Annual and seasonal variation trend of light-absorbing snow impurities components at Sapporo, Japan

*Akane Tsushima[1], Masashi Niwano[1], Teruo Aoki[2], Nozomu Ohkawara[1], Tomonori Tanikawa[1], Sumito Matoba[3], Kouji Adachi[1], Takeshi Kinase[1], Koji Fujita[4]

1. Meteorological Research Institute, 2. National Institute of Polar Research, 3. Institute of Low Temperature Science, Hokkaido Univ., 4. Graduate School of Environmental Studies, Nagoya Univ.

Light-absorbing snow impurities (LASIs), such as elemental carbon (EC), organic carbon (OC), and mineral dust are important parameters that control the snow albedo. Especially, EC, also known as black carbon (BC), is the most light-absorptive snow impurity and has gotten a lot of attention recently. LASIs reduce the visible albedo[1)], so that increase the absorption of solar radiation, thus promoting snow melting. Increase in snow grain size caused by enhanced snow melting reduces the near-infrared albedo, which would trigger a positive feedback on snowmelt. As a result, LASIs have a significant effect on the timing of snow disappearance in the seasonal snow-covered area[2)], therefore, it is important to understand the control factors of these variations. In this study, we showed the mass concentration of EC, OC, total carbon (TC=EC+OC) and total insolubility impurities(dust) in surface snow (surface layer; 0-2cm sub-surface layer; 0-10, 2-10cm) collected twice a week in winter season for 11 years at the Institute of Low Temperature Science, Hokkaido University, located in an urban area of Sapporo, Japan. In addition, we considered their changing factor by comparing with chemical components (SO_4^{2-}, NO_3^-, Cl^-, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}).

The EC, OC, and dust concentrations of the surface layer for 11 years fluctuated greatly in the ranges of 0.002-1.92, 0.013-12.7, and 0.137-260 ppmw, respectively. Also, the median values were 0.143, 0.301, and 3.57 ppmw, respectively. Here, we divided the snow-covered season (December to April) into the following two periods by referring to the variations of snow depth and snow surface temperature; that is, accumulation season and melting season. Seasonal fluctuation patterns of EC, OC, and dust in both the surface layer and the sub-surface layer were very similar, and all components showed high values in the snow melting season (Fig. 1). We also found the relationship between EC and OC concentrations were clearly different in each period (Fig. 2), and the relationship in the melting period (Fig. 2b) was similar to the previously reported result in aerosol of China[3)]. From the result, we suggest that the EC-OC relationship in the snow at Sapporo can be affected by the aerosol from China especially during the melting season when airmass transportation from China to Japan occurs frequently.

Reference;

1)Warren and Wiscombe, 1980, J. Atmos. Sci., 37, 2734-2745.
2)Niwano et al., 2012, J. Geophys. Res., 117, F03008.
3)Cao et al., 2005, Atmos. Chem. Phys., 5, 3127–3137.

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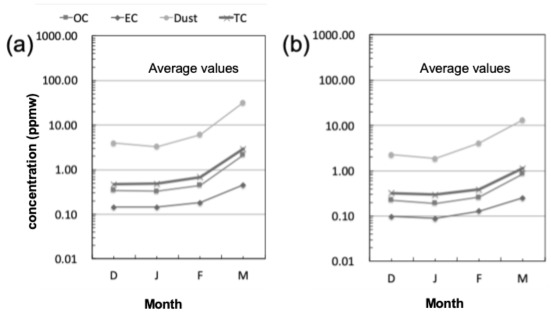

Fig.1 Seasonal variations of snow impurities (EC, OC, TC and dust) for 11 years in (a)surface layer and (b)sub-surface layer

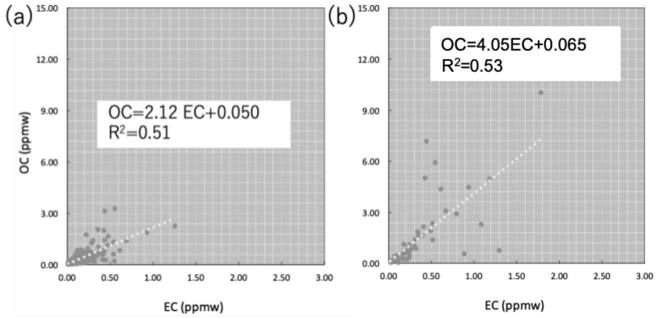

Fig.2 Scatter diagram of EC and OC concentrations in (a)accumulation season and (b)melting season