

## ***Interactive comment on “A Fourier transform infrared trace gas analyser for atmospheric applications” by D. W. T. Griffith et al.***

**Anonymous Referee #2**

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This paper describes an FTIR-based trace gas analysis system and touches upon some of its atmospheric measurement applications. The manuscript is well constructed, clearly written and interesting. It is basically a compilation of information and figures that were explained in much greater detail in several past publications, with some updates.

General Comments:

The number of figures (17) is quite high, and sometimes their very short descriptions (in text and captions) are inadequate for the non-expert reader. If the abbreviated descriptions are due to a page limit, my suggestion is to eliminate some of the figures and provide additional explanation of those that remain. For example, there are four

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figures showing chamber experiment results but only 27 lines of text that explain them. Figures 16 and 17 are described with only 8 lines of text.

The paper touts the FTIR analyzer as capable of “continuous” measurements, but presents measurements and results based on spectra co-added for periods of 1 minute or more to achieve adequate signal to noise. That is indeed a good data rate, but also similar to fast gas chromatography measurements described in this paper as “pseudo continuous”. In my opinion the term “continuous” overstates the capabilities of the analyzer throughout this paper and should either be tempered or removed.

At several points in the manuscript I questioned why the air stream into the analyzer was necessarily dried, with the exception of measuring water vapor (and its isotopes). Do the absorption lines of water vapor greatly interfere with those of the targeted trace gases? Are water vapor lines saturated, making it difficult to calculate the dry mole fraction of trace gases without independent water vapor measurements? This important conceptual point is overlooked in the manuscript, and I feel there is a need to include some information about it.

“Determine the fractionation” appears several times in the manuscript to describe measurements of the stable isotopic composition of a trace gas. Although this terminology is technically correct, the reader may be confused into thinking that you are measuring the influences of a process on isotopic composition rather than the isotopic composition itself. One of the benefits of the FTIR analyzer is that it can measure the absolute abundances (i.e., mixing ratios) of the isotopologues instead of just their ratios. This should be clearly emphasized in the manuscript. This is a minor point, but I greatly prefer “determine the isotopic composition” instead of “determine the fractionation”.

In the abstract the analyzer is described as capable of making “high precision and accuracy” measurements. The precision of measurements is fairly easily established, but the accuracy is not. Nowhere within this paper is an attempt made to estimate the accuracy of measurements. Comparisons with established calibration standards (reference

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gases) are mentioned, qualitatively (e.g., “good agreement”), but nothing quantitative is presented. How can you tout the analyzer’s ability to make measurements with “high accuracy” without providing quantitative evidence?

Specific Comments:

Page 3718 Lines 15-16 (P3718 L15-16): The connection between “isotopic tracer experiments” and “for example  $^{13}\text{C}$  in  $\text{CO}_2$  and  $^{15}\text{N}$  in  $\text{N}_2\text{O}$ ” is not at all clear. What is the relationship between these stable isotopes and “isotopic tracer experiments”?

P3719 L9-11: This makes it sound like  $\text{CH}_4$  and  $\text{N}_2\text{O}$  don’t accumulate in the atmosphere

P3720 L15-16: Optical techniques like ICOS or CRDS are well suited to continuous measurements, but FTIR spectroscopy requires a fair bit of signal averaging to obtain adequate measurement precision

P3720 L19-20: If a laser is a “single wavelength device” how can it be scanned over a “narrow wavelength interval” ?

P3721 L16: Is “clean” air the same as “background” air or has it been scrubbed of some gases?

P3725 L3-4: If the water vapor mixing ratio in dried air is  $<10$  ppmv then the correction to the dry mole fraction is  $<0.001\%$  (not just “small”)

P3726 L8: All versions of the Beer-Lambert Law that I can find state that the absorbance is directly proportional to the absorber concentration, not “approximately proportional”. There may be deviations from linearity under certain conditions, but Beer’s law has an equal sign.

P3729 L6-13: The “wide range of mole fractions” in Figure 5 isn’t very wide for  $\text{CO}_2$  or  $\text{N}_2\text{O}$  (only 10-20%). This section (3.2), although entitled “Calibration and accuracy”, doesn’t quantitatively address accuracy, either in terms of agreement with the U of

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Heidelberg reference tanks, or in terms of absolute accuracy (i.e., what are the uncertainties of the reference tanks and how do they propagate to the absolute accuracy of the FTIR measurements ?).

P3734 L25: I see 4 reference tanks in Figure 7b (not “5”) and this is confirmed in the Figure caption.

P3735 L5-17: This is an awkward place for the section 3.5 “Cross sensitivities” (immediately after a long discussion of  $^{13}\text{C}$  measurements). Would this section fit better before the isotope discussion?

P3736 L2: Again, “continuous” is overstating the capabilities of the FTIR analyzer, especially in this background monitoring application.

P3736 L10: Identify here that “AGAGE measurements” are “GC” and in Lines 13-14 mention for which type of “GC detector(s)” you are discussing response non-linearity.

P3736 L20: Presumably the locomotive is electric, not diesel, and there are no influences of train emissions (not just locomotive exhaust) on the trace gas measurements?

P3736 L23-25: The  $\text{CH}_4$  mole fractions don’t show “three distinct regions” but their “behavior is distinctly different in three regions”. Small but significant variations in the south . . . high variability north of 23 S. Are the “long pauses” at train stations? Why show the data at train stations or during stops downwind of cities when your discussion is focused on ecosystem influences?

P3737 L6: Which technology is “this technology” ?

P3737 L5-21: From my understanding, unlike all other measurement applications described in this manuscript, this section is not specific to the analyzer discussed in Section 2. Why does it appear in this paper? If you don’t limit yourself to results obtained with the described analyzer you could potentially add every atmospheric measurement result obtained by FTIR. I don’t think this section meets the objective of this paper.

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P3738 L1-4: Pertaining to my general comment (above) about sample drying, why here do you need one analyzer for water vapor analysis and another analyzer (sampling a dried air stream) for trace gas measurements? Could you do it all with one analyzer?

P3738 L10-18: It appears (Figure 12) that at least the top sampling inlet (70 m) and likely others are above the nocturnal stable layer, so there should be no nighttime build-ups or depletions. Is this the case? You attribute the nighttime gradients to low turbulence in the canopy, but are there any connections between the surface and these upper sampling levels? And during daytime the PBL height must be greater than that of the canopy, so isn't there strong turbulence throughout the PBL and not just within the canopy?

P3739 L2-6: It is unclear here what vertical scale length the flux gradient technique employs and how this scale length affects the minimum detectable flux values in Table 5. At what height(s) above the surface are measurements required to determine these minimum fluxes? The very brief description in this paragraph does little to help the reader understand the minimum detectable flux values in Table 5.

P3739 L24: Here is a good example of over-extending the term "continuous measurements" - at "1 minute resolution or better". At what temporal resolution do measurements become "discontinuous"? Three lines below also claims "continuous".

P3740 L7: Was the other system "applied" or "deployed" over a complete growth cycle?

P3740 L28: "... because the \*respired\* CO<sub>2</sub> is depleted in <sup>13</sup>C."

P3741 L8: Are the <sup>15</sup>N isotopologues of N<sub>2</sub>O not "natural" like <sup>14</sup>N<sup>14</sup>N?

P3742 L6: "... and isotopic measurements \*of\* atmospheric trace gases."

P3744 L24: "Hoffman" is misspelled here and in the text citation (P3719 L2)

Tables 1 and 2 share common information including species, units, and GAW targets.

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Why not combine them?

Figure 4: I'm a firm believer that Figure captions should explain all the symbols that appear in the graphs, so this caption needs to explain what the dashed lines mean.

Figure 8: Are these measurements by FTIR or by other instruments?

Figure 12: "represent measurement\*s\*" at different heights ..."

Figure 14: There should be at least one horizontal line added to each panel as visual guide. These will help to show that background <sup>13</sup>CO<sub>2</sub> and CH<sub>4</sub> were increasing over this period of seven sequential chamber closures. The behavior of several species in this plot is intriguing, yet the only description of this in the text is "complex". This comment very much pertains to my first general comment about overly brief descriptions of Figures.

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 3717, 2012.

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