Global simulations of tagged black carbon aerosols: Implications for Asian emissions and long-range transport to the Arctic

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Black carbon aerosols have substantial impacts on air quality and climate from regional to global scales. In the present study we implemented a tag-tracer scheme of black carbon (BC) into a global chemistry-transport model GEOS-Chem, and examined long-range transport of BC from various sources to the Arctic and quantified the source contributions. We distinguished BC tracers by source types (anthropogenic and biomass burning) and regions; the global domain was divided into 16 and 27 regions for anthropogenic and biomass burning emissions, respectively. Our simulation showed that BC originating from Europe and Russia is transported to the Arctic mainly in the lower troposphere during winter and spring. In particular, BC transported from Russia extensively distributed over the Arctic in winter and spring, leading to the dominant contribution of 62 % to the Arctic BC near the surface in annual mean. In the middle troposphere, BC from East Asia is transported to the Arctic mainly through Okhotsk Sea and East Siberia during winter and spring. We identified important region where a strong inflow from East Asia to the Arctic occurs (130–180˚E and 4–7 km altitude at 66˚N). The model demonstrated that the contribution from East Asia to the Arctic shows a maximum at about 5 km altitude due to the uplifting during the long-range transport in early spring. The efficiency of transport from East Asia to the Arctic is smaller than the other large source regions such as Europe, Russia and North America. However, the contribution of East Asia is most important to the middle troposphere (41 %) and BC burden (27 %) over the Arctic because of the large emission from this region. These results suggest that the main sources of the Arctic BC are different with altitude. The total contribution of anthropogenic sources to BC concentrations near the surface is dominant compared with that of biomass burning in annual mean. However, for total deposition of BC on the Arctic, the contributions of biomass burning from Siberia and Alaska and Canada that become large only during summer were estimated to be 15 % and 12 %, respectively.

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