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Bird's-eye View of Localized Methane Emission Sources

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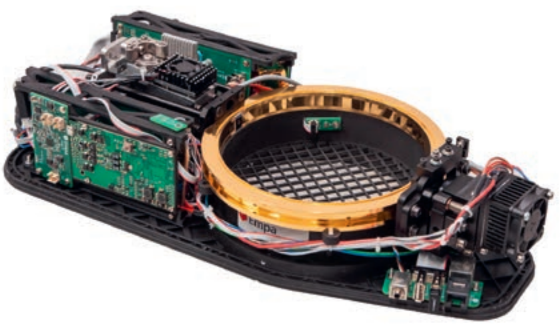
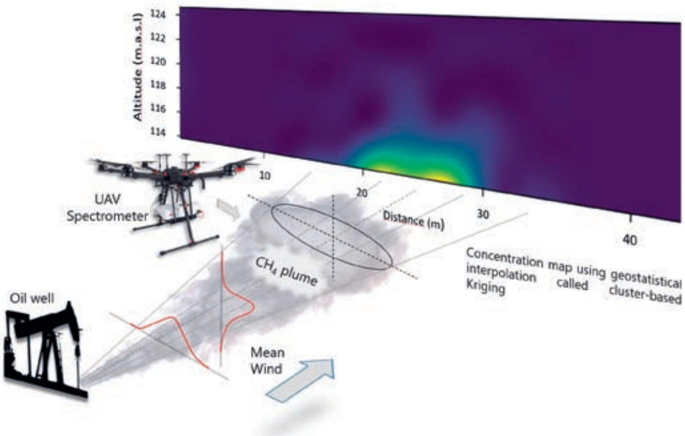
The increase of greenhouse gas emissions from anthropogenic activities and its negative impact on the Earth's climate is an urgent issue for our civilization. Beside the widely discussed carbon dioxide, methane (CH_4) represents the second most important anthropogenic greenhouse gas. Its relatively short lifetime in the atmosphere creates unique opportunities for effective mitigation of climate change, especially with short-term benefits. Detailed and accurate knowledge about its sources, spatial distribution, and temporal variation are, as yet, lacking, and the partitioning of CH_4 emissions by region and processes is currently not sufficiently constrained. To improve this situation, we developed laser-based sensing technologies that enable the tracking and identification of methane sources at local scale, regardless of terrain complexity. This is achieved by a dedicated lightweight and high-precision CH_4 sensor based on mid-infrared laser absorption spectroscopy. Using a quantum cascade laser as light source, a narrow spectral range around a specific absorption line of methane is rapidly scanned, while the transmitted signal is used to retrieve the atmospheric concentration. The instrument is lightweight enough to be carried by commercial drones, thus yielding in a fully autonomous and highly mobile analytical system.

For quantification of localized CH_4 emission sources, the mobile analyzer is combined with 3D sonic wind measurements, and the emission fluxes are estimated by mass balance. This approach is performed by flying the drone-integrated system through a vertical cross section, downwind of a given source, perpendicular to the main wind direction at several altitudes. A refined (cluster-based) Kriging framework was developed to spatially map individual CH_4 measurement points into the measurement plane, while taking into account the different spatial scales between background and enhanced methane values in the plume. Emission rates are derived by multiplying the CH_4 fields with a corresponding wind field, *i.e.* by taking the net difference between fluxes into and out of a volume containing the source.



Picture of the CH_4 laser spectrometer. The main parts are the quantum cascade laser, the segmented circular multipass cell, and a thermoelectrically cooled infrared detector.



Scheme of CH_4 emission source quantification using the mass balance approach.

We recently applied this method to support the ROmanian MEthane Emissions from Oil and gas (ROMEO) campaign, which quantified methane emissions from oil- and gas-production facilities in Romania using various techniques and approaches. Hundreds of facility scale observations were conducted to generate a robust quantification of individual sources, from which bottom-up estimates can then be derived.

In conclusion, mapping trace gas emission plumes using *in-situ* spectroscopic measurements from unmanned aerial vehicles (UAV) is an emerging and attractive possibility to quantify emissions from localized sources.

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Reference

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