Annual measurement of size resolved particle fluxes in an urban environment

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The turbulent exchange of aerosol particles between the urban boundary layer and the urban surface has been studied from March 2012 to March 2013. The scope of this experiment is to investigate and quantify the contributions of particles of various size classes (diameter range 0.6 µm < Dm < 10 µm) to total urban particle fluxes, and to study their seasonal variability. The data was collected on a radio tower of 62 m height within the urban area of Münster, a medium sized city (ca. 290 000 inhabitants) in northwest Germany. The combination of two fast optical particle counters (UHSAS and PCASP-X2, manufactured by Droplet Measurement Technologies, Boulder, Colorado (USA)) and three-dimensional wind measurement with an ultrasonic anemometer enabled us to calculate particle number fluxes for 16 size bins using the eddy covariance method.

Previous source apportionment studies found that a considerable portion of Münster's particle mass originates from distant sources (Gietl and Klemm, 2009). Furthermore, a first size-resolved particle flux study, using an electrical low-pressure impactor (ELPI) with the disjunct eddy covariance technique, observed a co-occurrence of positive (upward) number fluxes with negative (downward) mass fluxes (Schmidt and Klemm, 2008). These results are in good agreement with the direct EC-measurements, taken with 2 fast OPCs in the spring of 2011 (Deventer *et al.* 2011). The authors describe a tipping point between bi-directional particle fluxes at 168 ± 20 nm. Until now, negative particle fluxes were rarely reported for urban areas in the literature (Martin et al. 2009). Thus a long-term study can yield valuable information on how frequent such fluxes occur. Furthermore, the annual data set enables us to search for seasonal patterns in particle concentrations and fluxes as a function of particle size and to identify driving factors (e.g. turbulence development) for deposition fluxes.

The results reveal that particle concentrations as well as the particle fluxes exhibit a pronounced seasonality. Highest concentrations were observed during the winter months, whereas the lowest concentrations were sampled in the early summer. Furthermore, the average daily patterns differ notably: For winter days, we observed high concentrations for particles with diameters Dm up to 160 nm throughout the whole day. During spring and summer days the concentrations in this size range significantly decrease between 12:00 and 20:00, when turbulence tends to be well developed. Later in the evening, when turbulent transport ceases, the concentrations rise again.

Total particle number fluxes (0.6 µm < Dm < 10 µm) reach the highest values during the winter, peaking around $3 \cdot 10^7$ # m^{-2} s^{-1}. Summerly number fluxes are notably smaller. However, in this period, we frequently observed negative (deposition) fluxes for particles with diameters > 170 nm, whereas during the winter most of the fluxes for the entire size range were positive. The downward directed flux of particles within the accumulation- and coarse modes (diameter > 0.17 µm) during summer leads to a co-occurrence of a negative total mass flux, peaking at -0.2 µg m^{-2} s^{-1}.

The presentation will further analyse the above reported patterns and expand on topics like relevant time scales, correlations with turbulence characteristics, energy- and greenhouse gas fluxes as well as the impact of different flux source regions.

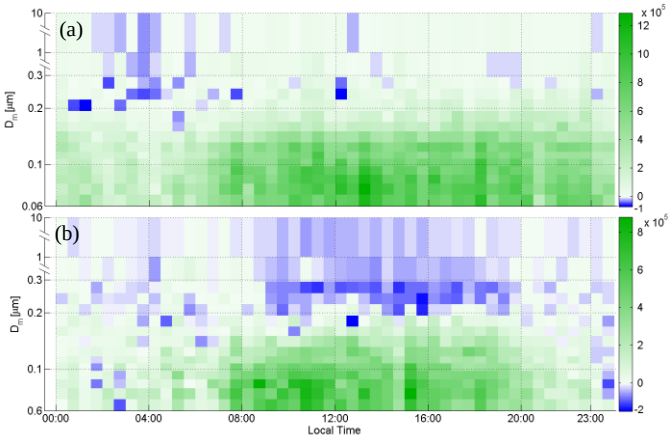

Figure 1. Averaged daily number fluxes for (a) december and (b) august. Colouring symbolizes number fluxes [# m^{-2} s^{-1}], normalized by dlog(D_m) .

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