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Atmospheric Measurement Techniques Discussions

AMTD

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Interactive Comment

Interactive comment on "Airborne multi-axis DOAS measurements of atmospheric trace gases on CARIBIC long-distance flights" *by* B. Dix et al.

B. Dix et al.

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Dear referee # 2, thank you for taking the time to review our paper and for your helpful comments.

The focus of this paper is indeed on the technical side, but we followed this reviewer's remarks on the presentation of our first results and added more information in the results section. Detailed below are our answers to all comments.

Comment 1: Page 276, lines 24-29: Please add that these measurements have been made in the nadir mode.

Answer 1: This is stated on page 276, line 26.

Comment 2: Page 278, lines 1-8: Could you give more details about the way you estimated the cloud properties (parameters you used + their values) ? In order to convert the HONO VCD into a VMR, you have to make an assumption on the thickness of the cloud. How did you proceed? Maybe you can show a plot with measured and modelled O4 SCDs. Which AMF value did you derive?

Answer 2: To address these questions, we changed the first paragraph on page 278 as follows: Converting the HONO peak slant column density into a mixing ratio yields about 70 ppt HONO. This conversion was done in two steps: 1) In order to derive a proper AMF for the measurement inside the cloud, the above introduced radiative transfer model Tracy II was used to vary modelled cloud properties, until measured and modelled O4 SCDs agreed. The single scattering albedo was set to 0.99999 and the asymmetry parameter g to 0.85, which are suitable values for most cloud scenarios. Initial cloud top heights (12-18 km) as well as cloud optical density (60) were taken from MODIS data (http://ladsweb.nascom.nasa.gov). The best agreement of O4 SCDs (within 5%) was achieved for a cloud with an optical density of 100, expanding from 2 km up to 14-15 km altitude, which are suitable values for a deep convective cloud near the Tropics. 2) Utilizing these best fitting cloud properties resulted in an AMF of about 8 for light path enhancements within the cloud.

Subsequently the above stated HONO mixing ratio was calculated, assuming a homogeneous trace gas distribution inside the cloud. To get a first estimate on the quality of this conversion, the peak O3 dSCD was also converted into a mixing ratio, yielding about 55 ppb, compared to 60 to 65 ppb measured in-situ (A. Zahn, personal communication, CARIBIC data base), which is within 15% and renders this method a reasonable approach.

As the focus of this paper is the suitability of these measurements, we would like to save a more detailed discussion on this as well as a plot on the measured and modelled O4 SCDs for a different publication.

Comment 3: Page 279, line 16: In order to derive VMRs of BrO, NO2, and O3, you need again to convert your slant columns into VCDs using AMFs. How did you proceed? You have to elaborate more on this in the present paper. What is the error bar on your 6ppt BrO?

Answer 3: To address these questions, we changed page 279, lines 14-17 to read as follows: We replaced "Assuming a cloud free..." by: "Judging from camera and O4 data, a cloud free atmosphere was present below the aircraft between about 03:30 to 05:30 UTC. Assuming that 1) stratospheric contributions are canceled out by the reference spectrum taken at 04:48 UTC, and that 2) the observed trace gas columns are confined within the area of elevated PV values as shown in Figure 11, i.e. between 8 - 11 km altitude, and homogeneously distributed, then averaged mixing ratios for this area (AMF = 6.7) yield about 6 ppt BrO, 0.5 ppb NO2 and 230 ppb O3 for the slant column density maxima at 04:15 UTC. In light of the above discussed reduced spectra quality of the 10° down viewing direction and the underlying assumption, an overall error of about 30% is estimated for these mixing ratios."

Comment 4: Page 280, line 1-9: The presentation of the results is again too concise. Could you add a plot with measured and modelled O4 SCDs as well as a plot with the retrieved aerosol profile? This will make the paper more robust. Page 280, line 12-13: What is the trace of the averaging kernel matrix? This parameter quantifies the information contained in the measurements.

Answer 4: We included a plot of measured and modelled O4 values (Figure 12) and the aerosol profile is indicated in Figure 13 (formerly Figure 12) as well as described in the added text. To explain the results in more detail, we added on page 280, line 6, after "... Frieß et al., 2006)." Therefore aerosol optical density, profile height and single scattering albedo were varied, while the asymmetry parameter g was fixed to 0.68, representing urban aerosol. The best match of measured and modelled O4 values is achieved for an aerosol box profile with an optical density of 1, a height of 1.8 km and a single scattering albedo of 0.75. Results for the 10° up and nadir viewing directions are shown in Figure 12. The strong reduction of O4 columns seen in the 10° up viewing direction upon entering the aerosol layer indicates highly absorbing aerosol. (The 10°

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down viewing direction was omitted, due to rather large uncertainties in the retrieval of the O4 column contained in the reference spectrum.)

NO2 columns from all viewing directions served as input parameters for the trace gas profile retrieval... continued on page 280, line 7.

New Figure 12 caption reads: Measured and modelled O4 SCDs in order to derive information on the aerosol profile upon descent in Guangzhou, China on 1 August 2006. The retrieved aerosol profile served as input parameter for a NO2 profile retrieval. Data points labeled as "roll impact" mark the effect of an aircraft turn within the aerosol layer with a maximum roll angle of 15°. This change in roll angle affects directly the telescope viewing directions and is correlated with the deviation of the measured O4 columns at this altitude (h = 1 km).

We further changed page 280, lines 13 - 20 as follows: After "... is taken from the measurements." Accordingly, profile inversion from CARIBIC DOAS measurements seems to be a suitable concept. However, the facts that the aircraft maneuvered within the boundary layer, that the nadir data contains little vertical information and that data of the slant directions are of inferior quality, limit the spatial information content of these measurements. The total descent inside this boundary layer averaged over a 50 km distance to the airport. Therefore the retrieved aerosol profile as well as the retrieved concentrations are the product of averaging over locally varying aerosol and trace gas distributions. Sensitivity studies need to be conducted to provide further insight on the accuracy of this profile retrieval.

Since the intention of this paper is to point out that profile retrieval is a suitable concept for these measurements, we believe that any further discussion other than the proposed changes is beyond the scope of this paper.

Interactive comment on Atmos. Meas. Tech. Discuss., 2, 265, 2009.

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