GENERAL COMMENTS

This article investigates the effect of denitrification on polar ozone loss in the Arctic winter 2004/05. Although similar works were reported earlier, this work uses three different scenarios of denitrification within the same model. The ozone loss deduced from the recommended version of the model runs, with DLAPSE scheme, agrees well with the measured ozone loss. These experiments are quite interesting. Therefore, the article should be published after addressing the following comments.

SPECIFIC COMMENTS

1. In order to emphasize the results, the authors need to present a few sentences or a short paragraph describing how "DLAPSE in SLIMCAT" helps to simulate better, as compared to other results. A comparison with previous results with DLAPSE or similar studies with other models will do (for e.g.: *Carslaw et al., Davies et al., Grooss et al., Tripathi et al.*, etc). Though other studies cannot be compared directly with EXP_B, a reasonable comparison with EXP_A and EXP_C is possible, as the other modellers usually conduct those experiments to study the sedimentation/denitrification effect in their models. Its is better to put the results in the context of previous related works rather than restricting them to a single year experiment.

2. There are three different studies on Arctic denitrification using various measurements for this particular winter (*Jin et al., Kelinboehl et al., and Schoeberl et al.*). These studies include measurements from both ASUR and MLS. Comparable results from these studies are to be discussed (e.g. winter conditions, HNO3 values, what they say about denitrification in this winter, etc). These are to be cited. This will also justify the usage of ASUR and MLS data in this study, as the above-mentioned studies clearly show the strength of these measurements for this kind of work.

3. Since the title itself deals with ozone loss, the discussion regarding ozone loss in 2004/05 should be strengthened with all available results for the winter. Some studies are obviously missing in this regard: *El Amaroui et al., Tvsetkova et al., Kuttippurath et al.*, etc. Those are to be cited and discussed in the relevant section with respect to the model experiments performed. Because the difference between EXP_A and EXP_B is about 20 DU, and the uncertainty of the measured loss (that compared with) is also about 20 DU. So it would be good to compare with other results (even if there are slight differences in the column range) to corroborate the author arguments! Abstract and Conclusion should be modified with respect to the comments #1, #2 and #3.

4. How was this 30% (see abstract and conclusion) overestimation calculated? Compared to the measured loss or the difference between the experiment results (EXP*) ? Please explain this in the text.

5. Retrieval techniques of ASUR, and the vertical range, vertical resolution and accuracy of the trace gases are to be explicitly mentioned. Resolution of the compared trace gases is a very important aspect of these comparisons. I am pretty sure that if the simulated/MLS profiles are convolved with the respective ASUR trace gas averaging kernels, the agreement will be much better. So it should be mentioned in the relevant section with some references (*Kleinboehl et al., von Koenig et al., Bremer et al.*).

6. As for ASUR, please provide a few more sentences about the MLS instrument, retrieval features and trace gas details relevant to this study. The v1.5 is almost 4 years old and now v3.3 is available. So give some more details about the improvement in the new versions and state what will bring those improvements in your comparison results.

7. Always use EXP_A, EXP_B and EXP_C to mention the respective model runs. For example: Sometimes it is referred to as "standard model run", "model runs with DLAPSE", etc. This makes confusion about the model runs.

TECHNICAL CORRECTIONS

Page 3858, Line 13: 5-10% is not small

Page 3859, Line 10: give reference after "chemistry"

Page 3859, Line 13: give reference after "components"

Page 3859, Line 21: "a latest version of the SLIMCAT" is it the same model used here, as defined by the "standard model run" ?

Page 3859, Line 22: delete "chemical transport model" and use CTM. It is already there in Line 10. Put the CTM in bracket there.

Page 3859, Line 28: "More details OF "

Page 3859, Line 28: delete the bracket for the references and delete "thereafter"

Page 3860, Line 02: coma after "effect"

Page 3860, Line 03: Airborne Submillimeter Radiometer (ASUR)

Page 3860, Line 04: Microwave Limb Sounder (MLS)

Page 3860, Line 07: "ASUR" is enough, already given the expanded form in Line 3

Page 3860, Line 13: "MLS" is enough, no need to repeat the expanded form in Line 4

Page 3860, Line 22: delete the website address and cite the validation papers.

Page 3861, Line 01: Here the authors can mention that ASUR measurements have been successfully used to quantify denitrification in the Arctic winters 2000 and 2005 (*Kleinboehl et al. 2002 and 2005*). Similarly, cite *Schoerbehl et al.*, from the MLS side. If there is a bias in the MLS data, it has to be mentioned.

Page 3861, Line 05: Ozone cannot be used as a dynamical tracer at all altitudes!

Page 3861, Line 14: "NCAR CCM": expand it. Is it better than the MIDRAD scheme?

Page 3862, Line 01: "determination"; may be another word "calculation" or "simulation" ?

Page 3862, Line 01-04: Rephrase the sentence.

Page 3862, Line 05: radius ?

Page 3862, Line 07: "the cold ARCTIC winter"

Page 3862, Line 13: put "DLAPSE" in brackets instead of its expanded form

Page 3863, Line 02: introduce Table 1 properly (not in bracket)

Page 3863, Line 13: State why these dates are selected for the comparisons.

Page 3863, Line 19: "denitrification having occurred" at what altitude? Write the altitude to make it more clear.

Page 3863, Line 20: "between 18 and 24 km"

Page 3864, Line 04: no ClO measurements available from ASUR ?

Page 3864, Line 05: no other (nearby) ASUR HCl measurements available ?

Page 3865, Line 02: delete "percent" to make it consistent with "The relative o3 differences "

Page 3865, Line 05: Is there any reason for the selection of 456 K ? if yes, state that in the text.

Page 3866, Line 12: ", which IS consistent "

Page 3867, Line 03: This paragraph should be modified, as discussed in Specific comments #3.

Page 3867, Line 07: "However, there are still large differences ". Consider the altitude and time of ozone loss estimations for the comparisons. The method of estimation and vortex definitions will definitely play a role in deciding the amount of ozone loss. So add the altitude level and time of estimation in the table.

Page 3867, Line 08: The table should be introduced properly and not in bracket.

Page 3867, Line 09: Sub-Millimetre Radiometer (SMR)

Page 3867, Line 11: What sort of measurement is from Geophysica? Is it a local/single day measurement? If so, it has to be mentioned. In this case the comparison holds only for the particular day and location.

Page 3867, Line 12: place *von Hobe et al.* in the previous line after "aircraft data"

Page 3867, Line 12: the lower limit of the ozone loss estimation from Jin et al. was 1.8 ppmv? They have used several methods for the loss computations. Which one is selected for this comparison?

Page 3867, Line 19: Give experiment name if applicable here (EXP_A, B, C)

Page 3867, Line 20: "slightly lower", give the value

Page 3868, Line 03: 121+/-20 DU (delete the space)

Page 3868, Line 05: It would be good to compare the results with other estimations too (e.g. *Jin et al., Singleton et al., Tvsetkova et al., Kuttippurath et al.,* etc).

Page 3868, Line 16: ". The partial ", delete coma and put fullstop

Page 3869, Line 20: acknowledge ASUR data

Table 1: Instead of none, "no denitrification " ?

Table 2: Add other avaialbe studies (*El Amaroui et al., Tvsetkova et al., and Kuttippurath et al.*)
Add time and altitude of the loss estimation too.

Figures 1-2: The latitude and longitude of which measurement is given here, ASUR or MLS?
Write that in the caption.

Figure 7-8: Write the experiment names in appropriate places, as did in Figures 5 and 6.
Is 25 km too high for 550 K? It depends though! May be 21-23 km?

General: minus is used instead of hyphen in some places. Please change that.

REFERENCES

Bremer, H., M. von König, A. Kleinböhl, H. Küllmann, K. Künzi, K. Bramstedt, J. P. Burrows, K.-U. Eichmann, M. Weber, A. P. H. Goede: Ozone depletion observed by ASUR during the Arctic Winter 1999/2000. J. Geophys. Res., 107, D20, 10.1029/2001JD000546, 2002.

Carslaw, K. S., J. Kettleborough, M. J. Northway, S. Davies, R. S. Gao, D. W. Fahey, D. G. Baumgardner, M. P. Chipperfield, A. Kleinböhl: A Vortex-Scale Simulation of the Growth and Sedimentation of Large Nitric Acid Particles Observed during SOLVE/THESEO 2000. J. Geophys. Res., 107, D20, 10.1029/2001JD000467, 2002.

Davies, S., et al.: Modeling the effect of denitrification on Arctic ozone depletion during winter 1999/2000. J. Geophys. Res. 107, 8322, doi:10.1029/2001JD000445(printed 108(D5), 2003), 2002.

El Amraoui, L., N. Semane, V.-H. Peuch, and M. L. Santee: Investigation of dynamical processes in the polar stratospheric vortex during the unusually cold winter 2004/2005, Geophys. Res. Lett., 35, L03803, doi:10.1029/2007GL031251, 2008.

Grooβ, J.-U., Gunther, G., Konopka, P., Muller, R., McKenna, D.S., Stroh, F., Vogel, B. Engel, A., Muller, M., Hoppel, K., Bevilacqua, R., Richard, E., Webster, C.R., Elkins, J.W., Hurst, D.F., Romashkin, P.A., Baumgardner, D.G.: simulation of ozone depletion in spring 2000 with the Chemical Lagrangian Model of the Stratosphere (CLaMS). J. Geophys. Res. 107(D20), 8295, doi:10.1029/2001JD000456, 2002.

Jin, J.J., K. Semeniuk, G.L. Manney, A.I. Jonsson, S.R. Beagley, J.C. McConnell, C.P. Rinsland, C.D. Boone, K.A. Walker, and P.F. Bernath: Denitrification in the Arctic winter 2004/2005: Observations from ACE-FTS, Geophys. Res. Lett. 33, L19814, doi:10.1029/2006GL027687, 2006.

Kleinböhl, A., Bremer, H., Küllmann, H., Kuttippurath, J., Browell, E. V., Canty, T., Salawitch, R. J., Toon, G. C., Notholt, J.: Denitrification in the Arctic mid-winter 2004/2005 observed by airborne submillimeter radiometry, Geophys. Res. Lett., 32, L19811, 10.1029/2005GL023408, 2005.

Kleinböhl, A., Bremer, H., von König, M., Küllmann, H., Künzi, K., Goede, A. P. H., Browell, E. V., Grant, W. B., Toon, G. C., Blumenstock, T., Galle, B., Sinnhuber, B.-M., Davies, S., Vortexwide denitrification of the Arctic polar stratosphere in winter 1999/2000 determined by remote observations, J. Geophys. Res., 107, 8305, 10.1029/2001JD001042, 2002 (printed 108, 2003).

von König, M., H. Bremer, A. Kleinböhl, H. Küllmann, K. Künzi, A. P. H. Goede, E. V. Browell, W. B. Grant, J. F. Burris, T. J. McGee, L. Twigg: Using gas-phase nitric acid as an indicator of PSC composition, J. Geophys. Res., 107, D20, 10.1029/2001JD001041, 2002.

Kuttippurath, J., Godin-Beekmann, S., Lefèvre, F., and Goutail, F.: Spatial, temporal, and vertical variability of polar stratospheric ozone loss in the Arctic winters 2004/2005–2009/2010, Atmos. Chem. Phys., 10, 9915-9930, doi:10.5194/acp-10-9915-2010, 2010.

Schoeberl, M. R., et al.: Chemical observations of a polar vortex intrusion, J. Geophys. Res., 111, D20306, doi:10.1029/2006JD007134, 2006.

Tripathi, O. P., et al. (2006), High resolution simulation of recent Arctic and Antarctic stratospheric chemical ozone loss compared to observations, J. Atmos. Chem., 55, 205– 226, doi:10.1007/s10874-006-9028-8.

Tsvetkova, N. D., Yushkov, V. A., Luk'yanov, A. N., Dorokhov, V. M., and Nakane, H.: Record-breaking chemical destruction of ozone in the arctic during the winter of 2004/2005, Izvestiya Atmos. Ocean. Phys., 43, 592–598, 2007.