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Impacts of Climatic Basic State and "Negative Precipitation Perturbation" on Simulating MJO Seasonal Variations in a 2.5-layer Model

Jeremy Cheuk Hin Leung and Weihong Qian
Peking University, School of Physics, Department of Atmospheric and Oceanic Sciences, China (chleung@pku.edu.cn)

In this study, the seasonal variations of Madden-Julian Oscillation (MJO) are simulated with a 2.5-layer model governed by a set of perturbation equations, considering the effects of boundary layer friction convergence, diabatic heating, moisture feedback and background flow, under a non-resting basic state. The governing perturbation equations are written under a basic state defined by the 30-year climatology of observation (reanalysis), in which daily/monthly climatic wind, geopotential and moisture act as a background forcing influencing the evolution and propagation of MJO. Under this climatic background state, the precipitation of basic state is no longer zero but equal to the 30-year precipitation climatology, which is generally larger in the tropical region and has a dominant seasonal cycle in the subtropical region.

Diabatic heating of convection is the key factor that produces the coupled Rossby-Kelvin structure of MJO and is a function of precipitation perturbation in the model. In common practice, precipitation perturbation can be derived from precipitation parametrization schemes, which usually consider only positive values during calculation because negative precipitation does not physically exist in the real world. However, the model in the study is run under a non-zero rainfall background, thus precipitation perturbation is not constraint to be non-negative. In this case, "negative precipitation" area is referred to as abnormally dry area, and leads to "diabatic cooling" (i.e. weaker diabatic heating compared to the basic state) to the troposphere.

Model simulations show that the climatic state and "negative precipitation" are two indispensable factors to the MJO seasonal variations. The climatic state provides a crucial background circulation and moisture distribution that favors MJOs / Boreal Summer Intraseasonal Oscillations (BSISOs), as reported in previous studies. On top of the climatic state, our results indicate that the "negative precipitation" effect is also essential to the simulation of MJO in different seasons. The MJO seasonal variations are less obvious if the model only incorporates positive precipitation. Results also reveal that the "negative precipitation" effectively damps shortwaves.