Process-oriented Diagnostic Metrics for the Madden-Julian Oscillation

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Despite its significant impacts on global weather extremes, the Madden-Julian oscillation (MJO) remains a grand challenge for present-day general circulation models (GCMs). Built-upon recent diagnoses of key processes in regulating MJO amplitude and propagation in multi-model simulations under a moisture-mode framework for the MJO, three diagnostic metrics are proposed to identify and characterize key model deficiencies in representing the MJO. The first metric is the efficiency of precipitation generation per unit column water vapor, or alternately the convective time-scale, which tends to be closely linked to model MJO amplitude across multi-model simulations. Models with stronger MJO amplitude is featured by more efficient precipitation formation or smaller convective time scales. The other two metrics, including low-tropospheric (900-650hPa) seasonal mean moisture distribution over the Indo-Pacific region, particularly near the Maritime Continent area, and low-level anomalous horizontal circulation corresponding to enhanced MJO convection, are found to be essential in driving the eastward propagation of the MJO, through moistening (drying) to the east (west) of MJO convection due to horizontal moisture advection. These two metrics not only provide critical insights into key model discrepancies in representing the eastward propagation of MJO, but are also able to provide an excellent interpretation of year-to-year variations in MJO propagation in both observations and model simulations.