Atmos. Chem. Phys. Discuss., 8, S4209–S4216, 2008
www.atmos-chem-phys-discuss.net/8/S4209/2008/

Atmospheric Chemistry and Physics Discussions

ACPD

8, S4209–S4216, 2008

Interactive Comment

Interactive comment on "Validation of ACE-FTS v2.2 measurements of HCl, HF, CCl_3F and CCl_2F_2 using space-, balloon- and ground-based instrument observations" *by* E. Mahieu et al.

E. Mahieu et al.

Received and published: 27 June 2008

We thank the reviewer for his/her comments. Hereafter, we present the original comments/questions [RC] followed by our responses [AC].

[RC]. Spatial Variability : a crucial aspect of any intercomparison exercise of this type is the coincidence criteria. A number of different criteria are used for the different instruments with spatial separations of up to 1200 km. A quantified assessment of the natural variability over these scales would provide both justification for the criteria used, and an indication of the contribution of the natural variability to the uncertainties in the comparisons.

[AC]. Ideally, the selection criteria should indeed be exclusively based on the real spe-

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cial variability characterizing the species under investigations, in order to ensure that the observed differences result only from the bias of one or both instruments. In real life however, the limited number of coincidence with measurements performed by space-based instruments, particularly in the occultation mode, requires us to make compromises. A reasonable geographical difference of 1000 km was used as a starting point. This was relaxed to 1200 km for the subtropical site, where the spatial variability of both species is expected to be small while it was tightened to a maximum of 500 km for the high-latitude sites, where winter-springtime comparisons were performed, at time and places where spatial variability is expected to be significantly higher. However, these initial values were shown to be slightly too loose as demonstrated by the significant decrease seen in the calculated fractional differences when limiting the latitude difference to 200 km (see below). This provides some indication on the possible contribution of the natural variability to the difference observed, with lower and upper limit values -fractional differences +/- standard errors - dropping from (5.8 to 7.8%) to (0.2 to 3.8%) for HCl, and from (6.3 to 8.5%) to (1.2 to 4.4%) for HF. When looking at these values, and considering that the closest comparisons are not affected by spatial variability, we can evaluate that at least a third of the fractional differences characterizing the complete datasets can be attributed to natural variability. The remaining contributions might correspond to a negligible up to a reasonable bias between the ground-based FTIRs and the ACE-FTS instrument, lower than 5% for both species. Discussions in sections 4.1.6 and 4.2.4 have been updated to include these new elements.

[RC]. Expected / required performance levels : at no point is the expected performance of ACE-FTS discussed. Does the performance demonstrated in this paper meet the original specification of the instrument and/or the scientific requirements for atmospheric studies?

[AC]. The following sentence has been added to section 2: "The requirement for the S/N of the instrument was 100 over the whole spectral range. Over most of the range, this has been exceeded by a factor 2 to 3", with reference to Châteauneuf, F.J., Fortin,

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S.Y., Bujis, H.L., Soucy, M.-A.A.: On-orbit performance of the ACE-FTS instrument, in Proceedings of SPIE vol. 5542, Earth Observing systems IX, edited by William L. Barnes and James J. Butler (Bellingham, WA), 2004.

[RC]. Common presentation of results : it would help the reader if all the results were presented in a common format. For example, Figures 3, 5 6 and 7 all compare HCl profiles, but each one has a different format and gives different information. A common style that gave VMR, difference in ppbv and difference in % would greatly help the interpretation.

[AC]. Figures mentioned here have been redone following the 3-frame format already used for the FIRS-2 comparison. Text and captions have been accordingly adapted.

[RC]. Conclusions : The general conclusion that the level of agreement is better than 5-10% for HCl and HF needs stronger justification, particularly as this is one of the headline results from the paper. As a minimum, the appropriate altitude range should be given, as this is clearly not the case at lower altitudes. Also, taking HCl as an example, half of the comparisons (3 out of 6) show the ACE-FTS results to have a significant positive bias. Although the bias to the HALOE results is justified by reference to previous exercises this is not the case for FIRS-2 or SPIRALE, and the possible reasons given in the conclusion are not really consistent with the discussions in the main body of the paper. A quantification of the spatial variability (as discussed above) may help with the justification.

[AC]. The general conclusions drawn for HCl explicitly exclude FIRS-2 and SPIRALE (p. 3461, l.10-13) while the bias noted for HALOE is well-documented. Hence, all three remaining sets don't indicate significant difference for HCl; in addition, two of them involve the higher number of coincidences and thus bring the largest confidence. As to the altitude range, it is clear that the HCl and HF comparisons are generally poorer for the lowermost levels, where their concentrations rapidly drop to very low values. For both species, it appears that comparisons are generally valid down to 20 km. Below

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that limit, the uncertainties affecting the available vmrs rapidly increase with decreasing altitudes. To highlight this, this limit is now explicitly indicated in the abstract and the following sentence has been added in the conclusions: "It should be noted that these uncertainties are valid for HCl and HF measurements taken down to about 20 km. Below this altitude, it is anticipated that the precision of the measurements will rapidly drop with decreasing altitude and vmr values. The lowermost ACE-FTS measurements available for HCl and HF should therefore be considered with care by the data users".

[RC]. Pg 3447, lines 28-29 state that the impact of uncertainites in spectroscopic parameters can be neglected. This is only true if the same pressure and temperature profiles are used in both analyses, and this is not the case. Some comment of the impact of using different p-T profiles should be made here or at the end of Section 3.

[AC]. The best available p-T profiles have indeed been used in all the retrievals (for both ACE-FTS and the ground-based FTIRs) and for the partial column calculations. As mentioned in the text (p. 3437, l. 18-20, p. 3449, l. 9-10), the values for ACE-FTS are derived from the spectra using T-sensitive CO2 lines. The impact of the uncertainties affecting the final products is presently not available for ACE-FTS (see response to Ref. #1). However, the paper by Abrams et al. (Geophys. Res. Lett., 23, 2337-2340, 1996) provides representative information on the precision achieved - by a FTIR instrument (ATMOS) operated in the occultation mode - on pressure and temperature retrievals. These authors have shown that temperature errors can be neglected while tangent pressure precision are generally better than 2% in the altitude range relevant to our investigations, and hence is not a dominant contributor to the global estimated precision evaluated for each species. For the ground-based FTIR instruments, the impact of these uncertainties is already included in the provided error budgets as well as in Rinsland et al. (2003), a study cited in the text.

[RC]. Pg 3448, lines 26-27. The extrapolation of the ACE-FTS results to the height of the ground-based site using the FTIR a priori could lead to an artificial correlation of the ACE-FTS and FTIR results. A justification of this procedure should be given.

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[AC]. The ACE-FTS occultation measurements of HCl and HF are generally available down to 10-12 km on average. When it comes to the smoothing of these profiles with the ground-based averaging kernels, you have several options available to extend down the ACE-FTS data, you can use a standard or a modeled profile, the ground-based a priori profiles... The latter option was selected here. These extensions are performed in altitude ranges which are not part of -or contribute little in terms of partial column to- the comparisons; hence the influence on the final results is expected to be negligible. In order to evaluate the impact of our choice, we have generated another subset of data for both HCl and HF, after extension of the ACE-FTS profiles with vertical profiles based on HALOE data, complemented with 3-D SLIMCAT model profiles. Comparison between both sets has indicated a marginal effect (a few tenths of a percent on average), which is well below the individual relative differences observed between the ACE and the ground-based partial columns, thus the corresponding conclusions drawn from our study remain valid. To make it clear to the reader, we have added the following sentence to section 3.6: "For verification, extensions with other plausible vertical distributions were also performed for part of our dataset; we noted only marginal impact (on the order of a few tenths of a percent on average) on the partial columns computed on the basis of the smoothed ACE-FTS profiles."

[RC]. Pg 3449, lines 4 to 7. What was the objective basis for the altitude range, and is this the sensitivity range given in Table 3?

[AC]. The altitude ranges in which the OEM retrievals are providing information have been determined on the basis of the averaging kernel matrices (e.g. by looking at averaging kernels for properly merged layers), and of its Eigen vectors and values. A description of the practical determination of these ranges has been given previously in Barret et al. [2003] and Vigouroux et al. [2007]. The text has been modified to redirect the reader to these studies and the sentences now read. "Determinations of the altitude range for partial column comparisons were objectively based on averaging kernel and/or eigenvector inspections, following the practical methods described previously in Barret et al. (2003) and Vigouroux et al. (2007). The adopted values are listed in columns 3 and 5 of Table 3, for each site and for both reservoir species."

[RC]. Pg 3450, line 26. Why are 5 sunrise coincidences not enough to give statistical significance ? If the instruments are well characterised and the coincidence criteria are appropriate then there is no reason that even a single profile intercomparison should not provide useful data, as is case with the SPIRALE data.

[AC]. The question here is not that a single comparison should not provide useful data but rather that it seems inappropriate to perform the sunrise and sunset comparisons separately, since no evidence for a SR/SS bias was found and the numbers of available coincidences for each subset are quite unbalanced (5 vs 31). All events have therefore been combined here. We have modified the sentence in order to avoid any misunderstanding to "Figure 3 shows the average HCl profiles measured by both instruments for all 36 available coincidences (left panel), i.e. considering simultaneously the sunset and sunrise events. Both instruments..."

[RC]. Pg 3451, lines 5-9. What is the significance of the comparison of the standard deviations ? Presumably the important question is whether both instruments are capturing the same natural variability. If this is the case, then it is the degree of correlation between the two datasets that is important rather than the level of variability, which could just reflect a similar instrumental uncertainty behaviour for the two instruments.

[AC]. As discussed in the text, these comparisons are included to address the question of whether these two different instruments are capturing the same natural variability. The HCl standard deviations are indeed in good agreement over the whole altitude range as shown in Figure 4. A good agreement is further observed for the HF comparison, with both profiles showing a similar feature from about 25 to 32 km (see lines 15-22 on page 3455). This feature is believed to be geophysical, and indicative of a higher variability occurring in this altitude range as described by Hoppel et al. (1999) for ozone. This is seen for another tracer, in the ACE-FTS vs HALOE comparisons for methane (De Mazière et al, 2008). Altogether, these observations support the idea that both ACE and HALOE are able to capture the natural variability of these species, in the altitude ranges indicated in the discussions of section 4.1.2 and 4.2.1.

[RC]. Pg 3454, lines 25-29. What are the uncertainties in the linear fit parameters?

[AC]. The uncertainties in the linear fit parameters are the following:

All datapoints:

y0 = (5.52+/-1.28) x E14 a = 0.895+/-0.039

"Closest comparisons" ($<$ 500km):

y0 = (1.82+/-1.41) x E14 a = 0.980+/-0.009

The second fitted line is compatible with the 1:1 line correlation at the 95% confidence level.

[RC]. Pg 3455, lines 1 to 5, the conclusion given here would be better demonstrated by restricting the comparison by latitude rather than by spatial proximity.

[AC]. We have reanalyzed the available data sets, taking into account this interesting suggestion. The criteria were kept identical to define the reference data sets (i.e. essentially coincidence within 1000 km, tightened to 500 km or relaxed to 1200 km for some sites), hence corresponding linear fits and statistics are unchanged in Figure 8 and 13 as well as in Table 4. But this time, further selection has been made on the basis of the difference in latitude. A maximum absolute difference of 200 km was accepted along the north-south direction (corresponding to 1.75 deg difference in latitude), allowing to keep a significant number of coincidences in both cases, i.e. 42 and 30 for HCl and HF, respectively, with most of the sites still represented. A significant improvement is noted in the statistics for the relative differences, with values of (2.03+/-11.74 [1.81]) % and (2.80+/-8.70 [1.59]) % for HCl and HF respectively. This is an obvious indication that the suggestion of the referee is justified and that this selection is more appropriate. The corresponding sections, figures and Table 4 have therefore been updated to include this better approach for the selection of the coincidences.

[RC]. Pg 3457, lines 8 to 10. Why shouldnt a direct comparison be made ? Although the HCl and HF measurements are not simultaneous they are presumably often made within 12 hrs of each other, which is within the temporal coincidence criteria used for the intercomparison implying that the HCl and HF fields do not change significantly in this time.

[AC]. In theory and provided that the sampling in time and location are identical or very close, such a comparison is possible, if not desirable. However, in our case we have dissimilar samplings which result from practical reasons, HCl and HF are measured in different optical filters, and are not necessarily available on the same day or close enough in time (there are generally fewer HF observations available, see Table 4), and not all the sites are involved in both comparison. To clarify this, the sentence has been modified to " No direct comparison should be made between the HCl and HF scatter plots and data point distributions, as ground-based observations of these two species are not performed simultaneously, and HF is currently not available from all sites involved in our study. ".

[RC]. Pg 3436, line 23. Section 2 should read Section 3

[AC]. Corrected

[RC]. Pg 3436, line 26. Section 2 should read Section 4

[AC]. Corrected

[RC]. Pg 3448, line 23. Xd in equation 1 is not defined.

[AC]. Should be Xa, corrected

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 3431, 2008.

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