Abundances of black carbon and iron oxide aerosols over East Asia and the Arctic from the aircraft measurements

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Black carbon (BC) and light-absorbing iron oxides (FeO_x) aerosols affect Earth's energy budget through their strong absorption of solar radiation. FeO_x aerosols can also affect global biogeochemical cycles through their role as a nutrient for oceanic phytoplankton. However, observational data (atmospheric concentrations and microphysical properties) for these light-absorbing aerosols, required for evaluating their effects using global climate models, are scarce, especially for FeO_x. Here, we summarize and compare the datasets of BC and FeO_x from three aircraft observation campaigns: A-FORCE 2009 and 2013W (Aerosol Radiative Forcing in East Asia) and PAMARCMiP 2018 (Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project), all of which relied on the same instrument, a modified single-particle soot photometer.

In these campaigns, > 80% of FeO_x-containing aerosols in the 170–270 nm size range had microphysical features indicating an anthropogenic origin. The mass concentrations of FeO_x were ~100–400 ng/m^3 in East Asia (A-FORCE 2009 and 2013W) but as low as ~5 ng/m^3 in the Arctic (PAMARCMiP 2018); the corresponding values for BC were ~300–1000 ng/m^3 in East Asia and ~25 ng/m^3 in the Arctic. Despite these large variabilities in mass concentration, the mass ratios of FeO_x/BC had a narrow range within ~0.2–0.5. In all observations, FeO_x, BC, and carbon monoxide (CO) concentrations were strongly correlated with each other. These results indicate that FeO_x, BC, and CO were emitted in nearly the same areas with similar emission ratios.

In the two East Asian campaigns (A-FORCE 2009 and 2013W), BC mass concentrations tended to decrease with altitude, but there was no such tendency in the Arctic campaign (PAMARCMiP 2018); the peak in BC concentration in PAMARCMiP 2018 locates at the highest altitude (~5 km), which might be contributed from emissions in lower-latitude sources.

The FeO_x/BC mass concentration ratios tended to increase with altitude in the A-FORCE 2009 and 2013W datasets from East Asia. This result might be due to an increased contribution of FeO_x-containing mineral dust at higher altitudes. In contrast, this ratio tended to decrease with increasing altitude in the Arctic dataset (PAMARCMiP 2018). The altitude dependence of the particle-size distribution of FeO_x in the PAMARCMiP 2018 dataset shows that, in contrast to the A-FORCE 2009 and 2013W campaign, large FeO_x particles (>1 μm) were not observed in high altitudes. These contrasts between the East Asian and Arctic regions might reflect differences in the fractional contribution of windblown mineral dust particles from desert regions and in the effect of wet removal processes during the transport of FeO_x from its source regions.

Abundances of BC and FeO_x using the dataset obtained from ground measurements in addition to aircraft measurements will also be discussed in the presentation.

Keywords: aircraft measurement, black carbon, iron, East Asia, Arctic

