Review of revision 2 egusphere-2024-3161 “Evaluating the accuracy of downwind methods for quantifying point source emissions”, Mbua et al. (Reviewer Comments by E. Thoma and S. Ludwig)

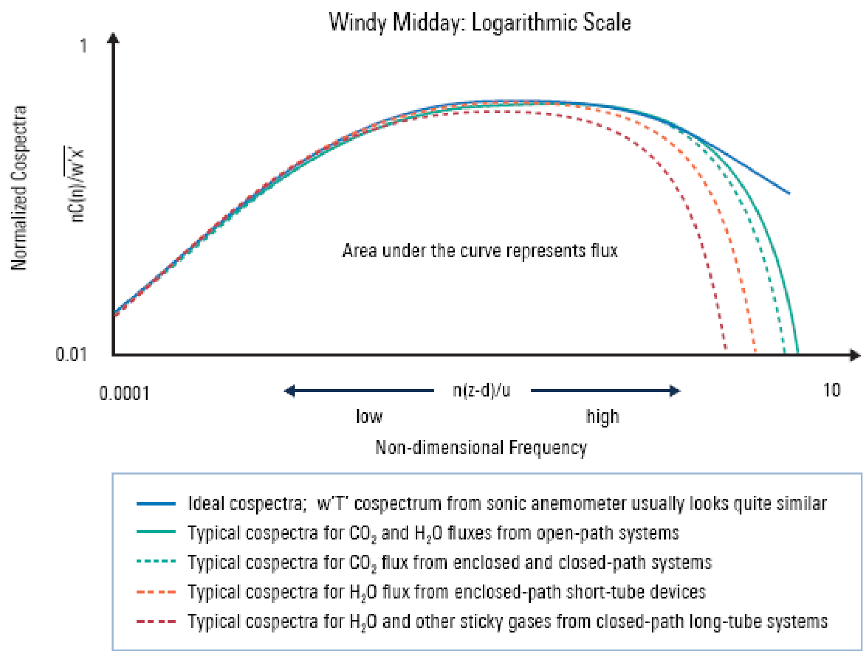
The authors were responsive to reviewer comments, offering a significantly revised manuscript with improved results visibility and supporting detail. The authors added critical QA/QC information on eddy covariance (EC) and decided to remove the aerodynamic flux gradient analysis. The authors modified the Gaussian plume inverse method (GPIM) approach, and backwards Lagrangian stochastic (bLs) analysis (based on WindTrax). Additional details were added for these emission calculation approaches.

There remains one major set of concerns with the revised manuscript relating to the EC analysis. As a first point, the EC results changed significantly from manuscript version 2. The reason for this is not clear and the authors are encouraged to double check the analysis and identify the root cause for this difference.

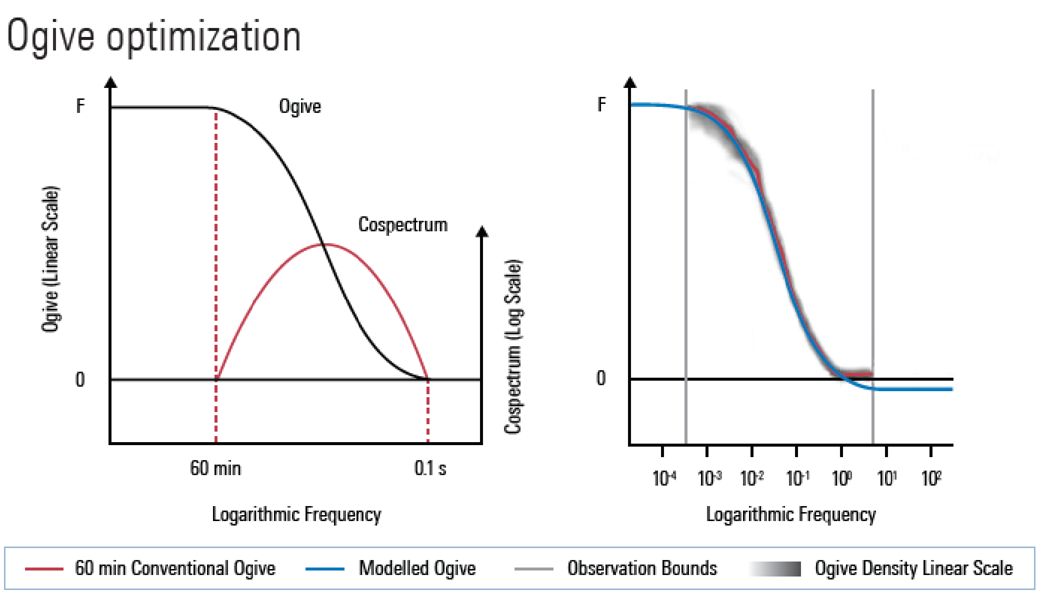
Assuming the current version of the EC analysis is final, the major concern centers on the strength of conclusions on the performance of the EC approach that can be drawn from this study. The authors have progressed their EC footprint and QA/QC analysis significantly from the original manuscript. However, new supporting information on ogive and cospectra departs significantly from expected form. These results indicate that EC analysis is likely not possible with these data and in fact illustrate “textbook examples” of issues illuminated by these QA/QC checks. This general issue with the EC analysis is further evidenced by the presence of large negative fluxes (which indicate issues in the EC data collection).

When examining both ogives and cospectra as a part of the QA/QC process, there is both a qualitative shape expected and quantitative metrics of slopes (for portions of the cospectra) and sigmoidal parameters (for the ogives) when good EC data are collected. Some deviations from the ideal form are expected. For example, especially in closed-path eddy covariance, there is often tube attenuation or increased lag that results in poorer performance with data at the highest frequencies. This is seen as a slightly steeper slope than ideal in the cospectra shape at high frequencies and is compensated for during the transfer function calculations when processing data into fluxes. However, even in closed-path EC or EC sampled at 5 Hz rather than 10 Hz, the cospectra still closely follow the ideal shape (especially when examining the cospectra of sonic temperature, which should not suffer any of the issues of the closed path gas sampling system), and slope changes at high frequencies are well modeled by the transfer functions. When the shape of cospectra deviate significantly from the ideal curve (as is the case here), it is an indication the data were not collected properly in a way that can be used for eddy covariance, with causes that include obstructions, mis-aligned time series, too slow system response time, among other issues with the instrumentation as seen here.

Similarly, the ogive analysis should follow a characteristic shape, a sigmoid curve plateauing at the y-axis at 1 and also at 0. The ogive analysis is used to indicate if an appropriate averaging interval was used, as those that are too short will not sufficiently plateau at 1. Furthermore, those ogives which do not follow a sigmoid shape at all indicate issues in data collection. Even accounting for the log-scale y-axis in the authors’ ogive figures, they do not follow an acceptable shape, and all ogives here would indicate issues leading to removing the data during QA/QC. I am including examples of the appropriate expected shapes of cospectra and ogives as described in the textbook “Eddy Covariance Method” by George Burba, section 5.1 “Quality Control of Eddy Covariance Flux Data”. This chapter provides several examples of how the shapes of cospectra can be used to diagnose issues with the instrumentation and data collection (such as is the case here) that invalidate the EC method.



From the book “Eddy Covariance Method” by George Burba, section 5.1 Quality Control of EC data; Cospectra Analysis. This figure depicts both the ideal cospectra and expected slope deviations at high frequencies for certain gases and systems.



From the book “Eddy Covariance Method” by George Burba, section 5.1 Quality Control of EC data; Ogive Optimization. This figure depicts the expected ogive shape for observations at a site with an optimized averaging interval of 60-minutes.

The authors now acknowledge the limitations in design of the EC data acquisition system for this study and attempt caveat in numerous places. They also point to non-stationarity in the data as part of the issue with the EC measurement.

However, if the EC results are deemed invalid, then these caveats are insufficient and conclusions around EC performance are not supported. The authors should either remove the EC analysis or suitably modify description to further clarify the severity of the issues for the reader. With little further work, the authors may choose to take this opportunity to illustrate some basic aspects of QA/QC assessment of EC data for this application. The information would be beneficial to the oil and gas/leak detection community (that largely consists of non-EC experts) and would assist future efforts to assess EC for this application.

Here is one example of unsupported conclusions from the abstract.

Ln 17 "*Generally, the closed-path EC system used in this study proved generally unreliable and largely underestimated emissions, primarily due to non-stationarity and study limitations associated with using a non-standard setup. In comparison, the Gaussian Plume Inverse Method (GPIM) consistently outperformed the EC system for both single-release and multi-release single-point emissions.*"

This is an inappropriate indictment of the EC methodology. If your primary QA/QC data indicate that the attempt at the application of the EC method was not successful (for whatever reason), then it is not possible to draw this conclusion. If the EC analysis is to remain in this manuscript, the description needs to be recast as an attempt at EC that failed. This would render the presented comparisons to other methods invalid. The issues with the method application were detected and reasons for these issues are presented here as lessons learned. Future attempts at exploring EC for this application will benefit from the information in this paper.