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Annual measurement of size resolved particle fluxes over an urban area

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Urban areas exhibit a multitude of well-known particle sources. Therefore, most flux studies over bigger cities detected almost exclusively upward fluxes or aerosol particles. In most of these studies, the total particle number concentration was measured for a broad size range, e.g. $PM_{2.5}$or PM_{10}. However, source apportionment and analytical studies suggest that particles within such wide size ranges may vary in their origin, longevity, and chemical composition. The scope of this study is to directly quantify turbulent exchange of atmospheric aerosol particles (AAP) of 16 different size classes. Aerosol dynamics are analyzed in combination with the exchange fluxes of sensible heat, water vapor, and carbon dioxide. Furthermore, annual time series are analyzed for seasonal trends.

We employed the Ultra-High Sensitivity Aerosol Spectrometer (UHSAS) and a Passive Cavity Aerosol Spectrometer Probe (PCASP-X2), both manufactured by Droplet Measurement Technologies, Boulder, Colorado (USA). This setup covers the aerosol particle size range between 0.6 μm and 10 μm diameters in up to 140 size bins. In order to reach acceptable counting statistics and to minimize random flux errors, we combine the initial 140 bins into 16 wider size bins. Nevertheless, the measurement yields a considerable improvement in terms of sizing information in comparison to that in previous studies. The measurements are conducted at a 65 m high telecommunication tower in the city of Münster (population $\sim$ 275.000), NW Germany, throughout the year of 2012 and beyond.

The results confirm the hypothesis that urban areas can act both as sources and sinks for AAP at the same time. We regularly observe bi-directional fluxes as a function of particle size. While smaller particles typically exhibit (upward) emission fluxes, the larger particles show deposition (downward fluxes). The tipping point (TP) between mostly up- and downward transported particles lies in the accumulation mode at about 180 nm diameter. Large numbers of particles smaller than the TP are emitted out of the city, leading to positive daily number fluxes of 2 – $4.8 \cdot 10^8$# m^{-2} d^{-1}. Comparatively few particles bigger than the TP deposit into the city, often causing a negative daily mass flux of -0.1 – -0.7 μg m^{-2} d^{-1}. Number fluxes show typical daily patterns, which are correlated to traffic activity and turbulence characteristics. Spring- and summer fluxes are up to two times as high as the winter fluxes, which can be attributed to the considerably less developed turbulence within the boundary layer during the cold season. Accordingly, particle concentrations are nearly doubled during winter.

The presentation will further deepen the size differentiated analysis of particle fluxes and concentrations.