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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Direct observation of two dimensional trace gas distribution with an airborne Imaging DOAS instrument" *by* K.-P. Heue et al.

K.-P. Heue et al.

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paper

The authors thank the referee for the helpful comments and advices.

General comments

Heue et al. introduce a novel technique airborne Imaging DOAS for investigation of two dimensional trace gases distribution on a small scale. The measurements of NO_2 distributions by aircraft over the industrialized area in South Africa are presented. The NO_2 columns were used to estimate NO_2 flux and compared with satellite data. The manuscript is well written. The topics addressed here are well within the scope of ACP.

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Specific comments

Page 11885, line8-9: "A normal in-flight spectrum in a remote and clean area is usually taken as the reference here". To have a good reference spectrum is very important for retrieving the weak absorptions by DOAS fitting. Is the reference spectrum sensitive to the ground surface, e.g. grass, water and concrete etc? I suggest adding more discussion.

The referee is right, there are some criteria to determine the reference spectrum i.e. the normal cruising altitude has to be reached, therefore spectra take during climb or descend must not be used. The spectrum should be well illuminated without being saturated nor too dark, no clouds are to be observed, and a remote and clean area is recommended. As a first approximation only the albedo is important to get a good reference spectrum for the DOAS technique, this assumption is used for most satellite data retrievals as well. However Wagner et al. (2007) found that the albedo structures changed for the red wavelength range ($\lambda > 600nm$) and improved the DOAS routine by including the albedo structures for several vegetation types. For the wavelength range used in the manuscript ($\lambda < 530nmn$) this effect is usually neglected. The albedo did not change that much, and the routine automatically adopted the integration time, but the cahnges were small, which also indicates low varialibity in the albedo. Therefore choosing a reference spectrum was very easy. Also the weather conditions in October 2006 were quite stable and the cloud coverage was low. Some details on the topic of reference spectrum are added to the revised manuscript in section 2.3 second paragraph.

Page 11886, first paragraph: For converting the SCD to VCD, the good weather conditions normally are chosen for simplifying the AMF calculation. I suggest adding sentences about suitable weather condition for the flight measurement.

If the weather is cloudy or unstable, you avoid flying with the DOAS instrument, not only because flying is much more comfortable if there are no clouds, but mainly because including clouds in the calculation of AMF is very difficult. In the South African dry season clouds are not a big problem, a respective sentence is added in section 2.3

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at the end of the third paragraph. See also answer to the other comment and table 1 in the revised manuscript.

Page 11885, line13: "Hence the results presented in Sect. 3 constitute lower limits of true troposphere SCDs". What is the meaning of "lower limits"?
The results (observed columns)are relative to an unknown reference, i.e. the observed columns equal the true column minus the unknown reference column. If the column density of the reference was 0, then the observations would equal the total tropospheric columns, but as soon as the reference's column density is larger than zero the observation underestimate the real column. That means the true column is at least as high as the observed columns.

Page 11886, section 3.1: It is better to have a table to list flight height, flight time, weather condition at each flight for easy reading. Is there any special concern about the flight track design?
We included a table (table 1) showing time of the day, SZA range, flight altitude and weather conditions for the three flights.
The flight tracks design focused on areas with strong local gradients, such as power stations, steelworks and refineries. Satellite overpasses were of second priority. This is also mentioned in the revised manuscript in the first paragraph of section 3.1.

Page 11887, line1-6: For the description of 2nd flight, there is no graph or data to support the text.
In the paragraph previous to the one the referee refers to we mentioned "An overview of the flight track from the first and the second flight (4 and 5 October 2006) is shown in Figure 8". But as it seems to be misleading a second reference to the figure is included.

Page 11888, line 20: "The position of the stack in Fig. 11 is determined based on the method described in Sect. 2.2". There is no clear relevant description in Sect. 2.2.
At the end of section 2.2 a comparison of the instruments intensity distribution with a high resolution satellite image is explained. The small scale fluctuation in the local

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albedo is compared to the intensity distribution of the iDOAS spectra. This can be used to determine the position of the observation with respect to the satellite image. We thought about adding a figure but if the figure is printed the transparency has to be adjusted to realise the details. Some more details are added to the explanation in section 2.2 in the last paragraph. See also comments to A. Cede.

Minor corrections

Page 11890, line 3: In the body text "the flight on 7 October 2006 in Fig. 14" whereas in Fig 14 caption "the averaged iDOAS column density data from 6 October 2006"
Done

Fig 14: The text font size on the graph indicating locations is too small to see.
We increased the font size by 50% and concentrated on the important locations.

References

Wagner, T. and Beirle, S. and Deutschmann, T. and Grzegorski, M. and Platt, U.: Satellite monitoring of different vegetation types by differential optical absorption spectroscopy (DOAS) in the red spectral range, Atmos. Chem. Phys., 7, 698211;79, 2007

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