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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Spatially resolved measurements of nitrogen dioxide in an urban environment using concurrent multi-axis differential optical absorption spectroscopy" *by* R. J. Leigh et al.

R. J. Leigh et al.

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The authors would like to thank the referees for their detailed and constructive comments on this paper. Many of the suggestions have been directly implemented, significantly strengthening the arguments made in this work.

All typographical mistakes have been corrected and additional information added to plots etc where requested.

The following changes have been made in response to reviewer's remarks:

Referee 1:

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Discussion Paper

I agree with referee 2, that information on the uncertainties of data presented here is needed.

Error estimates for differential slant column measurements from Leigh et al. 2006 have been added to the text and uncertainties for volume mixing ratios have been derived from the agreement with the in-situ monitor, and are quoted in the text and conclusions. A discussion of uncertainties on the plume reconstruction is also included.

It is also not clear to me, why the extra absorption path for 5 deg elevation angle is always 2 km. One might expect both, a seasonal (due to a higher PBL in summer than in winter) and a diurnal variation of this extra light path. If the authors argue, that most of the NO2 is in the lowest part of the PBL close to the sources and the last scatter happens before the rays enters the NO_2 layer (which might be a reasonable assumption), they should illustrate this in more detail. One possibility is for example to calculate the concentration also with the differences of slant column densities at 10 or 15 deg elevation angle assuming the same NO_2 layer height of approximately 200 m. The agreement between these data sets should be within the uncertainty of the DOAS retrieval itself.

In order to address these points, sub-section 1 of the results has been extensively re-written. The 2 km path length assumption has been replaced by radiative transfer modelling and an assumed PBL height. The entire 2004 dataset has therefore been re-analysed. Data from the 10 and 15 degree views have also been analysed as per referee 1's suggestion, and added into the discussion and Figure 3.

What is the reason, that the authors did not use complementary observations of O_4 to better characterize the radiative transfer / viewing conditions? At least those days with very low and/or broken clouds or hazy days could be excluded using these data. Than it might be possible to extend the comparison to the in situ data to other months than May and August.

In order to alleviate this problem, an aerosol profile retrieval scheme has been demon-

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strated for the 17th January data in section 3.2 (figure 6), giving a rough estimate of the aerosol optical depth on this day.

Further corrections/comments: • *Experimental: Some basic information on the instrument and the DOAS retrieval is needed here: estimated detection limit (using zenith background and/or back-ground from the same viewing direction, wavelength range (instrument and retrieval), aperture angle, elevation angles (only given in some figures), reference spectra, ... Not every reader is willing or able to read the paper in Applied Optics.*

Additional instrument description has been added to the experimental section, though the full description remains in a published paper.

• *Is the data set (124 days) well distributed throughout the year or is there a shift towards summer? An overview plot showing daily averages in 2004 might be useful.*

A more complete plot of the 2004 data has now been included in Figure 3.

• *Results: This section should be split into two or three subsections (e.g. 1. Comparison to in situ measurements and 2. Observations of NO2 plumes)*

The results section now contains 3 subsections, as per referee 1's suggestion: 1. Comparison with in situ monitors, 2. Observations of unmixed airmasses, 3. Source indications and strength estimations.

• *The primary quantities for ground-based DOAS measurements are differences of slant column densities (DSCD or DSC). Please rephrase the relevant paragraphs and figure captions making this more clear.*

Done

• *Table 1: Not sure, that this table is necessary but units should be given.*

Done

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• *Figure 1: Nice figure. No 2004 data available from ADMS?*

Data for 2000 is published as part of the Leicester city council reporting procedure. The ADMS data is used only to demonstrate the overall layout of major roads and emission sources in Leicester, which will not have changed significantly between 2000 and 2004.

• *Figure 2: Wrong units for O4. I would prefer a very clear day to illustrate the instrumental performance. Please add also information on the SZA.*

Units for O_4 have been corrected, and SZA information has been included. Very clear days in Leicester are very rare, and we would argue the hazy conditions of 20th May are more indicative of standard conditions. Performance during clear conditions can be seen in the analysis of 17th Jan.

• *Figure 3: typo: "tropospheric". Not very lucky with this sketch. X is not X but 200 m for 5 deg elevation angle. The last scatter is not only due to clouds.*

Figure 3 has been removed owing to the changed assumptions.

• *Figure 5: Again, if data are selected for reasonable weather conditions (high or no clouds, no haze), this might lead to a more impressive result. Not sure about the high values in the evening. Is there some remaining SZA dependency or stratospheric contribution?*

Using a simple cloud flag test in the differences between the O_4 slant columns, the relative performance of comparatively clear sky conditions was investigated and added into section 3.1. This analysis confirmed the relatively small influence of cloudy conditions.

The highest NO_2 values during a 24-hour period in Leicester are often in the evenings, we therefore have confidence that the higher evening values shown in Figure 4 are valid. A SZA dependency would also appear in the mornings, and all stratospheric contribution should have been removed with the subtraction of the zenith differential slant column.

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• *Figure 6: Very nice. Give unit for NO_2 concentration.*

Done

• *Figure 10: Date?*

Done

• *Figures 7,10,11: Differences of slant columns are shown here. See above.*

Done

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 12671, 2006.