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The effect of ozone loss on the polar vortices – A chemistry-climate model study

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Introduction

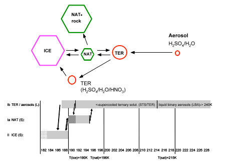
Ozone is a radiatively active gas and it is widely accepted that Antarctic springtime cooling and delay of vortex break-up are results from ozone depletion. In this study we test different schemes for polar stratospheric clouds (PSC) in the Hamburg Model of the Neutral and Ionized Atmosphere (HAMMONIA).

The previous model setup underestimated the chlorine activation and subsequently the polar ozone loss. The effect of an increased ozone loss on the SH vortex conditions was studied.

Model setup and PSC scheme

The chemistry-climate model HAMMONIA (Schmidt et al., 2006) is a chemistry coupled GCM covering the height range from the surface approx. 250 km. It has been developed at the Max Planck Institute for Meteorology in Hamburg. HAMMONIA is based on the MAECHAM5 with a vertical extension up to the lower thermosphere.

The model was run at T31 with 67 vertical levels up to 1.7e-7 hPa (ca. 250 km). The model has a full dynamic and radiative coupling with the MOZART3 chemical module, containing 48 compounds. The model was integrated with a 10 min time-step. Two five year simulations were made with the old and new PSC scheme.



The PSC module was originally developed for the FinROSE-CTM (Damski et al. 2007a,b) and includes heterogeneous processing through ten reactions on/in liquid binary aerosols and type Ia, Ib and II polar stratospheric clouds (PSC), and PSC sedimentation It also includes tracers for taking into account supersaturation and formation of large NAT particles.

Polar ozone depletion

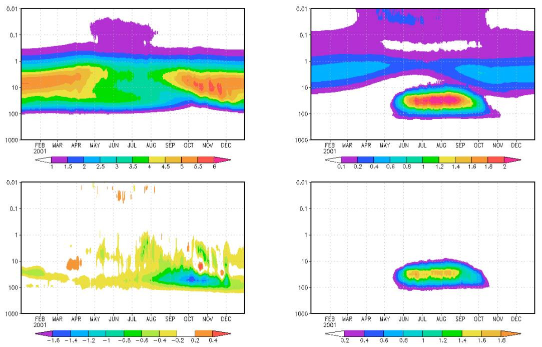


Figure 1. Examples of of chlorine activation (ClO_x) and ozone between 60 and 90°S using the new PSC scheme (upper panels). The difference between compared to the old scheme is shown in the lower panels. The dehydration and denitrification was also somewhat stronger with the new scheme.

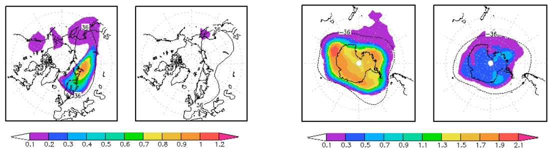


Figure 2. Comparison of ClO_x in the NH and SH vortices with the new and old PSC scheme. The vortex defined as abs(MPV) > 36 PVU is indicated with a black line.

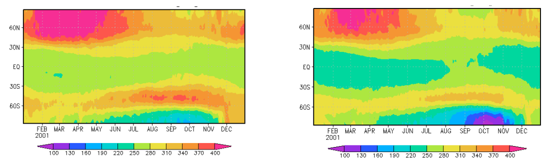


Figure 3. Example of the total ozone column development with the old (left) and new (right) scheme. The representation of the SH ozone hole improved. The overall total ozone also decreased probably due to reactions on aerosols. In addition, for some years the model exhibits unrealistically high ozone depletion in the NH vortex due to a too stable vortex

Vertical ozone distribution and polar vortices

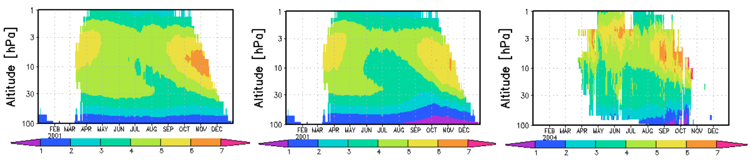


Figure 4. Vortex averaged ozone profiles using the old (left) and the new (middle) scheme compared to GOMOS data (right). GOMOS - Global Ozone Monitoring by Occultation of Stars on the ESA Envisat-satellite measures transmission spectra of light through the Earth's limb using the stellar occultation method (e.g. Kyrölä et al. 2006). The vortex defined as MPV < -36 PVU.

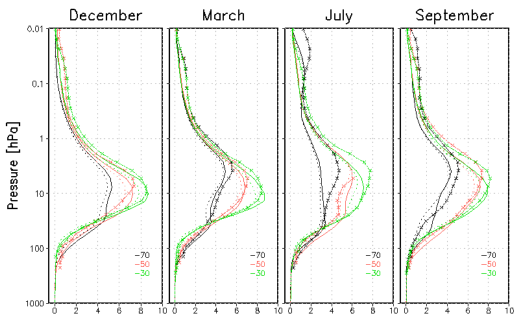


Figure 5. Zonally averaged ozone profiles using the old (continuous line) and the new (dotted line) scheme compared to GOMOS profile data (crossed line) at latitudes 30°, 50° and 70°S.

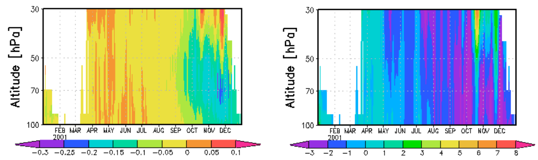


Figure 6. Difference in the SH vortex average SW heating tendency (K/dy) and temperature (K). Less ozone results in less heating by UV absorption in the spring. In general, the vortex became stronger and the break-up was delayed, as seen from the pv distribution.

Acknowledgements

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