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PARAMETERIZATIONS FOR SURFACE TENSION EFFECT ON EQUILIBRIUM RADIUS OF A HYGROSCOPIC AEROSOL PARTICLE

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ABSTRACT

The equilibrium size of an atmospheric aerosol particle is a key property, affecting its light-scattering behavior, dry deposition, and the like. For a hygroscopic particle of given composition this size is determined by the particle dry mass (which can alternatively be expressed as the equivalent dry radius rd) and the relative humidity RH. Surface tension also affects this equilibrium size (Kelvin effect) and thus the associated properties. To first order, the decrease in equilibrium particle radius at a given fractional relative humidity h (=RH/100) resulting from the Kelvin effect is approximately $r \sim c\,h/(1-h)$, where c is a constant that depends on the solute and varies only slightly with temperature. This decrease depends only on relative humidity and is independent of rd. For aqueous ammonium sulfate particles at typical temperatures $c \sim 0.25$ nm; at 85% RH neglect of the Kelvin effect results in overestimation of the equilibrium radius of such a particle by ~1.4 nm, independent of radius. This expression also yields a relationship between RH and rd (or radius at a given RH) describing when neglect of the Kelvin effect results in a specified error in determination of the particle radius. For example, for RH less than 95% neglect of the Kelvin effect results in less than a 5% overestimation of radius for an ammonium sulfate particle with rd greater than 30 nm; for RH less than 99% this criterion requires rd greater than 150 nm. An expression for the equilibrium radius of an aerosol particle as a function of RH that includes the Kelvin effect and is accurate over the range of relative humidities up to and including 100% is also presented.
