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

Update prepared by
Climate Prediction Center / NCEP
November 7, 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 (MC).
- Dynamical model MJO index forecasts continue to indicate eastward propagation of a MJO signal during the next two weeks with propagation considerably faster than statistical models.
- Based on the latest observations and model MJO forecasts, the MJO is forecast to remain active during the next two weeks with other forms of subseasonal tropical variability likely modulating tropical rainfall.
- The MJO is expected to contribute to enhanced rainfall across the MC and western Pacific Ocean (WPAC) during the period with suppressed rainfall favored for portions of the Indian Ocean. The forecast MJO phase enhances the threat for tropical cyclogenesis for areas of the Western North Pacific (Philippine Sea) during Week-1.
- For the U.S., the combination of La Nina and the enhanced phase of the MJO co-located over the MC region favors ridging over the central north Pacific and downstream troughing across the western CONUS which may be especially amplified as compared to normal La Nina conditions. This is indicated by nearly all numerical model guidance.
- MJO composites are consistent with model guidance for the favoring of above-normal temperatures across the eastern U.S. and above median precipitation in the Ohio Valley, Great Lakes and Northeast.

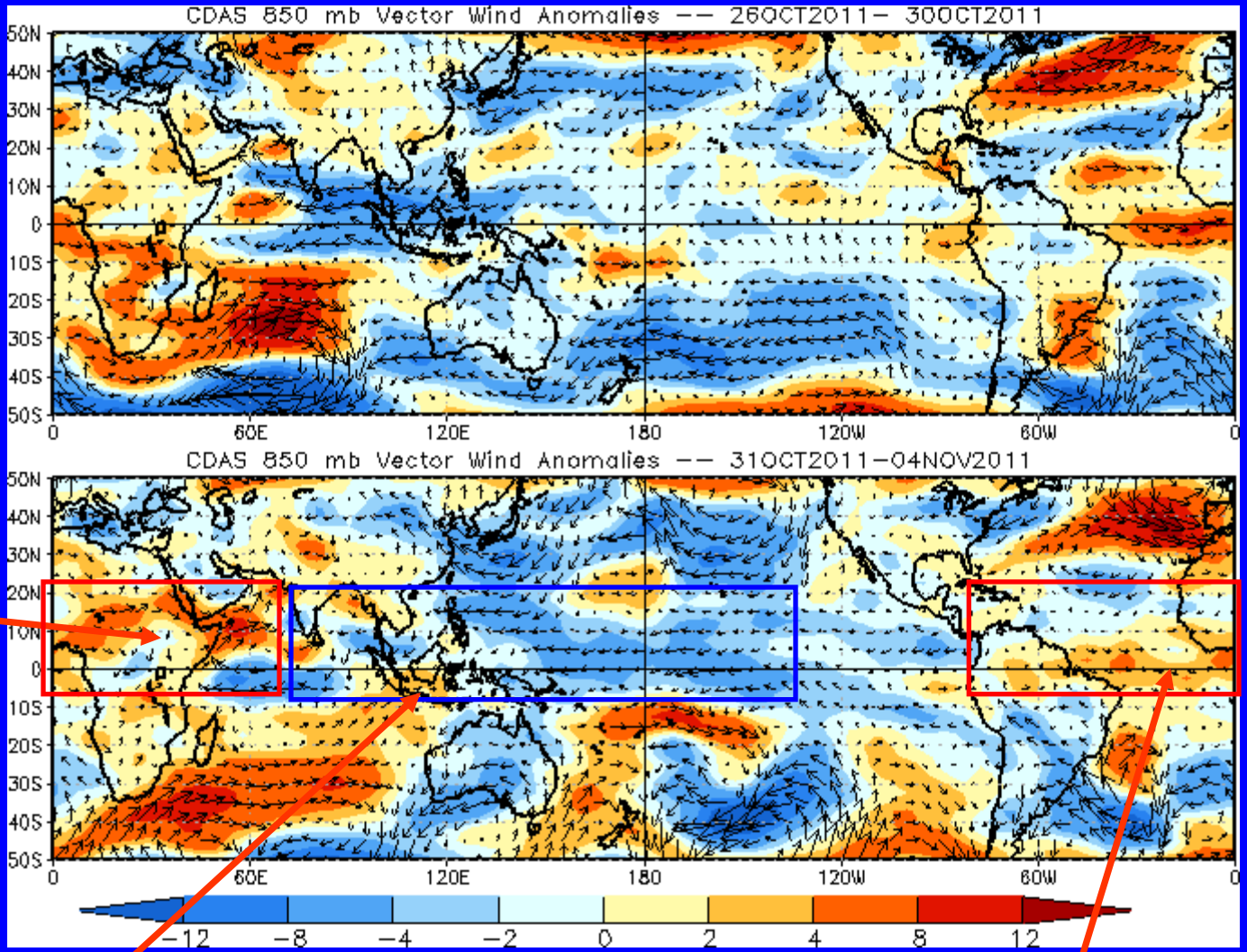
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Strong westerly anomalies increased across Africa.

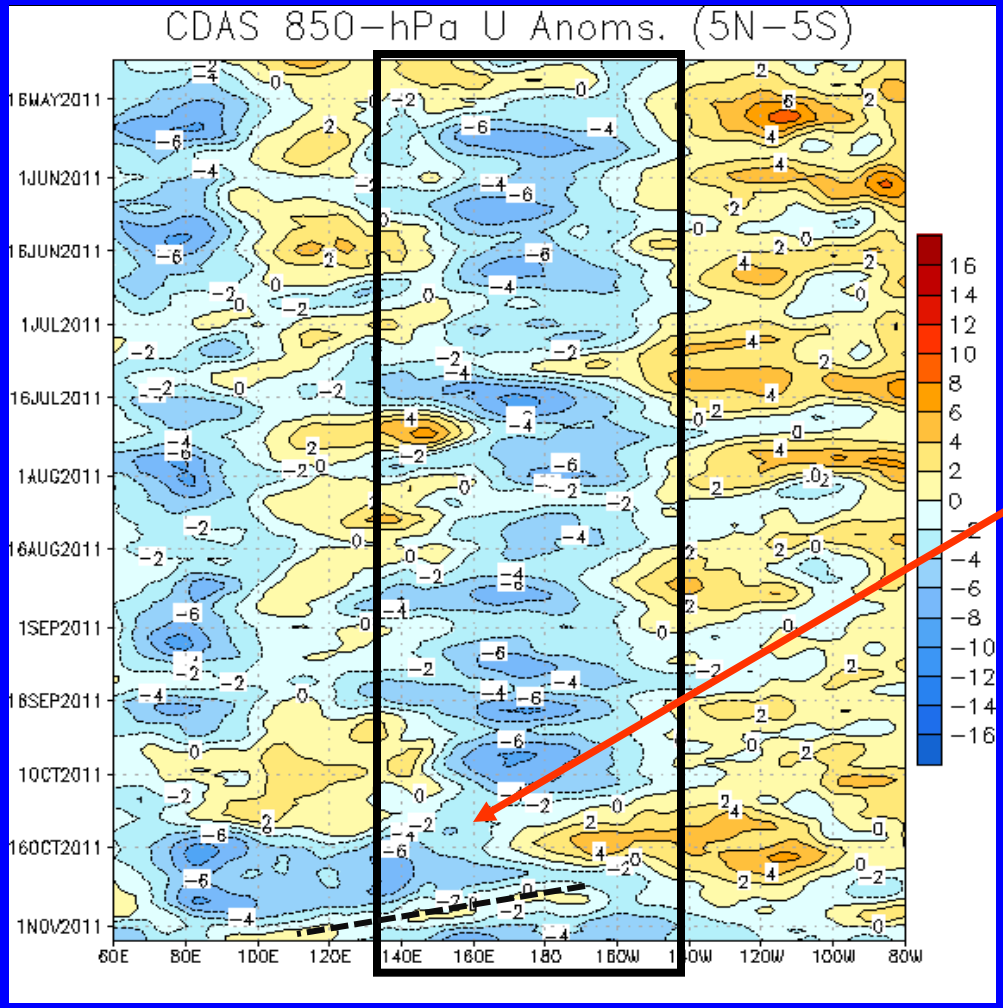
Easterly wind anomalies persisted across the Maritime Continent while expanding across the Pacific Ocean.

Westerly anomalies persisted across the Atlantic Basin 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

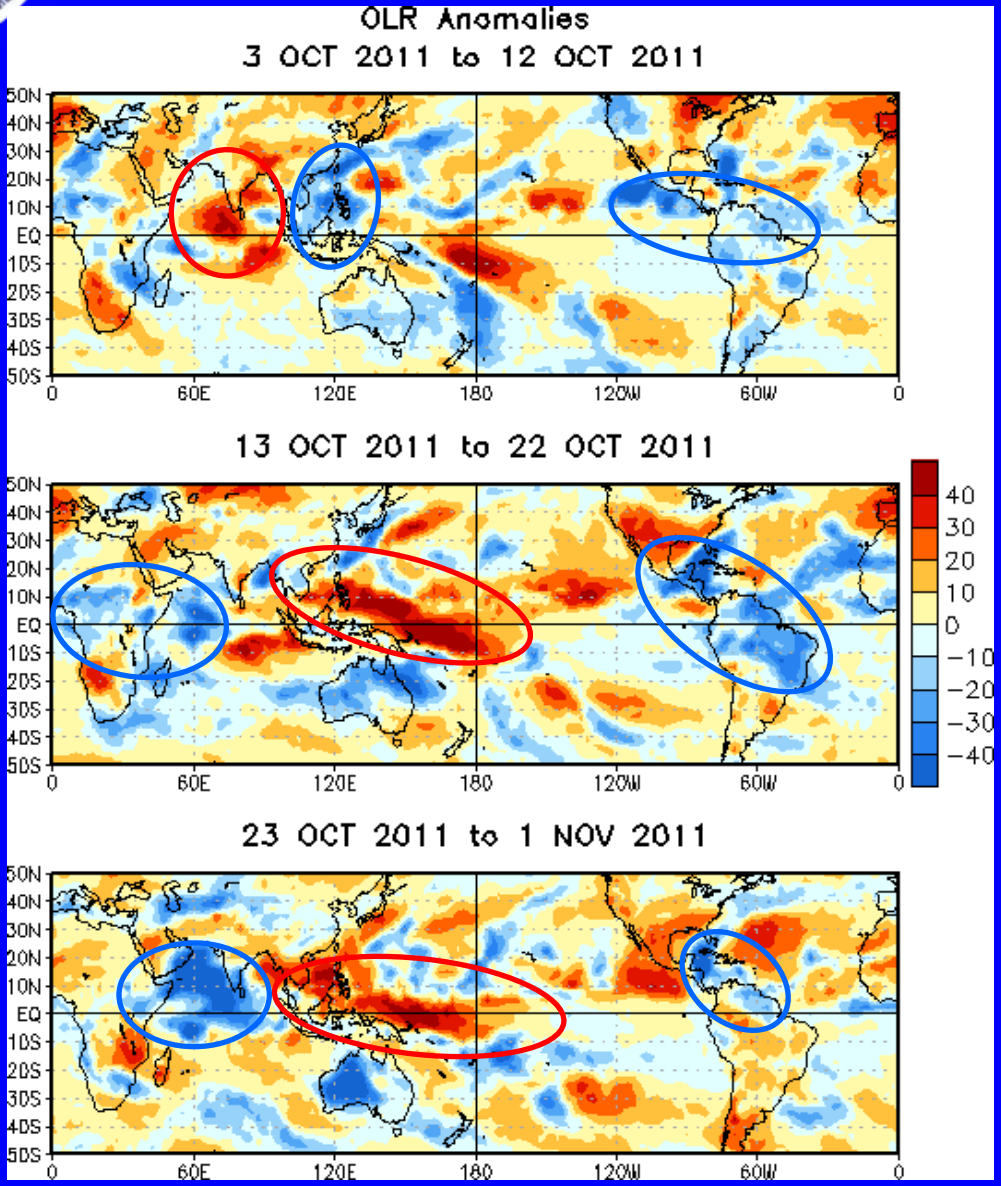
Easterly anomalies persisted across the west-central Pacific since May (black box) consistent with La Nina conditions during much of the period. The magnitude of these anomalies, varied during the period.

In early October, MJO activity weakened the persistent easterly anomalies across the central Pacific.

MJO activity contributed to increased easterly (westerly) anomalies across the Pacific Ocean (Indian Ocean).

An equatorial Rossby wave (dashed line) has also imparted westerly anomalies across much of southern Asia and the Indian Ocean (dashed line).

OLR Anomalies – Past 30 days



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

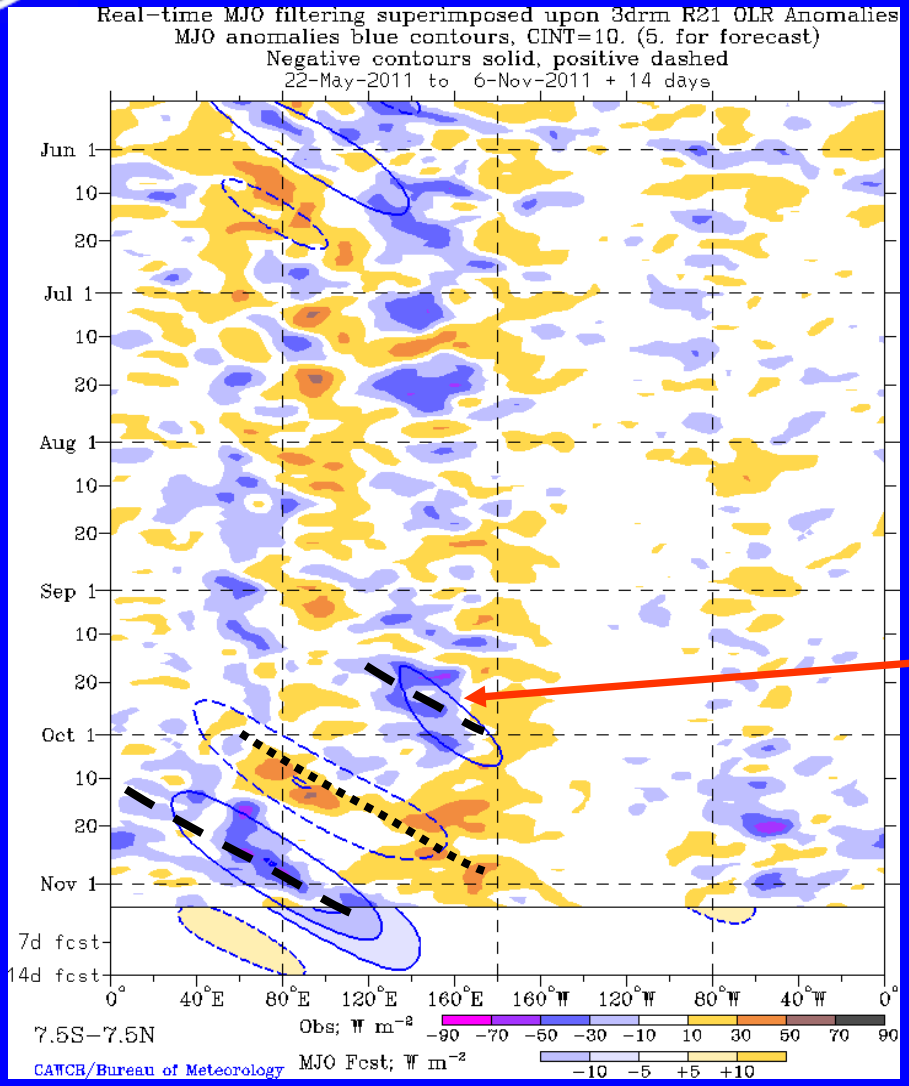
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During early October, suppressed convection (red circle) was observed across India, the Indian Ocean, and the Central Pacific Ocean, while enhanced convection covered part of southeast Asia, eastern Pacific and the Americas.

Enhanced convection continued across the Americas and developed over Africa and the western Indian Ocean, while suppressed convection spread eastward to the Western Pacific and Maritime Continent, all consistent with MJO activity at that time.

During late October to early November, enhanced convection diminished across the Americas and increased over the Indian Ocean. Suppressed convection persisted across the Maritime Continent and Western Pacific while also spreading across southeast Asia.

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 the summer period from June through August.

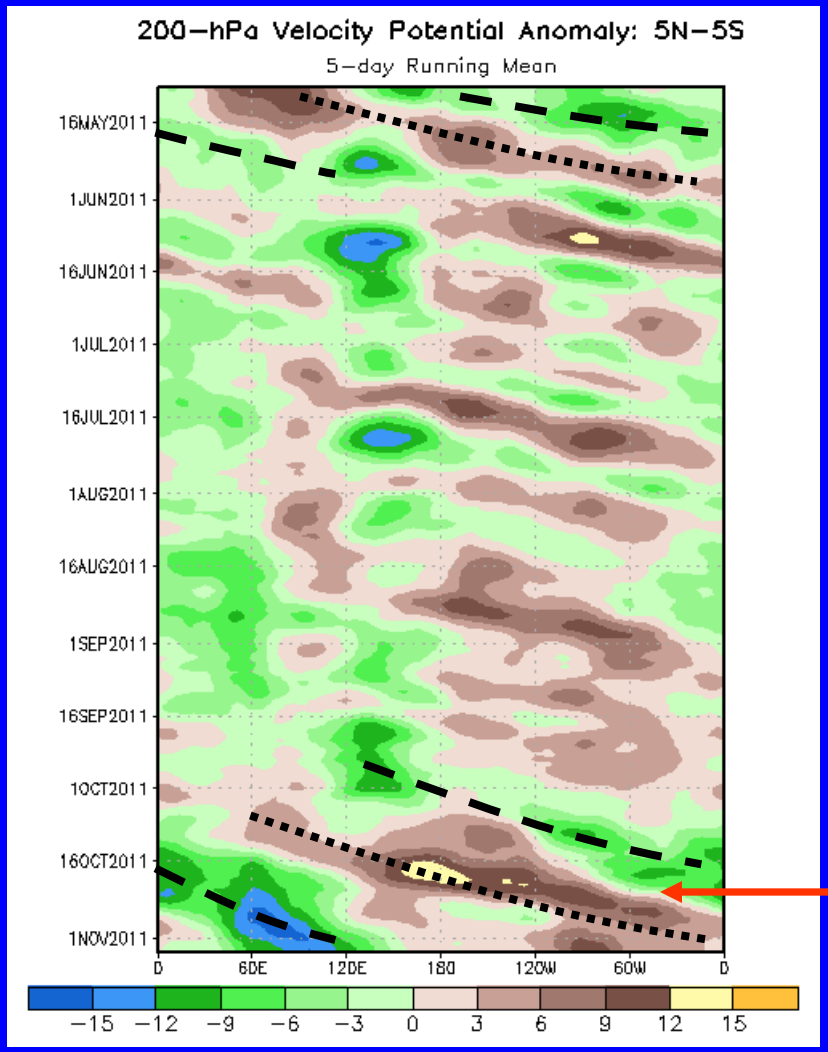
Beginning in mid-September, enhanced convection shifted from southern Asia to the western Pacific while suppressed convection developed during late September across India and also shifted eastward to the western Pacific.

Most recently, enhanced convection has become centered over the Maritime Continent with suppressed convection near the Date Line.

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

MJO activity was observed during late April into May as upper-level divergence (green shades) shifted eastward from the Indian Ocean beginning in early May followed by upper-level convergence (brown shades).

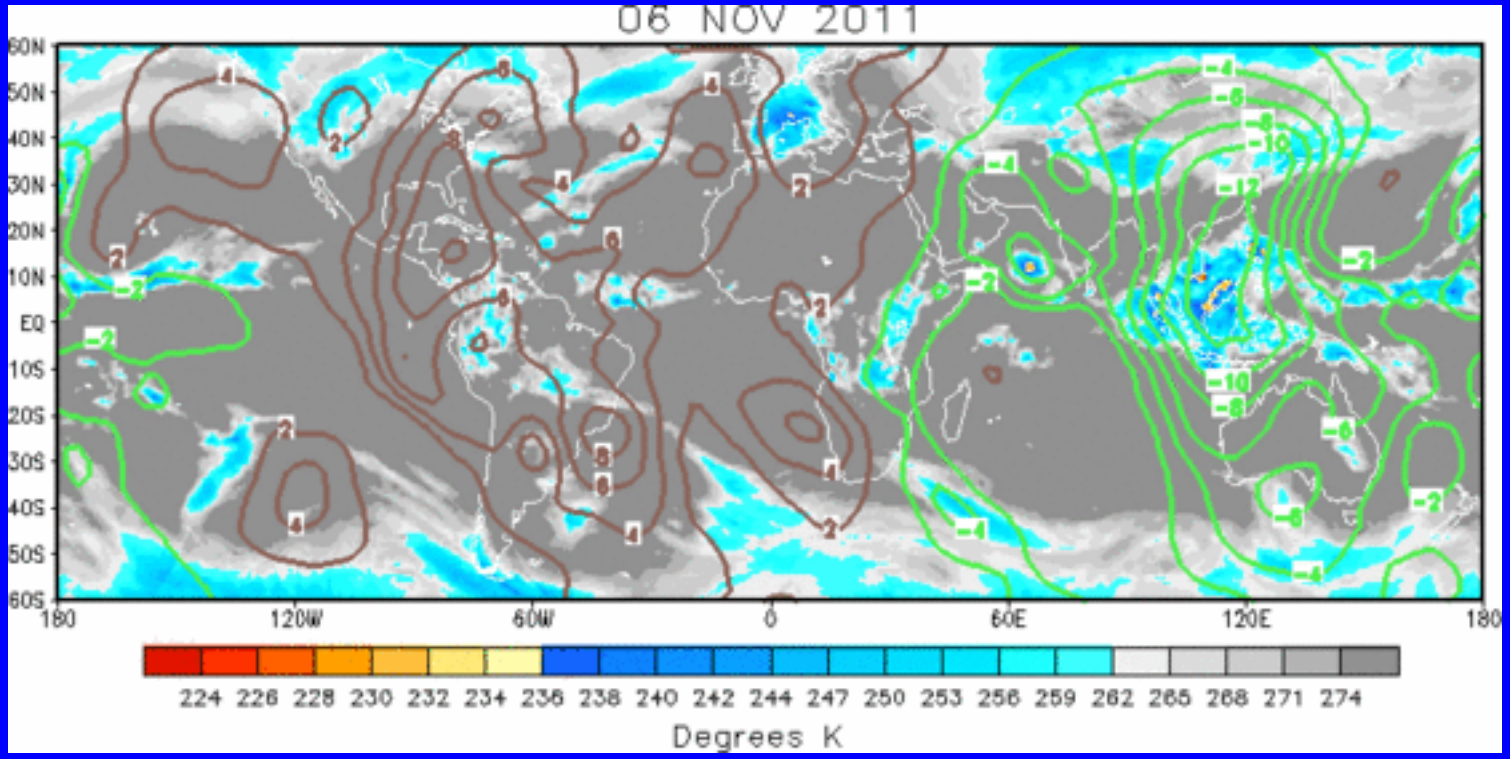
During parts of June, July and August very fast eastward propagation was evident at times and mainly associated with higher frequency sub-seasonal coherent tropical variability and not MJO activity.

During the second half of September, negative anomalies developed across the western Pacific and propagated eastward to the Indian Ocean. Positive anomalies followed and are now located mostly over the western Hemisphere. Higher frequency modes of variability are also evident.

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

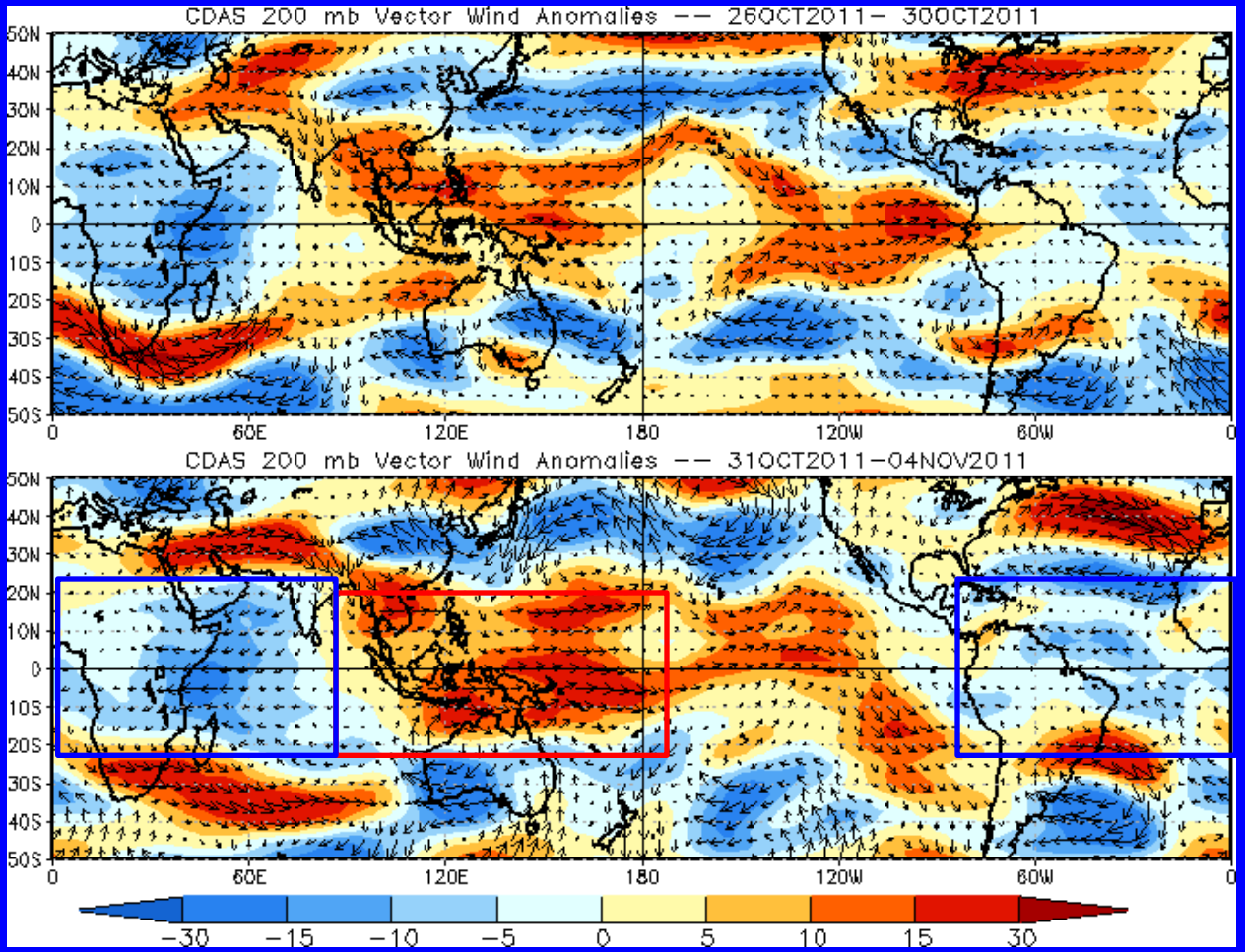
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern indicates generally a wave 1 structure. Anomalous upper-level divergence centered across the Maritime Continent is evident as is anomalous upper-level convergence across the Americas, Atlantic Ocean, and northern Africa.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

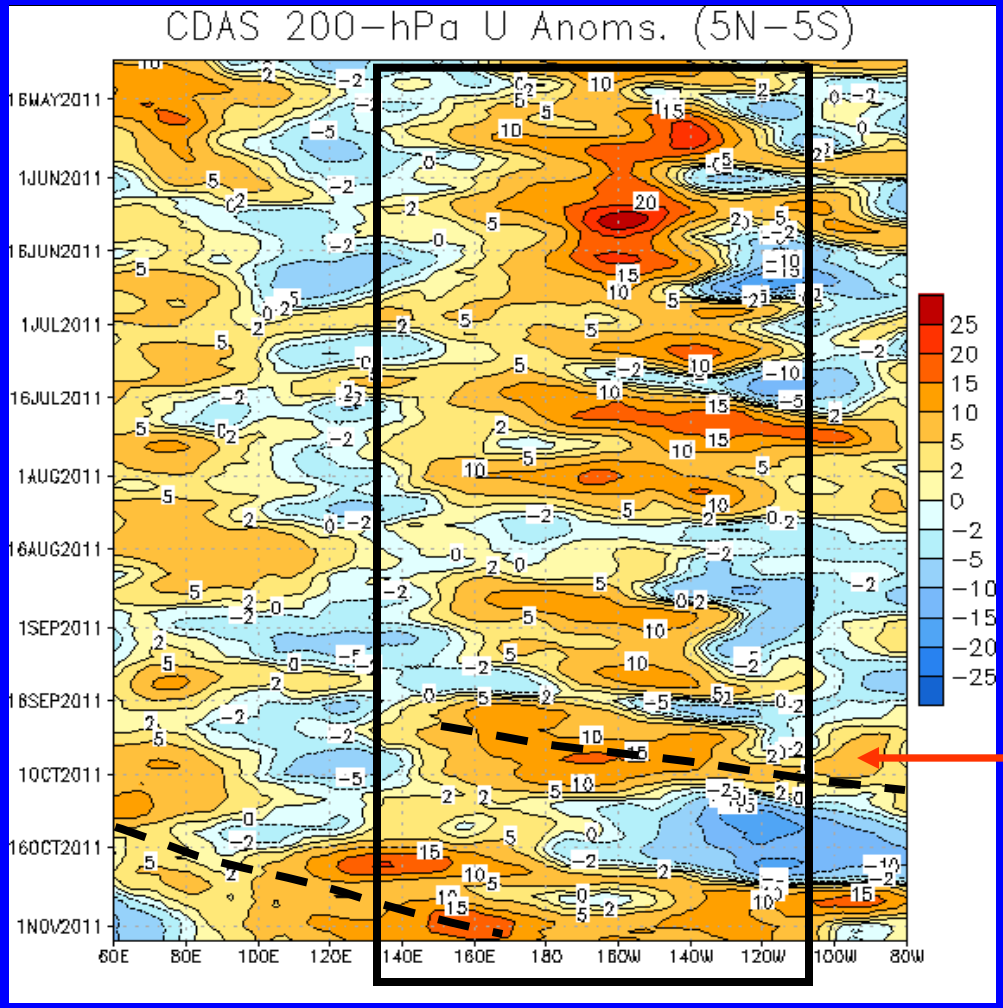
Red shades: Westerly anomalies

Upper-level westerly wind anomalies strengthened over the Maritime Continent. Easterly anomalies are present from the Americas to the central 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



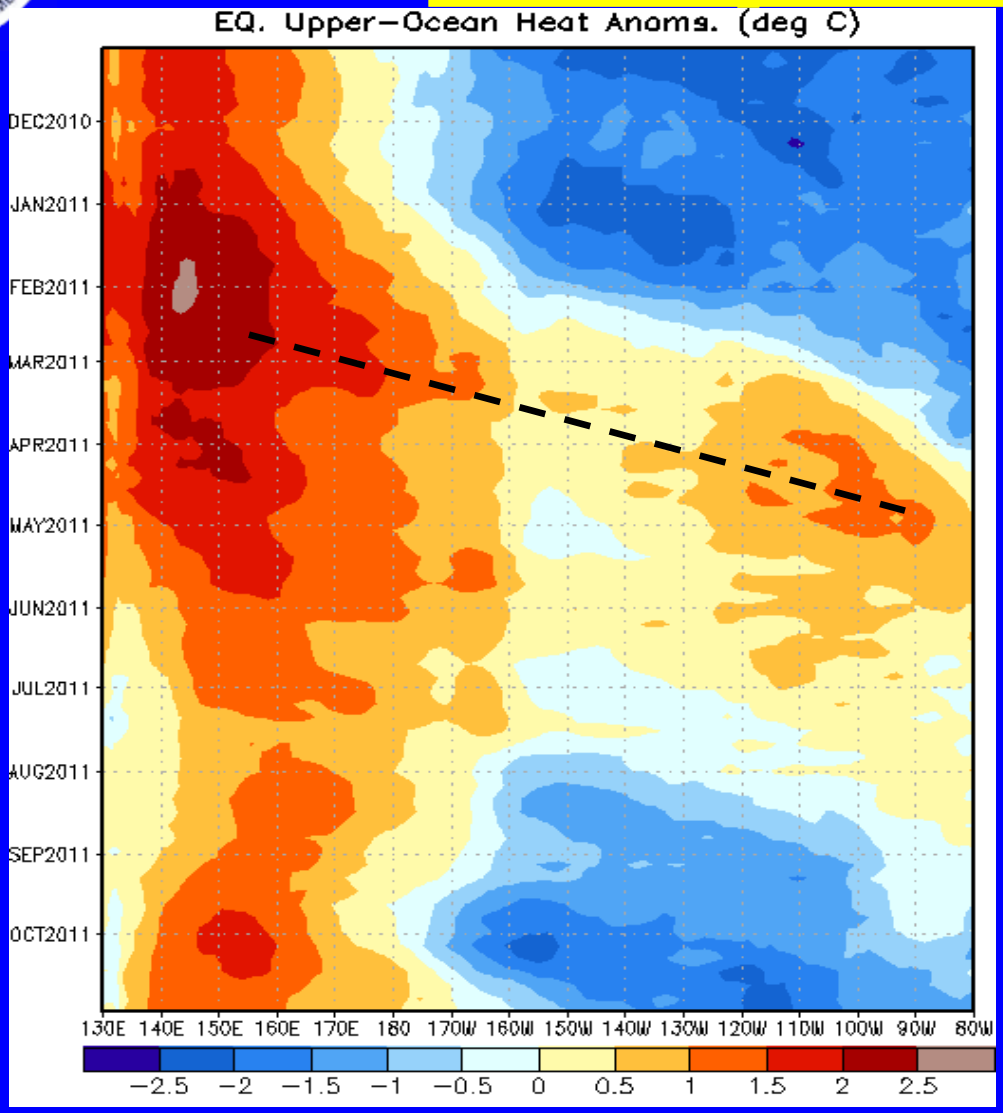
Time

Longitude

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

Westerly anomalies over the Pacific strengthened during late September and have shifted eastward 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).

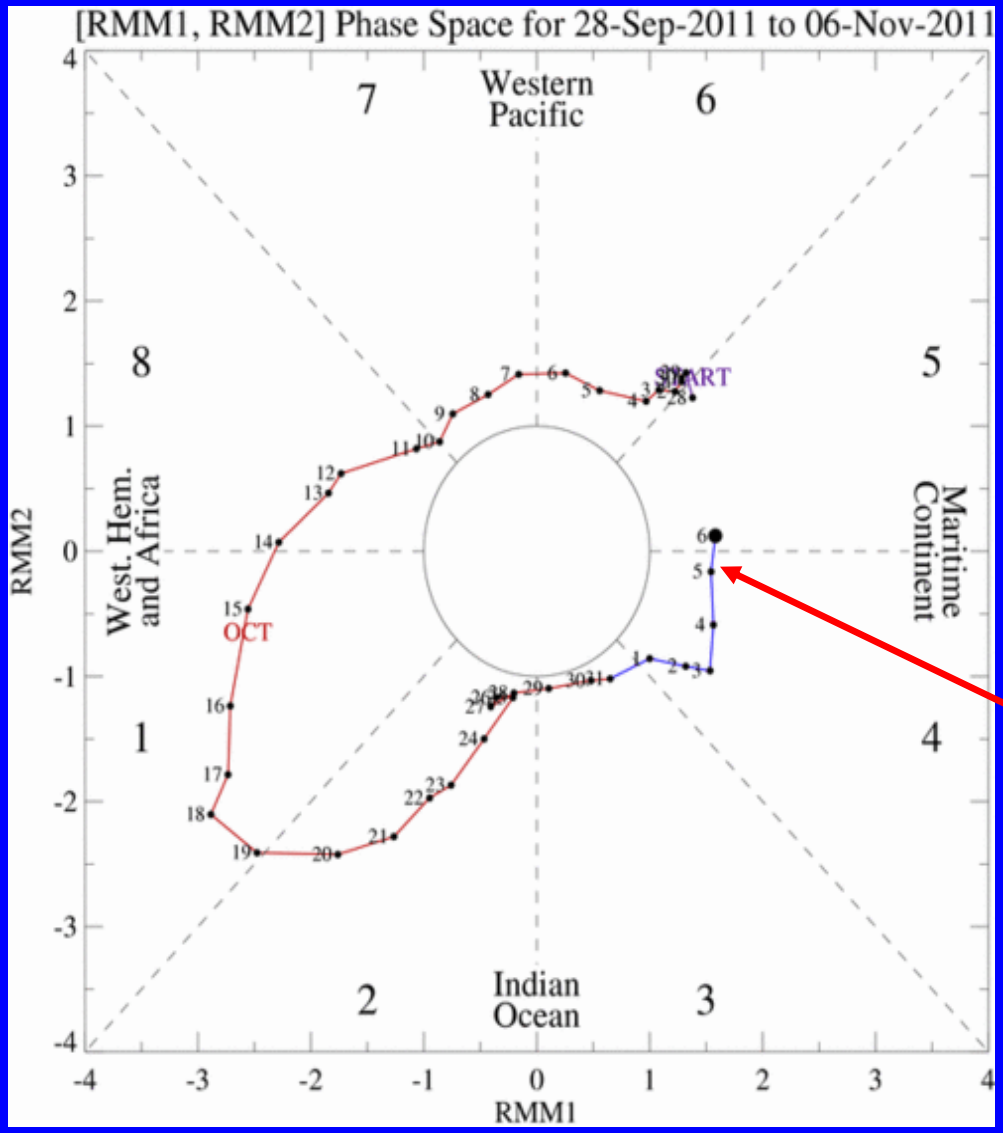
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

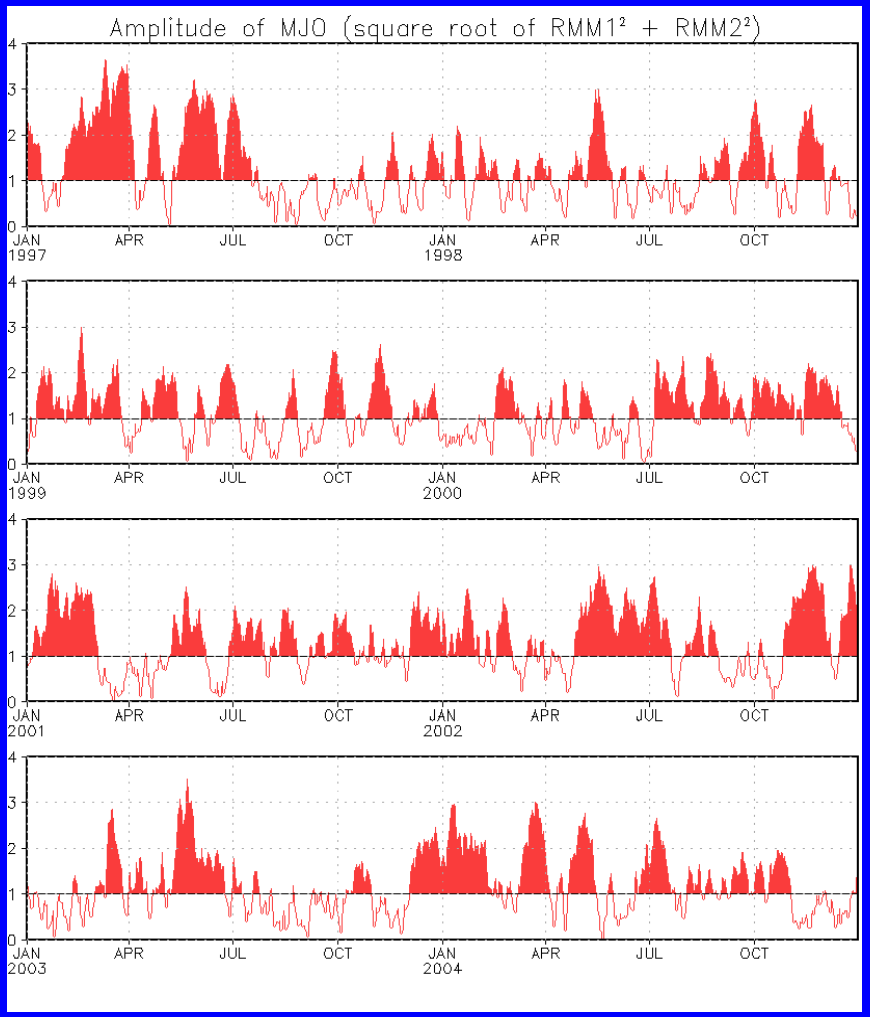
MJO Index -- Recent Evolution

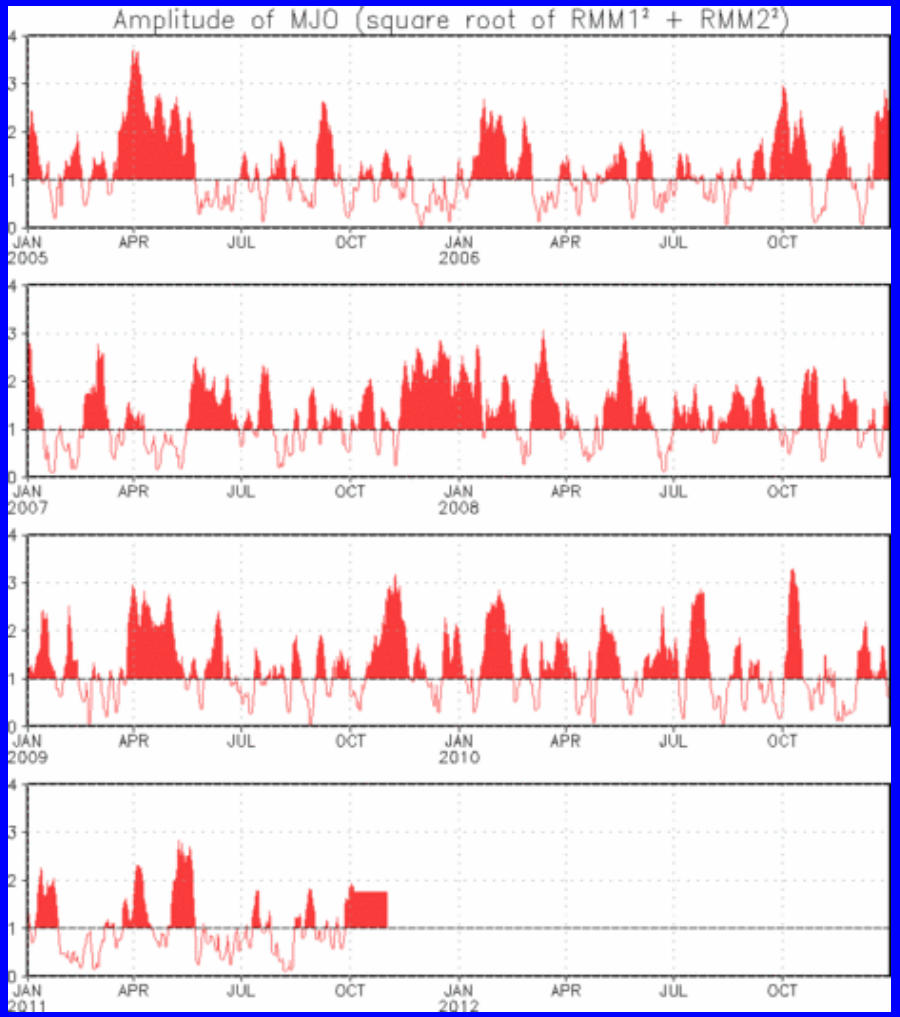


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates eastward propagation and little change in signal strength during the past week.

MJO Index – Historical Daily Time Series





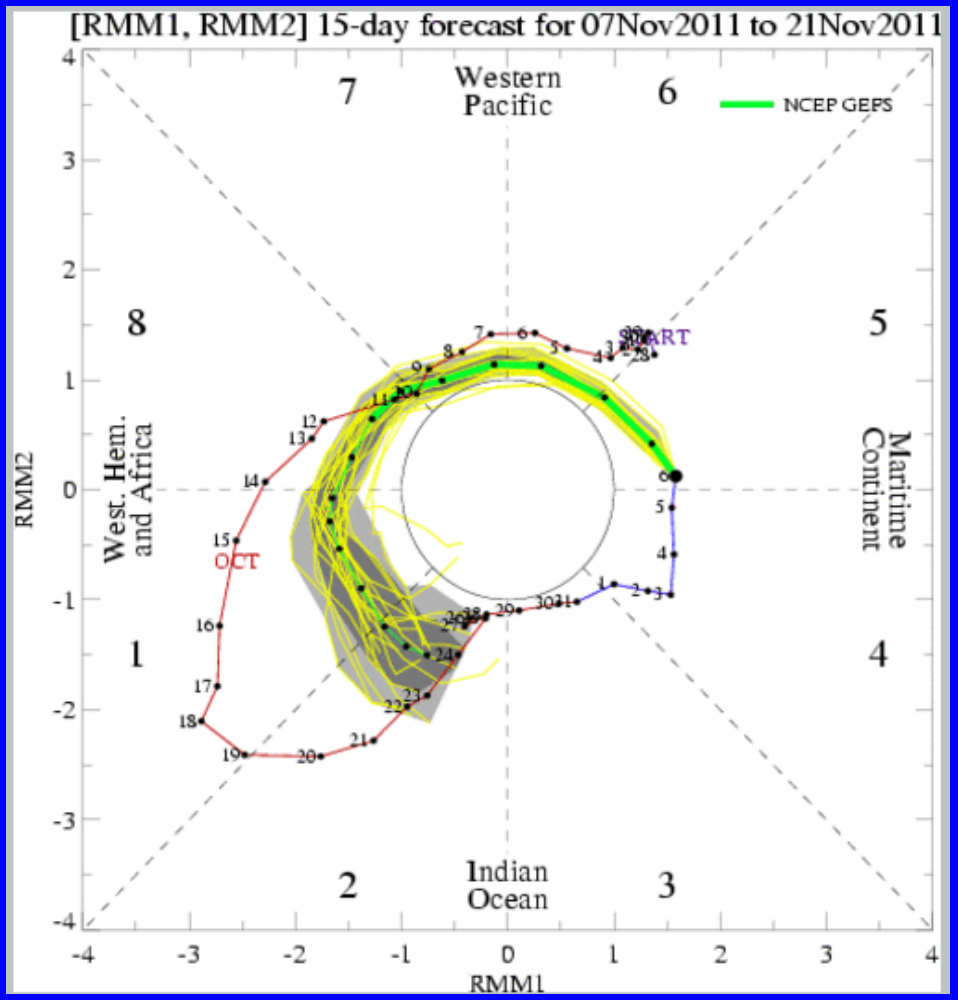
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

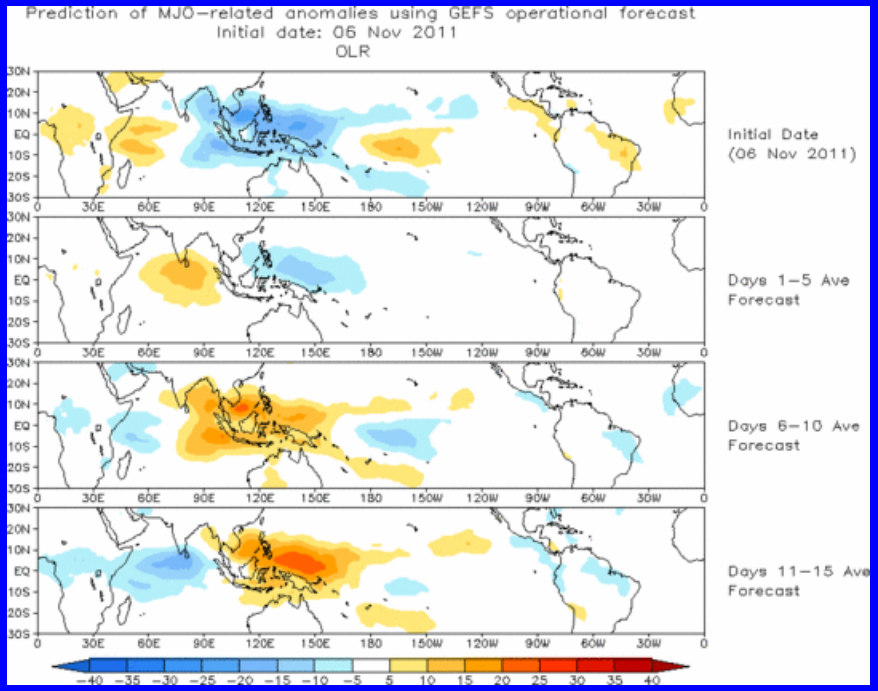


The ensemble GFS forecasts indicate rapid eastward propagation of a MJO signal during the period. During Week-2, the model indicates some strengthening of the signal.

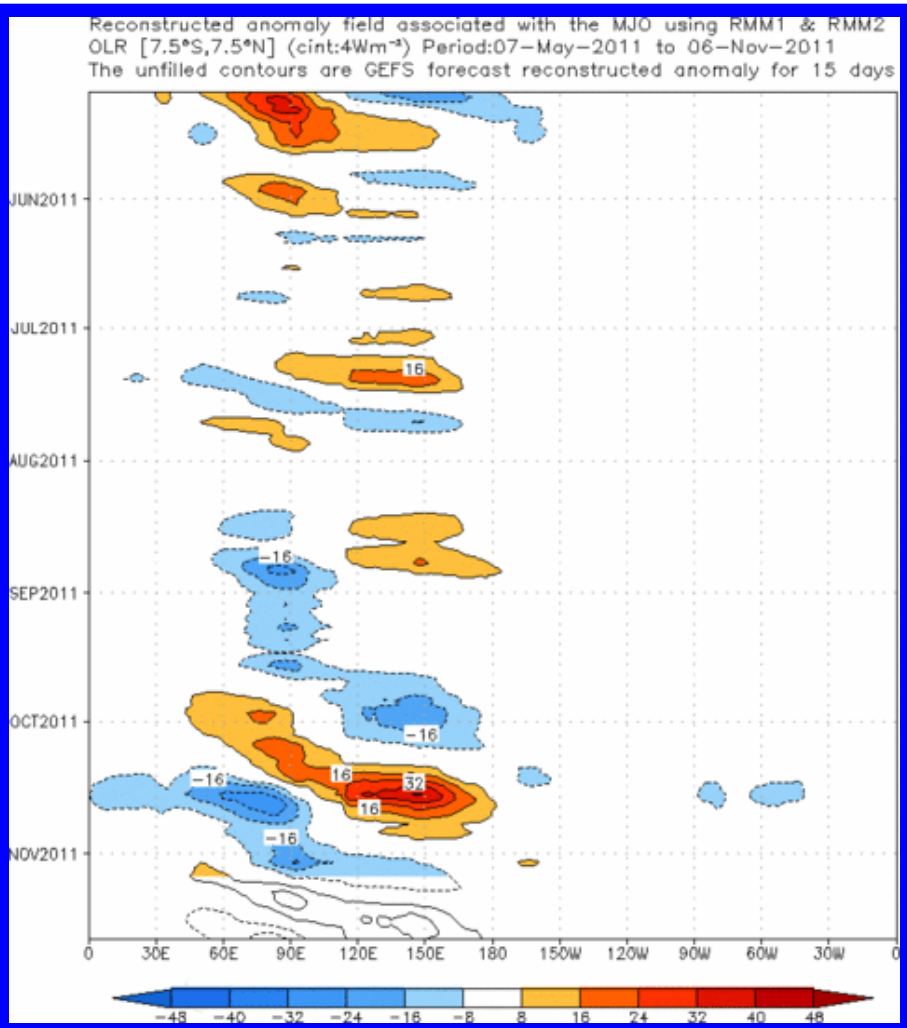
Ensemble Mean GFS MJO Forecast

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

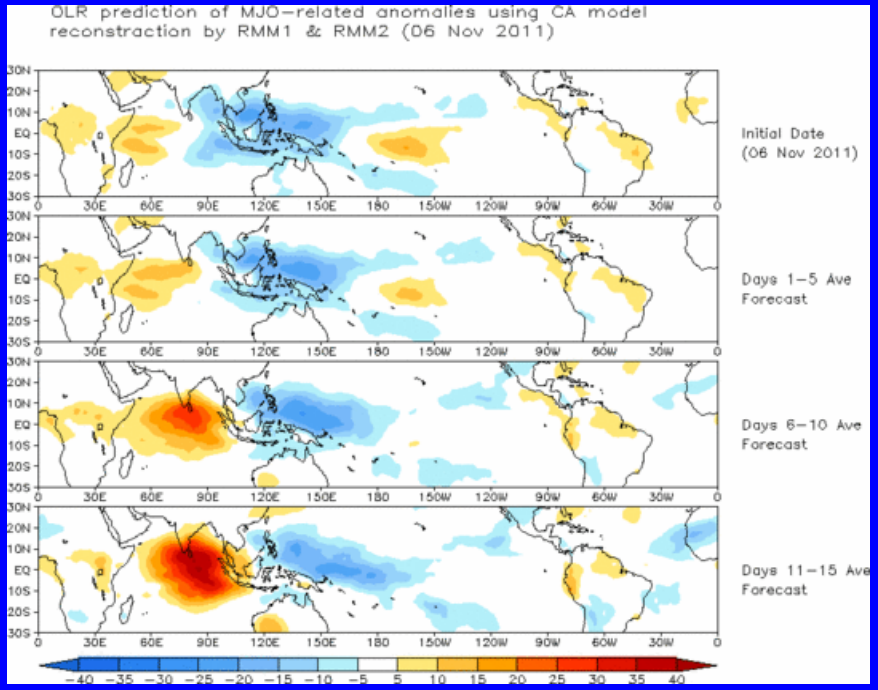


The ensemble mean GFS forecast indicates a rapid shift in the region of enhanced convection from across the Maritime Continent to the Pacific Ocean Basin during Week-1 with continued eastward movement during Week-2 crossing Africa.

Constructed Analog (CA) MJO Forecast

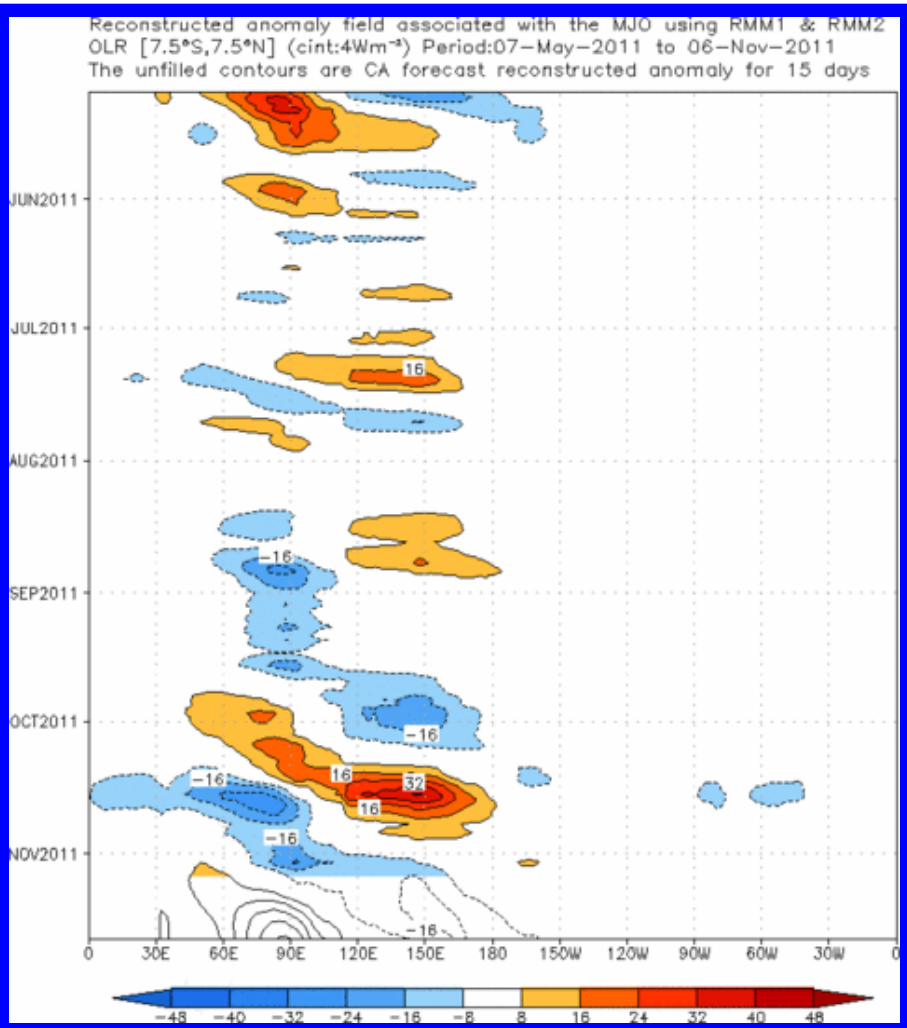
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



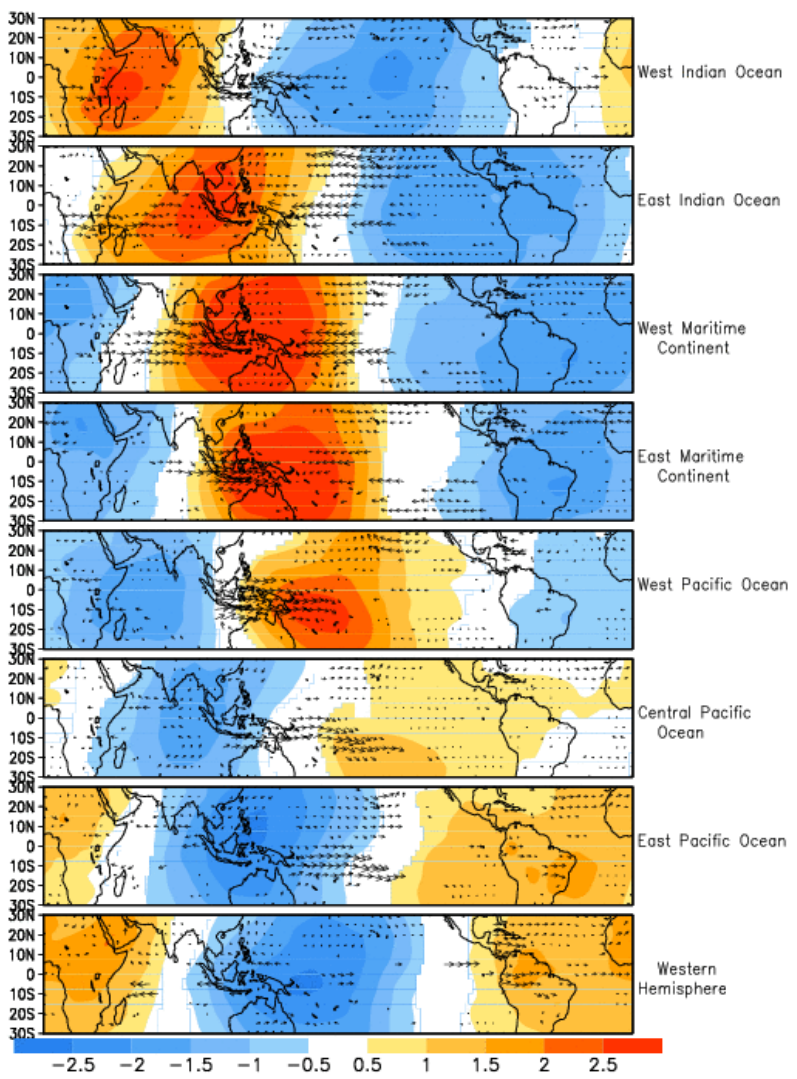
The CA forecast indicates slow eastward propagation with enhanced convection from the Maritime Continent to Western Pacific and suppressed convection strengthening across the Indian Ocean.

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

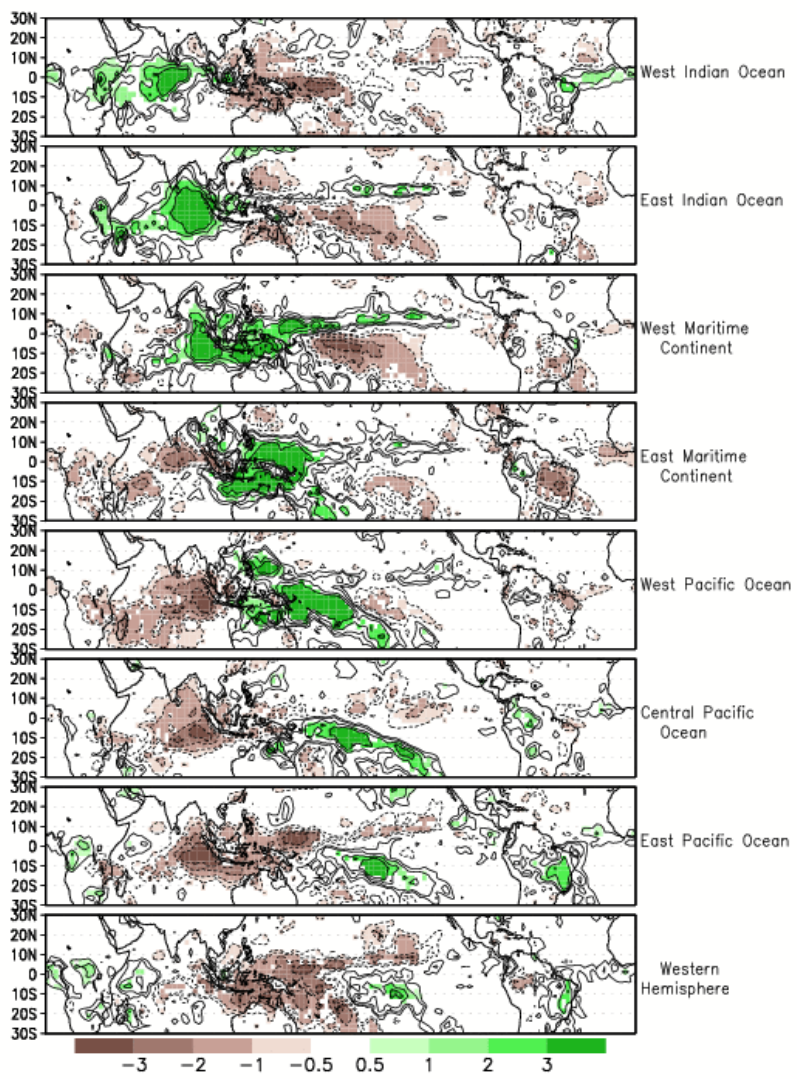


MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)

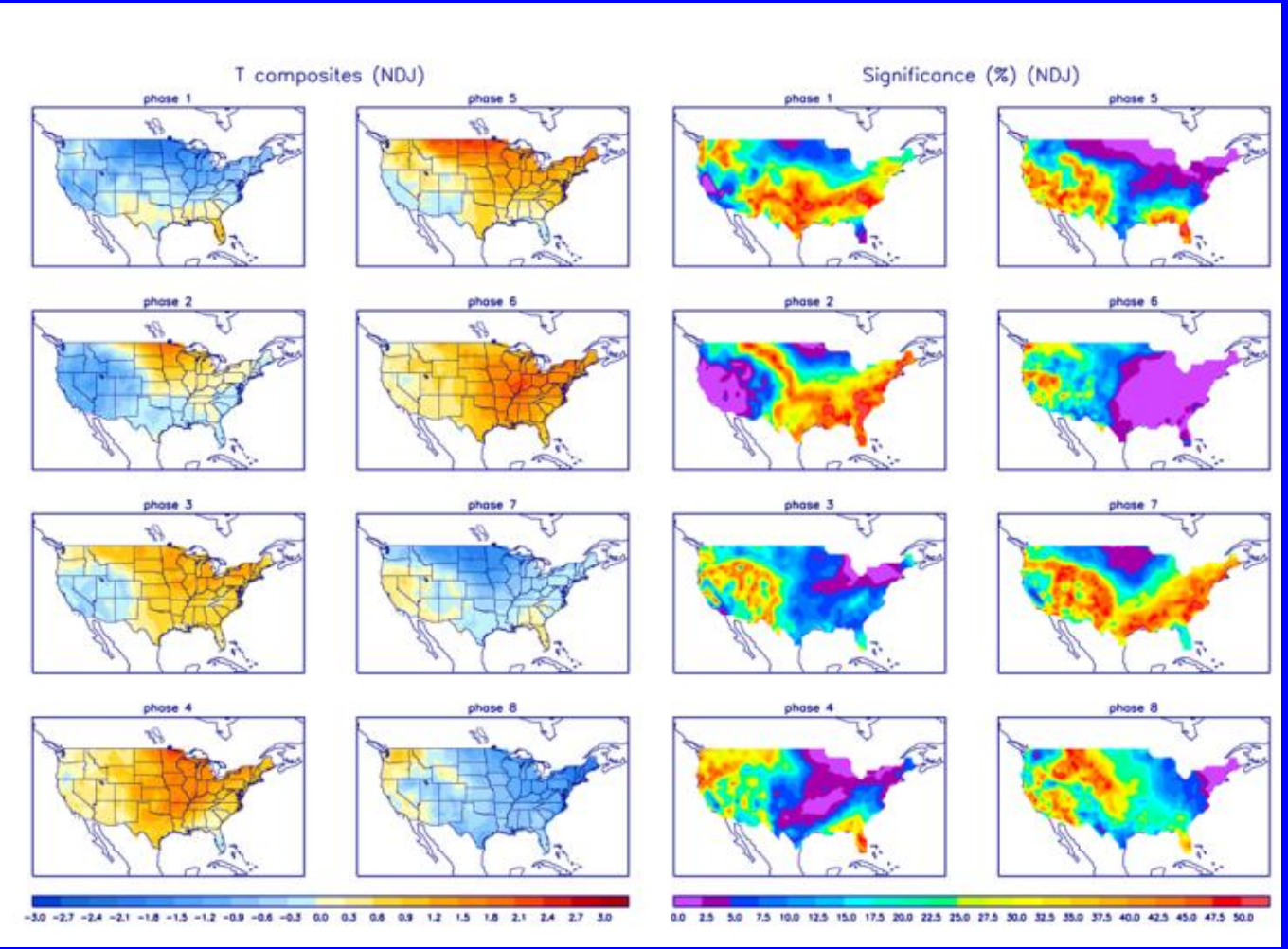


Precipitation Anomalies (Nov-Mar)



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.**

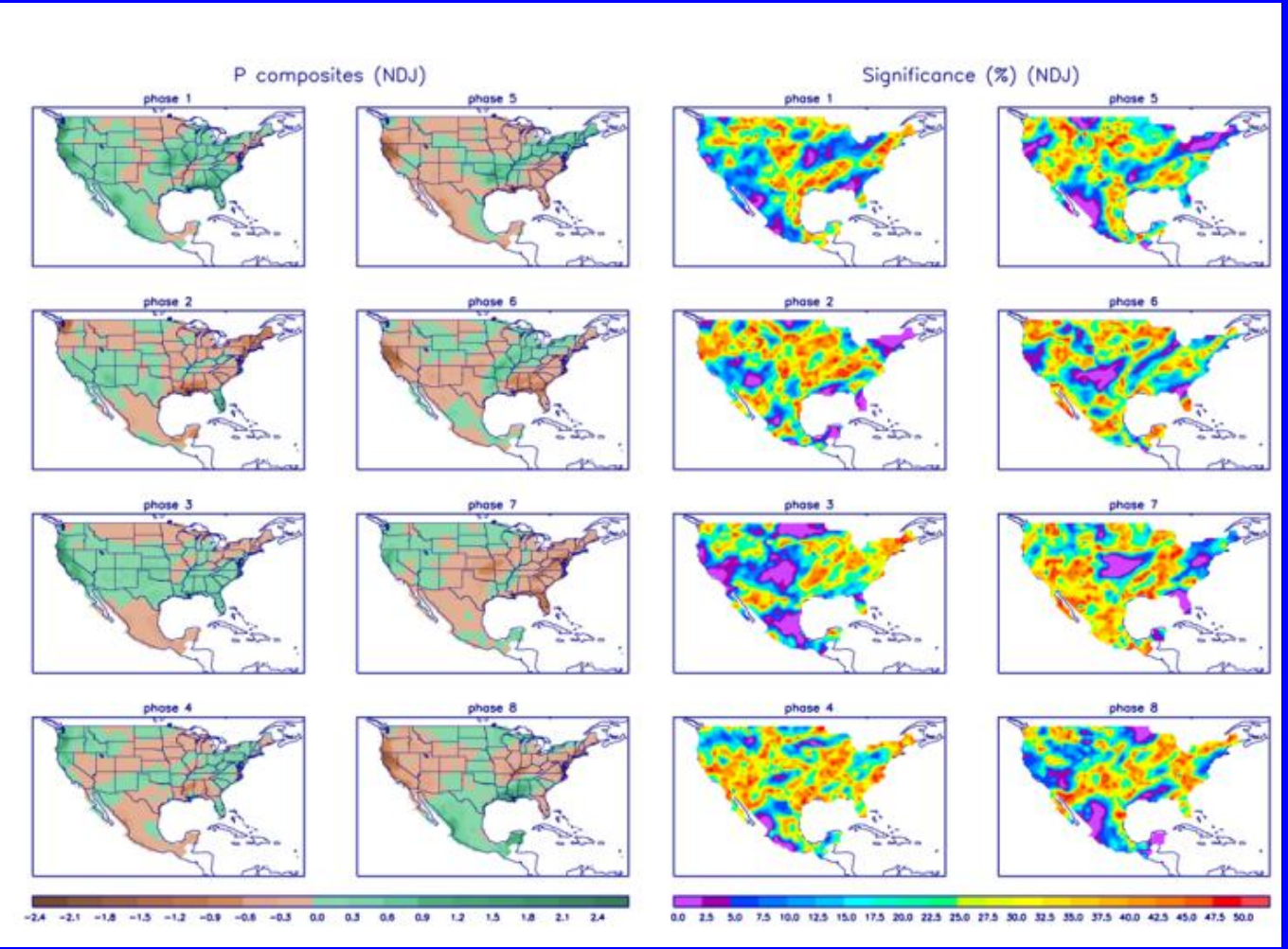


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.**



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