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QBO-like Oscillation in a Three-Dimensional Minimal Model Framework of the Stratosphere-Troposphere Coupled System

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We present a three-dimensional minimal model that produces a self-sustained oscillation reminiscent of the quasi-biennial oscillation (QBO) in a radiative–moist convective quasi-equilibrium state. The computational domain is rectangular 640 km x 160 km one with doubly periodic boundary conditions. After initial transient time, an oscillation with a period of about 300 days emerges in the stratosphere, both in the domain-averaged zonal wind and meridional wind. A synchronization of the zonal and meridional winds is observed. It is characterized as an anti-clockwise rotation of a skewed spiral feature with height in the horizontal mean wind vectors. A penetration of the QBO-like wind oscillations into the troposphere occurs. Modulations of tropospheric temperature anomaly and smoothed precipitation are also noted with irregular periods of about 100 days, in which heavy precipitation are associated with positive temperature anomaly. Fine temporal outputs of the simulation reveal three types of precipitation patterns: isolated quasi-stationary type clusters, fast-moving back-building type and squall-line type patterns. The quasi-stationary type is newly identified in this three-dimensional model. Intermittent self-reorganization of convective systems into quasi-stationary type and transition back to the fast-moving back-building type or squall-line type are fundamental characteristics of self-aggregation in the three-dimensional model.

The QBO-like oscillation obtained in this three-dimensional minimal model could become an idealized testbed of a new research field of the stratosphere-troposphere dynamical coupling in the tropics, in which aggregations of moist convection and their interactions in multiple temporal and spatial scales are one of the fundamental features. Furthermore, the QBO-like oscillation could be analyzed to answer the following fundamental questions on the dynamics of the QBO:
* What determines amplitude and period of the oscillation?
As the obtained oscillation is not a linear harmonic oscillation but a kind of relaxation oscillation, the period should be given by [depth] / [descending speed], but we do not know what determines the [descending speed] in this result.
* What determines the initiation of a new oscillation cycle?
As Plumb's switching mechanism in the laboratory analogue of the QBO does not work in the stratosphere-troposphere coupled system, we have to investigate the "source of momentum flux" in the troposphere of the present framework.

References

Bui, H.-H., E. Nishimoto, and S. Yoden, 2017: Downward influence of QBO-like oscillation on moist convection in a two-dimensional minimal model framework. J. Atmos. Sci., 74, 3635-3655.
Bui H.-H., S. Yoden, and E. Nishimoto, 2019: QBO-like oscillation in a three-dimensional minimal model framework of the stratosphere–troposphere coupled system. SOLA, under revision.
Held, I. M., R. S. Hemler, and V. Ramaswamy, 1993: Radiative-convective equilibrium with explicit two-dimensional moist convection. J. Atmos. Sci., 50, 3909-3927.
Nishimoto, E., S. Yoden, and H. Bui, 2016: Vertical momentum transports associated with moist convection and gravity waves in a minimal model of QBO-like oscillation. J. Atmos. Sci., 73, 2935-2957.
Yoden, S., H.-H. Bui, and E. Nishimoto, 2014: A minimal model of QBO-like oscillation in a stratosphere-troposphere coupled system under a radiative-moist convective quasi-equilibrium state. SOLA, 10, 112-116, doi:10.2151/sola.2014-023.