

Explaining the Evolution of the IPCC Structure and Process

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Abstract

Climate change is a problem which is global both in terms of causes and consequences. The uncertainties are large and likely to persist. Meanwhile, the political and economic stakes of both action and inaction are much higher than those in other transboundary concerns such as acid rain and ozone depletion. The public policy impact of scientific opinions on climate change, therefore, not only depends upon *what* is being said, but also, *who* is advancing those conclusions and *how* they were arrived at. This was the rationale behind the setting up of the Intergovernmental Panel on Climate Change (IPCC) in 1988. In the years since, the IPCC has attempted to walk the tightrope of being scientifically sound *and* politically correct. This paper examines the processes which led to its creation and how it has evolved over two assessment cycles. The paper attempts to address the question of whether such an assessment set-up was necessary, if indeed it has been relevant, and what some indicators might be to evaluate the performance of the IPCC.

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The Global Environmental Assessment (GEA) project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University, but includes substantial contributions from the International Institute for Applied Systems Analysis (IIASA) in Austria, Cornell University, Duke University and the Center for Integrated Study of the Human Dimensions of Global Change at Carnegie Mellon University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

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Publication abstracts of the GEA Project can be found on the GEA Web Page at <http://www.ksg.harvard.edu/bcsia/enrp/gea>. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

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Acronym List

AGGG	Advisory Group on Greenhouse Gases
CFC	Chloro-flouorocarbon
CIAP	Climate Impact Assessment Program (United States)
CoP	Conference of Parties (to the Climate Convention)
DoE	Department of Energy (United States)
EPA	Environmental Protection Agency (United States)
FCCC	(United Nations) Framework Convention on Climate Change
GARP	Global Atmospheric Research Programme
GCC	Global Climate Coalition
GCM	General Circulation Model
ICSU	International Council of Scientific Unions
IGBP	International Geosphere Biosphere Programme
INC	Intergovernmental Negotiating Committee (for the Climate Convention)
IPCC	Intergovernmental Panel on Climate Change
IPFGGE	Intergovernmental Panel on the First GARP Global Experiment
JWP	Joint Working Party (of the IPCC and INC)
JWG	Joint Working Party (of the IPCC and Climate Convention Bodies)
NAPAP	National Acid Precipitation Assessment Program (United States)
NGO	Non Governmental Organization
NRC	National Research Council (United States)
OECD	Organization for Economic Cooperation and Development
OTA	Office of Technology Assessment (United States)
SBSTA	Subsidiary Body for Scientific and Technical Advice
SCEP	Study of Critical Environmental Problems
SCOPE	Scientific Committee on Problems of the Environment
SEI	Stockholm Environment Institute
SMIC	Study of Man's Impact on Climate
TSU	Technical Support Unit (of IPCC Working Groups)
UN	United Nations

UNEP	United Nations Environment Programme
UNGA	United Nations General Assembly
US	United States (of America)
USSR	(former) Union of Soviet Socialist Republics
WG I	(IPCC) Working Group I
WG II	(IPCC) Working Group II
WG III	(IPCC) Working Group III
WMO	World Meteorological Organization

Explaining the Evolution of the IPCC Structure and Process

Shardul Agrawala

Introduction¹

Nine years have elapsed since the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to assess the available information on climate change. The IPCC was created jointly by two United Nations agencies: the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), and now has the participation of national governments worldwide. At the same time it attracts an exceptionally large number of qualified experts in an assessment process involving multiple worldwide peer reviews. Through this innovative set-up the founding fathers of the IPCC sought to advance what many thought was an oxymoron: quality scientific assessments by democratic consensus.

While there is considerable literature citing conclusions reached by the IPCC, detailed analyses of the institution, its assessment process and outputs are very limited. Past attempts in this direction can be broadly categorized as *output oriented*: both at the level of overall assessment reviews (Schneider, 1991; Jefferson, 1996; Singer, 1996), and at the level of questioning specific scientific and technical assumptions underlying sections of IPCC assessments (Lindzen, 1992; Linden, 1993; Meyer and Cooper, 1995); *process oriented* (Fitzgerald, 1990; Boehmer-Christiansen, 1994a; Boehmer-Christiansen, 1994b); and *use oriented* (Boehmer-Christiansen and Skea, 1994c). Analyses in the latter two categories are largely restricted to the First Assessment cycle of the IPCC which ended in 1990, or at most, until 1992, when an update for the Earth Summit negotiations was published. There has also been a tendency to focus almost exclusively on the "Science" Working Group of the IPCC - Working Group 1. Finally, while rudimentary descriptions of the IPCC history and process are invariably included in such accounts, very little attention is paid to the question of *why* an intergovernmental assessment mechanism was deemed necessary in the first place, *what* the various intricacies in its institutional structure are, and *how* they have been shaped over time.

This paper aims to fill these important research gaps. Its mission is threefold: descriptive, explanatory and evaluative. The unit of analysis is the assessment process itself, not

specific reports or Working Groups. The goal of this paper is not to delve into micro-level issues at the level of, for example, the choice of particular forcing parameters to drive General Circulation Models (GCMs). Yet, the analysis goes much beyond providing a simple historical narrative of the configuration of the IPCC. An attempt is made to highlight significant but hitherto neglected aspects of the process, such as, the involvement of developing countries, the logic underlying the scope and mandate of the IPCC Working Groups, who the intended users of IPCC assessments are, and whether and how the assessment process has been responsive to their needs over time.

Section 2 of this paper sets the context of the climate problem and how it evolved over time. Section 3 attempts to unravel the processes which caused the IPCC to be set up when it was and how it was, as opposed to different times and different forms. Section 4 accounts for the factors which shaped the form and structure of the IPCC between its conception and birth. Section 5 details the evolution of certain key aspects in its structure during the course of its First and Second Assessment cycles: the peer review process, developing country participation and the links between IPCC and the Framework Convention on Climate Change (FCCC). Finally, Section 6 draws conclusions as to whether an IPCC-like set-up was indeed necessary, whether an international effort more on the lines of the ozone assessments would have sufficed for climate change, and what some indirect indicators might be to measure the performance of the IPCC.

The Context

The theory of the greenhouse effect goes back to over a hundred years (Tyndall, 1863; Arrhenius, 1896). The role of human activities in increasing concentrations of greenhouse gases has come under growing scrutiny only since the late 1950s when monitoring of atmospheric carbon-dioxide concentrations began in Antarctica and Hawaii (Keeling et al., 1984). Scientific interest in man's impact on global climate and the possible societal impacts of these changes came to be mobilized through conferences, loose research networks and assessments, particularly from 1970 onwardsⁱⁱ (SCEP, 1970; SMIC, 1971; Mormino et al. 1975; NRC, 1979). There were relatively brief periods of interest in global *cooling* due to the effect of industrial aerosols from the late 1960s to early 1970sⁱⁱⁱ and climate *variability* which gained prominence in the mid-1970s due to the prolonged drought in the Sahel. However, by the early 1980s the predominant focus of the scientific community had converged on the possibility of *warming* trends in the *mean* climate stemming from increased greenhouse gas concentrations.

The First World Climate Conference in 1979 provided a major international forum devoted exclusively to climate change but it did not make any calls for policy action (WMO, 1979). It did, however, result in the creation of the World Climate Programme and set forth a series of workshops organized under the auspices of WMO, UNEP and the International Council of Scientific Unions (ICSU) to better understand the problem. These workshops were held in Villach, Austria in 1980, 1983 and 1985 and drew on a UNEP funded research effort underway at International Meteorological Institute, Stockholm between 1982 and 1985^{iv}. It was at Villach 1985 that a consensus was reached by an international group of scientists (participating in their *personal* capacities) that "in the first half of the next century a rise of global mean temperature would occur which is

greater than any in man's history". These experts also recommended that "scientists and policymakers should begin active collaboration to explore the effectiveness of alternative policies and adjustments"(WMO, 1985).

In the period immediate following Villach 1985, climate change had truly "arrived" both in the news media and on the international policy agenda. The range of factors that contributed to this issue build-up is extremely diverse, the feedbacks between them very complex and are well documented in several good historical accounts. The next section will trace one strand that has received considerably less attention: how the Villach 1985 findings influenced decisionmaking in the international bodies which had sponsored it, and how their institutional responses as well as influence from key individuals and one government eventually resulted in the setting up of an intergovernmental panel - the IPCC, to assess climate change.

Genesis of the IPCC

There were four key actors on the international arena at the time the Villach 1985 recommendations came out: UNEP, WMO, ICSU and the United States. UNEP, WMO and ICSU had been collaborating closely both in climate research through the World Climate Programme, and in assessments through the Villach series of workshops between 1980 and 1985. Following the 1985 workshop as discussions moved more towards international *policy* responses ICSU's involvement as an institution declined. Some key ICSU scientists, most notably Bert Bolin, did however play important roles in the evolving policy debate. ICSU meanwhile continued to focus on global change *research*, particularly through the International Geosphere Biosphere Program (IGBP) which it established in 1986.

The fourth and final player, the United States, was in a unique position. First, it had the most cumulative expertise both in climate change research and in assessments from the Climate Impact Assessment Program (Mormino et al., 1975) and National Research Council (NRC, 1977; NRC, 1979; NRC, 1983) to Environmental Protection Agency (EPA, 1983; EPA, 1986), and the Department of Energy (DoE, 1985). These assessments helped shape the flavor of those done in other countries (such as Germany) and the fledgling international effort. Second, the US had a huge stake in the climate problem. It was the biggest contributor to greenhouse gas emissions. Also, any measures at abatement of future emissions could significantly threaten its economic interests. Powerful fossil fuel lobbies with active support from a Republican White House were strongly opposed to *any* kind of action on climate change. Third, being the biggest financial patron of the UN system the US carried considerable clout in decisionmaking circles at WMO and UNEP. Fourth, and perhaps most interestingly, various US agencies and research establishments had very different positions on climate change, particularly with regard to the need for any policy responses to it. While assessments like NRC (1983) emphasized scientific uncertainties and advocated a cautious "wait and see" approach, an EPA assessment published the same year painted a dramatically different picture with potentially catastrophic consequences resulting from uncontrolled climate change (EPA, 1983).

Meanwhile, UNEP and its pro-active Director Mostafa Tolba had no doubts about the future course of action on climate change. Flush with the success of negotiating the Vienna Convention on Ozone, he felt that the time was ripe to repeat the ozone “miracle” for climate. Indeed, UNEP in its long range planning document of 1985 had called for a climate convention. In the wake of the 1985 Villach workshop Tolba began active consultations for a possible convention with WMO and ICSU, UNEP’s two long-standing collaborators on climate change. He also wrote to then US Secretary of State George Schultz urging the US to take appropriate actions (Hecht and Tirpak, 1995). Tolba’s efforts stimulated two sets of interactions between these four key actors.

An Immediate Response: The Advisory Group on Greenhouse Gases (AGGG)

In a meeting organized by UNEP, WMO and ICSU a decision was made to jointly set up an advisory panel : the Advisory Group on Greenhouse Gases (AGGG) in July 1986. This blue ribbon panel consisted of a total of six members: Gordon Goodman, Bert Bolin, Ken Hare, G. Golitsyn, Sukiyo Manabe and M. Kassas . Each of the three participating bodies had nominated two experts. The AGGG mandate, in fact, stemmed directly from Villach 1985 which had suggested that “UNEP, WMO, and ICSU should establish a small task force on greenhouse gases..to initiate if necessary, consideration of a global convention” (WMO, 1985). This was, however, not the first international advisory panel on climate change: two notable precedents are a panel of experts to better understand climate change set up by the Executive Council of the WMO in 1974, and another somewhat similar panel set up by the WMO, but under mandate from the UN General Assembly in 1975.

There were some crucial shortcomings in the design of the AGGG. Bert Bolin, a member of this group and veteran of almost all international climate change assessment efforts from 1970 onwards recalls that he was “very ambivalent to the work of the AGGG because it had no money and no muscle” (Bolin, 1997). Eventually, Gordon Goodman, another AGGG member and Executive Director of the Beijer Institute (later, the Stockholm Environment Institute) got money from the Rockefeller Brothers Fund to commission two inter-linked workshops in September and November 1987 at Villach and Bellagio respectively. It is important to note that Villach 1987 *was not* a continuation of the series of workshops held at the same venue between 1980 and 1985. The 1987 Villach and Bellagio meetings were held under AGGG auspices, even though many over-committed AGGG members had limited input or control over them. Many participants at these workshops believed that despite prevailing uncertainties, aggressive policy action was needed on climate change. This led to the Bellagio conference proposal that policymakers should set “maximum” rates of sea level increase at between 20 and 50 mm per decade and a maximum rate of temperature increase at 0.1°C per decade (Jäger, 1988).

Two facts need re-stating. First, these recommendations were not coming from the “officially mandated” group, that is the AGGG. Second, while ecological thresholds of climate change might exist under specific contexts, the scientific basis behind drawing

broadly generalizable thresholds across a whole range of natural and socioeconomic systems is questionable even ten years later. Furthermore, whether climate change under any particular (arbitrary) threshold should be defined as socially “tolerable” and exceeding it as “dangerous” was clearly a value judgment scientists were not qualified to make. This mood of policy activism continued on to the Toronto Conference of the Atmosphere in June 1988 (the first “million dollar” meeting on climate change) where a conclusion by a small group of energy experts up led to a conference declaration calling on national governments to reduce carbon-dioxide emissions by 20% from 1988 levels by 2005. The Villach/Bellagio recommendations meanwhile were eventually published as a four volume set by Stockholm Environment Institute in 1990 when they were eclipsed by the much more influential IPCC First Assessment Report. The last meeting of the AGGG was held during the Second World Climate Conference in 1990 and it has not undertaken or sponsored any activities since then.

A Parallel But Delayed Response: An Intergovernmental Assessment “Mechanism”

Meanwhile, in the United States, Tolba’s letter to George Schultz was discussed during 1986 by the inter-agency National Climate Program Policy Board. As referred to earlier, various US agencies had published their own extensive assessments on climate change which pre-dated the fledgling international assessment effort. They also had vastly different takes on both the magnitude of the problem, the need and nature of any possible responses to it. Due to lack of agreement, and for reasons that suited their own ideologies and agendas (see Section 3.3), a compromise was reached amongst participating agencies with the US recommending that an “*intergovernmental mechanism*” be set-up to conduct scientific assessment of climate change.

The US position was communicated to the WMO Secretariat and it helped shape resolution 9 of the Tenth WMO Congress which met in May 1987. This resolution recognized the need for an inter-disciplinary and multi-agency approach and asked the Executive Council of WMO “to arrange for *appropriate* mechanisms to undertake further development of scientific and other aspects of greenhouse gases”. The US also strongly influenced the WMO Executive Council resolution a week later, which in response to the call from the Congress, requested the Secretary General of WMO, “in coordination with the Executive Director of UNEP to establish an *intergovernmental* mechanism to carry out internationally coordinated scientific assessments of the magnitude, impact and potential timing of climate change”. Shortly thereafter, UNEP’s Governing Body welcomed the WMO initiative and asked its Executive Director to work with WMO on establishing such an intergovernmental assessment body.

This constitutes the famous “I” of what was to later become the IPCC and is the single most critical element in its design. It is the intergovernmental nature of the IPCC that gives its assessments a special *niche*, distinct from the myriad other assessments and vendors. According to Jean Ripert, founder chairman of the Intergovernmental Negotiating Committee (INC) who chaired the negotiations for a climate convention, the intergovernmental nature of the IPCC was in large part responsible for educating many

government bureaucrats about the problem which made them more willing to come to the negotiating table. This, according to Ripert, was key to the signing of FCCC in 1992 (Ripert, 1997). However, having an intergovernmental status has imposed significant costs also: IPCC assessment summaries are widely regarded as being politically negotiated which has, at times, undermined their credibility.

Counterfactual Analysis

Having discussed *how* an intergovernmental mechanism came to be set up, it is also important to explore *why* it might have been necessary. Many analysts offer a *sequential* explanation of events between 1985 and 1988. For example, Michael Oppenheimer, an active participant in the 1987 Villach/Bellagio workshops and the Toronto Conference notes, “the Bellagio Report provided a basis for the recommendations of the June 1988 Toronto meeting which in turn provided impetus to the formation of the Intergovernmental Panel on Climate Change” (Oppenheimer, 1989). However, as the preceding paragraphs clearly show, the process to set up the IPCC was in motion as early as 1986, and the WMO Executive Council resolution to this effect was passed in June 1987, a few months *before* the Villach/Bellagio workshops, and a full one year *before* the Toronto Conference and the hot summer of 1988. These events clearly had no role in the decision to set up the IPCC, though they might have influenced the level of interest the institution subsequently generated.

Instead, the trigger for the IPCC was the activism by Mostafa Tolba, the dissatisfaction in the US about the AGGG, and sharply differing views on climate change amongst various US government agencies and the White House administration. The subsequent shape the IPCC took reflected a common denominator agreement between various US agencies. Reportedly there were also strategic attempts both by WMO and the US to prevent Mostafa Tolba from “capturing” climate, the way he had, ozone.

A richer analysis of the question *Why IPCC ?* can be centered around, what political scientists term as counterfactuals. Or, what else was a possible option ?

The first viewpoint is that by the time of Villach 1985 there was enough scientific knowledge of climate change, no further assessments were necessary, and that it was time for policy action. Indeed, this is what UNEP’s Director Tolba had in mind when he put out the call for a climate convention in 1985. A convincing case can probably be made that the scientific basis on climate change by this time was at least as strong as that on ozone at the time of the Vienna Convention. And it was probably much stronger than that on acid rain when the Long Range Transboundary Air Pollution Convention was signed in 1979. Thus, historical precedents would argue for the feasibility of signing at least a “bare-bones” framework convention on climate change right after the 1985 Villach workshop.

The reason why even a framework convention did not happen in 1985 is probably political. By this time it had become evident that any serious response to the climate problem might eventually require a restructuring of *energy sectors* which formed the *heart* of most economies. This is very different from the cases of ozone depletion and acid rain. Policy action on climate change needed to be *global*, would affect *entire*

economies and hence widespread governmental support for any policy response from both developed and developing countries was a must. The international group of experts assembled in the 1985 Villach meeting were mostly from developed countries and had participated only in their personal capacities, not as representatives of their respective governments. Furthermore, in case of both acid rain and ozone depletion a coalition of influential governments strongly supportive of the idea a convention was already in existence before they were actually negotiated and signed. Such a governmental coalition *did not exist* in case of climate change in 1985. Therefore, irrespective of their *scientific* credibility, the Villach 1985 recommendations were not *politically* sufficient to generate momentum for a climate convention.

Another possibility could have been to use the Advisory Group on Greenhouse Gases (AGGG) to further develop scientific information and generate governmental interest necessary for a possible convention. Although the members of the AGGG had impeccable credentials, the hastiness with which the body was set up in the euphoria following Villach 1985 resulted in several major design flaws which were later to prove its undoing. First, the audience of this panel was very narrowly defined. One close observer compared the six AGGG members to a group of private consultants to the *heads* of WMO, UNEP and ICSU. In fact, there were no formal requirements for the group to report on its activities, or to seek direction from, even the governing bodies of the three sponsoring organizations, let alone national governments. The gulf between science and policy could not have been wider. The policy making community which had the ultimate responsibility of designing and implementing any policies on climate change had little idea what the AGGG was doing, little say in shaping its priorities and no sense of participation in the assessment process. Furthermore, the AGGG had no specific mandate on the range of issues it was supposed to address. Finally, it had no money.

It was under this context that the inter-agency US National Climate Policy Board met to discuss Tolba's letter for possible actions towards a climate convention. As noted earlier various US agencies had vastly different takes on both the magnitude of the problem, the need and nature of any possible responses to it. These opinions came to the fore in the discussions on Tolba's letter. Most agencies were not supportive of immediate negotiations for a climate convention. The role of the DoE is particularly interesting. It argued against using the Villach 1985 report as a justification for a convention on the grounds that it was "not prepared by government officials" (Hecht and Tirpak, 1995). The real reasons probably went deeper than that. DoE had its own climate assessment underway during the period the Villach series of workshops were being conducted at the international level in the early 1980s. The two processes were vying for the involvement of many of the same scientists. Some of these experts participated in both, others preferred the international assessment activity over DoE. Officials from DoE had also attempted to "market" their own assessment at the Villach 1985 workshop but met with limited success. Both these factors may have contributed to DoE's resentment against the international process already underway. This might explain their calls for involvement of *government experts* in future international assessment activity.

The dominant position of the (Republican) administration meanwhile was that scientific evidence on climate change was inconclusive at best and did not justify policy actions

that would likely be expensive. On the other hand, EPA and the State Department were supportive of the idea of a convention but suggested governmental involvement in an international assessment process to resolve contentious scientific issues first (Hecht and Tirpak, 1995). The eventual compromise: an intergovernmental assessment mechanism which the US finally proposed addressed DoE concerns regarding involvement of "official" experts. At the same time it precluded immediate action and provided an opportunity for the administration to buy time ("let's study the problem more"). Yet, by encouraging international participation it also made an eventual climate convention more feasible, consistent with the goals of EPA and the State Department.

There was also a recognition that any proposed international assessment process had to go much beyond the science of climate change. Thus while WMO was a natural sponsor for such a process, it did not have sufficient expertise to cover many other relevant aspects of climate change such as policy responses. This argued for UNEP involvement though the US had some reservations about Mostafa Tolba. This is because he had alienated many close allies of the US in Latin America during the ozone negotiations. There was thus a keen interest on the part of the US not to let Tolba run climate change with the same degree of control which he had wielded over ozone. Therefore, a proposal was made for a *joint UNEP/WMO intergovernmental* mechanism. ICSU, the only other candidate in the international arena to co-host such a body dropped out partly because it was more interested in global change research (as opposed to policy), and perhaps due to definitional reasons: the US proposal was for an *intergovernmental* mechanism while ICSU was *non-governmental*.

The idea for an intergovernmental mechanism got support by member governments of WMO and UNEP on account of several reasons. First, the US clout in the decisionmaking of these bodies cannot be overlooked. Second, due to linkages between climate change and the energy and land-use sectors the stakes were considerably higher than ozone for governments worldwide to take active interest in assessments of the problem. Third, the international environmental arena was already politicized *because climate change came in the wake of ozone*. Peter Usher, Tolba's key advisor during the ozone negotiations admits that the ad-hoc, low key, science driven (if politically undemocratic) nature of the early ozone assessments which led to the Vienna Convention could not be duplicated in climate change. This is because while "politics caught up with ozone, climate change was born in politics" (Usher, 1997).

A final question in this counterfactual analysis is whether an intergovernmental mechanism on climate change could have been set up sooner than it was. As noted earlier, expert panels were set up on climate change under WMO and UN General assembly mandates in 1974 and 1975 respectively, but the scientific information was too sketchy to justify any policy interest. Even as late as the 1979 First World Climate Conference, there was only enough evidence to provoke *interest* in climate change, not enough to provoke serious international *concern*. In fact, the earliest opportunity when steps could have been taken to set up an intergovernmental assessment mechanism was right after the Villach 1985 workshop when an international consensus on the seriousness of the issue was reached for the first time. In other words, under perfect hindsight, the AGGG was probably avoidable. However, the fact that a more appropriate international

assessment body was commissioned shortly thereafter reflects the uncharacteristic speed with which the concerned international organizations iteratively improved upon their earlier response.

From Conception to Birth: June 1987—November 1988

The precise form of the “intergovernmental mechanism” began to take shape in the months immediately following the WMO Executive Council resolution in early June 1987. This was primarily a back-room effort of design, negotiation and compromise. The hub of activity was in the US where a number of proposals were refined and discussed by the various agencies. Much of this process is still shrouded in mystery and by most accounts a large number of individuals at various US agencies including the State Department, DoE and EPA played key roles. One proposal which bears some resemblance to the eventual form of the IPCC can be traced back to Alan Hecht, Bo Döös and others at National Climate Program Office. Döös, a Swedish meteorologist and former director of the World Climate Program drew on his experience with the Intergovernmental Panel on the First GARP Global Experiment (IPFGGE) in the mid-1970s and proposed an “Intergovernmental Panel on the Assessment of Climate Change” on similar lines (Döös, 1997). The proposal which eventually emerged after inputs from a number of US agencies emphasized that this panel should include “representatives of countries making major contributions to various aspects of ..climate change”, and “allow for adequate representation of countries from all regions..(while)..representatives of..international organizations should participate as observers” (Anonymous, 1987).

This proposal was never sent out formally by the US government to WMO, in part because of the resistance of the then US Permanent Representative at the WMO to this idea. However, WMO had been closely involved in the US effort. In the absence of an official US initiative WMO took the lead and held discussions with UNEP on this proposal. Eventually, a slightly modified version was sent out by the Secretary General of WMO on March 25, 1988 to member governments inquiring whether their country would like to be represented on a proposed “Intergovernmental Panel on Climate Change” (Obasi, 1988).

One major design choice that was also made during this period which had considerable ramifications both on the subsequent size and structure of the IPCC was regarding the *scope* of the proposed assessments. Should the assessments focus on the *science* of climate change, its *impacts*, or the range of available *response* options, or all three? Rational actor models suggest that “better” decisions might result from a more comprehensive approach. Further, only comprehensive assessments can highlight key uncertainties and data gaps which span across disciplines. On the other hand, comprehensive assessments consume much more time, money and resources. Some argue that there is also the risk that authoritative judgments from more quantitative disciplines (usually in the natural sciences) might get “contaminated” by guarded conclusions from disciplines which face considerably higher uncertainties. In the case of climate change, conclusions regarding the magnitude and attribution climate change tend to be more authoritative than statements about physical impacts, while statements about the economic costs of damages and policy responses have vastly higher uncertainties. Thus,

“narrow” assessments focusing primarily on the natural science components of the problem could carry more certainty and hence, authority with policymakers. Therefore, some analysts have been puzzled as to why the IPCC chose to do *comprehensive* assessments of the science, impacts and responses in a manner which bore more resemblance to the Climate Impact Assessment Program (CIAP) effort of the early 1970s than to the more truncated assessments of the late 1970s and 1980s.

There is an intellectual and a human explanation for this puzzle. Intellectually, this proposed mechanism was going to be the *first* “official”, systematic assessment of climate change at the international level, much like CIAP was at the national level in the US. Therefore, it made some sense to investigate *all* aspects of the issue for precisely the same reasons as it did for CIAP in the early 1970s. On the human front, one of the key actors in the decisionmaking process which led to the formation of the IPCC was N. Sundararaman, a US Federal Aviation Administration scientist on deputation at WMO. He had started his career as a member of the CIAP assessment team between 1971-75 and believed that an approach on similar lines was the best way to structure the proposed intergovernmental assessment. Sundararaman reportedly emphasized the need for a comprehensive approach to his former colleagues in US agencies. He also helped draft the 1987 WMO Executive Council resolution which provides the first hints for such an approach: “(the) ad-hoc intergovernmental mechanism... (should) carry out internationally coordinated scientific assessments of the magnitude, timing and potential impact of climate change”. Though this resolution does not include response options, they were subsequently brought on board when UNEP and WMO established tentative terms of reference for the IPCC in summer 1988. An added impetus to the inclusion of response options was provided by a draft resolution introduced by Malta at the UN General Assembly, just weeks before the first plenary session of the IPCC. It called on the IPCC to “immediately initiate action leading...to a *comprehensive* review and *recommendations* with respect to...the science of climate change..., social and economic impact(s)..., possible policy responses by Governments to delay, limit or mitigate the impact of adverse climate change, relevant treaties and other legal instruments dealing with climate, (and) elements for possible inclusion in a future international convention on climate” (UNGA, 1988).

The science, impacts, responses scope also lent itself nicely to having three Working Groups to look at each of these focus areas. Malta’s proposal and calls for the IPCC to include legal instruments as well as elements for a possible convention (in addition to science, impacts and responses) did, however, provoke some discussion whether IPCC should have *five* Working Groups instead of *three*. This dilemma is reflected in the background papers prepared for the first IPCC plenary in November 1988 by N. Sundararaman who had been appointed Secretary of the IPCC a few months earlier in May (Sundararaman, 1988). Eventually, it was Mostafa Tolba who in his opening address entitled “Warming: Warning” to the participants at the first IPCC plenary in his characteristic authoritative style told the delegates “I suggest you consider establishing *three* sub-groups...to carry out *simultaneous* work in the three sectors of your activity: scientific assessment, socioeconomic impacts and policy responses” (Tolba, 1988). This shaped subsequent deliberations and a majority of the participating national delegations supported Tolba’s proposal of three Working Groups working in parallel: Working

Group 1 looking at Science, Working Group II at Impacts and Working Group III at Response Strategies. Malta's demand that IPCC also discuss legal instruments and elements of a possible convention were subsequently folded into the mandate of Working Group III (IPCC, 1989).

Bert Bolin of Sweden was elected to chair the first session of the IPCC, a formality prior to his formal election as chairman of the IPCC. The choice of countries to chair the three Working Groups reflected both technical and power endowments at that time, and had been pre-negotiated. The United Kingdom was elected to chair Working Group 1 under the leadership of meteorologist and WMO veteran John Houghton, the Soviets were given charge of Working Group II under another WMO veteran Yuri Izrael, while the US got the chairmanship of Working Group III and appointed Fred Bernthal, a State Department official to chair it. Under Tolba's directive, the IPCC also established a small bureau to coordinate the work of the Panel.

Evolution of the IPCC: 1988—1997

As the preceding discussion shows, by the time the IPCC was functional in November 1988 the following key features in its assessment structure were already in place: it had an *intergovernmental* status, *joint WMO-UNEP* sponsorship, a mandate to do *comprehensive assessments* of the science, impacts and responses of climate change, *three Working Groups working in parallel* to examine each of these components, and a *small Bureau* to oversee the work of the Panel. The rationale for, and evolution of each of these components have already been discussed. These design features have largely survived till the present day, except for a change in the mandates of Working Groups II and III and 1992.

It is also important to recognize what was missing in the IPCC structure and design in 1988 but evolved subsequently as the institution responded to fast ratcheting demands for enhanced representation, transparency, credibility and decisionmaking relevance. During the pre-establishment phase from 1986-88 the IPCC structure was shaped essentially by a small group of individuals at WMO, UNEP and the US agencies. Once the IPCC was out of the womb and buffeted by political pressures a somewhat different cast of characters was responsible for its subsequent evolution. First, the authorizing agencies: WMO and UNEP played increasingly marginal roles in the IPCC design. The US though still continued to wield considerable influence through its scientists and bureaucrats who were members of the Panel. Second, a new cast of influential individuals emerged led by the Chairman of the IPCC, Bert Bolin. Third, IPCC was shaped considerably by exogenous pressures which included demands of the FCCC bodies and the increased scrutiny of the IPCC process and outputs by special interest groups, in particular, by many oil exporting countries and the US fossil-fuel lobby.

BOX 1

Overview of the IPCC Assessment Process

The work of the IPCC is conducted at three distinct levels (Moss, 1994). First, the IPCC hosts a plenary session at the beginning of an assessment cycle. This also marks the end of the previous assessment. During this plenary session government representatives review and approve the completed reports from the previous cycle. They also set the agenda for the Panel's next round of activity. Environment and industry groups have observer status during these sessions. After the plenary each Working Group prepares detailed workplans and report outlines to implement its agenda. Nominations are then invited from experts from governments, international and non governmental organizations and writing teams are finalized by the chairs of individual Working Groups assisted by their respective Technical Support Units (TSU). In the third and final tier of the process, each of the writing teams work in coordination with their respective Working Group Chair, Bureau and Technical Support Units to draft their relevant section of the IPCC report. This process is iterative and typically takes between one and a half to two years. It includes comprehensive expert and government reviews and several "lead-author" meetings to review comments and resolve inconsistencies across different sections of the report. The final outputs from each Working Group are then presented for government approval their respective plenary session. The entire IPCC assessment is then approved at a full IPCC plenary session.

This section explores the evolution of three critical design features: the peer review process, the participation of developing country scientists and IPCC's attempts to abstain from policymaking and yet be policy relevant.

Peer Review

While many have acknowledged the existence of a peer review mechanism for IPCC reports, the extent and degree of sophistication of the process have largely been left unexplored. To most, peer review is a binary variable: either it exists, or it does not. Most recognized journals have peer reviews, as do many research reports. Thus, at first sight, while having a peer review mechanism within the IPCC design is important, it is by no means unique. However, the IPCC peer review is more comprehensive, *by many orders of magnitude*, than that in an average journal. For example, draft chapters of the 1995 Working Group II Second Assessment report went through two full scale reviews: the first involving anywhere from twenty to sixty expert reviewers per chapter (a total of 700 experts from 58 countries were involved) , and the second involving all IPCC member governments and the experts who had sent their reviews in the first round. The action taken by writing teams on review comments was monitored by the Working Group Bureau and the Technical Support Unit.

It is important to note that there are two different outputs from the IPCC process: policymaker summaries which are extensively reviewed and then approved line by line by governments, and the underlying reports which have extensive expert and government review, but are not subject to line by line approval. The latter has been much less political than the policymaker summaries as it does not require line by line approval by government representatives.

The organization of peer review process had not been discussed either in the negotiations prior to the establishment of the IPCC, or during its first plenary session in 1988. The

first discussion on this subject was held during the first session of the IPCC Bureau in February 1989. During this meeting Working Group 1 (WG 1) indicated that a review of its draft chapters by both contributing and external experts was included in its work plans while the Working Group II (WG II) only indicated a review by its contributing authors (IPCC, 1989). Somewhat more detailed discussions on the subject were held during the second meeting of the IPCC Bureau in February 1990 when the draft chapters for the First Assessment were nearing completion. The IPCC Bureau decided that “the draft reports of WG I and WG II will undergo peer reviews. These two Working Groups are free to choose the form of the peer review as long as the latter is conducted in such a manner as to assure quality products” (IPCC, 1990b). Thus, during the preparation of the First Assessment, the IPCC had no formal rules on who should participate in peer reviews, or formal follow up mechanisms to ensure proper action is taken. Peer review was more ad-hoc, based more on a tradition of scientific conduct and trust than on any political norms. There were also severe budgetary constraints and there was no money to impose more formal mechanisms.

The three Working Groups, however, catered to very different communities with vastly differing levels of disciplinary cohesion, clearly defined “experts”, or a shared set of peer review standards. The natural science community in WG 1 was relatively mature and well organized, experts on the subject were generally easily identifiable and a review process on the lines of a scientific journal was conducted (though with substantially more reviewers). The impacts community in WG II was, however, not so well developed. There were also some concerns voiced by western scientists regarding the management of the Working Group by the Soviets. This led the IPCC Bureau to impose some external pressure to ensure that a wider community of impacts experts participated in the review of WG II chapters. Working Group III (WG III) meanwhile was dominated by legal experts and negotiators. The Bureau felt that the standards of a scientific journal-type review could not realistically apply to this group and consequently did not impose any review requirements. The “policymaker” summaries of all three Working Groups, however, went through government review and approval before the First Assessment Report was released.

Between 1990 and 1992 a number of political factors forced the IPCC to ensure that its peer review process was formalized to carry more credibility with government negotiators. First, the release of its First Assessment prepared by, what was billed as “the best scientists in the world ” put the institution under intense media scrutiny. Second, as climate change neared the negotiation phase in the build up to the Rio Summit the political environment became increasingly polarized. Powerful interest groups with huge stakes in the issue now began to show much more interest in the IPCC assessment process. Two notable entrants were lobbying arms of the US fossil-fuel industry: the Global Climate Coalition (GCC) and the Climate Council. They brought with them the “if you don’t like the message, discredit the messenger” approach which had been perfected to an art form in Washington lobbying circles. Also, climate change was ratcheted one level above WMO and UNEP to the UN General Assembly when the latter established the Intergovernmental Negotiating Committee (INC). IPCC meanwhile was charged with preparing an interim report due for release in 1992 to aid the INC deliberations for a possible climate convention.

Since it was imperative that this interim report be *politically* credible to national negotiators at the time of the Rio Summit, the IPCC Bureau in its fourth session in August 1991 mandated that “the Working Groups should ensure as wide a peer review as possible in order that the Supplement (Report) may find acceptance by governments” (IPCC, 1991). The real hardening of IPCC rules of procedure (including peer review), however took place during its eighth plenary session in Harare in November 1992 after the Rio Summit and release of the 1992 Report. This is when The Task Force on IPCC Structure presented its report to the plenary session. Among other things this report emphasized that: the same review procedures should apply across all Working Groups, the process of selecting contributors and reviewers should be made more open, since developing country expert names might not show up in the “open” literature special efforts must be made to get their names from their governments, the IPCC should establish the best possible relations with relevant global research and observation programs (to get access to the best experts), a master list of experts from all countries should be available to all those involved in the IPCC, clear guidelines should be set regarding the time for reviews, and peer review requirements for policymaker summaries be carefully specified (IPCC, 1992).

Based on these recommendations, a formal set of rules governing peer review were adopted during the ninth plenary session of the IPCC in June 1993. Specifically, a two tier system of external reviews was formalized: the first by experts, and the second by all IPCC member governments and all experts and contributors from the first round. It was mandated that the expert review should include the following categories: specialists with significant publications in particular areas, experts named in IPCC “master lists” based on information supplied by various governments and organizations, and specialist reviewers nominated by international organizations including those in the UN system, The World Bank, Third World Academy of Sciences, OECD and so on. Perhaps most significantly in terms of its political implications, it was formally stated that all IPCC reports will have policymaker summaries which will be subject *to line by line approval* at a plenary session of the relevant Working Group (IPCC, 1993).

Despite the hardening of IPCC rules over the years, the peer review of the underlying assessment is not without its loopholes. First, the same review can often be submitted via multiple pathways, a fact that was exploited considerably by many US industry lobbying groups during the Second Assessment of the IPCC. They submitted identical reviews on behalf of individual experts, certain non governmental organizations and as part of the official US government review. This can lead to an unnecessary amplification of essentially minority opinions. This problem is probably easy to fix if the IPCC rules clearly stipulate that one review can only be submitted through a single channel. A second problem is, what one IPCC author calls the problem of the “silent majority” (Nakicenovic, 1997). Even if a majority of reviewers support certain conclusions they are unlikely to mention that as part of their review comments while the few reviewers who want the conclusions changed explicitly voice their dissatisfaction in their reviews. This may result in changes in the document in response to just a few critical comments. There are no easy remedies to solving this problem other than encouraging reviewers to include conclusions they support, not just the ones they disagree with, a point which the IPCC review guidelines already emphasize.

Finally, a third, and potentially the most significant flaw is that even though extensive peer review is conducted, the action on specific comments is largely left to the discretion of the writing teams. Technical Support Units do play a watch-dog role but they can only persuade authors to follow up on review comments which writing teams may have inadequately dealt with. If these writing teams are dominated by opinionated experts holding one particular viewpoint then conceivably, they could get away with ignoring some, or a majority of all critical review comments. This may have been the case in Chapter 6 of the Working Group III Second Assessment Report which used extremely controversial assumptions to calculate the “social costs” of potential climate change (Pearce et al., 1995). For example, a cash value of \$1.5 million was assigned to a human life in the OECD against a mere \$150,000 in the developing countries (Meyer and Cooper, 1995). As a result, the Working Group III report failed to get plenary approval in July 1995, a dubious first for the IPCC. The situation could have been avoided had there been greater external supervision regarding action by the authors on peer review comments. There is currently an active discussion within the IPCC to set up “editorial boards” on the lines of a scientific journal to fix this flaw in the peer review process (Watson, 1997). Whether this innovation is actually adopted and if it actually improves the review mechanism remains to be seen.

The *line by line consensus* approval of policymaker summaries, meanwhile, is an intensely political process. It is straightforward to see why countries such as small island states which feel threatened by sea level rise would push for much tougher language on climate change risks and the need for urgent action. Equally evident is why oil producing countries which might suffer economically from any shift away from fossil fuels would try to steer the IPCC message towards emphasizing scientific uncertainties and greenhouse gases *other* than carbon-dioxide. Then, of course, while developing countries want to emphasize that a bulk of *past* greenhouse gas emissions have come from the industrialized world, the developed world would rather have the IPCC emphasize that a bulk of *future* emissions will come from developing countries. All these are obviously different shades of “the truth”, none more scientifically defensible than the other. This makes the IPCC process particularly susceptible to political pressure in terms of which aspects its summaries should emphasize more.

Functioning in this highly polarized environment, the IPCC plenary approval process of policymaker summaries often resembles a fox-trot performed by a drunken couple: one lurch forward, followed by a sideways stagger, then a stumble backwards. A British diplomat who attended the fourth IPCC plenary in Sundsvall in 1990 when the First Assessment Report was released notes: “having started in a very organized fashion with songs about the future from children’s choirs...the meeting came close to a breakdown. It finished at four o’clock in the morning, one day late, with most of the delegates having abandoned their chairs in the conference hall to gather on the front podium and shout at each other” (Brenton, 1994). The final negotiated statements from such sessions are often based on least common denominator conclusions written in carefully hedged language. It is indeed true that many IPCC conclusions are generally more vague and have many more caveats than the more direct, policy-proactive statements that emanated from conferences such as Villach 1985, Villach and Bellagio 1987 and Toronto 1988. However, the IPCC conclusions, in their modesty, are much more scientifically

defensible than the distinctly activist stance taken by some of its predecessors, such as the 1987 call by Bellagio experts setting of “tolerable” rates of temperature and sea level rise.

It is important to recognize a frequent trade-off assessments are virtually driven to make is between scientific credibility and policy specificity of conclusions. Line by line approval of policymaker summaries by consensus in the IPCC is clearly an attempt to buy global credibility *amongst governments* while the Villach/Bellagio workshops were more an attempt to effect prompt policy outcomes. Neither approach is implicitly superior. However, the fact that key conclusions from both rounds of IPCC Assessments *did* manage to catalyze the policymaking process indicates that with adequate skill, expertise and persistence, policy impact *need not* come at the cost of credibility.

An important question is whether the political credibility of the IPCC can be preserved in ways other than requiring line by line consensus approval of summaries. After all, with the establishment of the Intergovernmental Negotiating Committee (INC) in 1990, the IPCC is no longer the forum to debate policy. And governments do not need to consensually approve science, particularly after their scientists have both participated in writing and reviewing the assessment. Furthermore, with the FCCC now having its own functional Subsidiary Body for Scientific and Technical Advice (SBSTA) to interface between the IPCC assessments and policymakers, it might be sensible to remove the line by line governmental scrutiny of IPCC summaries. In practical terms, however, it might not be politically feasible to take back what governments have already become used to. Moreover, plenary sessions often serve as the only forum for many governments, particularly developing countries, to openly hold the IPCC accountable for whether or not it adequately considered the views sent in by their experts during peer review. This is indeed a very important function which IPCC plenaries serve and should not be done away with. Therefore, a compromise solution might be to retain plenary acceptance of underlying documents. As far as policymaker summaries are concerned, even if line by line approval is retained, approval rules can be changed so that acceptance is by a *significant majority* instead of *complete consensus*. This would most likely retain political credibility with a majority of governments and yet prevent one or two governments (which is usually the case) from unnecessary holding the process hostage by stalling plenary approval or substantially diluting the IPCC conclusions.

Developing Country Participation

In his letter to member governments announcing the proposal to establish the IPCC on March 25 1988, WMO Secretary General Obasi noted that the membership of the Panel should include major greenhouse gas emitting countries, ensure equitable geographic representation and allow for participation by countries with considerable scientific expertise on the subject. At the same time Obasi cautioned “it is obvious, however, that the Panel should be small enough so that it can function effectively” (Obasi, 1988). This turned out to be an inconsistent set of goals and the idea of a small core membership for each IPCC Working Group which was adopted during the first IPCC plenary session (IPCC, 1988) was subsequently abandoned (IPCC, 1989) in order to allow for widespread participation particularly by developing countries. As Bert Bolin commented to a climatologist colleague soon after he was asked to chair the IPCC “right now, many

countries, especially developing countries, simply do not trust assessments in which their scientists and policymakers have not participated. Don't you think global credibility demands global representation?"(Schneider, 1991).

Operationalizing effective developing country participation, however, has been, and continues to be, a major challenge for the IPCC. In fact developing country participation is the only issue (other than the IPCC budget) to be discussed in almost every session of the IPCC Bureau from 1989 to 1996. In its very first session in February 1989 the IPCC Bureau established an "Ad-hoc Sub-group on Ways to Increase Participation of the Developing Countries in IPCC Activities" chaired by A. Al-Gain of Saudi Arabia, who was also the Vice-Chair of the IPCC. Other members of this group consisted of representatives from Brazil, Senegal and Zimbabwe. Their findings were presented to the second plenary session of the IPCC in June 1989. A number of action items were proposed by this group both for the short term and the medium to long term.

Four short term (18-24 months) items were identified: expanding financial support for developing country experts to attend sessions of the IPCC and its Working Groups; identification of developing experts and their area of expertise and to eventually develop "master resource lists" of these experts at the national level; formation of national committees which can use IPCC findings to garner resources to set up national action programs; and to have IPCC sponsored conferences and seminars to help increase awareness. For the longer term (2 - 10 years) the following four priorities were identified: the IPCC work should provide a useful input to existing technical cooperation plans, for example, to shape the research priorities of the African Center of Meteorological Applications for Development; using existing WMO and UNEP programs such as the Global Environmental Monitoring System and World Climate Programme to disseminate relevant information, technology and expertise; to encourage developing countries to include climate change considerations in their development plans; and to develop intellectual and scientific resources in developing countries.

Based on these findings, participants at the Second IPCC plenary in 1989 decided to establish a "Special Committee on the Participation of Developing Countries" under the chairmanship of Jean Ripert of France (who later became the first chairman of the INC) and with representatives from four other developed, and five developing countries. This committee met three times between September 1989 and June 1990 and its findings were presented to the fourth IPCC plenary session in Sundsvall (Sweden) in August 1990 when the First Assessment Report of the IPCC was also approved. The committee noted five factors which limit the full participation by developing countries: insufficient information about the problem, ineffective channels to disseminate this information, limited number of trained scientists, institutional difficulties such as lack of coordination between various ministries which might have a stake in the climate issue, and limited financial resources. Its recommendations largely echoed those made by its predecessor, the Ad-hoc group on developing country participation, discussed earlier.

Table 1—PARTICIPATION IN IPCC PLENARY SESSIONS

Year	Non-OECD Countries	Total Countries
1988 (IPCC I)	14	30
1989 (IPCC II)	25	44
1990 (IPCC IV)	48	70
1991 (IPCC VI)	57	79
1992 (IPCC VIII)	77	96
1993 (IPCC IX)	94	115
1995 (IPCC XI)	98	117

In terms of concrete action, IPCC efforts to encourage developing country participation over the years can be described as a partial success. By the time of the second plenary session of the IPCC in 1989 most OECD countries (and the USSR) were already represented on the Panel. Non-OECD participation took much longer to increase. As shown in Table 1 it has grown steadily from a mere 14 at the first plenary in 1988 to 48 in 1990 when the First Assessment Report was released, to 98 in 1995 during the eleventh plenary session of the IPCC when the Second Assessment was released. Recall, one of the primary goals of having an “intergovernmental” mechanism in the first place was to get governments involved in the climate change issue. In this respect the IPCC has certainly been an unqualified success. A majority of developing countries from Bhutan to Benin which might not have been interested in climate change nine years ago are now willing to send their delegates to IPCC sessions.

Over the years the IPCC has undertaken several specific measures to encourage participation by developing country scientists both as authors and reviewers. Almost half of the annual budget outlays from its Trust Fund are used to pay for trips made by these experts to attend the meetings of the Panel and its Working Groups. For example, as early as 1989 (barely a year after the IPCC was set up) about US \$ 254,000 were spent to pay for 85 trips by 80 developing country experts to attend IPCC meetings (IPCC, 1990a). This number has grown substantially in recent years. In fact, financial support for *at least* one developing country expert to attend *each* writing team meeting of every IPCC chapter was made mandatory during its Second Assessment cycle. Many developed countries have also stipulated part of their contributions to the IPCC Trust Fund to

support the research and/or travel of developing country experts. In addition, another significant component of the IPCC budget is used to translate its documents in all UN languages for broader outreach. Furthermore, when the rules of procedure of the IPCC were amended in 1993 it was explicitly stipulated that for *each* chapter in the Second Assessment there should be *at least* one developing country *lead-author*. Finally, the new rules stipulated that the chairmanship of each Working Group was to be shared by one developed and one developing country scientist.

Although these measures have improved the situation, they have clearly not been sufficient. A major shortcoming of all IPCC efforts including its Second Assessment has been that information on climate change impacts and the feasibility of adaptation and mitigation options is still sorely lacking for developing countries. Global generalizations are often drawn from a relatively over-sampled set of data from a few developed countries. This situation cannot be corrected unless assessments have a more regional focus, a fact which is currently under serious consideration by the IPCC for the design of its Third Assessment (Watson, 1997).

Perhaps even more importantly, the *assessment* efforts of the IPCC need to work in tandem with *research and data gathering*, particularly in developing countries to plug the gaps in existing knowledge. However, with the notable exception of the IPCC-OECD Methodologies for Greenhouse Gas Emissions Inventories which are being widely applied to construct national greenhouse gas inventories, there has been very little application of other IPCC methodologies to conduct standardized impact and mitigation assessments in developing countries, or to use the research gaps identified in IPCC reports to shape future research. One reason is that with a total professional staff of less than eight (to manage the Secretariat and all three Working Groups) and a shoe-string budget, the IPCC was never designed to duplicate research efforts of well established programs such as WCRP and IGBP. Further, while the IPCC has several design features (such as governmental participation and policymaker summaries) to build *the bridge forward towards policy*, it does not have effective mechanisms *to build the bridge back towards research*. Perhaps, at the end of the assessment process, there should be an institutionalized mechanism within the IPCC to engage its authors in a discussion with the managers of collaborative research programs, NGOs and multilateral development agencies. These meetings could be used both to market any methodologies the IPCC might have developed and to help such organizations plan future research so as to reduce existing research/data gaps which the IPCC assessment may have identified. However, IPCC Chairman Bert Bolin notes that the Panel has consciously stayed away from directly shaping research priorities. This is to avoid unnecessary politicization which he believes would undoubtedly result if IPCC experts had the power to influence where future research dollars went (Bolin, 1997).

The long term solution to improved developing country involvement in climate change assessments hinges critically on the building of indigenous capacity and awareness in these countries. The IPCC has only made some limited advances in this direction. According to Roberto Acosta-Moreno of Cuba, one of only a handful of developing country Convening Lead Authors in the IPCC Second Assessment, the Panel has helped raise awareness about the problem in Cuba. It has also helped train more than 50 Cuban

scientists through their participation in IPCC writing teams and workshops. However, he notes that the extent of benefits a developing country can draw from participation in the IPCC is a strong function of the prevailing levels of education and intellectual expertise. Cuba, in this respect, might have been an exception because it has reasonably trained experts which the IPCC could draw on and further encourage (Acosta-Moreno, 1997). This might not be true for a majority of other developing countries and therefore merely encouraging participation might not contribute significantly to capacity building in these countries.

Low preexisting levels of developing country research capacity which might inhibit their effective participation should realistically be recognized as an *externally imposed constraint* on the effectiveness of the IPCC. The IPCC does not have the mandate, funds or the expertise to conduct the job of national governments or multilateral development agencies in terms of capacity building. Neither can it micromanage dissemination and outreach of its assessments within these countries lest it be misconstrued as “propaganda” by the host government. Similarly, it is well known that most IPCC communications are dealt with by one specialized agency (such as the Department of Meteorology) within many developing countries. These agencies often do a poor job at transmitting IPCC communications and reports to other agencies (such as the Ministries of Environment, Energy, Transportation and so on) which might also have a stake in the climate problem. This constrains the effectiveness of several aspects of the IPCC process including author and reviewer nominations as well as dissemination of results. Yet, there is little the IPCC can do to improve these internal communication networks as it might be tantamount to interference in the domestic affairs of the concerned country.

In conclusion, while the IPCC has made concerted efforts to engage developing country scientists, these efforts have only met with limited success. There are also considerable gaps in data and research with regard to climate change impacts and mitigation information in developing countries. This, at least partially, stems from the lack of any formal coordination between IPCC assessments and the research priorities of multilateral programs in this field. The long term solution to more effective developing country participation is enhanced awareness and the building of indigenous research capacity. The IPCC however might not be the right forum to effectively address these endemic issues. They should, instead, be addressed by developing countries themselves in conjunction with multilateral development aid agencies.

Links to Decisionmaking

There are two intertwined aspects of the IPCC: assessment *outputs* and the assessment *process* itself. Similarly, policymaking has two aspects: the final outcomes in terms of conventions signed and decisions taken, and the process of arriving at these decisions. Policy influence of the IPCC therefore has four components: how the IPCC *outputs* have shaped policy *outcomes*, how the IPCC *process* has shaped policy *outcomes*, how IPCC *outputs* have shaped the policy *process*, and how the IPCC *process* has shaped the policy *process*. In the context of climate change few policy outcomes have been observed. Yet, it is premature to conclude that the IPCC has been ineffective. Instead, the policy

influence of the IPCC should be judged by how its outputs and process have shaped the policymaking process over time.

Links Between IPCC Assessment Outputs and the Policy Process

In its first session in February 1989 the IPCC Bureau adopted a proposal by Working Group I to incorporate a 20 page "policy document" in its assessment which would summarize the scientific results and place them into perspective. The Bureau then requested the other two Working Groups to produce similar "policy documents" (IPCC, 1989). These became the well known policymaker summaries of IPCC Assessments. The summary produced by Working Group I for its First Assessment is widely regarded as being very authoritative. One of its statements that (under a business as usual scenario) the world is likely to see "a rate of increase of global mean temperature during the next century...that is greater than that seen over the past 10,000 years" was, by most accounts, very influential in catalyzing the decisionmaking process which eventually led to the signing of the FCCC in 1992. The summaries for the other two Working Groups were much less successful due to a lack of consensus, significantly higher uncertainties, and the implicit value laden nature of many conclusions on climate change impacts and responses. This trend has largely continued on to the Second Assessment. Once again, it was a line in the Working Group 1 Summary: "the balance of evidence suggests a discernible human influence on climate change" which, in many ways, defined the entire Second Assessment and provided a rallying cry for environmentalists and governments (including the chief US negotiator Under Secretary Tim Wirth) that it was time to "put the science behind us" and commit to a legally binding climate treaty (Wirth, 1997).

That an assessment whose policymaker summaries require word by word consensual approval by government representatives with very obvious political stakes could still come up with a few key conclusions that provide significant triggers for subsequent policy action should not be dismissed lightly. On the other hand, the policy usefulness of IPCC impact and response assessments has been constrained by significantly higher uncertainties. They have also not done an adequate job of effectively communicating the nature of prevailing uncertainties (whether uncertainty stems from a lack of consensus or a lack of data, what the extent of disagreement is, where precisely uncertainties are in the causal chain, and so on) in these areas. Thus overall, the influence of IPCC outputs on the policy process has been occasional, but significant. The nature of the influence, on the other hand, has been largely symbolic in terms of triggering and sustaining policy concern and considerably less in shaping subsequent action.

Links Between the IPCC Assessment Process and the Policy Process

The interactions between the IPCC process and the climate change policymaking have had an interesting evolution and, in fact, go back to the time when the IPCC was established in November 1988. Two months later, in January 1989, the UN General Assembly adopted a resolution proposed by Malta on "Protection of global climate for present and future generations of mankind". In addition to requiring the IPCC to conduct assessments of science, impacts and responses, this resolution formally charged the heads

of WMO and UNEP working through the IPCC to provide a comprehensive review and recommendations on "the identification and possible strengthening of relevant existing international legal instruments having a bearing on climate; (and) elements for inclusion in a possible future international convention on climate" (UNGA, 1989). Thus, in its initial years the IPCC fulfilled the unique dual role of assessing knowledge to advise policy, and at the same time directly helping shape policy itself.

In response to the General Assembly resolution the heads of WMO and UNEP established a small "WMO/UNEP Task Force on a Convention on Climate Change" which met for the first time in October 1989. This advisory body consisted of two representatives each from WMO and UNEP, the coordinator of the Second World Climate Conference (to be held in 1990) and three experts from the IPCC Legal Measures Sub-group of Working Group III. The goal was to draw on the ongoing work in IPCC Working Group III which was debating possible elements for inclusion in a climate convention and use them to arrive at specific "action oriented measures" which national governments could agree to as part of a possible climate convention. A less obvious, if politically more important, goal of this task force was to keep the deliberations for the climate convention low key and to prevent them from becoming enmeshed in the much more political UN General Assembly. This was Tolba's attempt, assisted by WMO and IPCC, to duplicate the informal "ad-hoc group on legal and technical experts" which had led to the signing of the Vienna Convention on Ozone. The IPCC had direct input into this task force, but the latter was soon replaced by the more formal, Intergovernmental Negotiating Committee (INC) under the auspices of the UN General Assembly sponsored in 1990.

The IPCC process contributed to the setting of the INC in two ways. First, the high profile nature of the then ongoing IPCC First Assessment convinced many governments of the need to seriously negotiate a climate convention. Second, until then the IPCC had achieved limited success in its efforts to engage developing countries for its First Assessment cycle. This made some large developing countries, in particular Brazil and Mexico very suspicious of the IPCC (though it is important to note that many other developing countries, particularly from Africa were very supportive of the IPCC), and consequently of the small Task Force on a Climate Convention. Furthermore, they believed that climate change was closely linked to development, and hence not purely a technical issue (Bodansky, 1994). They therefore pressured a political body, the UN General Assembly, to take charge, a move which was eventually supported by the US, their close ally. These opinions came to the fore during the meeting of an open-ended ad-hoc group of government representatives convened by WMO and UNEP in September 1990. This led to the creation of the INC under the auspices of the UN General Assembly. Climate science and policy were thus formally split and housed in two separate intergovernmental mechanisms with different sponsorships.

The INC held its first session in February 1991 and met four more times until the signing of the Framework Convention on Climate Change (FCCC) in June 1992. According to Jean Ripert who chaired the INC since its inception until 1993, the IPCC process played important substantive and symbolic roles during the protracted negotiations for the climate convention. Ripert, a senior French diplomat had been closely involved in the

IPCC process prior to his election as INC chair. He had chaired the IPCC Committee on Participation of Developing Countries and had also attended the meetings of IPCC Working Group III where elements of a possible convention were being deliberated. Ripert believes that by providing a “first-cut” at elements of a possible convention, Working Group III of the IPCC made an important substantive contribution to the subsequent negotiations as it made the work of the INC more efficient than it would have been had they started from scratch (Borione and Ripert, 1994; Ripert, 1997). On the more symbolic side, the fact that the IPCC Chair Bert Bolin addressed each session of the INC and kept negotiators abreast with ongoing IPCC assessment activities helped keep “the pot hot”. More significantly, the scientific consensus reached by a credible, international group of experts in IPCC Working Group I during its First Assessment as well as its reaffirmation of earlier findings in the 1992 Report just prior to the Rio Summit played a critical role in pushing the negotiations towards a convention. Ripert concludes that the negotiation and signing of the climate convention would “definitely not” have been possible without the IPCC (Ripert, 1997).

Shortly after the FCCC was signed in 1992 the INC elected a new chairman, Ambassador Raul Estrada Oyela of Argentina. Meanwhile IPCC underwent a major restructure, guided in part by the twin goals of ensuring greater developing country representation and making its assessments more responsive to the changing needs of the policy makers. The challenge now was to operationalize the various goals of the FCCC. For example, Article 4.1 of the Convention called on all parties to the Convention “to develop, periodically update, publish and make available inventories of anthropogenic emissions... using compatible methodologies agreed upon by the Conference of Parties”. IPCC offered to build on an effort it already had underway in collaboration with the OECD to develop these methodologies, a proposal which was readily accepted by the INC. These methodologies are being widely tested and applied in many countries and form the internationally accepted basis for the reporting of greenhouse gas emissions by developed countries under the FCCC. This is a seminal example of a dynamic assessment process directly feeding into a dynamic decisionmaking process. The INC also expressed interest in receiving IPCC input in three other areas: “assessment of the relative forcing of different greenhouse gases, ..the state of knowledge for assessing impacts of climate change, ..and an evaluation of current scenarios of greenhouse gas emissions” (Estrada-Oyela, 1993). More importantly this information was desired before the First Meeting of the Conference of the Parties (CoP) in March 1995. The IPCC was able to respond to all three requests by producing a three-part 1994 Special Report, in time for the March 1995 meeting although its Second Assessment was released a year later.

Overall, however, the interaction between the IPCC and the FCCC process has had a rocky history. Over the years there have been concerns voiced within the INC as to whether IPCC would be able to deliver what the negotiators need and when they need it (Box 2). This problem has been an endemic feature of many institutionalized assessment processes. Lawmakers in the US, for example, had similar complaints about both the National Acid Precipitation Assessment Program (NAPAP) and the Office of Technology Assessment (OTA). In the case of the IPCC, however, the trade-off between the time required for “proper” assessment practice and decisionmaking relevance was even more exacerbated. This is because of many aspects in its design including intergovernmental

status, multiple rounds of peer review and a mandate to have adequate representation of developing country experts.

In recent years, the IPCC has initiated two institutional sets of responses to make its outputs more in tune with the needs of its primary users and to deliver them in a time frame which suits their decisionmaking cycles. In March 1993, a few months after the signing of the Climate Convention, IPCC Chairman Bert Bolin wrote to his counterpart at the INC to start an ongoing dialog between the two institutions. This resulted in the creation of the IPCC-INC Joint Working Party (JWP) consisting of senior officials from both organizations. The JWP met for the first time in November 1993 and has continued to meet regularly since then. The only cosmetic modification was that the INC was replaced by the Secretariat of the FCCC after the first meeting of the Conference of Parties (CoP) in March 1995. The (old) JWP now goes under the name of the Joint Working Group (JWG) of the officers of the IPCC and the Bodies to the Framework Convention. Issues discussed in these meetings over the years include the development and testing of IPCC-OECD methodologies for greenhouse gas emissions inventories, the contributions of different gases to climate change, decisions regarding allocation of emissions from bunker fuels, IPCC inputs to the INC review of adequacy of commitments made by certain parties to the FCCC, specific informational inputs the IPCC could provide at the various sessions of the INC/CoP, and so on.

BOX 2

The Frankenstein Syndrome

In his remarks to the Royal Geographic Society in London on May 31, 1994, INC Chairman Raul Estrada-Oyela said that for the time being the Convention process was "waiting for (scientific) inputs from the IPCC but I wonder if they will come in time. Almost one year ago, explaining the needs of the Convention to the IPCC Bureau, I had the feeling that the IPCC was suffering (some) kind of 'Dr. Frankenstein Syndrome'. After all, the idea of a Convention was nourished by the IPCC, but now the Convention starts to walk and begins to demand additional food, the IPCC answered that it had its own program of work and could not deliver products by client's request. ... We hoped, for instance that the Convention would profit from an IPCC workshop on the objectives of the Climate Convention in Fortaleza, Brazil, in April (1994). However, the workshop was postponed for October (1994), most probably for very scientifically sound motives. The point is that the INC shall meet next August and we are not going to have that input then" (Estrada-Oyela, 1994). London based New Scientist took these comments to make a news story entitled "Frankenstein Syndrome Hits Climate Treaty" marking the first public criticism of the IPCC by an INC official (The New Scientist, 1994).

The second institutional response instituted by the IPCC to make its outputs more timely and digestible without compromising their scientific credibility is its diversification of assessment outputs to include Special Reports and Technical Papers. Special Reports constitute a more targeted (as opposed to a comprehensive) assessment of specific issues of decisionmaking relevance on which information is needed on a one-two year time frame. The IPCC has published two Special Reports, one in 1992 before the signing of the FCCC and the second in 1994, before the first meeting of the CoP, both in response to specific demands from international negotiators. Technical Papers are an even more recent innovation and may owe their creation to the "Frankenstein Controversy"(Box 2). The IPCC realized that its continued relevance depended critically on its ability to

provide concise, “rapid response” reports on key issues relevant to the Convention. The four Technical Papers which the IPCC released in 1997 do just that. They were prepared on a schedule of about six months and essentially distilled information from the IPCC Second Assessment relevant to a few key issues that the FCCC bodies (the secretariat, SBSTA and Subsidiary Body for Implementation) were grappling with. Since these papers were essentially drawing on the Second Assessment which had already been approved by governments, the problem of line by line approval by government representatives was also skillfully avoided.

More important than the details of these institutional innovations is the fact that there is an ongoing dialog between the producers and users of assessments. This interaction between the assessment and decisionmaking processes has not been perfect, and indeed cannot be. Scientists cannot always deliver information in the form and time frame that political negotiators might find useful. Nevertheless, this ongoing interaction has not only provided useful inputs to the negotiation process but has also helped shape IPCC outputs in response to user needs. As shown by the examples of the Joint Working Group, the IPCC Special Reports and Technical papers, despite its cumbersome size, political and institutional constraints, the assessment process has indeed shown a capacity for iterative improvements and institutional learning. Thus, the richest interaction between the IPCC and climate change decisionmakers has been at the process level.

Conclusions

Assessments are often viewed as black boxes whose only measurable metric is the reports they produce. This paper underscores the importance of viewing them as dynamic social processes. The following paragraphs evaluate the institution along three critical dimensions: scientific credibility, institutional innovation and policy relevance.

Scientific Credibility

An important point which is often overlooked is that the IPCC was the product of an intensely *political* process within the US, and the UN system. The specific purpose for setting it up was also political: to engage governments worldwide in climate change decisionmaking. Thus, it is somewhat of a paradox that the IPCC managed to attract and sustain the participation of high caliber *scientists* and has consistently produced reports that carry credibility in scientific circles. Part of the answer lies in the *multiplicity* of political actors (various US agencies, UNEP, WMO, and many different countries) and the *divergence* in their respective interests. This may have led to a scenario in which *all actors had to give up control* of the assessment process by nominating a credible independent scientist to chair the IPCC, as well as through procedural rules such as universal participation, process transparency, and so on. Bert Bolin’s nomination as IPCC chair in 1988 lent credibility to the nascent assessment process and probably induced other eminent scientists to participate. This set forth a self-reinforcing mechanism: the more credible experts there were already in the IPCC, the more attractive it was for other established experts to join, the more internal strength the institution had to defend its scientific integrity against political pressures. It is not entirely inconceivable that had a single or more unified group of political actors been responsible for the creation of the

IPCC, or, if a bureaucrat or even a scientist of lesser stature been nominated as chair, the assessment process might have been a non-starter or spiraled towards lower and lower credibility.

Institutional Innovation and Learning

Although the external contours of the IPCC have by and large been preserved over the two assessment cycles, it has exhibited a certain amount of dynamism in response to changing circumstances. Some examples of institutional innovation discussed in this paper include: the decision to produce policymaker summaries (1989), establishment of a Special Committee for Participation of Developing Countries (1989-90), preparing a special report to aid Earth Summit negotiations (1992), restructuring of IPCC Working Groups to learn from the First Assessment experience (1992-93), starting a process of interactive dialog with officials from the FCCC bodies (1993-), the ongoing IPCC-OECD effort to standardize reporting on greenhouse gas inventories (1991-), and the introduction of “rapid response” Technical Papers for FCCC bodies (1996-). Few international organizations, let alone large scale assessment bodies have shown such institutional agility and learning.

These adaptations over the years have clearly enhanced the IPCC’s survivability in an environment where its predecessor, the AGGG failed to make a mark. A more interesting question, however, is not *whether* but *how* the IPCC has been able to display such institutional learning. First, there are in-built features within it such as plenary sessions and regular interaction with FCCC bodies which provide a forum for stakeholders to discuss and shape subsequent assessment activities. This dynamic interaction probably makes the assessment process more responsive to changing user needs. Another important feature of the IPCC is that participants do not get paid or hold “permanent” positions. Compared to more hardened bureaucracies this reduces incentives for maintaining “status-quo” within the IPCC. Finally, idiosyncratic factors such as leadership, both in stature and substance cannot be overlooked.

It must, however, be pointed out the IPCC has exhibited this dynamism within a rather limited domain. It studiously stays clear from policy recommendations. It even avoids shaping the priorities of global change research programs to avoid unnecessary politicization of its assessment process. Many argue that this sanitized approach and IPCC’s reluctance to “get its hands dirty” may have made it less useful than it could have been. Others, most notably IPCC managers contend that this was the only way the body could preserve its scientific credibility.

Relevance and Policy Impact

The appropriateness of an assessment activity is a function of where the issue is in the policy cycle. The Villach workshops in the early 1980s were probably an appropriate mechanism for assessing scientific knowledge on climate change at the time there were held. They were probably not sufficient to get global governmental agreement on a complex, multi-sectoral, uncertain and political problem as climate change. This paper argues that something like the IPCC was an evolutionary necessity.

Comparisons are often drawn between the ozone and climate change experiences. The ozone assessments through the 1980s did not have significant governmental involvement

or nearly as many procedural rules. Nor did they have as large and diverse a participant pool as the IPCC. One question therefore is, *could ozone have been duplicated in climate?* This research argues that it would not have been possible. Climate change bears a close relationship with the energy and land-use sectors which in turn are much more central to economic development than CFC use. Consequently, by its very nature climate change is much more political than ozone. Second, climate change may have suffered from *ozone recoil*. For example, there was reluctance in some quarters to let Mostafa Tolba dominate climate change the way he had, ozone. This may have influenced many aspects of IPCC design. Furthermore, agreement on a protocol after a framework convention was faster in ozone because the US and most other OECD countries were strongly behind it while major industry groups, Japan and Russia were no longer opposed to it. A climate protocol has not been negotiated thus far because some powerful governments, particularly the US are still not completely supportive of it. This in turn is because the extremely influential US domestic fossil fuel lobby is strongly opposed any binding agreement. Thus the extent to which different global environmental issues may or may not get resolved may depend more on where powerful political actors stand and the economic power of the lobbies opposed to an agreement than on whether or not assessments of those problems were inherently more or less superior.

Given that a climate protocol has still not been signed what are some benchmarks to assess the performance of the IPCC during its first two assessment cycles? As noted earlier, according to Jean Ripert, the founder chairman of the INC, the FCCC would “certainly not” have been possible without the IPCC. It is equally important to note that Ripert is not a scientist with a stake in the IPCC but a diplomat from France, a country which has limited political interest in climate change. The biggest contribution of the IPCC, however, has not been at the level of aiding spectacular decisions but rather at the level of low-key *process* interactions with its users. It has provided inputs which may not have caused decisions to be made but may have made decisionmaking more efficient than it would have been without the IPCC.

An indirect measure of the relevance of the IPCC to policymaking comes from the fact that many industry lobbying groups invest a lot of resources in reading the fine print of IPCC reports, attend its plenary sessions and even conduct expensive media campaigns which cast aspersions on IPCC findings and authors. They would clearly not have invested so much time and money had the IPCC not been critical to decisionmaking. On the other hand, environmental advocacy groups which were so active on the assessment arena in the 1980s have stopped doing their own assessments. In November 1988 only one environmental advocacy group attended the first plenary session of the IPCC. Many others had elected instead to attend a conference in Hamburg to follow their own climate agenda. Now, many draw legitimacy from the IPCC. They attend IPCC sessions in large numbers, cite its conclusions and their contributions to IPCC activity in public statements and even annual reports. The IPCC has not *demand*ed hegemonic status, it may have *commanded* it.

Finally, in the aftermath of big international conferences issue salience fades rapidly. This happened after the Stockholm Conference in 1972. It has also happened after the 1992 Earth Summit for two of the three issues for which conventions were signed:

desertification and biodiversity. Yet, climate change has remained highly salient both in the media and on the policy agenda. There were no major assessments other than the IPCC during this time, no major international environmental agreements (so no case for Montreal Protocol type spillovers), and no dramatically “hot summers” to capture media attention as they did in the late 1980s. In other words, most other causal factors were pointing in the direction of *decreased* policy salience of climate change after 1992. The fact that serious discussions are still on for a climate treaty is at least partly due to the IPCC Second Assessment activity and its findings.

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Endnotes

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ⁱⁱ The international atmospheric research community had, in fact, come to be mobilized with the setting up of Global Atmospheric Research Program (GARP) under WMO auspices a decade earlier. GARP was set up partly in response to President Kennedy's address to the United Nations General Assembly in 1961 in which he called for the "peaceful uses of satellites" (Bolin, 1997). One of the first recognitions by a non-governmental organization (NGO) of the climate change threat was at a 1963 meeting sponsored by the Conservation Foundation which concluded that "it is estimated that a doubling of carbon dioxide content of the atmosphere would produce a temperature rise of 3.8 degrees Celsius" (Kellogg, 1987). The first official recognition came from the US President's Science Advisory Committee in 1965 when, amongst other things, it recognized that climate change could be caused by human activities and could have important consequences (PSAC, 1965).

ⁱⁱⁱ The global cooling debate subsided after the WMO sponsored International Symposium on Long Term Climate Fluctuations in 1975. This resulted from a conclusion reached at this symposium that low-lying industrial aerosols and smoke particles *do not* cause a cooling of the lower atmosphere when they are over land, which is where much of the pollution exists (Kellogg et al., 1975).

^{iv} Coincident developments during this period included: two major assessments of climate change by the National Research Council (NRC, 1983) and the Environmental Protection Agency (EPA, 1983) in the United States, the widespread diffusion of the finding that the warming produced by carbon-dioxide would be matched in magnitude by the combined warming effect of other greenhouse gases over the long term (Ramanathan et al., 1985), and the high degree of public and policy-maker interest in the threat of ozone-layer depletion which eventually led to the signing of the Vienna Convention in 1985. Excessive detail is avoided to prevent digression from the main theme of this paper but the reader is referred to the many published historical accounts of this period, e.g. (Revelle, 1985; Kellogg, 1987; Brenton, 1994).

^v The years 1987 and 1988 were marked by severe heat waves in North America, Hurricane Gilbert struck the Caribbean and caused more than \$1 billion in damage, there was a freak hurricane in the English Channel and a chunk of ice approximately 100 miles long and 25 miles wide broke off the coast of Antarctica. These events contributed to heightened public concern both on the possibility of warming trends and the possibility of increased risk to extreme climatic events.