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

Update prepared by
Climate Prediction Center / NCEP
October 14, 2013

Outline

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

Overview

- The enhanced convective phase of the MJO shifted slowly east during the past week and is entering the western Hemisphere.

- Dynamical model MJO index forecasts and statistical guidance indicate eastward propagation of a weak to moderate signal over the next two weeks.

- Based on recent observations, statistical tools, and dynamical forecasts, the MJO is forecast to remain active, although uncertainty remains high for both its strength and propagation. Other types of subseasonal tropical variability are likely to influence the pattern of tropical convection.

- The MJO favors enhanced chances of tropical cyclone formation over the West Pacific during Week-1.

- Enhanced (suppressed) convection is favored across parts of Africa, the Indian Ocean, South Pacific Ocean, Mexico, South America (Southern India and parts of the Maritime Continent) during Week-1. Enhanced convection is expected to persist across parts of the Americas, Africa, Indian Ocean, and South Pacific Ocean during Week-2 with suppressed convection favored across the eastern Maritime Continent.

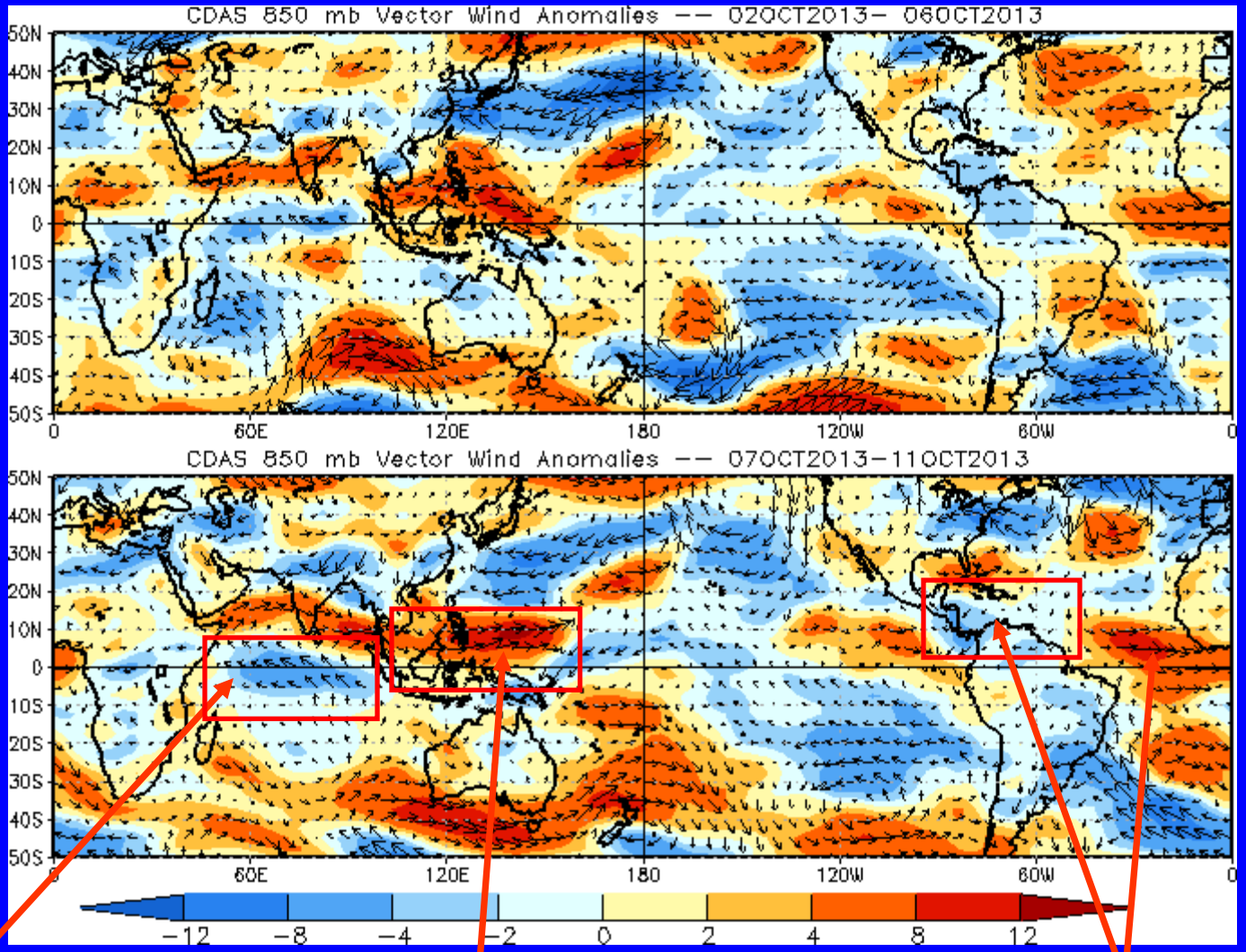
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted over the equatorial central Indian Ocean.

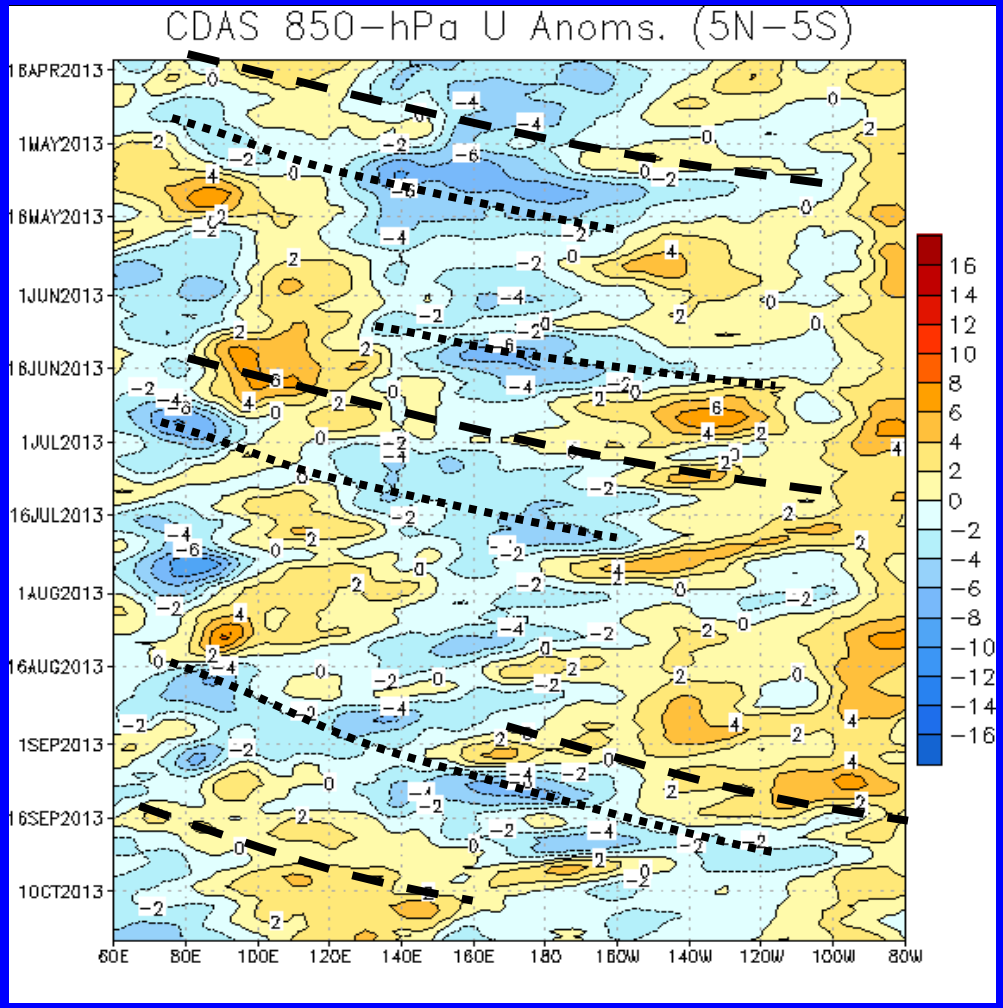
Westerly anomalies persisted across much of the Maritime Continent and western North Pacific.

Easterly anomalies continued over the Caribbean Sea while westerly wind anomalies strengthened over the eastern 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

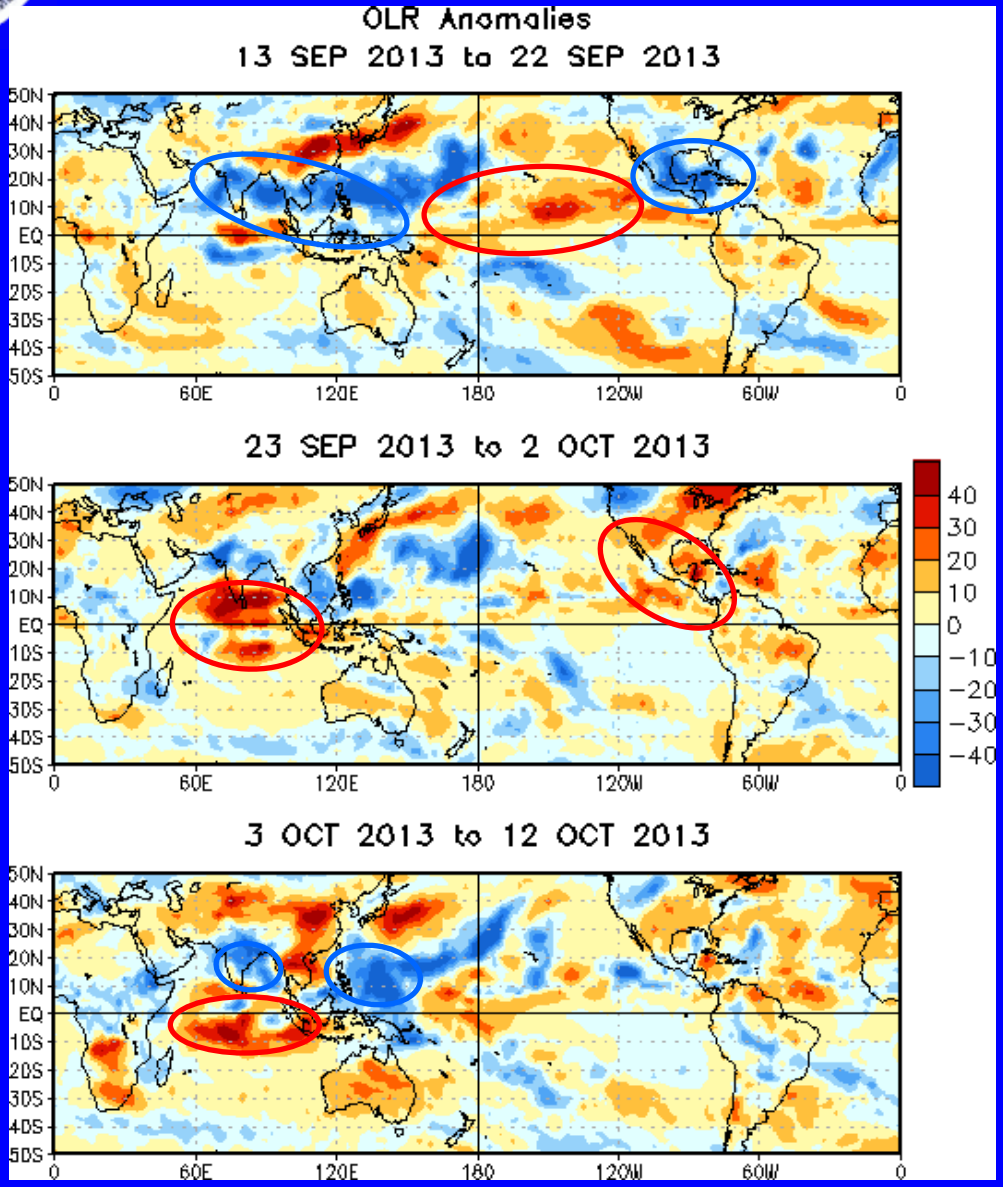
The MJO was active from April into early May as indicated by alternating dotted (easterly anomalies) and dashed (westerly anomalies) lines.

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.

Most recently, a more stationary pattern is observed in the low-level wind anomalies with other types of tropical intraseasonal variability also evident.

OLR Anomalies – Past 30 days



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

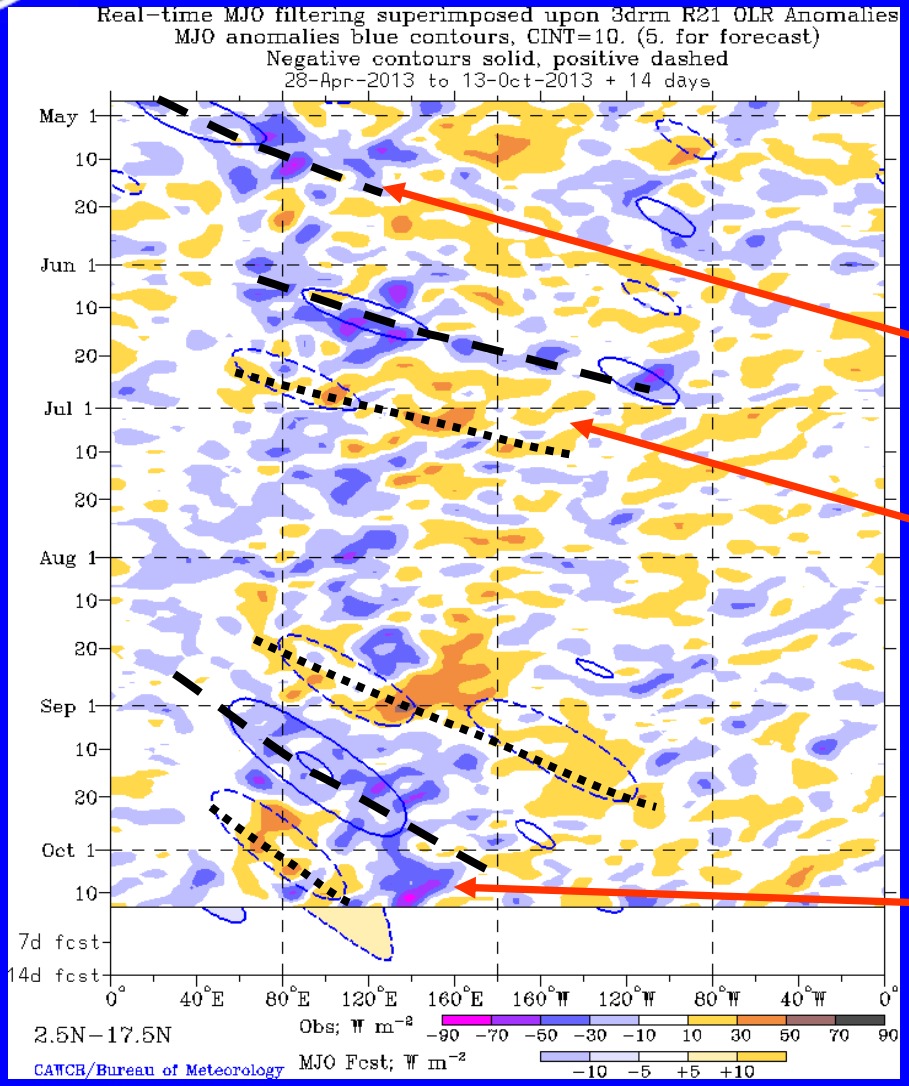
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-September, enhanced convection spread persisted over South Asia and shifted northeast across the Maritime Continent and west Pacific, consistent with the MJO. Enhanced convection persisted over North America due to tropical cyclone activity.

During late September, enhanced convection waned across the Maritime Continent as suppressed convection intensified across the Indian Ocean. Suppressed convection developed across North America as well.

Enhanced convection across the west Pacific and Bay of Bengal is associated with tropical cyclone activity during early October. Suppressed convection persisted across the equatorial Indian Ocean.

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 enhanced convection shifted east.

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

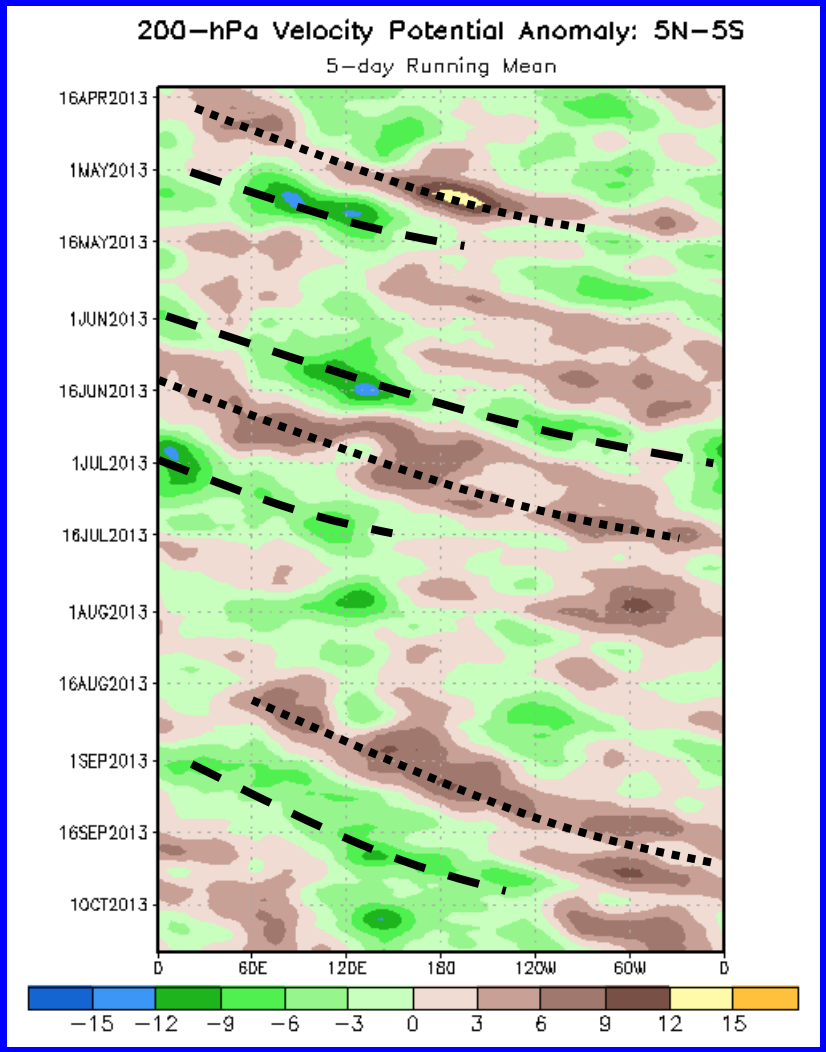
MJO was active during September, with the enhanced phase propagating east over the west Pacific Ocean, and the suppressed phase strengthening over the Indian Ocean.

Tropical cyclone activity contributed to the persistence of enhanced convection across the west Pacific as well as a weakened suppressed convective phase further west.

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.

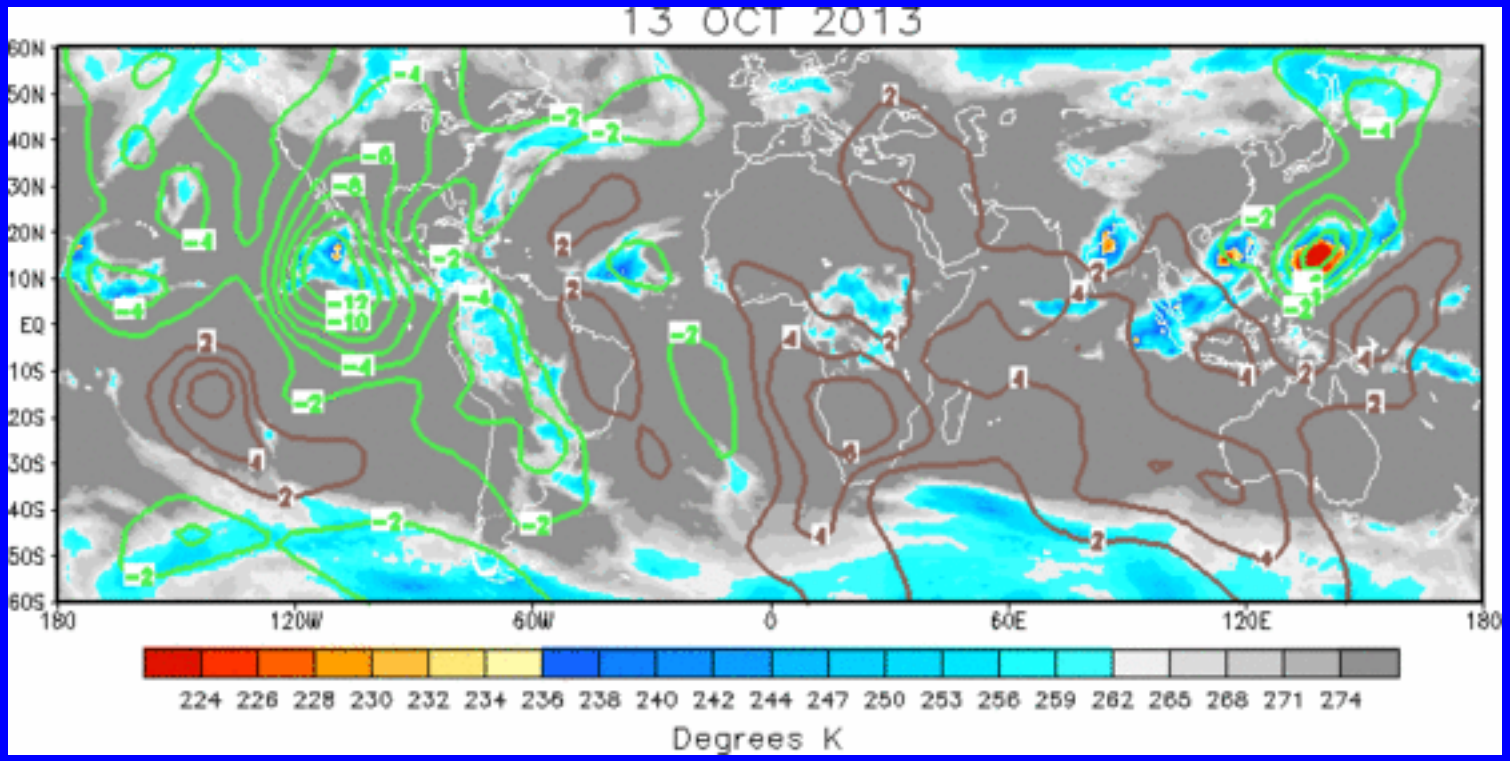
The MJO strengthened once again during June and the first half of July before weakening by the end of the month.

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

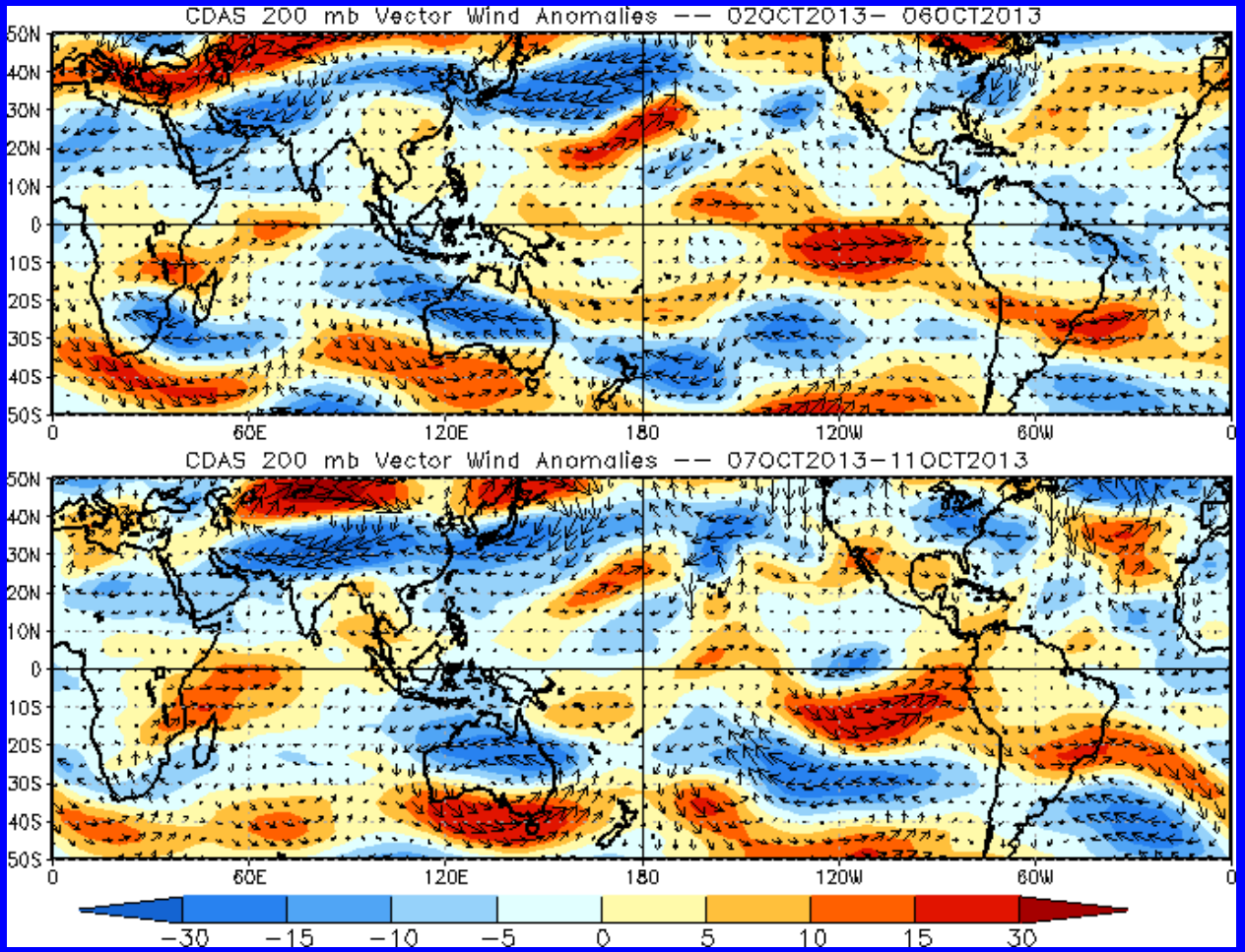
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The velocity potential pattern remains coherent with upper-level divergence shifting east across the Pacific to the Americas. Upper-level convergence prevails across Africa and the Indian Ocean with some interference from tropical cyclones across the Bay of Bengal and west Pacific.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

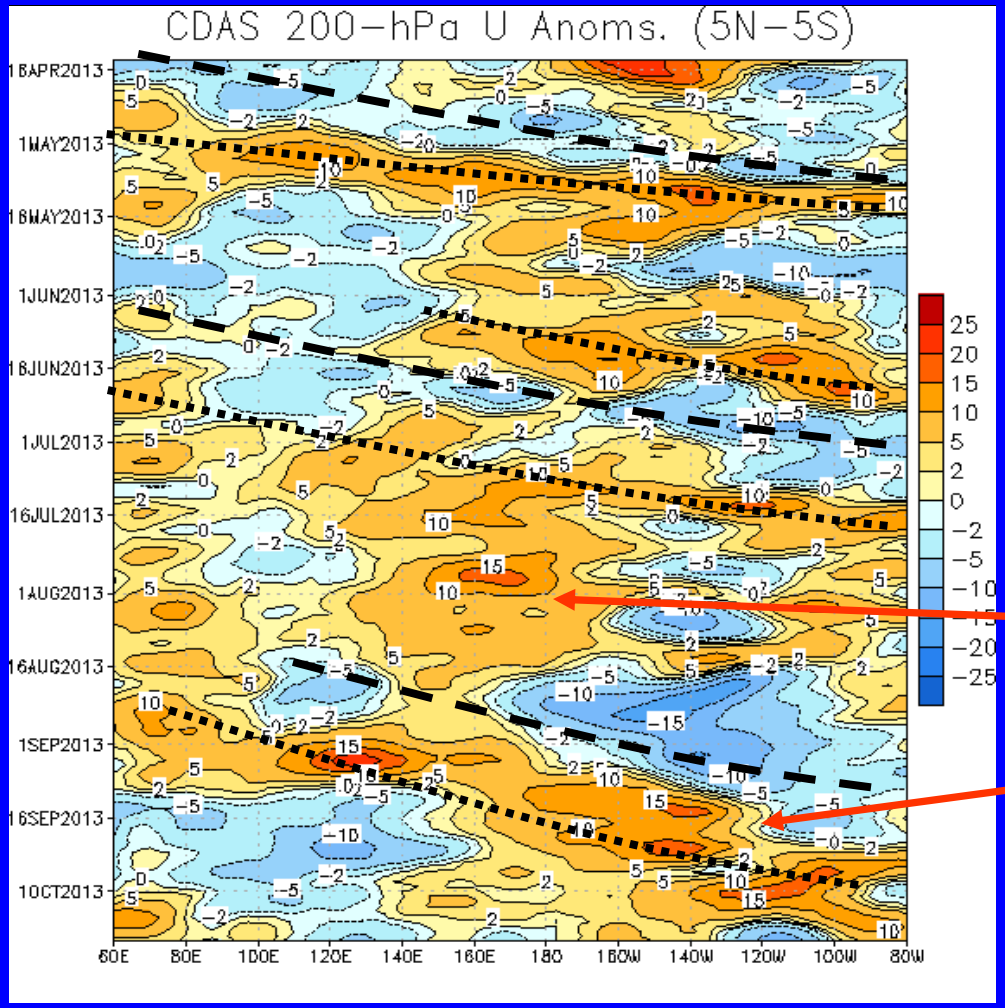
Red shades: Westerly anomalies

Westerly upper level zonal wind anomalies persisted across the equatorial Indian Ocean and weakened across the Pacific Ocean.

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

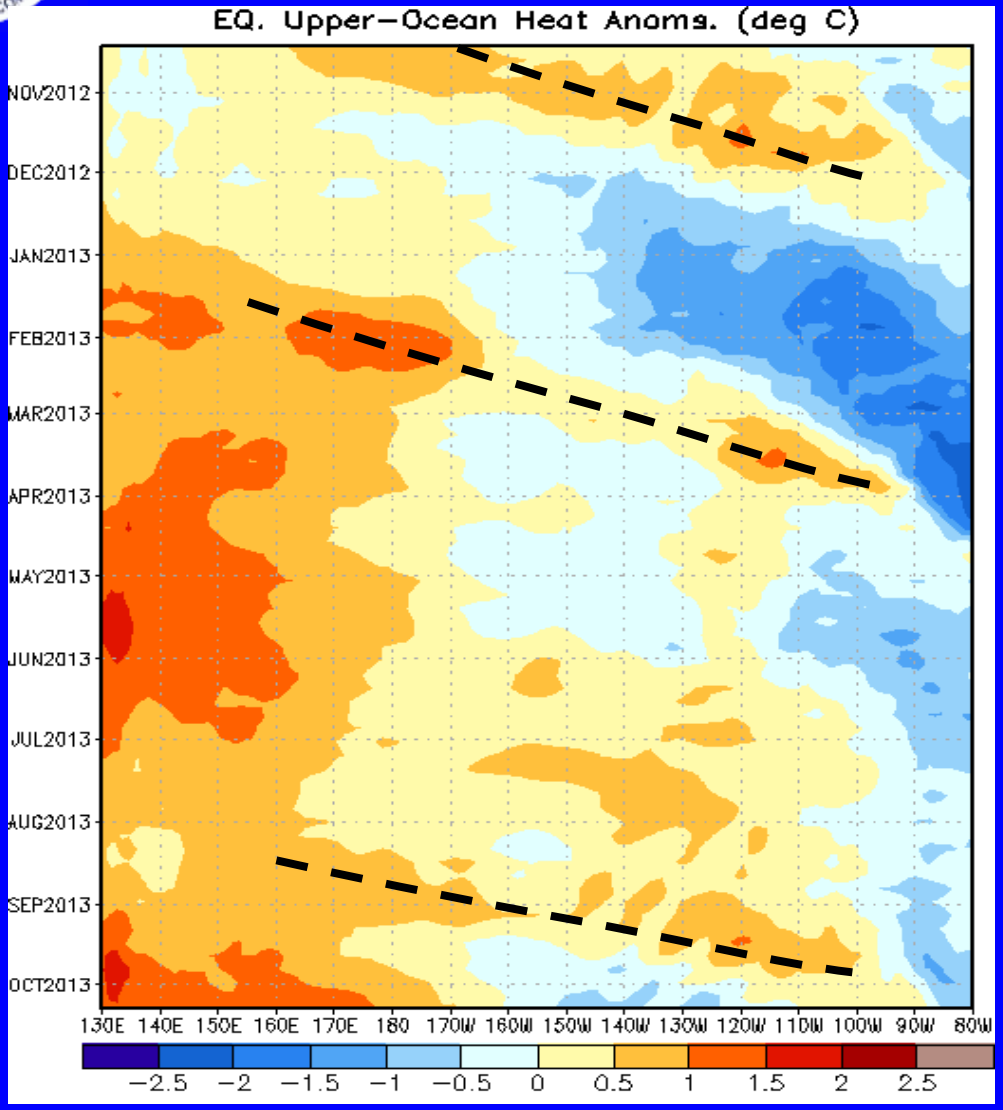
Eastward propagation of wind anomalies associated with the MJO (dotted and dashed lines) continued into May 2013.

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.

Renewed MJO activity occurred during late August and September with westerly wind anomalies shifting east to the eastern Pacific.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

An oceanic downwelling 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 evidence of an oceanic downwelling 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).

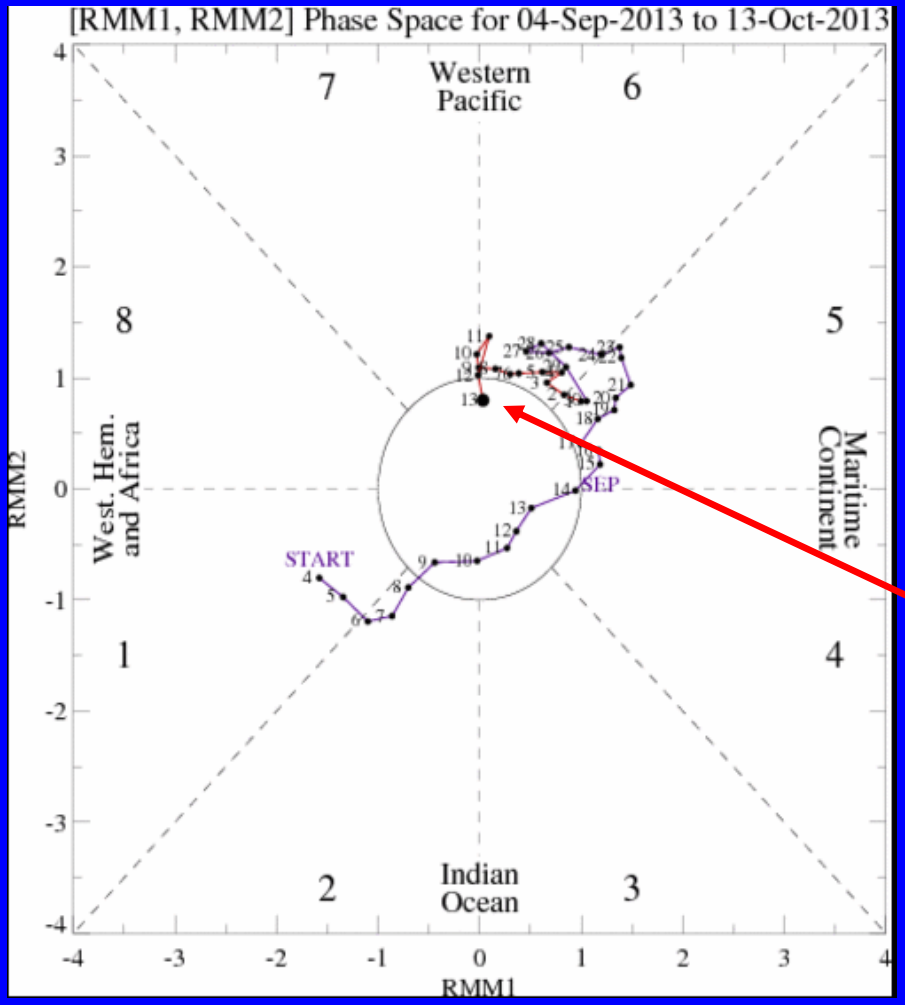
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

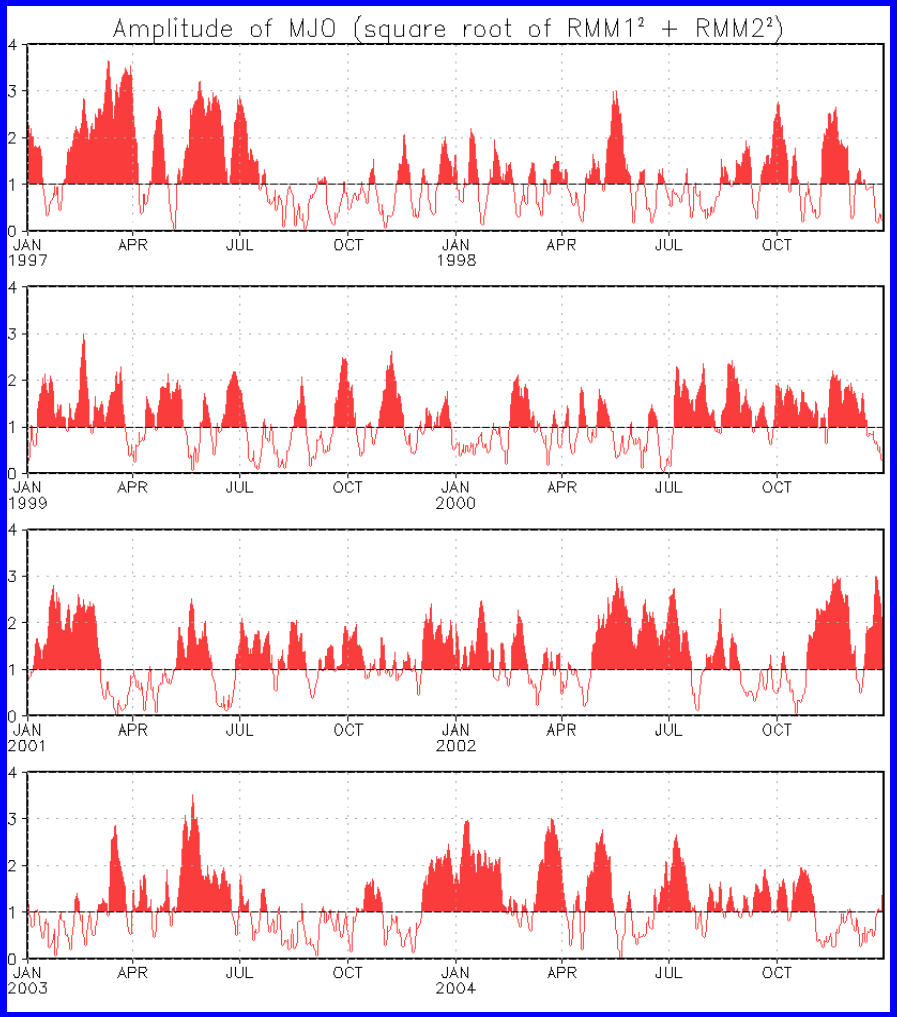
MJO Index -- Recent Evolution

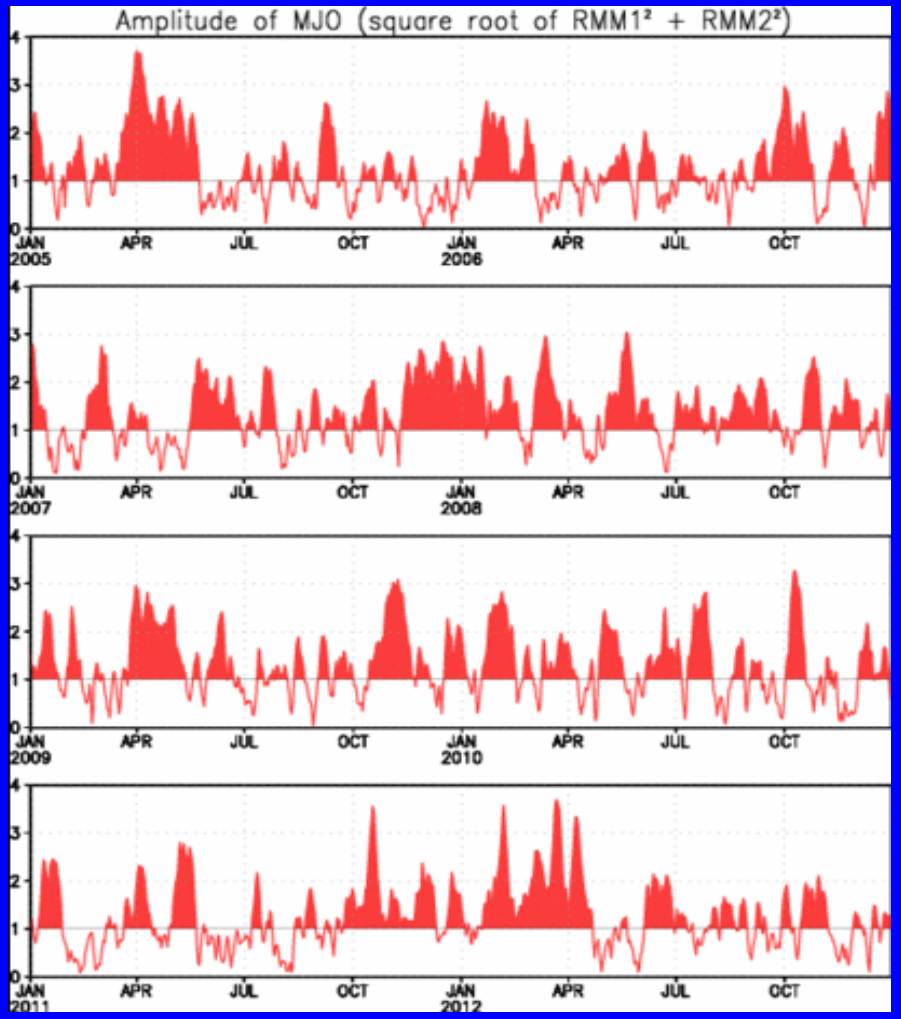


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

During the past two to three weeks, the MJO index exhibited little eastward propagation, in part due to the influence from other types of coherent 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.

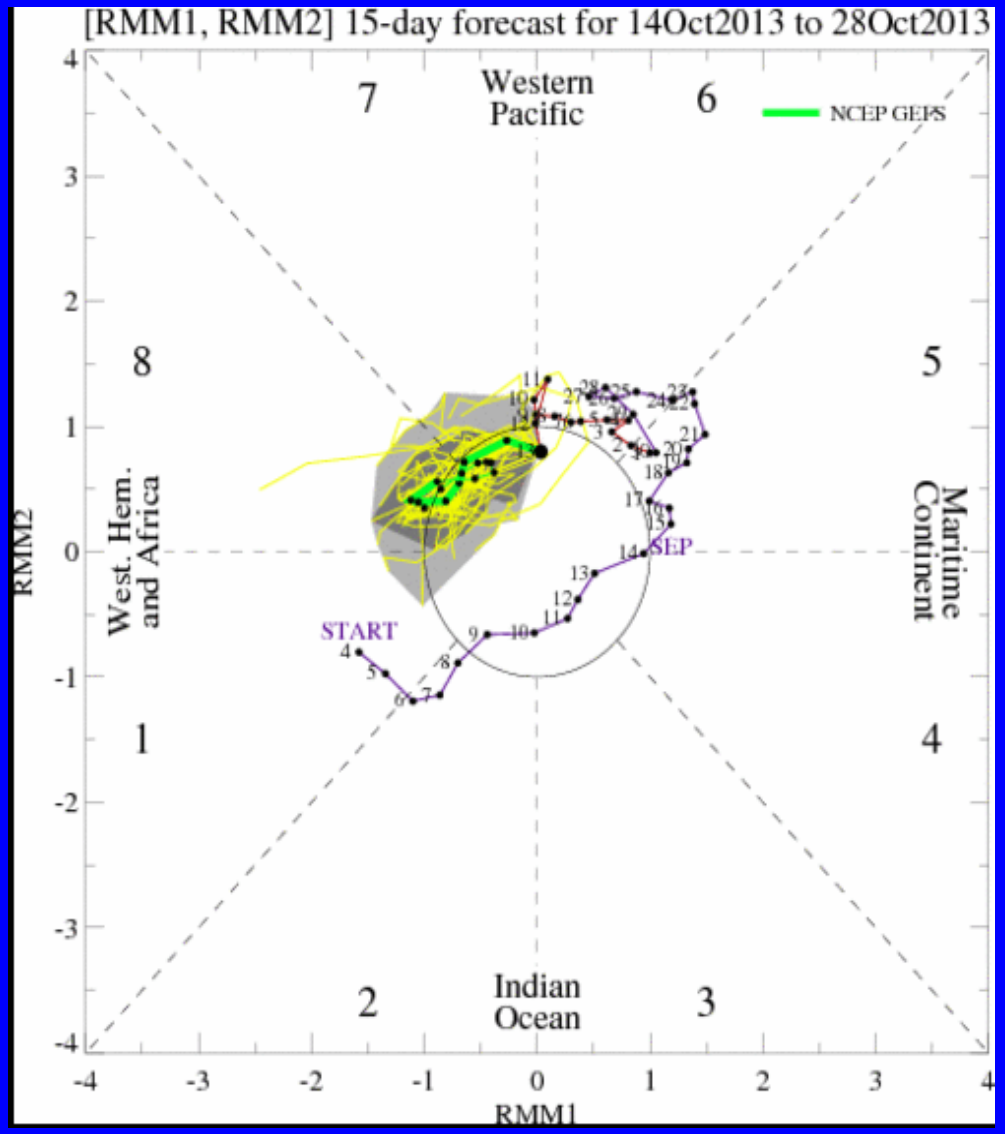
Ensemble GFS (GEFS) MJO Forecast

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

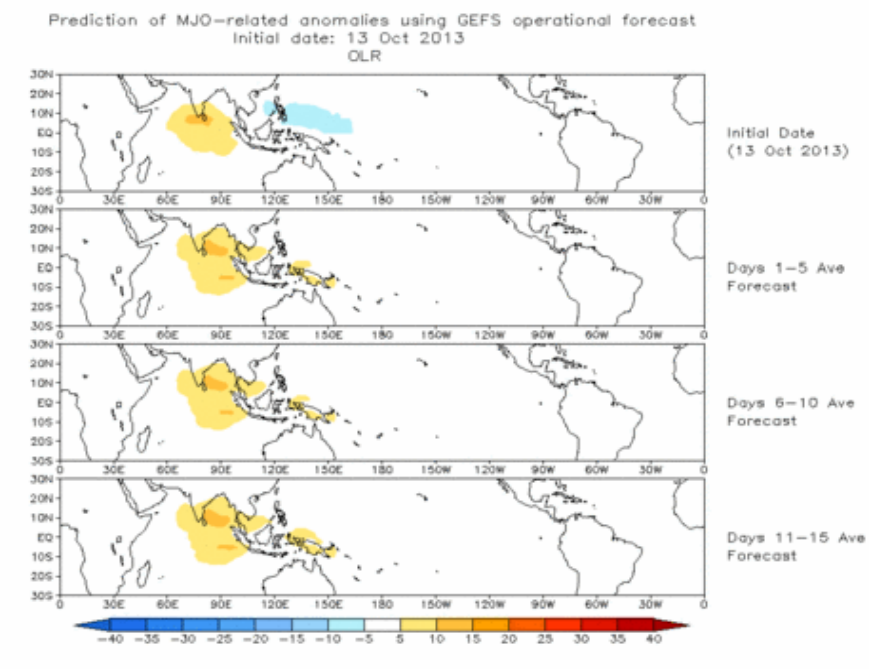
The ensemble GFS indicates a weak MJO signal shifting east during Week-1.



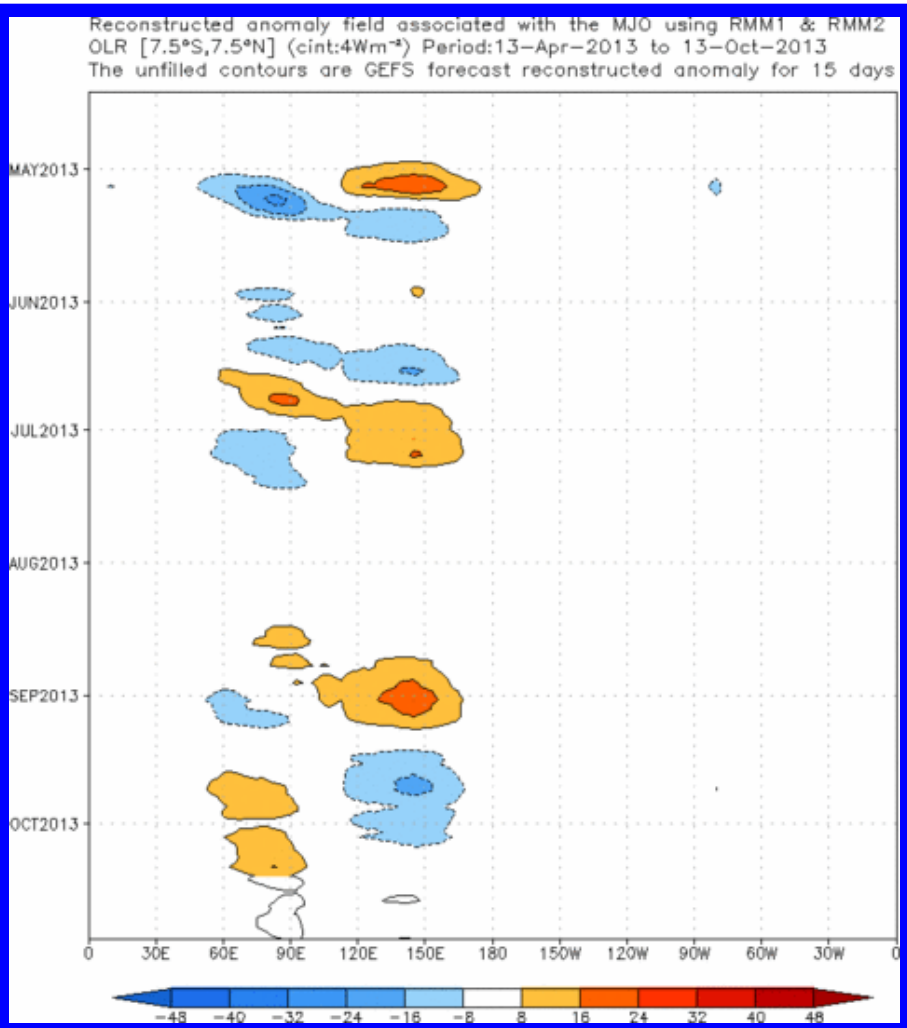
Ensemble Mean GFS MJO Forecast

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

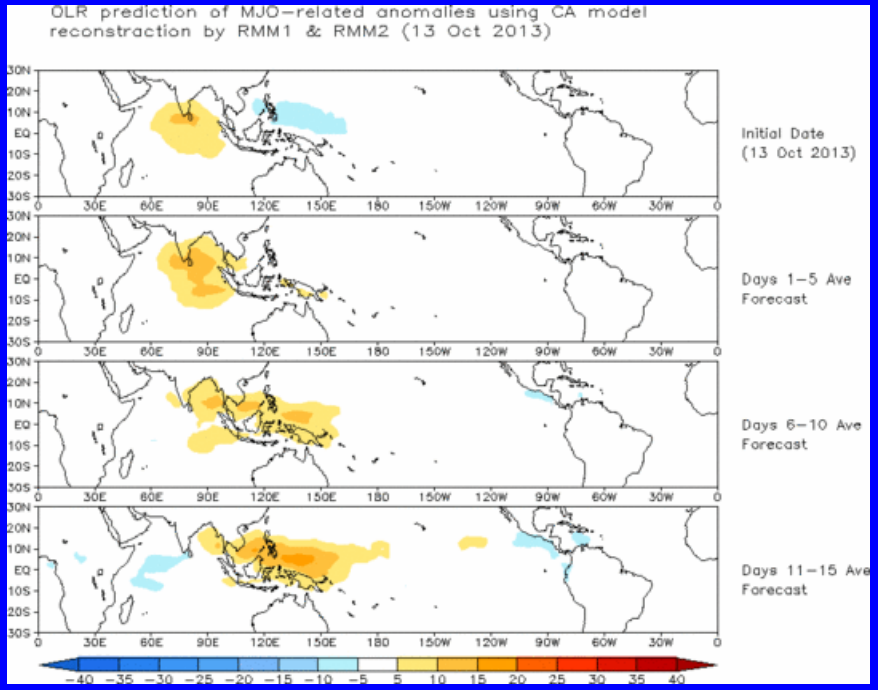


The ensemble mean GFS forecasts suppressed convection persisting across the Indian Ocean and expanding east to the Maritime Continent by Week-2.

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



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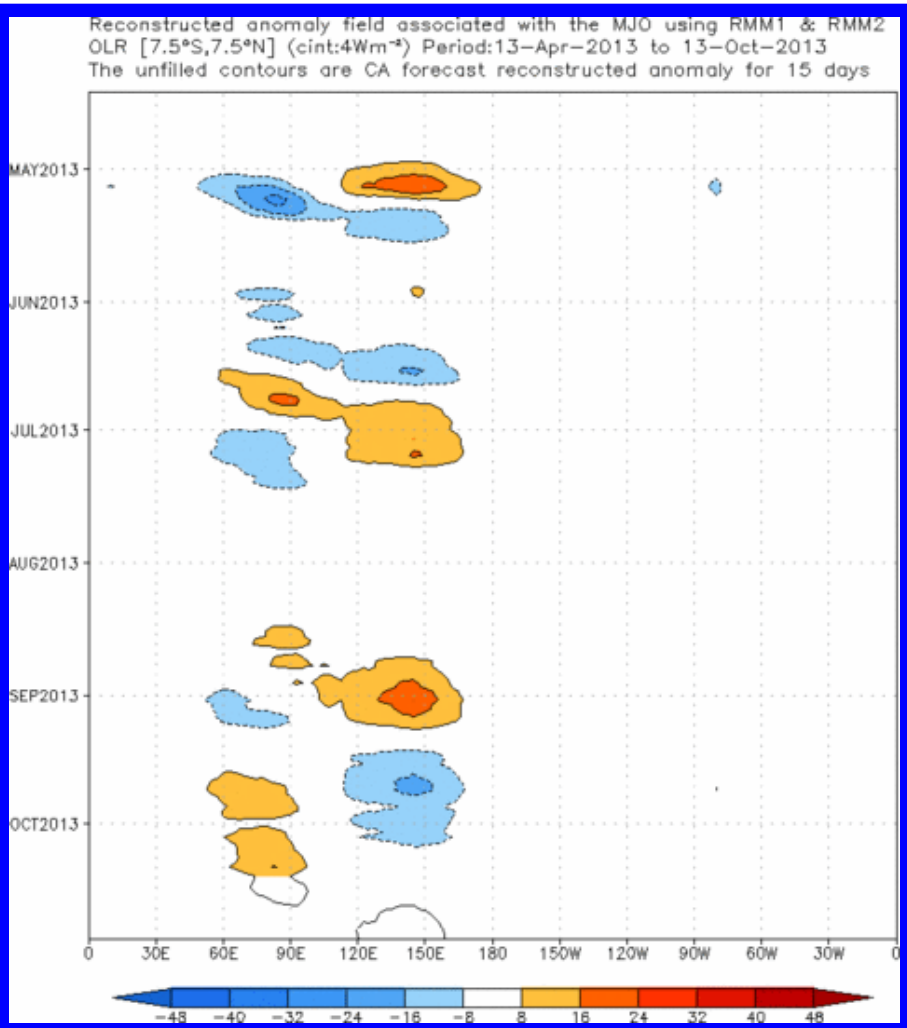
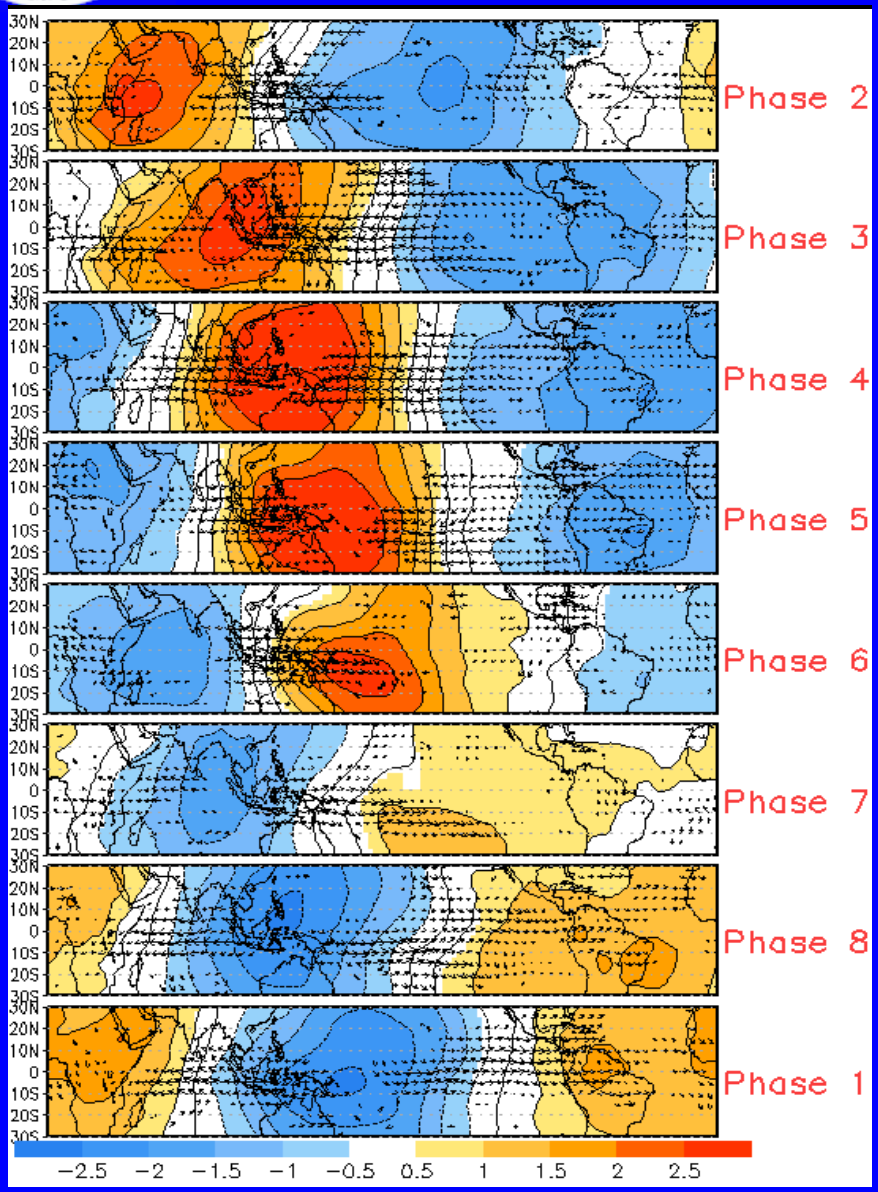


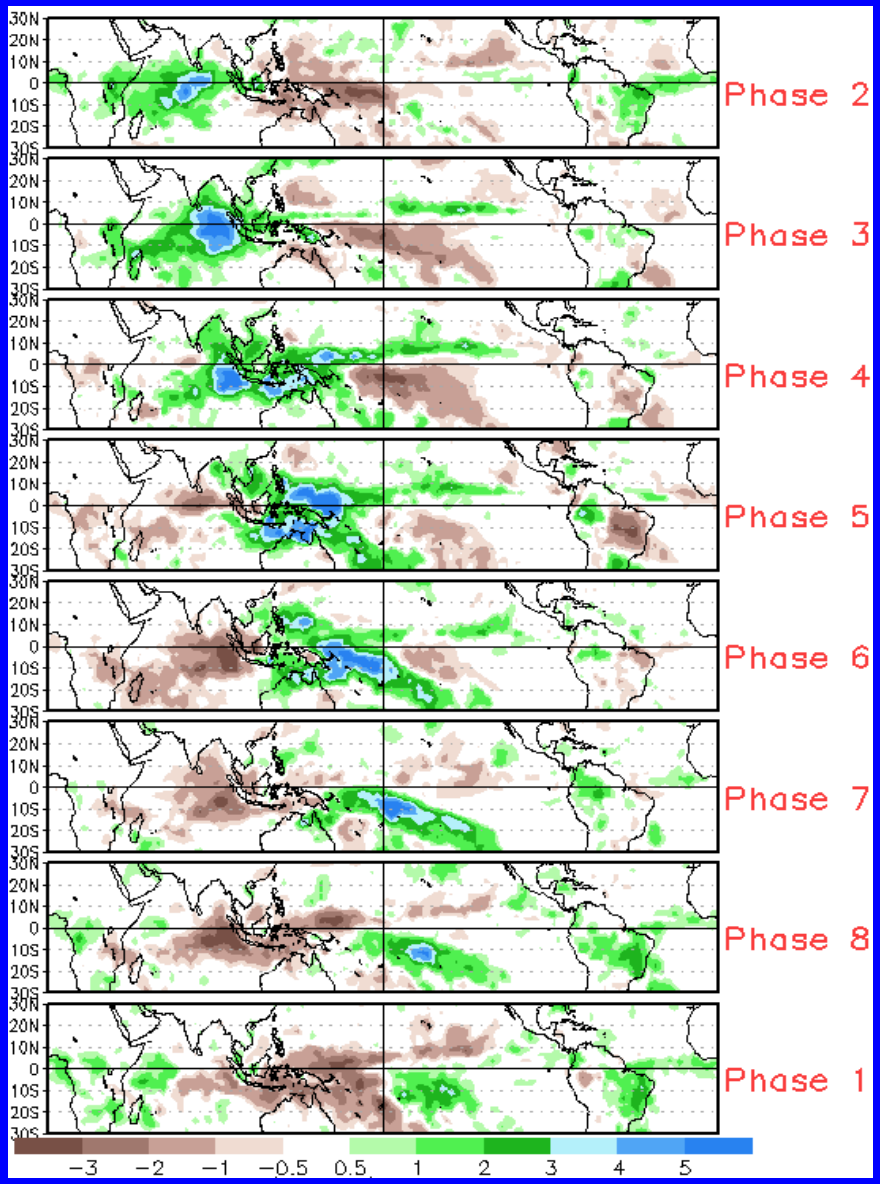
The constructed analog MJO forecast exhibits more eastward propagation of the signal than the dynamical GFS, with suppressed convection building over the Maritime Continent by the end of week-2.

MJO Composites – Global Tropics

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

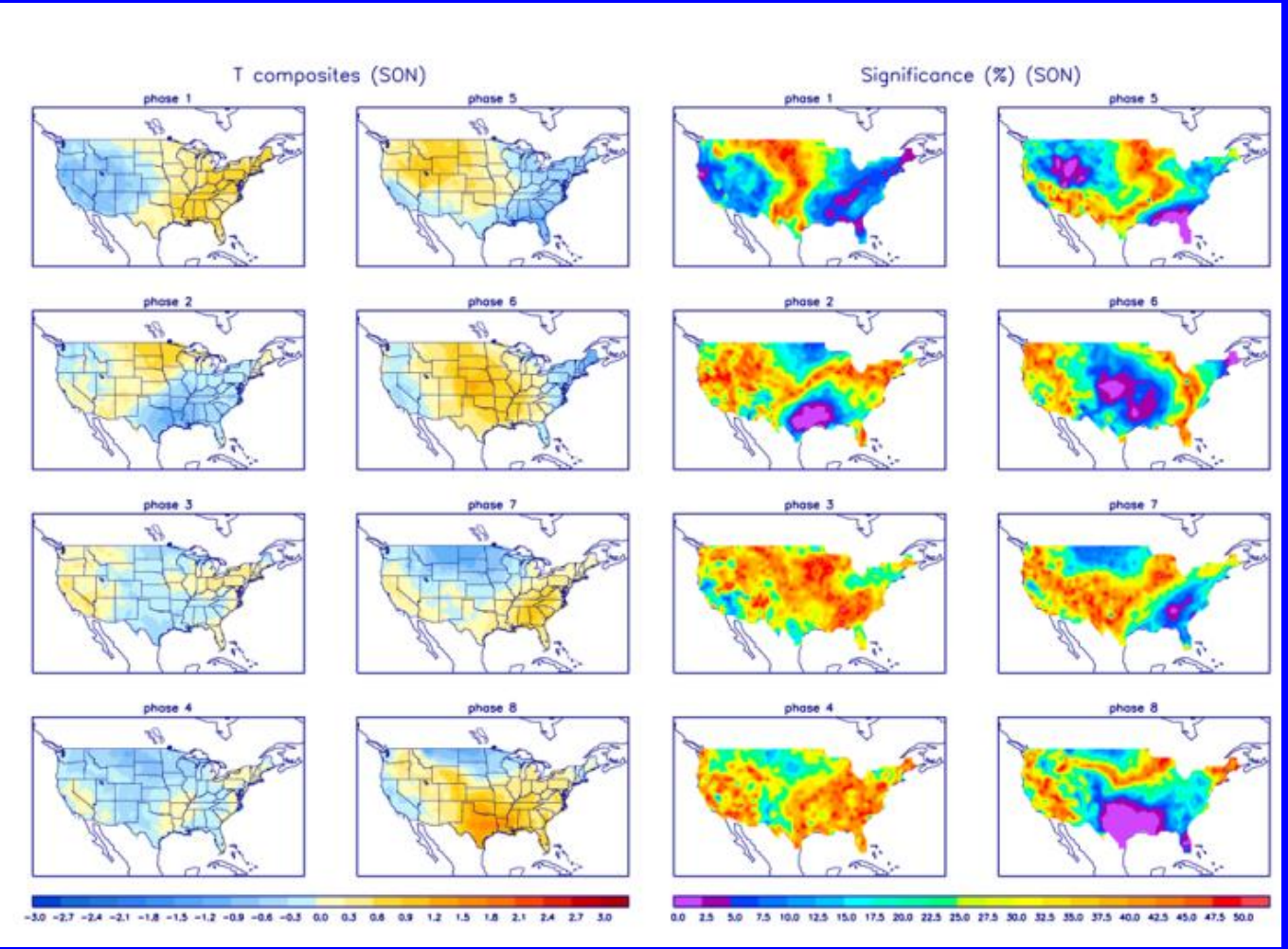


Precipitation Anomalies (Nov-Mar)



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.**

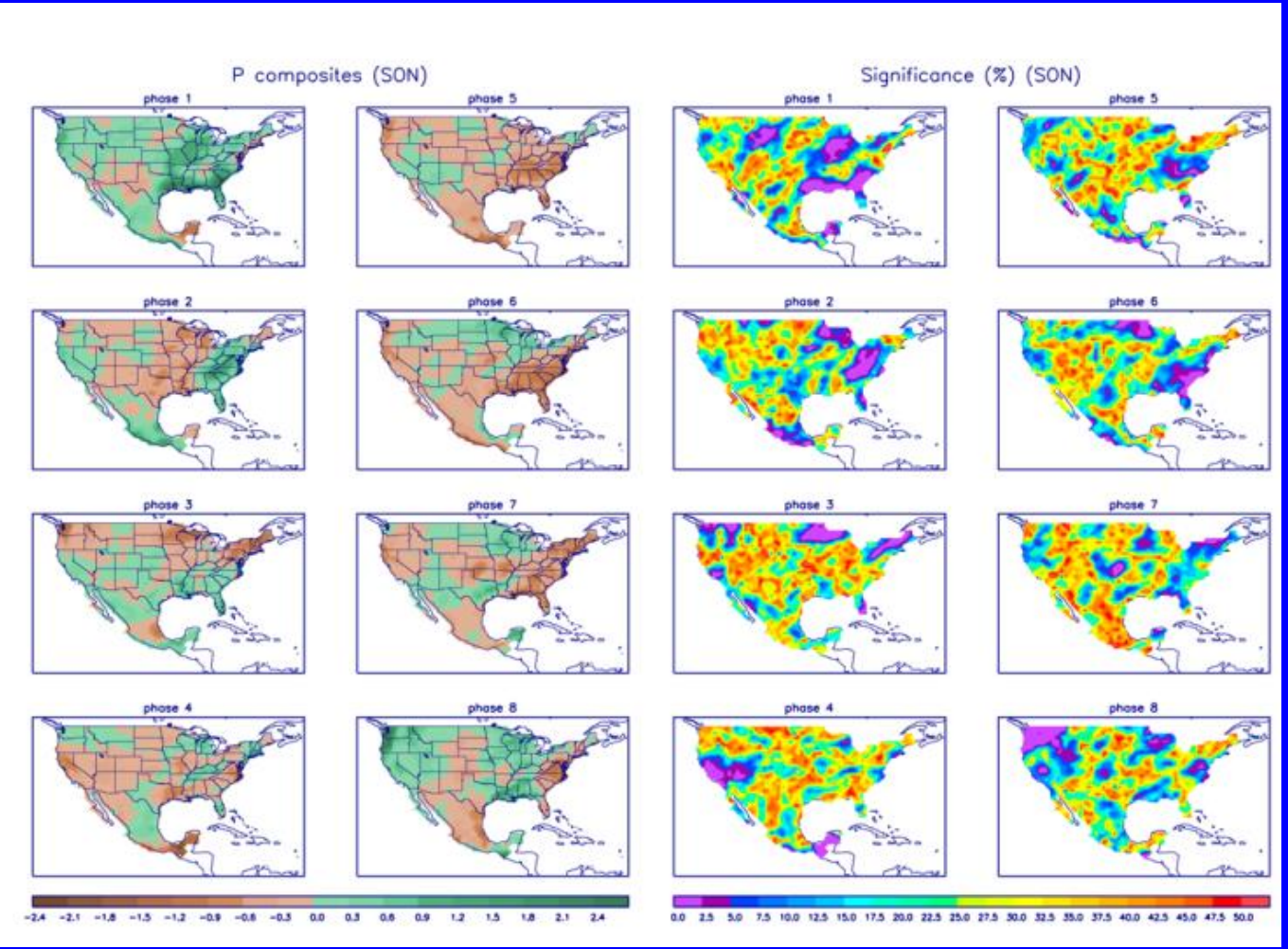


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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