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Radiative absorption enhancement of dust mixed with anthropogenic pollution over East Asia

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The particle mixing state plays a significant yet poorly quantified role in aerosol radiative forcing, especially for the mixing of dust (mineral absorbing) and anthropogenic pollution (black carbon absorbing) over East Asia. We have investigated the absorption enhancement of mixed-type aerosols over East Asia by using the Aerosol Robotic Network observations and radiative transfer model calculations. The mixed-type aerosols exhibit significantly enhanced absorbing ability than the corresponding unmixed dust and anthropogenic aerosols, as revealed in the spectral behavior of absorbing aerosol optical depth, single scattering albedo, and imaginary refractive index. The aerosol radiative efficiencies for the dust, mixed-type, and anthropogenic aerosols are -101.1, -112.9, and -98.3 $Wm^{-2}\tau^{-1}$ at the bottom of the atmosphere (BOA); -42.3, -22.5, and -39.8 $Wm^{-2}\tau^{-1}$ at the top of the atmosphere (TOA); and 58.7, 90.3, and 58.5 $Wm^{-2}\tau^{-1}$ in the atmosphere (ATM), respectively. The BOA cooling and ATM heating efficiencies of the mixed-type aerosols are significantly higher than those of the unmixed aerosol types over the East Asia region, resulting in atmospheric stabilization. In addition, the mixed-type aerosols correspond to a lower TOA cooling efficiency, indicating that the cooling effect by the corresponding individual aerosol components is partially counteracted. We conclude that the interaction between dust and anthropogenic pollution not only represents a viable aerosol formation pathway but also results in unfavorable dispersion conditions, both exacerbating the regional air pollution in East Asia. Our results highlight the necessity to accurately account for the mixing state of aerosols in atmospheric models over East Asia in order to better understand the formation mechanism for regional air pollution and to assess its impacts on human health, weather, and climate.