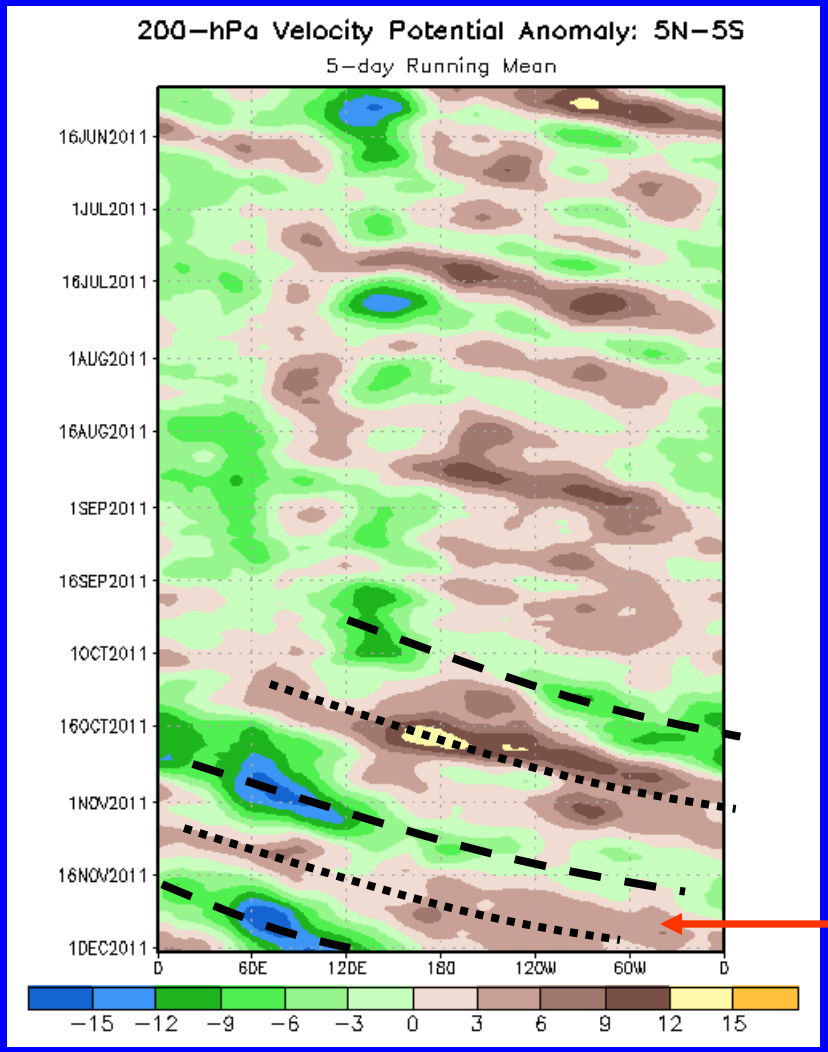
A second cycle of enhanced and suppressed convection was evident during the second half of October and first half of November.

Most recently, enhanced convection is shifted through the Indian Ocean with suppressed convection over the central Pacific Ocean.

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

During parts of June, July and August very fast eastward propagation was evident at times and mainly associated with higher frequency sub-seasonal coherent tropical variability not associated with MJO activity.

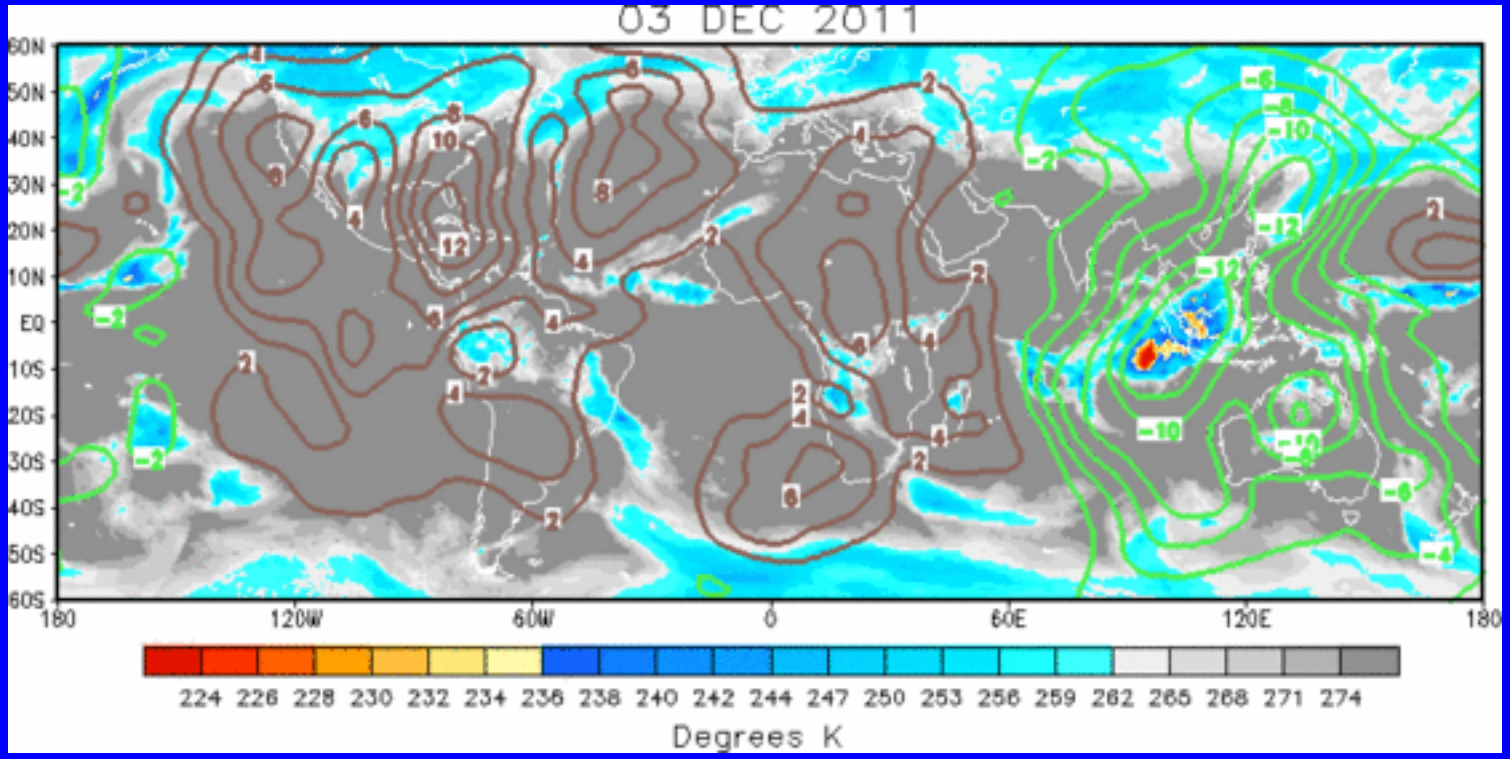
During the second half of September negative anomalies developed across the Western Pacific, with positive anomalies in the Indian Ocean, consistent with MJO genesis and subsequent circumglobal propagation.

Recently, negative anomalies are moving through the Indian Ocean and Maritime Continent with positive anomalies across the western Hemisphere and Africa in concert with the ongoing MJO event.

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

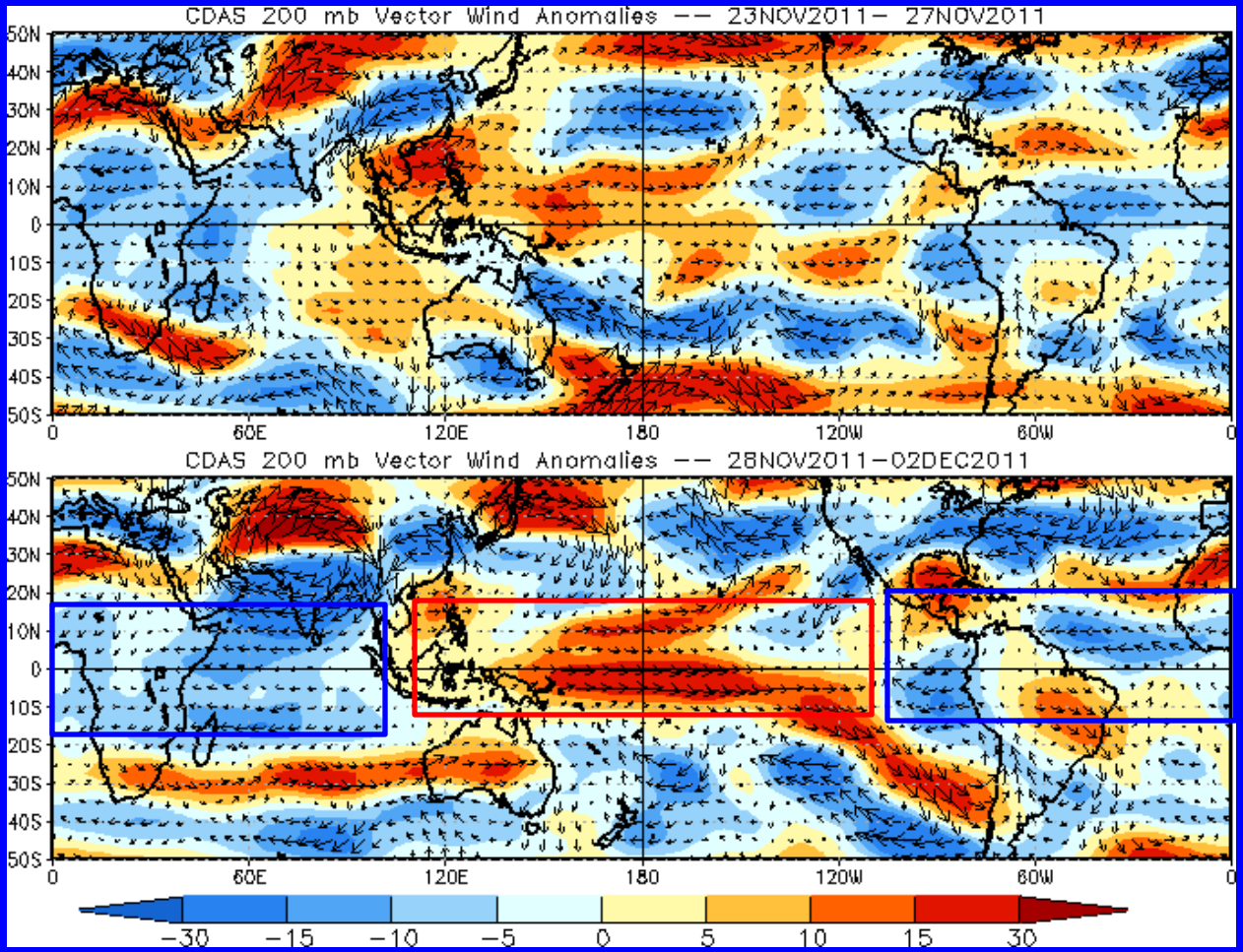
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern exhibits a coherent wave-1 structure. Anomalous upper-level divergence is centered across the eastern Indian Ocean and Maritime Continent with anomalous upper-level convergence across the western Hemisphere and Africa.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

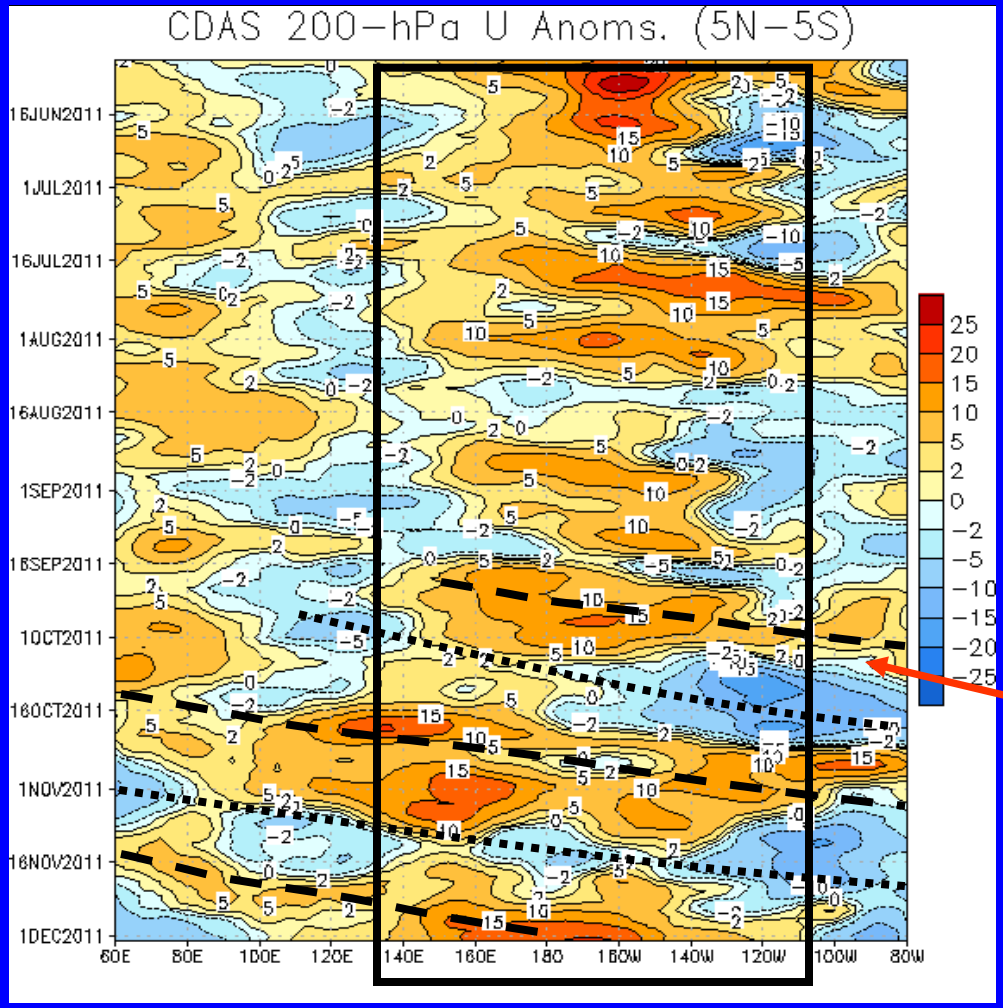
Red shades: Westerly anomalies

Upper-level westerly wind anomalies shifted through the Maritime Continent and strengthened in the west Pacific Ocean with easterly anomalies entrenched from the Atlantic Ocean, through Africa, and into the Indian Ocean.

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



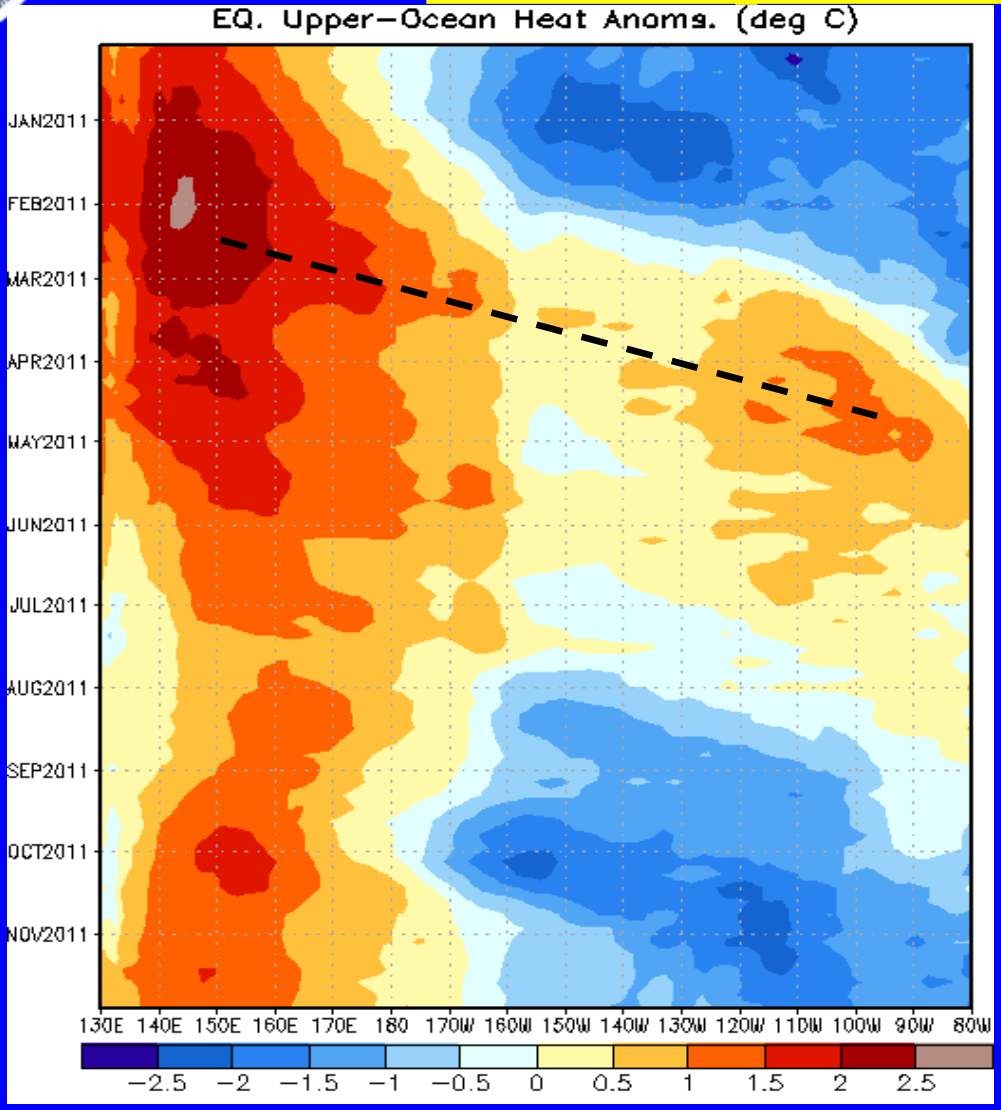
Time

Longitude

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

Westerly anomalies over the Pacific strengthened during late September and have shifted eastward during October and November associated with the MJO.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

Since the beginning of January 2011, positive heat content anomalies 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. Much of the Pacific basin now indicates above- or near-normal integrated heat content.

Since the beginning of August, negative heat content anomalies are evident across the equatorial central and eastern 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).

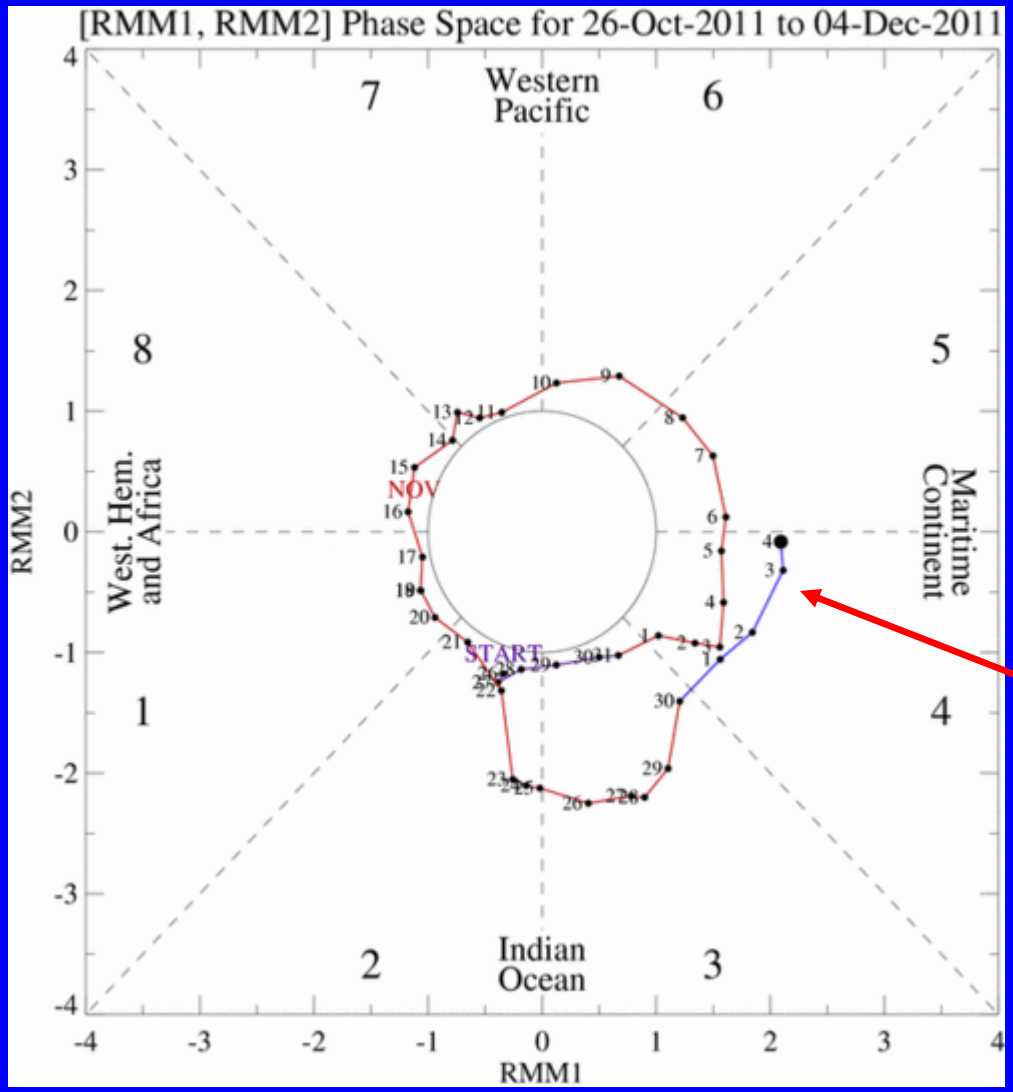
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

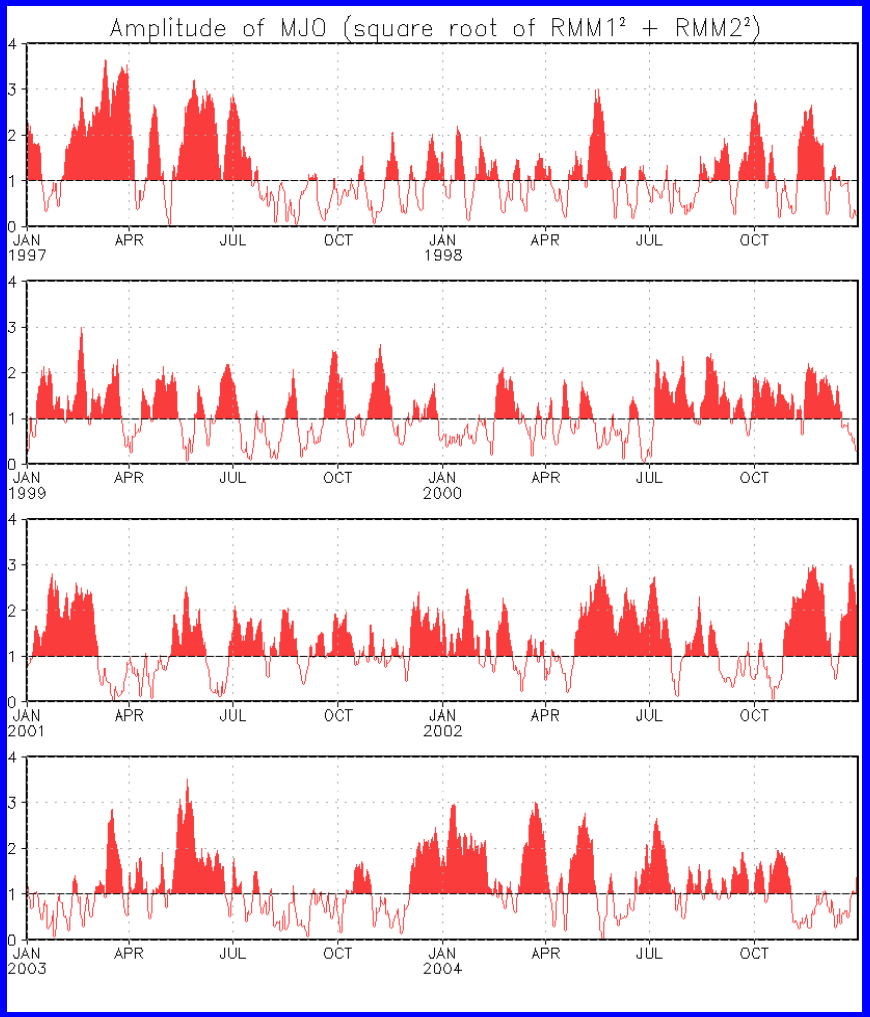
MJO Index -- Recent Evolution

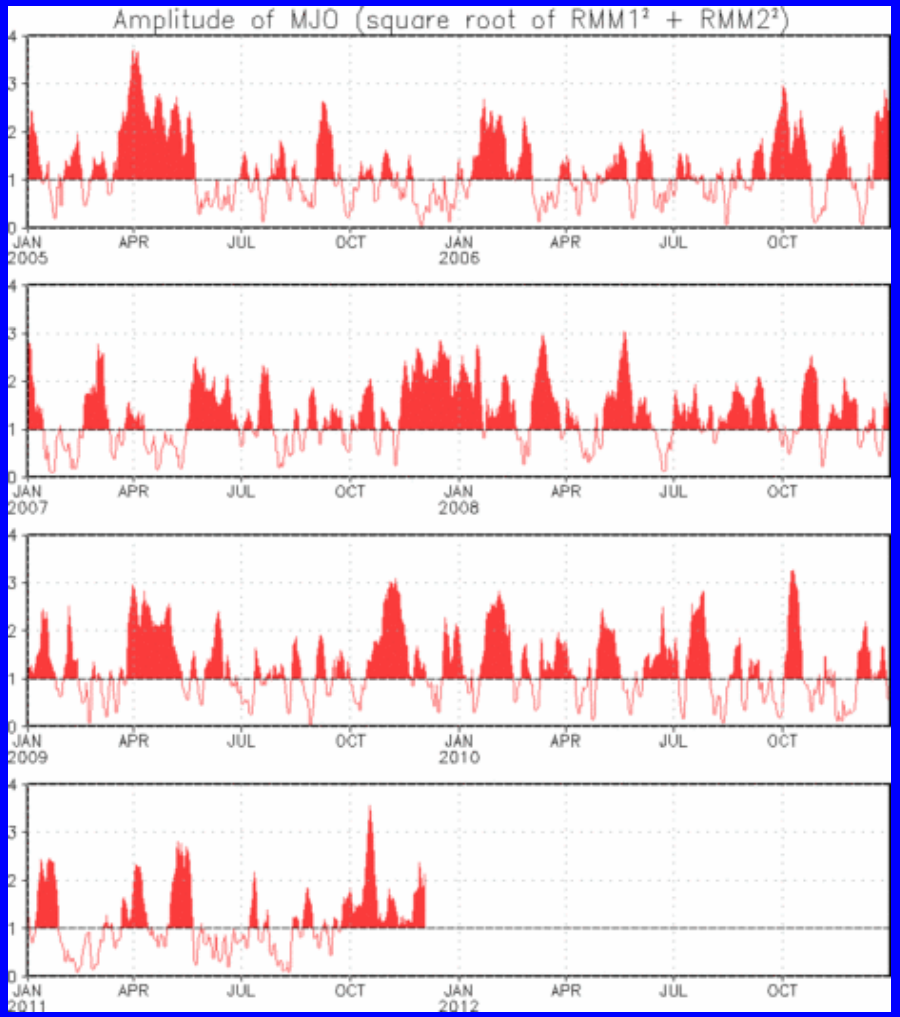


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index has continued its eastward propagation during the past week.

MJO Index – Historical Daily Time Series





Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

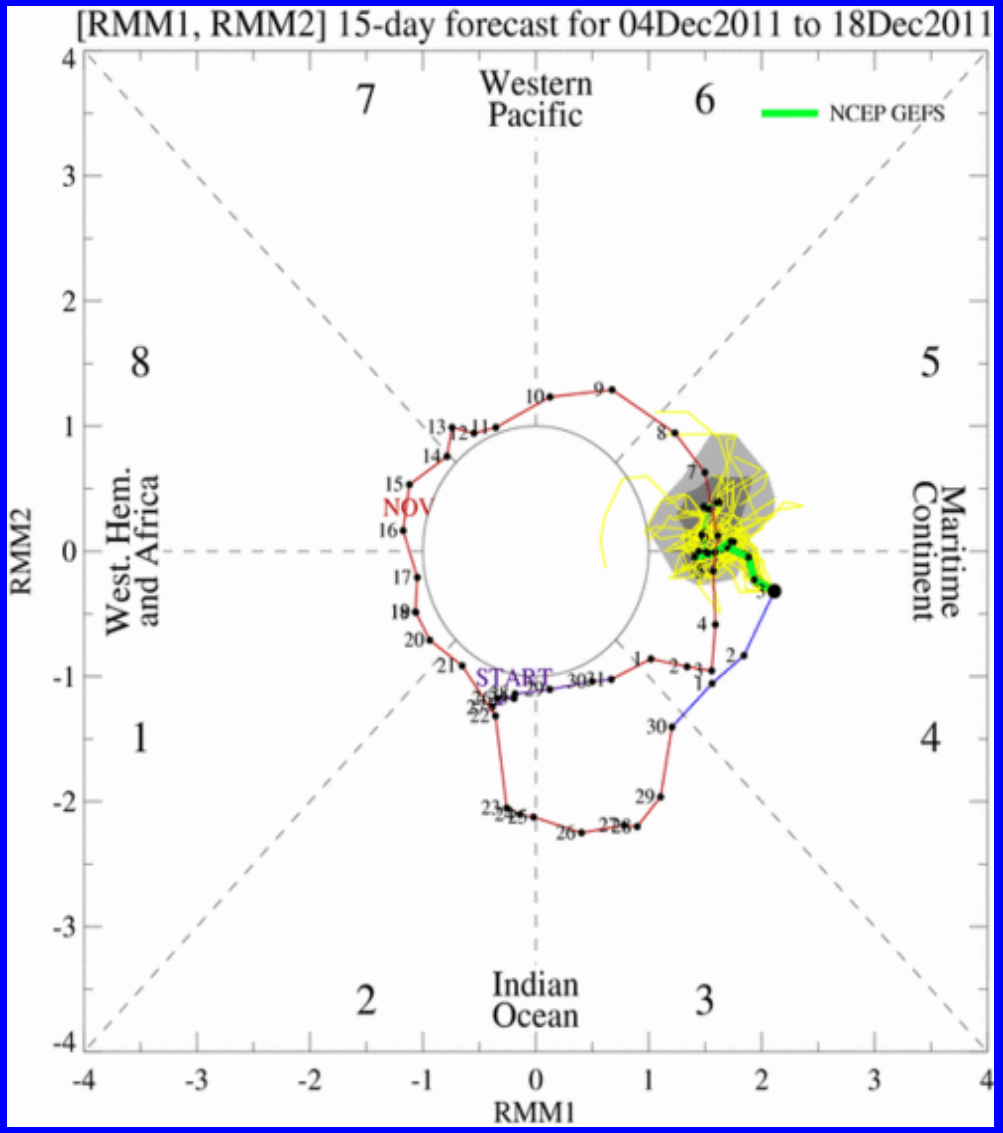
Ensemble GFS (GEFS) MJO Forecast

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

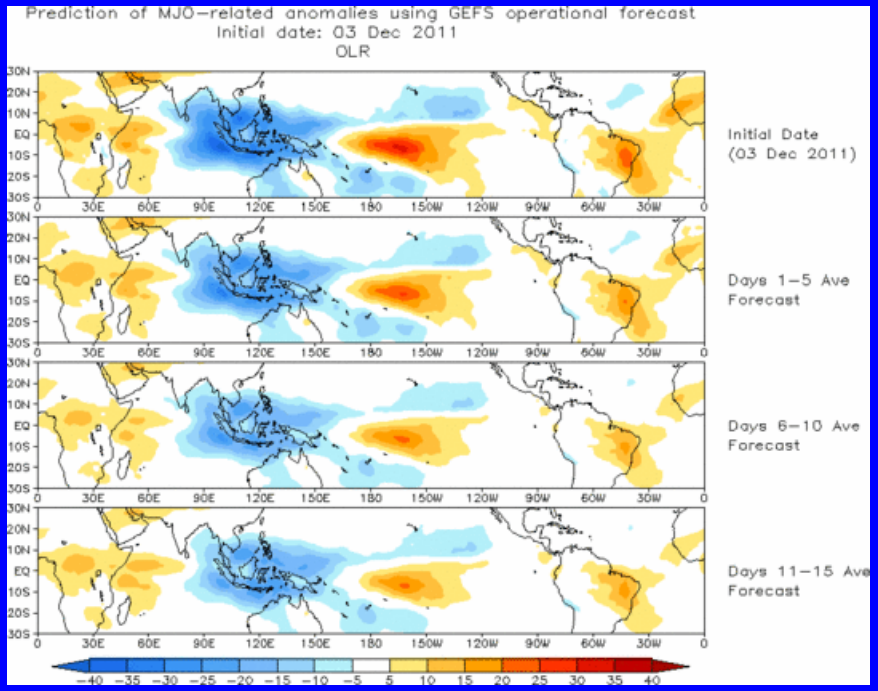
The ensemble GFS forecasts indicate minor eastward propagation with a weakening signal becoming less defined during Week-2.



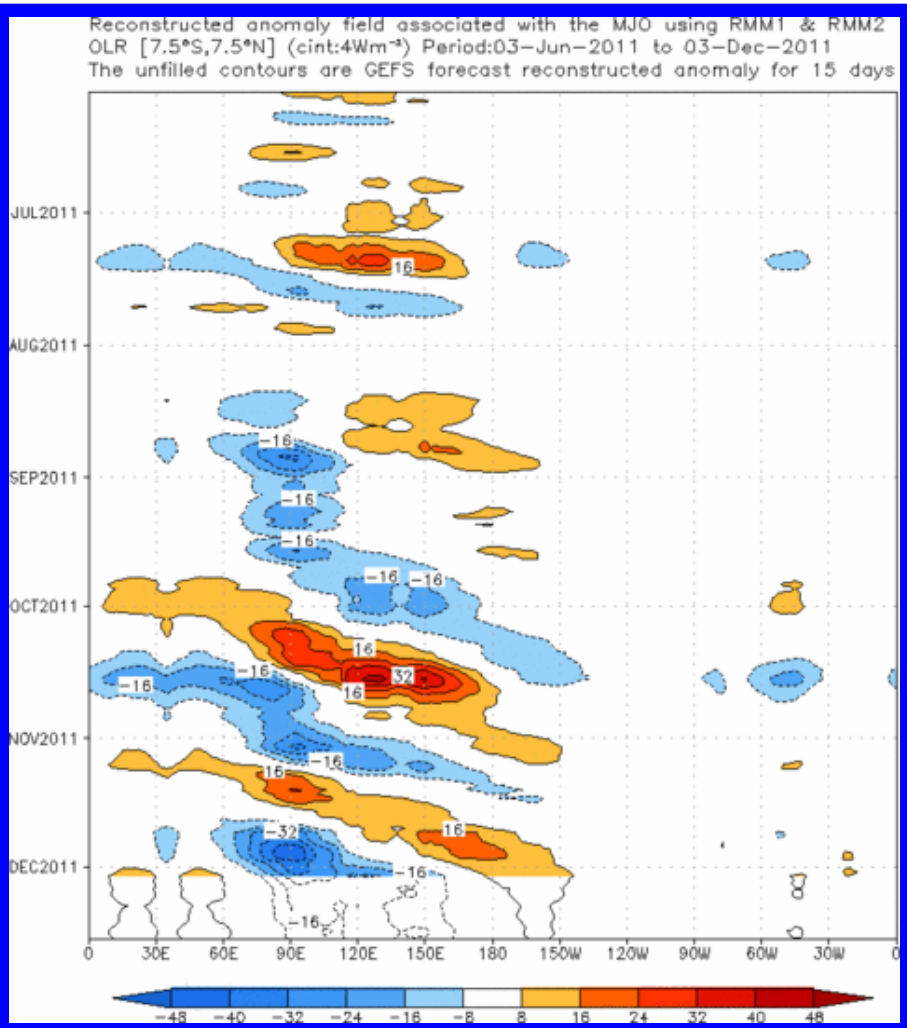
Ensemble Mean GFS MJO Forecast

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, etc.)

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

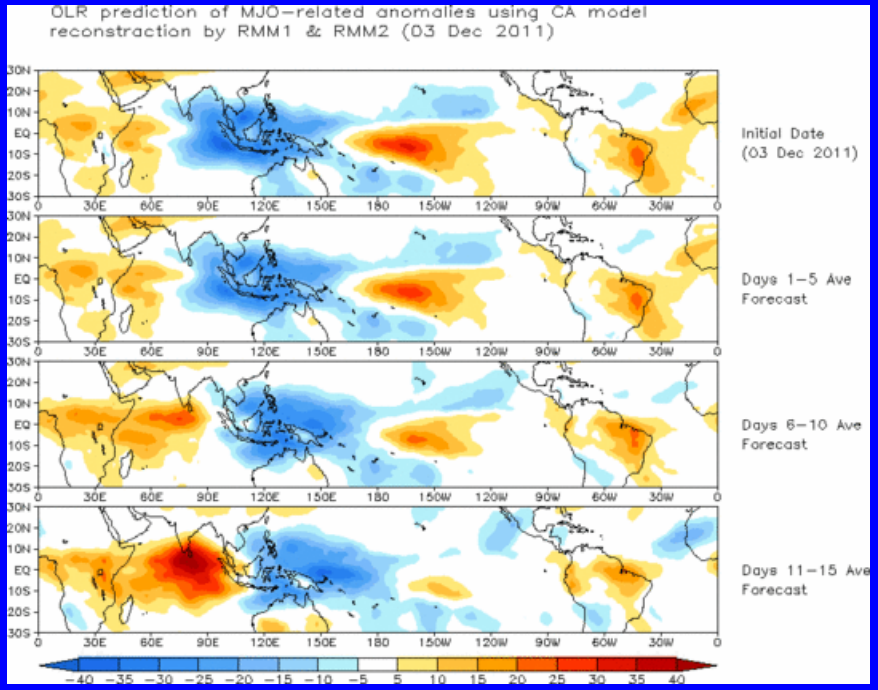


The ensemble mean GFS forecast indicates a persistent region of enhanced convection over the eastern Indian Ocean and Maritime Continent during Week-1, and a slight eastward shift through the Maritime Continent in Week-2

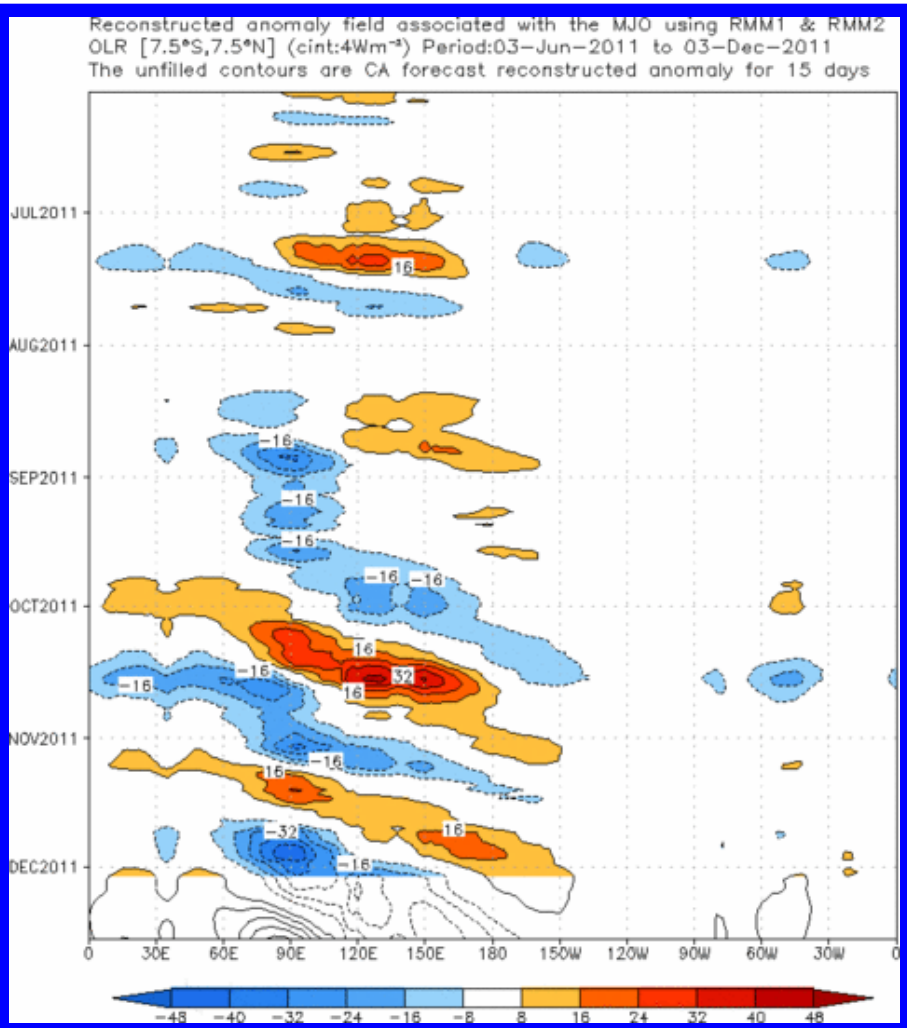
Constructed Analog (CA) MJO Forecast

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, etc.)

Spatial map of OLR anomalies for the next 15 days



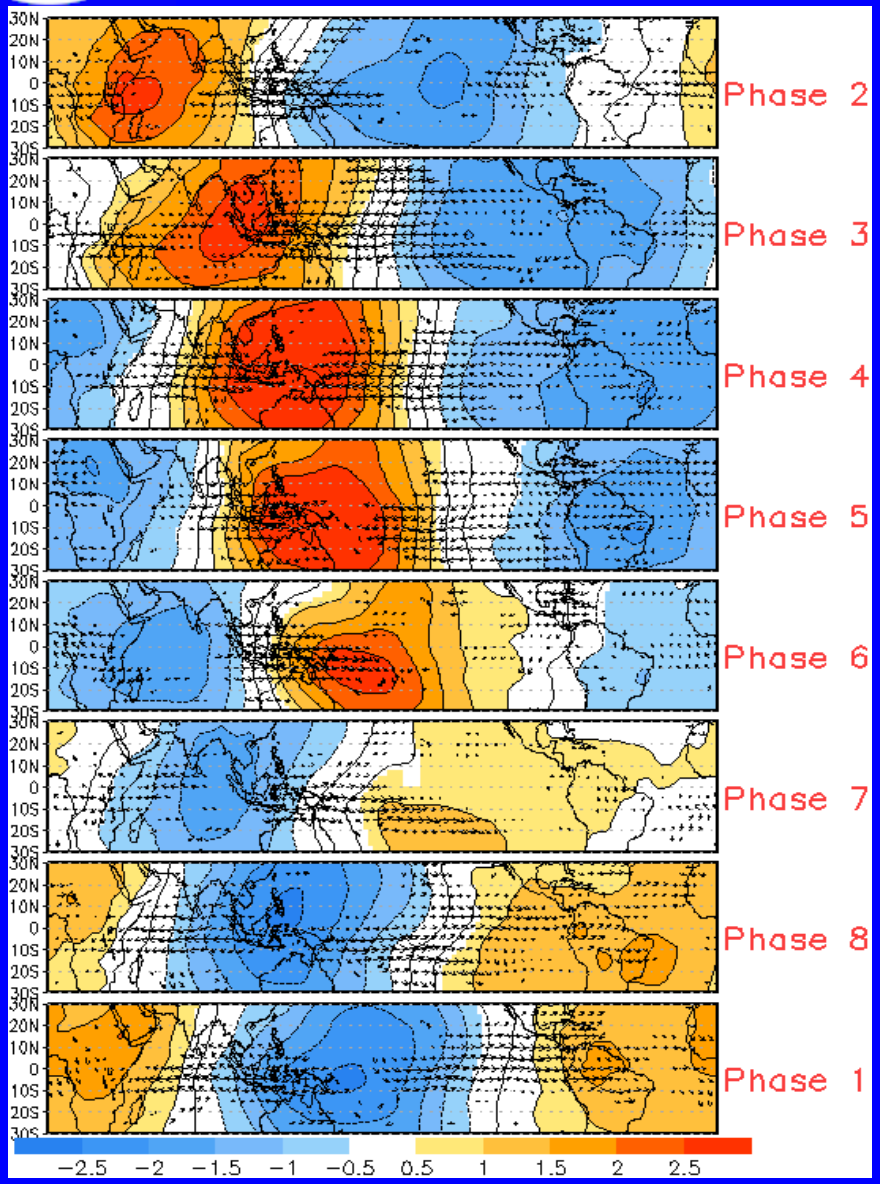
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



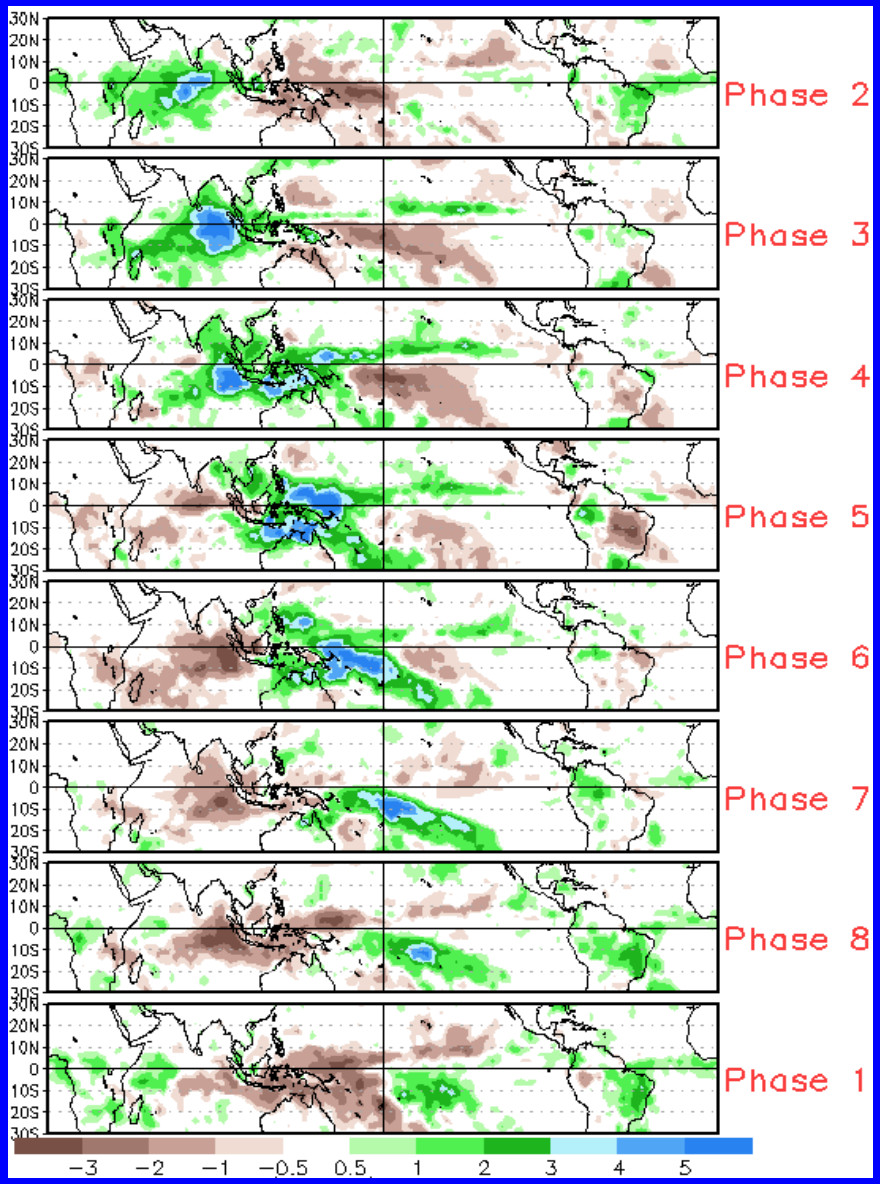
The CA forecast indicates eastward propagation with enhanced convection shifting through the Maritime Continent during Week-1, and the development of suppressed convection over the Indian Ocean during Week-2.

MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

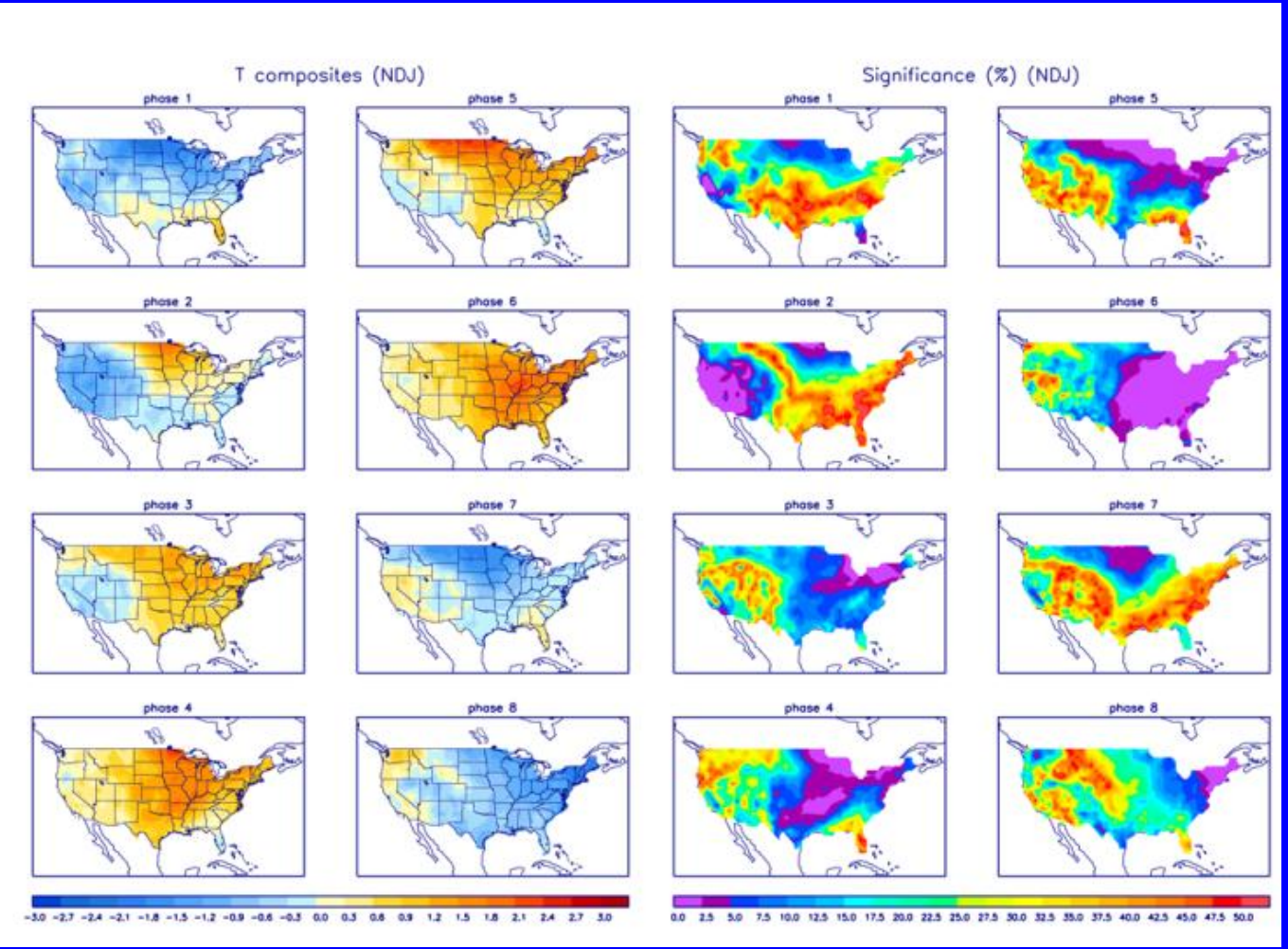


Precipitation Anomalies (Nov-Mar)



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.**

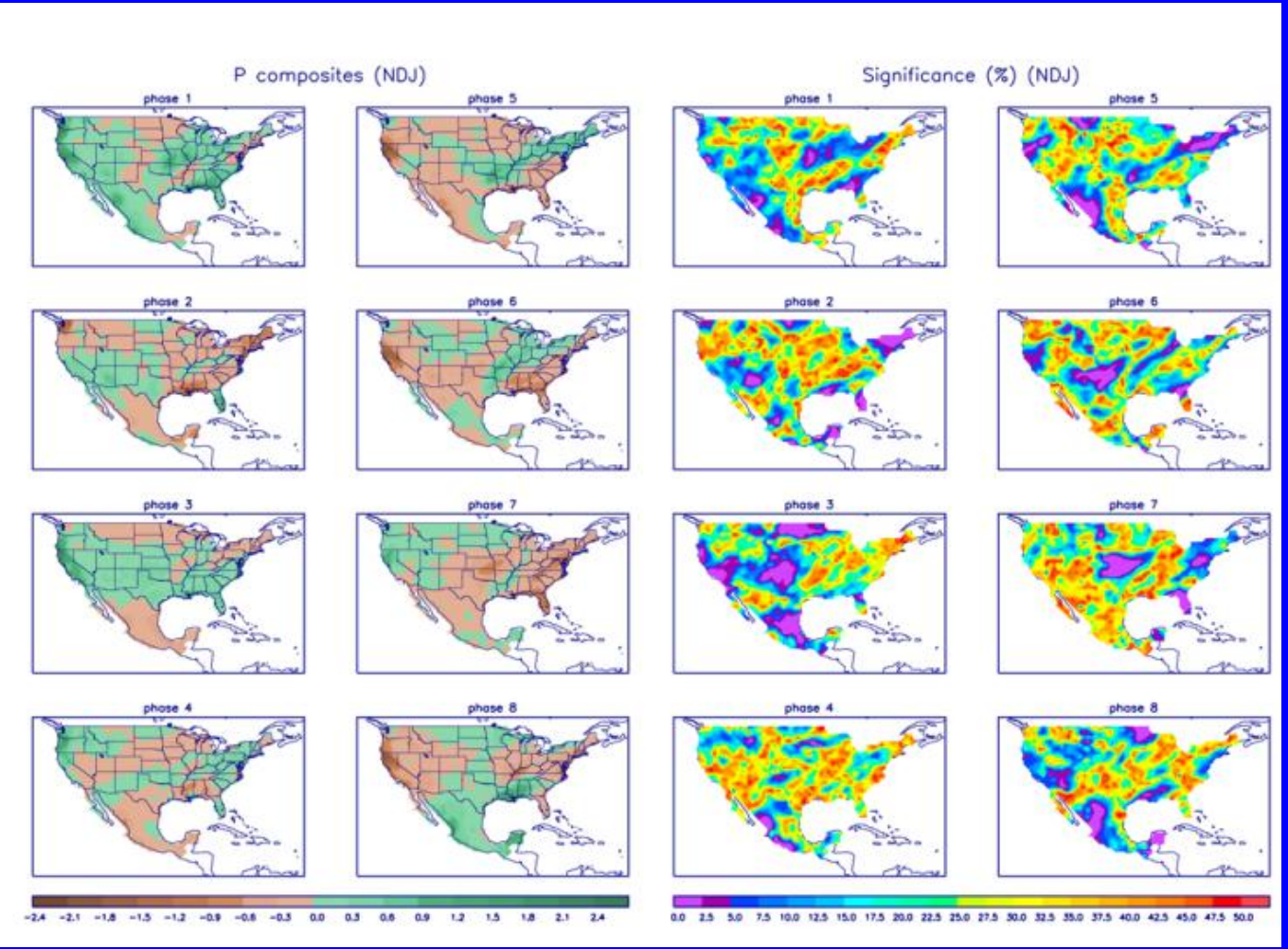


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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