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Black Carbon Particle Number Distribution Measurements during the ATHENS-2013 Winter Campaign

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Black Carbon (BC) particles emitted by anthropogenic sources play an important role both in climate change and in air quality degradation. Open burning in forests and savannas, combustion of diesel and solid fuels for cooking and heating in homes represent the majority of BC emissions. Earlier work has focused on the BC atmospheric direct radiative forcing that is mostly related to its mass concentration and optical properties of the corresponding particles. A variety of measurement techniques are used to measure the mass concentration of BC by taking advantage of its optical or physical properties. Moreover, the carbonaceous particles containing BC are also important for the indirect forcing of climate. This effect is mostly related to the number concentration of BC particles. The number distribution of BC particles especially below 100 nm is quite uncertain due to limitations of the existing measurement techniques.

In this work we employed a thermodenuder-based method as an approach for the measurement of the BC number distribution. More specifically, we combined a thermodenuder (TD) operating at temperatures up to 300 ˚C, with a Scanning Mobility Particle Sizer (SMPS) and a High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF AMS). Aerosol size and composition measurements were carried out both at ambient and at elevated TD temperatures in Athens field campaign during January and February of 2013. In parallel, a Multi-Angle Absorption Photometer (MAAP) provided information about the BC mass concentration while a Hygroscopic Tandem Differential Mobility Analyzer (HTDMA) measured the mixing state and the hygroscopicity of the particles as a function of their size. These measurements were then combined to estimate the number concentration of BC particles.

Our analysis focused on different periods during the study. During some of them one source dominated the carbonaceous aerosol concentration. Such periods included rush hour traffic, nighttime wood burning, clean air transported from other areas, mixed sources, etc. The number fraction remaining after heating at 300 ˚C for approximately 15 s during wood burning events was 80-90%, suggesting that practically all particles contained nonvolatile material. Combining the SMPS, MAAP, AMS, and HTDMA measurements we show that most of the sampled material was BC. On the contrary, during rush hour traffic the number fraction remaining was only 50-60% suggesting that more than half of the particles did not contain BC.