

Dear Reviewer,

Thank you very much for your valuable comments on our paper acp-2011-586 “Changes in chemical composition of the middle atmosphere caused by sudden stratospheric warmings as seen by GOMOS/Envisat”. Below we present the detailed replies to your comments.

Comments

Reviewer#2.

Major comments:

1. The manuscript focused on the response of the polar O₃, NO₂, and NO₃ within the polar night condition (70N-90N, from middle December to late January in most SSW cases or early February in 2008 case). In some years, there were minor or major SSW events taking place in February or March. Therefore, certain keyword like “polar night” or “polar winter” should be mentioned in the title. Also, the time period of “2003-2008” should be added to the title, since the GOMOS observations covers from late 2002 until the present

Authors

The title is changed to “Polar-night O₃, NO₂ and NO₃ distributions during sudden stratospheric warmings in 2003-2008 as seen by GOMOS/Envisat”.

Reviewer#2.

2. Page 23326-23327: Paragraphs between the title of Section 3.1 and title of Section 3.1.1 are generally the review of the background. Consider to re-organize them and moved most of them into the Introduction Section.

Authors:

In the section 3, each subsection contained a short theoretical part on what is expected from the current understanding of chemistry and dynamics. This introductory part is slightly longer for the stratospheric ozone, NO₂ and NO₃ than for tertiary and secondary ozone maxima. From our point of view, it is more logical to present such a discussion in section 3 than put it into the general introduction. In the revised version, we have shortened this discussion and have put in a separate subsection entitled “Introductory notes: stratospheric chemistry in polar night conditions”.

Reviewer#2.

3. Page 23327-23328, Section 3.1.1 and Figure 3: When the polar vortex is greatly disturbed by the SSW events, the average between 70N and 90N will be strongly affected by the location of the polar vortex. However, most of the results are based on the zonal average between 70-90N. Consider to look at the average within the polar vortex. Or, add some horizontal distributions of the temperature and trace gases (with some PV contour to mark the location of polar vortex).

Authors:

Of course, it is affected by the polar vortex in the stratosphere. Actually, we have evolution of 3D field in time. In our paper, we aimed at characterization of the changes in the atmospheric composition in polar regions that are caused by both chemistry and dynamics. We think that considering average only within polar vortex will limit our studies significantly, because:

- The polar vortex exists only in the stratosphere, while for ozone we show the vertical profiles in the whole middle atmosphere;
- During the major sudden stratospheric warmings, the polar vortex can be broken completely;
- Considering the averages within polar vortex will not eliminate the dynamical contribution (mixing).

Therefore, we have added the supplement file showing horizontal distributions during different phases of the considered sudden stratospheric warmings at three altitudes (~40 km, where NO₂ and NO₃ mixing ratio is maximal; ~ 72 km, the typical altitude for tertiary ozone maximum, and ~95 km, the mean altitude for the secondary ozone maximum). In the revised version, we discuss the observed distributions.

Reviewer#2.

4. Page 23329 line 11-15, Figure 4: The difference of NO₃ between the FinROSE and GOMOS seems a little bit larger compared to the temperature difference between MLS and ECMWF. Try to check the climatology of NO₃ in FinROSE and compare with previous observational result or simulation from other middle atmosphere chemistry models. Otherwise, try to drive SCI model with MLS and ECMWF respectively and find if the temperature difference could lead to the difference in NO₃ distribution.

Authors:

We have checked both vertical and horizontal distributions and confirm that NO₃ in FinROSE is perfectly correlated with temperature. This is also confirmed by the correlation analysis presented in our paper.

Reviewer#2.

5. Page 23329 line 19-22: The comparison of SIC simulation and GOMOS does imply that both chemistry and dynamics play some role in the budget of the NO₃ during the SSW event. Recently, Liu et al. (2011) quantified the contributions of both chemistry and dynamics to polar vortex ozone during the 2002-2003 SSW event using both MIPAS measurement and MOZART-3 chemical transport model. They also reported the enhanced ozone depletion by NO_x catalytic cycle inside the polar vortex during the SSW event. You can try the same method or run FinROSE with/without certain chemistry to separate the dynamical and chemical effects on the NO₃ budget, if it is not too difficult for FinROSE simulation (only a suggestion). (Liu, Y., C. X. Liu, X. X. Tie, and S. T. Gao, 2011: Middle stratospheric polar vortex ozone budget during the warming arctic winter, 2002–2003. *Adv. Atmos. Sci.*, 28(5), 985–996, doi: 10.1007/s00376-010- 0045-9.)

Authors:

Thank you very much for suggesting a very interesting paper. In the revised version, we have included the reference on this paper and its main results. The test, which you suggest, can be performed in the future with FinROSE, after resolving the discrepancy in NO₂ distributions.

Reviewer#2.

Minor Comments:

1. In the Introduction section, similar studies about the impact of SSW on stratospheric

ozone and NO_x based on other observational datasets (e.g., MIPAS also onboard ENVISAT satellite) should also be added.

Authors:

We have added many references in the introduction, including those you suggested.

2. Page 23321 line 24: should be reworded as " in detail by Kyrölä et al. (1993, 2010b)"

3. Page 23332 line 18: should be reworded as "The simulations by Sonnemann et al. (2006)".

4. Page 23332 line 23: should be reworded as "are reported by Smith et al. (2009)".

5. Page 23319 line 22: (Liu et al. 2009) investigated the impact of SSW in 2003-2004 winter on the stratospheric ozone and its downward transport together the changed meridional circulation in stratosphere. Therefore, this reference should be better moved to line 25 in the same page.

Authors: The text is corrected.