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

Update prepared by
Climate Prediction Center / NCEP
December 16, 2013

Outline

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

Overview

- The MJO remained weak during the past seven days, although some indicators show some better organization. Other types of subseasonal tropical variability remain quite active.

- Dynamical model MJO index forecasts indicate a weak MJO signal shifting slightly eastward over the next week, although this may be associated with other more transient subseasonal variability. Most models indicate a weakening signal during Week-2. Statistical forecasts show a slow propagation of a weak MJO signal during the period.

- It is unclear at the current time whether the persistent enhanced convection we have seen across the Indian Ocean over the last few weeks will shift eastward on MJO timescales and emerge over the western Pacific by the end of December.

- Based on the latest observations and some dynamical model guidance, the MJO is forecast to remain generally weak over the outlook period. The MJO may contribute to enhanced convection from the eastern Indian Ocean to the far western Pacific (Weeks 1-2) and suppressed convection in Indian Ocean (Week-2) during the period.

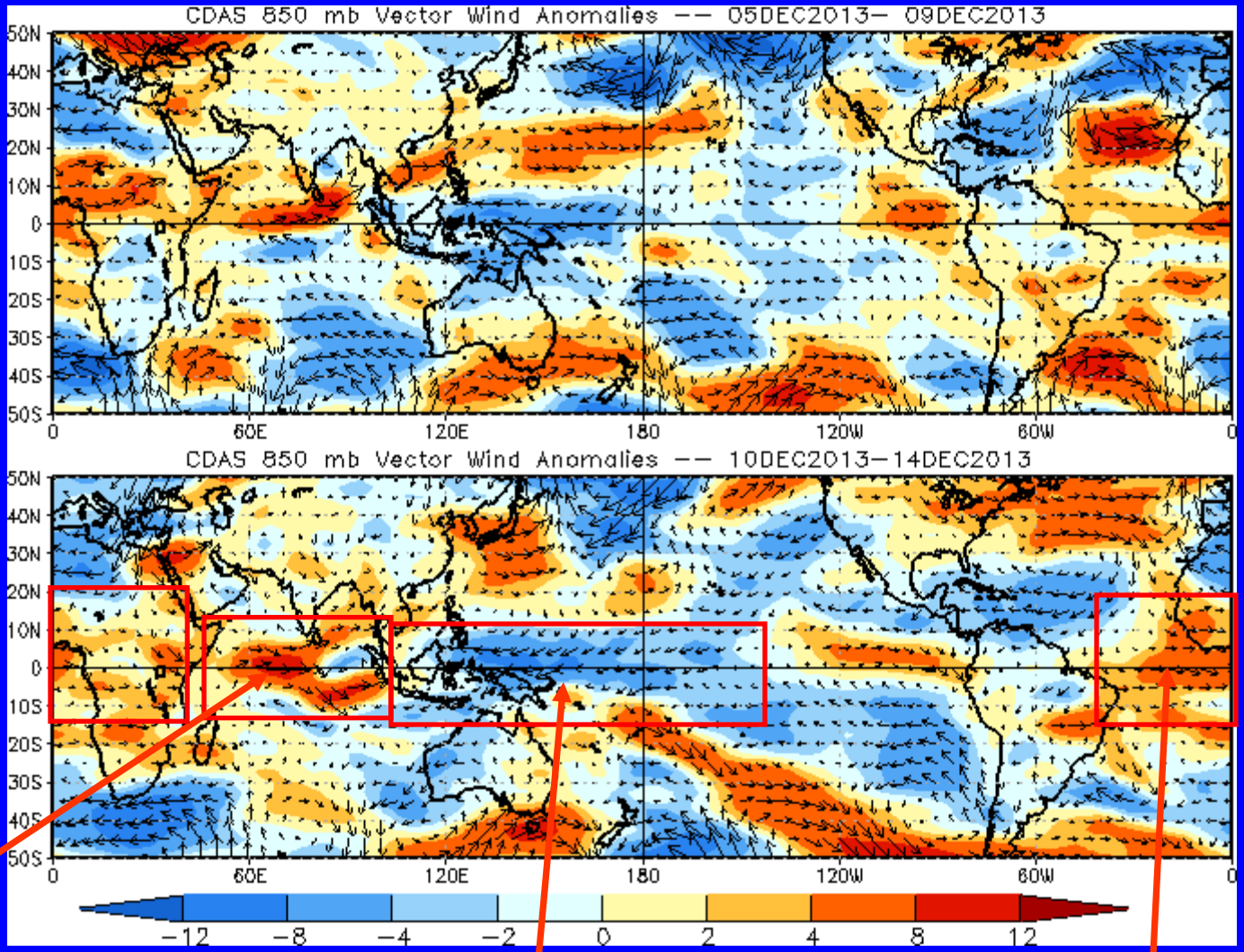
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 persisted across the equatorial Indian Ocean during the last five days.

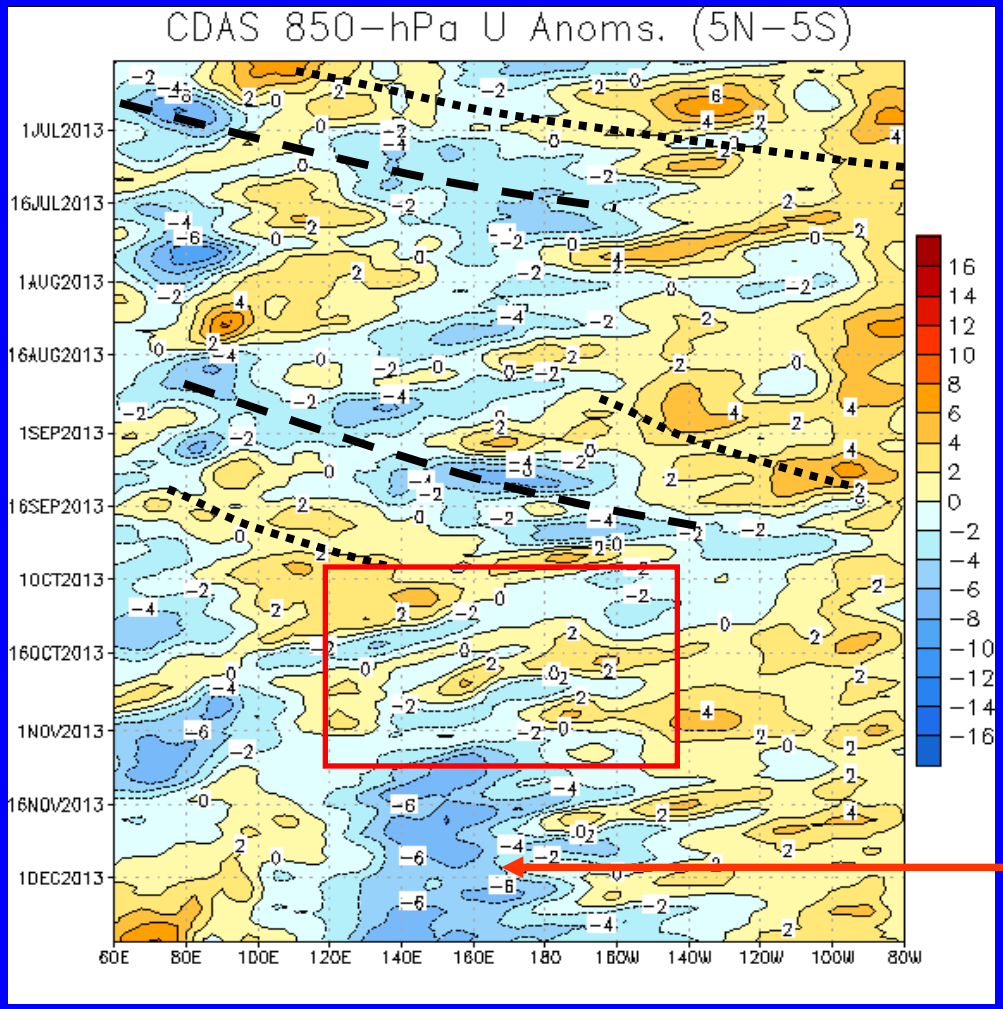
Easterly anomalies persisted over the eastern Maritime Continent and expanded over the equatorial western Pacific during the past five days.

Westerly anomalies continued across the Atlantic and central Africa 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

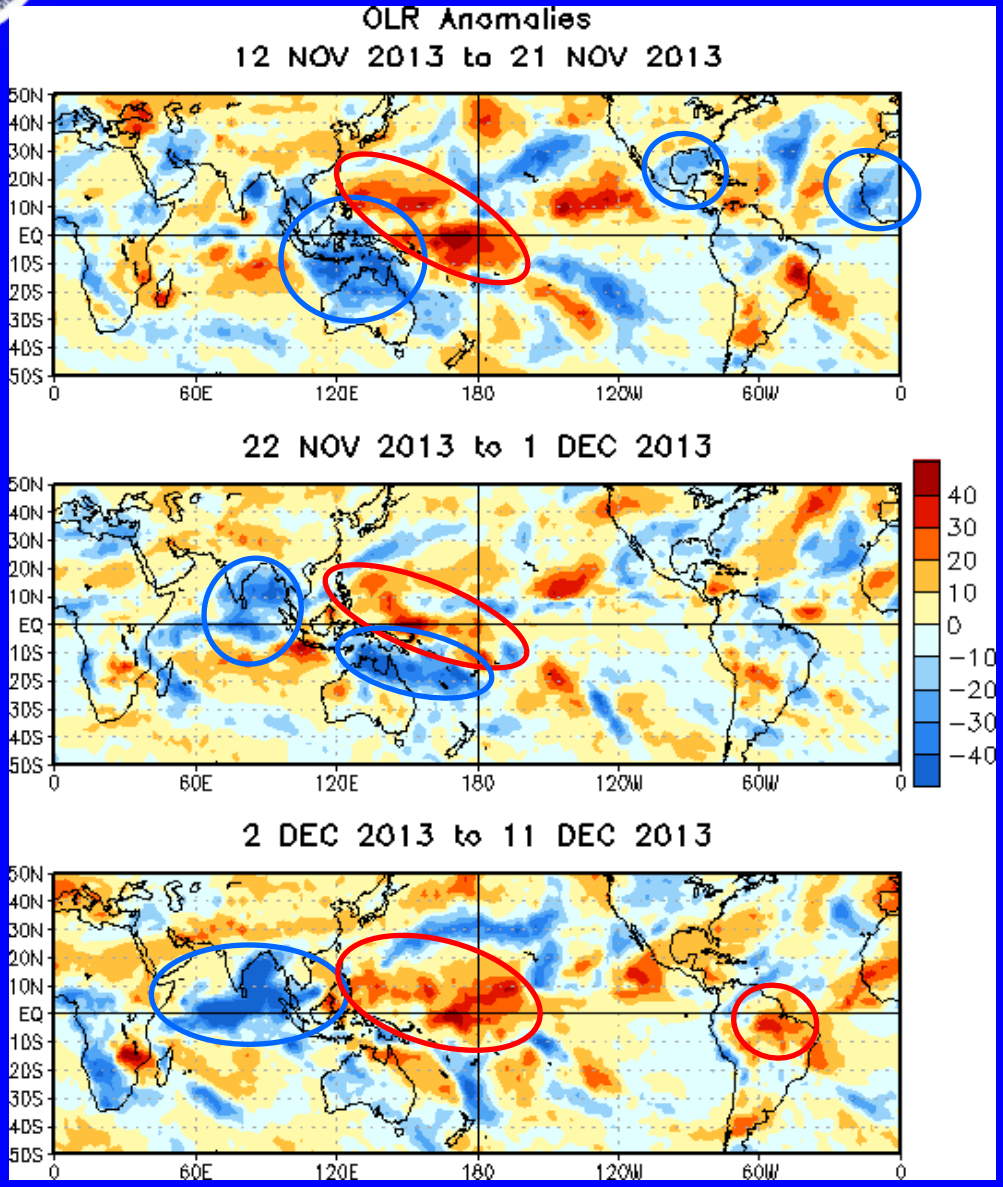
The MJO strengthened during June and continued until mid-July with fast eastward propagation.

During late July through mid-August, 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.

During November and December, easterly anomalies have been persistent from 120E to near the Date Line. There was little evidence of eastward propagation in the wind field during this period.

OLR Anomalies – Past 30 days



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

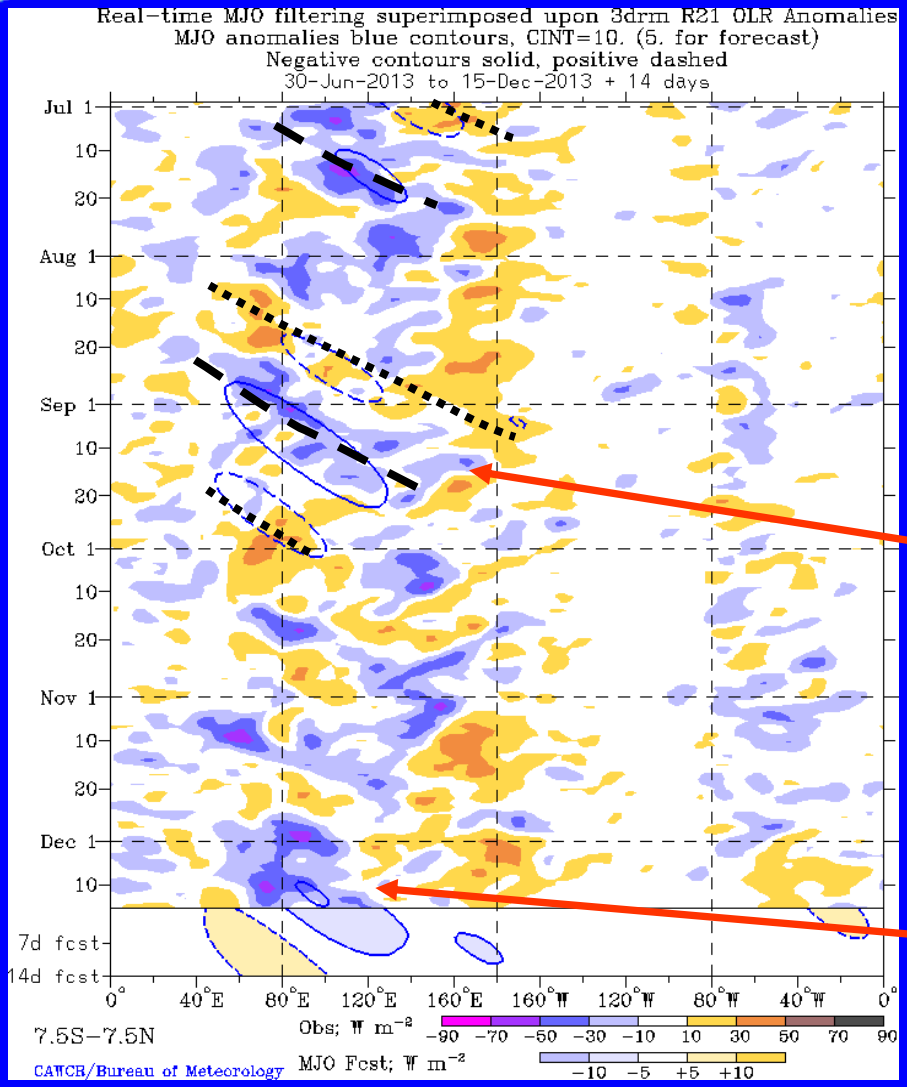
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-November, enhanced convection was observed over portions of western Africa, the Maritime continent and northern Australia while strong suppressed convection prevailed across the western Pacific. Wet conditions were also evident for Mexico, Central America and across the Gulf of Mexico.

Wet conditions were observed across parts of the Indian Ocean, India, and northern Australia during mid-to-late November, while suppressed convection continued for much of the western Pacific.

During early December, enhanced convection intensified across the Indian Ocean as suppressed convection persisted across the western Pacific. Drier-than-average conditions developed over parts of northern 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 during June and continued into early July as indicated by alternating dotted and dashed lines.

The MJO was active from late August through early October with the enhanced phase propagating eastward from the Indian Ocean to the western Pacific Ocean over this period.

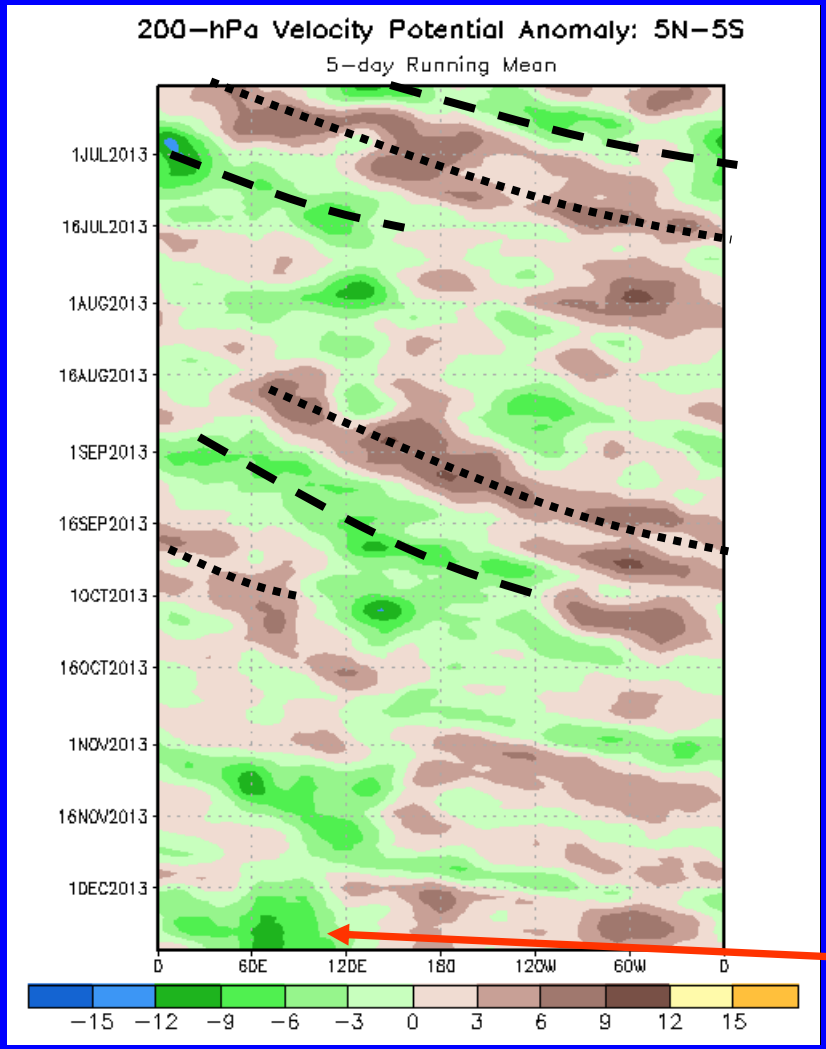
The MJO was generally weak or incoherent for much of November and other types of coherent tropical subseasonal variability were very active.

By early December, a large area of enhanced convection developed in the Indian Ocean, but this area has yet to shift eastward to date on the typical MJO time scale.

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.

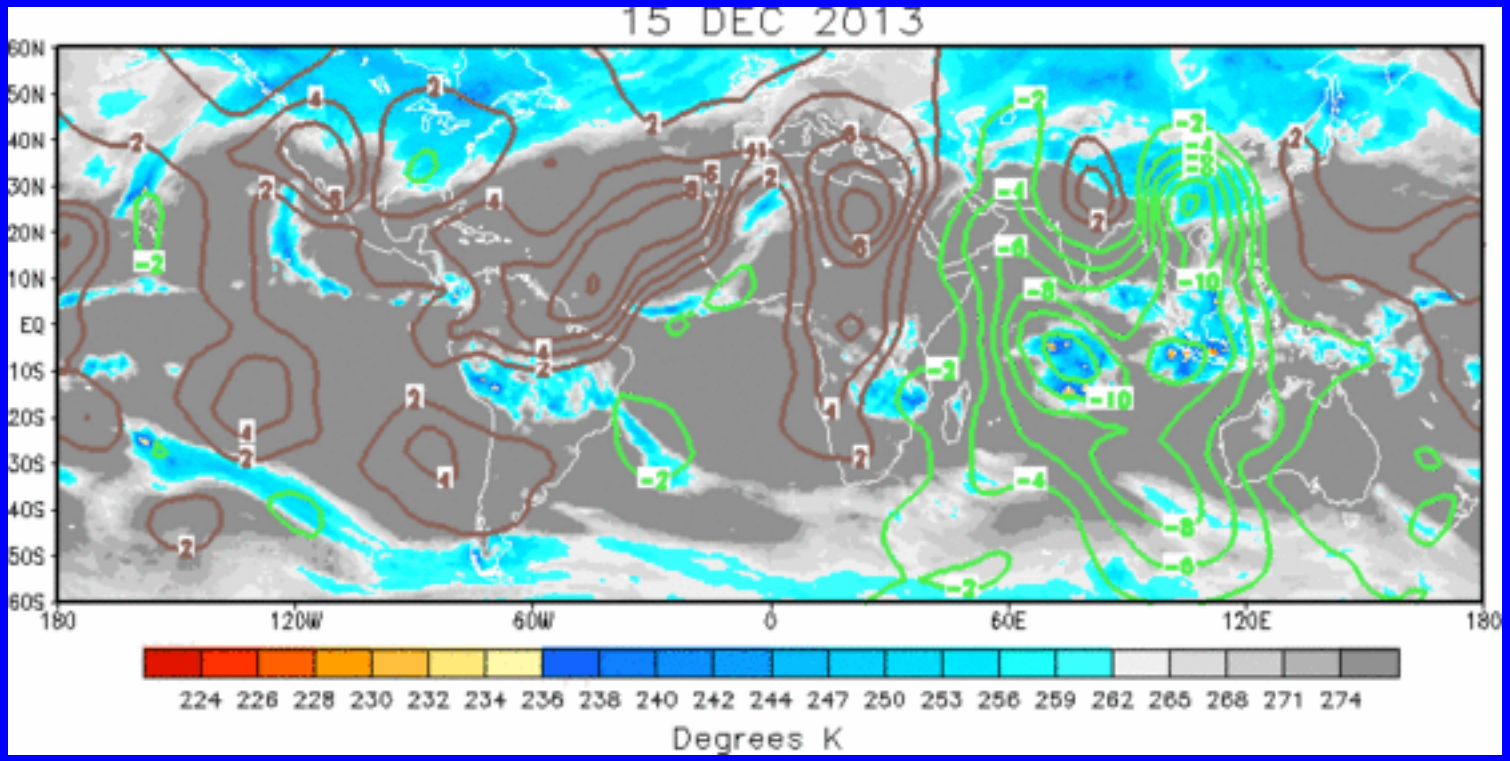
From late October to mid December, the MJO has not been very strong or coherent. There is evidence of coherent eastward propagation at times during this period, but much of this activity has fast propagation speeds more consistent with atmospheric Kelvin waves.

Strong upper-level divergence has been persistent across the Indian Ocean for much of December.

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



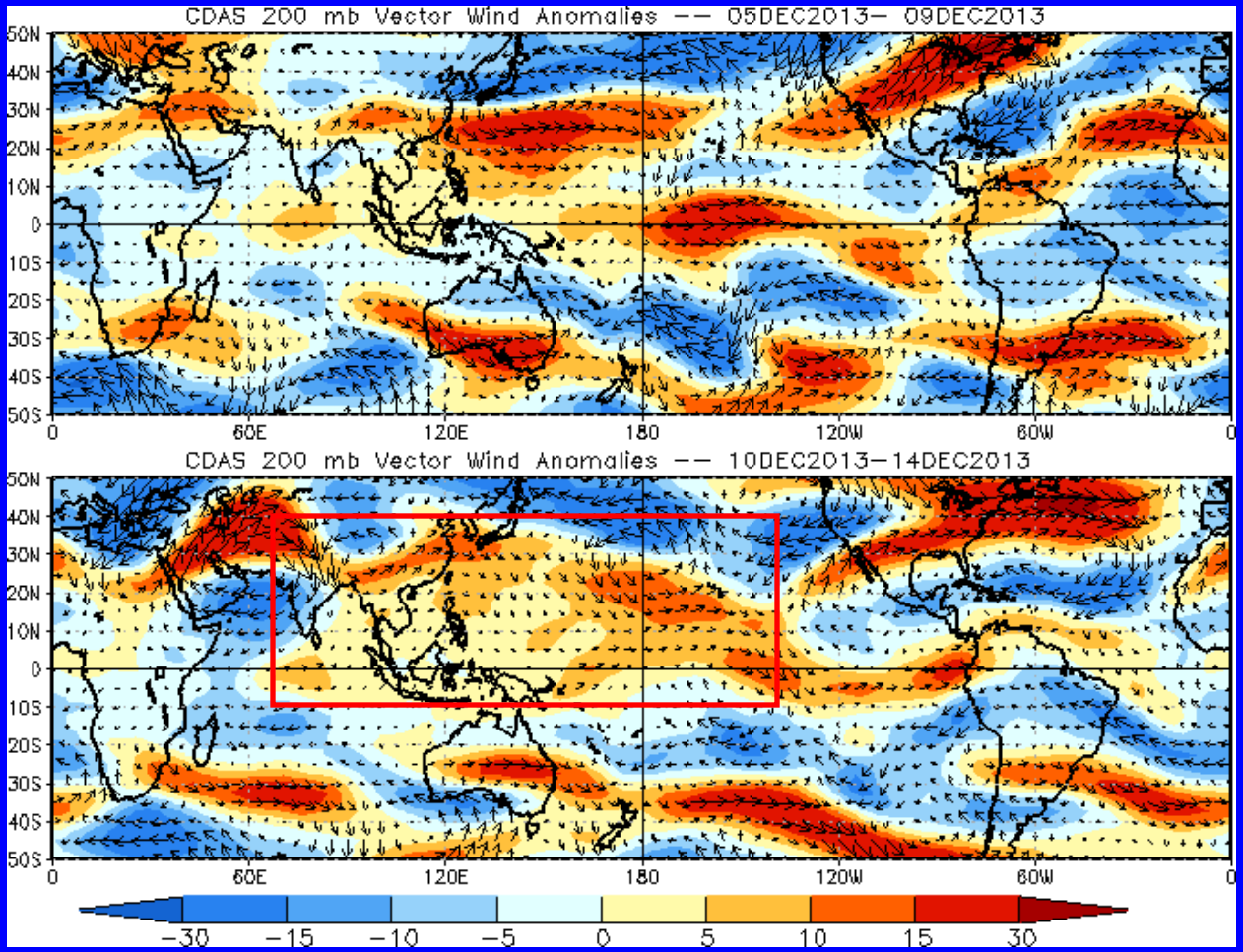
The current velocity potential pattern shows large-scale upper-level divergence (green contours) is evident across the Indian Ocean and western Maritime continent while upper-level convergence (brown contours) are depicted over portions of the Pacific, the Americas and the Atlantic Ocean.

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



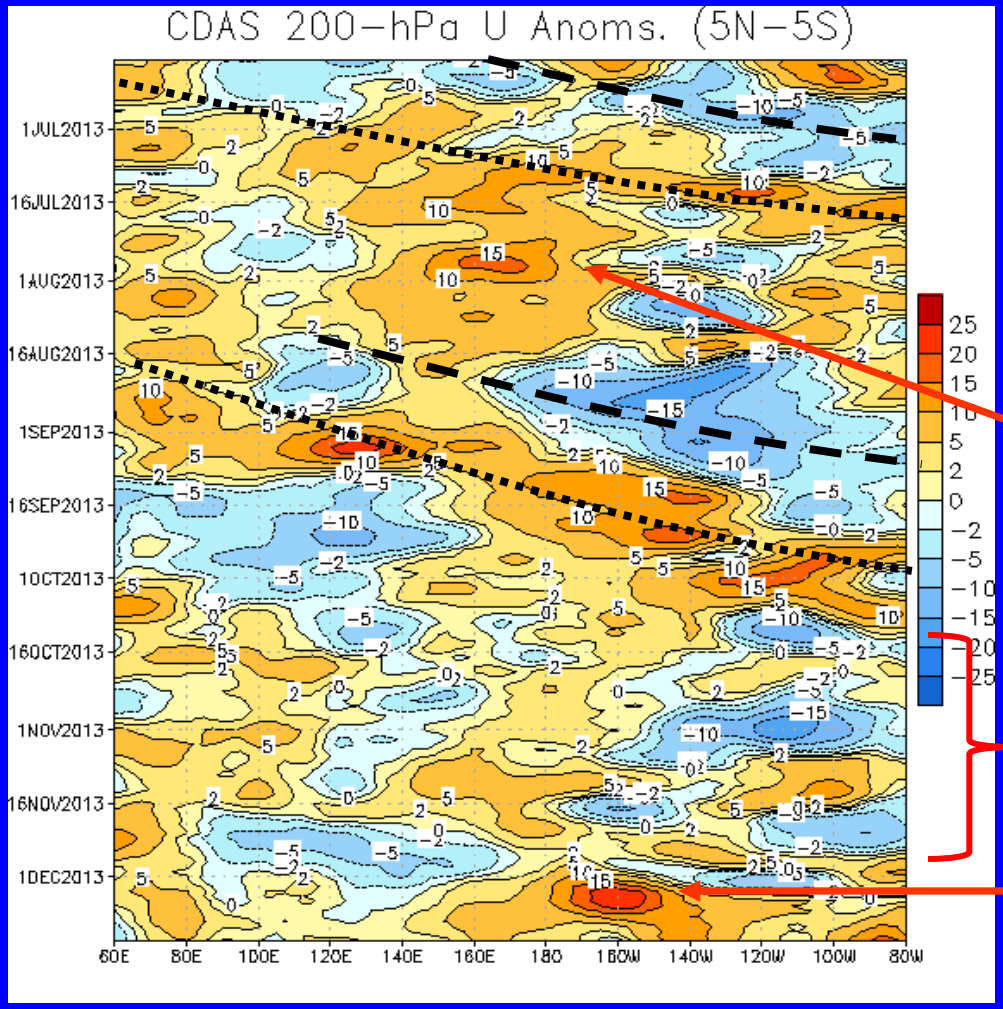
Sub-tropical and tropical westerly anomalies primarily north of the equator continued during the past five days (red box).

Small easterly wind anomalies persisted over parts of the tropical Atlantic Ocean and Africa 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

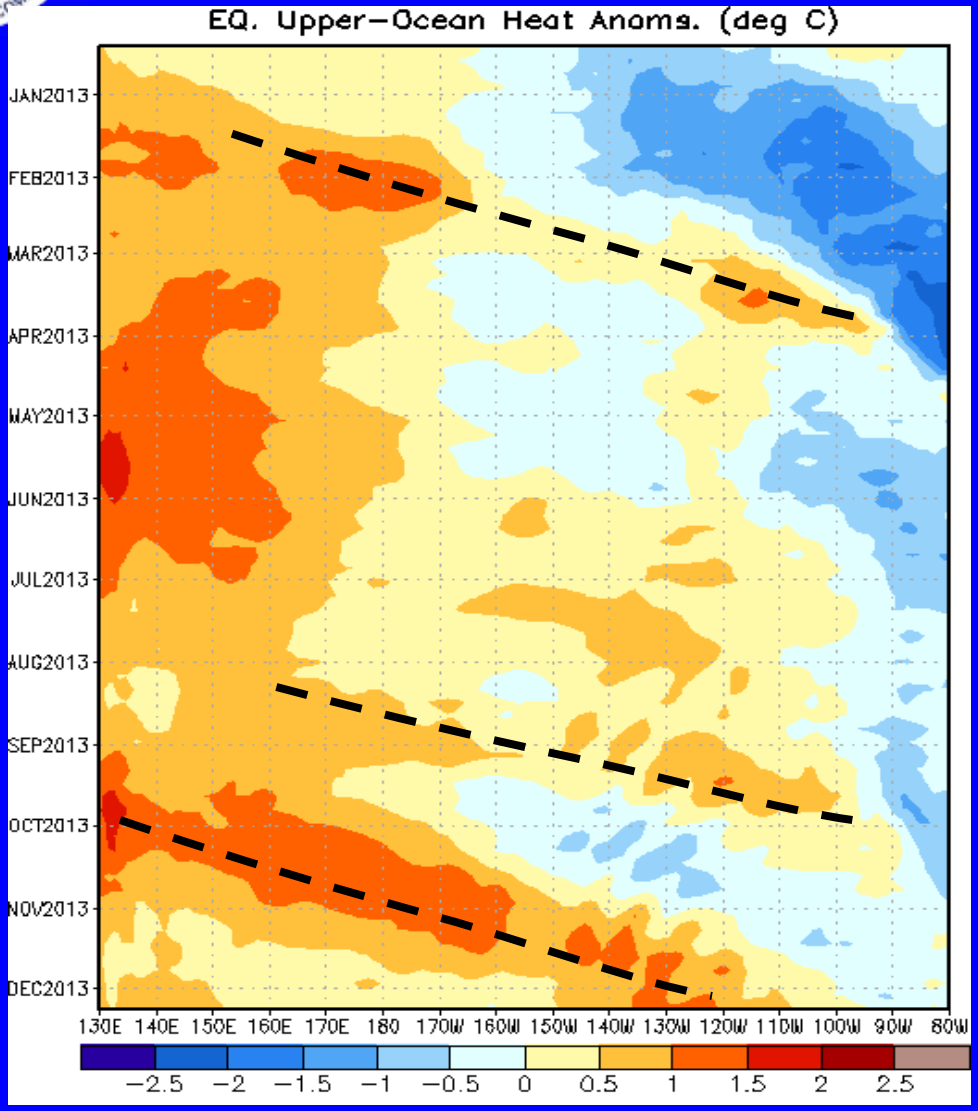
Longitude

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.

Anomalies of alternating sign are evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket). In early December, large westerly anomalies developed just east of the Date Line.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

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 (dashed line) can be seen during late February and March as anomalies became positive in the east-central Pacific.

Oceanic downwelling Kelvin wave activity is evident in late August and once again during October and November, the latter being the strongest wave to date in 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).

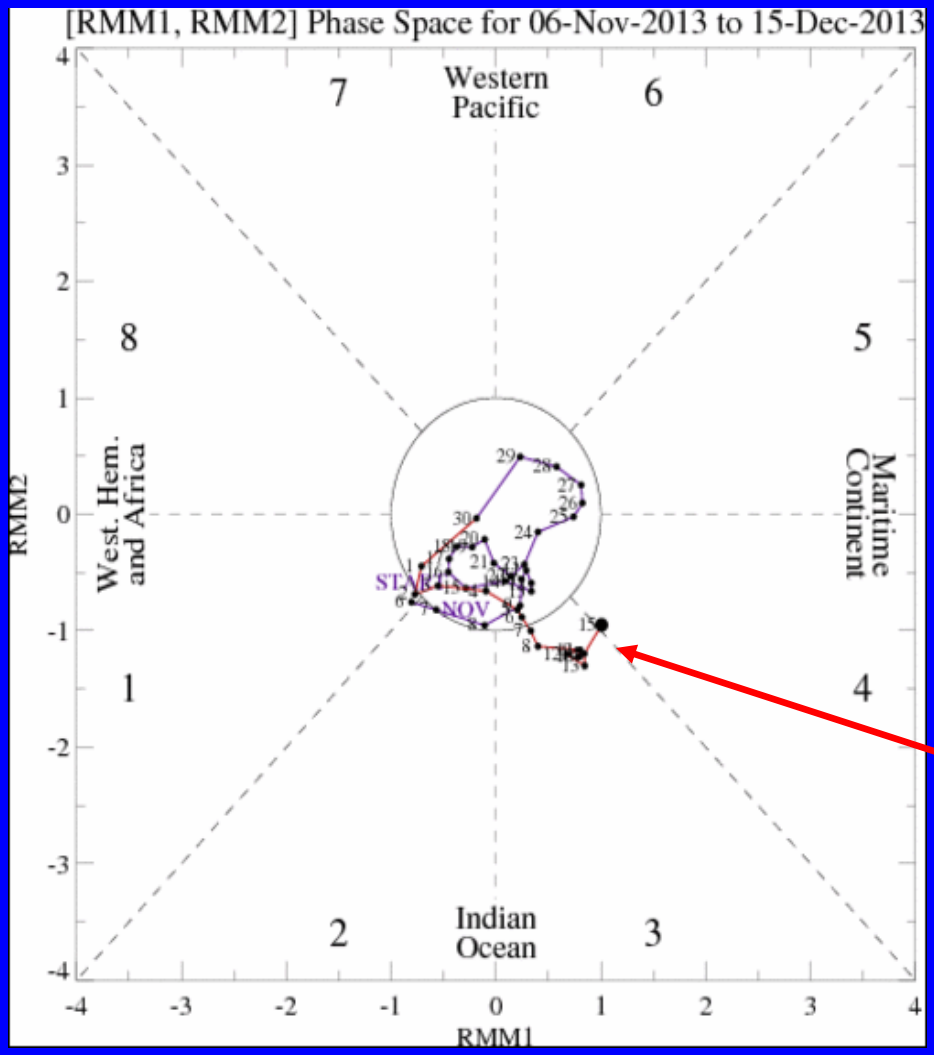
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

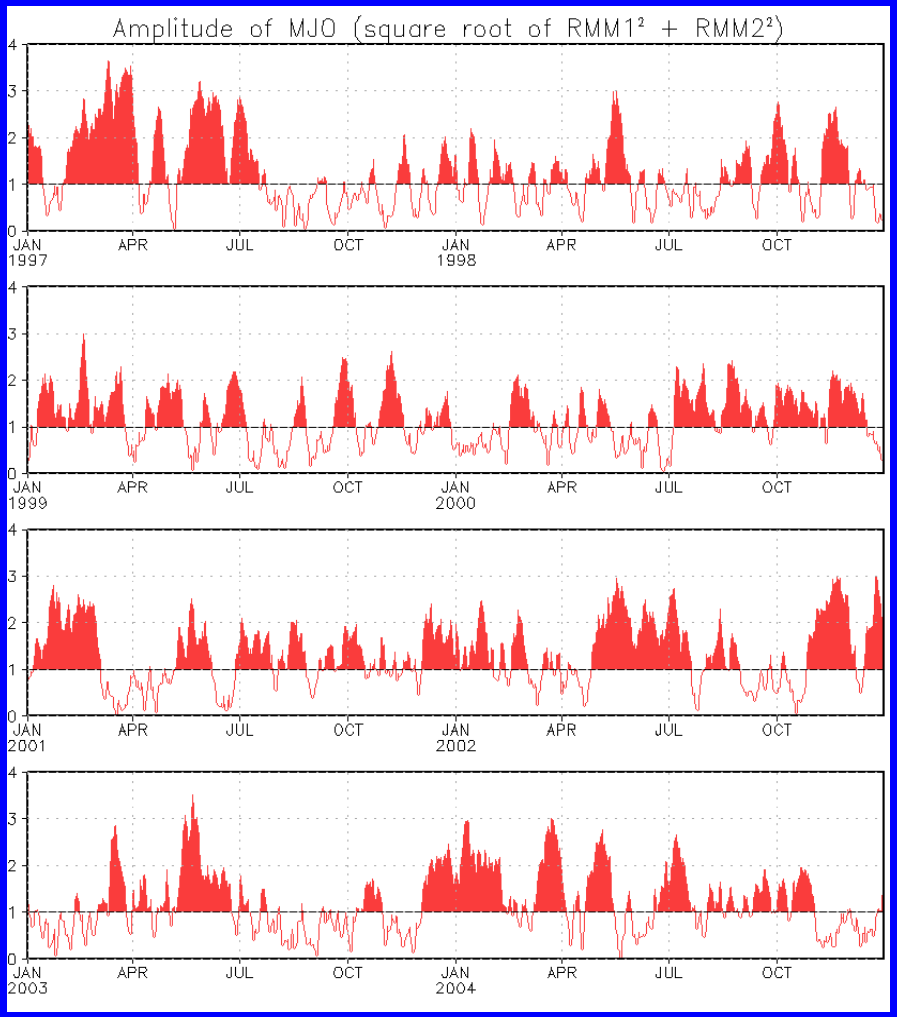
MJO Index -- Recent Evolution

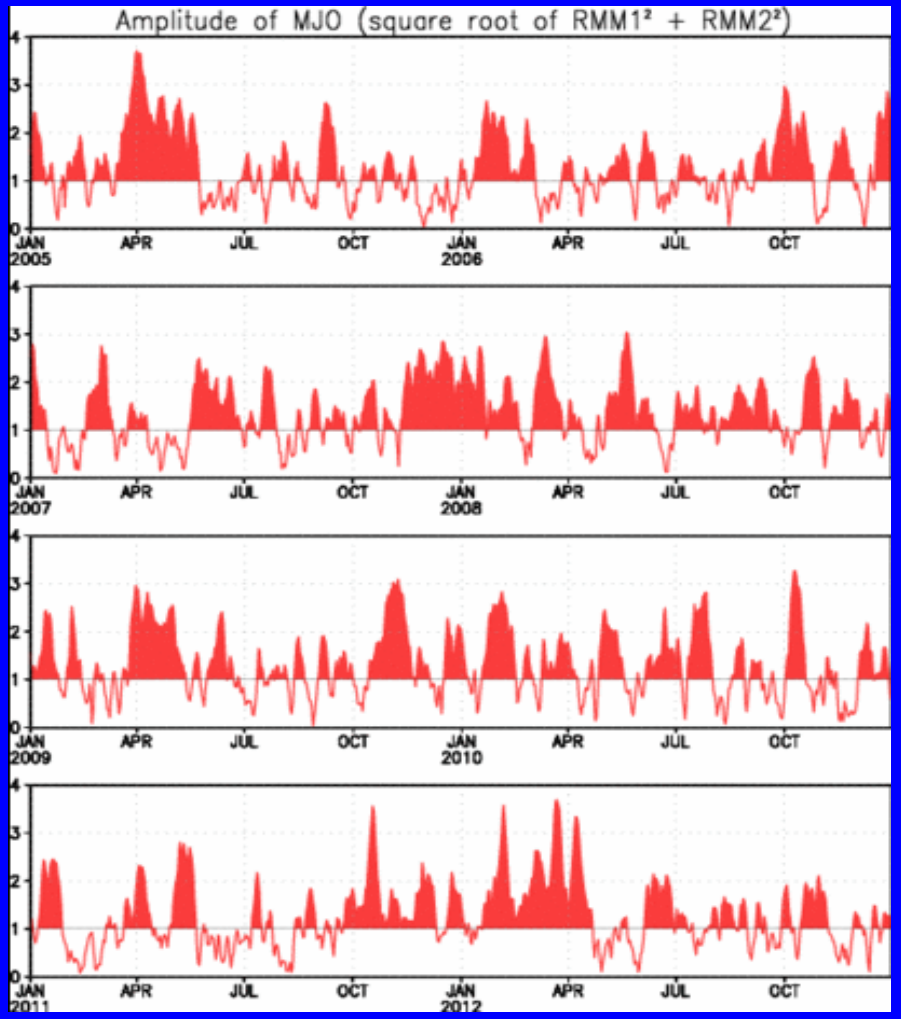


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index showed a small increase in amplitude and minor eastward during the past week.

MJO Index – Historical Daily Time Series





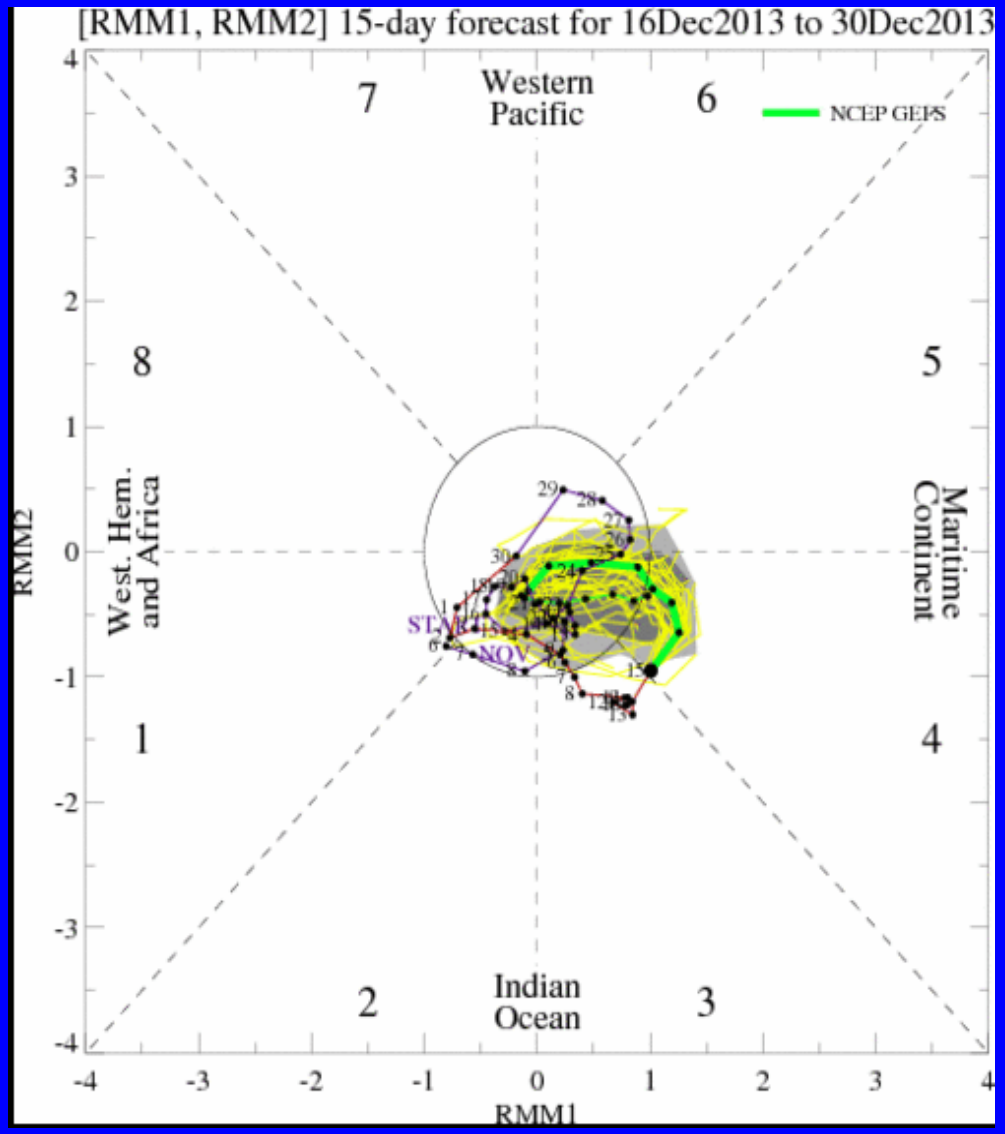
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

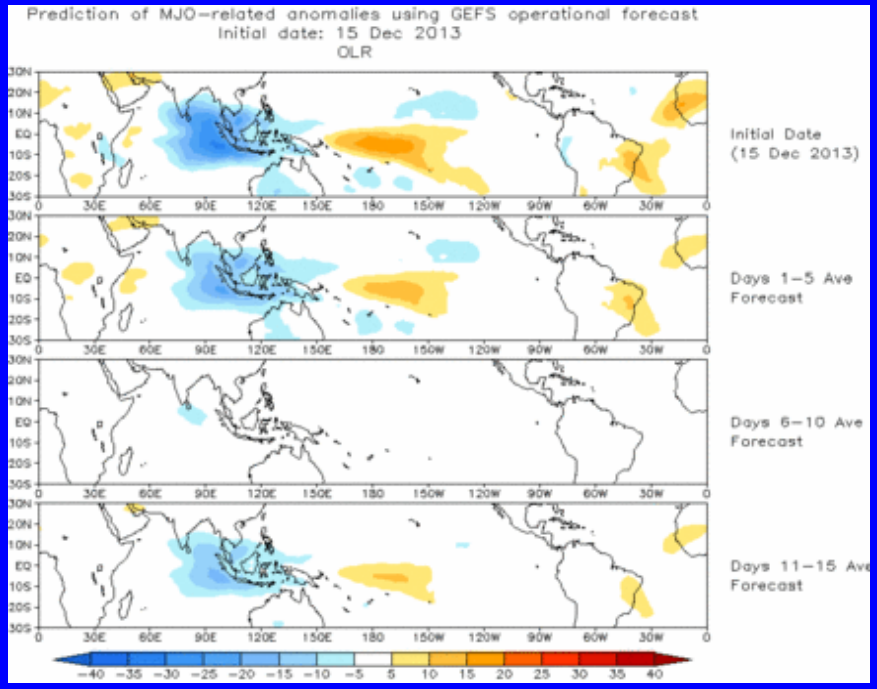


The ensemble GFS indicates some minor eastward propagation of a weak MJO signal during Week-1. Thereafter, little coherent MJO signal is indicated.

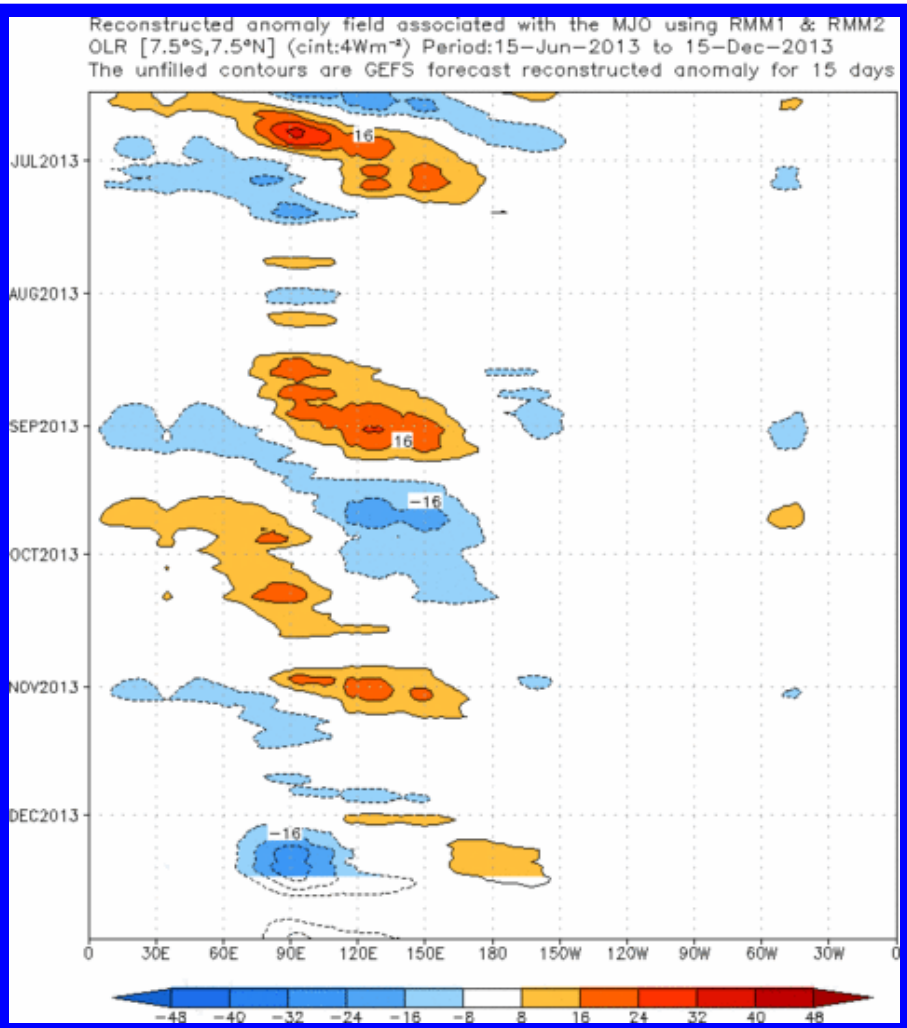
Ensemble Mean GFS MJO Forecast

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

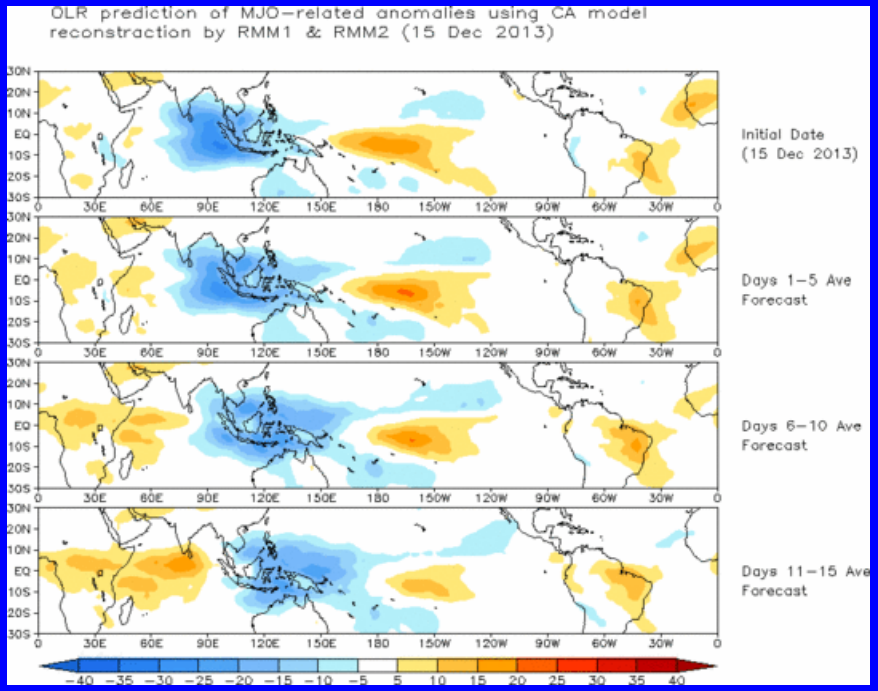


The ensemble mean GFS forecasts enhanced (suppressed) convection over the eastern Indian Ocean/western Maritime continent (central Pacific/parts of the western hemisphere) early during the period.

Constructed Analog (CA) MJO Forecast

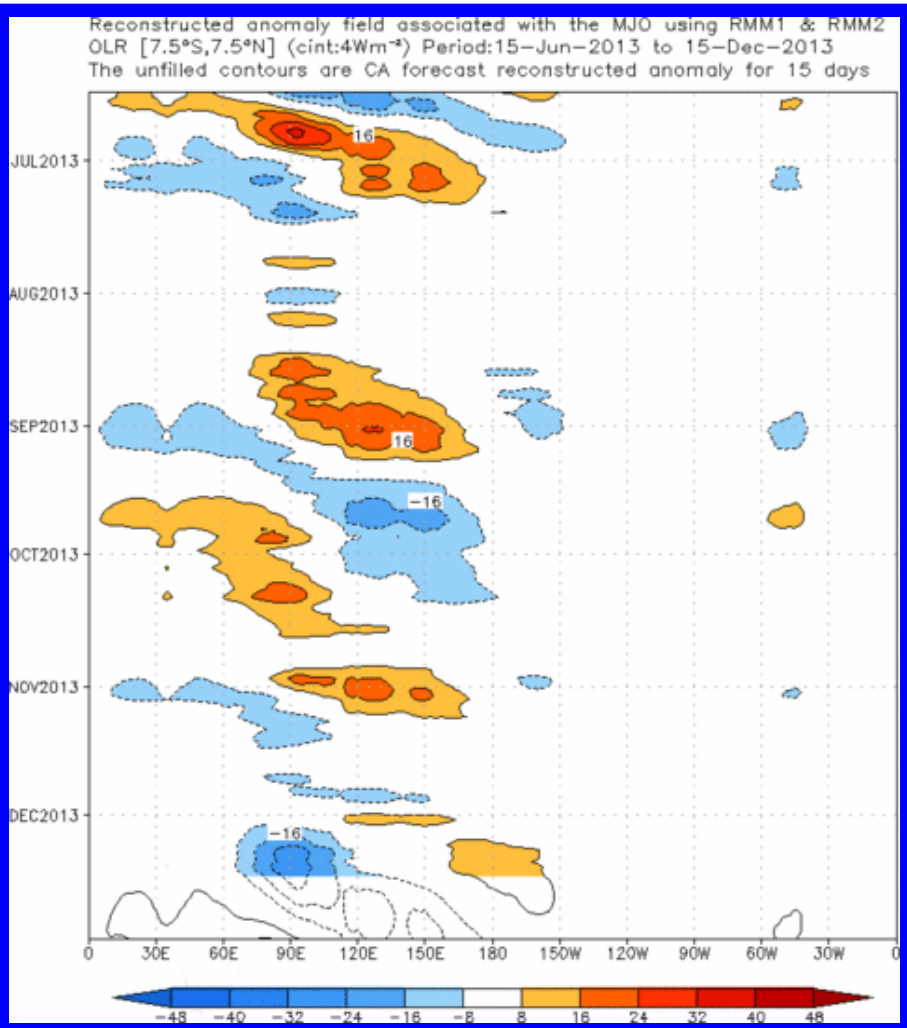
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



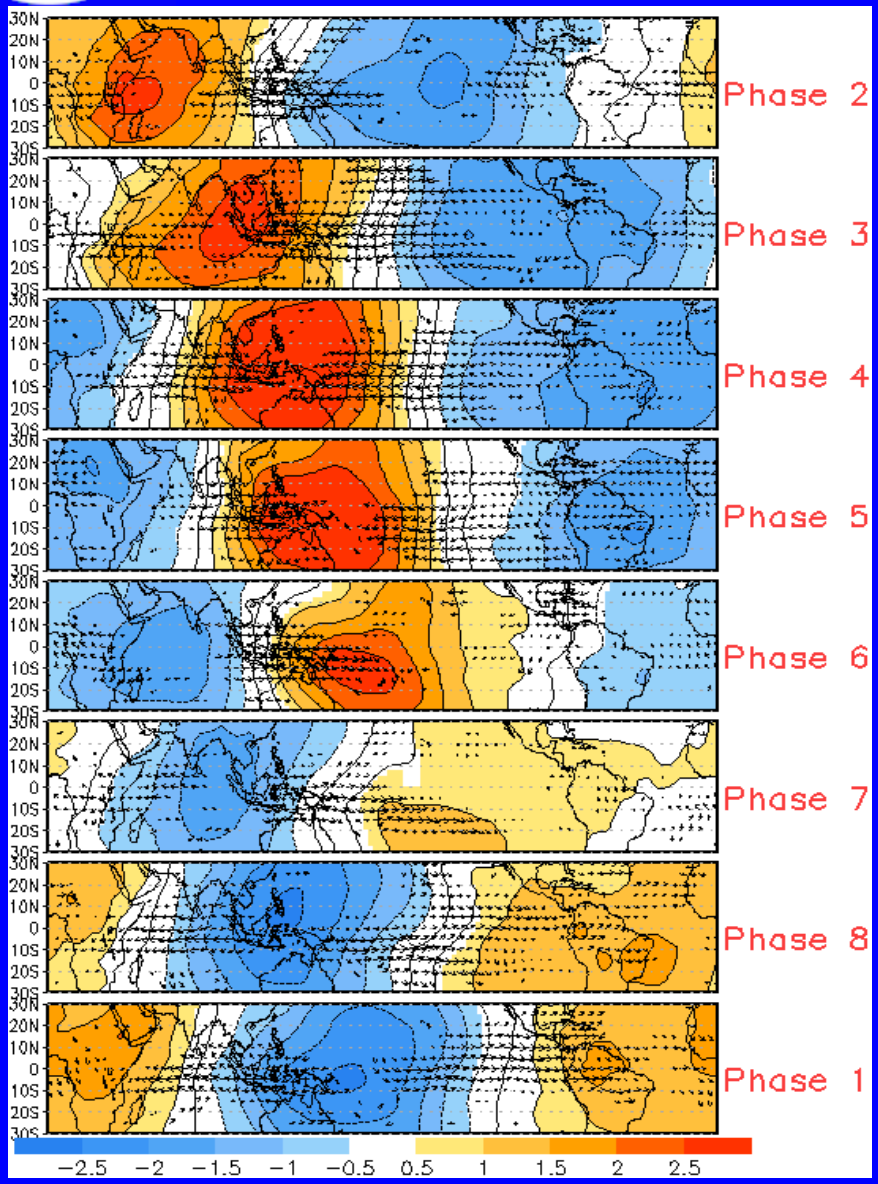
The constructed analog MJO forecast indicates slow eastward propagation of enhanced convection from the eastern Indian Ocean to the eastern Maritime continent during the period.

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

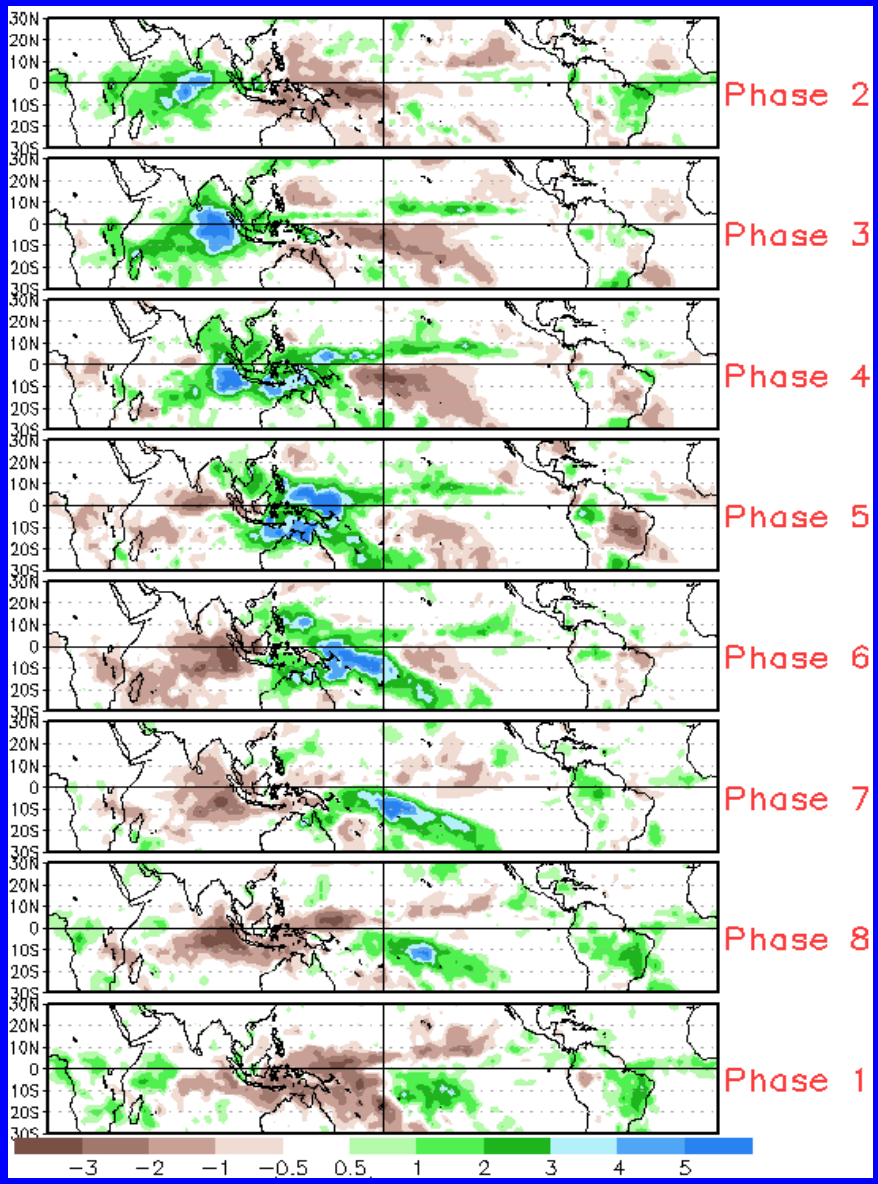


MJO Composites – Global Tropics

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

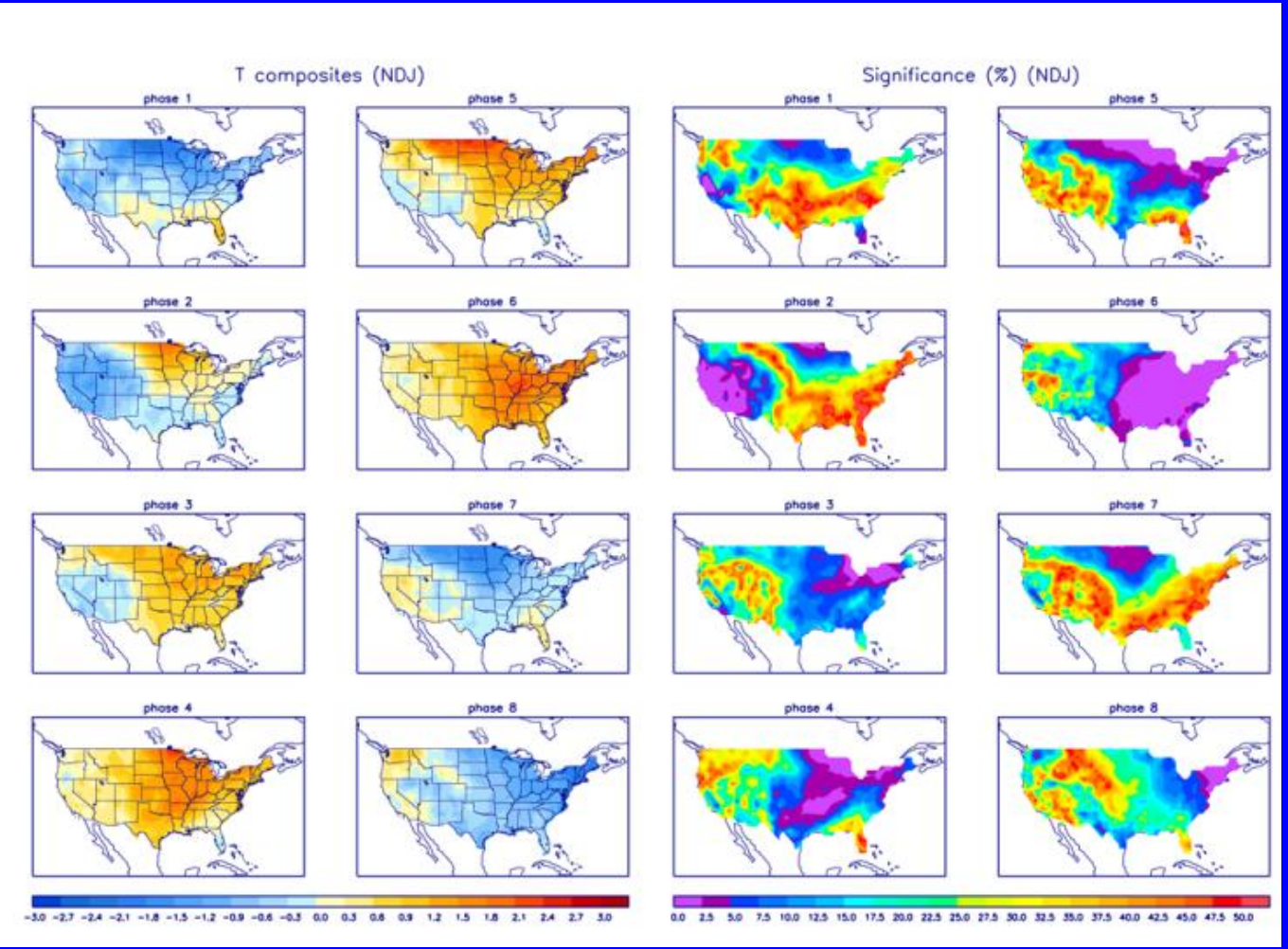


Precipitation Anomalies (Nov-Mar)



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.**

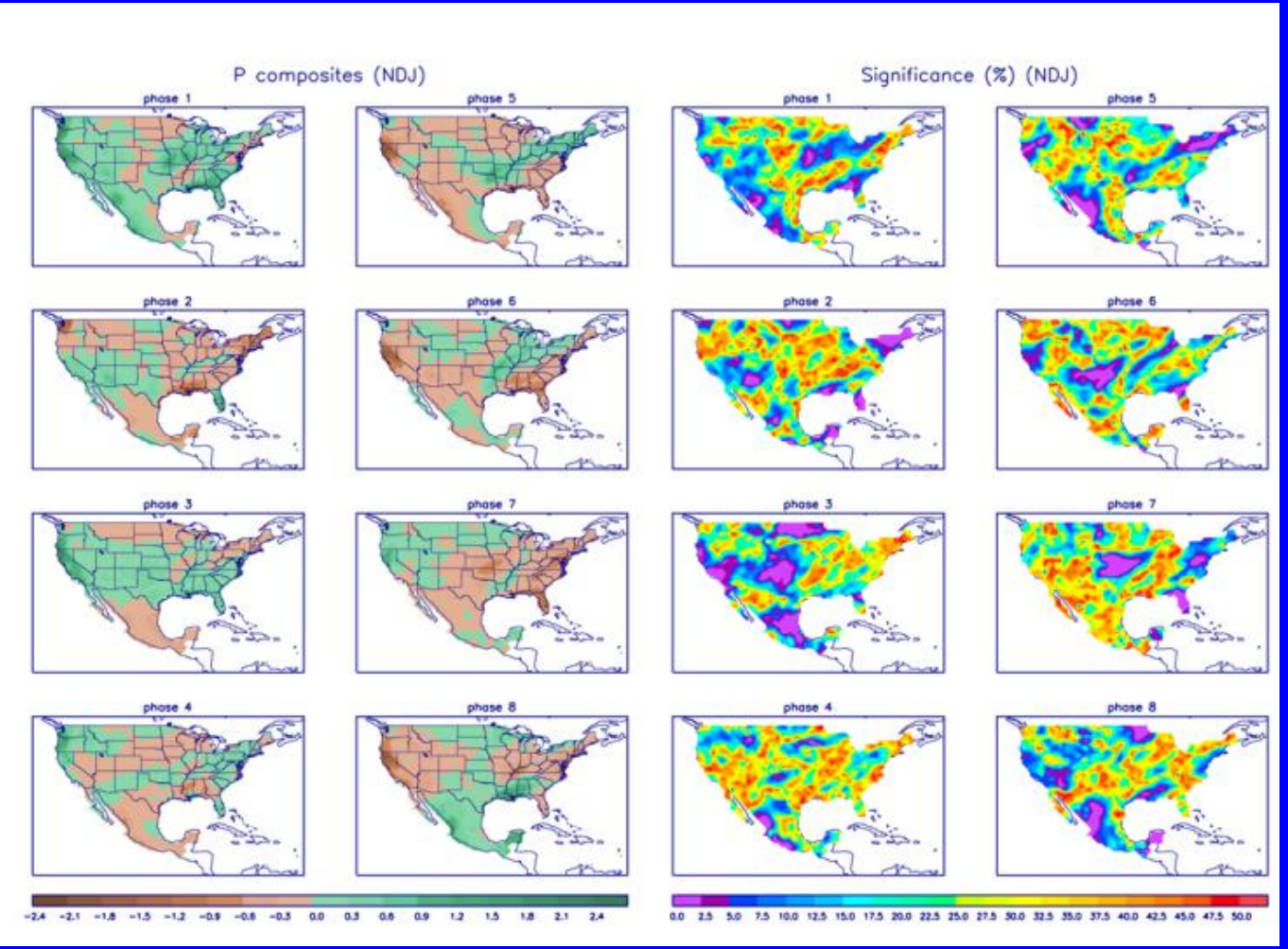


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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