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

**Update prepared by**
**Climate Prediction Center / NCEP**
**September 23, 2013**

# Outline

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

# Overview

- The MJO remained active over the past week with the enhanced convective phase now centered over the Maritime Continent and West Pacific.

- Dynamical model MJO index forecasts generally indicate a slowly propagating MJO signal into the western and central Pacific.

- Based on recent observations, statistical, and dynamical forecasts, the MJO is forecast to remain active and continue to impact anomalous tropical convection along with other types of subseasonal tropical variability.

- The MJO favors enhanced (suppressed) rainfall across much of the Western Pacific extending from Southeast Asia to the Date Line (equatorial Indian Ocean and Maritime Continent) during the next two weeks. The MJO also favors suppressed convection in the wake of ongoing tropical cyclone (TC) activity across parts of the East Pacific and Central America over the next one to two weeks.

- The MJO continues to elevate odds for tropical cyclone (TC) formation across parts of the western Pacific, while reducing odds for TC formation across the East Pacific (Week-1) and Atlantic (Week-1 and Week-2).

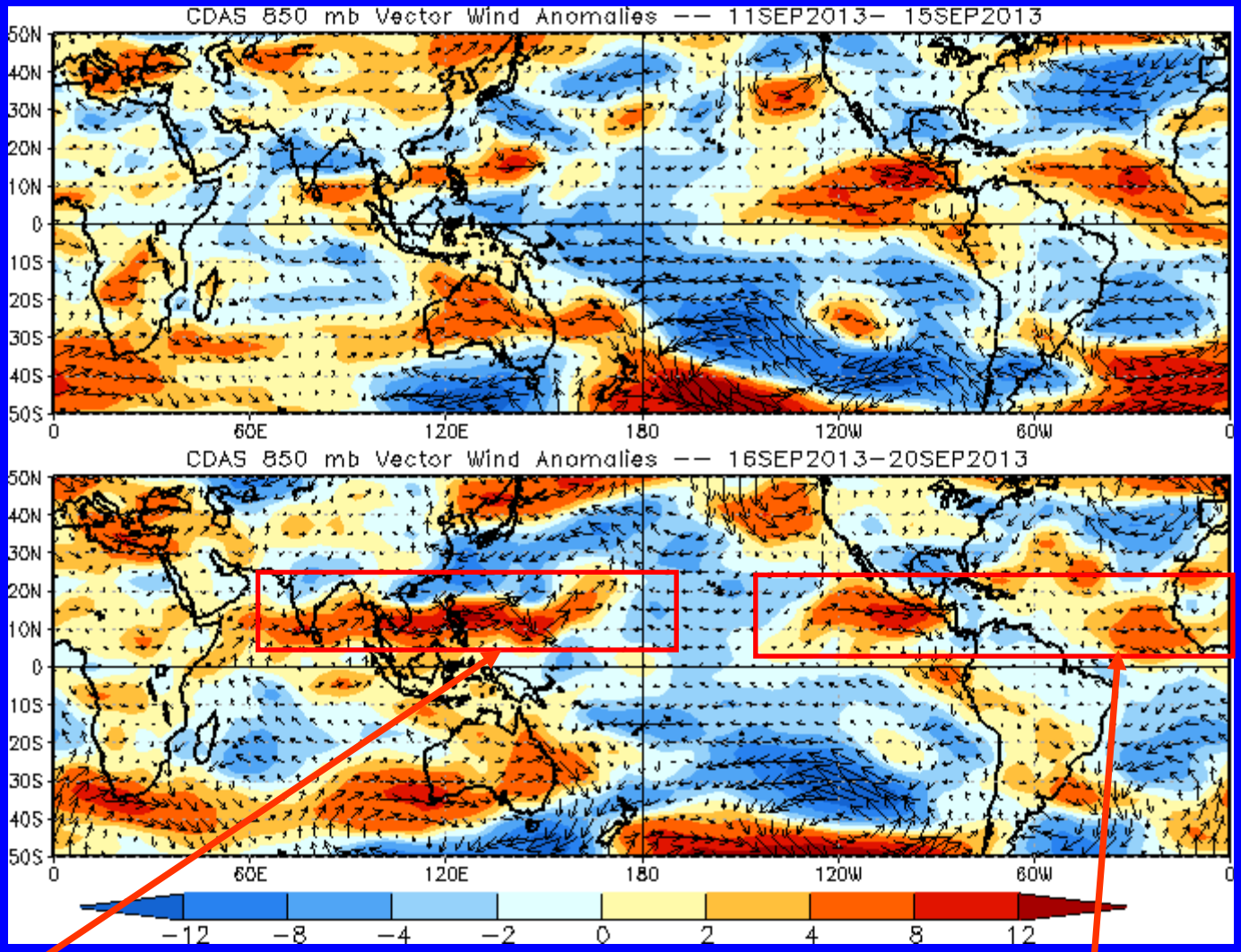
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

**Blue shades**: Easterly anomalies

**Red shades**: Westerly anomalies



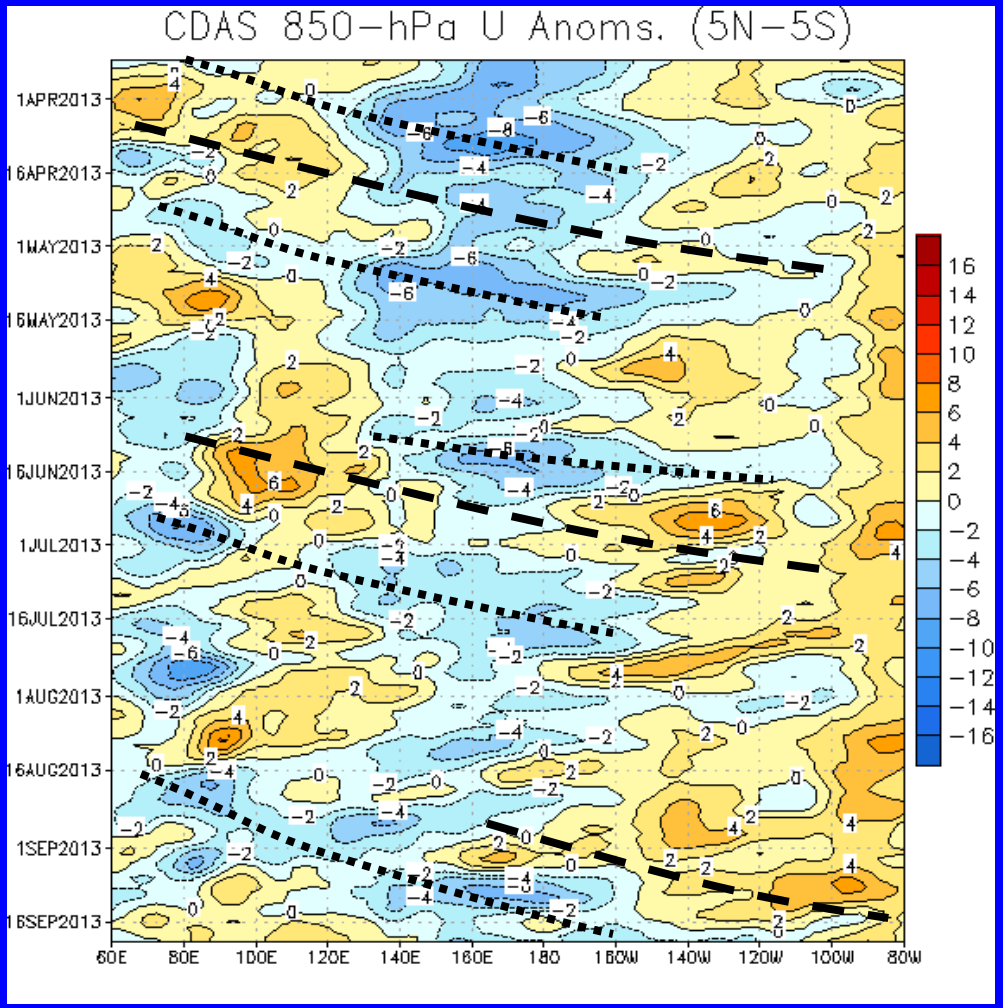

Westerly anomalies strengthened across much of the Indian Ocean, Maritime Continent, and West Pacific, north of the Equator.

Westerly anomalies continued over the eastern Pacific and the Atlantic basins while decreasing in amplitude.

# 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

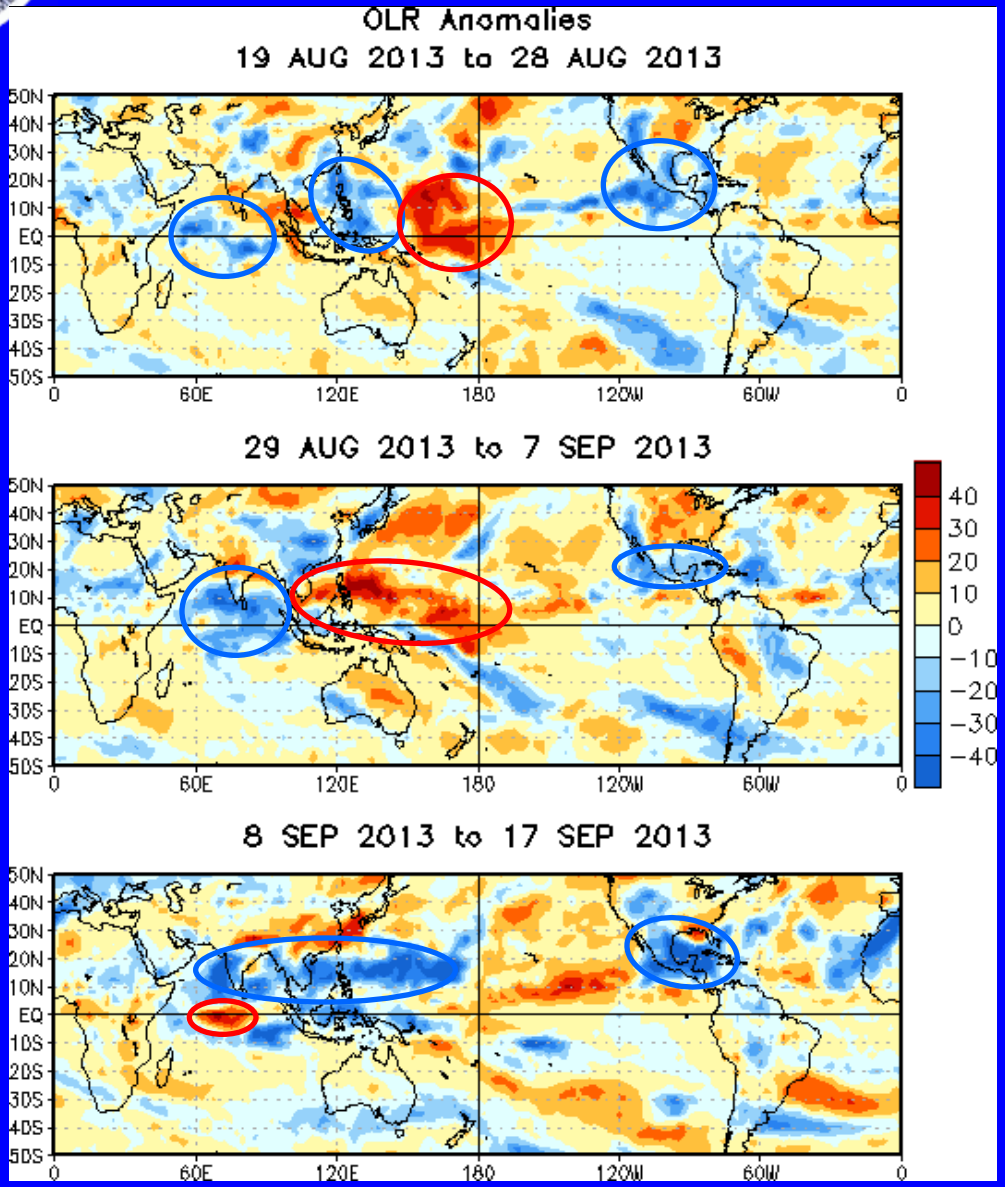
**The MJO was active from March into early May as indicated by alternating dotted (easterly anomalies) and dashed (westerly anomalies) lines.**

**The MJO strengthened again in June and continued to mid-July with fast eastward propagation.**

**During late July through mid-August, other types of subseasonal variability strongly contributed to the observed anomalies. In late August and early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.**

**Recently, there has been eastward propagation of both easterly and westerly anomalies, consistent with MJO activity.**

# OLR Anomalies – Past 30 days




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

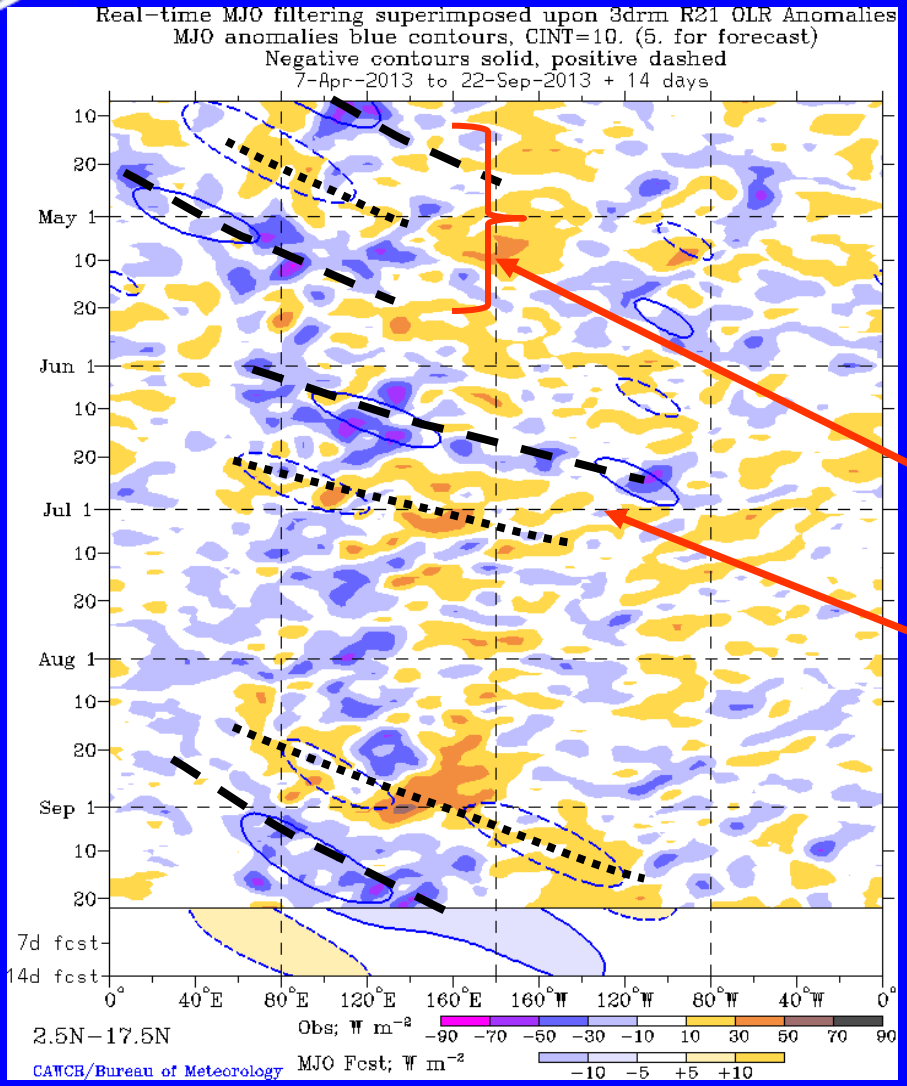
**Wetter-than-normal conditions, negative OLR anomalies (blue shading)**

**The MJO began to show signs of organization during late August, as enhanced convection developed across parts the western Hemisphere while subsidence increased near the Date Line.**

**During very late August and early September, convection increased in the Indian Ocean and began propagating eastward. Subsidence strengthened across the western Pacific, partially due to an equatorial Rossby wave.**

**In mid-September, enhanced convection spread eastward into the West Pacific. In spite of large-scale subsidence, weak TC activity enhanced convective activity across parts of Central and North America. Subsidence also started to develop across parts of the Indian Ocean, consistent with MJO evolution.**

# Outgoing Longwave Radiation (OLR) Anomalies (2.5°N-17.5°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)**

**The MJO was active from April into early May as shown by alternating dotted (suppressed convection) and dashed lines (enhanced convection).**

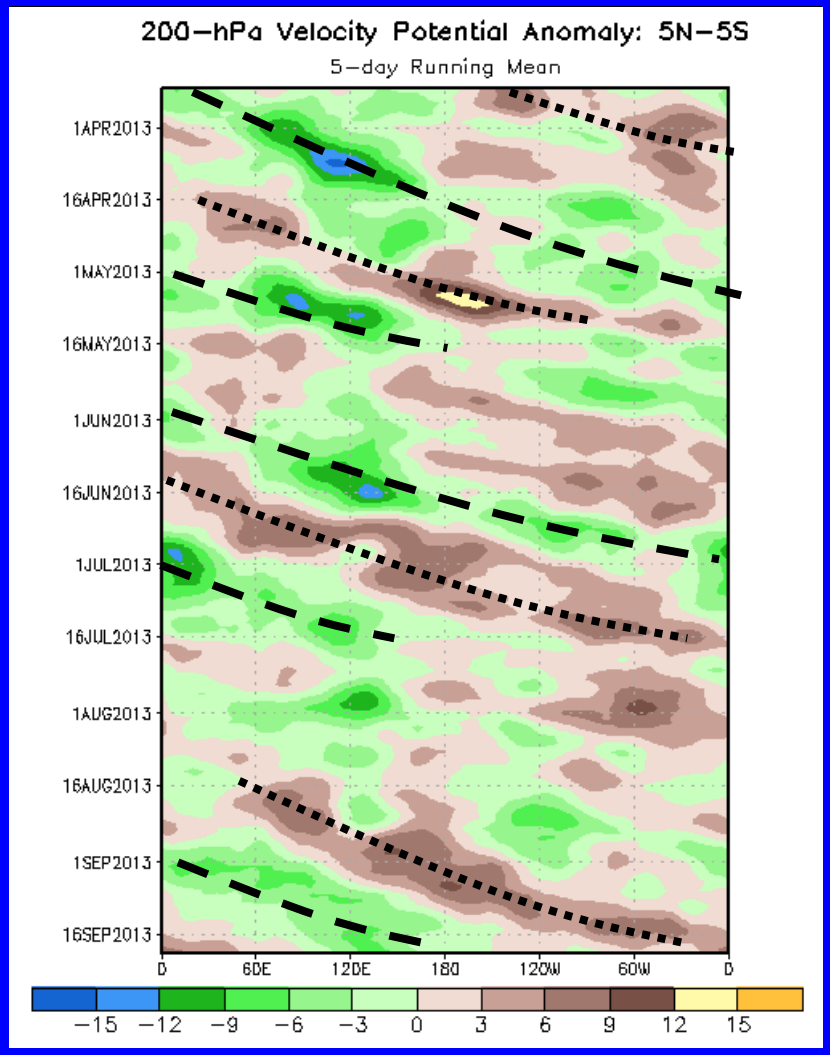
**The MJO strengthened once again during June and continued into July.**

**There is currently an ongoing MJO signal, with the enhanced phase propagating into the western Pacific recently.**

# 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 was active for much of the March to early May 2013 period as shown by generally alternating positive (brown) and negative (green) anomalies with clear eastward propagation.

The MJO was less coherent during much of May.

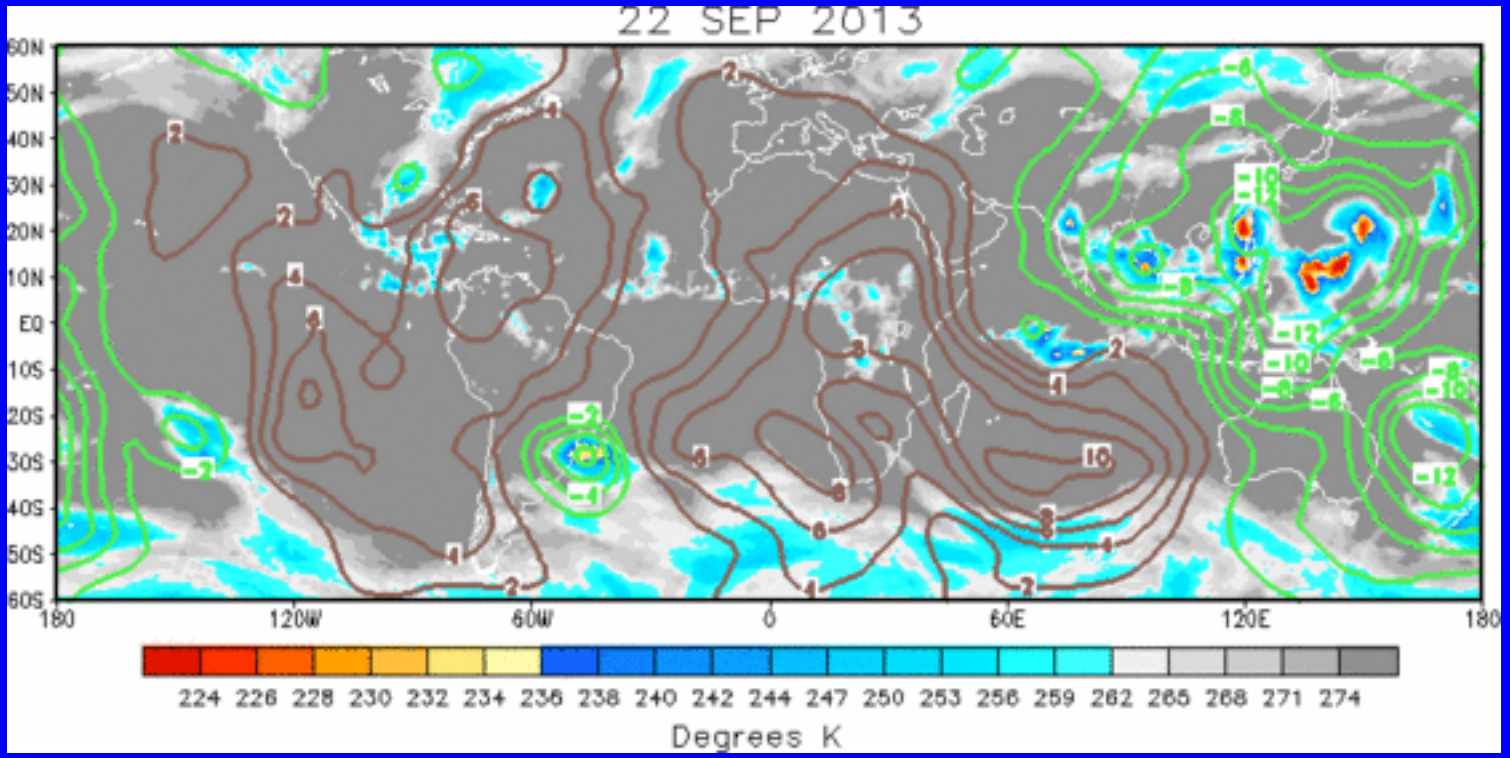
The MJO strengthened once again during June and the first half of July before weakening by the end of the month.

The MJO was not active during much of August, although within the past month upper-level velocity potential anomalies have increased in magnitude along with some eastward propagation, indicating fairly robust MJO activity.

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

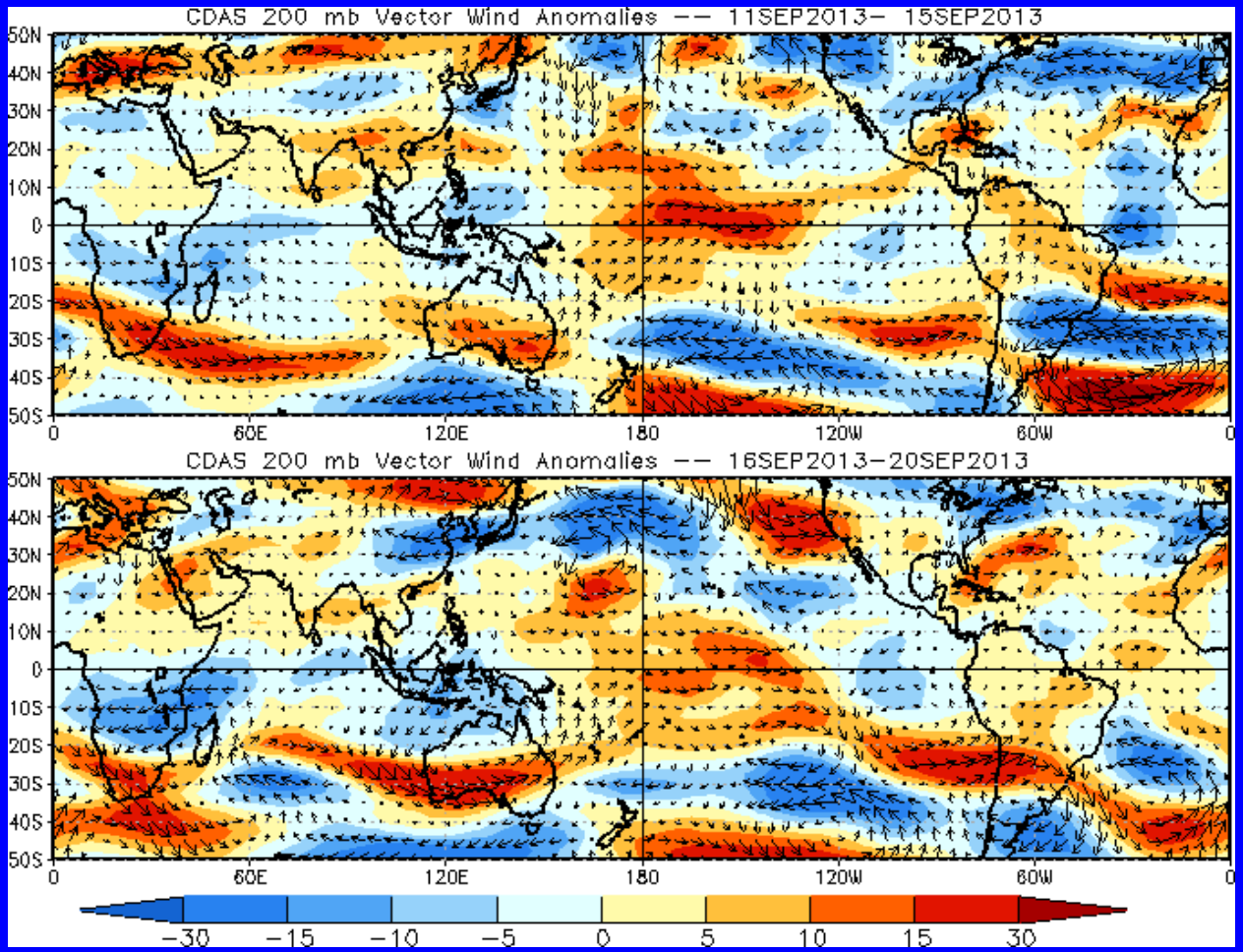
**Positive** anomalies (brown contours) indicate unfavorable conditions for precipitation

**Negative** anomalies (green contours) indicate favorable conditions for precipitation




**The velocity potential pattern remains coherent, nearly exhibiting the canonical wave-1 structure along the equator. Upper-level divergence is now centered over the Maritime Continent and West Pacific, while suppressed convection is centered over Africa.**

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




**Note that shading denotes the zonal wind anomaly**

**Blue shades: Easterly anomalies**

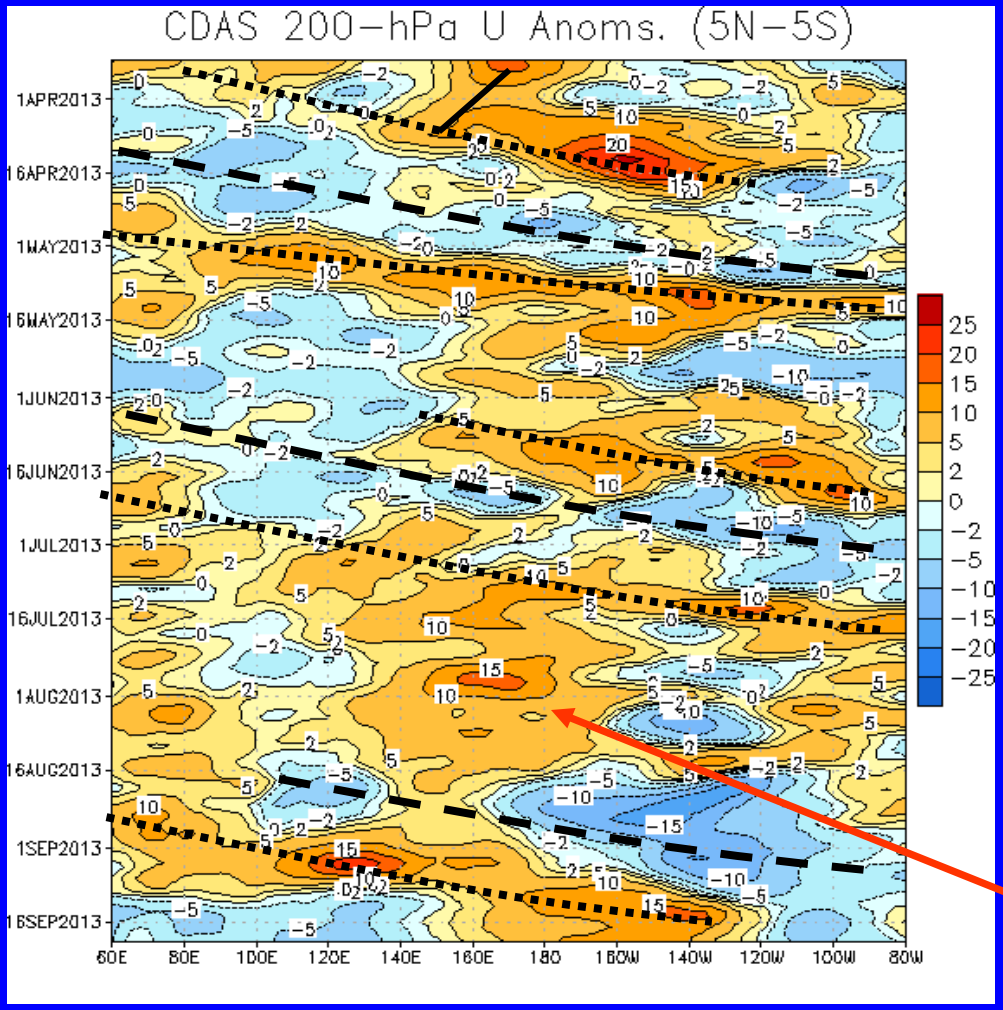
**Red shades: Westerly anomalies**

**Zonal wind anomalies along the Equator have remained fairly stationary for the past several days, though there is some evidence of enhanced easterly anomalies over the Maritime Continent.**

# 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

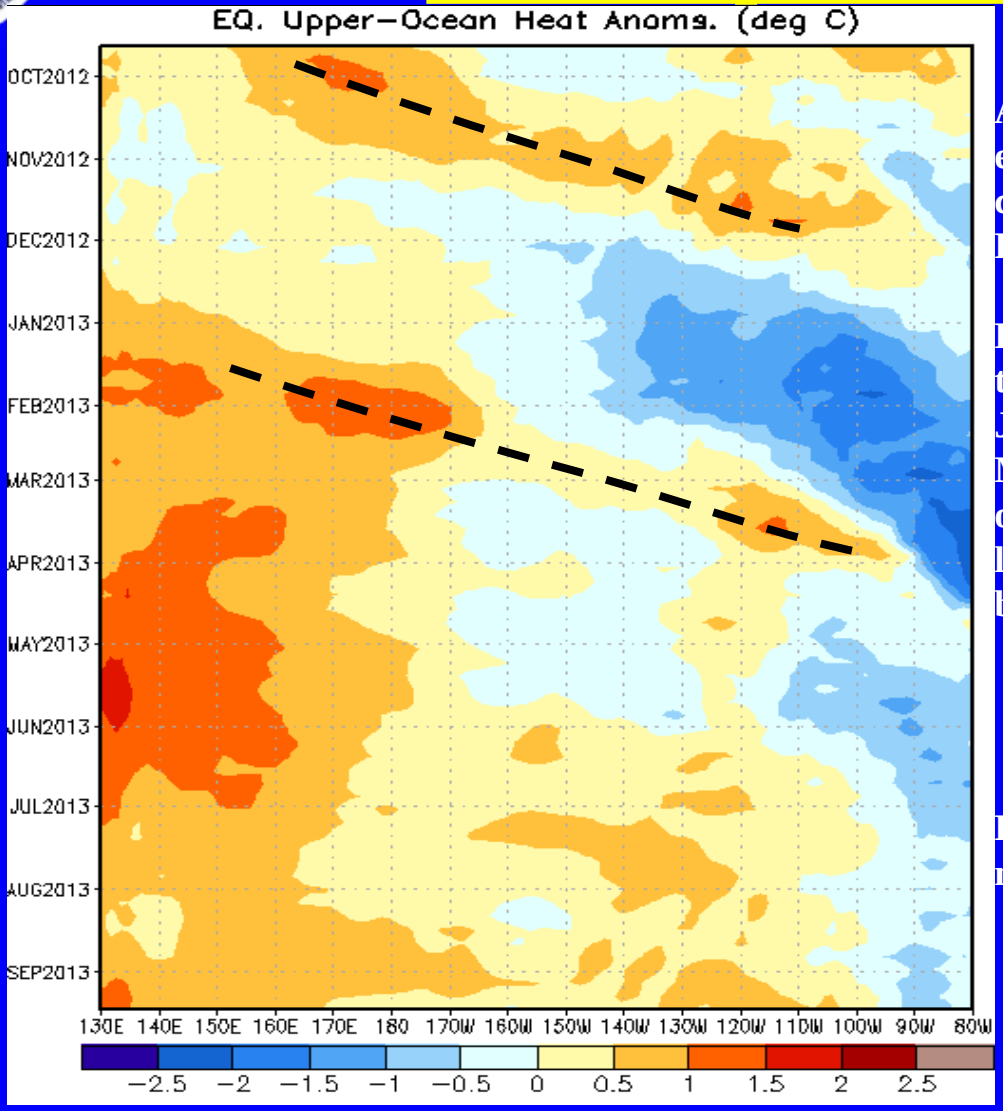
Longitude

**Eastward propagation of wind anomalies associated with the MJO (dotted and dashed lines) continued into May 2013. During late March and early April, anomalies were influenced by westward moving features (solid line) over the central and western Pacific.**

**The MJO strengthened during June and continued to mid-July, as eastward propagation of wind anomalies associated with the MJO were again observed.**

**During August, westerly wind anomalies were generally persistent just west of the Date Line, recently strengthening over the Maritime Continent and shifting eastward. This is consistent with renewed MJO activity.**

# Weekly Heat Content Evolution in the Equatorial Pacific




Time

Longitude

An oceanic Kelvin wave was initiated at the end of September and increased heat content across the central and eastern Pacific during October and November.

Positive (negative) anomalies developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave can be seen during late February and March as anomalies became positive in the east-central Pacific.

Positive anomalies have persisted across most of the basin since June 2013.

# 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).

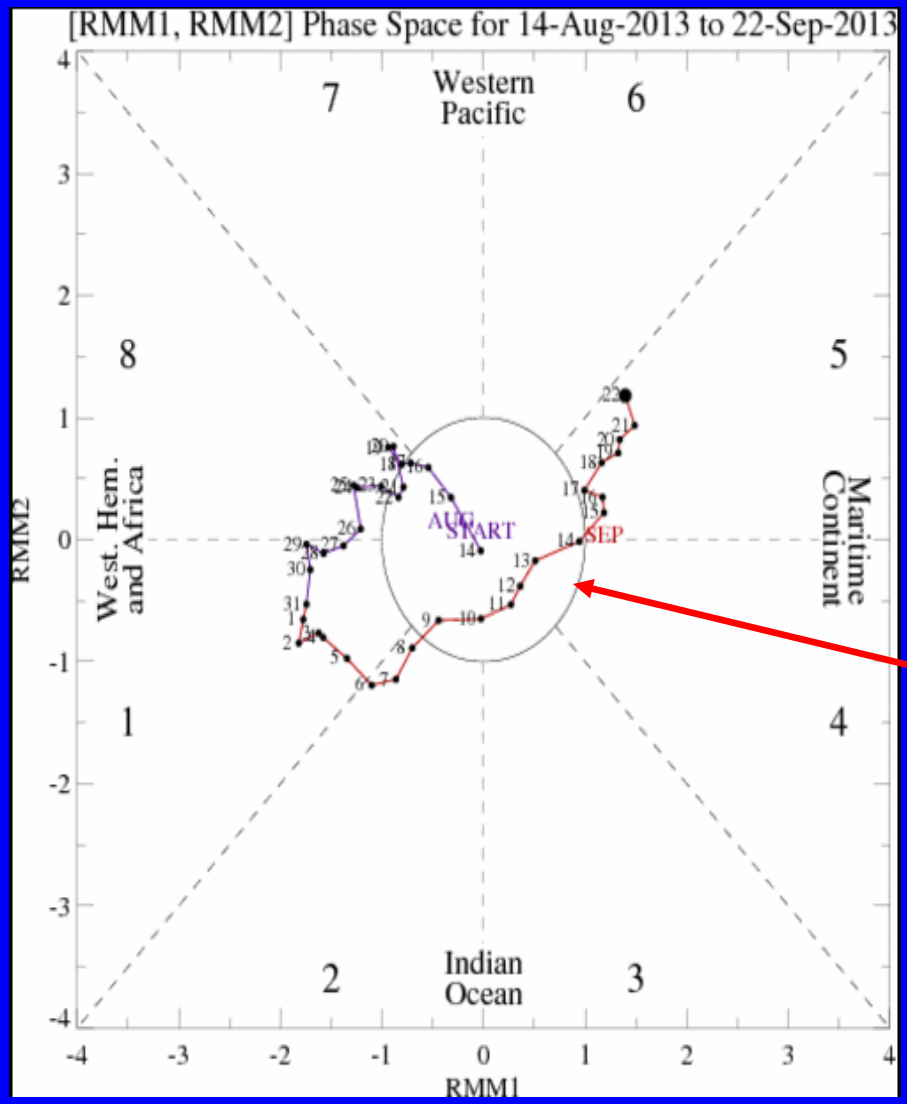
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

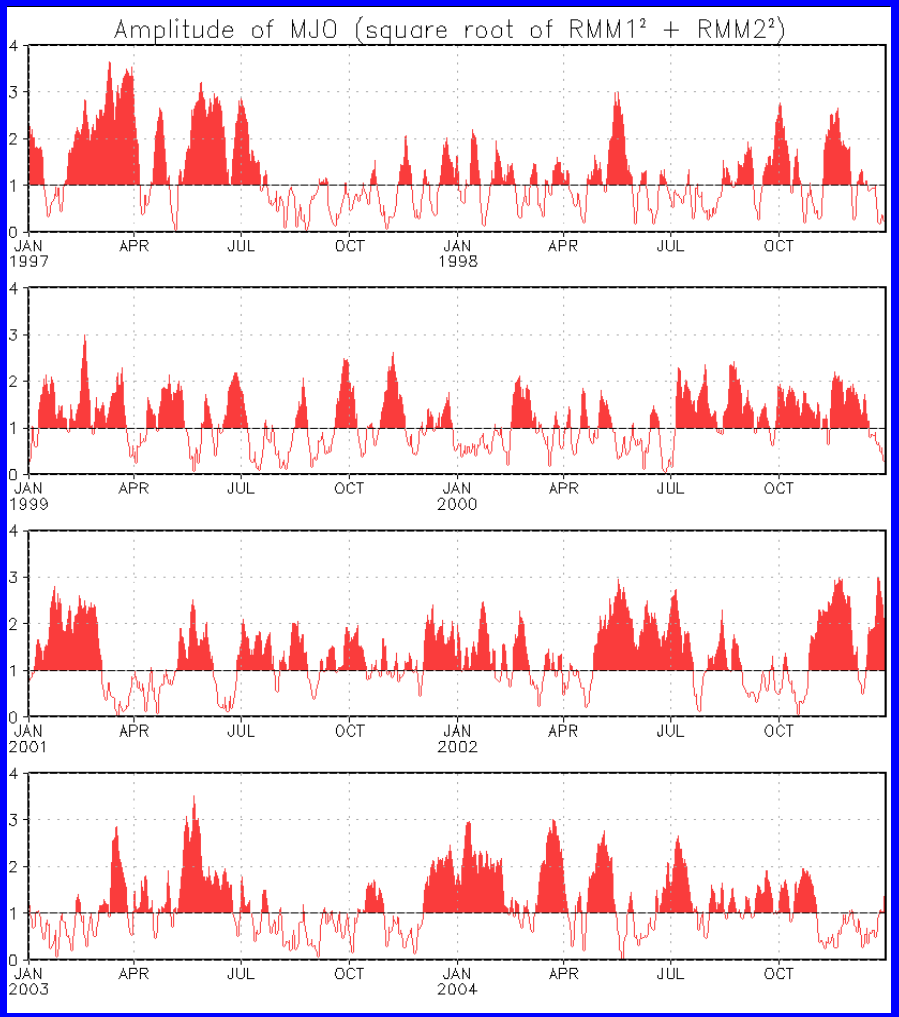
# MJO Index -- Recent Evolution

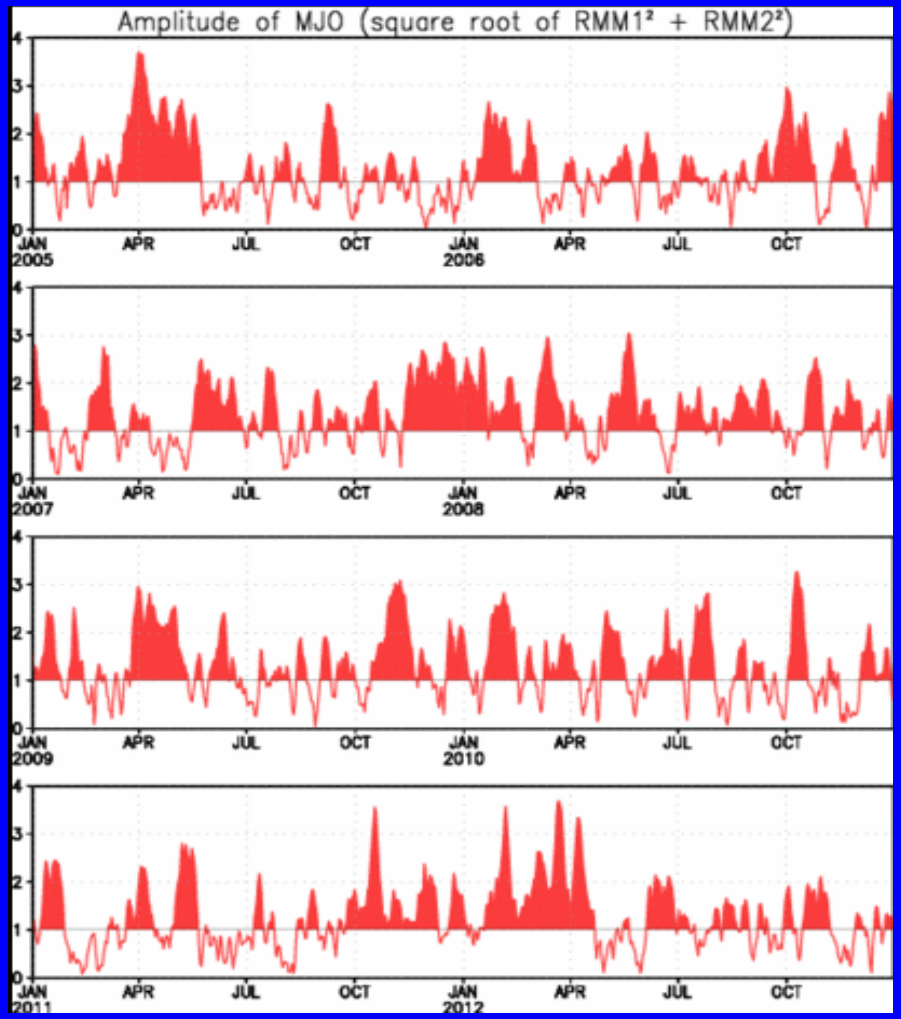



- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past two weeks, the MJO index exhibited eastward propagation while fluctuating in amplitude. This temporary decrease in amplitude was likely due to the influence of tropical cyclones and brief interference with other subseasonal variability.

# 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.

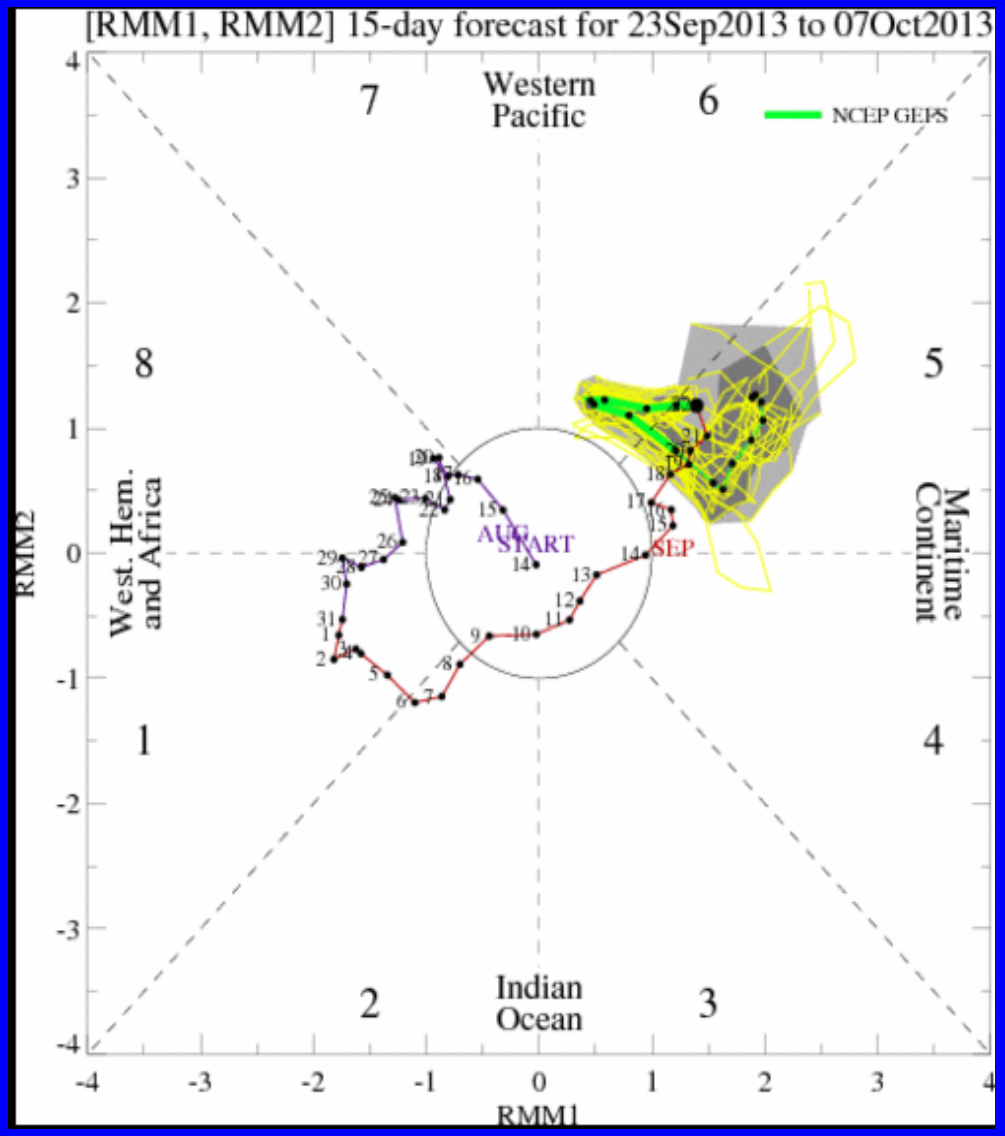
# Ensemble GFS (GEFS) MJO Forecast

**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**

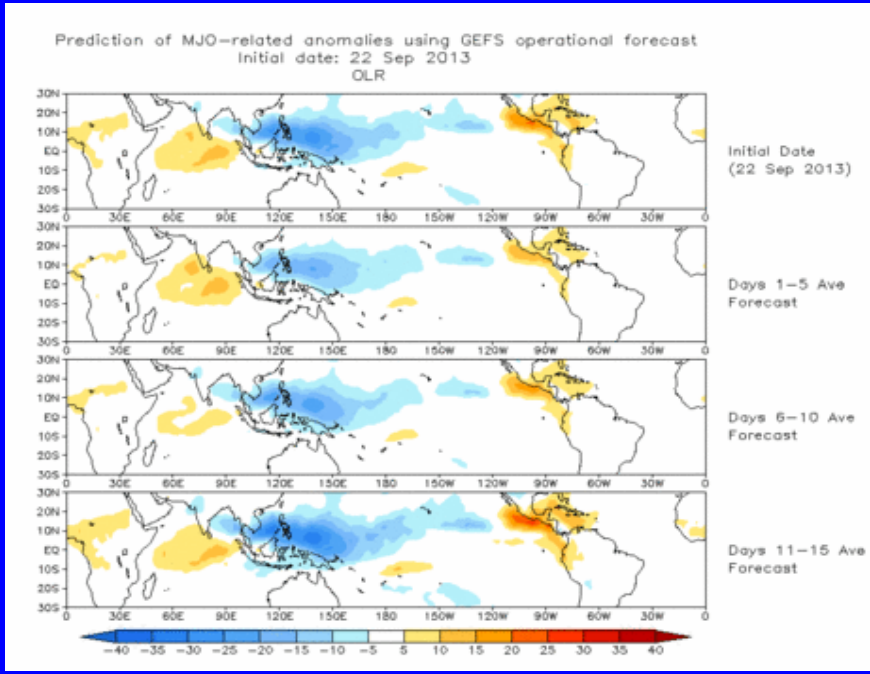
**The ensemble GFS indicates an MJO signal generally remaining stationary is Phases 5 and 6, possibly due to TC activity in the West North Pacific basin.**



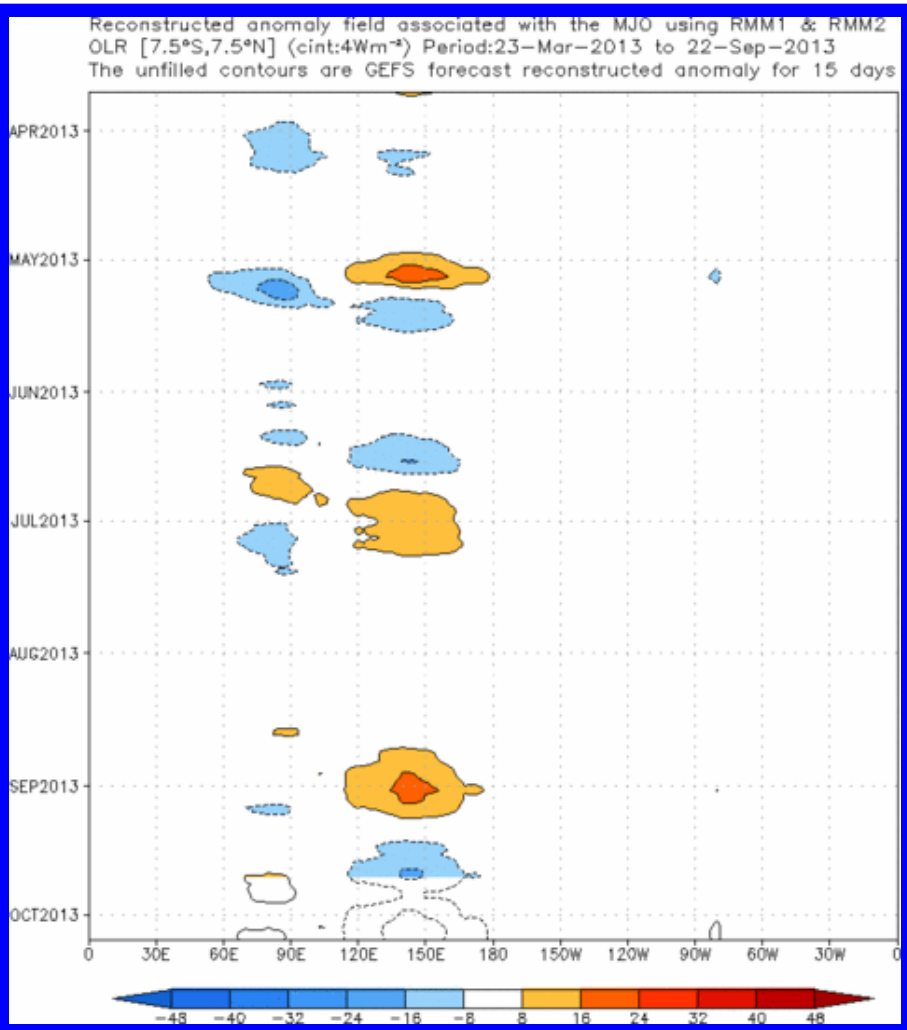
# Ensemble Mean GFS MJO Forecast

**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**

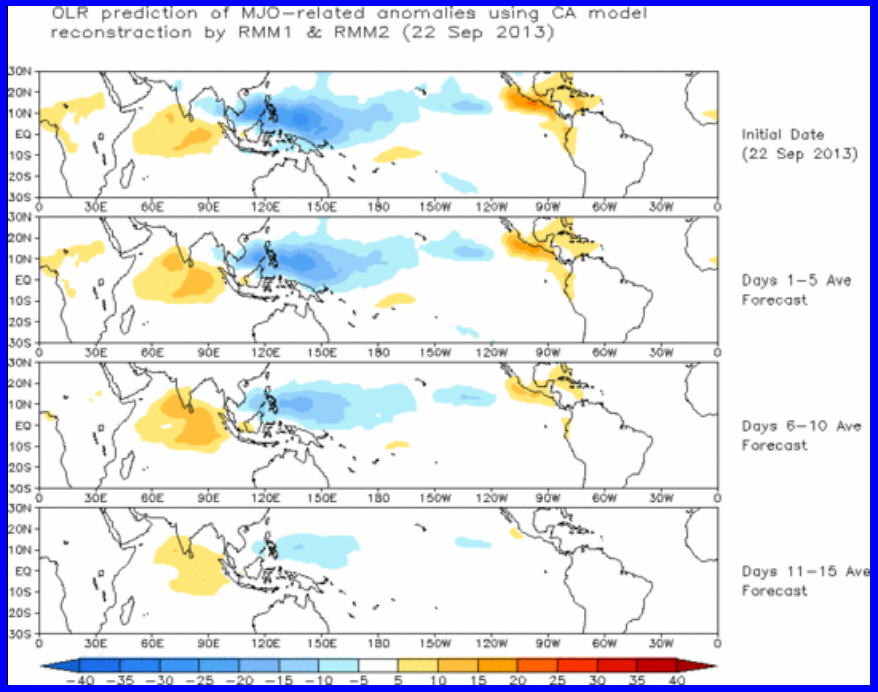



**The ensemble mean GFS forecasts enhanced convection remaining fairly stationary across the western and central Pacific. Suppressed convection is forecast to persist across parts of Central America and the Indian Ocean.**

# Constructed Analog (CA) MJO Forecast

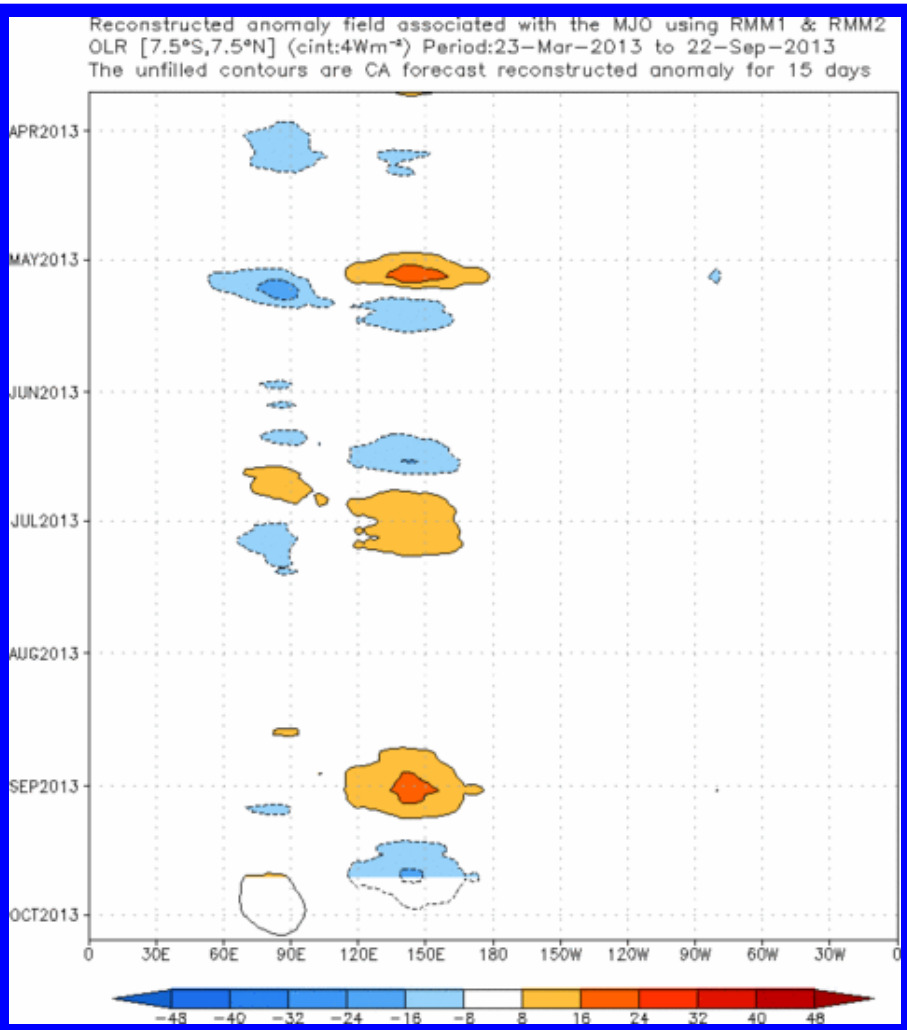
**Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)**

**Spatial map of OLR anomalies for the next 15 days**



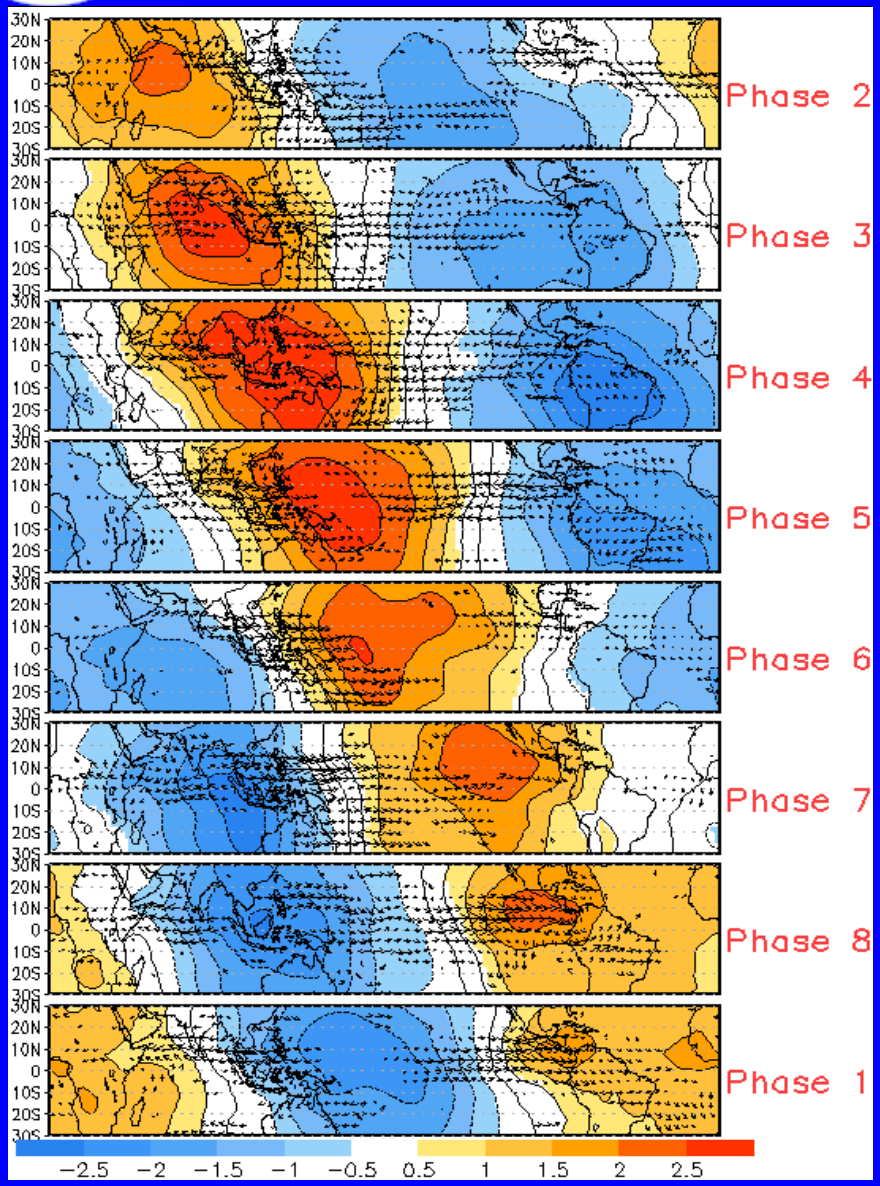

**This statistical forecast is similar to the GEFS forecast.**

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

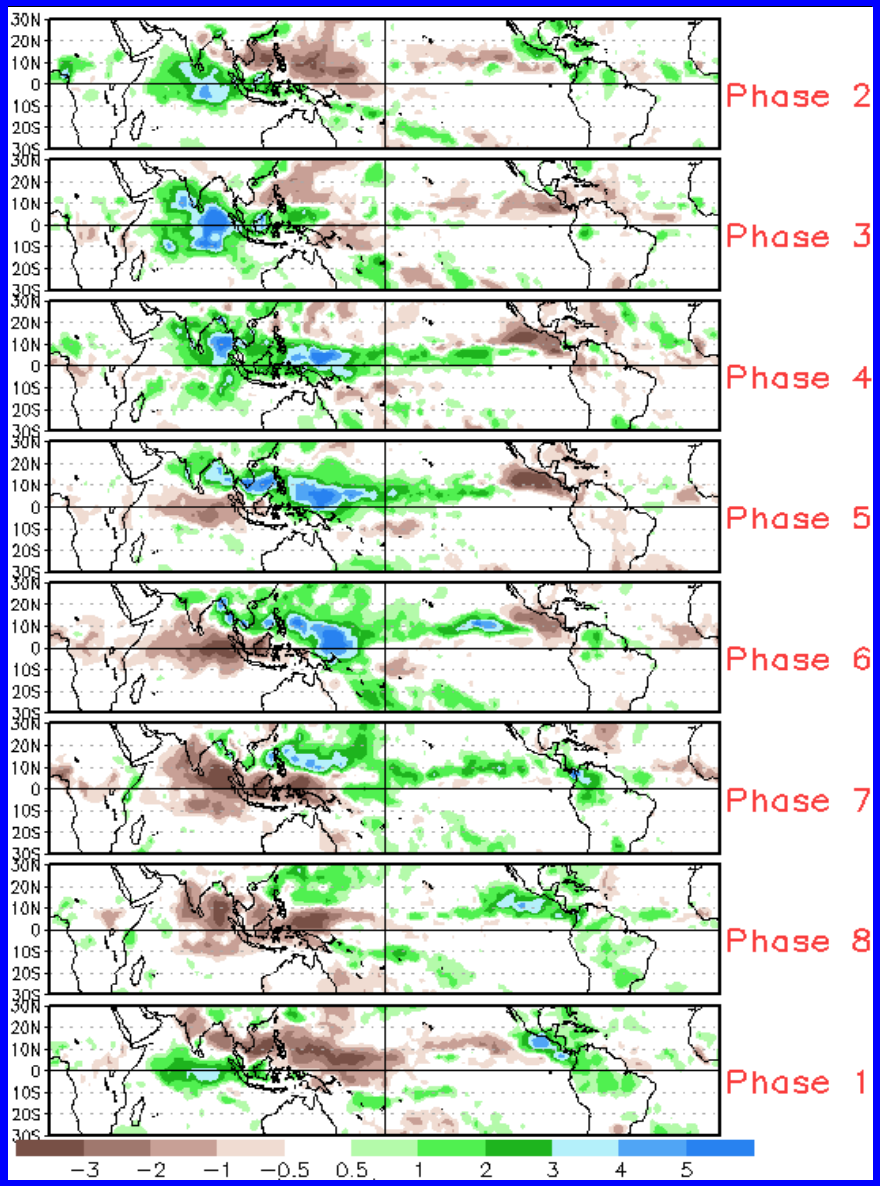


# MJO Composites – Global Tropics

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

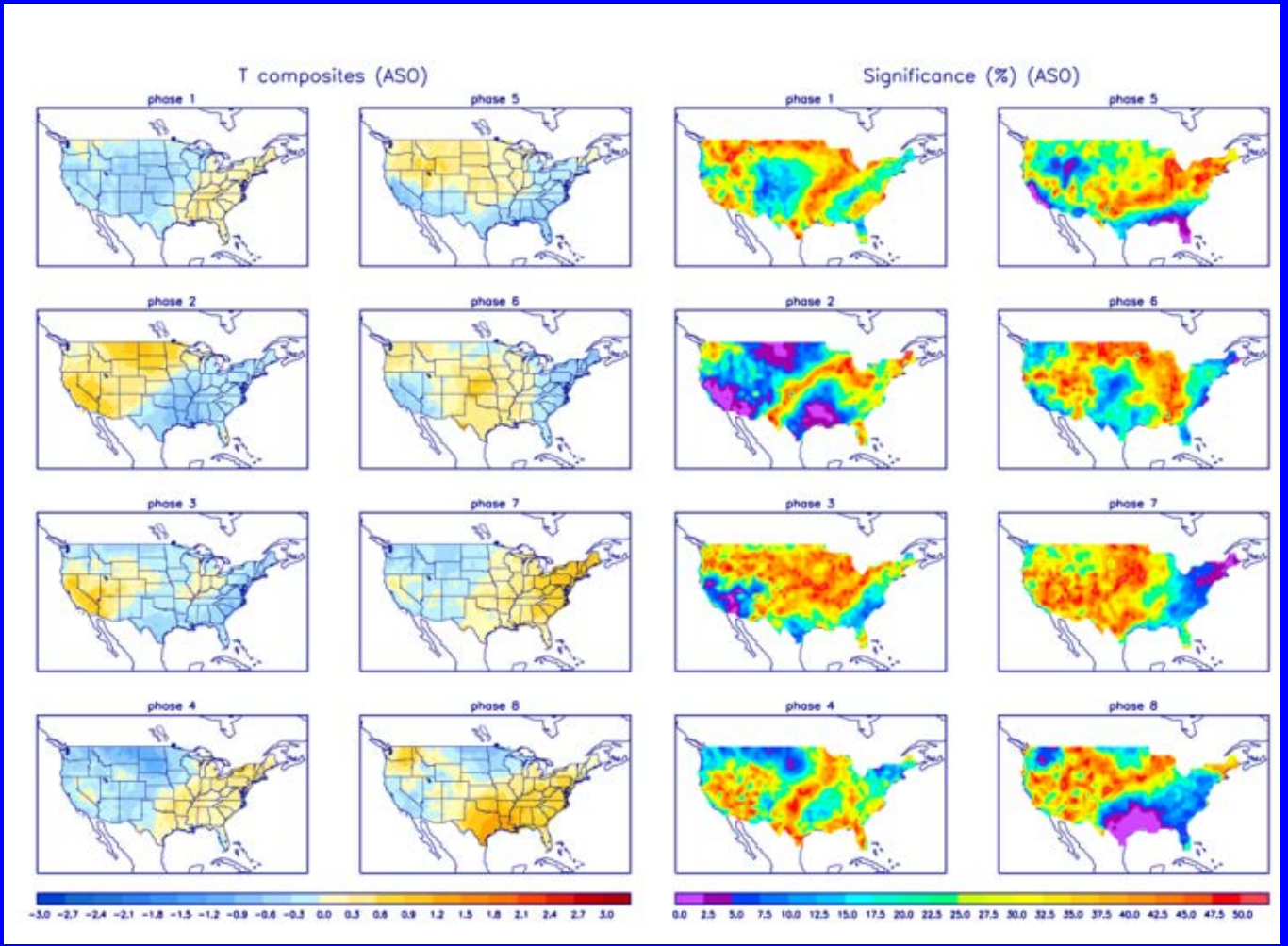



Precipitation Anomalies (May-Sep)



# 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.**

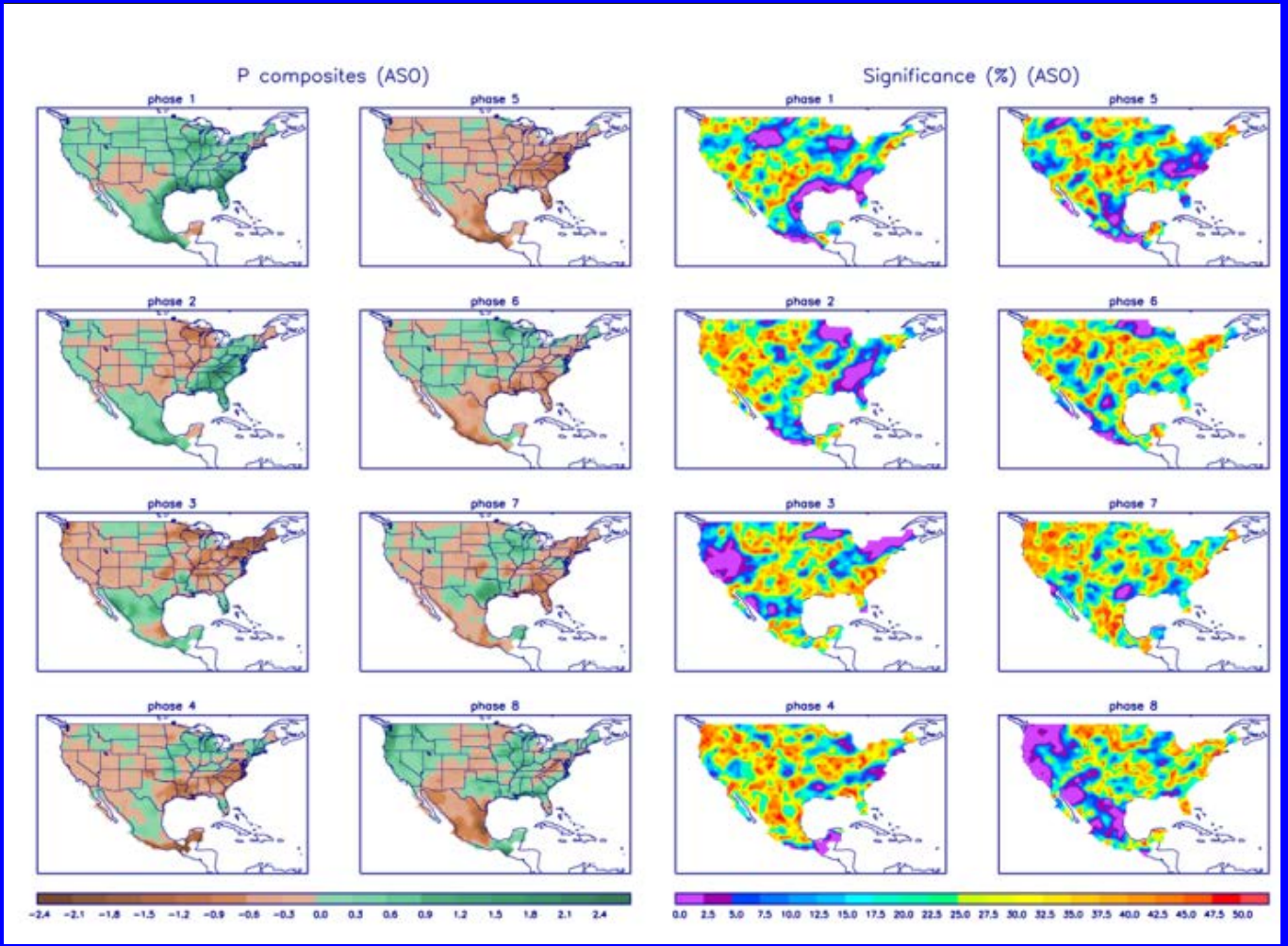



Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.**




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