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Spatiotemporal changes in communities of snow-ice microbes living on Gulkana Glacier, Alaska

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1. Introduction

In glaciers and snow packs, there are diverse microbes adapting to cold environments. During the melt season, snow and glacier ice algae and cyanobacteria grow, and change the color of the snow and ice surface then reduce its albedo which mean promoting the melting of glaciers. To quantify the melting rates promoted by the microbial blooming, it is necessary to evaluate the collective influence of biological communities on albedo (biological albedo reduction: BAR). However, many studies have focused only on each microbe and few conducted as a biological community. In addition, most of the sampling conducted at a single point or single area. Such sampling cannot consider the heterogeneity of the condition within the glacier. In order to understand how microbial growth is promoted on the glacier, it is necessary to clarify the spatiotemporal changes of various microbes. Therefore, the aim of this study was to describe the spatiotemporal changes of snow-ice microbes (focused on snow algae and microinvertebrates for thinking prey – predator relationship) in Gulkana Glacier, Alaska and to discuss the growth processes including and factors of distribution.

2. Methods

Study site

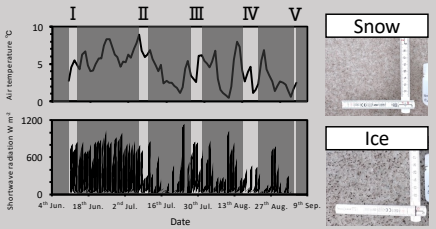
63°14'27"N 145°28'3"W
Gulkana Glacier, Alaska, USA

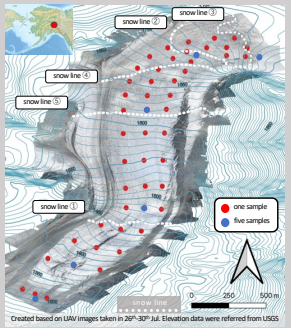
Sampling dates (melt season in 2022)

Ⅰ. 11th-14th Jun. Ⅱ. 7th-10th Jul.
Ⅲ. 26th-30th Jul. Ⅳ. 14th-20th Aug.
Ⅴ. 2nd- 3rd Sep.

Sampling collection

Collected ice surface, snow surface and cryoconite holes spatially (maximum 56 points)



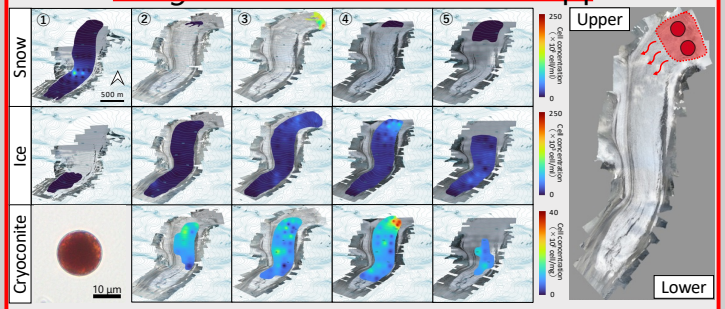


Sample analysis

- Counting with microscope
- Measuring chemical solutes, amount of impurities

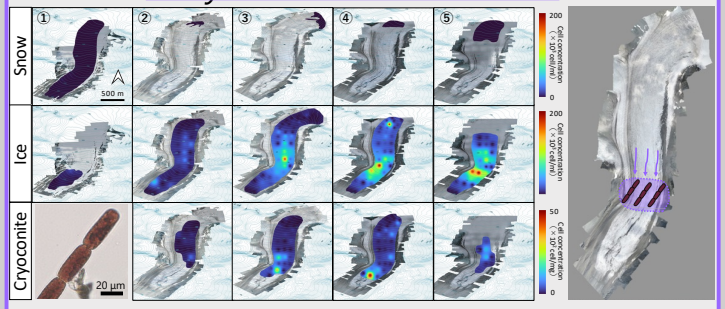
3. Results and Discussion

Sanguina and *Chloromonas* spp.



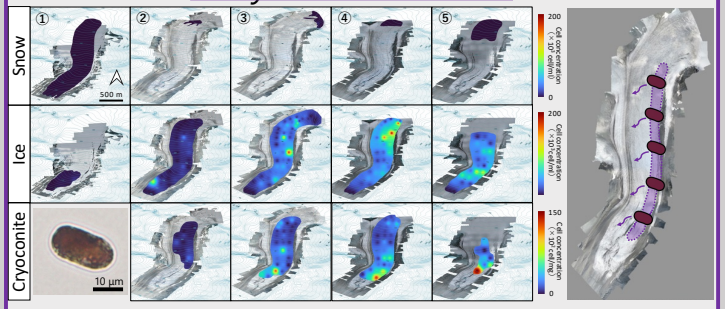
Meltwater flowing on the ice surface may affect migration into cryoconite holes

Ancylonema nordenskioeldii



Ice surface in the middle part may be preferable for this ice algae

Ancylonema alaskana



Their growth may be promoted by the presence of a moraine on the left side

Relationships between microbes and environmental conditions

On the bare ice surface

- There was not any significant correlation between microbes and chemical solutes
  → Nutrients can not explain spatial distributions of microbes in ice surface

On the snow surface

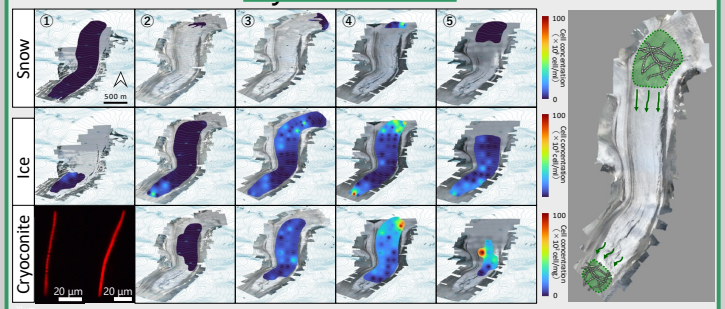
- Red snow algae and tardigrades had the significant positive correlations with PO_4^{3-}
  → There are possibilities that growth of red snow algae were limited by PO_4^{3-}, then tardigrades eat these algae

Cryoconite

- There was not any significant correlation between microbes and chemical solutes
  → Nutrients can not explain spatial distributions of microbes in cryoconite

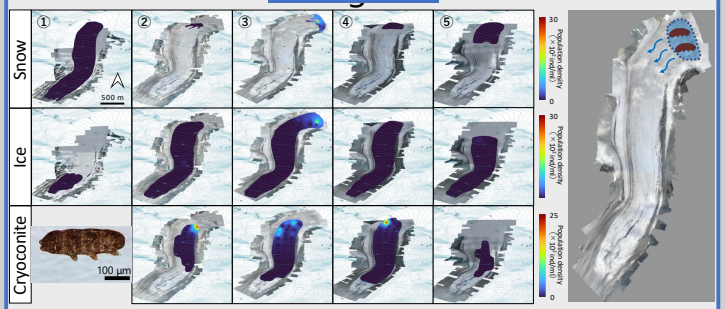
※More details were shown in appendix with spatiotemporal changes of environmental conditions

Cyanobacteria



Distribution of cyanobacteria may relate to dynamics of ice and cryoconite holes

Tardigrades



Their activity seems to be associated with snow algae

4. Conclusions

Based on the analysis of the samples collected spatiotemporally in Gulkana Glacier, Alaska, we revealed that spatiotemporal changes on the glacier differed in each microbe. It was suggested that topological heterogeneity on the glacier has possibility to provide the growth condition and determine the distribution of microbes. These results also suggeste that each microbe has different processes of growth and lead to different contributions of BAR at different points within the glacier.