Variability of CH_4:CO_2 ratio at Science Park manholes

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Background

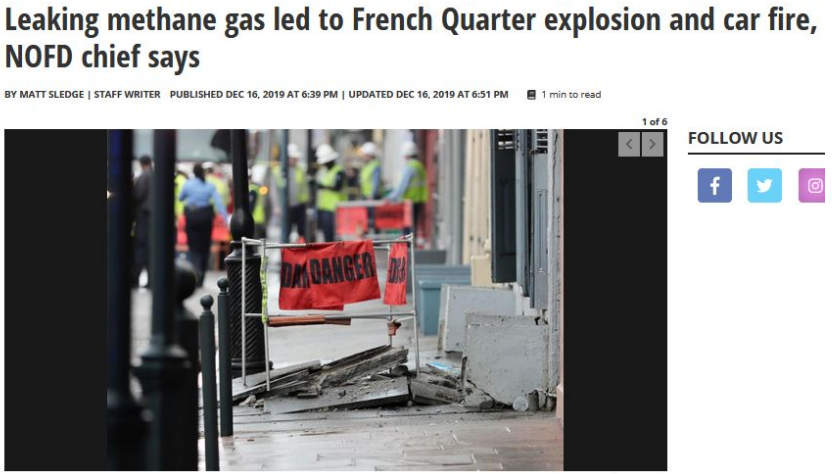
- **CH_4 is a strong greenhouse gas**
  - Direct and indirect effects
- **Sources of methane in urban areas**
  - Landfills
  - Wastewater
  - Leakage of natural gas pipeline
  - Sewer systems

Guisasola et al. (2007)

Background

- **Importance of measuring CH_4 in sewer systems**
  - Potential significant contribution to the greenhouse effect

    e.g. Gold Coast (Australia)
    Population: 540.000
    40–250 tCH4 annually
  - Health and safety risks (incidents of explosions)


Leaking methane gas led to French Quarter explosion and car fire, NOFD chief says

BY MATT SLEDGE | STAFF WRITER PUBLISHED DEC 16, 2019 AT 6:39 PM | UPDATED DEC 16, 2019 AT 6:51 PM 1 min to read

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Guisasola et al. (2007)

Background

- **Factors affecting methane production in sewer systems**
  - Hydraulic retention time (HRT)
  - Pipeline geometry (i.e. surface area to volume ratio, A/V)
  - Chemical oxygen demand (COD)
  - Atmospheric Temperature
  - Presence of Nitrogen-related compounds
  - pH level

Foley et al. (2009); Guisasola et al. (2008); Gutierrez et al. (2013)

Objectives

- Characterize possible methane sources from CH_4:CO_2 ratios
- Quantify CH_4 emissions from manholes
  - Quantify CH4 emissions of manholes failed because no accumulation was observed in the bucket

Methods: Instrument used

One cavity ring-down spectroscopy (CRDS) analyzer Picarro Inc. model G2301

- CO_2, CH_4, and H_2O concentrations
- Integration time of approximately 1s
- Frequency of 0.3 Hz for each species

Methods:

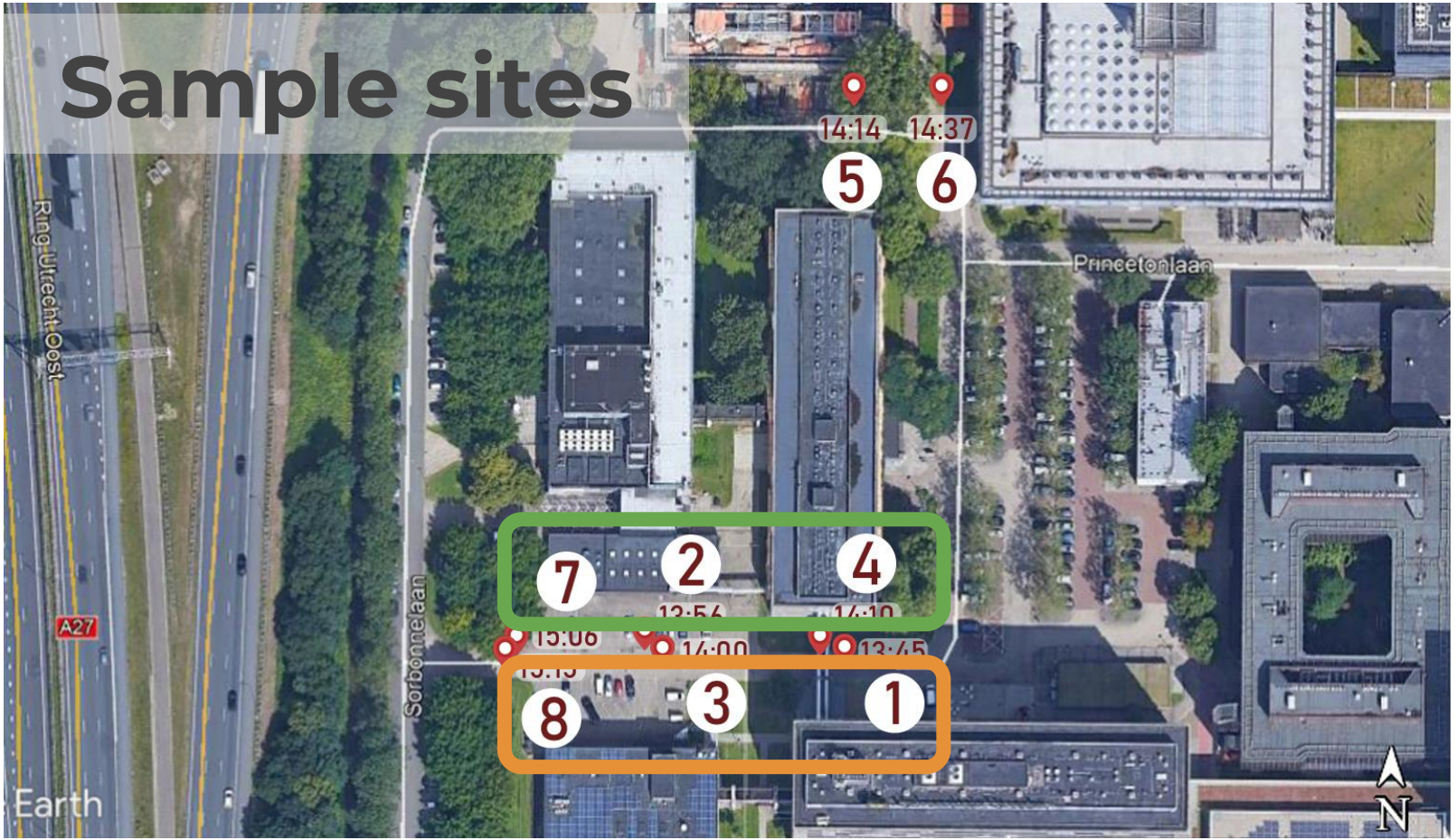
Mobile atmospheric measurements

- Installed on the back seat of a 2012 Volkswagen Transporter
- Measurements taken by directing a hose into the manhole opening
- Pumped into the CRDS machine

Additional info: Isotopic signatures

- Isotope-ratio mass spectrometry

Sample sites



Manhole info

- **4 November 2020:** Sampling date
- #1-4 and #6-8: Manholes
- #5: Storm drain

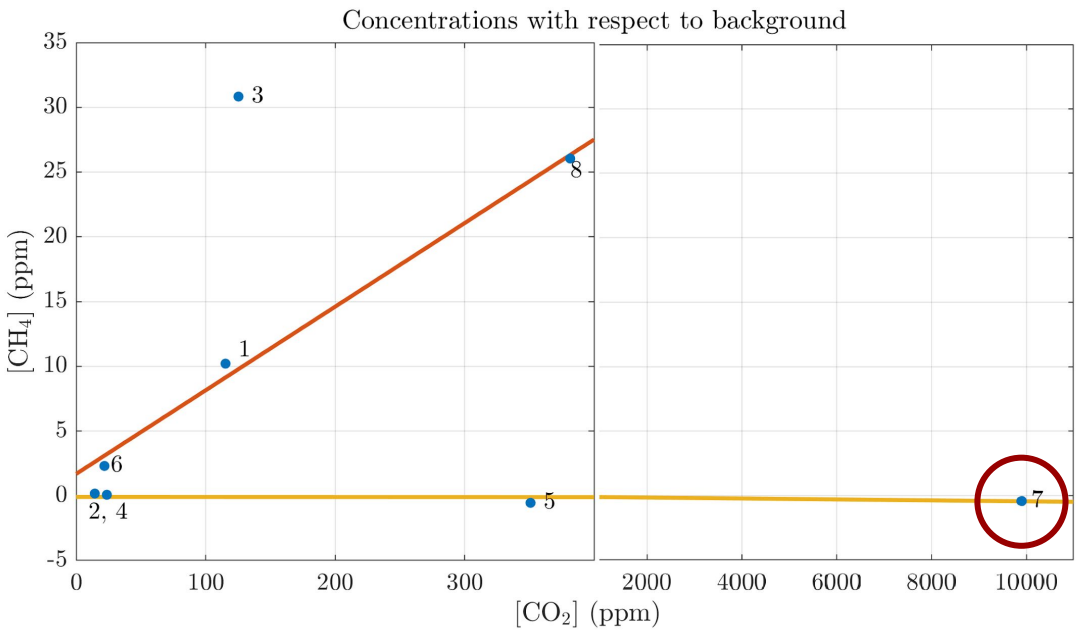
Isotope data

- #1, #3, and #5 have isotope measurements
- Background

CH_4 and CO_2 concentrations

	CO_2 (ppm)	CH_4 (ppm)
Background	420 ± 5.00	2.00 ± 0.01
1	536 ± 8.00	12.2 ± 2.70
2	435 ± 3.00	2.17 ± 0.01
3	546 ± 13.0	32.8 ± 2.40
4	444 ± 7.00	2.07 ± 0.01
5	771 ± 1.00	1.45
6	442 ± 13.0	4.30 ± 0.80
7	$103 \cdot 10^2 \pm 20.0$	1.56
8	802 ± 21.0	28.1 ± 0.90

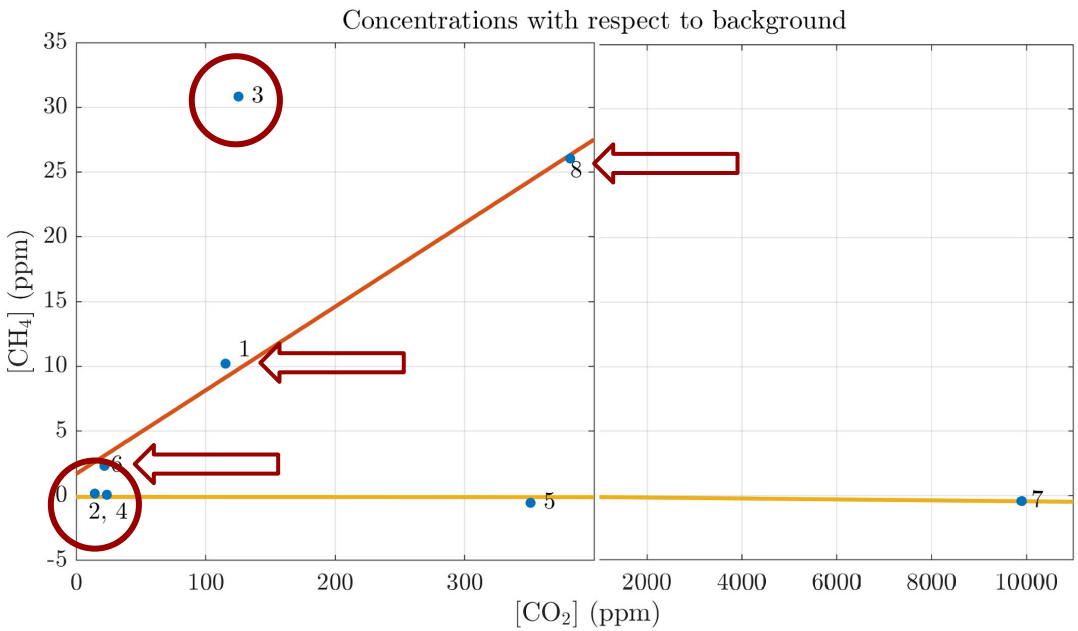
CO_2 and CH_4 concentrations above background



- #s 1, 6, 8:
  CH4:CO2 = 65 ppb/ppm
- #3:
  CH4:CO2 = 246 ppb/ppm *(corrected from presentation)*
- #s 2, 4, 5, 7:
  CH4:CO2 ≅ 0 ppb/ppm
  - Microorganisms can oxidize methane in sewers
  - Thought to be a weak sink

Liu et al. (2016)

CO_2 and CH_4 concentrations above background



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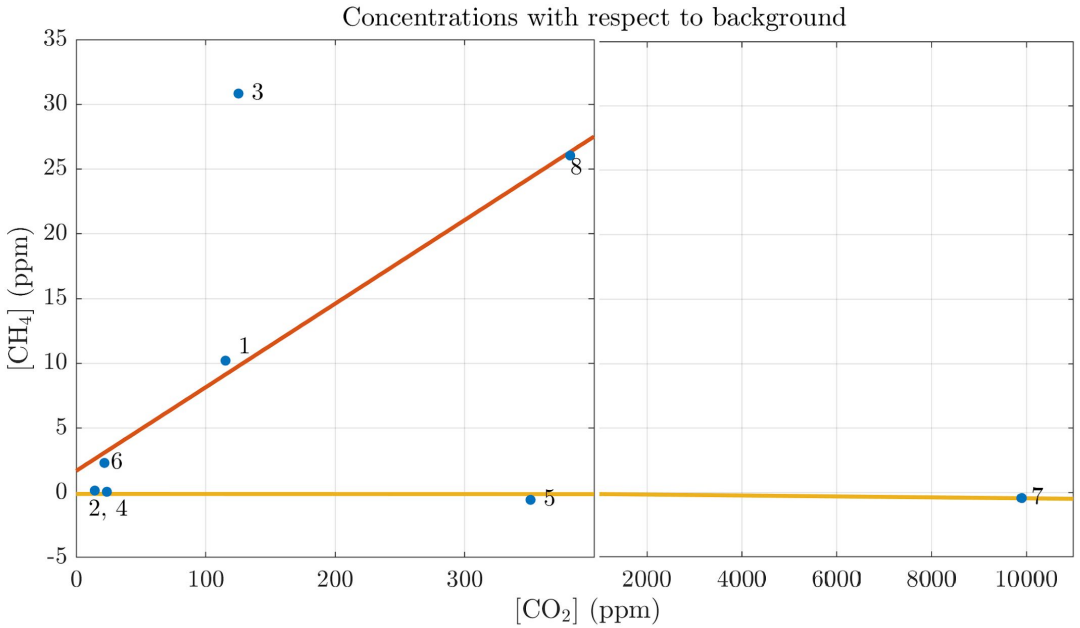
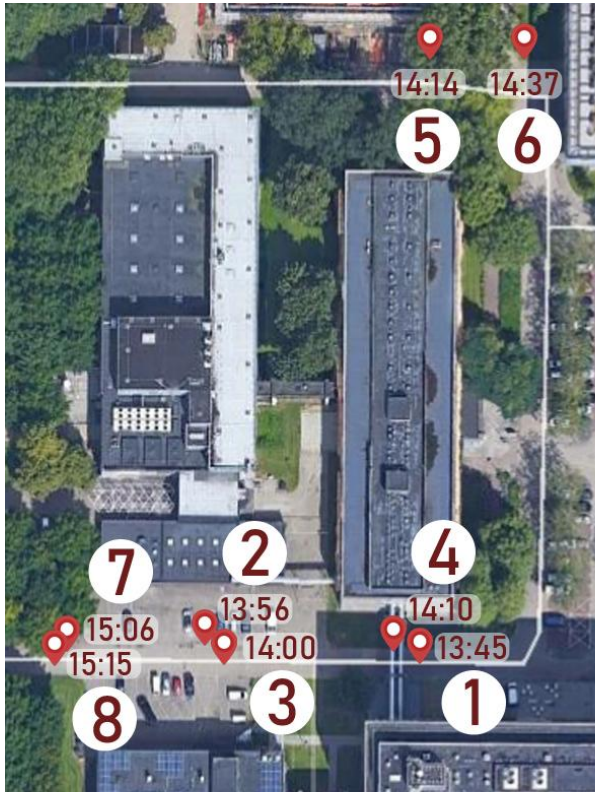
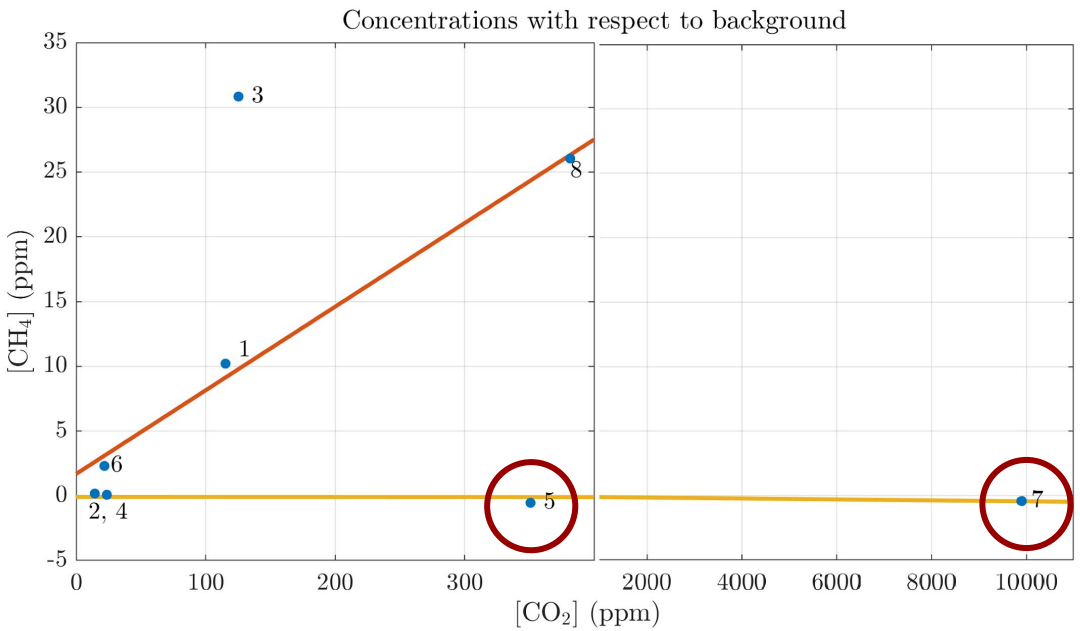




Liu et al. (2016)

CO_2 and CH_4 concentrations above background



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CH_4:CO_2 ratio -- This experiment vs. previous studies

Source	Combustion-related/ Open roads	Gas field
CH4:CO2 ratio (ppb/ppm)	Hamburg: 3.2±3.9 Maazallahi et al., 2020 Utrecht: 9.8 ±5.8 Maazallahi et al., 2020 4.6 x 10-2 Popa et al., 2014 0.41 Nam et al., 2004 0.3 Naus et al., 2018	13 Tait et al., 2013

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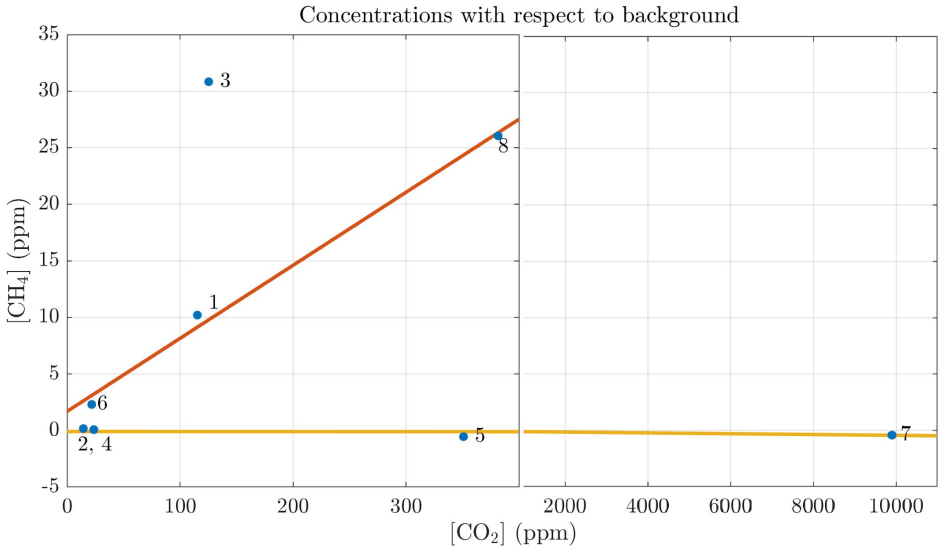
Isotope data

Manholes 1, 3, and 5

- δD = -264 ‰
- $\delta^{13}C$ = -51‰
- Indicates bacterial source (*Fries et al., 2018)*



Conclusions

- Within close proximity, manhole CH_4:CO_2 indicates different sources/“families”
  - Interesting for future work
- CH_4 concentrations can be significantly lower than background
- Emissions indicate microbial/biogenic sources

References

Fries A.E., Schifman L.A., Shuster W.D., Townsend-Small A.: Street-level emissions of methane and nitrous oxide from the wastewater collection system in Cincinnati, Ohio*, Environmental Pollution 236, 247-256, https://doi.org/10.1016/j.envpol.2018.01.076, 2018

Guisasola A., Sharmaa K.R., Kellera J., Yuana Z.:Development of a model for assessing methane formation in rising main sewers, Water Research 43, 2874-2884, https://doi.org/10.1016/j.watres.2009.03.040, 2009

Guisasola A., de Haas D., Keller J., Yuan Z.: Methane formation in sewer systems, WATER RESEARCH 42, 1421–1430, https://doi.org/10.1016/j.watres.2007.10.014, 2008

Liu Y., Ni B., Sharma K.R., Yuan Z.: Methane emission from sewers, Science of the Total Environment 524-525, 40-51, https://doi.org/10.1016/j.scitotenv.2015.04.029., 2016

Maazallahi H., Fernandez J. M., Menoud M., Zavala-Araiza D., Weller Z. D., Schwietzke S., von Fischer J.C., Denier van der Gon H., and Rockmann T.: Methane mapping, emission quantification, and attribution in two European cities: Utrecht (NL) and Hamburg (DE), Atmos. Chem. Phys., 20, 14717–14740, https://doi.org/10.5194/acp-20-14717-2020, 2020

Tait D.R., Santos I.R., Maher D.T.: Atmospheric radon, CO2, and CH4 dynamics in an Australian coal seam gas field, AGU Fall Meeting abstracts A53H-06, 2013