Energetics of Madden Julian Oscillations in the NCAR CAM3

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Abstract

This study analyzes the tropical intraseasonal variability and associated Madden-Julian Oscillations (MJO) simulated in the National Center for Atmospheric Research Community Climate Model CAM3 using two versions of the Zhang-McFarlane convection scheme. The results are compared with those from the Xie-Arkin observations and ECMWF reanalysis. It is shown that modifications to the convection scheme in the model lead to substantial enhancement of the intraseasonal variability and MJO. The spatial scale of the precipitation anomalies associated with intraseasonal variability and MJO is also in better agreement with the Xie-Arkin observations and ECMWF reanalysis. The analysis of the energetics of intraseasonal variability shows that perturbation kinetic energy (PKE) and its sources and sinks through conversion from potential energy and mean flow and generation from wave energy flux are too strong in the modified CAM3 and too weak in the standard CAM3 when compared with the reanalysis. It also shows that different mechanisms are responsible for the PKE production in different locations. In convectively active regions, conversion from potential energy and vertical transport are important to the maintenance of the upper troposphere PKE; in convectively suppressed regions, horizontal wave energy flux convergence and barotropic conversion are important.

Composite MJOs are constructed using EOF analysis. With the climatological mean of the energetics from the composite MJO removed, the energy budget terms show clear eastward propagation following MJO movement in the modified CAM3 and ECMWF reanalysis. Moisture flux convergence is responsible for the changes of specific humidity during the cycle of the MJO over the Indian and western Pacific Oceans. These results indicate that interaction between convection, moisture and convergence in the lower troposphere may be responsible for the MJO development over the Indian and western Pacific Ocean in both observations and simulations. The weak intraseasonal variability and MJO simulated by the original Zhang-McFarlane deep convection scheme is attributed to the lack of coherent shallow convection ahead of deep convection in the MJO cycle.