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

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Outline

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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The MJO is in RMM Phase 3 with active convection over the Indian Ocean.
- Dynamical guidance is in good agreement that convection will break up as the MJO moves over the Maritime Continent.
- The constructed analog, a statistical forecast tool, predicts the MJO to continue over the Maritime Continent at roughly its current amplitude. It's not clear which of these forecasts is most likely to be correct since dynamical models often have difficulty forecasting this stage of the MJO.

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})

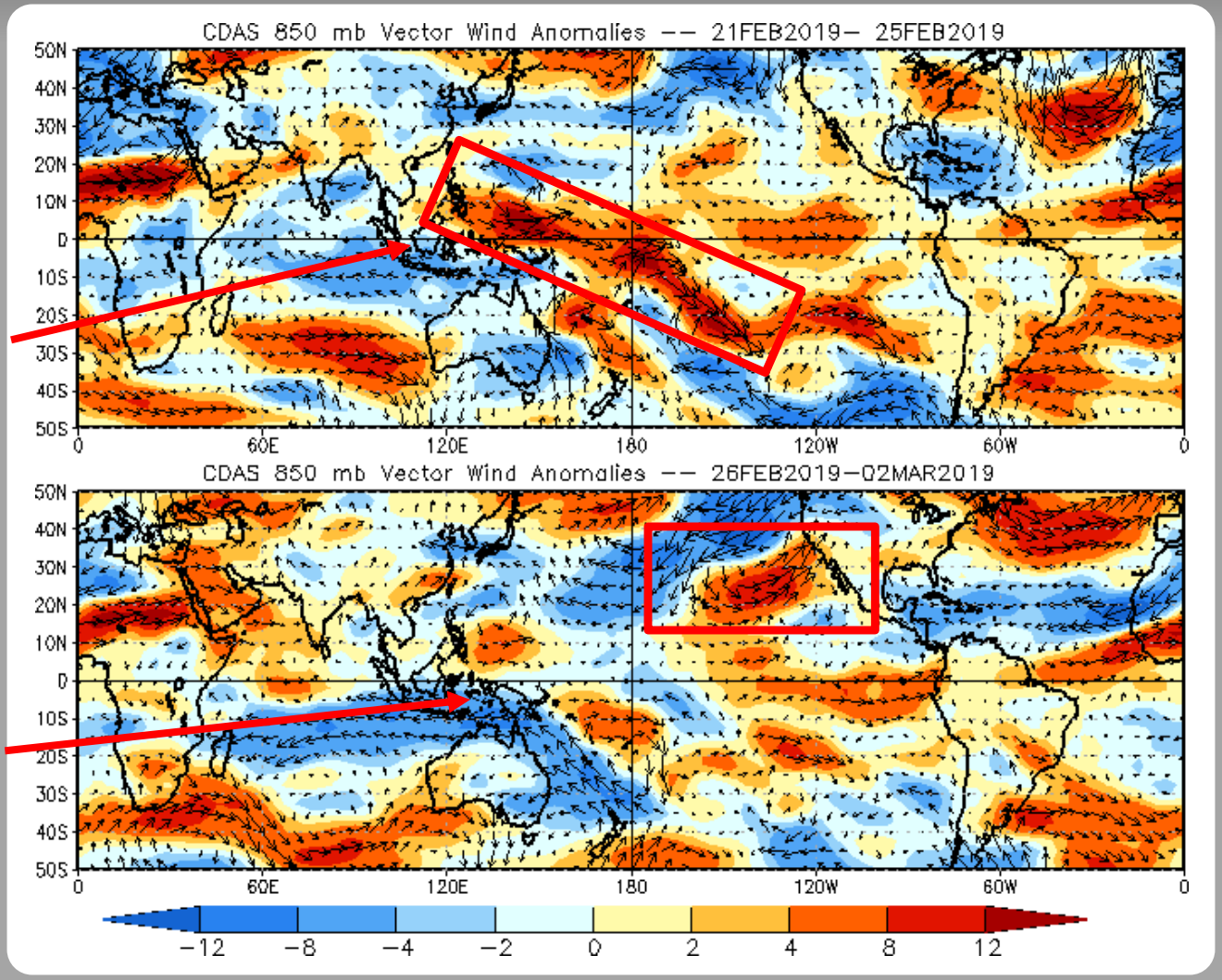
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

There was anomalous cross-equatorial flow in the western Pacific during late Februrary.

The anomalous tropical flow into California contributed to their recently observed enhanced heavy precipitation.



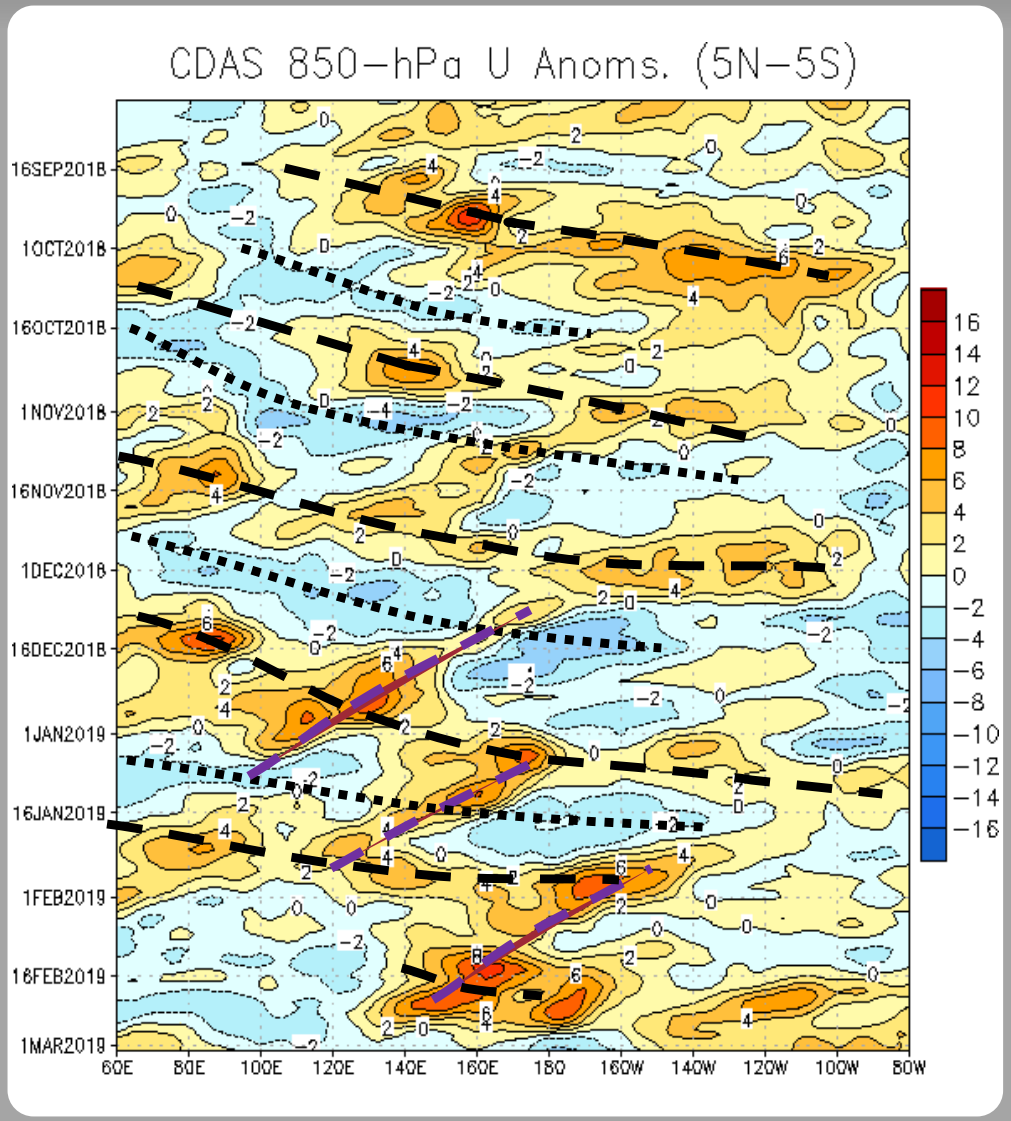
850-hPa Zonal Wind Anomalies (m s^{-1})

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

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

Periodic easterly moving features consistent with the MJO have been evident since mid-September, while westward-moving equatorial Rossby wave activity has increased since early December. Westerly anomalies have been generally present west of the Date Line throughout the period, aside from periods of destructive interference by intraseasonal modes, consistent with El Niño.

A westerly wind burst event centered near 160°E weakened, in conjunction with an equatorial Rossby wave, during the past couple of days.



OLR Anomalies – Past 30 days

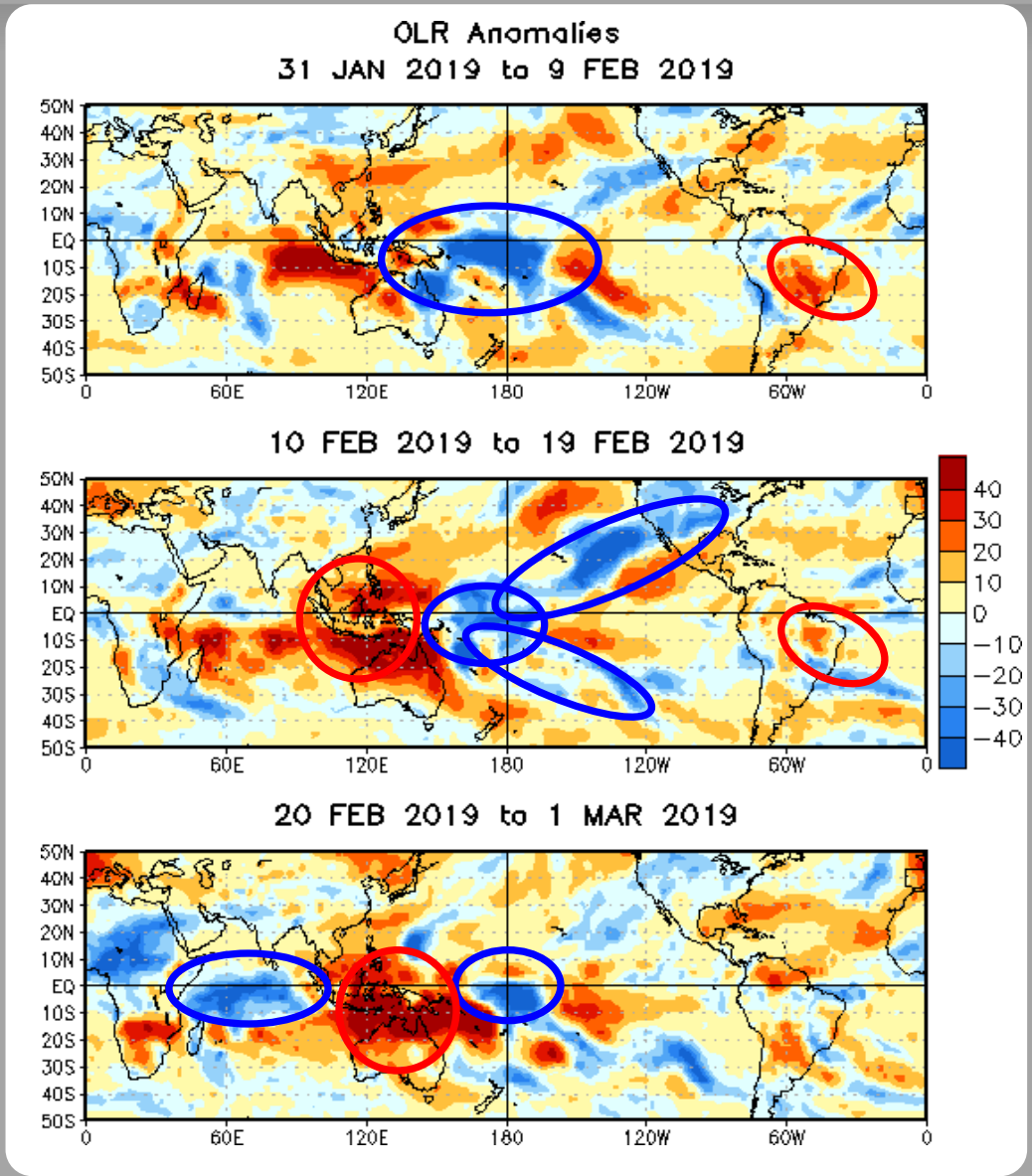
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

By early February, enhanced convection across the Maritime Continent was tied to the active phase of the MJO. Suppressed convection persisted over parts of Brazil and the South Atlantic until mid-February.

Mid-February, robust enhancement of convection was observed in the West Pacific, linked to constructive interference of El Nino, equatorial Rossby wave activity, and the MJO. This enhanced convection extended poleward and eastward in both hemispheres. A suppressed convective signal grew over the eastern Indian Ocean and Maritime Continent.

Suppressed convection associated with the MJO dominated the Maritime Continent during late February, while enhanced convection overspread the Indian Ocean.



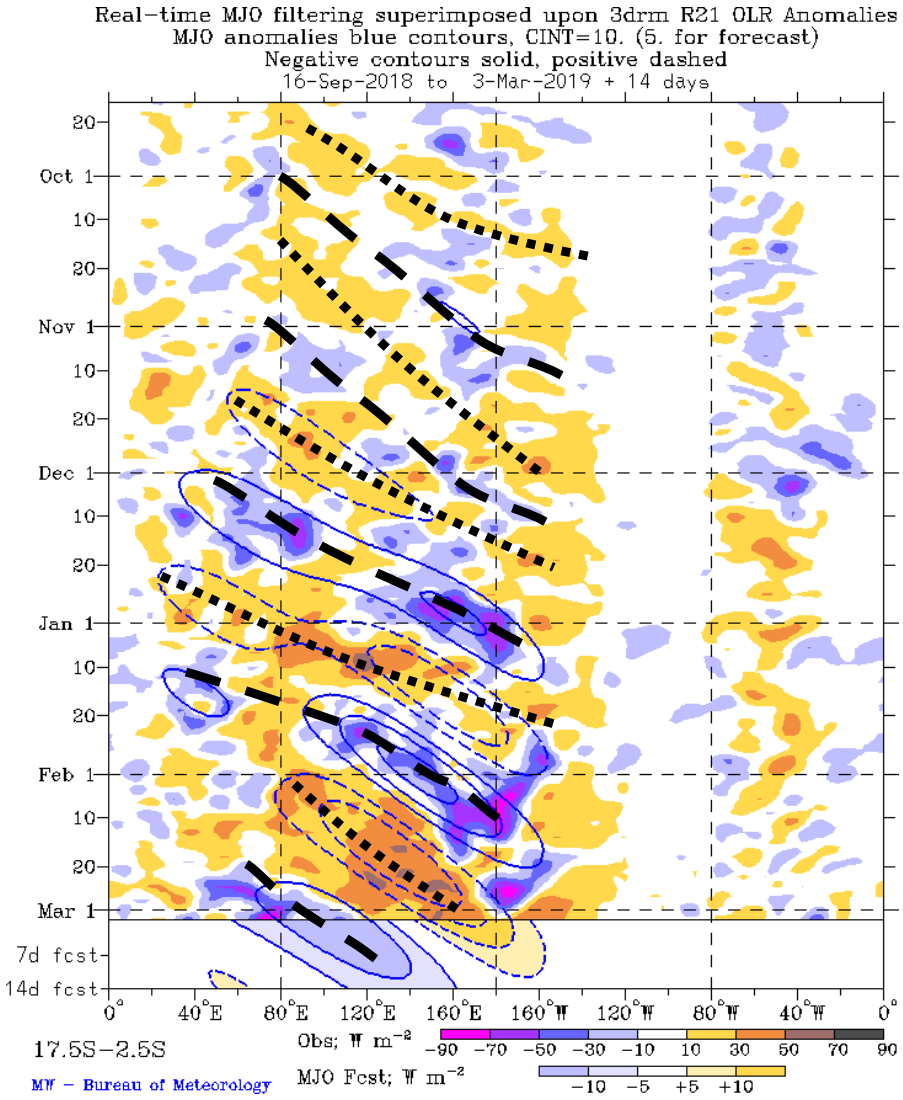
Outgoing Longwave Radiation (OLR) Anomalies (2.5°S - 17.5° S)

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

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

Since September, the MJO signal has seen alternative active and inactive phases crossing the Indian Ocean through the Central Pacific and influencing the convection for these regions.

An equatorial Rossby wave near 155°W drifted westward during late January. Another appeared in mid-February, but suppressed convection from the MJO destructively interfered with the ER wave and its signal in OLR field disappeared around March 1.



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

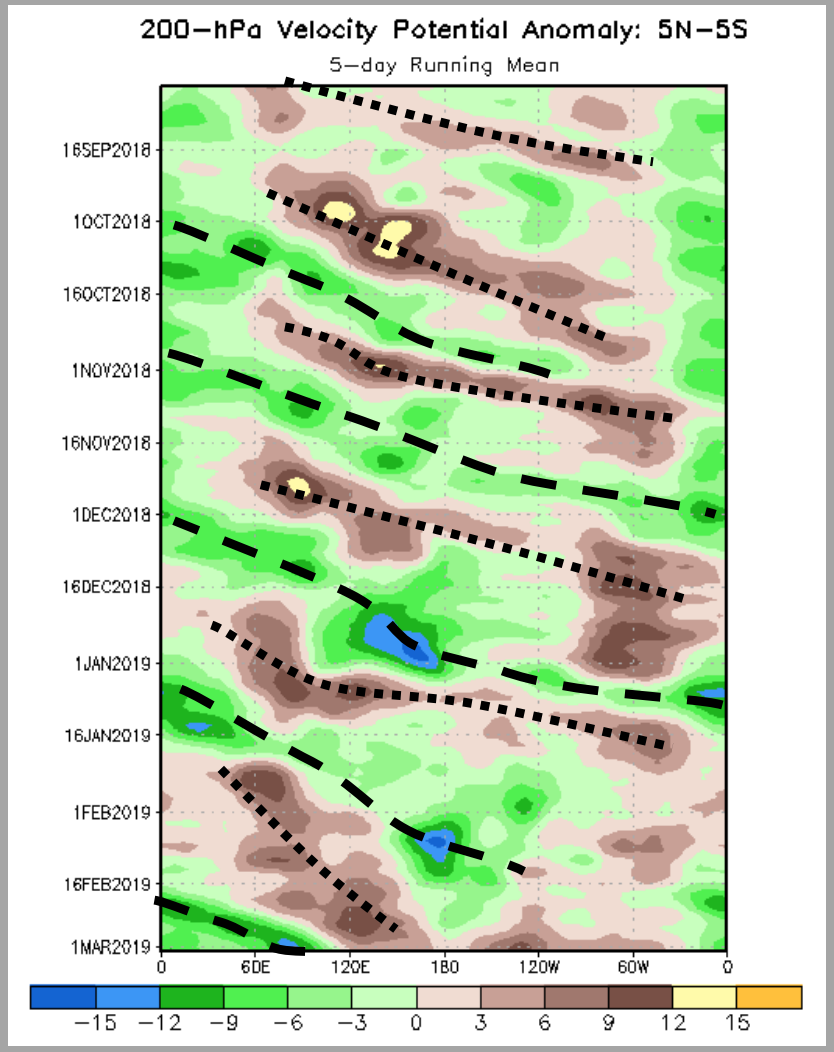
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

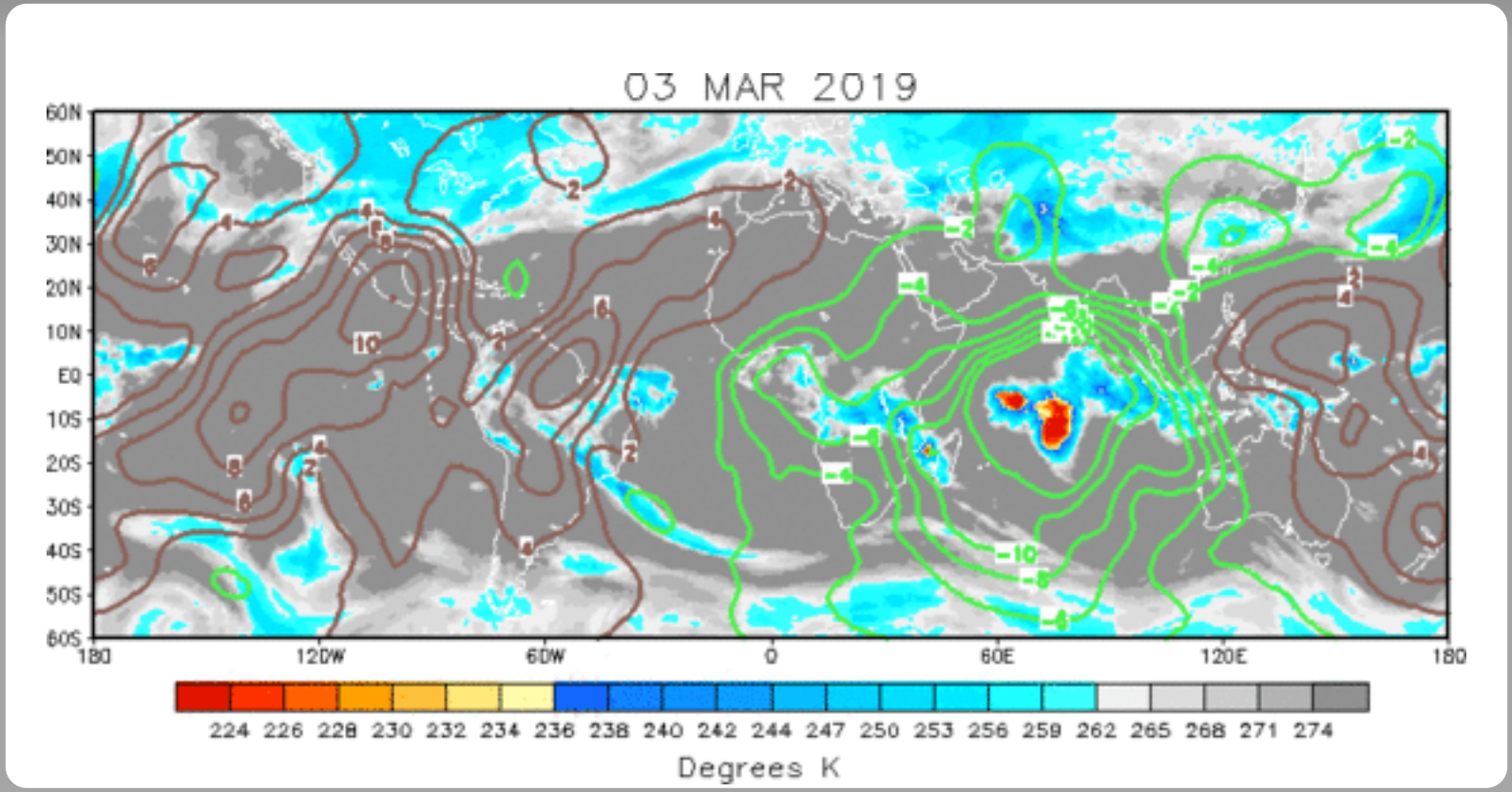
MJO activity since early September continues through early 2019, as does the persistent conditions tied to El Niño that favor convection near the Date Line (aside from when the inactive envelope of the MJO is present).

Equatorial Rossby wave activity also shows up here, with constructive interference of the MJO and Rossby wave activity resulting in the most prominent enhancement of observed velocity potential signatures near 160°E in late December and near the Date Line around the 10th of February.

Most recently, active convection associated with the MJO surfaced in mid-February over Africa and continues to propagate eastward into the Indian Ocean.



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



The upper velocity potential field shows a Wave-1 pattern with convection anchored over the Indian Ocean by the MJO, which is in RMM Phase 3.

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})

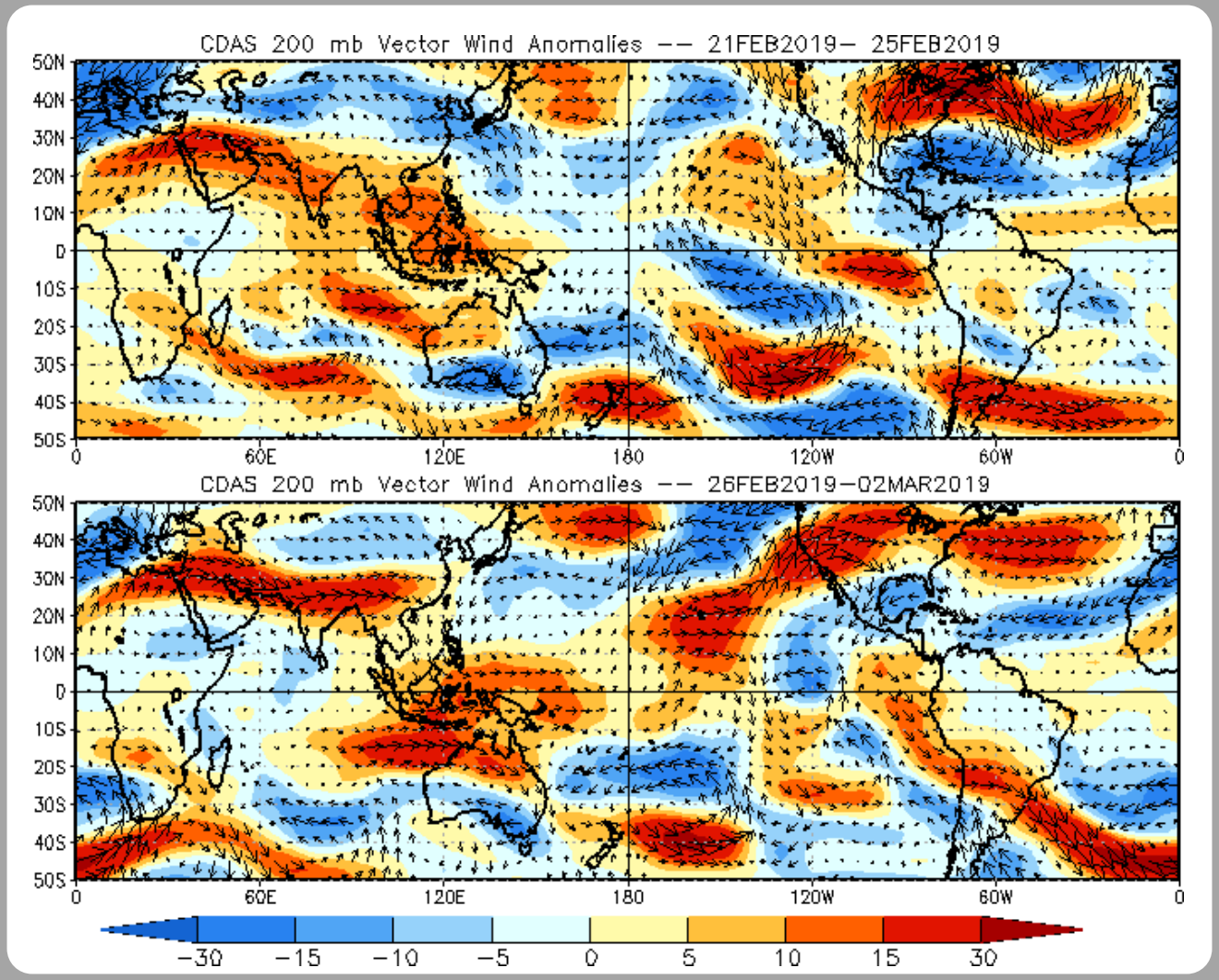
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Southerly tropical flow into Mexico during late February shifted northwestward to direct moisture into California during the turn of the month.

Cross equatorial flow, partially associated with persistent mid-latitude wave breaking, continues over the eastern Pacific.



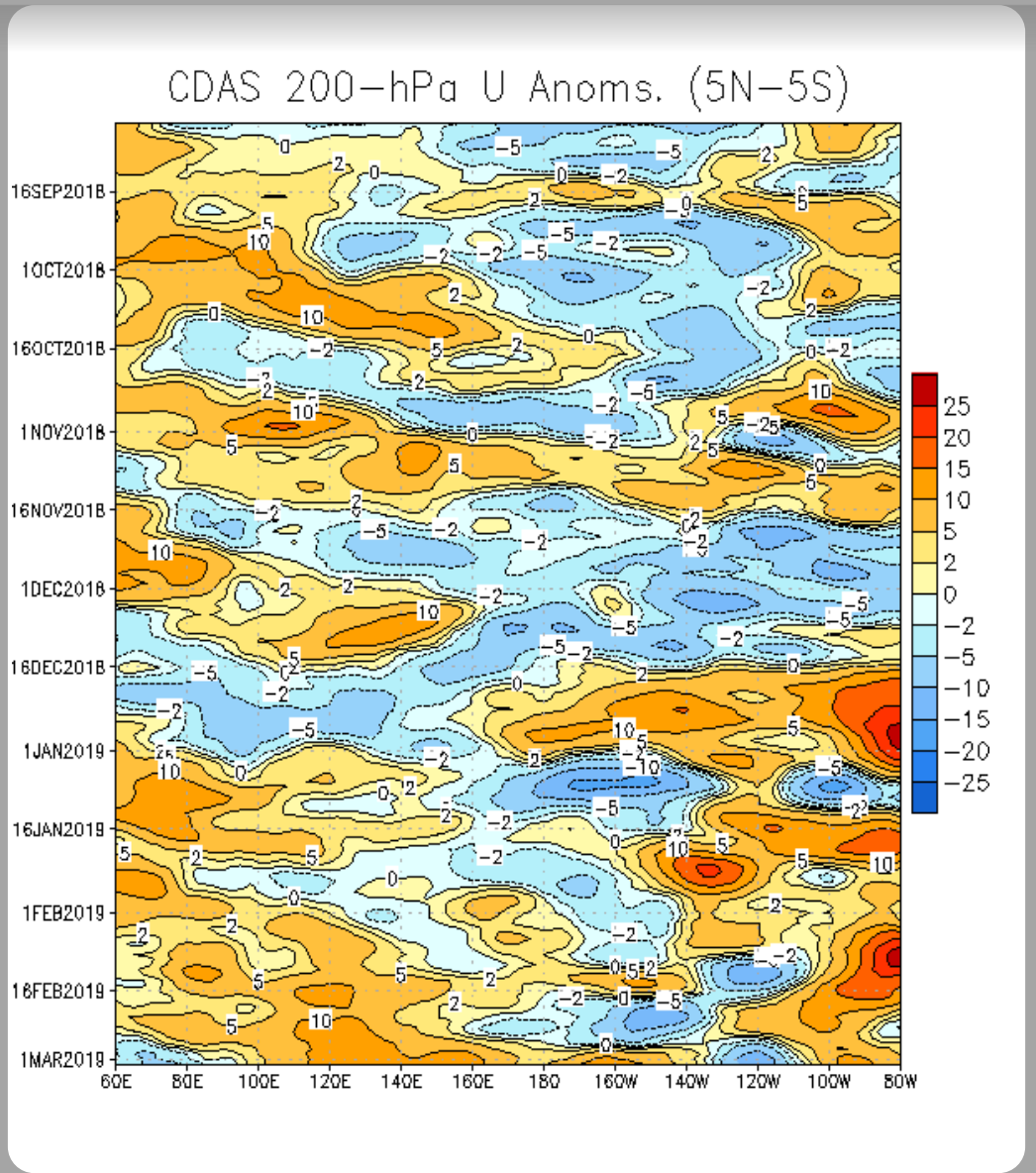
200-hPa Zonal Wind Anomalies (m s^{-1})

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

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

From mid-September through mid-December, upper-level winds have been marked by pronounced eastward-moving intraseasonal activity, interrupted by westward-propagating Rossby waves.

Most recently, anomalous westerlies have grown in coverage to encompass most areas between the Indian Ocean and East Pacific.



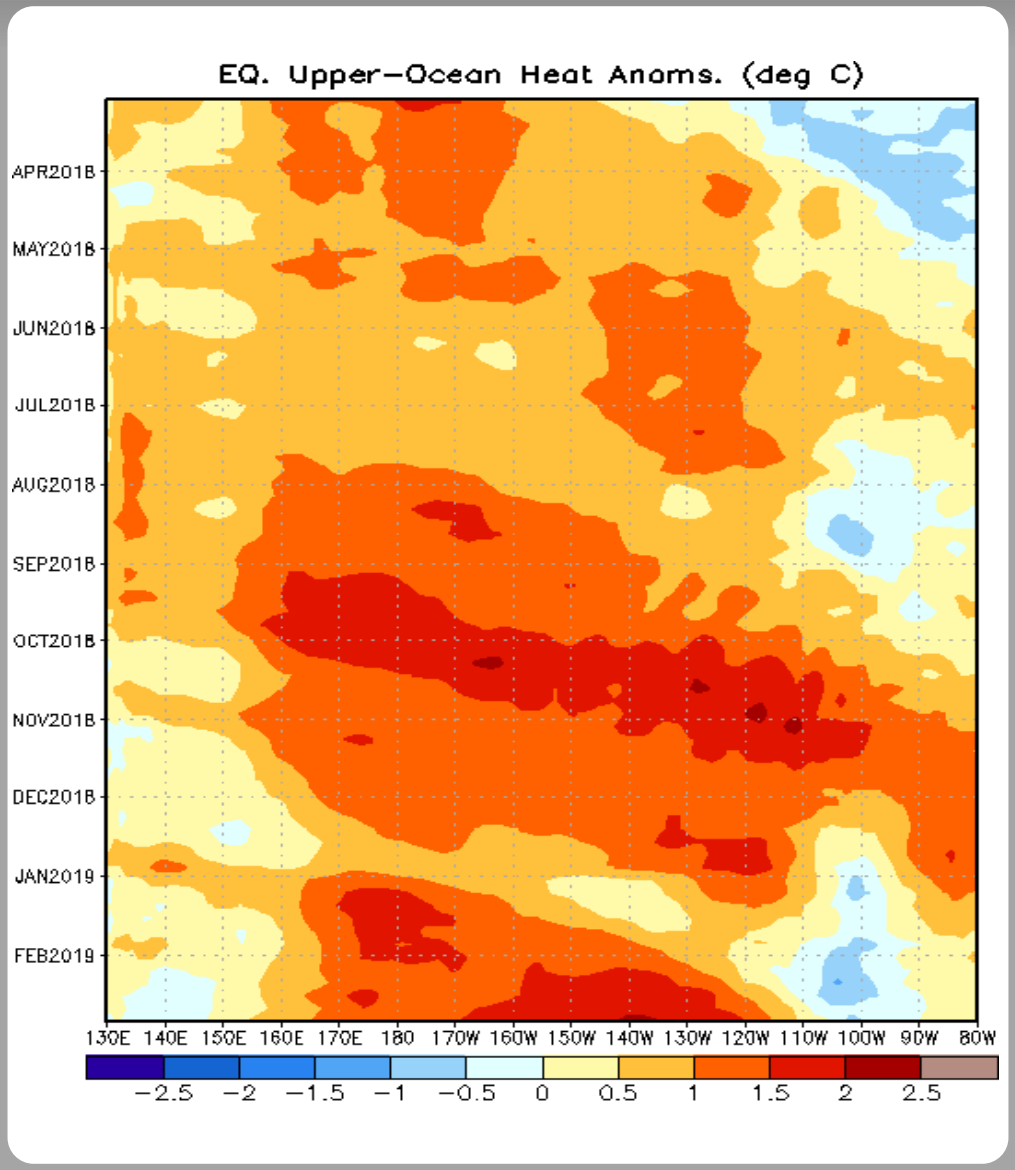
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Positive upper-ocean heat content anomalies have been observed over most of the basin since April 2018.

The westerly wind burst east of New Guinea in September triggered another oceanic Kelvin wave and round of downwelling, helping to reinforce the warm water availability for the current El Niño event.

Another downwelling Kelvin wave is evident since the start of 2019. The strengthened meridional oceanic heat content gradient may be tied to the more robust appearance of low frequency convection since the start of the new year to the east of New Guinea. The downwelling event has failed to reach the far East Pacific however, which retains negatively anomalies.



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

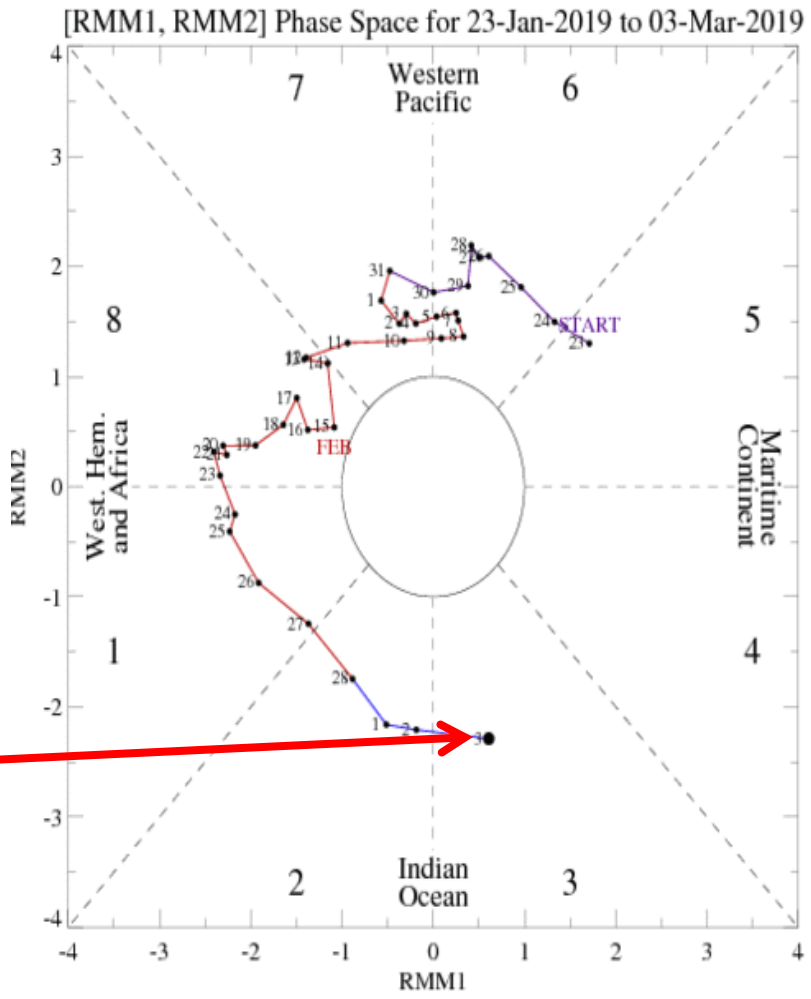
The triangular areas indicate the location of the enhanced phase of the MJO

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

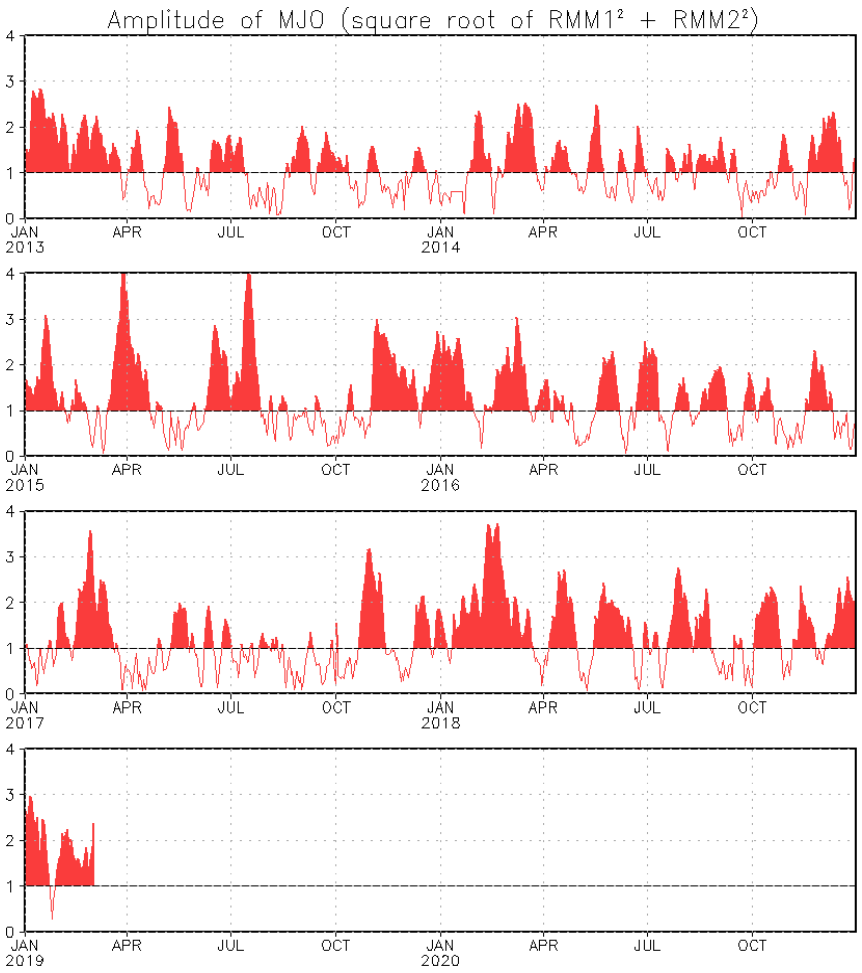
The MJO is in RMM Phase 3 over the Indian Ocean.



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

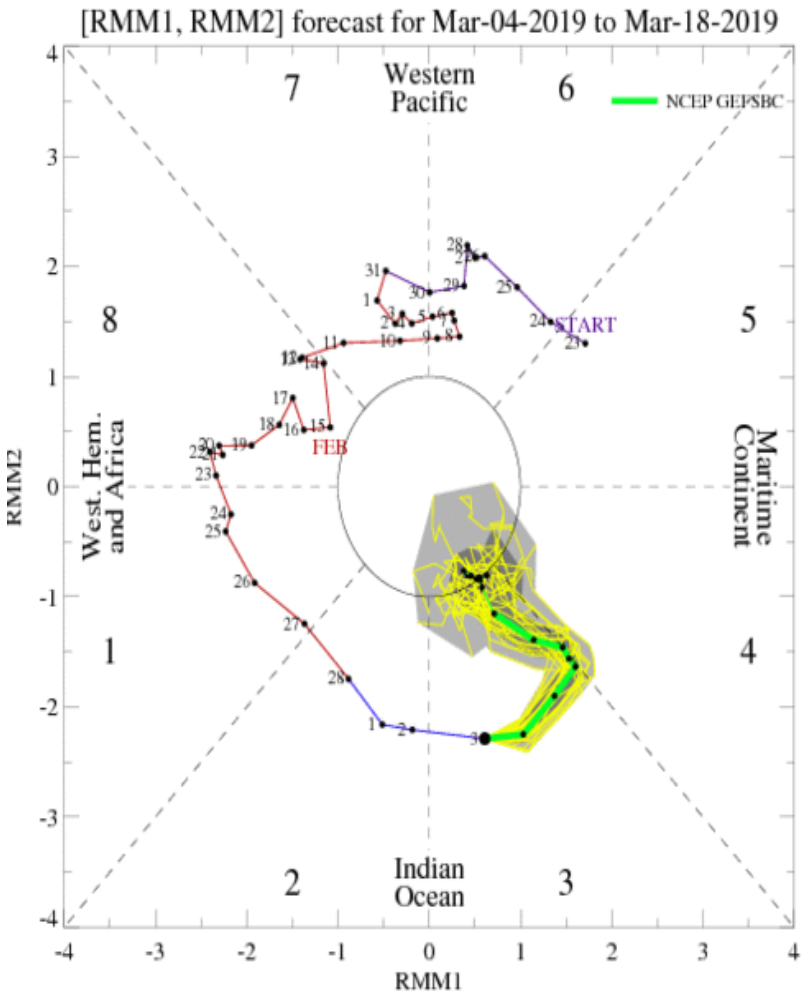
RMM1 and RMM2 values for the most recent 40 days and forecasts from the GFS ensemble system (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

The GEFS forecasts the MJO to weaken as it approaches the Maritime Continent. Dynamical models often have trouble propagating the MJO over the Maritime Continent, so this forecast should be taken with care.

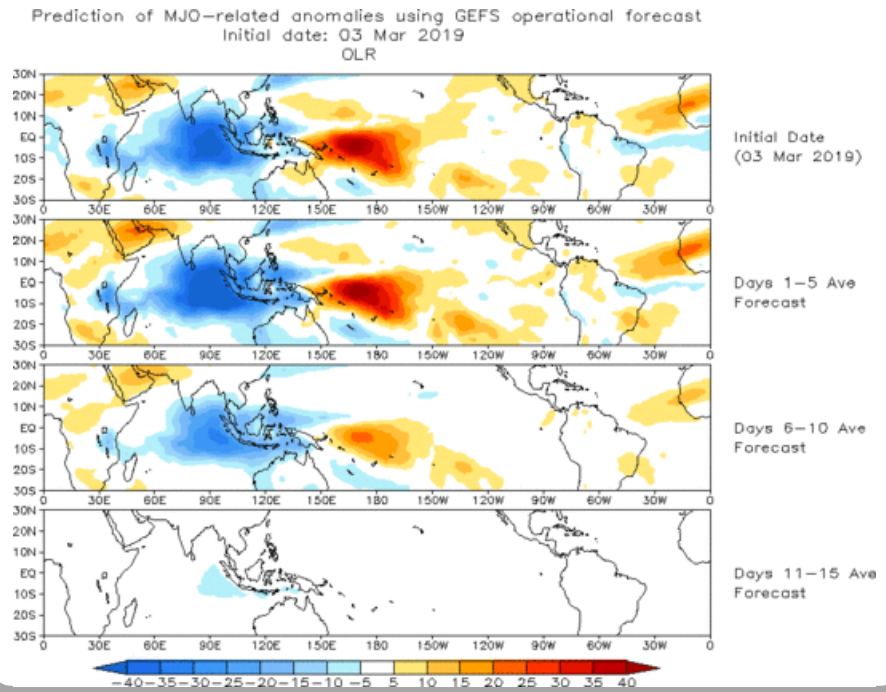
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean



Ensemble GFS (GEFS) MJO Forecast

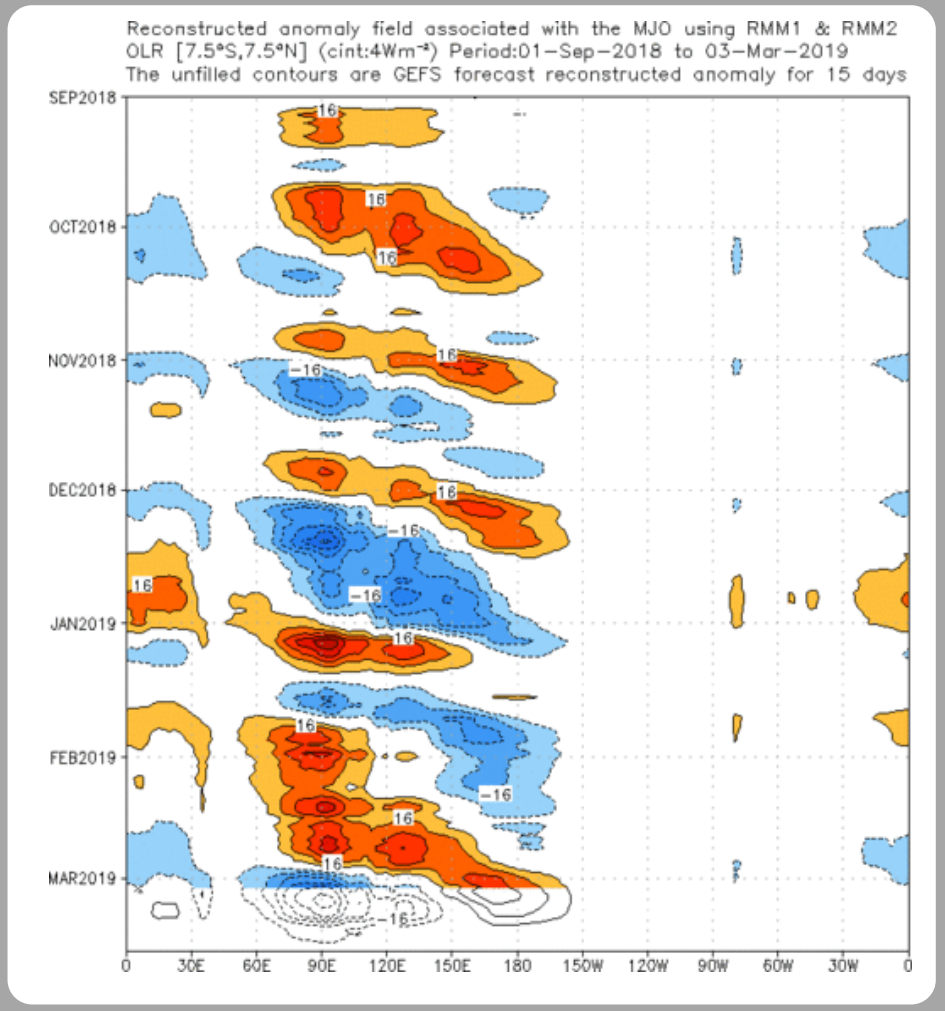
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS spatial forecast matches up with its RMM forecast and weakens convection as it approaches the Maritime Continent.

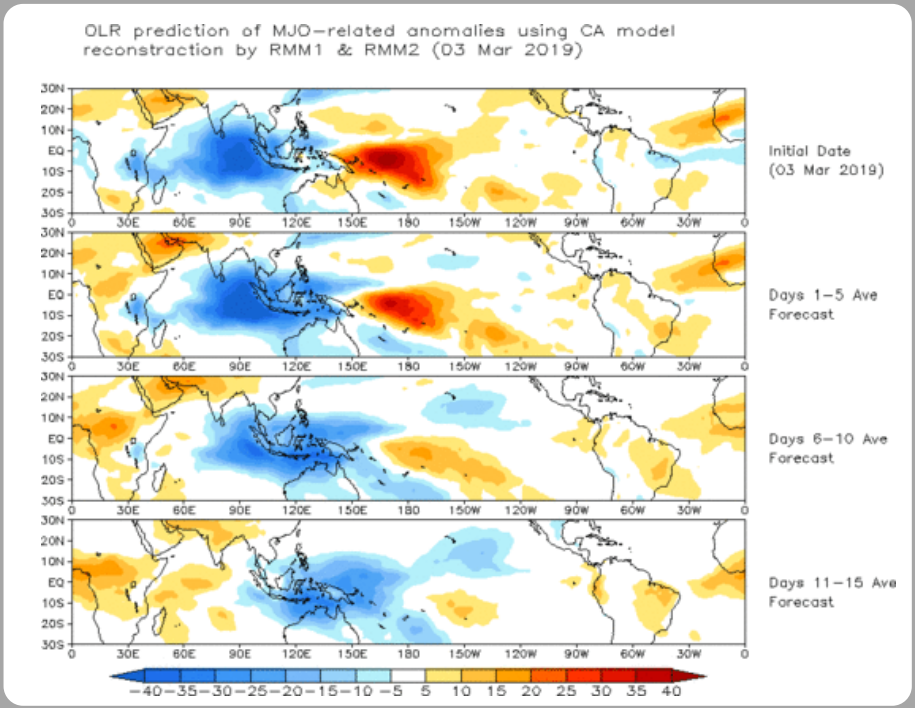
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



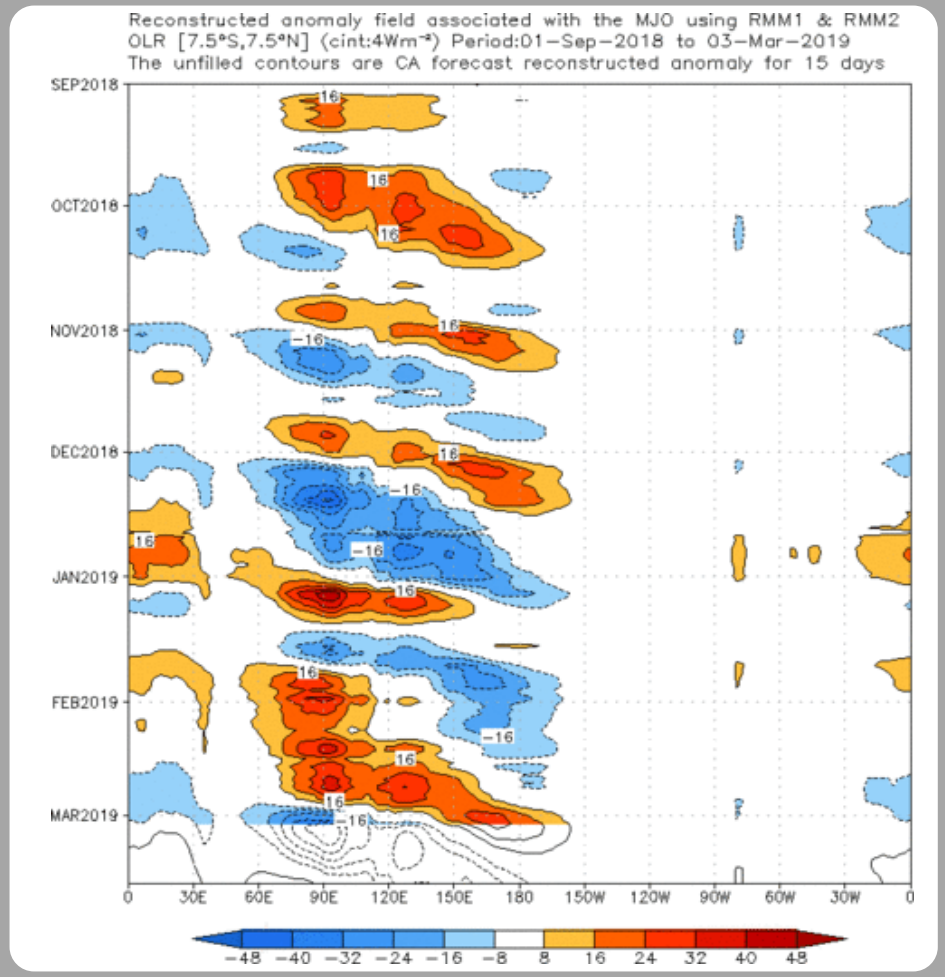
Constructed Analog (CA) MJO Forecast

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



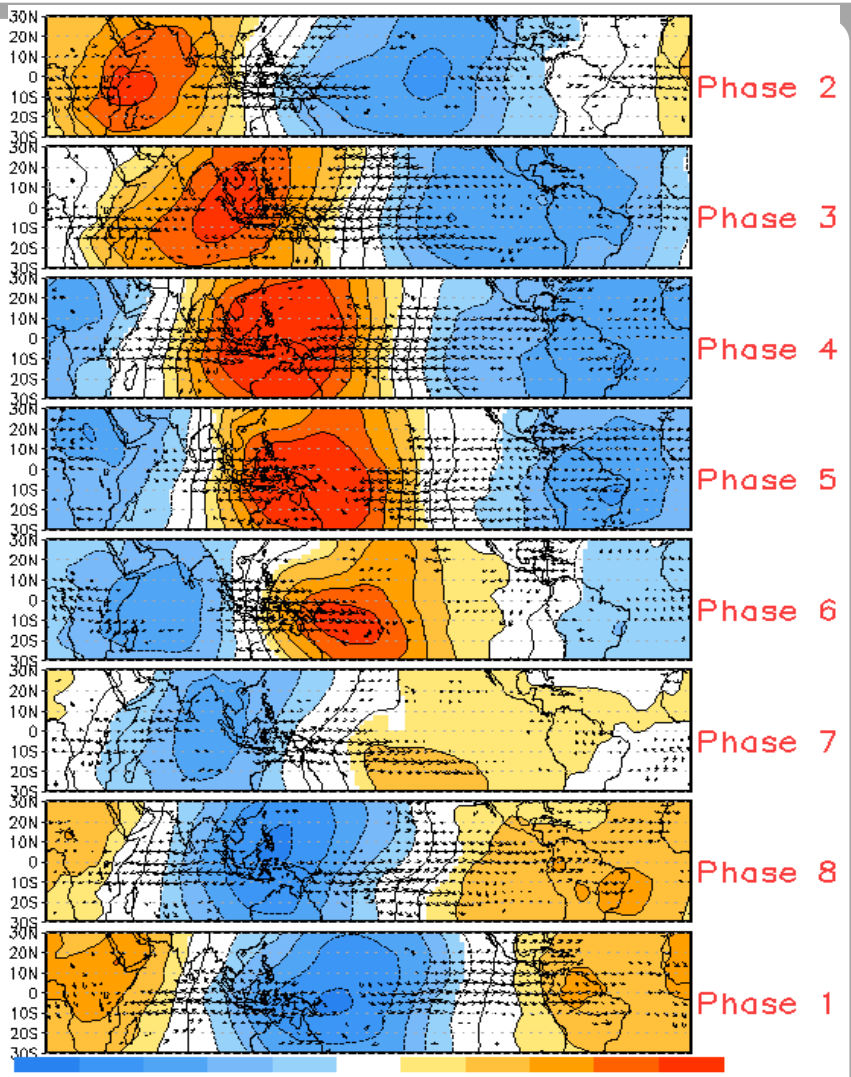
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



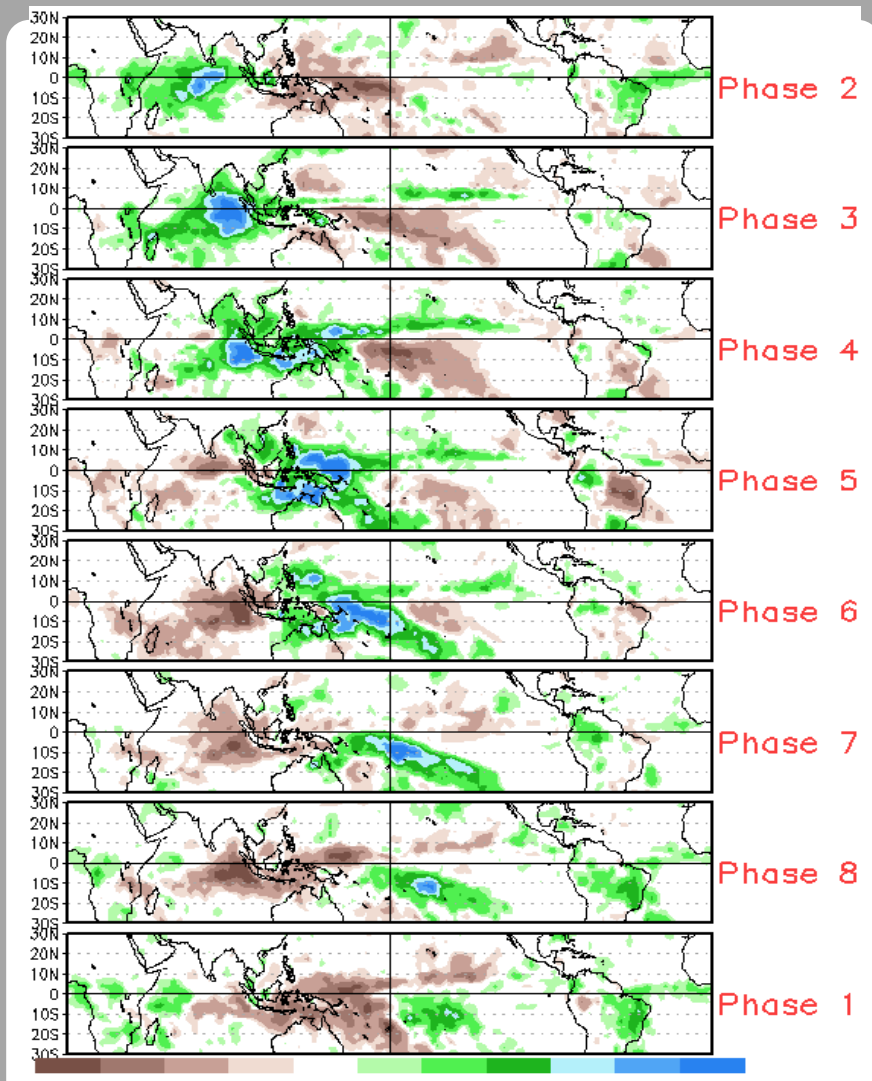
The constructed analog forecasts the MJO to continue over the Maritime Continent, which is different than the dynamical model forecasts. It's good to remember that this is a statistical model and is not subject to the same convection and physics parameterization issues over islands that dynamical models are.

MJO Composites - Global Tropics

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



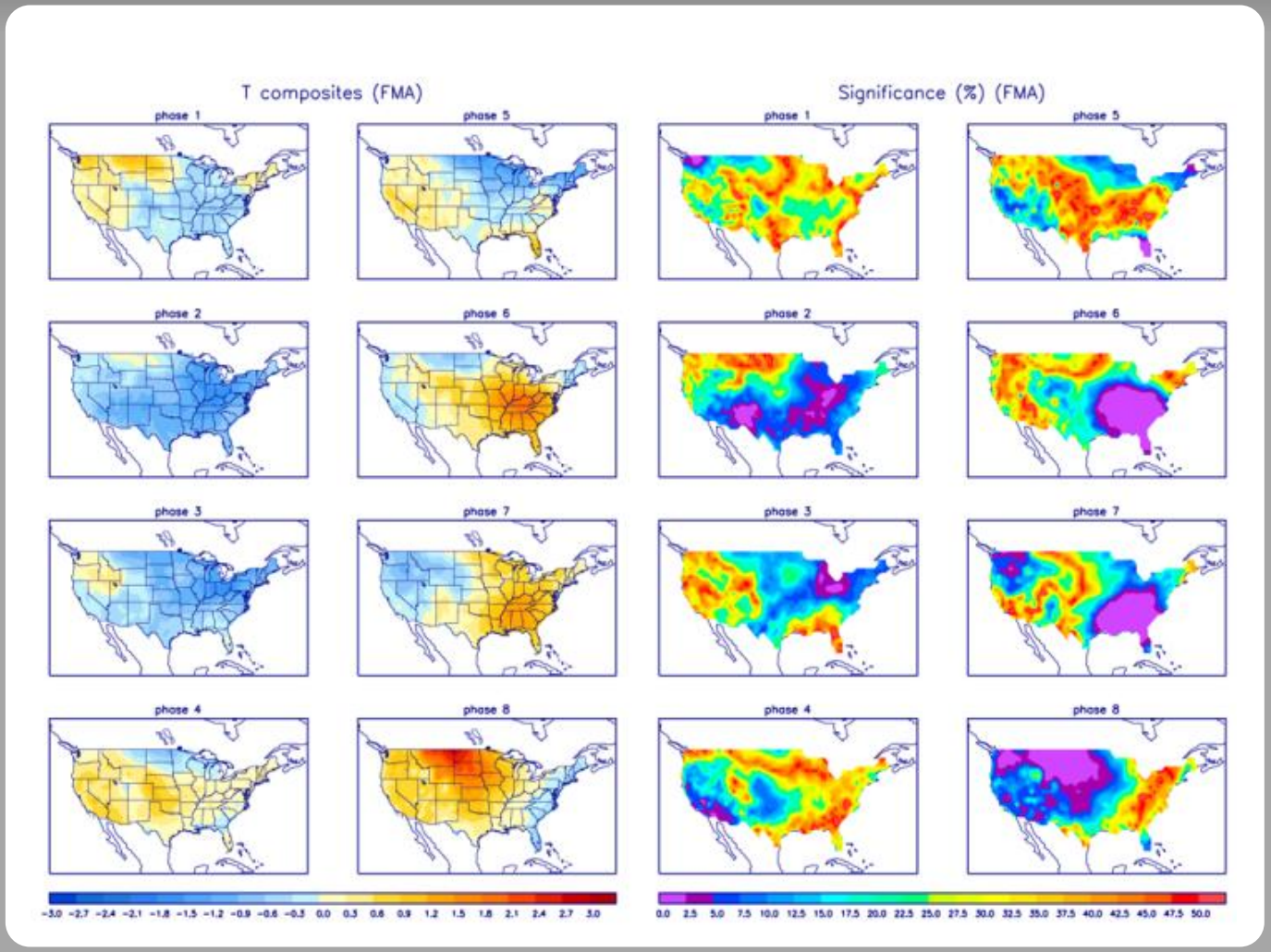
Precipitation Anomalies (Nov - Mar)



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.



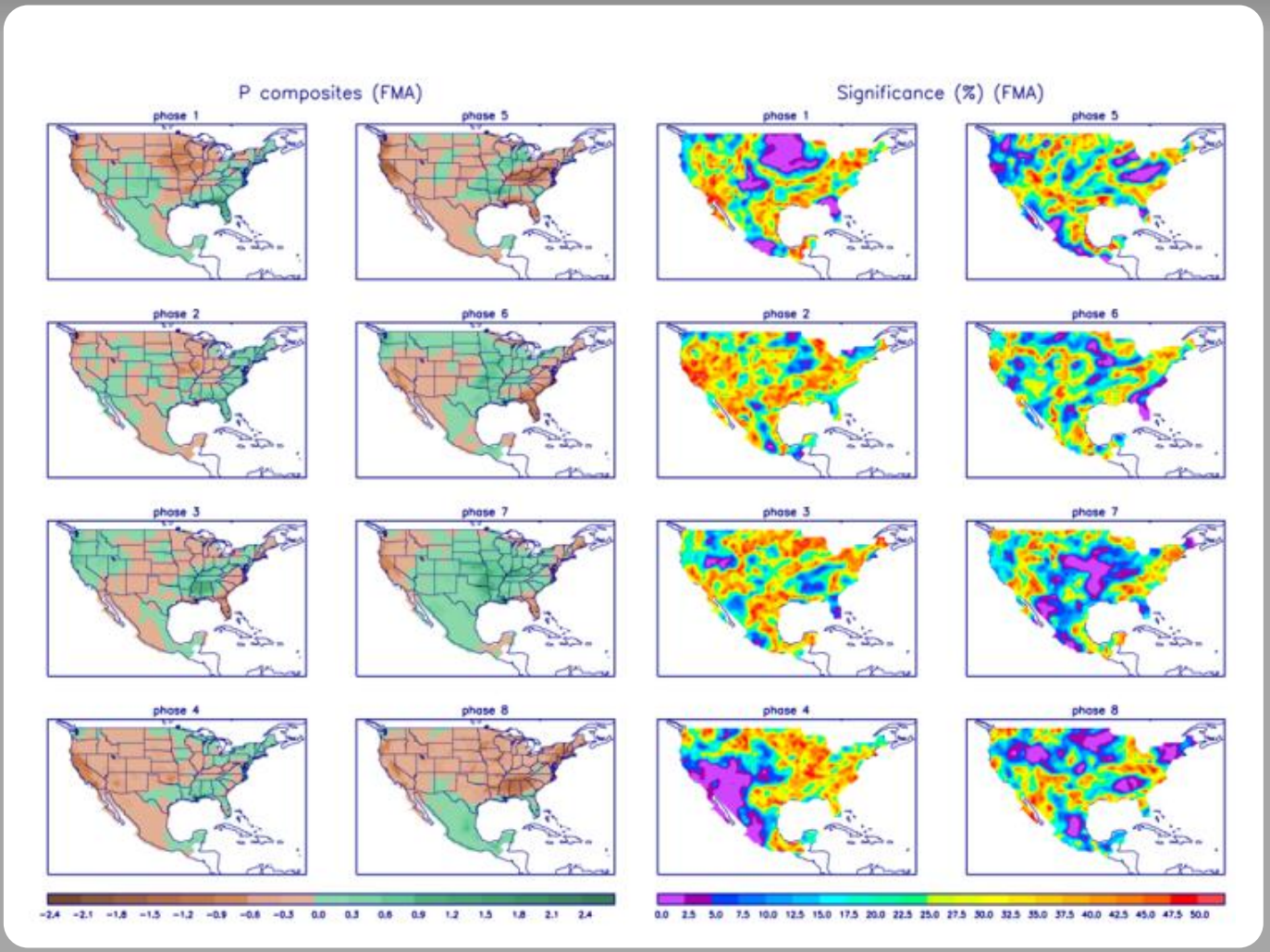
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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