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Particulate Matter Profiles along the Rack Railway Route Using Low- Cost Sensor

Abstract

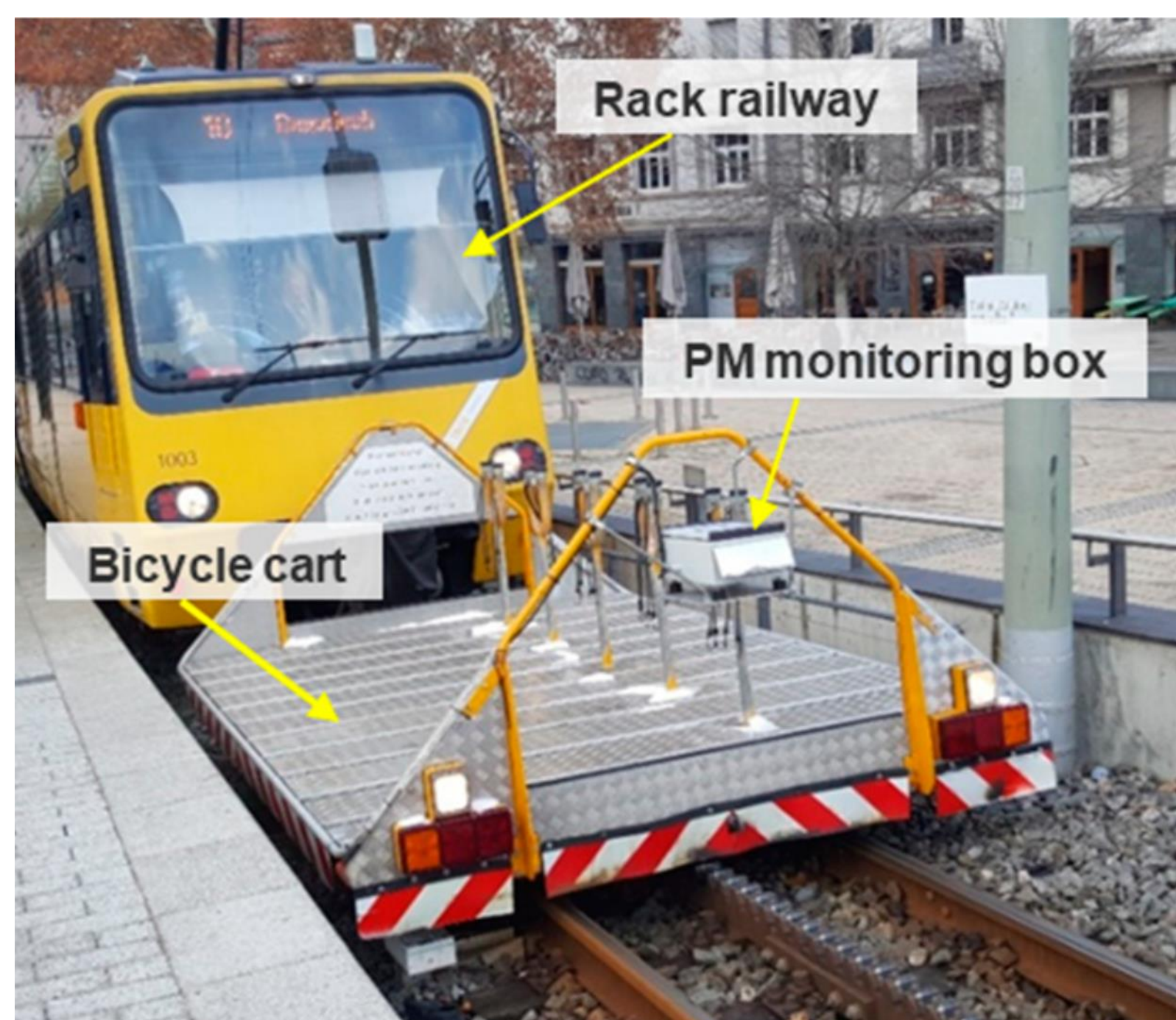
Air pollution due to Particulate Matter (PM) is an increasing concern of global extent and has been studied in various research projects. In this project, a low-cost PM monitoring platform was built with the objectives of evaluating its feasibility and its performance in mobile measurements. In addition, the temporal and spatial concentration profiles of PM₁₀, PM_{2.5} and PM₁ along the measurement route were characterized.

The measurements, from mid of January until mid of March 2019, showed that the PM concentrations were dominated by fine particulate matter. Higher PM concentrations were measured near the federal highway and high traffic area as compared to the residential area. An overestimation of PM concentration using the low-cost sensor platform was observed during high relative humidity conditions.

Introduction

Mobile measurements help to measure the air quality in an extended area and provide a high spatial resolution of the measured parameters. The location of Stuttgart in a basin with low precipitation and low wind speeds limiting the air exchange plays crucial role in the local PM concentrations as they considered to be higher compared to other cities in the region.

In this project, the rack railway in Stuttgart was selected to carry out mobile measurements using a low-cost PM monitoring platform in a semi-automated manner. This platform contained a low-cost PM sensor, an air temperature and relative humidity sensor with its respective electronic parts. It also contained a GPS to determine the geographical position of the platform.

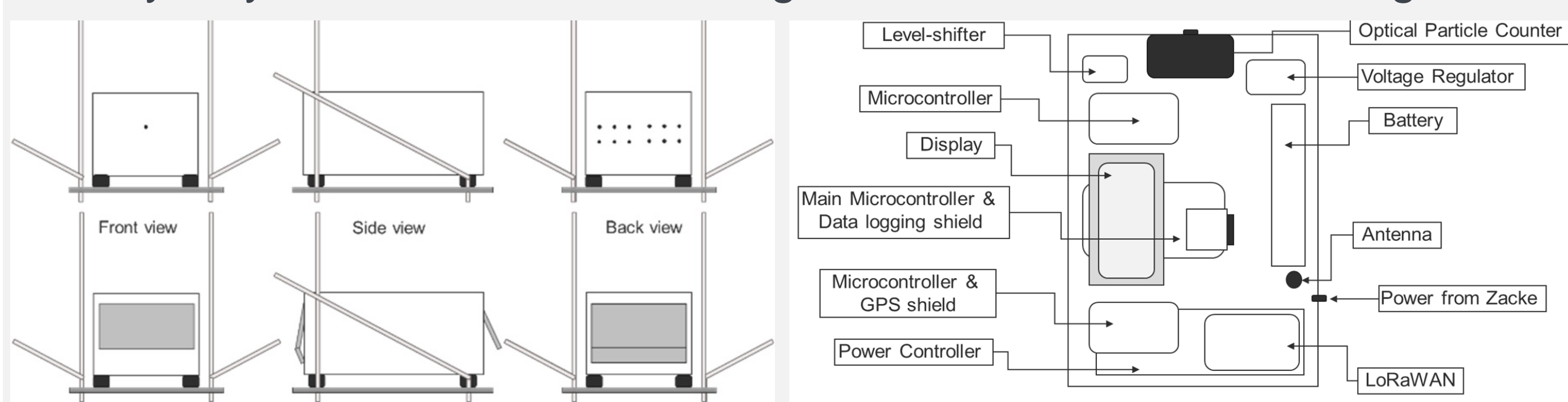


Methodology

The measurement campaign started in winter from mid of January 2019 until mid of March 2019. During this period, the measurements were performed for around 1600 trips in total with an average of 27 trips per day. The duration of one complete trip from Marienplatz to Degerloch was 30 minutes.

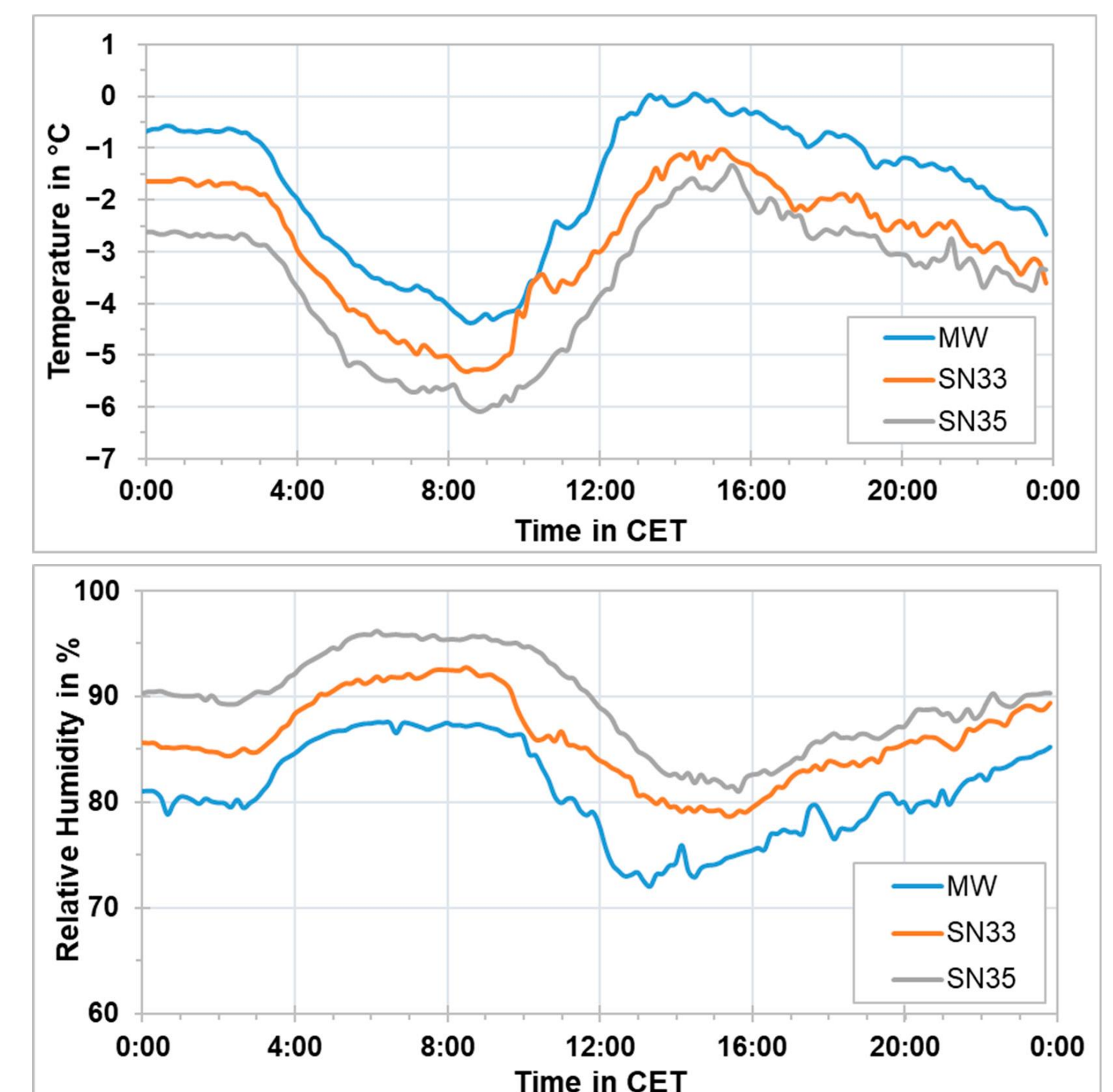
The measurement route was around 2.2 km long and surrounded by street intersections, green-residential areas and federal highways (B14 and B27). The altitude of the route increased when moving from Marienplatz (268m) to Degerloch (472m). This provided the possibility for capturing vertical profile for the meteorological parameters.

The low-cost PM monitoring platform was designed and constructed at the Department of Air Quality Control at the University of Stuttgart to investigate the ambient PM concentrations. It was installed inside a weather-proof housing and was it was mounted on the front of the rack railway bicycle cart with an inlet height of around 1 meter above ground.

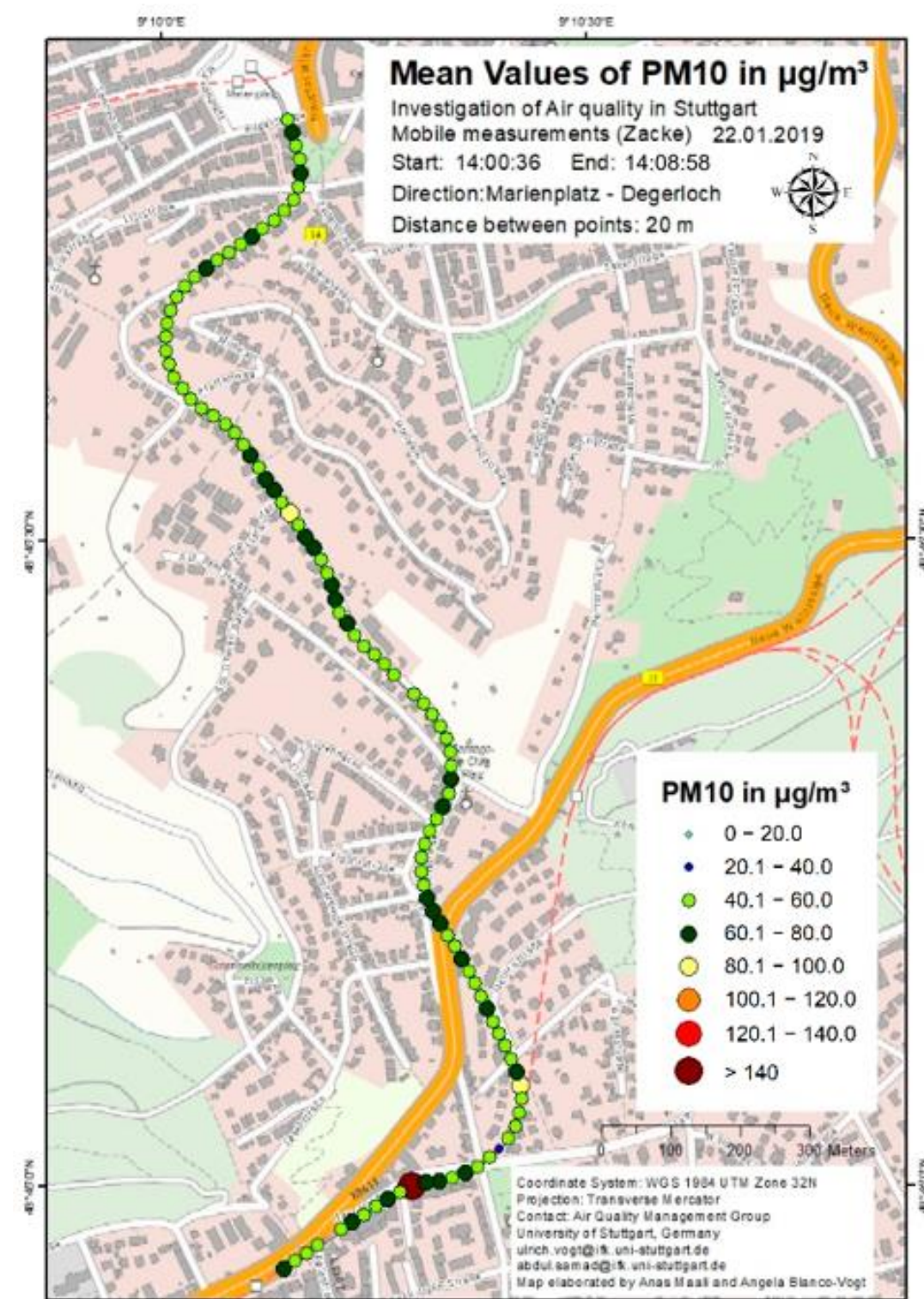
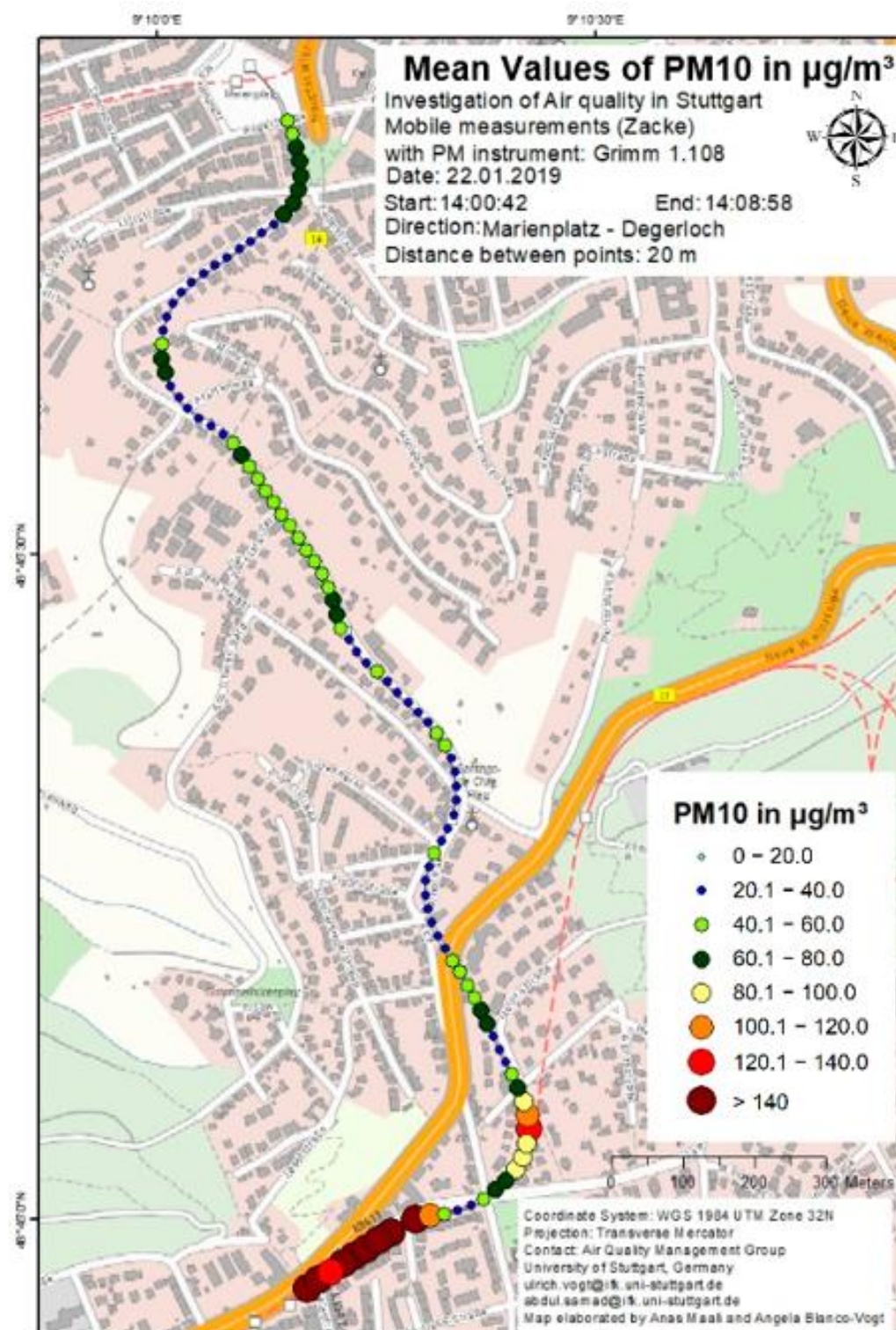


Results

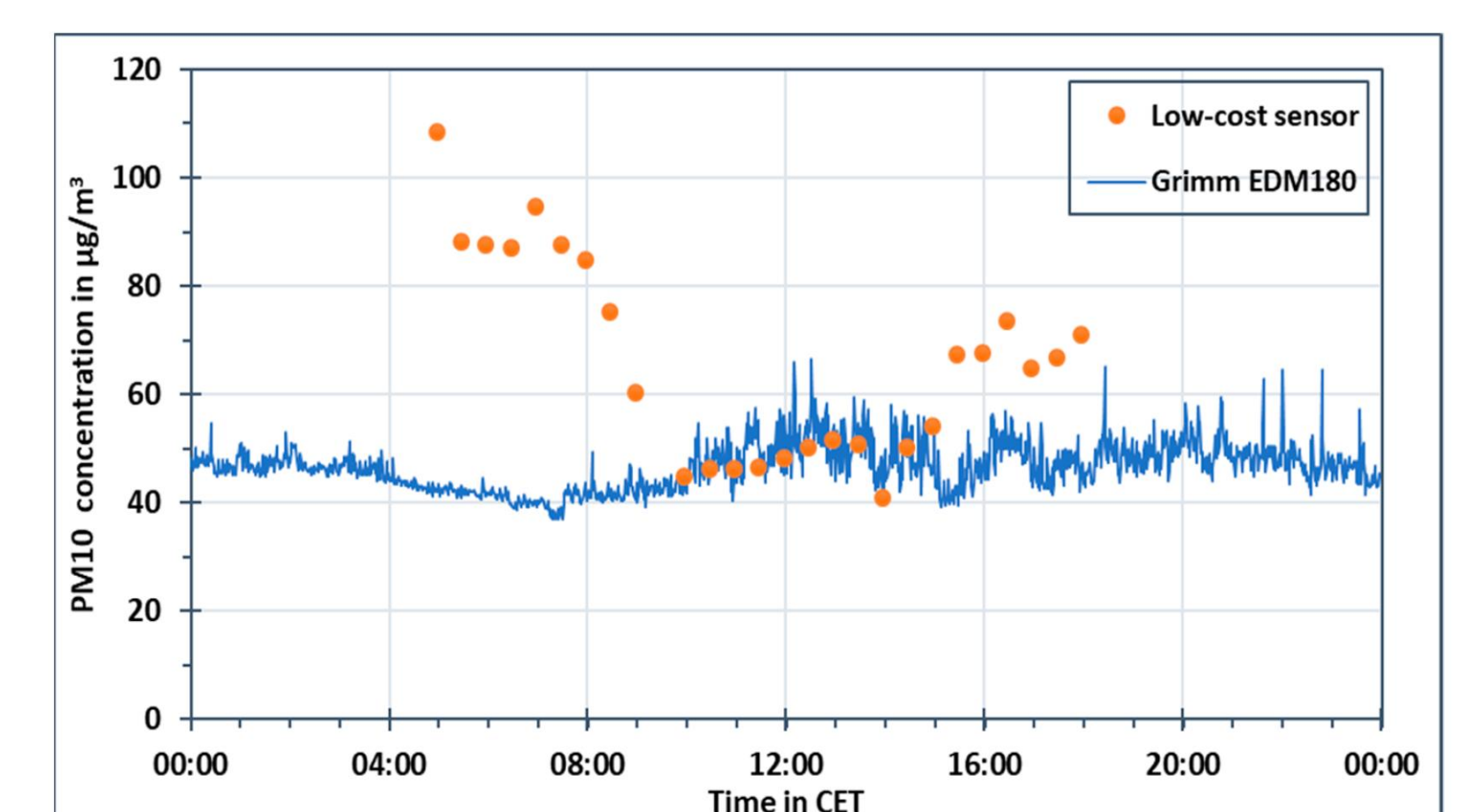
A significant difference in meteorological conditions between the stops was detected. The temperature was inversely correlated with the altitude having a difference of around 2°C between Marienplatz and Degerloch. The relative humidity was increasing with the altitude with around 10% difference between Marienplatz and Degerloch.



An overestimation of PM concentration was measured using the sensor-monitoring box. It is assumed to be related to the high relative humidity. However, the mobile aerosol spectrometer showed more accurate results than the PM monitoring box.



The PM₁₀ concentrations using the sensor-monitoring box were comparable to PM₁₀ concentrations using Grimm EDM180 only for the middle part of the day, as the relative humidity levels during that period were not high compared to the rest of the day.



Conclusions

This research project demonstrated that a rack railway along with the sensor-monitoring box could be used as a mobile platform for obtaining PM concentration profiles. The obtained PM concentration profiles were able to picture the air quality situation of the investigated area. The averaged PM concentration profiles illustrated the effect of federal highway B27 and traffic near the end of the measurement route, i.e. Degerloch. The overall comparison of the sensor-monitoring box with stationary and mobile aerosol spectrometers displayed similar PM concentrations. However, a significant overestimation of PM concentration was observed during high relative humidity conditions.

