THE ROYAL SOCIETY

*Issued March 2005*

# A guide to facts and fictions about climate change

It has become fashionable in some parts of the UK media to portray the scientific evidence that has been collected about climate change and the impact of greenhouse gas emissions from human activities as an exaggeration. Some articles have claimed that scientists are ignoring uncertainties in our understanding of the climate and the factors that affect it. Some have questioned the motives of the scientists who have presented the most authoritative assessments of the science of climate change, claiming that they have a vested interest in 'playing up' the potential effects that climate change is likely to have.

This document examines twelve misleading arguments (presented in bold typeface) put forward by the opponents of urgent action on climate change and highlights the scientific evidence that exposes their flaws. It has been prepared by a group led by Sir David Wallace FRS, Treasurer of the Royal Society, and Sir John Houghton FRS, former chair of Working Group I of the Intergovernmental Panel on Climate Change (IPCC). This document has been endorsed by the Council of the Royal Society, and draws primarily on scientific papers published in leading peer-reviewed journals and the work of authoritative scientific organisations, such as the IPCC and the United States National Academy of Sciences.

The IPCC is the world's leading authority on climate change and its impacts. It was set up in 1988 under the auspices of the United Nations Environment Programme and the World Meteorological Organisation. Membership of the IPCC is open to all members of the United Nations and World Meteorological Organisation. It has the following remit:

"The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature."

The IPCC has a task force on national greenhouse gas inventories and three working groups:

- Working Group I assesses the scientific aspects of the climate system and climate change;

- Working Group II assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adapting to it; and

- Working Group III assesses options for limiting greenhouse gas emissions and otherwise mitigating climate change.

The IPCC produces periodic assessment reports providing an overview of current knowledge about climate change and its impacts, as well as identifying uncertainties and gaps in knowledge. The preparation of these reports involves many hundreds of scientists across the world. The contributors, lead authors and reviewers of these reports include those nominated by the governments of the countries that are members of the IPCC, and some who do not hold mainstream views on climate change. These reports are reviewed by both members of the scientific community and by governments. The IPCC Third Assessment Report was published in 2001, and involved more than 2000 experts in its preparation. It is the most authoritative source of information on climate change due to human activities, including the emission of greenhouse gases such as carbon dioxide, and can be accessed at http://www.ipcc.ch. The report included a synthesis presenting the information in the form of answers to a broad range of key policy-relevant, but not policy-prescriptive, questions. The IPCC Fourth Assessment Report is due to be published in 2007.

The following abbreviations are used in this document:
GDP: gross domestic product
IPCC: Intergovernmental Panel on Climate Change
OISM: Oregon Institute of Science and Medicine
UNFCCC: United Nations Framework Convention on Climate Change
US NAS: United States National Academy of Sciences

***Misleading arguments 1.*** **The IPCC has become too politicised and does not accurately reflect the wide range of views within the scientific community. The IPCC summary for policy-makers does not adequately represent the scientific uncertainty.**

The work of the IPCC is backed by the worldwide scientific community. A joint statement of support was issued in May 2001 by the science academies of Australia, Belgium, Brazil, Canada, the Caribbean, China, France, Germany, India, Indonesia, Ireland, Italy, Malaysia, New Zealand, Sweden and the UK. It stated: "We recognize the IPCC as the world's most reliable source of information on climate change and its causes, and we endorse its method of achieving consensus."

In 2001, the United States National Academy of Sciences was commissioned by the Bush administration to assess the current understanding of global climate change. Its report, published in June 2001, stated: "The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the

scientific community on this issue."

Each part of the IPCC 2001 report included a summary for policymakers, each of which was agreed sentence by sentence at meetings of the governments from member countries of the IPCC. The purpose of the summaries was to provide an accurate and balanced assessment of the scientific information contained in the technical sections of the report in a manner that is clear, understandable and relevant to the policy process.

Some have claimed that the summary for policy-makers did not accurately reflect the technical parts of the report. The US NAS 2001 report concluded that the summary for policymakers from Working Group I "reflects less emphasis on communicating the basis for uncertainty and a stronger emphasis on areas of major concern associated with human-induced climate change". The NAS concluded that the full report of IPCC Working Group I in the Third Assessment is "an admirable summary of research activities in climate science, and the full report is adequately summarised in the *Technical Summary*", but pointed out that these are "not specifically directed at policy".

The IPCC 2001 report carefully distinguishes between what is known with reasonable certainty, and the areas in which large uncertainties remain. The report includes quantitative estimates of uncertainty throughout.

***Misleading arguments 2.*** **Many scientists do not think that climate change is a problem. Some scientists have signed petitions stating that climate change is not a problem.**

There are some differences of opinion among scientists about some of the details of climate change and the contribution of human activities, such as the burning of fossil fuels. Researchers continue to collect more data about climate change and to investigate different explanations for the evidence. However, the overwhelming majority of scientists who work on climate change agree on the main points, even if there is still some uncertainty about particular aspects, such as how the concentration of greenhouse gases in the atmosphere will change in the future.

In the journal *Science* in 2004, Oreskes published the results of a survey of 928 papers on climate change published in peer-reviewed journals between 1993 and 2003. She found that three-quarters of the papers either explicitly or implicitly accepted the view expressed in the IPCC 2001 report that human activities have had a major impact on climate change in the last 50 years, and none rejected it. There are some individuals and organisations, some of which are funded by the US oil industry, that seek to undermine the science of climate change and the work of the IPCC. They appear motivated in their arguments by opposition to the United Nations Framework Convention on Climate Change and the Kyoto Protocol, which seek urgent action to tackle climate change through a reduction in greenhouse gas emissions.

Often all these individuals and organisations have in common is their opposition to the growing consensus of the scientific community that urgent action is required through a reduction in greenhouse gas emissions. But the opponents are well-organised and well-funded. For instance, a petition was circulated between 1999 and 2001 by a campaigning organisation called the Oregon Institute of Science and Medicine (OISM), which called on the US Government to reject the Kyoto Protocol. The petition claimed that "proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind".

These extreme claims directly contradict the conclusions of the IPCC 2001 report, which states that "reducing emissions of greenhouse gases to stabilize their atmospheric concentrations would delay and reduce damages caused by climate change".

The petition was circulated together with a document written by individuals affiliated to OISM and to the George C Marshall Institute, another campaigning organisation. On 20 April 1998, the US National Academy of Sciences (NAS) issued a warning about the document circulated with the petition because it had been presented "in a format that is nearly identical to that of scientific articles published in the Proceedings of the National Academy of Sciences." The statement pointed out: "The NAS Council would like to make it clear that this petition has nothing to do with the National Academy of Sciences and that the manuscript was not published in the *Proceedings of the National Academy of Sciences* or in any other peer-reviewed journal".

***Misleading arguments 3.*** **There is little evidence that global warming is happening or, if it is happening, it is not very much. Some parts of the world are actually becoming cooler. Increased urbanisation could be responsible for much of the increase in observed temperatures. Satellite temperature records do not show any global warming. If there has been global warming recently, it would not even be a unique occurrence within the past 1000 years. Europe has been much warmer in the past.**

Few scientists dispute that the global average temperature has been rising for at least a century. The IPCC 2001 report concluded, based on worldwide measurements, that the average surface temperature of the Earth had risen by 0.6 centigrade degrees (+/-0.2°C) during the 20$^{th}$ century. The IPCC found that, in terms of the global average temperature, the 1990s were very likely (a 90-99% chance) to have been the warmest decade since records began in 1861, and that 1998 was the warmest year.

Furthermore, the increase in surface temperature during the 20$^{th}$ century in the Northern Hemisphere was likely (a chance of 66 to 90%) to have been greater than for any other century for the last 1000 years.

The IPCC report recognised that "temperature changes have not been uniform globally but have varied over regions and different parts of the lower atmosphere". For instance, some parts of the

Southern Hemisphere oceans and parts of Antarctica have not warmed in recent decades.
The report also noted that there have been two major periods of warming globally: 1910 to 1945 and since 1976. It concluded that "it is virtually certain that there has been a generally increasing trend in global surface temperature over the 20th century, although short-term and regional deviations from this trend occur".

It has been argued that recent warming trends are due to the effect of increasing urbanisation and the creation of 'urban heat islands'. However, Parker recently reported in the journal *Nature* that analyses of temperature trends show that globally "temperatures over land have risen as much on windy nights as on calm nights, indicating that the observed overall warming is not a consequence of urban development". The IPCC 2001 report noted that the analysis of temperature changes from across the world took into account increases due to urbanisation, and average temperature trends recorded over land were found to be similar to those observed over the oceans.

The IPCC report also noted that, since 1979, both satellites and weather balloons have recorded a lower rate of warming in the lower atmosphere than has been measured at the surface. The report acknowledged that the reasons for this gap are not yet fully understood, but it is likely to be due to the fact that temperatures in the lower atmosphere and at the surface are influenced differently by factors such as stratospheric ozone depletion, aerosols in the atmosphere and the El Niño phenomenon. Satellites and weather balloons have recorded a substantial cooling in the upper parts of the atmosphere, which is consistent with models of climate change.

Grody and others recently indicated in the *Journal of Geophysical Research* that much of the earlier inconsistency between the satellite and surface measurements arises from errors in analysing the data from the satellites which can "artificially suppress the temperature trend". Fu and others pointed out in the journal 'Nature' that the same warming trends are present in the lower atmosphere as occur at the surface, if the effect of the cooling of the upper atmosphere is taken into account, although this has been disputed.

Some have questioned whether natural temperature variations in the past 1000 years have been greater than those reported in the IPCC 2001 report. For instance, von Storch and others argued in the journal *Science* that the natural variations in average global temperature over the last 1000 years may have reached one centigrade degree, instead of the 0.5 centigrade degree implied by previous analyses. This conclusion was supported by Moberg and others in a paper in the journal *Nature*, in which they reported that natural variations in temperature may have reached up to one centigrade degree over periods of centuries during the last 2000 years. But they also pointed out: "We find no evidence for any earlier periods in the last two millennia with warmer conditions then the post-1990 period – in agreement with previous similar studies." They drew attention to the fact that models show natural factors alone could not be responsible for the recent warming trend.

According to the IPCC report, "regional temperature trends over a few decades can be strongly

influenced by regional variability in the climate system and can depart appreciably from a global average". For instance, there was significant cooling in the North Atlantic between 1946 and 1975, as well as much of the Northern Hemisphere, and warming in much of the Southern Hemisphere. Although some regions of the world experienced significantly warmer or colder periods during the last 1000 years, such as the 'Medieval Warm Period' and the 'Little Ice Age', these were not worldwide changes like the increase in global average temperature recorded during the 20th century.

***Misleading arguments 4.*** **The Earth is getting hotter, but not because of emissions of greenhouse gases from human activities. Carbon dioxide makes up such a tiny fraction of the atmosphere that even if it doubled it would make little difference to the climate. Variations in the sun are more likely to be the cause of climate changing than increases in greenhouse gases.**

About half of the solar energy entering the top of the Earth's atmosphere eventually reaches the surface where it is absorbed. Much of the solar energy is absorbed by the Earth's surface and then released as infra-red radiation, some of which is absorbed by greenhouse gases such as water vapour, carbon dioxide and methane. The greenhouse gases act like a blanket over the surface of the Earth, keeping it around 20 centigrade degrees warmer than it otherwise would be, which is a phenomenon known as 'the greenhouse effect'.

Increases in the concentrations of greenhouse gases in the atmosphere enhance the greenhouse effect and, on average, lead to further warming. It has been long established that carbon dioxide strongly absorbs infra-red radiation. The IPCC 2001 report pointed out that carbon dioxide is "the dominant human-influenced greenhouse gas", and is responsible for more than half the warming due to changes in atmospheric concentrations.

Based on direct analysis of gases found trapped in cores of polar ice, it is known that the atmospheric concentration of carbon dioxide for several thousands of years before 1750 was about 280 parts per million. Between 1750 and 2000, during which industrialisation has occurred, the concentration rose by about 31% to 368 parts per million. The IPCC report noted that the current concentration of carbon dioxide in the atmosphere has not been exceeded during the past 420,000 years and that "the rate of increase over the past century is unprecedented, at least during the past 20,000 years".

It has been claimed that the rise in atmospheric concentrations of carbon dioxide is actually a consequence of climate change, rather than a cause. The IPCC report pointed out that chemical analyses of the carbon dioxide show that the increase in the atmosphere, and an accompanying decrease in oxygen concentrations, are primarily due to the burning of fossil fuels and deforestation. Although some carbon dioxide taken up and released by oceans or land, it stressed that the average rate of increase in concentrations in the atmosphere since 1980 has been about 0.4% per year and that this is due to emissions. It stated "Most of the emissions during the past 20 years are due to fossil fuel

burning, the rest (10 to 30%) is predominantly due to land-use change, especially deforestation".
A number of other factors are known to influence climate and cause change, particularly volcanic eruptions, variations in the energy from the sun and particles released into the atmosphere from both natural sources and human activities. Particles in the atmosphere reduce the amount of energy from the sun that reaches the Earth's surface, and therefore cause a cooling effect. The IPCC has studied evidence of changes in these various factors and their likely influence on the global average temperature. It found that the variations over the 20th century can only be understood by taking all factors, both natural and human, into account.

Land use changes such as the spread or shrinkage of forest areas can also contribute to changes in temperature. The loss of forests can exert a cooling effect by increasing the reflectivity of the land surface, which means lower amounts of solar radiation are absorbed. The IPCC 2001 report noted that the overall effect of land use changes since pre-industrial times has been to produce cause cooling, and that this has mainly been due to the replacement at high latitudes of snow-covered forests by open, snow-covered areas. The report noted that the level of understanding of the overall effect of land use changes was lower than for other factors affecting global temperatures.

The IPCC found that the dominant influences on climate change in the early part of the 20th century were likely to be a small increase in solar output and a decrease in average volcanic activity. However, such natural factors cannot explain the warming in the latter half of the 20th century, and the IPCC concluded that there is "new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities". The report pointed out that natural factors on their own would have produced an overall drop in global average temperatures.

A recent study by Solanki and others, published in the journal *Nature*, found that the level of solar activity during the past 70 years has been "exceptional" when considered over the period of the last 11,400 years. However, they concluded that "although the rarity of the current episode of high average sunspot numbers may indicate that the Sun has contributed to the unusual climate change during the twentieth century, we point out that solar variability is unlikely to have been the dominant cause of the strong warming during the past three decades".

***Misleading arguments 5.*** **There is no reliable way of predicting how temperatures will change in the future. The climate is so complex that it is hard to predict what might happen. The IPCC's climate scenarios are developed by economists not scientists and are often misleadingly presented as predictions or forecasts, when they are actually just scenarios – the most extreme of which are totally unrealistic The IPCC's findings are dependent on models that are badly flawed. No climate model has been scientifically validated. The IPCC 2001 predictions showed a wider uncertainty range than that in earlier reports.**

Climate change is complex and not easy to predict. In order to make projections about climate change

in the future, the IPCC developed a set of scenarios that describe possible global emissions of greenhouse gases. These scenarios produced estimates of various concentrations of global greenhouse gas emissions in the atmosphere up to 2100, taking into account different projected trends in demographic, economic and technological developments, as well as changes in the political environment. Economists and sociologists helped to develop these scenarios. These scenarios include the whole range of likely changes in emissions of greenhouse gases.

In the studies cited in the IPCC 2001 report, the main tools used to describe the detailed response of the climate to any given future scenario of greenhouse gas emissions are numerical models that include mathematical descriptions of physical processes and the interactions between different components of the climate system. Because the models are based on scenarios of future human activities, their results should be considered to be projections rather then predictions. There has been, and continues to be, a major effort to compare the details of climate model results with actual observations. This leads to improvements in the representation of climate processes in the models. The IPCC 2001 report included results from these models showing that carbon dioxide concentrations in the atmosphere would increase to between 540 and 970 parts per million by 2100, compared to 280 parts per million in pre-industrial times, for the whole range of emissions scenarios and allowing for uncertainties in the models.

According to the models, changes in carbon dioxide concentrations in the atmosphere would affect global average temperatures during the 21st century. They suggested global average temperatures would rise by 0.4 to 1.1 centigrade degrees by 2025 compared to 1990, and by 1.4 to 5.8 centigrade degrees by 2100. The report pointed out that this rate of warming would be "much larger than the observed changes during the 20th century and is very likely without precedent during at least the last 10,000 years" based on measurements from ice cores and other sources of information about past temperatures.

The increase in temperatures would be above the global average on nearly all land areas, particularly in the high northern latitudes during winter.

The range of changes in global average temperatures was higher in the IPCC 2001 report than in previous assessments mainly because the models included a better representation of interactions within climate systems, and because a greater range of emissions of greenhouse gases were incorporated into the scenarios. The models cited in the IPCC 2001 report also included assumptions about a lower concentration of particles of sulphate in the atmosphere, which reflect back some of the incoming radiation from the sun, due to larger controls on air pollution.

The IPCC 2001 report openly acknowledged uncertainties in modelling climate change in the future. It stated that "because of uncertainty in climate sensitivity, and uncertainty about the geographic and seasonal patterns of projected changes in temperatures, precipitation, and other climate variables and

phenomena, the impacts of climate change cannot be uniquely determined for individual emissions scenarios".

Critics of the IPCC have not offered alternative numerical models that give different results for how climate will be affected by the range of possible future concentrations of greenhouse gases in the atmosphere.

***Misleading arguments 6.*** **Scientists have been exaggerating the evidence by claiming that individual extreme weather events have been caused by climate change. The recent flooding in the UK in places like Boscastle and Carlisle would have happened anyway, and the frequency of hurricanes hitting the Caribbean and Atlantic coast of the United States is no different than in the past. Even if they appear to be more severe, this is only because more people are living in places that are affected by natural extreme weather events.**

In general, it is not possible to state categorically that individual weather events are due to changes in climate, and reputable scientists are extremely cautious about such claims. However, there is a link, albeit complex, between changes in climate and regional and local weather events, including extreme ones. Changes in the global climate can be expected to lead to patterns of local and regional weather events, particularly extreme ones. While scientists may be able to estimate the change in the likelihood of such events because of climate change, they cannot predict individual events.

The IPCC 2001 report concluded it was very likely (with a 90 to 99% chance) that there was a 5 to 10% increase in total rainfall on land areas of the Northern Hemisphere during the 20$^{th}$ century, although some parts of the Mediterranean and north and west Africa had seen falls. It was likely (with a 66 to 90% chance) that the number of heavy rainfall events had increased at middle to high latitudes in the Northern Hemisphere.

During recent decades human populations have been affected more by extreme weather events in some areas. The IPCC 2001 report recognised that "there is emerging evidence that some social and economic systems have been affected by the recent increasing frequency of floods and droughts". However, the report acknowledged that "such systems are also affected by changes in socioeconomic factors such as demographic shifts and land-use changes". The report stated that, for the future, "models project that increasing atmospheric concentrations of greenhouse gases result in changes in frequency, intensity, and duration of extreme events, such as more hot days, heat waves, heavy precipitation events, and fewer cold days". It further drew attention to a projected increase in the frequency and severity of extreme events due to climate change in the 21$^{st}$ century. For instance, there are likely to be, with a certainty of 66 to 90%, intensified droughts and floods associated with El Niño events in many different regions (El Niño is a naturally-occurring disruption of the ocean-atmosphere system in the tropical Pacific), and an increase in tropical cyclone peak wind intensities and peak rainfall over some areas.

Some peer-reviewed papers have appeared in leading scientific journals since the publication of the IPCC 2001 report, shedding more light on the link between climate change and the occurrence of extreme events. For instance in 2002, Palmer and Räisänen reported in the journal *Nature* the results of analyses of 19 global climate model simulations that indicate "the probability of occurrence of a very wet winter over the UK is estimated to increase by a factor of 5 over the next 50-100 years, due to man's effect on climate". In this case, very wet winters are characterised by significantly above average seasonal rainfall. These models also imply "an increased risk of flooding in Bangladesh" over the same period.

In a paper published in *Nature* in 2004, Stott and others noted that the summer of 2003 was probably the hottest in Europe since at least 1500. It has been estimated that the heatwave caused 22,000-35,000 additional deaths. Stott and others acknowledged that it was not possible to meaningfully determine whether the heatwave was due to increased atmospheric concentrations of greenhouse gases "because almost any such weather event might have occurred by chance in an unmodified climate". However, they concluded from an analysis of instrument records since 1851 that "it seems likely that past human influence has more than doubled the risk of European mean summer temperatures as hot as 2003, and with the likelihood of such events projected to increase 100-fold over the next four decades". A further paper in *Nature* in 2004 by Schär and others reported the results of an analysis that found that "the European summer climate might experience a pronounced increase in year-to year variability" in response to rising greenhouse gas concentrations in the atmosphere. It concluded: "Such an increase in variability might be able to explain the unusual European summer 2003, and would strongly affect the incidence of heatwaves and droughts in the future".

The IPCC 2001 report acknowledged that it was not possible to tell what impact climate change would have on some individual local weather events. It concluded: "There is insufficient information on how very small-scale extreme weather phenomena (eg thunderstorms, tornadoes, hailstorms, and lightning) may change".

***Misleading arguments 7.*** **There is conflicting evidence about whether the ice at the poles is melting and, in fact, it is actually becoming thicker in Antarctica.**

The IPCC 2001 report indicated that in 2000 Arctic ice had thinned overall by 40% in the late summer and early autumn (with 66 to 90% certainty) in the past few decades, and decreased in extent by 10 to 15% since the 1950s in the spring and summer. There has also been a widespread retreat of non-polar glaciers. However, there was no demonstrated change in the overall extent of Antarctic sea ice between 1978 and 2000.

The models reported by the IPCC showed that glaciers would continue to retreat with rises in global average temperatures. The report recognised the complexity of projections, noting that "the Antarctic ice sheet is likely to gain mass because of greater precipitation, while the Greenland ice sheet is likely

to lose mass because the increase in runoff will exceed the precipitation increase."

Looking further into the future, larger changes in the ice sheets may begin to occur. The IPCC 2001 report also warned that a local average warming by 3 centigrade degrees would lead, over a thousand years, to "virtually a complete melting of the Greenland ice sheet with a resulting sea level rise of about 7 m [metres]". The report also warned that the West Antarctic Ice Sheet may start to break up if temperatures continue to climb.

A recent paper by Shepherd and others published in the journal *Science* in 2003, suggested that the Larsen Ice Shelf in Antarctica has begun to break-up over a very short period due to a sustained period of thinning of the ice. They concluded that "enhanced ocean-driven melting may provide a simple link between regional climate warming and the successive disintegration of sections of the Larsen Ice Shelf".

***Misleading arguments 8.*** **There is little evidence of a rise in sea level due to global warming. There is no correlation between rises in climate temperature and sea levels. There has been no consistent trend this century, with sea level rising in some places but not in others. Even if sea level is rising it has nothing to do with global warming and is actually due to the fact that southern England is sinking due to the bending of the Earth's crust.**

The IPCC 2001 report found that average sea level around the world increased at a rate of 0.1 to 0.2 centimetres per year during the 20th century. This had been caused by a combination of the thermal expansion of seawater (ie the volume of a fixed mass of water increases as it is heated) and the melting of land ice. The report acknowledged that there had not been a significant acceleration in the rate of sea level rise during the 20th century, and that this was "not inconsistent with model results". According to the IPCC models, global average sea levels would rise by 3 to 14 centimetres by 2025 compared to 1990, and by 9 to 88 centimetres by 2100, although the amount of sea level rise would vary very significantly between regions. The rise would be due to thermal expansion and the melting of glaciers and ice caps.

The IPCC 2001 report also noted that "compensating factors" have also affected sea levels during the 20th century, which would have reduced the rates of change. As Shennan and Horton reported in the *Journal of Quaternary Research* in 2002, sea levels around Great Britain have been influenced for instance by a phenomenon known as isostatic rebound. During the last Ice Age, Britain was covered by ice sheets as far south as the Thames Estuary. The ice sheet caused the land beneath it to sink, while the land in front of it, in southern England bulged up. When the ice sheet retreated after the end of the Ice Age, the land that had been beneath it started and continues to rise slowly, while the land in the bulge is sinking slowly. Other factors, such as the compaction of sediments, also cause changes in land movements. Shennan and Horton found that, overall, central and western Scotland are rising at about 1.6 millimetres per year while the south-west England is sinking by about 1.2 millimetres per

year.

***Misleading arguments 9.*** **Even if climate change is occurring, it won't be that dangerous. Abrupt climate change is just another scare story. While an atmospheric concentration for carbon dioxide of 550 parts per million has been proposed as a political target, there has been no scientific determination of "dangerous" levels of greenhouse gas concentrations.**

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 by nations to set an overall framework for intergovernmental efforts to tackle the challenges posed by climate change. There are currently 191 parties to the UNFCCC. It seeks to stabilise concentrations of greenhouse gas emissions in the atmosphere, and states:

"The ultimate objective of this Convention and any related legal instruments that the Conference of Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at such a level that would prevent dangerous interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner."
The IPCC report considered what is meant by "dangerous climate change". This involves taking into account not just the scientific evidence, but issues such as risk, social and political factors and economics. The impacts of climate change will differ around the world, and so what is considered dangerous will also vary. It will also depend on how well humans can adapt to climate change or take action to prevent its worst effects. The decision about what is "dangerous" needs to be taken by policy-makers rather than scientists, who should present their best analysis of all the risks as a basis for that decision.

The report also warned that rising greenhouse gas concentrations in the atmosphere could "set in motion large-scale, high-impact, non-linear, and potentially abrupt changes in physical and biological systems over the coming decades to millennia, with a wide range of associated likelihoods". It further stated: "Some of the projected abrupt/non-linear changes in physical systems and in the natural sources and sinks of greenhouse gases could be irreversible, but there is an incomplete understanding of some of the underlying processes."

Examples of these possible abrupt changes highlighted by the IPCC included a weakening during the 21st century, and even a complete shutdown thereafter, of the large-scale circulation in the oceans associated with differences in temperature and salinity (called the thermohaline circulation), reducing the amount of heat reaching the high latitudes of Europe, including the UK. The report warned: "some impacts of anthropogenic climate change may be slow to become apparent and some could be irreversible if climate change is not limited in both rate and magnitude before associated thresholds, whose positions may be poorly known, are crossed".

The IPCC recognized that while human ingenuity may allow humans to cope with some of the worst effects of climate change, we will not be able to prevent all damage. It noted that adaptation and mitigation are both required. Adaptation will be needed to cope with the impacts of climate change that is already happening and which will occur in the years before it is stabilised. Mitigation will be needed to slow climate change and eventually stabilise it, as set by the objective of the UNFCCC. The IPCC 2001 report stressed that actions to cope with or avoid climate change would take time to take effect and that "well-founded actions to adapt to or mitigate climate change are more effective, and in some circumstances may be cheaper, if taken earlier rather than later".

This is important because the report pointed out that carbon dioxide can remain in the atmosphere for up to 200 years, and as a result "stabilization of $CO_2$ emissions at near-current levels will not lead to stabilization of $CO_2$ atmospheric concentration, whereas stabilization of emissions of shorter lived greenhouse gases such as $CH_4$ [methane] leads, within decades, to stabilization of their atmospheric concentrations." The report also noted that the relatively long life of carbon dioxide in the atmosphere means its effects on climate would continue for an extended period: "After stabilization of the atmospheric concentration of $CO_2$ and other greenhouse gases, surface air temperature is projected to continue to rise by a few tenths of a degree per century for a century or more, while sea level is projected to continue to rise for many centuries".

The UK Government stated in the February 2003 Energy White Paper that "the UK should put itself on a path towards a reduction in carbon dioxide emissions of some 60% from current levels by 2050". Such a strategy is consistent with stabilisation of atmospheric concentrations of carbon dioxide at about 550 parts per million, and was based on a recommendation contained in a report by the Royal Commission on Environmental Pollution in 2000.

According to the IPCC 2001 report, to stabilise concentrations of carbon dioxide in the atmosphere at 550 parts per million (which would be 96% higher than pre-industrial levels and 49% higher than in 2000), emissions from human activities would need to fall below 1990 levels within much less than a century and continue to decrease steadily afterwards to a very small fraction of today's levels.
The IPCC report also considered what measures would be needed to tackle the predicted effects of climate change. The most important was that "the projected rate and magnitude of warming and sea-level rise can be lessened by reducing greenhouse gas emissions". It also pointed out that "the greater the reductions in emissions and the earlier they are introduced, the smaller and slower the projected warming and the rise in sea levels".

***Misleading arguments 10.*** **There is no evidence that climate change will be bad for people. In fact, warmer weather will actually be good for those people who live in cold countries. Climate change may make some places like Russia warmer and more productive places to live. A warmer climate will be good for the UK's economy, with more tourists and better**

**wine-producing conditions. Increasing levels of carbon dioxide would produce a rise in plant productivity and crop yields. Surely we should let the benefits and costs of climate change even themselves out.**

The IPCC models acknowledge that some parts of the globe would benefit, at least in the short-term, from climate change. Some high northern latitudes could experience less extreme cold and a longer growing season for crops. In addition, the higher concentrations of carbon dioxide in the atmosphere will boost growth of some important crops, and given adequate water and nutrients, will bring higher yields.

However, the IPCC models indicate that "the larger the changes and rate of change in climate, the more the adverse effects predominate". These adverse effects would be most severe in the tropics and subtropics. The IPCC pointed out that "reducing the projected increase in climate extremes is expected to benefit all countries, particularly developing countries, which are considered to be more vulnerable to climate change than developed countries".

While some commentators in the media have imagined that climate change will bring benefits to the UK, such as "better wine-producing conditions", they do not appear to take into account the significant problems that we will face through an increase in the likelihood of flooding in some areas, a reduction in the availability of fresh water in others, and more threats to sea defences due to sea level rise in many low-lying areas, as acknowledged in the UK Government's Energy White Paper in 2003.

The focus on the UK also ignores the misery and suffering that will increase for the world's poorest and most vulnerable people. The IPCC concluded that "the impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, and thereby exacerbate inequities in health status and access to adequate food, clean water, and other resources." The IPCC models indicate that the threats to human health will increase with climate change, "particularly in lower income populations, predominantly within tropical/subtropical countries". They showed, with a high level of confidence, that climate change would lead to an increase in heat-related death and illness, a drop in cold-related death in temperate countries, a higher frequency of epidemics of infectious diseases after storms and floods, and significant impacts from the displacement of populations in response to rises in sea level and greater storm activity.

In most of the IPCC models, overall crop yields would decrease as temperatures rise. The report warned that "warming of a few °C or more is projected to increase food prices globally, and may increase the risk of hunger in vulnerable populations". Those parts of the world already experiencing water shortages would find their problems worsen with climate change, although some places may see an overall increase in rainfall.

Humans would not be the only life that would be affected by climate change. The IPCC acknowledged that the average overall growth of plants would increase with the rise in atmospheric carbon dioxide concentrations, but this may not have an overall positive knock-on effect on animals and micro-organisms. Increased growth would mean a rise in the amount of carbon dioxide absorbed by plants. However, Knorr and others recently pointed out in the journal *Nature* that rising temperatures would mean higher rates of decomposition of dead material, thus releasing more carbon dioxide into the atmosphere.

The IPCC 2001 report also warned that natural systems are "vulnerable to climate change, and some will be irreversibly damaged". It stressed that "while some species may increase in abundance or range, climate change will increase existing risks of extinction of some more vulnerable species and loss of biodiversity". For instance, the report projected with "high confidence" that "future sea surface warming would increase stress on coral reefs and result in increased frequency of marine diseases".

***Misleading arguments 11.*** **There are too many uncertainties about climate change and its impacts to justify taking action. It would be better to wait until we are more certain about climate change before acting.**

The UNFCCC has been signed by 191 parties which recognise the need to tackle climate change, even if there are some uncertainties in our understanding. The parties to the UNFCCC are committed to stabilising concentrations of greenhouse gases in the atmosphere. The UNFCCC commits signatories to adopt policies and measures that are cost-effective. It states: "The Parties should take precautionary measures to anticipate, prevent, or minimise the causes of climate change and mitigate its adverse effects. Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible costs. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out collectively by interested Parties."

In 1997 parties to the UNFCCC agreed to an addition to the treaty, called the Kyoto Protocol, which has more powerful and legally binding measures for industrialised countries that are party to both the Convention and the Protocol, to limit or reduce their greenhouse gas emissions. The Protocol became international law in February 2005.

The IPCC report notes that the UNFCCC aims to identify short-term "hedging strategies" in light of long-term uncertainties. It suggests that "the relevant question is not 'what is the best course of action for the next hundred years' but rather 'what is the best course of action for the near-term given the long-term uncertainties'". The report states:

"Several studies have attempted to identify the optimal near-term hedging strategy based on the uncertainty regarding the long-term objective. These studies find that the desirable amount of hedging depends upon one's assessment of the stakes, the odds, and the cost of mitigation. The risk premium – the amount that society is willing to pay to avoid risk – ultimately is a political decision that differs among countries."

The UK Government carried out an analysis of the cost of stabilising atmospheric concentrations of carbon dioxide at 550 parts per million, assuming that the world's leading industrial nations acted together. It reported in the 2003 Energy White Paper that "the cost impact of effectively tackling climate change would be very small – equivalent in 2050 to just a small fraction (0.5-2.0%) of the nation's wealth, as measured by GDP, which by then will have tripled as compared to now". The 2000 report by the Royal Commission on Environmental Pollution outlined four scenarios in which the UK could use current technologies to reduce its carbon dioxide emissions by 60% by the year 2050.

***Misleading arguments 12:*** **The Kyoto Protocol is a waste of time because the United States will not ratify it. The emission reduction targets required under the Kyoto Protocol are "trivial" and would do no more than postpone global warming by six years. Implementing the Kyoto Protocol would be too costly. The trillions of dollars that would be wasted on the Kyoto Protocol should be spent on helping developing countries tackle poverty.**

The 38 parties listed in Annex B of the Kyoto Protocol each agreed to individual targets for their total annual greenhouse gas emissions, relative to levels in 1990, over the period 2008 to 2012. These targets if achieved would result in an overall reduction of emissions by 5.2% in 2008-2012 compared to 1990. The IPCC report summarised the results of studies into the potential cost to the 23 developed countries listed in Annex II of the UNFCCC of implementing the cuts in greenhouse gas emissions set out for the 38 industrialised countries listed in Annex B of the Kyoto Protocol. Without emissions trading between the Annex B countries, the majority of global studies show reductions in projected GDP of about 0.2% to 2% below the baseline by 2010 for different Annex II regions. With full emissions trading between Annex B countries, the estimated reductions by 2010 are between 0.1% and 1.1% of projected GDP. The report notes that there are many ways of presenting the potential costs: "For example, if the annual costs to developed countries associated with meeting Kyoto targets with full Annex B trading are in the order of 0.5% of GDP, this represents US$125 billion (1000 million) per year, or US$125 per person per year by 2010". The report points out that "this corresponds to an impact on economic growth *rates* over ten years of less than 0.1 percentage point".

One vociferous critic of the UNFCCC and Kyoto Protocol is Bjorn Lomborg, author of the book *The Skeptical Environmentalist* and organiser of the Copenhagen Consensus, an event organised in 2004 during which a group of economists attempted to assess the need to tackle various global problems on the basis of an economic analysis of costs and benefits alone.

Lomborg had previously labelled the benefits of the Kyoto Protocol as "marginal" and claimed that "global warming is not expected to have a severe impact on human welfare as a whole" in an article in 'The Lancet' in December 2002, but did not offer any evidence to counter the findings of the IPCC 2001 report.

In a paper commissioned by the Copenhagen Consensus, William Cline used an analysis of the DICE99 economic model to show that the overall benefits of the Kyoto Protocol would be higher than the costs, with the advantage accruing to developing countries rather than the industrialised countries that agreed to targets under the Kyoto Protocol. Lomborg and colleagues controversially re-interpreted the detailed analysis by Cline to reach the conclusion that "costs were likely to exceed benefits" for the Kyoto Protocol. Furthermore, the distinguished economist Jeffrey Sachs pointed out in *The Lancet* that the Copenhagen Consensus suffered from "severe shortcomings" because it did not include input from scientists and "scientific information is presented through the over-simplified lens of rudimentary cost-benefit analysis". He described the DICE99 model as "a plausible strategy for an economist, but it doesn't come close to engaging 'the best natural-science models'". Sachs concluded: "While simple economic models can be illuminating, and I applaud DICE99 for what it can do, having climate scientists at the table to highlight the shortcomings of grossly simplified economic models is invaluable for arriving at proper policy conclusions".

Although opponents of the Kyoto Protocol, such as Lomborg, have made many criticisms, they have not put forward any robust viable alternative mechanisms that are consistent with the principles set out by the UNFCCC.

In a paper published in *The Energy Journal* in 2004, Barker and Ekins examined the costs that the United States government has estimated of meeting its agreed target under the terms of the Kyoto Protocol of reducing annual emissions of greenhouse gases by 7% in 2008-2012 compared to 1990. They concluded that as long as the target was achieved through policies that are gradual and well designed that "the net costs for the US of mitigation are likely to be insignificant", amounting to no more than 1% of GDP.

The government of the United States indicated in 2001 that it would not ratify the Kyoto Protocol and would not be bound by its agreed target. According to figures published by the UNFCCC secretariat in October 2004, annual emissions of greenhouse gases from the United States by 2002 had increased by 13.1% compared to 1990. The Royal Society has calculated that, even if annual emissions from the United States remain at the same level until 2012, the rise per year in greenhouse gases of 805,000 tonnes of carbon dioxide equivalents compared to 1990 levels will still be larger than the combined cut per year of 523,000 tonnes of carbon dioxide equivalents by all the other parties listed in Annex B of the Kyoto Protocol.

Therefore, with the conservative estimate that emissions by the United States will remain at the 2002

value until 2012 and all other Parties meet their targets, the Annex B countries, including the United States, will achieve an overall 1.6% increase instead of a 5.2% reduction.

Nevertheless, the Kyoto Protocol, which came into force on 16 February 2005, remains a crucial first step towards the substantial cuts in emissions that will be required this century if atmospheric concentrations of greenhouse gases are to be stabilised. It is essential that the next commitment period for the Protocol, beyond 2012, includes both developing countries and industrialised countries such as the United States.

The joint statement by 16 national academies of science in May 2001 demonstrated support from the international scientific community for the Kyoto Protocol. It stated:

"The ratification of this Protocol represents a small but essential first step towards stabilising atmospheric concentrations of greenhouse gases. It will help create a base on which to build an equitable agreement between all countries in the developed and developing worlds for the more substantial reductions that will be necessary by the middle of the century."

The statement continued:

"There is much that can be done now to reduce the emissions of greenhouse gases without excessive cost. We believe that there is also a need for a major co-ordinated research effort focusing on the science and technology that underpin mitigation and adaptation strategies related to climate change. This effort should be funded principally by the developed countries and should involve scientists from throughout the world."

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