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"Some type of global warming is undoubtedly upon us. ... It should be a major concern even though we cannot predict to any reliable degree what is going to happen."

"Global warming ... it is not an issue I am going to lose any sleep over."

INSIDE SCIENCE

A Preliminary Investigation
of the Case of Global Warming

by

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Inside Science

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Abstract

In this paper we present a preliminary and exploratory analysis of a series of in-depth interviews conducted with twenty eight climate scientists. After justifying the need for such research we present some preliminary results. These are in the form of: (1) the perceptions of risk and hazard as they relate to global warming; (2) the typification of issues drawn from the triadic relationship of science-politics-public and; (3) the typification of 'scientific personalities'. The perceptions of risk and hazard and typifications of issues are presented as brief edited excerpts from a broader range of the interviews. The typification of 'scientific personalities' are presented as three lengthy edited excerpts from interviews with three scientists. Finally, based on the qualitative data in the interviews, we draw a brief conclusion regarding the nature of the research of global climate change.

While the data demonstrates that, for the most part, the risk of global climate change is a consensual product of scientific practice, the hazards associated with the event are determined to have a much closer affinity with the scientist's personal belief system. It is often these beliefs that come to play a role in the application of science to the public and political spheres.

1. Introduction

One could not deny that global warming, real or imaginary, is a major issue in contemporary Western society and an issue that demands policy attention. One of the major obstacles to overcome in the development of relevant policy is the divergence that exists among the public, scientific and political perspectives, for ultimately, all three components have input into policy development. In a recent ethnographic study of public perceptions, Kempton (1991) concluded that there is a great diversity of public opinions concerning the causes and consequences of global warming, as well as a divergence in the levels of concern. Kempton also concluded that the public perceptions, in turn, differed from those of the scientific community. We feel that the degree of divergence found among the public perceptions is likely also present within the scientific community involved with the climate sciences.

It would seem that it is generally, although not totally, accepted, that human actions are having an impact on the atmosphere and that the outcome will be a rise in the mean temperature of the globe as a result of these actions. As Brown (1992:208) points out, however, "there continue to be uncertainties about the size and speed of the temperature increase, its implications for human activities, and its ecological effects." Often these uncertainties are presented in the formal manner of scientific papers. The less formal debates among scientists, those occurring on a daily basis, are much more difficult to capture and almost absent in the existing literature. To this end, we have interviewed a

number of scientists working within the field of climate science and in the following we present a brief summary of the results thus far. We proceed with the assumption that the conceptions and perceptions of the magnitude and impacts of global warming are as much a matter of social construction as they are the result of natural forces.

We feel the phenomenon of global warming is also somewhat representative of a unique case. It is unique in that it has generated simultaneous extended debate within the realms of the social, political and scientific communities and this has generated multiple consequences *prior* to the realization of the event. In other words, climate, outside of scientific climatological exegeses, has been removed from the domain of fact to the realm of values, and there is no reason to expect that scientists themselves do not operate within similar realms of personal values, so shaped in concordance with the greater set of social values. Here, we investigate, through the use of in-depth, semi-structured interviews, the cognitive maps of those generating the base knowledge concerning climate change, namely the scientists involved in the generation of climatic knowledge.

We feel this is an imperative contribution to the literature for a number of reasons. First, the politics of global warming are almost wholly dependent on the word of the experts (for examples of the influence of elite and experts in ecological and environmental matters throughout history see Bilsky, 1980). Second, climate sciences are a relatively new player in the realm of science, and have possibly entered the realm when it is in a period of transition, namely the legitimization crisis of scientific rationality in which many of the founding certitudes of science have come under question. The claims of dispassionate science, of context-free truth, of value-neutrality, have all been subject to

attack. Third, climatology itself, until recently, was nested in geography, with the purpose of achieving stable climatic statistics, and was primarily a descriptive science. It was not until computing power was sufficient that there was a transformation to the analytical nature of the current state of the science. This transition of the science was also accompanied by a transition in the nature of the subject, namely, climate change was perceived as global in nature and demanded political and public actions. Subsequently, there was a tendency to change from a perception of global risk to a perception of global hazard[1], and this appears evident in the sudden allocation of resources[2]. The US global change research budget as presented by the Committee of Earth Science 1991, 1992, 1993 show the distributions of funds as follows;

Table 1.

US Global Environmental Change Research Budget (US$ millions)

Program	1990	1991	1992	1993*
Climate and hydrologic systems	291.7	450.7	505.5	629.4
Biogeochemical dynamics	198.7	249.1	288.8	333.2
Ecological systems and dynamics	90.2	140.0	152.8	240.4
Earth system history	7.7	18.2	19.3	23.4
Solid earth processes	57.4	53.6	108.6	105.2
Solar influences	8.8	13.8	18.8	15.1
Human interaction	4.8	28.3	16.8	25.9

*proposed FY 1993 budget
source: Committee of Earth Science 1990, 1991, 1993

[1] A discussion of the distinction between risk and hazard is presented in the respective section.

[2] According to Norman (1991-92) in the 1970s, the first intensive study of anthropogenic influence on climate, the Climatic Impact Assessment Program, received $50 million, by 1992 budget for climate research had reached $1.1 billion. Norman went on to estimate a 24% increase for the 1993 budget.

One should note the proportion of the budget allocated to research of climate and hydrologic systems, perhaps indicating the priority that had been assigned these topics. In 1994 and 1995, the focused budget for the US Global Change Research Program was $1446 million and $1794 million respectively, indicating a proposed increase of 11% of the total budget between 1993 and 1994, and a proposed increase of 24% between 1994 and 1995 (Pielke, 1994:6). However, these amounts are not confirmed. As Pielke points out, "The USGCRP has emphasized research on one major area of global environmental change, climate change." We could expect, then, that should the funding targets have been reached, a relative proportion would have been assigned to climate research.

Today, the consequences of the generation of climate knowledge reach far beyond the impact of mere *curiosity* research, with implications for international politics, economic restructuring and mass behaviors. As such, scientists are often asked to go beyond the intentions of their research and to make inferences and predictions for the sake of political decisions. As we shall see, some scientists encourage and enjoy political involvement, while others tend to have little or no involvement. In providing input to political or value laden questions, scientists are forced to use the same processes as lay people and are subject to the same cognitive limitations and liabilities. It is these minds, so attuned to climatic conditions, that we wish to explore, as their influence extends far beyond what they might initially perceive. This, of course, is not to say that commentary from outside the community of climate scientists does not follow similar practices of extending information to the public, and perhaps because of the nature of the presentation, in many cases, has a greater impact on public perceptions. Ecologist-environmentalist,

Paul Ehrlich's (1991:72) warning to the world that global warming marks "The beginning of the end" and Aaron Wildavsky's (1992:xv), a political scientist, claim that global warming is "The mother of all environmental scares" are good examples of the information that eventually reaches the public's ears. Other information, and as we shall see, misinformation, is often extended to the public via the various forms of mass media. Again, the involvement of the scientists with the media is a voluntary contribution, one not welcomed by all members of the scientific community. To this end, it might be suggested that participation outside of the scientific arena, that is, in the provision of information to political and public spheres, is indicative of a sense of obligation or a reflection of a personal measure of success, reflecting perhaps, traits of a particular 'scientific personality'. Almost absent in the commentary to the public however, is the input of the *typical* climate-scientist-at-work, although there have been some often repeated statements regarding the extreme nature of some announcements coming from within the climate science community. However, such statements tend to be the exception, not the rule. Nonetheless, we should not forget that those involved in the production of knowledge, in our case, climate-scientists-at-work, also perform their daily role in narrow spheres of cognitive reality and are, therefore, subject themselves to belief in situations so defined by others, a series of beliefs devoid of the knowledge of the inherent assumptions. In this sense, the producers of knowledge, the producers of science, are themselves faced with the same limiting qualities in spheres outside of their areas of expertise, as is the common lay person.

In presenting the results (Section 3) , we have divided the findings into two rather distinct parts. In Section 3.1, *Responses to Topical Issues*, we attempt to identify similarities and distinctions in relation to particular issues and topics of global warming, namely, the perceptions of risk and hazard, and the scientific perceptions of the relationships that exist between science, politics and the public. In Section 3.2, *The Typification of Scientific Personalities*, we develop what could be construed to be the typification of the scientist in relation to his or her beliefs and personal philosophy regarding global climate change. From this we have drawn some tentative categories of their cognitive apparatus.

2. Methodology

To attempt to capture the essence of the thoughts of scientists we thought the best possible tool would be a series of in-depth, semi-structured interviews. Each interview was tape recorded and then transcribed. The interviews were based on a loosely formed interview protocol, with the nature of the dialogue shaping the subsequent probes and questions. However, at the conclusion of each interview, all areas of interview protocol had been covered. This is not to say, however, that considering some of the topics and issues raised, some scientists were reluctant or unable to comment on specific areas of questioning.

The interview protocol extended far beyond the inner workings of climate science, with reference to perceptions of scientific obligations, the process of the communication of knowledge, and comments regarding the external influences shaping science, etc.[3] The mode of questioning began with somewhat general questions about the perceptions of the general relationships that exist between science and policy and then towards more specific questions pertaining to the climate sciences. We felt that starting with a general commentary, the scientist would feel more at ease when discussing his or her specialty. For reasons of anonymity, no scientist will be identified by name.

3. Results

Section 3.1 of our discussion is inclusive of the entire sample interviewed, and addresses individual topics as opposed to an individual scientific personality. For the second part of our discussion, Section 3.2, so as to provide a sense of the evolving typification of scientific personalities, we present three lengthy edited excerpts from contrasting interviews.

[3] The interview protocol is presented in Appendix A

3.1 Responses to Topical Issues

The responses to topical issues are further subdivided into five subsections: 3.1.1 Perceptions of Risk; 3.1.2 Perceptions of Hazard; 3.1.3 Science and Scientists; 3.1.4 Politics and Scientists, and; 3.1.5 Public and Scientists.

In regard to subsections 3.1.1 and 3.1.2, broadly speaking, we would like to suggest that while the 'risk' of global climate change *might* be real, the 'hazards' are largely a matter of social construction. We feel it is necessary to make the distinction between risk and hazard since risk may always be present but it is not until a risk is identified as being threatening that it is transformed into a hazard. That is, it is not until there is a *social interaction* with a risk that risk has the potential to become a hazard.

For our purpose, 'risk' will be defined as an identified measure of a threat of a hazard, in this particular case, the measure of the *likelihood of the occurrence of global warming*, for example, as could be presented as a statistical probability. 'Hazard' we define as that which is perceived as being an *actual threat* to people and things that are socially valued. (For a complete discussion of the terminology, see Kates and Kasperson, 1983:7027-7038.) 'Hazard', as used in the context herein, is given a much more encompassing meaning than 'risk'. As such, 'hazard' concerns not only the probability of the risk, but also the impact of the event and the socio-political context within which the event occurs. For example, while the determination of risk could possibly remain within the context of objective science, the determination of 'hazard' requires, to some extent,

the politicization of the knowledge of the risk[4]. Here, interest also includes the location and distribution of impacts, the populations who will feel the impacts, the magnitude of the impacts, the likely outcomes, and finally, suggestions of coping methods. As will be demonstrated, there is far from a consensus among climate scientists as to the 'risk' of global warming, and even less of a consensus regarding the 'hazard' of global warming.

Furthermore, scientists, we find, assign priority to the issue of global warming on the basis of two criteria[5]: (1). the dread factor, which refers to the magnitude of the impact, and (2). the unknown factors of the risk.[6] In other words, while one scientist, on the one hand, might suggest the *possible* magnitude of the impacts, for example, a worst case scenario, on the other hand, another scientist might emphasize caveats that must be taken into account, while still acknowledging the possibility or probability of global climate change. In effect, this demonstrates a personal preference for the nature of the presentation of scientific statements. Perceptions of both risk and dread, we hypothesize, are contentious in the issue of global climate change, and the perceptions of risk and dread are drawn from the subjective perspectives of the scientists as much as they are drawn from objective science. This acts to make issues of risk and dread equally a social

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[4] According to Cutter, 1993:2, "The divergence in viewpoints on how to identify, assess, and manage risks and hazards has led to different scientific approaches as well. Hazards management utilizes individual and collective strategies to reduce and mitigate the impacts of hazards on people and places. Risk assessment emphasizes the estimation and quantification of risk in order to determine acceptable levels of risk and safety; in other words to balance the risks of a technology or activity against its social benefits in order to determine its overall social acceptability."

[5] These criteria are drawn from the context of the interviews. They are a product of the application of grounded theory techniques. Such a technique refers to an inductive method of theory construction and the classifications evolve from the text. In short, they are classifications drawn form the actors' subjectively constructed realities.

[6] For example, a nuclear reactor accident represents one extreme since it has a high dread factor (everyone dreads the event) and a high degree of uncertainty with regard to knowledge of the full impact. The risk and dread associated with bicycle transportation as a technological innovation, on the other hand, are well known and considered minimal.

construct as much as they are the product of science. In short, the assessment of risk *and* hazard in this context, involves both an ethical and a scientific decision process.[7] Of course, in the case of global climate change, assessments are not simple. It is much easier, for example, to assess a localized risk such as a chemical spill, than it is to assess an event with global potential.

Consequently, and to this end, in this exploratory study we investigate the scientific perceptions of both risk and hazard as they relate to the issue of global climate change. We feel this is a necessary contribution since the actions and reactions of individuals and society are enhanced or constrained by all elements of society: the social, the economic, the political *and* by scientific institutions.

In regard to Subsections 3.1.3, 3.1.4 and 3.1.5, while the role of social, economic and political dialogue has been the topic of much discussion concerning global warming, the subjective side of science has, for the most part, been ignored. Such an investigation becomes particularly important if we draw the conclusion that scientific knowledge is itself socially constructed (cf. Harding, 1991) and as Cutter comments,

> Science is just one way of viewing the world, not the best, nor the only, just one. Thus we can think of science and scientific knowledge as an attitude or viewpoint where social and political considerations alter the production of scientific 'facts'. It is no wonder then that different groups of scientists working in similar circumstances often produce radically different 'facts'.
>
> (Cutter, 1993:9)

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[7] For a full account of this phenomenon see Whyte and Burton 1980 and Cutter, 1993.

We explore the degree to which these facts differ, eliciting the different scientific perspectives. This becomes an even more salient point if one considers that the development of policy typically involves the interaction of the public, political and scientific arenas. In fact, according to Cutter (1993:46)

> Perhaps the most profound change in the last twenty years that intensified the debate between experts and the public is the institutionalization of scientific conflict. Governmental decision-making on technological issues is driven by science. In fact, scientific experts and science advisors are becoming so entrenched in policy making many are beginning to investigate the role of the fifth branch. Also, divisions in scientific opinion between experts, often gets played out in public view, making the nightly news or front-page of the newspaper. This has led to a new level of scientific advocacy. Each side of the controversy calls their own litany of scientists to refute the findings and conclusions of the other.

In looking at the inner workings of science, we attempt to identify similarities and distinctions regarding how the individual scientist perceives intra-scientific relations (3.1.3), the relationship that exists between science and policy development (3.1.4) and between science and the public vis à vis the media (3.1.5). However, before moving to the larger scope of the interaction of science, politics and public, it is first necessary to determine the nature of the risk and hazard of climate change as perceived by our sample from scientific community. This will provide a basis for the perceptions of scientific involvement in the larger spheres of social activity. The first task then is to provide a sampling of the scientific perceptions of the measure of risk.

3.1.1 Perceptions of Risk

Risk, as discussed previously, refers to the measure of the threat, the likelihood of the occurrence of global climate change and the unknown factors associated with climate change. There is, of course, a diversity of perspectives, ranging from the scientists convinced that climate change represents not only a risk but can already be determined to be a hazard, to those who are not yet convinced that the prospects of climate change should yet be categorized as a risk, much less as a hazard. The majority of scientists tended to couch their perspectives, denying certainty but not possibility. This is well represented in the following statement:

> Some type of global warming is undoubtedly upon us. It is just a question of how much and how it is going to be distributed over the earth. It is certainly not going to be uniform. It is surely going to have an impact on human activity but it is awfully difficult to figure out what the impact will be. It should be a major concern since there are so many things at stake. It should be a major concern even though we cannot predict to any reliable degree what is going to happen.

Here, both risk and hazard are recognized as a possibility, however, while there is a high degree of a dread factor - "*It should be a major concern since there are so many things at stake*" - it is not at all explicit as to the nature of the consequent hazard - "*...even though we cannot predict to any reliable degree what is going to happen*". In fact, what tends to be emphasized is the unknown factor associated with the risk while at the same time

confirming that the impact, the impending hazard, should be a major concern. As will become apparent through other such excerpts, it is the unknown factor that seems to be generating the call for action, not the explicit measure of the threat, nor an explicit measure of the hazard, which, under these circumstances, would prove to be an impossibility. Again this is evident in the statements of another scientist:

> Nobody knows what the impact of climate change will be. Nobody knows how large the climate change will be. Nobody knows what the impacts will be. There will very likely be changes that require societal adjustments.

Again, the emphasis is on the unknown. As stated, "*nobody knows* ..." . We only know that there will "*very likely*" be an impact. It seems it is the unknown factor associated with the risk that is driving the statement. There are though, those more willing to concede to the existence of risk, with the uncertainty of the hazard posing as the unknown element.:

> There is a bottleneck at the moment in our scientific research. We can compute the changes in climate fairly well, given a certain emission scenario. There are of course uncertainties but there is a scientific basis for our computations. But what impacts these changes will have on society is very poorly understood. Most of the arguments about whether one should take climate change seriously concern not so much the climate change itself, but the impacts of climate change.

Here the risk of climate change is not questioned. It is the nature of the hazard that is seen as problematic as in the following statement. *"Most of the arguments about whether one should take climate change seriously concern not so much the climate change itself but the impacts of climate change"*. However, there is still an element of the unknown present in the statement. The same scientists continues:

> GCMs are advanced enough now to predict global climate change, to perhaps 120 years into the future. I think we can make a reasonably reliable prediction based on certain scenarios. This pertains to large scales but not to regional scales. So I think GCMs can certainly be used as a baseline of what to expect regarding the magnitude of the climate change based on that particular scenario. But there are also things that the models predict that we do not yet understand too well. For example, the models indicate a danger of the Gulf Stream breaking down. Although we cannot say for certain that this will happen, the models point to the existence of a risk of occurrence.

In short, even though this particular scientist definitely accepts that the risk is real, it is conceded that the 'risk' still contains many unknown elements. As before, we can only assume that, with the risk still unidentified, it is premature to begin speaking of the hazard as such. This position is further confirmed by another scientist:

> What we know at the scientific level is not very much. We do not know how global warming will present itself. We do not know much about the impacts. All we can say is that global warming will occur and the rate of warming will be unique. The impacts are difficult to determine since they are embedded in the larger social context.

This element of the unknown properties of global warming, or even the uncertainty that the event will occur, is continually expressed. As one scientist commented:

> I may be overstating it a bit, but I would estimate if you polled the scientists in this organization most likely a quarter of them would say they are not sure that global warming is going to occur.

Such sentiments are often represented in the dialogue. However it would be redundant at this point to continue presenting them in this text. Suffice to say, the measure of the risk of occurrence is far from being consensual and remains a contested issue within the scientific community. Nonetheless, some scientists went on to comment about the magnitude of the impacts of climate change, some with caveats of "if" it occurs, others with the diligence of the stewardship of the planet. However, one has to question the utility of a discussion of hazards when there is far from consensus on the existence of risk, a prerequisite for a hazard. As such, the discussion of magnitude of the impacts can only be considered as a subjective evaluation or a hypothetical issue. This raises the further question of whether policy should be based on hypotheses, on the notion of hypothetical hazards.

3.1.2 Perceptions of Hazards

Having established the fact that according to at least some scientists, climate change as identified by modern science does indeed pose a real risk and that there is a high likelihood of its occurrence, if it is not perceived as already underway, we turn our attention to the perceptions of the hazards which climate change might pose. As would be expected, this too is an area of contention, not only in the magnitude of the impact but also in the priority that should be assigned to global climate change and in the immediacy of the attention required for the event. At one extreme, one scientist stated, that even if global warming is a process under way "it is not an issue I am going to lose any sleep over". Nonetheless, there are those who expressed various degrees of concern ranging from agriculture to sea level rise to population dislocations. On agriculture, comments such as the following were forthcoming:

> In regard to agriculture, modern agriculture is so specialized that it can only succeed in a narrow margin of circumstances. If these circumstances change just a little, the productivity will decrease rapidly.

Others expressed their concerns in much more abstract terms:

> A basic problem with the whole issue is that nothing serious will happen within the next ten, twenty or thirty years. On the other hand, if we do not do something now we will feel the consequences in fifty years and this will be beyond the consequences that most politicians anticipate now.

Others stressed the importance of the interrelationship of climate with other aspects of society and in doing so, did not necessarily assign a high priority to climate change, although, at the same time, suggested that climate *may* play a role.

> It is difficult to assess the impact of climate change because there are many other global problems that might overshadow the impact of climate change. For example, there is the problem of over-population. On the other hand climate and over-population are related. If you do not solve the problem of over-population you will not be able to solve the climate problem. So these things are interrelated and it is difficult to determine climate as one of the leading issues because it is embedded in the larger social context.

Some scientists were willing to elaborate on this larger social context:

> Climate changes have always had an impact on society in one way or another. Although, they are not completely predictable. But clearly, agriculture is one example. If an area suddenly loses its ability to be agriculturally viable, agricultural activity will die forcing the population to relocate. Not fit for agriculture, the area may undergo the process of industrialization. What happens depends a lot on the locality. Ultimately there would be a cascade of events and ultimately it would change the nature of the society in that particular region.

However, as presented in the following, many of the scientists interviewed commented that climate change, while a scientific problem, did not, in their estimation, present itself as a hazard at all:

Quite frankly, I do not see global warming as a problem.

Well, we have had a lot of opportunity to study climate change because even in my life-time there has been a lot of change. I should distinguish here between climate change and climate variability. With climate change you go from one state, as it were, of climate, to another state. Climate variability is what occurs from one year to the next or from one decade to the next. If you have a real climate change, for example the cooling that started in the early 1940s, and it continued, then obviously this would require a very detailed planning effort. But if you could expect no more than a two or three year drought, or two or three years of floods, or a normal climate regime, there is not as much need for concern. This is simply climate variability. I think I have experienced a lot of climate variability in my life time. So we have in the past survived two little jumps, one in the 1920s and again now. We do not need to be concerned because life has continued in spite of these jumps.

The problem is pollution and abuse of natural resources. Global warming, if it occurs, is only symptomatic. The problem is over-population, over consumption.

Well I guess maybe part of my reason for saying global warming is not such an important problem is because I do not know what 2 or 3 degrees mean. Compared to other things that are happening, the climate issue is no big deal.

In most cases, as would be expected, the scientists working within the realms of the natural science of climate were vague on their perceptions of impacts. While a few specific scenarios were presented they were done so with the caveat of the lack of knowledge to discuss societal impacts. On a different level, scientists would remark on the ethics of intergenerational legacy, that is leaving a viable world for future generations. This argument, that is, the importance of maintaining a viable legacy for future generations is also well represented in public sentiments (cf. Kempton, 1995:95-102). However, as

depicted in the previous section, this was not typical since many scientists are not yet been convinced of the certainty of the event in the first instance.

One would suspect that the higher the magnitude of the impact that gets conveyed to agencies, the greater the degree of funding. This of course is somewhat analogous to the funding for the arms race, the greater the perception of threat, the greater the input of funds to combat the threat, be it real or otherwise. On the other hand, research for the deflection of comets threatening the earth may not have received such funding due to limitations of the scientific community to purvey such possibilities as a probable risk, although science was well able to demonstrate the magnitude of the impact. One major difference between the arms race and the cosmic collision may be the public involvement in the former, as is the case with global climate change. In other words, it may be that politicized issues come to receive more attention and consequently come to have more means at their disposal. To this end we address the broader scope of science, politics and the public. By their very nature, the contemporary issues such as climate change are, as are other environmental concerns, triadic in nature, extending to include the scientists, the politicians and the public.

3.1.3 Science and Scientists

We could not deny that the production of science is the realm of a limited number of people and is most often legitimated within this well self-defined assembly. In some

instances, even the legitimacy of science itself is brought into consideration by climate scientists, as attested to in the following statement:

> ... if I left here today I could go and supply enough evidence [as to why] science funding should be cut. I'm dangerous. I know too much information. I know the limitations of the policy making process as well, they give money to science and they expect something will come out of it. It was easier when there was the Cold War because you could always default and whatever else the scientists said they could claim that maybe they would find something to fight communism. Without communism there it is a little harder. Everyone is saying why do we need science. The claims I see out in the scientific community really, really irritate me, about what they can offer society. They are in a position where they have to make claims, absurd claims, I think.

Other criticisms of the inner workings of science were also forthcoming. As one respondent suggested

> I think personally you could stop El Nino research today, take some of the money, 10% or some small amount ... and mine the information that already exists... . The scientific community is so busy adding to the body of knowledge ... producing more and more information to which no one is paying any attention.

In some instances, it was further suggested that aspects of climate science might operate towards the maintenance of a status quo:

> ... if you do not get between one and a half and four °C. in your model run there is something wrong with the model, so you go back and fix it, because

> you've got an envelope. If you get 10 degrees warming or 5 degrees cooling, you throw it away because you know no one will publish it. I'm worried about this thing I call anchoring. It is like the ozone hole stuff, I mean the data were there and they just discarded it, it didn't fit, so I'm worried about a lot of things with these models. In the meantime, do not ask me to use a model.

This is not to say that all respondents shared similar convictions. Such comments were not typical of all interviews. However, there was a notable absence for an explicit praise for science, perhaps indicating the awareness that science, like everything else, has its pitfalls, but for the most part it is not a matter of immediate concern. On the contrary, those working with models were, in most instances, aware of the limitations but convinced of the value of the output.

3.1.4 Politics and Scientists

It is possible that once scientific knowledge escapes from the hands of the creators it has the potential for misuse, as it were. Scientific knowledge, through its political deployment, is often utilized to shape the operational reality of the everyday person, thereby linking the products of science to the shaping of social reality. This is not, of course, to say the members of any given society are powerless to demand a different course of action should opposition arise, nor are scientists themselves immune from making such suggestions.

Since climate sciences are a major public and political issue, as much, if not more, than they are a scientific issue, we felt it necessary to ask scientists what they perceived to be the interaction between science, the public, and politics. Consequently, the first question posed to the interviewees was "In general, what do you think is the nature of the relationship between science and policy?" The responses, of course, were very diverse. As one scientist commented:

> Well, it depends on the day [on which you ask me] ... but I think the relationship is one of mutual use. [...] The scientific community uses policy makers, and tries to play them like musical instruments. And I think that the politicians use the scientists like musical instruments. In other words, there is mutual exploitation. In America at the moment, we have a new Congress and they have little awareness of what it takes to do science. This is a somewhat pessimistic view of the political system, but it is the way it seems to be going in America. On the science side, it is a game. There is money for everyone to do their stuff, but now it is like a Darwinian situation as resources are becoming more scarce. [In other words, research funding is still available, but one must prove the worthiness of the research in order to receive funding.] To get the resources you have to sell programs and to sell a program you have to make claims. When you make claims some are rational and realistic, some are not. Often the ones that are not realistic, the wild claims, are the ones that get rewarded by the politicians who really do not know what science means, what it involves.

Another scientist was much more succinct:

> I think for a lot of science, there is no relationship. There is no connection, or a lot of scientists do not think there is any connection. There probably should not be any connection. There are some scientists who are willing and able to help out on policy matters. But I would like to think that for a lot of science there should be a separation. I'd rather not have policy requirements directing

> science. If every scientist was worried about policy, I'm afraid this would color what they do.

Even shorter response were forthcoming:

> To tell you the truth, I never really thought about it!

and

> Well an obvious but good question, and I can give you a firm 'I do not know'.

Of course, as with other areas of questioning, the forthcoming responses were quite diverse as is demonstrated in the following excerpt.

> Well, science is dependent on money and the money comes from industry or from government. Science has to fulfill some service for policy. On the other hand, policy also has to facilitate science. At the moment I fear the relationship is very bad. The politicians think that the climate issue is settled so we can stop climate research. I think we have to convince the politicians that the scientific questions are not yet answered.

Another comment suggested that the relationship depends on the individuals involved in the process:

> The relationship is fairly complex because politics has so many stratifications. They can be either genuinely concerned and try to understand the climate

> problem ... [or] ... they might be interested only in finding an argument to support their preconceived political ideals. So I think the relationship depends very much on which politicians are involved. Overall, in Germany, I think you find that there is a fairly responsible group of politicians.

This depiction of the relationship between science and policy was confirmed in the response of another respondent:

> In principle, I think in Germany there is probably quite a good relationship between scientists and politicians.

It would seem that the interaction between science and policy too, is far from consensual matter. In short, the range is from kudos to condemnation, from admitted non-concern to suggestions for the necessity for a better relationship. However, there was of course, no denial that a relationship existed, so logically, the next question to pose addressed the efforts of politics and policy to integrate the best of scientific knowledge. Again, the responses were equally diverse, with the extreme of skepticism well represented:

> Politicians want to be re-elected. I think they are more influenced by public opinion than by scientific findings.

And, at the other end of the scale:

> Yes, I would say policy draws from the best efforts of science. [... a particular political regime] needed our advice and drew from our national research program and from our advice. [At this time] we had an extremely strong influence on our politicians compared to any previous time. [However, when offering advice] ... there is a point where it is difficult for a scientist to judge what he is allowed to say, where the scientific statement ends and where it becomes your personal beliefs. [At that point] ... we must make it clear that it is a political statement that no longer has anything to do with science.

Although for the most part consensus was that policy makers in general do try to draw on the best efforts of science, the process of implementing the scientific knowledge of climate change at any level was perceived as a difficult task. Most scientists also suggested that policy makers might, in varying degrees, draw on the efforts of science in either the defense or attack of various politicized issues and that often the political interpretation of scientific knowledge is such so as to support the political viewpoint of the consumer of the knowledge. In such cases, it is difficult to determine if the *best* of scientific consensus is being used. Of course, from the perspective of the producer of the knowledge, this would represent a use of the best of scientific knowledge. On the other hand, for those of a contrary stance, this would seem not to represent the best of scientific findings.

3.1.5 Public and Scientists

Through a series of processes much of the scientific knowledge that is generated comes to play a role in social reality. Eventually, the knowledge produced by experts, and which is either condoned or condemned by politicians, is filtered into the daily routines of human existence. However, the process of how this occurs is somewhat shrouded in mystery, there are no set and definite patterns of the transformation. One such means, which is persistent, involves the interpretive expertise of yet another series of mediators, transforming the knowledge from a format bound by specialist languages and professional jargon (which in itself acts to mystify what is morally public knowledge) to a format understood by the everyday person. As one respondent noted:

> ... so it is the way we look at climate, it has kind of taken on an aura of mystery. ... I think climate is taken more seriously now."

This transformation is done with the assistance of the popular media and the scientist himself or herself so inclined. Nonetheless, the knowledge that reaches the public format, for reasons of clarity and understandability, is often presented in a simplified manner, devoid of the intra-scientific debates and caveats. And, more often than not, the consumers of this generalized knowledge have no option other than to readily accept or reject the claims, with little opportunity for weighing the unpublished pros and cons of the

argument, and they do so without the knowledge of the discretions employed by the authors. In short, what is transformed might be done so on a somewhat selective basis. However, we also felt that the public might have an influence over what gets scientific attention. When asked if the public influences the process of science, one respondent stated that the public does indeed influence the agenda of science:

> Sure, that is because scientists are human beings and human beings want to have success, some hope, and some people need to have public recognition to measure this. For some it is enough to have recognition from their colleagues. I believe it is those people that need the public recognition who get to the top of scientific organizations. These are the people who are extroverted. And these people become the rulers. And then the public will steer science because these people depend on the opinion of the public because they need to have the public applause.

However, comments were also made to the contrary

> I really do not think the public shape the scientific agenda. I think the public helps shape the political agenda. ... Scientists follow the whims of their own particular fashions.

It is logical that the knowledge that eventually filters through to the public , the knowledge that they accept as worthy of consideration, plays a major role in the public's selection of official representation. Should a political candidate be in concordance with public sympathies, then there is a good possibility that the political candidate will be

elected or re-elected to represent the public interests. This however, also has a timely quality, at least according to one respondent who claimed:

> The public is up and down. I think the public has the attention span of a couple of years anyway. ... I think there is a blind faith in science and technology and that the public wants to believe it, because they do not want to believe we cannot do something. I think they want to believe that there is ingenuity, ... that we will come up with something to solve the problem.

What is important, but nonetheless absent from this discussion, is the formation of public attitude, which incorporates scientific knowledge. This, of course, has been the topic of a considerable body of existing literature. Consequently, we can look to the process of science not only as the generation of objective knowledge in a purportedly dispassionate manner but also as a source of social action and a benefactor of social opinion.

3.2 Typification of 'Scientific Personalities'

The interviews chosen for verbatim presentation were selected on the basis of their overall characteristic of what we feel might prove to be representative of typifications of scientific personalities found among the climate science community. These typification, we feel, represent some of the conflict within the scientific community itself, and are, of

course, in a broader scope, most likely characteristic of all forms of science. Should it be that those who are more reluctant to communicate their findings in the public and political forums are those who are somewhat more cautious or skeptical of making claims about global warming, giving the *confirmed* believer or the *confirmed* skeptic the most public voice, the perspective that gets conveyed to the public and the policy makers does not due justice to the full scientific perception of the nature of risks and hazards associated with global climate change.

For reasons of concise representation we have chosen three typifications: first a person who is convinced of his finding and has enough confidence to make concrete statements; second, a person who is more cautious as to how he interpret research and might be suggestive, but not prescriptive, and; third, an individual who is somewhat skeptical of the conclusions drawn from the research to date. The three examples included however, do not do justice to the diversity found in the entire range of perceptions. Such a detailed representation would require a much longer manuscript. Nonetheless, three are included here since we feel that the way climatic risk comes to be interpreted by the larger societal context depends, in the first instance, on the way in which the knowledge is presented by the scientific community. In short, this would suggest that the translation of the story depends on the story teller, and this of course, would influence subsequent actions. In as much, it is possible that climate science, as represented in the above components, has equally a subjective component as it does the maintenance of scientific objectivity. The subjective component would, of course, evolve from the individual personality.

The interviews are not presented in their entirety for reasons of conciseness. However they are edited in an manner that attempts to convey the essence of the full dialogue. Each 'scientific personality' type is presented as a separate subsection.

3.2.1 The Convinced

What do you see as the relationship between science and policy as it exists in science in general?

> I think it is fairly complex because politics has so many stratifications and different interest groups and, depending on the politicians you speak to, he or she can be either genuinely concerned about understanding what the climate problem is and try shape policy accordingly or, very often, might just be trying to push some particular industry or preconceived notion. Politicians of this type are interested only in finding arguments to support their particular preconceived idea of what they want to do. So I think the relationship between science and policy depends very much on the type of politician you speak to.
>
> I have only spoken to politicians in Germany so I cannot generalize about the international scene. In Germany I tend to find politicians are a fairly responsible group of people, at least the politicians that are in the commission for investigating the impact of climate and of the atmosphere on society. This particular group of people were formed several years ago and I think they spent two or three years investigating the issue.
>
> The group consisted of all of the different parties and also a few scientists and they really did make a good effort to try and find out what the climate warming was and what one should do about it. They have actually had a strong influence on the climate policy in Germany. The Commission produced a couple of reports and so forth. One could really speak like a scientist with this group of people. Although they didn't have any scientific training, they tried to understand the problem and they went about their task like a scientist so there the communication was very good.
>
> But again, when you speak to other politicians, and sometimes to politically minded people in the funding agencies, these people might have some particular direction they are trying to push. They may be afraid of the

Green movement for example, or of the possible restructuring of the economy for the sake of the environment, and so forth. They might want to preserve the status quo and not risk any change that might produce an imbalance or change in the economic system. This type of person tends to be very skeptical of the climate issue and tries to down play it. He or she is often not interested in understanding what the problem is, and is simply trying to find arguments to support a particular political direction. And, of course, you also find that some of the time the politicians on the green side of the spectrum always try and draw on the real or projected calamities of the problem. They emphasize the of coming of the big crisis and so they tend to want, or use, the most dramatic arguments. They are not willing to listen to the fact that there are some things we do not know, nor to the possibility that some things might not be as bad as they think, and so forth. In short, you get people on the two edges of the spectrum which are difficult to speak to, but you do also find, at least in the Germany, a fairly good group of politicians that span all ranges of interests. They really try to understand what the climate problem is and what to do about it.

Does this balanced group of politicians draw on the best efforts of science?

I think they have done their best to get all of the opinions of all scientists. They have had a number of hearings to which they invited a number of people who represent the extreme opinions of the climatologists, exaggerating the problem (although there is really no extreme problem, no serious kind of problem), so the policy makers listen to both extremes as well as the more mainstream scientific view. They invited experts from the UK Meteorological Office and from Germany, of course, as well as from the USA to attend the hearings. So they really tried to draw on the scientific expertise, and I think they made a serious effort to get a good general idea of the range of scientific thought and opinion.

What happens when these scientists get together to assist in the formation of policy, and what kind of information do the politicians want?

Again, it depends on the group you are talking to, but this commission I was talking about, the commission that is having a strong impact on the German climate policy, really tried to not only get the bottom line regarding the climate issue, but to draw the whole picture and the reports they produced were rather similar to the IPCC reports and style, in that they really tried to describe the whole problem and describe the models and accommodations and what the problems are in computing the different

predictions. They produced a report that you can read as a layman and fully understand what the climate problem. So I think they really have tried to convey the problem so that the average citizen can understand the nature and implications of the global climate change issue.

Is it possible that scientific information, in some cases, may persuade the politician to redefine the problem?

I think so, if the politicians involved are open towards the problem and they speak to a number of different scientists. I think this attitude provides the politicians with a better assessment of the problem. At least I hope they follow this procedure. You also find the politicians that represent the interests of lobby group though, and they tend to be closed minded. They just want to hear those parts of the argument that represent their particular case and that is all they will focus on. In other words, they may present a skewed picture. You tend to get both types of politicians, those that interpret their role as presenting one side of the argument so that they can further some particular interest that they have, and others which really try to understand the whole problem and try to find a proper solution. Again, you get a broad spectrum of politicians, each with different ways of conducting politics and with different reasons for the justifications of their suggestions and actions.

When the public are presented with one of these skewed positions, such as a very one sided view of the climate issue, do you think it is the obligation of the scientist to inform the public of counter or contrary opinion?

Yes, I think it is the obligation of the scientist to try to inform the public. But I do not think the scientist himself can really do it because he is not trained as a journalist or so forth. I think the scientist should try to contact the media. Normally you do not have to use much effort because in most cases it is the journalists that contact the scientist. I think the scientist has the obligation to try to explain to the media the nature of the situation. But I also think it is the obligation of the media to try and present a fair picture. It is difficult for scientists to try to bypass the media because typically the scientist does not have the means to do so. Consequently, the scientist usually has little choice other than to work through the media to make a public dissemination of knowledge. In this

sense, I think the scientist has the obligation to try to inform the media as well as possible and to provide a fair picture of what is happening. It seems most scientists are prepared to do that.

The main problem is sometimes, on the one side, the politicians make a press release that expresses their particular views, which as I said before, may represent a partisan view, and on the other side, the media themselves very often distort things because the sensational makes better copy, it sells more newspapers. As scientists we must try and get the media to present a fair and objective picture. We normally ask the media to show us the articles so we can comment before they are released. But very often the media just go ahead and give a completely distorted and dramatic view, again for the sake of circulation figures. In a sense, we are at the mercy of what the media do with the information that we give to them.

Scientists, though, should never simply resign themselves to the whims of the media. I've been struggling with the media now for several years. There are a number of ways that they distort things and you have to continually try to rectify the matter. I had a series of letters that I was exchanging with the newspapers. They concerned a journalist who came out with the thesis that the whole climate problem was just an imaginary issue dreamt up by some particular lobby group. So, of course, I argued against this claim. I wrote an article and a couple of letters and so forth. I think one has to face up to these actions of the media and try to set the record straight. In this particular case it was definitely someone from the industrial lobby being represented in the media. But the media printed these claims without counter arguments. The origin of the confusion originates in a statement I made, claiming we think we can now detect an anthropogenic climate change with a 95% probability, which I tried to point out is somewhat of a risky statement, with a number of caveats.

Nevertheless, I made the statement and the immediate reaction was claims that the statement was not true, it was not to be believed, and so forth. Furthermore, the claim was made that you cannot believe in models anyway, they are a lot of trash and so forth. The author of this particular article was quoting people that were scientist employed by the coal industry in Germany. Of course, they were quite clearly lobby scientists. In response I wrote a couple of letters to the editor and an article contrary to the view that had been presented. So, in this particular case, it wasn't a case of the media chasing sensationalism, it was a skewed representation for the sake of the industrial lobby or at least, by someone sympathetic to industrial persuasions. In short, it seems someone with a vested interest in maintaining the coal industry questioning the integrity of the climate issue, claiming that the issue of global warming was nothing more than a sham.

So you get all different ways in which the information can be distorted that extend beyond mere sensationalism based on the possibility of catastrophic events. However, typically the distortion of information tends toward sensationalism. The climate problem is exaggerated and

portrayed much worse than it is in reality. But, in the example I have presented, it was the opposite. It was the perspective of an industrial lobbyist who was essentially making the argument that you cannot believe the climate problem and you cannot believe the models. It was the perspective of an advocacy group. The citations were correct and from a scientist, but they were presenting only one side of the issue, with overtones of vested interests. Nonetheless, the newspaper published my article without any serious shortenings and they gave my opposite point of view quite clearly to the public.

In complex issues like global warming is it possible for the scientific agenda to remain autonomous from politics?

I think the scientific agenda as such can remain autonomous. Scientists are not in anyway affected by the strings attached to the funding. I think we can do standard research without any political pressures, and one can say that quite fairly. Of course the questions that we are interested in are affected by politics. For example, we have done a number of global warming calculations that are of some interest to science, but we probably wouldn't have done so many if there was not a political interest in the answers to issues surrounding global warming. In this sense, there is definitely a societal impact on the nature of our research interests, but not a political one. I will simply say that it is a response to the fact that society wants to know the answers and we are willing to look at these things from a scientific point of view. So in that respect there is a pressure on us not just to do the things we like to do for fun but to also do things that contribute to the well being of society. I cannot speak of what happens in other countries, but I think, in general, I know of no country where there is real political pressure on the scientists to work in one particular direction or not, unless of course it is funding pressure, where you get more funding for one type of research than for another. Otherwise, scientists everywhere I know of, are really very free to follow their own direction of inquiry

Does the public help shape the scientific agenda?

I do not really think the public helps shape the scientific agenda. I think the public helps shape the political agenda. In other words, the public input is through the political process. In this sense the public has an input, but not directly. In Germany the public are generally more open and more aware of what is going on scientifically and they express their values in voting patterns. This public interest in science also means the politician must be attuned to scientific issues. Consequently, I think German politicians, on the whole, might be more interested in the scientific point of view than in many other countries. On the other hand, it might be that the politicians and the public are both interested in science and both respond to it independently, the politicians through the political process for the sake of societal well-being and also for the sake of their political careers, and the public by using the political process as a collective voice. But I would not say the public, in any way, has a direct impact on what the scientists do. I do not see any direct feedback in this direction. Science does not follow the whims of the public. This is not the case. The scientists follow the whims of their own particular fashions everywhere. If something happens to be exciting to the scientist, and they get recognition in what they are doing, then there is a sort of snowball effect. People jump on the band wagon and pursue similar research because that gives them recognition and furthers their career and so forth. But that feedback is entirely within the scientific community. Whether or not the newspapers pick it up or not is entirely irrelevant. Press does not really have a great feedback on the scientist. For example, I am a climatologist who is very often in the newspapers simply because people are interested in global warming, but this has no impact whatsoever on my scientific standard and my recognition as a scientist. In fact, if anything my colleagues tend to make jokes about it sometimes but it has no real impact at all. I would say the recognition of a scientist among the scientific community is derived from his peers and not through the media. Newspapers coverage is not a measure of a good scientist.

What impact might climate change have on society?

I think that is the big bottle neck in our scientific research right now. We can compute fairly well the change of climate in the future, given a certain emissions scenario, and of course the uncertainties involved, but, of course, there is a scientific basis for these computations. But what impact climate change might have on humanity, on society in general, I

think, is a very poorly understood area of inquiry. Most of the arguments of whether one should take climate change seriously or not revolve around not so much climate change itself, but on the impact of climate change on society. This, I think, is something that has to be studied in much more detail and effort than it has been to date. In fact, I've been pushing for an institute that looks at these types of things.

Do you think we have enough information regarding the physical world so as to enable us to begin to look at the interaction with the social world?

The knowledge is produced but not accurately enough. The GCMs do produce the regional changes but of course with a resolution of 500 km. or so. Consequently, individual regions cannot be addressed in any detail. Furthermore, on the regional scale of 1 or 2 thousand sq. km., the models differ quite strongly. So we do not really have very reliable information in that sense regarding local and regional changes. But, we do have scenarios where we can estimate what the possible changes could be and one could use these scenarios to see what the impact would be on the economy or agriculture, forestry, tourism and so forth. So it is possible to look at a range of different scenarios and say what the loss could be, but to actually say in one particular location, Baltimore or somewhere, such and such is going to happen with the climate, that, indeed, is not possible with the present climate models. To do so, is something which I think is just a question of the resolution of the models, and when we have better computers and higher resolution models than we already have we can get down to these scales and make a statement. So I think it is just a question of time before we can come up with some results that could be applied to local and regional issues of climate change.

Is the knowledge that we have of climate issues sufficient for the development of policies?

I think that it is sufficient to start making decisions because all of politics is really about making decisions for the future, and based on uncertainties. I think the uncertainties regarding climate change might be small compared to the uncertainties in political concerns regarding other areas, for example, the uncertainties in the political nature of China. In this sense, politicians make decisions based on uncertainties all of the time. In comparison, the uncertainties regarding the climate issue are really

relatively small so I do think the politicians have a good basis for their decisions regarding climate change.

Do you think all of the impacts related to climate change will be negative?

I think the changes include all of the stresses and strains that you might have with the reshuffling of resources and power. Consequently, while you might be in a country that will be better off, will benefit from climate change, you may be surrounded by countries for which climate change will be a detriment, and this will necessitate a series of negotiations and related problems. Overall, while there may be some areas which benefit from climate change, when we consider the overall readjustment of a global economy, the overall impact will likely be negative. That is the usual argument invoked when the conclusion is reached that the impact will be negative. But I think one could certainly point to particular areas of the globe where climate change would have a positive effect. Then too, it depends on how quick climate change occurs. Any adjustment, even to a better state, requires a lot of energy and effort. For example, the recent changes in the political regime in the old East Germany, we could say that while the present system may be better, we can see that it is simply not working yet to provide maximum benefit those who live there. There are a lot of strains in the readjustment. So in the long run, while the change may be better, it has negative effects during the time of change and readjustment. This may provide a metaphor for the issue of climate change.

How do you think climate scientists should be involved in interpreting the changes that occur in the social arena as a result of changes in climate?

They should be involved in both areas but they should be mainly information providers because they are not experts in areas of societal impacts. On the other hand, climate scientists are the experts in modeling and systems analysis and I think some of that could well be used in impact studies. Consequently both types of research could benefit from working in conjunction with one another. We are actually working together with economists and are employing both economic and climate models. Here the experience we have had with climate modeling has proved helpful.

Do you know what type of information the other disciplines need?

What they definitely need is information on the regional scale regarding precipitation, temperature, extreme events, in other words a lot of information we can ,in principle, provide with GCMs, but we just cannot yet provide a very accurate portrayal. We have to put more effort into computing the required statistics, seasonal variations for example.

Based on the concern for regional impacts, do you think this is an indication that there is a growing concern that research should have some policy relevance?

Yes, I think this is the main motivation for pursuing such research topics. Unless we can bridge the gap between the climate sciences and the people studying the impacts we are never going to get the policy more precise than it is at the moment. The main uncertainties remain with what the impacts are going to be on society. This is, of course, motivated by trying to provide the policy makers with the information they need. The people from the social sciences however need to be made more aware of the limitations of the knowledge stemming from the climate sciences. There is a tendency to be uncritical about the information produced from models. We do point out to them that the information that we produce is rather coarse and cannot be used to delineate a particular city for example. Rather, the information pertains to a particular and much larger region. The social scientists often do not have the same sense of the limitations of the models as do the climate scientists that work with the models all of the time. But this information is not too difficult to get across so this really is not a serious problem. But the interaction between the two areas should be increased. However, we do tend to have quite a different way of talking about things. In constructing an interdisciplinary team one would, first of all, need a strong economic component to determine the impact of climate change on the general economy. One should also include sociology to look at the impacts at a societal level assessing the role of the preferences and values of people. Political scientists should also be involved so as to discern the process of decision making. There are a number of applications for which the social sciences should be involved.

The basic problem with the whole area is that climate will not change dramatically within the next ten to twenty years. This is way beyond the time scale of the thought of most political careers, but in general I think there is a value attached to the distant future by both the average citizen and the political process. In the issue of climate I do not

think there is a natural discounting of future events and trends, and that there is an interest in a sustainable future.

3.2.2 The Cautious

In those cases where national policies related to the issue of climate change have been, or are being developed, do you think they draw on the best efforts of science?

I do not know how much science really has to do with it in fact. Science is there to a certain extent to raise the issue and say that there is an issue, but there is a lot of uncertainty in the predictions of the science. It is decision-making under uncertainty. Ultimately it comes back to what some people call politics. I prefer to think of it more as values and value systems. In the case of the greenhouse problem, a lot of it relates to how much you want to pay to take an action now against possibly having to pay a great deal more to take an action at sometime in the future. It relates to stewardship of the planet, what kind of an environment we leave the future generations, and how much of a burden we place on future generations in terms of cleaning up the environment. In the case of the greenhouse gases, and the climate response to what is already in the atmosphere, the impact has not been fully determined, and will not be seen for possibly decades. Certainly this is the case of sea level rise, where the real impact of what has already been put into the atmosphere will not be seen for many decades. At sometime in the future if many Pacific Islands suddenly become flooded because of rising sea level, it is too late to do anything then. It is an irreversible process causing tremendous damage. One has to try and assess the value of that versus doing something now and it is a very difficult decision. I do not think there is a clear answer. Economists have a way of doing it called discounting, but you can argue about the discount rate that is used.

So you are saying this value system might, in some sense, might even more important for decisions than the scientific information, or the scientific uncertainty.?

That is clearly the case. There are some people who have no regard whatsoever for the future generations. They will exploit the environment, or exploit the situation to the fullest right now, with no regard for the future generations. There are environmentalists of various kinds that have a great regard for a pristine environment, and are very concerned about over-crowding, pollution, environmental degradation and the fact that our economy and our way of life is really not sustainable in the longer term. They are looking for something that is more sustainable. The question is, "How far should you go and at what expense?", because there are expenses. There are the so-called "no regrets" kind of options, where you do things that will benefit the environment or benefit the climate change issue, because it has also has other kinds of benefits. So things like energy conservation, cleaning up the air, and reducing pollution have multiple benefits. Personally, I believe we should be doing much more than we are.

When you are called upon by politicians to provide some scientific evidence they will employ when they make there policies, obviously they do not ask you for a formula or a set of equations. What kind of information do *you think they want to use in the decision making process?*

They usually want a bottom line. They usually want a succinct conclusion, and they usually do not want to hear the uncertainties. I find this is one of the things that is difficult to deal with in writing the policy makers' summary for the IPCC. There is a tendency to make bold statements and yet sometimes those bold statements simply cannot be justified. An example is making statements about global mean precipitation and how it is changing. We do not have the information base to do that. There is no evidence to show that the global mean precipitation is increasing, which it is expected to do according to the GCMs. They should state that there is no information over the oceans to say one way or the other and so we really cannot tell them what they want to know. I think you have to make these qualifying statements but the politicians often do not want to listen. This is really related to the whole area of decision making under uncertainty. There is scope for doing a better job. A lot of people either do not want to know the uncertainties, or they want to replace them with their own prejudices, and say "All right there is uncertainty, therefore I do not have to pay any attention to this information

at all". I think that is what happens. There is also a lot of solid information that should be given much more attention.

There is a great need for continuing research to improve climate models to enable us to make more definitive statements about what an outcome will be, given a change in the composition of the atmosphere, so as to reduce the uncertainty. At the same time, there is a need to pay attention to what is happening and what is expected to happen based upon the information we have now.

Would you hazard a guess as to what the social impacts of climate change might be?

In fifty years, the middle of next century (that is supposed to be something like the time scale of the equivalent CO_2 doubling) substantial changes in climate could occur. My own guess is that climate by itself will not be the sole issue. There are a few cases where climate by itself might be the sole issue, but in most cases it will intersect with other social issues and, in particular, the burgeoning population, the increase in population pressures, and the increase in demands for things like water. I think water supply is going to be one of the key issues next century. The climate models indicate that the hydrological cycle is apt to speed up somewhat. This means both increases in rainfall in some sense, and increases in evaporation. My interpretation is, that there will be a greater increased risk of drought. I think naturally occurring droughts, such as those associated with ENSO, are apt to be more intense, to last longer, to be more severe, to have a greater impact, and their onset will be quicker. Because of the enhanced evapotranspiration, plants will wilt sooner. On the other hand, as we are already seeing in the United States, there is apt to be more extremes of rainfall, more flooding, and more intense rainfall events will occur Some of these may show up in thunderstorms or in tropical storms. There has been a tremendous amount of damage in the last 5-10 years in the US. The insurance industry is hurting substantially with unprecedented losses that exceed any of their projections. There is very clear evidence to show that in the United States rainfall events of 2 inches of rain or greater have increased with time. Whether this is exactly the way it will be manifest and is not entirely clear.

These kinds of things have impacts that might not be clearly tied to, for instance, greenhouse gas climate change issues. There is no clear linkage. You cannot say, "Yes, this is a direct link". It is the cumulative weight of evidence of this kind of thing which begins to convince people. In the United States we have seen tremendous water shortages in California, and throughout the Southwest. That area is growing enormously. The demand for water is increasing, and the conflict between urban usage, usage by cities, versus agriculture is an issue which is going to

increase in importance. I think global warming is the thing which is usually hyped more as increases in temperature and it may well be that increases in temperature, especially in summertime, and heat waves, will have an impact, but I'm inclined to think that water is where the biggest impacts will probably lie.

We are talking about a 50 year span here and politicians generally are not interested in the 50 year span. So what type of information would they ask you for? Do the politicians see a sense of immediacy for any issue, at the moment?

Often not, unless there is something in their district, such as in California, where they had a six year drought, or as in '92 -'93 or this past winter '94-'95, when they had a series of 100 year floods. They got the other extreme. To the extent that those things continue to occur, there is an awareness, and Mother Nature is going to continue to remind us and tap us on the shoulder. It has happened in Europe as well. So Mother Nature will continue to remind us, and maybe that is the main way it is trying to remind politicians that these things are going on and that we need to pay attention. But often, focus in the political world is on very short term and on short term accomplishments.

Would they ask you just for short term forecasts?

In the NOAA program we had a climate global change program which was a broad program from seasonal to century time scales. In this year's budget, all of the emphasis has gone into seasonal to inter-annual scales because of the perception that we can capitalize on ENSO forecasts and there is a direct benefit to society on that time-scale.

With your applied background, would you comment on general circulation models? Do you see any particular value for them at this point?

Well, they are a necessary tool. They are the only way that we can deal with the complexity that exists in the real world. It is all very well to say use simpler models, one dimensional models, and do global mean quantities, but that does not recognize the complexity and it does not recognize the fact that what is going on in one location is different than in another. There are some regions in the world where there will be above

normal temperatures and some regions where there will be below normal temperatures. Just because there is a cold outbreak, like the one the year before last in the East Coast, when Washington had a very cold winter, we cannot suddenly say "well, that is it for Global Warming", because the rest of the US and the rest of the Northern Hemisphere was above average, and the hemisphere as a whole was above average. At the same time, when there are a series of heat waves, it does not necessarily mean that global warming is taking place, because somewhere else it is almost guaranteed to be cool, and one should recognize these kinds of things. So the only way we can really capture what is going on is with GCMs with all of their complexity.

Do you think that in some sense GCMs are oversold, namely they are presented generally as representing first principles?

The thing that models do is to quantify things. I think that any model is only as good as its assumptions and the approximations that go in it. One should always interpret the results and the output, fully bearing in mind the assumptions and the approximations. I think there is a role for all kinds of models. There is a role for a hierarchy of models from simple models to complex models. We need to recognize that these models are not perfect.

The thing that worries me more than anything, especially in integrated assessment models, is that they are really only as good as their weakest link and some of the links are really quite weak. So we really have to be careful. I think they are very useful educational toys, but to treat their output and results as very serious would be misleading. I think all models are wrong but some are useful. They are useful if they are used appropriately as a tool. We should recognize that they all have short comings and often these are not properly taken into account.

Do you think the output of GCMs so far is robust enough to be used to influence policy?

That depends on what you are talking about. If you are talking about global warming, there are a number of facts that you can state. You know the greenhouse gases are clearly increasing. There is good evidence for that. That fact number one. Fact number two is that greenhouse gases produce radiative forcing. It has to change the climate in some fashion. The temperatures have increased, so there are observational records that

we can point to, along with their uncertainties. But to the best of our knowledge there has been warming of a half a degree over the last 100 years. So those kinds of things are pretty solid.

The thing we use models for is to take the radiative forcing from the increases in greenhouse gases and try and translate that into a response. How the climate actually responds is critically dependent upon feedbacks which are either amplifying or reducing the original perturbation. And there is a lot of uncertainty in feedbacks. Water vapor feedback is probably a positive feedback and reasonably well defined, in spite of what people say. But I think cloud feedback is very much up in the air. As for ice-albedo feedback, I think there is a great under appreciation for what it does. If we decrease the amount of sea ice, which is bright, and therefore reduce the albedo,(the ice albedo feedback mechanism) there is an extra increase in solar radiation absorbed ,and therefore an amplification occurs. But in the real world, there is more open ocean, there is more evaporation, a lot of fog, a lot of low stratus clouds, and these are not well depicted in models. There is, in some models, an increase in cloud, but no where near the extent that is observed. As a consequence the much brighter surface on all of these low clouds offsets the decrease in albedo and it is nowhere near as large as most of these models would suggest. The whole thing about climate models comes back to how well they model these feedbacks, and I think some of it is not done very well.

You mentioned a couple of facts and a long list of uncertainties. Does this mean that these models are robust enough to use for other purposes, or are they still in the development stage and should be used with extreme caution?

I would say "All right, here is our best state of knowledge. These are the best tools we have. This is what they suggest. We should make a judgment based on that". This is the best statement that we can make given the information we have. You use that along with some measure of uncertainties. To try and make decisions, whatever kinds of decisions you have to make, you have to build in the uncertainties that you know. Maybe you would not make such a decision if you were completely certain of the information, but I do not think you can back off and say "Well I am not going to make any decision. I am not going to do anything simply because of these uncertainties". You cannot let the uncertainties overwhelm you, because there are various things that *are* going on. You know that the climate has got to change, even if the way in which the climate changes is simply an increase in cloud, or something to partly offset the greenhouse warming.

Could you comment on the impacts?

I think the problem is the rate of change. There will be winners and losers but we can all be losers if changes are too fast. The possibility exists that the rate of change is potentially one which is so disruptive that we could not gradually adapt to it. If the change is gradual enough from year to year, then a farmer can see these changes as they are happening, and can adjust the way in which he farms, what crops he plants, and what strategy to use for applying fertilizer. All of these kinds of things, he can adapt to gradually. Rises in sea level might be so gradual that plans could be made to abandon an island or move all of the buildings back from the coast. There are certain ways in which we can plan to adapt perhaps if change is slow enough. But if it is too fast we could not make plans and this would be very disruptive. So we need to slow down the rate of change.

Are the predictions of rising sea-levels the outcome of GCMs?

General circulation models predict rising sea level and some of the simpler models are used to project much further into the future. The thing about sea level rise is that it comes about from the melting of glaciers and from the thermal expansion of the ocean. The oceans respond very slowly and the penetration of heat into the oceans is also a very slow process. Even if you are dealing just with the mixed layer, you are talking about 10 year time scales. If you are talking about the whole ocean, it actually takes thousands of years. So this process is a gradual one and sea level will continue to increase. The thing is that we can tolerate an increase in sea level of a few centimeters, until a major storm comes along. With a major storm either extra-tropical, or tropical, there is a storm surge. Whole areas could be destroyed or inundated in various ways. It is this combination of the gradual with the extremes that really produces the damage.

Can we even address the risks associated with global warming.

Well, there are risks of venturing into the unknown and it means that one needs to be a bit leery about the assumptions made that the climate of the past will continue into the future. If we build a bit more of that into our strategy, then we might not make decisions that are so critically dependent upon the weather being in a narrow area of expectation.

We need an approach with strong integration measures when possible, and planned adaptations for changes that will occur,

compensation plans for losers, and research to reduce uncertainties and improve planning.

3.3.3 The Skeptic

What do you think of the issue of global warming?

If one goes into the realm of the unproved but thus far not disproved possibilities or problems, we have such a huge number because this is such an open ended specification. The question is, "Is global warming different from this character?" What one has is a situation where one has a particular gas that has increased. There is very little argument about that. It is a gas that has thermal properties. Gases with this thermal property do play a role in determining the temperature of the earth. The particular gas, carbon dioxide, is by no means the most important. The most important is water vapor. Clouds are also important. And carbon dioxide is appreciably less important than these. It is expected that if you doubled carbon dioxide it will be equivalent to a forcing of 4 watts per meter squared. It does not much mater what that means. It is a number that has a unit. In order to calculate a response to that 4 watts per meter squared, out of a normal 200 or so, you need to know certain things about the atmosphere, the ocean, and about water vapor. There are a great number of uncertainties in those things and the errors in them are also large. It is clear that if models differ by a huge amount, not all of them can be right. The differences are equivalent to about 10 times to 20 times the 4 watts per meter squared. And it is not simply that these are independent processes and you could say ,well lets fix this one, and we could vary that; they are part of the chain of response. So I think objectively my opinion is we are still not in the position to calculate the response.

The fact that models have suggested change could be somewhere between, now what is it, somewhere between a half of a degree and four degrees. That is a huge range, and even that was based on models that were in no position to calculate it. So I feel it is in the realm of these problems whose existence does not depend on some definite information about the fact that there is indeed a problem rather than on the fact that at this point we cannot rigorously reject the problem. And, in fact, this is the

flavor of the comments mentioned by the IPCC. They say scientists now believe it is probable that some part of the small climate change of the last century is due to carbon dioxide. This is a meaningless statement. It is a statement that no one can disclaim, it has to be true, it has no numbers, no way of putting it in perspective, and so the public is given an impression that there is something very serious and the scientists are making statements that are in the realm of cover your ass, make a statement that sounds like you are saying something but make sure that if someone calls you up on it you can say well, this is what I said. What they said cannot be interpreted.

In the meantime this has grown into huge programs and trained lots of people. It has become a device that is confusing in its ramifications. It is a problem that has become confusing for scientific administrators. It does get science a lot of coverage, a lot of attention. And they regard that as a positive virtue in its own right. It has lead to programs that are tantalizingly large and I think they have become extremely unstable. They have provided vehicles for economists or health scientist who hop on the band wagon. Even for environmental groups, things like this, and ozone, provide a good next generation issue to be used after you have dealt with the pollution that people can see and feel and smell. Now it is in the realm of things people cannot assess without the assistance of the environmental experts.

There is no natural inhibition for this kind of problem once it takes off as a kind of hysteria. But the scientific foundations are weak and what I find disturbing is, if I were to sit down with the models, and say, where are the biggest weaknesses, I would personally conclude that the two biggest weaknesses are the numerical methodology associated with models, how you translate the equations into these discretized and computerized things, and water vapor. It is interesting when you read the IPCC that the numerics get almost no discussion at all. Instead one moves over to the periphery. I do not think it is healthy for the science.

If climate change occurred, do you think it would have an impact on society?

A lot of the argument that it would have an impact is based on the conjecture as follows. If we use what paleoclimate data we have we see that the earth has had ice ages and periods of extraordinary warmth and so on. When you look at all those, what you find, and this has been argued lately too, but the traditional picture that led to the claims was one where the tropics didn't change much, where what was really changing was the difference in the temperature between the tropics and the poles. So when you average the temperature change over the whole earth there was

actually very little change in the mean temperature associated with basic changes in the climate regime. Now what this means is that the changes in the mean were a residual. What really changed was the pole to equator temperature difference. On the other hand, the interpretation put forward was that the change in the mean drove the change in the distribution. This is physically impossible. And so if you said the temperature is going up one degree, what does that mean, well on the one hand the ordinary person can observe a thermometer that shows temperature can change by more than a degree in a matter of minutes so it cannot be that big a deal. So people, especially advocates, respond with "Well you may think it is not much, but between an ice age and the present it only changed 2 to 3 degrees". Well, they are unrelated statements. Personally I think 2 degrees would have some effect. But the truth of the mater is, any city, any region, probably even if you get to scales as large as the USA, the variability in temperature is several times larger than it is for the global mean. So places like the USA already undergo, or could undergo, fluctuations of a degree or two. And yes, there is no question, some years are different from other years and this has consequences. But we have already, so to speak, adjusted for that. We understand there is a certain variability. We have invented umbrellas, air conditioning, and things like that. And things like crop development. So my feeling is that temperature per se is not a big issue. But I'm told things like "It is fine for the human to adjust but think of the poor tree". In New England since 1900 the major species of hardwood has, I think, changed three times. It is not so obvious that even trees do not go through significant changes, at least as a system And the truth is, unless you are involved with trees, hardly anyone has noticed it.

Do you think global warming is a major issue facing humanity?

I would say at this point it is no more of an issue than if I were to say coffee drinking is a major issue facing humanity. That is to say, I do not think it is, but maybe somebody could come up with a reason why it would be. I just personally do not like to think our societies would be run on whatever could be, on whatever somebody could come up with.

It is possible we have reached an age where a lot of things are no longer serious and perhaps we need things to mobilize our fear. But I do not think this is in the same league. Again we do not have much perspective on what is terrible and what is good. It sounds like a crazy thing to say but every time I hear that we in the North will be able to deal with climate change but what about the people of Bangladesh - there will be hundreds of thousands who will die because of this that and the other thing - well, with all due respect, their agriculture depends on severe

flooding, which kills hundreds of thousands of people. No, I would not put global warming high on my list of concerns. That does not mean that in might not behoove mankind to try to understand the natural environment. First of all it would have the advantage that one would not have the irrational scares to the same extent. It would be a good thing to improve our record keeping on such things. It is astonishing how bad out data is on some of this stuff. And I think that cultural activities tend have their own virtue.

Do you think that climate change is getting a disproportional amount of support and resources?

Here's my point. The perceived basis of support is moving from gratitude to fear. This has its own dynamic. Last week a member here was a recipient of a Nobel Prize for the work done regarding ozone. At the end of his speech here a student asked if it was still necessary to study the stratosphere. A lot of the audience and faculty, I think, were hoping the response would be of course, it is a matter of scientific and intellectual interest, to the extent that support is available, there are exciting things to learn about it. Instead, his response was, "Oh no!", there are other chemicals that may be a problem and we can look at the effect of air planes and so on. And the whole orientation was that we can discover new environmental problems and they will keep us busy. It seems his thought has been transformed into looking at thing exclusively this way. It is not malice, it is not greed, it is just that we have had such a transformation on how we view the subject, that we no longer think of scientific questions, it is simply what can satisfy the purveyors of fear because that is the reason they support us.

Do you think that based on what we do know about global climate change it is too early to begin looking at policy issues?

Yes, of course. The main argument I hear for looking at policy issues from political sciences, is that global warming brings to the forefront the possibility that there can be a global problem that requires international cooperation in its solution and that we do not have the legal and political mechanisms for dealing with such a problem. Global warming provides a wonderful opportunity to explore this potential issue for governance. There is a case to be made for that. That it would be nice to know how to

deal with such a problem should it be real, should one come up. But it is an abstract exercise in governance. But the effect of the abstract exercise may not be benign. When you have countries signing international agreements regarding economic growth and development you are going to have infractions and the question then arises as to whether this is going to be a source of international cooperation or another source of international friction, another cause for international dispute, violence and so on. It has the potential for that and the question is, is it worth it. There is nothing that suggests to me that it is worth it at the moment. We tend to have very blunt instruments for international disagreements.

Assuming that we do have a rise in the mean global temperature will this have only a negative impact?

The warming will primarily be in the extra tropics. It will be primarily in winter. And could involve reduced energy usage. People in general also tend to find warm weather more comfortable. Agricultural productivity will increase. In short, there might be a lot of benefits associated with global warming. No, you could not come to the conclusion that global warming would be catastrophic. Sea level to me looks like a nonstarter simply because as long as the Greenland and Antarctic ice sheets remain below freezing, warmer weather will actually produce reduced sea levels. Storms, well it has been pointed out that in hurricanes, temperature is a minimal factor, that there are far more important things involved. We do not talk about the probable benefits because it is not news. Has the half a degree increase over the last century been associated with any catastrophe? Did anyone notice? Skepticism usually presumes there is a very good case but you see a loop hole in it. I do not think the issue of global warming is anything like that. There is no case. But climate issues have become a growth industry.

4. Conclusion

While, for the most part, there is agreement within our sample from the scientific community, regarding the physical nature of the phenomenon of global climate change, the impacts of such an event largely remain the contested product of the imagination. The everyday life of a scientist constitutes a testing ground for the cognitive structures of the scientist that produce such conclusions. This applies to the hypotheses, the theories and the 'natural laws', in our case, pertaining to global climate change. Since we have not yet felt the impact of global warming, or at best, the discussion of impacts is somewhat hypothetical, we must conclude that, as of yet, what is known is not the result of passive attendance to the phenomenon, but rather the product of scientists' activities. Thus the construction of the knowledge to date is constrained by the conditions that arise from the materials used in the construction of the knowledge, be it concrete, as in the case of actual measurements of the physical nature of climate change, or abstract, as in the case of knowledge of the impacts which is still untested. This, of course, leaves many contested issues within the production of *related* knowledge as it becomes applied to political and public actions

What we have presented addresses some of these issues as they stem from the cognitive apparatus of the scientists involved. The elaboration of the cognitive apparatus was presented as the typifications of scientific personalities, which speak for themselves, and attest to the differing perspectives which ultimately determine different approaches to the discussion of an, as-of-yet, contested manifestation of global climate change. To this

extent, the discourse of global warming to date is as much a social construction as it is the embodiment of 'scientific fact'.

Idiosyncratic interpretations of the contested issues of the phenomenon and related issues of global warming get played out in the triadic relationship of science, politics and public. In other words, these interpretations subsequently lead to greater actions, or at least suggestions for further actions, actions not necessarily based on 'objective knowledge' but rather, derived from the cognitive apparatus of the individual. While to some extent there is a degree of consensus, at least at the theoretical level regarding the hypothetical existence of global warming, there is far from consensus as to causes and effects and subsequent calls for public and political action. These differences and similarities were addressed in the section pertaining to topical issues. The ideas and suggestions made in this regard all have the potential to influence societal structure and individual behavior, and to do so long before the presentation of conclusive evidence that global warming even poses a major societal problem..

This should be reason for caution since conjectural 'suggestions' have led to disaster in the past, particularly when science has become intertwined with ideology. As Watzlawick (1984:238-239) points out;

> When a scientific theory is finally declared valid by political *fiat*, thus becoming a generally binding justification of the state's existence, the iron curtain of obscurantism comes down. Alfred Rosenberg's *Myth of the 20th Century* (a racial theory on account of which millions of human beings were declared worthless and killed) or Trofim Denisovitch Lysenko's theory of genetic transmission of acquired characteristics (a theory that led to the arrest and death of colleagues that refuted it, and which paralyzed the Soviet study of genetics) are particularly glaring examples - all the more glaring when one keeps in mind that even in both men's lifetimes these "theories" were

> preposterous nonsense. In the sublunar world of scientific ideologies there is no more place for further research, for questioning earlier assumptions, for creative doubt about what has already been established. What is self-evident condition in the world of free science becomes of necessity treason and subversion when those in power imagine that they possess the ultimate truth.

As to who possesses the ultimate truth in regard to global warming is still, of course, uncertain. However, various factions, be they political, public interest groups or individual scientists, all make use of what ammunition has been gained, and it is not the first time in history that climatic 'facts' have been the justification for social actions. In the contemporary situation, knowledge of 'global warming' has become the means to a realization of the environmentalists' and the new-left's dream of a more egalitarian society, rejecting economic growth and placing humanity on a lower level of the food chain. The political mechanism for the realization of this goal, is of course global policy, and already has a foothold in the likes of the Montreal Protocol. Success would mean the institution of *global* policy, unprecedented in history. Of course, there are also those at the other end of the scale proclaiming it is all nonsense. Nonetheless, the debate, as it stands, ranges between these two poles, and these two poles are determined by scientific proclamations. The nature of the scientific proclamations are, of course, dependent on the cognitive apparatus of the individual scientist.

Appendix A

Interview Protocol *

1. In general, what do you think is the nature of the relationship between science and policy?

2. Do you think this relationship draws on the best efforts of science?

3. From what I understand, knowledge or information seems to cascade down to various constructors of policies. What kind of information do you think they use in their decision making processes?

4. Do you feel that scientists have any relative influence over the transfer of this information?

5. Do you think the product of science is sometimes instrumental in causing the policy maker to redefine the perception of the issue at hand?

6 In those cases where policy obviously differs from the conclusion of science do you think it is the scientist's duty to inform the general public of these differences? And how could this be accomplished?

7. Do you have any comments on how it might possibly be done in a better manner?

8. Today, when attention is drawn towards complex global issues, climate change for example, do you think it is possible for the scientific agenda to be autonomous from politics?

9. In the same manner, do you think scientific agenda can remain autonomous from the demands of the general public that sometimes operates through various interest groups.

10. What impact do you think climate and climate change might have on the individual psyche, ...on society? ...the economy?

11. Throughout the seventeenth century there were many suggestions of what the impact of climate might be in regards to the individual. Do you think that climate impacts on the individual in any way?

12. How do you think the information now produced by the climate sciences is translated into public policy?

13. Could you comment on what you see as the relationship between science and policy as they relate to the sphere of climate change?

14. Science for the sake of policy seems to arise when scientific or technical information is required for solving a particular policy problem, assessing the use of a new drug for example. Do you think any of the research regarding climate and climate change has gone in this direction?

15. Global climate models are now the nodes of a number of major scientific undertakings, linking climate and climate change to other areas such as agriculture, or impact studies, or fishery concerns for example. In these cases the information produced by GCMs is employed as data in other orders of scientific work, which in turn, is being used to determine the direction of public policy. How best do you think this information could be transferred?

16. Has enough time been granted the climate sciences to produce the answers that policy makers are demanding?

17. Do you think the results produced so far by GCMs are sufficiently robust to be useful for policy decisions?

18. Do you think what information the climate sciences have produced, which has been used in making policy decisions, has constituted a substantive input for informing the content of SPECIFIC policy decisions by government?

19. What do you see as the involvement of a climate scientist in evaluating the local impacts of climate change?

20. Do you think the expectations of policy makers exceeds what the climate sciences are as of yet able to provide?

21. Do you think there is a growing pressure for climate research to be justified in terms of policy relevance?

22. Do you think the users of the information you generate are aware of the uncertainties pertaining to GCMs that are well represented in the scientific literature?

23. Could you comment on the possibility of interdisciplinary efforts to gain a better understanding of the nature of global climate change? What sort of components do you think an interdisciplinary program might have?

24. Do you think the phenomenon of global warming is a problem that requires an interdisciplinary effort?

25. While GCMs have a very significant scientific value, do you think GCMs can be or are being used as predictive tools?

26. Policy decisions are often concerned with regional impacts of climatic change. What would enable the climate science community to be able to produce robust regional climate scenarios for those people interested in determining impacts?

27. In general, are those scientists working with GCMs knowledgeable about what data is needed by the scientists that endeavor to study the impacts of climate change?

28. Do you think climate scientists do have, or should have, a role in changing or shaping policy decisions?

29. Do you think that science can provide us with what we need to know about the nature of the risk associated with global warming or should we also consider the cultural practices of the lay person and his or her operative world? In other words, should the general public also be involved in any policy decisions resulting from the scientific evidence produced by climate scientists?

30. Should the climate scientists involved with the physical effects of greenhouse gases in the atmosphere, in turn, be concerned in a professional manner, with the various societal effects, or should they restrict their investigation to the production of knowledge regarding only the physical effect of atmospheric dynamics? In other words, who should deal with the issue of the impacts that changes in the physical world might have on the social world?

* Throughout the project some questions were subsequently modified or deleted.

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