Aerosol chemistry in Beijing, China: Different pollution regimes and diurnal profiles

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Abstract

The rapid economic development during the last three decades in China has led to a severe decrease in air quality, especially in densely populated regions such as Beijing, Shanghai, and the Pearl River Delta. Although during last years a number of measures for air pollution control have been implemented especially in the capital Beijing, air pollution is still regarded to be one of the top environmental concerns in China during the next decade. To better characterize the processes leading to the frequently observed high concentrations of air pollutants on a regional scale, the international field campaign "Campaigns of Air Quality Research in Beijing 2006" (CAREBEIJING2006) was conducted in summer 2006. Organized by the Peking University, project partners from Japan, Korea, Hong Kong, Germany, and China studied the various aspects of gaseous and particulate air pollution in a megacity environment. In this contribution, we present chemical data of size-resolved particles, obtained by a 5-stage Berner impactor (0.05–10 µm) during 3 weeks at both an urban and a suburban site in the area of Beijing, China. The sampling time of the impactors was about 4-5 hours. This allowed for taking four size-resolved samples per day and obtaining rough diurnal profiles of particle components. The samples were analyzed for inorganic ions (Cl^-, SO_4^{2-}, NO_3^-, NH_4^+, K^+, Ca^{2+}, Na^+, Mg^{2+}), carbon sum parameters (OC, EC, WSOC), and a variety of organic compounds such as dicarboxylic acids, alkanes, PAHs and, for the first time in China, nitrooxy-organosulfates.

On average, the observed PM_{10} mass concentrations were 133 µg m^{-3} and 112 µg m^{-3} at the urban and suburban site, respectively. In general, the observed concentrations of particulate pollutants were similarly high as reported from previous studies in the Beijing summer atmosphere. A back trajectory analysis allowed the classification of the samples into different meteorological categories with different air mass origins. A high influence of meteorology on the PM pollution was observed: The highest concentrations of both PM mass and particle constituents were measured when sampled air masses originated south of Beijing and moved over the area with low wind speeds. During such periods, a strong increase of daytime concentrations of the secondary ions sulfate, nitrate, ammonium, and also some dicarboxylic acids could be observed.

The comparison of a suburban sampling site to an urban one revealed a clear influence of urban emissions on top of the regional pollution level for a period with relatively stagnant meteorological conditions and high photochemical processing. In contrast, during measurement periods with higher wind speeds and different air mass origins, the concentration levels of particulate pollutants were basically the same at the two sites.

During an intensive period, a strong diurnal variation of particle sulfate concentration with increasing values from morning to afternoon was observed, which could be attributed to regional production. Similar observations where made for oxalic acid. Generally, water soluble organic carbon concentrations were enhanced by a factor of 2 in fine particles during the studied period of intense photochemistry. Elemental carbon, alkanes, and PAHs showed clear nighttime concentration maxima obviously due to enhanced emissions and a relatively low mixing volume during night. For the newly studied compound group of nitrooxy-organosulfates qualitative data can be presented indicating an influence of night-time chemistry and/or anthropogenic activities on their concentrations.

The investigation of an intense nucleation and particle growth event revealed that the youngest particles largely consist of ammonium sulfate and primary carbonaceous material, with a possible contribution of secondary organic compounds.