



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

**Update prepared by
Climate Prediction Center / NCEP
September 9, 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 convection phase now centered over the Indian Ocean.**
- **Dynamical model MJO forecasts indicate a weakening MJO signal during the upcoming week, with potential reemergence of the signal over the Maritime Continent or western Pacific late in the Week-2 period.**
- **Based on recent observations and statistical 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 rainfall from southern India to the Maritime continent and western Pacific during the next two weeks, while favoring suppressed convection from the central Pacific into parts of the Western Hemisphere by the end of Week-2.**
- **The MJO elevates odds for tropical cyclone (TC) formation across parts of the western Pacific in Week-2, while reducing odds for TC formation across the East Pacific and Atlantic basins.**

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>

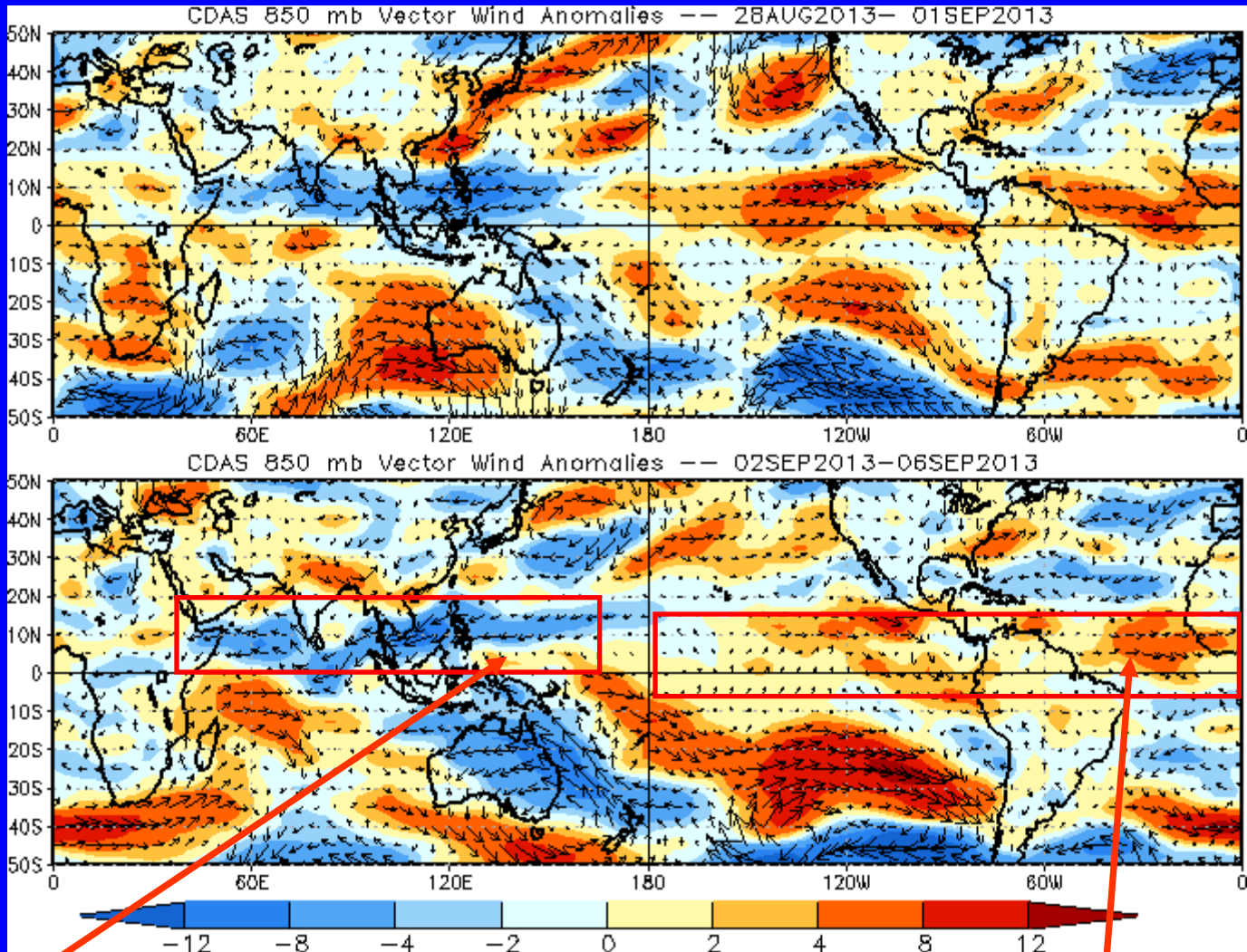


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted across much of the northern Indian Ocean, Maritime Continent, and western Pacific.

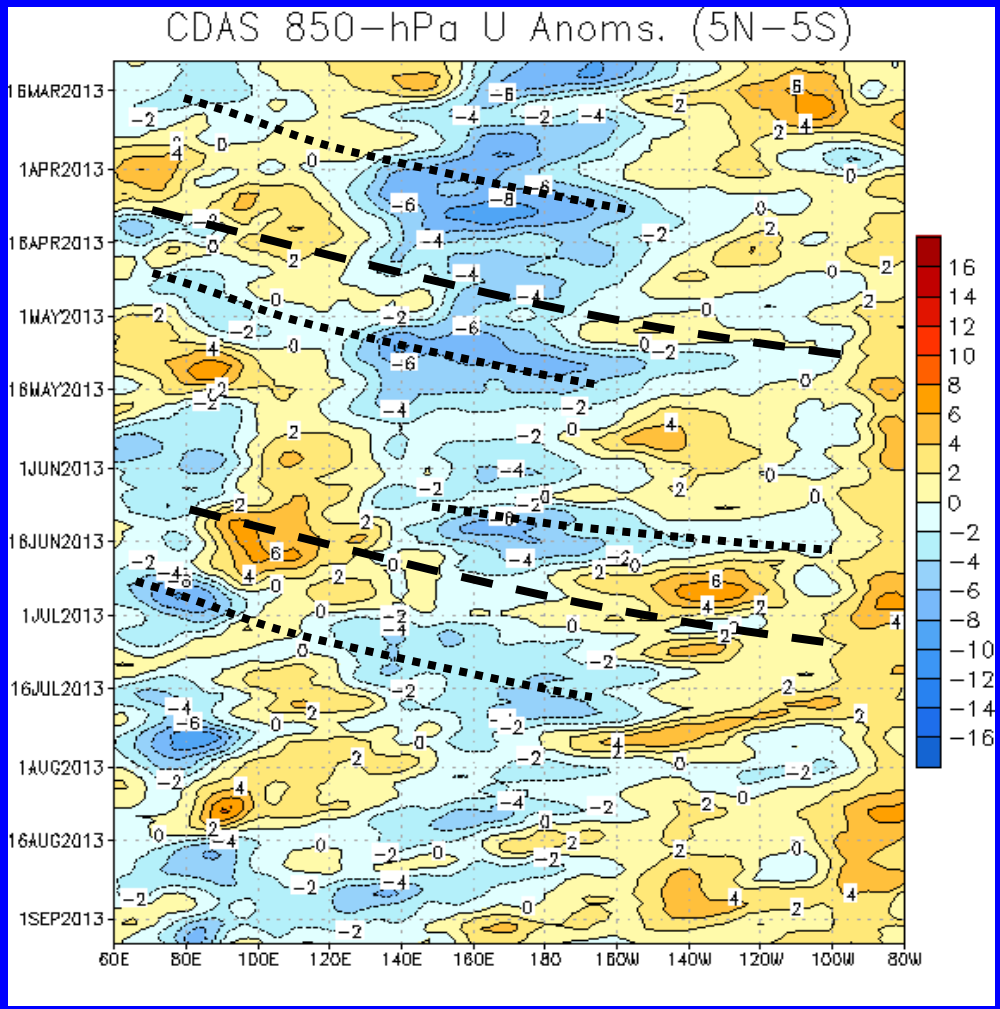
Westerly anomalies, weaker in magnitude, continued over the eastern Pacific and the Atlantic basins during the most recent five days



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
↓



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

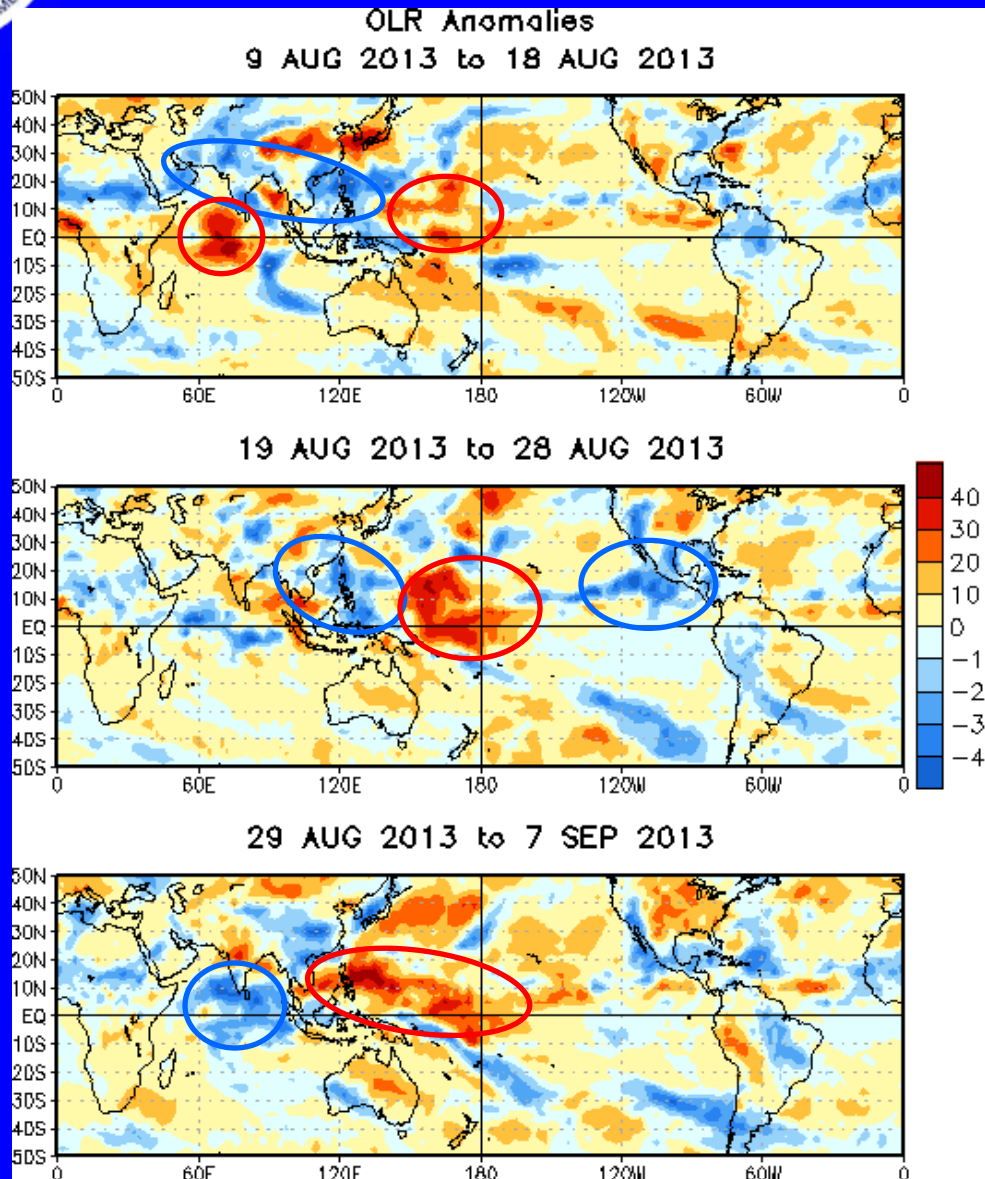
The MJO strengthened again in June and continued to mid-July with fast eastward propagation.

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.

Longitude



OLR Anomalies – Past 30 days



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

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

Although the MJO signal remained weak during the middle of August, enhanced convection persisted across parts of the Maritime Continent and western Pacific. Suppressed convection continued near the Date Line and across the North American monsoon region.

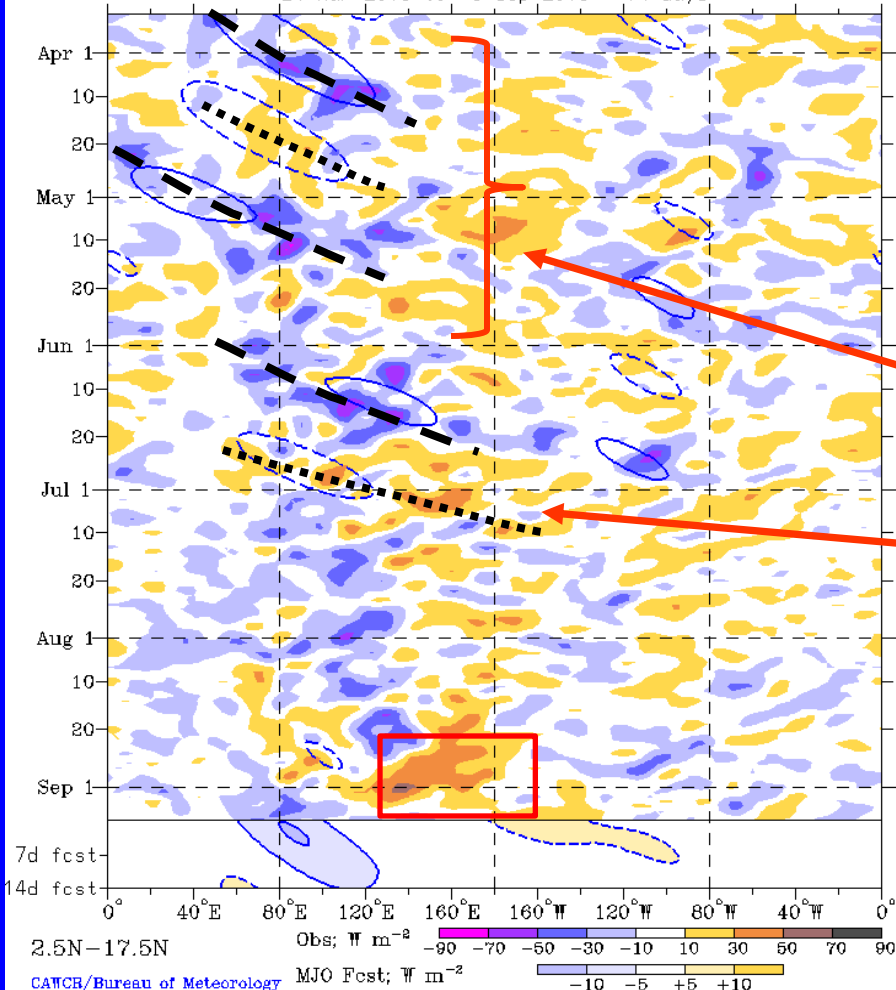
During late August, subsidence increased near the Date Line while enhanced convection lingered across parts of the western Pacific. Enhanced convection developed over the eastern Pacific and North American Monsoon regions.

In early September, suppressed convection dominated most of the central and western Pacific while enhanced convection strengthened across the Indian Ocean. This pattern is consistent with a slowly propagating MJO signal in Phase 2 of the Wheeler and Hendon index.



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

Real-time MJO filtering superimposed upon 3drn R21 OLR Anomalies
MJO anomalies blue contours, CINT=10. (5. for forecast)
Negative contours solid, positive dashed
24-Mar-2013 to 8-Sep-2013 + 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)

The MJO was active from late March 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.

Strong large-scale suppressed convection developed in mid August from 120°E to the Date Line (red box).

Recently, there has been some indication of a propagating MJO signal across the Western Hemisphere into the Indian Ocean.

Longitude

Time



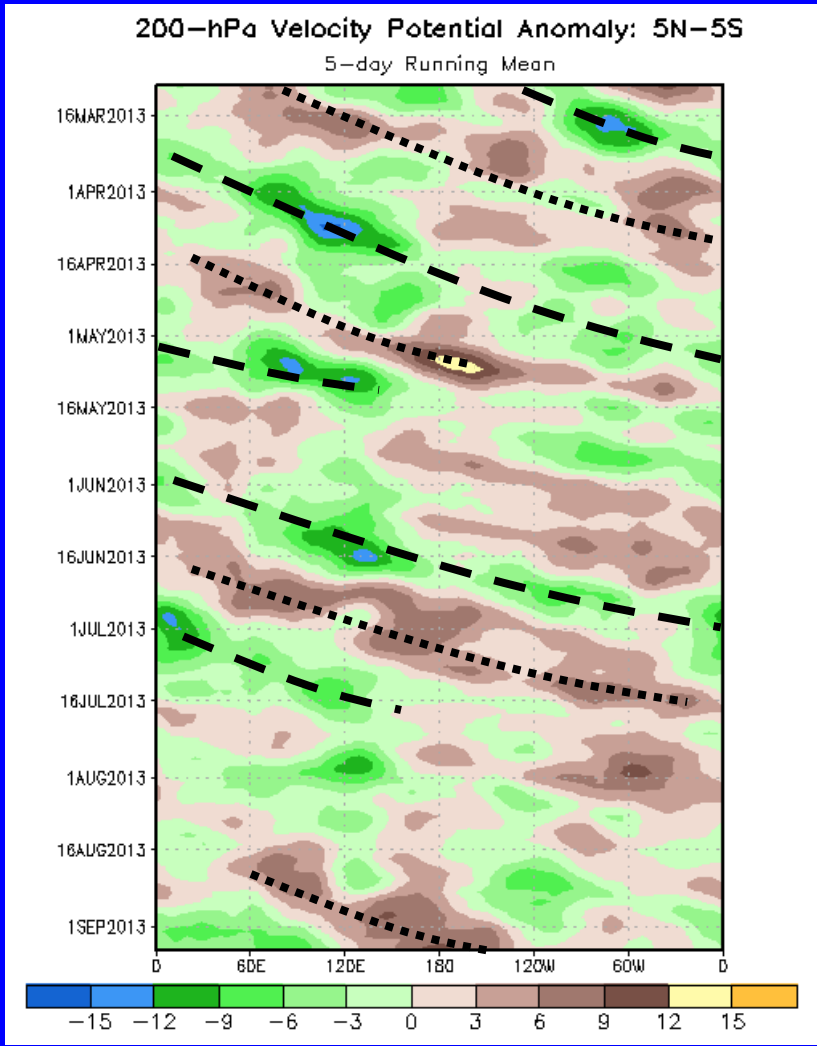


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time
↓



The MJO was active for much of the March to 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 August, although most recently, the upper-level velocity potential anomalies have increased in magnitude along with some eastward propagation.

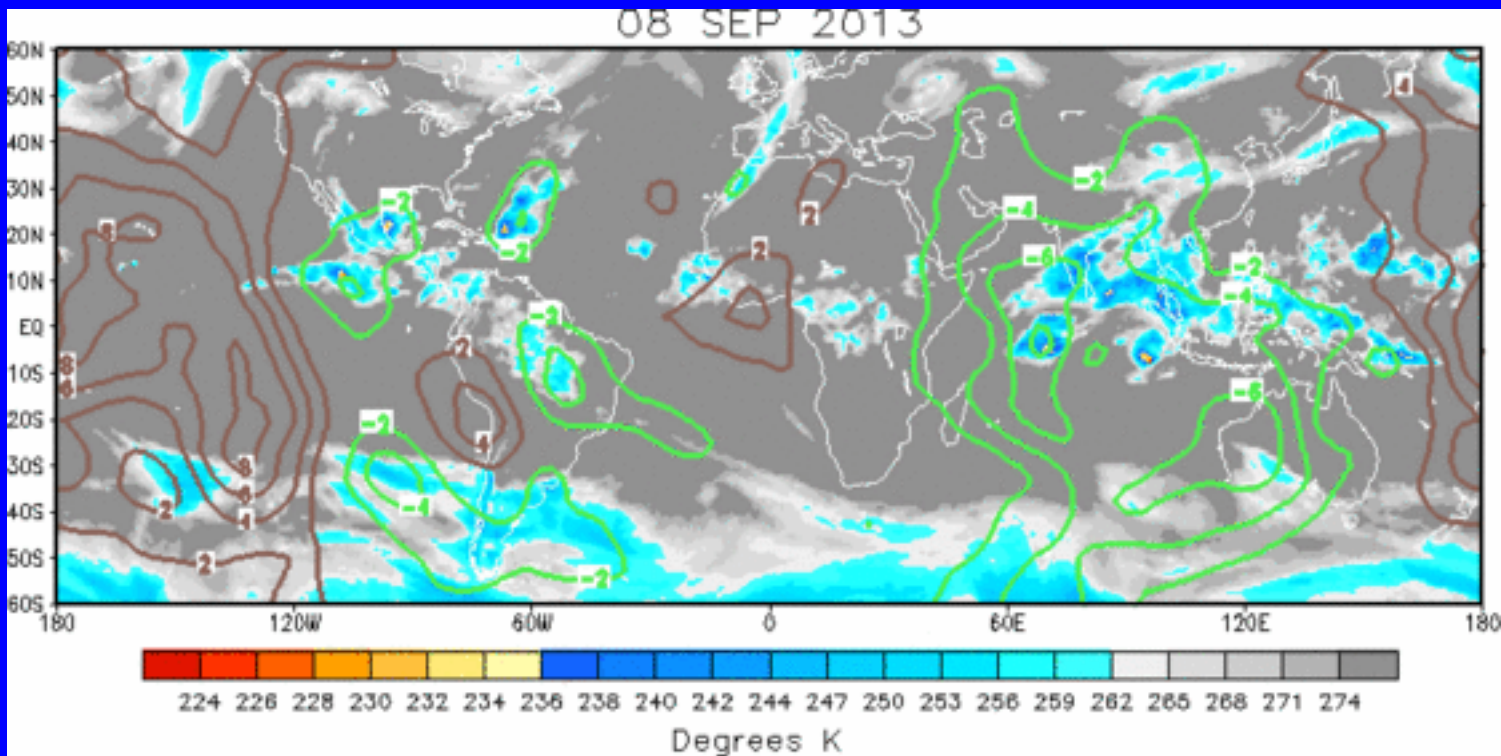
Longitude



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 has become more coherent, nearly exhibiting the canonical wave-1 structure along the equator. Upper-level divergence is now centered over the Indian Ocean, while suppressed convection dominates most of the Pacific Basin.

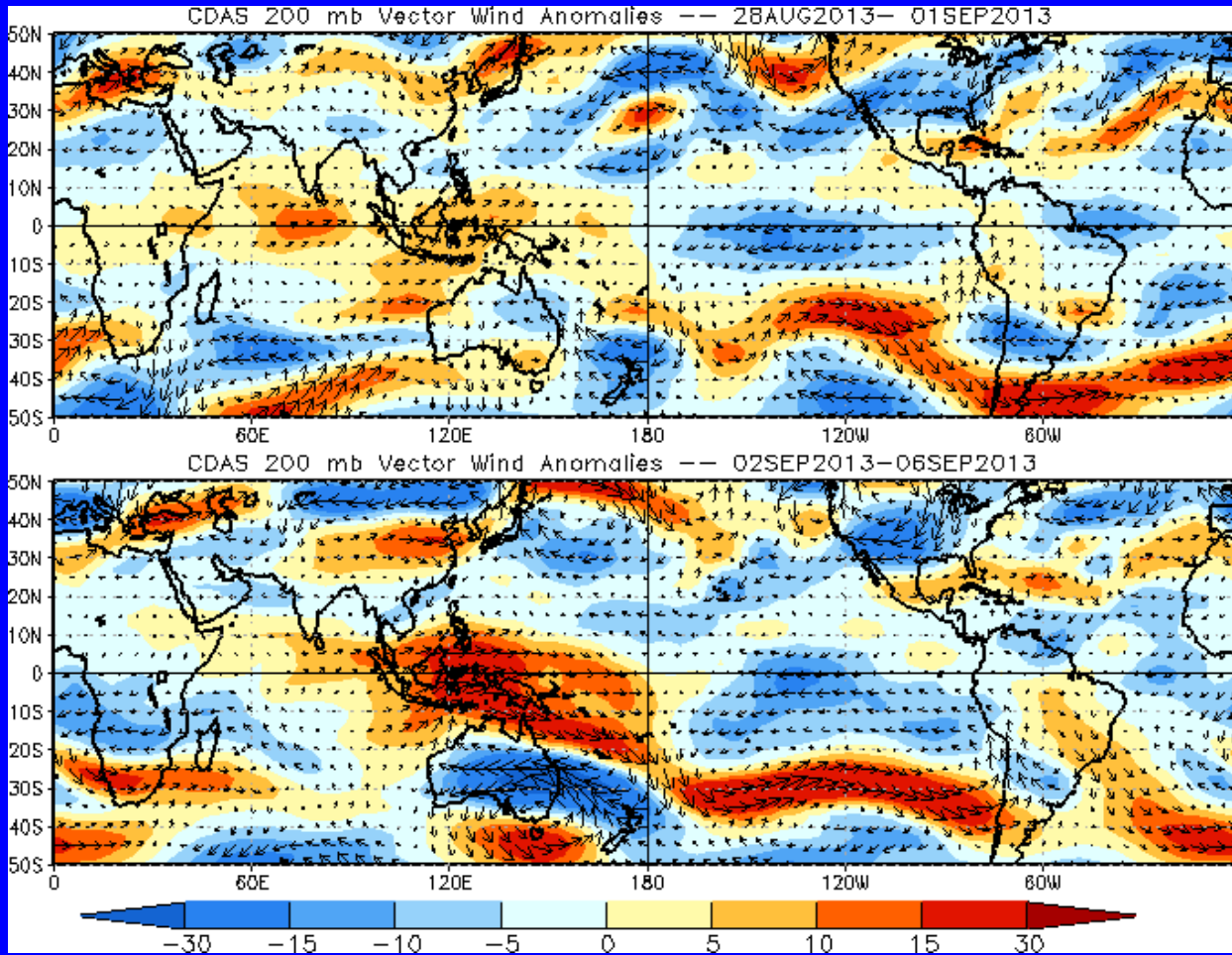


200-hPa Vector Wind Anomalies ($m s^{-1}$)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



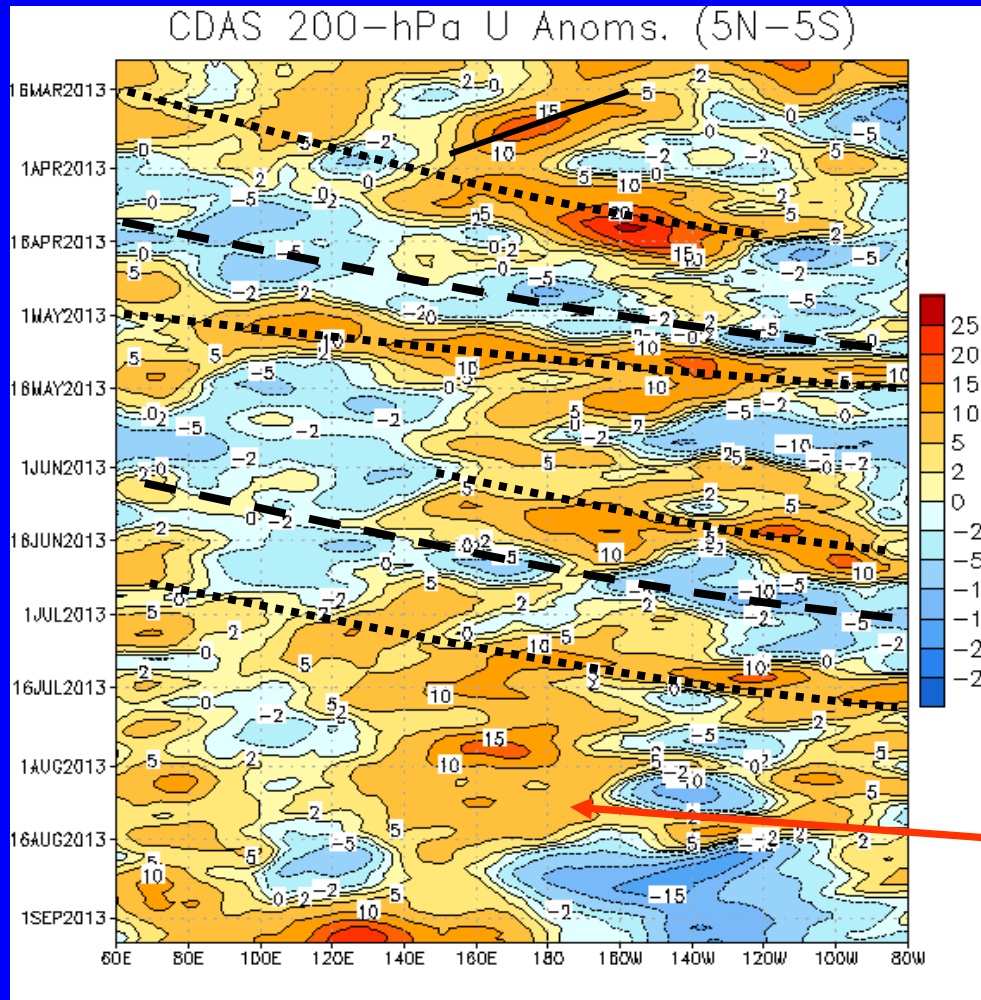
Westerly (easterly) anomalies persisted over the Indian Ocean / Maritime Continent (central Pacific) during the last five days.



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

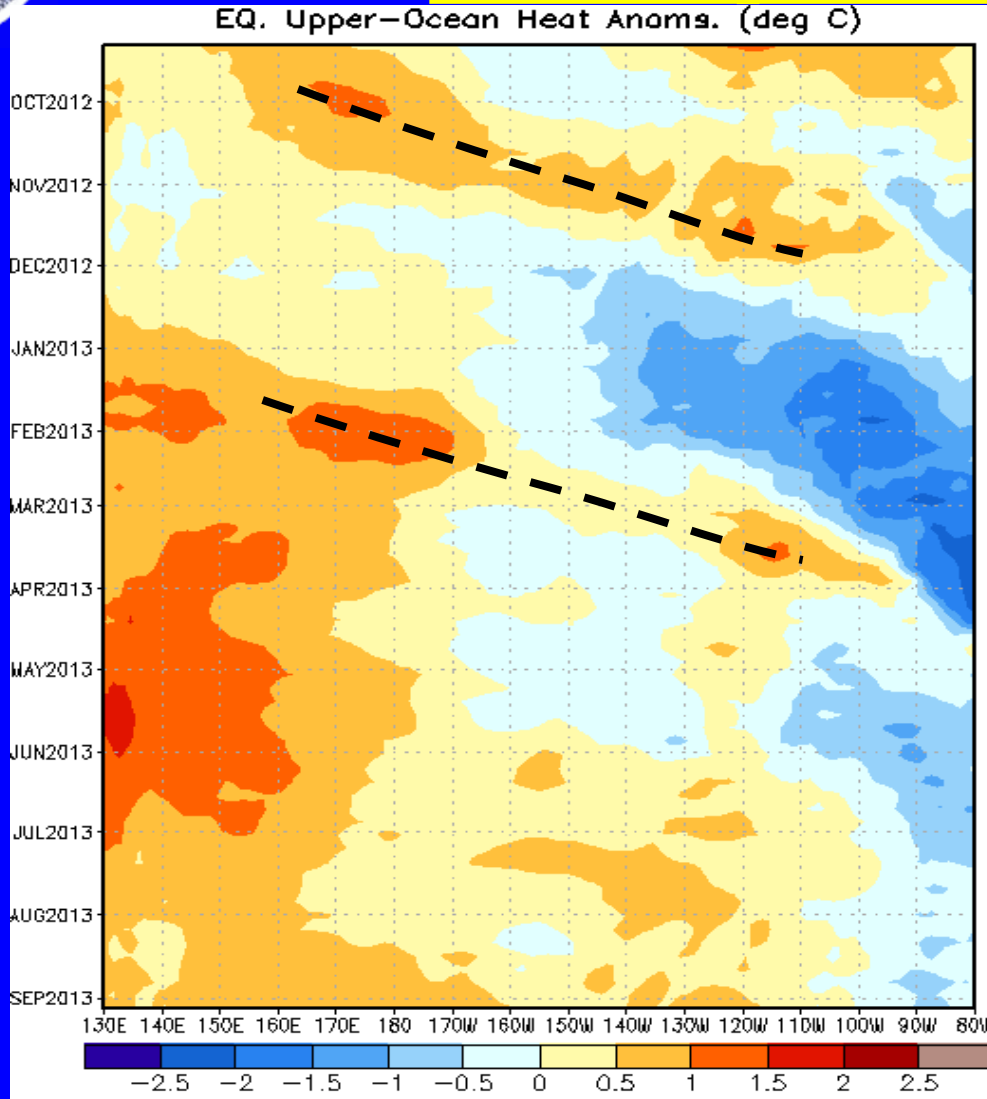
Eastward propagation of wind anomalies associated with the MJO (dotted and dashed lines) continued into May 2013. During March and early April, anomalies were influenced by westward moving features (solid line) over the central and western Pacific.

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.



Weekly Heat Content Evolution in the Equatorial Pacific



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 increased over the central Pacific during June and July 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.

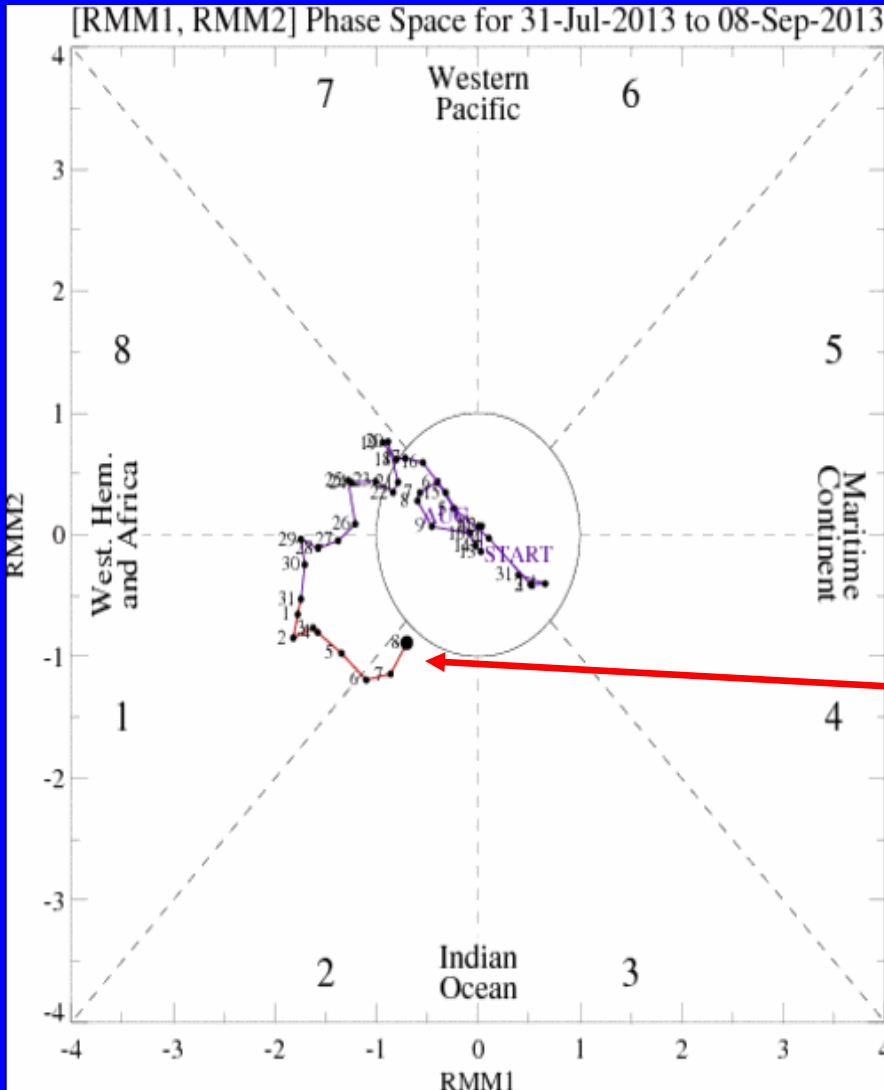
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

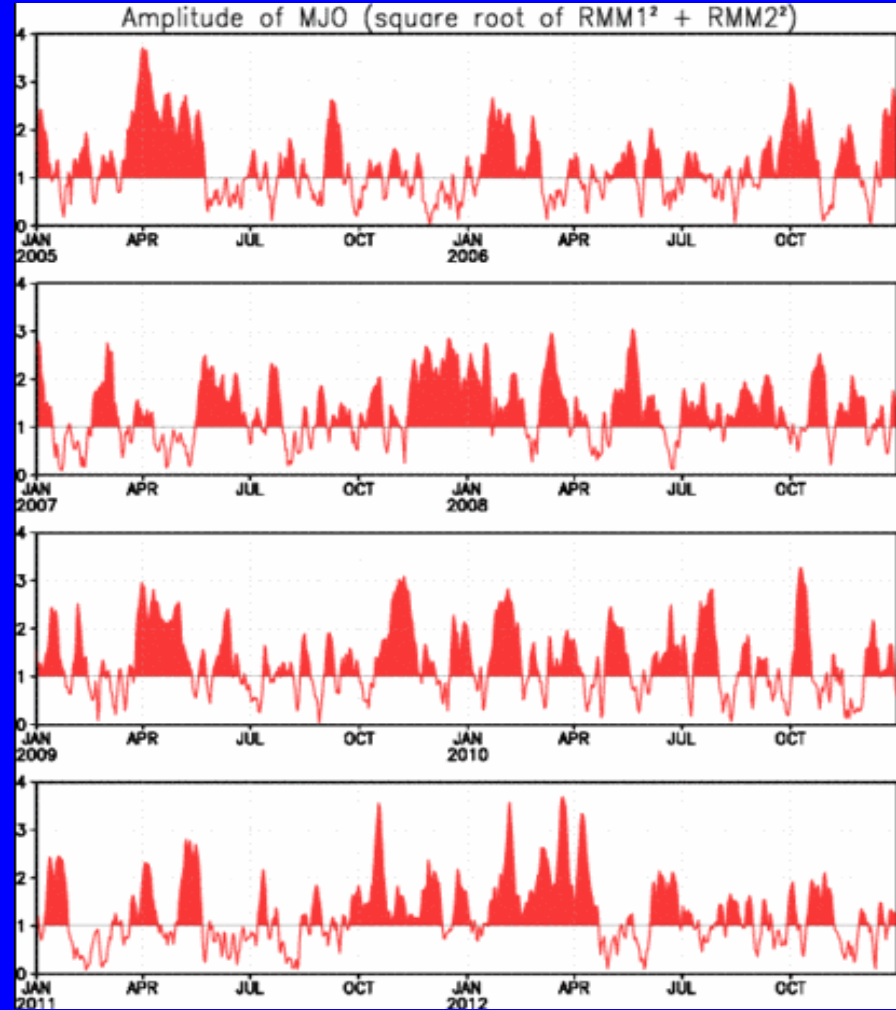
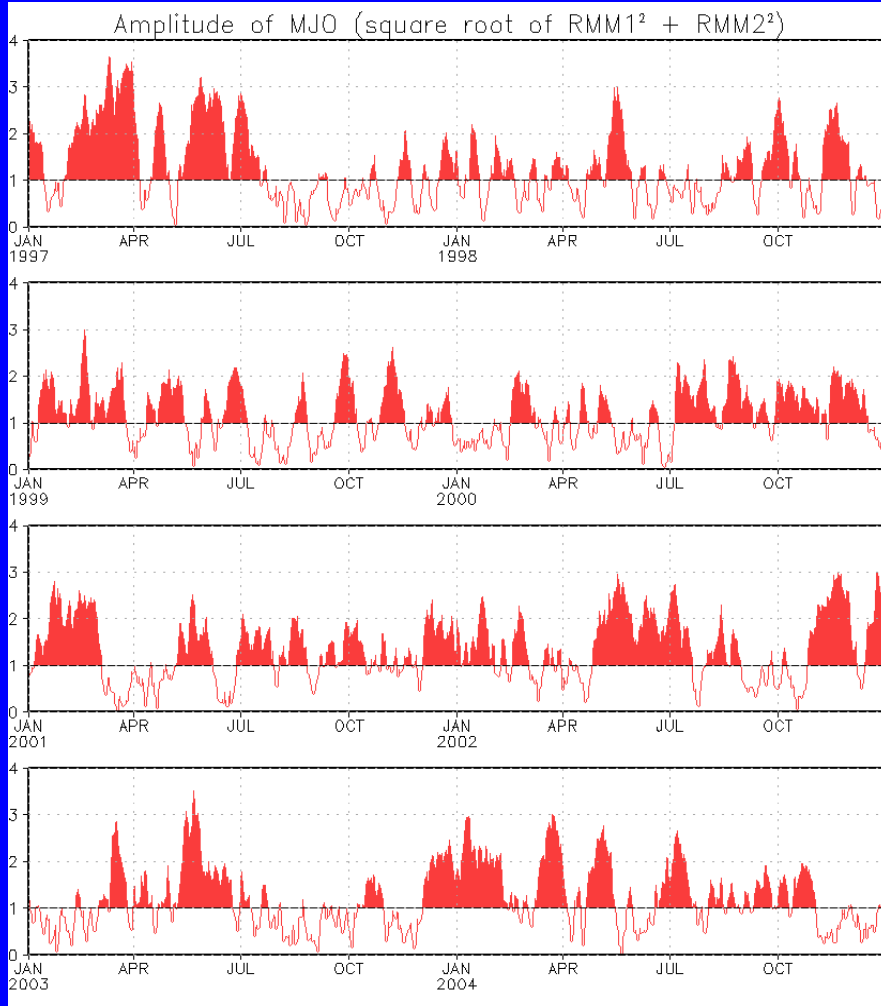


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past two weeks, the MJO index has increased in amplitude with eastward propagation from the Western Hemisphere to the Indian Ocean. A slight decrease in amplitude is noted during the most recent two days.



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.



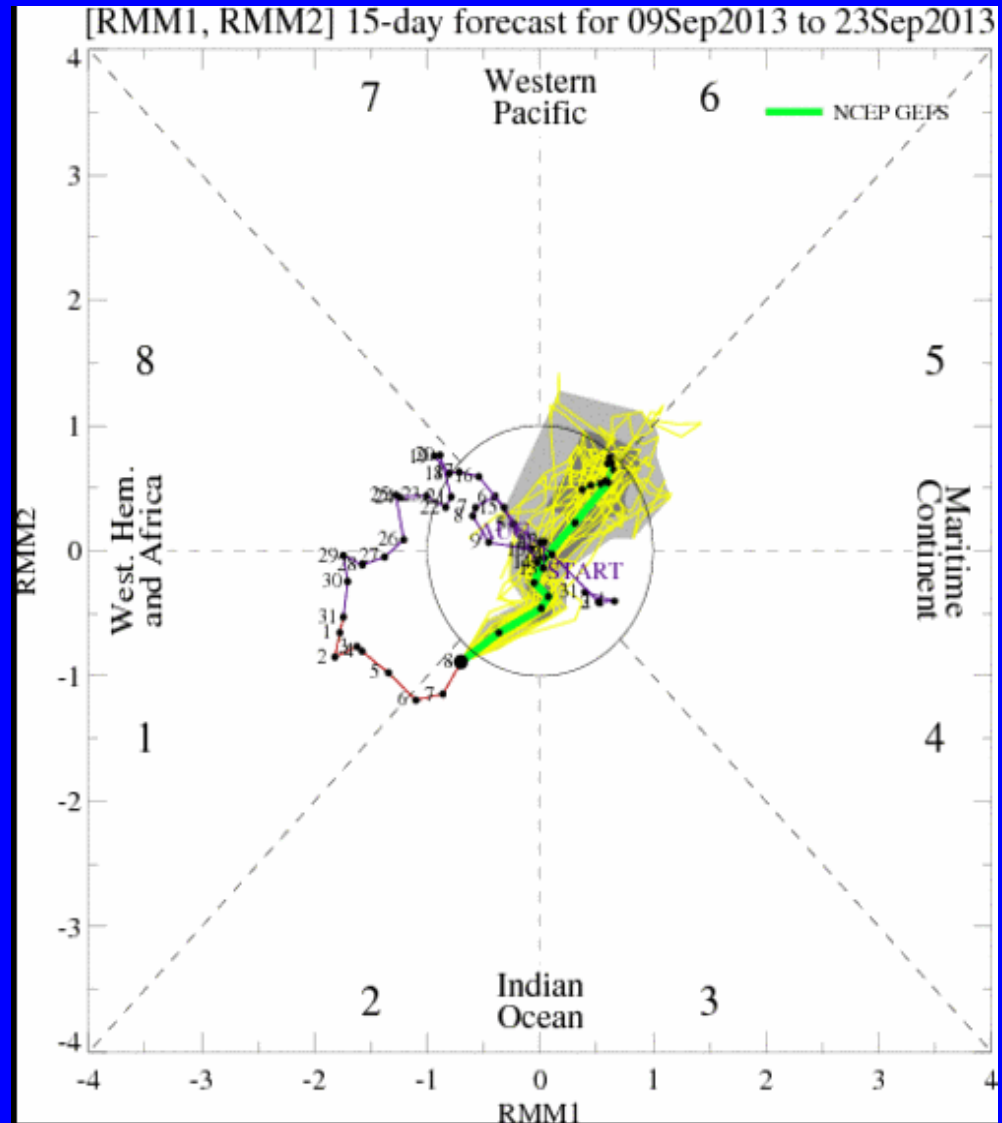
Ensemble GFS (GEFS) MJO Forecast

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 a weakening MJO signal during the upcoming week, with a potential increase in the amplitude of the signal over the western Pacific by the end of Week-2.



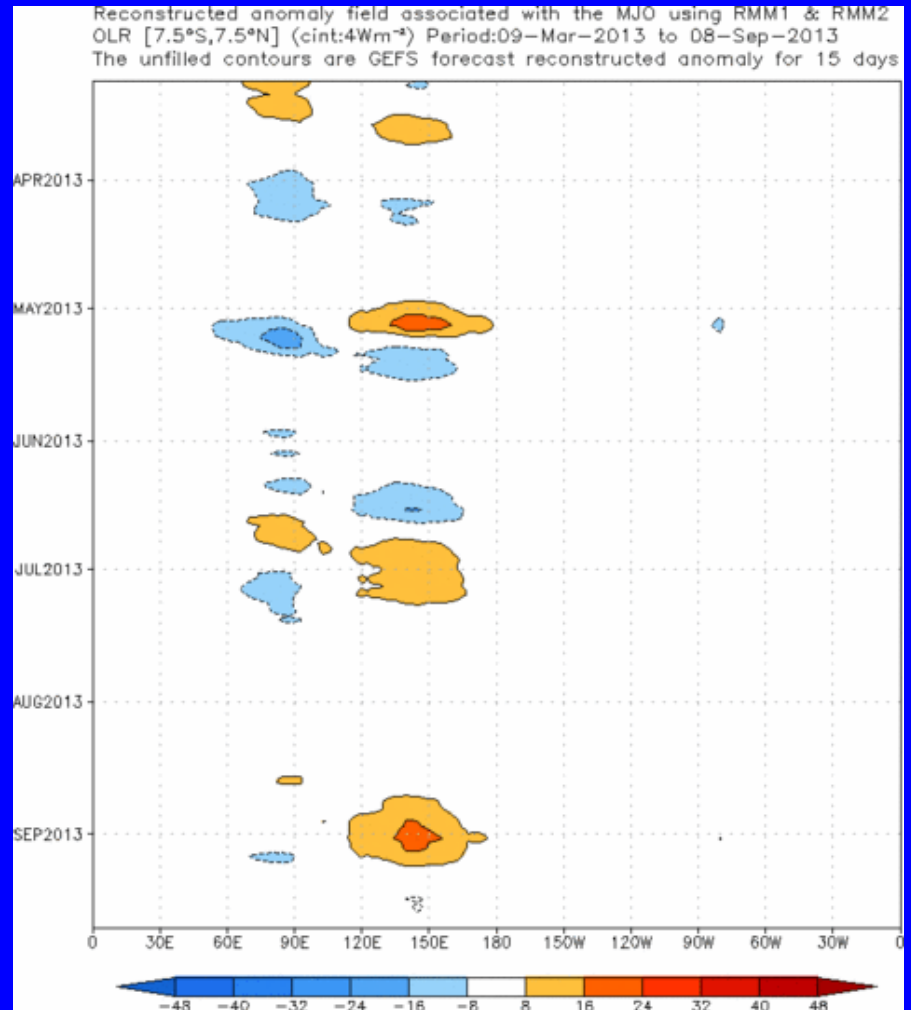
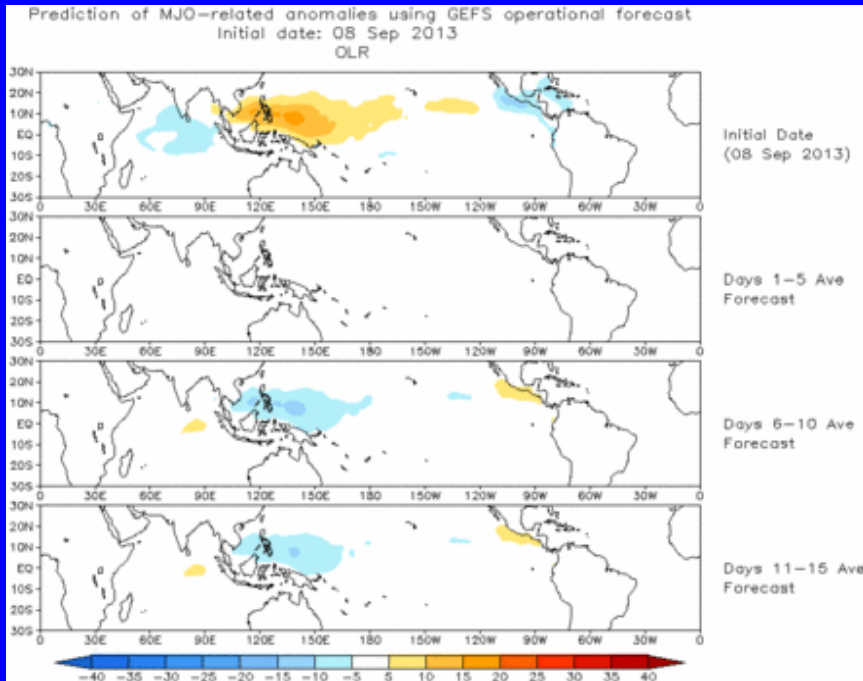


Ensemble Mean GFS MJO Forecast

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 shifting eastward from the Indian Ocean to the West Pacific.

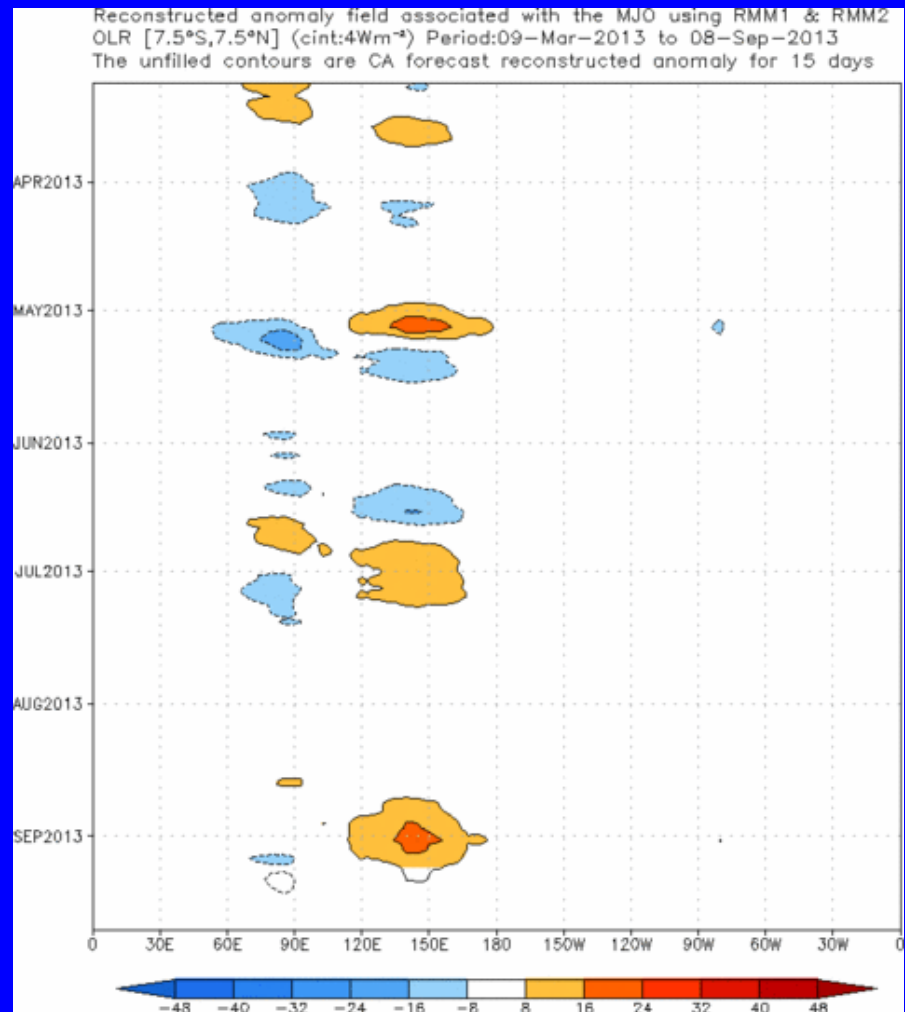
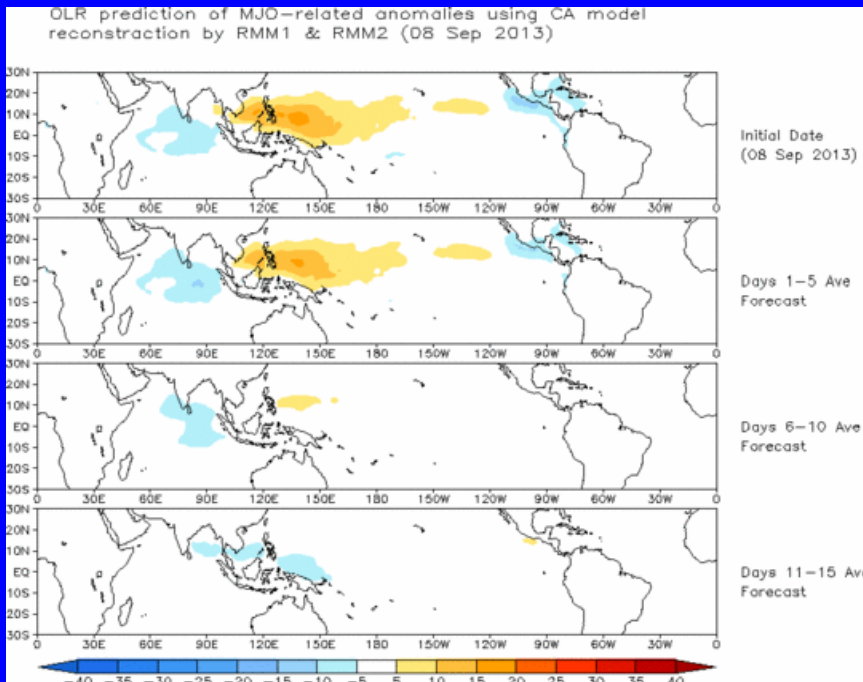


Constructed Analog (CA) MJO Forecast

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



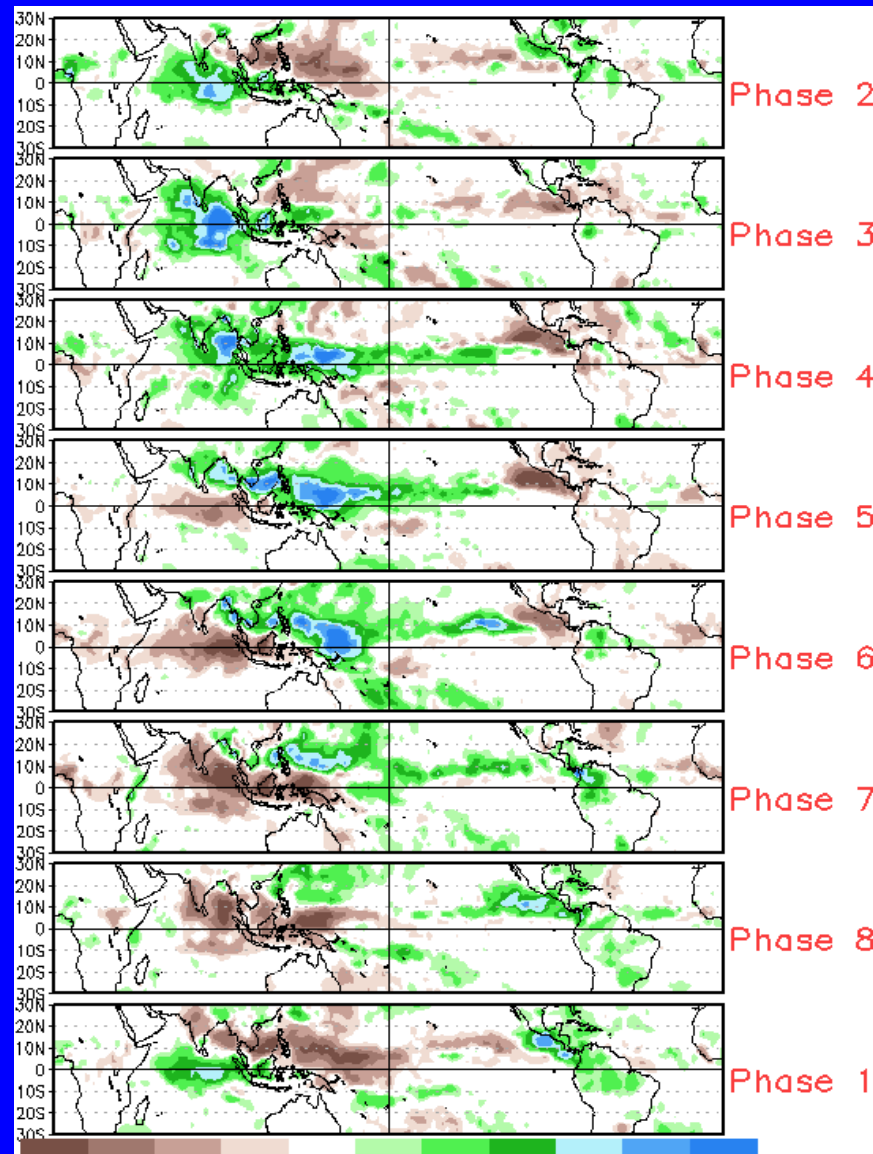
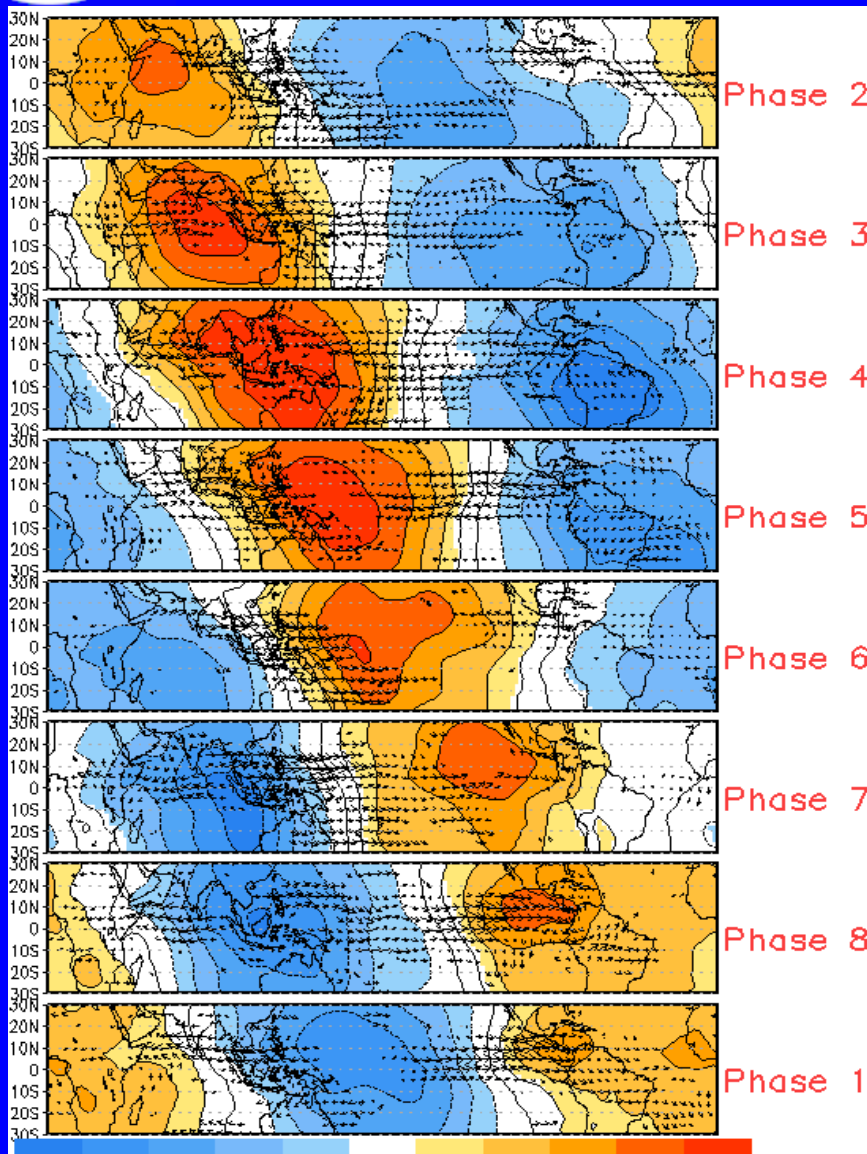
This statistical forecast indicates persistent suppressed convection over the western Pacific, with enhanced convection favored over the Indian Ocean. Weakening enhanced convection is forecast over the western Hemisphere.



MJO Composites – Global Tropics

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

Precipitation Anomalies (May-Sep)

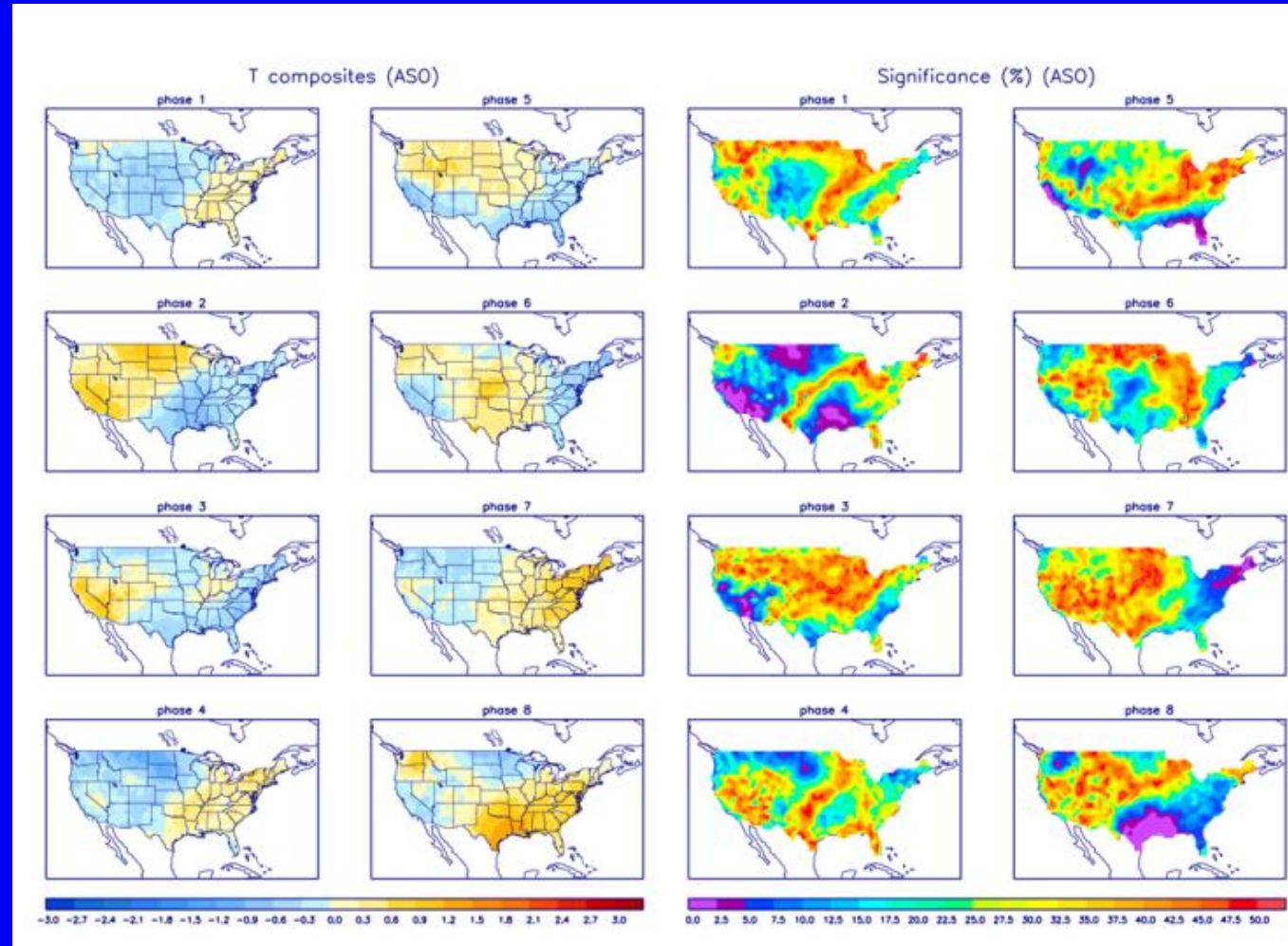




U.S. MJO Composites – Temperature

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.



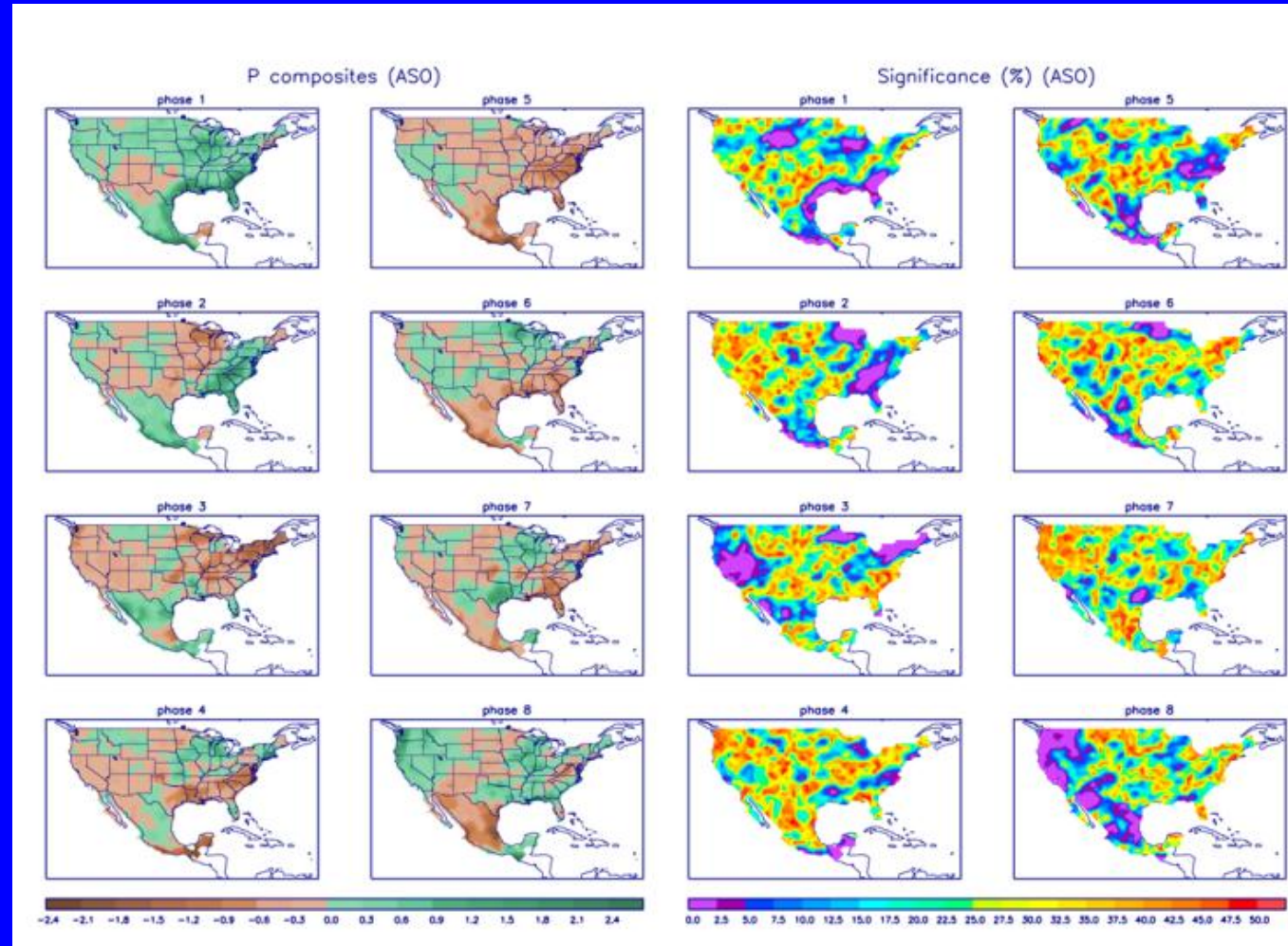
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>