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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Differential Column Measurements Using Compact Solar-Tracking Spectrometers" *by* J. Chen et al.

Anonymous Referee #1

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This paper describes some instrument characterisation and two applications of a recently commercially-available mobile Fourier transform spectrometer (Bruker EM27/SUN) coupled to a solar tracker for remote sensing of atmopsheric trace gases using the near infrared solar spectrum. The instrument is a low resolution mobile version of the FTS instruments used in the Total Carbon Column Observing Network (TCCON). The first part describes side-by-side measurements with three spectrometers and characterises the precision and stability amongst the three. The second part describes two applications of differential measurements when the spectrometers are located upwind and downwind of sources - a large dairy farm in California, and across an urban area in greater Los Angeles. The dairy farm is a nice example of exploiting the high repeatability and low bias of the instruments to detect small differences and spatial gradients.

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Discussion paper

Previous papers, eg by Gisi et al (2012), Frey et al., (2015) and Hedelius et al (2016, see references) have described similar characterisations and applications, but this does not take away from the usefulness of this paper, which extends rather than repeats those studies. The result is a useful addition to the characterisation of the precision, accuracy and stability of these spectrometers, which are finding many applications which complement TCCON. I recommend publication after addressing the comments listed below. The paper is rather technical in nature and does not contain a lot of new science, and therefore may be better suited to AMT than ACP.

General Comments:

In section 2 there is too little description of the basic solar FTS measurement - the reader is assumed to be familiar with solar FTS remote sesning and previous work. A summary of the measurement technique, referring back to TCCON and the previous papers on this instrument, would be useful for all readers, as it is it is directed only to those who are already involved in these measurements.

Section 3 is about precision and accuracy of the technique, but the authors use the term "precision" and other terms in incorrect ways. I recommend a reading of the IUPAC publication commonly known as GUM: "Evaluation of measurement data âĂŤ Guide to the expression of uncertainty in measurement" by the Joint Committee for Guides in Metrology, JCGM 100-2008 (available from the BIPM website). "Precision" is a general term which is not defined for quantitative uncertainty assessment - quantities such as repeatability and reproducibility have specific, quantitative meanings and should be used in quantitative assessments of random uncertainty. Similarly there are more specific terms for "accuracy". In particular, in most cases in this paper, "precision" is used very loosely and mostly means "repeatability". Since the focus of section 2 is quantification of uncertainty, I recommend using correct terminology.

The authors use "gradient" throughout when they really mean "difference". A gradient is difference per unit length, eg 2 ppm km-1, not 2 ppm as used here. I found this confusing when reading, and recommend that all instances of "gradient" be sought out and replaced with "difference" where appropriate.

Units: please quote units correctly, eg m s-1 not m/s, molec m-2 s-1, not molec/(m2s) as in Table 1. See the IUPAC "green book" (Cohen, et al. (2007). Quantities, Units and Symbols in Physical Chemistry. Cambridge, IUPAC, RSC Publishing) for authority on units.

Use of "%" and "‰: I found it very confusing to mix these two quantities, it is too easy not to notice ‰ and read it as %. I recommend using % throughout.

Specific and technical comments:

section 3.1. It is acceptable to use "precision" when speaking generally, but in cases when a value is assigned to an uncertainty, "precision" should be replaced by the appropriate specific quantity "repeatability" or "reproducibility". There are many instances, please search and replace.

P4 L10: "underestimate the true precision" really means repeatability and is ambiguous since high precision is a small number. Perhaps replace with "overestimate the true random uncertainty of the measurement."

P4 L21: Allan Deviation, not standard deviation.

P4 L28: "Allan standard deviation" is incorrect - replace with "Allan deviation", which is the square root of the Allan Variance,; they are not calculated in the same way as variance and standard deviation and should not be confused. There are many examples of "Allan standard deviation" throughout which should be replaced by "Allan deviation" = please search and replace (including figures, eg axis labels in Fig 1).

P5 L11 "System Robustness" "Robust" has a specific meaning in statistics, and since this is a statistical section, I would recommend System stability as a better title.

P11 L12: "Column gradient observations" - first of many examples where "difference" or "differential" should replace "gradient"

P6 L5: Here "precision" is used when "accuracy" is meant - this sentence describes a systematic error.

P7 L23: The usual Reynolds notation is to use u' for the turbulent wind speed component, rather than uturb, so that u(t) = u(bar) + u'(t)

P10 L19: Please explain the transient peak around solar noon - what is it due to, and justification for its removal.

P11 L14: The meaning of this heading is quite unclear. I suggest replacing "gradient" with "difference" as commented earlier, and bring the second the paragraph beginning Pasadena ..." ahead of the first, so it comes first after the heading. Most of the confusion lies in the incorrect use of "gradient"

P12 Fig 4: The lowest panel would be very much improved if both the XCO2 and XCH4 axis had a common zero line.

P12 Fig 5: In the plot, cut off the negative axes at (-1,-5) to better utilise the space and avoid large empty area of the plot. Use the (0,0) axes rather than L and right axes, so the origin is clear.

P13 Fig 6: Same comment as Fig 5. The origin crosses can't be seen. The time periods are quite unclear - what are [-1 h : 0 h] etc, relative to what time? More detail in caption required.

P13 L1: please rephrase as " a lower DXCH4/DXCO2 ratio" since this is the way the plots are presented (with CH4 on the Y axis).

Appendix D: The plots of the O2 column are not particularly informative, since they reflect mostly pressure not spectroscopic retrieval. I suggest to replace these plots with the O2 column : pressure ratio (corrected to dry air) - this should be a constant with a known value related to 0.2095 mole fraction of O2 in air.

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