

## Antarctica's recent climate

### Antarctic climate records

The collection of data about Antarctica's climate only really began during the International Geophysical year (1957-58) and even today is limited to coastal sites, the Antarctic Peninsula and a few remote stations deep in the interior of the continent.

Despite this limited data it is clear that on average Antarctic's atmosphere and oceans have warmed steadily for 50 years, although there is evidence of cooling in the interior during part of the 20th century.

This general warming, with interior cooling may simply be due to the drift towards the pole of the strong westerly winds that normally circle the continent, resulting in more storms and stronger winds nearer the continent's centre.

Such rapid warming of Antarctica's atmosphere and oceans is at least partly due to human (anthropogenic) activity especially increased greenhouse gases and ozone depletion.

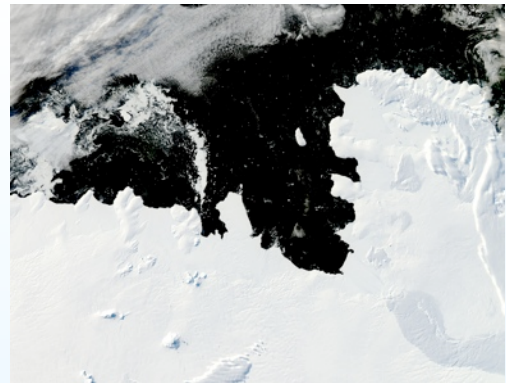
### What the ocean data shows

Considering its size and importance there has been little data collected from the southern ocean, with only a few ship-based measurements and a heavy reliance on 'Argo' buoys automatically uploading their temperature and salinity data to satellites. What is shown however is that the Southern Ocean is freshening (has less salt) and has warmed at nearly twice the global ocean average, especially the water circulating in the huge Antarctic Circumpolar Current (ACC).

Another large body of water affected is the Circumpolar Deep Water (CDW), which lies at intermediate depth. In a few sites the CDW floods onto the continental shelf around Antarctica, increasing the melting of ice sheets, reducing the extent of sea ice and producing more rain and snow. This has been especially so to the west of the Antarctica Peninsula where water temperatures have risen 1°C in just fifty years. Although this seems a small temperature rise it is really a very large increase because of the enormous volume of water involved.

### Less sea ice, more snow

The warming of Antarctica, especially in winter near the Peninsula is not fully understood, but appears to be caused by changes in the circulation of the atmosphere and ocean currents. These changes have had little effect for most of the continent with sea ice cover remaining the same since the late 1970s. However the marked warming near the Peninsula may be due to a loss of sea ice to its west, for sea ice is especially important in insulating the ocean from the atmosphere. The brilliantly white sea ice also reflects far more heat energy than the dark surface water - hence without an ice cover warmer, more moisture laden air flows further inland.



*Sea ice reflects more light than the dark seas.  
West Antarctic coastline.*

### The physical effects of warming

One of the most marked effects of warming near the Antarctic Peninsula has been the abrupt retreat or collapse of several Antarctic ice shelves - some of which have been spectacularly fast. For example the 3250 km<sup>2</sup> Larsen-B ice shelf collapsed in a matter of just a few weeks over the 2001 - 02 summer. Such a dramatic collapse is believed to be encouraged by surface meltwater lakes that fill crevasses, splitting the ice shelf vertically, a situation made worse by the sea melting the ice from below.

It is important to remember that the melting of an ice shelf or iceberg does not raise sea levels, as the water occupies the same space as the ice. However the collapse of ice shelves can indirectly allow the sea level to rise, if they no longer hold back land based glaciers and ice sheets.

Warming can also increase snowfalls as the air contains more moisture and large areas of Antarctica are receiving 1 - 4 cm of extra snow each year as a result, especially across the East Antarctic Ice Sheet (EAIS). Yet when comparing ice loss and extra snow the overall effect is that Antarctic is losing ice.

### The biological effects of warming

As Antarctica warms it becomes home to new species. Already over 200 alien species (microbes, invertebrates, plants and mammals) have been recorded, although most of these have settled on Sub - Antarctic Islands.

Some introductions were deliberate, such as reindeer to South Georgia, and others accidental such as seeds on the clothing of scientists or tourists. Although warming may make such introductions more successful it can also reduce some populations through competition and habitat loss, as with the ice loving Adélie penguin.

In the seas most Antarctic animals are very poorly-equipped to deal with environmental changes as they tend to be slow-growing, long-lived, and relatively slow to reproduce. Even the circular shape of the polar continent means that Antarctic organisms have nowhere cold to migrate to when the temperature rises.

Together these factors mean that Antarctica's wildlife, more than anywhere else in the world, is threatened by climate change.

## Web Activity: Tracking an Argo buoy

### Introduction

Tracking the path of an Argo buoy in the Southern Ocean can be done using Google Earth (a free virtual globe that can be downloaded onto personal computers, tablets and some smart phones) or the Google Earth plugin for web browsers.

### What to do

1. Using keywords such as "Argo buoy float track earth southern ocean" search the internet for websites providing live data from Argo buoys adrift in the southern ocean.

For example

[www.noc.soton.ac.uk/o4s/euroArgo/Argoeu\\_2.php](http://www.noc.soton.ac.uk/o4s/euroArgo/Argoeu_2.php)

2. Record what information is presented, especially

- the buoy number
- when it was launched
- when it last sent data
- what the graphs or charts show
- the high and low temperatures
- the highest and lowest salinity

### How it works

The Argo Project involves cooperation between 27 countries. and around New Zealand buoys are released by NIWA. An excellent explanation of the Argo Project can be found on the Science Learning Hub, under the context "The Ocean in Action". Go to

[sciencelearn.org.nz](http://sciencelearn.org.nz)

### Relevance

- Most of our current knowledge of the southern ocean comes from Argo buoys. These buoys are part of an international project requiring cooperation between many countries and the sharing of data.
- This sharing is often done over the internet and available to the all researchers as well as the public.

### Understanding floating

The method used to automatically sink and raise Argo buoys in the oceans can be demonstrated by making a simple "Cartesian Diver".

1. Place an eye dropper (or an upside-down test tube) that is about half filled with air into a plastic bottle completely filled with water.
2. Squeeze the bottle to change the volume of air in the eye dropper, causing it to sink.
3. By trial and error it is possible to 'float' the eyedropper at any level within the bottle.



*The level of the sea does not fall when it freezes to form sea ice.*

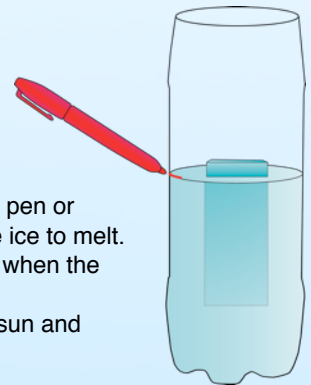
## Practical activity: Melting icebergs

### Introduction

This activity tests the statement that the melting of floating ice shelves and ice bergs will not cause sea levels to rise.

### What to do

1. Partly fill a tall container with tap water so you can float a large piece of ice in it.
2. Mark the water level with a pen or rubber band, then allow the ice to melt.
3. Mark the water level again when the ice has completely melted.
4. Stand the container in the sun and allow the water to warm
5. Mark the water level again



### How it works

When water freezes the ice crystals take up more space than the water did. This is why ice floats because there are the same number of molecules spread through a larger volume (i.e. ice is less dense than water)

When ice melts the opposite happens, so the melt water takes up less space than the ice did so the water level does not rise. The ice out of the water makes up the difference.

Warming the water in the sun will cause the water to expand and if the container is skinny enough (and there is enough water) this rise can be seen.

### Relevance

- The melting of floating ice shelves, ice bergs and sea ice does not raise sea level.
- The melting of ice sheets covering land can cause sea level to rise.
- Warming of the oceans is a cause of sea level rise.

Adapted from material by Prof. Mike Bentley, Durham University. United Kingdom.

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