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

Update prepared by
Climate Prediction Center / NCEP
March 16, 2015

Outline

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

Overview

- **Recent observations and MJO indices suggest a strong ongoing MJO event centered over the West-Central Pacific.**

- **Other modes of tropical convective variability, including a potent Equatorial Rossby Wave and a weak El Niño background state, continue to influence the pattern, constructively interfering with the MJO signal.**

- **The dynamical forecast models suggest that the MJO signal will weaken substantially over the next two weeks, with slower eastward propagation across the Western Hemisphere. Statistical models favor the continued propagation of a robust MJO event. The MJO is, therefore, expected to remain active but weaken over the next two weeks, with the low-frequency state playing an increasingly important role in the pattern of anomalous convection.**

- **The MJO could contribute to enhanced (suppressed) convection over the central Pacific (eastern Indian Ocean and Maritime Continent) during the next two weeks.**

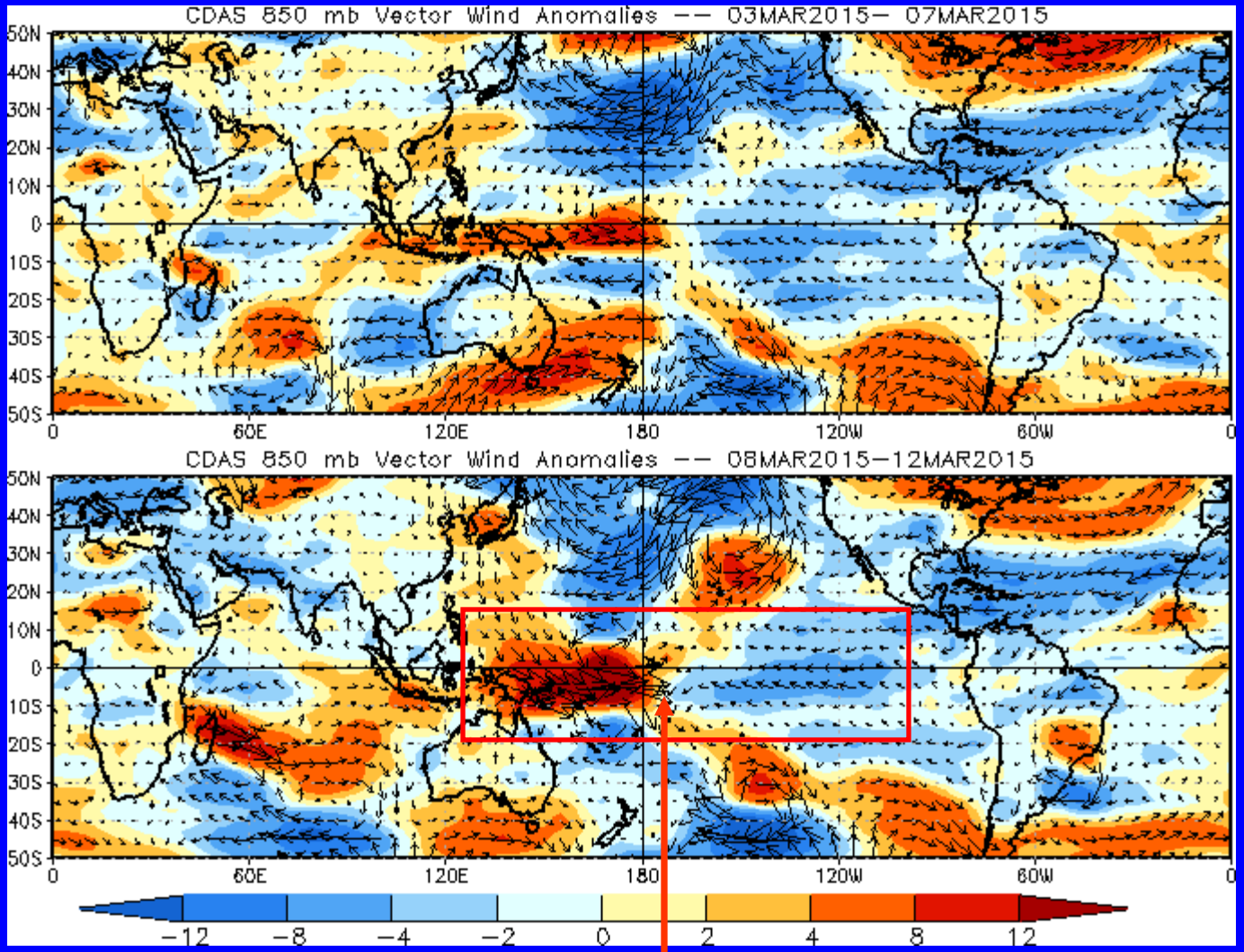
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies

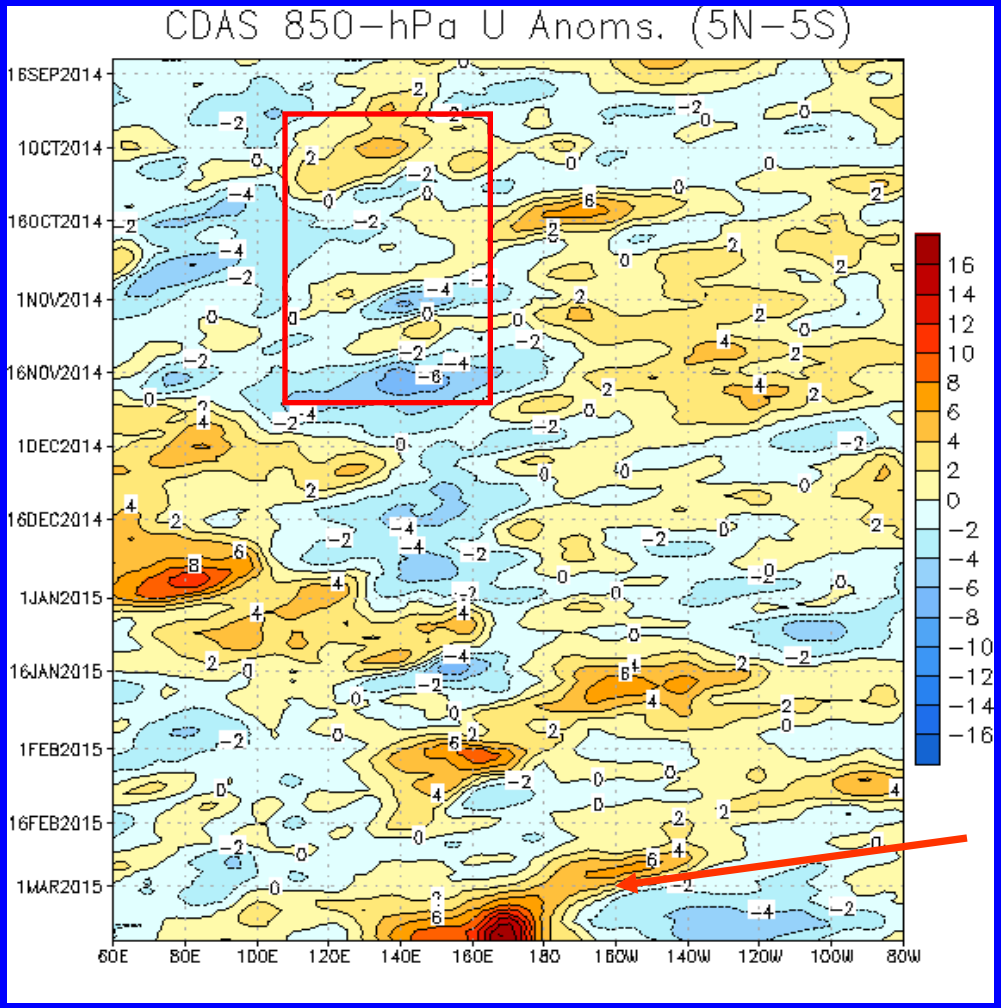


The lower-level zonal wind anomalies have been dominated by a west-east dipole across the Pacific. A strong westerly wind burst is evident, while stronger than normal easterlies have been maintained across the eastern part of the basin.

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



Time

Longitude

During October, equatorial Rossby wave activity was strong from 160E to 100E as westward movement features are evident (red box). MJO activity was less coherent during this period.

During November and December, easterly anomalies were persistent from 120E to near the Date Line. Westerly anomalies replace those easterly anomalies during January. Easterly anomalies disrupted the signal during early February. Westerly anomalies returned to the Western Pacific during late January.

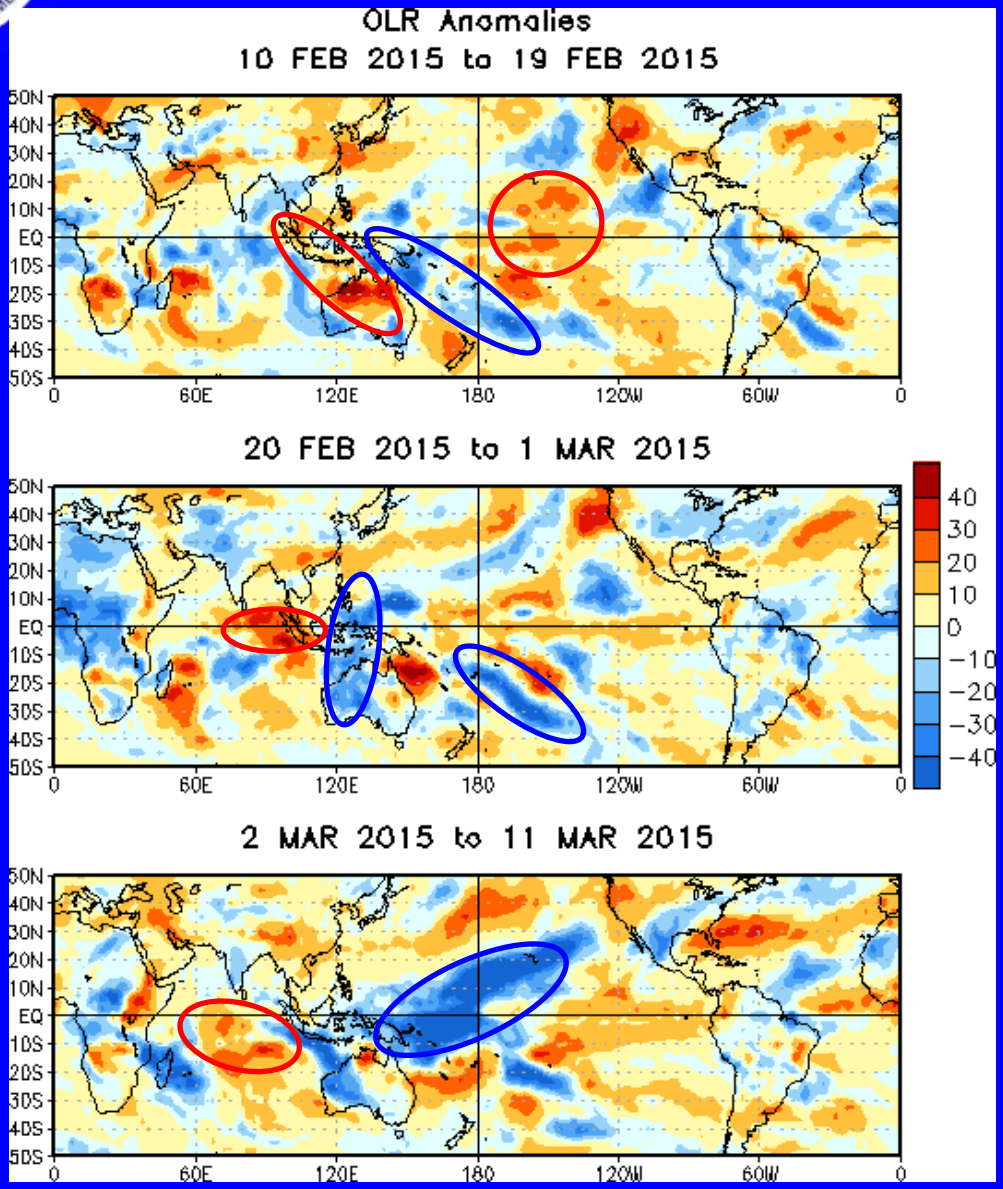
Strong westerly anomalies associated with an ERW propagated west of the Date Line during early March.

Recently, a strong westerly wind burst is evident just west of the Date Line, likely due to constructive interference among several modes of variability.

OLR Anomalies – Past 30 days

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

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

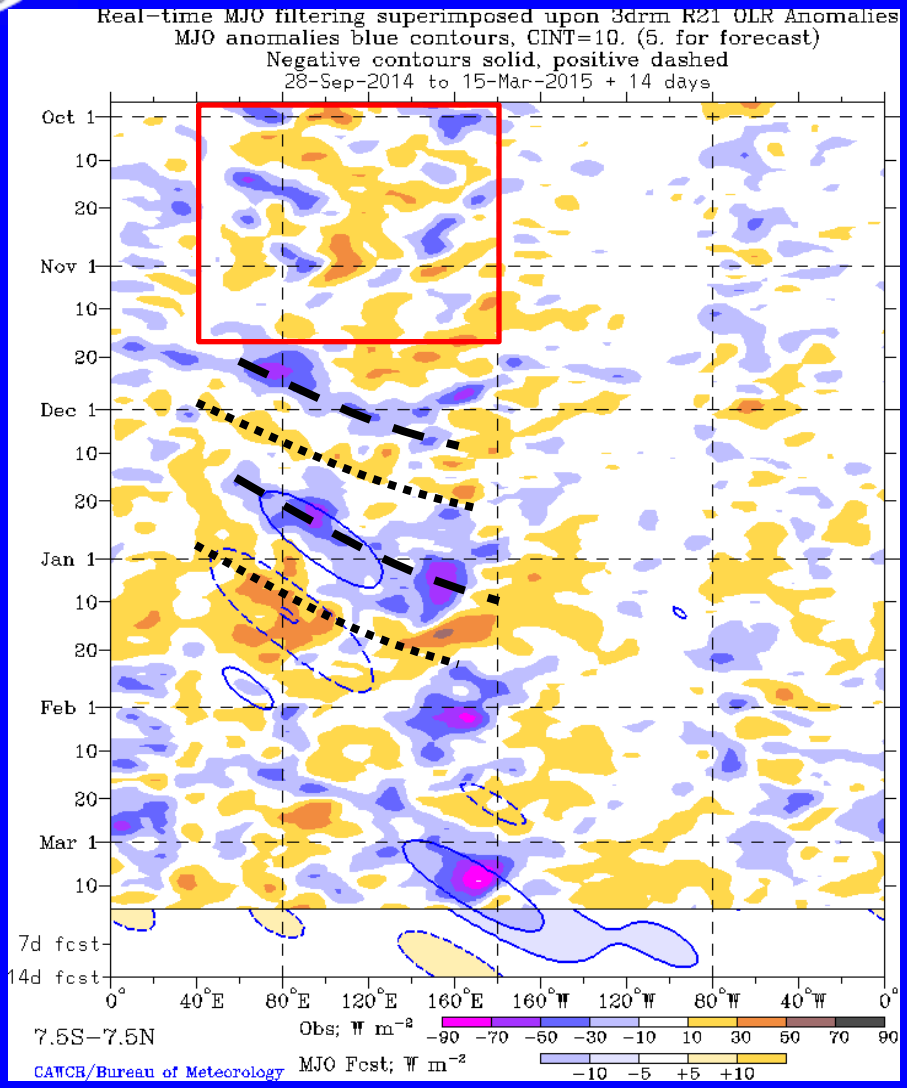


During mid-February, relatively small-scale areas of enhanced (suppressed) convection was observed over the SPCZ region (Maritime Continent and eastern Pacific).

During late February, smaller-scale OLR anomalies continued to dominate, with weakly suppressed (enhanced) convection over the eastern Indian Ocean (Maritime Continent, western Australia, and South Pacific).

During early March, suppressed convection continued over the eastern Indian Ocean , while enhanced convection developed over the West Pacific. A plume of moisture extended from the Date Line to Hawaii over the northern Pacific.

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



Time

Longitude

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 OLR anomaly pattern was less coherent with respect to canonical MJO activity during October and the MJO remained weak until mid-November (red box).

The MJO strengthened in late November with alternating areas of enhanced and suppressed convection moving from the Indian Ocean to the Date Line through January.

Enhanced convection persisted just west of the Date Line during late January and early February as the MJO signal broke down.

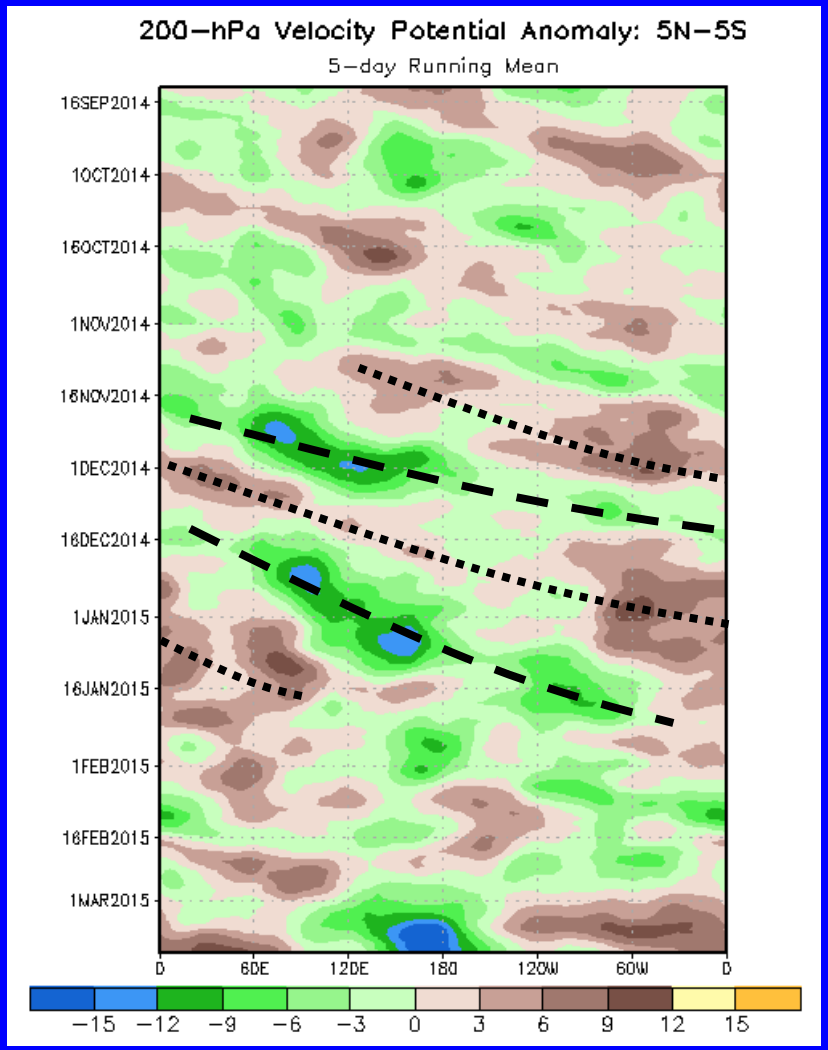
Convective anomalies were generally small during February as the MJO signal remained incoherent.

Recently, another burst of strongly enhanced convection was observed near and just west of 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



The MJO was incoherent from mid-September through October.

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 on the Kelvin Wave time scale, but from late December through mid-January the signal was more consistent with canonical MJO activity.

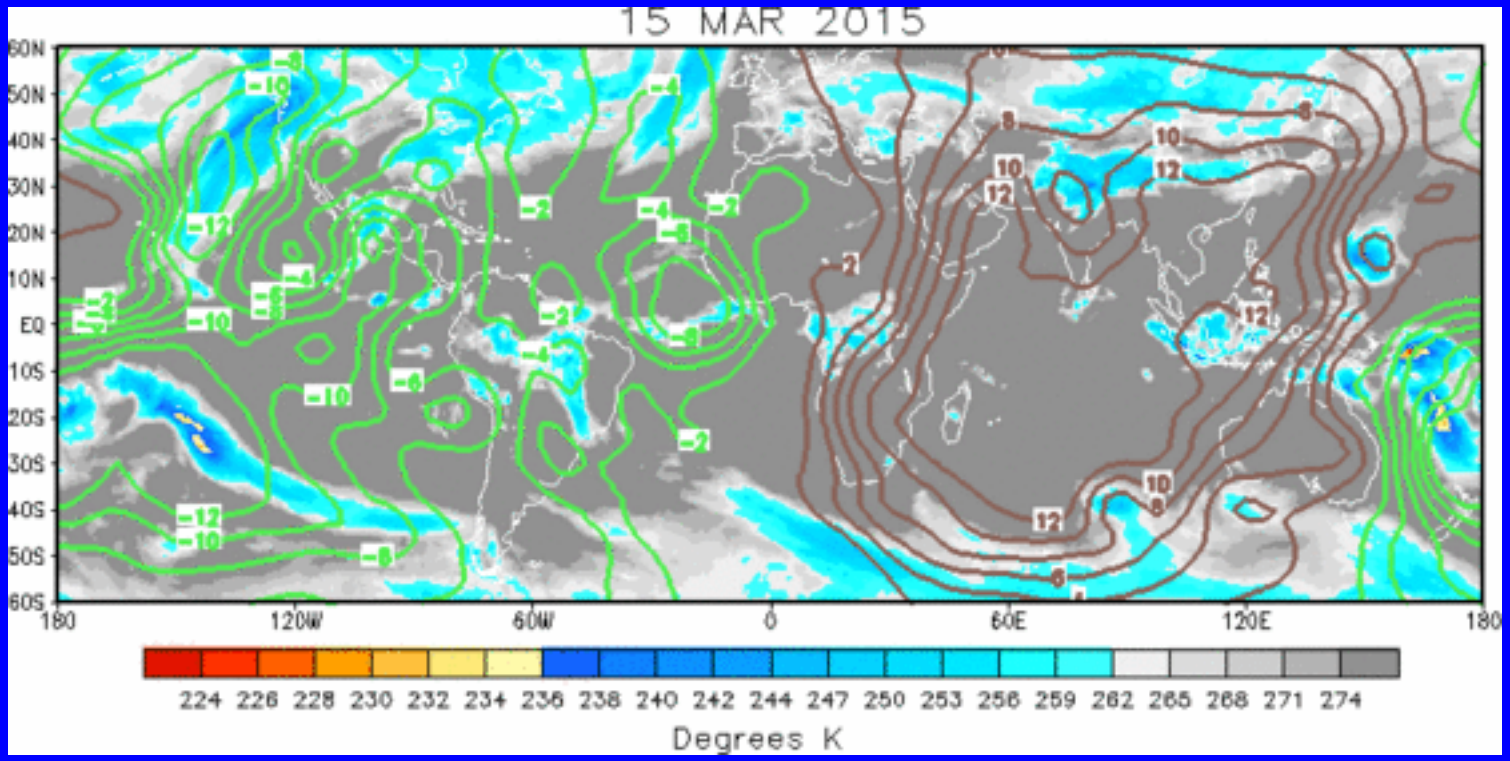
Beginning in mid-January, the signal broke down, with other modes of variability dominating the upper-level velocity potential anomaly pattern.

More recently, a strong anomaly couplet was observed, with negative (positive) anomalies over the West Pacific (East Pacific and Western Hemisphere).

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

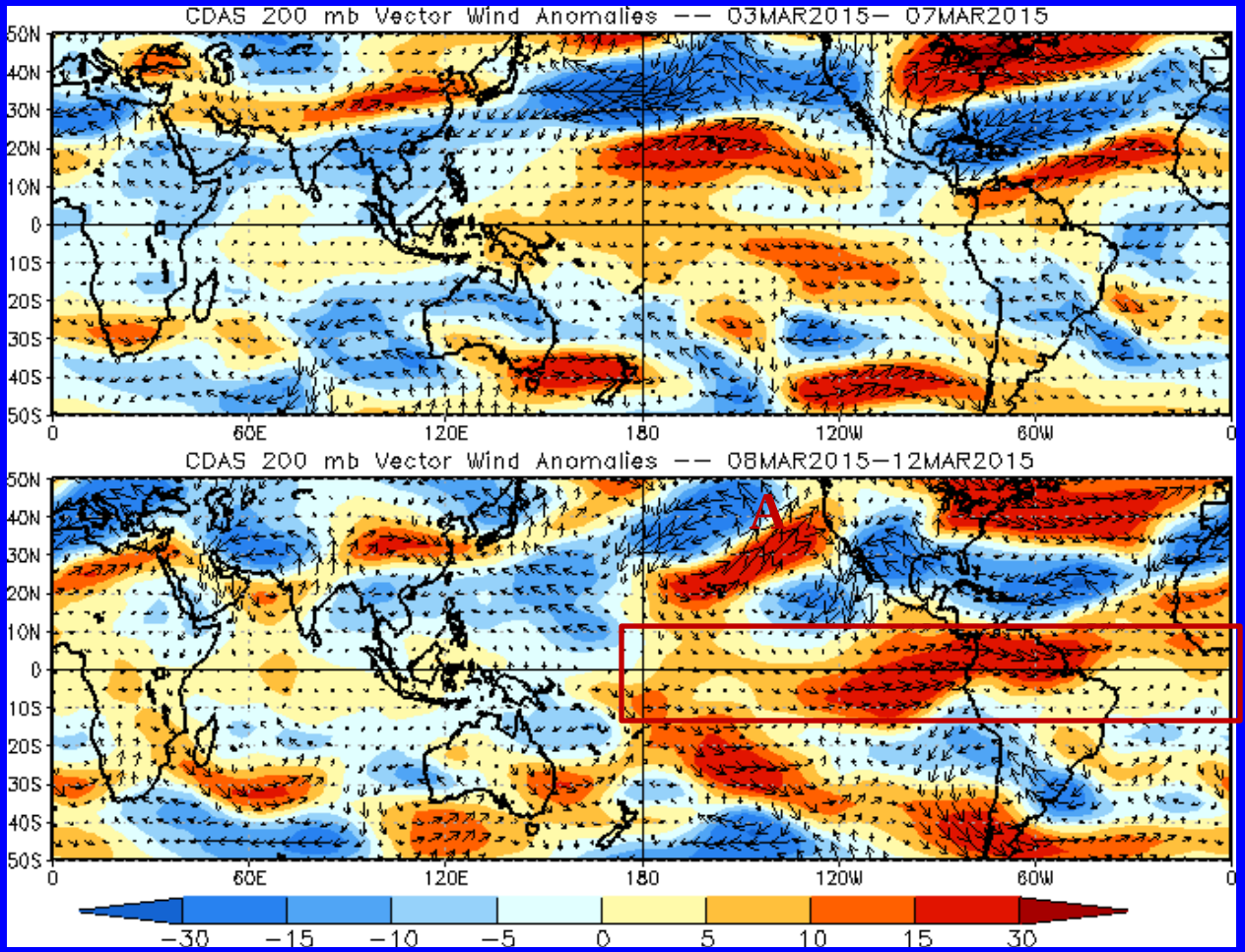
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The spatial pattern currently exhibits a strong wave-1 pattern, with anomalous upper-level convergence centered over the Indian Ocean and divergence over the Western Hemisphere.

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



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

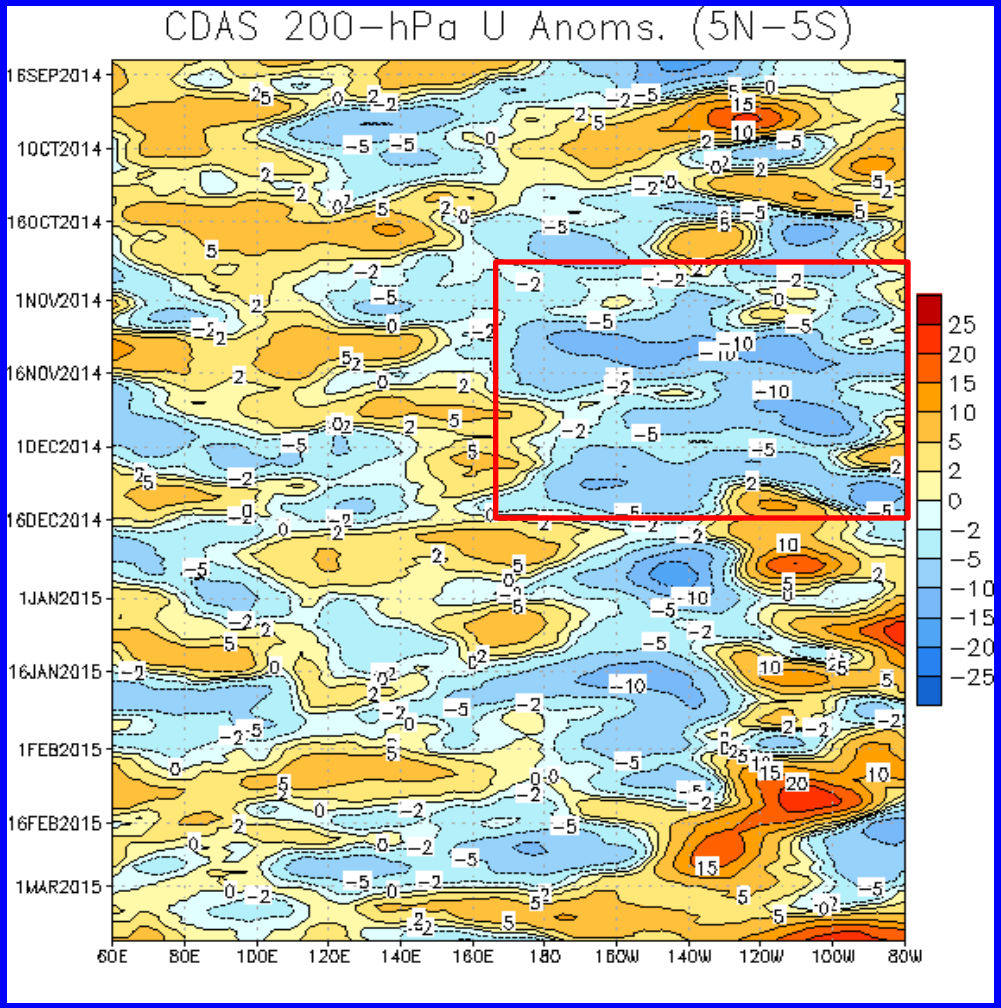
Red shades: Westerly anomalies

Generally westerly anomalies were observed across the Western Hemisphere during the recent period.

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



Time

Longitude

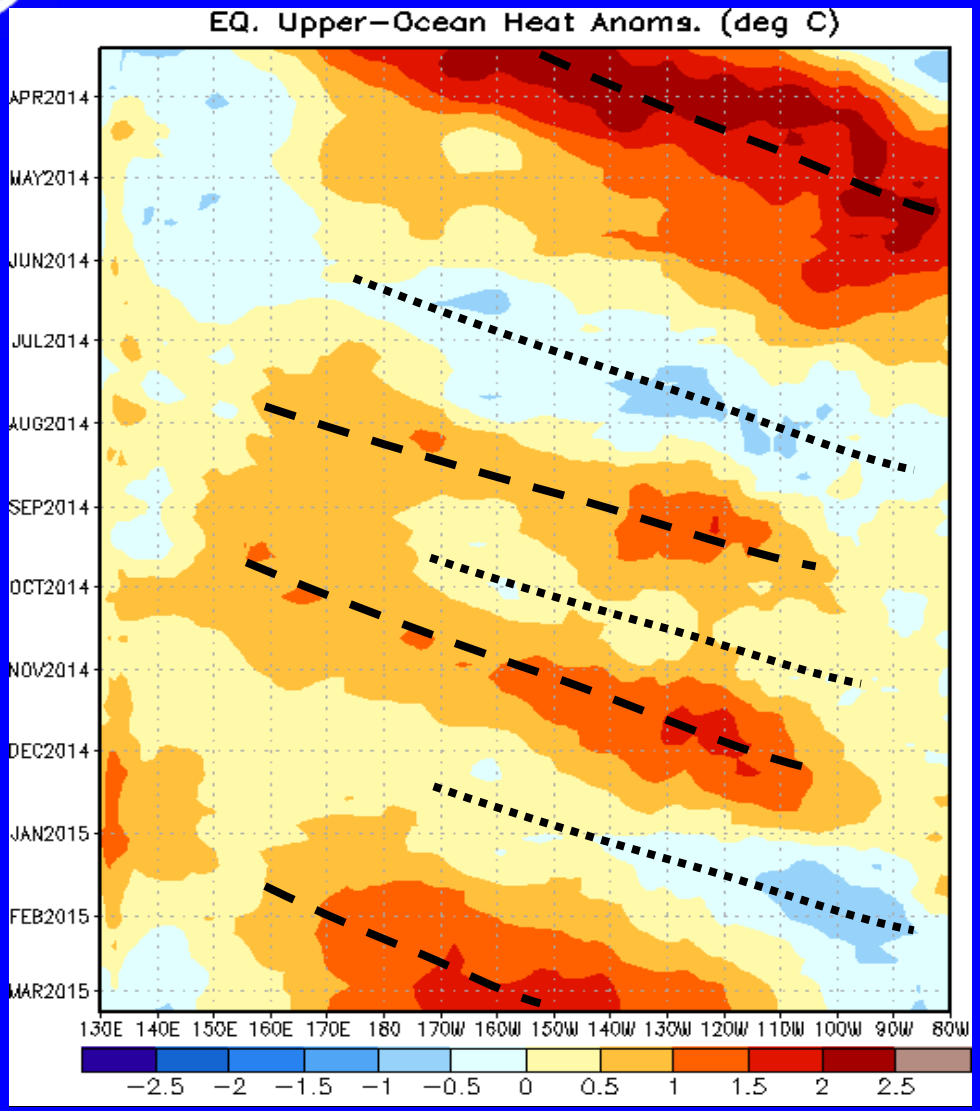
Westward propagating features are noticeable during September and early October over the eastern Pacific.

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.

More recently, westward propagation of westerly anomalies was evident over the eastern Pacific during late February, with westerly anomalies developing over much of the Pacific during early March. Some eastward propagation is evident of late.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

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 KW are evident over 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).

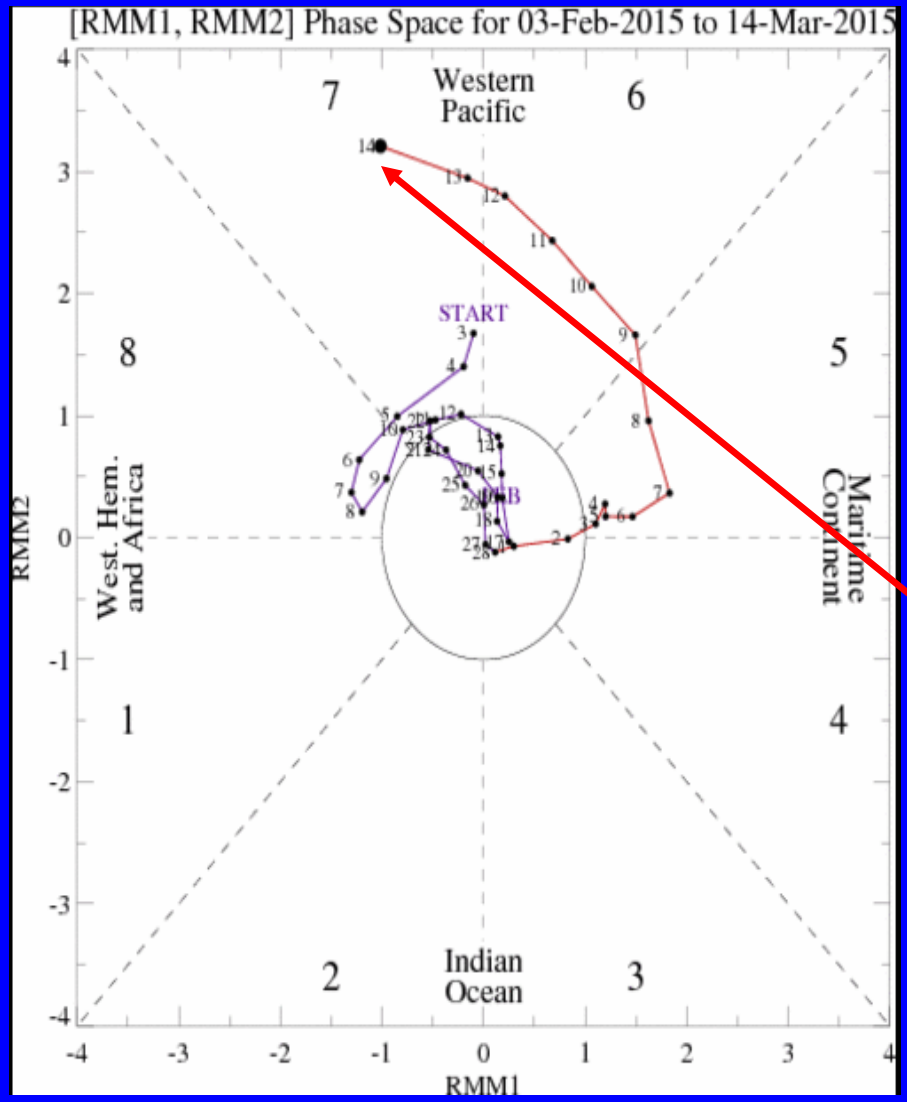
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- 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).

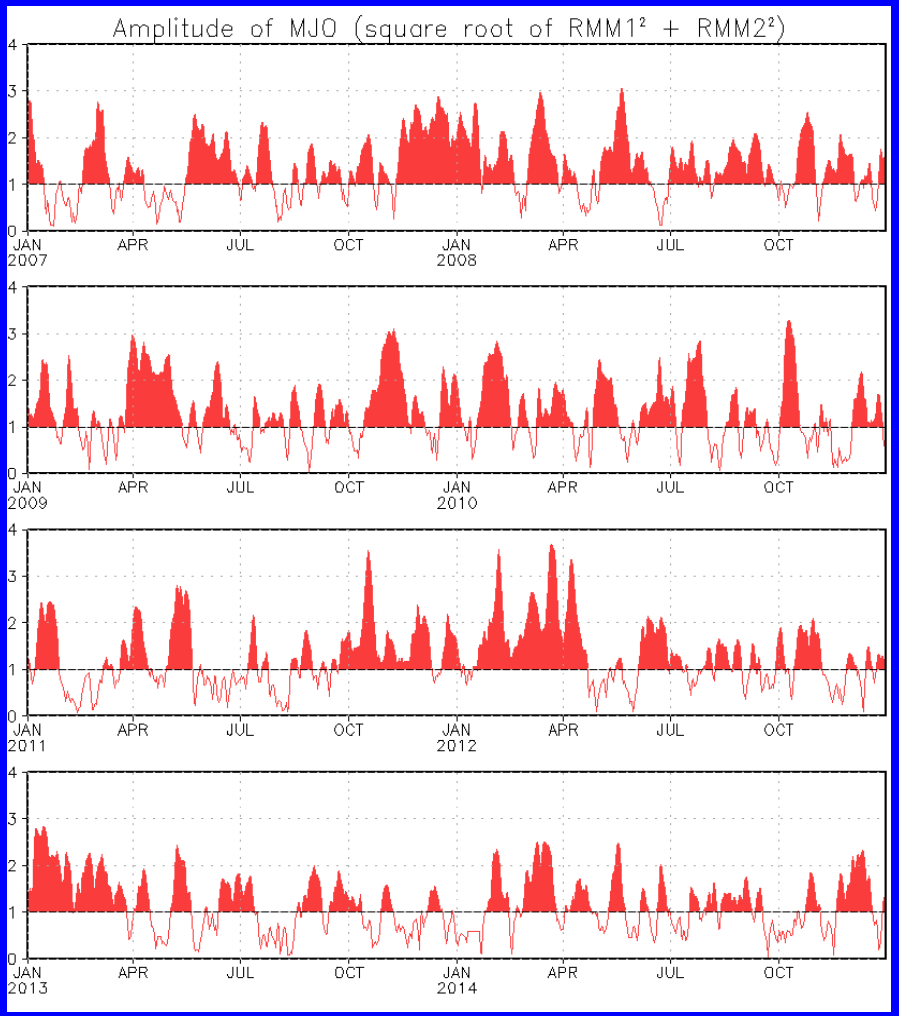
MJO Index -- Recent Evolution



- 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 RMM MJO index indicated rapid propagation across the western Pacific over the past week.

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.

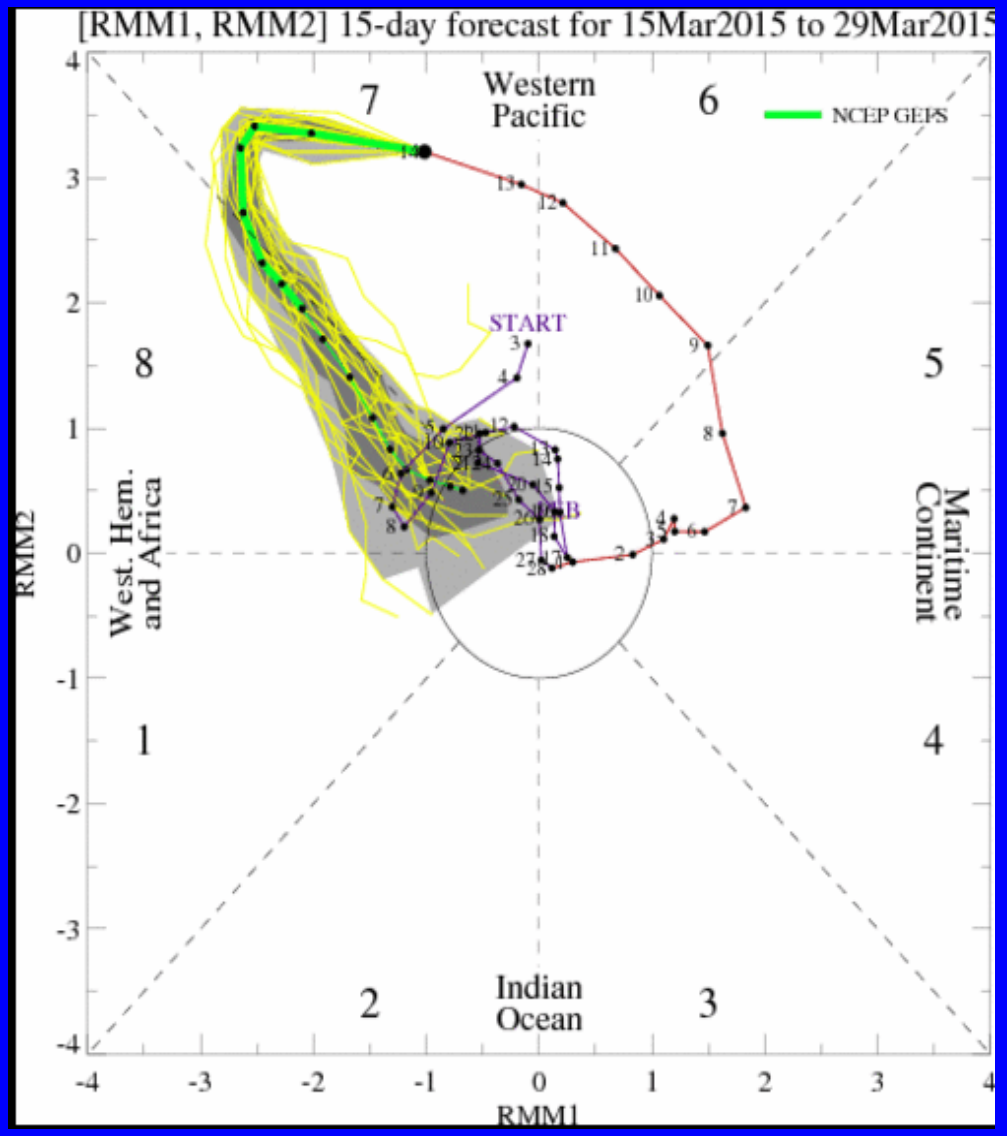
Ensemble GFS (GEFS) MJO Forecast

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

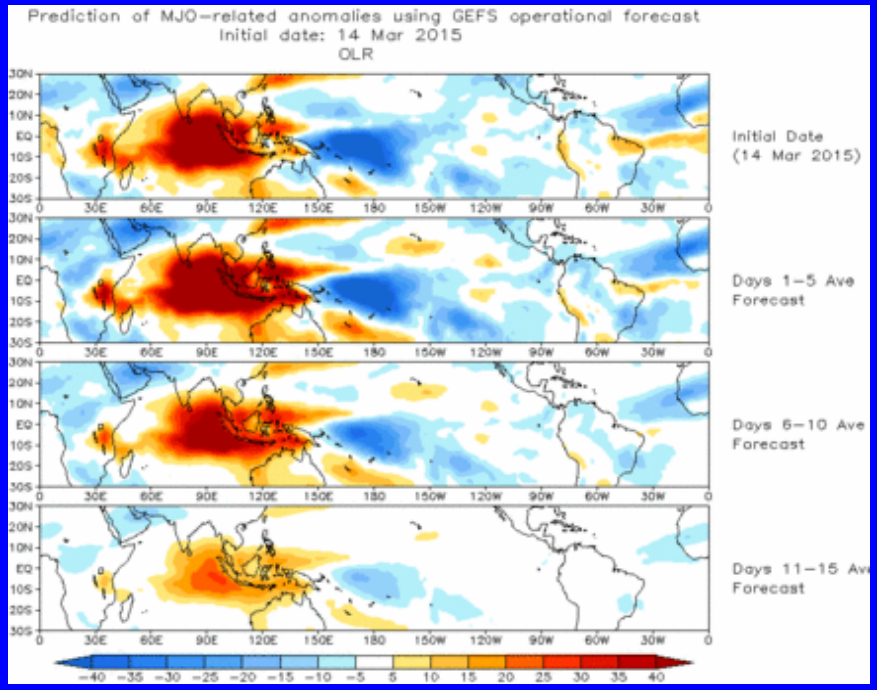
The GFS ensemble RMM Index forecasts depict little eastward propagation of a deamplifying MJO signal during the next two weeks.



Ensemble Mean GFS MJO Forecast

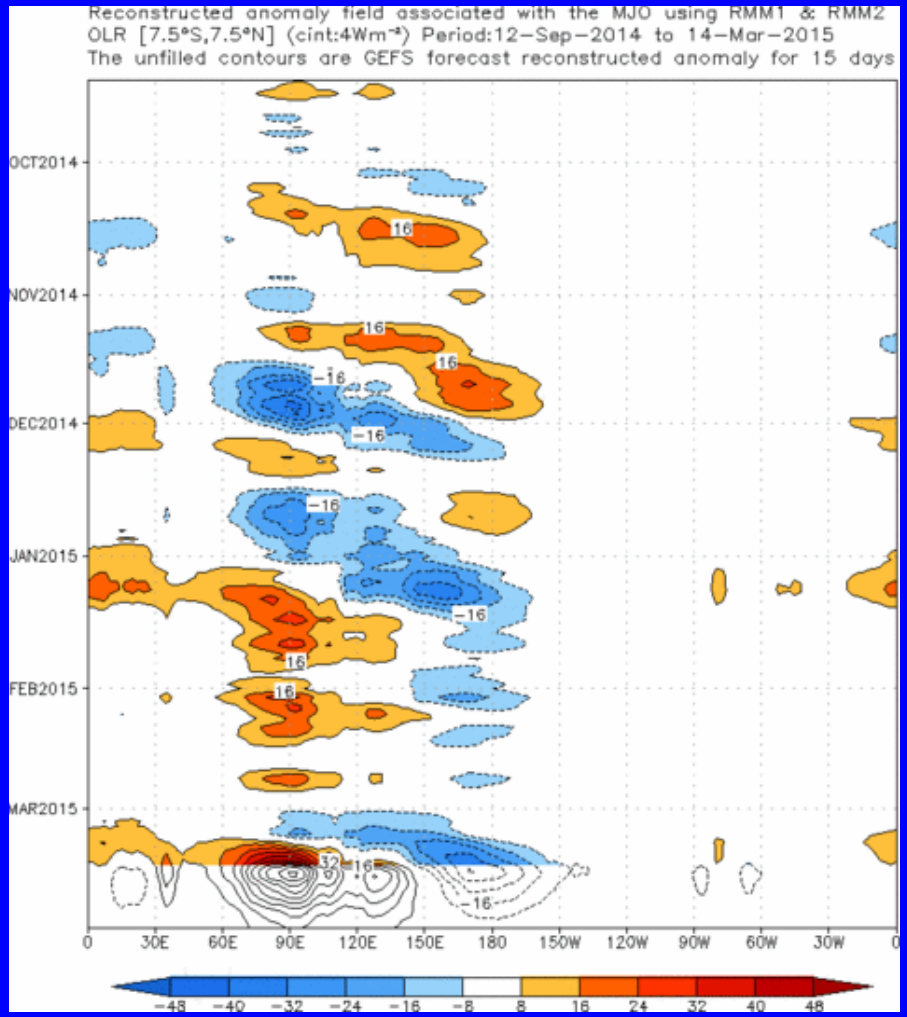
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The GEFS RMM Index based OLR anomalies forecast depicts a gradually weakening anomaly pattern over the next two weeks, with little eastward propagation.

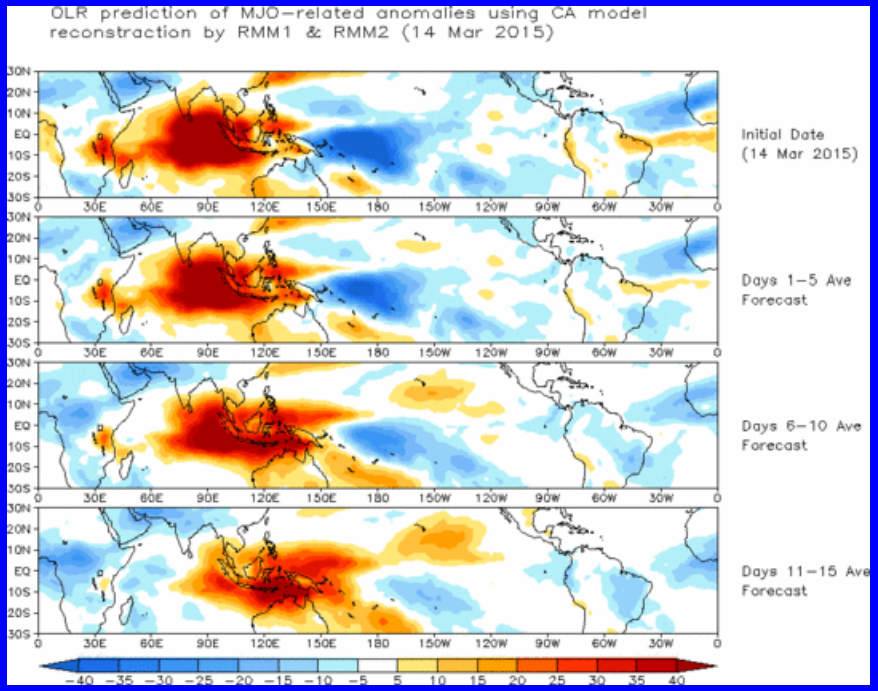
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

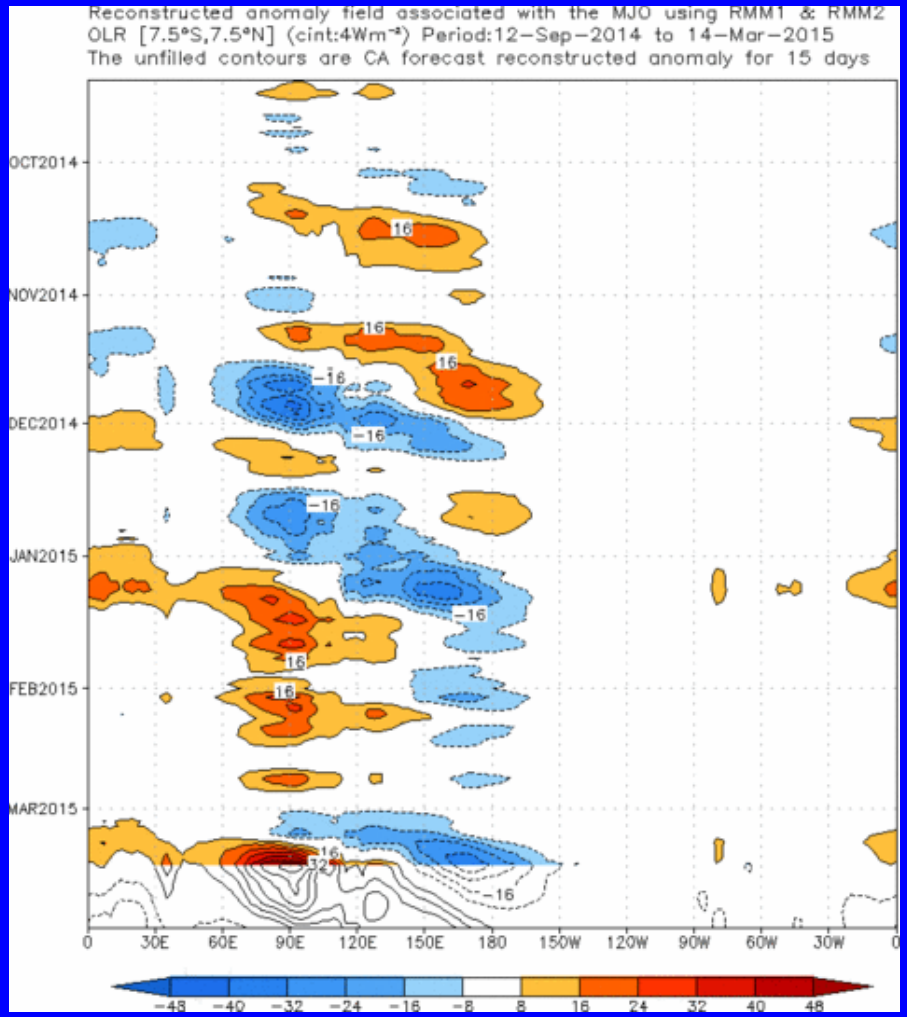
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



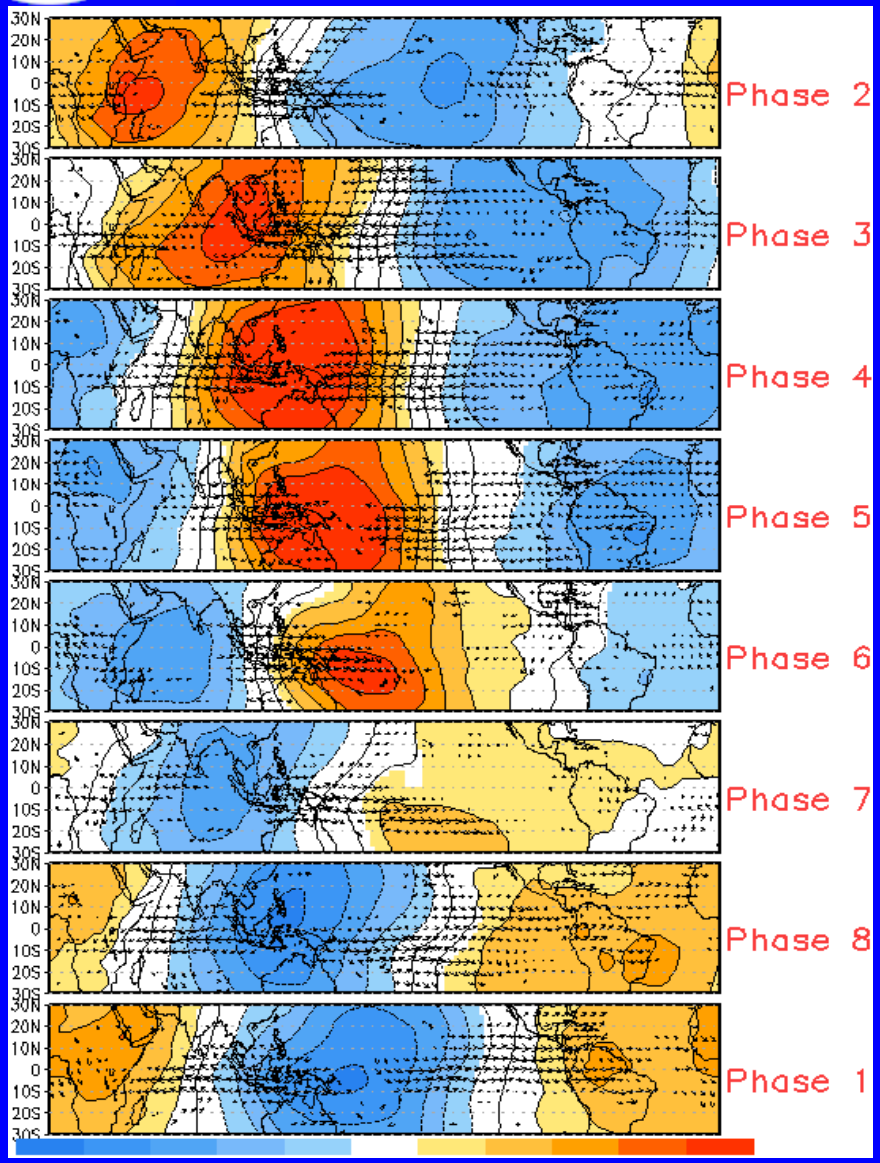
The statistical forecast depicts eastward propagation of a robust MJO signal over the next two weeks.

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

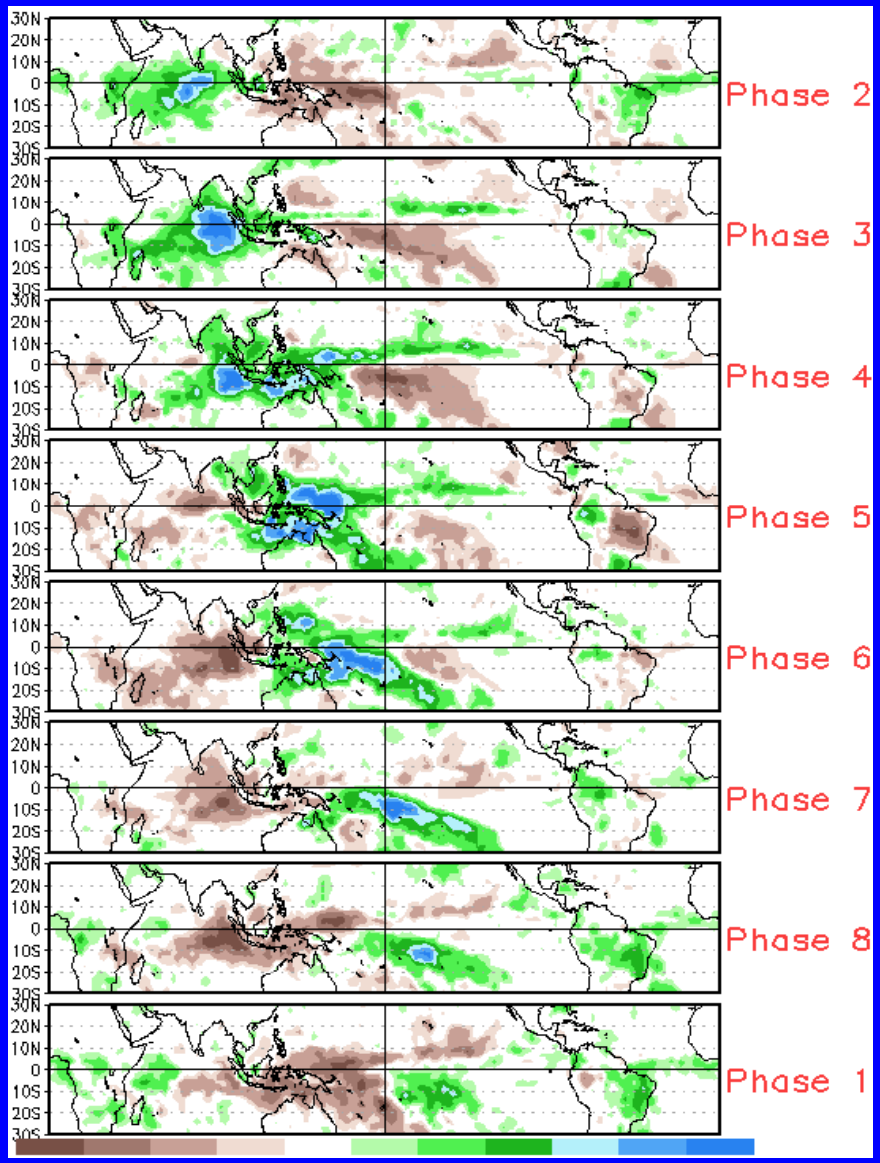


MJO Composites – Global Tropics

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

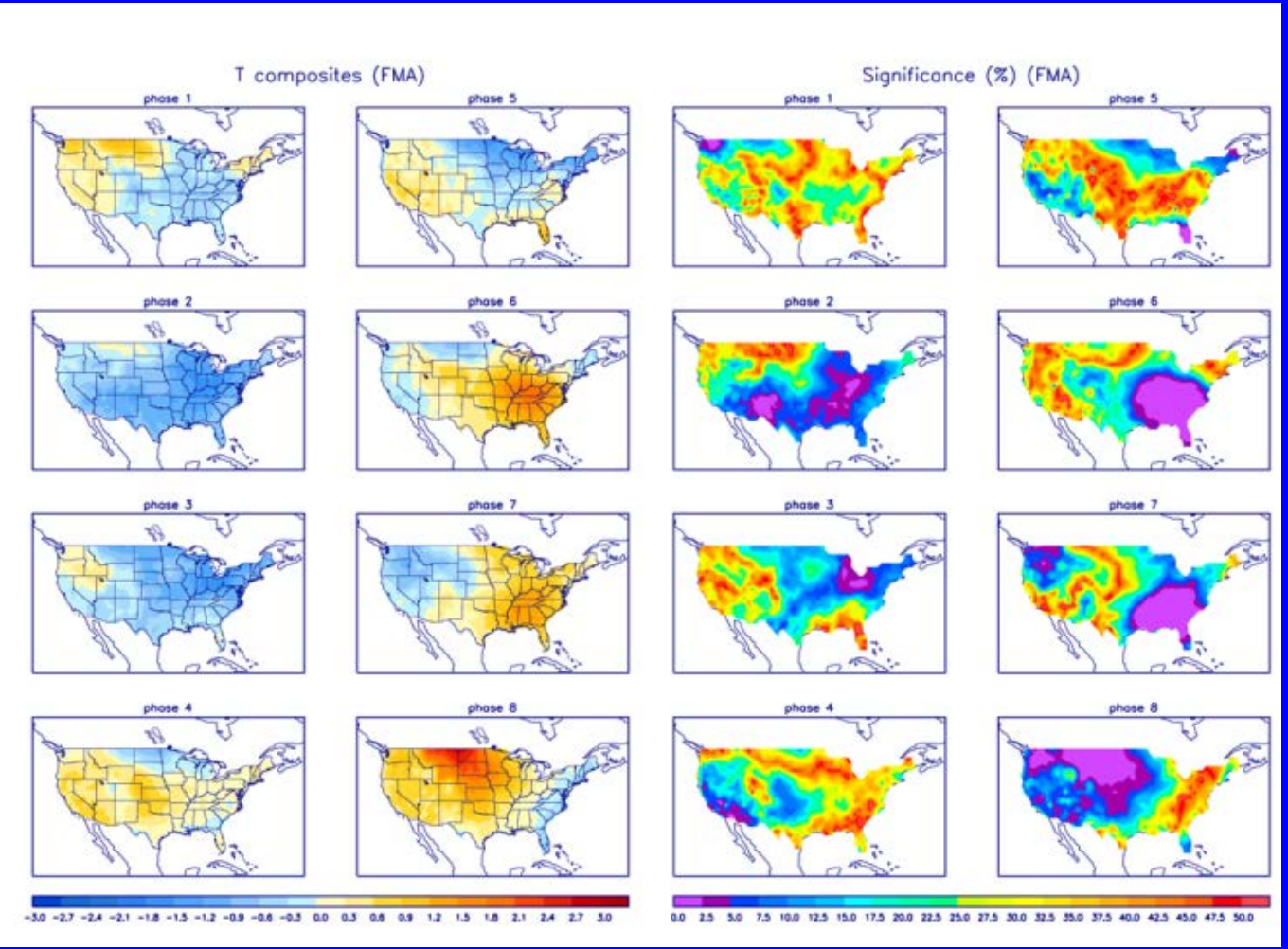


Precipitation Anomalies (Nov-Mar)



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.**

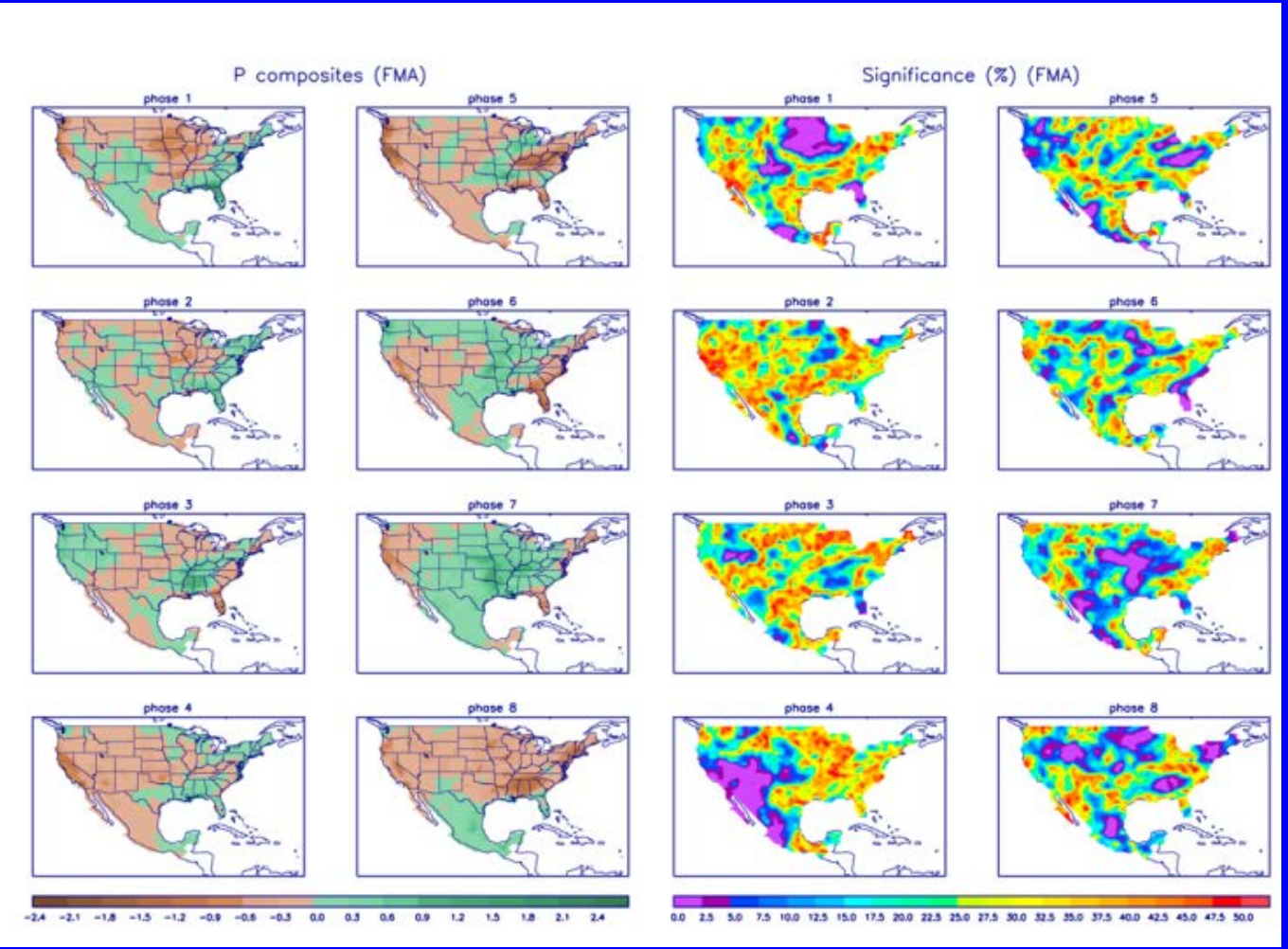


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml