Methane Emission Source Attribution and Quantification for Munich Oktoberfest

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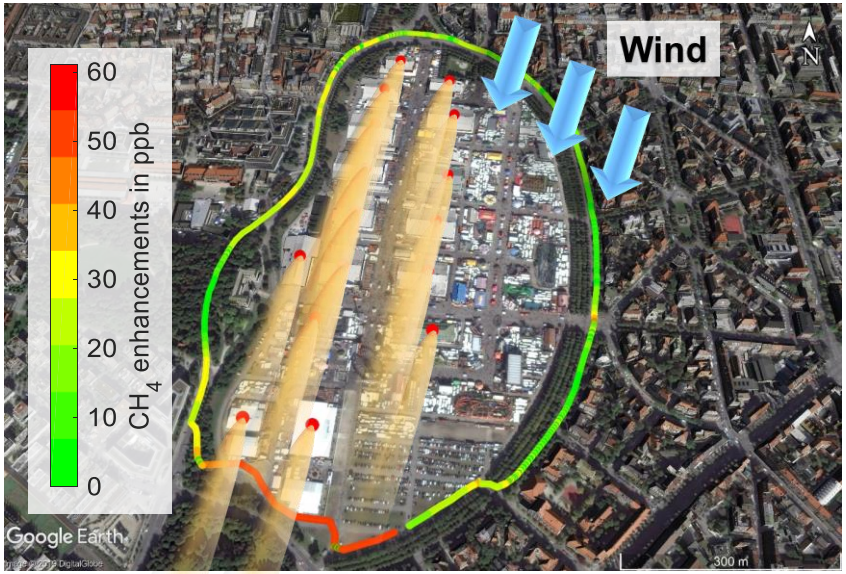
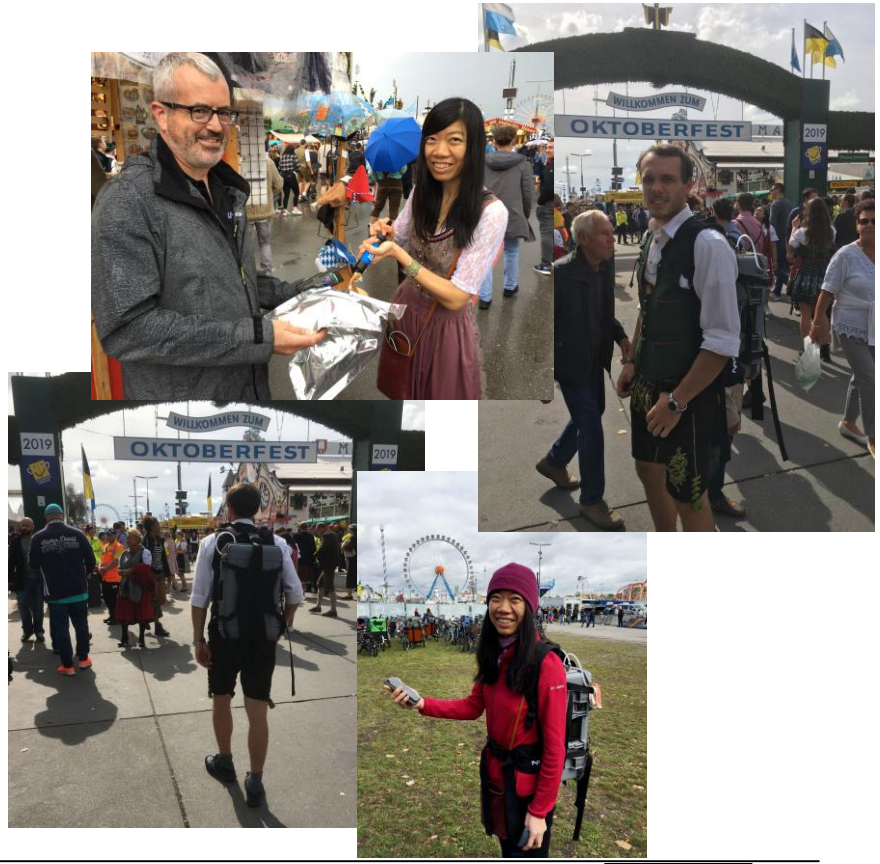
Oktoberfest Investigation 2018

(Chen et al. 2020)

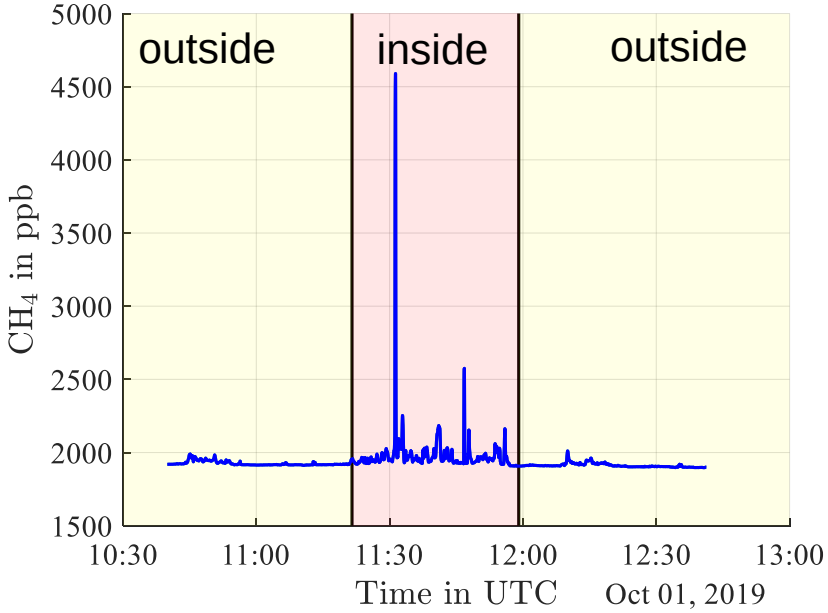


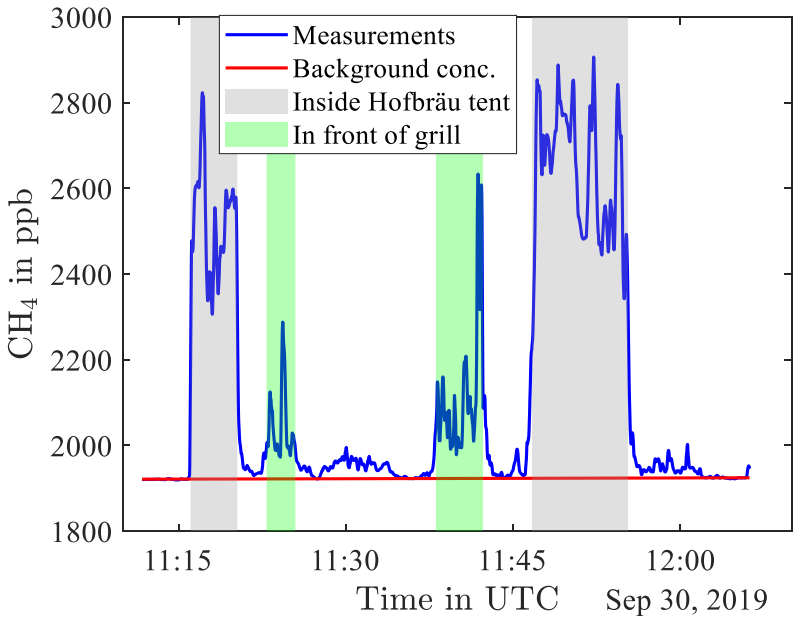
Oktoberfest Investigation 2019

- Backpack measurements around and **inside** the festival premises
- Instrument: ***LI-COR*** *LI-7810 CH_4/CO_2* 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



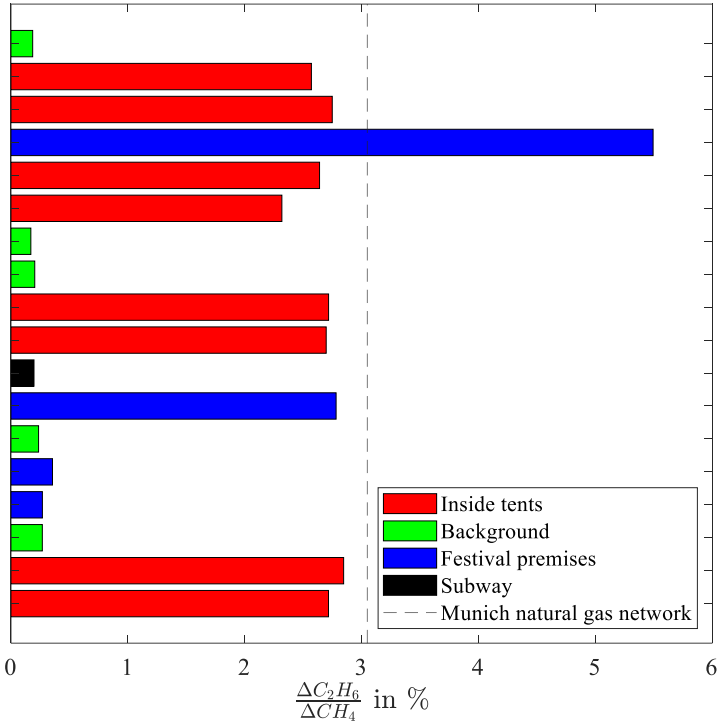
Outside vs. Inside Oktoberfest vs. Tents Comparison





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

ΔEthane/ΔMethane Ratios:

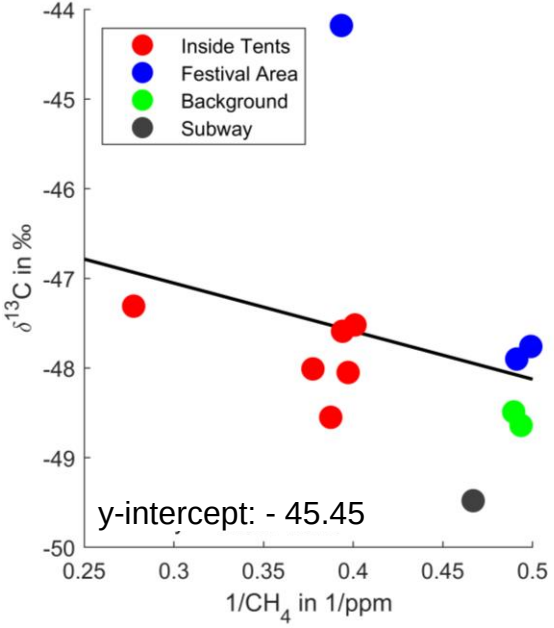


- Δethane/Δmethane ratio of the Munich gas network: 3.05 % for Sept. and Oct. 2019 (according to Munich City Utilities)
- Δethane/Δmethane ratios in tents: ~2.7%

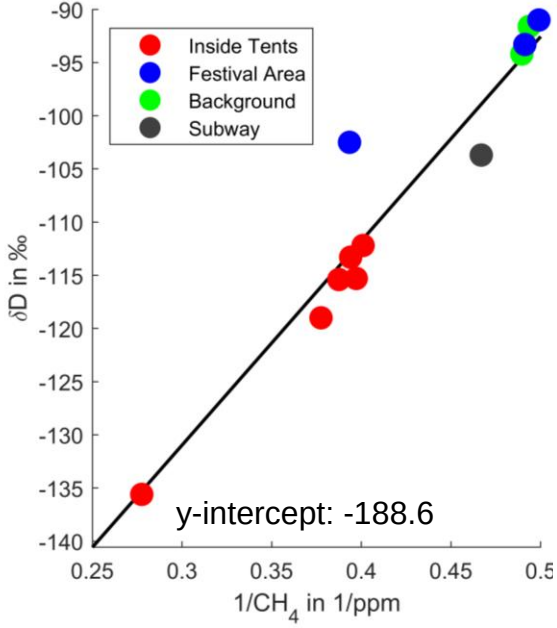
→ **~90 %** of the methane emissions in the tents are caused by leakage of **natural gas**

Isotopic Ratios: Clear Indication for Natural Gas

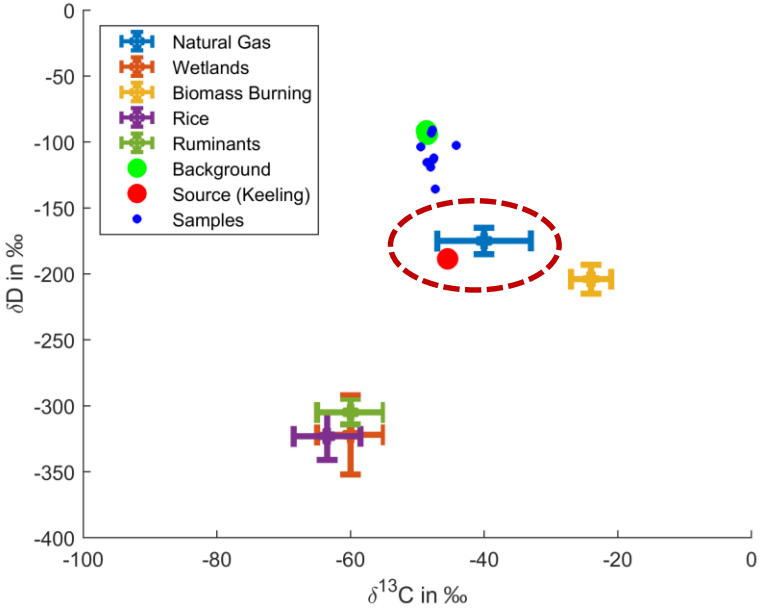
δ13C



δD

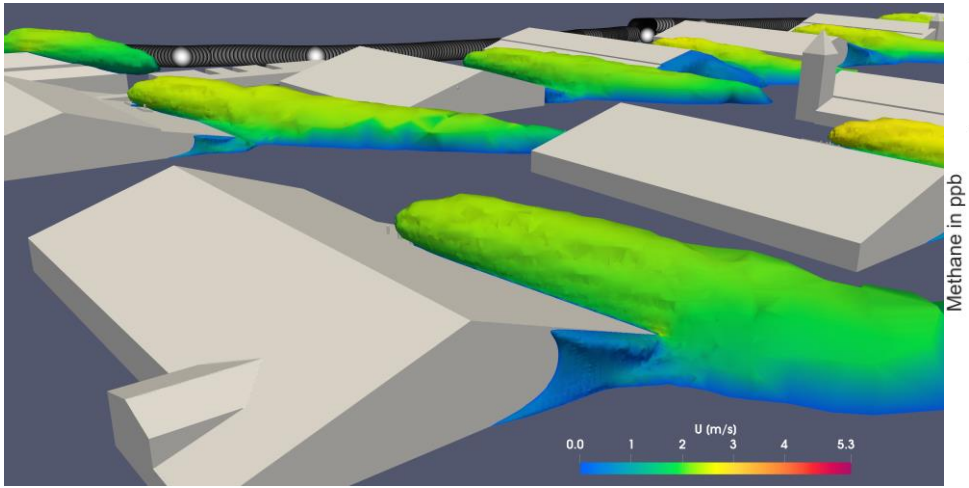


δD vs. δ13C

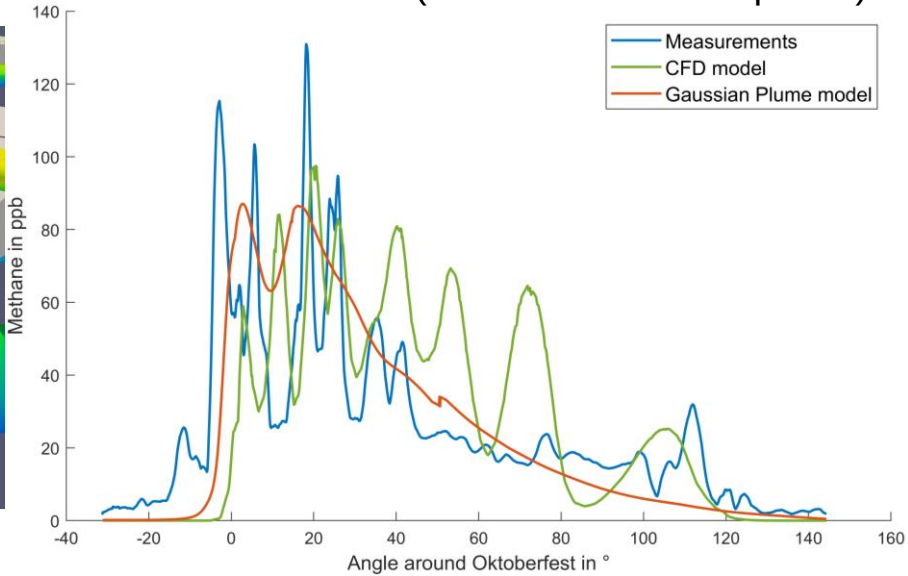


CFD Simulation (OpenFOAM)

Self-built 3D model of the Oktoberfest terrain



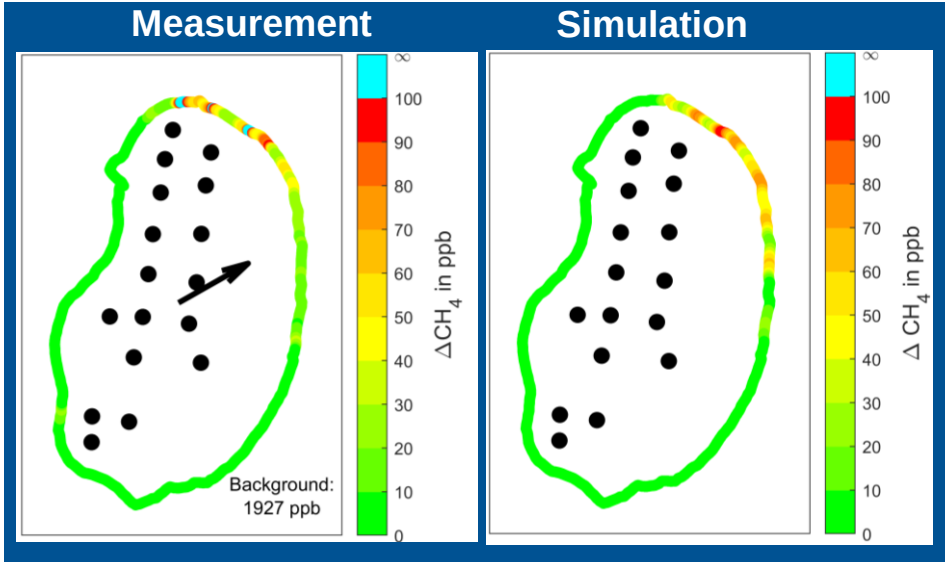
Meas. vs. Simulations (CFD and Gaussian plume)



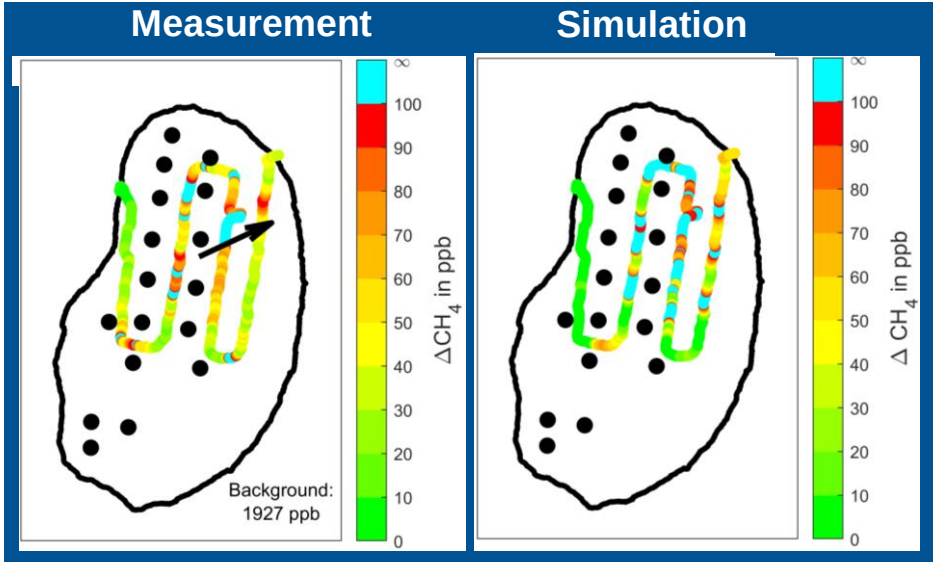
→ High frequency components are better captured by CFD compared to Gaussian plume model

CFD Simulation Results – Outside and Inside Oktoberfest

Outside



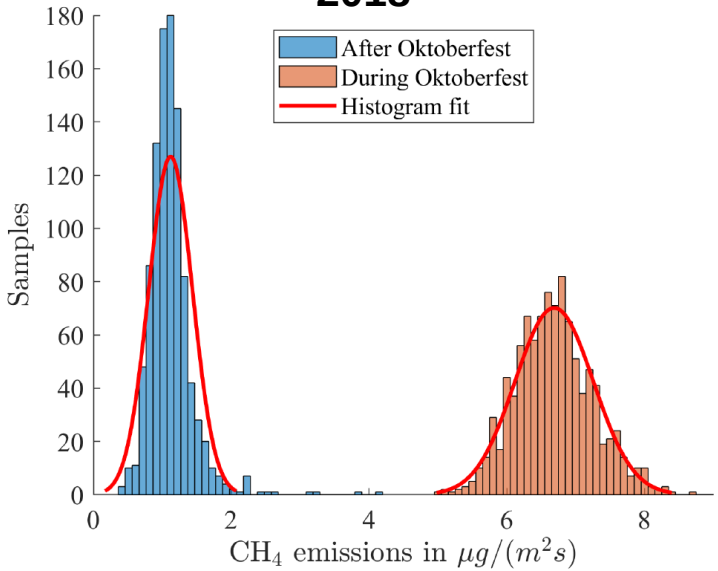
Inside



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

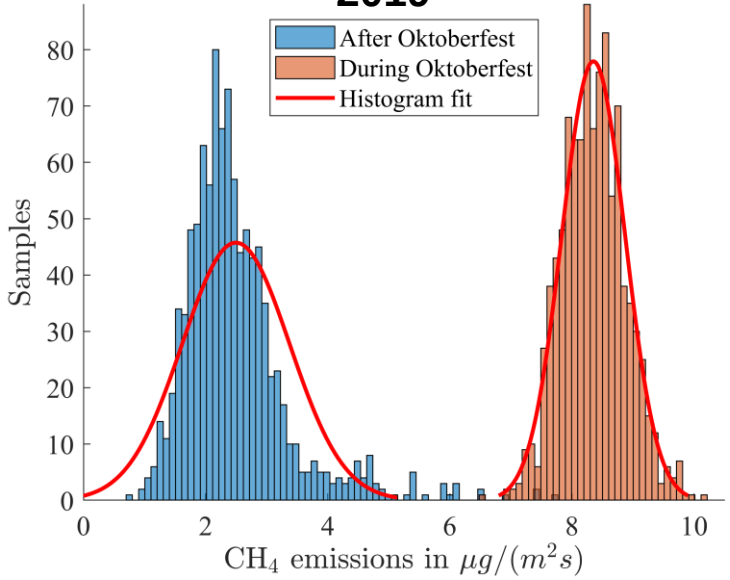
Emission Number Comparison

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 ~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

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Chen, J., Dietrich, F., Maazallahi, H., Forstmaier, A., Winkler, D., Hofmann, M. E. G., Denier van der Gon, H., and Röckmann, T.: *Methane emissions from the Munich Oktoberfest*, Atmos. Chem. Phys., 20, 3683–3696, https://doi.org/10.5194/acp-20-3683-2020, 2020

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