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Observation-based estimates of light-absorbing aerosol radiative forcing in East and South Asia

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Light-absorbing aerosols, such as black carbon (BC) are major contributors to the atmospheric heating and the reduction of solar radiation reaching at the earth's surface. In this study, we investigate light-absorption properties of aerosols (i.e. BC mass concentration, aerosol solar-absorption efficiency) and corresponding atmospheric heating effect in Asian continental outflow from ground-based in-situ and lightweight Unmanned Aerial Vehicle (UAV) measurements within the framework of UNEP Atmospheric Brown Cloud (ABC) project. We compared light-absorption properties of aerosols and its radiative forcing observed in East and South Asia. Black carbon (BC) mass concentration, aerosol scattering and absorption coefficients measurements and radiative forcing calculations were performed at four sites: Korea Climate Observatory-Gosan (KCO-G), Korea Climate Observatory-Anmyeon (KCO-A), Maldives Climate Observatory-Hanimaadhoo (MCO-H) and Nepal Climate Observatory-Pyramid (NCO-P). No significant seasonal variations of BC mass concentration, aerosol scattering and absorption coefficients, except for summer due to wet scavenging by rainfall, were observed in East Asia, whereas dramatic changes of light-absorbing aerosol properties were observed in South Asia between dry and wet monsoon periods. Although BC mass concentration in East Asia is generally higher than that observed in South Asia, BC mass concentration at MCO-H during winter dry monsoon is similar to that of East Asia. The observed solar absorption efficiency (absorption coefficient/extinction coefficient) at 550 nm at KCO-G and KCO-A is higher than that in MCO-H due to large portions of BC emission from fossil fuel combustion. Interestingly, solar absorption efficiency at NCO-P is 0.14, which is two times great than that in MCO-H and is about 40% higher than that in East Asia, though BC mass concentration at NCO-P is the lowest among four sites. Consistently, the highest elemental carbon to sulfate ratio is found at NCO-P. Throughout the UAV experiment in Jeju, Korea during August-September 2008, long-range transport of aerosols from Beijing, Shanghai and Marine plumes were sampled in aerosol layers up to 3-4 km above sea level. The diurnal mean solar heating rate, calculated from the observed solar fluxes in shortwave regime (0.3 $\sim$ 2.8 [U+F06D] m), at 3 $\sim$ 4 km altitudes for Beijing and marine plume conditions were about 1.0 and 0.75 K/day, respectively. This suggests that an increase of BC concentrations above the boundary layer in the polluted Beijing plume contributed about 30% of atmospheric heating. Furthermore, by comparing with observations of the S. Asian plumes over the N. Indian Ocean, we show that E. Asian aerosols are 100% more efficient in solar absorption, confirming that fossil-fuel-dominated BC plumes is more efficient as a warming agent than biomass-burning-dominated plumes.