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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Statistical atmospheric inversion of small-scale gas emissions by coupling the tracer release technique and Gaussian plume modeling: a test case with controlled methane emissions" *by* Sébastien Ars et al.

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Ars et al. introduce a method for inverting small-scale emissions using a statistical framework which incorporates a Gaussian plume model and observations from the tracer method (here with acetylene). This is motivated because in real-world environments the exact location of the methane source could be spread out, inaccessible, or not precisely known, limiting the accuracy of the single tracer release technique by itself. Validation of the combined approach is attempted using a controlled methane and

acetylene release experiment in four different configurations.

I read this paper with interest since I am also doing work related to quantifying methane emissions at small scale. From the measurement side, the experiment appears to be well conceived and performed. However, I noticed multiple things that could be clarified or improved on the analysis side. I think there are some key revisions needed to helpful clarify the method and results, along with additional suggestions to improve the overall manuscript that are given in this comment.

Major comments

1. Physical basis: On the basis for the approach, it makes sense a the tracer releases could, for instance, constrain the dispersion in the Gaussian model when the tracer source is collocated with the methane source. However, when the tracer is positioned farther away, for all the reasons outlined in the paper (lack of a homogeneous / stationary atmosphere), the information from the tracer should become decreasingly useful as one has to rely more heavily on the model results. This is both because the diffusion of air along the acetylene path (obstructions, elevation changes, etc.) may not be the same, but also because a Gaussian model is used to bias correct for differences in downwind distance between methane and tracer. Yet, the test which performed the worst (in terms of relative difference) for the combined approach was actually Configuration 1, with a collocated tracer, while it performed better for all of the three conditions which should have increased the uncertainty of incorporating the tracer information.

It makes sense that the uncertainty would be higher for the combined approach than the tracer for Configuration 1, and that the tracer generally was worse for the non-collocated experiments. However, the result for the combined approach is unexpected, both from the perspective of the theoretical basis for the combined approach, and the interpretation of the actual measurement results. Does the combined approach account for uncertainty of the tracer technique when used under ideal (collocated) vs. non-ideal conditions? Why where the combined results better (again, in terms of relative and absolute difference) when the tracer is used under less ideal conditions? More physical insight into how the combined approach works would be very helpful.

2. Organization: In general, there is unusually frequent referencing back and forth between Sections 2 and 3 and at one point even a “circular link” between section 2.5 and section 3.2 about the time lag, with neither quite containing the indicated information. Section 2 largely reviews the literature on these three techniques separate from the details of this paper, and could easily be condensed or even combined with section 3 since there are a lot of similarities between the two, and I think it would make it easier for the reader to understand specific aspects of the way the approach and experiment were conducted which is currently tedious going back and forth between the different sections and subsections.

3. Relationship to other literature: The effect of non-collocation, including distance of the measurement and magnitude of non-collocation, and the effect of being confined to the road which prevents non-orthogonal slices were discussed. These are all important issues for subsequent people using this method or similar experiments, and is also related to one of the conclusions [L676 - L679], so several recent papers would also be valuable to cite on these topics:

Goetz et al. 2015, Environ. Sci. Technol. (doi:10.1021/acs.est.5b00452) investigate issue where tracer not collocated and employs a correction based on the Gaussian plume

Roscioli et al. 2015, Atmos. Meas. Tech. (doi:10.5194/amt-8-2017-2015) also look at effect of the tracer and source not being collocated using the dual tracer framework to bracket possible errors, which is an alternative approach to what is given here and is likely applicable to similar types of sites

Albertson et al. 2016, Environ. Sci. Technol. (doi:10.1021/acs.est.5b05059) employs Bayesian framework and also specifically discusses and gives a correction for the issue of the road not being orthogonal to the wind direction also based on a Gaussian plume

formulation

4. Details missing that are important for understanding the approach/experiment:

- It is vague what information from the tracer is combined with the Gaussian, is it just the (rather coarse) adjustment of the stability class A-F, or more fine scale impact on the parameters (σy, σz, and/or wind)? It would be helpful to see how the parameters were actually affected during these experiments

- How the prior uncertainty is determined is not discussed, and the basis for model + observation uncertainty only briefly

- Both the method and results for the “multiple sources” inversion is brief other than that the plume is divided into five slices. Can a figure be added to illustrate how this works? Does using five slices mean up to five sources can be quantified? Can the approach resolve multiple sources when the plumes are overlapping, or only when they are basically non-overlapping?

5. Table 2: Two things stand out about Table 2, where results are given from the controlled release experiment.

First, why is there no row given for a Gaussian inversion, separate from combined approach? This is key information in evaluating the difference between the tracer release, Gaussian, and combined approaches.

Secondly, the uncertainty given for the combined approach is extremely small, several times smaller even than the controlled release uncertainty for Configurations 1, 2, and 3 which does not make sense. This is also noticeable in that for Configuration 2, the statistical chance of the uncertainty ranges 428 ± 7 and 464 ± 1 overlapping is 1-in-a-million, and for Configuration 1 the change of 382 ± 7 and 472 ± 2 overlapping essentially impossible. It is said all of the sources of error are considered, but this is clearly not the case - more thought should be given into how to derive a more representative uncertainty range for the combined approach.

6. Clarification on use of ‘transient’: The time dependence and transience of the problem is mentioned several times, but I do not think a clear explanation is given.

- In Figure 6 was the release not being run continuously? How was the time dependence of the prior derived?

- Additionally, the title says “Gaussian plume”, which is formulated for a continuous, averaged value, not a transient release. Clarification is needed on this issue.

Minor comments

L487-491 and L556-559: Both good points

L492-495: Sentence could be clarified

Table 2: including the bias due to mislocation as part of the “ +/- ” does not make sense since it is not a random error. Also what about the uncertainty of the bias, since presumably this is non-trivial?

Table 1: one of the columns says ‘wind direction (degree)’, when that column is given in letters rather than degrees

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