Science & technology | Out of sight, out of mind

Antarctica, Earth's largest refrigerator, is defrosting

The world must pay more attention to its southern pole

VIDEO: BRITISH ANTARCTIC SURVEY

Mar 27th 2024

THE DEADLIEST HURRICANE ever to hit America made landfall over Galveston, Texas, a barrier island in the Gulf of Mexico, on September 8th 1900. Terrified inhabitants watched a 4.5-metre-high wall of water approach their shores and tear through their homes. More than 8,000 people died. In the aftermath, a massive concrete seawall was built to keep future storm surges at bay. The engineers thought making it 5 metres tall would be enough.

And it was, for 120 years. But even as the wall was being built, human-caused climate change was getting under way, piling new heat and energy into the global climate system which would push the seas up shorelines around the world. Today, the US Army Corps of Engineers has a $57bn plan to build a new barrier, dubbed "Ike Dike", to protect Galveston as well as the Houston region and large petrochemical facilities that sit behind the island from ever bigger and more powerful storm surges. It could be the largest civil-engineering project in American history. Where will the water that it is designed to hold back come from? Much of it will hail from Earth's southernmost continent more than 10,000km away, home to the world's largest ice mass by a factor of ten: Antarctica.

When it comes to polar climate impacts, the Arctic receives most of the world's

attention. For years, scientists have warned of dramatic changes there being the canary in the climate coal mine. The blanket of summer ice that has persisted on the northernmost ocean for millennia steadily dwindled to almost nothing but it wasn't until Siberia, land of permanently frozen soil, caught fire in 2019 that anyone outside the (alarmed) climate community and (delighted) shipping industry paid much attention.

The southern pole, by contrast, has been neglected in the climate narrative. That is due in part to its remoteness and in part to an early scientific miscalculation. While the Arctic was melting rapidly, Antarctica looked relatively stable. Not only that, climate models suggested it would see more snowfall in a warming world, causing its ice pack to grow, not shrink.

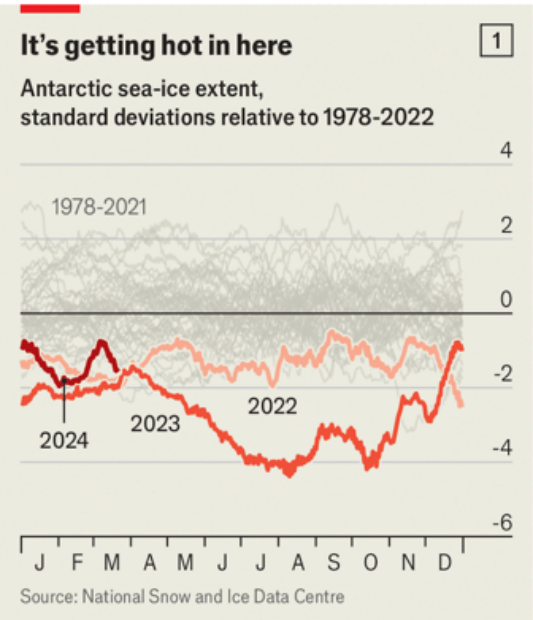
The models, it turns out, were wrong. A build-up of jaw-dropping events and extremes in recent years has shown that Antarctica is undergoing massive changes on land, sea and in the atmosphere above. As a result, a new portrait of the continent is emerging which has, so far, received little attention. Polar scientists are warning of a regime shift.

Terra incognita

This matters: despite appearances, Antarctica is not isolated from the rest of the world. For millennia, the continent has acted like a massive refrigerator for Earth. It sits at the centre of a vast ocean, which is full of krill and fish and is a huge sink for carbon dioxide. Its ice sheets store the largest volume of water on Earth, keeping it out of the seas. As that ice is reduced to liquid, the water will disproportionately raise sea levels in the northern hemisphere, where most humans live.

"When I first started working in Antarctic glaciology [30 years ago], it was about adventure and discovery," says Martin Siegert, director of the Grantham Institute for Climate Change at Imperial College London. "It still is about those things but it has got really serious really quickly."

Alarm bells rang loud and clear in the second half of 2023. They began with a second consecutive summer where the expanse of sea ice floating around the continent hit an all-time low—10% lower than it was in 2022, itself a record-setter. Then, from May onwards and as the region headed into its winter, researchers watched with increasing alarm as the ice struggled to recover. By July, the extent of sea ice was 2.5m square kilometres smaller than the recent average (see chart 1). Ella Gilbert and Caroline Holmes, researchers with the British Antarctic Survey, wondered: "Antarctica is missing a chunk of sea ice bigger than Greenland—what's going on?"



On thin ice

What is going on could be a long-term shift in the state of Antarctic ice. In an analysis published in the *Journal of Climate* earlier this month, Will Hobbs of the University of Tasmania in Australia, and colleagues, looked at 44 years of satellite records and found evidence of a regime shift in the seasonal waxing and waning patterns of the sea ice, starting 15 years ago. Since then the ice has been characterised by greater swings and variability. In a related analysis, Ariaan Purich at Monash University in Australia and Dr Hobbs's co-author Edward Doddridge, also at the University of Tasmania, showed that on average the extent of sea ice briefly increased around 2007 before abruptly entering a "new low-extent state" in 2016. Data for the Southern Ocean suggests that warmer water due to climate change could be partially to blame. The last two years of remarkable sea-ice lows accentuate the pattern.

"If Antarctica is starting to behave like the Arctic and losing sea ice, that is a major concern," says Dr Siegert. It would suggest a profound shift for a region that has for millennia helped to keep the rest of Earth cooler than it would otherwise be.

Less sea ice means more water is exposed to the sky. Because water is darker than ice, it absorbs more heat. This accelerates warming, a phenomenon known as the ice-albedo feedback. In the Arctic, this positive feedback loop is well-established and explains why the region is warming up four times faster than the global average. Recently, Antarctica has begun warming at twice the global average, a sign that it is also starting to become a driver of global warming rather than acting as a buffer. "We are deeply, deeply concerned about that," says Dr Siegert.

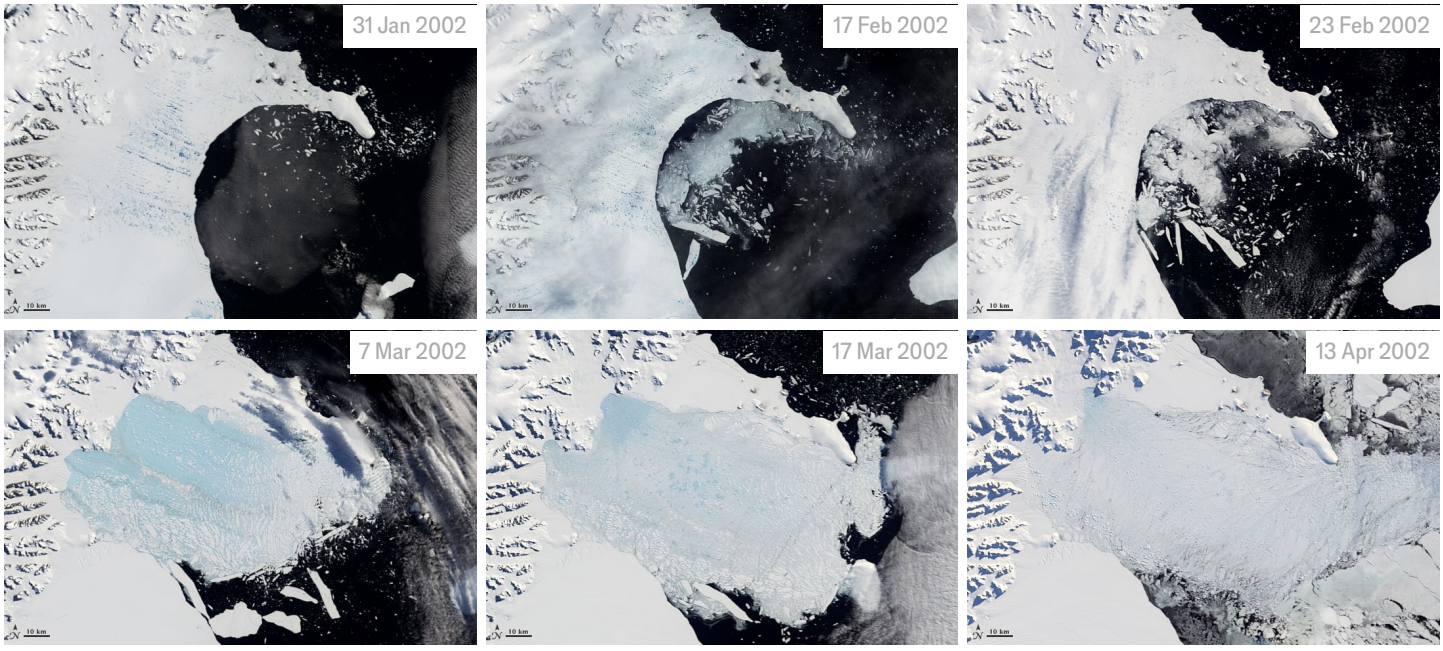
In an effort to raise the alarm, Dr Siegert and 13 other polar experts have compiled a list of anomalous events that have been observed both on the Antarctic continent and in the surrounding Southern Ocean, from sea-ice lows to marine heatwaves (19 between 2002 and 2018), and record numbers of melt ponds on top of the continental ice sheets. The most extreme heatwave ever recorded on Earth,

for example, happened in Antarctica in March 2022. Temperatures rose by 30 to 40°C above the norm for that time of year across large parts of East Antarctica. The Conger ice shelf, spanning an area 1.5 times the size of New York City and already in a critical state, collapsed within days.

Scientists are still trying to work out how these gobsmacking extremes are related to the continual fluctuations they see in the oceans and atmosphere, and the extent to which climate change is the ultimate culprit for each event or trend. Yet there have been signs of long-term climate-related change in Antarctica since about the turn of the 21st century, when several massive ice shelves collapsed.

Ice shelves are floating slabs of ice that form where glaciers on land flow out to sea. In Antarctica there are 15 large ones, each of which hugs a different part of the coastline. In January 1995, the Larsen A ice shelf, which covered 1,500 square kilometres, disintegrated. Seven years later, dramatic satellite images showed the neighbouring Larsen B ice shelf splinter in a matter of weeks. Some 3,250 square kilometres of ice were lost, an area the size of Rhode Island.

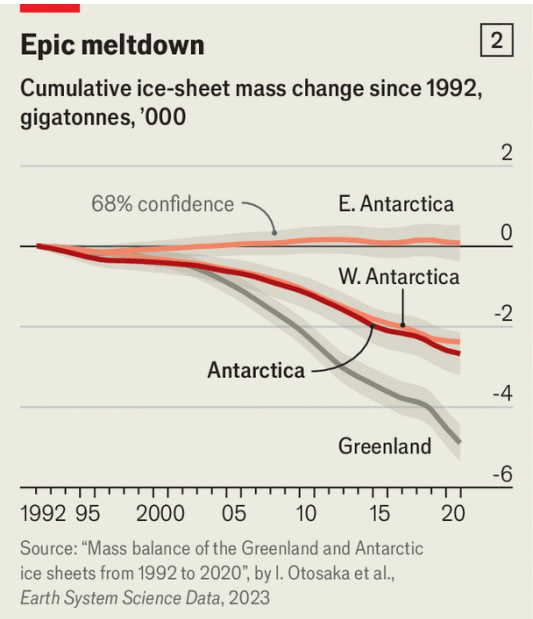
The Larsen B disintegration



Source: NASA

Despite the scale of these events—and studies that had warned, decades earlier, that this part of Antarctica was particularly vulnerable to warming and had helped push up sea levels by several metres during hotter times 120,000 years ago—the Larsen A and B collapses did not raise urgent worries about a long-term shift in Antarctic climate. At the time, computer models were not so good at simulating how polar ice would respond to a warming world. In December 1995, a year after

Larsen A collapsed, the Intergovernmental Panel on Climate Change (IPCC) declared in its second major assessment of climate change: "Little change in the extent of the Greenland and Antarctic ice sheets is expected over the next 50–100 years."



The intervening years have revealed just how wrong that prediction was. Antarctica's ice sheets are nearly 1.5 times as vast as the United States and so thick (up to 5km) that their smooth surface hides a mountain range as large and nearly as high as the European Alps. They hold 90% of the world's land ice. A 2019 report of the IPCC noted that, contrary to its earlier assessment, the rate at which they were losing mass had rapidly increased since 2002 (see chart 2). Water and ice flowing out of Greenland's and Antarctica's ice sheets will soon be the biggest driver of sea level rise, most of which was previously caused by seawater warming up and therefore expanding and taking up more room.

Several factors are to blame. Collapsing ice shelves, made more fragile from below by warming waters and jostled by more turbulent seas, have hurried things along. Ice sheets, which sit on the Antarctic continent, are connected to the ocean by glaciers that slowly flow towards the water. Ice shelves, which float at the edge of the continent, act like corks that buttress the glaciers behind them. Break the seal and the glaciers flow more quickly. Breakdown at the continent's edges also allows warmer ocean waters to creep up under the ice margins, seeping into cracks in the ice and between the ice and the bedrock. "That's a problem because when the oceans get involved, they can melt the ice ten times more quickly than atmospheric heat can," says Dr Siegert.

The greatest and most immediate concern is for the West Antarctic ice sheet, which is losing ice much faster than its East Antarctic counterpart (see map). The good news is it holds less than a tenth of the water sitting on East Antarctica. The

bad news is that despite appearances it does not sit on solid land but on a frozen landscape made up of islands separated by deep basins. As the ice margins move back towards the continent, ocean water is able to flow into this frozen landscape, exposing more and more of the ice's underbelly to melting from below.

All the ice we cannot see

West Antarctica's Thwaites glacier, which is the size of Great Britain, currently drives around 4% of global annual sea-level rise. It is melting rapidly, retreating hundreds of metres per year (new data published in February shows that this began, unnoticed, in the 1940s). Its upstream bedrock dips downwards towards the middle of the West Antarctic ice sheet, bottoming out around 2.5km below sea level. As a result Thwaites acts as a gateway that can either hold in or release a much larger mass of ice. "If Thwaites goes it's pretty much the whole of the West Antarctic ice sheet that follows," says Dr Siegert. Perhaps appropriately, it has been given the moniker "doomsday glacier".

The most obvious impacts of all this melting ice, beyond the Antarctic Circle, will be on global sea levels. Antarctica's ice sheets hold enough water to raise them by a staggering 60 metres, though such a catastrophic rise would take many centuries to occur. Much smaller changes, however, could still have a sizeable impact on coastal regions around the world.

The extra water from melting ice will not be distributed equally. Ice slipping off land and into the oceans decreases the gravitational pull of that landmass. Each mass of ice on Earth has its own gravitational fingerprint and its own associated geographical pattern of sea-level rise. Ice lost from Greenland's ice sheet, for example, decreases sea levels on the nearby shores of north-western Europe and eastern Canada, and raises them around South America. Losses of ice from West Antarctica push water up around the coastlines of North America, Australia and Oceania.

Greenland has been losing ice since the early 2000s, but losses from West Antarctica have been increasing since the early 2010s and are likely to continue on this path. This means that future sea level rise will have disproportionate consequences for the northern hemisphere (including the Houston area).

The consequences of defrosting Antarctica extend beyond rising seas. The Southern Ocean that surrounds it is the largest sink for carbon dioxide and heat on the planet, soaking up roughly 12% of annual carbon-dioxide emissions from human sources. Large-scale currents around Antarctica redistribute carbon, heat and nutrients to the rest of the world's oceans. The Southern Ocean's value as a carbon sink was recently estimated by Natalie Stoeckl, an economist at the University of Tasmania, to be between $28bn and $720bn per year depending on

the assumed cost of carbon, with a best estimate of $180bn, in the current climate. How the rate of carbon draw-down will change as the climate warms up even further is not yet known.

IMAGE: STEVE MCCURRY / MAGNUM PHOTOS

Already, though, there are signs that these ocean currents, known as the Antarctic overturning circulation, are slowing as more fresh water from melting ice flows off Antarctica. Fresh water is less dense than salty ocean water, so it floats at the surface. That puts the brakes on an underwater "waterfall" in which trillions of tonnes of water, rich in nutrients and gases, tumbles into the ocean's depths when it reaches Antarctica's icy shores.

Research led by Matthew England at the University of New South Wales in Sydney, Australia, showed last year that the Antarctic overturning circulation has slowed by 30% in 30 years, suggesting the vital carbon dioxide sink is being disrupted. The change is likely to have knock-on effects for fisheries north of the Antarctic circle, where a large share of wildlife relies on nutrients transported there from Antarctica's coastline. Populations of Antarctic krill, which is turned into food for people or feed for aquaculture, will probably also be affected.

Matt King, director of the Australian Centre for Excellence in Antarctic Science, recently warned that one of Antarctica's nearest neighbours, Australia, is woefully unprepared for the consequences that Antarctica's changing regime could have on its economy. Studies suggest what happens at the southern pole could be linked to Australia's weather patterns, temperature and rainfall. "Some of the studies are partially contradictory," notes Dr King. That only emphasises how much work remains to be done to truly understand what lies ahead.

And that is the crux of it. For too long, too few have worried about Earth's remotest continent and its largest refrigerator, while attention focused on the fires that burned, literally and figuratively, on more populated shores. Antarctica was variously portrayed as an explorer's playground, a utopian land of scientific co-operation or a poster child for environmental protectionism. The exceptionalism is misguided, as the people of Galveston are finding out. ■

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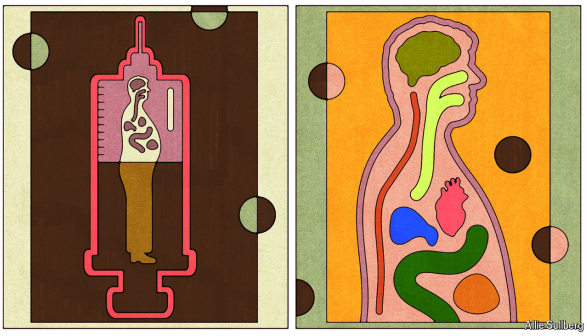

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