Particle number size distributions of ambient-state and non-volatile aerosols in the city of Augsburg, Germany

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Introduction

➢Atmospheric – especially anthropogenic aerosols cause adverse health effects (e.g. WHO 2004). It is being assumed that especially insoluble (non-volatile) fine (< 1 µm) particles such as soot have a strongly negative effect of the human health.

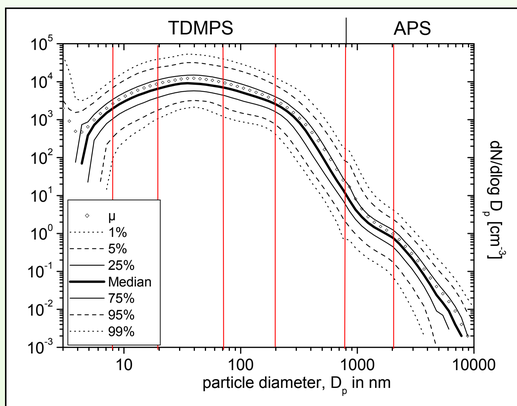
➢This work is concerned with the description and the meteorological analysis of a preliminary 2-year observation period (2004 – 2006) of particle number size distributions in an urban environment of Augsburg. The speciality here was the measurement and determination of ambient particles and the non-volatile residuals (with thermodenuder).

➢Augsburg is a centre of environmental epidemiological research (KORA, Holle et al.; 2005). Data collected at the measurement site will be correlated with health endpoints in the near future to identify the most health relevant sub-fractions of urban aerosols.

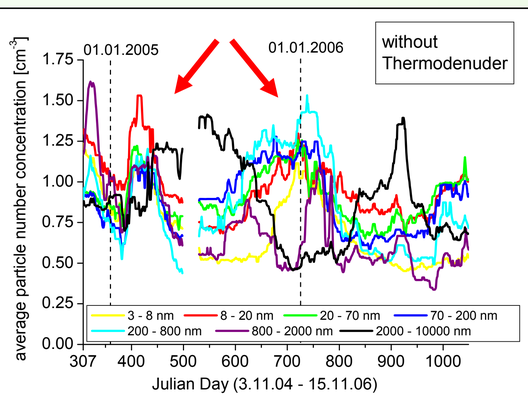
Measurements with TDMPS and thermodenuder

The combination of a Twin Differential Mobility Particle Sizer (TDMPS) with a thermodenuder allows to measure particle number size distributions (3 – 800 nm) at ambient temperatures or after heating to 300°C. For descriptions of the instruments, see Birmili et al. (1999) and Wehner et al. (2002).

General results

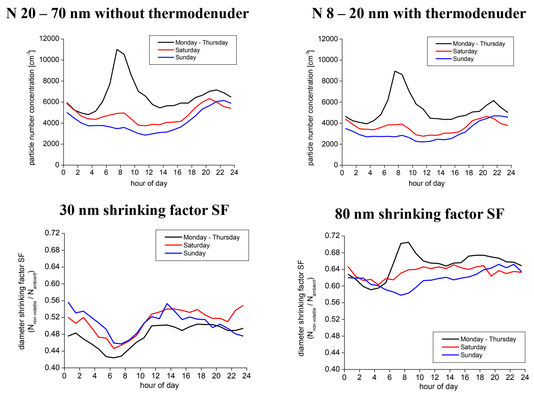


The average particle number size distribution (3 nm – 10 µm) in Augsburg 11/2004 – 11/2006.



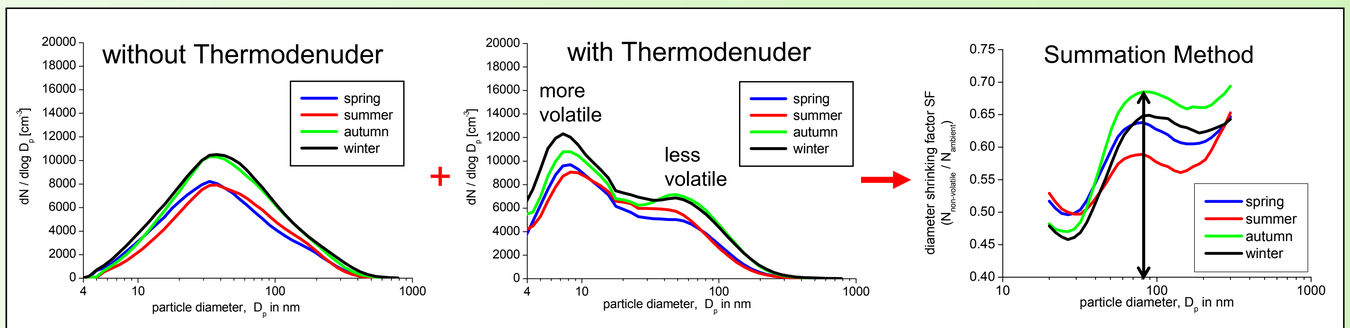
The annual cycles show a particle number concentration peak (< 800 nm) in winter.

Diurnal cycles

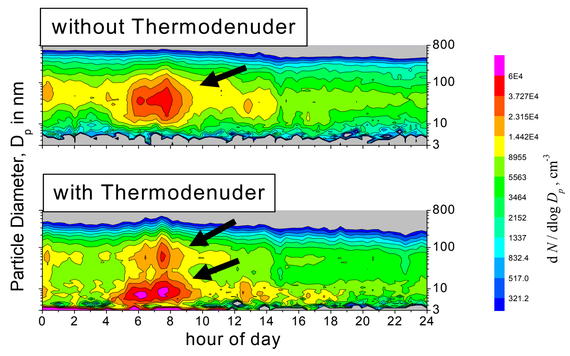


The effect of the local sources (e.g. traffic) can be seen best in particle number concentrations between 20 – 70 nm without thermodenuder and between 8 – 20 nm with thermodenuder. The shrinking factor SF shows that the soot fraction (non-volatile) has a maximum at 80 nm and a minimum at 30 nm during the rush hour.

Particle number size distributions

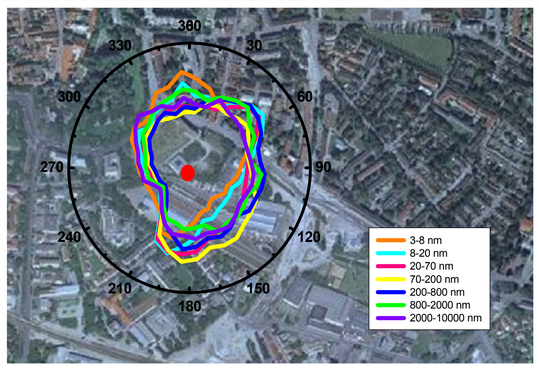


The comparison of the number size distributions between ambient (without thermodenuder) and non-volatile (with thermodenuder) particles shows high concentrations in autumn and winter. Furthermore, all particles between 20 – 800 nm seem to contain a non-volatile core. The Aitken mode decomposed after the thermodenuder in less (e.g. soot) and more volatile particles. The summation method is used here to relate ambient and non-volatile particle size distributions. The diameter ratio is interpreted as a particle "shrinking factor" of particulate matter loss due to volatilisation. The highest soot fraction occurs in autumn and winter at 80 nm.

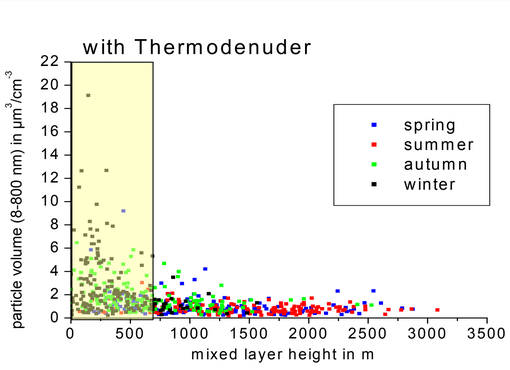


The colour plots show a diurnal variation of particle number size distribution without and with thermodenuder. The Aitken mode split-up after the heating in two peaks: at 80 nm (soot particles) and at 20 nm. The size distributions show the highest particle concentrations between 06:00 and 09:00 in the morning caused by vehicles (rush hour).

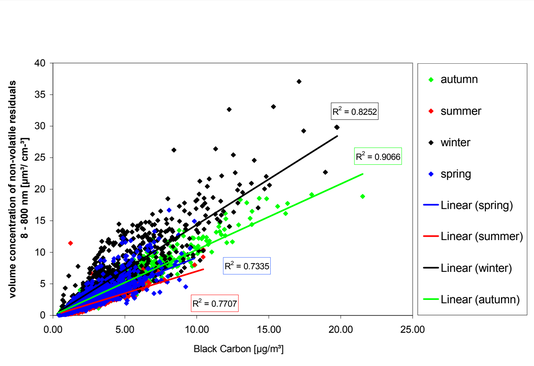
Comparison between particle concentration and other parameters



Particle number concentrations depend on local wind direction. The map characterize the measurement site in Augsburg (red point).

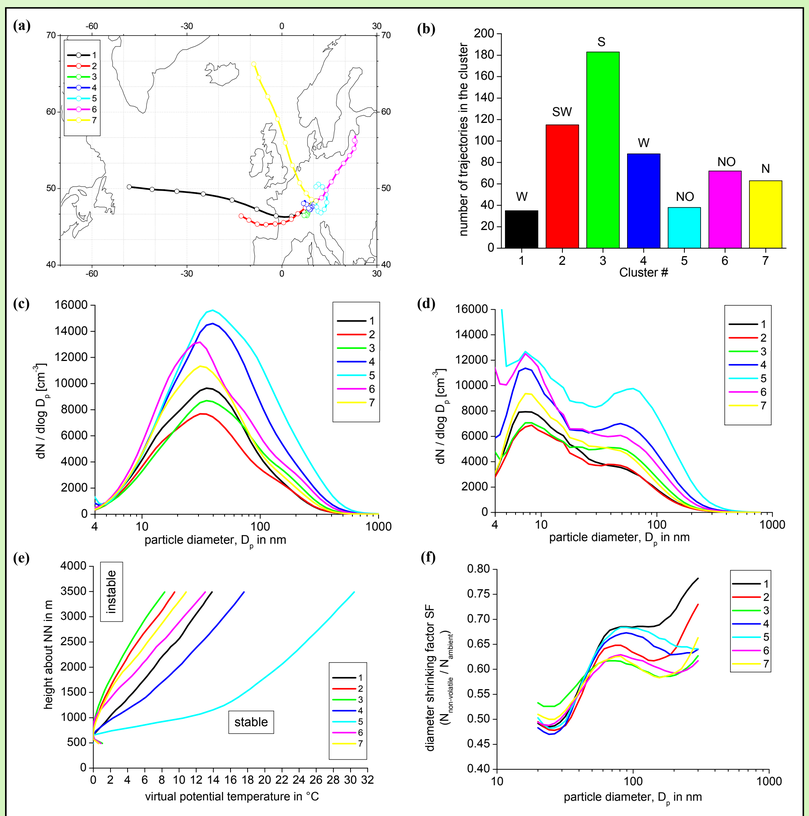


Particle volume and number concentrations depend on mixing layer height. The highest concentrations occurred during winter and with low mixing layer heights.



The volume of non-volatile particle residuals correlate with the optical Black Carbon ($PM_{2.5}$) measurements (R^2 = 0.9).

Back trajectory cluster analysis



The back trajectories show that the atmospheric stratification is more important than pure geographical air masses. Low mixing layer heights cause high particle number concentrations.

Acknowledgements

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Back trajectories were calculated on the NOAA ARL READY Website using the HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) Model (Reference: Draxler, R. R. and Rolph, G. D., 2003, NOAA Air Resources Laboratory, Silver Spring, MD, USA).

References

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