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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluation of stratospheric chlorine chemistry for the Arctic spring 2005 using modelled and measured OClO column densities" *by* H. Oetjen et al.

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We thank the reviewer for his/her comments. We have taken up the suggestions made, but do not agree with his overall assessment that the large difference between measurements and model indicate a problem in our analysis and that there is a robust linear relation between model and measurements. According to our analysis, the differences are much smaller than stated by the reviewer and are also clearly larger at large SZA.

In the following we address the individual points made by the reviewer.

Referee comment: The consistency between G-B and SCIAMACHY measurements is convincing (though the word excellent is a little exaggerated), but I do not share at all

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the conclusions made by the authors regarding OClO photochemistry.

Author's reply: In response to the comments made by the other reviewer as well, we have replaced the formulation "excellent agreement" by "fair to good".

Referee comment: The reason for this is the poor analysis of the difference between measured and modelled OClO slant columns. It is not clear that the difference between them "increases towards larger SZA and chlorine activation". Instead, the data displayed in Fig 6, just show a robust linear correlation between measured and modelled columns (ax + b with a= 1.97 $\pm$ 0.08 and b =-9.7 $\pm$1.32), independent of SZA, chlorine activation or sunset/sunrise. This is suggesting an error of about a factor 2 in the data or model processing...

Author's reply: We agree with the reviewer that the difference between model and measurements in figure 6 (please note, in the revised manuscript figure 8) seems to be linear at first inspection; however we do not understand how the reviewer retrieved a factor of 2 between measurements and model which according to our calculations is between 1.1. and 1.4. Nonetheless, we've included two extra figures to emphasise the increase of the difference between model and measurement with SZA as well chlorine activation (see also below). From this figure, the difference is about 30% for February 24th and about 40% for March 4th both at 90° SZA as already stated in the paper; about 13% for February 24th and about 25% for March 4th both at 88.5° SZA. Considering these numbers, we do not see a robust linear relationship between model and measurements which could be explained by an error in the absorption cross-section of OClO.

Referee comment: ... as well as a significant bias (i.e. the 4x1013 mol/cm2 OClO columns outside the vortex on 19-20 March in Ny-Alesund). Possible explanations for such a large difference needs to be discussed before stating that it is due to inadequate photochemistry.

Author's reply: The bias of 4x1013 molec/cm2 as pointed out by the reviewer is caused

ACPD

9, C11695–C11700, 2010

by a well-known problem for the OClO retrievals with the DOAS method: The proof of zero OClO is very difficult, and often a small positive offset is found even in situations where no chlorine activation is expected. This can also be observed in the data shown from the measurements in Bremen (Fig. 4, now figure 5) and in previous work, (e.g. Aliwell et al., 1997 and Frieß et al., 2005). Whether or not this offset is also present in measurements with high OClO columns is not entirely clear; judging from the behaviour of OClO columns with SZA this appears not to be the case. We have added a brief discussion of the offset problem in the revised manuscript.

Referee comment: A factor 2 certainly exceeds the uncertainty of OClO cross-sections used in the spectral analysis of both instruments but other sources of errors are possible, which requires discussion, e.g. the way model slant columns are calculated from the vertical profile of the species, which is not explained. An easy way to check this could be a comparison between ozone or NO2 slant columns available from both the measurements and the model.

Author's reply: In response to the reviewer's comment, we've added the following text and an extra figure (see also below) in the manuscript to describe in more detail the conversion from the vertical profiles as retrieved with the photochemical model into slant column densities on the example of NO2: "In more detail, SCIATRAN simulates the paths of the photons from the sun into the telescope. Along this light path, the SZA changes due to the curvature of the earth. In higher altitudes and towards the sun, the SZA is smaller than the one at the measurement site causing a changing photochemistry for atmospheric trace gases. In SCIATRAN for each local SZA, the corresponding absorber profile from the output of the photochemical model is chosen and the absorber density is integrated to yield the column density along the light path. For illustration an example of NO2 slant column densities is presented in Figure 3. Shown are measurements and simulations for Ny-Ålesund of the afternoon of February 24th. Due to the on average smaller effective SZA, the simulations including the photochemical enhancement result in smaller slant column densities which agree very

ACPD
9, C11695–C11700, 2010

well with the measurements."

Referee comment: Until differences between observations and model are not properly analysed and discussed, the conclusions of the paper are irrelevant.

Author's reply: As outlined above, we have added more discussion on the uncertainties and demonstrated the comparison between measurements and model (with photochemical RTM correction) on NO2. The remaining differences which are not a factor of 2 but rather 10 – 40% will have to be discussed in terms of model chemistry, and this is what we have done in the original manuscript.

References: U. Frieß, K. Kreher, P. V. Johnston, and U. Platt, Ground-Based DOAS Measurements of Stratospheric Trace Gases at Two Antarctic Stations during the 2002 Ozone Hole Period, Journal of the Atmospheric Sciences, Volume 62, Issue 3, 2005 S. R. Aliwell, R. L. Jones, and D. J. Fish (1997), Mid latitude observations of the seasonal variation of BrO 1. Zenith sky measurements, Geophys. Res. Lett., 24(10), 1195–1198.

Figure captions: Figure 1: The relative differences between modelled OClO columns and ground-based data for Ny-Ålesund. Top: all data until March 8th as given in figure 6. Bottom: differences for two selected days. The relative differences between modelled and measured OClO increases with chlorine activation as well as with SZA. Figure 2: Measurements and model calculations of NO2 slant columns at Ny-Ålesund (79°N, 12°E) for February 24th. The error bars represent the 2sigma error of the measurements. The model simulations with photochemical enhancement are smaller than the ones without due to the changing SZA along the line-of sight of the measurements.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 26539, 2009.

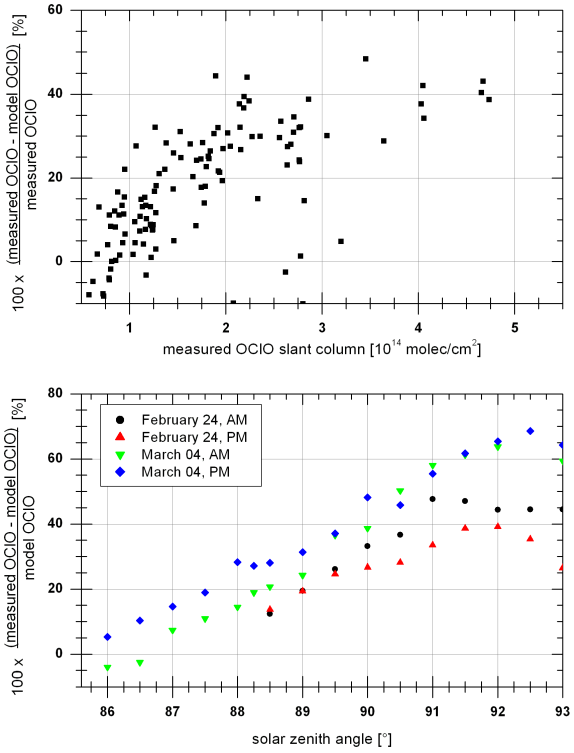

Fig. 1. The relative differences between modelled OClO columns and ground-based data for Ny-Ålesund

ACPD
9, C11695–C11700, 2010

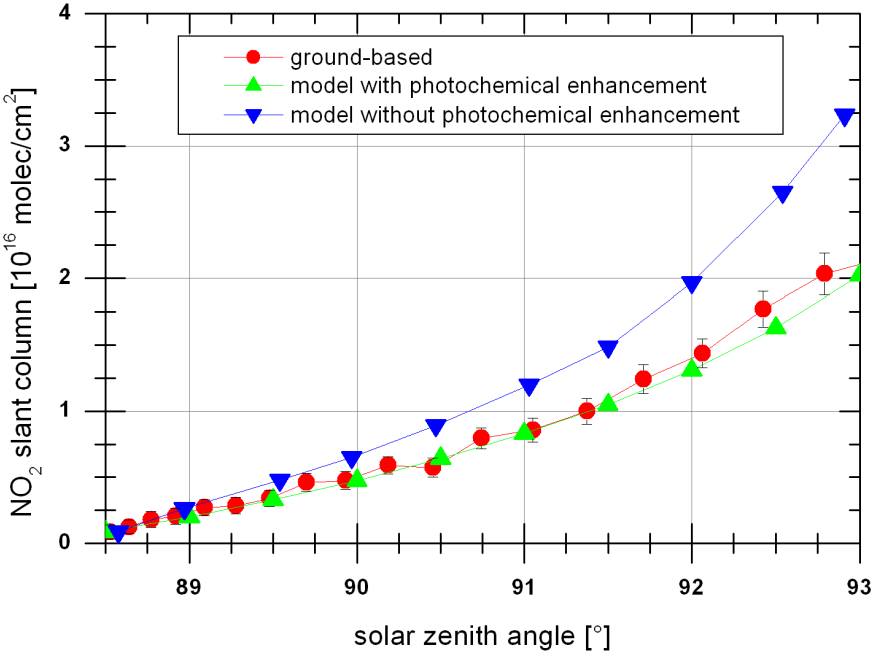

Fig. 2. Measurements and model calculations of NO2 slant columns at Ny-Ålesund (79°N, 12°E) for February 24th.

ACPD
9, C11695–C11700, 2010