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***Interactive comment on “Comparisons between
SCIAMACHY atmospheric CO₂ retrieved using
(FSI) WFM-DOAS to ground based FTIR data and
the TM3 chemistry transport model” by
M. P. Barkley et al.***

Anonymous Referee #1

Received and published: 10 July 2006

General comments:

The topic of the paper is the retrieval of vertical columns of carbon dioxide from satellite radiance spectra and the comparison of the resulting CO₂ data product with ground based FTIR measurements (at one station) and global model simulations. CO₂ retrieval from satellite is an important task because of the potential of the global satellite CO₂ data to overcome limitations of the ground based in-situ network but this is also a challenging problem because of demanding accuracy/precision requirements.

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In a previous paper the authors have presented their retrieval algorithm including an initial error analysis. In this paper they present a comparison of the retrieved CO₂ with reference data. The paper covers an important topic, provides new results and is relatively well written. I therefore recommend its publication after the detailed comments listed below have been carefully considered by the authors.

Specific comments:

Abstract, line 17:

I recommend to replace “good agreement” by “reasonable agreement”. In the paper various maps show comparisons of the retrieved CO₂ with TM3 (model) CO₂ on the same ppmv scale. The measured CO₂ typically covers the full 40 ppmv range (350-390 ppmv) whereas the model CO₂ shows much smaller variability (typically within 5 ppmv corresponding to just two 2 different colors).

Abstract, line 27:

From the abstract it is not clear if the estimated precision of 1% refers to single pixel CO₂ retrievals or to a time/space average. Please modify the abstract to clarify this.

Page 5394, line 11 and following:

The solar spectrum provided by ESA is an improved one with respect to Level 1 version 4 spectra (this was the version of the spectra when the ESA solar spectrum has been generated), not necessarily with respect to Level 1 version 5.04 spectra. Have the

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authors verified that the ESA spectrum has an improved calibration in comparison to version 5.04 solar spectra? Please clarify.

Page 5395, line 2 and following:

The authors refer to a “retrieved profile” although they do not retrieve profiles but only columns. Please correct this sentence.

I also recommend to improve the last sentence of this paragraph, e.g., by replacing “i.e. less sensitive that at lower altitudes” with “indicating a decrease of measurement sensitivity with increasing altitude.”

Page 5395, line 14 and following:

I wonder if Egbert is really so ideal for this comparison as Egbert is located in an area with significant traffic and industrial activity (Egbert is located Toronto) and the measurements are probably strongly influenced by local sources (in this case it will be problematic to compare with SCIAMACHY e.g. because of differences in spatial resolution). A strong contamination by local sources would be consistent with the Egbert CO₂ measurements shown in Dils et al., 2006 (the CO₂ varies quite irregularly by +/- 20 ppmv) and in Figure 2 of this paper. Another potential issue is the low accuracy of 8.9% of the Egbert CO₂ measurements. I recommend to replace “ideal” by a less strong classification and to at least mention the above listed difficulties.

Page 5395, line 24 and following:

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The FTIR CO₂ is retrieved from different spectral regions and at much higher spectral resolution compared to SCIAMACHY. Therefore the averaging kernels will probably be very different and the assumption of similar averaging kernels may not be valid. I recommend to take also the FTIR averaging kernels into account for this paper.

Page 5396, Equation (4):

Please check if B_i is really computed as stated in Equation (4), i.e., by dividing the column difference by FSI_i . Or has it been computed by dividing by PF_i ? This is of some relevance as the B_i values are compared with the corresponding values given in Dils et al., 2006 who divide by PF_i .

Page 5397, line 14 and following:

That the reference spectra are computed taking into account the solar zenith angle is a necessary but not a sufficient condition to avoid a solar zenith angle dependent bias of the retrieval. If there is for example a constant offset on the spectra due to a residual calibration error this would introduce a (column) measurement error which depends on the amount of the backscattered photons (more precisely on the ratio of the offset signal compared to the atmospheric signal). As the atmospheric signal goes down with increasing solar zenith angle there would be a solar zenith angle bias. This is only one example. Typically the sensitivity to albedo and aerosols also depends on the solar zenith angle. I recommend to replace “The bias cannot be attributed to a solar zenith angle dependence as ...” by “It is not very likely that the bias can be attributed to a solar zenith angle dependent error as ...”.

Page 5403, line 3 and following:

From the fact that the retrieval error has a small standard deviation one cannot conclude that the fitting procedure is “quite precise”. This only means that the retrieval error does not change very much. It might be nearly constant because of systematic errors which are nearly the same for every measurement resulting in a similar retrieval error.

Page 5403, line 6:

Please check the formular (shouldnt the right formular be sigma divided by square root of N ?).

Conclusions, page 5403, line 26:

CO₂ VMRs have not been retrieved but CO₂ columns (which are converted to VMRs after the retrieval step). Please correct this.

Conclusions, page 5405, line 1:

Please add which version of the calibration has been used for this paper.

Table 1:

Please check the entire table! Why are the “Number of observations” identical for the large grid and the small grid? The numbers given for WFM-DOAS_{IUP} are not identical

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with the numbers given in Dils et al., 2006. For example for the large grid the numbers given in Dils et al, 2006, are: 3221 (instead of 2232), -5.9 (instead of -12.0), 0.2 (instead of 7.4), and 3.4 (instead of 5.5). The number given in this paper are from the Dils et al., 2005, paper (ACPD version of Dils et al., 2006) for the Jungfraujoch station.

Table 2:

Please explain better what the numbers in the last column (Mean correlation) mean (what exactly has been correlated, the daily gridded data ?).

Caption Figure 1:

Averaging kernels are typically defined as the derivative (change) of the retrieved parameter with respect to the true parameter. Therefore V^{tu} in the numerator needs to be replaced by V^{ru} in the AK(z) formula. For a self consistent retrieval the numerical values of V^{tu} and V^{ru} should be identical. See Buchwitz et al., 2005a, where this formula is explained in detail using the same notation as used in this paper. Buchwitz et al., 2005a, should be cited rather than Buchwitz and Burrows, 2004. If the authors have verified that their retrieval is self consistent, only the formula will change but the numerical values of the averaging kernels (and Fig. 1) will remain unchanged.

Figure 2:

The right panel shows that a significant fraction of the retrieved CO₂ is below the cut-off limit of 340 ppmv. This has impact when the CO₂ averages are computed (the average CO₂ (red line) would be lower if the low values would not have been

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eliminated). The authors should at least mention this in the paper and discuss its implications.

The FTIR data show a large scatter. I wonder how meaningful a polynomial fit through these data is which has been used for comparison with SCIAMACHY. This needs clarification.

Caption Figure 3:

Please add that the bias refers to the difference to the Egbert FTIR.

Figure 10:

It is difficult to judge how significant the correlation of the CO₂ with the different surface types is. The division lines do not separate two clearly separated regions. I recommend to add more information, for example a table or a figure (x-y plot) showing the mean CO₂ and standard deviation for the major surface type regions.

Technical corrections:

Page 5393, line 19:

Two times “of the”.

References, page 5006 line 26 and page 5407 line 23:

Please check which of the two versions of “Breon” is the correct one.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 5387, 2006.

ACPD

6, S1669–S1676, 2006

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