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

Update prepared by:
Climate Prediction Center / NCEP
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Outline

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MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO emerged over the Western Hemisphere during the past ten days, following destructive interference with the background La Niña event over the Central Pacific.

- Dynamical model forecasts depict various degrees of eastward propagation of the MJO during the next two weeks, though nearly all significantly weaken the signal.

- The MJO is not anticipated to play a substantial role in the evolution of the global tropical convective pattern, as nearly all dynamical models predict rapid weakening of the signal. However, the MJO signal, in addition to other constructively-interfering modes of variability may help to spin up a tropical cyclone near the Horn of Africa during Week-1.

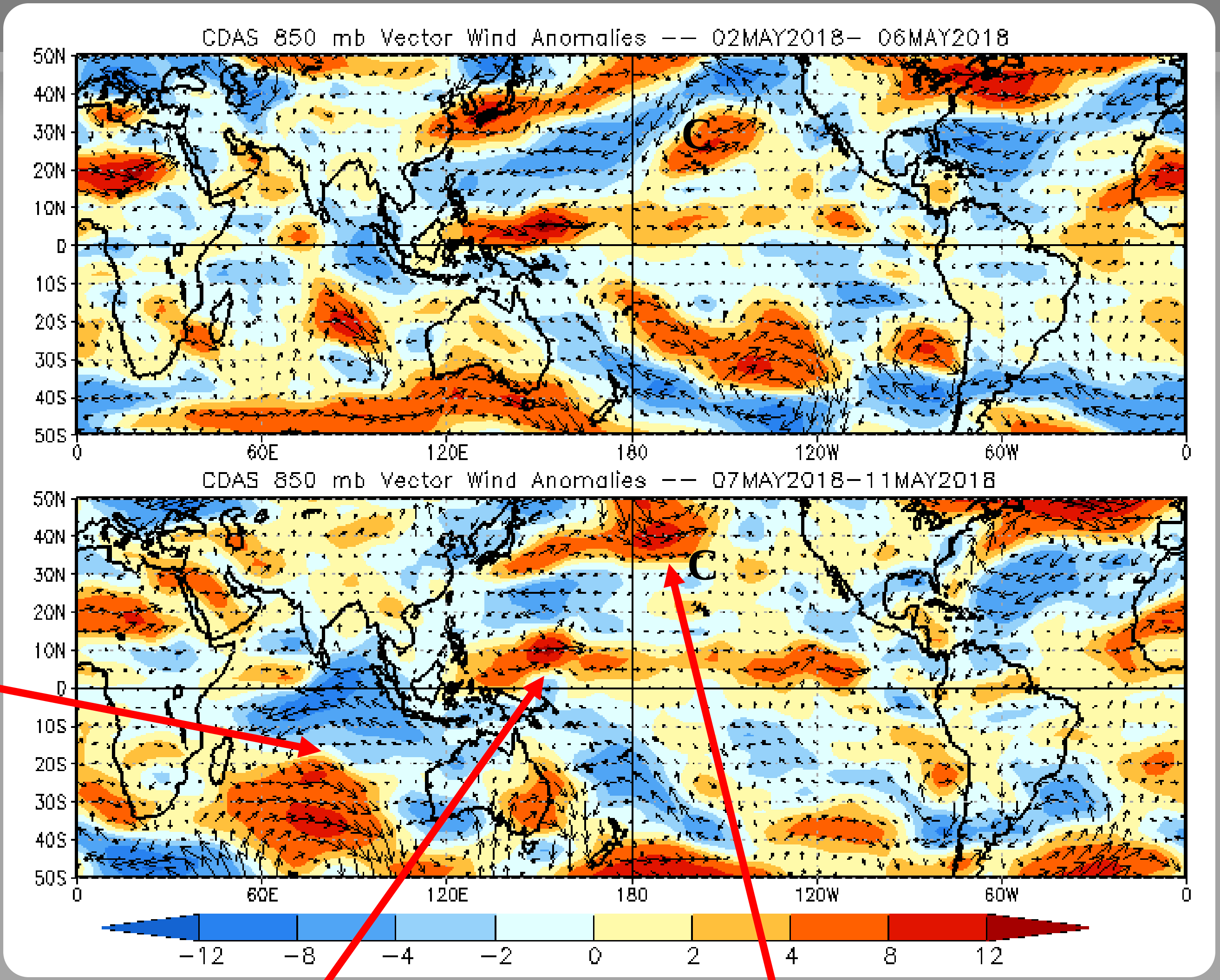
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

<u>Blue shades</u>: Easterly anomalies

<u>Red shades</u>: Westerly anomalies



A large-scale anticyclone developed over the South Indian Ocean and western Australia during the most recent pentad

Westerly wind anomalies continued to the north of the Maritime Continent through the Central Pacific

Anomalous cyclonic flow persisted to the north of Hawaii

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

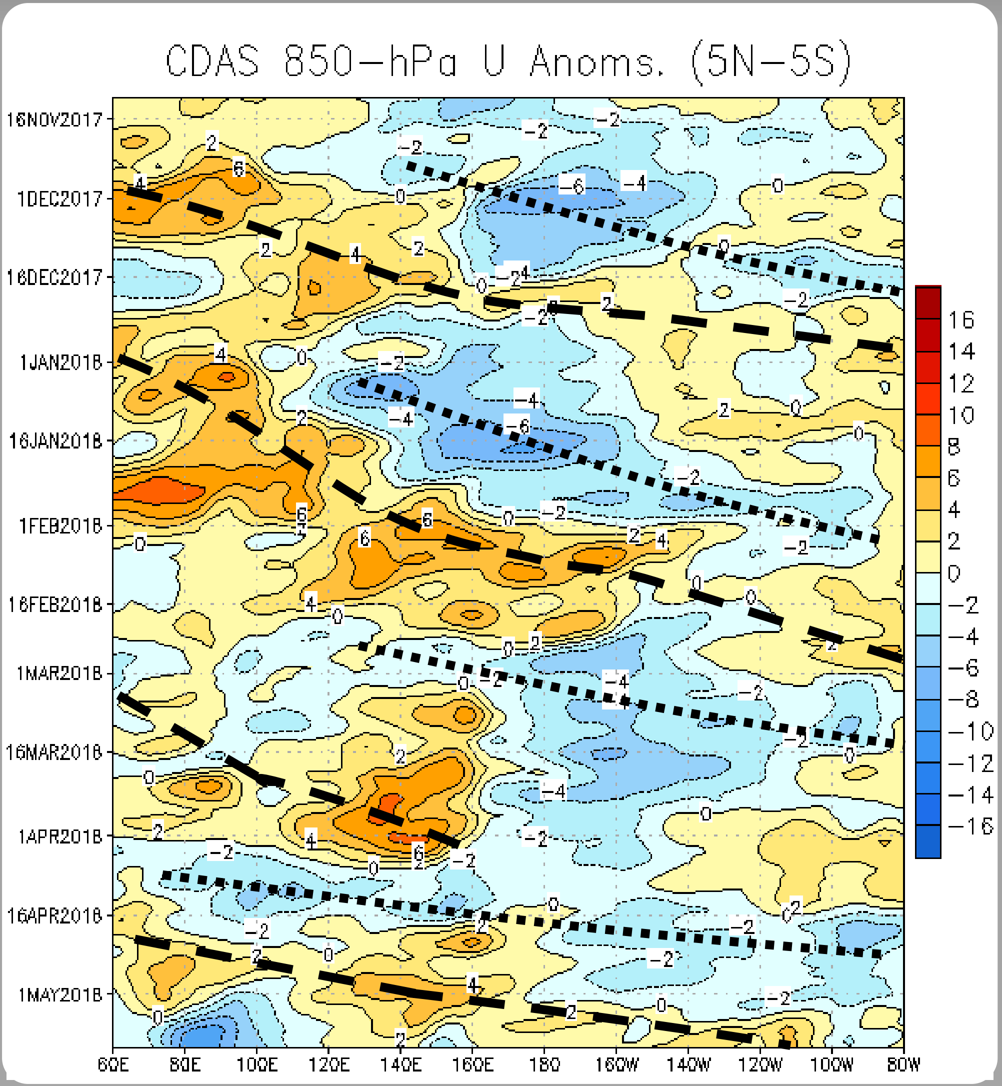
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

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.

The most recent eastward moving packet of anomalous westerlies is currently over the eastern Pacific, with time speeds on the relatively fast end of the MJO envelope.



OLR Anomalies – Past 30 days

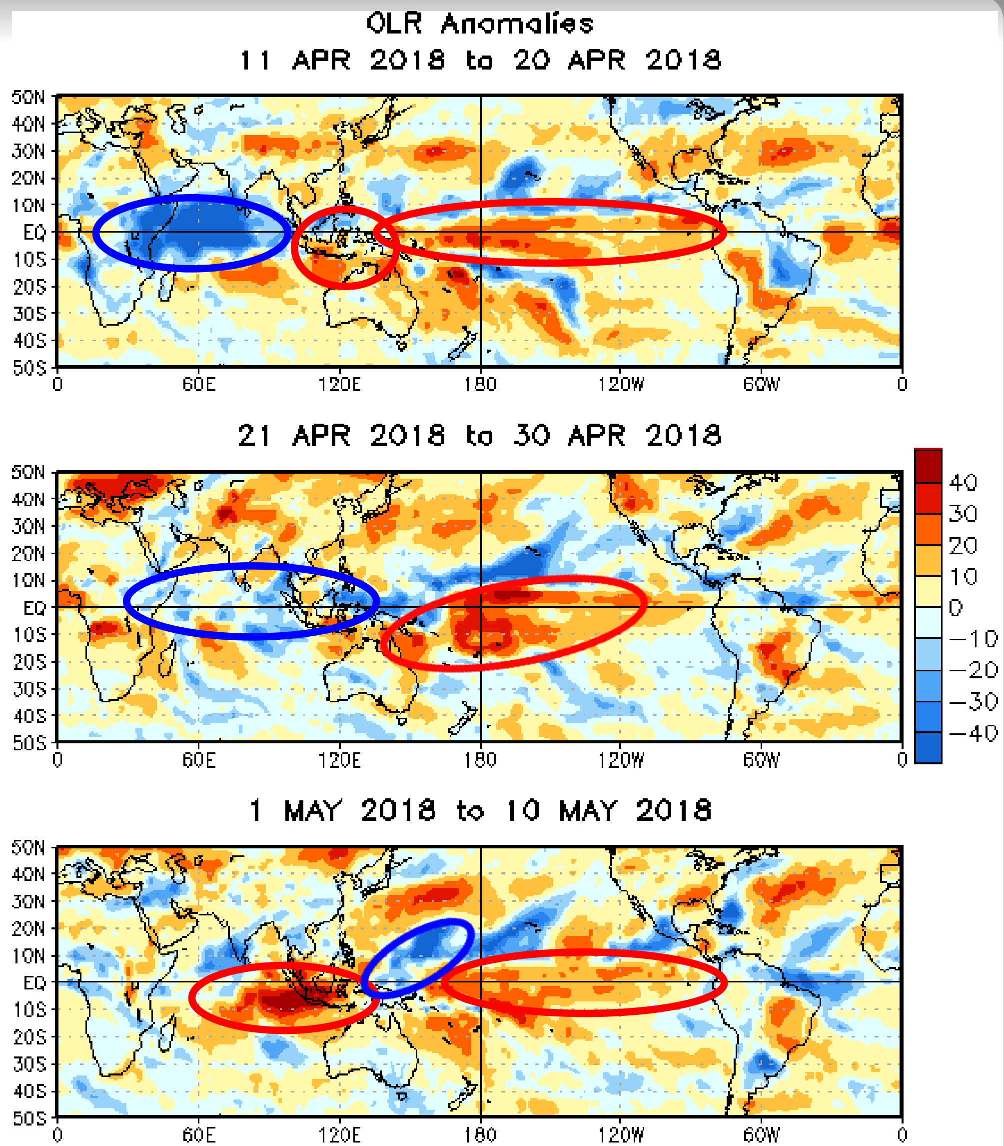
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-April, enhanced convection associated with the intraseasonal signal developed over the eastern and central Indian Ocean. Suppressed convection shifted to the Maritime Continent, and persisted over the Pacific tied to the weakening La Niña.

During late April, despite the weakening MJO signal, enhanced convection continued across the equatorial Indian Ocean while propagating eastward to the western Maritime Continent. Suppressed convection persisted across northern Australia and the central Pacific.

During late April and early May, enhanced convection shifted into the West Pacific, with suppressed convection backfilling across the Indian Ocean. Low frequency signals continued to suppress convection near the Date Line and across the East Pacific.



Outgoing Longwave Radiation (OLR) Anomalies (7.5ºS - 7.5ºN)

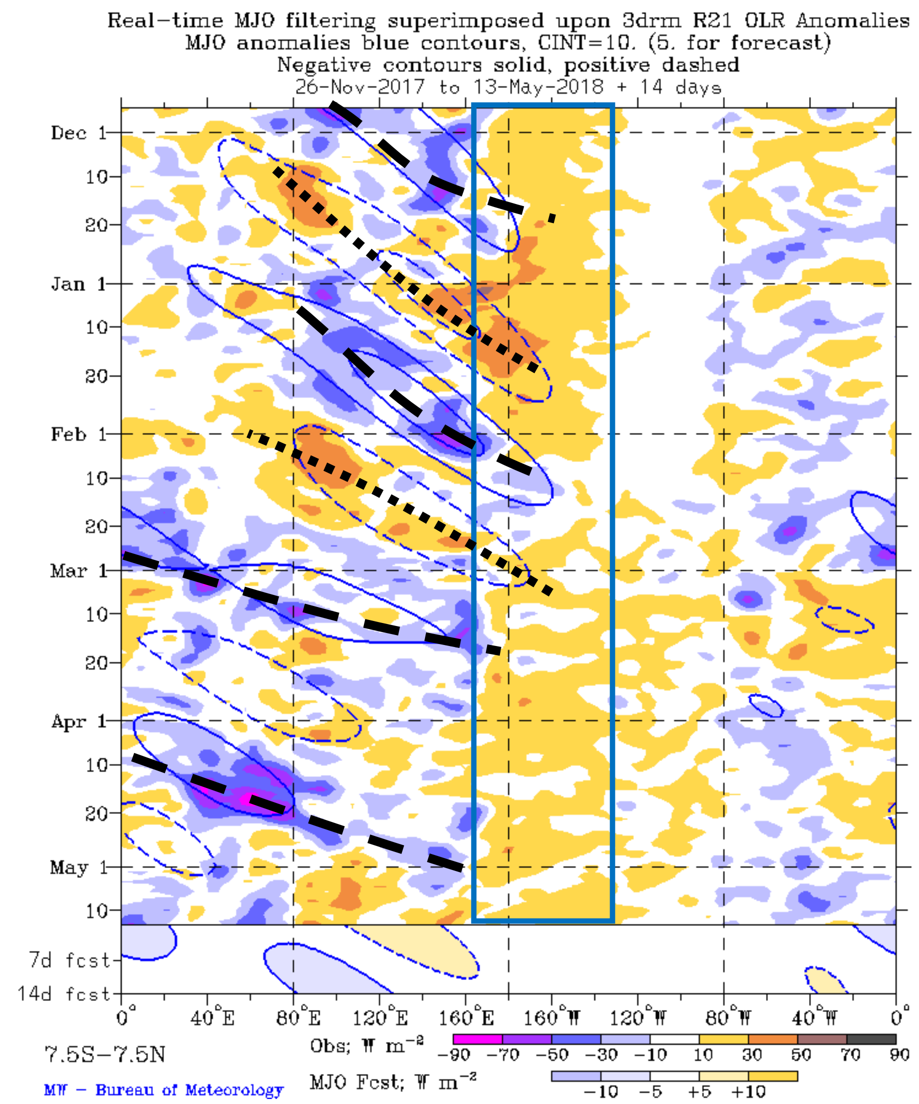
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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 (blue box).

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.

More recently the OLR signature of the MJO weakened as the signal crossed the Maritime Continent and eventually destructively interfered with the La Niña footprint.



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

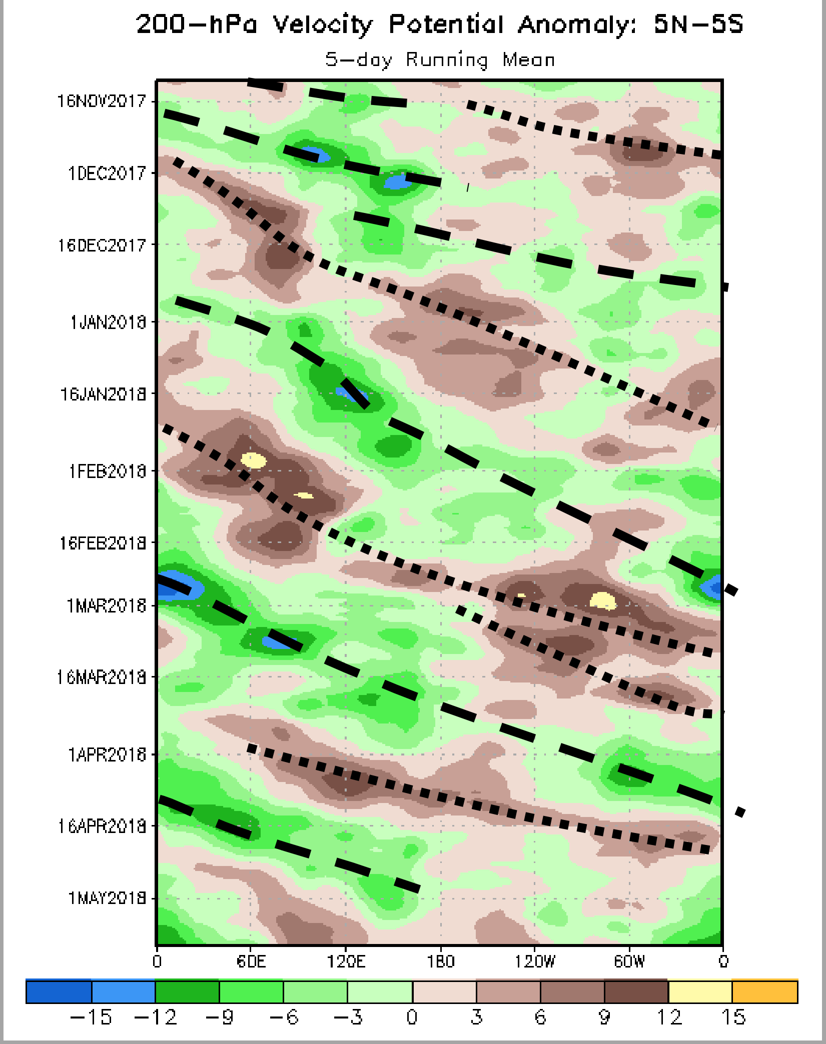
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

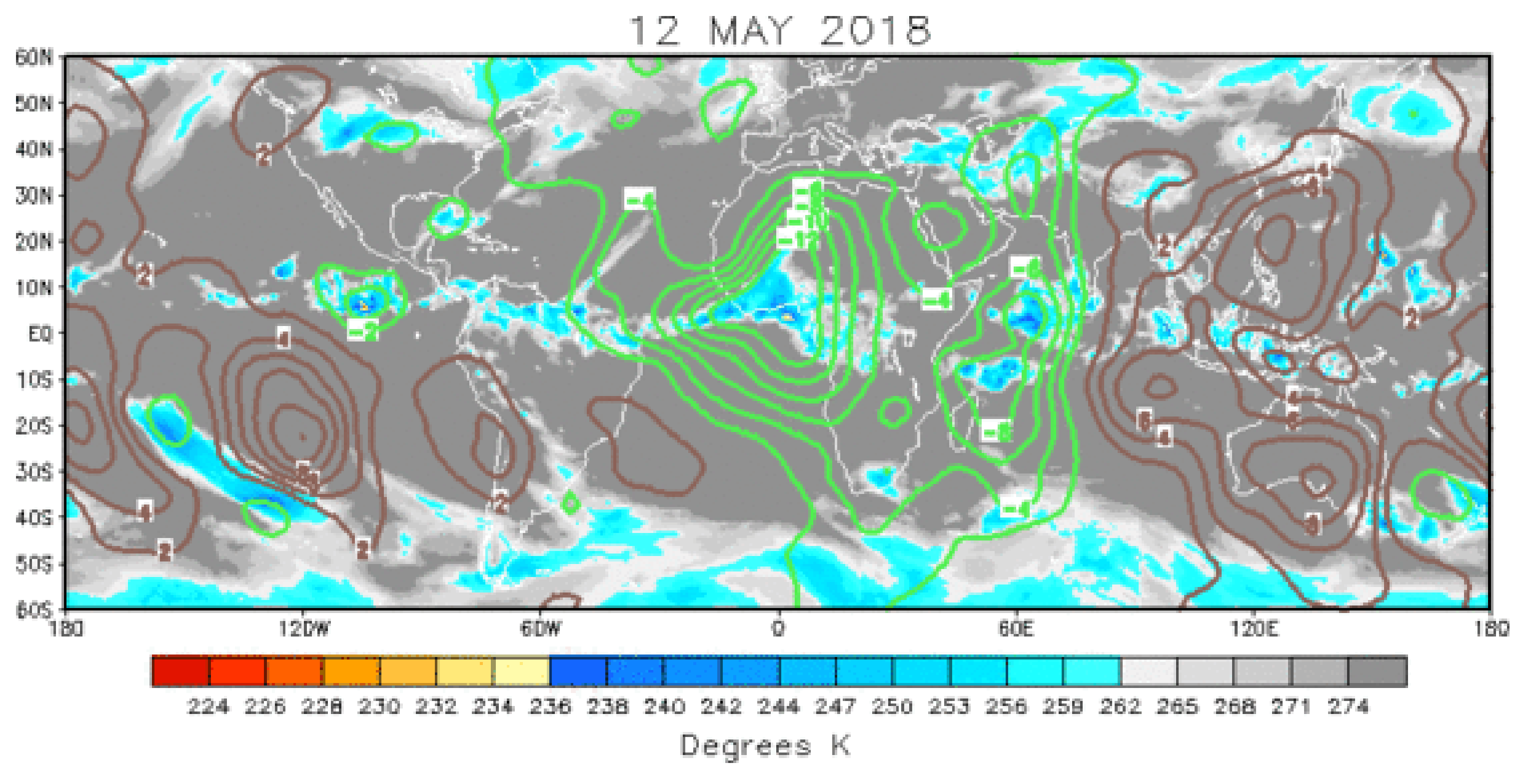
The aforementioned consistent MJO activity since mid-October can be seen in the upper level velocity potential field. Additionally, there are indications of atmospheric Kelvin wave east of the Date Line during late February and early March.

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 were also multiple westward propagating areas of suppressed convection that follow equatorial Rossby wave activity from early February to the present. More recently, the intraseasonal signal weakened considerably in the vicinity of the Date Line, with renewed upper-level divergence in the vicinity of Africa.



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



The upper-level velocity potential field exhibited a wave-1 character with favorable conditions for convection between 60W and 80E suggesting presence of the active MJO, while suppressed convection extended from the eastern Indian Ocean across the Pacific to the 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-1)

Note that shading denotes the zonal wind anomaly

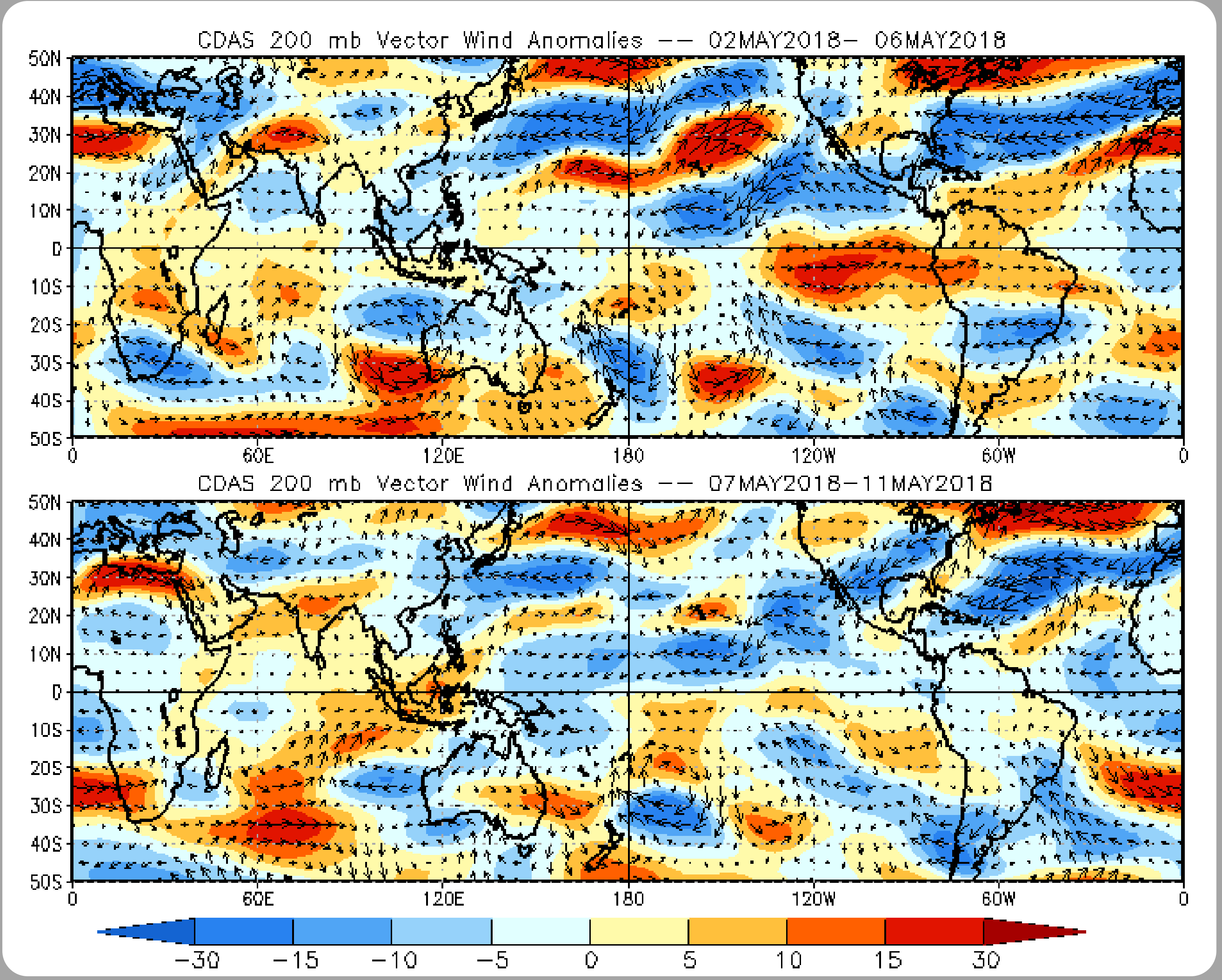
Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The upper-level zonal wind anomaly field was weak during late April and early May, with mid-latitude influences apparent across the Pacific and multiple areas of anomalous cross-equatorial flow.

Anomalous westerlies east of Peru that have persisted since mid-January appear to be the region teleconnecting most robustly with the mid-latitudes in recent weeks.

Most recently, the area of strong westerly anomalies at 200-hPa over the eastern tropical Pacific rapidly waned.



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

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

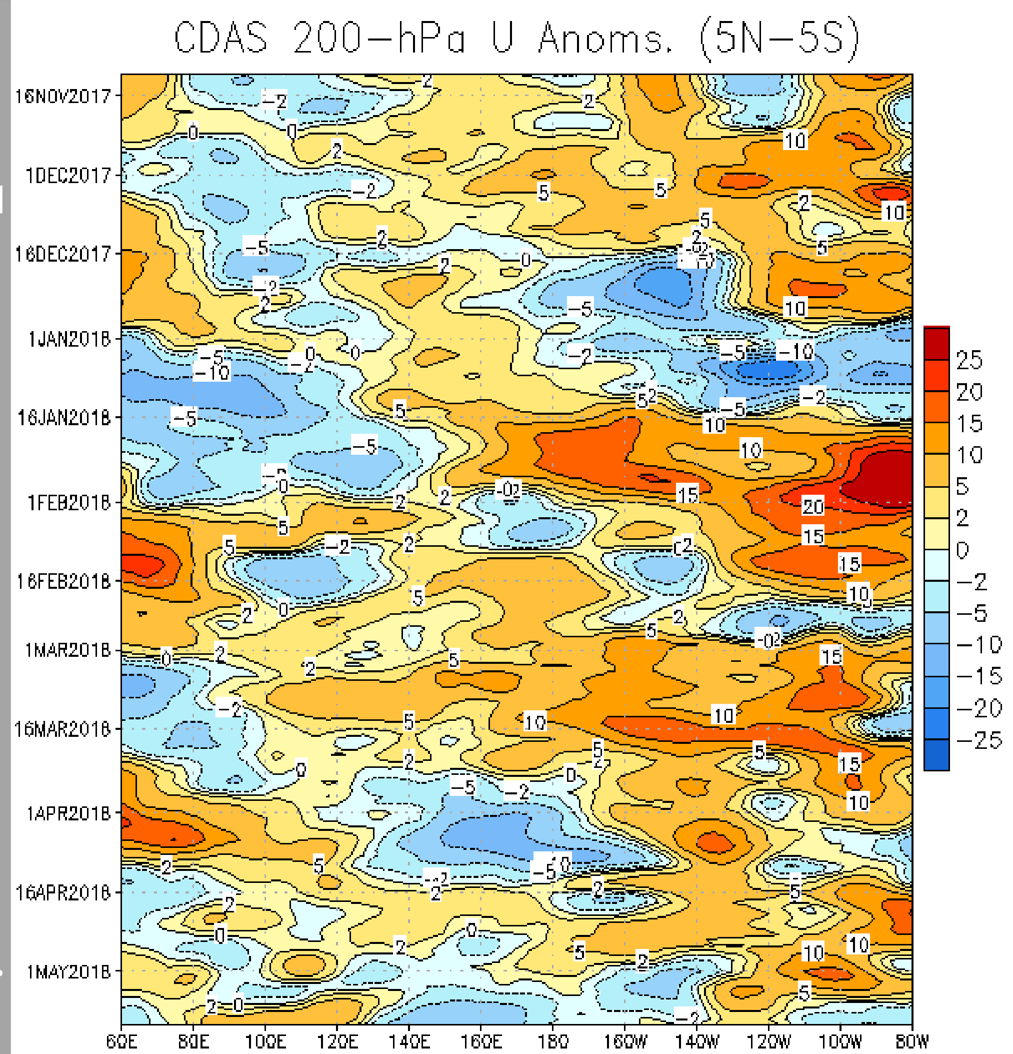
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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.

Two periods of easterly anomalies between 130E and 150W interrupted the relatively stationary anomalous westerlies that persisted across the Pacific since the middle of February.



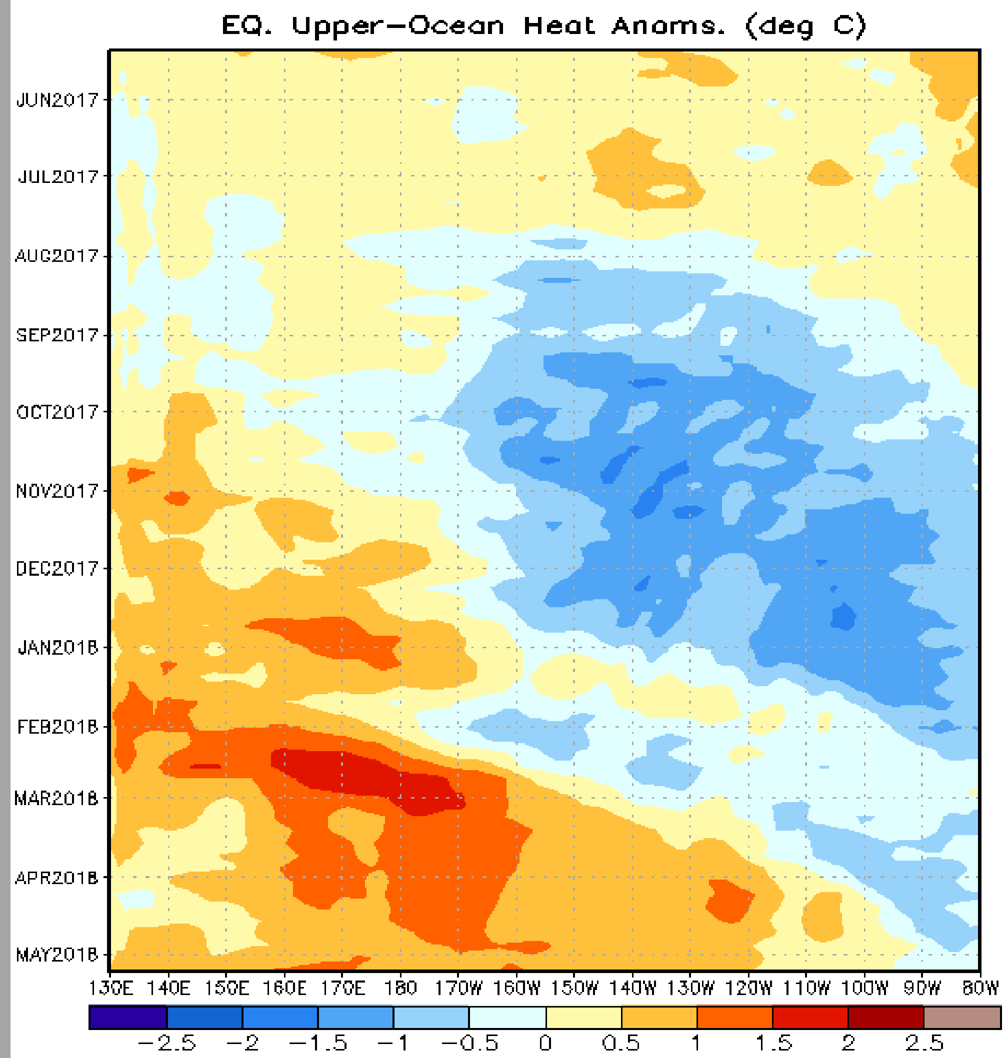
Weekly Heat Content Evolution in the Equatorial Pacific

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°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

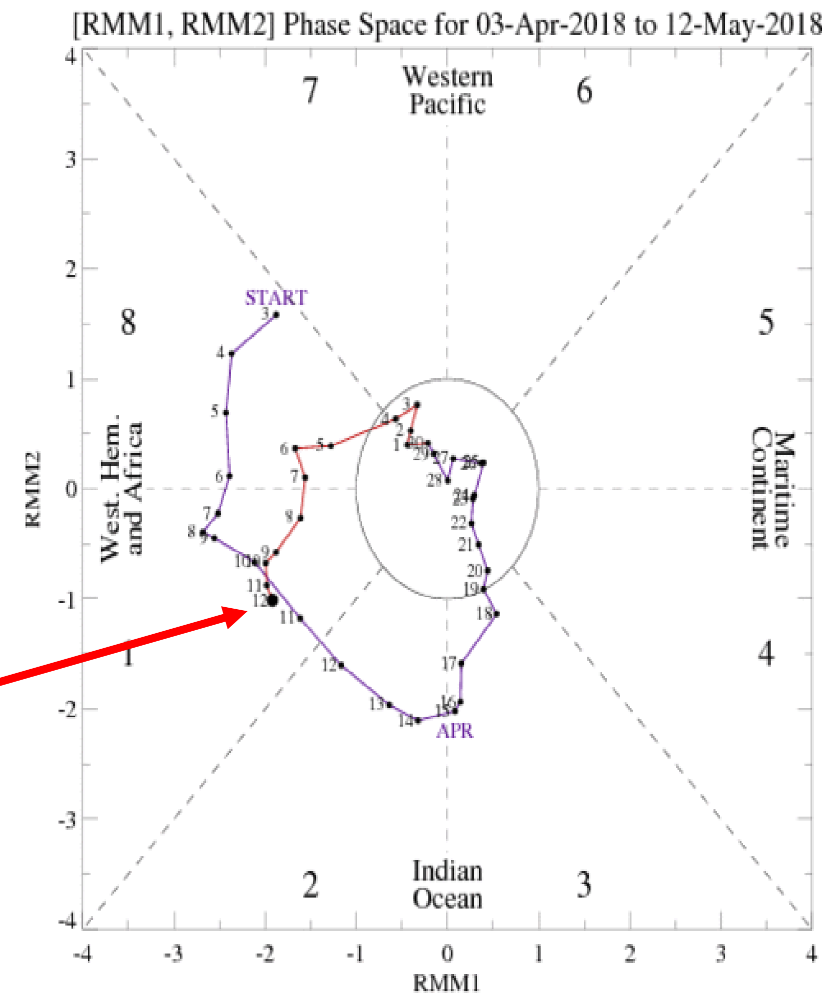
The triangular areas indicate the location of the enhanced phase of the MJO

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

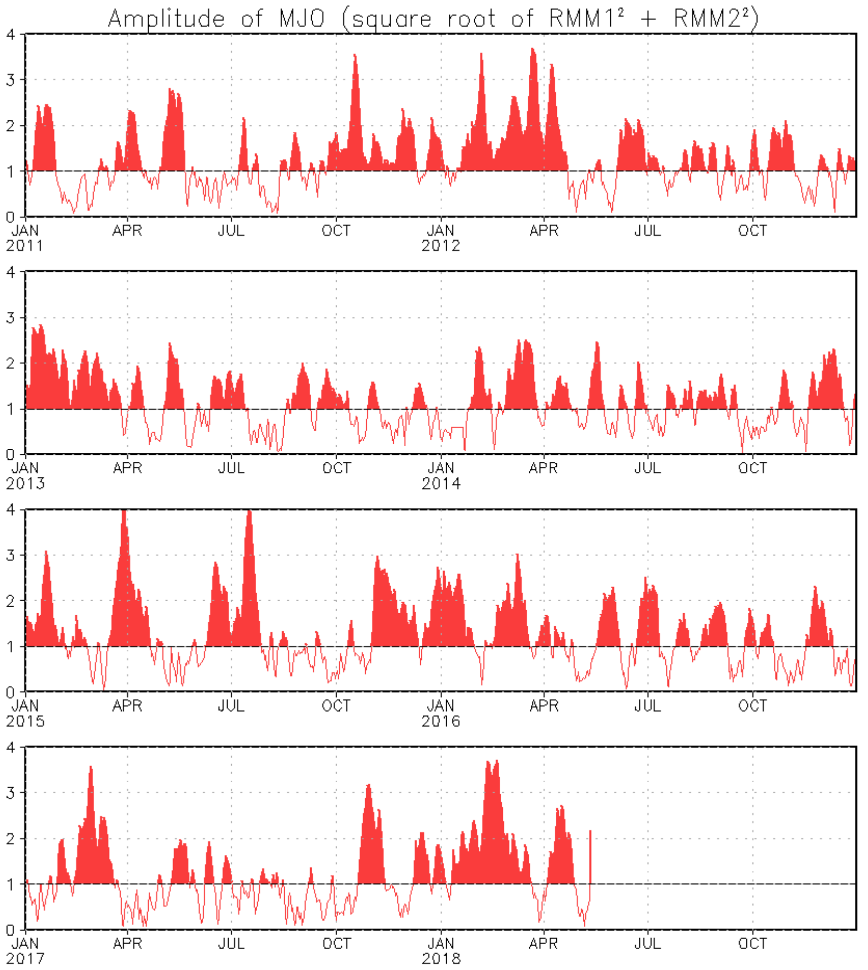
The RMM-based MJO projection shows a sub-seasonal signal that recently emerged and amplified across the Western Hemisphere in the past ten days, accompanied by some eastward propagation from phase 8 into phase 1.



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

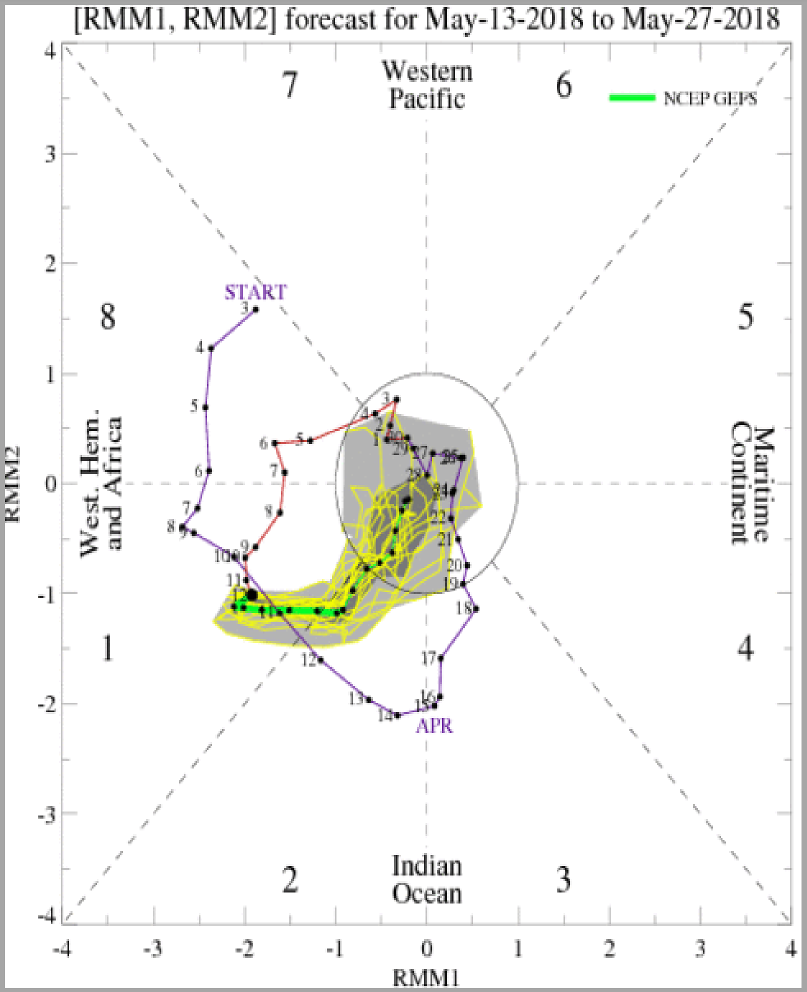
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

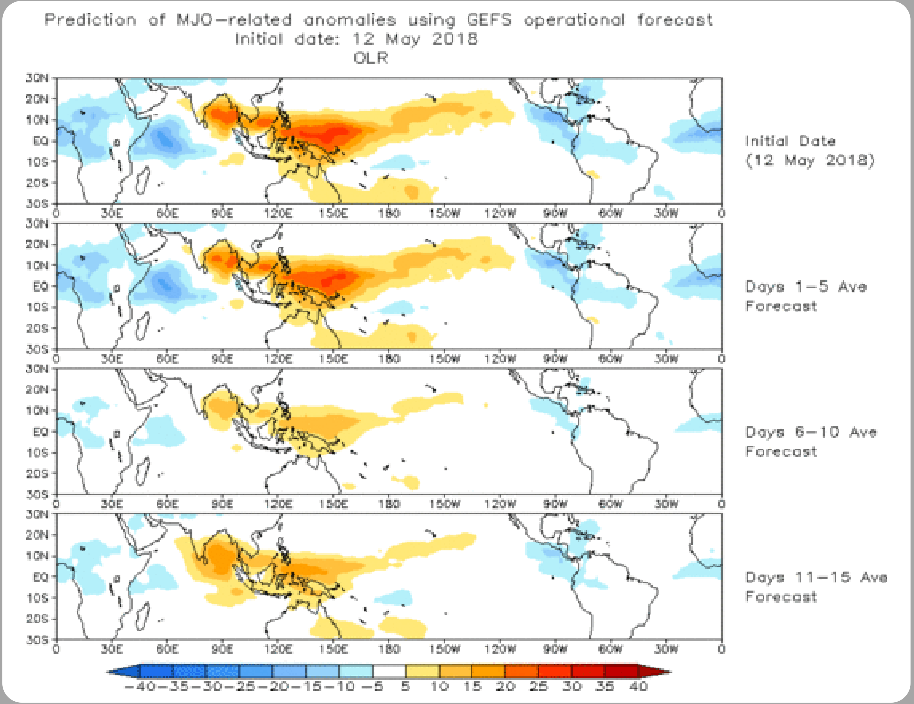
The GEFS depicts slight eastward propagation and rapid weakening of a subseasonal signal during Week-1. In Week-2, the signal is predicted to continue to weaken inside the unit circle, over the western Indian Ocean.



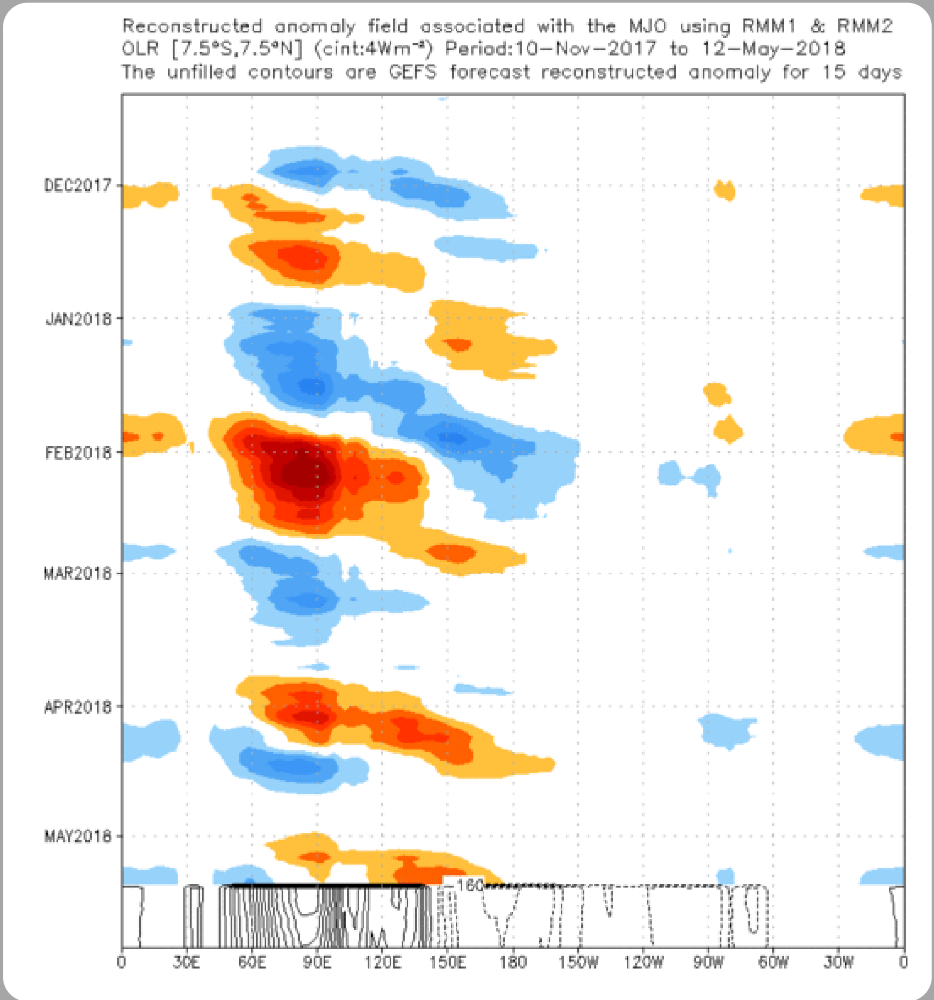
Ensemble GFS (GEFS) MJO Forecast

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

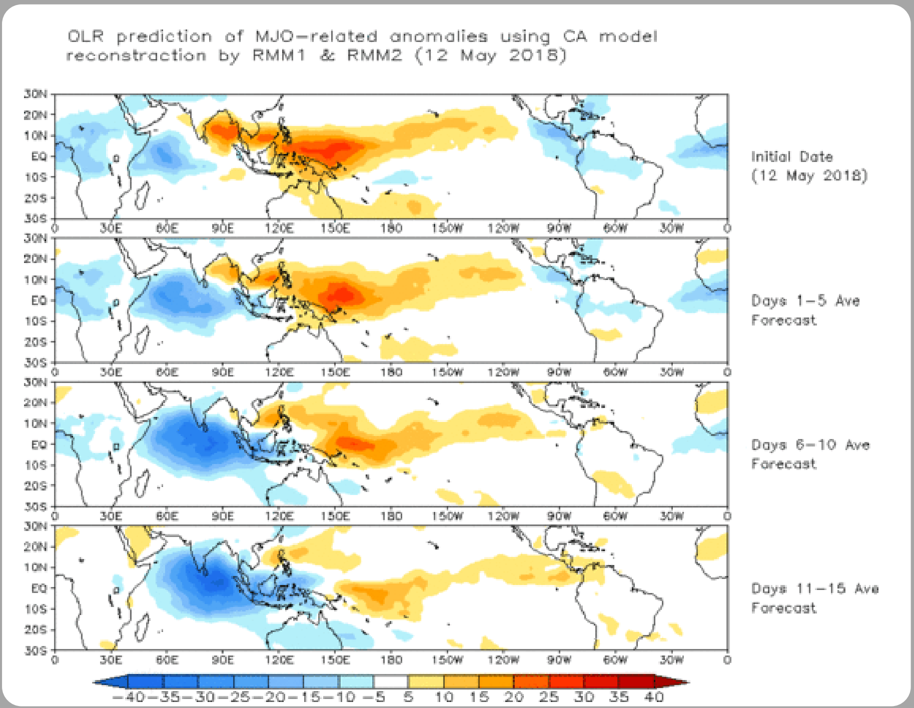


GEFS-based OLR anomalies associated with the MJO depict a stationary pattern, with weakening during Week-2. Enhanced convection is forecast over Africa and the western Indian Ocean, and a broad area of suppressed convection is indicated from the eastern Indian Ocean eastward to about the Date Line.

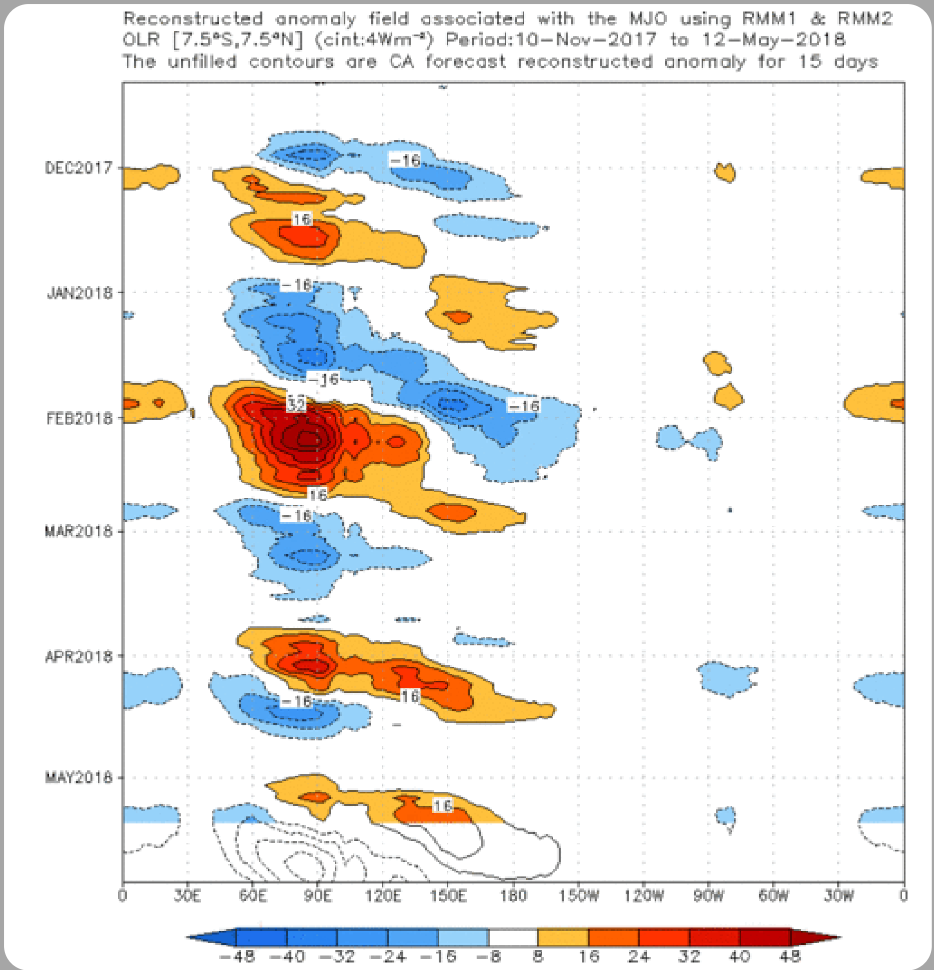
Constructed Analog (CA) MJO Forecast

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



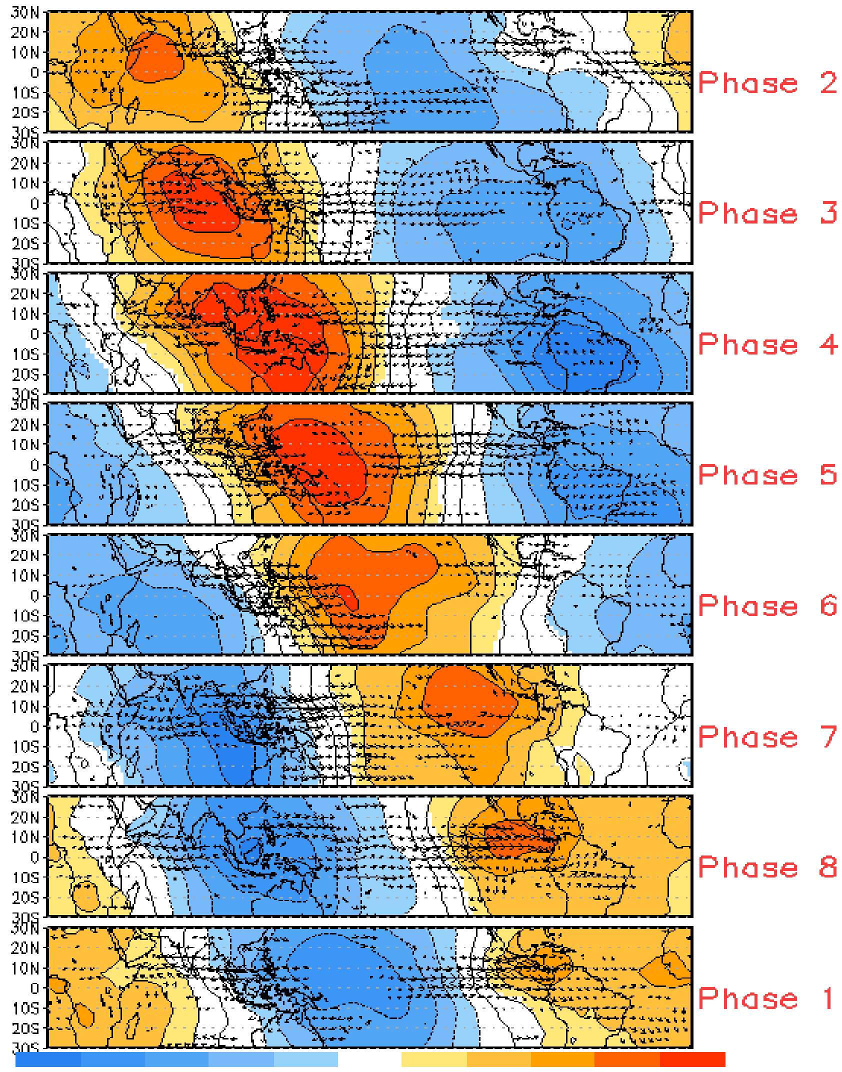
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



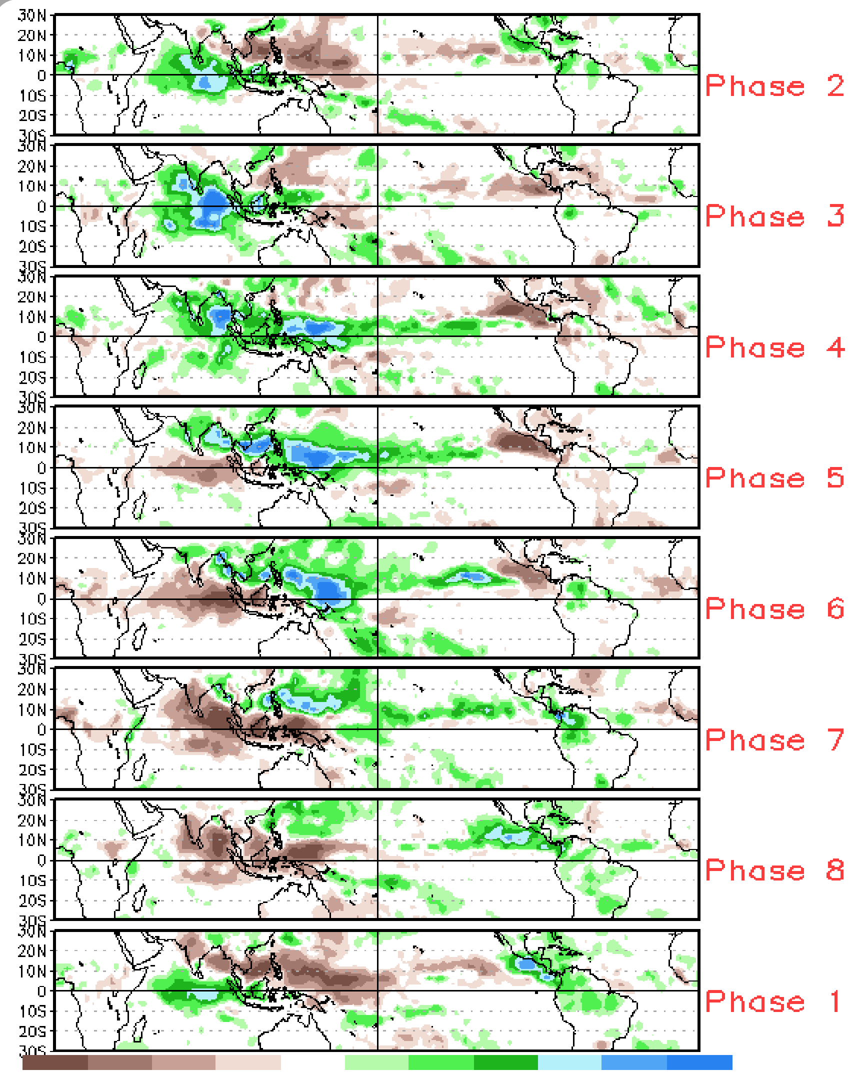
The OLR anomaly forecast based on the constructed analog MJO index forecast depicts enhanced convection over the Indian Ocean that amplifies with time, and suppressed convection over the Maritime Continent and western and central Pacific that weakens with time. A stationary pattern is indicated.

MJO Composites - Global Tropics

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



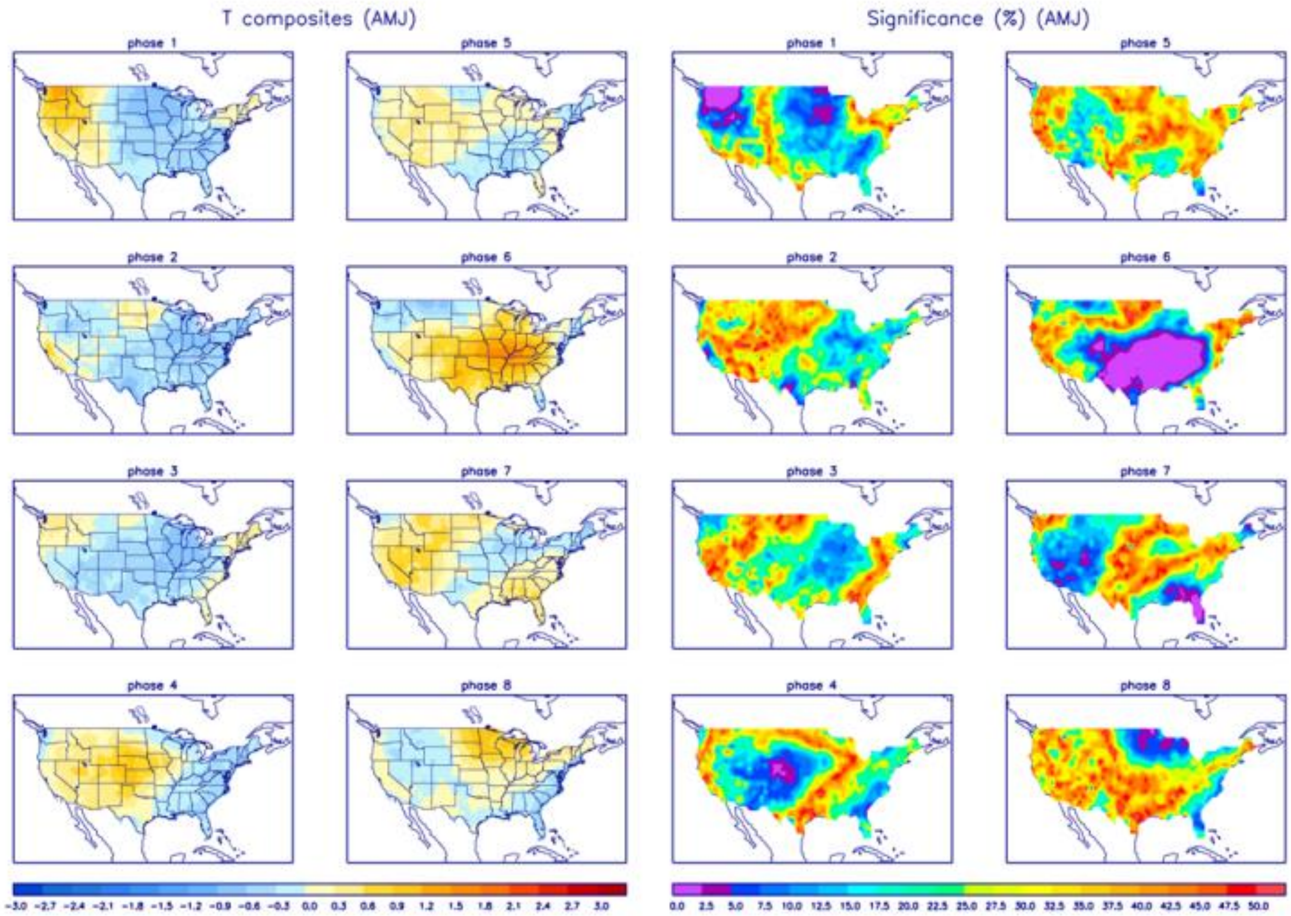
Precipitation Anomalies (Nov - Mar)



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.



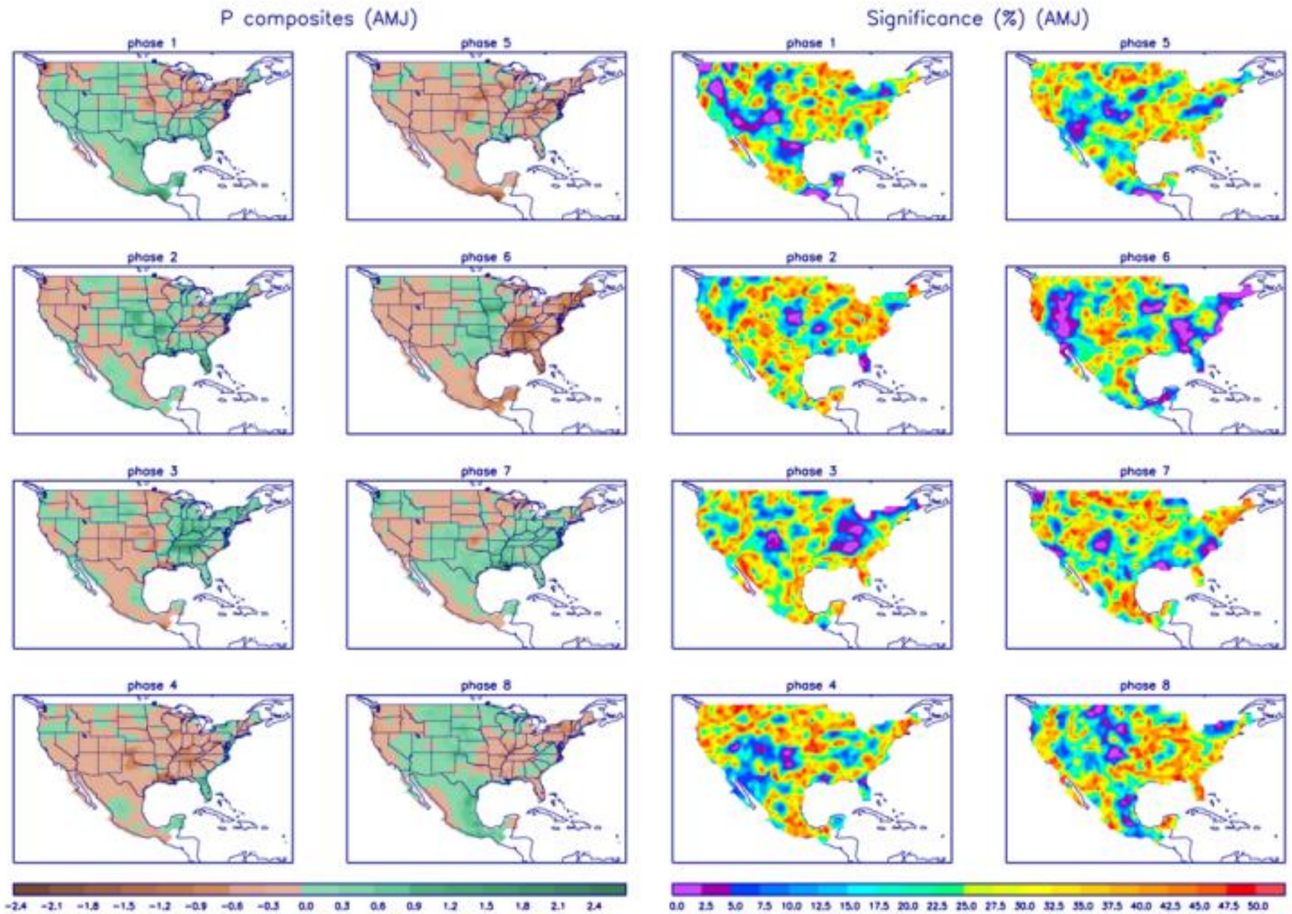
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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