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Influence of energetic particle precipitation on Antarctic stratospheric chlorine and ozone over the 20th century

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Chlorofluorocarbon (CFC) emissions in the latter part of the 20th century reduced the stratospheric ozone abundance substantially, especially in the Antarctic region. Simultaneously, polar stratospheric ozone is also depleted catalytically by reactive nitrogen (NOx) gasses. Energetic particle precipitation linked to solar activity and space weather produces NOx in the polar mesosphere/lower thermosphere, which during winter descend to stratospheric altitudes via mean meridional residual circulation. NOx can also limit the CFC ozone destruction, e.g., by transforming active chlorine and nitrogen into a reservoir of chlorine nitrate. We study the interaction between EPP produced NOx, ClO and ozone over the 20th century by using free running climate simulations of the chemistry-climate model SOCOL3-MPIOM. Substantial increase of NOx descending to polar stratosphere is found during winter, which causes ozone depletion in the upper and mid-stratosphere. However, the EPP-NOx induced ozone depletion becomes less efficient in the Antarctic mid-stratosphere after 1960s, especially during springtime. At the same time, significant decrease in Antarctic stratospheric ClO between 1-30 hPa over winter and spring can be ascribed to the EPP-NOx. This is true even during the CFC era. Hence, chlorine gasses contributed to reducing the efficiency of the EPP-NOx ozone depletion at these altitudes and vice versa. Our results show that EPP has been a significant modulator of reactive chlorine in the Antarctic stratosphere during the CFC era. With the implementation of the Montreal Protocol, stratospheric chlorine is estimated to return to pre-CFC era levels after 2050. We can thus expect increased efficiency of chemical ozone destruction by EPP-NOx in the future Antarctic upper and mid-stratosphere.