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

Update prepared by
Climate Prediction Center / NCEP
December 2, 2013

Outline

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

Overview

- The MJO remained incoherent during the previous week, with influence from other types of coherent tropical subseasonal variability dominating the anomalous convection and circulation pattern.

- Dynamical model MJO index forecasts indicate a strengthening signal during the next week over the Indian Ocean with some eastward propagation. There is considerable spread among the dynamical model forecasts during Week-1 regarding the amplitude of the signal. During Week-2, most models propagate the signal to the Maritime Content. Statistical forecasts suggest only a weak MJO signal.

- Based primarily on the latest observations and some dynamical model guidance, the MJO is forecast to strengthen over the next two weeks and would favor enhanced (suppressed) convection over the Indian Ocean and Maritime Continent (Western Pacific) during the period. Also, the forecast active phase of the MJO would support an increased threat of tropical cyclone formation over the Indian Ocean during both Week-1 and Week-2.

- There remains considerable uncertainty whether this potential signal organizes into a longer lived MJO event in coming weeks.

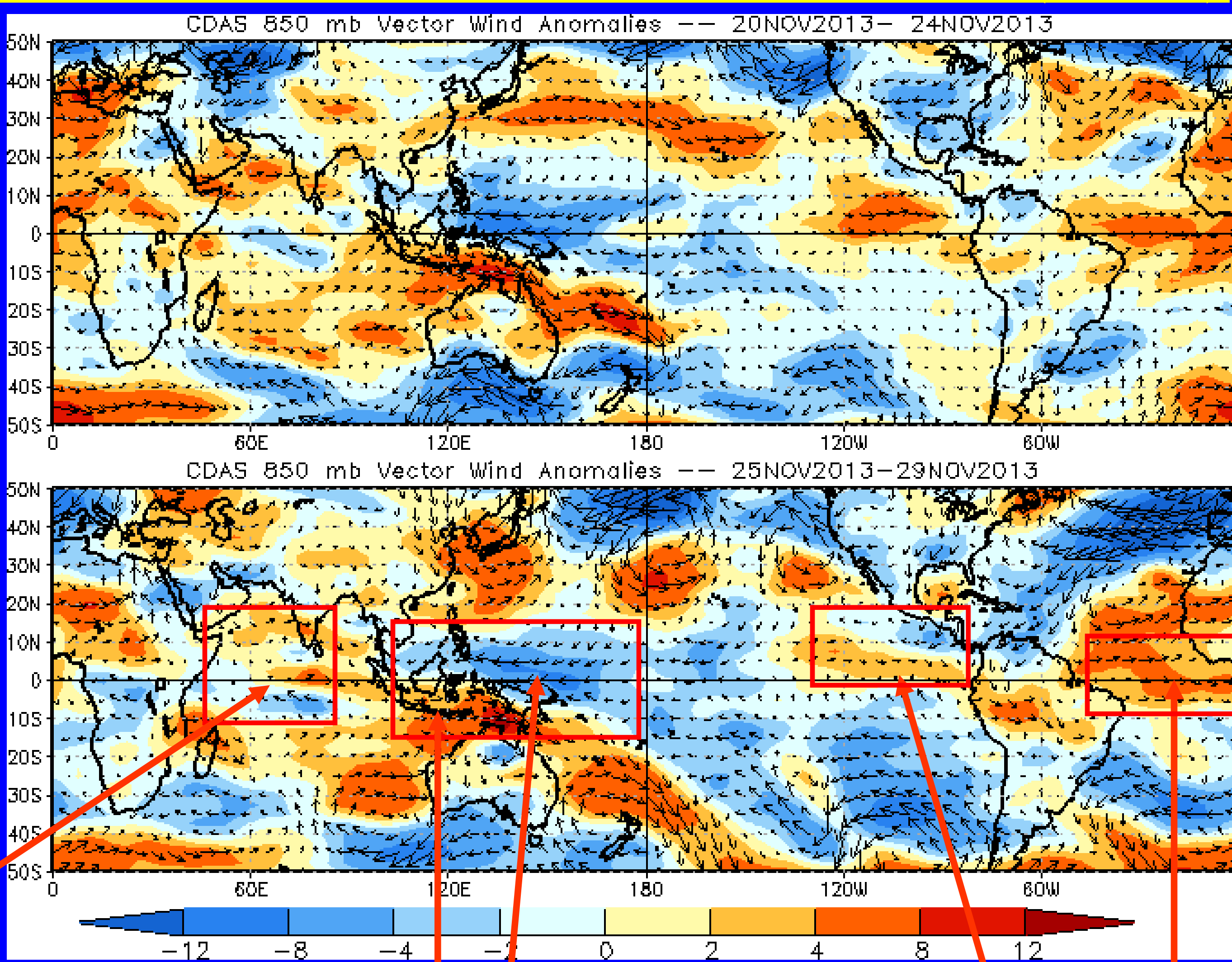
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalies weakened across parts of the equatorial Indian Ocean.

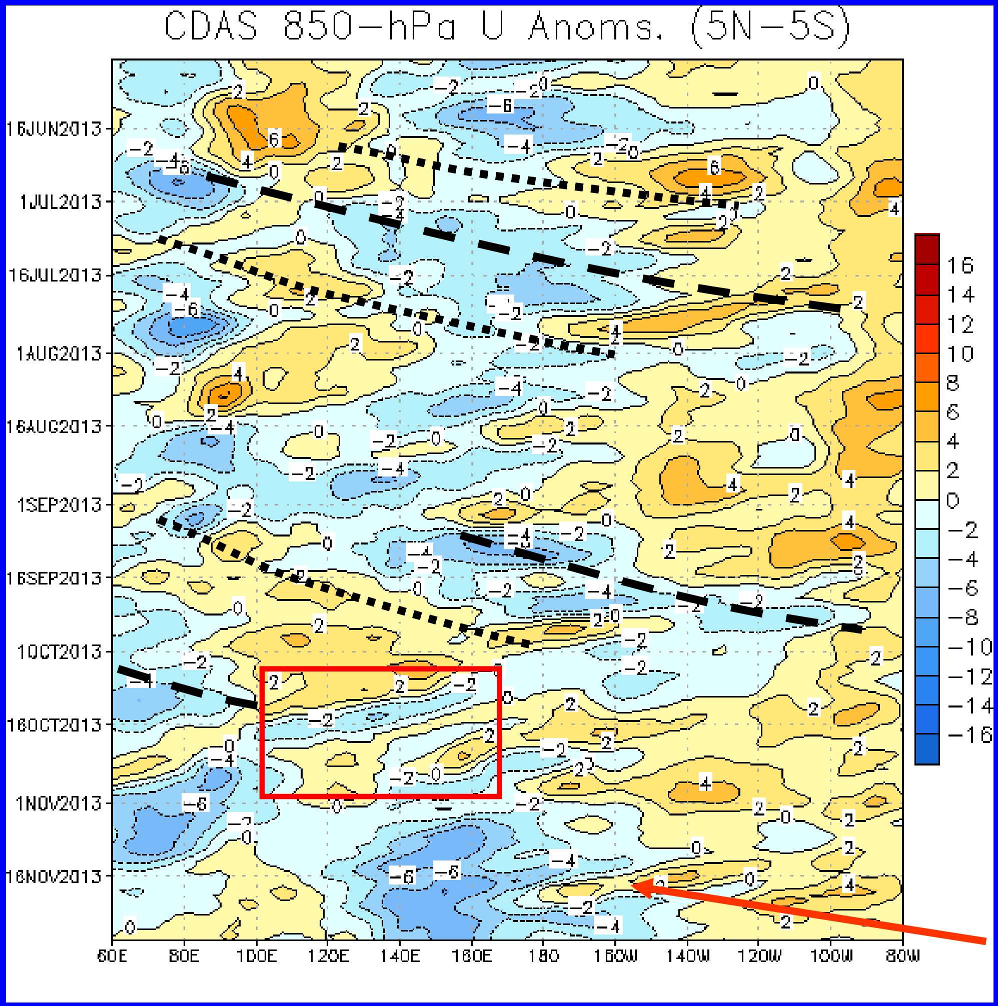
Easterly (westerly) anomalies persisted over the western Pacific and Maritime Continent north of the equator (remainder of the Maritime Continent and northern Australia).

Westerly anomalies diminished over the eastern Pacific during the past five days, and increased over the equatorial Atlantic.

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

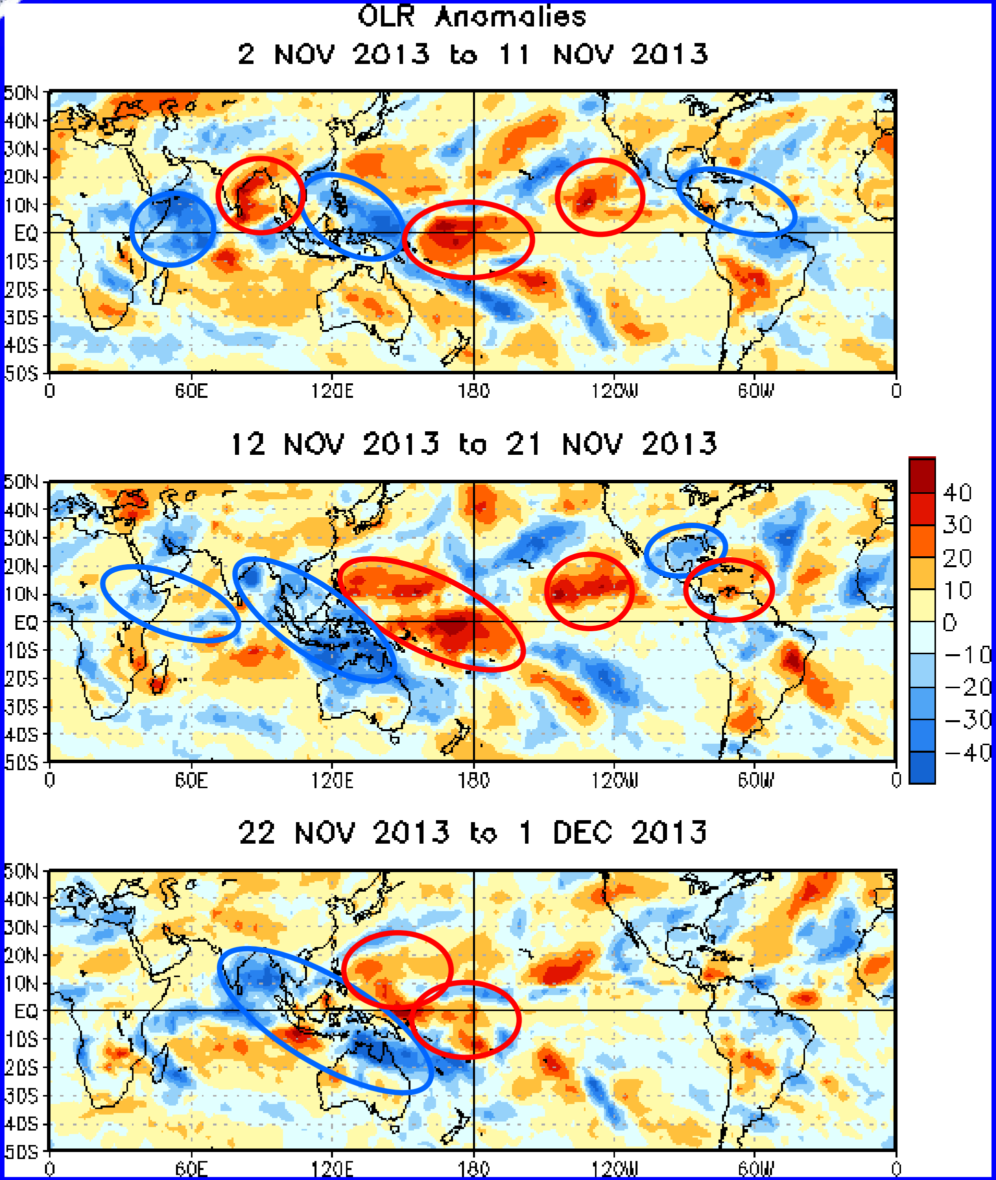
The MJO strengthened during June and continued until mid-July with fast eastward propagation.

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 the first half of November, MJO activity was not coherent as multiple westward moving features dominated the pattern of low level zonal wind anomalies.

OLR Anomalies – Past 30 days



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

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

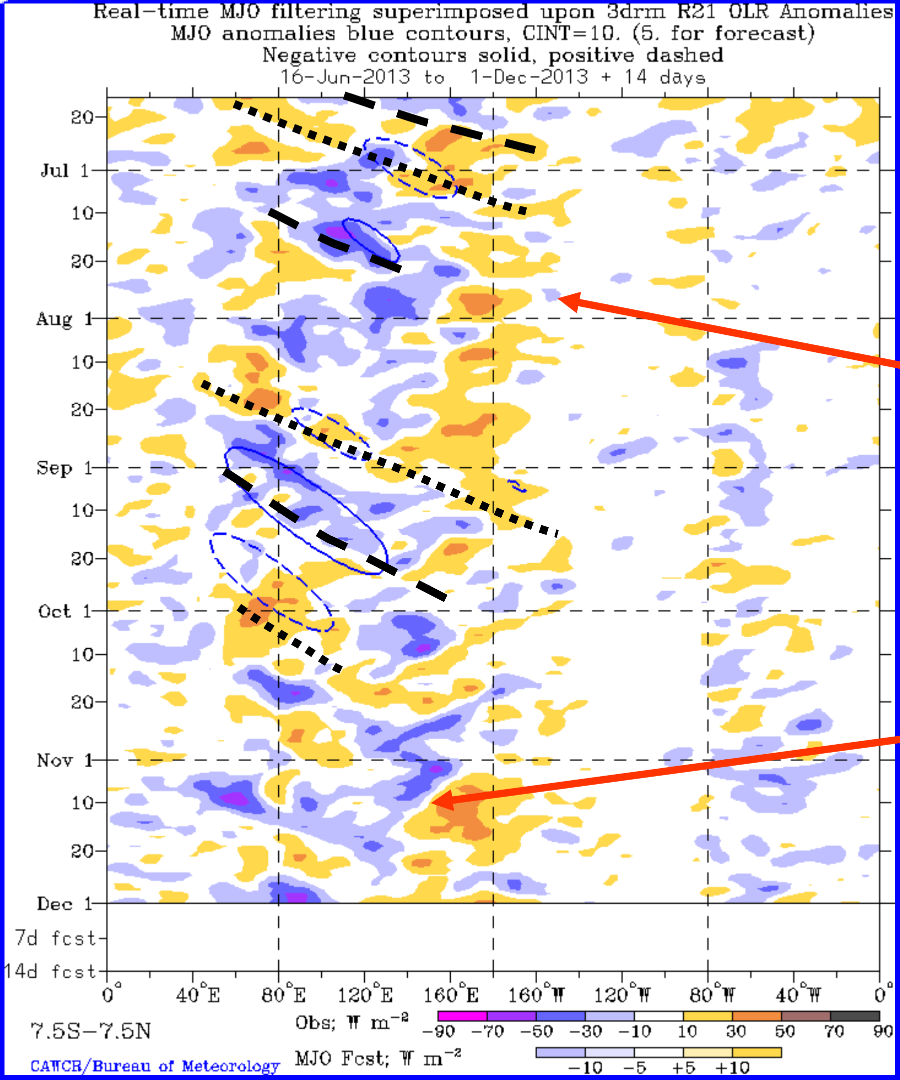
During early November, enhanced convection associated with tropical cyclones continued over the western Pacific. Enhanced (suppressed) convection was observed over the western Indian Ocean (near the Date Line)

During mid-November, enhanced (suppressed) convection was observed over the Bay of Bengal, Maritime Continent, Australia, and the Gulf of Mexico (western Pacific, Caribbean, eastern Brazil).

During late-November, enhanced convection persisted across the Bay of Bengal and Australia, while convection waned over the Maritime Continent and east-central Pacific.

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 from late August through early October 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.

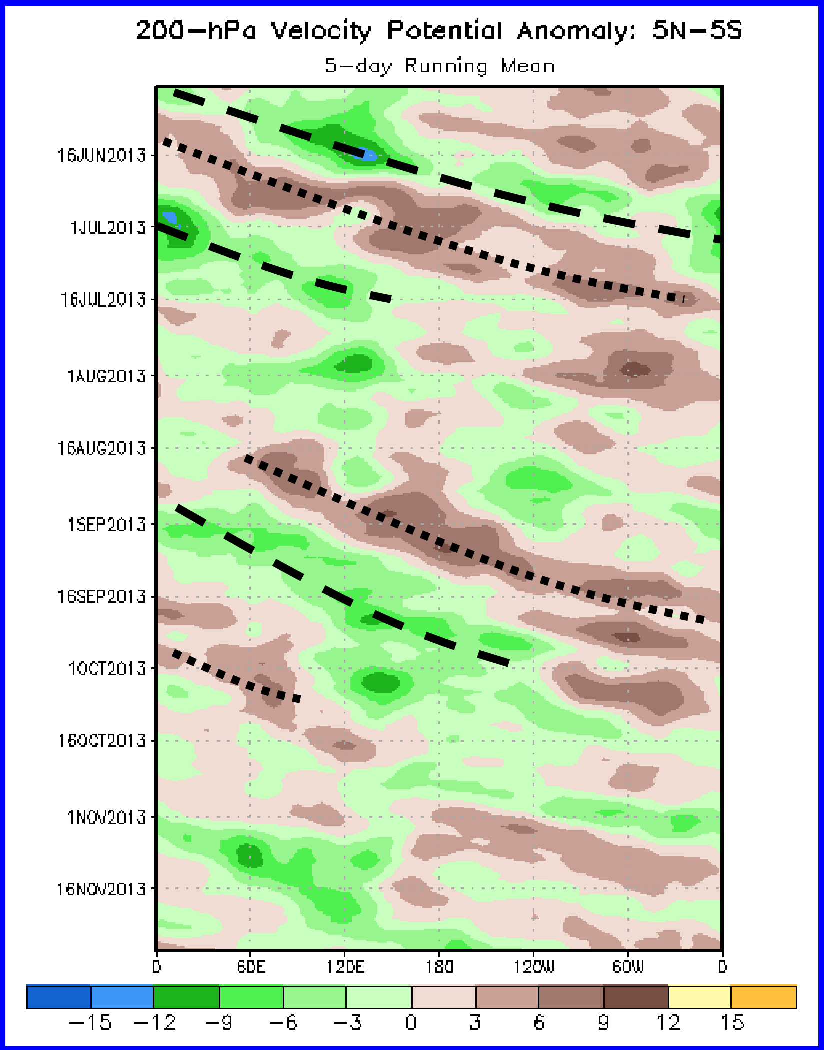
Recently, eastward propagating convective anomalies were measured over the Indian Ocean.

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

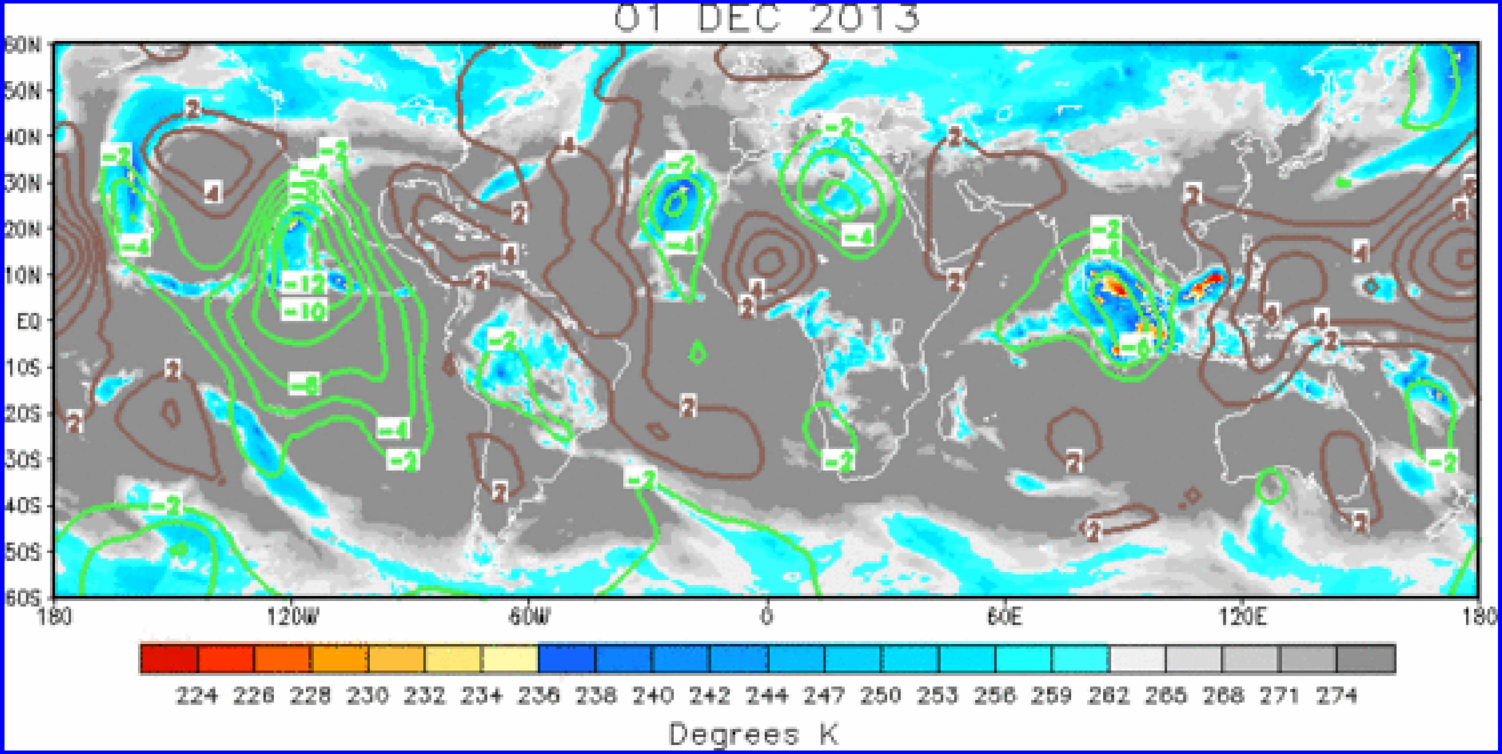
The MJO was not active during late July and much of August, but strengthened during late August and September, with eastward propagation of robust upper-level velocity potential anomalies. Other modes of tropical intraseasonal variability are also evident.

During late October and early November, some coherent eastward propagation on the fast side of the MJO envelope of phase speeds was observed, but the signal became less coherent during mid-November. Near the end of November, rapid eastward propagation is evident once again, especially near the Date Line.

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



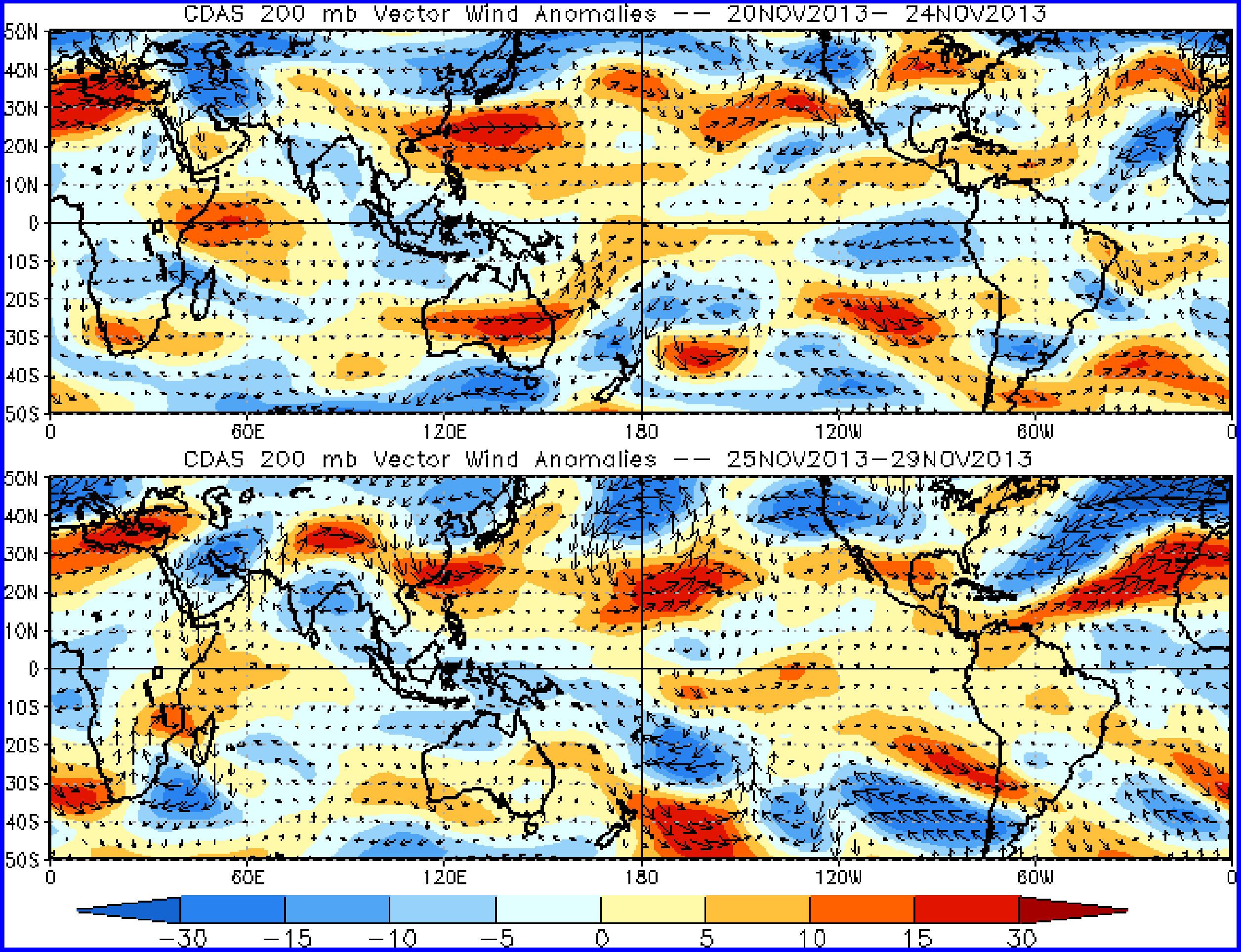
The velocity potential pattern remains incoherent from an MJO perspective, with areas of large scale upper level divergence (green contours) over the eastern Pacific and Indian Ocean, contrasting with areas of large scale upper level convergence (brown contours) over the Americas and Atlantic Ocean, Africa, and western North 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 wind anomalies continued over the western Pacific , while easterly anomalies abated over the eastern equatorial Pacific.

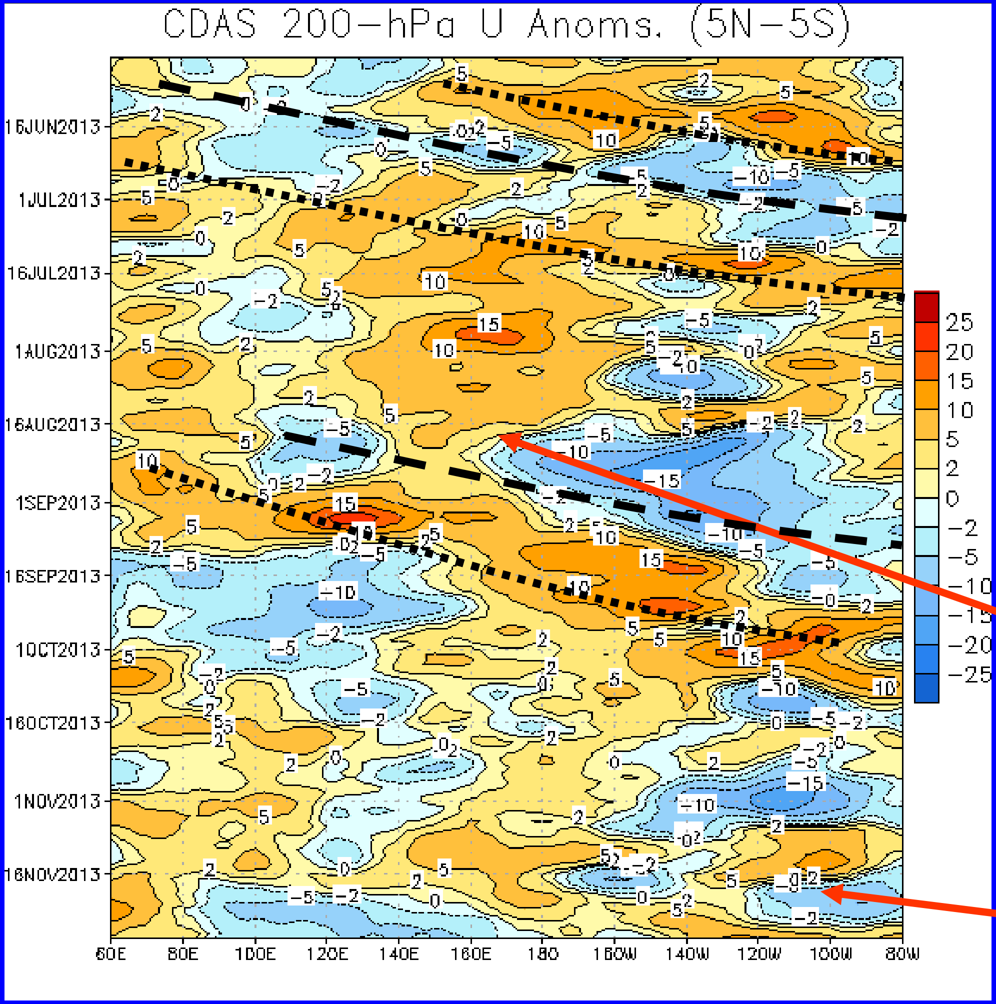
Easterly wind anomalies persisted over the Maritime Continent and expanded to over northern Australia.

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

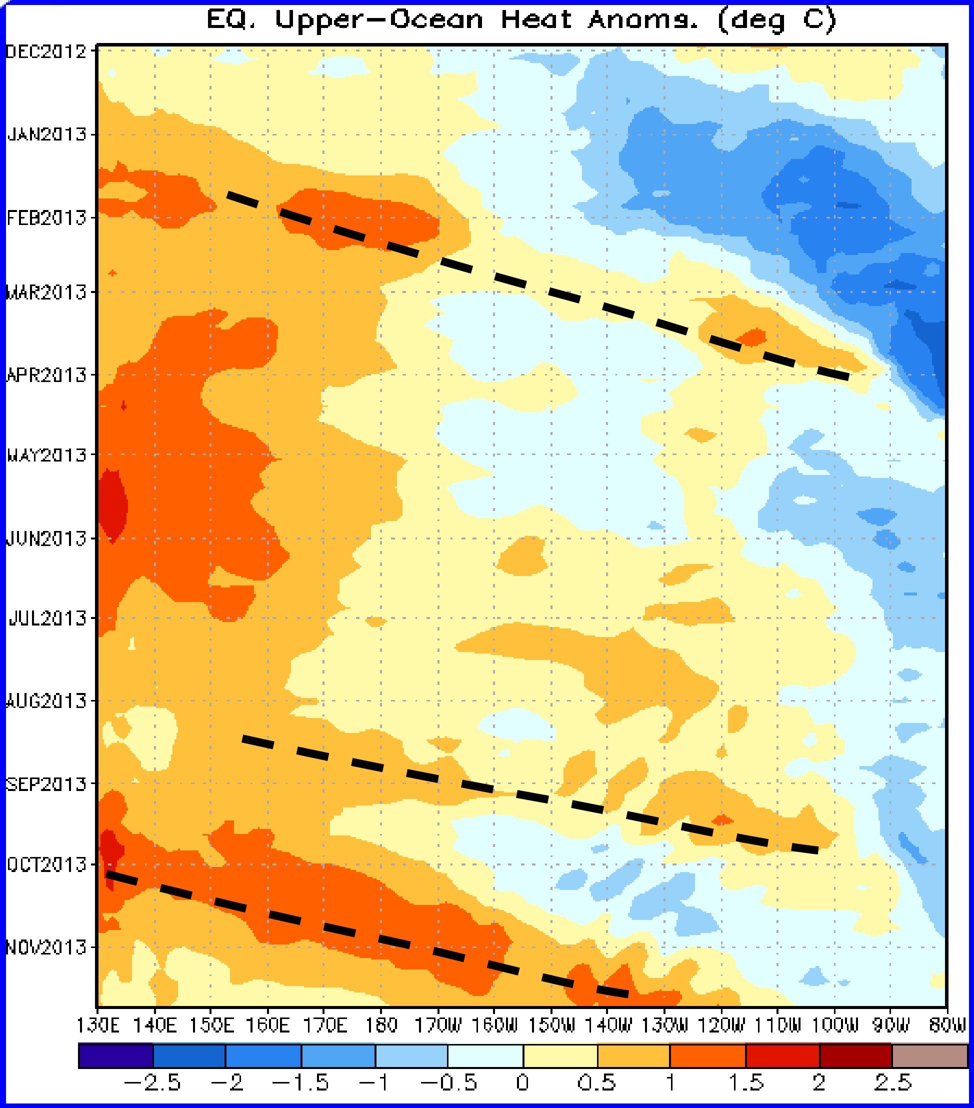
The MJO strengthened (alternating dotted and dashed lines) during June and its influence continued to mid-July, as eastward propagation of wind anomalies associated with the MJO were again observed.

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 have continued over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics. Some rapid, eastward propagation is also evident in the most recent data points.

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).

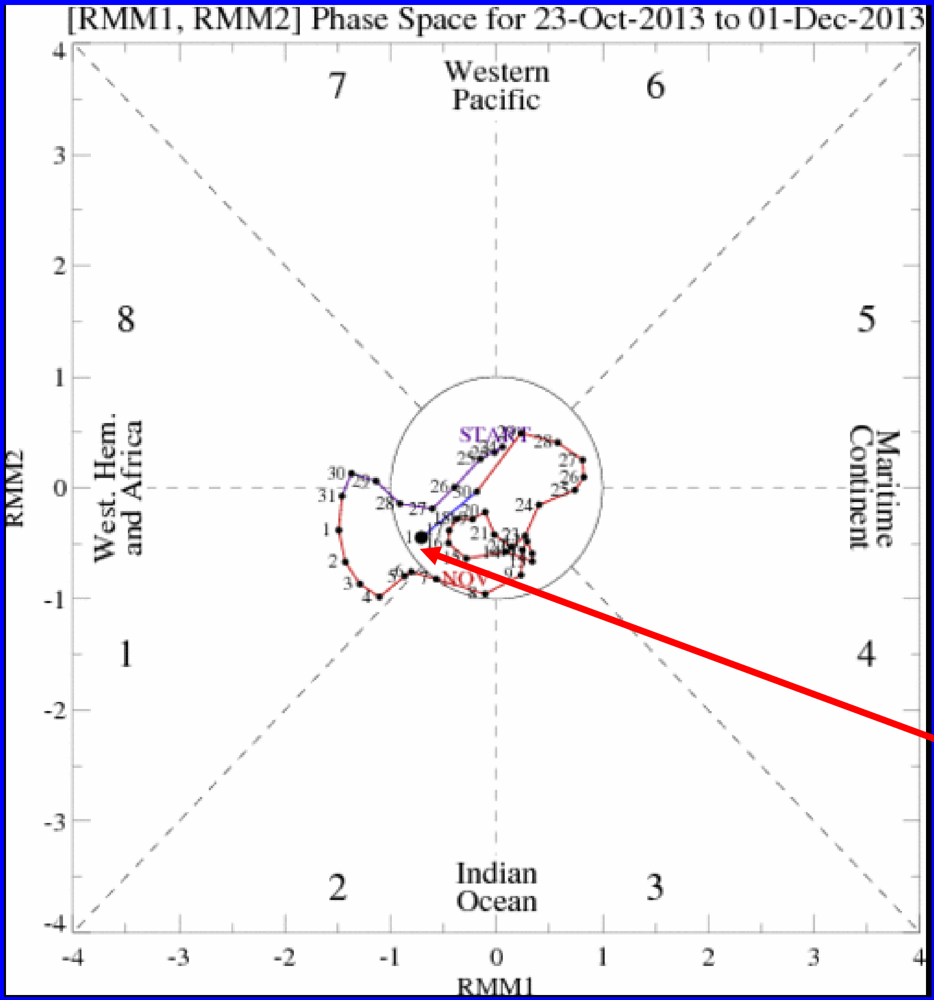
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

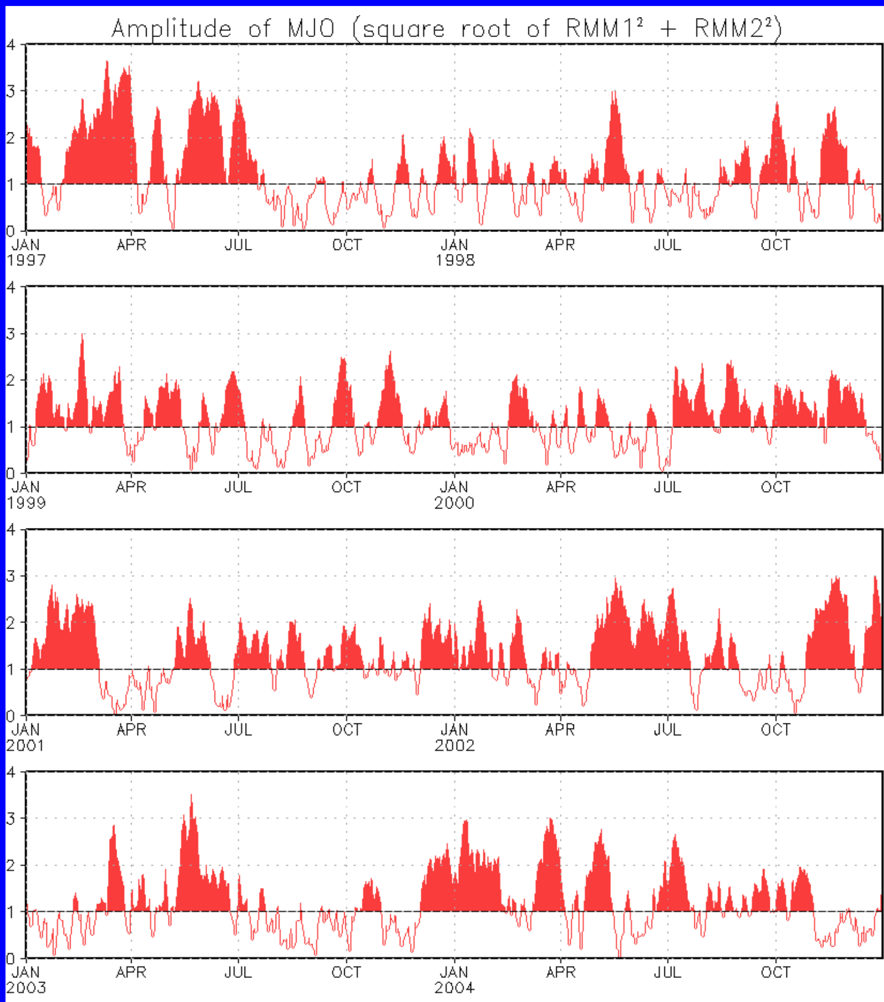
MJO Index -- Recent Evolution

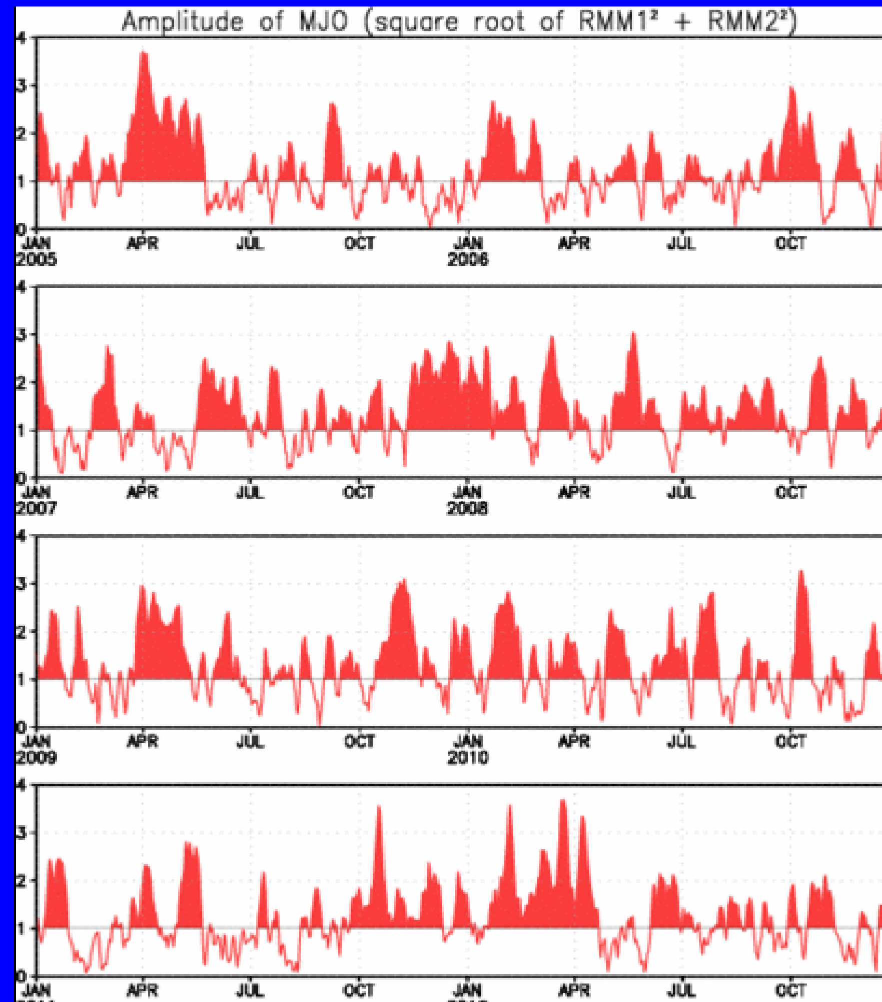


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO signal as measured by the RMM index has exhibited no coherence during the previous two weeks.

MJO Index – Historical Daily Time Series





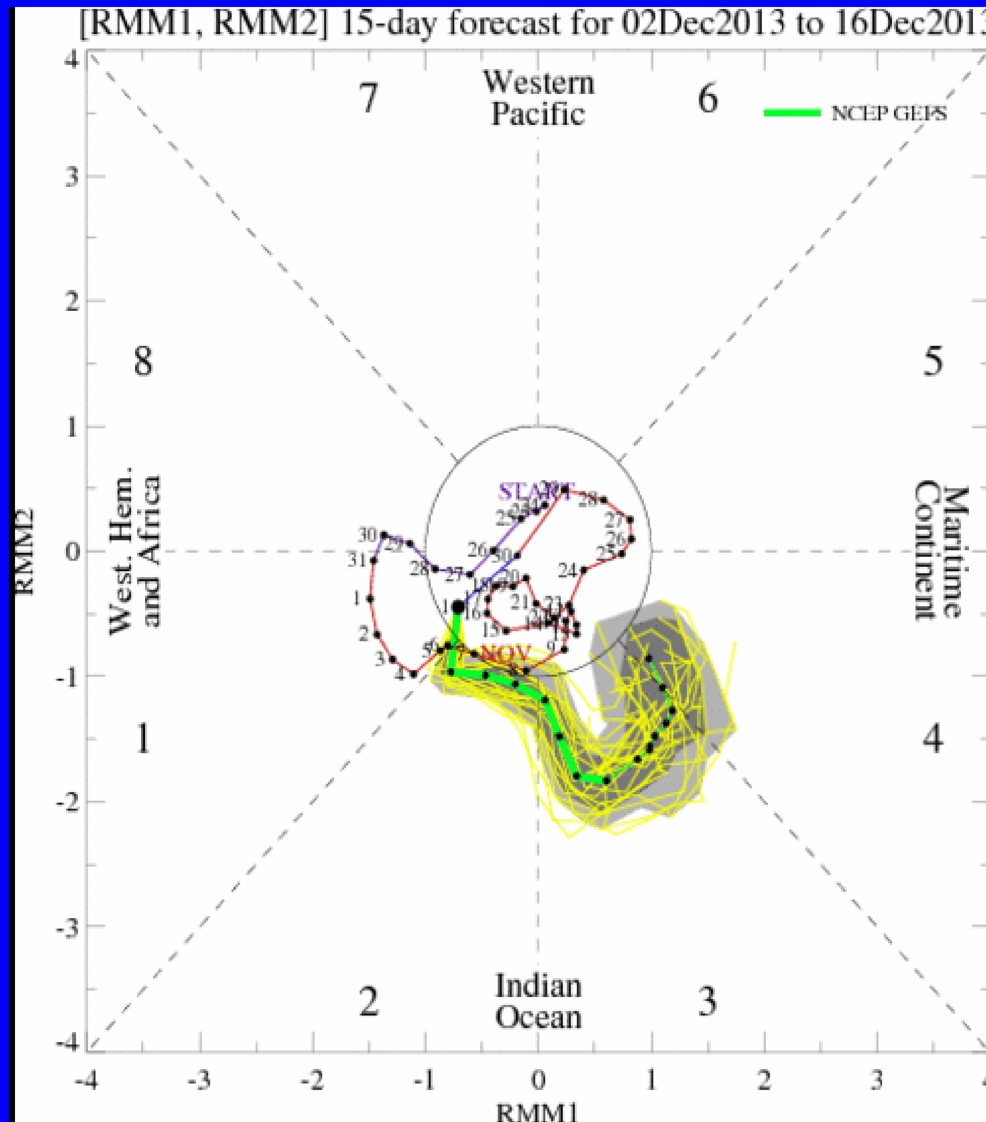
Time series of daily MJO index amplitude from 1997 to present.
Plots put current MJO activity in historical context.

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

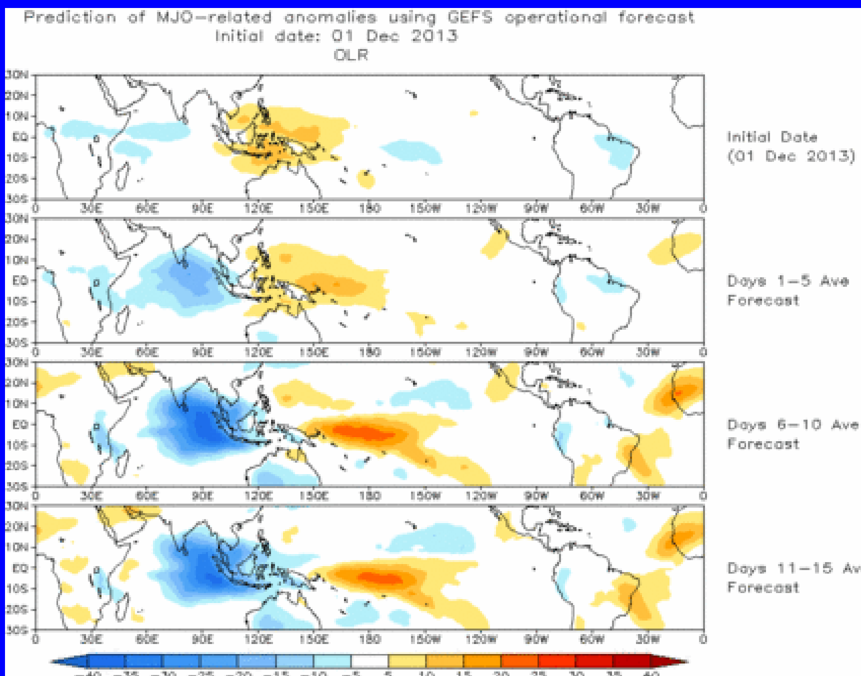


The ensemble GFS indicates a strengthening of the MJO signal across the Indian Ocean. This is consistent with some recent observations and other dynamical models.

Ensemble Mean GFS MJO Forecast

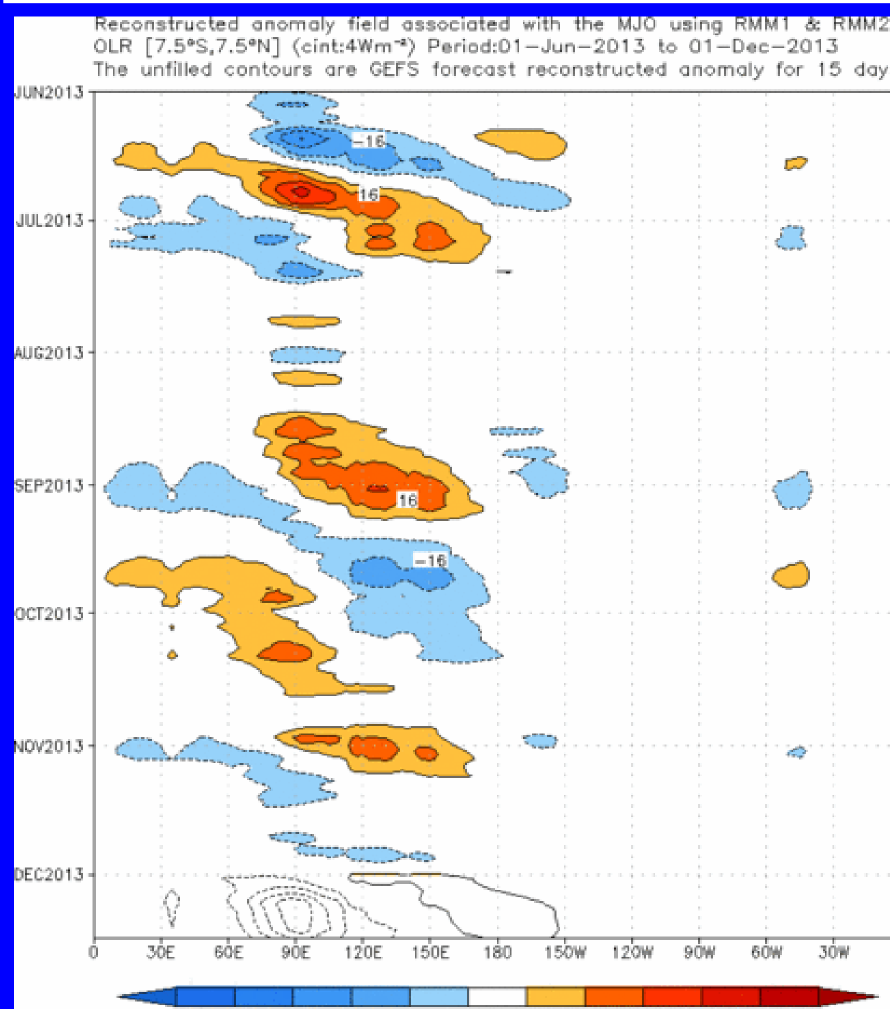
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts anomalous convection over Africa and the Indian Ocean during Week-1, with enhanced (suppressed) convection over the Indian Ocean and Maritime Continent (central Pacific) during late Week-2.

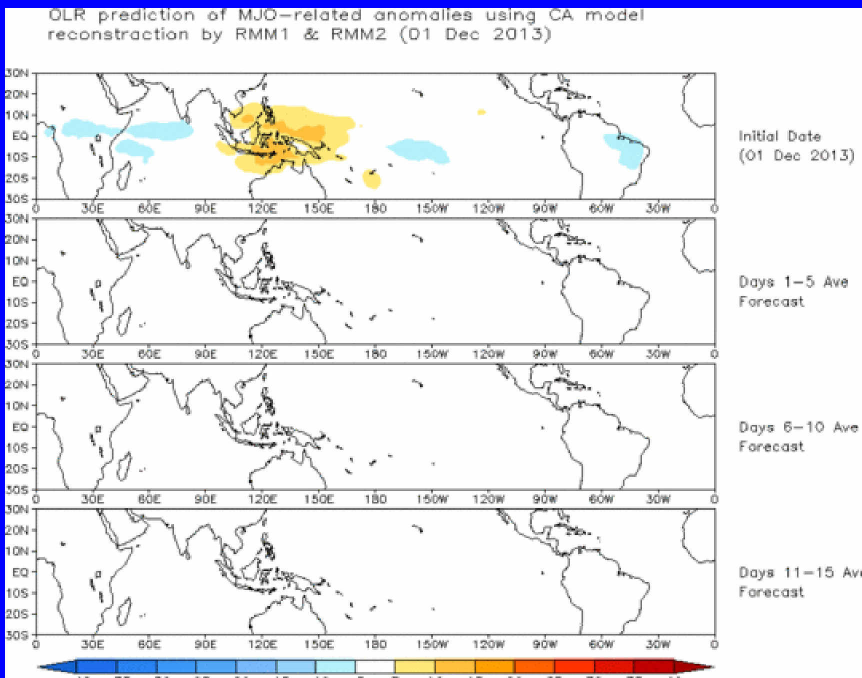
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

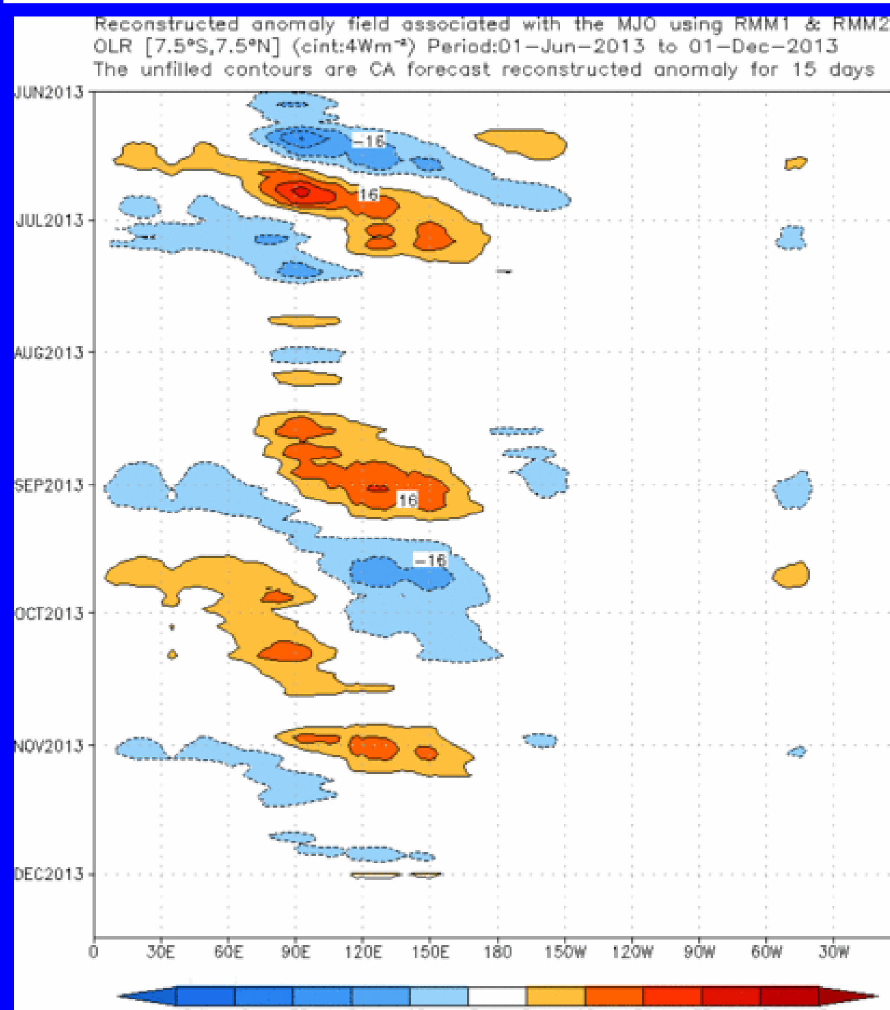
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



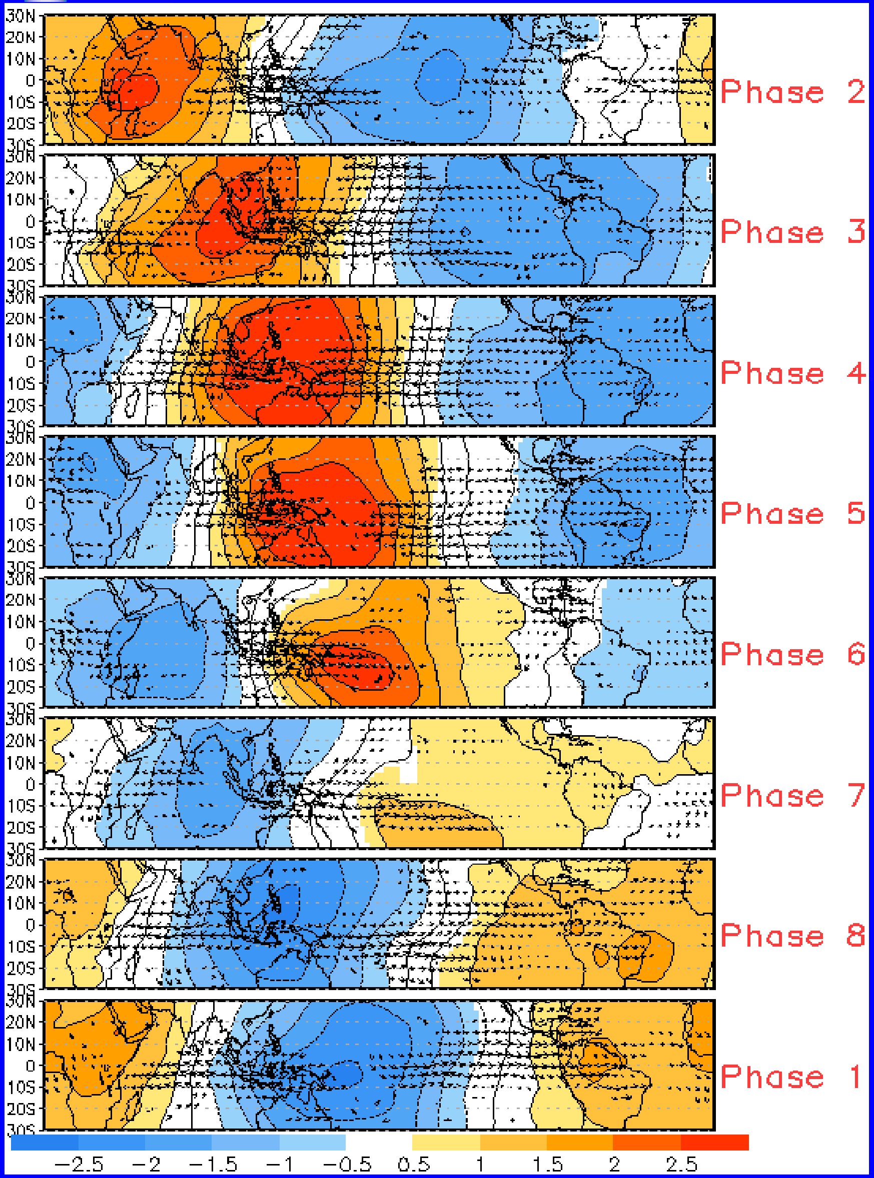
The constructed analog MJO forecast indicates no significant signal in the convective anomalies during the next 2 weeks.

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

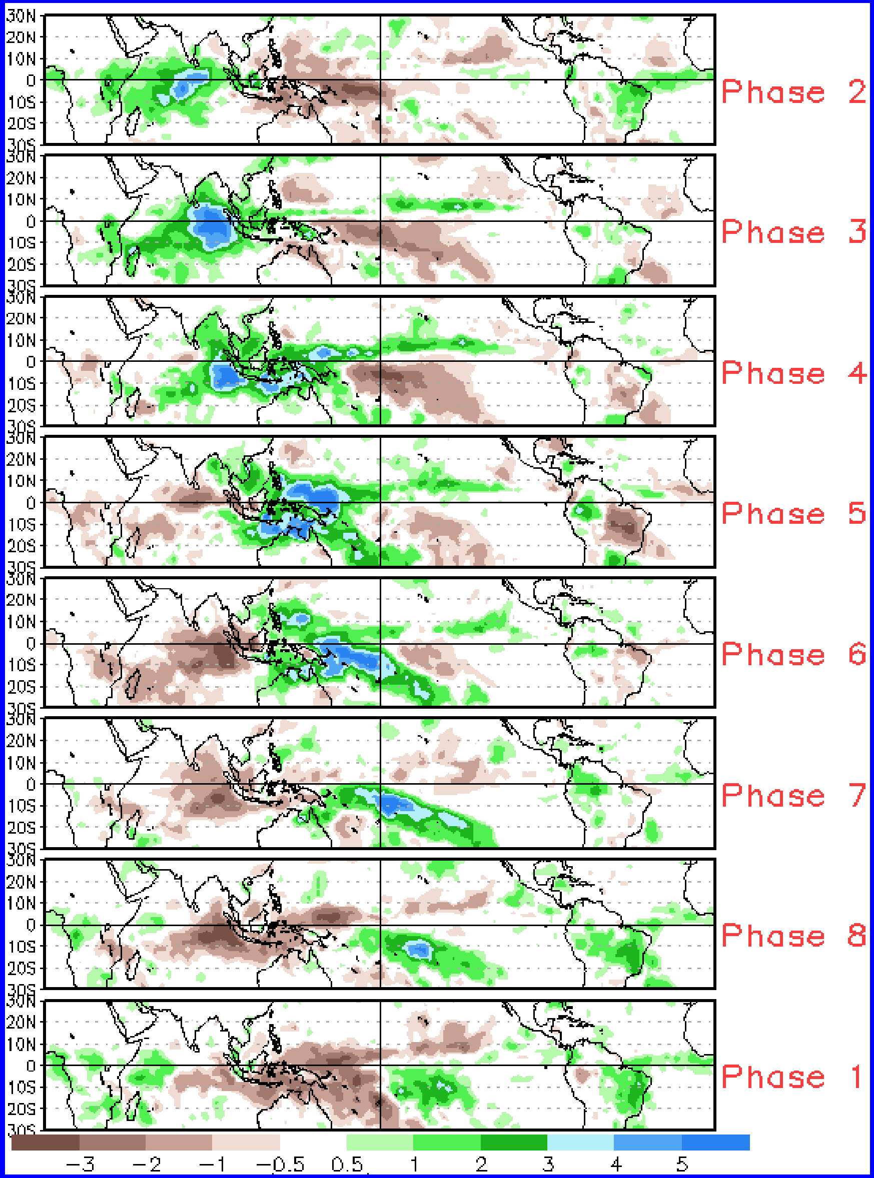


MJO Composites – Global Tropics

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

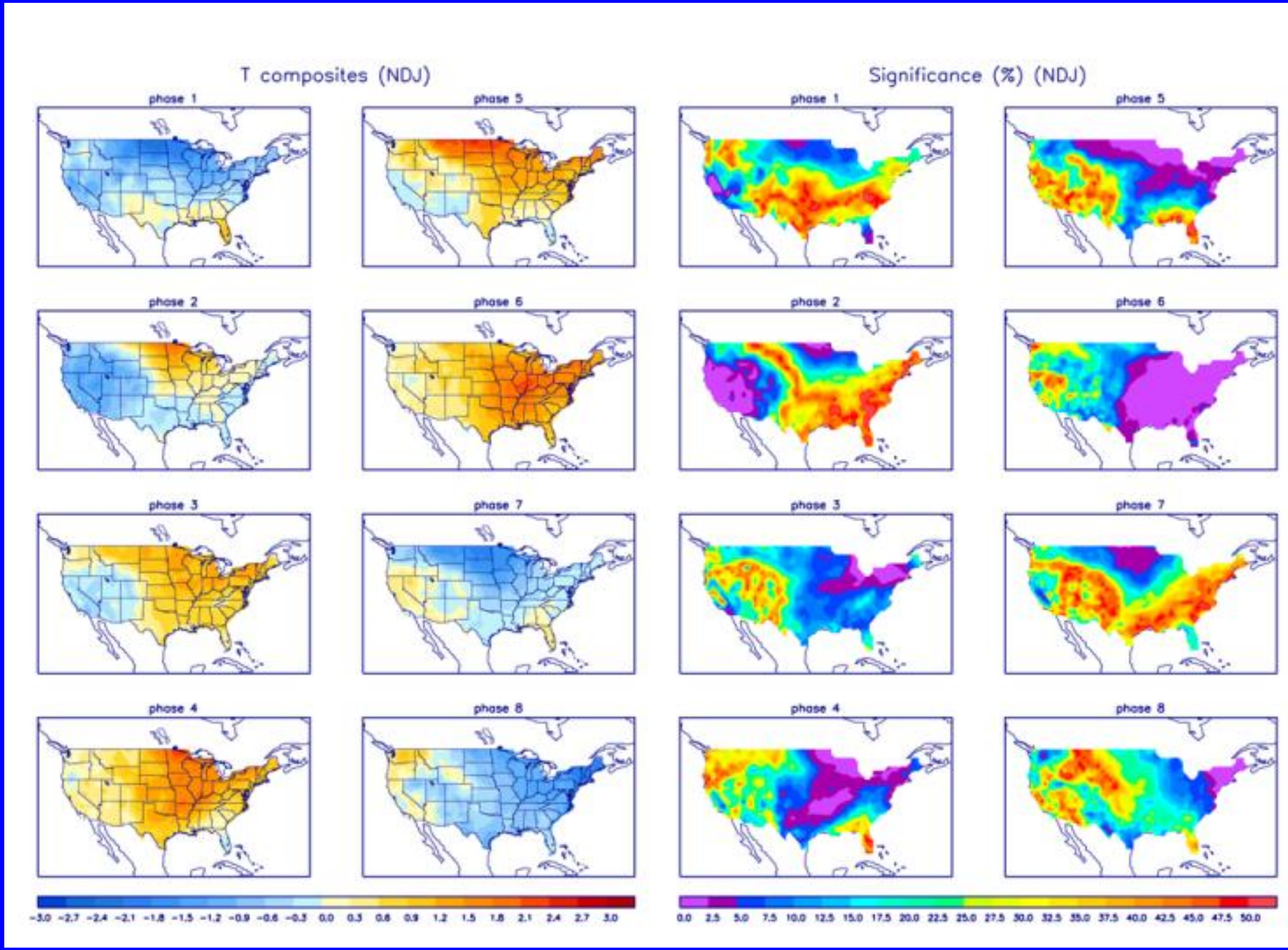


Precipitation Anomalies (Nov-Mar)



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.

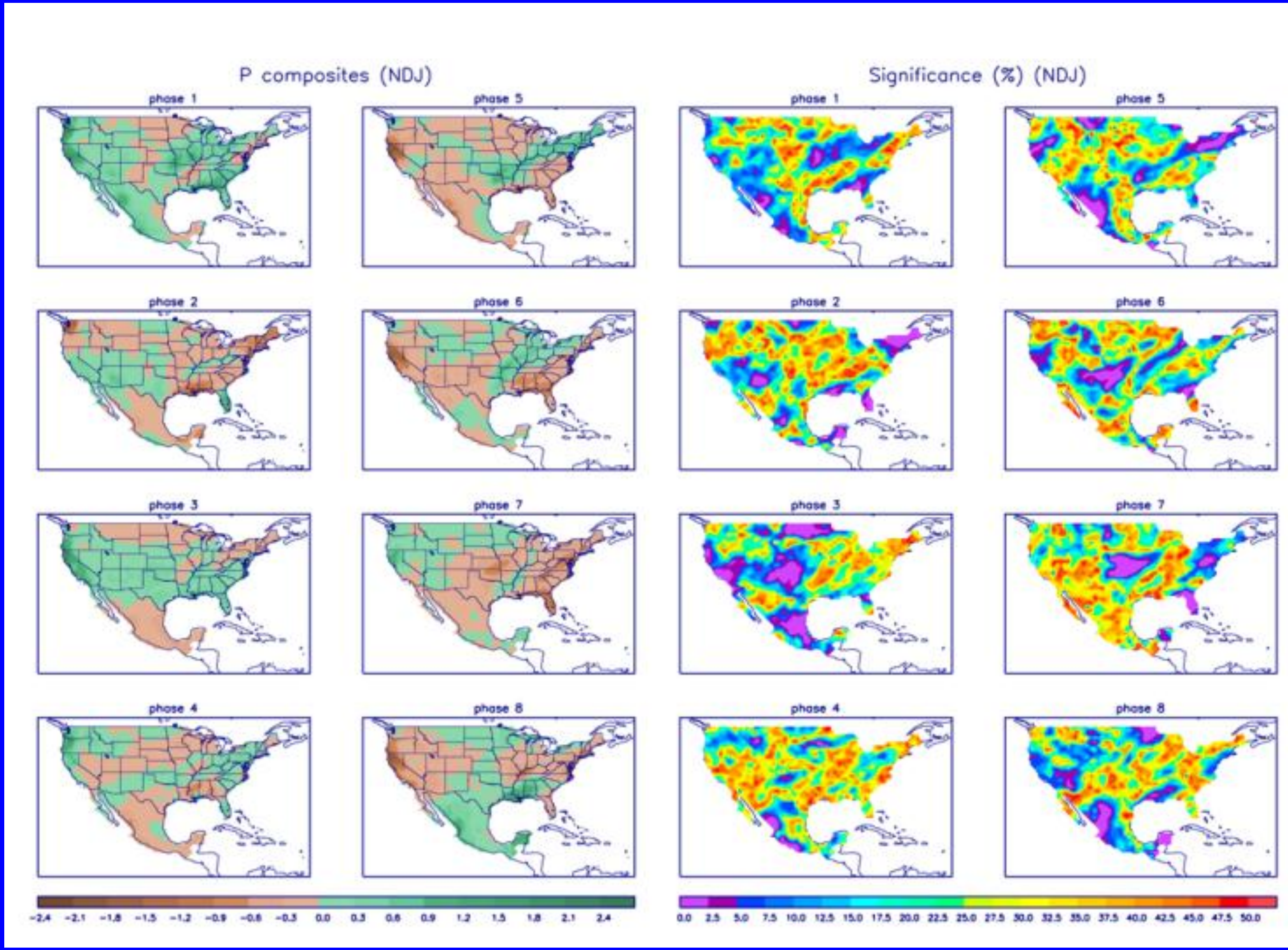


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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