Algae growth reduces reflectivity, enhances Greenland ice sheet melting

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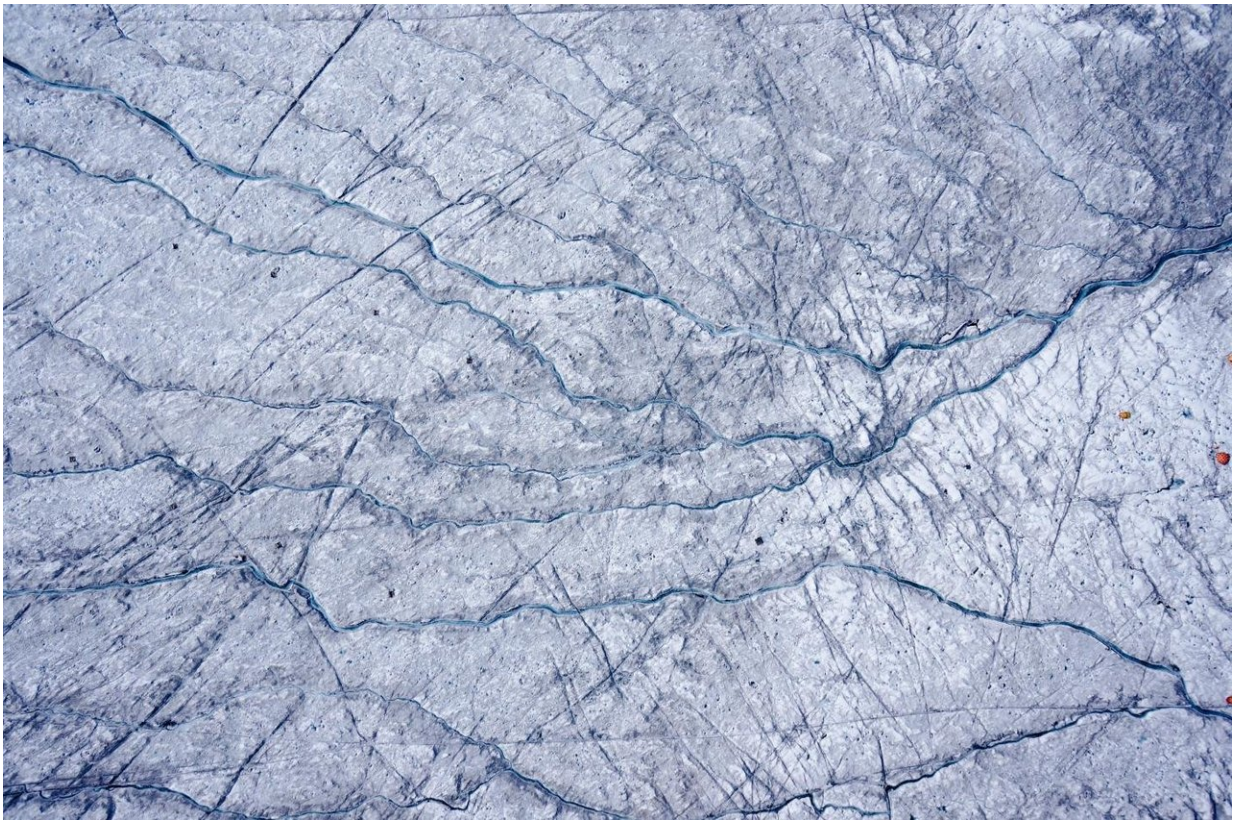


An aerial view of the study area on the Greenland ice sheet. Credit: Jason Box/Jonathan Ryan

New research shows algae growing on the Greenland ice sheet, the Earth's second-largest ice sheet, significantly reduce the surface

reflectivity of the ice sheet's bare ice area and contribute more to its melting than dust or black carbon. The new findings could influence scientists' understanding of ice sheet melting and projections of future sea level rise, according to the study's authors.

Glaciologists have long known materials such as mineral dust and black carbon can darken the surface of large ice sheets. Scientists study these impurities because they reduce the sheet's albedo, or the extent to which it reflects light, which increases melting of the ice and affects projections of sea level rise. But few studies had examined the darkening effect of algal cells, which naturally grow on the ice sheet.

The new study quantitatively assessed how surface ice algae contribute to darkening of the ice sheet, and found the algae reduce the ice sheet's albedo significantly more than non-algal materials, like mineral particles and black carbon. Algal darkening is responsible for 5 percent to 10 percent of the total ice sheet melt each summer, according to the new research published in *Geophysical Research Letters*, a journal of the American Geophysical Union.

The findings sharpen the way glaciologists think about melting of ice sheets and how ice reflects light, according to Marek Stibal, a cryosphere ecologist at Charles University in Prague, Czech Republic and one of the lead authors of the new study. A warming climate could also increase algal growth in the future, potentially boosting algae's influence on ice sheet melting, he said.

"The novel aspect of our study is that we discover biological processes play an important role in ice sheet behavior," Stibal said. "Glaciologists usually only look at inorganic materials when studying light reflectance and ice melt because biological processes are often too complicated to capture. But we find organisms can have a large-scale effect on a system that was previously studied in an abiotic context."

Study co-author Nathan Chrismas collecting surface ice for analysis. Credit: Karen Cameron/Sara Penrhyn Jones

Studying algae in the field

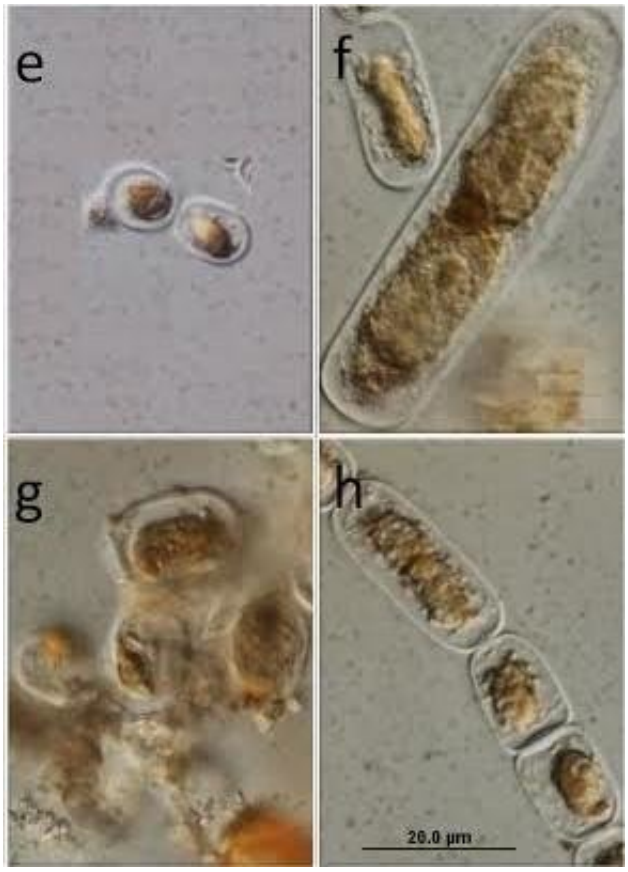
Previous studies suggested impurities such as black carbon and dust drive melting of bare ice on the lower part of the ice sheet. Impurities darken the surface of the sheet, reducing its albedo and allow it to absorb more light. The increased absorption of solar radiation raises the temperature of the ice sheet and accelerates the melting process.

Absorption of sunlight is responsible for most of the ice melt in Greenland, according to Jason Box, a climatologist at The Geological Survey of Denmark and Greenland and the other lead author of the new study.

Microbes such as algal cells colonize the ice and can accumulate over time given enough sunlight, water and nutrients. Surface ice algae produce dark pigments to protect themselves from high intensity radiation, further darkening the sheet surface, Stibal said.

The authors of the new study headed into the Greenland ice sheet in the summer of 2014 to quantify the contribution of algae to the darkening effect. Several members of their team camped at a study site in the southwestern region of the ice sheet for 56 days while gathering data on the sheet's reflectivity and algal population.

Stibal and his colleagues used portable spectrometers and albedometers to measure the reflectivity spectrum of the bare ice surface each day. They also collected samples of surface ice and used a field microscope to characterize the algae and count the number of algal cells in each sample. They analyzed the relationship between the growth of the algae and the amount of light being reflected by the ice sheet surface.



Microphotographs of ice algae (mostly the species *Ancylonema nordenskioldii*). Credit: Marian Yallop

The authors found the ice sheet reflected significantly less light as the algal population grew. They calculated algal growth accounted for approximately 70 percent of the variation in the light reflectance data, making it the dominant contributor to the phenomenon. The rest of the variation was due to rain and how much time had passed, and non-algal impurities weren't significant in their analysis.

The new study didn't estimate how much more ice could melt in the future due to algal darkening. But the results can lay the groundwork to devise more accurate projections of sea level rise scenarios due to melting ice from Greenland and other ice sheets, Stibal said. Algae grow

on other ice surfaces in areas such as the Himalayas, where they reside on water-producing glaciers.

He also believes a warming climate could be a boon to algal populations, potentially increasing their darkening influence.

"As the climate warms, the area that the algae can grow in will expand, so they'll colonize more of the ice sheet," he said. "Additionally, the growing season will lengthen, so the contribution of algae to melting of the ice will probably increase over time."

Nozomu Takeuchi, professor of earth sciences at Chiba University in Japan, said the new research highlights the importance of accounting for biological processes in the cryosphere, and believes the study will have an impact on glaciological research of the Greenland ice sheet.

"The major implication of their findings is that the ice sheet is not a simple abiotic system of snow and ice, but rather an ecosystem," he said. "Understanding this biological process more quantitatively could induce a new perspective on other climate cycles of the Earth, such as glacial-interglacial cycles."

More information: Marek Stibal et al, Algae Drive Enhanced Darkening of Bare Ice on the Greenland Ice Sheet, *Geophysical Research Letters* (2017). DOI: 10.1002/2017GL075958

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