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Atmospheric Measurement Techniques Discussions

Interactive comment on "Four Fourier transform spectrometers and the Arctic polar vortex: instrument intercomparison and ACE-FTS validation at Eureka during the IPY springs of 2007 and 2008" *by* R. L. Batchelor et al.

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The authors would also like to thank Anonymous Referee #2 for their helpful input on this paper. These comments are addressed in a point-by-point manner below.

Specific:

p. 2887, l. 16: The definition of the resolution of ACE-FTS and PARIS-IR (0.5/MOPD) is not compatible with those for the other two instruments (1/MOPD). This should be

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corrected.

We have discussed this point a lot (internally and with the editor), and believe that this inconsistent but clearly defined description of the resolution of the instruments in this paper is the best compromise between clarity and the different definitions of resolution that have been used for these instruments in the past. There is an extensive body of literature surrounding the ACE-FTS (and PARIS-IR) with the resolution defined as 0.02 cm-1 (0.5/MOPD), and we believe that quoting a different resolution for these instruments in this paper from that quoted in all other documents would cause more confusion than the internal consistency in the paper. Likewise, considerable documentation exists for the higher resolution instruments using either a 1/MOPD or 0.9/MOPD definition.

p. 2888, l. 10: 'the satellite borne spectrometer has considerably more vertical resolution'. Perhaps better 'due to the limb-sounding geometry, the satellite borne spectrometer rhas considerably better vertical resolution'.

This has been done. The text now reads:

The spectral range of the ACE-FTS is comparable to that of the ground-based FTIR spectrometers, with a spectral resolution of 0.02 cm-1, however, due to the limb-sounding geometry, the satellite-borne spectrometer has considerably more vertical resolution (typically 3 – 4 km) than any of the ground-based instruments (Boone et al., 2005).

p. 2889, l. 3: Could you add the information, which pressure/temperature profiles have been chosen for each instrument?

This has been added. The appropriate sentence reads:

Daily pressure/temperature profiles, determined from the average of twice-daily radiosondes launched at Eureka, coupled to the National Centers for Environmental Prediction analyses above balloon height to 50 km, and then to the US standard atmo-

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sphere to 100 km, have been used for all three instruments.

p. 2892, l. 24: ‘show excellent agreement’ ‘excellent’ should be substituted by a more quantitative measure (e.g. give % difference)

The text has been amended to read:

The DA8 and 125HR show excellent agreement, with mean discrepancies less than 3.5% and with the range of variation over each spring in all of the gases being well captured. The agreement with PARIS-IR is more variable. For O3 and HCl, the comparison is very good (with mean differences of ∼2 and 5% respectively), while there is an obvious bias in the HNO3 results.

Please note that the percentage differences are also given in Table 2.

p. 2894, l. 12-24: The explanation of the fact that after smoothing, the ozone column densities of the high resolution instruments fit much worse to the PARIS-IR is very vague and, thus, needs more investigation. I would suggest to use the higher-resolution result profiles for ozone of the DA8 and the 125HR as a-priori for PARIS-IR retrievals. These retrievals should be done with a scaling factor, not to change the shape of the profiles with altitude. This scaling factor should stay close to one in case the profile shape is responsible for the deviation between the instruments. This would also help to overcome possible effects of saturation within the spectral window used for ozone retrieval, since the smoothing approach is strictly only valid for linear cases.

We agree that this section was not clear, and have rephrased it as suggested by Reviewer 1. However, we have also added a reference to saturation of the features, which we agree is a limitation of the PARIS-IR retrievals in this region. We have deliberately not used the 125HR/DA8 profiles as a priori for the lower PARIS-IR retrievals as we wanted to maintain independent and consistent retrievals for each of the gases for validation of the individual measurements. The new text has been listed in the reply to Reviewer 1.

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p. 2895, l. 7: ‘Following standard conventions’ Could you explain more clearly what ‘standard conventions’ mean. Could you e.g. cite a publication which show that these conventions are valid for some situation/geographical region.

These conventions were based on the ACE validation studies quoted throughout the paper. However, those studies generally extended the coincidence criterion to 24 hours (as well as 1000 km) for the global comparisons with ground-based FTIR instruments in order to obtain reasonable numbers of coincidences, particularly for stations at lower latitudes. Because of the relatively large number of ACE overpasses near Eureka during spring, we were able to tighten our temporal coincidence criterion to 12 hours while still retaining a reasonable number of matches. We have thus removed the reference to "standard conventions". The text now reads:

Spectra were considered coincident if the 125HR and ACE-FTS measurements were recorded within 12 hours and the distance between the ACE 30-km tangent point and PEARL was less than 1000 km.

p. 2895, l. 13: ‘was interpolated to the 38-layer altitude grid’ How has the interpolation been performed?

The text has been replaced with:

As in previous ACE validation activities, for this comparison, each ACE-FTS profile was linearly interpolated from the ACE 1-km grid to the 38-layer altitude grid used for the 125HR retrievals

p. 2899, l. 8:

However, the standard deviation of $ClONO_2$ is worse. Can you try to explain why?

The standard deviation of $ClONO_2$ is large because this is a very difficult retrieval, particularly when there is very little $ClONO_2$ in the atmosphere, as is the case outside the polar vortex. The fact that the standard deviation increases in 2008 reflects this – there is a wide spread in the measurements, and because the number of measurements

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decreased after applying the stricter criteria, the standard deviation increased. The difficulty of the retrieval has been noted in the text, with reference to previous studies (see text changes listed in the final point below).

p. 2899, l. 8: A figure like Fig. 5 should be given for the stricter match criteria.

The figure has been added (Figure 9, shown below). The relevant text reads:

Figure 9 shows the comparison between those measurements remaining after the new criteria were applied, with the mean percentage differences, standard deviations, and standard errors shown in Table 4.

The caption for Figure 9 reads:

Figure 9: As for Figure 5, but with those comparison pairs remaining after tightened criteria have been applied. Note that the distances shown in this plot are now the distance between the measurements along the lines-of-sight at 18 km, as described in the text.

p. 2899, l. 11: 'the difference between the measurements is zero to within one standard deviation', and p. 2899, l. 13: 'within one standard deviation' This would be valid, if the standard deviation given in the table is really the standard deviation of the mean of the differences (i.e. the standard deviation of the ensemble of differences divided by sqrt(n)). Could the authors confirm this and state it clearly in the text?

The standard deviation in the text was not the "standard deviation of the mean of the differences" (or standard error), but this has now been added to the tables, and the text amended to reflect this. Significant changes have been made to the text to include description relative to these changes. The revised text from Section 5.2 is given below. Small changes have also been made in the conclusions and abstract based on these results.

Figure 9 shows the comparison between those measurements remaining after the new criteria were applied, with the mean percentage differences, standard deviations, and standard errors shown in Table 4. It can be seen that these stringent comparison requirements have significantly reduced the number of pairs contributing to the comparisons, particularly in 2007 when measurements made at Eureka were frequently near the edge of the polar vortex. However, both the mean differences and standard deviations between the two measurements have typically been reduced, and we are confident that these measurement pairs are highly comparable. The bias is seen to be zero within the standard error for O3, ClONO2 and HNO3 in 2007, with ACE showing a slight high bias of approximately 5% in HCl and HF, which is comparable with that seen in previous ACE comparisons (Mahieu et al., 2008). In 2008, the HCl and HF biases are non-significant (within standard error), however negative biases are seen in the other gases. The greater standard deviation in ClONO2 reflects the difficulty of this retrieval, particularly when the column of ClONO2 is low (common outside the polar vortex, thus dominant in the 2008 comparison). This was previously demonstrated in Wolff et al. (2008), who described large standard deviations and found a wide range of biases between ACE-FTS and ground-based FTIR measurements around the globe, with no discernible trend. A slight negative bias in ACE HNO3 was also reported in that study (Wolff et al, 2008), comparable in magnitude to that obtained here.

To conclude, having applied the stringent coincidence criteria, the differences between the two instruments are generally small and are in good agreement with previous ground-based FTIR/ACE-FTS comparisons of these five gases (Dupuy et al., 2009; Mahieu et al., 2008; Wolff et al., 2008). No clear bias is seen from year-to-year, and, in all cases, the difference between the measurements is zero to within one standard deviation, and non-significant in at least one of the years within standard error. As such, we can confidently say that the ACE-FTS shows excellent agreement with ground-based spectroscopic measurements made in the highly-variable spring-time northern polar stratosphere.

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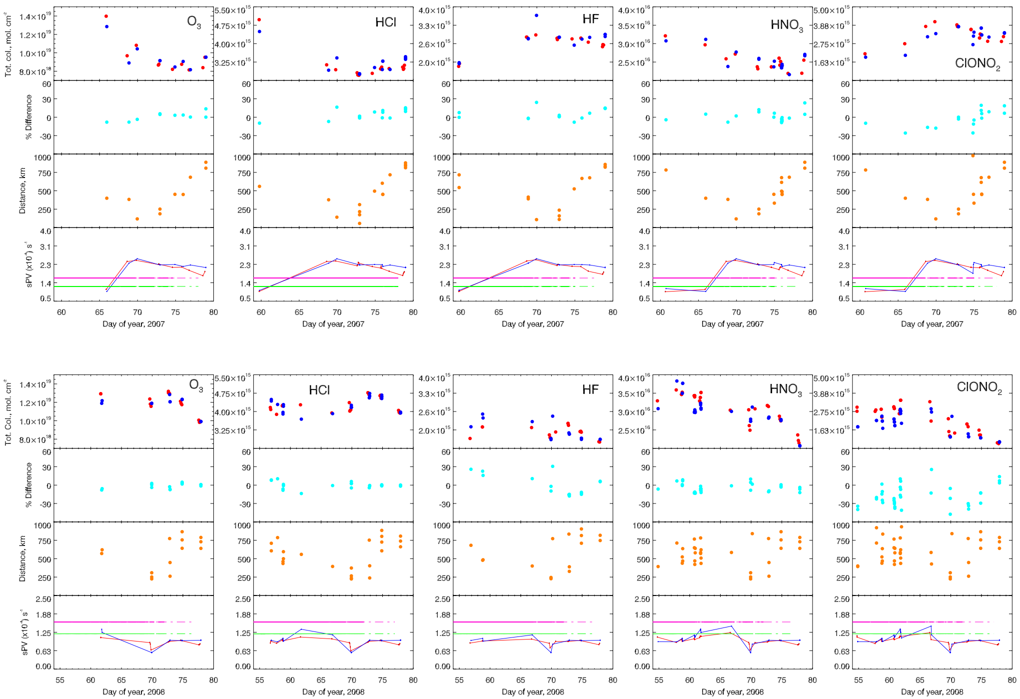

Fig. 1. New Figure 9, added as per referee's request.

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