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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The impact of mixing across the polar vortex edge on Match ozone loss estimates" *by* J.-U. Grooßet al.

Anonymous Referee #2

Received and published: 29 August 2007

The paper concentrates on the ozone budget in the lower stratospheric polar vortex in winter 2002/03. Mainly 2 methods are considered to make certain quantitative estimates. These are simulations of the Lagrangiang chemistry transport model CLaMS and measurements of the MATCH campaign.

Within CLaMS mainly 2 methods are considered (hereafter referred to as CLaMS method 1 or 2):

1. CLaMS has 2 ozone tracers, a chemically active O_3^{chem} and a passive O_3^{pass} tracer. The difference $O_3^{chem} - O_3^{pass}$ is used as method 1.
2. This method considers the CLaMS chemically active ozone alone.

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Interactive Discussion

Discussion Paper

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The stratospheric polar vortex ist bounded laterally by a function of Ertel's potential vorticity (EPV). In the vertical mainly a column between the isentropic surfaces of 400K and 500K is considered. Consequently, averaging is done over this hereafter "so-called "control volume.

This reviewer suggests the paper to be rejected for final publication in ACP for the following major concerns:

1 Major Concerns

1.1 Budget Calculations

The classical approach making budget calculations within a finite control volume (here the polar vortex) is to seperate between fluxes through the boundaries and the calculation of production or loss terms within the control volume. One of the major advantage of using numerical models is the ability to distinguish here carefully. With some effort this can also be achieved in a Lagrangian model like CLaMS. Beside the specific concern, that the authors do not distinguish between the overall ozone tendency within the polar vortex and the chemical ozone loss, the authors do by far not accurately enough take care about the fluxes of ozone through the boundaries:

1.1.0.1 Vertical fluxes: The fluxes through upper (500K) and lower boundaries (400K) are not discussed at all. The reviewer thus has to argue himself about, how these fluxes are taken into account and comes to the following statements:

- In CLaMS method 1, both ozone tracers are transported by diabatic processes in CLaMS. Thus, the difference might lead to an idea of the ozone loss due to

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chemistry within the column taking into account. However, to this reviewer, this might be a good idea for short term intergrations. Then, effects of 1st chemically processed ozone and 2nd transported through the boundary can a-priori assumed to be small. This argument, however, does not apply when integrating over an entire season.

- For CLaMS method 2, a mean diabatic descent rate $(\bar{w})$ is computed and discussed alone as a mean flux $(\overline{wq})$ through the isentropic surface, where q is the ozone mixing ratio. The authors neglect completely the eddy fluxes arising from standard perturbation theory giving: $\overline{wq} = \bar{w}\bar{q} + \overline{w'q'}$. This derivation lacks also from precision, since the variation of air density along an isentropic surface is not considered. This precision, however, is not the task of a review, but the authors of a scientific paper should adhere.

The rather complicated way, how CLaMS trajectories are compared with Match results and discussed with respect to coincidencies or discrepancies seems rather arbitrariliy, because for a comparison of this kind only, all trajectories being currently inside the vortex have to be collected and their properties are to be evaluated. Hereafter, higher derived properties may be considered.

1.1.0.2 Lateral fluxes: The fluxes through the lateral boundaries are named "mixing" by the authors. However, before denoting them to mixing alone, it has to be shown that advection (here due to production of EPV) plays a minor role here. This is missing at all within this paper, even though one of the production terms of EPV is diabatic heating, that was considered in the vertical flux discussion.

With CLaMS, advective fluxes can be computed from the production of EPV, derived from change in time of EPV from ECMWF analyses following each trajectory and the gradient of EPV. Independently of this paper, a discussion on the EPV conservation

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in CLaMS would be an evaluation of CLaMS using basic physical properties of the stratosphere.

1.2 One way "mixing"

In is unclear, why Match "does not include air masses transported into the vortex" (e.g. Conclusions, line 14 ff.; but also beginning of section 5.1 and other places). Instead, the opposite seems much more likely. Since Match takes into account only sonde measurements inside of the vortex, it cannot make estimates on air that left the vortex but sees any air transported into the vortex. Since this is a centrepoint of the interpretations of the authors, I expect careful arguments here that are well justified on a scientific basis.

1.3 Space gridding vs time stepping

CLaMS is used in a rather high horizontal resolution. This allows the explicit resolution of subsynoptic scale atmospheric patterns (e.g. gravity waves of different kinds). On the other hand, the meteorological parameters are taken from analyses provided every 6 hours. Even though an interpolation in time may be applied, the meteorology provided then can generally not provide the actual evolution in time of the small scale patterns resolved in each analyses.

Therefore, this reviewer is of the opinion, that the spacial resolution of CTM modelling is limited by the provision of analyses in time. It is part of the responsibility of the authors to discuss this problem based on physical arguments. E.g. an applicability proven by sampled matches of observations and model result is not sufficient, because in case of failure here this problem cannot be excluded as cause of the failure.

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2 Specific Comments

Because of the weight of the major concerns here, some specific concerns are listed below only, that highlighted while reading the paper

2.1 Use of technical terms

The authors use technical terms outside their classical interpretation. This reviewer works in a neighbored discipline and had to go to his colleague to get the possible meaning of specific terms here. Some of them are listed below:

2.1.0.3 The Correlation is an evaluation of 2 (or more) random variables based on the theory of probalistic. Therefore, e.g. fig. 1 right panel, or fig. 2 do not show correlations but plots of data of CFC-11 over CH4 or F11 over CH4.

2.1.0.4 Production or loss denotes to source or sink terms doing budget calculations. This paper uses the terms describing tendencies inside the vortex not excluding transport. Any kind of transport however is no sink but always describes a redistribution of the trace species (or other property like momentum or energy) considered.

2.1.0.5 Altitudes are never great (p. 11727, line 9). A piece of music may be great, altitudes are high or so. This and other places in the text lead to the very strong recommendation, to give the text for proof reading regarding proper English.

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2.1.0.6 The dynamics deal with forces and the motions governed hereby. Therefore, CLaMS (like all other CTMs) is note able to "reproduce the dynamics" (Conclusions) but the cinematics of the stratosphere.

2.2 Others

2.2.0.7 A model description is provided in section 2. Even though a horizontal "resolution" is discussed as low (100 km) an high (80 km), which seems not to be a significant difference, no information is provided regarding the vertical resolution. Please notice, that this is not a "resolution" but eventually an "initial spacing of the trajectories".

2.2.0.8 Section 5 and subsections contain critical remarks on Match alone. Having in mind the major concerns above, these sections have to be reworked entirely including deficiencies of CLaMS or results of CLaMS based upon the concerns here.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 11725, 2007.