Spatial variations in biogenic impurities in the ablation area of Gulkana Glacier in Alaska

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Glaciers and ice sheets in the arctic regions have recently decreased their mass due to not only warming climate but also to decline of surface albedo. Light absorbing impurities such as black carbon, mineral dust, and organic matter in snow and ice can reduce surface albedo and accelerate melting of snow and ice. In particular, cryoconite and glacier algae are major constituents of the albedo reducing impurities on glaciers. Cryoconite are dark-colored microbial aggregates formed by filamentous cyanobacteria and usually consisted of the small spherical aggregates, called cryoconite granules. Glacier algae are green algae growing on the ice surface and are mostly species of Ancylonema nordensholdii, which has deep-purple pigments in their cells. However, spatial variations of such microbial impurities and their controlling factors are not understood well. In this study, we investigated distributions of the microbial impurities in the ablating ice area on Gulkana Glacier in Alaska to describe their spatial variations and to discuss the darkening process of the ice surface.

The fieldworks were carried out in July, 2019 on Gulkana Glacier, which is one of the best studied glaciers located in the sub-arctic region in Alaska. We took aerial photographs of the ablation ice area using a UAV to describe distribution of dark colored impurities and topography of the ice surface. We also collected surface ice samples at the 42 points in the ablation area and analyzed concentrations of chlorophyll a and soluble ions in Chiba University.

The aerial photographs showed that the dark ice surface was distributed in the upper area near the medial moraine (western side of the glacier) in the ablation area (between 1600 m and 1700 m). In this area, the dark ice surface appeared particularly along the melt water streams. As we observed that cryoconite were deposited at the bottom of the streams, cryoconite in the melt water streams is one of the major factors causing the surface darkening in this area. The aerial photographs also showed that the red or purple-colored ice surface appeared partially in this area. The ice samples collected in this area contained abundant algal cells, which were mostly A. nordensholdii and M. berggrenii. The greater chlorophyll a concentration in the surface ice was also observed in this area. The results suggest that these glacier algae are also responsible for the surface darkening in this area.