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Estimating local methane sources from drone-based laser spectrometer measurements by mass-balance method

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Methane from facility-scale sources (e.g. landfills and oil and gas production facilities) are prone to leakage giving rise to highly uncertain emission flux estimates. To assess the overall impact of these sources, quantification from a representative set of individual sources – from which bottom-up inventories are generated - is necessary. An attractive approach to quantify emissions from diffusive and leaky sources involves deploying an unmanned aerial vehicle (UAV) equipped with a methane sensor which allows complete mapping of the spatial and temporal variability of emission plumes within a short period of time.

Atmospheric methane concentrations were measured using a Quantum Cascade Laser Absorption Spectrometer (QCLAS) developed in-house. The spectrometer reaches in-flight precision of a few ppb at 1s time resolution, and its lightweight and compact footprint (~ 2.0 kg, ~ 15.0 x 45.0 x 25.0 cm) allows it to be mounted and flown on a commercial drone.

We quantify methane emission fluxes from local sources by applying the mass balance method using the drone-based QCLAS system. The drone was flown downwind of a given source perpendicular to the main wind direction at different altitudes above ground, while geostatistical interpolation (Kriging) of the measured methane molar fractions was performed to spatially fill the gaps. The interpolated concentrations were multiplied by the cross-sectional area and the mean stream-wise wind profile obtained from a 3D sonic anemometer to get an emission flux.

We report on the analysis of how well known emissions can be reproduced using this quantification setup based on controlled release experiments. Furthermore, we discuss the sensitivity of different measurement configurations, and provide recommendations for an optimal sampling and quantification strategy. We demonstrate the suitability and flexibility of the quantification method in investigating a wide range of facility-scale sources, which are not attainable with measurements from conventional ground-based sensors.