

Response to Reviewer #3 of "Application of Gauss's Theorem to quantify localized surface emissions from airborne measurements of wind and trace gases" by Conley et al. submitted to Atmospheric Measurement Techniques 18-Apr-2017

The paper by Conley et al. presents and validates a technique to infer point-source emission rates from in-situ aircraft observations of the atmospheric concentrations in a cylindrical volume around the source. The technique is approached theoretically through LES modelling as well as experimentally through the analysis of actual aircraft observations. The observation part is, however, rather short deserving more detailed discussions.

The writing of the paper is somewhat unclear in some places and, it appears like the manuscript lacks some text at the end wrt. discussing Figure 8-10 and conclusions. I recommend reworking the manuscript for clarity along my comments below and extending the discussion of Figures 8-10.

We thank the reviewer for the constructive comments and have attempted to clarify the discussion and expand the discussion of the last 3 figures in accordance with the recommendations below.

### Comments

line 103, throughout the manuscript: Check usage of "`\citep`" vs. "`\citet`".

Done

line 137: Check usage of "ABL" vs. "CBL".

Done

line 155: Several symbols undefined. Use real equations instead of in-line math.

We removed the density in-line equation

line 176-178: I do not understand what the paragraph refers to. Isn't it redundant?

We have reordered and abridged the statements here to precede equation 3 in the hopes of making the mathematical procedures more clear.

line 199: "the two terms that make up the path integral in equation (5)". There is only one term in equation (5), the horizontal divergence term dropped out before. In general, the ordering of equ. (1) through (6) appears confusing. Please check whether section 3.1 can be improved wrt. clarity.

We apologize for the error, this was supposed to read equation 2 (not equation 5). We have rewritten Section 3.1 several times before submission and believe that this presentation is the most straight forward. The progression of equations 1-5 runs from the general governing equation (1), to picking apart the specific measurement terms in equations (2) & (3) and describing the approximations made in our analysis, and then reintroducing them into the governing equation in equations (4) & (5). We believe that the rewording of the discussion around equation (3), as per reviewer's suggestion, and the correction of the typo in line 199 helps eliminate unnecessary confusion.

line 200: Are all symbols defined? Use real equations instead of in-line math.

We removed the definition of the convective velocity scale, assuming that was common enough for a reader to know or easily look-up.

line 235: What is U, what is T?

In rewriting Section 3.4 for clarity's sake, we removed the equation for mean advective heat flux,  $UT$ .

line 254: "Assuming." Remove.

Done.

line 258: Explain what a cospectrum is.

In discussing Figure 4 we included this description of the cospectrum, *"Because the integral of the cospectrum yields the total flux (covariance), this function is useful for examining the contributions to the total flux from each of the scales of motion (represented by aircraft speed divided by frequency)."*

section 3.4: Rework for clarity considering background of the general reader of AMT.

We have reworked this section on counter-directed turbulent fluxes to explain their origin and provide additional evidence for their existence from previous studies. We have included three new references (one being a textbook) surrounding the discussion of equation (8), and a reader who is not familiar with this type of turbulence reasoning can seek out these references to better understand the discussion.

line 331: This paragraph explains the mass derivative term in equation (6). Mass  $m$ , however, does not occur in any of the explanations. What is "beta"? Why is the time rate of change of mass an uncertainty per se that needs to be added in quadrature? Please rework this paragraph for clarity.

We have rewritten this section to improve clarity and removed the extraneous equation describing a linear regression fit.

line 415: The version of the manuscript I reviewed (downloaded from the AMT website) ends with "rendering this technique completely unsuitable." I wonder whether this is actually intended to be a take-home message of the manuscript. Should there be a conclusion section which was accidentally missed out?

We thank the reviewer for pointing out the awkward ending of the submitted discussion paper. We have added a short conclusions section to more clearly describe the limits of our method and potential avenues for future improvements.

Table 1: What are the question marks?

They were typos, we removed the question marks.

Tables 2 and 3: Please use date formatting that is unambiguous for international readers (e.g. YYYY-MMM(string)-DD).

Made the date labels unambiguous.

Table 2: hr-11 -> hr-1. The difference column refers to ethane.

Headers fixed.

Table 3: The difference column refers to methane, right? Please make this clear.

Difference header clarified.

Table 4: Why is there the additional column "Hour"? What is the unit of the CO2 emission rate ("T")?

Added caption text to define T = metric tons.

Figure 1: "to right" -> "to the right."

Done.

Figure 2: "Equation (4)" Isn't it equation (3)?

Corrected the equation referenced in caption.

Figure 3: The title and color bar label of the figure "Cross wind concentration" are misleading since the contours represent the integral in cross wind direction not any kind of cross wind dimension.

We have removed the colorbar labels and title.

Figure 4: Please explain in more detail what a cospectrum is.

In discussing Figure 4 we included this description of the cospectrum, *"Because the integral of the cospectrum yields the total flux (covariance), this function is useful for examining the contributions to the total flux from each of the scales of motion (represented by aircraft speed divided by frequency)."*

Figure 5: Define "d" in mathematical terms and relate it to one of your equations. Is "Q" the same as "Q\_c" in the text?

We have described the variables more clearly in the caption.

Figure 6: "This figure shows" . . . unnecessary to say in a figure caption.

Removed redundant wording.

Figure 8, 9, 10: Are these figures ever used/referred to in the manuscript? Please discuss in detail.

We added text in the body of the manuscript to describe the results represented in these figures, and rearranged them slightly.