**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.

Anonymous Referee #2

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In this paper, the potential of the airborne multi-axis DOAS technique (AMAXDOAS) for the retrieval of NO2 vertical profile information in the troposphere is investigated, both on theoretical grounds and using actual measurements. Complementing studies previously published by the same group, this paper focuses on an analysis of the (improved) information content one obtains when combining NO2 absorption measurements simultaneously performed in different viewing directions and at different wavelengths. To demonstrate the method, results are presented for one flight in the Po-valley region. A major strength of the paper is that it includes an analysis of the information content of the measurements using the Rodgers formalism, which is used to assess the potential

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but also the limitations of the technique. Results presented here are innovative and very promising in the context of future developments for air quality monitoring using remote-sensing instrumentation on board airplanes. This subject is clearly of interest to the ACP readership.

Unfortunately the manuscript in its present state is often lacking of clarity. This is due in part to stylistic deficiencies but also to missing or inappropriate information. Therefore my recommendation is that the Bruns et al. study should be published in ACP, but only provided that significant revisions are brought to the text in order to improve its clarity, conciseness and accuracy.

1. General comments

1. The paper presents a detailed analysis of the information content of the so-called "4-3" measurement setup, including convincing averaging kernels and error bar estimates presented in Figure 2. However and despite these efforts, the reader is left without any clear information on the reasons why this particular setup was adopted. It is mentioned in Section 4, that the "4-3" setup **proved** to be the optimum one. Certainly the reader is eager to know how this conclusion was reached. One way to improve on that would be to show additional plots like the ones in Figure 2, for different (and presumably less favorable) observation setups. In my view Figure 3 is not absolutely necessary and could be advantageously replaced by another figure showing more results from the sensitivity study.

2. Results presented in Figure 5 are nice and apparently convincing, however it is rather unfortunate that the four profiles given as an illustration incidentally appear to be almost identical: same shape - same amount (in particular for the lower-most layer). Certainly it would be much more demonstrative to select profiles of different shapes and amounts.

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Specific comments

P495, L21: this sentence is unclear and should be rephrased, e.g. "An alternative method to derive trace gas vertical distributions from AMAXDOAS data was used by Wang et al. (2004)."

P495, I would suggest to move the last paragraph from the introduction to line 14.

P497, section 2.2: what was the float altitude of the airplane? From the settings used in model calculations (section 4), I suppose it was around 10 km. This information should be given explicitly in section 2.2 where measurements are described.

P498, L13: change "...taken at a specific LOS and a specific..." by "...taken at a specific LOS and in a specific..."

P498, L20: the definitions given for the weighting functions and how they are evaluated using SCIATRAN is rather fuzzy and in fact confusing for a non-expert reader. As I understand the problem reported here is rather technical: how to convert a radiance Jacobian (apparently the "natural" output of the RT code used in this work) into a slant column Jacobian w.r.t. layer mixing ratio. Although this conversion is rather straightforward, the formula provided here may be of interest for the reader wishing to use the same RT code. In any case the discussion should be made much more explicit and precise in the wording.

P500, L15: please give more details on the way the diagonal elements of the error covariance matrix have been evaluated "empirically". Is this based on some a-priori knowledge of the natural variability of the tropospheric NO2 content in the Po-valley region, climatological data sets, model data sets??

P502, L22: I suggest to make a table out of the list of parameters used for the simulations.

P502, L18-21: this sentence is really awkward. Even after several successive readings I was not able to understand what the authors mean here. Please clarify.

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Figure 4: there is an apparent inconsistency between this plot and the averaging kernels represented in Figure 2 → how is it possible to achieve a vertical resolution of 2 km above 15 km altitude when the AKs show virtually no information content in this altitude range?

P503, L10-23: this paragraph is badly written and hard to follow. Please try to improve clarity by making the text more specific and concise.

P503, last line: what is "APROVAL"? I guess it must be the acronym of the retrieval software used in this work. In this case, it must be introduced earlier in the paper.

P504, L6: replace "obtains" by "yields"

P505, L3: add "s" at the end of "location"

P506, L1: comparison with SCIAMACHY tropospheric NO2 columns. It should be mentioned whether AMAXDOAS measurements were in good temporal coincidence with the satellite – a lack of temporal coincidence could indeed strongly affects the comparisons given the large variability of the tropospheric NO2 emissions

P506, L6: the use of the word "because" is not adequate here. Please rephrase and be more accurate in the wording.

P506, L17: avoid repetition of the word "show"

P506, first sentence of the conclusions: I think it is somewhat exaggerated to say that AMAXDOAS is the first technique being able to measure tropospheric NO2 profiles by remote sensing (e.g. this can also be achieved from the ground using a similar approach, and tropospheric NO2 lidars have been demonstrated already).

P506, L27: The whole sentence starting with "The sensitivity study has shown . . ." is just a repetition of what has been said in the previous sentences and therefore can be safely removed.

Figure captions: for the sake of conciseness avoid starting caption text by "This plot

shows . . . "

Figure 7: there is a typo in the last sentence of the caption → "sciences" instead of "scienes"

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