Dear Reviewer,
Thank you very much for your attention to our paper acp-2011-586 "Changes in chemical composition of the middle atmosphere caused by sudden stratospheric warmings as seen by GOMOS/Envisat" and for your valuable comments and suggestions. Below we present the detailed replies to each comment.

Comments

Reviewer #1

1) The title is too vague. The changes presented here concern only ozone, NO2 and NO3. It seems that "Case studies of . . . (giving the dates) . . ." will be more appropriate.

Authors

The title will be made more concrete: "Changes in middle-atmospheric ozone, NO_2 and NO_3 caused by sudden stratospheric warmings as seen by GOMOS/Envisat"

Reviewer #1

The main criticism concerns the references.

2) I think this subject was already studied in the past with other satellite data. Can the author provide a survey of what have been done previously ?

Authors

The study of response of stratospheric ozone to SSW has been performed using SAGE data, [*Wang et al.*, 1983]. This reference will be added in the revised version. There have been also several studies on stratospheric ozone changes associated with SSW using balloon and ground-based measurements, which pointed out on necessity of considering 3D fields instead of 1D profiles. For other species, we are not aware of other studies on this subjects that are not mentioned in the introduction of our paper.

Reviewer #1

3) Page 23322 line 14: For the GOMOS validation, the authors give 2 auto-references that are only a compilation of the works done by other teams. This is not a fair approach for the teams who have really performed the work. The authors must refer to: Brachen et al., Adv. Space. Res., 36, 5, 855-867, for comparison with other satellite data. Marchand et al., GRL, 31, L10107 for 03, NO2 and NO3 for self-consistency of the measurements using data assimilation. Meijer et al., JGR, 109, D233052004, 2004, for ozone. Renard et al., JGR, 113, A02302, 2008, using balloon instruments.

Authors

In the discussed manuscript, we wrote: "Review of validation results is presented in (Bertaux et al., 2010; Kyrölä et al., 2010a) (see also references therein)". We thought this is sufficient, because validation is not the topic for our paper. Of course, it is not a problem to cite all validation works explicitly. In the revised version, we will cite the proposed papers and other validation papers on GOMOS data. Thank you for the suggestion.

Reviewer #1

4) Page 23327 line 3: The vertical descent of NO2 as well as its spatial distribution is well documented in the paper by Renard et al., JGR, 114, A12323, 2009.

Authors: Thank you, the reference will be added in the revised version.

Reviewer #1

5) Page 23327 line 13: The NO2 low abundance inside the polar vortex has been known since a long time. For measurements in such geophysical condition and at the time of GOMOS observations, the authors can give the Berthet et al., JGR, 112, D21310, 2007 reference.

Authors: Thank you, the reference will be added in the revised version.

Reviewer #1

6) Page 23328 line 3: If I well understand, "only" 9 cases are documented, and 2 cases do not follow the trend. What kind of conclusion can be derived, taking into account the previous studies on such phenomena?

Authors

As discussed below in the paper, due to influences of both dynamics and chemistry, the changes in trace gases distributions show rather complicated behavior. The relationship between stratospheric ozone and temperature generally exhibits behavior shown in Fig. 6 (correlation plots), which are found also in previous analyses (e.g., [*Wang et al.*, 1983]) , and predicted by theoretical studies and numerical simulations already a long time ago [*Rood and Douglass*, 1985; *Smith*, 1995].

Reviewer #1

7) Pages 23329 line 9 and 23330 line 17: The strong temperature dependence for the NO3 production was first demonstrated by Renard et al., J Atmos Chem, 51, 65, 2005 using balloon measurements. Thus, the fact that the NO3 enhancements are due to change in temperature is not a new result.

Authors

Thank you, the reference and the corresponding text will be added in the revised version.

8) Page 2331-2332: The discussion with the negative and positive correlation is partly unclear. We don't really understand which conclusions the authors want to propose.

Authors

Correlations between ozone and temperature are commonly used to investigate the photochemical and dynamical aspects of data. The correlation analysis provides a quantitative measure for the dependences, which are also seen during visual inspection. The correlation analysis helps to identify the relative importance of chemical and dynamical processes, as discussed in section 3.1.4.

In particular, the observations and conclusions are:

- NO_3 distribution is strongly controlled by temperature;
- Ozone changes associated with SSW are positively correlated with temperature changes in the lower stratosphere, i.e., in the dynamically controlled region below ~35 km, and they are negatively correlated with temperature in the upper stratosphere (altitudes 35-50 km), where chemical processes are significant.
- The experimental response of NO_2 to SSWs exhibits a complicated structure. Probably because of strong mixing with outside-vortex air, the response depends

on the amount of NO_2 inside and outside polar vortex. Models exhibit deviations from observations.

Reviewer #1

9) Page 23331 line 12: The fact that the SIC model does not include the heterogeneous chemistry on aerosols is a problem. The NO2 concentration is very dependent on the amount of sulfate aerosols, and on the occurrence of PSCs within the polar vortex prior to SSW periods. At least, the author must estimate the error induced by such approach.

Authors

As we said in the text, SIC is focused more on the upper atmosphere and it has no heterogeneous chemistry. We will stress in the revised version that in the case of NO_2, the SIC analysis is less robust/reliable below 30 km. The difference in T&NO2 correlation between SIC and FinROSE indicates influence of heterogeneous chemistry or dynamics on changes in NO_2.

Reviewer #1

10) Page 23332 line 10: The fact that the January 2006 and January 2008 events differ from what is observed during the other events can give some troubles on the general rules the authors want to propose.

Authors

As written in our manuscript (and also pointed by the study [*Smith et al.*, 2009] using SABER data), there is still a discrepancy in the current ozone-temperature relationship above ~90 km, which might be due to incomplete understanding of mesopause ozone or/and due to inconsistent observations. With the current GOMOS data, we cannot propose "the general rules", but only speculate on different influencing factors. This is stated explicitly in our paper.

Nevertheless, we think it is worth to show the experimental GOMOS data close to mesopause, because there are not many measurements at these altitudes.

Reviewer #1

11) Figures 3-4: Why the ozone climatology is stopped at a lower altitude of 20 km, and the NO2 and NO3 climatologies are stopped at 25 km? Is it based on validation works? In this cases, please give the appropriate references.

Authors

The selected lower limit is the rationale between the figure visibility and the best data precision. For GOMOS precision estimates of individual measurements are illustrated by Fig. 12 in [*Tamminen et al.*, 2010].

References

Rood, R., and A. R. Douglass (1985), Interpretation of Ozone Temperature Correlations 1. Theory, *J. Geophys. Res.*, *90(D3)*, 5733-5743.

Smith, A. K. (1995), Numerical simulation of global variations of temperature, ozone, and trace species in the stratosphere, *J. Geophys. Res.*, *100*(D1), 1253-1269, doi:10.1029/94JD02395.

Smith, A. K., M. Lopez-Puertas, M. Garcia-Comas, and S. Tukiainen (2009), SABER observations of mesospheric ozone during NH late winter 2002-2009, *Geophys. Res. Lett.*, *36*(23), L23804, doi:10.1029/2009GL040942.

Tamminen, J. et al. (2010), GOMOS data characterisation and error estimation, *Atmos. Chem. Phys.*, *10*(19), 9505-9519, doi:10.5194/acp-10-9505-2010.

Wang, P.-H., M. P. McCormick, and W. P. Chu (1983), A study on the planetary wave transport of ozone during the late February 1979 stratospheric warming using the SAGE ozone observation and meteorological information, *Journal of Atmospheric Sciences*, *40*, 2419-2431, doi:10.1175/1520-0469(1983)040<2419:ASOTPW>2.0.CO;2.