

# ***Interactive comment on “Autonomous Airborne Mid-IR Spectrometer for High Precision Measurements of Ethane during the NASA ACT-America Studies” by Petter Weibring et al.***

## **Anonymous Referee #1**

Received and published: 21 July 2020

This paper describes the operation and results from an ethane spectrometer. Overall the instrument appears to be state-of-the-art with superb sensitivity and the results are well described. I recommend the manuscript be published after addressing my one major comment and numerous smaller comments.

### Major comment:

The overall procedures for determining the background variability are robust and well described, and I especially appreciate the histogram shown in figure 8a. I am concerned, however, that the authors equate precision with the limit of detection (LOD). While the detection limit is determined by the noise of the measurements (and thus

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directly connected to the precision), presumably it is also affected by the uncertainty introduced by the need to subtract out the contribution of methane's absorption using data from the PICARRO instrument. At least one equation which defines the LOD (not the same as precision) at a given signal-to-noise ratio should be included. Note that for many other absorption-based measurements the LOD is defined as twice the 1-sigma precision (i.e., signal-to-noise ratio of 2).

Minor comments:

line 34 onward – sentence starting with “There are a . . .” has multiple grammatical errors: 1. remove colon 2. in the parentheses, do not write “i.e., x, y, z, etc.”. Just write “e.g., x, y, and z” 3. write “. . . coal mines, wildfires, ruminants and associated manure, landfills water treatment plants, wetlands, and stagnant water ponds” – leave off “as well as biogenic emissions from” and “to name a few”.

“Fast measurements, precisely co-aligned in time to remove temporal instrument differences, results in highly correlated emission ratios” 1. should be “result” not “results”. 2. The measurements themselves don't result in highly correlated emission ratios. The measures can result in highly correlated concentration ratios, from which emission ratios can be inferred.

“By contrast, biogenic methane sources reveal enhanced methane with no enhancements in ethane.” awkward. Just “By contrast, biogenic methane sources are usually not also ethane sources”

line 43: “ethane is the longest-lived and most abundant non-methane hydrocarbon” – longest lived, really? In some environments, other non-methane hydrocarbons could be more abundant (e.g., isoprene).

line 44: awkward: “higher than methane-OH”

line 44: I do not follow the logic regarding ethane acting as an indirect greenhouse gas. This needs to be better explained, and with a reference. “Greenhouse” need not be

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capitalized.

line 53: should be “DFG-based”

lines 59 and 619: metric units please!

line 66: should be “Aerodyne Research, Inc”

lines 70-71 are awkward: “. . .systems e.g. Pal et al., (2020), quantification of regional, season fluxes of CO<sub>2</sub> (Feng et al., 2019; and Zhou et al., 2020) and CH<sub>4</sub> Barkley et al, (2019a,b), and evaluation of the Orbiting Carbon Observatory-2 (OCO-2) satellite Bell et al., (in press)”

line 72: Replace “on average fell in the 80 pptv range” with “were approximately 80 pptv”

line 85: “The cabin pressure effect is endemic to all such spectrometers without optical compartment pressure control” The authors should clarify that “optical compartment pressure” refers not just to the optical cell itself but the entire optical set-up.

line 87: remove the colon!!! Later in the sentence, replace the semicolon with a comma.

line 102: remove “as will be discussed”

Figure 1 - nice photo, but please clarify what’s inside the black cylinder. That’s the optical compartment I assume?! It’s only labeled as “TEC Temperature Control” and “Vibration/Shock Isolated and Pressurized Enclosure”

line 119: remove comma

Overall I would have liked to have seen much better usage of commas and colons. I find it surprising that none of the co-authors objected to their frequent incorrect usage.

line 141: replace “. . .except for a couple of beam dumps” with “. . .except for two beam dumps”

line 151: “two orthogonally placed spherical mirrors” insert hyphen between “ortho-

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nally” and “placed”. Moreover, I am confused by what that means. The two Herriott cell mirrors are at right angles to each other? That can't be right! Also, how many passes are used for this multi-pass cell and what is the effective path length? The path length (48 m) is only noted in figure 2 but not the text.

lines 205 – 209 – What kind of Teflon - PTFE? PFA? Note that not all fluoropolymers are actually "Teflon" brand (from Dupont/Chemours). Easier to just not use the commonly-used word "teflon" and describe what it actually is!

line 210: remove comma

line 215 – this paragraph seems out of place. I recommend placing it after the sampling train and calibrations are described.

line 244 “Calibration standards are measured before and after each flight” The wording is a bit confusing – it could be interpreted to mean that the calibration standard cylinder was measured with something else before and after flights. Perhaps “Calibrations were performed before and after each flight” instead.

line 322: not “times the” but “multiplied by. . .”

lines 330 onward: I highly recommend using single-letter variables, e.g. P for path length rather than PL.

line 360: “we introduce known C<sub>2</sub>H<sub>6</sub>/CH<sub>4</sub> calibration standards in compressed gas cylinders from Scott Marrin into the inlet before and after each flight. CAMS direct absorption measurements retrieved ethane mixing ratios that were too low by 6% and all ACT-America data have been subsequently raised by this number” awkward sentences. Raised by what number? Were all the measurements lower than the standards by 6%? Or just some? Please clarify.

line 374: “are accurate on average to within  $\pm 6\%$  range” please clarify if you are referring to 1 or 2 sigma accuracy

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Figure 6, caption: “The ethane fits out to  $4.23 \pm 0.025$ -ppbv,” awkward language (“fits out”). Perhaps “The fit indicates an ethane mixing ratio of 4.23 . . .”?

line 393 and Figure 7a: “In the case of Period A, we show the residual fit of Bkgn acquired during this period minus Bkgn-1, acquired 7 minutes prior (not shown)” This is confusing. In the figure I do not see any “fits” – just concentrations. Should “fit” be replaced with “derived mixing ratio” or something similar? Ethane-methane slopes: personally I’d prefer to not see them expressed as percentages. ie, just 0.184, not 18.4%

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