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Impact of changes in tropical stratospheric water vapour on Arctic ozone depletion

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Stratospheric water vapor influences the chemical ozone loss in the polar stratosphere via controlling the polar stratospheric cloud formation. Chemistry-climate models (CCMs) have difficulties in capturing the complexity of processes that control the water transport across the tropopause. As a result there are large differences between the models in the water vapour entering the stratosphere through the tropical tropopause, and hence in the simulated stratospheric water vapour. Climate change is expected to alter the water vapour concentration in the tropical tropopause.

In this study we investigated the sensitivity of simulated Arctic ozone loss to the water vapour concentration in the tropical tropopause. We used a chemical transport model, FinROSE-CTM, forced by the European Centre for Medium-range Weather Forecasts (ECMWF) ERA-Interim meteorology. Simulations of the Arctic winters between 2010 and 2017 were performed. The water vapour concentration prescribed in the tropical tropopause was varied from 0.5 to 1.6 times the concentration in ERA-Interim, which is similar to the range seen in CCMs. The water vapour changes in the tropical tropopause resulted in about 1.5 ppm less and 2 ppm more water vapour in the Arctic polar vortex compared to the ERA-Interim, respectively. We found that the impact of water vapour changes on Arctic ozone loss depend on the meteorological conditions. When cold conditions persist for long periods the chlorine activation becomes nearly complete, and the additional water vapour increase the formation of PSCs, but does not increase ozone depletion significantly. In warm winters the impact of water vapour concentration on ozone loss is small, because the ozone loss is mainly NO_x induced. In intermediately cold conditions the effect of added water vapour is more prominent. The study showed that the simulated water vapour concentration in the tropical tropopause has a significant impact on the Arctic ozone loss and deserves attention in order to improve future projections of ozone layer recovery.