



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

**Update prepared by
Climate Prediction Center / NCEP
November 14, 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 but appears to have weakened and become less coherent with the enhanced convective phase centered across the Central Pacific.**
- **Dynamical model MJO index forecasts continue to indicate eastward propagation of a weaker MJO signal during the next two weeks.**
- **Based on the latest observations and model MJO forecasts, the MJO is forecast to remain active during the next two weeks, although the MJO may not play as large a role as in recent weeks on tropical rainfall variability.**
- **The MJO is expected to contribute to enhanced rainfall across the southwestern Pacific Ocean and Central and South America during the period with suppressed rainfall favored for portions of the Indian Ocean and Maritime Continent.**

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



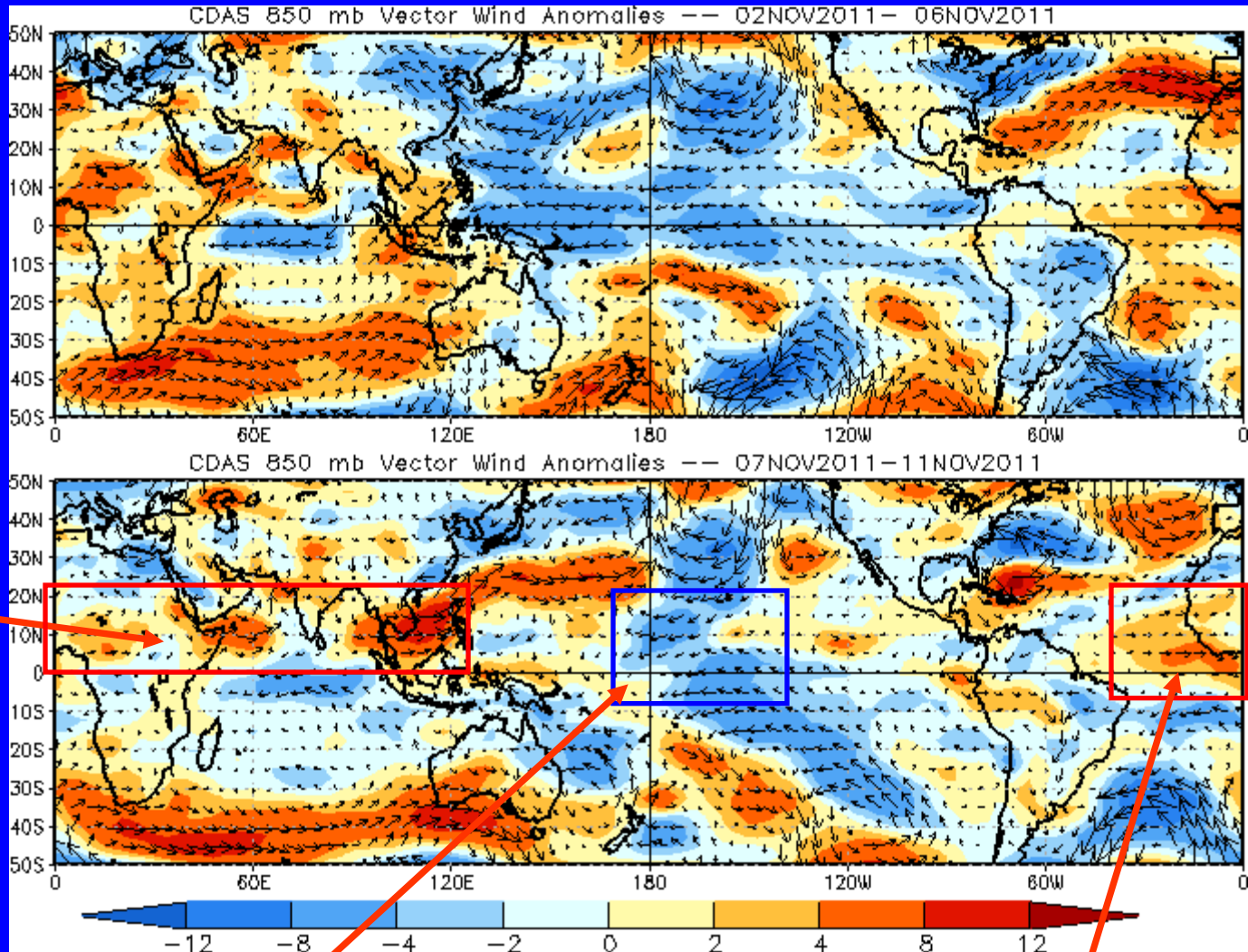
850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Westerly anomalies continued across much of the Indian Ocean north of the equator, southern Asia and the Maritime Continent.



Easterly wind anomalies decreased in coverage during the last five days over the Central Pacific.

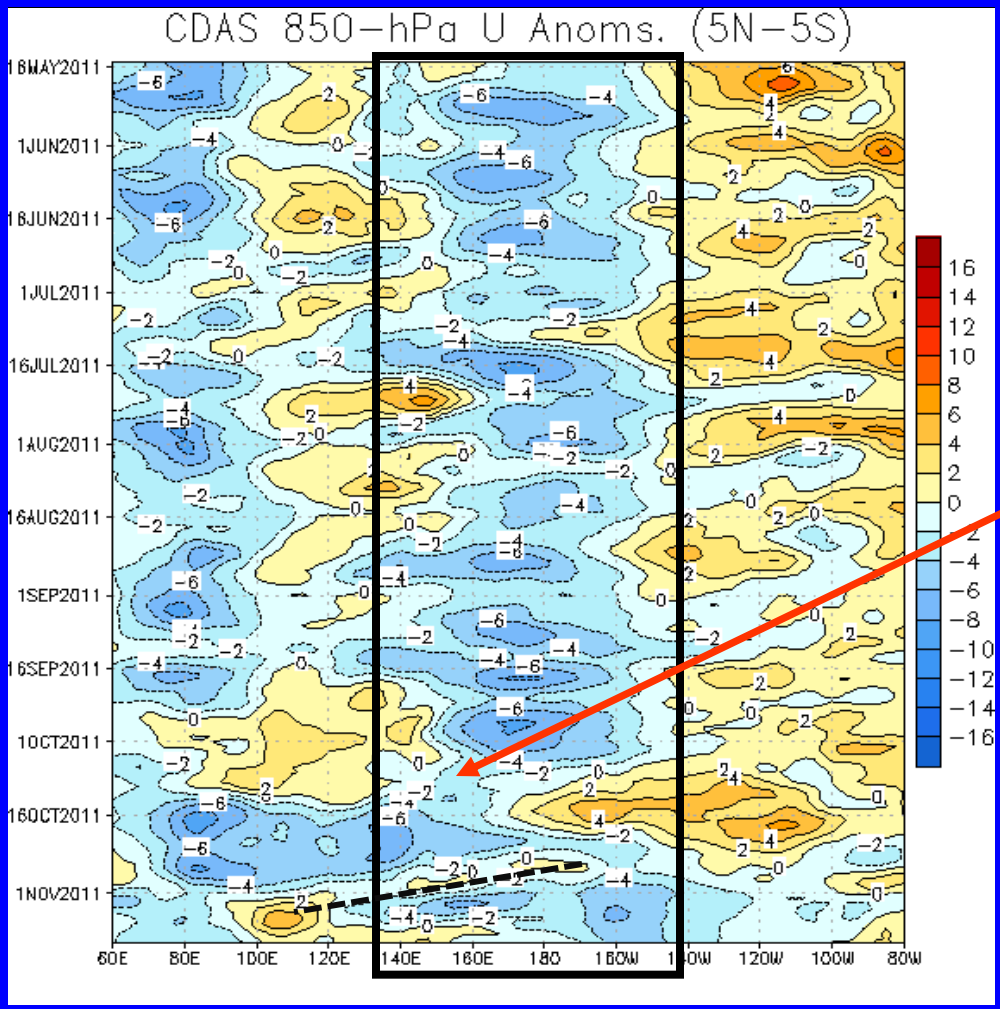
Westerly anomalies persisted across the eastern Atlantic and Africa during the last 5 days.



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.

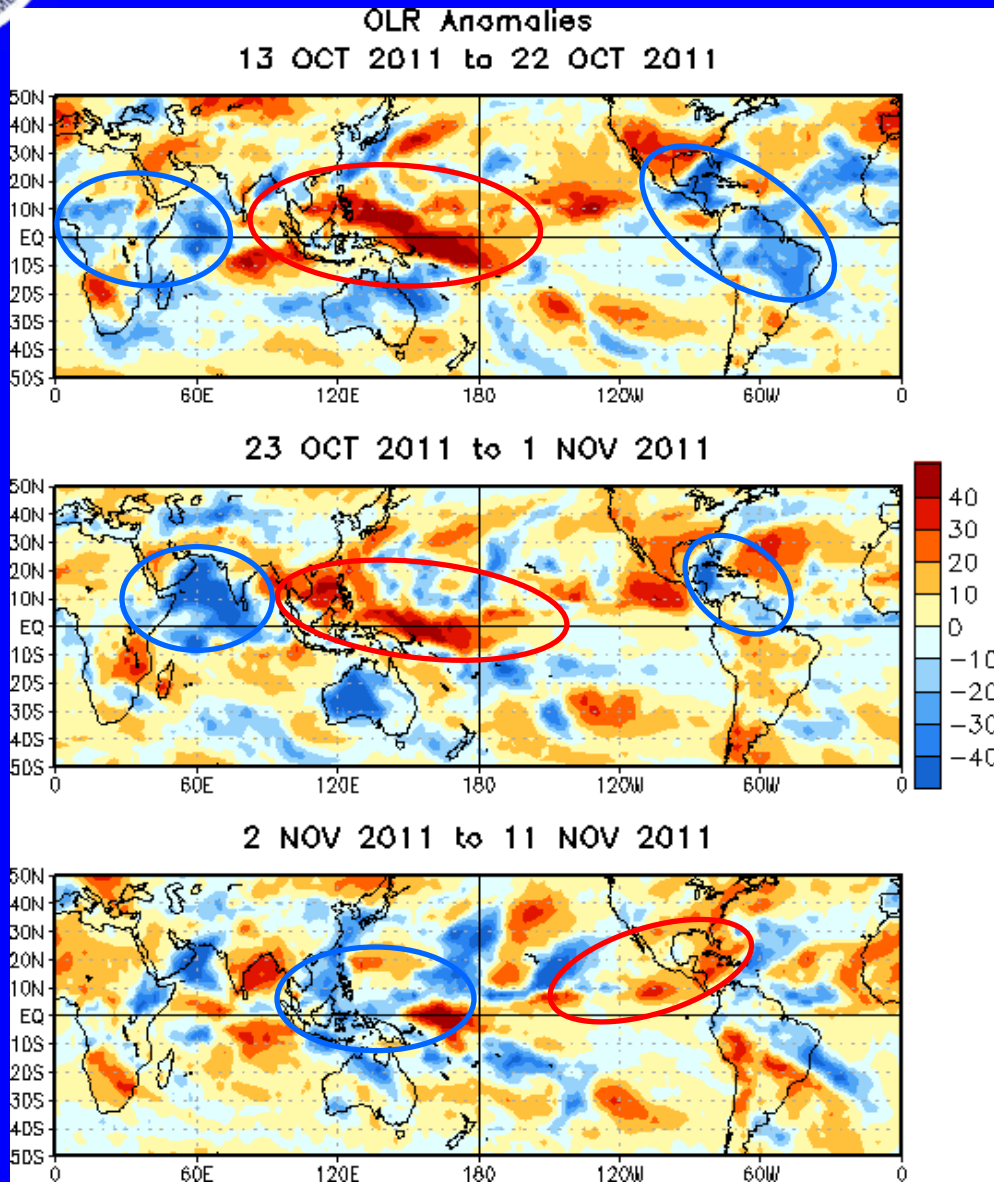
An equatorial Rossby wave imparted westerly anomalies across much of southern Asia and the Indian Ocean (dashed line).

Recently, continued eastward propagation of the MJO signal has contributed to westerly anomalies across the Indian Ocean and Maritime Continent, with a substantial reduction in easterly anomalies across the Western Pacific.



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 mid-October, suppressed convection (red circle) was observed across the Maritime Continent and Western Pacific, while enhanced convection covered the Americas and equatorial Africa.

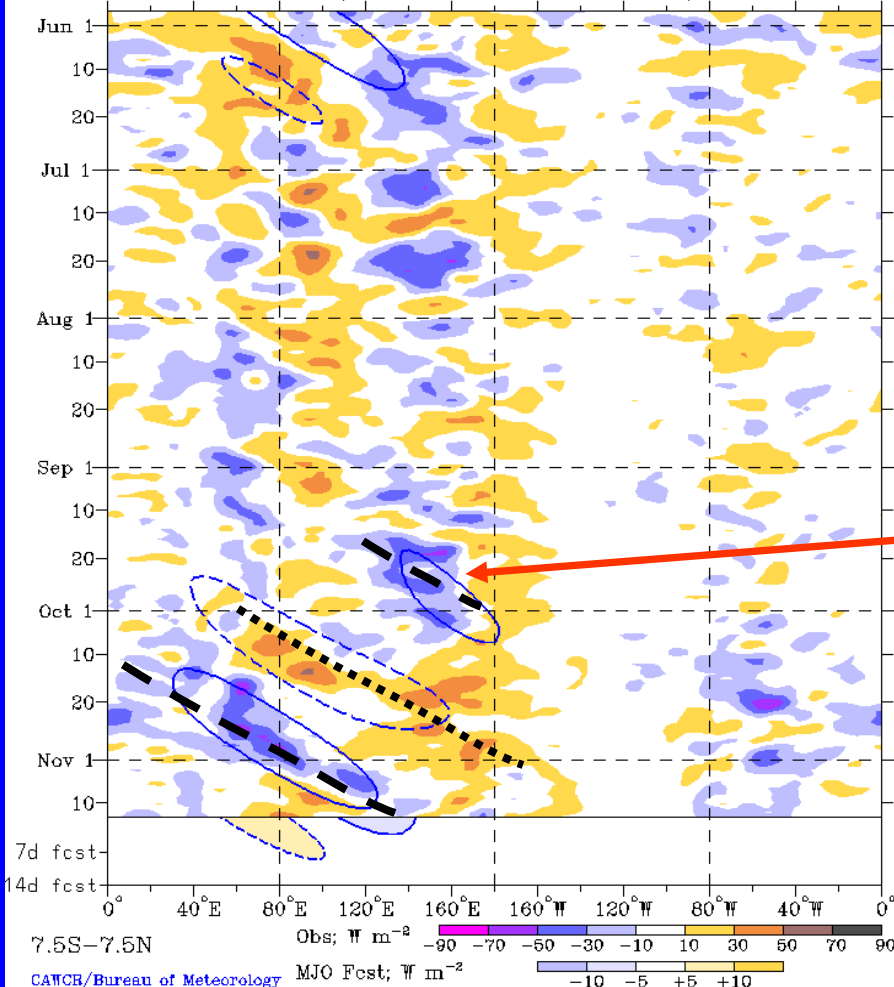
Enhanced convection diminished over the Americas and Africa, while enhanced convection developed over the Western Indian Ocean. Suppressed convection continued over the Western Pacific and Maritime Continent, all consistent with MJO activity at that time.

During early November, suppressed convection developed over parts of the Americas, the Bay of Bengal areas of the Indian Ocean. Enhanced convection developed across the Maritime Continent and the far Western Pacific.



Outgoing Longwave Radiation (OLR) Anomalies (7.5°S-7.5°N)

Real-time MJO filtering superimposed upon 3drmm R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
29-May-2011 to 13-Nov-2011 + 14 days



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 Western Pacific and South America with suppressed convection over the Indian Ocean.

Time
↓

Longitude

7.5S-7.5N Obs; $W m^{-2}$ -90 -70 -50 -30 -10 10 30 50 70 90
CAWCR/Bureau of Meteorology MJO Fcst; $W m^{-2}$ -10 -5 +5 +10

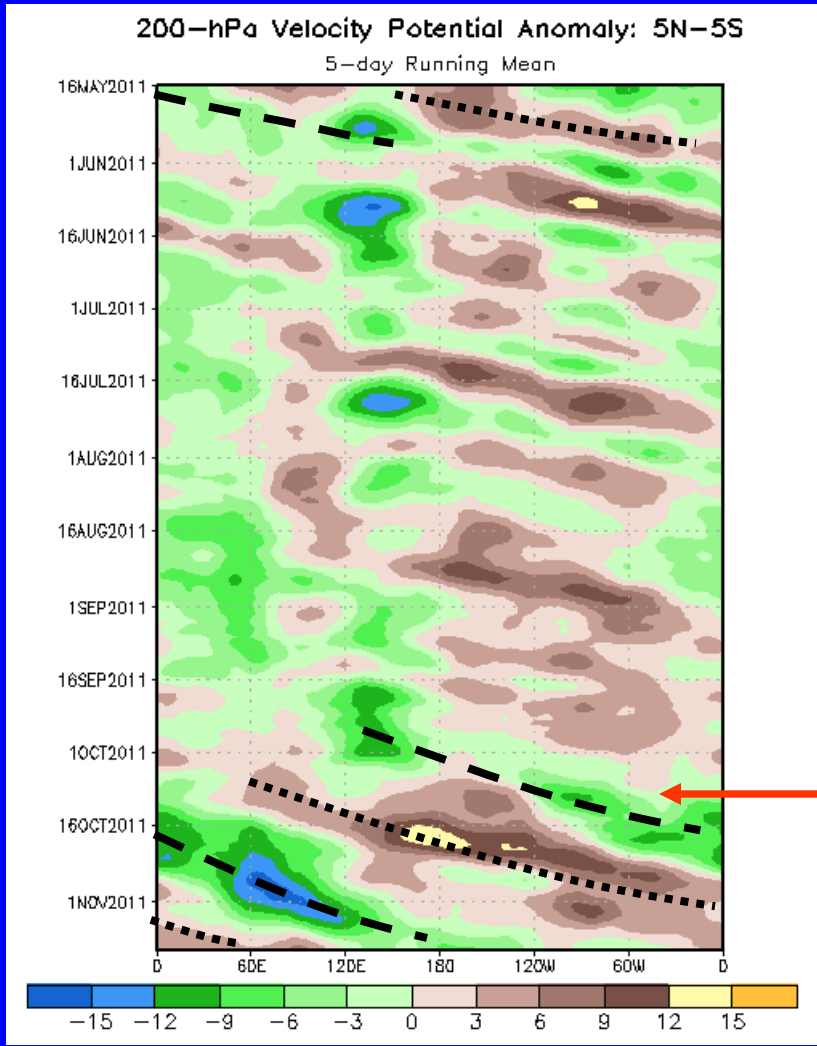


200-hPa Velocity Potential Anomalies (5°S-5°N)

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.

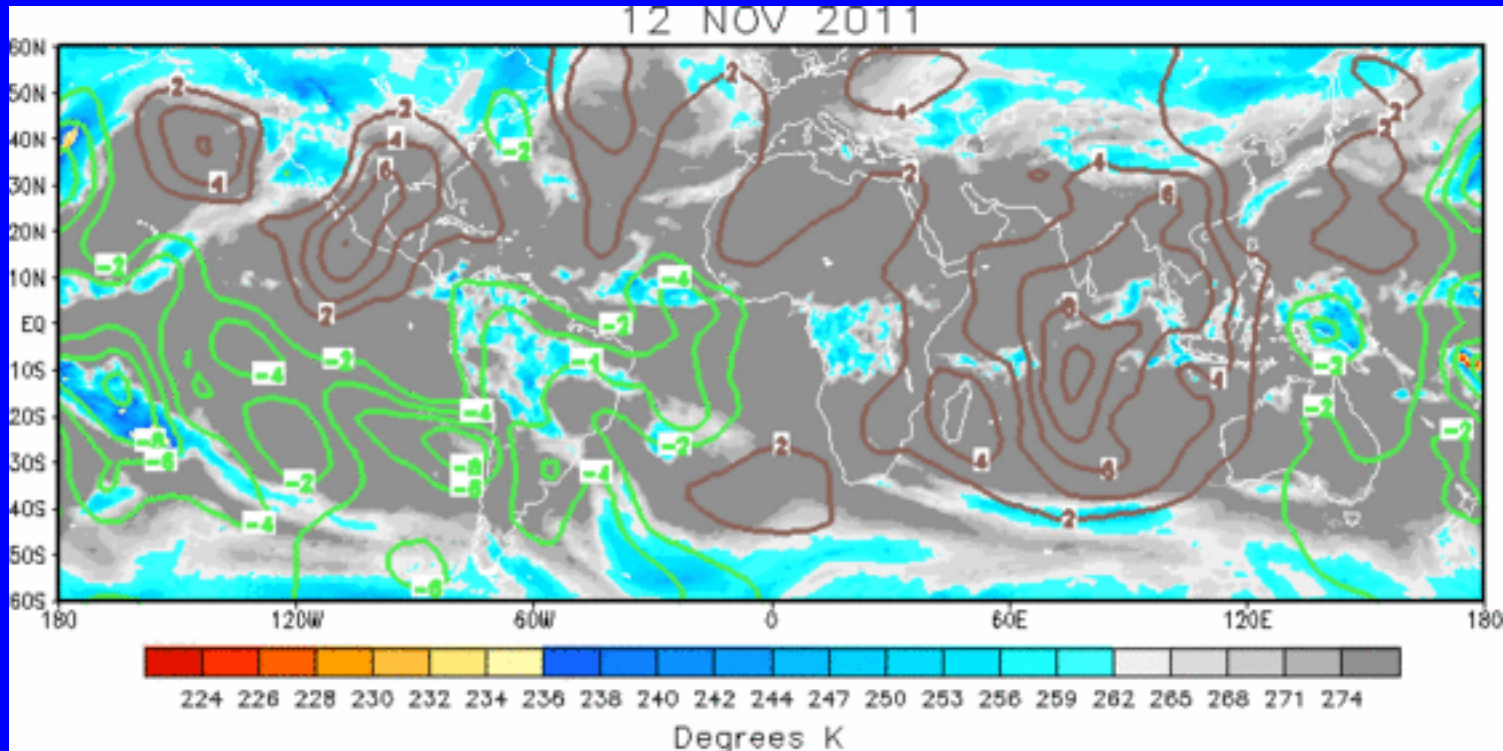
During the second half of September, negative anomalies developed across the Western Pacific, propagated eastward around the planet and are now located over the Central Pacific. Positive anomalies followed and are now located mostly over Africa and Indian Ocean. Higher frequency modes of variability 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 a less coherent structure than previous weeks. Anomalous upper-level divergence centered across the Central Pacific is evident as is anomalous upper-level convergence across North America, Africa and the Indian Ocean.

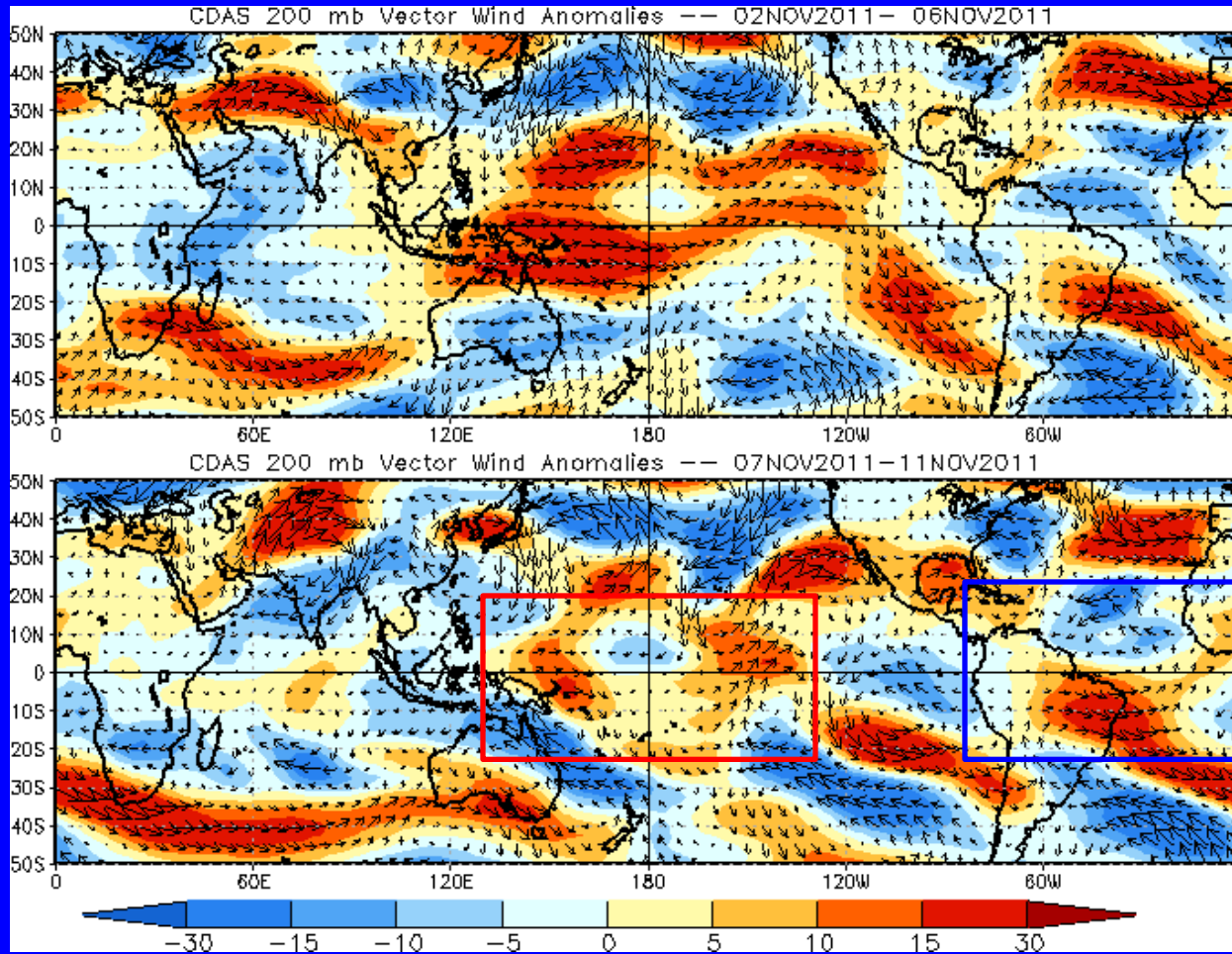


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



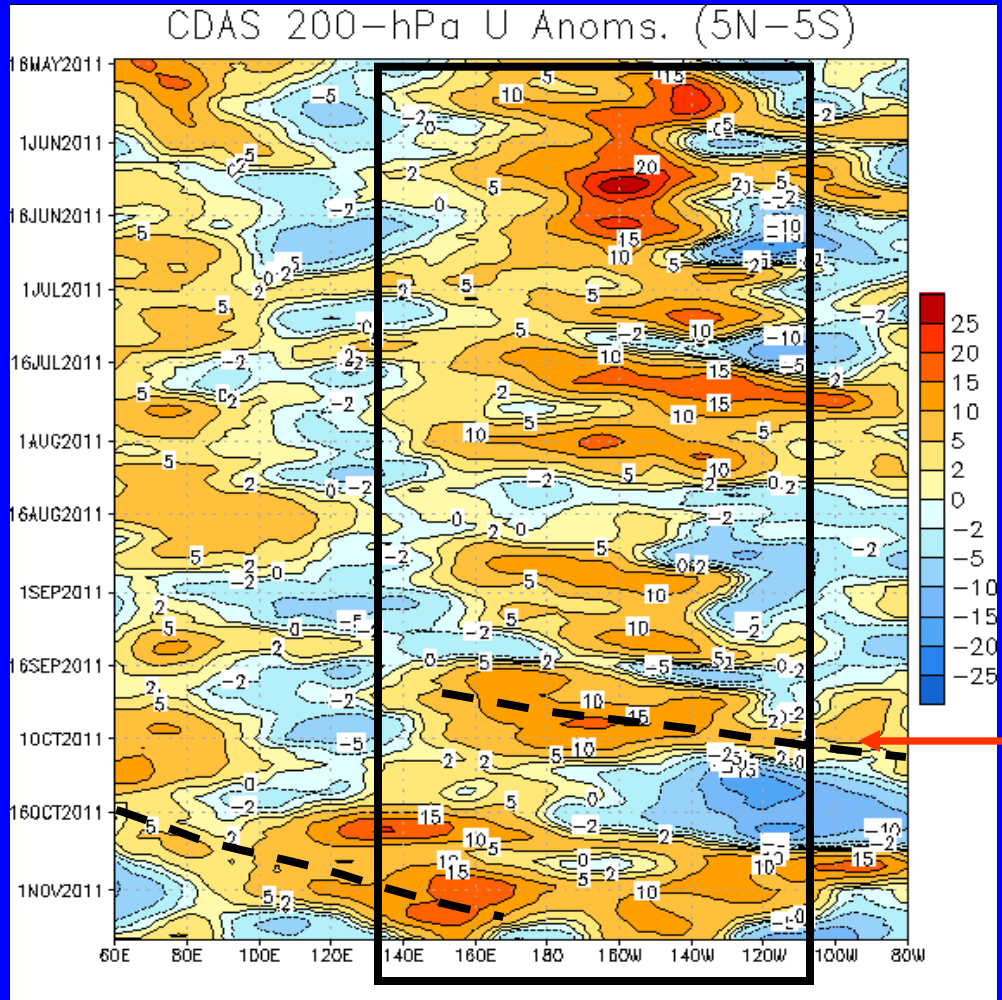
Upper-level westerly wind anomalies weakened over the Maritime Continent and are now mainly indicated over the Central Pacific Ocean.



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
↓

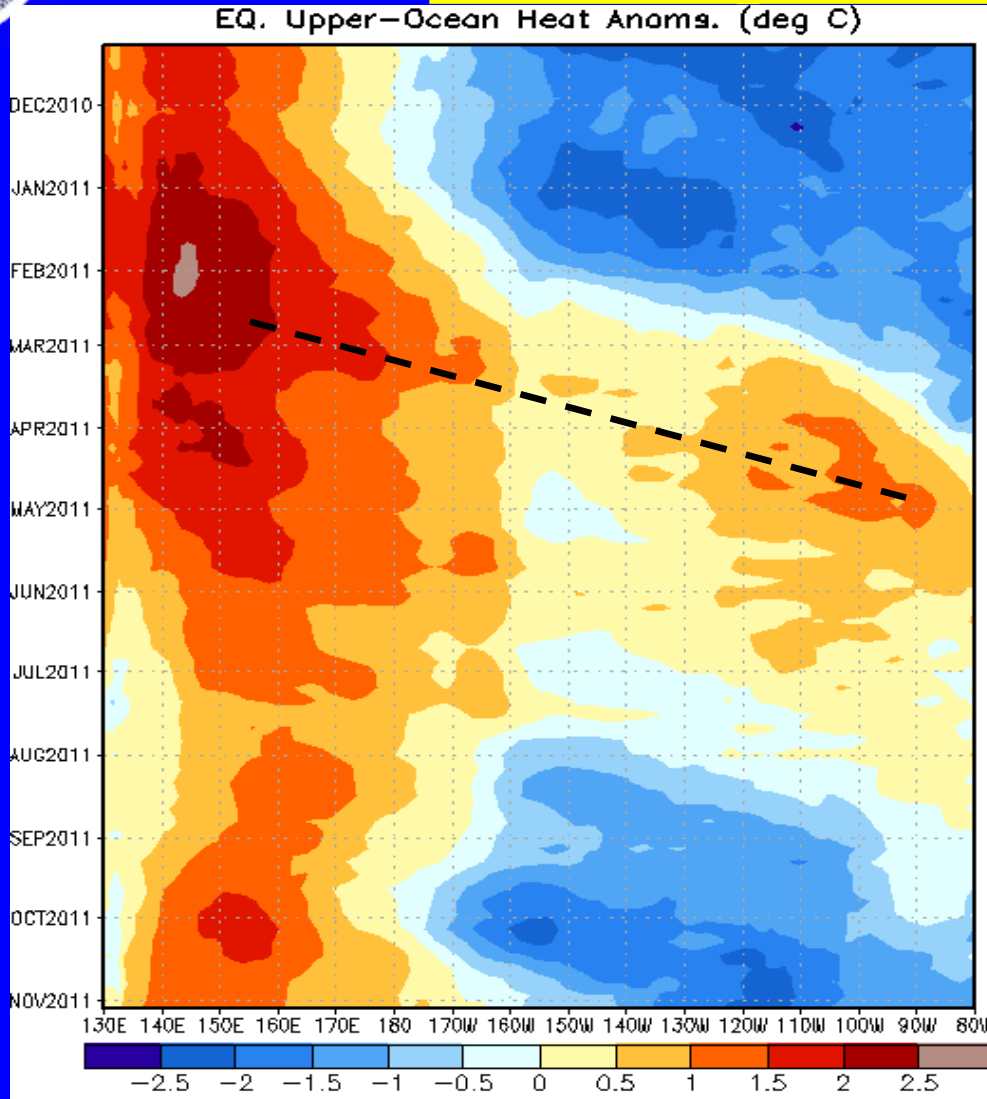
Longitude

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



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.

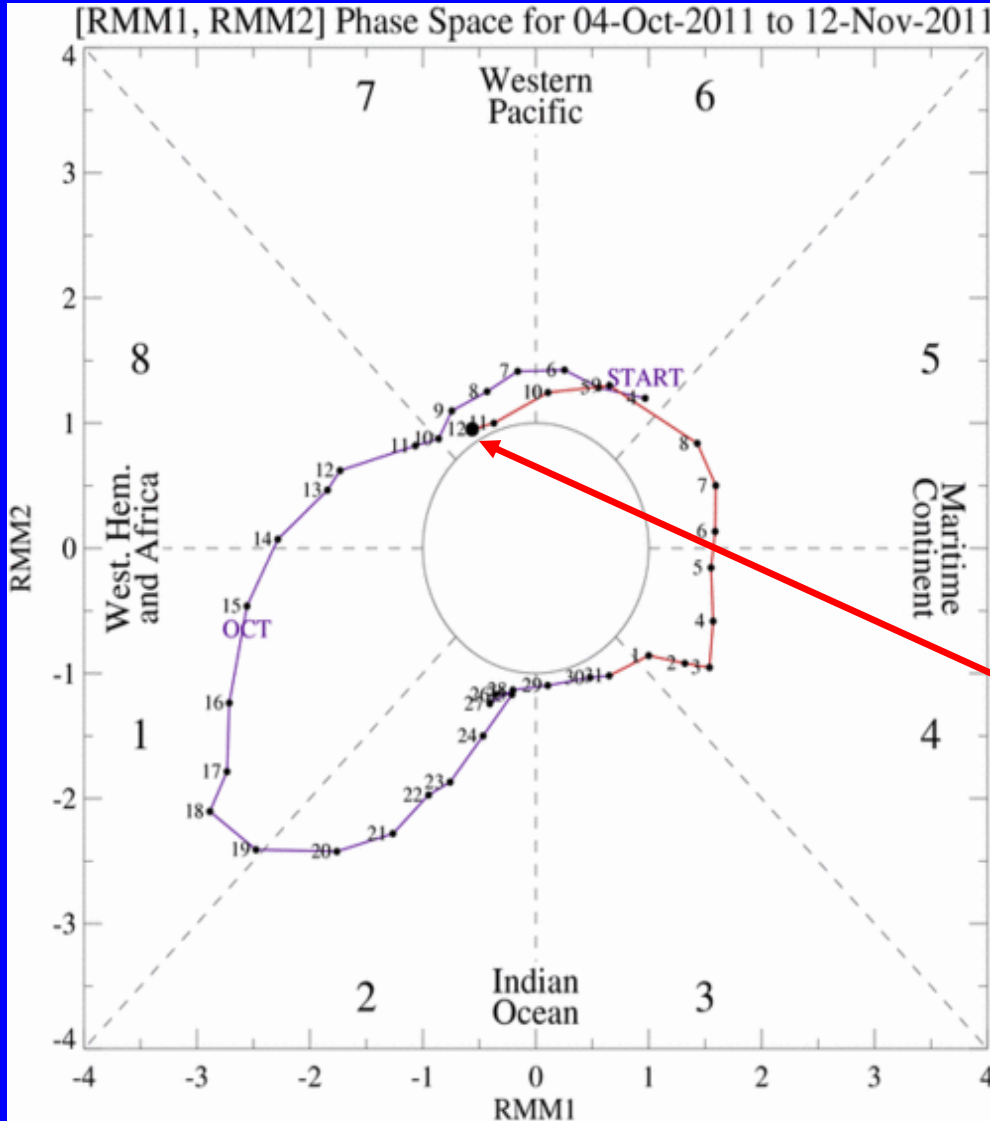
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

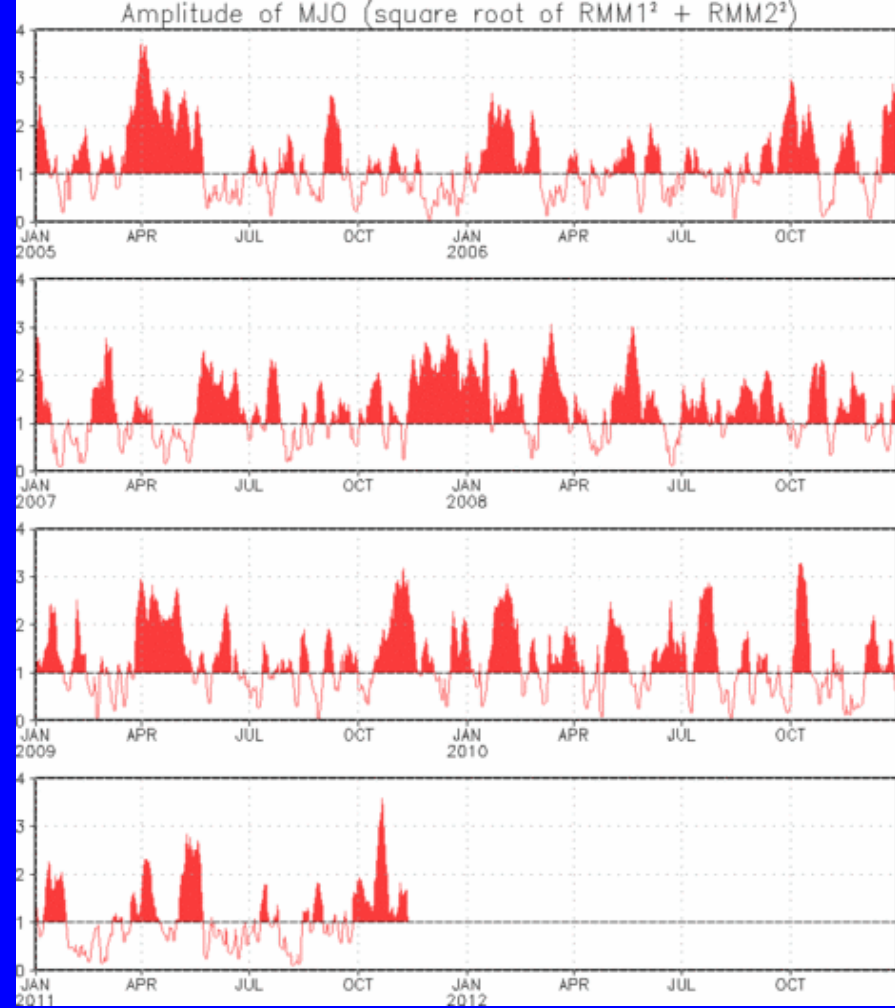
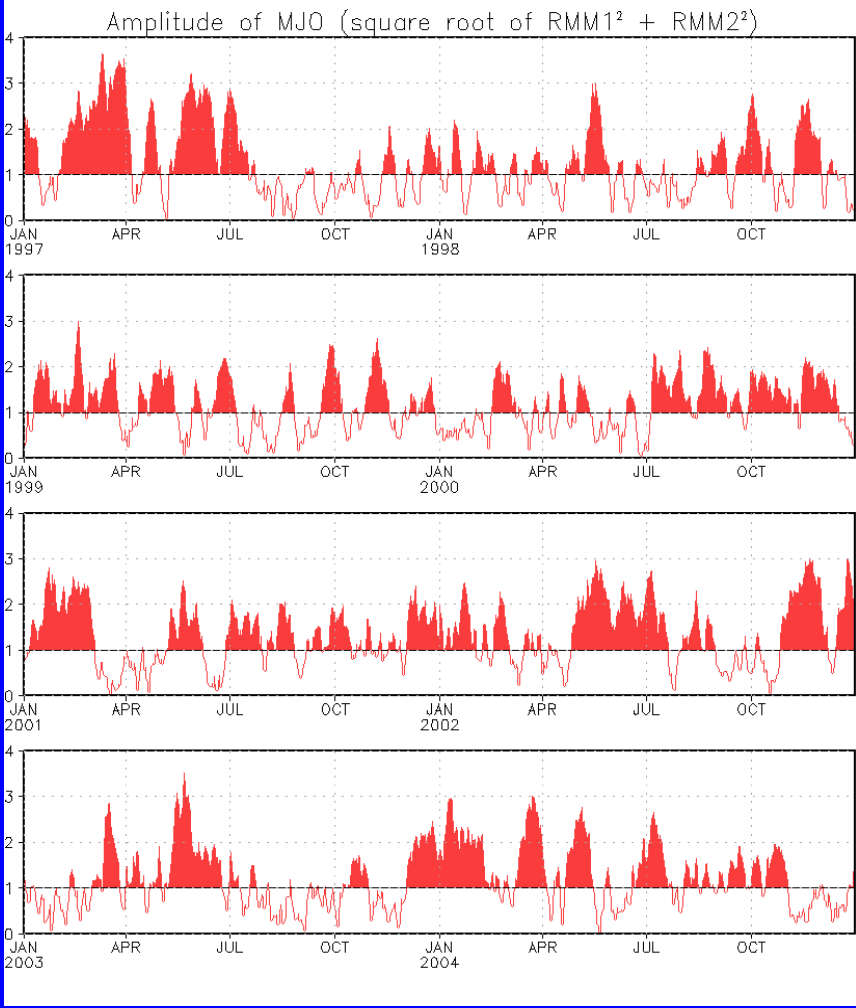


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates eastward propagation with a slight decrease in amplitude 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.



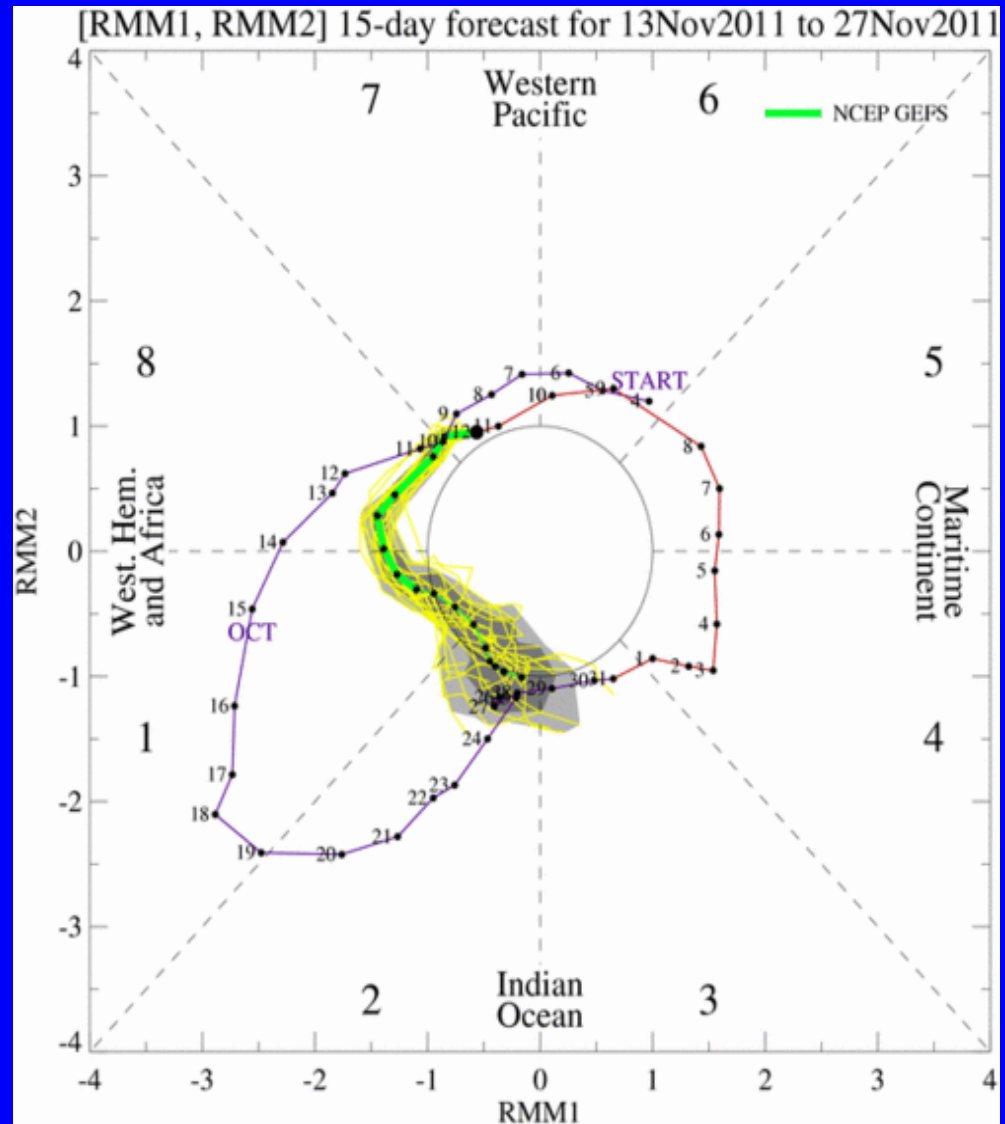
Ensemble GFS (GEFS) MJO Forecast

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 eastward propagation of a MJO signal during the period. During Week-2, the model indicates some weakening but continues the slow eastward propagation.



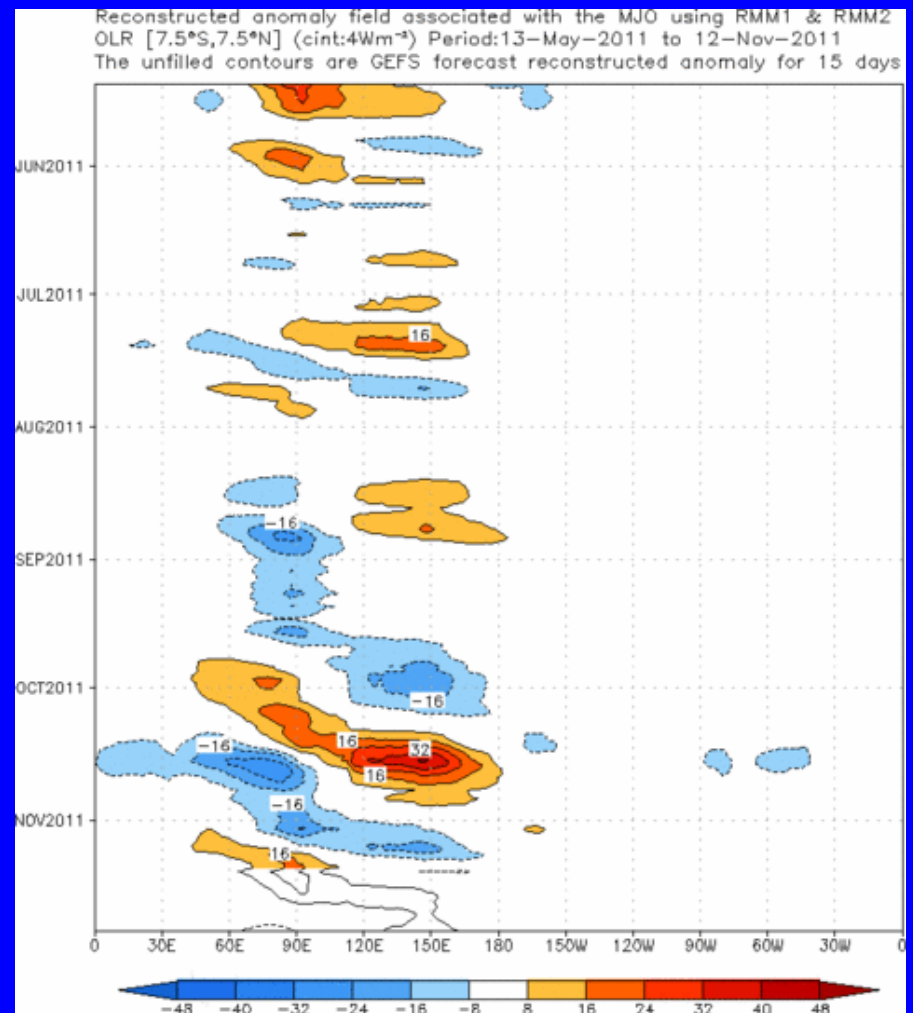
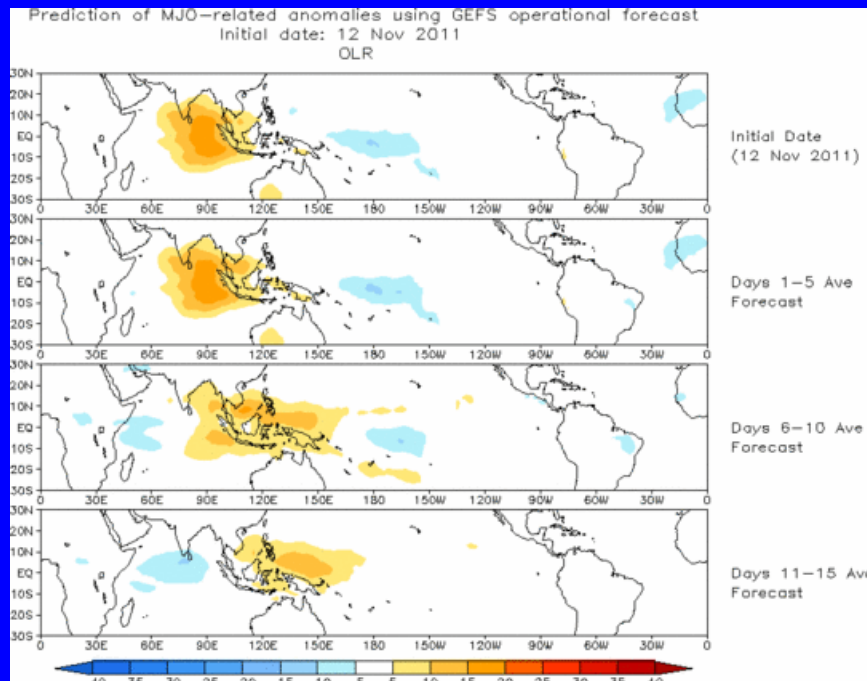


Ensemble Mean GFS MJO Forecast

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 from the Central Pacific to the Americas and Africa during Week-1. Continued eastward movement across Africa is forecast for the remainder of the period.

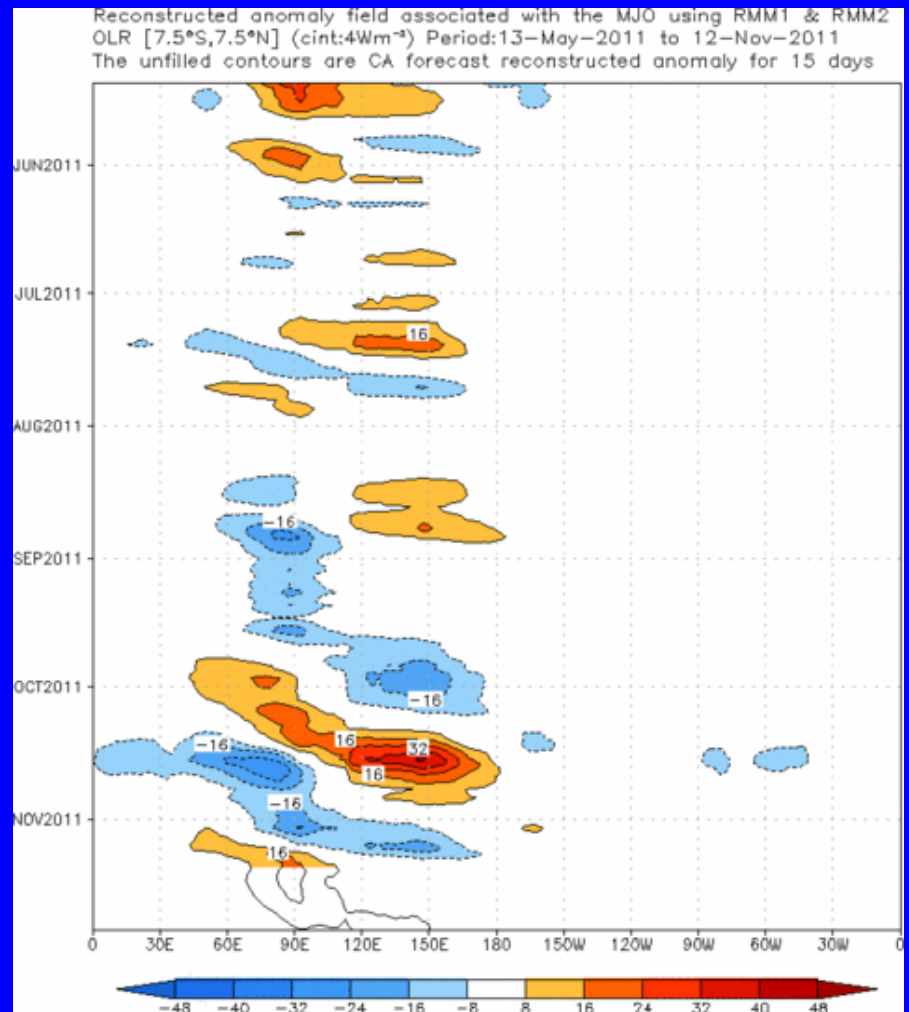
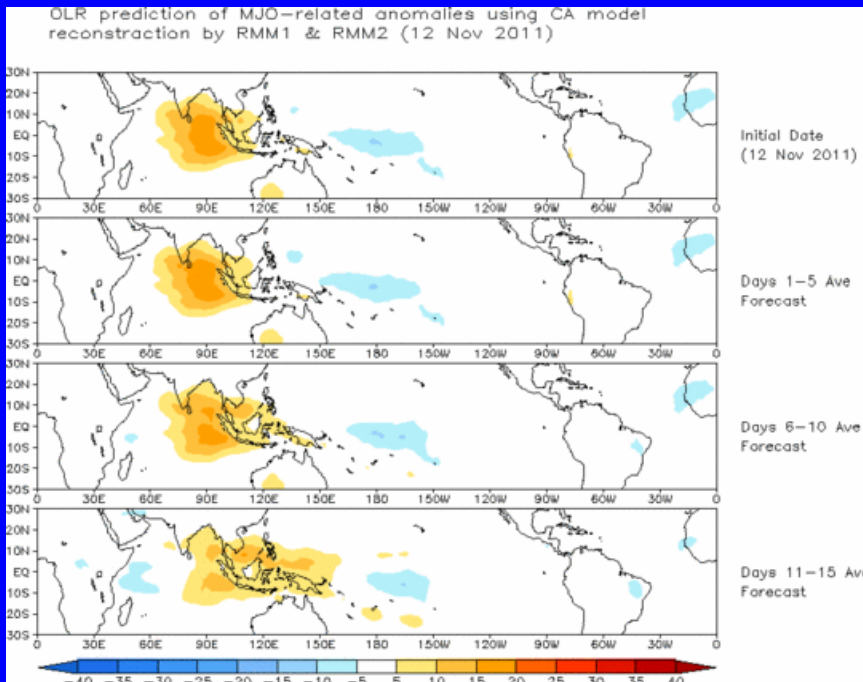


Constructed Analog (CA) MJO Forecast

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

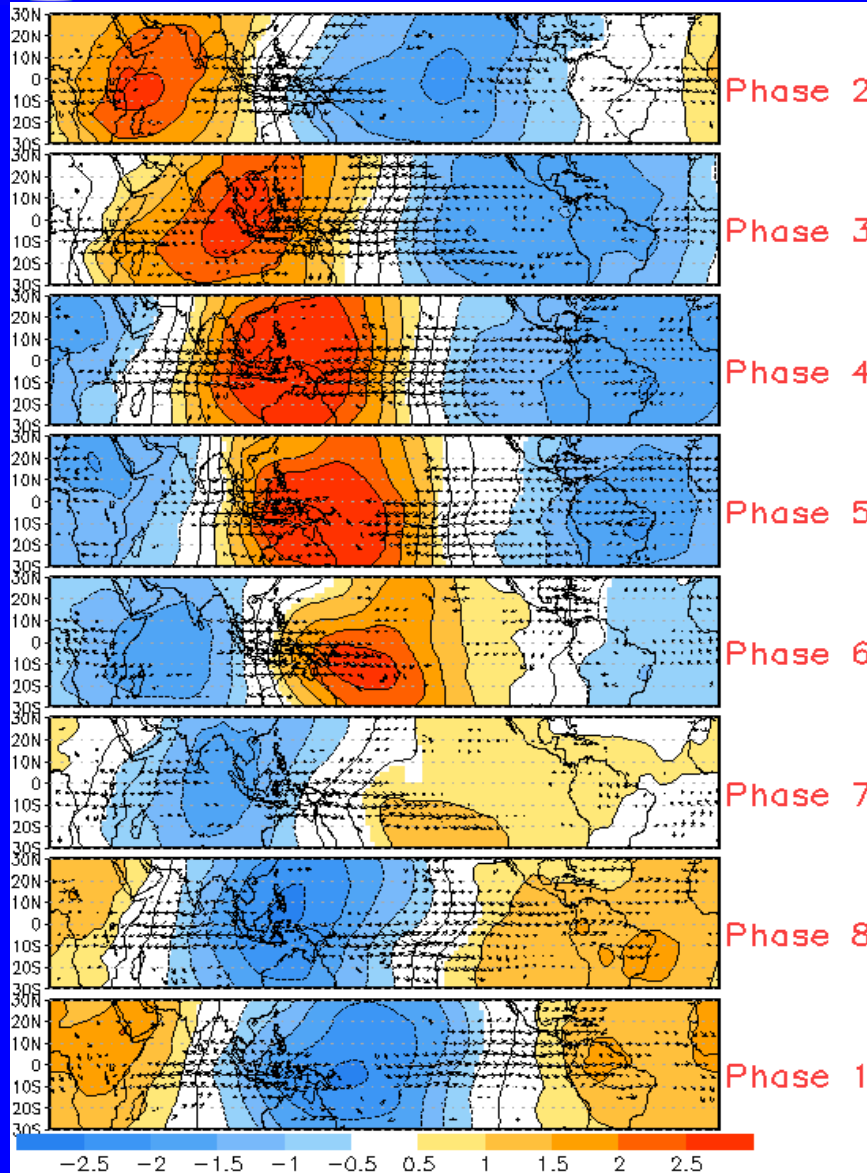


The CA forecast indicates very slow eastward propagation with suppressed convection slowly shifting east from the Indian Ocean. By week-2, enhanced convection is predicted to return to Africa and the western Indian Ocean.

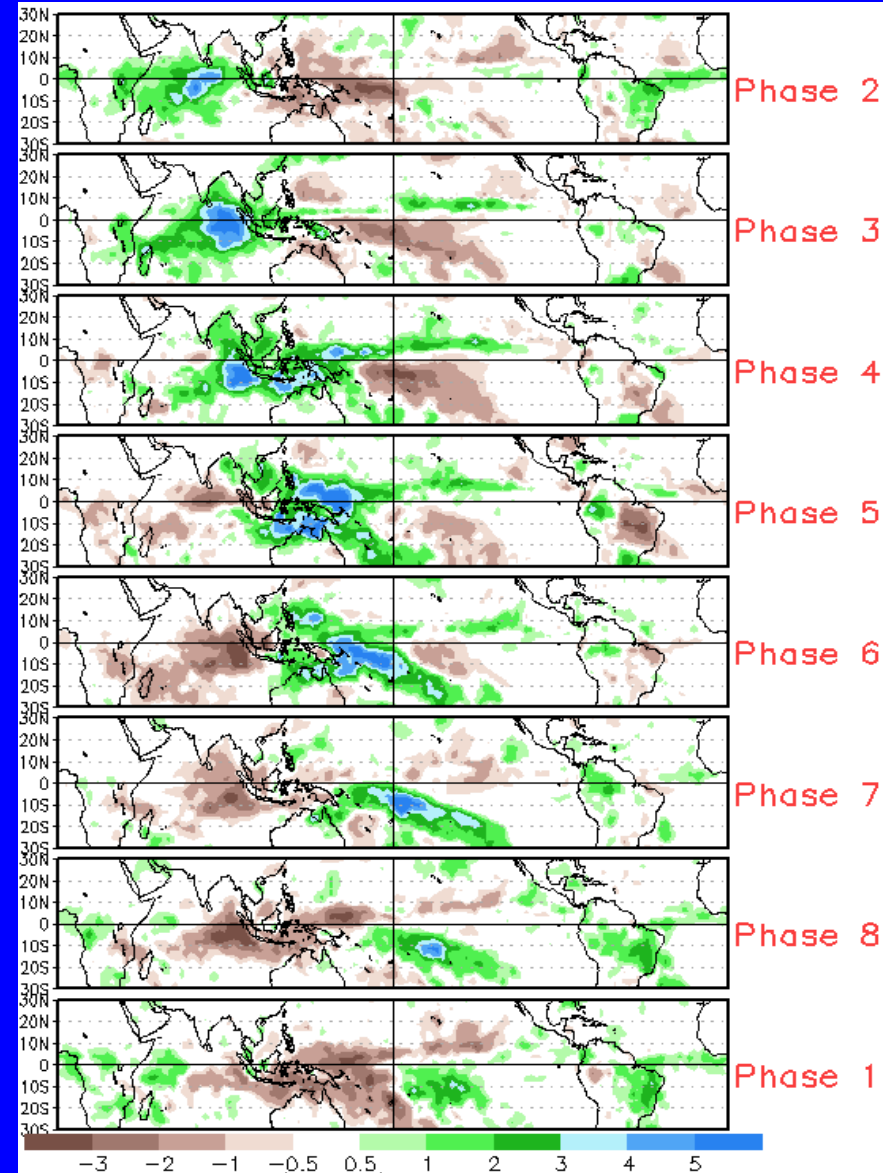


MJO Composites – Global Tropics

850-hPa Wind Anomalies (Nov-Mar)



Precipitation Anomalies (Nov-Mar)

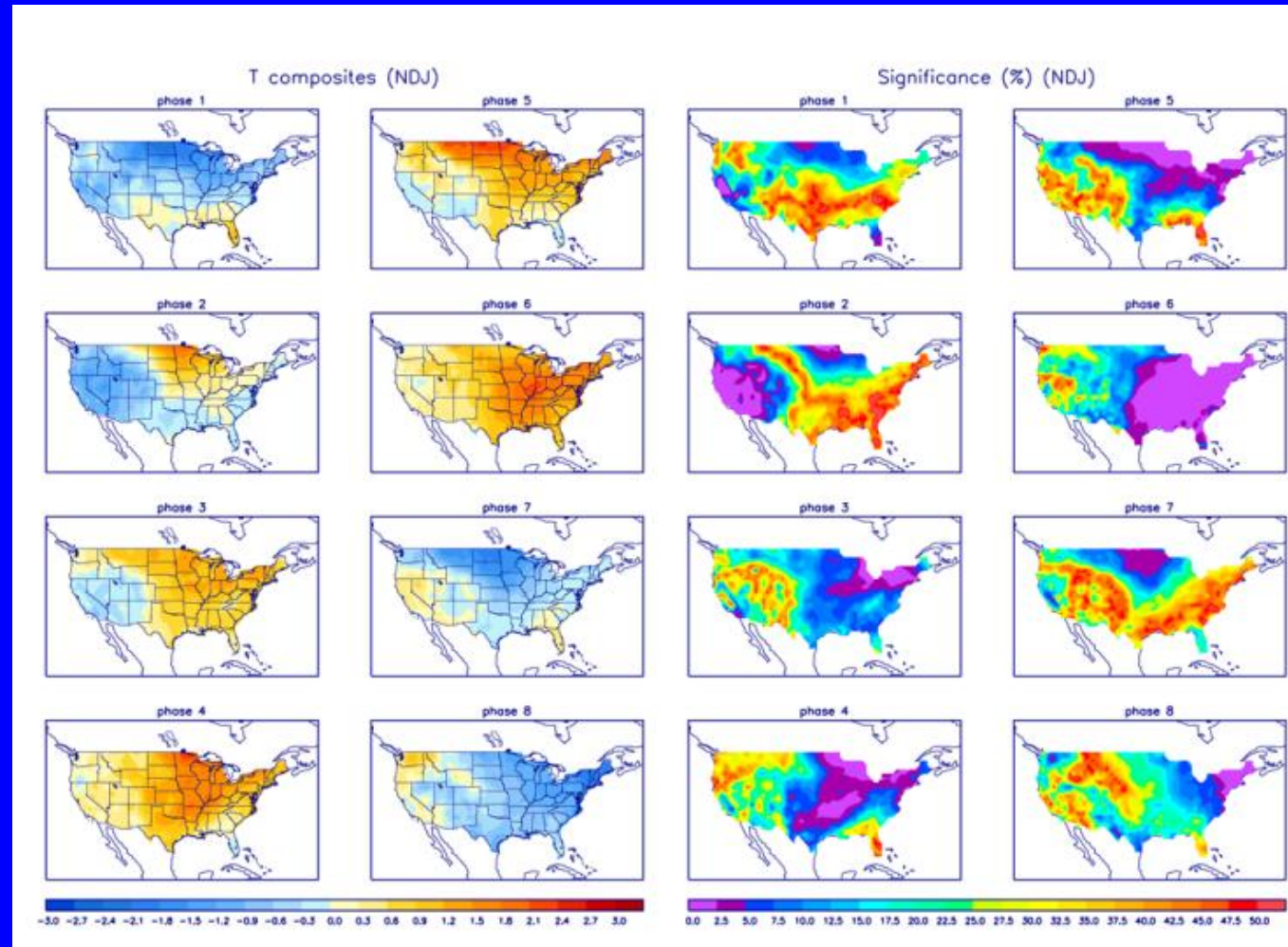




U.S. MJO Composites – Temperature

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.



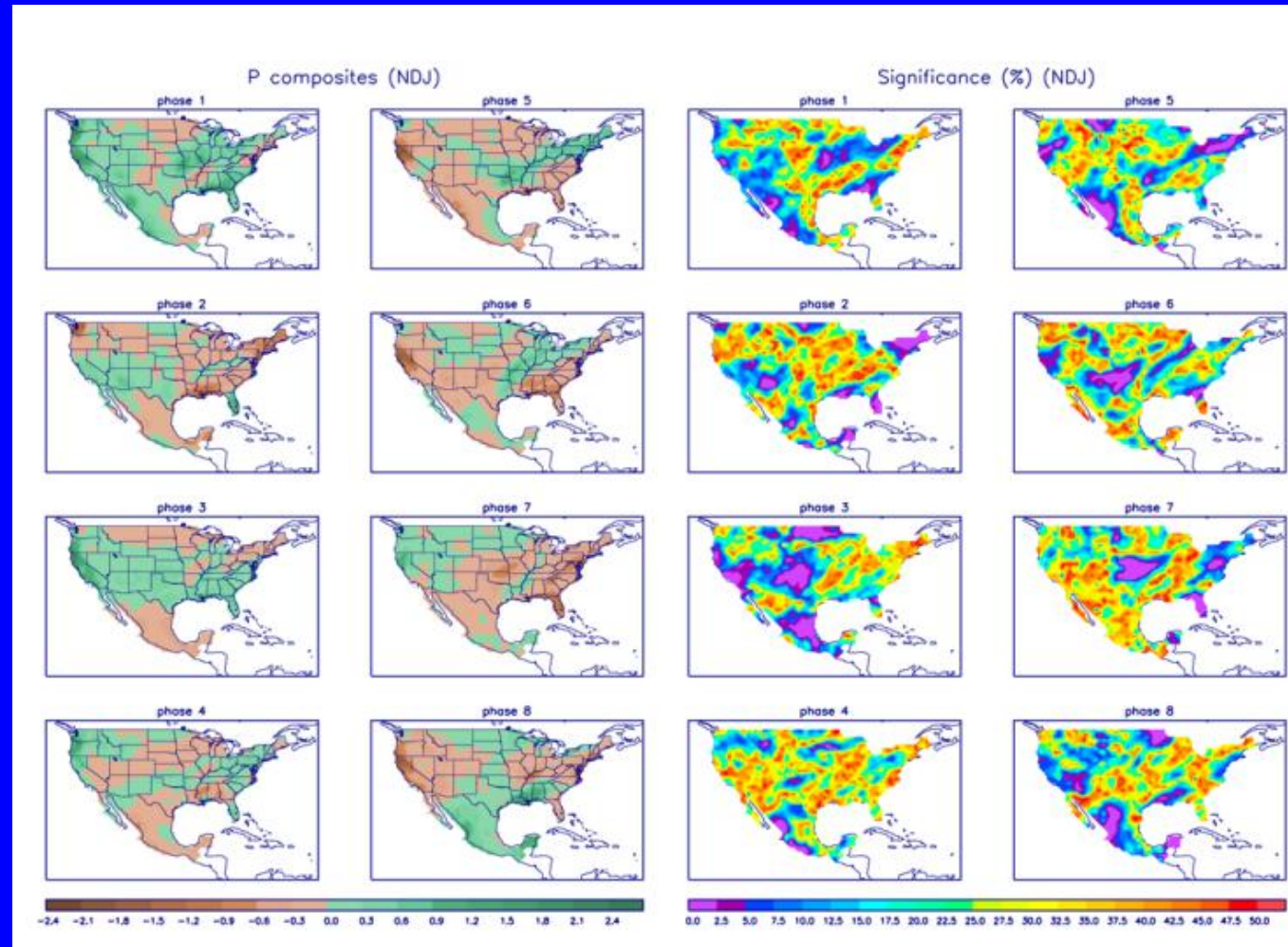
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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

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