The Physical Mechanisms of the Madden-Julian Oscillation

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An observational study of the propagation and onset mechanisms of the Madden-Julian oscillation (MJO) is performed using cyclostationary empirical orthogonal function analysis and Kelvin-Rossby wave decomposition method for the 22-yr period of outgoing longwave radiation and the NCEP-NCAR Reanalysis data. In these analyses, the region of surface convergence is identified just east of the enhanced convection core during the developing phase of enhanced convection and this tends to pull the convective anomaly to the east. The surface convergence is formed by zonal wind convergence, and Kelvin and Rossby waves both play a comparable role in the formation of the convergence zone. Therefore, the frictional Kelvin-Rossby wave-CISK is regarded as a primary factor for the eastward propagation of the MJO.

Over the western Indian Ocean, moistening in the boundary layer occurs ~2 weeks earlier than the beginning of a new MJO cycle, and accompanies low-level convergence by encircling Kelvin wave which has propagated from enhanced convection of the previous cycle, as well as by Rossby wave response from reduced convection in the Indian Ocean. This earlier formation of the boundary-layer moisture convergence provides a favorable environment for triggering a new convection. This interaction also accounts for the suppression of developed convection to the west. For example, in the Indian Ocean, anomalous surface divergence appears at the western edge of enhanced convection due both to circumnavigating Kelvin wave from reduced convection of the previous cycle and to Rossby wave response to the enhanced convection itself. Thus, the MJO is self-maintaining and self-generating tropical variability through the interaction

between convection and large-scale circulation in the presence of the boundary-layer dynamics.