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Possible effects of snow grain size and snow impurity concentration on the albedo measured at SIGMA-A in Greenland

Teruo Aoki[1*], Sumito Matoba[2], Satoru Yamaguchi[3], Tomonori Tanikawa[4], Masashi Niwano[1], Tetsuhide Yamasaki[5], Katsuyuki Kuchiki[1], Hideaki Motoyama[6], Masahiro Hori[4]

[1]Meteorological Research Institute, [2]Institute of Low Temperature Science, [3]National Research Institute for Earth Science and Disaster Prevention, [4]Japan Aerospace Exploration Agency, [5]Arctic Explorer, [6]National Institute of Polar Research

Snow and ice in the Arctic are presently undergoing drastic changes. The snow surface albedo strongly depends on snow grain size and mass concentration of light absorbing impurities. To clarify the contributions of light absorbing snow impurities to recent abrupt melting of snow/ice in Greenland, intensive observations of meteorological and snow parameters have carried out at the site SIGMA-A (78^{o}03'N, 67^{o}38'W, 1,490 m a.s.l.) on northwestern Greenland ice sheet during the intensive observation period (IOP) from June 26 to July 16, 2012. We installed automatic weather station to measure the meteorological elements, radiation budget, snow temperatures, and relative snow height. We have also performed snow pit work and snow samplings for light absorbing snow impurities. During the IOP no precipitation was observed in the first two weeks and a large amount of rainfall with remarkable lowering of snow surface was observed in the middle of July, when a melting event of surface snow/ice over 97% of Greenland ice sheet occurred. Snow grain shapes observed from snow pit work for snow layer of about 80 cm (annual accumulation) changed from melt forms for upper layer and depth hoar beneath that to melt forms for all layers during the IOP. Light absorbing snow impurities found from snow samples were black carbon (BC) and mineral dust, whose concentrations at surface were both increased from 0.9 ppbw to 4.9 ppbw and from 102 ppbw to 1327 ppbw during the IOP, respectively. We calculated the possible albedo reduction by the measured snow impurity concentrations using a physically based snow albedo model. The maximum albedo reduction due even to EC of 4.9 ppbw is less than 0.01 for typical grain size of melt forms, while it could be enhanced by the effect of dust of 1327 ppbw. BC equivalent total impurity concentration is estimated to be about 15 ppbw (albedo reduction -0.015). This result was consitent with the albedos measured during the IOP. The particle size of mineral dust found in surface snow during the latter half period of IOP was larger than 5 micrometers. This indicates a possible transport of mineral dust onto ice sheet surface. Mineral dust is important as nutrient salt for glacial microbial activities, which reduce the albedo in ablation area and could accelerate the melting of ice sheet.

Keywords: Greenland, albedo, snow grain size, light absorbing snow impurities, black carbon, dust