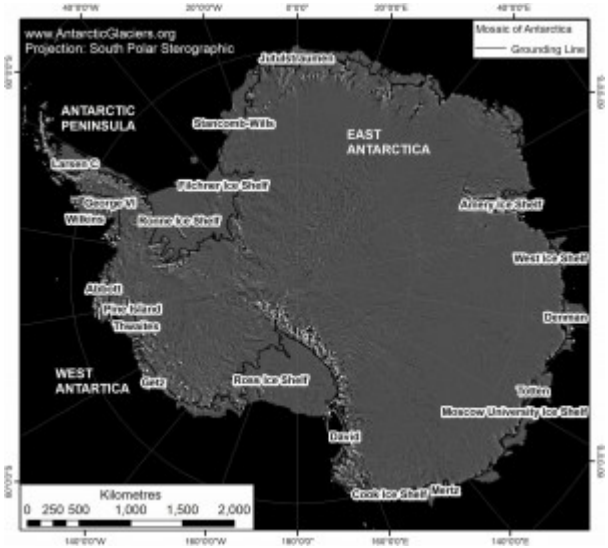
East Antarctic Ice Sheet

The East Antarctic Ice Sheet today

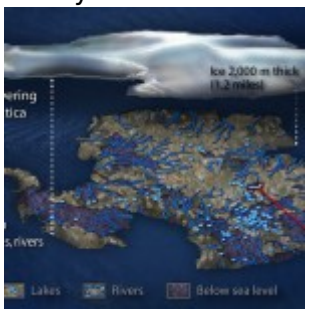


Landsat Image Mosaic of Antarctica (LIMA) showing location of key ice shelves.

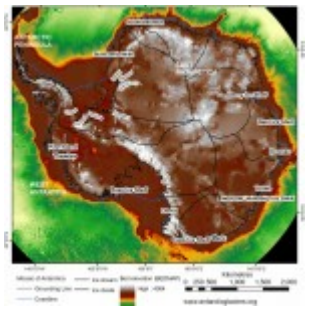
The East Antarctic Ice Sheet is the largest of Antarctica's ice sheets, and has a very different behaviour to its counterparts. Its dynamics and geography are distinctive, and the East Antarctic Ice Sheet behemoth warrants a closer look in its own right.

The total volume of ice in the Antarctic Ice Sheet today is 27 million km^3, which is equivalent to 58 m of global sea level (i.e., if all the ice in Antarctica melted, sea levels would rise by 58 metres). The Antarctic Ice Sheet is usually divided into three ice sheets: The Antarctic Peninsula Ice Sheet, the West Antarctic Ice Sheet, and the East Antarctic Ice Sheet. The East Antarctic Ice Sheet makes up the majority of the Antarctic Ice Sheet, and has a global sea level equivalent of 53 m [1]. 19 of these metres would be from glacier ice grounded below present sea level. The South Pole is found in East Antarctica. It lies at 2835 m above sea level.

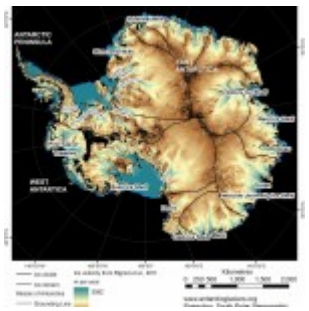
Amundsen-Scott South Pole Station, with the ceremonial South Pole and the flags for the original 12 signatory nations of the Antarctic Treaty



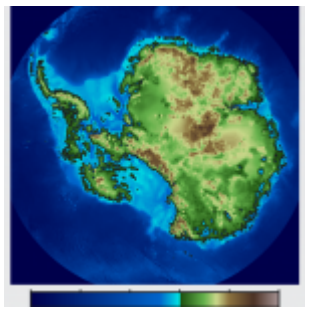
Subglacial lakes around Antarctica



BEDMAP: The bedrock topography of the Antarctic Ice Sheet



Velocity of the Antarctic Ice Sheet, showing the ice divides.



Isostatically corrected Antarctic continent with the ice removed. Global Warming Art Project.

Because the bulk of the ice sheet rests on bedrock high above current sea level, the East Antarctic Ice Sheet is more stable than its neighbours. However, the East Antarctic Ice Sheet has received less scientific attention than its more headline-grabbing neighbours. Its extent at the Last Glacial Maximum is comparatively poorly resolved, and its dynamics and the interior's geomorphology is less well understood. In part, this is because this high, cold, windy place is still inaccessible, as well as huge.

Ice flow in East Antarctica

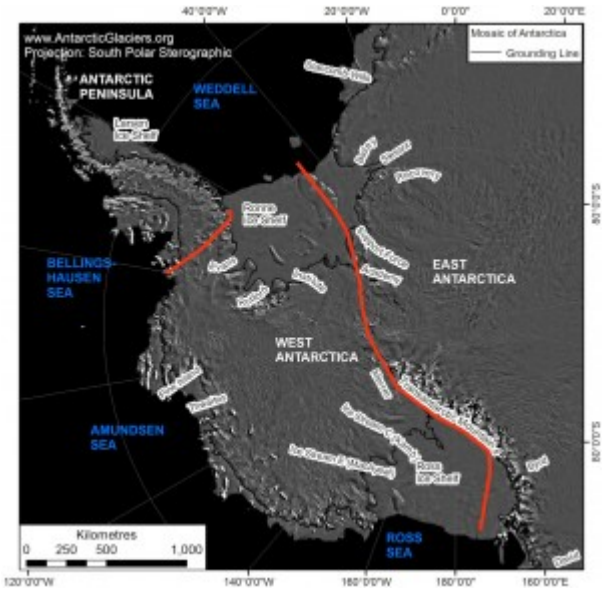
The East Antarctic Ice Sheet has a complex configuration, with ice velocity being slow near the ice divide, but feeding out into a number of ice streams. Many of these ice streams end in ice shelves, floating glacier ice that is no longer in contact with the bed. Many of these ice shelves receive snow and ice in their own right, from freezing sea water below or from snow falling on them from above. One of the largest ice streams in East Antarctica is the Lambert Glacier System, which drains around 16% of the ice sheet by area [2].

Topography of the East Antarctic Ice Sheet

Mountains hidden under the ice

The East Antarctic Ice Sheet may look smooth and flat, but the ice sheet covers whole mountain ranges. The Bed Elevation figure shows these mountains, which have beautiful valleys carved into them. Some of these valleys have a geomorphological signature that indicates that they were initially incised by rivers. The Gamburtsev Mountains are under 3 km thick ice in East Antarctica, and they can be seen and visualised by aerogeophysical surveys flown over the East Antarctic Ice Sheet. These mountains are located in the central East Antarctic Plate, and are around 400 km wide. Ice thickness varies considerably over these mountains, from 1-3 km thick [2]. Other important features of East Antarctica include Dome C, which is a lowland area, and Ridge B, which rests over regions of high bedrock topography.

The Transantarctic Mountains



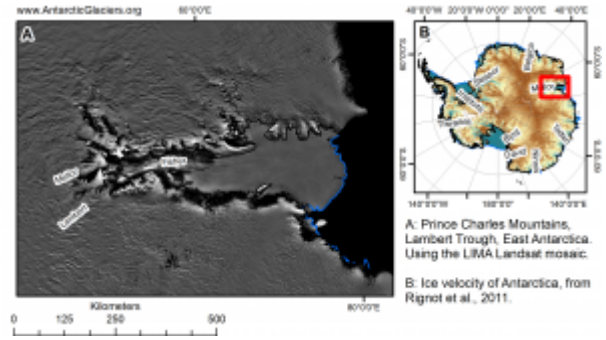
Landsat Image Mosaic of Antarctica, showing the different ice sheets of Antarctica

The East Antarctic Ice Sheet is bounded by the Transantartic Mountains, which are around 4 km high and are visible as nunataks, poking up out the top of the ice sheet. This 2000 km long mountain range divides the East and West Antarctic ice sheets [2]. The East Antarctic Ice Sheet also contains the enigmatic Dry Valleys, a region with so little precipitation that the region has been ice free for millions of years.

In the Google May below, you can explore the Byrd Glacier, which flows through the Transantarctic Mountains into the giant Ross Ice Shelf. Byrd Glacier is a major ice stream, and you can see the convergent flow as it is channelled through a valley in the mountain range.

View Byrd Glacier in a larger map

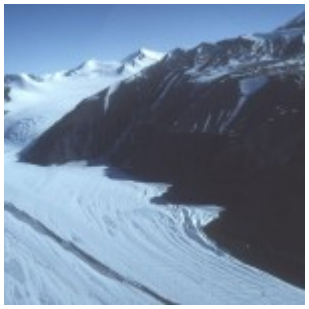
Prince Charles Mountains



The Prince Charles Mountains, East Antarctica

Another mountain range is the Prince Charles Mountains, located near the Lambert Glacier. These mountains are important geologically, as they contain sediments deposited millions of years ago by the first Antarctic ice sheets. The mountains reach elevations of 3228 m, and the mountain range is 260 km long. They were only discovered in the late 1940s.

The photographs below are from the Prince Charles Mountains, taken by Professor Michael Hambrey during fieldwork there.



Pagodroma Group sediments resting on a glacial erosion surface, Fisher Massif

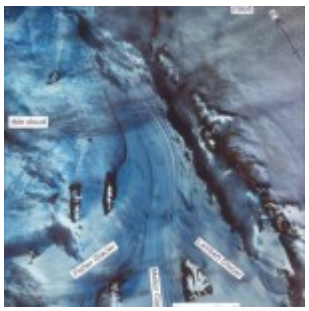
Barry McKelvey using a Jacob's Staff to measure a section through Pagodroma Group.

Typical diamictite of the Pagodroma Group, Fisher Massif. Note the range of clast sizes.

Australian field camp by Raddok Lake with Pagodroma Group section in background on Dragon's Teeth (1994).

Pagodroma Gorge flanked by diamictites

Quad bikes were used to explore the terrain in the Prince Charles Mountains.

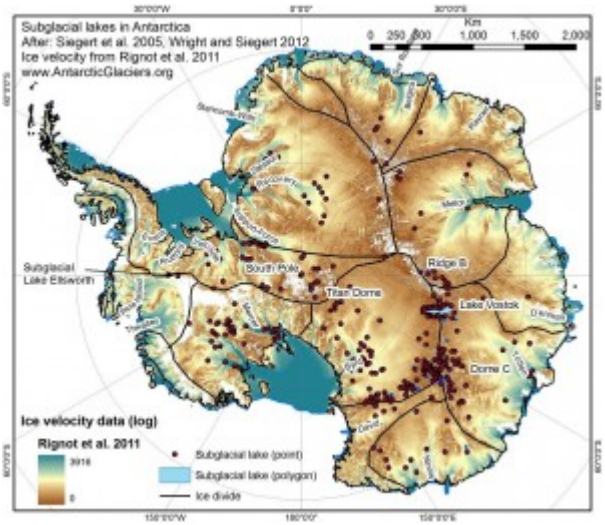


Landsat image of the Lambert Glacier-Amery Ice Shelf system

Another way in which scientists can analyse the rocks hidden underneath the East Antarctic Ice Sheet is by looking at mineral grains washed up in sediment drifts on the continental slope, in deep sea water. These mineral grains were eroded by the ice sheet, transported to its edge, and then released into the open as icebergs calved off the edge of the massive ice sheet. Analysis of these sediments

help scientists analyse the evolution of the Lambert Glacier system over the last 34 million years [3]. Over millions of years, this ice stream incised the trough by 1.6-2.5 km.

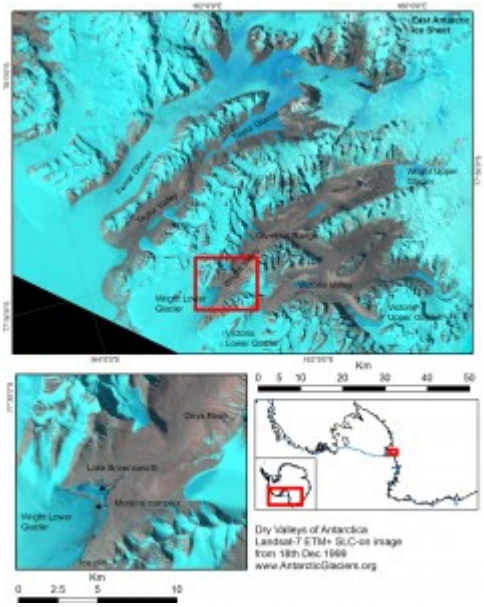
Subglacial lakes underneath East Antarctica



379 subglacial lakes have now been identified beneath the Antarctic continent. This map, using data from Wright and Siegert 2012 [1] shows that many are located in ice-stream onset zones as well as underneath slow-moving ice domes.

Although much of the East Antarctic Ice Sheet is very cold, and above pressure melting point, in some places, the ice is so thick that it does reach this magic temperature. In some of the deep troughs, where ice is over 3.5 km thick, pressure melting point is reached [2]. This means that there is water underneath the ice sheet. The East Antarctic Ice Sheet therefore hides a huge number of subglacial lakes, the largest being Subglacial Lake Vostok [4].

The Dry Valleys of East Antarctica

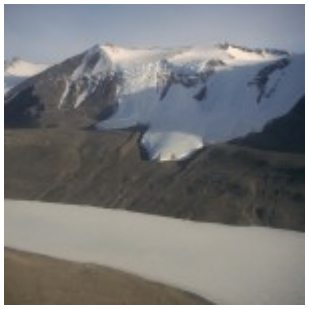


Satellite image of the Dry Valleys

The Dry Valleys of East Antarctica are in Southern Victoria Land, near McMurdo Station. This is the

largest ice-free part of Antarctica, with glaciers limited by the extremely low precipitation they receive. These glaciers receive only 10 mm of water through precipitation per year, and mean annual air temperature is around -19.8°C. These cold-based glaciers move very little and very slowly, and some of the ice in the Dry Valleys is thought to be millions of years old.

These photographs of the Dry Valleys are credit Professor Michael Hambrey.



Cold glaciers above Lake Bonney

Mackay Glacier skidoo party

Mount Erebus

Wright Lower Glacier sand apron

Wright Lower Glacier ice pinnacles

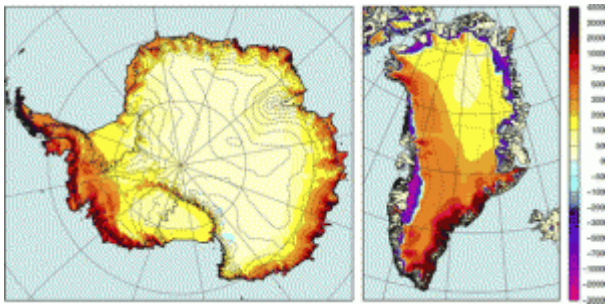
You can use the Google Map below to explore the Dry Valleys of East Antarctica by yourself.

View Larger Map

Climate of the East Antarctic Ice Sheet

The East Antarctic Ice Sheet is very cold. Temperatures as low as -85°C have been recorded at Dome C [5]. It is also dry, receiving very little annual precipitation and far less than the Antarctic Peninsula Ice Sheet[6]. East Antarctica is so cold, high and dry, that it creates its own climate [7].

Surface mass balance



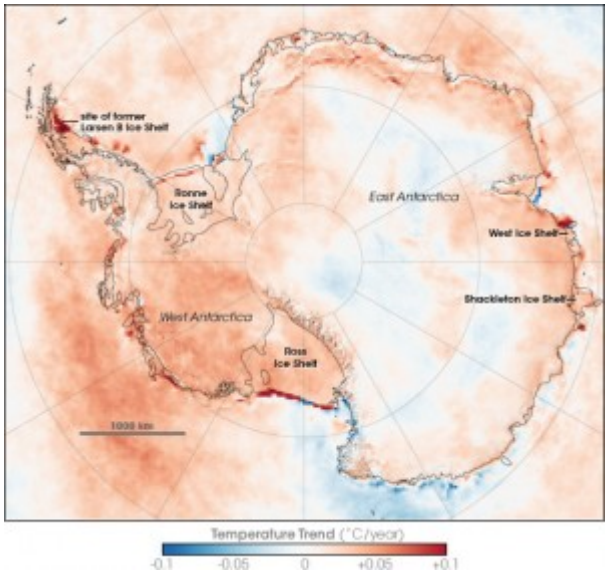
Surface mass balance of the Antarctic and Greenland ice sheets. From Van den Broeke et al., 2011.

The surface mass balance of the East Antarctic Ice Sheet is shown in this figure, from Van den Broeke et al., 2011. Surface mass balance is the sum of accumulation (snow, rain) and melting (by sublimation and run off). This can be calculated using measurements from satellites[8]. This figure is the average surface mass balance from 1989-2009. This figure shows that the Antarctic Peninsula, West Antarctic Ice Sheet and the coastal regions of the East Antarctic Ice Sheet are significantly wetter than the ice sheet interior. Peak values of 3000 kg per metre per year of accumulation are experienced in the western Antarctic Peninsula, but the interior of the East Antarctic Ice Sheet receives less than 50 kg per metre per year.

Although there has been rapid ice sheet thinning observed in West Antarctica and on the Antarctic Peninsula, so far, this has not been observed around East Antarctica [9]. In fact, parts of the East Antarctic Ice Sheet are thickening, especially deep in the interior, which contrasts strongly with the observed rapid thinning of the West Antarctic Ice Sheet [10]. Shepherd et al. indicate that the East Antarctic Ice Sheet gained 14 ± 43 gigatonnes between 1992 and 2011 [11]. This is because precipitation in the interior increases under a generally warmer global climate [7].

Although most of the glaciers in this region are close to mass balance (input = output), some of the glaciers of the East Antarctic Ice Sheet are thinning and receding. These glaciers include Totten Glacier, the largest discharger of ice within the ice sheet [7]. Moscow University Ice Shelf and most glaciers in Wilkes Land are also thinning. These glaciers are grounded well below sea level.

Current cooling



Antarctic temperature trends, 1981-2007. By Robert Simmon, NASA [Public domain], via Wikimedia Commons

The East Antarctic Ice Sheet is currently cooling slightly [12], probably as a result of changes in the circumpolar vortex. This results in falling pressure over Marie Byrd Land and northerly flow anomalies [6]. The warming over the Antarctic Peninsula and West Antarctica and cooling over East Antarctica is also related to changes in regional sea surface temperatures, broader changes in atmospheric circulation and changes in sea ice[13].

Some models predict that continued climate change will actually result in increased snowfall around East Antarctica. A recent numerical ice sheet model projected climate change and snow fall in East Antarctica until AD2500 [14]. However, this increased snowfall increased ice discharge around the continent, meaning that it had little effect in mitigating global sea level rise caused by the melting of other glaciers and ice caps, and global ocean thermal expansion. Generally, dynamically driven ice loss as a result of increased snowfall was around 30-60% of the mass gain. Indeed, the authors reported a 1.25 m global sea level contribution from the East Antarctic Ice Sheet by 2500 under the strongest warming scenarios [14].

To learn more about the East Antarctic Ice Sheet, you can read:

- Glacial Processes
- The Sirius Debate
- Subglacial Lakes
- Van den Broeke et al. 2011

You can also read this article on Antarctica's changing ice by Skeptical Science, or see some Quick Facts on Ice Sheets by the NSIDC.

Go to top or click here to see some Photographs.

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