low carbon liverpool

Building the Low Carbon Economy on Merseyside

Findings No.5 - The science base

Key messages

1. Global warming is happening. 2010 tied with 2005 as the second hottest year since records began. The hottest was 1998.
2. There is a demonstrable and well known connection between levels of greenhouse gases in the atmosphere and global warming.
3. We are responsible for emitting the greenhouse gases that are warming the planet, and have been since the industrial revolution (if not before).
4. We must reduce CO_2 levels to 350 parts per million, and temperature increase to below 2°, to avoid major problems that will severely impact on our economy and wellbeing: loss of arctic ice and of glaciers that feed major rivers, sea level rise, storms, desertification, drought and extensive rainforest fires.
5. The costs of taking action to avoid dangerous climate change now are much less than coping with it in the future.

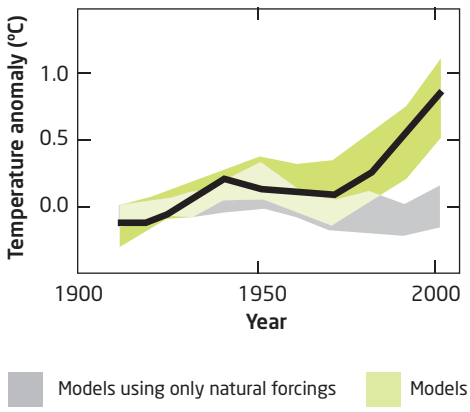

Figure 1.

Comparison of observed temperature with climate models using 'natural' or 'natural plus human' climate change drivers (forcings).

Solid line = recorded temperature;
Upper (green) band = calculated temperature range (natural plus human sources);
Lower (grey) band = calculated temperature range (natural sources only).

Only by including the human-induced greenhouse gas component do the models match recorded temperatures (IPCC 2007).

What do we know about climate change?

There is a scientific consensus on the reliability of evidence for the existence of human-induced climate change. Climate change is happening, and human activities are causing it. That is easy to understand, even if the science itself is complex.

- A well-established and demonstrable physical relationship exists between carbon dioxide (CO_2) concentration in the atmosphere and global temperature. The scientist Arrhenius demonstrated that that adding CO_2 to the atmosphere will increase the temperature by a known amount. We have known this since 1896.

- Examining ancient air trapped in bubbles in glaciers shows that before the industrial revolution in the late eighteenth century, concentrations of CO_2 had not risen above 300 parts per million of atmosphere (ppm) for the past 650,000 years. The amount and rate of warming in the last few decades is unprecedented.
- Hundreds of scientific studies indicate that the warming we are witnessing today is caused by human-derived CO_2. No evidence contradicts this conclusion.
- Observed temperature increases match the curve predicted by scientists from climate models, and can be accounted for only by inclusion of anthropogenic (i.e. human-derived) emissions of CO_2 (often referred to as anthropogenic forcing).

Predictions of what is to come

To take the right steps to avoid dangerous climate change, we need to make policy choices that are based on what science tells us about how the climate is expected to change over the next few decades. Science cannot tell us what to do, but it can tell us what to expect if current trends continue.

When quantifying the amount of greenhouse gases in the atmosphere, scientists quantify the amount of CO_2 equivalent (CO_2e) in the atmosphere. The term CO_2e means CO_2 plus other greenhouse gases, e.g. methane, nitrous oxide and fluorocarbons, converted into equivalent units. The maximum atmospheric concentration of CO_2e now considered 'safe' by scientists is 350 ppm (equivalent to 1990 levels). The UK Government's target (for 2050) is 450 ppm CO_2.

The limit of 450 ppm is thought to be the point where the risk of 'catastrophic' climate change is 50%, but does not take account of 'positive feedback' mechanisms which put more CO_2 into the atmosphere even without extra fossil fuel emissions. It is likely that we will have to limit emissions to 350 ppm, and it is very likely that this will be extremely difficult to achieve. Maximum CO_2 levels measured in 2010 were 389.78 ppm. Thus we need to take CO_2 out of the atmosphere at massive rates. Apart from planting millions of trees, we do not have technology to do that at present.

Despite agreements to curb greenhouse gas emissions, the rate of CO_2 increase in the atmosphere over the last decade is greater than that envisioned as the worst case scenario in IPCC's 2007 report. Unless we take urgent action, we are on course for major disruptions that will severely impact our economy and wellbeing: loss of arctic ice and of glaciers that feed major rivers, sea level rise, storms, desertification and extensive rainforest fires – the rainforest literally burning down to be replaced by savannah or droughts.

Positive feedbacks

Positive feedbacks are relationships that lead to an amplification of effects. They occur because of inevitable consequences of what has already happened. For example, when ice melts, the reflective white colour is lost from the earth's surface, and so the newly exposed darker surface absorbs more of the sun's heat than did the ice. This leads to further warming and thus more melting of ice, and so on: a reinforcing loop.

Unfortunately, positive feedbacks can be chaotic, and amplify warming processes very quickly, making the future hard to predict. As a result, things might actually be significantly more dangerous than we think they will be.

The most serious positive feedbacks arise from melting of frozen carbon deposits in peat and tundra, and in methane deposits on the sea floor. On melting, massive amounts of greenhouse gases that were safely stored underground or in the deep ocean are released, which will significantly add to existing carbon concentrations, pushing the global temperature higher and at a faster rate. Methane is 80 times more potent as a warming gas than CO_2, but only stays in the atmosphere for a couple of decades: CO_2 stays in the atmosphere for thousands of years. The geological record shows us that extreme climate change has happened in the distant past, in decades. It could happen again.

Unfortunately, these feedbacks are already happening, and are observable in the arctic and in tundra regions. Methane can be measured as it bubbles out of melt pools on permafrost that is melting. The target of 350 ppm takes account of the potential for significant methane emissions to reduce the likelihood of feedbacks pushing the system from difficult but manageable levels of warming, to catastrophic climate change.

What does this mean for the UK?

The consequences of climate change for the UK are predicted to include drier and hotter summers with occasional heavy downpours, and mild, wet winters. Flooding is expected to be much more common. Crop yields are expected to decrease as climate warms (reports of 10% yield loss per 1°C). High demand for water for cooling in industry and for irrigation will put pressure on reduced supplies. The climate is likely to be more unstable. Increased weather variability, e.g. greater extremes of drought and floods, will bring physical damage and lost work days.

Losses of biodiversity, including many characteristic British species of plant, bird, mammal, fish, invertebrate (mostly insects) and fungi, will be substantial. Diseases of animals, crops and trees, as well as humans, are likely to be more prominent as pests begin to spread from warmer climes.

Sir Nicholas Stern, in his review for the British government of the economic impacts of climate change, concluded that climate change is the greatest and most wide-ranging market failure ever seen. Stern stated categorically that mitigation of climate change must be viewed as an investment because the consequences of not taking action will be around five times greater than the costs of mitigation. Lord Stern later said that his report had significantly **underestimated** climate change and the problems that it will bring.

To keep inevitable climate change to manageable levels and avoid catastrophic change we should act immediately and decisively to reduce our use of fossil fuels.

"If global warming is happening, why has it been so cold?"

To understand this, it is important to differentiate between climate – long term trends in temperature, rainfall, windspeeds and the like – and weather – short term phenomena. The British climate is generally a northern maritime climate – cool wet winters, warm (but not hot) changeable summers. That does not mean we can't from time to time have very hot, or very cold spells lasting many days or weeks. But what matters is the long term trend. This makes the climate.

In the winters of 2009/10 and 2010/11 northern latitudes in Europe and North America were unusually cold as a result of changes in the weather system in the North Atlantic. But the arctic was unusually warm. The long term trend shows 2010 actually came in as the second hottest on record.

What about 'climategate?'

The hacked e-mails from the University of East Anglia (UEA) were claimed in the press and by climate change 'sceptics' to be proof that scientists had lied in order to pretend that climate change is real.

Three independent enquiries were held into the 'climategate' affair. All of them concluded that:

- climate scientists had **not** colluded to withhold scientific information;
- scientists had **not** interfered with the peer-review process to prevent dissenting scientific papers from being published;
- scientists had **not** deliberately deleted raw data; and
- scientists had **not** manipulated data to make the case for global warming appear stronger than it is.

In other words, the scientists had neither lied, hidden or deleted evidence, or distorted results to fool the public or win grants. There was nothing in climategate to suggest that we cannot trust the overwhelming scientific consensus that global warming is (a) happening, (b) a problem, and (c) man-made.

Suggested reading:

This is a selection of non-specialist writing on climate change, for a general reader.

Broecker, W. (1987). "Unpleasant surprises in the greenhouse?" Nature 328: 123-126.

Friedman, T. L. (2008). Hot, flat and crowded. London, Allen Lane.

Hansen, James (of NASA) (2009) Storms of my Grandchildren, London, Bloomsbury.

Hulme, M. (2009). Why we disagree about Climate Change. Cambridge, Cambridge University Press.

IPCC (2007). Climate Change 2007: The Intergovernmental Panel on Climate Change fourth assessment report http://www.ipcc.ch.

Lynas, M. (2007). Six Degrees: Our Future on a Hotter Planet. London, Fourth Estate.

Monbiot, G. (2006). Heat: how to stop the planet burning. London, Allen Lane.

Pearce, F. (2007). With Speed and Violence: why scientists fear tipping points in climate change. Boston, Beacon Press.

Pearce, F. (2010). The Climate Files: the battle for the truth about global warming. London, Guardian Books.

Stern N. 2006. Stern Review on the Economics of Climate Change. Cambridge University Press, Cambridge, UK.