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Effects of BC concentration recently measured in snowpack and possible change of snow grain size on albedo reduction

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Drastic melting of snow and ice has been occurring recently in the Arctic and the melting rate is in general higher than predictions by general circulation models (GCM). The one possible reason is black carbon (BC) contained in snow and ice, which could reduce the albedo. However, snow albedo strongly depends not only on light absorbing snow impurities such as BC but also on snow grain size which is associated with temperature increase. Furthermore, the albedo reduction rate per unit concentration of snow impurities depends on snow grain size. On the other hand, many efforts were dedicated to measure the BC concentrations in snowpack or ice core in the Arctic, midlatitudes and Antarctica since 1980s. Using these results we can approximately classify the ranges of BC concentrations in each area as follows: around one ppbw in Antarctica, of the order of 1 ppbw in Greenland, of the order of 10 ppbw in the Arctic except Greenland, and of the order of 100 ppbw in the midlatitudes. According to these values, we estimated the snow albedo reductions due to BC in snow together with the possible range of snow grain size change from new snow to melting snow using a physically based snow albedo model. We found that (1) BC has no effect on albedo reduction in Antarctica, (2) albedo reduction in Greenland due to BC is less than 0.01, (3) BC effect on albedo reduction (0.01-0.05) is smaller than snow grain growth effect (0.15) and it could enhance the albedo reduction when snow grain size increases in the Arctic except Greenland, and (4) BC effect (0.15) is comparable to snow grain growth effect on albedo reduction in the midlatitudes. For more accurate predictions of climate condition in cryosphere, both the effects of light absorbing snow impurities like BC and snow grain growth associated with temperature increase on albedo reduction are needed to be incorporated in GCMs.

Keywords: snow albedo, black carbon, snow grain size, Arctic, Antarctica