

Exploring Climate Change

Predictions

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Climate change is widely seen as the most serious threat facing our planet in the 21st century.

Scientists have developed sophisticated climate models as they attempt to accurately predict how the Earth's climate will change this century. A key question is 'how much will the sea level rise?' In Scotland we are warmed by the Gulf Stream but what happens if the Great Ocean Conveyor shuts down?

Our actions will decide the future of the Earth's climate. By taking action, conserving energy and using green technologies we can help to reduce our impact on the planet.

As responsible global citizens we have to try to make informed choices and decisions. Scotland is a small country in a world of over 6 billion people but we have an important role to play in tackling climate change.

The Intergovernmental Panel on Climate Change (IPCC), representing the views of thousands of scientists across the world, produced its authoritative Fourth Assessment Report in 2007 which summarised the huge amount of research taking place on climate change.

Climate modelling

The greatest challenge in understanding climate change comes in answering the simple-looking question, 'what happens next?'

Because of the complexity of the world's climatic and geophysical systems, this is a very difficult question to answer but there is now a high degree of agreement about what is likely to happen (although this has to be expressed in ranges and probabilities).

There are a number of climate models, each with different ways of working and assumptions, run by research groups around the world. These are used to predict the results of a range of scenarios, ranging from what might happen if we cut greenhouse gas emissions to pre-industrial revolution levels, to what will result from carrying on as if there isn't a problem.

These models show high degrees of agreement and form the basis of the advice given to the United Nations by the Intergovernmental Panel on Climate Change (IPCC).

Even when the question 'what happens next?' has been answered as best we can, we have to work out how the changes will affect us, our farming, our economies and our societies.

How much change can a country absorb - could the UK survive the loss of large parts of some of our major cities through flooding? How will increasing drought in eastern parts of the UK affect us? Moving to a global scale, what will be the effects of loss of land in Bangladesh, or extensive drought in Africa?

Based on the answers to these questions, Scotland, the UK and the other countries of the world must decide how they will respond to climate change.

The UKCP09 Climate Projections: <http://ukclimateprojections.metoffice.gov.uk/>

The latest package of climate change scenarios for the UK was published in June 2009 and is known as UKCP09 or the Projections for short.

UKCP09 reflects recent advances in climate science to better quantify some of the uncertainties associated with climate modelling, understanding of how the climate system operates, and how it might change in the future. UKCP09 has provided information on current and projected future climate change for the UK up to 2099.

All sorts of people will use UKCP09 information to assess what the impacts of a changing climate might be on, for example, rail networks, habitats, health services or coastal defences.

The key findings from UKCP09 suggest how our climate might change. For example:

- All areas of the UK will get warmer, and the warming will be greater in summer than in winter.
- There will be little change in the amount of precipitation (rain, hail, snow, etc) that falls annually, but it is likely that more will fall in the winter, with drier summers, for much of the UK.
- Sea levels will rise, but more in the south of the UK than the north.

Sea levels



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Sea ice and land ice

Scientists predict that global sea level rise will have two main sources. Firstly, as the oceans heat up the water expands. At present this thermal expansion accounts for about half of the observed increase in sea level. The other cause is melting land ice from glaciers and ice caps. The rate of melt and the volumes of water locked within these sources are uncertain and this is a cause for concern.

In recent years, ice shelves have broken off huge ice sheets in Antarctica and Greenland. The ways in which they are melting is only now beginning to be understood fully enough to allow estimates of how fast this melt is occurring and how much this will affect sea levels.

If they melt as fast as is now thought to be possible, sea levels could rise dramatically over the next century, flooding many of the world's major cities and much of the world's most productive farmland.

Latest predictions

In 2009 scientists revealed that sea levels could rise twice as fast as was forecast by the UN as recently as 2007. Rapidly melting ice sheets in Greenland and Antarctica could push up sea levels by a metre or more by 2100, flooding some coastal cities and the homes of 600 million people who live in deltas, low-lying areas and small island states.

Low-lying countries with increasing populations, such as Bangladesh, could see large parts of their surface areas vanish. Experts in Bangladesh estimate that a one-metre rise in sea levels would swamp 17% of the country's land mass; and as salty water reaches further inland staple crops like rice would be much harder to cultivate. Pacific islands, where 12,000 people live just a few feet above sea level, would disappear completely.

The UK

According to the UKCP09 Projections¹, sea level rise around the UK will be between 12 and 76 cm for the period 1990–2095. However, the rise will be more in the south of the UK, where the land mass is actually sinking slightly.

This will provide real challenges in lower-lying areas along the east coast, from Lincolnshire to the Thames estuary, along with a much greater risk of catastrophic 'storm surges' such as the great flood of 1953 that killed 307 people.



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London and the Thames Barrier

The Thames Barrier was built in 1982 to prevent tidal flooding of central London. At the current likely rate of sea level rise the Thames Barrage could be overwhelmed. The UK Government is considering options for a second larger barrier to address this issue.

¹ <http://ukclimateprojections.metoffice.gov.uk/>

Changes in sea temperature and salinity

Changes in the Earth's climate also affect the salinity, or saltiness, of the oceans and seas, as well as their temperature. The shallow shelf seas around the UK are projected to be 1.5 °C to 4°C warmer and fresher (ie less salty) by the end of the 21st century. This will impact on the delicate balance of ocean life, which could lead to disruption of the marine ecosystems of the world.

The Ocean Conveyor



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The Earth's oceans and atmosphere act like a huge transport system, moving heat from the warmer regions around the equator to the colder areas at the poles. These sea currents and winds follow established patterns which encircle the globe and are known as the Great Ocean Conveyor Belt.

One of these conveyors, the Gulf Stream (the North Atlantic Thermohaline Conveyor), carries warm water from the tropics (around the Caribbean) to North West Europe. One arm of this Gulf Stream, the North Atlantic Drift, flows up the west coast of Scotland and is responsible for maintaining a temperate climate.

Scotland's climate is, as a result of the conveyor, very much warmer than other parts of the world at the same latitude. Edinburgh is at the same latitude as Hudson Bay in North America, where the sea freezes in winter. Thousands of species of exotic plants flourish at Inverewe Garden in Wester Ross, farther north than Moscow where winter temperatures regularly fall to -20°C.

It is possible that the Gulf Stream will decrease in strength over the next 100 years as a result of global warming. But models suggest that even with decreases of as much as a quarter of its current strength and the cooling effect this will have the overall result of climate change is expected to be a warmer Scotland.

There is however a scenario in which the conveyor could stop completely.

About 8,000 years ago a vast lake, dammed behind an ice barrier where the St Laurence River now is, suddenly burst. This allowed billions of litres of cold freshwater into the North Atlantic.

This stopped the Gulf Stream, plunging what is now Scotland into a 1,000-year mini ice age. The drained remains of the ice-dammed lake are now the North American Great Lakes.

It has been noted that the rapid melting of the Greenland Ice cap could lead to the Gulf Stream shutting down. While this scenario is judged to be unlikely and certainly not within the next 100 years it is never the less one of the possible future consequences of climate change.

The IPCC

The Intergovernmental Panel on Climate Change (IPCC)² is a scientific intergovernmental body set up by the World Meteorological Organisation (WMO) and by the United Nations Environment Programme (UNEP). It is made up of:

- **Governments:** the IPCC is open to all member countries of WMO and UNEP.
- **Scientists:** hundreds of scientists all over the world contribute to the work of the IPCC as authors, contributors and reviewers.
- **People:** as a UN body, the IPCC work aims to promote the UN human development goals.

The IPCC provides regular assessment reports on what we know about climate change. The first report was produced in 1990, the second in 1995, the third in 2001, and the fourth and latest in 2007. The fourth assessment is the largest and most detailed summary of the climate change situation to date, involving thousands of authors from dozens of countries, and states in its summary:

- 'Warming of the climate system is unequivocal.' (This means there is no doubt that global warming is taking place.)
- 'Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.' (This means that most of the warming in the 20th century has been caused by human-induced greenhouse gas emissions.)

The IPCC is currently starting to outline its fifth assessment report AR5, which will be finalised in 2014. Because of errors found in AR4, there have been calls for the IPCC to review how it works, both from critics and from scientists working within IPCC.

There is a great deal of talk of consensus in climate change science and politics. Because of the importance of the research and the consequences of making mistakes, the IPCC reports are a way, not found in other areas of science, of bringing together the experts in many areas that contribute to our understanding of climate change and producing a broadly agreed common view.

While there are researchers who will disagree with the detail of parts of the IPCC reports, there are very few people actively working in the field who disagree with the broad conclusions of the IPCC reports.

In December 2007, the IPCC was awarded the Nobel Peace Prize for its efforts to discover and share greater knowledge about man-made climate change, and to help understand what we need to do to counteract such change. The award is shared with former US Vice-President Al Gore for his work on climate change and the documentary 'An Inconvenient Truth'.

² <http://www.ipcc.ch/>