Microscale variations of atmospheric particle number size distributions in a densely built-up city area

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Motivation

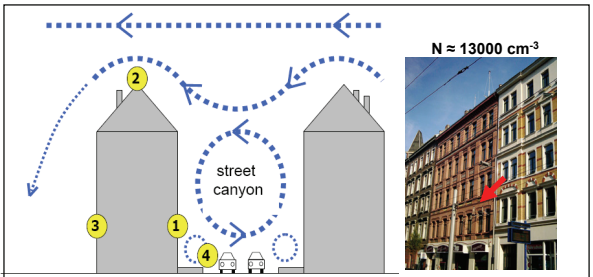
- Urban submicron (< 1 µm) und ultrafine (< 0.1 µm) particles have moved into the focus of public health interest because they are suspected to contribute to acute and chronic disease in susceptible parts of the population (HEI, 2002).
- The dominant source of aerosol particle number concentration in urban areas is combustion of fossil fuel in motor vehicles. Particle number size distributions near roads with high traffic are dominated by particles smaller than 100 nm in diameter.
- To investigate the spatially-resolved exposure of the population to these particles, fundamental knowledge about the spatial and temporal variability of fine und ultrafine particles in the urban atmosphere is needed.

Spatial aerosol measurements during PURAT III and IV

- A field experiment (PURAT*) was conducted to investigate the **spatial** and **temporal** variability of **fine** and **ultrafine aerosol particles** in the microscale environment around the street canyon Eisenbahnstraße in Leipzig, Germany.
- Continuous measurements with TDMPS and SMPS systems
- PURAT III: three sites (1,2,3) in winter 2005/2006
- PURAT IV: four sites (1,2,3,4) in July and August 2006
- The measurements of aerosols were supplemented by:
  - roof level wind direction and wind speed
  - manual and automatic traffic counts
  - nitrogen oxides at the roof-top and the street canyon
  - particle number size distributions at a reference background station (“IfT”), 2 km northeast

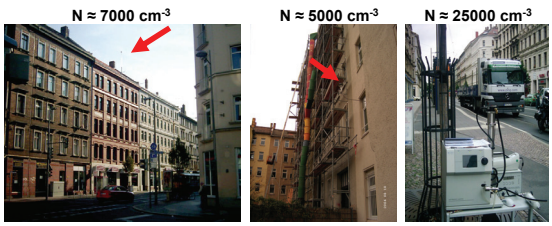
*PURAT - Particles in the urban atmosphere: Behaviour of fine and ultrafine particles, their spatial variation and relationships with local policy action

Instrumental set-up



Sketch of the atmospheric air flow in the vicinity of the street canyon “Eisenbahnstraße” in Leipzig

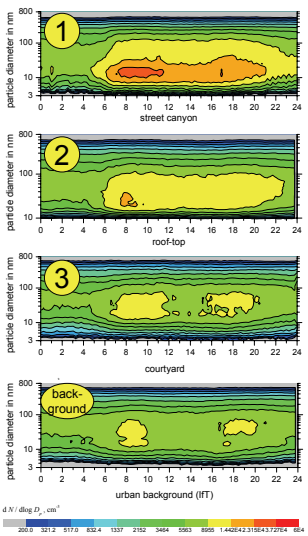
(1) street canyon



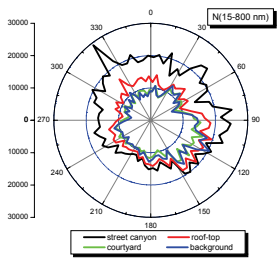
(2) roof-top *(3) courtyard* *(4) sidewalk*

Differences between the measurement sites

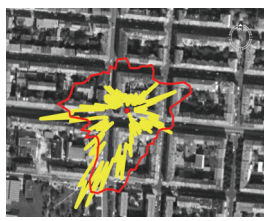
PURAT III



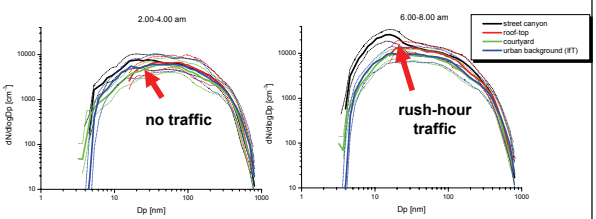
Total concentrations and diurnal variations



Average wind distribution of number concentrations

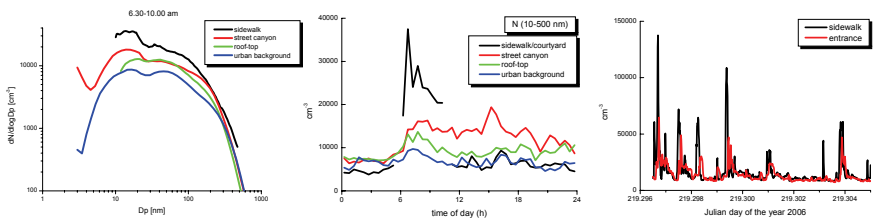


Distribution of wind direction (yellow) and wind velocity (red) in connection with local topography



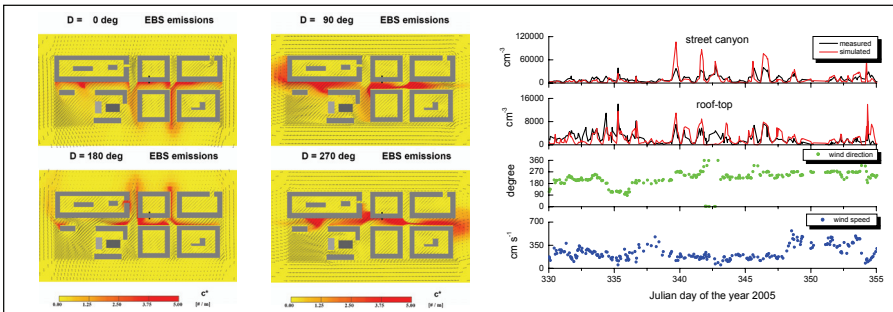
Median particle number size distributions for day times with low (left) and high traffic volume (right)

PURAT IV



Mean number size distributions and diurnal profiles (N[10-500 nm]) *CPC-3007 measurements*

3D-Simulations



Simulation results with ASAM: normalized concentrations and flow field for various wind directions (top view)

Measured vs. simulated particle concentration for changing wind directions and wind speeds

Conclusions

- general trend in particle number concentration: **urban background ≈ courtyard < roof-top < street canyon < sidewalk**
- ultrafine particles are distributed very inhomogeneously
- the measured concentrations were strongly influenced by the wind direction inside the street canyon
- the dominating process affecting the dispersing aerosol is dilution with ambient air, coagulation and condensation are playing only a minor role in microscale transports (the half-lifetime of a 12 nm-particle against coagulation is about 40 minutes)
- qualitative agreement between measured data and the results of the three-dimensional dispersion model ASAM (Hinneburg and Knoth, 2005)

References

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B. Wehner, W. Birmili, T. Gnauk and A. Wiedensohler (2002) Particle number size distributions in a street canyon and their transformation into the urban-air background: measurements and a simple model study. *Atmospheric Environment*, **36**: 2215-2223

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