Planetary Scale Selection of the Madden-Julian Oscillation

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Abstract

Numerical experiments with simple models are conducted to examine the planetary scale selection of the Madden-Julian Oscillation (MJO). Our strategy is to examine the evolution feature of an initial perturbation that has an equatorial Kelvin wave structure with a zonal wavenumber of 1 to 15. In the presence of a frictional boundary layer, the most unstable mode prefers a short wavelength under a linear heating; but with a nonlinear heating, the zonal wavenumber-one grows fastest. This differs from a model with no boundary layer. In the latter case, neither linear nor nonlinear heating leads to long wave selection. Thus the numerical simulations point out the crucial importance of the combined effect of the nonlinear heating and the frictional boundary layer in the MJO planetary scale selection.

The cause of the scale selection under the nonlinear heating is primarily attributed to the distinctive phase speeds of dry and moist Kelvin waves. The faster dry Kelvin wave may “catch up” and suppress the wet Kelvin wave/convection ahead of it if the distance between the two neighboring convective branches is smaller than a critical distance (about 16000 km). The interference between the dry and wet Kelvin waves may “filter out” and dissipate shorter wavelength perturbations and lead to longwave selection. The boundary layer plays a role in 1) destabilizing the MJO through a frictional moisture convergence and 2) retaining the in-phase wind-pressure structure by reducing the asymmetric pressure tendency induced by conditional wave-convergence heating.

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