Glacial microclimates mimic climate change

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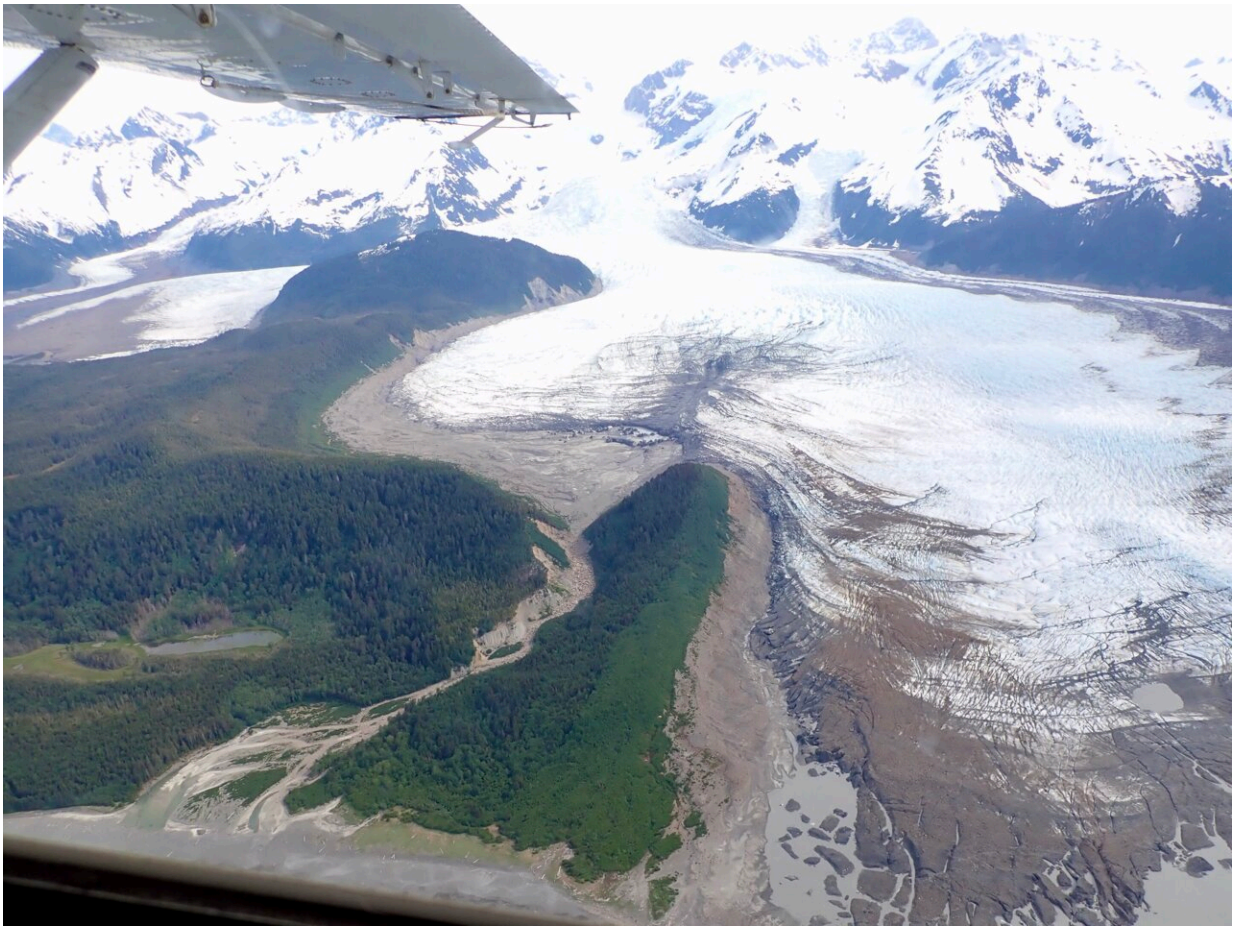

The trees around La Perouse glacier, in Glacier Bay National Forest, recorded microclimate changes as the glacier advanced and retreated. A new study in AGU's *Geophysical Research Letters* reports on how scientists can use those records to predict how near-glacier ecosystems will respond to future climate change. Credit: Benjamin Gaglioti

A cool pocket climate around the snout of a glacier could help researchers predict how forests will respond to fast climate change, according to the authors of a new 120-year case study of a rapidly advancing and retreating glacier in Alaska.

Hiking in snowy mountains or trudging by a snowbank on the sidewalk, you may have felt a cool pocket of air near a pile of snow. Trees near glaciers experience that same effect and it can slow their growth. Trees record the history of cooling in their yearly growth rings, as a new study in AGU's *Geophysical Research Letters* reports.

Tree ring growth depends on many factors, including temperature. For many species, cooler, drier conditions lead to slower growth and smaller or denser rings. The study, led by ecologist Ben Gaglioti, documents this relationship on the La Perouse glacier and the surrounding Glacier Bay National Forest in an unprecedented up close and personal view of past glacial microclimates.

From historical accounts, tree cores and aerial imagery, the team knew the glacier had rapidly advanced hundreds of meters during the late 1800s, ping-ponged during the early 1900s, and began retreating around 1950. The next step was to check whether the trees recorded microclimate shifts during those periods.

Using 118 cores from the old-growth forest of yellow cedar, they reconstructed temperatures from 1855 to 2021. After taking into account regional temperatures and elevation, the researchers found a clear slowdown of growth as the glacier advanced and increase in growth rates as it retreated. The glacier advance cooled the forest almost 4 degrees Celsius (about 7 degrees Fahrenheit) in the summer.

"That was stunning to me," Gaglioti says. "Because of the glacier's advance and retreat, the La Perouse forest experienced some of the

fastest rates of historical cooling and warming on Earth, but climate models indicate these rates of change will become more common in the next century. Studying these types of glacier-adjacent ecosystems can help us understand how they may respond to the unprecedented rate of warming in the future."

Camping on ice

Gaglioti and his colleagues stumbled onto the find while studying once-buried layers of trees that had been plowed down by glaciers in the 19th century. While sampling the rainforest trees just outside the glacier's footprint, they noticed the tree rings had compressed growth during the late 1800s, as the glacier advanced—pushing its bubble of cold air out into the woods.

"Then we had this idea to monitor the size and intensity of the cold microclimate around the ice using temperature sensors," Gaglioti says. "If the glacier went back and forth and this microclimate influenced the surrounding forest, we could use it as an experiment," he explains, to judge how ecosystems might respond to rapid climate change in the future. But first, they had to map out the seasonality of the microclimate today.

A core from a yellow cedar tree near the La Perouse glacier shows compressed growth rings during cold, dry periods, as the glacier advanced. Credit: Benjamin

Gaglioti and his colleagues installed a network of temperature sensors for hundreds of meters surrounding La Perouse Glacier and collected the data for three years, from July 2018 to July 2021. The microclimate extended at least 600 meters into the forest, the farthest distance they'd placed sensors. Without more distant sensors, "it's hard to constrain where it actually ends," Gaglioti says.

The findings also add an important source of information in reconstructing the movement of past glaciers and their influence on the surrounding biosphere. "If you look at trees that were run over by the ice, you can see the cooling effects as the ice approaches them, before they die," Gaglioti says. The trees left behind offer important climate records as the glacier retreats, as well as insights into the rate of retreat and possible influences on ecological succession once the ice has gone.

There's work yet to be done. There are five other tree species in La Perouse's microclimate and preliminary results suggest each species responds differently to the climate changes. Gaglioti hopes he can use these records to better understand how a whole forest responds to large magnitude cooling and warming. Similar microclimate records elsewhere can be used to examine climate sensitivities of other biological systems, from microbes to mammals.

More information: B. V. Gaglioti et al, Ecosystems at Glacier Margins Can Serve as Climate-Change Laboratories, *Geophysical Research Letters* (2022). DOI: 10.1029/2022GL098574

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