

Brown Carbon in East Asia: Seasonality, Sources, and Influences on Regional Climate and Air Quality

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Brown carbon (BrC) has been recognized as an important light-absorbing carbonaceous aerosol, yet understanding of its influence on regional climate and air quality has been lacking, mainly due to the ignorance of regional coupled meteorology-chemistry models. Besides, assumptions about its emissions in previous explorations might cause large uncertainties in estimates. Here, we implemented a BrC module into the WRF-Chem model that considers source-dependent absorption and avoids uncertainties caused by assumptions about emission intensities. To our best knowledge, we made the first effort to consider BrC in a regional coupled model. We then applied the developed model to explore the impacts of BrC absorption on radiative forcing, regional climate, and air quality in East Asia. We found notable increases in aerosol absorption optical depth (AAOD) in areas with high OC concentrations. The most intense forcing of BrC absorption occurs in autumn over Southeast Asia, and values could reach around 4 W m^{-2} . The intensified atmospheric absorption modified surface energy balance, resulting in subsequent declines in surface temperature, heat flux, boundary layer height, and turbulence exchanging rates. These changes in meteorological variables additionally modified near-surface dispersion and photochemical conditions, leading to changes of $\text{PM}_{2.5}$ and O_3 concentrations. These findings indicate that BrC could exert important influence in specific regions and time periods. A more in-depth understanding could be achieved later with the developed model.