Chapter 9

Climate Science and the Transfer of Knowledge to Public and Political Realms

by Dennis Bray and Hans von Storch

9.1 Collegial Comments

"The questions [in this survey] are very much flawed as subjective, and the replies will constitute nothing more than an opinion poll. Hence I put very little credence in these results as having much bearing on affecting our work." (sic) case usa072: US physicist with more than 20 years in the field.

"This survey contributes to the problem. The questions are worded very precisely. There is the potential for misusing the results of this survey." case usa079: US physicist with 0-5 years experience.

"Thank you for the opportunity to respond in this survey." case usa096: US meteorologist with more than 20 years experience

"There should be more surveys like this" case usa098: US meteorologist with 11-15 years experience.

"This is a good survey and I hope you repeat it in about 10 years." case usa127: US meteorologist with more than 20 years experience.

Abstract

This paper presents the results of a survey of the perspectives of climate scientists on the topic of global warming. It addresses both internal and external elements of the science. A total of 412 responses from climate scientists in Canada, USA and Germany are analyzed. Differences among those groups with higher levels of involvement with policy makers, with the media, and the less vocal members of the scientific community are the focus of this paper. Statistically significant differences were found among these three groups on a number of pertinent issues. These differences were more often among those areas which were beyond the areas of the scientists' areas of expertise. More precisely differences were found in: the assessment that global warming is a process already underway, the nature of the impacts of climate change, the knowledge transfer process, and the conduct of the climate sciences. These perspectives are of considerable importance for they relate to the transfer of scientific knowledge to the public and political realms. In short, this paper contributes to the discussion of the socio-scientific construction of the climate change issue.

The paper describes the data collection method and provides a description of the sample. In the results, a series of *t*-tests are used to identify differences that exist among three identified groups: 1. those scientists with a high level of contact with the media; 2. those scientists with a high level of contact with policy makers, and; 3. those scientists with a low level of external contact outside of the scientific community. Greater differences were found when considering the extension of knowledge to matters outside of the scientists' areas of expertise.

This analysis raises the question of how scientific knowledge is transformed into high levels of public and political significance. This transition could not, as of yet, be attributed to the human experience since the experience of any expression of climate change, with the exception of extreme events (a highly contested relationship), is typically well below the thresholds of human climatic perception. However, it could not be denied that the *issue of climate change* has had, and creates the potential, for significant social impacts.

What we discuss in this paper represents only one aspect of the science-politico-society triad. More specifically, we address the role of the human element in the interpretation of scientific "fact" or, even more specifically, the *scientific construction* of the climate change issue. Not only do we suggest, in light of the now *globalness* of many contemporary issues, the requirement to make assessments of all of the triadic interactions, but also to address the process by which multiple interpretations stem from a single scientific artifact.

9.2 Introduction

In recent years global warming has been among the most publicized of environmental issues, raising both public and political debate. Climate change however, at least in terms of the thresholds of human sensory experience, remains a future event, and consequently it remains, as of yet, a resident (mostly) of the lay imagination. (Science, of course, does more to substantiate its claims.) Certainly some climatic events have sparked this imagination at times, of both the general public and the scientific community. At the times of the occurrence of these events, the public imagination now well versed in the climatic terminology, is further excited by the sometimes ominous commentary of some of the climate experts, at least as it is reported via knowledge brokers. Public comments to the contrary, that is, positive interpretations of the events referring to the potential for positive benefits due to climate change are rather rare since, perhaps because they do not make good copy, or, at least they do not arouse a similar response as a report couched in fear.

The impact and content of what reaches the public ear and how it is interpreted by the public has become a timely topic represented in the body of literature addressing the social construction of climate, climate change, and numerous other environmental issues (for examples see Kempton et al., 1995, or Dunlap et al., 1993). While the public's interpretation of the global warming issue and the social construction of climate change and other environmental issues has been a well addressed topic, little attention has been given to the construction of the issue within the scientific community. To that extent this paper discusses the *socio-scientific construction* of the climate change issue.

The conception of risks associated with climate change, and indeed the phenomenon itself, are assumed herein, in light of them being a *future* event, to be socio-scientific constructions which are open to multiple interpretation. This is a significant consideration since the issue of climate change has arisen, coincidentally or otherwise, with the rise of the new environmental ideology or environmental ethic and environmental organizations intent on addressing global environmental issues. This gives rise to the opportunity for sentiments to begin to feed back into science. This influence is obvious in public declarations of environmental organizations, as for example the declaration of the WWF: "This is what makes WWF's European Policy Office so important. Started in 1989, it acts as the eyes and ears of the worldwide WWF Network. Based in Brussels, its job is to influence the political developments in the "capital" of Europe which have far-reaching environmental effects for the rest of Europe and worldwide."(see www.panda.org) Assuming that the political ear is attentive, we can also assume that it has some ramifications for the conduct of science. Furthermore, we also assume that scientist being humans, neither can they fully escape the influence of contemporary ideologies, and as the discussion will demonstrate, the threat to scientific objectivity is

well noted by scientists.

Furthermore, while within the scientific community the debate continues regarding the numerous aspects of global climate change, in the public disclosure of science the debate often seems settled. According to the WWF, a well founded and publicized organization, "99 % of scientists agree, global warming is real, it's happening now, and it's getting worse." (www.panda.org/climate/impact.html). In fact, according to Auer et al. (1996:145) "Public opinion and mass media have taken over the topic to such an extent that in the meantime it begins to repenetrate and influence scientific discussion." This line of reasoning is discussed in detail in the body of this paper. If this is indeed the case then climate change aside, we are at the risk of a mutual relationship between science and ideology, a relationship that has not always proved favorable. In the following, the inner workings of the climate science community are explored using the results of a survey questionnaire distributed to climate scientists in the USA, Canada and Germany.

9.3 The Survey

A series of in-depth interviews were conducted with scientists in major institutions in the USA, Canada and Germany. A list of pertinent themes were drawn from the interviews and used to construct a survey questionnaire. The questionnaire, consisting of 74 questions was pre-tested in a German institution and after revisions, distributed to 1,000 scientists in North America and Germany.

Most questions were designed on a seven point rating scale. A set of statements was presented to which the respondent was asked to indicate his or her level of agreement or disagreement, for example, 1 = strongly agree, 7 = strongly disagree. The value of 4 can be considered as an expression of ambivalence or impartiality depending on the nature of the question posed. In spite of the pretesting, comments made on the survey indicated that some of the respondents were critical of some of the questions. Additional space was left on the booklet for respondents to make comment, some of which were presented at the beginning of this paper.

9.4 The Sample

The sample chosen for this study was largely a result of available funding. The initial intent was to limit the study to the perceptions and interpretations of the German climate science community. Upon the suggestion of those who endorsed the project, the project was redesigned to allow for a comparative study of the German and North American climate science communities. (For a more detailed discussion of the differences based on host societies, see Bray

and von Storch 1996.)

An anonymous, self-administered questionnaire was distributed by post to samples of US climate scientists, Canadian climate scientists and German climate scientists. The sample for the North American component was drawn from the EarthQuest mailing list. Due to the fact that the mailing list is more extensive than the discipline of climate science, a true random sampling technique was not employed. Rather, subjects were selected according to institutional and disciplinary affiliations. This resulted in a final sample of 460 US scientists and 40 Canadian scientists. The sampling of German scientists, due to reasons of confidentiality, was beyond full control. A random sample of German scientists was drawn from the mailing list of the Deutsche Meteorlogische Gesellschaft by its administration, resulting in the distribution of 450 survey questionnaires. A further 50 questionnaires were distributed to members of the Max-Planck-Institut für Meteorologie, Hamburg, and members of the University of Hamburg. Returns of the German sample extended beyond Germany and included 13 respondents reporting to be other than German. In the analysis this group are included in the 'German' category since they originated from a German mailing list. A description of the sample is presented in Tables 9.1 through 9.3.

The mail-out was one time only and no follow-up letters of reminder were distributed. The number of completed returns were as follows: USA 149, Canada 35, and Germany 228, a response rate of approximately 40 %. Additional questionnaires were returned due to noncurrent addresses. A response rate of 40 % and the total number of respondents can be considered as quite good when compared to other similar surveys. Stewart et al. (1992) for example in a SCIENCEnet electronic survey received 118 responses from "a computer-based network ... which has over 4000 subscribers"(p.2); the National Defense University Study (NDU, 1978) based its conclusions of the responses from 21 experts; the Slade Survey (1989) based conclusions on responses from 21 respondents; the Global Environmental Change Report Survey (1990) had a response rate of approximately 20 % from a sample of 1500; the Science and Environmental Policy project (Singer, 1991) received a 32 % response rate from a sample of 102, and later a 58 % response rate from another sample of 24; the Greenpeace International Survey received 113 responses from a sample of 400, and; Auer et al (1996) report that "about 250 questionnaire were distributed [by method of personal contact at conferences] and 101 were sent back".

As Tables 9.2 and 9.3 indicate, the sample is well diversified. While categories in Table 9.3 could possibly be collapsed they are presented in their entirety to demonstrate self constructed divisions within the climate sciences, in short, a preliminary basis for the social construction of the science, each label possibly representing different perspectives and different vested interests.

Table 9.1: The institution in which I work is located in:

Country	Total
USA	149
Canada	35
Germany	128
Grand Total	412

Table 9.2: The number of years I have worked in the climate sciences is:

Years	USA	Canada	Germany	Grand Total
0-5	15	3	104	122
6-10	16	12	46	74
11-15	20	4	23	47
16-20	24	7	10	41
> 20	72	9	39	120
missing	2	0	6	8
Grand Total	149	35	228	412

9.5 Results

This analysis attempts to determine, through a series of t-tests, if there are statistically significant differences in the perspectives of the vocal and non-vocal members of the scientific community. (All tests of statistical significance are at the level of .05) "Vocal" is further subdivided into two categories, those scientists with a high level of involvement with policy makers and those scientists with a high level of involvement with the media.

Should we fail to reject the null hypothesis, we can assume that the *voice* of science is representative of the scientific consensus. This is not to say, however, that the voice is representative of reality. On the contrary, it might indicate a discipline well inoculated with ideology, sharing a common imagination.

Before beginning the analyses it is necessary to present the data in terms of media and policy involvement so as to distinguish these sectors of the climate science community. This is indicated in the Figures 9.1, 9.2 and 9.4 below. Responses of less than three have been chosen to represent the 'high' contact category, in other words, those scientists who responded with a value

Table 9.3: The area in which I conduct most of my research is (U: USA, C: Canada, G: Germany, GT: Grand Total):

Country	U	C	G	GT		U	C	G	GT
impact assess.	8	5	1	14	science policy	1	0	0	1
geosc. instrum.	0	1	0	1	biochemistry	1	0	0	1
oceanography	2	1	3	6	physical chem.	1	0	0	1
observations	22	9	34	65	chemistry	2	0	3	5
bio-geo cycles	0	1	1	2	atmos.processes	2	0	9	11
climate sc.	0	1	1	2	climate theory	1	0	2	3
modeling	38	8	48	94	air-sea int.	1	0	2	3
measurement	4	1	1	6	diagnostics	3	0	0	3
nutrient cyc.	0	1	0	1	convection	1	0	0	1
administration	5	1	2	8	turbulence	1	0	0	1
fluid dynamics	13	2	1	16	engineering	1	0	0	1
monitoring	0	1	0	1	cloud physics	2	0	5	7
boundary layers	0	1	0	1	strato. dyn.	1	0	1	2
ecology	0	1	2	3	solar influ.	1	0	1	2
ecosystems	0	1	0	1	snow ice	1	0	0	1
physical proc.	17	0	23	40	public forecast	0	0	2	2
radiation	1	0	1	2	agrometeorol.	0	0	1	1
nonlinear dyn.	1	0	1	2	regional clim.	0	0	6	6
computer apps.	1	0	0	1	thermodynamics	0	0	1	1
ocean modeling	1	0	0	1	flight meteor.	0	0	2	2
environ. chg.	1	0	0	1	economic geogr.	0	0	2	2
physics	1	0	1	2	stochastic proc.	0	0	2	2
remote sensing	2	0	0	2	forecasting	0	0	3	3
global policy	1	0	0	1	data systems	0	0	2	2
experimentation	2	0	11	13	synoptics	0	0	2	2
atmospheric rad.	1	0	0	1	climate change	0	0	14	14
interseasnl. cl.	1	0	0	1	meteorology	0	0	2	2
biometeorology	1	0	0	1	meso climat.	0	0	1	1
paleoclimatology	1	0	0	1	hydrodyn.	0	0	4	4
fluid dynamics	1	0	0	1	missing	4	0	24	28
					other	0	0	6	6

of less than 3 are for the sake of this analysis considered to be the vocal members of the climate science community. Figures 9.1 and 9.2 indicate that only a small proportion of the climate science community represents the voice of the scientific community to the more public consumers of knowledge. What this voice might convey is the topic of the following discussion.

The response rate indicates that 48 people (12 % of the sample) reported a high level of contact with policy makers, and 45 respondents (11 % of the sample) reported a high level of contact with the media. In Figure 9.4, the main diagonal indicates frequencies that are above those expected by chance. Seventeen of the scientists reported themselves as being at a level of high involvement with both media and policy makers, whereas 48 scientists reported as having a high level of contact with policy makers and 45 reported as having a high level of contact with the media. The number of scientists claiming almost no contact with either the media or policy makers was 150. Regarding only media contact, 197 claimed very little or no contact, and regarding contact with policy makers, 224 scientists claimed very little or no contact. Twenty eight percent of the scientists often contacted by the media claimed to have almost no contact with policy makers and, twenty four percent of scientists claiming a high level of involvement with the media reported to have almost no contact with policy makers. As Figure 9.4 indicates, those scientists with a high level of contact with the media are not necessarily the same scientists with a high level of contact with policy makers. Furthermore, Figure 9.4 indicates considerable differences between the observed frequencies and frequencies expected of the two variables were independent.

Logically, the best place to begin is the consensus regarding the phenomenon of global climate change. Figure 9.3 refers to scientist's response to his or her level of certainty that global warming is underway, the 99 % claim of the WWF. Here, only 10 % of the respondents express *no* doubt that global warming is a process already underway. With a marginal expression of doubt, those scientists responding with a value of 2 or 3, the percentage of the sample of scientists that would hedge towards agreement that global warming is underway includes an additional 55 % of the respondents. When asked if global warming would definitely occur in the future if human behavior did not change (Figure 9.4) there is a large shift in the perspectives of the respondents. Here 29 % strongly agree that without change in human behavior, global warming will definitely occur sometime in the future. Again, taking those respondents more inclined to agree (values 2 and 3) with this prospect the percentage increases greatly to include another 50 % of the respondents. In short, 65 % of the respondents express some level of agreement that global warming is a process underway while 79 % of the respondents express a level of agreement that without change in human behavior, global warming will occur sometime in the future.

A further analysis of the data in Figures 9.3 and 9.4 indicates that scientists more involved with those people who make climate related policy deci-

Figure 9.1: How much have you been involved with those people who make climate related policy decisions?

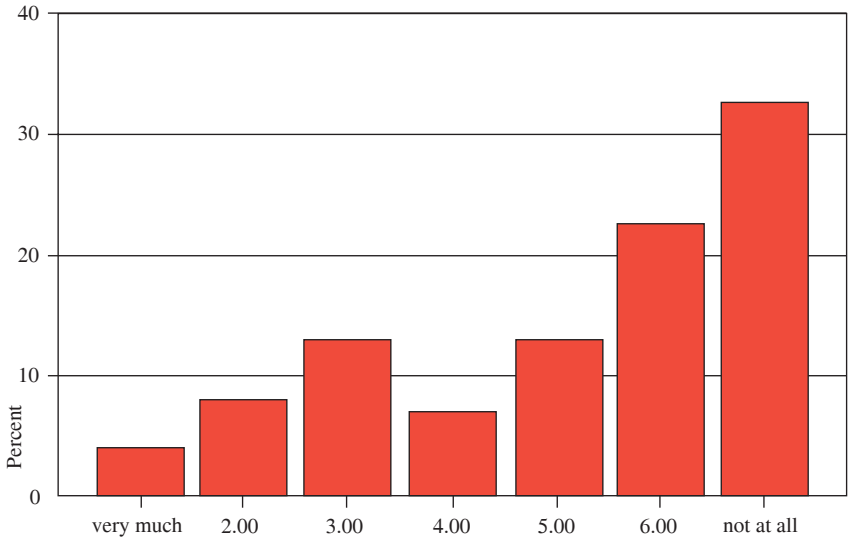


Figure 9.2: How often are you contacted by the media for information pertaining to climate change?

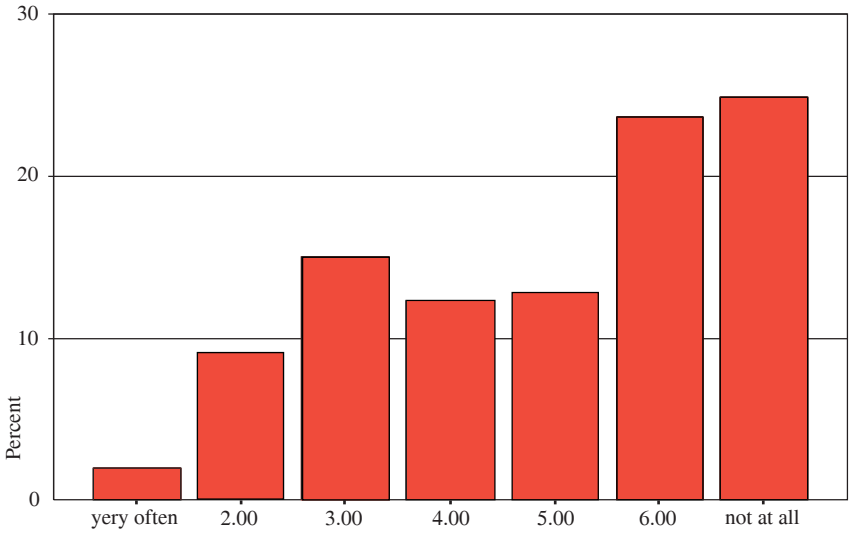


Figure 9.3: We can say for certain global warming is a process already underway

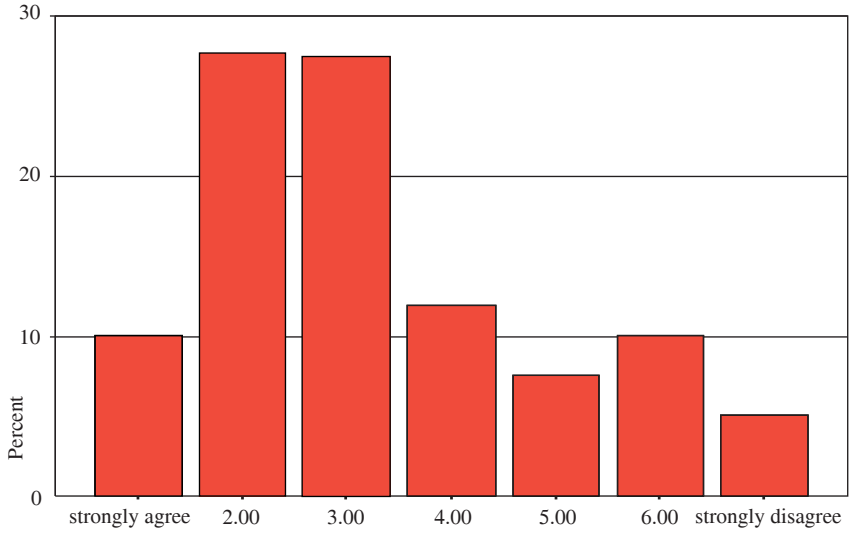


Figure 9.4: We can say for certain that without change in human behavior global warming will definitely occur sometime in the future.

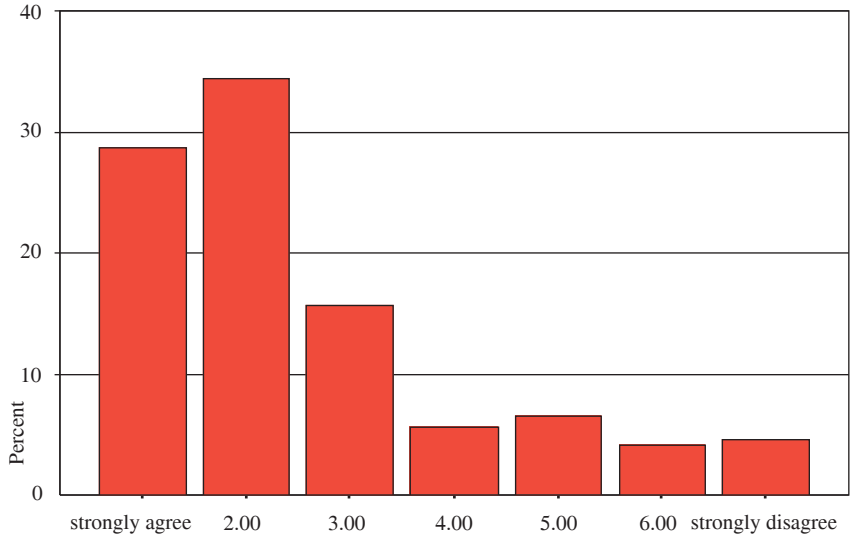


Table 9.4: Crosstabs of Policy and Media Involvement
Normal size: observed frequency, small: expected frequency, **bold:** below expected frequency, *italic:* above expected frequency

	Policy							
Media	1.00 often	2.00	3.00	4.00	5.00	6.00	7.00 never	row total
1.00 often	*2* *.3*	*3* *.6*	1 1	**0** **.6**	**0** **1**	*2* *1.8*	**0** **2.6**	8 2.0%
2.00	*2* *1.5*	*10* *2.9*	*5* *4.8*	*3* *2.6*	*6* *4.8*	**6** **8.2**	**5** **12.2**	37 9.1%
3.00	*4* *2.4*	*7* *4.8*	*16* *7.8*	*9* *4.4*	**7** **7.8**	**11** **13.6**	**7** **20.2**	61 15.1%
4.00	*3* *2.0*	4 4.0	*13* *6.4*	*7* *3.6*	*10* *6.4*	**9** **11.1**	**4** **16.5**	50 12.3%
5.00	**0** **2.1**	**3** **4.1**	**5** **6.7**	*5* *3.7*	*9* *6.7*	*19* *11.6*	**11** **17.2**	52 12.8%
6.00	**3** **3.8**	**3** **7.6**	**8** **12.3**	**2** **6.9**	*15* *12.3*	*32* *21.3*	*33* *31.8*	96 23.7%
7.00 never	**2** **4.0**	**2** **8.0**	**4** **13.0**	**3** **7.2**	**5** **13.0**	**11** **22.4**	*74* *33.4*	101 24.9%
Column total	16 4.0%	32 7.9%	52 12.8%	29 7.2%	52 12.8%	90 22.2%	134 33.1%	405 100.0%

sions (Figure 9.5) demonstrate a statistically significant difference from the other categories in the their level of certainty that global warming is a process already underway, being more inclined to agree and express that we are, at present, experiencing global warming. ("high policy involvement" mean: 2.82; "others" mean 3.63). If there would be no link between high level of contact with policy makers and a high level of agreement that global warming is a process already underway then we would expect the observed frequencies to closely approximate the expected frequencies in the four upper left cells of Figure 9.5. This however, is not the case, with the observed frequency being 26 and the expected frequency being 17. In short, there are more scientists than would be expected by chance that have a high level of contact with policy makers and strongly agree that global warming is a process already underway. There is no statistically significant difference between that group which frequently speaks to the media and that group which does not (Figure 9.6) in regards to a greater expression that global warming is already underway, with the observed frequency being 21 and the expected frequency 17. It would seem then that those scientists who have higher contact with policy makers are more inclined to agree that global warming is indeed a process already underway while those scientists with high levels of media contact

perhaps draw from a broader range of perspectives and that the media might be more likely to seek out opposing views. Nonetheless, the advice given to the policy arena is that global warming is a process already underway while commentary directed to the public (via the media) is typically less committed to such a position. Consequently, while perhaps not being able to spark the public imagination and maintain a degree of significance in light of absence of dramatic changes, it would seem the issue of climate change is presented so as to maintain a high priority in the political realm.

The data in Figures 9.3 and 9.4 might, as stated, also be an indication, since we are dealing with statistical artifacts, that the press might be inclined to seek out opposing extremes, thereby negating statistical differences. This is evident in a comparison of Figures 9.5 and 9.6. Under the categories of strongly disagreeing that climate change is underway, of the 47 scientists with a higher level of contact with policy makers (i.e. values 1 and 2) there is evidence of only four individuals from the sample claiming a strong level of disagreement (values 6 and 7) while when considering the 45 scientists claiming higher levels of media contact there is evidence of 8 individuals claiming that global warming is *not* underway (values 6 and 7).

In an effort to account for any bias in the above line of questioning, scientists were asked to comment on the *future* possibility of global warming, that is, if "We can say for certain that without change in human behavior, global warming will definitely occur sometime in the future." In essence, this gives credence to the theory of global warming in lack of the manifestation of the event (Figure 9.4).

The analysis of the data indicates that there is little difference in the acceptance of the *theory* of global warming between those who speak to policy makers and those who do not. The question of differences remains in the manifestation of the event, evident in the higher level of acceptance of the theory (means: high policy involvement group 2.23, high media involvement group 2.8) than of the manifestation of the event (means: policy involvement 2.8, media involvement 3.6). This is also the case when responses were given regarding reporting to the media, that is, those who spoke to the media also had a higher level of consensus regarding the *theory* of global warming than they did the event of global warming.

Overall, the theory of global warming seems to be less contentious than the actual event, although even the theory is far from a state of unanimous consensus. However, it would seem that those scientists from the sample with a higher contact to policy makers are more convinced that the process of global warming is already underway and those scientists with higher levels of media contact are more likely to present both extremes. Given that the theory of global climate change has moved beyond the scientific context (in spite of less than consensual acceptance of the theory) it is necessary to ask what global climate change might mean in terms beyond academic significance, since it is at the social and political levels of interpretation that the

Table 9.5: Crosstabs of Level of Policy Involvement and Certainty of Global Warming Underway
Normal size: observed frequency, small: expected frequency, **bold:** below expected frequency, *italic:* above expected frequency

	Certainty							
Policy	1.00 agree	2.00	3.00	4.00	5.00	6.00	7.00 disagree	row total
1.00 often	*2* *1.5*	*10* *4.2*	**1** **4.1**	**0** **1.8**	**0** **1.1**	**1** **1.5**	*1* *.8*	15 3.7%
2.00	*4* *3.2*	*10* *8.9*	**8** **8.7**	*5* *3.9*	*3* *2.4*	**2** **3.2**	**0** **1.7**	32 7.9%
3.00	*7* *5.3*	**12** **14.7**	*15* *14.5*	**5** **6.4**	4 4.0	*7* *5.3*	*3* *2.7*	53 13.0%
4.00	**1** **2.9**	*10* *8.1*	**4** **7.9**	*5* *3.5*	*6* *2.2*	**2** **2.9**	**1** **1.5**	29 7.1%
5.00	*6* *5.2*	**12** **14.4**	*18* *14.2*	**5** **6.3**	**3** **4.0**	**4** **5.2**	*4* *2.7*	52 12.8%
6.00	**9** **9.4**	**24** **25.8**	**23** **25.4**	**10** **11.2**	*10* *7.1*	*12* *9.4*	*5* *4.8*	93 22.9%
7.00 never	**12** **13.4**	**35** **36.9**	*42* *36.3*	*19* *16.0*	**5** **10.1**	**13** **13.4**	*7* *6.9*	133 32.7%
column total	41 10.1%	113 27.8%	111 27.3%	49 12.0%	31 7.6%	41 10.1%	21 5.2%	407 100%

phenomenon becomes interpreted into action and policy. To this end scientists were asked to make some initial assessments regarding impacts. These are presented in Figures 9.5 through 9.7.

Figure 9.5 summarizes the responses to a question regarding the potential for a rapid onset of climate change and a lack of preparation to result in devastation of some areas of the world. Results indicate there are no statistically significant differences between the general scientific community and those speaking to the media and/or policy makers. The distribution in the bar chart indicates panic is not the general status of the scientific community.

Figure 9.6 represents the responses when scientists were asked if the potentially detrimental impacts can yet be identified. As the data indicates, there is a high level of uncertainty within the scientific community regarding this assessment. Figure 9.6 implies that there might be a split in the scientific consensus as to the level of achieved scientific knowledge regarding the impacts of climate change. However there are no statistically significant differences between those groups with high levels of media and policy maker contact and the general scientific community. We can assume that both perspectives are represented in the public and political forums.

Figure 9.5: Assuming climate change will occur, it will occur so suddenly that a lack of preparation could result in the devastation of some parts of the world.

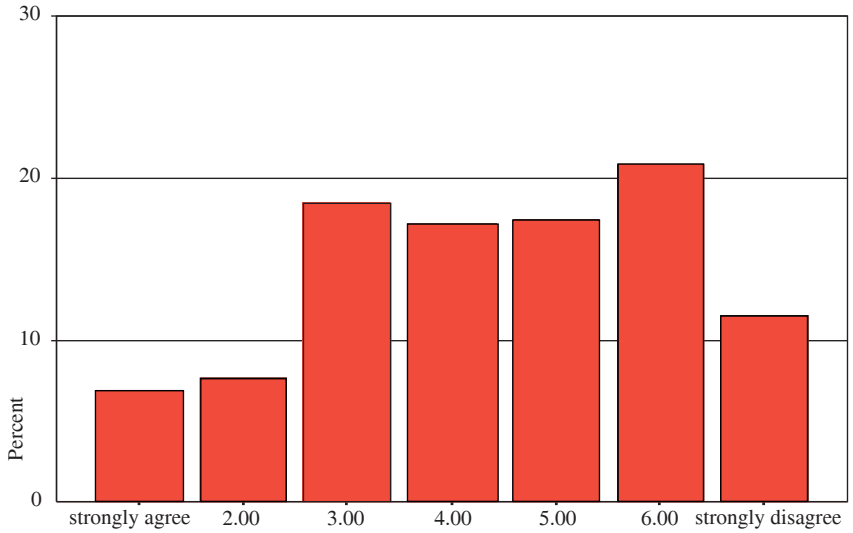


Figure 9.6: To what degree can we explicitly state the *detrimental* effects that climate change will have on society?

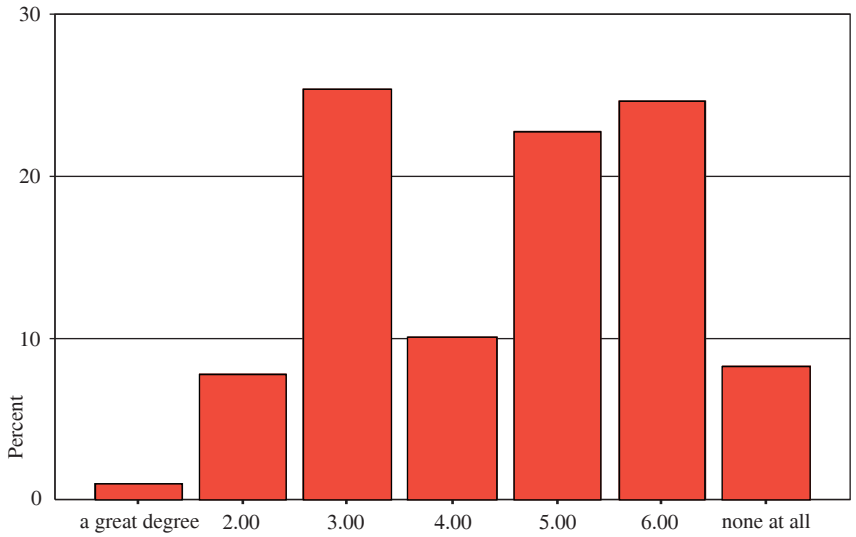


Figure 9.7: To what degree do you think that climate change will have a detrimental effect for the society in which you live?

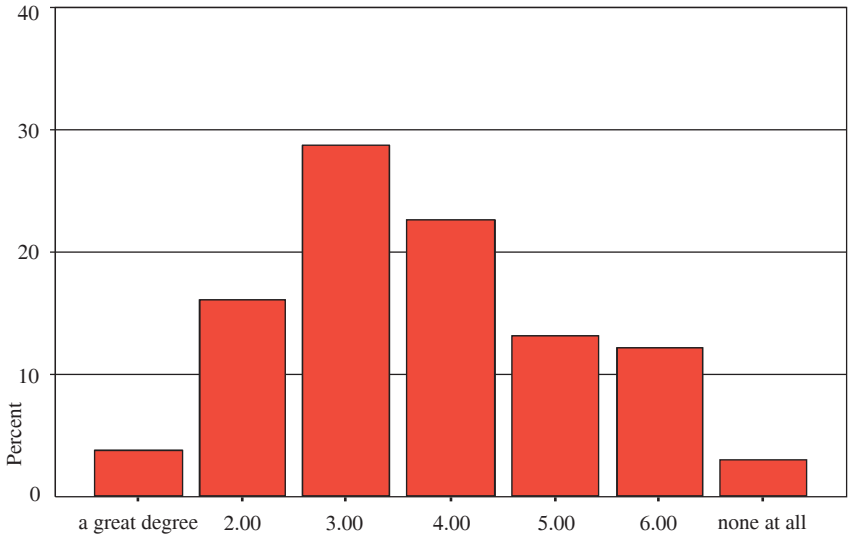


Figure 9.8: To what degree do you think that climate change might have some positive effects for the society in which you live?

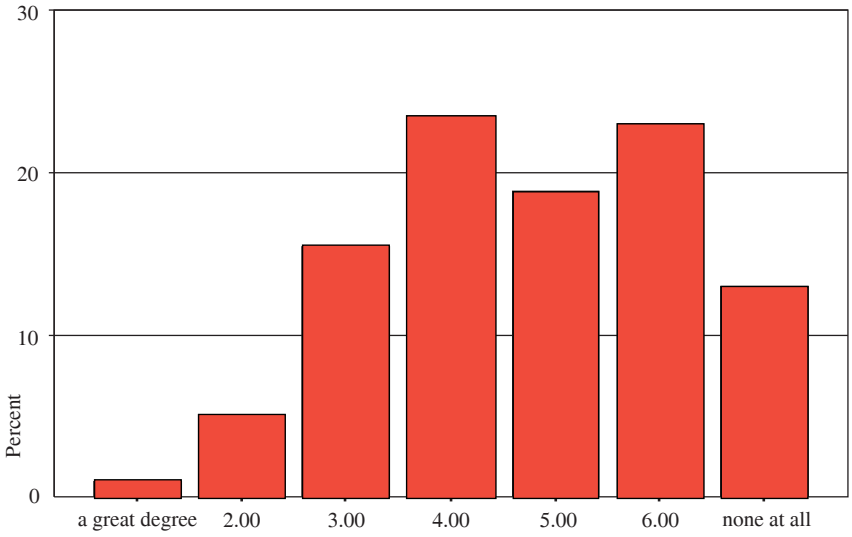


Table 9.6: Crosstabs of Level of Media Involvement and Certainty of Global Warming Underway
Normal size: observed frequency, small: expected frequency, **bold:** below expected frequency, *italic:* above expected frequency

	Certainty							
Media	1.00 often	2.00	3.00	4.00	5.00	6.00	7.00 never	row total
1.00	*2*	*4*	**2**	**0**	**0**	**0**	**0**	8
often	*.8*	*2.2*	**2.2**	**1.0**	**.6**	**.8**	**.4**	2.0%
2.00	*4*	*11*	**7**	**4**	*3*	*5*	*3*	37
	3.7	*10.2*	**10.1**	**4.5**	*2.9*	*3.7*	*1.8*	9.2%
3.00	**3**	**15**	**16**	*10*	*6*	*7*	3	60
	6.0	**16.6**	**16.5**	*7.3*	*4.6*	*6.0*	3.0	15.0%
4.00	*8*	*18*	*14*	**3**	**3**	**3**	**1**	50
	5.0	*13.8*	*13.7*	**6.1**	**3.9**	**5.0**	**2.5**	12.5%
5.00	**4**	**14**	**9**	*8*	*8*	*6*	*3*	52
	5.2	**14.4**	**14.3**	*6.4*	*4.0*	*5.2*	*2.6*	13.0%
6.00	**9**	**25**	*30*	*14*	**5**	**9**	**3**	95
	9.5	**26.3**	*26.1*	*11.6*	**7.3**	**9.5**	**4.7**	23.7%
7.00	*10*	**24**	*32*	**10**	**6**	*10*	*7*	99
never	*9.9*	**27.4**	*27.2*	**12.1**	**7.7**	*9.9*	*4.9*	24.7%
column	40	111	110	49	31	40	20	401
total	10.0%	27.7%	27.4%	12.2%	7.7%	10.0%	5.0%	100.0%

Pursuing further the general nature of the possible impacts of climate change, scientists were asked to respond to similar lines of questioning, one pertaining to the world in general, the other to his or her more familiar host society. The results are presented in Figures 9.7 and 9.8.

When asked about the respective host society (Figure 9.7) regarding the explicit nature of the impacts of climate change, there appears to be somewhat more of a consensus that climate change is perceived of as having a greater potential for negative consequences. There were no statistically significant differences between the groups. It seems that the people who have a high degree of contact with policy makers share a similar perspective as the general scientific community as do those who have a high degree of contact with the media. In short, there is a considerable degree of consensus that climate change is prone to produce negative consequences in the scientist's host society while at the same time, the scientific community is far from making the claim of being able to state the characteristics of the impact. This has implications for the construction of science-policy dialogue procedure, particularly in light of the fact that scientists with a higher degree of policy contact are more inclined to perceive global warming as underway but are

not necessarily able to state the specific nature impacts, only that they will be detrimental, an attitude which would be conveyed to policy and public attention.

To determine if the impact of climate change was limited to a negative connotation, scientists were asked if they perceived climate change as possibly resulting in *benefits* for the host society (Figure 9.8). It appears in general that climate change as a negative impact outweighs the perspective of climate change as a positive impact (overall means: Figure 9.7: 3.9, Figure 9.8: 4.2) however, *scientists with a high level of involvement with policy makers were more inclined to perceive the possibility for positive benefits for the host society* which, among a variety of other reasons, might add to the reluctance of political bodies to engage in political action in terms of climate policy and to raise differing perspectives in international negotiations. When asked to what degree climate change might have some positive effect there was a statistically significant difference between those scientists with a high level of contact with policy makers and the remainder of the sample. The mean response of those with high contact to the policy makers was 4.0 as compared to 4.8 for the remainder of the sample with a value of "1" representing "a great" potential for positive impacts and a value of "7" representing "no" possibility at all.

In brief, while the scientists with a high level of contact to policy makers might be more inclined to believe that climate change is underway, they might also be more inclined overall to feel that climate change has the potential to spawn some positive benefits for society as well as negative impacts. This potential was worthy of further analysis and is elaborated in Figures 9.7 and 9.8. Again, using the values of 1 and 2 to indicate high levels of involvement with policy makers and with the media, the data indicates that from among the scientists who responded to this question and also claimed a high level of policy contact, 22 % saw the potential for positive outcomes stemming from climate change (values 1-2) and 29 % saw little potential for positive outcomes (values 6-7). Of those claiming a high level of contact with the media who responded to this question, however, only 11 % saw the potential for positive benefits while 44 % saw little or no potential for a positive outcome from climate change. Consequently we could assume the likelihood that more often than not the perception of the climate change issue being presented to the public is one of mostly negative impacts.

Scientists were also asked to what degree they felt that global climate change was one of the leading problems facing society. As Figure 9.9 indicates, the status of global climate change, in spite of areas of contention, is generally assigned a high global priority from among the members of the climate science community, and opinions would suggest this is drawn from the perception of negative consequences assigned to the event, in spite of the inability to explicitly state these consequences. Among the groups being considered, there were no statistically significant differences.

Table 9.7: Crosstabs of Level of Policy Involvement and Positive Benefits
Normal size: observed frequency, small: expected frequency, **bold:** below expected frequency, *italic:* above expected frequency

	Positive benefits							
Policy	1.00 great	2.00	3.00	4.00	5.00	6.00	7.00 none	row total
1.00 often	*1* *.2*	*2* *.8*	*4* *2.5*	*5* *3.8*	**1** **3.0**	**0** **3.7**	*3* *2.1*	16 3.9%
2.00	*1* *.3*	*3* *1.6*	*6* *4.8*	*11* *7.3*	**4** **5.9**	**4** **7.1**	**2** **4.0**	31 7.6%
3.00	*1* *.5*	**1** **2.7**	*13* *8.2*	*15* *12.5*	*15* *10.0*	**6** **12.2**	**2** **6.9**	53 13.0%
4.00	**0** **.3**	*3* *1.4*	*6* *4.2*	**6** **6.4**	**3** **5.1**	*8* *6.2*	**1** **3.5**	27 6.6%
5.00	**0** **.5**	*3* *2.7*	**8** **8.2**	**7** **12.5**	*15* *10.0*	*15* *12.2*	**5** **6.9**	53 13.0%
6.00	*1* *.9*	*5* *4.8*	**11** **14.4**	**19** **21.9**	**16** **17.6**	*26* *21.4*	*15* *12.1*	93 22.8%
7.00 never	**0** **1.3**	**4** **6.9**	**15** **20.8**	*33* *31.8*	**23** **25.5**	*35* *31.1*	*25* *17.5*	135 33.1%
column total	4 1.0%	21 5.1%	63 15.4%	96 23.5%	77 18.9%	94 23.0%	53 13.0%	408 100.0%

On this basis one would assume that the theory, at least, would have a high degree of consensus regarding its derivation. To this end, scientists were posed questions pertaining to the tools of their trade. In regard to the internal assessment of the science, scientists were asked to assess the inner workings of their science, the results of which (as indicated in the above discussion) have led to multiple interpretations reaching far beyond some scientists' intentions.

Table 9.9 presents the responses in rank order. The most problematic area indicated by the data is the ability of atmospheric models to deal with the influence of clouds while the least problematic area is the ability of atmospheric models to deal with hydrodynamics.

Figures 9.10 through 9.14 demonstrate graphically the responses of scientists to questions pertaining to some of the components of modeling, the test of climate theory. There were no statistically significant differences among the public and political voices and the more silent majority. The ambivalence indicated by the mean in Figure 9.10 (overall means: 4.6, Std. Dev. 1.5) however, suggests less than unanimous faith in the output of climate models. This tendency is repeated when specific aspects of climate science are addressed in figures 9.11 through 9.15.

Table 9.8: Crosstabs of Level of Media Involvement and Positive Benefits
Normal size: observed frequency, small: expected frequency, **bold:** below expected frequency, *italic:* above expected frequency

	Positive benefits							
media	1.00 great	2.00	3.00	4.00	5.00	6.00	7.00 none	row total
1.00 often	**0** **.1**	*1* *.4*	**1** **1.3**	**0** **1.9**	*3* *1.5*	*2* *1.8*	**1** **1.1**	8 2.0%
2.00	*1* *.4*	*2* *1.9*	*6* *5.6*	**8** **8.4**	**6** **6.8**	*9* *8.1*	**4** **4.7**	36 9.0%
3.00	*1* *.6*	*5* *3.2*	*13* *9.6*	*17* *14.3*	**8** **11.5**	**11** **13.8**	**6** **8.0**	61 15.2%
4.00	*1* *.5*	*4* *2.6*	*8* *7.7*	**10** **11.5**	*13* *9.3*	**10** **11.1**	**3** **6.5**	49 12.2%
5.00	*1* *.5*	**2** **2.7**	**6** **8.0**	*11* *11.9*	*13* *9.6*	*13* *11.5*	**5** **6.7**	51 12.7%
6.00	**0** **1.0**	**4** **5.0**	*20* *15.0*	*24* *22.4*	**13** **18.1**	*21* *21.7*	**14** **12.7**	96 23.9%
7.00 never	**0** **1.0**	**3** **5.3**	**9** **15.8**	*24* *23.6*	*20* *19.1*	*25* *22.9*	*20* *13.3*	101 25.1%
column total	4 1.0%	21 5.2%	63 15.7%	94 23.4%	76 18.9%	91 22.6%	53 13.2%	402 100.0%

When questioned about the ability to deal with precipitation (Figure 9.11), particularly in light of some of the more public claims of the impacts of global warming, scientists, vocal and otherwise, demonstrated limited faith in the ability for precipitation to be accounted for in climate modeling. Scientists were then asked to comment on the ability of models to incorporate the influence of clouds (Figure 9.12) and this produced similar results. Scientists were then asked to comment on the perceived abilities of ocean models (Figure 9.13). The question of the ability to deal with convection in ocean models resulted in responses similar to the questioning of the ability to deal with the components of atmospheric models. When asked about the coupling of atmospheric and ocean models (Figure 9.14) similar responses were forthcoming.

While other similar questions were posed it is redundant at this point to discuss each in detail as similar responses were presented throughout the entire line of questioning. As Figures 9.10 through 9.14 indicate, the scientific community makes no claim of perfection. Nonetheless, much rests on the products of these tools, namely the future direction of climate policy. It is the output and interpretations of these models that are employed by policy makers. In short, it is the predictive powers of the science that are

Figure 9.9: How much do you think global climate change is one of the leading problems facing humanity?

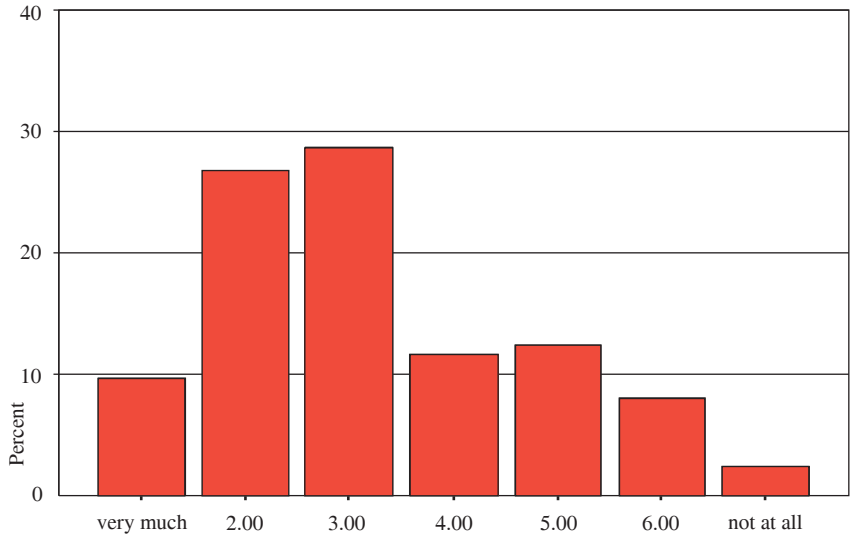


Figure 9.10: Climate models accurately verify the climatic conditions for which they are calibrated.

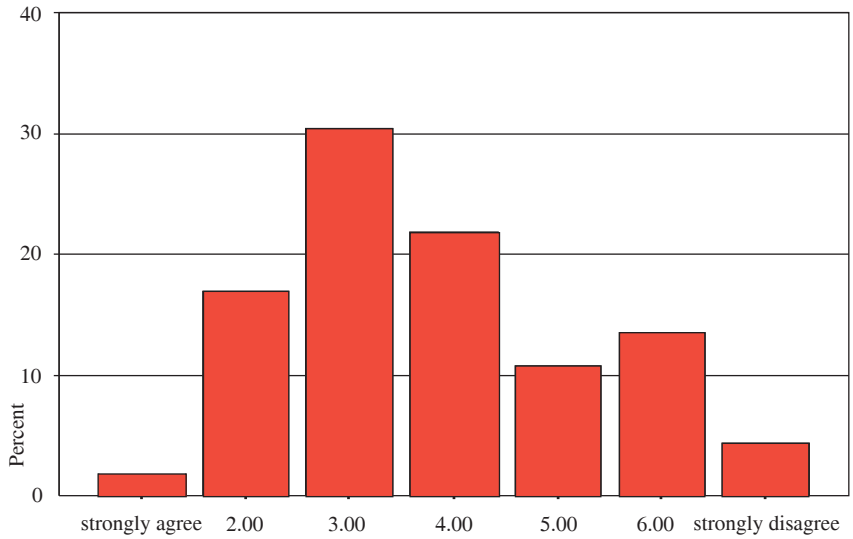


Table 9.9: Assessment of Components:

Component	**Mean**	**Std.Dev.**	**N**
Climate models	1 = strongly agree 7 = strongly disagree		
accurately verify the conditions for which they are calibrated	3.8	1.5	407
accurately predict climatic conditions of the future	4.6	1.5	407
How well do atmospheric climate models deal with	1 = very inadequate 7 = very adequate		
the influence of clouds	2.9	1.4	405
precipitation	3.0	1.4	405
atmospheric convection	3.5	1.3	404
atmospheric vapor	3.5	1.4	406
radiation	4.6	1.4	406
hydrodynamics	4.7	1.4	406
How well do ocean models deal with	1 = very inadequate 7 = very adequate		
coupling of ocean and atmospheric models	3.3	1.3	401
oceanic convection	3.7	1.3	396
heat transport in the ocean	4.5	1.2	397
hydrodynamics	4.7	1.3	396
The state of knowledge allows for reasonable assessments of	1 = strongly agree 7 = strongly disagree		
turbulence	3.6	1.4	397
land surface processes	3.6	1.4	399
sea-ice	3.9	1.3	402
green-house gases	4.5	1.5	404
surface albedo	4.6	1.3	403

Figure 9.11: How well do atmospheric models deal with precipitation?

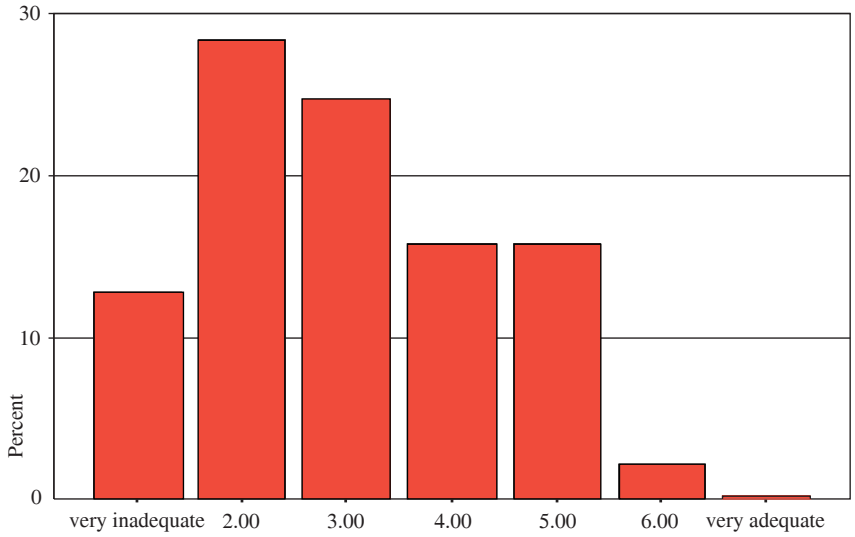


Figure 9.12: How well do atmospheric models deal with clouds?

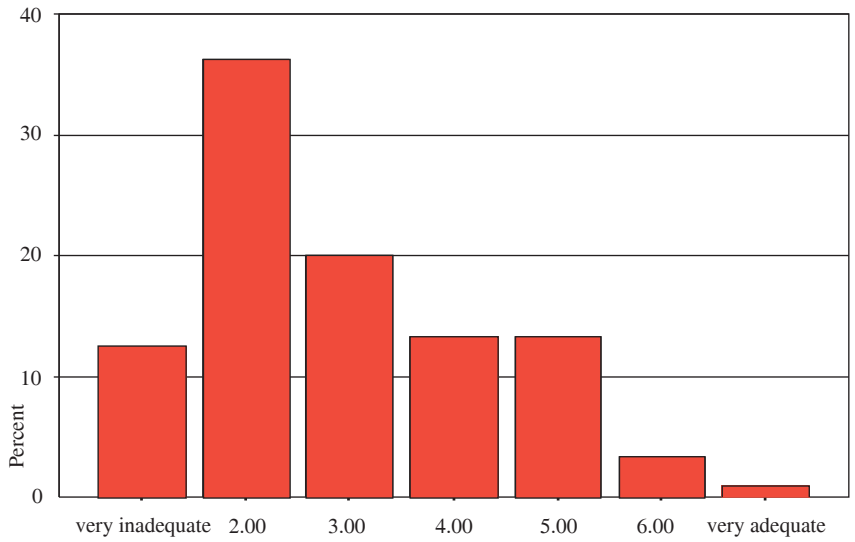


Figure 9.13: How well do ocean models deal with convection?

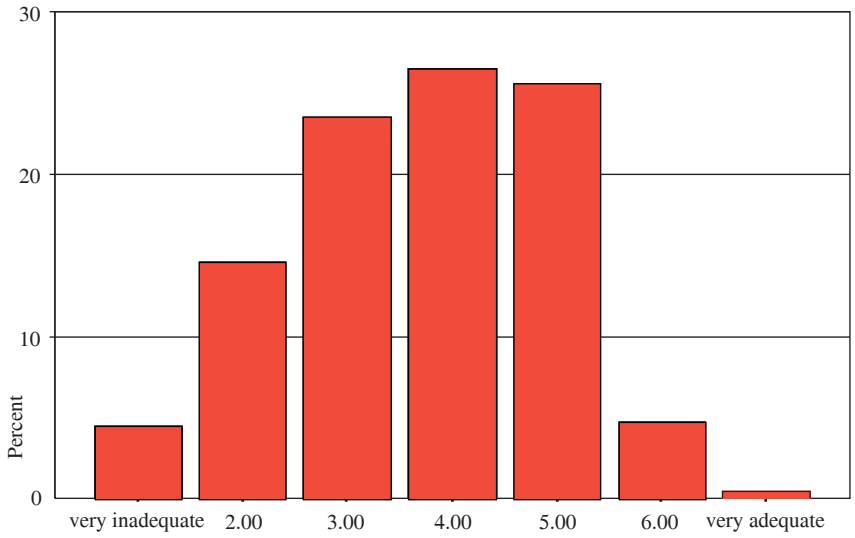


Figure 9.14: How adequate is the coupling of atmospheric models and ocean models?

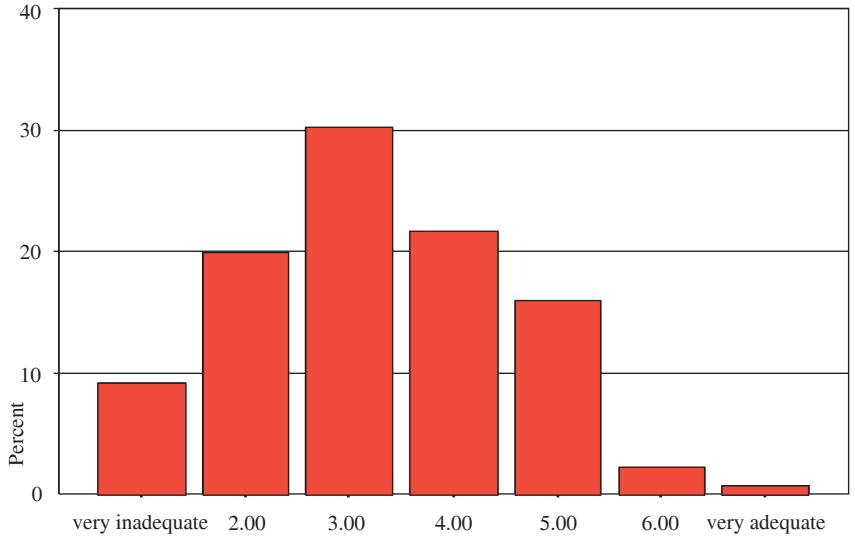
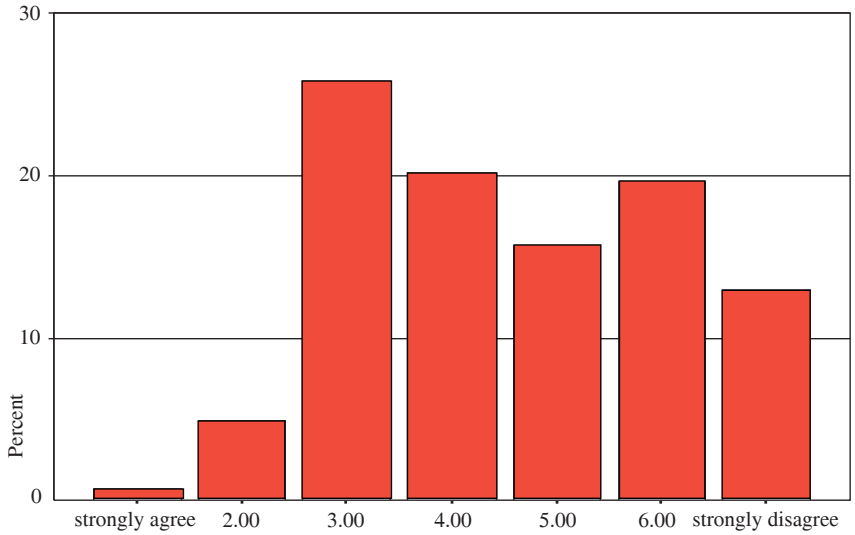


Figure 9.15: Climate models can accurately predict climatic conditions of the future.



anxiously awaited and often, by what ever means, extrapolated for policy considerations. In the process of employing the current state of knowledge, it is sometimes the case that the expert opinion of uncertainty demonstrated in the above is sometimes transformed into, or misinterpreted as, an expert *prediction* of the future.

As the following responses suggest, most scientists would tend to agree that this ability is well beyond the state of the science. Considering some of the lay perceptions of the issue of global climate change, it is interesting to note that the limited faith in the ability of climate models was prevalent among both the vocal and non-vocal sectors of the climate science community, suggesting the public applies its own interpretation.

The phenomenon of the extension of knowledge beyond its capabilities is further expressed when scientists were asked to comment on the predictive ability of the current state of the science (Figure 9.15). This raises the question of how, in the transformation of knowledge, a major degree of uncertainty is removed.

In an attempt to further explore the prediction potential of climate science, questions were posed incorporating the specification of time spans (Figures 9.16 through 9.18).

Figure 9.16 indicates the responses to a short time span perspective. Data indicates there is far from a consensus regarding the ability to predict inter annual variability. In Figure 9.17, the time frame is extended to a period of 10 years. And, again, as would be expected, the scientific community

Figure 9.16: To what degree can climate models provide *reasonable* predictions of inter annual variability?

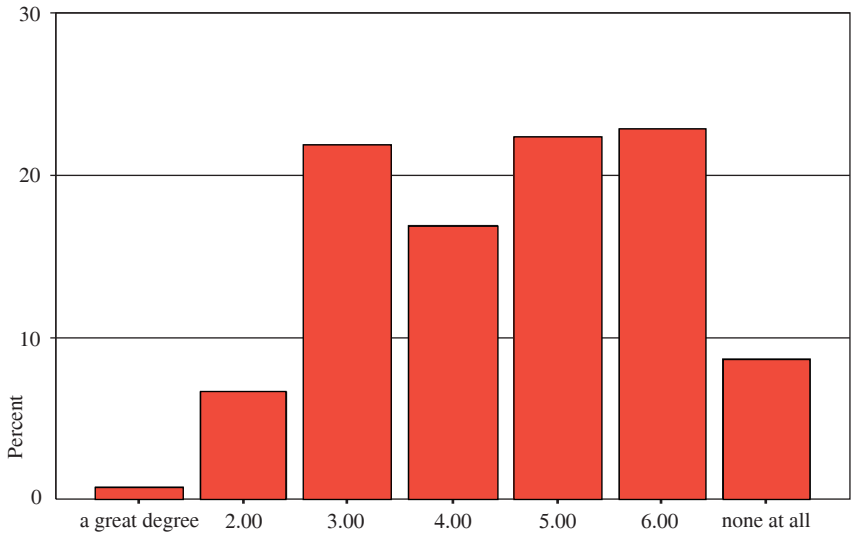


Figure 9.17: To what degree can climate models provide *reasonable* predictions of climate variability of a time scale of 10 years?

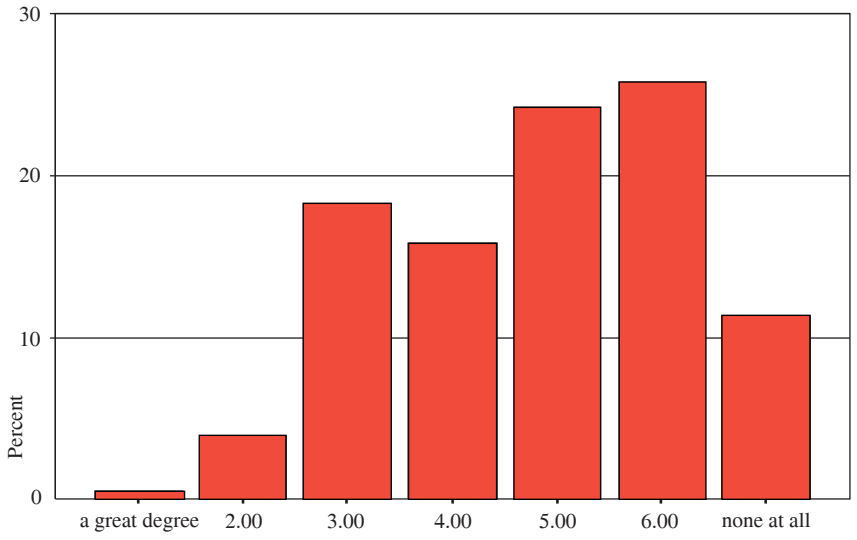
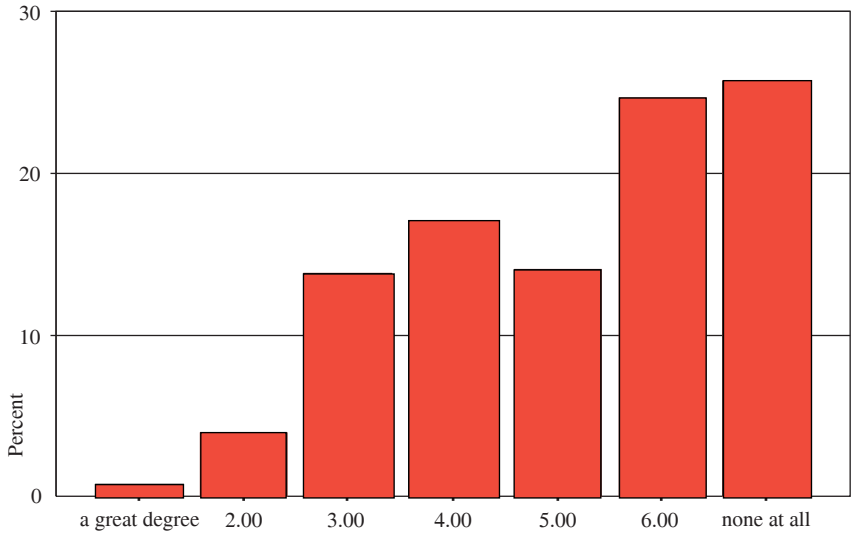


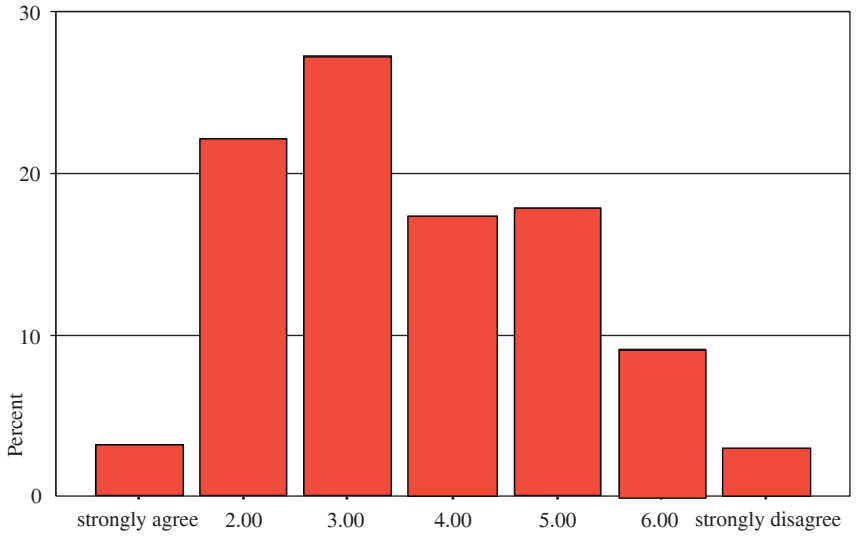
Figure 9.18: To what degree can climate models provide *reasonable* predictions of climate variability of time scales of 100 years?



expressed little faith in the ability of the models to predict future climatic conditions. The time span was further extended to a period of 100 years (Figure 9.18). It was suspected that perhaps a more general trend could be better endorsed in terms of predictions. However, as Figure 9.18 indicates, this was not the case. The inability to state with any level of certainty the future characteristics of climatic conditions again points to the role of the imagination in the socio-scientific construction of climate change. On the matter of predictive capabilities, no statistically significant differences between or among any of the groups were evident.

In short, Figures 9.15 through 9.18 indicate that the scientific community is far from being convinced of its predictive powers. Nonetheless, the products of the science are in many circumstances interpreted precisely as being predictions. Undoubtedly, if this interpretation was without the possibility of climate change having a significant impact sometime in the future, climate change would not be perceived as a major issue. Furthermore, the nature of the impact is also a concern. Impacts must be presented to coincide with human perceptual thresholds in terms of both time and magnitude. To this extent, scientists were asked to comment on the transformation from the physical to socially relevant aspects of climate change. It is at this point that statistically significant differences become more readily apparent between the vocal and non-vocal sectors of the climate science community. Figure 9.19 pertains to the intra-science transfer of knowledge. As the data indicates, this is perceived as being far from a perfect relationship.

Figure 9.19: In general, those scientists producing GCMs are knowledgeable about what data are needed by those scientists that endeavor to study the impacts of climate change.

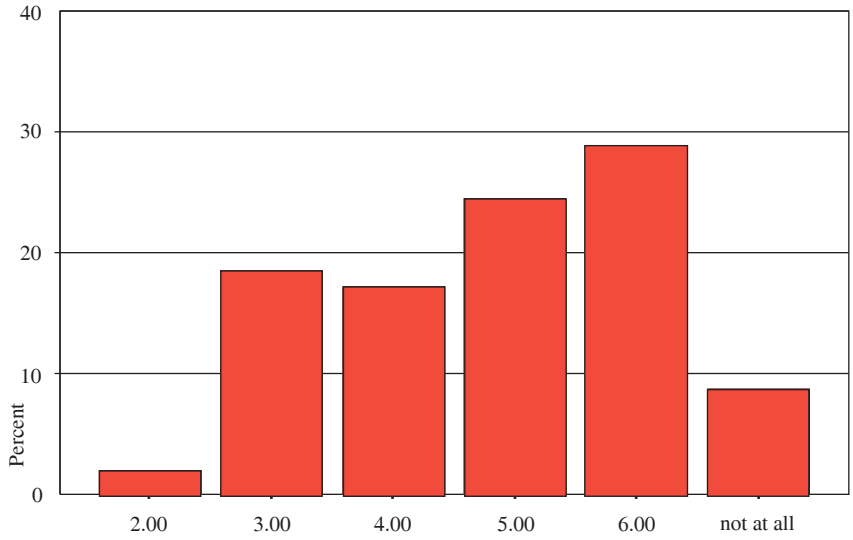


Notable here is the statistically significant differences among those vocal members of the scientific community and those less vocal members, particularly between those who have a high level of interaction with policy makers (mean 4.5) and those who do not (mean 3.5). Those who deal with policy makers expressed a lower level of confidence in the typical level of expressed awareness of the knowledge needs of the more external parts of the climate science community. This is perhaps due to their increased exposure to the needs of other sectors in the debate, as derived from multiple levels of involvement.

When asked of the ability to determine local climate impacts, through the process of downscaling (Figure 9.20) the mean response indicated that this ability is perceived also to be in need of great development and again, a greater awareness of this problem was expressed by those with a higher level of contact with policy makers, with a statistically significant difference between the means of those with a high level of contact with policy makers (mean 5.2) and the remainder of the sample (mean 4.8). Among those with high media contact and the remainder of the sample there was no statistically significant difference. In short, what gets reported to the media does so with a greater faith in the ability of science, and the voice to policy makers is more likely to heed on the side of caution.

When asked if the science is developed to the degree that information could be provided for local social impact assessments (Figure 9.21), the need

Figure 9.20: To what degree, through the process of downscaling, is it now possible to determine local climate impacts?



for further research was again made very evident but no statistically significant differences were found among the groups. This is noteworthy in light of the numerous local impact assessments that can be found in the literature and have become the basis of policy discussion. We can assume that policy debates often proceed on the findings of "what-if" as opposed to "what-is" analyses.

In spite of the lack of consensus as to the ability of the climate sciences to provide information for local impact assessments, a minority of scientists felt the issue of global warming should extend beyond a discussion limited to the physical world and begin to incorporate the social scientists in the discussion. These tendencies are evident in Figure 9.21. Here, there is the indication of a bipolar distribution when it comes to the readiness of the science to point to social relevance. While there is a tendency for scientists to claim knowledge of what is required, the ability to generate such knowledge is still a contested area. Regarding the data summarized in Figure 9.22, no statistically significant differences were found among the groups under consideration.

Regarding the broader scope of the implications of climate change, and in light of the perception that climate change will have (mostly negative) social impacts, climate scientists were asked of their perceptions of the integration of the social and physical worlds (Figure 9.23). Here there is a statistically significant difference between those with higher levels of involvement with policy makers (mean 4.8) and those with lower levels of involvement (mean

Figure 9.21: The climate sciences are developed well enough to provide information for local social impact assessment.

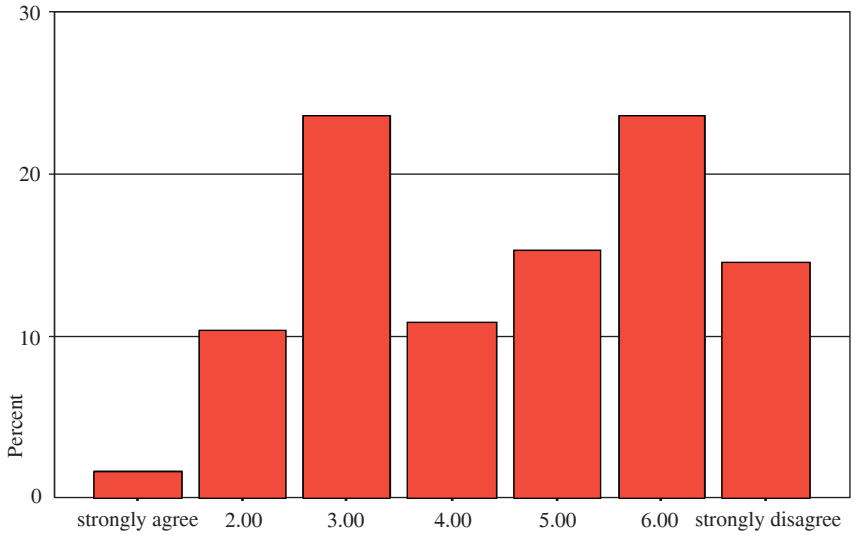


Figure 9.22: Natural scientists have established enough physical evidence to turn the issue of global climate change over to social scientists for matters of policy discussion.

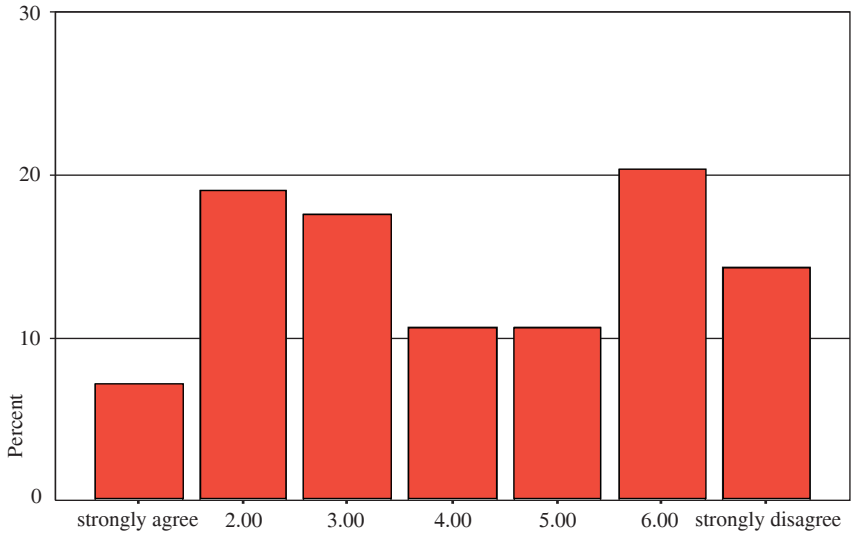
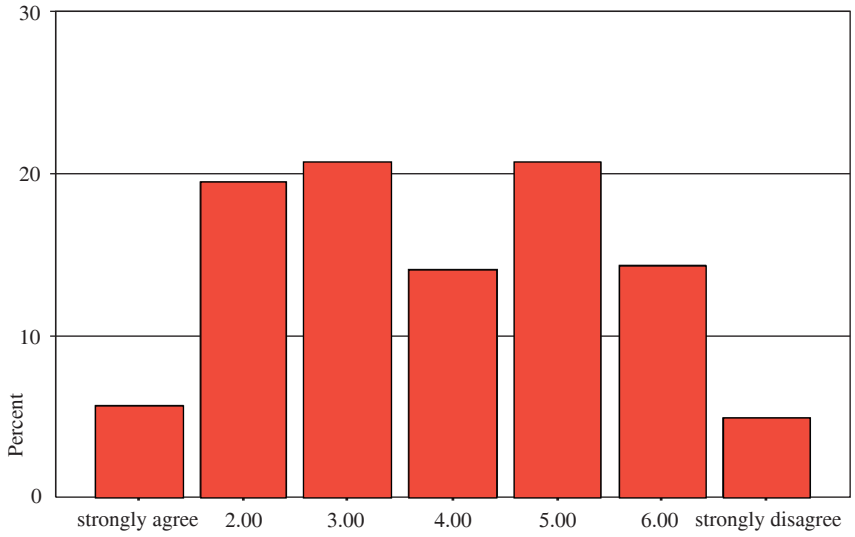


Figure 9.23: Climate scientists are well attuned to the sensitivity of human social systems to climate impacts.

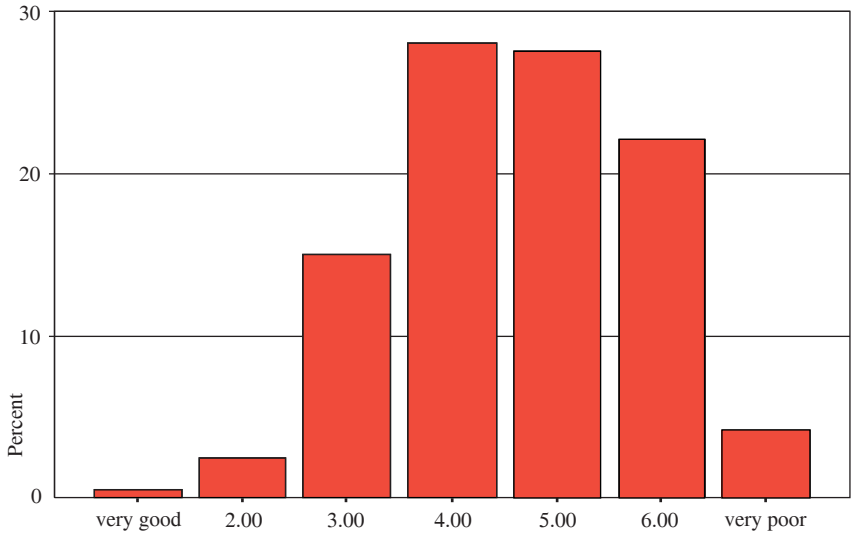


3.7). Those with less involvement with the political realm tended to perceive that scientists have a higher level of understanding of the sensitivity of the human social system than did those with higher levels of involvement with the political realm. Perhaps higher levels of policy involvement create a greater awareness of the complexities of the social world, while those with a lesser degree of integrated involvement, that is limited activity in the political sphere, maintain a somewhat naive interpretation of the social world. There were no statistically significant differences when concerning the group with higher levels of media contact, perhaps suggesting a contribution to the reason why somewhat naive statements often find their way to press, and ultimately, why media might begin to feedback into science.

That scientific claims are reaching the public and political ear could not be contested. The next section of this paper explicitly asks climate scientists how they perceive the relationship between the scientific community and the external users and reporters of scientific knowledge. This is a descriptive account of the *transfer and transformation* of knowledge. In light of the data presented above, this is an issue of particular relevance, for once outside of the scientific community, hypotheses and propositions are often ascribed the status of scientific fact. In addition to the science community, three key players enter into the debate of climate change, namely those who design climate related social and economic policies, the media and the general public.

The interaction of the scientific community and policy makers is by no means a new phenomenon. What is historically (somewhat) unique in this

Figure 9.24: How would you describe the working relationship between climate scientists and policy makers?

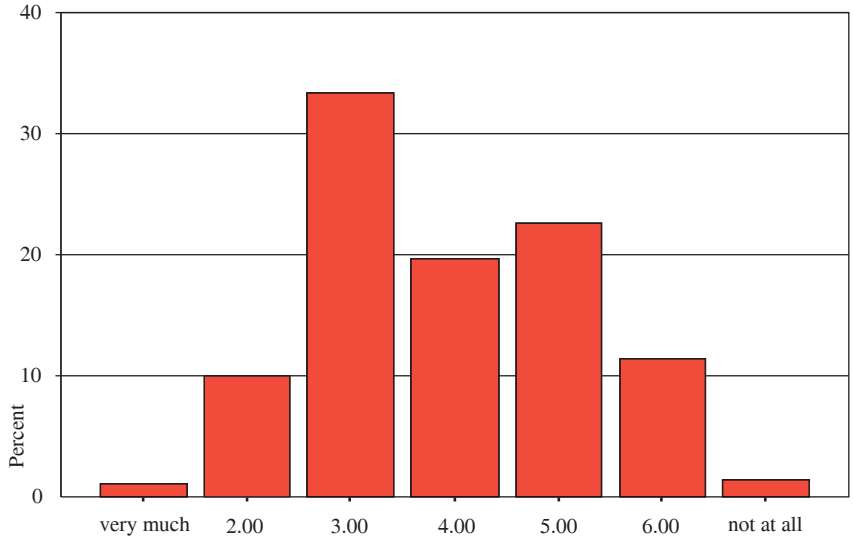


case however is the fact that climate policy has global implications. The following provides a descriptive account of some elements of the perceived relationships that exist among science, policy makers, the media, and the general public. It is assumed that ultimately these relationships all constitute a system of feedbacks. The importance of such considerations is further emphasized when one considers that social-feedback loops are most noticeably absent in all but a few impact scenarios.

The science-policy relationship is addressed in Figure 9.24 and presents the results of the assessment of the relationship made by climate scientists. The analysis of the data produced a statistically significant difference between the means of those scientists who have a high level of contact with policy makers (mean 4.2) and those who do not (mean 4.7). As would be expected, it was those scientists who claimed a high level of contact with policy makers that perceived the relationship with policy to be more satisfactory. There is no evidence of a statistically significant difference when considering that group that claimed a high level of involvement with the media and the rest of the climate science community in regards to the science-policy relationship.

Figure 9.25 indicates scientists' perceptions of the impact of their scientific endeavors on political matters. When asked about the impact of scientific knowledge on the political sphere an analysis of the data resulted in a statistically significant difference between those claiming a higher level of involvement with the policy sphere (mean 3.4) and those scientists claiming a lesser degree of involvement (4.0). Those scientists with a higher level of

Figure 9.25: To what degree do you think that the results of scientific inquiry are instrumental in causing policy makers to redefine their perceptions of climate related issues?



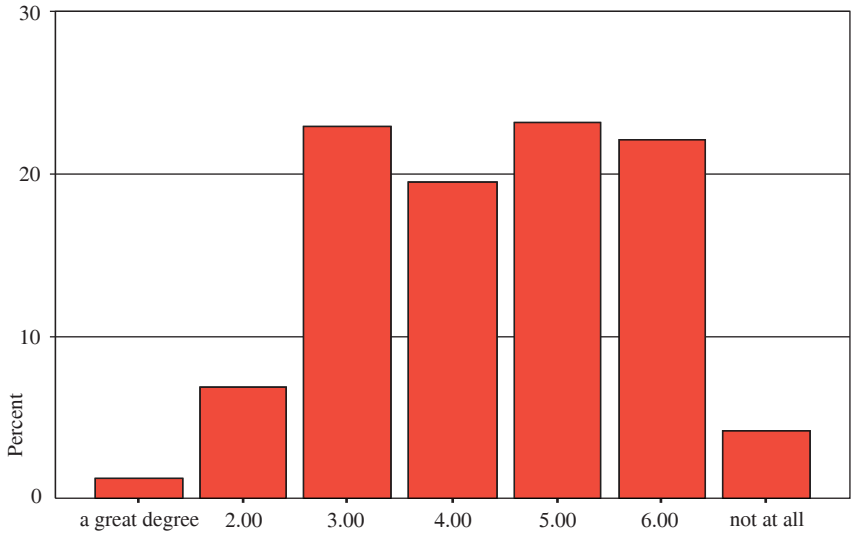
contact with policy makers perceived the efforts of science to be slightly more effective than those less involved with policy. This difference might simply indicate that those scientists involved with the policy arena might, as would be natural, have the tendency to slightly overstate their own impact. More noteworthy, however, is the apparent overall dissatisfaction with the process of the transfer of knowledge.

In short, the data indicates that while some scientists are inclined to believe that their efforts are instrumental in shaping policy, less perceive the working relationship that exists between policy makers and scientists to be satisfactory.

In an effort to determine if scientists felt there was two way casual relationship between science and politics, that is, if as well as a process of the scientification of politics there was a process of the *politicization of science*, they were asked if they felt that politics might influence the direction of scientific research. These results are summarized in Figures 9.26 (Figure 9.26 overall mean 4.4). The data indicates this to be a somewhat contentious area within the scientific community, with a wide variation of perspectives. In this instance, an absence of a statistically significant difference between those who have a high level of involvement with policy makers and those who do not is noteworthy.

This line of reasoning was continued as represented in Figure 9.27, where the influence of politics on the direction of science is given more prominence

Figure 9.26: To what degree are policy makers influential in causing scientists to redefine their perceptions of the climate issue?



(overall mean 3.2).

When comparing the data of Figures 9.26 and 9.27 it appears more unanimous that while politics are not perceived of as having a great influence on the individual perspectives of scientists, politics are perceived of as having a strong influence on the collective scientific community. This suggests the possibility that scientists are undertaking scientific research against that which would be of a natural inclination and raises the question of how influential public demand might be on politics and, in turn, on science. Again, it is noteworthy to mention the lack of a statistically significant difference between the mean responses of those with a higher level of interaction with policy makers and those who do not.

To determine how this political influence might be put into effect, scientists were asked to comment on the necessity to justify research in terms of policy relevance. As Figure 9.28 indicates, scientists felt there is a great demand to justify research in terms of policy relevance.

Due to the political and social implications of the climate change issue, the fact that there was the inclination to perceive that research now has an added requirement of justification in terms of policy relevance is no surprise. Neither should it be surprising to note that those scientists with a higher degree of contact with policy makers are slightly more aware of the situation (as represented by a statistically significant difference from the group with a lower level of contact (mean high policy contact 2.6, mean remainder of sample, 2.9). However, if, as Figure 9.26 tends to indicate, there is a perception

Figure 9.27: How much do you think the direction of research in climate science has been influenced by external politics?

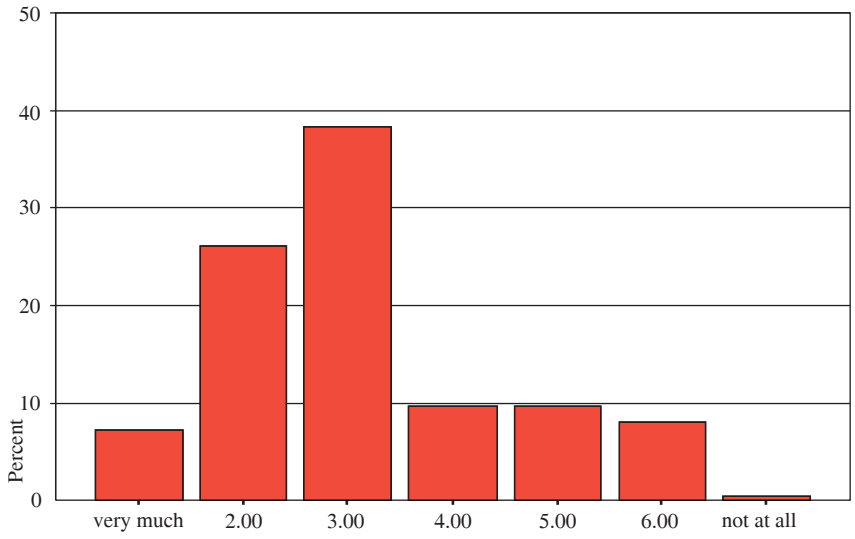


Figure 9.28: To what degree do you think there is growing pressure for climate research to be justified in terms of policy relevance?

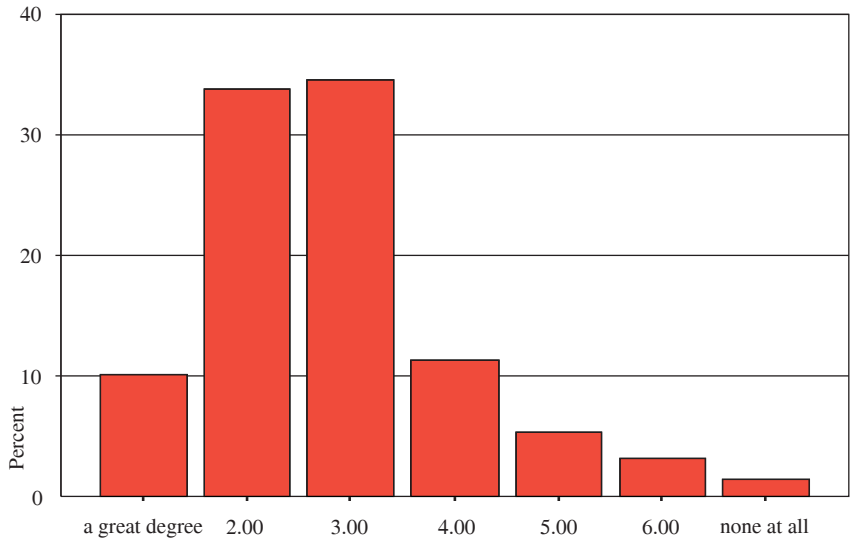
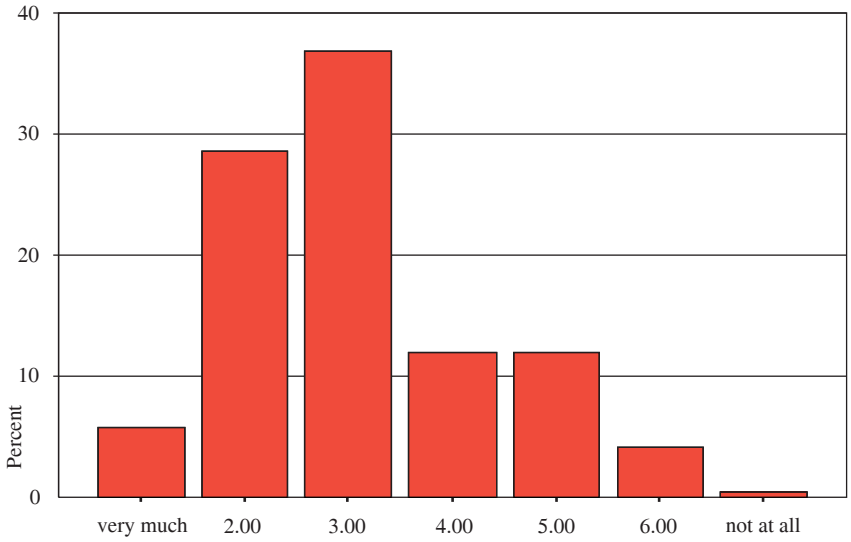


Figure 9.29: How much have climate scientists played a role in transforming the climate issue from a scientific issue into a public issue?



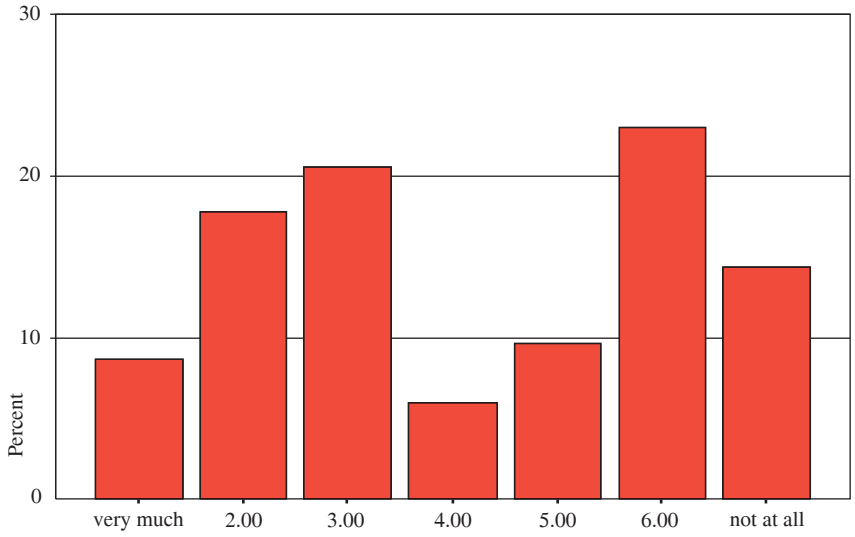
that policy makers are at least sometimes perceived as being influential in causing climate scientists to redefine their perspectives of the climate issue, not simply address policy relevant research, then there is a risk of the development of *science-for-politics*, a somewhat less than favorable situation and in contradiction to the notion of a value-neutral science.

If, as Auer et al. suggested (1996:145) "Public opinion and mass media have taken over the topic to such an extent that in the meantime it begins to repenetrate and influence scientific discussion.", there is the potential for the public to have an influence on science, then one has to ask from where does the public gain its information and what information is it getting? Consequently it is necessary to consider not only the relationship between science and policy, but also the relationship between science and the public.

The interaction between science and the public is mediated by other sources, one example being the media. To address this relationship, scientists were asked to comment on what they perceived to be the role of *scientists* in this process of knowledge transfer (Figure 9.29). While generally the sample of the scientific community in this study was inclined to perceive itself as somewhat instrumental in the transformation of the scientific issue into a public issue, those who reported a higher level of involvement with the media attributed more to the role of the scientist in this area of concern (statistically significant different means: high media involvement 2.7, others 3.2) than those with less contact with the media.

As to the perceptions of acceptable practice in conveying scientific infor-

Figure 9.30: Some scientists present the extremes of the climate debate in a popular format with the claim that it is his or her task to alert the public. How much do you agree with this practice?



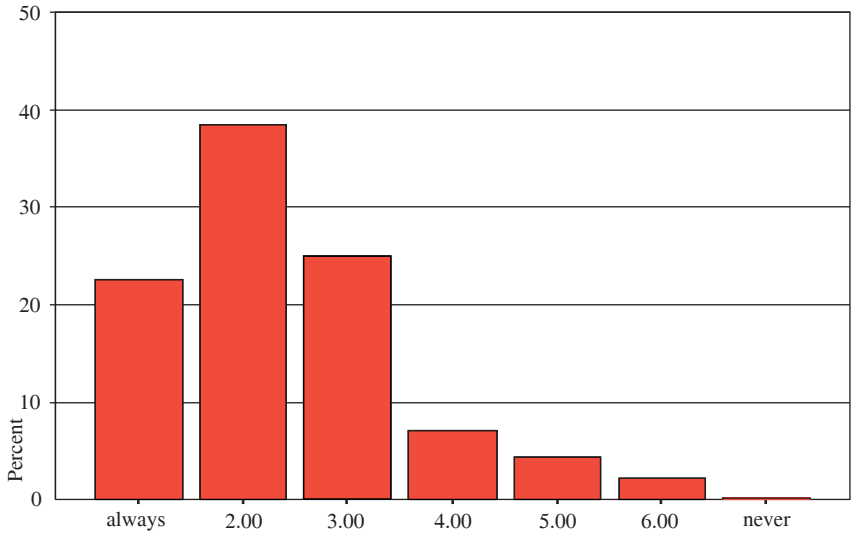
mation to the public, scientists were asked to comment on the practice of presenting extreme statements and worst case scenarios (Figure 9.30). There are a number of statistically significant differences. Those scientists with a high level of policy contact (mean 4.7) were less inclined to agree with the practice of presenting the extremes to the public than were the remainder of the sample (mean 4.1) although overall neither group condoned the practice. When concerning the group with the high level of media contact and the remainder of the sample there is no statistically significant difference. It is perhaps possible that those with a high level of policy contact witness the public pressure as it is transformed back into the political spectrum and subsequently back into science. However, this remains a proposition beyond the limits of this data.

Nonetheless, as Figure 9.31 indicates, the scientific community was quite explicit in stating the perception that the general public seldom get presented with the full picture of the global warming issue. Here there are no statistically significant differences among the group.

In summary, Figures 9.29 through 9.31 indicate that while scientists feel they have been somewhat instrumental in transforming a scientific debate into a public issue, the mechanism by which the transfer takes place is perceived as less than ideal.

If it is assumed that public wishes can be transformed into political actions then the potential exists for an indirect public influence into the workings

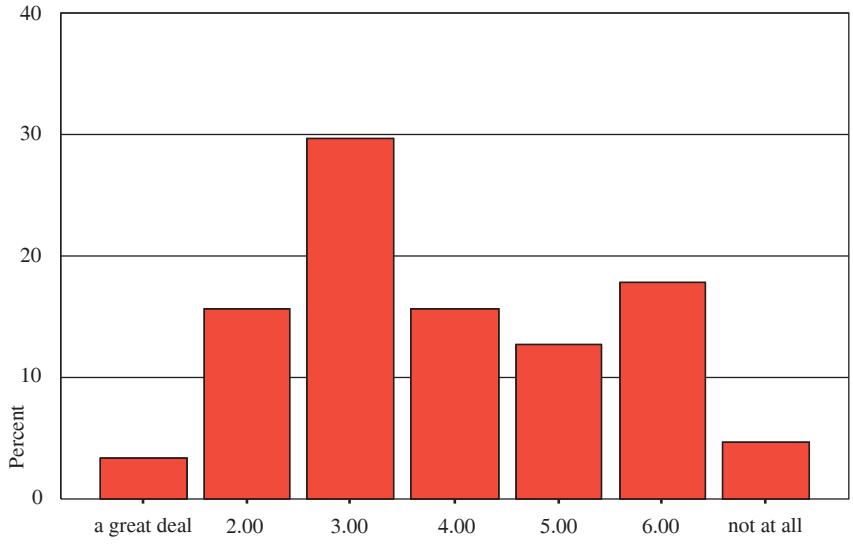
Figure 9.31: How often are the general public presented only part of the picture?



of science. Consequently the content and context of information presented to the public might be an issue of greater significance than it is typically attributed. To reach a broad and diversified public audience requires a broker with the ability to transform scientific information into a format palatable for the general public. Here lies the role of the media. Consequently, scientists were asked to comment on both his or her personal experience with the media and on his or her perception of the general pattern of interaction between science and the media. First, scientists were asked if they felt a high level of media contact could influence the individual (Figure 9.32). The results indicate mixed perceptions although some members of the scientific community express a high degree of concern. There were no statistically significant differences among the group of scientists with a high level of media contact, a high level of political contact or the less vocal members of the scientific community.

Scientists were then asked if they felt the contact with the media could play a role in influencing the direction of future research (Figure 9.33). The results of the analysis of the data presented in Figure 9.33 indicate some concern that publicity via the media has the potential to influence the direction of future research. Here the data indicates statistically significant differences among all three groupings of scientists (means: high policy involvement 4.2, others 3.7, high media involvement 4.4). When compared to the rest of the sample, the scientists with a higher level of contact with the political realm saw less potential for publicity to influence the direction of research. When

Figure 9.32: To what degree does exposure to the media have the potential to change the attitudes of a scientist?



compared to the rest of the sample, scientists with higher levels of contact with the media perceived the same, that is, a lessor potential for publicity to influence the shaping of research. Nonetheless, the overall means (Figure 9.32: 3.8, Figure 9.33: 3.9) suggest concern within the scientific community regarding the science-media-public interface.

Assuming the potential influence of politics and the potential influence of media have come to play a role in the shaping of climate science, scientists were asked to assess this impact on the conduct of science. Scientists were questioned regarding one of the basic tenets of science, that is, to what degree he or she felt climate science has remained value-neutral (Figure 9.34).

Statistically significant differences evident between the group with high levels of contact with policy makers (mean 4.5) and the remainder of the group.(mean 4.1) indicate that those with a higher degree of involvement with policy makers are more inclined to notice the shift away from value-neutrality, perhaps due to the greater insight of the external impositions on science. There was no statistical significant difference among the sample and the group with higher media contact. This perhaps suggests that those scientists that are privilege to the interactive process at the policy level are more aware of the process and outcomes. Nonetheless, the expression of the entire scientific community is less than favorable, depicting considerable concern that climate sciences are questionable in terms of value-neutrality, perhaps again pointing to the infusion of public and political concerns into an area of science with high levels of external vested interests, and again to

Figure 9.33: How much do you think a scientist's exposure to publicity influences the direction of his or her future research?

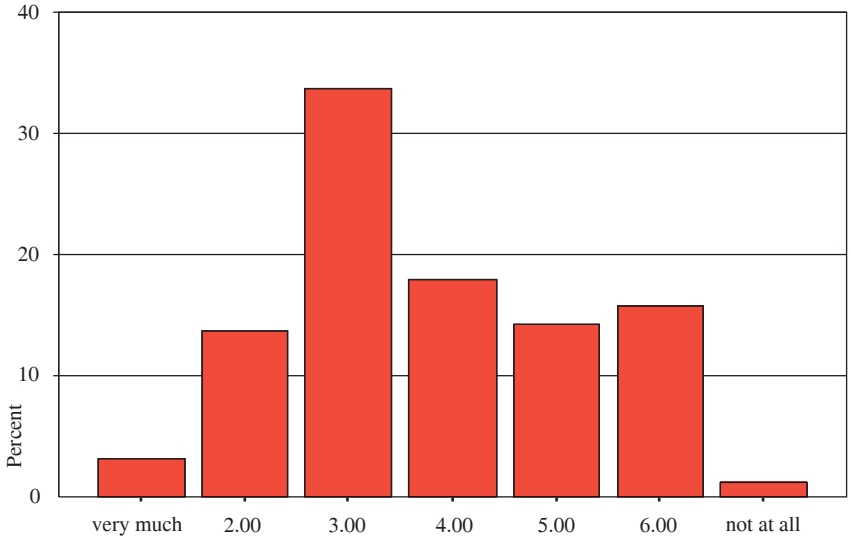


Figure 9.34: To what degree do you think climate science has remained a value neutral science?

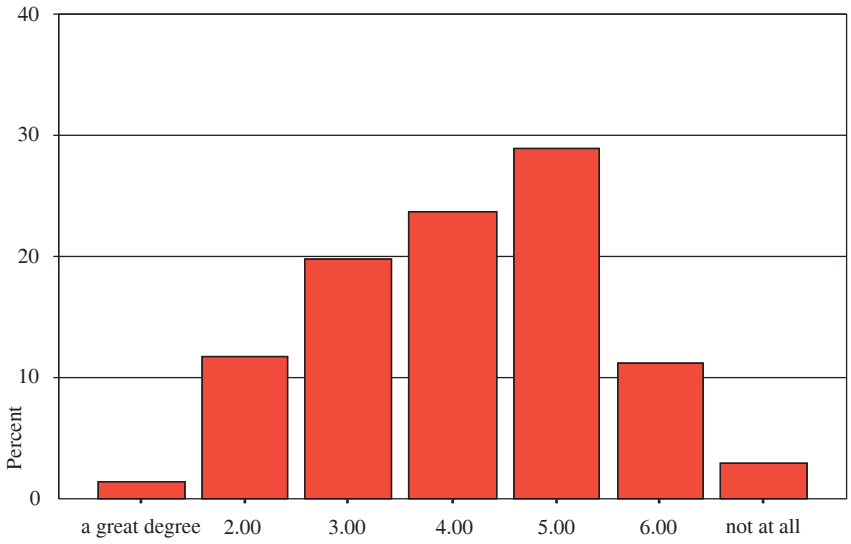
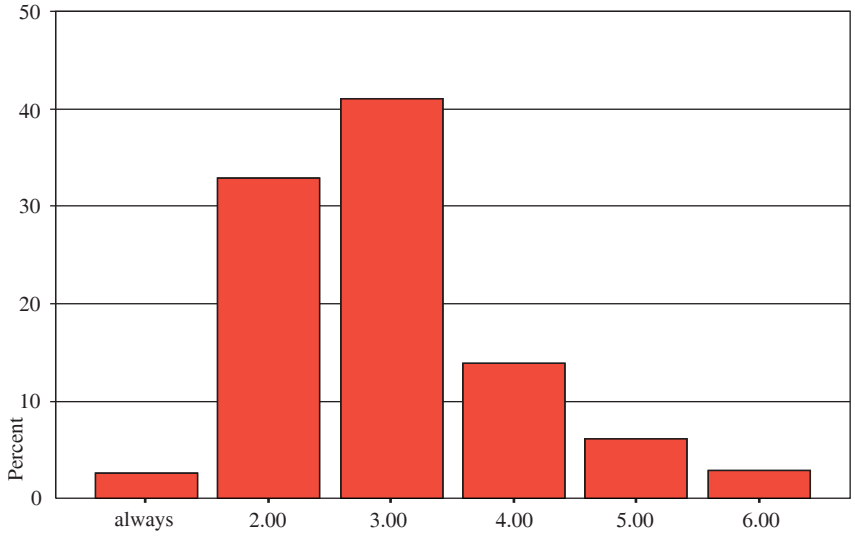


Figure 9.35: How often do you think experts frame problems so that the solution fits his or her area of expertise?



the uniqueness of the global phenomenon at hand.

Furthermore, and unfortunately, scientific research is often forced into the position to enter into competition for limited funds. This too might, in the long run, have a negative impact on the progress of science since the continuation of research may require a reformulating of the problem so as to fit into the current vogue (Figure 9.35).

There were no statistically significant differences among the groups when asked "How often do you think experts frame problems so that the solution fits his or her area of expertise?" The overall mean of the responses was 2.97. This is highly indicative of a perception of such practices. While this practice might not necessarily be condoned by the scientist it may be a necessary means in times of limited and competitive funding. Unfortunately, this tendency may act to perpetuate disciplinary isolation at a time when interdisciplinarity and transdisciplinarity are demanded by the magnitude of the phenomenon at hand.

9.6 Conclusion

Climate science, according to the responses of the sample of this survey, has not developed the level of ability or accuracy of prediction with which it has been popularly attributed. Consequently, on the acceptance of *theory*, limited scientific knowledge has been transformed into a social and political issue. In

spite of the inability to make certain, robust and reliable predictions, and to explicitly state the potential impacts, the impacts have been assigned a mostly negative connotation. One could assume this interpretation acts to maintain the issue as publicly and politically significant.

The reasonable consensus among the sample regarding the imperfection of the components of the science and the reasonable consensus among the sample regarding the inability of the science to provide a detailed picture of the future do not necessarily correspond to the differing perspectives that climate scientists have regarding the impacts of climate change that seem to reach the general public or the political body. One can only assume that larger forces than scientific objectivity are at play and that the cognitive interpretative mechanisms employed are shaped by the influence of personal persuasions as well as by scientific fact. However, those scientists with a greater level of outside contact tended to be more cautious in their claims than those scientists with less contacts, perhaps suggesting the potential that the levels of prominence of the issue is assigned *outside* of the scientific community, as much, if not more, than from within science.

Briefly, in spite of the discrepancies in the scientific interpretation of the general nature of global warming, there does seem to be a reasonable level of agreement that global climate change does indeed pose a major problem to be confronted. Considering the apparent lack of agreement as to the ability to *state* the detrimental effects (Figure 9.8) it is difficult to determine on what basis scientists made their judgments in Figures 9.7 through 9.9. This may be a case of sentiment, public, political or popular scientific, feeding back into the body of science.

Furthermore, the statistical mean 3.3 associated with the ability to say for certain that global warming is a process already underway (Figure 9.5) suggests that this possibility still remains highly contested within the scientific community. The *potential* for the event, that is, the *theory* of global warming, however is much more readily accepted (Figure 9.6) with a statistical mean of 2.6, although as the means suggests, even the acceptance of the theory is far from a unanimous consensus. Here, however, "theory" does not necessarily apply to the green house theory as put forward by Arrhenius, but to the notion that anthropogenic greenhouse effect will have a significant effect on, for example, mean global temperature.[1]

As to what it might mean when global warming arrives, the climate science community is much more reluctant to make a committed estimate, with responses falling mostly within the range of ambivalence. For example, when asked if a lack of preparation for climate change would lead to devastation (Figure 9.7) the statistical mean of the response was 4.4, when asked about the ability to explicitly state the detrimental effects of climate change (Fig-

[1]These findings do no imply that the authors necessarily share the views put forward as responses to the survey. Indeed, Hans von Storch is co-author of an earlier study claiming the detection of climate change in the present global mean temperature record (see Hergel et al, 1995).

ure 9.8) the mean of the responses was 4.5. Only when questioned about the detrimental effects for the *host* society (Figure 9.7) does the mean (3.7) shift to an extremely weak position of commitment.

Yet, in spite of this expression of ambivalence and uncertainty, scientists in general were slightly more inclined to agree that global warming is a leading problem facing society (mean 3.3). Nonetheless, a mean of 3.3 is not representative of a collective call for alarm coming from the scientific community. It does however suggest that in spite of the lack of any specifics, global warming appears to have been assigned, through whatever process, a negative connotation.

This analysis raises the question of how scientific uncertainty is transformed into high levels of public and political significance. This transition could not, as of yet, be attributed to the human experience since the experience of any expression of climate change, with the exception of extreme events (a highly contested relationship), is typically well below the thresholds of human climatic perception. However, it could not be denied that the *issue of climate change* has had, and creates the potential, for significant social impacts.

What we have discussed in this paper represents only one aspect of the science-politico-society triad. More specifically, we have addressed the role of the human element in the interpretation of scientific "fact" or, even more specifically, the *scientific construction* of the climate change issue. Not only does this suggest that, in light of the now *globalness* of many contemporary issues, the requirement to make assessments of all of the triadic interactions, but also to address the process by which multiple interpretations stem from a single scientific artifact.

9.7 Acknowledgements

We would like to thank the Thyssen Stiftung whose generous funding made this project possible, the Max-Planck-Institut für Meteorologie, Hamburg, and GKSS, Geesthacht for ongoing support, and all of those scientists who made time to participate in interviews and time to respond to the survey questionnaire.