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

Update prepared by
Climate Prediction Center / NCEP
September 26, 2011

Outline

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

Overview

- The MJO strengthened during the past week. Enhanced convection intensified across the western Pacific and suppressed convection developed over parts of India and the Indian Ocean.

- Dynamical model MJO index forecasts continue to indicate an eastward propagating MJO signal during the next two weeks with the enhanced phase shifting to the western Pacific during the period.

- Based on recent observations and model MJO index forecasts, the MJO is forecast to continue to during the period.

- The MJO is expected to contribute to continued enhanced rainfall across the western Pacific and suppressed rainfall for India, parts of the Indian Ocean and portions of the western Maritime continent during the period.

- The forecast MJO phase favors above-normal temperatures across portions of the central U.S. during this time of the year. The current MJO activity is expected to contribute considerable energy and moisture to a strong Pacific Jet and favors much above-average precipitation across the Pacific Northwest during late Week-1 and Week-2.

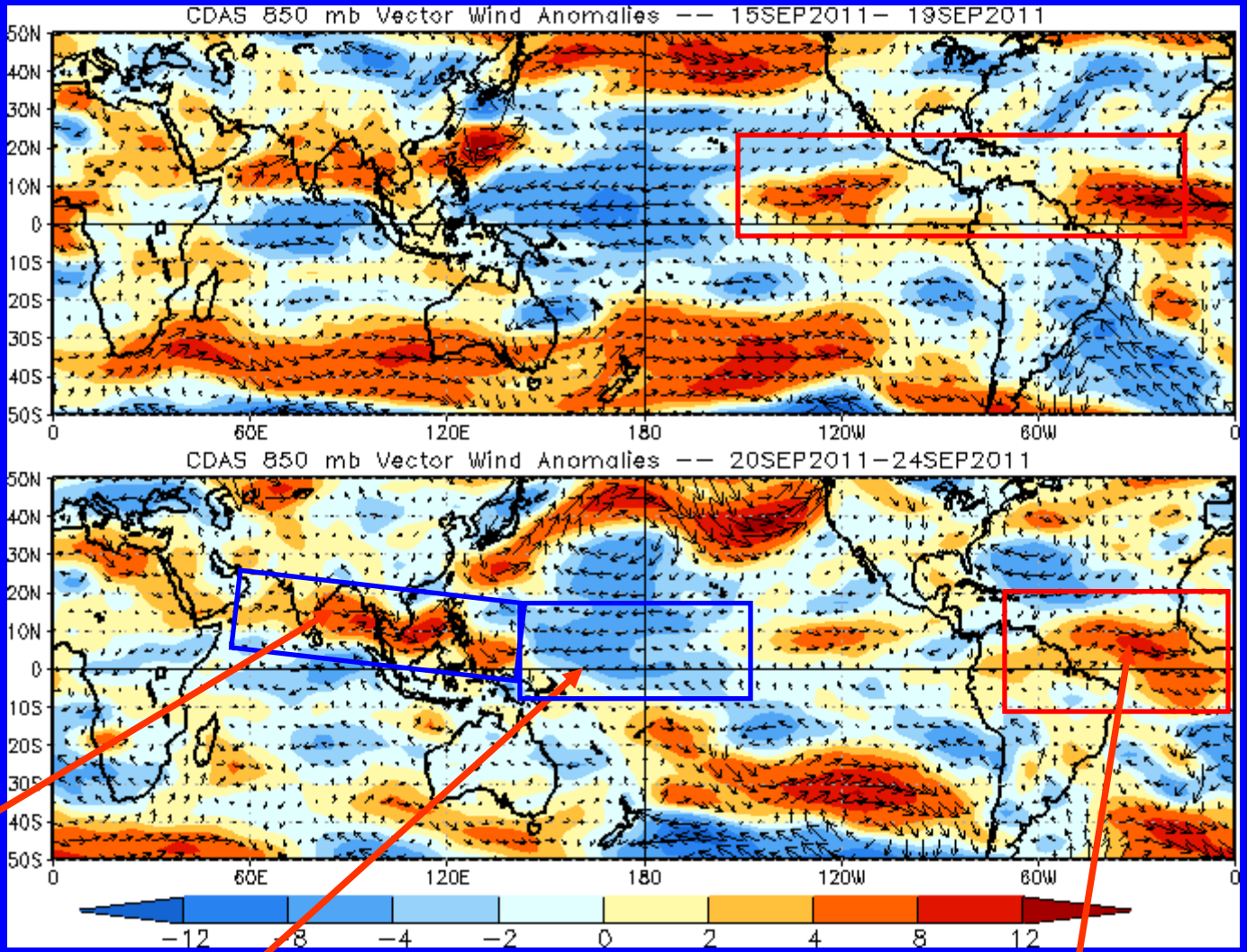
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 stretched from India to just north of New Guinea.

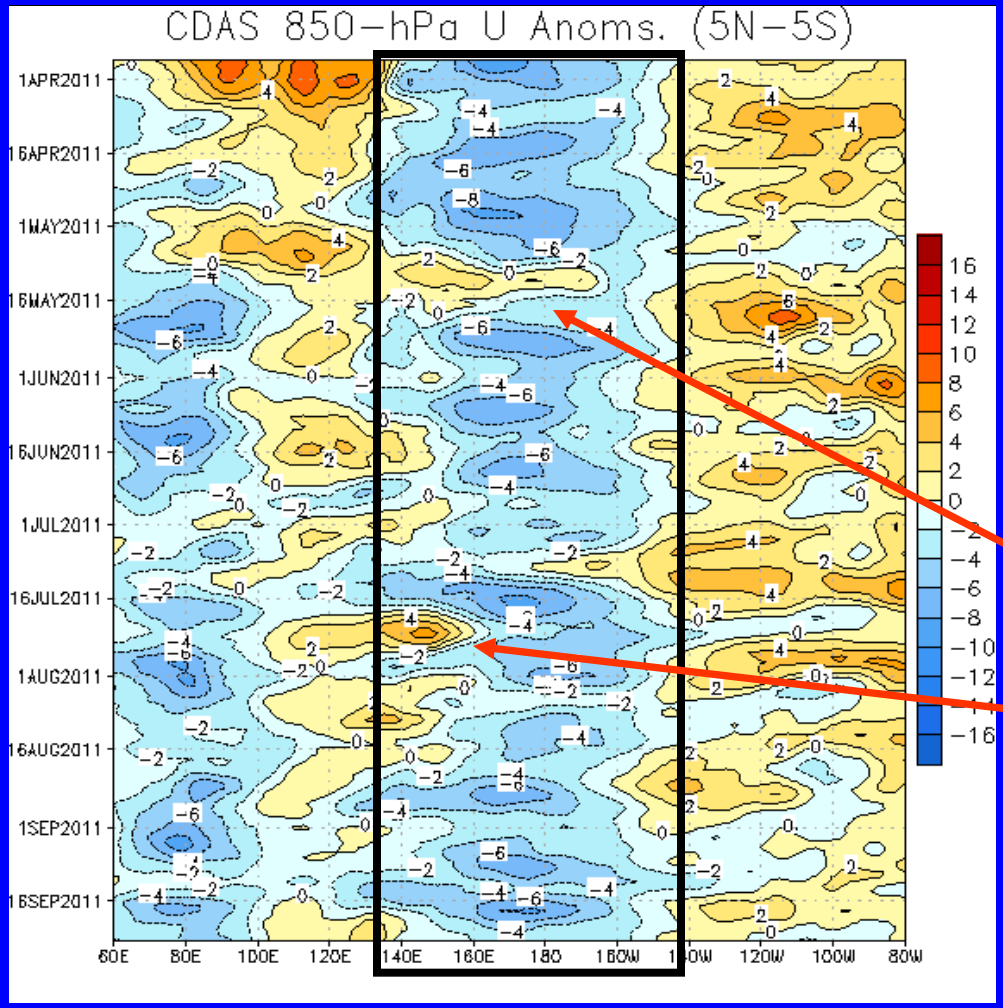
The coverage of easterly wind anomalies decreased during the last five days over the western Pacific.

Westerly anomalies continued across the tropical Atlantic and west 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

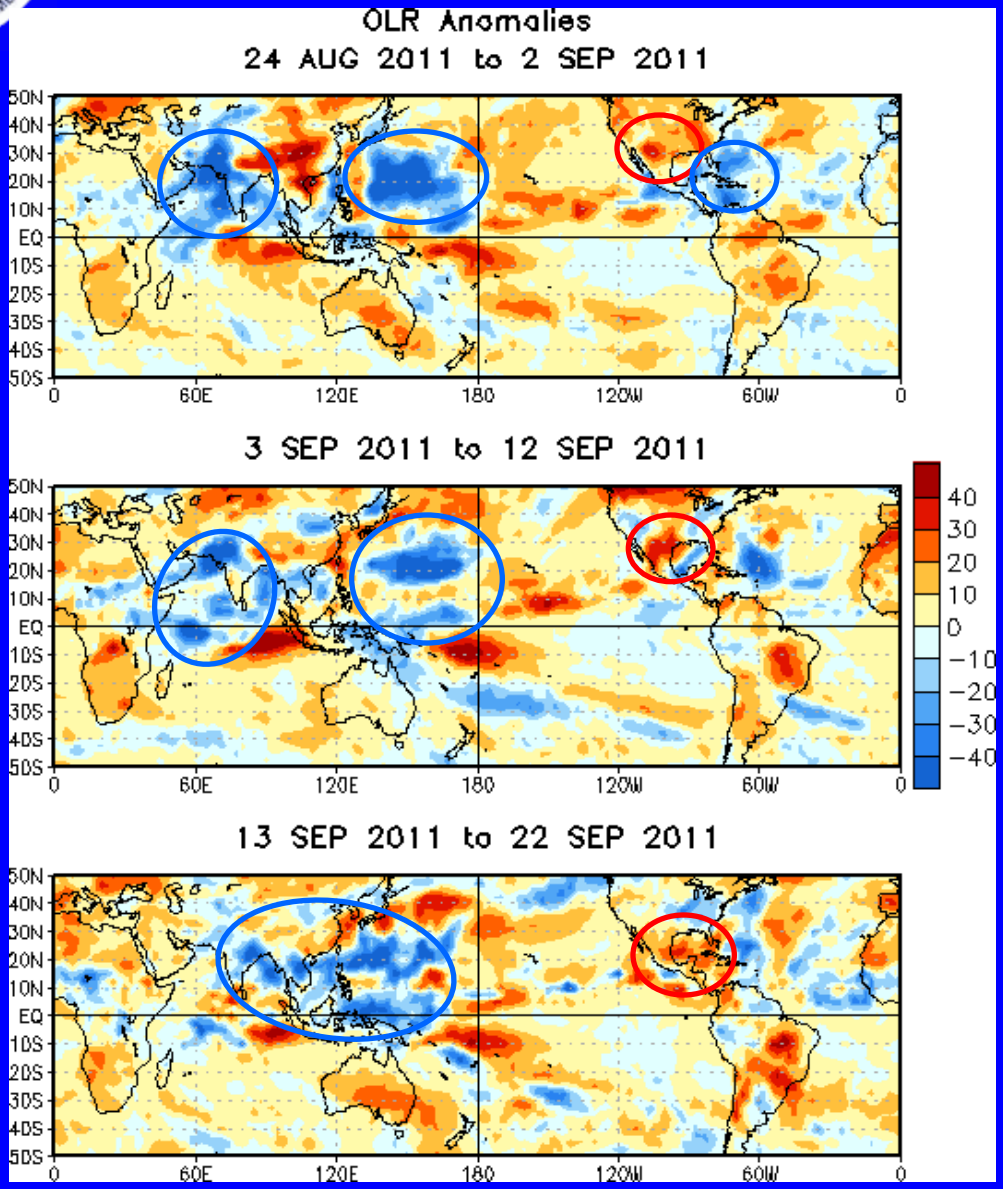
Longitude

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.

OLR Anomalies – Past 30 days



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

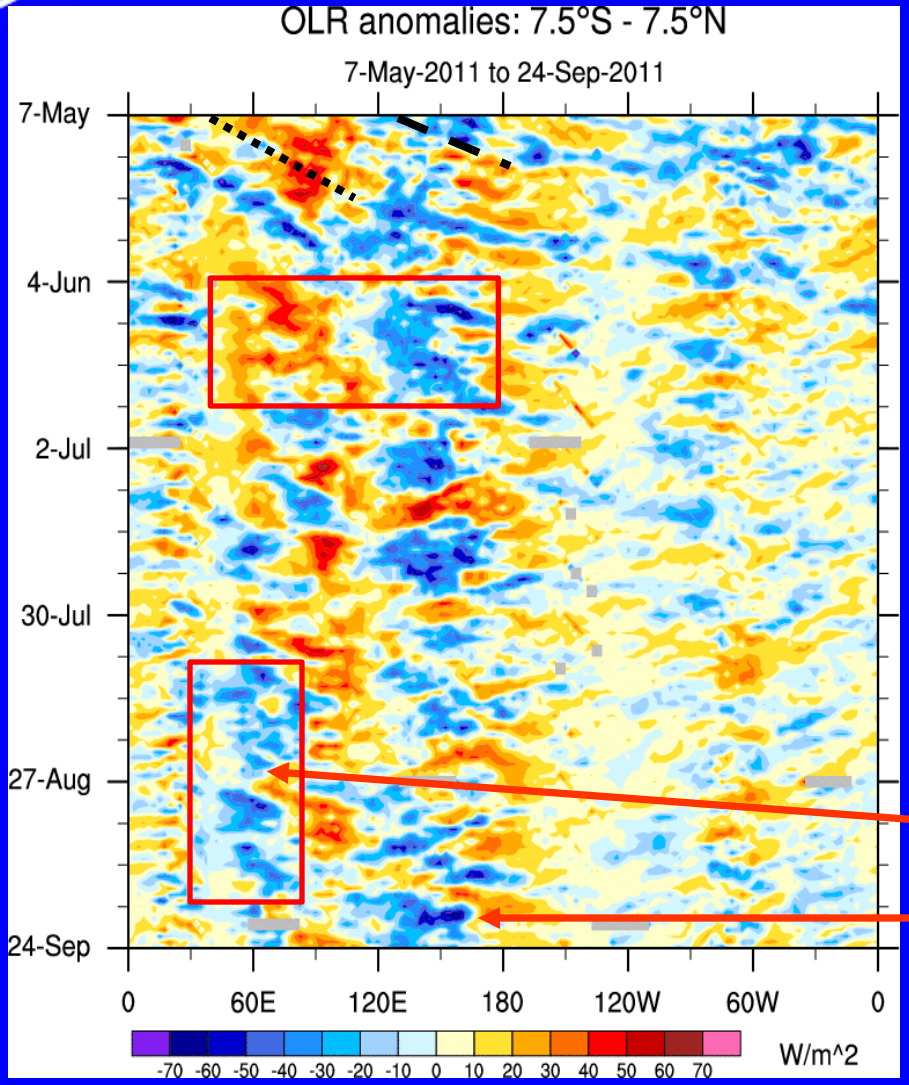
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During late August, enhanced convection was associated with an increase in tropical cyclone activity across the Atlantic, east Pacific, and west Pacific as well as an intensification of the Indian Monsoon (blue circles). Suppressed convection was also observed across the southern U.S. and northern Mexico.

In early September, enhanced convection continued across much of the western Indian Ocean, parts of southern Asia, and the western Pacific while suppressed convection continued over northern Mexico.

Enhanced convection was observed from Southeast Asia to the western Pacific during mid-September as drier-than-average conditions developed over Central America and the Caribbean.

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 late April, an area of enhanced convection propagated eastward followed by suppressed convection in early May. This activity was in part associated with the MJO.

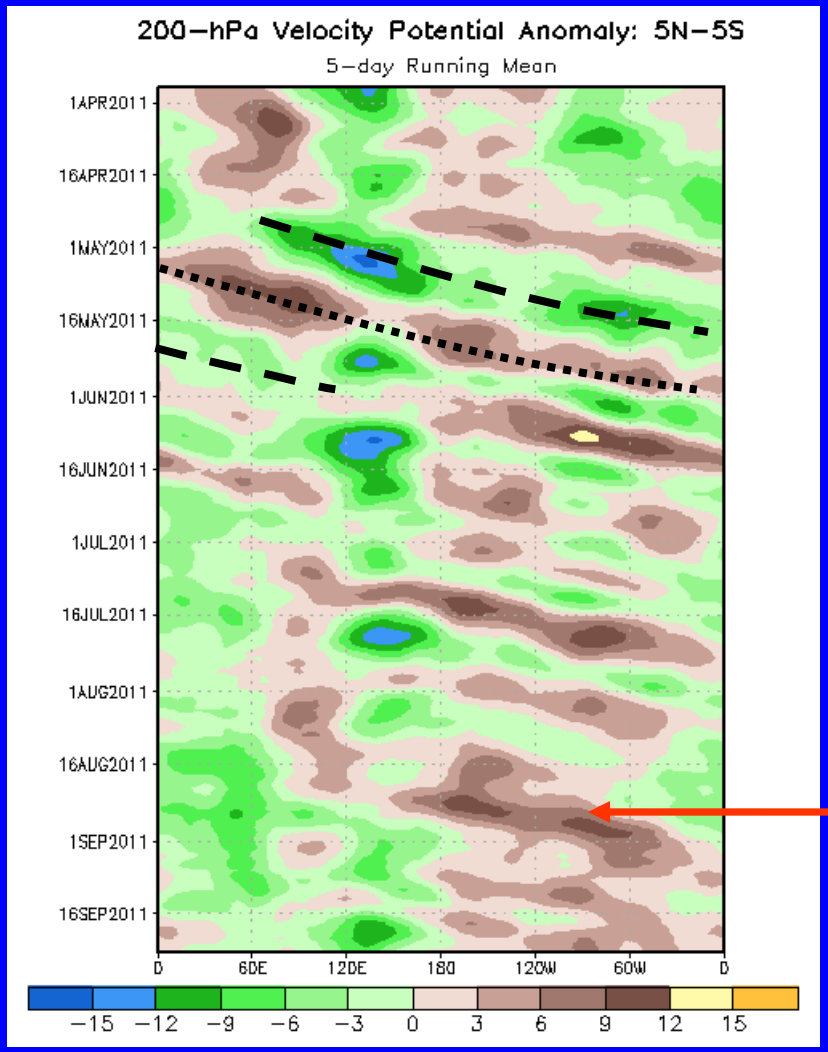
During mid-June, a couplet of suppressed (enhanced) convection was evident and centered near 80E (140E).

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).

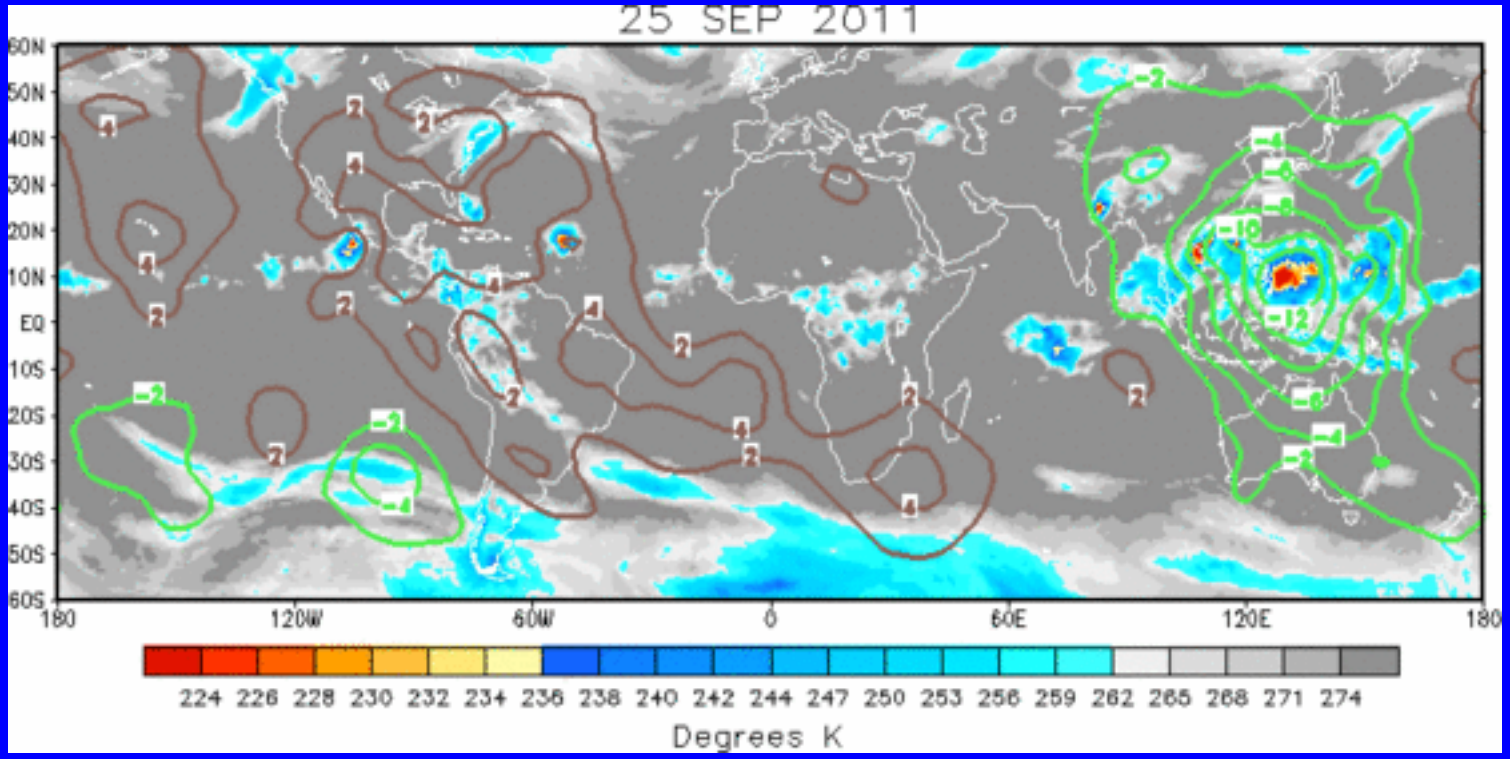
During parts of June, July and August very fast eastward propagation was evident at times and mainly associated with higher frequency sub-seasonal coherent tropical variability and not MJO activity.

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.

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

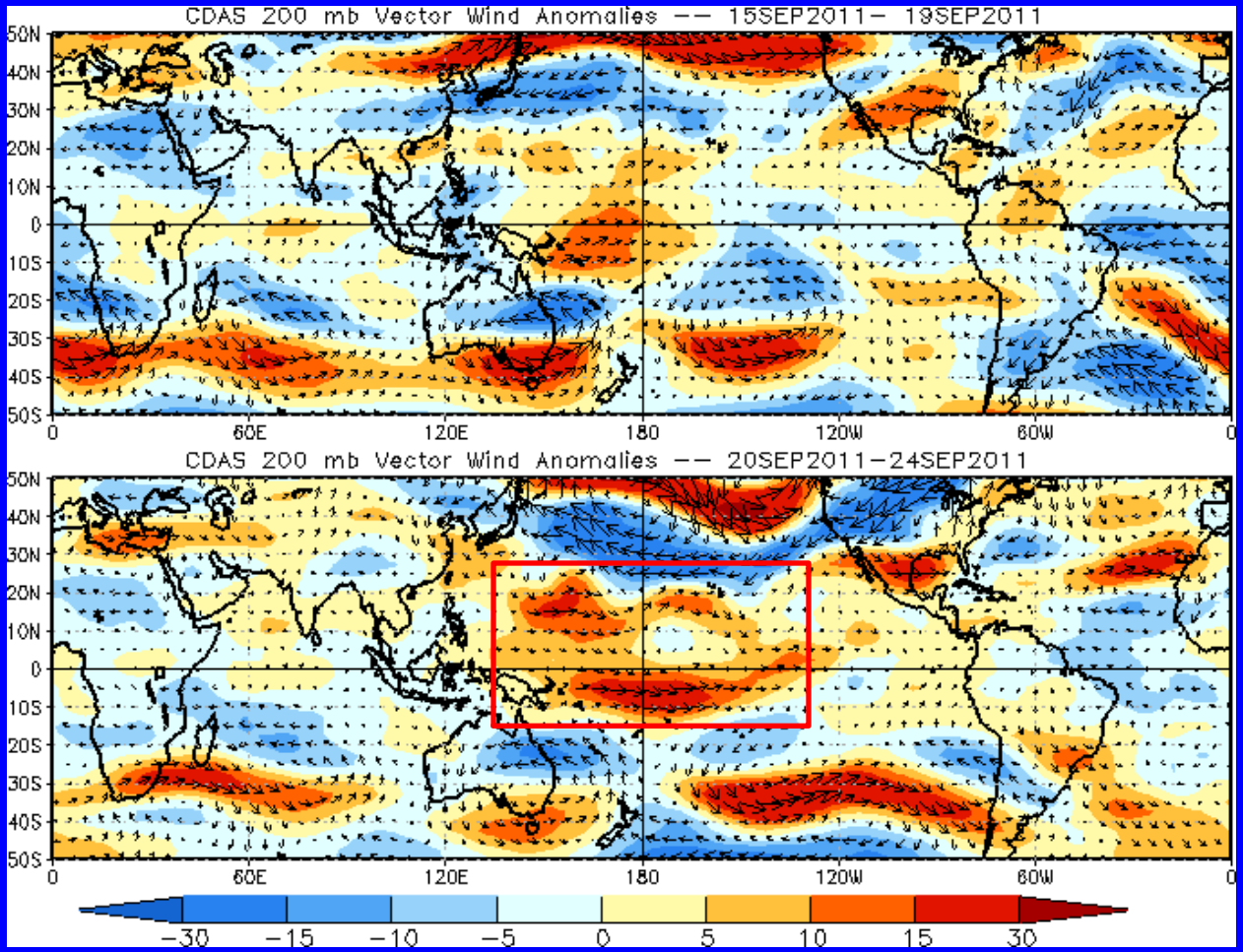
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

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 across the Americas and parts of Africa.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

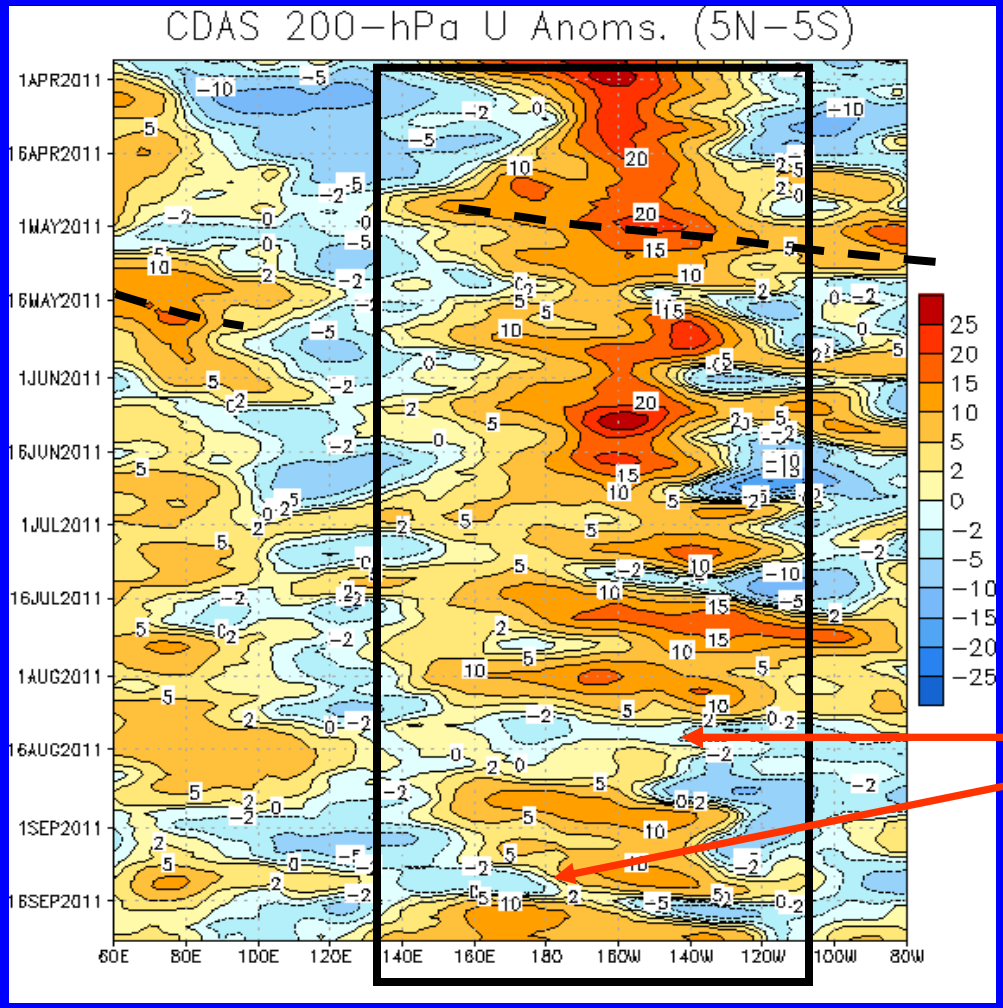
Red shades: Westerly anomalies

Upper-level westerly wind anomalies (red box) are evident once again across the central Pacific during the last 5 days.

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

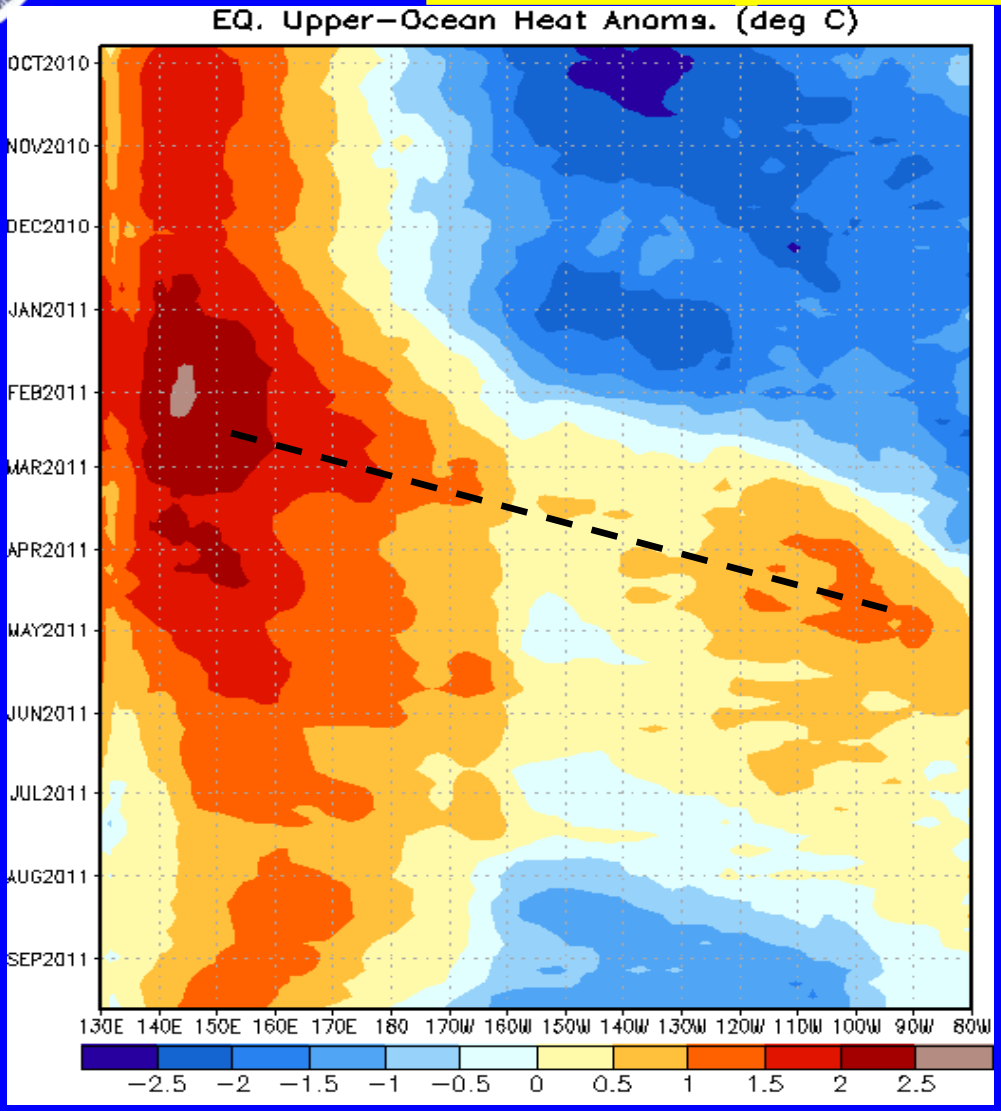
Longitude

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.

During early-to-mid August and again in early-to-mid September, westerly anomalies eased near the Date Line.

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).

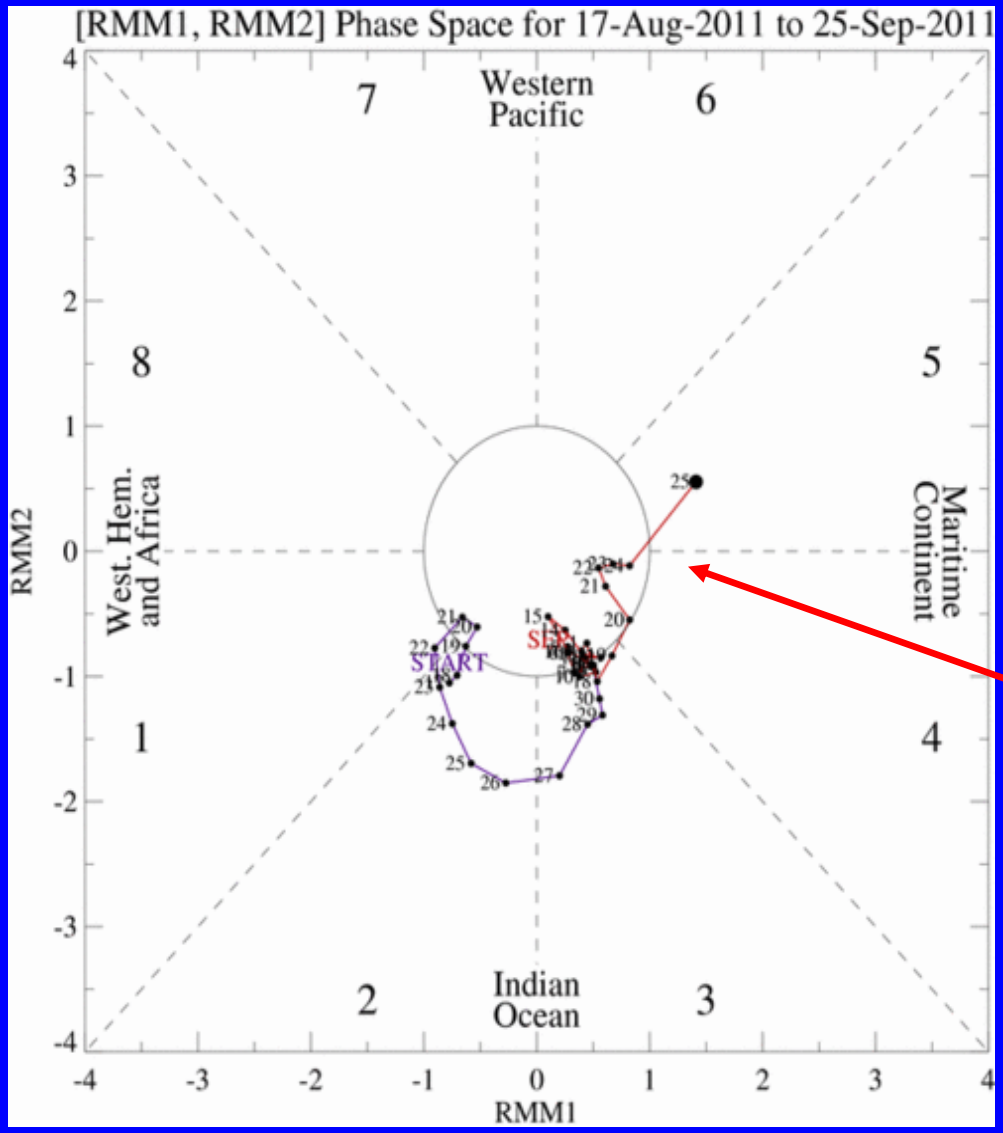
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

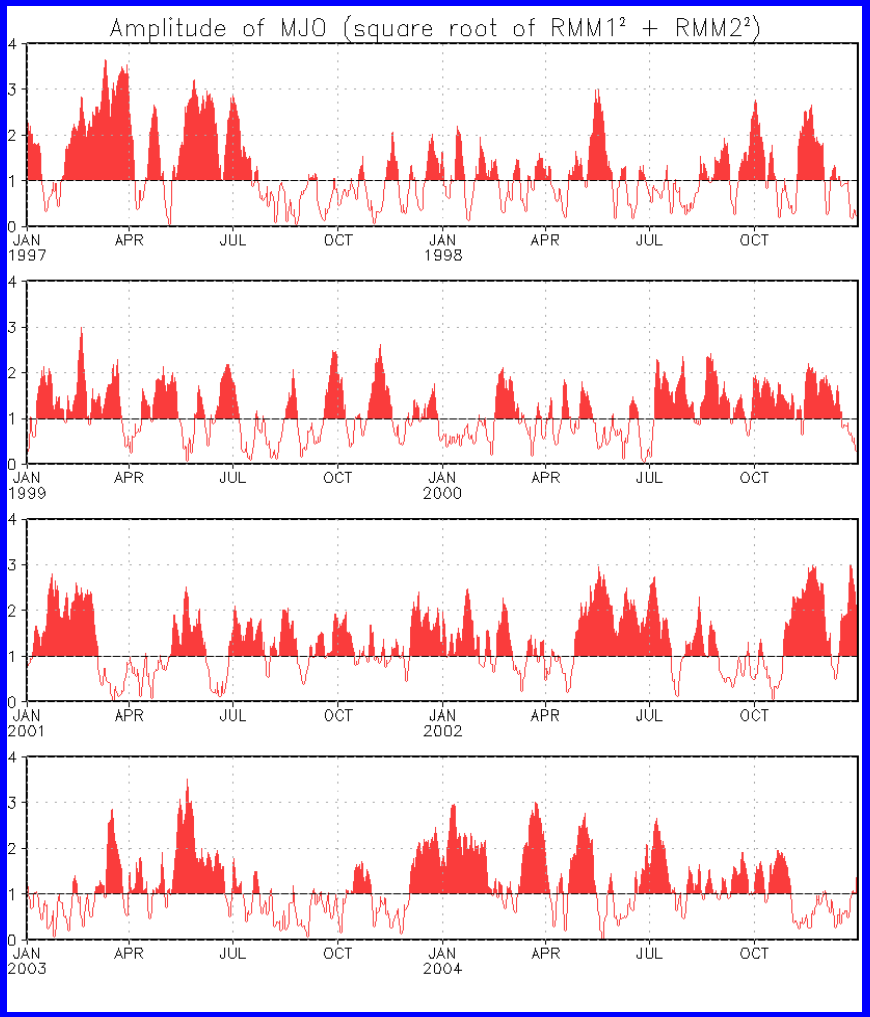
MJO Index -- Recent Evolution

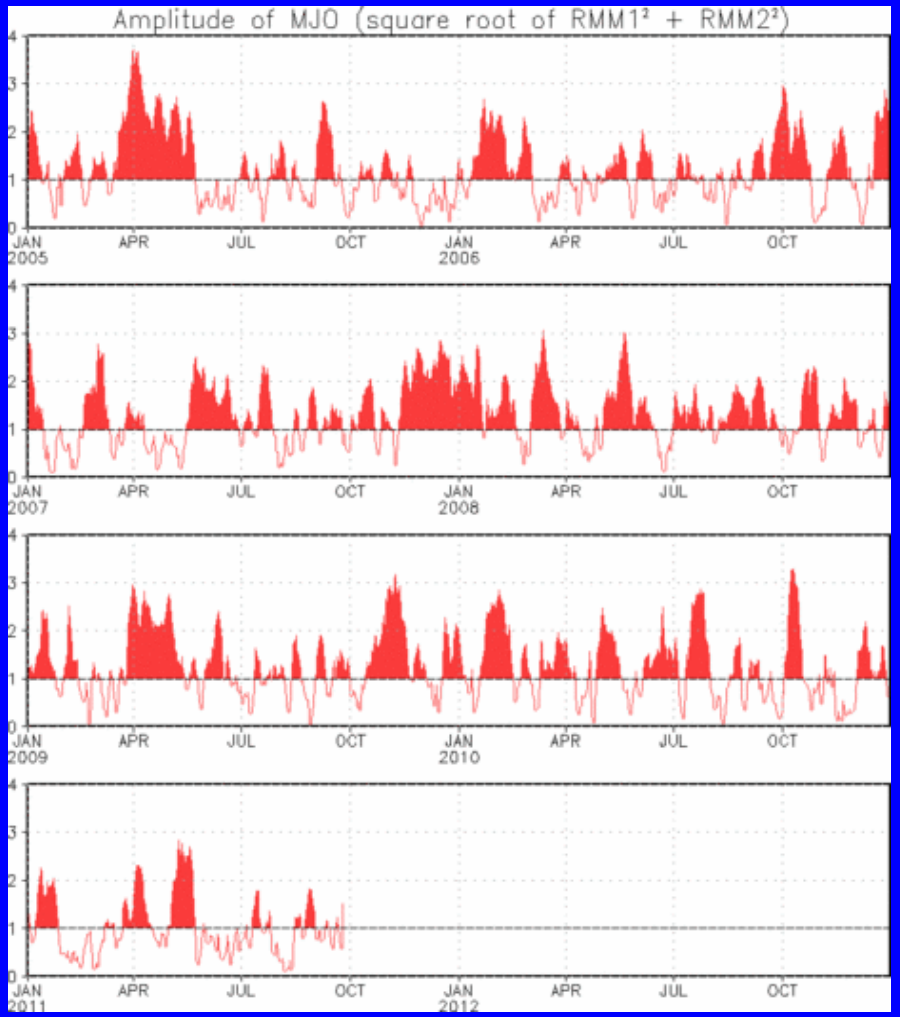


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates some irregular eastward propagation of a signal during the past week.

MJO Index – Historical Daily Time Series





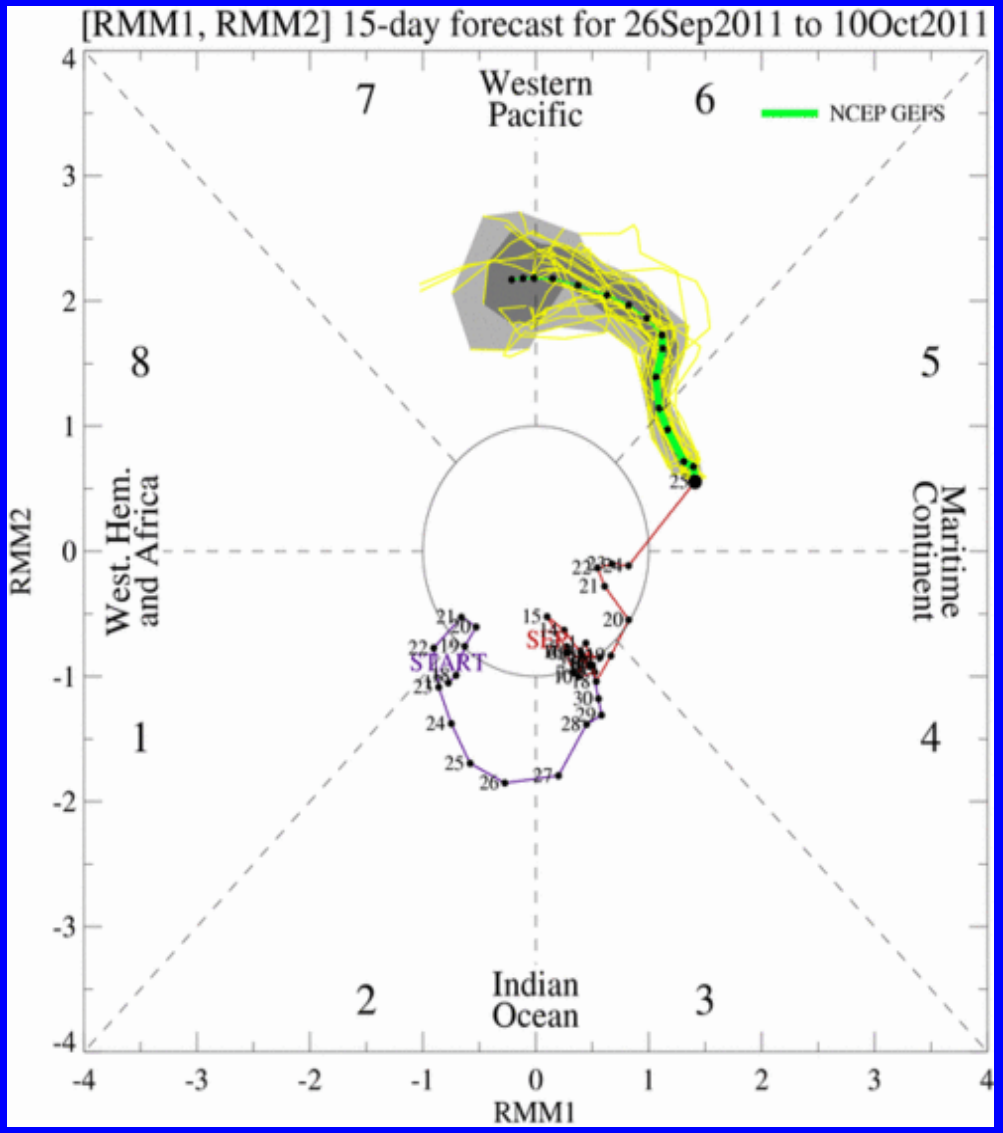
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

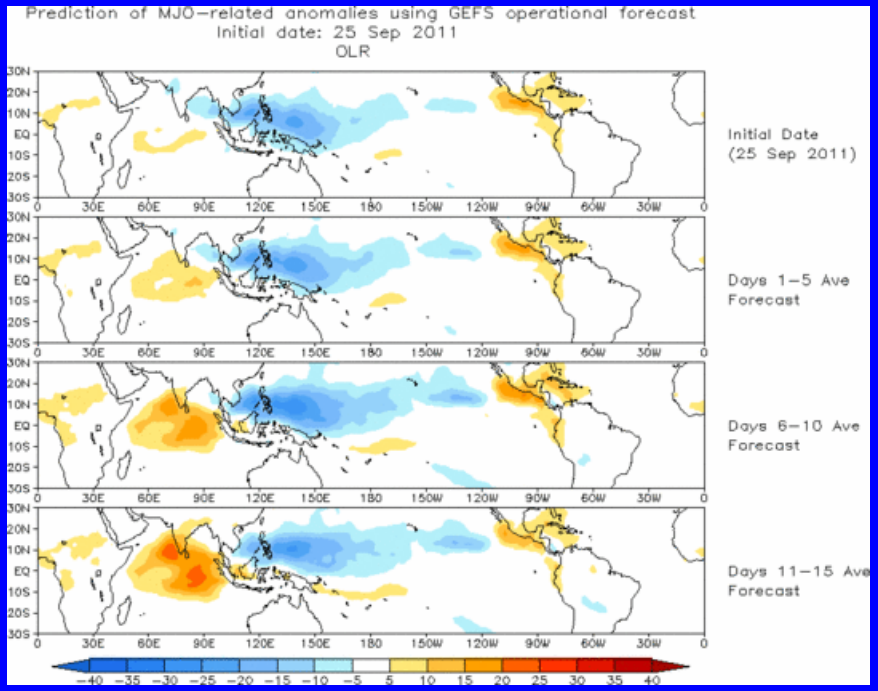


The ensemble GFS forecasts indicate a MJO signal continuing during the period with the enhanced phase shifting from the Maritime continent into the western Pacific. There is generally low spread amongst the forecast members during Week-1.

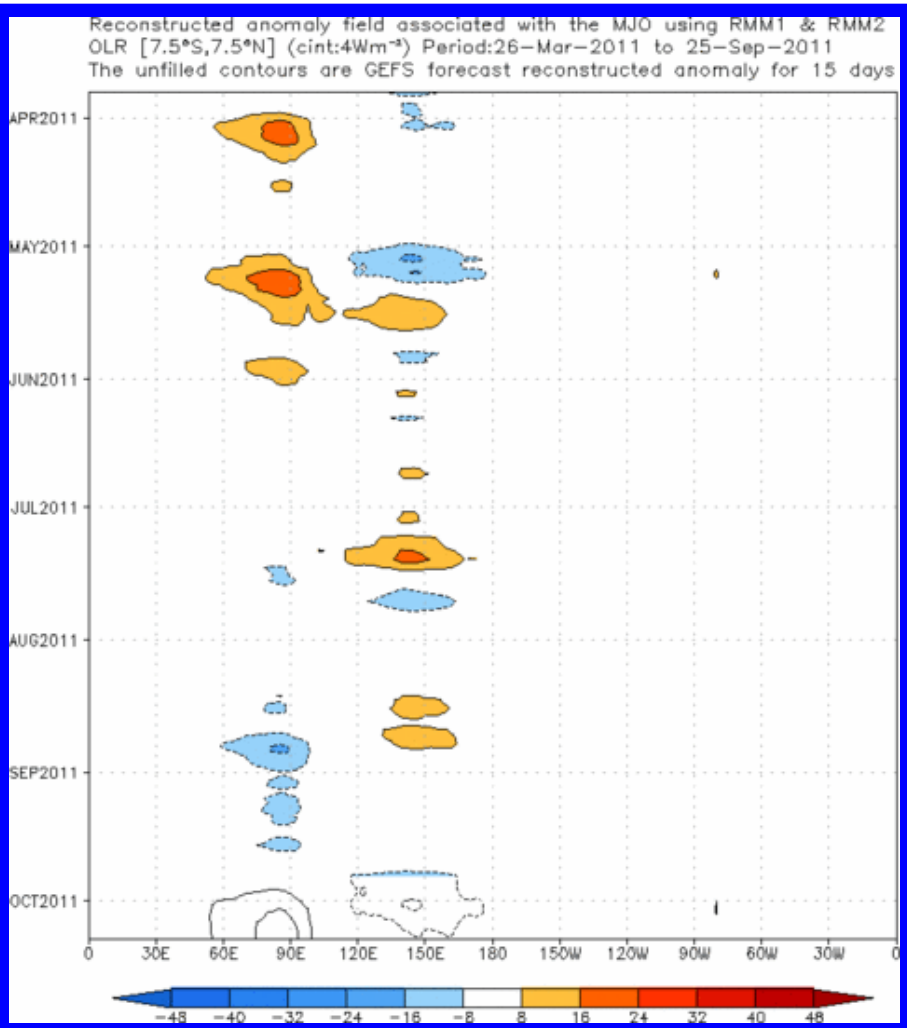
Ensemble Mean GFS MJO Forecast

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

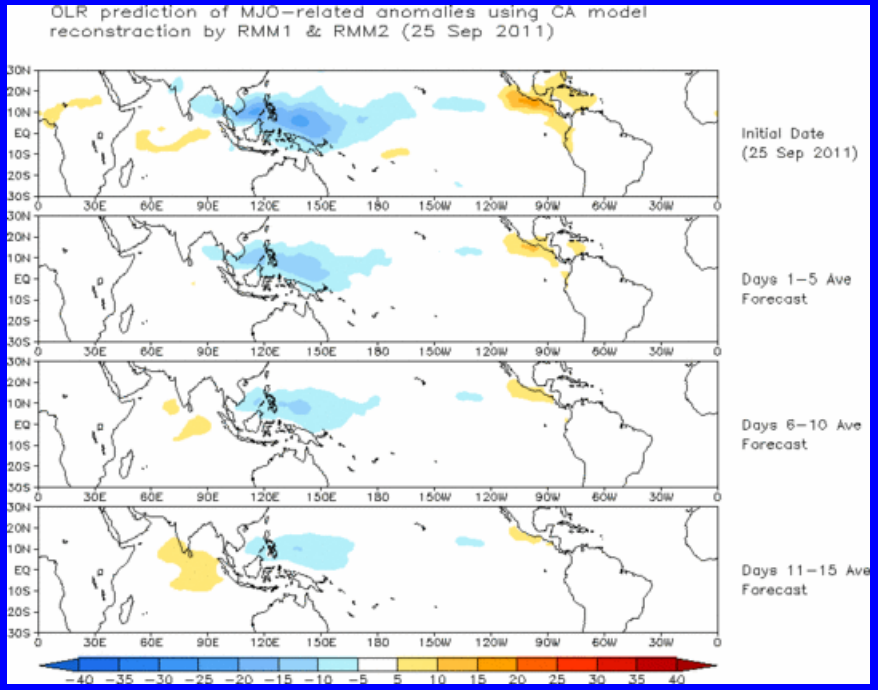


The ensemble mean GFS forecast indicates enhanced convection for the western and central Pacific during the period. Suppressed convection is forecast across the Indian Ocean by Week-2.

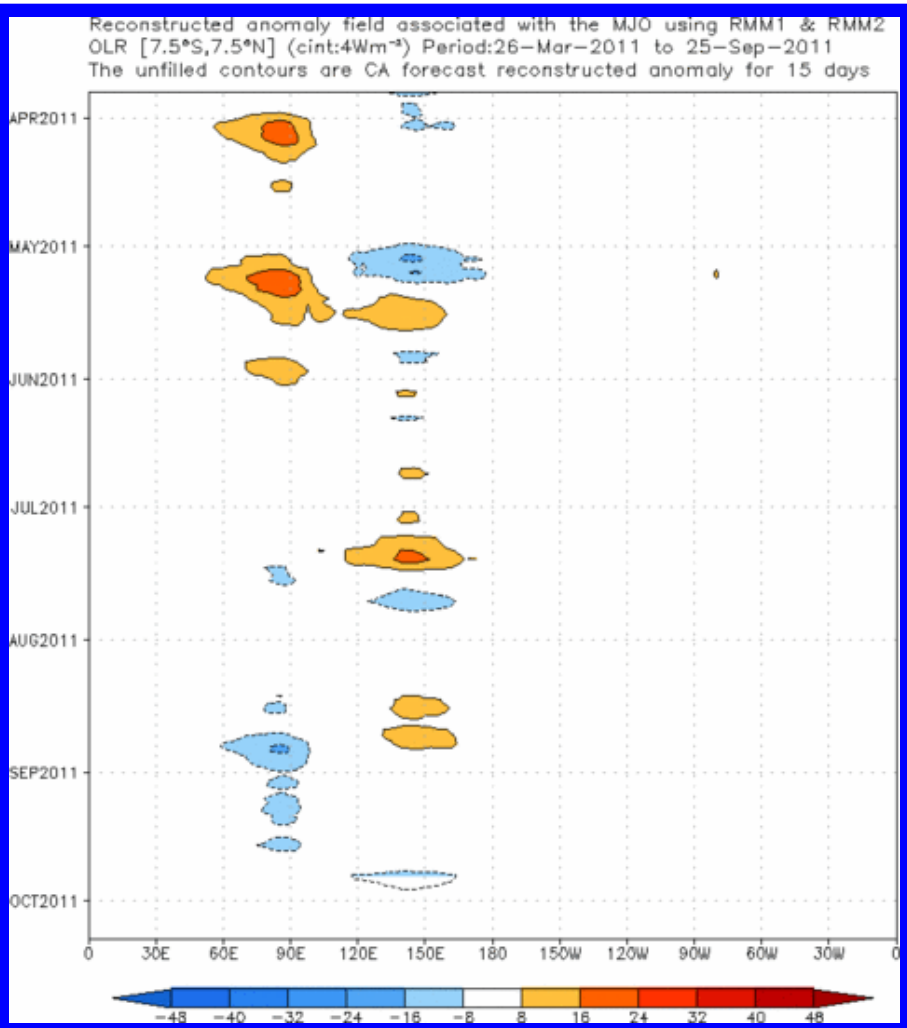
Constructed Analog MJO Forecast

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



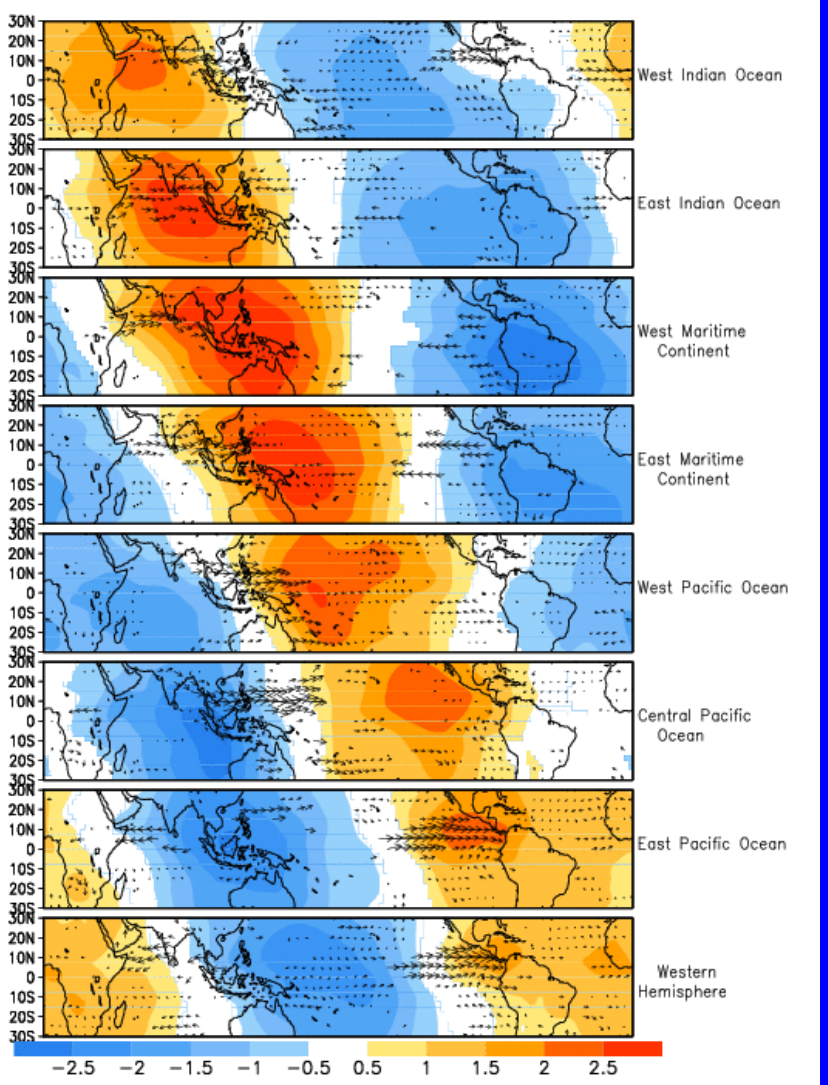
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



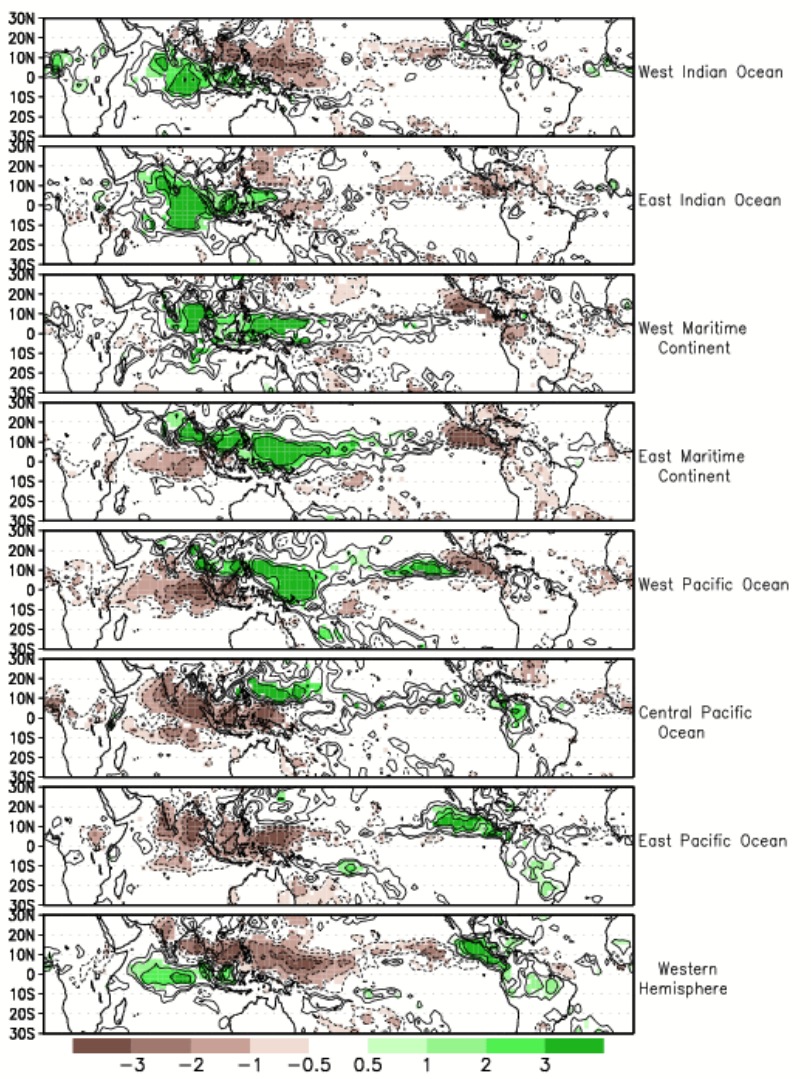
The CA forecast indicates moderate enhanced convection for the western Pacific during the period with weak suppressed convection developing in the Indian Ocean by Week-2.

MJO Composites – Global Tropics

850-hPa Wind Anomalies (May-Sep)

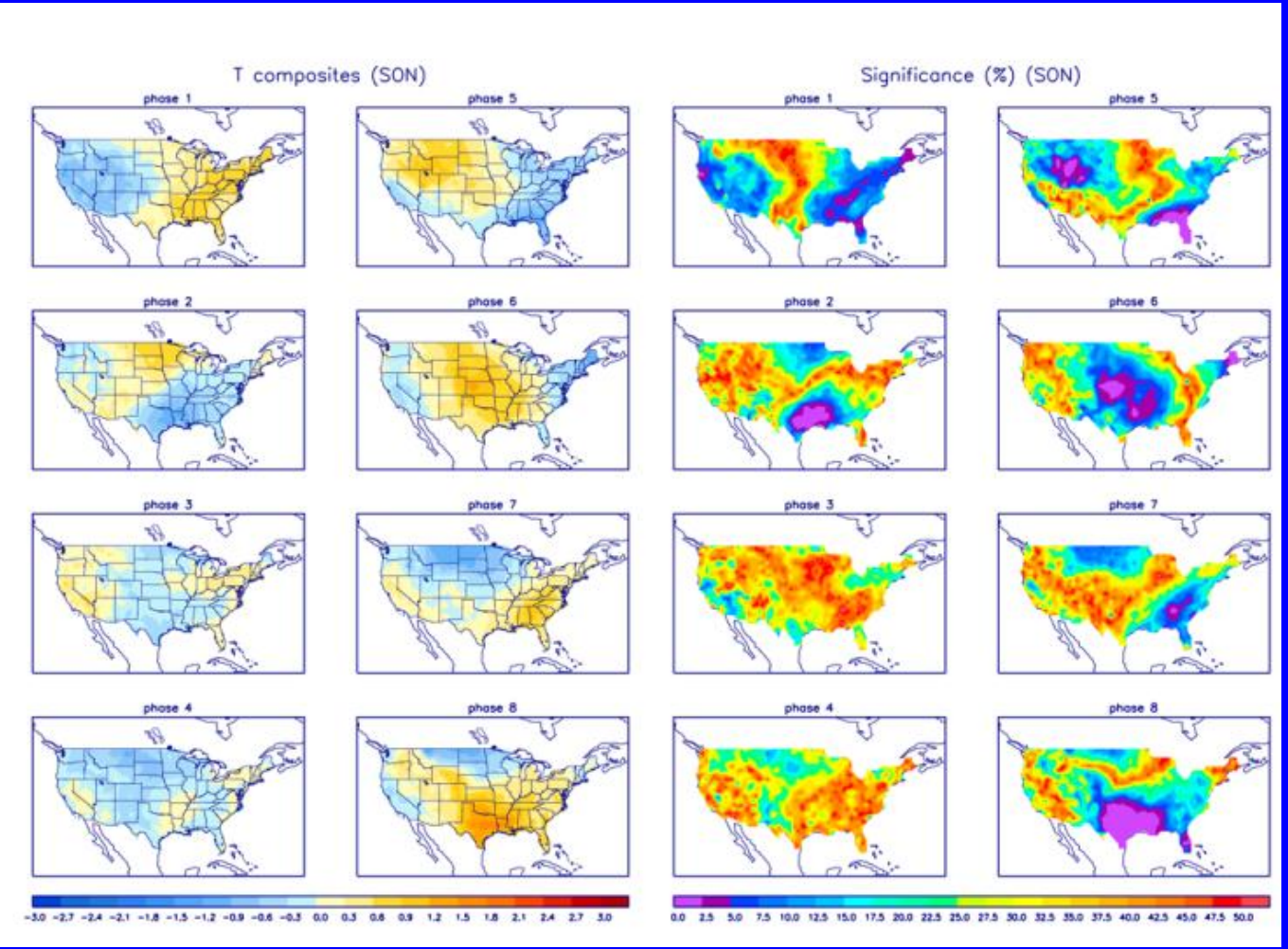


Precipitation Anomalies (May-Sep)



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.**

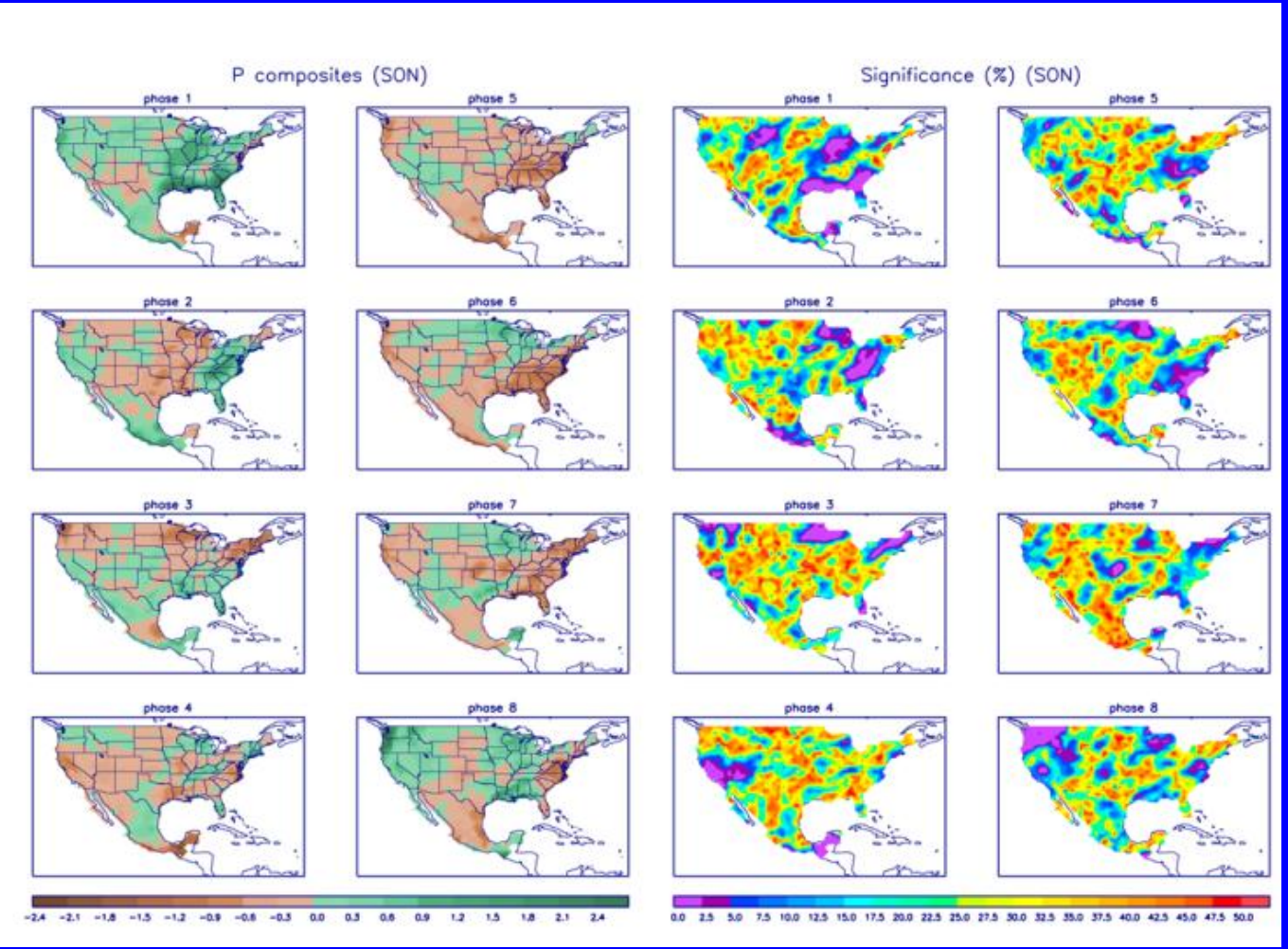


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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