Black Carbon in Snowpack over the Different Regions in the Arctic

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Black carbon (BC) deposited on snow lowers snow albedo, potentially contributing to the warming in the Arctic. It is critically important to measure the spatial distributions of BC in snowpack in different regions of the Arctic to quantify this effect. However, accurate measurements of BC in snowpack are very limited because of the large uncertainties in the previous measurements. We measured size-resolved BC mass concentrations (C_{MBC}) in snowpack over Finland, Alaska, Siberia, Greenland, and Spitsbergen in early spring between 2012 and 2016 by using a single-particle soot photometer. We collected 108 samples of surface snow, 77 samples of subsurface snow, and 112 columns of snowpack in these regions in total. The amounts of BC deposition (DEP_{MBC}) during snow accumulation periods were derived from C_{MBC} and snow water equivalent (SWE). The average C_{MBC} in each region was well correlated with the average anthropogenic BC emission flux (r^2 = 0.77), suggesting significant influences of anthropogenic BC emissions on C_{MBC} on regional scales. The average size distributions of BC in snowpack shifted to smaller sizes with the decrease in C_{MBC}, likely due to an increase in the removal efficiency of BC with the increase in BC diameter during the transport from major sources. The previous C_{MBC} obtained by using an Integrating Sphere/Integrating Sandwich spectrophotometer were much larger than our C_{MBC} in the overlapping regions. The present data of C_{MBC}, SWE, and DEP_{MBC} will be useful in constraining climate model to estimate the effect of BC on the climate of the Arctic.