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

Update prepared by
Climate Prediction Center / NCEP
November 11, 2013

Outline

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

Overview

- The MJO was active but fairly weak over the past 7 to 10 days with the enhanced phase propagating eastward to the Indian Ocean.

- Dynamical model MJO index forecasts generally indicate a weak signal over the next several days as other modes of variability interfere with and overwhelm the MJO signal. The dynamical forecasts show an eastward moving signal reemerging over the Western Hemisphere during Week-2. Statistical forecasts suggest a continued weak signal.

- Based on recent observations and dynamical MJO index forecasts, the MJO is forecast to remain generally weak over the next one to two weeks, with any enhanced phase moving into the Pacific toward the Western Hemisphere. However, other subseasonal modes are likely to play a bigger role in tropical convective anomalies over the upcoming two weeks.

- The forecast evolution of the weak MJO could favor enhanced (suppressed) convection over parts of the Indian Ocean (southwestern Pacific) during Week-1. During Week-2, the MJO could contribute to enhanced (suppressed) convection across parts of the West Pacific (Indian Ocean).

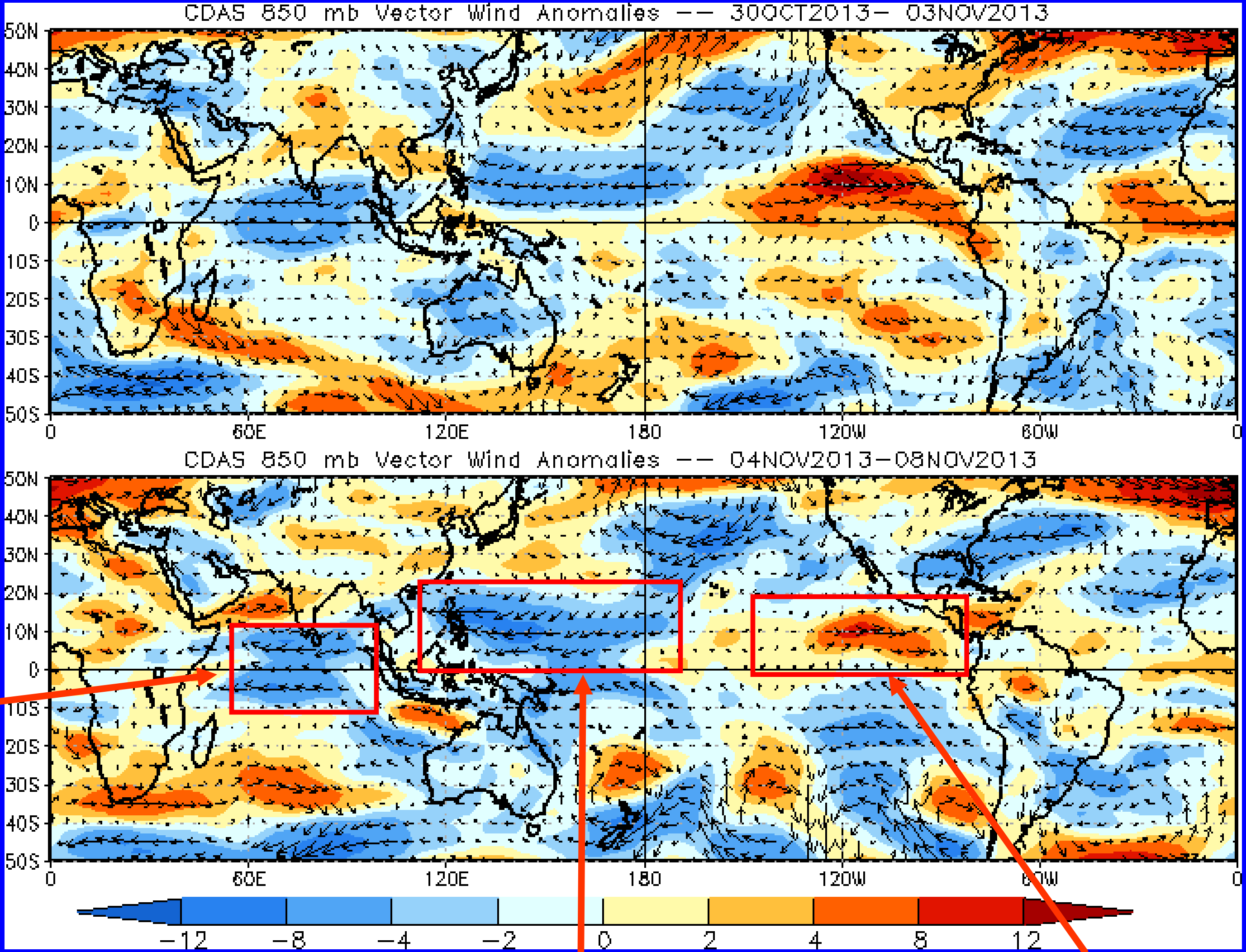
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 continued over the central Indian Ocean.

Easterly anomalies continued across the West Pacific, expanding westward with associated TC activity.

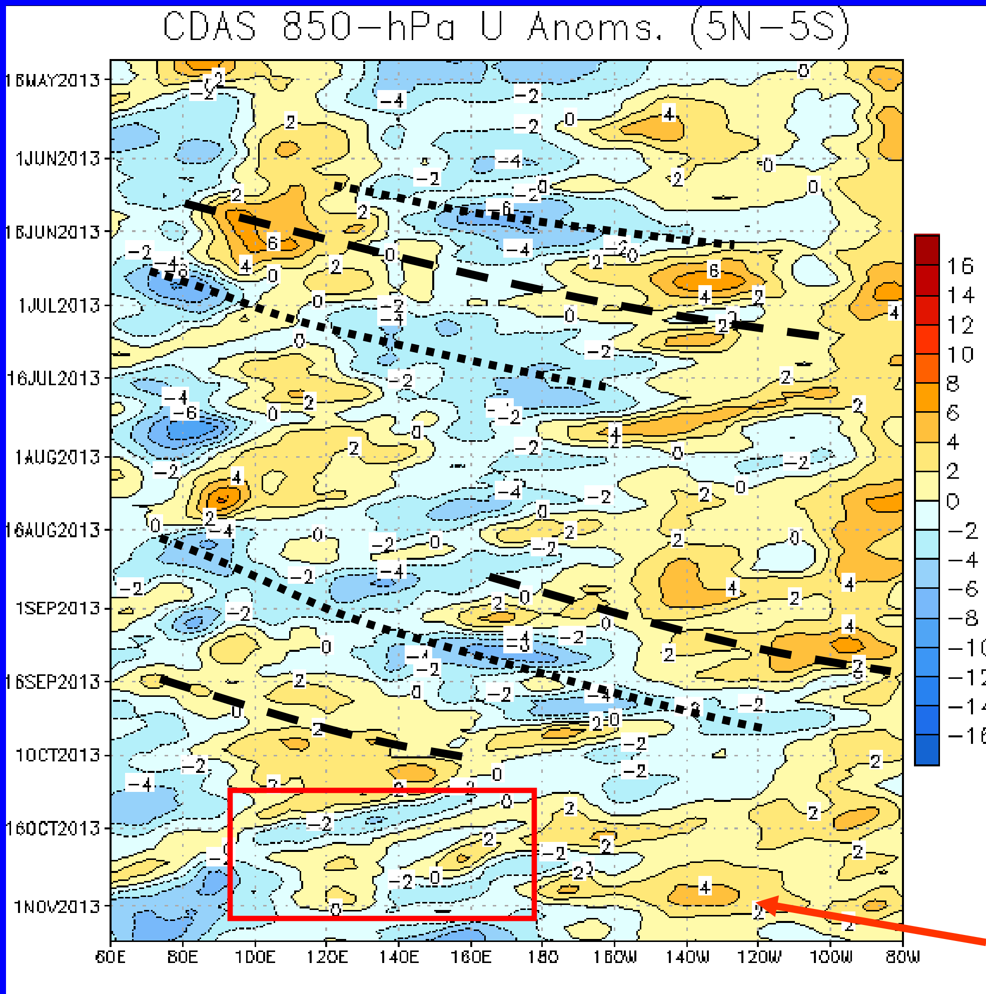
Westerly anomalies weakened over the eastern Pacific during the past five days.

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



Longitude

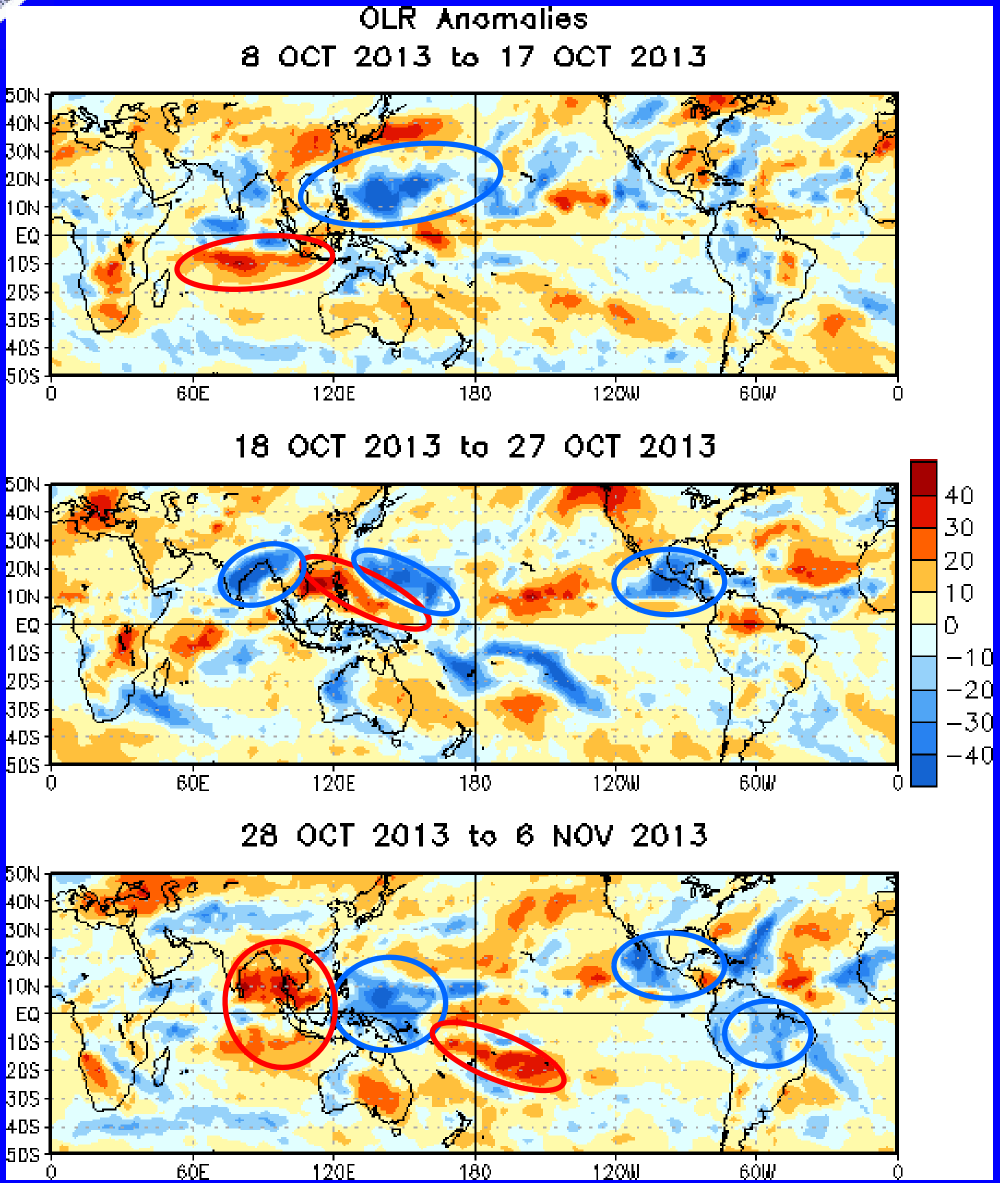
The MJO strengthened during June and continued until mid-July with fast eastward propagation.

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

During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

Westerly anomalies persisted across the Western Hemisphere during the second half of October.

OLR Anomalies – Past 30 days



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

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

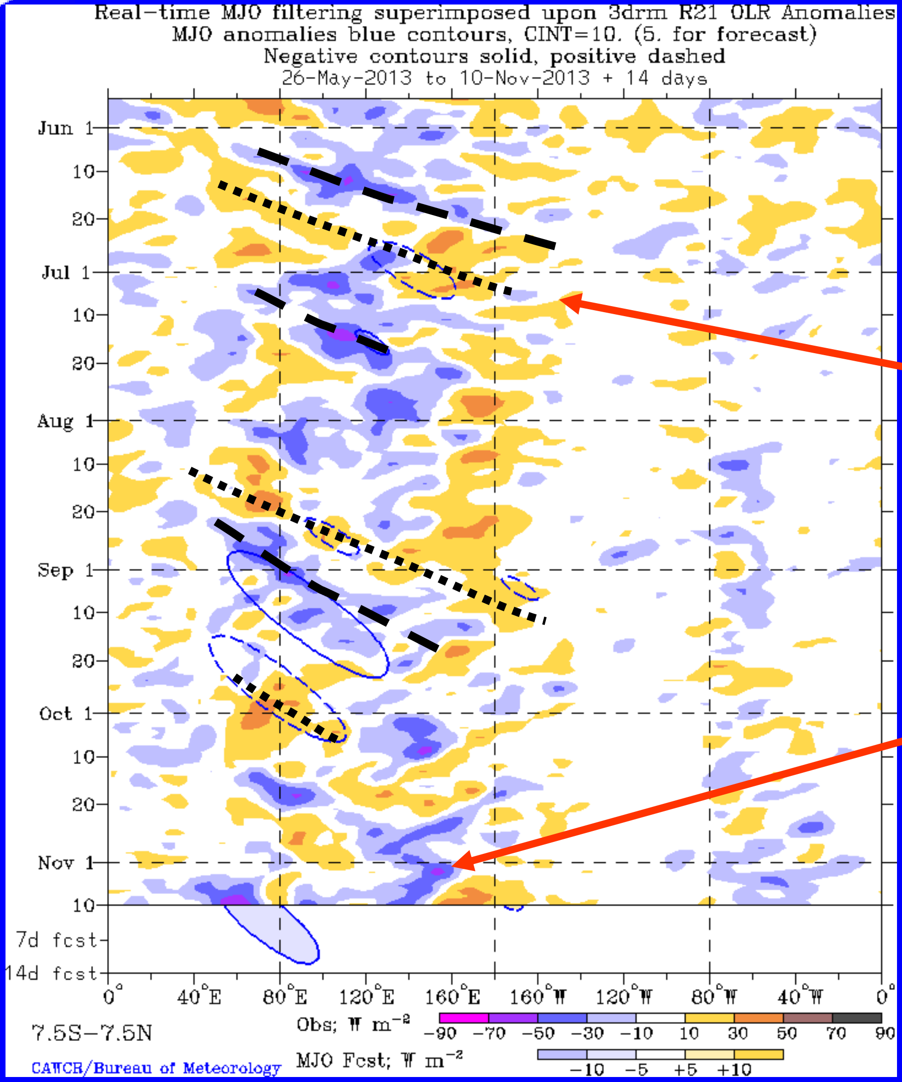
During the middle of October, enhanced convection was centered north of the equator across the West Pacific where tropical cyclones were active. Convective signals were mixed over much of the Indian Ocean.

Late in the month, convective activity was strongest across parts of the West Pacific (again due, in part, to tropical disturbances). Convective activity also increased across parts of southern Asia and Central America.

During late October and early November, enhanced (suppressed) convection was observed across parts of the eastern Maritime Continent and West Pacific(eastern Indian Ocean and parts of the South Pacific). Anomalous convection continued across the east Pacific and Central America while developing across parts of South America.

Outgoing Longwave Radiation (OLR) Anomalies (7.5°N-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)

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

MJO was active during late August and September with the enhanced phase propagating eastward over the western Pacific Ocean, while the suppressed phase strengthened over the Indian Ocean.

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

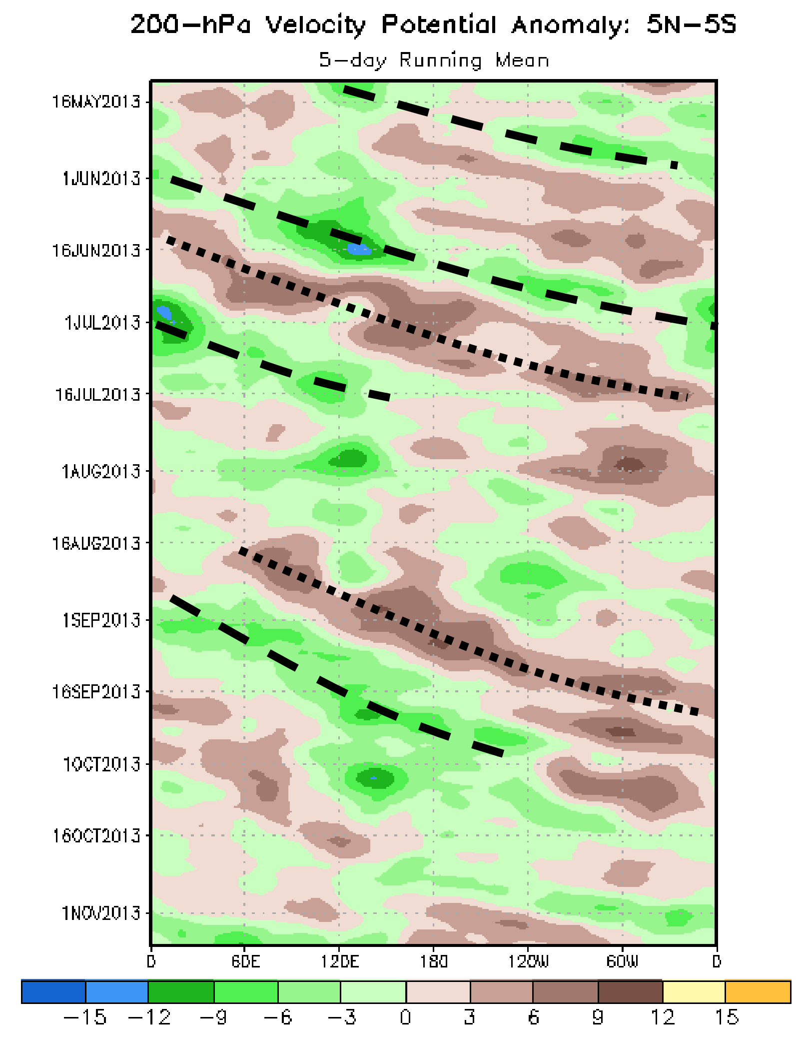
Recently there has been some development of convective anomalies across the western Indian Ocean, consistent with the evolution of the MJO through phases 1 and 2.

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 (alternating dashed and dotted lines) during June and early July before weakening at the end of the month.

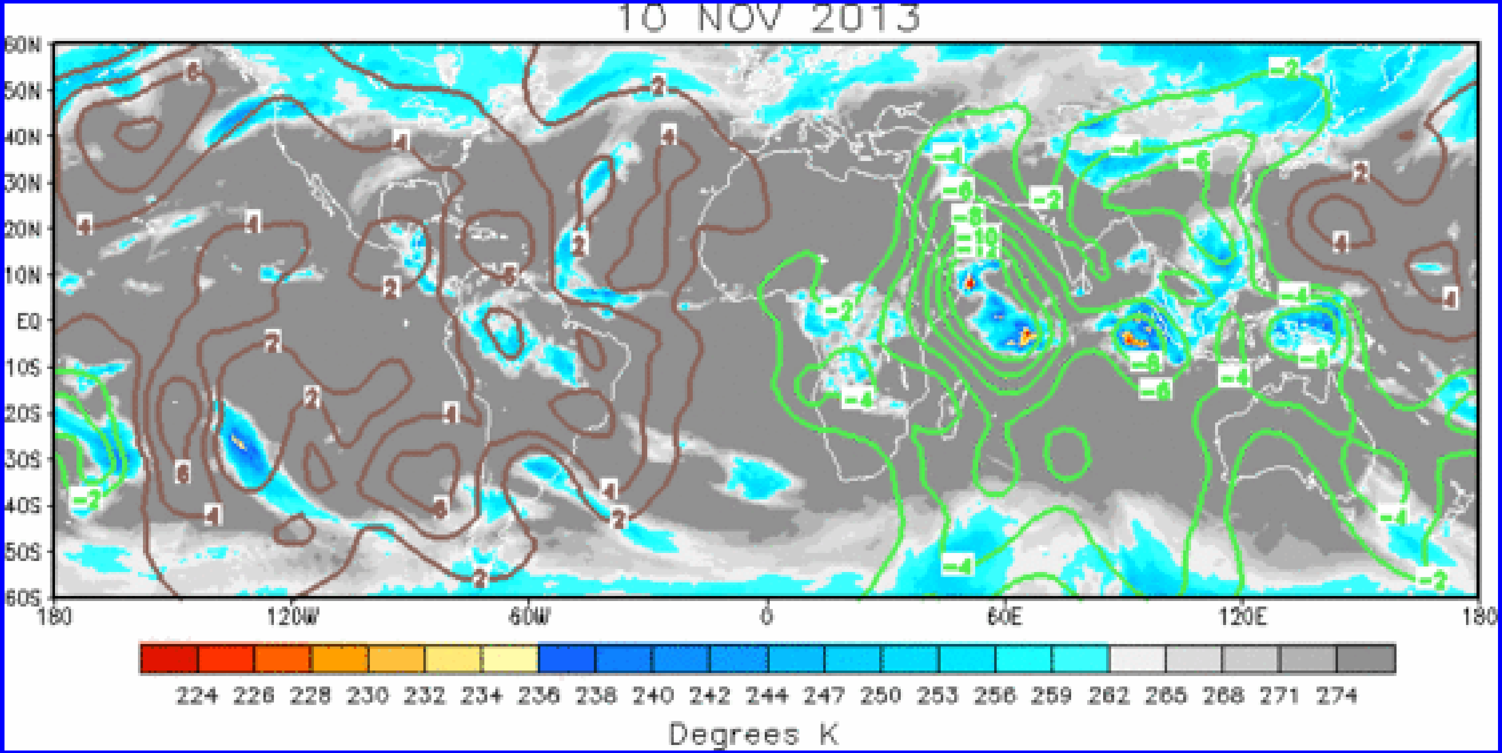
The MJO was not active during late July and much of August, but strengthened during late August and September, with eastward propagation of robust upper-level velocity potential anomalies. Other modes of tropical intraseasonal variability are also evident.

During the second half of October, upper-level velocity potential exhibited little MJO related variability. Recently, some coherent eastward propagation on the fast side of the MJO envelope of phase speeds has been observed.

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



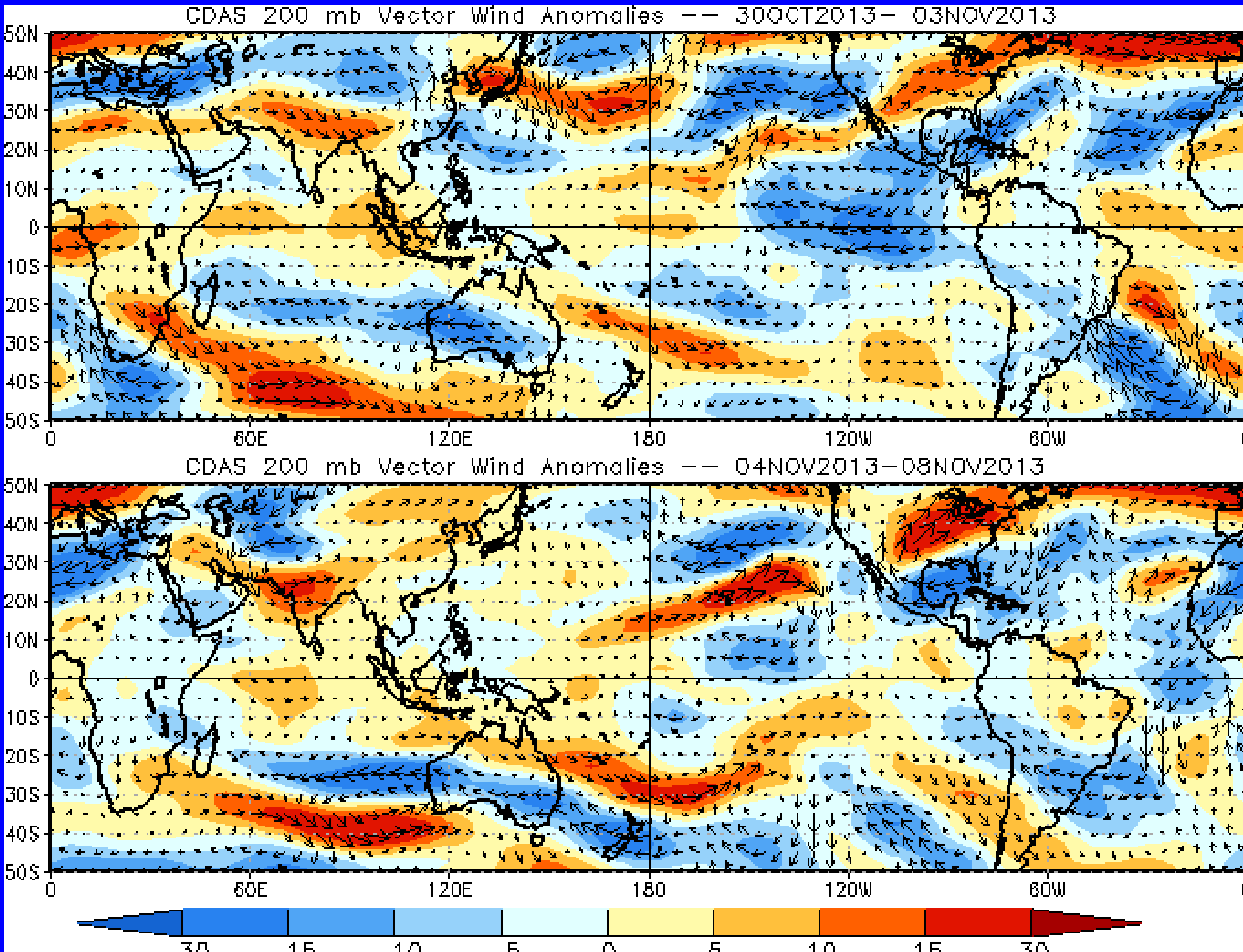
The velocity potential pattern has remained organized during the past week, with a classic Wave-1 structure evident across the Tropics. It is consistent with an MJO enhanced phase propagating from the Western Hemisphere to the Indian Ocean, though other modes of variability are evident.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



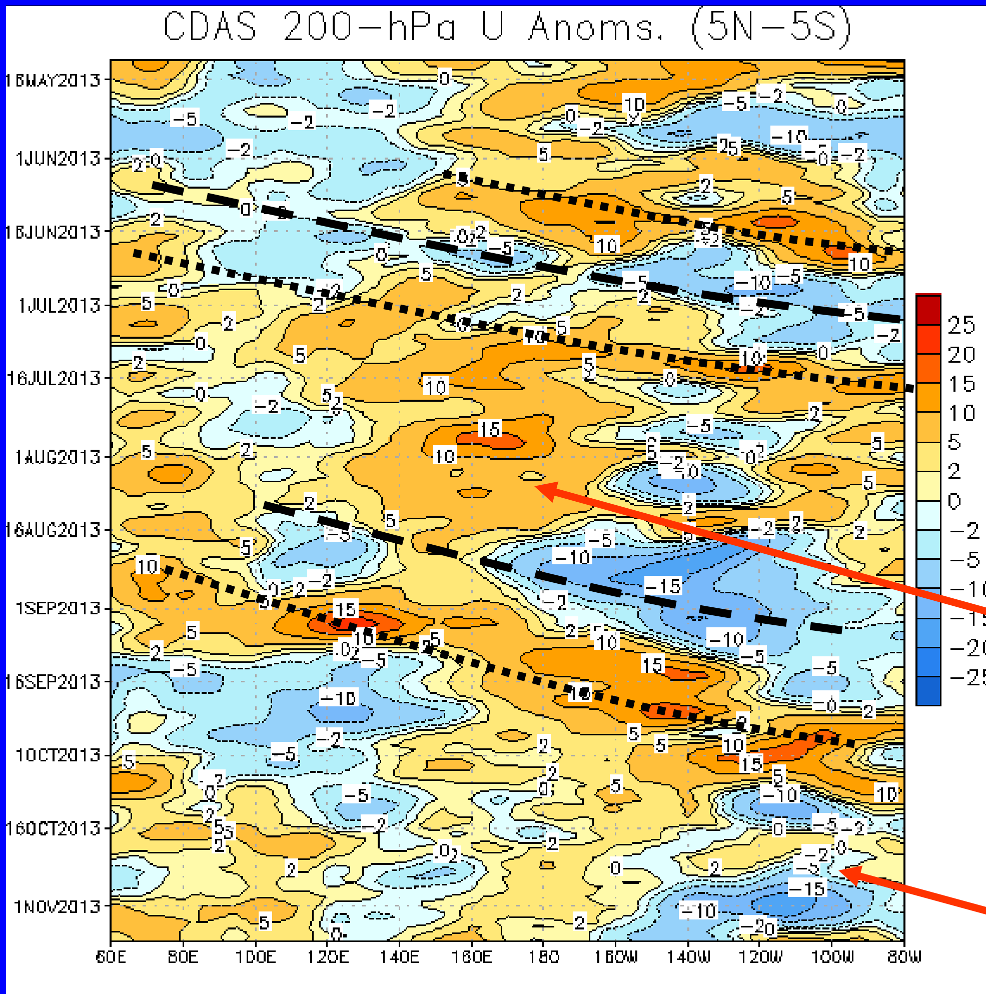
Upper-level zonal wind anomalies are generally weak across the Tropics.

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

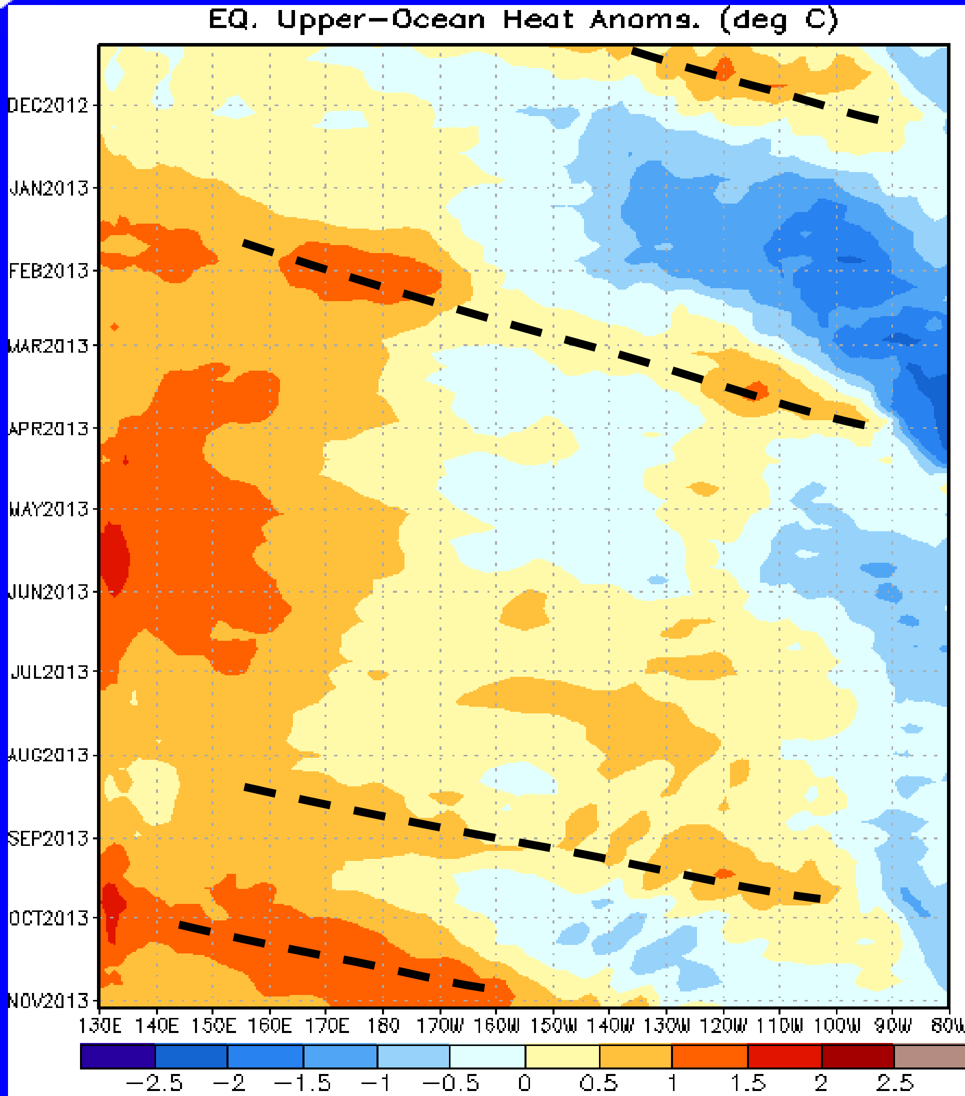
The MJO strengthened (alternating dotted and dashed lines) during June and its influence continued to mid-July, as eastward propagation of wind anomalies associated with the MJO were again observed.

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.

Most recently, anomalies of alternating sign have continued over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics.

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 2012.

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.

Evidence of oceanic downwelling Kelvin waves are seen in late August and October/November.

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).

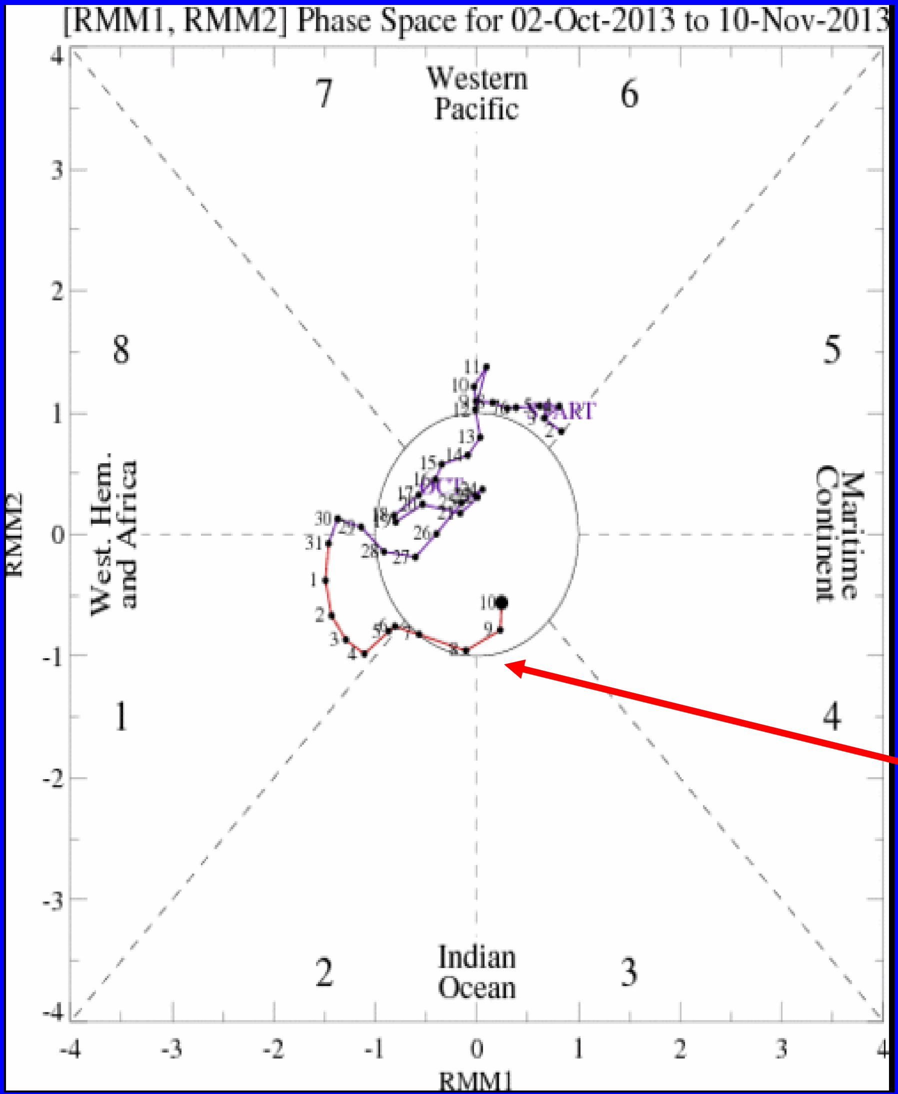
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

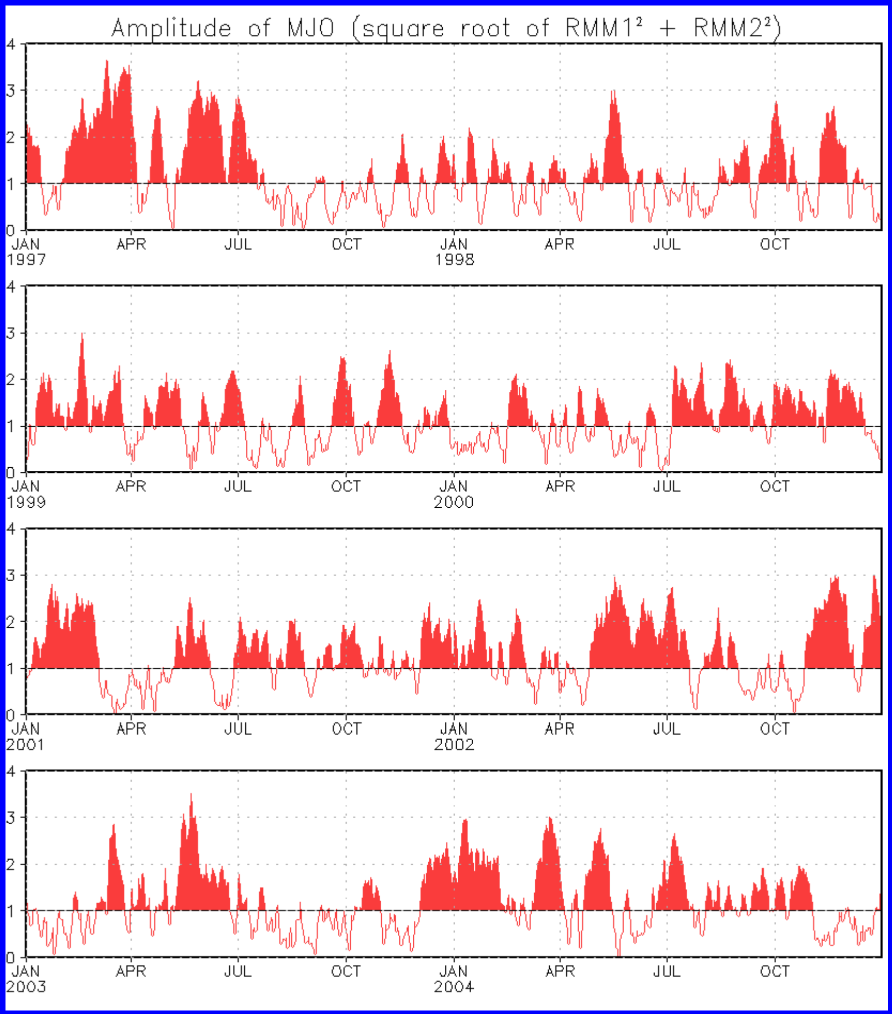
MJO Index -- Recent Evolution

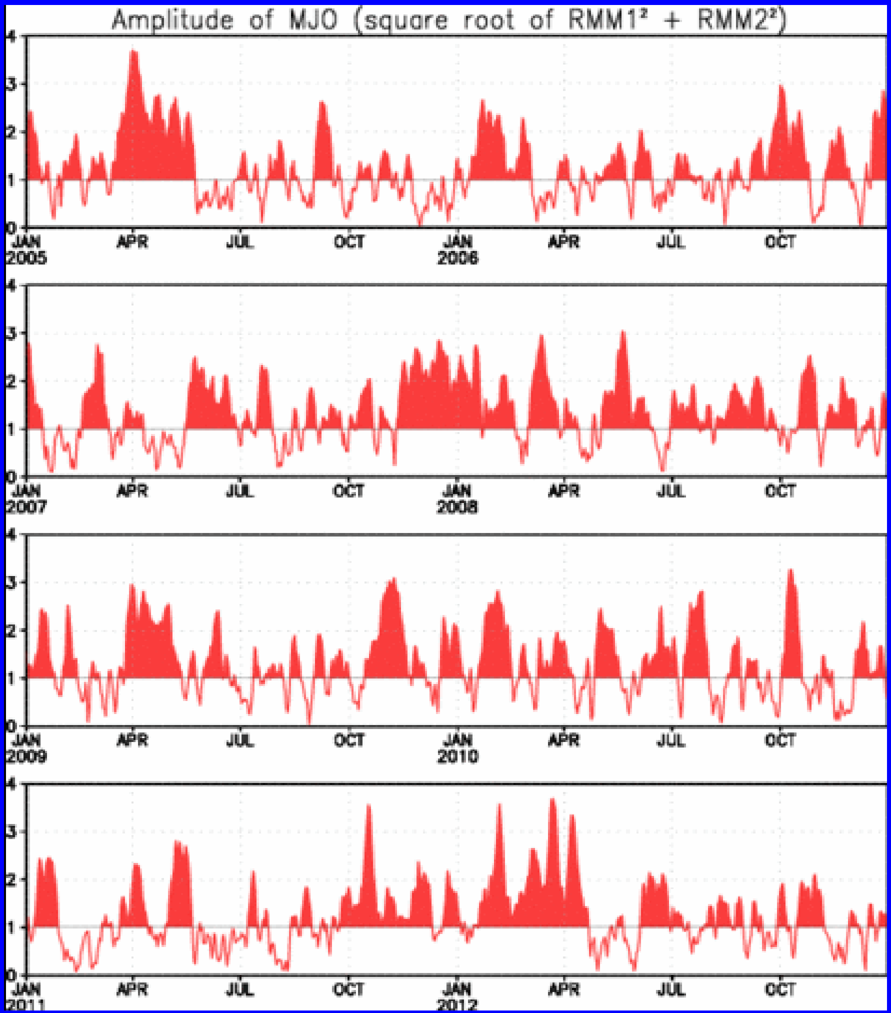


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index emerged in Phase 8 and exhibited a more canonical eastward propagation than predicted by the dynamical models over the last ten days. Recently the MJO signal as measured by the RMM index has decreased in amplitude as other subseasonal modes (esp. equatorial Rossby waves) interfered.

MJO Index – Historical Daily Time Series





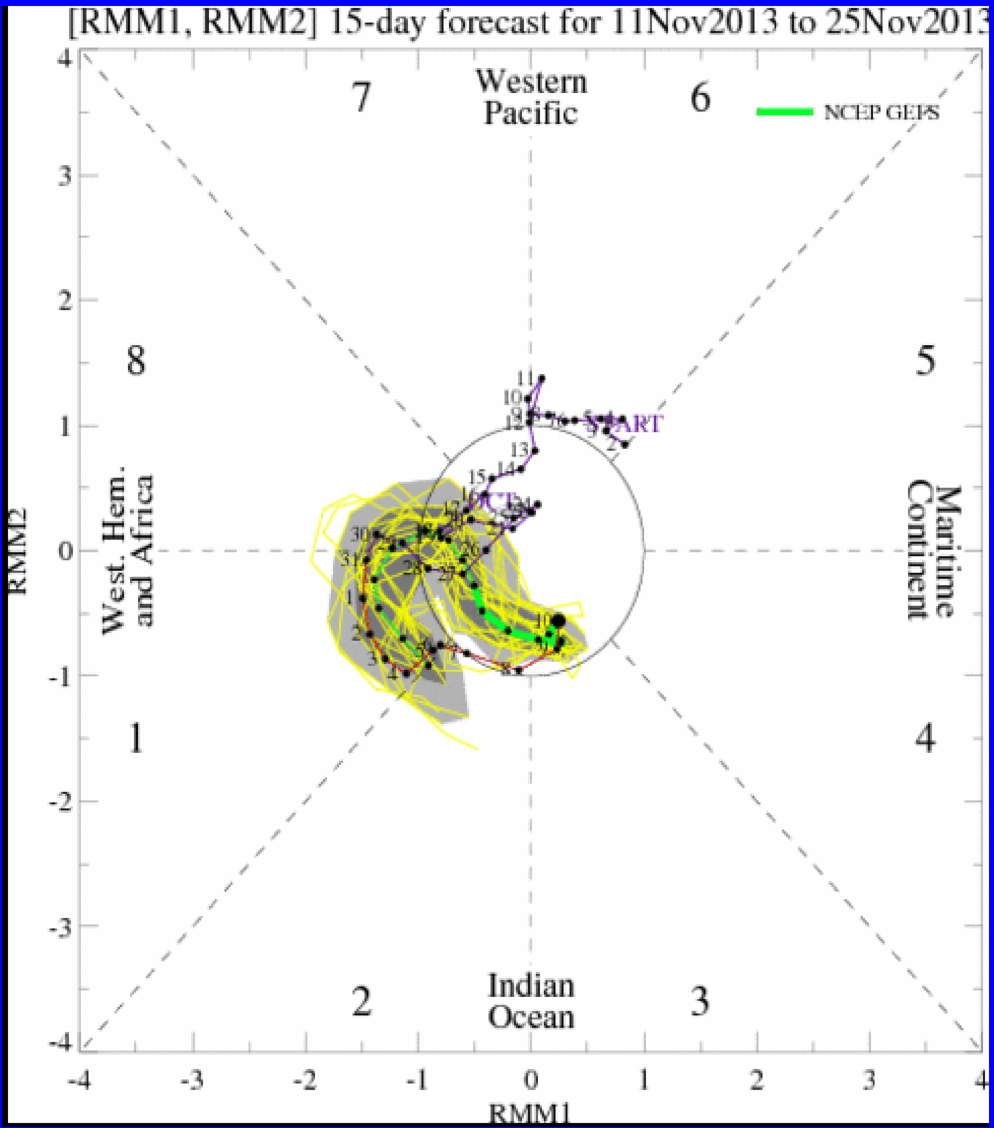
Time series of daily MJO index amplitude from 1997 to present. Plots put current MJO activity in historical context.

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

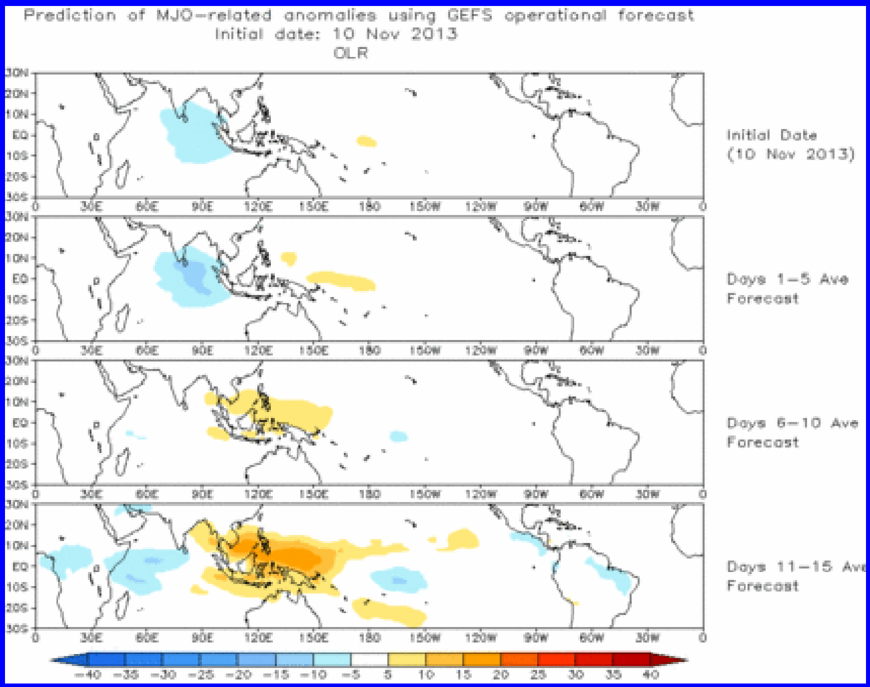


The ensemble GFS indicates a weak MJO signal under the influence of other modes of variability during Week-1, emerging again over the Western Hemisphere and Africa during Week-2.

Ensemble Mean GFS MJO Forecast

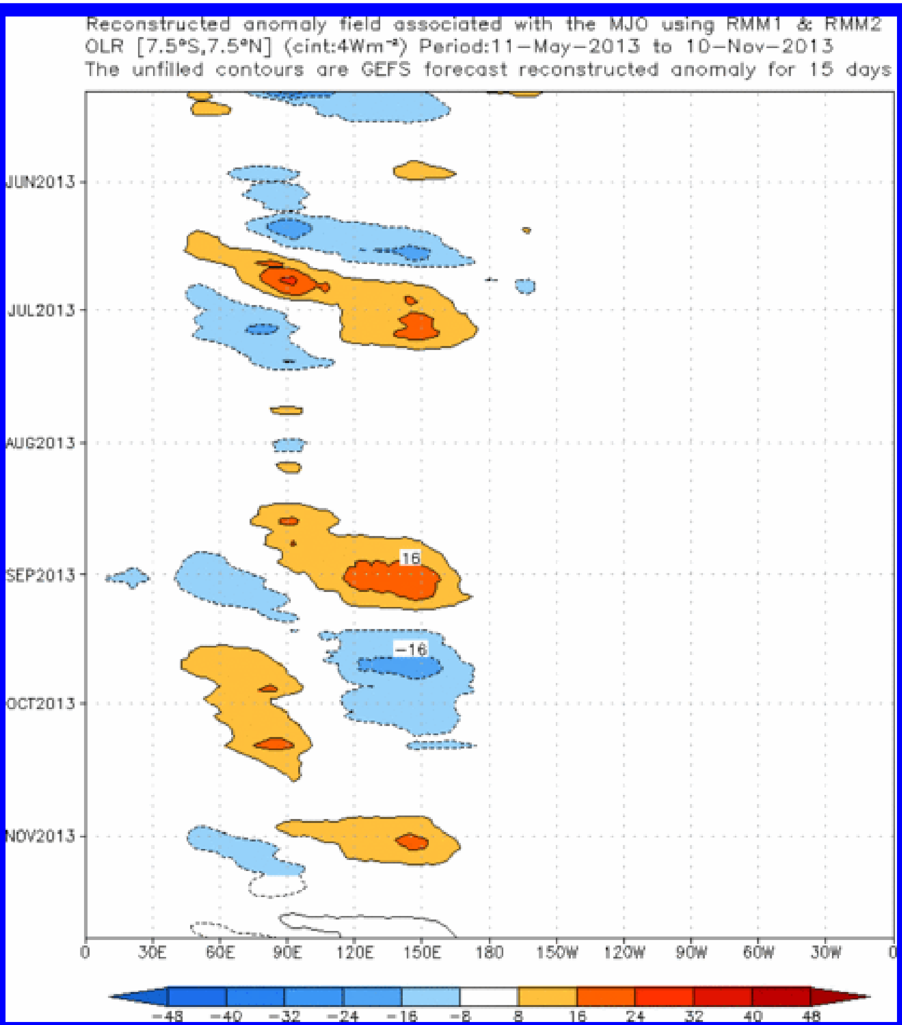
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts suppressed convection developing over the Maritime Continent.

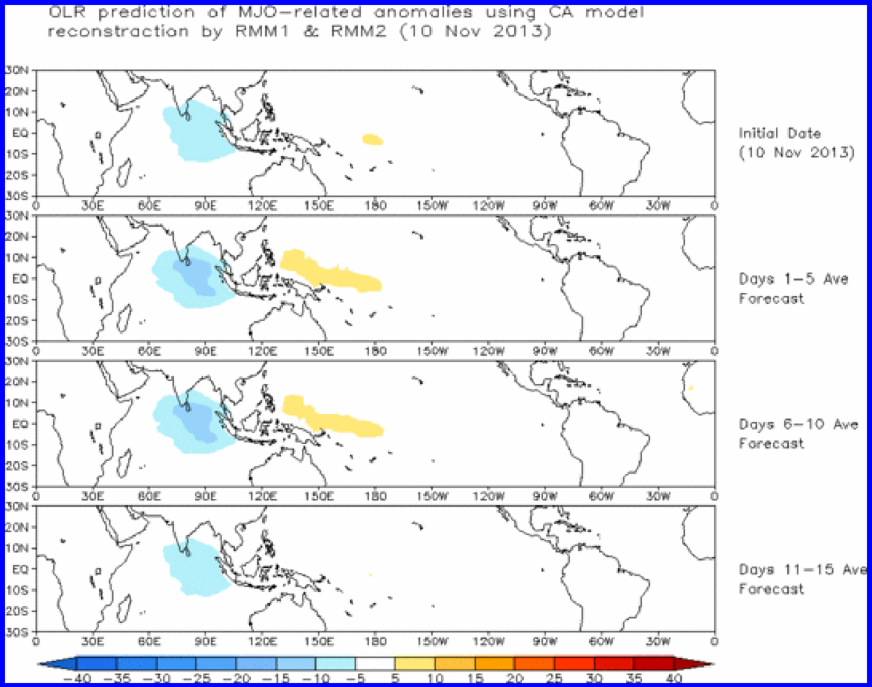
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



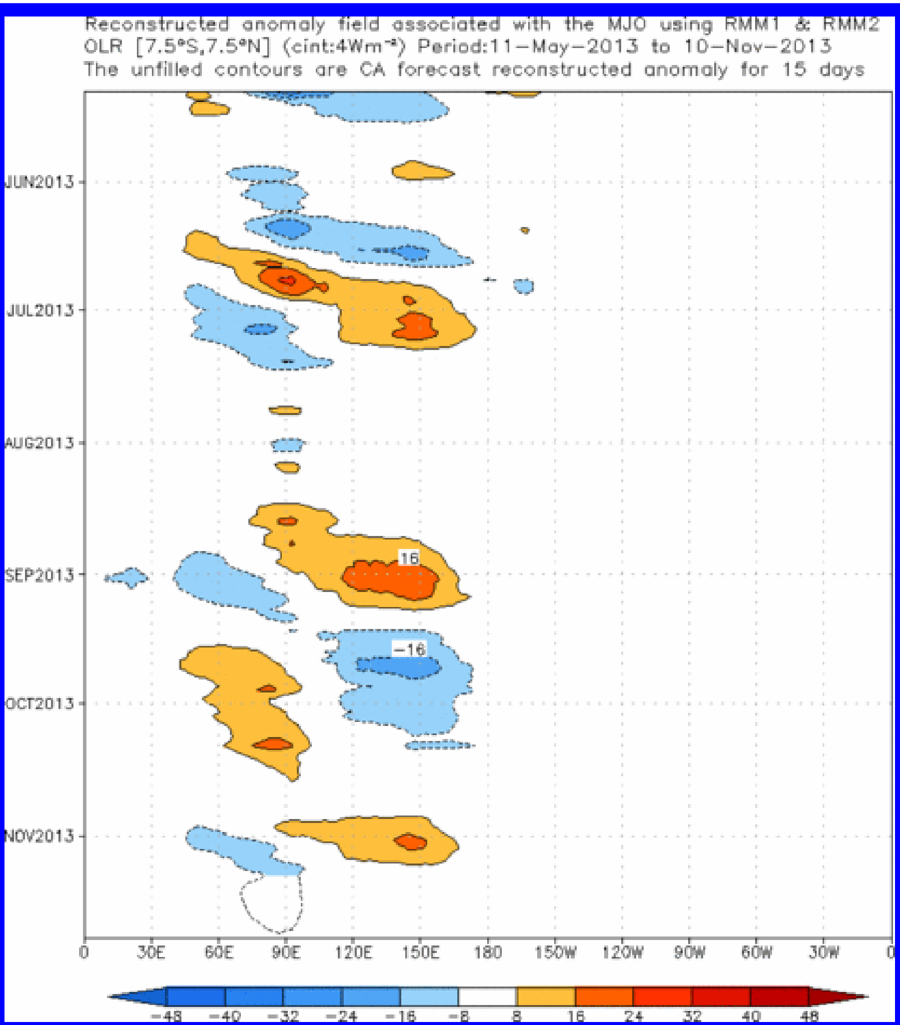
Constructed Analog (CA) MJO Forecast

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



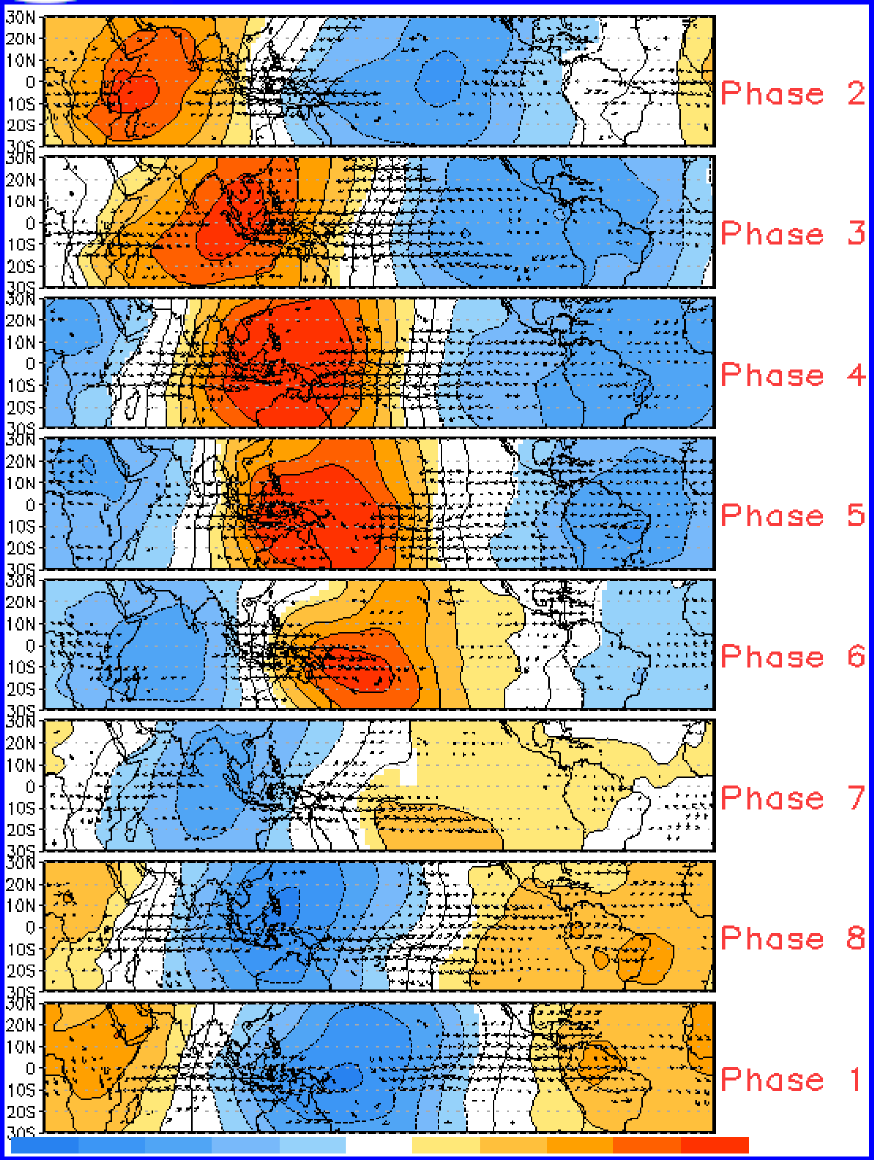
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



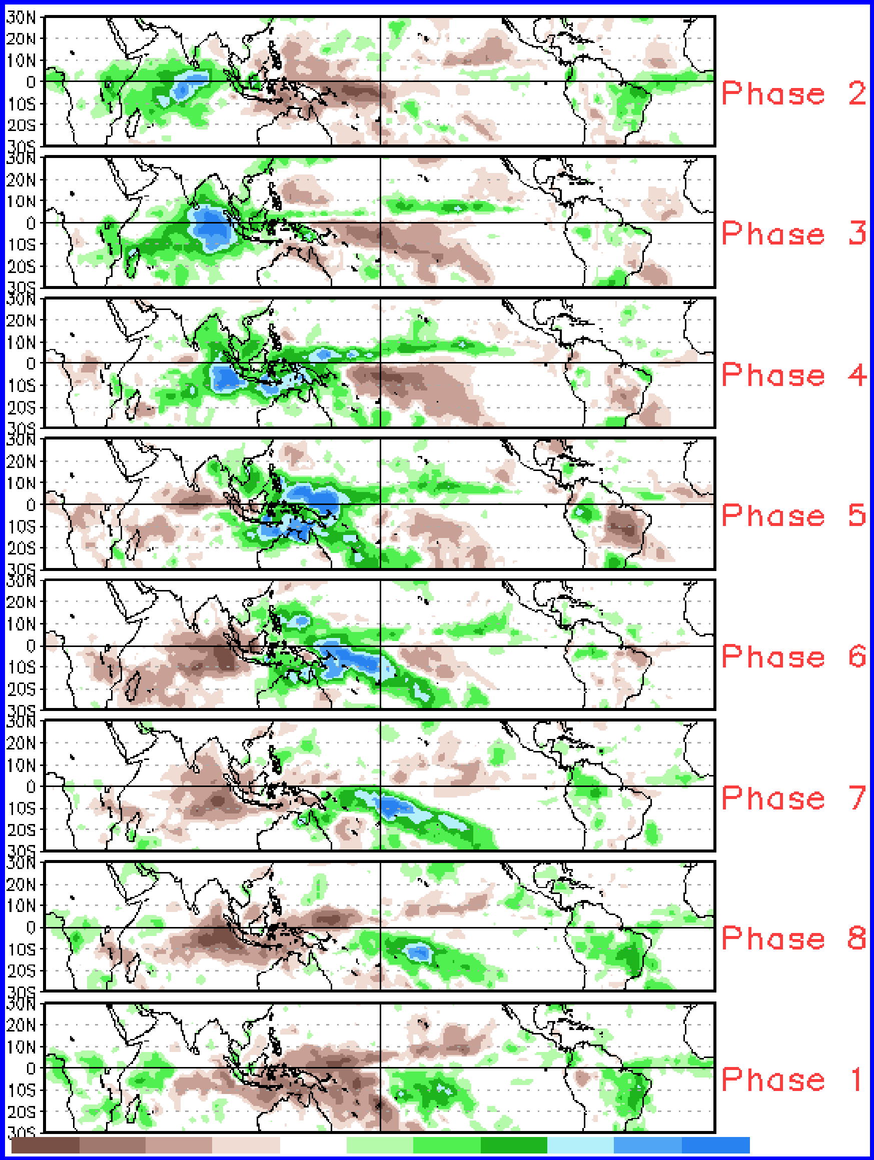
The constructed analog MJO forecast indicates a weak, nearly stationary signal.

MJO Composites – Global Tropics

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

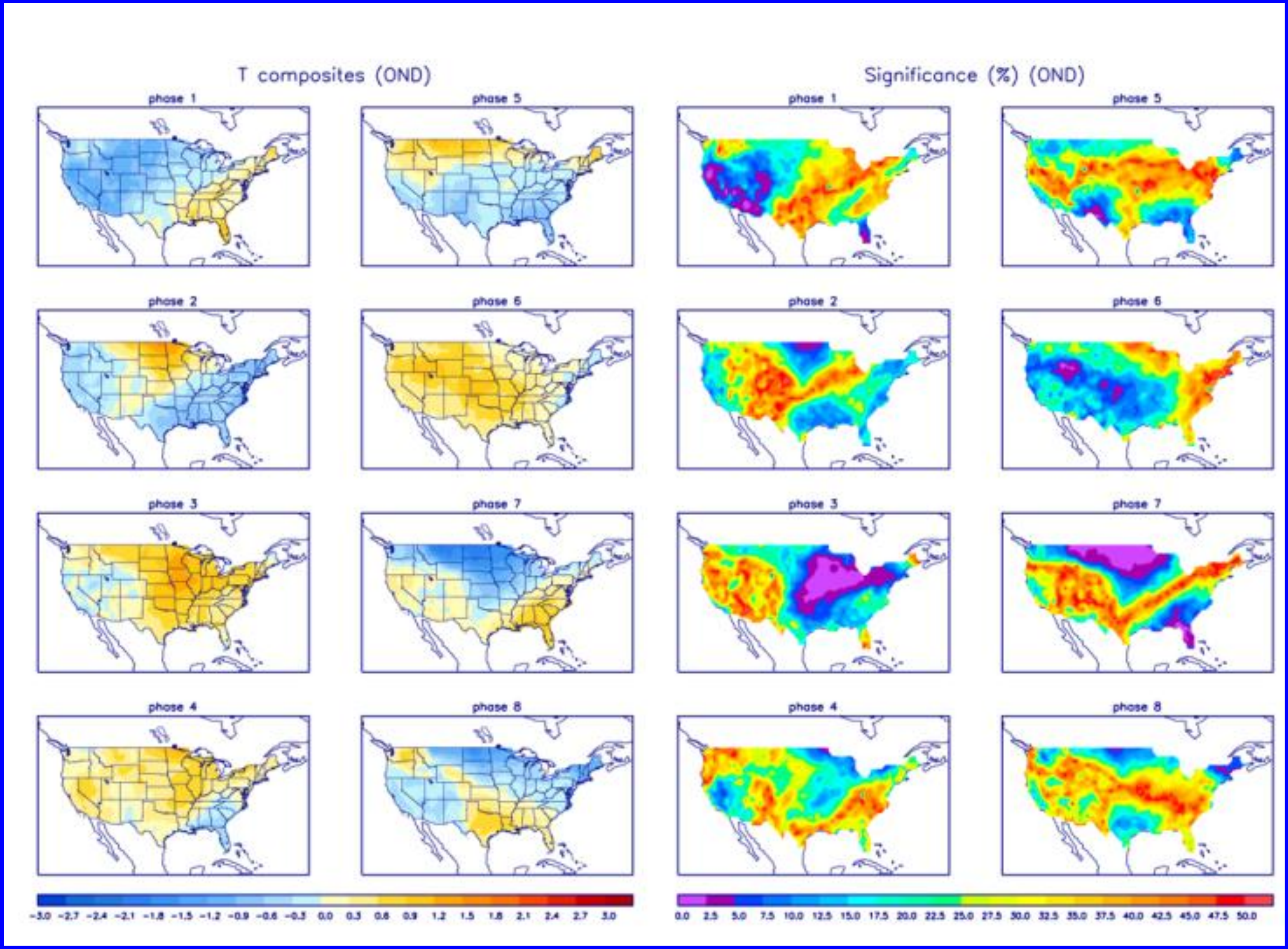


Precipitation Anomalies (Nov-Mar)



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.

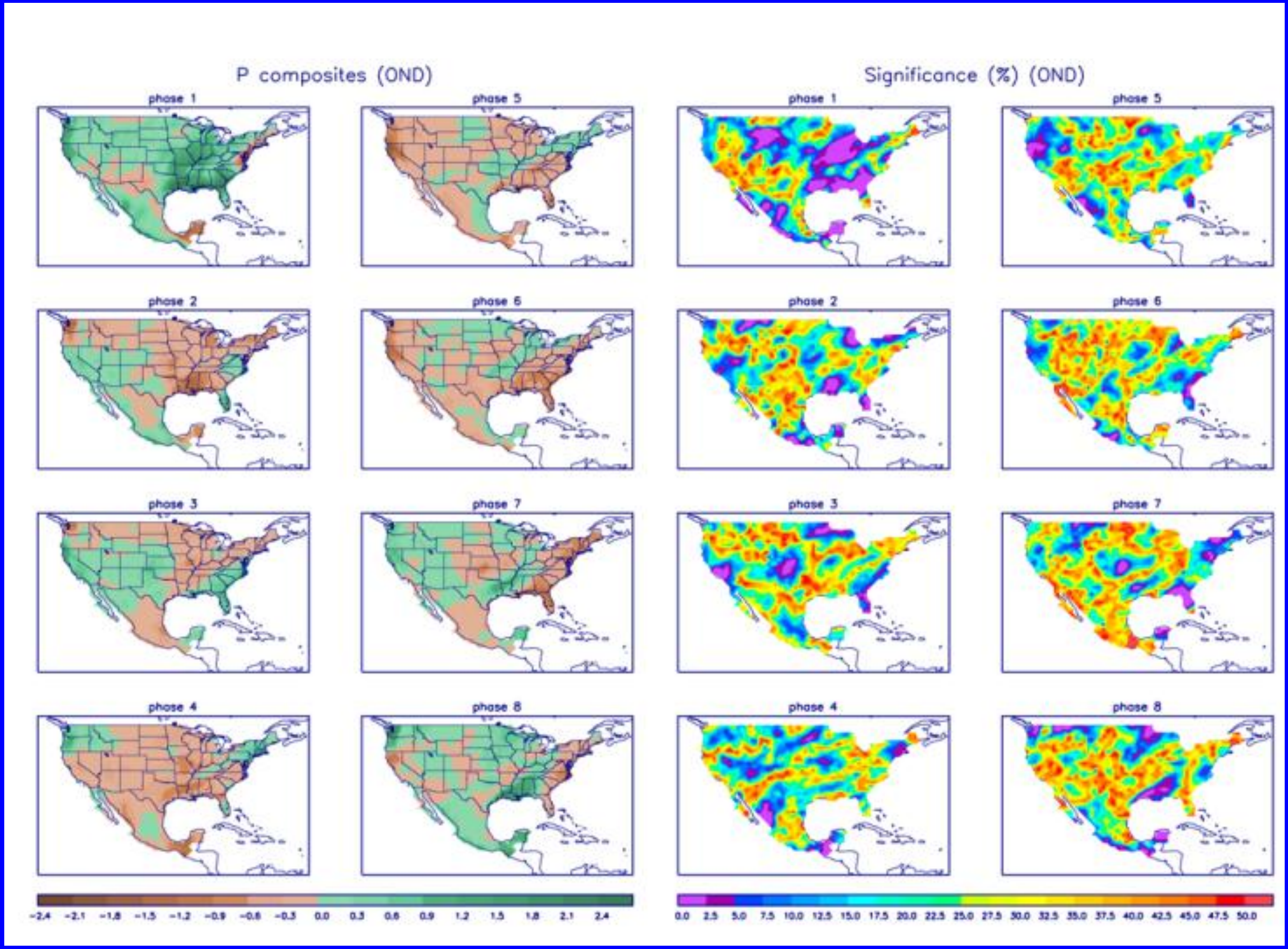


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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