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Atmospheric Measurement Techniques Discussions

Interactive comment on "Flow rate and source reservoir identification from airborne chemical sampling of the uncontrolled Elgin platform gas release" *by* James D. Lee et al.

Anonymous Referee #2

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1 Overview:

Review of "*Flow rate and source reservoir identification from airborne chemical sampling of the uncontrolled Elgin platform gas release.*" by Lee *et al.*

Lee *et al.* present an analysis of the 2012 gas leak at the Elgin platform. The manuscript utilizes methane, NMHCs, and $\delta^{13}C_{CH_4}$ observations to determine the source of the leak (e.g., *"was it at the wellhead?"*, *"what formation is the leak coming from?"*). The authors claim to use two different methods to quantify the magnitude of the leak and argue that the methods compare well with each other. Based on the

abstract, I expected the authors to be comparing fundamentally different methods for quantifying the emissions. Instead the authors present an estimate of the source using a Gaussian plume and another estimate for a case when the plume has sufficiently mixed throughout the mixed layer. This is not necessarily problematic, but I don't think the methods used here can really be viewed as different. The manuscript is scientifically interesting but the description of the methods section is sloppy. I strongly suggest the authors go back through the derivations in Section 3 to ensure they are correct (e.g., Eq. 2 is clearly incorrect and the authors add/remove the "(x, y)" from equations seemingly at random between steps). Assuming this does not impact the actual analysis later on, the paper should ultimately be publishable because the findings are scientifically interesting. However, I suggest major revisions for the current manuscript.

2 Major comments:

2.1 "Two" methods for estimating the source

It seems that the authors are, in fact, just using one method for estimating the source. The authors are fitting a Gaussian plume based on their Eq. 1:

$$C(x, y, z) = \frac{q}{\pi \sigma_y \sigma_z U} \exp\left(-\frac{(y - y_0)^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2}\right).$$

The second method is simply a case where the plume has had time to sufficiently mix throughout the mixed layer, allowing them to neglect variations in the vertical and reduce Eq. 1 to (their Eq. 3):

$$C(x, y, z) = \frac{q}{\sqrt{2\pi}\sigma_y U H} \exp\left(-\frac{(y - y_0)^2}{2\sigma_y^2}\right).$$

As I mentioned above, this is not necessarily problematic but I do not think these should be presented as independent measures of the flow rate (unless I'm missing some fundamental difference). It gives the impression that multiple, independent methods for estimating the flow rate are in agreement. At best, it seems to indicate that the latter method (based on Ryerson *et al.* (2011)) is a valid simplification for when the plume is sufficiently mixed.

2.2 Presentation of the methods

The presentation of the methods is sloppy.

2.2.1 Equation 2

Eq. 2 is clearly incorrect. Eq. 1 is supposed to be a simplification of Eq. 2 where the plume has not reached the mixing height. However, the authors have written Eq. 2 as:

$$C(x,y,z) \;=\; \frac{q}{\pi\sigma_y\sigma_z U}\,\text{exp}\left(-\frac{(y-y_0)^2}{2\sigma_y^2}\left[\text{exp}\left(\frac{z^2}{2\sigma_z^2}\right)+\text{exp}\left(-\frac{(z+2H)^2}{2\sigma_z^2}\right)+\text{exp}\left(-\frac{(z-2H}{2\sigma_z^2}\right.\right.\right.$$

Taking $H \to \infty$ should return Eq. 1 but instead reduces to:

$$\begin{aligned} C(x,y,z) &= \frac{q}{\pi\sigma_y\sigma_z U}\,\text{exp}\left(-\frac{(y-y_0)^2}{2\sigma_y^2}\left[\text{exp}\left(\frac{z^2}{2\sigma_z^2}\right)+\text{exp}\left(-\frac{(z+2H)^2}{2\sigma_z^2}\right)+\text{exp}\left(-\frac{(z-2H}{2\sigma_z^2}\right.\right.\right. \\ &= \frac{q}{\pi\sigma_y\sigma_z U}\,\text{exp}\left(-\frac{(y-y_0)^2}{2\sigma_y^2}\left[\text{exp}\left(\frac{z^2}{2\sigma_z^2}\right)+\text{exp}\left(-\frac{(z+2\infty)^2}{2\sigma_z^2}\right)+\text{exp}\left(-\frac{(z-2\infty}{2\sigma_z^2}\right.\right.\right. \\ &= \frac{q}{\pi\sigma_y\sigma_z U}\,\text{exp}\left(-\frac{(y-y_0)^2}{2\sigma_y^2}\,\text{exp}\left(\frac{z^2}{2\sigma_z^2}\right)\right) \end{aligned}$$

I'm guessing the authors meant to write the following expression?

$$C(x,y,z) \;=\; \frac{q}{\pi\sigma_y\sigma_z U}\,\text{exp}\left(-\frac{(y-y_0)^2}{2\sigma_y^2}-\frac{z^2}{2\sigma_z^2}-\frac{(z+2H)^2}{2\sigma_z^2}-\frac{(z-2H)^2}{2\sigma_z^2}\right)$$

2.2.2 Nomenclature and the x, y, and z dependence

It was not initially clear where the x dependence is coming from in Eq. 1 as x does not appear anywhere on the RHS. σ_y and σ_z are both a function of x and I'm used to computing these based on the atmospheric stability class (where the dependence of σ on x is clear because there's an expression showing it). It wasn't clear to me – until much later – that the authors were recomputing the dispersion parameters based on each transect (*that is what you are doing, right?*).

Related to this point, Eq. 4-7 are confusing because the authors include (x), (x,y), and (x,z) for some of the equations but not others. For example, C_0 has the (x) dependence in Eq. 5 but not Eq. 4 or when it is defined in Eq. 6. Is this the same C_0 in all of these cases? It would greatly help if the authors were consistent in their nomenclature (especially given the potential errors in the derivation of the earlier expressions. . .).

Additionally, the authors introduce an undefined U' in Eq. 6 and an undefined H' in Eq. 9, what are these variables? Are the primes typos?

3 Minor comments:

3.1 What about the reflection at the ground in Eq. 1 (and subsequent equations)?

I thought Gaussian plumes that included a vertical dependence typically included an imaginary source below the ground plane. This is because a plume cannot spread realistically in the vertical and will, instead, be reflected at the ground (imagine a cone that is sliced through the middle, that bottom half is reflected back up). This is why their Eq. 2 has those additional terms for a case where the plume has restricted mixing in the vertical. This would result in the dropping of the 1/2 factor in the z term in their Eq. 1:

$$C(x, y, z) = \frac{q}{\pi \sigma_y \sigma_z U} \exp\left(-\frac{(y - y_0)^2}{2\sigma_y^2} - \frac{(z - z_0)^2}{2\sigma_z^2} \underbrace{-\frac{(z + z_0)^2}{2\sigma_z^2}}_{\text{ground reflection}} \right),$$

for $z_0 = 0$ this would reduce to:

$$C(x, y, z) = \frac{q}{\pi \sigma_y \sigma_z U} \exp\left(-\frac{(y - y_0)^2}{2\sigma_y^2} - \frac{z^2}{\sigma_z^2} \right).$$

It does not seem that ground reflection is accounted for? It seems that this would impact the derived emissions?

3.2 Figures

The figures could be better.

- **Fig. 1:** Could use more description. Presumably the red box in the left panel is the domain of the right panel? Is the black dot the location of the platform?
- **Fig. 2:** The units on Fig. 2 are non-intuitive. Could the authors convert this to ppb? It also seems weird to have a massive NOAA logo. I can't think of any other paper where I've seen a large logo included in their figure. It doesn't seem appropriate for a publication. . .
- **Fig. 3:** I couldn't find a description of what "Shearwater", "Jasmine", "Judy", or "Franklin" were (a search of the manuscript didn't seem to show them anywhere except for the legend in Fig. 3), what are they? Other platforms?
- **Fig. 4:** Pretty hard to see what's going on in this figure, there's a lot of whitespace that's taken up by the legend (almost half of each panel is blank).

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