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Relationship between aerosol hygroscopicity and relative humidity dependence of optical properties

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Atmospheric aerosol particles affect the Earth's radiative energy balance directly by scattering and absorbing incident light. Therefore, accurate determination of optical properties of atmospheric aerosols is essential. The magnitude of the direct radiative forcing is affected by changes in aerosol optical properties (scattering, absorption, extinction) due to water uptake under conditions of increasing relative humidity (RH). Aerosol hygroscopicity such as hygroscopic growth factor has been measured by hygroscopic tandem differential mobility analyzer (HTDMA). However, relationship between hygroscopicity and RH dependence of optical properties of ambient aerosols has not been well studied.

In this study, simultaneous measurements of hygroscopicity and RH dependence of light extinction of ambient aerosols were performed using a HTDMA system and a newly developed cavity ring-down aerosol extinction spectrometer (CRDS) at Higashiyama campus of Nagoya University from 18 to 26 February 2009. During the period, aerosol size distributions and scattering coefficients were also measured by a scanning mobility particle sizer (SMPS) and a nephelometer, respectively. Ambient particles were dried using diffusion dryers with silica gel and molecular sieves after passing through a PM1 cyclone and introduced into these instruments. Distributions of hygroscopic growth factor at RH of 85% for ambient aerosols with diameters of 100, 200, 300, and 400 nm were measured using the HTDMA system. RH dependence of aerosol extinction coefficients, were measured using the CRDS instrument with two measurement cells, in which the RH were controlled at <30% and 85%, respectively. f(RH) values are calculated from the ratio of measured extinction coefficients at <30% and 85%. f(RH) values are also estimated using the observed distributions of hygroscopic growth factor and size distributions of dried aerosols by applying Mie scattering theory. As a results, temporal variations of the f(RH) observed by the CRDS were well reproduced by those estimated from hygroscopicity data obtained by the HTDMA. In this presentation, possible factors (such as aerosol size, refractive index, and mixing state) contributing to RH dependence of extinction coefficients will be discussed.

Keywords: Aerosol hygroscopicity, Aerosol optical properties,
Relative humidity dependence of extinction, Cavity ring-down spectroscopy,
Hygroscopic tandem differential mobility analyzer