



## **Model analysis of long-range transport of black carbon to the Arctic with tagged tracer simulation**

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We investigated long-range transport of black carbon (BC) from various sources to the Arctic and quantified source contributions using a tagged tracer simulation with a global chemical transport model GEOS-Chem. We firstly evaluated the simulated BC by comparison with observations at the Arctic sites and found that seasonal variations are improved by implementing an aging parameterization and reducing wet scavenging rate by ice clouds. For tagging BC, 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.