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

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Climate Prediction Center / NCEP
27 November 2017

Outline

Overview

Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- The CPC velocity potential based and RMM-based MJO indices both depict an amplifying MJO signal over the western Maritime Continent. Little eastward propagation is currently evident.

- Constructive interference between a robust Rossby wave and Kelvin waves may be contributing to the projections on the MJO indices.

- Dynamical model MJO index forecasts depict rapid shifts during Week-1 due to interactions among the modes, however many solutions show a more robust MJO-like evolution over the West Pacific by Week-2.

- Extratropical patterns, although not directly a response to MJO activity, are fairly consistent with a canonical response to Indian Ocean or Maritime Continent convection. Should an MJO event emerge from the current confluence of various modes, it will likely play a role in the evolution of the downstream pattern.

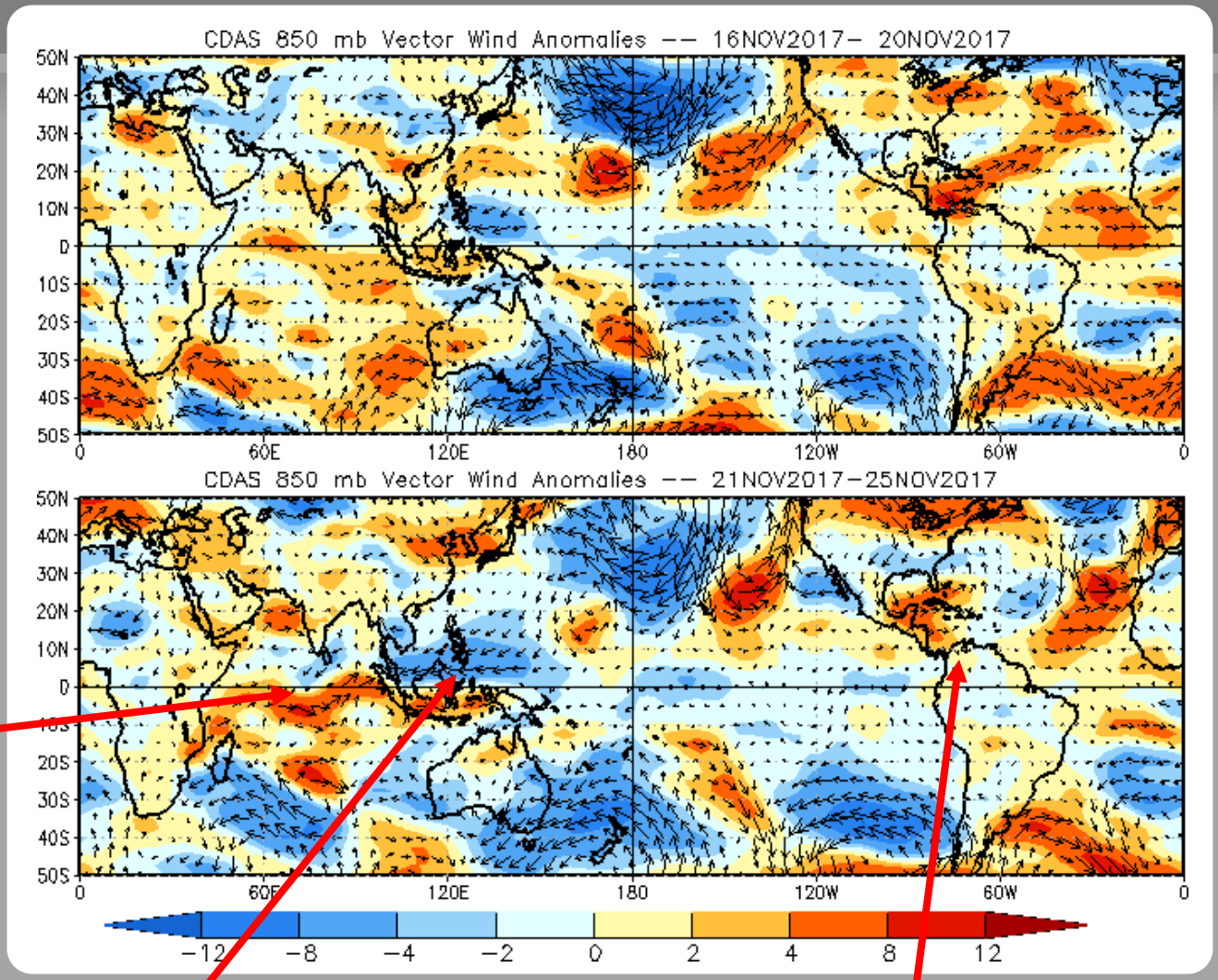
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies weakened over the North Indian Ocean, while persisting across the southern and far eastern Indian Ocean.

Easterly anomalies moved westward over the South China Sea. Weak easterlies persisted across the Pacific basin.

Westerly anomalies persisted over the western Caribbean and equatorial Atlantic.

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

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

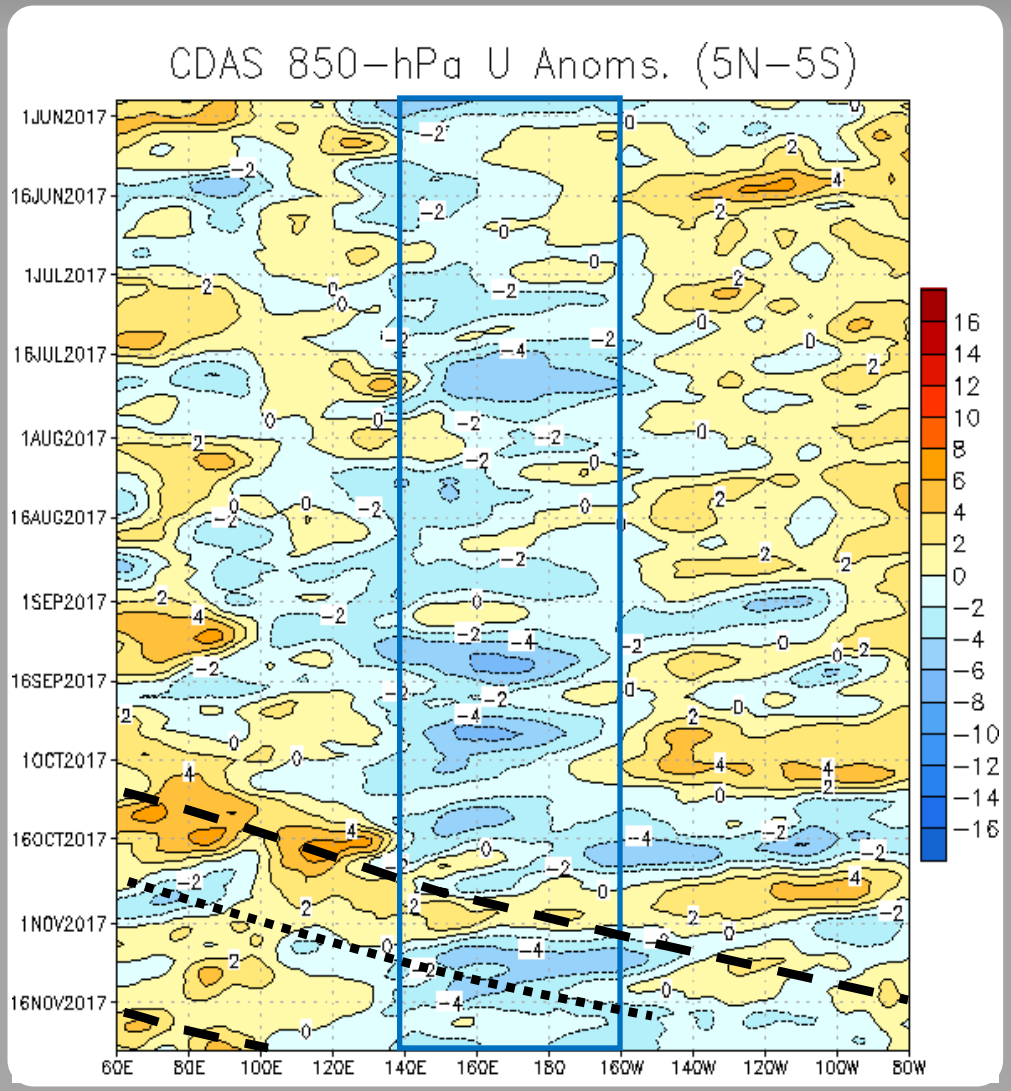
Easterly anomalies (blue shading) represent anomalous east-to-west flow

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

Equatorial zonal wind anomalies were of low amplitude in June. During July, a slight eastward shift in the low-frequency pattern is noted, related to short-lived MJO activity.

During August and September, the low-frequency envelope of easterly anomalies re-established from 140E to just east of the Date Line. During October, a robust MJO event developed, with eastward propagation of westerly anomalies.

Recently, residual MJO activity may have constructively interfered with the low-frequency state.



OLR Anomalies – Past 30 days

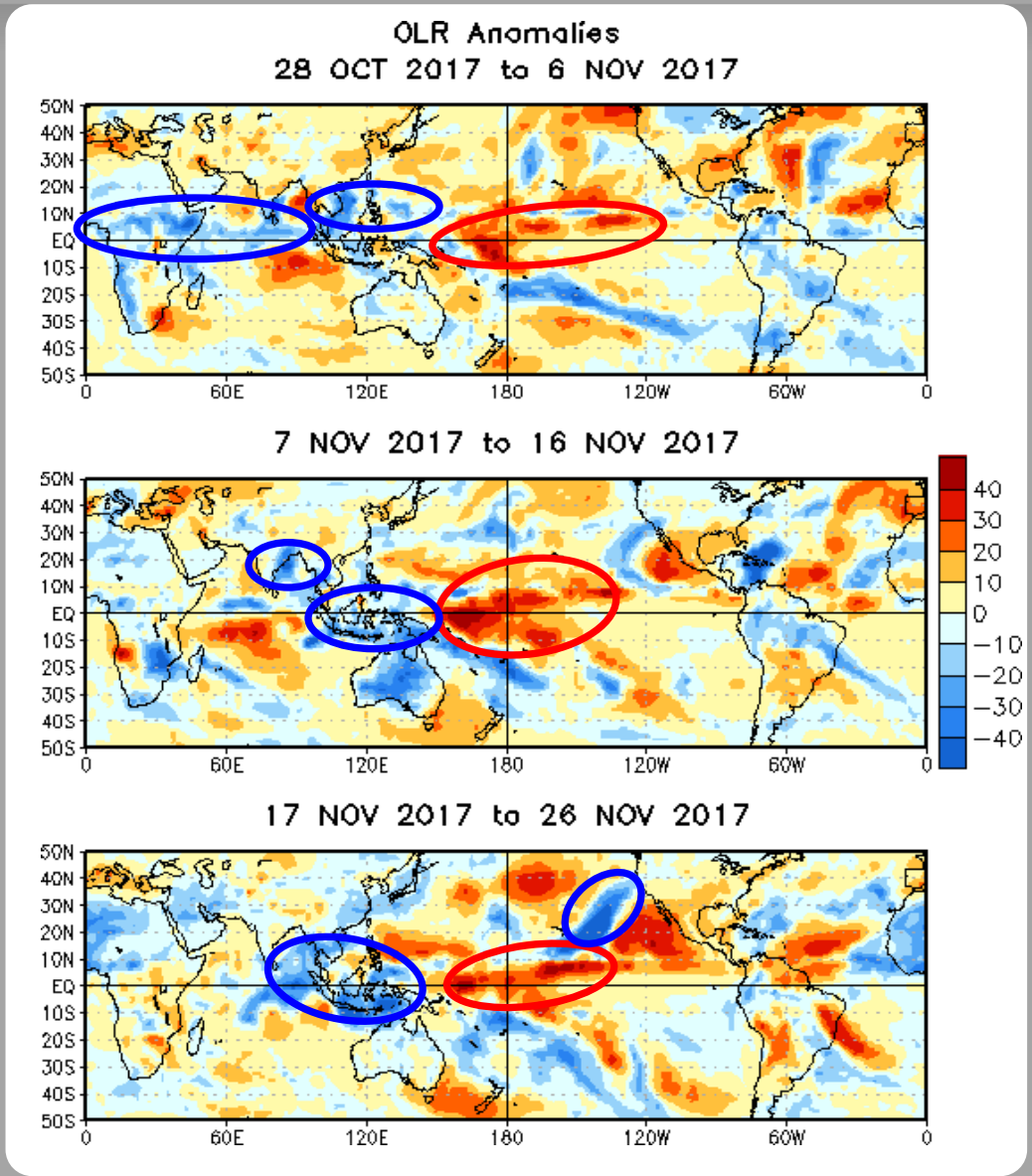
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During late October and early November, the MJO propagated across the Western Hemisphere, although the convective response was muted. Suppressed convection returned to the central Pacific.

During early to mid November, the MJO signal broke down. Low frequency enhanced (suppressed) convection over the Maritime Continent (west-central Pacific), consistent with the base state, became the dominant features.

During mid to late November, enhanced convection increased over the eastern Indian Ocean and western Maritime Continent, partly due to Rossby wave activity. Suppressed convection persisted across much of the tropical Pacific, with an atmospheric river transporting moisture from the central Pacific to the northwestern CONUS.



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

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

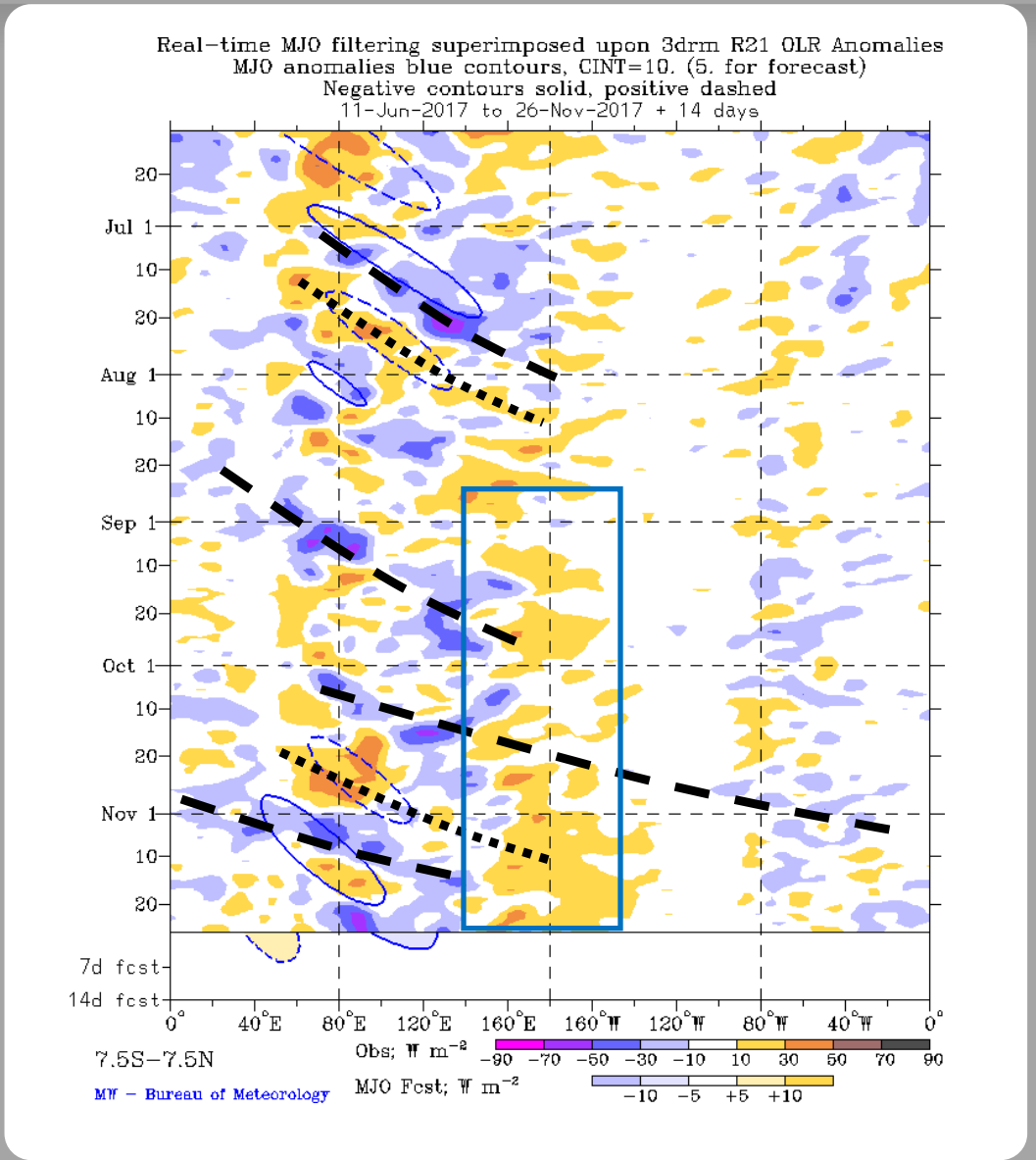
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

During mid-July, there was a burst of enhanced convection over the Maritime Continent, due to interactions between a short-lived intraseasonal signal and the low-frequency state.

Multiple modes of variability including tropical cyclones contributed to the pattern of anomalous convection during August and September. Weak MJO activity was present during August and early September. The low-frequency signal emerged more fully in August.

The MJO became active in October, with a stronger projection in the upper-levels than in the equatorial OLR field. After circumnavigating the globe, the signal weakened in early November.

More recently, Rossby wave activity is apparent over the Maritime Continent.



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

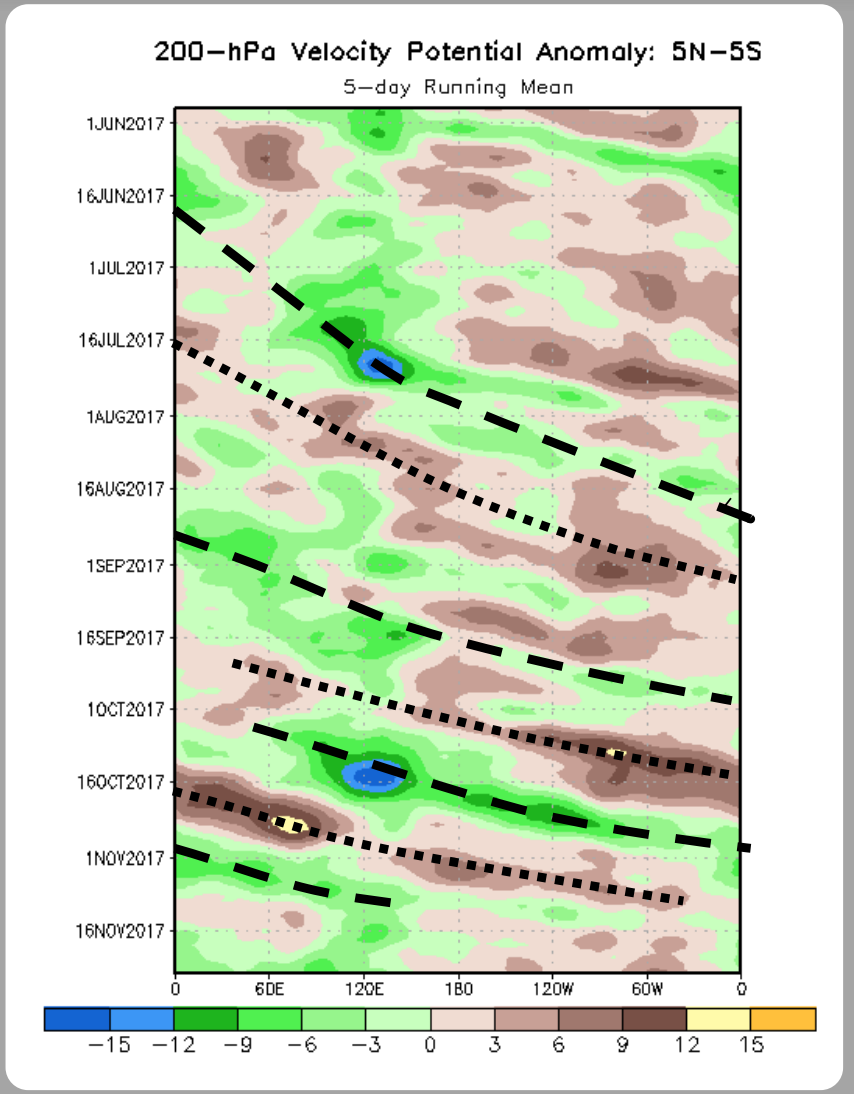
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

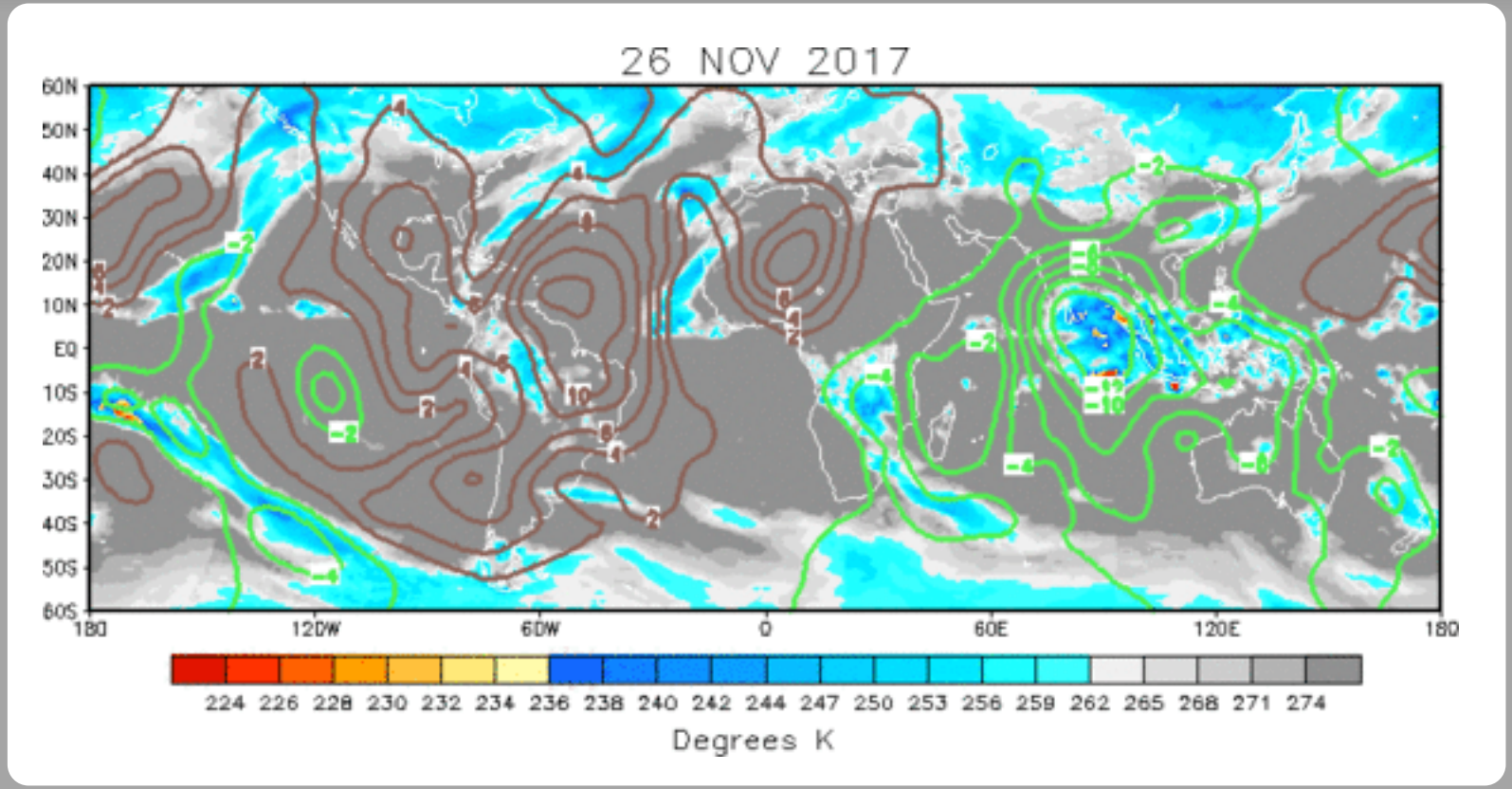
During July, enhanced convection strengthened over the Maritime Continent as the low-frequency signal constructively interfered with an easterly propagating signal. This eastward propagating signal appears more or less intact with a period in line with canonical MJO phase speeds.

A 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, and is beginning to constructively interfere with the low-frequency wet signal over the region. The subseasonal signal, however, has weakened substantially. More recently, Rossby wave activity was apparent over the Maritime Continent, with Kelvin Waves traversing the Pacific.



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



A largely Wave-1 pattern in upper-level anomalous velocity potential is apparent, with divergence (convergence) centered over the eastern Indian Ocean (western Atlantic). The pattern over the Pacific is weaker, as Kelvin waves destructively interfere with the base state.

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)

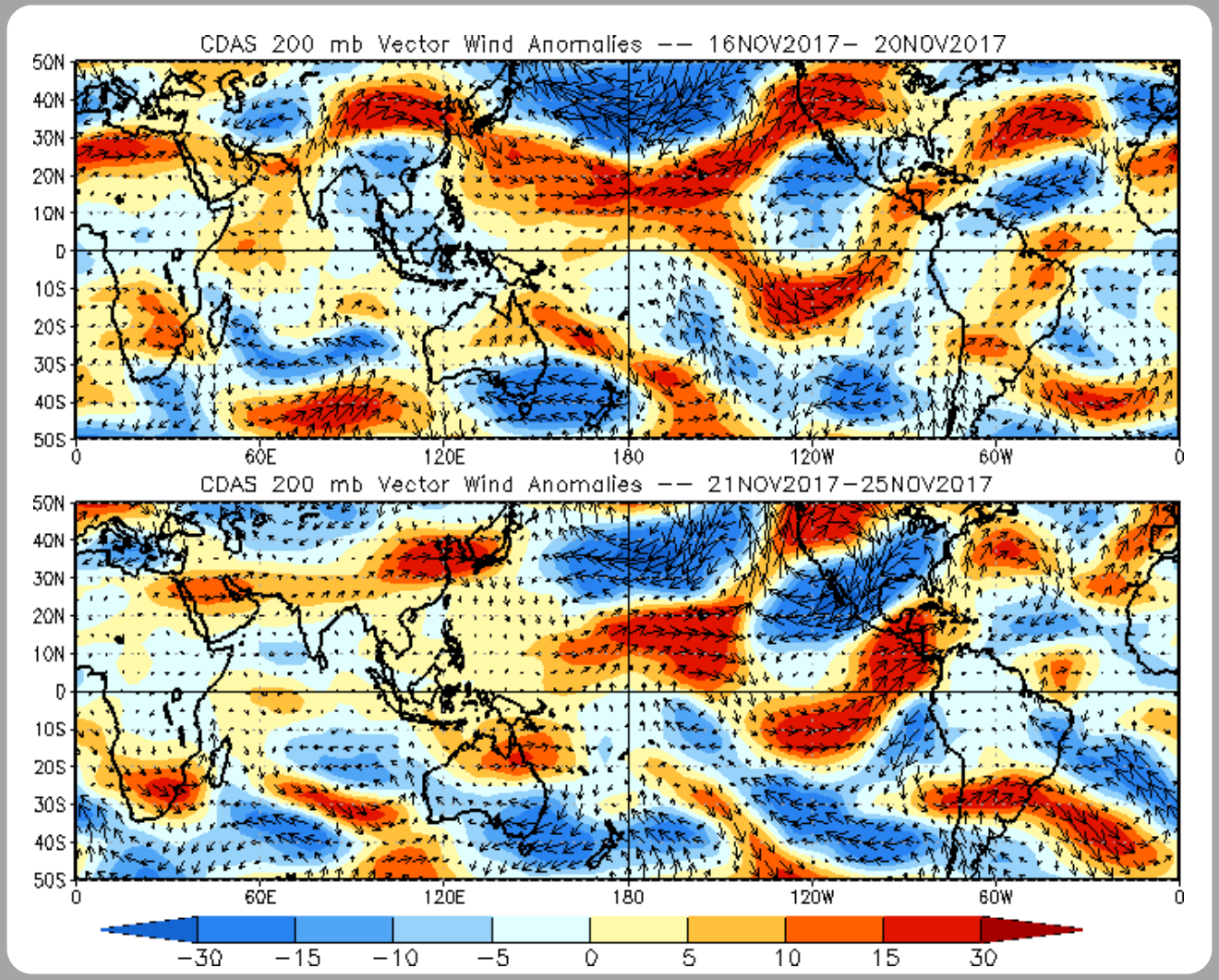
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Easterly anomalies weakened over the Maritime Continent.

Mid-latitude influences from both hemispheres continue to be apparent in the wind anomaly pattern over the eastern Pacific.



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

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

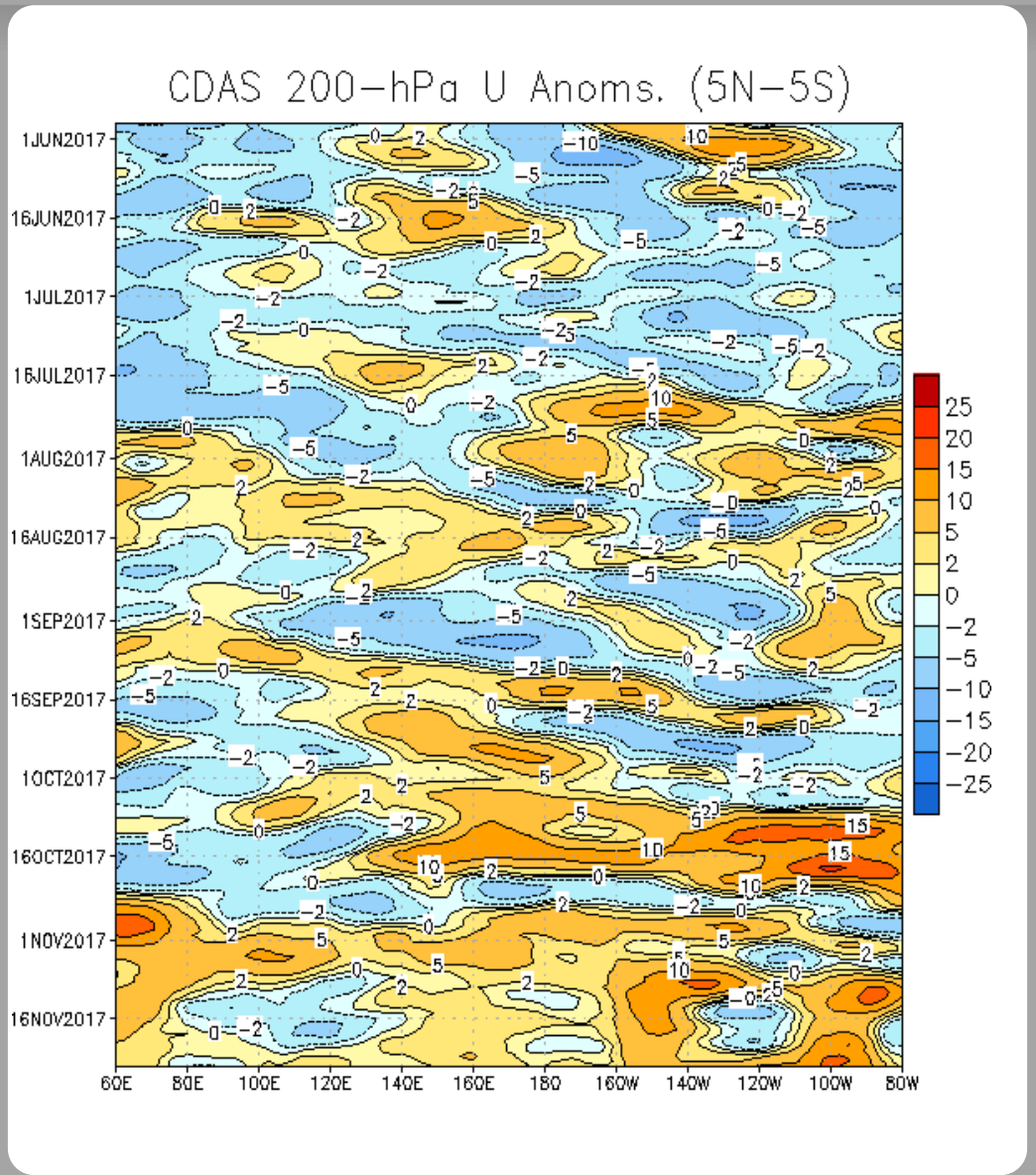
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During early to mid-June, easterly anomalies were most prominent across the global tropics, in part due to mid-latitude influences.

Starting in July, the 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.

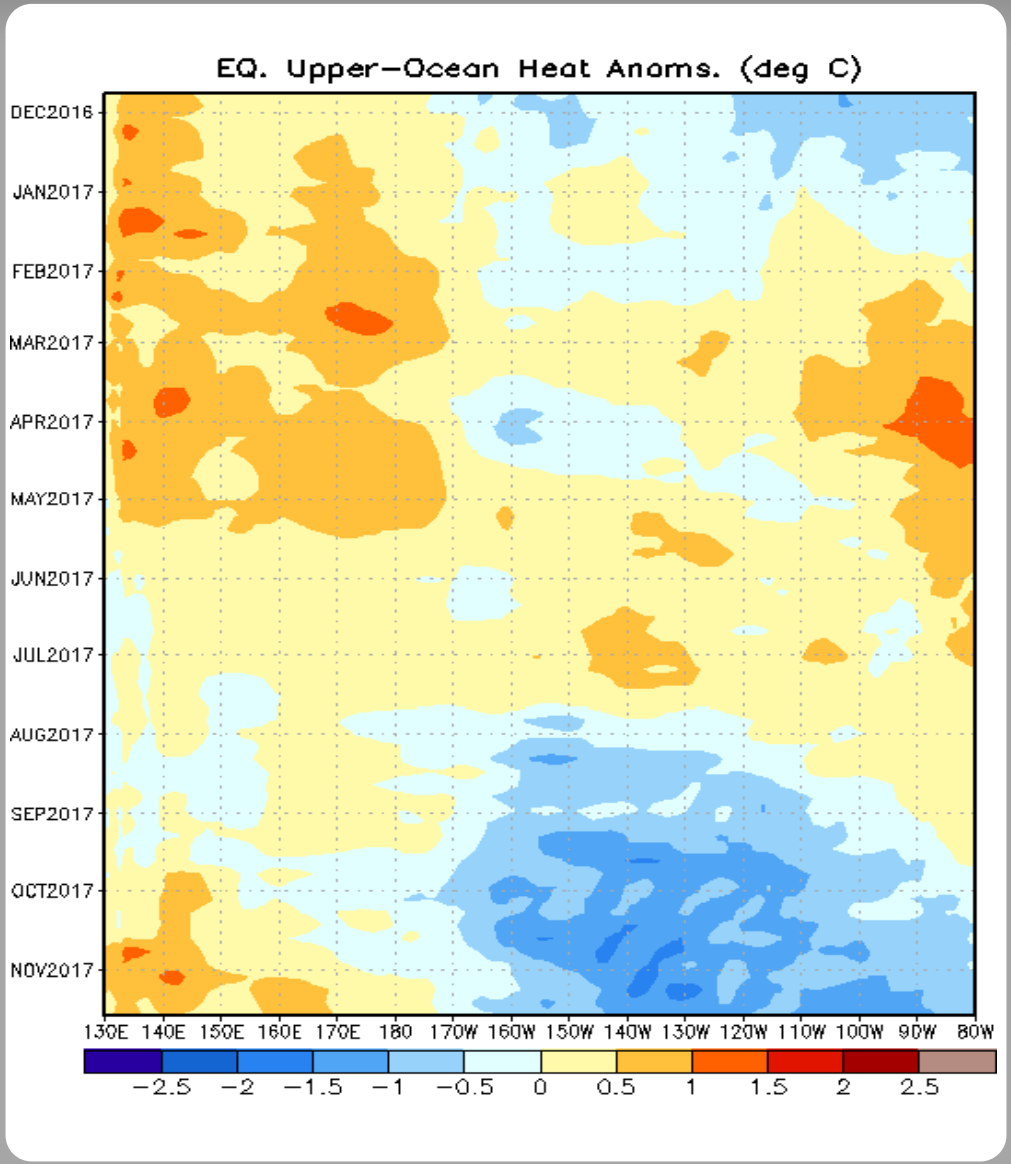
Westerly (easterly) anomalies expanded across much of the Pacific (Indian Ocean) during late October, and have remained. More recently, westerly anomalies have also increased over the Maritime Continent.



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 remain entrenched in the eastern Pacific, with some strengthening near 100W.



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

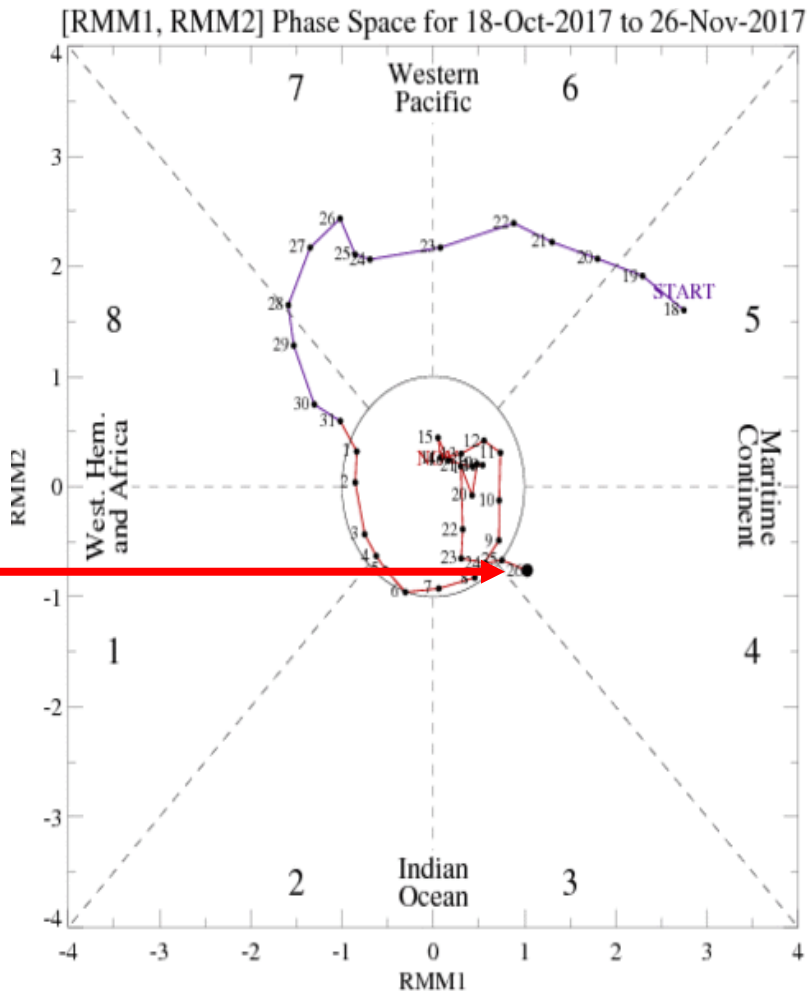
The triangular areas indicate the location of the enhanced phase of the MJO

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

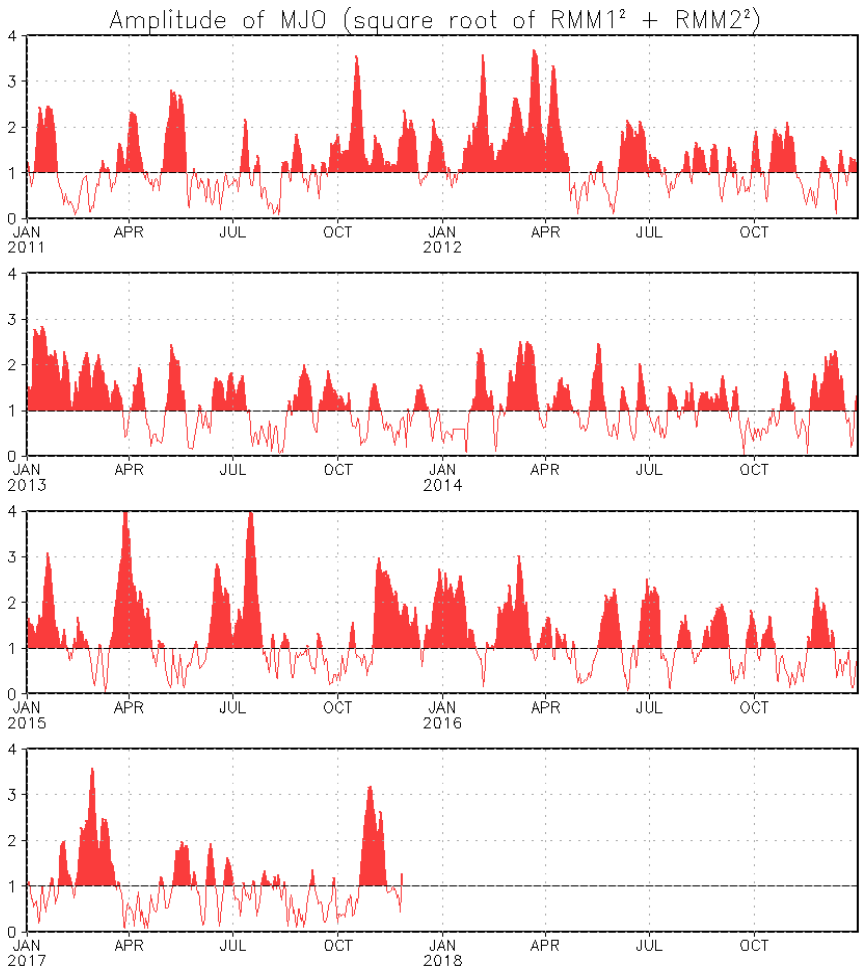
The RMM-index depicts increased amplitude over the far eastern Indian Ocean/western Maritime Continent. Little eastward propagation is evident on the index at this time.



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.



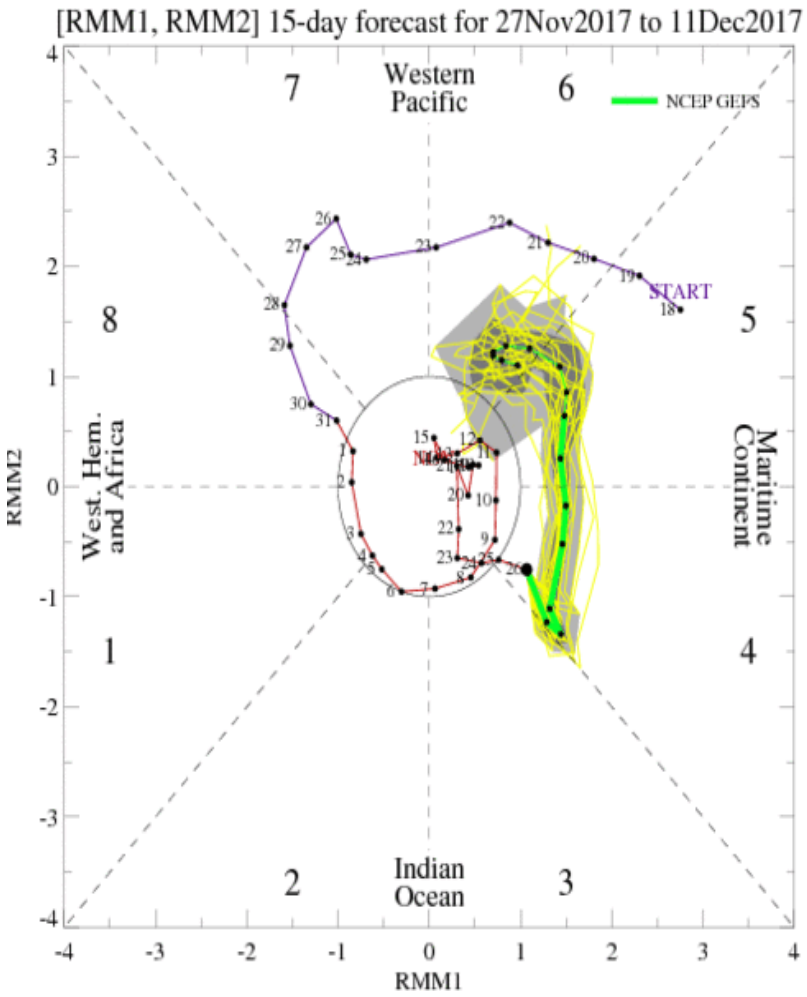
GFS Ensemble (GEFS) MJO Forecast

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

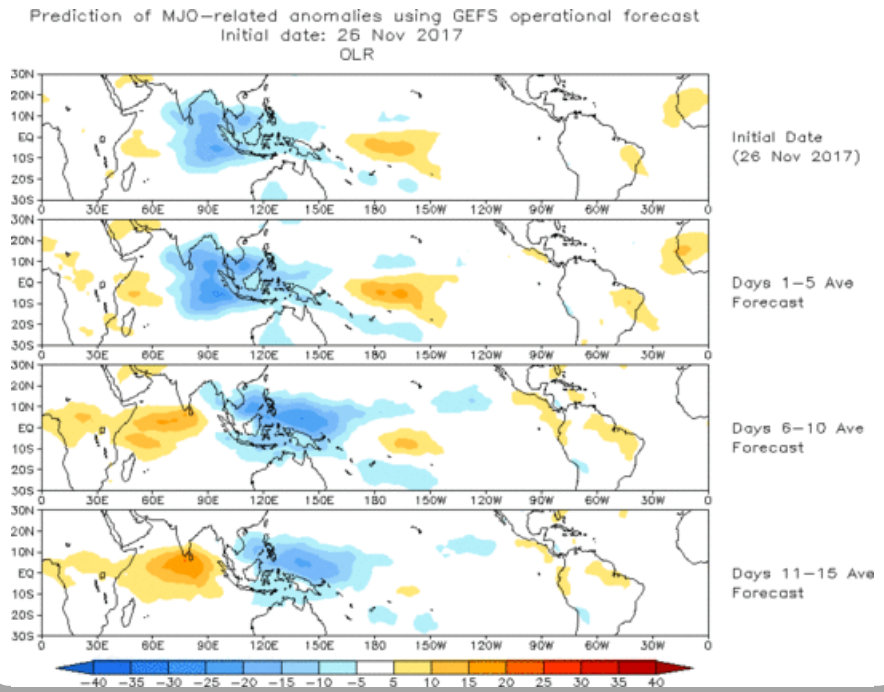


The GEFS forecasts rapid eastward propagation of an amplified MJO signal across the Maritime Continent during Week-1 (propagation speed more consistent with Kelvin wave activity). The eastward propagation slows during Week-2, as the signal emerges over the West Pacific.

Ensemble GFS (GEFS) MJO Forecast

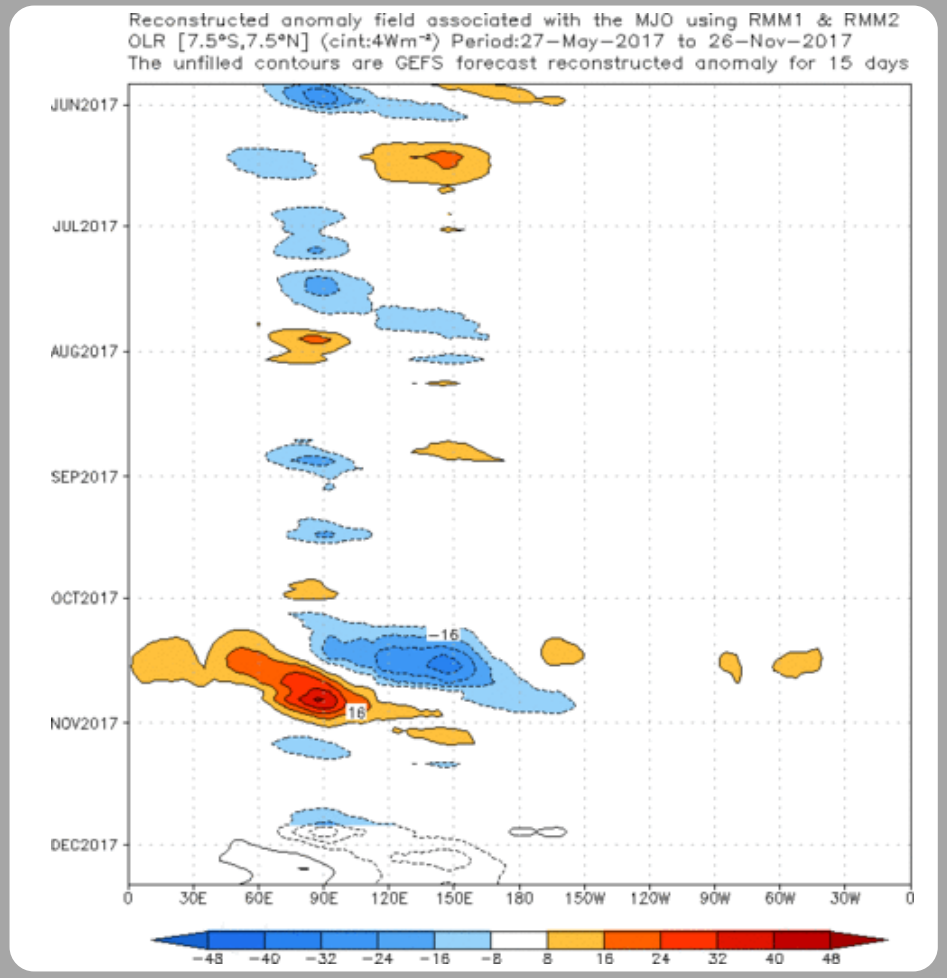
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



OLR anomalies based on the GEFS RMM-index forecast reflect a transition from a eastern Indian Ocean MJO event to a West Pacific event by Week-2.

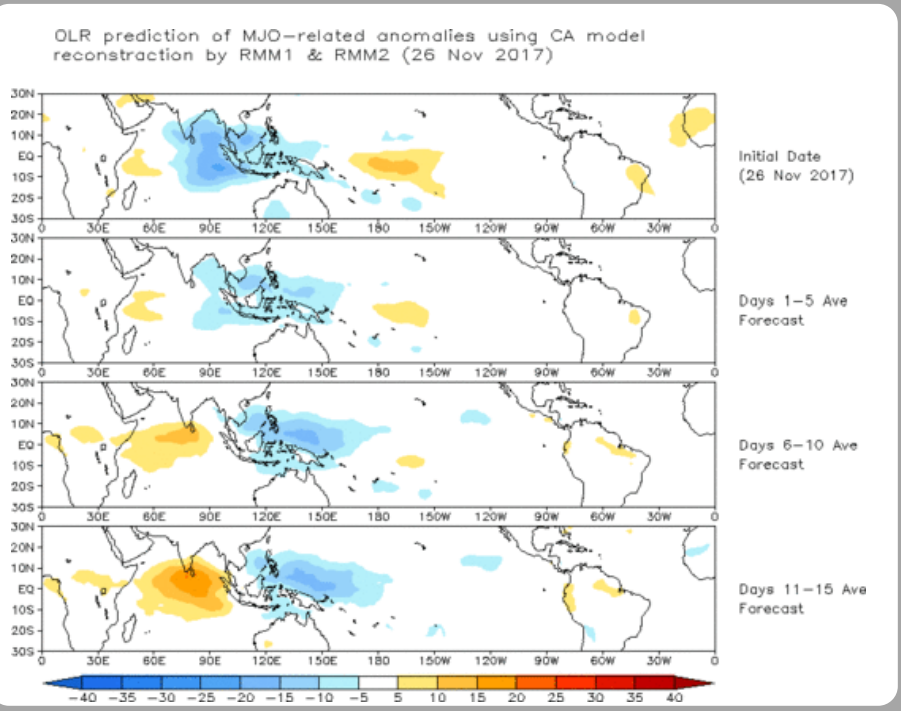
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



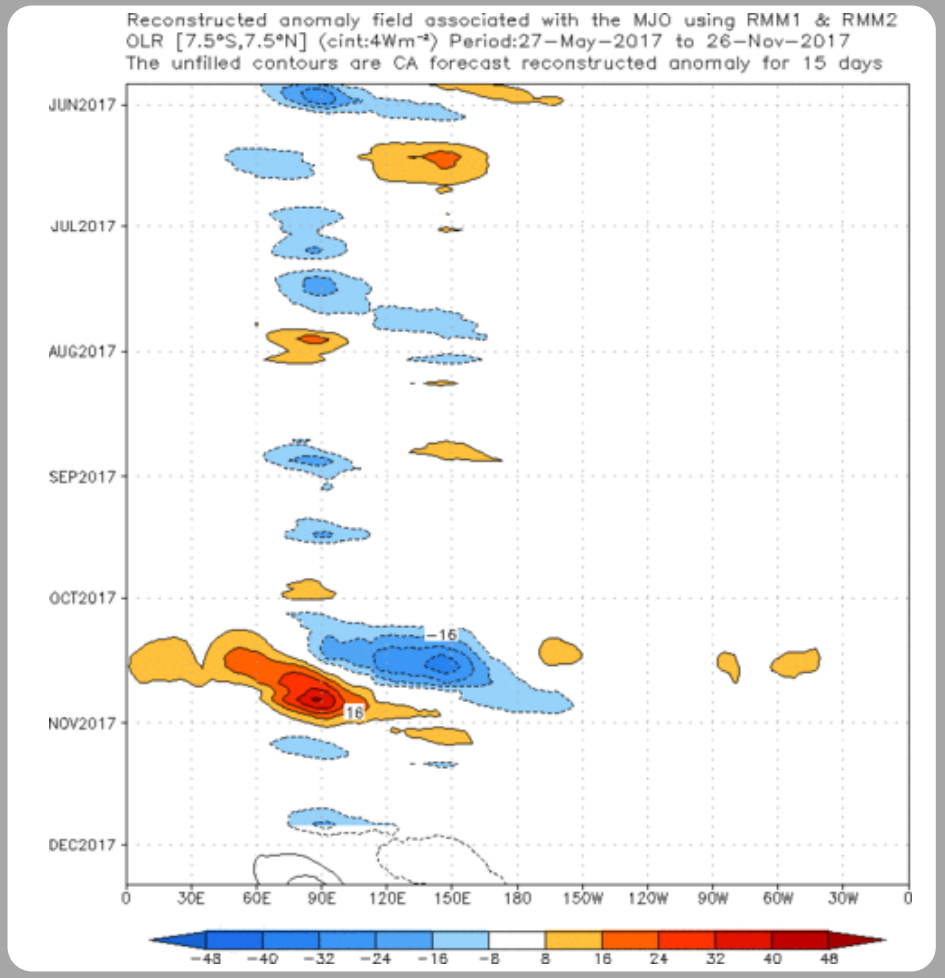
Constructed Analog (CA) MJO Forecast

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



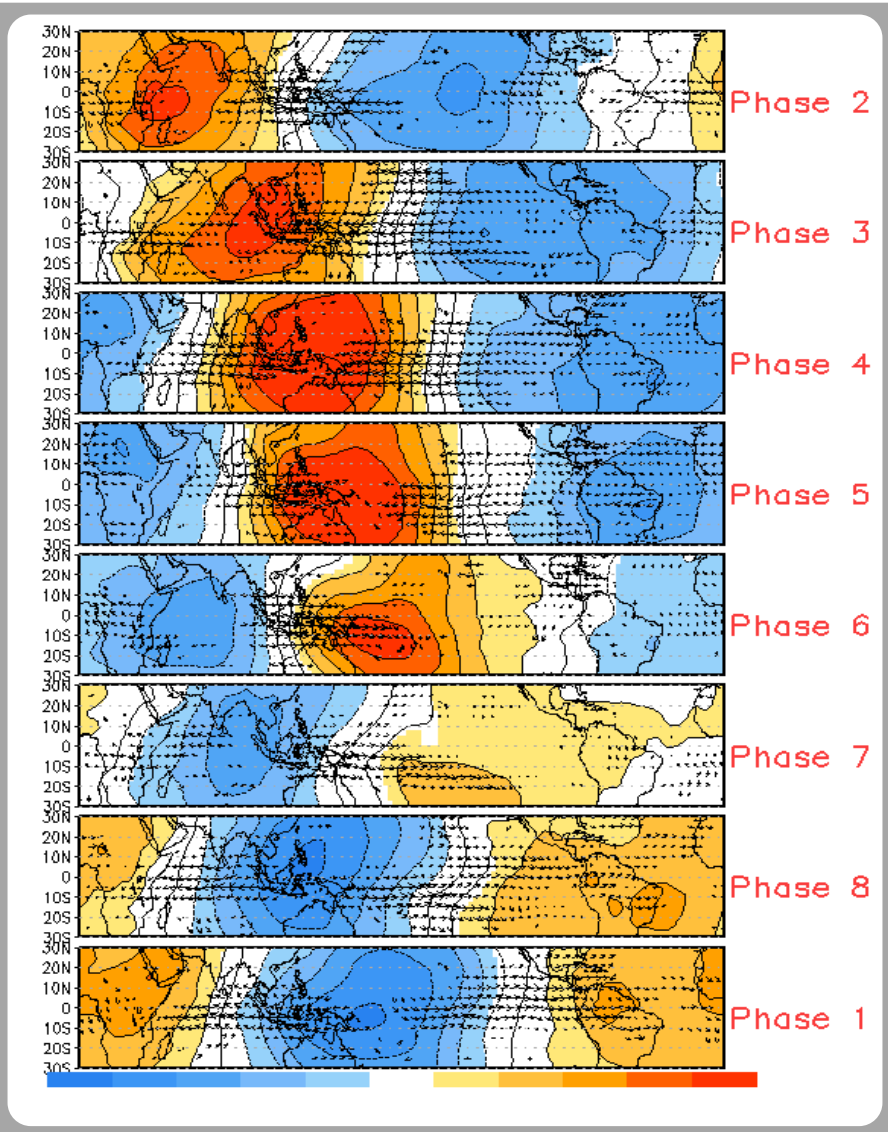
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



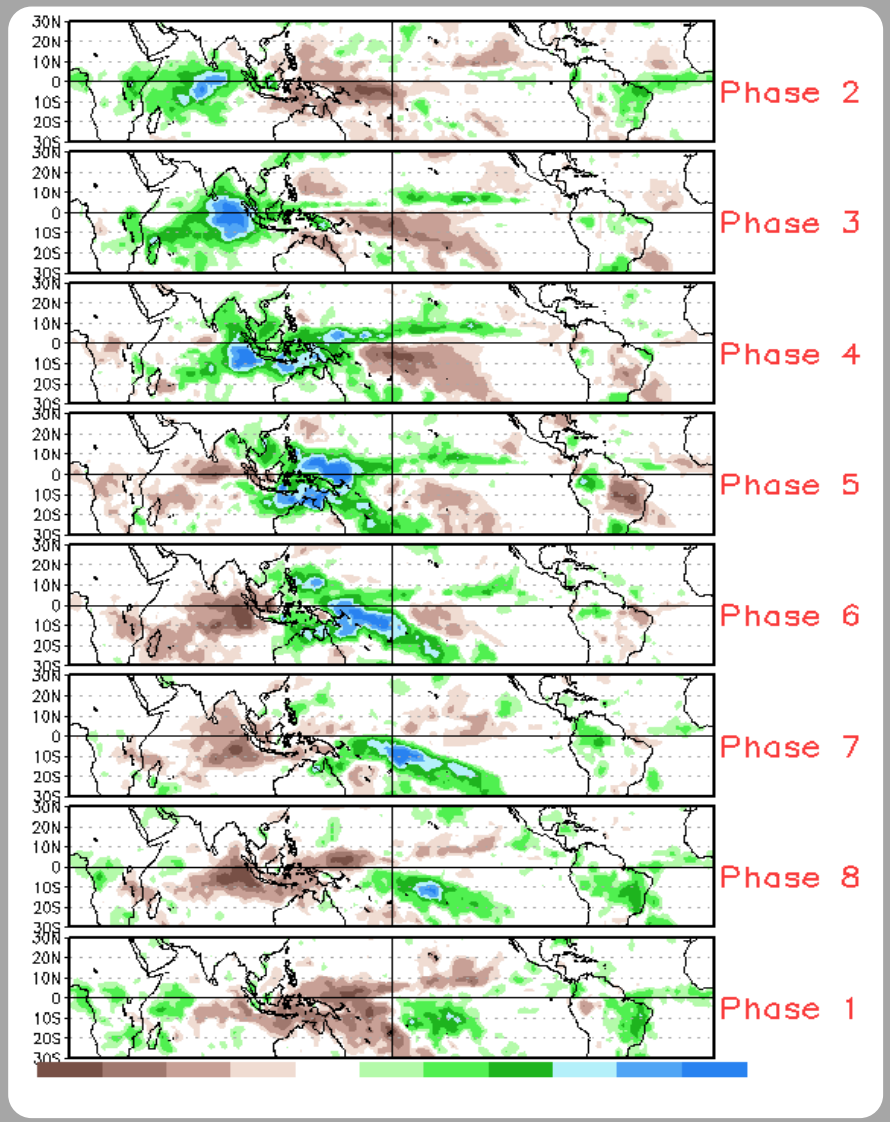
The constructed analog depicts a more canonical evolution of OLR response to an MJO event propagating from the Maritime Continent to the West Pacific.

MJO Composites - Global Tropics

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



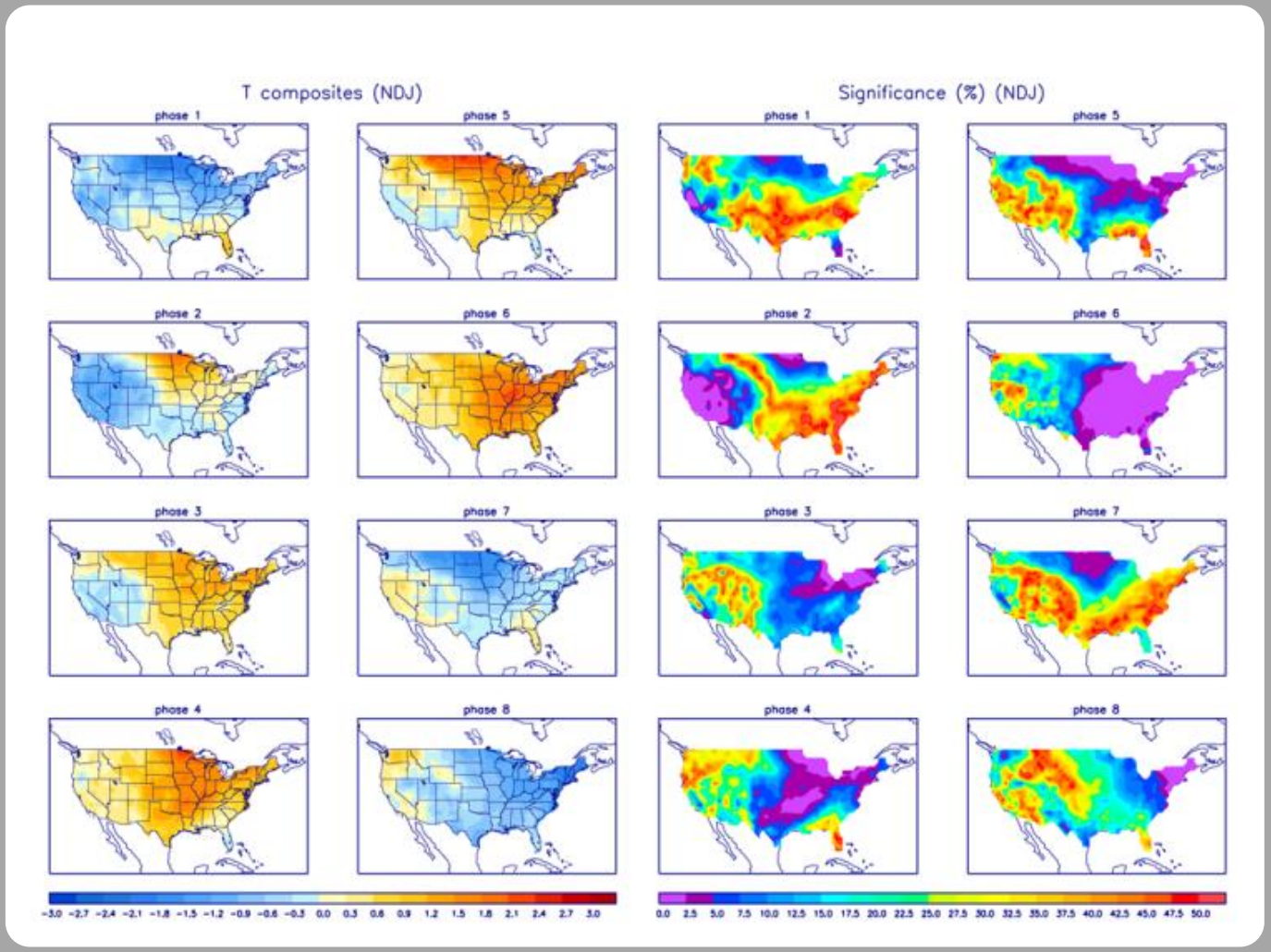
Precipitation Anomalies (Nov - Mar)



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.



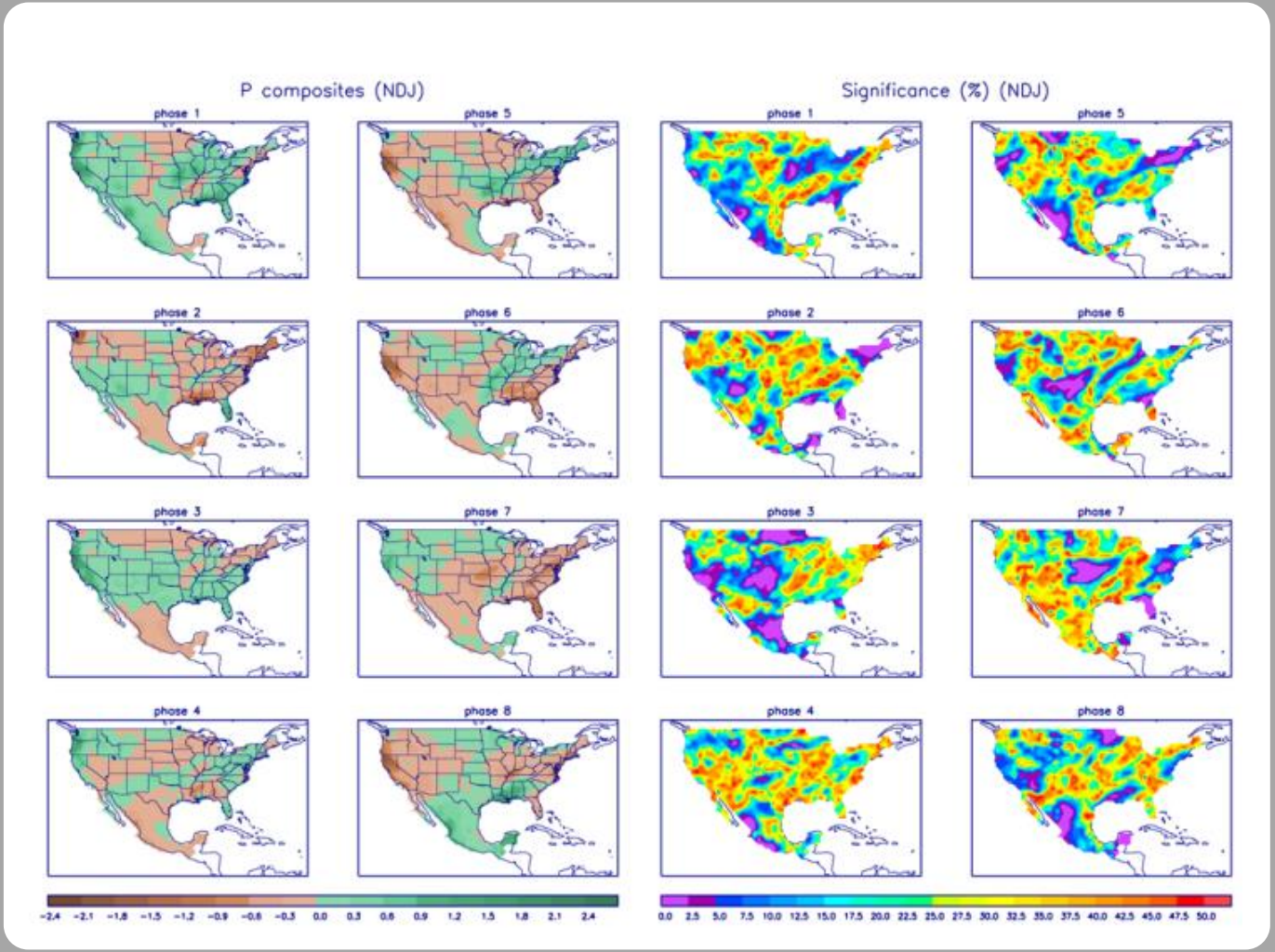
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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