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

Update prepared by
Climate Prediction Center / NCEP
July 4, 2011

Outline

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

Overview

- The MJO signal remained weak during the past seven days.
- The dynamical model MJO index forecasts indicate an increase in projection during the period, however, there is large spread across the model solutions. Several forecasts are not consistent with coherent, eastward propagating MJO activity.
- Based on the latest observations and latest forecasts, the MJO is not expected to contribute substantially to anomalous rainfall across the global Tropics.

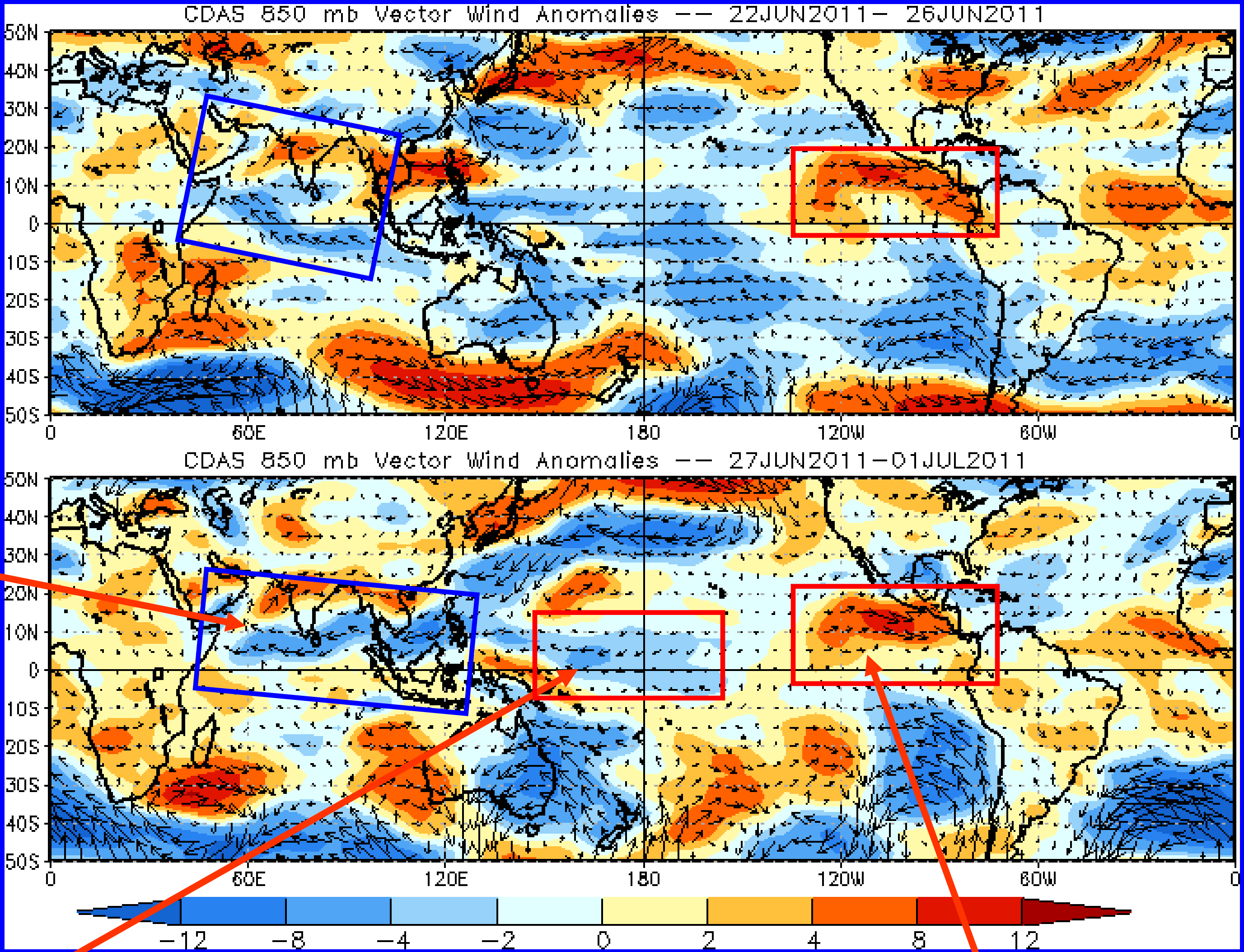
Additional potential impacts across the global tropics are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

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

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Suppressed monsoon flow is evident across South Asia and the Indian Ocean.

Small easterly wind anomalies remain evident near the Date Line.

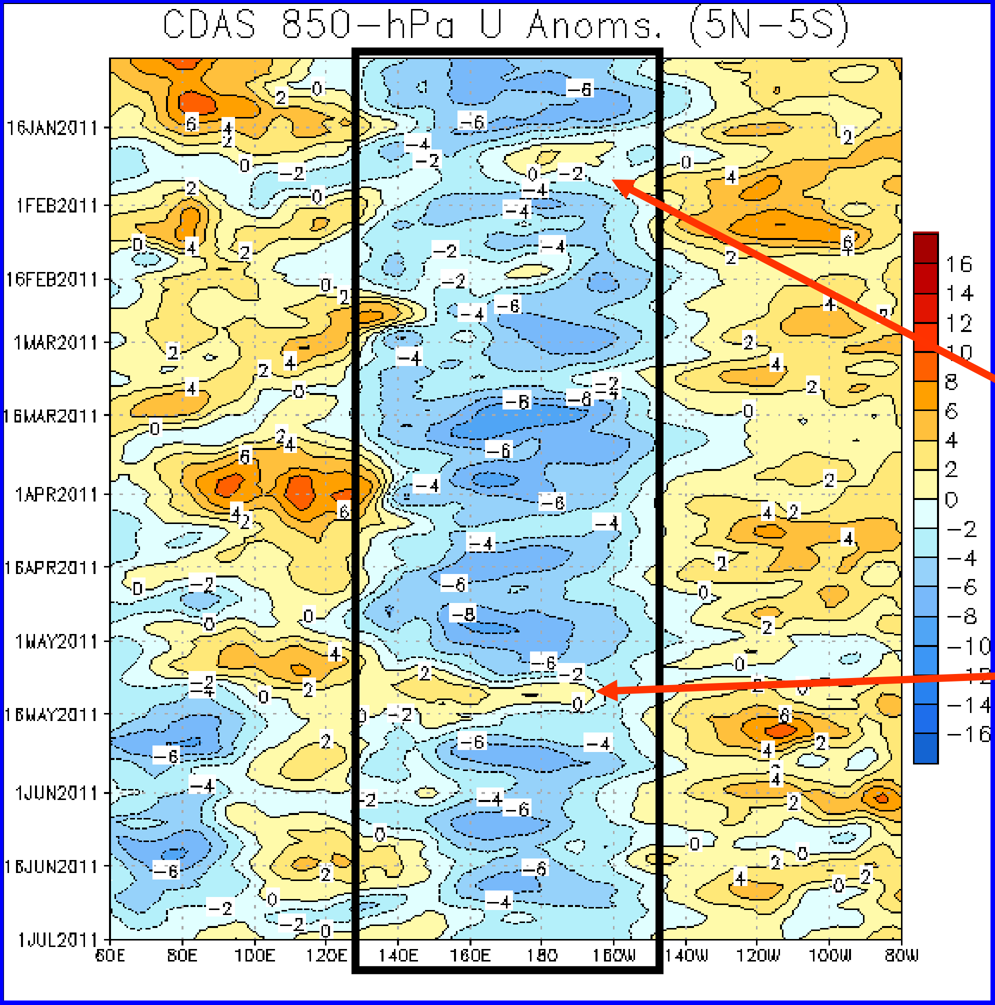
Westerly anomalies persisted across the eastern Pacific Ocean during the last five days with a slight increase in intensity.

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

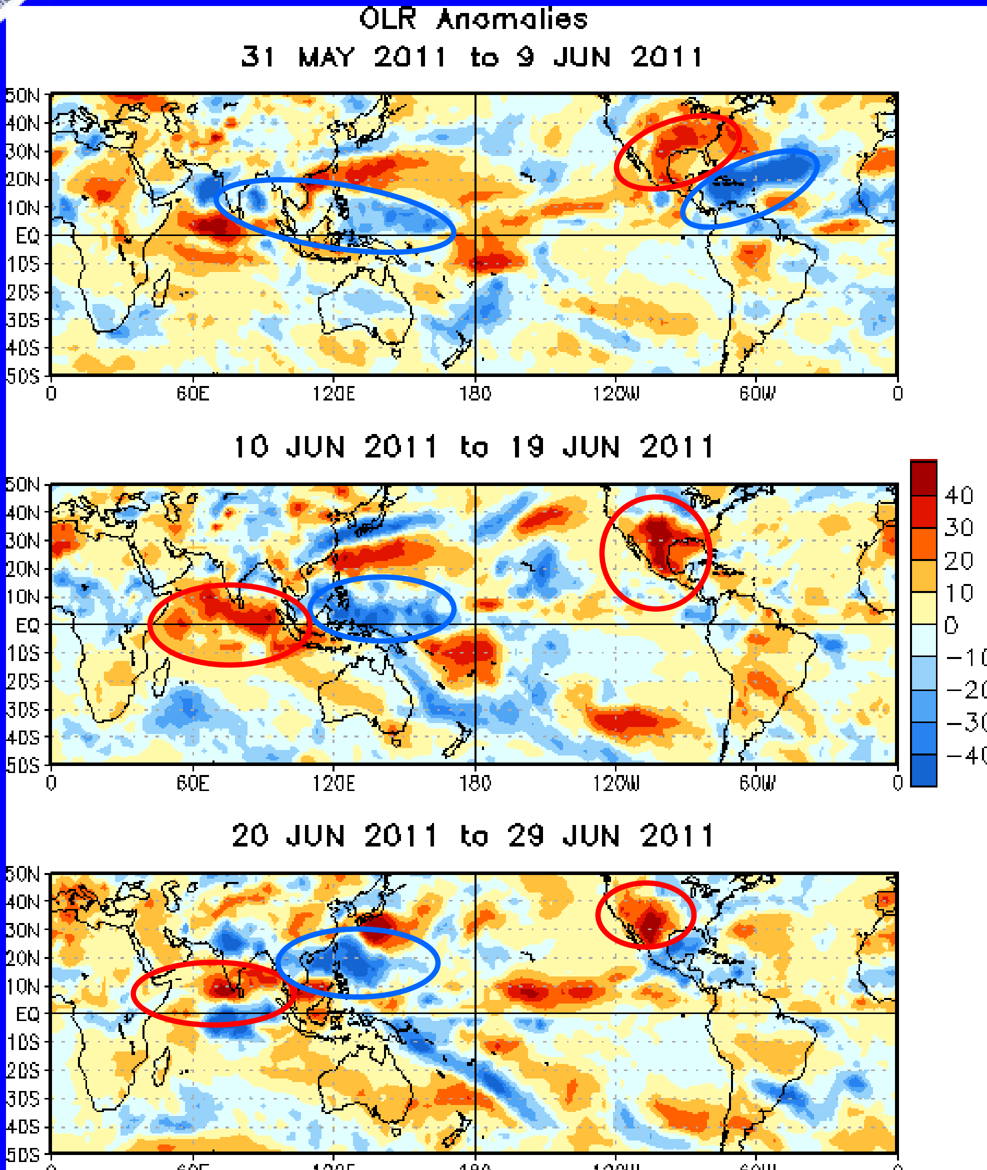
Easterly anomalies have persisted in the west-central Pacific since January (black box) consistent with La Nina conditions. The magnitude of these anomalies, however, has gradually weakened over the period.

In late January, easterly winds weakened and westerly anomalies developed near the Date Line due to MJO activity.

A burst of westerly wind anomalies associated with the MJO moved across the Pacific in early-to-mid May.

Most recently, near normal conditions (on average) have developed across the tropical Indian and Pacific Oceans. Westerly anomalies are evident across the eastern Pacific and Caribbean.

OLR Anomalies – Past 30 days



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

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

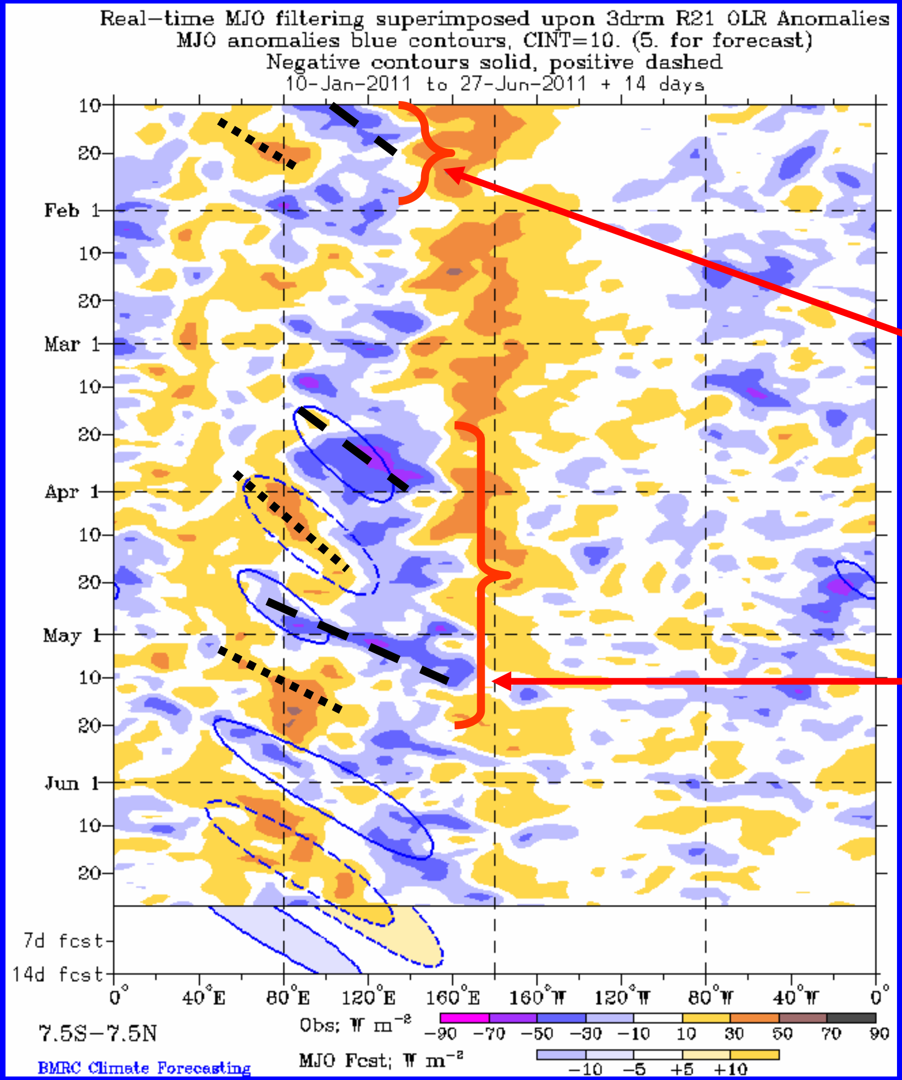
During late May and early June, enhanced convection (blue circle) was evident across the far western Pacific and western Atlantic, while suppressed convection (red circle) was present across the southern CONUS, Mexico, and the western Indian Ocean.

In mid-June, suppressed convection was evident across most of the Indian Ocean and southern CONUS, with enhanced convection continuing across the western Pacific.

Suppressed convection waned across the Indian Ocean during mid-June while enhanced convection was evident across the South China Sea and western Pacific. Drier-than-average conditions continued over the southern CONUS and northern Mexico.

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 the Bureau of Meteorology (BOM) - Australia)

Weak MJO activity was experienced during January. Enhanced convection developed near 80E and shifted to the Maritime continent followed by an area of suppressed convection.

During late March and again in late April, two distinct areas of enhanced convection propagated eastward followed by suppressed convection thereafter. This activity was in part associated with MJO activity.

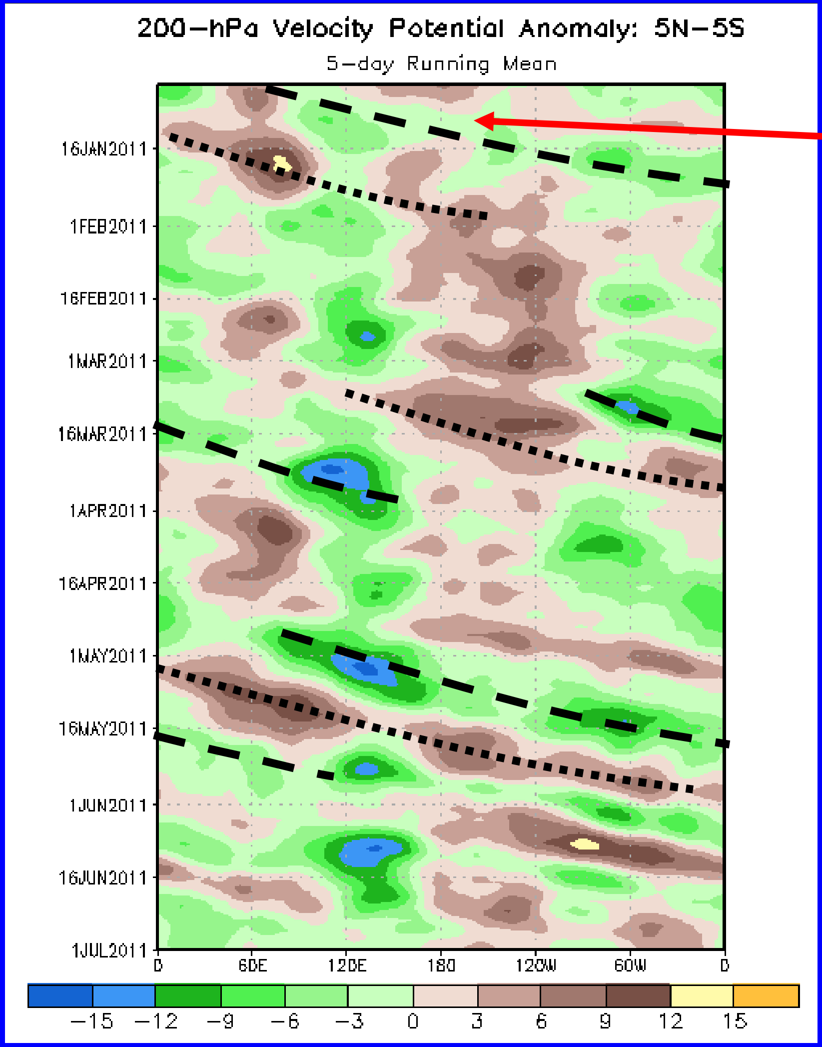
During mid-June, a couplet of suppressed (enhanced) convection is evident and centered near 80E (140E).

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

During mid-to-late January, the MJO strengthened and upper-level divergence shifted eastward from 120E and upper-level convergence shifted from Africa to near the Date Line.

Eastward propagation of anomalies was observed during March associated with weak MJO activity.

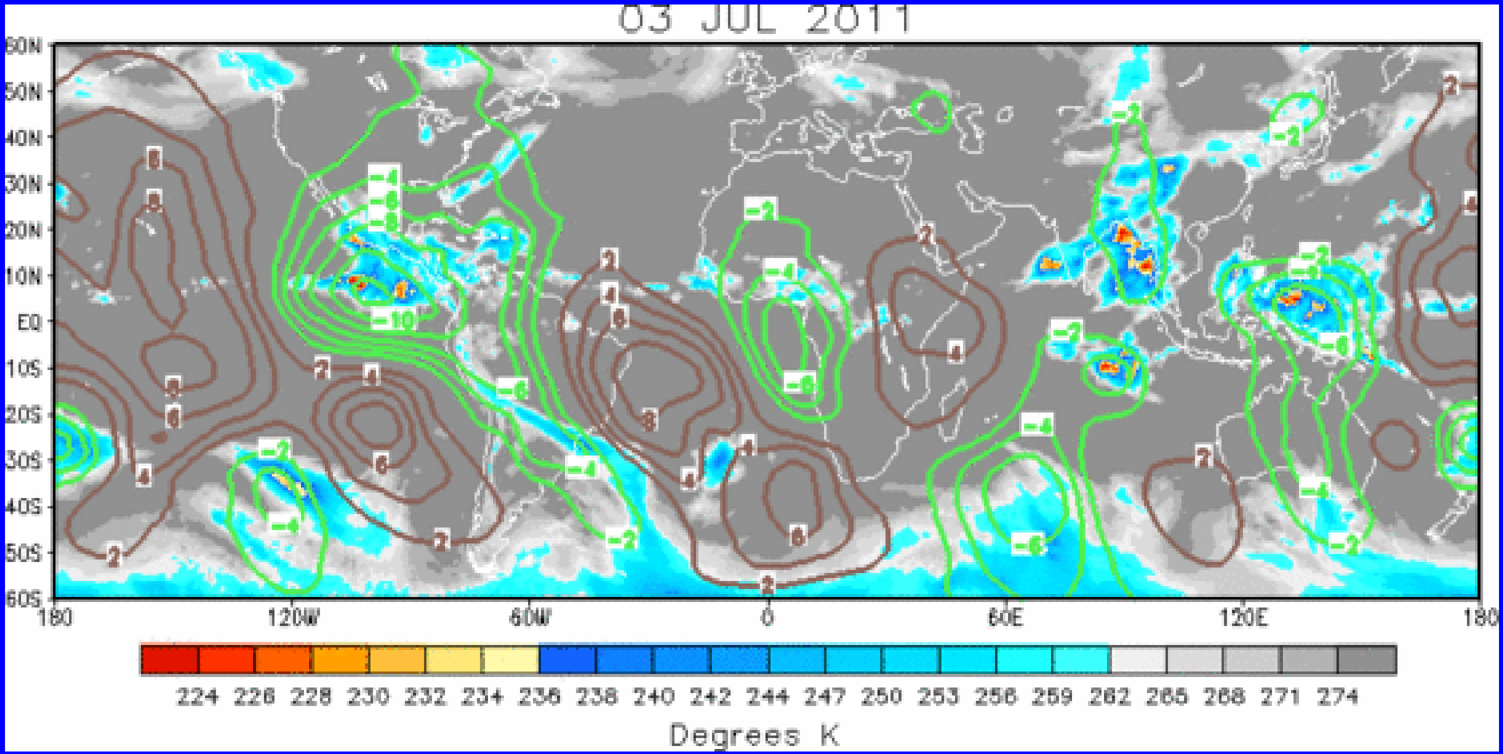
Robust MJO activity was observed during late April into May as upper-level divergence (green shades) shifted eastward from the Indian Ocean beginning in early May followed by upper-level divergence (brown shades).

During parts of June, very fast eastward propagation is evident and mainly associated with higher frequency sub-seasonal coherent tropical variability.

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



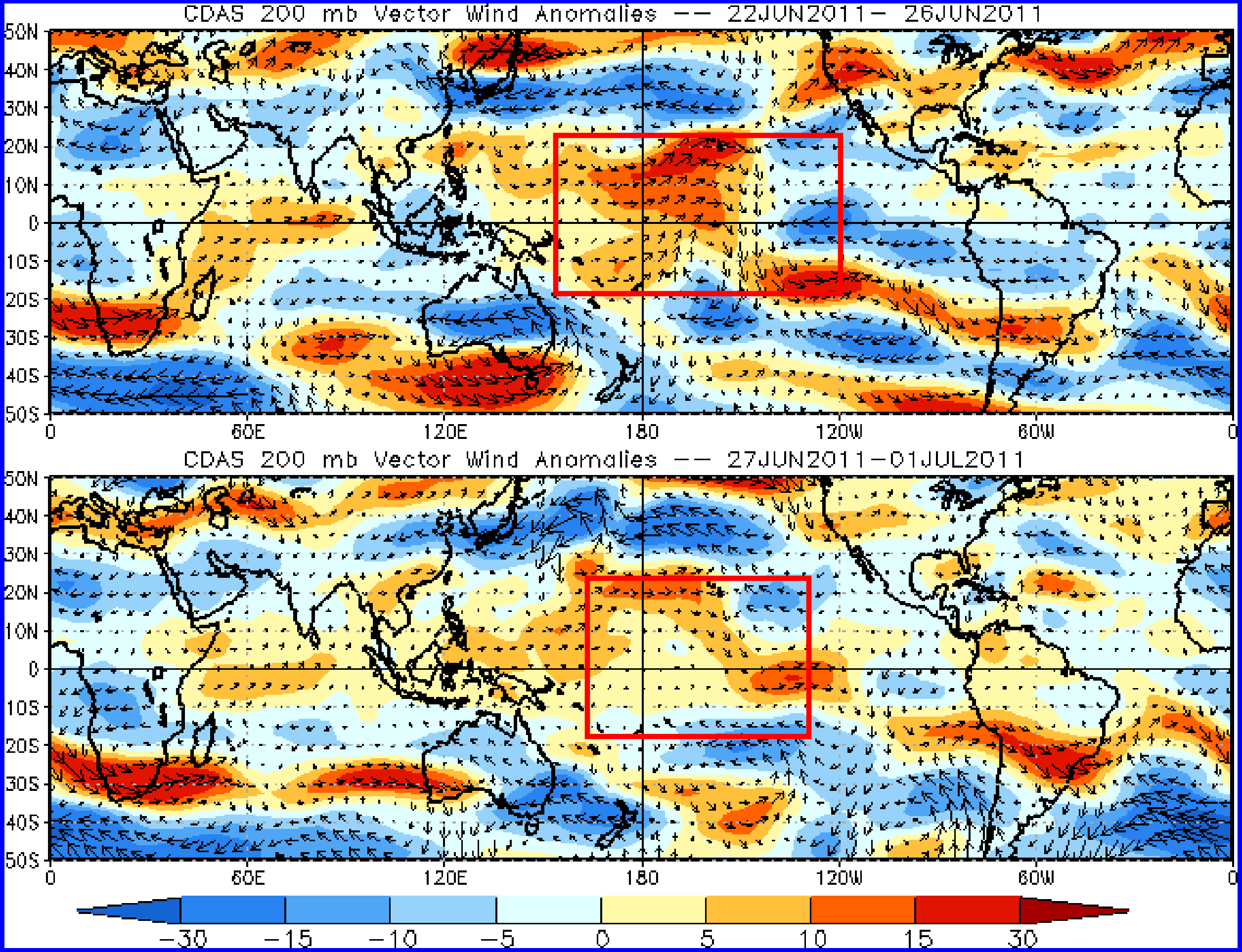
The large scale velocity potential pattern shows strong anomalous upper-level divergence over the Americas and western North Pacific, while anomalous upper-level convergence is observed primarily over the Central Pacific.

200-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 continue across the central Pacific Ocean (red box), but have weakened during the last 7 days.

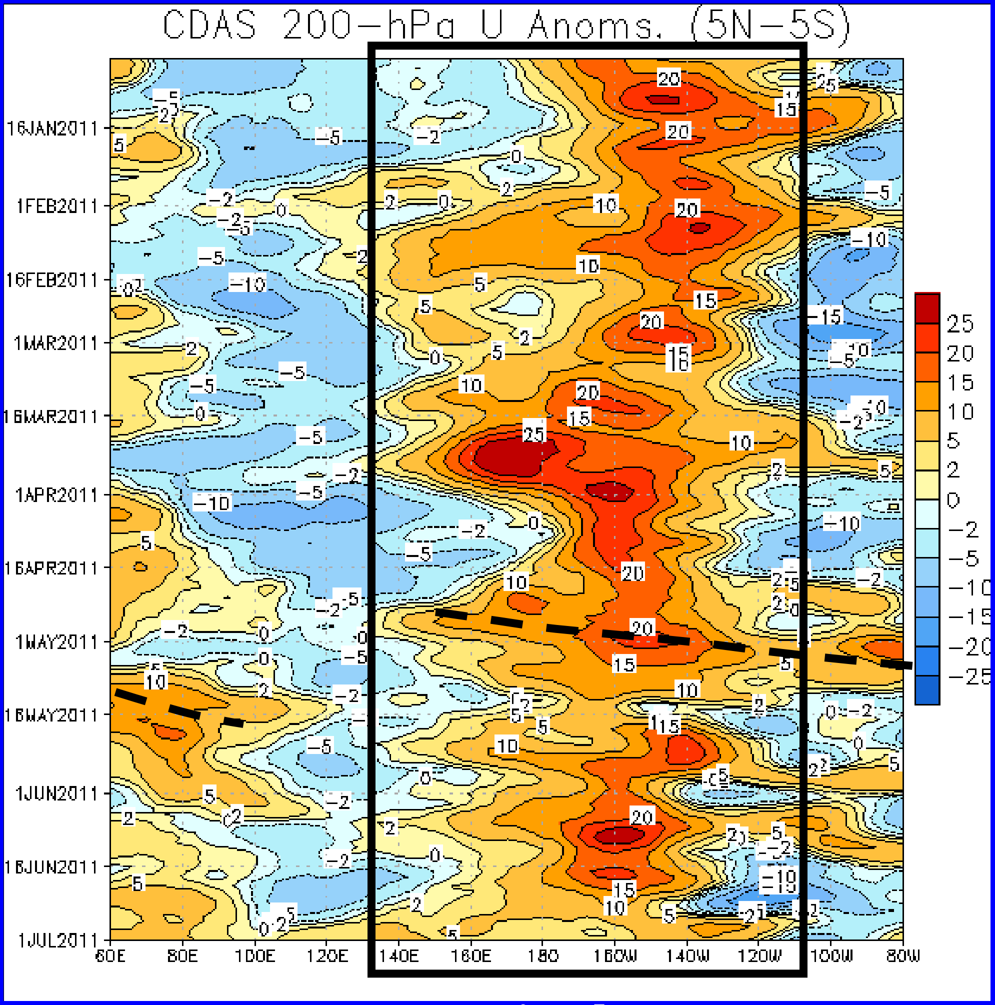
Westerly anomalies are evident across the equatorial Indian Ocean, indicating a reduced monsoon flow.

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



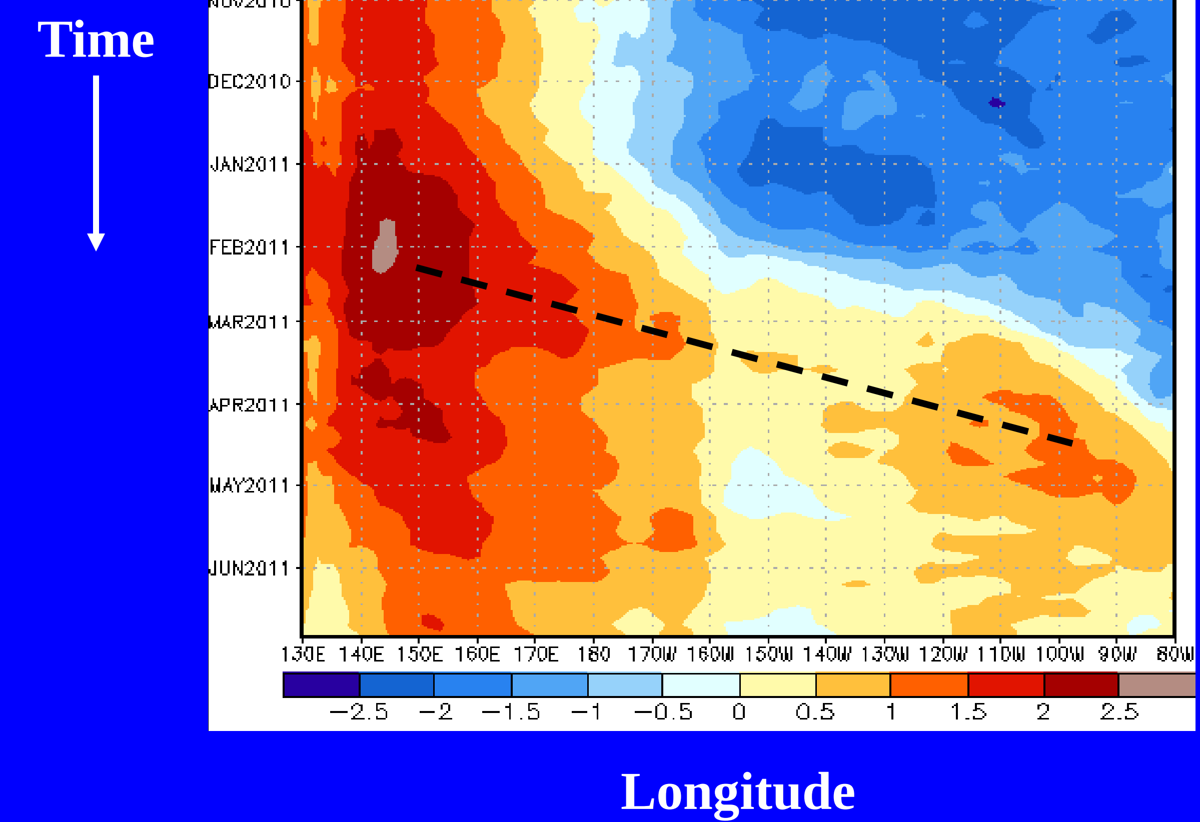
Longitude

Westerly anomalies persisted across a large area from the Maritime Continent to the central Pacific (black solid box) since November.

Significant eastward propagation of westerly anomalies was evident in late April and May (dashed line) associated with the MJO.

Evidence of faster eastward moving waves is present during June.

Weekly Heat Content Evolution in the Equatorial Pacific



Beginning in April 2010 positive heat content anomalies decreased across the Pacific in association with the upwelling phase of a Kelvin wave and later during the early summer due to the development of La Nina.

Since the beginning of January 2011, positive heat content anomalies shifted eastward, while negative heat content anomalies weakened and then became positive across much of the Pacific basin.

An oceanic Kelvin wave (dashed line) shifted eastward during February and March 2011. The entire Pacific basin now indicates above-normal integrated heat content.

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).**

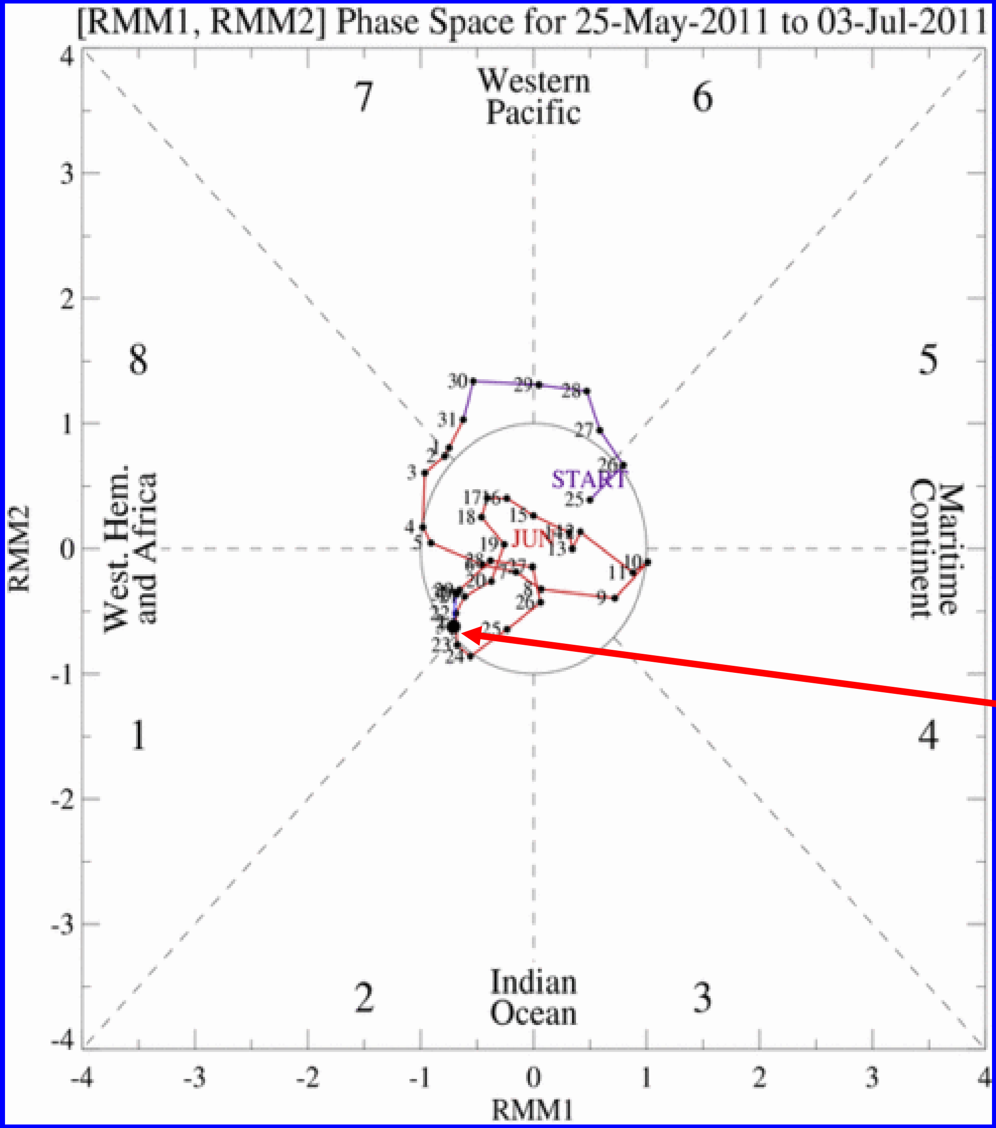
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- **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).**

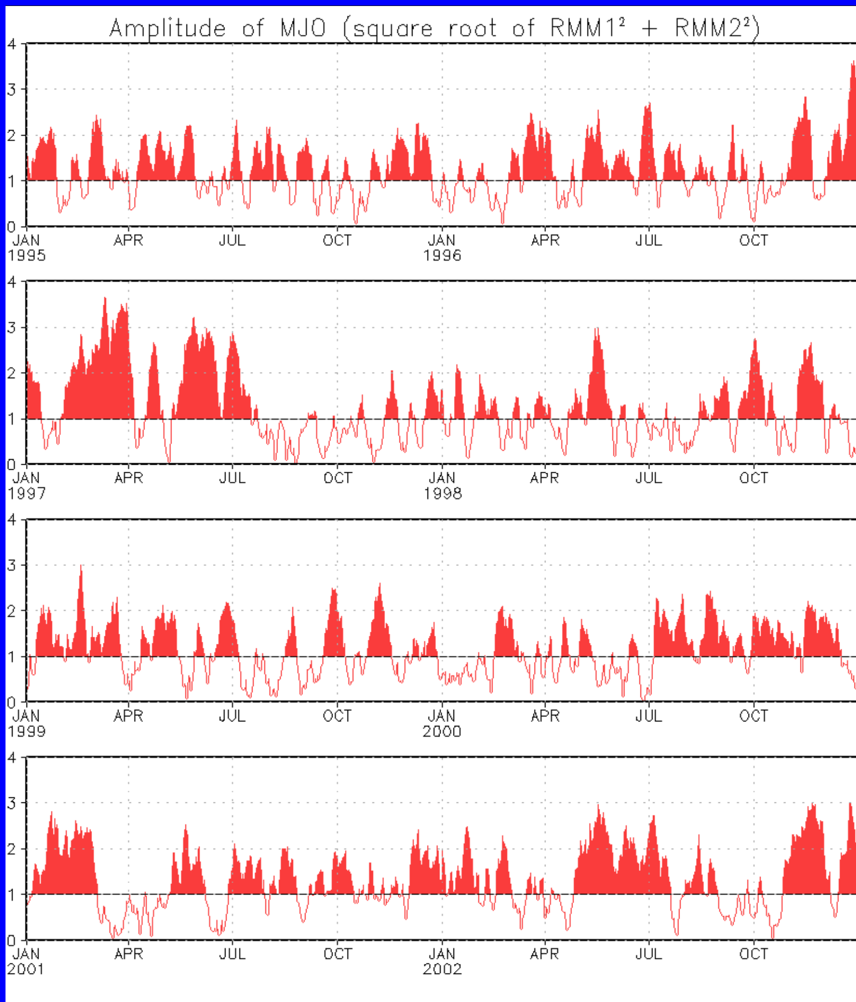
MJO Index -- Recent Evolution

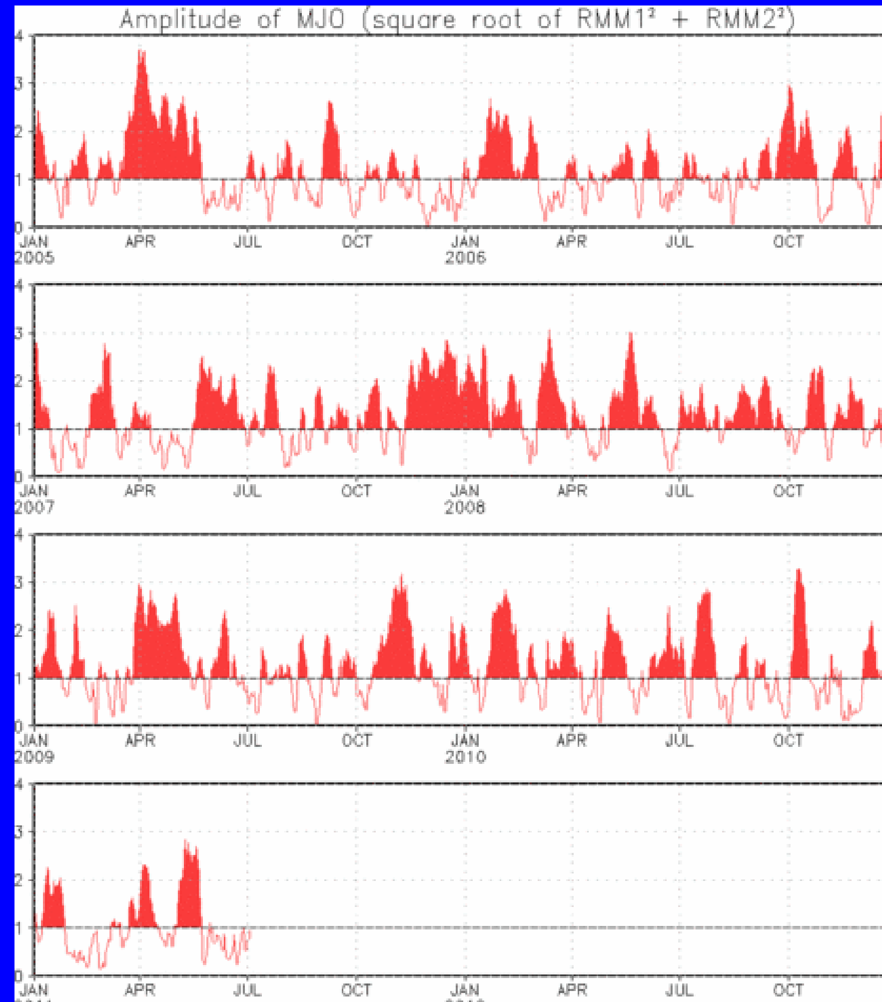


- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the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

The MJO index indicates continued weak activity during the past week.

MJO Index – Historical Daily Time Series





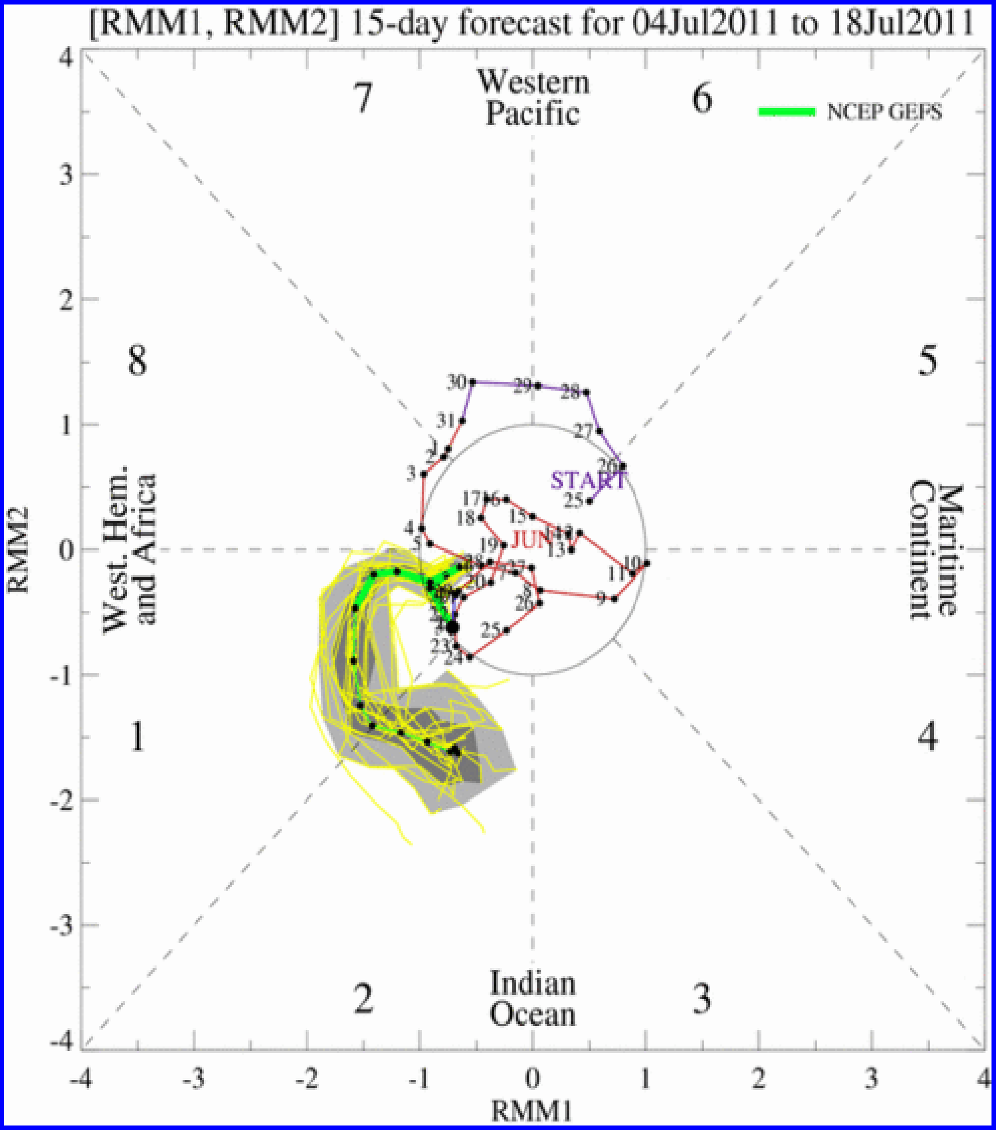
Time series of daily MJO index amplitude from 1995 to present. Plots put current MJO activity in historical context.

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

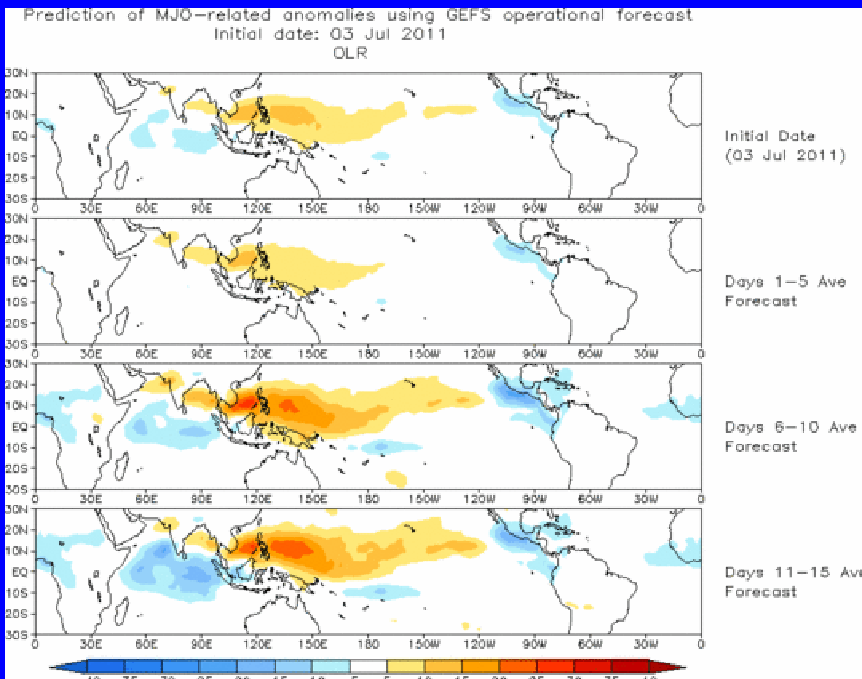


The ensemble GFS forecasts generally indicate a continued weak signal during most of Week-1 and some projection of a stronger and more coherent signal later in Week-1 and during Week-2.

Ensemble Mean GFS MJO Forecast

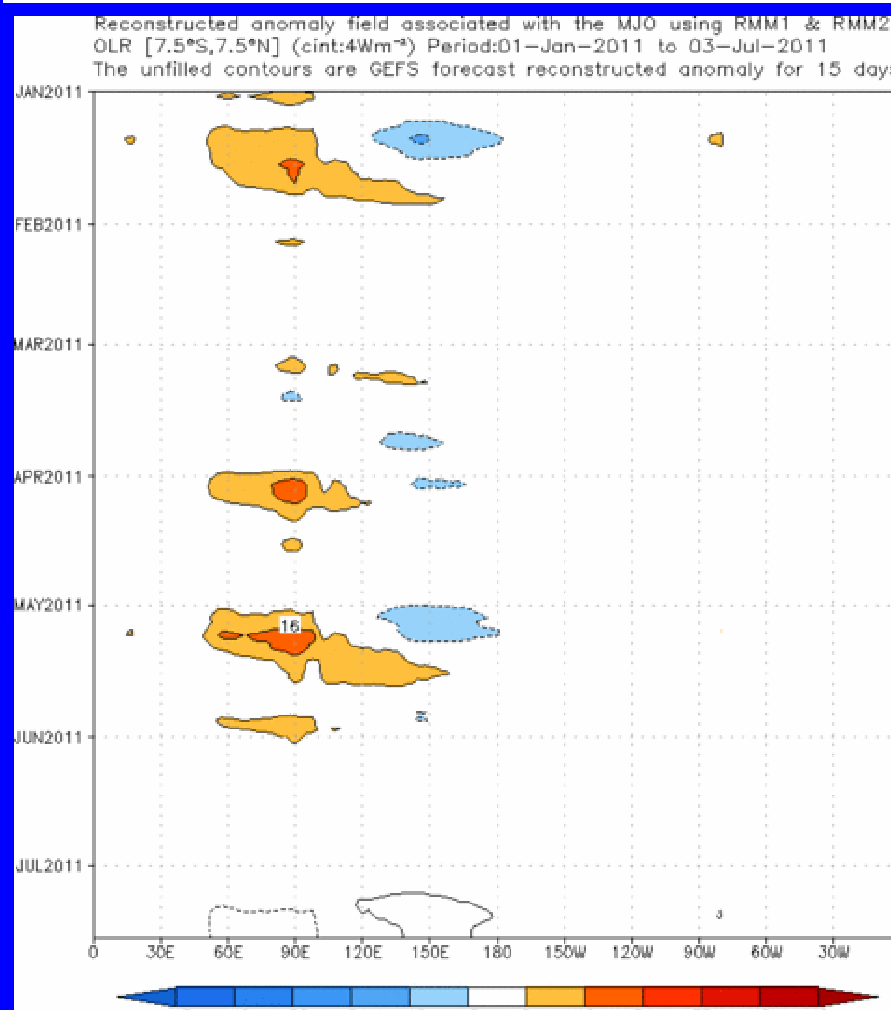
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons)

Spatial map of OLR anomalies for the next 15 days



The GEFS ensemble mean forecast indicates slight strengthening during late Week-1 and Week-2 with enhanced (suppressed) convection from Africa to the Indian Ocean (South Asia and Western North Pacific).

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



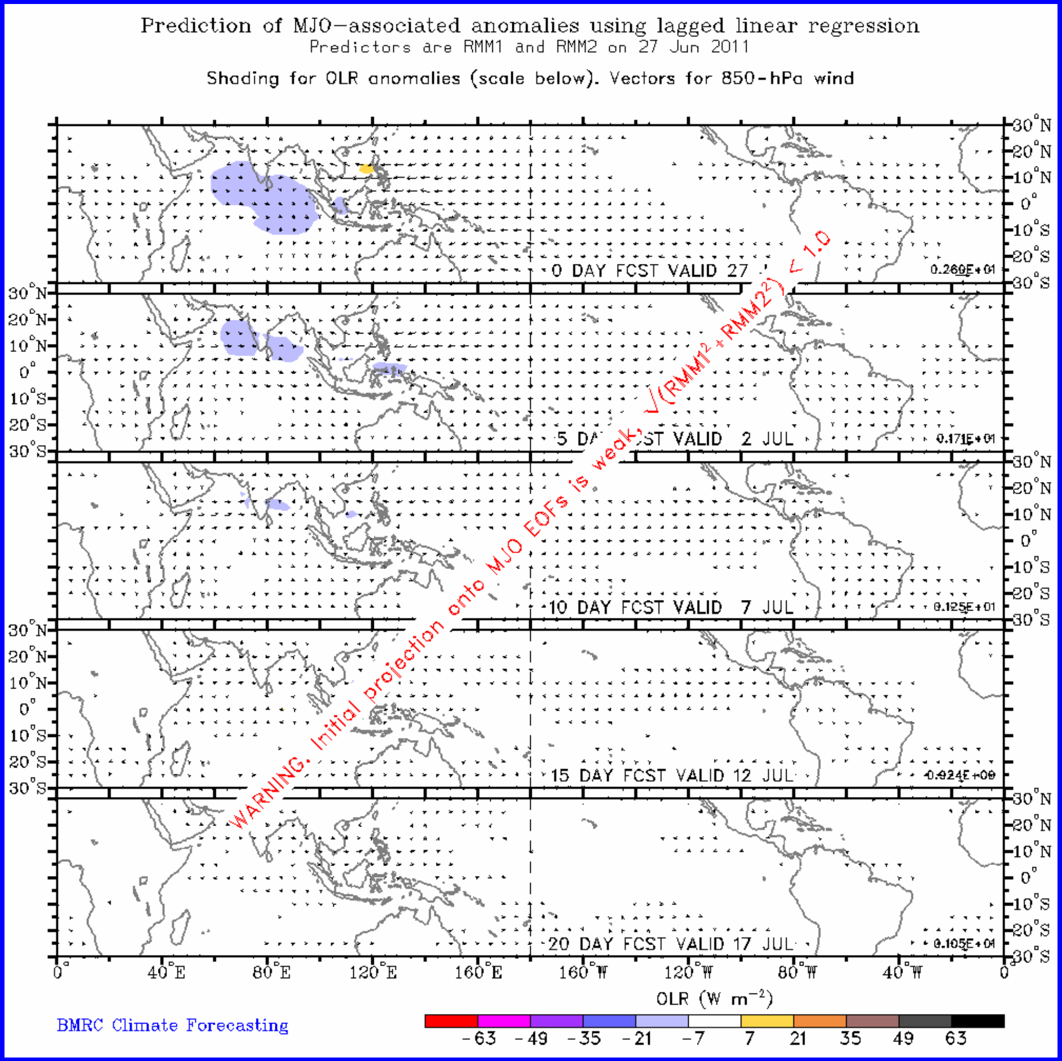
Statistical MJO Forecast

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)

Spatial map of OLR anomalies and 850-hPa vectors for the next 20 days

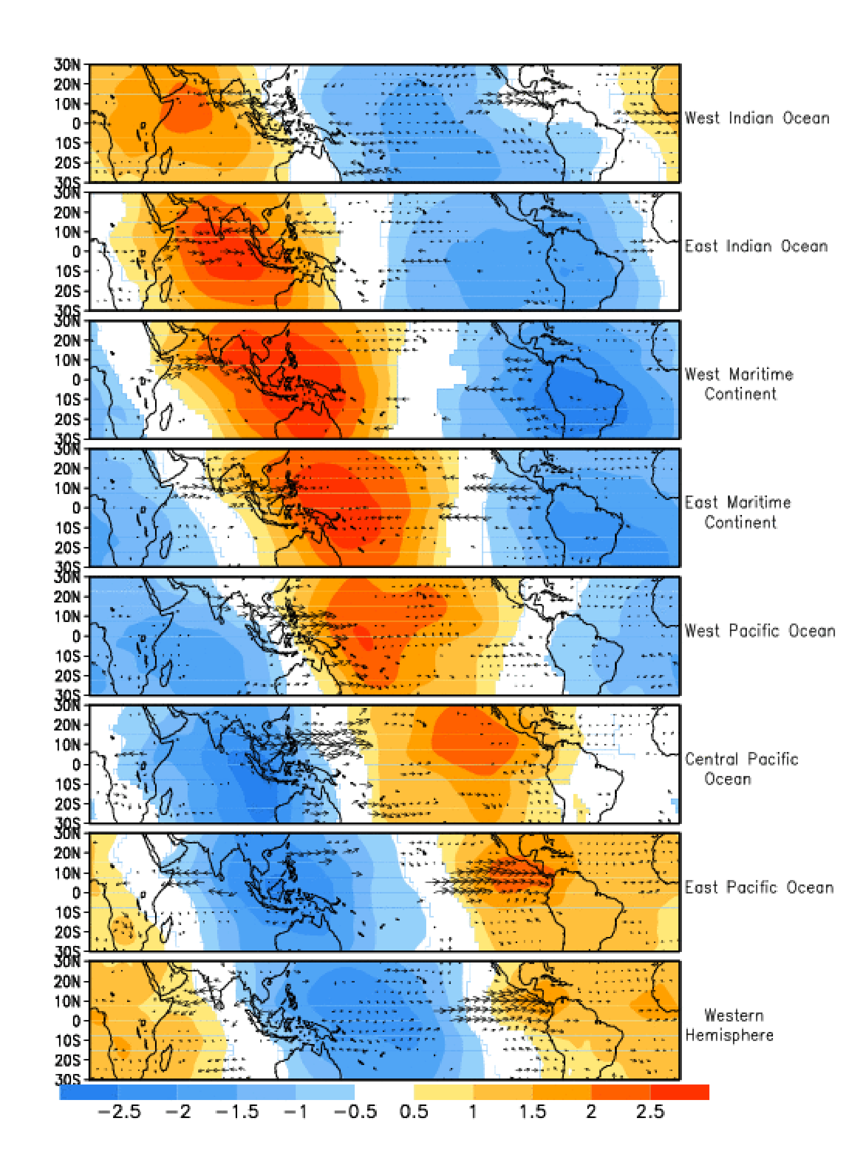
(Courtesy of the Bureau of Meteorology Research Centre - Australia)

The forecast calls for little MJO activity during the period.

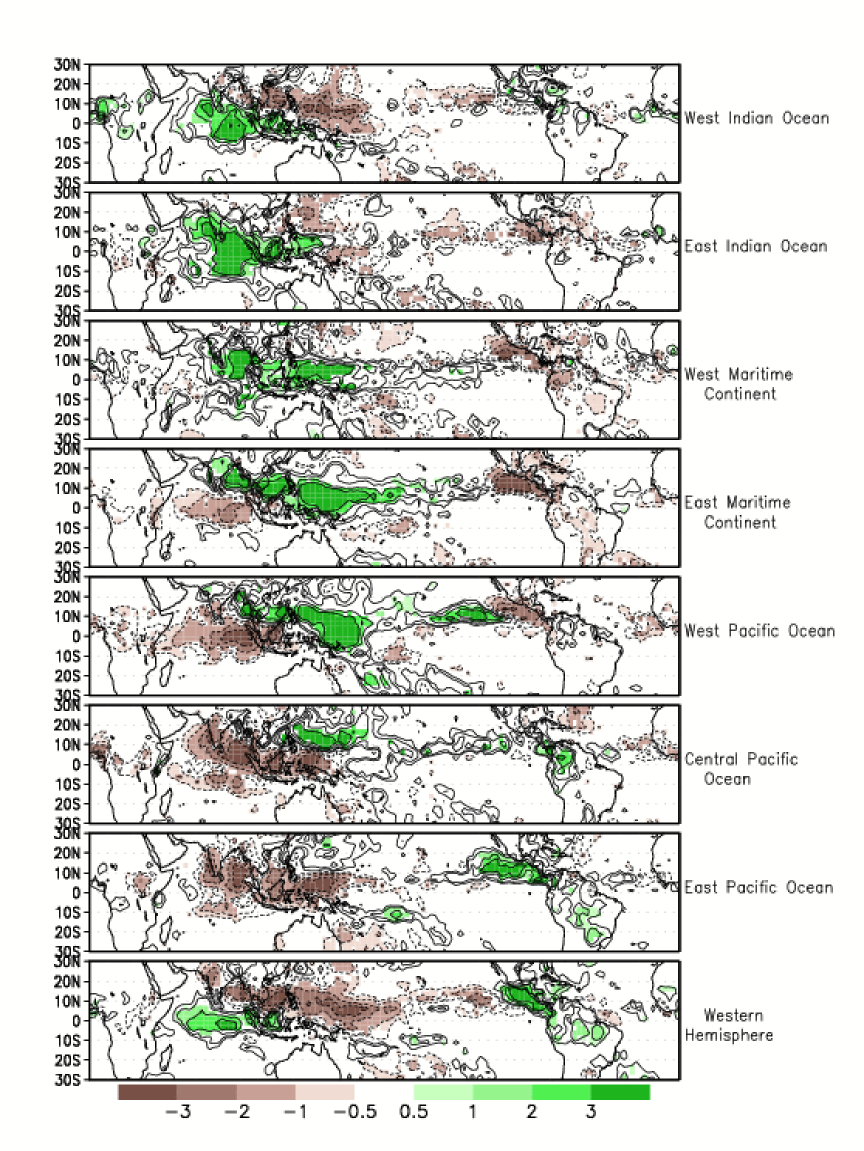


MJO Composites – Global Tropics

850-hPa Wind Anomalies (May-Sep)

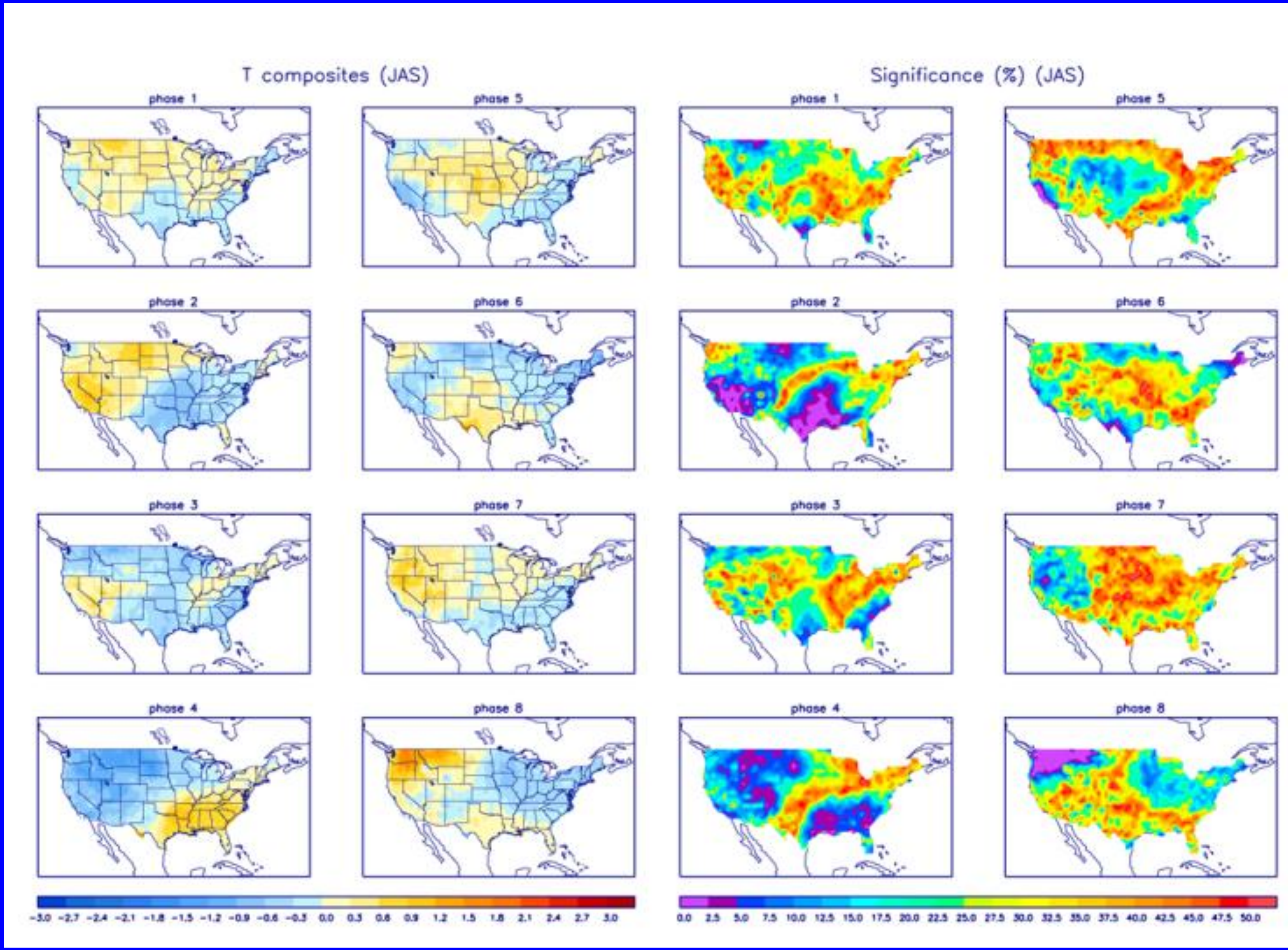


Precipitation Anomalies (May-Sep)



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. Dark blue and purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.

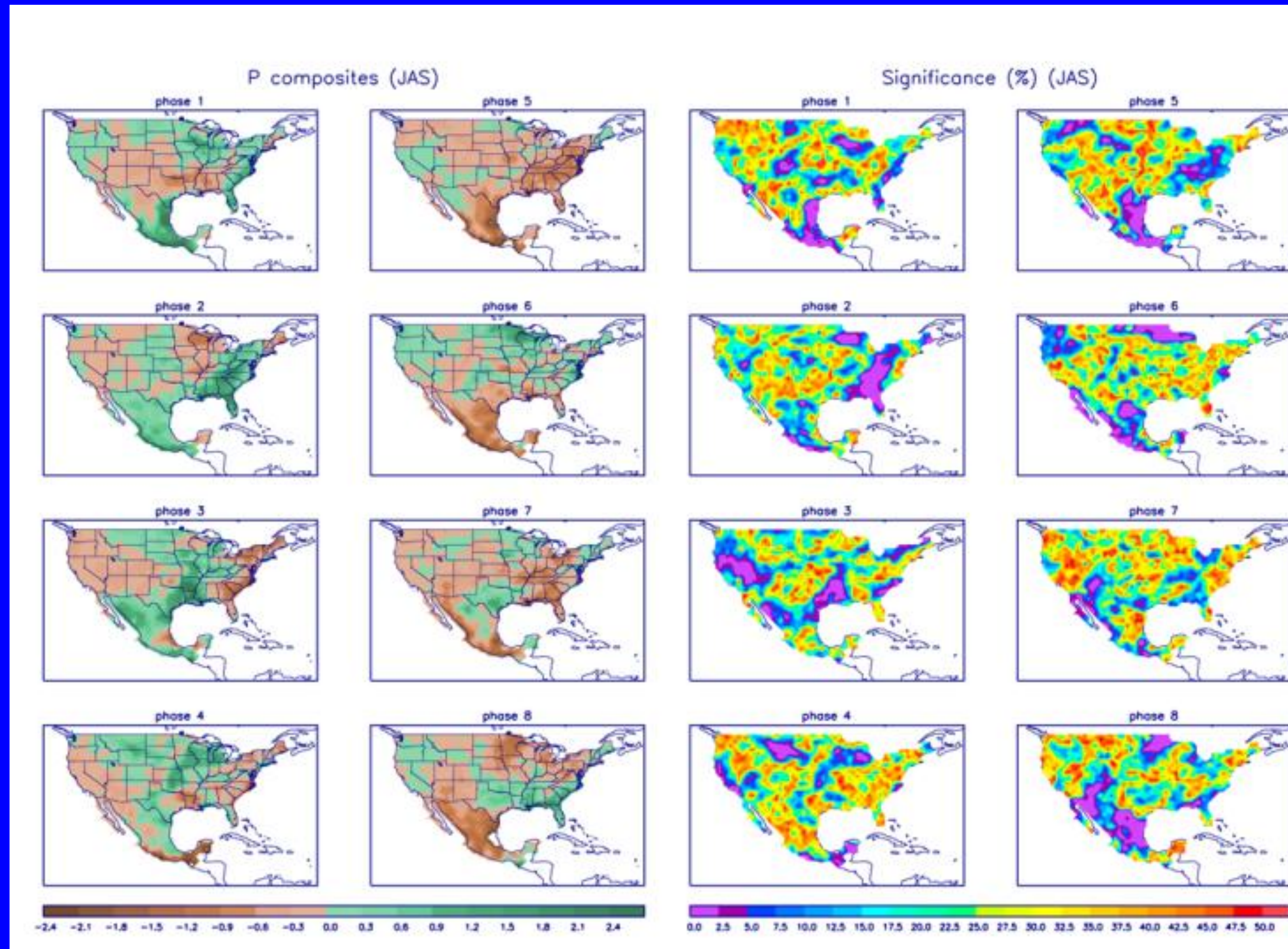


Zhou et al. (2010): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, Submitted.

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. Dark blue and purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**



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