Climate Science Observations and International, CESA, DECC
7 March 2012

Event: *"Climate Change or Climate Gate – Are the sceptics winning the battle of ideas in the Conservative Party?"*

Briefing for Lord Marland

Background

Lord Marland has agreed to sit on a panel at an event being organised by the Bow Group. The discussion will address the question *"Climate Change or Climate Gate – Are the sceptics winning the battle of ideas in the Conservative Party?"*

It is expected that the journalist James Delingpole, who is well known as a climate change sceptic and 'Climategate' critic, and an academic expert in the field of climatic research will also sit on the panel.

This briefing provides some key facts on climate science, together with background information on the 'Climategate' issue and the Intergovernmental Panel on Climate Change (IPCC), which has also recently faced major criticism. A sceptical Q&A on basic climate science is also included (see Annex).

1. Climate Science – Key Facts

- Atmospheric CO_2 levels are at their highest for at least the last 800,000 years and are about 40% above pre-industrial levels.

- The Earth has warmed by about 0.8˚C since 1900 with the last decade (2001 to 2010) being by far the warmest ten year period in the 150 year instrumental record. The warmest years in the record are jointly 2005 and 2010.

- Arctic sea ice summer extent has declined by at least a staggering 35% since the end of the 1970s. Winter ice thickness has also declined by about a half.

- Globally, there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights and increases in the number of heavy precipitation events at least in some regions.

- A recent study shows that the damaging UK floods of 2000 were about twice as likely than they would have been a century ago, because of greenhouse gas emissions.

- **There is robust evidence, from the IPCC's AR4 Report and also more recent work, that warming of the climate system is unequivocal and that** the observed increase in global average temperatures since the mid-20th century is ***very likely*** due to the observed increase in greenhouse gas concentrations.

- The IPCC is preparing its 5th Assessment Report. Some 8 hundred leading experts from 85 countries are involved in writing and reviewing the report. (67 from the UK).

- Global sea levels rose by about 170mms (6.7 inches) over the last century and the longer term trend shows they are rising at an average rate of around 3mm (0.1 inches) per year.

2. 'Climategate' - Allegations of scientific impropriety at the University of East Anglia (UEA) Climatic Research Unit

Key points

- Climate scientists at the University of East Anglia were comprehensively cleared of any malpractice by four successive independent reviews, following the illegal release of emails in 2009 and subsequent allegations of scientific impropriety.

- The quality of science conducted in the UK is world class and the Government remains proud to host some of the world's leading climate science institutions.

- The release of 5,000 more of the emails hacked in 2009 just ahead of the UN Climate summit (the UNFCCC COP17) in Durban in late 2011 didn't generate the intense media interest of the initial 2009 release, as it was seen as a poor and discredited attempt to disrupt the Durban meeting.

Background

- In November 2009, a server at UEA's Climatic Research Unit (CRU) was hacked, releasing emails between climate scientists. The emails described the scientists' work using phrases including 'trick' and 'hiding the decline', which was taken to suggest the scientists had manipulated data trends.

- Together with the Met Office, CRU is responsible for producing one of three analyses of near surface temperature that provide core evidence of global warming. NASA and NOAA (the US National Oceanic and Atmospheric Administration) provide the others.

- The three teams use different methodologies to combine thousands of raw measurements; the analyses differ in detail but all show significant warming trends (around 0.8°C since 1900). Warming is corroborated by data from instruments on satellites and seen in physical indicators of temperature (e.g. sea level rise). Such temperature analyses do not make any judgements about whether the warming is human-induced or natural; that assessment is provided by other research.

- In the weeks after the emails became public, CRU was heavily criticised, particularly in the English-language press. Public confidence in climate science appeared to drop. A number of independent inquiries were initiated in the UK:

    - The House of Commons **Science and Technology Committee** initiated the first inquiry (reporting March 2010).

- **The Scientific Appraisal Panel** chaired by Lord Oxburgh examined the conclusions of CRU's key scientific publications (reporting April 2010).
- The **Independent Climate Change Emails Review** chaired by Muir Russell was conducted at the request of the University, to examine the veracity of all criticisms directed against the University after the hacking incident (reporting in June 2010).
- The House of Commons **Science and Technology Committee** reconvened to consider the two independent reviews (chaired by Lord Oxburgh and Muir Russell) and reported in January 2011.
- Further reviews were conduced outside of the UK.

- These reviews all confirmed there is no evidence of scientific malpractice at the University, and the evidence of 20th century warming remains strong.

- The main criticism of these independent reviews has been that researchers at CRU were insufficiently open and transparent. However, a widespread criticism of CRU that they had not made raw data available to people externally who may wish to test their analysis, was show to be unfounded.

- The Berkeley Earth Surface Temperature Project is an independent re-analysis of land temperature records conducted by scientists outside the field of climate change and initiated in response to events at CRU. Its pre-publication results, released in October 2011, very closely match the observed warming trend seen in CRU's analysis.

3. The Intergovernmental Panel on Climate Change (IPCC)

Role of the IPCC

- The IPCC is the leading body for the scientific assessment of climate change and is recognised by governments around the world as the primary authority on the science.

- It provides member states with robust assessments of climate change science, impacts and mitigation options. It reviews and reports on the most recent scientific, technical and socio-economic information produced worldwide, relevant to the understanding of climate change. It does not conduct any research of its own.

- The IPCC has produced four major assessment reports since 1990, and its fifth is underway, to be published in 2013 and 2014.

Independent review of the IPCC

- In early 2010 a few errors were discovered in the IPCC's Fourth Assessment Report. The most serious of which misquoted the projected date for the melting of Himalayan glaciers. Only a very small number of errors were discovered in a three volume report containing many thousands of references.

- Following criticism for these errors, an independent review in 2010 by the InterAcademy Council made a number of recommendations for strengthening the IPCC's Procedures and Governance.

- Between 2010 and November 2011, the IPCC considered and took steps to implement the key recommendations of the InterAcademy Council review. Key outcomes were; establishment of an Executive Committee, improved procedures for handling non-peer reviewed literature and errata, development of a communications strategy and a conflict of interest policy. These changes have put the IPCC in an even stronger position for preparing the next (Fifth) Assessment Report.

- The UK government retains confidence in the leadership of the Intergovernmental Panel on Climate Change and welcomes the decisions taken to strengthen its management processes.

- The UK's Climate Change policy does not, however, rely on a single source of evidence (the IPCC) but on the peer-reviewed work of many research groups in the UK and around the world. Indeed, the IPCC reports are an assessment of a broad body of scientific literature.

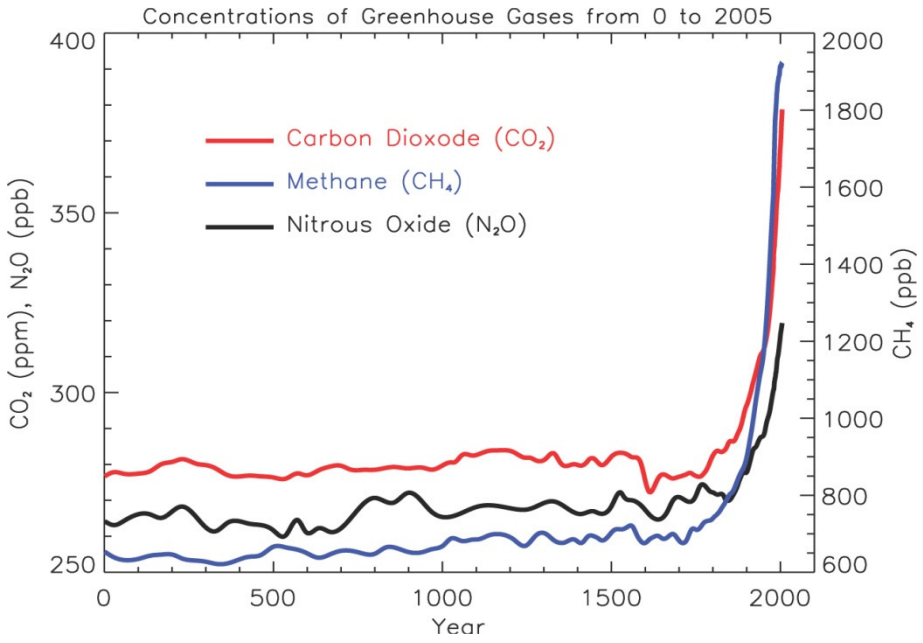
- The scientific evidence for climate change as a result of human activities, and the risks that it poses, is robust and continues to strengthen year-on-year.

Annex

Basic Climate Science: Sceptical Q+A

1. Isn't the current global warming just natural variability?

A. No. Long-term (decadal and longer) warming continues. Both the spatial patterns and trend of warming can only be explained by taking account of human emissions, especially of carbon dioxide but also of methane and nitrous oxide.



Atmospheric greenhouse gas concentrations in the last two millennia

2. Don't scientists disagree about climate change? Many reputable scientists believe that climate change is not caused by human activities.

A. It is relatively easy to look at how climate change issues are covered in the media and believe that there are balanced scientific arguments for and against a human cause of climate change. This is absolutely not the case.

The overwhelming majority of climate science experts agree on the fundamentals: that climate change is happening and has recently been caused by increased greenhouse gases from human activities. The physics is incontrovertible.

In 2010 Met Office Hadley Centre climate scientists published a seminal paper showing that discernible human influence on climate now extends, not only to temperature increase, but also to increases in atmospheric humidity, changes to the hydrological cycle causing changes in global rainfall patterns, increases in Atlantic

ocean salinity in the tropics, reductions in Arctic sea ice extent, and changes in Antarctic temperatures.

There are some people who argue that recent climate change is not the result of human activity. While some of these individuals have scientific backgrounds, these opinions are very rare indeed amongst scientists working on climate science.

3. Didn't the 'Climategate' controversy cast doubt over whether the Earth is warming?

A. No. Three independent data analyses agree with the Met Office and Climatic Research Unit (CRU) findings; all show clear evidence of warming going back to before 1900.

The CRU's Professor Phil Jones admitted using the term 'trick' to 'hide the decline' in a temperature graph used in the World Meteorological Organization (WMO) report in 2000. The Muir Russell review confirmed that the graph was misleading. But this was **not** a criticism of Jones' science but rather of how it was communicated. DECC backs moves led by Sir John Beddington, and supported by the Royal Society and NERC, to improve climate science communication and transparency.

4. We can't trust climate models, can we?

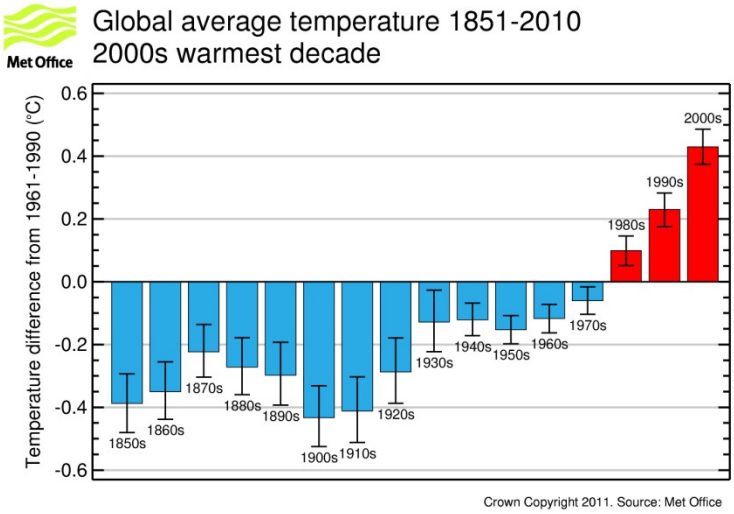
A. Confidence in climate models comes from several independent evidence strands. They are based on fundamental physics and are rigorously tested to ensure their reliability. They do not depend on observational data trends, such as the CRU analysis, to make their projections but are tested and validated by comparing their outputs with observational data. They are able to simulate key features of major climate and weather systems and processes, as well as past climate variability.

5. Hasn't global warming stopped? No warming has happened since 1998.

A. No - this is a classic case of cherry picking data. Over short intervals of a few years natural climate variations can temporarily mask long term trends. 1998 was equal warmest year on record (since 1850), together with 2005 and 2010, but every year since then (in fact every single year for the past three decades) has been significantly warmer than the temperatures you'd expect if there was no warming [*1861-1900 baseline*].

Globally , the ten year period 2001 - 2010 was significantly warmer than any previous ten years in the record. Yes, most individual in the 2000s years have not been quite as warm as 1998. This is because the human-forced warming trend is taking place on top of natural variations. These natural variations made 1998 particularly warm (because there was a very strong Pacific El Niño event). We will

always see such short-term fluctuations but to confirm climate change we need to rely on long-term trends of decades and longer.



6. Isn't it the case that satellite data don't support the 'theory' of global warming?

A. Not so. Initial estimates of temperatures in the lowest parts of the atmosphere in the early 1990s and based on satellite and weather balloon measurements, did not appear to mirror the temperature rises measured at the Earth's surface. However, these discrepancies have long since been found to be related to problems with how the satellite and balloon data were gathered and analysed and have now been resolved.

7. We can't trust the IPCC process, can we?

A. The IPCC process has been widely acclaimed as an example — probably the best example in the world — of a comprehensive, thorough and fair assessment of a complex scientific problem.

It is testament to the level of transparency and fairness that IPCC summary texts have been agreed by every country in the world and have been formally accepted as the guidance documents for the UNFCCC.

The IPCC's 2007 Fourth Assessment Report on the physical science basis of climate change[1] was written by 619 named scientists and reviewed by another 622. In total, the IPCC's Fourth Assessment was written by more than 1,250 authors from more than 130 countries and reviewed by an additional 2,500 experts, over six years.

Two factual errors, on the rate of Himalayan glacier melt and proportion of the Netherlands vulnerable to sea level rise, were found in this large, 3-volume report.

[1] Working Group 1's contribution to the Fourth Assessment Report

Several other minor errors were also identified but none of these mistakes related to the core evidence for human-induced climate change.

8. The evidence is equivocal. Shouldn't we wait to act?

A. Some individuals are keen to suggest that climate science is so uncertain that we should delay action on climate change. But we cannot afford to wait. We know that limiting warming to 2°C (over a pre-industrial temperatures) gives us the best chance of avoiding the worst impacts of climate change during this century.

More warming in coming decades is unavoidable owing to past and current greenhouse gas emissions. Each year we delay action it is becoming increasingly difficult to keep below our two degree target and emissions need to peak soon and then fall rapidly. To delay action, and allow this opportunity to pass, would be wholly irresponsible.

9. Climate change varies across the world. Doesn't this allow climate-change 'proponents' to 'cherry pick' the examples they use to support their position?

A. Climate change caused by greenhouse gas emissions is not expected to be uniform across the world. For example, all the examples presented in Lord Lawson's book — including those that he presents as 'inconsistent' with global warming — are actually fully consistent with scientific understanding of how greenhouse gases affect climate. For example:

- The physics tells us that high latitudes should warm faster than low latitudes, owing to feedback effects associated with the retreat of snow and ice. This is exactly what we are seeing.
- Around the world many more glaciers are retreating than are advancing. This evidence comes from the National Snow and Ice Data Center in the US, and the World Glacier Monitoring Service. Glaciers have advanced in some regions because glacier extent is determined by the amount of snowfall as well as temperature and climate change has increased snowfall in some regions.
- Similarly, snowfall has increased over the cold interior of the Greenland ice sheet, increasing its thickness there but rising temperatures have also increased melting around the ice sheet's edge.

10. Haven't temperatures been higher in the recent past?

A. In 2006, the US National Academies of Science carried out a full review of the evidence of temperatures in the last millennium. They found that for the Northern Hemisphere at least, 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 the past 1300 years.

Natural processes including changes in solar output, volcanic eruptions and changes in the Earth's orbit can affect climate and have led to relatively warm periods in the past butt what matters now is that we're seeing warming now. Temperatures are rising rapidly due to human activities and are set to increase by between 1.1 and

6.4°C over the coming century, depending on emission levels. Only by limiting this warming can we avoid the worst impacts of the climate change.

11. What about the Mediaeval Warm Period and Little Ice Age? We know that temperatures have varied in the past.

A. We do know that the climate has varied naturally in the past. But there is no evidence that natural forces can explain all of the warming being seen today. And there is strong and compelling evidence that the warming is linked to human activities.

The Medieval Warm Period and Little Ice Age are often quoted as examples of past temperature change. The changes being observed today are global; there is little evidence that either of these periods of temperature change were observed globally, only mainly in parts of the Northern Hemisphere, especially Europe.

12. In the distant past, CO_2 changes lagged behind temperature changes. How can we now say that CO_2 emissions are driving temperature increases?

A. We know that CO_2 and temperature are closely linked but we also know that the current rise in CO_2 is caused by the increase in human emissions. The corresponding temperature rises are occurring on a much faster timescale than those of the past, which were caused by, for example, slow, long-term changes to the earth's orbit.

13. The CO_2 trend over the past century doesn't match the trend in global warming. How can it be the cause?

A. Warming caused by human greenhouse gas emissions lags behind the emissions because of the inertia of the climate system (primarily because of the huge thermal inertia of the world's oceans). Second, greenhouse gases are not the only determinant of temperature. Aerosols also emitted by human activities are important and can be shown to explain much of the slight cooling observed between the 1940s and 1960s. Volcanic eruptions and small changes in solar output also complicate the picture.

Sophisticated climate and earth system models now include the physics and chemistry that factor in all these natural and human drivers. These models simulate historic changes in global and regional temperatures and show it's very likely that nearly all of the warming over the past half century has been caused by the rise in greenhouse gas concentrations.

14. Human emissions of carbon dioxide are tiny in relation to natural flows of carbon dioxide. How then can humans be responsible for global warming?

A. Isotopic analyses confirm the human sources of carbon dioxide. There is no doubt that the amount of human (or 'fossil') carbon in the atmosphere is increasing.

While human emissions are relatively small compared to natural emissions from terrestrial ecosystems and the oceans, these natural emissions are in close balance with removal: the amount emitted is reabsorbed by 'sinks' in the geosphere and biosphere. Human emissions have tipped the balance, leading to an accumulation of carbon dioxide and other greenhouse gases in the atmosphere.

15. Water Vapour is the primary greenhouse gas in the atmosphere. How can carbon dioxide being added by human actions really make a difference?

A. Whilst water vapour is the most abundant greenhouse gas in the atmosphere (making 95% of the total), individual water vapour molecules only stay in atmosphere for a few days, whereas carbon dioxide remains for decades, continuously increasing global temperatures over that time. The effects of increasing carbon dioxide concentrations are magnified by feedback loops which allow more water vapour to be held in the atmosphere. This greatly exacerbates the warming due to CO_2 alone – the so-called water vapour feedback effect.

On its own, we know that doubling the pre-industrial concentrations of CO_2 from around 275ppm to 550ppm would lead to around 1.2°C warming. However, we understand that the water vapour feedback dramatically increases this 'climate sensitivity' and all else being equal (e.g. if cloud feedbacks were on balance neutral) the real-world 'climate sensitivity' is very likely closer to 3.2°C ± 0.7°C (also see Q16 below).

Famously, Prof Richard Lindzen is at odds with the consensus but his evidence is almost universally considered weak and his arguments misplaced.

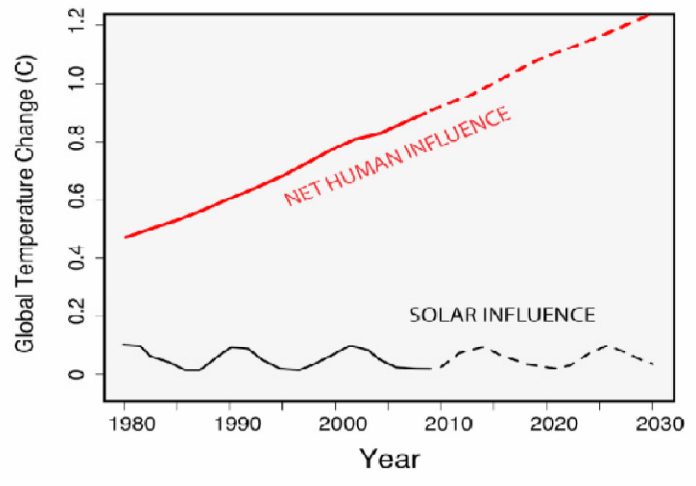
16. The sensitivity of the climate system to increasing carbon dioxide is much lower than the IPCC asserts. Won't doubling CO_2 concentration only increase global temperature by about 1°C?

A. It's true that the main uncertainty in climate science remains climate sensitivity and mainly because of uncertainties concerned with cloud feedbacks. However, nearly all recent scientific analysis and modelling strongly suggests that climate sensitivity ranges between around 2.5 and 4°C.

17. Haven't variations in the Sun's output been the cause of recent climate change?

A. The Sun's output varies slightly with the famous 11-year sunspot cycle and longer term variations. Overall, though, the sun's brightness has been constant or decreasing slightly over the past few decades and this can't account for recent global temperature increases.

The influence of the Sun's recent variability on the climate is very small: around 10% of the influence of human greenhouse gases since the start of the industrial revolution (1750), according to the last IPCC assessment. Recent research has also confirmed that warming over recent decades cannot be explained by solar variability.



The relative influence of the Sun since 1980 – Source "The Copenhagen Diagnosis"

18. Isn't global warming caused by cosmic rays?

A. No. Variations in cosmic rays over the past few decades cannot explain the long-term global warming trend. Some laboratory experiments have indicated their possible influence on cloudiness but these have not been validated in the real world and even if a viable mechanism were confirmed, the size of the effect is thought very unlikely to be significant. Further improvements in atmospheric models will help us improve our understanding of this second- or third-order effect.

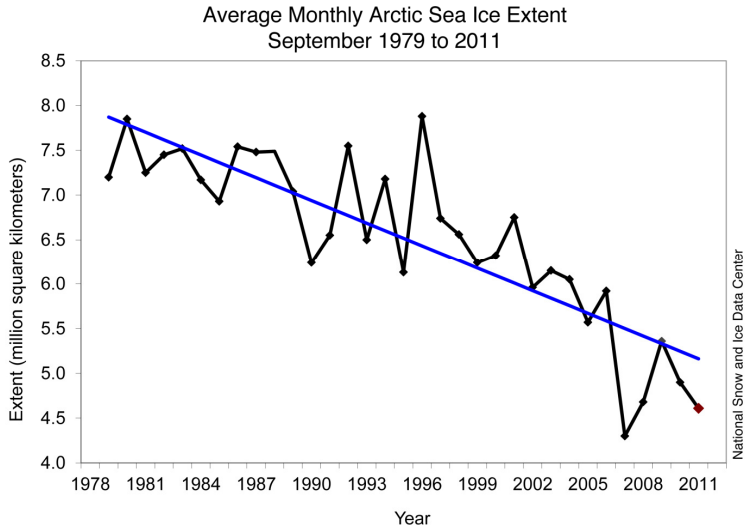
19. Isn't the apparent warming just due to urbanisation?

A. No. Climate scientists have conducted rigorous tests to determine the effects of urbanisation on temperatures trends and found this to be negligible. The IPCC concluded that urban heat island effects have a negligible influence on the global scale, contributing less than 0.006°C per decade (<1%) to observed trends over land and zero over the oceans.

20. Isn't Arctic sea ice re-growing?

A. Absolutely not. The late summer Arctic sea ice extent in 2011 was the second lowest on record (at 4.61 million km^2) and was only fractionally higher than the 2007

record. The long-term decline in summer sea extent continues, on top of weather-related year-on-year variability.



Decline in late summer Arctic sea ice extent, 1979 to 2011

21. If we can't predict the weather next week, how can we predict the future climate?

A. We know that the weather is a fundamentally chaotic system and small changes in the initial conditions tend to grow with time. This limits the number of days ahead that reliable weather forecasts can be made. Modelling the climate is a different problem; it involves representing the long term balances in the system. These are slowly varying and easier to predict over long timescales.

22. Wouldn't we be better off just adapting to climate change?

We know that some climate change is unavoidable, so it is absolutely right that we research and fund adaptation strategies such as flood defences and better fresh water management. However, compelling scientific evidence shows us that the more our emissions grow, the more we risk dangerous climate change, leading to severe impacts for all societies.

It will not be possible to adapt to *all* the potential impacts of climate change if emissions are unrestrained. Only by cutting greenhouse gas emissions can we hope to keep future climate change impacts to manageable levels.

23. So, DECC contends that the climate science 'debate' is settled?

A. No. Science focuses on exploring uncertainty. What policy makers need to know is: do we know enough to act? When climate experts confirm that recent warming is unequivocal, that there is a very high likelihood that we are causing the warming – beyond reasonable doubt - and that the sooner we act, the more

opportunity we have to limit the impacts of the warming.... the answer is, yes, we know enough to act.

24. Isn't DECC ignoring valid scientific uncertainties to drive forward policy?

A. No. We must focus on where the uncertainty is. Greenhouse gases trap heat and warm the planet. This is certain (basic 19th century physics). Global GHG emissions continue to climb. This is certain (observation). The world continues to warm, decade on decade. This is certain (observation).

Yes, there are uncertainties, for example, about exactly how much further warming we might see in coming decades, how the Earth will respond and what the impacts might be. We need further scientific analysis, better understanding of the detailed working of the Earth's immensely complex climate system, observations and even more sophisticated modelling to refine predictions. ***The risks of inaction are potentially huge and very long term*.**

25. So where is the smoking gun; the human fingerprint?

A. Taken together, the observed patterns of warming across the world and through the whole depth of the atmosphere provide compelling evidence that the recent observed warming has been mostly caused by human activities.

We know that the European intensely hot summer of 2003 was made at least twice as likely by 20th century CO_2 emissions. Research shows that human greenhouse gas emissions have contributed to the observed increases in the intensity of heavy rainfall events in the Northern Hemisphere and research led by the Met Office Hadley Centre shows that the damaging UK floods of 2000 were about twice as likely than they would have been a century ago because of human emissions.

Finally, because of human CO_2 emissions, the world's ocean are already more acidic (or, strictly speaking, less alkaline) than at any time in millions of years. As atmospheric CO_2 concentration continues to increase, ocean acidification *will* get worse with as yet poorly understood consequences for ocean ecosystems.