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Earth & Space

Past ice, future ice

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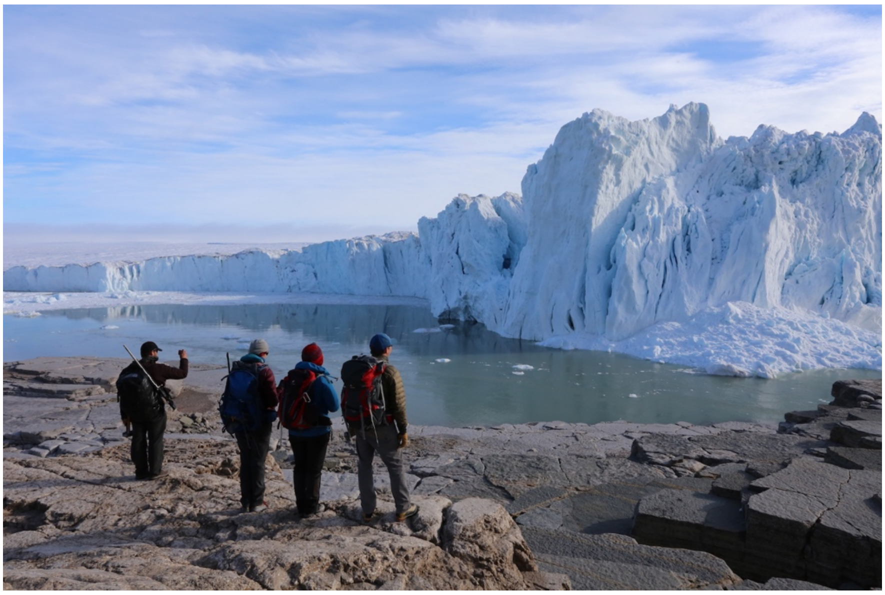
ABSTRACT

We use intricate models to predict the future of Earth's climate, and an important component of our climate system is the Greenland Ice Sheet. We are investigating the past behavior of this ice and have learned more about its sensitivity to changes in climate through time, which can help tune our models to be as accurate as possible.



Petermann Glacier from the researchers' fieldwork - Image credits: Dr. Julia Rosen ©

In order to predict the impacts of Global Warming, scientists develop climate models that attempt to represent our real, complicated climate as closely as possible. Climate is the intertwined system of the Earth's atmosphere, ocean, and ice. If we can understand how these variables interacted in the past, we can better inform climate models of future warming. Is ocean warming or atmospheric warming going to have a larger impact on ice retreat? Is there a certain glaciated part of the world that is more vulnerable? Our study aims to inform these sorts of questions.

We investigated one of the largest glaciers in Greenland: Petermann Glacier. We chose this area because it has lost a large amount of ice in the last decade, and is a major "drain" for the entire Greenland Ice Sheet. Since accelerated melting of the Petermann Glacier can have a large effect on the whole ice sheet, we want to see how this glacier responded to past changes in climate. To do this, we documented the position of the Petermann Glacier through time as it retreated away from Canada during the Last Glacial Maximum (i.e. the last "Ice Age") and compared the timing of retreat to climate records (such as atmosphere and ocean temperatures).

When a glacier or ice sheet retreats (i.e. melts back), large boulders are left on the landscape, their location representing where the edge of the ice. These are like breadcrumbs left out to tell us where the ice used to be, and this information is precisely what we need to be able to see how the ice retreated. The problem is we need to know when each boulder was abandoned to be able to compare the ice position at that time to climate at that time.

This can be done with exposure dating. We collect a rock sample from the top surface of a boulder, and measure the amount of Beryllium-10 in that sample: the more Be-10 is in that sample, the longer that rock has been exposed to the atmosphere since it was abandoned by the ice. We need to choose the largest boulders that have not rolled, which would expose a second surface to the atmosphere. Sometimes, the boulders have much more Be-10 than was expected; this is called inheritance because it likely means that boulder was exposed to the atmosphere earlier on, "inheriting" Be-10 that we measure after it is exposed for a second time.

We went to northwestern Greenland to measure where the ice sheet margin or edge had been in the past in order to learn something about how this area has responded to climate variations in the past. Our results showed that this part of the ice sheet retreated from Canada ice ~10,000 years ago and melted back to its current position with two "stops" along the way: at both 8,300 years ago and 300 years ago the ice advanced before continuing to retreat. This means that even though climate was generally warming this entire time, something in the climate system changed at or around those intervals that allowed for a healthier glacier! We looked at temperature data from ice cores and other exposure ages from the area, and correlated the pause 8,300 years ago to abrupt cooling caused by cooler ocean temperatures 8,200 years ago. The most recent advance, 800 years ago, is part of the Little Ice Age atmosphere cooling that affected all of the North Atlantic in the middle ages, and marks the most recent advance of many glaciers in the northern hemisphere.

What we've learned from our results is that this part of the Greenland Ice Sheet has responded strongly not only to the large-scale warming of the atmosphere since the last "Ice Age", but also to very abrupt and relatively small changes in ocean temperatures. Even at these high latitudes, glaciers are very sensitive to both air and ocean changes.

Think about a climate model like a big dashboard with a bunch of nobs: one for local ocean temperatures, one for atmospheric temperatures, one for precipitation, etc. The real Earth is a complicated system with many moving parts, and earth scientists of all kinds are helping to describe it. This study helps to inform climate modelers about how to adjust these nobs to better represent the real Greenland Ice Sheet. This in turn helps us predict what the future outlook is for sea level rise, as well as inform policymakers and citizens to help prepare us for a changing world.