

Exploring Climate Change

Evidence

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'When one tugs at a single thing in nature, he finds it attached to the rest of the world.'

John Muir, Scottish naturalist and writer, 1838-1914

Global average temperatures rose by around 0.7°C over the 20th century and 1998 was the warmest year since records began in 1861, with 2005 almost as warm.

Evidence of global warming has been found in ice cores from Greenland and Antarctica, and in changes to nature's calendar already seen in Scotland. Spring plants are blooming earlier in Scotland (on average three weeks earlier since 1978) and migrating birds are arriving earlier.

All of the evidence points to the primary cause of this warming being an increase in concentrations of greenhouse gases in the Earth's atmosphere, as a result of human activities since the industrial revolution. Concentrations of carbon dioxide (CO₂) in the atmosphere have risen by more than 30% since the industrial revolution and are now rising faster than ever before. Greenhouse gas emissions are driving climate change.

Climate scientists are studying the ice in Greenland and Antarctica as they have both shown important melting over the last 50 years. Around the world, glaciers are retreating and disappearing in line with warming trends in global and local temperature.

In recent years every summer has seen less and less Arctic sea ice. Scientists predict that there may be no Arctic sea ice in summer months by 2040.

Visit the National Snow and Ice Data Center website at the University of Colorado at Boulder to find out more about reducing levels of sea ice and to get a daily update on sea ice coverage: http://nsidc.org/data/seaice_index/

Nature's calendar



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Living things co-ordinate their activities with the seasons. Birds nest when the weather is warm and there is food for their young. Flowers need to be ready when bees are around to pollinate them. One of the results of climate change is that these patterns will change and in some cases be disrupted.

These changes in timing - phenology - are not evidence that climate change is caused by greenhouse gases, but it is one of the easiest ways to see for yourself that the climate of Scotland is warming.

'Out of more than 500 spring and summer biological events, such as wild birds laying eggs, emergence of aphids or butterflies, and flowering of plants, 74 per cent show some evidence of being earlier.'

Scottish Natural Heritage (SNH)

Scottish Natural Heritage has brought together information from a wide range of sources to show how Scotland's biodiversity is changing, presenting a huge amount of information on flowers, birds and insects and the way they are responding to climate change.

- Flowers bloom earlier: the average change is 3.2 days earlier every ten years over the last 100 years.
- Migrating birds arrive earlier: the average change is 2.6 days earlier every ten years over the last 100 years.
- Butterflies become adult earlier: the average change is 2.7 days earlier every ten years over the last 100 years.
- Plankton blooms in the North Sea now appear 3 days earlier every ten years over the last 100 years.

The comma butterfly has recently been spotted in gardens as far north as Tayside.



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These changes could be relatively harmless for wildlife, especially if everything changed at the same rate, but different species respond to climate in different ways. We are beginning to see evidence of problems as species change at different rates; insects appearing before the plants they feed on, migrating birds arriving before their food is available.

'These results show that species are responding at different rates to the effects of warming temperatures on land, air, freshwater and sea, and this could ultimately mean that timings of natural events will become so out of balance as to affect food webs and competition between species. The challenge now is to develop conservation plans which will help vulnerable species adapt to these continuing changes here in Scotland, as well as supporting ongoing international initiatives to reduce carbon emissions.'

Professor Colin Galbraith, Director of Scientific and Advisory Services, SNH

Greenland and Antarctica

Almost all of the world's ice is found in Greenland and Antarctica, covering about 10% of the global land surface and storing over 70% of the Earth's freshwater. The future of these two huge areas of ice is one of the most active and most important areas of research into climate change.

Reliable records for ice depth and extent in Greenland and Antarctica exist only for the last 40 years. There is much research going on now to try to understand how much ice was present in the past, including the distant past. Measuring the ice now and understanding how the ice has changed in these areas is extremely important because of the potential effects on sea levels and ocean currents if there is widespread and sustained ice melt.

Both Greenland and Antarctica have shown significant melting over the last 50 years, fitting with the rise in global temperature. As a result of the way in which the atmosphere and oceans move heat around the world, temperatures will rise faster at the poles than at the equator.

The Larsen B Ice Shelf

In 2002 the Larson B Ice Shelf suddenly broke up, off the Antarctic Peninsula; 3250 km² of ice broke off, an area almost twice the size of the Isle of Skye. While the Ice Shelf was sea

ice and so contributed little to sea level rise it was holding back the land ice. The flow rate of land ice on the peninsula falling into the sea has now increased.

Images and more information on the Larsen B collapse are available at Nasa's Earth Observatory. <http://earthobservatory.nasa.gov/Features/WorldOfChange/larsenb.php>

The Wilkins Ice Shelf

In April 2009 the Wilkins Ice Shelf broke apart. The Wilkins is following a pattern of instability and rapid collapse that many Antarctic Peninsula ice shelves have experienced in recent years. Scientists think that the dramatic loss of these ice shelves, which have existed for hundreds to thousands of years, is an important sign of climate change in the Southern Hemisphere.

Images and more information on the Wilkins collapse are available at Nasa's Earth Observatory. <http://www.earthobservatory.nasa.gov/IOTD/view.php?id=37806>

Greenland

In Greenland, there have also been recent rapid increases in melting rates on the edges of the ice sheet. This has been accompanied by increased ice sheet thickness at the centre of the island, attributed to increased snow fall.

A major aim of climate change science is to understand what is happening in these areas. While there is evidence that they are melting fast and the process is getting faster, there is still a great deal of doubt about the rates. The answers to these questions are essential if we are to predict how much sea levels will rise due to climate change.

Watch a video demonstrating major ice collapse in Alaska and Greenland.
http://www.ted.com/talks/james_balog_time_lapse_proof_of_extreme_ice_loss?nolanguage=en

Glaciers



Photo credit: Paul Keller 1

Vanishing glaciers around the world give us some of the starkest images of rising global temperatures.

Glaciers develop in areas of high snow fall where low temperatures mean that snow accumulates faster than it melts. The snow changes to ice and slowly moves downhill. Scotland was shaped by glaciers in the last Ice Age, ending about 10,000 years ago. Glaciers cut deep valleys, carved corries and dumped huge amounts of debris when they melted. Both Edinburgh and Glasgow owe much of their shape to underlying glacial landforms.

The rate at which glaciers retreat has increased dramatically in the last decades and is in line with the known trends in global and local temperature. These changes have occurred on all continents.

Some scientists predict that ice melt from glaciers will be the major cause of sea-level rise in the 21st century. They estimate that the accelerated melting of glaciers and ice caps around the world will cause global sea levels to rise add between around 100 and 240 mm by 2100.

In a few places glaciers are actually increasing in size, for example in parts of Norway. Since glacial advance or retreat is controlled by the balance between snowfall and melt, in these areas increased snowfall, consistent with climate change, is greater than the increased rate of melting.

The melting of glaciers and ice fields in the Himalayas is of particular concern. The seasonal melting of this ice feeds the great rivers of India, South East Asia and China, including the Ganges, the Yangtze and the Mekong. These rivers provide half of the drinking water for 2.6 billion people, 40% of the world's population.



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