Felix R. FitzRoy and Elissaios Papyrakis

An Introduction to Climate Change Economics and Policy

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Preface

There is now an overall scientific consensus that Earth is warming as a consequence of reckless human activity. What still remains contentious is the appropriate response to climate change. In recent years, the political and public debate on how we should respond to the threat has intensified. How should we divide investment between mitigation and adaptation? Should we give priority to renewable technologies, the development of carbon capture and storage, or halting deforestation? How much of our income should we sacrifice to prevent further warming for the sake of the poor and future generations? Without doubt, there is an increasing interest in economic and policy aspects of climate change, which is reflected in the rapidly rising number of scientific publications, informal reports, newspaper articles and public debates. In 2009, 'climate change' attracted approximately 50 million hits with Google, more than 'inflation' and 'unemployment'. Increasing interest is certainly encouraging, but the flood of information can easily become daunting and overwhelming for the average reader.

While there are many good and accessible introductions to climate science and to the policy debates, they usually include much more detail than the average interested but non-specialist reader is willing or able to assimilate. With this book, we offer readers a short, uncluttered introduction to the *key* scientific developments on climate change, the most threatening consequences and the most appropriate policies in response. We avoid less relevant detail and technical terminology, but rather analyse current issues in a simple, systematic way that does not require prior knowledge of the problems. Anyone with an interest in the most vital environmental and development issues should benefit from reading the book, and quickly become familiar with the recent evidence on global warming – and what we should do about it – without having to follow complicated jargon, numerous acronyms and a mass of statistics.

We do cover a wide range of topics, some of which have been neglected in discussions of climate change. In particular, we emphasize the role of global agriculture, already facing severe problems of erosion and water shortages, since climate change will amplify existing risks and challenges in the sector. Long before rising sea levels flood the world's coastal cities, prolonged drought in major food-producing areas could lead to starvation for the poorest populations and large-scale loss of life. Such catastrophes are not included in

economic cost–benefit analysis that only relates future consumption of survivors to current investment in reducing emissions. In addition to the ethical obligation of the rich countries that are responsible for most past emissions, we emphasize the local and short-term benefits to all countries from conservation agriculture, reforestation and energy saving. All mitigation policies incur political costs of persuasion and redistribution, but in contrast to widely held views, many generate net economic benefits, as well as insurance against the incalculable human costs of truly disastrous climate change under continued growth of greenhouse gas emissions.

Some of the material here has been included in courses at various levels at the Universities of St Andrews, Edinburgh and East Anglia for a number of years. This includes a first-year, interdisciplinary introduction to sustainable development at St Andrews, undergraduate and postgraduate environmental economics options at St Andrews and Edinburgh, and the Master's programme in climate change and international development at the University of East Anglia. We hope the book will also be particularly useful for undergraduate students in environmental sciences, economics, geography and development who want a simple introduction to the current debate on climate change issues and policies. It should also be helpful to more advanced students and academics, as we put more emphasis on the interdisciplinary nature of the problems considered than is usual, and throughout all chapters provide notes and references to more advanced readings on specific aspects of climate change and policy.

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We were particularly privileged to work with Earthscan, who provided continuous support and detailed comments for both the content of the manuscript as well as the overall presentation, production and marketing. We received extremely useful input from our editor Rob West, who oversaw the whole process. Claire Lamont assisted us in designing the book cover and provided help and guidance whenever called upon. Gudrun Freese looked after marketing, and Hamish Ironside managed the complexities of copy-editing. At St Andrews, Nikos Terzopoulos expertly organized our manuscript into final format.

Last but not least, our deepest thanks go to our immediate family and friends, who patiently read drafts of the book, without having any particular expertise either in economics or in climate change issues. Their feedback was important in shaping the style of the book. With their help, we produced a book that we hope is accessible to a broad audience. They contributed to every single stage of our ambitious endeavour to synthesize the rapidly expanding literature on the economics and policy of climate change, just by being there for us and responding critically to our preoccupations. This book would simply not be the same without the presence of our children, nieces and nephews, who continuously reminded us that this is a book for the benefit of future generations. We therefore thank Tina Caba, Ali Caba, Ozan Caba, Elif Caba, Renate FitzRoy, Jamie FitzRoy, Olga FitzRoy, Andries Kamminga, Manolis Papyrakis, Kostis Papyrakis, Katia Stavroulaki and Maira Stavroulaki.

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Introduction

Climate Change and the Political Landscape

Climate change has moved rapidly up the political agenda as the scientific evidence has become better known. The perils of extreme weather conditions, such as the disaster of Hurricane Katrina in New Orleans in 2005 and the more deadly, record European heatwave of 2003, attracted widespread public attention. Following the success of his documentary *An Inconvenient Truth*, former US Vice-President Al Gore was awarded the Nobel Peace Prize, jointly with the Intergovernmental Panel on Climate Change (IPCC) for their Fourth Assessment Report early in 2007. This contained stark warnings on the threat of global warming and the urgency of mitigation measures to reduce greenhouse gas (GHG) emissions, but was not entirely up to date. Newer scientific predictions have become considerably more pessimistic, with Arctic sea ice and snow cover in particular receding far more rapidly than expected, which in turn will accelerate warming and sea-level rise.

Another milestone in the discussion of climate change was the first official government review of its economic effects, led by British economist Lord Nicholas Stern and known as the Stern Review, in 2006. The estimated costs of global warming from continued business as usual were much larger than previously claimed – however, what Stern called 'strong policies' and targets for mitigation still imply very high risks of catastrophic warming that could destroy civilization and agriculture as we know it over much of the planet. Stern thinks the very worst possible outcome could be the loss of 20 per cent of future global economic output, which would still be much greater than current output, because he assumes that economic growth will continue unabated. He does not consider the possibility of collapsing agriculture and economies under runaway warming, or the real risk of mass starvation facing the world's poorest people. However, as the first study of this kind by a government team, the work attracted widespread publicity – as well as criticism, mainly for the wrong reasons, from other economists and, more soundly, from environmentalists. Stern's analysis has influenced government targets, but they, too, remain

seriously inadequate. Thus the official UK target, in the Climate Change Act of 2008, is an 80 per cent reduction of emissions only by 2050 (which is much too late according to the latest science), and little in the way of concrete policy measures has been announced since.

After European Union governments had also announced (weak) targets for reducing GHG emissions, a United Nations conference in Bali in December 2007 reached agreement in principle on the need for a successor to the now largely defunct Kyoto Protocol, in spite of fierce opposition by the US Bush Administration's representatives. Serious negotiation was postponed to the next UN climate conference at Copenhagen in December 2009, when cooperation from new US President Barack Obama is expected, with plans for a US carbon cap-and-trade system and other energy-saving policies. After poor management of the EU emissions trading system (ETS) since its launch in 2005, there is now the prospect of US leadership for improved regional or national cap-and-trade systems, which might pave the way to global carbon pricing.

The sheer flood of commentary and information on the science, policy and economics of climate change has left many people unclear or confused on key questions – just how great and how urgent is the threat from climate change, and what will it cost to take appropriate action? For many years, confusion has been deliberately spread by lobbyists for the fossil fuel industries (some of whom had previously worked in a similar capacity for tobacco companies) and a few eccentrics who ignored the real science. Confusion has been fostered by the media everywhere, including public service broadcasters such as the BBC, which until recently gave more-or-less equal coverage to warnings by serious scientists and to denials by lobbyists. Systematic public education on these vital questions has been neglected in most countries.

Much has also been written on policy for reducing GHG emissions from various perspectives. Economists have usually ignored the possibility of large-scale loss of life under catastrophic climate change if present policies are continued with 'business as usual'. They also exaggerate the costs of mitigation by neglecting the additional health and efficiency benefits from energy saving, conservation agriculture and a greener economy. However, there are always political costs of change. Increasing efficiency by shifting taxes from labour to pollution, and switching subsidies from fossil fuels and industrial agriculture to sustainable alternatives, does generate strong opposition from the losers and their government supporters.

Structure of the Book

Any book on the economics and policy of climate change needs to be rooted in the science of climate change and what it implies for how we react or should react as a global society. Chapter 2 provides a brief, non-technical overview of the consensus on the basic science of climate change. It explains the role of greenhouse gases and carbon sinks, as well as the key feedback mechanisms that are likely to accelerate the pace of climate change and carry the risk of

runaway warming, such as methane emissions from thawing permafrost and decreased surface albedo or reflectivity as ice and snow cover recede.

Most writers on the consequences of climate change acknowledge that the world's poorest countries will bear the greatest burden of water shortages and falling food supply. However, most discussions of *policy* response to climate change pay little or no attention to agriculture, which is of particular importance for the livelihoods of billions of poor households in the developing world (while accounting for tiny fractions of output and employment in developed countries). Chapter 3 examines the prospects for agriculture in a changing climate, summarizing extensive evidence that modern agriculture is *already* under severe threat from the very same methods that have dramatically raised yields – as well as water and energy requirements – over the past 50 years. The predicted rising temperatures and worsening droughts in major food-producing regions which are already hot and arid are likely to have devastating consequences for agriculture, with global impact. Each additional temperature rise of one degree Centigrade during the hot growing seasons of many southern agricultural areas is predicted to reduce grain yields by at least 10 per cent. Just a small decline in the world output of wheat, in the face of growing demand, doubled its price in 2007. The further, rapid rise of grain and oil prices was only halted by the financial crash and global recession of 2008. Really large-scale crop failures resulting from future warming and water shortages in developing areas would cause prices of staple foods to rise many times over and lead to mass starvation among the world's poorest people.

Historically, famines have always been local or regional, and there has never been a global food shortage, but the combination of declining water reserves, increasing temperatures and growing population in the developing countries means that agricultural catastrophe, probably accompanied by global conflict, becomes the most immediate threat from continued climate change. Surprisingly perhaps, simple well-tried techniques of conservation, or no-till agriculture and large-scale reforestation, could substantially reduce this threat. As well as lowering the GHG emissions from modern agriculture, these methods reverse currently accelerating carbon loss from eroding soils and actually capture atmospheric carbon in accumulating organic material. Input costs are reduced, and sustainable yields increased in the long run, so abatement of GHG emissions can be combined with the co-benefits of more efficient and sustainable farming. Further mitigation measures are, of course, urgently required, as even the most robust agriculture will ultimately be decimated if runaway warming is triggered by growing fossil fuel consumption.

Chapter 4 looks at the links between economic growth, wellbeing and the environment. A major theme of our approach is that the costs of climate change mitigation have been exaggerated under the influence of fossil fuel lobbying and the prevailing ideology of ever-increasing material consumption and economic growth, whatever the real environmental costs. One reason is that many policies to reduce emissions will have substantial additional or co-benefits, in the form of reduced pollution and better human and animal health in the short to

medium term. A second point is that possibly slower economic growth due to mitigation policies is not really a 'cost' in the advanced economies. In fact, 30 years of careful survey research by social scientists show clearly that in rich countries, subjective wellbeing does not increase with average real incomes in the long run (though short-term economic fluctuation certainly influences welfare). The reason is partly the erosion of 'social capital' and human relations that is often the price of material growth and partly the fact that subjective wellbeing depends on relative rather than absolute income when basic needs have been met. Recent surveys suggest that even in China, where fast growth and poverty reduction have been absolute priorities, rapidly increasing inequality has been accompanied by declining happiness and life satisfaction.

It follows that even if mitigation policies to reduce emissions also slow down the rate of material growth in rich countries, this does not imply a future cost in terms of reduced subjective wellbeing. In poor countries, which are the main focus of Chapter 5, economic growth can bring real benefits to all, though most of the benefits are usually appropriated by a wealthy minority. Sustainable development and distributional justice, without the environmental degradation and growing inequality that have hitherto always accompanied early industrialization, should thus become a major goal of international policy. The developed economies are responsible for most of the existing stock of GHGs in the atmosphere, and most discussion of policies for abatement has focused on these countries. But the largest developing countries, China and India, are now among the fastest-growing polluters (and economies), and China has actually caught up with the US in total emissions. We will therefore consider policies for reducing GHG emissions in both developing and developed countries, as well as the related issues of aid, trade and globalization in relation to the environment and sustainable development.

In Chapter 6 we argue that the ethical principles of justice provide an essential foundation for policies to protect unborn generations, and the poorest countries, from climate change, though this aspect has been neglected by many economists. Related issues arise in connection with persistently inadequate aid for these nations, in the face of growing threats to agriculture and water supply, and rules of international trade which mainly benefit the rich countries. Increasing aid for the world's poorest peoples can be an integral part of effective mitigation. With 20 per cent of carbon emissions from (mostly tropical) deforestation, carbon credits for forest preservation would combine aid to poorer countries with one of the most cost-effective forms of abatement. Perhaps the most cost-effective but politically fraught policy reform would be the removal of several hundred billions of dollars of annual subsidies from the two biggest recipients in the Organisation for Economic Co-operation and Development (OECD) – destructive industrial agriculture and fossil fuels. A small fraction of this would accelerate the already rapid rate of technical progress in renewable energy, and the still glacial pace of adoption in most areas, as well as encouraging the essential switch to conservation agriculture.

Turning to international agreements in Chapter 7, we evaluate the Kyoto Protocol and its mechanisms as a means to reduce global emissions. With few incentives for mitigation, and the absence of sanctions against the worst polluters such as China and the US, we argue that Kyoto has largely been a failure in the fight against climate change. Emissions trading in the EU has been equally unsuccessful in its first phase, with free distribution of carbon allowances or permits to the biggest emitters, who have used their market power to raise prices and generate huge windfall profits. Permit prices have fluctuated, but generally remained too low to provide an adequate incentive for investment in alternative or decentralized energy generation. While more permits should be auctioned in future stages of the EU ETS, there is strong industry lobbying for exceptions, which are, of course, easier to justify during the current economic downturn.

Chapter 8 reviews the economic instruments and incentives for reducing GHG emissions. Although carbon taxes have many theoretical advantages, new US President Obama has made a commitment to a comprehensive carbon cap-and-trade system. Applied 'upstream' to all producers and importers of fossil fuels, this could improve considerably on the European system, which only covers large industrial emitters, and perhaps be politically more acceptable than new taxes, though likely to be delayed by the recession. As in the EU, an initial free allocation, with a limited but growing share of auctioned permits, will reduce industry opposition, and in the long run could approach an ideal carbon tax. This long-overdue initiative by the US may encourage other countries to follow, so that international, and ultimately global, carbon trading could result. On the other hand, there is very little prospect at the moment of starting with one of the far-reaching, 'top–down' global agreements on carbon trading that have often been proposed before there is more experience with functioning national or regional systems.

Most economic analysis of climate change and mitigation, as we explain in Chapter 9, has seriously underestimated the risks of runaway warming under current policies, or 'business as usual', and resulting catastrophic effects on third world agriculture. At the same time, the costs of switching to sustainable conservation farming and alternative energy supply have been exaggerated by agribusiness and fossil fuel industries. Economic growth is simply assumed to continue unabated for the next century or two, and the very worst impact of climate change has been compared by Lord Stern to the Great Depression of the 1930s, though he still thinks this 'worst case' is very unlikely. This means that our descendants, who will be many times richer than we are, might lose at most 20 per cent of their incomes. How many lives might be lost is not generally considered.

We shall argue that this position is based on fundamental misunderstanding of the latest climate and environmental science, as well as neglect of the basic ethical issues. Really catastrophic outcomes of runaway warming are not only possible but even likely if GHG emissions are not reduced much more rapidly than under Stern's – and all government – targets to date. The global

conflict potential of large-scale starvation in the poorest regions, and the collapse of fragile but nuclear-armed states, will threaten prosperity and security even in the most affluent countries. Prudence and concern for the welfare of our children justify major investment in mitigation as insurance against these risks. In the developed countries we have the additional ethical responsibility for having produced most of the GHGs in the atmosphere today. The biggest developing nations are now catching up as polluters, while devastating their environments and the health of their citizens, increasing the likelihood of globally catastrophic climate impact in the future. These countries are repeating all the mistakes made by the West in earlier industrialization, with little public awareness of the prime threat to their own populations. A refocusing of trade and aid policies to promote 'cleaner', sustainable development thus becomes all the more urgent.

In our concluding Chapter 10 we show that the current economic crisis offers huge opportunities for 'green fiscal policy', government spending on energy-saving projects that would also reduce unemployment, particularly in construction sectors that have been hardest hit by collapsing housing bubbles. These opportunities have been largely missed, with only a very small share of green projects in the stimulus packages of the major economies. In our discussion of policy responses to climate change and environmental degradation we emphasize the ethical and distributional issues to complement the economic, cost–benefit aspects that usually dominate the discussion. We find that substantial mitigation can be achieved with measures that actually improve health and welfare, and that most of the perceived costs of the necessary drastic emissions reduction are political and distributional. However, there are also real psychological costs of changing familiar habits, even when more environmentally friendly behaviour also brings personal benefits in the long run. So we come back to the crucial issue of public education about the magnitude of the threats facing us all and, more optimistically, about the feasibility and multiple benefits of effective 'insurance' policy – which summarize the two main aims or themes of this book.

2

Basic Science of Climate Change

New findings by climate scientists are reported ever more frequently in the media, as public interest in the prospects of climate change has grown dramatically in the recent past for a number of reasons. The long-standing consensus among almost all scientists on the human causes of current rapid global warming and its huge threat for life on Earth has been widely disseminated by former US Vice-President Al Gore in his 2006 book and Oscar-winning documentary *An Inconvenient Truth*. Early in 2007, the IPCC summarized the scientific consensus in its Fourth Assessment Report, and shortly afterwards the EU announced commitments to reduce emissions of greenhouse gases by increasing the share of renewable energy. The IPCC and Al Gore then shared the 2007 Nobel Peace Prize in recognition of the importance of their work for the future of humanity. At about the same time, the Stern Review commissioned by the British Government provided estimates of huge expected economic costs of global warming and emphasized the urgent need for major investment in mitigation.[1]

Some political commitments and much discussion at a series of EU and UN conferences have followed the publicity. Late in 2008, the global economic crisis took centre stage, but new US President Barack Obama, in striking contrast to his predecessor, has announced plans for a carbon cap-and-trade system and other initiatives to reduce emissions by 80 per cent by 2050. In December 2009, the UN climate change conference in Copenhagen is scheduled to negotiate a successor to the ill-fated Kyoto agreement. As we shall show, all targets that have been announced so far are woefully inadequate in the light of the science that we review here.

Unfortunately, there remains much confusion among the general public about the key facts and implications of climate change. This is partly due to the veritable flood of media reports on climate change, including the science, policy discussion and possibly related-weather phenomena. At the same time, ever more frequent, usually vague and often misleading statements by leading politicians make it difficult for the layperson to see the wood for the trees. More fundamentally, however, the long-standing campaign by the fossil fuel lobbies to systematically confuse and misinform public opinion has been

regularly and uncritically reported by the media and raised honest doubts among some who are unfamiliar with the evidence.

In this chapter we start with a brief summary of key facts from the geological history of the Earth's climate – the 'palaeoclimate' – that are particularly relevant for predicting how our climate is likely to react to various future scenarios of human activity. We then turn to the evidence on current climate change and the actual predictions of the complex computer models of the global climate system that have reached close agreement on many important issues. The absurdity of the claims made by climate change deniers will be exposed on the way, and for the benefit of readers unfamiliar with their tactics we will present some background to the most egregious examples.

A Very Short History of Climate

For as far back as temperatures can be estimated from geological evidence, the Earth's climate has undergone major fluctuations. These have ranged from the extremes of 'Snowball Earth' when most of the planet was probably covered with ice around 600 million years ago, to more frequent and extended 'hothouse' periods of global tropical climate with no polar ice. The most detailed records come from ice cores drilled out of the ice caps that cover Greenland and Antarctica. The annual snowfall that has built up the ice sheets to a thickness of several kilometres also traps microscopic air bubbles from the atmosphere, and these can be analysed for their content of carbon dioxide, methane and other greenhouse gases. These gases (and also water vapour) absorb infrared, or long-wave, heat radiation from the Earth's surface better than other components of the atmosphere such as oxygen and nitrogen, and thus warm the atmosphere as their name 'greenhouse gases' implies. The ratio of oxygen isotopes in the ice cores also provides a precise record of the prevailing temperature when the snow fell.

The ice core records now go back 800,000 years and reveal a remarkable pattern of cold periods that lasted about 100,000 years, with warmer spells of variable length in between. Other evidence shows extensive coverage of northern regions by ice sheets up to four kilometres thick during the cold periods, which are commonly referred to as 'ice ages'. Our current warm 'interglacial' spell – called the Holocene – has lasted about 11,000 years and enabled the development of human culture in benign climates.

Ice ages were probably triggered by small changes in the Earth's axis of rotation, and orbit around the sun, that alter the distribution and intensity of solar radiation, particularly in the polar regions. A slight initial cooling then began to remove CO_2 from the atmosphere, probably through biological activity in the oceans, which amplified the cooling effect. At the same time, expanding ice and snow cover reflected more of the incoming radiation back into space – a process known as the 'ice albedo effect'. These positive 'feedbacks' were ultimately the main reason for much lower temperatures persisting throughout the ice age, with the albedo effect responsible for two-

thirds of the cooling. Just what started the warming process that ended the ice ages is less clear, but the same feedbacks operated in reverse to increase greenhouse gases and reduce albedo as the ice cover receded and temperatures rose. While sea levels were about 120 metres lower than at present during the greatest extent of ice, melting then accelerated to a dramatic pace, raising the sea level by about a metre every 20 years for four centuries around 14,000 years ago.

This is an ominous portent for our near-term future, with rapidly accelerating loss of Greenland ice observed in the last few years, though this development was ignored by the IPCC in its 2007 Assessment Report, which foresees only slow melting and sea-level rise over the next century. However, this forecast (like the rest of the report) is based on research that had already been published, after often lengthy peer review, when it was being prepared in 2005–2006. Thus the 2007 IPCC report summarizes research that was already several years old and thus obviously did not consider the most recent observations pointing to a possible break-up and collapse of the ice caps, rather than a slow melting from the top down. The need for consensus among the hundreds of scientists involved, from many different countries, also means that the IPCC reports are quite conservative documents and is another reason why they do not always represent the frontiers of current climate science.

During the last ice age, the quantity of carbon dioxide in the atmosphere was about 190 parts per million by volume (ppm). This increased over a few millennia to about 280ppm in the current interglacial, an amount that remained stable until industrialization, but has now increased by more than a third to about 390ppm.[2] Global mean temperature has increased by nearly 0.8°C over the past 150 years.

Records from the ice cores also reveal rapid, short-term temperature oscillations of several degrees between the two polar regions throughout the ice ages. A likely candidate for explaining this instability is the ocean current that transports warm, salty surface water from the South Atlantic to the North Atlantic between Iceland and Greenland, where it cools and sinks, returning south as a deep, cold ocean current. This Atlantic 'meridional overturning circulation' (also called 'thermohaline circulation' and sometimes, incorrectly, 'the Gulf Stream') is responsible for north-western Europe's relatively mild climate. The circulation probably stopped abruptly at the end of the last ice age, about 12,800 years ago, as a giant freshwater lake left by the receding ice sheet over North America suddenly flooded into the North Atlantic, diluting the salty surface current sufficiently to prevent it sinking. The break lasted for 1200 years and plunged Europe into a local ice age called the Younger Dryas, though it probably had little effect in much of the southern hemisphere. Interruption or slowing of the circulation at regular intervals before this may well have caused the observed swings of temperature between the poles, though the reasons remain unclear. A major slowdown or interruption of the Atlantic circulation is now thought by most scientists to be unlikely in the medium-term future.

There was another similar, though less severe, 'mini ice age' starting about 8200 years ago but only lasting a few centuries, but then the climate settled into the current stable, warm period known as the Holocene, with only minor fluctuations. The last of these was the 'little ice age', a cool spell that was depicted by the great Flemish and other artists of the 17th and early 18th centuries in their paintings of skaters and revellers on frozen rivers, scenes that became increasingly rare with subsequent warming. Prior to that, the 'medieval warm period', when Viking settlers could grow crops in southern Greenland, as their descendants have recently started to do again, has attracted some attention. However the consensus is that current global mean temperatures are definitely higher than at the medieval maximum, though of course the latter can only be estimated indirectly from evidence such as tree rings, and individual results for particular regions are subject to some uncertainty.

An interesting question, then, is what caused these fluctuations when atmospheric greenhouse gases were quite stable. One likely factor in relatively small historical temperature variations is fluctuating solar activity, which follows cycles in the number of sunspots. For most of the 20th century there was a close correlation between solar activity and global mean temperature, but the most accurate measurements to date, by Mike Lockwood of Oxford University and Claus Fröhlich from the Davos Observatory in Switzerland, show the opposite development since 1985.[3] During these last two decades of most rapid warming, all solar indicators have been *declining*, which provides conclusive confirmation of what earlier observations had already suggested, that recent warming would have been even greater without solar effects.

This important scientific advance also puts the final nail in the coffin of the 'denial industry', or 'contrarians', who contest various aspects of climate science with false or misleading claims, many of which were recently broadcast in a notorious TV programme.[4] The latest climate models also show that the effect of solar activity was fairly small over the last 100 years, with most of the warming explained by rising concentrations of greenhouse gases. The slight cooling observed in the 1950s and 1960s is also explained by the same models as a result of sulphates and dust, or 'aerosols', in the atmosphere; these reflect more radiation than they absorb and thus have a cooling effect. A further decline in solar activity is possible, though speculative, and could briefly slow down the warming process. A diminishing North Atlantic circulation could have a similar but stronger local effect in Western Europe, though this is now considered unlikely by most experts.

There is an erroneous popular view that evidence for climate sensitivity to natural 'forcing', such as orbital or solar variation, in some way undermines the importance of current anthropogenic greenhouse gas emissions for future climate change. This quite illogical conclusion is close to the opposite of the truth. Greater sensitivity of the complex climate system to one kind of forcing influence and associated feedbacks is actually more likely to imply greater sensitivity to other influences. All the evidence we have suggests that the