An MJO analog and intraseasonal variability in a multi-cloud model above the equator

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Abstract

The Madden–Julian Oscillation (MJO) is the dominant component of tropical intraseasonal variability, and both a theory explaining its structure as well as successful numerical simulation remain major challenges. A successful model for the MJO should have the following features: a propagation speed of 4–7 m/s predicted by theory; a wavenumber-two or -three structure for the planetary scale low frequency envelope with distinct active and inactive phases of deep convection; an intermittent turbulent chaotic multi-scale structure within the planetary envelope involving embedded westward- and eastward-propagating deep convection events; and qualitative features of the low-frequency envelope from the observational record as regards its zonal flow structure, heating, etc. Here such an MJO analog with all of these features is produced by utilizing the recent multi-cloud model of Khouider and Majda [Khouider, B amp; Majda, A. J. newblock (2006) it J. Atmos. Sci. bf 63, 1308–1323] in an appropriate intreaseasonal parameter regime for flows above the equator so that rotation is ignored. Key features of the multi-cloud model are (i) systematic low-level moisture convergence while retaining conservation of vertically integrated moist static energy and (ii) the use of three cumulus cloud types – congestus, stratiform, and deep convective – in the model together with their differing vertical heating structures. Besides all of the above structure in the MJO analog waves in the

model, there are accurate predictions of the phase speed from linear theory and transitions from weak, regular MJO analog waves to strong, multi-scale MJO analog waves as climatological parameters vary. With all of this structure in a simplified context, these models should be useful for MJO predictability studies in a fashion akin to the Lorenz 96 model for the midlatitude atmosphere.