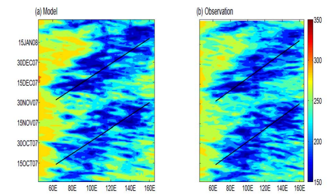
# Atmospheric Moistening by Clouds Sustains Madden-Julian Oscillation

## Research Highlight

Originating over the Indian Ocean, the Madden-Julian Oscillation (MJO) is an equatorial planetary-scale envelope of complex multi-scale cloud systems that propagates eastward at a speed of about 5 m/s across the Indian Ocean, the Maritime Continent, and the western Pacific. Since its discovery in 1971, understanding the underlying processes responsible for MJO and producing accurate model simulations of it has been "The Holy Grail" of tropical atmospheric dynamics research. MJO influences weather systems worldwide within and outside the tropics including the onset and break of the Asian and Australian summer monsoons and the formation of tropical cyclones. Modeling MJO and the associated tropical convection remains a significant challenge for climate models, impacting their ability to predict tropical variability. This study answers long-standing questions about where the MJO gets its energy and how its access to moisture affects the regularity and recurrence of the MJO signal.

Two MJO episodes observed during the winter of 2007–2008 (Figure 1) were simulated using a regional model to explore the role of thermodynamics and moisture on MJO maintenance. Simulations were performed with and without moisture constraints, which frequently nudge the models' moisture fields towards observations. With a moisture field constrained by observations, the simulations were able to represent several characteristic features of the MJO that were not captured by the model without moisture constraints. The two simulations were then analyzed to identify the main sources and sinks of energy associated with MJO convective activity and the roles of the various types of atmospheric instabilities in the lifecycle of MJO. Furthermore, through systematic evaluation of the effect of the moistening constraint on the simulation, insight was gained into the physical processes that are critical for a robust, realistic simulation of MJO. Moisture and temperature in the MJO were found to be strongly linked; the MJO instabilities are created by co-variation of moisture condensation with fluctuations in temperature.

The results of the study have important implications for improving global model simulations of the MJO. The lessons learned are being utilized in the development of new approaches to parameterize tropical convection and in designing modeling strategies for using data from the ARM MJO Investigation Experiment (AMIE) field campaign.




Outgoing longwave radiation (OLR Wm-2) signals in the tropics averaged between 10°S and 10°N from (a) a regional simulation with moisture constrained by observations and (b) NOAA-CPC satellite observations. The lines mark the eastward MJO propagation speed of 4 m/s. The constrained model is able to reproduce the key OLR features in the observations.

### Reference(s)

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### Working Group(s)

Cloud Life Cycle