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# Aging of black carbon and its impact on aerosol optical properties using a size and mixing state resolved model

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The mixing state of black carbon (BC) aerosols, namely, the degree to which BC particles are coated with other aerosol components, has been recognized as important for evaluating aerosol radiative forcing. In order to resolve the BC mixing state explicitly in models and accurately simulate the time evolution of the entire BC mixing state, the Model of Aerosol Dynamics, Reaction, Ionization, and Dissolution (MADRID) with resolution of a mixing state of BC (referred to as MADRID-BC hereafter) has recently been developed. In this study, we apply MADRID-BC to evaluate the influence of changes in BC mixing state on aerosol optical properties and cloud condensation nuclei (CCN) activities in air parcels horizontally transported out from an urban area in Japan within the planetary boundary layer (PBL) over the ocean. The evaluation shows that the coatings on BC particles enhance light absorption at a wavelength of 550 nm by 38% in air leaving the source region and by 59% after transport over the ocean for half a day. When the model treats aerosols using the conventional size-resolved sectional representation that does not resolve BC mixing states, the simulated absorption coefficients and single scattering albedos are greater by 35-44% and smaller by 7-13%, respectively, than those from a simulation that resolves the BC mixing state. These results indicate that it is essential to take into account BC-free particles in atmospheric models for accurate prediction of aerosol optical properties, because the conventional representation cannot separately treat BC-containing and BC-free particles in each size section. The evaluation also shows that BC-containing particles having 55% and 83% of the BC mass can act as CCN at a supersaturation of 0.05% when they leave the source region and after transport for half a day, respectively. These results suggest the importance of the uplifting of BC particles from the PBL near source regions for their efficient long-range transport in the free troposphere. Results from comparisons with aerosol optical measurements conducted during various campaigns, such as the Asian Aerosol Characterization Experiment (ACE Asia) and the Indian Ocean Experiment (INDOEX), suggest that MADRID-BC simulations can capture general features of aerosol optical properties in outflow from anthropogenic sources.