Mobile methane measurement in UK cities – partitioning sources and comparing spectroscopic analysers

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Royal Holloway's MIGGAS (Mobile Integrated Greenhouse Gas Analysis System)

- Toyota RAV4 hybrid AWD vehicle with rooftop inlets
- set up to locate and quantify methane emissions, and to identify the source type
- 3D sonic anemometer (10 Hz)
- Bag sampling for lab analysis of methane $\delta^{13}C$ by isotope ratio mass spectrometry

Instrument	Species measured	Measurement frequency (Hz)	Flow rate (L/m)	Cavity volume (mL)
Picarro G2301	CH_4, CO_2, H_2O	0.3	<0.4	35
Picarro G2311-f	CH_4, CO_2, H_2O	10	>5	35
Picarro G2210-i	CH_4, CO_2, H_2O, C_2H_6, $\delta^{13}C_{CH4}$	1	0.04	35
LGR UMEA	CH_4, C_2H_6, H_2O	1	1.7	400
LI-COR LI-7810	CH_4, CO_2, H_2O	1	0.25	6.41

Comparing Mobile Methane Spectroscopic Measurements

In recent years multiple mobile methane studies have been carried out to estimate emissions from fugitive gas leaks. Many use the peak height of the instrument with an empirical equation to estimate leak rates (e.g. using the algorithm of Weller et al., 2019).

In this study 5 different instruments measuring methane were simultaneously run for a mobile campaign around Surrey and Berkshire, SE England, with the aim of comparing the relative signals of the measurements. All instruments took in air from inlets on the roof of the vehicle. For the 5 instruments used here, methane peak heights tended to be highest with the 10 Hz Picarro G2311-f instrument, and lowest (but broader) with the 1 Hz Picarro G2210-i. If the same empirical equation were used for all instruments the gas leak rate may be overestimated or underestimated depending on the instrument used.

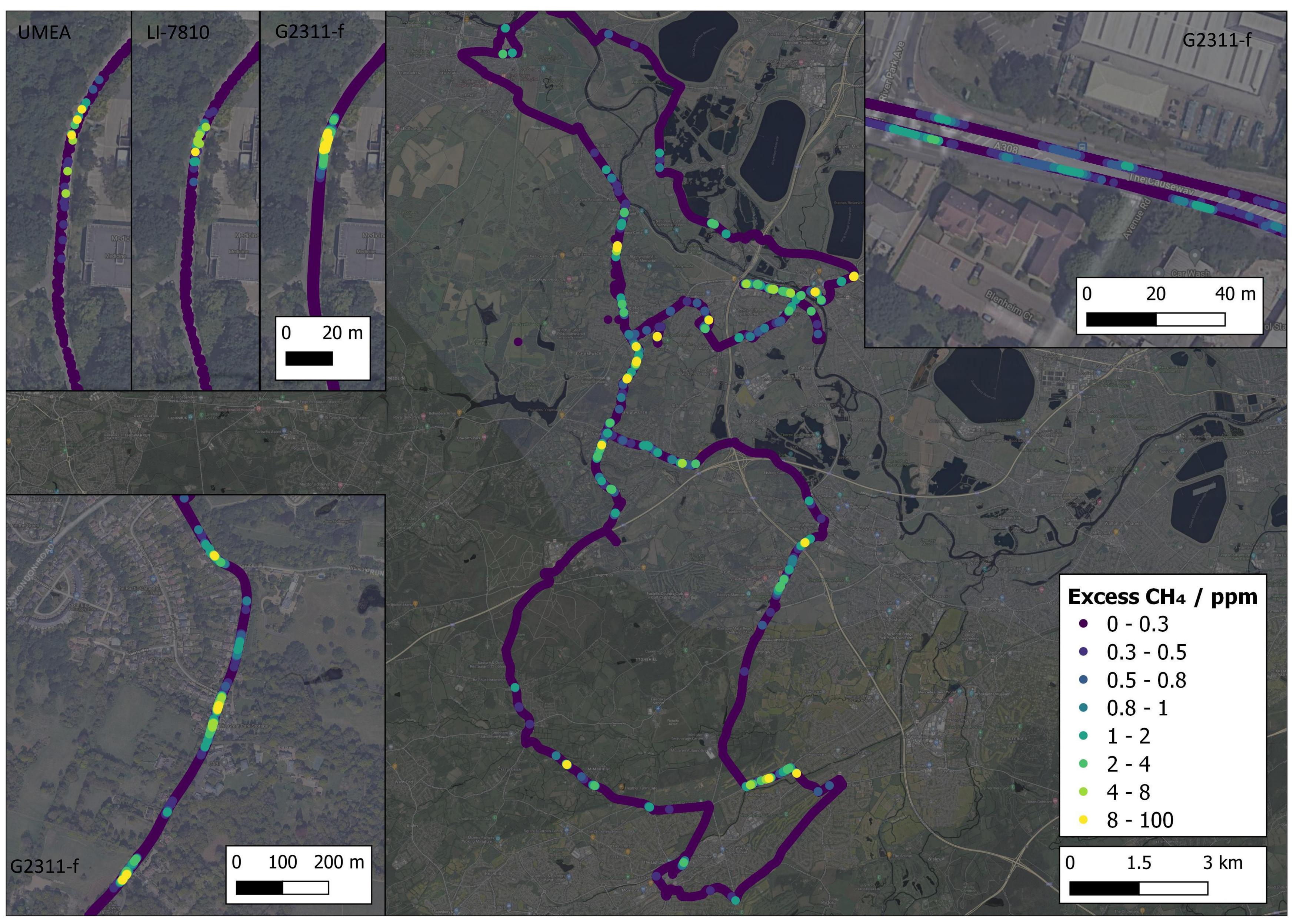

Figure 1. Map of methane over baseline for a mobile survey in SE England in July 2022. The inset images are zoomed in areas showing multiple gas leakage locations along some of the roads surveyed. The main map shows measurements using the LI-7810.

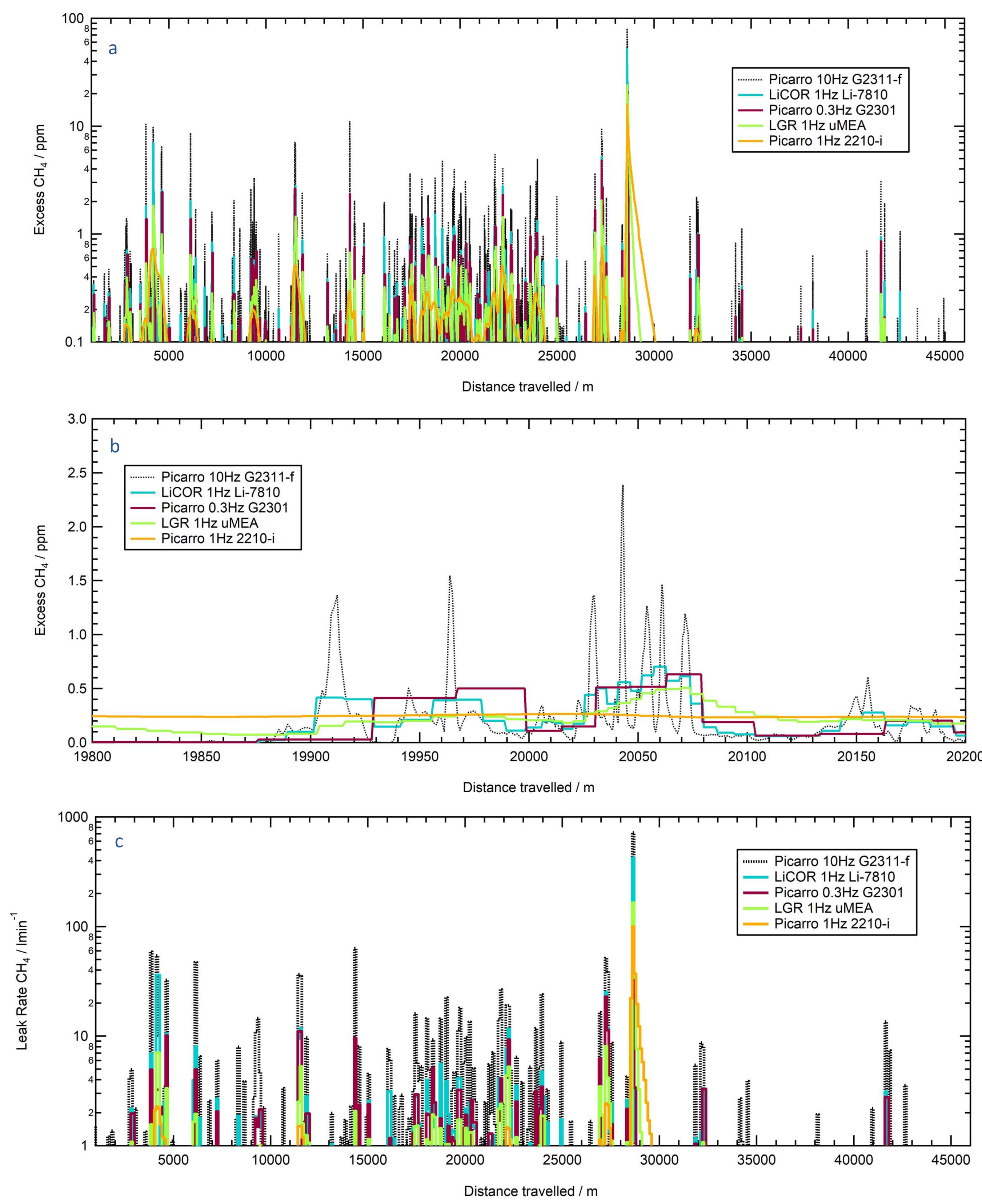

Figure 2.
a: Plots of the excess methane over baseline recorded during the 5 instrument mobile survey.
b: Identification of gas leaks along a 400m length of road. The high frequency and high flow rate of the G2311-f measurements allows separation of peaks less than 10m apart.
c: Estimate of the leak rate using the empirical equation derived in Weller et al. (2019). Note that this equation was derived for the Picarro G2301, and likely overestimates leaks if used with the Picarro G2311-f or LiCor LI-7810, and underestimates leak rate if used with the LGR UMEA or the Picarro G2210-i

UK city surveys – London and Glasgow

Mobile instruments have been deployed to measure and identify the source of fugitive methane emissions in UK cities including London and Glasgow. Different instruments were used for the studies: the Picarro G2301 and LGR UMEA in London and the LI-COR LI-7810 and LGR UMEA in Glasgow.

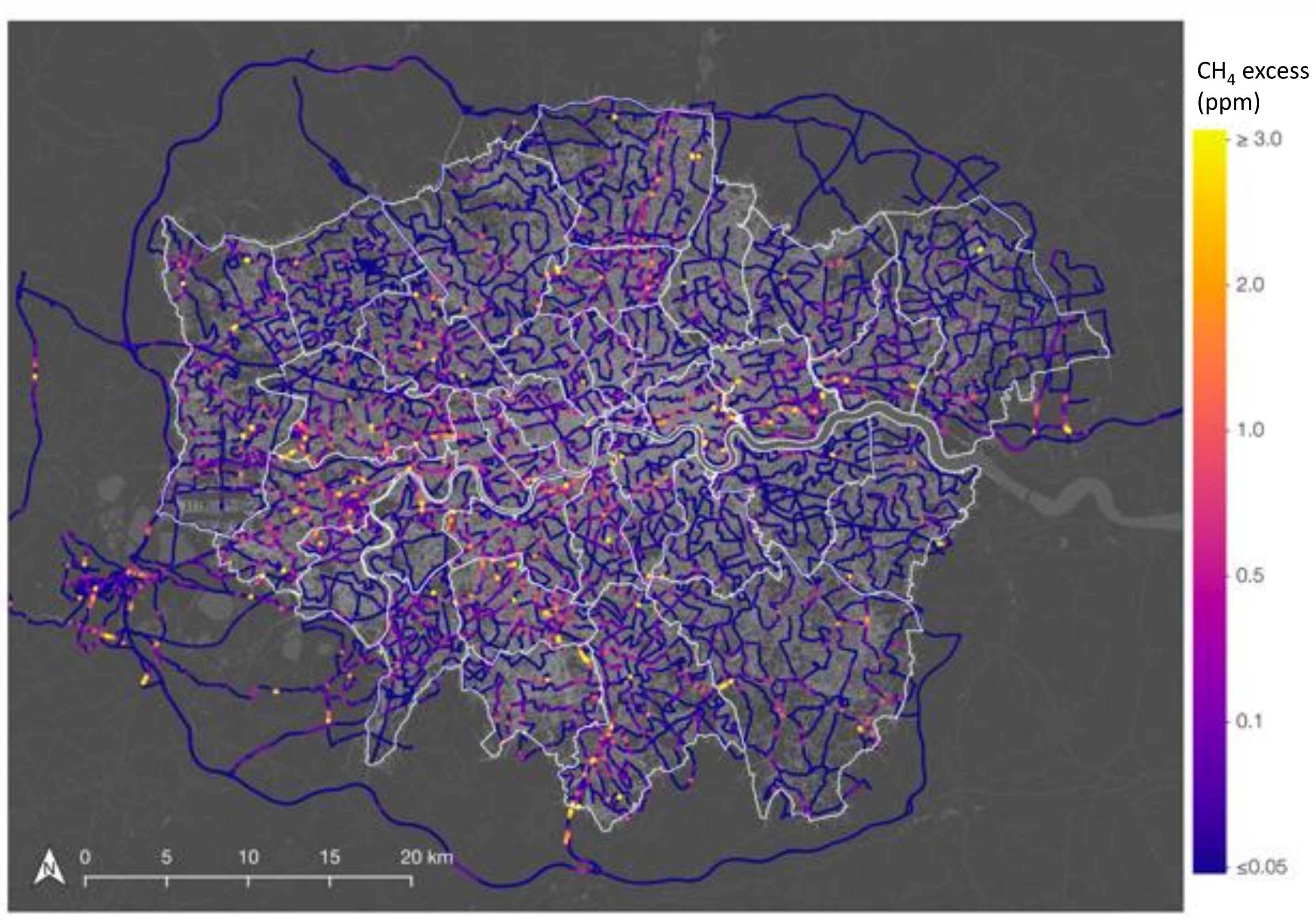

Figure 3. London methane. Map of survey driving tracks with calculated CH_4 excess above background mole fractions in ppm (measured using the Picarro G2301). London boundary and boroughs outlined in white. Fernandez et al., in prep.

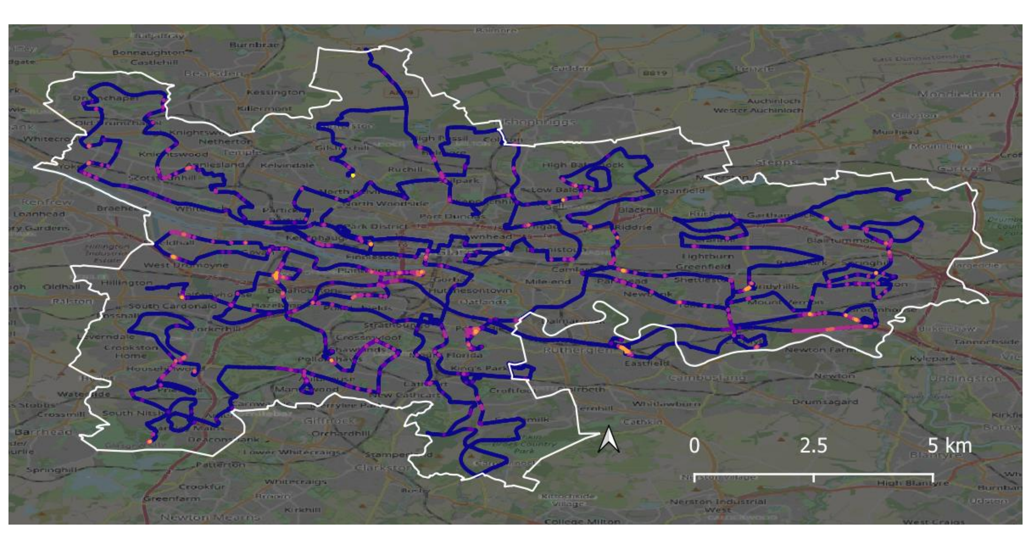

Figure 4. Glasgow methane. Map of survey driving tracks with calculated CH_4 excess above background mole fractions in ppm (measured using the LI-7810 in August 2021). Glasgow city boundary in white.

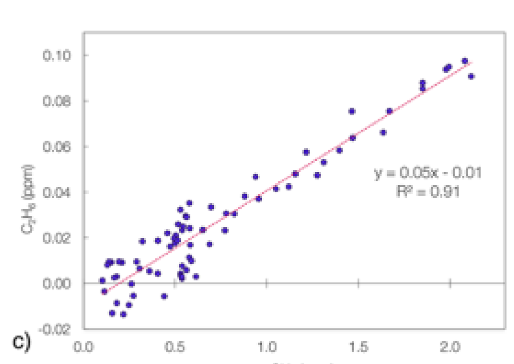

Figure 5. C_2H_6 against CH_4 for a methane peak identified close to Wembley Stadium. The C_2H_6:CH_4 ratio of 0.05 is typical of a leak from the gas distribution network (LGR UMEA measurements). Fernandez et al., in prep.

In the UK both the distinct $\delta^{13}C$ isotopic signature (~-40‰) and ethane:methane ratio (~0.05) of pipeline gas can be used to partition this from other methane sources, and the measurements show that emissions in both cities are dominated by gas pipeline leaks.

Conclusions

We have shown the variability in methane peak height in commonly used optical spectrometers when simultaneously carrying out mobile surveys. Empirical equations linking peak height to leak rate are useful, but care should be taken to ensure that the equation used is instrument specific when comparing emissions measured using different instruments.

In UK urban studies both ethane:methane ratio and $\delta^{13}C$ can be used to identify the source types. In both London and Glasgow most emissions identified in street surveys were from gas pipeline leaks.

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References
Weller ZD, Yang DK, von Fischer JC (2019) An open source algorithm to detect natural gas leaks from mobile methane survey data. PLoS ONE 14(2): e0212287. https://doi.org/10.1371/journal.pone.0212287

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