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Hygroscopic growth of urban aerosol particles in Beijing (China) during wintertime: a comparison of three experimental methods

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Abstract. The hygroscopic properties of atmospheric aerosols are highly relevant for the quantification of radiative effects in the atmosphere, but also of interest for the assessment of particle health effects upon inhalation. This article reports measurements of aerosol particle hygroscopicity in the highly polluted urban atmosphere of Beijing, China in January 2005. The meteorological conditions corresponded to a relatively cold and dry atmosphere. Three different methods were used: 1) A combination of Humidifying Differential Mobility Particle Sizer (H-DMPS) and Twin Differential Mobility Particle Sizer (TDMPS) measurements, 2) A Hygroscopic Tandem Differential Mobility Analyzer (H-TDMA), and 3) A simplistic solubility model fed by chemical particle composition determined from Micro Orifice Uniform Deposit Impactor (MOUDI) samples. From the H-DMPS and TDMPS particle number size distributions, a size-resolved descriptive hygroscopic growth factor (DHGF) was determined for the relative humidities (RH) 55%, 77% and 90%, and particle diameters between 30 and 400 nm. In Beijing, the highest DHGFs were observed for accumulation mode particles, 1.40 (±0.03) at 90% RH. DHGF decreased significantly with particle size, reaching 1.04 (±0.15) at 30 nm. H-TDMA data also suggest a decrease in growth factor towards the biggest particles investigated (350 nm), associated with an increasing fraction of nearly hydrophobic particles. The agreement between the H-DMPS/TDMPS and H-TDMA methods was satisfactory in the accumulation mode size range (100–400 nm). In the Aitken mode range (<100 nm), the H-DMPS/TDMPS method yielded growth factors lower by up to 0.1 at 90% RH. The application of the solubility model based on measured chemical composition clearly reproduced the size-dependent trend in hygroscopic particle growth observed by the other methods. In the case of aerosol dominated by inorganic ions, the composition-derived growth factors tended to agree (± 0.05) or underestimate (up to 0.1) the values measured by the other two methods. In the case of aerosol dominated by organics, the reverse was true, with an overestimation of up to 0.2. The results shed light on the experimental and methodological uncertainties that are still connected with the determination of hygroscopic growth factors.

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