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

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Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO remained active during the past week. It is now in RMM phase 2, emerging over the Indian Ocean.
- The GEFS forecasts the MJO to slowly propagate into RMM phase 3 and then weaken during the next 2-3 weeks.
- In sharp contrast to the GEFS forecast, our constructed analog statistical model forecasts the MJO to continue propagating around the globe without significant weakening.

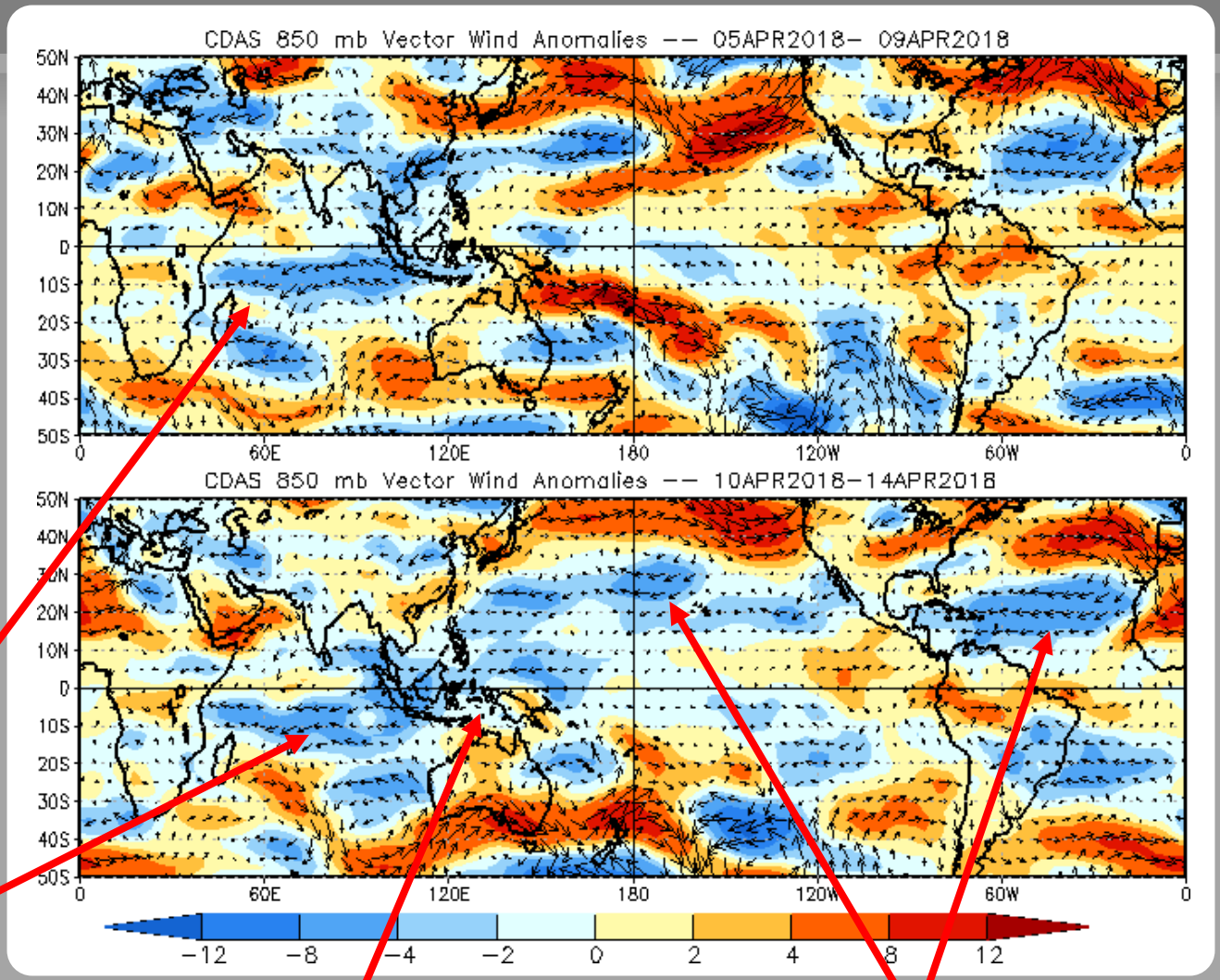
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 easterlies continued across the southern Indian Ocean.

Winds over the Maritime Continent weakened over the past week.

Persistent wave breaking over the north Pacific & Atlantic reinforced blocking patterns.

850-hPa Zonal Wind Anomalies (m s-1)

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

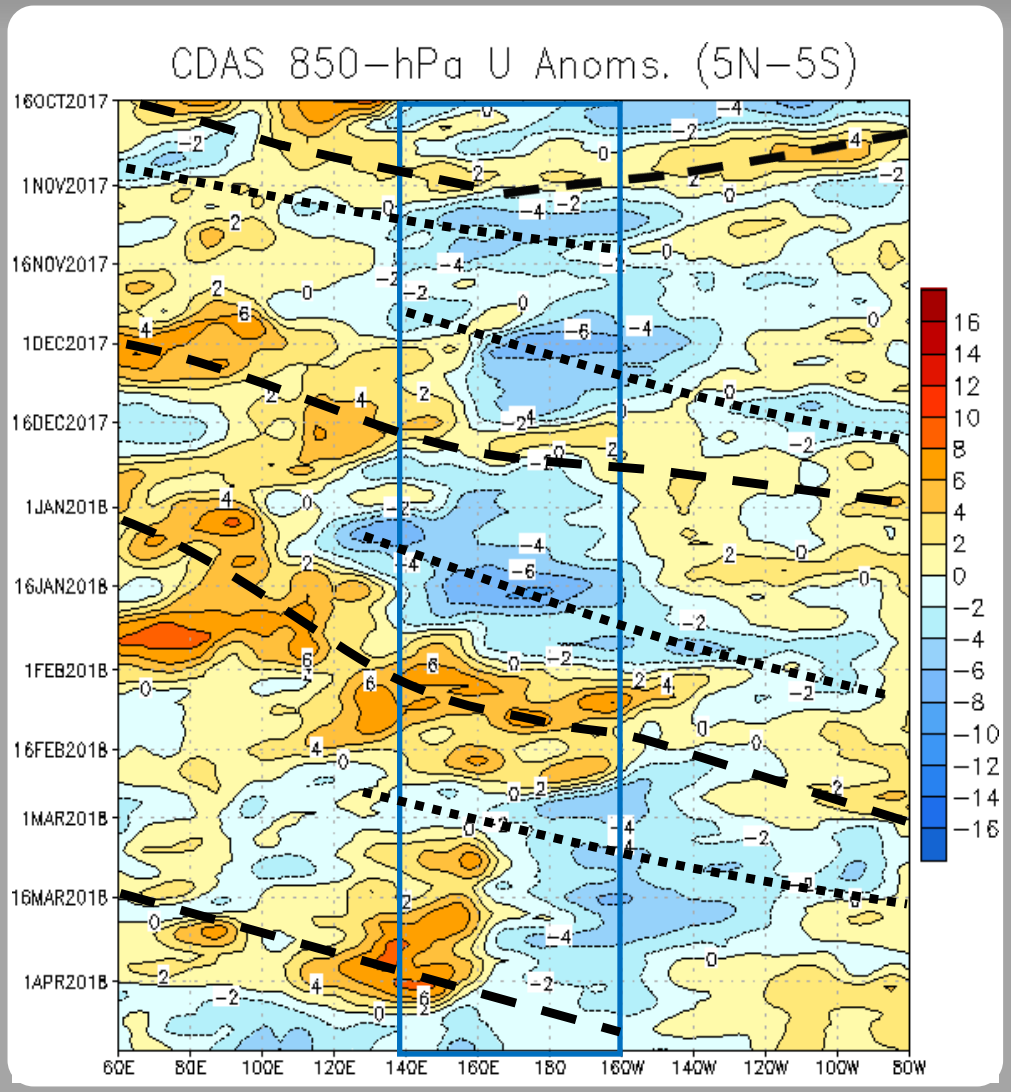
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During October and early November a robust MJO event developed. This event weakened in early to mid-November.

A strong MJO event formed in early December and circumnavigated the globe twice through January and mid-February.

During mid to late March, anomalous westerlies shifted east from the Indian Ocean to the Maritime Continent as the MJO signal re-emerged. These westerlies were associated with the envelope of active MJO convection.

Anomalous easterlies over the central and eastern Pacific have weakened since the beginning of April, which is an indicator of waning La Nina effects.



OLR Anomalies – Past 30 days

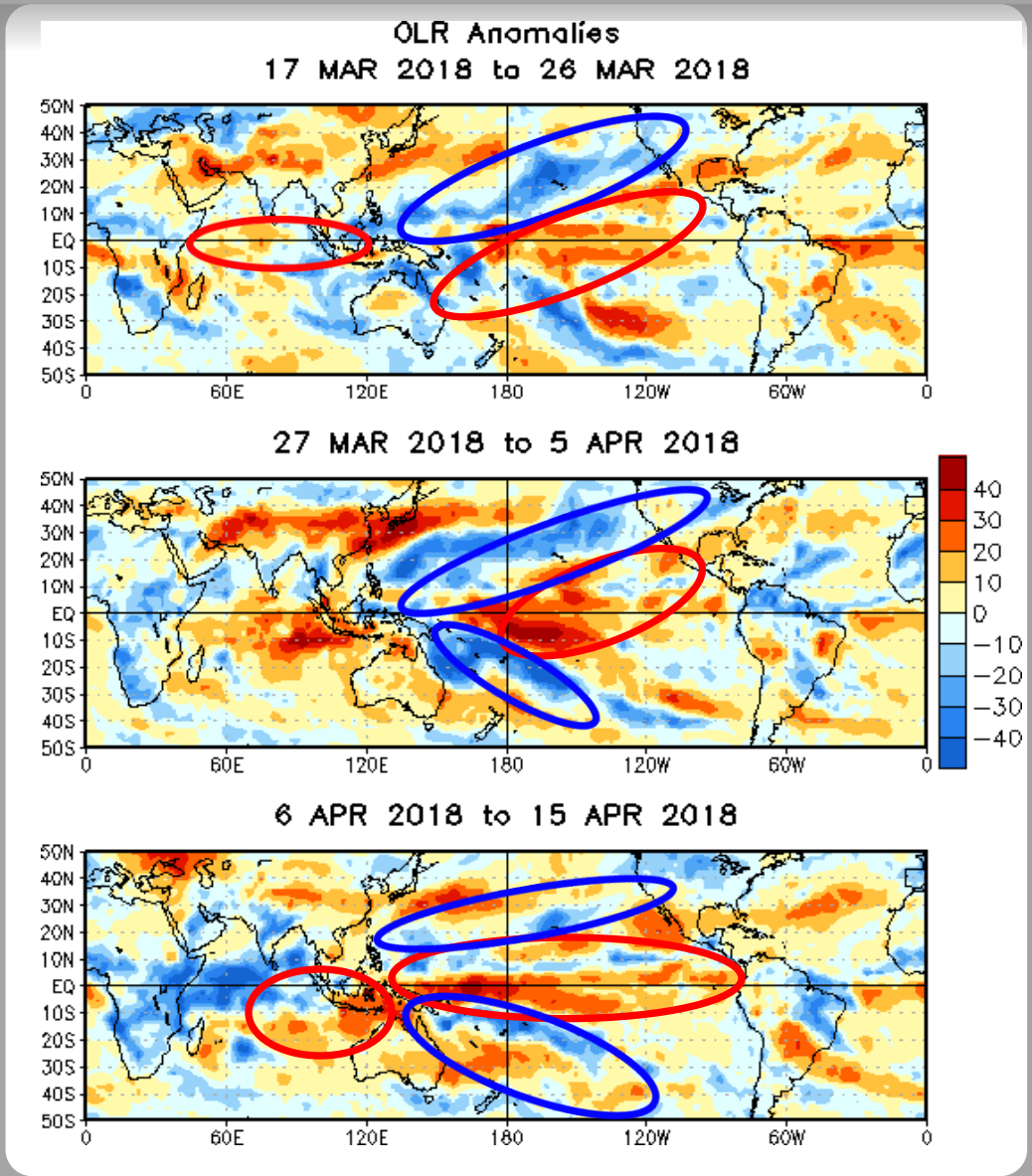
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-March, positive OLR anomalies dominated the Indian Ocean and moved over the Maritime Continent during the remainder of the month, but weakened along with the MJO. Positive OLR anomalies, associated with an active La Nina, persisted over the central Pacific from mid-March to mid-April.

Negative OLR anomalies, mostly associated with transient equatorial waves and atmospheric mid-latitude wave breaking, were found both north and south of the equator during March and early April.

Positive OLR anomalies intensified over the eastern Indian Ocean and Maritime Continent during early April, associated with the suppressed phase of the MJO.



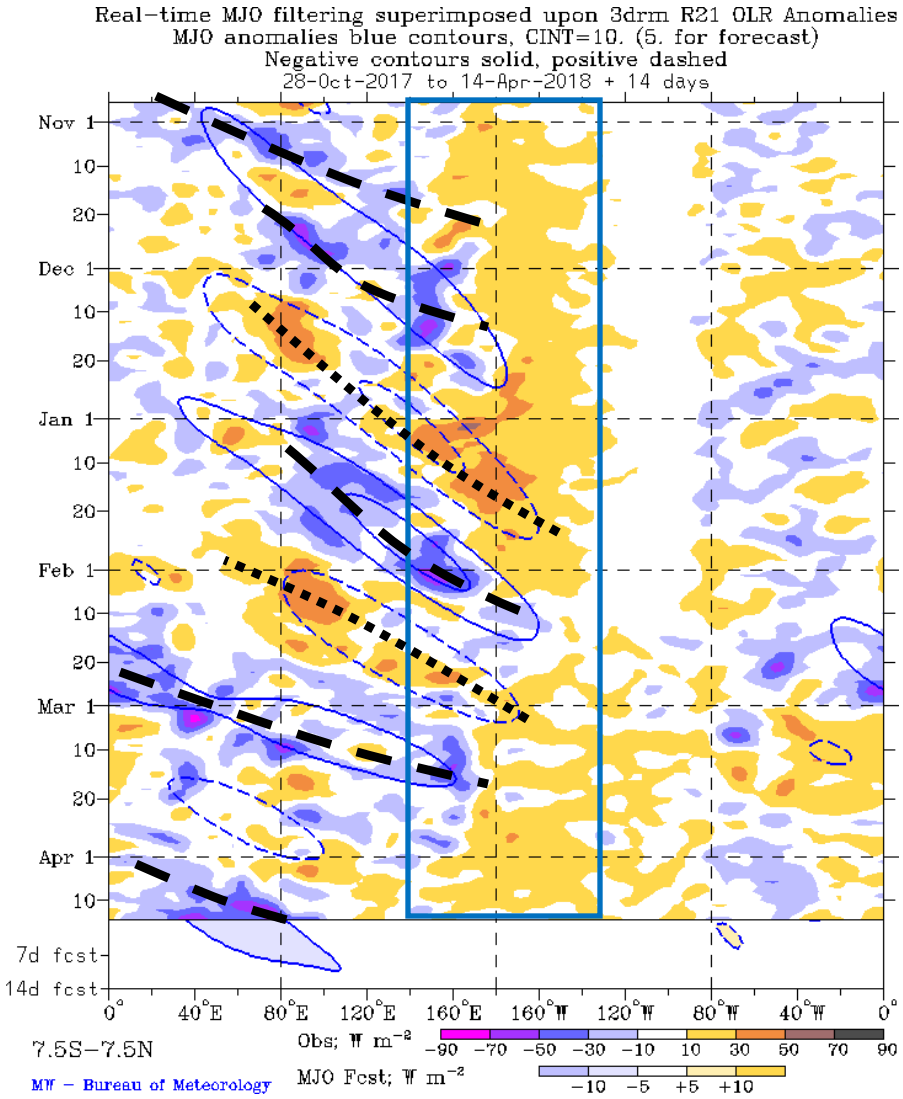
Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

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

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

There has been consistent MJO activity since last October. During early February the MJO was strong enough to temporarily reverse the low-frequency dry signal associated with La Niña along the Date Line until early March.

An active MJO event propagated east from Africa to the Indian Ocean during early April. Active convection now extends from equatorial Africa to about 80 degrees east and is expected to continue shifting eastward to the Maritime Continent.



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

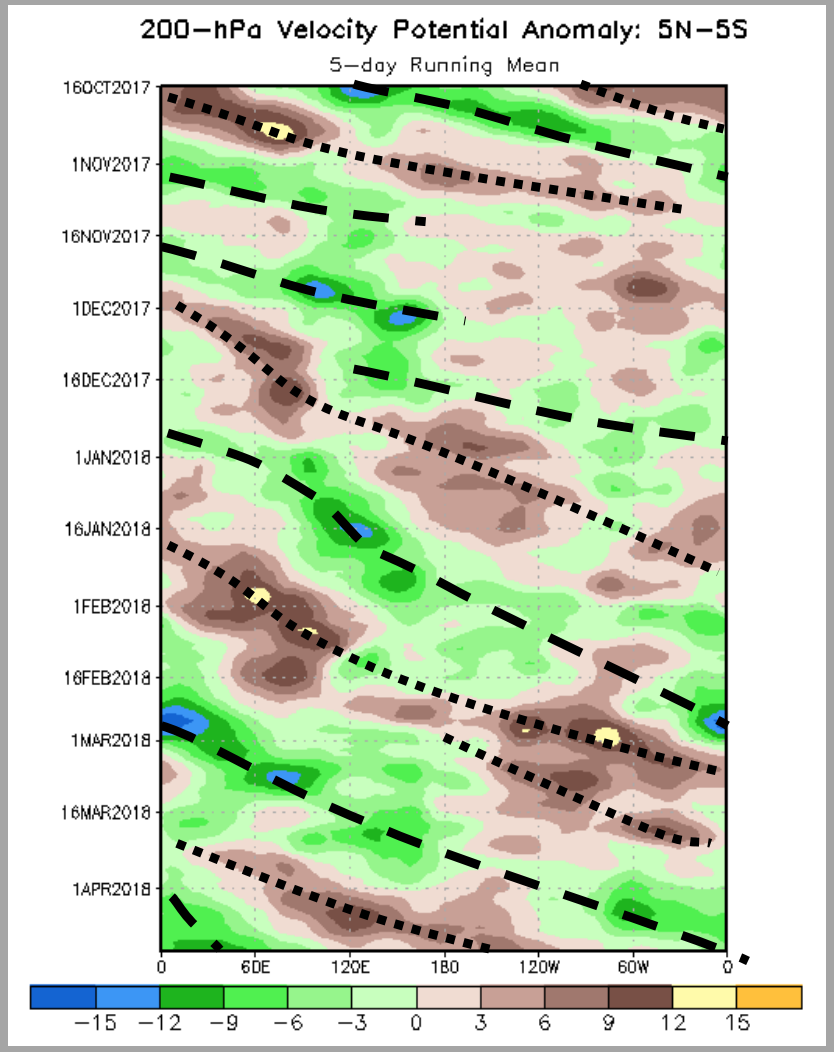
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

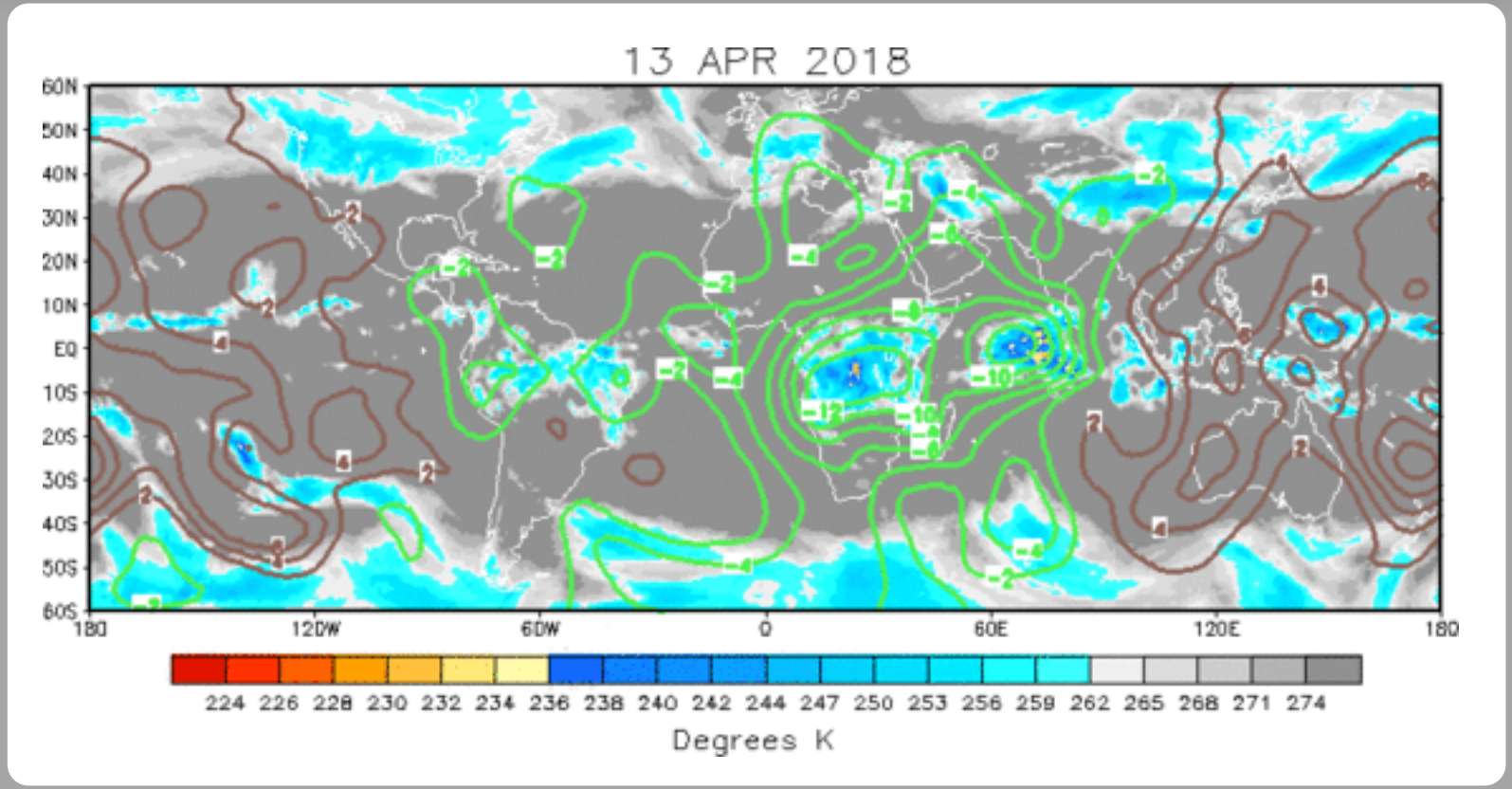
The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric Kelvin wave east of the Date Line during late February and early March.

The large-scale region of suppressed convection along the Date Line associated with La Niña is less apparent in the velocity potential field than the OLR field. This is primarily because velocity potential is a smoother field than OLR and is dominated by frequent MJO activity.

By early April the MJO and its associated upper-level divergence returned to Africa and the western Indian Ocean. There are also multiple westward propagating areas of suppressed convection that follows equatorial Rossby wave activity from early February to the present.



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



A Wave-1 pattern is present with suppressed (enhanced) convection from the Maritime Continent to the eastern Pacific (North America to the eastern Indian Ocean). This is consistent with an MJO signal in RMM phase 2.

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)

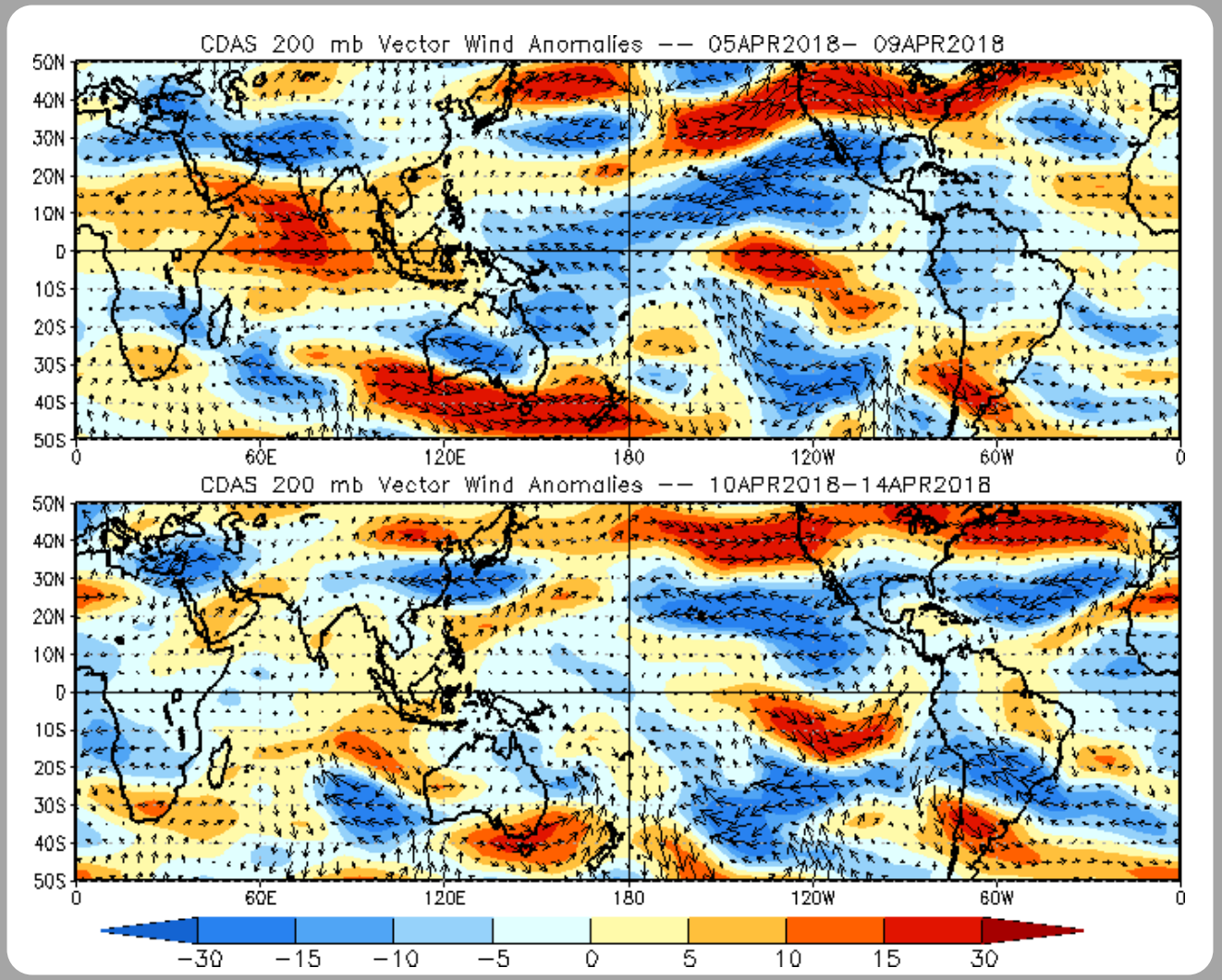
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The anomalous westerlies which stretched from Hawaii to California broke down at the end of March, cutting off the subtropical moisture feed that had been in place over the previous month.

Westerlies over the eastern north Pacific have become more zonally oriented during the past week, preventing another subtropical moisture stream from taking hold.



200-hPa Zonal Wind Anomalies (m s-1)

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

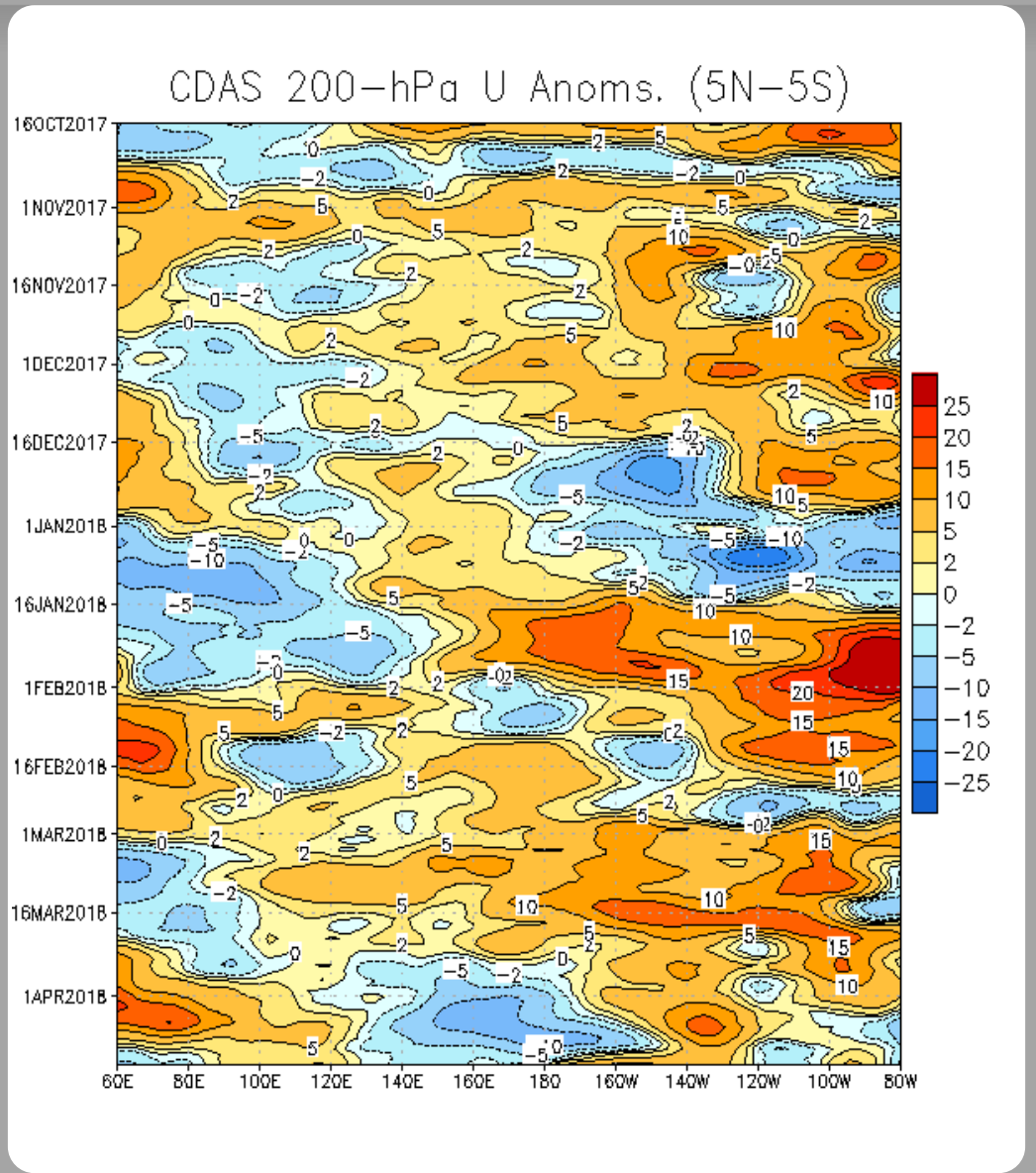
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency anomalous westerlies remained in place east of 140E starting in October, with a few periods of brief interruptions.

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

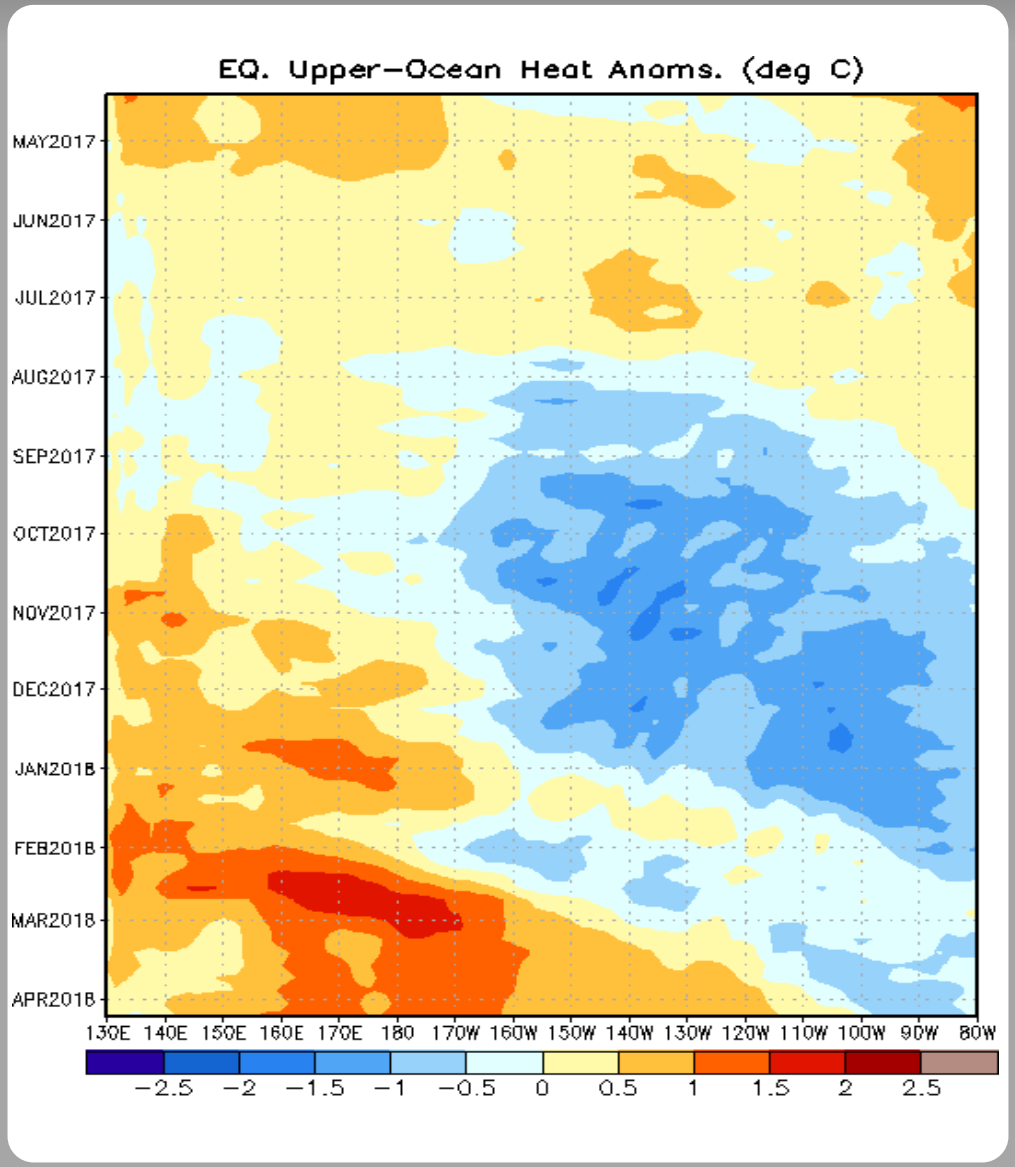
Strong anomalous westerlies that formed in early January just west of the Date Line propagated eastward, consistent with a strong MJO event during this period.

Recently, easterly anomalies have developed between 130E and 160W, interrupting the relatively stationary anomalous westerlies that have persisted across the Pacific since the middle of March. Westerly anomalies are also becoming established over the eastern Indian Ocean.



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 persisted in the central and eastern Pacific from August-December.

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

Several downwelling oceanic Kelvin waves (associated with a relaxation of the trade winds) have contributed to the eastward expansion of relatively warm subsurface water (as much as 1.5-2.0 deg C above normal between 160E and 170W). Residual, negative heat content anomalies are now found only over the far eastern Pacific.

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

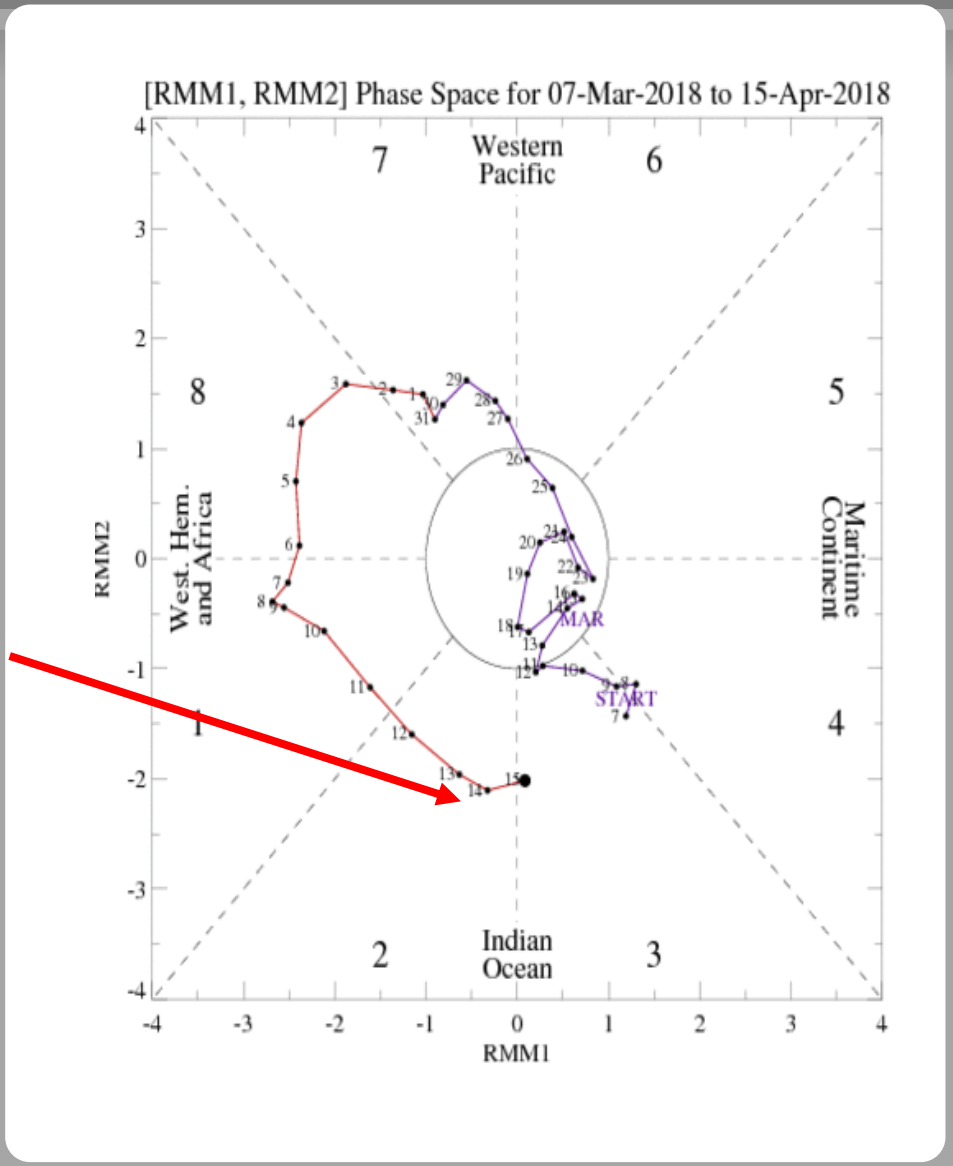
The triangular areas indicate the location of the enhanced phase of the MJO

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

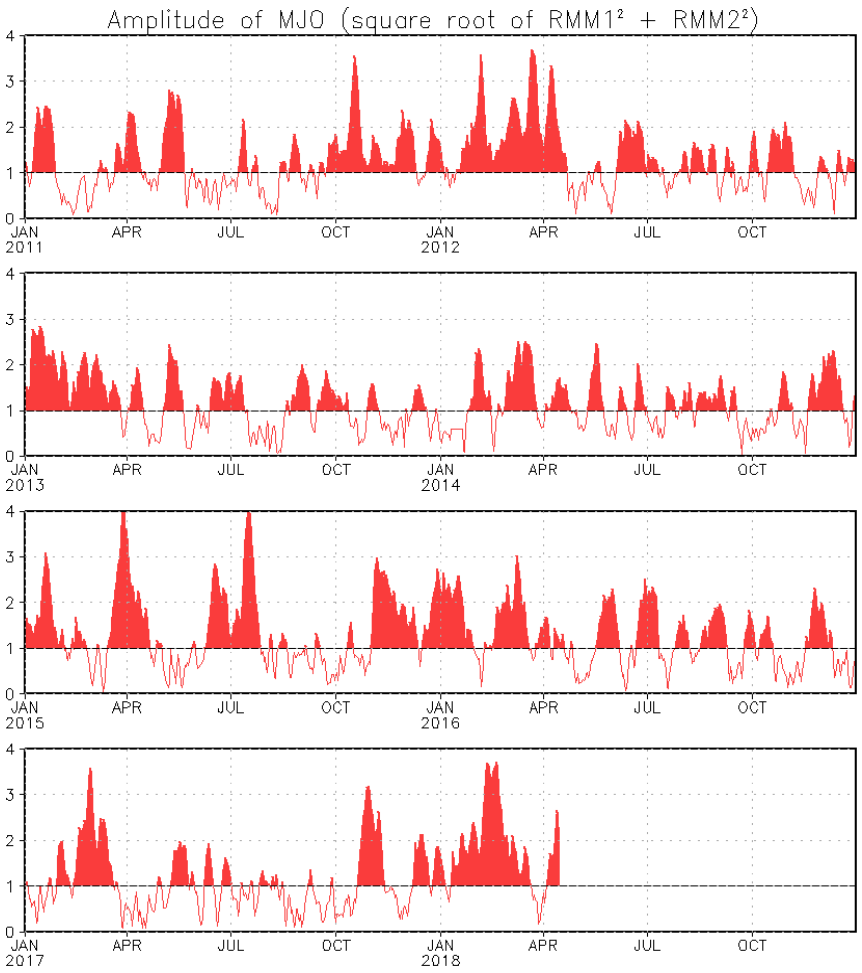
The MJO has moved into the Indian Ocean and is currently in RMM phase 2.



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

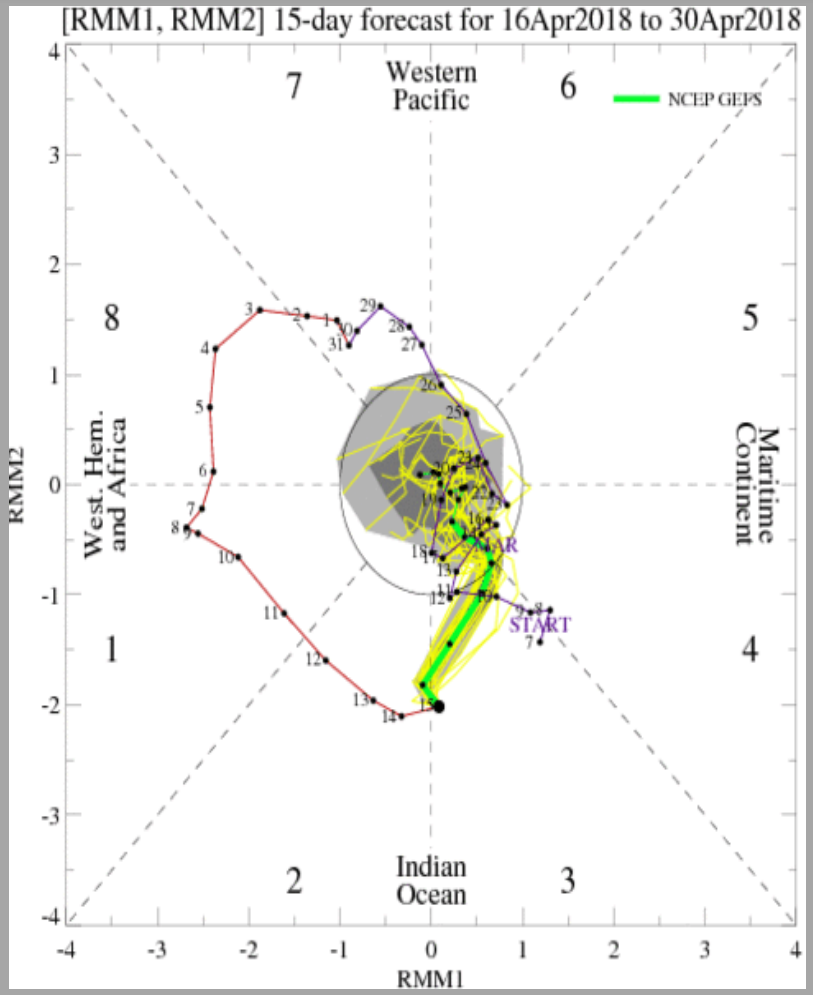
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

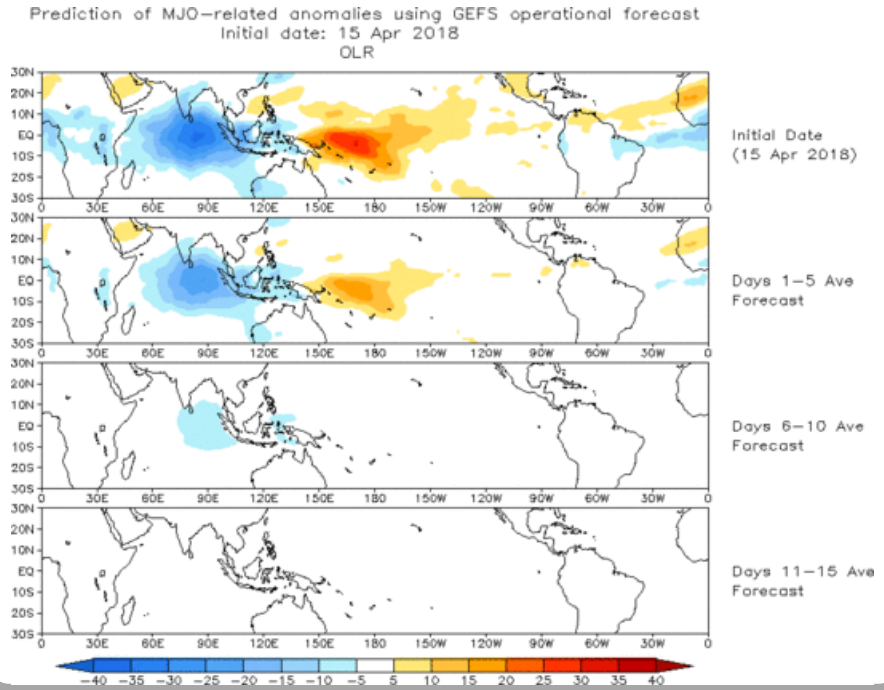
The GEFS predicts that the MJO will weaken substantially during Weeks 2-3 as it propagates east.



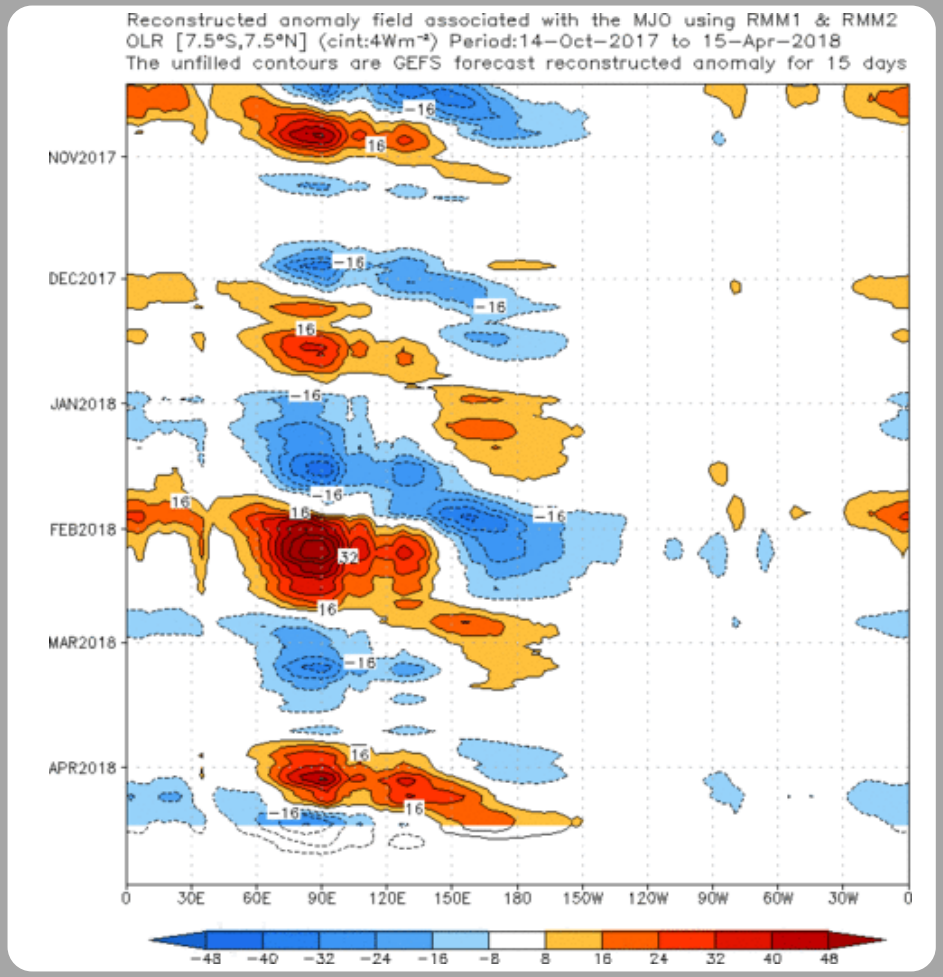
Ensemble GFS (GEFS) MJO Forecast

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 - last 180 days and for the next 15 days

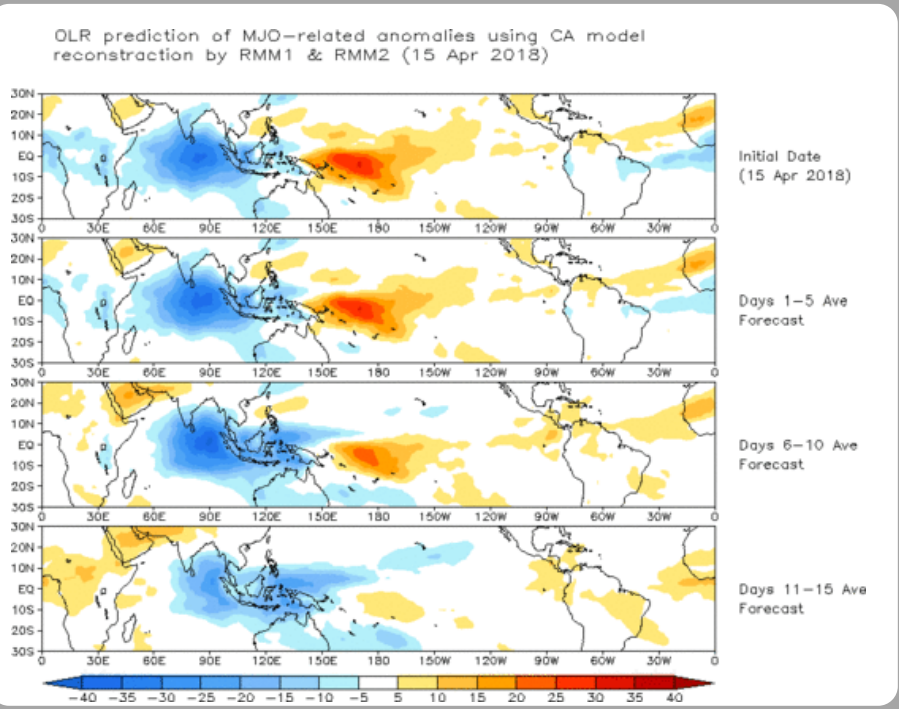


OLR anomalies associated with the MJO (based on the GEFS) indicate enhanced convection weakening as it shifts east from the Indian Ocean to the Maritime Continent and West Pacific.

Constructed Analog (CA) MJO Forecast

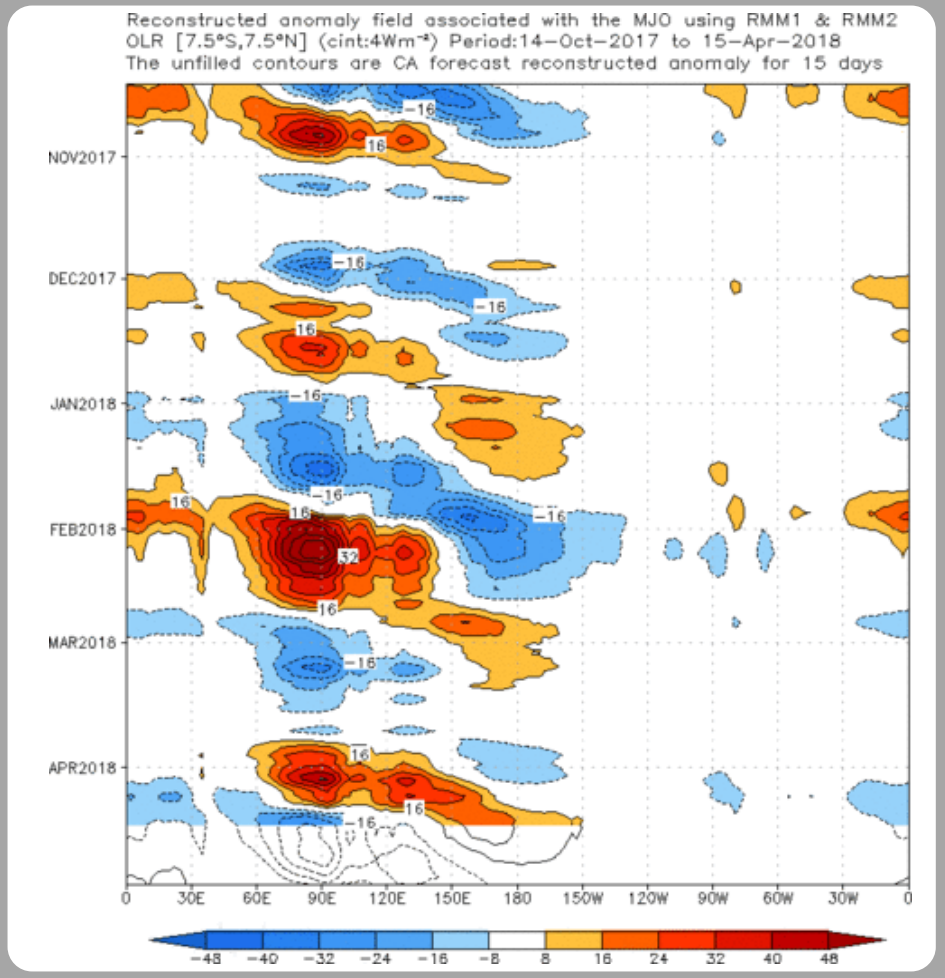
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



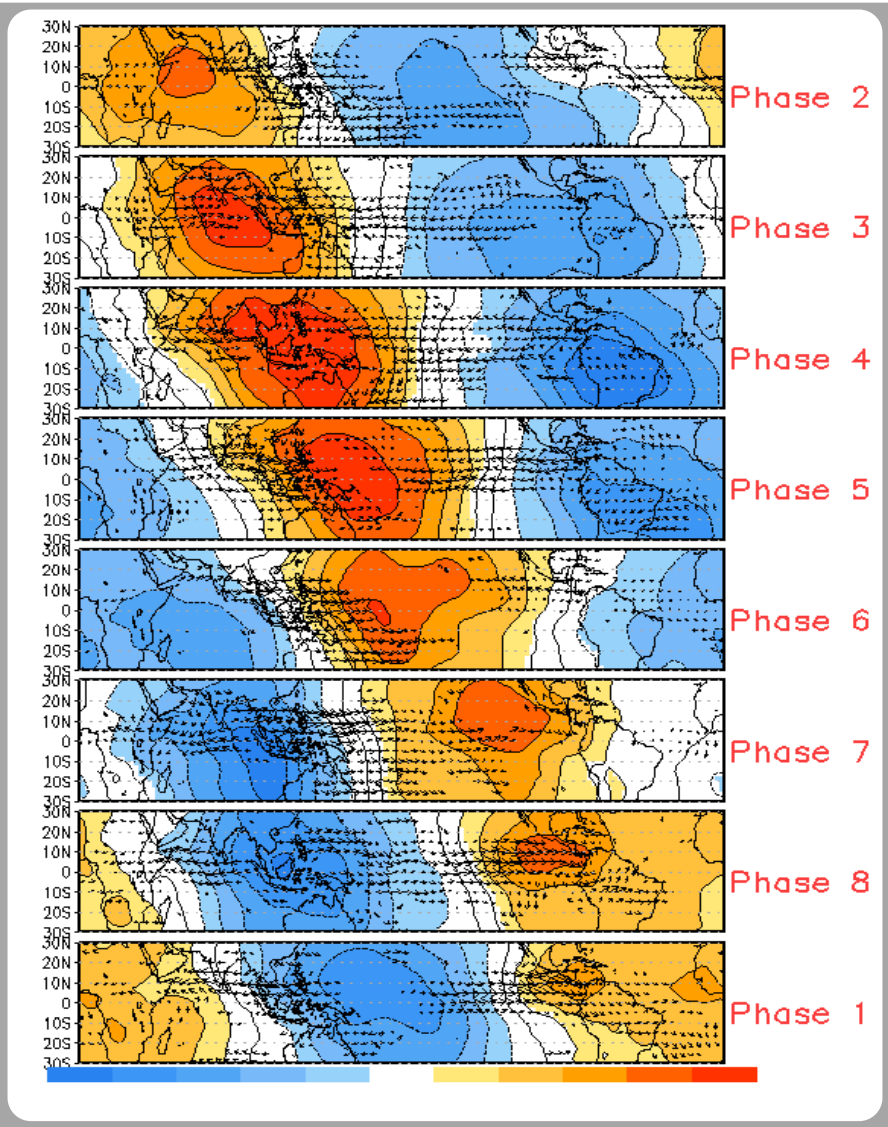
The constructed analog predicts an amplifying MJO signal during the next two weeks, which slowly propagates across the Indian Ocean.

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

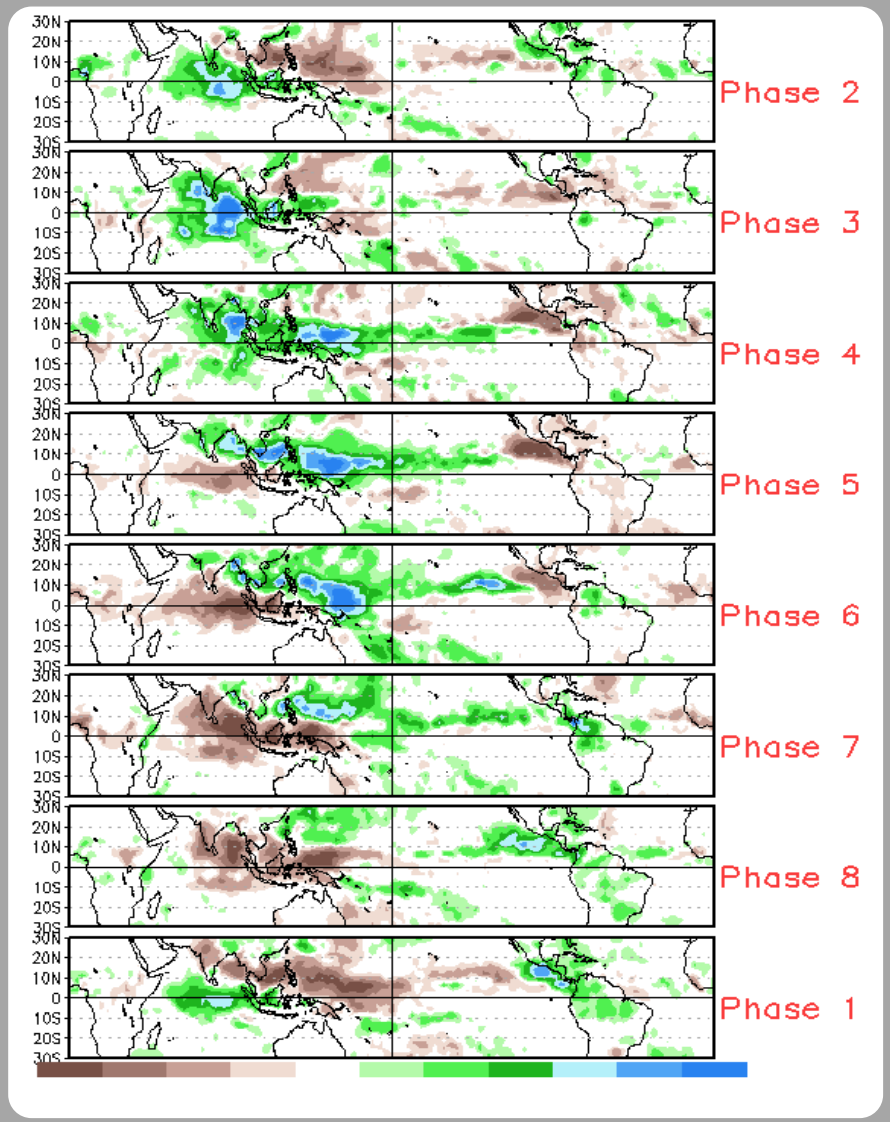


MJO Composites - Global Tropics

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



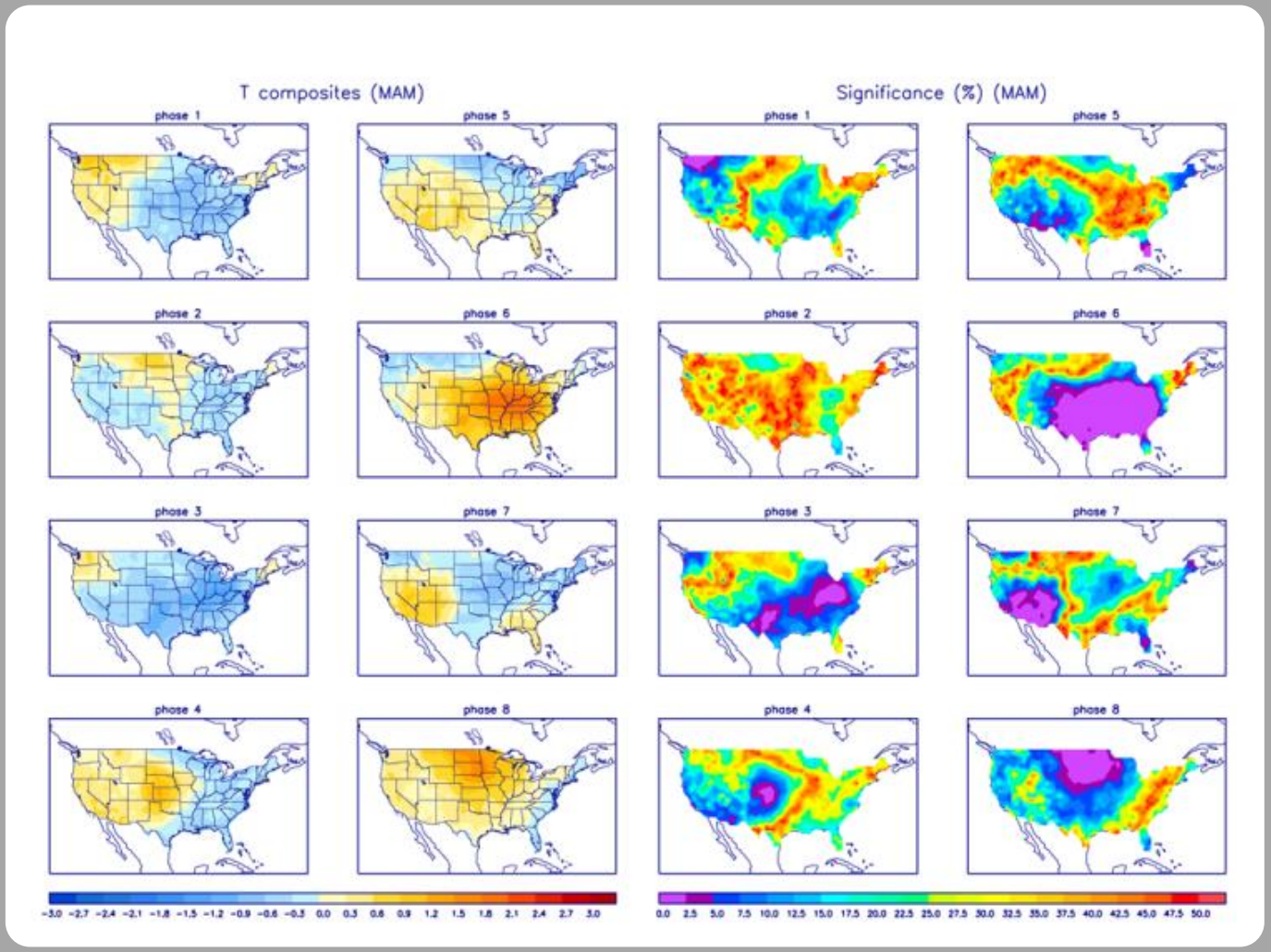
Precipitation Anomalies (Nov - Mar)



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.



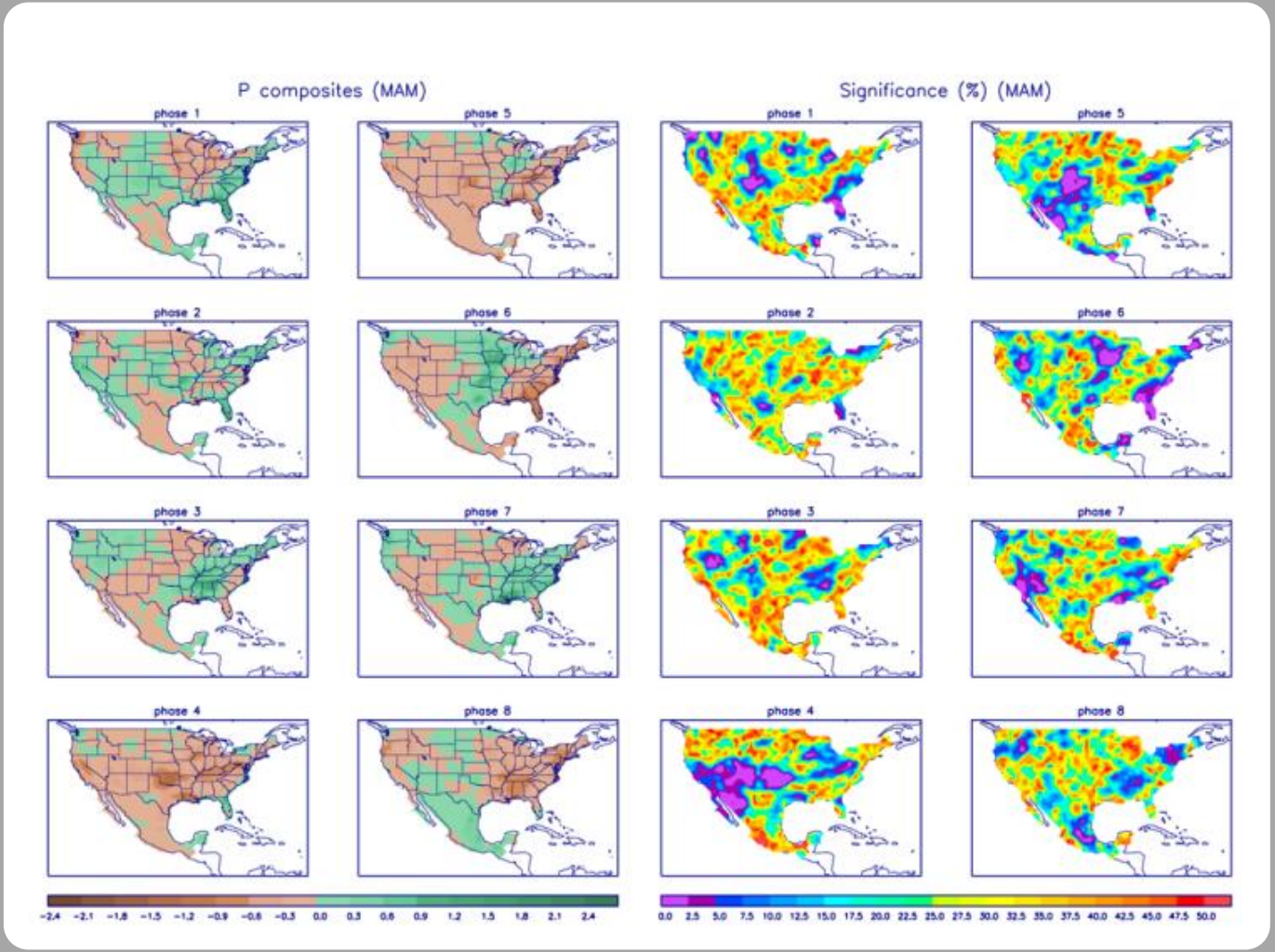
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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