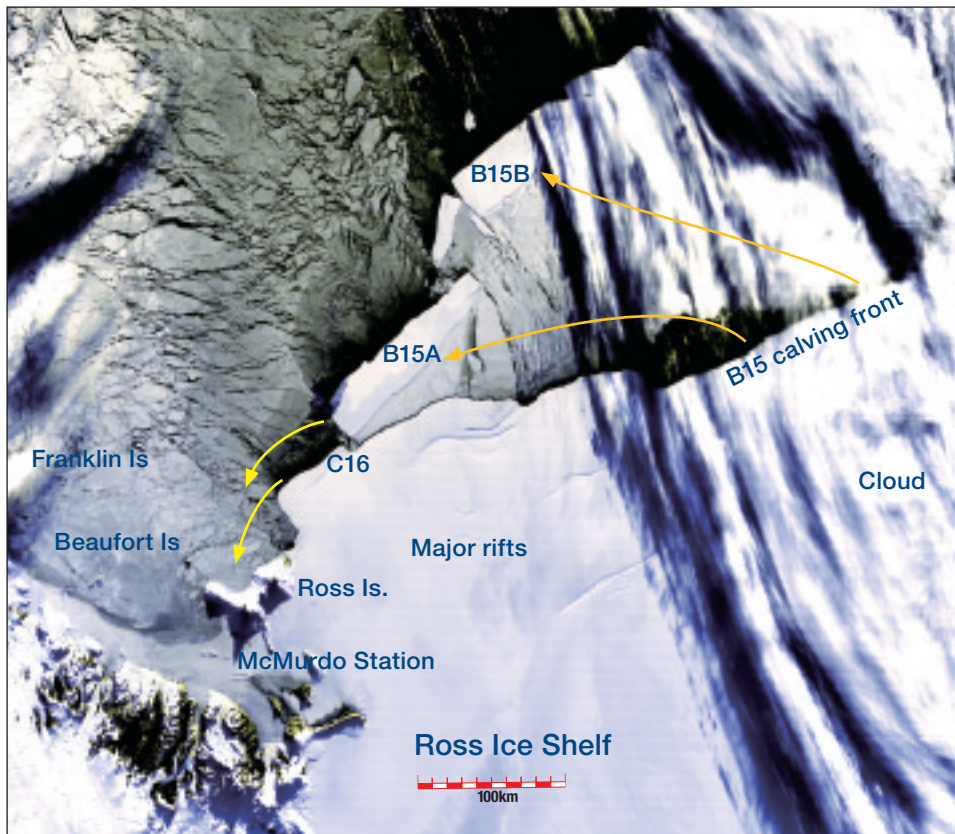


An iceberg the size of Jamaica!



A satellite image of the Ross Sea and Ross Ice Shelf acquired by the MODIS instrument on NASA's TERRA satellite on 21 September 2000. Several sections of the massive iceberg B15, which calved in March 2000, are visible. The orange arrows show their approximate drift tracks away and along the ice shelf front. Cloud partly obscures the ice shelf and some icebergs to the east. The US Antarctic station, McMurdo, is located on the south west corner of Ross Island at the southern end of McMurdo Sound. Beaufort Island is about 23 km from Cape Bird, and Franklin Is another 100 km further north. The section of ice shelf labled C16 (15 km x 43 km) calved a few days later and has since drifted up to Ross Island, near Cape Bird, with B15A (35 km x 161 km) following in behind to Cape Crozier at the eastern end of the island (yellow arrows). Depending on their future drift and the time they remain in the area these two icebergs could have a major impact on the distribution and movement of sea ice, and thus on wildlife, such as the emperor penguins of Cape Crozier, or shipping access to McMurdo Sound. The remainder of the icebergs are drifting slowly north west across the Ross Sea towards Cape Adare from where they are likely to head west around the coast.

Data provided by NASA/GSFC/DAAC. Image produced by Glenn Hyland, Antarctic CRC.

SEVERAL IMMENSE ANTARCTIC ICEBERGS CALVED FROM Ross Ice Shelf in the Ross Sea sector, and from Ronne Ice Shelf in the Weddell Sea sector during 2000. Those icebergs are now slowly drifting around and away from the continent. The first of these events, in March 2000, produced iceberg B15, the largest ever observed. When it calved, it was approximately 295 km long by 37 km wide, with an area of about 10,600 km². On the other side of the continent, two immense icebergs calved from the Ronne Ice Shelf: A43 (250 km by 34 km), and A44 (60 km by 32 km). Since then, further events on Ross Ice Shelf have led to the calving of icebergs B16, B17, B18, B19, and C16. Altogether, ice has calved from more than 65% of the 750 km length of the front of Ross Ice

Shelf, and a similar proportion for Ronne Ice Shelf.

The icebergs receive their names from the (US) National Ice Center (NIC). The NIC records and follows the drift of any iceberg greater than ten nautical miles in length. The nomenclature they use divides the Antarctic region into four quadrants, each designated by a letter from A to D. The 'A' quadrant is from the Greenwich meridian of longitude (0°E) to 90°W, and spans the Atlantic sector, including the Weddell Sea. Quadrant B is from 90°W to 180°E, C from 180°E to 90°E, and D from 90°E to 0°E. Each iceberg is designated by the letter corresponding to the sector in which it is first sighted, which is usually where it is formed, and a number which is next in sequence for the sector. So B15 is the 15th iceberg identified by the NIC in the 'B' sector. When one of the tracked icebergs splits into two or more sections, each daughter iceberg greater than 10 nm long is designated by the name of the parent iceberg and an additional letter. Over the time since its calving, B15 has broken into six sections, B15A, B15B, to B15F. Ross Ice Shelf spans the boundary between sectors 'B' and 'C' and thus one iceberg which

calved from the western end is named 'C16'.

The calving of icebergs, even of the size of B15, is a natural consequence of the development of an ice shelf. Snow which has fallen on the surface of the Antarctic ice sheet compacts and forms ice as further snow accumulates on top. The ice gradually flows outwards till it crosses the grounding line, the boundary between the grounded ice and floating ice. Along large sections of the grounding line, this ice flows into floating ice shelves. Ice is lost from the ice sheet by calving of icebergs from the outer perimeter and by melting from the basal surface of ice shelves and glaciers. The rate of loss roughly balances the input of snow to the surface.

In satellite images, rifts in Ross Ice Shelf are seen

tens and even hundreds of kilometres inland from the outer margin, and running parallel to the margin. These rifts typically develop and extend over many years till an iceberg breaks off. The rifts which formed the 'calving front' for B15 could be clearly seen in images acquired by the Canadian Radarsat in September 1997 over a length of about 240 km. The precursors to these rifts were identifiable in Landsat images acquired many years before this. The calving of B15 could thus be anticipated, but the actual timing of such events is very difficult if not impossible to predict.

The total area of ice shelf lost during the year 2000 by the various calving events from Ross Ice Shelf and Ronne Ice Shelf is about 23,000 km², or around 1.5% of the area of all ice shelves around Antarctica. The total volume of water contained in just those icebergs is over 5,000 Giga-tonnes, more than twice the estimated annual turnover of ice for the whole Antarctic continent. This is equivalent to sufficient water to supply all of the world's water needs, agricultural, industrial, and domestic, for more than a year. The estimated annual average accumulation of snow on the ice sheet, and therefore average annual turnover of ice, is around 2,500 Gt.

While the scale of these events and the volumes are immense, the calving of this many very large icebergs is believed to be the consequence of a natural progression of events that occur in ice shelves, and quite unrelated to 'Global warming' or 'Greenhouse' effects. Mean annual air temperatures at the ice shelf fronts, between latitudes of 75°S and 78°S, are around -20°C, and summer

air temperatures rarely reach melting point. Ocean temperatures are at, or close to, freezing throughout the year. Calving of ice from any section of the front of an ice shelf may occur frequently and produce a few or many small icebergs, or occur rarely and produce one or a few very large icebergs. Typical period of calving for a section of Ross or Ronne Ice Shelf appears to be around several decades. For the whole of Antarctica, very large icebergs with a length of several tens of kilometres can be expected to be produced several times a decade.

By way of contrast to these 'normal' events, there has been a dramatic decrease in the area of relatively small ice shelves fringing the Antarctic Peninsula over several decades, and the disintegration of the northernmost section of Larsen Ice Shelf (Larsen 'A', at latitude 65°S) in January 1995. These changes have accompanied a warming of several degrees observed since the 1940s in the Peninsula region, with mean summer temperatures approaching 0°C, and significant melt water production on the surface of many of the ice shelves. Re-freezing in crevasses of melt-water runoff has progressively weakened the structure of those shelves.

There is much to be learnt from observing these calving events and the evolution of the resulting icebergs. Information about the fracture processes that contribute to the calving of icebergs is required for incorporation into computer models of the ice shelves in order to assess their future development. Observing the drift of the icebergs gives information on the ocean currents with which they move. Observations of their breakage and melt rates as they drift into progressively warmer waters provides information on the probable impact on the ice shelves of warmer temperatures in the air or polar waters accompanying a climate change.

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Map of Antarctica showing sections that calved in 2000 from the fronts of Ross Ice Shelf and Ronne Ice Shelf. Arrows indicate approximate current and predicted drift tracks of those icebergs. The Ross Ice Shelf icebergs, are likely to follow a path similar to another large iceberg, B9, that calved from the eastern end of Ross Ice Shelf in 1987. B9A has already drifted round the coast to Weddell Sea. It spent many years grounded near the Antarctic coast. B9B, the largest section of B9, is still grounded close to Mertz Glacier. B16, the first of the new icebergs to drift out of the Ross Sea past Cape Adare, is now heading west round the coast.

