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Evaluation of black carbon radiative effect using a mixing state resolved three-dimensional model

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This study evaluates the uncertainties in black carbon (BC) and its optical and radiative parameters over East Asia (spring 2009) using a BC mixing state resolved three-dimensional model that can explicitly calculate BC processes in the atmosphere such as emissions, aging processes by condensation and coagulation, the enhancement of absorption and CCN activity by the aging, activation to cloud, and dry and wet deposition. The focus of this study is the uncertainties in the size distribution and the mixing state in emissions. One base case simulation and 14 sensitivity simulations are conducted to understand the variability of BC mass concentrations in column, absorption aerosol optical depth, and the radiative forcing by BC absorption due to the uncertainties in emissions. The variability of BC optical and radiative parameters is estimated to be 39-59%. This variability corresponds to BC absorption forcing from -12.6 to 6.5 W m^{-2} at the surface and from 4.3 to 6.6 W m^{-2} at the top of atmosphere over East Asia, showing the importance of the treatment of the size and the mixing state in emissions. In contrast, the variability of BC mass concentrations is 17% and smaller than that of BC optical and radiative parameters. Therefore, BC optical and radiative parameters (BC mass concentrations) are more (less) sensitive to the size and the mixing state in emissions. This result shows that the following two points are important in the estimation of BC radiative forcing. The first is to reduce the uncertainties in the size and the mixing state in emissions. The second is to improve the representation of BC mixing state and the enhancement of BC absorption in aerosol models because most models do not treat them sufficiently. My analysis also shows that coagulation and lens effect (absorption enhancement due to the change in BC mixing state) play important roles to make the different variability between BC mass concentrations and BC optical and radiative parameters.

Keywords: aerosol, black carbon, mixing state, mixing state resolved three-dimensional model, absorption enhancement, radiative forcing