Possible effect of snow contamination with soot on albedo reduction

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The effect of atmospheric aerosol deposition into snowpack (snow impurities) on snow albedo reduction is discussed using radiation budget observation, atmospheric aerosol monitoring, and snow pit work during the winter of 2003/2004 in Sapporo, Japan (Aoki et al., 2006). To investigate the effect of optical properties of snow impurities, we compared the measured visible albedos with theoretically calculated ones. Figure 1 illustrates the relationship between mass concentration of snow impurities and measured 30-minute mean visible albedo, and theoretically calculated maximum and minimum visible albedos during observation period using a radiative transfer model for the atmosphere-snow system (Aoki et al., 1999). The maximum and minimum curves are determined from simulated albedos for the all possible ranges of geometric condition, sky condition and, snow physical parameters during observation period using a method of Aoki et al. (2003). The maximum visible albedo is expected for the smallest snow grain radius (25 um) at the largest solar zenith angle (66.6 deg) under clear sky, and the minimum visible albedo is calculated for the largest snow grain radius (1000 um) at the smallest solar zenith angle (66.6 deg) under clear sky.

Since the optical properties of snow impurities are uncertain factors, we assured the typical aerosol models as the same manner as Motoyoshi et al. (2005), in which three types of aerosol mixings from mineral dust (MD) and soot (ST) were assumed as: (1) MD-only model (MD only), (2) MD with ST of 0.25 ppmw model (MD+ST0.25), and (3) MD with ST of 0.5 ppmw model (MD+ST0.50). In these impurity models, light absorption is weakest for MD-only and strongest for MD+ST0.50. The optical properties for MD and ST were employed from the transport mode of the mineral dust model and the soot model of Optical Properties of Aerosols and Clouds (OPAC) database by Hess et al. (1998). In Fig. 1, the range between the maximum and minimum albedo curves for each aerosol mixing type means the possible variation range of visible albedo. The data of visible albedos of approximately 0.9 were measured for new snow during the core accumulation season. These data are not distributed in the range of theoretically predicted visible albedo for the MD-only case, but in ranges for MD+ST0.25 or MD+ST0.50. Even the highest albedos are lower than the maximum albedo curve of MD+ST0.5. These results suggest that the snow was contaminated with not only mineral dust but also more absorptive soot.

Recently, it was reported that the light absorption of natural mineral dust is weaker than those of existing mineral dust models containing OPAC mineral dust model from the atmospheric aerosol studies (e.g., Aoki et al., 2005). If we assume the mineral dust model with weaker absorption, theoretically calculated all curves in Fig. 1 shift to the higher direction. It further supports our result of a possibility of snow contamination with soot.

References

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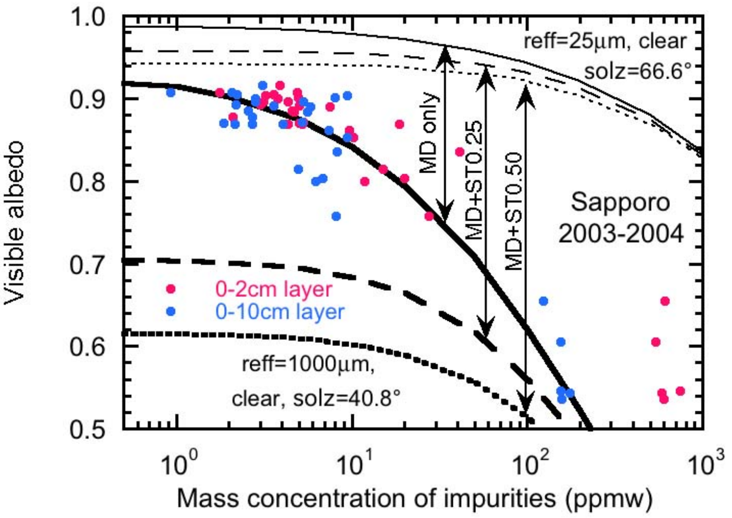
Fig. 1 Relationship between mass concentration of snow impurities and visible albedos averaged from 1131 to 1200 LT at each day (colored dots). Red circles indicate the snow sampling layer 0 to 2 cm, and blue circles denote 0 to 10 cm. Thin and thick curves indicate theoretically predicted maximum and minimum albedos during the observation period for snow impurity models (1) MD only, (2) MD+ST0.25, and (3) MD+ST0.50. 'reff' is effective snow grain radius and 'solz' is solar zenith angle assumed in albedo calculations.



Visible albedo
Mass concentration of impurities (ppmw)
1.0
0.9
0.8
0.7
0.6
0.5
10^0
10^1
10^2
10^3
reff=25µm, clear
solz=66.6°
MD only
MD+ST0.25
MD+ST0.50
Sapporo
2003-2004
0-2cm layer
0-10cm layer
reff=1000µm,
clear, solz=40.8°