Two possible pathways of the Southern Hemisphere polar vortex response to the QBO from winter to early summer

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The mechanism by which the quasi-biennial oscillation (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. We investigate the effects of the stratospheric QBO on extratropical circulation in the SH from winter to early summer. Previous studies employed composite analysis that possibly includes signals other than the response to the stratospheric QBO. In this study, multiple linear regression analysis of the linear trend, two orthogonal QBO components, El Niño-Southern Oscillation (ENSO), and the volcanic aerosol terms as explanatory variables is conducted using the Japanese 55-year Reanalysis (JRA-55) dataset over a 51-year period from 1960 to 2010. Here, middle- and lower-stratospheric QBO are defined by the equatorial zonal wind phases in the middle and lower stratosphere, respectively. The results show that the contribution to the SH polar vortex of ENSO and solar activity other than the QBO are important in SH early winter (June) to mid-winter (July), while that of middle-stratospheric QBO is important from spring (September to November) to early summer (December).

Analyses of the regression coefficients associated with both middle- and lower-stratospheric QBO suggest two possible pathways of influence on the SH polar vortex from winter through early summer. One is that the middle-stratospheric QBO modifies the distributions of air temperature related to zonal wind and planetary wave activities, and meridional circulation in the low latitudes. This can lead to delayed evolution of the polar-night jet (PNJ) at high latitudes (around 60°S) from late winter (August) to spring (September–November) during the westerly phase of the middle-stratospheric QBO, consequently tending to strengthen westerly winds from stratosphere to troposphere in spring. Lower-stratospheric QBO is also related to temperature in low latitudes and zonal wind in low- and mid-latitudes, although not always observed from winter to early summer. During the westerly phase of the lower-stratospheric QBO from winter (July to August) to early spring (September), the other pathway involves upward propagation of planetary waves from troposphere to stratosphere, which is consistent with weakening of the PNJ.

Key words: quasi-biennial oscillation (QBO), extratropical circulation in the Southern Hemisphere, multiple linear regression