

# Reactivation of a Mobile Lidar System

Stijn Berkhout<sup>(a)</sup>, René van der Hoff<sup>(a)</sup>, Thomas Kotte<sup>(a)</sup>, Kevin Felter<sup>(a)</sup>

<sup>(a)</sup> National Institute for Public Health and the Environment (RIVM), the Netherlands  
[www.rivm.nl](http://www.rivm.nl)  
[stijn.berkhout@rivm.nl](mailto:stijn.berkhout@rivm.nl)

**Abstract:** We report on the reactivation of our mobile lidar system. It is capable of measuring concentrations and emissions of NO<sub>2</sub>, SO<sub>2</sub>, benzene and NH<sub>3</sub>. We used it in the past for satellite validation campaigns, transport and industrial emission monitoring and research into agricultural emissions. After reactivation, the system took part in a cow shed ammonia emission measurement campaign.

## 1. Introduction

The RIVM Mobile Lidar System was developed more than 20 years ago. Over the years its capabilities were extended several times. It saw use in a variety of roles. Due to budgetary and personnel constraints, it was mothballed in 2017. We now report that we are working to reactivate this system.

## 2. System Design

The system uses the DIAL technique to measure concentrations of trace gases in the atmosphere. Its light source is a 30 Hz dye laser – ND:YAG laser combination. Between shots, the dye laser is (de)tuned to alternate between the on and off wavelengths. A 28 cm telescope is used to collect the return light. Figure 1 shows the optical layout of the system [1].

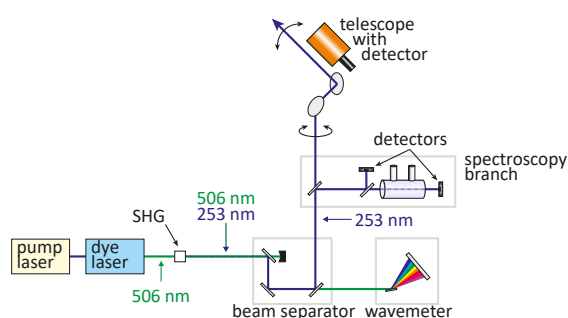


Figure 1. The optical layout of the mobile lidar system.

The system is designed with flexibility in mind. The dye laser is tunable over a wide range in the visible part of the spectrum. A second harmonic generator enables the creation of UV light, down to 205 nm. All optics are mounted on kinematic base plates, so they may easily be

exchanged. Likewise, the dye laser has an easily exchangeable set of laser dye circulators.

The outgoing laser beam and the telescope are fully steerable. This enables the system to be positioned anywhere and still do measurements.

When measuring emissions from point or diffuse sources, the system relies on the wind to carry any emitted gas through a vertical measurement plane (Figure 2). The lidar maps the size and concentrations of the emitted plume. Auxiliary measurements of wind speed and direction are needed to arrive at an emission rate.

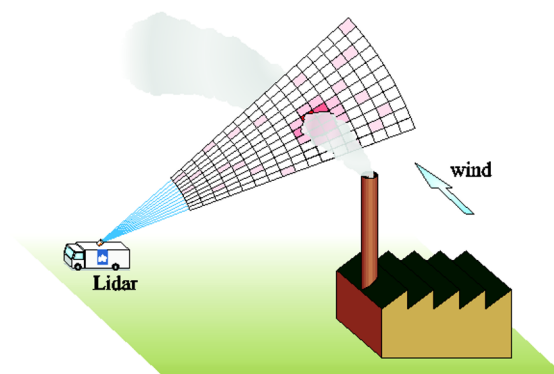


Figure 2. Measuring the emission from an industrial source.

The system is housed in a fully self-supporting measurement vehicle (Figure 4). It is currently able to measure four different gases, these are listed in Table 1.

**Table 1. System capabilities**

Gas	Laser wavelength (nm)
NO <sub>2</sub>	414 (direct dye laser output)
SO <sub>2</sub>	300
NH <sub>3</sub>	208
benzene	253

### 3. Deployment

The system has been deployed for all four gases. The measurement objectives varied.

#### NO<sub>2</sub>: Satellite Validation

For this gas, we measured NO<sub>2</sub> profiles in the lower part of the atmosphere. These were used in studies to validate satellite NO<sub>2</sub> measurements. All profile measurements were part of multi-instrument validation campaigns [2,3].

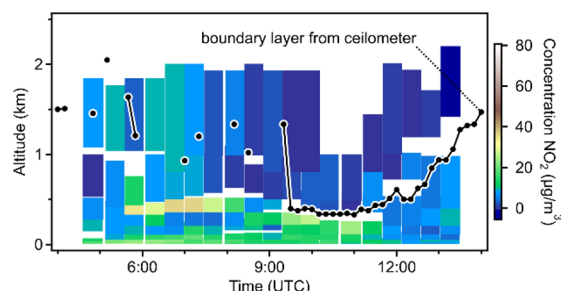


Figure 3. NO<sub>2</sub> profiles measured on 15 September 2016 in Cabauw, the Netherlands.

#### SO<sub>2</sub>: Emission Monitoring

SO<sub>2</sub> emissions from ocean-going ships were measured while these ships were on inland waterways. This was done to investigate compliance with fuel sulfur content regulations [4].

#### NH<sub>3</sub>: Emission Research

To investigate the rate of ammonia emission from agricultural sources, a series of experiments was set up to measure the ammonia plumes from freshly manured fields, both on experimental farms and in real-life agricultural practice [5].

#### Benzene: Emission Monitoring

For benzene emissions from industrial sources, lidar measurements not only indicated the emission strengths but also identified the likely locations of their sources [6].



Figure 4. The mobile lidar system in an industrial environment.

### 4. Conclusions

In November 2023, the system was serviced and reactivated. Some pieces of equipment had broken down during the protracted period of inactivity and were replaced or repaired. Replacement of components is still going on, but taking measurements is again possible.

The first measurement activity was a short campaign to map the ammonia plume emanating from a cow shed. In this campaign, the lidar worked alongside a great number of other instruments. Data analysis is ongoing. We envisage to continue with these measurements in 2024.



Figure 5. Ammonia plume campaign. The lidar is to the left of the large wind turbine.

### 5. References

- [1] Volten, H., E.J. Brinksma, et al., NO<sub>2</sub> lidar profile measurements for satellite interpretation and validation. *Journal of Geophysical Research D: Atmospheres*, 2009. 114(24).
- [2] Piters, A.J.M., K.F. Boersma, et al., The Cabauw Intercomparison campaign for Nitrogen Dioxide measuring Instruments (CINDI): Design, execution, and early results. *Atmospheric Measurement Techniques*, 2012. 5(2): p. 457-485.
- [3] Tirpitz, J.-L., U. Frieß, et al., Intercomparison of MAX-DOAS vertical profile retrieval algorithms: studies on field data from the CINDI-2 campaign, *Atmospheric Measurement Techniques*, 2021. 14: p. 1-35.
- [4] Berkhout, A.J.C., D.P.J. Swart, et al., Sulphur dioxide emissions of oceangoing vessels measured remotely with Lidar. RIVM, Bilthoven, Research report 609021119, 61 pp., 2012.
- [5] Berkhout, A.J.C., G.R. van der Hoff, et al., Measuring ammonia emissions from manured fields. RIVM, Bilthoven, Research report 680150003, 80 pp., 2008.
- [6] Berkhout, A.J.C., G.R. van der Hoff, and L.F.L. Gast. Lidar Measurements of Industrial Benzene Emissions. in *27th International Laser Radar Conference, ILRC 2015*. 2016. EDP Sciences.