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Diagnosing MJO Destabilization and Propagation with the Moisture and MSE Budgets

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Novel diagnostics obtained as an extension of empirical orthogonal function analysis are used as a composting basis to gain insight into MJO dynamics through examination of reanalysis moisture and moist static energy budgets. The net effect of vertical moisture advection and cloud processes was found to be a modest positive feedback to column moisture anomalies during both enhanced and suppressed phases of the MJO. This positive feedback is regionally strengthened by anomalous surface fluxes of latent heat. The modulation of horizontal synoptic scale eddy mixing acts as a negative feedback to column moisture anomalies, while anomalous winds acting against the mean state moisture gradient aid in eastward propagation. These processes act in a systematic fashion across the Indian Ocean and oceanic regions of the Maritime Continent. The ability to approximately close the MSE budget serves an important role in constraining the moisture budget, whose residual is several times larger than the total and horizontal advective moisture tendencies. Comparison with TRMM precipitation anomalies suggests that the moisture budget residual results from an underestimation by ERAi of variations in both total precipitation and vertical moisture advection associated with the MJO. The results of this study support the concept of the MJO as a moisture-mode. This analysis is extended to examine the impact of boundary layer convergence driven by MJO SST anomalies on the vertically-integrated moisture budget. Results from a coupled version of the SP-CAM suggest that SST-driven moisture convergence anomalies are of a sufficient amplitude to be important for MJO propagation and destabilization, and may help explain why coupled models produce better simulations of the MJO than uncoupled models.