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雪氷微生物で覆われた北西グリーンランドの氷河表面の波長別アルベド
Spectral albedos of glacier surfaces covered with glacial microbes in northwestern Greenland

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Snow and ice in the Arctic are presently undergoing drastic changes. The mass balance loss from the Greenland Ice Sheet increased significantly after the mid-1990s. One of the possible reasons of snow/ice surface melting is due to the increases of light absorbing impurities in snow/ice and snow grain size. This is because the surface albedo of snow (ice) is strongly controlled by mass concentration of light absorbing impurities including glacial microbes and snow (ice) grain size. To clarify this we carried out the spectral albedo measurements on ablation area in Qaanaaq Glacier in northwestern Greenland in July 2011. The almost glacier surfaces in the ablation area were covered with cryoconite (biogenic dust) on ice grain layer with the size of 1 to 2 centimeters and the several-centimeter depth above bare ice. There were also cryoconite holes (a water filled cylindrical melt-holes with cryoconite on the bottom), red snow (snow algae) and rivulets in some parts of the glacier surfaces. We measured the spectral albedos of the glacier surfaces using a spectrometer FieldSpecr3 (ASD Inc., USA) for a spectral range from 350 to 2500 nm. The target surface conditions are comparatively homogeneous cryoconite, bare ice, and red snow. The measured spectral albedos had a remarkable contrast between red snow surface and ice surface covered with cryoconite mainly for the ultraviolet to visible regions (350-750 nm), where red snow albedo increased rapidly with the wavelength, while cryoconite surface albedo was relatively flat. The spectral albedos of cryoconite surface in the spectral domain from 1000 to 1400 nm were higher than that for the underlying bare ice. This is due to light scattering by ice grains, on which the cryoconite covers, above the bare ice. We also simulated the spectral albedos of cryoconite surface and red snow surface with a radiative transfer model for the atmosphere-snow system. The snow grains are assumed to be spherical particles with the size of several millimeters and the ice grains are non-spherical particles with the size of several tens millimeters. Those grain sizes are based on in-situ measured values. For the effects of snow impurities of cryoconite and snow algae (red snow), we simply assumed the optical properties of mineral dust of in-situ measured mass concentrations with external mixtures. The theoretically calculated albedos were higher than the measurements for the spectral region less than 750 nm for both cases of cryoconite and red snow. The differences would be the effects of glacial microbes.

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