THE WORK OF THE IPCC

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To assist in discussions about the reliability of the conclusions of the Intergovernmental Panel on Climate Change (IPCC), I summarise the work of the IPCC in terms of its constitution, its scientific task, its procedures and how it reaches its conclusions. I add some brief comments on criticisms of the IPCC and the need for open debate in the scientific community and how it might be achieved.

The IPCC was founded in 1988 by two UN agencies, the World Meteorological Organization and the United Nations Environment Programme. Its mandate is to produce accurate, balanced honest assessments about human induced climate change. Because this is a topic with a broad scientific scope that concerns all nations, the IPCC has ensured that many hundreds of scientists from many countries and a wide range of disciplines contribute to its assessments.

The IPCC has published 4 comprehensive Reports – in 1990, 1995, 2001 and 2007. Each Report is in three volumes. For the 4th Report in 2007 they were around 1000 pages each, covering respectively the basic science, impacts and mitigation. Their main content is a detailed review of thousands of papers in the scientific literature - all examined for their scientific content; none are dismissed without being carefully considered. Each Report contains a dozen or more chapters addressing different parts of the subject. Lead authors for the chapters are chosen for their scientific standing and expertise, for their writing and organising ability and for their representation of different continents and countries.

I was chair or co-chair of the Science Working Group from 1988 – 2002, through the first three IPCC Reports. About 70 scientists from around the world attended the first meeting of the Group at Nuneham Courtenay near Oxford early in 1989. The task was to scope and draw up an outline of the first report due in 1990. We began with no preconceived agenda regarding our conclusions. In fact, at the start, a number of the scientists present argued that insufficient was known about human induced climate change to produce any significant report. However, we agreed that we would identify carefully what we knew with reasonable certainty, estimate the uncertainties and distinguish it from what we were much more uncertain about – a general formula that has been followed through all subsequent reports.

Climate Forcings

The climate system consists of components generally identified as the atmosphere, ocean, ice, land and biosphere. It is a chaotic system with large natural variability due to interactions within the climate system on all scales of space and time. The smallest scales of variability, up to days or weeks in time, are known as weather. Climate is also subject to external forcings that bring about changes in the radiation balance at the top of the atmosphere – hence called radiative forcings. These can arise from natural causes such as variations in incident solar radiation (its amount or its distribution due to regular changes in the Earth's orbit), or volcanic activity (due to large amounts of aerosol that enter the atmosphere). Human induced forcing of climate arises from the greenhouse effect (known for over 200 years) of the main greenhouse gases – CO_2, CH_4, N_2O etc – as they change concentration and radiative forcing from anthropogenic aerosols (e.g. sulphate particles from power stations' emissions and black carbon from biomass burning etc).

Components of scientific task

The scientific task of the IPCC has five major components as follows:

1) Estimate human induced climate forcings and compare them in magnitude and scale with other external forcings and natural variability.

2) Address, through process studies allied with observations, effects on the climate system and its dynamics, of feedbacks, positive and negative, due to water-vapour, ice-albedo, clouds, ocean circulation, CO_2 fertilization, climate-carbon-cycle connections etc.

3) Add together the effects of all the radiative forcings, feedbacks, processes and dynamics through numerical computer modelling applied to all relevant time and space scales including simulations of past and present climate and projections of future climate.

4) Compare a wide range of model simulations from different modelling groups with the enormous range of observations that are available from past and present climates, and through these detailed comparisons, balance out the contributions to climate change from all external forcings together with their associated uncertainties.

5) Describe the likely future impact on human communities or ecosytems.

Climate Modelling

I comment particularly on computer models mentioned in (3) and (4) above. These are not empirical or statistical models attempting to extrapolate past climates. For the atmosphere they are based on integrations through time using the known dynamical and physical equations together with algorithms describing motions and phenomena on all scales that have been tested individually and collectively in a wide range of contexts. The models available for the first IPCC Report in 1990 were crude by comparison with models today that possess great sophistication and capability. Models provide a powerful means, in fact the only means, of adding together all the non-linear processes involved in the wide range of components included in (1) to (3) above. Models are tested as thoroughly as possible by comparison with observations of current climate, the climate of the 20th century, periods that include major volcanic eruptions and with past climates, including periods when changes in the Earth's orbit had altered the distribution of solar radiation at the Earth's surface. For the 20th century, for instance, agreement with observations can only be achieved when both natural and anthropogenic forcings are included.

Some of the parameters within models, for instance those concerned with clouds and aerosols, aspects of ocean circulation and ice dynamics, contain large uncertainties. Models provide a powerful tool to explore the sensitivity of climate to ranges of values of these and other parameters.

The 'balancing-out process'

The 'balancing-out' process, mentioned in (4) above, is key to the formulation of IPCC conclusions and is where the contribution of the IPCC process has been particularly crucial and effective. In preparing conclusions of individual chapters, taking into account the large number of review comments, meetings of lead authors debate at length the formulation of balanced conclusions on the most important issues, the numbers to be presented and the size of the uncertainties. A similar process occurs when the draft chapters are available and representatives of the chapters and other scientists meet to debate the conclusions of the overall Report. These debates are exciting occasions, long, thorough, even heated, but only scientific arguments are

allowed – no influence from political or personal agendas can interfere. It is during these discussions that numerical values of probability are attached to uncertainties based on statistical analysis of model results together with judgements regarding other factors that the models do not include or address.

A key example of this balancing process concerns the best value of what is known as the *climate sensitivity*, that is the increase in global average temperature associated with a doubling of atmospheric carbon dioxide that, unless severe mitigating action is taken, is likely to occur during the second half of the 21st century. The likely value of climate sensitivity has large relevance for consideration of the likely magnitude of impacts from climate change in the future. Relevant information regarding its value comes from observations of past climates (including the ice age period) and from model simulations. The IPCC 1990 report estimated its value as 2.5ºC with an uncertainty range of 1.5 to 4.5ºC. The largest uncertainty arises from the lack of knowledge of clouds, in particular the average magnitude of cloud-radiation feedback. Subsequent reports all gave detailed consideration to the value of climate sensitivity. The 1995 and 2001 Reports maintained the same best value and range as in 1990. The 2007 Report increased the best estimate to 3ºC and reduced the range to 2.0 to 4.5ºC, considering that evidence now makes it unlikely the value will be less than 2ºC.

Uncertainty in IPCC Reports

Throughout IPCC Reports, statements of levels of uncertainty are frequently made; in the latest report many of these are quantified. For instance, the increased risk of extremes may be described as likely (67% likelihood) or very likely (90% likelihood). Some who look at IPCC reports interpret these references to uncertainty as an indication that the science of climate change is as a whole very uncertain. Such a superficial interpretation is quite false; the IPCC has always sought to distinguish clearly those conclusions that are relatively certain from those where there is large uncertainty. Few if any scientific conclusions concerning the climate can be completely certain but to ignore those that appear likely or very likely would be highly irresponsible.

The IPCC Review Process

Each chapter of an IPCC Report goes through three reviews before acceptance. The first is by a restricted number of expert scientists. For the second review, a general invitation to take part is sent to the international community of climate scientists and others with an interest (including industrial and 'green' NGOs) and the third review is by governments. The chapter authors consider all review comments, keep a record of them and of the actions taken for each comment. For the last two IPCC Reports, during these review processes, each chapter's authors were assisted by a Review Editor chosen to be independent of the chapter authorship.

Finally, included in each IPCC Report is a Summary for Policymakers, typically around a dozen pages, the first draft of which is based on the chapters' summaries and prepared by a small group that includes a representative author from each chapter. It is then scrutinised sentence by sentence at an IPCC plenary meeting over a period of three or four days at which, in addition to national delegates, about 40 scientists are also present to explain the content of the Reports' chapters and also to guarantee the meeting's scientific integrity. Despite being a meeting of delegates from around 100 countries having a wide variety of political backgrounds (e.g. from oil producing states like Saudi Arabia and Kuwait and also from some states with a strong 'green' ethos) it is a strictly scientific not a political meeting. Its purpose is to ensure that the Summary is clearly written, consistent, relevant to policy making and

that it accurately represents scientific information without either under or overstatement. It provides an effective but very tough filter. In every case in my experience the meeting concluded with a Summary having greater clarity and accuracy than the version with which it began.

The IPCC's caution

The IPCC has sometimes been accused of being alarmist in its conclusions. Others have complained that the IPCC has been too cautious. In general I believe the IPCC has been much closer to the latter than the former – although the recent exposure of a mistake over the timing of disappearance of Himalayan glaciers is interpreted by some as suggestive of an alarmist attitude. There are, however, many examples of caution in the IPCC Reports. For instance, the 1990 IPCC Report stated with some certainty that the increases in greenhouse gases were causing global warming but added that, because of natural climate variability, this warming could not be clearly detected in the observed record. As warming has continued at about the rate projected by the Reports, each subsequent Report has in general shown increasing confidence in its conclusions, but still retained appropriate caution. Further, the 2007 Report in estimating future sea level rise declined to make any estimate of the possible effect of accelerated melting of ice caps as it considered no reliable estimates were available in the literature at that time.

In 1996 I invited Professor Richard Lindzen to be a lead author of the chapter on Climate Processes in the 2001 IPCC report; I was keen that someone who had been so openly critical of the IPCC process and conclusions should see our work at first hand. Lindzen has never denied that global warming due to human influences is occurring but he has argued that the effects are much smaller in size and in importance than the IPCC has been predicting. He signed up to the chapter of which he is a lead author - although its conclusions disagree with many statements he commonly makes. A widely quoted statement of Lindzen's about IPCC Reports is that the chapters are fine but that the Policymakers' Summaries contain different messages and do not faithfully represent the content or conclusions of the chapters. Despite his constant repetition of this comment, he has never to my knowledge presented a single concrete example to support it. In any case discrepancies between the chapters and the Summary would never survive the scrutiny of the final intergovernmental IPCC plenary.

IPCC Assessments, because of their thorough process of preparation have often been described as the most well researched and reviewed assessments carried out by the world scientific community. Because so many scientists and also governments are involved, the Reports possess a high degree of ownership by top scientific bodies and by governments.

Criticism of the IPCC

Much false material regarding the IPCC process and IPCC science has been published on the Internet and in the media over the years. For their part, scientists involved in the IPCC have not, in general, been sufficiently willing to explain their work in ways that the public and even that many in the science community can understand. For instance, there is widespread ignorance about the construction, essential role and power of climate models even within the science community. Further, critics often home in on the nature and size of climate variability and wonder how it is possible to draw any conclusions about climate change on a scale of decades or centuries when it seems impossible to forecast regional and seasonal climate

changes a few months in advance. It is an entirely appropriate question to ask but wrong to jump to the conclusion that human induced climate change is therefore not occurring. The answer to the question involves knowledge of climate variability (including its spectrum in time and its variability in space) and whether the 'signal' of external radiative forcings of the kind described above can rise above the 'noise' of climate variability. Comparisons with observations suggest that it can - over periods as far apart as within the ice ages and the 20th century.

An illustration of this problem comes from the current attention that is given to the lack of significant increase in global average temperature over the last decade or so which has been suggested as providing evidence against human induced global warming. What others have pointed out, however, is that the level of natural year to year variability in the temperature record suggests that a decade is too short a time to establish a long term trend. Further, it is known that a significant amount of the shorter-term variability is associated with variations in the El Nino Southern Oscillation. In fact, it is the Pacific sector that has been cooler during the last decade consistent with the La Nina phase of the phenomenon that has persisted since the last unusually strong El Nino event in 1998 until a new El Nino began in 2009.

The need for informed debate

There is a very large body of evidence within the volumes of the IPCC Reports. From this evidence conclusions have been drawn that are summarised in the Policymakers Summaries. However, none of the conclusions are absolutely certain, the IPCC has associated with them varying degrees of certainty and it is important that they be subject to fair and proper debate. Scientists who have been close to the IPCC process are often accused of wanting to impose the IPCC conclusions and of being unwilling to debate them. But I believe that confidence in IPCC work will only be accepted if it is open to wide debate. I also believe that IPCC scientists are very willing to see their conclusions debated providing the debate can take place on the basis of available evidence. They are bound to appear unimpressed by those who criticise or even lampoon IPCC's work on the basis of false information or who clearly have never taken the trouble to find out about the IPCC and the evidence it has presented. A good place to begin with an effective open scientific debate on the main IPCC conclusions would be to consider in depth the IPCC's statements of confidence and uncertainty.

Possibly the largest problem faced by developed nations like our own concerns the public acceptability of the science of human induced climate change. In the UK only about 60% of the general population (less than half in the USA) believe that human induced climate change is the serious problem that scientists make it out to be. Many feel they are being steamrollered into believing something that may not be true and that may seriously impact their lifestyle. If governments are going to be comfortable about taking the necessary action, therefore, an urgent need is for much better information and education about the science of climate change to be presented to a confused public in a completely honest, open and effective way.