

Just a big downer?

Historic and satellite measurements of Antarctica's ice sheet highlight its complexity...

AMERY ICE SHELF

Satellite images reveal just how quickly the Antarctic ice sheet is changing. But how long has this been going on? Revisiting old studies can shed light on a complex situation, as Matt King explains.

Antarctica is a big, complex place. Its ice sheet is vast in area and thickness, and yet measurements that help us understand it only began during the 1960s. But the real revolution occurred in the 1990s with the launch of satellites that for the first time let us measure ice height and speed almost continuously over nearly the entire continent.

And as the stack of those measurements has grown, week on week, year on year, the picture has become increasingly clear: while much of the ice sheet is showing little sign of change, important regions are shifting dramatically. Scientists are concerned about how fast the ice is going into the oceans.

After the initial shockwave caused by these measurements had passed, one key question that needed an answer was this: how long has it been going on? Clearly these signals did not start when the satellites were switched on!

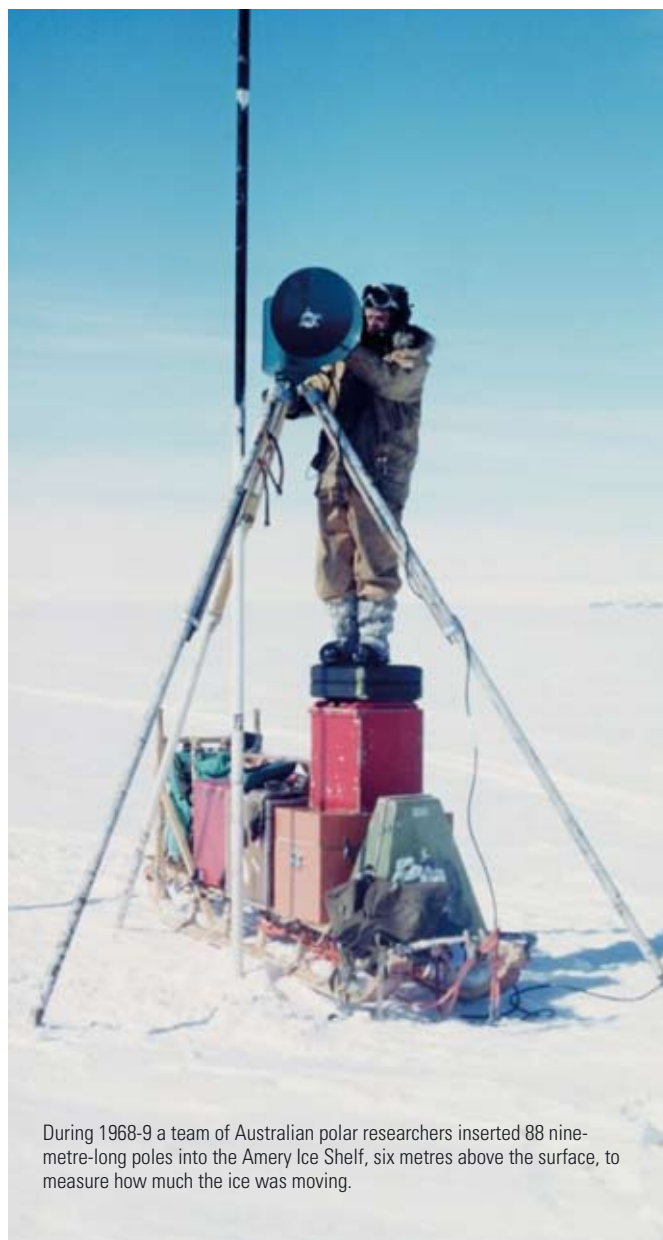
To answer this question we need long-term datasets, preferably spanning several decades. This meant returning to the pre-satellite era – to the initial measurements of the 1960s. Unfortunately, though, only a handful of really high-quality large-scale glaciological studies were done back then. But the studies that survive in the archives of scientific literature have an ever-increasing value. They

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now provide an irreplaceable measurement of change.

One of the 1960s studies focused on the Amery Ice Shelf, located in East Antarctica due south of India. At about three times the size of Wales, it is an important ice shelf. About 16 per cent of East Antarctica's ice drains into the ocean through it.

Ice shelves – the floating extensions of the grounded ice that surround Antarctica – do not affect sea level directly since they are already floating. But they have been shown to slow the flow



During 1968-9 a team of Australian polar researchers inserted 88 nine-metre-long poles into the Amery Ice Shelf, six metres above the surface, to measure how much the ice was moving.

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In 1998-99, a team returned to the original poles to see how much has changed. Metres of snow in the intervening years mean the tops of the poles are easier to reach and some of the poles had disappeared.

of grounded ice into the oceans. They are a visible indicator of a changing climate because the warmer oceans beneath and the air above can combine to melt them. Any changes to the ice shelves are of major interest to polar researchers, especially given that several have already dramatically thinned and retreated in recent decades.

In January 1968, four men – Max Corry (surveyor-glaciologist), Nev Collins (mechanic), Alan Nickols (electronics engineer) and Julian Samson (doctor) – made their home on Amery's snowy surface. They didn't just live on the ice shelf. As the winter snow arrived, they found their caravans – glorified shipping containers – increasingly snowed over. Digging tunnels to the surface and between the caravans earned them the title of 'the troglodytes of the Amery Ice Shelf'.

Despite being buried alive in the ice, as the winter passed the team continued their pioneering research. They aimed to travel 500 kilometres across its length and breadth to measure its velocity and elevation.

They placed survey marker poles in the ice (analogous to mountain top cairns) in the form of Vauxhall drive shafts sticking six metres out of the ice every 3-7km and made meticulous measurements between poles. To enable an absolute measurement of velocity and elevation, they also made measurements of stable bedrock on nearby mountain ranges and to sea level through a crack in the ice.

In the late 1990s I led a team of six researchers in a search for the poles. Once one was found and identified, the likely location of the others could be closely predicted based on the original survey data. In all, we found more than a dozen standing straight and tall. Some had disappeared beneath the snow, but those that remained were easily seen – one just 10cm above the snow was visible from hundreds of metres away.

The Amery Ice Shelf now becomes an important benchmark against which future measurements may be compared.

measured in the late 1960s – to within the measurement uncertainty of around one third of a metre.

Based on these results, the Amery Ice Shelf now becomes an important benchmark against which future measurements may be compared – any substantial change will show something truly unusual is happening.

So what does this mean for the wider Antarctic ice sheet? The contribution that the Antarctic ice sheet is making to sea level change is the sum of its parts. The Amery Ice Shelf highlights that this is a complex sum. There is no doubt that very important regions are losing ice fast and sea level is rising as a result.

On the other hand, many regions, including the Amery Ice Shelf, have remained largely unchanged in recent history. One could conclude that everything is not as bad as it could be. That is true, but considering the sea-level rise that could come from the regions that are already changing, and widespread scientific concern that they could expand further, that may just be cold comfort. ❖

MORE INFORMATION

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Further reading

M. A. King, R. Coleman, A. Freemantle, H.A. Fricker, R.S. Hurd, B. Legrésy, L. Padman, and R. Warner. 2009. A 4-decade record of elevation change of the Amery Ice Shelf, East Antarctica, *Journal of Geophysical Research-Earth Surface*, 114, F01010, doi:10.1029/2008JF001094.

M. A. King, R. Coleman, P.J. Morgan, and R.S. Hurd. 2007. Velocity change of the Amery Ice Shelf, East Antarctica, during the period 1968-1999, *Journal of Geophysical Research-Earth Surface*, 112, F01013, doi:10.1029/2006JF000609.

Last year, a study led by Newcastle University took the original measurements and compared them to more recent ones made since the early 1990s, using GPS on the ground, and also data from satellites.

We found the original 1960s field books and reanalysed the raw data. Missing information was gleaned from the personal diaries of the original surveyor. However, before we could compare with newer data, we had to make the old data compatible with modern measurements. We needed to account for the effect of ocean tides, changes in atmospheric pressure, and other technique-specific errors. Missing one out could lead to an incorrect estimate of the change in ice-elevation.

It was vital to work out the coordinates of the original ice poles in the same coordinate system used by modern-day GPS. But once all of these critical error sources were removed or reduced, we could make the comparison. The results are intriguing.

After all those years, and using very different measurement types, the overall change in terms of velocity and elevation amounted to almost nothing! The speed and direction of the ice in the late 1990s was within 0.6 per cent of the original value from 30 years before.

The overall change of the ice elevation was even smaller,

although there were yet-to-be-explained fluctuations over shorter periods of time – periods when the ice shelf surface went up or down for several years in a row, before returning to its original level. All in all, though, it stayed at the same level as was