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
Outside vs. Inside Oktoberfest vs. Tents Comparison

Higher spikes and enhancements inside the festival area. Even higher concentration inside the tents.

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**ΔEthane/ΔMethane Ratios:**

- Δethane/Δmethane ratio of the Munich gas network: 3.05% for Sept. and Oct. 2019 (according to Munich City Utilities)

- 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

\[ \delta^{13}C \]

y-intercept: -45.45

\[ \delta D \]

y-intercept: -188.6

\[ \delta D \text{ vs. } \delta^{13}C \]
CFD Simulation (OpenFOAM)

Self-built 3D model of the Oktoberfest terrain

→ 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: $6.7 \pm 0.6 \, \mu g/(m^2s)$
- 1st week after Oktoberfest: $1.1 \pm 0.3 \, \mu g/(m^2s)$

2019

- During Oktoberfest: $8.4 \pm 0.5 \, \mu g/(m^2s)$
- 1st week after Oktoberfest: $2.8 \pm 0.9 \, \mu g/(m^2s)$
Conclusion

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

- Oktoberfest methane emission flux is ~10 times of Boston urban region (McKain et al. 2015), ~20 times of Munich (TNO-MACC).

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

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