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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The maintenance of elevated active chlorine levels in the Antarctic lower stratosphere through HCl null-cycles" *by* Rolf Müller et al.

Rolf Müller et al.

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We thank the referee for the review and for very helpful comments. We give a point-by-point reply below, where the reviewer comments are repeated in italics.

General

The manuscript by Müller et al. represents an important process study for stratospheric chemistry in the Antarctic. The manuscript details a mechanism for the maintenance of high ClOx through effective chemical cycles (termed HCl null-cycles) that inhibit

chlorine deactivation. The authors apply state-of-the-art box model calculations to determine chemical reaction rates and chemical pathways, explore the effects of future changes in chlorine and methane levels and provide a sensitivity analysis for different initial ozone mixing ratios and HNO3 levels. The manuscript is well prepared, and I find it suitable for publication in ACP after a few minor additions/corrections detailed below.

Thank you very much. In the revised version all comments have been taken into account.

Specific Comments

P3, L13: please provide briefly a few specifics of the radiation code applied

We agree, we have added the following text to the paper: "The diabatic descent rates were calculated using a radiation code (Morcrette, 1991; Zhong and Haigh, 1995) assuming a cloud-free atmosphere. We use temperatures from the ECMWF operational analyses and climatological ozone and water vapour profiles (Grooß and Russell, 2005)."

P3, L32: I understand why the authors use the 0% and 100% branching ratios as limit cases, but performing integrations with a small set of intermediate, more realistic, branching ratios would strengthen the manuscript.

We agree and have conducted additional simulations assuming a 20% increase (yellow line in Fig. 1) and decrease (light blue line in Fig. 1) of the recommended branching ratio for the radical channel of the formaldehyde photolysis; the value of 20% is deduced from the study of Röth and Ehhalt (2015). The results are shown in Fig. 1 and will be added to the paper.

P11, L24: please provide a little more detail on the diabatic descent and latitude varia-

tions considered

We agree. We have inserted the following text in the paper: "In the period early August to early October all trajectories are subject to roughly the same diabatic descent of ≈ 10 K, similarly as for the reference run. In this period, all trajectories show strong variations in latitude, again similar as for the reference run. The latitude varies between the South Pole and $\approx 65°$S with some equatorward excursions to $\approx 60°$S or, even more rarely, to $\approx 55°$S."

Technical Comments

Figures 2, 3, A1, A2: readability of panel (a) would be improved by extending the axis to 0 ppb.

Thanks very much for pointing out this oversight! All figures are corrected in the revised version.

Figure 4: adding the results of the reference simulation (in color) to this figure would be helpful

We agree. The revised figure (Fig. 2 of this reply) is shown here.

All Figures: alternating the labels between left and right y-axis among panels would improve readability and allow for larger axis labels.

As suggested, we have increased the size of the axis labels.

References

Grooß, J.-U. and Russell, J. M.: Technical note: A stratospheric climatology for O_3, H_2O, CH_4,

NO_x, HCl, and HF derived from HALOE measurements, Atmos. Chem. Phys., 5, 2797–2807, 2005.

Grooß, J.-U., Brautzsch, K., Pommrich, R., Solomon, S., and Müller, R.: Stratospheric ozone chemistry in the Antarctic: What controls the lowest values that can be reached and their recovery?, Atmos. Chem. Phys., 11, 12 217–12 226, 2011.

Morcrette, J.-J.: Radiation and cloud radiative properties in the European Centre for Medium-Range Weather Forecasts forecasting system, J. Geophys. Res., 96, 9121–9132, 1991.

Röth, E.-P. and Ehhalt, D. H.: A simple formulation of the CH_2O photolysis quantum yields, Atmos. Chem. Phys., 15, 7195–7202, doi:10.5194/acp-15-7195-2015, http://www.atmos-chem-phys.net/15/7195/2015/, 2015.

Zhong, W. and Haigh, J. D.: Improved broadband emissivity parameterization for water vapor cooling rate calculations, J. Atmos. Sci., 52, 124–138, 1995.

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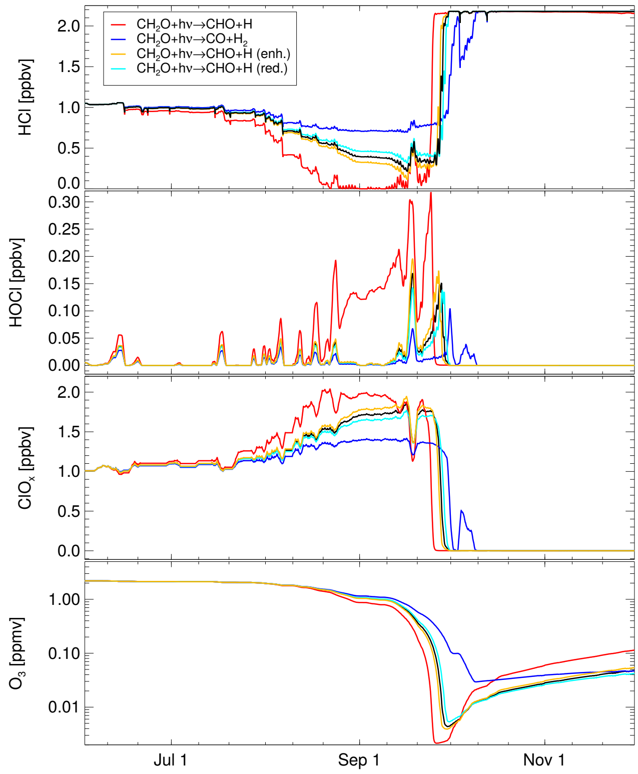

Fig. 1. Improved version of Fig.∼2 showing the effect of realistic estimates of the uncertainty of the branching ratio of the formaldehyde photolysis (light blue and yellow lines).

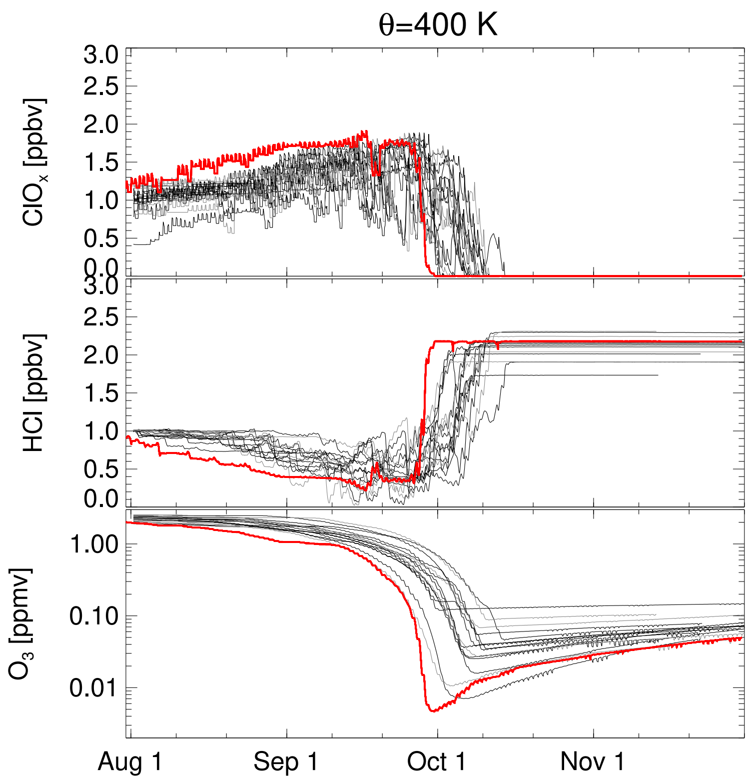

Fig. 2. Results from multi-trajectory simulations of CLaMS. Box-model simulations were performed for a set of trajectories passing the South pole at 400 taken from Grooß, et al. 2011.