



**Figure 1 | The Antarctic ice sheet.** Marine sectors of ice in Antarctica lose mass mostly through fast-flowing outlet glaciers (purple) that feed into ice shelves in the surrounding ocean. Two of these glaciers — the Thwaites Glacier and the Pine Island Glacier — feed into the Amundsen Sea. Cornford *et al.*<sup>2</sup> have modelled the West Antarctic Ice Sheet's response to climate warming in the next 300 years. They find that the Thwaites Glacier could already be undergoing runaway retreat, and that it may be a substantial source of future, century-timescale sea-level rise. Figure adapted from ref. 12.

just thin enough to float, separating grounded ice sitting on land in the interior from the floating ice shelves.

In a warming climate, marine sectors of ice are thought to be particularly vulnerable. Runaway ice-sheet retreat associated with instability of the grounding line can occur when the bed of a marine outlet glacier deepens upstream of the grounding line<sup>3</sup>, as is the case for most of the major outlet glaciers in the West Antarctic<sup>4</sup>. The floating ice shelves on the periphery of these ice sheets stabilize the outlet glaciers, inhibiting the ocean-bound flow of grounded ice and slowing ice loss. But when the ocean warms, these buttressing ice shelves are melted from below and can break up, initiating faster ice flow and rapid retreat of the grounding line<sup>5</sup>.

Cornford *et al.* predicted the impact of ongoing climate warming on the stability of the West Antarctic Ice Sheet by using the BISICLES ice-sheet model<sup>6</sup> with a sophisticated treatment of the grounding line, forced by a suite of the most recently available atmosphere and ocean model projections<sup>7,8</sup>. Marine ice sheets interact strongly with both the atmosphere and the ocean, and the computational expense of coupling ice-sheet models to state-of-the-art climate models with a full range of ocean-atmosphere interactions is currently prohibitive. The approximate treatment adopted by the authors is among the best available methods with which to model this complex coupling.

Simulating the migration of the grounding

line requires very high spatial resolution, and this limits the spatial and temporal scales that regional ice-sheet models can consider. To clear this technical hurdle, Cornford and colleagues used a numerical approach known as adaptive mesh refinement to focus in on the ice flow at the critical zone near the ice sheet's grounding line. The authors' treatment does not, however, take into account some of the factors that affect ice-sheet dynamics, such as changes in the elevation of Earth's solid surface beneath the ice, and depression of the local sea surface as the gravitational attraction of the ice sheet on the surrounding water weakens<sup>9</sup>. It also neglects some processes that take place at the ice-bed interface, which are challenging to observe. All of the above factors can change the timing and extent of ice-sheet retreat in some regions. But no existing ice-sheet model accounts for all of these effects.

Cornford and colleagues' simulations show that the grounding line retreats by hundreds of kilometres in all major marine outlet glaciers in West Antarctica when ice shelves are melted from below and break apart. However, recent projections using ocean-circulation models<sup>7,8</sup> indicate that ocean warming sufficient to break apart ice shelves in the coming decades will occur only in the Amundsen Sea Embayment, into which the Thwaites and Pine Island glaciers flow (Fig. 1). When the authors used these more-realistic projections of sub-ice-shelf melt rates to drive their simulations, they predicted a contribution of up to 50 mm of global average sea-level rise from the West



## 50 Years Ago

There is an inborn fascination ... in the discovery and unearthing of relics of life as it existed centuries ago. None of these is perhaps more generally exciting and popular than the Roman mosaic pavements ... constructed floorings in regular cubes of stones of many colours, beautifully contrived in patterns and pictures ... Proof of life as it existed in Yorkshire during A.D. 100–400, as evidenced by the discovery of two excellent examples of Roman mosaic handiwork, is furnished by the Rudstone pavement ... and by one at Brantingham ... At Rudstone three mosaics were originally uncovered ... and were ultimately removed to Hull Museums ... It is indeed no boastful claim that “... these beautiful pavements are now permanently preserved for the benefit of posterity”.

From *Nature* 23 October 1965

## 100 Years Ago

The autumn number of *Bird Notes and News* contains much readable matter in regard to the effect of the war on bird-life in France and Flanders. Swallows returning this spring to their accustomed nesting sites only too often found them reduced to a heap of ruined masonry. In such cases huts erected for military purposes have been adopted as substitutes. This fact shows the tenacity with which these birds cling to their old haunts. Birds roosting between the lines of the opposing forces have on more than one occasion given timely warning to the sleeping men of the near approach of poison gas fumes, by the rustle of their wings and low cries as they passed over our trenches. Except, indeed, when actually within the zone of fire the birds have shown themselves strangely indifferent to the strife around them.

From *Nature* 21 October 1915