Influence of aging on the cloud condensation nuclei (CCN-)activity of black carbon in the city of Zurich

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Aerosols are defined as a mixture of solid and liquid particulate suspended in a gas. In the atmosphere, these solid particles show distinct properties, thus their impact on health but also on Earth climate can occur in different ways. On the one hand, aerosols have been tied to both acute and chronic respiratory disease (Dockery and Pope 1994; Peters et al. 1997; Li et al. 2003). On the other hand, two main effects can be distinguished concerning the aerosols impact on climate: aerosol-radiation interactions (ari) and aerosol-cloud interactions (aci). Emissions from urban environments contribute significant amounts of fine and ultra-fine aerosols that affect both the local population's health and climate.

Incomplete combustion occurring in vehicles engines is known to be a source of black carbon (BC). Therefore, cities with continuous vehicles traffic are favorable locations to measure emissions of BC particles and to investigate their properties. Freshly emitted particles usually show fractal-like shapes, inducing a low effective density because of void space within the chainlike structure; at this stage, their CCN-activity is little or non-existent (Tritscher et al., 2011). These BC particles may become CCN-active after atmospheric aging (Chung and Seinfeld, 2002). During aging, secondary organic aerosols (SOA) and volatile organic compounds (VOC) can condense on particles, thus increasing their water uptake and their CCN-activity. This study aims at improving our understanding of this topic, by investigating the ability of BC to act as CCN depending on aging, from fresh vehicles emissions to aged particles and background aerosol.

A field campaign took place in the city of Zurich, Switzerland, during spring 2013. A schematic of the experimental set-up for the characterization of the CCN-activity of black carbon particles is shown in Figure 1. In order to select particles with a known effective density, a differential mobility analyzer (DMA) and an aerosol particle mass analyzer (APM) were placed at the beginning of the instruments line. The particle diameters selected to pass through the DMA were chosen to obtain effective densities of 300, 600 and 1600kg.m^{-3}. The effective density is an indicator of a particle's age, and increases with aging. For example, low effective densities (<200-300kg.m^{-3}) were related to fresh emissions coming from road traffic. Conversely, effective densities of approximately 1500kg.m^{-3} were linked to a background source. BC-containing particles were detected using a single particle soot photometer (SP2). Their CCN-activity was measured in parallel with a CCN counter operating at supersaturations from 0.1 to 1.8. By testing at which supersaturation particles of known effective densities activate, we are able to study how the activation behavior changes with particles age.

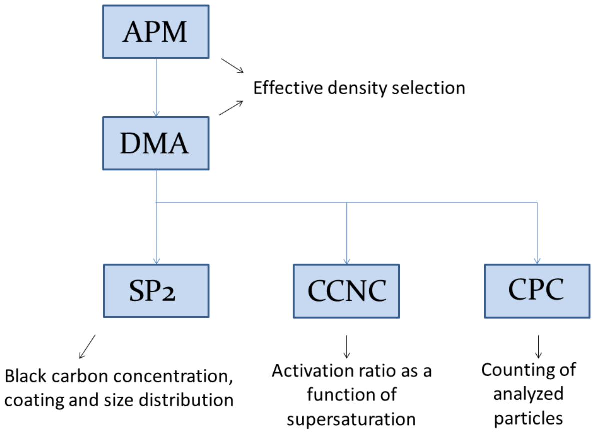

Figure 1. Schematic diagram of the experimental set-up.

After retrieving the effective density from the measurements of mass and diameter of the particles, we were able to link this property with aging and sources. Using the SP2, we were also able to retrieve information on BC particles coating and size distribution, two other indicators that enable us to get more certainty concerning the assignment of age and sources of particles.

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