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Inclusion of polar sea-ice emissions and sea-salt aerosol recycling of bromine into the global CAM-Chem chemistry-climate model

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The global CAM-Chem chemistry climate model has been updated by including a coupled polar module with a full halogen chemistry mechanism and time-varying organic and inorganic halogen emissions into the polar marine boundary layer. The baseline halogen CAM-Chem setup has already been validated for the tropics and mid-latitudes and includes natural sources of very short-lived (VSL) halocarbons from the oceans; reactive chlorine, bromine and iodine species; related photochemical, gas-phase and heterogeneous reactions, as well as wet and dry deposition for relevant species. The coupled polar module considers i) time-dependent sea-ice emissions of Br_2 and BrCl as result of recycling over the deposited snow over sea-ice, *ii)* sea-salt aerosol recycling of $BrONO_2$, $BrNO_2$ and HOBr in the polar boundary layer and *iii)* improved sea-salt recycling efficiency over fresh sea-ice regions representing the contributions from blowing snow.

The external brominated sources posses a 2-fold dependence on both solar zenith angle and local sea-ice cover. The time/sea-ice dependent local Br_2 flux was scaled to reproduce observations of reactive bromine species over coastal Antarctica. This results in an Antarctic mean sea-ice flux of $\sim$200 Gg Br yr^{-1} with maximum emissions in late spring, as a compromise between sea-ice coverage and intensity of radiation. Recycling of bromine over sea-salt aerosol is the dominant factor controlling the tropospheric vertical column density (VCD) of BrO and other inorganic bromine species. A monthly-dependent depletion factor is introduced to account for the net fraction of Br in sea-salt that is released to the atmosphere.

Model results have been validated locally against measurements of BrO performed at several Antarctic stations, showing a good agreement both in the boundary layer concentrations for the entire year and the springtime maximum BrO observed in October. The seasonality and intensity of the BrO total and tropospheric columns are also in agreement with BrO VCDs results reported from satellite platforms, showing a polar BrO cloud distribution coincident with the Antarctic monthly sea-ice coverage. Further work will quantify the contribution of halogen chemistry to the oxidation capacity of the polar atmosphere.