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Micro-scale variability of particulate matter and the influence of urban fabric on the aerosol distribution in two mid-sized German cities

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Spatial micro-scale variability of particle mass concentrations is an important criterion for urban air quality assessment. The major proportion of the world's population lives in cities, where exceedances of air quality standards occur regularly. Current research suggests that both long-term and even short-term stays, e.g. during commuting or relaxing, at locations with high PM concentrations could have significant impacts on health.
In this study we present results from model calculations in comparison to high resolution spatial and temporal measurements. Airborne particles were sampled using an optical particle counter in two inner-city park areas in Aachen and Munster. Both are mid-sized German cities which, however, are characterized by a different topology. The measurement locations represent spots with different degrees of outdoor particle exposure that can be experienced by a pedestrian walking in an intra-urban recreational area. Simulations of aerosol distributions induced by road traffic were conducted using both the German reference dispersion model Austal2000 and the numerical microclimate model ENVI-met.
Simulation results reveal details in the distribution of urban particles with highest concentrations of PM10 in direct vicinity to traffic lines. The corresponding concentrations rapidly decline as the distances to the line sources increase. Still, urban fabric and obstacles like shrubs or trees are proved to have a major impact on the aerosol distribution in the area. Furthermore, the distribution of particles was highly dependent of wind direction and turbulence characteristics. The analysis of observational data leads to the hypothesis that besides motor traffic numerous diffuse particle sources e.g. on the ability of surfaces to release particles by resuspension which were dominantly apparent in measured PM(1;10) and PM(0.25;10) data are present in the urban roughness layer.
The results highlight that a conclusive picture concerning micro-scale patterns of PM helps to understand the effects of urban fabric and obstacles of both natural and artificial origin (e.g. street furniture, vegetation elements and buildings) on the local patterns of aerosol distribution. Simulation results with Austal2000 and ENVI-met indicate that there is potential to support urban planners in designing urban infrastructure and open spaces with reduced local particle concentrations through modelling. This approach seemingly is i.e. relevant for inner-city recreational areas.