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Hygroscopicity Behavior, Activation Properties and Chemical Composition of Atmospheric Aerosol at a Background Site in the Megacity Region of Peking

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Large areas of China suffer from heavy air pollution (both gaseous and particulate) caused by strong economic growth in the last two decades. However, knowledge concerning the physical and chemical properties of the resulting aerosol particles populations, and their effects on the optical properties of the atmosphere, is still sparse.
In the framework of the investigations presented here, comprehensive measurements concerning aerosol particle hygroscopicity, CCN ability, composition, and optical properties were performed. The investigations are part of the DFG-funded project HaChi (Haze in China) and are conducted in collaboration with the Peking University. A conclusive parameterization of aerosol hygroscopicity and activation data is aimed for, which will then be implemented in a meso-scale model to investigate aerosol-cloud-radiation and precipitation interactions.
During two intensive measurements campaigns (March 2009 and July/ August 2009), in-situ aerosol measurements have been performed in an air-conditioned mobile laboratory next to the Wuqing Meteorological Station (39°23'8.53"N, 117°1'25.88"E), which is located between Bejing and Tijanjin and is thereby an ideal background site in a megacity region.
The particle number size distribution (TDMPS), the particle optical properties (MAAP and nephelometer) and their hygroscopic properties at high RH (HH-TDMA, LACIS-mobile) were characterized as well as their cloud nucleating properties above supersaturation (DMT-CCNC).
24 h PM1 particle samples were continuously collected over the two campaigns in winter and summer using a DIGITEL high volume sampler (DHA-80). Additionally two 6h size-resolved samples (daytime and night-time) were collected each day applying an 11-stage Berner impactor. The size-selection of HH-TDMA, LACIS and the CCNC was synchronized with the Berner stages.
Opening analysis of the winter campaign data showed that the HH-TDMA usually detected a hydrophobic and a hygroscopic mode, i.e. the particles were externally mixed. On average the growth factor in the hydrophobic mode was about 1.1 (200nm @ 98.5%). 12% of the particles were of hydrophobic nature for 200 nm and 15% over all sizes. LACIS-mobile focused on the hygroscopic mode, as this mode is mainly responsible for the optical properties of the atmosphere at high RHs. During the whole campaign very high growth factors (GFmedian = 3.56, 200 nm @ 99.2%) were observed, close to those of ammonium sulfate, with only slight dependence on the air mass.
The analysis of the DIGITEL samples showed that the main components of PM1 are inorganic ions like the secondary formed ammonium nitrate und ammonium sulphate, as well as carbonaceous material. The organic carbon fraction is mostly dominated by water soluble organic carbon (80% in average) and was more analyzed in more detail for dicarboxylic acids, fatty acids, sugars and sugar related compounds. High concentrations of tracers like the anhydrosugar levoglucosan suggest biomass burning emissions as a dominant source of organic particles in the area.
Closure between hygroscopic growth, CCN activation and chemical composition is aimed for with two different approaches: a) one single-parameter Köhler model applying the hygroscopicity parameter kappa following [Petters and Kreidenweis, 2007] and b) a standard Köhler model using as input parameter 4 major chemical components as analyzed from the DIGITEL samples. First tests for 200 nm particles showed very good agreement for the

kappa-approach between measured and predicted critical activation. In the second approach the mass of 4 major components, namely ammonium sulfate, ammonium nitrate, sodium chloride and soluble organic mater were used as input parameter of a standard Köhler model including an insoluble core. Here the hygroscopic growth factor was underestimated, but the activation point was predicted well.

Petters, M. D., and S. M. Kreidenweis (2007), A single parameter representation of hygroscopic growth and cloud condensation nucleus activity, Atmospheric Chemistry and Physics, 7, 1961-1971.