

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



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Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

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MJO Composites

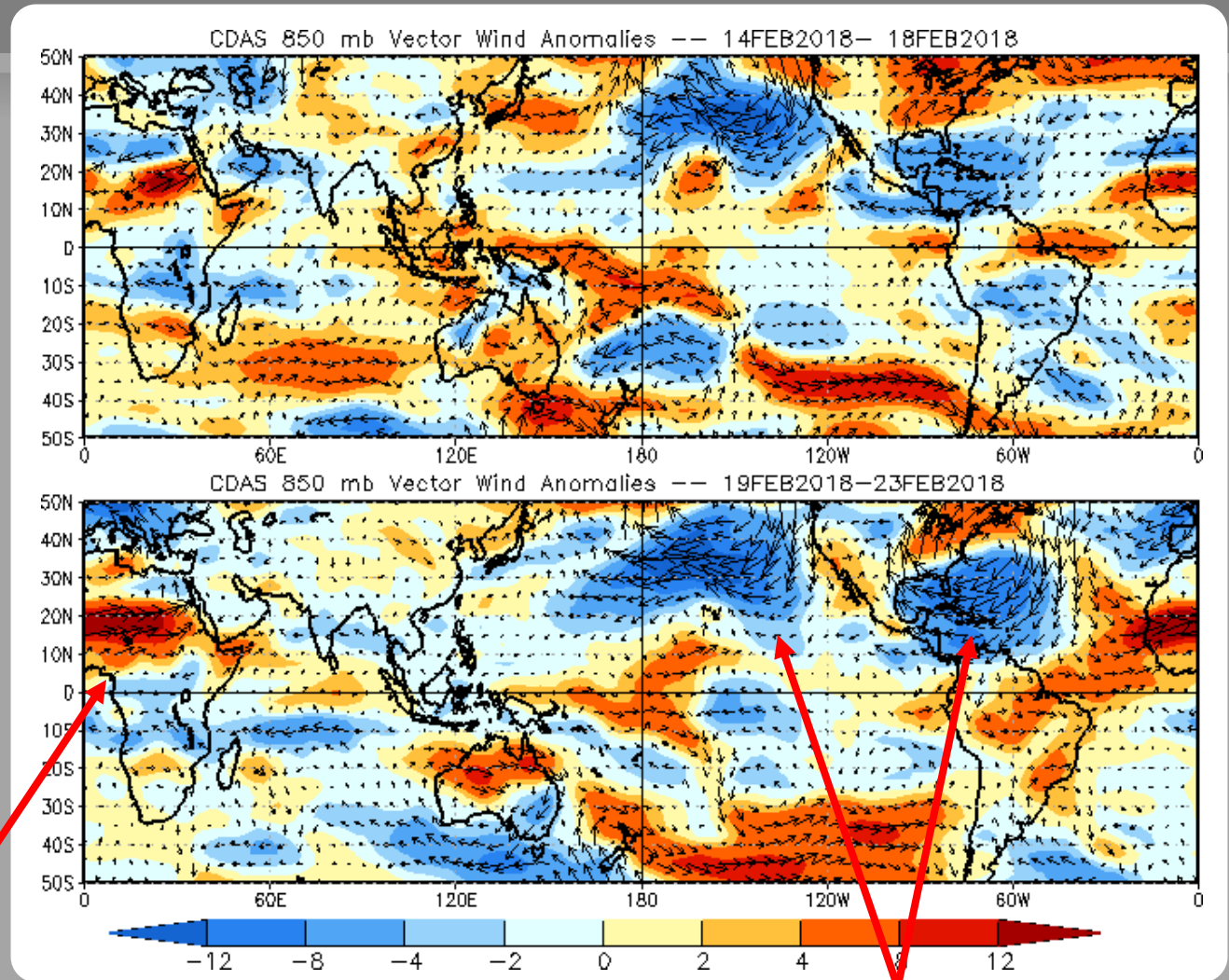
Overview

- The MJO has weakened substantially over the past few weeks and is now re-emerging over western Africa.
- Amplified mid-latitude flows on both sides of the Equator are interacting with the tropical environment.
- The GEFS forecasts the MJO to continue to propagate eastward across Africa and into the Indian Ocean during the next two 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



Anomalous westerlies over Africa have strengthened, largely due to the MJO Phase 1 signal.

Strong mid-latitude troughs extend south into the tropics.

850-hPa Zonal Wind Anomalies (m s⁻¹)

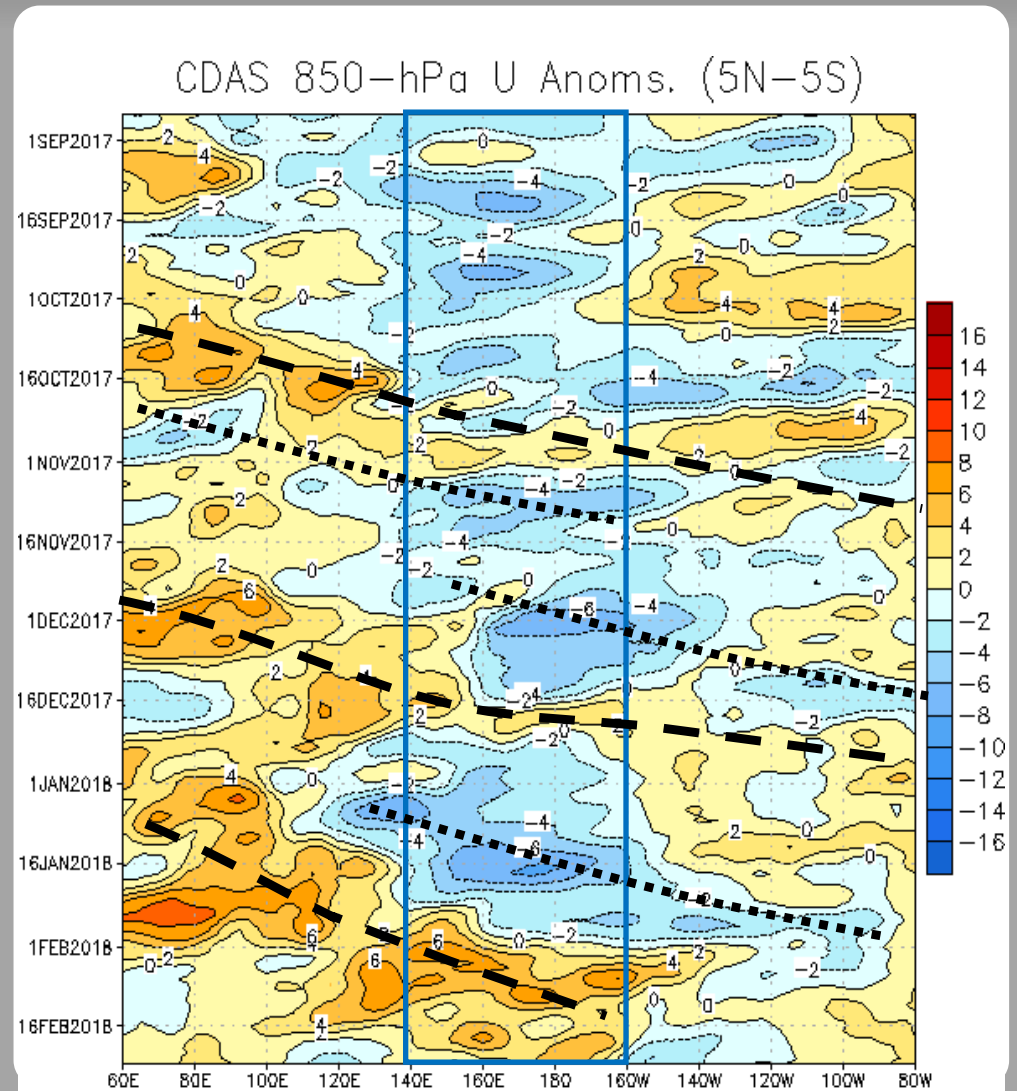
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Low frequency anomalous easterlies that have been present since before early September reversed sign during February.

During October and early November, a robust MJO event developed, with eastward propagation of westerly and easterly anomalies. This event weakened in early to mid-November.

A new MJO event became organized in December, propagating from the Indian Ocean to the Pacific. The signal crossed the Western Hemisphere in late December, re-emerging over the Indian Ocean early January. The signal continued to propagate eastward, moving into the central and eastern Pacific and began weakening over the past couple of weeks.



OLR Anomalies - Past 30 days

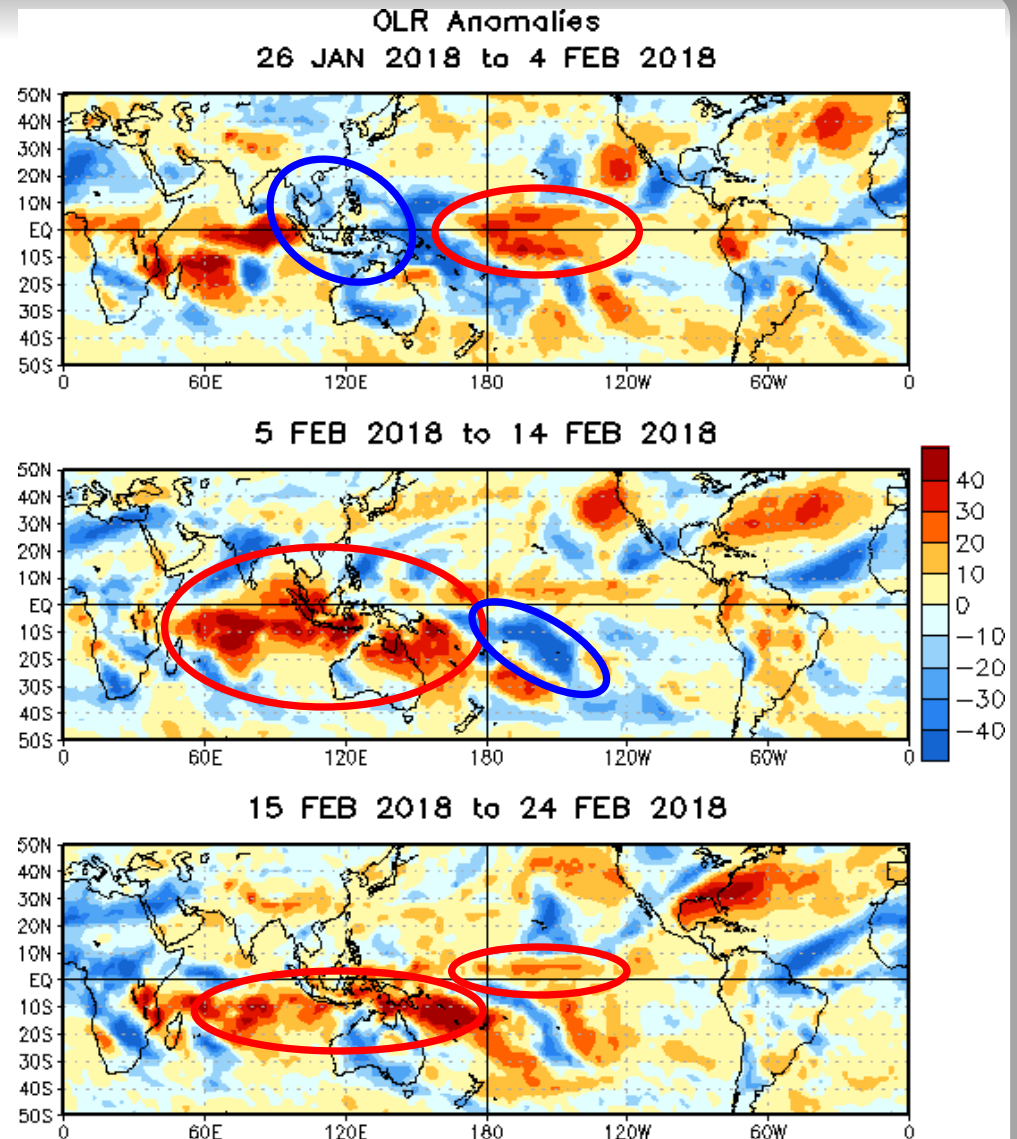
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

The enhanced phase of the MJO moved from the Maritime Continent over the West Pacific during late January resulting in anomalously weak convection over the central Pacific just east of the Date Line.

The suppressed phase of the MJO led to positive OLR anomalies over much of the Maritime Continent and southern Indian Ocean during mid-February. The enhanced phase destructively interfered with ENSO over the central Pacific.

Positive OLR anomalies have weakened but continue to dominate the Indian Ocean and Maritime Continent south of the Equator.



Outgoing Longwave Radiation (OLR) Anomalies (2.5°S - 17.5° S)

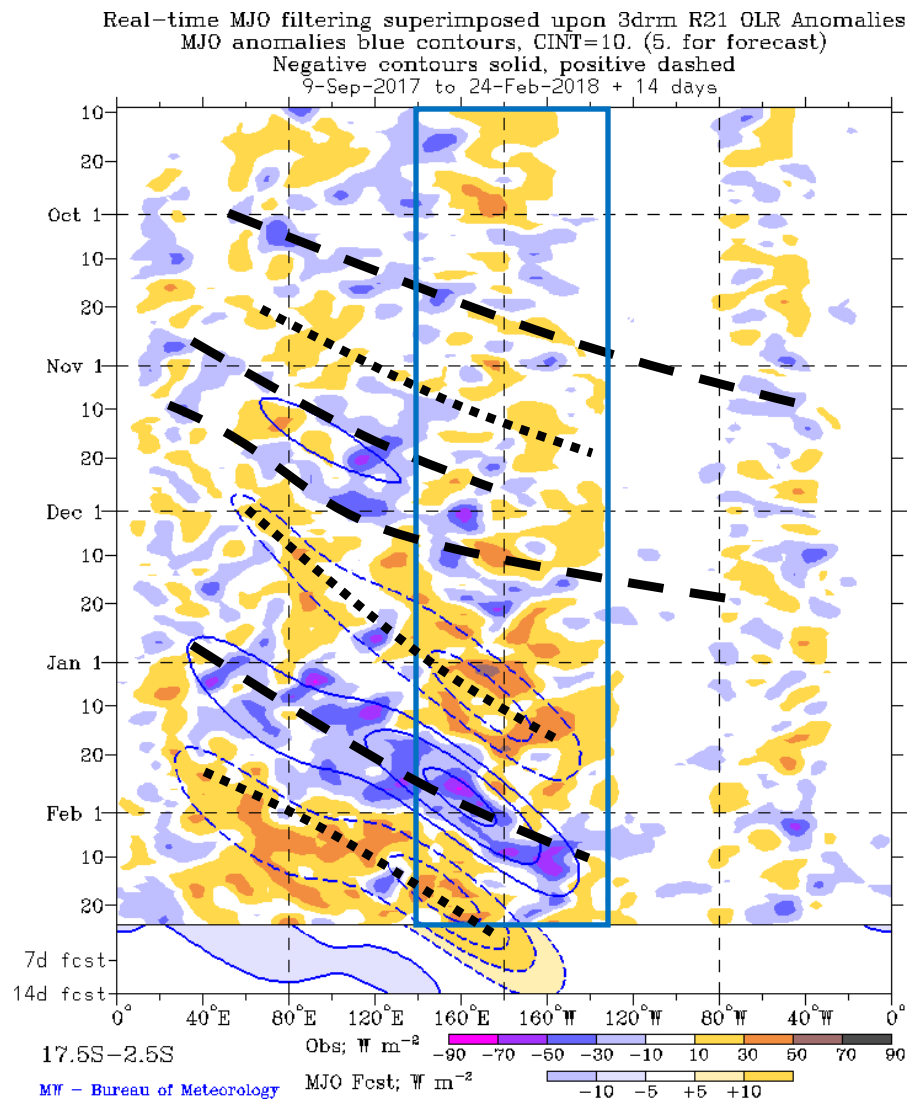
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

An active MJO formed in early October and circumnavigated the globe by early November.

Another MJO event developed in late November over the eastern Indian Ocean and Maritime Continent that was able to briefly disrupt the La Niña convective suppression near the Date Line. It re-emerged in the Indian Ocean at the end of December and strengthened as it shifted east towards the Date Line at present.

A third MJO event developed during January, leading to a reversal of the La Niña convective signal over the Date Line in early February.



200-hPa Velocity Potential Anomalies (5°S - 5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

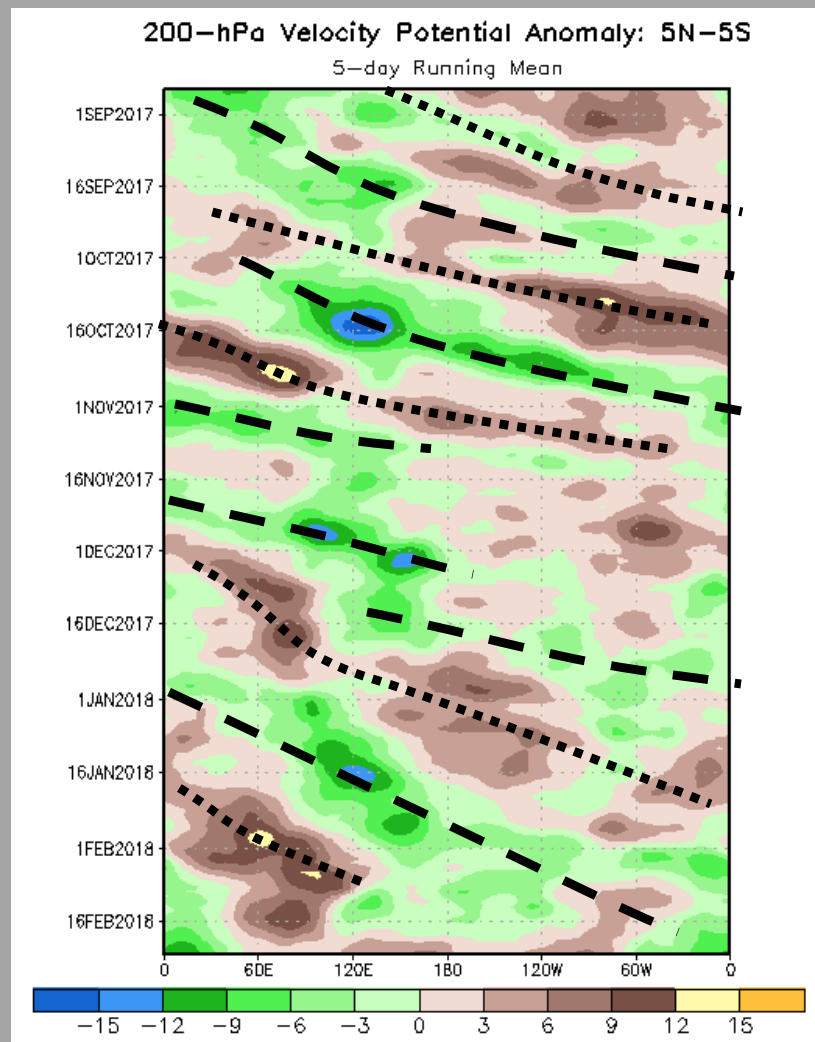
Negative anomalies (green shading) indicate favorable conditions for precipitation

An MJO event developed near the Maritime Continent during early October with strong anomalous upper-level winds near 120E. The signal circumnavigated the global tropics and weakened about 30 days later.

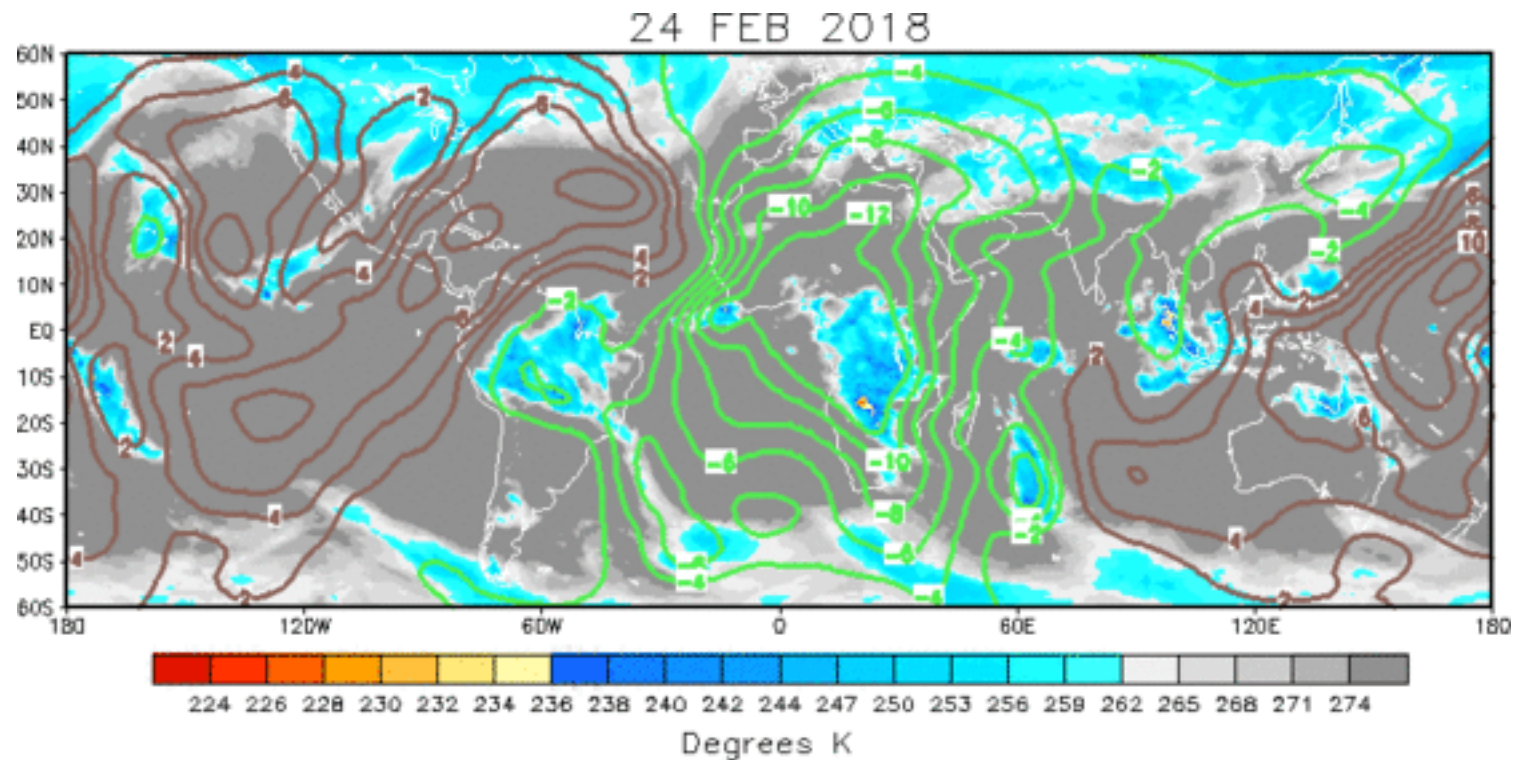
MJO activity renewed in November. The intraseasonal signal associated with this MJO event was weaker than the previous episode due to destructive interference from an equatorial Rossby wave.

The signal destructively interfered with the base state through the end of December, crossing the Western Hemisphere into the Indian Ocean for the beginning of January. Since then, it has continued eastward and strengthened.

This MJO event further intensified during January and early February. The suppressed region of the MJO is now just east of the Maritime Continent and the active region has recently intensified over the Prime Meridian.



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



A Wave-1 pattern is present around the globe. Anomalous convection centered over the Prime Meridian is partially associated with the active phase of the MJO that is emerging over Africa.

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⁻¹)

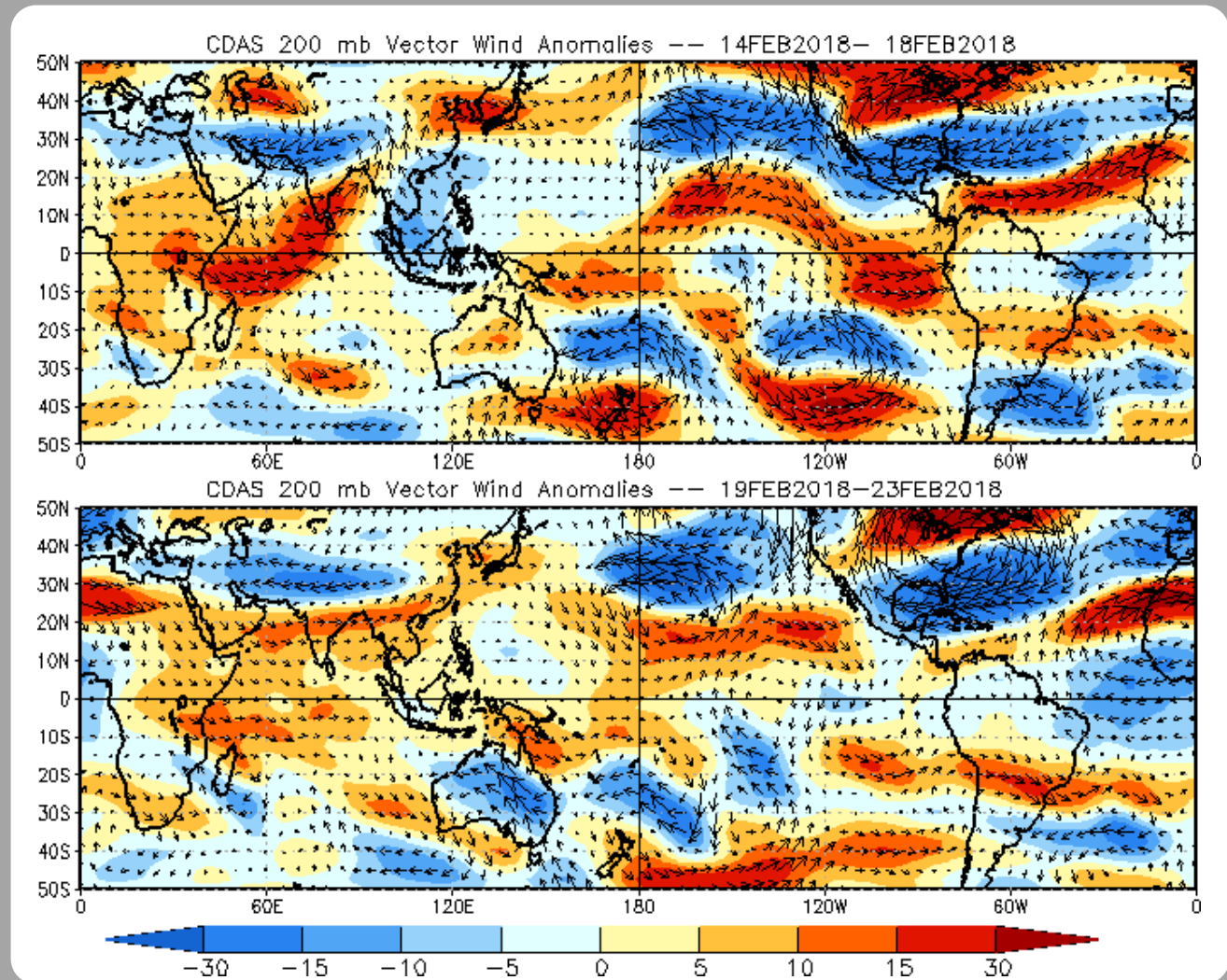
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

There is significant upper-level cross equatorial flow over the East Pacific that is interacting with amplified mid-latitude flows in both the northern and southern hemispheres.

The strong upper-level anomalous westerlies over the Indian Ocean weakened during the second pentad as the MJO continued to circumnavigate the globe.



200-hPa Zonal Wind Anomalies (m s⁻¹)

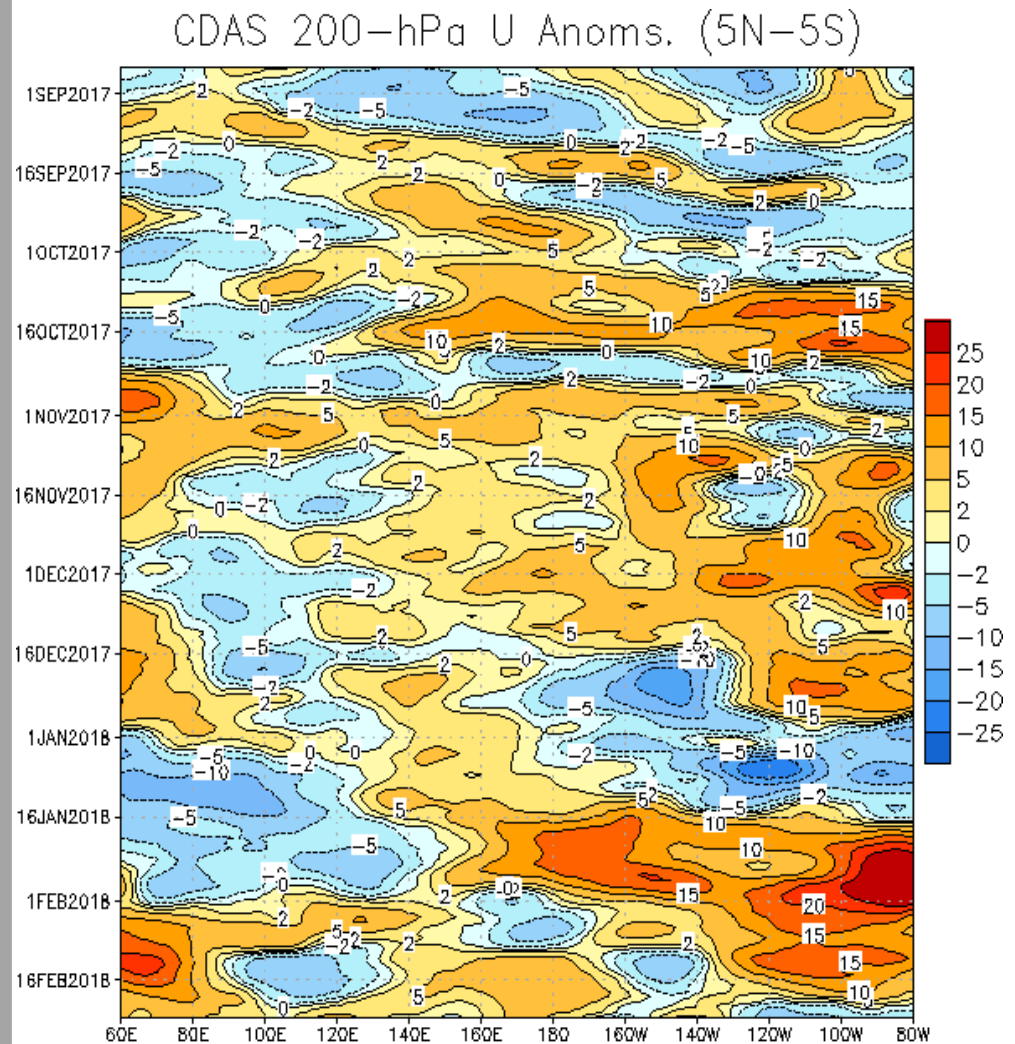
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Low-frequency westerly anomalies remained in place east of 140E starting in October, with the exception of a brief period of easterlies in late October. There is also some recent evidence of easterlies over the far Eastern Hemisphere over the last week or so that appear to have extratropical sourcing.

In mid-December anomalous easterlies developed east of the Date Line, replacing the westerly anomalies that had been generally present since October.

Strong anomalous westerlies that formed in early January just west of the Date Line propagated eastward, consistent with a strong MJO event during this period.



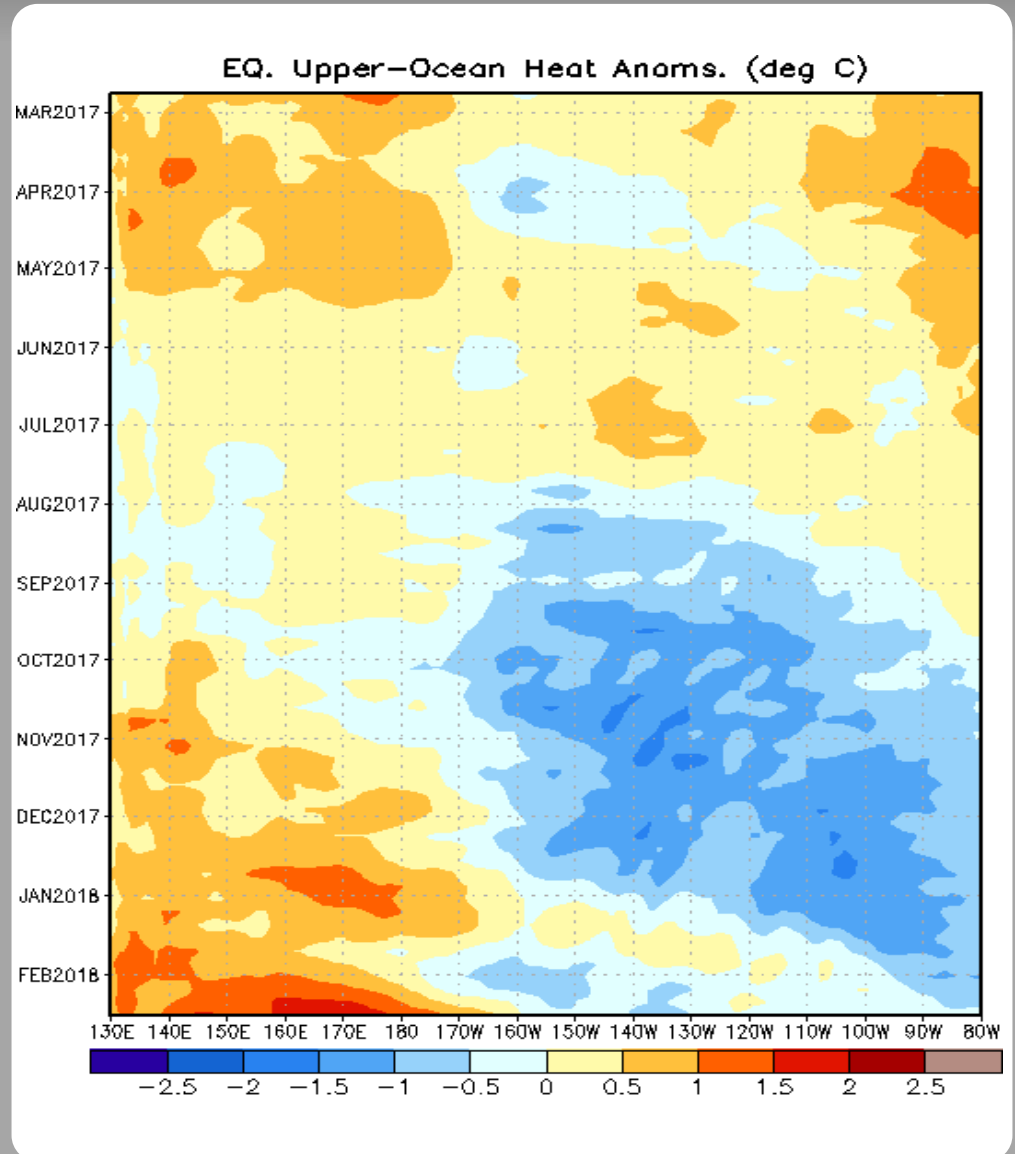
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Negative upper-ocean heat content anomalies have persisted in the central and eastern Pacific since late summer.

A downwelling Kelvin wave associated with the intraseasonal signal has weakened the negative anomalies across the east-central Pacific during late January and early February.

Another downwelling Kelvin wave appears to be leading to strongly positive, eastward-propagating anomalies near and just west of the Date Line.



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

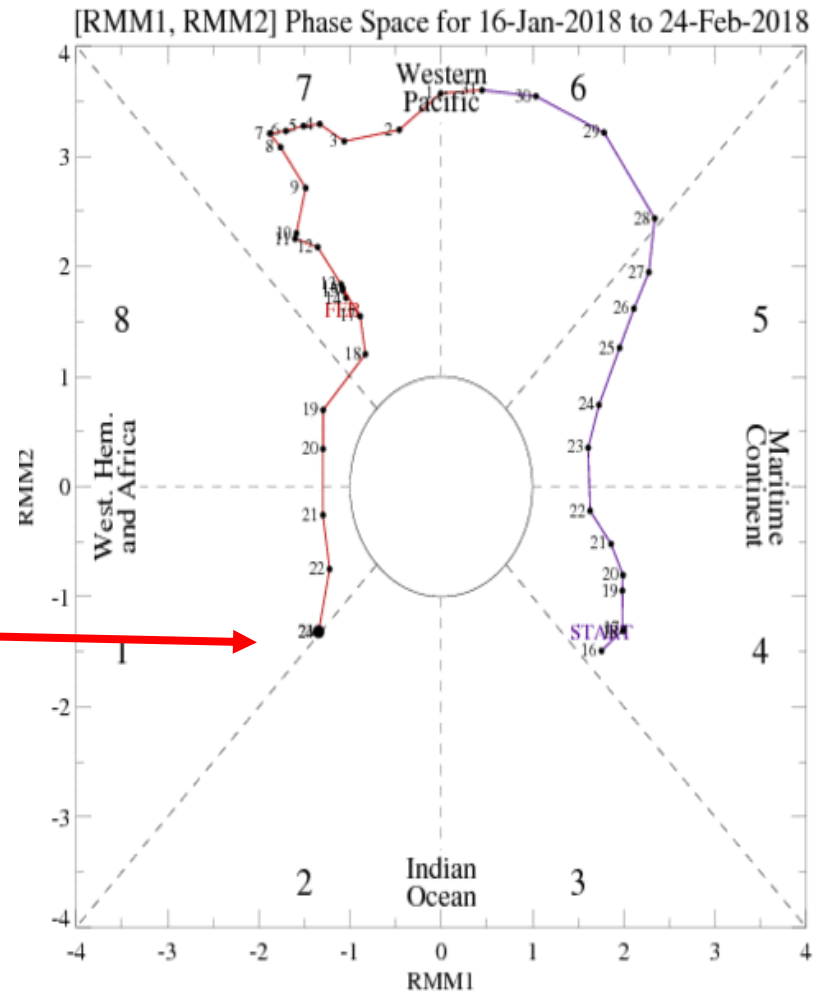
The triangular areas indicate the location of the enhanced phase of the MJO

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

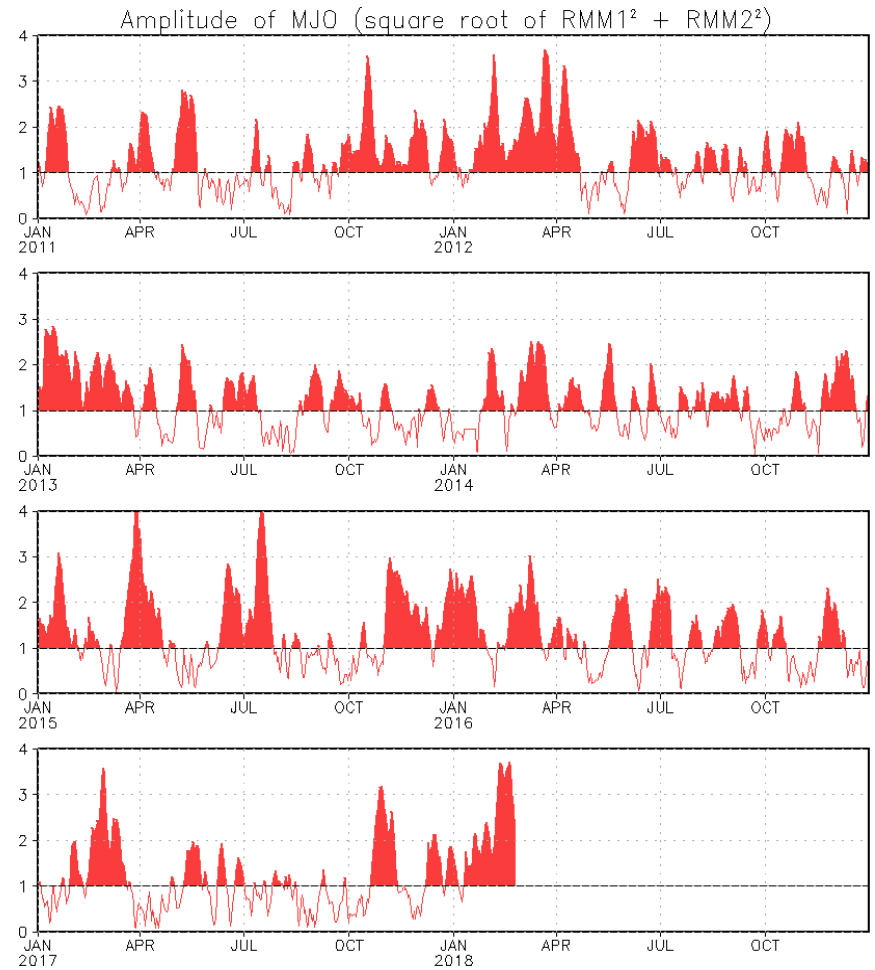
The MJO weakened rapidly during mid-February and is now re-emerging in Phase 1 over Africa.



MJO Index - Historical Daily Time Series

Time series of daily MJO index amplitude for the last few years.

Plot puts current MJO activity in recent historical context.



GFS Ensemble (GEFS) MJO Forecast

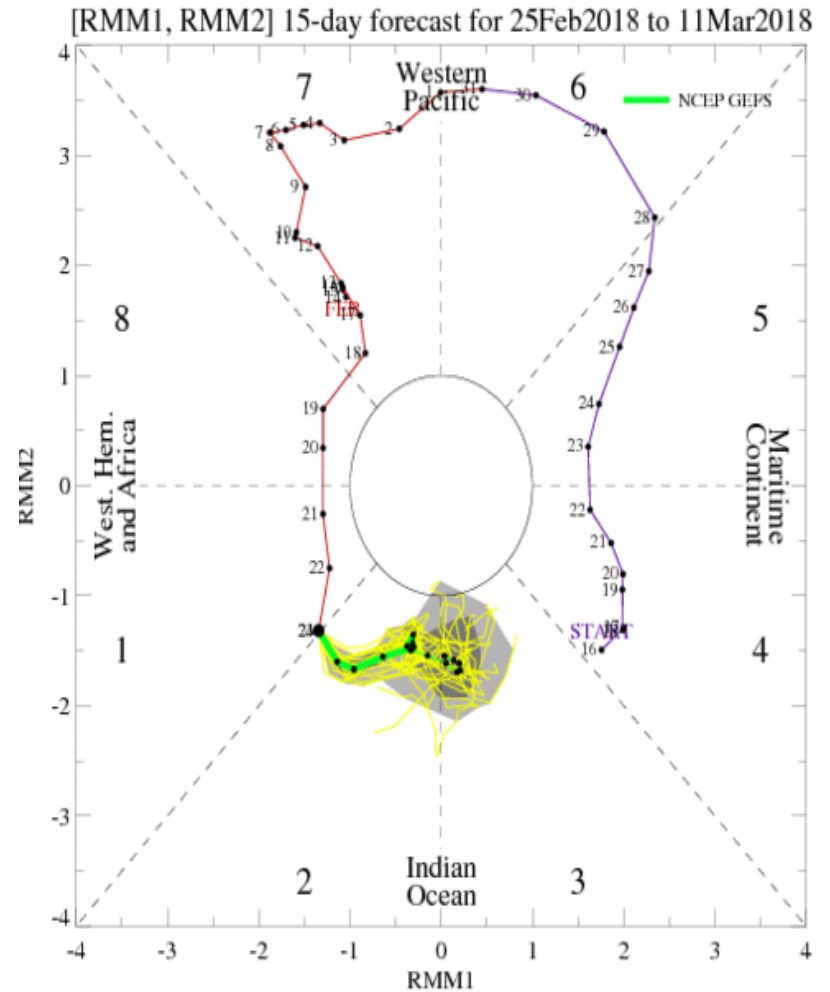
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

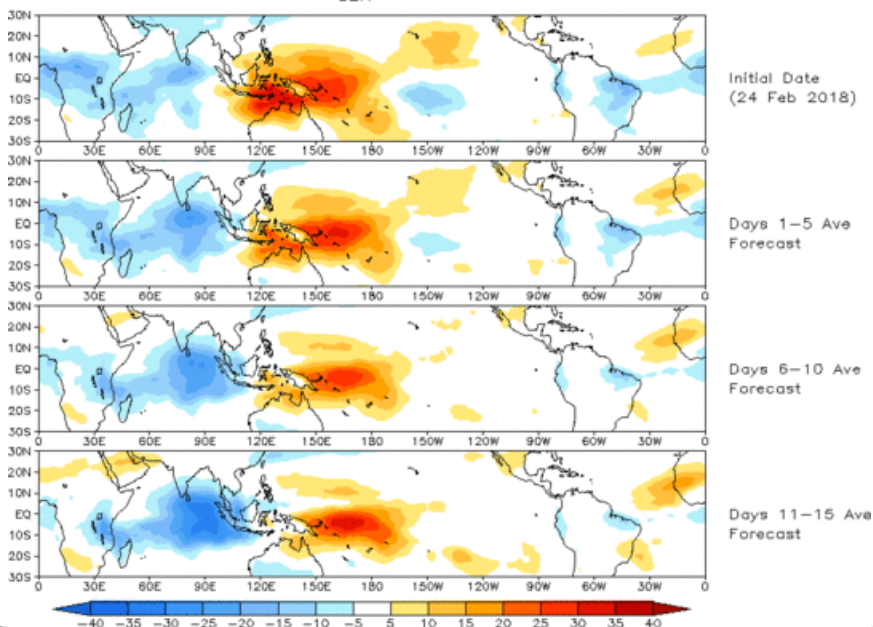
The GEFS forecasts MJO propagation across the Indian Ocean over the next 15 days.



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: 24 Feb 2018
OLR

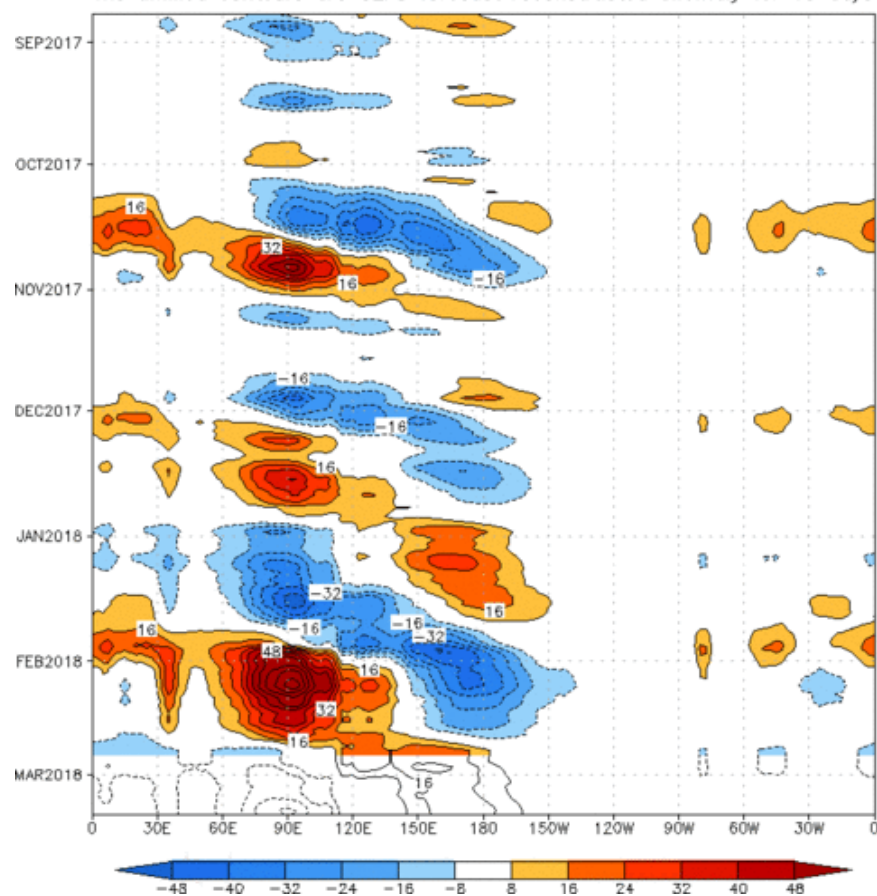


OLR anomalies associated with the MJO based on the GEFS show slow eastward propagation of a coherent convection dipole.

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

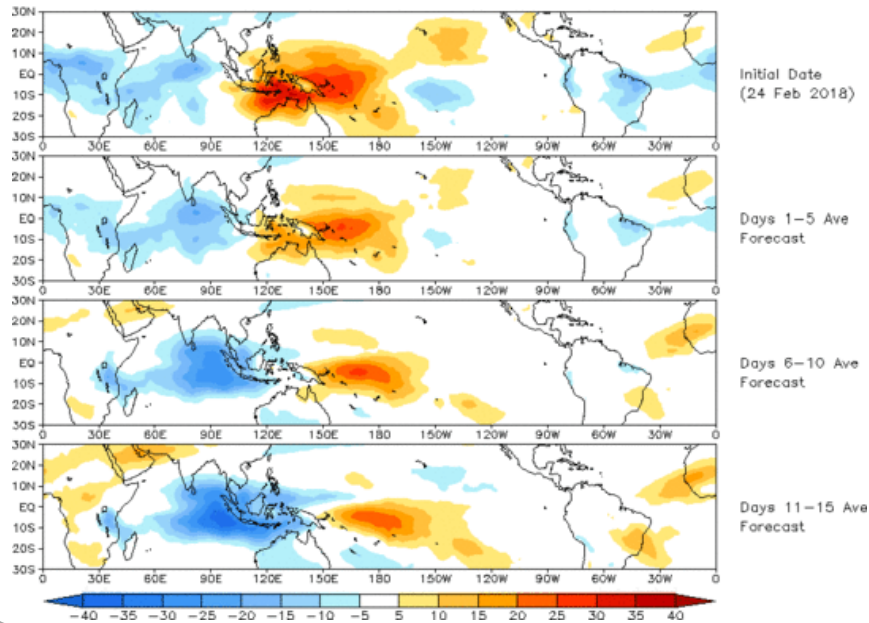
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cint:4Wm⁻²) Period:25-Aug-2017 to 24-Feb-2018
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



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 (24 Feb 2018)

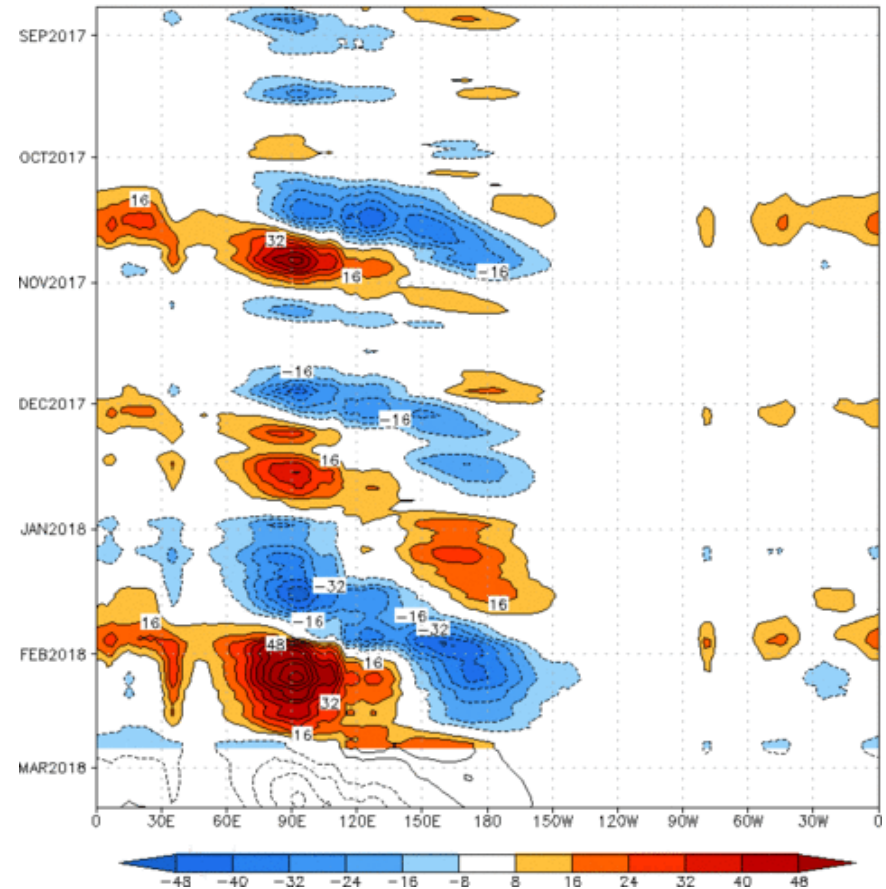


The constructed analog supports the slow propagation seen in the GEFS forecast; however, the weakening of the anomalies is not as pronounced in this solution.

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.)

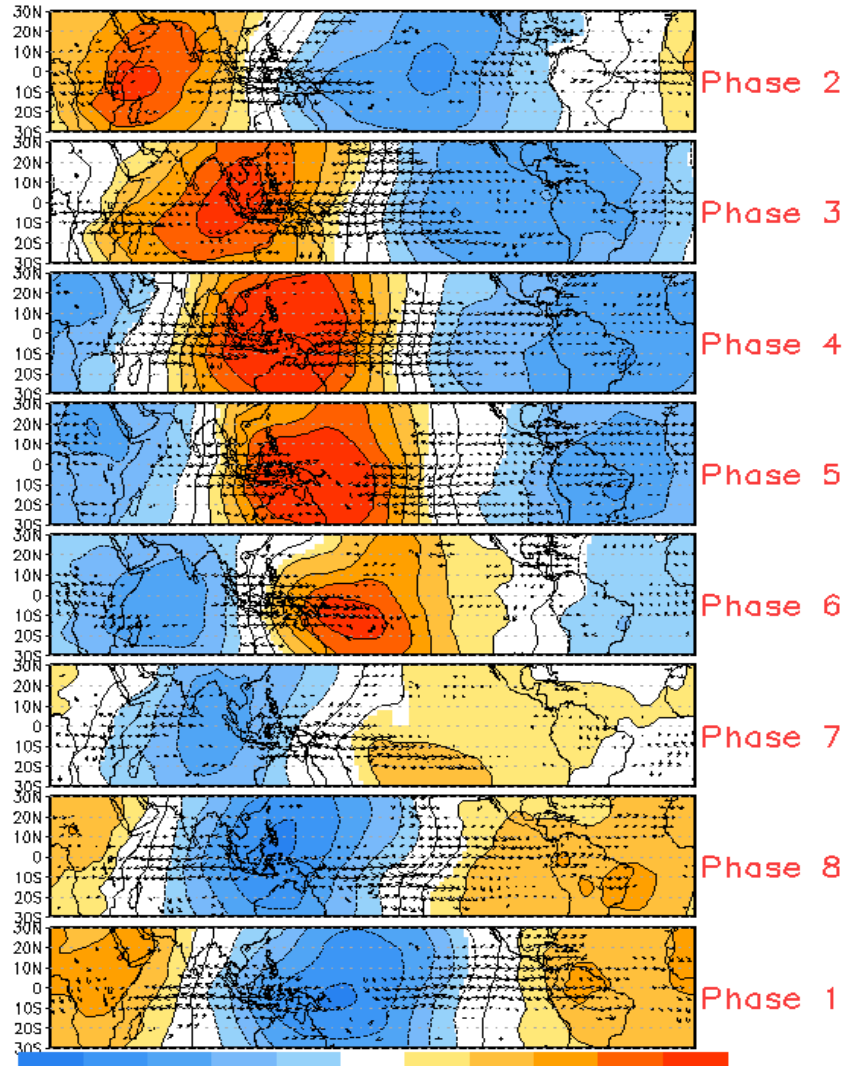
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:25-Aug-2017 to 24-Feb-2018
The unfilled contours are CA forecast reconstructed anomaly for 15 days

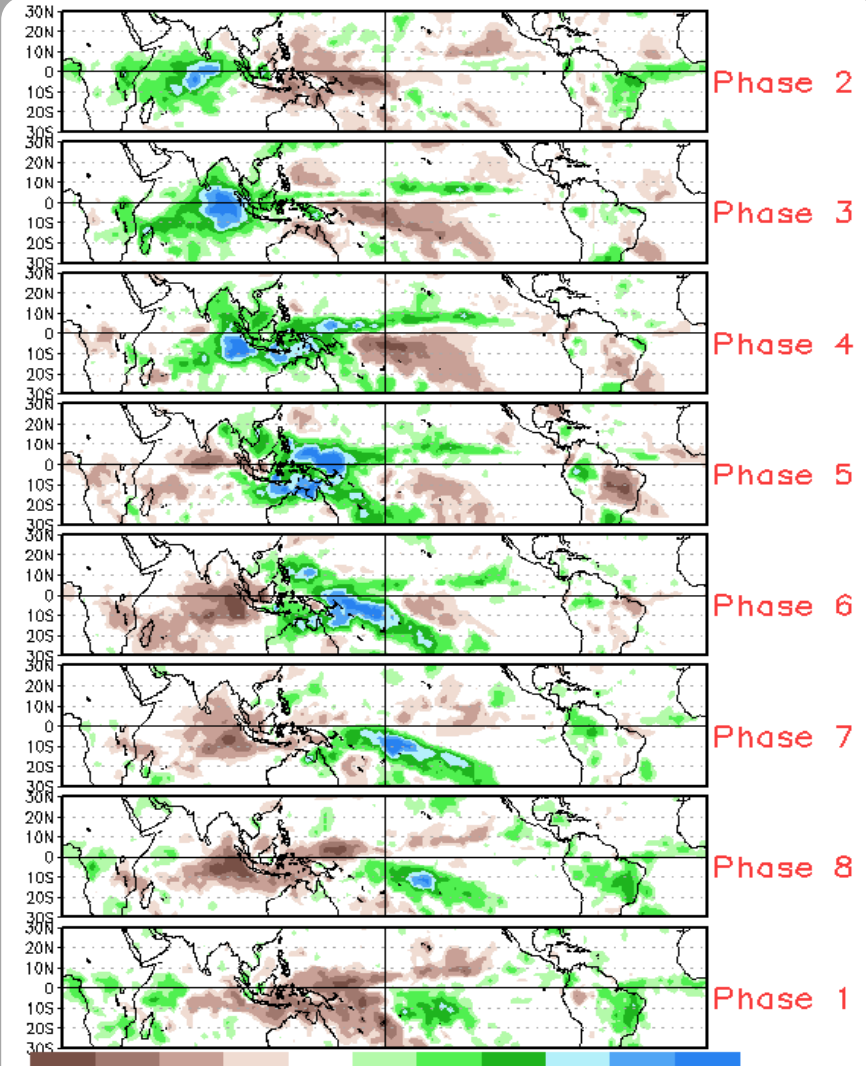


MJO Composites - Global Tropics

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



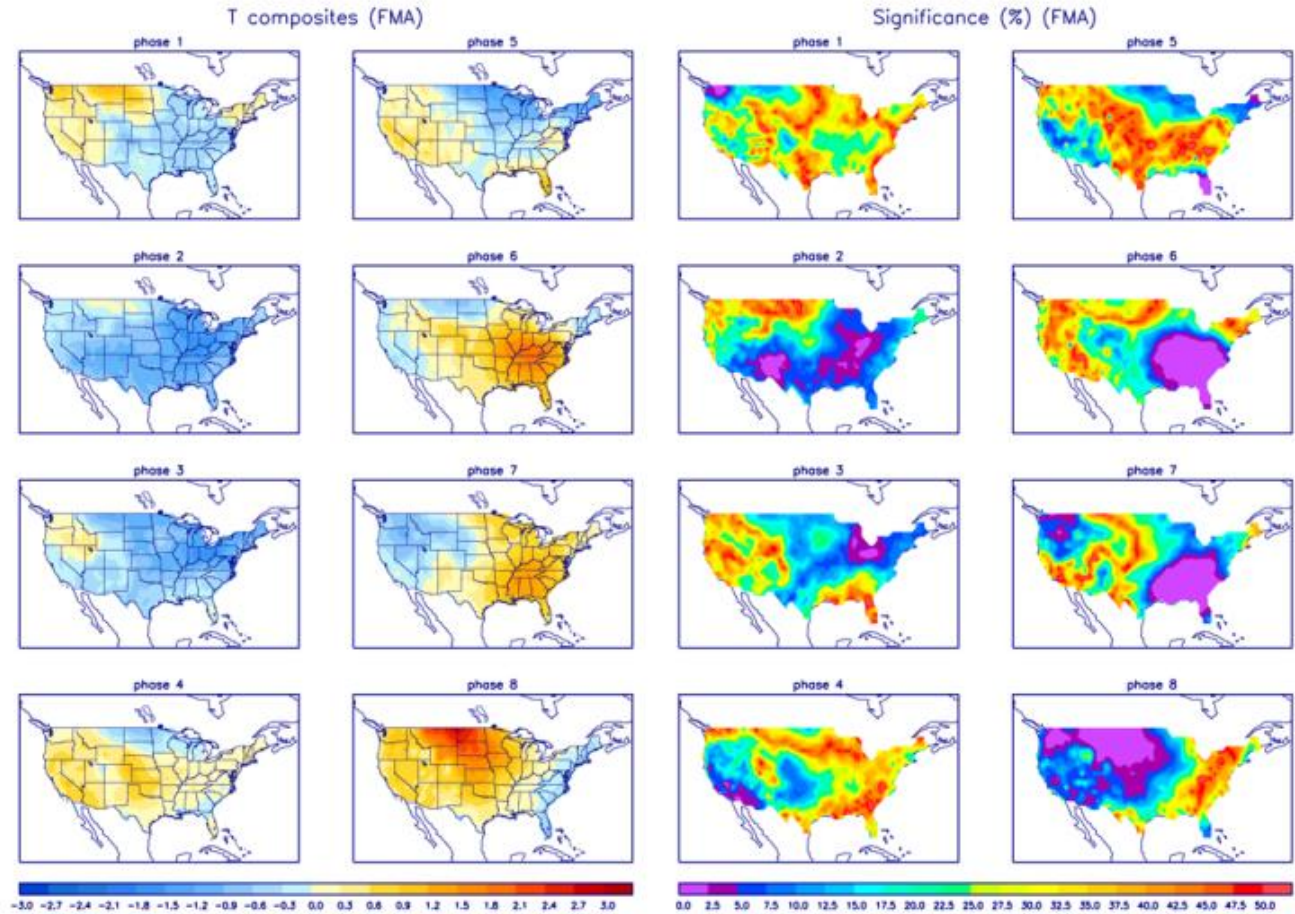
Precipitation Anomalies (Nov - Mar)



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.



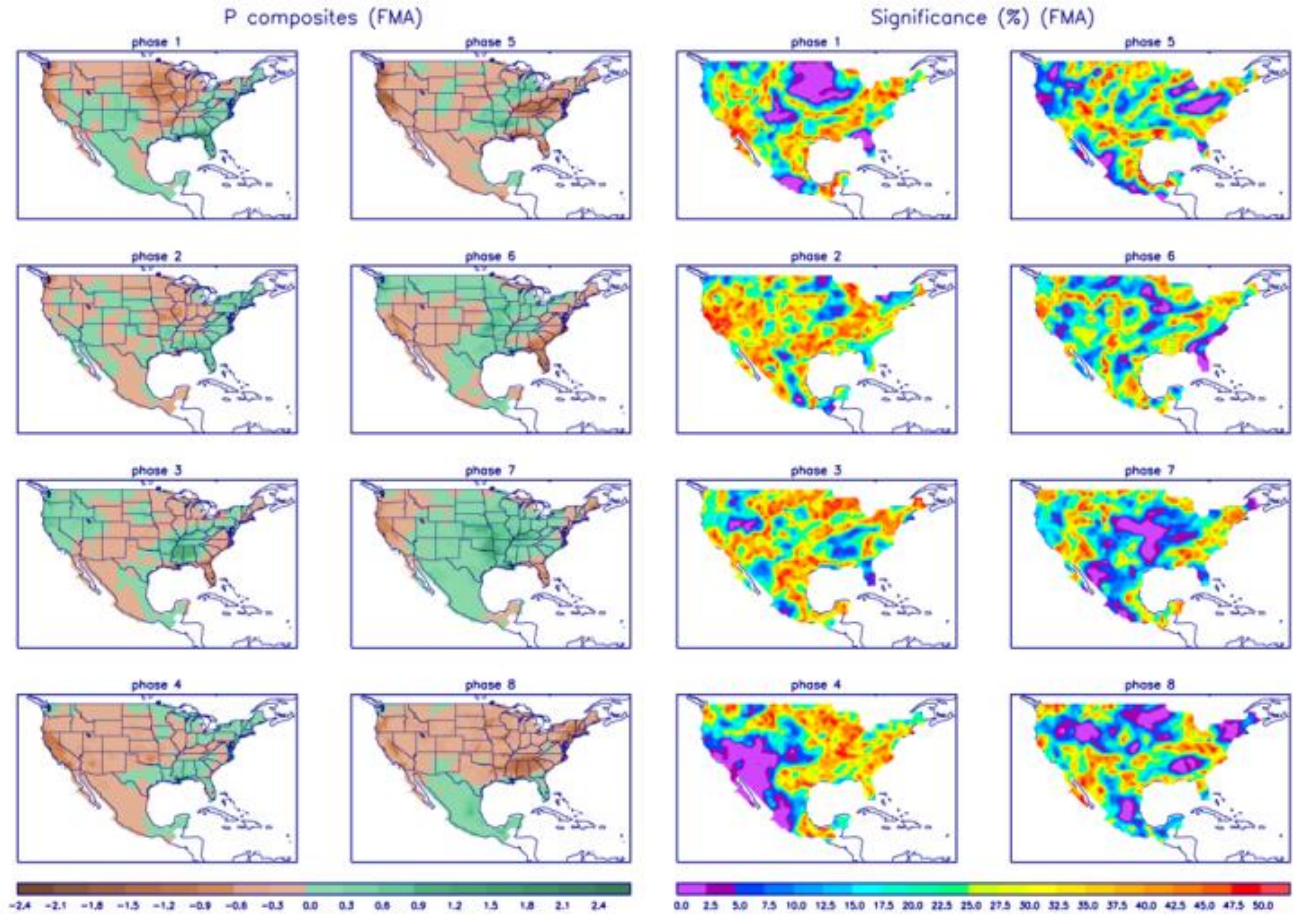
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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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