Mobile monitoring of fugitive methane emissions from natural gas consumer industries

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Abstract

Natural gas is used as a feedstock for major industrial processes, such as ammonia and fertilizer production. However, fugitive methane emissions from many large-scale, point source industries could potentially pose an unquantified, new threat to climate change. This manuscript presents recent results from field measurements conducted downstream of several industrial plants using a specialized vehicle equipped with a fast-response methane sensor that circles around the targeted facility. These measurements along with the local meteorological data, a Bayesian approach is applied to probabilistically infer methane emission rates. Data from controlled release experiments are then used to validate the approach. With access via public roads, this mobile monitoring method is able to quickly assess the emission rate of facilities. This work is developing the capacity for efficient regional coverage of potential methane emission rates in support of leak detection and mitigation efforts.

Introduction

Natural gas is considered as a bridge fuel toward clean energy due to its potential low greenhouse gas (GHG) emissions compared with other fossil fuels [Albertson et al., 2015]. Natural gas is the largest source of anthropogenic methane (CH4), which is a more potent (28 times) GHG than CO2. Natural gas leaks could happen at any point along the path from production to end use, thus requiring a targeted approach to detect fugitive methane sources. The current work focuses on the quantification of fugitive methane emissions from oil and gas processing facilities. A recently developed mobile plume integration method [Albertson et al., 2015] is used to probabilistically infer leak rate from field measurements along with the local meteorological data. These data are then utilized to analyze the emission rate from the facility using the mobile approach.

Method validation with controlled release

Using a mobile OTM 31 collection approach, data were collected for a controlled release (CR) experiment conducted on May 15, 2010 in Durham, North Carolina where three passes were made. The point source release rate was controlled at 0.56 g/s. The passes do not start and end at the same location, which explains why the plumes in the figures below do not appear at the same distance along the transects.

An example of plume transect in the field

Here an example plume transect is plotted in Google Earth with the red bar indicates above-ambient methane concentrations. The vehicle traversed the plume of elevated CH4 concentrations multiple times. Finally, the vehicle was parked to obtain additional methane data. The methane concentrations in the figure below are used in the dispersion model along with the methane concentration measurements. Based on the mobile method, the PDF of leak rate can be estimated after each pass. It is shown that the posterior PDF peaks around the true release rates of 0.56 g/s, and the recursive updating leads to more accurate leak rate estimation and reduced uncertainty (a sharperness of the posterior) with increased sensor passes.

Sensitivity analysis

A sensitivity analysis of α, Z0, and Cs is performed here and only the posterior pdf of the final pass is plotted. In clear conditions, C0/Cf is most effective in controlling the shape of the posterior pdf comparing with Z0 and Cs. A small α/Cf indicates higher confidence thus help the inference converges faster with narrow pdf. Despite the different simulation results, the estimated emission rate is still around 250 gram/min.

Conclusion

Conclusively successful has been achieved using the mobile sensing approach for detecting fugitive methane emissions in subarctic and rural environments. More analytical work is needed to be done to quantify α and underlying meteorological and obstacle conditions.

References


An example of plume transect in the field

Here an example plume transect is plotted in Google Earth with the red bar indicates above-ambient CH4 concentration. At that time, the wind was blowing from northeast, which also suggests fugitive emissions from the facility. We found a total of 12 plume transects from this facility during a span of 50 minutes, during which the wind direction is almost steady. These data are then utilized to analyze the emission rate from the facility using the mobile approach.

Field experiments

Sampling locations: May 15, 2010, Woodard, TX.

Time: Jun. 16th to 19th, 2015.