Major Antarctic ice survey reveals dramatic melting

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Some have thinned by up to 18 per cent in the past two decades, and the process is accelerating. The most rapidly melting ones are likely to be gone within 100 years.

As this happens, the ice sheets sitting over Antarctica's land – which holds the equivalent of 60 metres of sea level – will accelerate their descent into the ocean, causing it to rise globally.

These new findings are the culmination of a torrent of studies over the past few years that have significantly boosted our understanding of what is happening to Antarctica. And it's rarely been good news (see box below).

What confounds our ability to predict sea level rise stems from uncertainly over how ice sheets will respond to climate change, says Fernando Paolo from the University of California, San Diego. That realisation has led to an explosion of research on the topic, he adds.

Ice shelves matter, but not because their melting would directly raise sea levels: it won't, because they are already floating on the ocean. But they act like the crust at the edges of a lemon tart, preventing the filling from seeping outwards. In the case of Antarctica, the filling corresponds to the ice sheets, which will flow into the ocean and cause sea level rise once the ice shelves are gone. Already, the loss of ice shelves in West Antarctica has led to a 59 per cent increase in ice discharge from some regions.

So far, how quickly the ice shelves have been melting has been a matter of debate, confused by

a plethora of satellite observations that cover short periods of time.

Paolo and colleagues have developed a model that combines data from three satellite missions, so that they could look at all the ice shelves over a period of 18 years. This allowed them to produce the first continuous plot of how the ice volume of the whole system was evolving. "We show not only that the total ice shelf volume is decreasing, but we see an acceleration in the last decade," says Paolo.

Poor second half

For the first nine years the average thinning of the ice shelves across Antarctica was negligible. Consistent losses in vulnerable West Antarctica were mostly offset by gains in East Antarctica, which Paolo says might be a result of increased snowfall there – itself something that is forecast to happen as the globe warms.

But the second half of the study period, from 2003 to 2012, was completely different. Ice shelf loss off West Antarctica increased by 70 per cent and even East Antarctica showed a small loss. On average, some 310 cubic kilometres of ice was lost from the ice shelves each year during this time, and the rate of loss is increasing rapidly.

"The fact that the rate of their thinning is increasing is alarming," says Ben Galton-Fenzi from the University of Tasmania in Hobart, Australia.

The accelerating ice shelf loss in West Antarctica is mostly down to warmer water flowing underneath, says Paolo. That is happening because the water surrounding Antarctica is warming, and the winds that push it against the ice are getting stronger (see diagram below).

Changes in East Antarctica are harder to understand because we have less data for that region, says Paolo. More snowfall in the first nine years of the study might have masked any thinning, he says, but the factors that are melting West Antarctica could be starting to play a role in East Antarctica too.

Some of the disappearing ice shelves are particularly important in holding back the ice sheets. In particular, ice shelves in the Amundsen Sea, which regulate a lot of West Antarctica's ice, lost 8 per cent of their volume on average over the 18 years of the study.

"We are seeing large changes over the course of decades," says Paolo. "At current rates of change some of these ice shelves could disappear within 100 years."

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Correction, 27 March 2015: *When this article was first published, it gave an incorrect figure for the amount of warming at the Antarctic peninsula. This has now been amended. We have also clarified the status of the possible tunnel under the ice shelf at the Totten glacier.*

The heat is on

Some parts of Antarctica are melting much faster than others (see this map). The results were revealed by Fernando Paolo from the University of California, San Diego, and his colleagues, who looked at ice loss across Antarctica between 1994 and 2012 (see main story).

THE WEST CRUMBLES
West Antarctica has been warming quickly. The ice held there, if it melted completely, would raise sea level by more than 3 metres. Some studies suggest that the complete collapse of glaciers within the next 200 to 1000 years is now inevitable. The Antarctic Peninsula, which juts towards South America, could be most affected: it has seen some of the fastest warming in the world, of about 2.5 °C.

The Larsen collapses There were three connected ice shelves on the Antarctic Peninsula, called Larsen A, Larsen B and Larsen C. Larsen A collapsed in 1995, followed by Larson B in 2002. Larsen C (labelled **1** on the map) is also at risk as the climate warms. Paolo's study shows that it is thinning and could separate from the continent within 100 years if the current rate of loss persists.

The southernmost collapse In 2009, the Wilkins ice shelf (**2**) all but completely collapsed. It does not hold in any ice sheet, so the event will not contribute to sea level rise, but the collapse was significant as it was closer to the South Pole than any similar event.

Crosson and Venable ice shelves Each of these (**3**) has lost some 18 per cent of its thickness over the 18 years of the study, and could disappear within the next 100 years.

Troubled seas The Bellingshausen Sea (**4**) ice shelves have been thinning at more than 7 metres per decade. Those in the Amundsen Sea (**5**) have been thinning much faster, at almost 20 metres per decade according to the study by Paolo and colleagues. Together they account for only 20 per cent of the ice shelf area in West Antarctica but their melting has accounted for 85 per cent of loss there. Those in the Amundsen Sea are slowing the flow of some large glaciers and will increase the rate of sea level rise.

Getz ice shelf Getz (**6**) is particularly thick but has thinned by a whopping 66.5 metres per decade, losing some 6 per cent of its volume over the 18 years of the study. It alone accounts for 30 per cent of the ice volume lost from West Antarctica.

THE EAST CLINGS ON
East Antarctica, facing the Indian Ocean, has experienced some of the slowest warming on Earth. That's fortunate, because it makes up two-thirds of Antarctica and holds most of the continent's ice. But not everything is hunky-dory.

Mixed news from Totten Totten glacier (**7**) drains ice from a huge part of East Antarctica – an area around four times the size of England – dumping about 70 billion tonnes of ice into the ocean each year, which is roughly on par with the amount of snowfall, keeping things in balance. The ice locked up in this glacier alone is equivalent to about 3.5 metres' worth of sea level.

Earlier studies suggested that the adjoining ice shelves could be thinning, although the Paolo study did not find any thinning in the 18 years to 2012. But this month it emerged that a tunnel under the ice shelf may be letting warm water reach the glacier. That could be increasing the flow of the glacier and hence sea level rise.

Small relief from greater snowfall Climate models have predicted that snowfall will increase over Antarctica as the world warms. An ice core study published this month confirmed that snowfall did respond this way to temperature over the past 20,000 years. That should offset a small amount of the sea level rise caused by ice sheets easing more quickly into the sea.