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A new born theory for the genesis and dynamics of Madden–Julian oscillation-like structure

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By means of a new multilayer pseudo-spectral moist-convective thermal rotating shallow-water (mcTRSW) model in a full sphere, we present a possible equatorial adjustment beyond Gill's mechanism for the genesis and dynamics of the Madden–Julian oscillation (MJO). According to this theory, an eastward-propagating MJO-like structure can be generated in a self-sustained and self-propelled manner due to nonlinear relaxation (adjustment) of a large-scale positive buoyancy anomaly, depressed anomaly, or a combination of these, as soon as this anomaly reaches a critical threshold in the presence of moist convection at the Equator. This MJO-like episode possesses a convectively coupled "hybrid structure" that consists of a "quasi-equatorial modon" with an enhanced vortex pair and a convectively coupled baroclinic Kelvin wave (BKW), with greater phase speed than that of dipolar structure on an intraseasonal time-scale. Interaction of the BKW, after circumnavigating the entire Equator, with a new large-scale buoyancy anomaly may contribute to excitation of a recurrent generation of the next cycle of MJO-like structure. Overall, the generated "hybrid structure" captures a few of the crudest features of the MJO, includingits quadrupolar structure, convective activity, condensation patterns, vorticity field, phase speed, and westerly and easterly inflows in the lower and upper troposphere. Although moisture-fed convection is a necessary condition for the "hybrid structure" to be excited and maintained in the proposed theory in this study, it is fundamentally different from moisture-mode theories, because the barotropic equatorial modon and BKW also exist in "dry" environments, while there are no similar "dry" dynamical basic structures in moisture-mode theories. The proposed theory can therefore be a possible mechanism to explain the genesis and backbone structure of the MJO and to converge some theories that previously seemed divergent (DOI:10.1002/qj.4388).