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

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Overview

- The enhanced convective phase of the MJO has remained over the Indian Ocean through the last week, with some movement toward the Maritime Continent.

- Dynamical models show eastward propagation of the MJO signal, with enhanced convection over the eastern Indian Ocean and parts of the Maritime Continent for Week-1 and further east over the Maritime Continent for Week-2. Dynamical and statistical tools show a possible slight increase in amplitude into Week-2.

- Based on dynamical and statistical model guidance, the suppressed envelope of the MJO is likely to constructively interfere with the base state of La Niña as it moves toward the Central Pacific into Week-2. Enhanced convection is expected over the Maritime Continent.

- An active MJO over the Indian Ocean during boreal winter is generally one of the more coherent scenarios for yielding a teleconnection response in the Northern Hemisphere. Typical lagged extratropical circulation responses favor enhancement and extension of the jet across the far North Pacific in addition to ridging building across the lower-48 states.

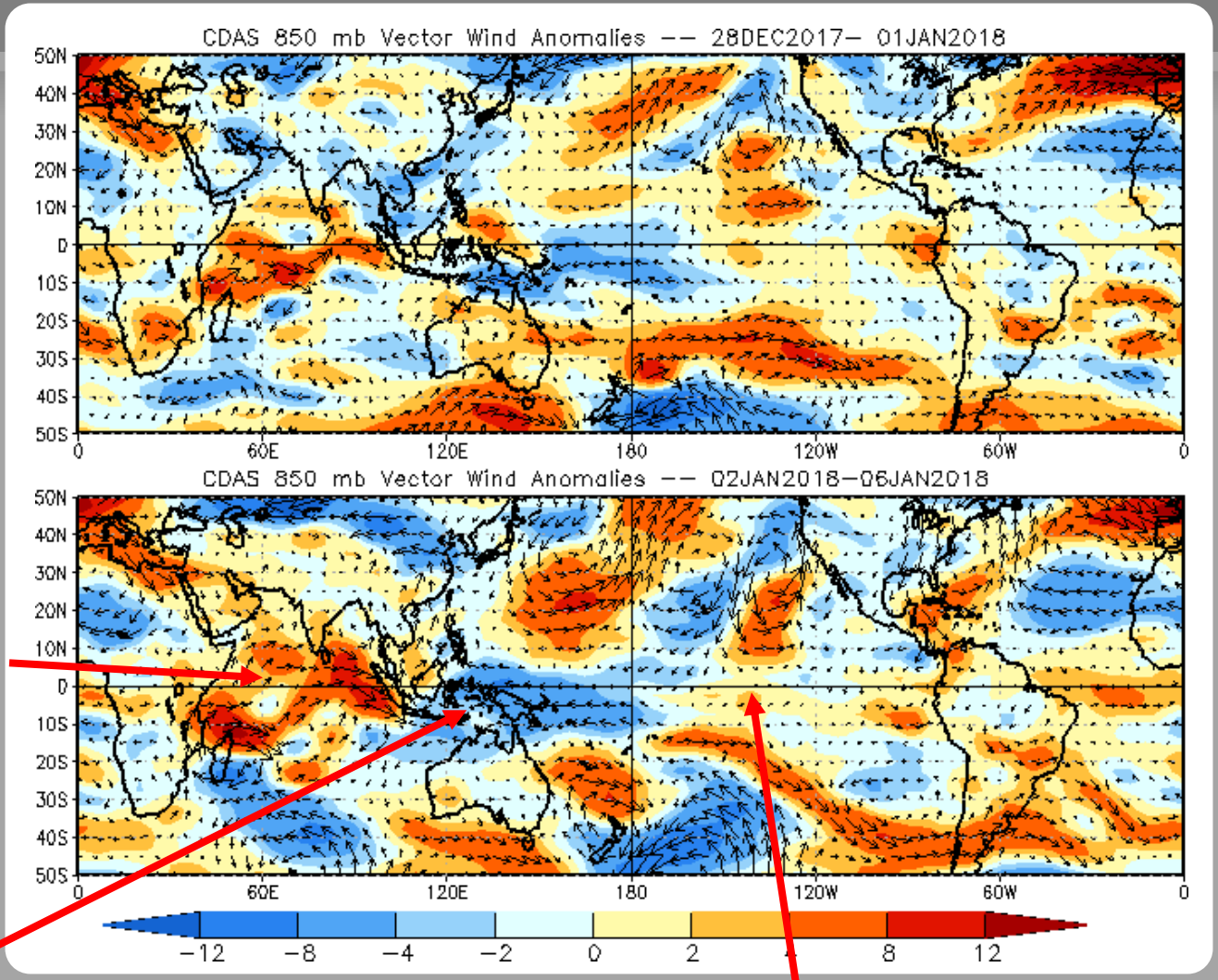
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerlies continued over the Indian Ocean in association with the active MJO signal reaching the basin.

Low-level convergence persisted over the Maritime Continent tied to the low frequency state.

Weak anomalous westerlies continued east of the Date Line in the Pacific and across much of the Western Hemisphere.

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

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

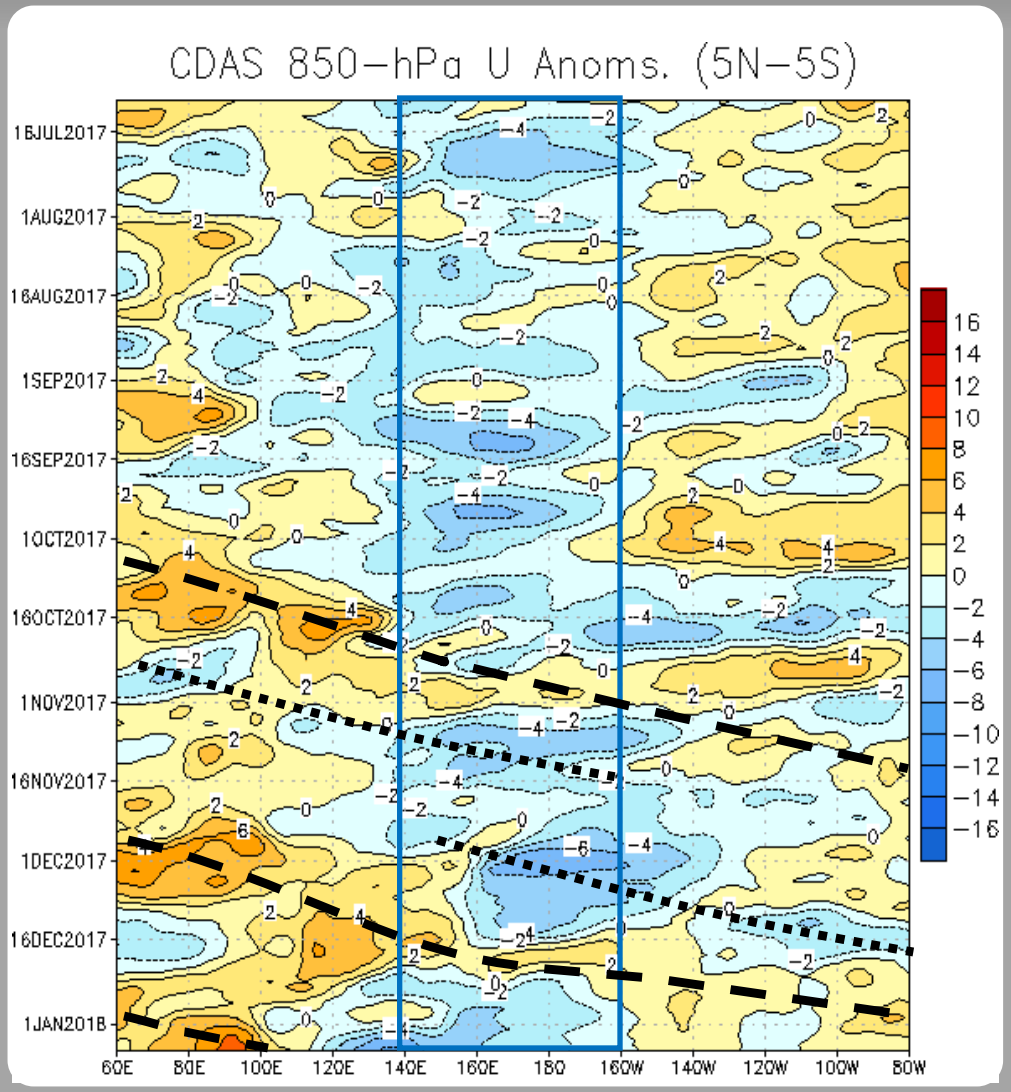
Easterly anomalies (blue shading) represent anomalous east-to-west flow

Low-frequency easterly anomalies (blue box) have largely persisted over the west-central Pacific throughout the last 180 days.

During July, a slight eastward shift in the low-frequency pattern is noted, related to short-lived MJO activity. By August and September, the low-frequency envelope of easterly anomalies re-established from 140E to just east of the Date Line.

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. During the past two weeks this signal has crossed the Western Hemisphere to re-emerge over the Indian Ocean.



OLR Anomalies – Past 30 days

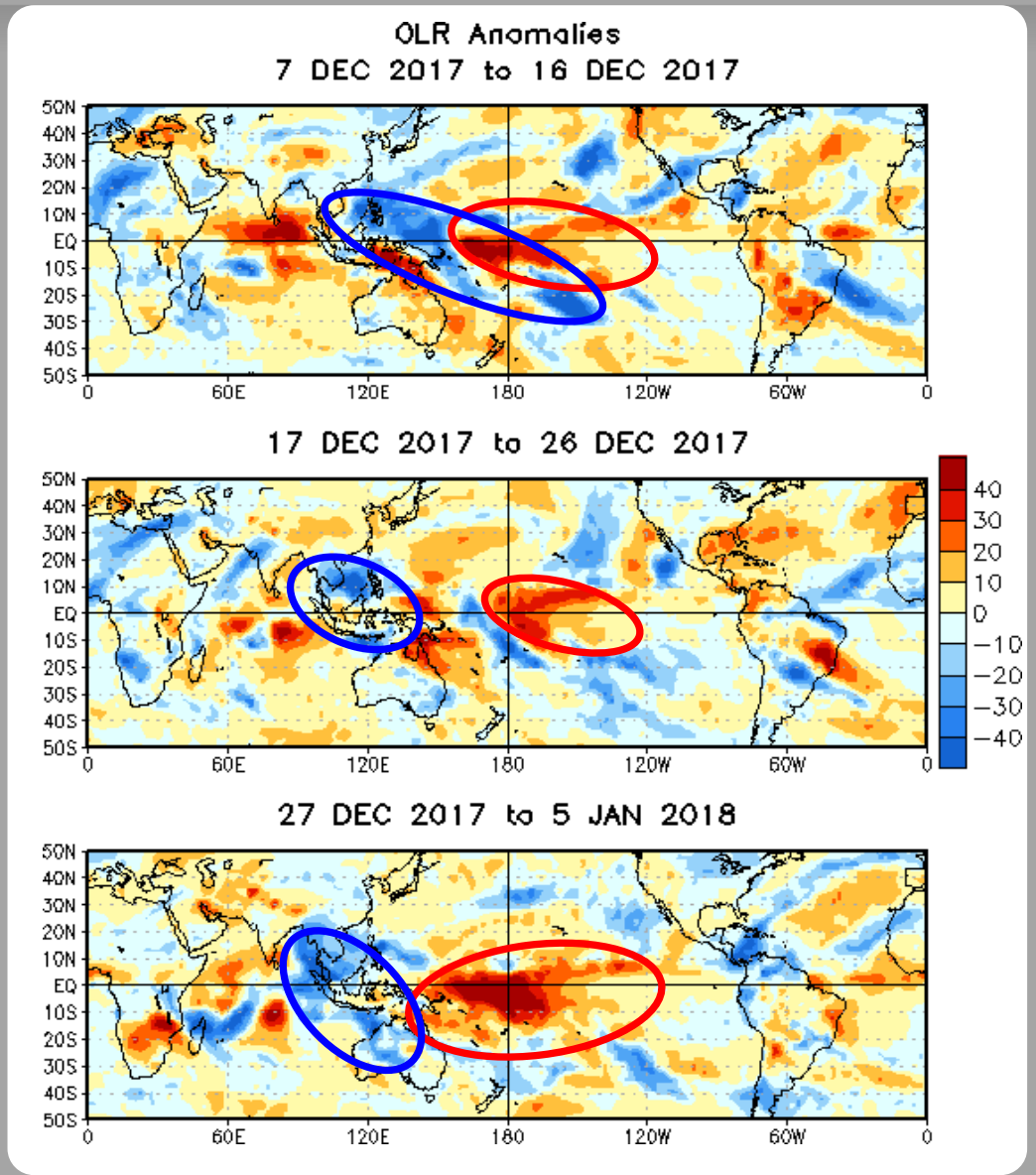
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

In early December, the MJO enhanced phase moved into the western Pacific. It minimally impacted the La Niña atmospheric response aside from enhancing the South Pacific Convergence Zone (SPCZ).

During the mid-December, little eastward propagation of the MJO signal was evident, as Rossby wave activity, and associated TCs, over the West Pacific influenced the convective pattern. Suppressed convection overspread the Indian Ocean, and remained entrenched over the central Pacific.

The MJO signal remained in Phase 2 through the beginning of January, with little propagation eastward of the suppressed envelope due to Rossby wave activity over the Indian Ocean. Enhanced convection expanded towards the Maritime Continent. Suppressed convection near the Date Line from the MJO signal constructively interfering with the base state is also evident.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

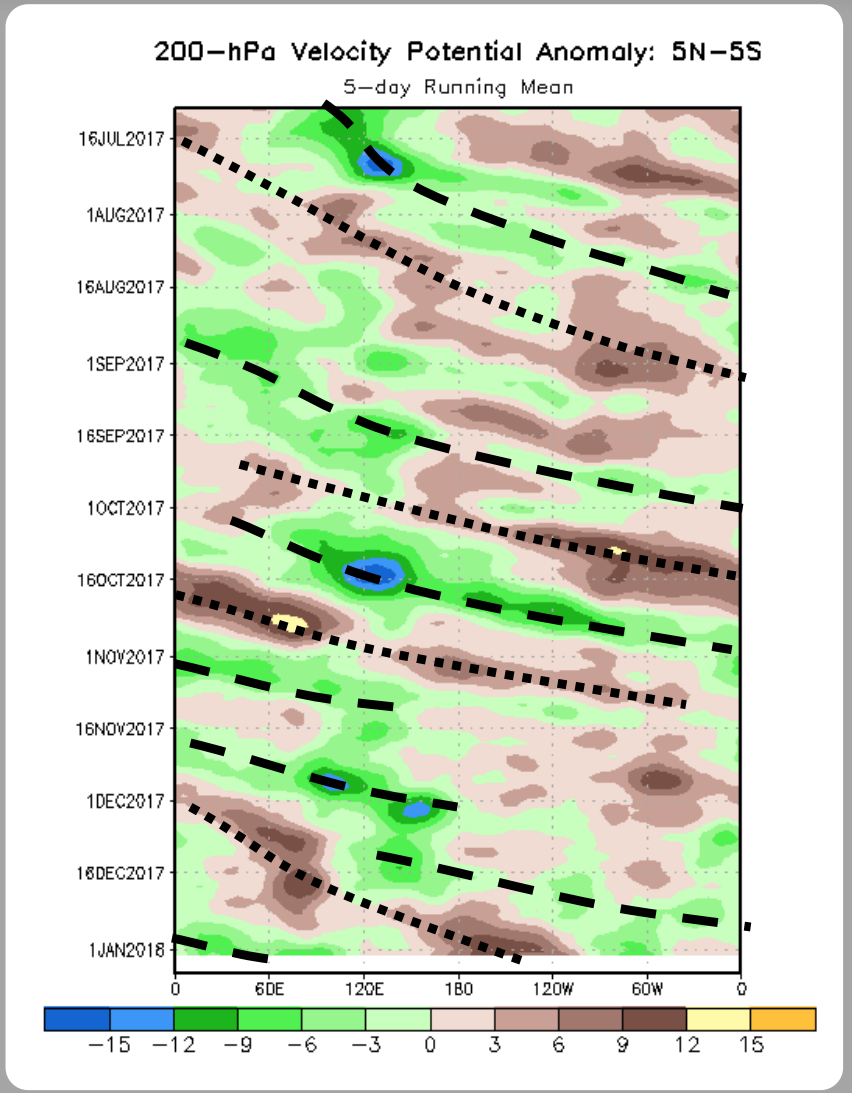
Negative anomalies (green shading) indicate favorable conditions for precipitation

During July, an east-ward propagating enhanced convective signal strengthened over the Maritime Continent that was consistent with the MJO.

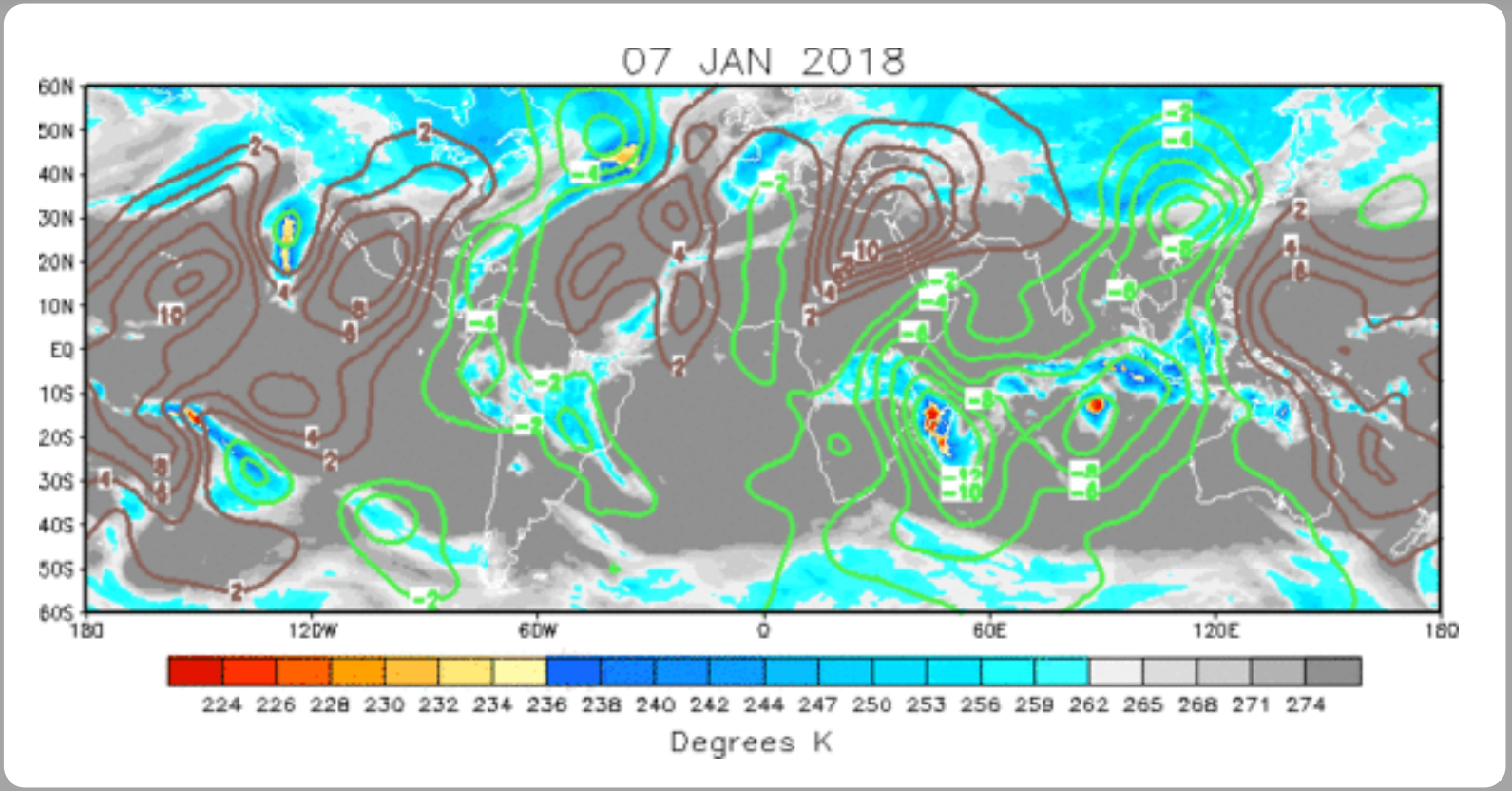
Another signal on the MJO timescale is evident in this field during late August and September.

Another MJO event developed near the Maritime Continent during early October, with a large upper-level footprint near 120E and robust eastward propagation. The signal circumnavigated the global tropics, reaching the Maritime Continent region about 30 days later, weakening at that time.

Since mid-November, renewed MJO activity has been observed. This intraseasonal signal has been weaker than the previous episode, with disruption from Rossby wave activity. 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.



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



The upper-level anomalous velocity potential field is consistent with an MJO event over the Indian Ocean as a general wave-1 signature is apparent with enhanced (suppressed) convection east of Africa through the Maritime Continent (Pacific, Americas, and Atlantic). Some noise is evident in the positive anomalies, most likely attributed to Rossby wave activity.

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)

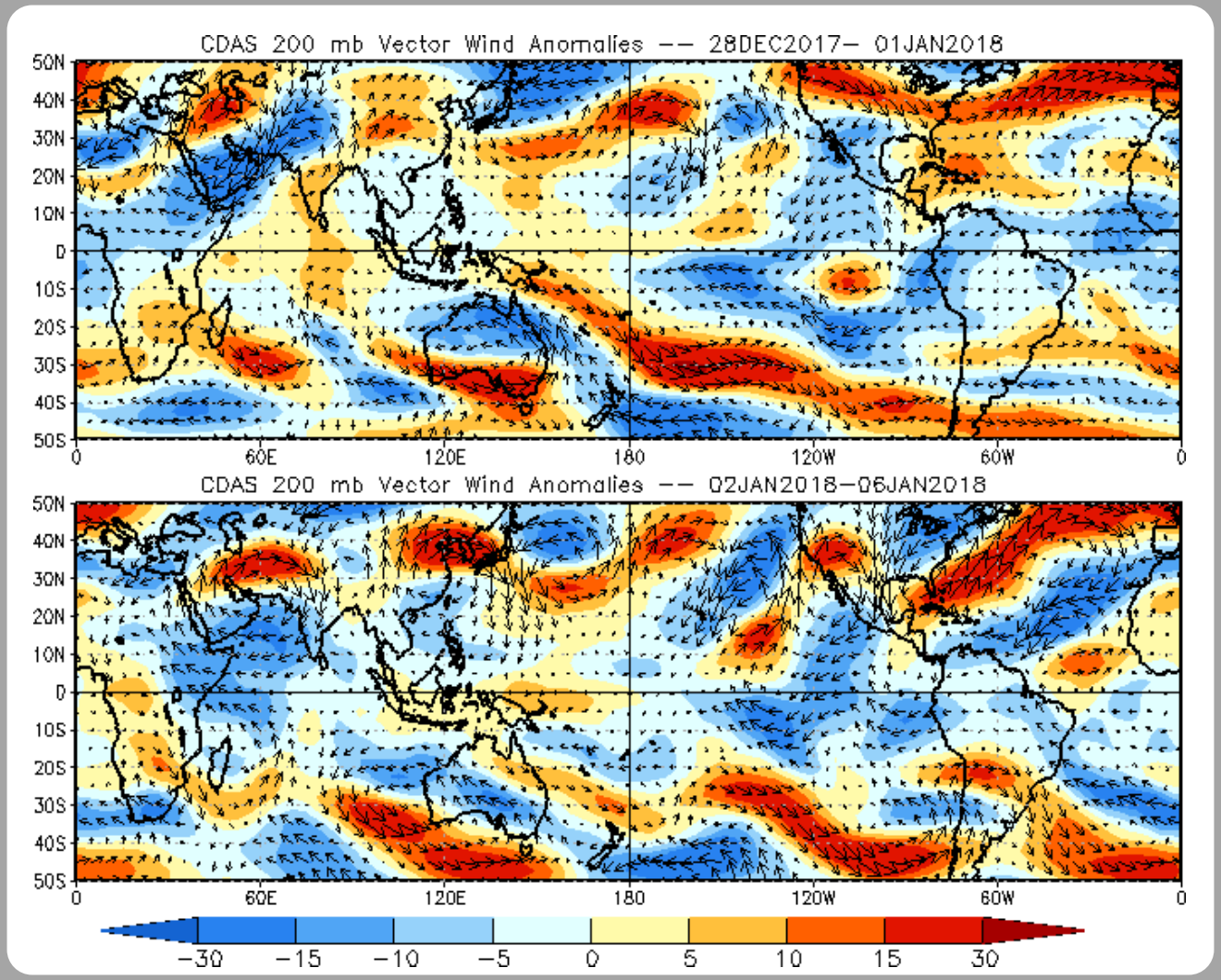
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Both feedback of wave-breaking from the mid-latitudes and extratropical influences from the anomalous tropical convective state are apparent across both hemispheres.

There has been a weakening in the robust anomalies over the South Pacific, as the MJO suppressed envelope propagated further eastward toward the Date Line.



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

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

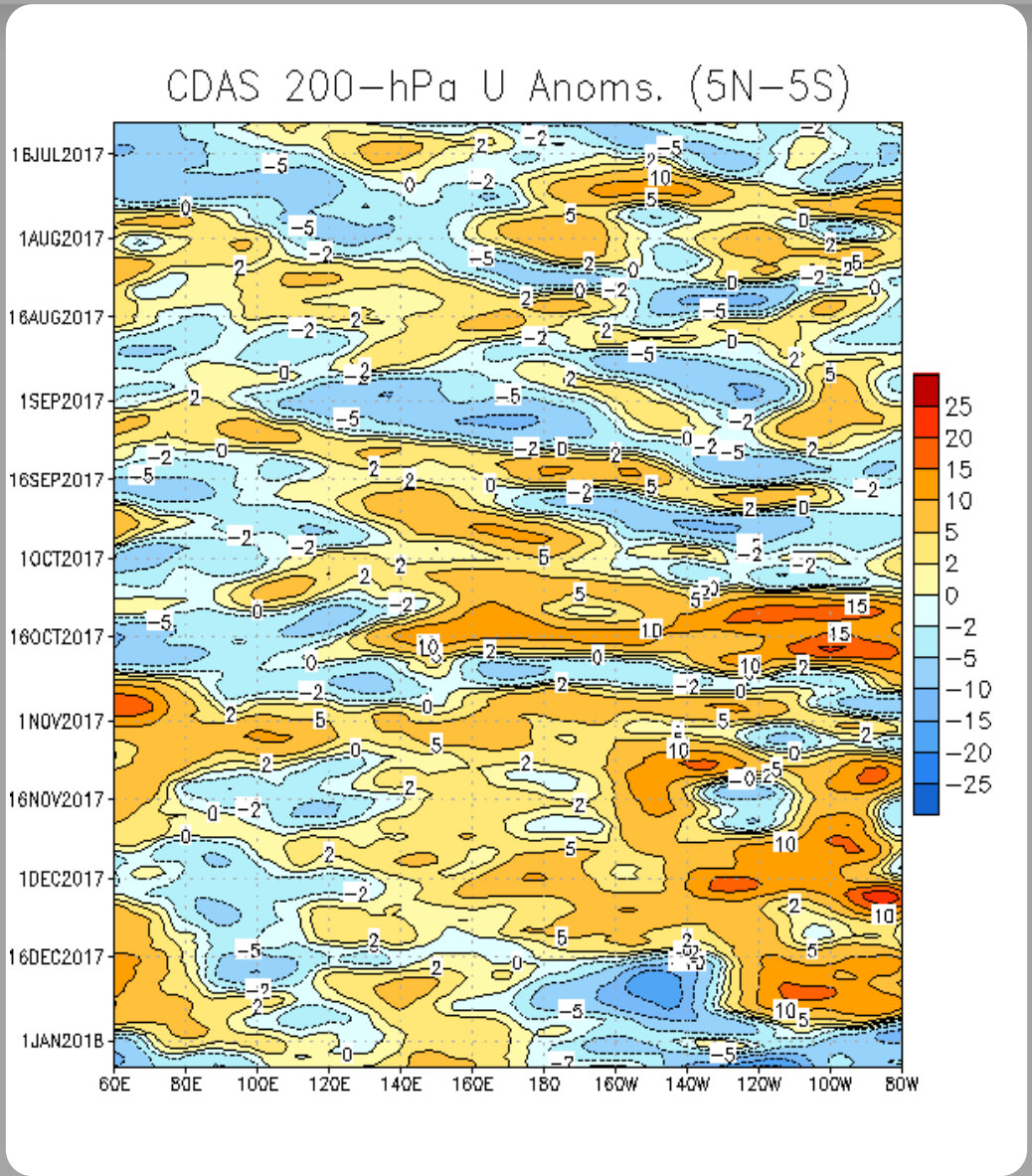
Easterly anomalies (blue shading) represent anomalous east-to-west flow

In mid-July through August, anomaly patterns propagated eastward, associated with weak MJO activity and atmospheric Kelvin waves.

During September, fast-moving eastward propagation of anomalies continued, consistent with additional atmospheric Kelvin Waves. A slower signal was evident over the eastern Maritime Continent and west Pacific.

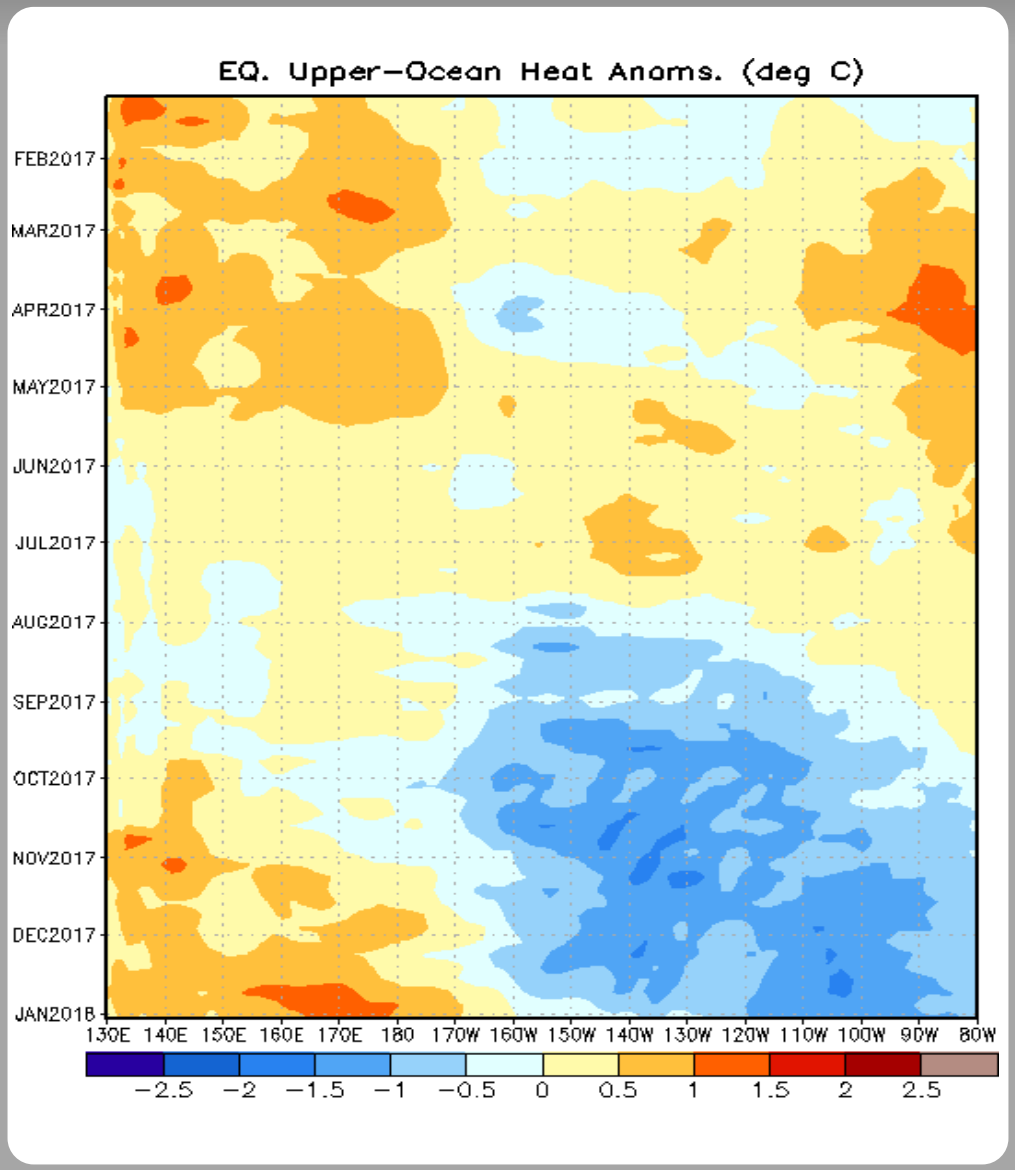
Low-frequency westerly anomalies remained in place east of 140E starting in October, with the exception of a brief period of easterlies in late October. There is also some recent evidence of easterlies over the far Eastern Hemisphere over the last week or so that appear to have extratropical sourcing.

In the past few weeks, easterly anomalies have developed in the east of the Date Line, replacing the westerly anomalies that had been generally present since October.



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 over the eastern Pacific.

Anomalous upper-ocean warmth has been building to the west of the Date Line over the last few months, tied to westerly wind bursts with the intraseasonal atmospheric envelope.

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

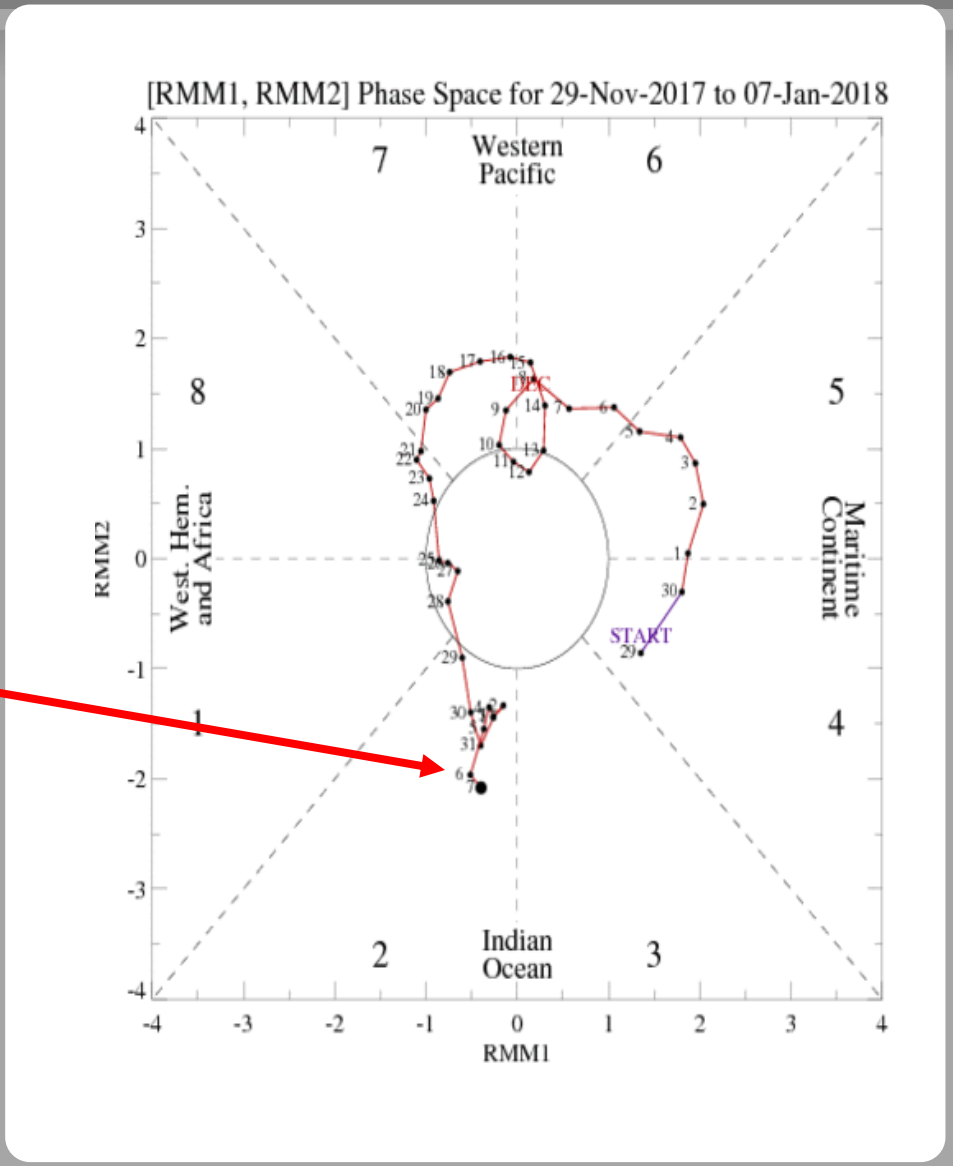
Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.

Distance from the origin is proportional to MJO strength

Line colors distinguish different months

The RMM-index exhibited shows a stall in the MJO signal, remaining in Phase 2 over the past week.

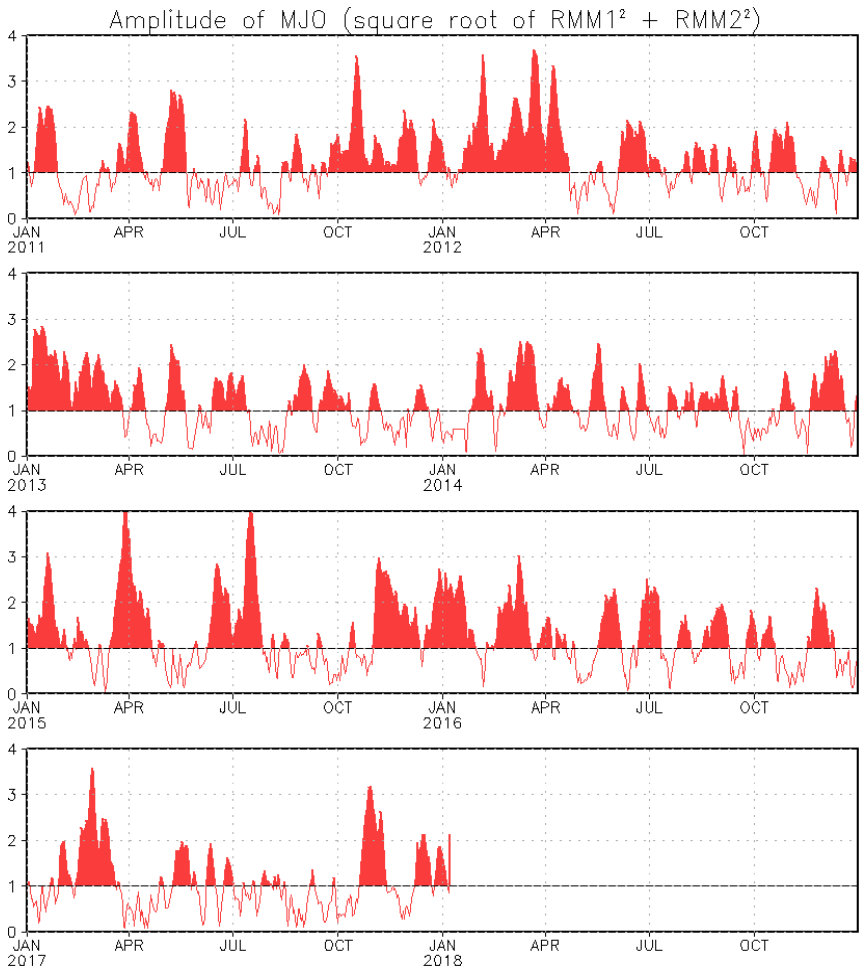
The signal strength remained consistent throughout the week, though the eastward propagation was slowed as the signal circled around in Phase 2 due to Rossby wave (and associated tropical cyclone) activity over the southern Indian Ocean.



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.



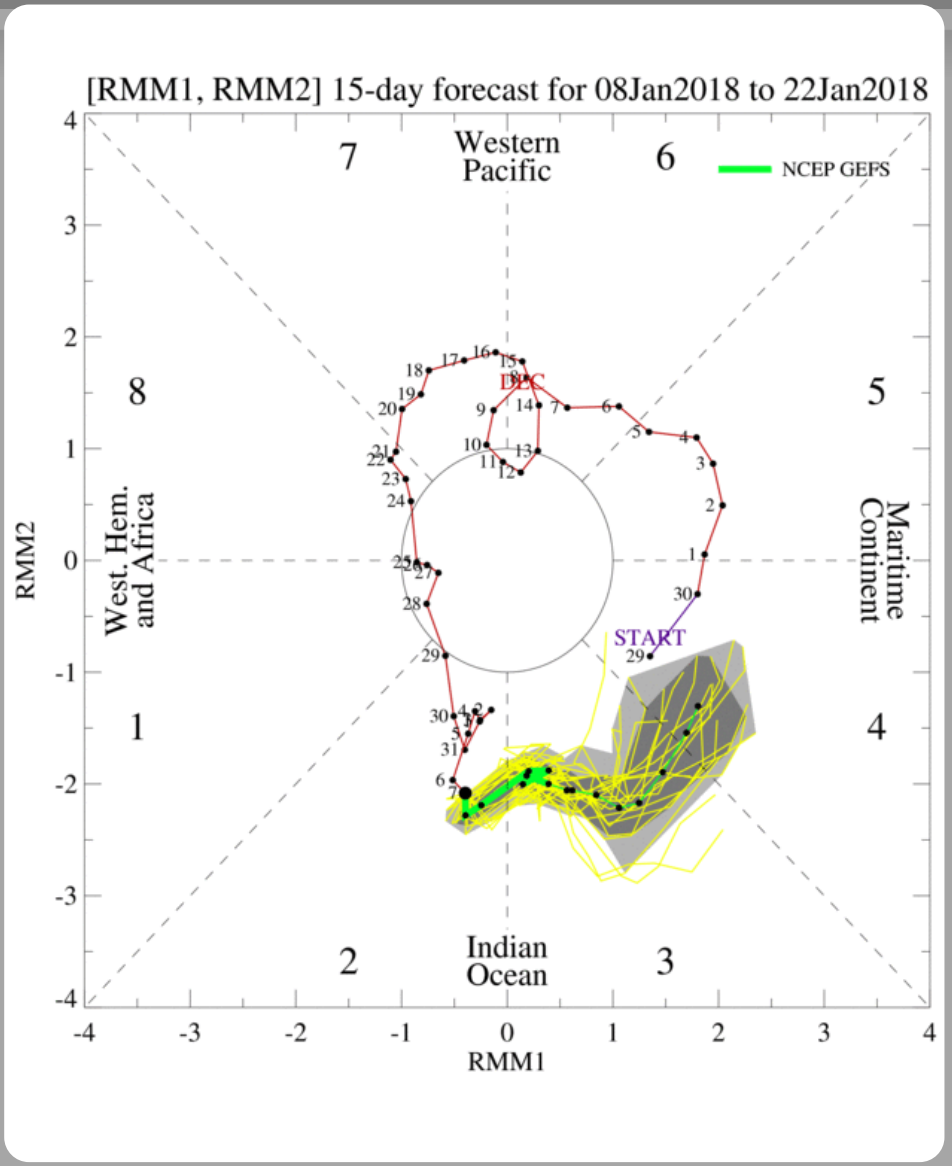
GFS Ensemble (GEFS) MJO Forecast

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



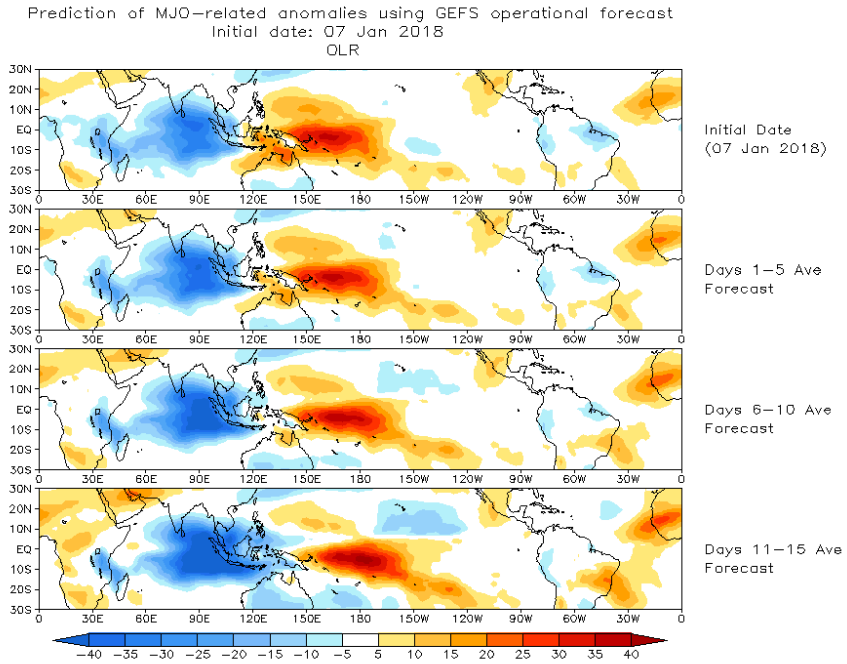
The GEFS forecasts shows fairly consistent signal strength as the signal propagates into Phase 3 through Week-1. There is a brief pause in eastward movement, possibly due to tropical cyclone activity in the Indian Ocean.

In Week-2, continued eastward propagation moves the signal into Phase 4, over the Maritime Continent, with most members maintaining the current amplitude. Spread among the members shows uncertainty in the speed of the progression, though most forecast the signal to be in Phase 4 by the end of Week-2.

Ensemble GFS (GEFS) MJO Forecast

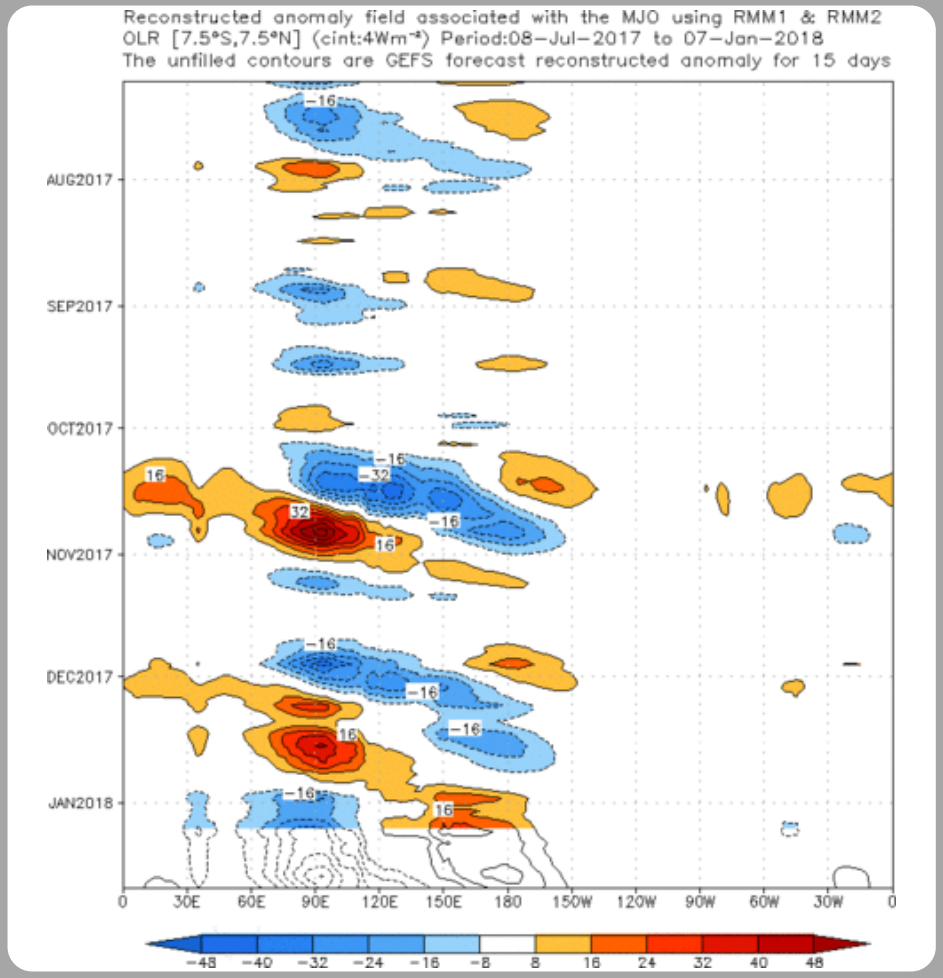
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



MJO-driven OLR anomalies based on the GEFS support the convective signal moving over the Maritime Continent during the next two weeks, with suppression of convection shifting toward the Date Line.

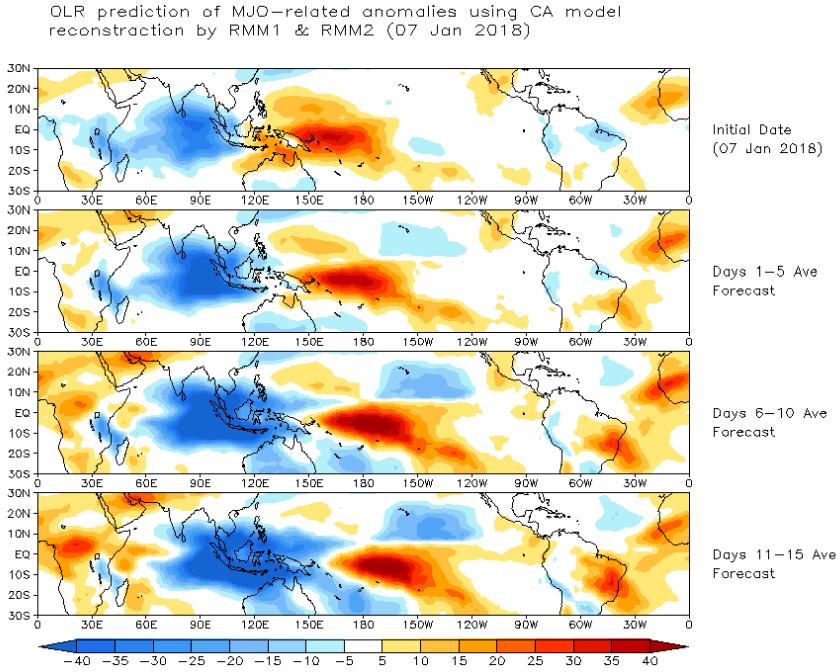
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



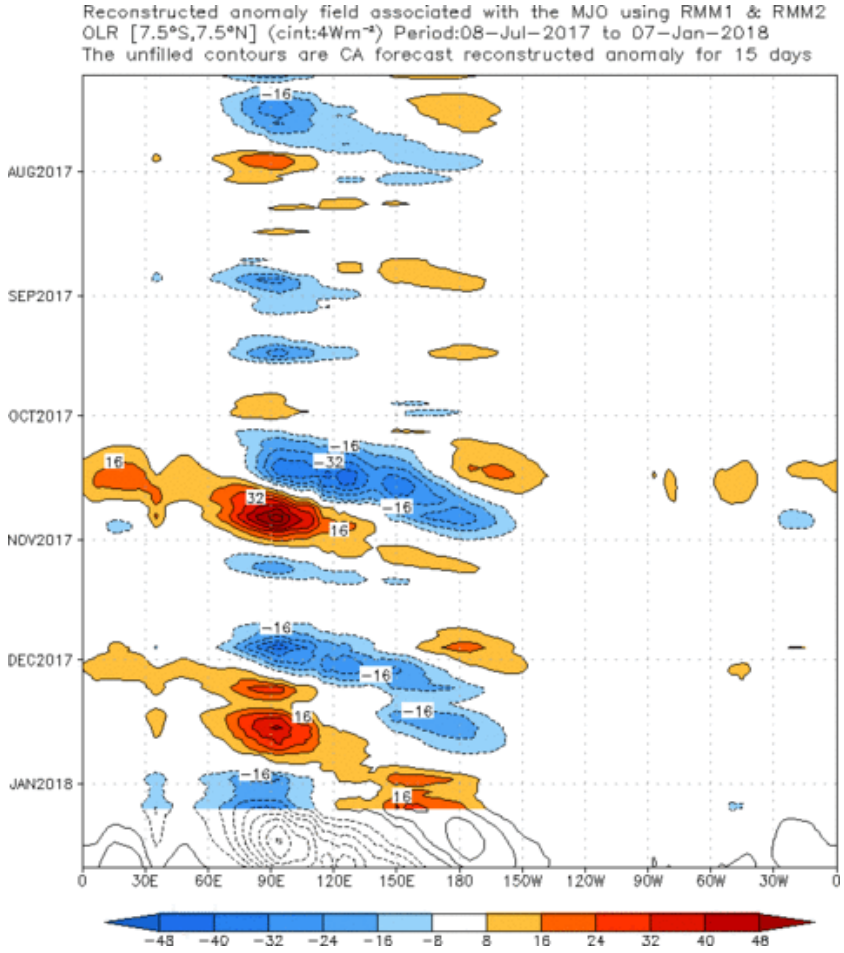
Constructed Analog (CA) MJO Forecast

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



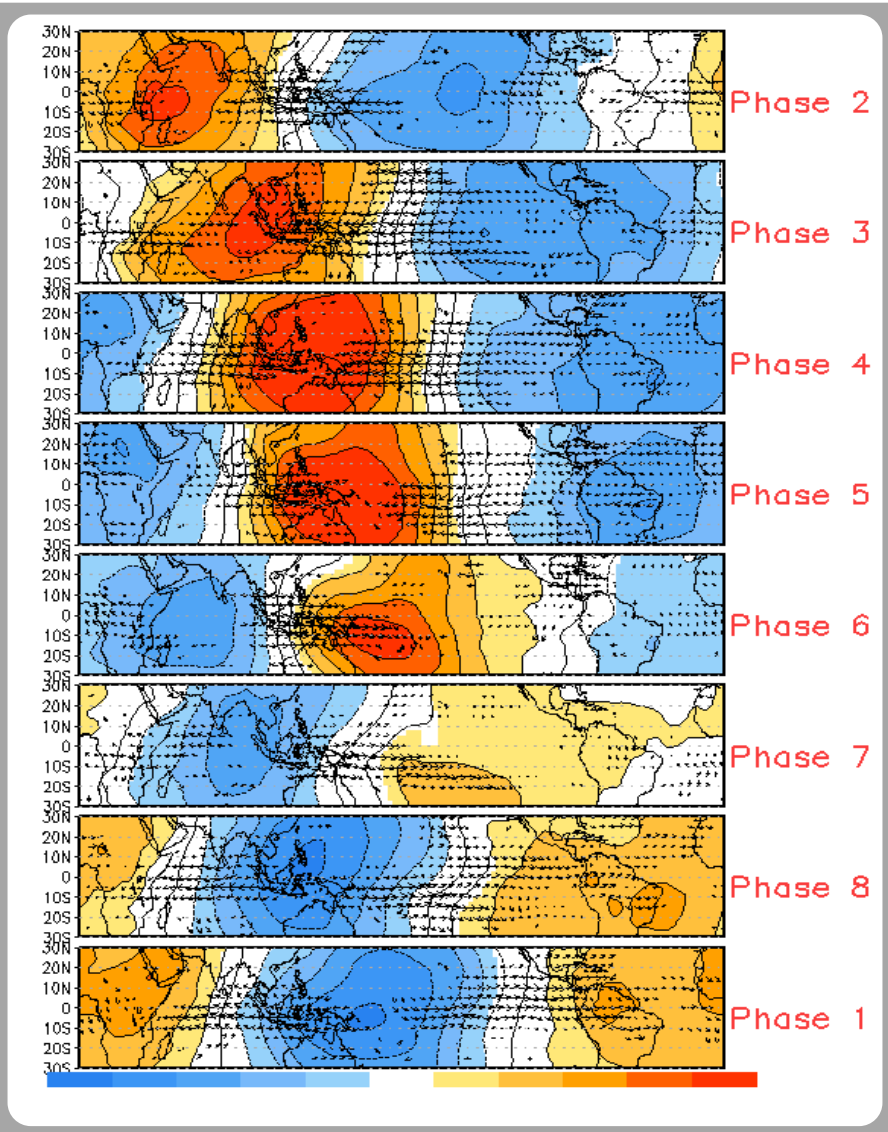
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



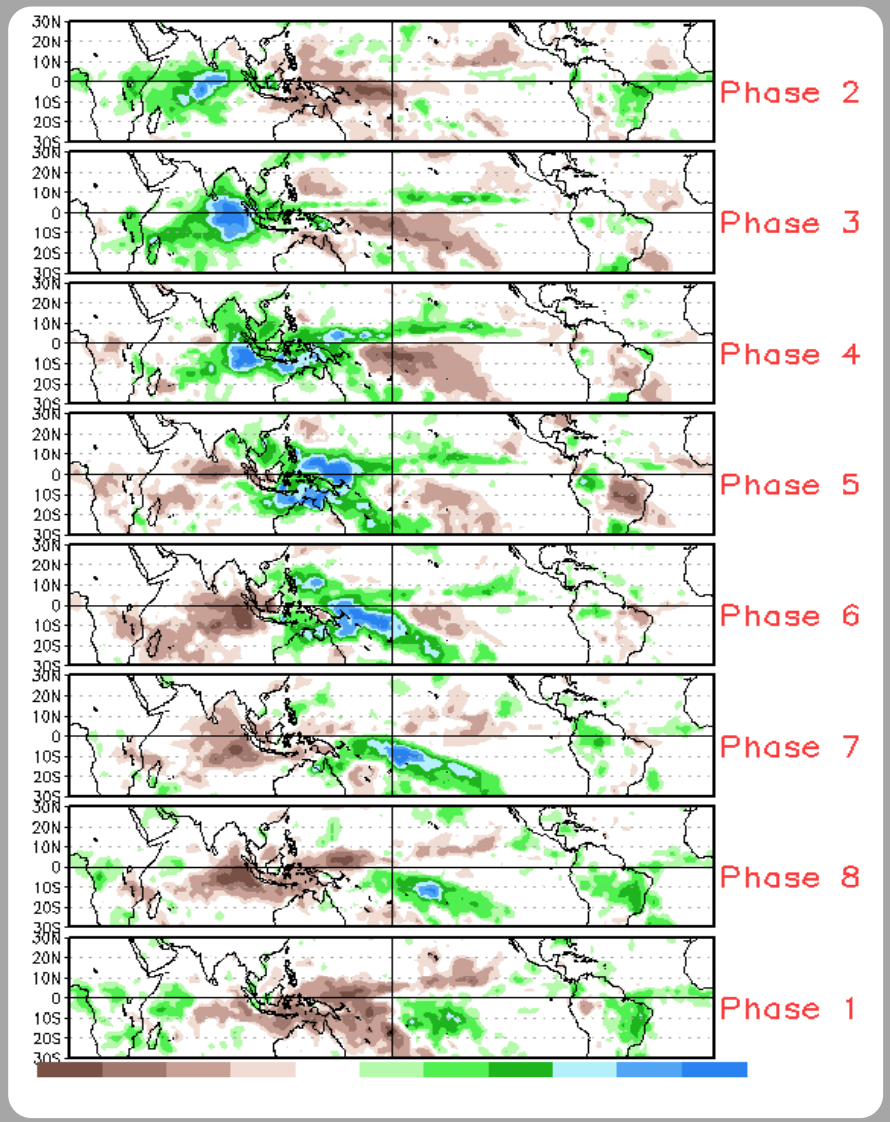
The constructed analog also supports the eastward propagation of the MJO signal, though the forecast is slightly faster than the GEFS. It also shows increased amplitude of the signal into Week-2.

MJO Composites - Global Tropics

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



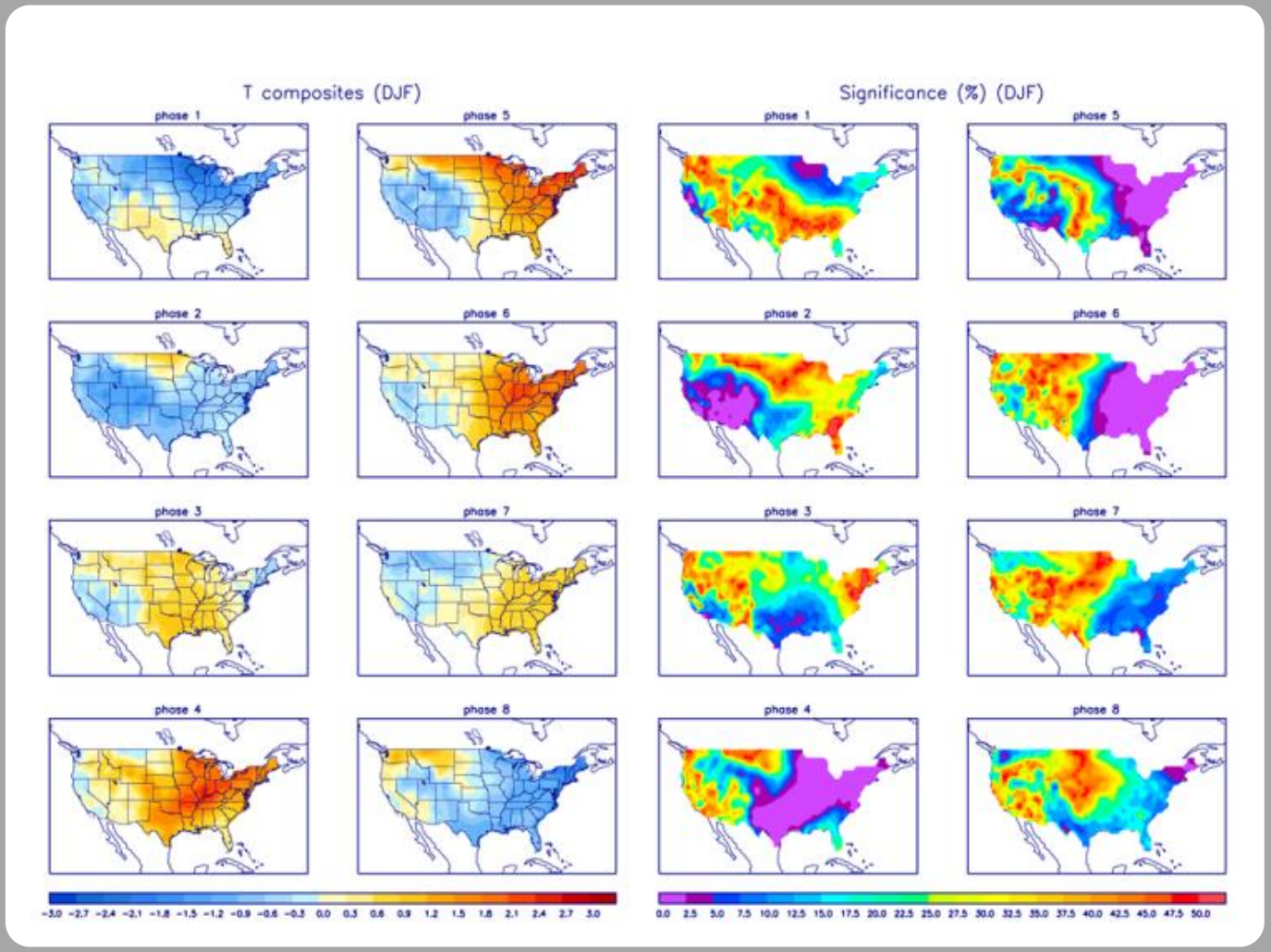
Precipitation Anomalies (Nov - Mar)



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.



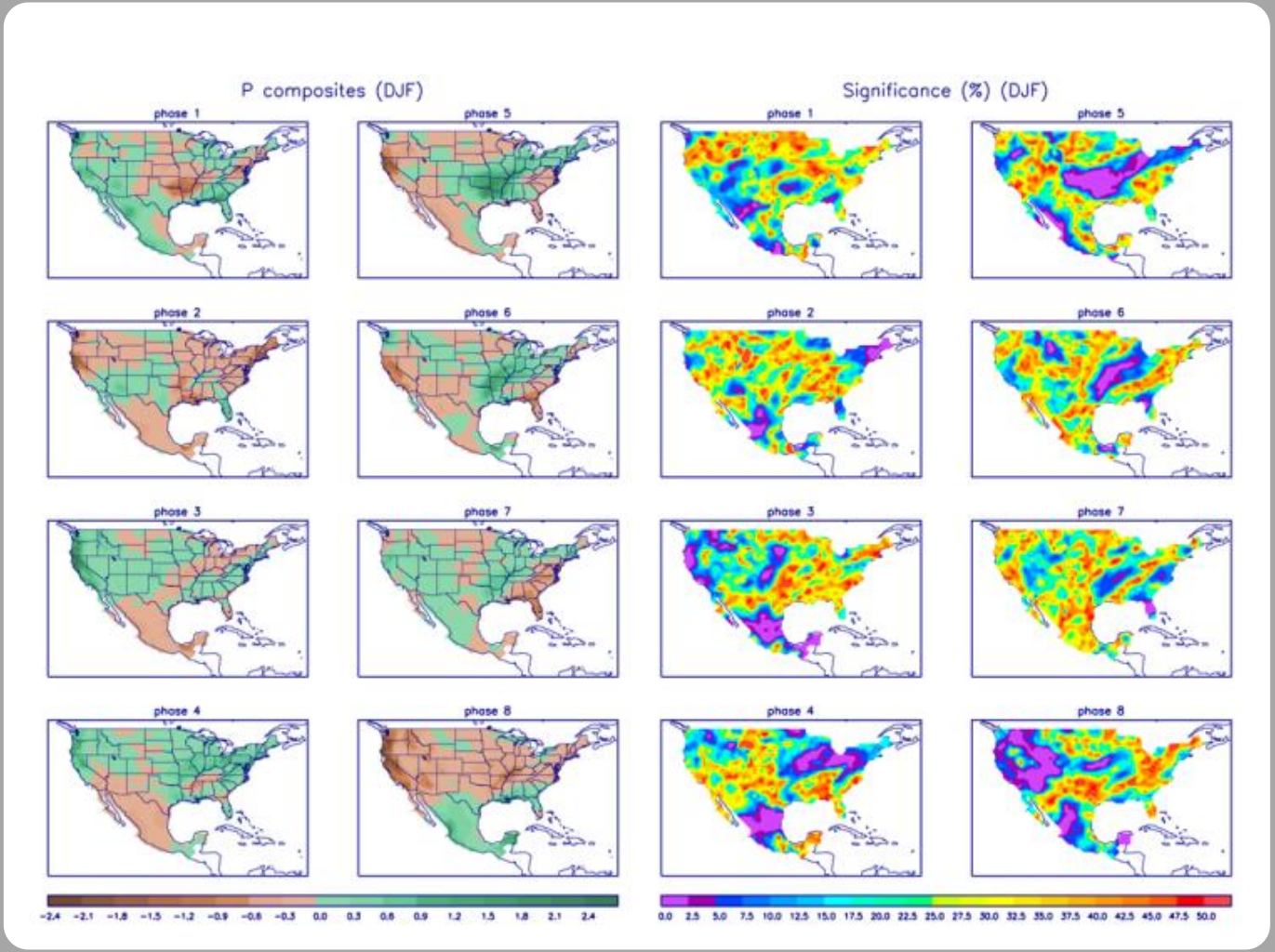
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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