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地上及び衛星リモートシングによって推定された北西グリーンランド氷床上SIGMA-Aにおける積雪粒径
Snow grain size retrieved with ground and satellite-based remote sensing at SIGMA-A on northwestern Greenland ice sheet

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Snow grain size is one of the most important physical parameters which represent the qualitative snow surface condition. A metamorphosis of snow grains such as sintering or melting causes a snow grain growth, thus the estimation of snow grain size is useful for detecting signs of snowmelt. Snow grain size can be remotely sensed from the near-infrared albedo or reflectance. Furthermore, the vertical information of snow grain size also can be estimated using the wavelength dependence of the photon penetration depth. The snow grain size derived from the shorter wavelength contains the information on a deeper snow layer than those from the longer wavelength. To validate the remote sensing of snow grain size and its vertical profile, snow grain sizes retrieved with ground and satellite-based remote sensing using different spectral channels at 865, 1240 and 1640 nm were compared with in-situ measurements at the SIGMA-A site (78^{o}03'N, 67^{o}38'W, 1,490 m a.s.l.) on northwestern Greenland ice sheet during June 26 to July 16, 2012.

The ground-based remote sensing are from spectral albedos measured with a spectrometer, while the satellite-based remote sensing are from reflectances at the top of the atmosphere by Terra/Aqua MODIS. The snow grain sizes retrieved from both the ground and satellite-based method were consistent well for the same spectral channels with the root mean square differences of less than 0.1 mm. This result implies that the algorithms for snow grain size retrieval were reasonable each other. In-situ measured snow grain size was defined as the width of the narrow portion of broken crystals. On July 4 and 5, melt forms with the radius of 0.5 mm beneath surface hoar of 0.15 mm were measured with snow pit work. The snow grain radii derived from the 1640, 1240 and 865 nm channels were 0.1, 0.25 and 0.6 mm, respectively, which agreed with the in-situ measured profile of snow grain size. During July 6 to 9, the top 10 cm snow layer was mainly composed of melt forms around 0.50 mm. The remotely sensed snow grain radii were 0.1, 0.6 and 1.1 mm for the 1640, 1240 and 865 nm channels, respectively. The overestimation at 865 nm might be result from the reduction in the snow reflectance by the ice layers observed in near snow surface. The underestimations at 1640 nm were also reported in previous studies when the grain size was large. The size derived from the 1640 nm channel would be affected by the microstructures on snow crystal surface as well as the grain size itself due to the smaller penetration depth for large snow grains. After the rainfall event from July 10 to 13, the extreme melt was detected as the increase of the MODIS-derived snow grain radii up to 0.4, 1.0 and 1.3 mm for the 1640, 1240 and 865 nm channels, respectively.

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