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

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Outline

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Overview

- The MJO increased in amplitude during the past week, with the enhanced phase propagating eastward across Western Hemisphere and Africa. The MJO is expected to propagate eastward across the Indian Ocean to the Maritime Continent over the next two weeks, though there is some uncertainty with regard to strength and phase speed.

- There is minimal tropical cyclone activity over the global tropics at this time, with the official Atlantic and East Pacific hurricane seasons now over. Tropical Cyclone Owen (Solomon Sea/Coral Sea region) is weakening, and no other systems are forecast to develop at this time.

- The MJO is expected to play a role in tropical-extratropical teleconnections over the next several weeks. Short-term colder-than-normal temperatures forecast over the east-central U.S. are consistent with MJO forcing, while the enhanced phase over the Indian Ocean during the next one to two weeks favors a warmer pattern during the second half of December.

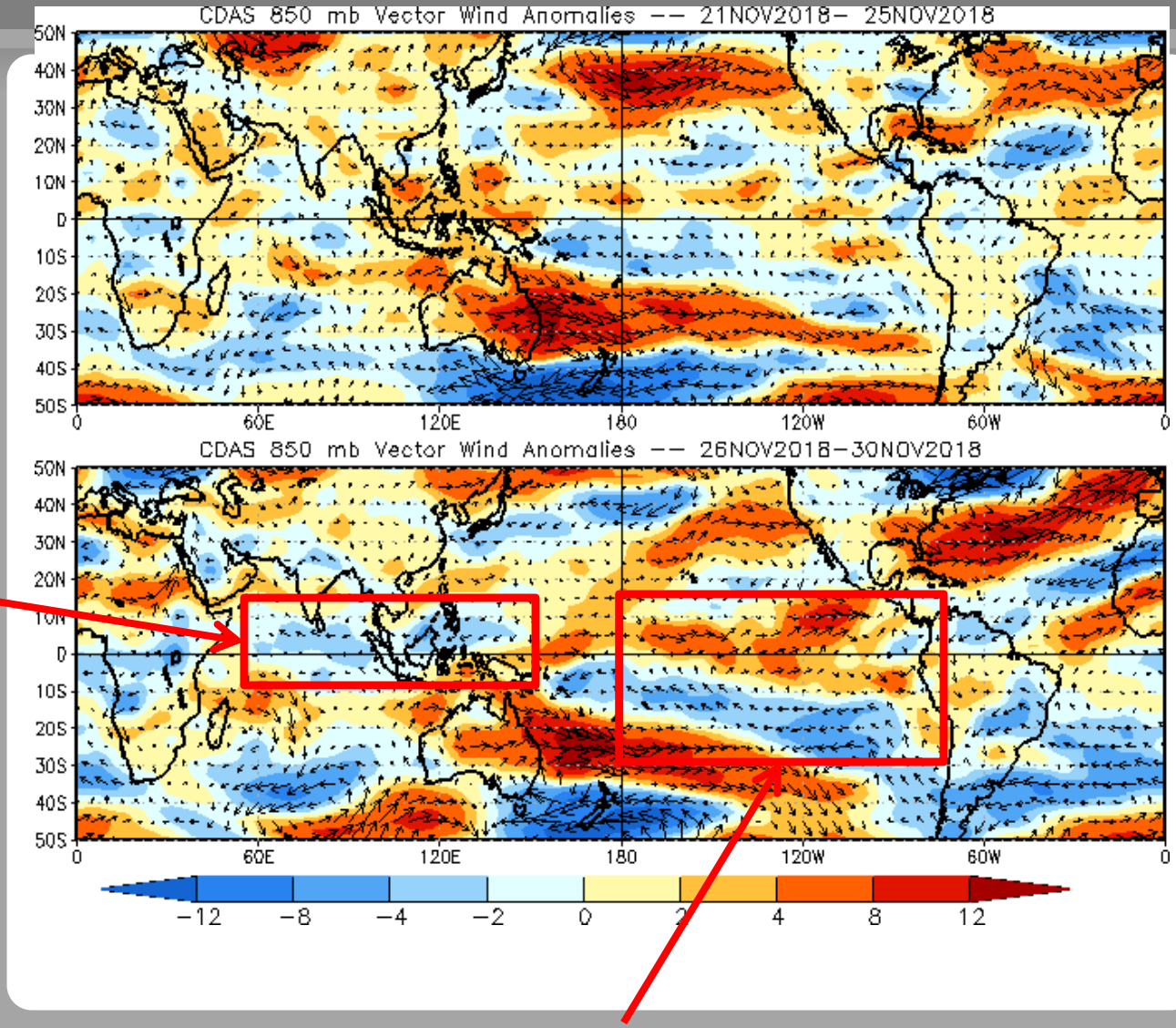
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 easterly winds were observed across the tropical Indian Ocean and Maritime Continent region.

Low-level westerly anomalies strengthened over the central and eastern tropical Pacific, with invigorated easterly anomalies south of there.

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

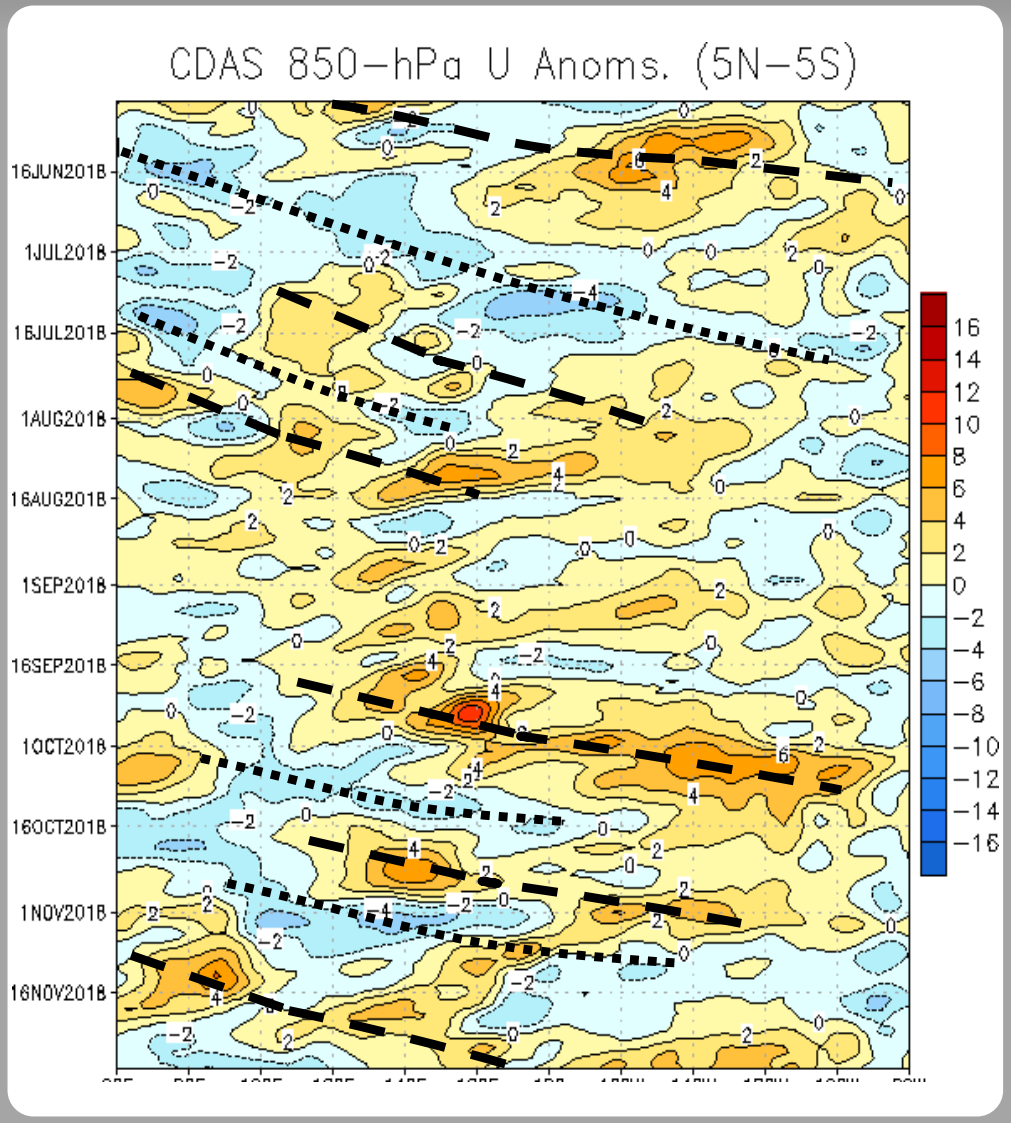
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Westward moving variability weakened the MJO signal in June. A weak intraseasonal signal re-emerged during mid to late July.

From August through mid-September, other modes, including Rossby wave and tropical cyclone activity, influenced the pattern. Another rapidly propagating intraseasonal feature during late September generated robust westerly wind anomalies across the Pacific.

During late September and October, westerly anomalies increased in amplitude and duration over the equatorial Pacific, consistent with a gradual transition towards El Niño conditions. More recently, another robust MJO event interfered with the base state, while Rossby wave activity interfered with the MJO. Easterly anomalies now appear over the Indian Ocean.



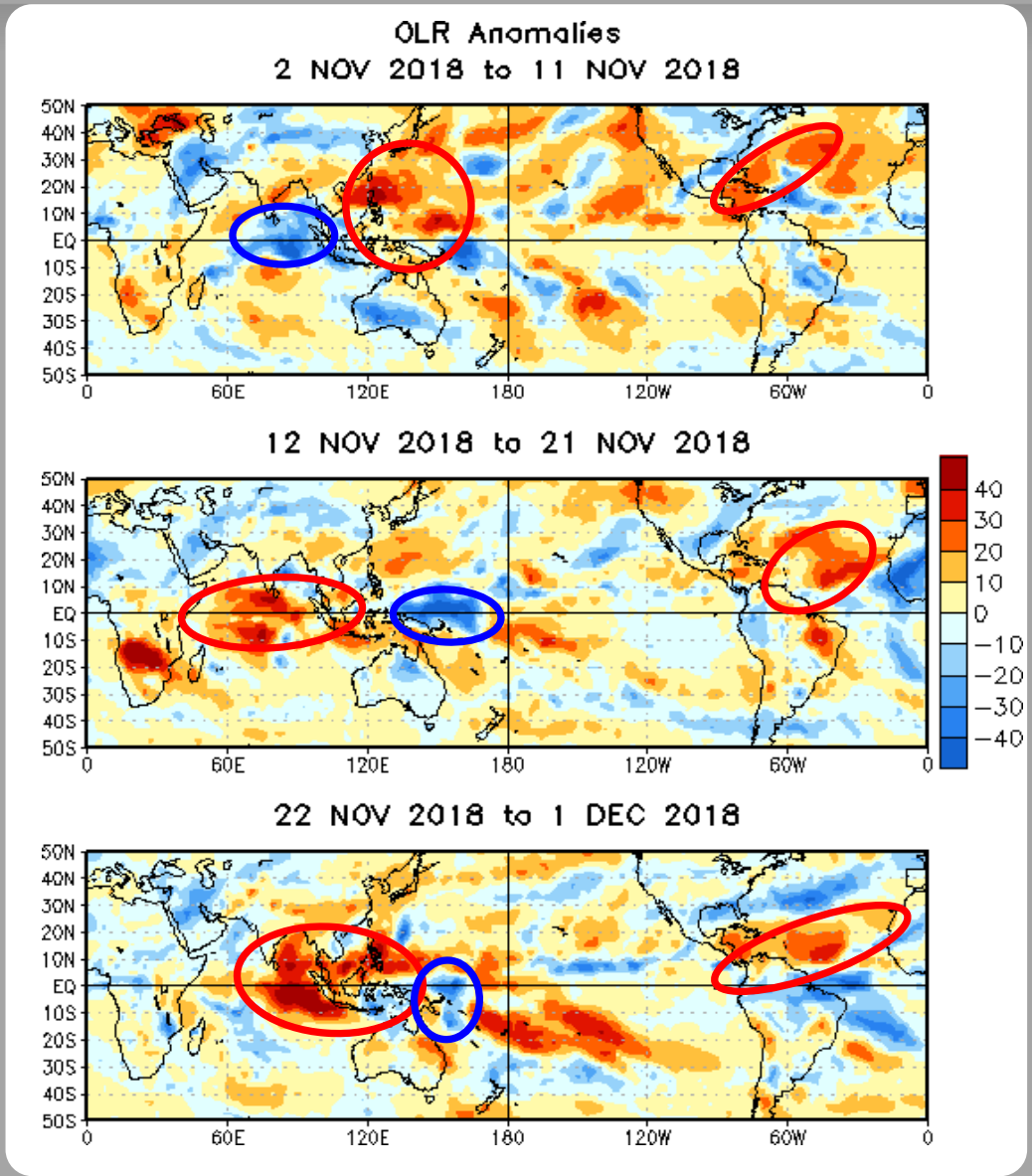
OLR Anomalies – Past 30 days

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

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

During early November, suppressed convection shifted eastward to the West Pacific. A budding MJO event brought an increase in convection to the Indian Ocean. The western North Atlantic quieted down as the latter part of the hurricane season arrived.

An area of enhanced convection persisted over the equatorial West Pacific, due in part to Rossby wave activity. During mid to late November, suppressed (enhanced) convection prevailed across the Indian (Pacific) Ocean. Suppressed convection over the low-latitude North Atlantic was constrained by baroclinic activity to its north.



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

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

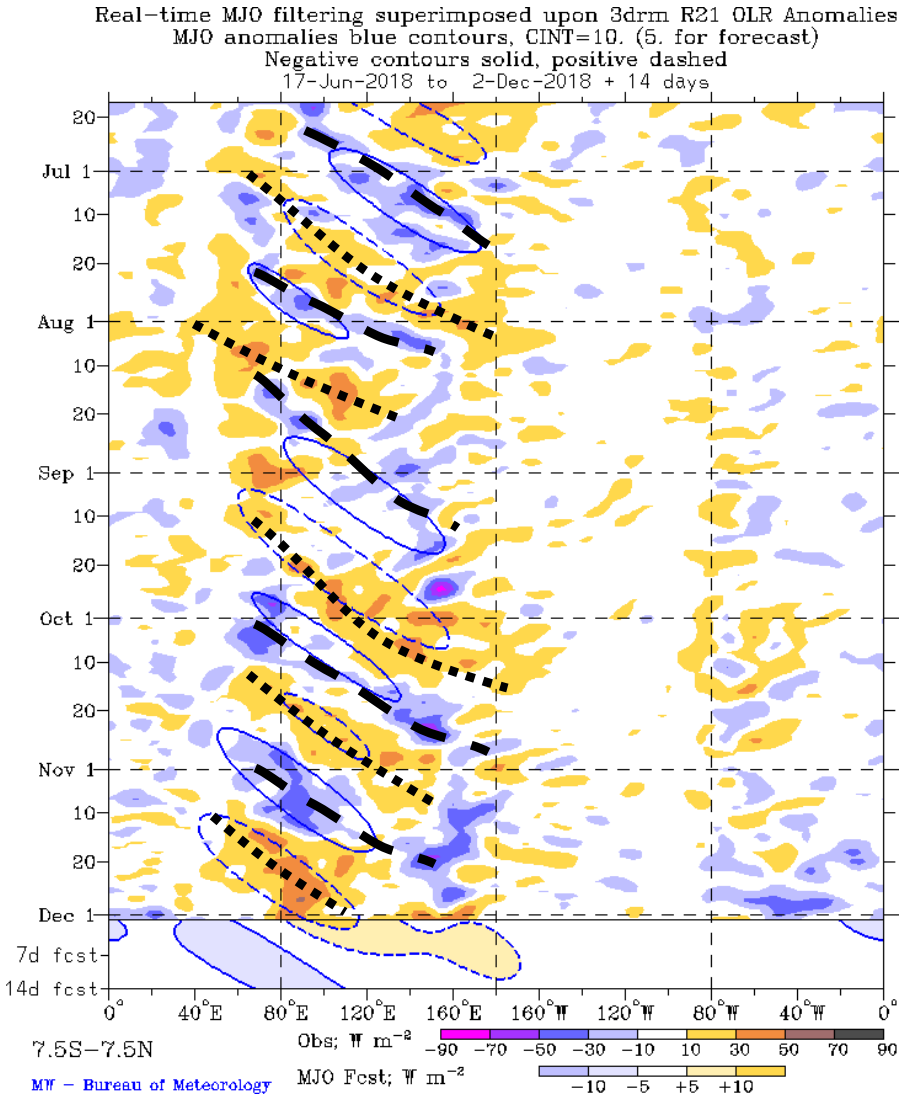
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

The MJO became more active during July.

Kelvin waves, Rossby waves, and tropical cyclones dominated the pattern during August and early September, while the intraseasonal signal remained fairly weak.

During mid-September, the suppressed phase of the MJO emerged over the Eastern Indian Ocean and Maritime Continent. During early October, the suppressed signal propagated further east and enhanced convection emerged over the western Indian Ocean.

During November, the intraseasonal signal re-emerged over the Indian Ocean, and destructively interfered with the base state as the enhanced phase moved across the Maritime Continent. More recently, Rossby wave activity over the West Pacific interfered with the suppressed phase.



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

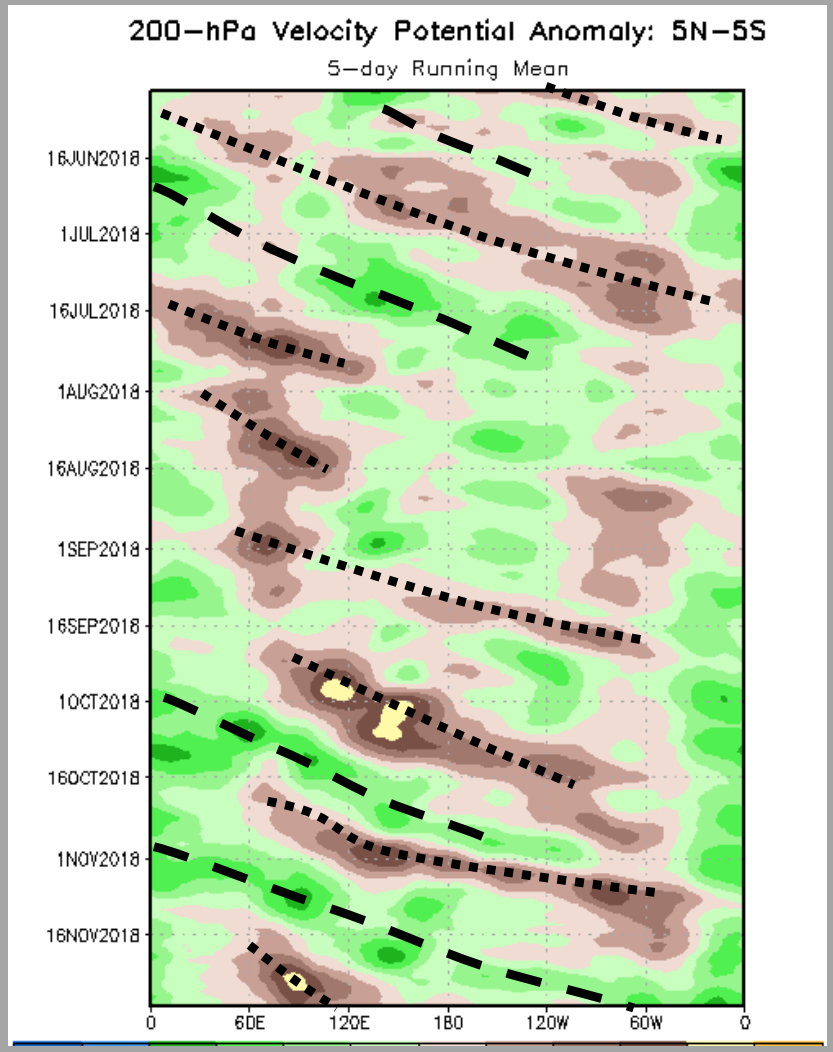
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

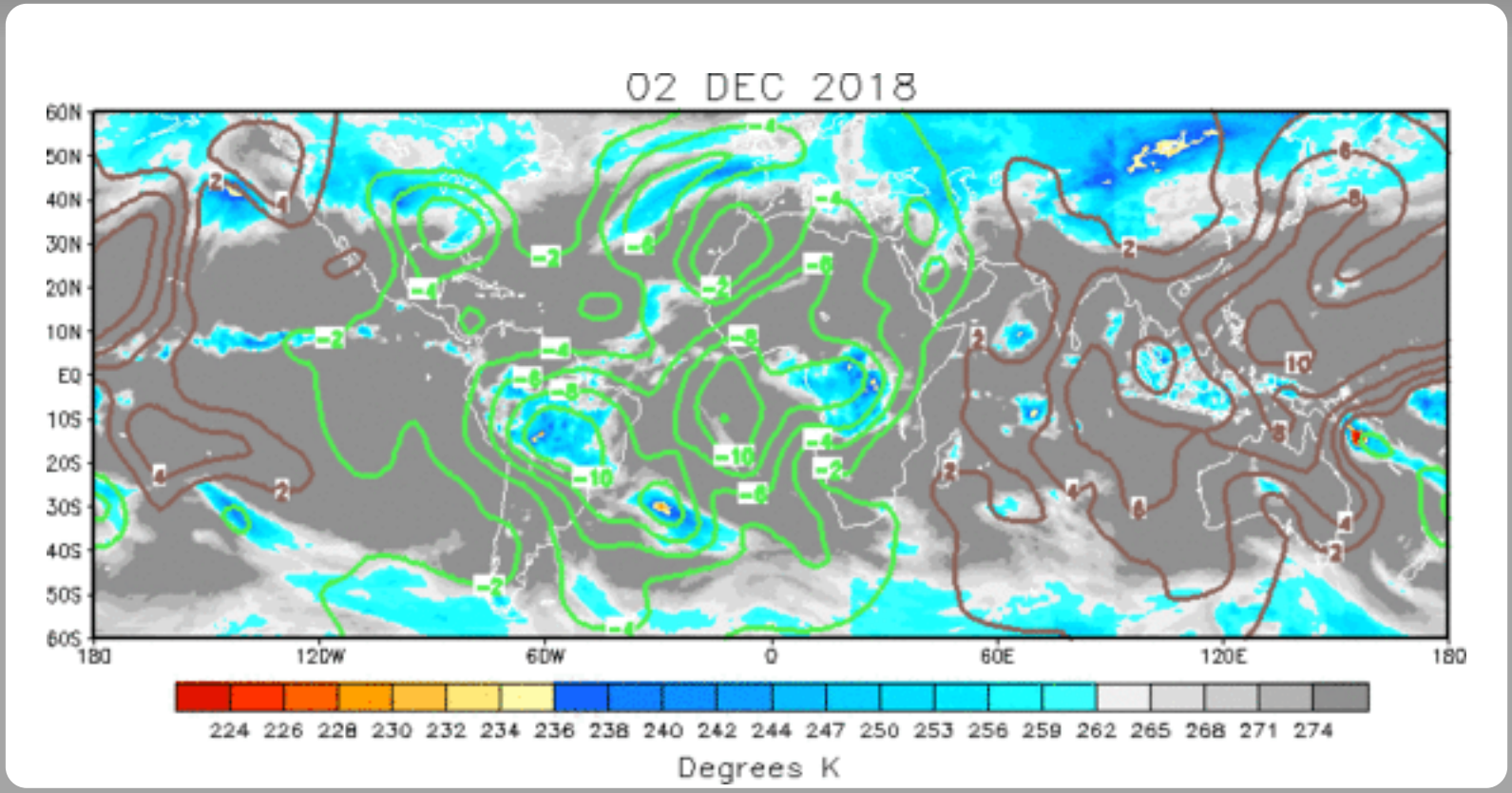
The enhanced phase of the MJO weakened east of the Date Line during June. Eastward propagation of broad suppressed convection continued into early July. The upper-level footprint of the MJO re-emerged during mid-July, with a broad divergent signal propagating from the Maritime Continent to the central Pacific.

Starting in mid-July, a low-frequency dipole favoring enhanced (suppressed) convection over the east-central Pacific (Indian Ocean) emerged, consistent with a gradual transition towards El Niño conditions.

During mid-September, a robust intraseasonal signal constructively interfered with the base state over the Maritime Continent. The MJO signal persisted into October, and destructively interfered with the base state. Most recently, the active phase of the MJO was located over the Western Hemisphere and Africa, and the suppressed phase was propagating eastward toward the Maritime Continent.



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



There is a mostly Wave-1 pattern in the upper-troposphere, with enhanced convection from the Americas to Africa, and suppressed convection from the Indian Ocean across the Maritime Continent and Australia to the central Pacific.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation

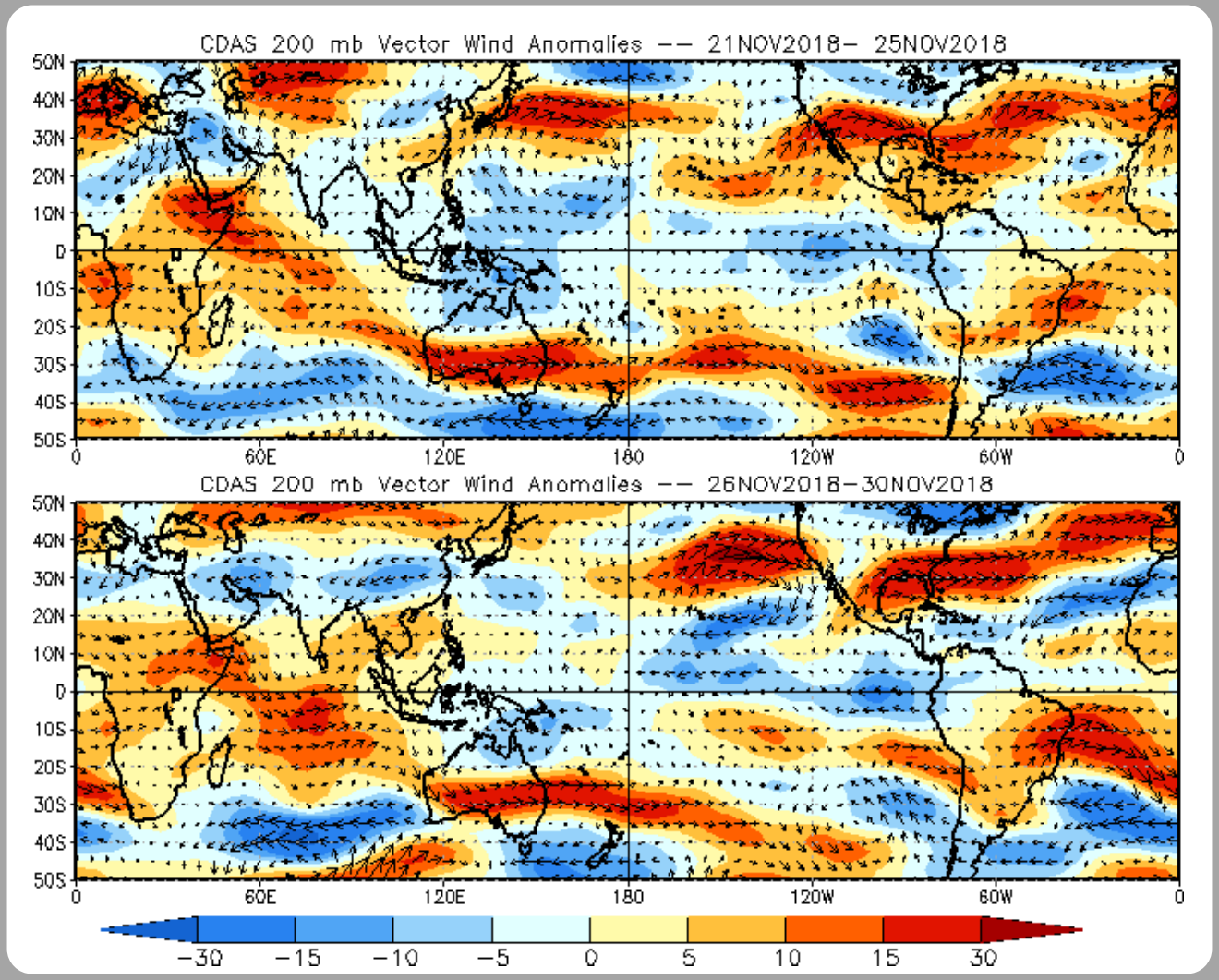
200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

The upper-level jet shifted south over the Pacific Coast of North America, favoring stormy conditions for the U.S. West Coast states, especially California.



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

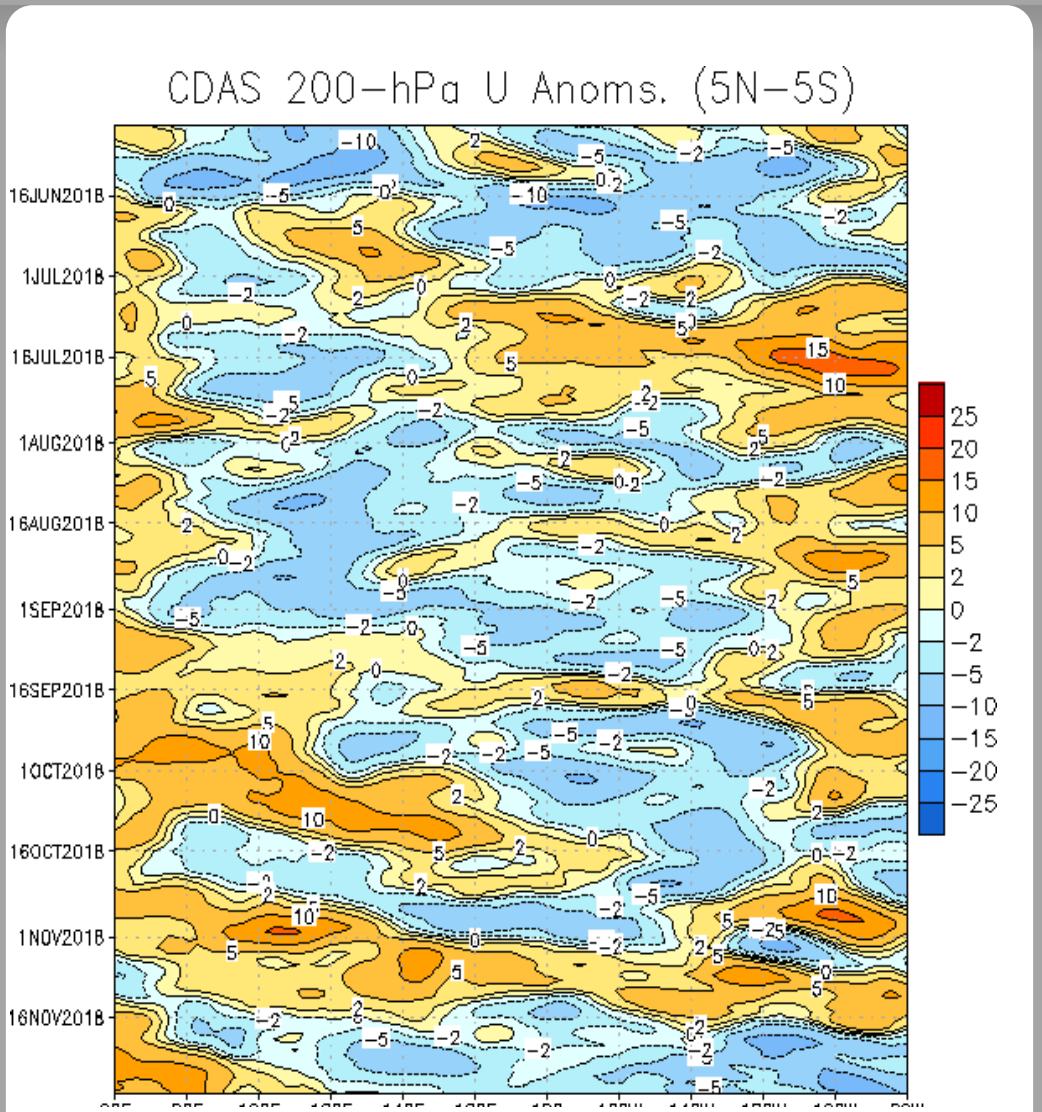
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

Anomalous westerlies amplified over the Maritime Continent in mid-June and propagated eastward at MJO-like phase speeds.

During August the intraseasonal pattern weakened, with Rossby wave activity influencing the West Pacific pattern.

Toward the end of October, anomalous westerlies strengthened over the Indian Ocean and since early November, have shifted east, persisting across the entire tropical Pacific. Thereafter, easterly anomalies returned to this broad area. Most recently, westerly anomalies re-emerged over the Indian Ocean.



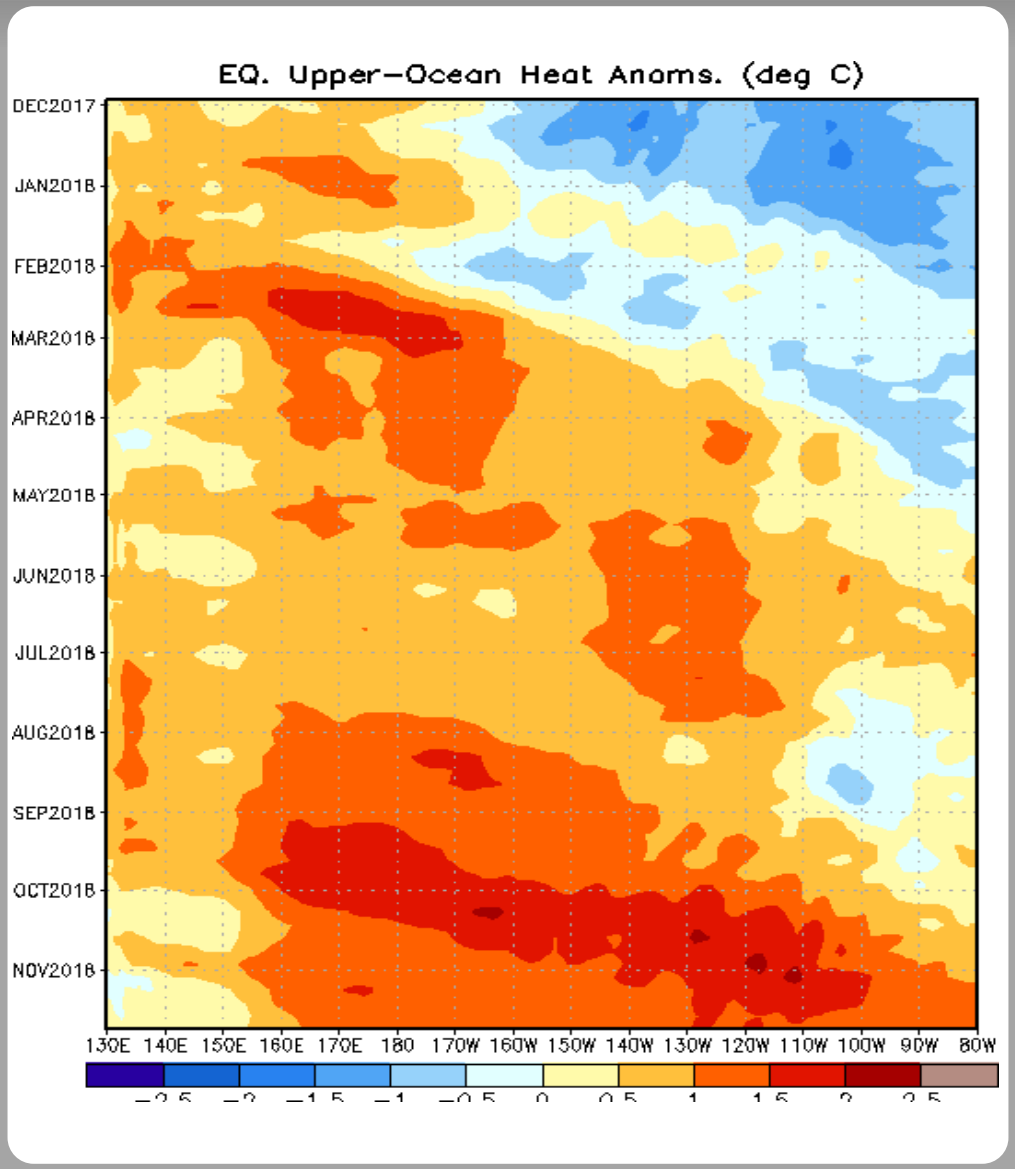
Weekly Heat Content Evolution in the Equatorial Pacific

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 through 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 contributed to the eastward expansion of relatively warm subsurface water during February. Positive anomalies have now been observed over most of the basin since April.

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 a potential El Niño event.



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

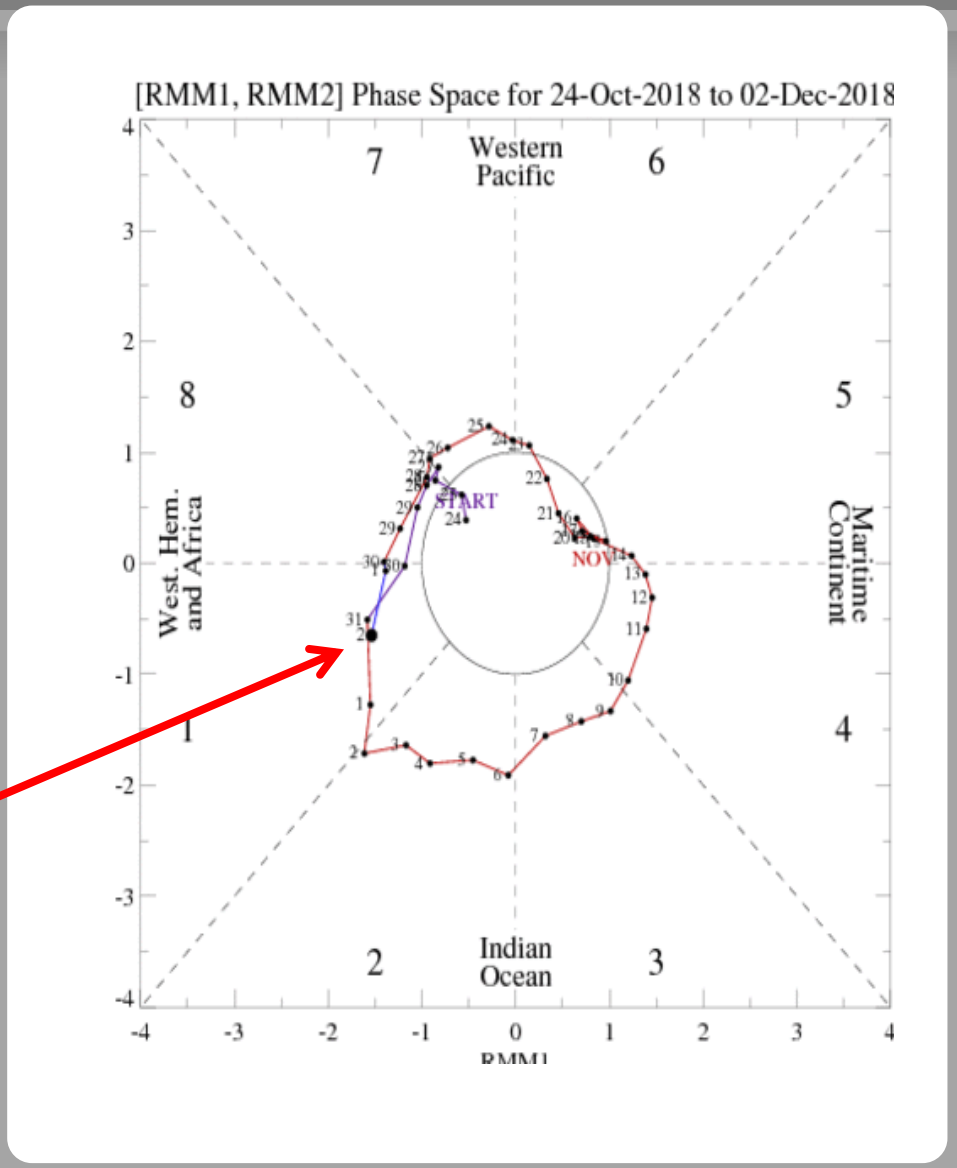
The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes

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

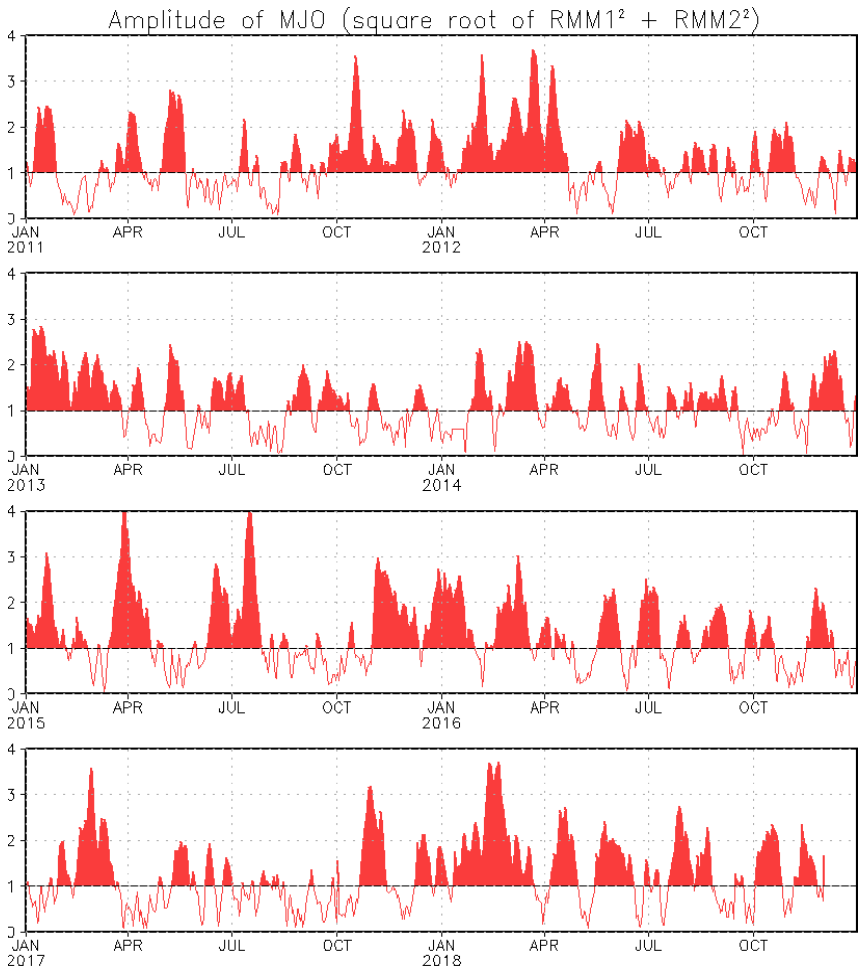


The RMM index suggests that the MJO increased in amplitude during the past week, and propagated from Phase 8 well into Phase 1.

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.



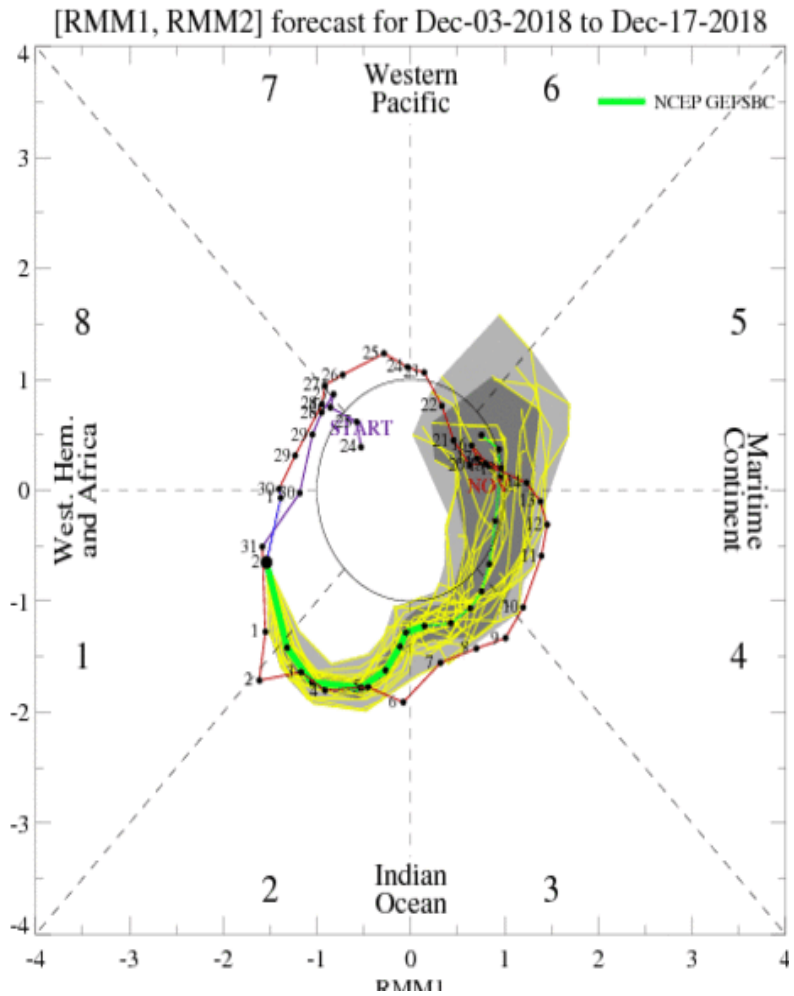
GFS Ensemble (GEFS) MJO Forecast

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

Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

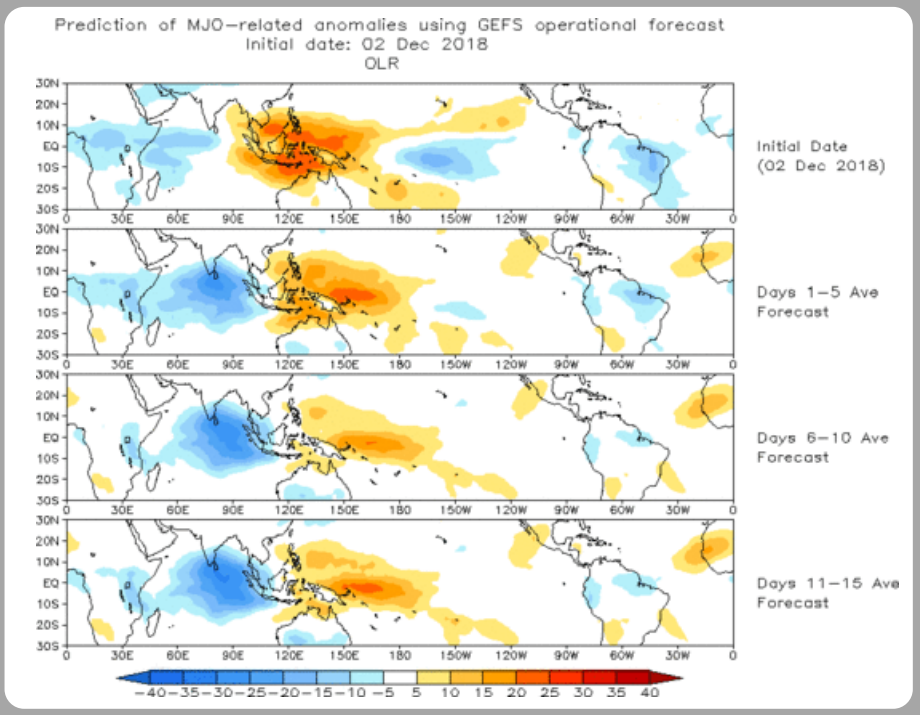


The GEFS forecast of the RMM index suggests that the MJO will briefly strengthen in Phase 2 (western Indian Ocean) before it weakens and continues to propagate eastward over Phases 3, 4, and 5 (eastern Indian Ocean and Maritime Continent).

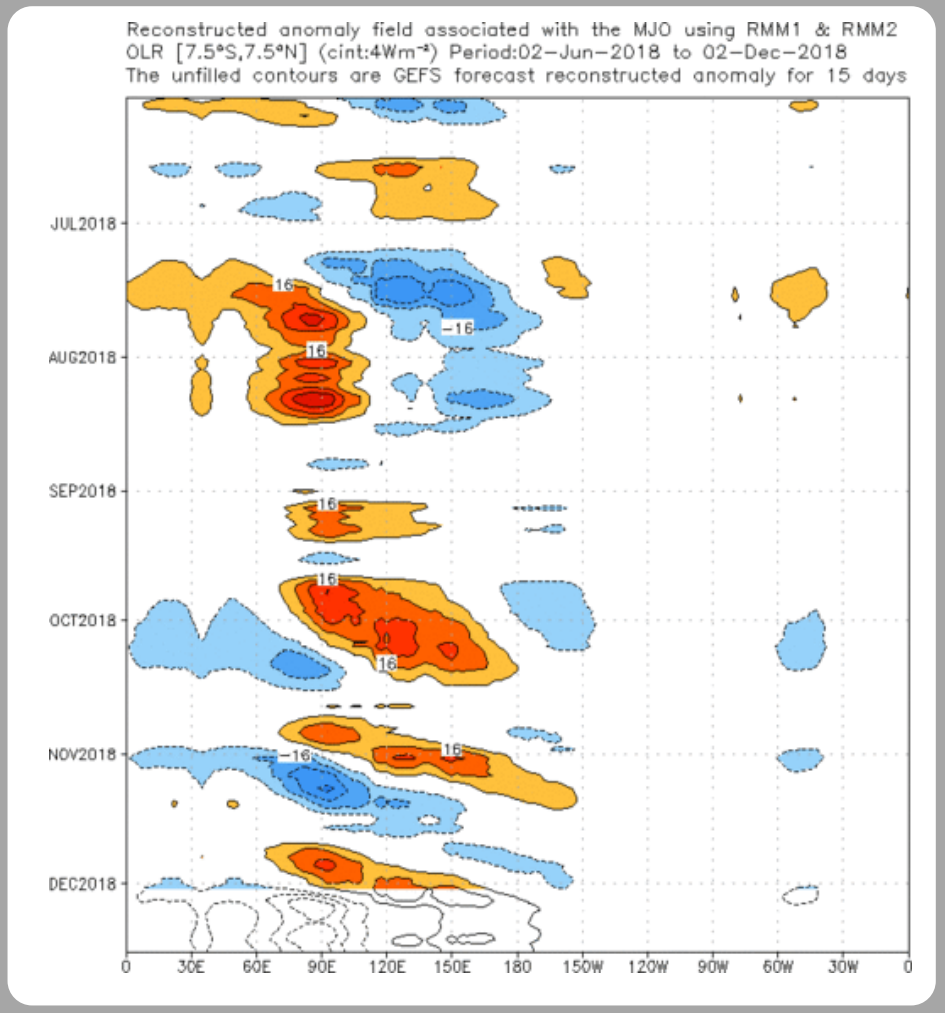
Ensemble GFS (GEFS) MJO Forecast

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



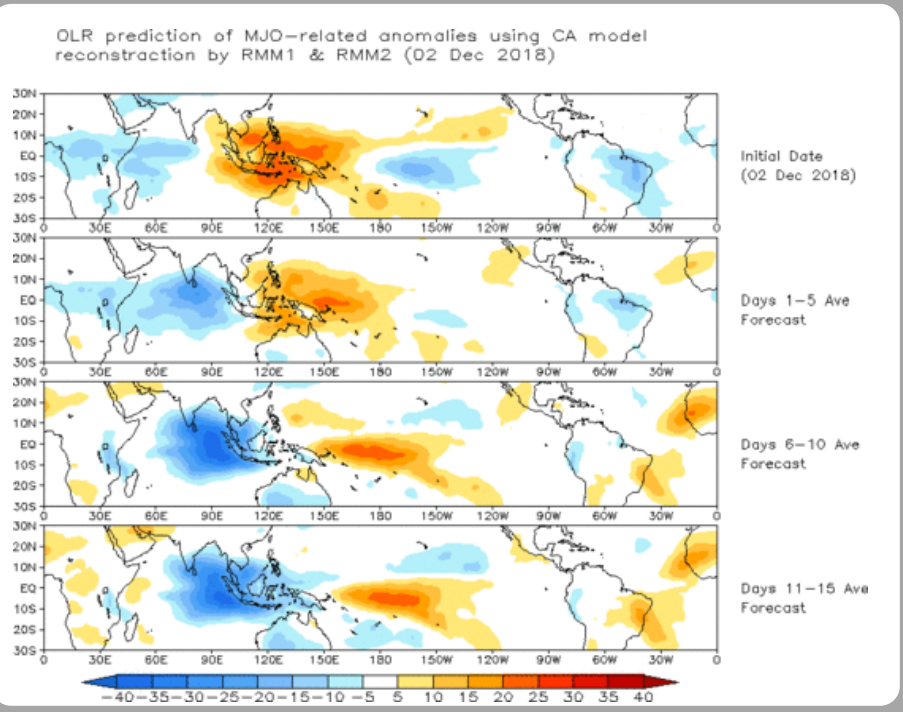
The GEFS RMM-based OLR forecast shows high-amplitude anomalies consistent with a robust MJO event. Enhanced convection is predicted across the Indian Ocean during the next two weeks, and suppressed convection is forecast to shift eastward from the Maritime Continent to the west-central Pacific.

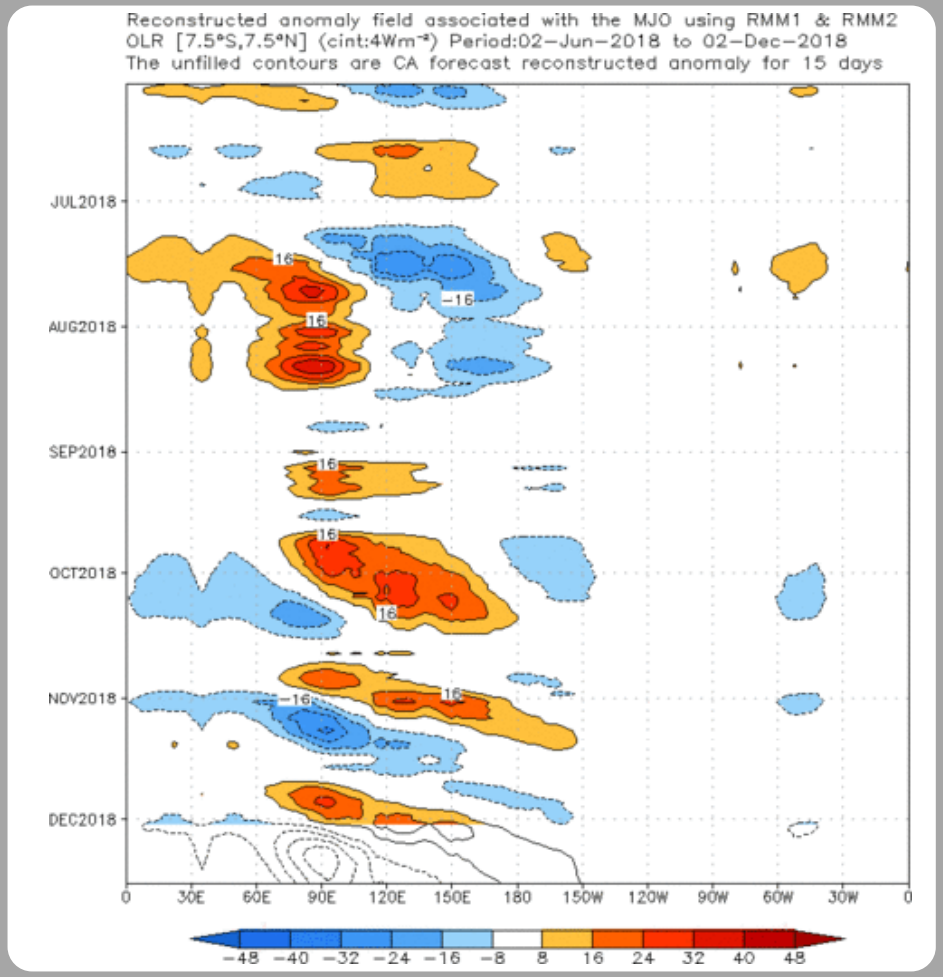
Constructed Analog (CA) MJO Forecast

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

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

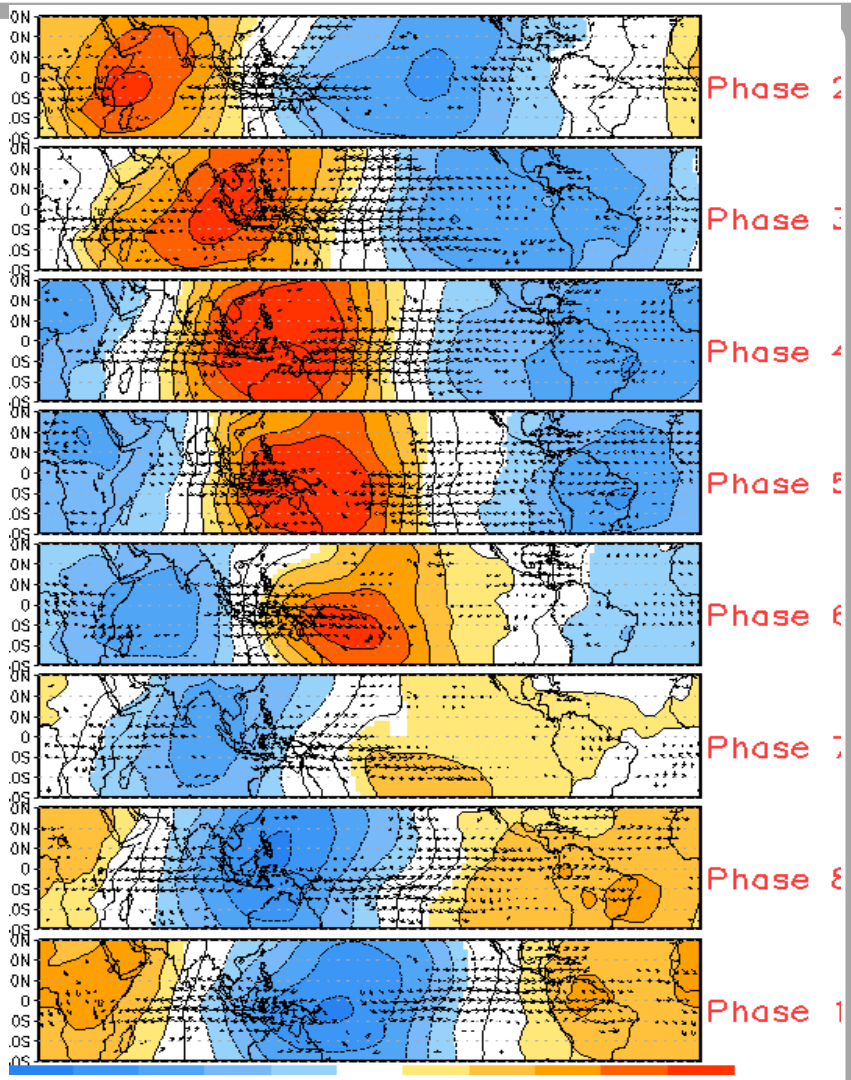




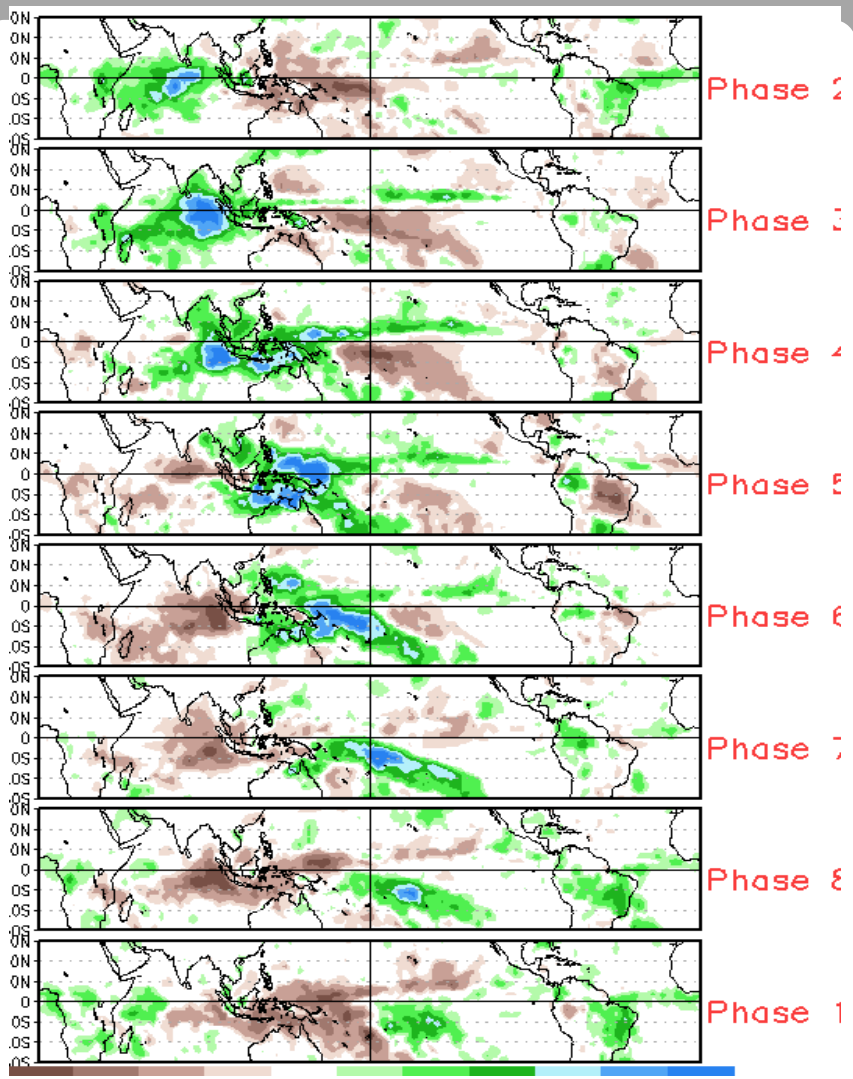
The constructed analog tool suggests a similar OLR anomaly pattern, with noticeable strengthening and eastward propagation of the convective envelope over the Indian Ocean during the next two weeks.

MJO Composites - Global Tropics

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



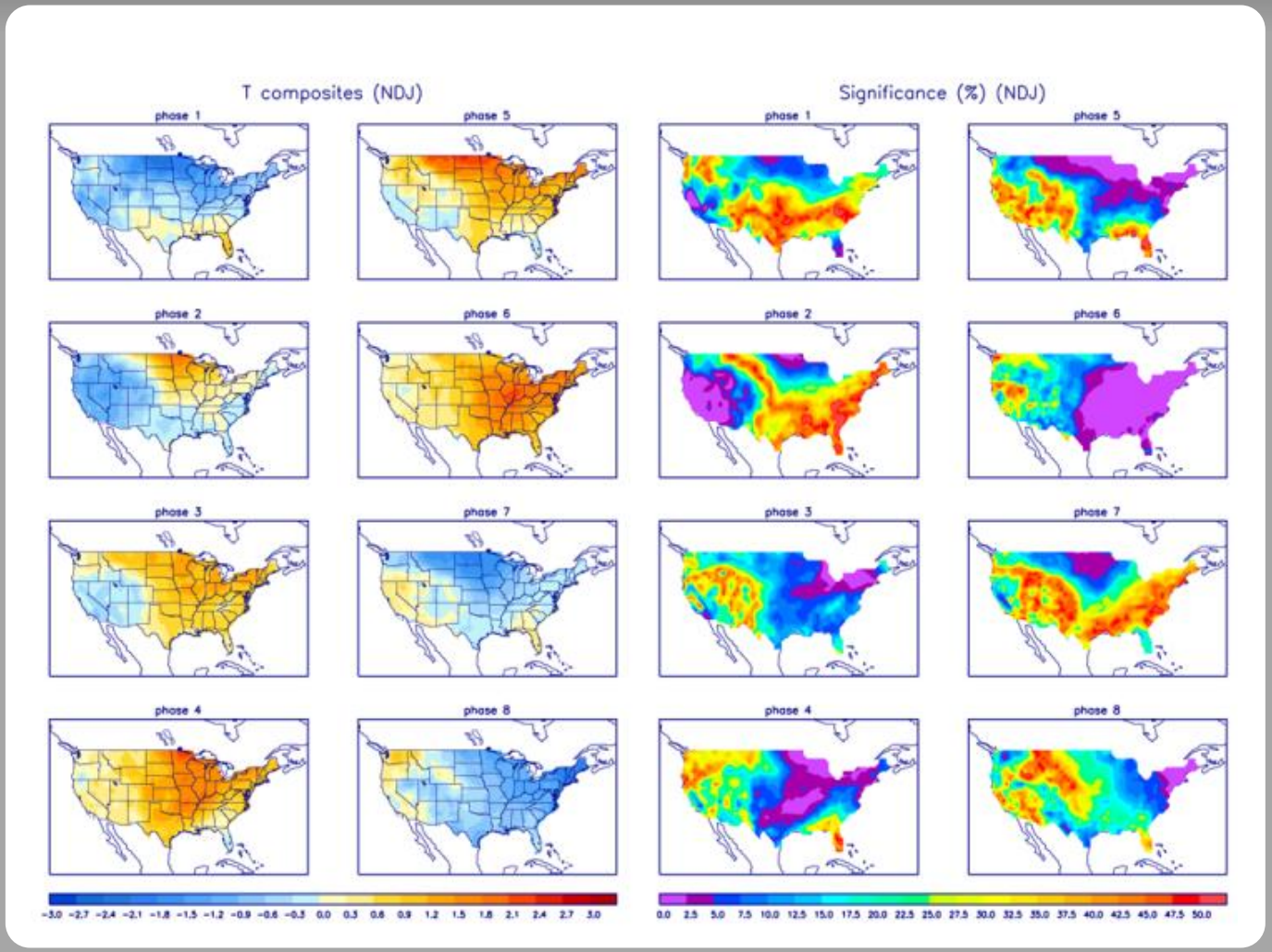
Precipitation Anomalies (Nov - Mar)



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.



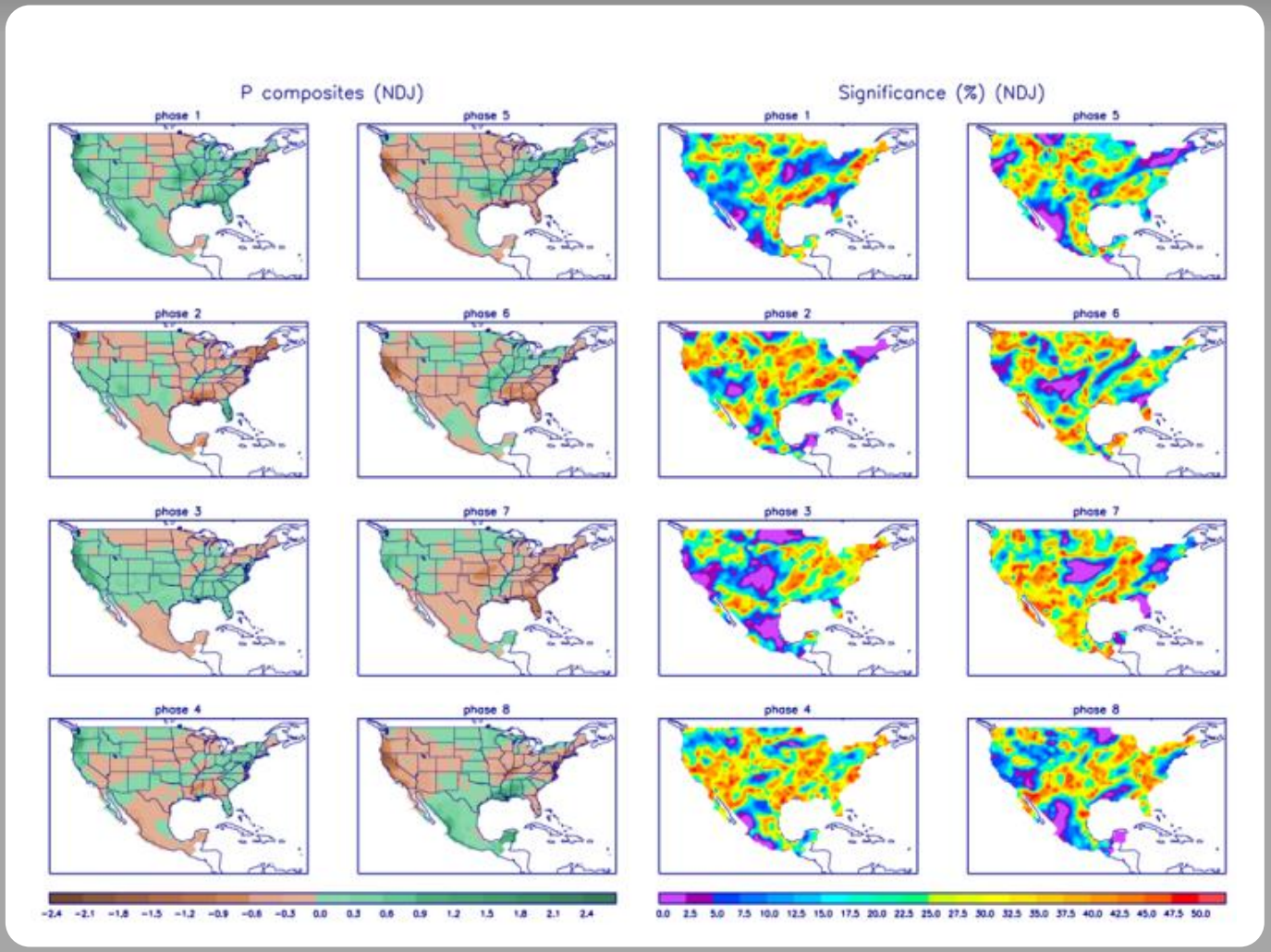
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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