Permafrost thawing below shallow Arctic lakes

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Shallow lakes on the Coastal Plain of Alaska. New research finds permafrost below shallow lakes such as these is thawing as a result of changing winter climate. Credit: Christopher Arp, University of Alaska Fairbanks.

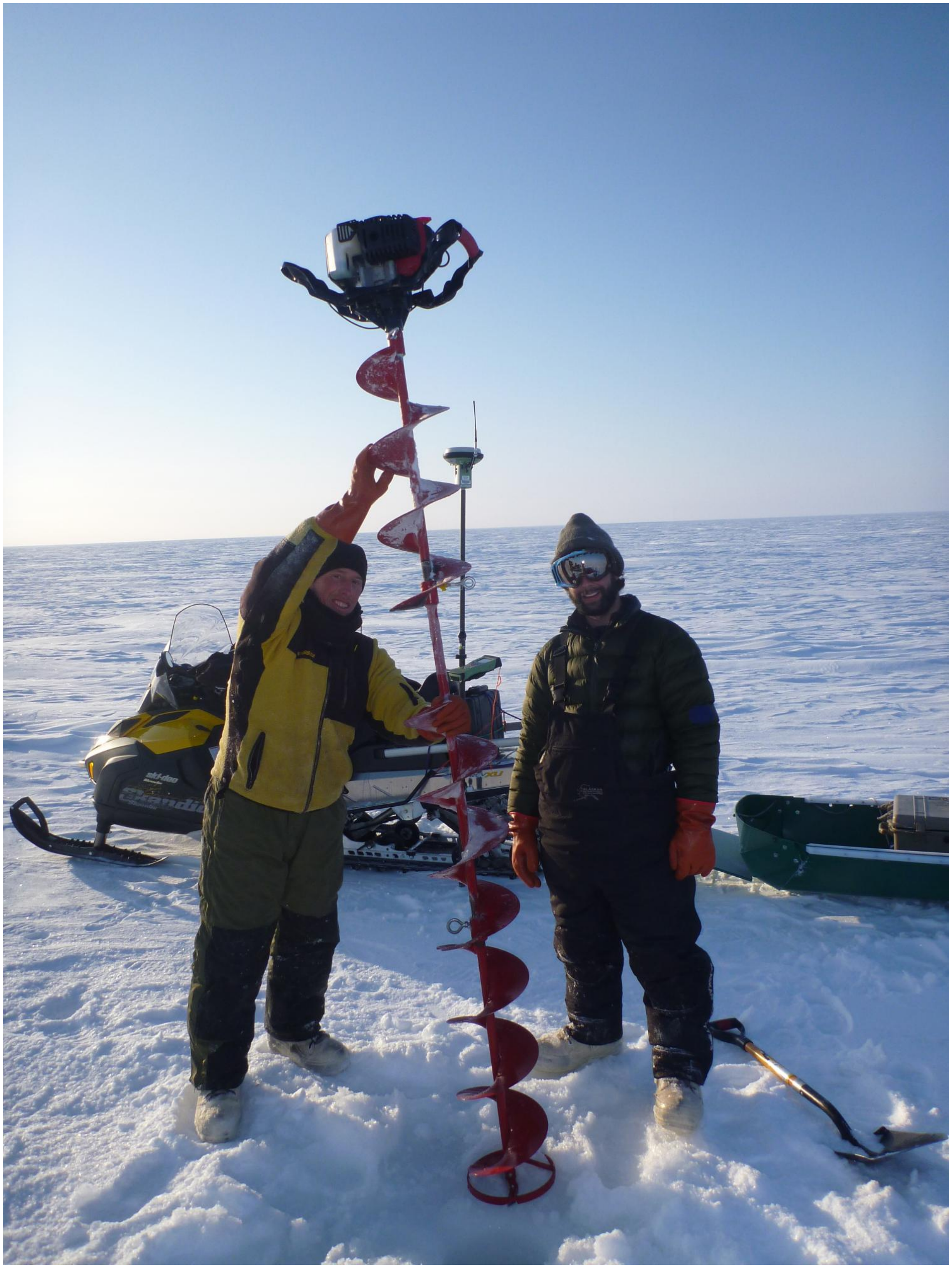
New research shows permafrost below shallow Arctic lakes is thawing as a result of changing winter climate.

Warmer winters combined with an increase in snowfall during the last 30 years have limited the growth of seasonal lake ice. In response, lakebed temperatures of Arctic lakes less than 1 meter (3 feet) deep have warmed by 2.4 degrees Celsius (4.3 degrees Fahrenheit) during the past three decades, and during five of the last seven years, the mean annual lakebed temperature has been above freezing.

These rates of warming are similar to those observed in terrestrial permafrost, yet those soils are still well below freezing and thaw is not expected for at least another 70 years. However, a regime shift in lake ice is leading to sub-lake permafrost thaw now.

Since permafrost underneath lakes is generally warmer than the surrounding terrestrial permafrost, rising temperatures in the lakebeds make permafrost thaw sooner than beneath surrounding dry land. These lakes may cover 20 to 40 percent of the landscape in vast areas of Arctic lowlands.

"During the 1970s, late winter lake ice thickness measurements commonly exceeded 2 meters (6.5 feet) in northern Alaska. Such thick ice growth helps to limit sub-lake permafrost thaw by freezing the sediments solid each winter. However, during winter field surveys over the last decade, lake ice has typically only grown to 1.5 meters (5 feet) thick, and has been as thin as 1.2 meters (4 feet)," said Christopher Arp, research assistant professor at the University of Alaska Fairbanks (UAF) Water and Environmental Research Center and lead author of the new study accepted for publication in *Geophysical Research Letters*, a journal of the American Geophysical Union.



Chris Arp, lead author of the new study (left), and Ben Gaglioti of UAF (right) hold a drill bit used to take samples of permafrost. Credit: Guido Grosse, Alfred Wegener Institute.

These drastic reductions in lake ice, caused by changes in winter climate, are the primary reason that shallow lakebed temperatures are warming and the permafrost below them is thawing.

Interactions and feedbacks among climate, permafrost, and hydrology underscore the complexity of forecasting change in the Arctic. For example, thinner lake ice may help fish overwintering, or it may help the oil industry since they need lake water to build winter ice roads. However, sub-lake permafrost thaw will likely unlock a portion of the permafrost carbon pool and potentially release this carbon in the form of greenhouse gases.

These findings also highlight the importance of conducting winter fieldwork in the Arctic.

"Arctic lakes and ponds are typically ice covered for nine months of the year, but research on them typically occurs during the short Arctic summer. To more fully understand Arctic lake dynamics and to document the changes we have observed requires also doing fieldwork under often harsh conditions during the cold and dark arctic winter," said Benjamin Jones of the U.S. Geological Survey in Anchorage and co-author of the new study.

"With further thawing of sub-lake permafrost there is a good chance that the ground will subside, increasing the lake depth and accelerating further permafrost thawing. In contrast, the warming on the land may increase the protective vegetation layer and delay thawing of permafrost outside of lakes," said Vladimir Romanovsky of the UAF Geophysical Institute and co-author of the new study.

With increasingly warmer and snowier winters yielding thinner lake ice, shallow lakes will likely continue to warm, Arp said.

More information: Christopher D. Arp et al, Threshold Sensitivity of Shallow Arctic Lakes and Sub-lake Permafrost to Changing Winter Climate, *Geophysical Research Letters* (2016). DOI: 10.1002/2016GL068506

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