ASSESSING THE SPATIO-TEMPORAL DISTRIBUTION OF URBAN AIR PULLUTANTS – AN INTEGRATED SYSTEM BASED ON CROWDSENSING WITH MOBILE SENSORS AND MULTI-SCALE MODELLING

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Summary
This study aims to investigate the details of the spatial and temporal distribution of air pollutants in urban areas. Distributed air-quality measurements with mobile sensors for particulate matter (PM) and black carbon (BC) have been carried out across the City of Leipzig by scientists and citizen volunteers during the period 2019/2020. This has been accompanied by real-time air-quality modelling from regional to pedestrian-level scale, using an up-to-date chemistry transport model framework. As expected, observations and model results show high concentrations along busy roads and lower concentrations in parks and backyards with a distinct dependence on commuting during the course of a day or week. Further work will focus on integrating the rich set of mobile measurements, model data and population statistics to obtain more reliable information on the exposure of individuals

Introduction
The urban atmosphere is strongly influenced by a range of short-lived pollutants. Many of them are known to cause adverse health effects (ultrafine particulate matter, soot, nitrogen oxides, ozone). These air pollutants show a high spatio-temporal variability, which is currently not well represented by standard air quality monitoring meant to measure at main sources as well as by common air-quality forecast. In recent years, TROPOS has developed and explored the potential of spatially differentiated measurements with mobile BC and PM mass sensors (e.g. Alas et al., 2019). Additionally, a sophisticated but efficient model system has been developed, which allows for simulations from regional to street-level scale. Within a knowledge-transfer project, the combination of mobile crowdsensing and high-resolved air-quality forecast recently have been used to assess the spatial distribution of BC and PM2.5 in the medium-sized city of Leipzig in eastern Germany.

Methodology and Results
A set of mobile measurement packages for PM and BC, which are designed lightweight, easy to use and conform with scientific standards, have been developed and used to carry out distributed air-quality measurements by scientists and citizen volunteers across the City of Leipzig in 2019/2020. The data is collected on a web-based platform and is used to improve a real-time model for predicting small-scale pollution. The quasi-operational forecast is based on simulations with the multi-scale chemistry-transport model COSMO-MUSCAT (Wolke et al., 2012), which is equipped with a building effect parameterization, for grid spacings between 28 km over Europe to about 500 m over the city area. Computational Fluid Dynamics (CFD) modelling is then used to bridge the gap to street-level conditions.
The observations and model results show similar patterns with high concentrations along busy roads especially at crossings, while lower concentrations occur in parks or areas with little traffic. This is in dependence of the day of the week with a typical daily cycle through rush-hour traffic. Due to the strong concentration gradients, the exposure to individual citizens however remains difficult to deduce.

Fig.1 Wintertime distribution of BC in the City of Leipzig as measured with mobile sensor. After Alas et al., 2019.

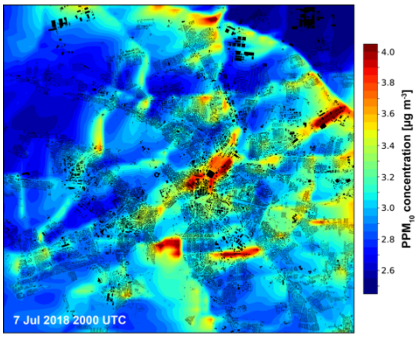

Fig.2 Primary PM concentration from 500–m simulations with the COSMO-MUSCAT model.

Conclusions
The integration of detailed air-quality measurements and high-resolution model simulations promises to enhance our knowledge about the links between pollutant emissions, air quality, and urban climate. The long-term objective of the study is that more reliable exposure information will be obtained by means of measurement and model data and statistical data on the daily patterns of movement and residence of the population.

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