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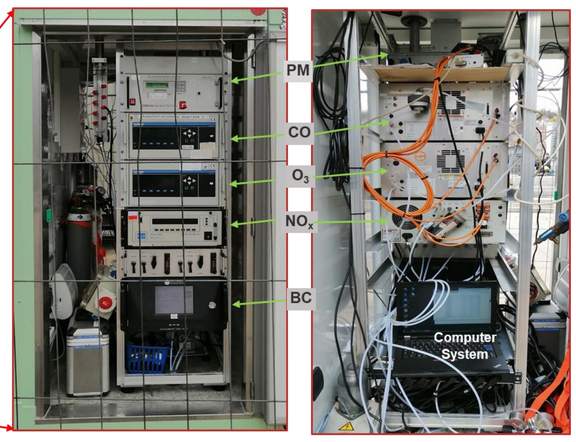
# Three-dimensional urban climate analysis of Stuttgart – Results of six years urban climate research

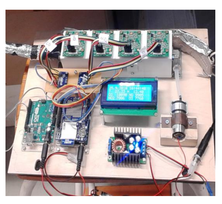
## Introduction

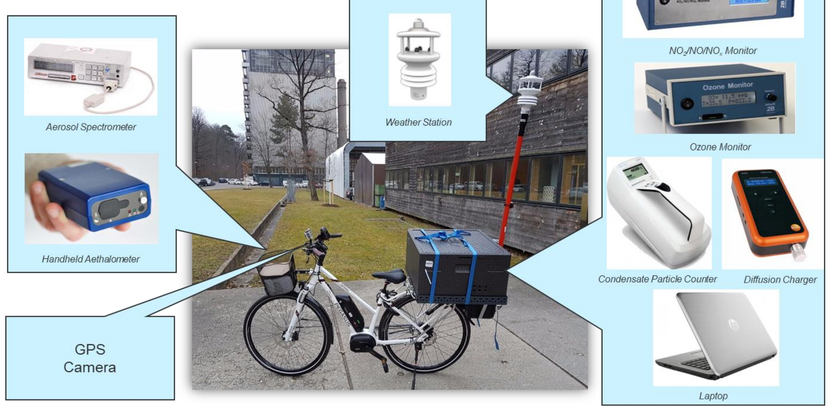
As part of the "Urban Climate Under Change [UC²]" project supported by the Federal Ministry of Education and Research (BMBF) Germany, extensive research in the field of urban climatology was carried out over a period of six years from 2016 to 2022 by a large number of research groups. The department of Flue Gas Cleaning and Air Quality Control (RuL) at the University of Stuttgart was among them. The results presented here, were gained by RuL research group.

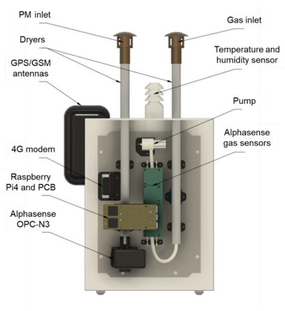
## Methodology

During the investigations, a monitoring station was operated for measuring meteorological parameters and air pollution since 2016 at a central square in the city center, affected by a heavy traffic road. As part of recurring intensive measurement campaigns, mobile measurements using a bicycle were carried out to record the spatial distribution of air pollution within the city area. To determine the vertical distribution of measurement parameters, a tethered balloon and a measurement drone were used. In addition, low-cost PM and gas sensors were tested and deployed to record the air pollutant concentrations.

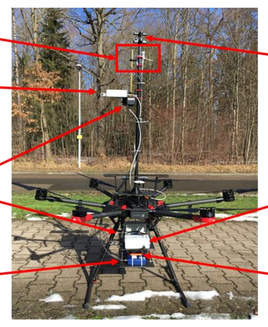



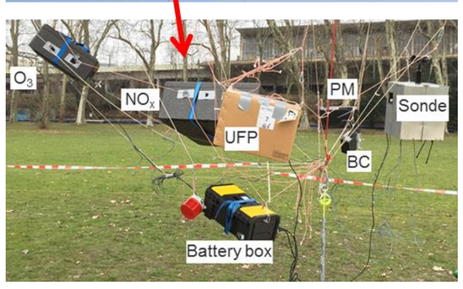







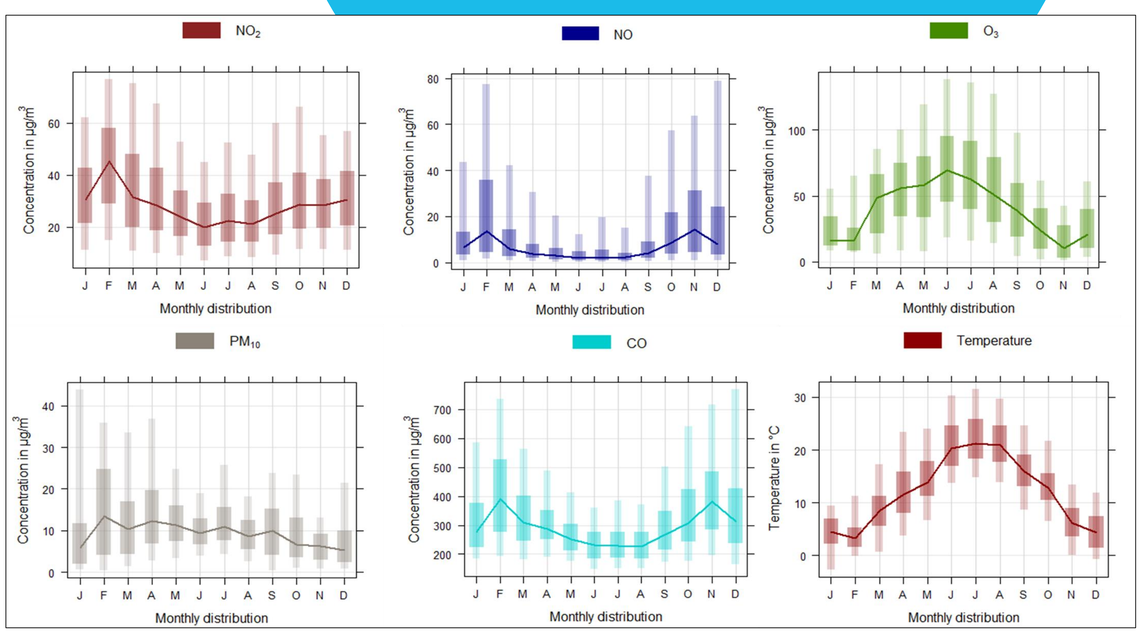


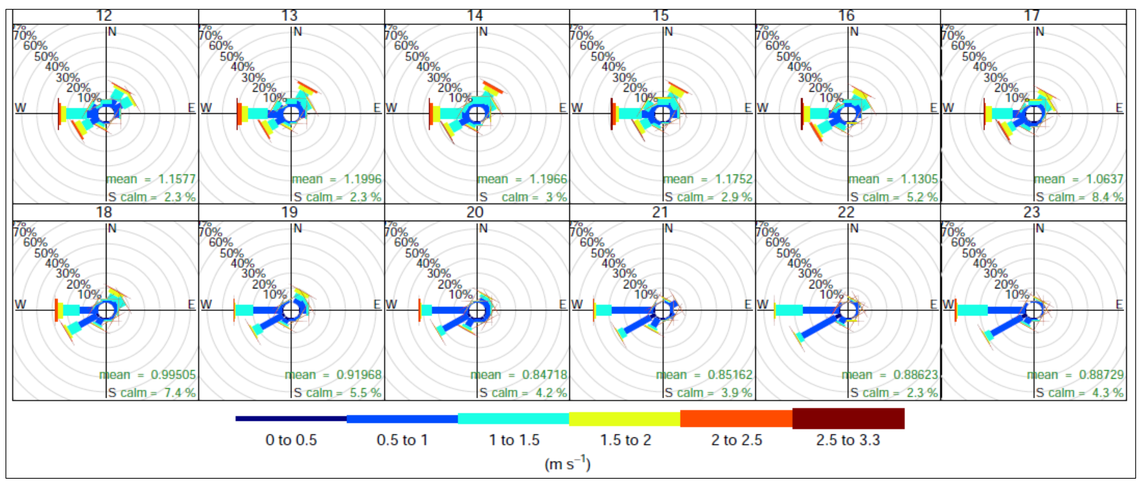



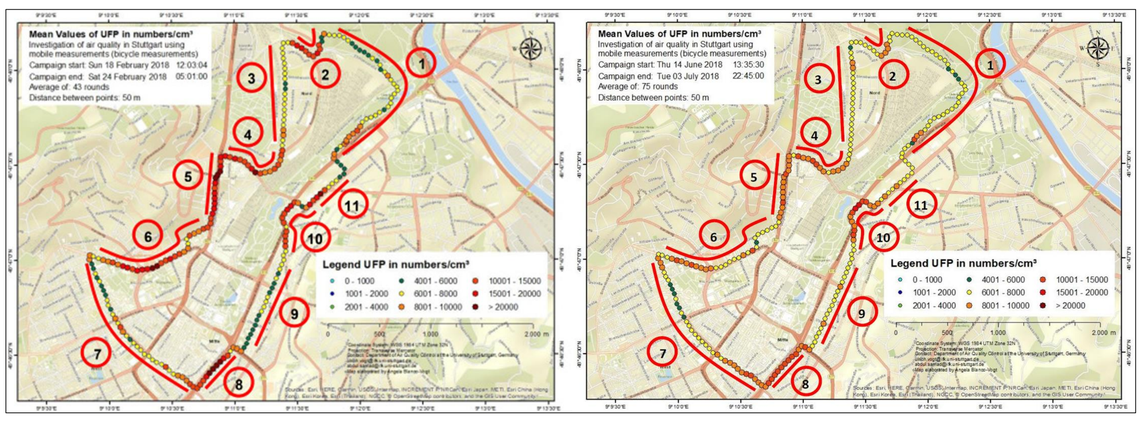

## Results

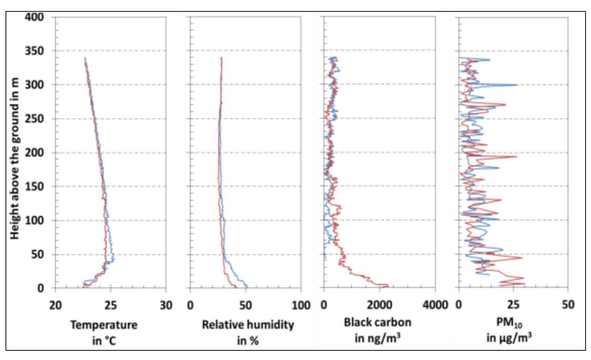
In the measurement period under consideration from 2016 to 2022, emissions were reduced by implementing various air pollution control measures, with improved exhaust technology for vehicles and finally by lockdowns due to COVID-19 pandemic. The development of the air quality situation was shown using the extensive measurement results. The strong decrease in air pollution concentrations with increasing distance from busy roads was illustrated with the help of maps along the mobile measurement route. The results of the vertical soundings provided insights to the effects of surface temperature inversions on the vertical distribution of air pollution. Results of drone measurements were used to determine the intensity and vertical thickness of inversion layers. Cold air flows, intensified by the complex terrain, were found to have a major impact on the air quality in Stuttgart city area.

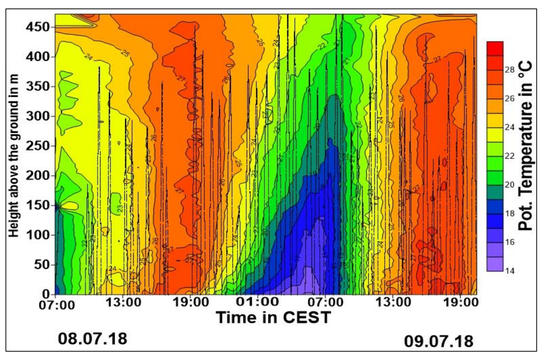
## Results




## Conclusions

Stationary measurements: Relatively high concentrations of NO and $NO_2$ are observed during rush hours on weekdays

Increase in temperature showed a decline in CO concentration due to reduced domestic heating and instable atmospheric conditions

The main wind direction in the investigated area was observed to be south southwest in the evening. During the daytime, the northeast component was also significant

Bicycle measurements: Higher UFP concentrations in the winter campaign as compared to the summer campaign

Local traffic contributing more than 50% to pollutant concentrations

Balloon measurements: Temperature inversion during the night causing higher pollutant concentrations near the ground up to the inversion layer

Stable atmospheric conditions were seen during the inversion period

Low-Cost Sensors: The quality of data can be improved by quantifying the effect of the meteorological parameters affecting the reliability of results obtained by the low cost PM and gas sensors

A low cost dryer seems to be a good solution to solve this problem

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