Thorough survey of zonal-mean influence of the stratospheric QBO on the troposphere

Eriko NISHIMOTO[1] and Shigeo YODEN[2]

[1] *Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan*
[2] *Kyoto University, Kyoto, Japan*

A systematic analysis method is introduced in this study to investigate downward influence of the stratospheric quasi-biennial oscillation (QBO) on the tropospheric circulations and convection in the zonal-mean perspective for the periods without El Nino or La Nina events during 1979--2015, by using the monthly mean datasets of NOAA/OLR, GPCP precipitation, and ERA-Interim reanalysis datasets (JRA-55 and MERRA as well). The QBO phase is defined with the first two principal components (PCs) derived from the EOF analysis of the zonal-mean zonal wind in the equatorial lower stratosphere. The central value, θ_c, and the range, $\Delta\theta$, of the phase angle in the polar coordinate of the two-dimensional PC phase space are introduced to define the two groups with θ_c and the opposite phase of $\theta_c + 180°$. A composite analysis of any quantity is performed for the two groups and the statistical significance of the composite difference is determined by a two-sided Student's t-test. Then the parameters θ_c and $\Delta\theta$ are swept from $0°$ to $180°$ with an $1°$ interval to conduct a thorough survey of the QBO influence on the troposphere.

Statistically significant composite differences (with confidence levels of 90% and greater) are present in the troposphere from the South Pole to the North Pole during DJF and JJA, including the previous findings associated with the Holton-Tan relationship in the northern high-latitudes during DJF, the QBO modulation of tropical deep convection during DJF and JJA, and variations of the zonal-mean zonal wind near the subtropical jet in the northern hemisphere during DJF. Related to these previously reported QBO influences, this study adds some meteorological variables including the vertical motions and precipitation that have statistical significance in the composite difference. This study also reveals some statistically significant features modulated by the QBO, which have not been reported previously. One of them is modulation of the circulations around the summer poles (i.e., the South Pole during DJF and the North Pole during JJA) and its associated variations of moist convections. They are significantly stronger when the equatorial QBO has an easterly peak at 70 hPa in the lower stratosphere. Another new finding feature is the meridional displacement of the subtropical jet in the southern hemisphere during DJF and JJA associated with the QBO, and it is significantly observed in the zonal-mean zonal wind, vertical wind, and precipitation. Further analyses including non-zonal components would be needed to understand the features and causality of these new finding features.

Key words: QBO, stratosphere-troposphere coupling, downward influence