Black carbon aging and its impact on the spatial distribution and radiative forcing using a MRI global climate model

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A new parameterization of black carbon (BC) aging, which enables the representation of spatial and temporal variations of the conversion rate from hydrophobic BC to hydrophilic BC, has been developed (Oshima and Koike, 2013) using a size and mixing state resolved aerosol box model, Model of Aerosol Dynamics, Reaction, Ionization, and Dissolution (MADRID) (Zhang *et al.*, 2004) with resolution of the mixing state of BC (MADRID-BC) (Oshima *et al.*, 2009a; 2009b). In this study, we apply the parameterization to the Model of Aerosol Species IN the Global Atmosphere (MASINGAR-mk2), which is included in the earth system model of the Meteorological Research Institute (MRI-ESM) (Yukimoto *et al.*, 2012), to evaluate the impact of the BC aging on its spatial distribution and radiative effects. We conducted the model calculations for the years of 2008-2009 with horizontal resolutions of approximately 120 km (TL159) and 48 vertical layers from the surface to a model top of 0.01 hPa. The model calculation with the parameterization shows that the conversion timescales from hydrophobic BC to hydrophilic BC exhibit distinct spatial variations. Their annual averages are approximately within one day and one week over East Asia (source regions) and the Arctic (remote regions), respectively. Comparisons with the calculation using the constant conversion rate (1.2 days, used in the original approach) show that both calculations reproduce the seasonal variations of BC mass concentrations observed by the surface measurements reasonably well over East Asia. On the other hand, although the constant-rate calculation largely underestimates the BC mass concentrations observed over the Arctic, the use of the parameterization improves the concentration levels and reproduces the seasonal variations. The direct radiative forcing by BC (annually and globally averaged at the top of atmosphere) is estimated to be approximately 0.3 W m^{-2} for the calculation with the parameterization (0.2 W m^{-2} for the constant-rate calculation). These results indicate that the aging process of BC can significantly impact on its spatial distribution and radiative forcing in the global-scale.

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