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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Recent Evolution and Current Conditions

MJO Index Information

MJO Index Forecasts

MJO Composites

Overview

- MJO indices show a organized intraseasonal signal over the past week, with fast eastward propagation. The RMM index now places the MJO in Phase 8 at moderately strong amplitude, while the CPC velocity potential index likewise indicates enhanced convection over the Western Hemisphere.

- Dynamical model forecast solutions continue to depict coherent eastward propagation of a fairly strong signal over the next week, with a significant weakening of the predicted signal amplitude over the Indian Ocean during Week-2.

- It is unclear what role the MJO may play in the short-term climate forecast for the United States during the next two weeks.

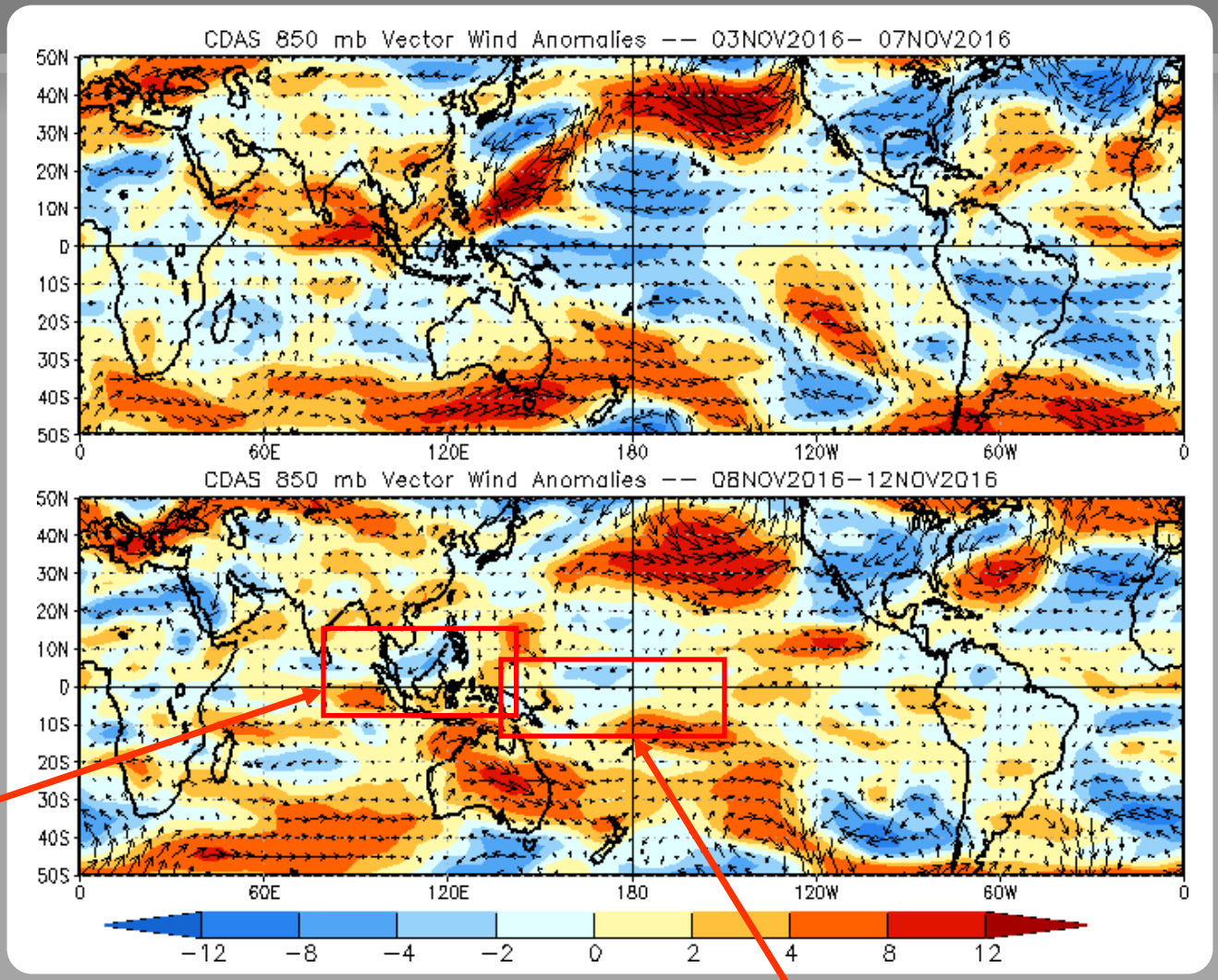
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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 across the eastern Indian Ocean & adjacent Maritime Continent during the past five days.

Easterly anomalies weakened rapidly over the west-central Pacific.

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

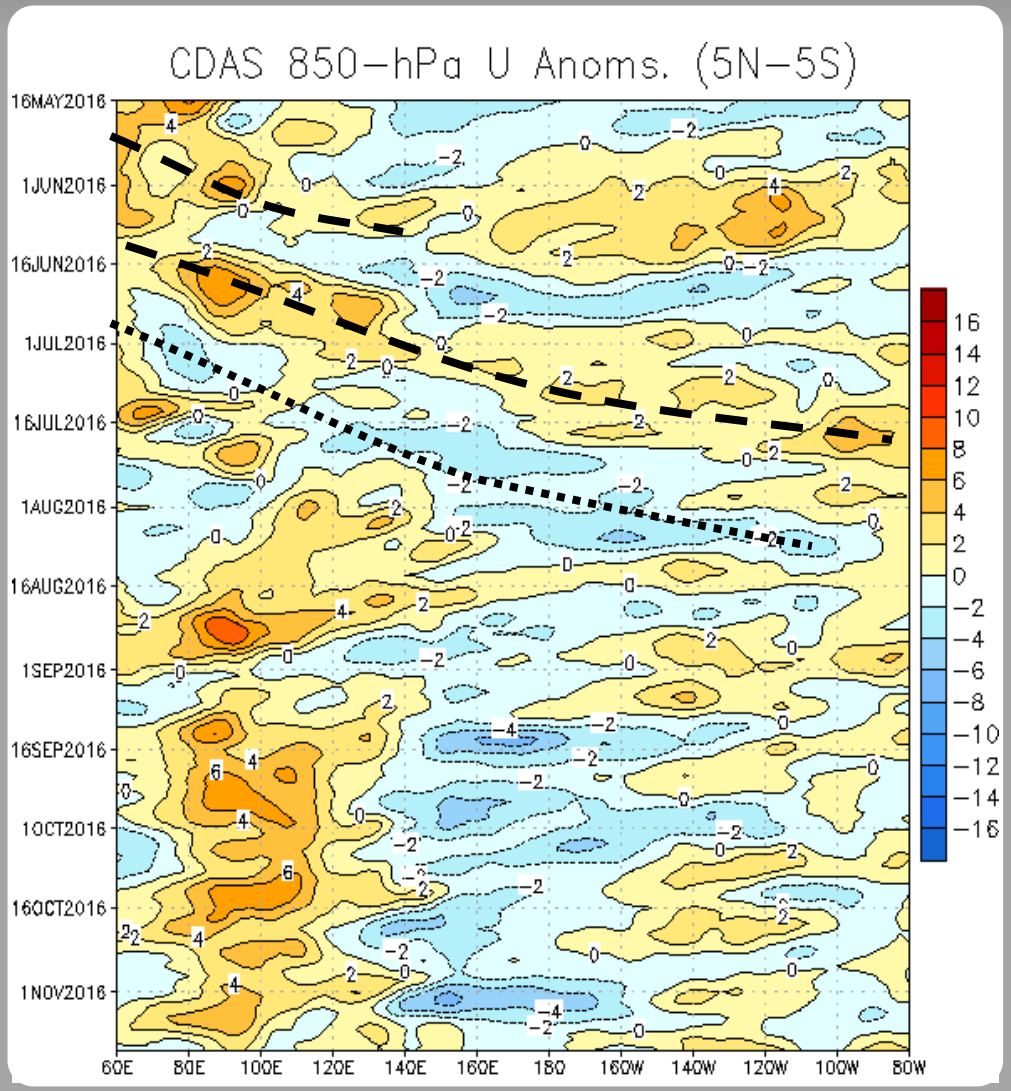
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

During May and June, westerly anomalies were persistent over the Indian Ocean (IO), with higher frequency modes periodically propagating across the Pacific.

During late August, westerly anomalies were evident across the IO and western Pacific.

During September and October, persistent westerly (easterly) anomalies were evident over the eastern Indian Ocean and western Maritime Continent (central Pacific). These anomalies are low frequency in nature, and reflect a developing La Niña base state as well as a negative phase of the Indian Ocean Dipole (IOD). During the past week, the anomaly pattern appears noisier and somewhat less coherent.



OLR Anomalies – Past 30 days

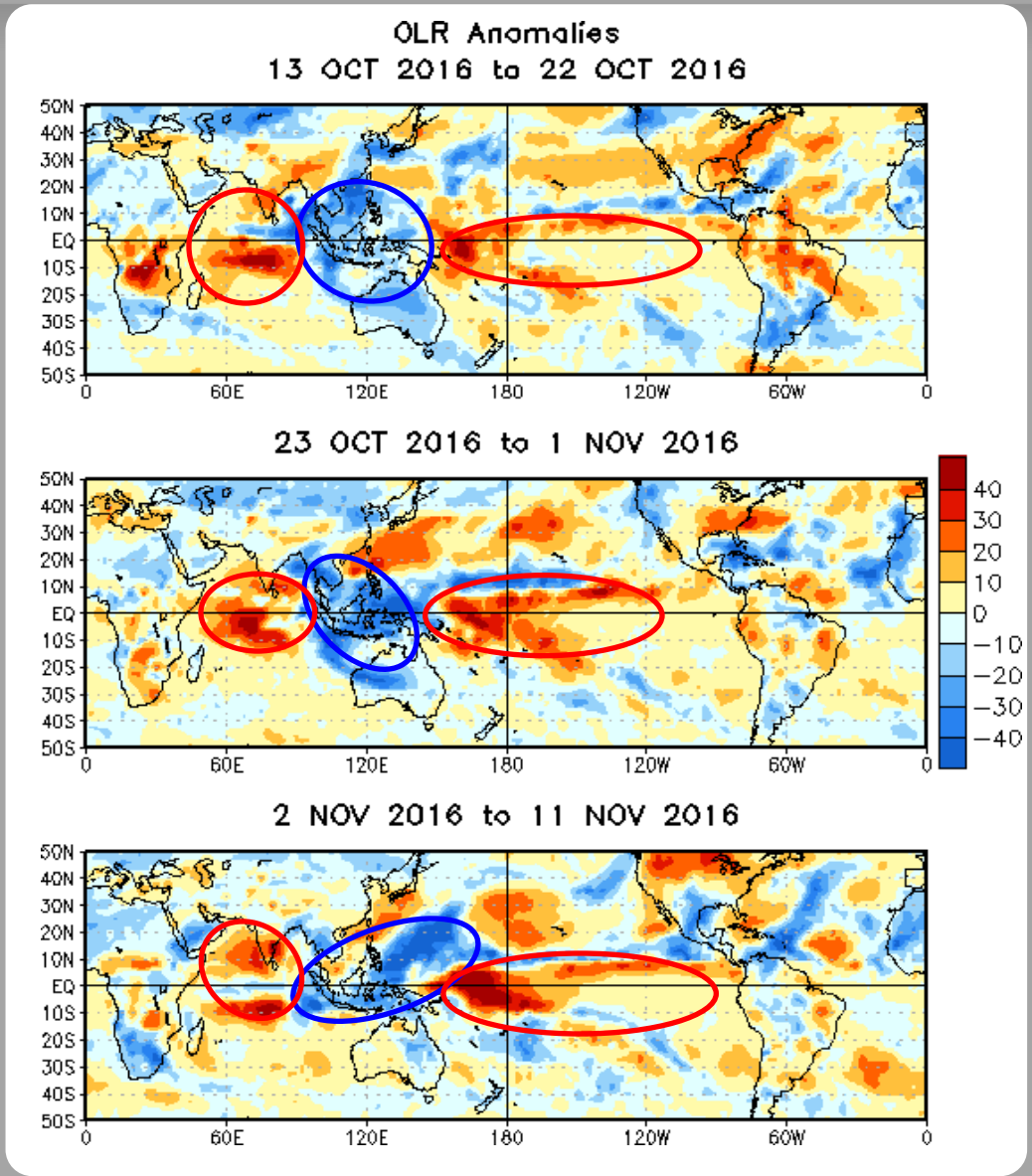
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During early to mid-October, enhanced (suppressed) convection was observed over the Maritime Continent (central Indian Ocean and equatorial Pacific basin).

The same general pattern persisted during the mid- to late October, consistent with the low frequency state and an absence of robust subseasonal tropical variability.

The stationary pattern continued into early November, though enhanced convection overspread parts of the northwestern Tropical Pacific.



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

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

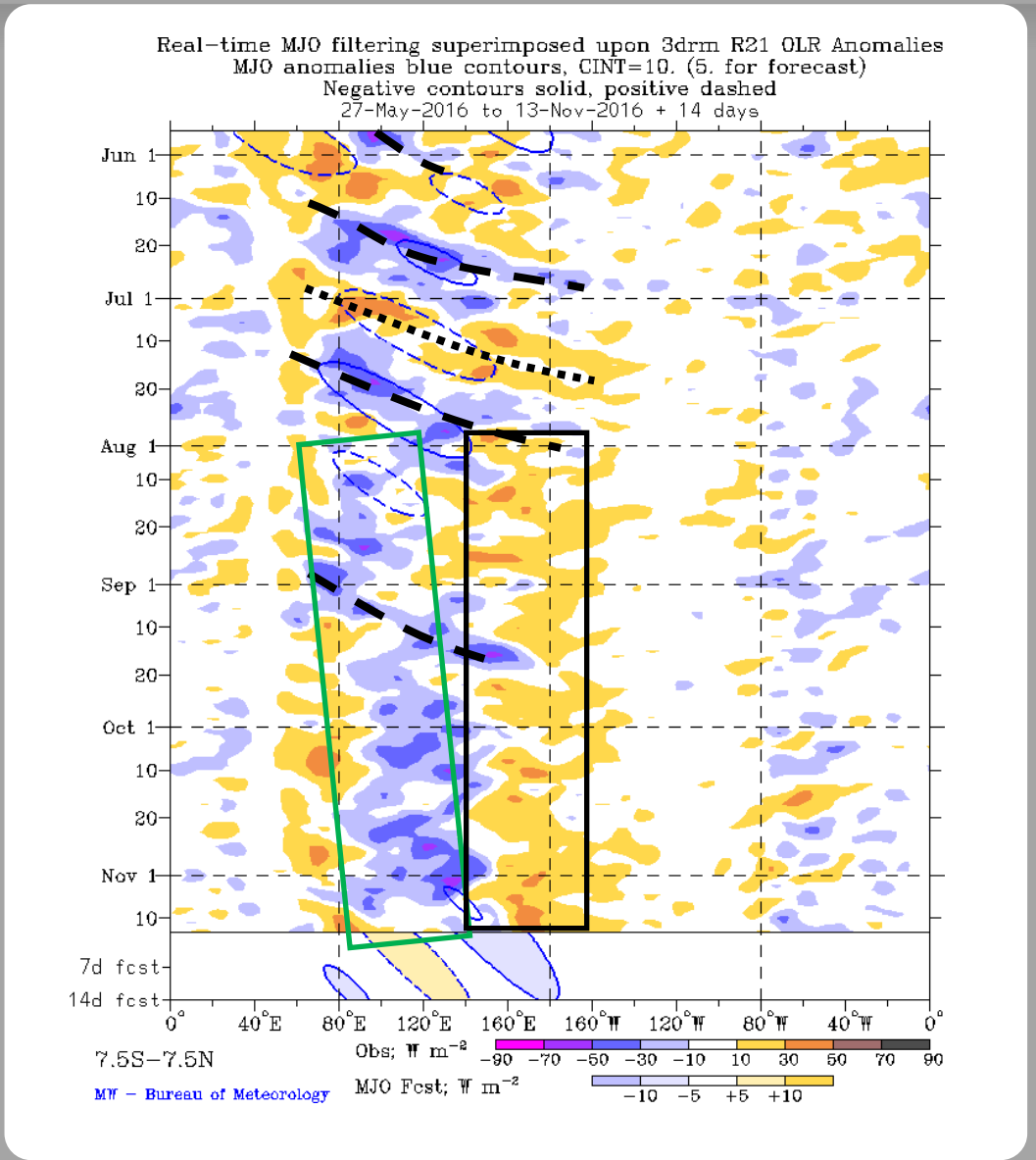
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Several intraseasonal events were observed through July, with other modes such as tropical cyclone activity also influencing the pattern.

A low frequency state favoring enhanced convection shifted slowly east from the eastern Indian Ocean to the Maritime Continent has been evident since July (green box).

Low frequency suppressed convection, tied to the developing La Niña conditions, has been apparent near the Date Line since late July (black box). A fast eastward propagating convective envelope was evident during early September.

More recently, robust negative OLR anomalies exhibited some eastward propagation, while the suppressed convection remained near the Date Line.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

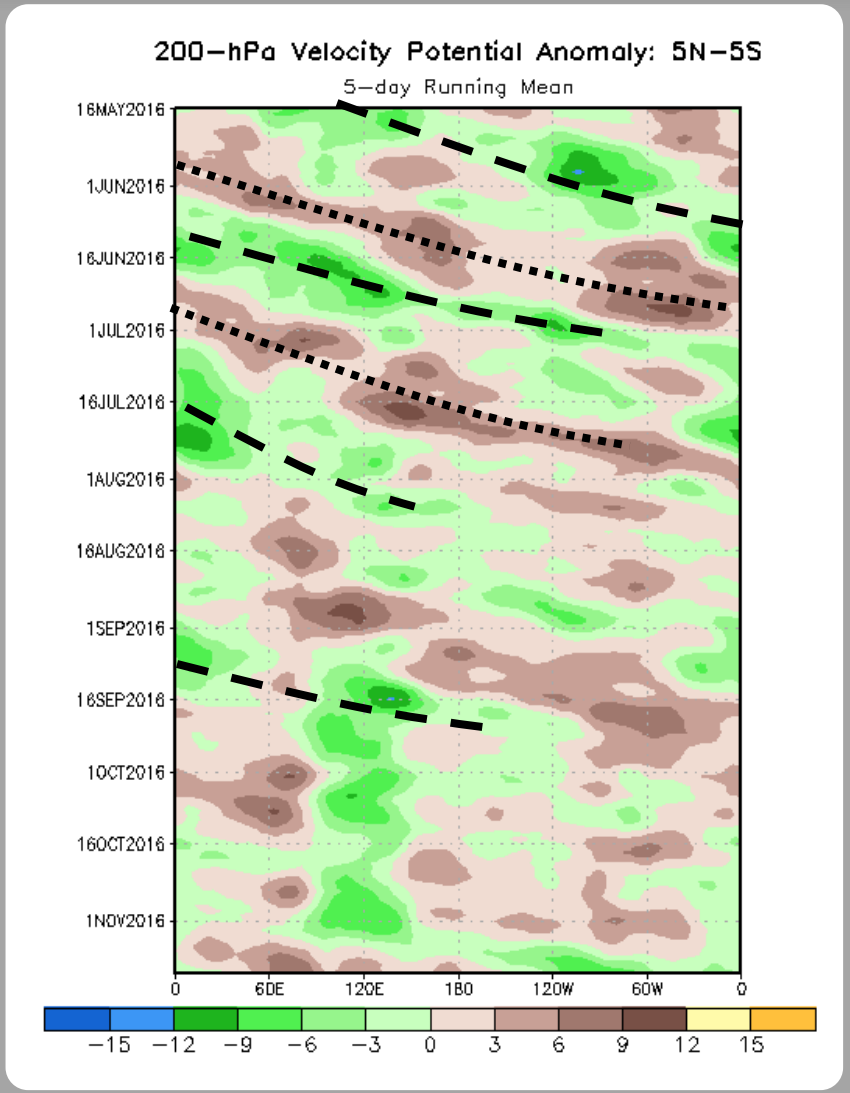
Negative anomalies (green shading) indicate favorable conditions for precipitation

From May through early August, an eastward propagating signal was evident, with multiple periods of variability apparent.

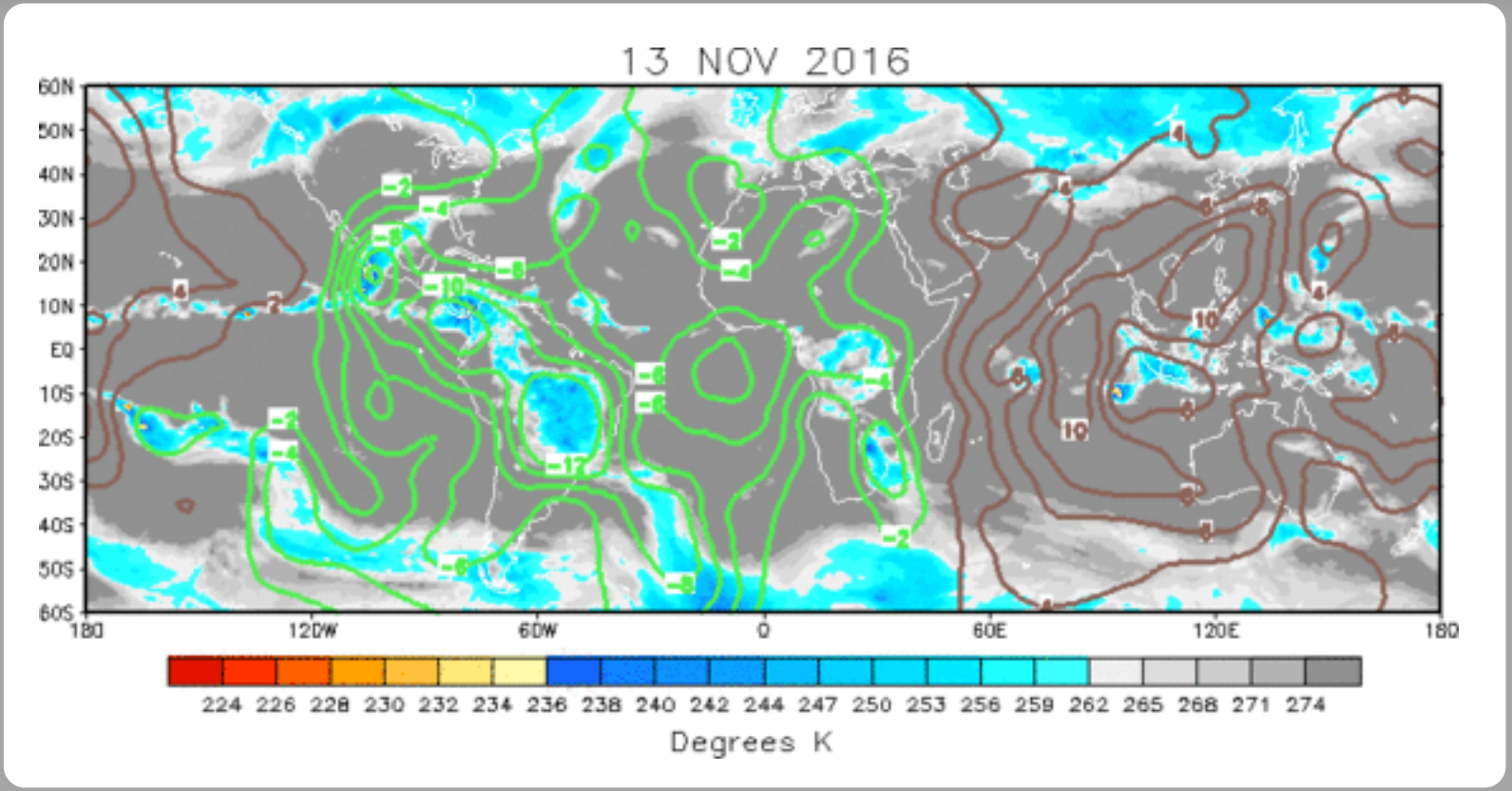
During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

Since probable Kelvin wave activity during the first half of September, the pattern has given way to lower frequency modes and a quasi-stationary state. In the recent absence of intraseasonal variability, the standing negative velocity potential anomalies near 120E associated with the negative IOD event are apparent.

Most recently, the VP anomalies suggest rapid propagation of the enhanced divergence aloft near 120E to about 120W, and at least a temporary break in the stationary pattern.



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



The overall spatial pattern of upper-level velocity potential anomalies has become more organized of late, with anomalous upper-level divergence (convergence) over much of the Western Hemisphere (Eastern Hemisphere).

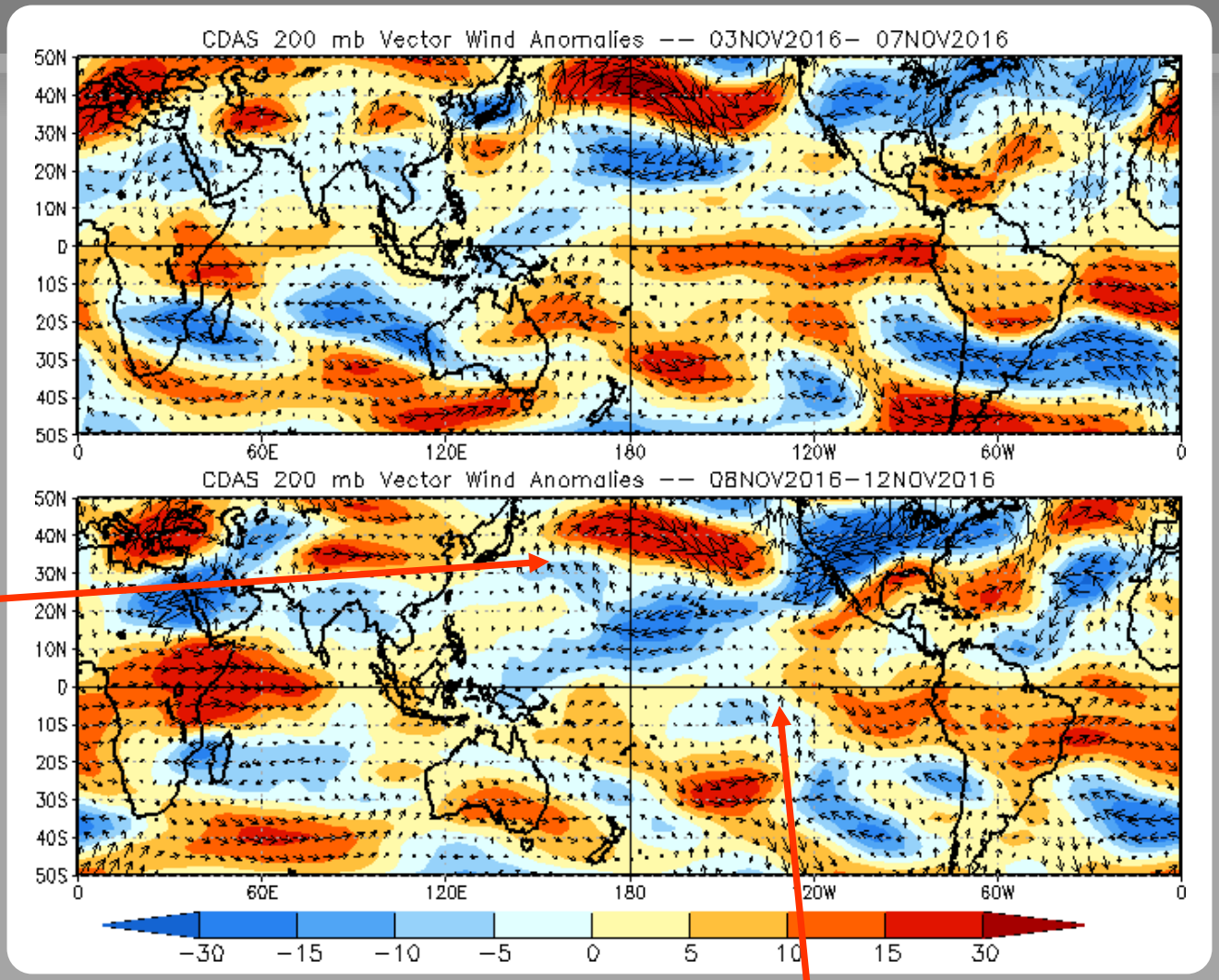
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 large mid-latitude anticyclone across the north central Pacific has not changed much in position during the past ten days.

Upper-level westerlies weakened over the east-central equatorial Pacific, and became southerlies (cross-equatorial).

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

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

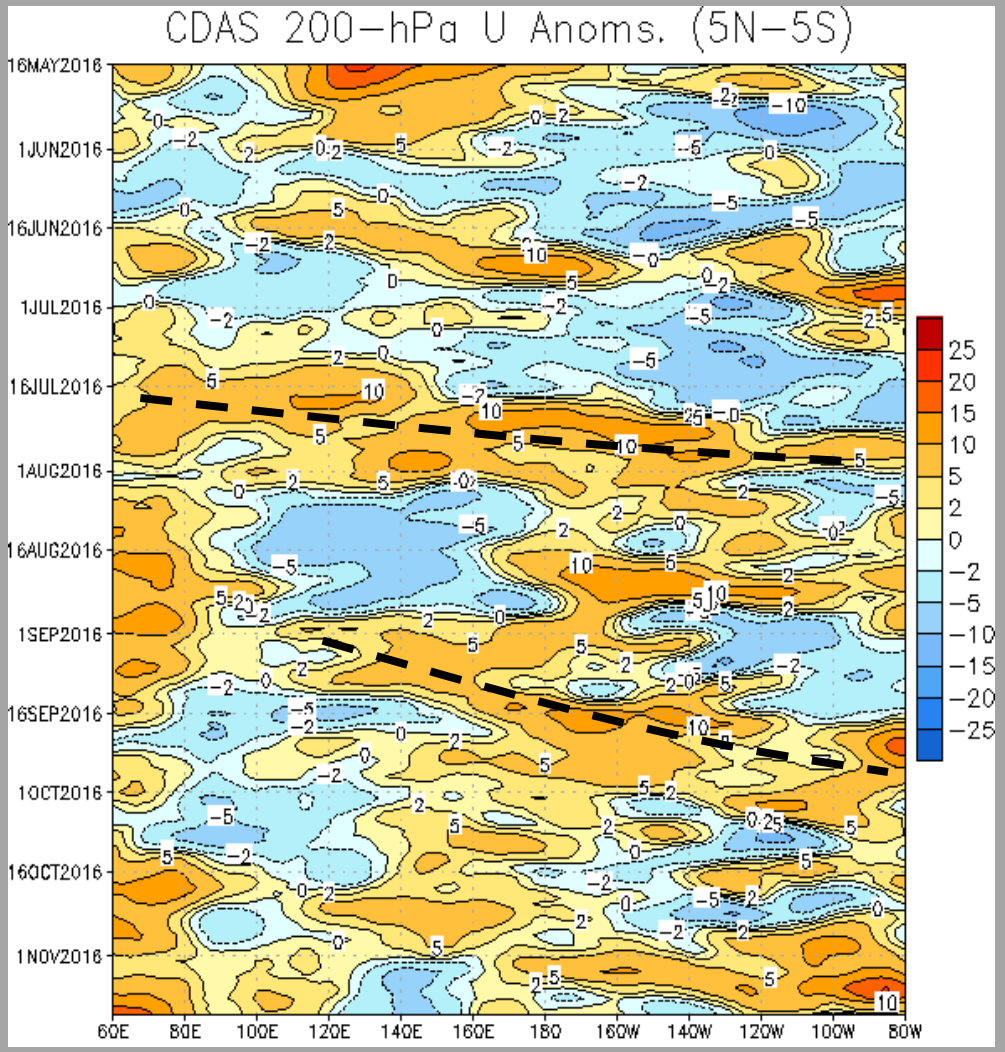
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During May, westerly anomalies expanded eastward to the Date Line. Faster modes were evident in the upper-level wind field.

During July, some eastward propagation in large scale anomalies are evident, although the spatial consistency implies higher frequency variability than expected with MJO activity.

During September, eastward propagation of westerly anomalies was broadly consistent with organized MJO activity.

In the past 30-days, anomalous westerlies from the Maritime Continent eastward across much of the Pacific were replaced by anomalous easterlies.



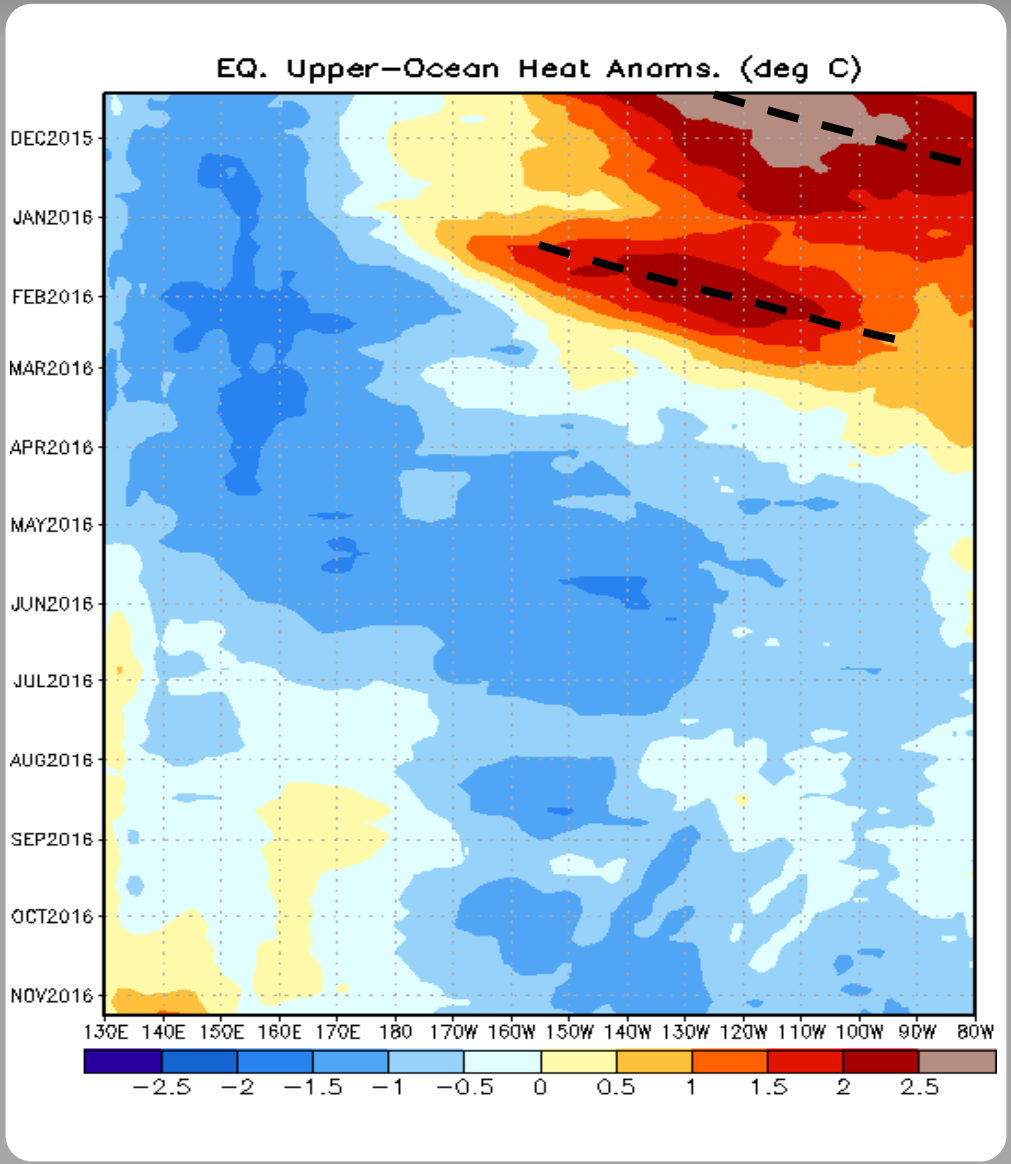
Weekly Heat Content Evolution in the Equatorial Pacific

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.

Downwelling events were observed during late 2015, resulting in persistently above-normal heat content from the Date Line to 80W over that period.

An eastward expansion of below average heat content over the western Pacific is evident since January, with widespread negative anomalies building across the Pacific.

The strongest negative anomalies now persist east of the Date Line.



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

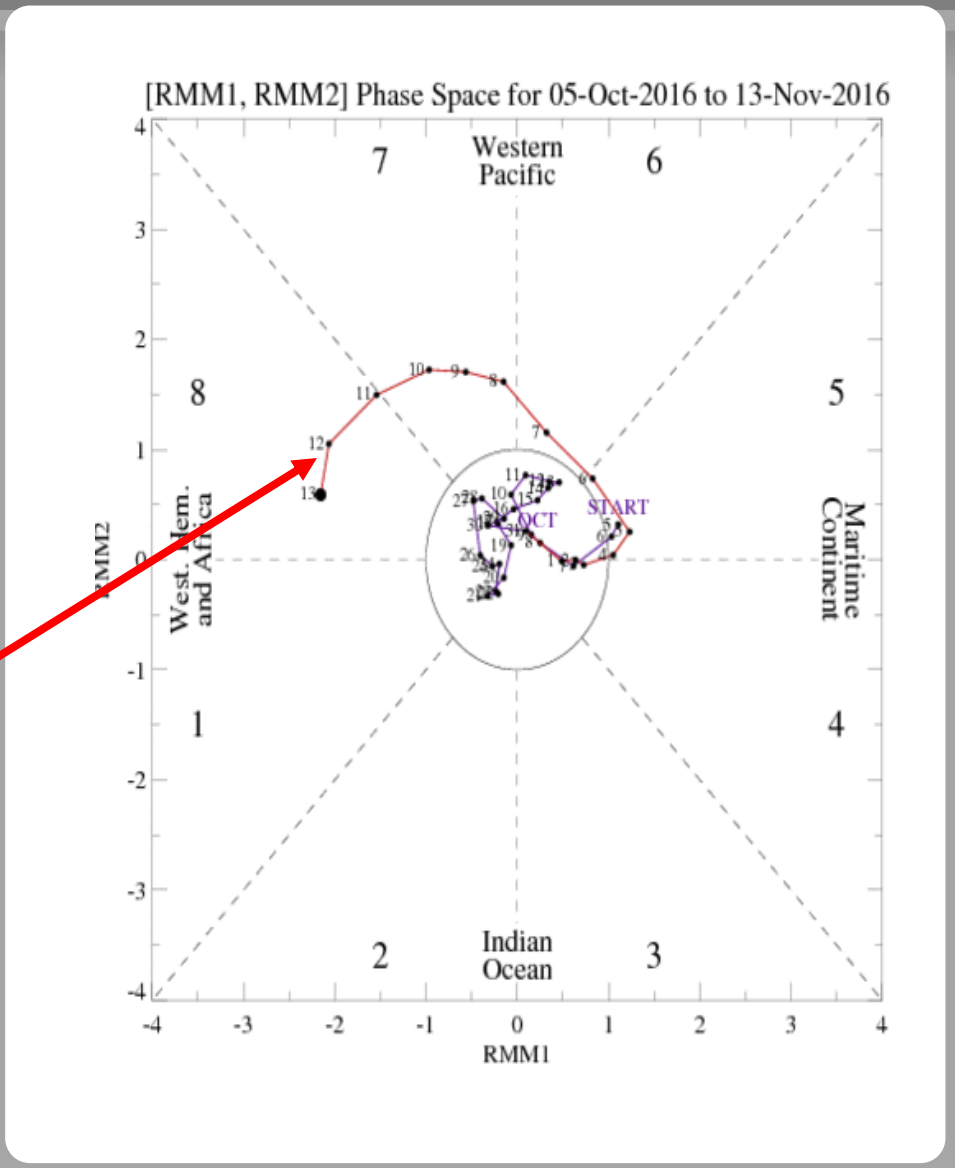
The triangular areas indicate the location of the enhanced phase of the MJO

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

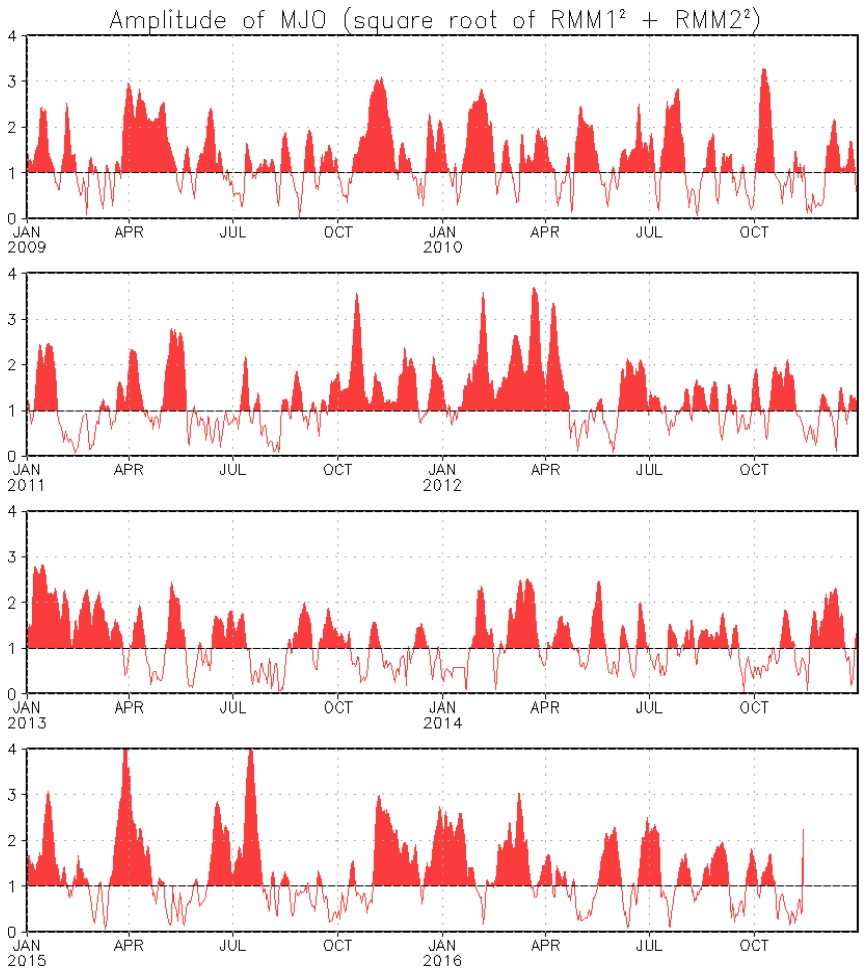
The RMM index shows recent strengthening of the MJO, and rapid propagation during the past week from phase 5 to phase 8. This is likely associated with kelvin wave activity.



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.



Ensemble GFS (GEFS) MJO Forecast

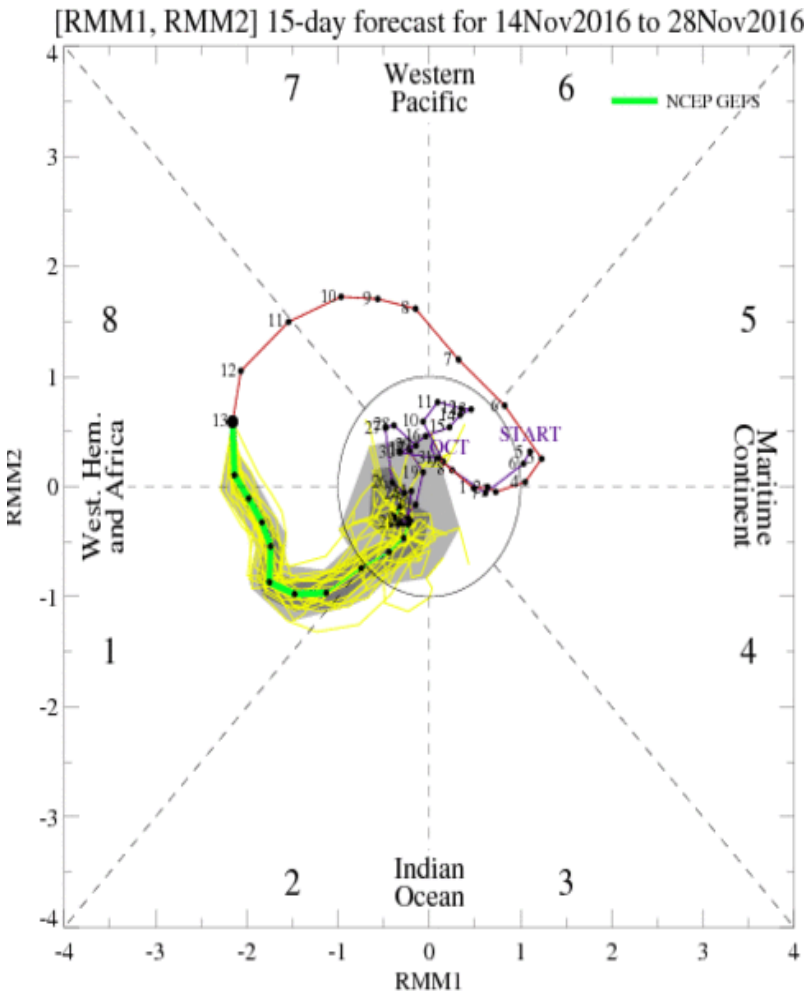
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts

dark gray shading: 50% of forecasts

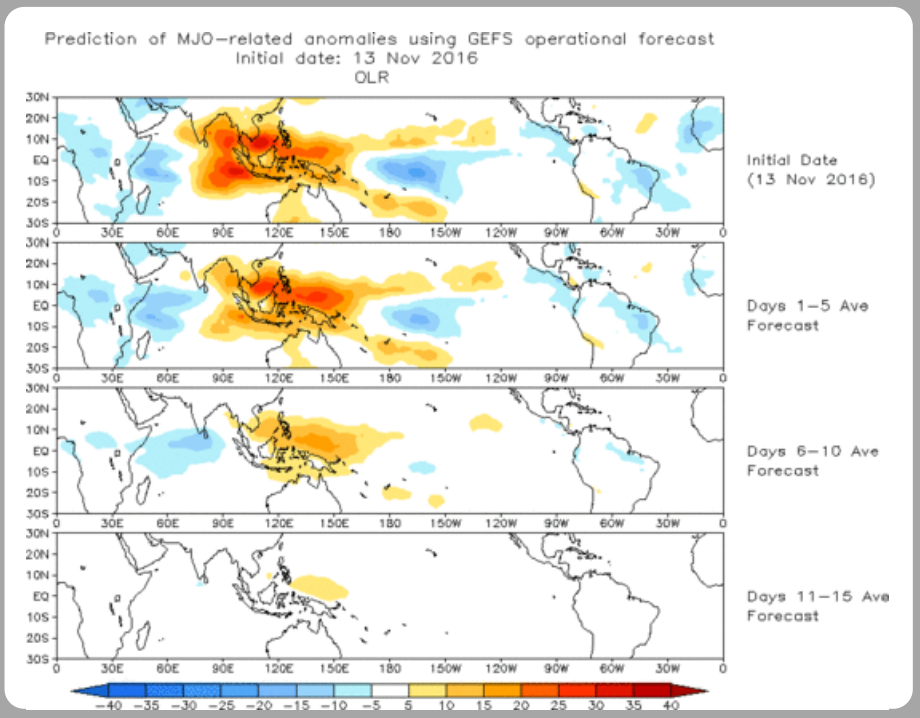
For the next two weeks, the GFS ensemble forecast depicts rapid eastward propagation of a strong signal (kelvin wave) from phase 8 to the Indian Ocean, before rapidly weakening.



Ensemble GFS (GEFS) MJO Forecast

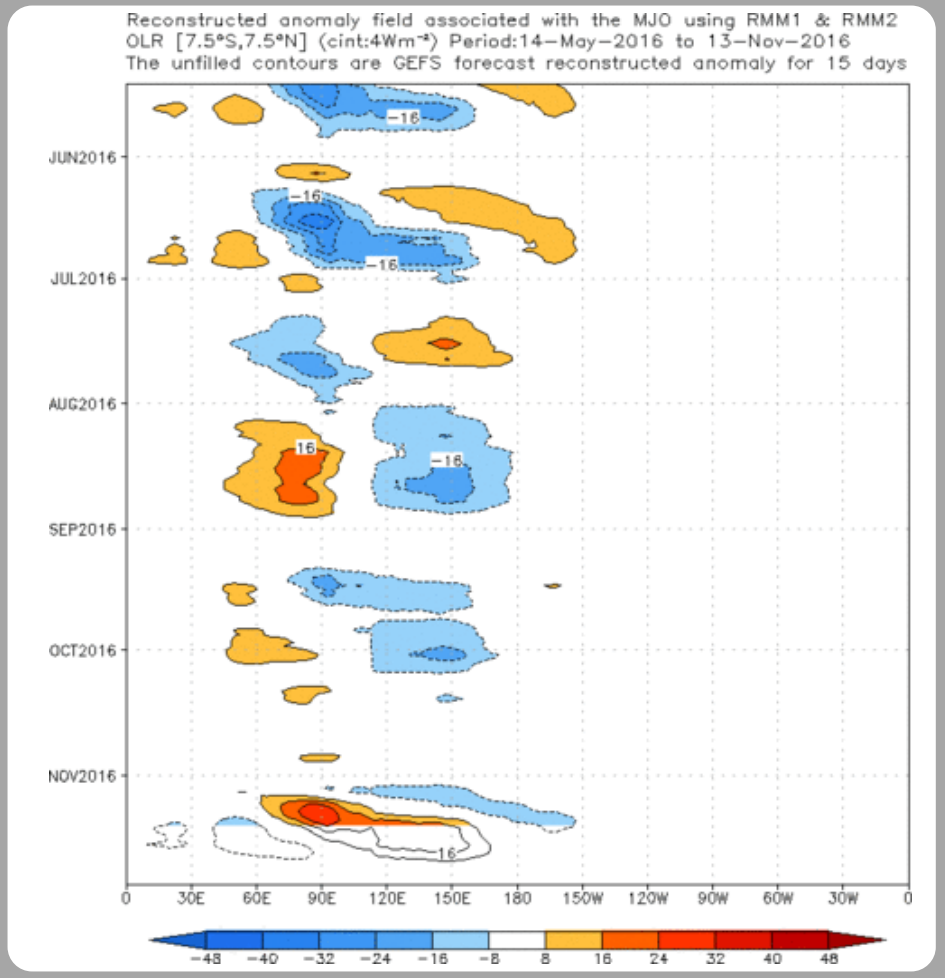
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM Index forecast OLR anomalies show enhanced (suppressed) convection propagating from Africa across most of the Indian Ocean (eastern Indian Ocean to the far western Pacific) during the next two weeks.

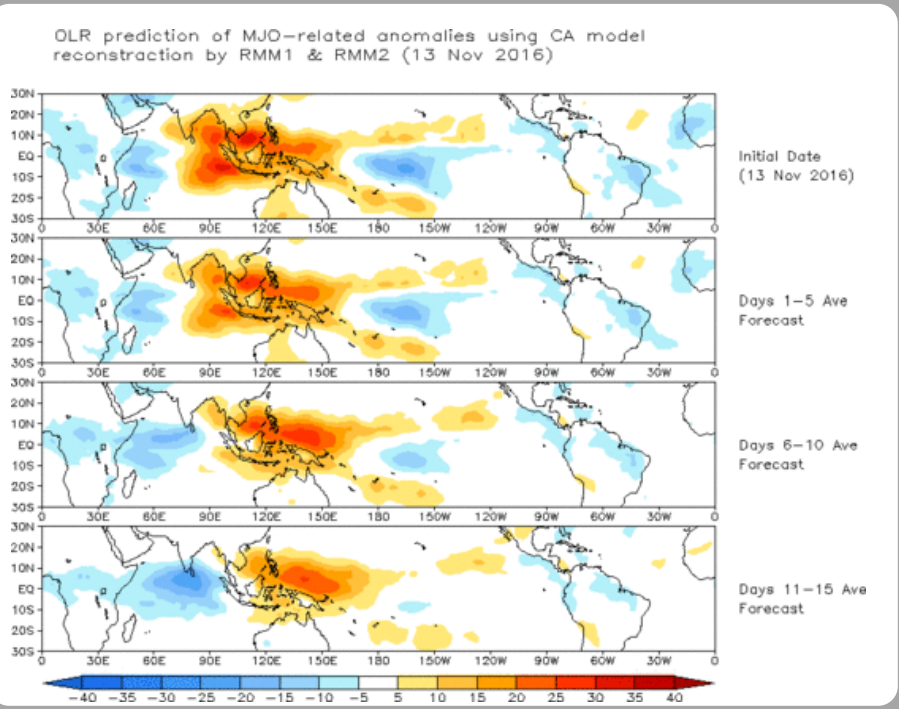
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



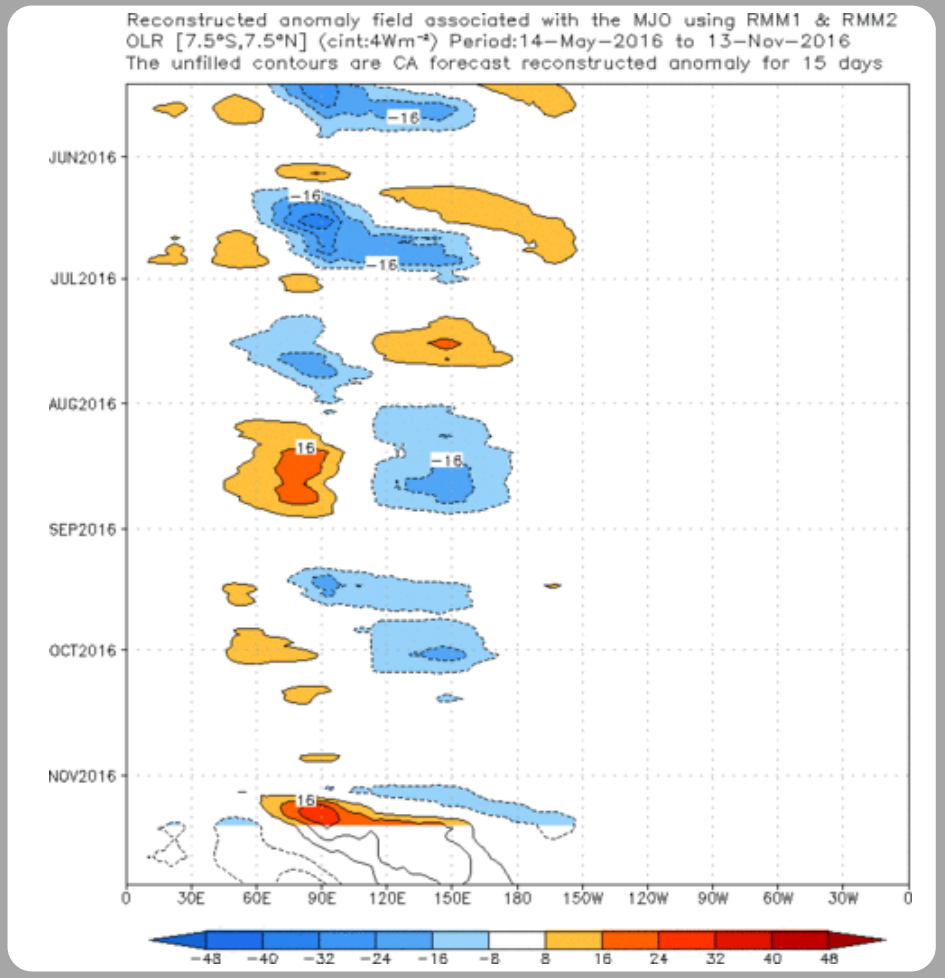
Constructed Analog (CA) MJO Forecast

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



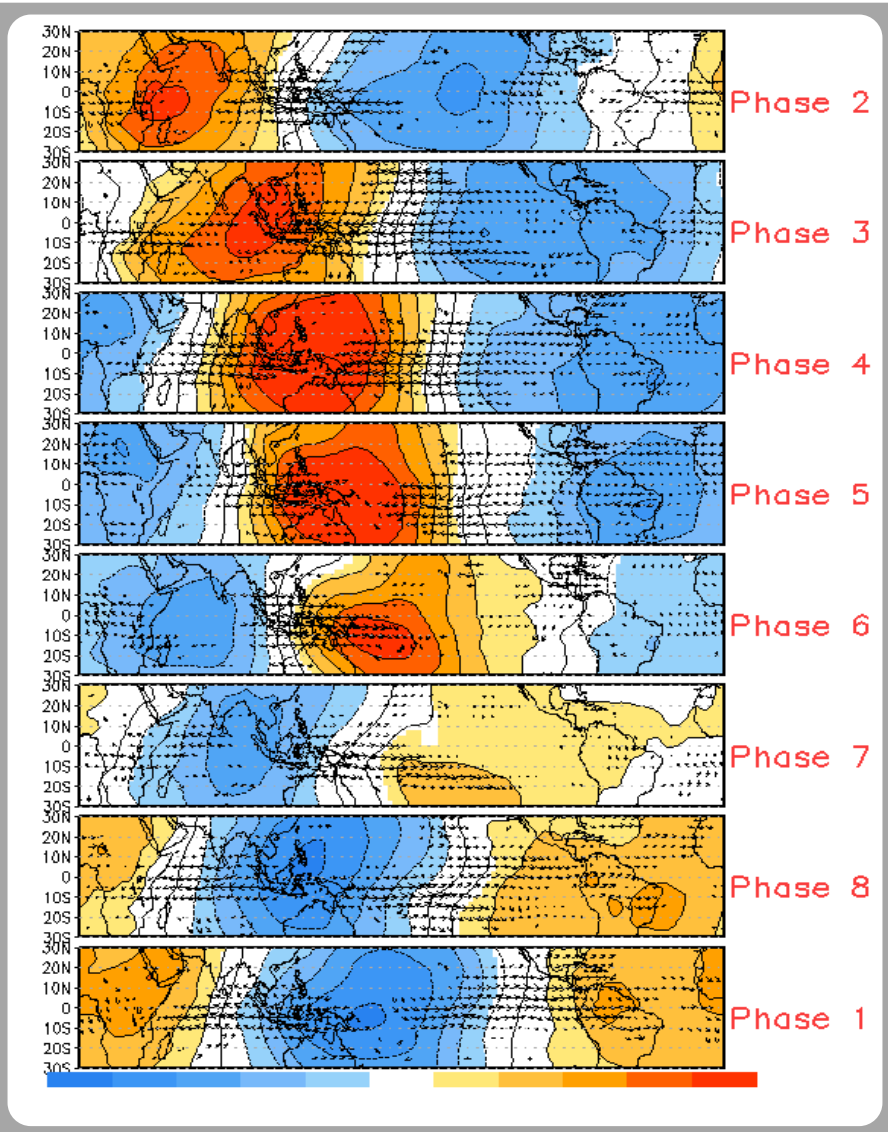
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



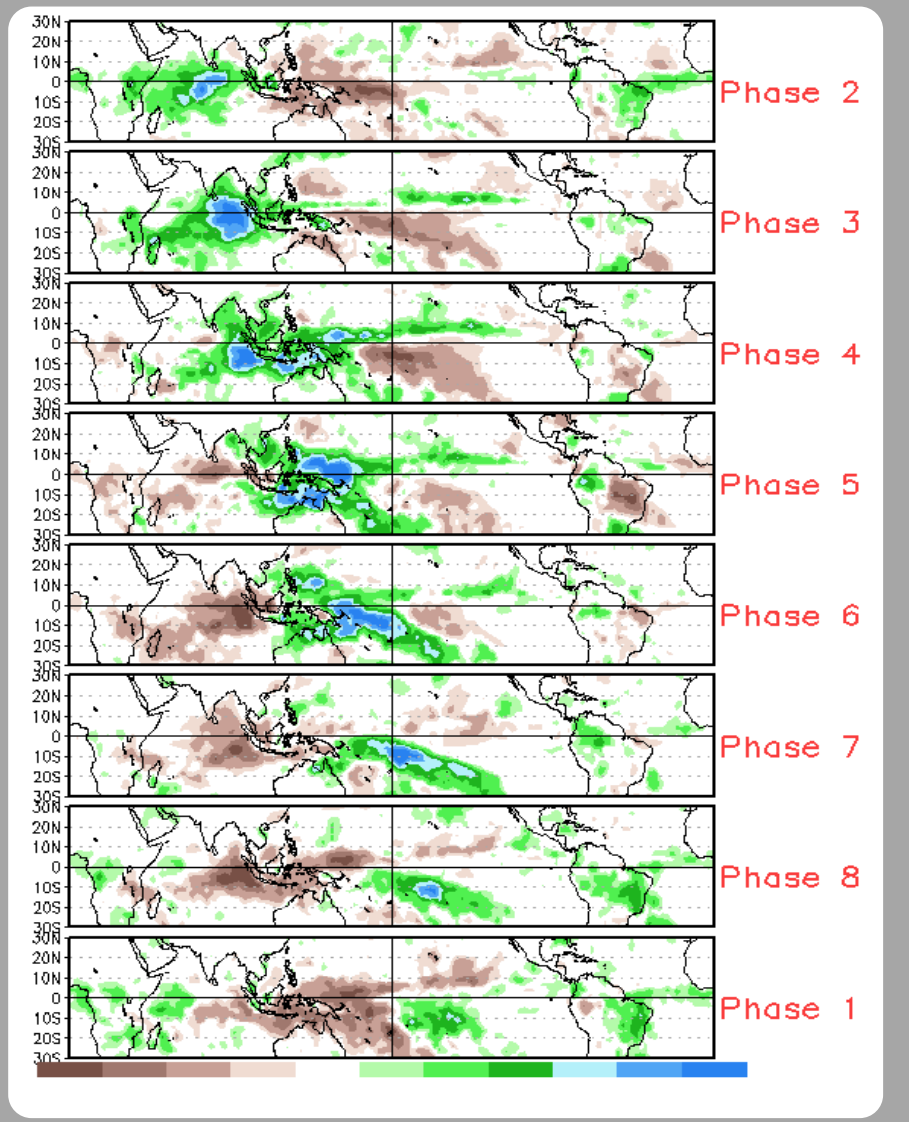
The Constructed Analog model depicts slow, eastward propagation of the OLR anomaly pattern; with enhanced convection moving across the western and central Indian Ocean, and suppressed convection from the eastern Indian Ocean to the far western Pacific.

MJO Composites - Global Tropics

850-hPa Velocity Potential and Wind Anomalies (May - Sep)



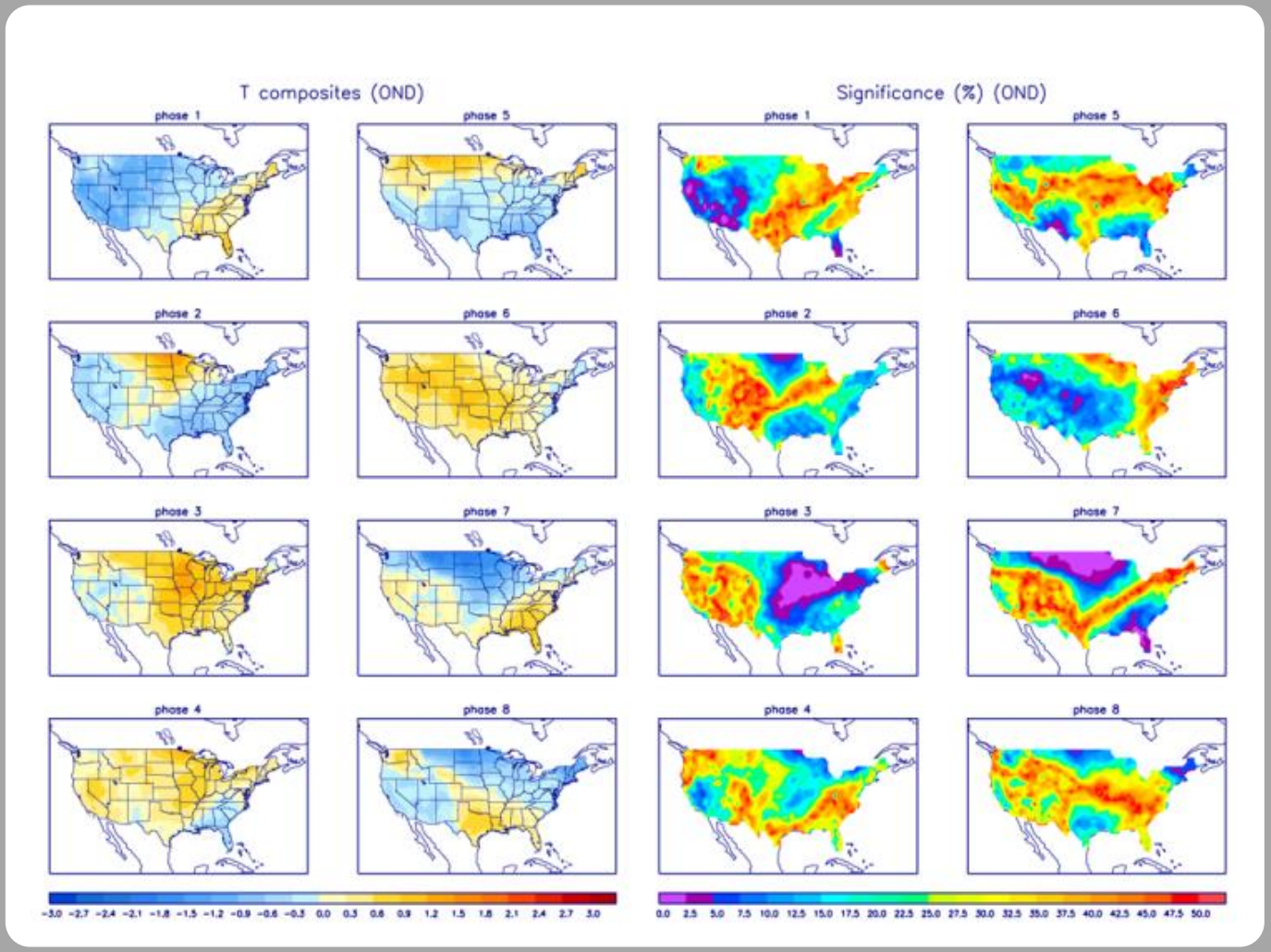
Precipitation Anomalies (May - Sep)



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.



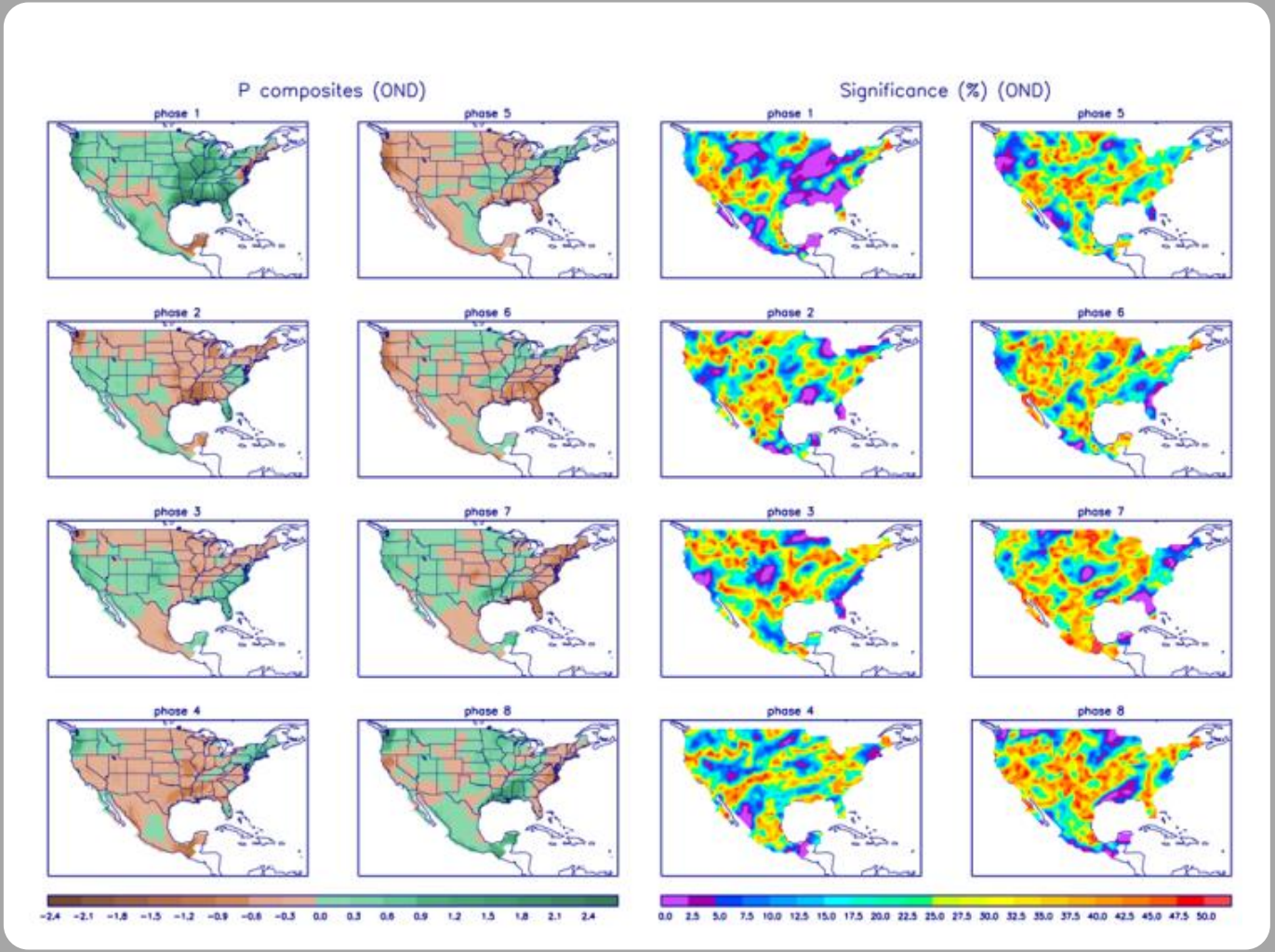
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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