

Madden-Julian Oscillation:

Recent Evolution, Current Status and Predictions



Update prepared by the Climate Prediction Center
Climate Prediction Center / NCEP
18 March 2019

Overview

- The Madden-Julian Oscillation remains across the Maritime Continent, although per the RMM perspective, its amplitude has decayed substantially over the past 7 days.
- This decay appears to be two-fold in nature, tied to a Kelvin wave across the western hemisphere and the removal of the long-term mean signal while the current El Niño event has strengthened. The former is roughly 180° out of phase with the MJO, helping to split the signal. The latter is biasing the RMM index towards Phases 7/8 and away from Phases 3/4.
- Both dynamical and statistical model guidance generally propagate the active MJO envelope eastward across the Maritime Continent and into the West Pacific over the next two weeks, although at a relatively small amplitude.
- Given the low frequency state in the Pacific (i.e. anomalously warm sea-surface temperatures in addition to enhanced low-level convergence and upper-level divergence near the Date Line), there is little reason to believe the MJO will not make it into the Pacific during the next two weeks despite the apparent weakness from the RMM perspective.

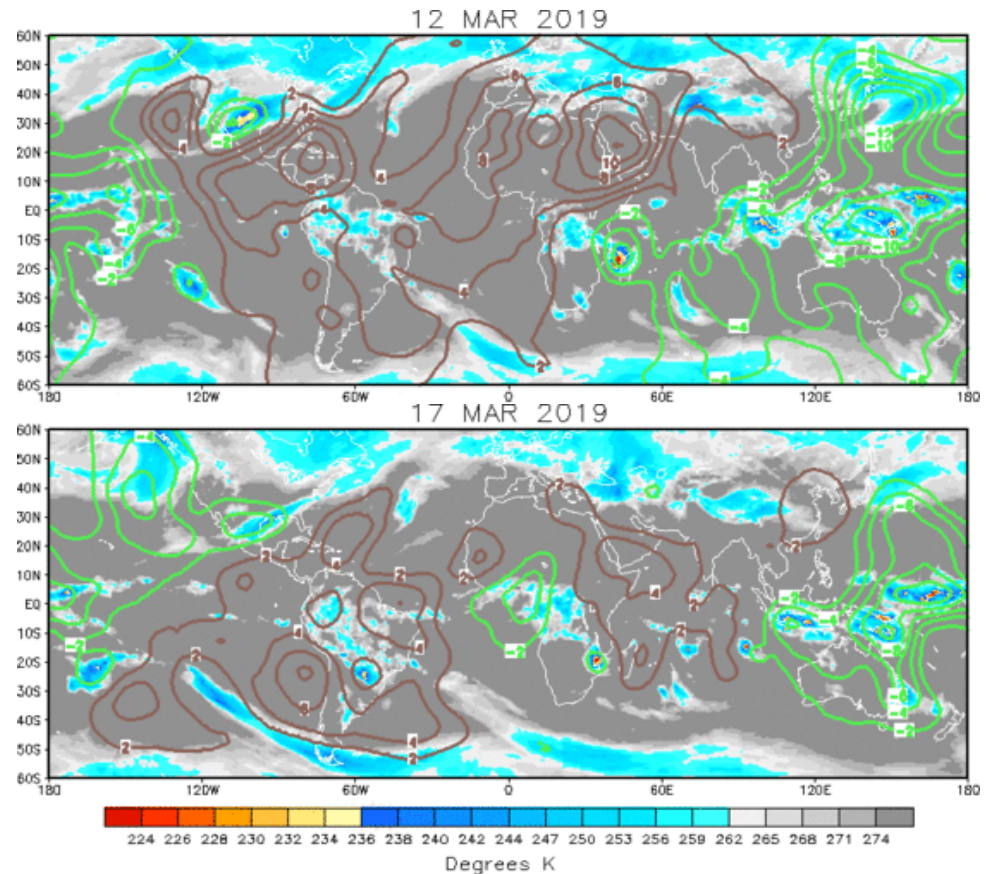
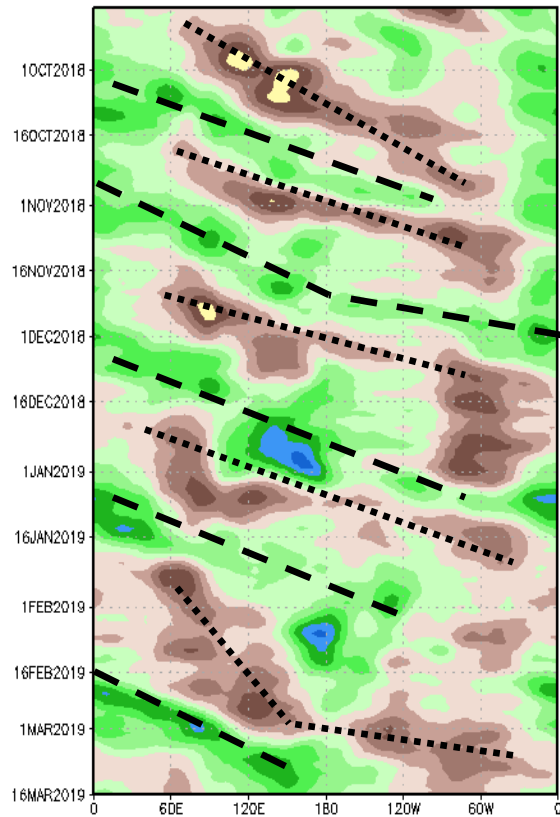
A discussion of potential impacts for the global tropics and those related to the U.S. are updated on Tuesday at:
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php>

200-hPa Velocity Potential Anomalies

Green shades: Anomalous divergence (favorable for precipitation).

Brown shades: Anomalous convergence (unfavorable for precipitation).

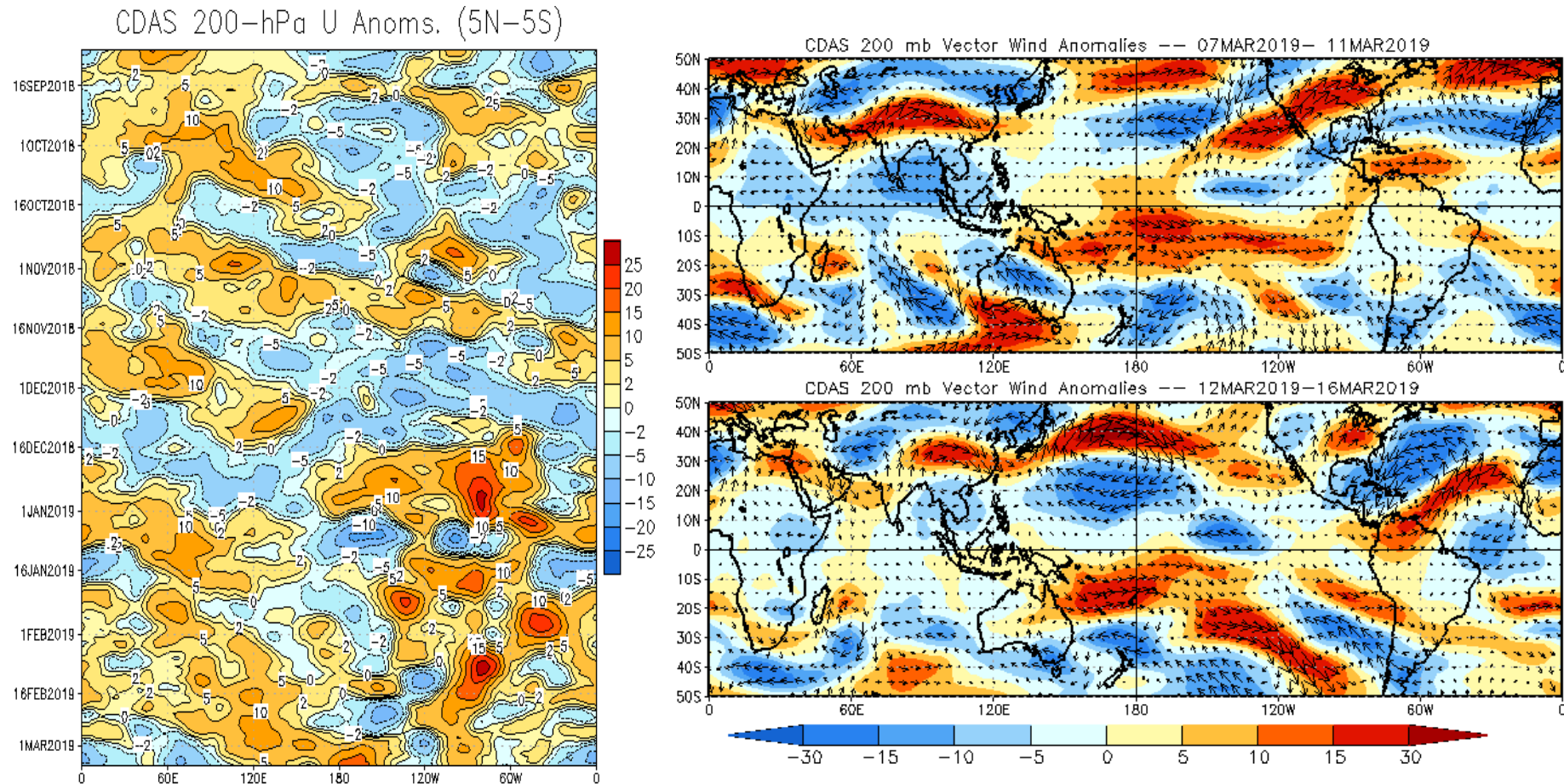
200-hPa Velocity Potential Anomaly: 5N-5S
5-day Running Mean



- The MJO has been active since September 2018.
- Since the start of 2019, atmospheric Kelvin and equatorial Rossby wave activity have also been high.
- The most recent eastward moving envelope of enhanced divergence is currently near the Date Line, coincident with the persistent low frequency footprint that has been present over the last 6 months, save for periods of destructive interference with the suppressed phase of the MJO.

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

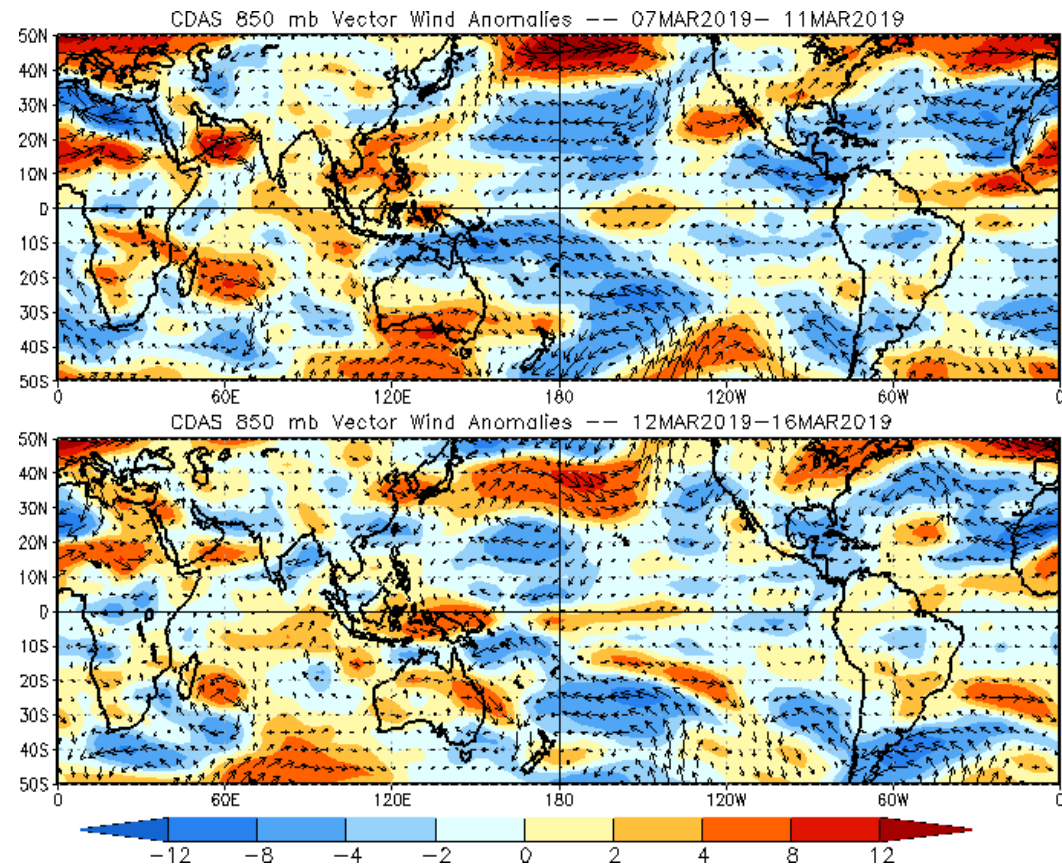
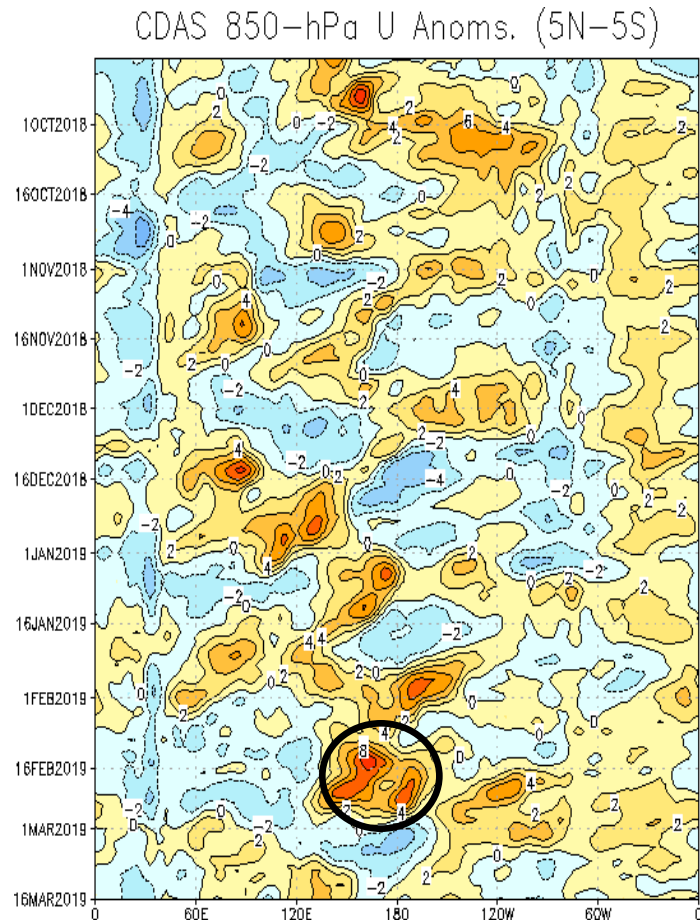
Shading denotes the zonal wind anomaly. **Blue shades:** Anomalous easterlies. **Red shades:** Anomalous westerlies.



- The MJO activity since September 2018 is also evident in the upper-level wind field.
- There has been anomalous flow into the southwestern U.S. in recent days, with a tropical connection apparent between the 7th and 11th, that has helped bring above-normal precipitation to the region.
- More recently, there is less evidence of tropical connections to the subtropics of the Northern Hemisphere, with the most pronounced being an anomalous trough across the Leeward Islands and northern South America.

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

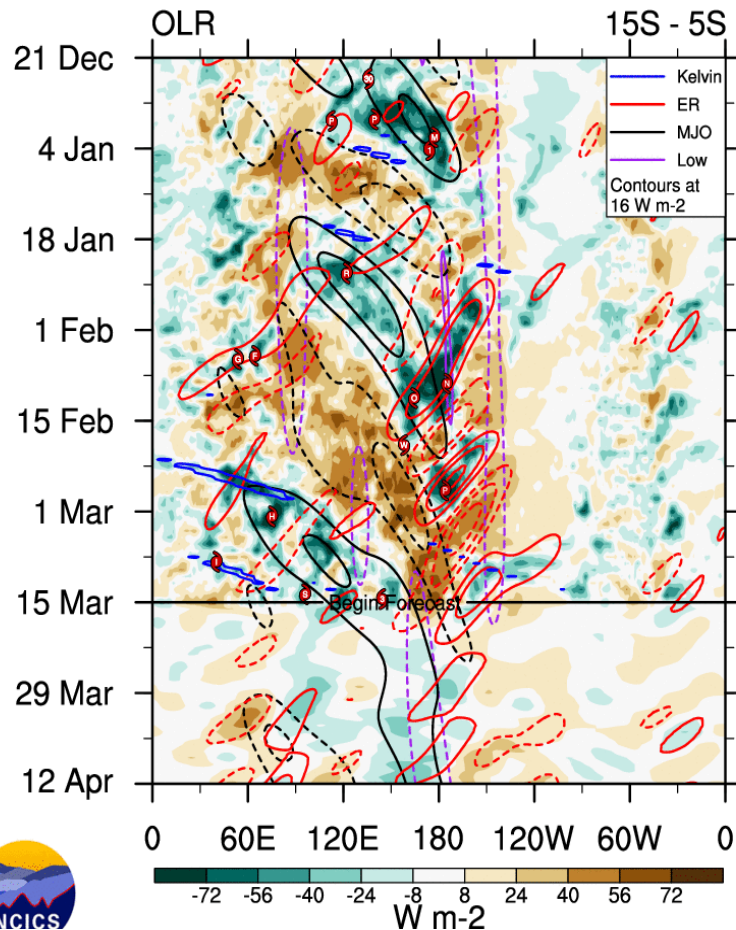
Shading denotes the zonal wind anomaly. **Blue shades:** Anomalous easterlies. **Red shades:** Anomalous westerlies.



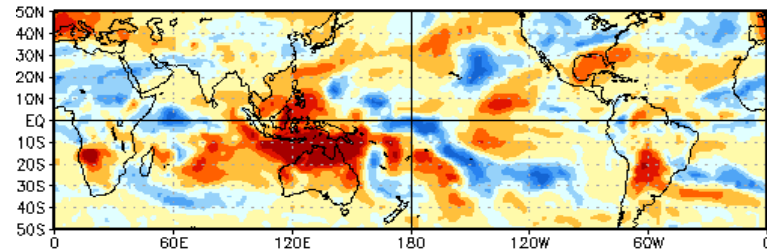
- The most recent westerly wind burst occurred around mid-February just west of the Dateline, partially the result of constructive interference between the MJO and an equatorial Rossby wave.
- There has been anomalous flow into the southwestern U.S. in recent days, with a tropical connection apparent between the 7th and 11th, that has helped bring above-normal precipitation to the region.

Outgoing Longwave Radiation (OLR) Anomalies

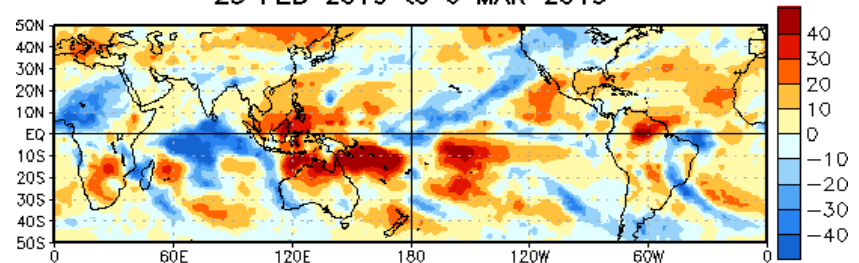
Blue shades: Anomalous convection (wetness). Red shades: Anomalous subsidence (dryness).



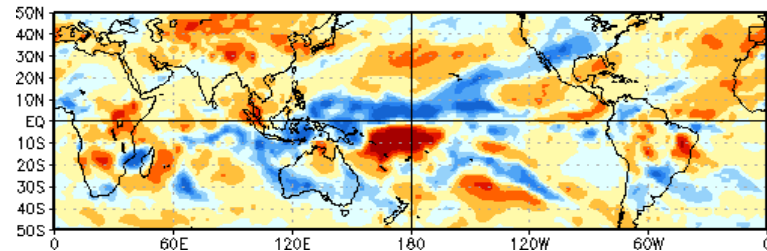
OLR Anomalies
15 FEB 2019 to 24 FEB 2019



25 FEB 2019 to 6 MAR 2019

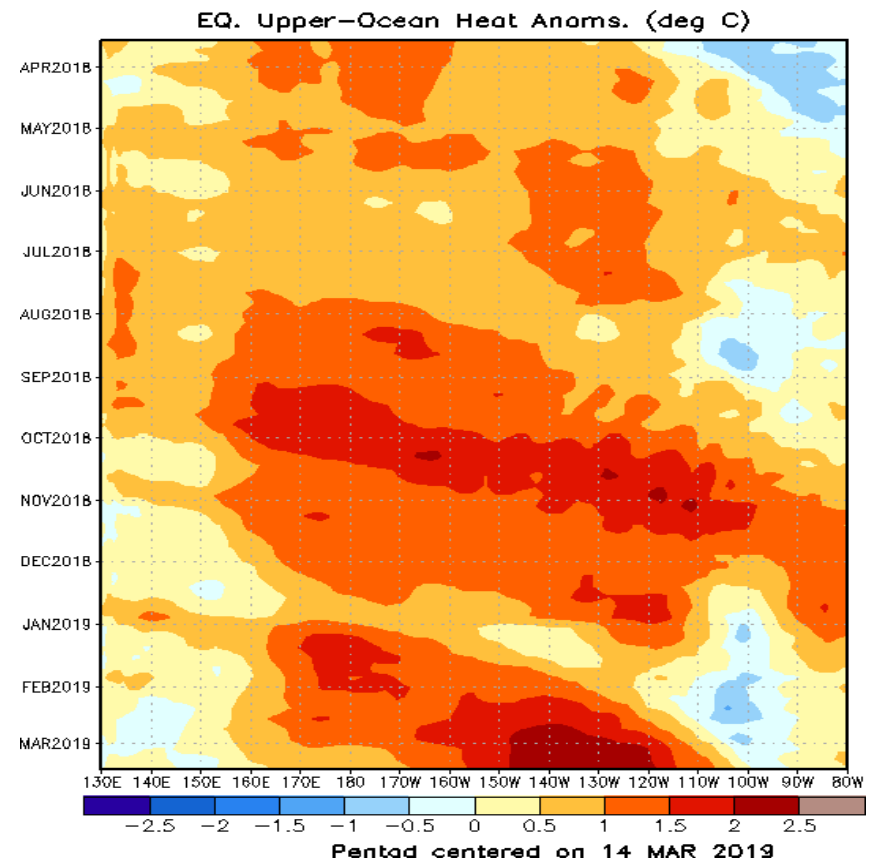
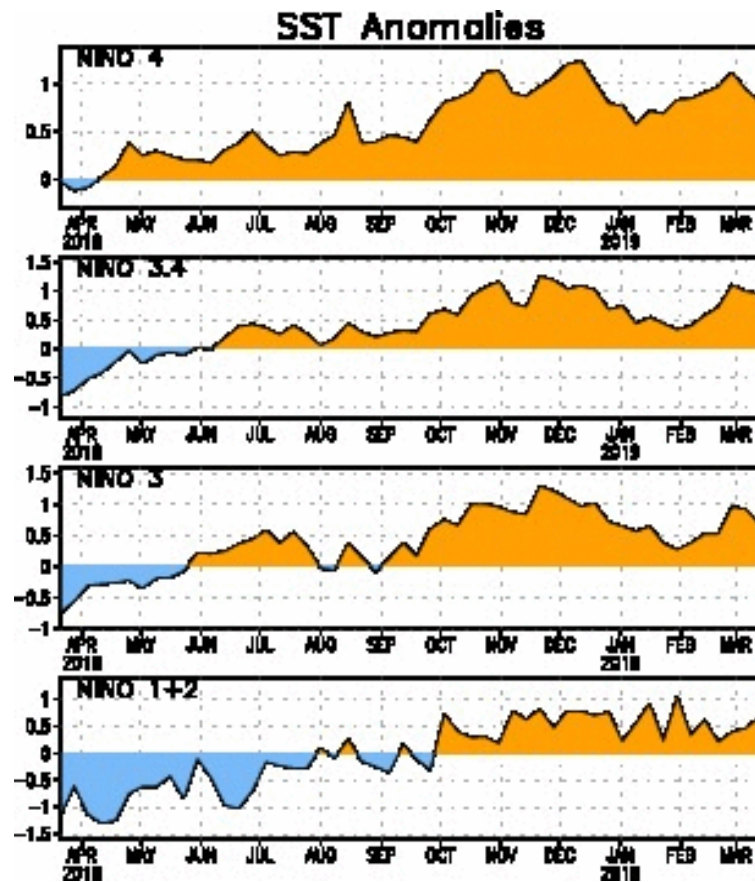


7 MAR 2019 to 16 MAR 2019



- The eastward propagating enhanced phase of the MJO (**solid black contours**) has helped flip the Maritime Continent towards wetter than normal conditions during mid-March, in spite of the low frequency signal supporting persistently dry conditions here (**dashed purple contours**).
- Conversely, the Indian Ocean has dried out in the most recent period as the suppressed phase of the MJO has shifted into the basin (**dashed black contours**).
- A Kelvin wave (**solid blue contours**) is currently over the Western Hemisphere.

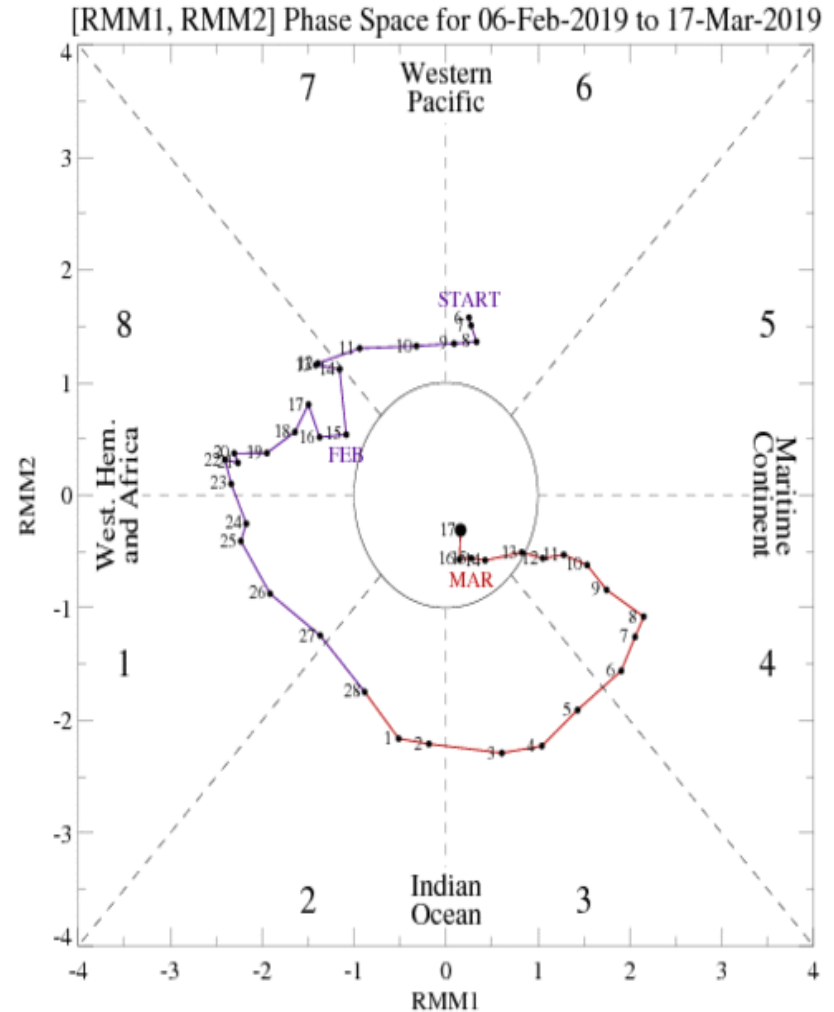
SSTs and Weekly Heat Content Evolution in the Equatorial Pacific



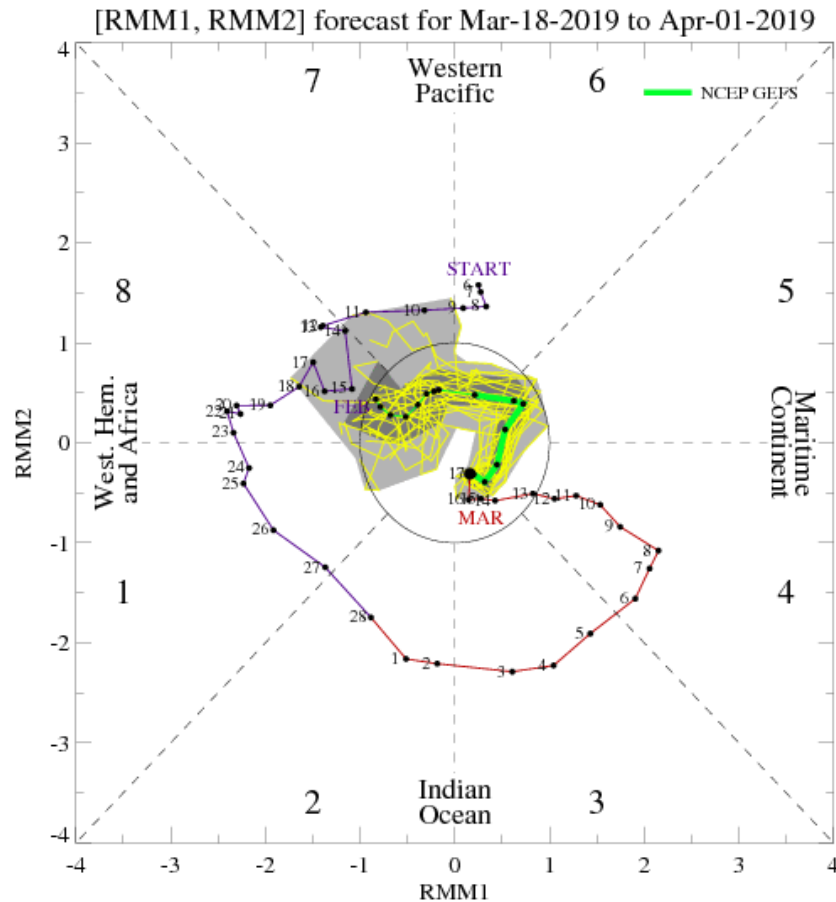
- Positive oceanic heat content anomalies have been observed over most of the Pacific basin since last April.
- There was a downwelling Kelvin wave last Fall and another that began around the turn of the year. These likely helped push the thermocline down and develop/reinforce the current El Niño.
- The greatest near-surface anomalous warm water volume is presently between 145°W-120°W (western half of Niño 3 region, eastern half of Niño 3.4 region).

MJO Index: Recent Evolution

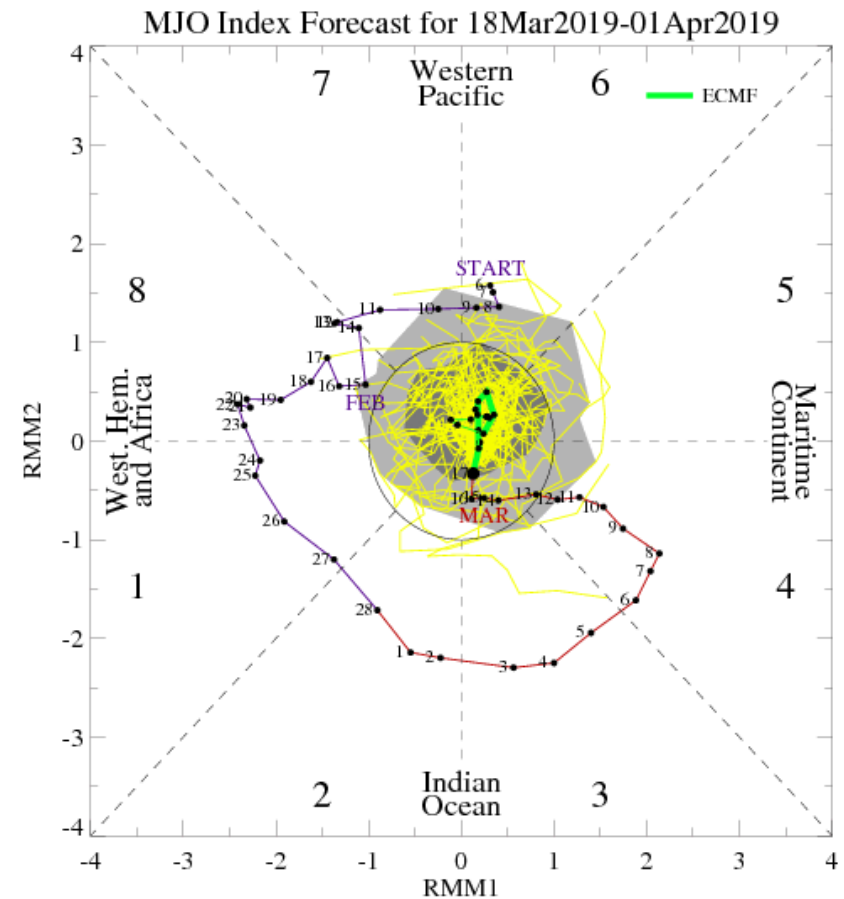
- The MJO is currently near the origin, indicative of an incoherent MJO, after weakening across the western Maritime Continent in recent days.
- The transition toward El Niño over the last 120 days has been serving to “pull” the RMM index toward Phases 7 and 8, with persistent westerlies and enhanced convection near the Date Line. When this signal is removed from this graphic, it results in a relatively weaker signal in Phases 3/4, and is likely responsible for the MJO’s “decay”.
- In addition, the Kelvin wave noted across the Western Hemisphere (apparent on the OLR hovmöller in slide 6) may be helping to weaken the RMM projection by splitting the signal between two centers of action that are roughly 180° out of phase.



MJO Index: Forecast Evolution



GEFS Forecast



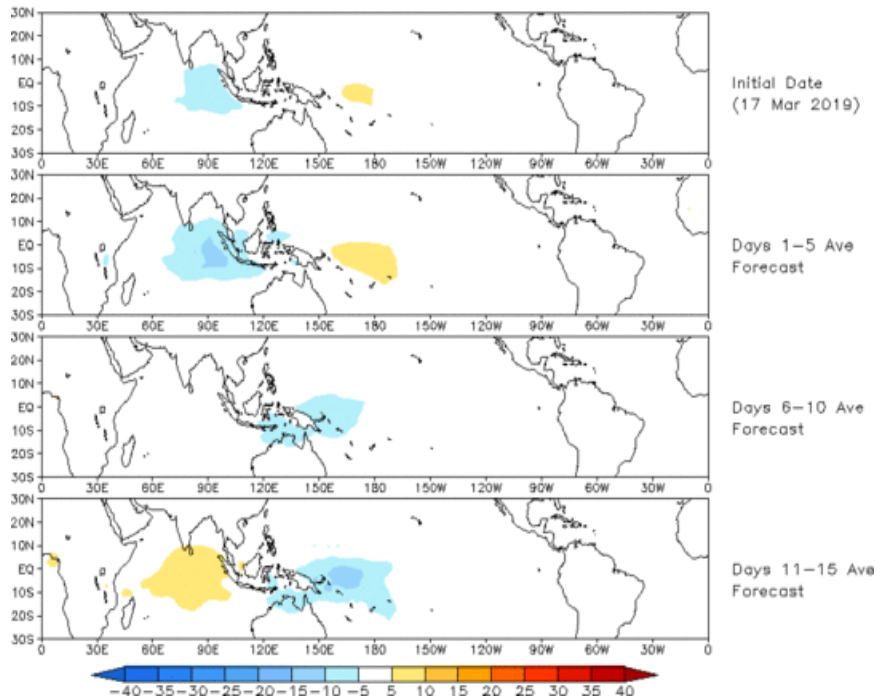
ECMWF Forecast

- The GEFS and ECMWF forecasts suggest that the MJO will remain weak through the end of March, with varied degrees of eastward propagation.
- The ECMWF is less progressive with its ensemble mean perspective of the MJO envelope, tied to a diverse range of solutions that serve to largely cancel out on the whole. The GEFS is much more tightly clustered together around a gradual eastward propagation.

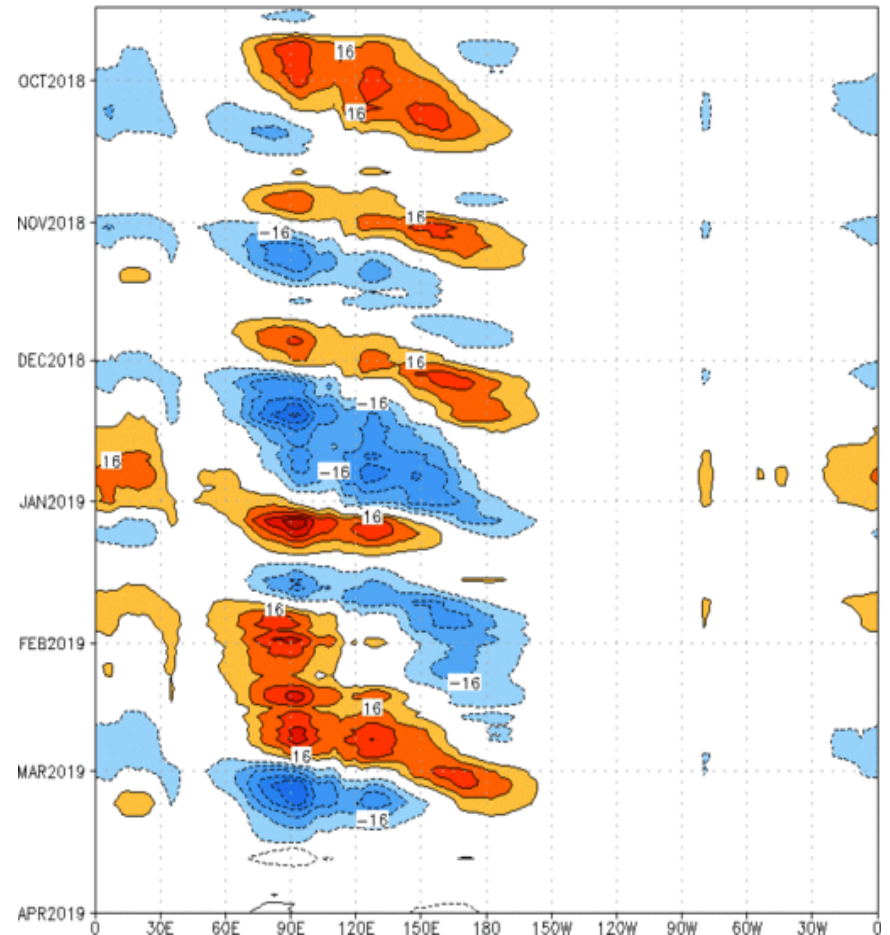
MJO: GEFS Forecast Evolution

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.)

Prediction of MJO-related anomalies using GEFS operational forecast
Initial date: 17 Mar 2019
OLR



Reconstructed anomaly field associated with the MJO using RMM1 & RMM2
OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:15-Sep-2018 to 17-Mar-2019
The unfilled contours are GEFS forecast reconstructed anomaly for 15 days

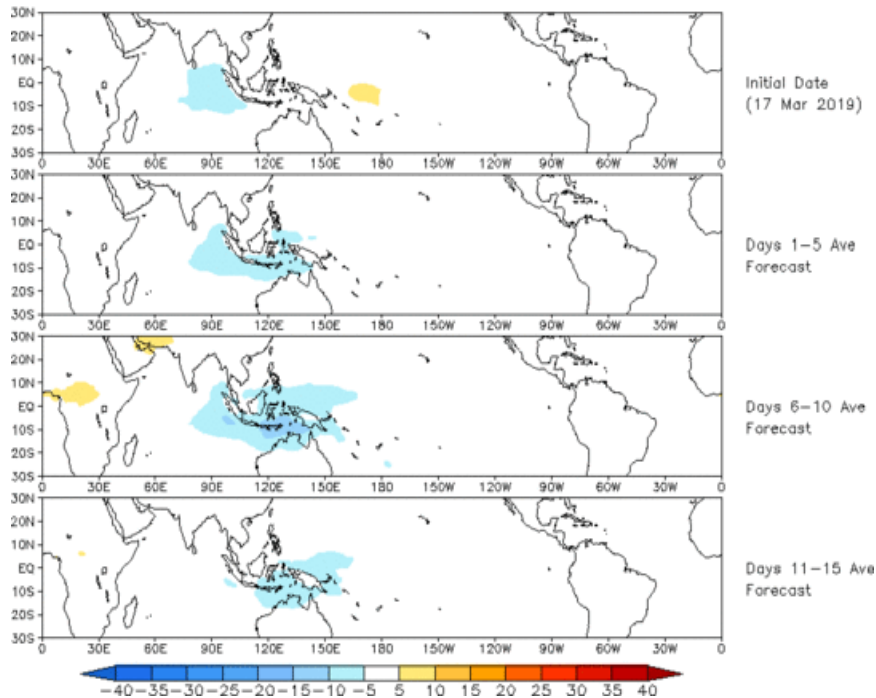


- Active convection associated with the active phase of the MJO is forecast to enter the West Pacific in the next two weeks, albeit at a fairly weak magnitude.
- Suppressed convection is forecast to build across the Indian Ocean late in Week-2, also consistent with this progression.

MJO: Constructed Analog Forecast Evolution

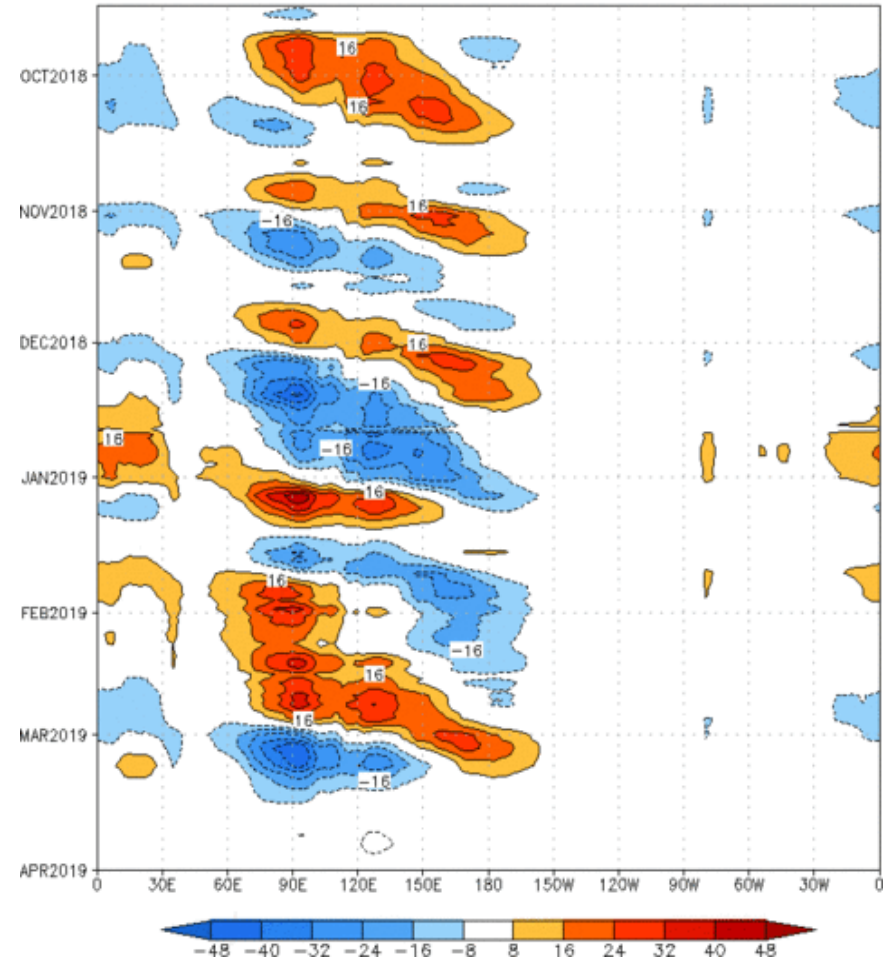
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

OLR prediction of MJO-related anomalies using CA model reconstruction by RMM1 & RMM2 (17 Mar 2019)



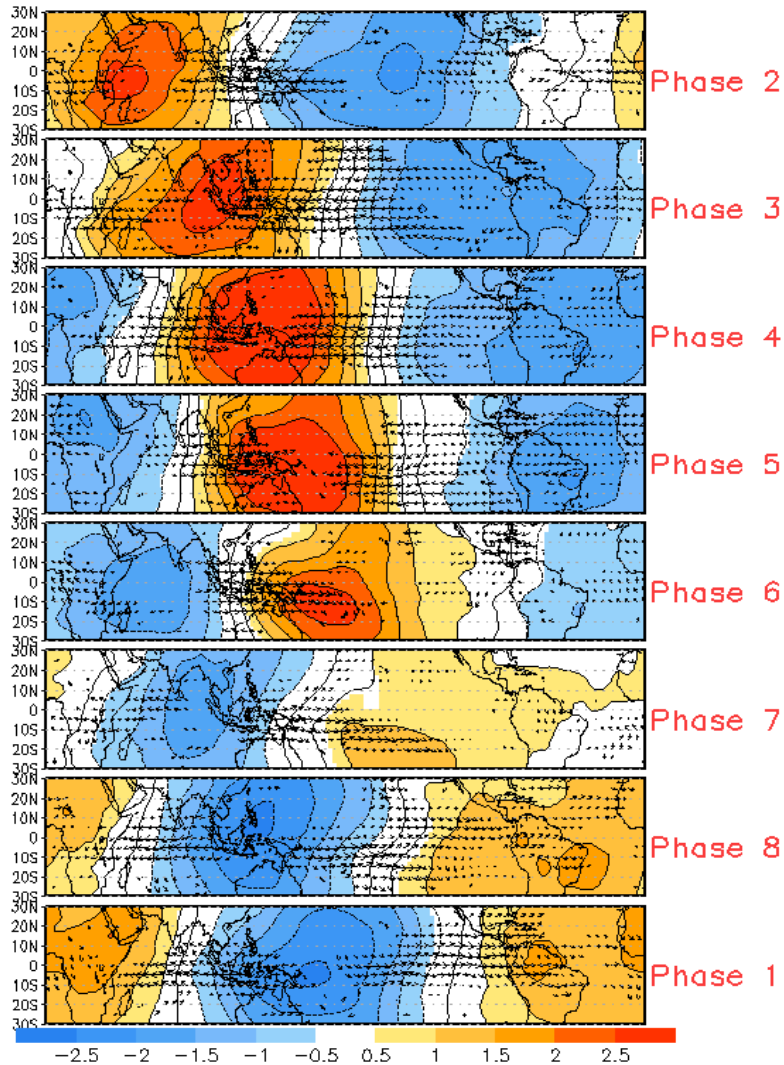
- The constructed analog outlook also forecasts the MJO to cross the Maritime Continent during the next two weeks, although slower than the GEFS. Convective anomalies tied to the MJO are also fairly weak in this perspective.

Reconstructed anomaly field associated with the MJO using RMM1 & RMM2 OLR [7.5°S,7.5°N] (cont:4Wm⁻²) Period:15-Sep-2018 to 17-Mar-2019
The unfilled contours are CA forecast reconstructed anomaly for 15 days

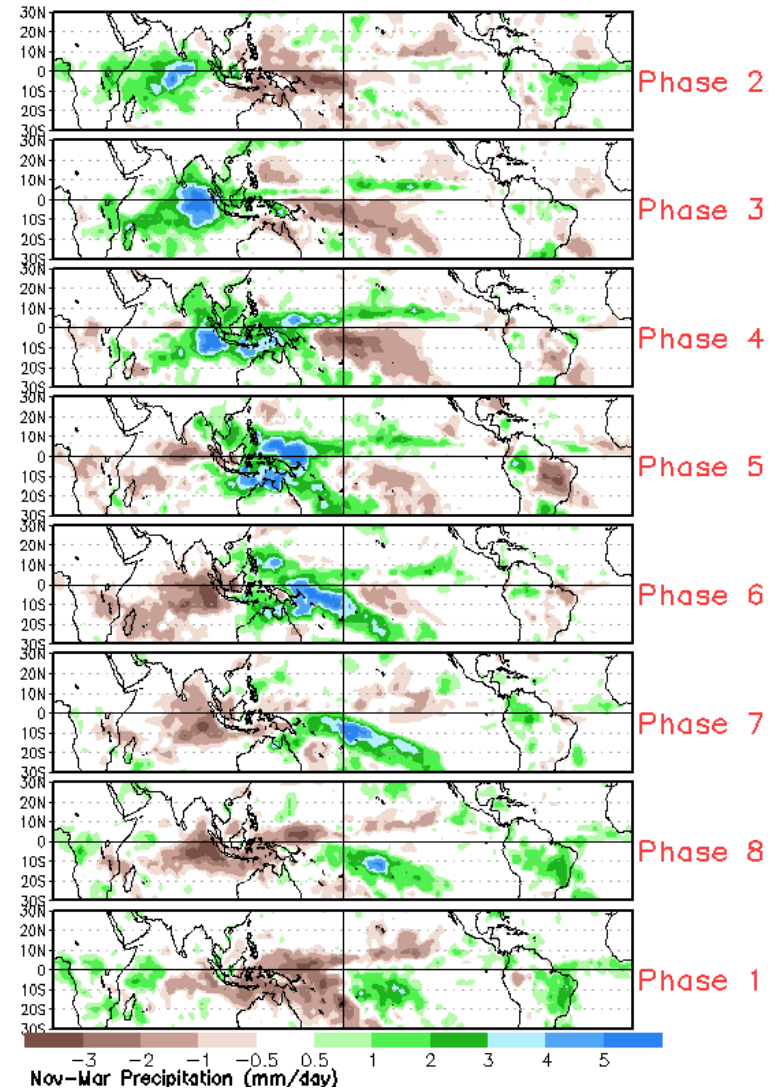


MJO: Tropical Composite Maps by RMM Phase

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



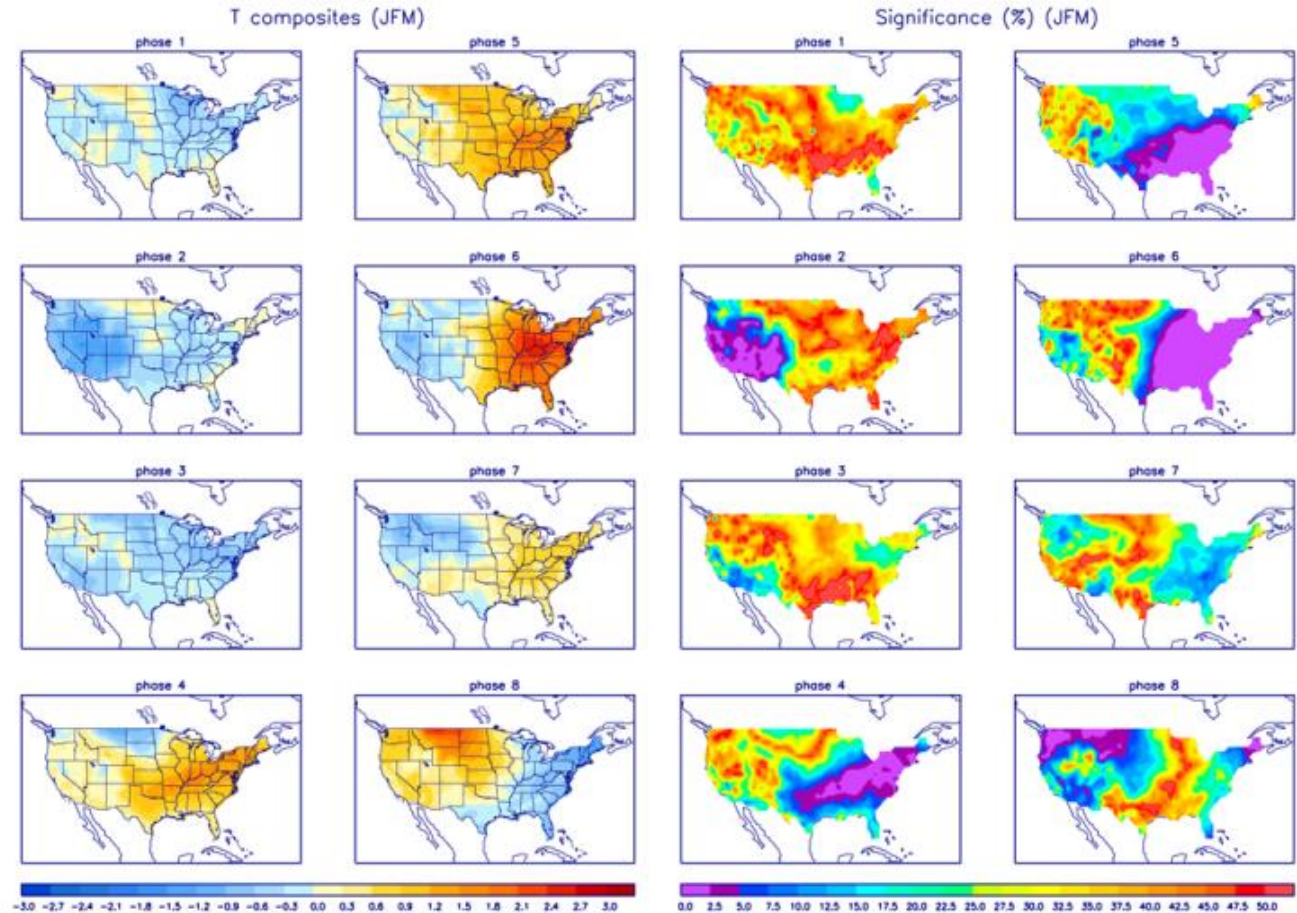
Precipitation Anomalies (Nov - Mar)



MJO: CONUS Composite Maps by RMM Phase - 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.



MJO: CONUS Composite Maps by RMM Phase - Temperature

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.

