Response of the Southern Hemisphere atmosphere to the QBO from winter to early summer

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The equatorial quasi-biennial oscillation (QBO) is dominant variability in the tropical stratosphere and is characterized by the oscillation of downward propagating easterly and westerly wind regimes. Several studies have examined possible linkages between the QBO and atmospheric circulations, such as the meridional circulation around tropics and the polar vortex intensity in the Northern Hemisphere (NH), which are related to the changes of waves and circulations in the stratosphere (e.g., Plumb and Bell 1982, Holton and Tan 1980). On the other hand, the mechanism by which the QBO modulates extratropical circulation over the Southern Hemisphere (SH) is poorly understood, as the various studies employed different height levels and metrics to define the phase of the QBO (e.g., Garcia and Solomon 1987; Baldwin and Dunkerton 1998; Naito 2002; Hitchman and Huesmann 2009). Previous studies employed composite analysis that possibly includes signals other than the response to the stratospheric QBO, such as the responses to solar cycle and El Niño-Southern Oscillation (ENSO). In this study, we examined the response of atmospheric circulation over the SH to the stratospheric QBO, using multiple linear regression analysis for the long-term Japanese 55-year Reanalysis (JRA-55) dataset to separate the influences of the QBO and other factors on the SH polar vortex. In addition to the terms of middle- and lower-stratospheric QBO, the multiple linear regression includes equivalent effective stratospheric chlorine (EESC), solar cycle, ENSO, and volcanic aerosol terms as explanatory variables. Analyses of the regression coefficients associated with both middle- and lower-stratospheric QBO suggest an influence on the SH polar vortex from SH winter through early summer in the seasonal evolution. One possible pathway is that the middle-stratospheric QBO results in the SH low latitudes stratospheric response through the QBO-induced mean meridional circulation, leading to a high-latitude response. This favors delayed downward evolution of the axis of SH polar vortex at high latitudes (around 60˚S) from August to November during the westerly phase of the QBO. Although this pathway is inconsistent with weakening of the SH polar vortex in August, the other possible pathway is unveiled from the detailed analysis. The other possible pathway involves the response to lower stratospheric QBO that induces the increase in upward propagation of planetary waves from the SH extratropical troposphere to stratosphere in August. This pathway is consistent with weakening of the SH polar vortex in August.

Keywords: quasi-biennial oscillation, Southern Hemisphere polar vortex, multiple linear regression

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