Supplement of Atmos. Meas. Tech., 19, 4459–4475, 2026
https://doi.org/10.5194/amt-19-4459-2026-supplement


Atmospheric Measurement Techniques
Open Access

*Supplement of*

# Fugitive natural gas emissions in York, United Kingdom: updating the parameters of existing algorithms to be based on instrumental limitations

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## S1. Controlled release experiment additional information

| Release no. | Release description | $CH_4$ release rate L min$^{-1}$ | $C_2H_6$ release rate L min$^{-1}$ | $NH_3$ release rate L min$^{-1}$ |
|---|---|---|---|---|
| 1 | Ring, ground height | $70.48 \pm 1.36$ | $3.50 \pm 0.23$ | 0.00 |
| 2 | Ring, ground height | $50.52 \pm 1.16$ | $6.01 \pm 0.24$ | 0.00 |
| 3 | Ring, ground height | $30.58 \pm 1.00$ | $2.00 \pm 0.04$ | 0.00 |
| 4 | Ring, ground height | $10.63 \pm 0.96$ | $0.51 \pm 0.02$ | 0.00 |
| 5 | Ring, ground height | $5.64 \pm 0.96$ | $5.00 \pm 0.23$ | 0.00 |
| 6 | Ring, ground height | $0.99 \pm 0.32$ | $0.10 \pm 0.02$ | 0.00 |
| 7 | Ring, ground height | $30.60 \pm 1.00$ | $2.00 \pm 0.03$ | 0.00 |
| 8 | Ring, ground height | $0.99 \pm 0.32$ | $0.10 \pm 0.02$ | 0.00 |
| 9 | Ring, ground height | $0.49 \pm 0.30$ | $0.20 \pm 0.02$ | 0.00 |
| 10 | Ring, ground height | $0.20 \pm 0.30$ | $0.03 \pm 0.02$ | 0.00 |
| 11 | Ring, 1 m height | $70.46 \pm 1.40$ | $3.53 \pm 0.23$ | 0.00 |
| 12 | Ring, 1 m height | $50.51 \pm 1.16$ | $6.01 \pm 0.24$ | 0.00 |
| 13 | Ring, 1 m height | $30.56 \pm 1.01$ | $2.03 \pm 0.23$ | 0.00 |
| 14 | Ring, 1 m height | $10.61 \pm 0.96$ | $0.51 \pm 0.02$ | 0.00 |
| 15 | Ring, 1 m height | $5.62 \pm 0.95$ | $5.02 \pm 0.23$ | 0.00 |
| 16 | Ring, 1 m height | $5.61 \pm 0.96$ | $5.02 \pm 0.23$ | 0.00 |
| 17 | Ring, 1 m height | $0.99 \pm 0.32$ | $0.11 \pm 0.02$ | 0.00 |
| 18 | Ring, 1 m height | $0.49 \pm 0.30$ | $0.21 \pm 0.02$ | 0.00 |
| 19 | Ring, 1 m height | $0.20 \pm 0.30$ | $0.03 \pm 0.02$ | 0.00 |
| 20 | Linear vertical, ground to 3 m elevation | $50.49 \pm 1.16$ | 0.00 | 0.00 |
| 21 | Linear vertical, ground to 3 m elevation | $30.54 \pm 1.01$ | 0.00 | $3.33 \pm 0.10$ |
| 22 | Linear vertical, ground to 3 m elevation | $30.58 \pm 1.01$ | $2.99 \pm 0.06$ | $3.34 \pm 0.10$ |
| 23 | Linear vertical, ground to 3 m elevation | $50.49 \pm 1.16$ | $5.02 \pm 0.23$ | $5.60 \pm 0.17$ |
| 24 | Linear vertical, ground to 3 m elevation | $40.51 \pm 1.07$ | 0.00 | 0.00 |
| 25 | Linear vertical, ground to 3 m elevation | $20.56 \pm 0.97$ | 0.00 | 0.00 |
| 26 | Point, 1 m elevation | $70.45 \pm 1.40$ | $5.03 \pm 0.23$ | 0.00 |
| 27 | Point, 1 m elevation | $50.50 \pm 1.16$ | $5.03 \pm 0.23$ | 0.00 |
| 28 | Point, 1 m elevation | $30.55 \pm 1.01$ | $5.03 \pm 0.23$ | 0.00 |
| 29 | Point, 1 m elevation | $10.60 \pm 0.96$ | $5.03 \pm 0.23$ | 0.00 |
| 30 | Point, 1 m elevation | $5.62 \pm 0.95$ | $5.03 \pm 0.23$ | 0.00 |
| 31 | Point, 1 m elevation | $0.99 \pm 0.32$ | $5.03 \pm 0.23$ | 0.00 |
| 32 | Point, 1 m elevation | $0.10 \pm 0.30$ | $5.03 \pm 0.23$ | 0.00 |
| 33 | Point, 1 m elevation | $2.99 \pm 0.53$ | $5.03 \pm 0.23$ | 0.00 |
| 34 | Point, 1 m elevation | $0.50 \pm 0.30$ | $5.03 \pm 0.23$ | 0.00 |
| 35 | Point, 1 m elevation | $30.55 \pm 1.01$ | $5.03 \pm 0.23$ | 0.00 |
| 36 | Point, 1 m elevation | $30.55 \pm 1.01$ | $5.03 \pm 0.23$ | 0.00 |
| 37 | Point, 1 m elevation | $10.60 \pm 0.96$ | $5.03 \pm 0.23$ | 0.00 |
| 38 | Linear vertical, ground to 3 m elevation | $10.63 \pm 0.96$ | $2.50 \pm 0.05$ | $1.07 \pm 0.03$ |
| 39 | Linear vertical, ground to 3 m elevation | $30.58 \pm 1.01$ | $2.99 \pm 0.06$ | $3.34 \pm 0.10$ |
| 40 | Linear vertical, ground to 3 m elevation | $55.52 \pm 1.21$ | $5.02 \pm 0.23$ | $5.60 \pm 0.17$ |
| 41 | Multi point $CH_4$ & $NH_3$ at 9.5 m elevation, $C_2H_6$ at 1 m elevation | $70.48 \pm 1.40$ | $7.01 \pm 0.24$ | $7.87 \pm 0.24$ |

***Table S1:*** *Details of releases during controlled release experiments.*

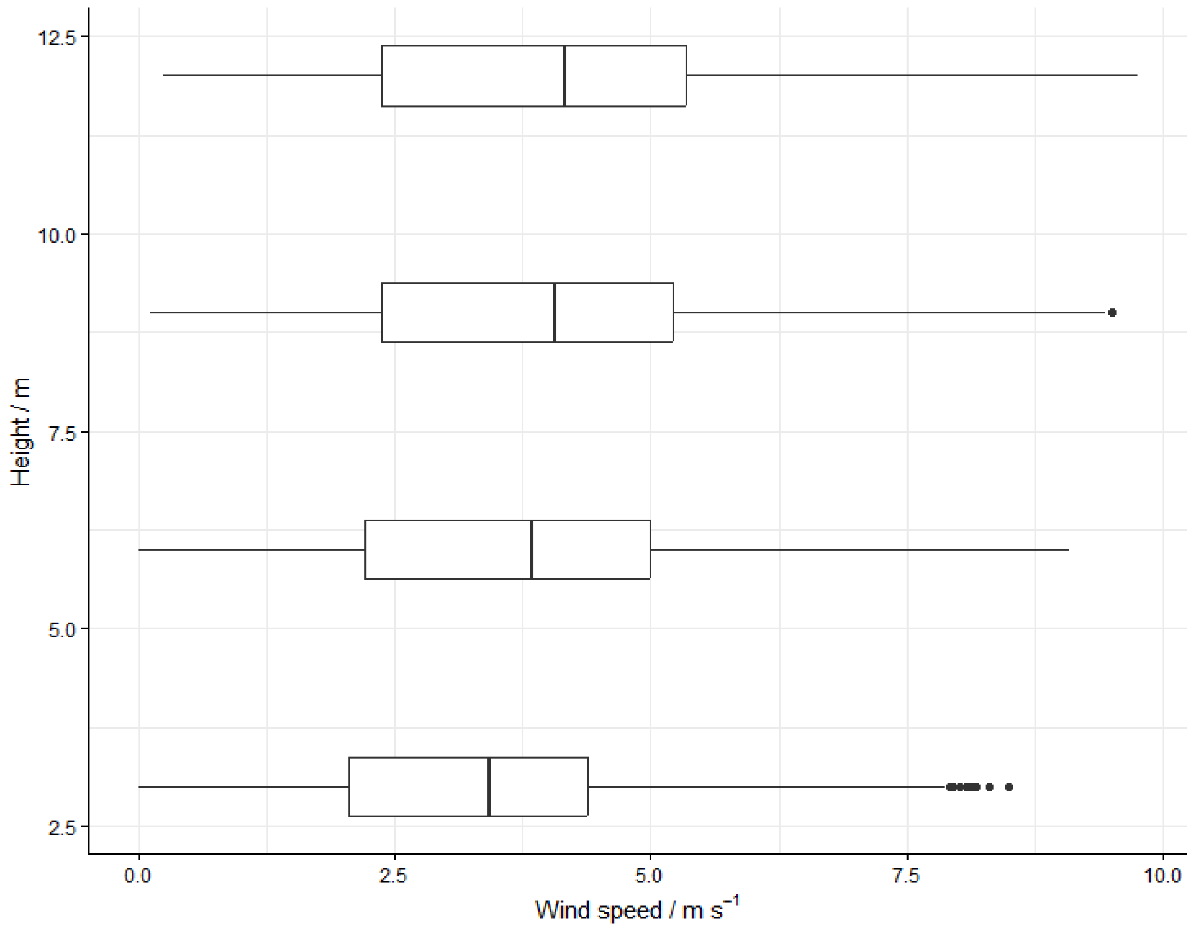


***Figure S1:*** *Wind speeds measured across duration of controlled release experiment.*

**S2. Controlled release $C_2H_6$ to $CH_4$ time lag plots**

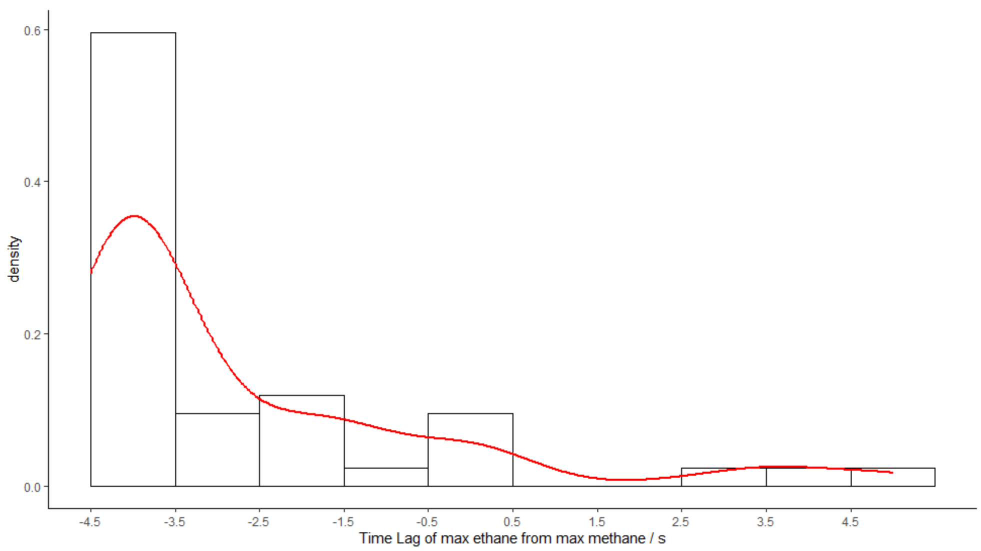


***Figure S2:*** *Density plot of time lag of the maximum ethane measurement from the maximum methane measurement.*

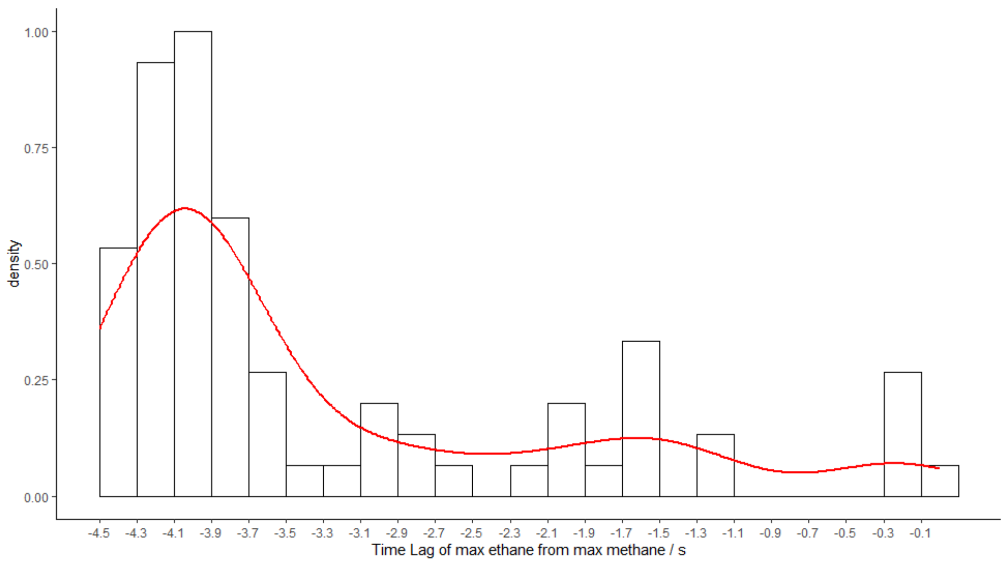


***Figure S3:*** *Density plot of time lag of the maximum ethane measurement from the maximum methane measurement (Only including ethane measurements that precede the methane)*

**S3. Controlled release**

To demonstrate the variability expected in utilising an algorithmic method for determining emission flux estimates, we run two simple emission scenario experiments utilising the Graz Lagrangian Model (GRAL), a Lagrangian particle dispersion model to simulate approximations of the open field controlled release and the conditions that may be more akin to those experienced during the driving surveys.

The first scenario is a model environment replication of the Bedford controlled release experiment, with flat topography and no obstructions. Emission location was a single point source, with wind fields and emission rate matched with data from a single test from the controlled release.

Under the idealised conditions in GRAL, it can be seen that the cross-sectional area of the modelled plume is expected to decrease by approximately 60 % depending upon whether the plume is intersected at 8 m (the closest distance from plume centre to release) to 30 m (a generalised maximal distance expected for a roadside plume to be intersected). In comparison with using a peak maxima as opposed to cross-sectional area, the peak maxima value decreases by 82 % in the model over the same distance difference. This adds to the growing guidance as to why using an area metric is considerably more informative than using a peak maxima.

However, when comparing the same metrics using real measured data, as opposed to the model, it becomes clear that the simplification of the plume at close distances from release is not completely realistically modelled. The real-world dispersion of the plume appears to be less than the model predicts, leading to a smaller difference in cross-sectional area of the plume than expected with increasing distance from the plume. A relative difference of only 25 % in cross-sectional area between 8 m and 30 m sample distance implies that this methodology should not be unduly influenced by distance to the emission source.

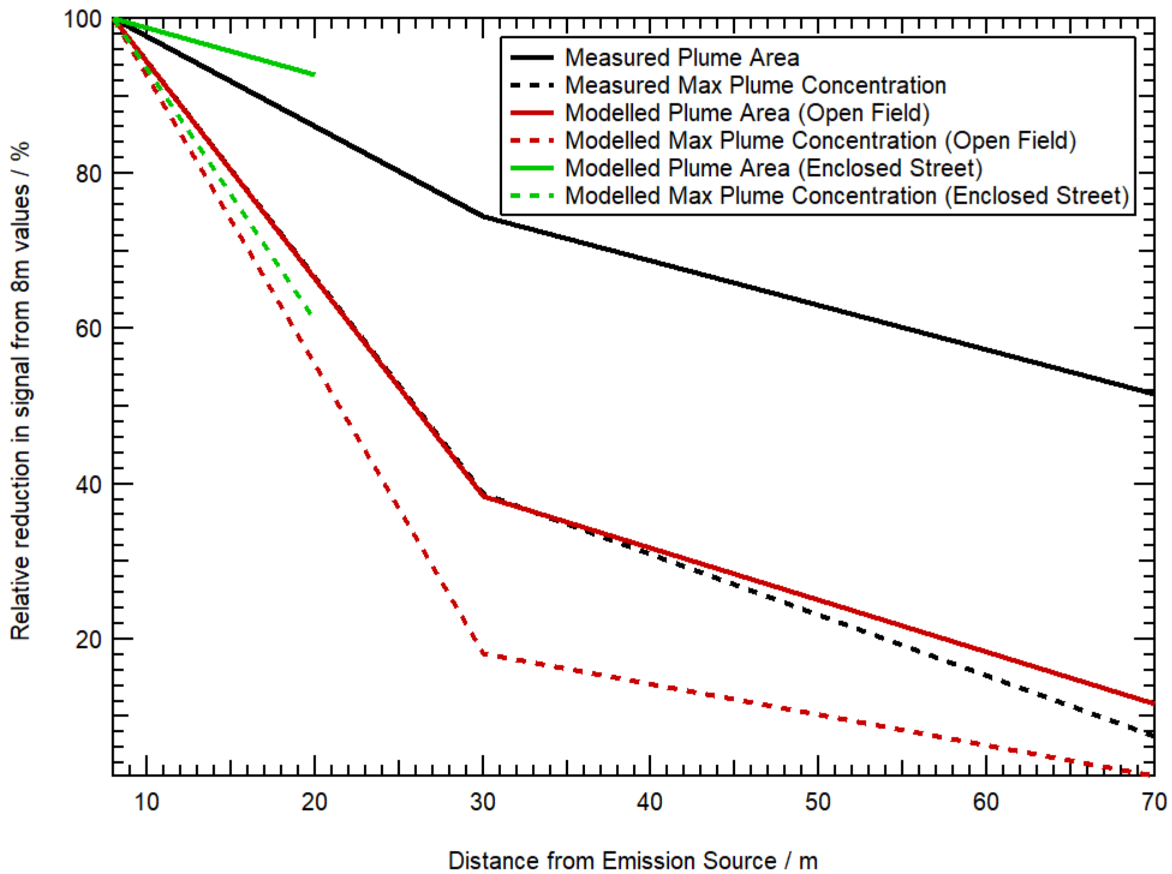


*Figure S4. Modelled and measured plume areas (and max plume concentrations for comparisons) for Bedford controlled release (Measured), Open Field (Model) and Enclosed Street (Model). The results show how quickly the plume metrics decrease with increasing distance from plume emission source.*

Further to this model scenario, it has been postulated that this method may struggle in urban areas due to the complex impact of canyoning and shadowing due to buildings and other obstacles to airflow. To help contextualise this concern, we have modelled a second scenario where buildings have been added to line the Bedford controlled release scenario to create a simulation of a heavily built-up road with 6 m tall buildings continuously lining each side of the road. This is the most extreme urban situation in comparison to the open field scenario. The distance between buildings is 25 m, modelled on the major urban through roads in York (e.g. Lawrence St).

The same release rates and wind conditions were applied as in scenario 1, with the results shown as the green lines in ***Figure S4***. There are no measurements to compare in this situation, but we can hypothesise based on the differences between model and measurements in Scenario 1. The model measurements are made at 8 m and 20 m from the release point with an assumption that 20 m is a reasonable maximal distance from a roadside emission point to interception and 8 m to match with the distances used in Scenario 1. Due to the effect of the buildings deflecting the emissions and preventing direct flow, the difference between 8 m and 20 m sampling is considerably reduced in the model, with relative difference of only 8 % in plume cross-sectional area. Given the comparison between model and measurement from the open field scenario, we could anticipate that the real-world measurements may show even smaller relative differences in plume cross-sectional area.