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Interactive Comment

Interactive comment on "Evaluation of CLaMS, KASIMA and ECHAM5/MESSy1 simulations in the lower stratosphere using observations of Odin/SMR and ILAS/ILAS-II" *by* F. Khosrawi et al.

F. Khosrawi et al.

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We thank reviewer 2 for the constructive, helpful criticism. We followed the suggestions of reviewer 2 and revised the manuscript. Please note: The line numbers given by reviewer 2 and thus used in this reply refer to the original manuscript submitted.

Major concerns:

1. It is correct that the N_2O/O_3 diagnostic as introduced by Proffitt et al. (2003) and Khosrawi et al. (2004) is also a function of descent. Descent is visible in the N_2O/O_3 curves by a change of the correlation from negative to positive and an extension of the curves to lower N_2O values ($<$ 50 ppbv). However, for this study one year of data is enough since we focus on the same year for all data sets, namely 2003, and thus

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chemistry and transport should be the same in the model simulations and satellite data. Solely, the CLaMS data is for the winter 2002/2003 and thus for November and December CLaMS data from 2002 is compared with data from 2003. As already discussed in our previous publications (Khosrawi et al., 2006, 2008) differences in the monthly averages are small between different years and can easily be distinguished from model deficiencies. However, to make this more clear in the present paper we included a figure which compares Odin/SMR data from 2003 with Odin/SMR data from 2004 and 2005 and added the following text in section 4: *In Figure 2 monthly averages of N_2O and O_3 derived from Odin/SMR at 500±25 K and 650±25 K for the year 2003 are compared with the two following years (2004 and 2005). As can be seen from this figure, differences between monthly averaged N_2O and O_3 binned by potential temperature are low between different years and can clearly be distinguished from model deficiencies.*

Further, to make more clear that we separate between chemistry and transport we included in the introduction the following sentence: *In this method, tracer-tracer correlations are used in a somewhat different way as in the classical sense which helps to separate O_3 variability due to latitudinal transport from photochemical changes. Thereby, monthly averages of the O_3/N_2O correlation binned by potential temperature are derived.* Additionally, in section 4 the following sentence has been added: *At and below 500±25 K the curves are influenced by a combination of diabatic descent and polar winter ozone loss. Descent is visible in these curves as an extension of the curves to N_2O mixing ratios < 50 ppbv.*

2. It is indeed true that the averaged ozone is the simpler metric to understand. However, the average of the differences of the monthly averaged ozone mixing ratios derived from the model simulation and ILAS data, respectively, from Odin/SMR are calculated. Thus, this calculation is built on the comparison of the monthly averages derived from the satellite data and model simulation data. Therefore, we doubt that a change of order would make the paper easier to understand. However, we are confident that the changes made in the text due to the comments of both reviewers

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make the content of the paper easier to understand.

Specific points:
L70: Why should the usage of only a few months be problematic? We do not see any problem in analysing only a few months of CLaMS data. Of course, in principle, using longer time periods and including more model data sets might be of interest, but such an analyses is beyond the scope of this paper. If, however, reviewer 2 is aiming here at the fact that we cannot compare here for all months the same years, we would like to refer to the figure which has been included in section 4 showing that differences between different years are small (see also our response to major concerns (1)).

L203: The curves used in Figure 1 a, b and c describe schematically descent, polar winter ozone loss and summer ozone loss and are derived from ILAS and ILAS-II data. Solely, the reference curves shown in Figure 1d are derived from ATMOS data. We changed the caption and the text to make this more clear.

L219: The curves are influenced by both processes, descent and photochemical ozone destruction. In the previous paragraph the influence of descent on the curves is described while in this paragraph the influence of polar winter ozone loss on the curves is described. Descent results in a positive correlation of the curves *above* 500 K while polar ozone loss causes a slope change of the curves *below* 550 K. We improved the paragraph describing the influence of descent on the curves and added “below 550 K” in the paragraph describing the influence of polar winter ozone loss on the curves. We hope that these improvement make the text more clear.

L224: The N_2O bins have a width of 20 ppbv. This is already stated on line 195. We do not think it is necessary to include the bin size here again. However, we inlcude the bin size in the figure caption of Figure 2.

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L264: We prefer to use percentage rather than sigma to state about the agreement of the models with the measurements. However, the 20% we used as a measure for a good agreement between models and measurements agree roughly with 1σ. We changed the text as follows: *We refer to a good agreement in case of differences within* $\pm$*20% (which roughly agrees with 1*σ*) and to a reasonable agreement for differences within* $\pm$*40%.*

L269: We agree, that the Antarctic is the best place to look for extreme ozone loss. However, recent analyses of chemical ozone loss in model simulations (Tilmes et al., 2007, Lemmen et al., 2006) have shown both a substantial underestimation of ozone loss in the Antarctic and a severe underestimation of ozone loss in the Arctic. Thus, model evaluations are still needed for both hemispheres. Further, Arctic ozone loss is even more difficult to simulate accurately than Antarctic ozone loss.

L275: To make this more clear, we included a figure which compares the monthly averages of N_2O and O_3 for the years 2003-2005. We included the following sentence referring to this figure: *How small the differences between different years are can be seen from Figure 2 where the monthly averages of* N_2O *and* O_3 *derived from Odin/SMR at 500*$\pm$*25 K and 650* $\pm$ *K are shown for three different years.*

L284: We included a figure showing the monthly averages of CLaMS, KASIMA, E5M1, ILAS/ILAS-II and Odin/SMR including standard deviations for the month March. Additionally to the figure the following text has been added: *However, Figure 3 shows the comparison of the models with Odin/SMR including the standard standard deviations for one month (March, northern hemisphere) to give a better impression on the magnitude of the standard deviations of the models.*

L352: Indeed, we could decrease the resolution of the models and do the comparison once again. Nethertheless, we think the best method would be to compare

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Odin/SMR monthly averages of O_3 and N_2O with another globally measuring satellite (as it is stated in the paper), but this is however beyond the scope of this study and a subject of further studies.

L355: The size of the N_2O bins is already stated at line 195.

L407: In the northern hemisphere the inflection point is generally found around 150 to 200 ppbv N_2O. At the beginning of the winter the inflection point is found at around 150 ppbv and then shifts to higher N_2O mixing ratios with increasing ozone loss. In cases where data of the same years are considered the inflection point should be found in these data sets at approximately the same N_2O mixing ratio. However, differences in the location of the inflection point cannot only occur due to differences caused by considering data of different years but also when the data sets do not cover the same latitude region and e.g. measure a different amount of air from within the vortex. We added the following text: *The inflection of the curves is generally found around 150 to 200 ppbv N_2O. Thereby, the inflection is shifted to lower N_2O mixing ratios with increasing ozone destruction. Differences in the location of the inflection between different data sets cannot only occur due to differences caused by considering data sets of different years but also when the data sets do not cover the same latitude region and e.g. measure a different amount of air from within the vortex.*

L415 (L413): Yes, underestimation of ozone loss is found in KASIMA which can be seen by higher than observed ozone mixing ratios. Would ozone loss be as strong as in the Odin/SMR measurements the O_3 mixing ratios from KASIMA should be lower.

L400 (L415): The lower ozone loss in WACCM was indeed caused by too warm temperatures simulated in the polar vortex. However, this was at least partly caused by the rather low horizontal resolution used in the model that was not able to simulate the observed sharp transport barrier at the polar vortex. The usage of the rather rough

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horizontal resolution in a CTM can also affect the simulation results significantly. Thus, why should that not be a issue in a CTM? The following text has been included to discuss this issue: *The main reason for the underestimation of Arctic O_3 loss in WACCM reported by Tilmes et al. (2007) is an overestimation of polar temperatures, a problem that does not occur in a CTM (like CLaMS) and to a lesser extent in a nugded global models (like KASIMA and E5M1). A second important problem is the quality of the simulation of the strength, sharpness and location of the transport barrier at the vortex edge (Sankey and Shepherd, 2003; Tilmes et al., 2007), which is an issue for both CTM and CCM. Indeed, a WACCM simulation at higher horizontal resolution (Tilmes et al., 2009, manuscript under revision by JGR) yields a substantially improved chemical ozone loss in the Arctic.*

428: ILAS profiles have a higher accuracy and a higher vertical resolution than the Odin/SMR profiles, causing a lower variability of the monthly averages derived from ILAS compared to the monthly averages derived from Odin/SMR.

L470: The inflection point is caused by polar winter ozone loss. Thus, if differences in the inflection point occur between different data sets this can indicate that chemical ozone loss is not simulated correctly. Of course, differences can also occur if different years are considered or when the data sets do no not cover the same latitude region (see also reply to L407).

L482: It is indeed true that the averaged ozone is the simpler metric to understand. However, the average of the differences of the ozone mixing ratios derived from the model simulation and ILAS, respectively, from Odin/SMR are calculated. Thus, this calculation is build on the comparison of the monthly averages derived from the satellite data and model simulation data. Therefore, we doubt that a change of order would make the paper easier to understand. However, to make this more clear we write now in the paper “average difference of the monthly averaged O_3 mixing ratios” instead of only “average differences of the O_3 mixing ratio”.

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L535: The differences between models and measurements in the polar regions are caused by an underestimation of ozone loss as discussed in section 5.2.3 and in the conclusion. The differences between models and measurements in the tropical regions are caused by a combination of the rather coarse altitude resolution of Odin/SMR that is interpolated to potential temperature levels and a not accurate simulation of transport processes by the models. These differences are discussed in section 5.2.1 and in the conclusion. We are confident, that the changes we made in the manuscript due to the previous comments make this more clear now.

L567: see reply to comment on L482.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 1977, 2009.

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