Persisted negative Antarctic oscillations after sudden stratospheric warming in the Southern Hemisphere in 2019

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In the early September 2019, a sudden stratospheric warming (SSW) occurred in the southern hemisphere for the first time in 17 years. The impact extended downward to the Earth’s surface, and the negative-phase of the Antarctic Oscillation (AAO) in the troposphere persisted from mid-October to the end of December. In this study, the relationship between SSW and negative AAO persistence in the troposphere was investigated from the viewpoint of wave-mean flow interaction applying the mass-weighted isentropic zonal mean (MIM) method to the Japan Meteorological Agency's 55-year reanalysis dataset (JRA-55). With this method, it is possible to evaluate the divergence of E-P flux in the troposphere including near the surface, the anomalies of the meridional circulation in the troposphere and the outflow of cold air to mid-latitudes. The anomalies are deviation from climatology of the 30-year average of 1981-2010.

First, the time-altitude cross-section of the standardized anomalies of the zonal mean geopotential height field averaged from 60S to 90S is examined to see the temporal change in the strength of the polar vortex from the stratosphere to the troposphere due to the SSW. After the SSW in the early September, weak state of the polar vortex persisted in the upper stratosphere, and the center of the height anomalies descended to the lower stratosphere in the mid-October. At the same time, the positive anomalies exceeded one sigma in the troposphere and then the situation continued throughout the end of December. The zonally averaged 300 hPa geopotential height anomalies shows positive anomalies over high latitudes area (60S-90S) and negative anomalies over the area from 35S-60S, indicating that negative AAO phase persists corresponding to the weakening of the polar vortex from mid-October to December.

In order to investigate the tropospheric situation during the period of negative AAO phase (16Oct-31Dec), the zonal-mean zonal wind, E-P flux and meridional circulation are compared with climatology in terms of wave-mean flow interaction. The stratospheric polar night jet seen in the climatology lacks in 2019 in the zonal-mean zonal wind field. Associated to the lack, there is no waveguide along with the polar night jet that exists in the climatology. The analysis on the refractive index in 2019 indicates the region where planetary waves from the troposphere cannot (or hardly) propagate vertically above the tropopause region of 40S 70S. This situation resembles the situation in December after the final warming of the stratosphere in the climatology. Associated with the situation, the vertical propagation of the E-P flux of stationary waves from the troposphere to the stratosphere over the high-latitudes is weak and converges more in the upper troposphere. In addition, the meridional distribution of the E-P flux of transient waves shifts to the low latitude side, and contributes to the persisted southward shift of the subtropical jet. The convergence anomalies of the E-P flux of these waves over the 40S-70S in the troposphere induce the direct circulation anomalies in the high-latitude. As a result, high-latitude cold air flow to mid latitudes and is likely to contribute to the maintenance of negative AAO.

Keywords: sudden stratospheric warming, Antarctic Oscillation, persisted tropospheric zonal-mean anomaly

