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

Update prepared by
Climate Prediction Center / NCEP
October 3, 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 shifting from the Maritime continent into the western Pacific.
- Dynamical model MJO index forecasts continue to indicate an eastward propagating MJO signal during the period with the enhanced convective phase shifting to the western Hemisphere 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.
- The MJO is expected to contribute to enhanced rainfall across parts of the western-central Pacific and northern South America with suppressed rainfall favored for parts of the Indian Ocean and Maritime continent during the period.
- The forecast MJO phase favors continued above-average precipitation for the Northwest quarter of the U.S. including parts of California during much of the period and enhances the threat for tropical cyclogenesis for the western Caribbean Sea during Week-2.

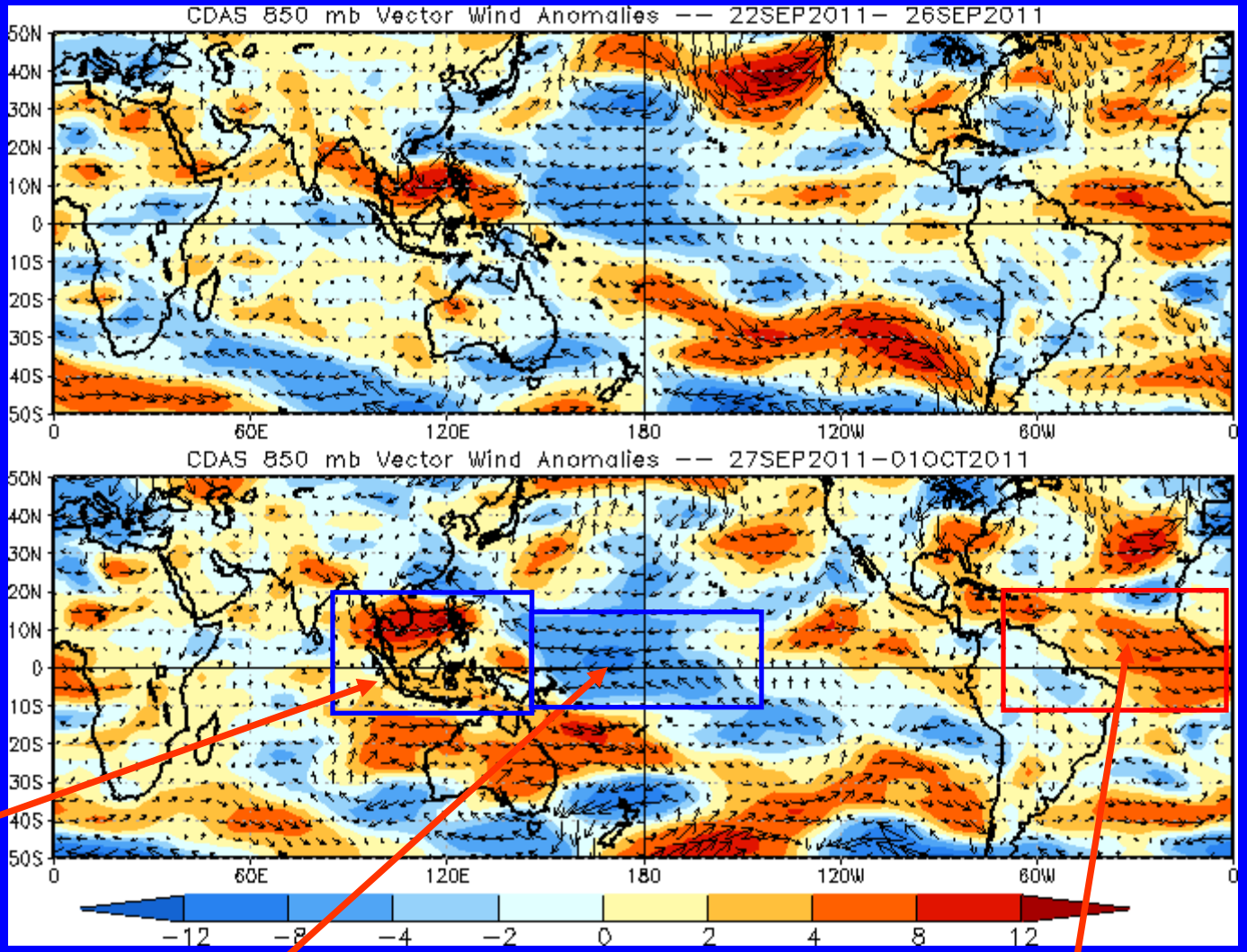
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



During the last five days, westerly anomalies were evident across Southeast Asia and Maritime continent.

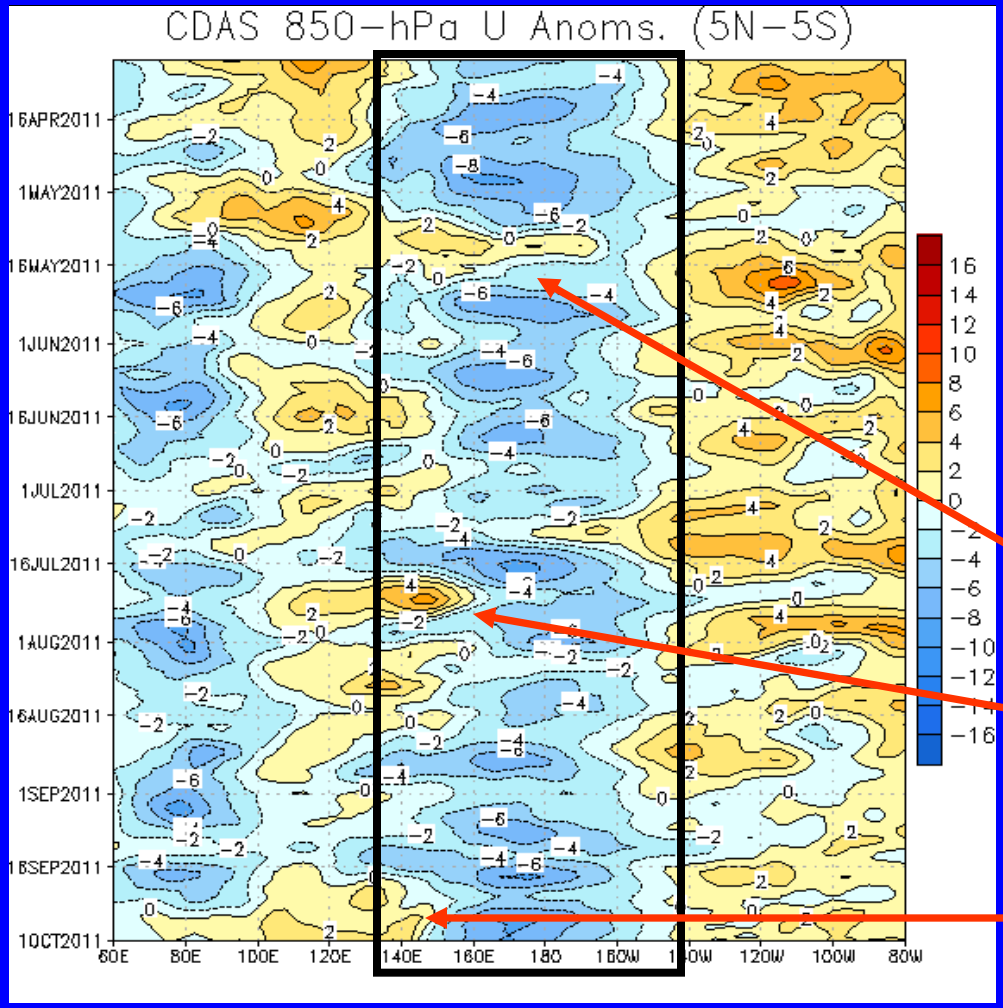
Easterly wind anomalies remained centered near the Date Line along the equator during the last five days.

Westerly anomalies continued across the tropical Atlantic and west central Africa during the last five 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

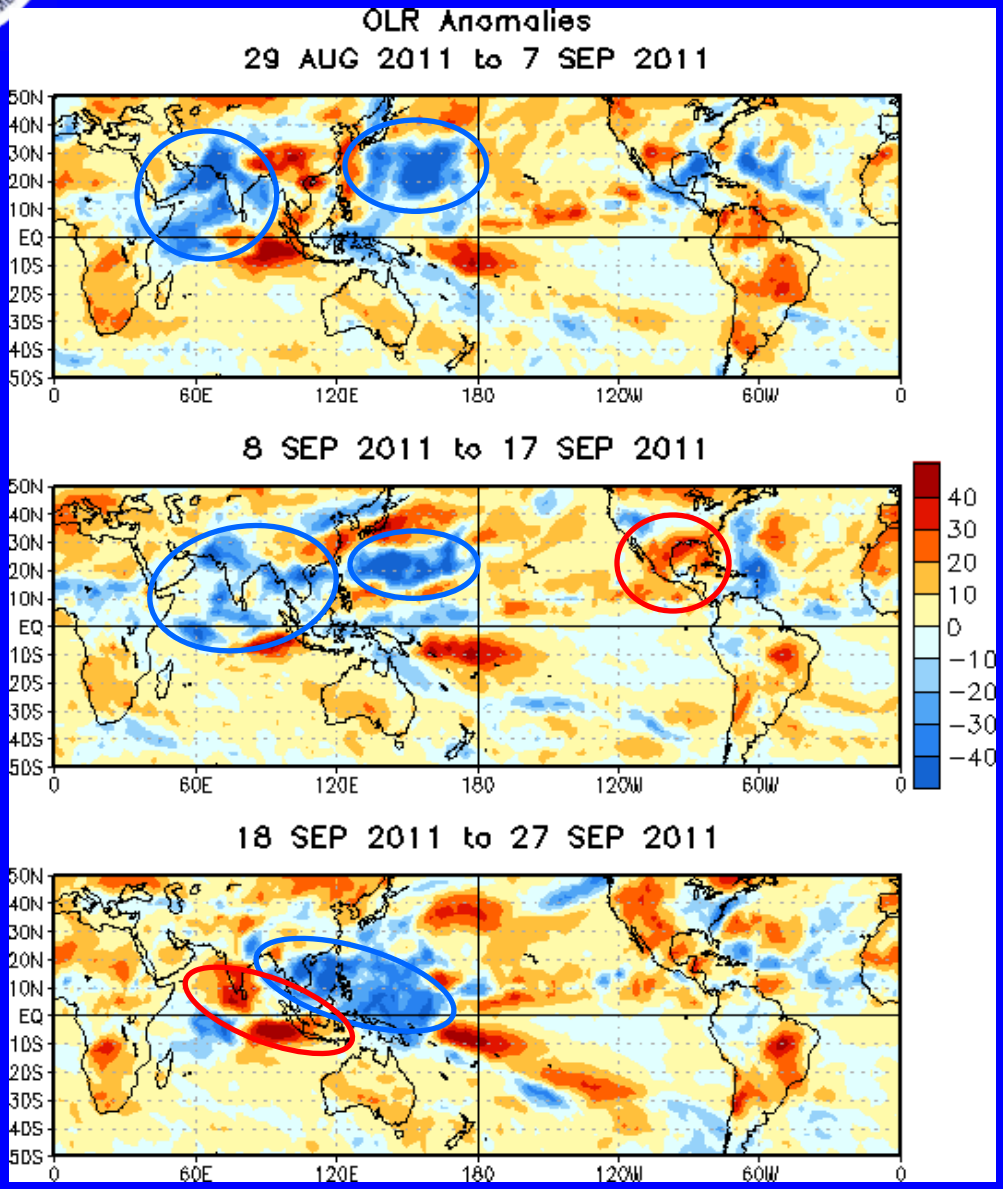
Easterly anomalies have persisted in the west-central Pacific since late March (black box) consistent with La Nina conditions during much of the period. The magnitude of these anomalies, however, weakened somewhat from the early portion of the period.

A burst of westerly wind anomalies associated with the MJO moved across the Pacific in early-to-mid May.

Strong westerly anomalies developed across the western Pacific near 150E during the second half of July.

During mid-to-late September, westerly anomalies stretch from the Indian Ocean to near 140E.

OLR Anomalies – Past 30 days



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

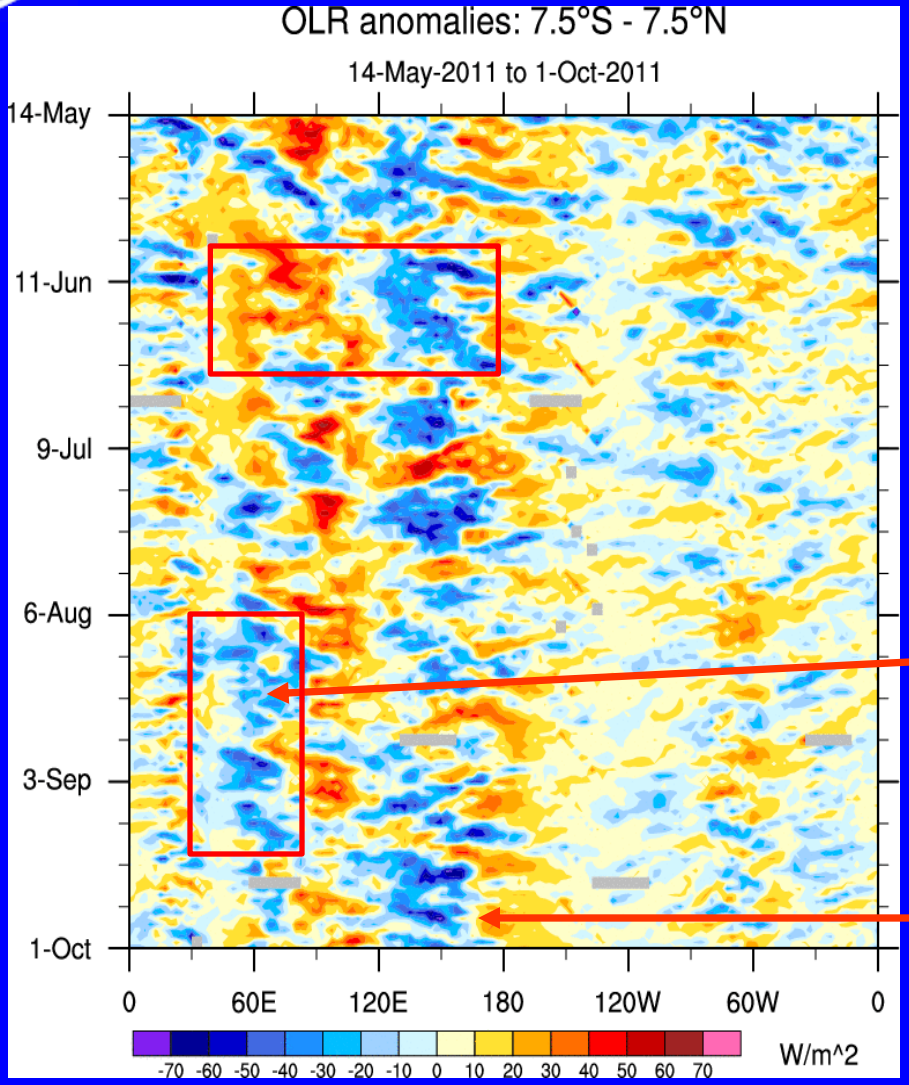
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During late August into early September, the Indian monsoon remained enhanced and wetter-than-average conditions continued across parts of the western Pacific (blue circles).

In mid-September, suppressed convection was observed across the southern U.S. and northern Mexico while enhanced convection continued across much of the western Indian Ocean, southern Asia, and parts of the western Pacific.

Enhanced convection shifted east during late September and was observed from Southeast Asia across much of the western Pacific. Drier-than-average conditions developed over India and parts 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 the Cooperative Institute for Climate and Satellites (CICS-NC))

During mid-June, a couplet of suppressed (enhanced) convection was evident and centered near 80E (140E).

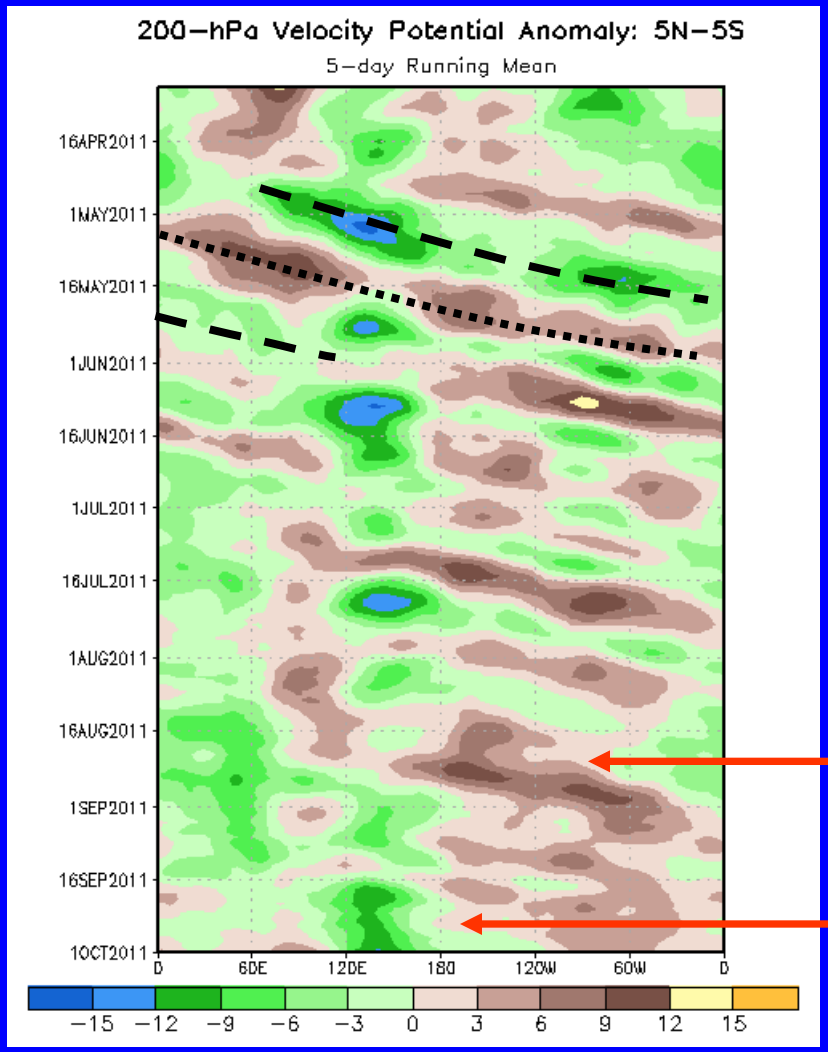
In early August, enhanced convection centered near 60E intensified and persisted into September.

Most recently, during late September, the strongest enhanced convection is located over the western Pacific region while convection over the Indian Ocean has decreased.

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 divergence (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.

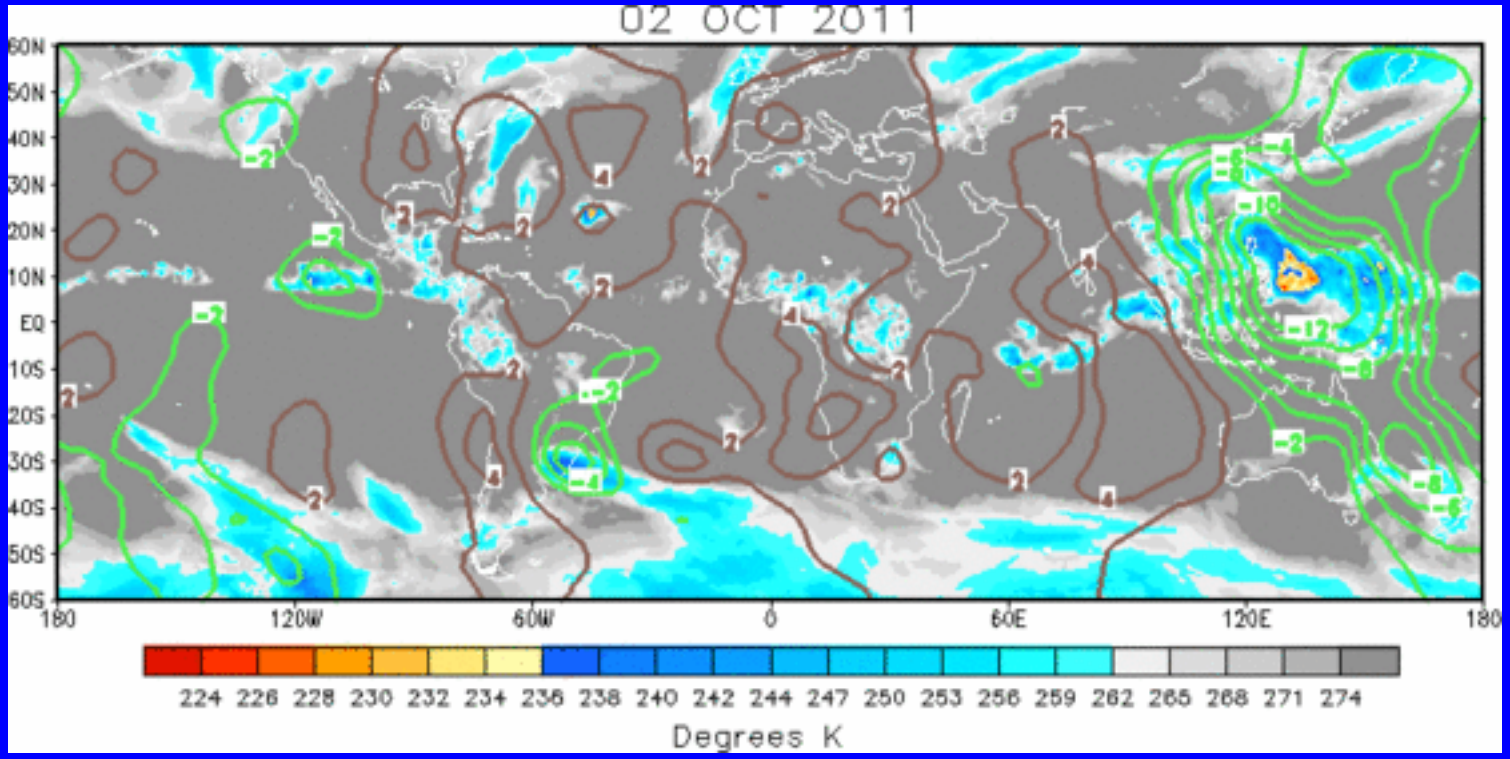
Anomalies increased in magnitude and in coverage during mid-to-late August and the first half of September, but there was little in the way of coherent MJO activity during that time period.

Most recently, there are some signs of eastward propagation of negative anomalies across the western Pacific in late September.

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

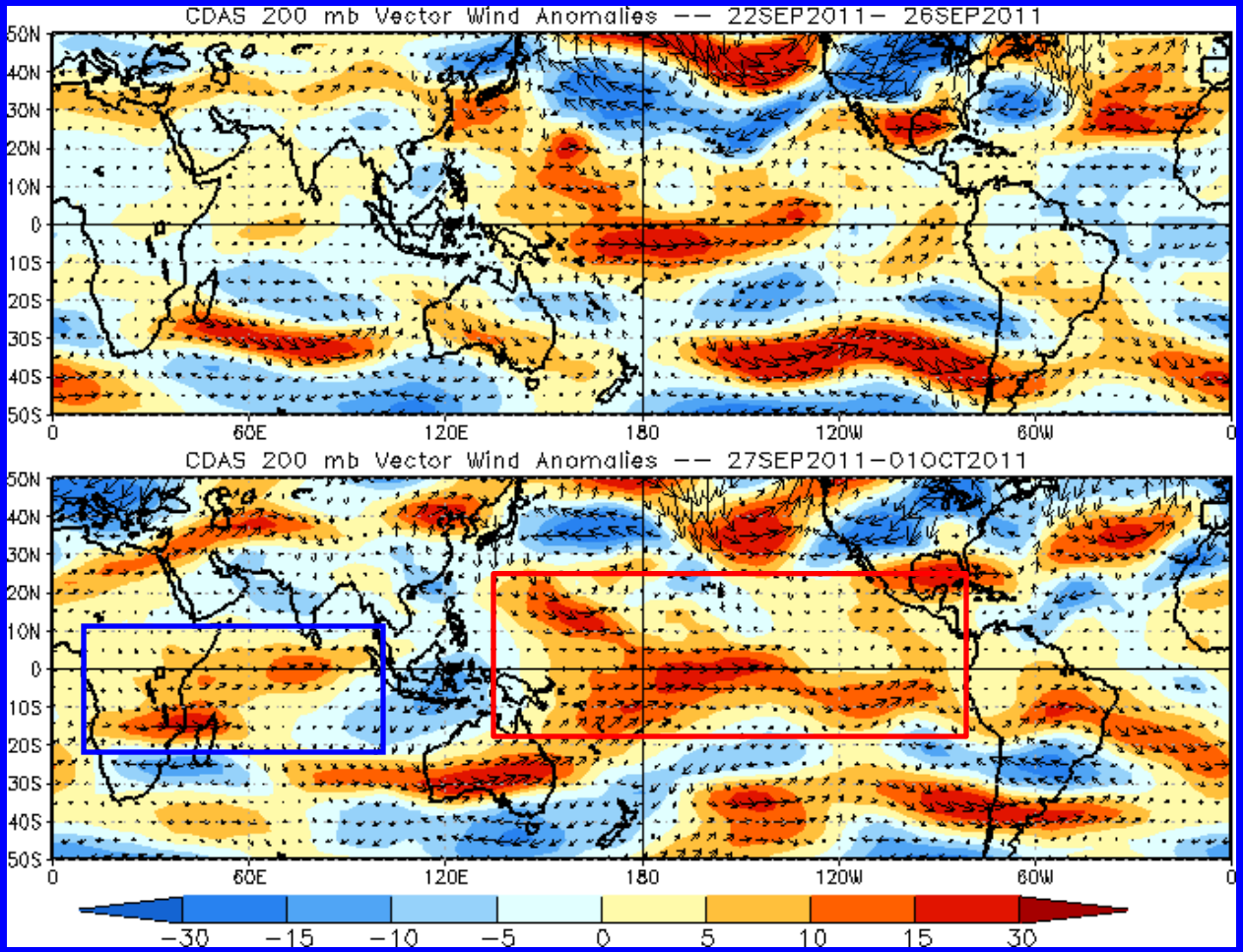
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern indicates anomalous upper-level divergence over the Maritime Continent and the western Pacific while weak anomalous upper-level convergence is observed from the Americas to 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

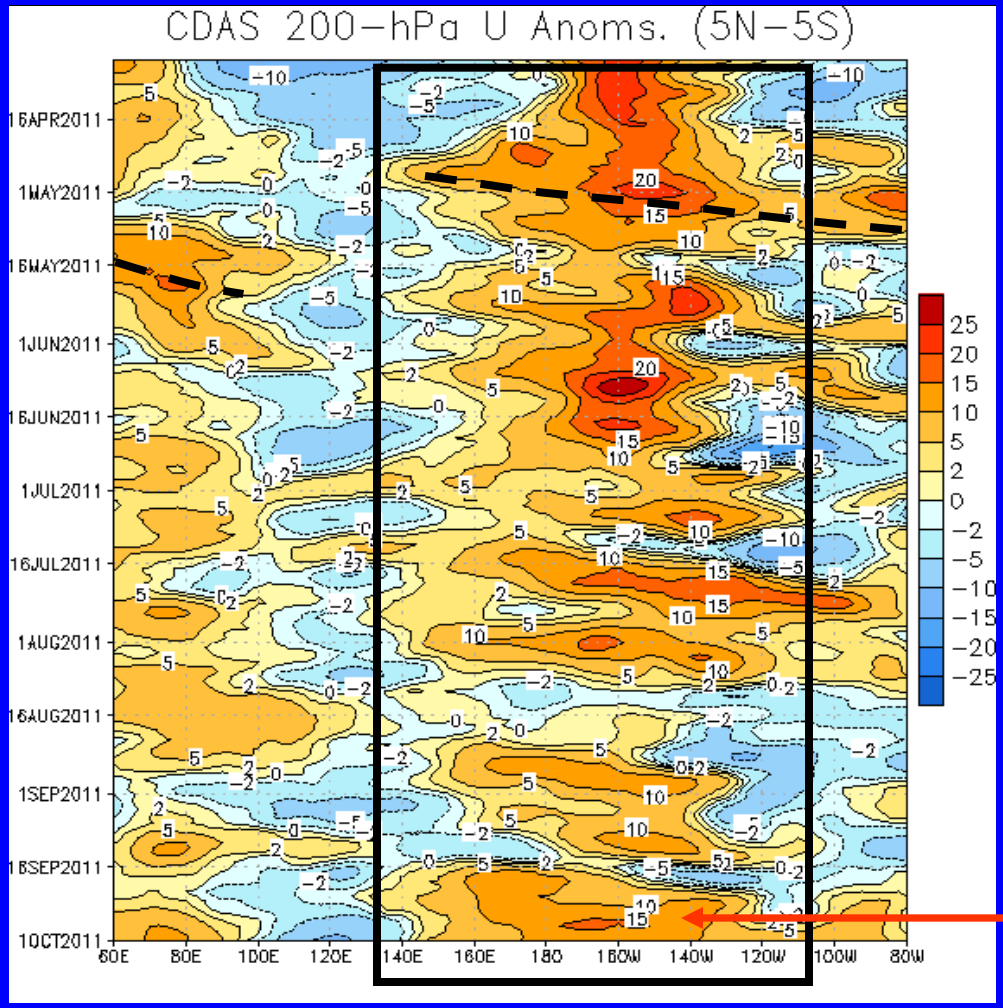
Upper-level westerly wind anomalies in the Pacific (red box) extended further east and strengthened during the last 5 days.

Westerly anomalies entered the Indian Ocean during the last five days (blue box).

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

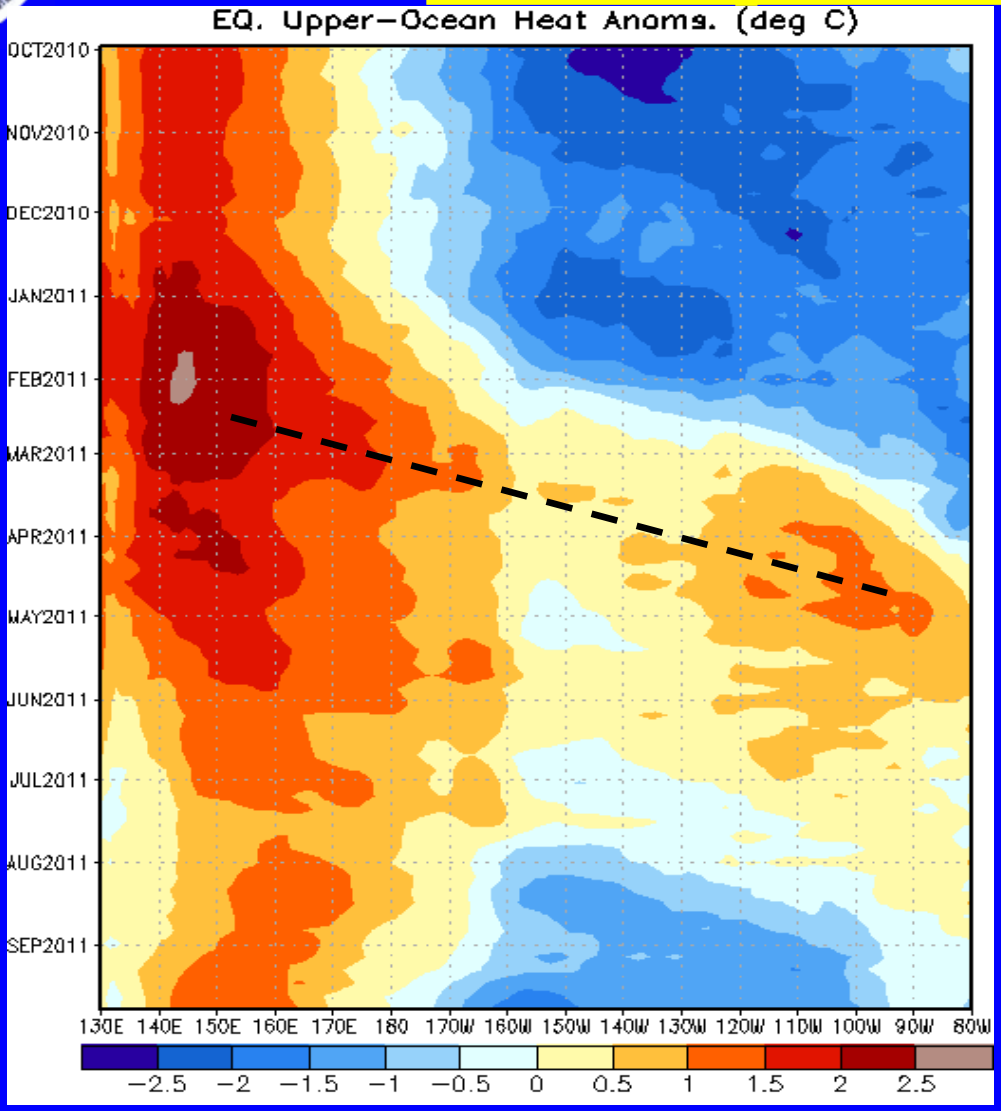
Longitude

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

Significant eastward propagation of westerly anomalies was evident in late April and early May (dashed line) associated with the MJO.

Westerly anomalies strengthened and now extend from 140E to 80W.

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).

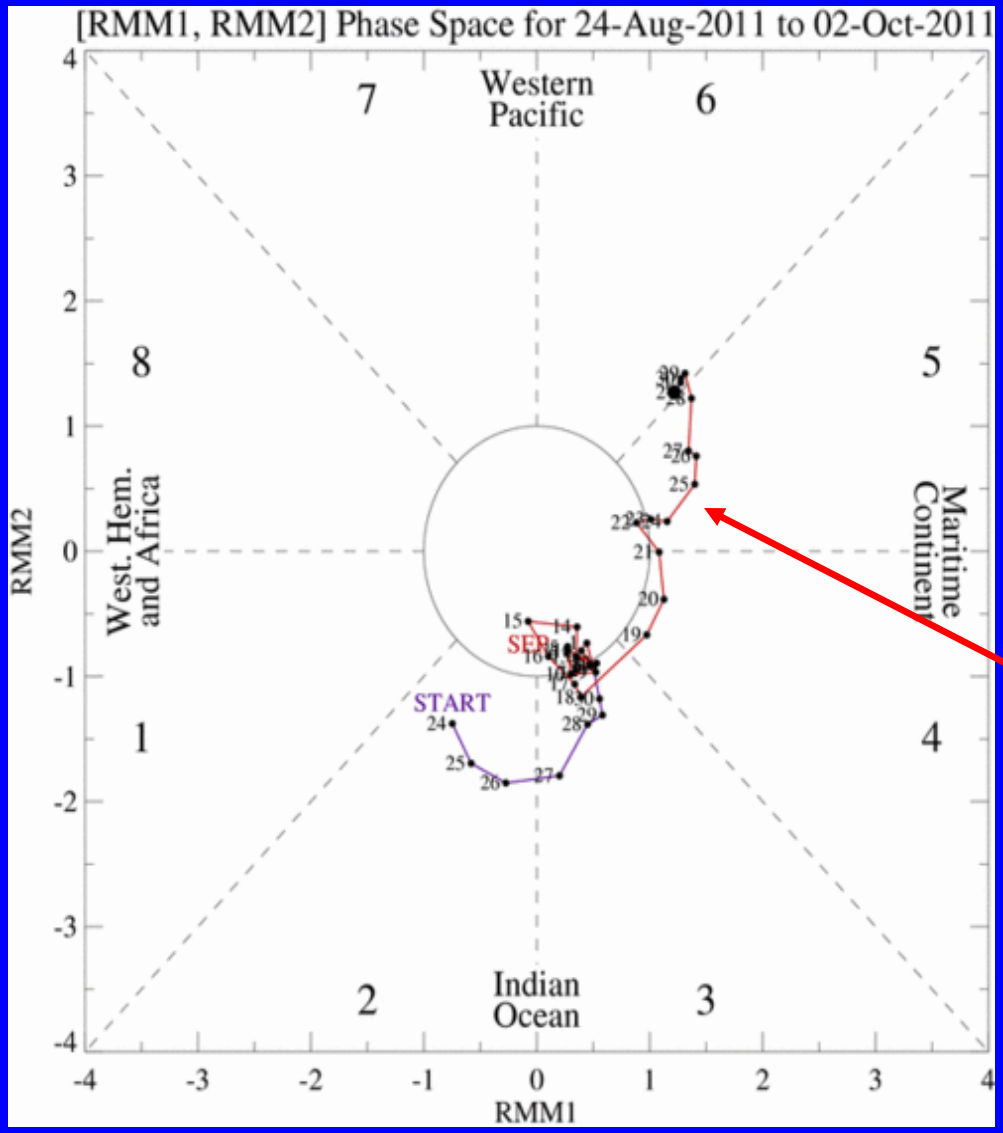
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

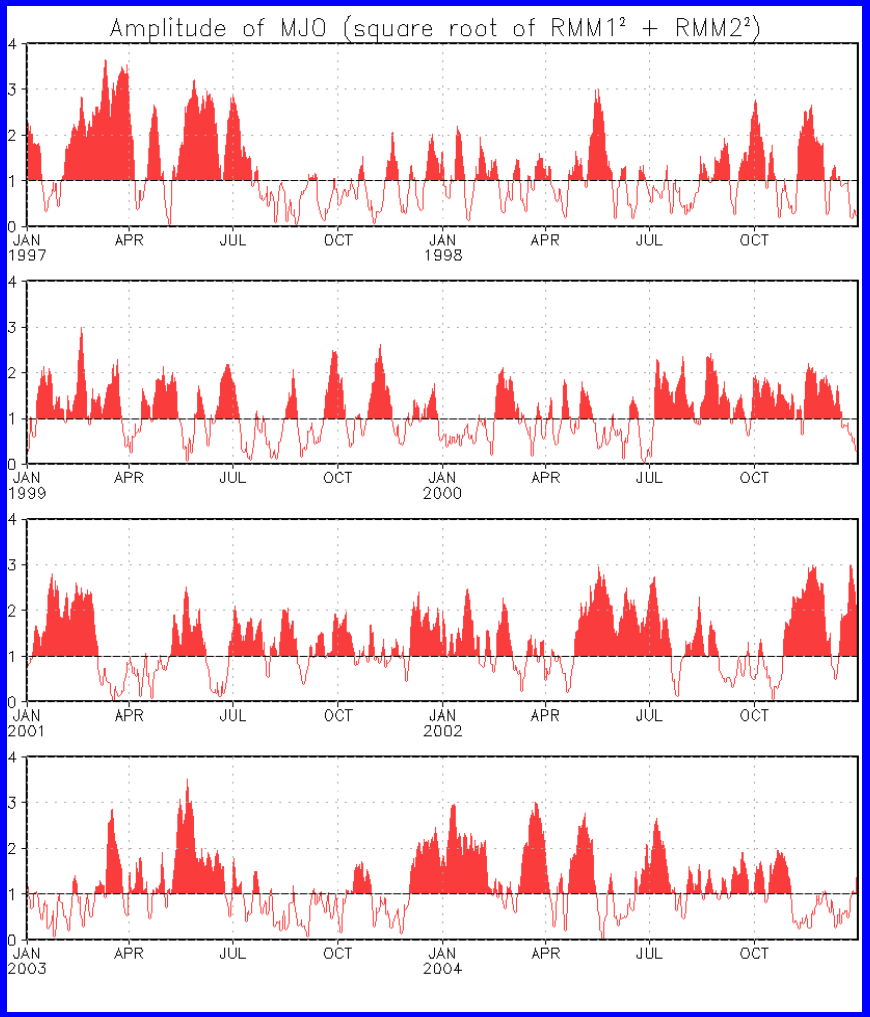
MJO Index -- Recent Evolution

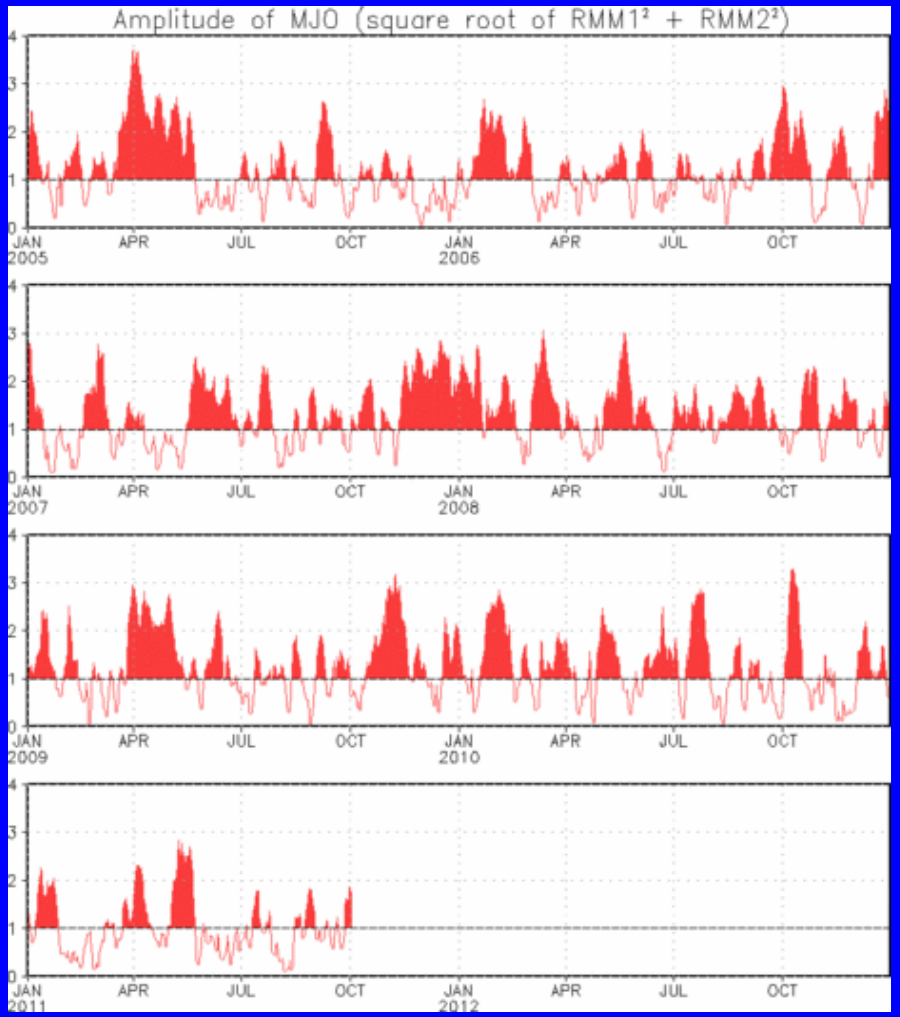


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates an increase in amplitude with eastward propagation during the past week.

MJO Index – Historical Daily Time Series





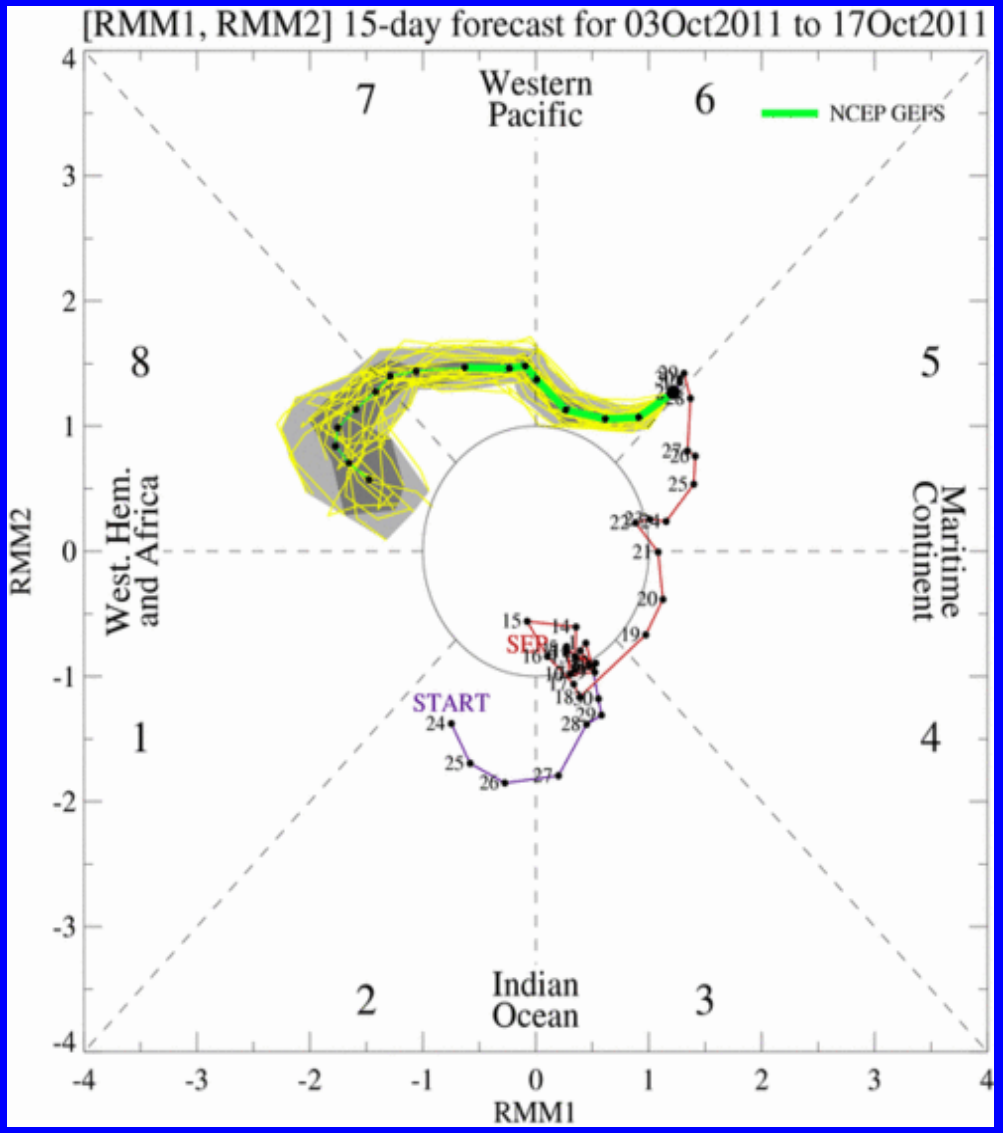
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

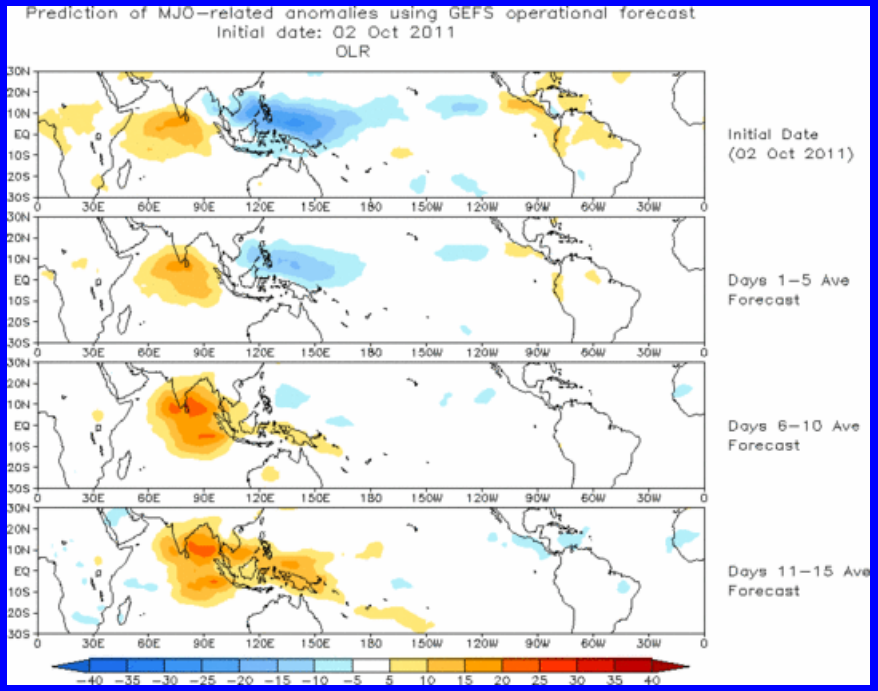


The ensemble GFS forecasts indicate a MJO signal continuing during the period with the enhanced phase shifting from the western Pacific to the western Hemisphere. There is generally low spread amongst the forecast members.

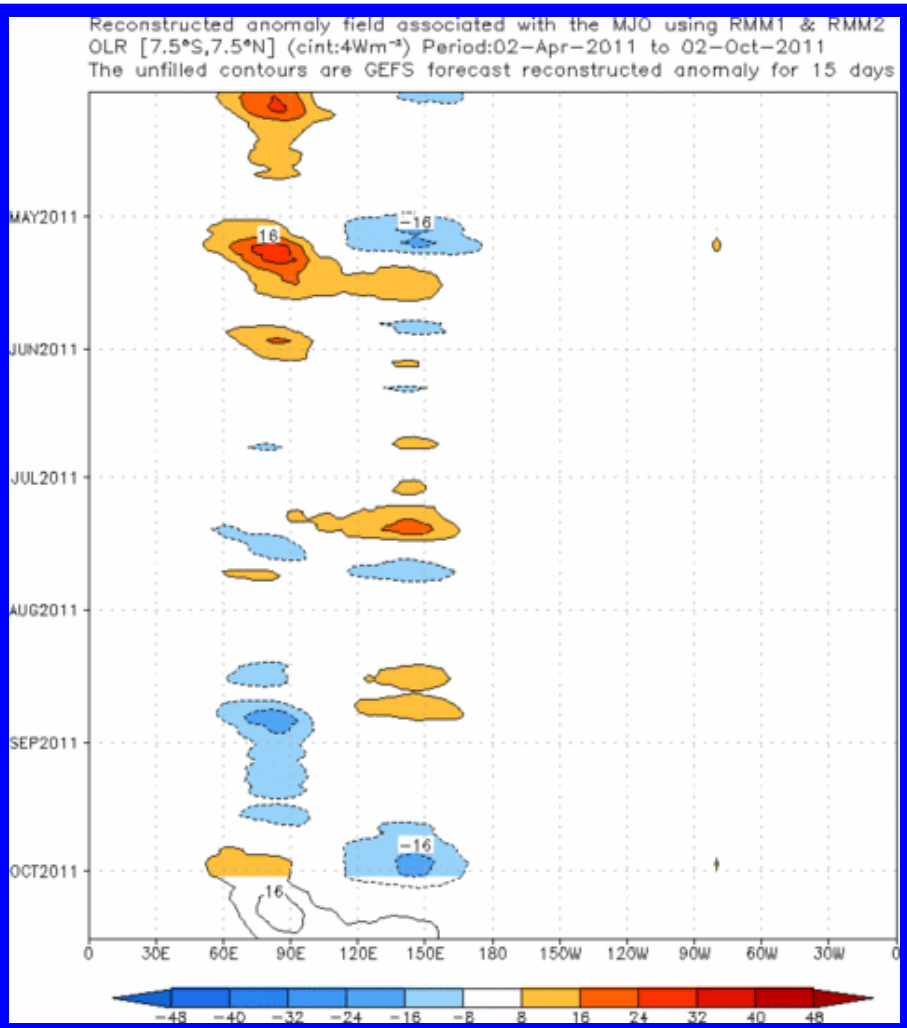
Ensemble Mean GFS MJO Forecast

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

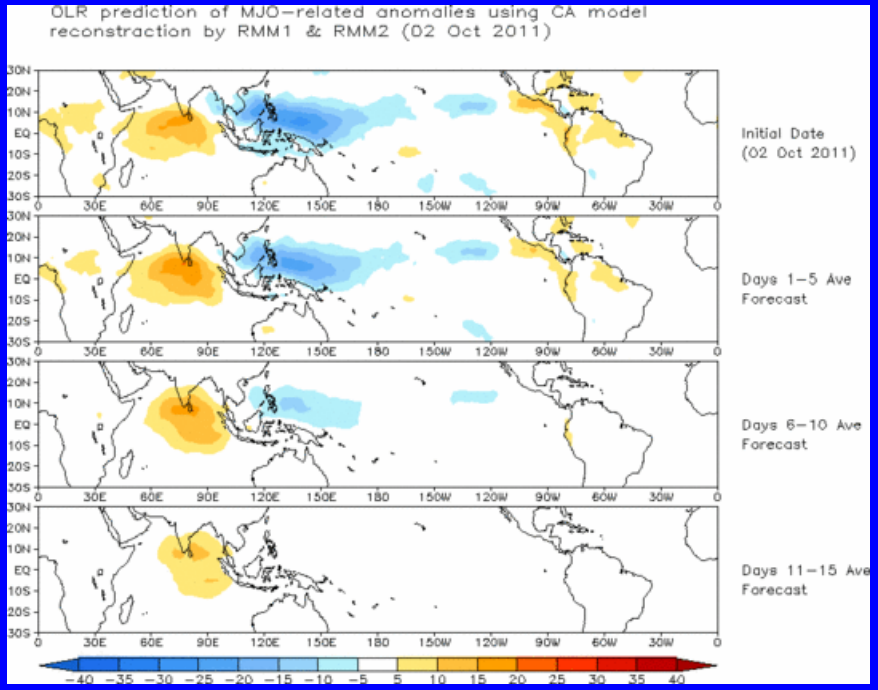


The ensemble mean GFS forecast indicates enhanced convection for the western and central Pacific during Week-1 with parts of Central America during Week-2. Suppressed convection is forecast across the Indian Ocean and later the Maritime continent during the period.

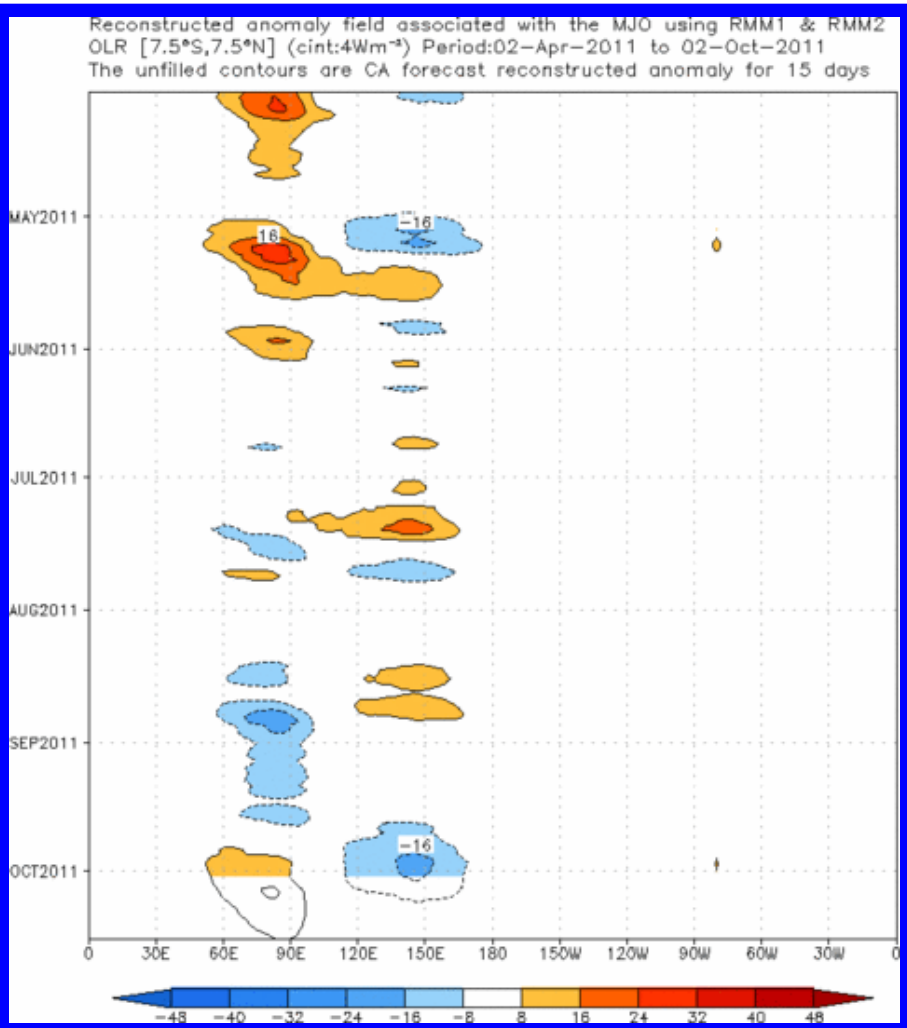
Constructed Analog MJO Forecast

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



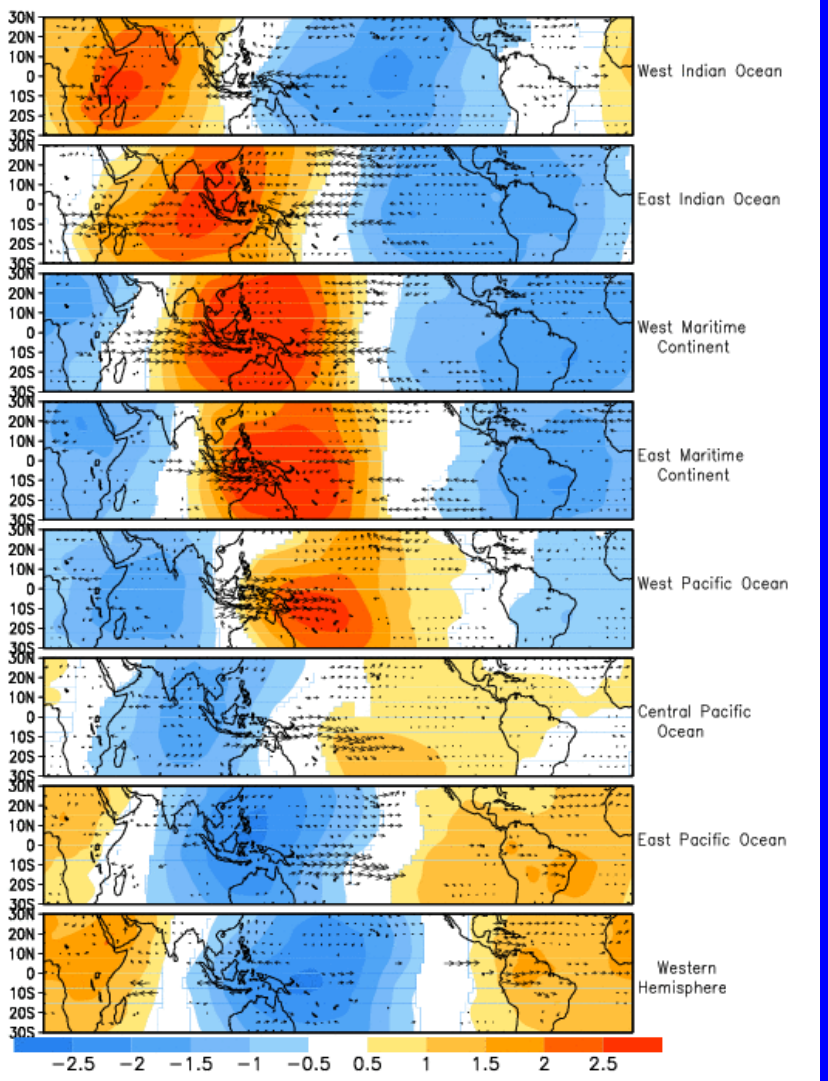
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



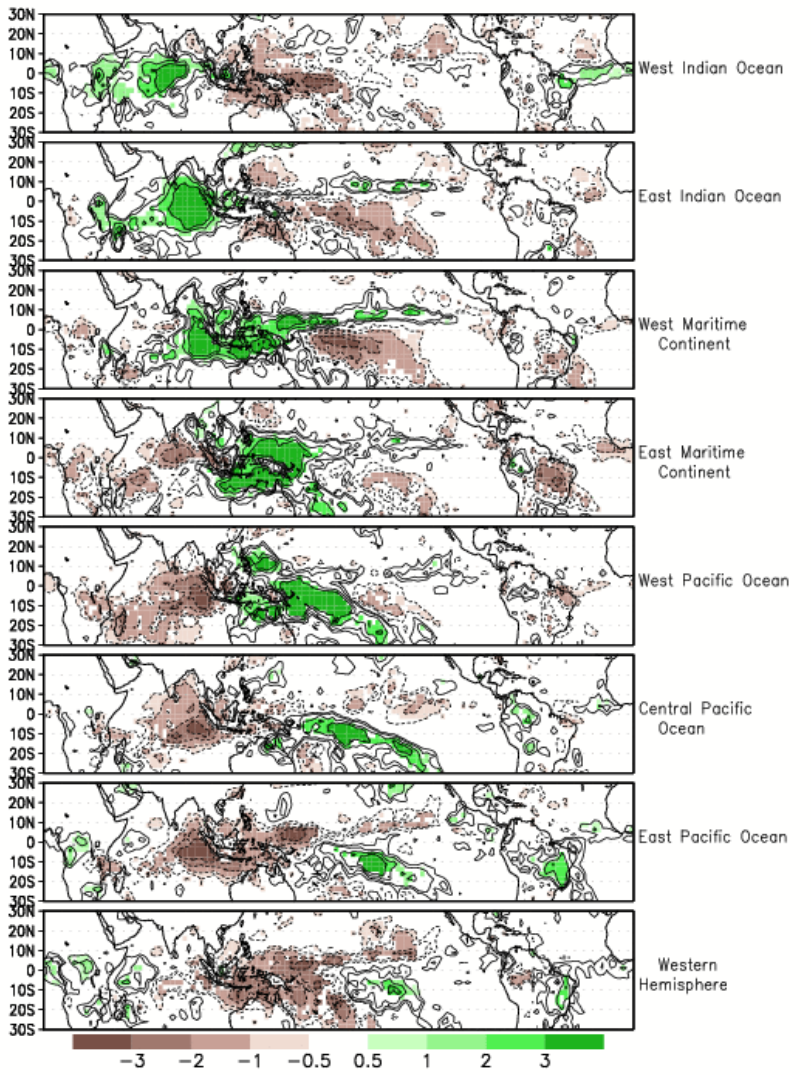
The CA forecast indicates enhanced convection for the western and central Pacific and suppressed convection for the Indian Ocean (Weeks 1-2) and Central America (Week-1).

MJO Composites – Global Tropics

850-hPa Wind Anomalies (May-Sep)

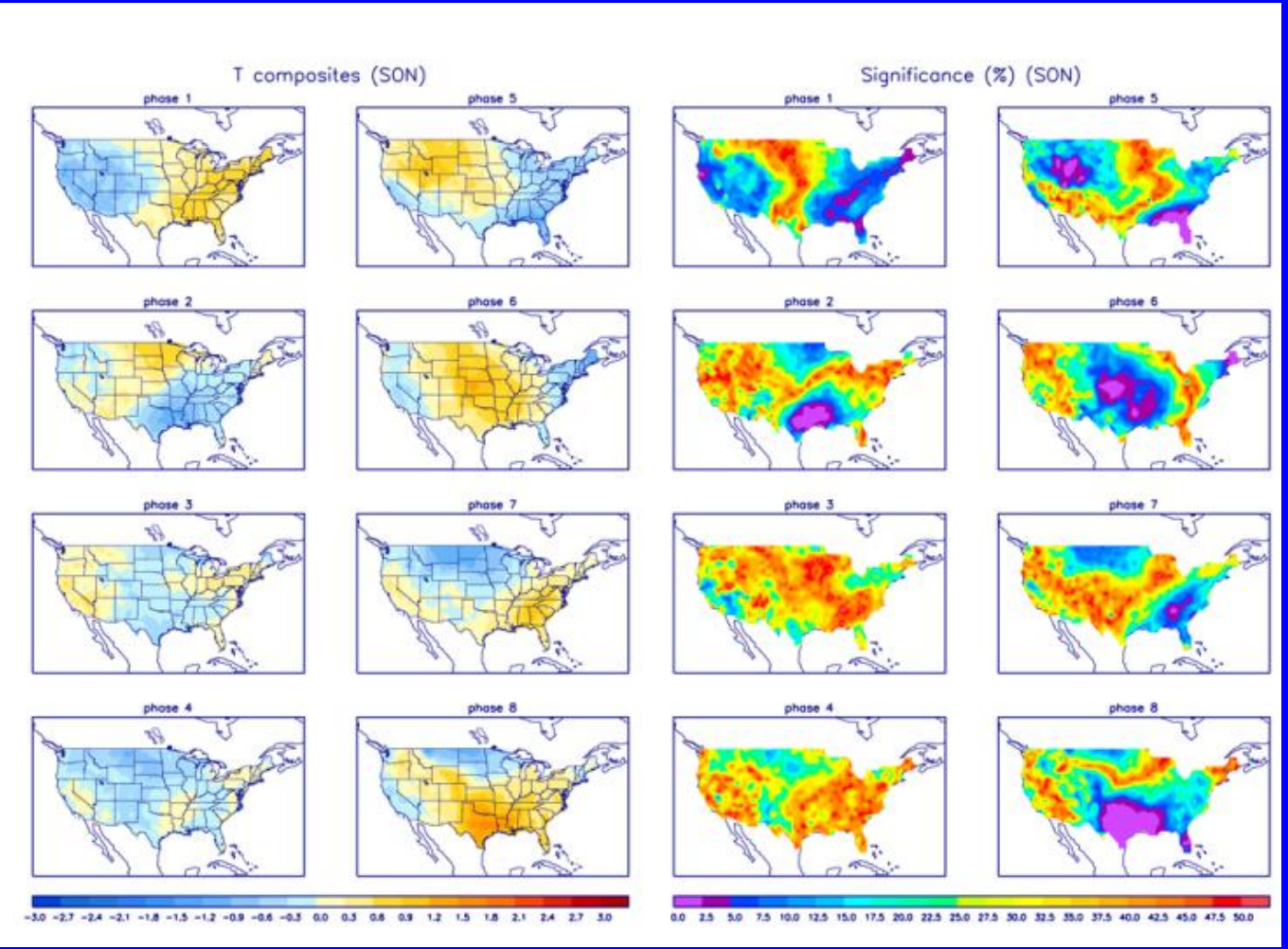


Precipitation Anomalies (May-Sep)



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.**

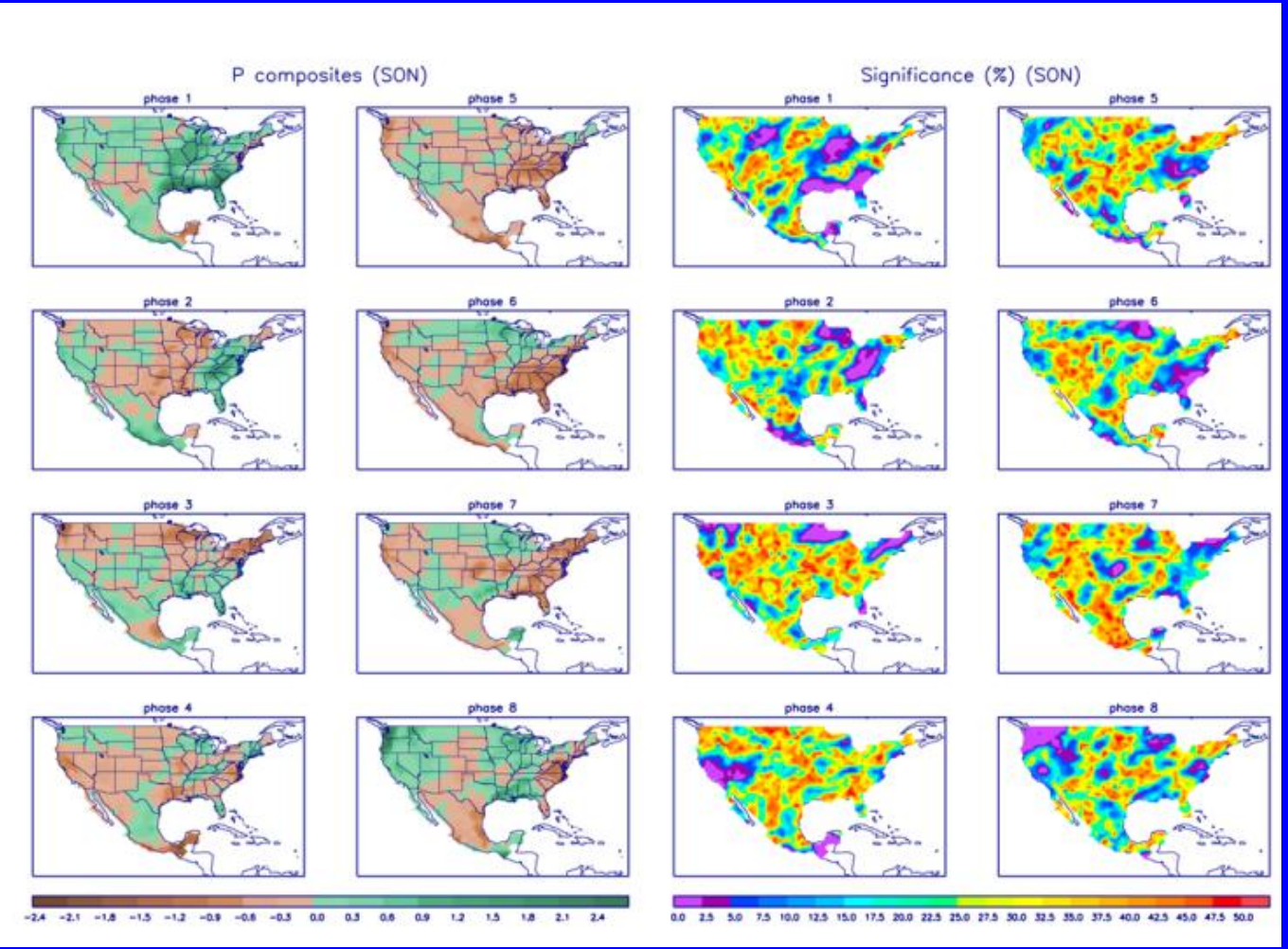


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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