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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Quantification of the impact in mid-latitudes of chemical ozone depletion in the 1999/2000 Arctic polar vortex prior to the vortex breakup" *by* G. Koch et al.

Anonymous Referee #2

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General Remarks

Koch et al. present simulations for 120000 long-time trajectories starting inside the vortex on December 1999 and examine the cross vortex edge transport as well as ozone depletion for those trajectories that leave the polar vortex.

The most interesting point of this paper would be a quantification of this effect including the impact on mid-latitude ozone. However, my opinion is that the authors have not done this in a conclusive way as will be explained below. Therefore I suggest not to accept it for publication in ACP.

Specific Points

1. This is a pure model study. The simulated cross vortex edge transport is not validated by any observations. Therefore it is not possible to judge, whether the presented results are real, especially as the authors use simplified and out-dated parameterizations in their simulation (see especially points 2, 7, 9, and 12) that may in total be crucial.

2. In this study, no interaction between the individual air masses are considered. However, it is well known that mixing of airmasses must be taken into account to achieve realistic view of the atmosphere [e.g. McKenna et al. 2002, Konopka et al., 2003]. Especially at the locations with inhomogeneous wind fields mixing is important.

3. The view of multiple single air parcel trajectories without mixing can only meaningful in a statistical sense, which is done in most parts. But it is problematic to look at single example trajectories as it is done in figures 2 and 8.

4. The subject of mixing in fragments of the vortex into mid-latitudes has been the subject of an EU project SAMMOA from which a number of publications has been achieved. These should be cited and compared with the presented approach. In 1919.7ff the argument that the vortex air is mixed with mid-latitude air cannot be justified by the chosen method. In fact, fragments of vortex air can survive over long time periods, although analyzed PV decreases in the air masses.

5. The argument why the results differ from those of Hauchecorne et al. (2002) is not clear (1924.16-23). Why should a "better" definition of the vortex edge lead to more transport through the vortex edge?

6. The paper could be shortened as it includes some of "textbook knowledge" that is not at all new, e.g.

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- p.1922: Without heterogeneous chemistry, much lower ozone depletion is found
- p.1923.7-12 chlorine loading in the stratosphere

7. Details of the trajectory calculation:

    - The program to calculate the trajectories is not explained or referenced in the paper even though it is a central tool to the analysis. E.g. what is the method to calculate the trajectories, which time-step is used, how are singularities handled that arise potentially at the North pole, etc. It is only mentioned which analysis and resolution is used.
    - It is well known that due to uncertainties in the wind data and trajectory algorithms, trajectories longer than about 10 days do not predict reliable positions of the air masses. Here, also the vertical velocity is assumed to be uniform for all trajectories, an assumption that is likely wrong [Ray et al., 2002] which again would increase the trajectory error.
    - The authors use fraction of air and fraction of trajectories synonymously, but it is not clear, whether the non-interacting trajectories are still equally distributed over the vortex or if they cluster at certain locations.

8. Definition of the vortex edge The method to define the vortex edge (page 1915) sounds very similar to the method of Nash et al. [1996] that is used in numerous studies. It is not clear what the difference to Nash et al is.

9. Denitrification

    - To just remove NOy linearly in time is a very crude approximation and there is better knowledge about the microphysics that underly the denitrification. Although the denitrification is not yet fully understood, it is for example known that temperatures must be below T_{NAT} to denitrify the air. At the

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least the authors should show in the figures how much NOy is removed in the model.

- Are the results for NOy comparable with the observations of Popp et al, (2001). If so, a comparison should be shown. As denitrification changes with time, this comparison should be for comparable time.

10. 1920.23ff "Chlorine concentrations ...stratosphere" The meaning of this sentence is not at all clear.

11. 1922.7ff, figure 11: This point is not clear: Why should ozone depletion saturate with time? As long as there is active chlorine, the ozone depletion should continue. The shown linear correlation between O3 and time (T$<$T$_{NAT}$) less than $\approx$24h and the saturation behavior thereafter does not fit to current theory. Please explain more why this behavior is found, if this is not a sampling artifact.

12. Outdated model information and missing model description details

    - The assumed NAT number density of 1 cm^{-3} is much higher than what is typically observed. Besides the very large NAT particles that have been observed first in 2000 by Fahey, also the 'background' NAT has lower number densities by about 2 orders of magnitude. Probably it does not matter too much with respect to chlorine activation.

    - For reaction kinetics, the recommendations of DeMore et al. (1997) and Atkinson et al. (1999) are used. For DeMore there have been two updates since 1997 [Sander et al., 2000; 2003] and it is not clear why the two recommendations by DeMore and Atkinson need to be used. If so, which reactions are taken from which recommendation?

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Minor Points

1916.18 Say "NOy loss term" or "HNO3 loss term" instead of "denitrification loss term"

1917.6 "In the late winter ... 90°" Do you mean "In late winter where sunlight is available, Cl2O2 photolyzes..."?

1917.25/1918.12 How can 90% stay in the vortex and 24% leave the vortex prior to the vortex breakup?

1919.7 The amount of vortex air

1920.1 Is the North pole (90N) really outside the vortex?

1920.5 What is an "ozone production/destruction rate" ?

1920.6 The peak values of ozone depletion rate are not the most interesting. More interesting would be a running average along the trajectory of the ozone loss per sunlight hour

1921.7; 1921.9; 1921.13, figure 10, and other places: It is disturbing to read about ozone destruction/decline/depletion by a negative number. Say either ozone destruction by 5% or ozone change by -5%

1921.17 "...lower temperatures lead to reduced ozone destruction" The opposite is true!

1922.20 The classical definition of NOx is NO+NO2; therefor I don't understand this point

figure 2 This figure is not easy to read, especially diurnally varying species like ClO could be left out in the bottom left panel

figure 4, caption Change "top", "bottom" in "left, "right" ; similar in figure 5

figures 9, 12 you likely mean "mixing ratio" instead of "concentration"

figure 10 Does the ozone depletion differ from those air parcels that stay inside the vortex over the whole period?

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 1911, 2004.

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