Effect of snow impurities on albedo observed during 8 winter seasons in Sapporo

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Recently, snow accumulation area and snow covering period are decreasing mainly in the Arctic region. As the snow and ice surface has generally high albedo, the albedo decreases due to melting of snow and ice accompanying by global warming. As a result, absorption of solar radiation by the ground increases, which could accelerate global warming furthermore. In Sapporo, a typical domestic snow cover area, it is reported that the snow albedo depends strongly on snow grain size and snow impurity concentration (Aoki et al., 2003, 2007). In this study, we investigated the effect of snow impurity concentration on albedo in Sapporo using physical based snow albedo model (PBSAM) developed by Aoki et al. (2011). The observation site is the meteorological observation field (43° 04' 56"N, 141° 20' 30"E, 15 m a.s.l) of the Institute of Low Temperature Science of Hokkaido University. The observation period is 8 winter seasons from 2007 to 2015. We compared the observed broadband albedos with the theoretical values calculated by inputting the observed snow and radiation data into the PBSAM. In addition, numerical sensitivity experiments on albedo changes due to snow impurities were conducted.
Comparing the time series of the observed albedo and the model calculated value in each year of the analysis period, it is found that the simulated albedo variations due to the change in snow grain size and impurity concentration agreed well with the observations. The determination coefficient (R^2) and the root mean square error (RMSE) in the whole period obtained from the albedo comparison between the observation and the calculation in the shortwave (SW) region were 0.831 and 0.045, respectively, confirming the high accuracy of PBSAM. Next, sensitivity experiments were conducted on albedo changes in the visible (VIS), near-infrared (NIR), and SW regions depending on the presence or absence of snow impurities which consist of black carbon (BC) and mineral dust. The albedo change due to snow impurities (BC + dust) in the whole period was -0.085 in the VIS region, -0.016 in the NIR region, and -0.053 in the SW region. We also investigated the contributions from BC and dust to the total SW albedo change, which were -0.043 and -0.009 by BC and dust, respectively. In addition, the ratio in SW albedo change during accumulation period and melting period (melting period / accumulation period) was 4.1 times for BC, 12.0 times for dust, and 4.9 times for BC + dust.

References

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