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Study of physically measured and chemistry-based modeled hygroscopic growth of atmospheric aerosol particles over Central Europe

Joanna Stepien (1,2), Alfred Wiedensohler (1), Wolfram Birmili (1), and Erik Sogaard (2)
(1) Leibniz Institute for Tropospheric Research (IfT) Leipzig, Germany, (2) Aalborg University, Esbjerg, Denmark

In the face of the existing uncertainties related to the climate-relevant predictions of global aerosol models there is a clear need to develop hygroscopic growth modules that are simplistic enough for application in global aerosol models, but which are tested against in-situ observations. Hygroscopic growth factors (HGF) of atmospheric particles (diameter range 50-265 nm) at 90% relative humidity (RH) were determined in this study at the atmospheric research station Melpitz, Germany, between September and October 2008 using a Hygroscopic Tandem Differential Mobility Analyzer (H-TDMA). Simultaneously, the chemical particle composition (mass concentrations of the sulfate, nitrate, and ammonium ions, as well as organic matter) was measured by an Aerosol Mass Spectrometer (AMS, Aerodyne Research Inc.). Additionally, the total mass concentration of black carbon was measured by a Multi Angle Absorption Photometer (MAAP). In this investigation, we calculated HGF at 90% RH using a simplistic particle growth model assuming a homogeneous particle mixture (Zdanovskii-Stokes-Robinson mixing rule), initialized by experimental chemical composition. The calculated HGFs were compared against the H-TDMA growth factors of 265nm particle diameter, which is taken representative of the accumulation particle mode. A main result is that temporal variations in the observed mean HGFs (1.2 - 1.7) could be well explained by changes in chemical particle composition. A main determinant for these temporal changes was the mass fraction of inorganic ions (ammonium sulfate and nitrate). The correlation (R) between measured and predicted hygroscopic growth factors was between 0.82 and 0.84 for the set of 230 data points, and depended only weakly on the exact choice of hygroscopic growth factors for the pure chemical sub-fractions. The most significant disagreement between measured and predicted HGFs occurred when the aerosol was strongly externally mixed (as determined from H-TDMA data). Under these circumstances, the model overestimates the observed HGFs. The best selected model which corresponds most precise to GF measured values had four fractions of solubility classes: ammonium sulfate, ammonium nitrate, OM and EC. The range of partial growth factors for different solubility classes have been calculated and evaluated in IDL code. Our work indicates that variations in the hygroscopic growth of continental aerosol particles can be related within reasonable accuracy to the observed chemical composition of the particles.