The Symmetric and Antisymmetric Madden-Julian Oscillations

by

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The eastward-propagating Madden-Julian oscillation (MJO) has gross scales in the 30--90-day intraseasonal time range and zonal wavenumber 2--4 in space. It dominates the tropical predictability in the subseasonal time scales, exerting global influences through tropical and extratropical interactions and affecting weather and climate variability. The simplest theoretical model for the MJO describes the planetary-scale response of a moving heat source through the linear shallow water equations for a first baroclinic mode. Atmospheric responses to heat sources symmetric and anti-symmetric about the equator are therefore of fundamental interests. In this work, we examined the predominantly symmetric MJO events with the predominantly anti-symmetric ones in observations. Satellite infrared brightness temperature data during 1983--2006 were decomposed to subsets symmetric and anti-symmetric about the equator, respectively. Modes of variability representing the symmetric MJO and the antisymmetric MJO were extracted, along with a plethora of other modes of tropical variability, using the nonlinear Laplacian spectral analysis. It was found that the boreal winter MJO emerges as unique modes in both symmetric and antisymmetric components. Further examination showed that the symmetric MJO is out of phase with the symmetric diurnal cycle, while the antisymmetric MJO is in phase with the antisymmetric diurnal cycle. The former relationship breaks down during strong ENSO events, which likely spatially skewed the MJO to be more antisymmetric. Dynamical and thermodynamical fields associated with various phases of the symmetric and antisymmetric MJOs were reconstructed using the ERA-Interim analysis, further establishing the antisymmetric MJO as a distinctly different entity from the symmetric MJO.