EMS Annual Meeting Abstracts
Vol. 15, EMS2018-371-1, 2018

Influences of the Quasi-Biennial Oscillation (QBO) on the Northern Hemisphere winter stratosphere in QBOi experiments

Hiroaki Naoe and Kohei Yoshida
Meteorological Research Institute, Tsukuba, Japan (hnaoe@mri-jma.go.jp)

The quasi-biennial oscillation (QBO) dominates the variability of the equatorial stratosphere and its influence extends extratropical circulation during winter in both hemispheres. During Northern Hemisphere (NH) winter, one fascinating phenomenon is known as the Holton-Tan (HT) effect, whereby a polar vortex is stronger when the QBO in the lower stratosphere (~50hPa) is in its westerly phase (QBO-W), and, conversely, a polar vortex is weaker when the QBO is in its easterly phase (QBO-E). The conventional HT explanation (or hypothesis) was believed that the QBO would involve the width of the extratropical waveguide for quasi-stationary waves propagating in the mid-latitude. During E-QBO, this waveguide should be narrower due to a result of a latitudinal shift in the subtropical critical line, and as a result, the planetary waves would be refracted away toward the polar vortex and upward planetary waves are restricted in polar region. Many previous studies have supported the extratropical response to the QBO (HT relationship) in NH winter, and, however, the mechanism behind the HT effects is still under debate.

Here, we investigate dynamical response to the QBO in the NH winter extratropical stratosphere with regard to modulation of planetary wave activities, by using the internal-QBO driven Meteorological Research Institute Earth System Model version 2 (MRI-ESM2; updated version) and its former version, under the auspices of the SPARC QBO initiative (QBOi) activity which designed a set of coordinated experiments. Diagnostic tools used here are composite differences in zonal wind, temperature and EP-fluxes to understand how Rossby wave propagation is modulated in the presence of equatorial QBO winds.

Our results about the QBO-composite differences show that EP flux anomalies between QBO-E and QBO-W are actually directed equatorward (i.e. enhanced equatorward flux for QBO-E) in the midlatitude lower stratosphere in the QBOi simulations as well as ERAi. This result suggests that the conventional HT hypothesis do not support these EP-flux composite differences. Also, analyses of the composite differences in zonal wind and temperature in the set of coordinated experiments show that the HT effect is distinguishable when the composite difference in the QBO-induced mean meridional circulation is strong in the vicinity of upper subtropical jet. This implies that the QBO-induced mean meridional circulation causes a poleward shift of the subtropical jet, which would trigger variability of polar vortex by means of modulation of upward propagation of quasi-stationary planetary waves from the troposphere.