



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

**Update prepared by
Climate Prediction Center / NCEP
May 4, 2015**



Outline

- **Overview**
- **Recent Evolution and Current Conditions**
- **MJO Index Information**
- **MJO Index Forecasts**
- **MJO Composites**



Overview

- **Recent observations indicate that the MJO remained weak during the past 7 days.**
- **Other modes of tropical convective variability, including the El Niño background state and a robust atmospheric Kelvin wave over the Western Hemisphere, continue to influence the pattern of tropical convection.**
- **Dynamical and statistical models generally predict weak MJO activity over the next two weeks.**
- **The MJO is therefore not expected to play a significant role in the pattern of tropical variability during the next two weeks. The low frequency ENSO state, modulated by more transient features such as Kelvin Waves, is anticipated to remain the dominant factor in the global tropical convective 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>

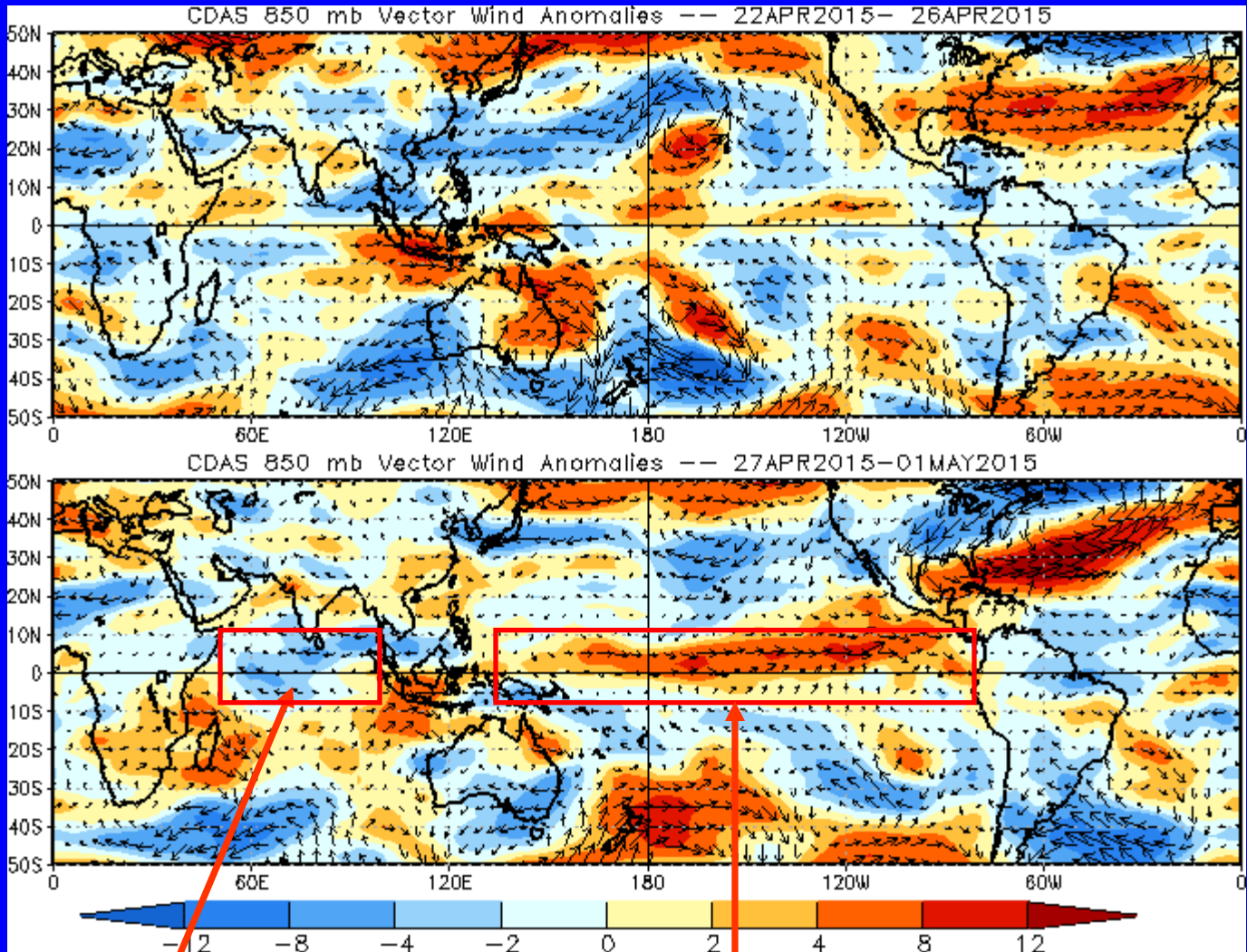


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Weak easterly anomalies were observed over the Indian Ocean.

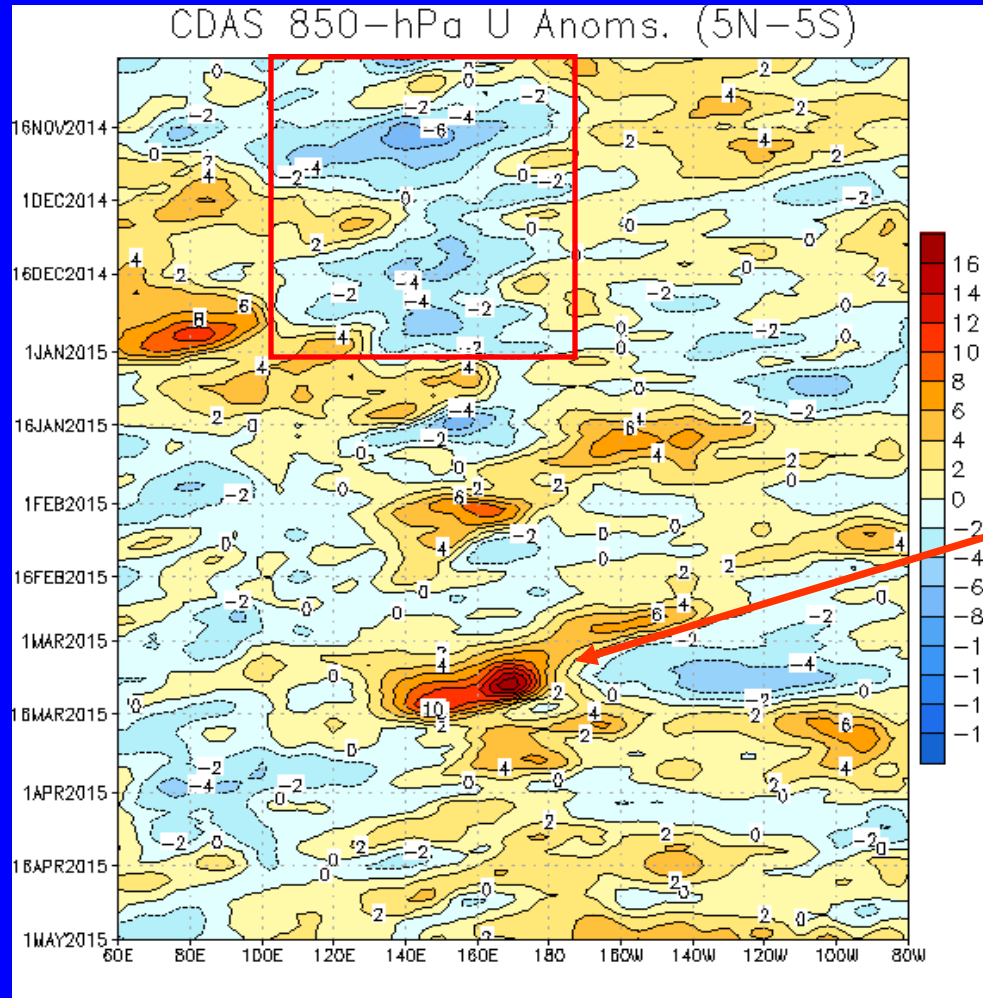
Westerly anomalies intensified across much of the equatorial Pacific.



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 November and December, easterly anomalies were persistent from 120E to near the Date Line (red box). Westerly anomalies replace those easterly anomalies during January. Easterly anomalies disrupted the signal during mid-January. Westerly anomalies returned to the Western Pacific during late January.

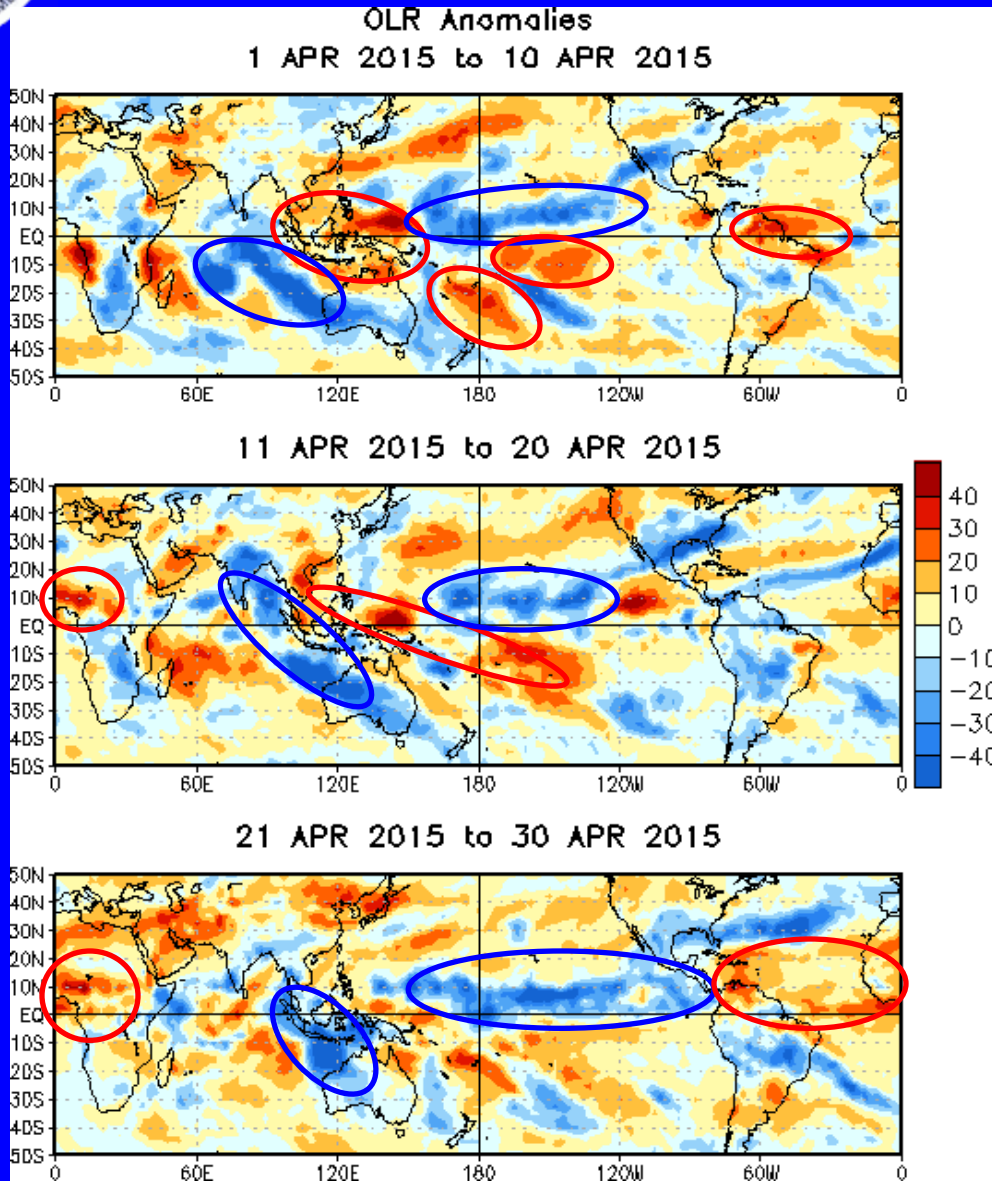
Strong westerly anomalies associated with an ERW propagated west of the Date Line during early March.

Recently, westerly anomalies have expanded over much of the central and eastern Pacific, consistent with the ongoing El Niño.



OLR Anomalies – Past 30 days

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



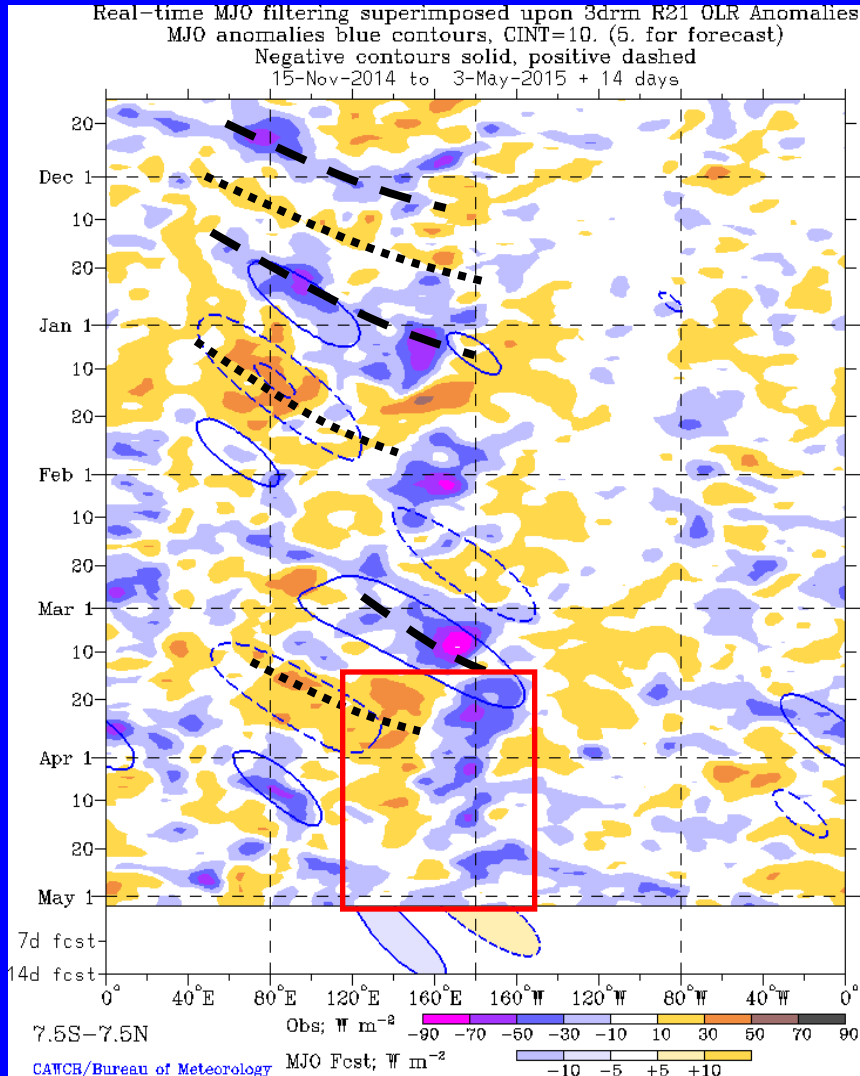
During early April, enhanced (suppressed) convection was observed across much of the Pacific north of the equator and across the southern Indian Ocean partly associated with TC activity (Maritime Continent, parts of the South Pacific, and northern South America).

During mid-April, enhanced convection persisted across the Central Pacific and eastern Indian Ocean. Suppressed convection continued north of New Guinea and across the south-central tropical Pacific.

During late-April, enhanced convection expanded east across the equatorial Pacific, and was also observed across the western Maritime Continent. Suppressed convection was observed across the tropical Atlantic and western Africa.



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)

(Courtesy of CAWCR Australia Bureau of Meteorology)

The MJO strengthened in late November with alternating areas of enhanced/suppressed convection moving from the Indian Ocean to the Date Line through January. During early February the MJO signal broke down.

Convective anomalies were generally small during February as the MJO signal remained incoherent.

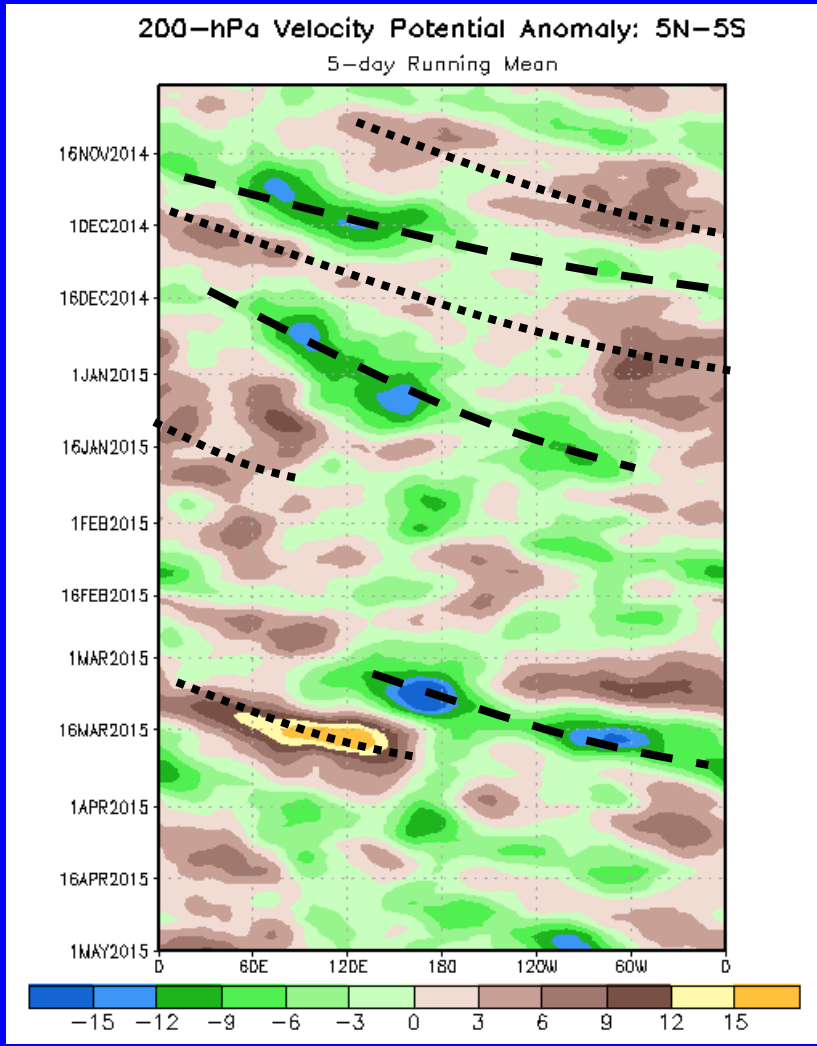
The MJO became active again during March, with eastward propagation of enhanced (suppressed) anomalies evident across the Pacific (Indian Ocean and Maritime Continent). Beginning in mid-March enhanced (suppressed) convection persisted near the Date Line (Maritime Continent), consistent with the ongoing El Niño (red box). More recently, robust Kelvin wave is evident, interrupting the dry signal 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



Time
↓

Beginning in November the MJO strengthened as indicated by eastward propagation of alternating anomalies into January 2015. At times, the signal was dominated by faster-moving variability (likely Kelvin Wave activity), but most of the signal was more consistent with canonical MJO activity.

Beginning in mid-January, the signal broke down, with other modes of variability dominating the upper-level velocity potential anomaly pattern.

During March, eastward propagation of a strong anomaly couplet was observed, with negative (positive) anomalies propagating over the Western Hemisphere (Maritime Continent and far West Pacific).

Negative anomalies persisted near the Date Line due to the low-frequency state, while subseasonal eastward propagation due to Kelvin wave activity has continued during the past two weeks.

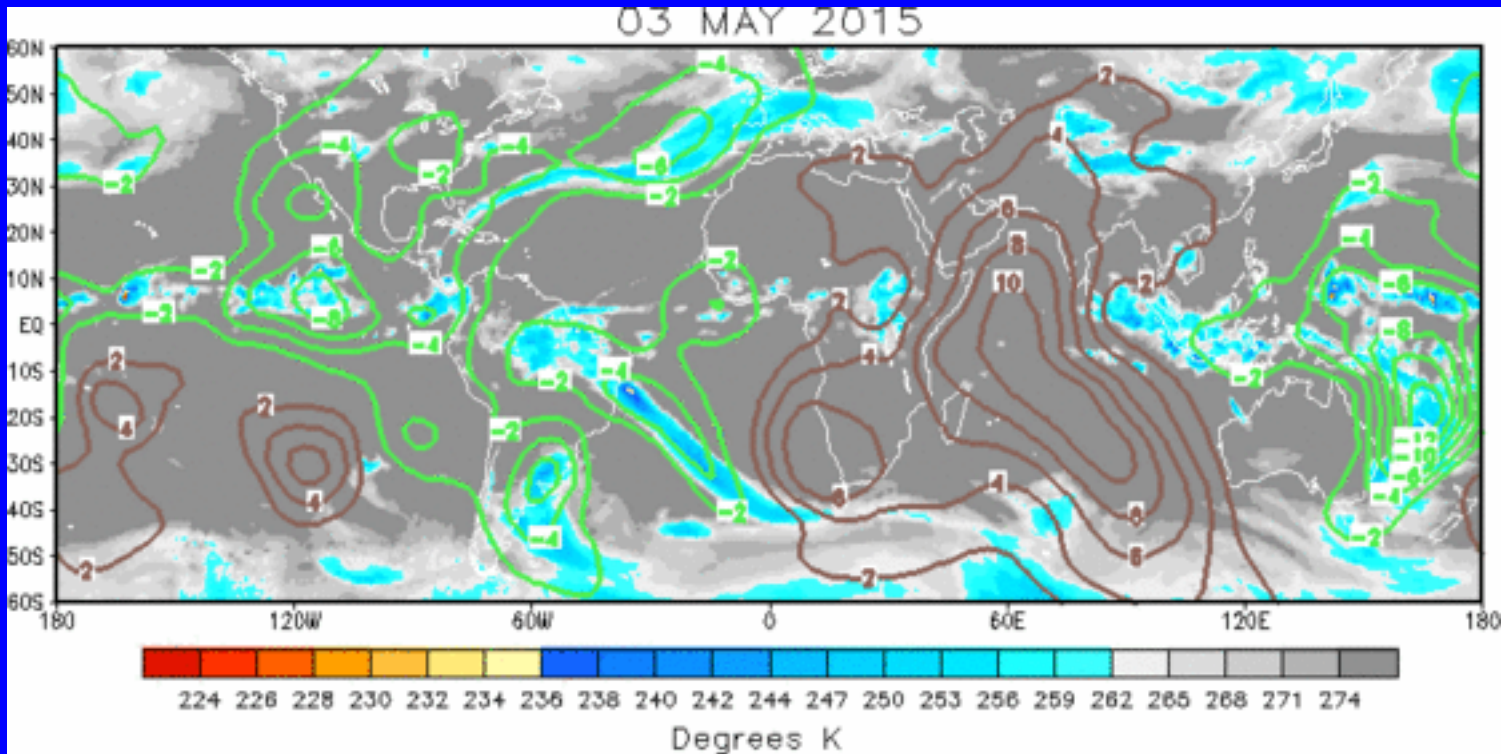
Longitude



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

Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The spatial pattern of velocity potential anomalies continues to reflect the ENSO state over the Pacific, while a robust atmospheric Kelvin wave is observed over the Western Hemisphere.

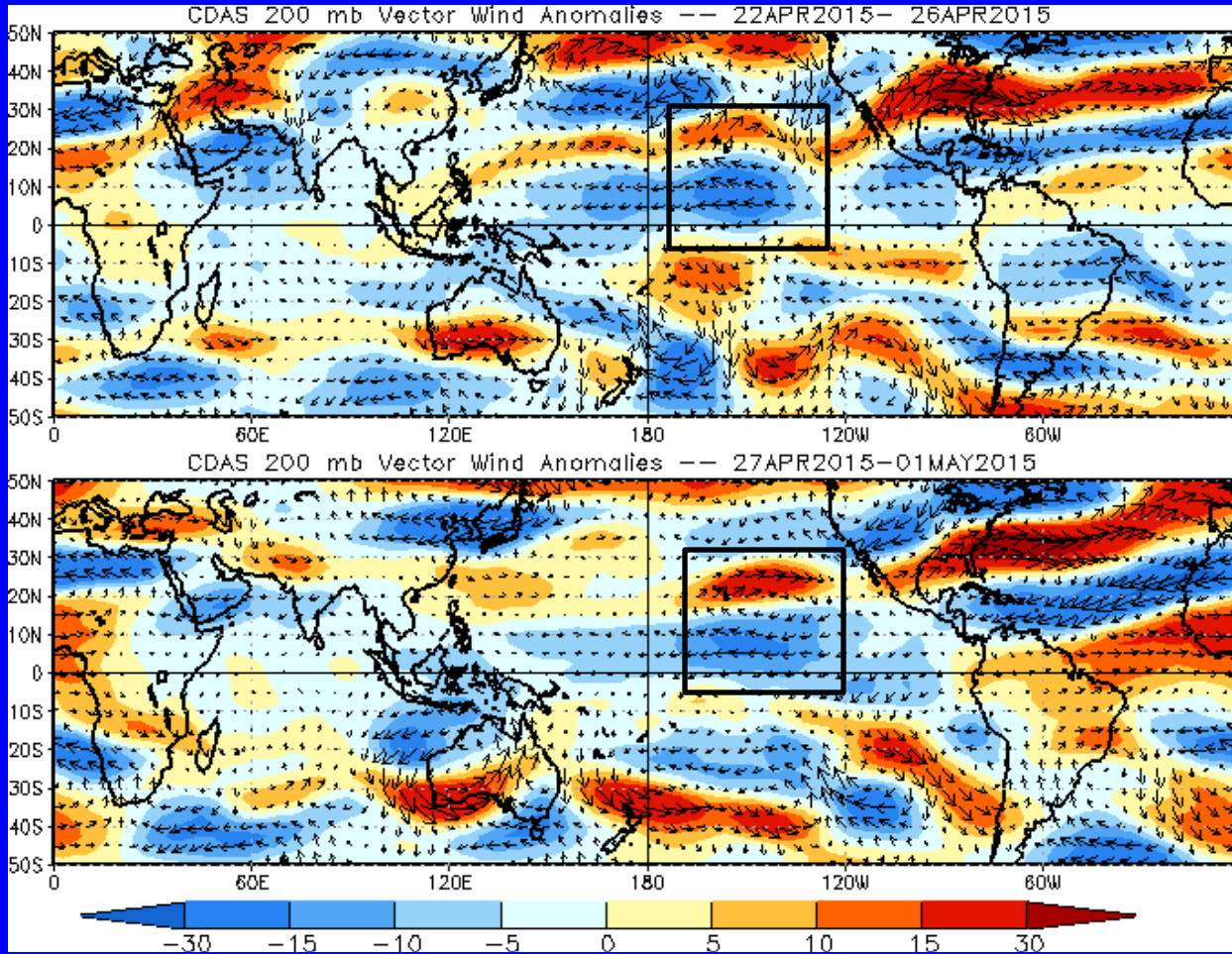


200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



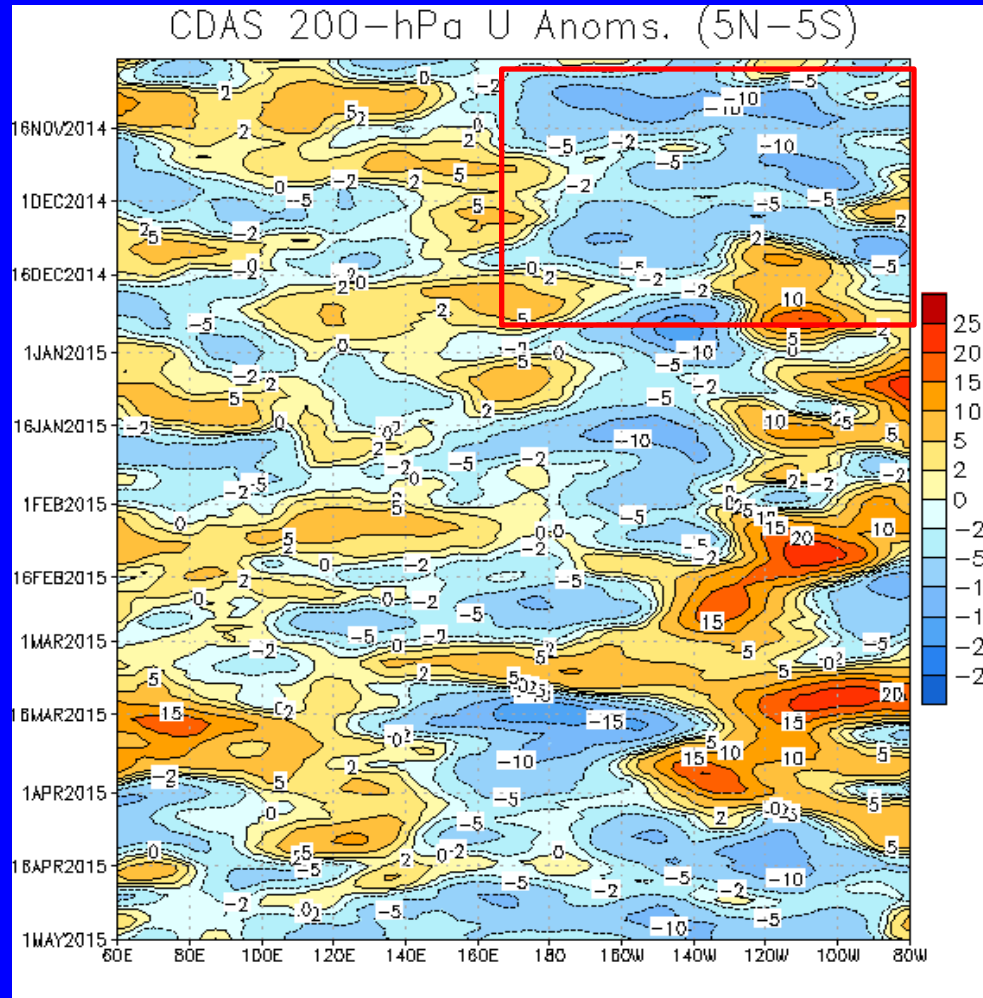
Anomalous ridging continues over the subtropical central Pacific, consistent with the anomalous divergent circulation related to El Niño.



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 wind anomalies persisted east of the Date Line from late October through early December (red box).

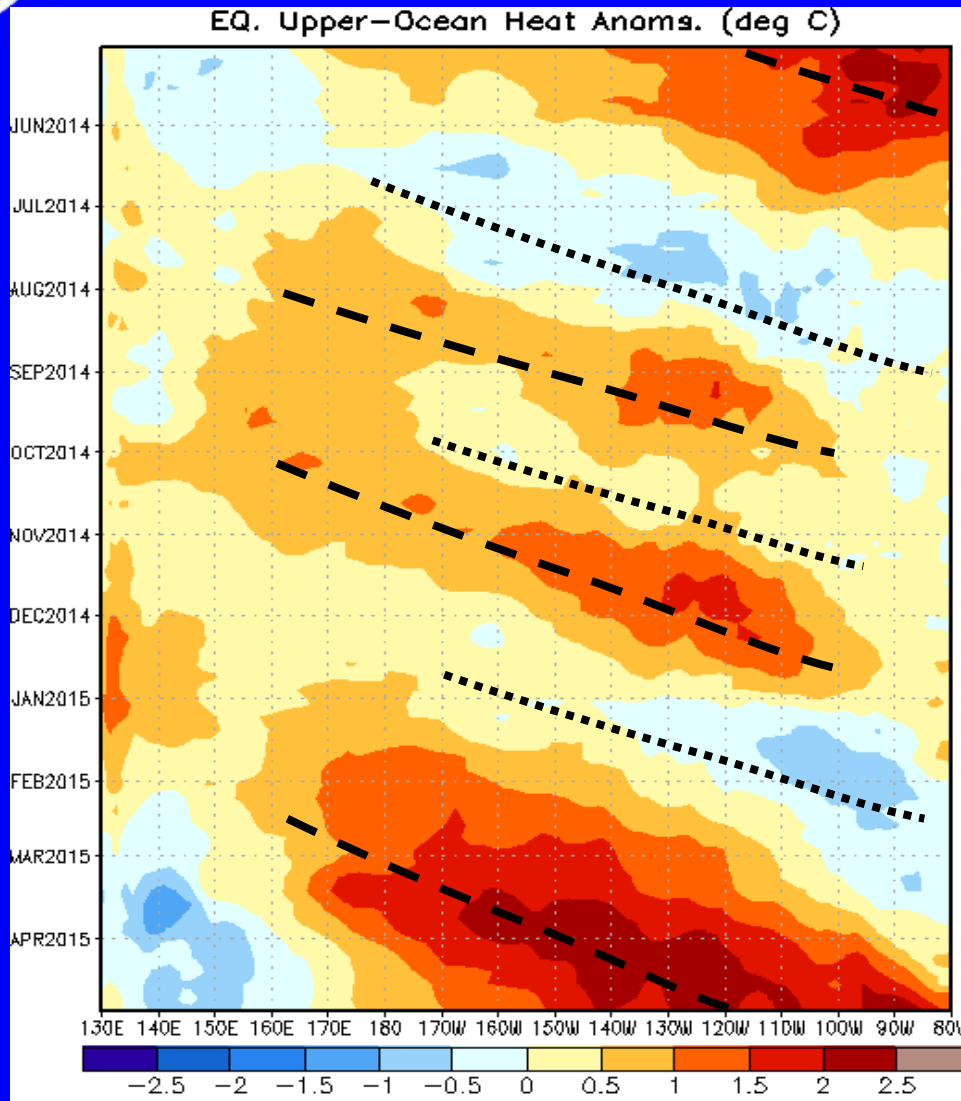
During late December through the present, westerly anomalies increased in coverage and intensity from 120W to 80W, similar to September and October 2014. Westerly anomalies also became more persistent over the Indian Ocean.

Westward propagation of westerly anomalies was evident over the eastern Pacific during late February.

Recently, easterly anomalies have generally persisted over the central Pacific.



Weekly Heat Content Evolution in the Equatorial Pacific



A strong downwelling event began in January 2014 and propagated across the Pacific, reaching the South American coast by May 2014.

Warm anomalies persisted over much of the Pacific during April and May, though basin-averaged anomalies decreased during June and July associated with an upwelling Kelvin wave (dotted line).

Warm anomalies increased across much of the Pacific basin due to another moderate downwelling Kelvin wave traversing the Pacific during October and November 2014. The upwelling phase was evident in the central and eastern Pacific during January.

Warm anomalies associated with another downwelling Kelvin Wave are evident over the central Pacific, with warm anomalies persistent near and 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.

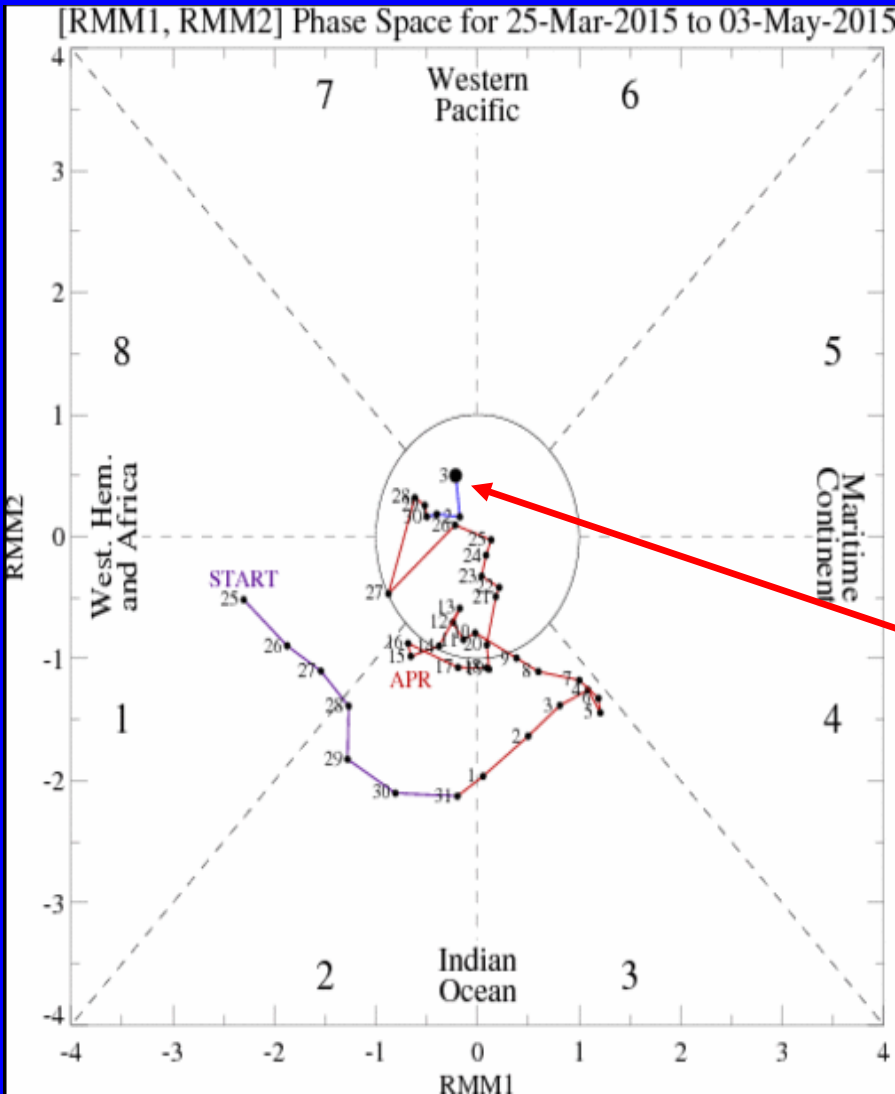
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

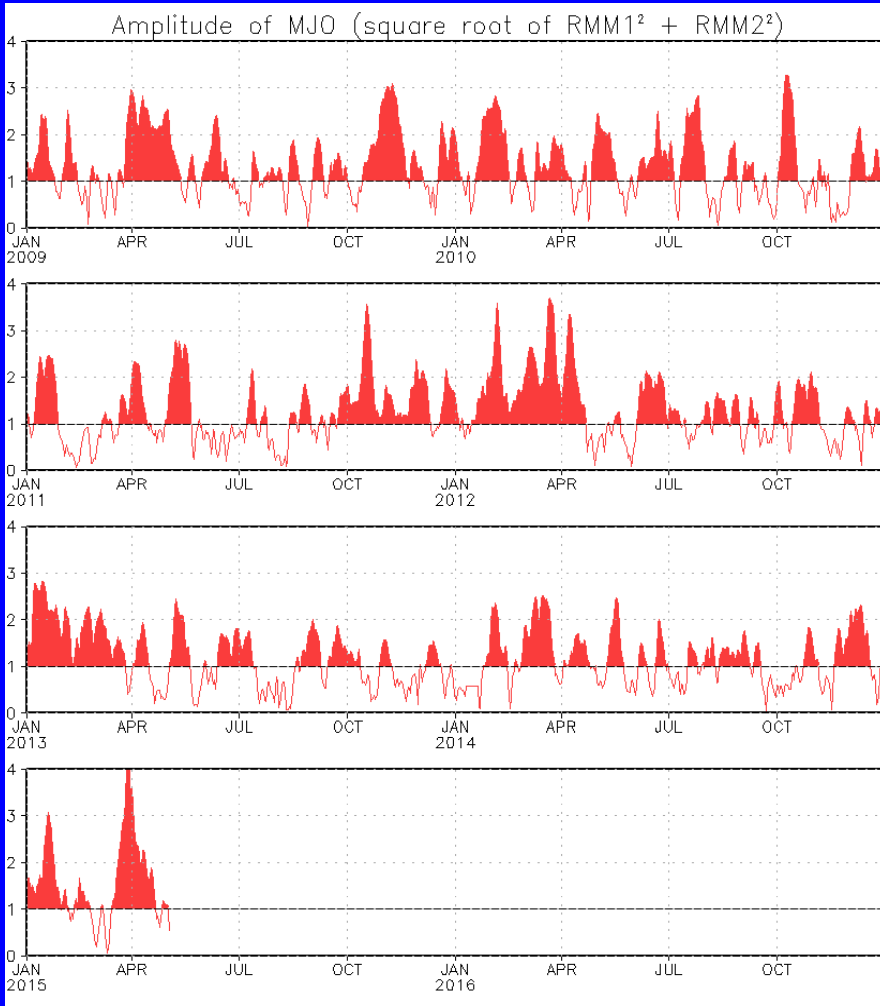


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the origin is proportional to MJO strength
- Line colors distinguish different months

The RMM MJO index indicated an incoherent signal during the past 7 days.



MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

Plot puts current MJO activity in recent historical context.



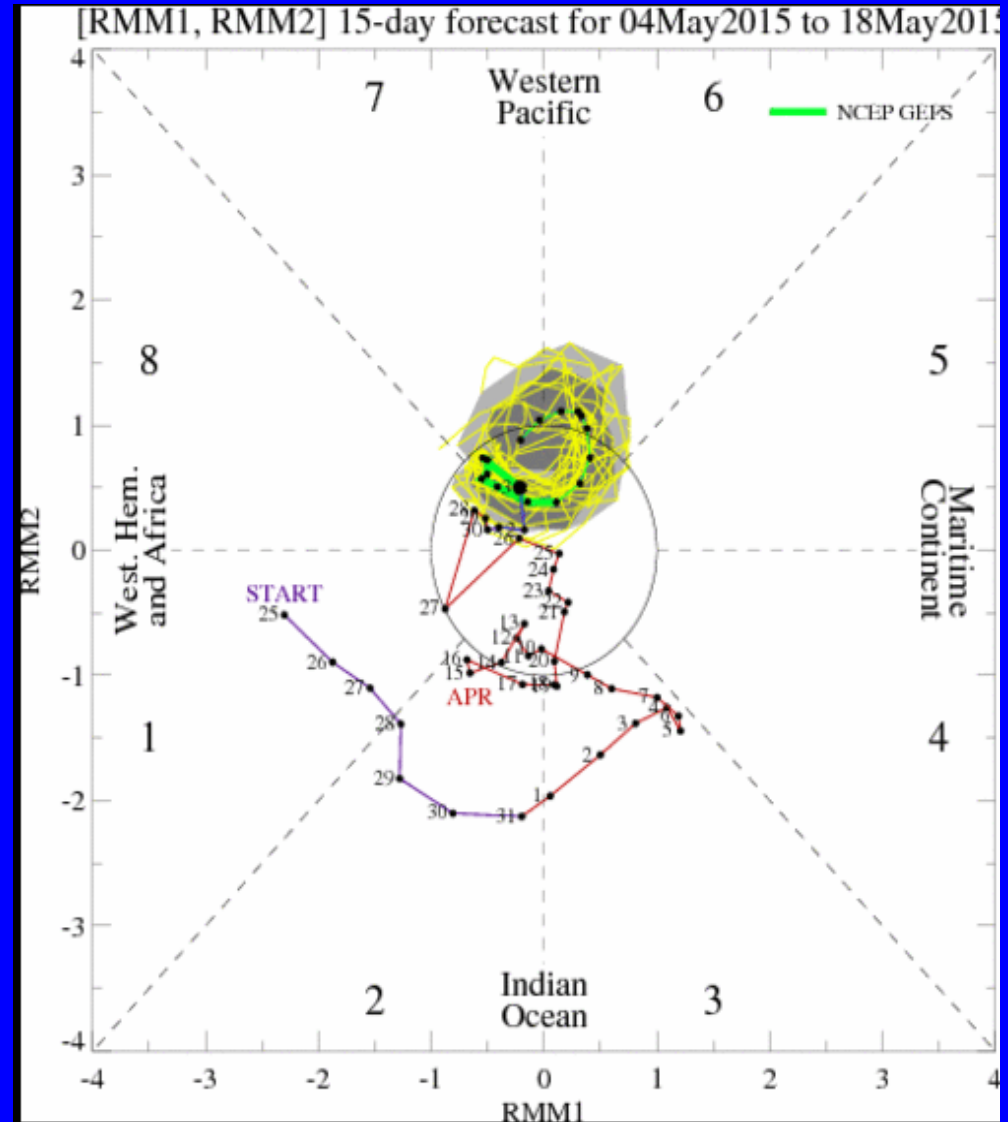
Ensemble GFS (GEFS) MJO Forecast

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 RMM Index forecasts depict a generally weak signal during the next two weeks.

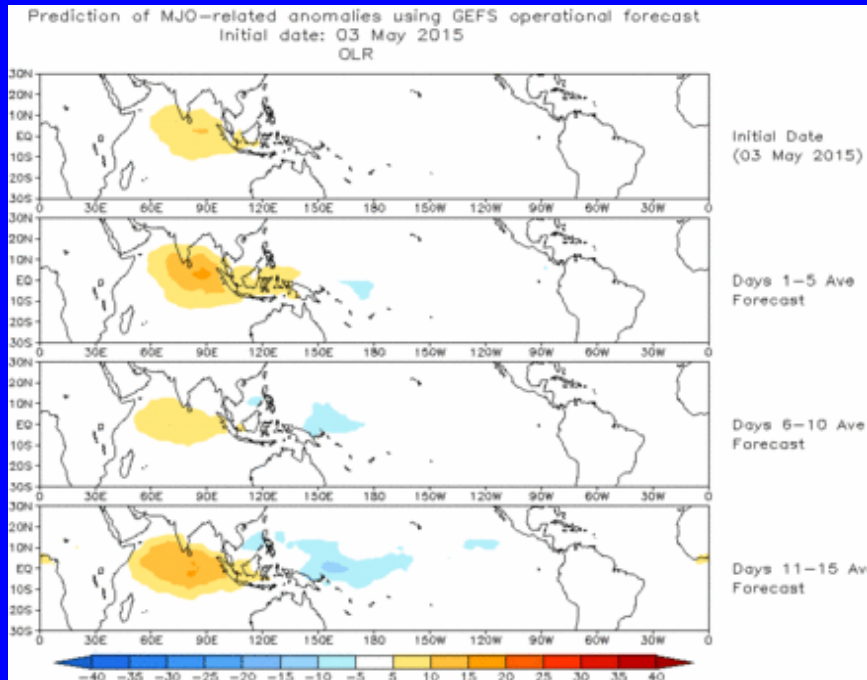




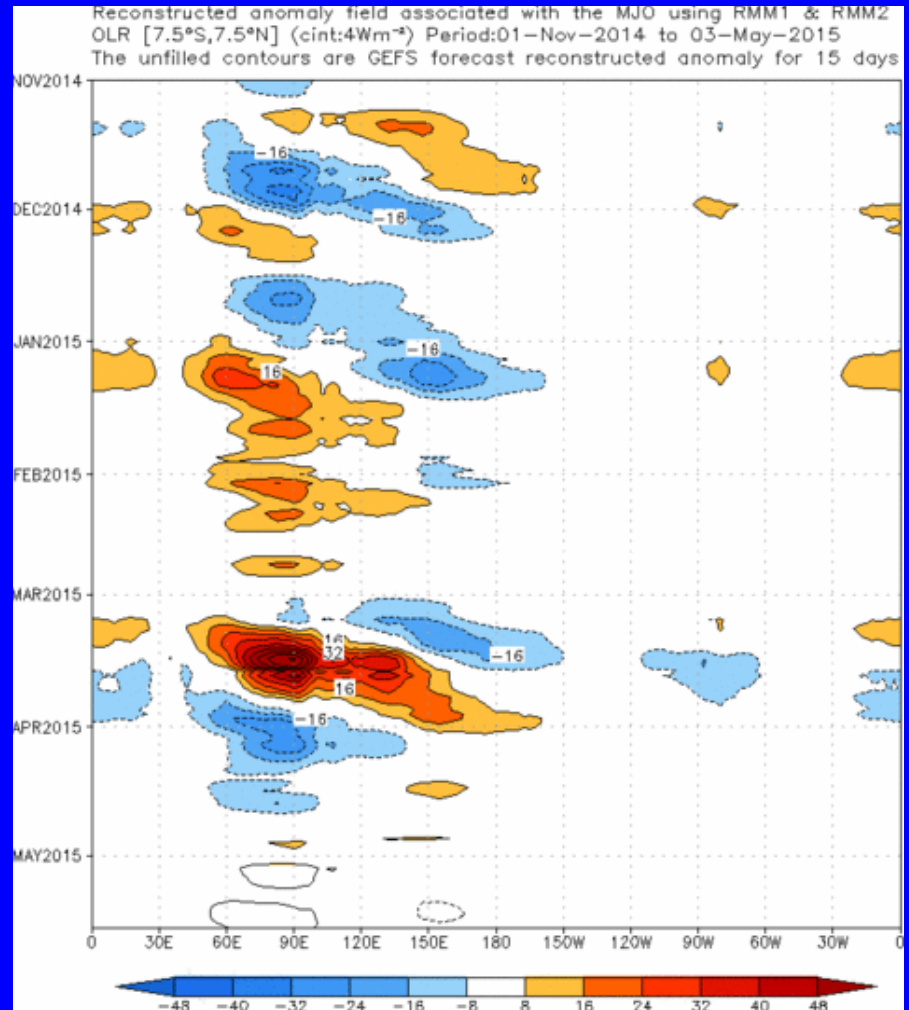
Ensemble Mean GFS MJO Forecast

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 for the last 180 days and for the next 15 days



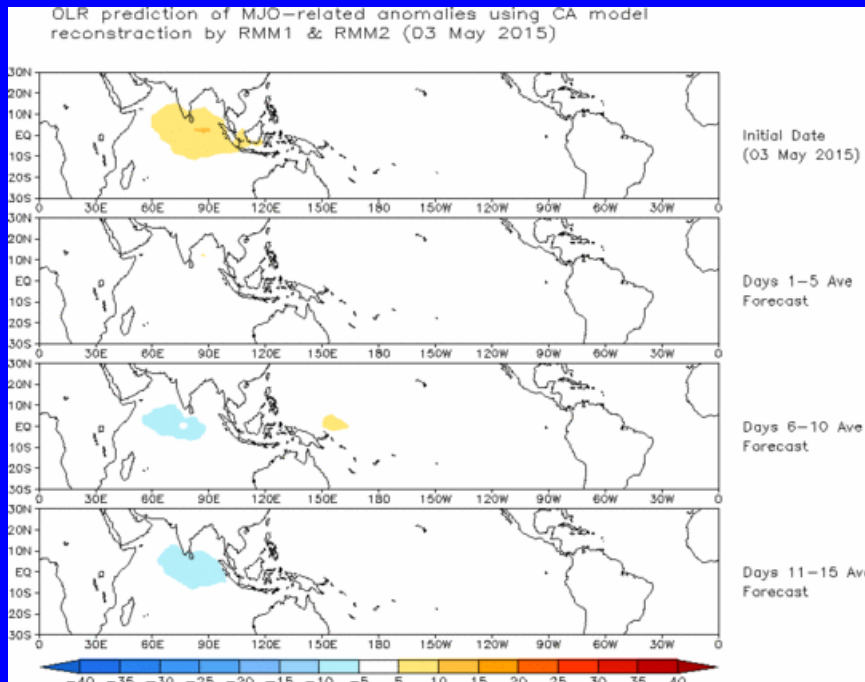
The GEFS RMM Index based OLR anomalies forecast a strengthening signal favoring enhanced (suppressed) convection over the western Pacific (Indian Ocean) during the upcoming two weeks, which is displaced westward of the low frequency state.



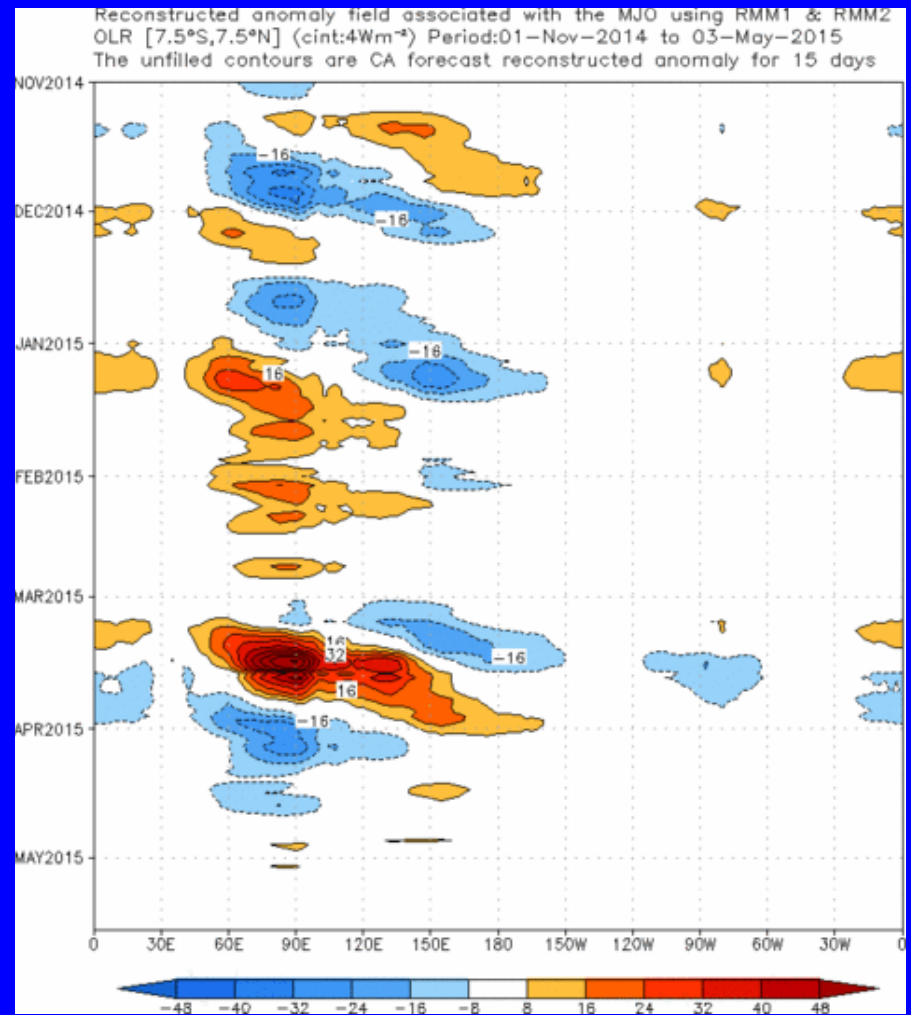
Constructed Analog (CA) MJO Forecast

Figure below shows 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 for the last 180 days and for the next 15 days



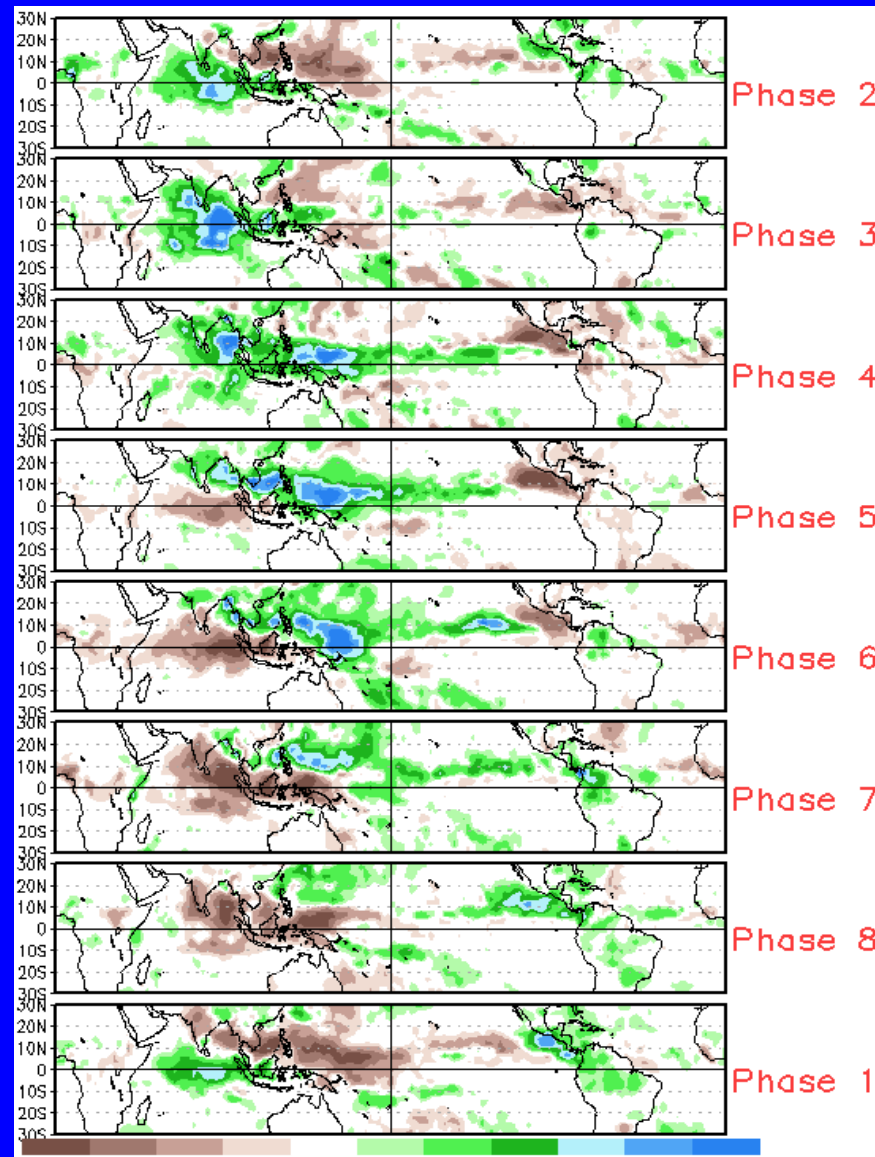
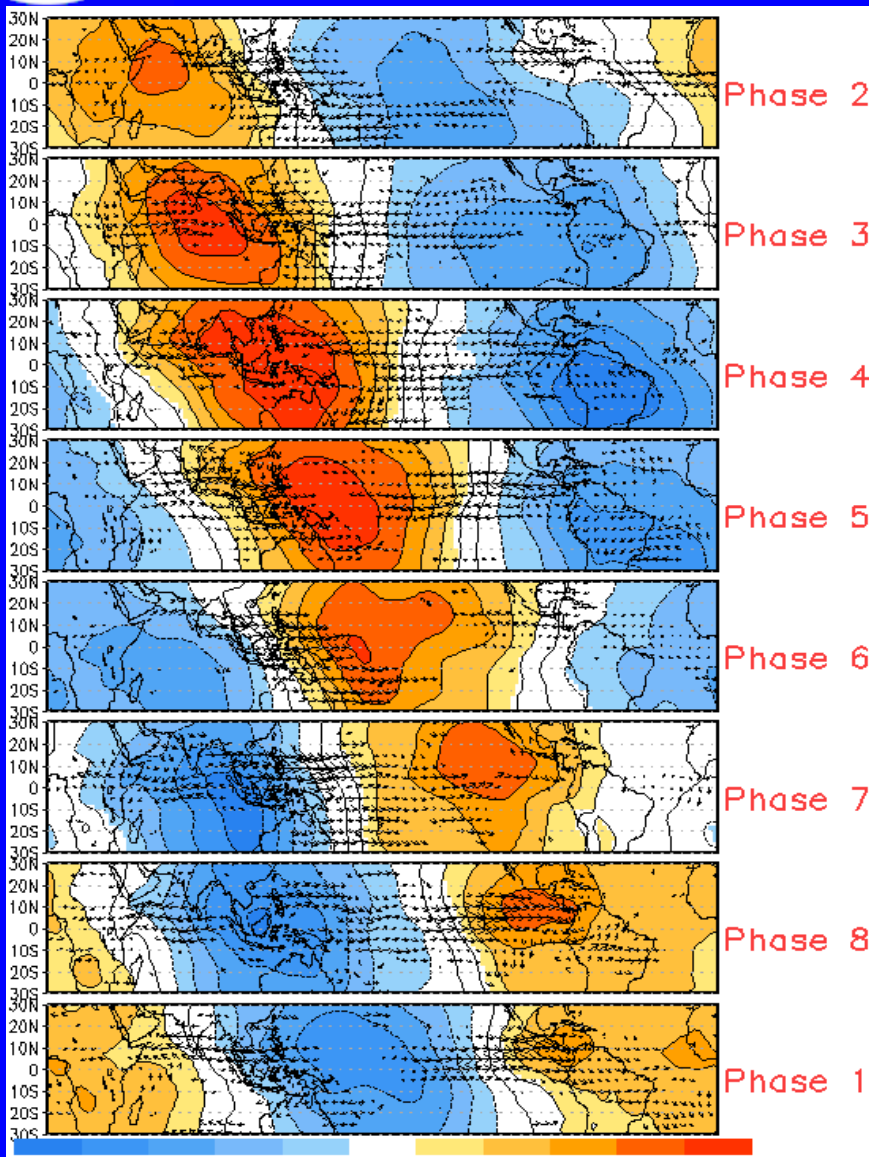
The statistical forecast depicts a weak signal that is out of phase with the GEFS dynamical model forecasts.



MJO Composites – Global Tropics

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

Precipitation Anomalies (Nov-Mar)

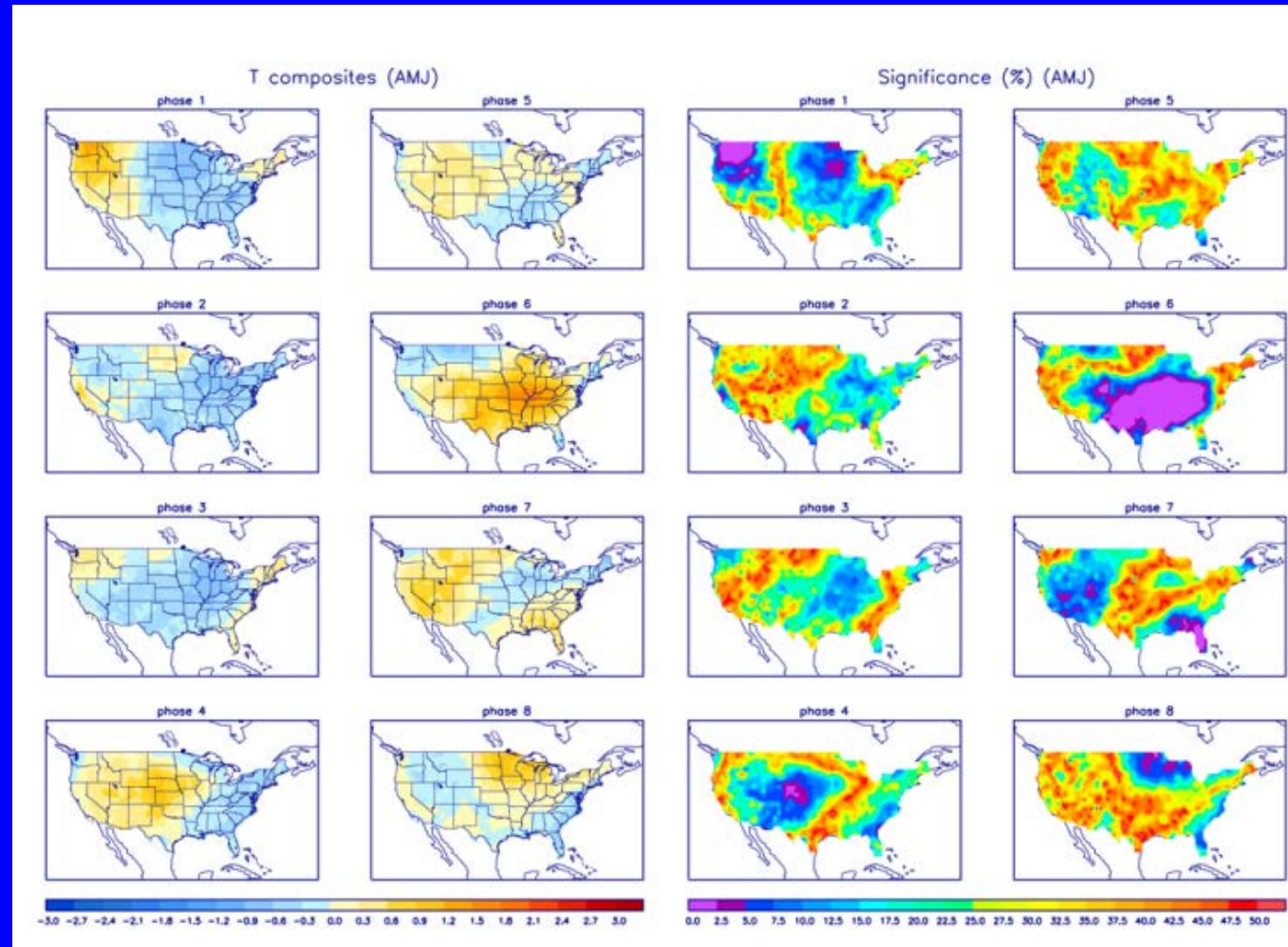




U.S. MJO Composites – Temperature

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.



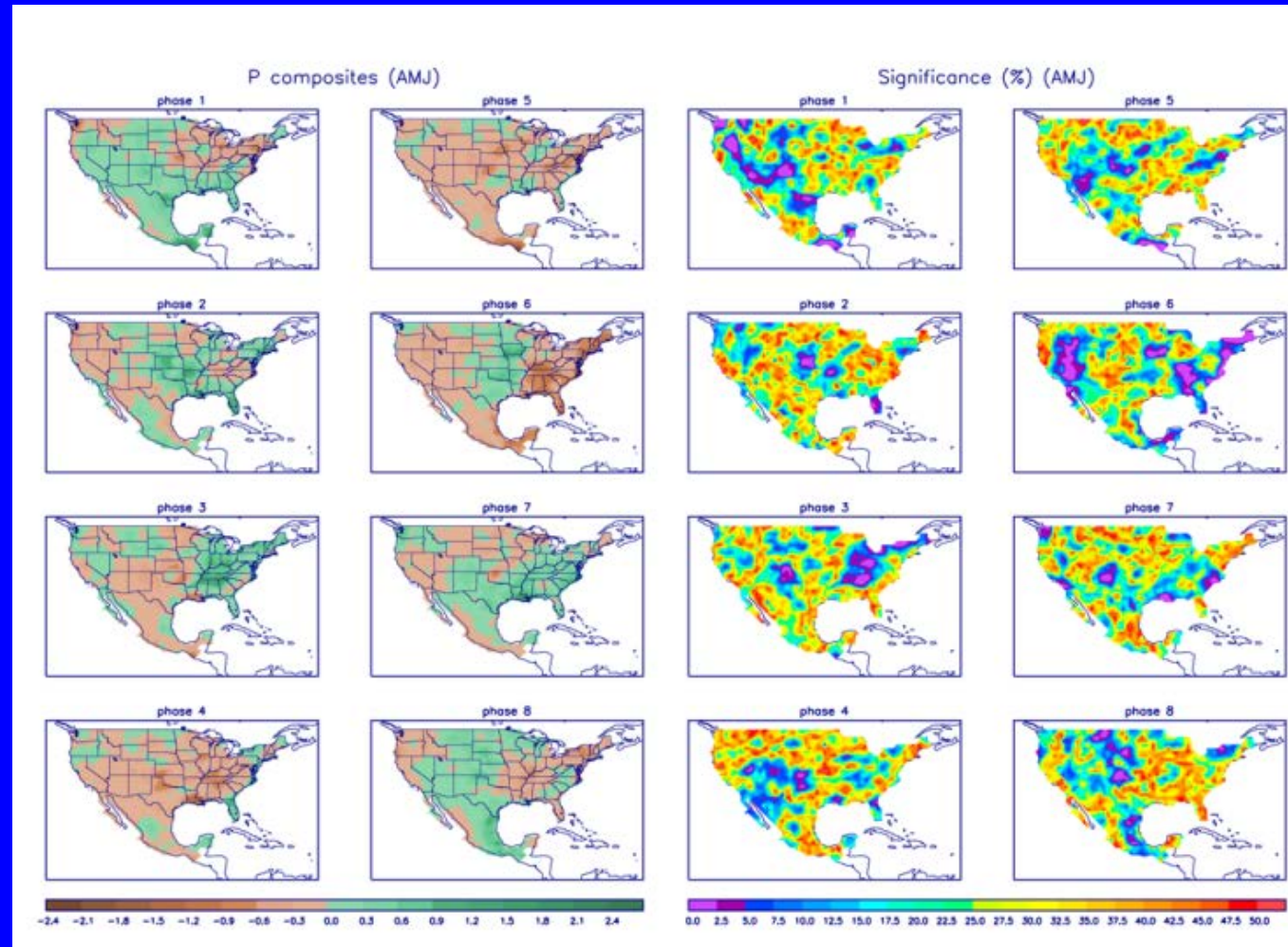
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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.



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

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