Stephen H. Schneider

Confidence, Consensus and the Uncertainty Cops: Tackling Risk Management in Climate Change

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UNCERTAINTY BEDEVILS COMPONENTS OF THE SCIENCE OF CLIMATE CHANGE. IT WILL NOT BE ELIMINATED FROM MANY ASPECTS ANY TIME SOON, SO THE BEST WAY TO HELP POLICY-MAKERS IS TO TRY AND FORGE A CONSENSUS ABOUT THE DEGREE OF CONFIDENCE THAT CAN BE ASSESSED FOR EACH IMPORTANT CONCLUSION. STEPHEN SCHNEIDER EXPLAINS THE LONG STRUGGLE TO UNDERSTAND HOW TO DO THAT EFFECTIVELY.

Human activities are changing the climate. But how large and how fast will these changes be? What systems will be only partly disturbed and what other systems seriously disrupted? And how can our policy choices reduce the threat they pose to natural and social systems?

The policy problem is hard because the global scale of climate change and its subtly intensifying impacts contrast uneasily with the short-term, local-to-national scales of most management systems. Furthermore, significant uncertainties plague projections of climate change and its consequences.

Such projections stretch the traditional scientific method of directly testing hypotheses because there can be no data for the future before the fact. Any prognostication into that unknown territory is, by definition, a model of the factors that are believed to determine how the future will evolve. But even though we can never fully solve the climate prediction problem, we can go a long way toward bracketing probable outcomes, and even defining possible outliers.

Progress here depends on an international community of scholars, who repeat what others have done with different computer models, make comparisons across models of various designs, compare relevant aspects of simulations to existing observational data to test model performance from 'retrodiction' of past changes, and pioneer new models as data and theory advance. Back in the early 1970s, when a reporter asked how long this model-building and validation process would take to achieve high confidence, I said that our models were 'like dirty crystal balls, but the tough choice is how long we clean the glass before we act on what we can make out inside'. That is still the issue, even as models become more sophisticated and simulate the Earth's conditions increasingly well. What constitutes 'enough' credibility to act is not science per se, but a subjective value judgment on how to gauge risks and weigh costs.

Modelling Future Climate

How large are the scientific uncertainties, though? People often say that meteorologists' inability to predict weather credibly beyond about ten days bodes ill for climate projection over decades. This misses a key difference between the instantaneous state of the atmosphere – weather – versus its time and space averages – climate. Even though the evolution of atmospheric conditions is inherently chaotic and the slightest perturbation today can make a huge difference in the weather a thousand miles away and weeks hence, large-scale climate shows little tendency to exhibit chaotic behaviour (at least on timescales longer than a decade). Good models can thus make reasonable climate projections decades or even centuries ahead if the processes forcing change are large enough to detect above the background 'noise' of the climate system – the unpredictable part. The Intergovernmental Panel on Climate Change (IPCC)'s laboriously compiled projections combine such modelling with scenarios for greenhouse gas emissions based on different assumptions about economic growth, technological developments, and population increase.[1]

These scenarios, despite major differences in emissions, show paths for global temperature increase that do not diverge dramatically until after the mid twenty-first century. This has led some to declare that there is very little difference in climate change across scenarios, and therefore, emissions reductions can be delayed many decades. That is a big mistake. It takes many decades to replace current polluting energy systems. There is also delay between emissions and temperature change due to the thermal inertia in the climate system caused by the large heat capacity of the oceans. After the mid twenty-first century, there are large differences based on emissions over the next few decades in the projected temperature increases – and the risks of associated dangers – for the late twenty-first century and beyond. Some of these risks imply irreversible changes.

Much of the uncertainty contributing to the ranges of projected future temperature increase derives from the so-called climate sensitivity. How much warming can we expect a given amount of greenhouse gas to cause? It is often estimated as the equilibrium global mean surface temperature increase due to a doubling of atmospheric CO_2 from pre-industrial levels of about 280 parts per million. The IPCC estimates that it is 'likely' (there is a 66–90 per cent chance) that the climate sensitivity is between 2 and 4.5 °C and roughly a 5–17 per cent chance that it is above 4.5 °C (with the remainder being the chance it is less than 2 °C). They also offered a 'best guess' of 3 °C climate sensitivity.

Many studies have produced probability distributions for climate sensitivity with a long right-hand tail, meaning that high climate sensitivity values, while relatively unlikely, still register a probability of a few per cent or more. One example is displayed in figure 1, which shows a very

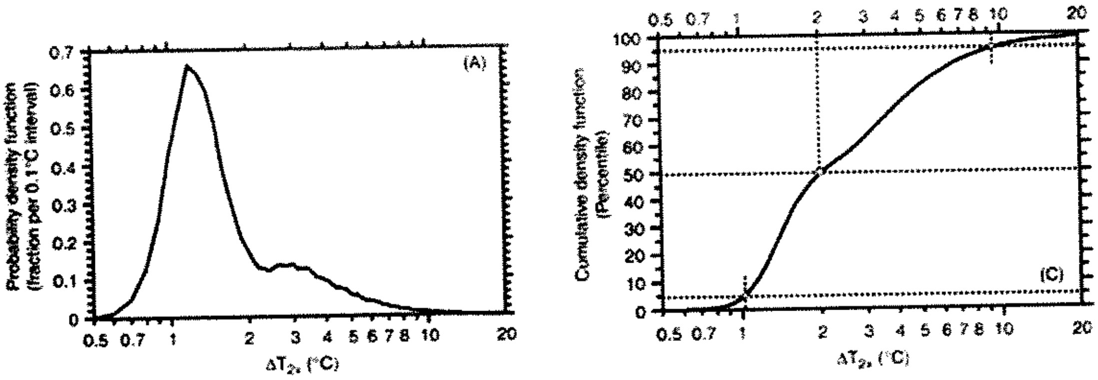


Figure 1: Probability density function (*panel A*) and cumulative density function (*panel C*) for climate sensitivity from Andronova and Schlesinger (2001) generated by scaling observed temperature trends against estimates of radiative forcing over the twentieth century. Owing to uncertainties of the indirect effects of aerosol emissions on the brightness of clouds, the distribution in panel A has a long 'right-hand tail', leaving open some 10 per cent chance of extremely high values for climate sensitivity.[2]

uncomfortable 10 per cent chance that the climate sensitivity is higher than 6.8 °C. The median result – that is, the value that climate sensitivity is as likely to be above as below – is 2.0 °C, while there is a 10 per cent chance the climate sensitivity will be 1.1 °C or less. Like all model dependent studies, the detailed numerical values should not be taken literally, but the overall message must be taken seriously.

Our uncertainty goes beyond scientific understanding of the scale and distribution of climate changes from any single scenario of increasing greenhouse gases to include the trajectory of human development and our adaptive capacity. Moreover, future greenhouse gas emissions are heavily dependent on policy choices worldwide. But we do know that if we wait to act until an increase in undesirable impacts occurs, the inertia in the climate system and in the socioeconomic systems that produce greenhouse gas emissions will have committed us to even more severe impacts stretched out over many decades to centuries.

We cannot eliminate all of the important scientific uncertainties, but we can be more precise about their extent. That, however, is only part of the scientists' job. We also have a responsibility to communicate all of this as well

1 IPCC: N. Nakicenovic and R. Swart (eds), *Emissions Scenarios – A Special Report of Working Group III of the Intergovernmental Panel on Climate Change* (Cambridge, Cambridge University Press, 2000).

2 N.G. Andronova and M.E. Schlesinger, 'Objective Estimation of the Probability Density Function for Climate Sensitivity', *Journal of Geophysical Research*, 106 (2001), 22605–12.

as we can. Communicating this complex systems science to policy-makers and the public is difficult. Too often, confusion reigns when an advocate for strong policy cites a well-established severe outcome as the most important consideration, and another advocate from some enterprise institute disliking public control of private decisions cites speculative components of the systems analysis as if that is all there were. Not surprisingly, politicians, media, and just plain folks get frustrated by this 'duelling scientists' mode of presentation, an unfortunate staple of the mainstream media.

Professional training also leads too many scientists to 'bury our leads', as American journalists would put it, rather than finding effective ways to communicate complex ideas. Being straightforward and understandable is a challenge given the strong scientific tradition of full disclosure, which makes us lead with our caveats, not our conclusions. But what I call the 'double ethical bind' – be effective in public communication even if that means there isn't enough space or time to present all of the caveats – is not unbridgeable. It calls for the scientist to develop a hierarchy of products ranging from sound-bites on the evening news to get our findings head-lined on the agenda, to short but meatier articles in semi-popular journals like *Scientific American*, to more in-depth websites, to full-length books in which that smaller fraction of the public or policy worlds that actually want the details about the nature of the processes and how the state of the art has evolved can find them. Yes, it is very time-consuming to produce websites or long books with the details, but it is also necessary for those in complex systems science fields like climate science to simultaneously be effective in public messaging, where all the details are not feasible to communicate, but the longer backup materials can honestly separate the components of the science that are well established from those best characterised as competing explanations and from those which are still speculative.

The Royal Society and my own National Academy of Sciences (if less boldly, I think) have moved into this realm with clear statements of the potential risks of climate change. An evolving series of pronouncements include the joint statement of 2001 of the Royal Society with fifteen other national science academies on the science of climate change.[3] The statement of June 2005 on global response to climate change by the science academies of the G8 nations and of China, India and Brazil stressed that the scientific understanding of climate change is now sufficiently clear to justify prompt action.[4] There followed the May 2007 statement on sustainability, energy efficiency and climate protection of the national science academies of the same countries plus Mexico and South Africa[5] and most recently the June 2009 joint statement calling for the transformation of the G8+5 nations' energy strategies.[6] In addition, I always push at our annual US National Academy membership meetings for us to be more publicly oriented, but it comes slowly. I am glad that our new NAS President, Ralph Cicerone, is committed to communicating quality science in the public interest. It is also encouraging that President Obama's new science adviser, John Holdren, is more in the mould of former UK government adviser and Royal Society President Lord May than some previous science advisers in the US who tended to carry the administration's message to the science community, rather than the other way around, as in the case of May or Holdren.

Along with climate projections, scientists also have to explain how systems science gets done. We cannot usually do traditional 'falsification' controlled experiments. What we can do is assess where the preponderance of evidence lies, and assign confidence levels to various conclusions. Over decades, the community as a whole can 'falsify' earlier collective conclusions – like the sporadic suggestions in the early 1970s that the world would cool. But in systems science it sometimes takes a score of years to even discover that certain data were not collected or analysed correctly, as well as continuing to identify new data, and such discoveries are rarely by individuals but by teams and even assessment groups.

3 'The Science of Climate Change': Joint statement of sixteen national academies of science, 18 May 2001; http://royalsociety.org/displaypagedoc.asp?id=13619
4 'Global Response to Climate Change': Joint science academies' statement, 7 June 2005; http://royalsociety.org/displaypagedoc.asp?id=20742
5 'Sustainability, Energy Efficiency and Climate Protection': Joint science academies' statement, 16 May 2007; http://royalsociety.org/displaypagedoc.asp?id=25576
6 'Climate Change and the Transformation of Energy Technologies for a Low Carbon Future': Joint academies' statement, 11 June 2009; http://royalsociety.org/displaypagedoc.asp?id=34103

THE SCIENCE OF CLIMATE CHANGE

A joint statement issued by the Australian Academy of Sciences, Royal Flemish Academy of Belgium for Sciences and the Arts, Brazilian Academy of Sciences, Royal Society of Canada, Caribbean Academy of Sciences, Chinese Academy of Sciences, French Academy of Sciences, German Academy of Natural Scientists Leopoldina, Indian National Science Academy, Indonesian Academy of Sciences, Royal Irish Academy, Accademia Nazionale dei Lincei (Italy), Academy of Sciences Malaysia, Academy Council of the Royal Society of New Zealand, Royal Swedish Academy of Sciences, and Royal Society (UK).

The work of the Intergovernmental Panel on Climate Change (IPCC) represents the consensus of the international scientific community on climate change science. We recognise IPCC as the world's most reliable source of information on climate change and its causes, and we endorse its method of achieving this consensus. Despite increasing consensus on the science underpinning predictions of global climate change, doubts have been expressed recently about the need to mitigate the risks posed by global climate change. We do not consider such doubts justified.

There will always be some uncertainty surrounding the prediction of changes in such a complex system as the world's climate. Nevertheless, we support the IPCC's conclusion that it is at least 90% certain that temperatures will continue to rise, with average global surface temperature projected to increase by between 1.4 and 5.8°C above 1990 levels by 2100[1]. This increase will be accompanied by rising sea levels, more intense precipitation events in some countries, increased risk of drought in others, and adverse effects on agriculture, health and water resources.

In May 2000, at the InterAcademy Panel (IAP) meeting in Tokyo, 63 academies of science from all parts of the world issued a statement on sustainability in which they noted that "global trends in climate change ... are growing concerns" and pledged themselves to work for sustainability – meeting current human needs while preserving the environment and natural resources needed by future generations[2]. It is now evident that human activities are already contributing adversely to global climate change. Business as usual is no longer a viable option.

We urge everyone - individuals, businesses and governments - to take prompt action to reduce emissions of greenhouse gases. One hundred and eighty-one governments are Parties to the 1992 UN Framework Convention on Climate Change, demonstrating a global commitment to *'stabilising atmospheric concentrations of greenhouse gases at safe levels'*. Eighty-four countries have signed the subsequent 1997 Kyoto Protocol, committing developed countries to reducing their annual aggregate emissions by 5.2% from 1990 levels by 2008-2012.

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.

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.

The balance of the scientific evidence demands effective steps now to avert damaging changes to the earth's climate.

The Royal Society

Opposite: The joint statement of 2001 on the science of climate change.

Back to Bayes

When I first got involved in discussing the range of outcomes in climate change, I didn't understand Bayesian versus frequentist statistics, but in fact that was the heart of the matter – how to deal with objectivity and subjectivity in modelling and in projections.

As Bill Bryson mentions in the Introduction, the English clergyman and mathematician Thomas Bayes (circa 1702–61) formulated an approach to probability now called Bayesian inference. His key theorem was published posthumously in 1764. In essence, it expresses how our knowledge base – and prejudices – establish an *a priori* probability for something (that is, a prior belief in what will happen based on as much data and theory as is available). As we further study the system, obtaining more data and devising better theories, we amend our prior belief and establish a new, *a posteriori* probability – after the fact. This is called Bayesian updating. Over time, we keep revising our prior assumptions until eventually the facts converge on the real probability.

Since we cannot do experiments on the future, prediction is wholly a Bayesian exercise. This is precisely why the Intergovernmental Panel on Climate Change produces new assessments every six years or so, since new data and improved theory allow us to update our prior assumptions and increase our confidence in the projected conclusions.

That confidence still falls short of certainty for most aspects of the problem. For example, there is only maybe a fifty-fifty chance of sea levels rising many metres in centuries to come. The conclusion cannot be objective, since the future is yet to come. However, we can use current measurements of ice sheet melting. We can compare them with 125,000 years ago, when the Earth was a degree or two warmer than now and sea levels were four to six metres (thirteen to twenty feet) higher. Because that ancient natural warming had a different cause (changed orbital dynamics of Earth around the Sun) from recent and near future warming caused primarily from current anthropogenic greenhouse gas increases, we can't say with high confidence that a few degrees of warming from greenhouse gases will also cause a four-to-six-metre rise in sea levels. But it undoubtedly indicates an uncomfortable Bayesian probability of something similar to that happening in the next few centuries. This indeed was the conclusion of the Synthesis Report of the IPCC's Fourth Assessment in 2007, for exactly those reasons.

Some statisticians and scientists are leery of Bayesian methods. They prefer to stick only with empirical data and well-validated models. But what do you do when you don't have such data? One example is found in clinical trials in cancer treatments, a subject in which I have had a very personal interest. The 'gold standard' is a double-blind trial where half the patients receive a placebo and the other half receive the drug being tested, and neither the patients nor the researchers know who got what. After five or ten years, if there is a statistically significant difference between the recovery rate of drug and placebo, the trial is declared successful. The trial isn't designed to pinpoint individual differences. Even if we knew the odds of recovery for the average person from different treatments, there is a wide spread in individual responses. So medicine should try to tailor treatments to the individual's idiosyncrasies. That makes some doctors – and many insurance companies – nervous. Likewise, some scientists and many policy-makers are nervous about Bayesian inferences based on the best assessment of experts, preferring hard statistics. But as there are no hard statistics on the future, Bayesian methods are all we have. They are certainly better than no assessment at all and hoping that everything will work out fine with no treatment. If we care about the future, we have to learn to engage with subjective analyses and updating – there is no alternative other than to wait for Laboratory Earth to perform the experiment for us, with all living things on the planet along for the ride.

Changing the Culture of Science

While we have refined our models, it has also taken decades to develop the right approach to these scientific realities, and to find the language to convey them properly to policy-makers. In the global climate policy discussion, the most important assessments have been produced by the Intergovernmental Panel on Climate Change, in an extraordinary exercise which involves thousands of scientists reviewing the latest evidence. Ever since the IPCC was founded in 1988, I have pushed hard for a cultural change in the assessments. As I have said, overcoming uncertainties, the traditional approach of what the philosopher Thomas Kuhn[7] called 'normal science', will take an unforeseeably long time. Climate systems science demands a shift to managing uncertainties instead.

That means we scientists, and policy-makers, grappling with climate change impacts are dealing with risk management. As the sea level rise example indicates, outcomes cannot be assessed with high confidence in many important cases, but the probable range can often be estimated.

Risk-management framing is a judgment about acceptable and unacceptable risks. That makes it a value judgment. As with the Bayesian approach to probability, many traditional scientists are uncomfortable with that. I am one of them, but I am more uncomfortable ignoring the problems altogether because they don't fit neatly into our paradigm of 'objective' falsifiable research based on already known empirical data.

Systems science also alerts us to the possibility of 'surprises' in future global climate – perhaps extreme outcomes or tipping points which lead to unusually rapid changes of state. By definition, very little in climate science is more uncertain than the possibility of 'surprises'. But it is nevertheless a real one. Even so, it took several long rounds of assessment just to get IPCC to mention surprises, let alone discuss formal subjective probabilistic treatment of such potentially irreversible, large changes.

John Houghton, former director of the UK Meteorological Office and the IPCC Working Group I leader for the first three assessment reports, was initially very reluctant to get into the surprises tangle. I recall a very clear exchange at a climate meeting in Oxford University in 1993.[8] Houghton thought the public discussion about 'surprises' was too speculative

7 T. Kuhn, *The Structure of Scientific Revolutions* (Chicago, University of Chicago Press, 1962).
8 Oxford Environment Conference: 'Climate Change: Potential for Interactions and Surprise' Oxford University, Oxford, England, 15–16 July 1993.

and would be abused by the media. 'Aren't you just a little bit worried that some will take this surprises/abrupt change issue and take it too far?' he asked. 'I am, John; we have to frame it very carefully,' I replied. 'But I am at least equally worried that if we don't tell the political world the full range of what might happen that could materially affect them, we have not done our jobs fully and are substituting our values on how to take risks for those of society – the right level to decide such questions.'[9]

In the end, despite the worry that discussions of surprises and non-linearities could be taken out of context by extreme elements in the press and NGOs, we were able to include a small section on the need for both more formal and subjective treatments of uncertainties and outright surprises in the IPCC Second Assessment Report (SAR) in 1995.[10] Chapter 11, 'Advancing Our Understanding', was about what to do later, and so was not directly assessed in the more politically sensitive conclusions of the report. Thus, John did not object to the few sentences on those topics in that chapter. As a result, the very last sentence of the IPCC Working Group I 1995 Summary for Policy Makers (SPM)[11] addresses the abrupt non-linearity issue. This made much more in-depth assessment in subsequent IPCC reports possible, simply by noting that 'When rapidly forced, non-linear systems are especially subject to unexpected behaviour.'

A Language for Risk

Now we had licence to pursue risk assessment of uncertain probability but high consequence possibilities in more depth; but how should we go about it? The basics are that scientists can help policy-makers by laying out the elements of risk, classically defined as *consequence* × *probability*. In other

9 S.H. Schneider, 'The Future of Climate: Potential for Interaction and Surprises' in T.E. Downing (ed.), *Climate Change and World Food Security* (Heidelberg, Springer-Verlag, 1996), NATO ASI Series 137: 77–113.

10 G. McBean, P. Liss and S. Schneider, 'Advancing our understanding' in J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg and K. Maskell (eds), *Climate Change 1995: The Science of Climate Change, Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, Cambridge University Press, 1996).

11 Houghton et al., 'Summary for Policy Makers' in J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg and K. Maskell (eds), *Climate Change 1995: The Science of Climate Change, Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, Cambridge University Press 1996).

words, what can happen and what are the odds of it happening?

The plethora of uncertainties inherent in climate change projections clearly makes risk assessment difficult. The inertia in the climate and socio-economic systems and the fact that greenhouse gases emissions will continue to rise, given the absence of strong mitigation policies (or unexpected events like a prolonged recession), indicate that globally most policy-makers have been reluctant to make long-term investments beyond their expected terms in office. But that is changing both in some regions like the EU and even in the US. These kinds of decision-makers are increasingly wary of making what is known as a Type II error – fiddling while the Earth burns. A Type I error is a false positive, which in this case would mean taking action against climate change which subsequently proved relatively needless. Scientists are often leery of making a Type I error when data are scarce for fear of misleading society into unnecessary actions and being blamed for undue alarm. The other kind, a Type II error, is a false negative, and in this case would mean assuming it is preferable to do little or nothing until there is less uncertainty, and subsequently finding that serious climate change ensues unabated with much more damage than if precautionary policies had been undertaken to adapt to and mitigate the effects. So it appears that many scientists are often Type I and our future-oriented decision-makers Type II error avoiders. A less charitable interpretation of those reluctant to invest in precautionary adaptation and mitigation measures is that they know that the really adverse outcomes will likely occur in the future when current decision-makers are not in office and not likely to be held accountable. The short-term incentives are to delay action and pass the risks and the recriminations on to the next generation. None of this is scientific risk assessment, but value judgments on where and how to take risks and make investments in policy hedges – in short, risk management. But risk management is put on a much firmer scientific basis when the managers are schooled in the best risk assessments that state-of-the-art science can produce.

To help decision-makers, the IPCC produced a Guidance Paper on

Uncertainties in 2000[12] which was a foundation for the 2007 Fourth Assessment Report.[13] I prepared the original draft with Richard Moss, now a Senior Scientist, Joint Global Change Research Institute, after convening a meeting in 1996 in which about two dozen IPCC lead authors met with decision analysts to fashion a better way to treat uncertainties in scientific assessments. The final guidance eventually agreed to within the IPCC was a quantitative scale. We would define 'low confidence' as a less than one-in-three chance; 'medium confidence', one-in-three to two-in-three; 'high confidence', above two-thirds; 'very high confidence', above 95 per cent; and 'very low confidence', below 5 per cent.

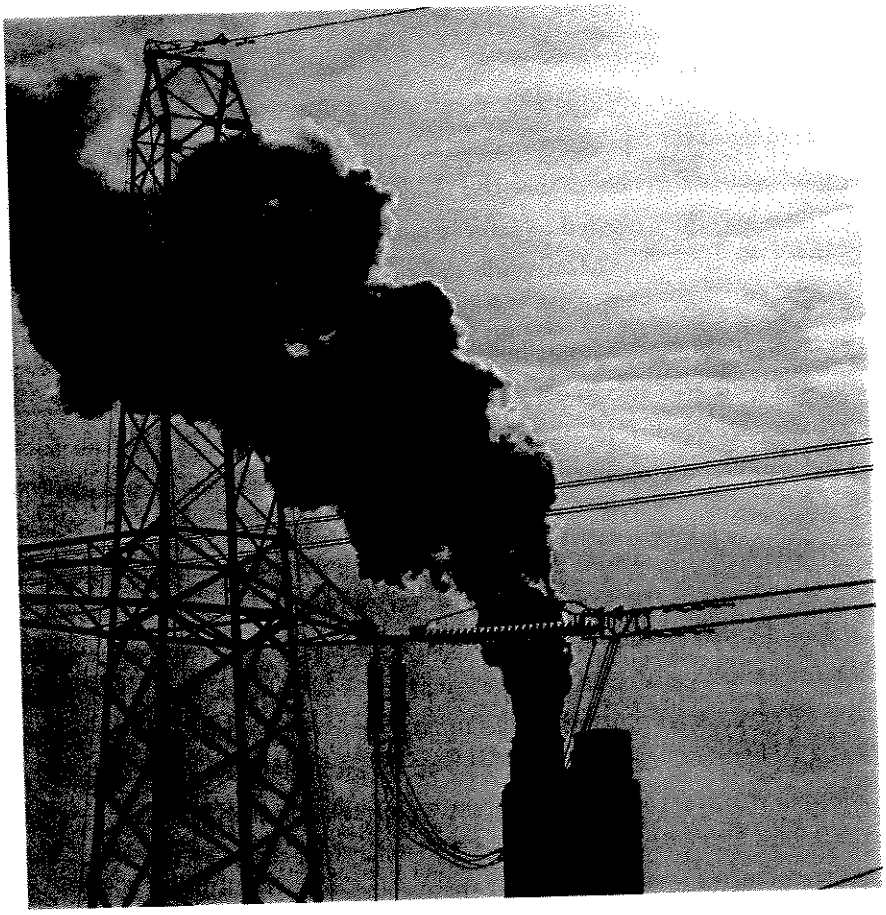
It took a long time to negotiate those numbers and those words in the Third Assessment Report cycle. There were some people who still felt that they could not apply a quantitative scale to issues that were too speculative or 'too subjective' for real scientists to indulge in 'speculating on probabilities not directly measured'. One critic said, 'Assigning confidence by group discussions, even if informed by the available evidence, was like doing seat-of-the-pants statistics over a good beer.' He never answered my response: 'Would you and your colleagues think you'd do that subjective estimation less credibly than your Minister of the Treasury or the President of the US Chamber of Commerce?'

So we had two things we wanted everyone to use – a set of numbers defining the probability ranges for words such as 'likely', and a set of qualitative phrases for our confidence in the results, going from 'well established' if there were a lot of data and a lot of agreement between theory and data, to 'speculative' without much data and when there wasn't much agreement. We had 'established but incomplete' and 'competing explanations' for the intermediate cases.

And then for the next two years Richard and I became what a journalist later called 'the uncertainty cops'. I read three thousand pages of draft material for the IPCC's Third Assessment Report. People did not always

12 R.H. Moss and S.H. Schneider, 'Uncertainties in the IPCC TAR: Recommendations to Lead Authors for More Consistent Assessment and Reporting' in R. Pachauri, T. Taniguchi and K. Tanaka (eds), *Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of the IPCC* (Geneva, World Meteorological Organization, 2000), pp. 33–51.

13 Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge and NY, Cambridge University Press, 2007).



Steam rises from the cooling towers of the Eggborough electricity power station near Selby, England.

use uncertainty terms according to our simple rules. For instance, they would say that because of uncertainties, we can't be 'definitive'. I wrote back, 'What is the probability of a "definitive"?' Early drafts would put the range of outcomes anywhere from a one to five degrees Celsius change in temperature. And then they would say in parentheses 'medium confidence'. That was completely incorrect. It was 'very high confidence', because they were talking about the fact that *between* one and five degrees was a very, very likely place to arrive. But people didn't want to say 'very high confidence' because nobody felt very confident about the state of the science at the level of pinning it down to, say, one degree. So Richard or I would help them to rewrite, and say that we have 'low confidence' in specific forecasts to a precision of a half degree, but we have 'high confidence' that the range is one to five degrees. Simple things like that were needed to achieve consistency of message.

Meanwhile the political chicanery of ideologists and special interests was shamelessly exploiting systems uncertainty by misframing the climate debate as bipolar – 'the end of the world' versus 'it's good for you'. The media compliantly carried it in that frame much of the time, too. But those were and still are, in my view, the two lowest probability outcomes. The confusion that bipolar framing has engendered creates in the public at large a sense that 'if the experts don't know the answers, how can I, a mere lay citizen, fathom this complex situation?' To this, industry-funded pressure groups added the old trick of recruiting non climate scientists who are sceptical of anthropogenic climate change to serve as counterweights to mainstream climate scientists. This spreads doubt and confusion among those who don't look up the credentials of the apparently contending scientists – and that, unfortunately, includes most of the public and too much of the media. The framing of the climate problem as 'unproved', 'lacking a consensus', and 'too uncertain for preventive policy' has been advanced strategically by the defenders of the status quo. This is very similar to the tactics of the Tobacco Institute and its three-decade record of distortion that helped stall policy actions against the tobacco industry, despite the horrendous health consequences and eventually billions of dollars in successful lawsuits against big tobacco.

In the face of such tactics, the IPCC assessment reports are intended to be the best achievable statement of current scientific consensus. But 'consensus' is not necessarily built over conclusions but the *confidence* we have in a host of possible conclusions. With that kind of information policymakers can make risk-management decisions by weighing both the possible outcomes and the assessed levels of confidence – we know it well, sort of know it, or hardly know it at all. Scientists should just say what we do know and don't, and not leave something out because it isn't a well-established consensus yet. It is the job of society, through its officials, to make the risk-management decisions informed by our conclusions and accompanying confidence estimates.

Again, the groups preparing IPCC reports had many hot, contentious discussions on that issue. Working Group I, for example, initially balked at the notion of including subjective estimations, and then embraced it, but then said that they needed to have finer gradations, because they had real data, not just subjective judgments, and they wanted to have a 99 per cent and a 1 per cent. There were also interesting disciplinary differences. Linda Mearns at the National Center for Atmospheric Research, one of the few lead authors in two working groups, helped reconcile the physical scientists in Working Group I who were leery of subjectivity and risk management and the ecologists and social scientists in Working Group II who felt that society, not scientists, should choose how to take risks after *all* the possible conclusions were reported. It took us quite a long time to get both sides to first understand and eventually respect the other point of view. My role was not to endorse one or the other, but rather to be sure all our reporting was explicit about assumptions, so we could have a 'traceable account' of all underlying processes behind important conclusions. That process is building, but is not yet complete across the IPCC or the scientific community in general.[14]

WHERE NEXT?

As I've said, normally science strives to reduce uncertainty through data collection, research, modelling, simulation, and so forth. The objective is to overcome the uncertainty completely – to make known the unknown. Short of that, new information may narrow the range of uncertainty. No doubt further scientific research into the interacting processes that make up the climate system can reduce uncertainty about the response to increasing concentrations of greenhouse gases. This is very unlikely to happen quickly,

14 S.H. Schneider, *Science as a Contact Sport* (Washington DC, National Geographic Press, 2009a), 295 pp.

however, given the complexity of the global climate and the many years of high quality data which will be needed. Meanwhile, even the most optimistic 'business-as-usual' emissions pathway is projected to result in dramatic, dangerous climate impacts. That means making policy decisions before this uncertainty is resolved, rather than using it to justify delaying action.

Risk management also means understanding what is truly uncertain, and what is not. Sometimes critics claim that there should be no strong climate policy until the science is 'settled' and major uncertainties resolved, whereas supporters of strong policies suggest the science is already 'settled enough' and it is time to proceed with action to reduce risks. The science which demonstrates a significant warming trend over the past century is settled; moreover, it is virtually settled that the past several decades of warming have been largely caused by human activity and that much more is being built into the emissions pathways of the twenty-first century. Sounds like the 'settled already' side has won the debate: warming is occurring and human activities are the primary driver of recent changes.

Al Gore may be considered a future-oriented decision-maker. He has done much to suggest to the public that the science of climate change is 'settled enough' and that human activities are the primary driver of recent changes.

That leaves the uncertainty about how severe warming and its impacts will be in the future, especially when projections for 'likely' warming by 2100 vary by a factor of six. The task then is to manage the uncertainty

THE TIMES Wednesday July 8 2009 News

Blitz spirit? It's needed again to beat global warming, Gore says

Ben Webster Environment Editor
Robin Pagnamenta Energy Editor

Al Gore invoked the spirit of Winston Churchill yesterday when he urged political leaders to follow the example of Britain's wartime leader in the battle against climate change.

The former US Vice-President accused governments around the world of exploiting ignorance about the dangers of global warming to avoid taking difficult decisions.

Speaking in Oxford at the Smith School World Forum on Enterprise and the Environment, sponsored by *The Times*, Mr Gore said: "Winston Churchill aroused this nation in heroic fashion to save civilisation in World War Two. We have everything we need except political will, but political will is a renewable resource."

Mr Gore admitted that it was difficult to persuade the public that the threat from climate change was as urgent as that from Hitler.

"The level of awareness and concern among populations has not crossed the threshhold where political leaders feel that they must change," he said. "The only way politicians will act is if awareness raises to a level to make them feel that it's a necessity."

Mr Gore, who brought the issues around climate change to a mass audience with the 2006 documentary *An Inconvenient Truth*, said that the great

Churchill: fought to save civilisation

hope for the future lay in the high level of environmental awareness among young people.

He said sceptics who refused to believe that dramatic cuts in carbon emissions could be delivered should consider the example of the young scientists in the Nasa team who put a man on the Moon on 1969.

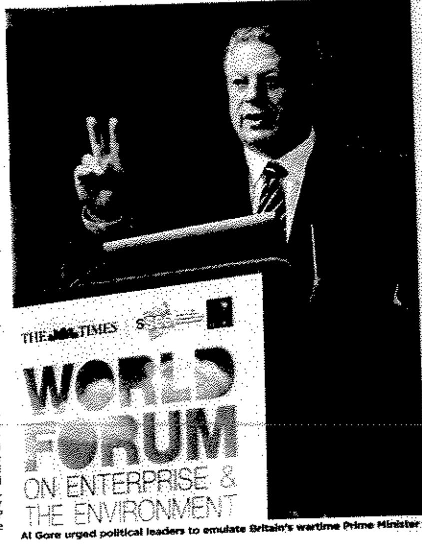
"The average age of scientists in the space centre control room was 26, which means they were 18 when they heard President Kennedy say he wanted to put a man on the Moon in ten years. Neil Armstrong did it eight years and two months later." He said future generations would put one of two questions to today's adults.

"It will either be 'What were you thinking, didn't you see the North Pole melting before your eyes, didn't you hear what the scientists were saying?'. Or they will ask 'How is it you were able to find the moral courage to solve the crisis which so many said couldn't be solved?'."

Sir David King, the Government's former Chief Scientist and now director of the Smith School, also berated politicians. "I do think it's relatively easy for a prime minister to make a speech on climate change, which sounds committed, and very much more difficult for that prime minister to persuade the Treasury to put the finance behind that commitment to make it a reality.

"There is a long distance in government between saying what you think needs to be said and then making budgets available."

Sir David expressed disappointment that no senior British politician had agreed to address a conference attended by top climate scientists, business leaders and the presidents of the Maldives and Rwanda. "I tried to pull in a lot of IOUs. But where was Lord Mandelson [the Business Secretary], where was Ed Miliband [the Energy and Climate Change Secretary]? Where was David Cameron? Where was William Hague?"



Al Gore urged political leaders to emulate Britain's wartime Prime Minister

rather than master it, to integrate uncertainty into climate research and policy-making. This kind of risk-management framework is often practised in defence, health, business and environmental decision-making. But the thresholds for action often seem lower. The US has a military arm, of course, and although I may not like everything we do with it, I don't know anybody who says you should get rid of it because a nation has to have security precautions, even against only very low probability – but potentially dangerous – threats. Well, the climate change threat is not 1 per cent. It's more than 50 per cent for many really significant troubles, and maybe 10 per cent for absolutely catastrophic troubles.

In my personal value frame, it is already a few decades too late for having implemented some policy measures against such risks. Had we begun mitigation and adaptation investments decades ago, when a number of us advocated them,[15] the job of remaining safely below dangerous thresholds would be easier and cheaper. Similarly, beyond a few degrees Celsius of warming – at least an even bet if we remain anywhere near our current course – it is likely that many 'dangerous' thresholds will be exceeded. Strong action is long overdue, even if there is a small chance that by luck climate sensitivity will be at the lower end of the uncertainty range and, at the same time, some fortunate, soon-to-be-discovered low-cost, low carbon-emitting energy systems will materialise. For me, that is a high-stakes gamble not remotely worth taking with our planetary life-support system. Despite the large uncertainties in many parts of the climate science and policy assessments to date, uncertainty is no longer a responsible justification for delay.

Adapted in part from S.H. Schneider, *Science as a Contact Sport* (2009a) and S.H. Schneider and M.D. Mastrandrea, 'Managing Climate Change Risk' (2009b).[16]

15 Ibid.
16 S.H. Schneider and M.D. Mastrandrea, 'Managing Climate Change Risk'. Chapter 15 in S.H. Schneider, A. Rosencranz, M.D. Mastrandrea and K. Kuntz-Duriseti (eds), *Climate Change Science and Policy* (Washington DC, Island Press, 2009b).