Emily Riley
Physical Meteorology
25 April 2007

Three-Dimensional Water Vapor and Cloud Variations Associated with the Madden-Julian Oscillation during Northern Hemisphere Winter: Summary

This study utilizes 21+ years of TOVS Pathfinder-A data onboard NOAA 9, 10, 11, and 12 polar-orbiting satellites and ISCCP data to gain insight on the moisture evolution and cloud variations associated with different phases of the MJO. 46 MJO events are identified using indexing from rainfall data from CMAP. The vertical resolution of TOVS allows the retrieval of specific humidity and temperature at multiple levels. While difficult to obtain humidity profiles from an IR sounder, TOVS proved useful when compared to several other data sets, namely ECMWF reanalysis and TOGA COARE IFA (intensive flux array) data, making it a viable resource for examining the evolution of the MJO. [A brief explanation on how the IR instrumentation produced the temperature and humidity profiles is provide by the attached figures.]

Composites of specific and relative humidity, as well as total cloud fraction and cloud fraction by height anomalies for pentad data are then presented from lag -30 to lag +30 for the MJO events. The most striking feature is the prevalence of dry anomalies and negative cloud fraction anomalies in the east Pacific through all phases of the MJO. Reasons for the curious nature of the east Pacific are unclear. Other notable features in the moisture composites include: (1) a Rossby-like feature at lag +20 that tilts southwest to north east in the N. Hemisphere and southeast to northwest in the S. Hemisphere and slightly westward with height, (2) a faster eastward propagation of the anomalies in the Western Hemisphere versus Easter Hemispher, possibly due to the MJO becoming more Kelvin-like, and (3) a westward tilt in the moist phase over the Indian Ocean becoming more vertical as the Central Pacific is approached. Evidence is also provide that shows the atmosphere undergoes “moisture pre-conditioning” for convective activity, as low-level maximums in moist anomalies proceed cloud fraction and precipitation maximums, while upper level moisture maximums lag the precipitation. With respect to cloud fractions by height anomalies, mid (high)-level clouds were found to increase (decrease) with eastward propagation. Additionally, higher cloudiness occurred at the trailing edge of precipitation maximums, consistent with more extensive cloud cover in stratiform rain regions trailing the convective cells.

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In summary, the TOVS data proved to be a viable source of information from which to gain insight on the MJO and showed that there is a distinct relationship between precipitation, cloud fraction, and moisture associated with the evolution of the MJO.