Methane Emission Source Attribution and Quantification for Munich Oktoberfest

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Oktoberfest Investigation 2018

(Chen et al. 2020)
Oktoberfest Investigation 2019

- Backpack measurements around and **inside** the festival premises
- Instrument: **LI-COR LI-7810 CH₄/CO₂ analyzer**
- Air sample **inside and outside** of the tents
  - Δethane/Δmethane ratio
  - Isotopes: δ¹³C, δD
- Computational fluid dynamics (CFD) simulation and Gaussian plume model for assessing emissions
Higher spikes and enhancements inside the festival area. Even higher concentration inside the tents.
ΔEthane/ΔMethane Ratios:

- Δethane/Δmethane ratio of the Munich gas network: 3.05 % (Sept. and Oct. 2019)
- Δethane/Δmethane ratios in tents: ~2.7%

→ ~90 % of the methane emissions in the tents are caused by leakage of natural gas
Isotopic Ratios: Clear Indication for Natural Gas

**δ13C vs. 1/CH₄ in ppm**

- Indoor: Red circles
- Outdoor: Blue circles
- Background: Green circles
- Subway: Black circles

Equation: $y = -5.36x - 45.45$

**δD vs. 1/CH₄ in ppm**

- Inside Tents: Red circles
- Festival Area: Blue circles
- Background: Green circles
- Subway: Black circles

Equation: $y = 192.10x - 188.60$

**δD vs. δ13C**

- Natural Gas
- Wetlands
- Biomass Burning
- Rice
- Ruminants
- Background
- Source (Keeling)
- Samples

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CFD Simulation (OpenFOAM)

Self-built 3D model of the Oktoberfest terrain

Meas. vs. Simulations (CFD and Gaussian plume)

High frequency components are better captured by CFD compared to Gaussian plume model
CFD Simulation Results – Outside and Inside Oktoberfest

→ CFD reproduces the spatial pattern inside and outside of Oktoberfest premises
Emission Number Comparison

2018

- During Oktoberfest: 6.7 ± 0.6 µg/(m²s)
- 1st week after Oktoberfest: 1.1 ± 0.3 µg/(m²s)

2019

- During Oktoberfest: 8.4 ± 0.5 µg/(m²s)
- 1st week after Oktoberfest: 2.8 ± 0.9 µg/(m²s)
Conclusion

- Oktoberfest is a notable methane source, although it is not included in the emission inventory.

- Oktoberfest methane emission flux is notable, ~10 times of that of Boston urban region (McKain et al. 2015).

- CFD simulations capture the spatial and temporal pattern of our concentration measurements.

- The emission is fossil fuel based. 90% of the emissions inside the tents come from natural gas.
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