Improved simulations of global black carbon distributions by modifying wet scavenging processes in convective and mixed-phase clouds

*Mingxu Liu[1], Hitoshi Matsui[1]

1. Graduate school of environmental studies, Nagoya University

In-cloud wet scavenging dominates the wet removal of aerosols in the atmosphere, but is not well represented in climate models. Aircraft measurements of black carbon (BC) concentrations suggest that models commonly overestimate BC concentrations in the upper troposphere of the tropics by more than one order of magnitude but underestimate BC burdens in polar latitudes. In this study, we improved the in-cloud wet scavenging parameterizations for convective clouds and mixed-phase clouds to better characterize BC abundances in the remote atmosphere (remote oceans and polar regions) with a global model, CAM5-ATRAS2. The modified wet scavenging processes in the model achieved a more realistic simulation of BC concentrations over both the tropics and the Arctic. The new, unified scheme for vertical transport and wet removal during deep convection generally reproduced the observed low mixing ratios (about 0.1 ng kg^{-1}) of BC in the middle and upper troposphere over the tropics, and the Wegener–Bergeron–Findeisen process lowered the wet removal efficiency of BC from mixed-phase clouds and consequently increased BC burdens in the Arctic by about a factor of 2. The BC direct radiative forcings increased by 20% globally (from 0.26 to 0.31 W m^{-2}), and more importantly by a factor of 2 in the Arctic (from 0.09 to 0.18 W m^{-2}). Our results indicated that good agreement between modeled and observed BC concentrations could be obtained in the remote atmosphere without requiring the relatively short global BC lifetime (~4 days) suggested by previous studies.

Keywords: Black carbon, Global climate model, Aerosol-cloud interactions, Deep convection, Mixed-phase clouds