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The Role of Science in the Global Climate Negotiations

John Lanchbery and David Victor

Introduction

Perceptions vary as to how large a role science and scientists played in the negotiations which led to the signature of the Climate Change Convention at the Earth Summit in Rio[1] and, indeed, have continued to play in the negotiations prior to the first Conference of the Parties (CoP) in Berlin, in March 1995.

'Science' certainly put the climate issue on the political agenda, and scientists have retained a visible role in the negotiations on the Convention, but the nature and extent of their influence on the negotiations are unclear and widely misunderstood. One common perception is that the Convention, together with the international ozone agreements,[2] represents a new type of international response to global environmental issues, where the scientific community plays a major part both in identifying problems and in shaping the regimes designed to solve them. Another, opposing, view is that the negotiations on the Convention were dominated by political and economic considerations and that scientific evidence about possible climate change was given scant consideration.

In this article we seek to clarify the role of science in the climate negotiations before and after Rio. We adopt the perspective that, in addition to putting the climate-change issue on the agenda, science has shaped the convention in limited ways. Our view rests between the contrasting views mentioned previously: the Convention is neither all science nor all politics. The types of expert advice that the core natural science research programme can offer are increasingly less relevant to implementing the detailed workings of the international legal machinery on climate change. With the passage of time, the international organizational framework for assessing climate science has become more distant from its connection and relevance to the Climate Convention.

We first address some basic considerations, such as what causes the greenhouse effect and why the climate might change as a result of human activities. We then relate how the debate on climate change arose, first amongst scientists and later in political fora, eventually leading to the negotiations on the Climate Convention. Some major issues under debate during preparations for the first Conference of the Parties (CoP) to the Convention are then discussed, and we conclude with a discussion of possible future roles of science in the development of the Convention.

The Nature of the Greenhouse Problem

Heat Balance in the Natural Atmosphere

The concept of global warming is the enhancement of the natural phenomenon known (incorrectly)[3] as the 'greenhouse effect', which has been understood for nearly a hundred years. The effect is caused by certain trace gases, particularly water vapour and carbon dioxide, which occur naturally in the atmosphere. These gases absorb energy in the infra-red region[4] of the electromagnetic spectrum but do not absorb much energy in the visible region. Consequently, most of the energy (mainly visible light) radiated by the sun passes through the atmosphere to the Earth's surface where it is absorbed and then re-radiated, primarily as infra-red radiation (heat). This heat is absorbed by the trace gases in the atmosphere and finally re-radiated back into space. The greenhouse gases thus act rather like a blanket, absorbing and re-radiating heat.

The heat absorbed by the atmosphere as a result of the greenhouse effect maintains the average temperature at the Earth's surface about 33 °C higher than it would be if it contained no heat-absorbing (greenhouse) gases.[5] The greenhouse effect is thus essential for the existence of life on Earth, certainly in its present forms.

The concentration of greenhouse gases[6] in the atmosphere is quite low, totalling less than 1 per cent of all gases, and it is maintained by a balance between emission sources[7] and 'sinks'.[8] Concentrations can change if either the sources or the sinks (or both) change and, indeed, the natural sources and sinks of all the greenhouse gases have varied in the past.

Anthropogenically Induced Climate Change

Current concerns about climate change arise from the fact that mankind is causing greenhouse gas concentrations to rise significantly and at a comparatively high rate. This trend is forecast to continue and could have effects on the climate. Many human activities give rise to greenhouse gas emissions, particularly those associated with energy use and agriculture. Burning of coal, oil and gas (fossil fuels) generates carbon dioxide (CO_2); rice paddies release methane

(CH_4); and nitrogen-based fertilizers used in agriculture tend to release nitrous oxide (N_2O). Increased industrial and agricultural activity over the last 200 years, coupled with the rapid rise in the human population, have led to a significant increase in emissions of greenhouse gases and a consequent rise in their atmospheric concentrations. Human activities have also reduced the size and capacity of some sinks, particularly forests, further increasing the concentrations of some gases. As a result, carbon dioxide concentrations in the atmosphere have increased by more than one-quarter since the Industrial Revolution, methane concentrations have more than doubled over the same period, and nitrous oxide concentrations have increased by more than 15 per cent since 1950.[9] Moreover, mankind has invented and released into the atmosphere some wholly artificial greenhouse gases, notably chlorofluorocarbons (CFCs).

If greenhouse gas concentrations in the atmosphere have been increased by human activities, it should follow from 'greenhouse theory' that the atmosphere will trap more of the sun's heat and become warmer. The nub of the debate about climate change is the magnitude of this warming ('climate sensitivity') and the extent to which it will have adverse consequences in terms of things that society values, such as crop yields and the protection of coastal zones.

There is no dispute amongst scientists about the fact that greenhouse gas concentrations have been, and are,[10] increasing; but there is dispute about the degree to which they are coupled to rising temperatures. The Intergovernmental Panel on Climate Change 'judge that'[11] the average global temperature has risen by between 0.3 and 0.6 °C in the last hundred years (with a concomitant rise in mean sea level of 10–20 cm). Many scientists think that it is more than likely that some of the increased temperature is due to rising greenhouse gas concentrations, but a definitive fingerprint of climate warming due to greenhouse gases does not yet exist. The crucial question is what may happen in the future, if greenhouse gas concentrations rise significantly. IPCC forecasts[12] from current models, that the mean global surface temperature will continue to rise at an average rate of 0.3 °C per decade if no action is taken to control emissions. However, this is only one of many possible predictions because the relevant models are very complex and dependent upon many assumptions. Forecasting the effects and impacts of any such changes is thus fraught with difficulty; research into the impacts of changing climate on society is generally at an early stage.

Identification of the Climate 'Problem' and Responses To It

Identification

Although the greenhouse effect was identified and described by the Swedish scientist Svante Arrhenius[13] at the turn of the century, and many scientists realized that anthropogenic emissions of greenhouse gases must be increasing, little systematic research was done on the topic of climate change until the early 1970s. Some small, scattered, research projects were conducted, mainly in Sweden, the UK, and the USA as early as the 1930s and 1940s. These projects included some measurements of atmospheric carbon dioxide concentrations and led to speculation about the sources and consequences of climate change (most thought that warming would be a welcome 'improvement' in the weather).[14]

Systematic measurement of air and sea temperatures began around the turn of the century, much earlier in a few locations, with the creation of meteorological services. However, continuous measurements of atmospheric carbon dioxide only began in the 1950s as part of the International Geophysical Year (IGY), in an effort to understand better the global carbon cycle. The other main greenhouse gases (methane, CFCs, and nitrous oxide) have been measured continuously only since the late 1970s. Indeed, much of the research conducted prior to the last three decades was limited in scope and did not fire the imagination of the public. It was undertaken because of its intrinsic intellectual interest to a few curious scientists, not because of its relevance to policy or society.

The main reasons for lack of systematic attention to anthropogenic climate change were probably threefold. First, until the 1950s most scientists believed in 'gradualism' (that changes in nature occur gradually, usually over very long periods of time), and they were thus predisposed to think that the climate could not change significantly in the course of a generation or two. Secondly, virtually all scientists were sceptical that the actions of humans could change climate on a planetary scale. There was abundant evidence of local changes, including heat island effects near cities, but global consequences were much more difficult to fathom.[15] Scientists consistently underestimated the future volume of carbon dioxide emissions, probably because they did not imagine exponential growth in these sources, and this further reduced the likelihood that they would take the possibility of global climate change seriously. Thirdly, the evidence for climate change was inconclusive and contradictory. Temperatures had risen after the turn of the century but declined in the 1940s and 1950s. There was no clear sign of temperatures rising continuously and significantly.

The predisposition not to study climate change system-atically reversed in the 1950s, primarily because of

the new role of science in Western society after the Second World War. 'Big science' came to atmospheric, oceanic, and geological research with the International Geophysical Year (1957 to 1958), during which many climate-related measurements were made around the globe, some of which have continued to the present (the first permanent Antarctic stations were, for example, established in the IGY).

Generally, the war changed the relationship between government and science, especially in the USA and in US universities, in part because it demonstrated the practical values of science and engineering research (RADAR and the atomic bomb were both products of basic science). A 'social contract' of government support for basic science, therefore, emerged after the war, particularly in the USA but also in many Western European nations. In the USA the contract has been nurtured by a scientific élite that has simultaneously steered not only science but also government policy concerning it. The disciplines that became climate research, as with most sciences, benefited from this support. The cold war included a race in science which bolstered the contract. Indeed, one of the challenges to emerge since the cold war is how to sustain the contract and its support for basic science. In general, climate science has attracted sustained support after the cold war because of popular concerns about 'the environment' including fears of global warming; scientists in other areas, notably theoretical physics, have found that justification for their work has become more difficult and they now face severe cuts in government funding.

Following the measurement programmes begun in the IGY, the 1960s saw the development of the first theoretical models of the circulation of atmospheric air currents. Begun in the 1940s, the early models were funded by the US Defense Department, initially as part of a numerical weather prediction programme. (This new field of research was made possible by the development of computing machines, also a product of the war and defence funding.) From the mid-1960s onwards it was commonplace to illustrate the sensitivity of such models by showing their response to a doubling of carbon dioxide concentrations in the atmosphere, not because of fears that carbon dioxide would double but rather because this was, and remains, a convenient bench-mark. More widely applicable General Circulation Models (GCMs) began in this way at Princeton University: at present, perhaps two dozen exist world-wide, a third of which are 'state of the art'. Virtually all of these are now used for the development of scenarios for possible climate change.

The politically detached nature of greenhouse science changed in the 1960s, largely because of the rise of popular environmentalism, leading eventually to the Stockholm Conference on the Human Environment in 1972, which prompted an increase in research both into possible climate change and allied issue areas. In science it became common to identify the practical environmental consequences of one's research, and global warming was no exception. The science of global warming cuts across many other environmental issues, and thus when scientists worried about the effects of supersonic aircraft on climate (a fear of the late 1960s) or the effects of perturbations in the global atmospheric chemistry (possibly leading to stratospheric ozone depletion, a fear beginning in the mid-1970s), what they learned was also relevant to the understanding and eventual prediction of climate change.

There were many sources of fears about climate change in the mid-1970s, some related to possible global cooling, and these helped to build up climatology as a multidisciplinary field. For example, in the 1980s climate studies focused on the possible consequences on climate of nuclear war or of an asteroid or comet impacting the Earth (such as probably led to extinction of the dinosaurs). Other fields of science experienced a similar development. In particular, energy economics grew markedly in response to the first oil crisis (1973), and a large amount of expertise in forecasting energy use became available 'off the shelf' when fears of global warming prompted efforts to predict future emissions from burning fossil fuels and concomitant policy responses for reducing greenhouse gas emissions. The first full assessment of the climate problem by the US National Academy of Sciences (published in 1983) was originally commissioned to examine the effect on climate of high-carbon synthetic oil ('synfuels'), which the USA was contemplating using as part of a strategy to reduce dependence on imported oil.

Responses

By the end of the 1970s scientists had begun to see climate change as a potentially serious problem. Some politicians and international bodies, notably some within the UN, had also become acquainted with the issue and had begun to consider policy-related actions for the mitigation of climate change. By 1979 there was sufficient interest, globally, for the World Meteorological Organization (WMO) to call the first World Climate Conference in Geneva. At the end of the Conference the following statement was issued:

> The present understanding of the climate process leads to the recognition of the clear possibility that these (anthropogenic) increases in carbon dioxide may result in significant and possibly major long-term changes of the global-scale climate.

The first Climate Conference, which was attended mainly by scientists, was followed in rapid succession by a series of other meetings sponsored by the WMO, the United Nations Environment Programme (UNEP), and the International Council of Scientific Unions (ICSU) which were held at

Villach, in Austria, in 1980, 1983, and 1985, followed by further independent meetings in 1987.[16] At the domestic level some countries were, and had been, conducting assessments of possible climate change. The US National Academy of Sciences conducted a small-scale assessment in 1979, which reported an estimate of 1.5 to 4.5 °C global warming in response to a doubling of carbon dioxide emissions—a number based on an informal poll of participants, but which is now conventional wisdom because it is repeated so often. The Academy also produced a study in 1983, mentioned earlier. The US Department of Energy published a massive assessment in 1985, and the US Environmental Protection Agency increased its research into climate in the 1980s, publishing an assessment in 1983 and a full assessment later in the decade. Other countries lagged behind, but many had assessments under way or completed by the late 1980s. In this context of domestic and international attention the now famous Toronto Conference was held in 1988.[17]

The Toronto Conference marked the beginning of high-level political debate on the climate-change issue.[18] It concluded with a call for political action, and included suggestions as to what targets might be adopted for greenhouse gas emission reductions, the so-called Toronto Targets.[19] The final statement from the Conference included the following remarks:

> The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fuel use, and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe . . . Far reaching impacts will be caused by global warming and sea level rise which are becoming increasingly evident as a result of atmospheric concentrations of carbon dioxide and other greenhouse gases.

This was probably an overstatement, if not a distortion, of the scientific evidence, but it did serve to prompt a flurry of political activity. This activity was further reinforced by a series of hot summers and natural disasters in the 1980s, notably the hot summer of 1988 in the USA, which led to high-visibility hearings in the USA and created a momentum that did not die to do something about climate change. There was, and is, no credible evidence that the hot summers of the late 1980s were due to anthropogenically induced global warming, but they did create an opportunity that was seized upon by environmentalists and interested climate scientists to push for policy action on global warming. The Toronto Conference became an international focal point for such action.

The Toronto Conference and the public concern about climate issues had two main outcomes in terms of institutional development, one with implications for further research into climate change, and one which led eventually to the development of the Climate Convention.

The political attention to climate change elevated by the Toronto Conference, and furthered by domestic and international environmental pressure to do something about global warming, helped make the activities of the nascent Intergovernmental Panel on Climate Change (IPCC) more salient. Independent of the Toronto Conference, the IPCC was set up by the WMO and UNEP in 1988 and dates to discussion earlier in the decade.[20] The Panel, which is composed mainly of government scientific representatives from all over the world, has since been generally accepted as the main, expert, scientific body on climate change issues. Evidence that governments view the IPCC process as credible and legitimate is the fact that there are many fewer national assessments of the climate problem than might be expected given the salience of the issue; most governments are content to rely upon the international review process of the IPCC.

Additionally, two months after the Toronto Conference the Maltese government proposed to the UN that the global climate be declared a 'common heritage of mankind', reminiscent of the developing countries' claims to the deep seabed floor in the Law of the Sea negotiations. This led the General Assembly, in December 1988, to adopt a resolution on the protection of the climate for present and future generations of mankind which, in turn, led to discussion amongst policy-makers as to what legal and policy options might be adopted by the international community in response to the perceived threat of climate change. The Maltese effort was the most salient of many attempts to get international negotiations under way, but no sustained negotiations began until after the publication of the first IPCC Report in 1990.

The scientific and policy-making processes were not, initially, strongly linked, although it was always assumed that the former would inform the latter. However, the results of the first IPCC scientific report,[21] which were widely known beforehand, stimulated considerable debate amongst policy-makers. By the time of the second World Climate Conference in November 1990 political interest was sufficient for the UN General Assembly to agree to establish an Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change in December 1990. That the General Assembly did this—and not UNEP, WMO, or some other agency—is important because the General Assembly's patrimony has helped make the negotiations broader in character, focusing on development as well as environmental aspects of climate change. The importance of the process has probably increased because the General Assembly is the supreme body of world governance. We trace the General Assembly's role in part as an extension of its earlier activities led by Malta and, in part, to dissatisfaction by developing countries with UNEP's

highly visible role in promoting the environmental aspects of earlier international environmental agreements, at the expense of economic development and resource transfers.

The INC was charged with drawing up a Convention for signature by world leaders at the Earth Summit in Rio de Janeiro in June 1992. This the INC did, but in a rather incomplete manner which left large sections of the agreement open to a variety of different interpretations. Consequently, the INC has continued to meet since Rio in order to try to clarify exactly what the Parties should do, and how they should do it, at the first Conference of the Parties (CoP) to the Convention, which will be held in March 1995 in Berlin.[22]

The remainder of this article is devoted to an examination of the relationship between scientists, in particular the IPCC, and the INC. First, however, it is worth recounting in a little more detail how the IPCC has developed.

The Development of the IPCC

The Origins and Structure of the IPCC

The IPCC was set up by the WMO and UNEP in 1988 to undertake three main tasks: to assess how much the climate might change as a consequence of human activities; to estimate what the environmental and socio-economic impacts of any climate change might be; and to formulate response strategies for the management and mitigation of any adverse environmental impacts. To carry out these three tasks the IPCC was originally divided into three groups:

- *Working Group One* (WG1), composed mainly of climate scientists whose job was to gather information about, and come to considered judgements on, the likelihood and extent of any change in climate resulting from anthropogenic emissions of greenhouse gases;
- *Working Group Two* (WG2), a multidisciplinary group whose task was to assess the impacts of any climate change;
- *Working Group Three* (WG3), another multidisciplinary group whose job was to formulate response strategies and policy options for coping with climate change.

The IPCC as a whole was headed by Professor Bert Bolin, an eminent Swedish climatologist who is still chairman of the panel, and the chairs of the three working groups were divided between the UK (WG1), Russia and Australia (WG2), and the USA (WG3).

From the outset WG1, chaired by Sir John Houghton of the UK Meteorological Office, was the dominant group. This was partly because of general interest in its scientific findings and partly because natural scientists are better organized and have a long history of conducting focused reviews and comparisons of the literature, which is the main mode of IPCC's operation. At the time that the IPCC was set up there was considerable popular interest in whether or not global warming was occurring, stimulated by a series of natural phenomena at the time (hot summers, droughts, unusually severe storms, and so on) which seemed to indicate that the climate was changing. This interest was enhanced by the importance attached to the group by some political leaders (notably UK prime minister Margaret Thatcher). However, the dominance of WG1 principally stems from the fact that the outcome of its work would necessarily determine the work of the other two groups. (Without evidence of a changing climate, and its extent and magnitude, there was evidently little point in trying to assess impacts or policy options.) Partly because of this, Working Groups 2 and 3 never really got their acts together, even after the publication of the first WG1 report in 1990 which gave some basis for their work.

It is generally accepted that the IPCC WG1 has done a good job in summarizing scientific findings concerning climate change, and the scientific strengths of the group have been widely praised. However, we contend that it also has weaknesses which are especially evident in the way it communicates with the INC and the domestic policy-makers who control it. These weaknesses derive both from the backgrounds and experience of members of the group and from its mode of working. For example, the sheer size of WG1 limits its effectiveness both in making and communicating decisions, and certainly, the fact that most governments can be, and are, represented on the IPCC and its committees means that it is very slow at coming to decisions. The adverse effects of its size are aggravated by the panel's mode of making decisions. Like most international institutions associated with the UN, it operates broadly by consensus.

Apart from taking up a lot of time, the combined effects of size and the consensus mechanism tend to result in the IPCC never making recommendations of a radical nature or reaching conclusions which are at all controversial. By its very nature, a consensus-oriented process finds it difficult to deal with extreme views, in spite of the fact that clearly a credible review of climate science must identify not only the central views of mainstream experts but also those of 'outliers' and 'outsiders'—the science of potential climate change is so uncertain and surprise-ridden that unorthodox views cannot be discounted simply because they are not part of the mainstream. However, although non-controversial conservatism may be quite a good feature in a body designed to reflect the balance of scientific thought, it is not necessarily a good feature in a body called upon to inform a negotiating process.

The IPCC undoubtedly fulfils its role as a provider of balanced scientific judgements but it is much less comfortable, and much less effective, in its role as an informer

of the treaty negotiating process. Indeed, this is a role that it has never quite accepted. The IPCC is, therefore, always likely to fail to provide timely information for the treaty negotiating process.

The IPCC's reluctance to act as an advisor to the negotiating process is a problem, in that the INC increasingly looks to the IPCC for scientific advice on specific questions and the IPCC often feels unable to reply sufficiently rapidly or in sufficient detail to satisfy the INC (or rather the nationally based policy-makers who direct the course of the negotiations in the INC). This apparent vagueness derives, in part, from the complexities and uncertainties inherent in trying to assess the extent of climate change, but it is also due to differences between the way in which the scientists are trained to report and the types of report which diplomats and policy-makers are used to receiving. Policy-makers are used to founding their judgements on reports which are based largely on opinions and 'best guesses'. Scientists, on the other hand, tend to be extremely cautious in venturing unsubstantiated opinions. Scientific culture stresses evidence, careful testing, scepticism, and constant doubting.

Conservatism within the IPCC has tended to increase as it has developed and this is probably, to some extent, inevitable.[23] In its role as a provider of balanced scientific advice it is desirable that it be (and be perceived to be) a careful, methodical, and rather conservative group. It is, after all, meant to give advice on matters of global importance. It cannot afford to make many mistakes, and should not, perhaps, be rushed. On the other hand, the negotiating process is sometimes rushed and the negotiators have, generally, only the IPCC to turn to for reliable scientific advice. In the absence of such advice the INC, the Conference of the Parties (CoP), and policy-makers have to get their information from elsewhere, and this is likely to be less sound than that of the IPCC. We will return to the question of what types of information are needed and demanded by the international negotiating process later.

The Role of Science in the Development of the INC

The Development of the Negotiating Process: Early Days[24]

In the early INC meetings the IPCC played a central, if largely tacit, role. The INC had, after all, been established by the UN General Assembly partly as a result of the first IPCC report,[25] which concluded that:

> emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases . . . These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface.[26]

This carefully worded message did not give much sense of direction to the INC, and at its first few meetings the Committee was unsure of what was required of it. It was particularly uncertain about the level of commitments it should contain concerning limiting greenhouse gas emissions. The UN General Assembly, when establishing the INC, had envisaged a 'framework' convention in which the level of commitments might be changed as necessary, but this did not help to resolve the question of what level of commitments to include in the first place. The first IPCC report had stated that a cut in anthropogenic emissions to less than 50 per cent of 1990 levels would be needed to stabilize greenhouse gas concentrations in the atmosphere, but did not say whether this was necessary in order to limit dangerous climate changes. When speaking on this point to the INC, the IPCC, usually in the person of Professor Bolin, avoided answering this question. Such an answer would have depended on a full assessment of the impacts of climate change, and an estimate of the optimal policy required to balance the costs of impacts with the costs of mitigation and adaptation. The IPCC had only conducted a partial analysis of impacts and, in its first assessment, essentially no analysis of the economics of adaption.

At the time the IPCC was not in a position to forecast the exact extent of any climate change, nor was it in a position to estimate the impacts of any change. However, it was in a far better position than any other group to give a well-informed estimate of the likely extent of any climate change and what might be done about it. It would have helped the negotiations considerably if the IPCC had given the INC an opinion at this early stage.

Here it should be stressed that the INC negotiators are, generally, scientifically literate. It is commonly supposed that delegates to the INC are diplomats and lawyers and that there is consequently a large comprehension gap between the negotiators and scientific advisors such as the IPCC. This is not generally the case. Although many delegations are headed by professional diplomats and lawyers, many of these have specific expertise in environmental agreements. Moreover, many of the more influential delegations include one or more trained scientists from their environment ministries. Also, some smaller nations send as their sole representatives to the INC the same people who attend meetings of the IPCC. Comprehension gaps, therefore, tend to occur not between the IPCC and the INC negotiators but mainly between the negotiators and their domestic political masters.

As a consequence of their backgrounds, the members of most delegations to the INC have always had a very good idea of what the IPCC is doing and what its best guess would be on the level of commitments that should be included in a convention designed to limit climate change. Their actions

have, however, been severely curtailed by their national governments. This has led to a characteristic feature of many INC debates, where delegations, particularly from northern countries, have proposed courses of action in which they did not personally believe and the arguments for which they regarded as insupportable. In general, this has only applied to countries whose delegation leaders were senior civil servants and do not change with their governments, but even within delegations led by political appointees, notably the US, clearly visible fights have broken out between delegates and their governments.

In many respects, a broad range of scientific views was better put by observers to the INC process (particularly non-governmental environmental organizations) than by delegations or international scientific bodies such as the IPCC and WMO. Indeed, the non-governmental organizations (NGOs) played an important role, not only in informing the INC process but also in raising scientific and technical issues, particularly sensitive issues which delegations were reluctant to raise. For example, some of the environmental NGOs, who considered that significant and damaging climate change was likely, conducted their own research into what the more extreme consequences of climate change might be, at a time when most governments were considering more conservative scenarios. They also often acted as problem-solvers to the process, researching complex issues such as 'Joint Implementation' in far more depth than most negotiators, and acting as legal and scientific advisors to both small and large delegations and to the secretariat.

Like the IPCC, progress in the INC is slow because of consensus decision-making. (The use of the consensus approach is understandable, given that the Convention needs large-scale support, but it does not need universal support.) This slowness was particularly evident in the early days of the negotiations, when there were many diverse ideas on what form the Convention might take. Achieving consensus on matters of importance, such as commitments, invariably proved difficult. Frequently, adopting options agreeable to a substantial majority of delegations would be delayed by one or two; for example, the Saudis and Kuwaitis were not in favour of any limitations on emissions,[27] and they hampered moves to introduce substantial commitments on this topic. This type of occurrence eventually led, just before the Rio Conference, to the consensus mechanism being temporarily and unofficially suspended, but in the meantime it had wasted a considerable amount of time.

Drafting the Climate Convention

By the end of 1991 most governments were clear that they wanted a Climate Convention to sign at the Earth Summit in Rio in 1992. While most agreed that they had to do something, there was considerable divergence between governments about the level of commitment to emission reductions that should be included in the agreement. There was not even much agreement between traditional regional and economic groupings. Within the OECD, for example, Germany was committed to substantial emission reductions in line with the Toronto targets, whereas the UK and the USA were opposed to any cuts. Similarly, amongst the developing countries' negotiating alliance, the Group of Seventy Seven (G77),[28] many larger nations, such as India and China were opposed to emission reductions except in the north,[29] whereas the Alliance of Small Island States (AOSIS), a new group within the G77 created for the climate talks, who risk inundation if sea-level rise occurs, were in favour of massive cuts in emissions. Both the G77 and AOSIS favoured resource transfers, the former generally and the latter especially to help compensate and adapt to changing climate and rising sea level.

Arguments for or against emission reductions turned on quite fine interpretations of the IPCC findings, in particular, on the rate at which the climate might change as a result of anthropogenic emissions and what changes would be dangerous to mankind. The basic finding that the climate had probably changed was not challenged. Both the USA and the UK, for example, took the possibility of climate change seriously, and yet both were heavily influenced against cutting their emissions by fears of the economic consequences (fanned by fossil-fuel and industrial lobbies), whereas Germany, with if anything a far greater reliance on fossil fuels and heavy industry, was determined to cut emissions drastically.[30] The economic argument promoted by governments such as the USA and the UK was that any emission reductions would necessarily mean cutting energy (fossil fuel) use, and that this would be costly to industry and harm job prospects. The main ramification of that argument was that the Convention should not contain commitments to cut greenhouse gas emissions unless quite large, rapid, and dangerous climate change was more certain. The USA was the most important advocate of this argument[31] and was a key player in the INC debates, not simply because of its general political and economic power but also because it emits more greenhouse gases than any other single country. Participants in the INC process thus appropriately expected the USA to take the lead on any commitments on emission reductions. Europe could have pushed for a more stringent treaty that excluded the USA, hoping that it would be forced by domestic political pressure ultimately to join the agreement, but the Europeans lacked the political will and cohesion for this risky strategy. Probably, many actually preferred a weak Convention and were secretly delighted that the USA was bearing the criticism.

The debate before the Rio Conference thus centred around

the now standard issues of the likelihood, magnitude, and rate of climate change. The IPCC did not contribute to this debate other than via its 1990 Report. The negotiating process might have benefited considerably from its advice in early 1992, and at that time the IPCC was compiling a supplementary report to its first 1990 report. As it happens, this did not contain any substantial new ideas that might have informed the INC debates, but it was perhaps indicative of the IPCC process that the report was published just after the Rio Conference, in what appeared to some as a deliberate attempt to distance the IPCC from 'political' matters in general, and the negotiating process in particular. Fundamentally, the IPCC had little to say about impacts of climate change (the Impacts Report was of very low quality) and nothing to say about the economic costs and benefits. Yet these were the issues that governments now faced as they negotiated what policy measures were warranted. As the INC process had evolved, the kinds of advice it needed gradually drifted away from the broad advice of the IPCC towards more detailed issues of law, organization, and policy areas where the panel had little expertise and little desire to contribute.

By the time of the last INC meeting before the Rio Conference the draft treaty was a mess. There was little agreement on all of the more important issues and, in particular there was no consensus on what commitments states should make in terms of limiting their greenhouse gas emissions. The negotiations might have been expected to founder at this stage. However, the political imperative to have some sort of agreement for signature in Rio was paramount. The Earth Summit was originally to have seen the opening for signature of three major environmental agreements: the Climate Convention, the Biodiversity Convention, and the Forests Convention. Negotiations on the Forests Convention had already failed and those on biodiversity were nearing possible completion but were acrimonious and unsatisfactory to many negotiators. Climate was the treaty flagship of the Rio Conference, and the pressure for some agreement was intense. In the final days the key countries, therefore, agreed on a compromise text.

The Convention Signed in Rio

The Convention signed in Rio contains no substantial commitments concerning emissions other than, loosely, for some (primarily developed) countries to limit greenhouse gas emissions at 1990 levels by the year 2000. Indeed, the Convention is full of ambiguities reflecting the compromises that needed to be made in order for the INC to reach consensus on the document and thus the exact interpretation of its obligations is contentious. Nevertheless, the treaty does lay down some clear and helpful guide-lines as to how it should evolve with time, and probably it is better to have an agreement on which to build rather than try to negotiate another (which would probably be impossible for some time into the future without the political imperative of the Earth Summit).

Some of the more attractive features of the agreement which might serve to make it effective in the long term are that it lays the foundations for reviewing not only the implementation of the Convention, but also the adequacy of national policies for mitigating climate change and the overall adequacy of commitments. The commitments can be changed should the Parties be convinced of the need.

The Convention sets up a body for reviewing scientific and technical matters. A strong scientific component is thus firmly embedded in the treaty, although exactly what form this body might take is left unclear and will be decided by the INC, or rather by the first Conference of the Parties (CoP) in March 1995.[32] Indeed, although the Convention is now in force, all of its more important features are still under negotiation.

The Negotiations since Rio[33]

In the months following the Rio Conference most aspects of international environmental diplomacy experienced depression and exhaustion. The Rio process had been so exhaustive in terms of time and resources that the characteristic mood of the INC in the immediate post-Rio phase was one of relief. However, the Climate negotiations resumed in December 1992, on the principle that, although the Convention was not yet in force, the negotiations could productively work through some issues that had not been fully addressed by the agreement and which needed to be resolved if the Convention was to get off to a prompt start. This principle has proved itself. By the time of the first Conference of the Parties in March 1995 as many Negotiating Committee meetings will have been held since Rio as were held before it. The subsequent meetings have been productive, elaborating terms of the Convention that were left constructively vague in the rush to get an agreement before Rio, for example, although the agreement mentions reporting and review processes, they are not specified in any detail and much work remained to be done on exactly how to implement them.

Fundamental aspects of the negotiations have not changed. There is still deep disagreement about financial and technological resources, expressed in debates over the proper role of the financial mechanism created under the Convention. Some governments want to move quickly to negotiating protocols to limit global warming more stringently, but there is little agreement on exactly what form these protocols might take. There has, for example, been talk amongst some northern nations of a 'fast track' protocol on carbon dioxide, but this probably lacks sufficient

support to be a realistic prospect for the first CoP. The arguments about the likelihood of climate change and its consequences remain much as before Rio. The underlying physical sciences and impact assessments are still highly uncertain. The change in government in the USA has led to a more conciliatory US delegation, but its fundamental position against more stringent abatement of greenhouse gas emissions remains as before, as do the basic positions of most other states.

Broadly, science has not been very relevant in the post-Rio negotiations. Most of the issues facing negotiators are either not scientific or are only very narrowly so. The IPCC's 1992 Supplementary Report appeared after the Rio Conference, but it contained little new information, and none of it has been directly relevant to the negotiations on the Convention since Rio.[34] The IPCC is now in the midst of its Second Assessment Report, which will be formally published after the first CoP in 1995. Drafts of some chapters will be circulating for peer review prior to this meeting, so perhaps some of the results, if any are relevant, will be reflected in these discussions. Also, the IPCC is publishing a special report of six critical chapters drawn from the larger Assessment in late 1994, in time for the first CoP, although these will be on science—not impacts. The Assessment will be a reorganized repeat of the first IPCC 1990 Report published by Working Group 1 in 1990. Working Group 1 remains on the scene. Working Groups 2 and 3, which are now officially merged, are still working on impacts, 'cross-cutting issues', and economics, including issues of fairness and assessments of earlier IPCC emissions scenarios.

Working Group 1 of the IPCC has been actively engaged in devising inventory compilation methods for states to use when compiling their formal reports on emissions to the Convention. They have shared this task with the OECD, which has played an important part in ensuring that the compilation system really works and can be based, to a large extent, on data already collected by governments for other purposes (in particular, energy related statistics). The system has been of considerable assistance to the participants in the INC process (later to be the CoP) and it has been delivered in time for the developed countries to use its methodologies in the first reports they submitted beginning in September 1994. Both the IPCC and the OECD deserve credit for this achievement. However, there is some doubt as to whether the OECD will wish to be involved in continued development of the system, and whether the IPCC will continue to regard such work as part of their key role or roles. The system is fairly simple at present—deliberately so—but if it is to continue to be useful in the future it will need to be developed in the light of practical experience and the demands placed on it by the review processes in the Convention.

With the exception of the inventories work, the IPCC and the INC have been drifting apart, as evidenced by the creation by the INC of a separate subsidiary body for scientific and technological advice. The functions of that body are still unclear, but many in the INC hope that it will be a forum for raising and answering technical questions that are directly relevant to the Convention. What these might be is unclear; one area of potential advice is on how to apply Global Warming Potentials for converting different greenhouse gas emissions into common units, and on this issue there are many opinions—the IPCC's is only one.[35] In short, the IPCC and the INC might continue to drift apart, with the former perhaps relevant only in a very broad sense.

The IPCC could ultimately provide more useful advice if it included disciplines that are directly relevant to the evolution of the Convention, notably law and organizational science which have much to offer to the treaty and have a track record of research findings that can be reviewed and applied to the case of climate. Just as the relevant natural sciences have been reviewed by the IPCC, the IPCC could also become more relevant if it were to engage in giving more timely advice. In some cases this need only take the form of a fairly simple adjustment, such as publishing reports before rather than after critical meetings on the Convention. (Finishing and publishing the Second Assessment Report before the 1995 Conference of the Parties is impossible, but if the IPCC publishes a third assessment it should aim to do so before the 1998 review of the adequacy of commitments mandated by the Convention.) However, a regular and timely advisory function by the IPCC could require large changes in the mandate and culture of the panel, away from detached reviews of the science and into a more pro-active mode.

Some governments have conducted their own reviews of possible climate change and its likely consequences for their countries. Also, of course, most industrialized countries have begun the process of preparing national reports to the Climate Convention and a few have considered how they might implement greenhouse abatement strategies. In general, governments are finding that devising and implementing realistic policies to slow down global warming is much more difficult than they assumed before Rio. This is a matter for some concern, because widespread non-implementation of the Convention could prove a very serious impediment to serious negotiations about further commitments.

Conclusion

Science put the greenhouse issue on the political agenda as a matter meriting serious attention at an international level. The fear of global warming became an issue of prime public policy attention when public concern about the issue was raised by the unusual climatic events of the 1980s, a concern

which was further stimulated by environmental groups and some scientists. Science was not irrelevant in the international policy-making process on climate change but, beyond its broad importance, science is only one of many factors that has shaped the debate.

Since the late 1980s a number of international processes have led to the development of international policy concerning climate change. The IPCC was created to assess the findings of climate science, which it did admirably, at least for the physical sciences. The IPCC has helped in achieving an understanding of the climate problem, and it continues as an international assessor of scientific research. The negotiations that led to the Framework Convention on Climate Change were largely initiated by the first IPCC Report, but as time has passed the IPCC has become more distant from the negotiations in the INC. Maintaining some distance between the two bodies is probably wise, if only to avoid the appearance of conflict between the negotiating process and the IPCC scientific assessments, which are supposed to be detached and objective. However, the existence of a large gulf between the two reflects the decreasing relevance of formal science to the INC process. The IPCC might help reconnect physical science to the negotiating process by producing reports which are more timely and which involve disciplines that are more directly relevant to the problems now facing the Convention: such as those which address how to design policies, legal instruments, and organizations. But, even with those changes, science will remain only one of many factors that shape greenhouse policy.

The IPCC will always face two major tensions that will necessarily keep it from being the central or sole international source of advice. First, it is an inherently conservative enterprise which was designed to review and assess the state of the science and then subject those reviews to a massive peer review process. In this mode the IPCC finds it difficult to address extreme views. Extreme views will, therefore, primarily affect the Convention outside the normal scientific process, such as through media reports. Presentation of the full range of scientific opinion, including extreme views, will remain a noisy process. Secondly, science and diplomacy operate in very different ways: scientists enjoy the time to conduct thorough reviews and analysis, but diplomats have erratic and unpredictable demands for information. A body of scientists, especially one conceived around the task of conducting large-scale reviews over long periods of time, with extensive peer review, will always find it difficult to influence diplomatic processes. We do not lament most of these attributes, but merely note that they further limit the direct relevance of the international scientific review processes to the international negotiations.

The power of the IPCC in large measure stems from its being 'scientific', and thus for it to sustain its power it must maintain its scientific culture, despite the fact that the culture leads to time-consuming peer review and some distance between the scientific and diplomatic processes. The culture of science confers a power on its élite spokesmen akin to the oracle power of clergy in centuries past. None the less, a distance remains between science and the production of useful advice.[36]

Ultimately, what matters most is what happens at the domestic level, where the pressure to negotiate agreements originates and where international agreements are implemented. Here we have focused on the use of science within the international negotiation and policy-making process, and especially the role of the IPCC. We have suggested that at the domestic level the broad advice of the IPCC is being used, but we urge analysts of the policy-making process to be to be aware of other sources of domestic expert advice. Within countries that have well-developed scientific infrastructures, domestic advice will be more important. Indeed, although there has been a lull in domestic assessments of the causes and effects of climate change (we have suggested that this stems from the adequate job of the IPCC at the international level and because the IPCC has followed, confirmed, and extended earlier domestic assessments) now that governments must implement the Climate Convention and decide whether it is in their interest to strengthen the treaty, domestic assessments may become more numerous.

Notes and References

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1. The United Nations Framework Convention on Climate Change was opened for signature on 5 June 1992 at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. By the end of the Conference representatives of more than 150 nations had signed the Convention, which came into force in March 1994 after being ratified by fifty states. For negotiating histories see n. 24 and 33.
2. The Vienna Convention for the Protection of the Ozone Layer (1985), the Montreal Protocol on Substances that Deplete the Ozone Layer (1987), and the Amendments to the Protocol (London, 1990 and Copenhagen, 1992).
3. Greenhouses (or 'hothouses') work primarily by blocking convection. The clear glass in a greenhouse allows visible light to enter and warm the plants inside. In the open atmosphere that warm air would then rise and carry the heat elsewhere in the atmosphere, but the glass enclosure contains the air inside the structure. The error in interpretation dates to the mid-19th century, with Fourier's experiments where he described the heating of the atmosphere as a 'hothouse'. For more on the prehistory of the climate issue see generally the annotated bibliography of Handel and Risbey, special issue of *Climatic Change*.

4. Infra-red radiation is heat radiation, i.e. having fairly long wavelength. (The infrared waveband spreads from about 1 micrometre—near infrared—to about 1 mm—far infrared/microwave but the more energetic radiation is in the near infrared, 1 to about 20 micrometres.
5. J. T. Houghton, G. J. Jenkins, and J. J. Ephraums, (eds.) (1990), *Climate Change: The IPCC Scientific Assessment* (Cambridge: Cambridge University Press).
6. The main naturally occurring greenhouse gases are water vapour, carbon dioxide, methane, and nitrous oxide. For details of all of these gases see the IPCC reports mentioned in reference n. 5 above.
7. Natural greenhouse gas sources include all animal life, which 'burns' its carbon-based food in oxygen to give carbon dioxide; all ruminants, which emit methane; and volcanoes, which emit a variety of greenhouse gases.
8. Sinks take up and retain (sequester) greenhouse gases and come in many different forms. For example, carbon dioxide is absorbed by the oceans in which it dissolves and can then be incorporated into the skeletons of marine animals as carbonates. Carbon dioxide is also taken up by all green plants which combine it with water to form carbohydrates and more complex organic compounds.
9. See n. 5 above.
10. There is evidence that growth in all of the major greenhouse gases stalled in the late 1980s and early 1990s—some may even decrease in the mid-1990s—but there is no consensus on why.
11. See n. 5 above.
12. The forecast is based on a set of complex assumptions about population growth, fossil fuel-burning, agricultural activities, and human life-styles.
13. S. Arrhenius (1896), 'On the Influence of Carbonic Acid upon Temperature at the Ground', *Phil. Mag.* 41, 237.
14. The history given here is very brief. For more extensive coverage see primarily David G. Victor and William C. Clark, (1991), 'The Greenhouse Effect in the US: A History of the Science up to 1985' (Jan.). Contribution I-2 on the project on Social Learning in the Management of Global Environmental Risks and references therein. See also W. W. Kellogg, (1987), 'Man's Impact on Climate: The Evolution of an Awareness', *Climatic Change*, 10, 113–36, and M. D. Handel and J. S. Risbey (eds.) (1992) 'An Annotated Bibliography on the Greenhouse Effect and Climate Change' special issue of *Climatic Change*, 21: 2 (June), 97–255. A helpful analysis and history of the co-evolution of climate politics, climate research, and international scientific advice on climate is: Sonja Boehmer-Christiansen (1994), 'Global Climate Protection Policy: The Limits of Scientific Advice, Part 1', *Global Environmental Change*, 4: 2, 140–59; and Sonja Boehmer-Christiansen, 'Global Climate Protection Policy: The Limits of Scientific Advice, Part 2', *Global Environmental Change*, 4: 3, 185–200. (Notably, Boehmer-Christiansen offers a sceptical conclusion about the role of scientific advice, arguing that scientists have used the IPCC and fears of global warming to the advantage of their own scientific institutions).
15. For scientists studying the atmosphere, the regional and global effects of fallout from atmospheric nuclear testing in the 1950s helped reverse the perception that climatic effects of human activities could not occur on a planetary scale.
16. Continued in Bellagio, Italy, 1987.
17. The World Conference on the Changing Atmosphere: Implications for Global Security.
18. Some observers mark the 1985 Villach conference as the beginning of high level debate (e.g see Sonja Boehmer-Christiansen's essays, notably part 1, cited in n. 14). Our opinion is that Villach marks the beginning of sustained high level attention among scientists and, crucially, is a starting point for the development of an international group of scientific advisors (and, ultimately, the IPCC). However, the Toronto conference marks the beginning of sustained high level political attention.
19. Essentially the 'targets' were a return to 1988 levels of greenhouse gas emissions by the year 2000 and a 20% cut by the year 2005. Some countries have unilaterally adopted these targets, notably Germany, one of the larger emitters of greenhouse gas.
20. For a review of the different international scientific events and their connection to the IPCC, see Sonja Boehmer-Christiansen, n. 14 above.
21. See n. 5 above. The report said that anthropogenic greenhouse gas emissions will enhance the greenhouse effect resulting in additional warming of the Earth's surface. It also, with less certainty, gave estimates of the rates of temperature and sea-level rise.
22. For more on the development of the Convention and subsequent negotiations, see below and n. 24 and 33.
23. e.g. a sense of ownership of, and a tendency to defend, its own reports is bound to occur in any organization, and this occurred in the IPCC after the publication of the first and second WG1 reports.
24. For an extensive review of the development of the Convention, especially its legal aspects, see D. Bodansky (1993), 'The United Nations Framework Convention on Climate Change: A Commentary', *The Yale Journal of International Law*, 18: 2 (summer).
25. See n. 5 above.
26. The IPCC also predicted, with provisos, that during the next century the mean global temperature would rise by about 0.3 °C per decade.
27. Because they did not want any lessening of their oil revenues.
28. The G77 consists of most of the developing countries. It does not have, and never had, seventy-seven members. The name was derived as a sort of pun on the G7 group of industrialized countries.
29. Partly on the grounds that they would impede their development and partly because climate change was perceived to be a mess created by the 'North', whose job it was to clean it up.
30. The German government unilaterally committed its country to, essentially, the Toronto targets. Denmark, Luxembourg, and a few local governments have made similar statements.
31. The US administration's economic argument was, of course, based largely on domestic considerations. The year that the Convention was to be ready for signature, 1992, was a presidential election year and the US economy was in recession. The Bush administration (the EPA had no say in this) was not going to risk upsetting his electorate by telling them that they had to cut back on energy use.
32. One option is that the IPCC WG1 may be asked to fulfil this role.
33. An overview of negotiations for the period since the Convention was signed is: David Victor and Julian Salt, (1994), 'Climate since Rio', *Environment* (forthcoming, Nov.).
34. The one exception is the use of Global Warming Potentials (GWP) to convert emissions (and sinks) of different greenhouse gases into common greenhouse units. On this topic, the 1992 Supplementary Report dampened the 1990 IPCC report's claims that GWPs could be quantified. Notably, the indirect effects of different greenhouse gases—which must be quantified in order to quantify an overall GWP—are quite uncertain. The original IPCC report over-stated the extent to which indirect effects could be quantified, and the 1992 report simply reported the sign (but not the magnitude) of indirect effects. GWPs remain unquantifiable in detail.
35. See n. 34 above.
36. A stronger version of this argument is that the IPCC has become purposely more distant because it has served the interests of the IPCC élite and the institutions of science to be seen as apolitical advisors. See Sonja Boehmer-Christiansen, especially part 2, n. 14 above.