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Three-dimensional Modeling of Tropospheric Ozone Depletion Events in the Arctic Spring using WRF-Chem

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Tropospheric ozone depletion events in the Artic spring are studied by means of three-dimensional unsteady numerical simulations. An ozone depletion event (ODE) is defined by a decrease of the ozone background mixing ratio of 30-60 parts per billion (ppb) to less than a few ppb in a full depletion or to less than ten ppb in a partial depletion event. Ozone is most likely depleted by reactive halogen species during an ODE. On the surface of substrates such as snow, ice, or aerosols, an autocatalytic, heterogeneous reaction cycle may release bromide, providing a source for reactive halogens. Reaction of ozone with bromide or chloride in the aqueous phase of the substrates may provide an alternative source for reactive halogens. ODEs are driven by emission, transport, mixing, chemical reactions of trace gases and aerosols which interact with the meteorology. The software package "***W**eather **R**esearch and **F**orecasting model coupled to **Chem**istry"*, WRF-Chem, is employed to simulate ODEs in the Artic spring. For this purpose, the "MOZART" chemical reaction mechanism is extended to include both bromine and chlorine species and their chemical reactions. Moreover, the heterogeneous recycling of bromine on aerosols is considered. The main sources of reactive bromine are heterogeneous reactions on the surface of sea ice. The present computational domain is centered at the coordinates 75° N, 156° W which is north of Barrow, Alaska, and consists of 200 times 200 horizontal grid cells with horizontal resolutions of 20 km. 47 non-equidistant vertical layers from the ground up to 50 hPa are considered with a higher resolution at low altitudes. The simulations are initiated with "ERA-INTERIM" data and the nudging to "ERA-INTERIM" data ensures realistic meteorological conditions. The time from February to May 2009 is simulated using time steps of one minute. Satellite data of bromine vertical column densities with a stratospheric correction are available for comparison with the present simulations, which show a good qualitative agreement. The simulations predict a bromine build-up period of five days before the ODE is initiated, which again lasts about one day. The predicted site and time scale of the ODE agree with the observations. However, both the lifetime and the size of the BrO clouds are overestimated in the present simulations, which is likely to be due to the lack of a distinction of the representation of the sea ice generated during the first-year and multi-year sea ice, which will be studied in future.