Concentrations and Size Distributions of Black Carbon in the Surface Snow at Syowa station in Eastern Antarctica in 2011

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Aerosol particles are emitted from both natural and anthropogenic sources and travel across the globe. They influence the climate through becoming cloud condensation and ice nuclei and absorbing and scattering solar radiation both in air and on snow/ice surfaces. Black carbon (BC) is one of the most important aerosol particle for the climate and absorbs light as an impurity in surface snow/ice. As the result, BC exhibits positive radiative forcing and contributes to global warming. However, the climate effect by BC in snow still has large uncertainties because observations of BC concentrations and size distributions within surface snow are limited, especially in Antarctica. This study measured the concentrations and size distributions of BC and inorganic ions in snow samples collected at the Syowa station in Antarctica from April 2011 to December 2011 and along a traverse route to an inland (Mizuho) station during the 52nd Japanese Antarctic Research Expedition (JARE52).

The modified single particle soot photometers (SP2) were used for analyses of BC concentrations and size distributions between 70 nm and 4170 nm in snow. The average mass and number concentrations of BC (C_{MBC} and C_{NBC}) between April and November were 288.2 ng L^{-1} and 101.5 particle μL^{-1}, respectively, and those during December increased to 2117.3 ng L^{-1} and 812.7 particle μL^{-1}, respectively. The C_{MBC} and C_{NBC} of the Mizuho traverse route samples were 727.7–1153.2 ng L^{-1} and 249.6–454.6 particle μL^{-1}, respectively and were 1.7–2.7 times higher than those of the Syowa samples during the same period. The C_{MBC} values were consistent with those in previous studies observed in other areas of Antarctica. The size distributions of BC in snow were bimodal with MMD values of ~140 nm (fine) and ~690 nm (coarse). The MMD estimated by single lognormal functions in our study (149–191 nm) were smaller than those in other areas of Antarctica, and the average mass of BC particle (m_{BC}) was 2.8 (1.8–5.8) fg particle^{-1}, which is smaller than typical values in the Arctic. Inorganic ions in snow in Syowa mainly originated from sea salt and did not correlate with C_{MBC} and C_{NBC}. The Na^+ and Cl^- concentrations in snow largely decreased with increasing distance from the coastal area.

The BC concentrations in the ground-level atmosphere did not correlate with those of snow; i.e., the BC concentrations increased in December when the ambient temperature increased above 0 °C with strong solar irradiance. This result indicates that the BC concentrations in snow are largely influenced by postdeposition processes such as sublimation, snow melting and evaporation. Inorganic ion concentrations away from the coastal area were lower than those at the Syowa station (coastal area), suggesting that small contributions of snow transported from the ocean in the inland region. Relatively high BC concentrations away from the coastal area suggest the transport from the upper atmosphere and the less snow accumulation in inland. BC size distributions in our samples were smaller than those in other regions with neighboring BC sources. This result suggests that the BC in the Antarctic snow originated through a long-range transport, resulting in decrease in m_{BC} values by the removal of large BC particles during the transport.

References

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