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

Update prepared by
Climate Prediction Center / NCEP
October 7, 2013

Outline

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

Overview

- The MJO weakened during the past week, with little eastward propagation. The enhanced convective phase remains centered over the western Pacific.

- Dynamical model MJO index forecasts generally indicate slow propagation and a weakening of the MJO signal, while statistical guidance indicates a faster eastward propagation.

- Based on recent observations, statistical tools, and dynamical forecasts, the MJO is forecast to remain active, although uncertainty is elevated this week. Other types of subseasonal tropical variability are likely to influence the pattern of tropical convection.

- The MJO phase favors enhanced chances of tropical cyclone formation over the West Pacific, and suppressed tropical activity across parts of the Atlantic Basin.

- Enhanced (suppressed) convection is favored from South Asia to the western North Pacific (Southern India, the eastern Indian Ocean, and portions of the Maritime Continent) during Week-1. During Week-2, enhanced (suppressed) convection is forecast to expand over the central Pacific (South Asia and the Maritime Continent).

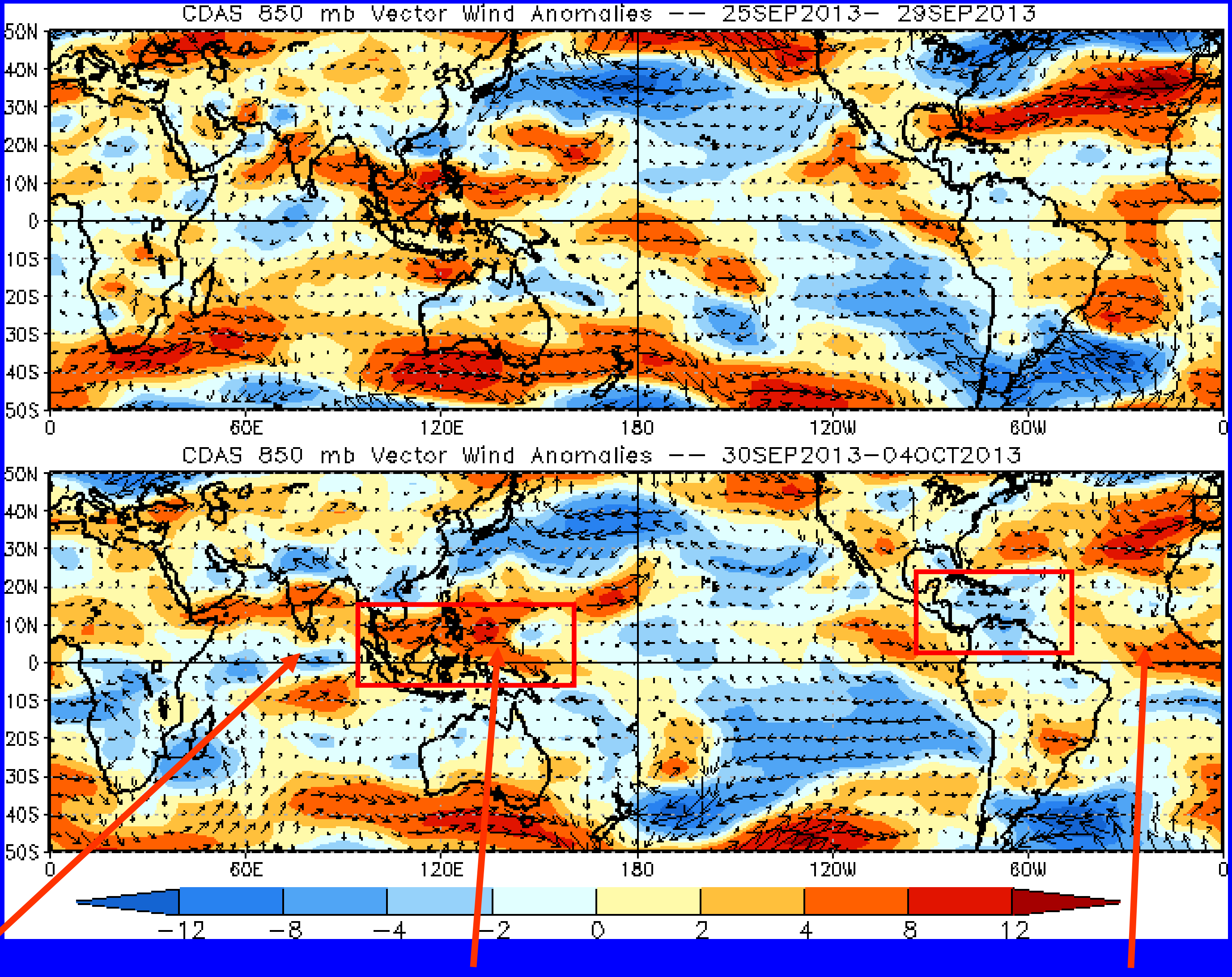
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



A small area of easterly anomalies persisted over the equatorial central Indian Ocean.

Westerly anomalies persisted across much of the Maritime Continent and western North Pacific.

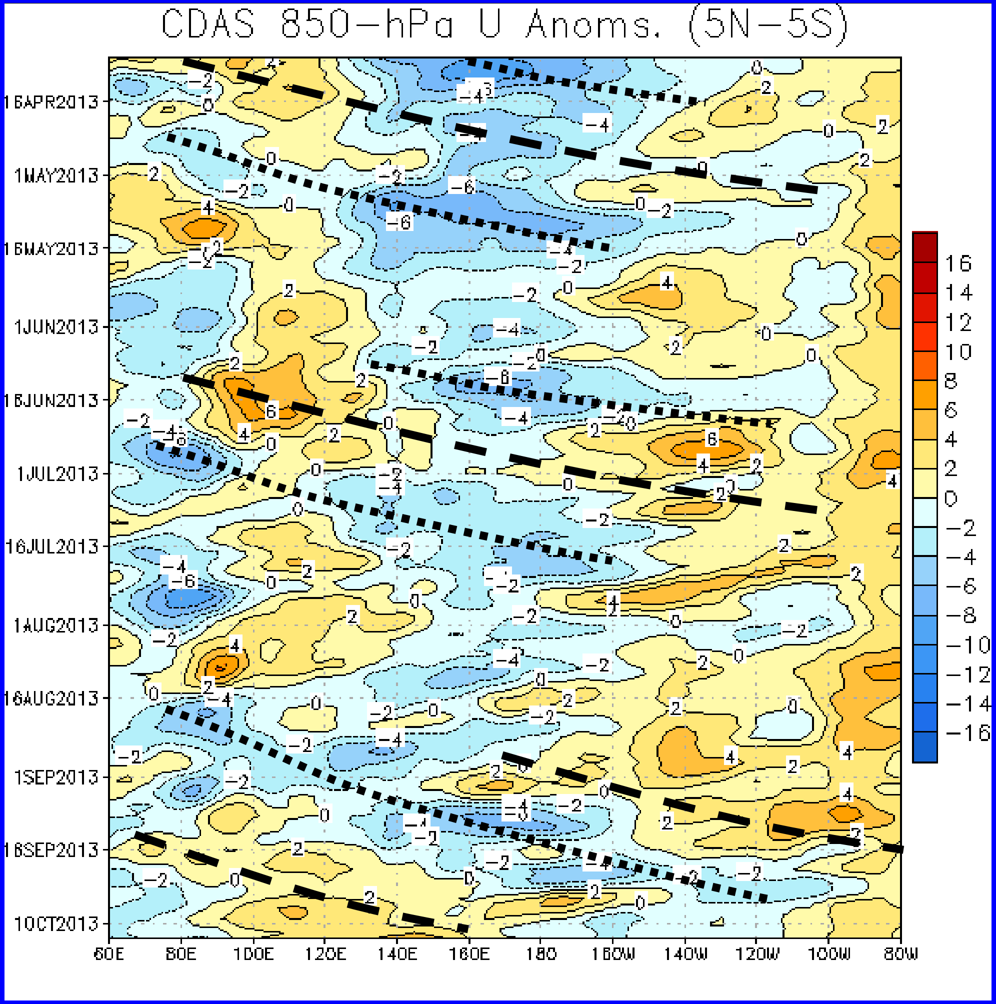
Easterly anomalies developed over the Caribbean Sea while westerly wind anomalies developed over the central Atlantic Ocean.

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

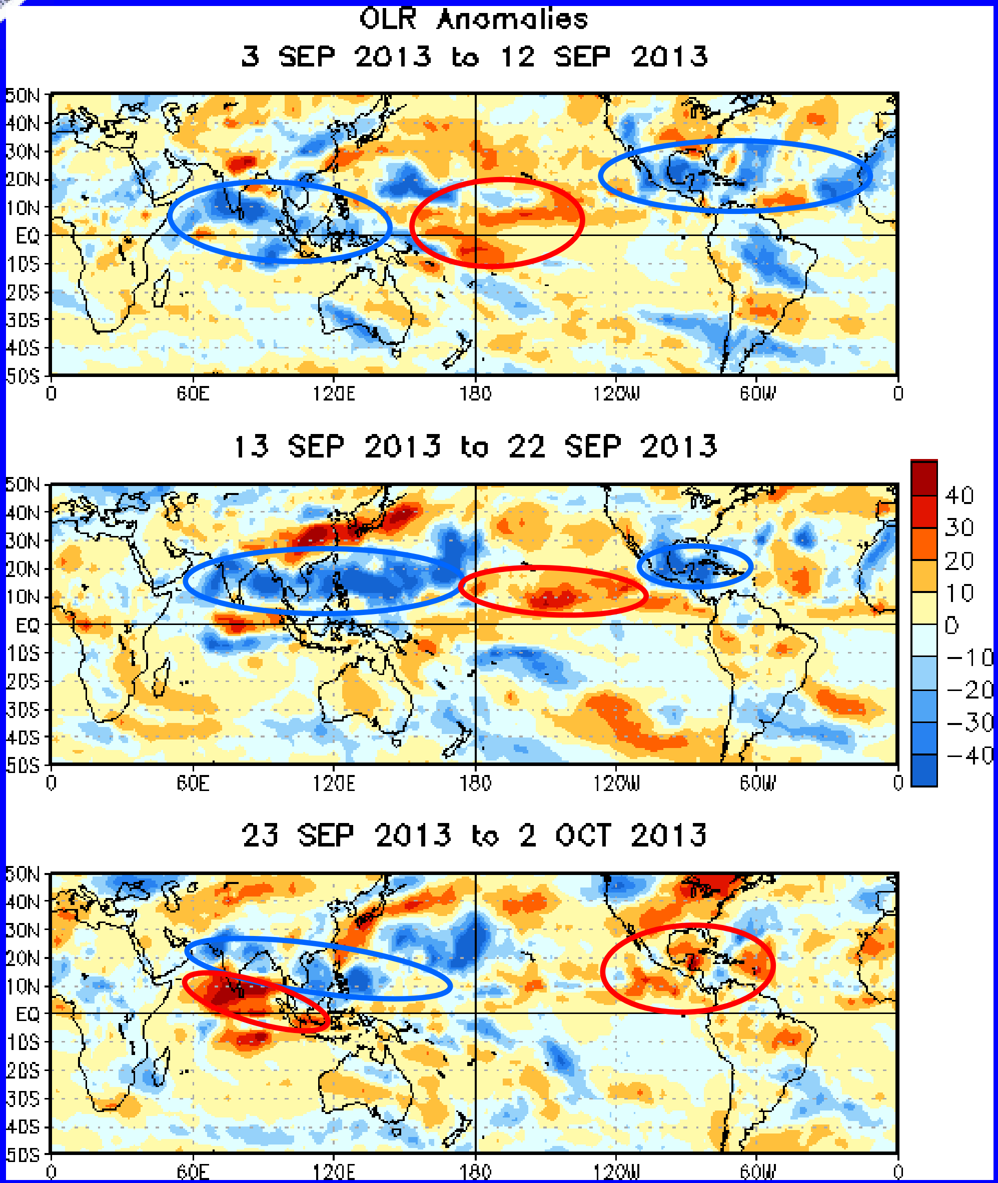
The MJO was active from April into early May as indicated by alternating dotted (easterly anomalies) and dashed (westerly anomalies) lines.

The MJO strengthened again in June and continued to be significant until 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, westerly anomalies propagated across the Indian Ocean to the Maritime Continent, consistent with MJO activity. Other modes of tropical intraseasonal variability are also evident.

OLR Anomalies – Past 30 days



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

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

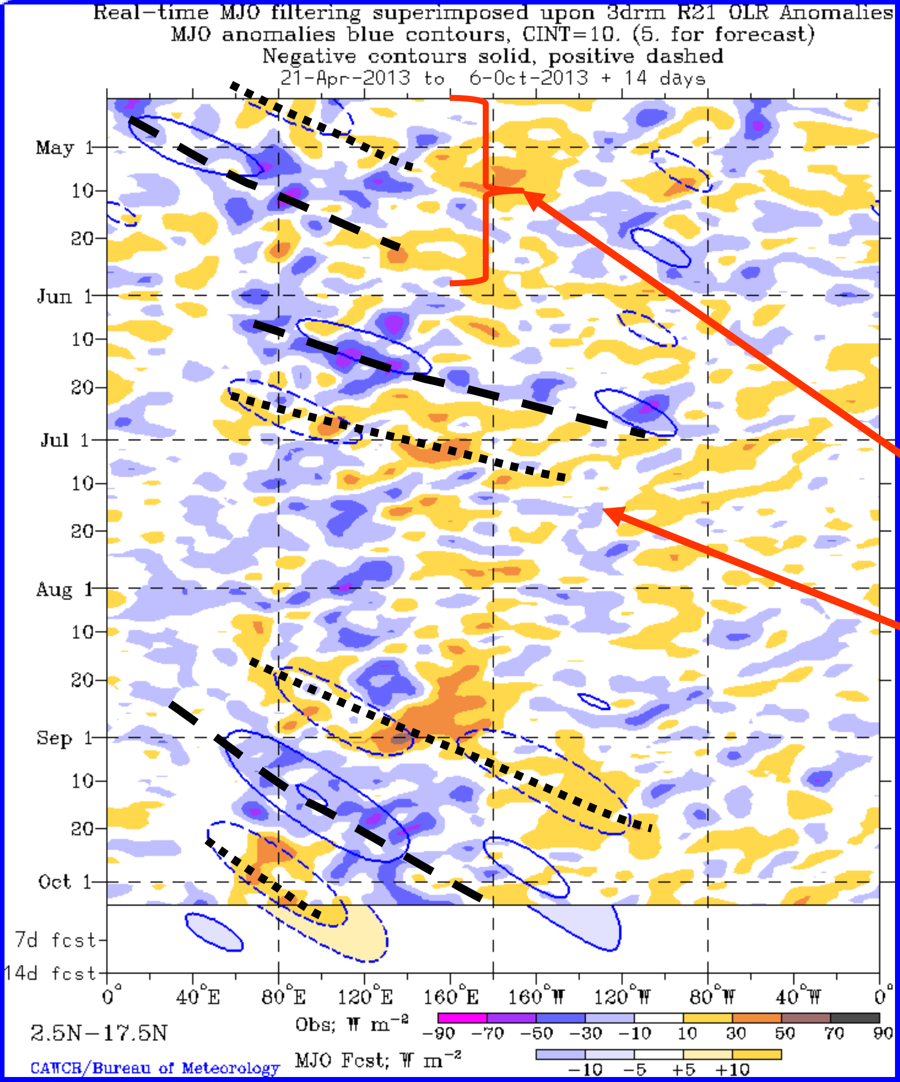
The MJO became increasingly coherent during early September, as enhanced convection persisted over the Western Hemisphere and developed over the equatorial Indian Ocean.

During mid-September, enhanced convection spread eastward (northward) into the western Pacific (South Asia), and suppressed convection developed over the equatorial central Indian Ocean, consistent with the MJO. Enhanced convection persisted over North America due to tropical cyclone activity.

In mid-September, enhanced convection persisted over South Asia and the western Pacific, while a region of suppressed convection spread over the western Maritime Continent and intensified over the Indian Ocean, exhibiting a typical northwest-southeast tilt.

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).

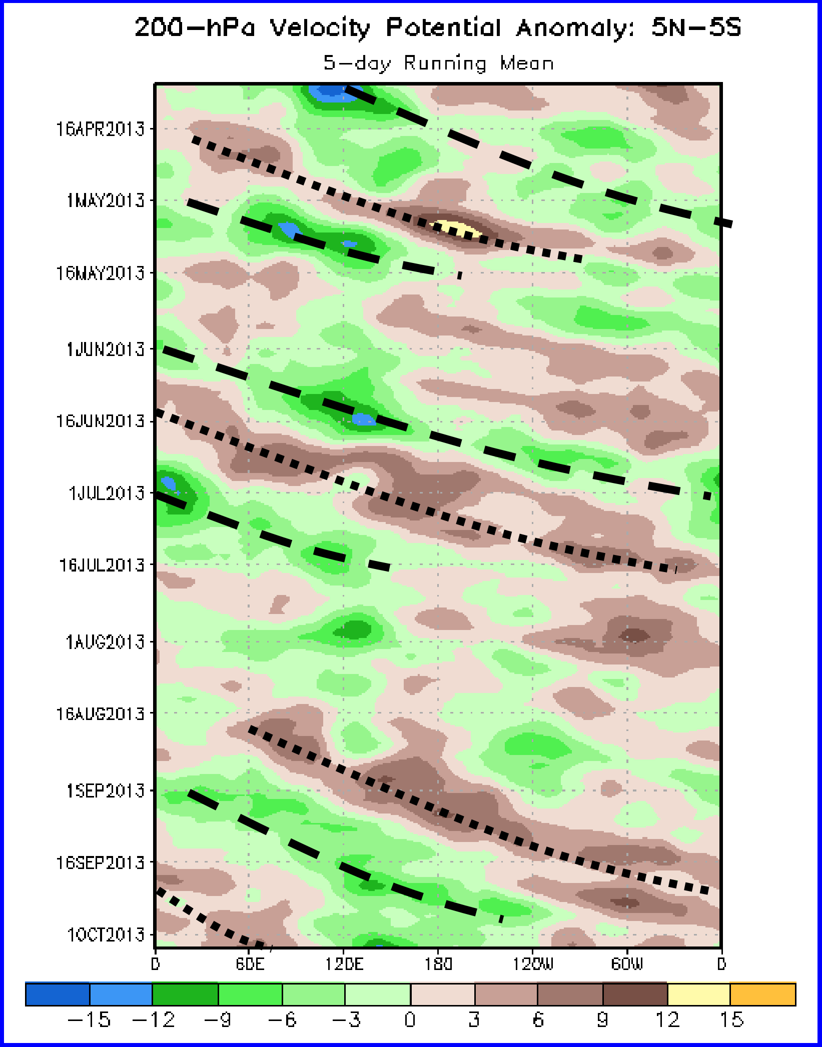
The MJO strengthened once again during June and continued into July.

There is an ongoing MJO signal, with the enhanced phase currently propagating over the western Pacific, and the suppressed phase strengthening over the Indian Ocean.

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.

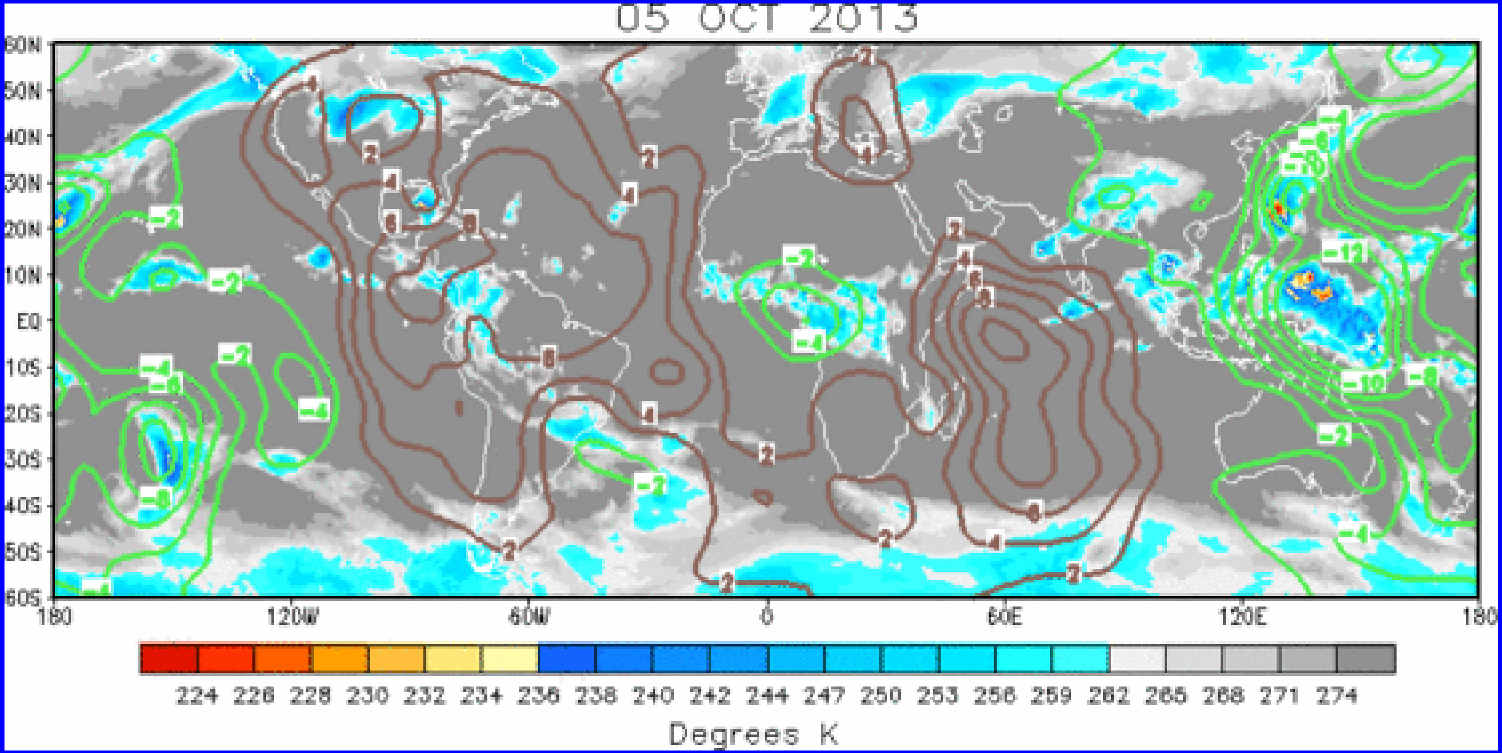
The MJO strengthened once again during June and the first half of July before weakening by the end of the month.

The MJO was not active during late July and much of August, but strengthened during September, with eastward propagation of robust upper-level velocity potential anomalies. Other modes of tropical intraseasonal variability are also evident.

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



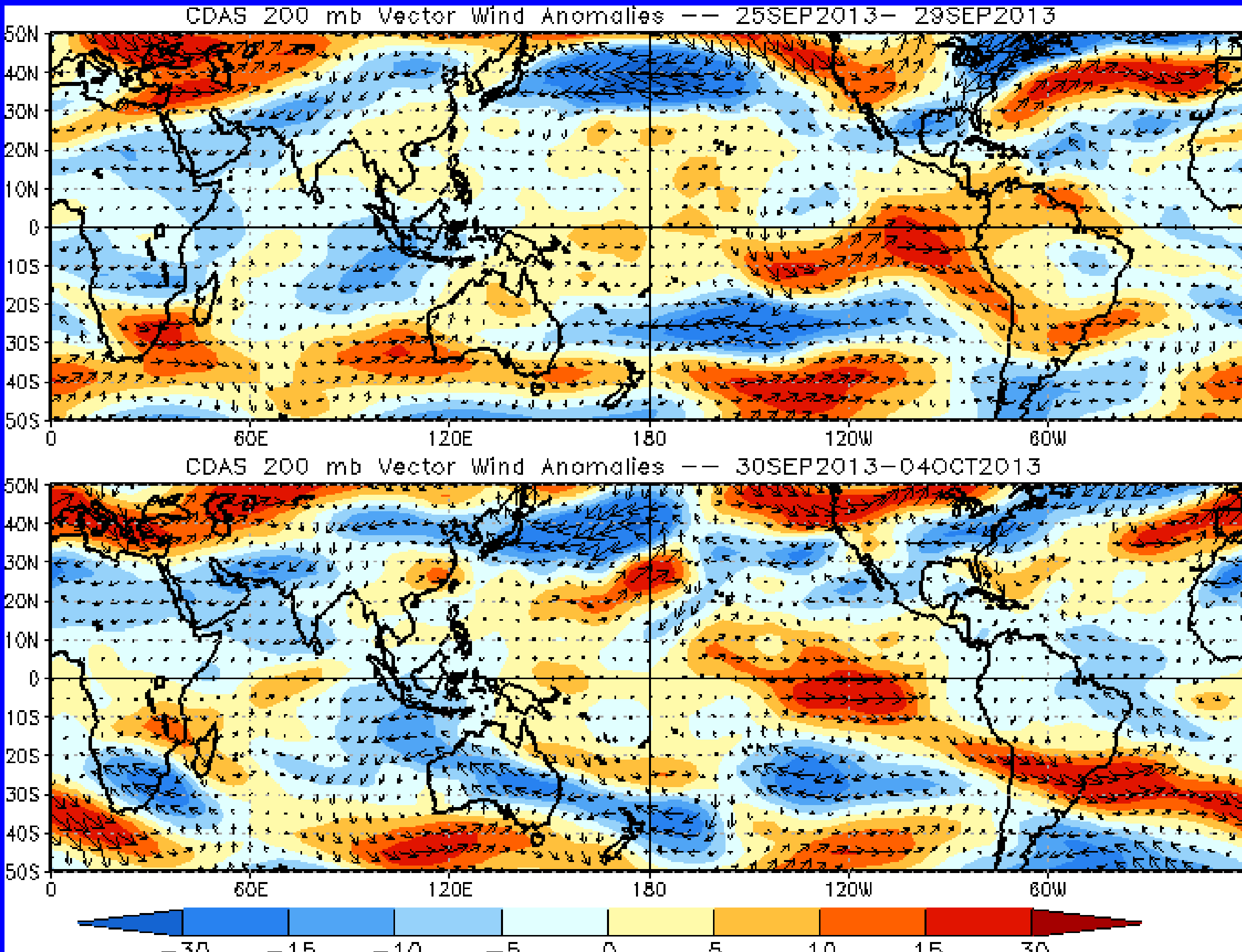
The velocity potential pattern remains coherent, exhibiting wave-2 structure due to influence from multiple modes of variability, including the MJO. Upper-level divergence is now centered over the western Pacific Ocean, while suppressed convection stretched from the Americas to the western Indian Ocean.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



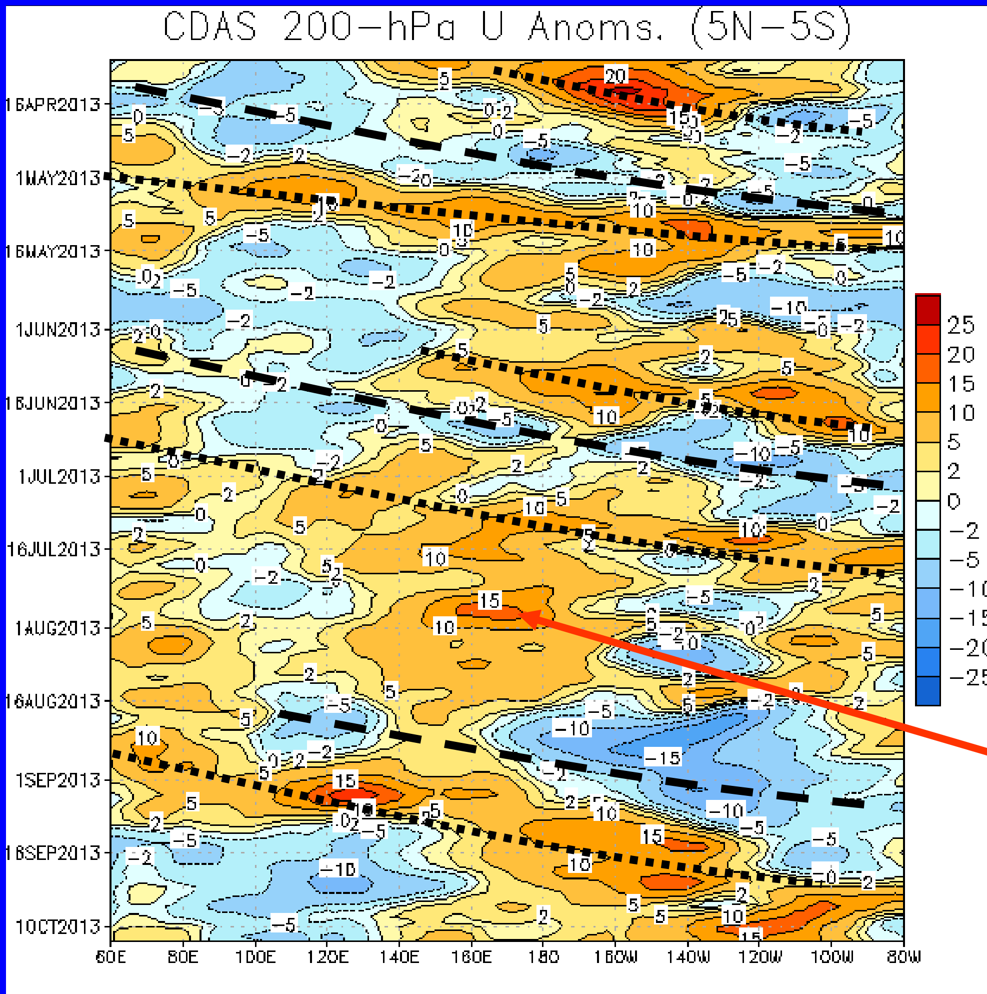
Easterly (westerly) upper level zonal wind anomalies were observed over the Maritime Continent and equatorial eastern Atlantic (eastern Pacific).

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

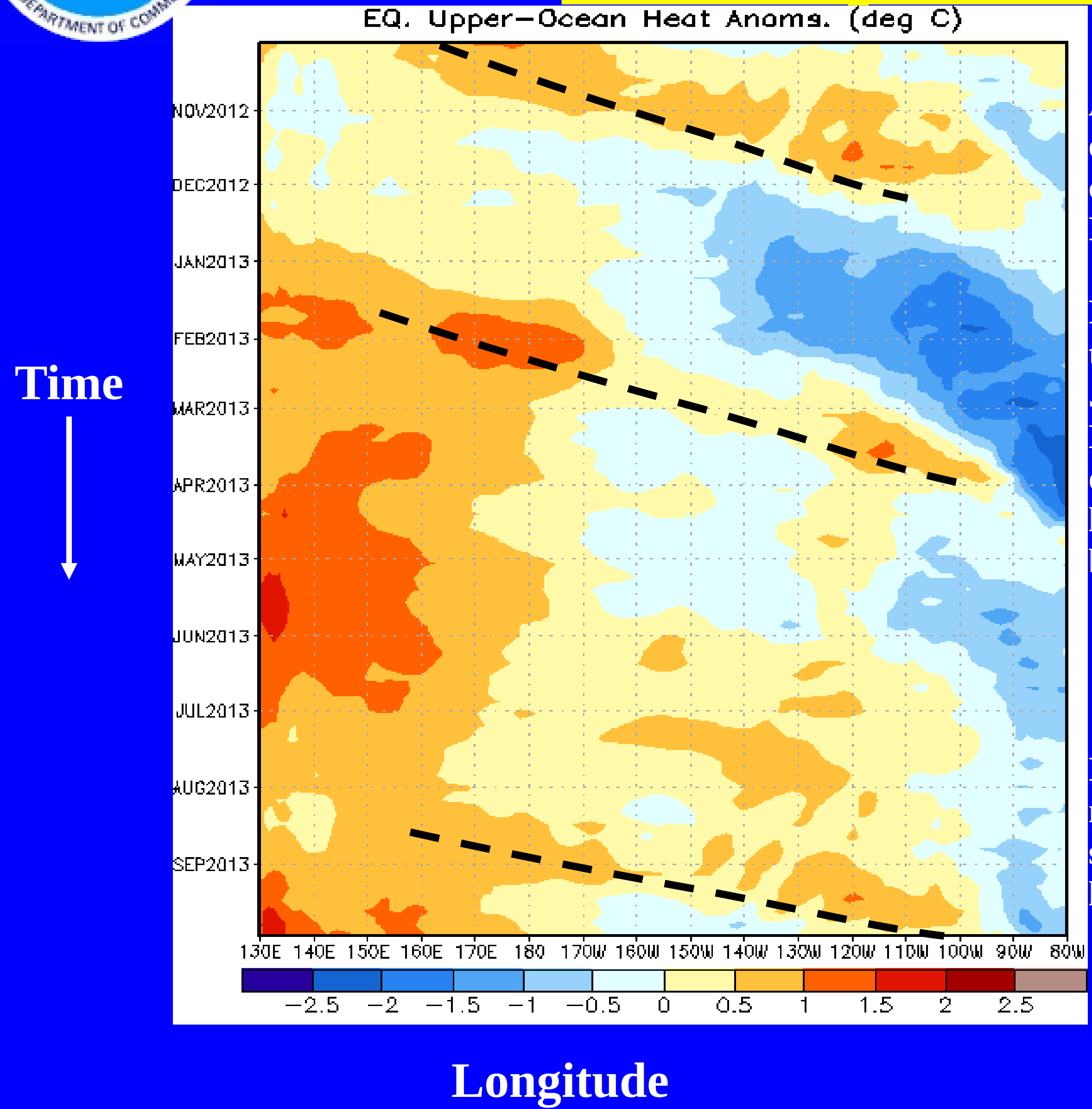
Eastward propagation of wind anomalies associated with the MJO (dotted and dashed lines) continued into May 2013.

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, westerly wind anomalies propagated eastward with the most intense anomalies now located over the eastern Pacific. Easterly wind anomalies are now located over the Indian Ocean. This is consistent with renewed MJO activity.

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 have persisted across most of the basin since June 2013, with some evidence of an oceanic Kelvin wave in late August and September.

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).

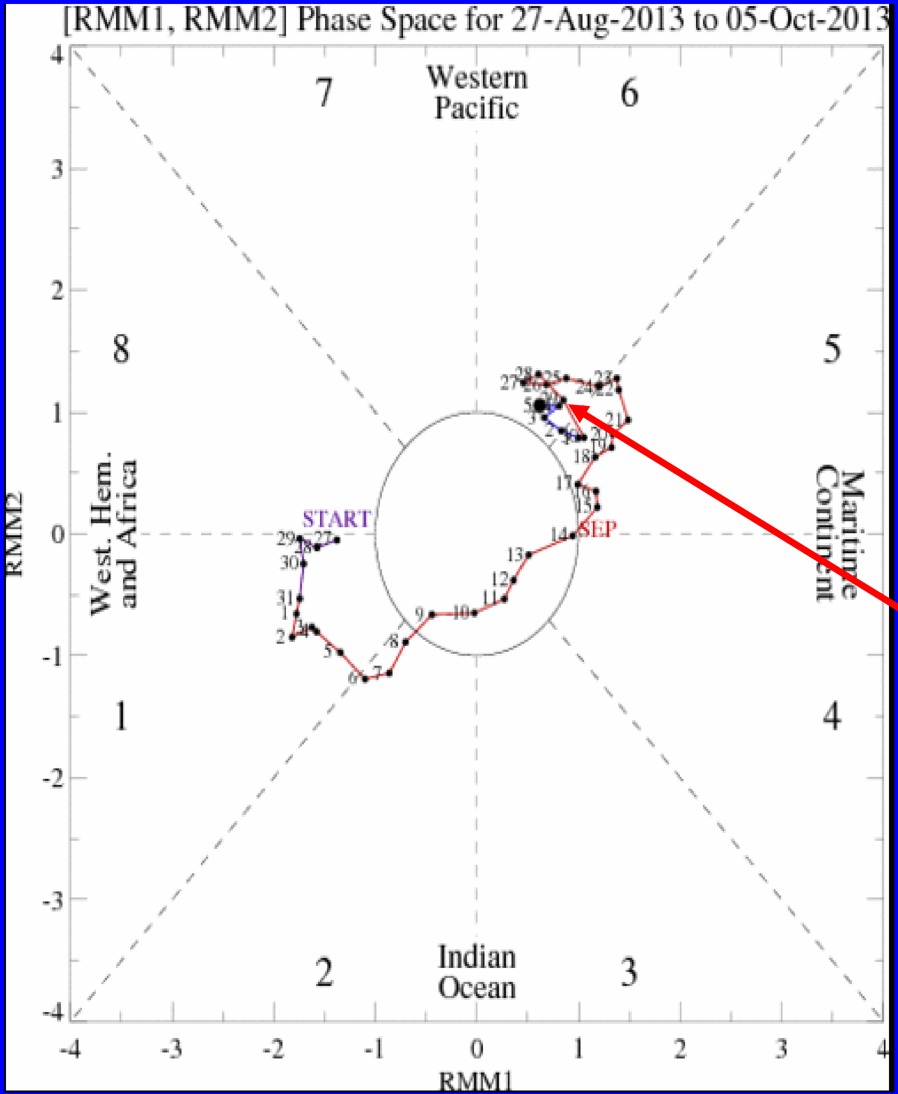
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

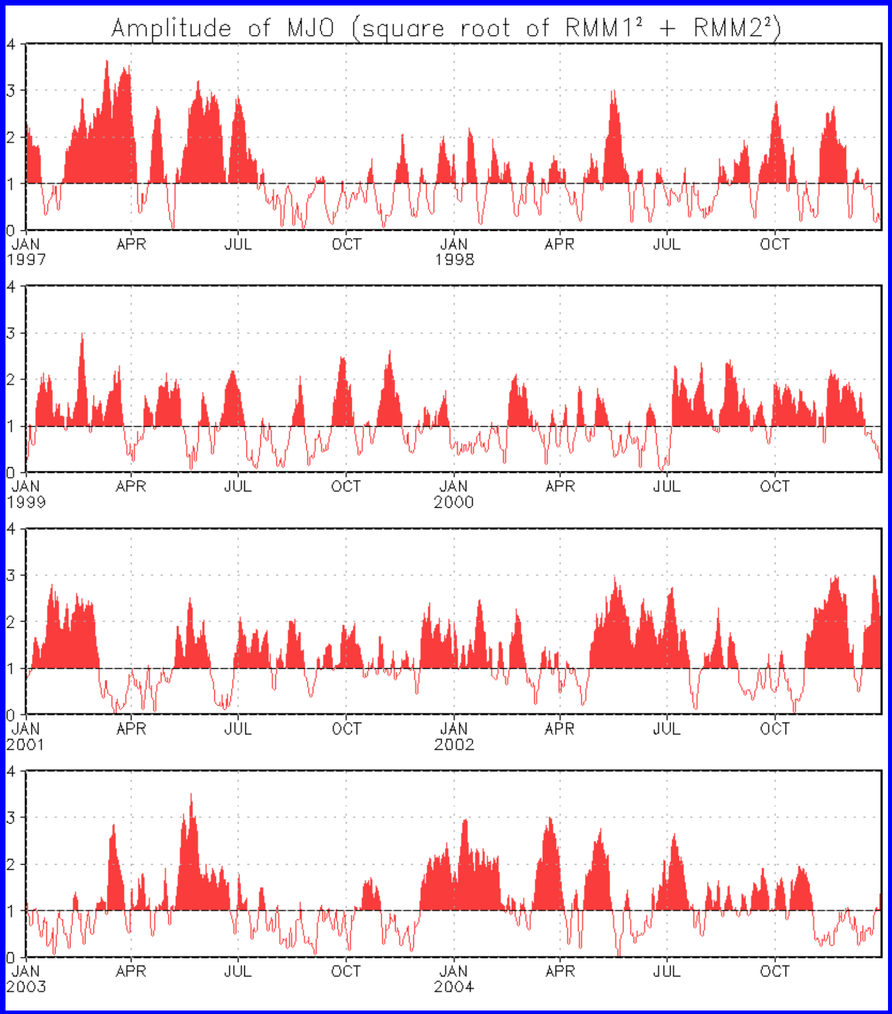
MJO Index -- Recent Evolution

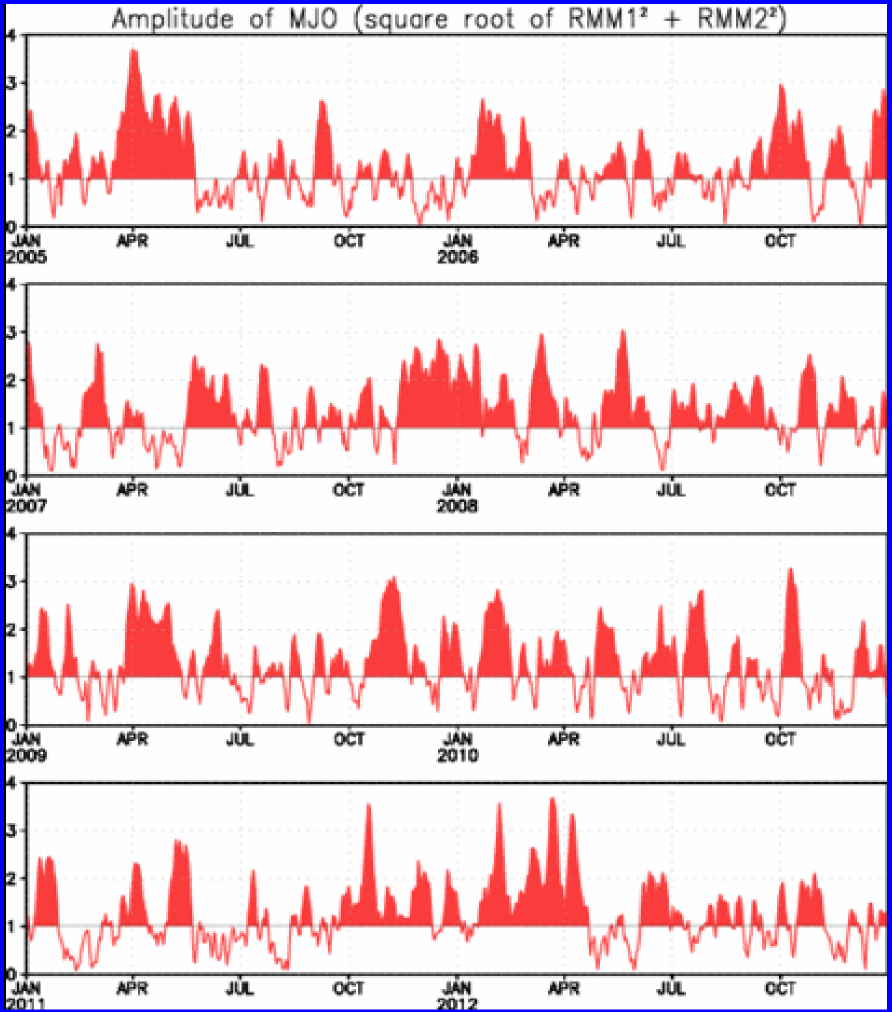


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past two weeks, the MJO index exhibited little eastward propagation, most likely due to influence from other modes of tropical intraseasonal variability.

MJO Index – Historical Daily Time Series





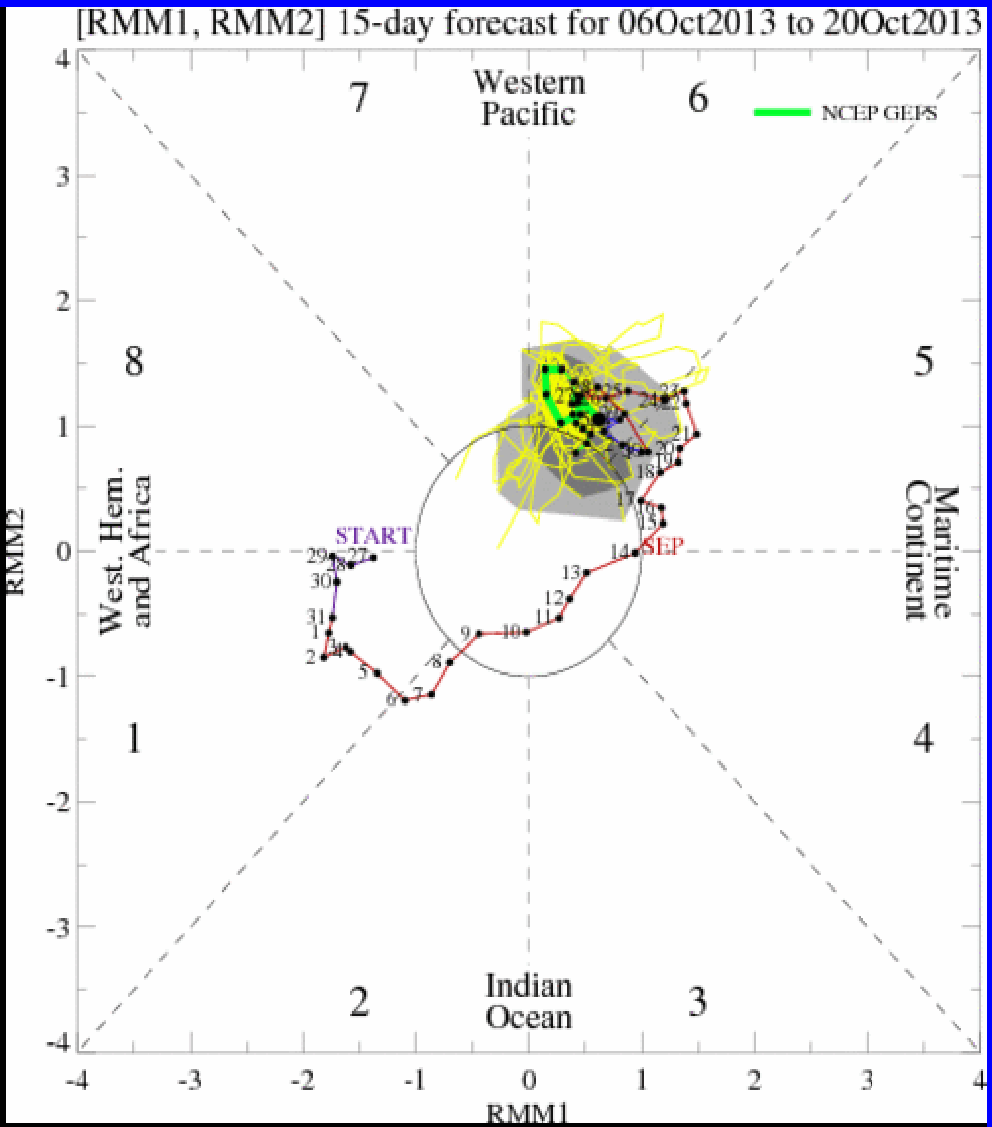
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

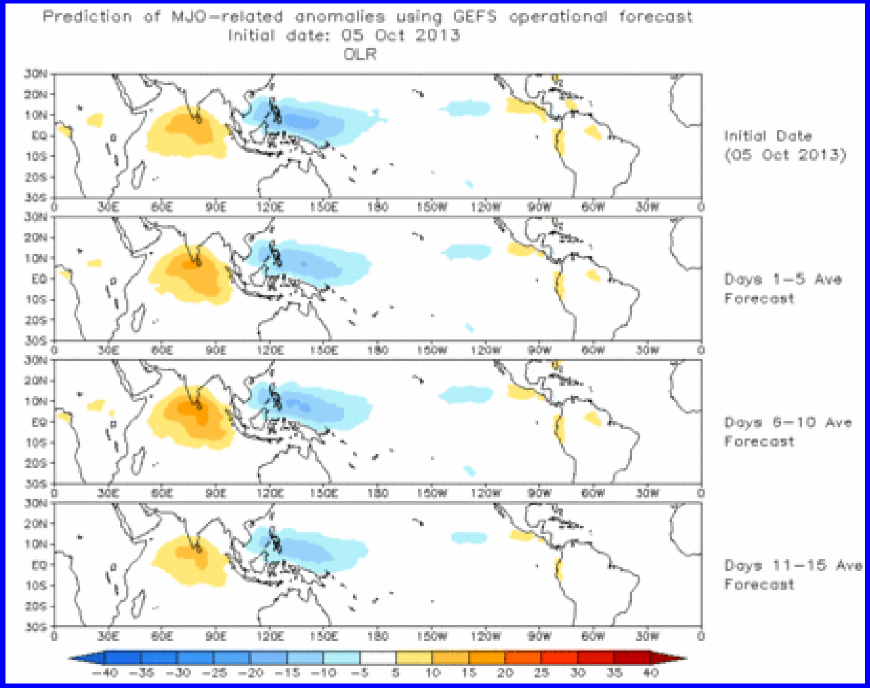


The ensemble GFS indicates an MJO signal generally remaining stationary in Phase-6.

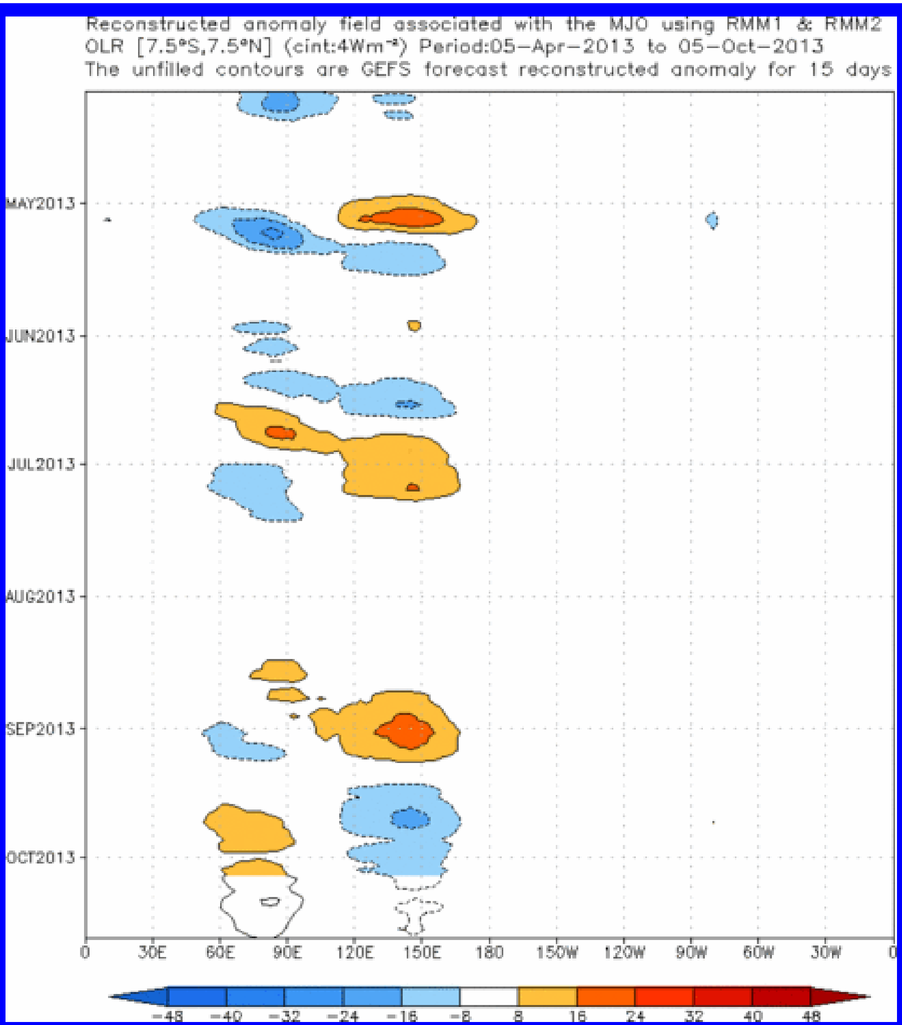
Ensemble Mean GFS MJO Forecast

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



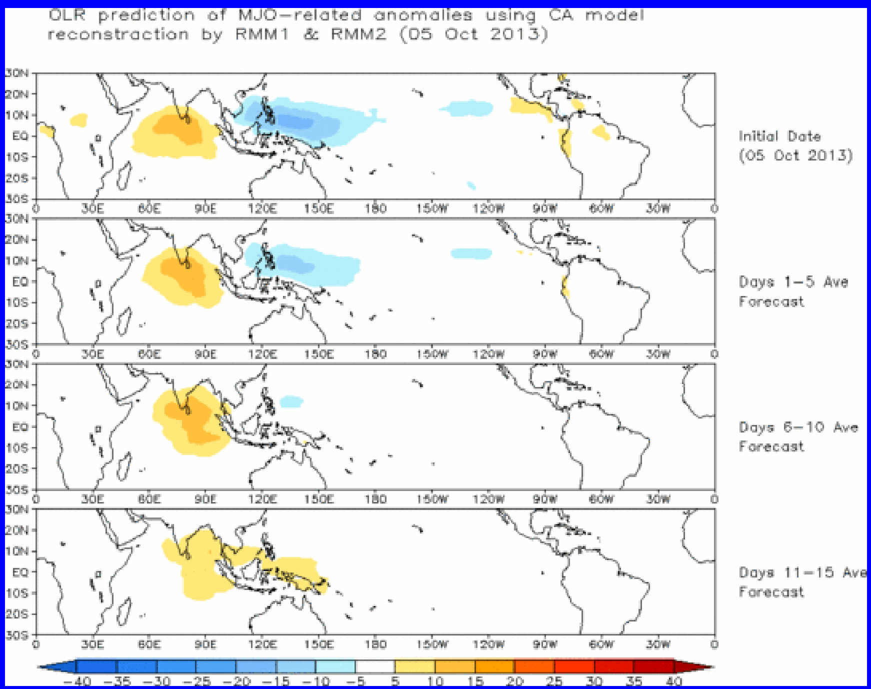
The ensemble mean GFS forecasts enhanced convection remaining fairly stationary across the western and central Pacific. Suppressed convection is forecast to persist across parts of Central America and the Indian Ocean.

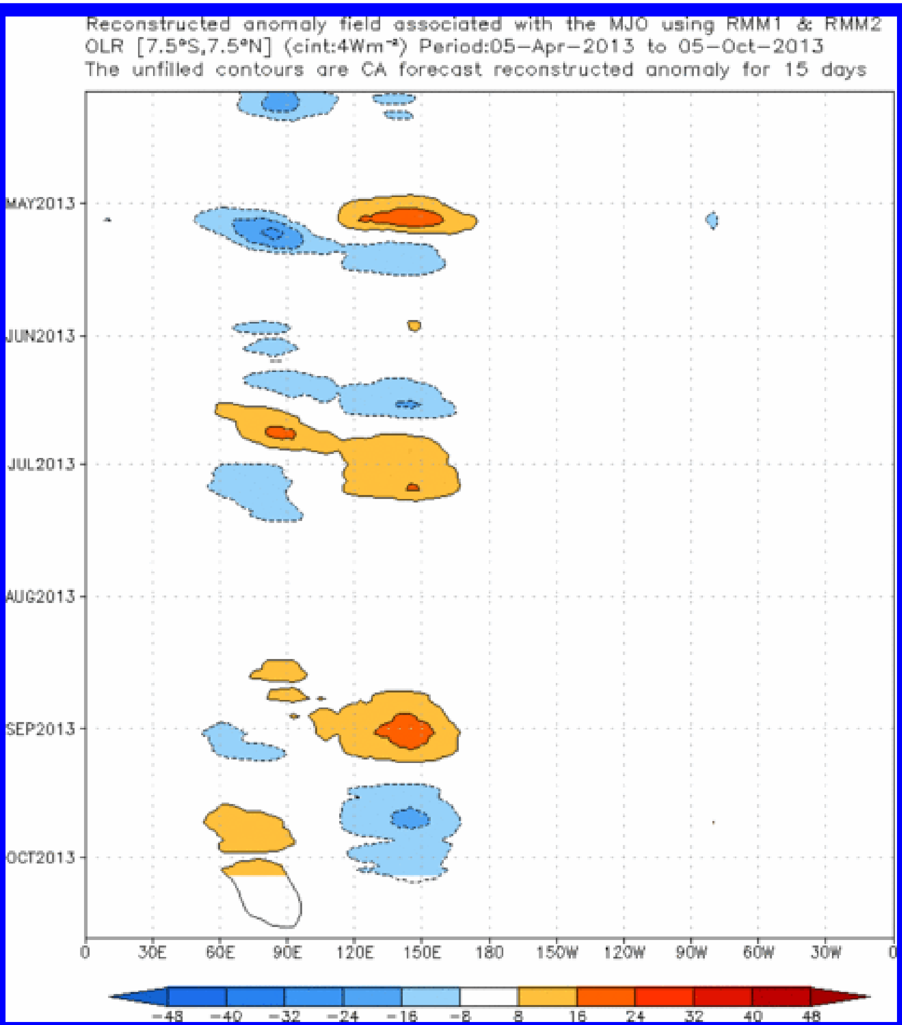
Constructed Analog (CA) MJO Forecast

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

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

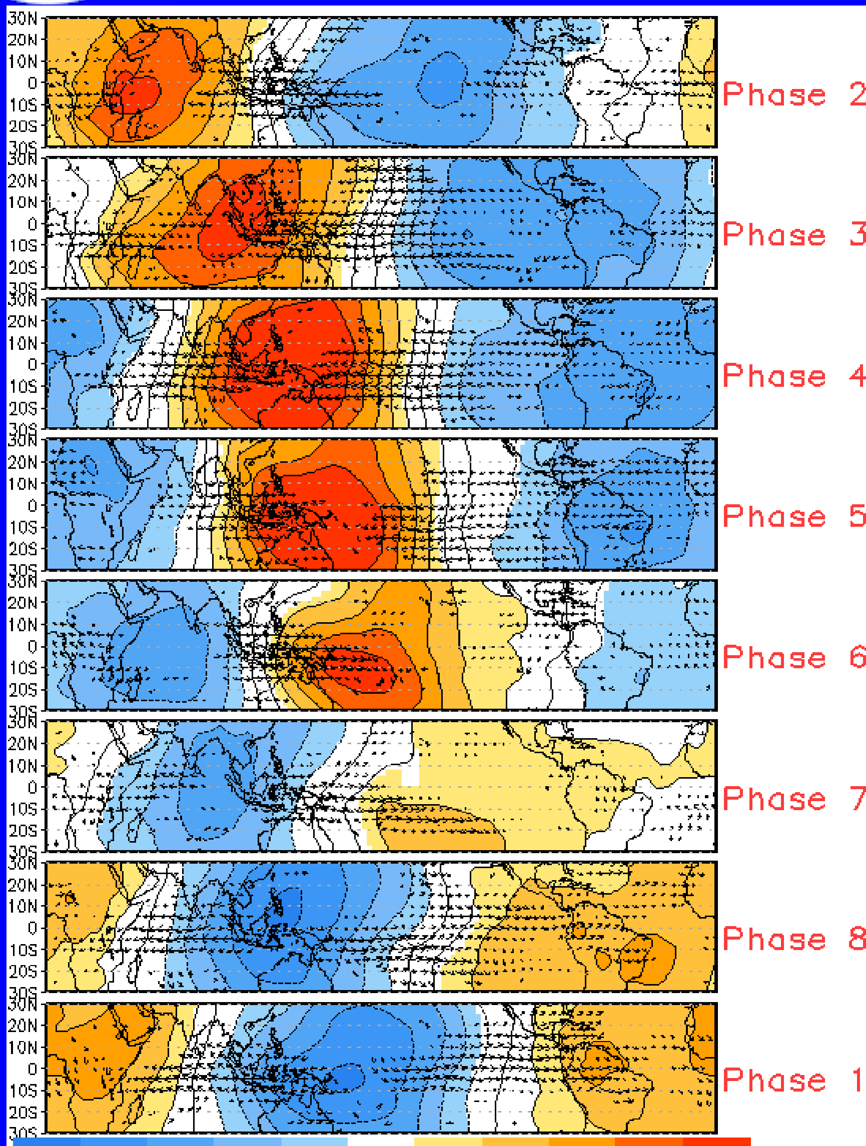




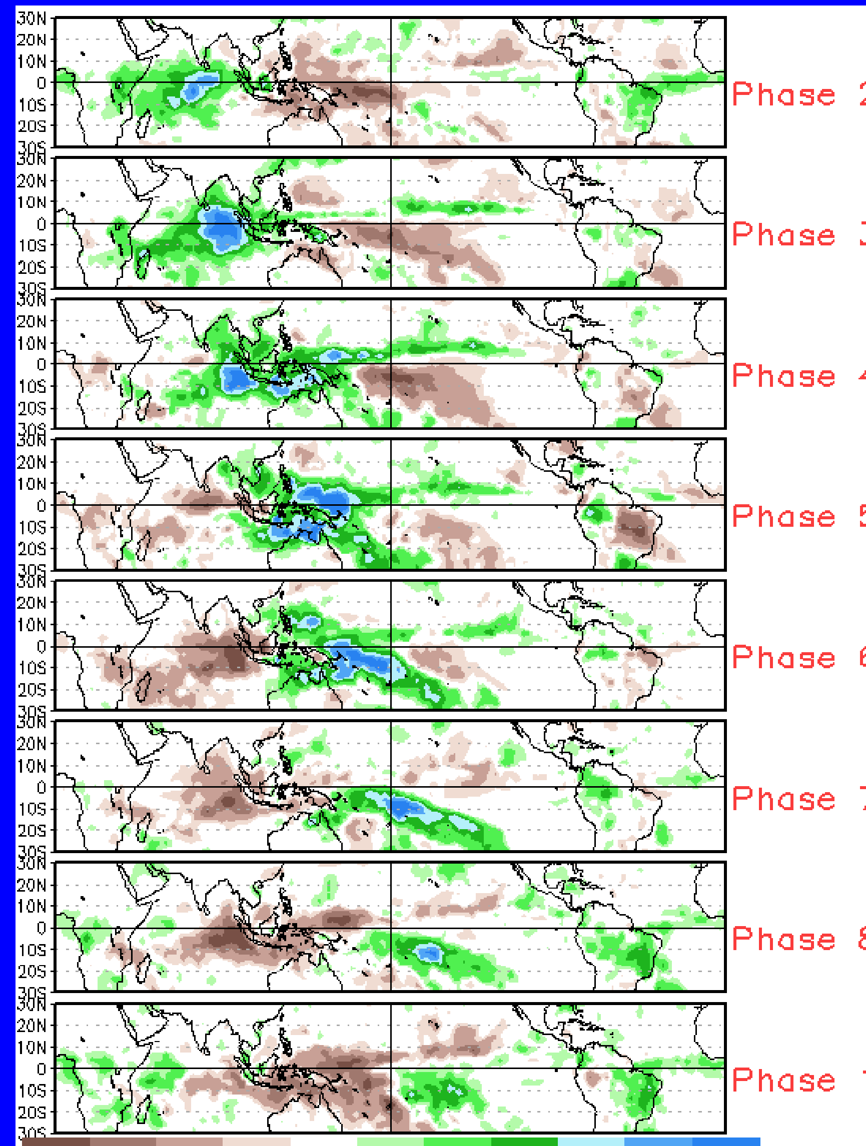
The Constructed Analog statistical MJO forecast exhibits more eastward propagation of the signal than the dynamical GFS, with suppressed convection building over the Maritime Continent by the end of week-2.

MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (Nov-Mar)

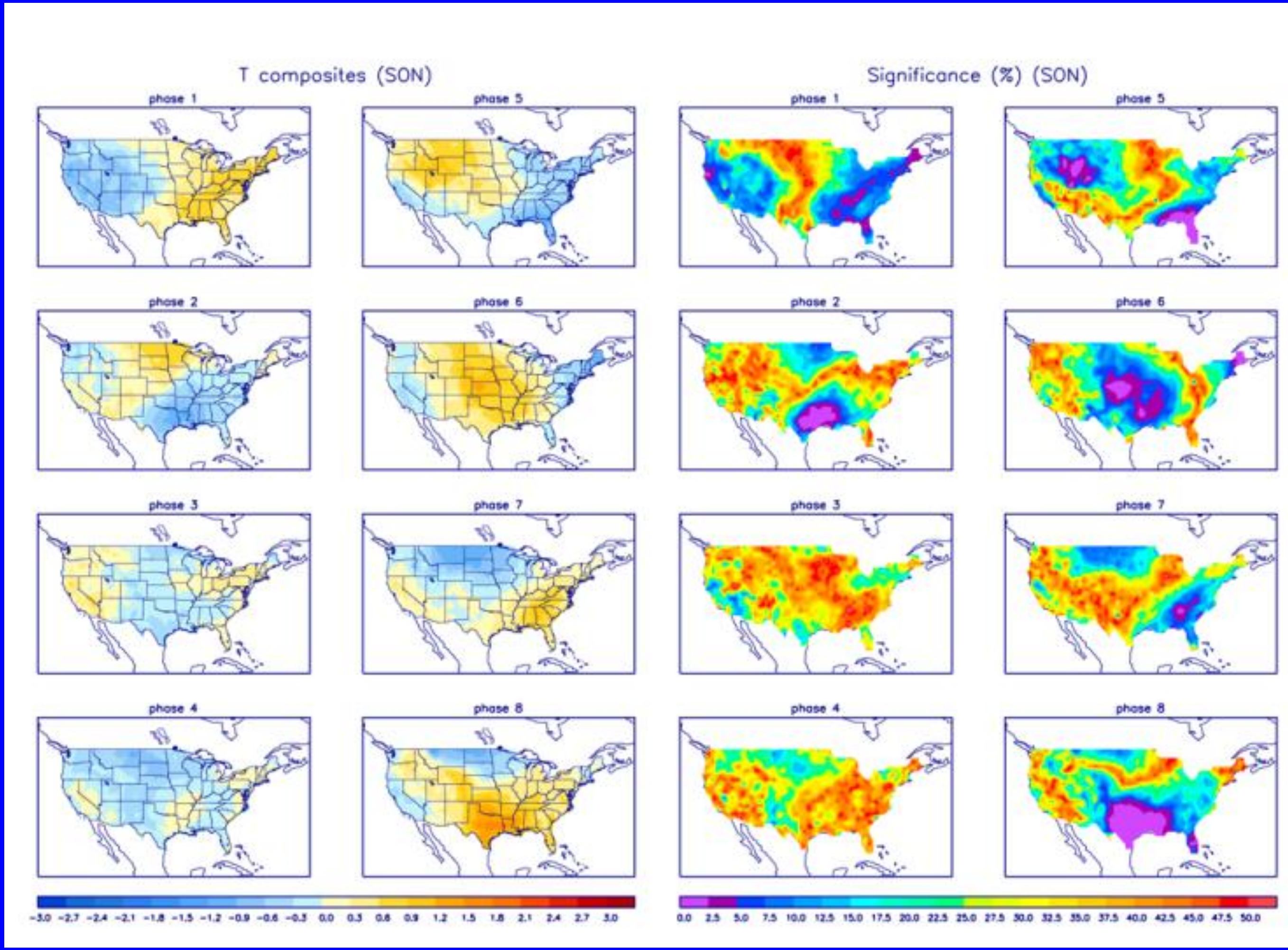


Precipitation Anomalies (Nov-Mar)



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.

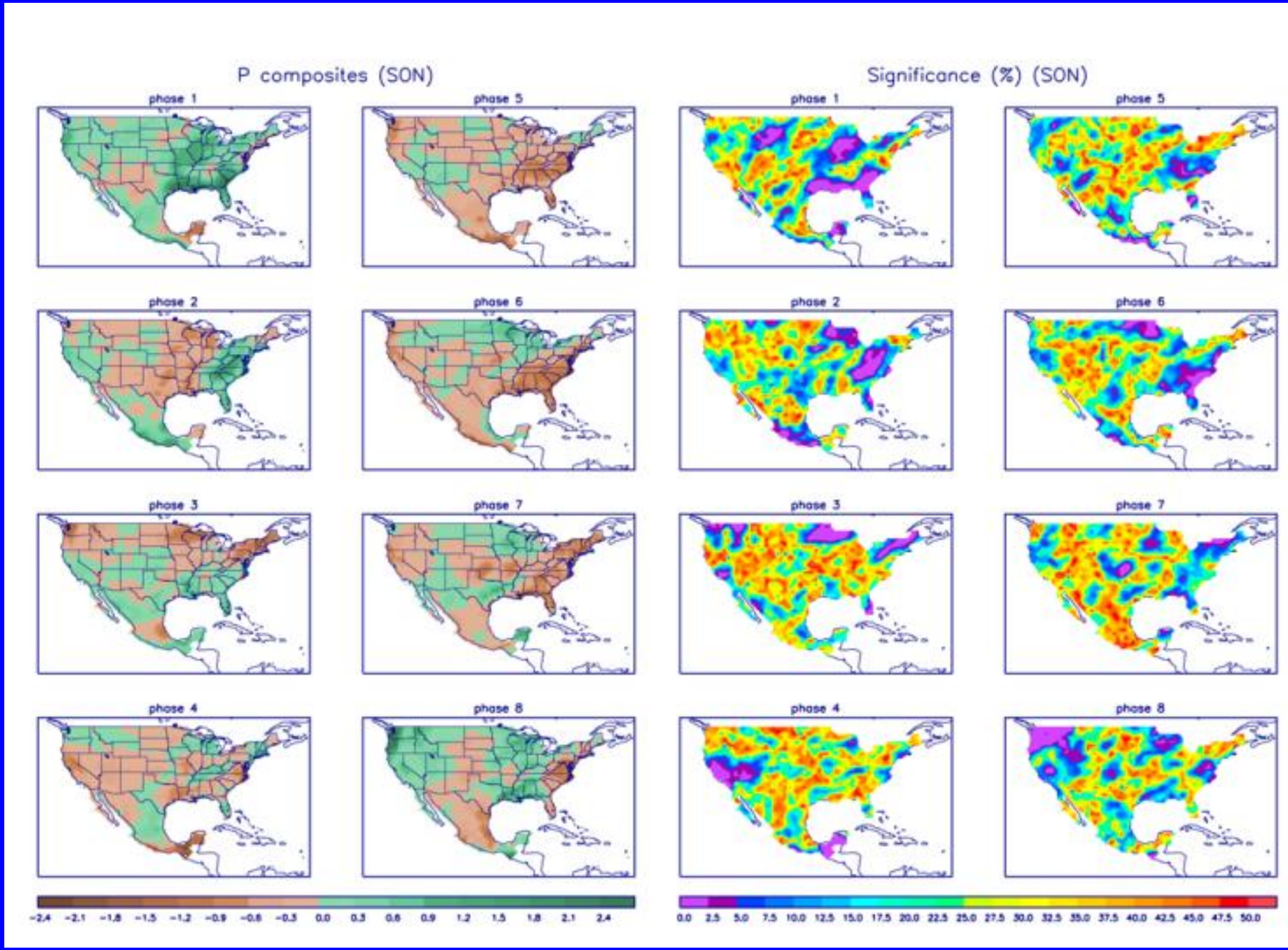


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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