Atmos. Meas. Tech. Discuss., 5, C394–C404, 2012
www.atmos-meas-tech-discuss.net/5/C394/2012/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Validation of ACE and OSIRIS ozone and NO_2 measurements using ground-based instruments at 80° N" *by* C. Adams et al.

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Received and published: 27 March 2012

Thank you for your comments, which have helped us improve the manuscript. We respond to each of the points below, with the referee's comments given in italics.

General comments:

1. In terms of the FTIR NO2 measurements only partial columns were used for the comparison with the satellite instruments. The latter are characterized by a fairly good vertical resolution, which is probably not the case for the FTIR observations. The question is, whether this difference in vertical resolution is dealt with in some way?

Data were not smoothed prior to comparison for this study. We will add the following paragraph to Section 4.

"The OSIRIS, ACE-FTS, and ACE-MAESTRO satellite instruments have better vertical resolution than the ground-based ozone and NO2 instruments included in this study. Some studies (e.g., Batchelor et al., 2010; Dupuy et al., 2009; Kerzenmacher et al., 2008) account for this by smoothing the higher-resolution measurements by the averaging kernel of the lower-resolution measurements (Rodgers and Conner, 2003). Data were not smoothed in the present study because averaging kernel matrices were not available for some of the ground-based instruments and we preferred to treat all datasets in a consistent manner. In previous studies, ACE-FTS data have been smoothed to the resolution of the Bruker FTIR (Batchelor et al., 2010; Lindenmaier et al., 2011). Smoothing is expected to have a small impact on ozone intercomparisons, since the Bruker FTIR has good sensitivity for most of the ozone column (Batchelor et al., 2009). A subset of ACE-FTS NO2 measurements was smoothed to the resolution of the Bruker FTIR by Lindenmaier et al. (2011). ACE partial columns for 17-40 km changed on average by 1

2. The abbreviations used for the different data sets are somewhat confusing. In several cases "G1", "G2" appear in the figures, but in the main text "GBS-vis", "GBSUV" etc. are used to discuss the Figure. This isn't a really big point, but the paper would be easier to follow if only one set of abbreviations would be used. Wouldn't it be possible to use, e.g. "GBS-vis" and GBS-UV" for the Figures?

We needed to abbreviate the dataset names in order to fit them on figure labels etc. To make this a bit easier to follow, we will change the table/figure abbreviations to GV for GBS-vis and GU for GBS-UV.

3. The quality / resolution of Figures in the ACPD version not very good. Perhaps this is a feature of the ACPD version, and not of the original figures. If this is an

issue with the original figures, please increase the resolution of the figures.

We will work with AMT to make sure that the figure resolution is better in the next version.

Specific comments:

Page 520, line 5: "and/or in the coincidence criteria". What would possible systematic errors in coincidence criteria be?

We were referring to possible differences in, e.g., average latitude sampled by the various instruments. Given that this is already discussed later in the abstract, we will simplify this statement to:

"... suggesting that there are systematic errors in the measurements and/or the photochemical model corrections."

Page 528, line 21: "the average fitting errors". It's not entirely clear to me what you mean by "fitting errors" here. Are these the random errors in the retrieved partial columns associated with the spectral fit in combination with the random noise on the measured spectra?

We were referring to spectral fitting errors in the ACE measurements. Since these are random errors, we will change "fitting errors" to "random errors" in the text.

Page 535, line 11: "The lower value of this range was determined by GBS partial columns, which range from 17 km to the top of the atmosphere." How are the differences in vertical resolution between the FTS and satellite measurements treated? The vertical resolution of the satellite measurements significantly better than for the GB FTS.

See response to "General comments 1."

Page 536, 1st paragraph: Have the model results been degraded to the vertical resolution of the instrument with the worst vertical resolution? Probably not. This may be important for the GB profiles with poorer vertical resolution, and this aspect should be discussed in more detail.

No the model has not been degraded to the vertical resolution of the instruments. The figure below shows scale factors as a function of altitude for various days throughout a year. These were calculated with the photochemical model at 80°N, using climatological ozone and temperature for an evening twilight measurement. Twilight is defined at SZA 90° or the smallest available SZA during the summer months of 24-hour sunlight. The scale factor does not change much with altitude, particularly for 15-35 km, where the bulk of the NO2 column is found. Therefore, we don't expect this to contribute a large error to our comparisons. We will add a note of this possible source of error to the text:

"The model profiles were not degraded to the resolution of the ground-based instruments prior to scale-factor calculations. The modeled ratio of twilight to noon NO2 does not vary greatly with altitude for 15-35 km, where the bulk of the NO2 column resides. Therefore, the error that this introduces is expected to be small."

Page 537, line 18: "When applied to the ACE profiles used in this study .." It's not entirely clear (at least to me) what this part of the sentence refers to. What is applied to the ACE profiles?

We will clarify the text to the following:

"When the ACE profiles included in this study were increased by 50

Page 539, lines 7/8: "The agreement .. IS similar .." Same sentence: Considering the differences between your results and the other published results discussed in

the following sentences, I'm not sure how similar the different results are. Perhaps the sentence should be changed?

We will change this to:

"ACE-FTS v2.2, ACE MAESTRO v1.2, and OSIRIS SaskMART v5.0.x ozone measurements have been compared in previous studies."

Page 540, line 20: "using the new NDACC settings". This phrase may suggest that for the results presented in the previous section the new NDACC settings were not used (which is probably not the case). Perhaps you can add a brief clarifying statement.

We will change this to

"using the NDACC settings"

Page 542, line 19: "The agreement in Hendrick et al. (2011) is better than the present study for several possible reasons." Another reason can certainly be that the satellite data products compared in the Hendrick paper are all dedicated total ozone column retrievals (from nadir sounders). Here you use limb profilers and integrate the profiles.

We will add the following to the text:

"Furthermore, the satellite instruments compared by Hendrick et al. (2011) are all nadir sounders, which take dedicated ozone column measurements, while in the present study, satellite and ozonesonde profiles are combined to calculate a total column."

Page 542, last line: "(see Fig. 7)". Fig. 7 does not show comparisons with the Bruker instruments. This should probably refer to Fig. 8?

We will correct this in the text.

Page 543, line 3: "The comparisons worsen for 14–52 km partial columns, to -3.3% for OSIRIS minus Bruker FTIR, -12.2% [-9.6 %] for ACE-FTS v2.2 [v3.0] minus Bruker FTIR, and -11.2% for ACE-MAESTRO minus Bruker FTIR." Here again the issue with the vertical resolution of the FTIR measurements arises. Can one simply compare the FTS profile (having poor vertical resolution) above 14 km with the satellite profiles (having much better vertical resolution). I'm not sure how this should be done properly, but this issue should at least be discussed, and/or its impact on the comparisons estimated.

See response to "General comments 1." We will also add the following to the text in this section.

"This may be due in part to the altitude resolution of the Bruker FTIR, which is lower than the satellite instruments (see Sect. 4). Bruker FTIR 10-50 km partial columns of ozone have on average 4.4 degrees of freedom for signal. Therefore, there is sufficient information to calculate partial columns in the 14-52 km altitude range."

Page 544, line 2: "NO2 17–40 km partial column measurements made by the groundbased". Sorry, I think I'm missing something here. I thought the 17-40 partial column is retrieved by the FTS, but the other ground-based instruments retrieve the total column?

We discussed this in Sect. 4., but it's probably worth reminding the reader. We will add the following text to the top of Sect. 6:

"NO2 partial column measurements made by the ground-based and satellite instruments were compared using the methods described in Sect. 4. ACE, OSIRIS, and Bruker FTIR partial columns were calculated for 17-40 km; GBS-UV and GBS-vis partial columns were retrieved for 17 km to the top of the atmosphere; and SAOZ total

column measurements were scaled to partial column amounts (see Sect. 4.3)."

Page 545, line 16: "The GBS measures partial columns from 17km to the top of the atmosphere". OK, that wasn't clear to me. I couldn't find any information on that in the earlier sections.

See previous comment.

Page 558, line 16: "Thomasson" -> "Thomason"

This will be corrected, as suggested.

Page 558, Burrows reference: Journal title incomplete and spelling incorrect

This is the abbreviation given the AMT guidelines: $http://images.webofknowledge.com/WOK46/help/WOS/J_abrvjt.html$

Page 560, Fraser 2009 reference: Is the journal title complete?

See above.

Page 562, line 11: "Proeedings"

This will be corrected.

Page 563, line 25: "McConnel" -> "McConnell"

This will be corrected.

Page 564, line 13: "No2" -> "NO2"

This will be corrected.

Page 564, Piters reference: has already been accepted by AMT.

This will be updated.

Page 566, Sung reference: journal title complete?

See comments above.

Page 577, Caption of Fig. 5, and line 3, page 538: "Evening twilight is defined as SZA = 90 deg or the nearest available SZA for the given time of the year." I'm not sure I understand this sentence. During spring and fall, when the sun rises and sets, SZA = 90 deg occurs 2 times per day. In this case you're using SZA = 90 deg for the model simulations, right? During polar summer, when the sun does not set, you use the largest SZA. Is that the correct interpretation? It would be good to mention this explicitly, and the crucial point is that the same SZA values are used at the different latitudes outside of polar summer.

Yes, you understand this correctly. We will modify the figure caption:

"Ratios of 17–40 km NO2 partial columns at various latitudes during the evening twilight, calculated with photochemical model initialized with climatological ozone and temperatures. During the spring and fall, when the sun rises and sets, the evening twilight is defined as SZA=90°. During polar night, the evening twilight is defined as the minimum available SZA. During the summer, when the sun is above the horizon 24 hours per day, the evening twilight is the maximum available SZA. 76° N to 84° N is the maximum range over which coincident measurements were selected (see Fig. 2). The thin black line indicates a ratio of one."

Page 568, Table 2: More detailed information on the meaning of the errors would be useful. Are these values comparable?

No they are not all comparable as, for some datasets, only random errors are calcu-

lated. We will add the following to the table caption.

"Note that for some instruments, error estimates include systematic and random errors, while for others, only random errors are calculated."

Fig. 7 and 8: I suggest adding a few minor y-axis marks to all panels of these plots

We will add these, as suggested.

Fig. 9, panel a): The slope of the linear fit is "m=1". Is it really "1.000" ? I suggest listing the slopes with the same number of digits in all panels. Perhaps you are only listing the significant digits (which could explain, why 2 or 3 digits after the decimal point are listed).

We will modify all the correlation figures so that we show a consistent number of digits.

Fig. 13: The number of digits of the slopes differs from panel to panel. Is this intended?

See above.

Fig. B1, caption, line 2: "as a function of altitude" -> "as a function of scattering altitude"?

This is as a function of the altitude of the airmass being sampled. We will modify the caption to make this clear:

"(b) horizontal distance of sampled airmass from the PEARL RidgeLab as a function of the altitude of the sampled airmass for various SZA and wavelengths. Note that the horizontal distance of the sampled airmass was calculated with fixed scattering heights, given in Table B1."

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 517, 2012.

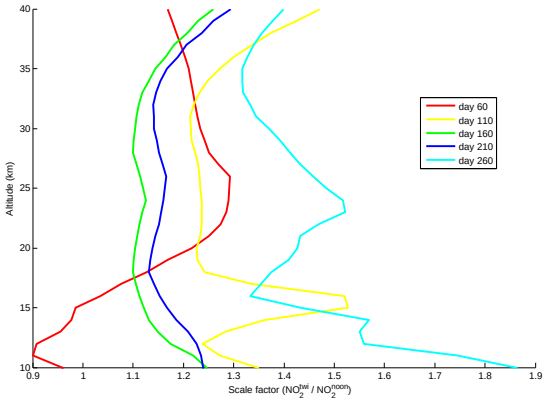
day 60
day 110
day 160
day 210
day 260
Altitude (km)
Scale factor (NO_2^{sat} / NO_2^{noon})

Fig. 1.