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Multi-Site Measurements of Particle Number Concentrations and Number Size Distributions Across an Urban Area

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In a sampling campaign conducted in January and February 2017, measurements of aerosol properties were made at five sites in London representative of differing microenvironments. The sites were as follows:
• Marylebone Road, a heavily trafficked street canyon location
• Westminster University, a rooftop site overlooking the Marylebone Road ground-level site
• Regent's University, a site in a major park frequently downwind of Marylebone Road
• North Kensington, a well characterised urban background site located 4 km from the Marylebone Road site
• BT Tower, an elevated site close to Marylebone Road at an altitude of 160 metres above ground-level (1)

Measurements included total particle number count by CPC, particle number size distribution by SMPS and black carbon by aethalometer. Daily measurements of semi-volatile organic compounds were also made during the campaign at Westminster University and Regent's University, and subsequently at Marylebone Road and Eltham, the latter as a background site in south London.

The SMPS and black carbon data showed substantial diurnal variations which when averaged showed a typical diurnal profile associated with road traffic emissions. Concentrations were highest by a factor of 2-3 fold at the Marylebone Road site. However, there was a large divergence between the integrated counts from the SMPS instruments (covering a size range from 17 to 650 nm) and the condensation particle counters which measure all particles greater than 2.5 nm (TSI 3776) or 3.5 nm (TSI 3775). Mean ratios of CPC to SMPS integrated number concentration were typically close to 1 at their minimum (which on average pertained from around 9am to 10pm) and their maximum which frequently reached values of 5-10 between 3am and 6am. The CPC data did not show a strong diurnal variation but tended to be highest when black carbon and integrated SMPS number counts were at their lowest. Ratios of CPC number count to black carbon showed a very similar and massive diurnal variation ranging from around 0.5 x 1010 #μg-1 to maxima of around 8 x 1010 #μg-1. This implies very large numbers of particles within the range of 3-17 nm diameter. The reasons for this unique behaviour will be discussed.

Another facet of the data which confirmed earlier observations (2,3) is of particle shrinkage by evaporation of semi-volatile components between Marylebone Road and downstream Regent's Park. Rates of evaporation have been calculated following modal analysis and compared to rates measured previously3 and those estimated theoretically from knowledge of the composition of semi-volatile compounds within the particles.

References:
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2 Dall'Osto M et al., Atmos. Chem. Phys., 2011, 11, 6623-6637.
3 Harrison RM et al., Atmos. Environ., 2016, 125, 1-7.