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Investigation of water adsorption and hygroscopicity of atmospherically relevant particles using a commercial vapor sorption analyzer

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Water adsorption and hygroscopicity are among the most important physicochemical properties of aerosol particles, largely determining their impacts on atmospheric chemistry, radiative forcing, and climate. Measurements of water adsorption and hygroscopicity of nonspherical particles under subsaturated conditions are non-trivial because many widely used techniques require the assumption of particle sphericity. In this work we describe a method to directly quantify water adsorption and mass hygroscopic growth of atmospheric particles for temperature in the range of 5-30 ^{o}C, using a commercial vapor sorption analyzer. A detailed description of instrumental configuration and experimental procedures, including relative humidity (RH) calibration, is provided first. It is then demonstrated that for $(NH_4)_2SO_4$ and NaCl, deliquescence relative humidities (DRHs) and mass hygroscopic growth factors measured using this method show good agreements with experimental and/or theoretical data from literature. To illustrate its ability to measure water uptake by particles with low hygroscopicity, we used this instrument to investigate water adsorption by $CaSO_4$•$2H_2O$ as a function of RH at 25 ^{o}C. The mass hygroscopic growth factor of $CaSO_4$•$2H_2O$ at 95% RH, relative to that under dry conditions (RH $<$ 1%), was determined to be (0.450$\pm$0.004)% (1 σ). In addition, it is shown that this instrument can reliably measure a relative mass change of 0.025%. Overall, we have demonstrated that this commercial instrument provides a simple, sensitive and robust method to investigate water adsorption and hygroscopicity of atmospheric particles.