Quantification of Gaseous Emissions from Gas Stations, Oil Wells and Agriculture using Optical Solar Occultation Flux and Tracer Correlation Methods

A&WMA's 109th Annual Conference & Exhibition
New Orleans, Louisiana
June 20-23, 2016

Extended Abstract # 947

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INTRODUCTION

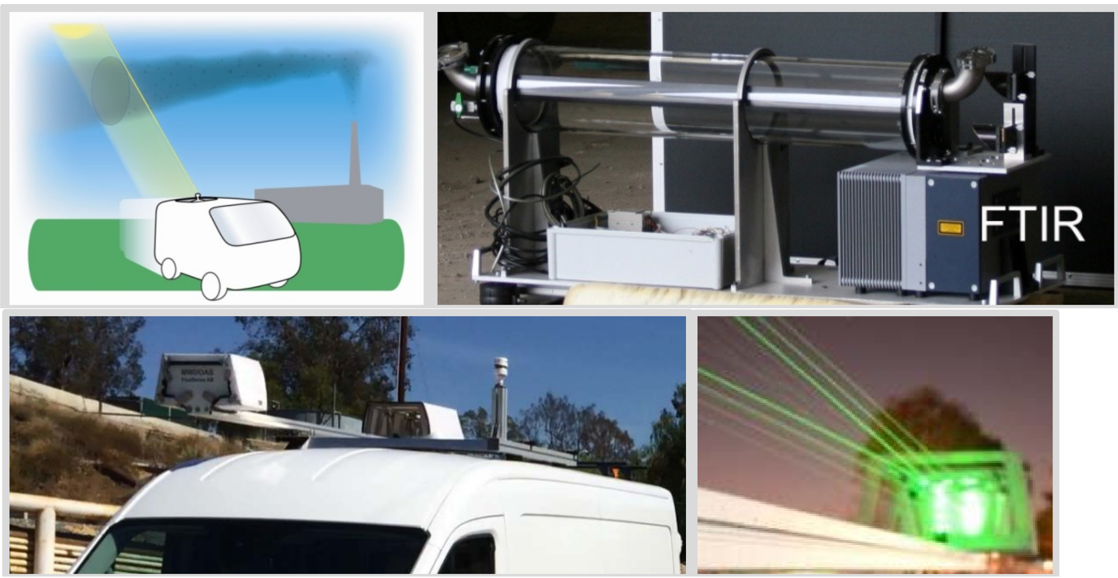
Industrial volatile organic compound (VOC) emissions may contribute significantly to ozone formation[1]. In order to investigate how much small sources contribute to the VOC concentrations in the Long Angeles metropolitan area a comprehensive emission study has been carried out on behalf of the South Coast Air Quality Management district (SCAQMD). VOC emissions from small sources such as oil wells, petrol stations and oil depots, and oil platforms were measured in September and October 2015 using several unique optical methods, including the Solar Occultation Flux Method (SOF)[2,3]. In addition ammonia emissions from farming in Chino were demonstrated. The measurements in this study were quality assured by carrying out a controlled source gas release study and side by side measurements with several other techniques. During this presentation the main results from the field campaign will be shown and discussed.

METHOD AND RESULTS

The methodologies and techniques used are described briefly below. More information can be found in paper 948 of this conference, in the report of a previous pilot study[4,5] or elsewhere[6].

The SOF (Solar Occultation Flux) method[2,3] is based on the recording of broadband infrared spectra of the sun with a Fourier transform infrared spectrometer (FTIR) that is connected to a solar tracker. The latter is a telescope that tracks the sun and reflects the light into the spectrometer independent of its position. Using multivariate optimization it is possible from these solar spectra to retrieve the path-integrated concentrations (referred to as column concentrations), in the unit mg/m^2, of various species between the sun and the spectrometer. The measurements are carried out from a mobile platform making it possible to measure in a circle around leaking areas discriminating between upwind and downwind mass fluxes. The column measurements are combined with wind measurements to estimate the gas flux. In this study a wind LIDAR operated by SCAQMD was utilized together with wind mast measurements.

Figure 1. The methods used are shown here. From SOF measurements (upper left) the flux of alkanes are obtained. From extractive infrared absorption measurements (upper right) the concentration of alkanes, methane and other species including tracer gases on the ground is measured. From ultraviolet absorption measurements on the ground using an open path multi reflection cell the concentrations of aromatic VOCs are measured. The instrument is placed in a vehicle which is moved across the plume.



The column measurements using SOF were complemented by ground concentration measurements using multi-reflection absorption cells in the infrared of ultraviolet region (MeFTIR and Mobile White cell DOAS, respectively). Such extractive measurements have better speciation than the SOF measurements and by measuring the composition of various VOCs downwind the studied industries it is possible to infer emissions of more species than obtained by the SOF instrument alone, i.e. aromatic VOCs (BTEX) and methane. Here it is assumed that the ratio of BTEX versus alkanes that is measured on the ground represents the overall ratio in the emission plume. This may not be true, especially for the process area, and therefore the derived emission value is more uncertain.

The extractive measurements were also complemented by tracer gas releases at the sources to estimate emissions independently from the SOF, using the tracer correlation approach[7].

In Figure 2 is shown SOF column measurement in a box around an oil production area with oil wells and treatment plants in Signal Hill. Data from this type of measurement and several others are summarized in Table 1.

Table 1 Preliminary results from the study showing the obtained emission ranges.

Source	Number of unique sites	Typical emissions kg/h
Derrick Pump and Drill sites (usually contains several derricks)	15	0.03-40
Tankfarms, tankgroups and terminals (sea, harbor and land)	15	3-500
Treatment plants and other sources	7	0.3-400
Gas stations	8	0.4-3
Oil platforms and fuel islands	5	1-25
Validation study	3	2-300

Figure 2. Example of a SOF column measurement in Signal Hill measured in October 2015. The height of the staples corresponds to the relative column amount of alkanes (i.e. path integrated concentration). The wind was blowing towards north (inwards in the picture). Blue areas correspond to oil wells, cisterns and Derricks and purple areas to treatment plants and tank farms.

SUMMARY

Emission measurements of VOCs from small sources have been carried out with several unique optical remote sensing techniques during a 2 month campaign in the Los Angeles metropolitan area. The small sources studied correspond to areas with oil wells and cisterns, treatment plants oil storage depots, petrol stations, fuel islands and a few oil platforms. In addition ammonia emission from farming was demonstrated. In the presentation we will describe the used methods and discuss the obtained emissions.
The methods were compared in several side-by-side measurements with other techniques and in an experiment with a controlled tracer source release.

ACKNOWLEDGEMENTS

The South Coast Air Quality Management District is acknowledged for financial support, provision of a wind LIDAR and tracer gas.

REFERENCES

1. S.-W. Kim, et al., Atmos. Chem. Phys., **2011**,11, p 11361–11386

2. Mellqvist, J., et al., J. Geophys. Res., **2010**, , 115, D00F17, doi:10.1029/2008JD011682

3. Johansson, J., et al., J. Geophys. Res., **2014** ,Vol 119, Issue 7, pages 4303–4322,

4. Mellqvist, J. et al., Report to SCAQMD, **2013**, Pilot study to quantify industrial emissions of VOCs, NO2 and SO2 by SOF and mobile DOAS in the Carson Area

5. Mellqvist, J. et al., Report to BAAQMD, **2013**, Pilot study to quantify industrial emissions of VOCs, NO2 and SO2 by SOF and mobile DOAS in the Bay Area

6. Johansson, J., et al. J. Geophys. Res., **2014**, Vol 119, p 1973–1991

7. Galle, B et al., Environmental Science & Technology, **2001**, Vol 35, No 1: p21-25