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The impact of aerosol hygroscopic growth on the single-scattering albedo and its application on the NO_2 photolysis rate coefficient

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Hygroscopic growth of aerosol particles can significantly affect their single-scattering albedo (ω), and consequently alters the aerosol effect on tropospheric photochemistry. In this study, the impact of aerosol hygroscopic growth on ω and its application to the NO_2 photolysis rate coefficient (JNO_2) are investigated for a typical aerosol particle population in the North China Plain (NCP). The variations of aerosol optical properties with relative humidity (RH) are calculated using a Mie theory aerosol optical model, on the basis of field measurements of number–size distribution and hygroscopic growth factor (at RH values above 90 %) from the 2009 HaChi (Haze in China) project. Results demonstrate that ambient ω has pronouncedly different diurnal patterns from ω measured at dry state, and is highly sensitive to the ambient RHs. Ambient ω in the NCP can be described by a dry state ω value of 0.863, increasing with the RH following a characteristic RH dependence curve. A Monte Carlo simulation shows that the uncertainty ofω from the propagation of uncertainties in the input parameters decreases from 0.03 (at dry state) to 0.015 (RHs > 90 %). The impact of hygroscopic growth on ω is further applied in the calculation of the radiative transfer process. Hygroscopic growth of the studied aerosol particle population generally inhibits the photolysis of NO_2 at the ground level, whereas accelerates it above the moist planetary boundary layer. Compared with dry state, the calculated JNO_2 at RH of 98 % at the height of 1 km increases by 30.4 %, because of the enhancement of ultraviolet radiation by the humidified scattering-dominant aerosol particles. The increase of JNO_2 due to the aerosol hygroscopic growth above the upper boundary layer may affect the tropospheric photochemical processes and this needs to be taken into account in the atmospheric chemical models.