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Research on the stratospheric ozone depletion in the polar spring

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In recent years, the severe stratospheric ozone depletion events (ODEs) were reported in the polar spring. We retrieved the critical indicator ozone vertical column densities (VCDs) using zenith scattered light differential optical absorption spectroscopy (ZSL-DOAS) located in Chinese Great Wall Station, South Antarctic (62.22° S, 58.96° W) and Chinese Yellow River Station, Ny-Ålesund (78.92° N, 11.93° E). The ozone holes appeared above Antarctic in September and October each year (from 2017 to 2020), with ozone VCDs less than 220 DU. Furthermore, during March and April 2020, ozone VCDs over Ny-Ålesund, Arctic was only about 64.7% of that in normal years. The retrieved daily averages of ozone VCDs were compared with satellite observations from Global Ozone Monitoring Experiment 2 (GOME-2), Brewer spectrophotometer, and Système d'Analyze par Observation Zénithale (SAOZ) spectrometer; the resulting Pearson correlation coefficients were relatively high at 0.94, 0.86, and 0.91, with relative deviations of 2.3%, 3.1%, and 3.5%, respectively.

The polar vortex has strong influence on stratospheric ozone depletion. Potential vorticity (PV), which is used to characterize the polar vortex and determine the edge of polar vortex, is positively correlated with total ozone columns in Antarctic, and the trend of PV and total ozone columns is at the same pace. While during the 2020 Arctic spring ODE, the ozone VCDs and potential vorticity (PV) had a negative correlation with their fluctuations, which is opposite to Southern Hemisphere. The stratospheric ozone profiles and PV profiles show that the most severe ozone depletion caused by polar vortex appeared at the altitude of 19.5-20.5 km.

To better understand the cause of the ozone depletion, we considered the chemical components of ODE process in the Arctic winter of 2019/2020 with the specified dynamics version of the Whole Atmosphere Community Climate Model (SD-WACCM). The SD-WACCM model results indicated that both ClO and BrO concentrations peaked in late March, which was a critical factor during the ozone depletion observed in Ny-Ålesund. Chlorine activation was clearly apparent during the Arctic spring of 2020, whereas the partitioning of bromine species was different from that of chlorine. By combining observations with modeling, we provide a reliable basis for further research on global climate change due to polar ozone concentrations and the prediction of future polar ozone holes.