The isotopic composition of water vapor during the Madden-Julian Oscillation: a comparison between satellite retrievals and isotope-enabled GCMs

Max Berkelhammer¹, David Noone¹, Camille Risi¹, John Worden², Kei Yoshimura³, Naoyuki Kurita⁴, Robert Field⁵ and Daehyun Kim⁵
¹University of Colorado, Dept. of Atmospheric and Oceanic Sciences/CIRES, ²Jet Propulsion Laboratory, ³U. Tokyo, ⁴JAMSTEC, ⁵GISS

Summary:

Changes in isotopic composition of water vapor during the MJO should reveal shifts in the fluxes of water “types” into the system and provide information on precipitation efficiency and convective processes

An analysis of the isotopic composition of mid-tropospheric water vapor from TES using a 5-year composite of MJO events confirm the MJO leaves a strong isotopic footprint.

Using the joint-distribution of H₂O and HDO, it is shown that the onset of the MJO is associated with a strong evaporative flux, which is also persistent during the peak of the event. Additionally, we identify critical moisture sources including that from rainfall re-evaporation and from convergence by way of westward-propagating Rossby waves.

A series of similar isotopic diagnostics are performed on GCMs that include isotope tracers. These models have been nudged to Reanalysis fields thus, we ask if after the synoptic circulation is corrected towards ‘reality’, are the moist processes during the MJO events comparable to observations?

The isoGCMs all show a clear mid-tropospheric isotopic signature associated with the MJO but the footprint is typically weaker than observed.

All the GCMs show an isotopic depletion and moistening during the MJO lifecycle. However, unlike observations, the trajectory falls along a straight line with a negative slope. Therefore, the GCMs fail to capture discrete shifts in moisture sources during the MJO lifecycle. Notably, there is an absence of an evaporative flux during the peak of the MJO, which Cloud Resolving Models have shown to be critical to the moisture-convection feedbacks that sustain the MJO.

Water Isotope Basics:

The vertical gradient of δD is useful in understanding precipitation efficiency and different moisture sources as a function of altitude. We use δD as an indicator of isotopic “lapse”.

The vertical gradient of δD is shown to change systematically during the onset of MJO and rapidly relaxes after the system has passed. This feature is nicely replicated by all of the models. Note, the absolute vertical scale is not the same for all models but the amplitude is similar.

References:


