# Antarctic ice shelves hold twice as much meltwater as previously thought

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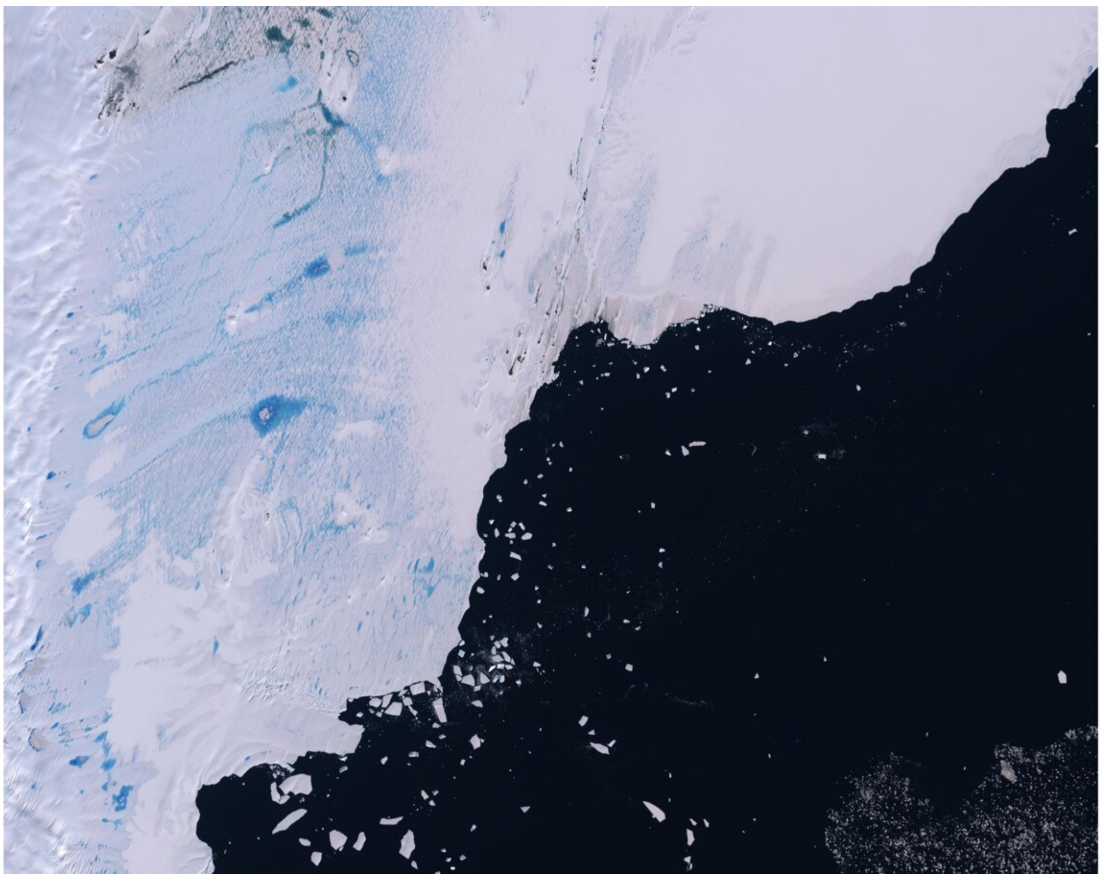


Pooled meltwater and slush on the Tracy Tremenchus Ice Shelf, which flows into the Southern Ocean. Contains modified Copernicus Sentinel data [2018], processed by Rebecca Dell. Credit: Rebecca Dell

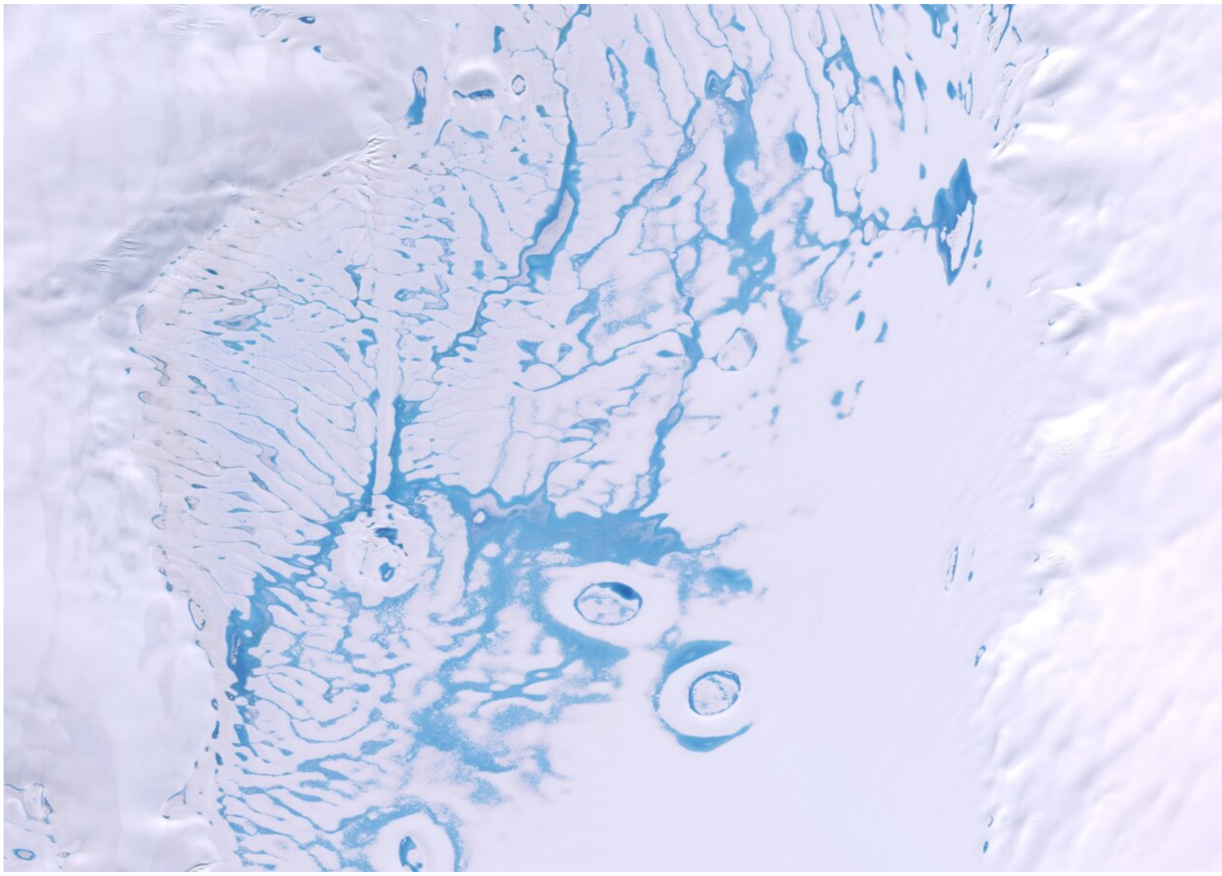
Slush—water-soaked snow—makes up more than half of all meltwater on the Antarctic ice shelves during the height of summer, yet is poorly accounted for in regional climate models.

Researchers led by the University of Cambridge have used artificial intelligence techniques to map slush on Antarctic ice shelves, and found that 57% of all meltwater is held in the form of slush, with the remaining amount in surface ponds and lakes.

As the climate warms, more meltwater is formed on the surface of ice shelves, the floating ice surrounding Antarctica that acts as a buttress against glacier ice from inland. Increased meltwater can lead to ice shelf instability or collapse, which in turn leads to sea level rise.

The researchers also found that slush and pooled meltwater leads to 2.8 times more meltwater formation than predicted by standard climate models, since it absorbs more heat from the sun than ice or snow. The results, reported in the journal *Nature Geoscience*, could have profound implications for ice shelf stability and sea level rise.

Each summer as the weather warms, water pools on the surfaces of Antarctica's floating ice shelves. Previous research has shown that surface meltwater lakes can contribute to ice shelf fracture and collapse, as the weight of the water can cause the ice to bend or break. However, the role of slush in ice shelf stability is more difficult to determine.



Pooled meltwater and slush on the Bach Ice Shelf. Contains modified Copernicus Sentinel data [2023], processed by Rebecca Dell. Credit: Rebecca Dell

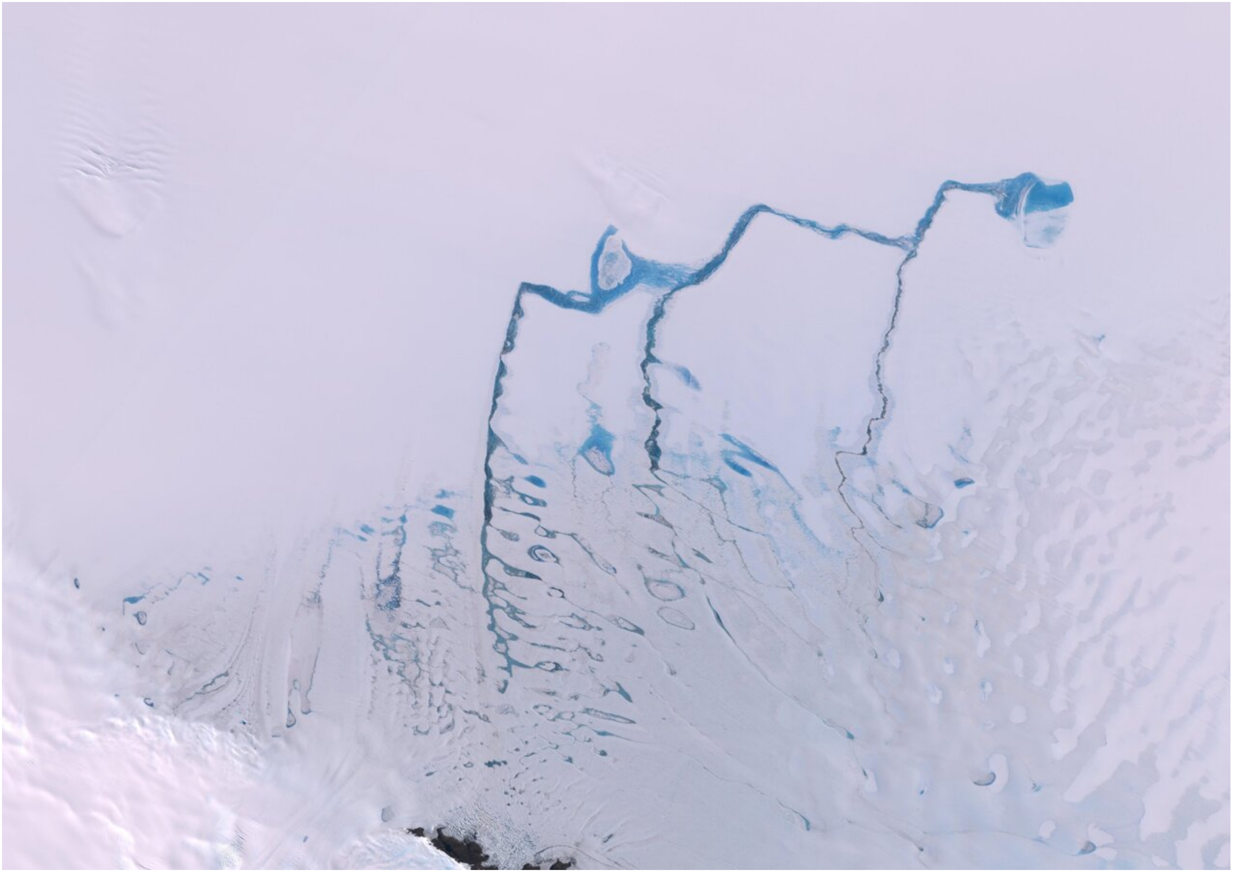
"We can use satellite imagery to map meltwater lakes across much of Antarctica, but it's hard to map slush, because it looks like other things, such as shadows from clouds, when viewed from a satellite," said lead author Dr. Rebecca Dell from Cambridge's Scott Polar Research Institute (SPRI). "But using machine learning techniques, we can go beyond what the human eye can see and get a clearer picture of how slush might be affecting ice in Antarctica."

Using optical data from NASA's Landsat 8 satellite, the Cambridge researchers, working with researchers from the University of Colorado Boulder and the Delft University of Technology, trained a machine learning model to obtain monthly records of slush and meltwater lakes across 57 Antarctic ice shelves between 2013 and 2021.

"Machine learning allows us to use more information from the satellite, since it can work with more wavelengths of light than the human eye can see," said Dell. "This allows us to determine what is and isn't slush, and then we can train the machine learning model to quickly identify it across the whole continent."

"We're interested in learning how much slush is present during the Antarctic summer, and how it's changed over time," said co-author Professor Ian Willis, also from SPRI.

Using their machine learning model, the researchers found that in the peak of the Antarctic summer in January, over half (57%) of all meltwater on Antarctica's ice shelves is held in slush, with the remaining 43% in meltwater lakes.



Pooled meltwater and slush on the Nivlisen Ice Shelf. Contains modified Copernicus Sentinel data [2020], processed by Rebecca Dell. Credit: Rebecca Dell

"This slush has never been mapped on a large scale across all of Antarctica's large ice shelves, so over half of all surface meltwater has been ignored until now," said Dell. "This is potentially significant for the hydrofracture process, where the weight of meltwater can create or enlarge fractures in the ice."

Meltwater affects the stability of the floating ice shelves that fringe the Antarctic coastline. As the climate warms and melt rates in Antarctica increase, meltwater—whether in the form of lakes or slush—can get into cracks on the ice, causing the cracks to get bigger. This can cause fractures in the ice shelf, and could cause vulnerable ice shelves to collapse, which in turn would allow inland glacier ice to spill into the ocean and contribute to sea level rise.

"Since slush is more solid than meltwater, it won't cause hydrofracture in the same way that water from a lake does, but it's definitely something we need to consider when attempting to predict how or whether ice shelves will collapse," said Willis.

In addition to the potential implications of slush on hydrofracture, it also has a large effect on melt rates. Since slush and lakes are less white than snow or ice, they absorb more heat from the sun, causing more snowmelt. This extra melt is currently unaccounted for in climate models, which may lead to underestimates in projections of ice sheet melting and ice shelf stability.

"I was surprised that this meltwater was so poorly accounted for in climate models," said Dell. "Our job as scientists is to reduce uncertainty, so we always want to improve our models so they are as accurate as possible."

"In the future, it's likely that places in Antarctica that currently don't have any water or slush will start to change," said Willis. "As the climate continues to warm, more melting will occur, which could have implications for ice stability and sea level rise."

**More information:** Substantial contribution of slush to meltwater area across Antarctic ice shelves, *Nature Geoscience* (2024). DOI: 10.1038/s41561-024-01466-6

Provided by University of Cambridge