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Micrometeorological flux measurements of aerosol and gases above Beijing

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Air pollution is estimated to cause 1.6 million premature deaths in China every year and in the winter 2016/17 Beijing had to issue health alerts and put in place ad hoc limitations on industrial and vehicular activity. Much of this pollution is attributed to emissions from industrial processes and in particular coal combustion. By contrast, the diffuse pollutant sources within the city are less well understood. This includes, e.g., emissions from the Beijing traffic fleet, the sewage system, food preparation, solid fuel combustion in the streets and small industrial processes.

Within the framework of a major UK-Chinese collaboration to study air pollution and its impact on human health in Beijing, we therefore measured fluxes of a large range of pollutants from a height of 102 m on the 325 m meteorological tower at the Institute of Atmospheric Physics. Several instruments were mounted at 102 m: fluxes of CO_2 and H_2O were measured with an infrared gas analyser (LiCOR 7500) and fluxes of ozone with a combination of a relative fast-response ozone analyser (ROFI) and a 2B absolute O_3 instrument. Total particle number fluxes were measured with a condensation particle counter (TSI CPC 3785), and size-segregated fluxes over the size range 0.06 to 20 μm with a combination of an optical Ultrafine High Sensitivity Aerosol Spectrometer (UHSAS) and an Aerodynamic Particle Sizer Spectrometer (TSI APS3321). Ammonia (NH_3) fluxes were measured for the first time above the urban environment using an Aerodyne compact quantum cascade laser (QCL). In addition, composition resolved aerosol fluxes were measured with an Aerodyne Aerosol Mass Spectrometer (HR-ToF-AMS), operated in a measurement container at the bottom of the tower, which subsampled from a 120 m long copper tube (15 mm OD).

The analysis so far suggests that, due to often low wind speeds, fluxes were at times de-coupled from the surface. Fluxes normalised by CO_2, a tracer for the amount of fossil fuel consumed, should be less sensitive to transport effects. However, not only fluxes, but also these CO_2-ratioed fluxes are highly variable in both space and time, indicating a complex mix of sources, which will be further investigated. The organic aerosol fluxes were the largest we have recorded to date at any urban measurement site. Nitrate, sulphate, chloride and ammonium all showed emissions that followed a similar diurnal cycle as the organic aerosol. Much of this aerosol is likely to have been formed by chemistry below the measurement height, but it nevertheless indicates significant sources of the precursor gases within the footprint. Comparing the measured fluxes of gas-phase NH_3 and aerosol NH_4^+, at 102 m the aerosol phase makes a significant contribution to the reduced nitrogen emission.