

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



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23 April 2018

Outline

Overview

Recent Evolution and Current Conditions

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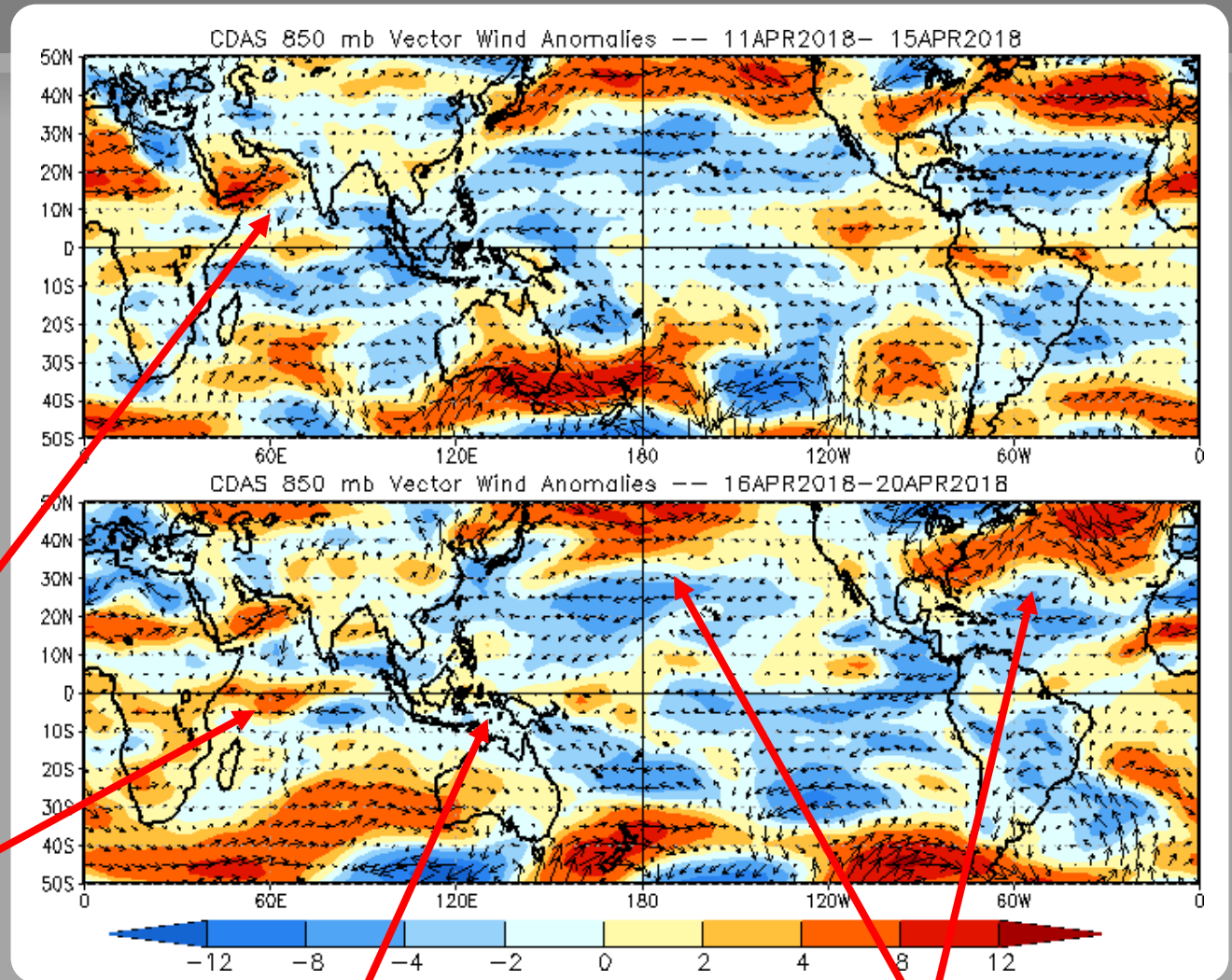
Overview

- The MJO weakened as it crossed the Indian Ocean over the past week. Other modes of tropical convective variability have interfered with canonical eastward propagation. MJO related convection is currently ongoing over the central Indian Ocean.
- Dynamical model forecasts depict a generally weak MJO signal over the next one to two weeks. The empirical constructed analog model retains eastward propagation of a coherent signal across the Maritime Continent.
- MJO-related tropical impacts include likely tropical cyclogenesis over the South Indian Ocean during Week-1, and enhanced convection over parts of the West Pacific during Week-2.
- Recent MJO evolution slightly favors a transition toward a warmer climate regime over eastern North America during Week-2.

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



A small region of anomalous westerlies increased in magnitude over the western Indian Ocean.

Generally low-amplitude anomalies were observed recently over the Maritime Continent.

Persistent anticyclones remained in place near 30N over both the Atlantic and Pacific.

850-hPa Zonal Wind Anomalies (m s⁻¹)

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

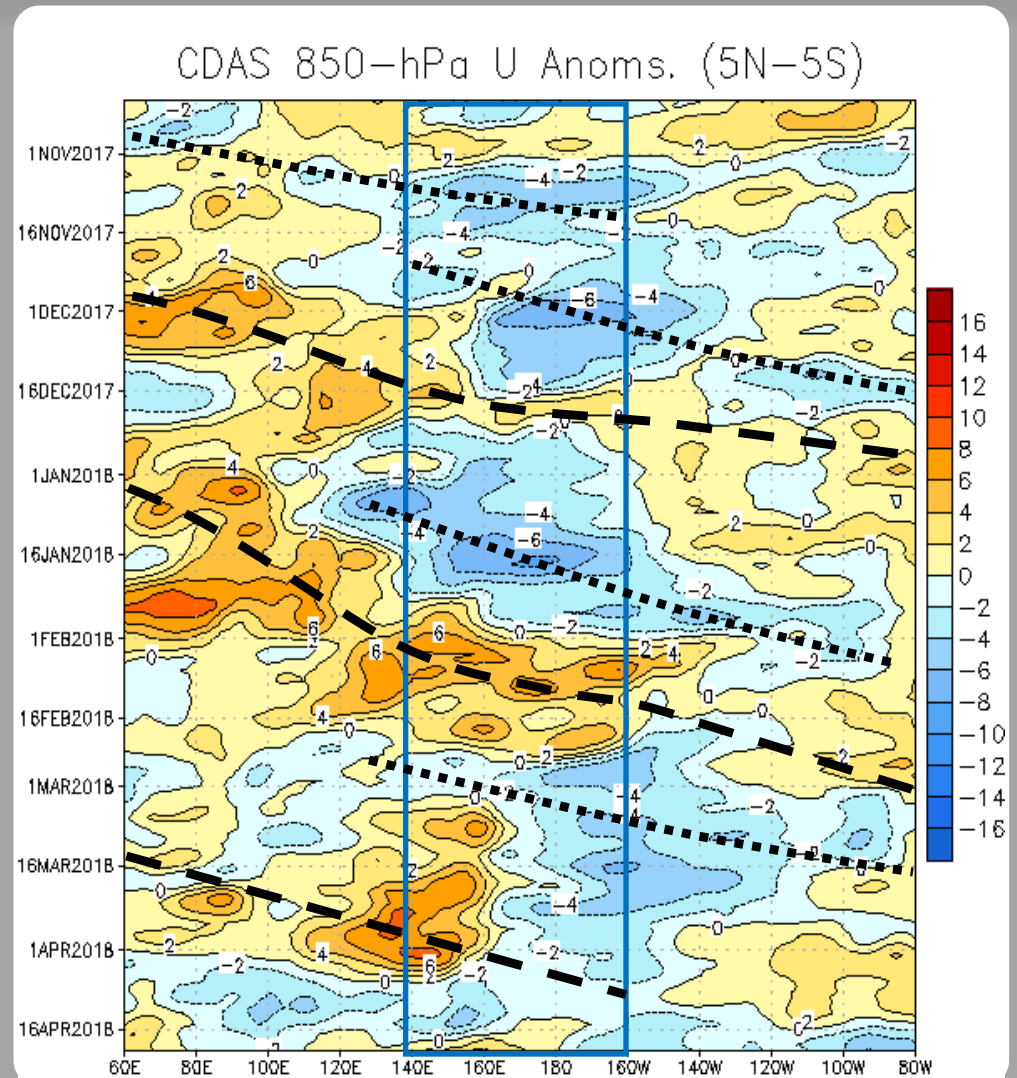
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During late 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. This signal began to break down during April.

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



OLR Anomalies - Past 30 days

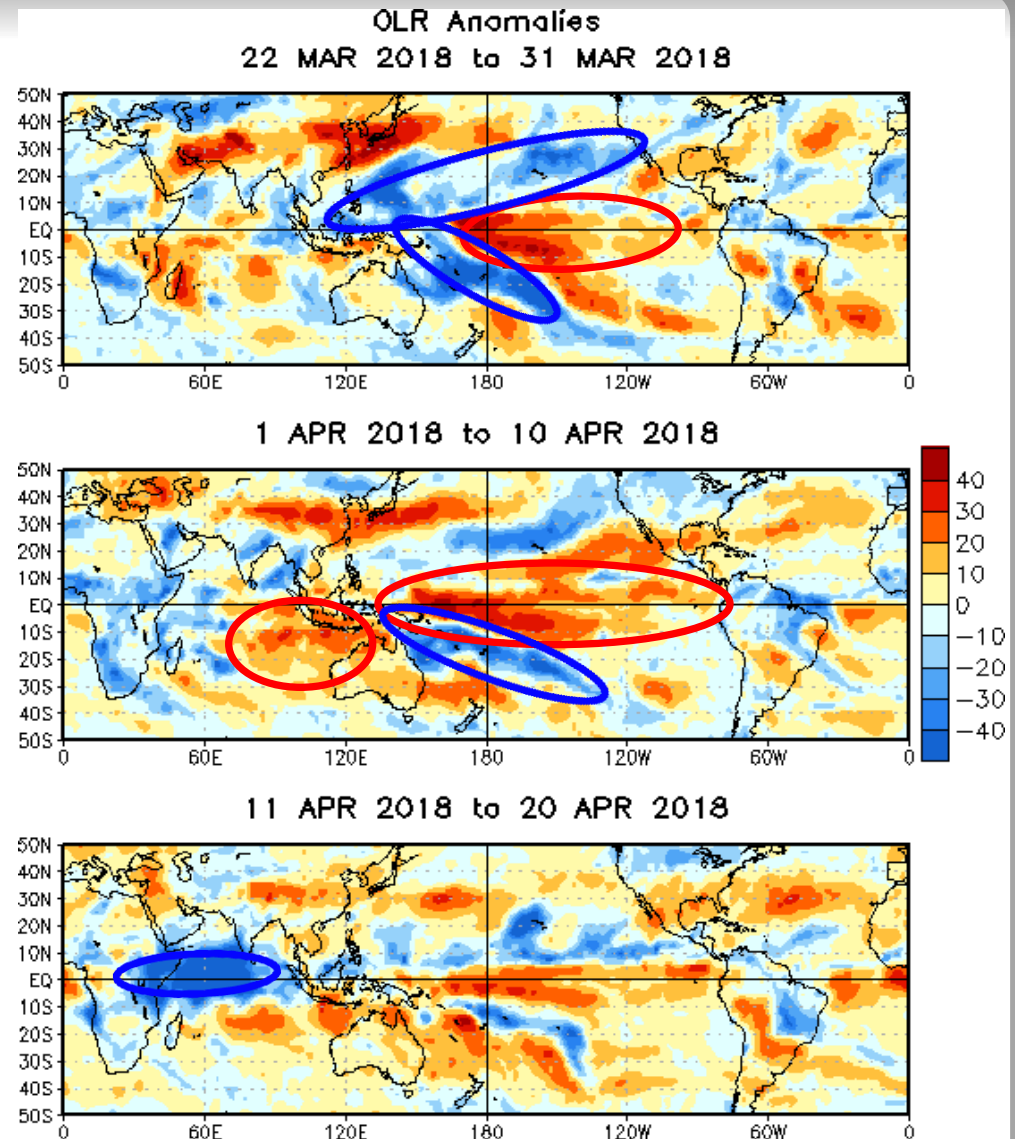
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late March, enhanced convection developed over the western and southern Pacific associated with the emergence of a robust MJO signal. The pattern was also influenced by La Niña and midlatitude wave breaking.

By early April the active MJO phase shifted to the Western Hemisphere, where its convective footprint is less readily observed. There was some MJO-related subsidence over the eastern Indian Ocean, and the pattern over the tropical Pacific was dominated by the low-frequency state and lingering convection over the South Pacific.

Most recently, enhanced convection developed over the western Indian Ocean, consistent with observed MJO evolution. Smaller scale convective anomalies are present throughout the rest of the Tropics.



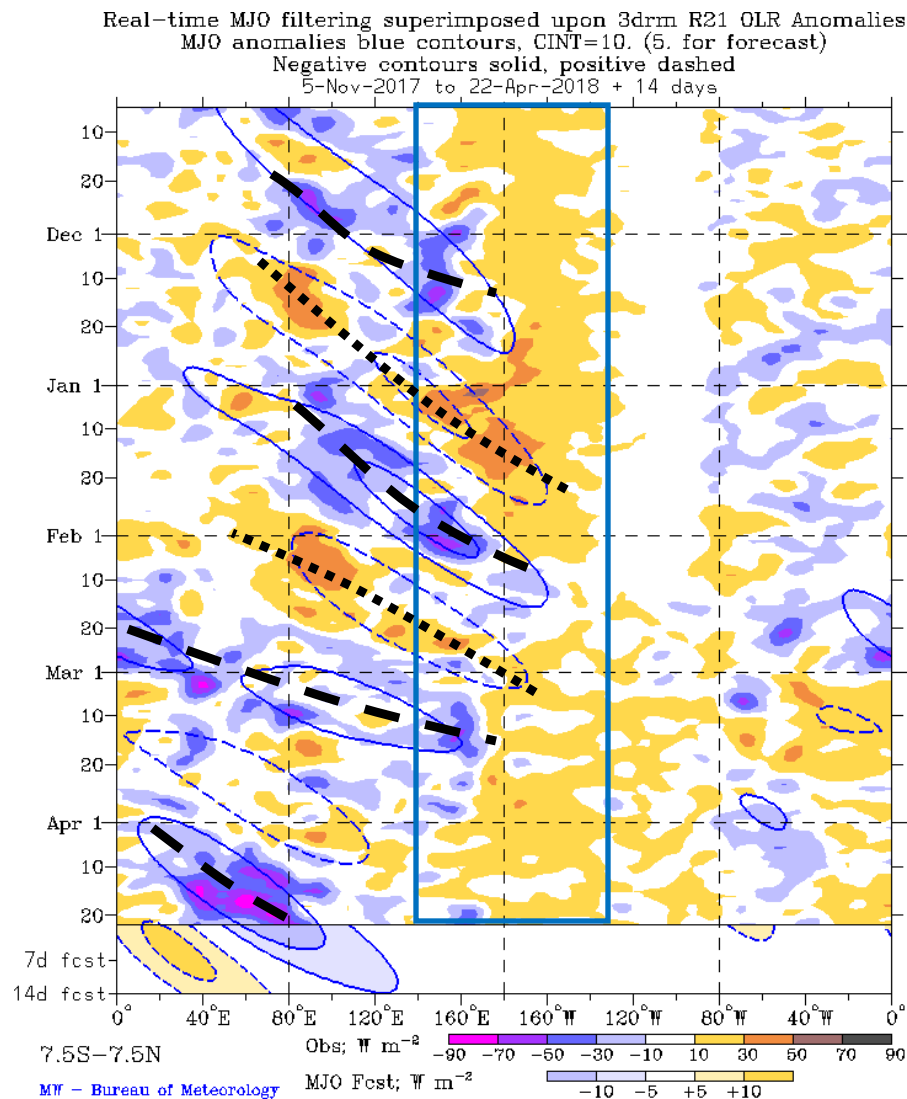
Outgoing Longwave Radiation (OLR) Anomalies (7.5°S - 7.5°N)

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 to mid-April. This is the strongest MJO-related convective signal over the Indian Ocean during the past six months.



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

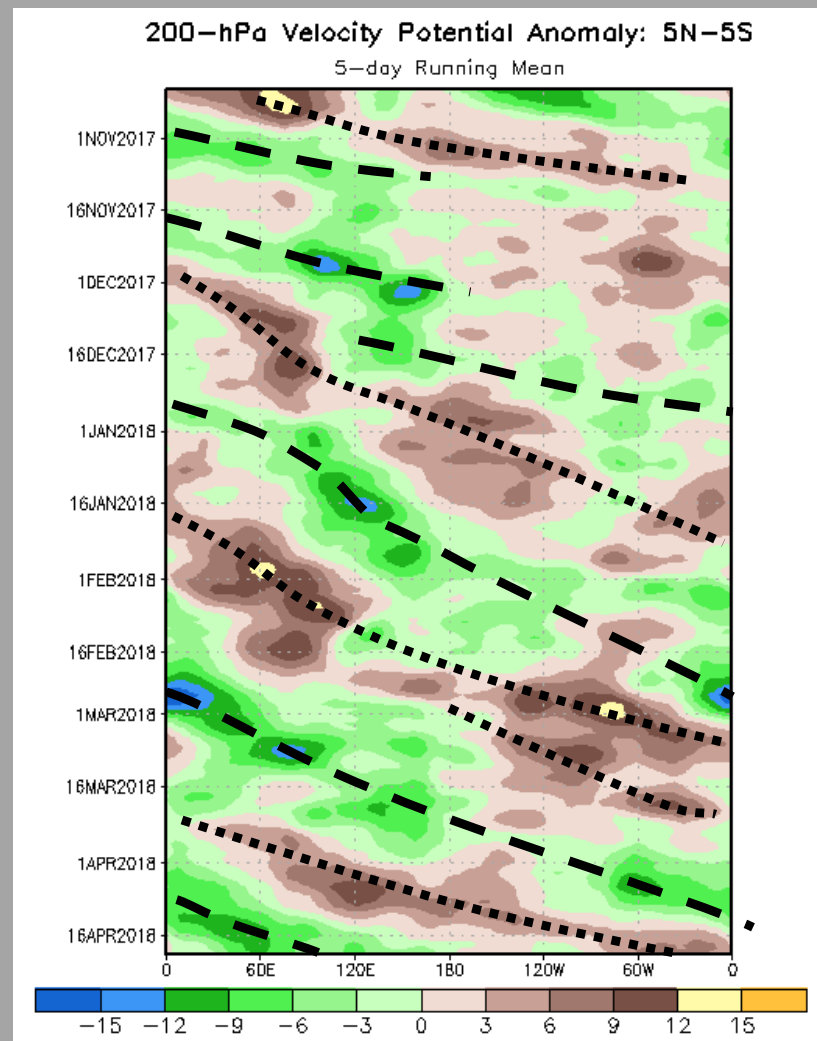
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

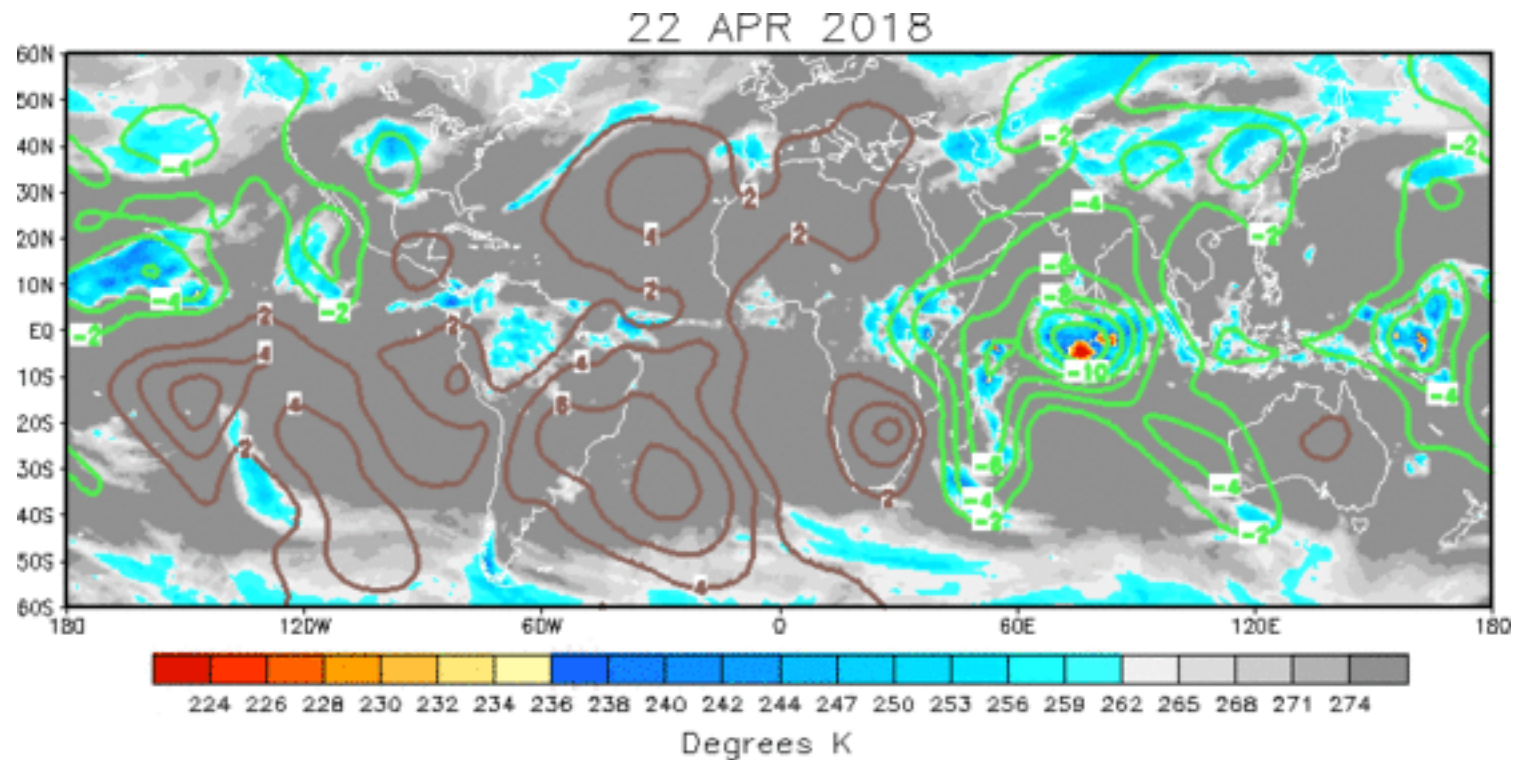
The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric Kelvin wave east of the Date Line during late February and early March.

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



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



A low-amplitude Wave-1 pattern is present with suppressed (enhanced) convection over the eastern Pacific and Atlantic (Indian Ocean). A secondary area of enhanced convection is observed over the West Pacific.

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)

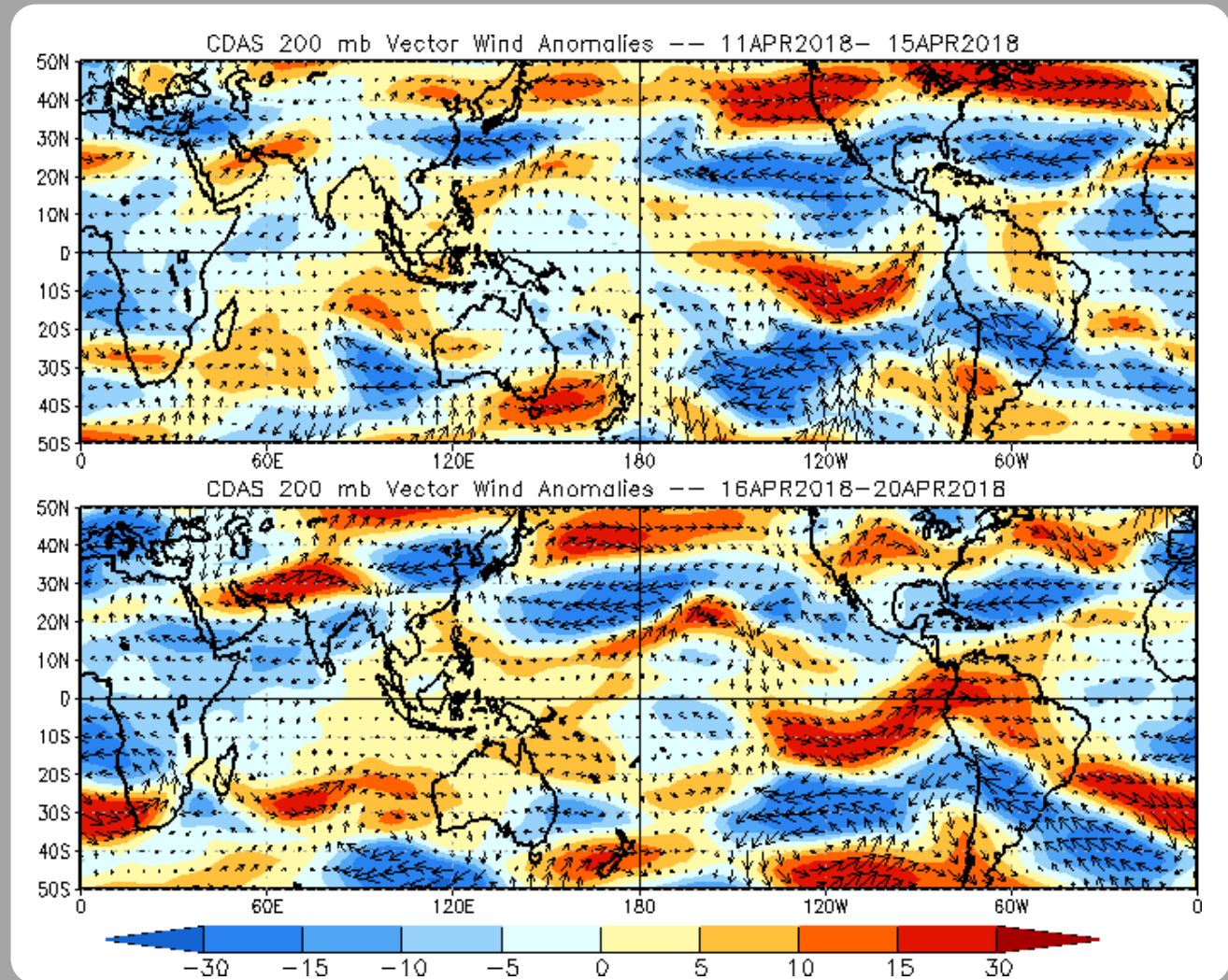
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Zonally oriented anomalies dominated the northern mid-latitudes in the early period, with wave breaking evident over the eastern Pacific from both hemispheres.

The structure of zonal wind anomalies over the Eastern Hemisphere is broadly consistent with the enhanced MJO phase over the eastern Indian Ocean, but at very low amplitude.



200-hPa Zonal Wind Anomalies (m s⁻¹)

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

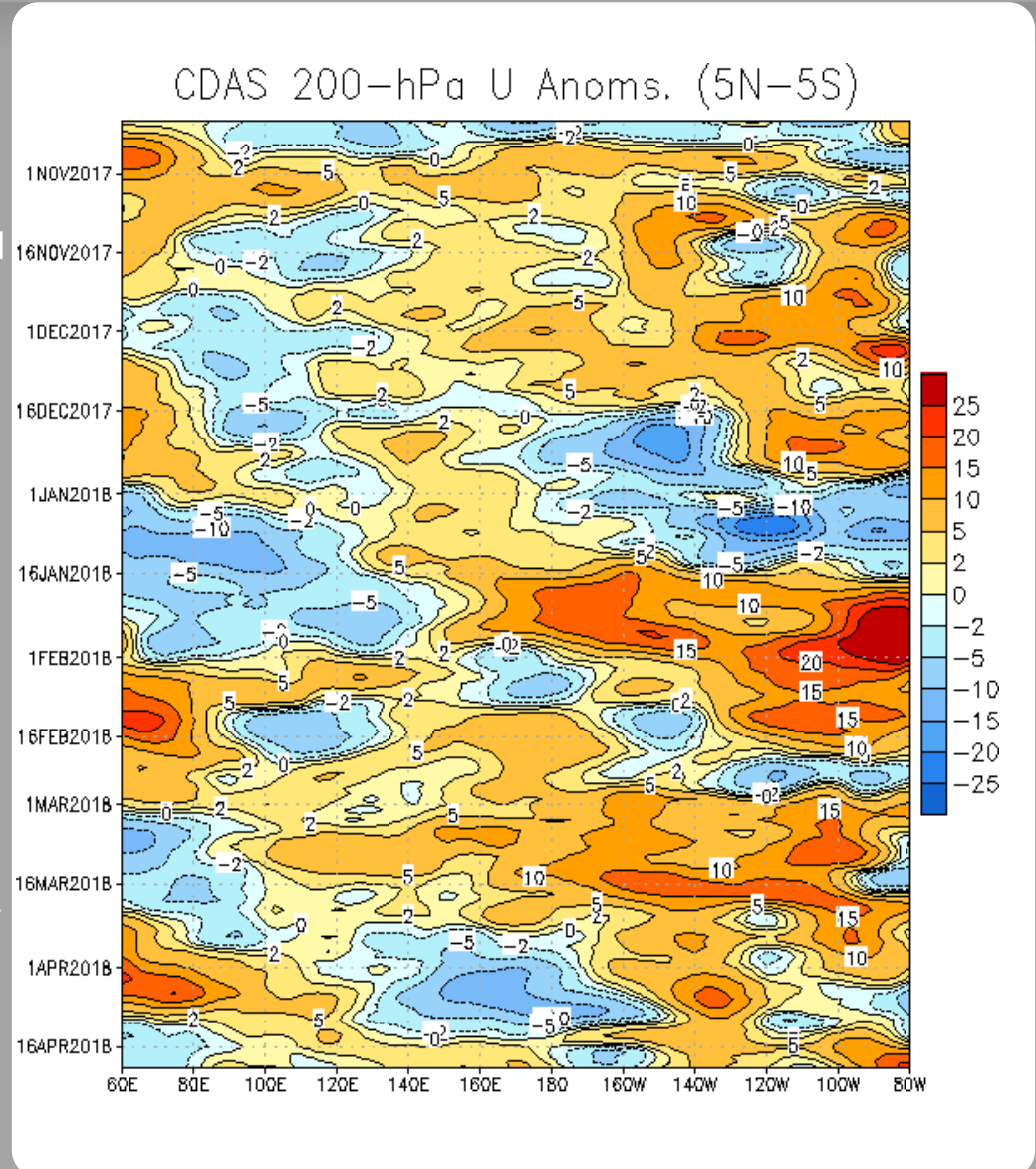
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

A period of easterly anomalies between 130E and 160W interrupted the relatively stationary anomalous westerlies that persisted across the Pacific since the middle of February. Low-amplitude westerly anomalies have reemerged recently over the western Pacific.



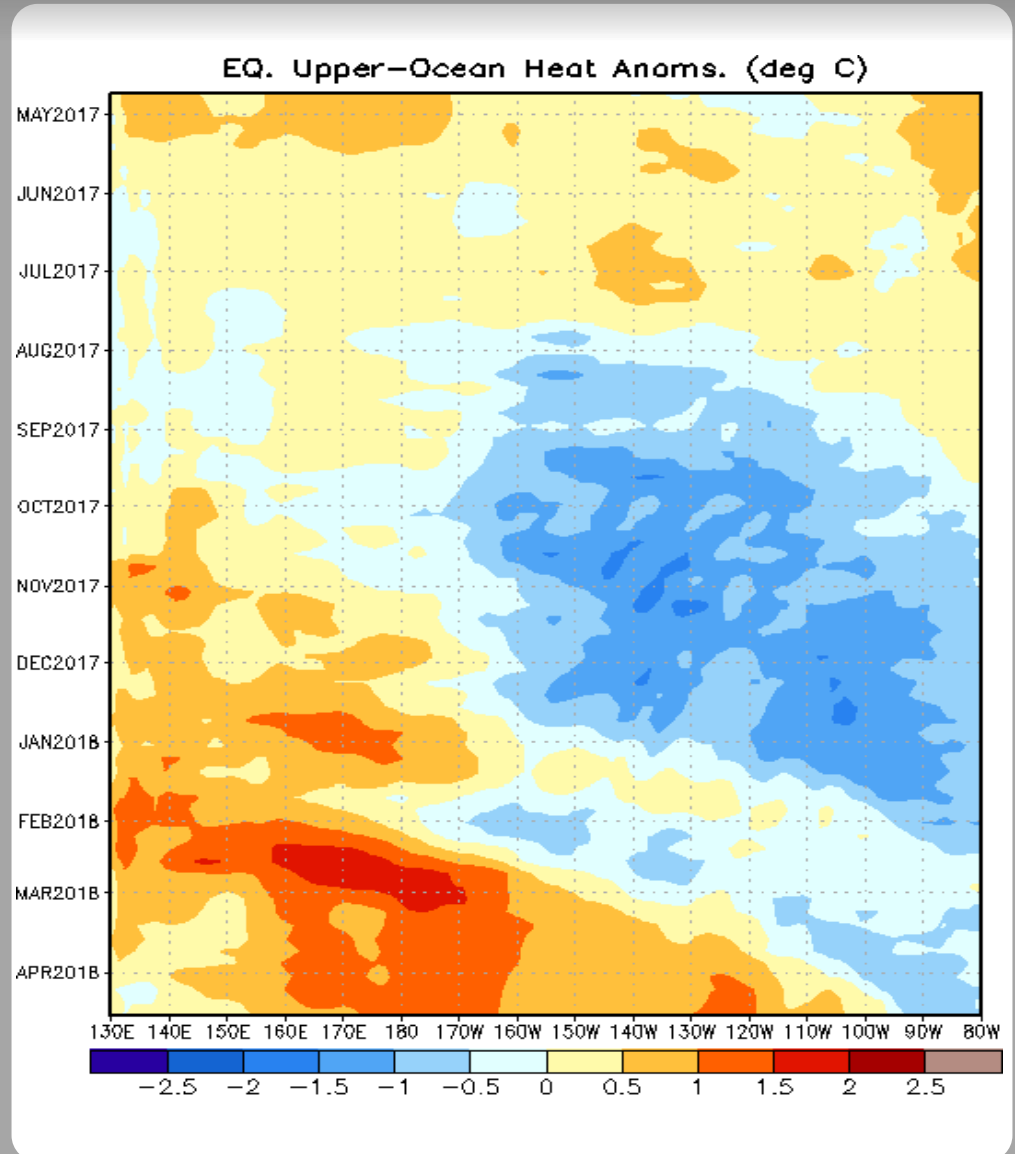
Weekly Heat Content Evolution in the Equatorial Pacific

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 during February). Positive anomalies are now observed over nearly the entire basin.



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

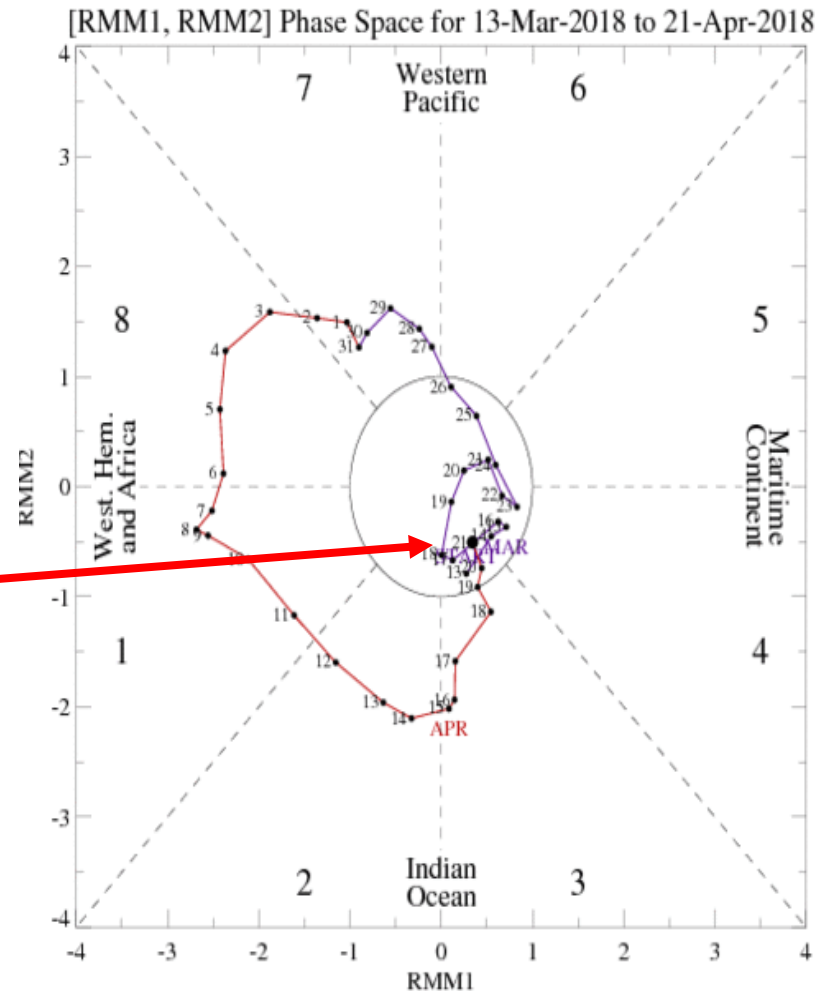
The triangular areas indicate the location of the enhanced phase of the MJO

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

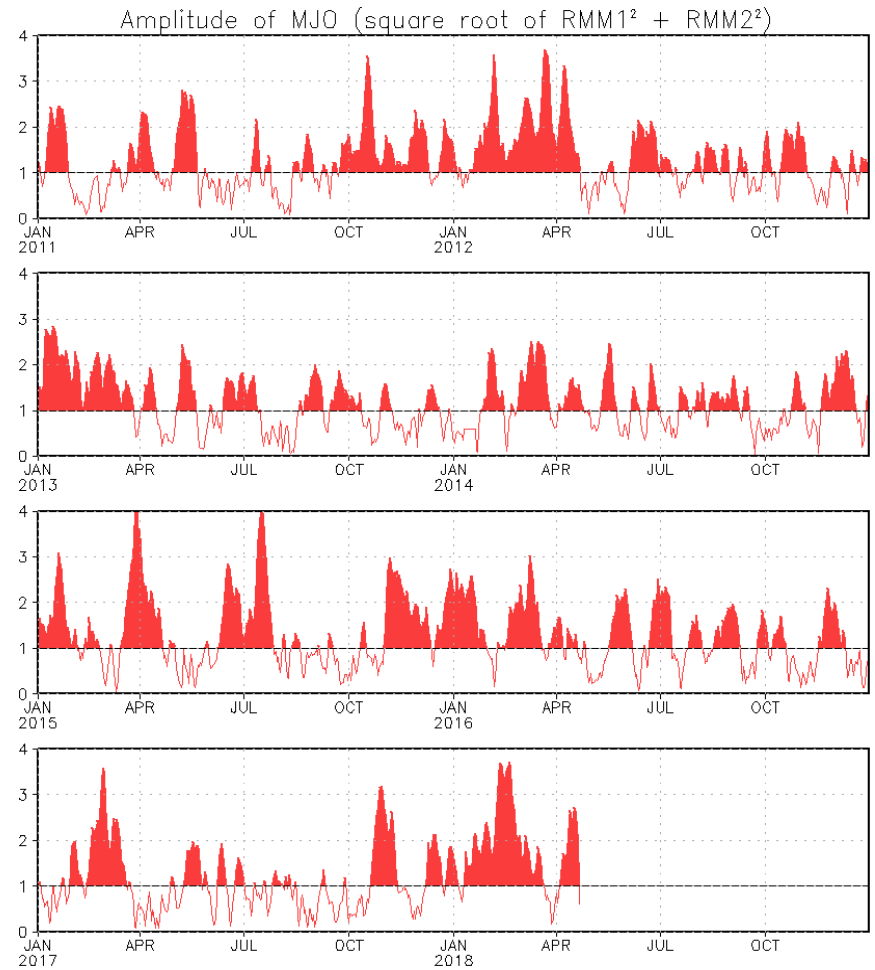
The MJO amplitude has decreased rapidly over the past week, as observed by the RMM index.



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

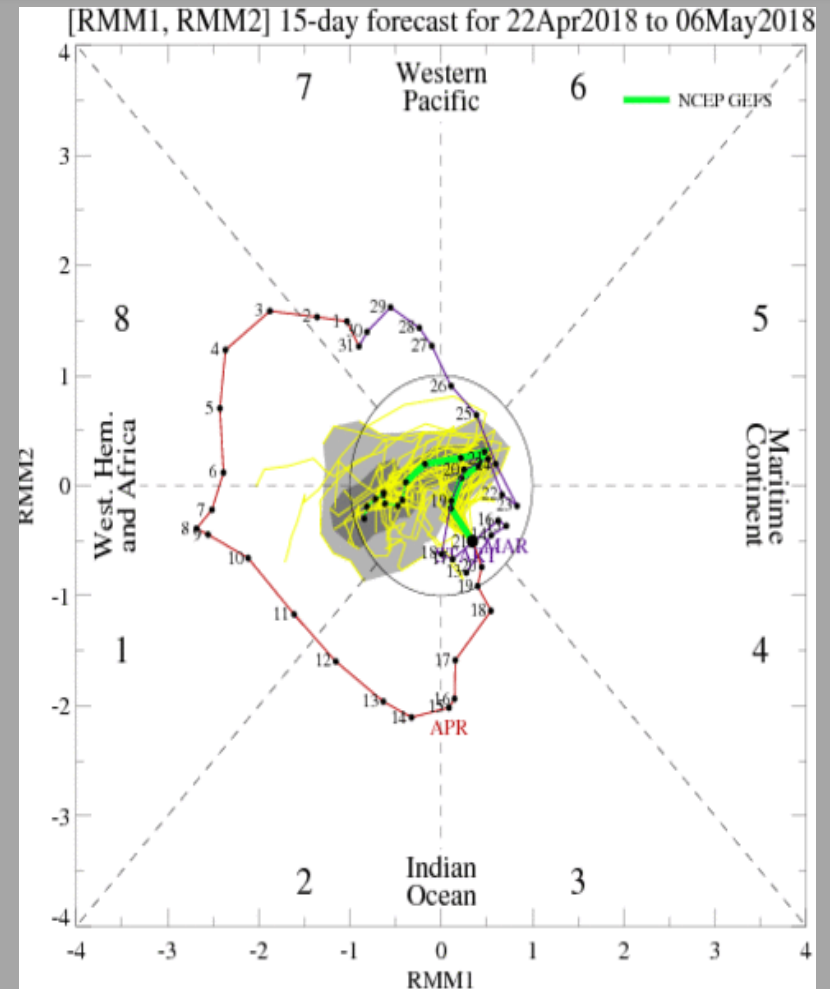
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

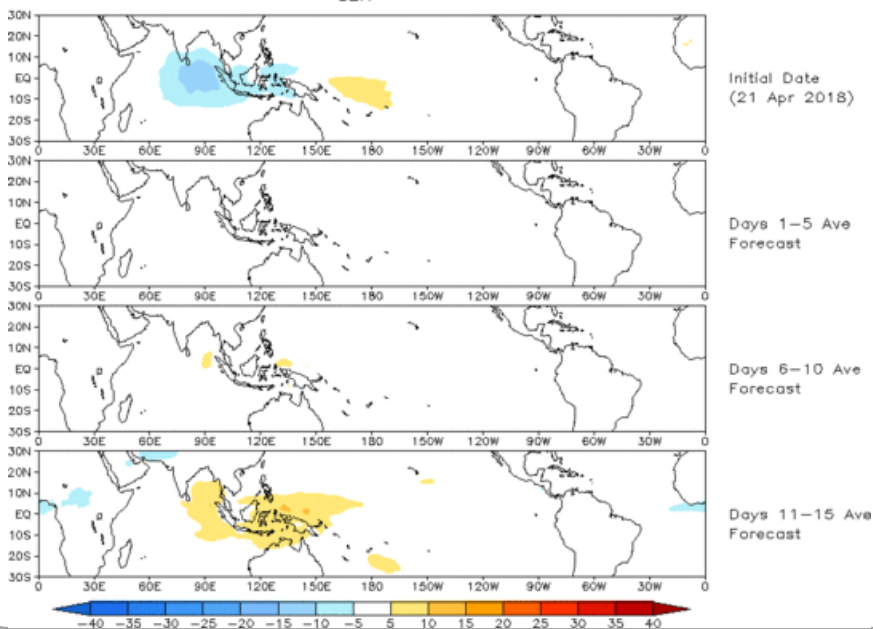
The GEFS predicts generally weak MJO activity during the next two weeks.



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: 21 Apr 2018
OLR

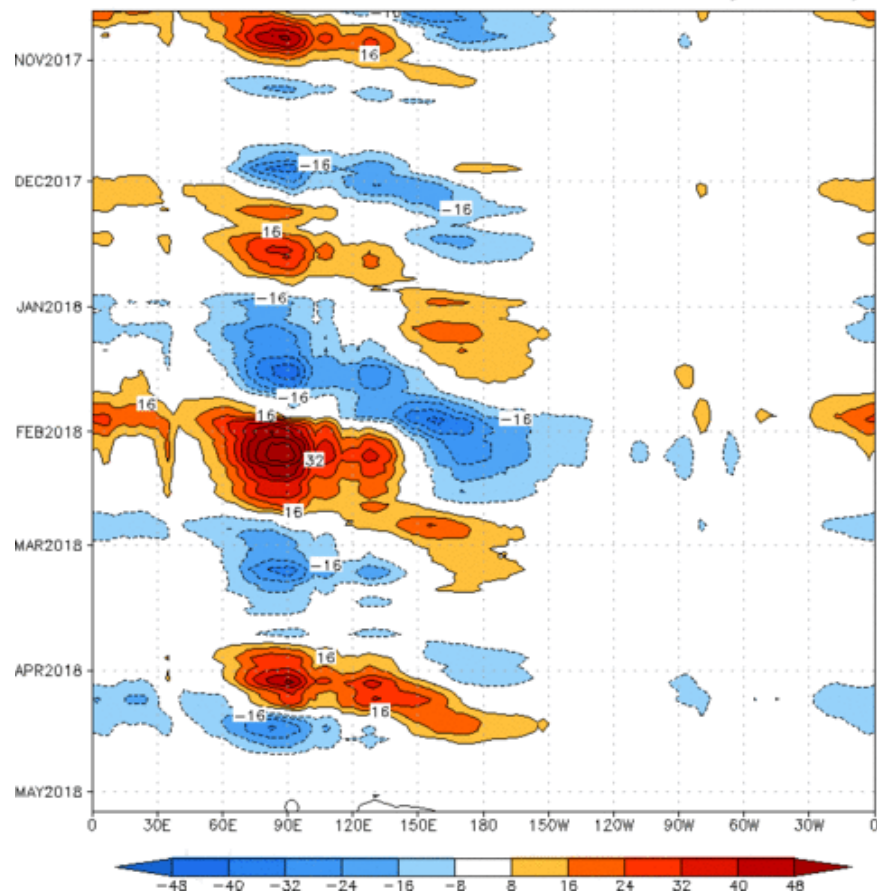


OLR anomalies associated with the MJO (based on the GEFS) indicate only weakly anomalous convection during the next two weeks.

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

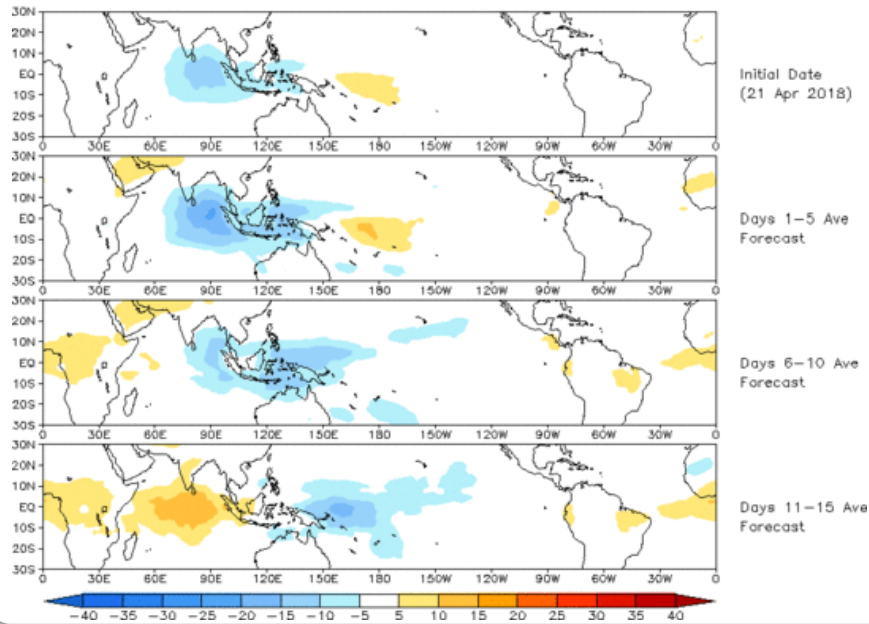
Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:20-Oct-2017 to 21-Apr-2018
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days



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 (21 Apr 2018)

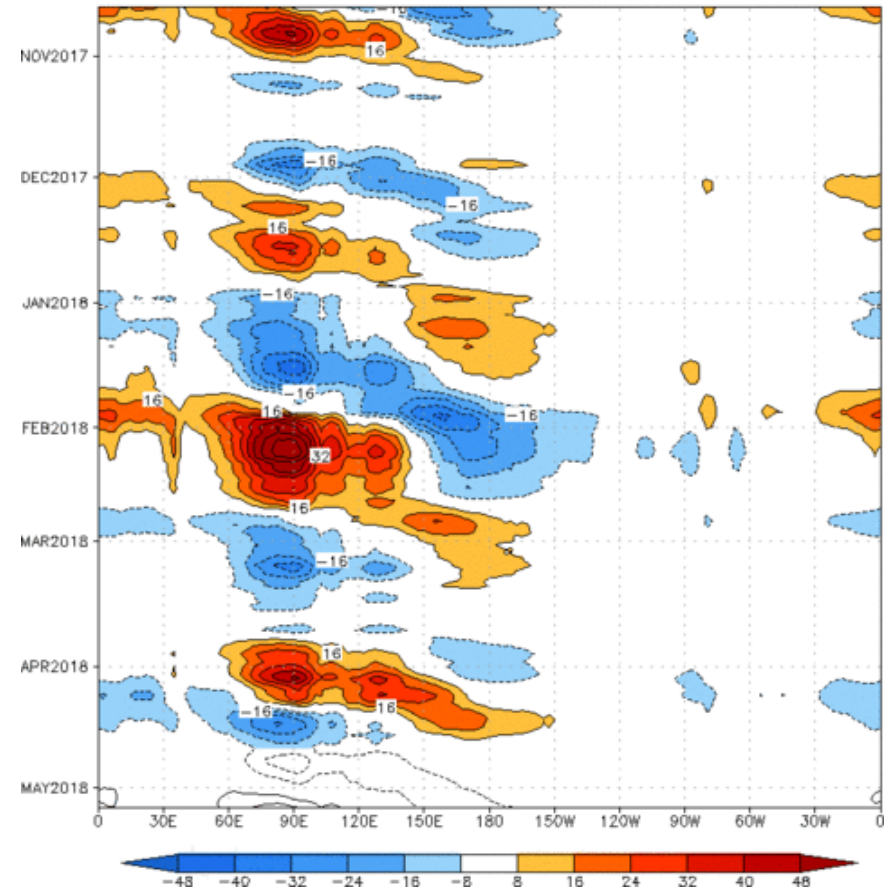


The constructed analog maintains a more robust MJO footprint, with a canonical propagation across the Maritime Continent during the next two weeks.

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.)

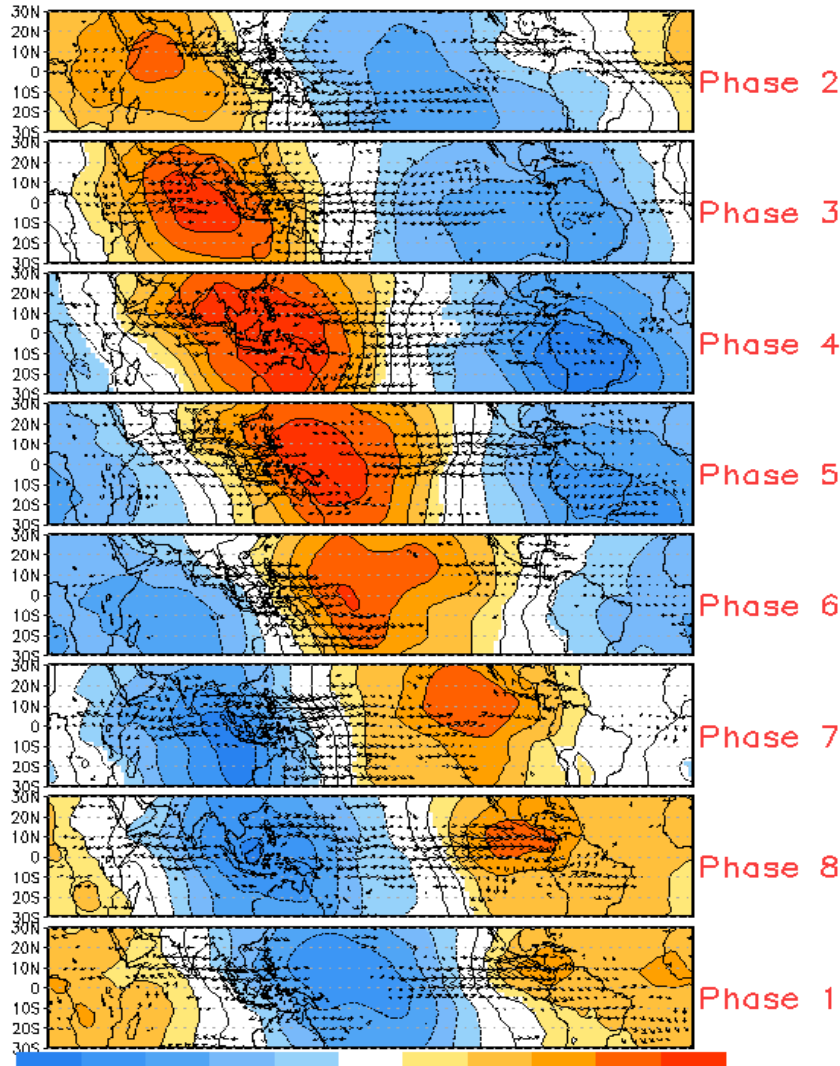
Time-longitude section of (7.5° S- 7.5° N) OLR anomalies - last 180 days and for the next 15 days

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5° S, 7.5° N] (cont:4 Wm^{-2}) Period:20-Oct-2017 to 21-Apr-2018 The unfilled contours are CA forecast reconstructed anomaly for 15 days

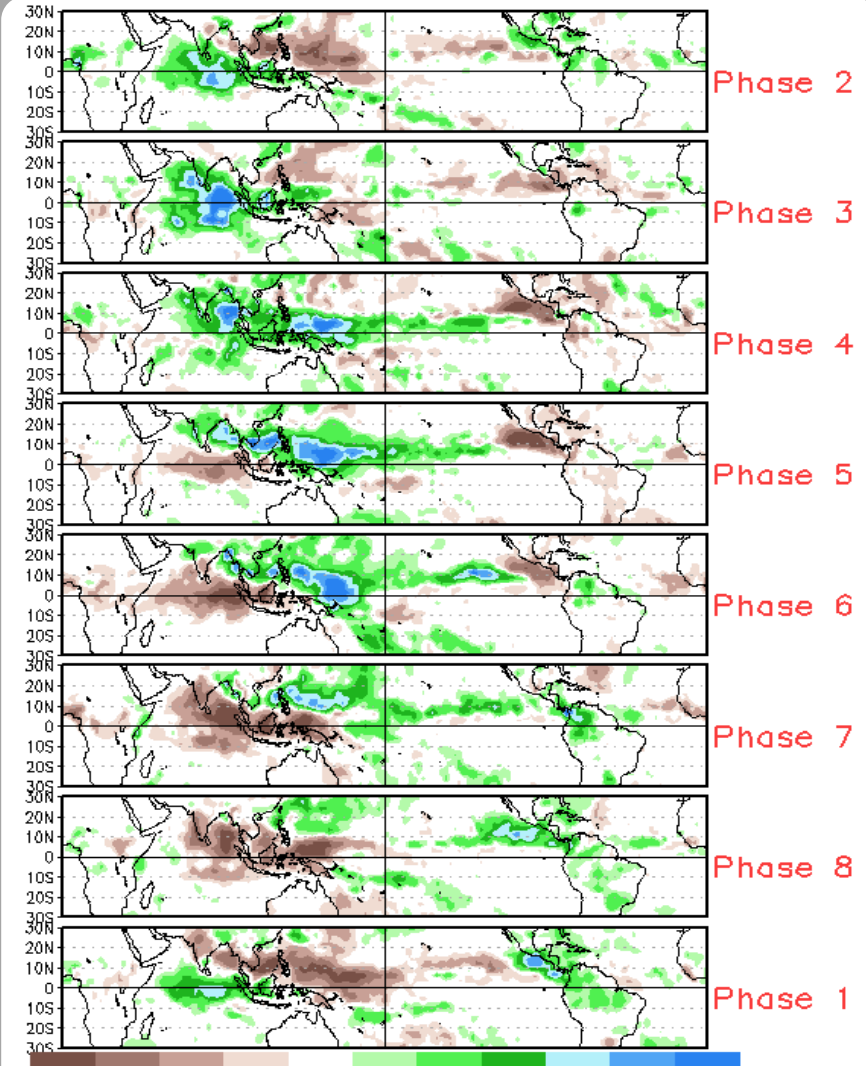


MJO Composites - Global Tropics

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



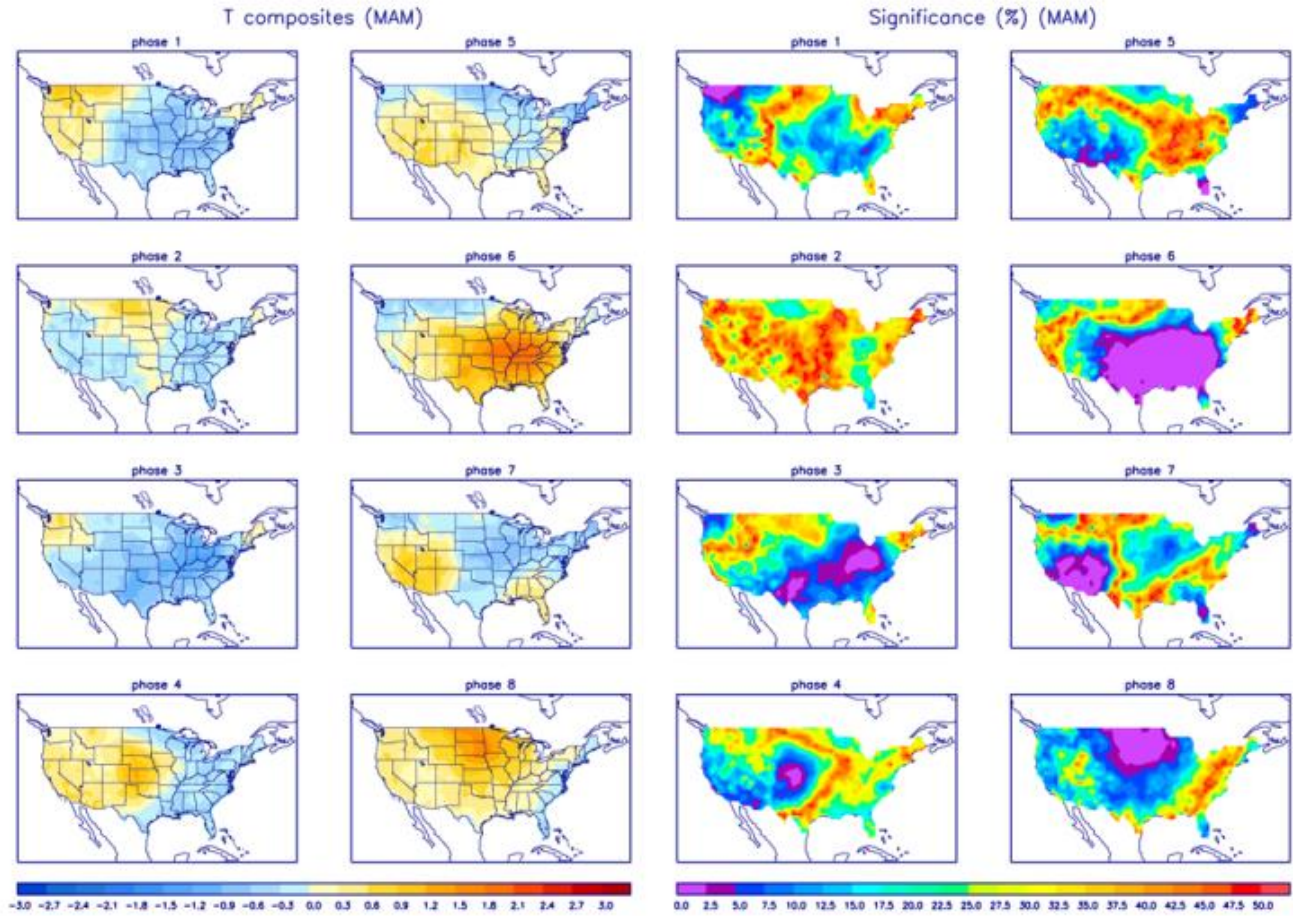
Precipitation Anomalies (Nov - Mar)



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.



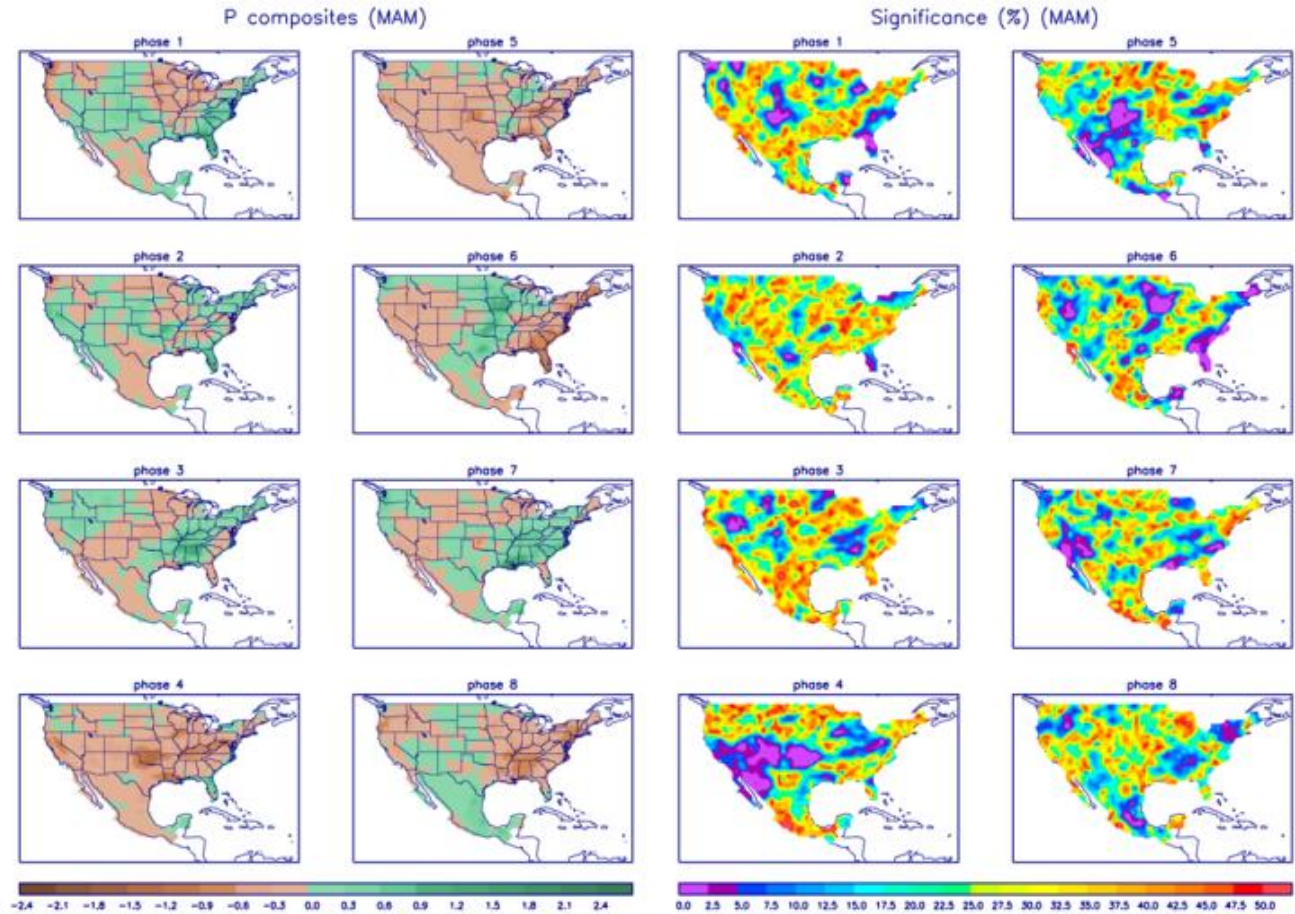
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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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