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On the Response Time of Single Levitated Particles of Atmospherically Relevant Composition to Changes in Relative Humidity at Low Temperatures

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Recent studies have shown that atmospheric aerosol particles can adopt an amorphous solid state, particularly under cold and dry conditions. The diffusion of water molecules in these particles is believed to be slow enough such that the particles are not able to equilibrate immediately to changes in the relative humidity. This retarded response has consequences for both the heterogeneous chemistry on these particles and their ability to act as cloud condensation nuclei. In this work, we present the experimentally observed signatures of particles which showed kinetically impeded water uptake and release. Single levitated particles, 2 to 20 microns in radius, are levitated without wall contact in an electrodynamic balance and analyzed with optical techniques. Further, we demonstrate that these signatures can be used to compute the liquid-phase water diffusion coefficient in the concentration range where the liquid-phase diffusion limits the equilibration to the gas phase, i.e. in the highly concentrated range for most aqueous systems. As heterogeneous crystallization is suppressed, the procedure described here is sensible to a concentration and temperature range where traditional methods to measure diffusion coefficients might produce unsatisfying results. The model substances investigated in this study can be regarded as surrogates for atmospheric aerosol. The derived diffusion coefficients together with literature data on pure water are parameterized as a function of concentration and temperature and can be used to directly calculate the response time of aerosol particles to changes in the ambient conditions.