



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

**Update prepared by
Climate Prediction Center / NCEP
January 20, 2014**



Outline

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



Overview

- **The MJO has remained fairly incoherent during the past week, despite anomalous convection across parts of the Maritime Continent and western Pacific.**
- **Dynamical models are in good agreement that the RMM index will likely be in phases 6 or 7 for the next two weeks, with little coherent propagation. Other modes, such as atmospheric Kelvin waves will play an important part in the pattern of anomalous convection. Statistical tools are split, with some suggesting MJO-like eastward propagation while others emphasize Kelvin waves and westward-moving modes of variability.**
- **Based on the latest observations and most model forecasts, the MJO is forecast to remain weak during the next 1-2 weeks, even with large amplitude convective anomalies forecast across parts of the Maritime Continent and West 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>

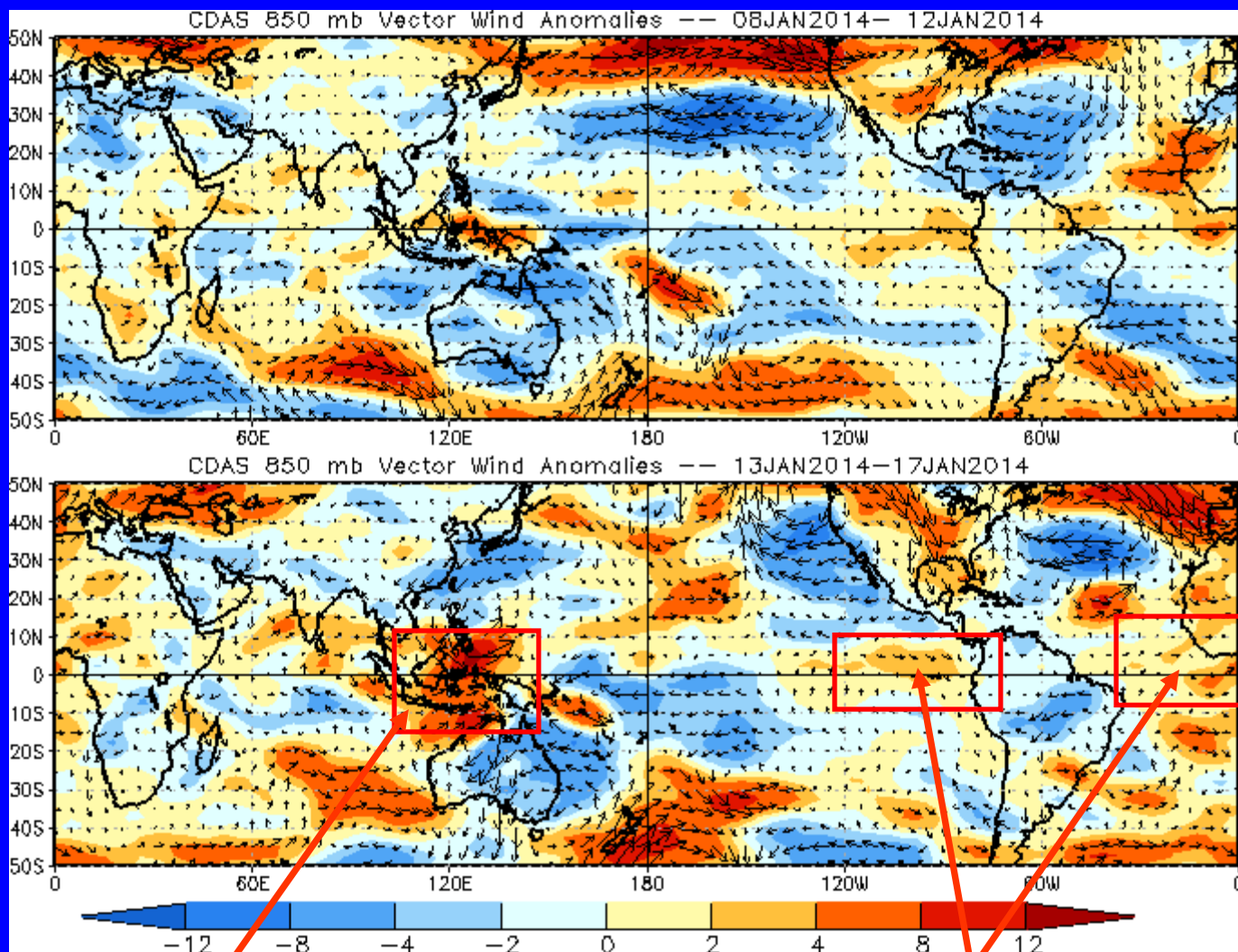


850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Anomalous westerlies intensified over the Maritime Continent, in part due to tropical cyclone activity.

Westerly anomalies persisted west of South America and over portions of Africa during the past five days.

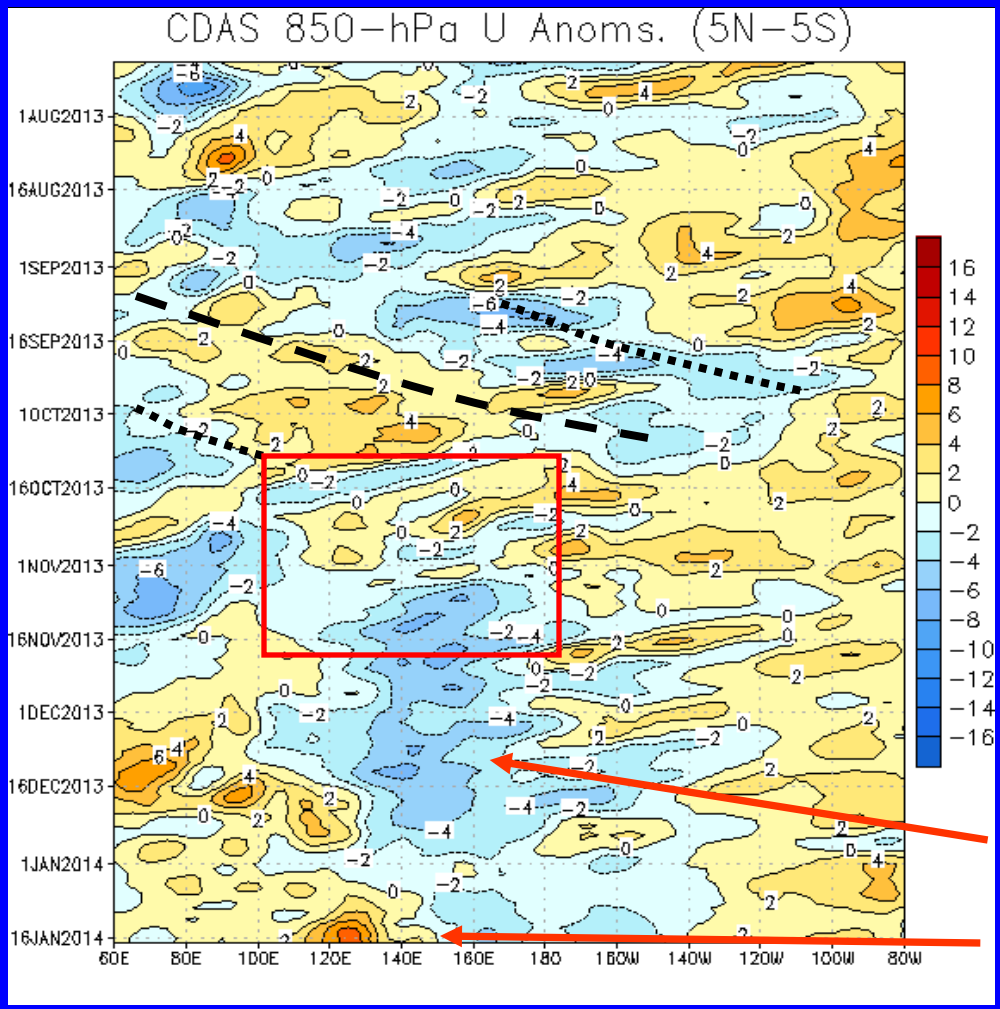


850-hPa Zonal Wind Anomalies (m s^{-1})

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

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

Time
↓



Longitude

During late July through mid-August, the MJO was weak.

In late August and 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.

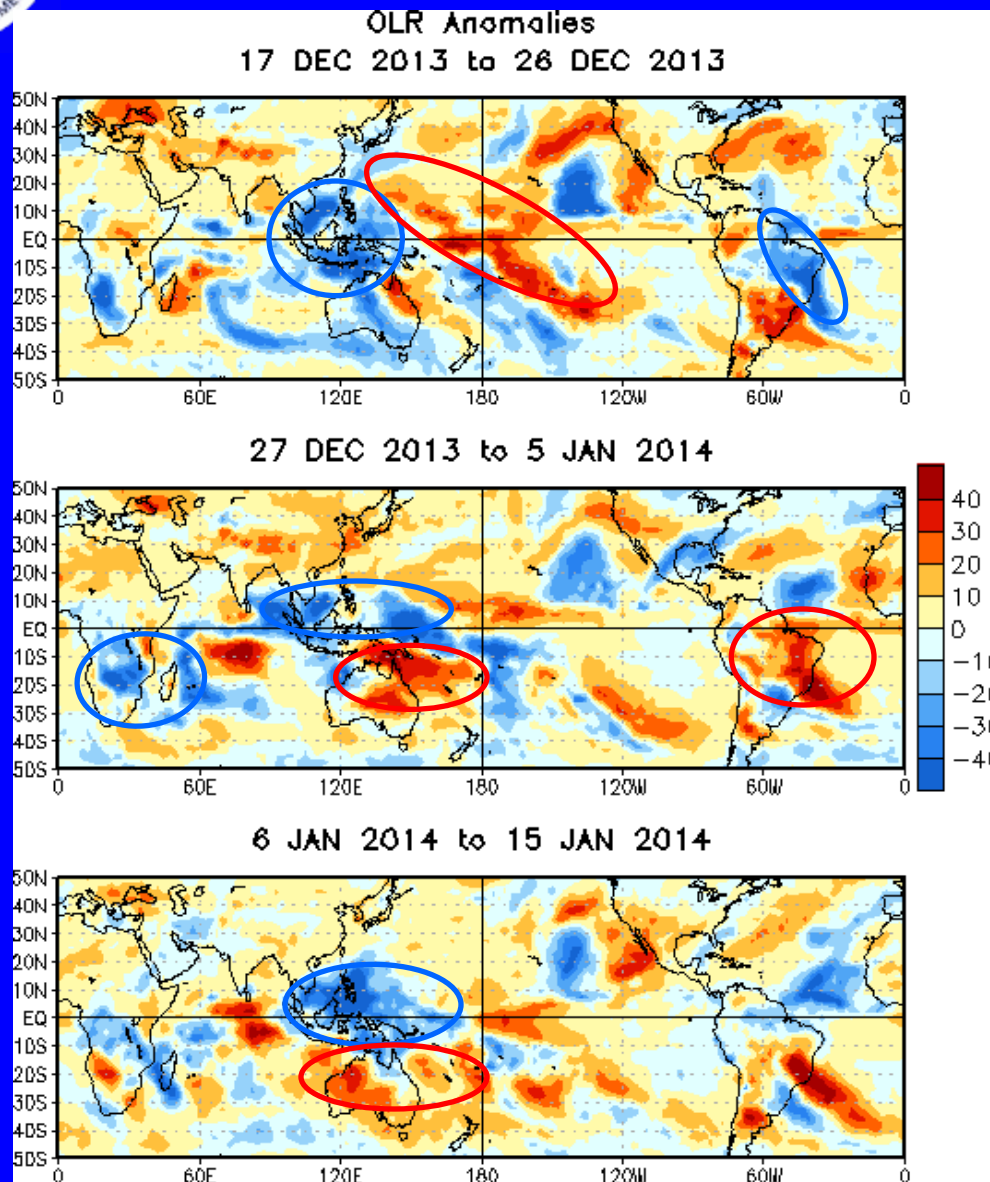
During November and December, easterly anomalies were persistent from 120E to near the Date Line. Westerly anomalies were also evident across the Indian Ocean during this period. During January, westerly anomalies shifted eastward to the Maritime Continent and into the far western Pacific.



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- to late December, enhanced convection shifted east to the Maritime Continent with suppressed convection persisting across much of the western and central Pacific. Enhanced convection intensified across Brazil with suppressed convection indicated over parts of south-central South America.

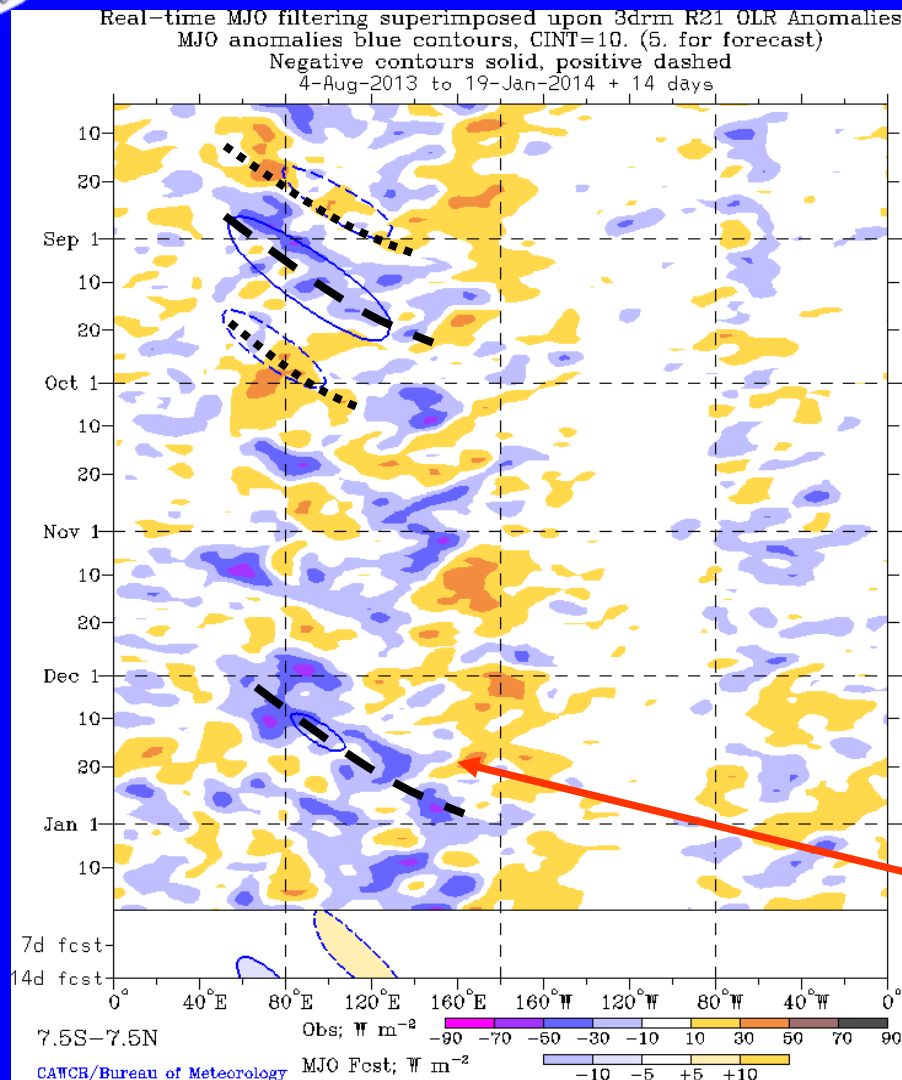
In late December and early January, enhanced convection shifted into parts of the western Pacific while continuing across parts of the Maritime Continent. Suppressed convection developed across much of Australia, the southwest Pacific Islands, and Brazil. Enhanced convection was also evident from parts of southern Africa to the southwestern Indian Ocean.

Mid-January saw enhanced convection focused over the northern Maritime continent and parts of the western Pacific, while suppressed convection continued over Australia and the Southwest Pacific.



Outgoing Longwave Radiation (OLR)

Anomalies (7.5°N-7.5°S)



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 was active from late August through early October with the enhanced phase propagating eastward from the Indian Ocean to the western Pacific Ocean over this period.

The MJO was generally weak or incoherent for much of November and other types of coherent tropical subseasonal variability were very active.

During late November, a large area of enhanced convection developed in the Indian Ocean and propagated eastward to the west Pacific Ocean. Enhanced convection has persisted near 120E to 140E, most recently shifting eastward toward 160E.

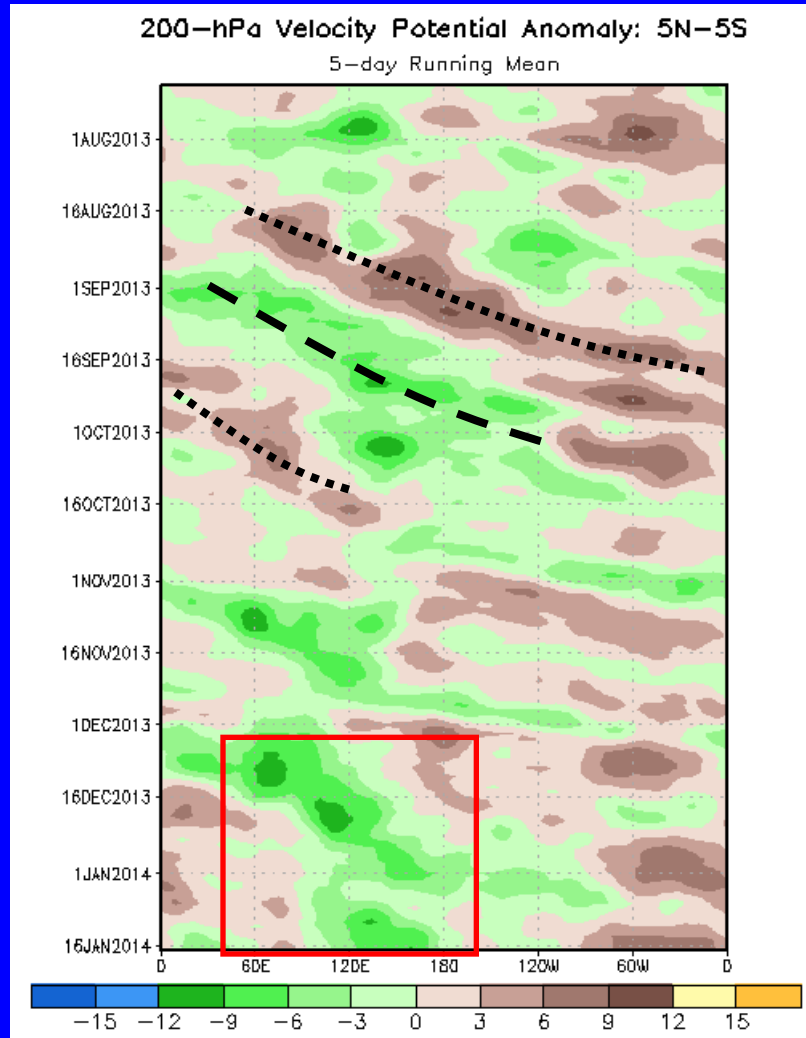


200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation

Time



The MJO was not active during late July and much of August, but strengthened during late August and September, with eastward propagation of robust upper-level velocity potential anomalies (alternating dashed and dotted lines). Other modes of tropical intraseasonal variability are also evident.

From late October to early December, the MJO was not very strong or coherent. There was evidence of coherent eastward propagation at times during this period, but much of this activity exhibited fast propagation speeds more consistent with atmospheric Kelvin waves.

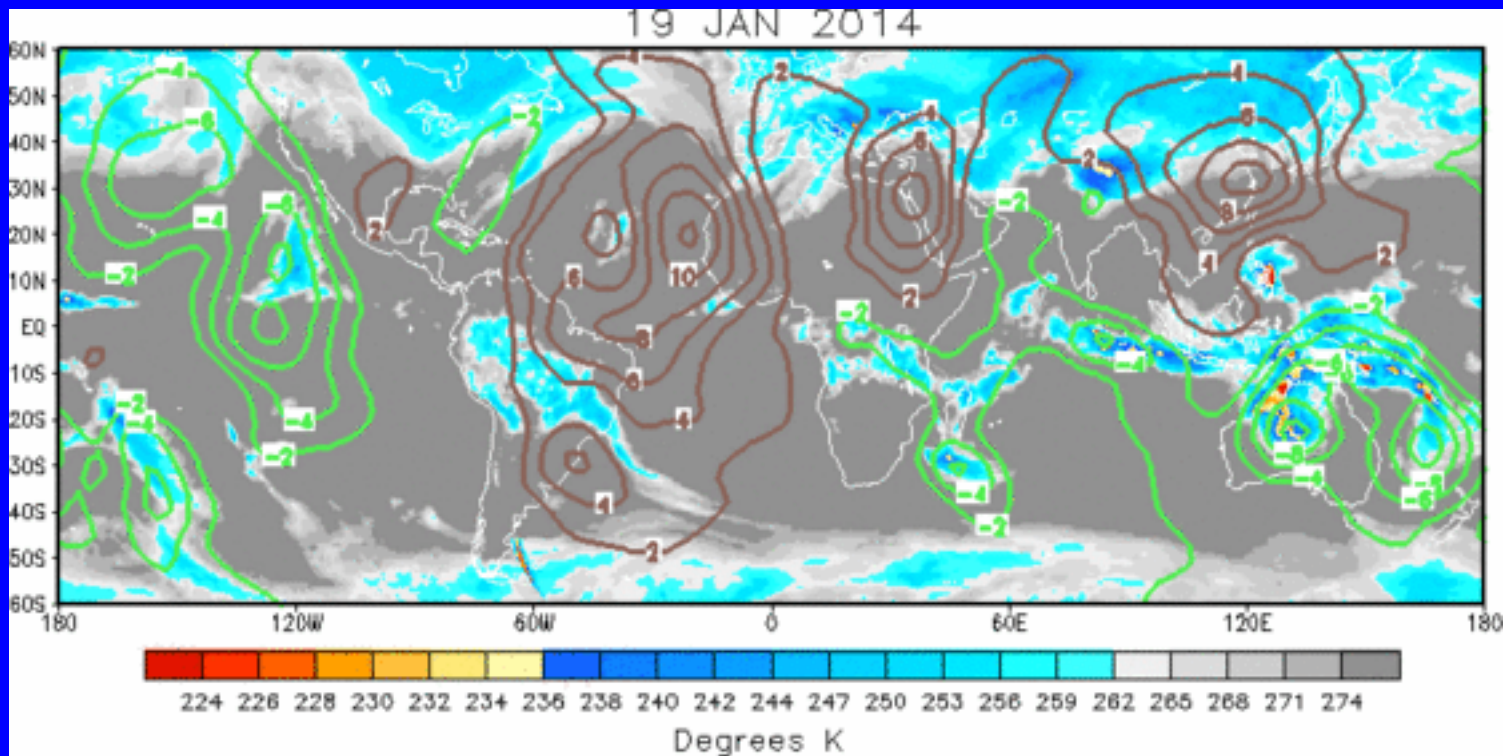
A slower eastward propagation of 200-hPa velocity potential anomalies was observed from mid-December to mid-January across the Indo-Pacific warm pool region (red box). A clear suppressed convective phase has not been evident.



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



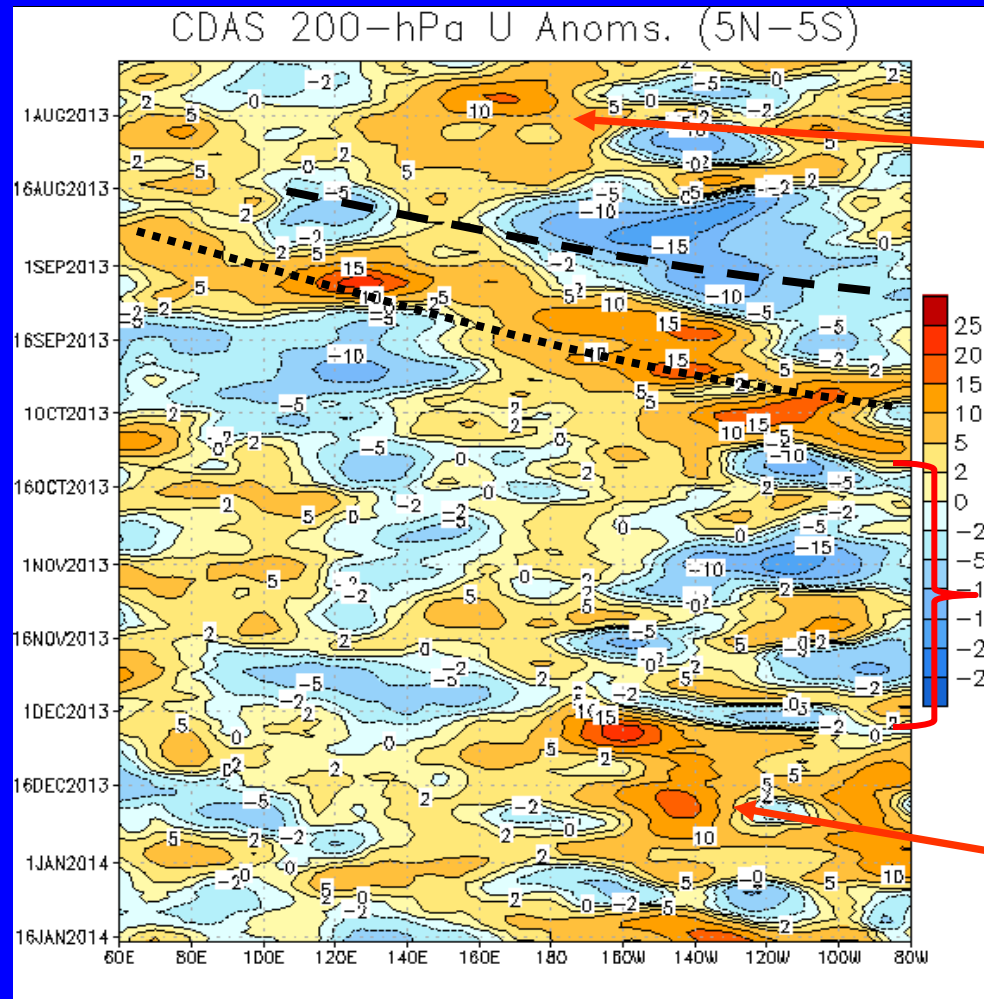
The current velocity potential data does not indicate a coherent pattern of large scale anomalies of upper-level divergence or convergence. There is, however, a continued strong signal for upper-level divergence over the Maritime continent, West Pacific, and Australia.



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 August, westerly wind anomalies were generally persistent just west of the Date Line.

Renewed MJO activity (alternating dotted and dashed lines) occurred during late August and September with westerly wind anomalies shifting east to the eastern Pacific.

Anomalies of alternating sign are evident over the eastern Pacific, due in part to extratropical Rossby waves breaking into the Tropics (red bracket).

Westerly anomalies increased in December across the western Hemisphere and persisted into early January.



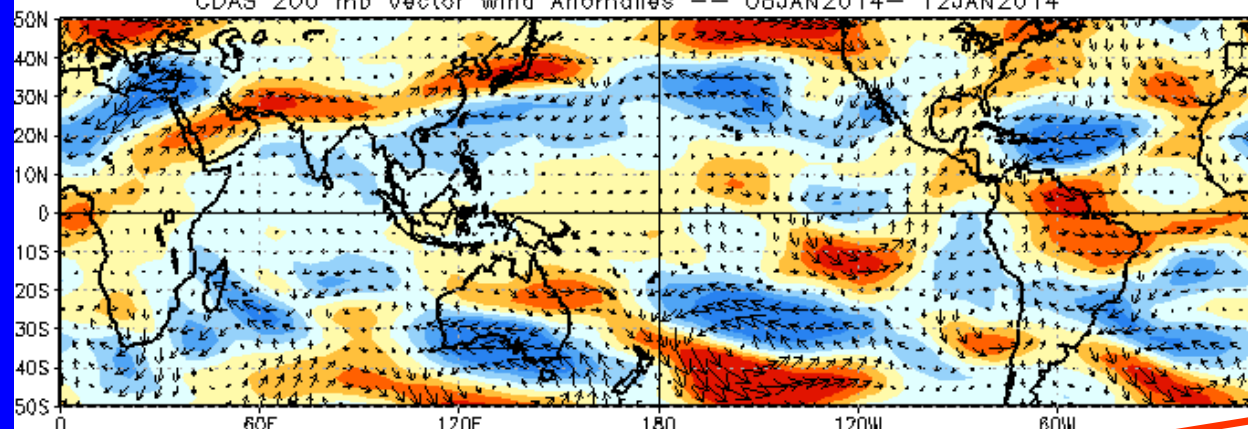
200-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

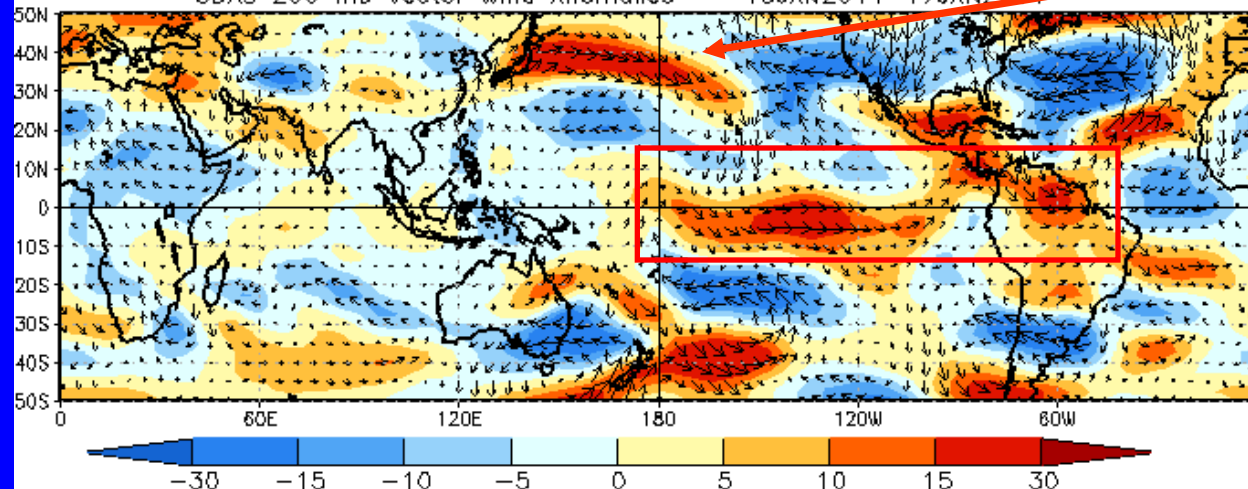
Blue shades: Easterly anomalies

Red shades: Westerly anomalies

CDAS 200 mb Vector Wind Anomalies -- 08JAN2014-- 12JAN2014



CDAS 200 mb Vector Wind Anomalies -- 13JAN2014--17JAN2014

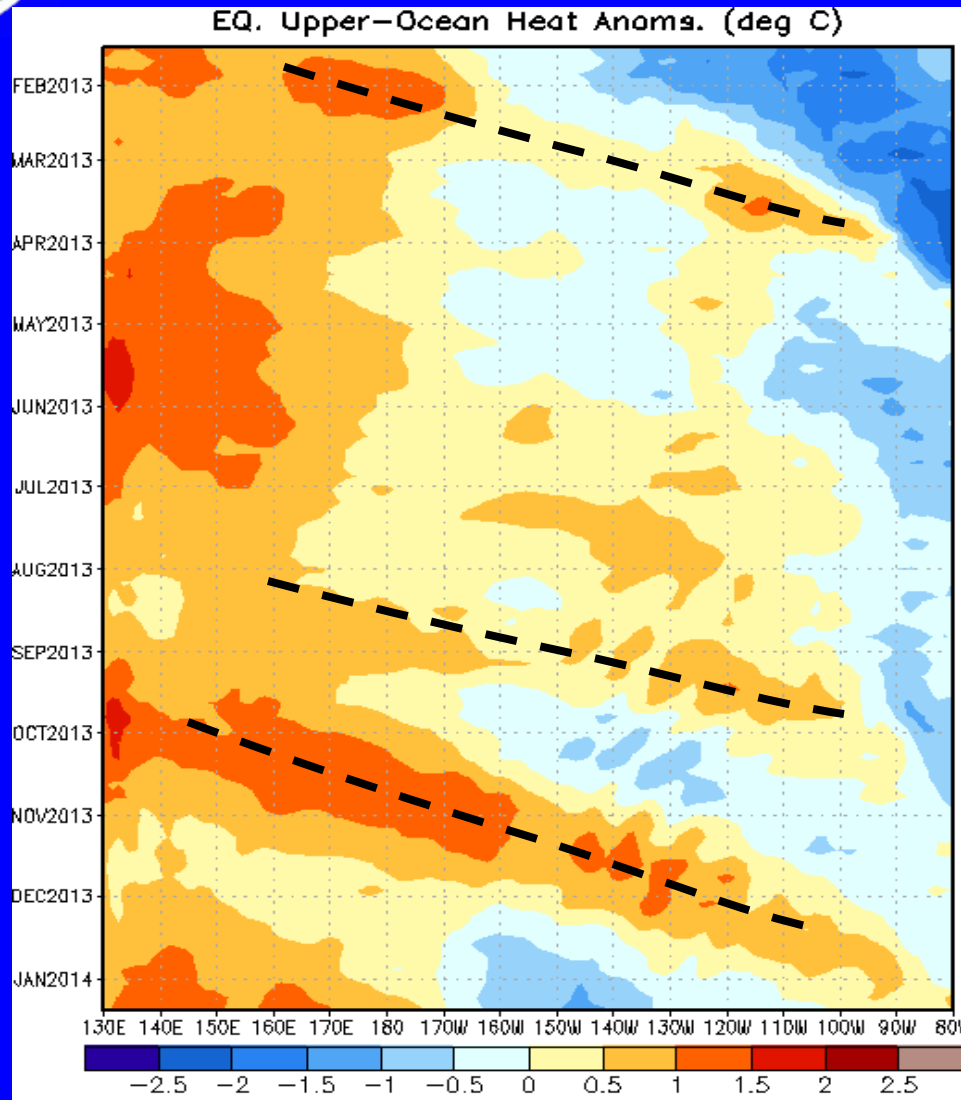


A prominent extension of the East Asian jet stream is observed. This signal is consistent with convection over the tropical West Pacific.

Westerly anomalies continued across parts of South America and intensified across the eastern Pacific (red box).



Weekly Heat Content Evolution in the Equatorial Pacific



Positive (negative) anomalies developed in the western (eastern) Pacific during January 2013 and persisted into early March. The influence of a downwelling oceanic Kelvin wave (dashed line) can be seen during late February and March as anomalies became positive in the east-central Pacific.

Oceanic downwelling Kelvin wave activity is evident in late August and once again during October through early December, the latter being the strongest wave during 2013.

There is some evidence that another downwelling event is beginning in the West 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.

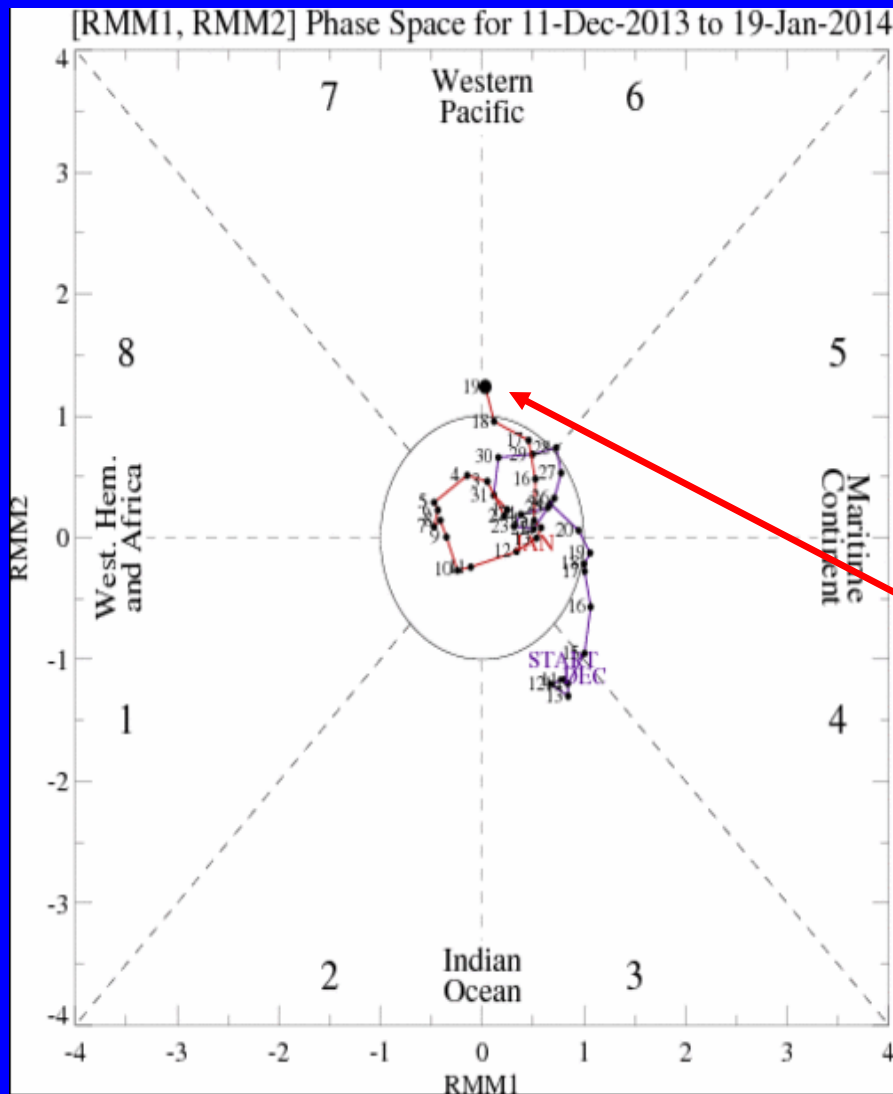
- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

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

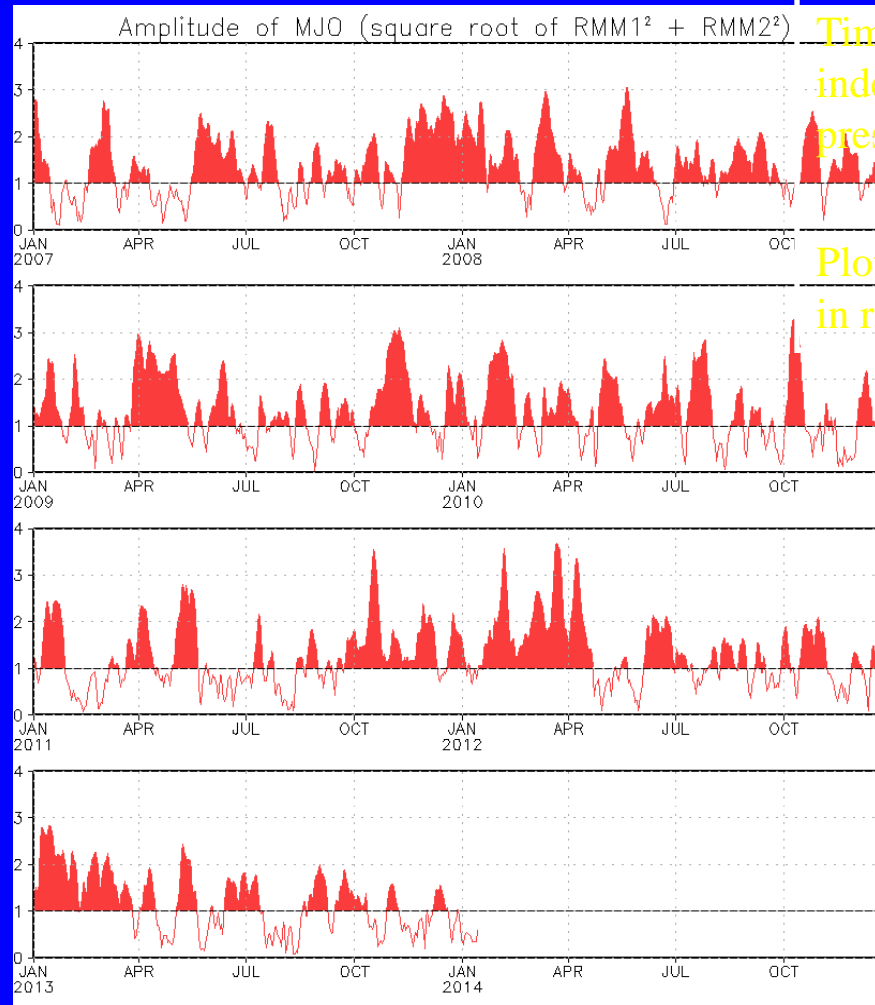


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index has emerged between phases 6 and 7 in response to convection in the West Pacific.



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

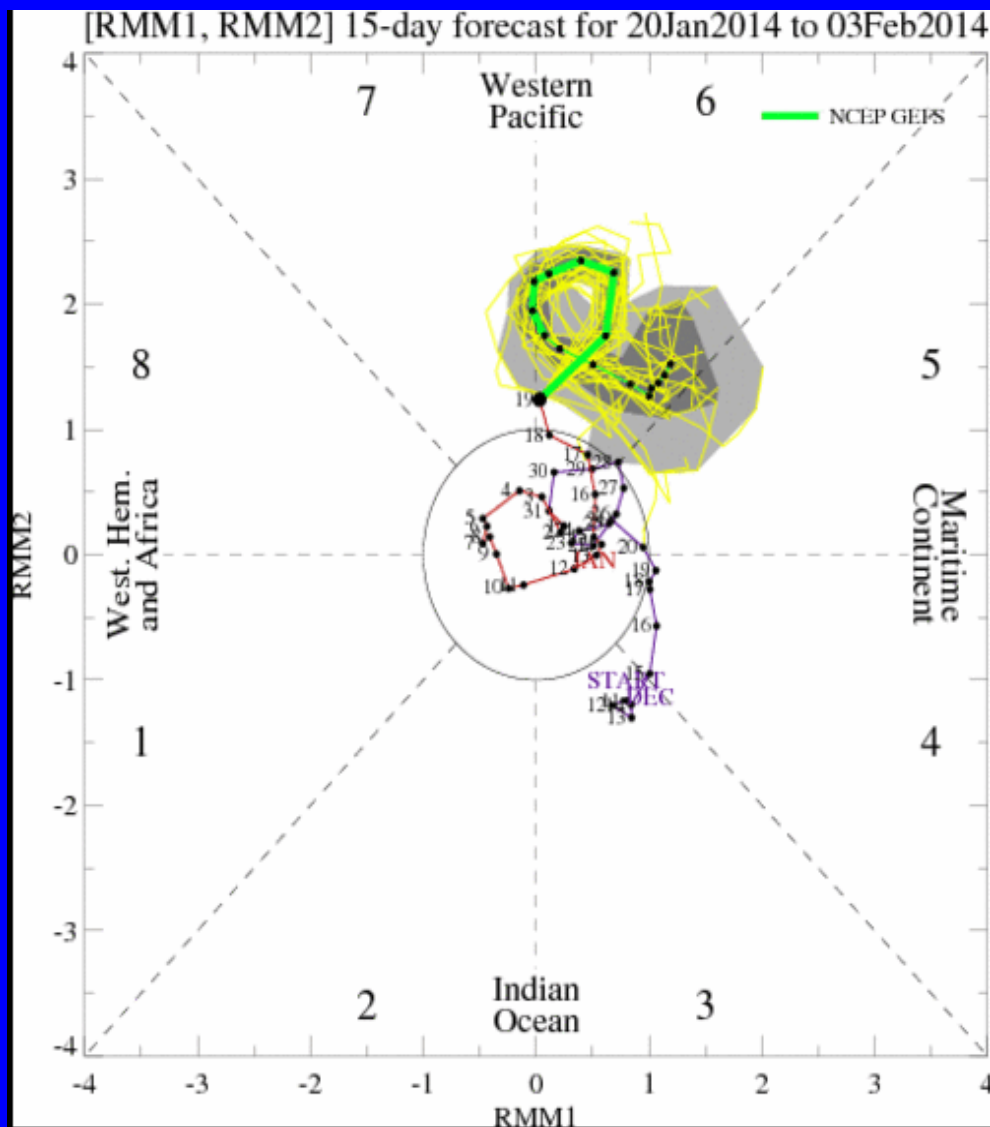
Green Line – Ensemble Mean

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 ensemble GFS forecast indicates a fairly robust signal in phase 6 during the next two weeks. There is no clear, long lived eastward propagation during the period, however.

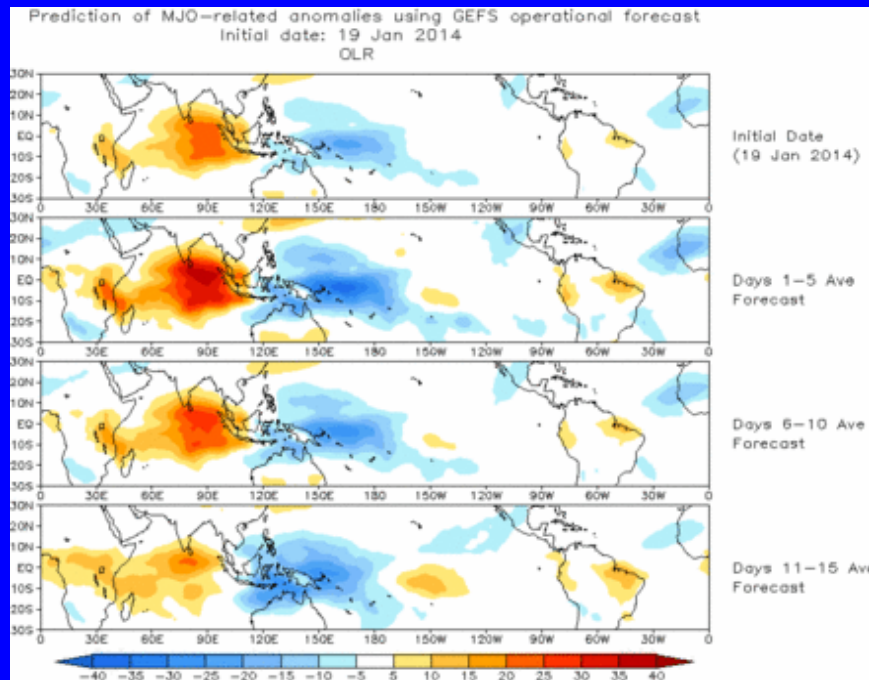




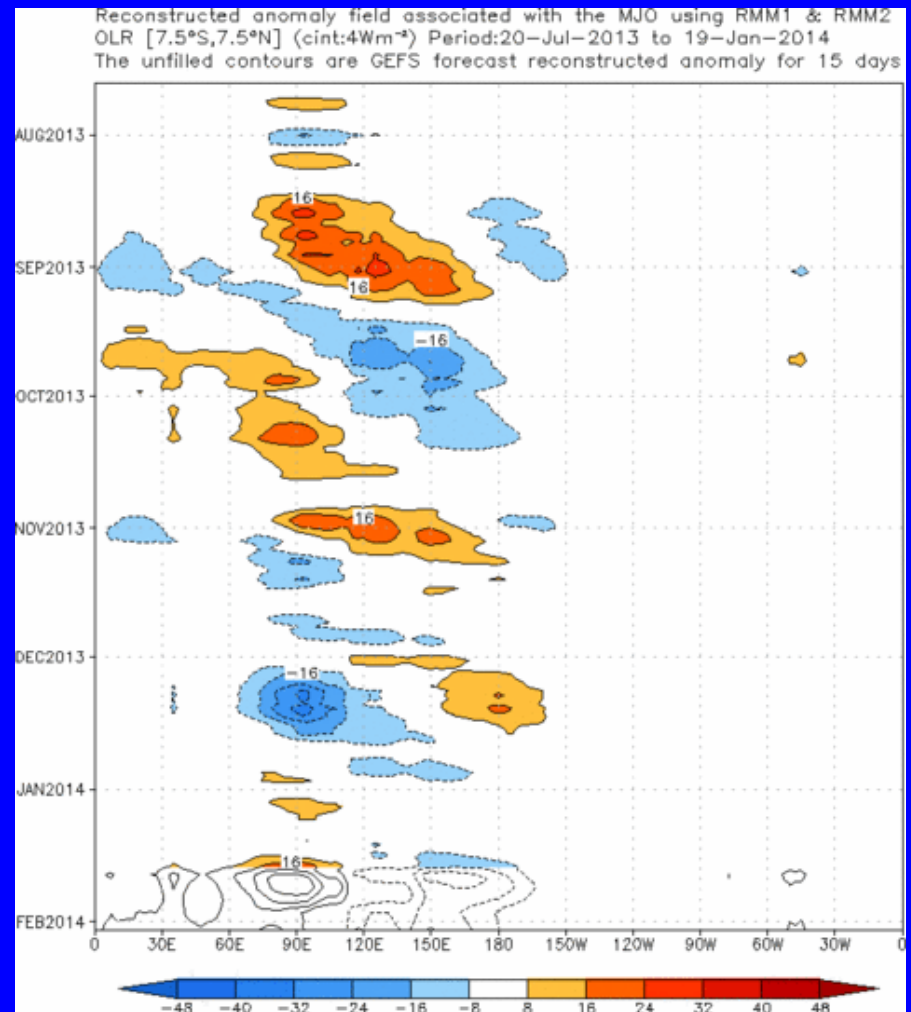
Ensemble Mean GFS MJO Forecast

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



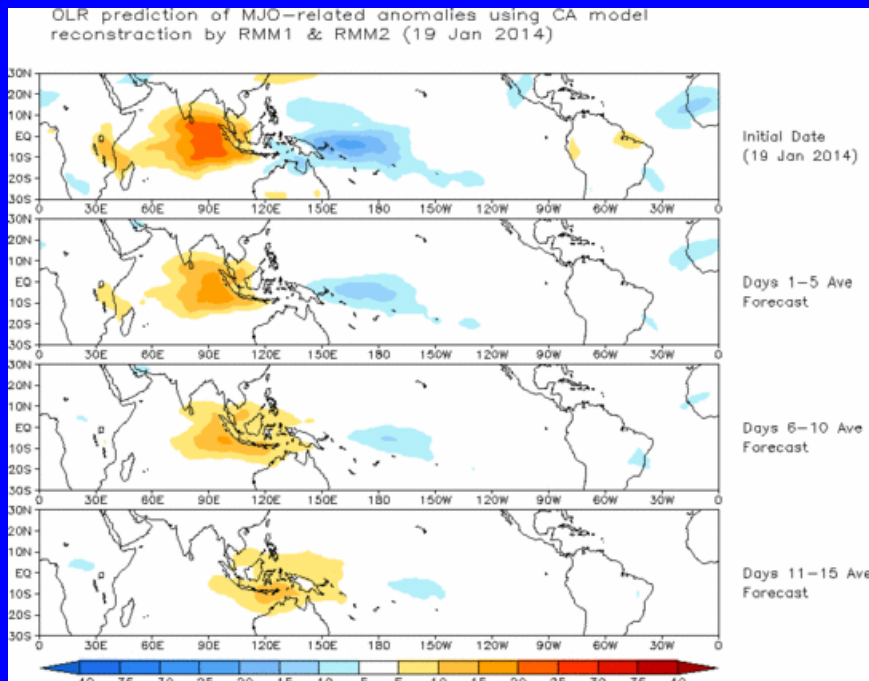
The ensemble mean GFS forecasts a nearly stationary pattern of anomalous convection with enhanced (suppressed) convection across the western Pacific (Indian) Ocean.



Constructed Analog (CA) MJO Forecast

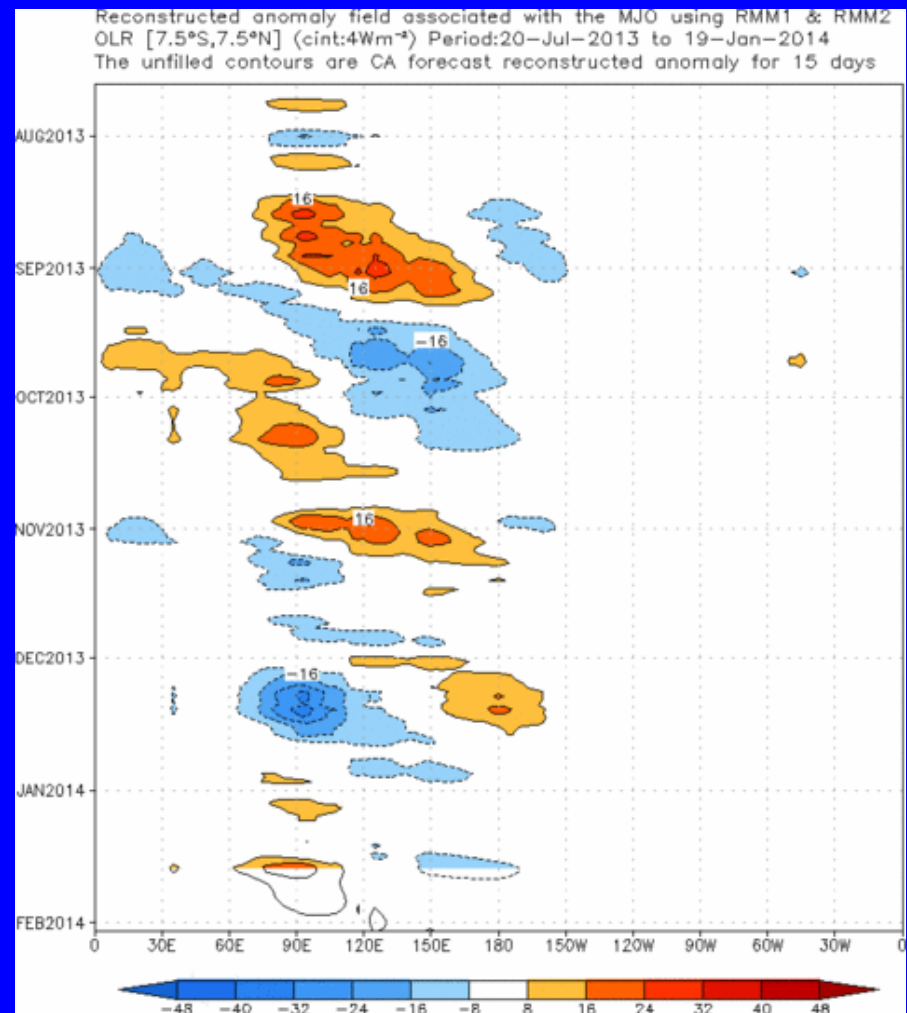
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The constructed analog MJO forecast indicates weak anomalies during the outlook period, though with eastward propagation.

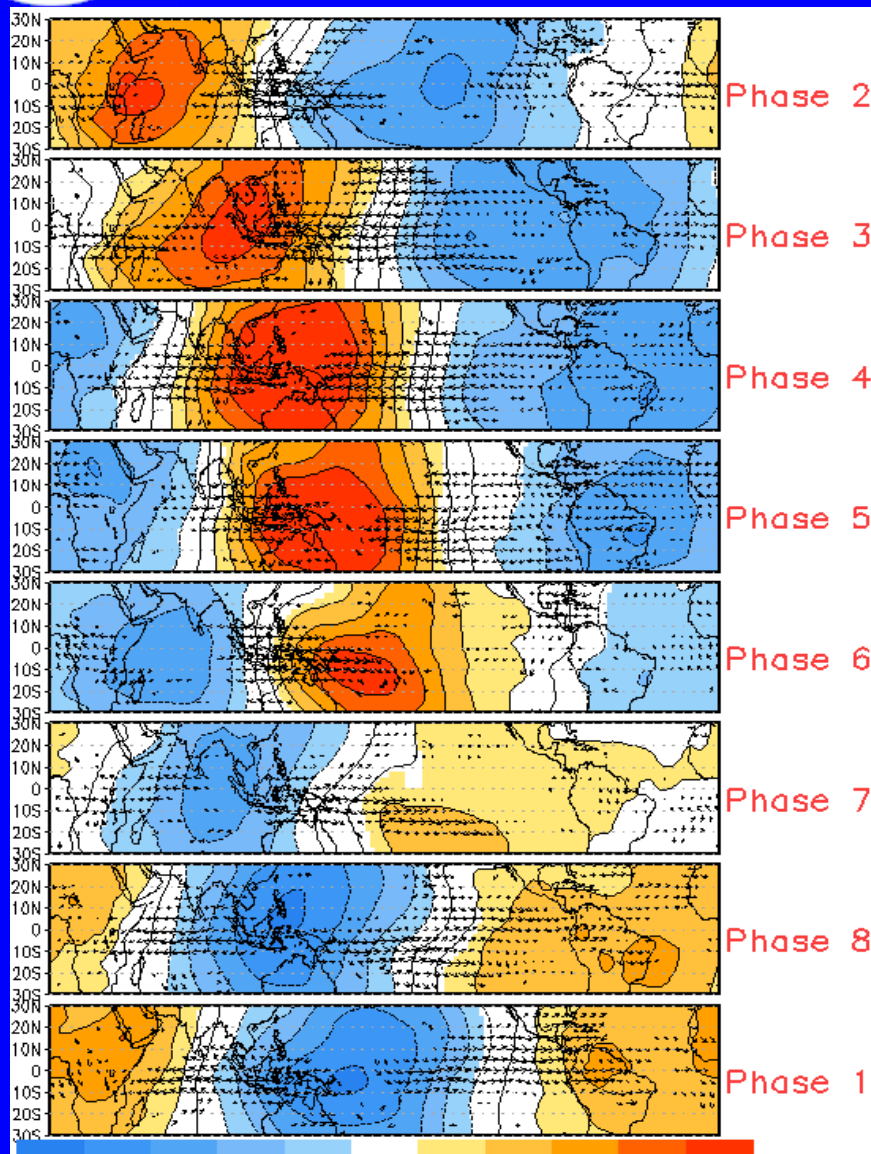
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



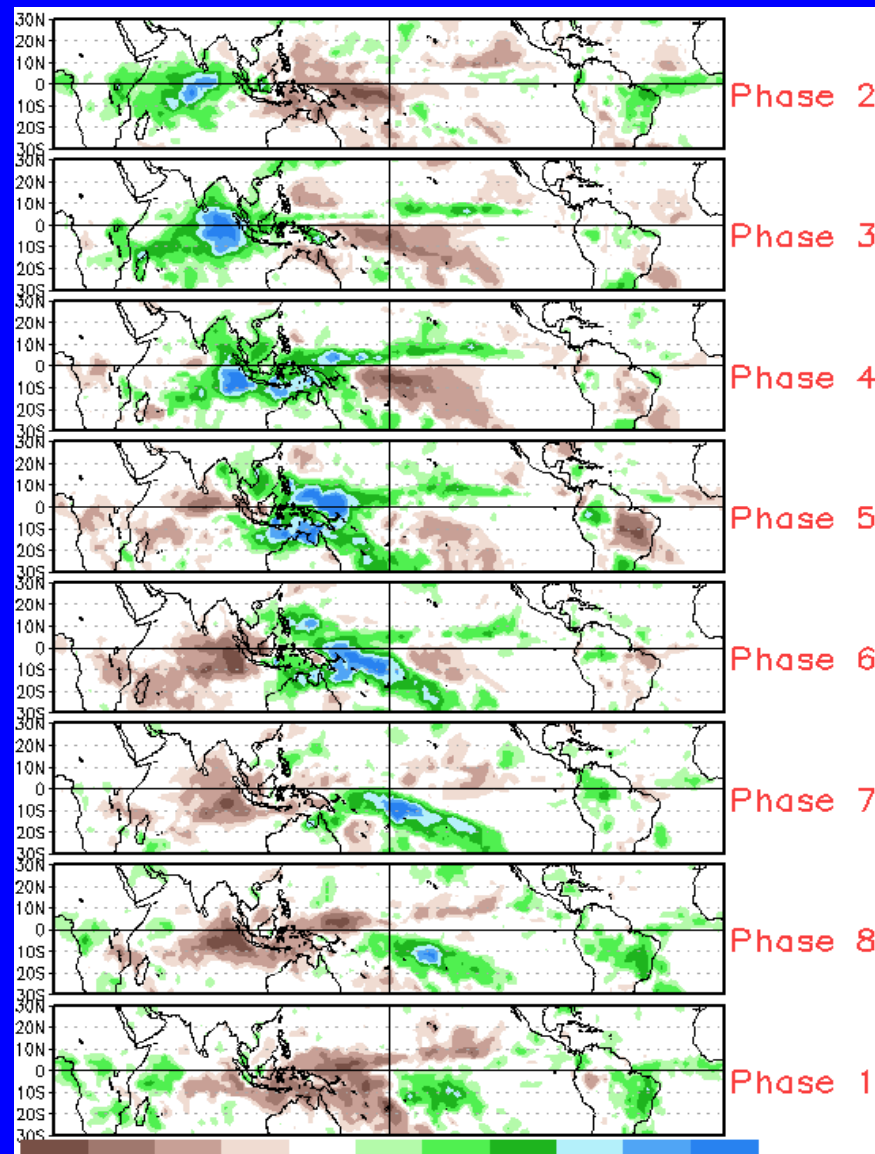


MJO Composites – Global Tropics

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



Precipitation Anomalies (Nov-Mar)

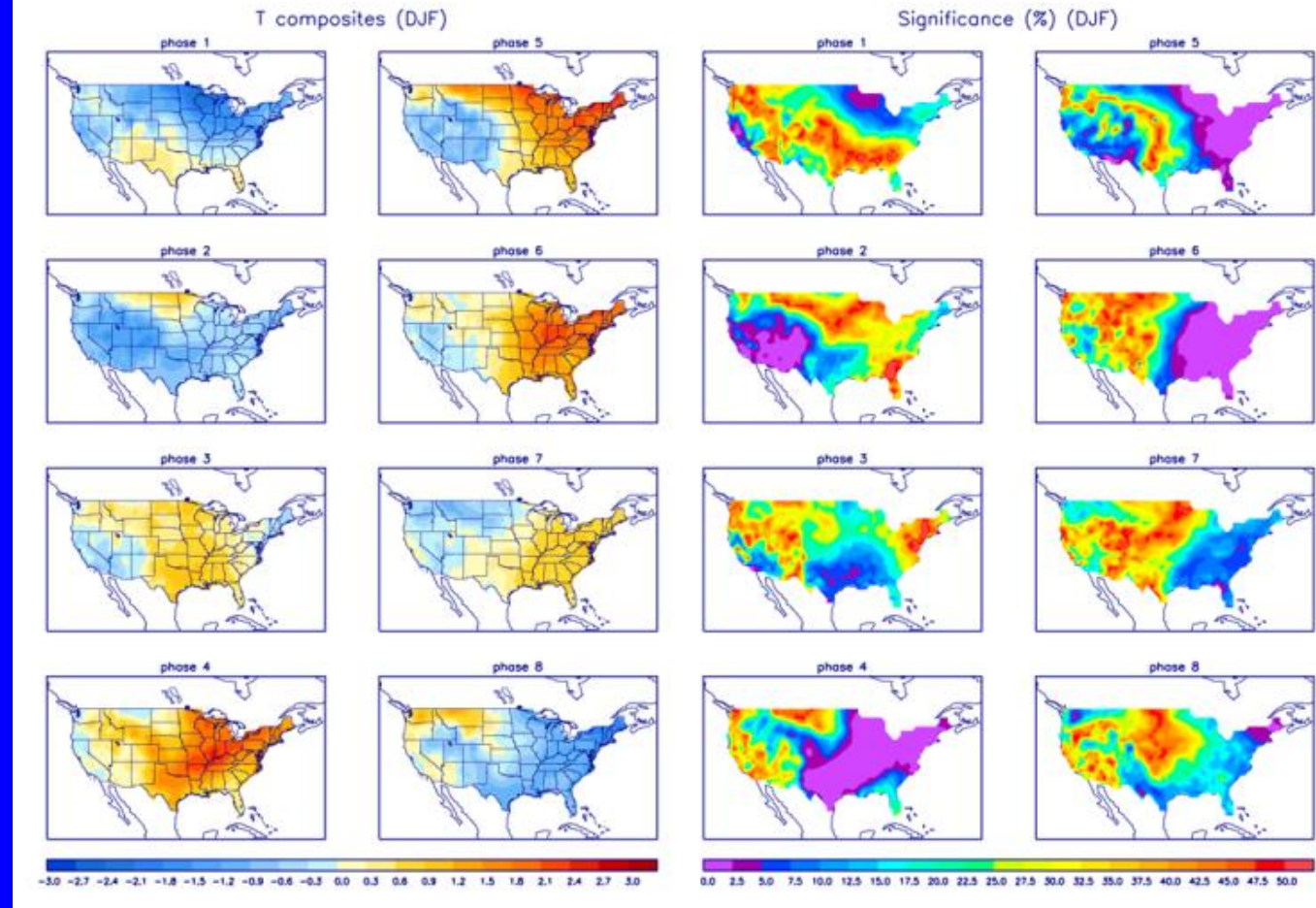




U.S. MJO Composites – Temperature

- 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.



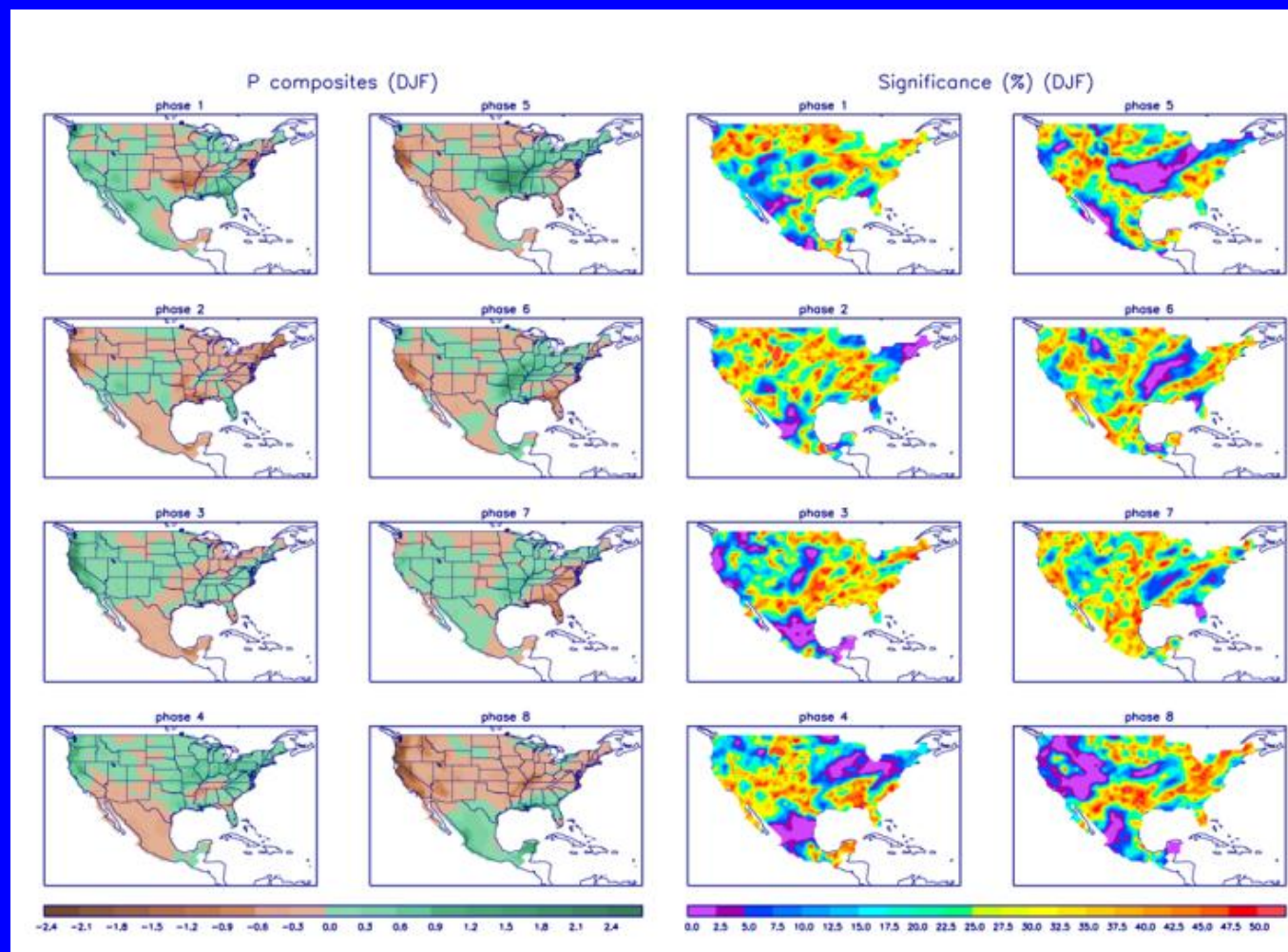
Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

<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>