Nudging experiment with a minimal model of QBO-like oscillation to understand the downward influence to convection

Hoang-Hai BUI[1,2], Eriko NISHIMOTO[1], Shigeo YODEN[1]

[1] *Department of Geophysics, Kyoto University, Kyoto, Japan*
[2] *Hanoi University of Science, Hanoi, Vietnam*

A self-sustained oscillation which is dynamically analogous to the equatorial quasi-biennial oscillation (QBO) was firstly obtained as a radiative-moist-convective quasi-equilibrium state in a minimal model of the stratosphere-troposphere coupled system by Held, Hemler, and Ramaswamy (1993), and the robust feature of the oscillation, not sensitive to the choice of model configurations or top and bottom boundary conditions, was confirmed by Yoden, Bui, and Nishimoto (2014). The minimal model is a two-dimensional cloud-system-resolving nonhydrostatic model without Coriolis effect, under a periodic lateral boundary condition to permit the oscillation of zonal mean zonal wind. The QBO-like oscillation shows downward propagation of the zonal mean signals in the stratosphere as observed, and also the periodic variations of organized features of moist-convective systems associated with the periodic variation of the mean zonal wind in the troposphere.

Alternative appearance of squall-line-type or back-building-type precipitation patterns modulates the spectral features of the vertical flux of horizontal momentum separated into three contributions of convective momentum transport and momentum transports by upward- and downward-propagating gravity waves, as analyzed by Nishimoto, Yoden, and Bui (2016). In this idealized minimal model, the variations of the mean zonal wind modulate the organization of convective systems, whereas the modulation of convective systems alters the momentum fluxes to accelerate the mean zonal wind very periodically.

Downward influence of the stratospheric QBO-like oscillation to convection in the troposphere is further investigated with the same minimal model in a couple of series of parameter sweep experiments; model top experiments and tropospheric nudging experiments. In the model top experiments in which the total zonal wind in the upper most layers of 5 km is nudged to 0 m/s, QBO-like oscillations are obtained even in the low top experiments with a top boundary set at 20 km or 15 km, with oscillations of the mean zonal wind only in the troposphere. Amplitude and period of the tropospheric QBO-like oscillations are largely different from those in the oscillations with the stratospheric component. In the tropospheric nudging experiments,

on the other hand, only the zonal mean component of the zonal wind is nudged to 0 m/s in a certain depth from the bottom boundary to investigate the impact of the vertical shear of the mean zonal wind near the surface on the evolution of convective systems and the mean zonal wind oscillation. Changes in the convective systems and its role in the mean zonal wind acceleration are quantitatively diagnosed with the time-space momentum budget analysis we have introduced recently.

Key words: stratosphere-troposphere dynamical coupling, QBO, deep convection