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

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Climate Prediction Center / NCEP
16 November 2015

Outline

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Overview

The MJO weakened during the past week.

Generally stationary convection across the central Indian Ocean, a slow-moving equatorial Rossby Wave (ERW) over the west-central Pacific, and a resurgence of the El Niño atmospheric response helped weaken the MJO signal.

Dynamical models generally do not depict additional eastward propagation of the MJO, although they favor a stationary pattern of enhanced convection over parts of the Indian Ocean, and some eastward propagation of westerly anomalies across the eastern Pacific during Week-2.

The MJO is not anticipated to play a significant role in the evolution of the global tropical convective pattern during the next two weeks, but any remnant enhanced phase may help to enhance ENSO-related convection across the central and eastern Pacific.

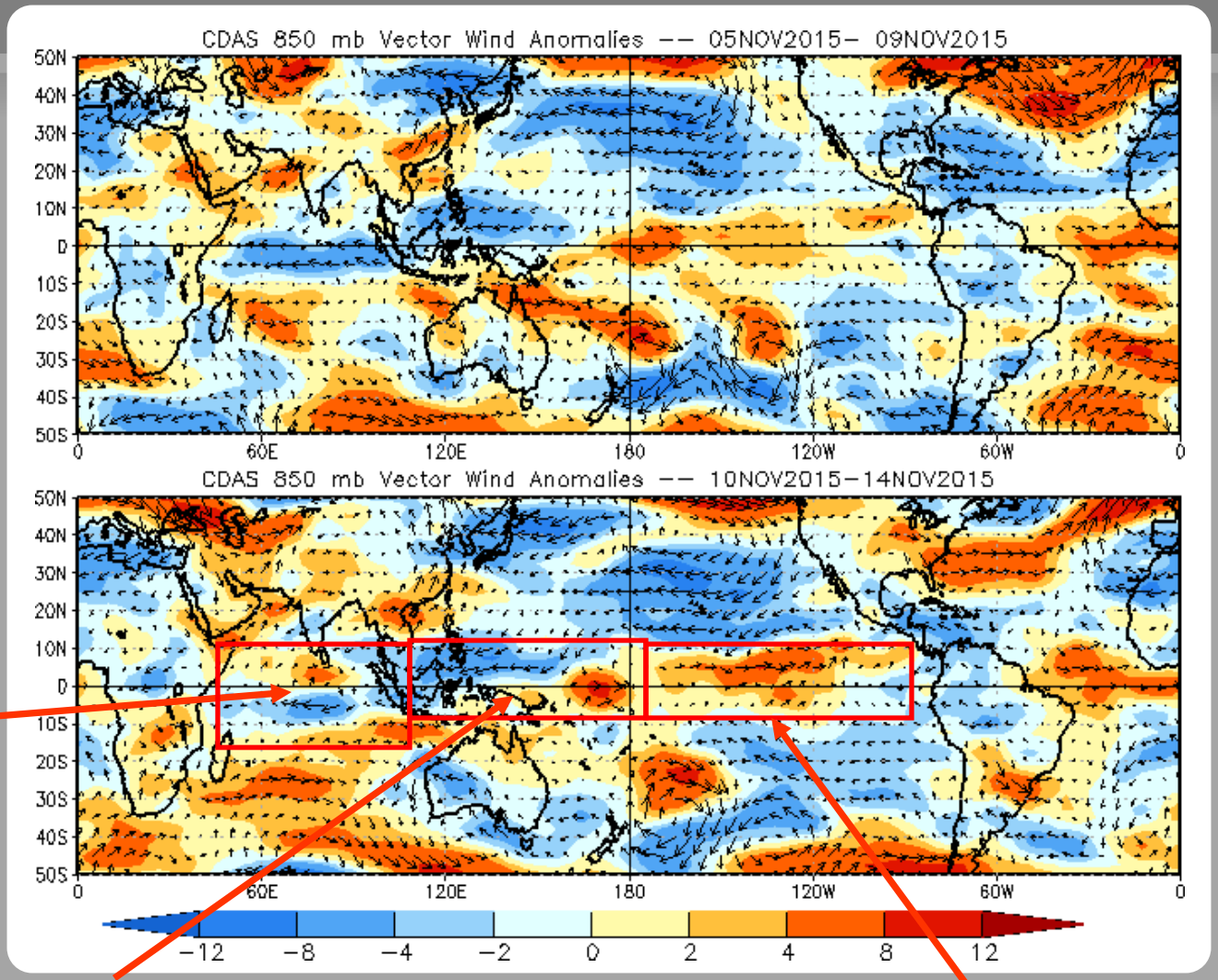
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Easterly anomalies persisted just south of the equator over the Indian Ocean, while westerlies developed to the north.

Easterly anomalies persisted over much of the western and northern Maritime Continent. Westerly anomalies crossing the Date Line are possibly associated with an ERW feature.

Westerly anomalies increased across the central and eastern Pacific, reflecting a resurgence of the El Niño base 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

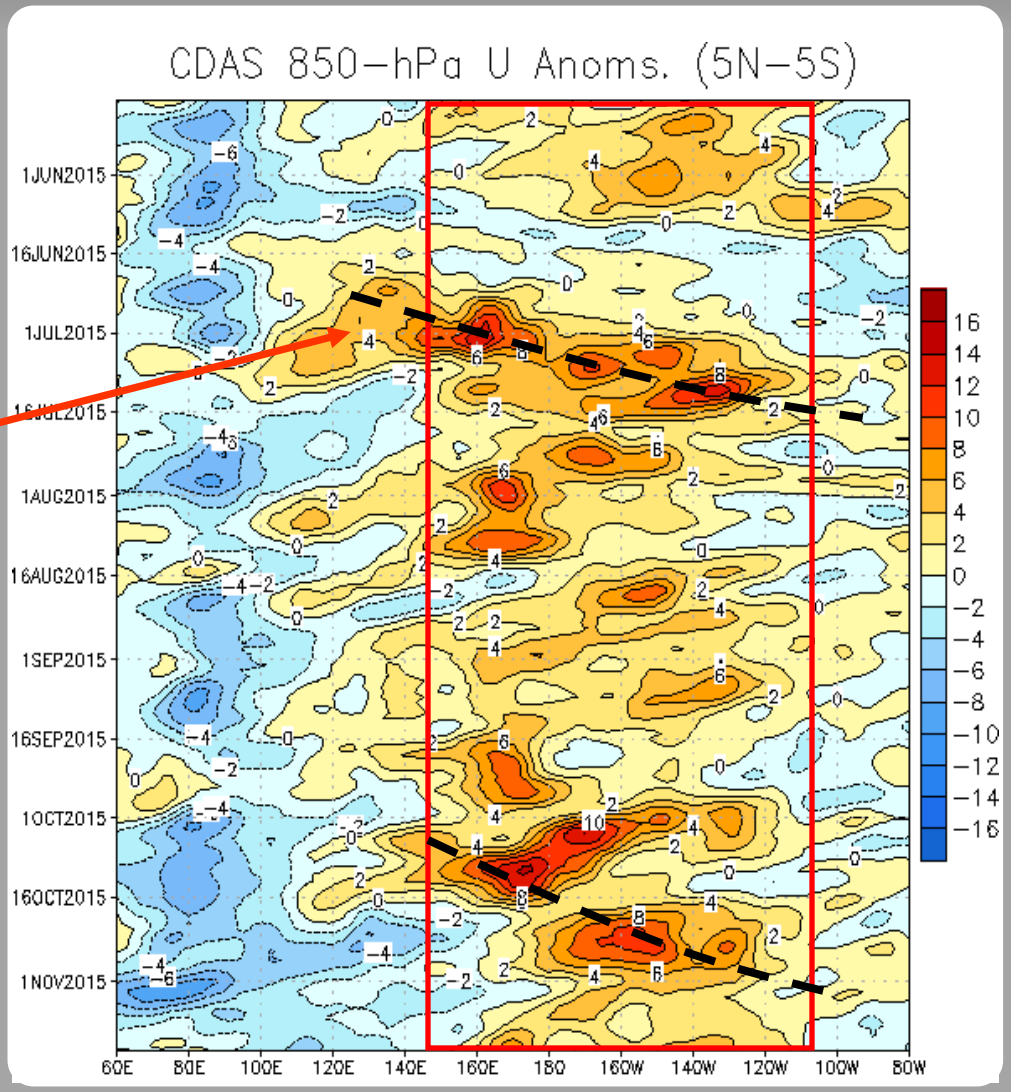
The red box highlights the persistent low-frequency westerly wind anomalies associated with ENSO.

A robust MJO event was observed in late June through mid-July, constructively interfering with the background state.

Otherwise, tropical cyclone activity across much of the Pacific provided the primary transient influence on the overall ENSO pattern.

An eastward shift in the pattern was observed in late October, related to activity in the MJO time band.

More recently, westerly anomalies propagated west of the Date Line due to an ERW, interfering with the MJO signal.



OLR Anomalies – Past 30 days

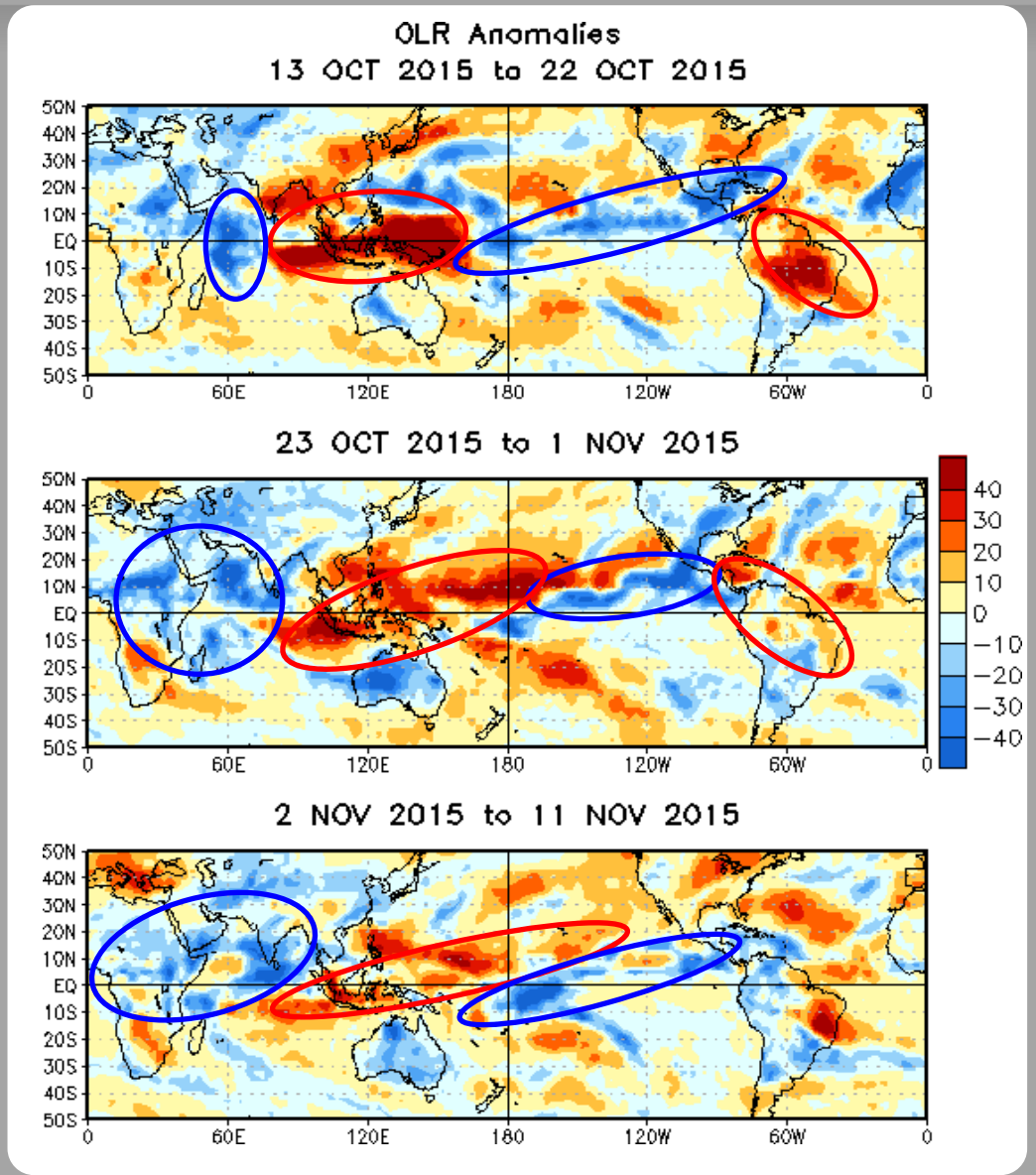
Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

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

Typical El Niño anomalies – enhanced (suppressed) convection over the central and eastern Pacific (Maritime Continent) - persisted through mid-October, with enhanced convection developing over the western Indian Ocean.

Eastward propagation of the suppressed signal to the mid-Pacific was evident during late October, while enhanced convection persisted over the Indian Ocean, along with TC activity over the Arabian Sea.

During early November, enhanced convection expanded across the Indian Ocean, while the ENSO-based enhanced signal across the Pacific diminished. A small area of enhanced convection near the Date Line was likely associated with an equatorial Rossby Wave.



Outgoing Longwave Radiation (OLR) Anomalies (5°N-5°S)

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

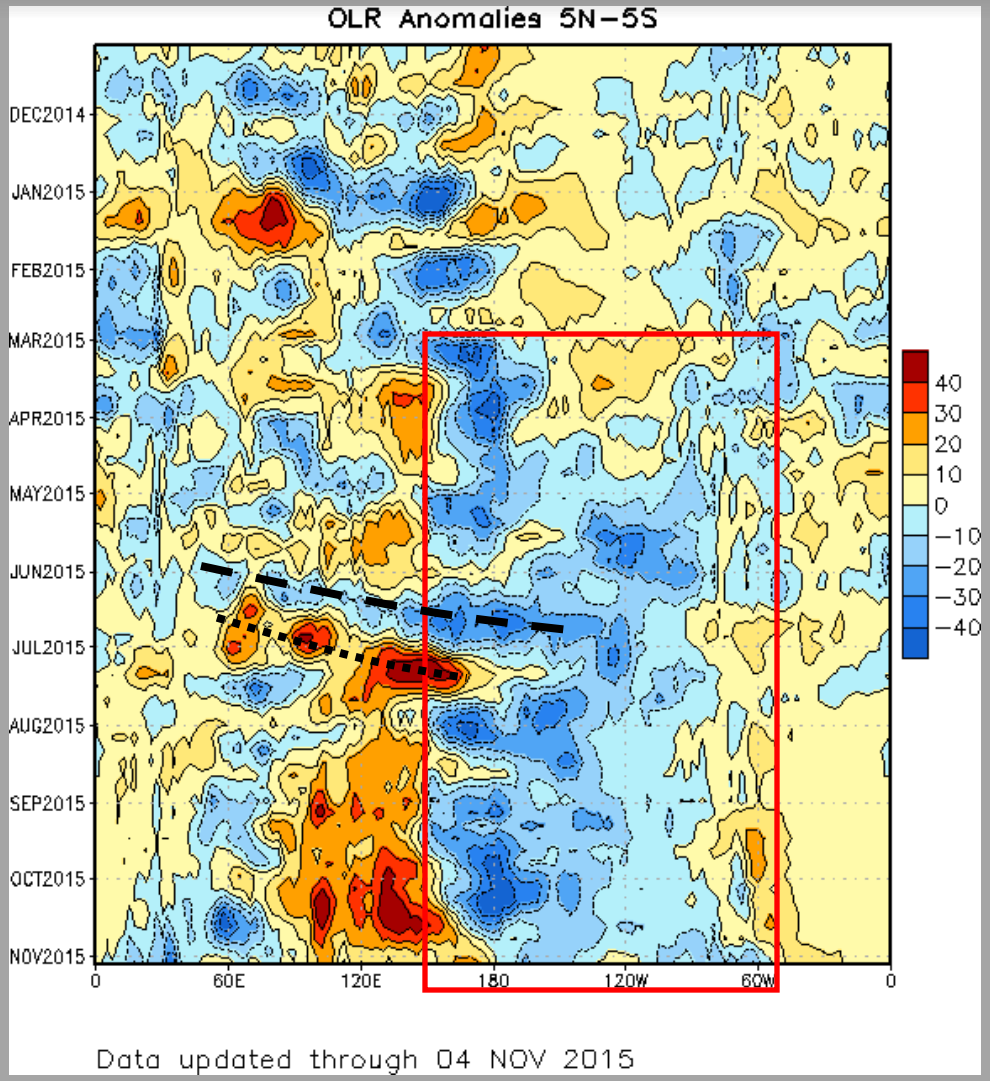
Wetter-than-normal conditions, negative OLR anomalies (blue shading)

Since April, the ongoing El Niño is observed (red box) as a tendency toward a dipole of anomalous convection extending from the Maritime Continent (suppressed) to the East Pacific (enhanced).

During June and early July, the MJO become active, interfering with the ENSO signal at times.

Since July, the MJO has remained weak, with strong El Niño conditions and tropical cyclone activity dominating the pattern.

A couplet of enhanced/suppressed convection intensified over the western Indian Ocean/Maritime Continent early in October, but weakened as the signal moved eastward.



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

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

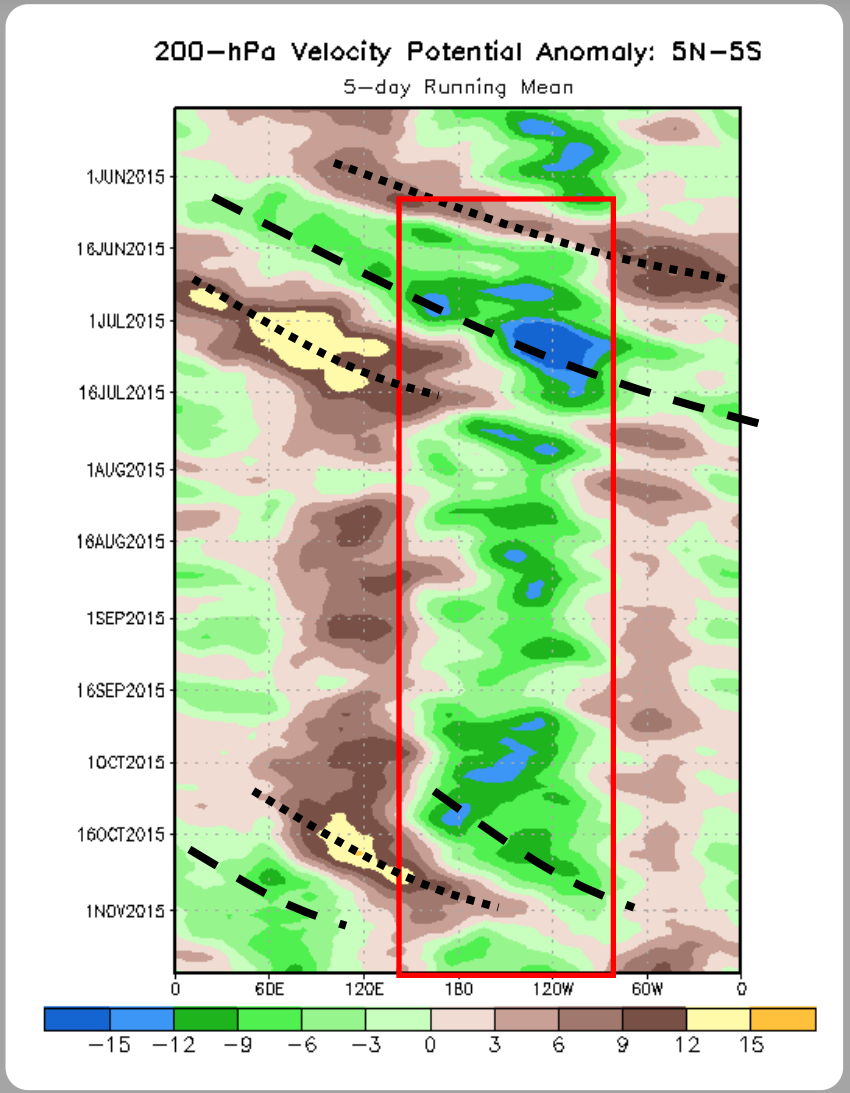
Negative anomalies (green shading) indicate favorable conditions for precipitation

The ongoing ENSO state is highlighted by the red box, showing anomalous divergence over the central and eastern Pacific. This pattern has only been temporarily interrupted by strong Kelvin wave/MJO activity at times.

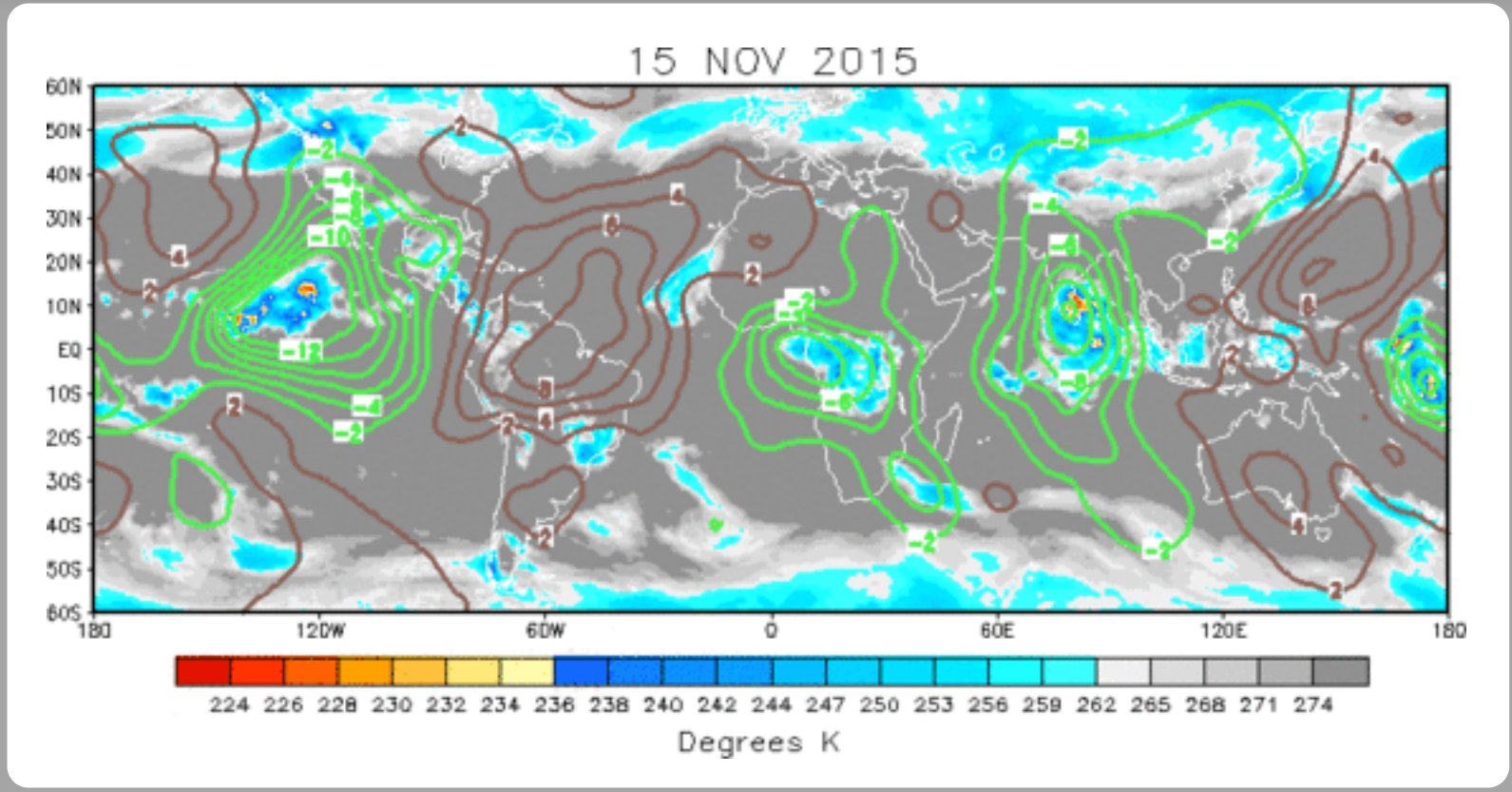
During June and early July, a high-amplitude MJO event was observed, constructively interfering with the El Niño signal in early July.

From July through early October, a generally stationary pattern, reflective of El Niño conditions, was observed.

During late October, there was an eastward shift in the pattern associated with MJO activity. More recently, the pattern was noisy, but enhanced divergence associated with El Niño re-strengthened over the central and eastern Pacific.



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



The upper-level velocity potential anomaly pattern resembles a wave-2 pattern, with anomalous upper-level divergence strengthening over the eastern Pacific. Enhanced convection persisted over the central Indian Ocean basin and Bay of Bengal.

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

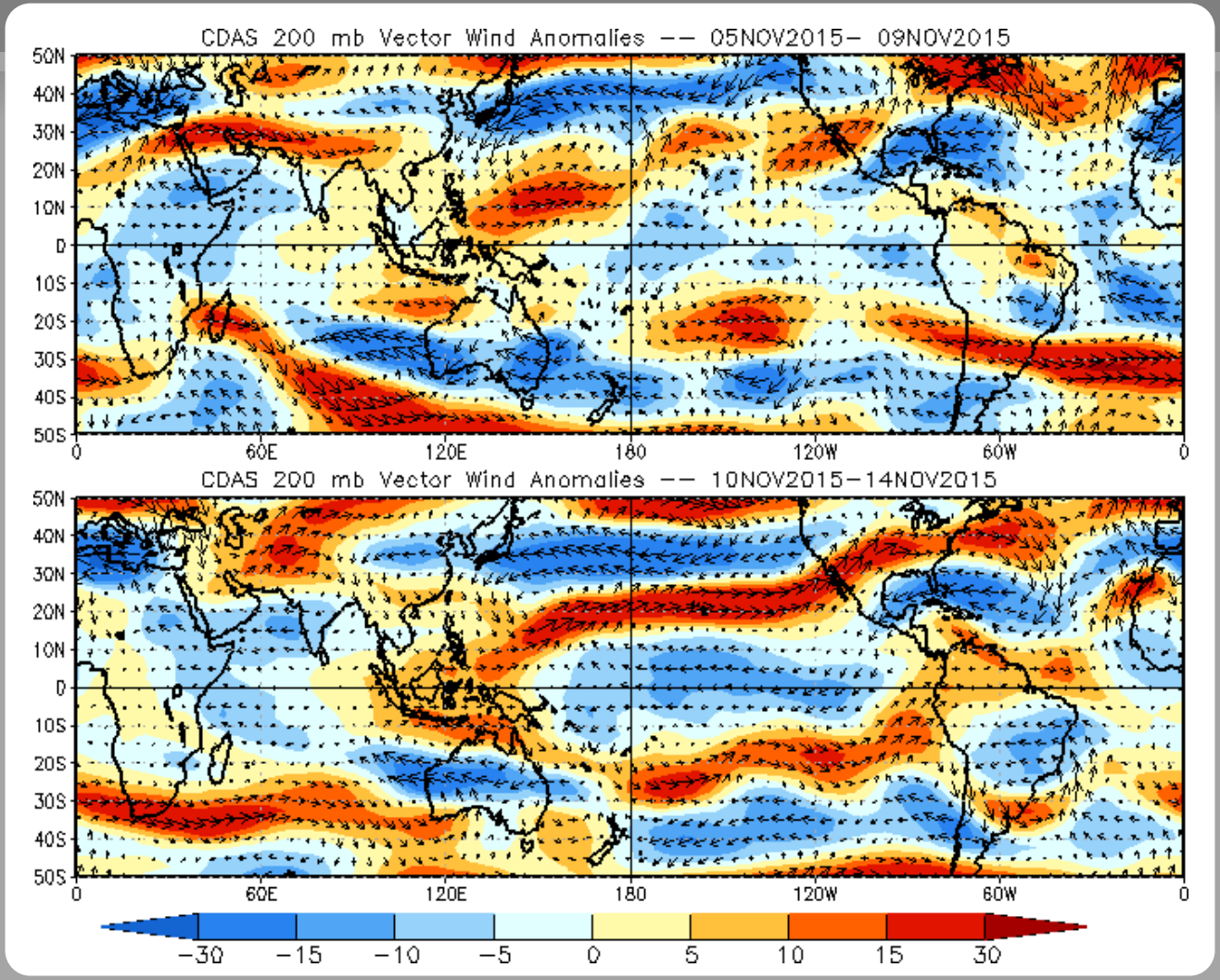
Negative anomalies (green contours) indicate favorable conditions for precipitation

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 (westerly) anomalies re-strengthened across the central and eastern Pacific (Maritime Continent), with a strongly enhanced southerly jet over the boreal mid-latitudes, reflecting a return to the canonical El Niño atmospheric response.

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

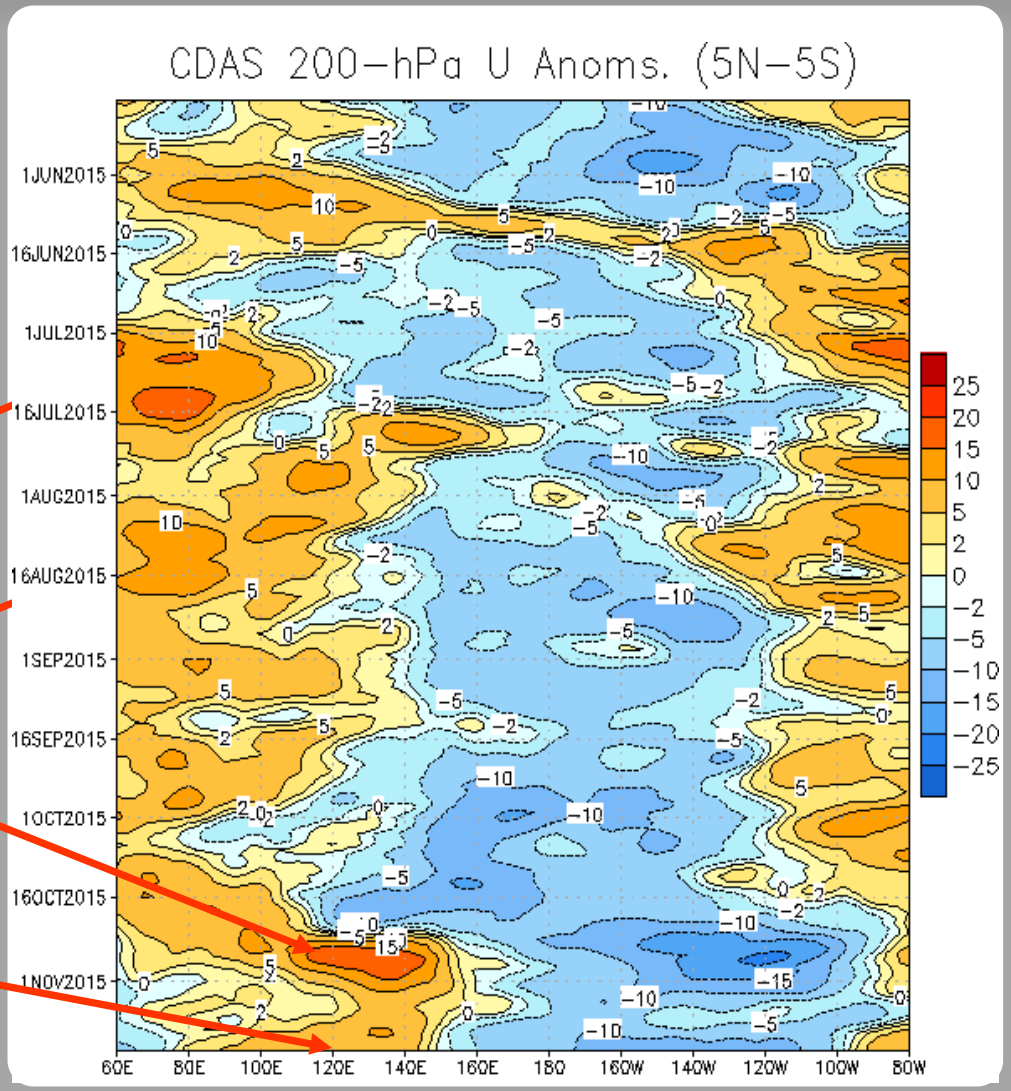
Easterly anomalies have persisted over the central and eastern Pacific associated with El Niño since mid-April (red box).

During June, these easterly anomalies were interrupted by robust atmospheric Kelvin wave/MJO activity.

During August, some westward propagation of westerly anomalies from the Maritime Continent to the Indian Ocean was evident.

During late October, an eastward shift in the pattern was evident, with westerly anomalies propagating as far as 160E.

More recently, ERW activity was evident, along with a return to the ENSO base state.



Weekly Heat Content Evolution in the Equatorial Pacific

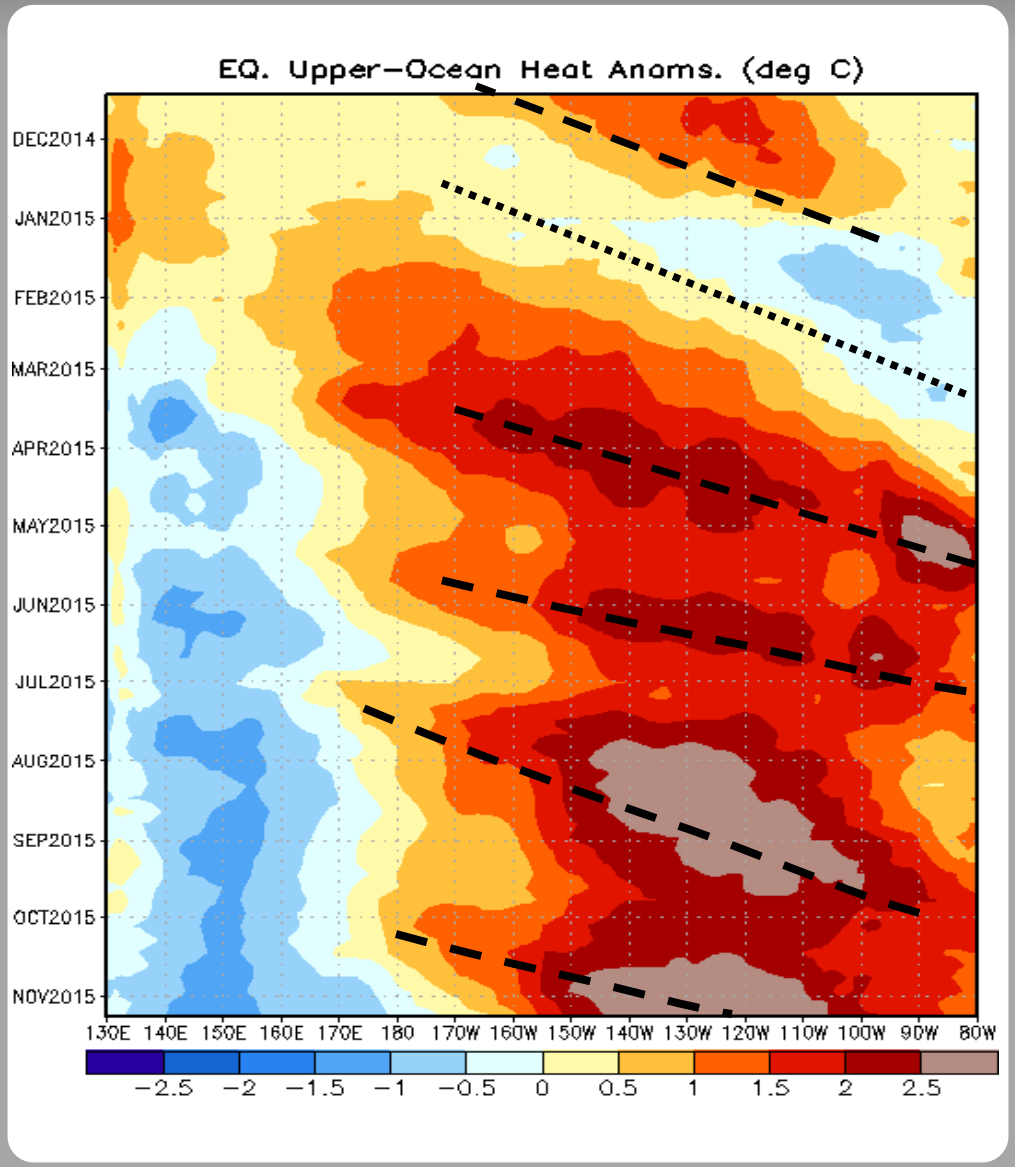
Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Downwelling and warming occur in the leading portion of a Kelvin wave, and upwelling and cooling occur in the trailing portion.

During November, positive subsurface temperature anomalies increased and shifted eastward in association with the downwelling phase of a Kelvin wave. During November - January, the upwelling phase of a Kelvin wave shifted eastward.

Following a strong westerly wind burst in March, another downwelling phase of a Kelvin wave propagated eastward, reaching the South American coast during May.

Reinforcing downwelling events have followed, resulting in persistently above-normal heat content from the Date Line to 90W.

Recently, another downwelling phase of a Kelvin wave developed in the Pacific Ocean associated with anomalous low-level westerlies.



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

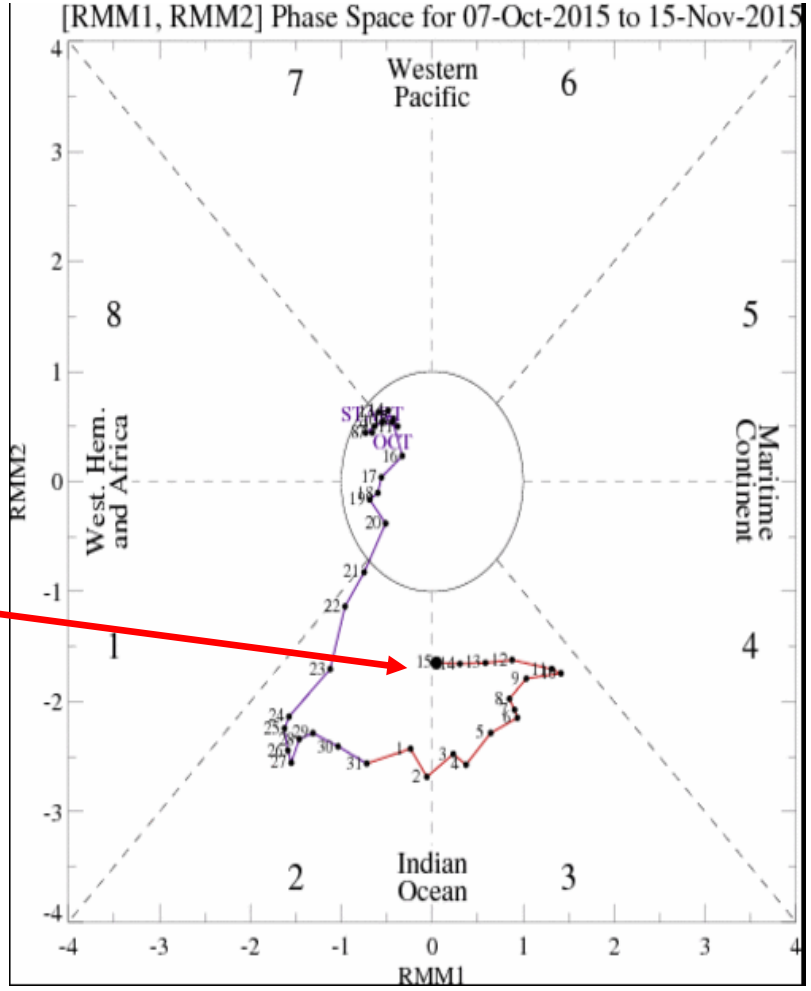
The triangular areas indicate the location of the enhanced phase of the MJO

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

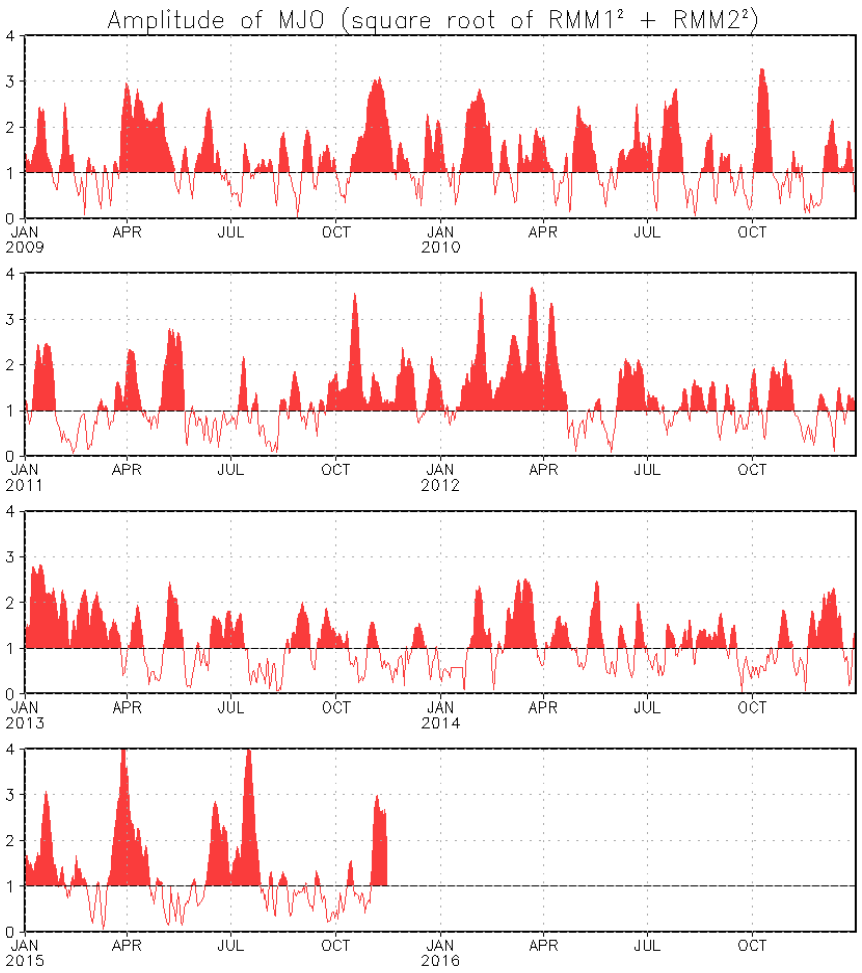
Eastward propagation of the MJO was evident early in the week, but Rossby Wave activity over the West Pacific strongly interfered with the pattern during the last several days.



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

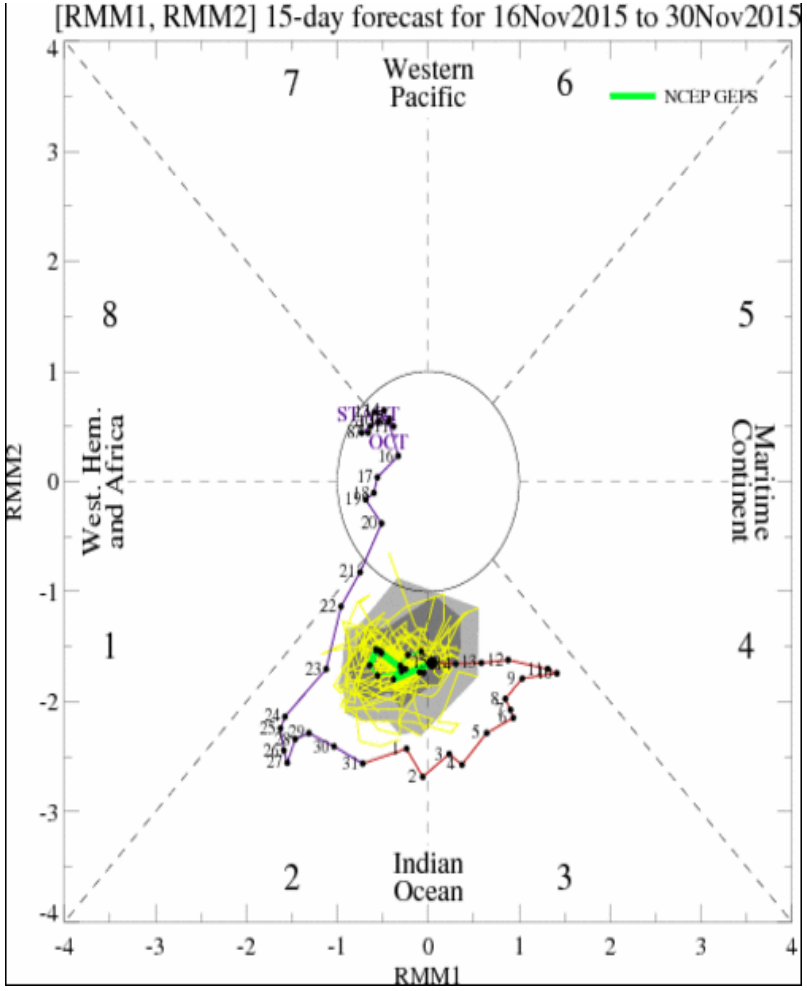
Yellow Lines - 20 Individual Members
Green Line - Ensemble Mean

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

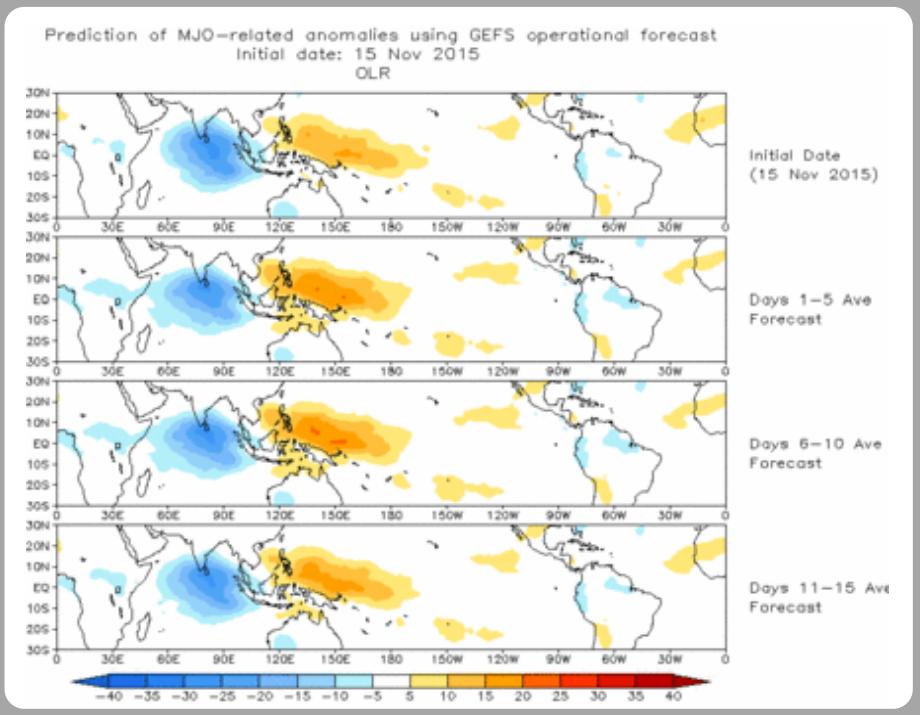
The GFS ensemble MJO index forecast depicts little further eastward propagation of the MJO index during the next two weeks.



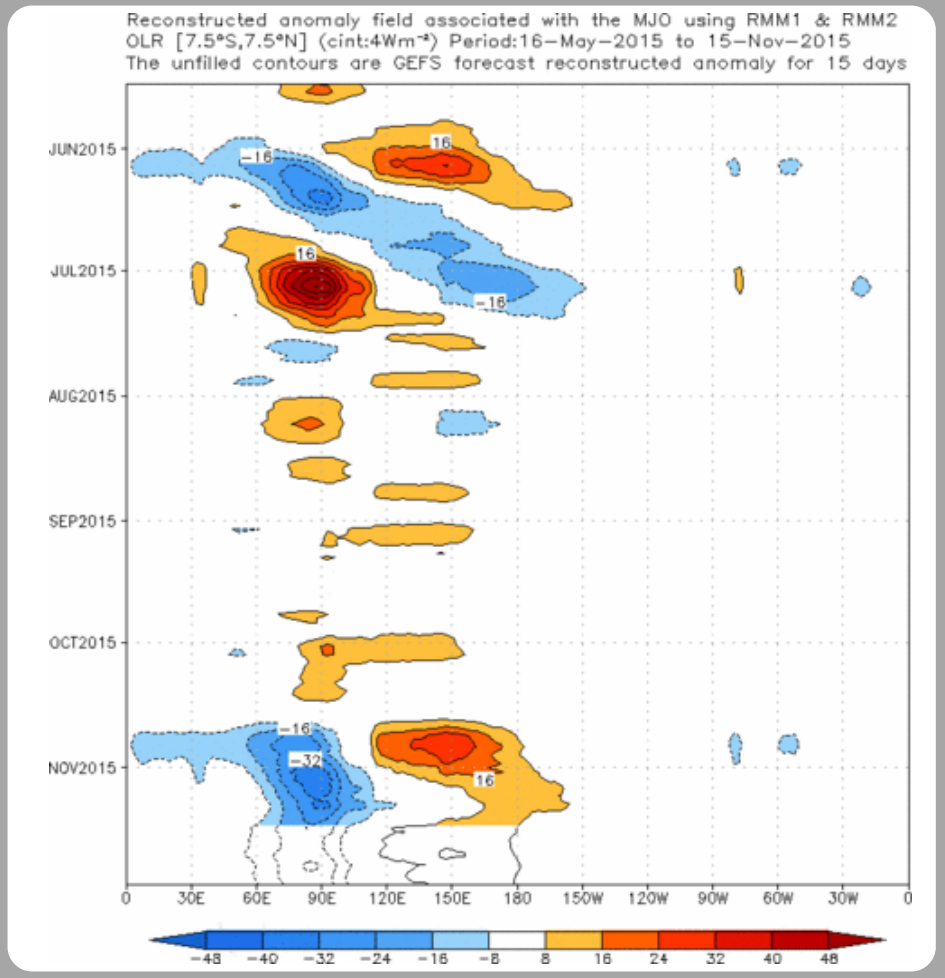
Ensemble GFS (GEFS) MJO Forecast

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

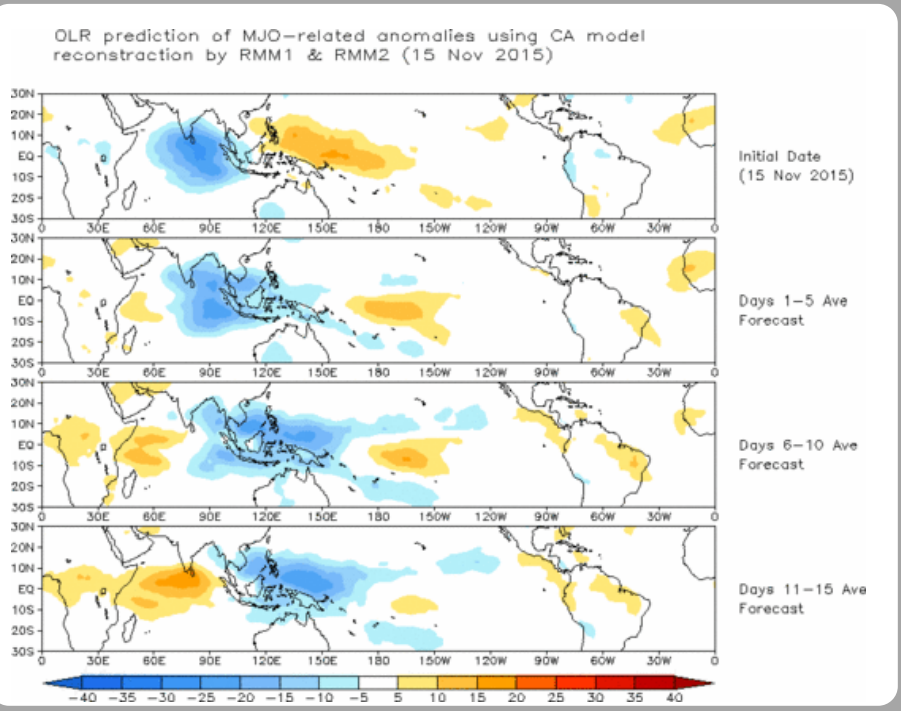


The GEFS MJO index-based OLR forecast depicts a stationary anomaly pattern favoring enhanced (suppressed) convection over the Indian Ocean (northwestern Pacific) during the next two weeks.

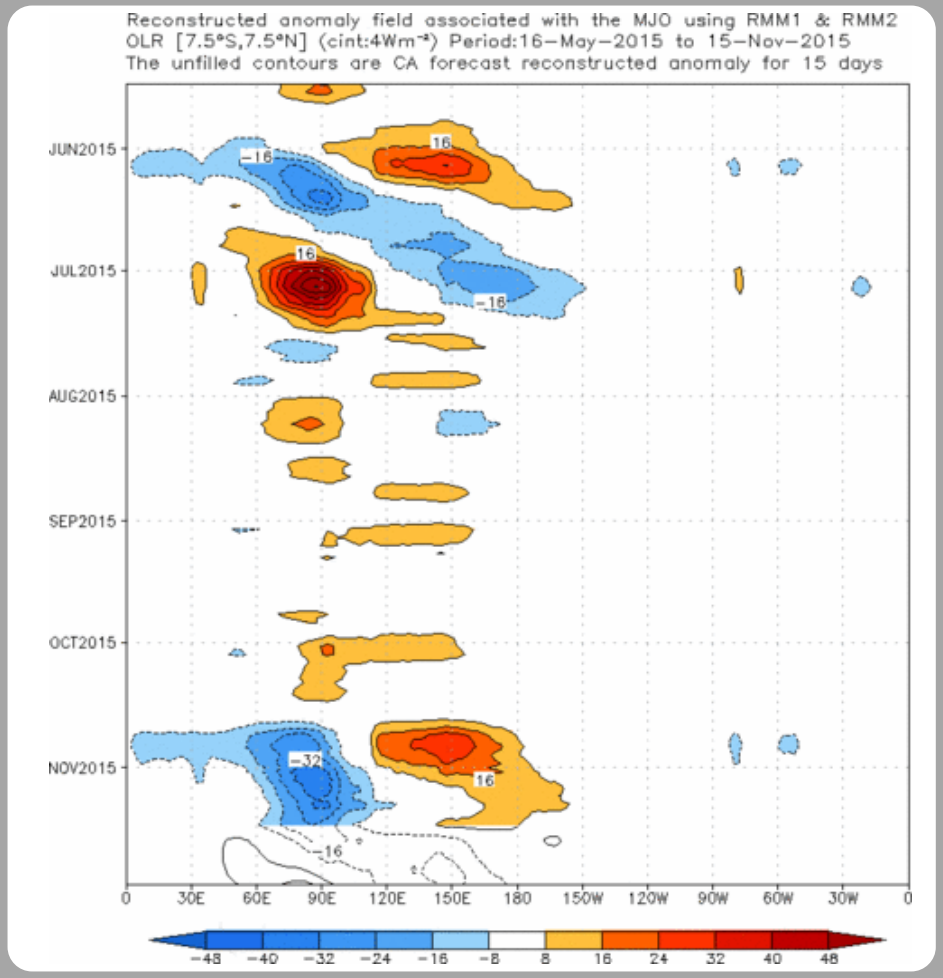
Constructed Analog (CA) MJO Forecast

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



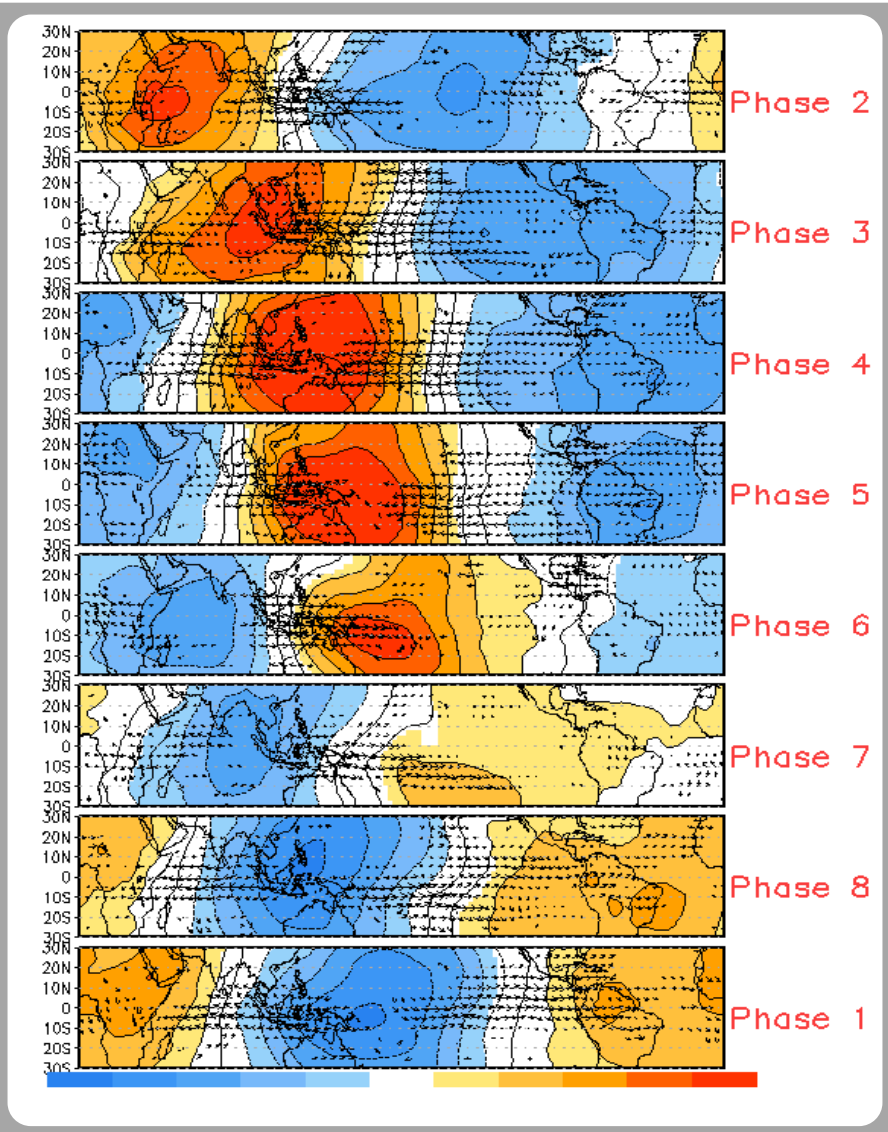
Time-longitude section of (7.5° S-7.5° N) OLR anomalies - last 180 days and for the next 15 days



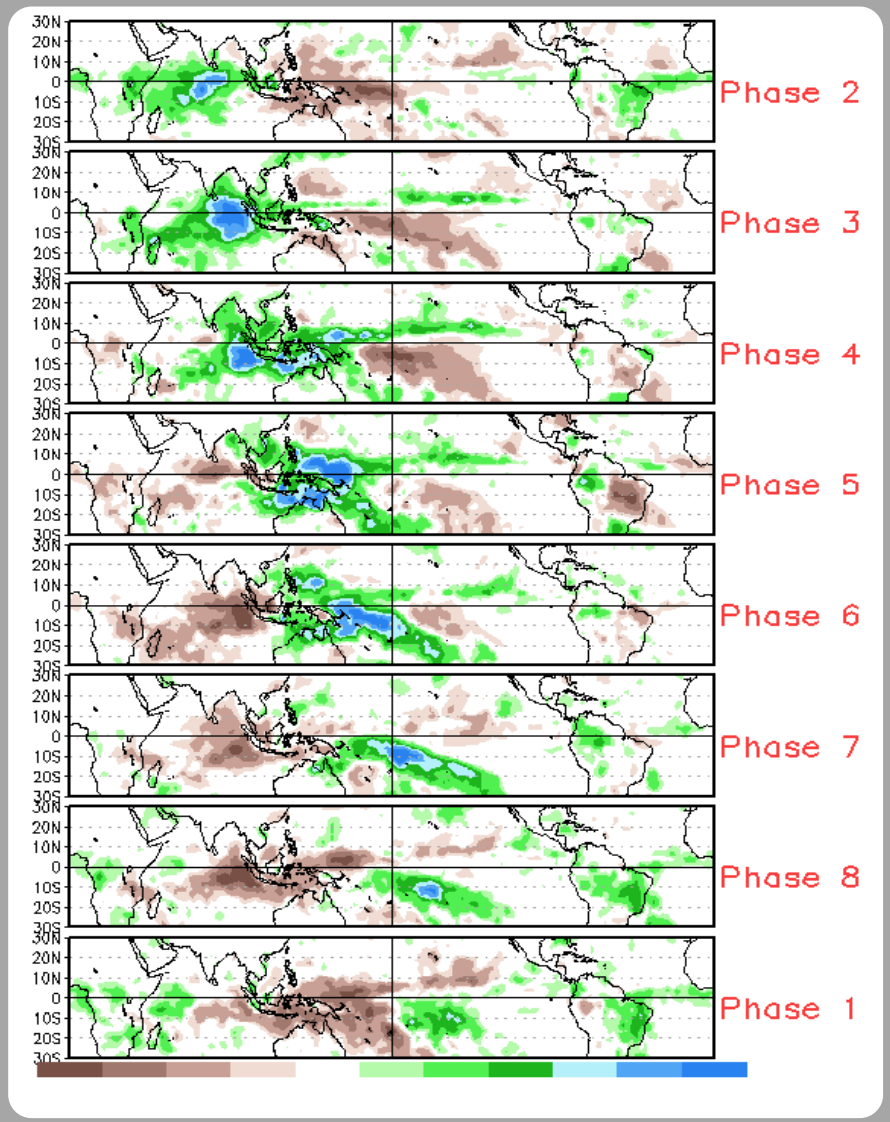
The constructed analog model depicts more robust eastward propagation of the subseasonal signal, with enhanced (suppressed) convection propagating from the Indian Ocean to the West Pacific (returning to the equatorial Indian Ocean).

MJO Composites - Global Tropics

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



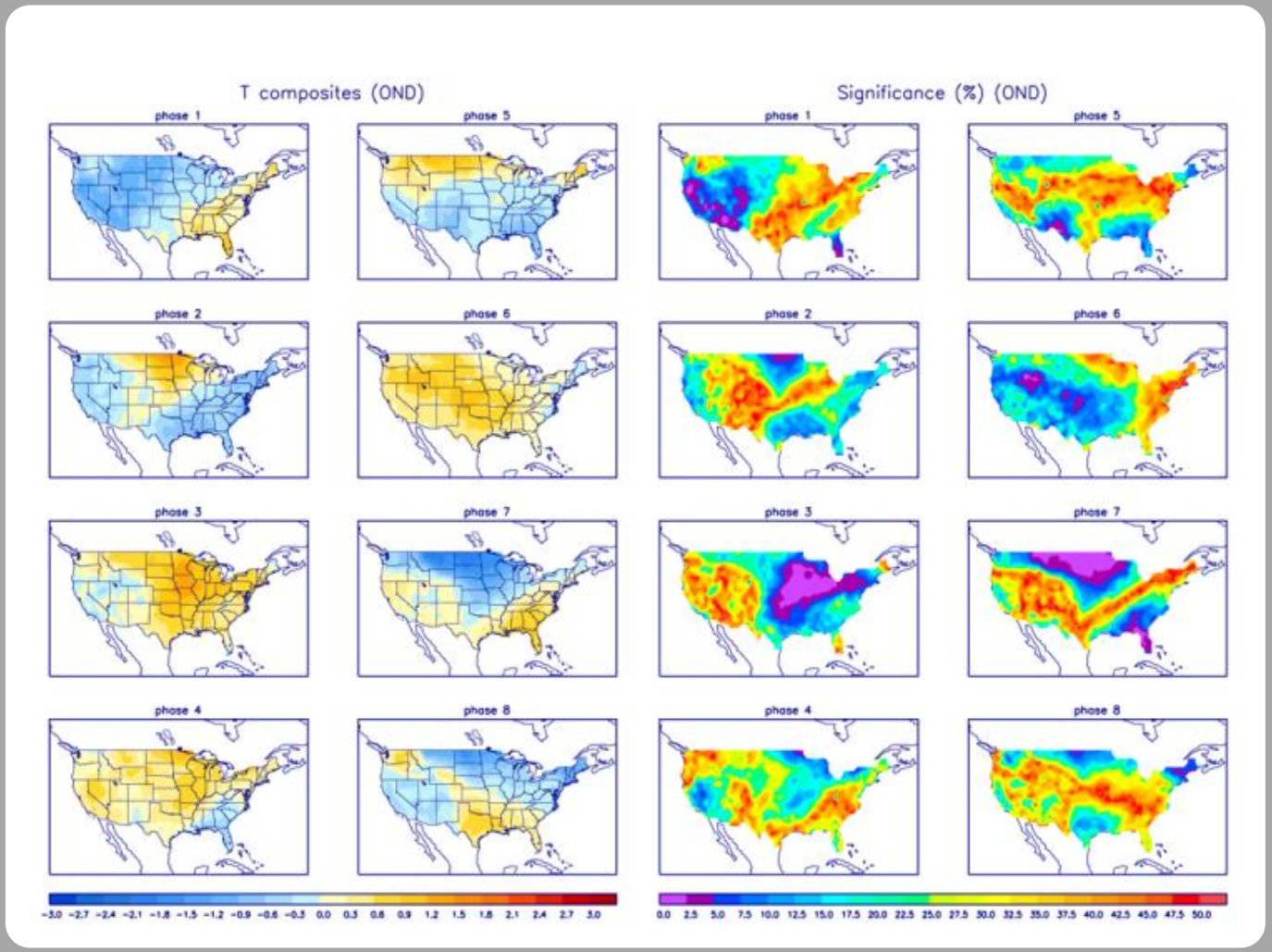
Precipitation Anomalies (May-Sep)



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.



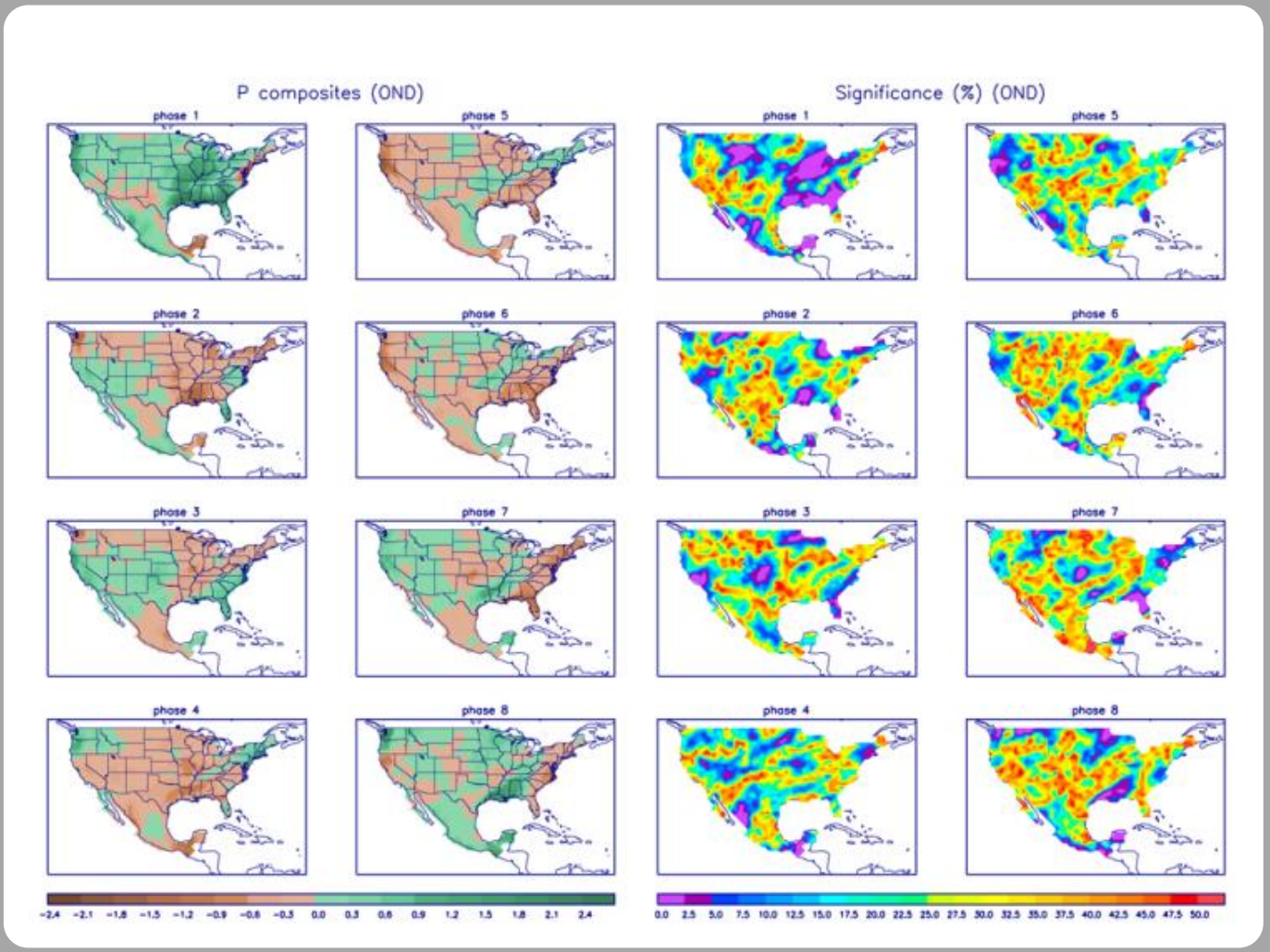
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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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