

The science of climate change

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Introduction

The Environment Agency supports the following statement by John Mitchell, Director of Climate Science at the Met Office, regarding debate over the science of climate change.

"The Met Office welcomes debate and recognises that climate change is a complex subject. There are genuine areas of uncertainty and scientific controversy. There are also a number of misunderstandings and myths which are recycled, often by non climate scientists, and portrayed as scientific fact".

"Recent coverage has questioned man's influence on climate. While the arguments used might have been regarded as genuine areas of sceptical enquiry 20 years ago, further observed warming and advances in climate science render these out of touch".

Source: [John Mitchell - Director of Climate Science at the Met Office](#)

Carbon dioxide

Don't ice core records show that changes in temperature drive changes in carbon dioxide, and therefore that it is not carbon dioxide that is driving the current warming?

Ice core records do show this, but that does not mean that CO₂ cannot be driving current warming. Over the several hundred thousand years covered by the ice core record, the temperature changes were primarily driven by changes in the earth's orbit around the sun. Over this period, changes in temperature did drive changes in carbon dioxide.

Concentrations of CO₂ are now much higher and increasing much faster than at any time in at least the last 600,000 years. This should be a warning that what is happening now may be very different to what happened in the past.

In fact, over the last 100 years, carbon dioxide concentrations have increased by 30% due mainly to human induced emissions from fossil fuels. Because carbon dioxide is a greenhouse gas, the increased concentrations have contributed to the recent warming, and probably most of the warming over the last 50 years.

The bottom line is that temperature and carbon dioxide concentrations are linked. In recent ice ages, the fall in carbon dioxide (due to cooling) amplified cooling because of a weaker greenhouse effect. In the same way there is evidence now that the recent warming may be amplified by the human-induced increases in carbon dioxide.

Source: [John Mitchell - Director of Climate Science at the Met Office](#)

Basic physics tells us that an increase in greenhouse gas concentrations will have a warming effect on the climate. Levels of carbon dioxide alone now far exceed that at any time in at least the past 650,000 years. The trend and pattern of current warming is consistent with what we would expect for the observed rise in greenhouse gases.

It is true that temperature changes appear to have preceded CO₂ changes through glacial-interglacial cycles in the distant past. However, this just suggests that CO₂ was not the initial driver of the glacial cycles. The evidence suggests that CO₂ levels rose as a result of warming, possibly as the surface of the ocean warmed. As CO₂ has a warming effect on the climate, it would then act as a feedback – stimulating additional warming. Now human emissions are causing the rise in CO₂ levels, and therefore, the resulting warming of the climate.

Source: *Defra's internal briefing*

Looking further back in time, there is strong evidence of a direct link between temperature and CO₂ on geological timescales. The sun was weaker in the distant past, yet at times the Earth was warm, and these times coincide with high levels of atmospheric CO₂. Indeed, it is not possible to explain the range of past climates without ascribing a significant warming role to CO₂. Fifty five million years ago there was an abrupt warming which appears to have been caused by increases in the greenhouse gases methane and CO₂.

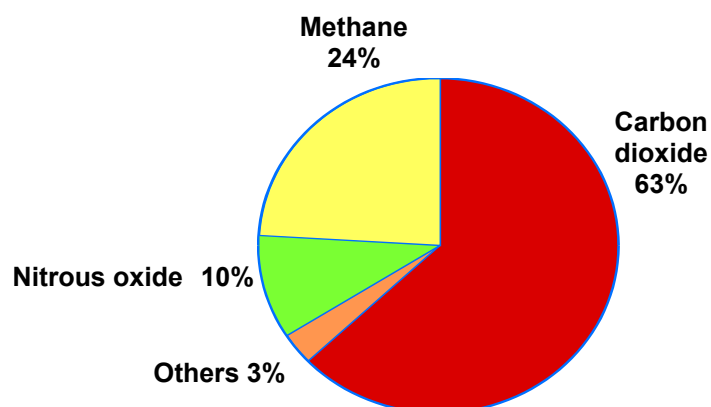
Isn't CO₂ a very small proportion of overall greenhouse gases?

"[It] is true that carbon dioxide is only a small fraction of the atmospheric mass. [One] is left to infer that means it couldn't really matter. But even a beginning meteorology student could tell you that the relative masses of gases are irrelevant to their effects on radiative balance."

Source: [Carl Wunsch on website RealClimate](#)

Equal amounts emitted of each greenhouse gas will have a different capacity to cause global warming. This depends on its lifetime in the atmosphere, the amount of extra outgoing infrared radiation it will absorb and its density. The future warming effect, taken over the next 100 years, of an extra 1kg of a greenhouse gas emitted today, relative to 1kg of CO₂, is known as its Global Warming Potential (GWP).

The warming effect over the next 100 years of current emissions of greenhouse gases will depend upon the amount of each gas being emitted globally and its GWP. The diagram below shows that that CO₂ will be responsible for about two-thirds of expected future warming:



Source: [Climate change and the greenhouse effect, Hadley Centre, December 2006](#)

The trend in carbon dioxide concentrations over the past century does not match that of temperature. Doesn't this show that carbon dioxide cannot be the key driver?

It is true that the trend in CO₂ concentrations over the last century does not exactly match the trend in temperature. But we do not expect it to. This is for two key reasons. Firstly, there is a time lag between warming and changes in CO₂, caused by the inertia in the climate system.

Secondly, greenhouse gases are not the only determinant of temperature. Aerosols, which are also emitted from human activities, are also important and can be shown to explain much of the cooling seen in the middle of the 20th century.

Climate models represent the lag in the response of the climate, and the influence of many external factors. These show that the trend in temperatures does match what we would expect. Based on these analyses and others, the recent report of the IPCC concluded that most of the warming over at least the last 50 years has been caused by the rise in greenhouse gas concentrations.

Source: [David Milliband's blog](#) and Defra's official response to 'The Great Global Warming Swindle'

Didn't most of the 20th century warming occur before 1940, when carbon dioxide emissions were still relatively low?

The first part of this question is not correct. Global temperatures did rise during the first few decades of this century, but much of the warming seen this century has occurred since around 1970 (0.4°C of the total 0.74°C warming). Global temperatures have risen almost continuously since 1950. The linear growth rate in temperature during the past 50 years is nearly twice that of the last 100 years. While the IPCC concluded that much of the warming over the past 50 years is very likely due to greenhouse gases, the cause of the warming in the first half of the century is not clear. Current thinking is that it was likely a mixture of natural and human factors.

Source: [David Milliband's blog](#)

Despite increasing levels of carbon dioxide in the atmosphere, global temperatures have remained at roughly the same level since 1998. Doesn't this show that climate change is natural not man-made?

Global temperature will change when climate is "forced" by a number of different agents. These include the amount of heat the Earth receives from the sun, the amount of solar radiation reflected back by the atmosphere (which is greater after energetic volcanoes release aerosol particles into the stratosphere), and of course the concentration of greenhouse gases in the atmosphere. But it will also change without being forced, as the various components of the climate system (oceans and atmosphere, for example) interact in a chaotic way.

This natural variability is seen in the year-to-year and even decade-to-decade changes in the Earth's temperature, which will also include some effects of changes in solar radiation and volcanic aerosols. The yearly variability is shown as the red bars in the figure at the top of the Met Office web page given below and the decadal variability by the blue filtered line on the same diagram. Hence at the same time as global temperatures are rising because of increasing man-made greenhouse gas concentrations, natural variability may be acting to either add to this or subtract from it, and this can make trends based on changes over a few years very misleading.

The period 1998 to 2005 is a good example of this. The global temperature in 1998 (the warmest year in the instrumental record so far) was enhanced by the major 1997-8 El Nino, a natural warming episode in the tropical Pacific (also shown at the end of the web page given below). However, there was no El Nino in 2005, yet this was the second warmest year in the record.

<http://www.metoffice.gov.uk/research/hadleycentre/obsdata/globaltemperature.html>

Source: *"How to Silence the Climate Sceptics"*, Dr. Geoff Jenkins, Met Office's Hadley Centre

Natural variability

Isn't current global warming just natural variability?

It is very unlikely that the rapid increase in global temperatures seen over the past half century could be caused by natural factors alone. The IPCC Fourth Assessment Report concludes that most of the observed warming since the mid-20th century is very likely, i.e. a more than 90% chance, due to human emissions of greenhouse gases. Both the spatial patterns and trend of warming can only be explained by the inclusion of human emissions. The IPCC's conclusion is based on a comprehensive peer-reviewed analysis using several lines of evidence.

Source: [David Milliband's blog](#) and Defra's official response to 'The Great Global Warming Swindle'

Haven't temperatures been higher in the past, for example, during the Medieval Warm period (800-1300AD)?

It is true that temperatures have been higher than today's in the distant past; however, at these times, atmospheric levels of CO₂ were also high. But, for the Northern Hemisphere at least, it is clear the rapid warming of the past half century has resulted in a level of warmth not seen in at least 500 years, and likely for at least the past 1300 years. For the Southern Hemisphere, long records of temperatures are more scarce and therefore it is difficult to draw such clear conclusions. The important characteristic about the current warmth is that it is global, whereas many previous warming periods have occurred over smaller areas.

Globally, eleven out of the last twelve years (1995-2006) rank among the warmest 12 years since records began in 1850. Over the past century, temperatures have risen by 0.74°C, with 0.4°C of this warming since 1970.

Climate models indicate that if greenhouse gas emissions continue unabated, by the middle of the century the world could reach a level of warmth not seen since the peak of the last interglacial period, around 125,000 years ago. At that time, sea levels were around 4 – 6 meters greater than today.

Source: [David Milliband's blog](#) and Defra's official response to the 'The Great Global Warming Swindle'

Many of the prominent climate changes over past centuries have been regional in scale. Global Warming is concerned with global scale changes. The IPCC 4th Assessment Report Summary for Policymakers has a particular section summarising the conclusions of detailed studies using a wide range of paleoclimate data. It concludes that 'Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years.'

Source: [Sir John Houghton's, former Chief Executive of the Met Office, critique of 'The Great Global Warming Swindle'](#)

Past changes in climate have been driven by natural factors, such as changes in solar radiation. Isn't it likely that these same natural factors are causing the current warming?

It is true that natural factors have driven climate changes in the past. But it is considered very unlikely that the rapid increase in global temperatures seen over the past half century could be caused by natural factors alone. Both the spatial patterns and trend of warming can only be explained by the inclusion of human emissions.

It is clear that changes in solar radiation are a significant driver of the climate. However, there is strong evidence that changes in solar radiation could not have caused the rapid warming observed over the past half century. The warming effects of changes in solar output since pre-industrial times are estimated to be less than around one tenth that of human emissions of greenhouse gases.

Despite recent claims, there is no scientifically robust evidence suggesting that cosmic ray variations have, or could even, play a significant role in recent warming. Variations in cosmic rays over the past few decades can not explain the long-term global warming trend.

Source: [David Milliband's blog](#)

Changes in solar output together with the absence of large volcanoes (that tend to cool the climate) are likely to have been causes for the rise in temperature between 1900 and 1940. However, the much more complete observations of the sun from space instruments over the past 40 years demonstrate that such influences cannot have contributed significantly to the temperature increase over this period. Other possibilities such as cosmic rays affecting cloud formation have been very carefully considered by the IPCC (see the [3rd Assessment Report](#)) and there is no evidence that they are significant compared with the much larger and well understood effects of increased greenhouse gases such as carbon dioxide.

Source: [Sir John Houghton's, former Chief Executive of the Met Office, critique of 'The Great Global Warming Swindle'](#)

Isn't solar activity the main driver of climate change?

There are many factors which may contribute to climate change. For example, over the last million years, most of the long term changes in climate are probably due to small but well understood changes in the earth's orbit around the sun. Over much of the last 1,000 years most of the variability can probably be explained by cooling due to major volcanic eruptions and changes in the sun's heating.

However, the situation in the twentieth century is more complicated. There is some evidence that increases in solar heating may have led to some warming early in the 20th century, but direct satellite measurements show no appreciable change in solar heating over the last three decades. Three major volcanic eruptions in 1963, 1983 and 1992 have led to short periods of cooling. Throughout the century carbon dioxide increased steadily and has been shown to be responsible for most of the warming in second half of the century.

The final piece of the jigsaw is that as well as producing carbon dioxide, burning fossil fuels also produces small particles called aerosols which cool climate by reflecting sunlight back into space. These have also increased steadily in concentration over the 20th century, which has probably offset some of the warming due to increased carbon dioxide (and any solar contribution). Only when all of these factors are included do we get a satisfactory explanation of the magnitude and patterns of change over the last century.

The bottom line is that changes in solar activity do affect global temperatures. However, what research also shows is that increased greenhouse gas concentrations have a much greater effect than changes in the sun's energy.

Source: [John Mitchell - Director of Climate Science at the Met Office](#)

Isn't global warming caused by Cosmic Rays?

Despite recent claims, there is no scientifically robust evidence suggesting that cosmic ray variations have, or could even, play a significant role in recent warming. Variations in cosmic rays over the past few decades can not explain the long-term global warming trend.

Source: *Defra's internal briefing*

The mechanism by which cosmic rays might affect climate is as yet purely speculative and unquantified. Cosmic rays reaching the earth are modulated by solar activity and produce ions (electrically charged particles) in the atmosphere, and recent laboratory experiments suggest ions can, under the right conditions, lead to increases in cloudiness. However, there is no compelling evidence that this effect is large enough or acts on the right type of cloud to produce the required effect.

The bottom line is, even if cosmic rays have a detectable effect on climate (and this remains unproven), measured solar activity over the last few decades has not significantly changed and cannot explain the continued warming trend. In contrast, increases in carbon dioxide are

well measured and its warming effect is well quantified. It offers the most plausible explanation of most of the recent warming and future increases.

Source: [John Mitchell - Director of Climate Science at the Met Office](#)

What would happen if the climate suddenly cooled? Why are we obsessed with keeping the climate as it has been for the past century when we know it changes all the time?

Responding to climate change is not about trying to stop the natural variability in the climate system. There is evidence that both human societies and natural ecosystems have had trouble adapting to relatively small climatic changes even before humans begin altering the climate system. Given this knowledge, the prospect of climate change occurring very rapidly and leading to conditions that human society has never experienced before has been enough to force the issue high up the international political agenda.

Source: *Environment Agency's Climate Change Unit*

Human emissions of greenhouse gases

Human emissions are only a tiny fraction of total natural emissions. Surely they can't be important in causing climate change?

It is true that human emissions are relatively small compared to natural emissions, particularly from ecosystems and the oceans. However, these natural emissions are in balance: the amount emitted is then reabsorbed. Human emissions tip the balance and lead to an accumulation of gases in the atmosphere. The human source can be shown through, for example, examining the chemical make-up and distribution of CO₂ in the atmosphere.

Source: [David Milliband's blog](#)

Don't volcanic eruptions emit more carbon dioxide than fossil fuel burning?

No, in fact none of the large volcanic eruptions over the last 50 years feature in the detailed record of increase in atmospheric carbon dioxide.

Source: [Sir John Houghton's, former Chief Executive of the Met Office, critique of 'The Great Global Warming Swindle'](#)

It was stated in the Channel 4 documentary that volcanic emissions of CO₂ far exceeded those from human activity. This is untrue. Annual emissions from volcanoes are only 1% of the amount emitted to the atmosphere by humans. Please see this report from [the British Geological Society](#).

Source: [RealClimate](#) (Nick Riley at the British Geological Survey)

Isn't it true that there is no evidence that human emissions are causing the current warming trend?

This is not true. As stated in the IPCC's Fourth Assessment Report, a growing body of evidence demonstrates that increases in greenhouse gas concentrations, due to human emissions, have caused most of the warming observed over the past half century. Both the spatial patterns and trend of warming can only be explained by the inclusion of human emissions. It is very unlikely that the rapid increase in global temperatures seen over the past half century could be caused by natural factors alone. For example, the most recent report of the IPCC concludes that the warming effect of human emissions is around ten times that of solar variations.

Source: [David Milliband's blog](#)

Could global dimming help to solve the climate change problem?

Global dimming is the gradual reduction in the amount of direct light at the Earth's surface, observed since the 1950's. The effect varies by location, but worldwide it is of the order of a 4% reduction over the three decades from 1960–1990. It is currently thought that the effect of global dimming is probably due to the increased presence of aerosol particles, such as soot, in the atmosphere. Aerosol particles and other particulate pollutants absorb solar energy and reflect sunlight back into space. Global dimming creates a cooling effect that may have partially masked the effect of global warming.

Some scientists have suggested using aerosols to stave off the effects of global warming as an emergency measure. In 1974, Mikhail Budyko suggested that if global warming became a problem, we could cool down the planet by burning sulphur in the stratosphere, which would create a haze. According to Ramanathan (1988), an increase in planetary reflectivity (albedo) of just 0.5 percent is sufficient to halve the effect of a CO₂ doubling.

However, we would still face many problems, such as acid rain caused by sulphur dioxide and human health problems, from breathing in particulates for example. There would also be side effects from a deliberate increase in global dimming, notably changes in evaporation and rainfall patterns and the practical problem that aerosols have a lifetime in the atmosphere measured in days and weeks, whilst carbon dioxide's is measured in decades.

Most scientists do not consider global dimming as a serious mitigation measure to tackle global warming.

Source: *Environment Agency's Climate Change Unit*

Measurements

I've heard that the patterns of warming in the atmosphere do not match what we would expect for a warming caused by rising greenhouse gas concentrations. Is this true?

This is not correct. The patterns of warming in the atmosphere do match what we would expect. Previously reported discrepancies were due to problems with early versions of observed data from satellites and radiosondes. These errors were corrected a few years ago.

Source: [David Milliband's blog](#)

This raises a debate that took place in the 1990s but which has now been resolved. There is now agreement among the scientists involved in measurements that trends in satellite observed tropospheric temperatures when properly analysed agree well with trends in surface temperature observations. The programme also stated that warming should continue to higher levels. That is not the case. In fact, higher levels are observed to be cooling, consistent with the science of global warming that indicates that there is warming below and cooling above the 'blanket' of additional carbon dioxide.

Source: [Sir John Houghton's, former Chief Executive of the Met Office, critique of 'The Great Global Warming Swindle'](#)

We expect greater warming in the upper atmosphere than at the surface in the tropics, but the reverse is true in high latitudes. This expectation holds whether the cause of warming is due to greenhouse gases or changes in the sun's output. Until recently, measurements of the temperature changes in the tropics in recent decades did not appear to show greater warming aloft than at the surface. It has now been shown that allowing for uncertainties in the observations, the theoretical and modelling results can be reconciled with observations.

The bottom line is that observations are now consistent with increased warming through the troposphere.

Source: [John Mitchell - Director of Climate Science at the Met Office](#)

Models

Global Climate Models assume that CO₂ drives temperature. Does this mean they're wrong?

Climate models are a mathematical description of the processes in the Earth's climate system; atmosphere, ocean, land, cryosphere. The representation of climate processes in the model are based on experimental measurements in the real atmosphere, ocean etc, and these can be chosen within the constraints of these experiments to give the best possible agreement between model simulation of current climate and observations.

The Met Office evaluates their reliability in a number of ways. Firstly, by comparing their representation of the current climate and observations, including not just means but variability and extremes. Secondly, by driving them with the best estimates of changes to climate forcings over the last 150 years (natural, such as volcanoes and solar radiation, and man-made such as greenhouse gases and aerosols) and comparing the simulation of climate change from the model with observations of trends over the same period.

Lastly, some validation can be carried out by comparing model simulation of climates many thousands of years ago with reconstructions of climate of the period (so called palaeoclimatologies). Validation exercises such as these provide compelling evidence that, at least in terms of gross temperature response, the model is effectively reproducing what has been observed, and this gives us confidence that the models are adequate tools for the prediction of future climates.

Source: [Met Office](#)

There is considerable confidence that climate models provide plausible quantitative estimates of future climate change, particularly at continental scales and above. Confidence in these estimates is higher for some climate variables like temperature, than it is for others, such as precipitation. This confidence comes from the foundation of the models in accepted physical principles and from their ability to reproduce observed features of recent climate and past climate changes.

Source: [IPCC](#)

Can't models be altered to produce the results scientists want? Even if they haven't been altered, aren't they too complex and uncertain to provide useful projections of climate change?

Climate models are an essential tool in understanding how the climate will respond to changes in greenhouse gas concentrations, and other external effects, such as solar output changes and volcanoes. The models use fundamental physics and chemistry to simulate processes within the climate system and are rigorously assessed to ensure their reliability.

Source: [David Milliband's blog](#)

Modern models include detailed coupling of the circulations of atmosphere and ocean and detailed descriptions of the interactions between all components of the climate system including ice and the biosphere. They have been tested thoroughly in their ability to reconstruct current and past climates. The 30 or more major modelling groups in the world regularly compare their methods and their findings.

Source: [Sir John Houghton's, former Chief Executive of the Met Office, critique of 'The Great Global Warming Swindle'](#)

There have been major advances in the development and use of models over the last twenty years. The models are based mainly of the laws of classical physics, with some empiricism based on observational studies and physical understanding for some of the detailed process such as cloud formation. Modern models include detailed coupling of the circulations of atmosphere and ocean and detailed descriptions of the feedbacks between all components of the climate system including the cryosphere and biosphere. Climate models have been used to reproduce the main features of the current climate, the temperature changes over the last hundred years and the main features of the Holocene (6000 years ago) and Last Glacial Maximum (21000) years ago.

The bottom line is that current models enable us to attribute the causes of recent climate change and predict the main features of future climate. We now need to provide more regional detail and more complete analysis of extreme events.

Source: [John Mitchell - Director of Climate Science at the Met Office](#)

Climate models are an essential tool in understanding how the climate will respond to changes in greenhouse gas concentrations, and other external effects, such as solar output changes and volcanoes. The models use fundamental physics and chemistry to simulate processes within the climate system and are rigorously assessed to ensure their reliability.

Validation exercises provide compelling evidence that, at least in terms of gross temperature response, the model is effectively reproducing what has been observed. For example, first report of the IPCC in 1990 correctly projected the observed warming up to the present. This gives us confidence that the models are adequate tools for the prediction of future climates.

Source: *Defra's official response to 'The Great Global Warming Swindle'*

To prove something don't you need a "control" experiment? What is climate science based on? Just models?

This is not true – what was the control experiment that proved the Earth was round? Science works by testable hypotheses, a control experiment is simply a powerful methodology that can be used to help test these hypotheses.

Models are an essential part of the way we view the world and have a long and established pedigree. Climate models are based upon Newtonian mechanics, which has a 300-year history and proved reliable enough to put man on the moon.

Source: *Environment Agency's Climate Change Unit*

Hasn't CO₂ has been put into the models to increase at 1% per annum even though the recorded rise is 0.5% per annum?

It's true that many computer scenarios are based on a 1% compound increase in CO₂ equivalent (using CO₂ as a proxy for the radiative impact of a whole basket of greenhouse gases), but these are idealised studies to enhance our understanding of key processes in the climate system. The SRES scenarios on which the IPCC projections are based, have been arrived at in a rigorous manner and are consistent with observed increases in greenhouse gases.

When we look back to the early predictions of greenhouse gas concentrations made in 1990 and compare them with observations now, we can see that these predictions have been largely borne out.

The process of producing science

Some people claim that the scientific process is biased. Is this true?

The IPCC is the most authoritative voice on climate change. Its assessments represent the consensus of thousands of scientists worldwide, based on peer-reviewed research. Objectivity is ensured by the broad and open review process and shared responsibility for the report. No one government, organisation or individual has sole responsibility for any part of the report.

Source: [David Milliband's blog](#)

Doesn't the IPCC process itself stifle debate?

"I chaired the main meetings of Working Group I during the production of the first three IPCC scientific assessments. I can say categorically that the process was very open and honest. The aim was to distinguish between what was reasonably well known and the areas where there is large uncertainty. The chapter groups had complete freedom to investigate and assess the scientific literature and draw their conclusions.

"Contrary to the impression given in the 'The Great Global Warming Swindle', no one ever resigned from being a lead author in Working Group I because of their disagreement with the process or the final content of their chapter. In fact, no one ever communicated to me a complaint about the integrity of the process.

"I should mention, however, a case of disagreement that occurred in Working Group 2 of the IPCC that dealt with the impacts of climate change – a more complex area to address than the basic science of Working Group I. Professor Reiter, who appeared in 'The Great Global Warming Swindle' described how, unfortunately, his expert work on malaria failed to get recognition in the relevant IPCC chapter [in 1995's Second Assessment Report]."

However, Professor Reiter has stated in a Memorandum to the House of Lords in May 2005 that the Third Assessment Report put right the mistakes made in the Second Assessment Report. "The 2001 report is much more comprehensive, more accurate, and gives a much better perspective of the diseases and their dynamics. The selection of references was biased towards models that predict an increase in range and prevalence of mosquito-borne disease, but there were refreshingly frank statements on the fundamental limitations of such models".

"Even Professor Lindzen, who appeared at length on 'The Great Global Warming Swindle', stayed the course as lead author within Working Group I, expressing his satisfaction with the report's chapters as good scientific documents. He has often, however, gone on to express his view that the conclusions of the Policymakers Summary did not faithfully represent the chapters. But he has never provided any supporting evidence for that statement – nor, to my knowledge, has anyone else who has quoted that statement originating from Lindzen.

"It is important to note that IPCC Policymakers' Summaries are agreed unanimously at intergovernmental meetings involving over 200 government delegates from around 100 countries. This agreement is only achieved after several days of scientific debate (only scientific arguments not political ones are allowed) the main purpose of which is to challenge the scientific chapter authors regarding the accuracy, clarity and relevance of the summary and most especially its consistency with the underlying chapters. Agreement at such a meeting has ensured that the resulting document, so far as is possible, is scientifically accurate, balanced and free from personal or political bias.

"Reference was made in the programme to an article in the Wall Street Journal in 1995 about the 1995 IPCC report accusing the IPCC of improperly altering one of the agreed chapters before publication. This was a completely false accusation as was pointed out in the Bulletin of the American Meteorological Society, September 1996, 77, pp1961-1966."

Source: [Sir John Houghton's, former Chief Executive of the Met Office, critique of 'The Great Global Warming Swindle'](#)

Source: House of Lords Economic Affairs [Memorandum by Professor Reiter](#)

What is the IPCC's review process and how is its objectivity maintained?

Lead authors review the literature available and provide a first draft of a report, with the help of contributing authors, who submit information. The draft is then reviewed by experts and governments in an open review process, and undergoes revision in light of the comments received. Objectivity is ensured by the broad and open review process and shared responsibility for the report. No one government, organisation or individual has sole responsibility for any part of the report.

Source: *Defra's internal briefing*

Can we be sure that the science is not biased by its association with political issues?

The IPCC is careful to keep science separated from the political negotiations that take place at the United Nations Climate Change Convention meetings. The scientists in the Working Groups write the reports, which are then extensively reviewed and edited in draft before government review and final acceptance. IPCC assessment report and technical documents are not written or changed by governments.

Source: *Defra's internal briefing*

Summaries for policy makers accompanying the IPCC Assessment Report are approved by government representatives. Are they not politicised?

The Summary for Policy Makers (SPM) is drafted by scientists and agreed by all governments at IPCC plenaries. The agreement of the SPM helps communicate IPCC outputs to governments. Political bias is unlikely to appear in the summary for policy makers given the entire range of opinion represented by governments who support the IPCC and the dialogue between the government representatives and the IPCC authors. In addition, convening lead authors play a central role in the approval meeting to ensure that any adjustments to the SPM are consistent with the scientific report and to advise delegates on any issues that are queried.

Source: *Defra's internal briefing*

How does the IPCC deal with uncertainty about future climate change?

IPCC reports provide a synthesis of the state of the science that represents uncertainties in the science, differences in opinion, and the uncertainties associated with projections of future actions. Where consensus on a topic is lacking, this is clearly demonstrated in the reports. The IPCC has also an established way of expressing uncertainties by using a spectrum of degree of confidence, ranging from "extremely unlikely" to "virtually certain".

Source: *Defra's internal briefing*