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

Update prepared by
Climate Prediction Center / NCEP
November 28, 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 Indian Ocean.**

- **Dynamical model MJO index forecasts continue to indicate eastward propagation of a MJO signal during the period. Some decrease in MJO index amplitude is forecast during Week-2, but model forecasts often struggle in this region.**

- **Based on the latest observations and model MJO forecasts, the MJO is forecast to remain active during the period with the enhanced phase shifting to the Maritime continent.**

- **The MJO is expected to contribute to enhanced rainfall across the Indian Ocean and Maritime Continent, while suppressed rainfall is favored for the central Pacific (Week-1 and Week-2) and parts of Africa (Week-2).**

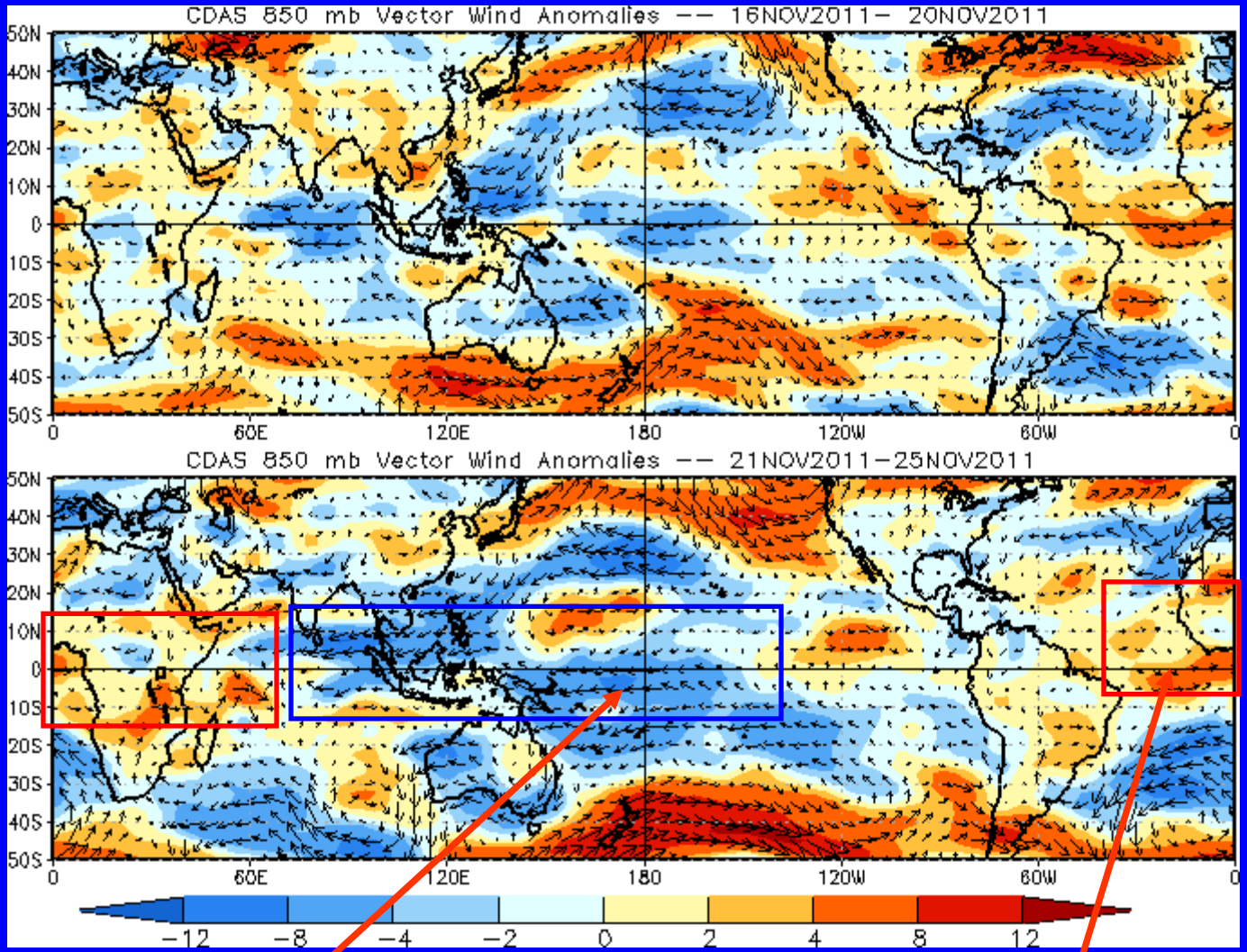
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



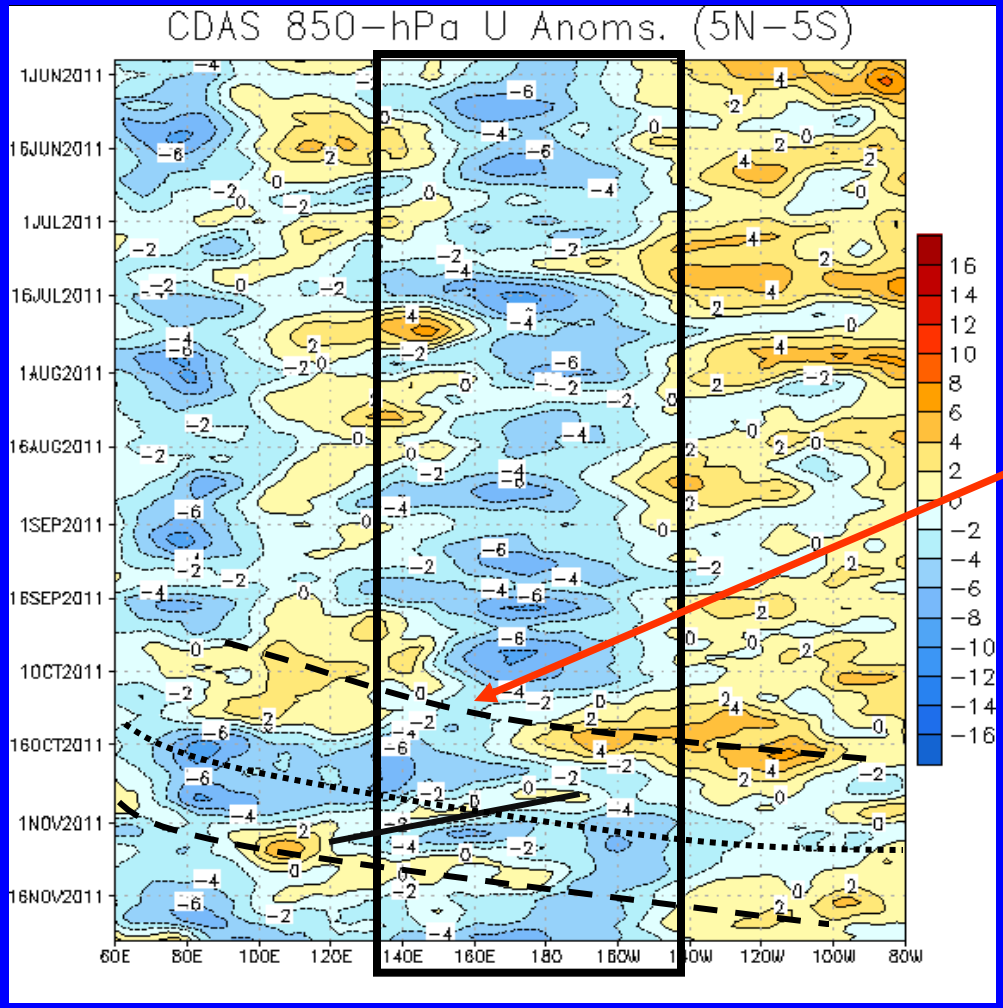
Easterly wind anomalies have strengthened across the western Pacific, Maritime Continent, and Indian Ocean.

Westerly anomalies persisted across the Atlantic and Africa and increased in parts of the western Indian Ocean during the last 5 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

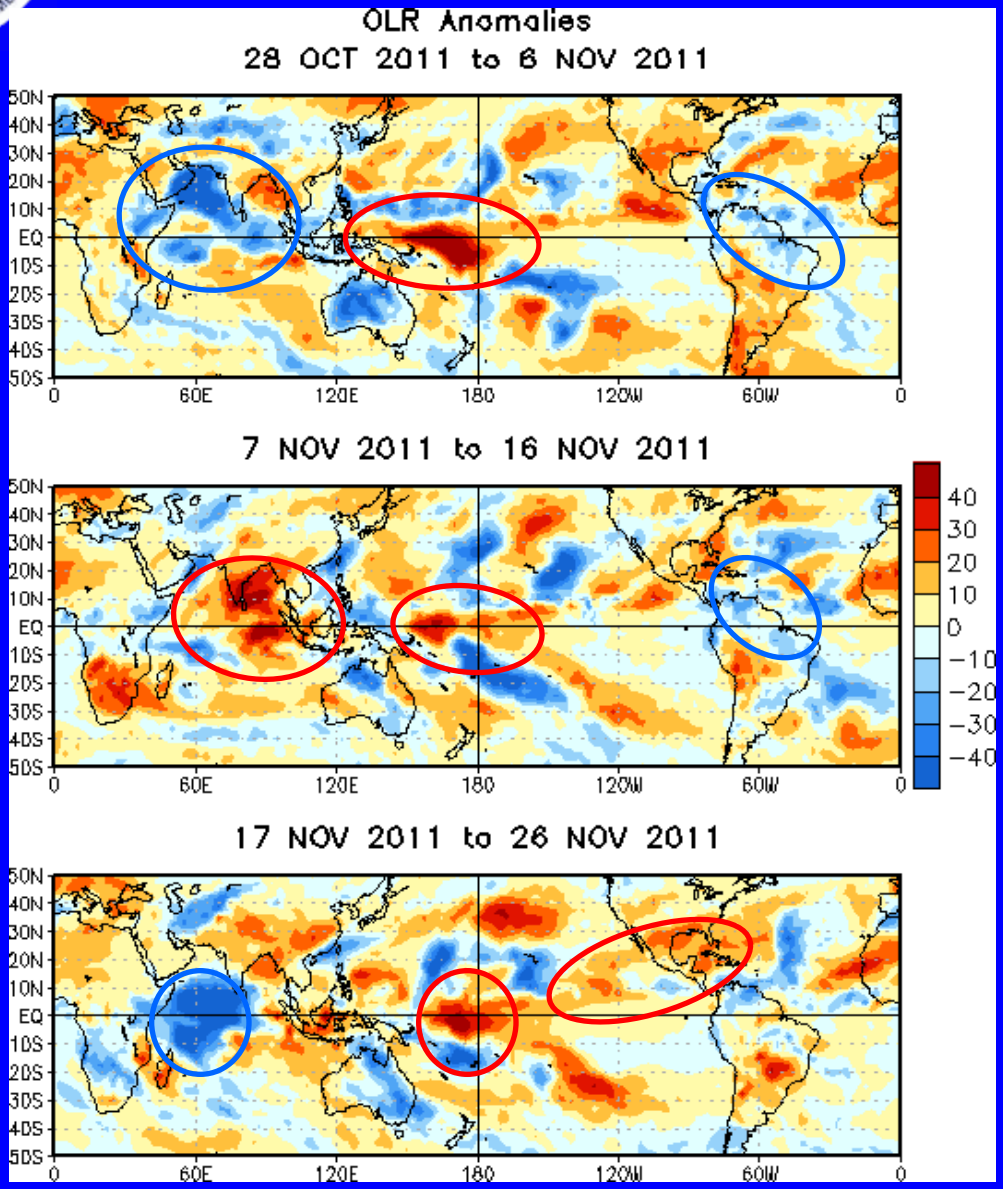
Easterly anomalies persisted across the west-central Pacific since May (black box) consistent with La Nina conditions during much of the period. The magnitude of these anomalies has varied during the period.

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

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

Recently, continued eastward propagation of the MJO signal has contributed to westerly anomalies across the Indian Ocean and easterly anomalies across the Maritime Continent and the Pacific Ocean.

OLR Anomalies – Past 30 days



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

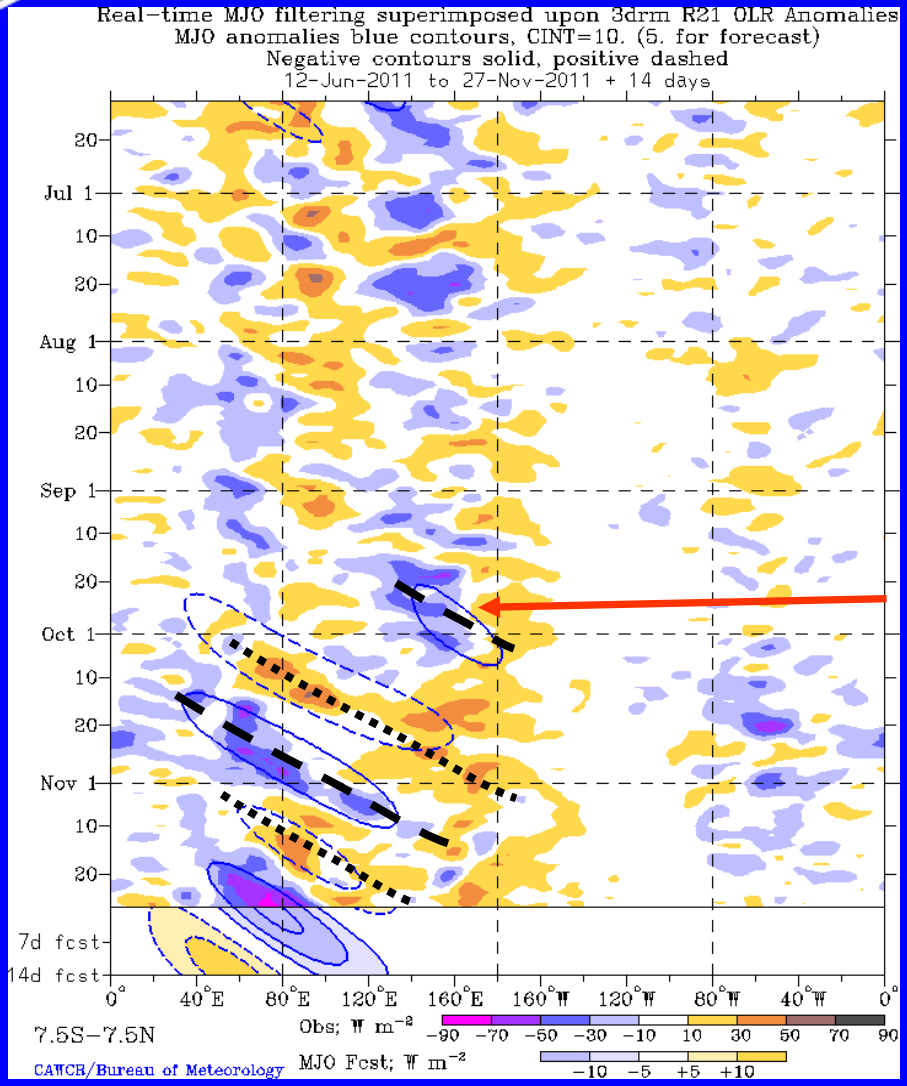
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During late October and early November suppressed convection (red circle) was observed across the Western Pacific, while enhanced convection (blue circle) covered portions of the Americas, eastern Africa, and the Indian Ocean.

During mid November enhanced convection persisted over South America, and was replaced by suppressed convection over the Indian Ocean, both consistent with MJO activity at that time. Suppressed convection continued over the Western Pacific near the Date Line.

During mid-to-late November, suppressed convection developed over parts of the eastern Pacific, Central America and Maritime Continent. Enhanced convection developed across the western and central 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.

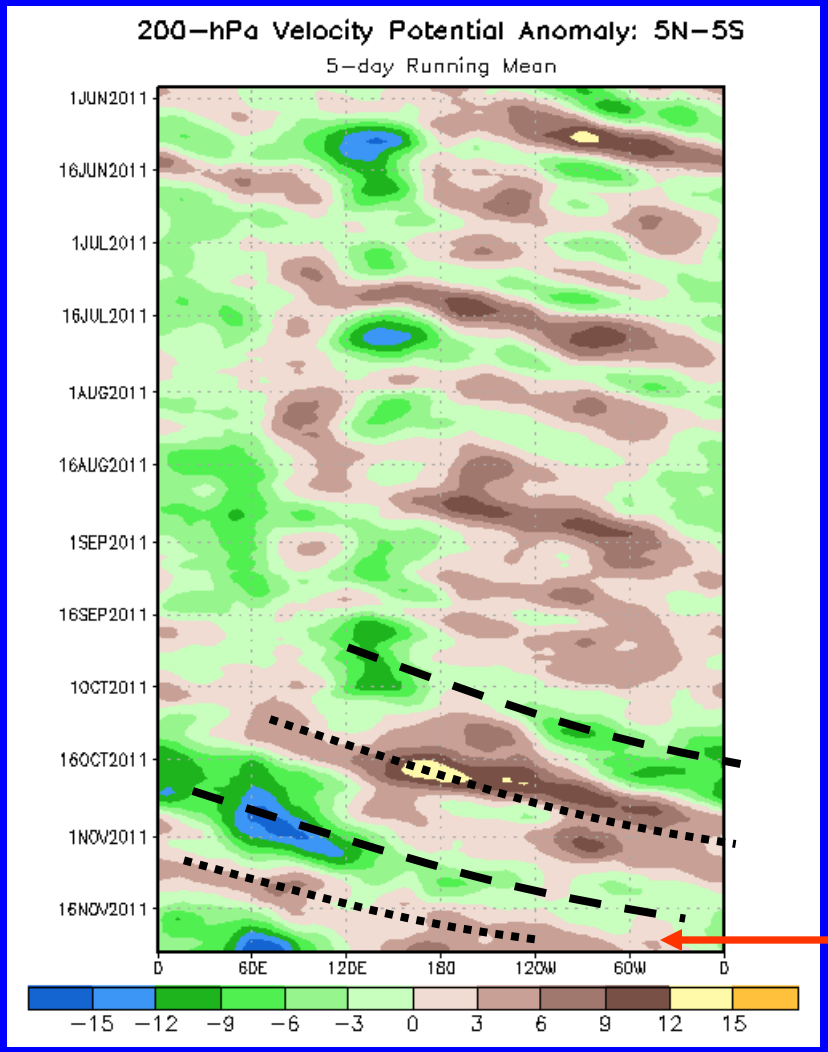
A second cycle of enhanced and suppressed convection was evident the second half of October and first half of November.

Most recently, enhanced convection has developed over 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.

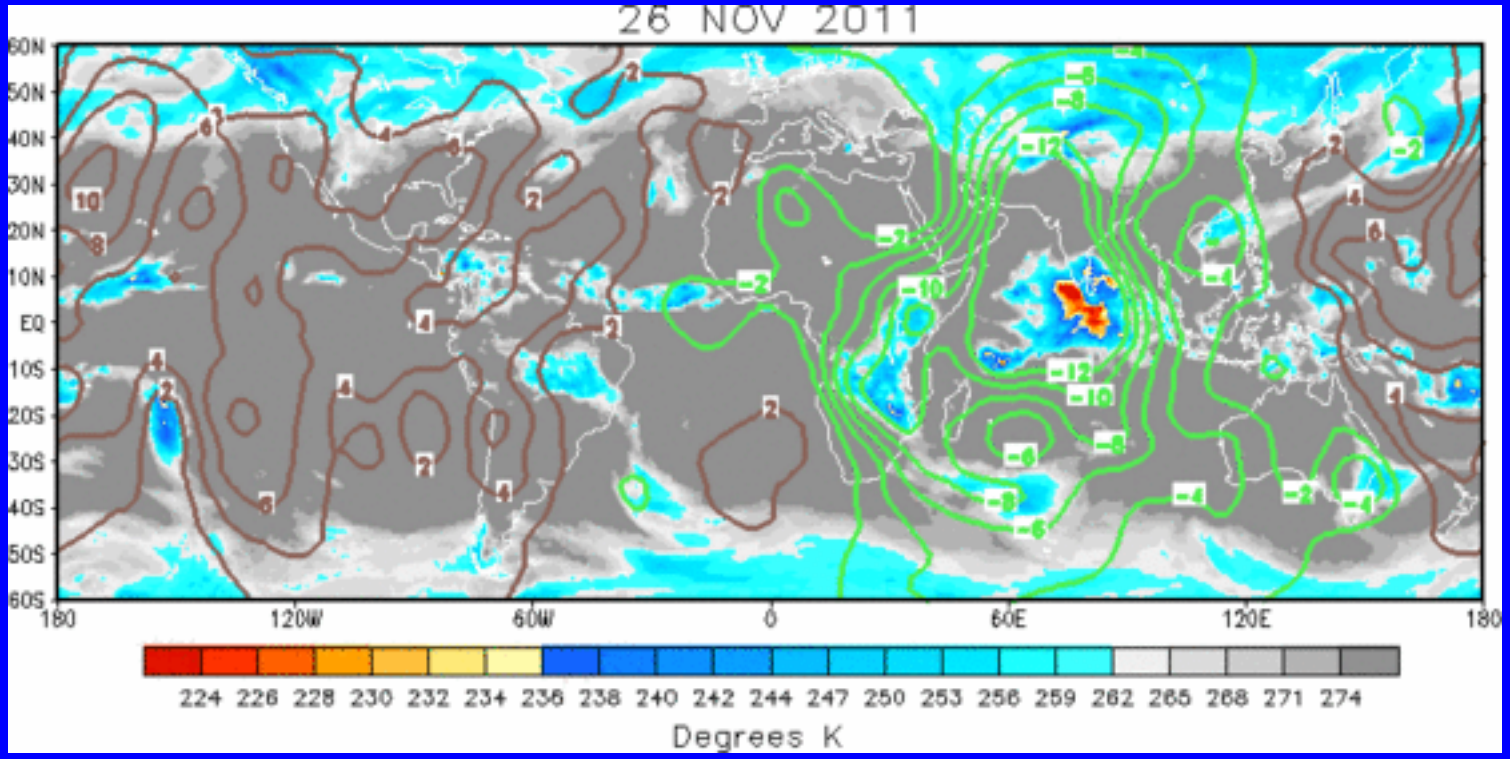
During the second half of September negative anomalies developed across the Western Pacific, with positive anomalies in the Indian Ocean, consistent with MJO genesis and subsequent circumglobal propagation.

Recently, negative anomalies have re-appeared in the Indian Ocean with positive anomalies across the Pacific Ocean in concert with the ongoing MJO event.

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

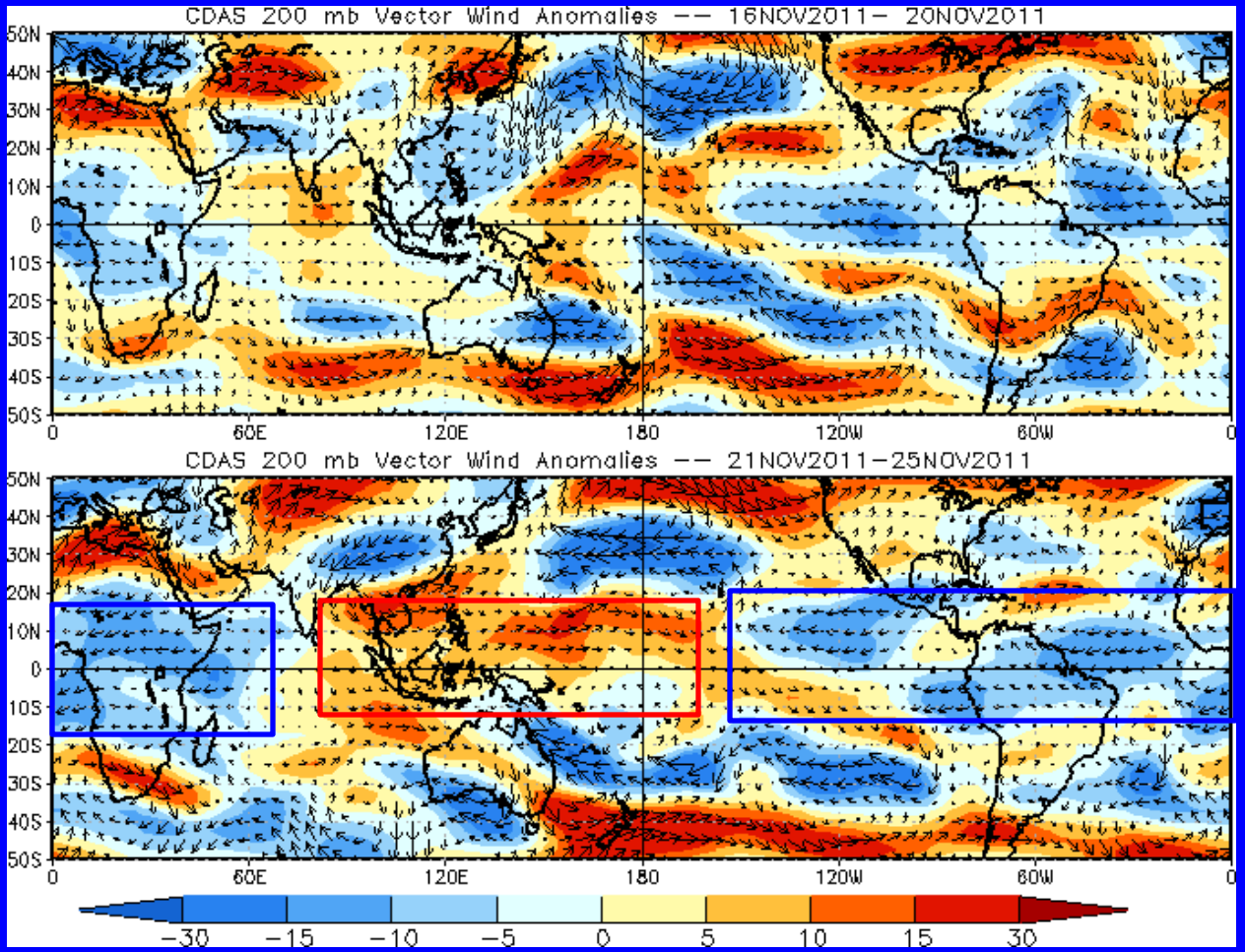
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

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 Indian Ocean with anomalous upper-level convergence across the Pacific Ocean and the Americas.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

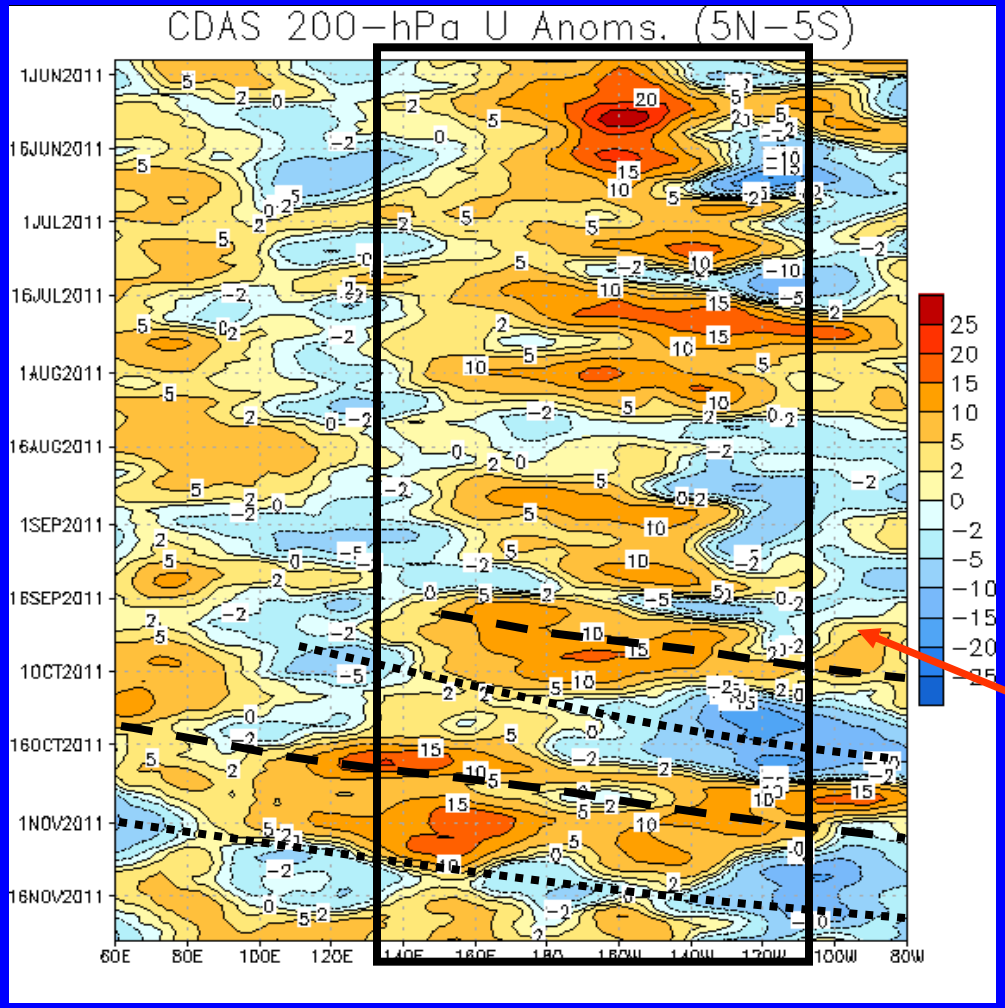
Red shades: Westerly anomalies

Upper-level westerly wind anomalies strengthened over the Maritime Continent and west Pacific Ocean with easterly anomalies entrenched over the Americas, Atlantic Ocean, and Africa.

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



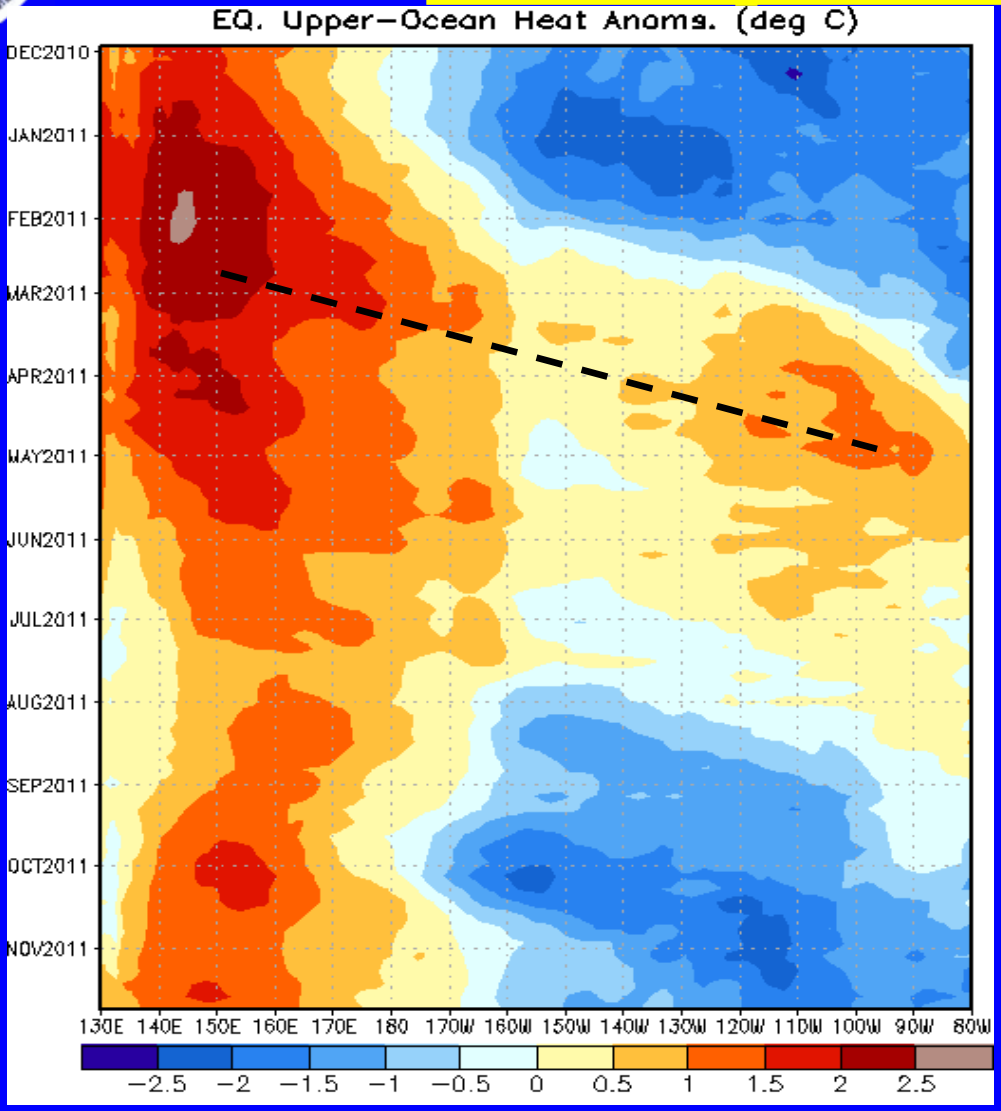
Time

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 increased across the equatorial central 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).

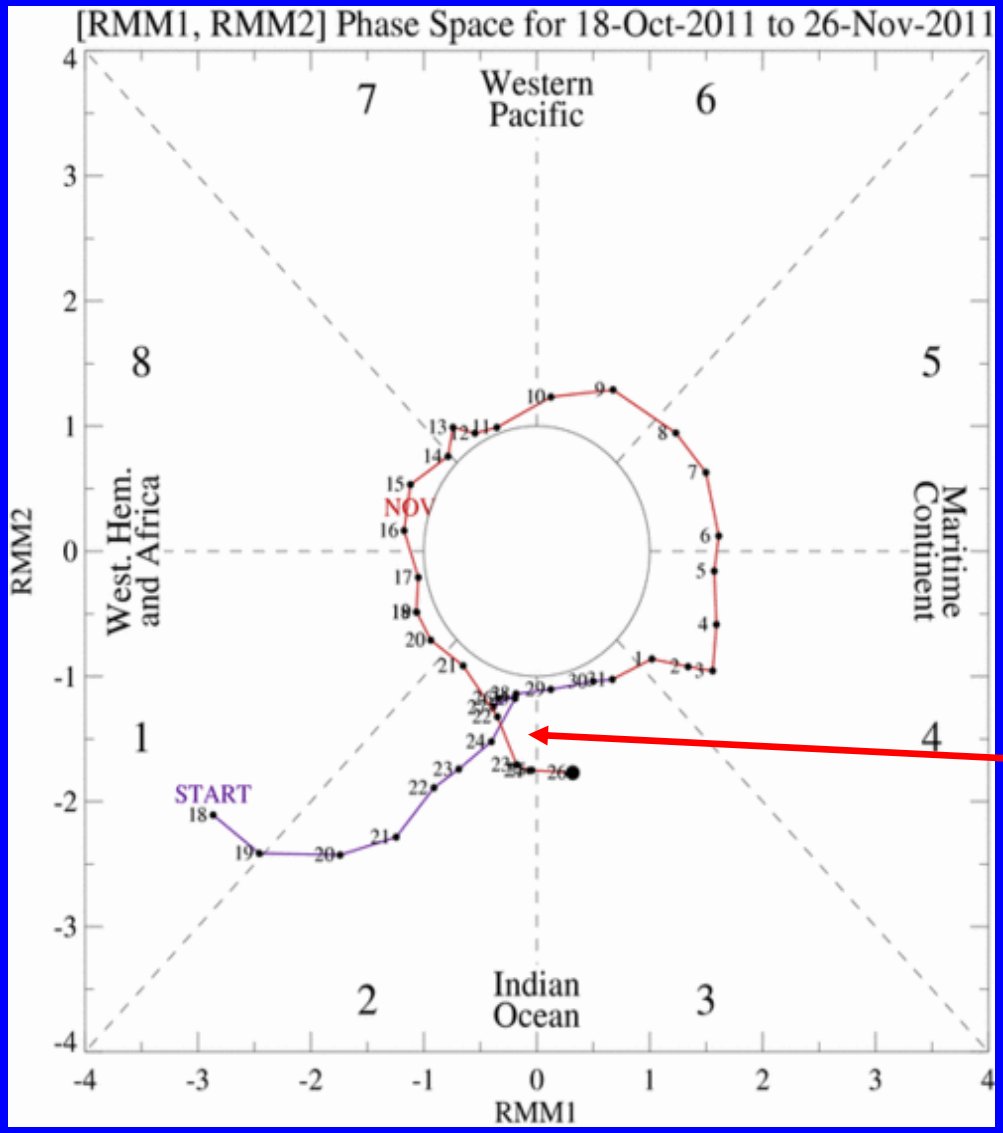
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

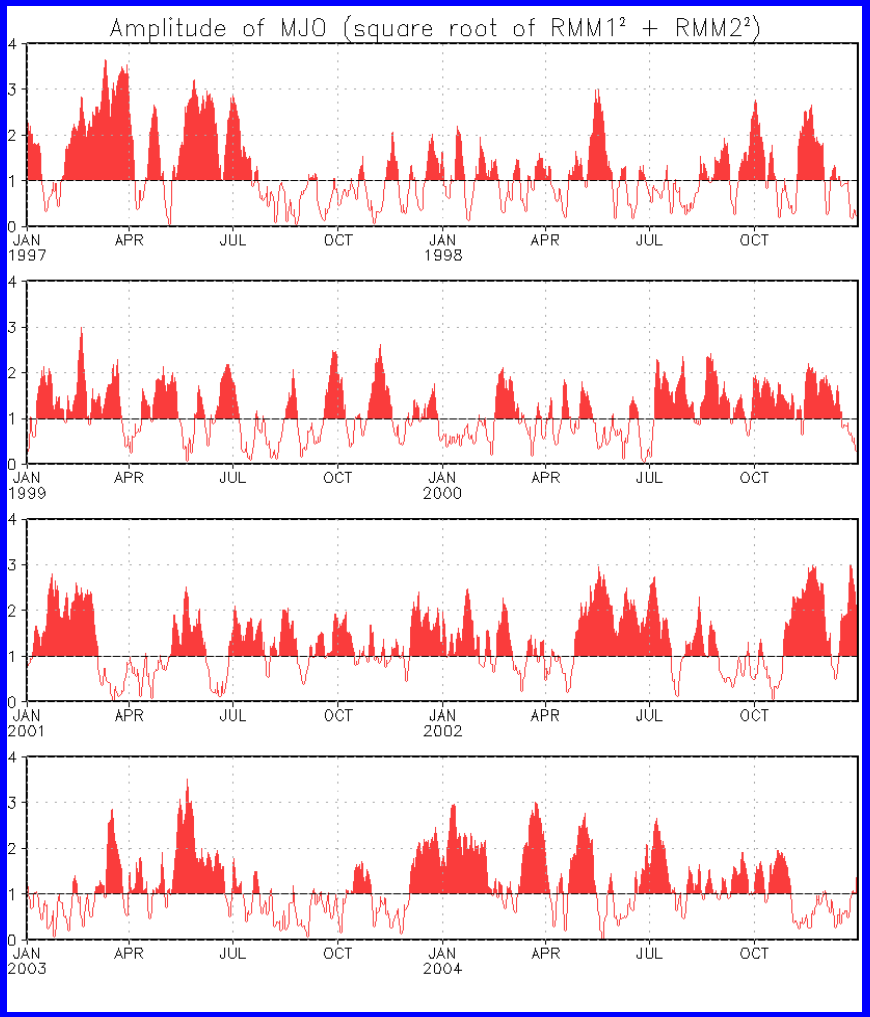
MJO Index -- Recent Evolution

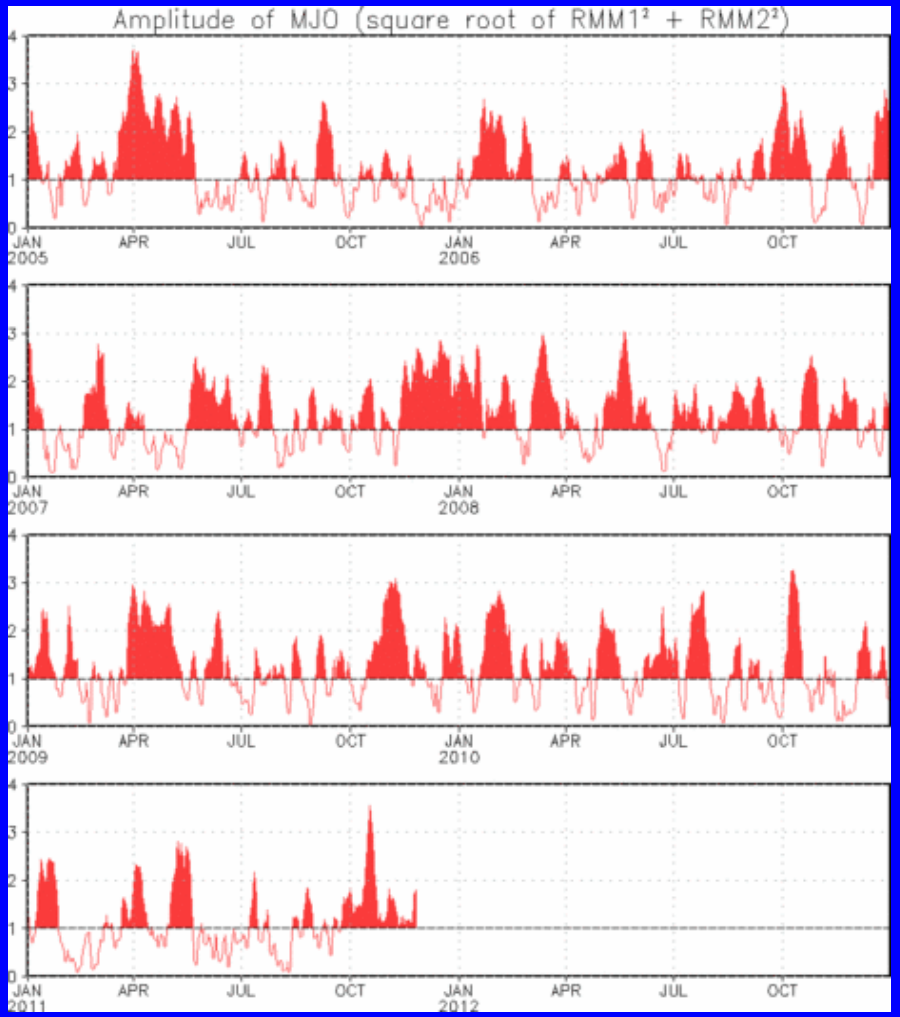


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The amplitude of the MJO index has increased and eastward propagation continued 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.

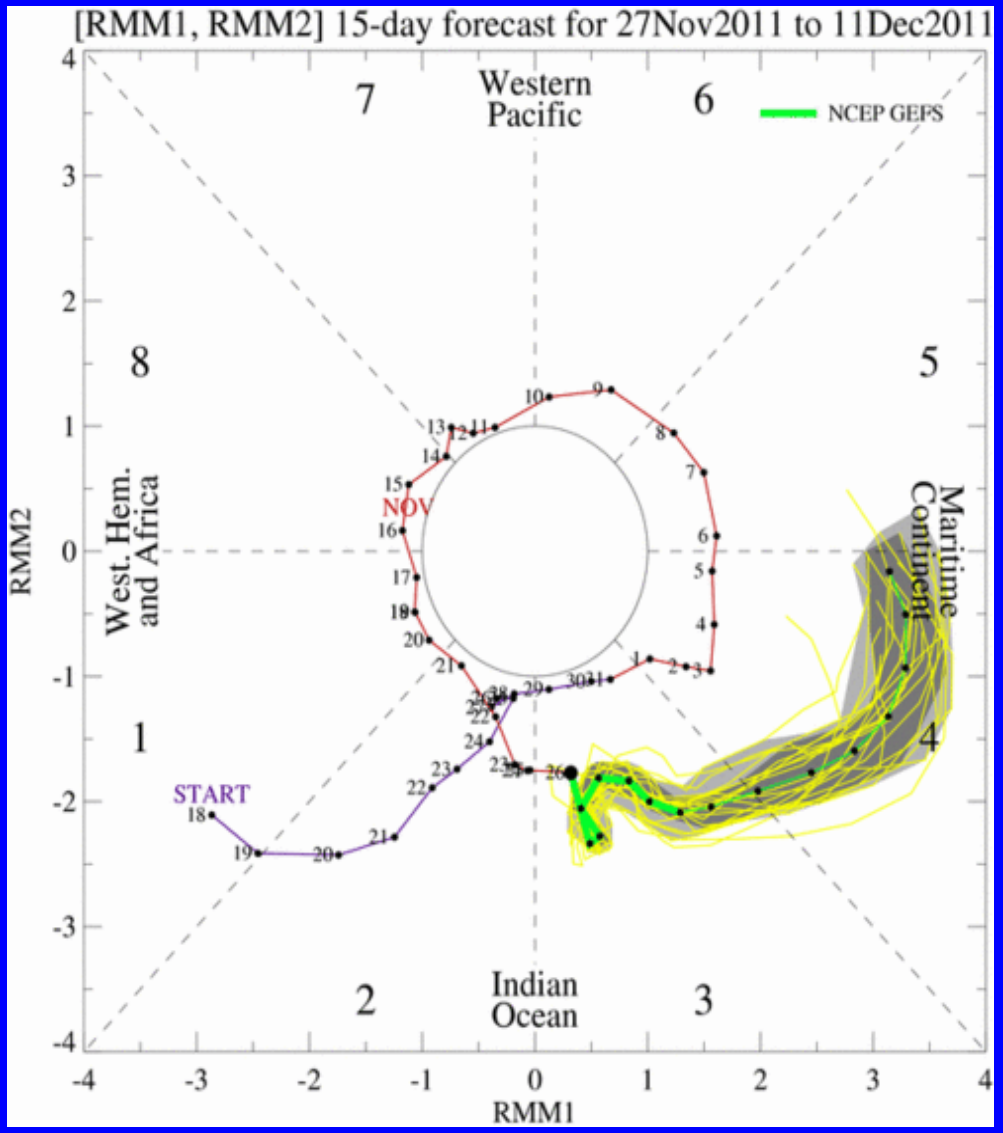
Ensemble GFS (GEFS) MJO Forecast

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

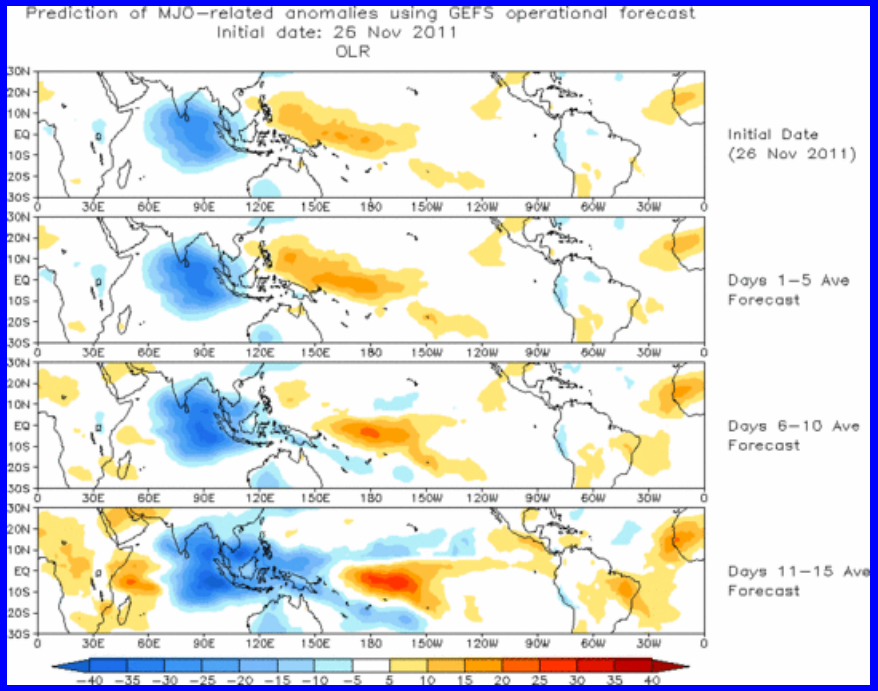
The ensemble GFS forecasts indicate continued strengthening and eastward propagation of a MJO signal during the period. A majority of other model forecasts indicate similar eastward propagation, however, with a weakening signal during Week-2.



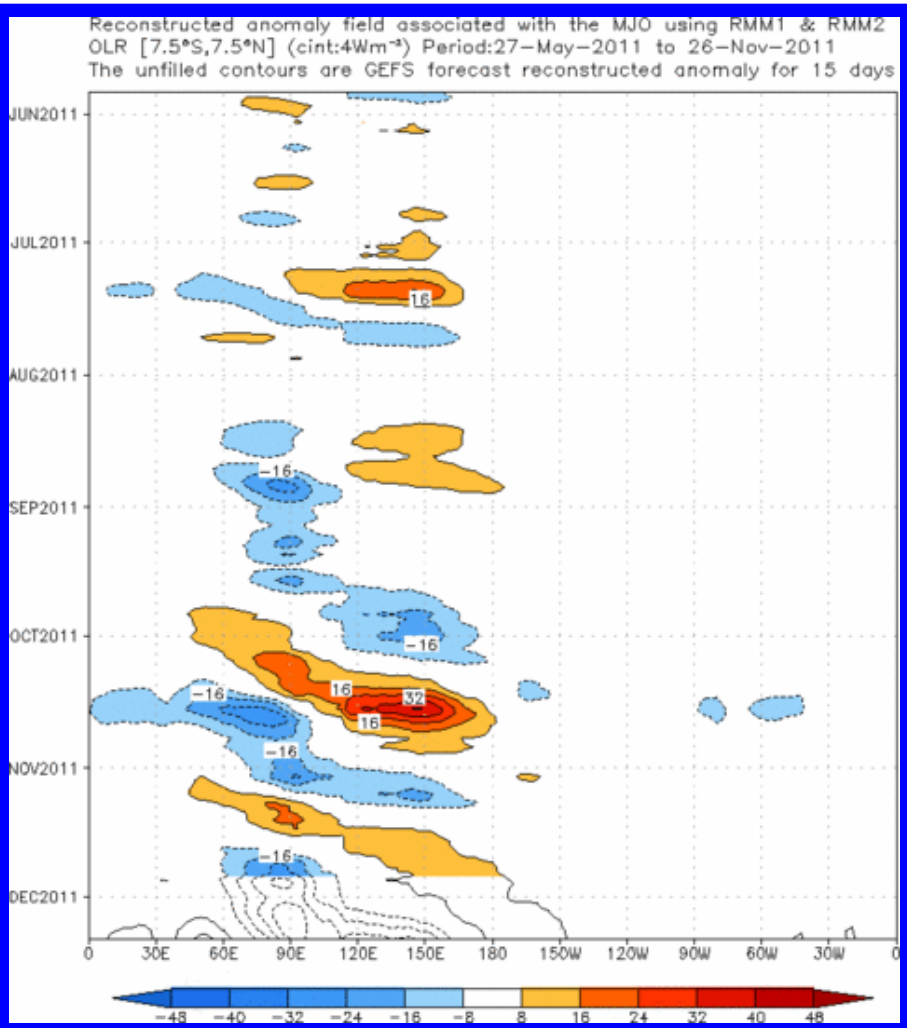
Ensemble Mean GFS MJO Forecast

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

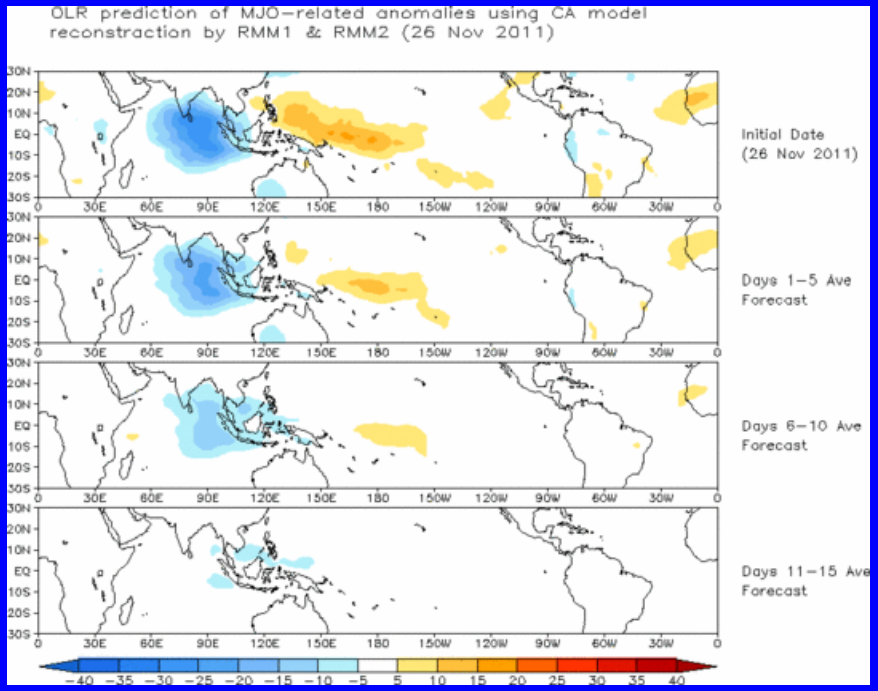


The ensemble mean GFS forecast indicates an eastward shift in the region of enhanced convection through the Indian Ocean during Week-1, and over the Maritime Continent in Week-2

Constructed Analog (CA) MJO Forecast

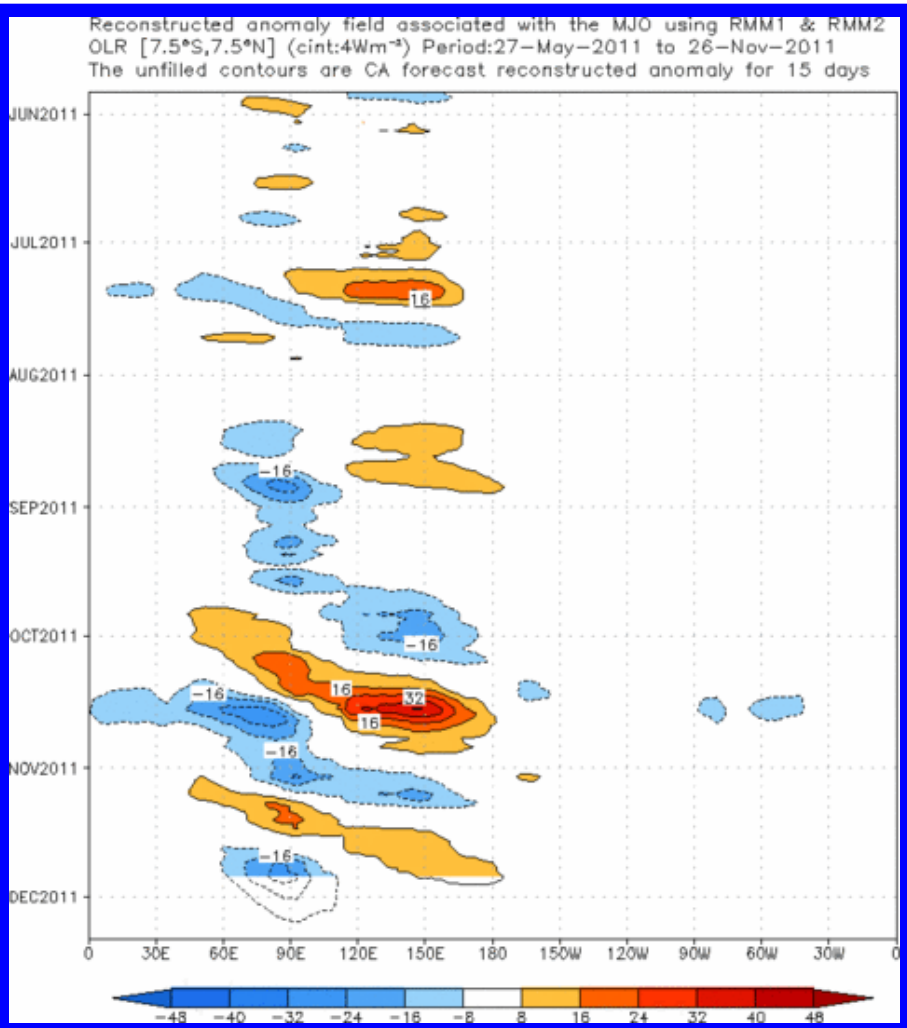
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



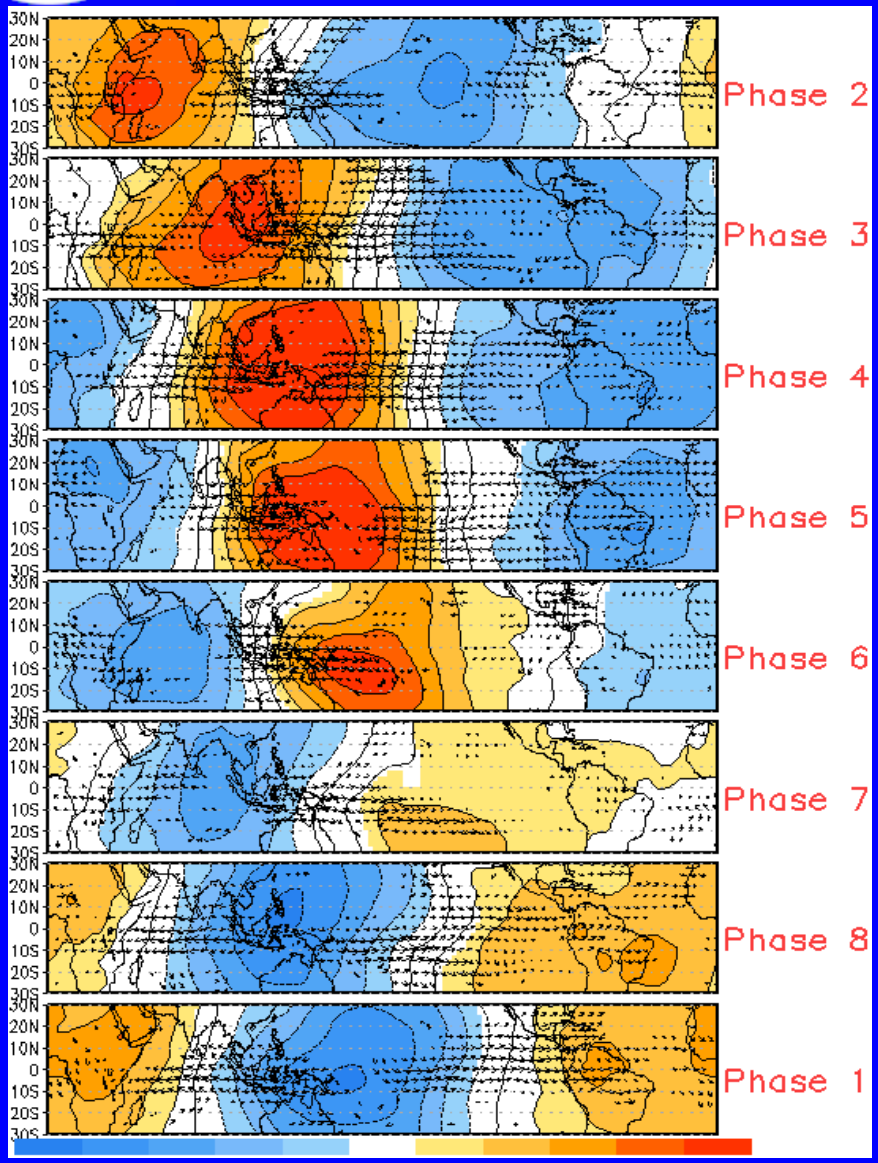
The CA forecast indicates slow eastward propagation with enhanced convection across the eastern Indian Ocean during much of the period.

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

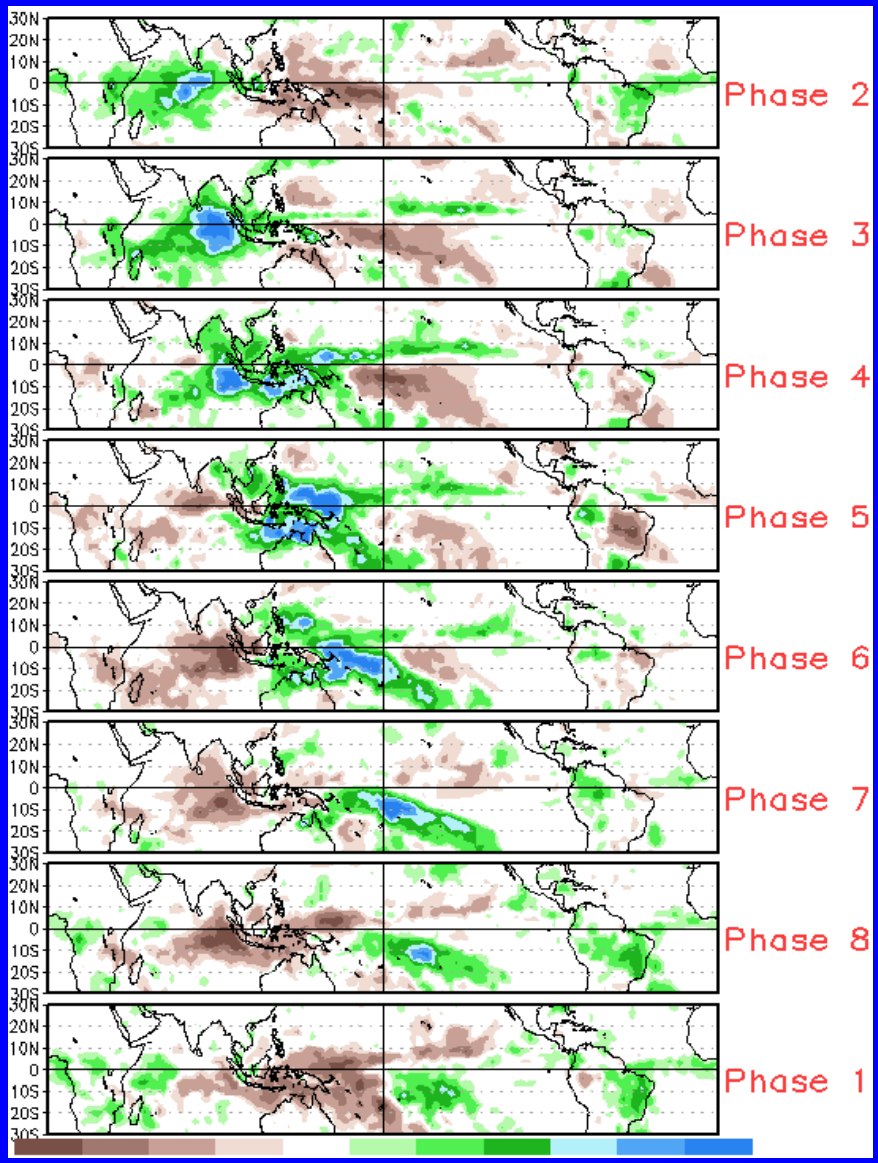


MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

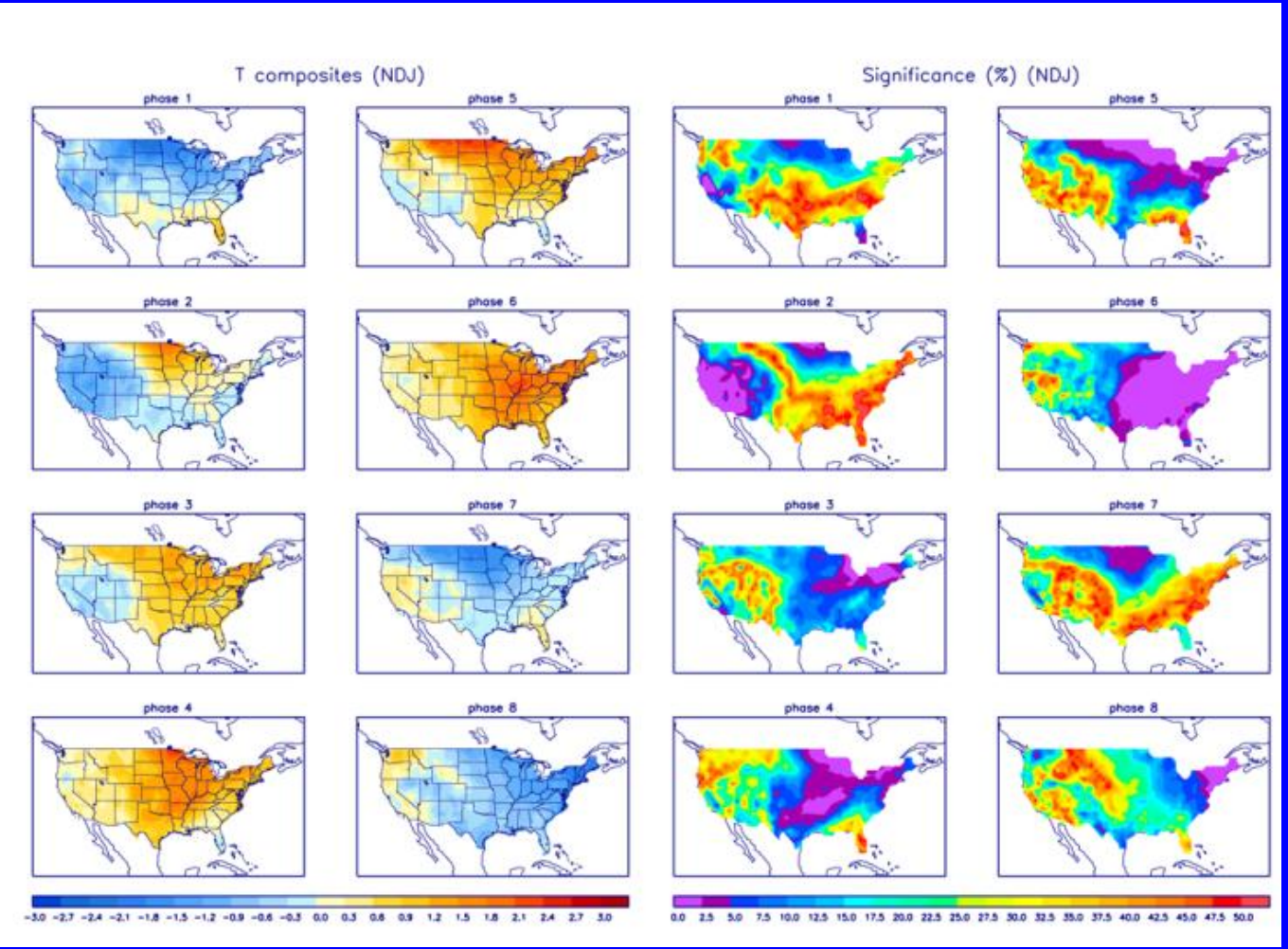


Precipitation Anomalies (Nov-Mar)



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.**

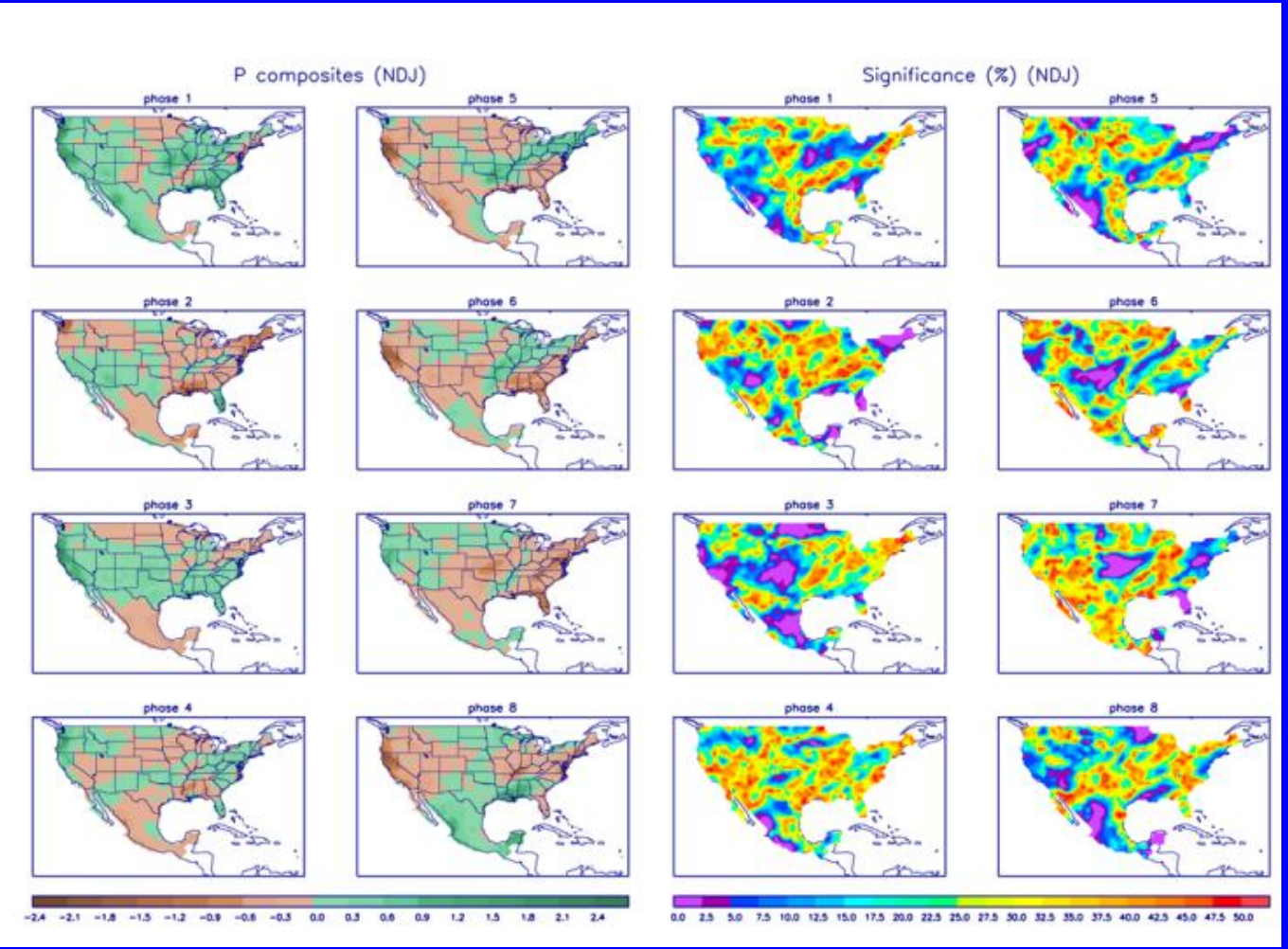


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.**



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