

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



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30 January 2017

# Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

# Overview

- The MJO is active, with both the RMM based and CPC velocity potential based MJO indices depicting robust eastward propagation of an enhanced (suppressed) convective envelope over the Maritime Continent (Central Pacific).
- A weakening La Niña and the Indian Ocean Dipole continue to influence the pattern. MJO activity is constructively interfering with those two modes, though there is some mid-latitude influence evident in the Southern Hemisphere of Africa and South America.
- Dynamical model RMM index forecasts indicate continued propagation with strengthening as the signal moves across the Maritime Continent and the Pacific.
- The MJO is anticipated to influence the evolution of the global tropical convective pattern, and may contribute to enhanced convection over the Maritime Continent. The interference of the IOD pattern, which will also continue to play a substantive role, increases the uncertainty.

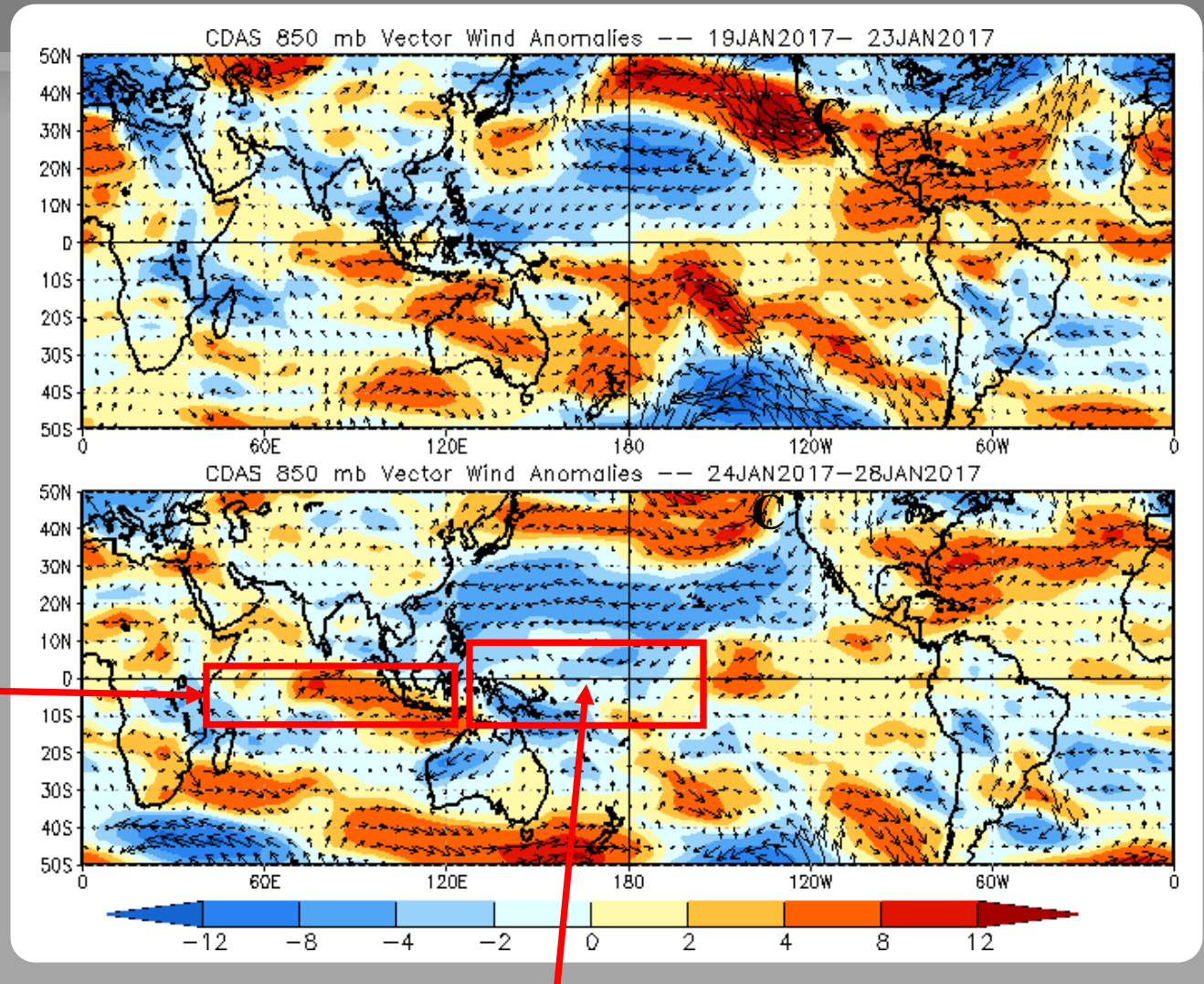
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:  
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

# 850-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

**Blue shades:** Easterly anomalies

**Red shades:** Westerly anomalies



# 850-hPa Zonal Wind Anomalies (m s<sup>-1</sup>)

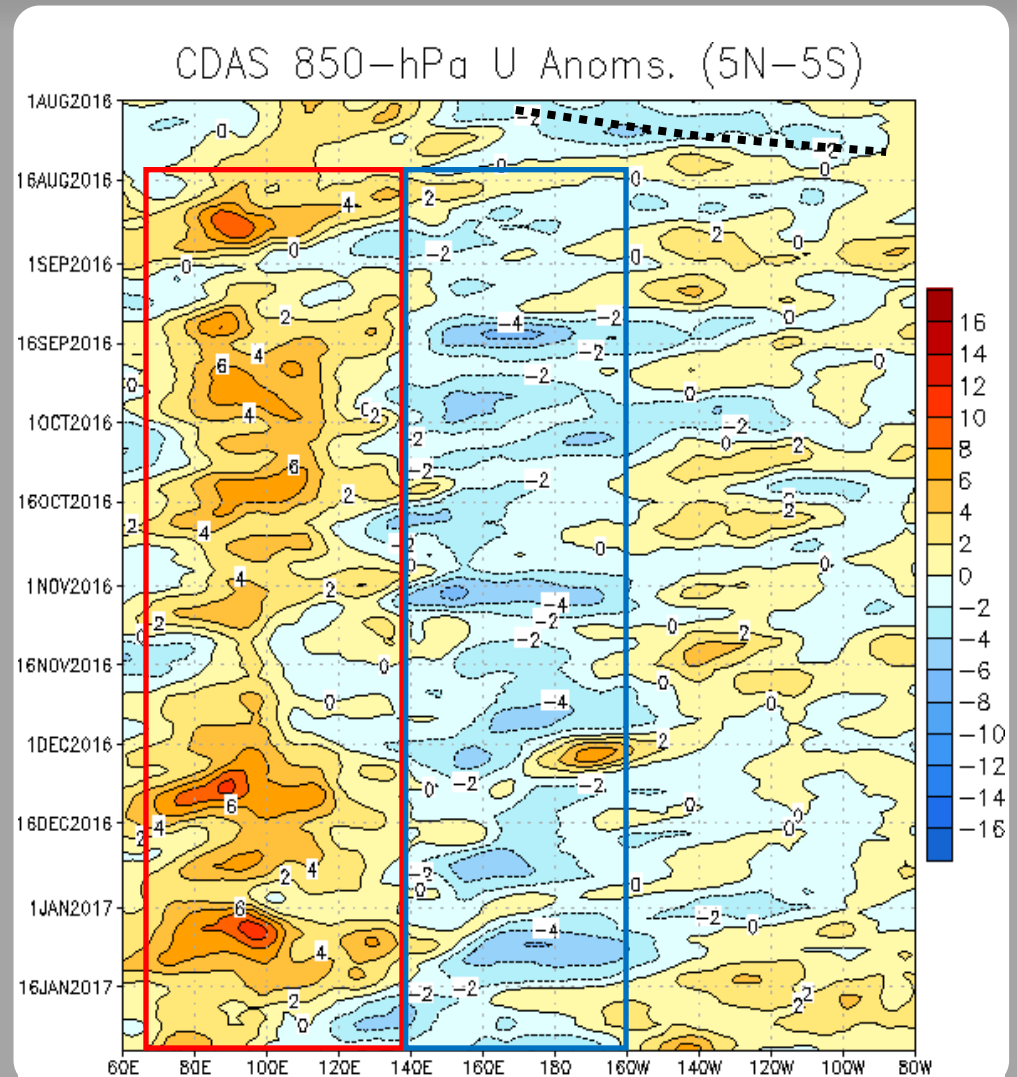
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

Since late August, persistent westerly (easterly) anomalies were evident over the eastern Indian Ocean and western Maritime Continent (central and western Pacific) as shown by the red (blue) box at right. These anomalies are low frequency in nature, associated with the negative phase of the Indian Ocean Dipole (IOD), and later, La Niña.

During mid-January, Rossby Wave activity was evident in the low-level wind field, destructively interfering with the base state.

Recently, a resurgence in the easterly anomalies near the DateLine is evident.



# OLR Anomalies - Past 30 days

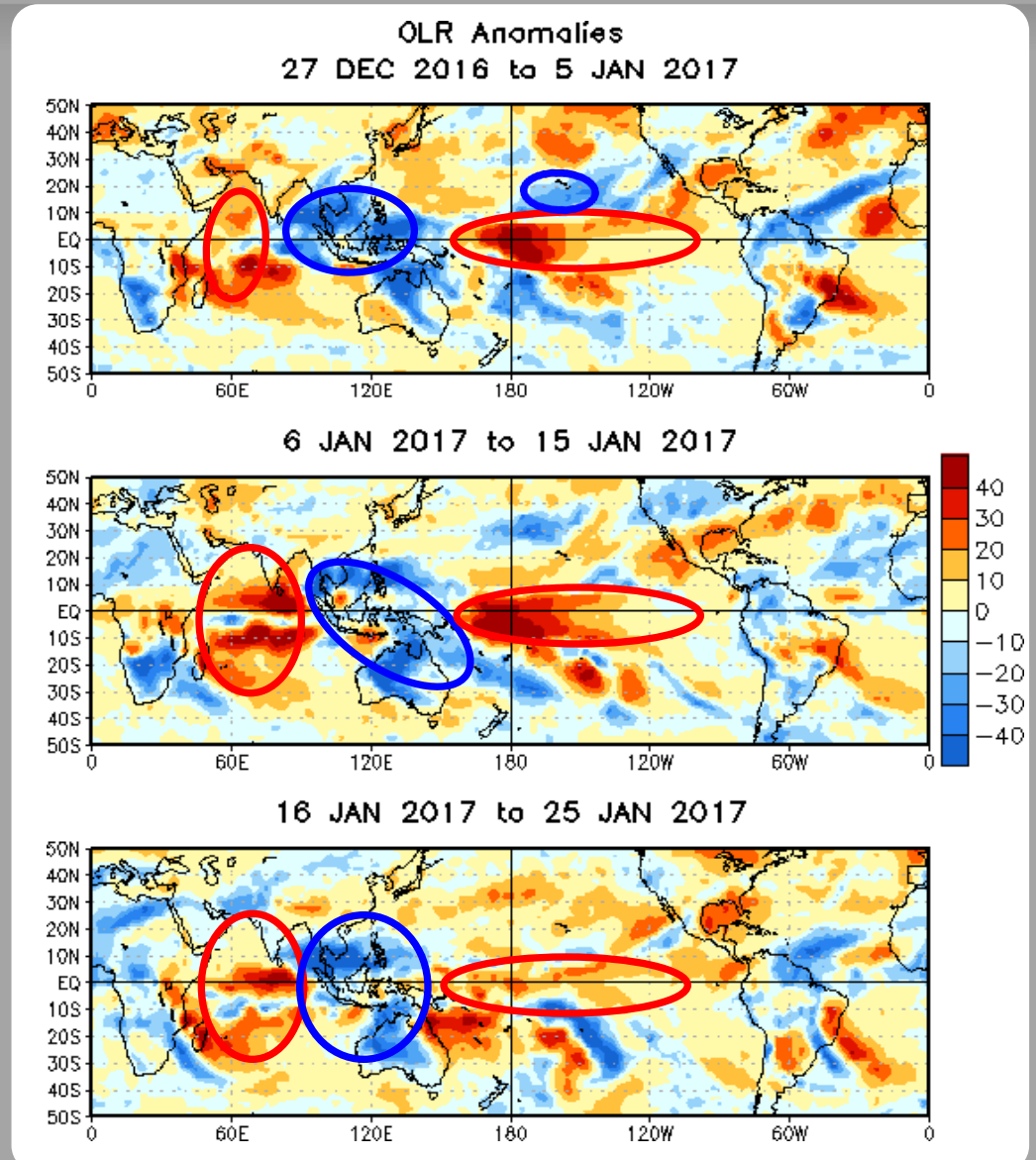
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

From late December through early January, the low frequency state supported enhanced (suppressed) convection persisting over the Maritime Continent (central Pacific). The pattern was influenced by higher frequency modes, such as equatorial Kelvin Wave activity over the Indian Ocean in late December.

During mid-January, Rossby Wave activity was evident over the West Pacific while the low-frequency state remained evident.

Convection remained enhanced (suppressed) over the Maritime Continent (central Pacific and Indian Ocean) during mid to late January.





# 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

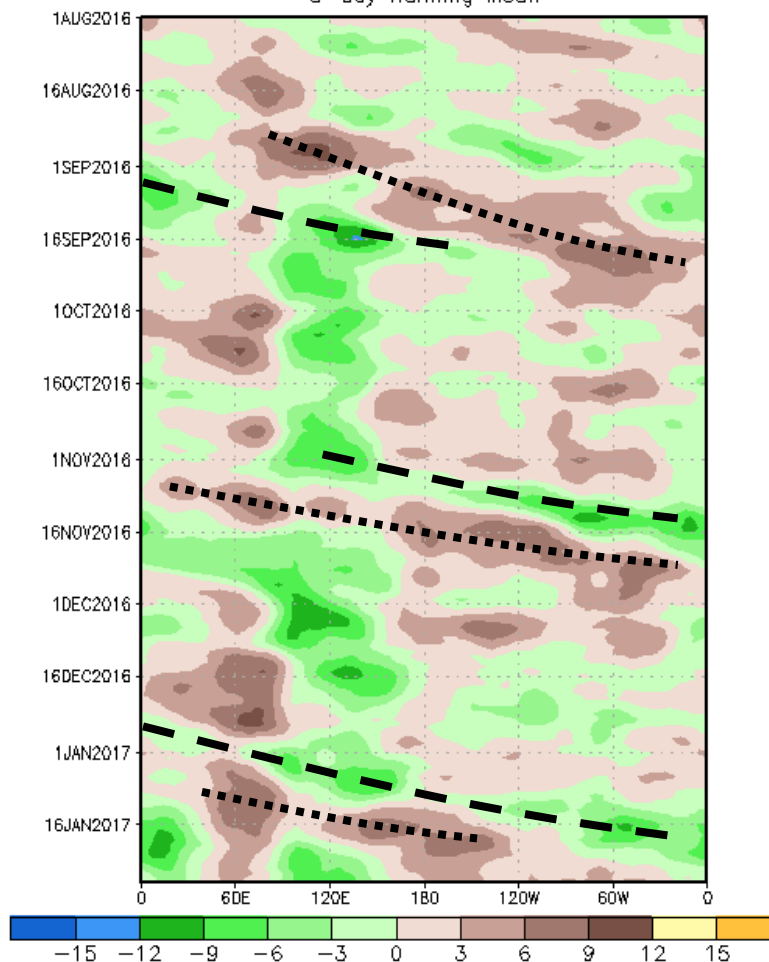
During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

From mid-September to late October, the low frequency signal dominated the pattern. During November, eastward propagation was observed consistent with MJO activity on the fast end of the intraseasonal spectrum.

During December, the IOD/La Niña influenced base state re-emerged as the dominant mode. The intraseasonal signal returned during January.

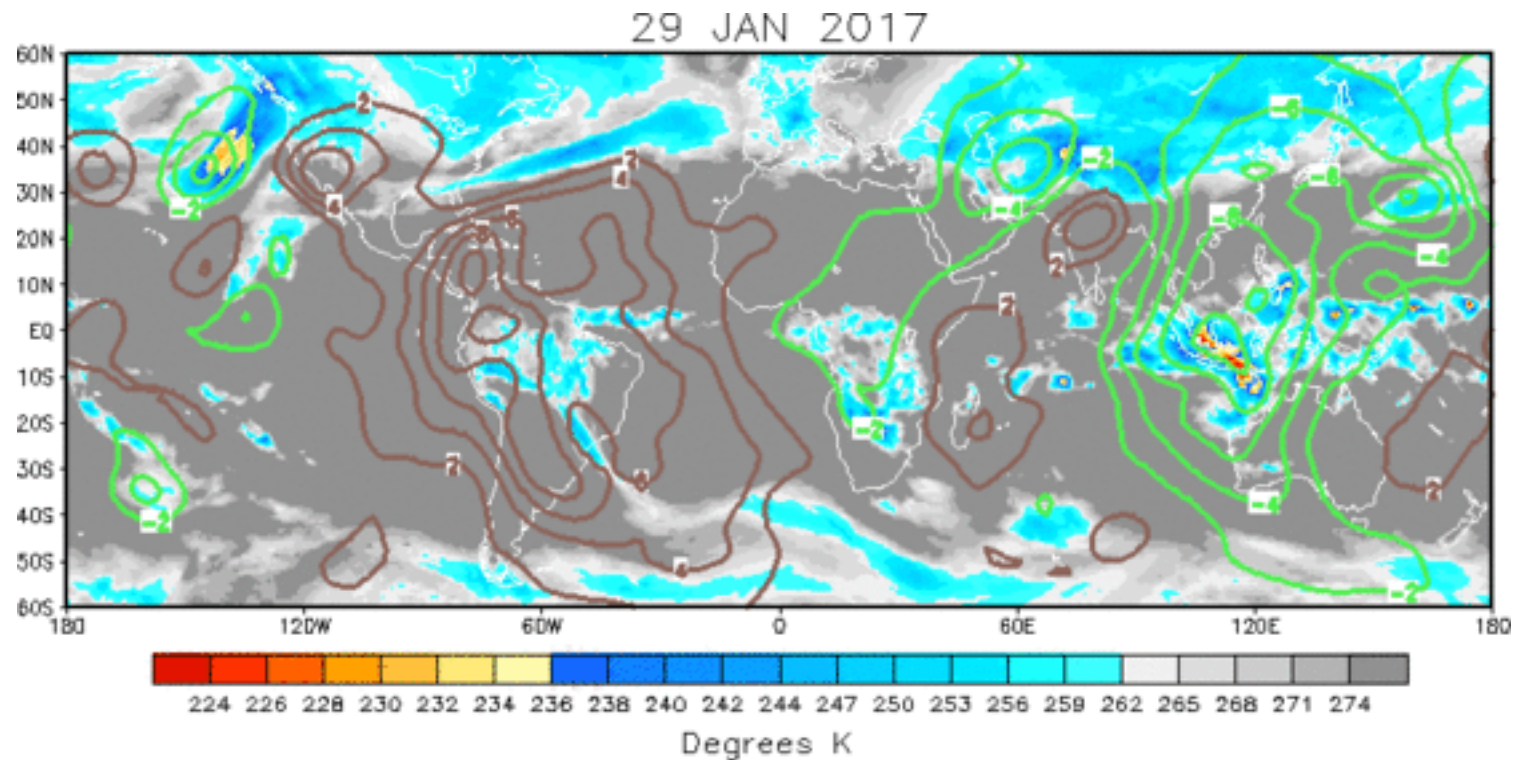
Recently, the enhanced (suppressed) phase of the intraseasonal signal was over the Western Hemisphere and Africa (Pacific).

200-hPa Velocity Potential Anomaly: 5N-5S  
5-day Running Mean





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



Upper-level velocity potential anomalies remain fairly coherent, though there is some interference over Africa. Enhanced (suppressed) convection remains over the eastern Indian Ocean and Maritime Continent (Americas).

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation  
Negative anomalies (green contours) indicate favorable conditions for precipitation

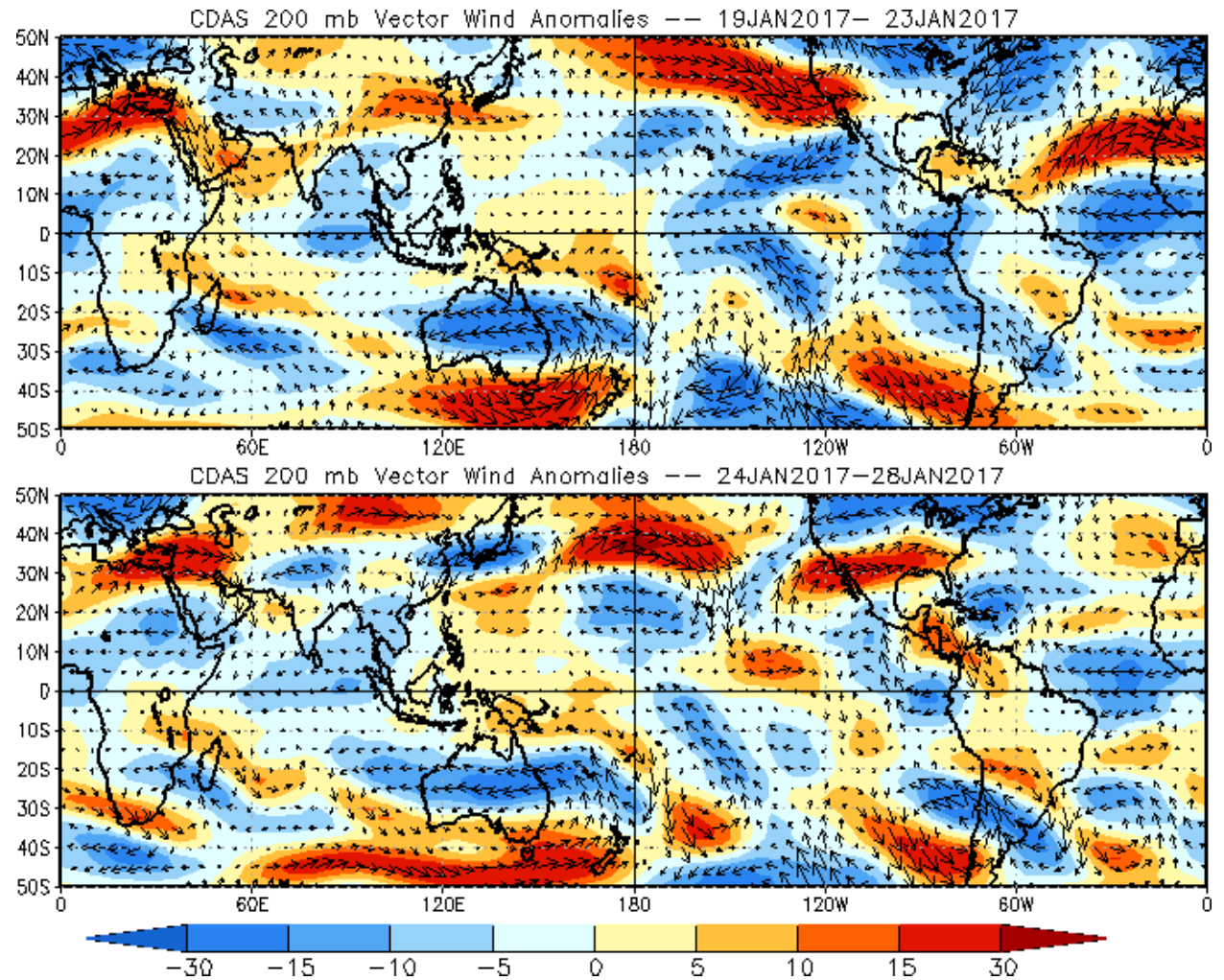
# 200-hPa Vector Wind Anomalies (m s<sup>-1</sup>)

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Anomalous divergence is evident over the Maritime Continent with anomalous convergence near the Date Line.



# 200-hPa Zonal Wind Anomalies (m s<sup>-1</sup>)

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow

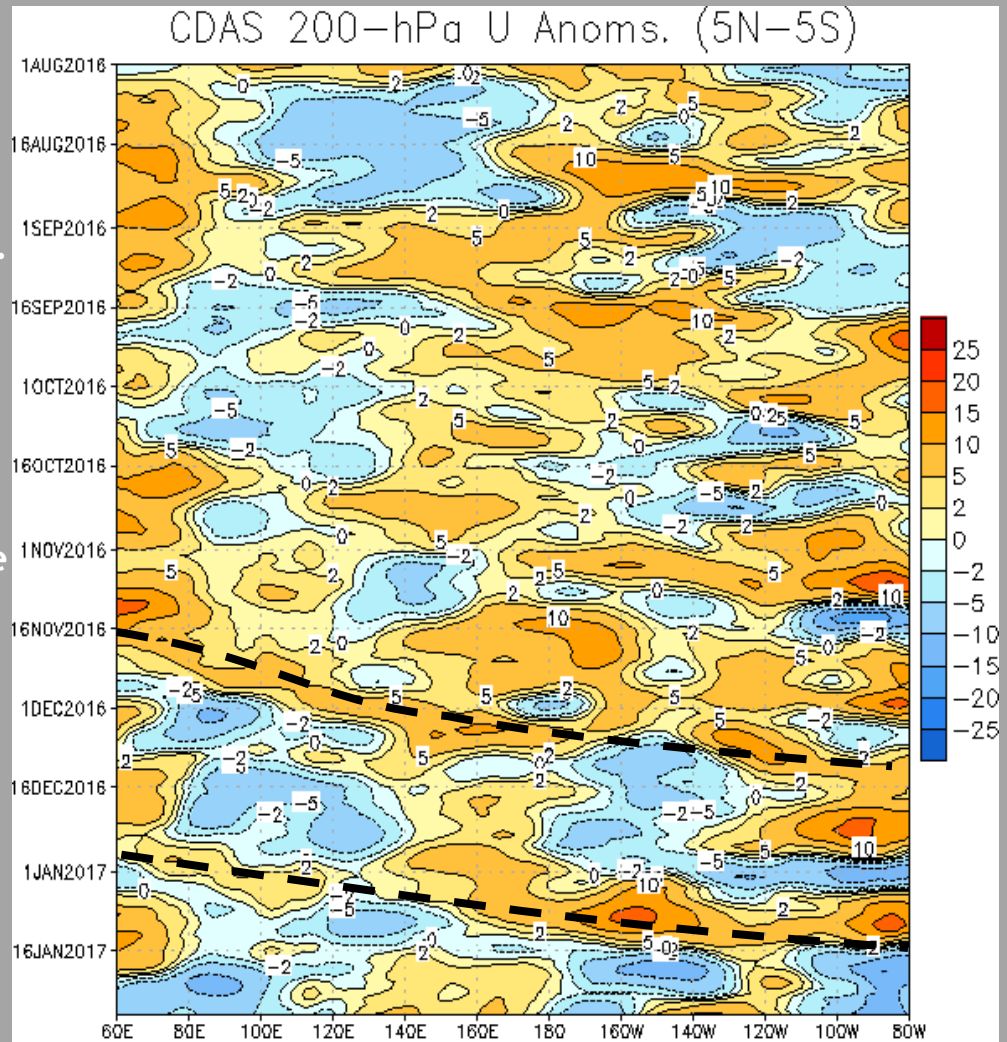
After a quiet August, eastward propagation of westerly anomalies was broadly consistent with organized MJO activity during September.

In November, anomalous westerlies persisted near the Date Line, though intraseasonal variability associated with the MJO is evident.

In late November, easterly anomalies re-emerged across the Indian Ocean and Maritime Continent, consistent with the passage of sub-seasonal activity and the re-alignment of the low frequency base state.

Near the end of 2016 a period of westerlies disrupted the low frequency state between 80-130E and continued propagating eastward through the Western Hemisphere.

More recently, the low frequency state has re-emerged as destructive interference with the intraseasonal signal waned.

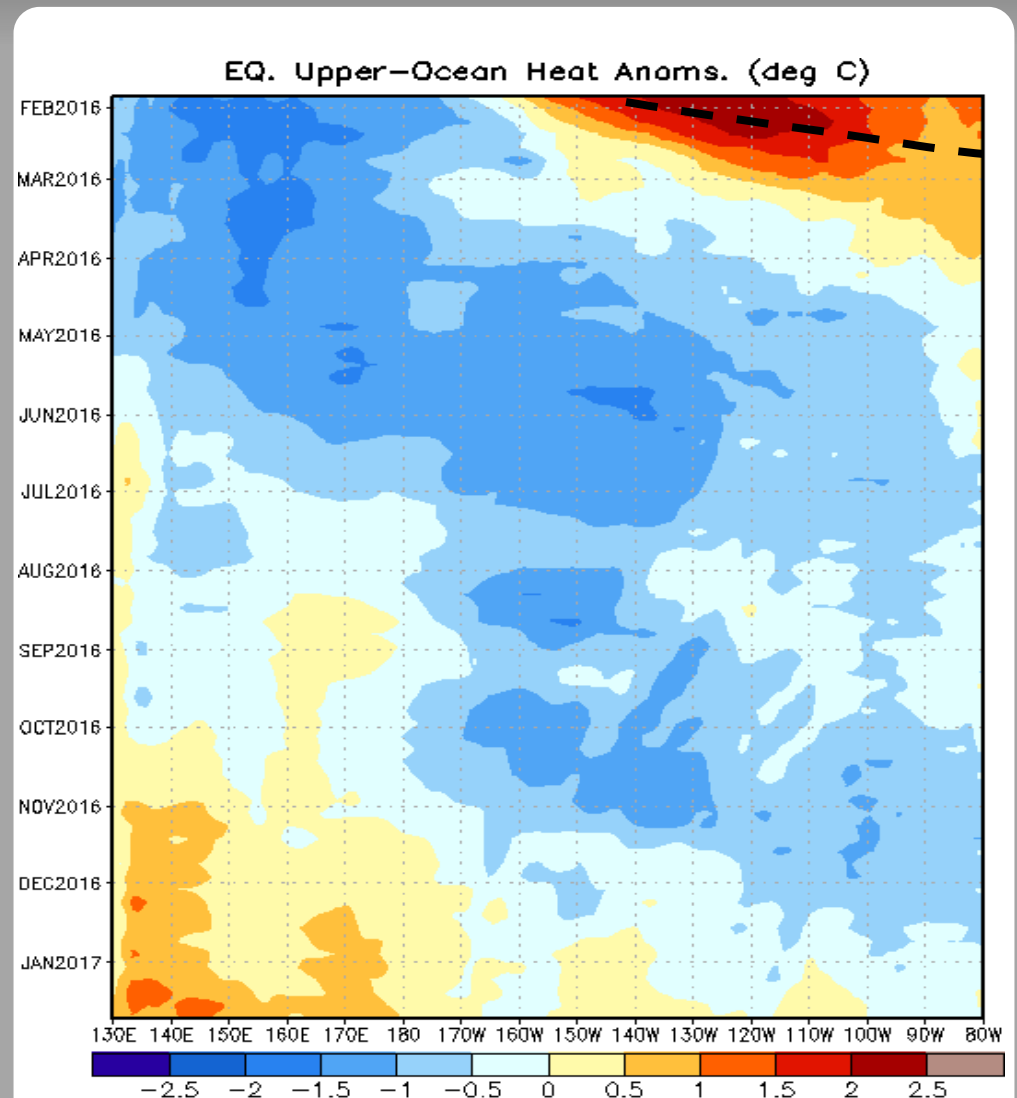


# Weekly Heat Content Evolution in the Equatorial Pacific

Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

An eastward expansion of below average heat content over the western Pacific is evident through June, with widespread negative anomalies building across the Pacific over the course of the spring and summer months.

Most recently, upper-ocean heat content anomalies have been low amplitude, consistent with the forecast transition to ENSO-neutral conditions over the coming months.



# 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

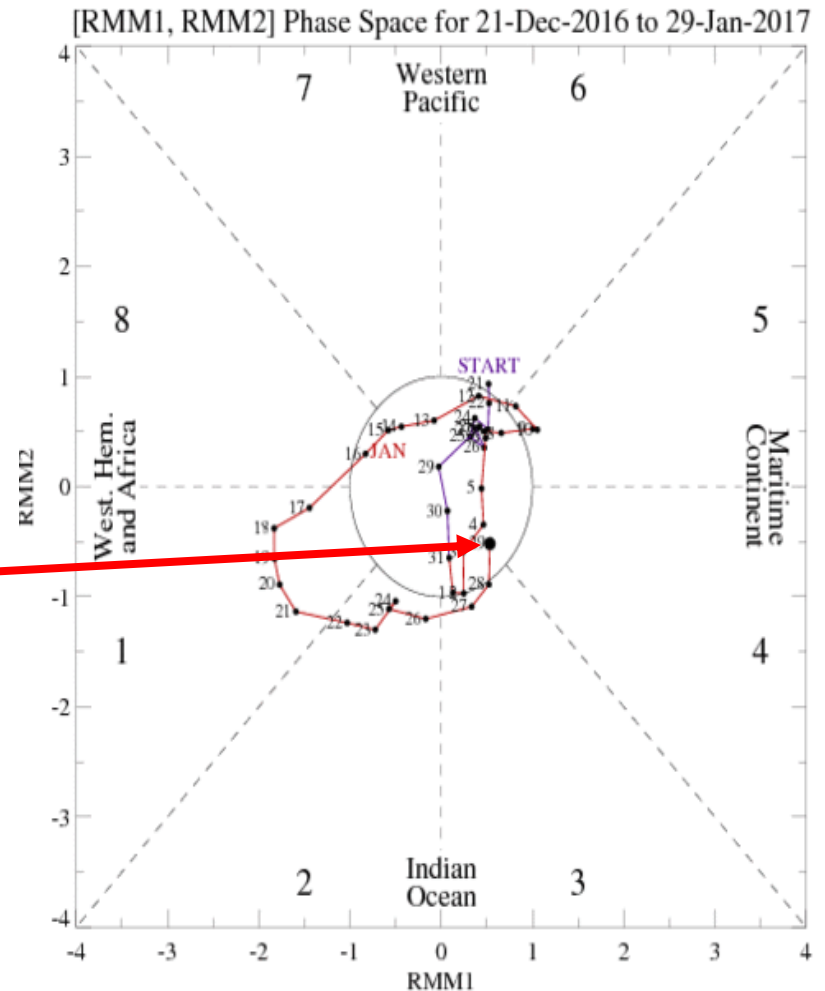
The triangular areas indicate the location of the enhanced phase of the MJO

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 week, eastward propagation of an MJO signal was evident over the Indian Ocean.





# GFS Ensemble (GEFS) MJO Forecast

RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

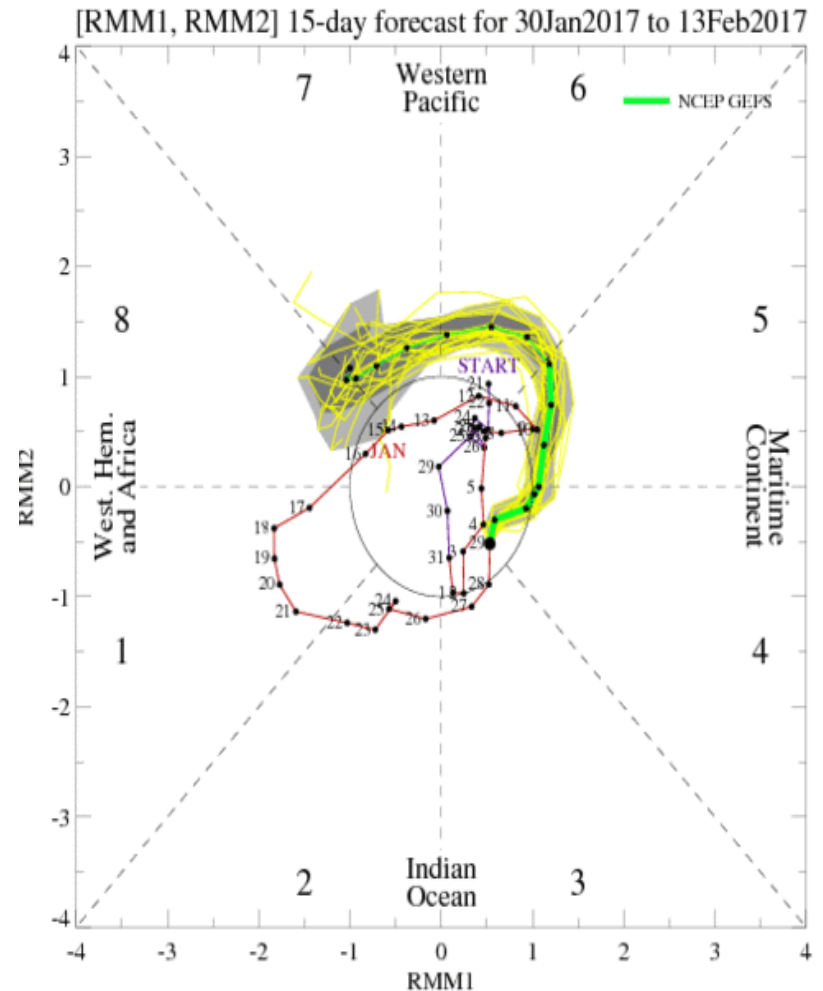
light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS depicts continued eastward propagation over the next several days, followed by a strengthening of the signal over the Western Pacific.

Note: The 120-day period mean is removed from this product, so the low frequency state favoring enhanced convection over the Maritime Continent may be playing a role in the amplitude of the MJO signal.

Yellow Lines - 20 Individual Members  
Green Line - Ensemble Mean

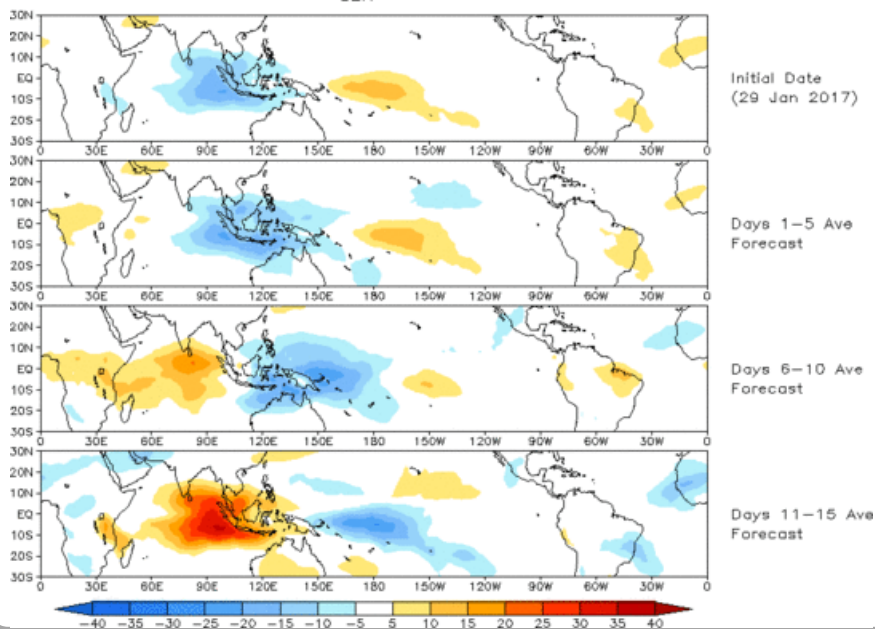




# Ensemble GFS (GEFS) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

Prediction of MJO-related anomalies using GEFS operational forecast  
Initial date: 29 Jan 2017  
OLR

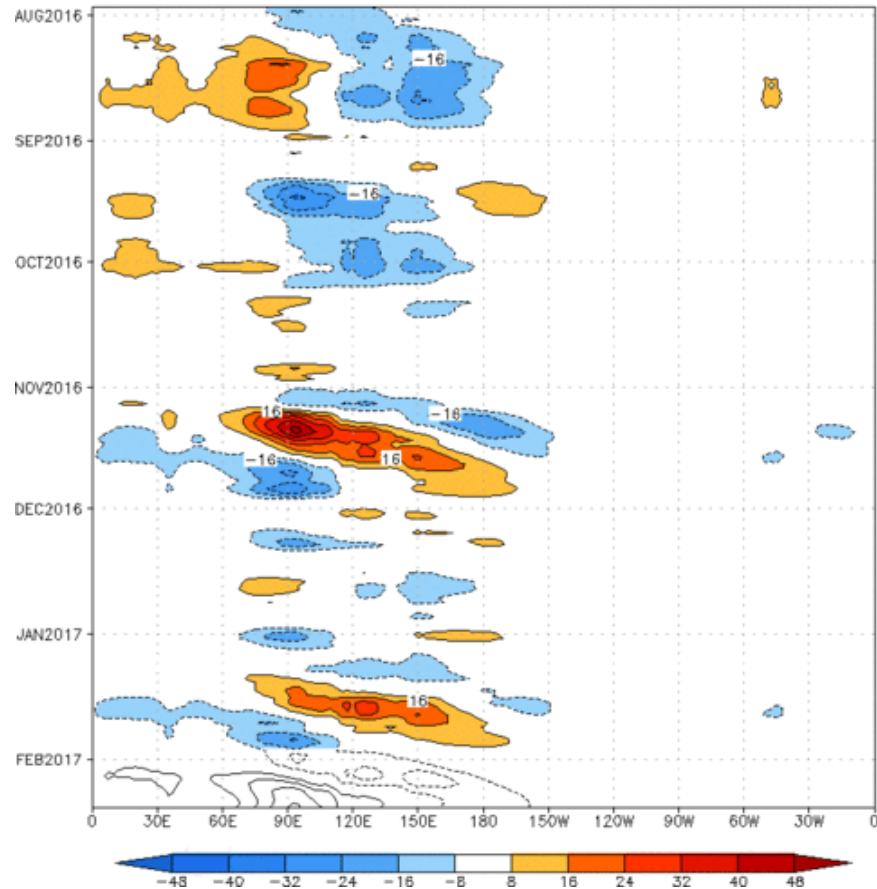


The GEFS prediction for RMM Index-based OLR anomalies over the next two weeks depicts robust eastward propagation of OLR anomaly envelopes.

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.)

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

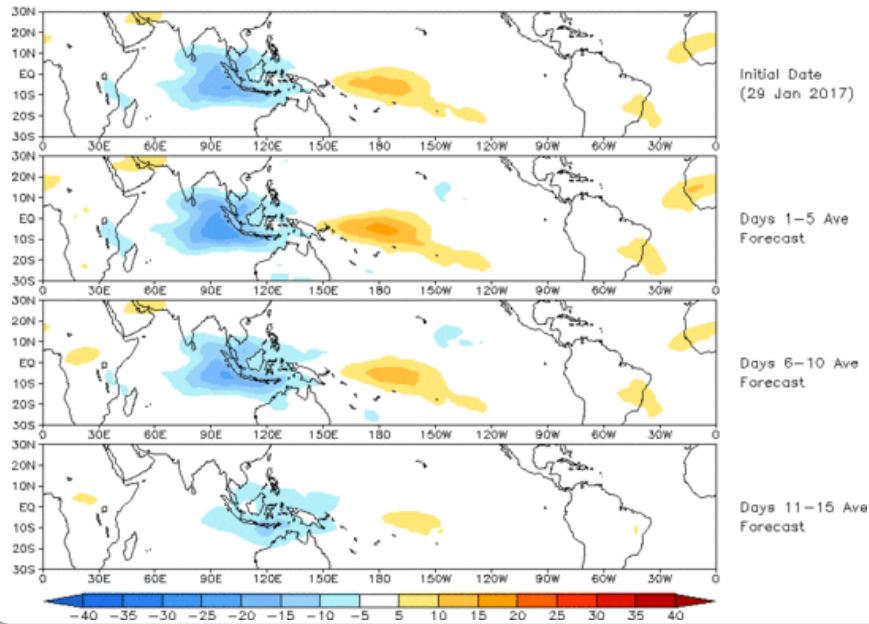
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2  
OLR [7.5°S,7.5°N] (cint:4Wm<sup>-2</sup>) Period:30-Jul-2016 to 29-Jan-2017  
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



# Constructed Analog (CA) MJO Forecast

Spatial map of OLR anomalies for the next 15 days

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (29 Jan 2017)

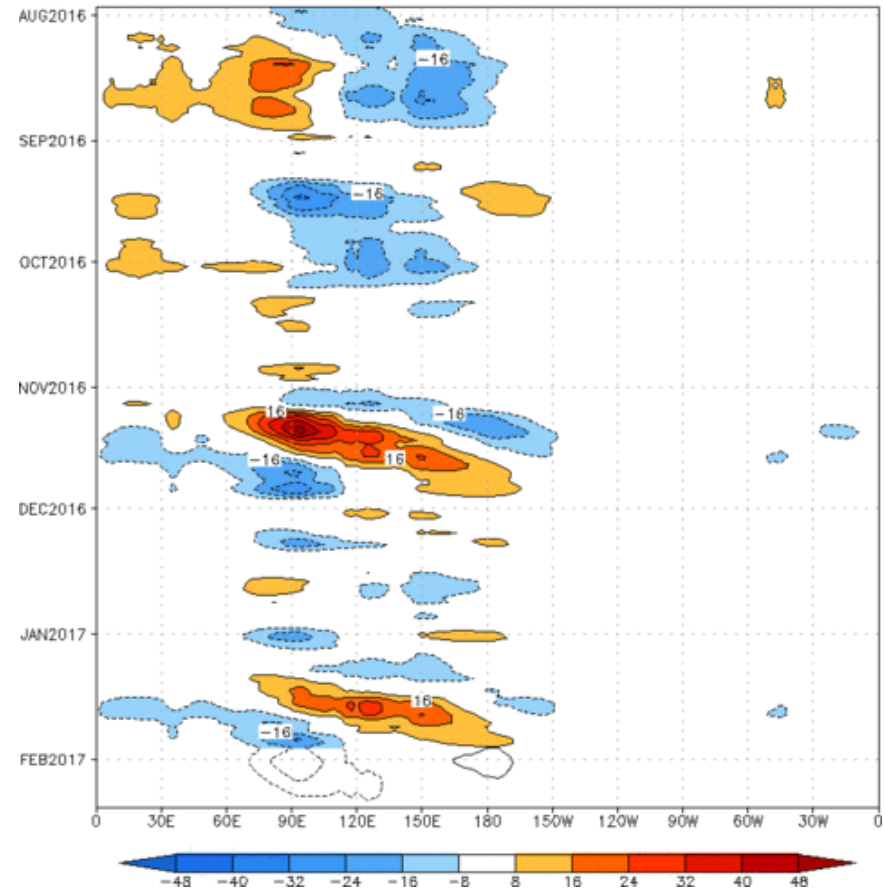


The statistical (Constructed Analog) RMM-based OLR anomaly prediction depicts a robust Indian Ocean MJO event propagating to the Maritime Continent. Propagation is slower than in the dynamical models.

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.)

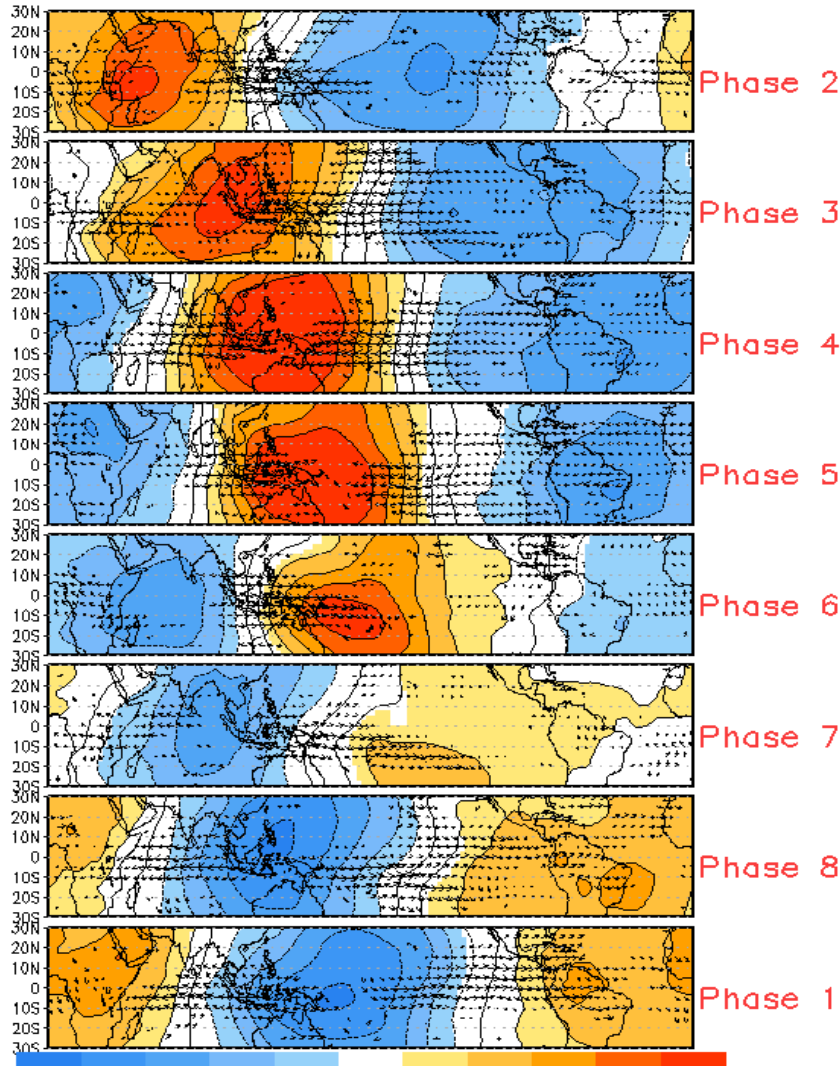
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cint:4Wm<sup>-2</sup>) Period:30-Jul-2016 to 29-Jan-2017  
The unfilled contours are CA forecast reconstructed anomaly for 15 days

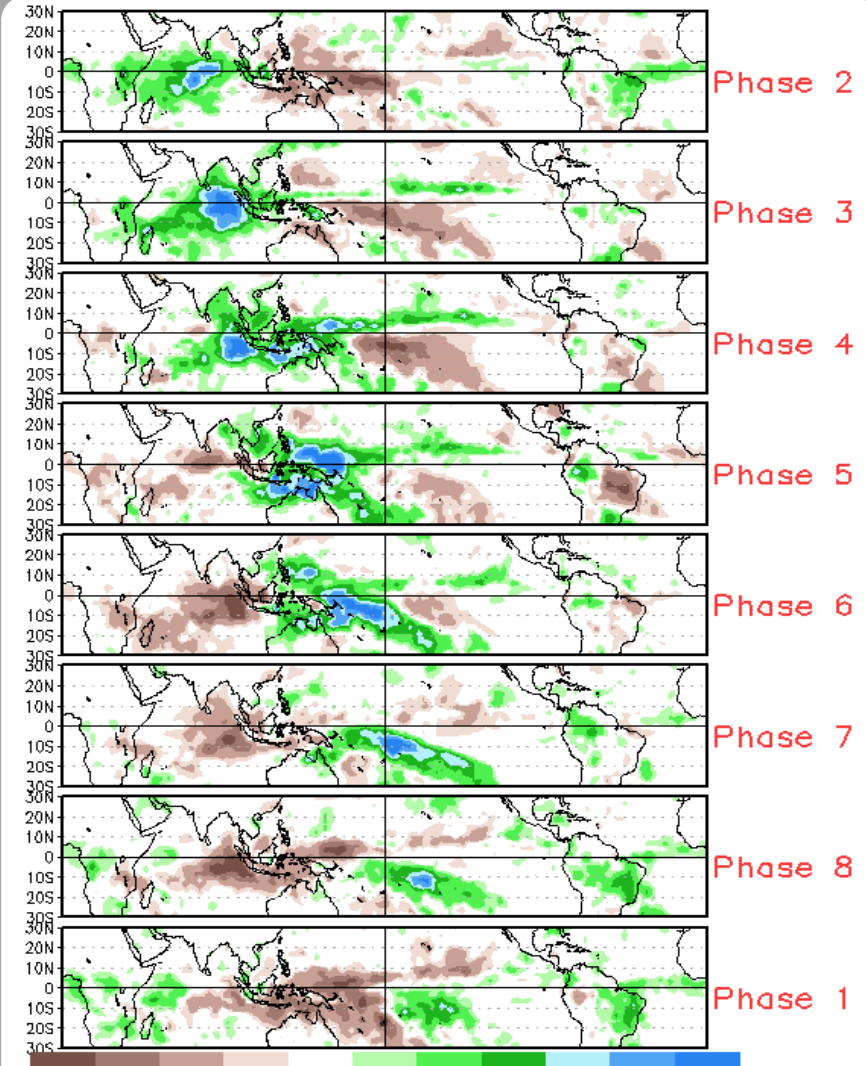


# MJO Composites - Global Tropics

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



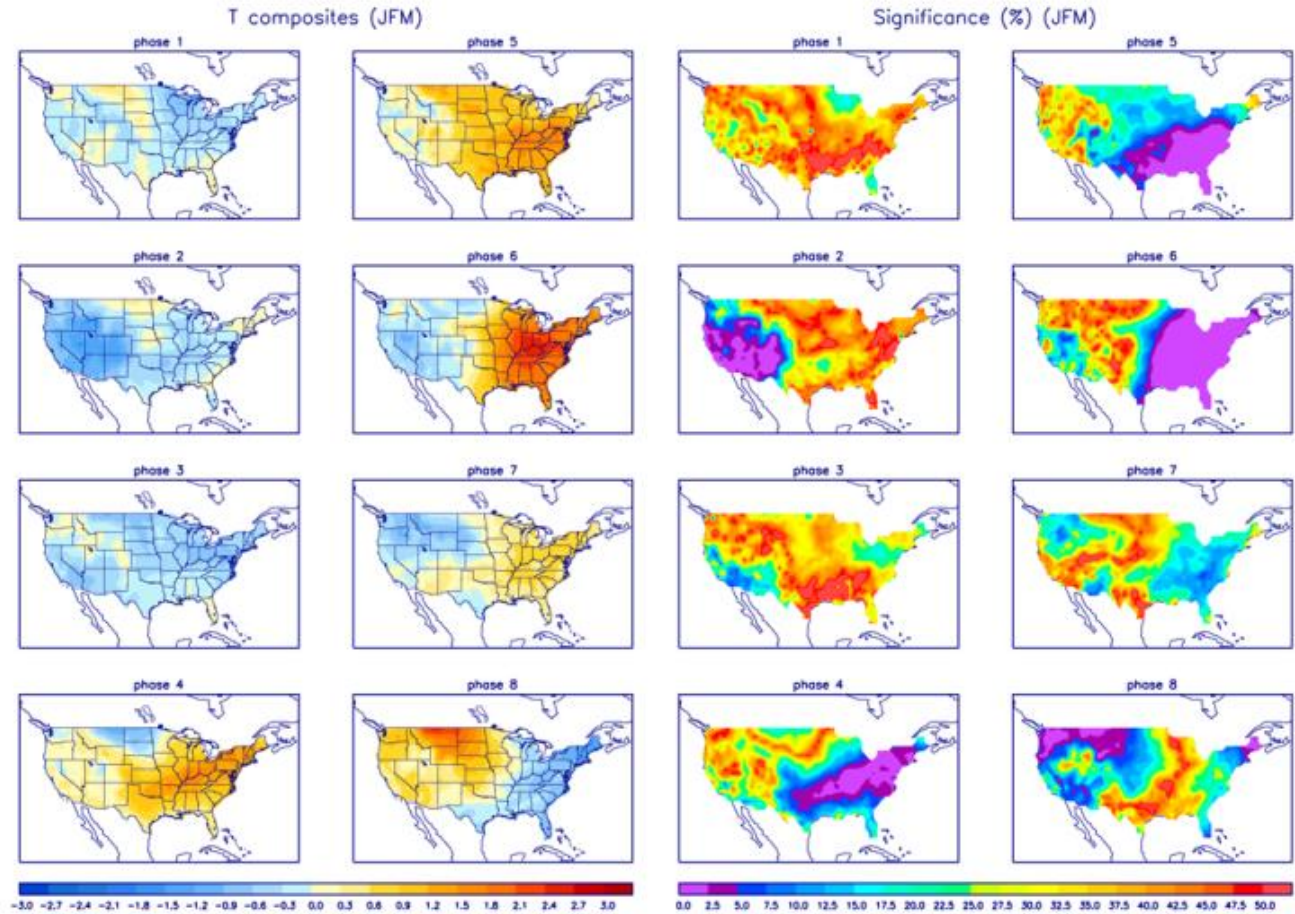
Precipitation Anomalies (Nov - Mar)



# 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.



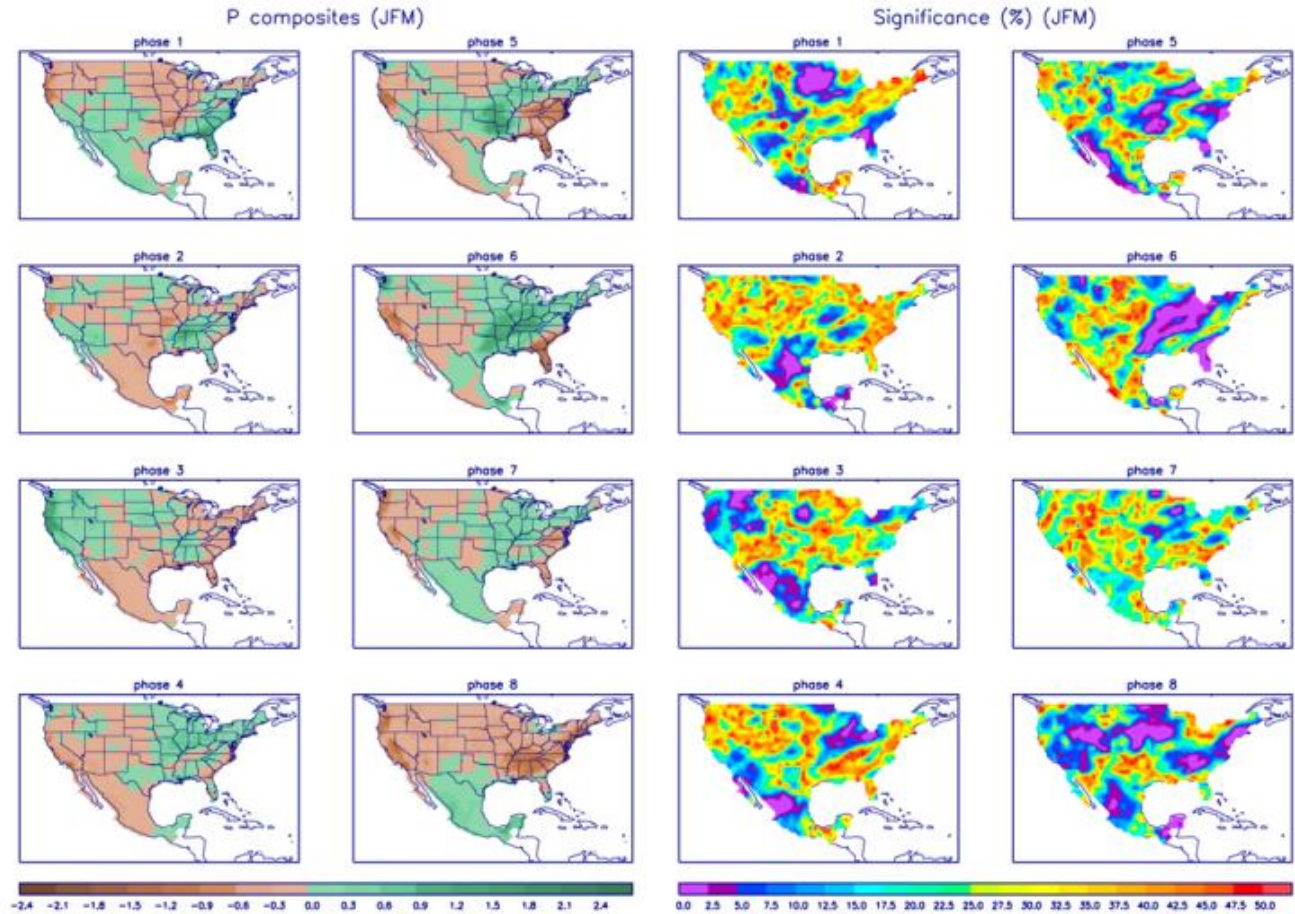
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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

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