Scientists reveal two previously unknown mechanisms for Antarctic ice shelf melting

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Two papers published in *Nature Geoscience* in June indicate that Antarctic ice shelves are melting more rapidly than previously anticipated. The papers detail two distinct mechanisms for melting that had not been incorporated into previous models for the breakup of the ice shelves.

The ice shelves that surround most of the Antarctic coast, together with the ice sheet that covers most of the continent, have an area of 14 million square kilometres. At the thickest point, the ice sheet is 4.9 km deep. The combined shelves are estimated to hold 30 million cubic kms of ice. If they were to melt completely, they would raise sea levels by 58 meters. This would completely inundate coastal cities, and many low-lying islands would be completely submerged, affecting a large portion of the world's population. Major cities such as Shanghai and New York would be inundated.

The paper, "Tipping point in ice-sheet grounding-zone melting due to ocean water intrusion," indicates that the ice sheets are being undermined at their grounding zone where the continental ice meets the sea ice, by warming sea water underneath the ice sheet. It was produced by Alexander Bradley, postdoctoral researcher in the Modelling Group of the Ice Dynamics and Paleoclimate team at the British Antarctic Survey in Cambridge, and Ian Hewitt, applied mathematician at Oxford University.

The scientists used modelling techniques that determined that small temperature increases in the sea water due to global warming can undermine the iceshelf, contributing to its collapse. The process is that the warmer water underneath the shelf produces cavities in the ice, allowing more water to seep in and further increasing the melting, producing a feedback loop. The paper identified this as a new tipping point for the breakup of the ice shelves.

The study stated: "Marine ice sheets are highly sensitive to submarine melting in their grounding zones, where they transition between grounded and floating ice. Recently published studies of the complex hydrography of grounding zones suggest that warm ocean water can intrude large distances beneath the ice sheet, with dramatic consequences for ice dynamics."

This work means that the current models for the breakup of the ice shelves may involve a very serious underestimate.

"[Seawater intrusion] could basically be the missing piece. We don't really have many other good ideas. And there's a lot of evidence that when you do include it, the amount of sea level rise the models predict could be much, much higher," Bradley told the *Guardian*.

An earlier study in February 2022 by climate change and glaciology scientist Alexander Robel and his team, published in the journal *The Cryosphere*, "Layered seawater intrusion and melt under grounded ice" predicted that the sea water intrusion could double the rate of the ice shelf collapse.

The study reported that earlier observations found "intriguing evidence of seawater intrusion in observations of grounding lines," but that further work was necessary.

The team carried out a simulation of the impact of the sea water intrusion using the Ice-sheet and Sea-level System Model (ISSM) to show that "even just a few hundred meters of basal melt caused by seawater intrusion upstream of marine ice sheet grounding lines can cause projections of marine ice sheet volume loss to be 10 %–50 % higher. Kilometers of intrusion-induced basal melt can cause projected ice sheet volume loss to more than double."

Robel commented on Bradley's paper for *New Scientist:* "That positive feedback can cause there to be much more intrusion than we thought possible. Whether that will be a tipping point that will lead to unrestrained incursion of seawater under the ice sheet—that's probably a stretch."

The second *Nature Geoscience* paper was produced by Assistant Professor in Glaciology Rebecca Dell, at the Scott Polar Research institute at Cambridge, under the title, "Substantial contribution of slush to meltwater area across Antarctic ice shelves." It used artificial intelligence to examine satellite images taken between 2013 and 2021 by NASA's Landsat 8 satellite to detect sludge pools on the ice shelves. The sludge pools are formed by melt water that also exists as pools of water. The sludge consists of waterlogged snow. The researchers observed the pools monthly.

"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. 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," said Dell.

The researchers found 17,000 square km of such pools and in January at the height of the Antarctic summer over half (57 percent) of all meltwater on Antarctica's ice shelves is held in slush, with the remaining 43 percent in meltwater lakes.

They found that the slush pools transition to water pools. The lakes are often found in areas where Antarctic ice becomes sea ice. Scientists think that the pooling of water can fracture the ice

leading to the fracturing and collapse of the ice shelf.

Importantly, the researchers identified another warming effect as sludge reflects less heat back into space than does ice thus increasing the melting of the sludge into water and further undermining the sea shelves. This is not currently incorporated into models for the breakup of the ice shelves.

"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. This is potentially significant for the hydrofracture process, where the weight of meltwater can create or enlarge fractures in the ice," said Dell.

Ice shelves perform an important role in protecting continental ice in a process called buttressing, slowing its flow. While the collapse of ice shelves is a natural process, this process has been accelerated by capitalist-induced global warming. The importance of the *Nature Geoscience* papers is that they explain the processes driving the disintegration of the ice shelves.

Recent collapses include the Prince Gustav ice shelf (from 1989 to 1995), Larsen A ice shelf (1995), Larsen B (2002), and Wilkins ice shelf (2008 to 2009), all from West Antarctica. In East Antarctica Conger ice shelf disintegrated in 2022 while the Cook ice shelf was partially lost in the 1970s.

Professor of Glaciology at the Northumbria University in Newcastle Hilmar Gudmuudsson and his colleagues published a comment on the collapse of the Conger ice shelf in 2022 in the *Conversation.* In "Conger ice shelf has collapsed: what you need to know, according to experts," they stated, "Taken together, this series of collapses suggests that some underlying environmental conditions, such as ocean and atmosphere temperatures, are changing. It is too soon to say what triggered the collapse of the Conger ice shelf, but it appears unlikely to have been caused by melting at the surface—there are no indications of any ponds atop the ice shelf. The most recent sequence of events also preceded the record high air temperatures recorded in Antarctica on March 18."

Antarctica has been one of the most rapidly warming areas of the world. According to the Discovering Antarctica webpage, upper ocean temperatures to the west of the Antarctic Peninsula have increased over 1°C since 1955. The Antarctic Circumpolar Current is warming more rapidly than global oceans. For the globe as a whole, 2023 was the hottest year on record, on average 1.5 degrees C above preindustrial levels. Scientists consider 2024 may go over the record.

The effect in Antarctica of the warming ocean and atmosphere is that the amount of ice in the shelves is diminishing, particularly in west Antarctica. The amount of ice fluctuates over the year, building to a peak in the Antarctic winter (northern summer) but shrinking over summer (northern winter).

Research published in December 2023 in *Science Advances* by research fellow at the Earth Observation of the Polar Regions at the University of Leeds Benjamin Davison and his team studied the shrinkage using satellite images.

The study, "Annual mass budget of Antarctic ice shelves from 1997 to 2021," pointed to the implications of the thinning of the ice shelves: "Ice shelf thinning or retreat can reduce the buttressing force provided by the ice shelf, leading to an increase in the speed of the upstream grounded ice and an increase in the ice sheet contribution to global sea level rise."

They estimated that over the 24-year period a staggering 67,000 ± 3,200 billion tonnes or 2,680 ± 580 gigatonnes per year of fresh water were added to the Southern Ocean.

The greatest reductions were in the Thwaites, Getz, Larsen C, and Pine Island ice shelves. Although there were large increases in the mass of Filchner, Amery, and Brunt ice shelves, the study noted, "Nevertheless, ice shelf mass loss was widespread around Antarctica: 71 out of 162 ice shelves lost mass."

The disintegration of the Antarctic ice shelves has enormous implications for the future of the world's coastal habitations, including some of the largest cities that are threatened with inundation. Scientists have called for drastic cuts in greenhouse gasses but capitalist politicians, who are committed to safeguarding the profits of the energy giants, are completely unmoved.

While professing concern about climate change and introducing measures to cut greenhouse gasses, in 2023 President Joe Biden approved 17 new fossil fuel projects. According to the Centre for Biological Diversity (CBD) this will wipe out any gains from the reduction of emissions.

"The potential carbon emissions from 17 massive fossil fuel projects approved by the Biden administration are larger than the projected emissions reductions from the Inflation Reduction Act (IRA) and other climate policies," the CBD report stated. In the same way governments adoption of "forever COVID" allowed 28 million people to die internationally, even though well-understood public health measures could halt the pandemic.

Seeking to pressure capitalist governments to change course is a completely bankrupt perspective. The only viable solution is that workers in alliance with principled scientists have to fight for the implementation of scientifically proven measures to resolve the climate crisis, but this will require the socialist transformation of society to go forward.