Long-term observations of black carbon at Fukue Island during 2009–2015: Rates of emissions from East Asia and removal

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Black carbon is a component of atmospheric fine aerosol particles contributing to global warming. However, its emission strengths and removal rates have not been sufficiently understood. We have conducted long-term observations of black carbon mass concentrations using a COSMOS instrument since 2009 at Fukue Island (32.75°N, 128.68°E), western Japan, to provide information on the emission strengths of important source regions in East Asia and on wet removal rate constraints. The annual average mass concentration was 0.36 μg m^{-3}, with distinct seasonality; high concentrations were recorded during autumn, winter, and spring, and were caused by Asian continental outflows, which reached Fukue Island. Statistical analysis of the observed ΔBC/ΔCO ratio was separately made for two classes of data with and without a wet removal effect, using the accumulated precipitation along a backward trajectory (APT) for the last 3 days as an index. The emission ratios estimated from observations with zero APT (5.2–6.9 ng m^{-3} ppb^{-1}) varied over the six air mass origin areas; the higher ratios for South Central East China and South China indicated the relative importance of domestic emissions and/or biomass burning sectors. The BC/CO emission ratios adopted in the bottom-up Regional Emission inventory in Asia (REAS) version 2 (6.5–23 ng m^{-3} ppb^{-1}) over the continent were significantly higher; the ratios needed to be reduced by 60% for China and by a factor of 3.5 for Korea, although the ratio for Japan was in an acceptable range. The wintertime enhancement of the BC emission from China, predicted by REAS2, was verified for air masses from South Central East China. Wet removal of BC was clearly identified as a decrease in the ΔBC/ΔCO ratio against APT. The transmission efficiency (TE), defined as the ratio of the ΔBC/ΔCO ratio with precipitation to that without precipitation, was fitted reasonably well by a stretched exponential decay curve against APT. The dependence on APT was almost similar among the air mass types. An accumulated precipitation of 15 mm halved the BC mass concentration. This expression of wet removal and the emission constraint for East Asia help to test and improve chemical transport and/or climate model simulations.

Keywords: aerosol particles, trans-boundary air pollution, climate Effect, budget analysis, process analysis

