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

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Climate Prediction Center / NCEP
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Outline

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MJO Index Forecasts

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Overview

- The CPC velocity potential index suggests possible MJO activity in the far West Pacific, while the RMM index has been low amplitude with a tendency towards a solution generally in Phase 5/6.

- Ongoing co-located Kelvin wave activity and La Niña contributions to the tropical circulation introduce further uncertainty in discerning any potential MJO presence.

- Dynamical model forecasts of the RMM index generally bring the intraseasonal signal westward initially, before eastward propagation of a potential MJO event that appears to be of marginal amplitude and towards the faster end of the phase speed spectrum.

- Some enhancement of the convective signal is possible across the Western Pacific in the next two weeks, although interference with the low frequency state, in addition to the forecast weak amplitude and high phase speed of the potential MJO, limit confidence in the extent and magnitude of the response. Extratropical impacts are not anticipated at this time.

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)

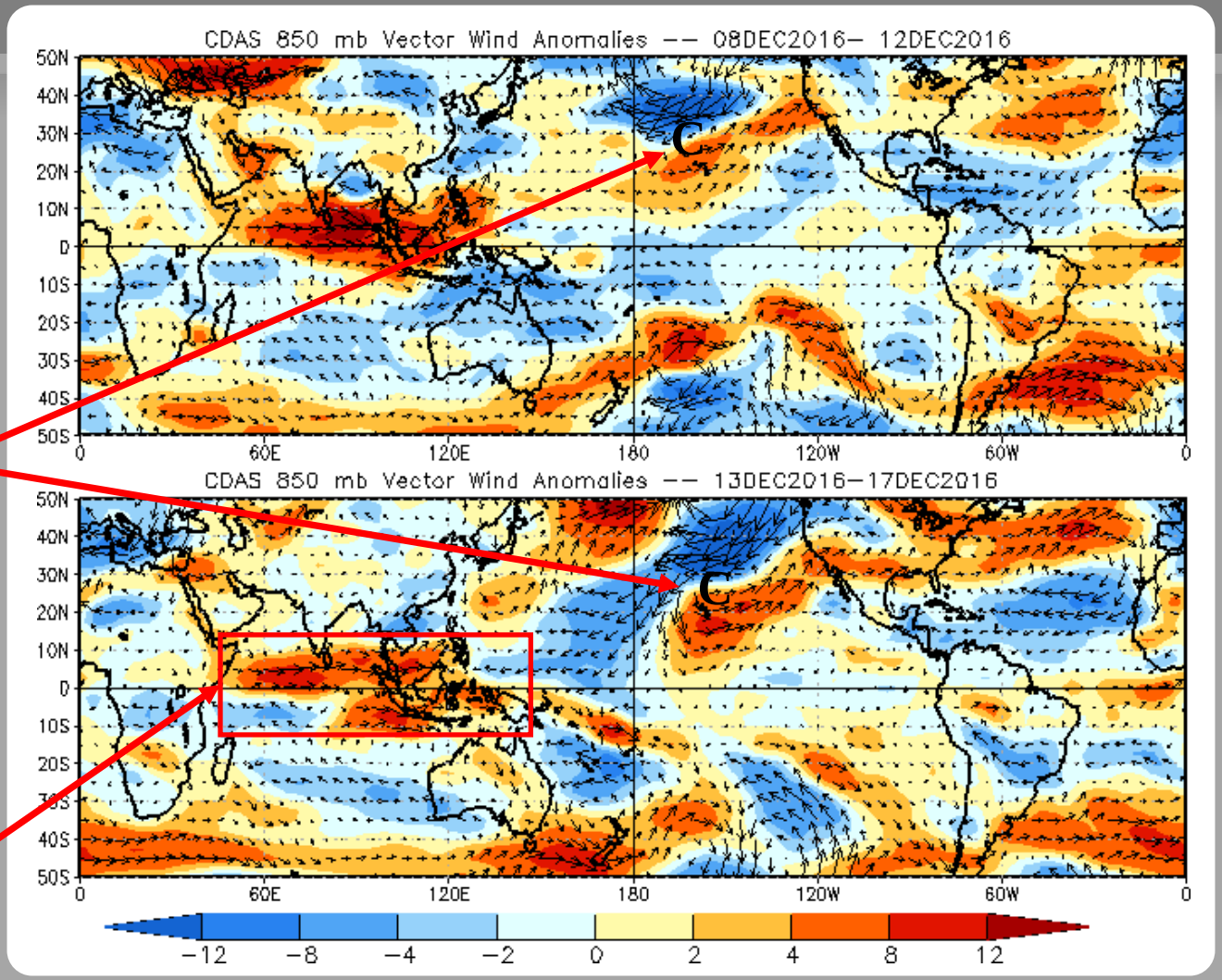
Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

Anomalous cyclonic flow near Hawaii has promoted a surge of tropical Pacific air into the western U.S.

Anomalous westerlies continue over the equatorial Indian Ocean and Maritime continent, consistent with the low-frequency state.



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

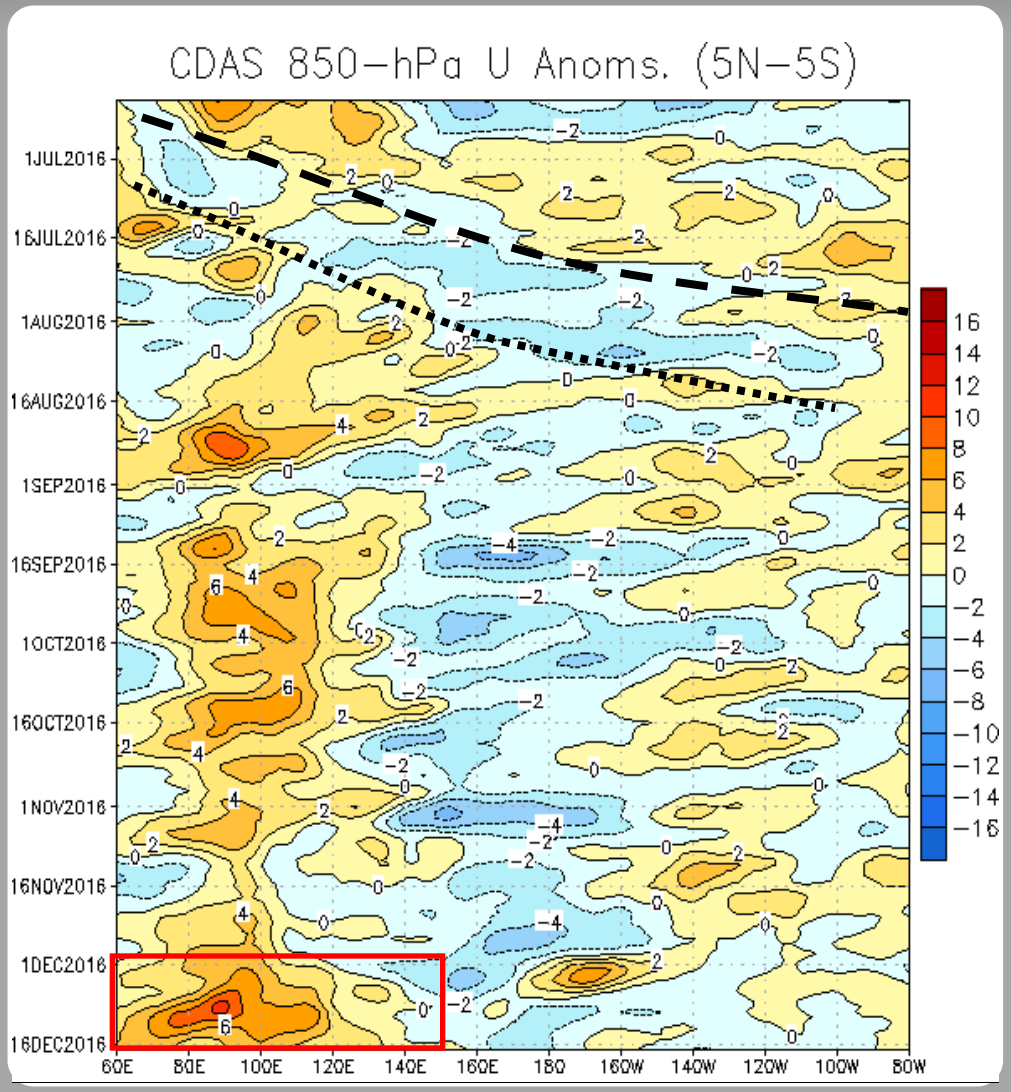
Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

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

In July and early August, high frequency, eastward-propagating modes were observed crossing the 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 the La Niña base state as well as a negative phase of the Indian Ocean Dipole.

In early December, westerly anomalies continued to persist across the Indian Ocean while increasing in coverage and intensity (red box).



OLR Anomalies – Past 30 days

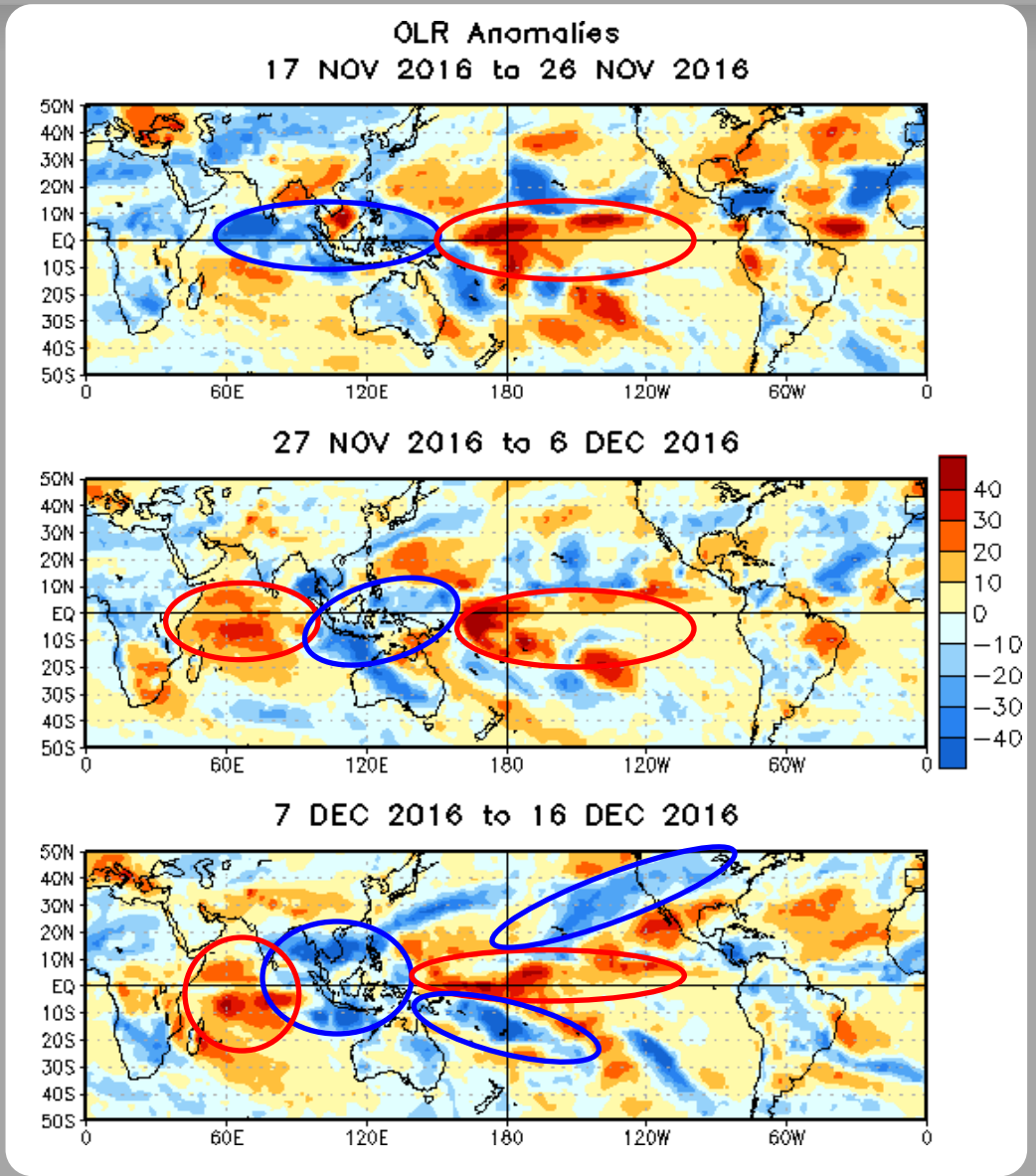
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

During mid-November, enhanced (suppressed) convection was observed over the Maritime Continent and Indian Ocean (equatorial Pacific basin). Aside from the Indian Ocean, this activity is consistent with the base state.

The low-frequency signal continued to influence the pattern of anomalous convection in late November and early December, with subseasonally-linked drying observed in the western Indian Ocean yielding a tripole of anomalous convective activity for the Indo-Pacific region.

In early December, the aforementioned tripole persisted across the Indo-Pacific region. Elsewhere in the Pacific, anomalous convection extended from Hawaii through California and an enhanced South Pacific Convergence Zone was apparent.



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

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

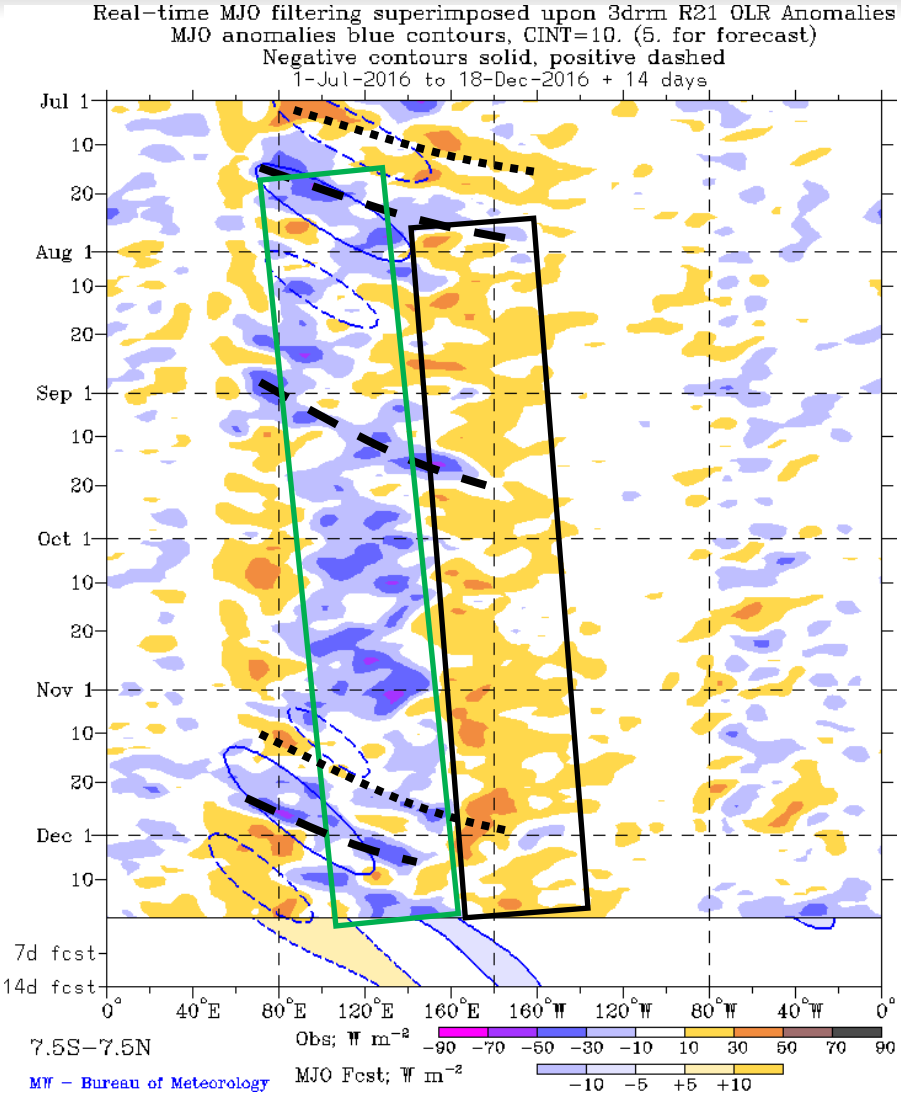
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Several intraseasonal events were observed through July, with other modes 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 building 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.

Since mid-November, eastward propagating modes (Kelvin waves, possibly MJO) were periodically apparent in the Indian Ocean and West Pacific.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

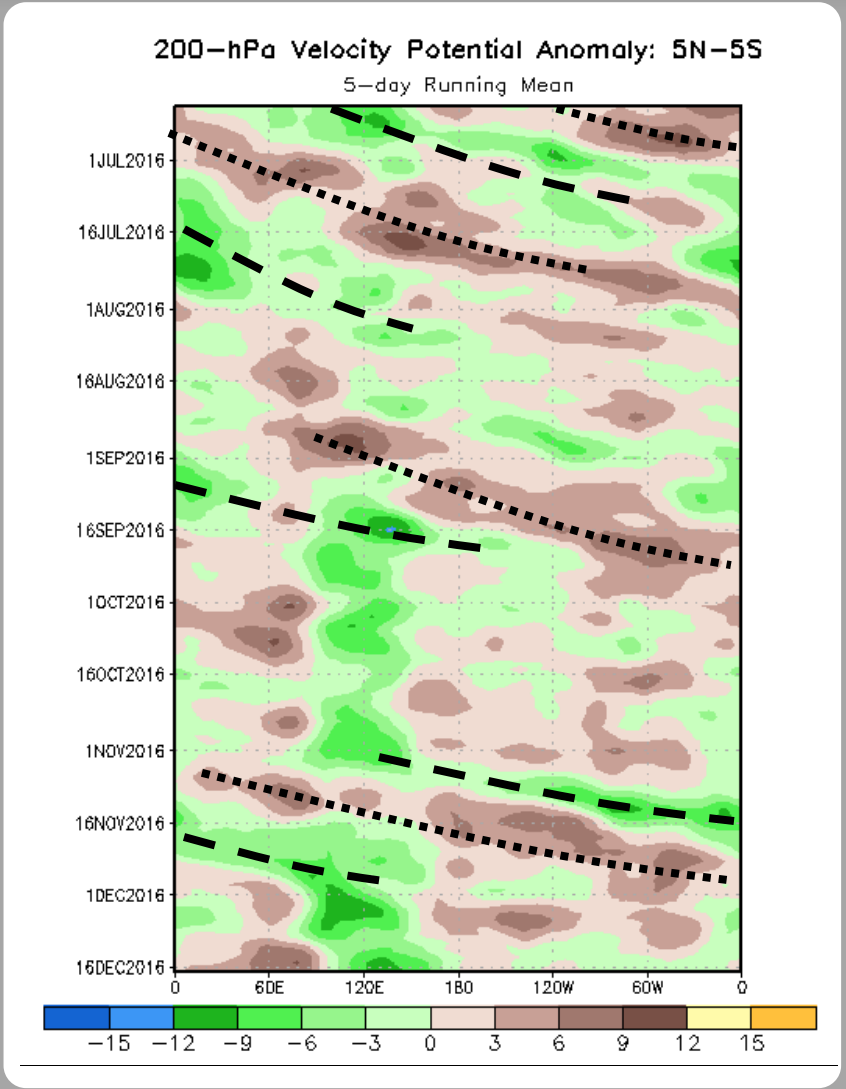
Negative anomalies (green shading) indicate favorable conditions for precipitation

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

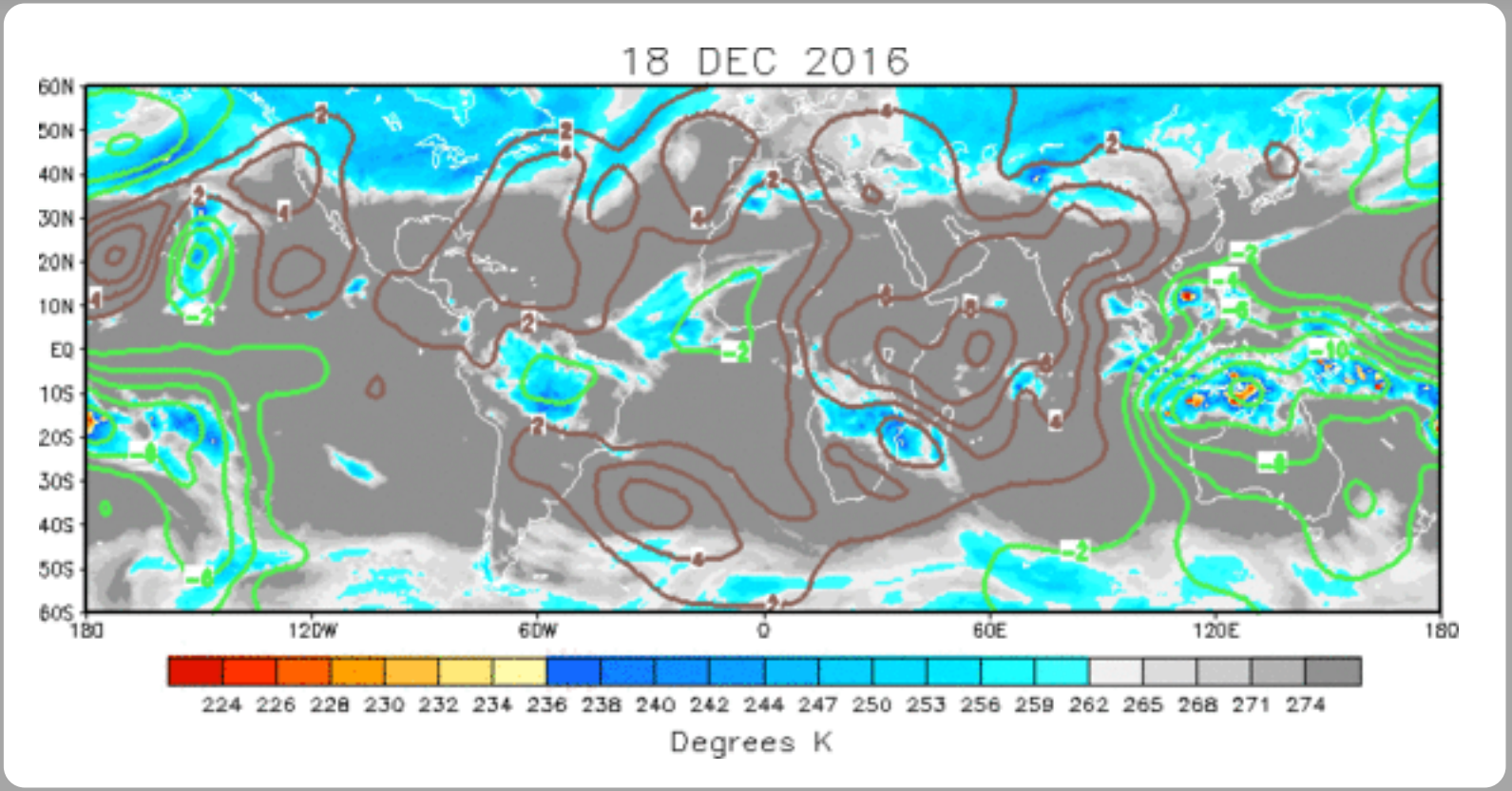
During August, the intraseasonal signal became less coherent, with a weaker and somewhat more stationary anomaly field in place. By late August and early September, there was renewed propagation of the intraseasonal signal.

From mid-September to late October, the low frequency signal dominated the pattern. Persistent negative velocity potential anomalies near 120E associated with the negative Indian Ocean Dipole event were apparent over this period.

During November, eastward propagation has been observed consistent with MJO activity on the fast end of the intraseasonal spectrum, with negative anomalies returning to the Maritime Continent. These exhibit some slower eastward propagation through the end of the period.



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



The spatial pattern of upper-level velocity potential anomalies is most pronounced over the Eastern Hemisphere with enhanced (suppressed) convection over the Maritime Continent and West Pacific (Africa and western Indian Ocean).

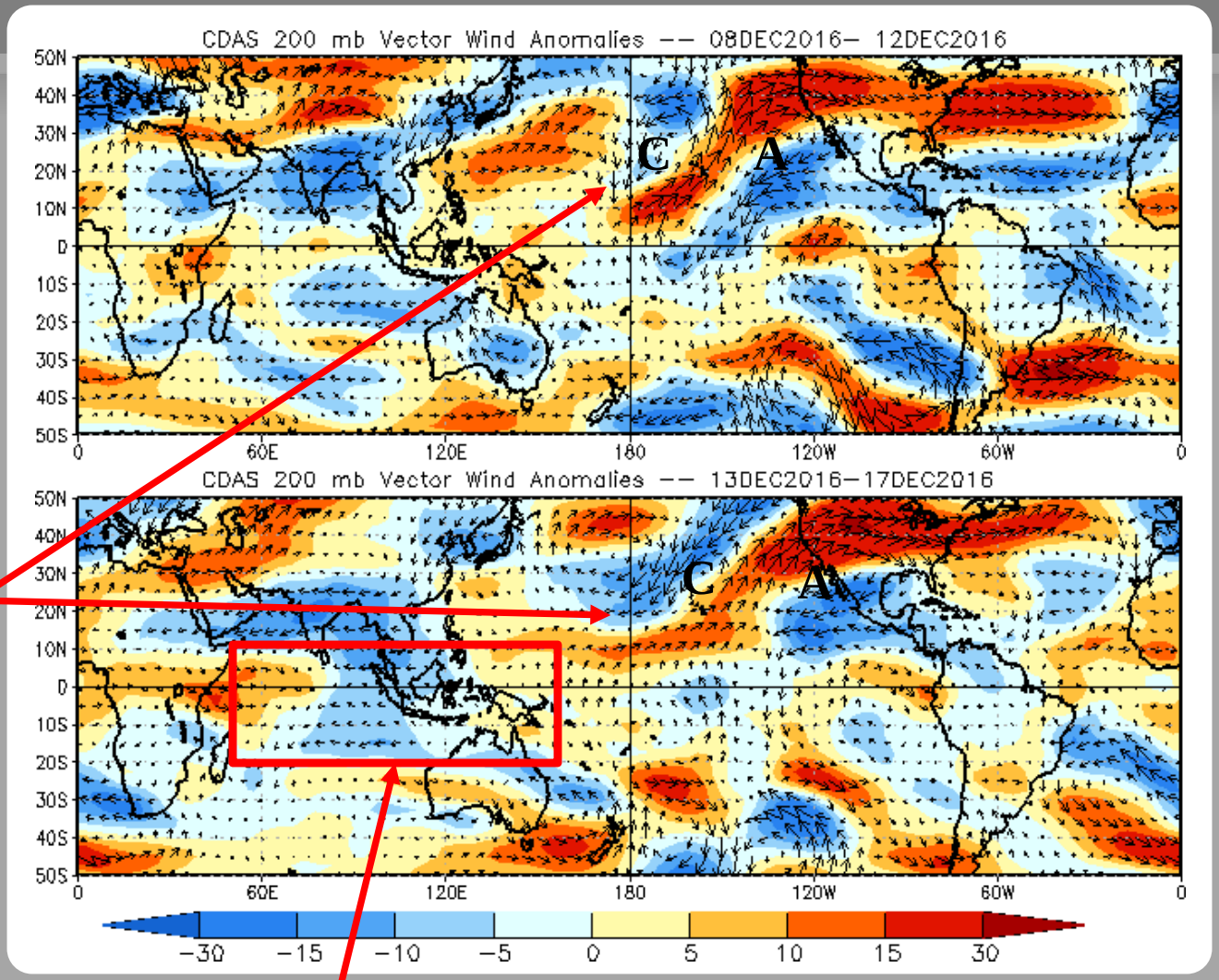
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation
Negative anomalies (green contours) indicate favorable conditions for precipitation

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Cyclonic/anticyclonic couplets in the North Pacific have helped bring a stream of tropical moisture to the Pacific U.S.

Anomalous convergence (divergence) was apparent over the Indian Ocean (Maritime Continent).

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

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

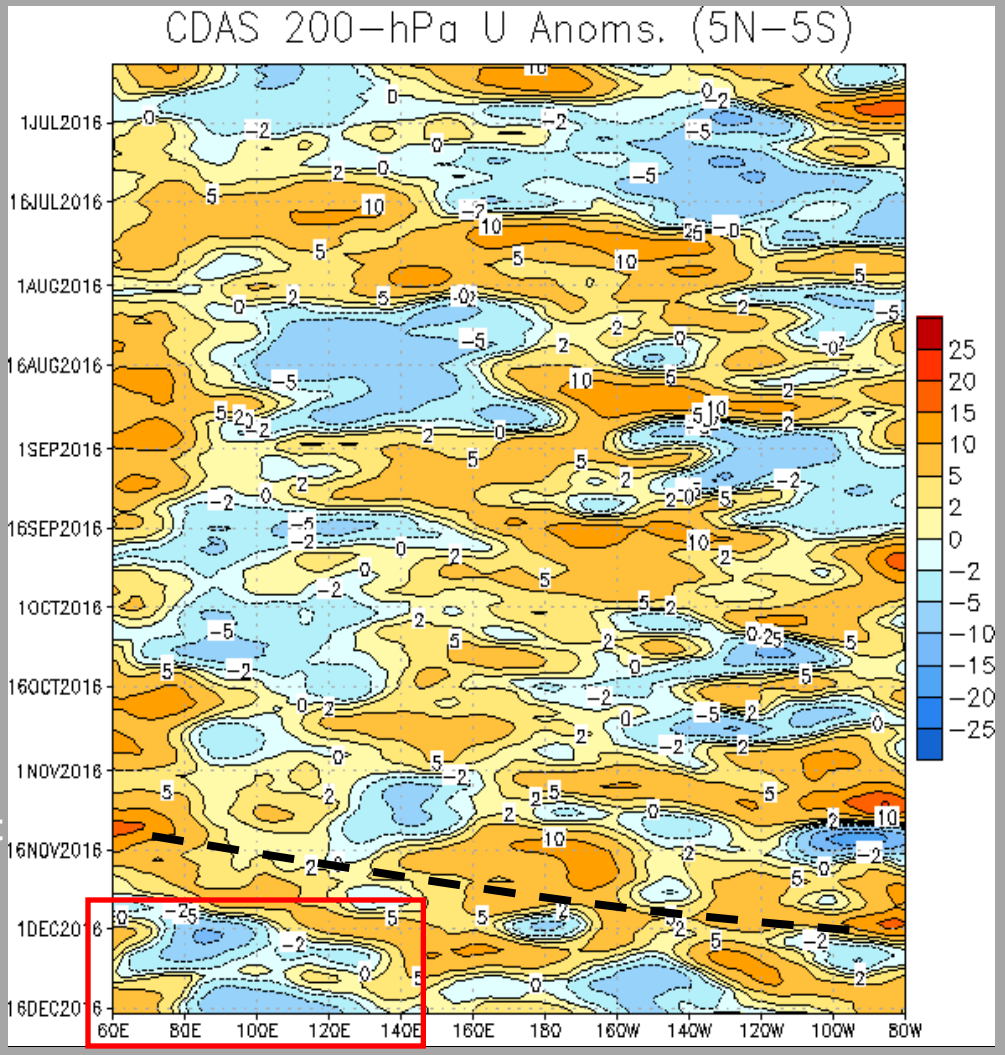
Easterly anomalies (blue shading) represent anomalous east-to-west flow

During July, some eastward propagation was evident, although the spatial consistency implies higher frequency variability than expected with the MJO.

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

During November, anomalous westerlies persisted near the Date Line, though intraseasonal variability associated with the MJO is evident.

Since late November, easterly anomalies have re-emerged across the Indian Ocean consistent with the passage of subseasonal activity and the re-alignment of the low frequency base state (red box).



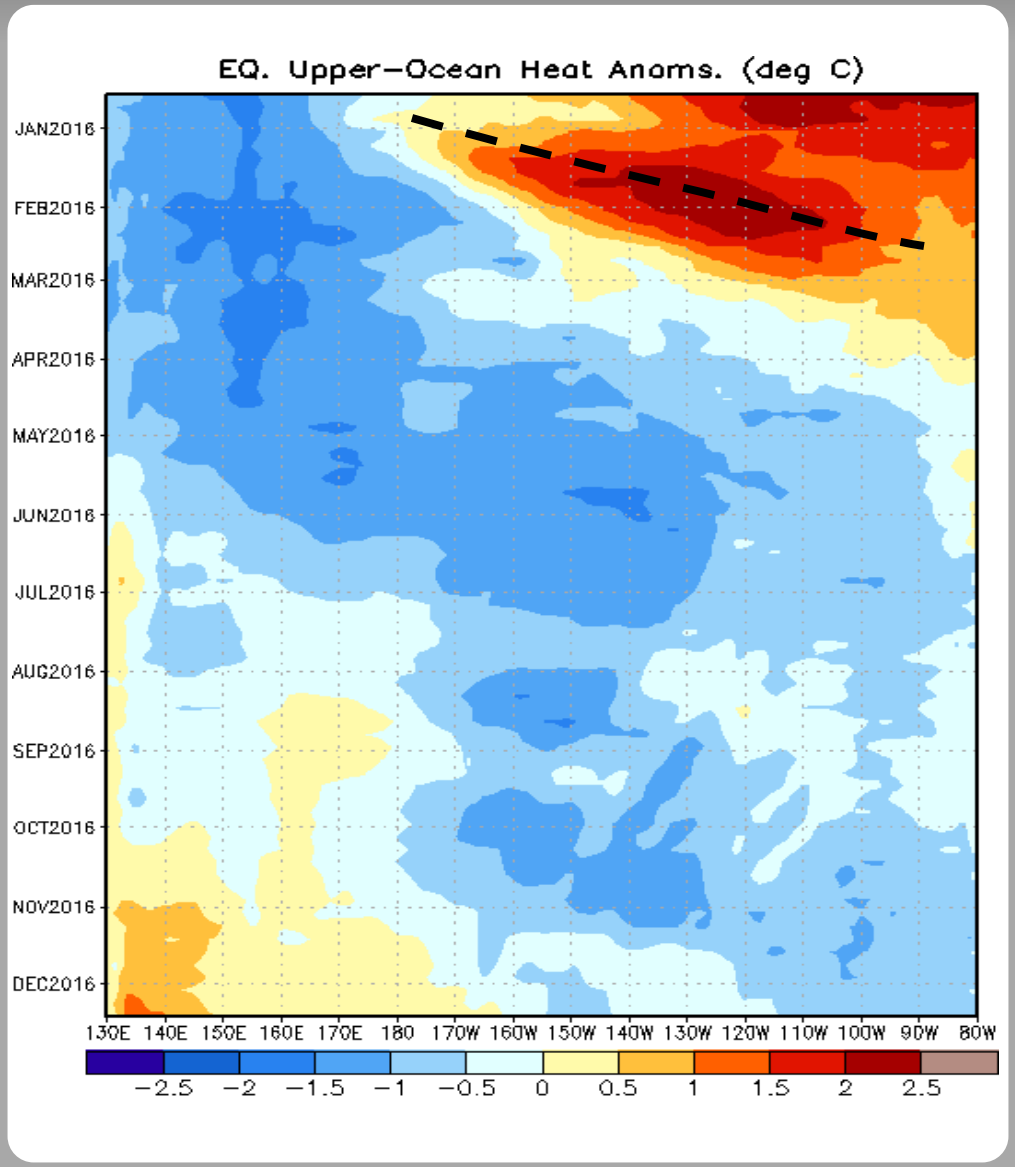
Weekly Heat Content Evolution in the Equatorial Pacific

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 through early February, 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 through April, with widespread negative anomalies building across the Pacific over the course of the spring and summer months.

The strongest negative anomalies now persist in the East Pacific as the negative oceanic heat content anomalies have decreased across the central Pacific.



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

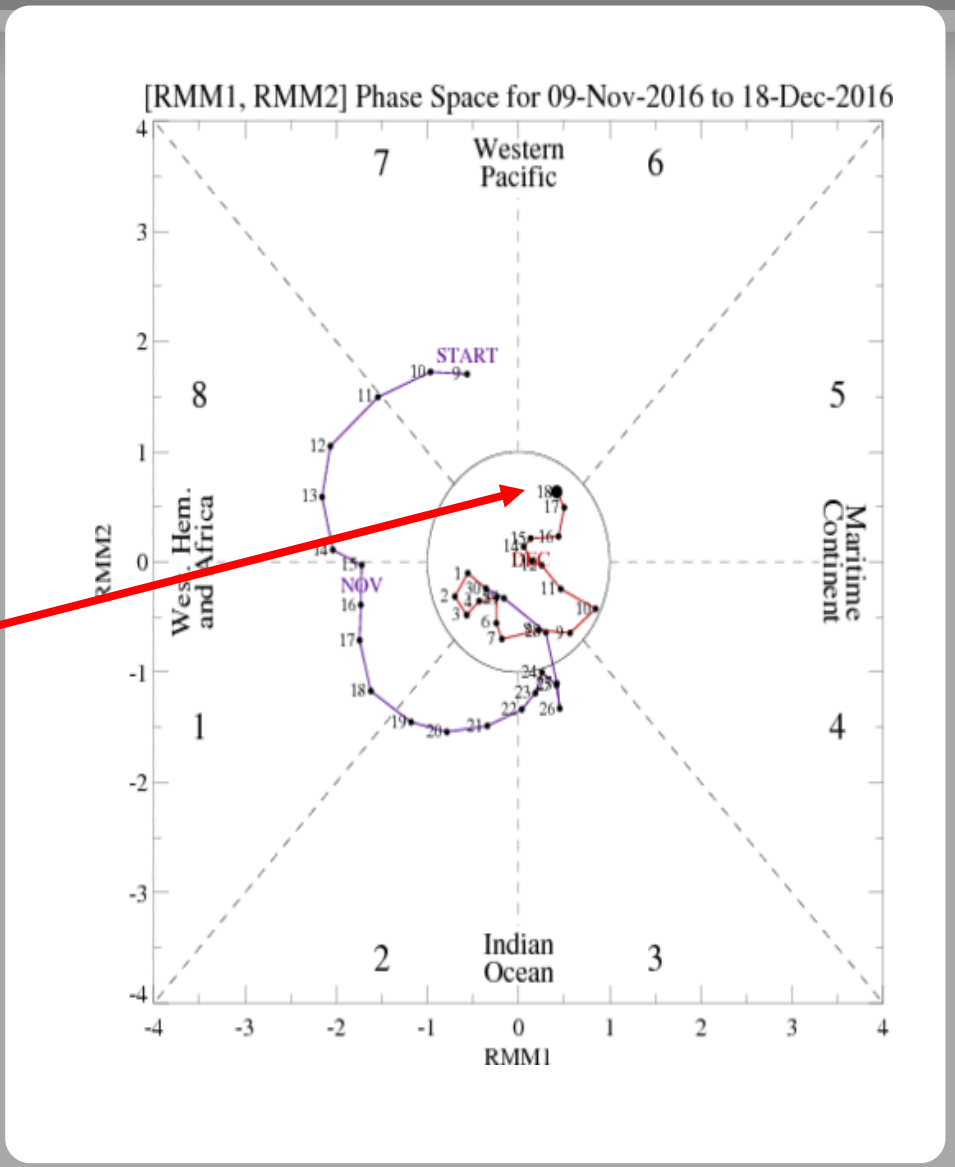
The triangular areas indicate the location of the enhanced phase of the MJO

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

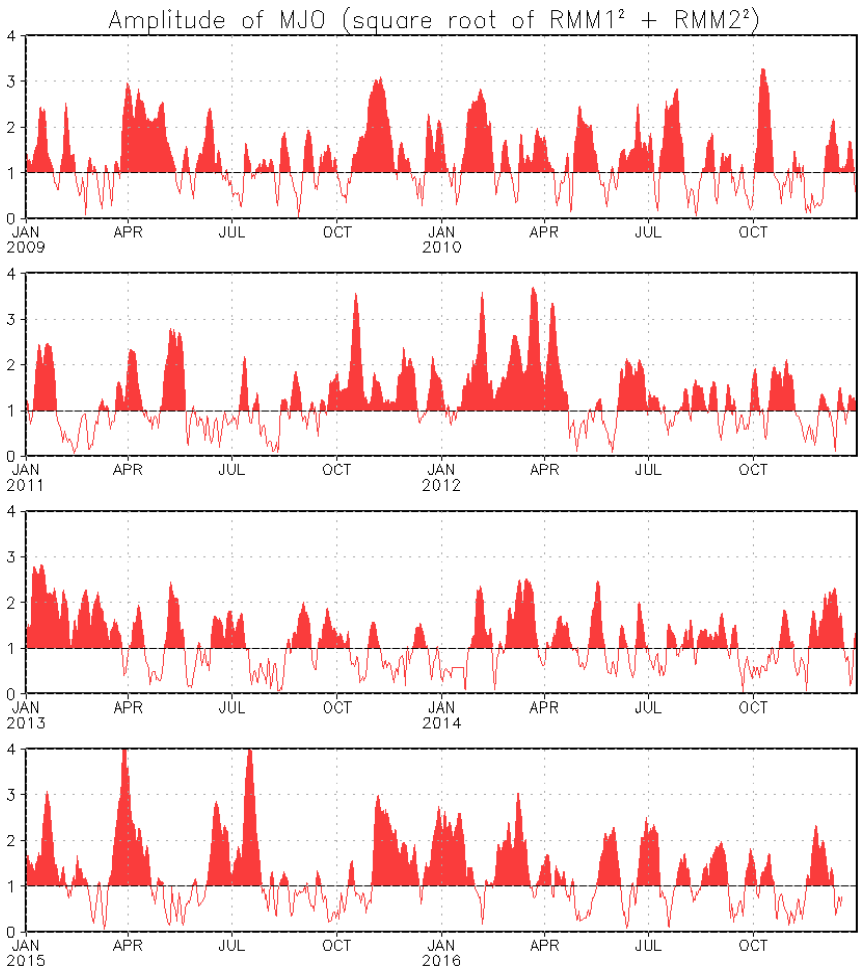
The MJO index remained at low amplitudes during the past week, but has been trending towards a solution over the eastern Maritime Continent or far West Pacific.



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

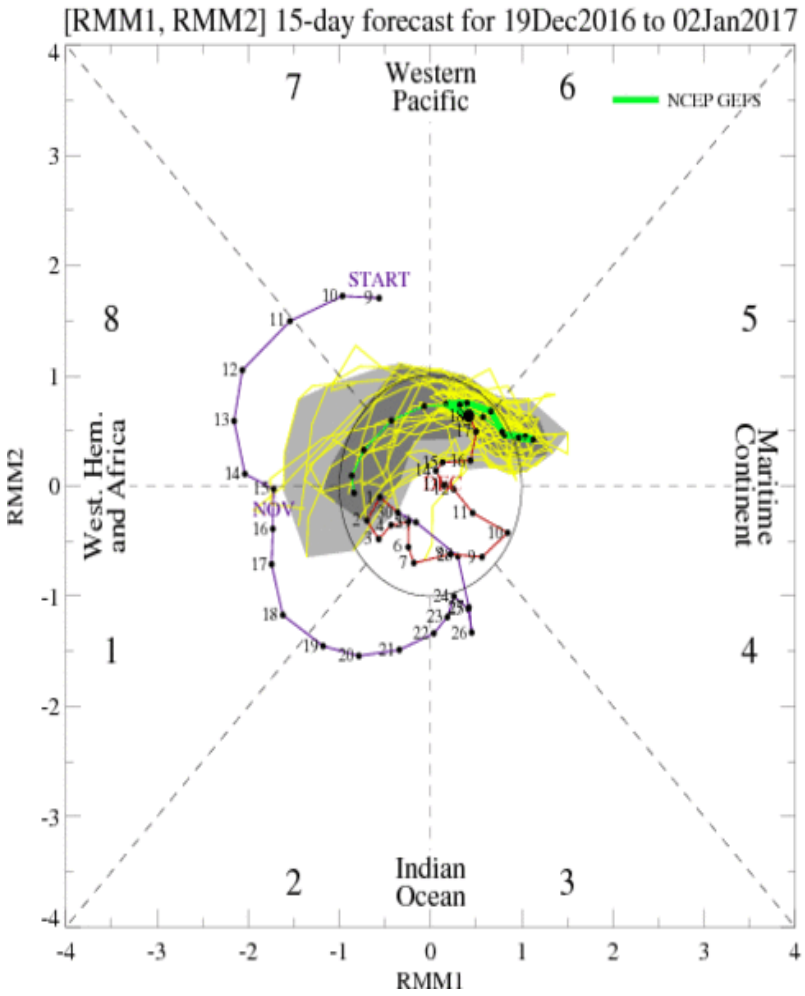
Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean

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

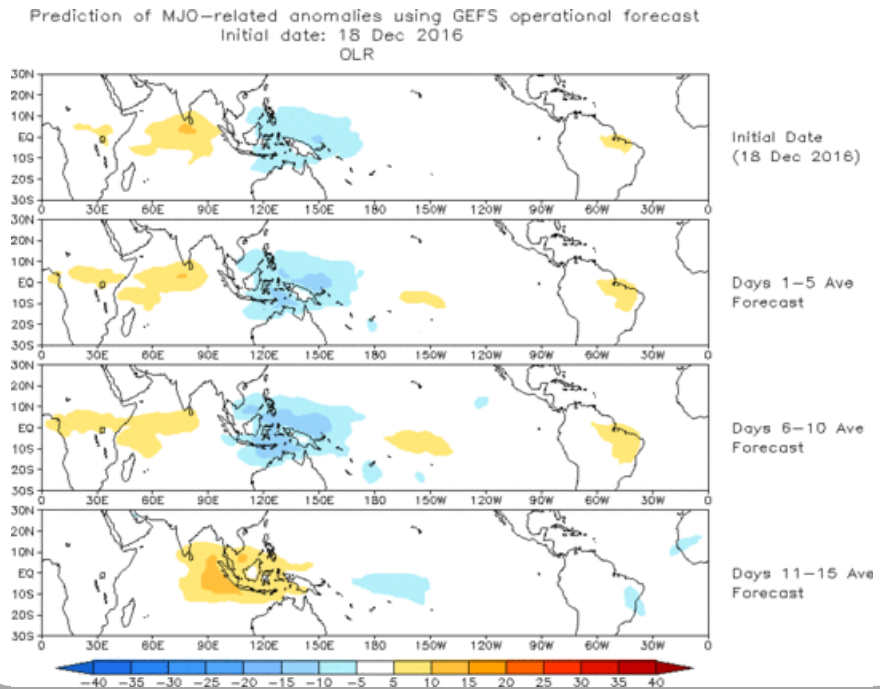
At the current time, the GFS ensemble forecast depicts an initial westward shift before a coherent, fast-propagating signal to the east with an amplitude slighty less than 1.



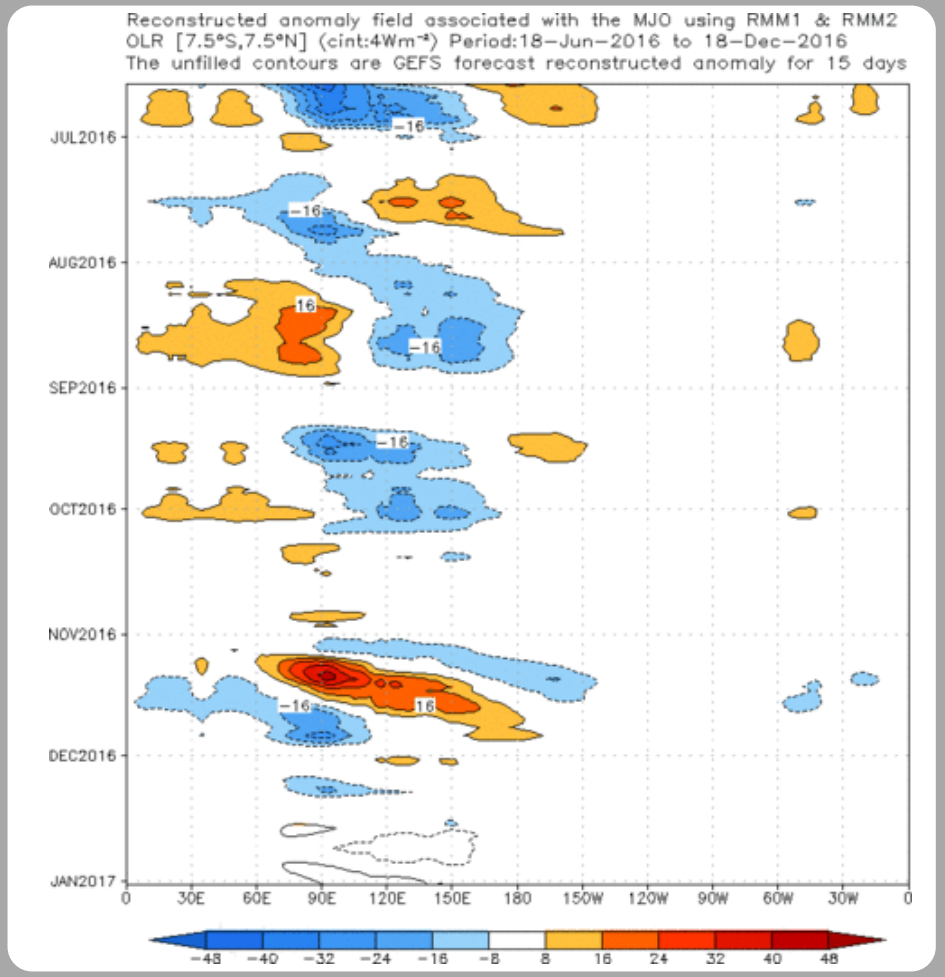
Ensemble GFS (GEFS) MJO Forecast

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

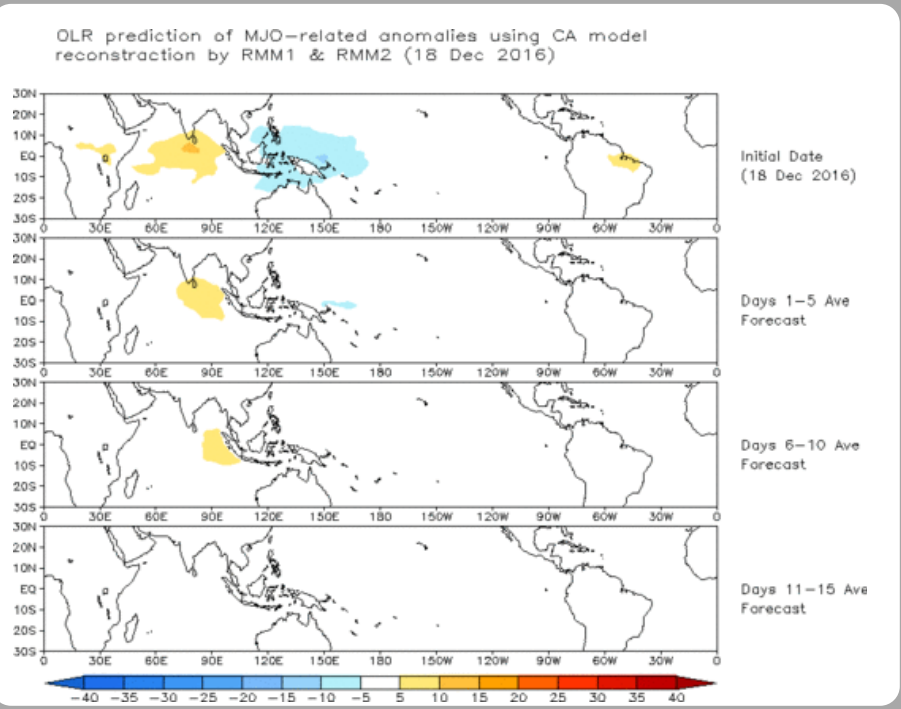


The prediction for OLR anomalies over the next two weeks based on the GEFS RMM forecast indicates quasi-stationary conditions through day 10, before an eastward shift for days 11-15.

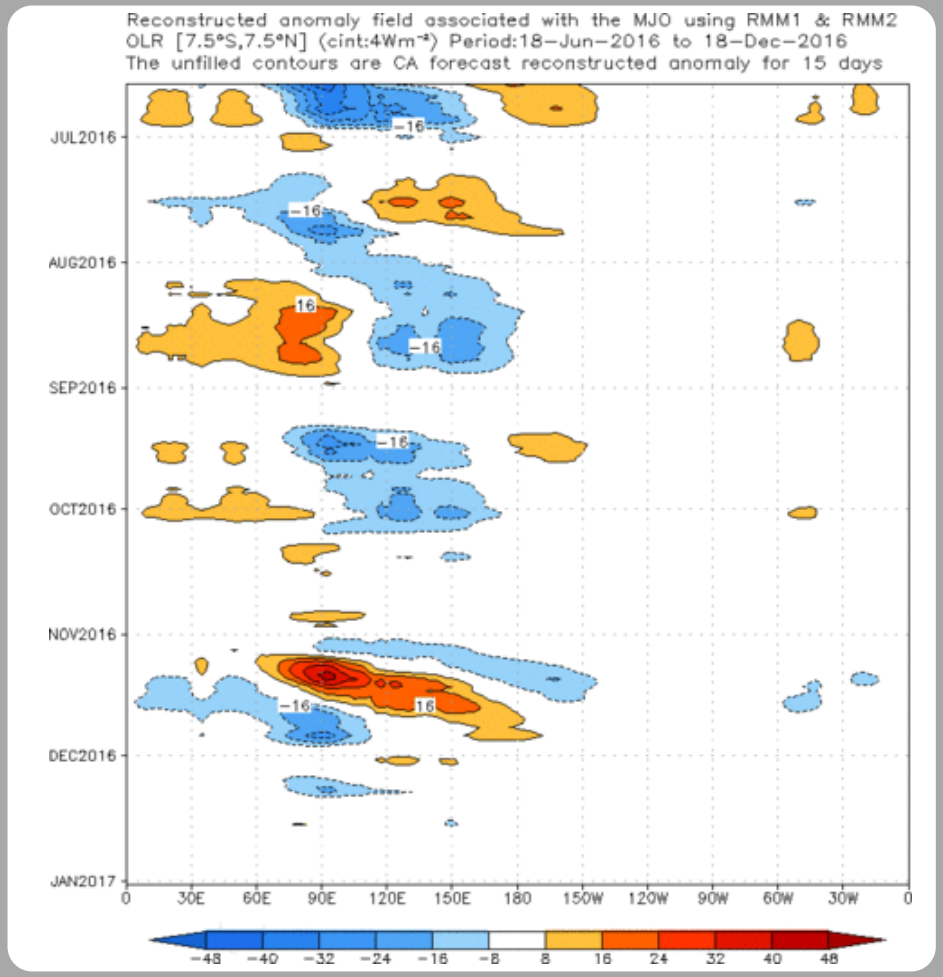
Constructed Analog (CA) MJO Forecast

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



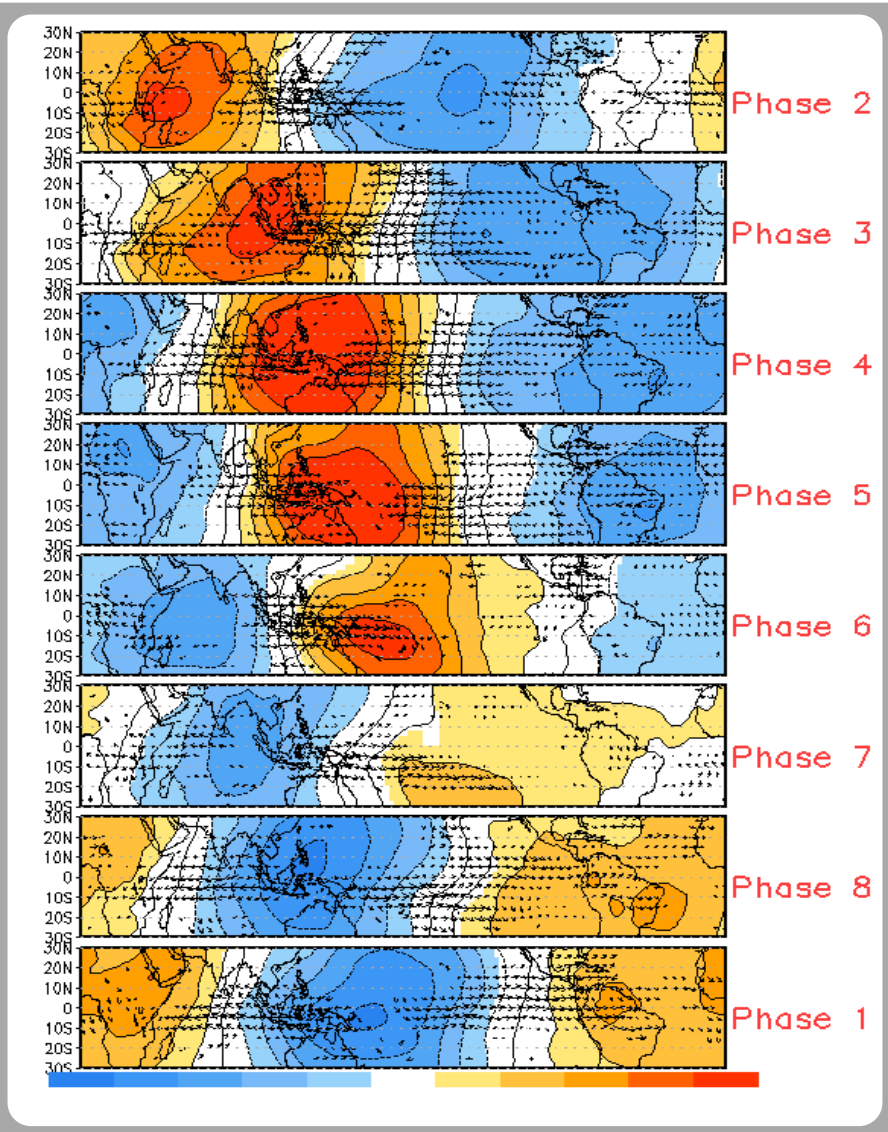
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



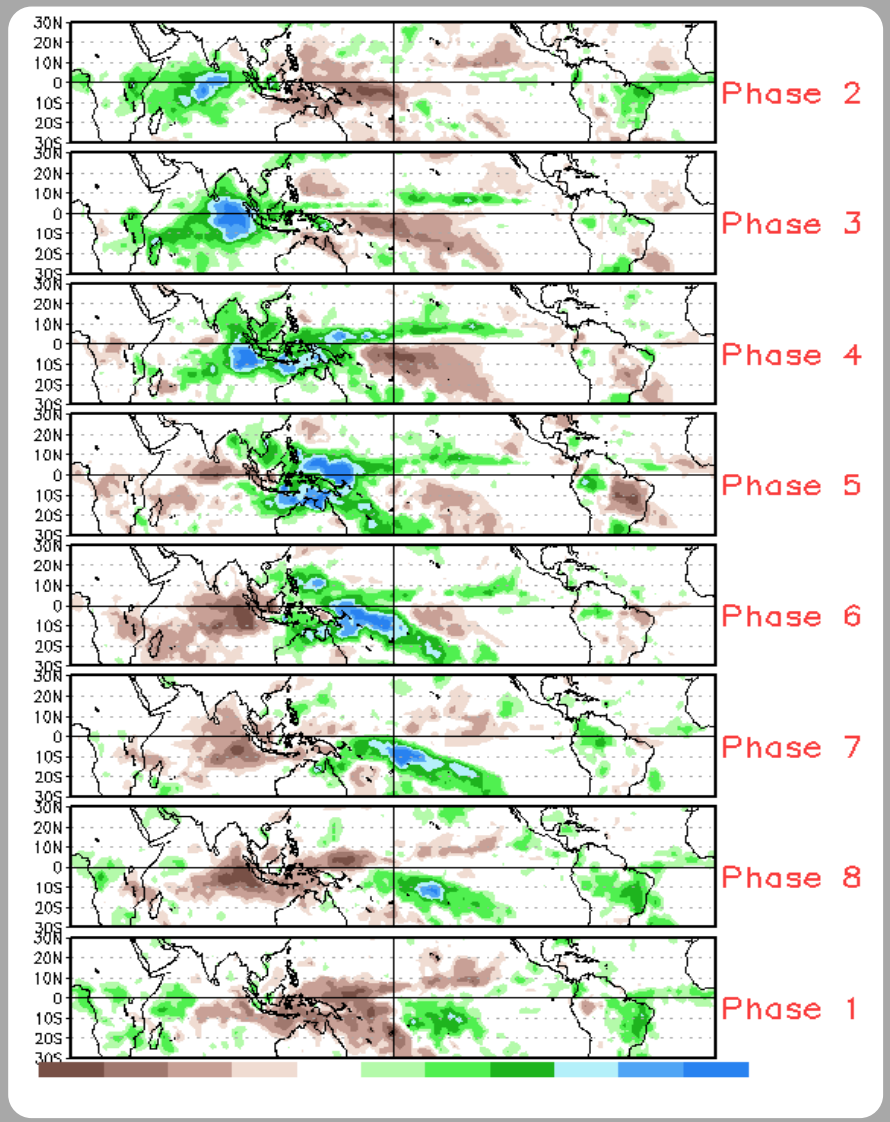
The prediction for OLR anomalies based on the constructed analog RMM forecast indicates slight eastward propagation and weakening throughout the next two weeks.

MJO Composites – Global Tropics

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



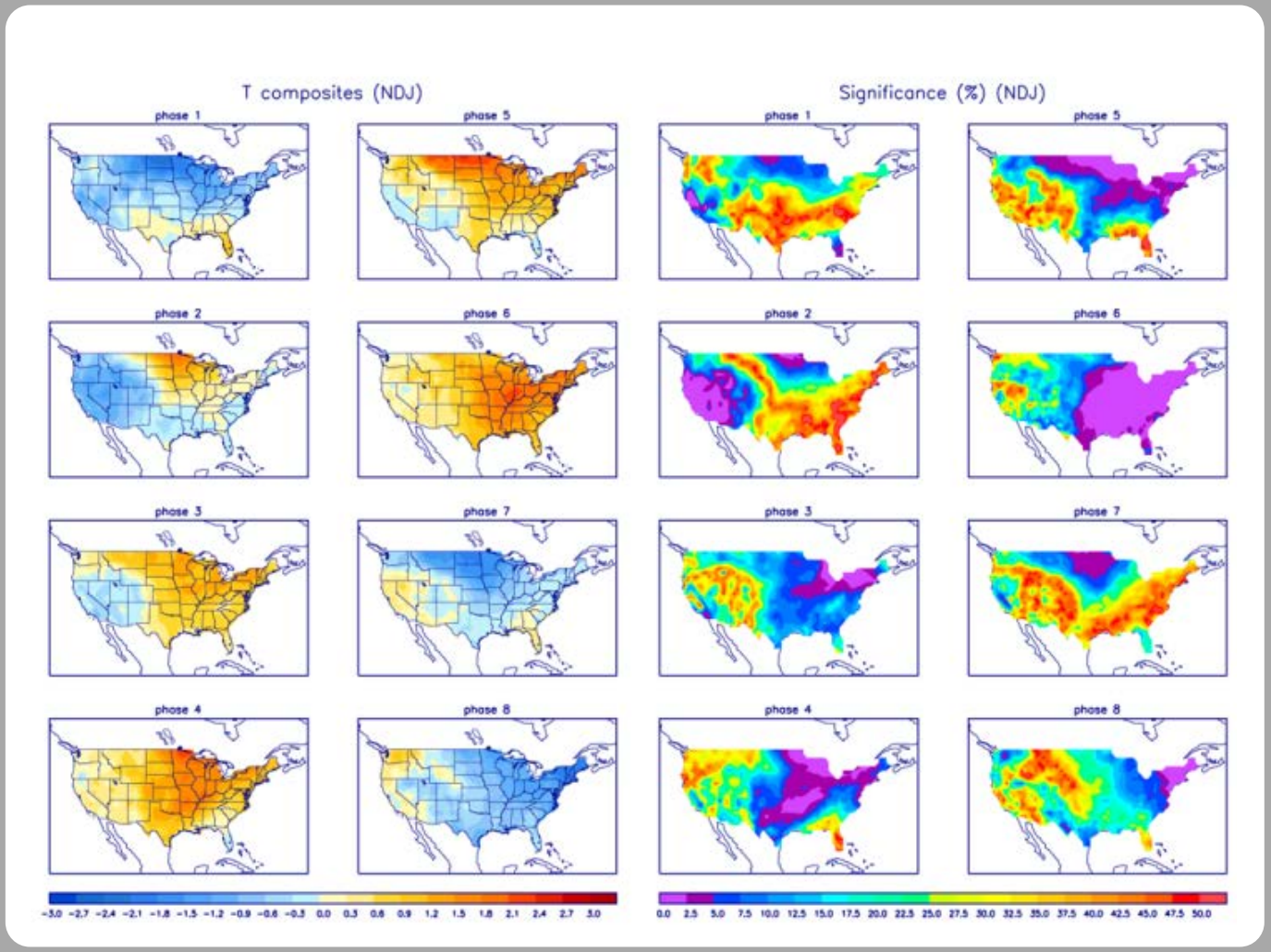
Precipitation Anomalies (Nov - Mar)



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.



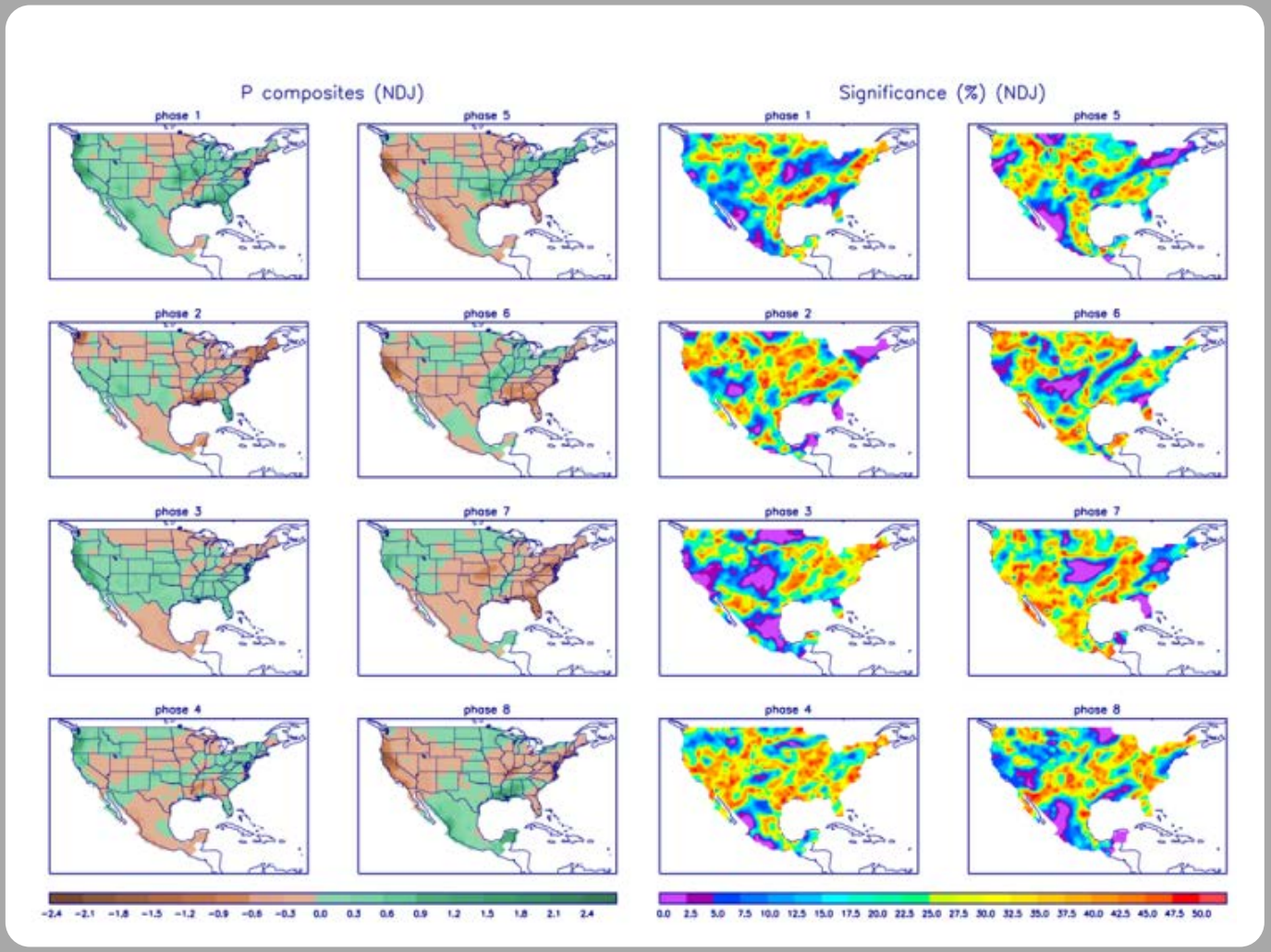
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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