Atmos. Chem. Phys. Discuss., 6, S544–S548, 2006
www.atmos-chem-phys.org/acpd/6/S544/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "NO_2 Profile Retrieval using airborne multi axis UV-visible skylight absorption measurements over central Europe" *by* M. Bruns et al.

M. Bruns et al.

Received and published: 14 April 2006

We would like to thank the reviewer for his encouraging response and the constructive criticism. In our opinion it is much better paper now. Below one can find the detailed responses to the individual issues.

Specific Comments:

(1) We agree with the reviewer, that it would be nice to discuss NO2 retrieved above the boundary layer. Unfortunately, during our flights NO2 values were only significantly enhanced in the boundary layer and not at higher altitudes. Therefore, in those parts of the profile the a priori information dominates. It is clear to us what the referee is

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implicating with this comment: it should be demonstrated that this retrieval algorithm and setup is able to retrieve NO2 profile information which peaks at different altitudes. Since there were no NO2 profiles found on these flights matching these criteria we have to refer the reader to a sensitivity study presented in the dissertation Bruns, 2004 (chapter 8.1.2). There it is demonstrated that this profile retrieval algorithm is in theory capable of retrieving NO2 profiles with peaks at different altitudes. Nevertheless we have included a short discussion of the entire profile as an example in the last profile discussed in chapter 'Results and Discussion'.

(2) In our opinion the values at 7 km altitude are not significantly negative in most cases, because the error bars are large enough so that the upper error boundaries are positive. We agree with the referee that negative volume mixing ratios are unphysical. This effect was reduced significantly by introducing a regularization (the values of the diagonal elements of Sa have been reduced for higher altitudes) described in chapter 'Error Analysis' and using extra diagonal elements (eq. 9). In our opinion the behavior of the retrieval at 7 km altitude can be improved by using using more LOS in addition with three different wavelength regions.

(3) Done. In addition those areas where the upper error boundary in not positive are marked also by polygons with thick solid lines.

(4) The horizontal smoothing is pretty weak because all retrieved profiles are presented and the integration time of one set of measurements leading to one profile is 30 seconds. The vertical smoothing was reduced by limiting the number of colors in the color bar. In addition the layer boundaries are marked by thin solid horizontal lines at the altitudes of the layer boundaries.

(5) In theory this is true but according to Rodgers you need enough measurements to retrieve on a finer retrieval grid (as a rule of thumb: at least one measurement per retrieval grid point). To see what happens when using a retrieval grid with too many grid points see Bruns, 2004 (chapter 7.7).

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(6) Since it is difficult to put the uncertainty of the aerosol profile optical properties into numbers, the phrase (neglecting the uncertainty of the aerosol profile optical properties) was added in the text.

(7) The sentence 'This choice was made because the largest step size of the retrieval grid points is 3 km.' was added.

(8) They are very realistic compared to real measurements because they were chosen that way with the exception of an albedo 0.1 which is a bit large for land and ocean surfaces. A more detailed sensitivity study can be found in Bruns, 2004 (chapter 7). This retrieval grid proved to result in the best averaging kernels and smallest retrieval errors.

(9) No, we do not assume a boundary layer from 0-2.5 km. This is just the lowest layer APROVAL can retrieve. Since we don't have any other information we have to assume that the retrieved value at 1 km is equally distributed in this layer. This is the reason for comparing the column resulting from this layer with the tropospheric column from SCIAMACHY. In our opinion it is trivial to convert a VMR into a column when the thickness of the layer is given, and therefore have not added it to the paper.

(10) In our opinion this figure would not be very useful since the difference in size of both footprints is so large that the small footprint of the AMAXDOAS measurement (6.6 km times 0.1 km) is not visible on a scale of 60 km times 30 km.

(11) We would rather leave it unchanged.

(12) The term 'ideal' was changed to 'very good'.

(13) 'quite good agreement' was changed into 'reasonable agreement'.

Technical Comments:

(14) We would rather not.

(15) p 494, l 11: the sentence 'The method used in this work is a combination of two

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previously established methods described in Petritoli et al. (2002) and Wang et al. (2004)' was added.

(16) We didn't find any chemical species written in lower cases.

(17) 'are' was replaced by 'is'.

(18) 'As can be seen below' was deleted.

(19) 'different' was replaced by 'several' (twice).

(20) Unchanged

(21) Sentence changed to 'A different method to derive vertical distributions for trace gases from AMAXDOAS data was used by Wang (2004).'

(22) Paragraph moved to the beginning of the introduction

(23) We don't agree. Chapter 2.1 is an instrument description.

(24) Again, we don't agree,

(25) 'the' was replaced by 'a'.

(26) Sentence changed to 'y is a vector of slant columns as a function of LOS and wavelength obtained from the AMAXDOAS raw spectra using the DOAS method'.

(27) The sentence 'where delta x is the perturbation in the vertical profile, delta y is the change in the slant columns due to the perturbation in the vertical profile,' has been added.

(28) Paragraph removed starting l. 20 p. 498.

(29) see (28).

(30) see (28).

(31) The sentence 'The unit of the diagonal elements of Sa is ppbv2' has been added.

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(32) P503, L10-23: This part has been rewritten: 'Two physical effects provide vertical information from the measurements: By using measurements taken simultaneously in different lines of sight, different paths through the atmosphere are probed with varying vertical sensitivity. In particular, the measurements pointing close to the horizon have a long light path near the altitude of the aircraft and therefore are very sensitive to absorptions at this height. The second source of profile information is the wavelength dependence of the signal. As result of increased Rayleigh scattering in the UV, the sensitivity to layers close to the surface is reduces compared to measurements at visible wavelengths. By combining retrievals at different wavelengths, some vertical resolution can be obtained even for one viewing direction (see Wang et al., 2004).'

(33) see (32)

(34) p 504 l 9: The sentence 'During this time 104 profiles have been retrieved with an integration time of 30 seconds each (this translates to an AMAXDOAS footprint of 6.6 km x 0.1 km).' has been added.

(35) couldn't find the phrase 'location do'.

(36) 'the flight' was replaced by 'the AMAXDOAS flight'.

(37) We don't agree.

(38) (channel 4) was added to the caption of Figure 1.

(39) Figure 2 plot a was reproduced in color and plot b was removed, because it now appears in the newly inserted Figure 2 as plot b.

(40) see (34)

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 493, 2006.