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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparison of GOME tropospheric NO_2 columns with NO_2 profiles deduced from ground-based in situ measurements" *by* D. Schaub et al.

D. Schaub et al.

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Responses to Referee comments in ACPD (acpd-2005-0453)

I would like to thank the anonymous referees for their helpful reviews and hints which allow us to improve our paper. Below are the responses to the specific comments.

Anonymous Referee #2 (comments from 22 May 2006)

The abbreviations (such as SCIAMACHY, OMI, KNMI/BIRA) will be explained in the text.

Page 2190, lines 15-16: The relative difference between the data sets is given 2 lines below. But we agree that this information should be given to the reader already when

the “good agreement” is pointed out at lines 15-16. This will be changed.

Page 2191, line 19: We agree with the referee that during the summer season over rather polluted continental regions the NO2 (NOx) lifetimes can be distinctly lower than one day. We will point this out additionally and cite some literature.

Page 2191, line 25: We fully agree and will change this in the text! (See also 2nd and 4th comments of referee #1).

Section 1.1: We will additionally mention the problem of comparing ground-based point measurements with horizontally (large footprints) and vertically integrating column measurements from space-borne instruments. Section 1 or the beginning of section 3 would be a good place for this. There, we will point out how we meet this issue (by mentioning the use of measurement stations at different altitudes for the “vertical” issue and the use of different PBL measurement stations for the “horizontal” issue).

Page 2194, line 23: In this work we do not explicitly account for the Ring effect as we do a comparison study between publicly available NO2 retrievals and NO2 columns derived from independent NO2 measurements. However, the Ring effect is accounted for in the retrieval (where corrections for the Ring effect are performed in the first step in the forward modelling, i.e. in the spectral fitting procedure). Generally, we agree with the referee insofar as satellite retrievals can have a number of error sources (with only a part of it investigated in the present study). These will be mentioned, e.g. in section 2.1 (description of GOME data).

Page 2195, line 14: Similarly to the previous point, we did not explicitly account for aerosols within the present work (but we will additionally mention it as a further error source for the retrieval). The influence of aerosols on the AMF calculation has been investigated in Boersma et al. (2004) where it was found that cloud algorithms implicitly correct for aerosol through their modified cloud fraction and height under presence of aerosol.

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Page 2196, line 17: We agree with the referee that it could be helpful for the reader to mention the basic idea of constructing NO2 profiles from NO2 in situ measurements at different altitudes already at this point (and that our phrase “Combining the measurements provides profile information which can subsequently be integrated to a tropospheric NO2 column” might be somewhat to vague). This will be changed in the text.

Page 2197, line 4: We will repeat the GOME overpass time here.

Page 2198, line 13: The authors agree with the referee that the frame given in Figure 1 could mislead a reader that shortly has a look at it (and maybe does not have the large GOME pixel footprints in mind). We will additionally indicate the resulting region that is covered by the GOME pixels with centre coordinates within the frame from Figure 1.

Page 2199, line 15: We agree and will add references!

Page 2199, line 16: The referee wants the authors to explain how NO2 in situ data from one station are used to assess vertical fluctuations. In fact, we do not really assess small scale vertical fluctuations. It might be that our phrase “To capture the effect of a varying NO2 profile in the PBL, we use in situ measurements from the Laegeren station that is located on a mountain ridge” is somewhat misleading here. The reason for including an additional PBL station (located 250 m above the ground) was the fact that trace species in the PBL are not necessarily well mixed. Many studies assume a homogeneous distribution of trace gases in the PBL. We suggest that also including only one station (note, however, that a 3-hour average concentration is used) will result in a more realistic picture of the complex boundary layer than assuming a homogeneous distribution.

Page 2199, line 26: The authors assume that during anticyclonic (high pressure) clear sky days the NO2 at higher altitudes is distributed rather homogeneously and cite Ridley et al. (1998) that found a good agreement between local and regional aircraft NO2 profiles simultaneously measured during such meteorological conditions. The referee

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rightly says that this latter campaign has been performed at lower latitudes and asks about the representativity for Switzerland. Ridley et al. (1998) measured between 30° and 34° northern latitude. This is in fact more south than Switzerland. This latitude range furthermore is stronger affected by stable high pressure situations than middle Europe. However, due to the fact that we also have one focus on high pressure days we would suggest that the general findings from Ridley et al. (1998) should also apply in our region under such meteorological conditions (although a clearer statement about the representativity for Switzerland cannot be given). We will elaborate this in the text and mention that an error source may remain due to this assumption.

Page 2200, line 9: As pointed out above we will show the region that is effectively covered by the GOME columns of interest in Figure 1. Concerning the polluted Po valley affecting the GOME columns in our study: A direct impact in the sense that GOME pixels are partly covering the Po valley can be ruled out. The exclusion of the Alps (as far as possible) and the Po valley was the reason of using the frame given in Figure 1. Due to the extension of the GOME pixels, the Alps cannot be excluded in all the pixels. But the authors are sure that there are no GOME pixels in the study that are affected by the Po valley. But, surely, it is known that polluted air masses from the Po valley can be transported northward. This pollution, however, should then also affect the ground stations. Furthermore, for the anticyclonic clear sky days, we would suggest this to be a minor problem, because strong and near ground winds are rather prevail during (or before) frontal passages.

Section 3.1.2 c): The assumptions made in this section can in fact be seen as the most critical points in this work. Nevertheless, we used this approach and argued with several studies that have been performed in the Swiss Alps (other studies or works in progress that might validate this method are not known to the authors).

Page 2206, line 5: This will be replaced.

Pages/lines 2205/17, 2206/4 and 2206/10: We will change this and communicate the

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idea of calculating Delta2 where it is really needed.

Page 2208, line19: Here, a “case” means a single GOME pixel. We will formulate this more clearly.

Pages/lines 2209/8 and 2210/8: Here we refer to the slopes from Figures 4a and 5. Due to the comparison of two column data sets (both having the units molecules cm-2) the resulting slopes are dimensionless.

Page 2211, line 13: Error estimates are given in the KNMI/BIRA data set for every single GOME pixel. The clear sky GOME pixels used in the study have been calculated to have - in average - an error of 50%. The comparison with the ground-based columns yields a standard deviation from the relative difference of 40%. Accounting for the fact that also the independently derived NO2 columns have their uncertainties, this can at least be an evidence that the errors given in the KNMI/BIRA data set are rather high.

Section 5: We agree with the referee that a GOME column of 500 x 1015 molec cm-2 is unrealistically high and will mention this in the paper and Figure 7. (See also last response to referee #1).

Section 5: The referee misses the discussion about the difficulty of calculating AMFs under cloudy conditions and argues that uncertain cloud parameters can cause a wrong AMF. Although the present study does not focus on retrieval issues concerning cloud characteristics, we agree that this should at least be stressed in the text as a further important reason that can lead to problems in the retrieval (similarly to other error sources such as the Ring effect and the aerosols).

Page 2217, line 25: The referee is right when saying that the 50% threshold (SCDtrop/SCD) used for rejection of extreme cloudy cases is arbitrarily. This is also mentioned in the paper. The reason for using the SCDtrop/SCD criterion at all was the finding from Figure 7b showing that large differences between the column data sets occur rather for high SCDtrop/SCD ratios. A (possible) explanation for this latter find-

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ing is given on page 2217. The referee further suggests to analyse CTHs as a possible parameter further explaining extreme differences between the column data sets. We had a look at this, but did not find a correlation between CTH and the difference between the columns. Furthermore, from present studies that we are carrying out with both GOME and SCIAMACHY data, we find that extreme values for NO2 VTCs under cloudy conditions ($>$100 x 1015 molec cm-2) occur for both low (even very low: e.g. high fog over Switzerland) as well as for high clouds.

Conclusion: We will additionally mention the difficulty of retrievals for cloudy scenes in the conclusion (due to the findings from the present study but also due to inaccuracies in the cloud characteristics).

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 2189, 2006.