THE CRACK

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Hello strangers, it's been a while. I've been buried under a mountain of reports and travelling all over the country so it's not been so easy to record a new podcast. But here we are! This episode I'm going to talk about the thing that's catapulted Larsen C into the news recently: the crack. [dun-dun-DUUUUUUUHHHNN!!!]

So. What's the craic?

Unsurprisingly, the crack is… er… a crack. It's been travelling across the front of the ice shelf at an alarming rate, and currently threatens to break off a chunk of ice the size of Norfolk. For those that don't have an encyclopaedic knowledge of the areal extent of English counties, that's around 5,000 square kilometres. When it goes, it will be one of the largest ever recorded icebergs, and will reduce the size of Larsen C to the smallest it's been in the last 115,000 years.

Does that sound dramatic? It is. But Antarctica is a dramatic place. It's just business as usual: another example of what has been happening there for as long as the continent has been ice-covered. In other words, it's natural behaviour.

But. There's always a 'but'.

Most newspapers reporting on this have linked the crack to climate change. I think that's quite an important point to address because it's a lot more complicated than is often suggested by the media. Journalists like to report simple messages that translate easily into articles or news items, because they are simpler to explain and simpler to understand. I'm saying that because I am a science journalist myself, and I know from experience how much harder it is to write about something that's really complex. Stories need to have a beginning, a middle and an end, and if it's too complicated, there just isn't anything to tie it all up neatly. Plus, drama sells. Climate change is dramatic, it's something we've all heard of, and its impacts will be universal. Unfortunately though, nothing is ever nice and simple and easy in the real world, and science doesn't lend itself to drama.

Cracks and rifts appear naturally in ice shelves. It's all part of their dynamic evolution. Ice shelves are the terminus of glaciers. By that I mean that glaciers, which are essentially frozen rivers that flow down mountains, end in ice shelves because when glaciers meet the sea, they spread out on top of the ocean. Ice floats, like in a drink, because water is one of the few substances that is less dense when in solid form than liquid form.

Glaciers are fed by the accumulation of snow at the top of mountains. That's their ultimate input source. Gravity makes the ice move downhill, so there is a sustained transport of that accumulated snow and ice down the mountain. Because those glaciers are always flowing, the ice shelf is continually receiving more ice. It can't continue to grow forever, so at the very edge of the ice shelf, a process called calving occurs. Calving is the process that produces icebergs: like the ice shelf giving birth to many little icy mini bergy versions of itself.

That process is a balance of what's going in, in the form of precipitation, which is mainly snow, vs. what's coming out, in the form of icebergs. Glaciologists, who study ice in glaciers, ice shelves and ice sheets, call that balance the surface mass balance.

So, with that theory in mind, maybe it makes more sense now when I say that rifts and cracks appear naturally at the edge of the ice shelf – at what is called the calving front. The calving front is the very edge of the shelf that produces (or calves) bergs; hence the name. Larsen C's calving front stretches between two rocky outcrops called the Bawden Ice Rise and the Gipps Ice Rise, which pin the ice in place. As a result, they're known as pinning points.

The crack in question has actually been present on Larsen C since at least the 1960s, when the first satellite images were taken. It had remained more or less stationary since then until 2012, when it broke through a region of softer ice, which had previously prevented it from going anywhere fast. In the summer of 2014 it suddenly sprung into life and leapt around 22 km in about eight months. It then chilled out a bit, until the second half of December 2016, when it grew 18 km, having made steady, yet slow advances since 2014.

The crack made the news in early 2017 because of its rapid development. It threatens to produce one of the largest ever recorded icebergs in history, which will be around 5,000 square kilometres – 10% of the ice shelf's total volume. That's also the size of Delaware, or Trinidad and Tobago, or a quarter of Wales, depending on your geographical frame of reference. Since the start of 2017, the crack has ripped through the shelf in fits and starts. It popped through one stabilising region of softer ice but then got stuck in another. The most recent development however, is that the rift has forked, growing 17 km between the 25th and 31st May 2017 and veering off towards the edge of the shelf. That's where it is now. It's just 13 km from the calving front, meaning a chunk of ice the size of a whole US state is held on by just 8 miles of ice.

The question is: what made it propagate in the first place? And what made it jump so quickly in successive seasons? Can its development be linked to climate change? That's where it gets a bit complicated.

First of all, there is the natural mass balance – the more ice there is pushing against the shelf, the greater the stress there is across the whole thing. Imagine the calving front as an elastic band stretching between the two 'pinning points' I mentioned earlier. The more ice that flows into the shelf from glaciers, the higher the pressure it exerts on that band. It might stretch and expand a bit, but eventually the pressure will be too great and it will break, calving an iceberg or two.

Rifts develop naturally in the calving process – it's all part of the evolution of the shelf. Before an iceberg breaks off, the shelf will crack.

So, like I said before, part of the answer is that it's just natural processes.

Secondly though, there's the effect of melting. This is also a natural process, but one which can be exacerbated by atmospheric warming. When the ice on the surface melts, it saturates the lower layers of the shelf. When that refreezes during winter, it makes the whole ice shelf a lot less permeable, which means that melt that is generated the following summer can't trickle down as easily through the ice shelf. Over many years, that means that the entire ice shelf becomes one big ice block, so these melt ponds appear on the surface because the water just has nowhere to go.

Thing is, like I alluded to earlier, liquid water is denser than ice, which means it is heavy. When water gets into pre-existing cracks and crevasses, it exerts pressure on the edges of those little cracks, and makes them widen. That process, called hydrofracturing, can cause small rifts and openings to grow and propagate, much like the crack that we're seeing move across Larsen C right now.

Of course melting happens naturally too, mainly in summer, but it's happening slightly more frequently now. Larsen C is now a more lonely ice shelf than it was 25 years ago. In 1995, the northernmost Larsen ice shelf, Larsen A, collapsed. Then, in 2002, Larsen B, which is a little further south, collapsed in spectacular fashion. Now, the future stability of Larsen C is in question. This is consistent with the pattern you might expect in the collapse of ice shelves. There is a poleward march where the most northern shelves go first, because they are furthest from the South Pole, and therefore warmest. Then, one by one, others break off in order of their proximity to the main continent.

Larsen C has been retreating for decades – it lost around 5,000 km^2 between the 1960s and 2009 and more recent work has shown that the height of the surface is falling, which suggests that the shelf is thinning. That indicates that the ocean is warming it from beneath. But – it's also being warmed from above by the atmosphere.

Atmospherically driven melting was shown to be an important factor in the collapse of Larsen C's neighbours, and there's plenty of evidence to suggest that the same is true of Larsen C. Lots of work has been done to show that changing wind patterns are responsible for a large proportion of the melt on Larsen C.

One of the most recent papers released by Project MIDAS, who are the team monitoring and researching glaciological processes on Larsen C, and the ones providing all the satellite data that shows the crack, shows that melt is much more pronounced where the effect of these changing wind patterns is most extreme. That suggests that the overall stability of the ice shelf is being weakened, at least in part, by changing atmospheric conditions. And as you might imagine, weaker ice shelves are more susceptible to collapse.

If you think about the processes that lead up to it, you can see that ice shelf collapse is a symptom of a warming climate. Ice shelves are vulnerable to change because they are at the interface between two systems: the atmosphere and the ocean. That means that they are affected by changes in the atmosphere AND the ocean, whereas most other systems are affected by either/or. A lot of work has been done on the warming of oceans beneath ice shelves. Equally, a lot of work has shown that the atmosphere is changing on the Antarctic Peninsula, though temperature trends there are really variable. However, while these warm, melt-inducing winds may be driving melt, and while the shelf is thinner than it was a few decades ago, the ice shelf is not critically unstable just yet. I'd like to labour that point: Larsen C isn't about to collapse into the Southern Ocean any day soon. In fact, the area is so changeable that what we're seeing now is still well within the bounds of natural variability.

That's the bigger picture on Larsen C. We're talking about the crack. The overall stability of the ice shelf will have an impact on whether cracks and rifts can develop and evolve, but cracks and rifts appear naturally on healthy ice shelves. And, just like we can't attribute individual storms or extreme weather events to climate change, you cannot make the link between climate change and an individual, specific crack. Besides, there is a triple-edged sword here: there are so many factors to consider, we have very little data, and trends are extremely changeable, which all makes it more complicated.

So, I guess that's another part of the answer – the overall stability of the ice shelf might be related to melt and therefore indirectly to climate change, but we cannot say that the crack has any connection to recent changes.

So, there are a few key take home messages here.

1) There is no evidence to link the crack to climate change. It is probably just a part of the natural process of calving and accumulation that takes place on ice shelves.
2) Ice shelves collapse. Sometimes that is natural, and sometimes it is triggered by climate change.
3) The stability of ice shelves like Larsen C is eroded over time by continual melt and refreezing, which makes the ice shelf less able to absorb further melt. This causes cracks and rifts to form and grow, and ultimately leads to collapse. This is likely the process responsible for the loss of Larsen A and B.
4) Increases in melt are driven primarily by atmospheric processes, such as changing wind patterns. Those patterns may be partly driven by global temperature change, but it is complicated.
5) The stability of Larsen C as a whole is declining, but that is unconnected to the crack.
6) Larsen C is not going to collapse this month, or this year, or this decade… probably.

On that last point: it looks like the imminent calving of this mega-berg is unlikely to lead to any dramatic change on Larsen C beyond reducing its size by 10%, which is part of the natural processes of ice shelf development. However, depending on how far it travels, there is a very slim chance it could destabilise the ice shelf's 'compressive arch'. That would pull the plug, like removing a crucial keystone from a stone archway. If that happens, the whole shelf would splinter and collapse, as we saw with the collapse of Larsen A and B. But then again, it probably won't. But we won't know for sure until the iceberg breaks off.

How exciting. We might get to witness a dramatic and unprecedented natural event in the next few months. Beware all the alarmist hype in the media when it happens and remember it's really complicated!

Don't forget to keep an eye out for the latest – I'll post about any developments on LarsenC.com.

Until next time!

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Some excellent articles, for those who want to know more:

http://www.climatesignals.org/headlines/events/larsen-c-ice-shelf-calving-and-retreat-2017

https://www.theguardian.com/science/2017/jun/23/melting-and-cracking-is-antarctica-falling-apart-climate-change?CMP=share_btn_tw

http://www.antarcticglaciers.org/2017/06/larsen-c-ice-rift/