

Validation and application of a novel optical particle counter

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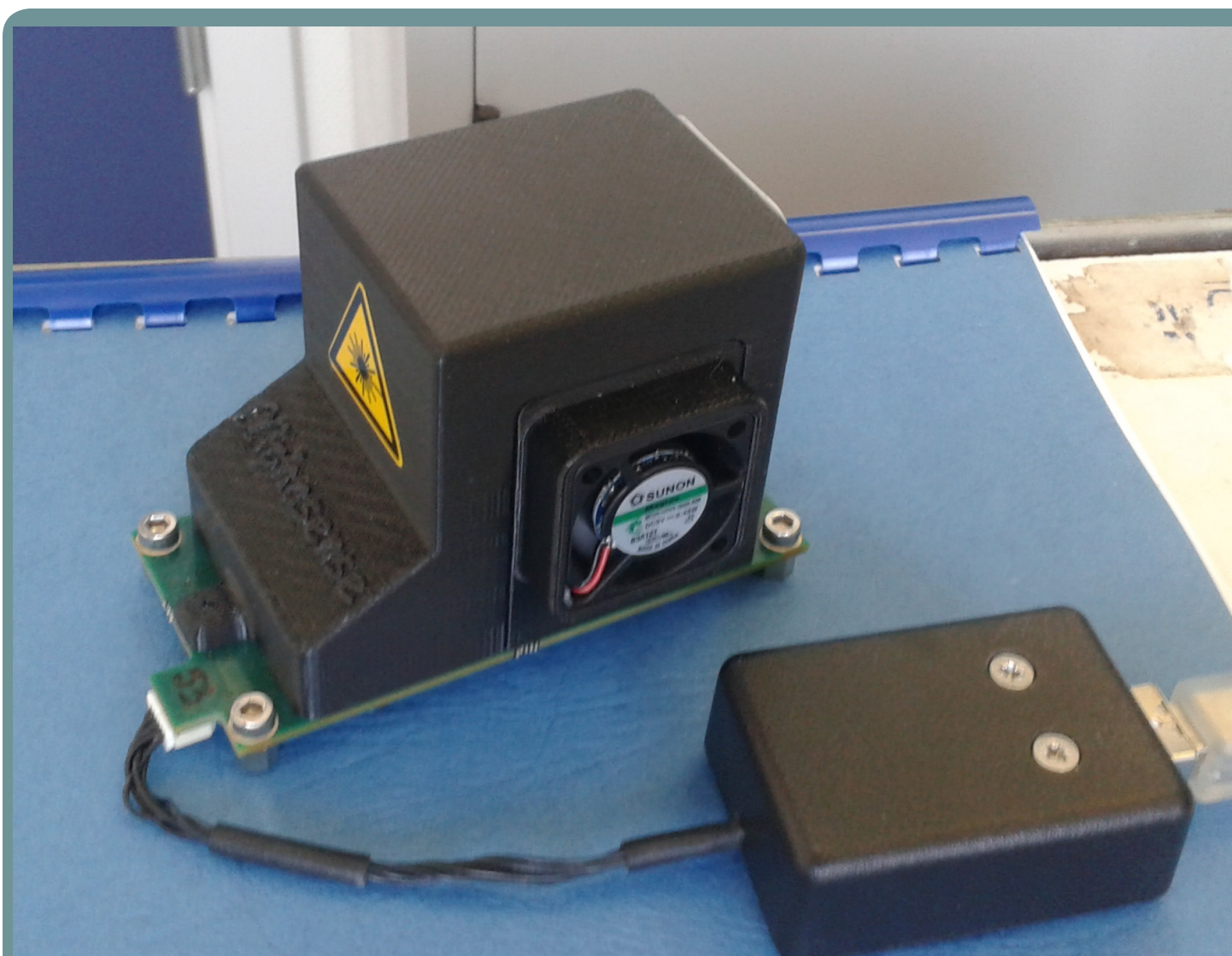
1) FORCE Technology, 2) Explicit I/S

Introduction

Recent studies have focused on the effect of smaller size fractions of the combustion generated particles, such as $PM_{2.5}$, PM_1 and $PM_{0.1}$ as these have the ability to penetrate deeper into the human respiratory system and cause damage.

Various instrumentation can measure the number and mass concentrations of these small particles in the air. These instruments are based on different measurement principles and many of them are large, heavy and power consuming, limiting the applications to mainly stationary measurements.

Recent development within optical measurement methods has made it possible to assess the mass PM_{10} , $PM_{2.5}$ and PM_1 using small, portable and low power consuming instrumentation. However, the optical method has limitations with respect to the smallest size of particles that can be detected. We have tested such a small, novel optical particle counter.



Optical Particle Counter (OPC) N1
The specifications of the particle counter allows counting the number of particles in 16 size bins between 0.4 and 17 μm in diameter and has a temporal resolution of 1 Hz.

Figure 1. A close-up of the Optical Particle Counter (OPC) N1 and the USB adaptor.

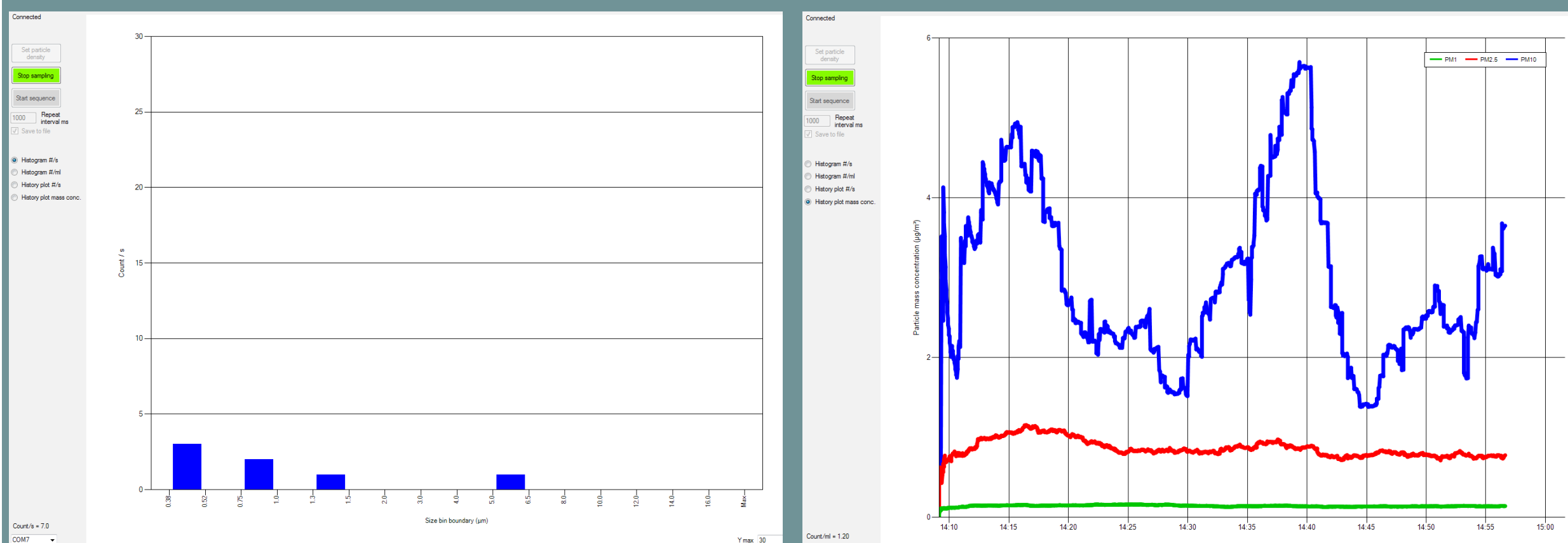


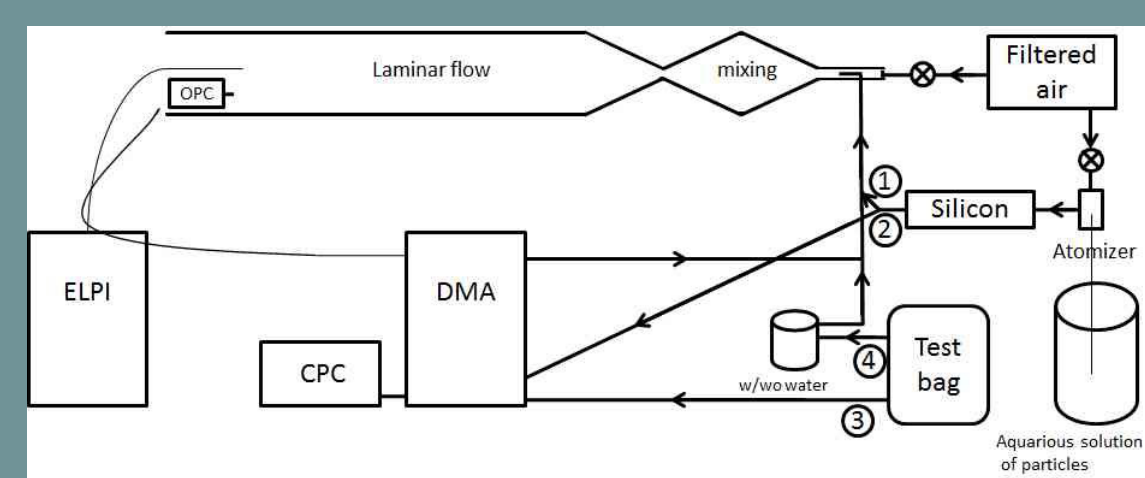
Figure 2. Graphical user interface for the OPC. Left: Counts in each of the 16 size bins. Right: PM mass concentration.

Laboratory test

The test involved generation of standard size particles and diesel combustion particles. The performance of the optical particle counter was compared with an ELPI (Electrical Low Pressure Impactor) (Dekati, Finland) and a Scanning Mobility Particle Sizer (TSI, USA).



Figure 3. Laboratory setup for testing the Optical Particle Counter using standard particles or sampled air.



Particles larger than 600 nm are fully counted, while the OPC is only able to detect about 10% of the generated 300 nm particles. Particles smaller than 100 nm are not counted.

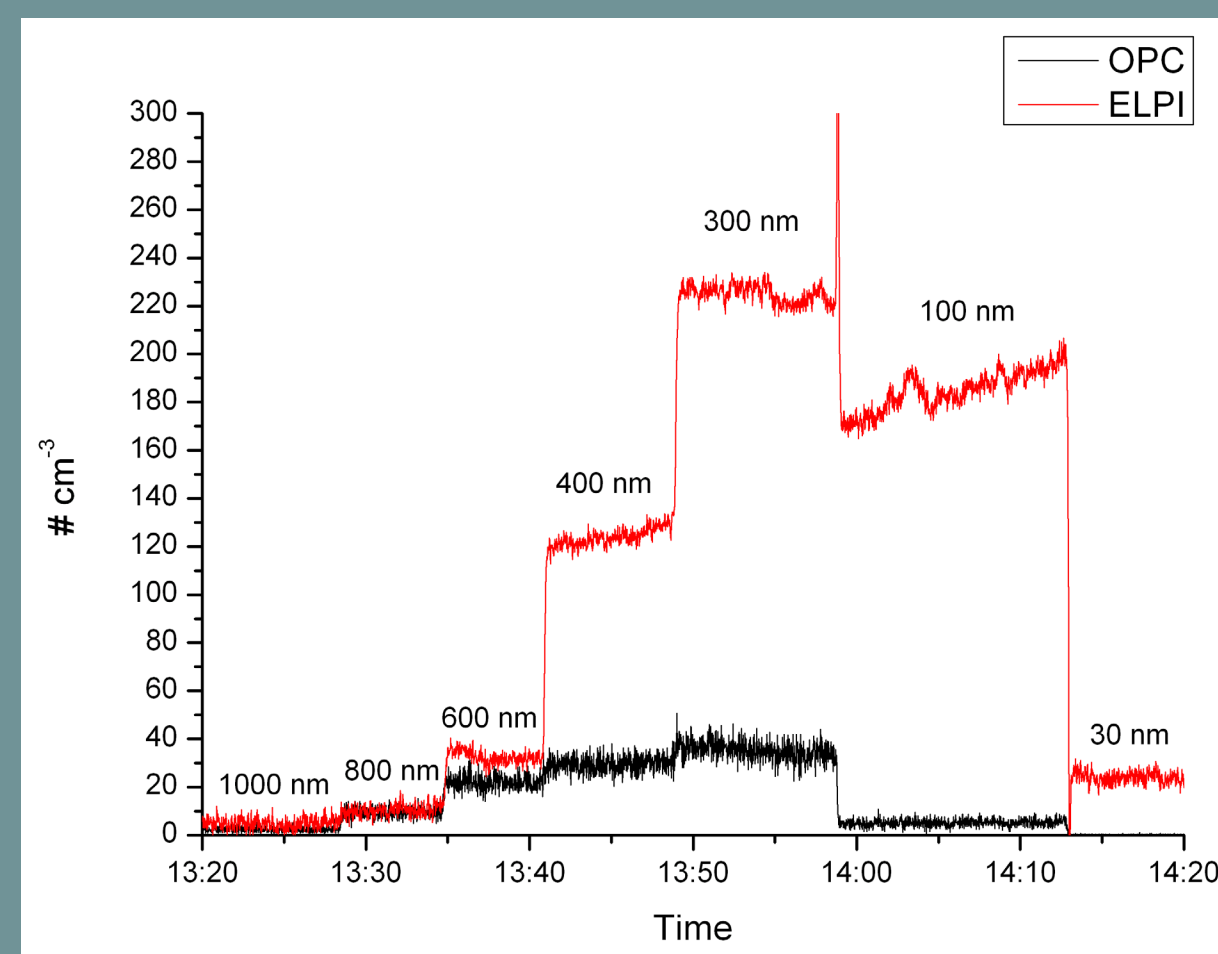


Figure 4. Comparison of particle counting at different particle sizes selected by the Scanning mobility particle sizer.

Case studies

Work safety in a helicopter

Measurements inside a helicopter cockpit during ship plume measurements showed significant increase of particle mass, both for PM_1 , $PM_{2.5}$ and PM_{10} . However, the concentrations does not exceed the current particle safety concentration limit for working areas.

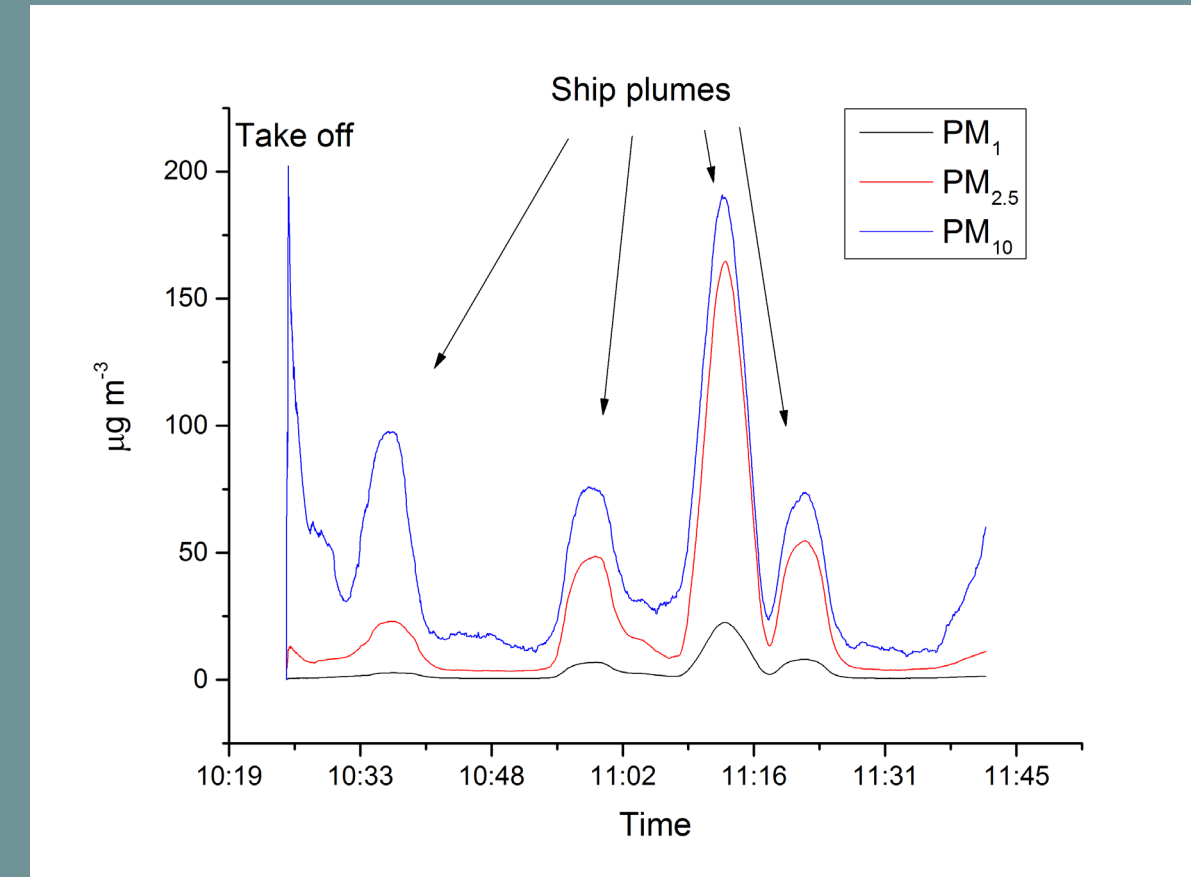


Figure 5. Particle mass concentrations PM_1 , $PM_{2.5}$ and PM_{10} inside a helicopter cockpit during a flight with four ship plume measurements.

Measurement of personal exposure

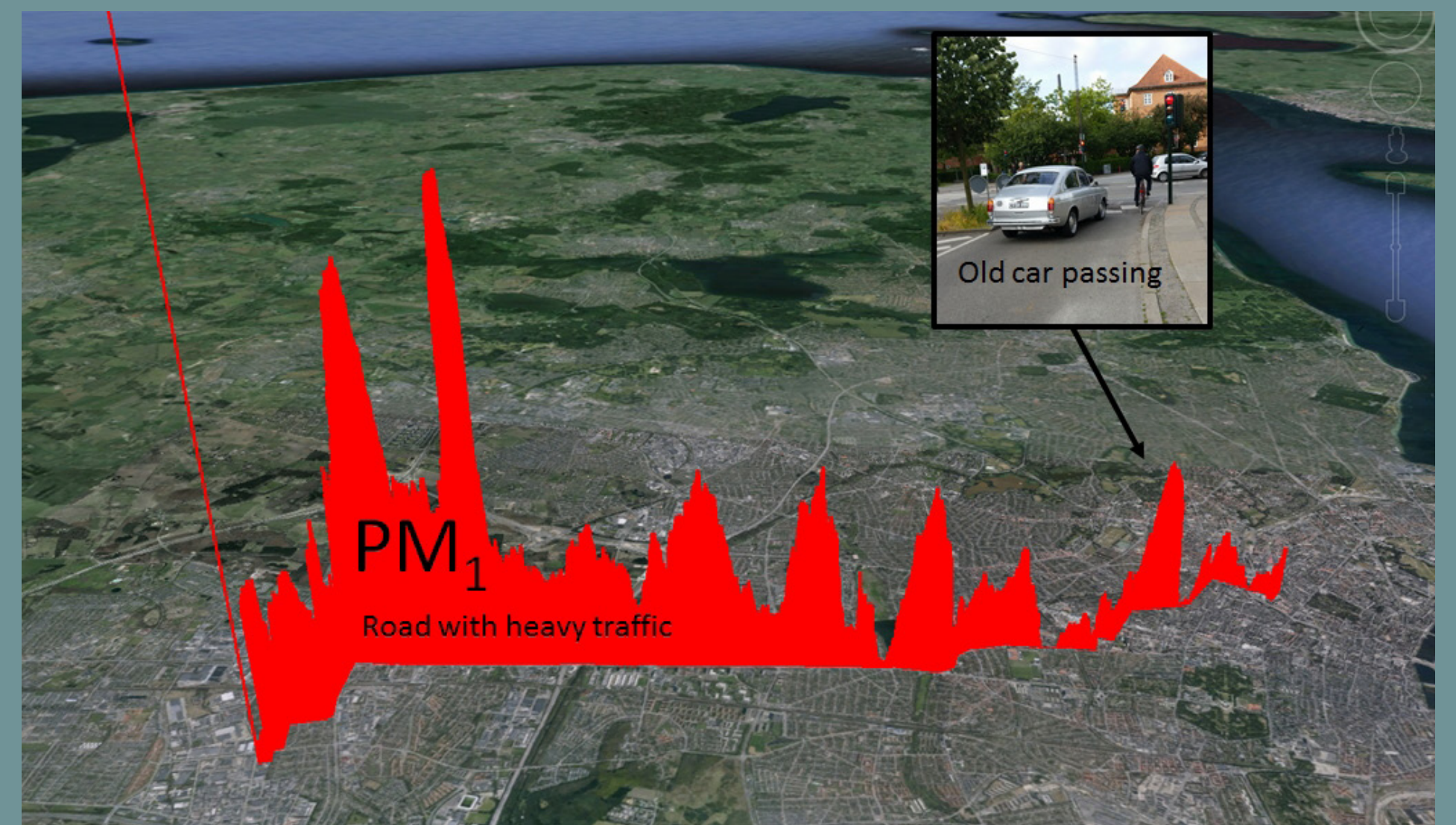


Figure 6. PM_1 concentration during a morning bicycle trip in Copenhagen, Denmark.

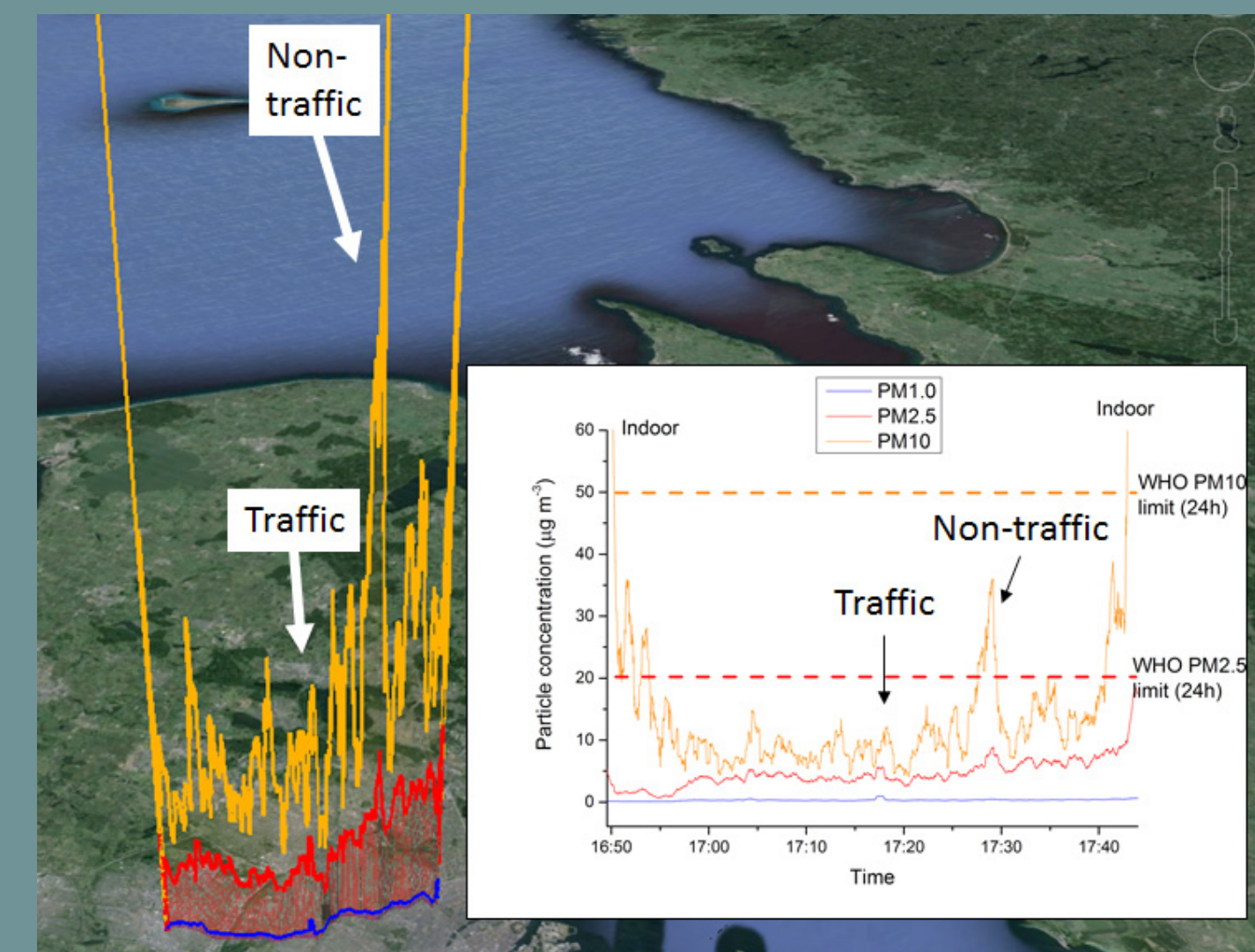


Figure 7. PM concentration during an afternoon bicycle trip in Copenhagen, Denmark.

Conclusion

- Laboratory tests shows good counting ability for particles > 600 nm
- Good for measuring the mass concentration of PM_1 , $PM_{2.5}$ and PM_{10}
- The small size and low power consumption make the particle counter very useful for portable measurements - e.g. for personal exposure studies or monitoring from unmanned aerial vehicle
- Useful for both indoor and outdoor particle exposure monitoring to check excidings of occupational health limits and environmental monitoring.

Future work

- Field test of OPC in unmanned aerial vehicle

