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

Update prepared by
Climate Prediction Center / NCEP
December 23, 2013

Outline

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

Overview

- The MJO became more coherent during the past week, with the enhanced convective phase over the Maritime Continent. Other types of coherent subseasonal tropical variability also remained active.

- Dynamical model MJO index forecasts support the propagation of a weak MJO signal into the western Pacific during the Week-1 period, with considerable spread in the amplitude and speed of the event.

- Statistical forecasts suggest a slower propagation of the MJO signal into the western Pacific during the two-week period.

- The MJO is forecast to contribute to enhanced (suppressed) convection over parts of the Maritime Continent and southwestern Pacific (Indian Ocean) during the next two weeks, with enhanced probabilities for tropical cyclogenesis north of Australia and over the southwestern Pacific basin.

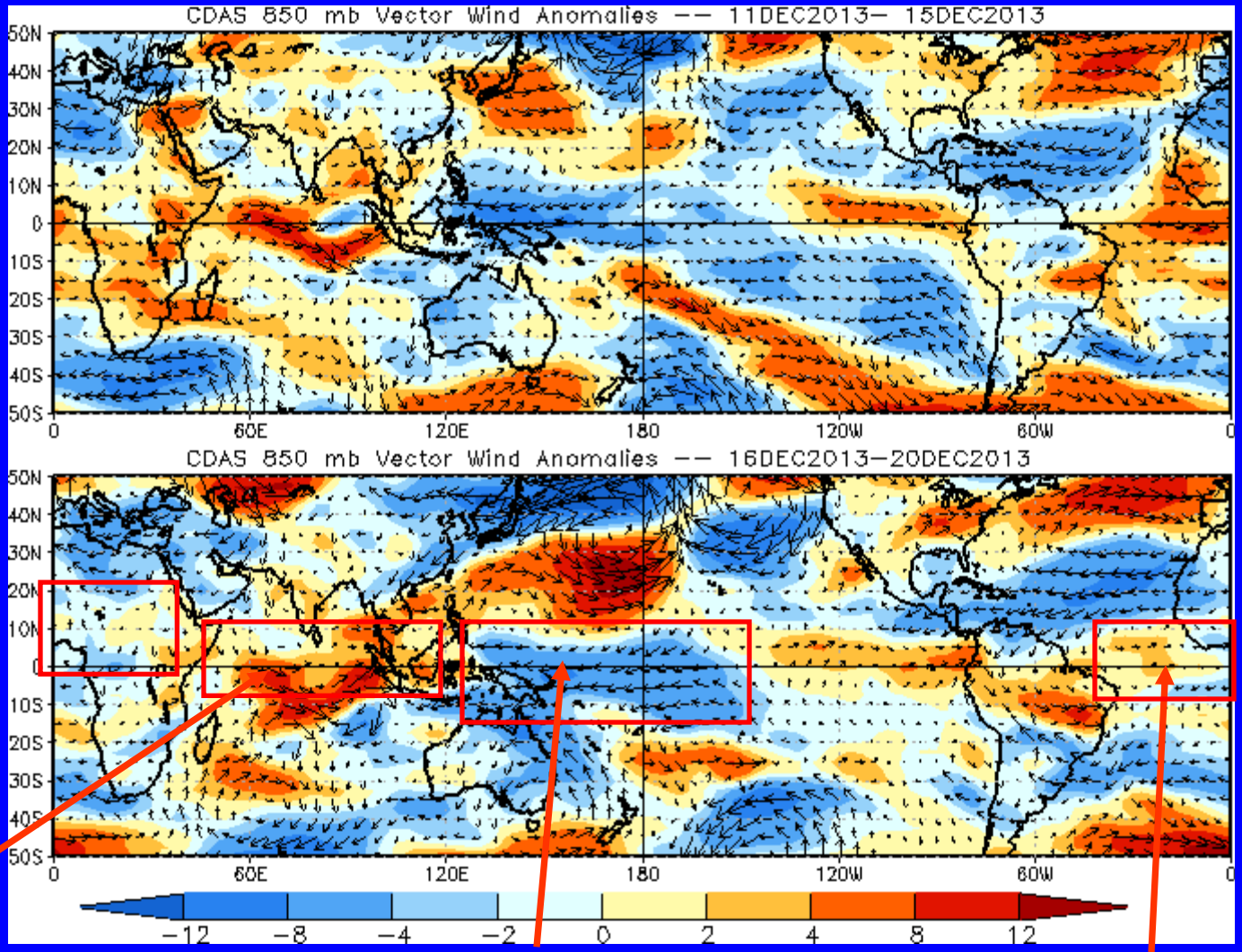
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 over the equatorial Indian Ocean and spread eastward over the western Maritime Continent.

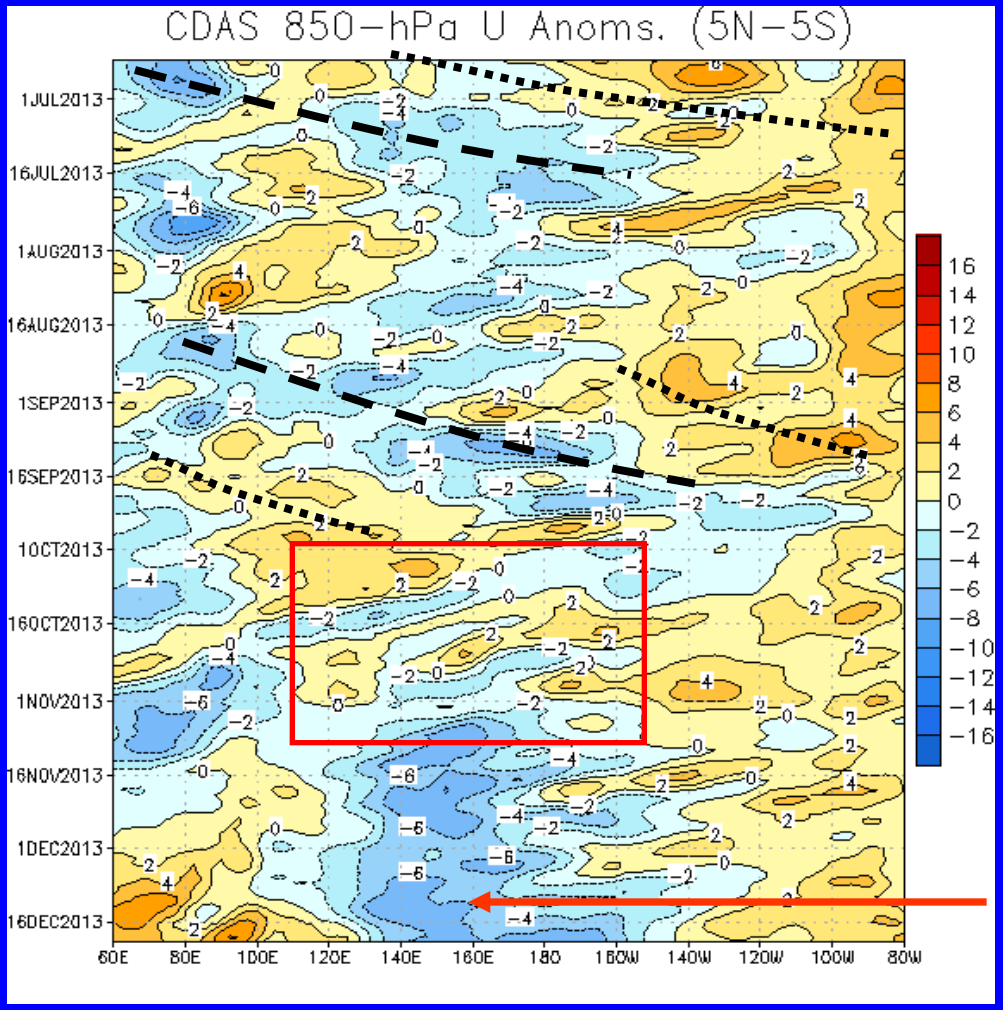
Easterly anomalies persisted over the equatorial western Pacific.

Westerly anomalies weakened 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

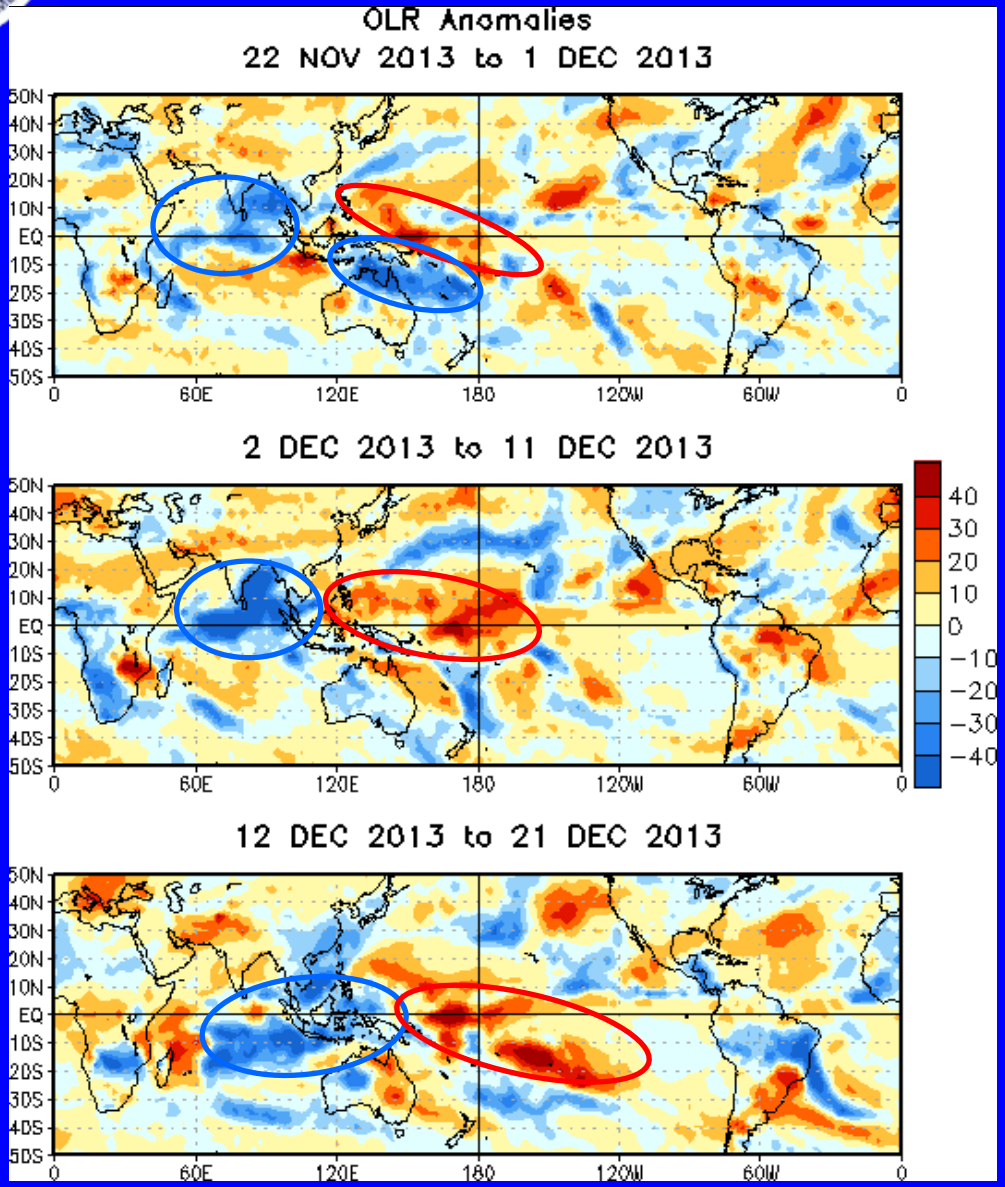
The MJO strengthened during June and continued until mid-July with fast eastward propagation.

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 is some evidence of eastward propagation at the end of the period.

OLR Anomalies – Past 30 days



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

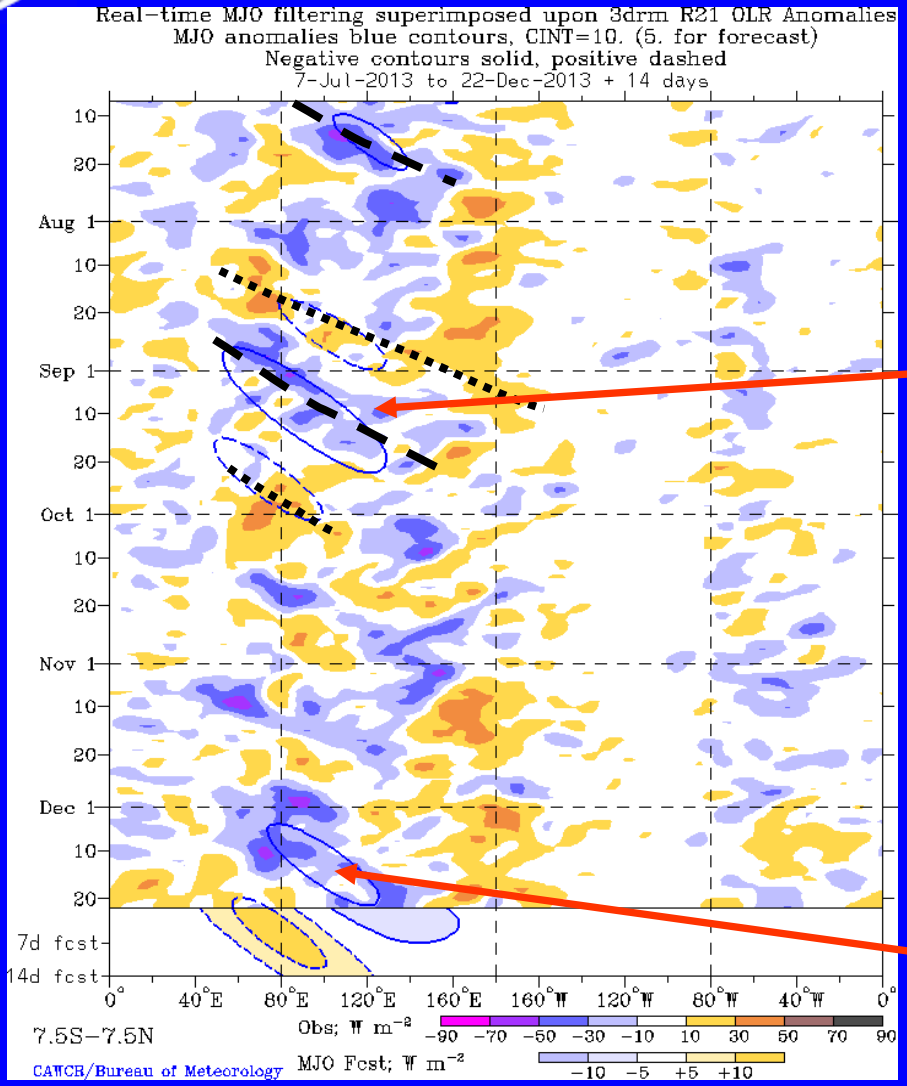
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Wet conditions were observed across the eastern Indian Ocean, southern Maritime continent, and northern Australia during mid-to-late November, while suppressed convection continued for much of the Pacific basin.

During early December, enhanced convection persisted and intensified across the Indian Ocean, while suppressed convection continued over much of the equatorial Pacific.

During mid-December, enhanced convection associated with tropical cyclone activity continued over the southern Indian Ocean, while enhanced (suppressed) convection was observed over the Maritime Continent (Pacific Ocean).

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 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.

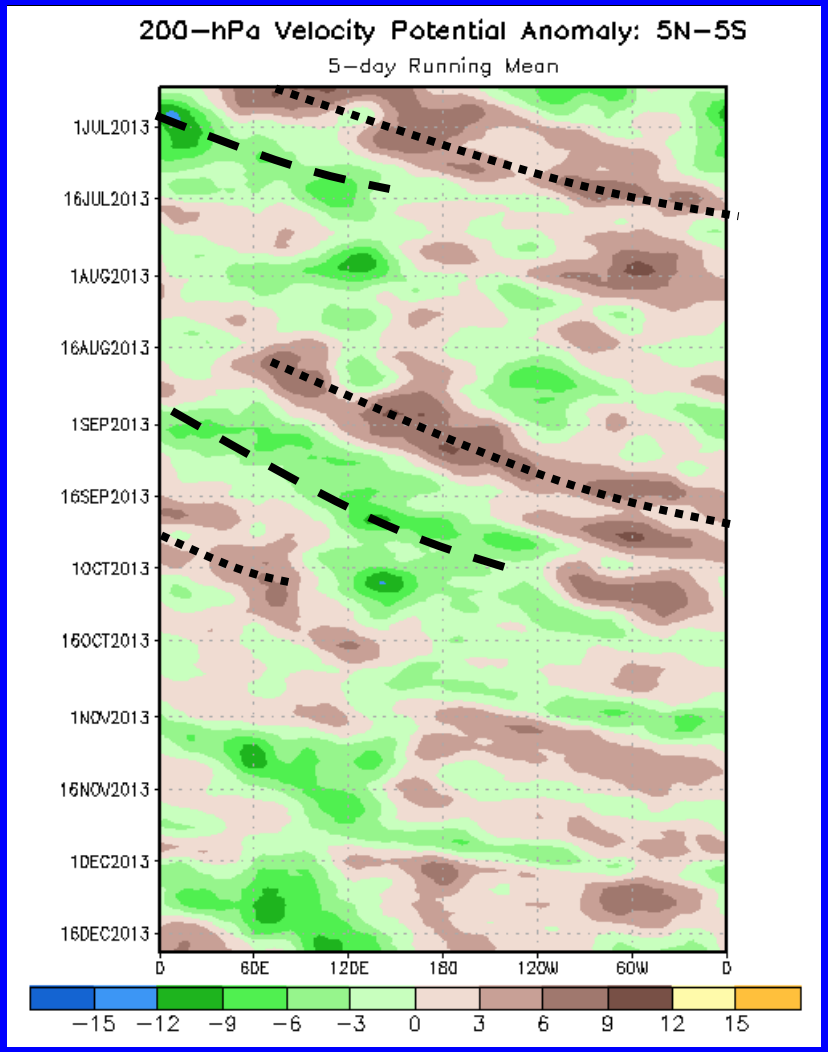
The MJO was generally weak or incoherent for much of November and other types of coherent tropical subseasonal variability were very active.

During late November, a large area of enhanced convection developed in the Indian Ocean and remained stationary for several weeks, but has exhibited some eastward propagation in mid-December.

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.

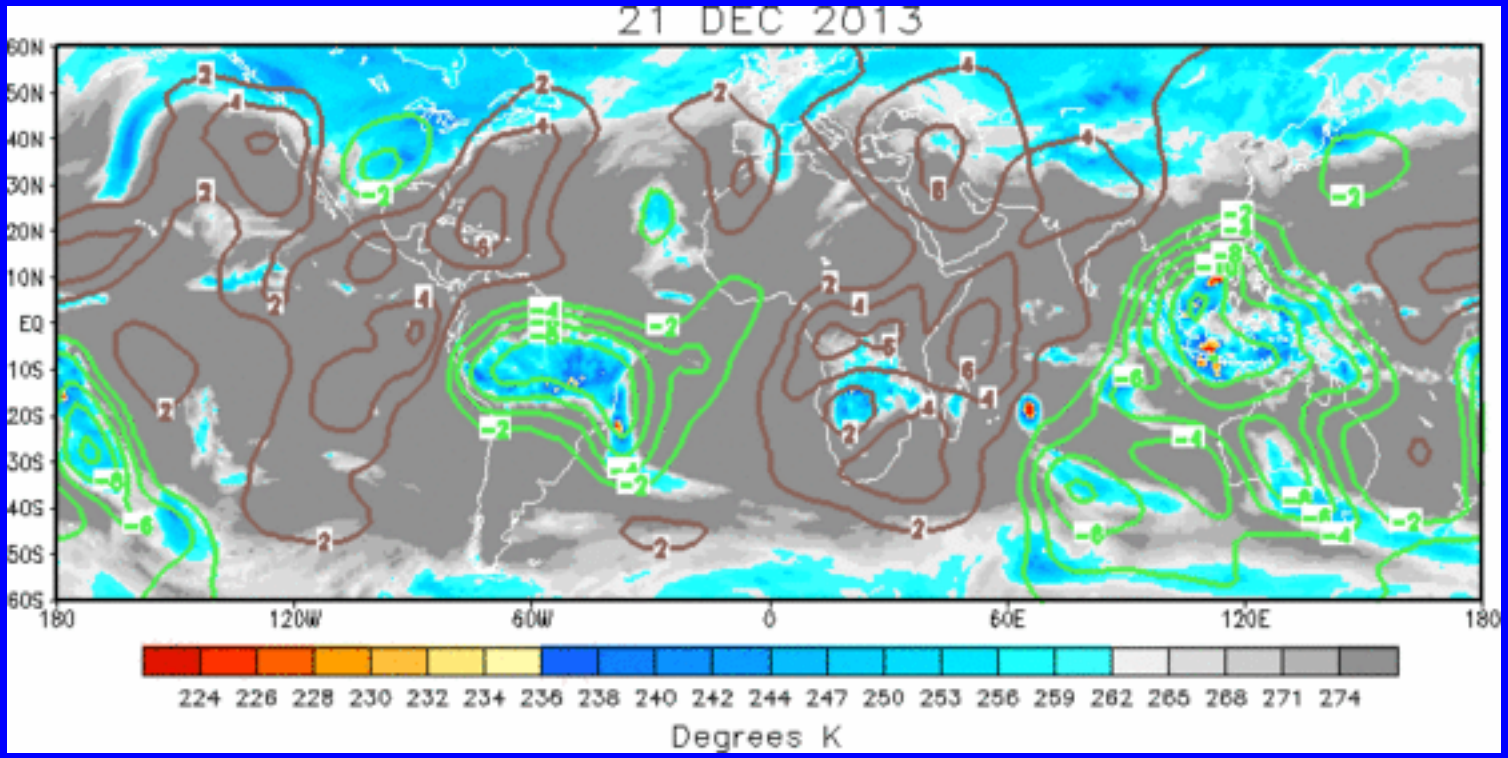
From late October to early December, the MJO was not very strong or coherent. There was evidence of coherent eastward propagation at times during this period, but much of this activity exhibited fast propagation speeds more consistent with atmospheric Kelvin waves.

A slower eastward propagation of 200-hPa velocity potential anomalies was observed during mid-December.

IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

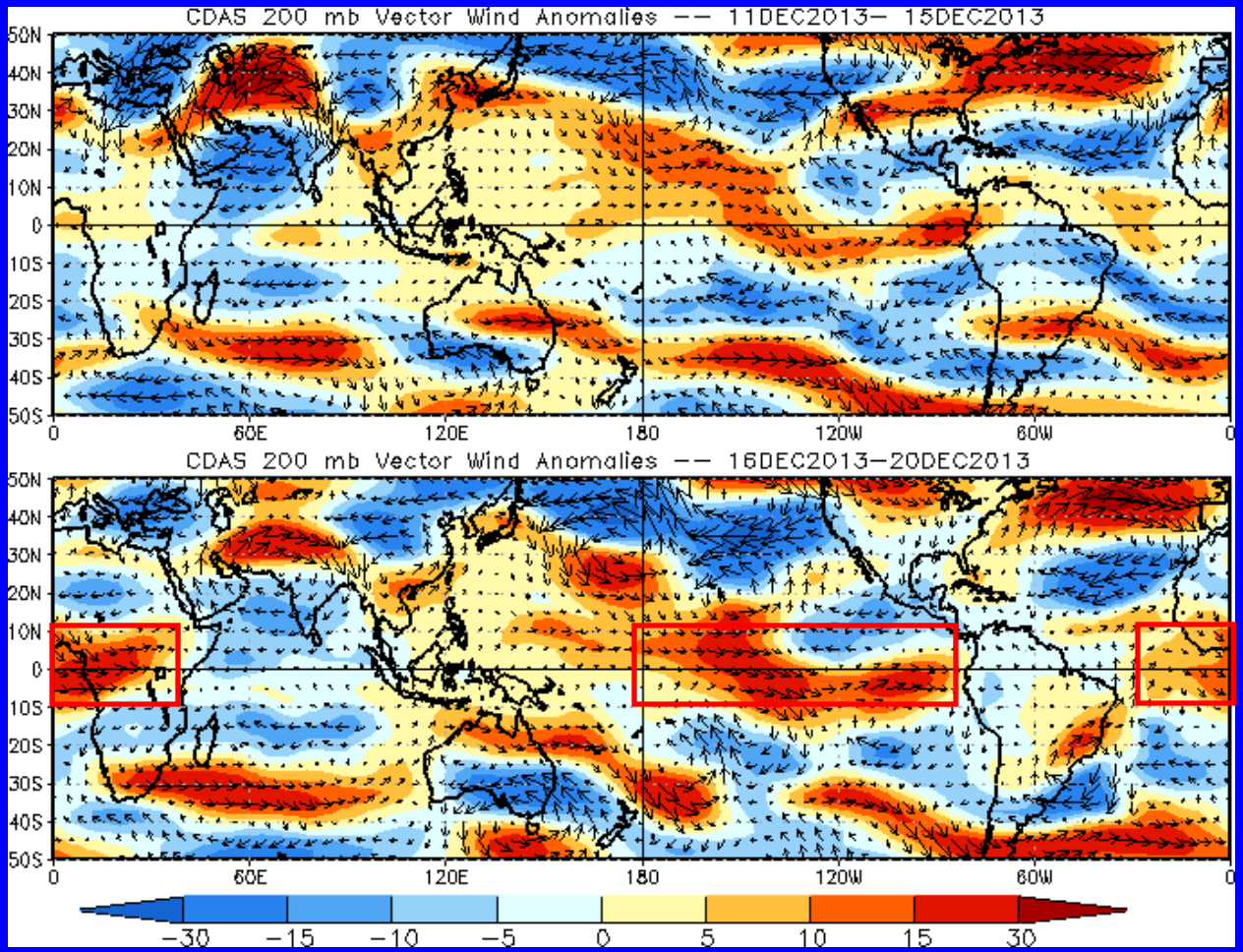
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The current velocity potential pattern shows large scale upper-level divergence (convergence) over the Maritime Continent (central and eastern Pacific, Africa, and the western Indian Ocean). The enhanced phase of a Kelvin Wave is evident over the western Pacific, and negative velocity potential anomalies (green contours) over South America may be partly associated with mid-latitude features.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

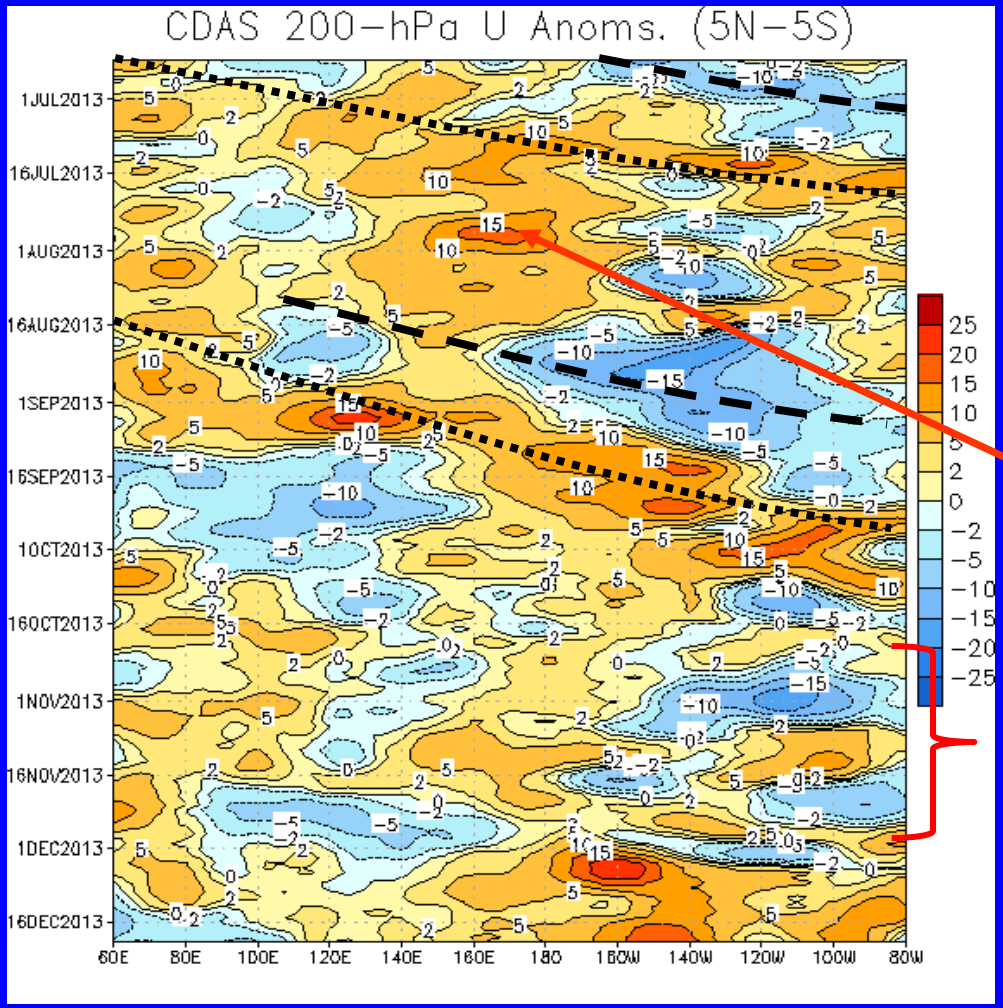
Westerly anomalies intensified over the tropical eastern Pacific, Gulf of Guinea, and western equatorial Africa during the previous five days (red boxes).

Easterly wind anomalies increased in coverage over the Indian 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

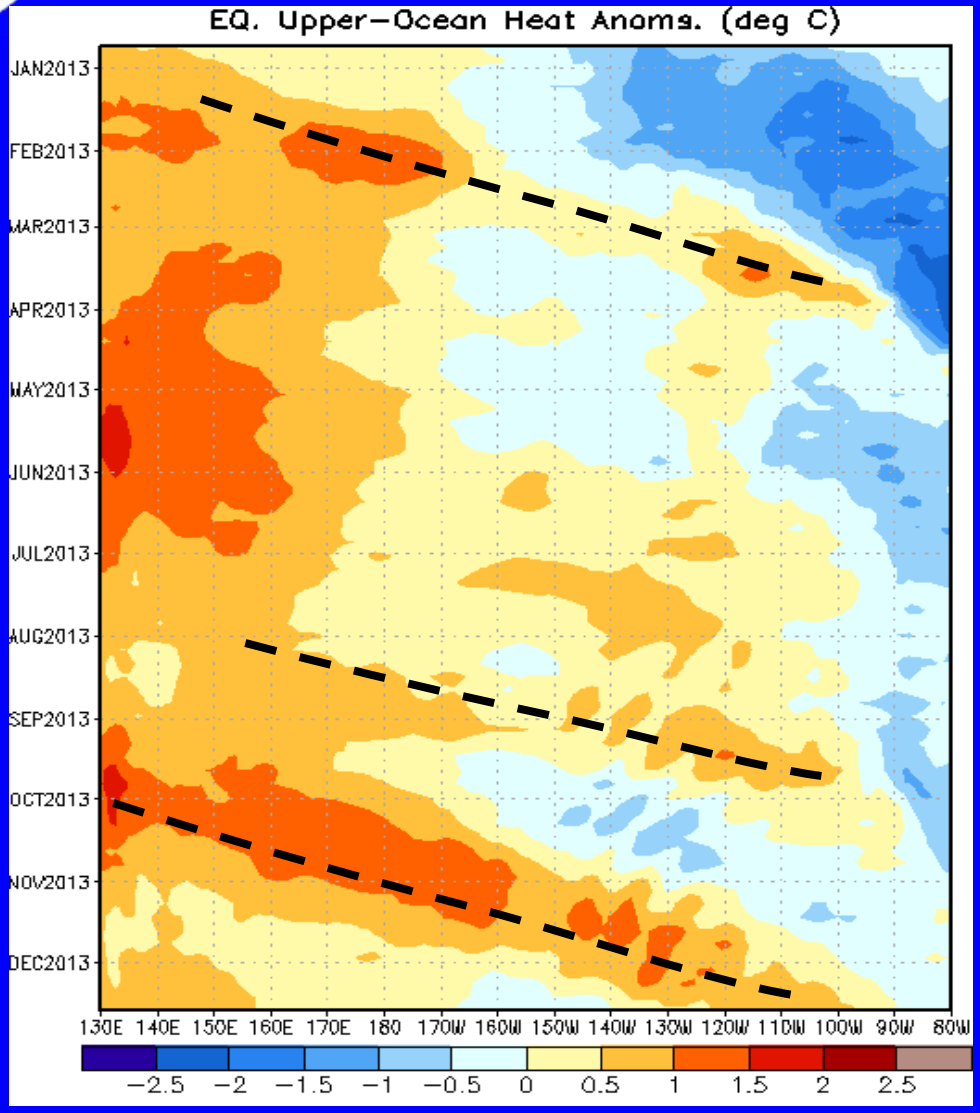
Longitude

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). Also, westerly anomalies have strongly increased in December just east of the Date Line, while easterly anomalies developed over the Indian Ocean.

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 through early December, 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).

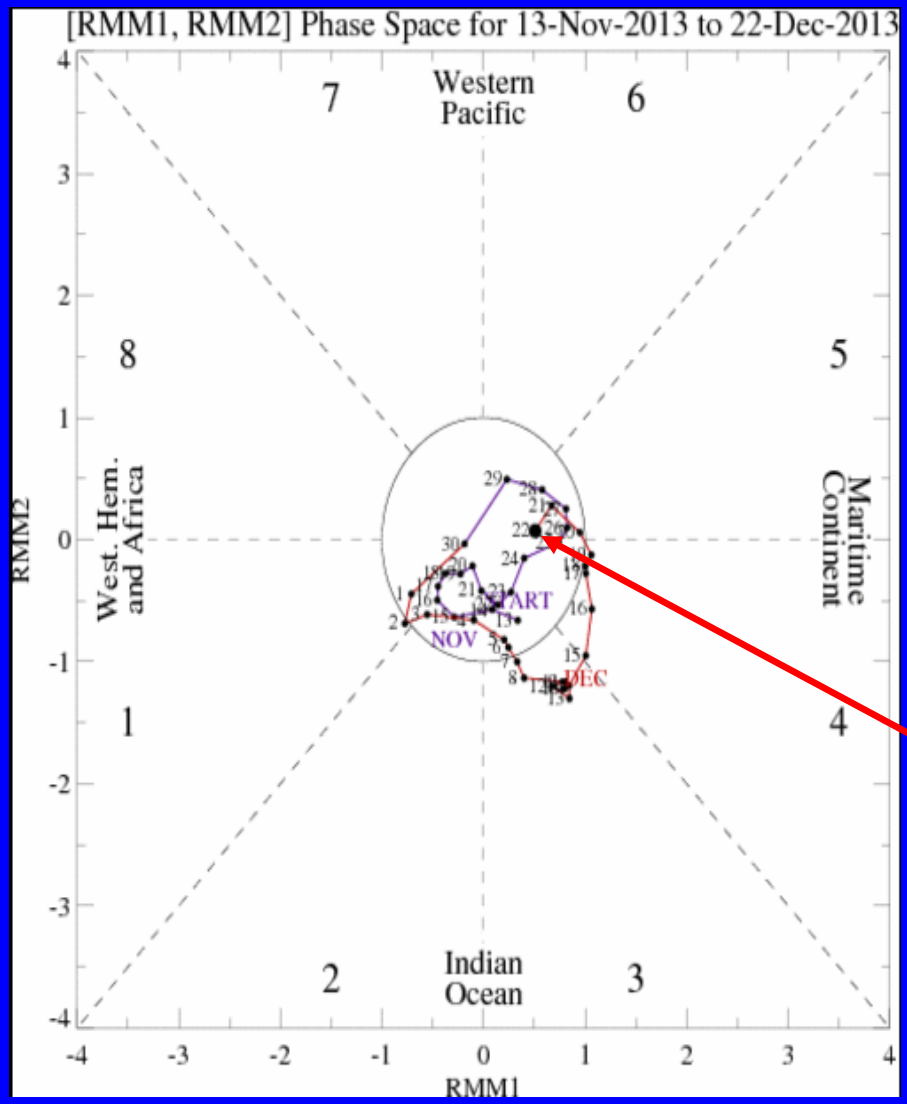
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

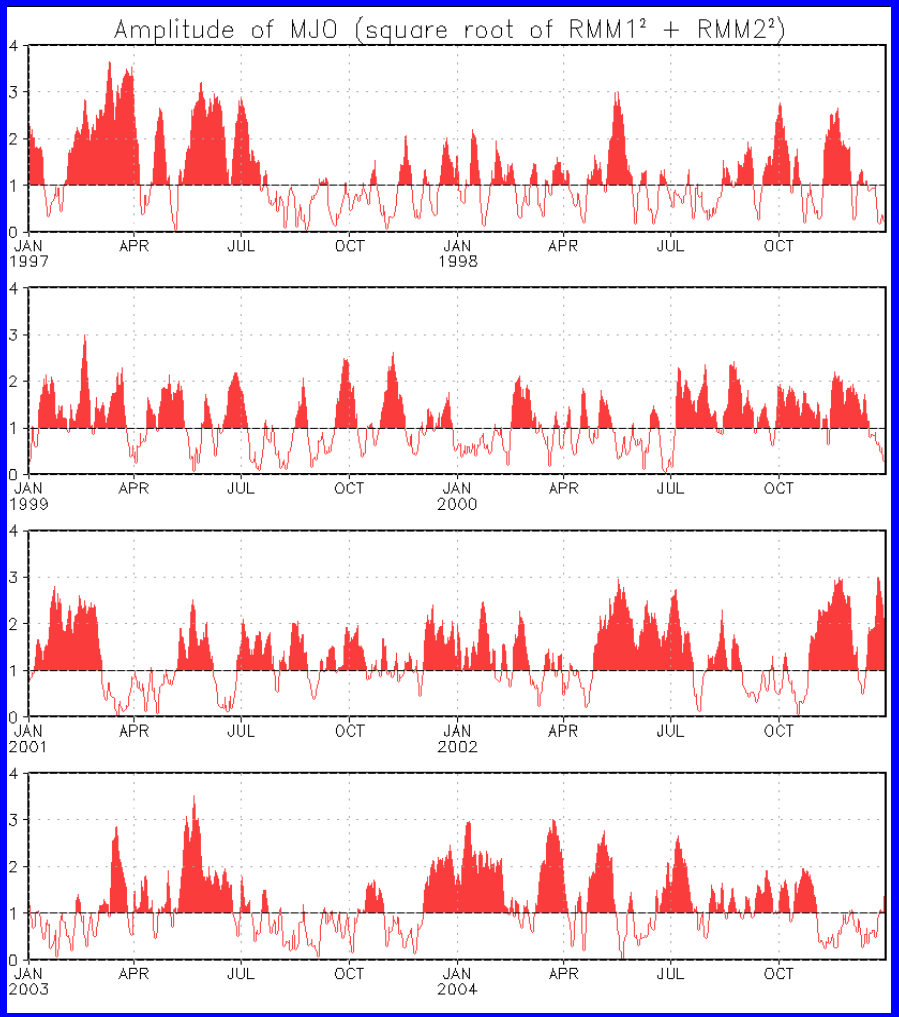
MJO Index -- Recent Evolution

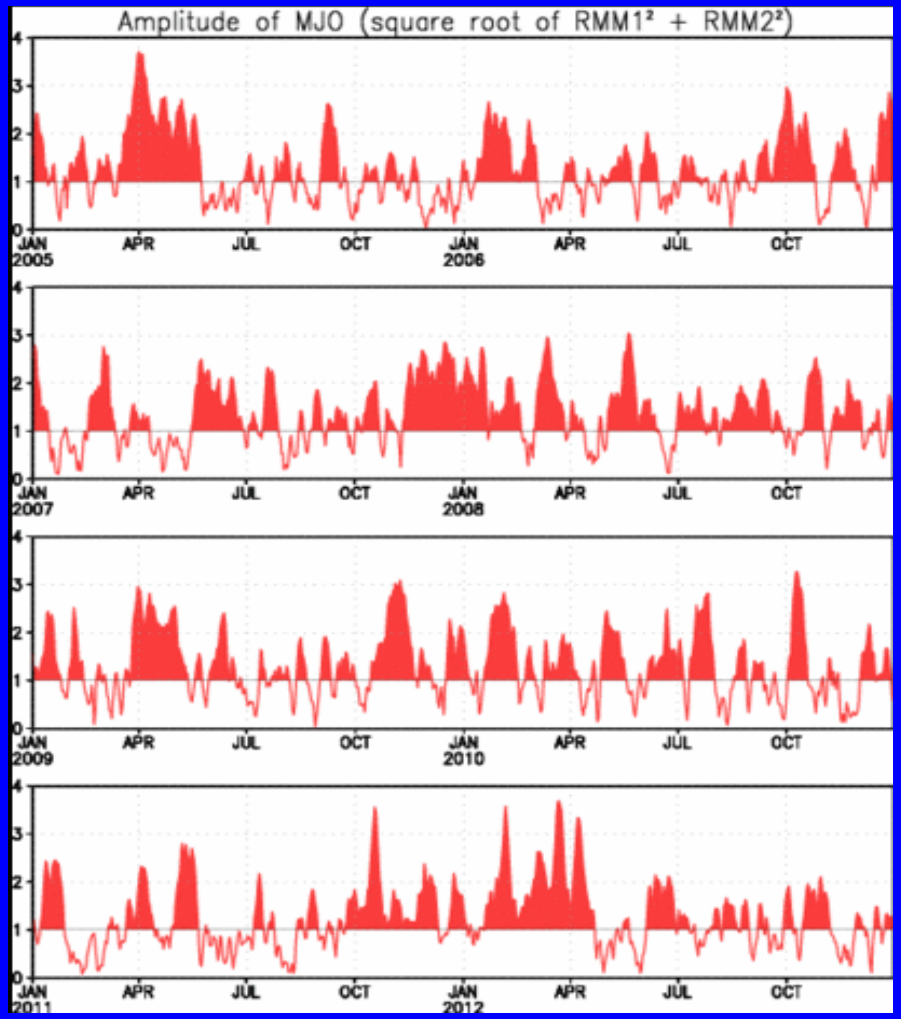


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index showed a fast eastward propagation with decreased amplitude during the previous week, as other forms of coherent tropical subseasonal convective anomalies influenced the pattern.

MJO Index – Historical Daily Time Series





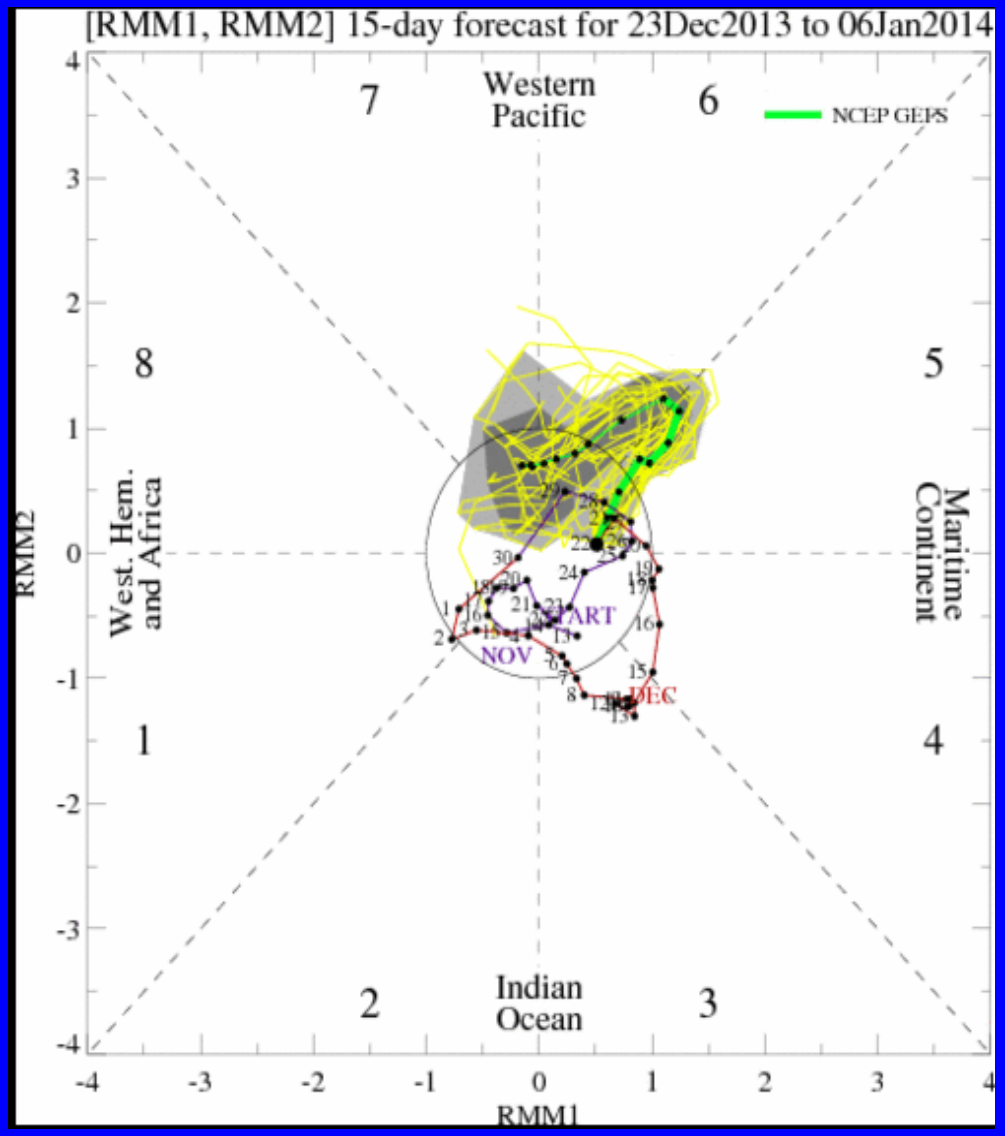
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

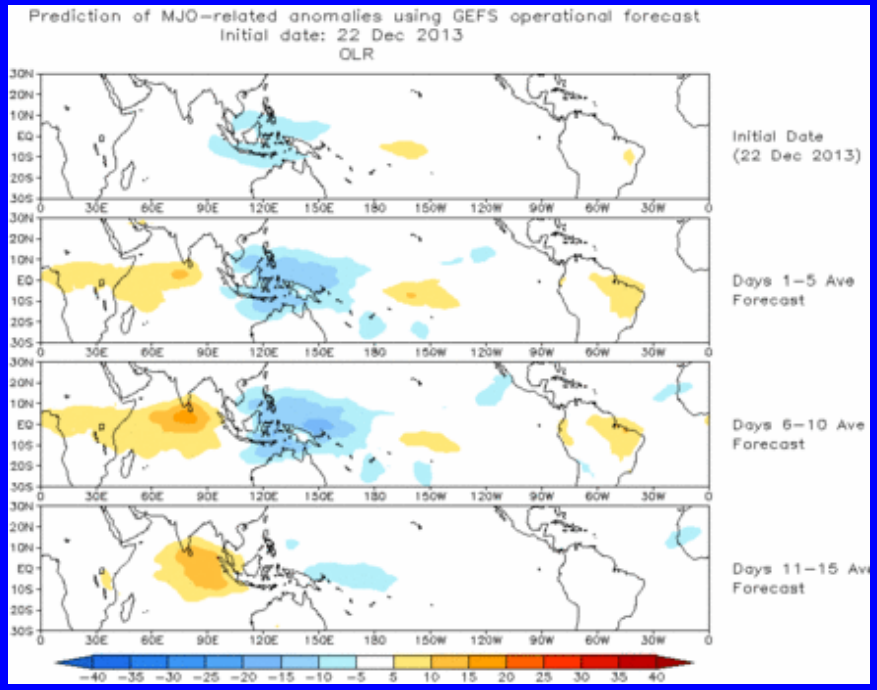


The ensemble GFS forecast indicates a strengthening MJO signal during the Week-1 period, with some eastward propagation into the western Pacific. There is considerable spread among the ensemble members during the Week-2 period, with most indicating a weaker signal.

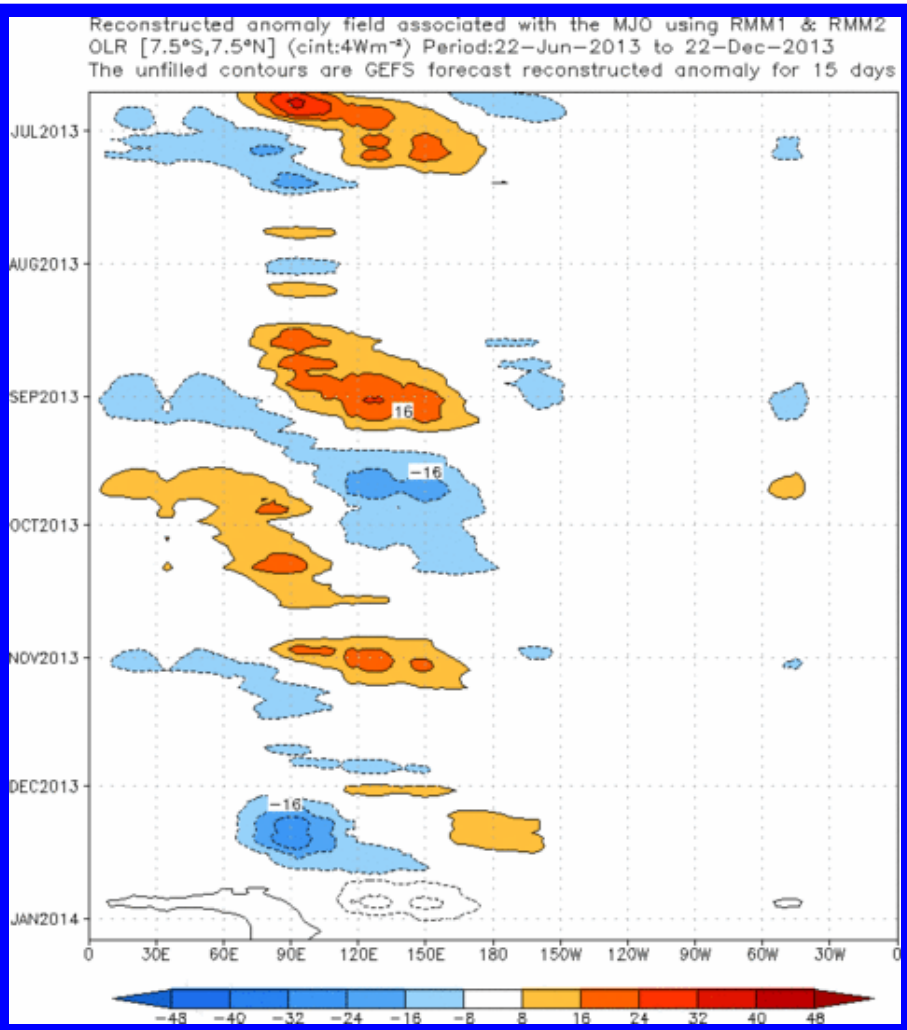
Ensemble Mean GFS MJO Forecast

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

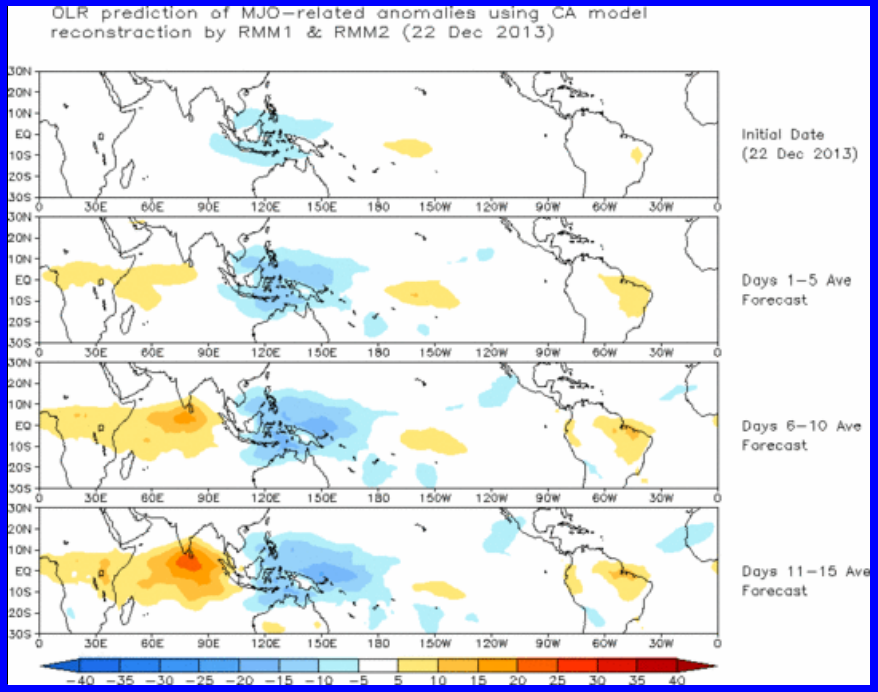


The ensemble mean GFS forecasts enhanced (suppressed) convection propagating eastward into the western Pacific (Indian Ocean), with decreasing amplitude of the anomalies during the latter part of the Week-2 period.

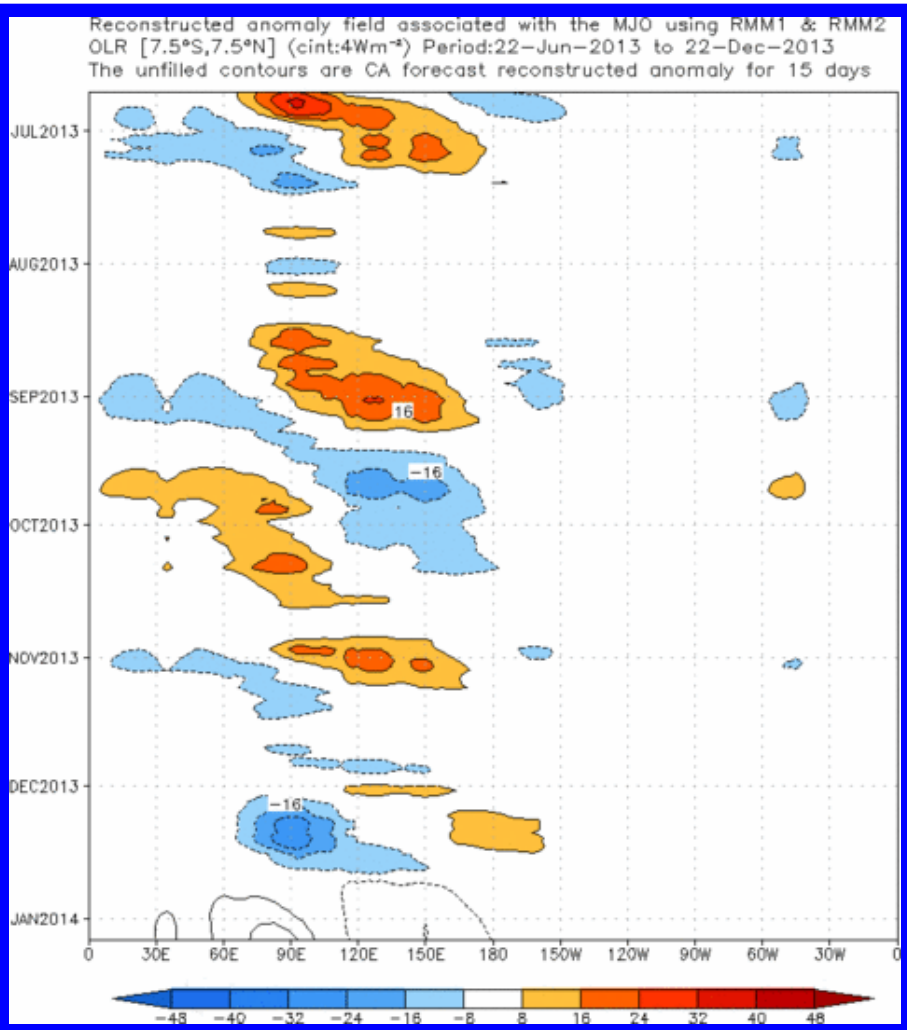
Constructed Analog (CA) MJO Forecast

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



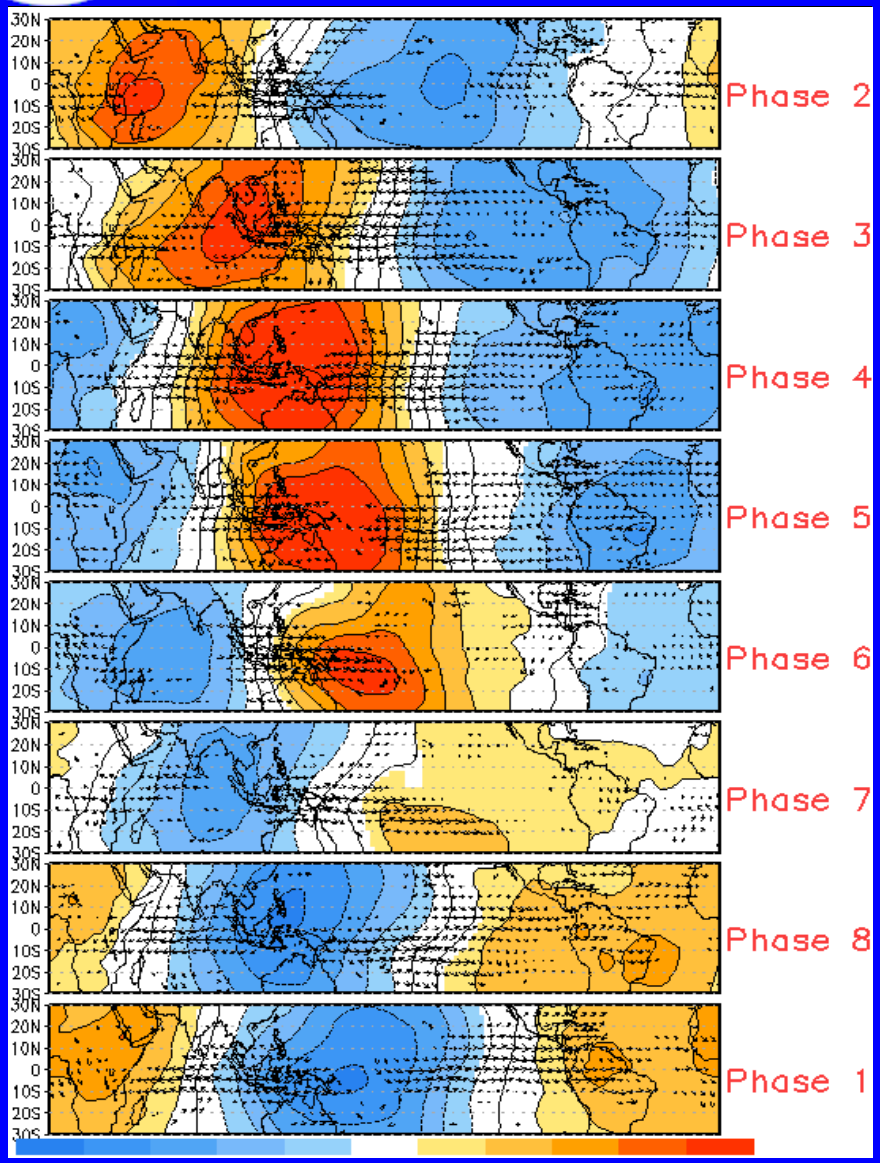
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



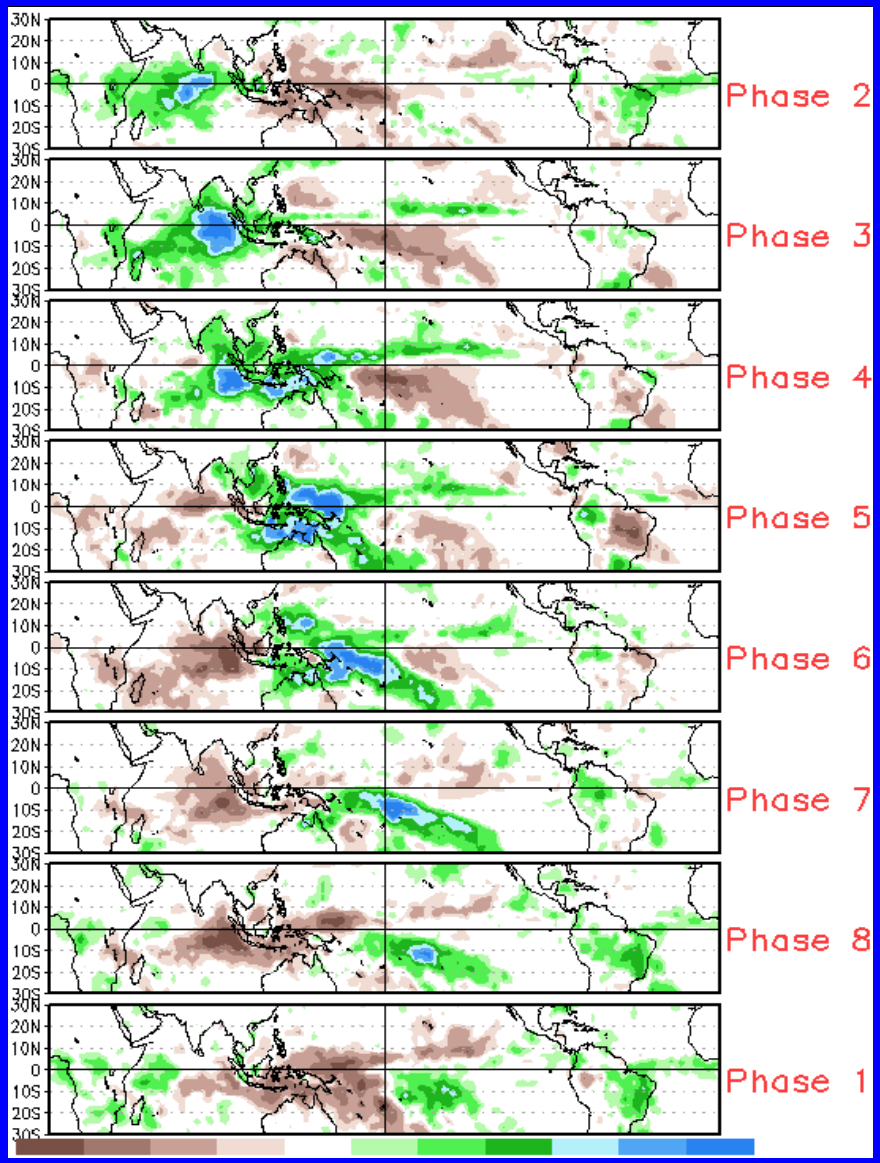
The constructed analog MJO forecast indicates a slow eastward propagation of enhanced (suppressed) convection from the Maritime Continent to the western Pacific (Indian Ocean) during the upcoming two weeks.

MJO Composites – Global Tropics

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

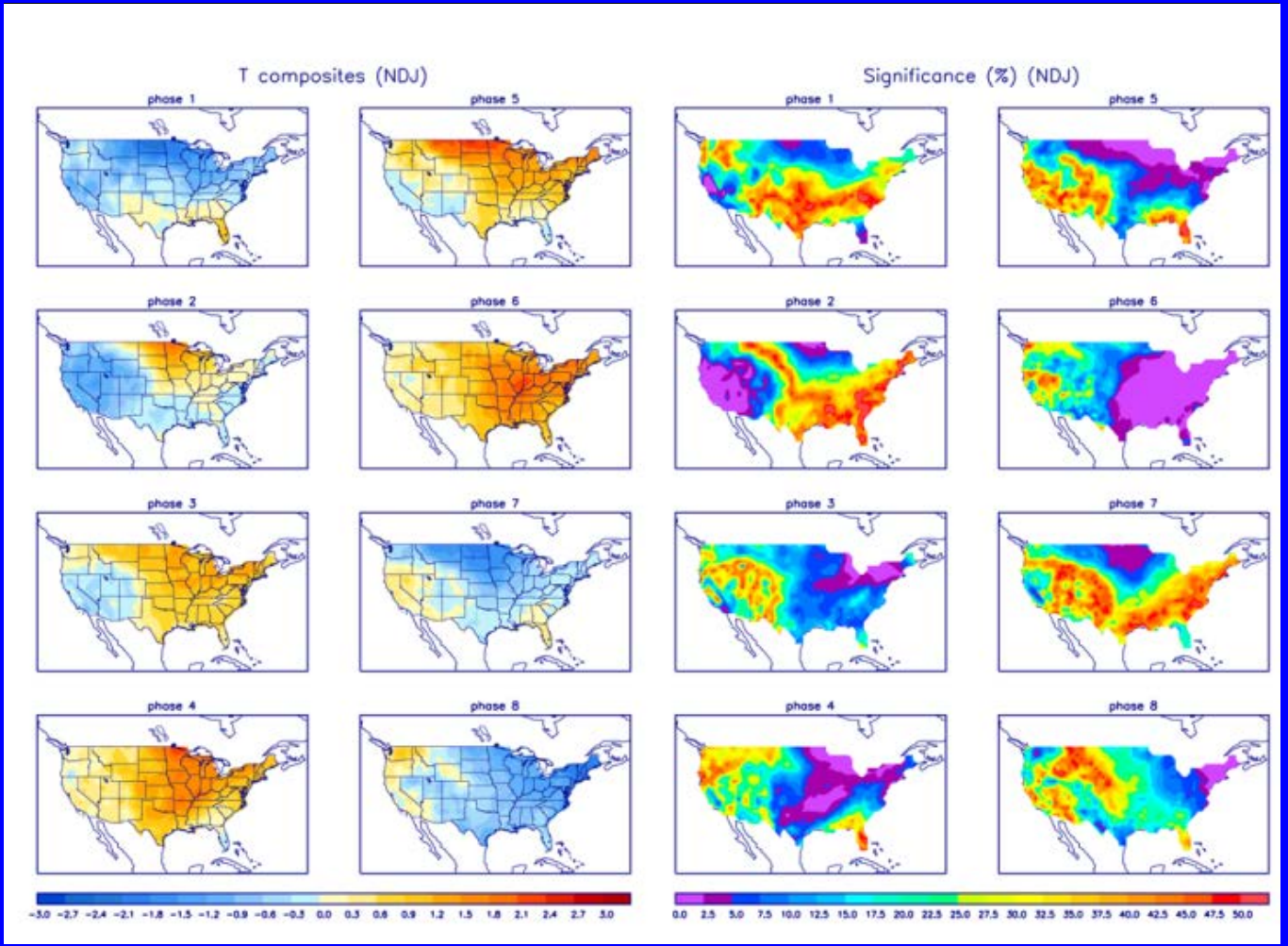


Precipitation Anomalies (Nov-Mar)



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.**

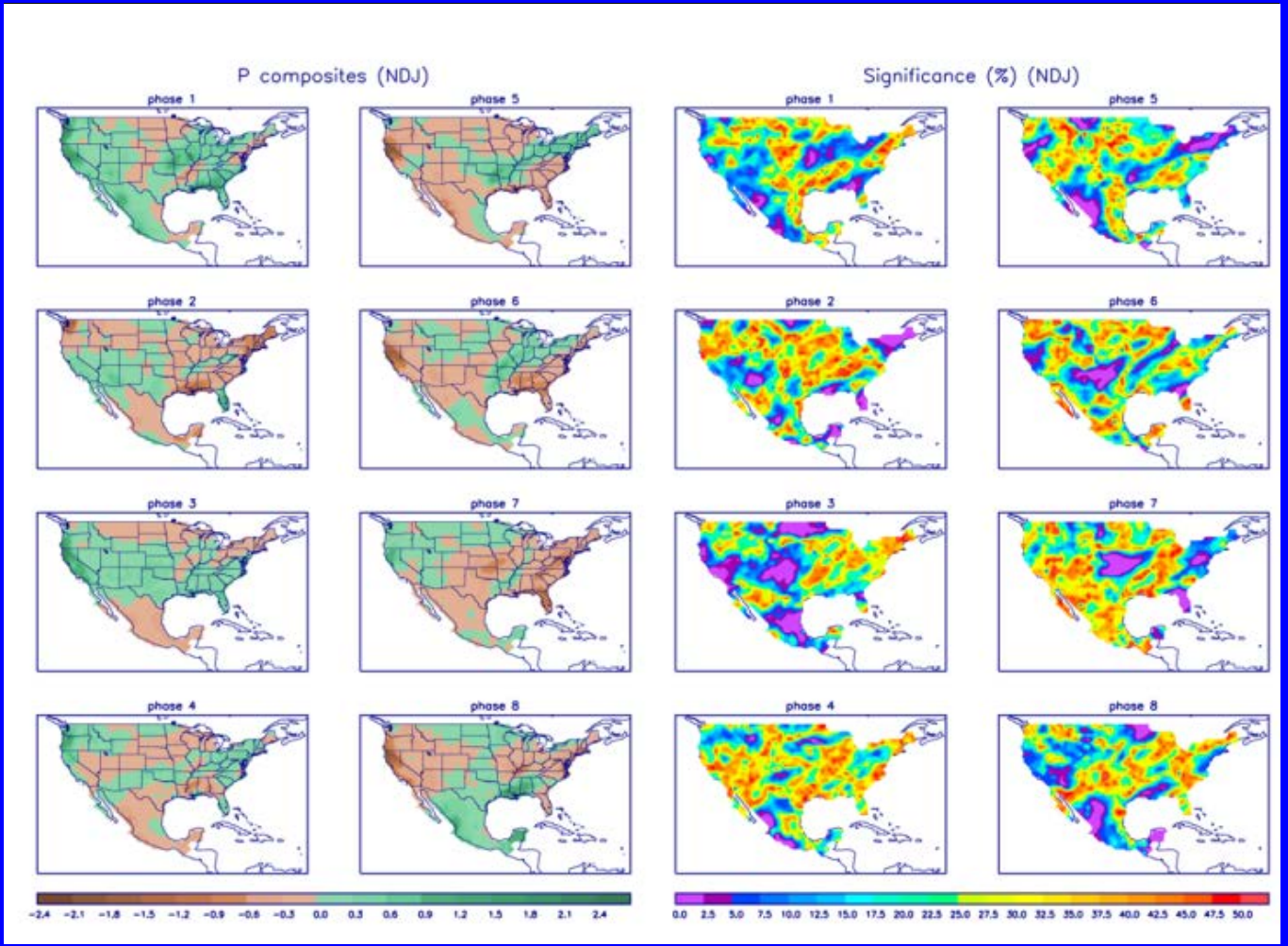


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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