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

Update prepared by
Climate Prediction Center / NCEP
March 9, 2015

Outline

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

Overview

- Recent observations and MJO indices depict an increasingly coherent signal, with the enhanced phase currently over the eastern Maritime Continent.

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

- The dynamical forecast models indicate a remarkable strengthening of the MJO signal during the upcoming two weeks, with the enhanced phase propagating over the western Pacific. Statistical models also favor a robust MJO event.

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

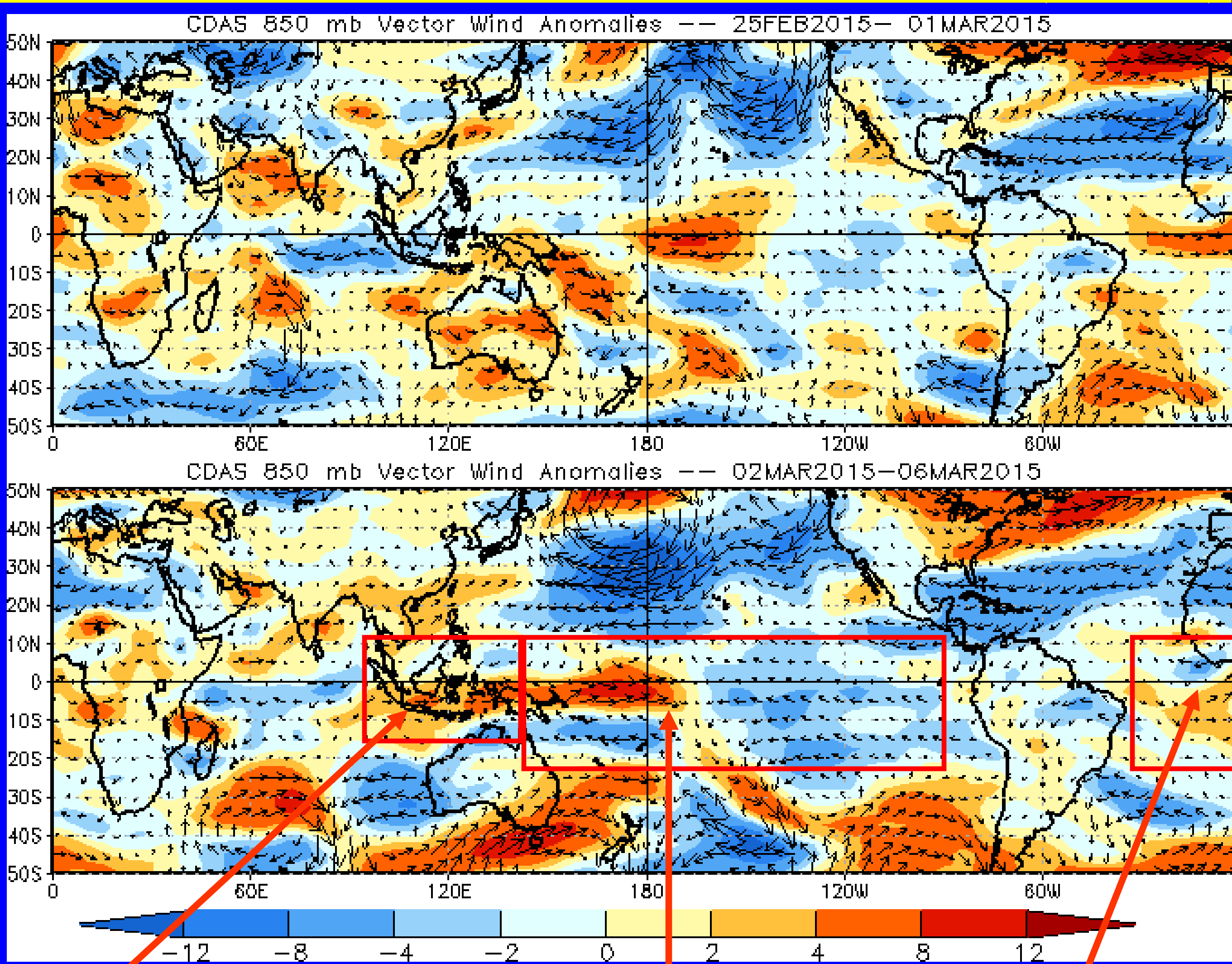
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies developed across most of the Maritime Continent.

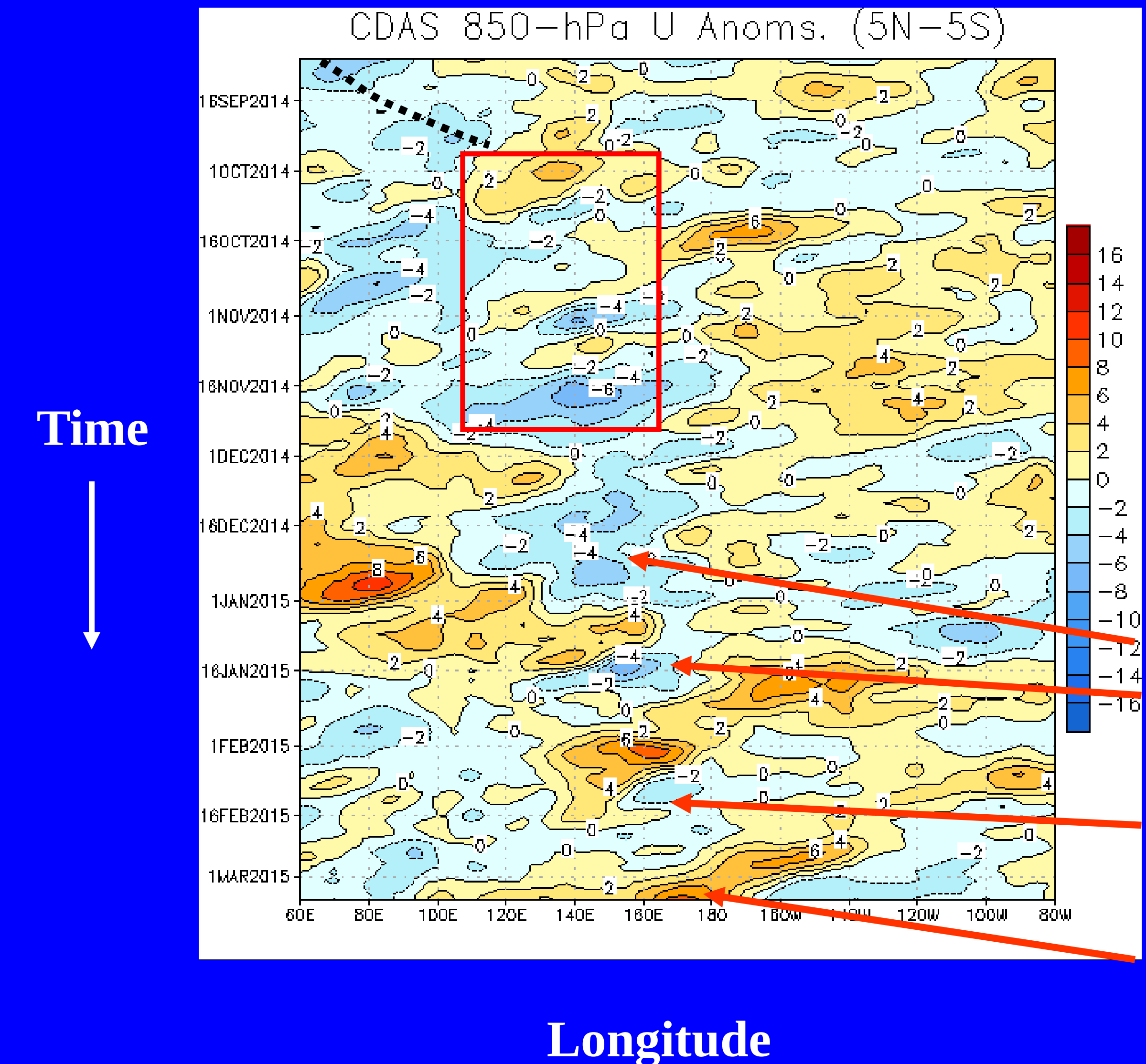
A couplet of westerly and easterly anomalies along the equator propagated westward across the central Pacific.

Westerly anomalies weakened over the equatorial eastern Atlantic.

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



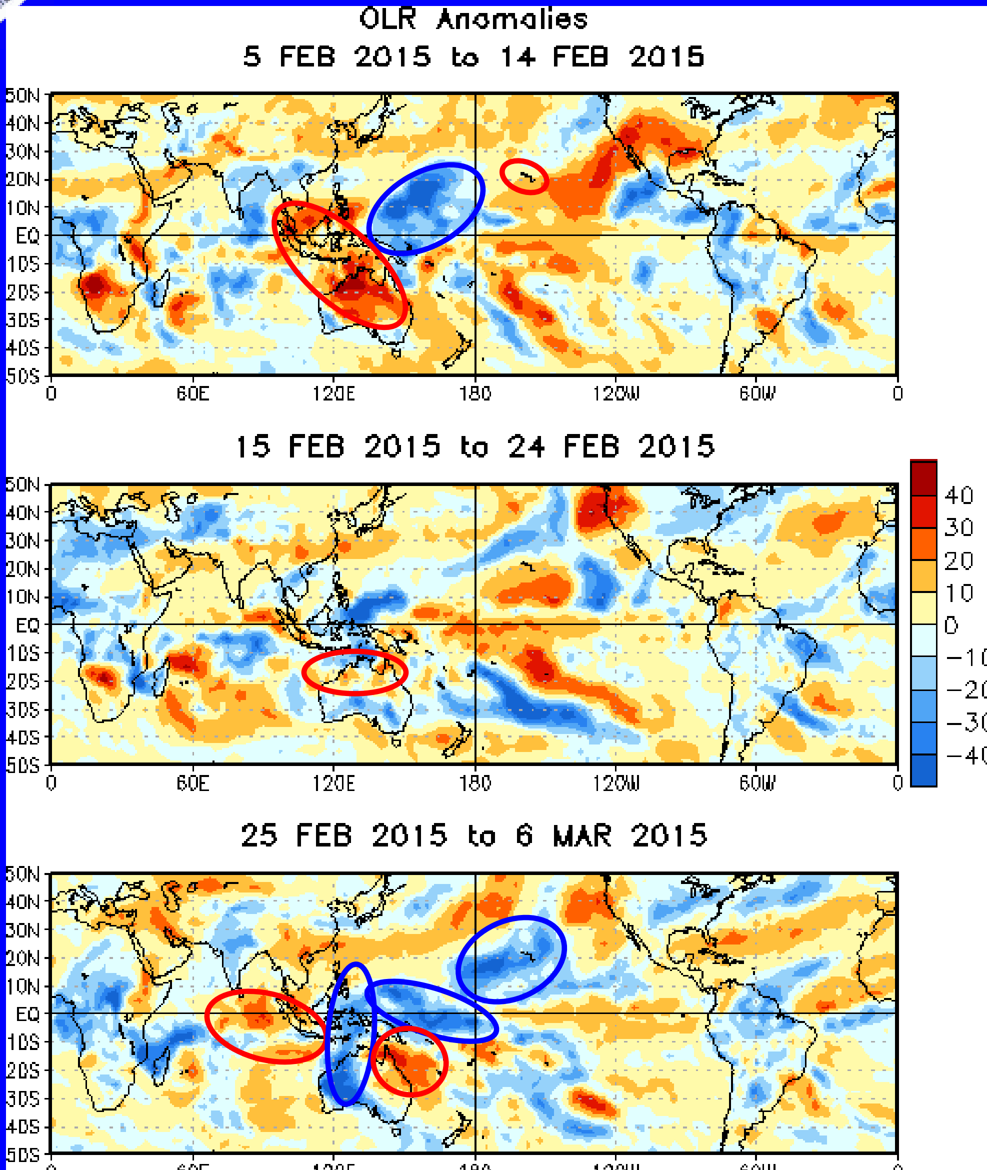
In early September, westerly (easterly) anomalies increased over the eastern (western) Pacific in associated with renewed MJO activity.

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.

OLR Anomalies – Past 30 days



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

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

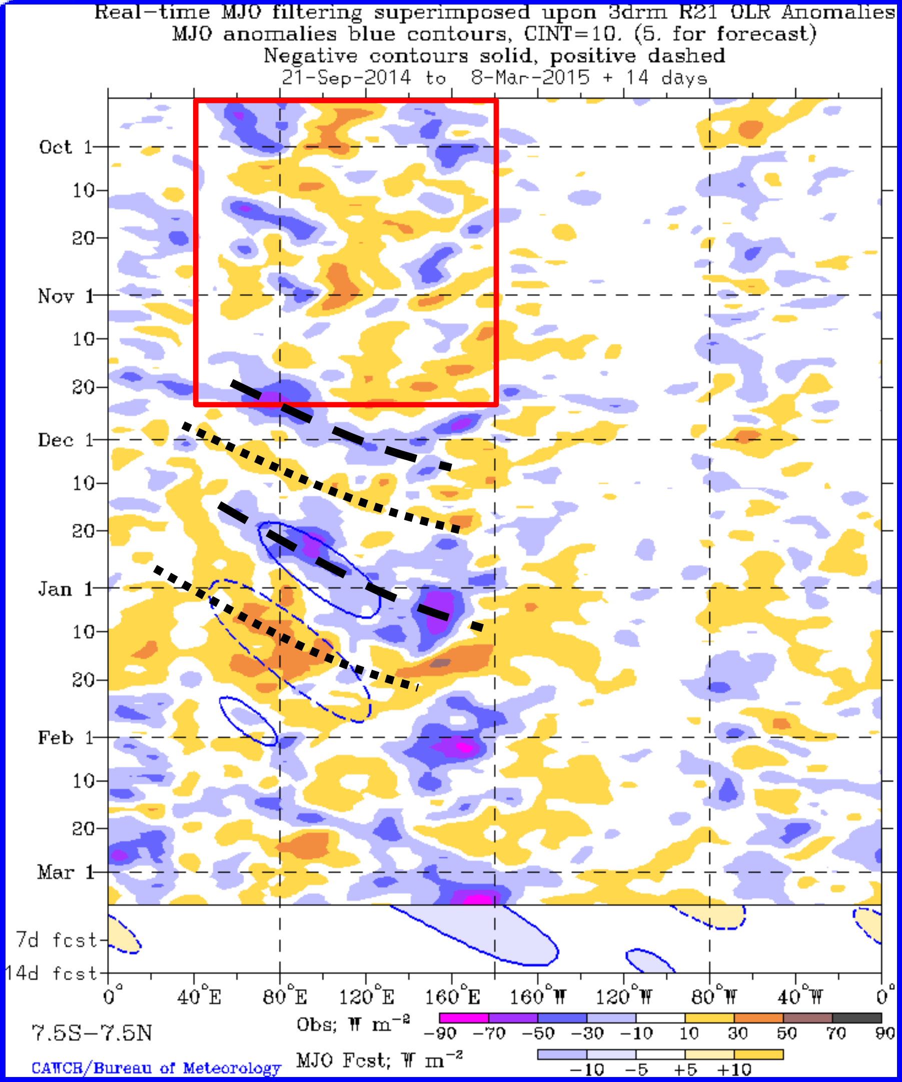
During early February, enhanced (suppressed) convection was observed over the northwestern Pacific (Maritime Continent and Hawaii).

During mid to late February, smaller-scale OLR anomalies prevailed, with weakly suppressed (enhanced) convection over northern Australia (northwestern Pacific). Generally suppressed convection persisted across the central Pacific, including Hawaii.

During late February and early March, suppressed (enhanced) convection overspread the eastern Indian Ocean (central Maritime Continent, northwest Pacific). Suppressed convection developed over the Coral Sea, while 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 became less coherent with respect to canonical MJO activity during September 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.

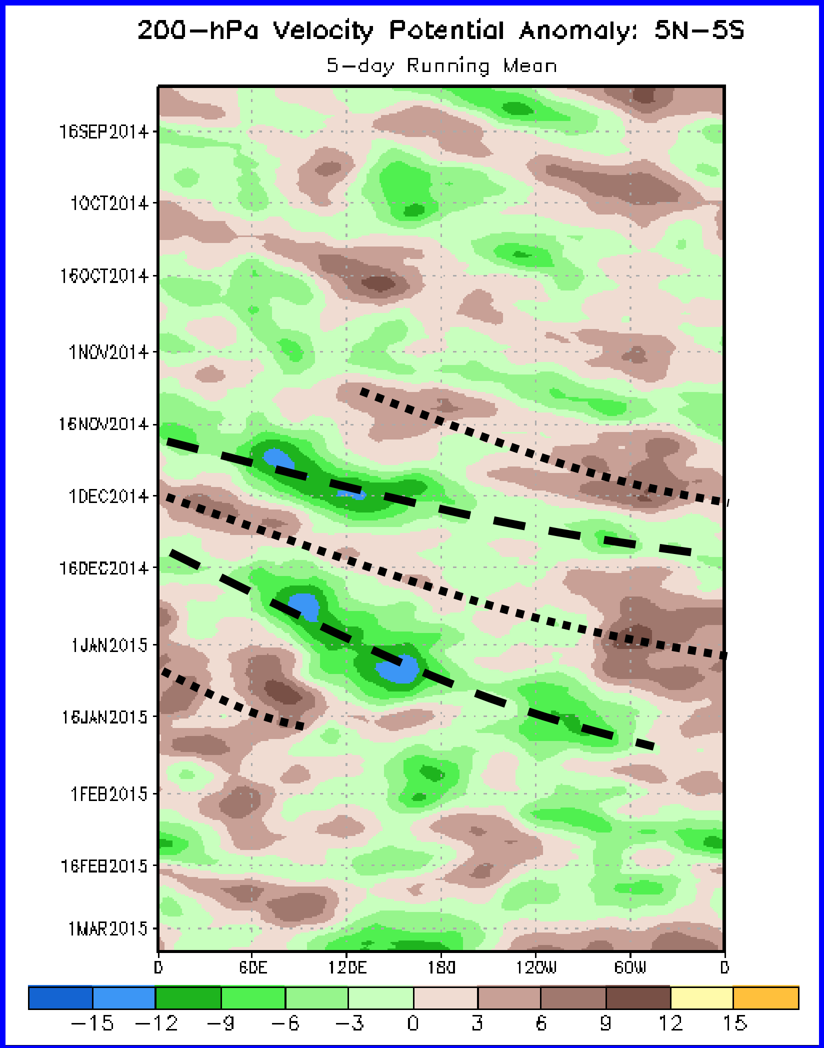
More recently, another burst of enhanced convection was observed near and just west of the Date Line.

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

Time



Longitude

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.

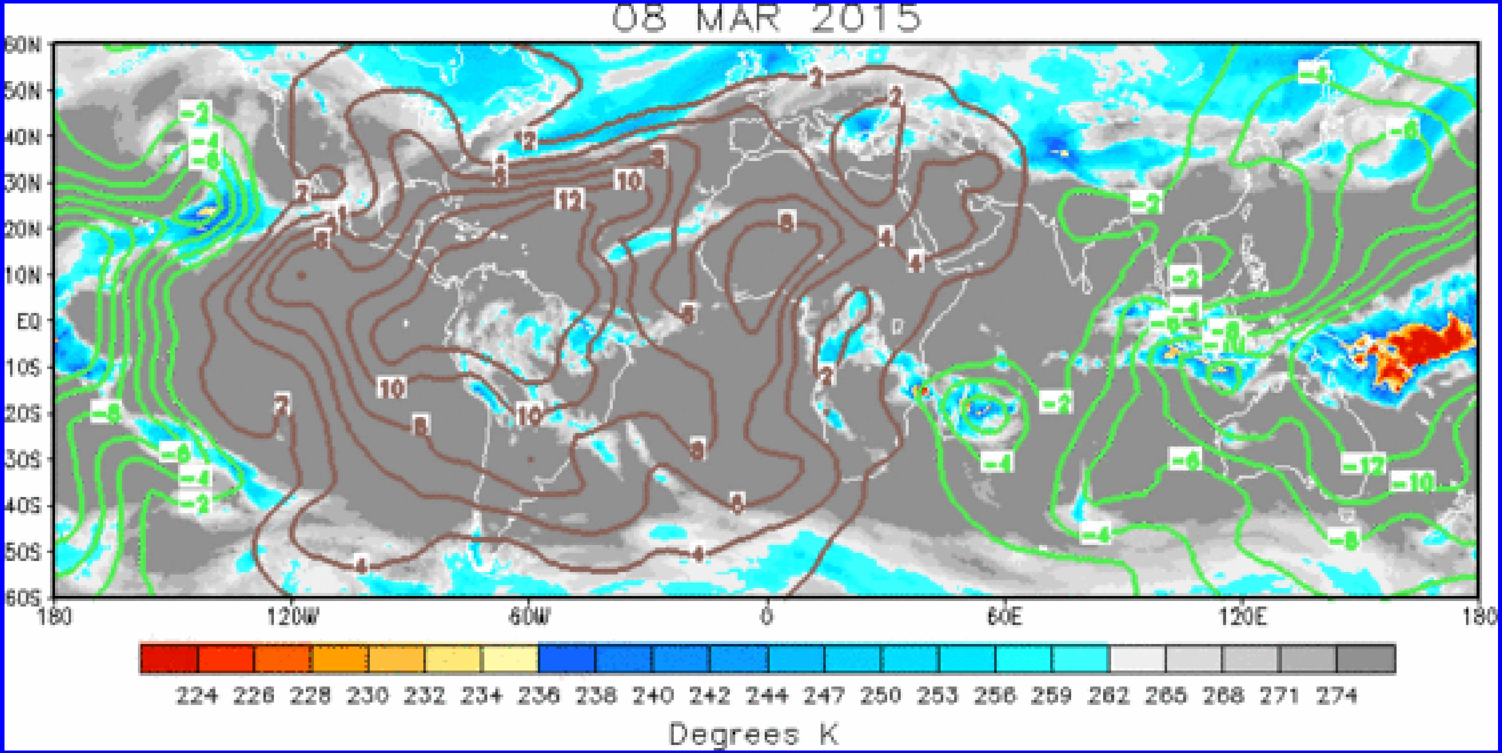
Beginning in mid-January, the signal broke down, with other modes of variability dominating the upper-level velocity potential anomaly pattern.

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



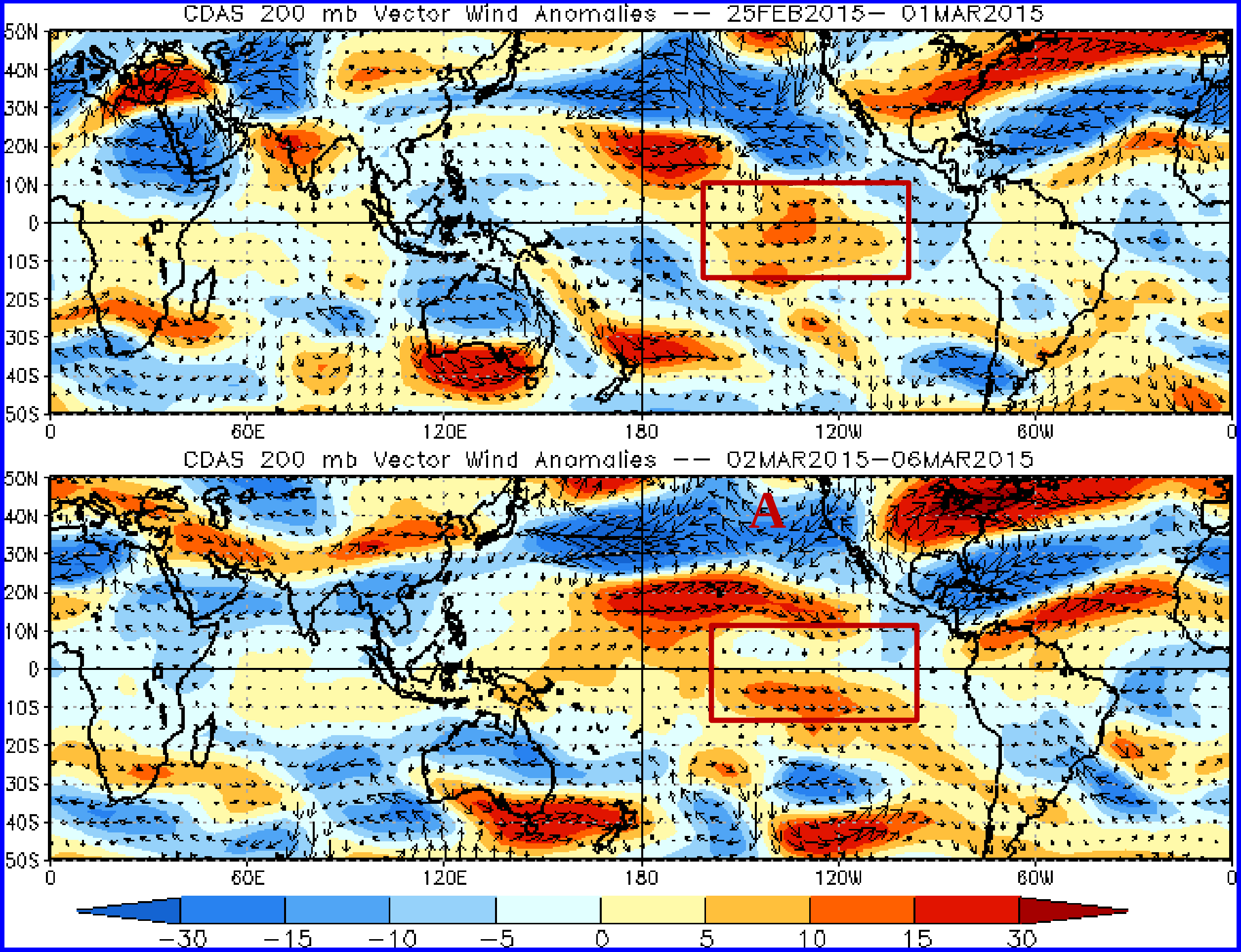
The spatial pattern has become much more coherent with respect to the MJO, with negative (positive) anomalies associated with enhanced (suppressed) convection over the eastern Maritime Continent and West Pacific (East Pacific and Western Hemisphere).

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



An Upper-level anticyclone shifted west to the northeast Pacific over the middle latitudes during late February.

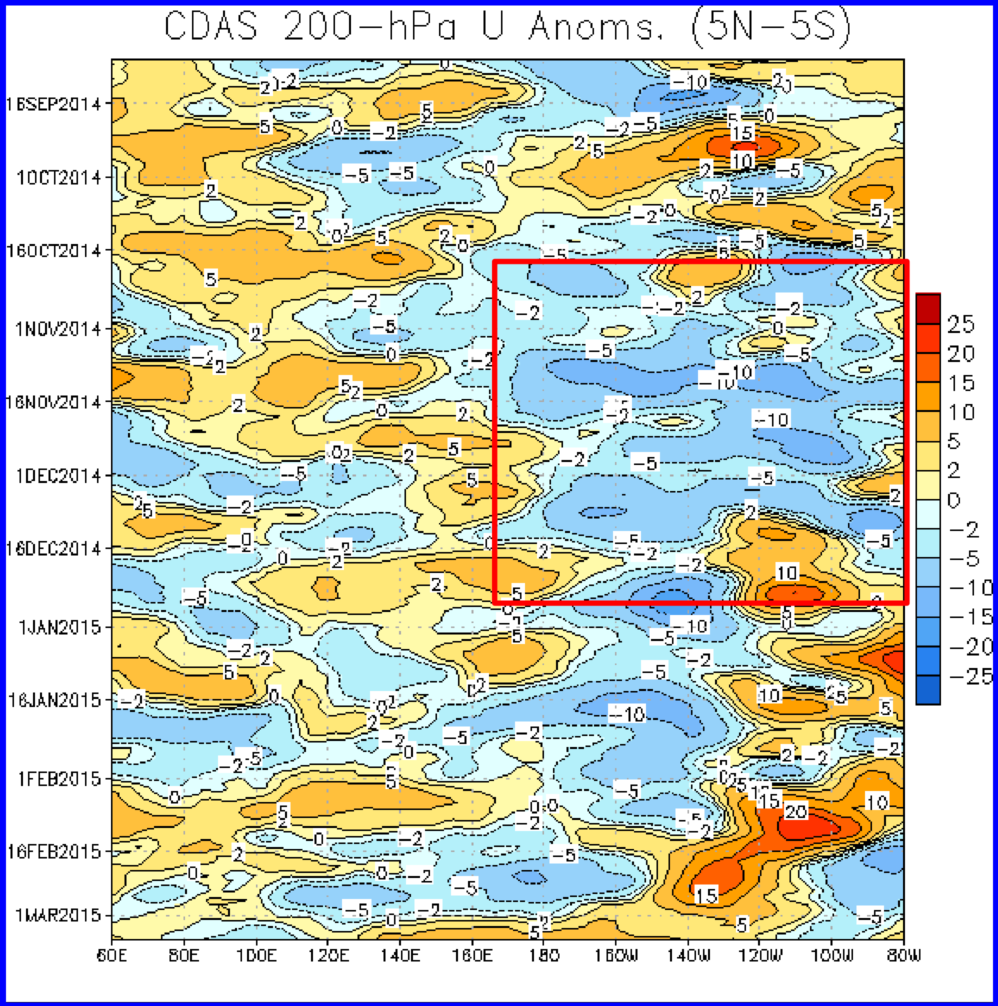
Generally westerly anomalies were observed across the Pacific during the recent period.

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

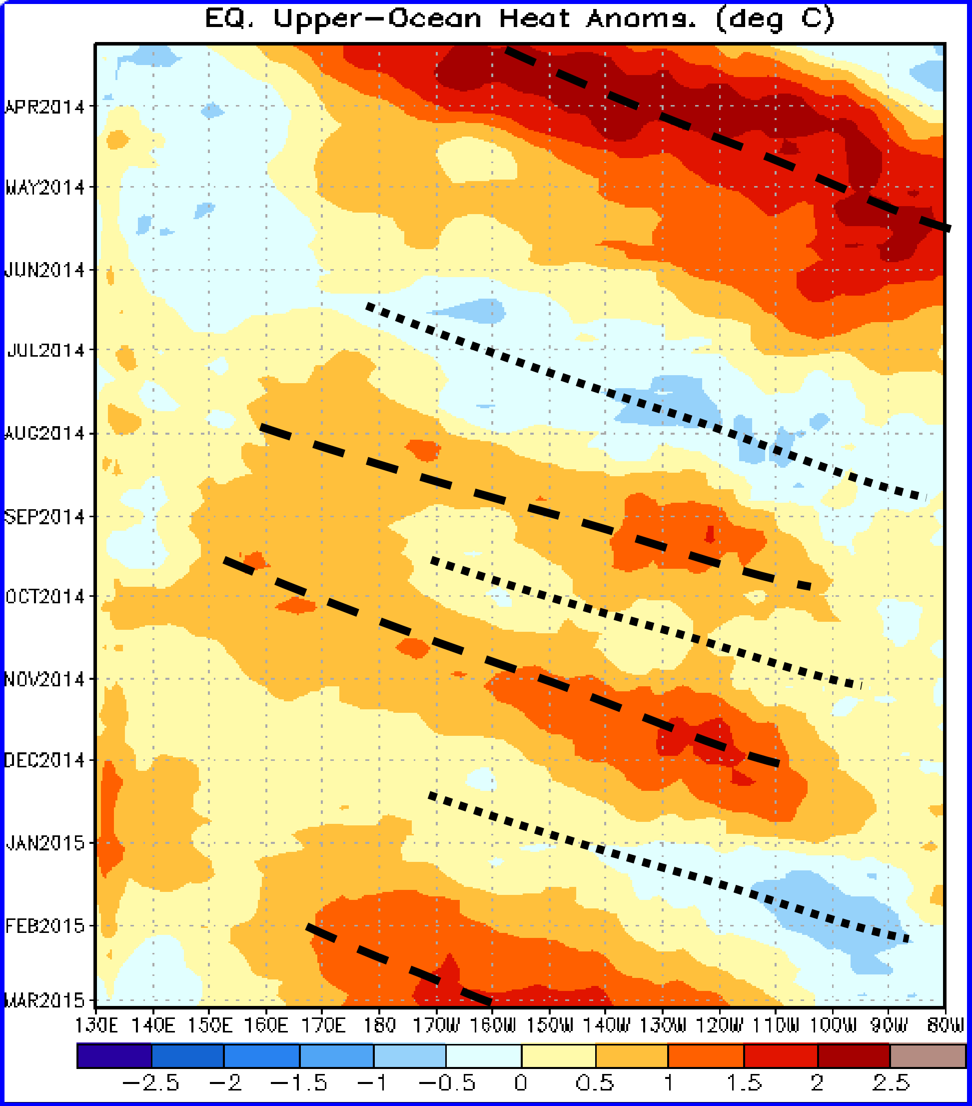
Westward propagating features are noticeable during September and early October over the eastern Pacific.

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.

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).

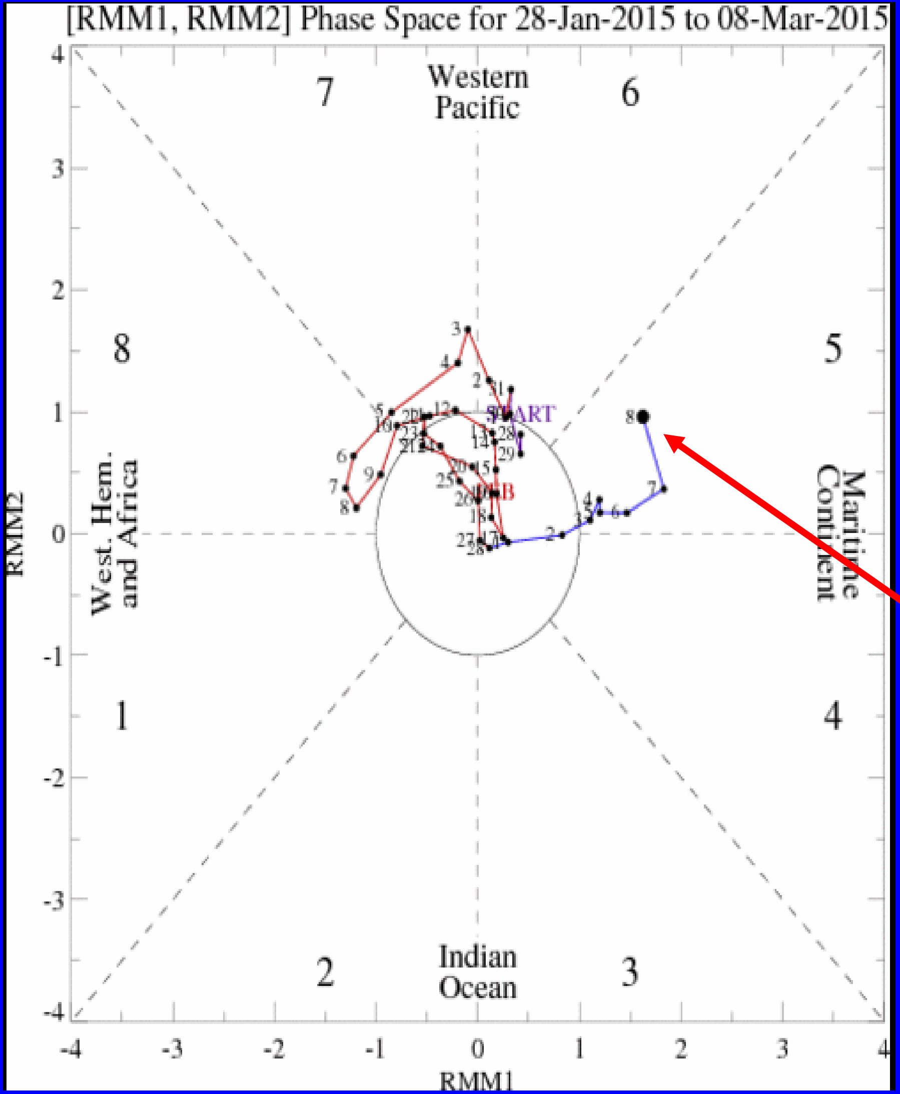
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

• 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).

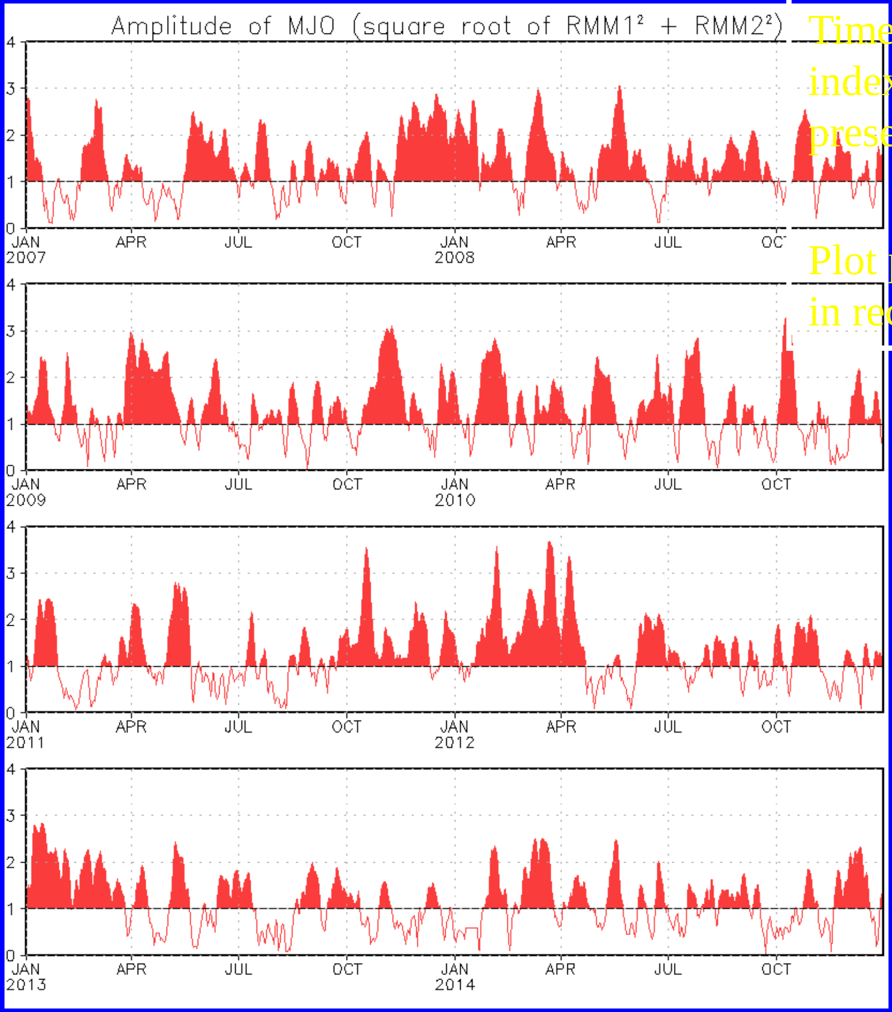
MJO Index -- Recent Evolution



- 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 increased in amplitude over the eastern Maritime Continent during the past week.

MJO Index – Historical Daily Time Series



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

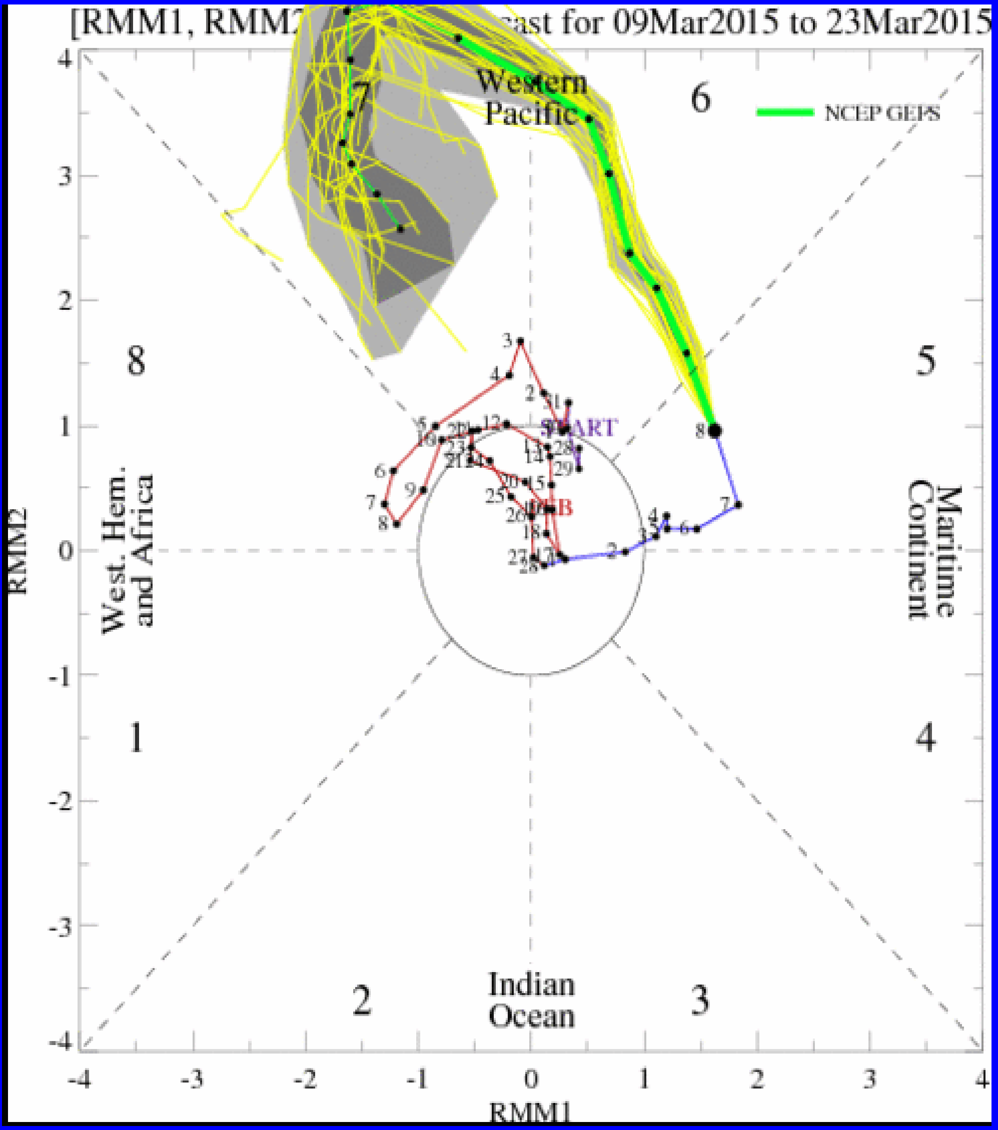
Plot puts current MJO activity in recent historical context.

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

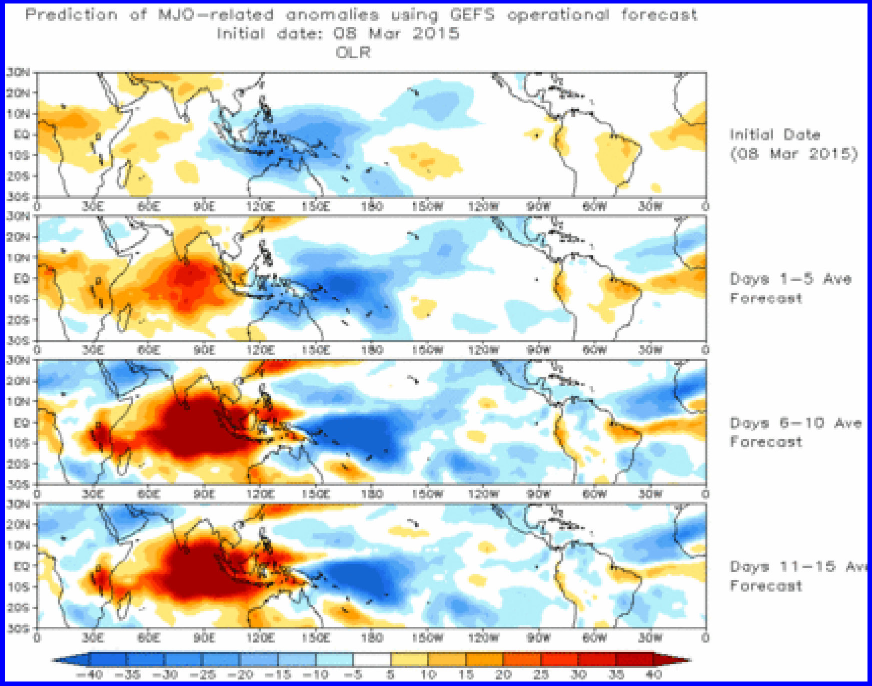


The GFS ensemble RMM Index forecasts depict eastward propagation of a strongly amplifying MJO signal during the next two weeks, with the index shifting from the eastward Maritime Continent to the west-central Pacific.

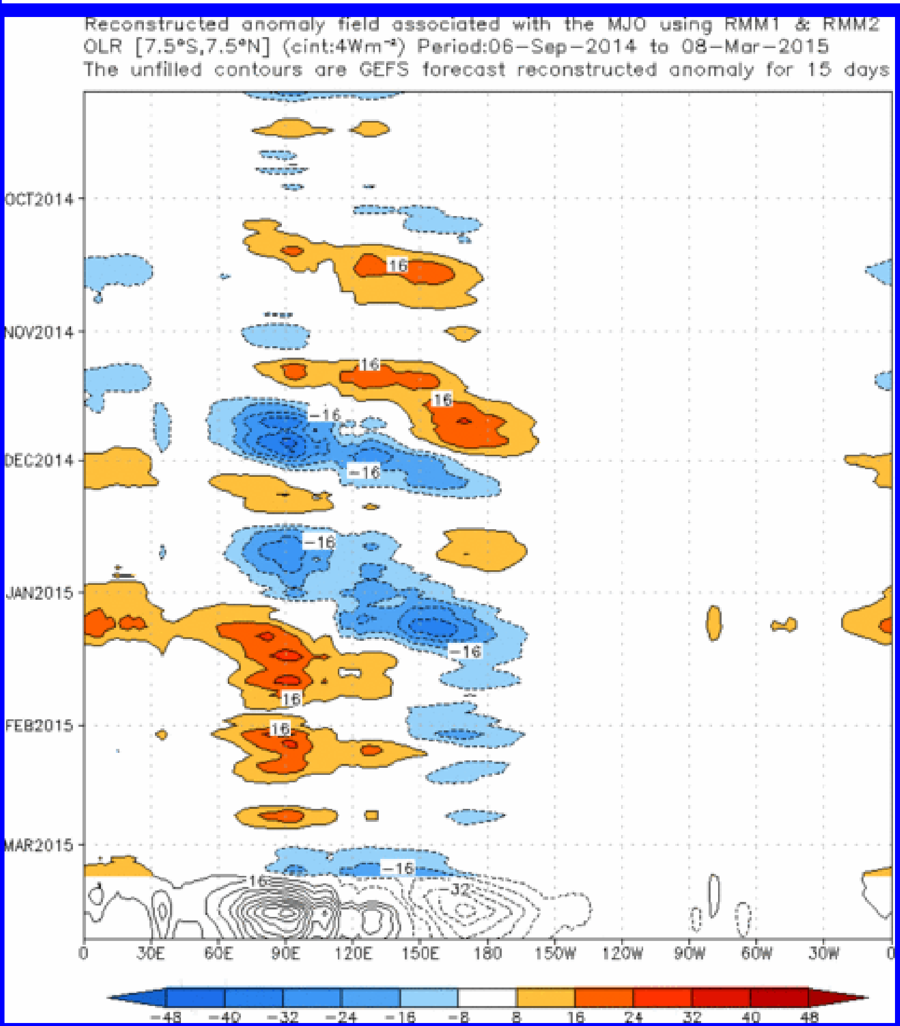
Ensemble Mean GFS MJO Forecast

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

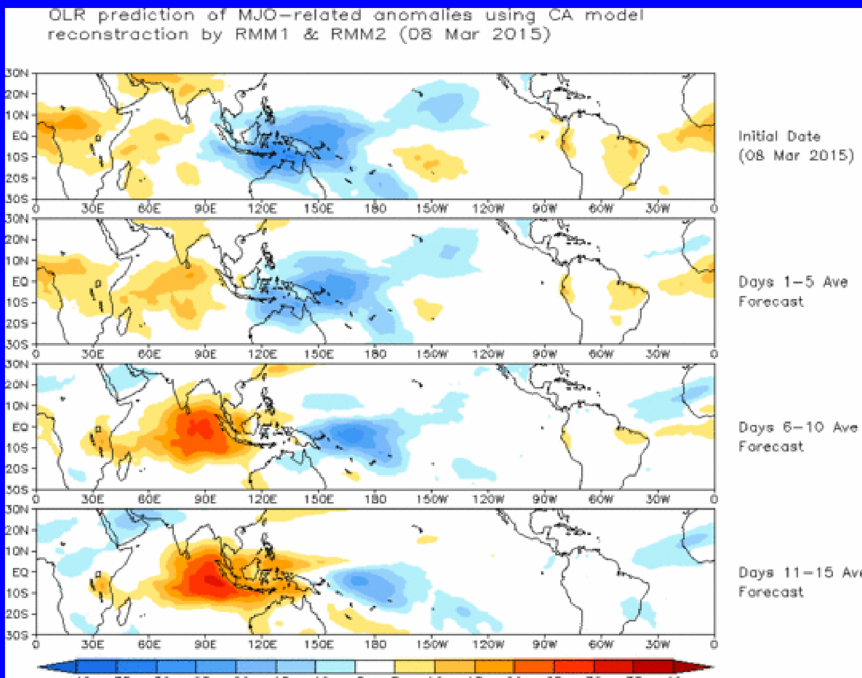


The GEFS RMM Index based OLR anomalies forecast depicts increasing anomaly patterns consistent with a West Pacific MJO event, including enhanced (suppressed) convection over the southwestern Pacific (Indian Ocean and western Maritime Continent).

Constructed Analog (CA) MJO Forecast

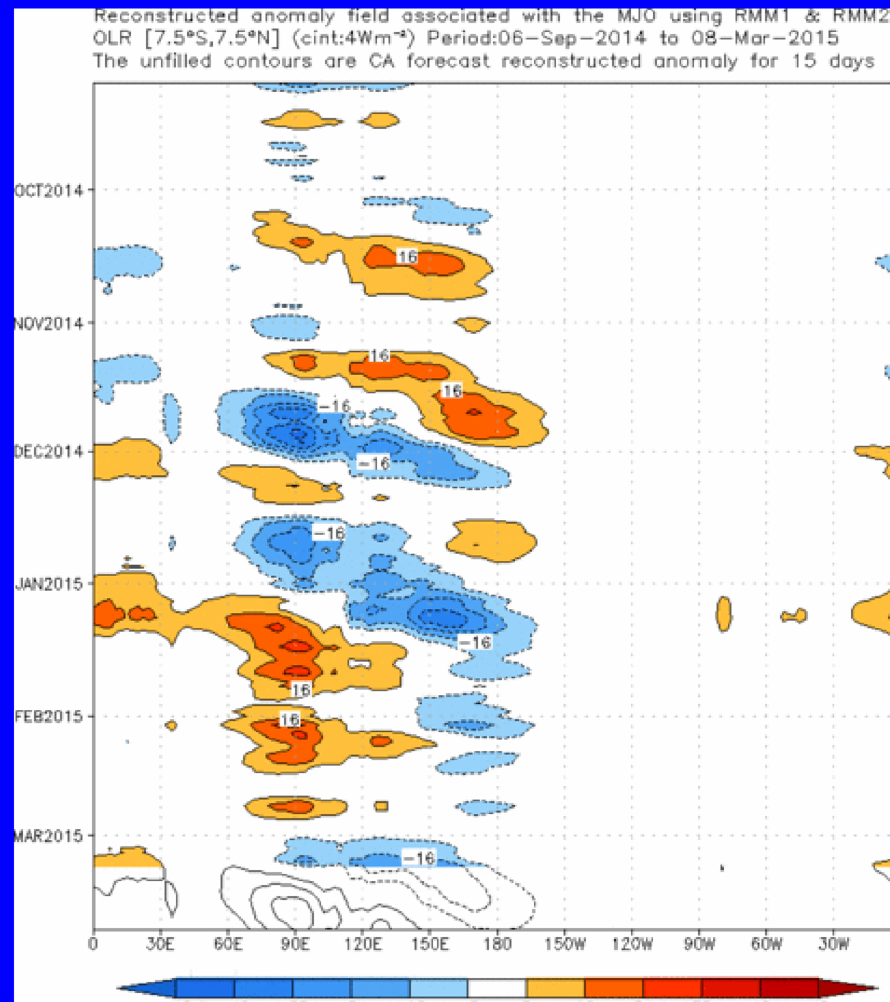
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



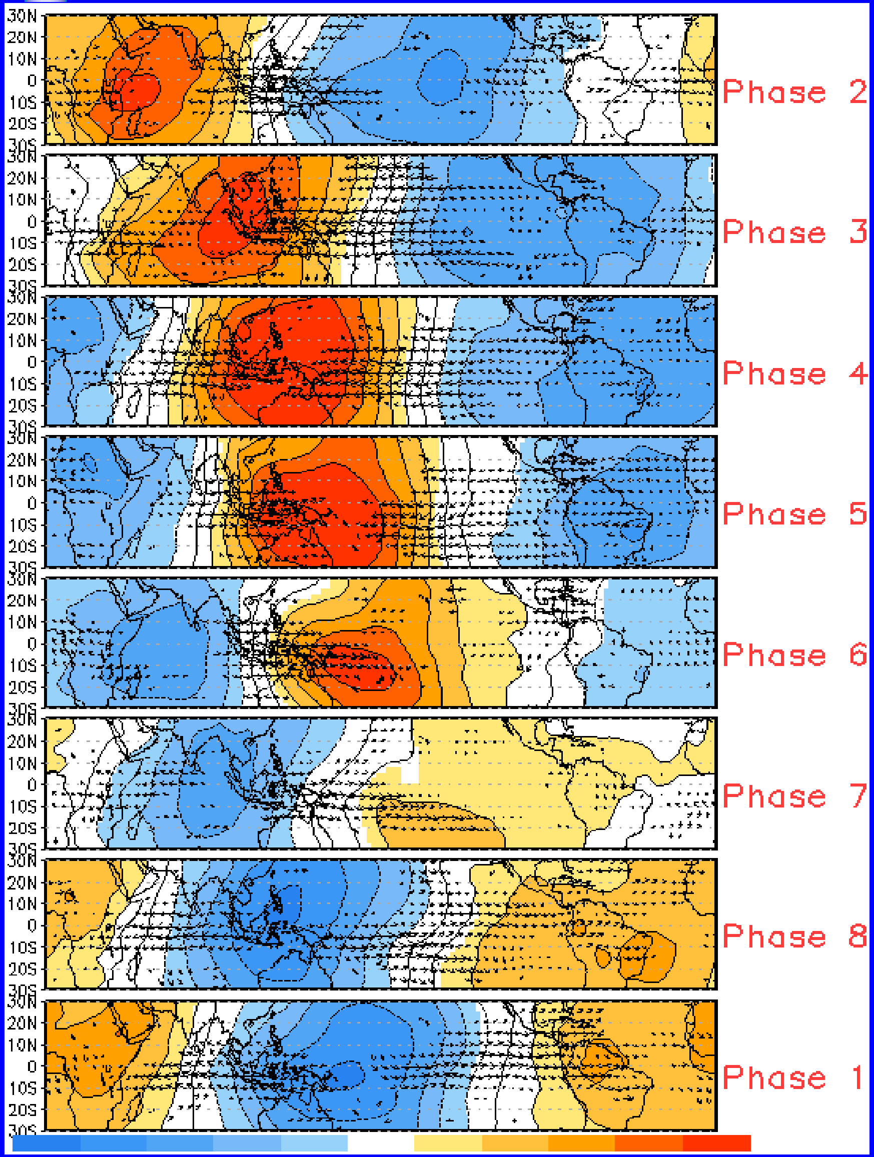
The statistical forecast depicts eastward propagation of a robust MJO signal from the Maritime Continent to the western Pacific during the next two weeks.

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

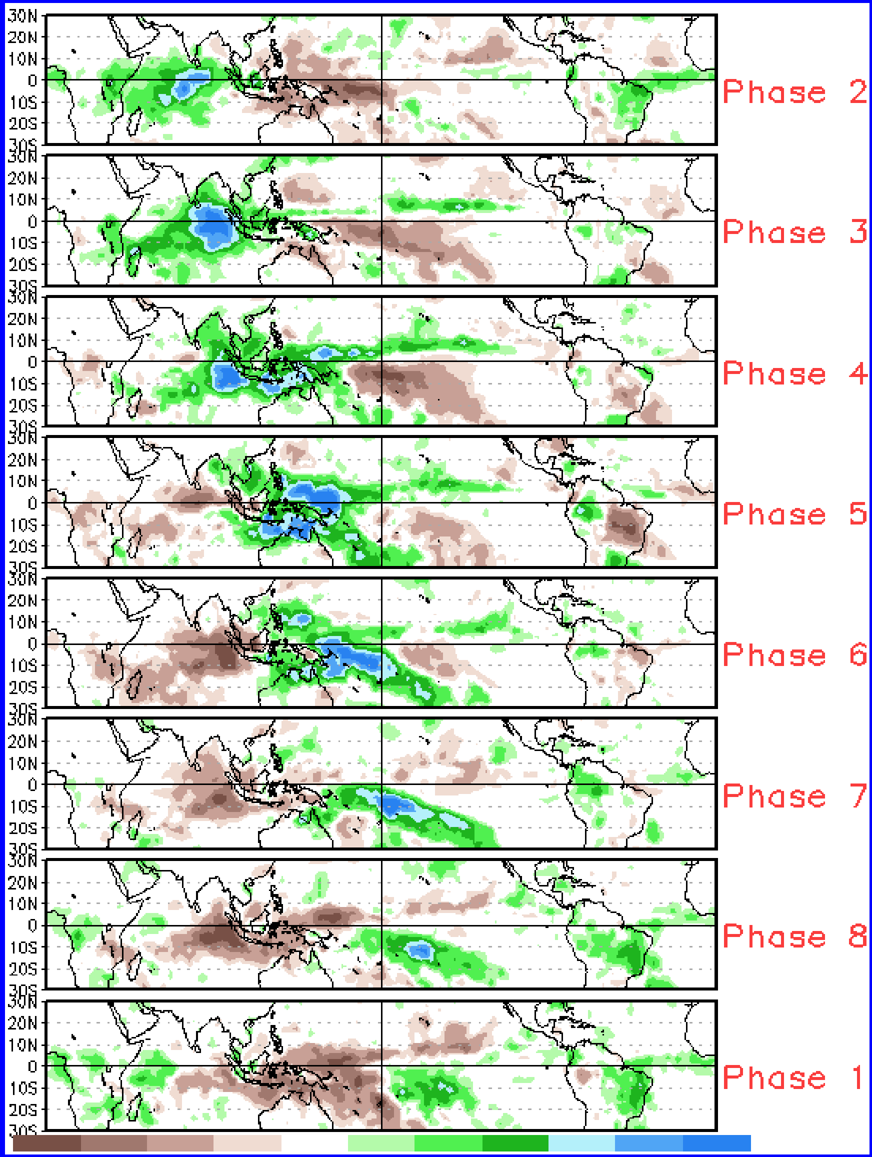


MJO Composites – Global Tropics

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



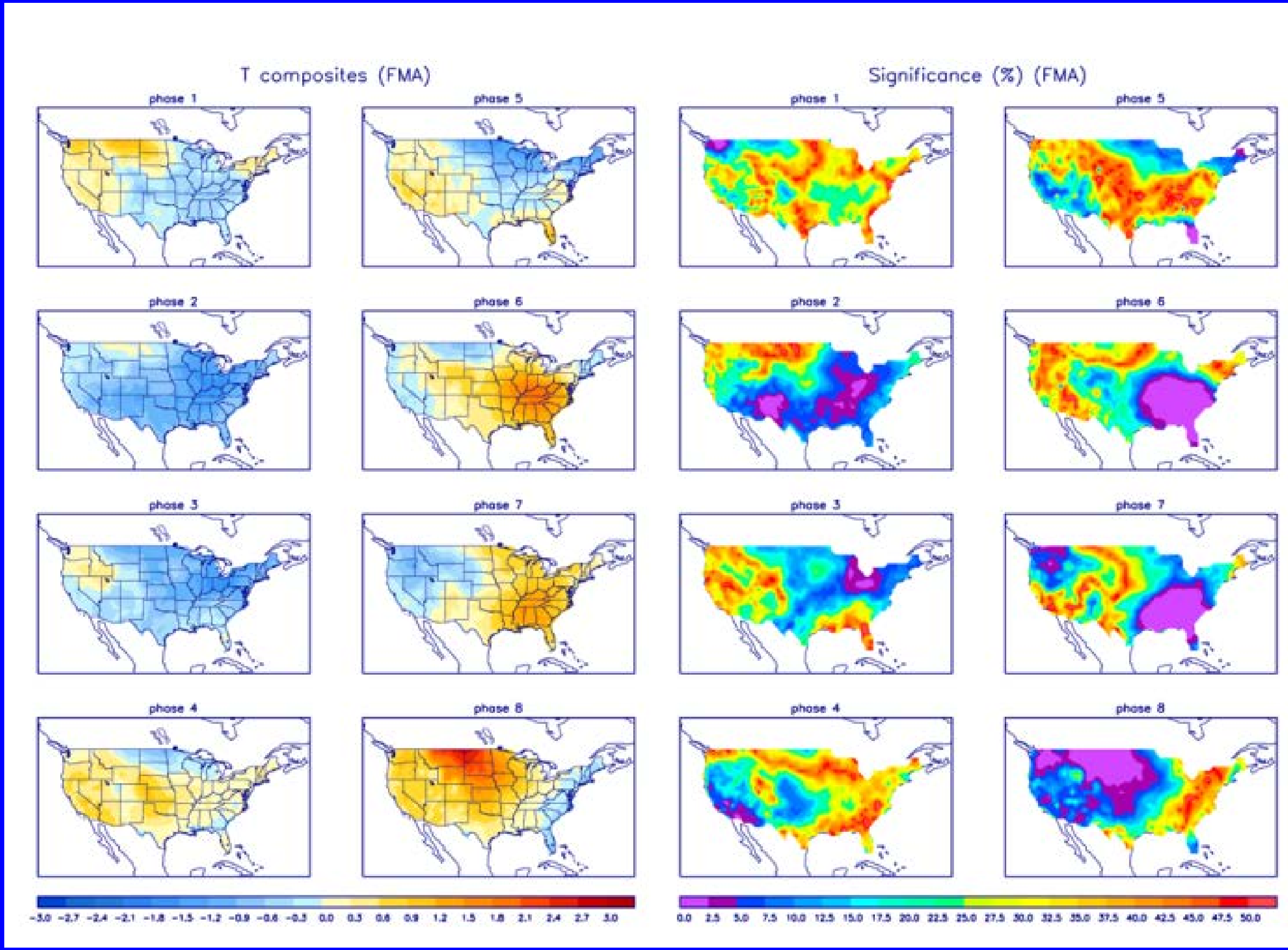
Precipitation Anomalies (Nov-Mar)



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.

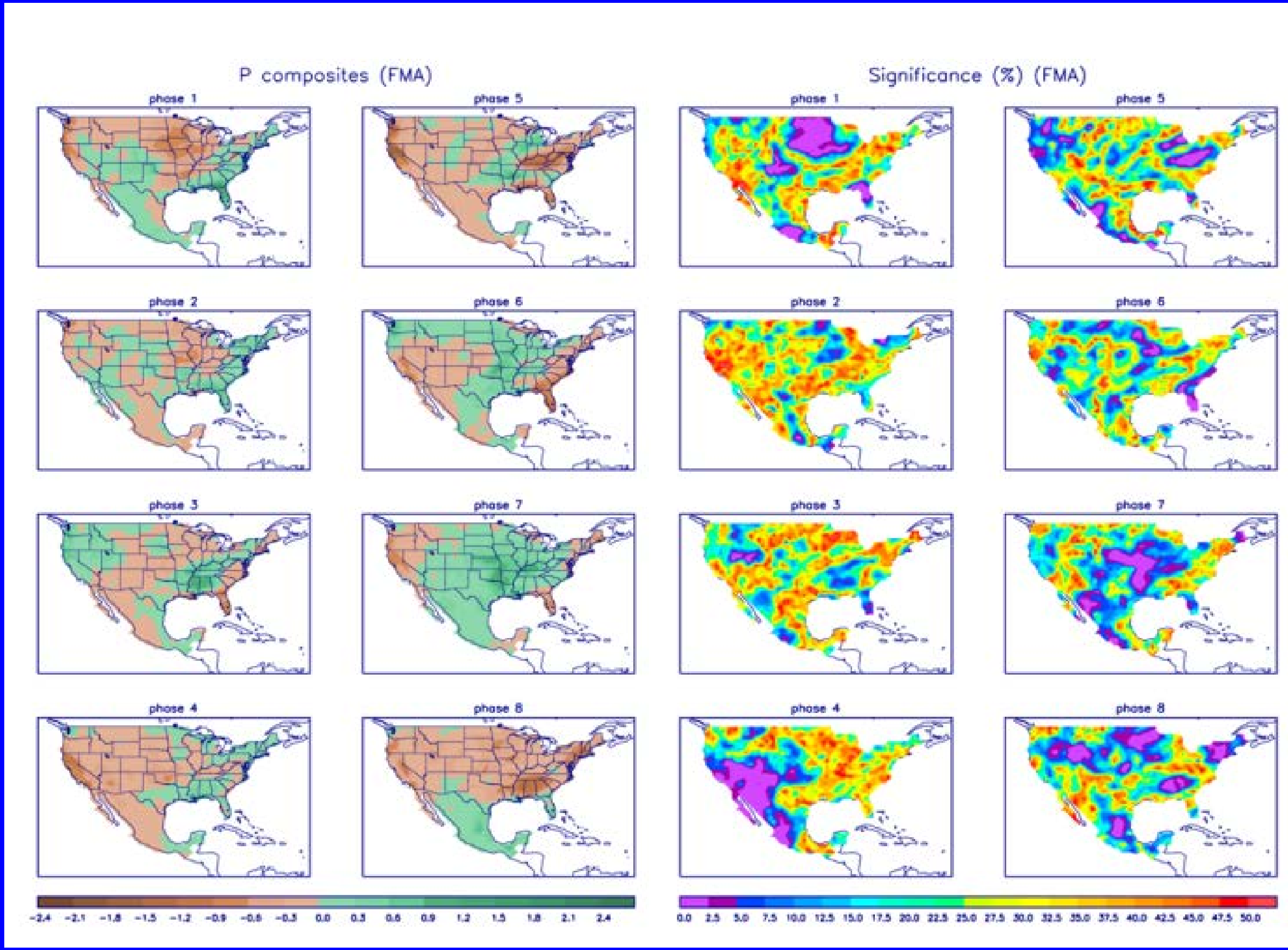


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

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.



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