Atmospheric Chemistry and Physics Discussions

Interactive Comment

Interactive comment on "Technical Note: REFIR-PAD level 1 data analysis and performance characterization" *by* G. Bianchini and L. Palchetti

G. Bianchini

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Page 369, line 15: What is the maximum optical path difference corresponding to the resolution of 0.5 cm-1? Since "resolution" is not unambiguously defined, the maximum optical path difference should also be mentioned here.

Reply 1: the definition of resolution given in the paper is 1/2l where l is the maximum path difference (in cm). We will make this clear in the text.

Page 372, line 11: Could it be that you mean "higher" instead of "lower"?

Reply 2: actually, the detector response con be modeled with a combination of a low and a high pass filter which are in a configuration that is "inverted" with respect to the usual band pass configuration, that is, the term "lower" is correct

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Page 373, line 9: It would be interesting to know the sampling frequency of the infrared signal in the time domain. This could either be stated here or on page 369, paragraph beginning line 13.

Reply 3: We will specify in the text the sampling frequency range of the instrument electronics and the actual values used during measurements

Page 373, line 11: Since the interferogram can only be cut at an integer number of points, the desired resolution must correspond to an interferogram length being an integer multiple of the laser wavenumber. Does this mean that the desired resolution is maybe not reached exactly?

Reply 4: that's correct, but since the number of points in the interferogram is about 640000, the roundoff error in the resolution is of the order of few parts in 10^{-6} and is thus negligible from the data analysis point of view

Page 373, line 24: What else but noise is included in the high resolution component of the phase spectrum? I would expect that all phase features have low resolution and thus the high resolution component of the phase only contains noise. If the phase spectrum contained other features than noise, it would be necessary to take them into account within the phase correction.

Reply 5: see Reply 10

Page 373, same paragraph: I would mention already here that the beam splitter emission needs not to be considered (as stated on page 375, line 11). What degree of isothermy is required for neglecting the beam splitter emission?

Reply 6: the product of thermal anisotropies inside of the istrument and of the instrumental emissivity should be smaller than the required radiometric error in terms of temperature (about 0.1K). For anisotropies of the order of few K this is generally true, with the exception of some narrow regions of the spectrum where absorption features due to the beam splitter substrate are present, these are anyway outside of the most

interesting regions of the spectral range.

Page 374, last paragraph: In this paragraph, only the precision of the blackbody temperatures is stated. However, for a good calibration, a high accuracy is also required. What is the accuracy of the temperature measurements?

Reply 7: actually, the correct statement is that the results given in the text refer to the accuracy of the temperature measurement system, and not to the precision. This will be corrected

Page 375, line 2: "calibrated housekeepings": In which way are the housekeepings calibrated? Or do you mean something like "housekeepings used for calibration"?

Reply 8: the housekeepings are stored in terms of digital readout (16 bit unsigned) from the A/D boards. These values are then calibrated to physical quantities through formulae and coefficients that are determined a-priori in laboratory tests

Page 375, lines 6/7: How is the laser frequency calibrated? What kind of single measurement is used for the frequency calibration? Could a misalignment between laser and infrared beam (leading to slightly different OPDs) affect the quality of the frequency calibration?

Reply 9: the laser frequency is calibrated using the center frequency of atmospheric lines in the measured spectra, thus misalignment between laser and infrared is automatically taken into account. Fine-tuning of frequency calibration is then performed during data analysis (introducing a fitted frequency correction coefficient) in order to correct for possible small fluctuations of the laser frequency due to thermal excursions.

Page 375, line 17: "Complex spectra are used ..." : What kind of residual phase error do you expect? Why should these phase errors not be corrected during the phase correction you describe on page 373? If the residual phase errors are not the same in all spectra (atmosphere and blackbodies), the complex calibration will not eliminate these errors. Since you do a complex calibration anyhow, why do you perform an

extra phase correction before? I have the feeling that by this way of data processing two phase correction methods are mixed up which maybe does not really improve the result.

Reply 10: the approach of using both phase correction and complex calibration comes from the fact that in absence of an absolute zero path difference reference complex calibration alone is not sufficient, since it would require the same dephasing in every spectrum (calibrations and atmospheric). On the other hand, the phase correction scheme used assumes a slowly varying phase, which is generally true except than in coincidence with narrow absorptions inside of the instrument (due to beam splitter substrates and water vapour strong lines). The phase correction procedure alone assures a correct calibration on the most of the spectral range, the residual errors due to the effects above described can be further corrected with the use of a complex calibration. It should be noted that this correction is very small and furthermore, it affects only the low frequencies below 300 cm-1 (water vapour) and the high frequencies above 1000 cm-1 (mylar absorptions).

Page 376, calibration formulas: I am missing the offset (i.e. the instrument self emission) in the calibration formulas. Can this contribution be neglected? This should be addressed in the text. I suppose that all the calibration formulas have to be applied for each of the two output channels separately and that the two channels (if available) are combined after calibration. This should be stated clearly at this point.

Reply 11: in interferometers using double input/output configuration, if we neglect the beam splitter emission, the instrument self emission corresponds to the emission Br of the second input port looking at the reference BB. This emission is correctly considered in the calibration procedure with the term F2*Br in Eq.1. It is correct that the calibration formulas have been applied for each of the two output channels separately and that the two channels have been combined after calibration with a weighted mean according to the noise level of the two channels. This will be made clearer in the revised text.

Page 376, line 23f: What has the pressure level to do with the size of the imaginary part? What do you mean with "the imaginary part is smaller"? Smaller than what? And what does the imaginary part of the spectrum prove about the symmetry of the acquired interferogram? I would expect that after phase correction, the imaginary part should generally contain nothing but noise, no matter how symmetric the acquired interferogram originally was. Page 377, line 2: From Fig. 8 I cannot see any deviation from noise in the imaginary part. What is meant by the "small effect"? Page 377, line 9: The imaginary part of the calibrated spectrum also contains some interesting information: Does it show only noise as one would expect after correct data processing? Has the "small effect" mentioned in line 2 disappeared in the imaginary part of the calibrated spectrum?

Reply 12: see Reply 10 for the phase correction/complex calibration issue. We will rewrite in a more clear way some statements, for example the pressure issue is related to water vapour absorption, the statement about symmetry of the interferograms is also misleading and not useful. The whole thing about the "small effect" will be restated in a more quantitative way.

Page 377, line 15: Here you talk about the measurement accuracy of the blackbody temperatures, while on page 374, you only discussed the precision.

Reply 13: see Reply 7.

Page 378, line 9/10: When you measure n calibration sequences, this leads to 2n single spectra. In order to make this clear, I suggest to write "... an average of n single spectra, respectively (i.e. ..."

Reply 14: We will specify better in the text as suggested.

Page 379, line 10: Again, only the precision of the blackbody temperature is considered, while the estimation of the systematic calibration error requires the accuracy.

Reply 15: see Reply 7.

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Page 379, section 4.2: General comment on the systematic error: What about the water vapour inside the instrument wich is clearly seen in the calibration functions? I would assume that these spectral features could also affect the radiometric accuracy.

Reply 16: water vapour inside of the instrument can affect radiometric accuracy only if it undergoes a substantial variation on a timescale of the order of the interval between calibrations (which is not the case). It can also give phase errors, but only through the absorption that occurs in the optical path difference between the two arms of the interferometer. The latter (1 cm max) is small with respect to the total optical path inside of the instrument (about 2 m), thus the observed water vapour absorption is mostly taken into account and corrected for during calibration.

Page 380, line 20f: Just a comment: The self validation gives a much better result than one would expect from the systematic calibration error shown in Fig. 11. This suggests that the error estimation for the calibration blackbodies is maybe too careful.

Reply 17: this could be correct, the systematic error estimation could be overestimated. However it is difficult to quantify this parameter with higher precision. In order to be conservative, it is chosen to use this figure of merit.

Page 381, line 15: Why don't you use the standard deviation of the imaginary parts of the calibrated spectra in order to determine the NESR? The imaginary part should be insensitive to the atmospheric variability.

Reply 18: this is likely true and the possible use of the imaginary part will be tested in the next experiments. However for the determination of NESR, only the measurement of the on board BB sources have been used. The on board reference sources do not have variability during the measurements.

Page 388, Fig. 4: The two curves in Figs. b,c, and d are very close, therefore a residual plot would be more informative.

Reply 19: We'll insert the residuals in the figure.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 367, 2008.

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