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

Update prepared by
Climate Prediction Center / NCEP
August 20, 2012

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 phase centered across the western Hemisphere.

- Dynamical model MJO index forecasts indicate considerable spread, although most show a MJO signal propagating slowly eastward.

- Based on the latest observations and most model forecasts, the MJO is forecast to remain active with the enhanced phase shifting eastward to the Indian Ocean and Maritime Continent during the next two weeks. Other modes of subseasonal variability are also forecast to have significant impacts on the distribution of anomalous rainfall across the Tropics.

- During Week-1, the MJO is expected to contribute to enhanced rainfall for parts of Mexico and suppressed rainfall from southern Vietnam to the southern Philippines. Enhanced rainfall can be expected in the northwest Pacific due to ongoing tropical cyclone activity. During week-2, enhanced (suppressed) rainfall is expected to shift east to parts of the Maritime continent (eastern Pacific).

- Elevated chances for tropical cyclone development are forecast for the tropical Atlantic during the next two weeks.

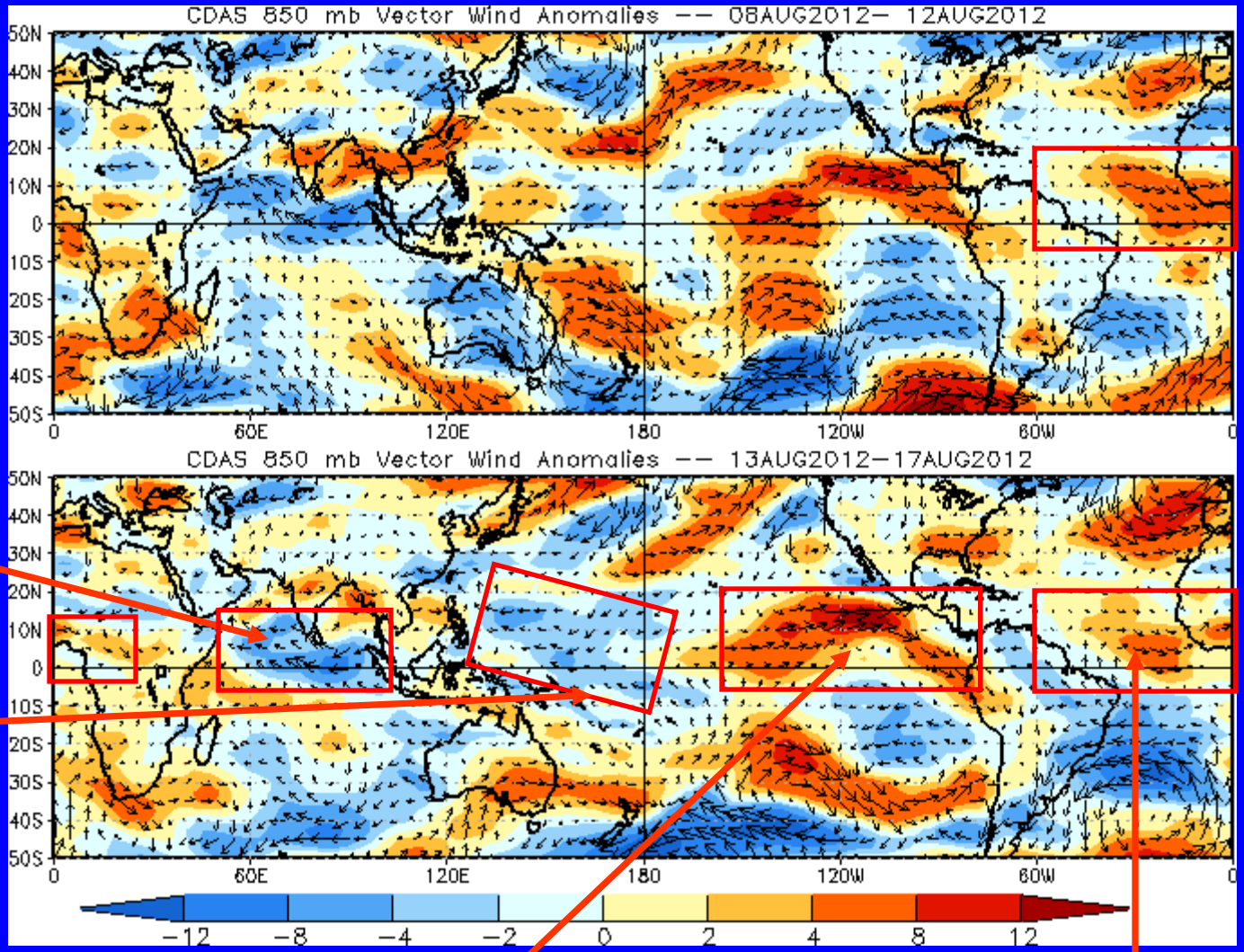
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 anomalies continued over the Indian Ocean, while easterly anomalies expanded across the west-central Pacific during the past five days.

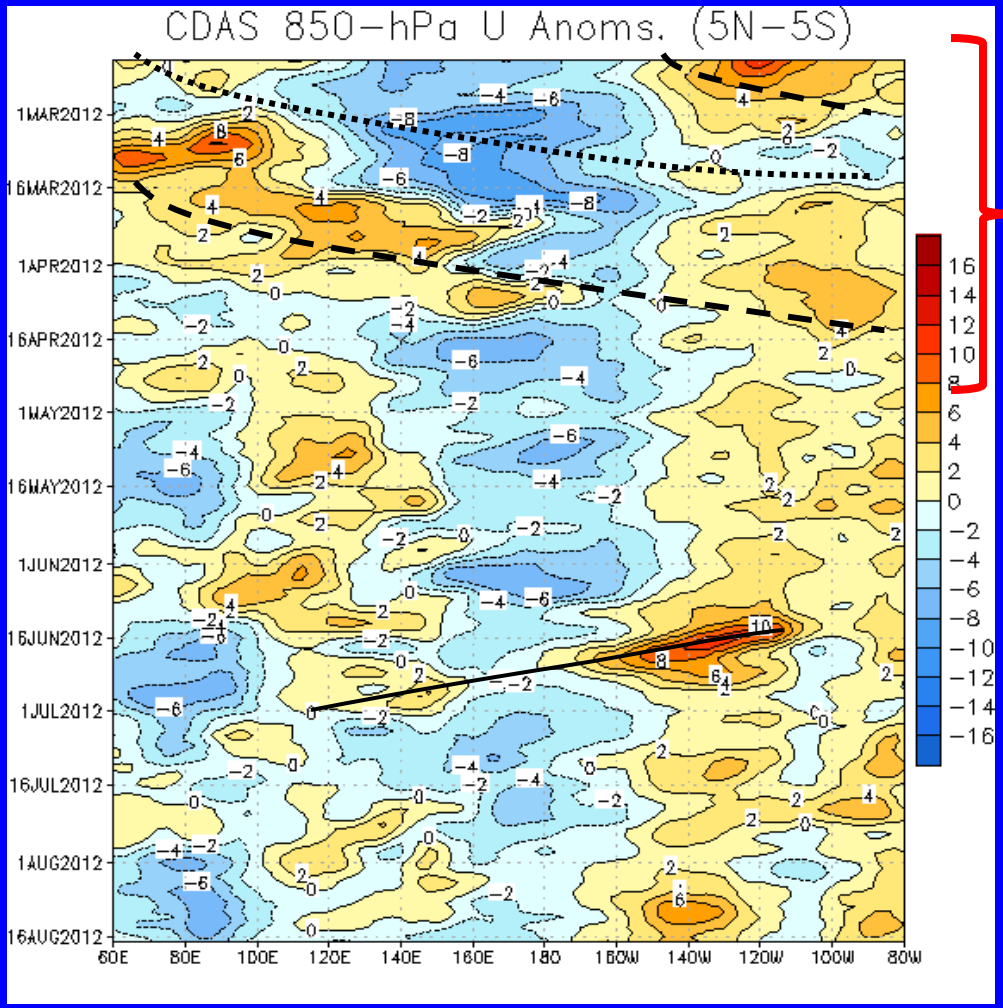
Westerly wind anomalies remained strong across the eastern Pacific during the last five days.

Westerly wind anomalies continue across the eastern tropical Atlantic and western Africa.

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

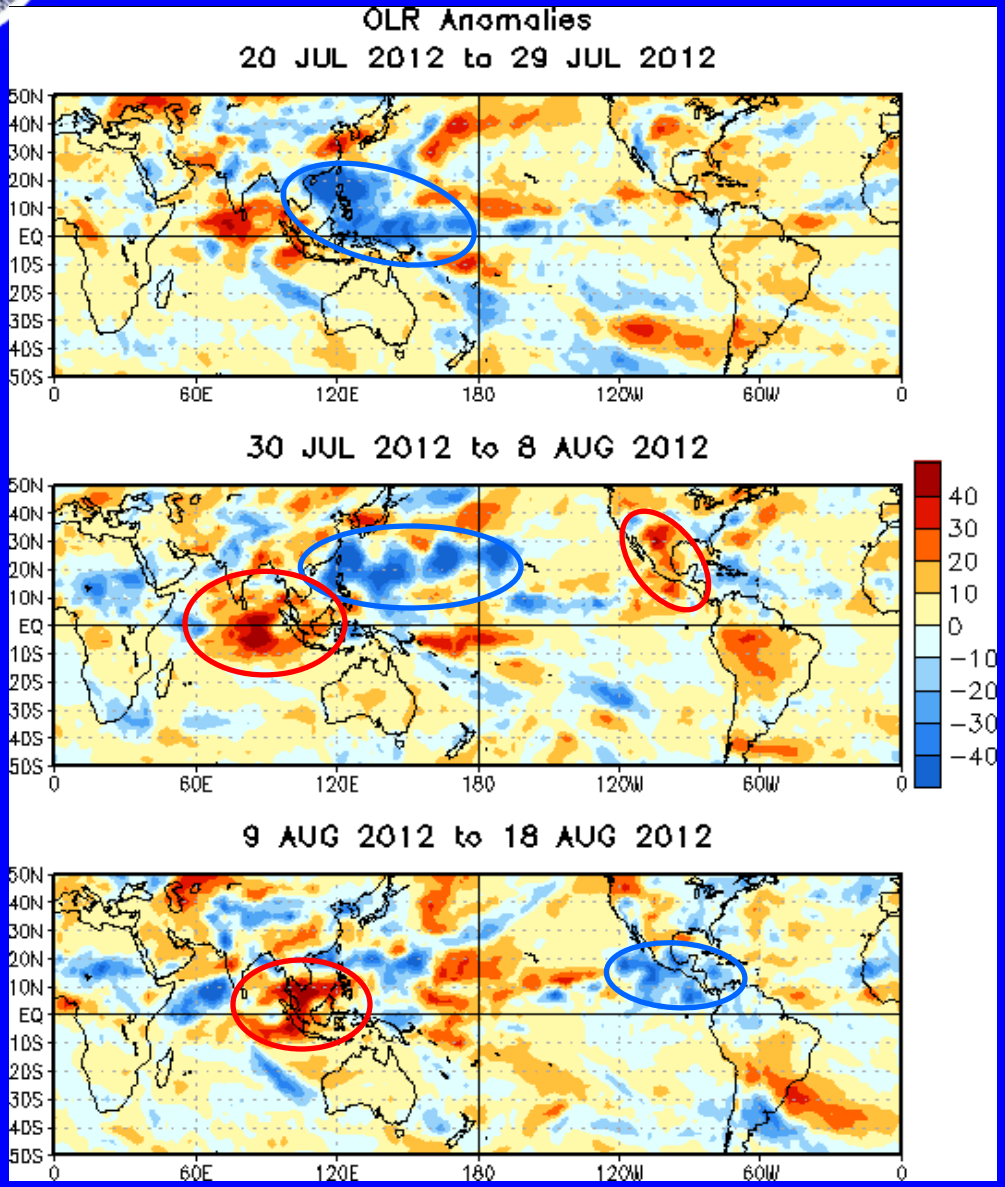
Longitude

During February, the MJO (alternating black dashed and dotted lines) contributed to increased westerly anomalies near 140E and across the eastern Pacific while decreasing easterly anomalies in the central Pacific. MJO activity continued into April, with westerly anomalies associated with the MJO located near the Date Line and western hemisphere early in the month.

Strong westerly anomalies developed across the eastern Pacific in mid-June and shifted westward (black solid line).

Most recently, easterly anomalies have persisted near 90E, while westerly anomalies have persisted east of the Date Line .

OLR Anomalies – Past 30 days



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

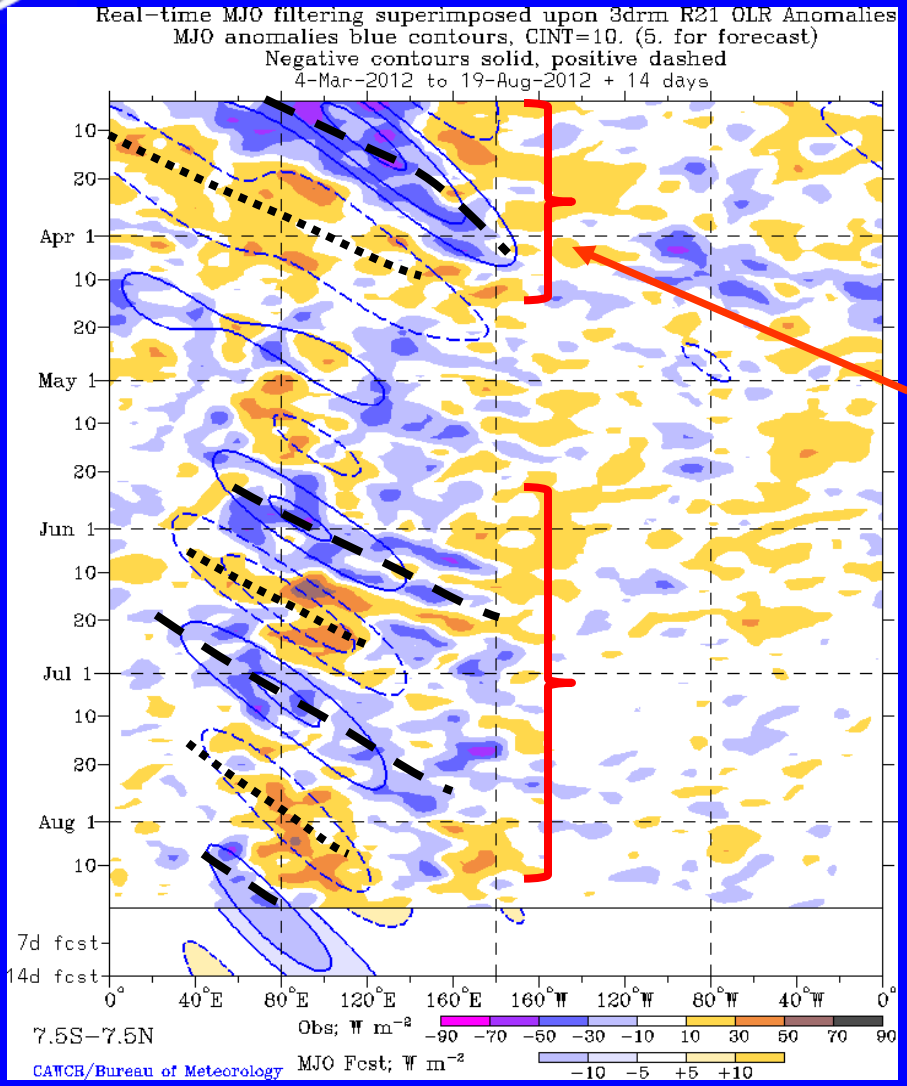
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Enhanced convection was observed over the Western Pacific during late July while suppressed convection developed across the Indian Ocean.

By early August, anomalous convection shifted northeast across the western Pacific, while suppressed convection continued across the Indian Ocean and developed over the western Maritime Continent. Drier weather was observed for the North American monsoon region.

During early to mid-August, suppressed convection shifted east across the Maritime Continent with enhanced convection developing across the east Pacific, southern Mexico, and the western Caribbean Sea.

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)

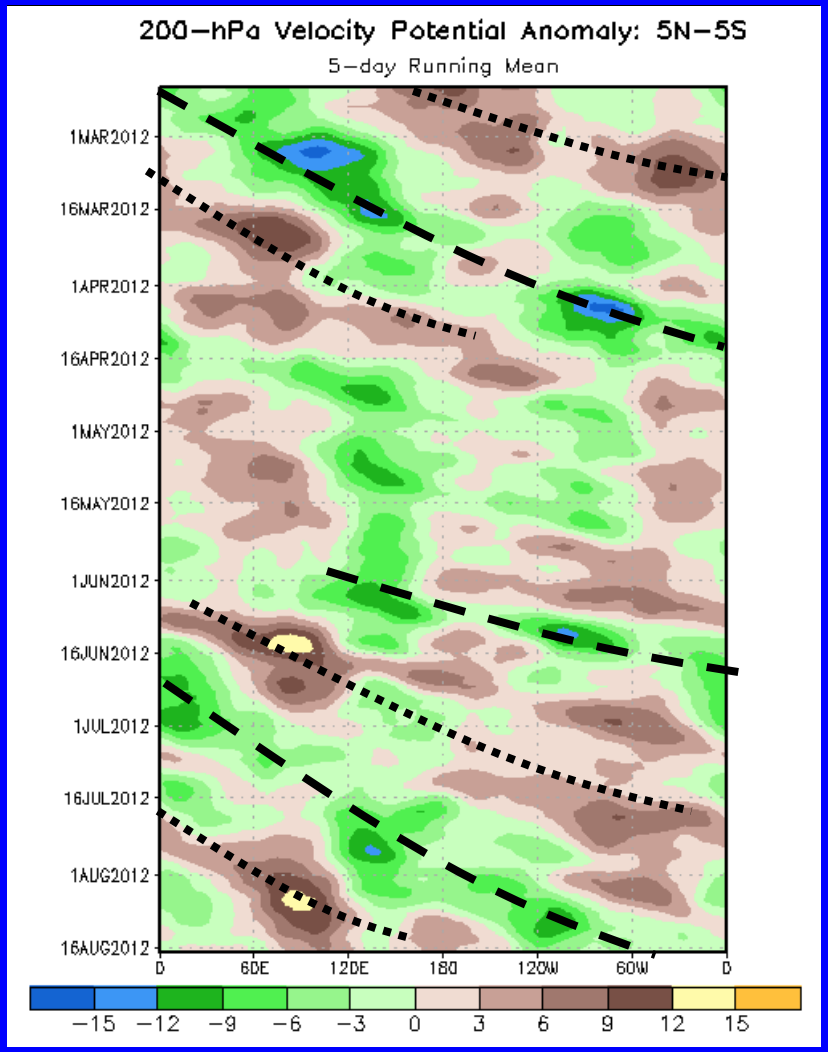
Strong MJO activity (alternating dashed and dotted lines) was evident during February and continued into mid-April.

In late May into August, eastward propagation of both enhanced and suppressed convection is evident across the eastern hemisphere. Atmospheric Kelvin wave activity also played a large role in the pattern of anomalous convection across the Pacific and western Hemisphere during this period.

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

The MJO strengthened in late January as indicated by alternating negative (dashed lines) and positive (dotted lines) anomalies with eastward propagation. The activity continued into mid-April.

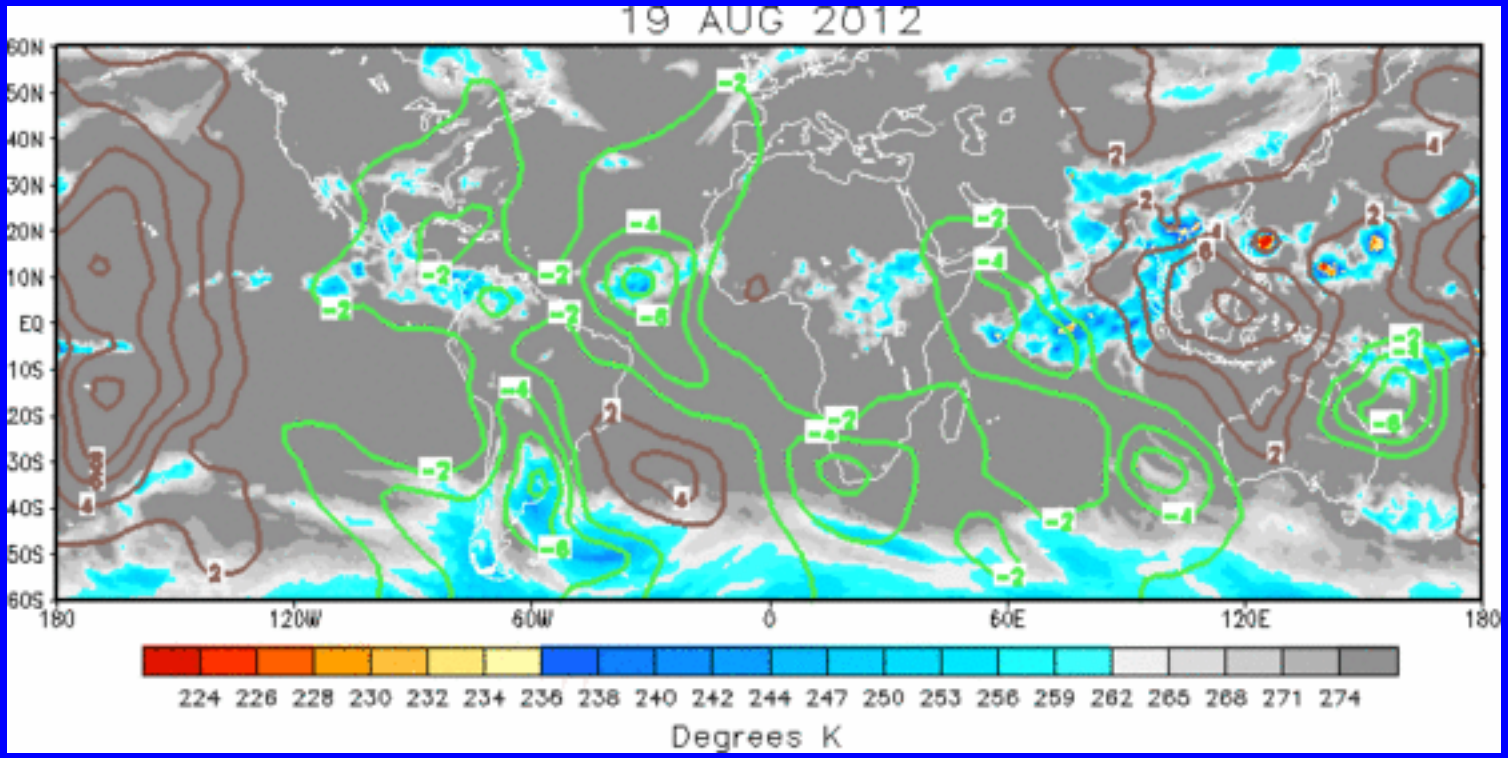
Beginning in late April, anomalies became weaker and less coherent than earlier in the year.

Eastward propagation was once again evident from late May into August associated with the MJO as well as atmospheric Kelvin wave activity, which at times resulted in fast eastward propagation of observed anomalies. Most recently, anomalies of upper-level convergence and divergence have decreased somewhat.

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

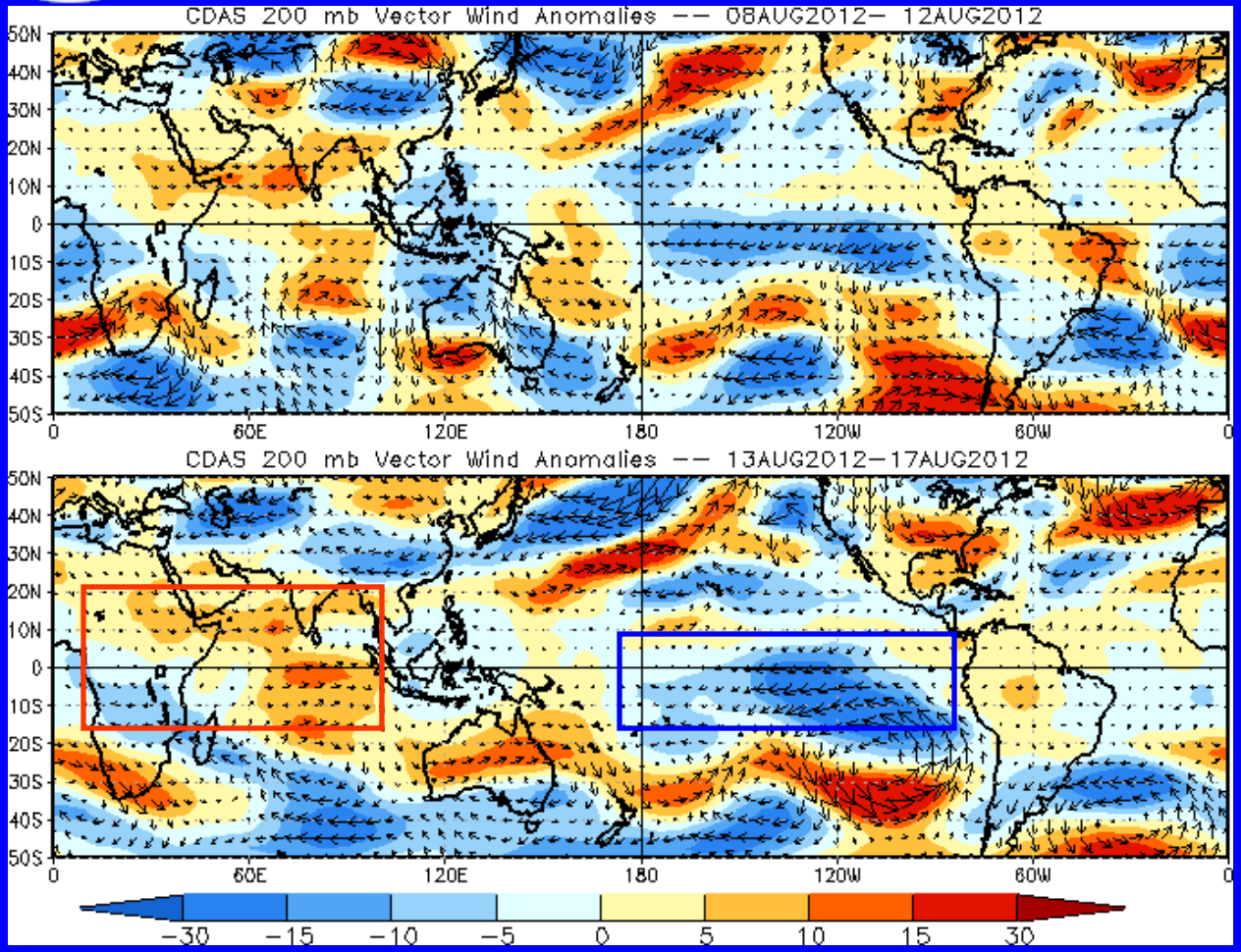
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The large scale velocity potential pattern reflects anomalous upper-level divergence across the Americas, tropical Atlantic, and western Indian Ocean. Anomalous upper-level convergence is evident over the Maritime Continent and western/central Pacific Ocean.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

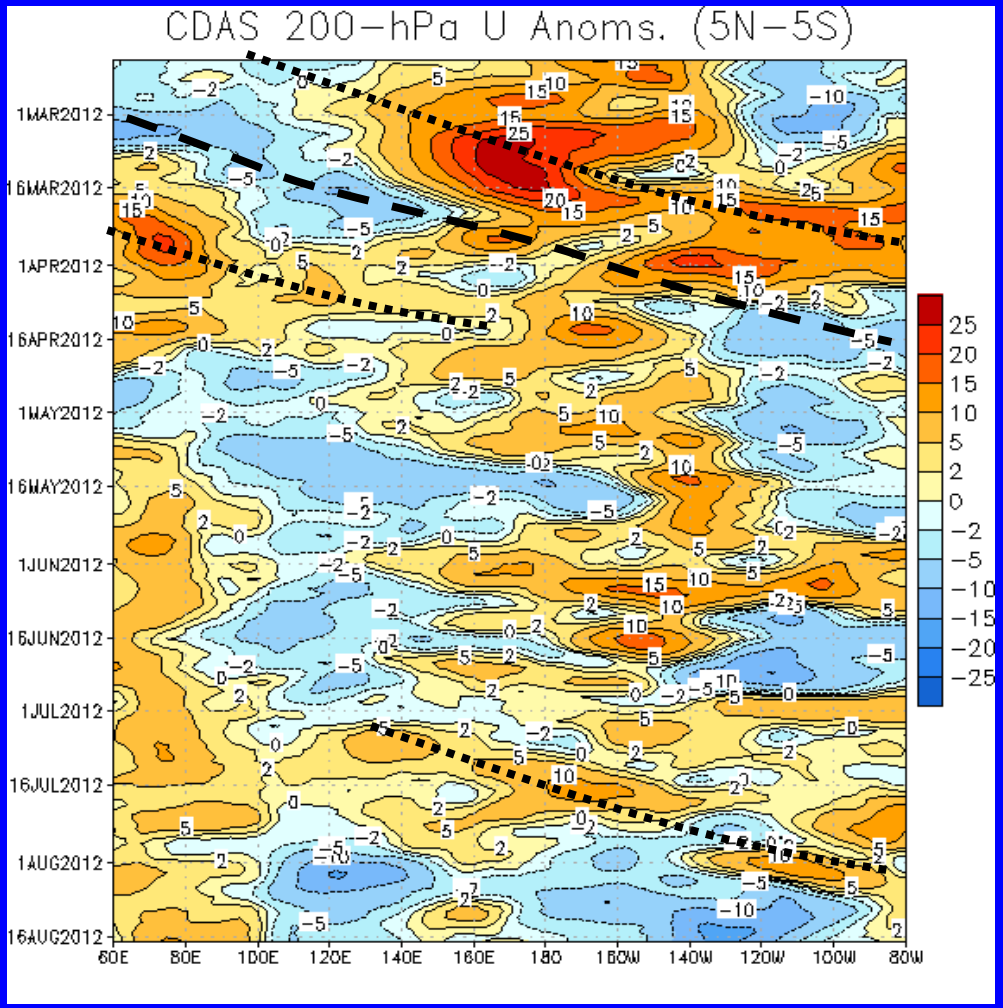
Red shades: Westerly anomalies

Weak easterly anomalies persisted over most of the eastern equatorial Pacific (blue box) during the past five days. Westerly anomalies (a weak Tropical Easterly Jet) persisted across the Indian Ocean (red 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

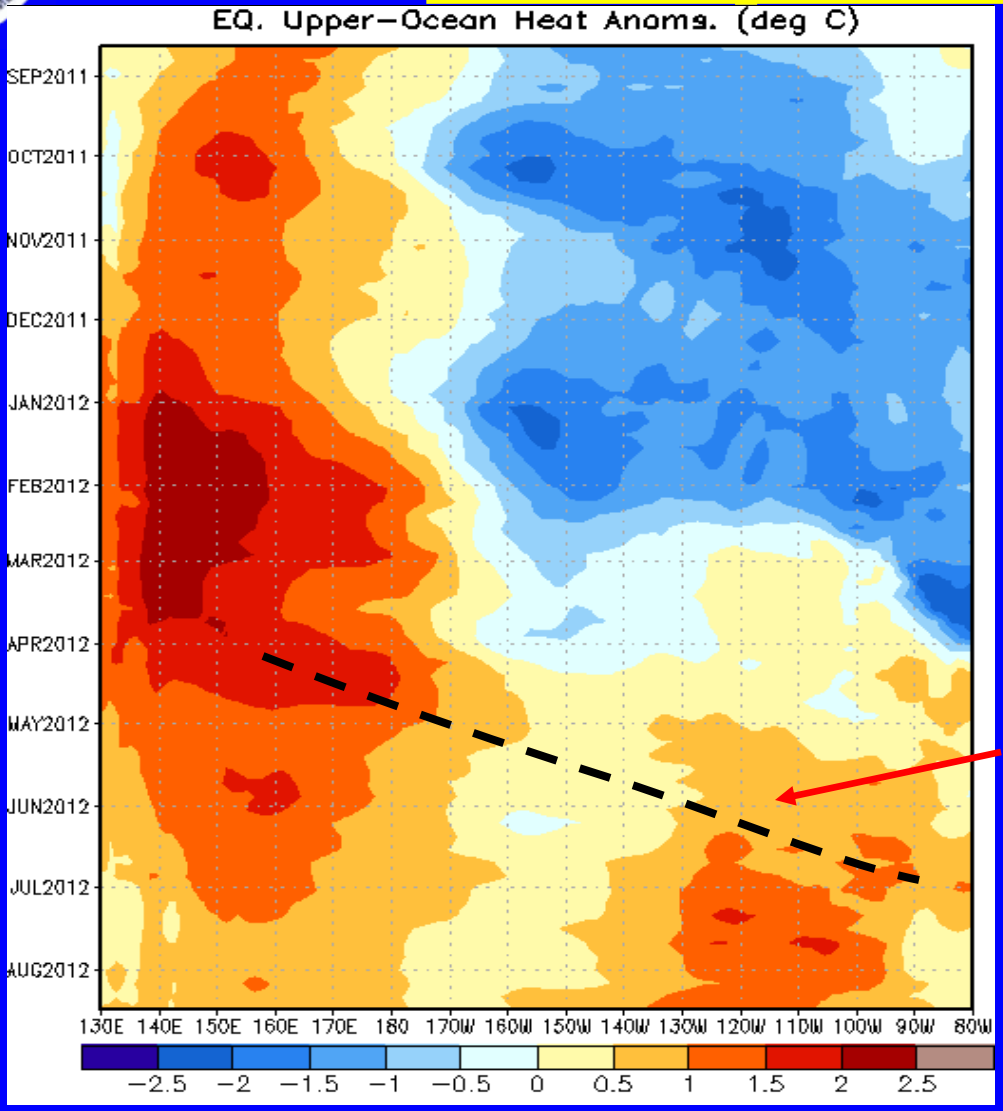
Longitude

The MJO strengthened once again in late January as indicated by alternating westerly (dotted lines) and easterly (dashed lines) anomalies. This activity continued to mid-April.

Anomalies were less coherent during much of April and May.

Westerly anomalies shifted eastward across the Pacific during July and early August. Most recently, easterly anomalies have become strong over the eastern Pacific while westerly anomalies have persisted over the Indian Ocean.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

From July 2011 through February 2012, heat content was below average in the central and eastern equatorial Pacific.

From March into July 2012, heat content anomalies became positive and increased in magnitude across eastern equatorial Pacific, partly in association with a downwelling Kelvin wave.

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).

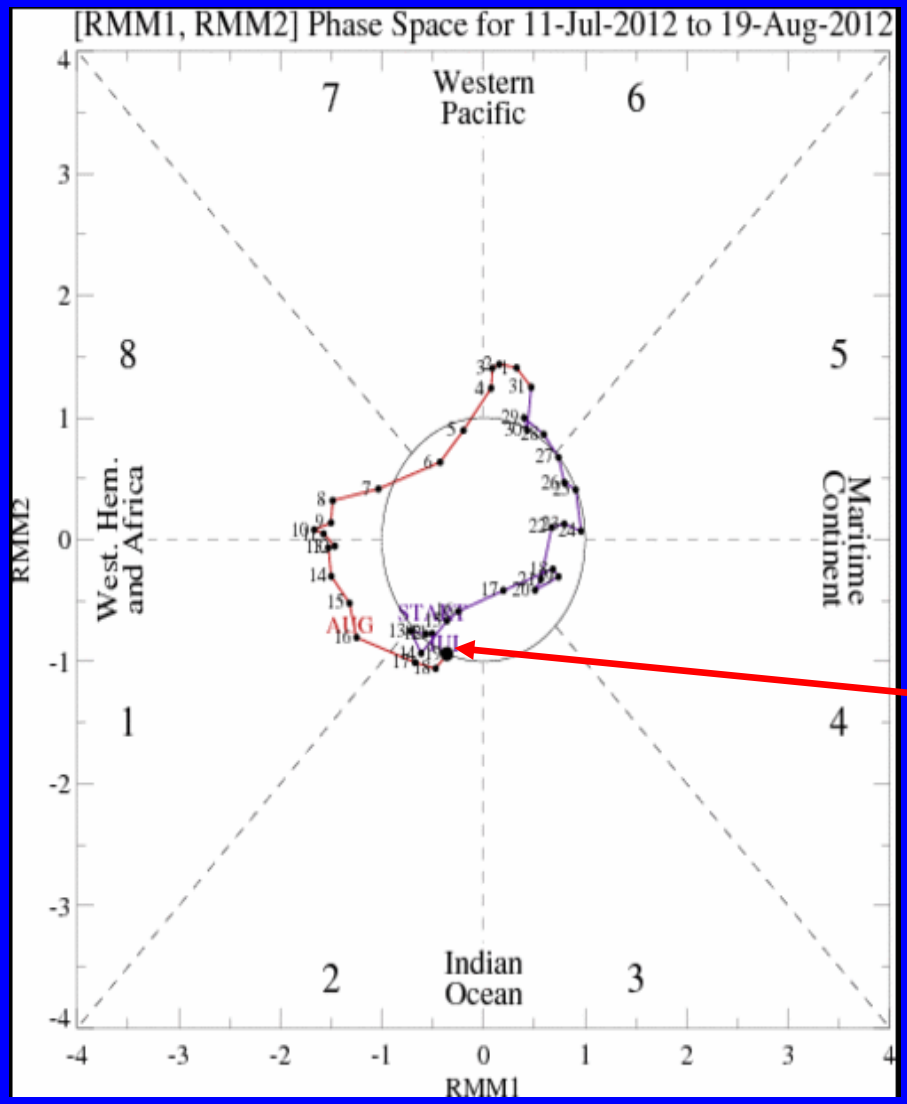
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

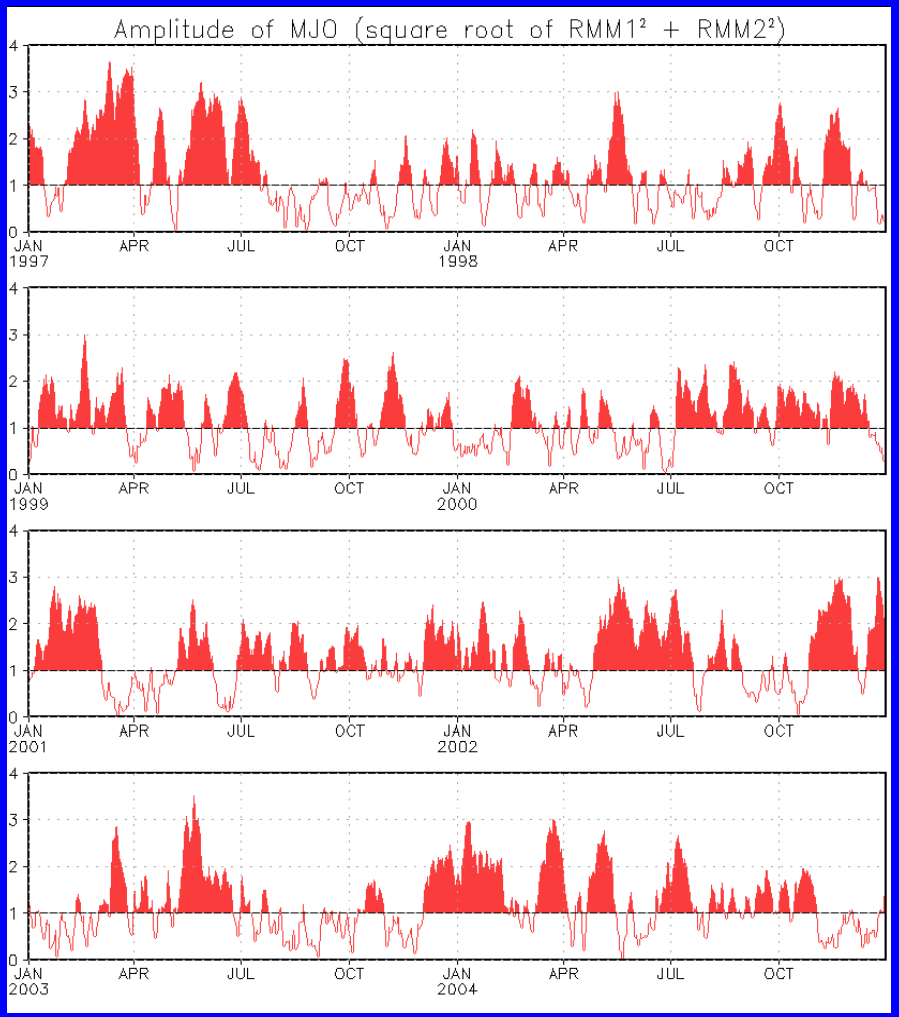
MJO Index -- Recent Evolution

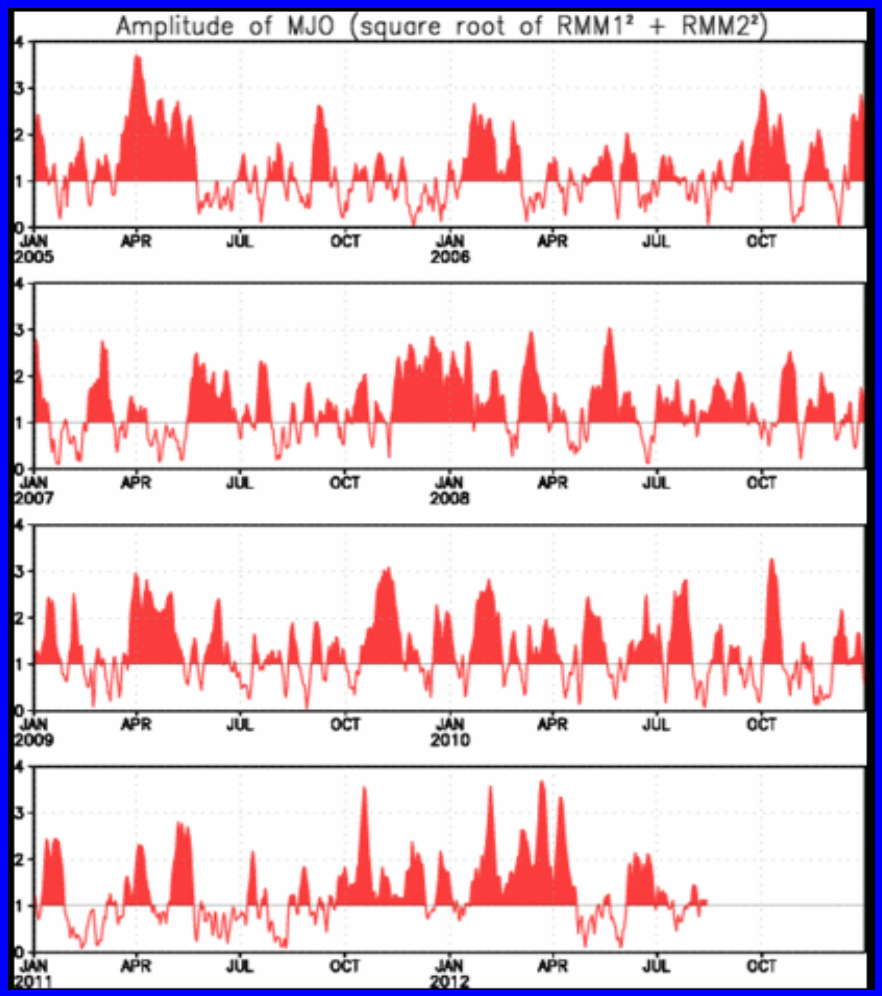


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index continued its eastward propagation during the past week, albeit with a slight decrease in amplitude.

MJO Index – Historical Daily Time Series





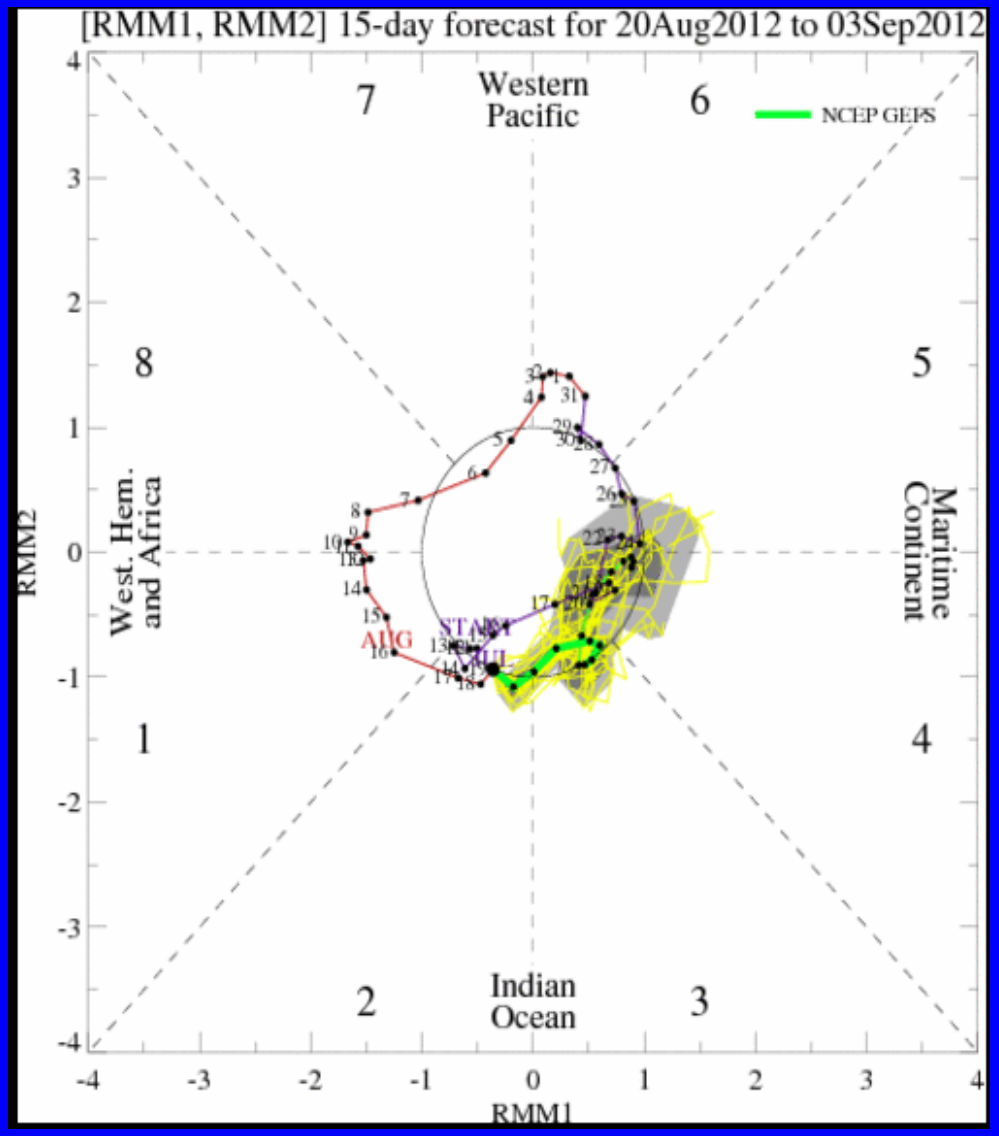
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

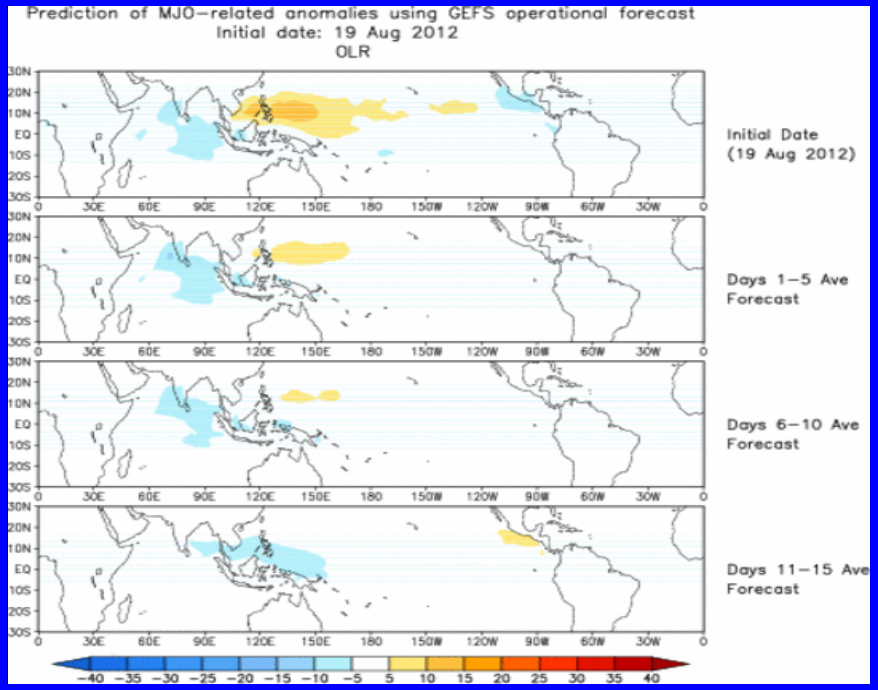


The ensemble GFS forecasts an eastward propagating MJO signal, albeit with a weak amplitude.

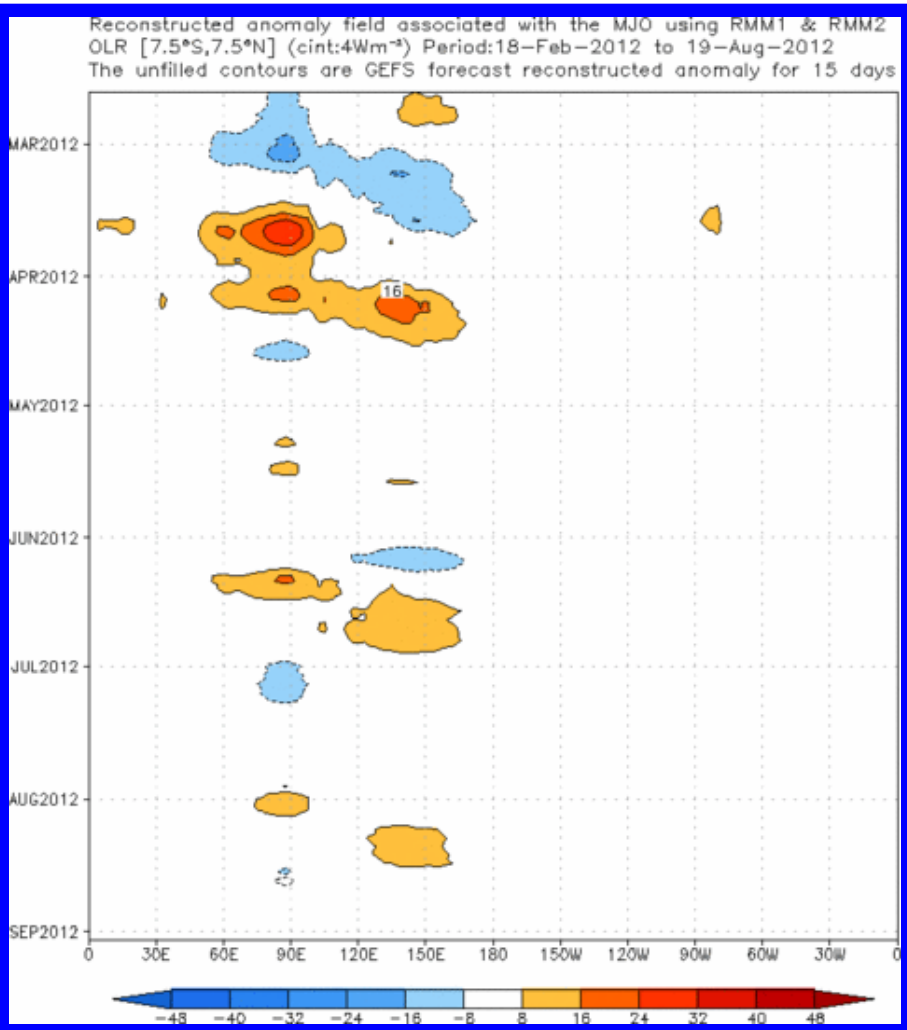
Ensemble Mean GFS MJO Forecast

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

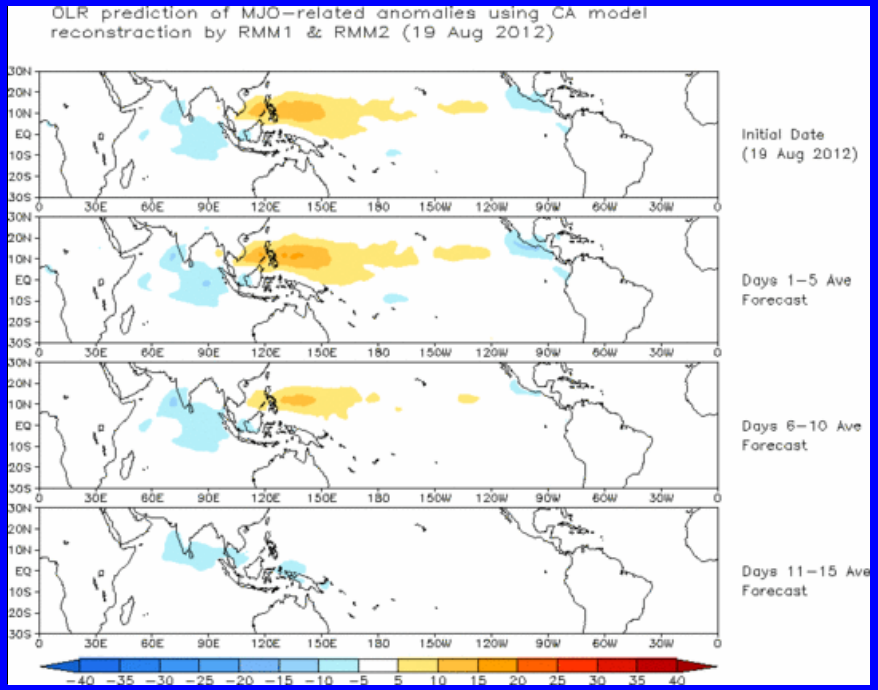


The ensemble mean GFS forecast indicates generally weak anomalous convection during much of the forecast period.

Constructed Analog (CA) MJO Forecast

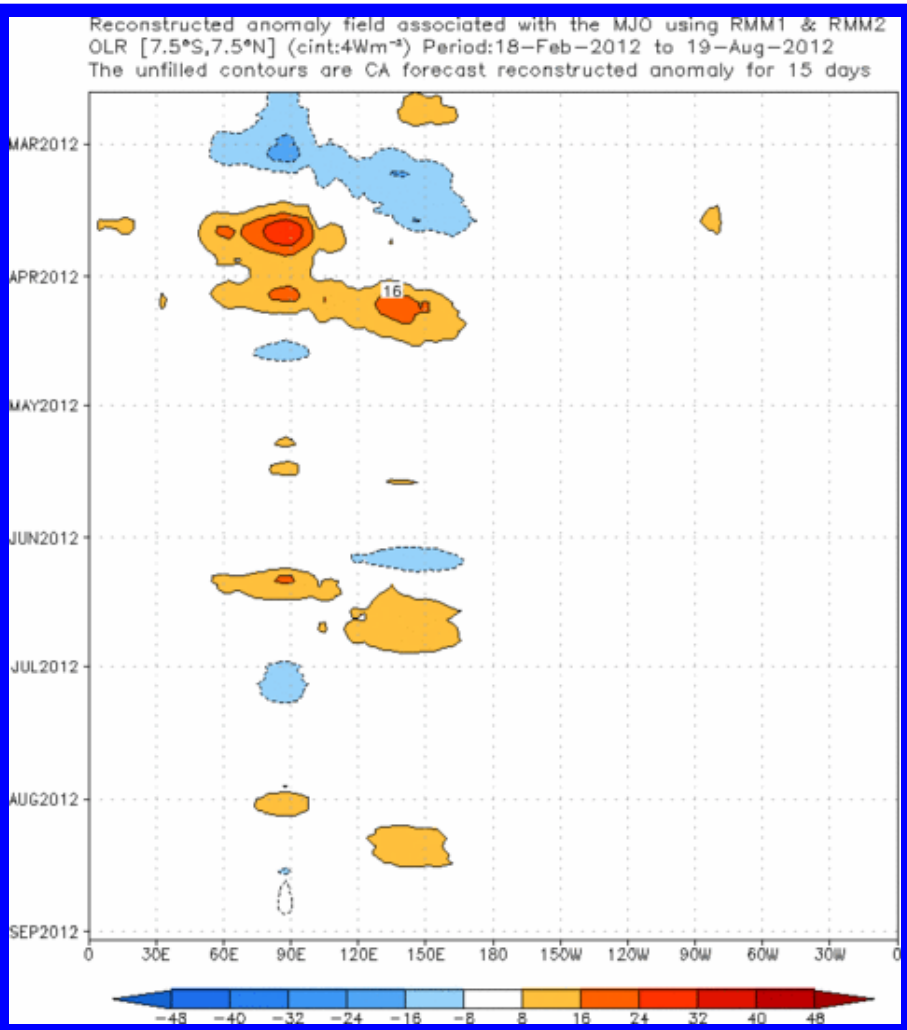
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



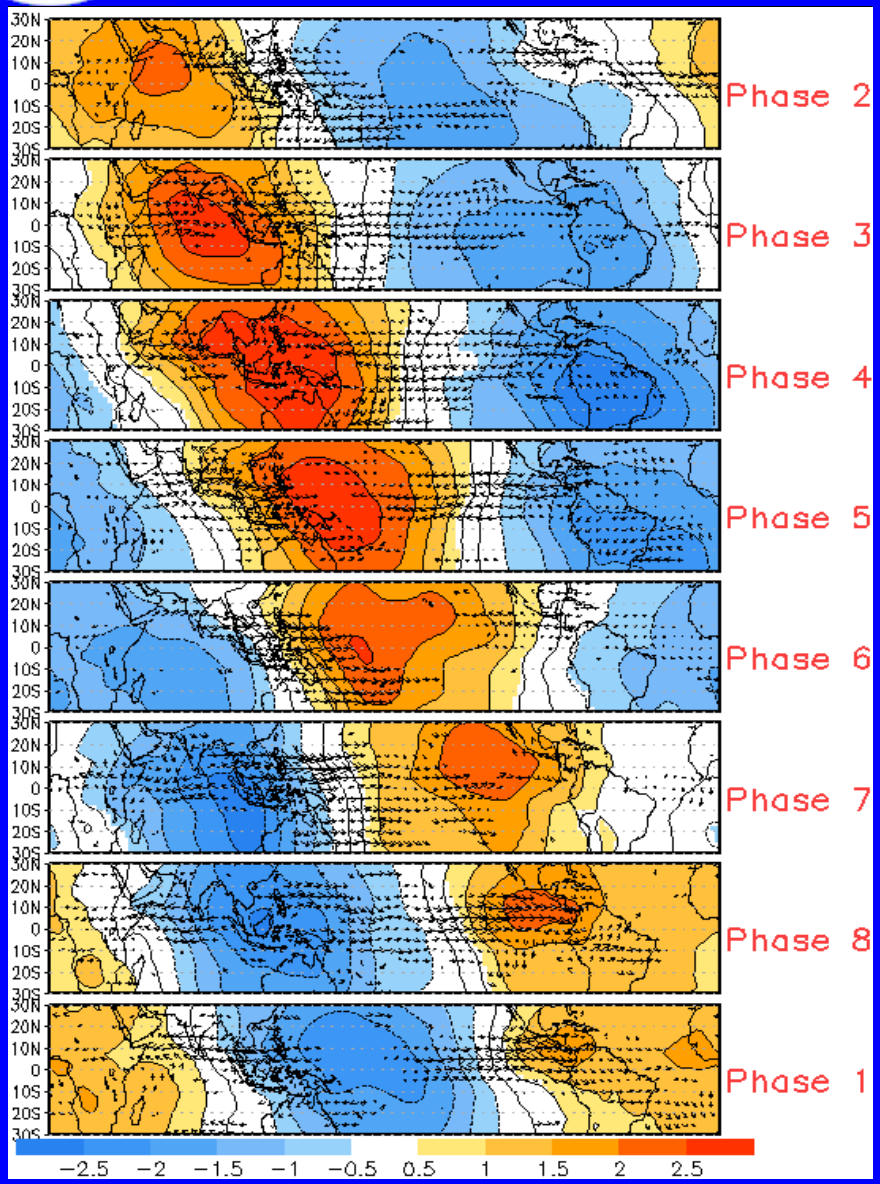
The forecast indicates enhanced (suppressed) convection diminishing across the eastern (western) Pacific.

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

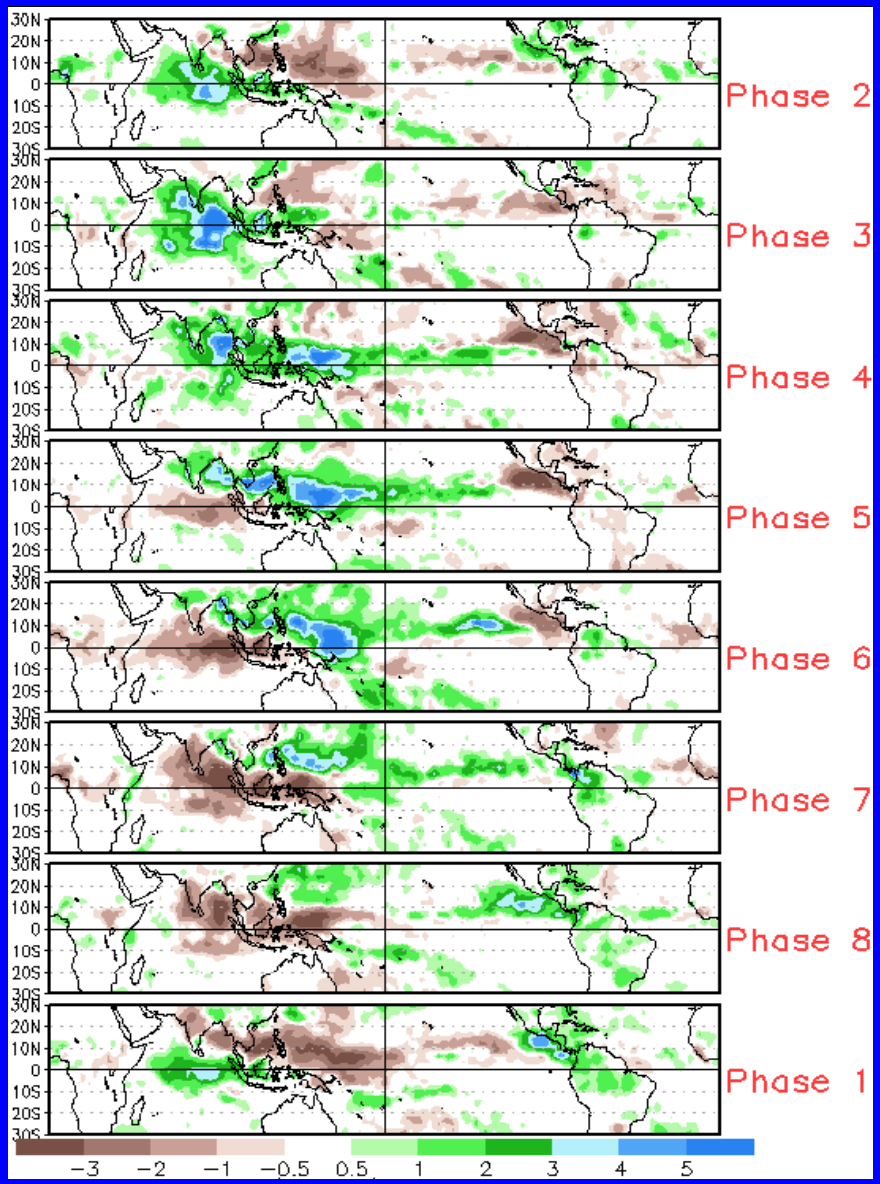


MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (May-Sep)

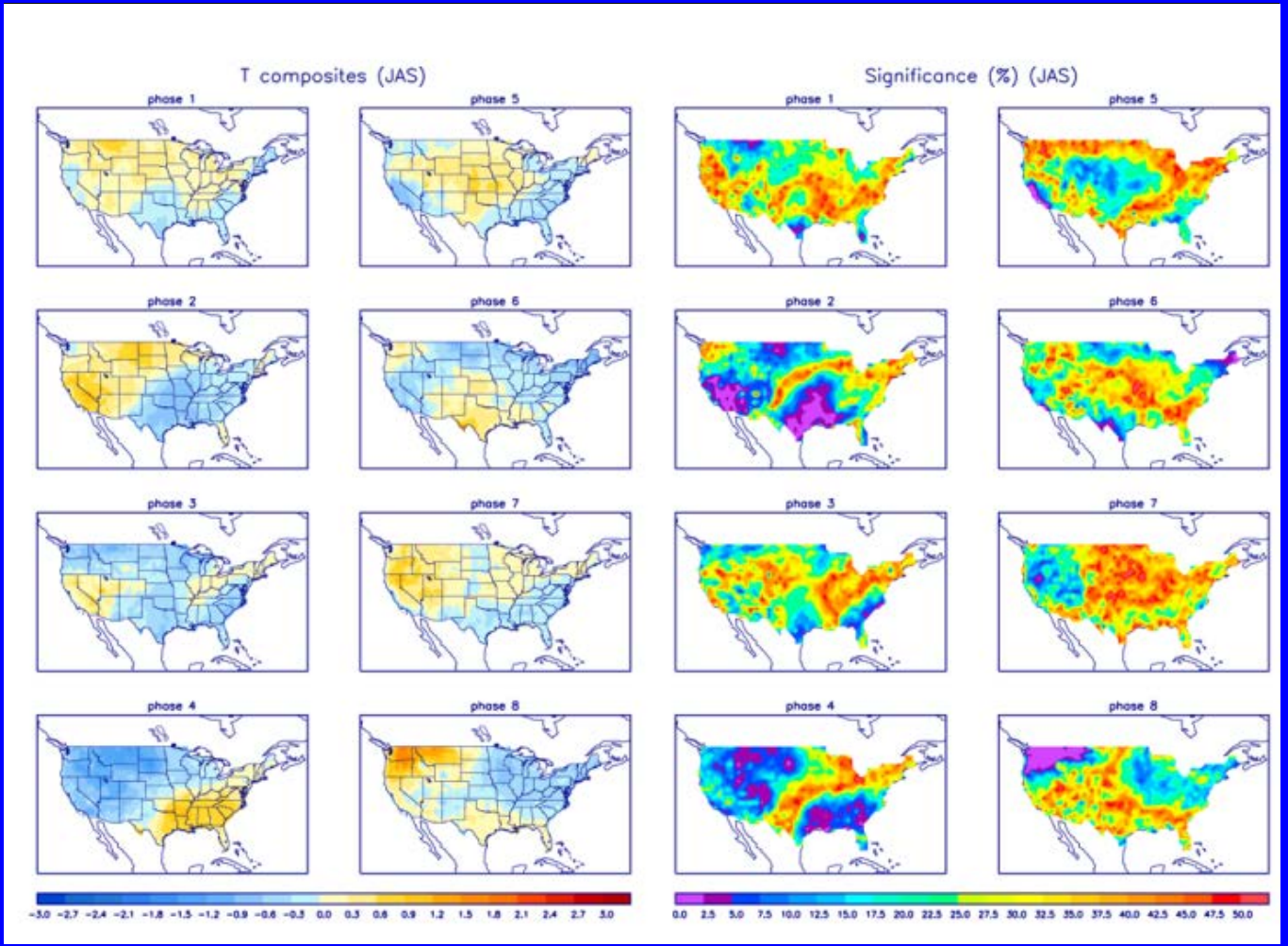


Precipitation Anomalies (May-Sep)



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. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**

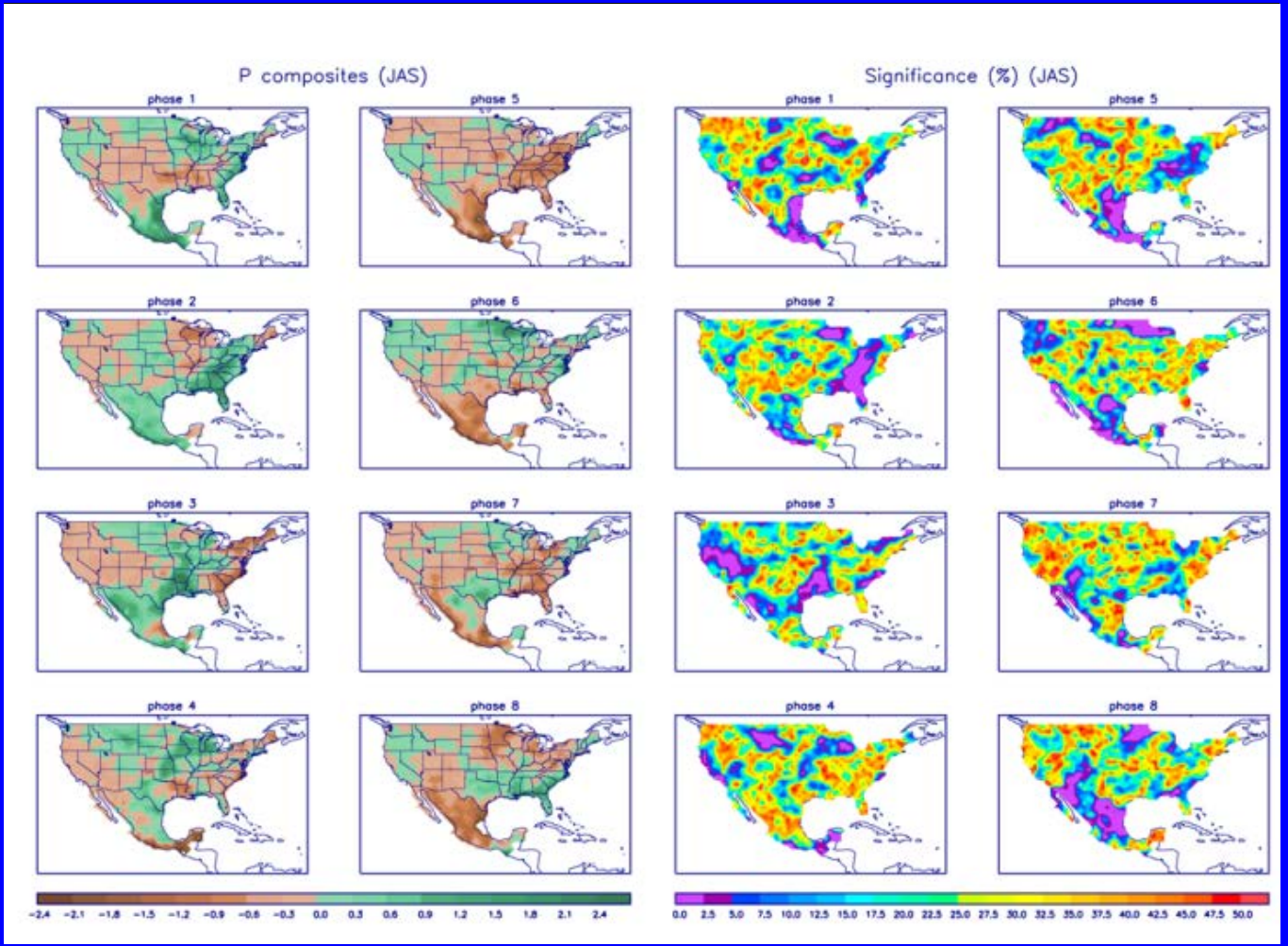


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**



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