A Series of Numerical Experiments on Stratosphere-Troposphere Two-Way Dynamical Coupling in the Tropics through Organizations of Moist Convective Systems

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Recently, we started a new international research activity on Stratospheric And Tropospheric Influences on Tropical Convective Systems (SATIO-TCS) under WCRP/ SPARC. It focuses on stratosphere-troposphere (S-T) two-way dynamical coupling in the tropics, where moist convection and its large-scale organization in the troposphere could be influenced by the stratospheric variations, such as stratospheric sudden warming events, the equatorial quasi-biennial oscillation (QBO), or anthropogenic cooling trend in the lower stratosphere, as revealed by some observational studies. For example, Nishimoto and Yoden (2017) made a statistical analysis on the influence of QBO on the Madden-Julian oscillation (MJO) during boreal winter in neutral ENSO periods during 1979-2013, and showed that the composite OLR anomaly for a particular MJO phase over the Maritime Continent has a larger negative value and slower eastward propagation with a prolonged period of active convection in the easterly phase of QBO than in the westerly phase.

The tropical dynamics is largely different from the counterpart in the extratropics where dry quasi-geostrophic dynamics prevail. Multi-scale dynamics of moist convection and its organizations are likely to play a vital role in determining the tropospheric response to the stratospheric variations, but numerical model studies from such viewpoint are still limited. Thus, we have performed a series of numerical experiments on radiative-moist convective quasi-equilibrium states in a highly-idealized two-dimensional regional model of an S-T coupled system with explicit moist convection under a periodic lateral boundary condition without Coriolis effects, in which self-sustained oscillations dynamically analogous to the QBO were obtained (Yoden et al. 2014). Modulation of moist convective systems is associated with the QBO-like oscillation of the mean zonal wind, as alternative appearance of squall-line- or back-building-type precipitation patterns, and vertical momentum transports associated with slant-wise moist convection and convectively generated gravity waves are periodically modulated in the oscillation (Nishimoto et al. 2016). Downward influence of the QBO-like oscillation on organized moist convective systems was further investigated in a series of experiments that control the vertical shear of the mean zonal wind with a nudging term (Bui et al. 2017). A new result for a three-dimensional model framework will be reported in the presentation.

References

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