SOCIAL EPISTEMOLOGY, 2000, VOL. 14, NOS. 2/3, 109–127

Of loaded dice and heated arguments: Putting the Hansen–Michaels global warming debate in context

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1. *Introduction*

A recent article in the *New Yorker* said that global warming is 'without doubt the biggest weather story of our time' (Seabrook 2000, p. 44). It also may be the most heated and complicated debate of our time. Although from a scientific perspective the controversy is more than one hundred years old, the public debate over what to do about possible warming is relatively new. It all started on a sweltering June day in 1988, when James E. Hansen, the director of NASA's Goddard Institute for Space Studies (GISS), took centre stage in Washington DC and announced that he was '99 %' certain that global warming was here (1988b). In many ways, Hansen's testimony, which sparked front-page coverage across the globe and touched off an unprecedented public relations war and media frenzy, marks the official beginning of the global warming policy debate that continues to this day.

This debate is certainly one of the most sophisticated and heated science policy controversies in recent history.[1] One of the reasons the debate is so hotly contested is because the science of climate change is enormously complex and, despite years of research, many uncertainties remain. An accurate understanding of the earth's climate system depends upon correctly simulating future climatic events by using complicated computer models built upon often incomplete data sets of past climate performance and countless other variables. We all know how difficult it is to predict the weather a few days in advance. It takes little imagination to wonder how much more difficult it is to predict the weather a few decades in advance.

In the global warming debate, the very future of life on the planet is pitted against the wealth-generating capacity of the modern economy. Needless-to-say, the stakes are enormous and the stakeholders are numerous. 'Global warming is the mother of environmental scares. In the scope of its consequences for life on planet earth and the immense size of its remedies, global warming dwarfs all the environmental and safety scares of our time put together' (Wildavsky 1992, p. xv). Climate change research is a 'quintessential' interdisciplinary undertaking, involving virtually every field in both

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Social Epistemology ISSN 0269-1728 print/ISSN 1464-5297 online
http://www.tandf.co.uk/journals

the natural and social sciences and drawing hundreds, even thousands of scientists who have benefited from the controversy's lucrative research opportunities (Handel and Risbey 1992a). In the USA alone, the federal government has poured roughly $8 billion into climate change research in the last four years (Michaels and Balling 2000).

However, climate change research has not always been a bed of roses for scientists. Several researchers have endured malicious and slanderous attacks as a result of their involvement in the global warming debate. Additionally, the debate involves more than scientists. It also includes environmentalists; the fossil fuel lobby; developing countries and industrialized countries, politicians and policy analysts of every stripe; small island nations and big oil producing nations; physicians; economists; unions; and ordinary citizens. These diverse participants bring to the table a host of special interests and a raft of deep ideological commitments. 'Indeed, the argument over global warming has been the main set piece of the international environmental culture wars for several years, with activist Cassandras and conservative Pollyannas both trying to marshal the authority of science as justification for their views' (Tucker 1997, p. 78). And finally, while the debate is enormously technical, the media has packaged and repackaged it for consumption by a worldwide, public audience.

Because of the debate's complexity, the purpose of this essay is to introduce some of the issues involved in the global warming controversy, with an eye toward preparing the reader to critically approach the transcript of the inaugural American Association for Rhetoric of Science and Technology (AARST) Science Policy Forum (SPF). Although an exhaustive treatment of the controversy is not possible in this limited space, it is still useful to situate the SPF in the broader historical context of the global warming dispute. This exercise promises to illuminate some of the issues that lurk beneath the surface of the SPF transcript, as well as provide background on James E. Hansen and Patrick J. Michaels, protagonists in the debate.

A key insight from science and technology studies (STS) is that scientists make arguments—especially in policy circles—in ways that are coloured by their interests. And, to infer interests, readers need to understand the richly textured historical circumstances that surround any given forum, as well as the affiliations, histories and experiences that shape each protagonists' contributions to the proceedings. Furthermore, as an episodic moment in a larger historical progression, the SPF is just a mere snapshot of the global warming controversy. It is only one of many chapters in a long-running debate that is always connected to what has come before. Thus, a basic understanding of the global warming controversy should help readers locate the significance of the SPF within a wider frame of reference.

On closer inspection, one finds two debates unfolding simultaneously in the inaugural SPF. On the one hand, we have a global warming debate that features two prominent figures who represent the two major camps in the controversy: the so-called 'believers' and 'sceptics' of the greenhouse warming hypothesis. To this extent, the topics selected for discussion and the arguments performed on the evening of 22 November 1998, represent a continuation of the larger global warming debate. But, at the same time, the SPF also is a continuation of a narrower (but no less interesting) debate between two individuals with a long and complex history of disputatious interaction.

This essay is divided into two sections. Part I lays out crucial features of the larger global warming debate. I begin by outlining the history of the scientific controversy in broad strokes as it has evolved from the earliest scientific work on the question to the mid-1980s. Continuing the historical perspective, I then discuss the evolution of the debate as science merged with policy considerations to form a full-fledged science policy

debate in the late 1980s and into the 1990s. I conclude this part of the essay by highlighting some of the key areas of contention that have served as points of stasis in the debate. Part II offers a narrower discussion of the pertinent historical background, shaping the more focused controversy renewed in the SPF. I begin by discussing how each SPF protagonist individually provides a sense of the biographical nuances that shape each advocate's approach to the debate. I then discuss the relationship between Hansen and Michaels—one that was influential in the SPF's inauguration and in the shaping of arguments voiced at the forum.

2. *The global warming debate in historical perspective*[2]

No scientist disputes the greenhouse effect. It is a natural and necessary process to sustain life on planet Earth, which is dependent on radiant energy from the sun. While a large percentage of the sun's energy is reflected back into space, a certain percentage is trapped in the atmosphere by water vapour (largely in the form of clouds) and gases such as carbon dioxide, ozone and methane. Much like the glass in a greenhouse, water vapour and greenhouse gases prevent the sun's heat from escaping, which results in a warmer planet. Today, the question is how much humans are adding to this warming effect by generating greenhouse gases—especially carbon dioxide from the burning of fossil fuels.

The idea that changes in climate could alter the planet has a long history, dating back more than a century.[3] French scientist Jean Baptiste Fourier was first to recognize the natural greenhouse effect in 1827, and he is often credited with coining the term 'greenhouse effect'. In 1860, Irish scientist John Tyndall took up Fourier's work, and, as part of an effort to explain the ice ages, Tyndall suggested that a reduction of carbon dioxide was the culprit responsible for long periods of global cooling. Apparently, 'he never considered the other side of the coin—that human intervention might trigger global warming' (Christianson 1999, p. 110). In 1896, Swedish chemist Svante Arrhenius was first to measure the consequences of increased carbon dioxide in the atmosphere caused by the industrial revolution.[4] Arrhenius predicted that a doubling of carbon dioxide in the atmosphere would increase global temperatures between 5–6 °C, but he did not view this as a significant problem, since he thought the long-term warming process likely would take several centuries (Handel and Risbey 1992a). Many years passed before Arrhenius' ideas were developed further, when, in the 1930s and 1940s, British meteorologist G. S. Callender published a number of papers on the topic. He was first to match observational data with theory. In comparing data from numerous weather stations around the globe, he concluded that the observed rise in global temperatures between 1880 and 1930 was a product of the build-up of carbon dioxide in the atmosphere. Others, however, largely ignored Callender's work, as 'he left no programmatic or institutional legacy' (Hart and Victor 1993, p. 647).

More concerted scientific efforts to study climate change did not take shape until the 1950s, when the Cold War sparked interest in human-induced (anthropogenic) climate change. 'The invention of nuclear weapons appears to have raised the legitimacy of the idea that humans could change the climate' (Hart and Victor 1993, p. 647). It was then that two primary issues began to drive climate change research efforts: concern over the climatic impacts of nuclear weapons and the growing fear that the Soviet Union was experimenting with weather modification techniques. During this time, researchers

successfully linked research funding for climate research to the 'opportunities offered by the Cold War', and laid the foundation for what would later 'fuse into a coherent greenhouse effect research programme' (Hart and Victor 1993, pp. 648, 650). Cold War institutions, such as the USA Office of Naval Research and the Atomic Energy Commission sponsored early research in the field. Yet, even then, only a few scientists were working on climate change, and they were doing so in relative obscurity behind the iron gates of the military industrial complex.

But, by the late 1960s and early 1970s, things began to change. Growing environmental awareness, especially concern over the environmental impacts of supersonic air transportation and fears of global cooling, invigorated the discussion of climate change. Still, however, scientists could not even say for certain that atmospheric concentrations of carbon dioxide were increasing, because they had no way of measuring this over time. Thus, scant 'observational evidence' and substantial scientific 'uncertainty' meant that the scientific debate rarely extended to public life (Boehmer-Christiansen 1994, p. 153).

The first actual observational evidence that carbon dioxide concentrations in the atmosphere were increasing since the beginning of the Industrial revolution came from the peak of a dormant volcano in the Pacific. In the International Geophysical Year 1957–1958, scientists set up a carbon dioxide measuring station at the top of the Mauna Loa volcano in Hawaii. It did not take long before the Mauna Loa Observatory was recording direct observational evidence indicating that concentrations of carbon dioxide were, in fact, increasing steadily.

By the mid-1970s, the USA was well on its way to creating a 'national climate program designed to study climate change in a more systematic way' (Hecht and Tirpak 1995, p. 375). At that time, a few climate-modelling centres were operating around the country, such as National Aeronautics and Space Administration's (NASA) Goddard Institute for Space Studies (GISS) in New York City and the US Department of Commerce's Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey. By 1978, the US federal government had created several governmental institutions, like the National Climate Program Office (NCPO), to offer scientific advice. Over the next several years, a constant stream of reports and assessments from both national and international scientific groups and institutions began to highlight the potential seriousness of the climate change problem.

One of the first, and certainly on of the most prominent and respected of these reports was the so-called 'Charney report'—the product of a 'blue-ribbon panel' appointed by the National Research Council in 1979 and chaired by Jule Charney, Sloan Professor of Meteorology at MIT. Based primarily on data generated by the GFDL and GISS models, the report concluded that, on average, a doubling of carbon dioxide would increase the earth's surface temperature by 1·5 to 4·5 °C. Despite the fact that the report carried considerable authority 'among scientists' it made a 'less then impressive public splash' (Stevens 1999, p. 149). Nevertheless, after more than 20 years of scientific work, the report's estimated range remains the most widely accepted estimate of human-induced climate change.

One of the reasons why the Charney report failed to attract much public attention is that, at this time, global warming was overshadowed largely by concern over stratospheric ozone depletion from chlorofluorocarbons (CFCs). In climate change news, it was global cooling—not global warming—that was still grabbing the headlines. Nevertheless, the two issues did begin to dovetail in a way that conveyed 'to the general public the concept of a real environmental threat' which, ultimately, was the foundation

of what is today a 'well organized' environmental constituency (Hecht and Tirpak 1995, p. 377).

3. *Global warming as a policy issue*

In the 1980s, 'science and policy began to merge', as an intense debate developed over whether there was sufficient scientific evidence warranting reductions in the consumption of fossil fuels (Hecht and Tirpak 1995, p. 379). By this time, the concern over climate change had grown sufficiently to generate substantial congressional interest in the problem. As budgets or climate research increased, several federal agencies joined the debate including the US Environmental Protection Agency (EPA) and the US Department of State. In 1983, with Hansen's assistance, the EPA published a study titled, 'Can We Delay a Greenhouse Warming?' (Stevens 1999, p. 150). The report predicted dire consequences from global warming, including massive disruptions in agriculture, the economy, and political institutions. 'The report was… a red flashing light, raising the spectre of a world on a collision course between the need for energy derived from coal and a global warming of potentially catastrophic proportions' (Hecht and Tirpak 1995, p. 380). By 1986, several key congressional leaders, including then-Senator Al Gore (D-Tennesee), were sufficiently interested in the matter to call for hearings on the science of climate change. Then, in 1988, Hansen's pivotal testimony to the US Congress—that he was '99%' certain that global warming was real—ignited public discussion of global warming and moved the controversy from a largely scientific discussion to a full blown science policy debate (Hansen, 1988b). By the end of the year, sufficient momentum existed for the United Nations to create the Intergovernmental Panel on Climate Change (IPCC).

Established as an international organization to collect, review and synthesize the state of climate science, the IPCC's work was a monumental effort. In all, 2500 scientists from around the world, representing a variety of disciplines, participated in drafting two voluminous reports. The IPCC is touted as the source or the much-heralded 'consensus' said to exist among scientists about the nature of the global warming problem. IPCC's first report, released in 1990, concluded that continued greenhouse gas emissions would 'enhance the greenhouse effect' (IPCC WGI 1990). Five years later, the IPCC released its second assessment, containing the bolder statement that 'the balance of evidence suggests that there is a discernable human influence on climate change' (IPCC WGI 1996). Although the IPCC's conclusions seemed definitive, detractors questioned the veracity of the findings. To this day, some suggest that the IPCC exaggerates and misrepresents the perspectives of the majority of the world's scientists (see Singer 1997).

In 1992, at the Earth Summit in Rio de Janeiro, more than 150 nations signed the Framework Convention on Climate Change (FCCC). The FCCC established the goal of stabilizing atmospheric concentrations of greenhouse gases to prevent a dangerous interference with the earth's climate system. In the short-term, this meant reducing, by the year 2000, worldwide greenhouse gas emissions to 1990 levels. However, because the FCCC failed to identify binding emission reduction targets and specific penalties for failure to achieve them, the goal was nothing more than a symbolic pledge by the parties to make an effort to reduce emissions. As a result, few countries followed through on their pledge and the convention languished.

In 1995, at the first Conference of the Parties (COP-I) in Berlin, FCCC signatories agreed to the 'Berlin Mandate', which required convention members to adopt specific

emission reduction targets at COP-III in 1997. The Berlin Mandate promised to give COP-III enormous significance because industrialized countries would be expected to adopt—by 1997—a legally binding protocol with specific emission reduction targets. Convened in Kyoto, Japan in early December 1997, the conference received great fanfare and media attention. 'It was high politics on a global stage, and not since Jim Hansen's testimony in 1988 pushed the climate question onto the front burner had the climate question attracted such a bright spotlight' (Stevens, 1999 p. 289).

Ultimately, however, the 1997 Kyoto negotiations nearly broke down. An impasse was averted by only the narrowest of margins when US vice-president Al Gore flew to Japan in the waning hours of negotiations. Constrained by congressional opposition to the treaty, the USA was in a particularly awkward position going into the meeting. In the summer of 1997, the US Senate passed the Byrd–Hagel resolution, which declared that no Kyoto agreement would be acceptable unless it included developing countries and would not negatively impact the US economy. The Senate's requirement that developing countries be included in the protocol flew in the face of the long-standing policy that wealthy nations should shoulder the early responsibility for emission reductions.

Sensing the negotiations were heading for collapse, Gore instructed US negotiators to be more flexible. Ultimately, the USA prevailed in its demand for an emission-trading scheme. But, they failed in their efforts to include reduction goals for developing countries. Although the Clinton administration was able to obtain a short-term victory by completing the Kyoto protocol, the long-term prospects for Senate ratification appeared bleak.

At about the same time that global warming became a significant international policy issue, a small, but vocal group of 'contrarians' began gaining notoriety for their criticisms of the global warming 'scare'.[5] Although, in reality, there is a wide variety and range of views among scientists actively working on climate change, the debate 'has become cast as a dispute between "believers in global warming" and those who have come to be called "contrarians"' (Stevens 1999, p. 242). The most famous of the so-called sceptics are Patrick J. Michaels, S. Fred Singer, Robert Balling and Richard S. Lindzen.[6] As one commentator remarked: 'Their prime motivation seems to be indignation, coupled with a maverick instinct to buck the latest fashion. But they have managed to secure some lucrative lecturing fees and consultancy deals with commercial concerns—such as the coal industry—who are anxious to undermine international efforts to control emissions of greenhouse gases such as CO2' (Pearce 1997, p. 38).

There is a diversity of opinion as to whether the sceptics have helped or hindered discussion of global warming. 'Contrarians play a constructive role, many of their intellectual adversaries say, by raising legitimate criticisms that keep mainstream scientists honest and on their toes.... But other scientists charge, off the record, that some contrarians exploit and exacerbate uncertainties needlessly and even spread outright disinformation and misrepresentation' (Stevens 1999, p. 242). Whatever the case, the presence of the sceptics certainly has invigorated the global warming debate.

As a science policy controversy, global warming poses significant problems for decision-makers in a democratic society and illustrates one of the essential tensions between science and public policy. Policy-makers are tasked with making judgements in the face of scientific uncertainty. The polarized nature of global warming discourse complicates further this task. The range of available options is all too often whittled down to a Hobson's choice: do nothing and face potentially cataclysmic consequences or act expeditiously and risk destroying the global economic infrastructure.

4. *Stasis in the global warming debate*

Stasis is a rhetorical term of art that refers to the vortex of deliberation—the place where arguments tend to cluster and swirl around each other. It is useful to explore points of stasis in the global warming controversy, as this will shed light on key points of consensus and disagreement and show how arguments relate to each other. In this regard, a crucial question emerges: will the build-up of carbon dioxide in the atmosphere produce warmer temperatures on the earth's surface? In the past few years, there has been relatively little debate on this issue. It is generally accepted that elevated levels of carbon dioxide in the atmosphere will increase surface temperatures. On this point, even the sceptics agree that some warming will occur.[7] So, if even the most diehard sceptics agree that the planet will warm as a result of a build-up of carbon dioxide, what is the fuss all about?

Today, the debate turns on other, more contentious questions. How will the planet warm? Where will it warm? How much will temperatures rise? How rapidly will they rise? Answers to these questions are far harder to come by, because they require accurate predictions of the future. Global circulation models (GCMs) are the primary instruments scientists use to project future climate patterns. Using supercomputers that run through numerous calculations in an instant, climate modellers attempt to simulate future events in the earth's atmosphere. One of the primary arguments sceptics make is that these GCMs are grossly inadequate, predicting too much warming. As we shall see in the SPF, a significant difference of opinion regarding the usefulness of such models persists between the sceptics and the believers.

Expert opinion is also split over when the earth will warm and where it will warm. Some of the sceptics have suggested that most of the warming will occur at night rather than during the day and that it will occur in the coldest regions of the globe rather than in the warmest regions. Opinions are divided also over the pace of temperature increase. If we take the Charney report's projection of a temperature increase of between 1·5 and 4·5 °C over the next hundred years, the sceptics favour the low end of the estimate, while the believers favour the high end.

Finally, what are the consequences of global warming? Assessments of the impacts of global warming span a wide spectrum, ranging from the beneficial and benign to the deadly and catastrophic. Some scientists have argued against reductions in carbon dioxide emissions and instead have suggested that a build-up of carbon dioxide will have enormous benefits for the globe, including longer growing seasons, increased plant growth, and, fewer droughts. For example, Idso (1989) has suggested that limiting carbon dioxide production would 'be like cutting our own throats—or, more properly, the throats of 'generations yet unborn'—to attempt to thwart the very phenomenon which has the proven ability to dramatically boost crop yields, enhance plant water use efficiencies, and give us the edge we need in our fight against world hunger' (p. 132). Others, however, predict that rapid warming will bring catastrophic consequences, including rising sea levels, increased frequency and intensity of storms, and increased droughts.

5. *The SPF protagonists*

The SPF not only presents a significant slice of the larger global warming debate, it is also another chapter in the ongoing public debate between two of the debate's most

intriguing and significant voices: James E. Hansen of NASA's GISS and Patrick J. Michaels of the University of Virginia. In this latter sense, the SPF is unique, insofar as it brought the two protagonists together in an adversarial public forum for the first time. But, the pairing of the two is also significant for other reasons, not the least of which is that each is a distinguished scientist in his own right. Additionally, Hansen and Michaels have been, and continue to be, vocal participants in the global warming debate. In certain respects, their positions (and interactions with each other) have set the tone of climate change discussions for some time.

To better understand the arguments that they make in the forum, it is useful to consider the details of their own backgrounds as scientists and policy advisors. Of particular interest in this regard is what Hansen and Michaels have said to each other in the past. Thus, to catalogue some of the baggage that each of our protagonists shouldered as they entered the forum, I examine the 'public' record of what they have said about, and to, each other through the years.

5.1. *James E. Hansen*

Hansen has been the director of GISS for more than a decade.[8] He was one of the first investigators to utilize a computer model to study the greenhouse effect and has been one of the most 'influential players' on the issue of global warming (Stevens 1999, p. 146). His June 1988 testimony before the US Congress earned him such nicknames as the 'godfather' of global warming and the 'Paul Revere of climatology' (Lore 1996). More than anyone else, he put global warming on the world's radar screen. Although he does not venture into the public arena to the same degree that Michaels does (the SPF was only his second public debate), he is one of the first people reporters call when writing about recent global warming news. He is also one of the sceptic's main targets and has been both lampooned for exaggeration and excoriated for this lack of scientific caution.

Often, testimony at congressional hearings goes largely unnoticed, especially when the testimony is technical in nature. In the summer of 1988, however, the whole world noticed when Hansen came before the Senate Committee on Energy and Natural Resources. During a summer in which a catastrophic drought was squeezing the life out of USA's Midwest, freak storms were raging in other places around the globe and a hunk of an iceberg in the Antarctic broke free, a 'mild mannered and even tempered' scientist from a sleepy Midwestern town was about to change everything (Stevens 1999, p. 131). With thermometers around Washington, DC, pushing 101 °C, Hansen offered testimony before the Senate that would 'shake up the world' (Stevens 1999, p. 131). According to at least one source, the unusually hot June day was no coincidence. 'Senator Timothy Wirth (D-Colorado) had been deeply exasperated by his inability to draw public attention to the subject. When summer arrived he waited for a day forecast to be spectacularly hot, and called a hearing' (Anderson 1997b, p. 4).

Hansen based his testimony largely upon a recently published article in the *Journal of Geophysical Research*, which detailed the results of GISS's latest three-dimensional climate model (Hansen 1988a). In speaking to the Senate Committee, he emphasized three points (Hansen 1988b). First, 'the earth is warmer in 1988 than at any time in the history of instrumental measurements ... [and] barring a remarkable and improbable cooling, 1988 will be the warmest year on the record'. Second, 'global warming is now large enough that we can ascribe with a high degree of confidence a cause and effect

relationship to the greenhouse effect'. And third, 'the greenhouse effect is already large enough to begin to affect the probability of extreme events such as summer heat waves' (Hansen 1988b, p. 39).

In making his presentation to the committee, Hansen used several graphs to illustrate his points. One of the graphs showed the GISS model's calculations for annual mean temperature change between 1958 and 2020 (Hansen also used this graph in the SPF. It is reproduced as figure 9, this issue p. 140). It projected three different scenarios for average temperature changes, based upon three different scenarios for the accumulation of greenhouse gases. Scenario 'A' projected the most dramatic temperature rise (approximately 0.04 °C between 1987 and 1997). It was based upon a 'business as usual' forecast in which carbon dioxide emissions continued to rise rapidly. Scenario 'B' assumed reduced growth in the accumulation of emissions and, scenario 'C' assumed 'draconian emission cuts'. Scenarios B and C both indicated significantly smaller temperature increases than did scenario A. The GISS model's projected temperature increases did not, however, figure prominently in Hansen's testimony. Instead, he chose to focus on the agreement between GISS's model and the observational record of temperature measurements over the previous 30 years.

The alarming part of Hansen's testimony came when he told the Committee that he was '99% certain' that global warming was responsible for the observed warming trend and that there was only a one percent chance the warming of the last 30 years was due to chance variability. 'In my opinion the greenhouse effect has been detected, and it is changing our climate now', said Hansen (1988b, p. 40). After the hearing, Hansen told a reporter from the *New York Times*: 'It is time to stop waffling so much and say that the evidence is pretty strong that the greenhouse effect is here' (Shabecoff 1988, p. A1). Hansen's testimony ignited a frenzy of public discussion about global warming and the news media rushed to cover the story.

Although many of Hansen's colleagues in the scientific community (even those who privately concurred with his statements) were disgruntled that he aired his views in such a high profile public manner, the testimony certainly propelled global warming into public consciousness and gave scientists working on climate change a much higher profile and long sought-after attention (Kerr 1989). Hansen's testimony was a 'defining moment' that transformed global warming from a mostly scientific issue to an enormously volatile political issue (Paterson 1996, p. 1). It acted as a 'trigger' in raising public discussion of global warming to the issue that it is today (Anderson 1997a).[9] 'Had it not been for Hansen and his fame, few in public office, and certainly not the public itself, would have paid much attention.... After all, experts had been hemming and hawing for a decade on the likely magnitude of the problem, and hardly anyone had listened. Then came Hansen' (Kerr 1989).

Hansen's testimony was pivotal for several reasons. He was the first scientific authority to assert—publicly—that sufficient evidence existed to suggest that anthropogenic greenhouse gases were causing global warming. As the head of GISS, he was particularly well regarded and had a great deal of institutional clout. At the time, he was reputed to choose his words carefully and was known to be very cautious with his public statements. He was not known for whipping up environmental hysteria or for urging draconian reductions in fossil fuel consumption; prior to his testimony, he was widely regarded as 'a proponent of the wait and see approach' (Paterson 1996, p. 33).[10]

Hansen's testimony, coincidentally, was timed as a prelude to an international conference on global warming in Toronto, Canada, which began just four days later. Hosted by the Canadian government on 27–30 June 1988, it brought together 300

scientists and policy-makers from 48 countries (Paterson 1996). This meeting proved to be historically significant because it was one of the first concerted efforts to bring scientists and policy-makers from around the globe together to devise a concrete plan for carbon dioxide emissions reductions. It led directly to further international collaboration and dialogue, which 'provided a great deal of pressure and momentum' for the creation of the IPCC by the UN General Assembly in December 1988 (Paterson 1996, p. 35).

As the director of NASA's GISS, Hansen is a government scientist. When he speaks as GISS's director, he speaks for NASA, and when he speaks for NASA, he speaks for the government. For Hansen, this has been a mixed blessing. On the one hand, he has benefited tremendously from the visibility afforded him by his institutional affiliation. Because of his considerable authority and credibility, when Hansen talks, people listen. On the other hand, being on the government dole and speaking as a government official impedes and limits what he can say and how he can say it. For example, in 1981, one of his papers that forecast warming of an 'unprecedented magnitude' so enraged officials as the US Department of Energy that research funding for Hansen's work was rescinded (Stevens 1999, p. 150). However, none of these early problems prepared him for what would happen in May 1989. Less than a year after his June 1988 testimony, Hansen returned to Capitol Hill for more testimony. But, this time the Bush administration's Office of Management and Budget (OMB) changed his written testimony. Since Hansen works for a government laboratory, he was required to submit his testimony for OMB review prior to his appearance. In the process, an anonymous reviewer inserted the following paragraph into Hansen's prepared statement:

> Again, I must stress that the rate and magnitude of drought, storm and temperature change are very sensitive to the many physical processes mentioned above, some of which are poorly represented in the [models]. Thus, these changes should be viewed as estimates from evolving computed models and not as reliable predictions (Quoted in Marshall 1989).

At the hearing, when queried about the incident by Senator Gore, Hansen said that he objected to the change because 'in essence it says that I believe that all the scientific conclusions that I just discussed are not reliable, and I certainly do not agree with that' (Hansen 1989b, p. 143). Gore responded by calling the incident 'science fraud' by the 'Science Politburo of the Bush administration' and he threatend to start the 'congressional equivalent of World War III' if anyone attempted retribution (Gore 1989, pp. 145–147).

Shortly after appearing before the Senate, Hansen took his testimony to the House of Representatives, but this time, he took a pair of dice with him. One of the consequences of the hype surrounding his 23 June 1988 testimony was that he was frequently mistaken for saying that global warming was responsible for the heat wave sweeping the country at that time. Hansen said no such thing. Instead, he said only that the greenhouse effect was approaching the point when it would have a 'noticeable' impact on the probability of a warm season. To clarify his position, he told the Representatives: 'Please don't call me next season if it's cold in Indiana and tell me that the greenhouse theory is wrong, because that's not an inference which you could make' Hansen 1988c, p. 16). To illustrate his point, he pulled out the set of coloured dice. As time goes by and the greenhouse effect continues to increase, he explained, more sides of the die are coloured red as the probability of having a host summer increases. By 1995, he expected that the 'man in the street' would recognize that the 'die is loaded' (Hansen 1998c, p. 17).

5.2. *Patrick E. Michaels*

Depending on your perspective, Michaels either could be a henchman for the fossil fuel industry or the 'Horseman of the Anti-Apocalypse' (*Global Change* 1997). One of the most vocal and well recognized of the sceptics, he is a professor of environmental sciences at the University of Virginia, and a senior fellow at the Cato Institute, a Washington, DC think tank. He is a prolific author, writing in both the scientific journals and the popular press (he writes a frequent column in the conservative newspaper *The Washington Times*). Michaels is a frequent witness on Capitol Hill, has appeared in numerous radio and television programmes, and is the author of two books on global warming. Michaels writes in a self-proclaimed 'catty' style, 'honed to a low art' by his collegiate sparring at the University of Chicago and by many years of publishing the *Virginia Climate Advisory*—the 'nation's only magazine of climate and humour' (Michaels 1992, p. xi). But Michaels' good humour should not be mistaken. He is 'ebullient, upbeat, and optimistic', and has a 'nimble tongue' (Stevens 1999, p. 249). He also is bold, brash and firm in his convictions. 'What if I am wrong?' he asks, 'If my conclusions turn out to be totally wrong, it will mean that the observed data are the most accomplished compulsive liars in the history of science' (Michaels 1992, p. xi). 'He reminds some of his scientist adversaries ... of a good defence lawyer—selectively mining the scientific literature for material to bolster his point of view, molding it into a case, and then presenting it' (Stevens 1999, p. 249).

Michaels began his career as a sceptic in 1983 when he watched major television network reports about an EPA press conference that predicted catastrophic consequences of climate change (Michaels 1992, p. ix). The press conference to which Michaels refers is the one in which the EPA released *Can We Delay Greenhouse Warming?*—a report Hansen helped prepare. Although Michaels 'knew' that the 'EPA's position could not be based on data', he did not 'write anything on the subject in a public venue until 1986, two weeks after [he] was promoted to associate professor', because of 'fear of losing [his] position' (Michaels 1992, p. x). Published by the *Washington Post* on 15 June 1986, Michaels' first public comments on global warming were intended to be an 'entertaining' attempt to alert the public to the inconsistencies between the 'observed data and apocalyptic projections' (Michaels 1992, p. x). 'Just to make sure' that the piece was accurate, Michaels explains, ' I read the article over the telephone to James Hansen .... He said it was fine' (Michaels 1992, p. x) Michaels soon learned, however, that all was not fine. A few weeks later, Senator Gore wrote what Michaels calls a 'nasty little attack' in the 6 July 1986 edition of the *Washington Post*. Gore was 'disappointed' with Michaels' attempt 'to put a good face on the greenhouse effect', because 'there is no longer any significant disagreement in the scientific community that the greenhouse effect is real and already occurring' (Gore 1986, p. B6).

Over the next few years, Michaels grew bolder with his public statements, plunging himself into the public spotlight in earnest. He established himself as the 'pre-eminent critic' of global warming with a 1989 *Washington Post* opinion piece titled 'The Greenhouse Climate of Fear' (*Global Change* 1997). In that piece, Michaels began his long-standing practise of attacking Hansen publicly, explaining that Hansen is the only scientist to claim that a 'cause-effect' relationship exists between 'current temperatures and human alteration of the atmosphere' (Michaels 1989, p. C1).

Apparently, Michaels' opinion piece 'caught the attention' of the Western Fuels Association, a trade group for the US coal industry (*Global Change* 1997). This marked the beginning of a long and mutually supportive relationship between Western Fuels

and Michaels that continues to this day. Michaels praises Western Fuels CEO, Frederick Palmer, for his support and steadfastness in preventing 'economic suicide'. 'Without Fred, I truly believe the onerous Kyoto Protocol on global warming—or something like it—would be the law of this land today' (Michaels and Balling 2000, p. viii). In fact, Western Fuels had a direct hand in securing Michaels' participation in the SPF. When one Western Fuels official (originally scheduled to appear in the SPF) cancelled because of a scheduling conflict, the organizers were told: 'Pat is really the best at this sort of thing'. Soon thereafter, Michaels was booked to travel to New York. In 1992, Western Fuels and Michaels teamed up to publish the biweekly *World Climate Review*, which has since been renamed the *World Climate Report*.[11] Michaels calls it the 'sassiest, hippest, nastiest, and best online newsletter in history on climate change' (Michaels and Balling 2000, p. viii).

5.3. *A debate 10 years in the making*

The phone conversation between Michaels and Hansen over the details of Michaels' first public statement on climate change (in a 1986 *Washington Post* article) was not the last time that these two climate scientists would be in contact. If Hansen's testimony shocked the world and put global warming on the map, it also opened a seam in the public controversy, giving Michaels his chance to burst onto the scene. Michaels' 1989 *Washington Post* opinion piece, charging that Hansen's testimony represented a minority view among scientists, was based on faulty data and was part of an alarmist 'climate of fear' that flies in the face of sound science, began with the suggestion that Hansen was the only scientist who had stated publicly that there was a strong 'cause and effect' relationship between global temperatures and anthropogenic causes of warming. He further suggested that the other 'hundred-odd scientists in the world actively involved in the study of long-term climate data' disagree with Hansen's assessment (Michaels 1989, p. C3).

Michaels then chastised Hansen for the need to recant his prediction before the Senate that '1988 will be the warmest year on record' (Michaels, 1989, p. C3). As Michaels asserted, 1988 was not the warmest year on record, because cooling in the tropical Pacific in the latter half of the year (After Hansen's testimony) brought the annual temperature down considerably. Later in the year, Hansen apparently admitted that this cooling was 'remarkable'. But, Michaels didn't see it as remarkable. Instead, he explained that cooling occurs regularly and suggested that Hansen's model failed to consider it because it didn't include 'temperatures for the sea surface which covers 70 percent of the earth' (p. C3).

Michaels argued also that Hansen's Senate testimony was misleading because GISS's surface temperature calculations also failed to consider the urban heat island effect. 'Twentieth-century US temperature data, which formed a part of NASA's congressional testimony last year, hide a drastic warm-measurement bias … [because] cities tend to grow up around weather stations'. Michaels (1989) concluded by suggesting that scientists—namely Hansen—needed to be more cautious in their public statements. 'A little more candour from our media stars wouldn't hurt. In fact, more of us lesser beings emphasize the limitations of our work every time we get near a reporter' (p. C3).

A month later, the *Washington Post* printed Hansen's (1989a) reply, which claimed: 'I'm not being an alarmist about the greenhouse effect' (p. A23). Hansen stated that 'the evidence for an increasing greenhouse effect is now sufficiently strong that it would have been irresponsible if I had not attempted to alert political leaders'. He also went

on to dispute Michaels' criticism that the GISS model failed to consider the urban heat island effect. He claimed that the urban effect is 'neither hidden nor drastic' in the GISS model, and that it includes a 'full correction for the urban effect'. He stressed the unanimous agreement between observational evidence and the models on the point that 'the Earth was warmed 0·5C in the past century'. He then acknowledged Michaels' claim that there 'was strong global cooling in the last seven months of 1988', but pointed out that Michaels 'fails to mention that despite this, the global temperature was remarkably high in 1988'. In fact, it was so high that the five warmest years in the history of temperature records occurred in the 1980s (1980, 1981, 1983, 1987, 1988). Hansen (1989a) continued: 'It would be an amazing coincidence if this was chance and not an indication of a long-term warming trend' (p. A23).

Hansen concluded his response to Michaels by attempting to restore the legitimacy of his model and by placing himself back in the majority of credentialed scientists. He explained that the models do not serve as proof of warming on their own, but rather cohere with a variety of additional evidence: 'Our understanding of the greenhouse effect is based on studies of other planets, on records of the Earth's paleoclimate history during which the atmospheric composition varied, on the warming of the past century, and on climate studies'. He then suggested that it was Michaels, and not he, who was in the minority. 'The scientific community is convinced that we are headed for substantial climate changes in coming decades if greenhouse gas emissions continue to grow, as discussed in several reports by the National Academy of Sciences and by prestigious international organisations' (Hansen 1989a, p. A23).

Hansen's efforts to publicly refute Michaels' 1989 attacks did not stem the tide of additional criticism. Over the years, Michaels has taken frequent jabs at Hansen and has been especially vigorous in attacking Hansen's famous 1988 congressional testimony. For example, in his book *Sound and Fury*, Michaels (1992) accuses Hansen of committing a cardinal sin: 'Hansen, as writer of congressional testimony, was both author and editor—a very dangerous position that abrogates the normal review process' (p. 16). Michaels (1992) goes on to infer that Hansen distorted data and was guilty of 'mixing scientific apples and oranges' (p. 17). Notably, Michaels (1992) comes up short of suggesting that Hansen deliberately manipulated data for his congressional audience, acknowledging that his mistakes were 'perhaps inadvertent'. Yet, Michaels' (1992) point is strikingly clear: 'It is difficult to believe that [Hansen] was unaware of [the problem of inflated variance]' (p. 18).

There are several strategic reasons why Michaels may have chosen to continue his vigorous criticism of Hansen. First, as the 'godfather' of global warming, Hansen is the ideal target. He is both one of the most recognizable figures in the controversy and one of the most influential. If the person responsible for igniting the controversy can be discredited, then the whole mainstream view may be cast in doubt. Second, Hansen's predictions make him a stable target. He has warned consistently that the warming from anthropogenic forcings is more likely to be in the upper end of the range, rather than the lower end of the range. In fact, Hansen's model was the basis for the high end of the Charney estimate (Stevens 1999, p. 149). Third, discrediting Hansen—and his models—gives Michaels an argumentative launching pad to discredit the IPCC because Hansen's conclusions have been integrated directly into the IPCC assessment. As Michaels notes, '[Hansen's model] was one of many similar calculations that were used in the First Science Assessment of the UN IPCC' (Michaels 1998b, p. 4). On Michaels' logic, if Hansen were wrong in 1988 and if his model were instrumental in constructing the IPCC's perspective, then the IPCC must be wrong too. Finally, if Michaels can take

the models out of play in the global warming debate, then the only argumentative resources left are the data, and this is where Michaels shines brightest.

Between 1989 and 1998, there were no discernable public exchanges between Hansen and Michaels. Hansen spent much of the decade working at GISS away from the spotlight. In contrast, Michaels spent much of the intervening time sharpening his reputation as the 'pre-eminent critic'. He was busy making the rounds on Capitol Hill, writing regular newspaper columns, publishing the *Global Climate Report*, as well as publishing papers in scientific journals. Then, early in 1998, the potential for another exchange—that would ultimately lead to their joint appearance at the SPF—began to brew.

In the long history of the climate debate, 1998 undoubtedly will prove to be a significant year. At the beginning of the year, public discussion of global warming was at a feverish pitch as a result of the Kyoto conference, (which just wrapped up a few weeks earlier). In the USA, advocates on both sides of the climate debate were readying themselves for a possible Senate ratification row over a treaty that might emerge out of the Kyoto deliberations. But, 1998 also was significant because it marked the ten-year anniversary of Hansen's congressional testimony. Like all anniversaries, this one was cause for reflection and celebration. It had been ten years since Hansen unveiled his GISS climate model to the world and it was time to see if the observational data squared with the model's prediction. Adding to the drama, both Hansen and Michaels believed they had cause for popping the champagne.

Michaels approached the ten-year anniversary of Hansen's testimony, prepared to use the occasion's symbolism to mount a new round of critiques. If he could prove that Hansen was wrong ten years ago, then he would be able to prove that it was Hansen—not nature—who had loaded the famous climate dice. 'Ten years ago—June 23, 1988—NASA scientist James E. Hansen lit the Bonfire of the Greenhouse Vanities', Michaels (1998a) wrote. He went on to explain that 'Hansen's forecast was a bust' and 'we could have saved a lot of time and grief if we had just listened to the cynics when Mr Hansen made his 1988 splash'. Michaels then said that Hansen's predicted '0·34 °C' temperature rise over the 'succeeding decade' fell considerably short when compared to the mere '0·11 °C' rise that has been observed on the surface. He concluded by arguing that Hansen's efforts over the past decade to explain discrepancies between observation and his model's predictions were perfect examples of Thomas Kuhn's point that 'explanations become increasingly ornate and bizarre as the disconnection between models and reality broadens' (Michaels 1998a) The 'ornate' and 'bizarre' explanations to which Michaels referred was Hansen's search for auxiliary explanations to account for more modest temperature increases than earlier predicted.

On 29 July 1998, Michaels took his argument to Capitol Hill, where he offered testimony before the House Small Business Committee. In sketching the historical background for testimony arguing that his position had been 'validated', Michaels circled back once again to Hansen's 1988 testimony. 'At the time, Hansen also produced a model of the future behaviour of the globe's temperature .... That model predicted that global temperature between 1988 and 1997 would rise by 0·45 °C' (Michaels 1998c). Then, Michaels showed a chart closely resembling the one that Hansen used in 1988 to depict the three possible scenarios for warming generated by the GISS model (see figure 20, this issue p. 147). Using another chart, which compared Hansen's prediction to the observed temperature changes over that period, he went on to say that the actual temperature increase was 'more than four times less than Hansen predicted', and therefore, Hansen's forecast 'was an astounding failure, and IPCC's

1990 statement about the realistic projection of these projections was simply wrong' (Michaels 1998c).

At this point, you may be wondering why Hansen even participated in the SPF. Why would he want to take the stage if the ten years since his testimony proved his original predictions wrong? After all, he had largely avoided the public spotlight for the previous decade and was not a polished and practiced debater like Michaels. Hansen himself (1998d) has admitted that 'Communicating with the public ... is not easy, at least not for many of us'. Why would he decide to risk a public appearance—especially if the data were likely stacked against him?

Further investigation reveals that the opportunity to engage in a public debate with Michaels appealed to Hansen for several reasons. These reasons were laid out explicitly in a short piece Hansen published on-line at the GISS website. First, Hansen seemed to have concluded that scientists have an obligation to teach the public about science, admitting that 'we have failed to use the opportunity [of the global warming debate] to help teach the public about how science research works'. (Hansen 1998d). In this think piece, Hansen recognized that failure to convey the 'fun in science' has consequences because 'financial support for most research is provided ultimately by the public'.

Second, Hansen was genuinely concerned about the tactics used by the 'sceptics' in the global warming debate. Early in 1998, Hansen (1998c) wrote: 'Many of the participants in his debate have ceased to act as scientists ... but rather act as if they were lawyers hired to defend a particular perspective. New evidence has no effect on their preordained conclusions. This is abhorrent to science and spoils the fun of it' (p. 410; see also figure 43, this issue, p. 171). But, he was also troubled by what he saw as the failure of many in the scientific community, he included, to function as effective advocates, allowing that 'we are not doing as well as we could in the global warming debate' (Hansen 1998d). Apparently, Hansen (1998d) concluded that to do better, the differences between the two camps needed to be made a matter of public record: 'It seems to me that one useful thing that can be done is to clearly delineate the fundamental differences ... this is a way to pin down those who keep changing their arguments'.

While these factors probably influenced Hansen's decision to participate in the SPF, there may have been other reasons why he accepted the invitation to appear with Michaels. To begin with, Hansen believed that he was right and the sceptics were wrong about the 1988 model that was central to his congressional testimony. In a 1998 article published in the *Proceedings of the National Academy of Sciences*, Hansen trumpets the remarkable accuracy of his 1988 model:

> It has been one decade since the first climate predictions were made using time-varying greenhouse gases in a global climate model. Subsequent observations and the model are in good agreement.... Predicted change in the frequency of unusually warm seasons, a climate indicator noticeable to people, also has proven accurate (Hansen *et al.* 1998a, p. 4120).

However, there is yet another and possibly more significant reason why Hansen may have chosen to participate in the SPF. In the same article that discusses his post-SPF reflections, he states his motivation simply: 'I agreed to participate in this debate with Dr Michaels after learning that he had used (or misused) a figure of mine in testimony to the Unites States Congress' (Hansen 1998d).

During controversies, most advocates pay attention to what their adversaries say. In this regard, Hansen is no different. When Hansen learned of Michaels' (1998c) testimony before the House of Representatives, he was not amused. On Hansen's (1998d) account:

> When Pat Michaels testified to Congress in 1998 and showed our 1988 predictions, he erased the curves for scenarios B and C, and showed the result only for Scenario A. He then argued that, since the real world temperature had not increased as fast as this model calculation, the climate model was faulty and there was no basis for concern abut climate change, specifically concluding that the Kyoto Protocol was a 'useless appendage to an irrelevant treaty'.

When Hansen received the invitation to participate in the inaugural SPF, perhaps he accepted the offer to debate because he saw the AARST-sponsored forum as a platform for him to 'pin down' Michaels. If this is, indeed, the case, then an interesting exercise would involve comparing the arguments contained in the transcript against new data that have emerged since November 1998. Such a project might begin with a review of recent developments.

6. *Conclusion*

Ongoing international efforts to carry through with the Kyoto protocol, Al Gore's involvement with the global warming controversy in the USA and the forthcoming release of the IPCC's third major report in 2001 make it likely that this controversy will continue to hold a prominent place in the public sphere for some time to come. Although the SPF provides some insight into this controversy, a single debate is really just a snapshot of a much larger picture.

The SPF occurred in 1998, and each day that passes marks the arguments with age. In fact, there have been numerous developments since 1998 that might interest concerned citizens who read the transcript and wish to connect the arguments advanced in the SPF to the present day. For example, shortly after the SPF, Hansen's research team released GISS's year-end analysis of temperature trends, which claimed that global surface temperatures in 1998 'smashed' the previous record set in 1995 (Hansen *et al*. 1998e). One year later, Hansen *et al*. (1999) pointed out that, despite a slight decline from the record set in the previous year, 1999 'was still on of the warmest years of the century' and the 'climate "dice" are being "loaded" to a degree that is beginning to be noticeable to people'. Early in 2000, the National Research Council (2000) released a report, which discusses the disparity between satellite and surface temperature trends during 1979–98 (a key point of stasis in the Hansen–Michaels debate). The report suggests that this disparity 'in no way invalidates the conclusion of the IPCC that global surface temperature has warmed substantially since the beginning of the twentieth century .... The warming of surface temperatures that has taken place during the past 20 years is *undoubtedly real*' (p. 21). In March 2000, scientists at the National Oceanic and Atmospheric Administration (NOAA) published a report in the journal *Science* that claims that the temperature of the world's oceans has increased dramatically in the past four decades (Levitas 2000). This finding may contribute to the explanation of why temperatures have not risen as much as the models predict (another point of stasis in the Hansen–Michaels debate).

As this issue of *Social Epistemology* was going to press, Michaels (Michaels and Balling 2000) published his latest book which claims to 'clear the air' in preparation for the November 2000 presidential election in the USA. Michaels and Balling (2000) suggest that Hansen's 'current position is very close to that expressed in this book' (p. 58). Although the reader will have to judge for herself whether or not 'Hansen and Michaels agree' (as Michaels suggested in his opening SPF argument), the broader global warming controversy shows few signs of abating. The stakes are too high, the momentum

is too great and the interests are too deeply entrenched for closure. In coming years, stakeholders will be watching rolls of the climate dice closely. Given that society may be betting its future on our ability to make sound collective judgements on the climate change issue, concerted efforts to understand the heated arguments of the global warming controversy would seem imperative.

Acknowledgement

The author would like to thank Gordon Mitchell, Ann O'Donnell and Mary Catherine O'Donnell for helpful editorial suggestions.

Notes

1. For a thorough annotated bibliography of the early publications on the greenhouse effect and climate change see Handel and Risbey (1992b).
2. Although the debate over global warming is certainly international in scope, a good deal of this introduction to the controversy focuses on the USA because it was the early leader in climate change research and the 'first country to take the threat of climate change seriously' (Brown, 1996, p. 14). It also is responsible for a significant portion of increased atmospheric concentrations of carbon dioxide to date, and is widely considered to be the most intransigent actor in current international negotiations.
3. For further details on the history of the science, some of the best accounts are Hart and Victor (1993), Paterson (1996), Christianson (1999) and Stevens (1999).
4. Christianson (1999) provides an insightful discussion of Arrhenius' work.
5. Michaels and Balling (2000) object to the description of the sceptics as 'small' group. They write: 'The environmental community is fond of labeling us and our friends a "small band of scientific sceptics" (usually numbering around ten). But the scientific "mainstream"—the 70 or so other bona fide climatologists in the IPCC—is at best an only slightly larger "band"' (p. 17).
6. See Stevens (1999) for a lengthy discussion of these contrarians. For a less even handed treatment see Gelbspan (1997). Singer (1997), Balling (1992) and Michaels (1992) have each written a book which develops their views in detail.
7. For example, Singer (1997) has written: '[S]ome modest future warming should not be ruled out' (p. 37). In the SPF, Michaels makes a similar remark when he chastises the moderator at the beginning of his opening remarks: 'You really mis-introduced me when you said that I was some skeptic who didn't believe in global warming; I surely do. You can see it in the temperature history of the twentieth century' (Michaels, this issue, p. 148).
8. See Stevens (1999) for further biographical details on Hansen, especially pp. 146–152.
9. Although Hansen's testimony is widely cited as instrumental, some scientists disagree, suggesting that the public attention would have happened with or without Hansen. See Oppenheimer and Boyle (1990, p. 228).
10. Hansen is reported to have been particularly crucial in persuading Margaret Thatcher that global warming was a pressing concern. In 1988, he made a presentation to her, and she is reported to have read his famous 1988 congressional testimony (see Paterson, 1996, pp. 34–35). For further discussion of the evolution of the issue in the UK, especially Thatcher's role, see Courtney (1999).
11. The World Climate Report is a bi-weekly publication edited by Michaels. It is available on the Internet from the Greening Earth Society (http://www.greeningearthsociety.org/climate/). The Greening Earth Society is a 'not for profit grassroots organization created by Western Fuels Association to promote the viewpoint that humankind is a part of nature, rather than apart from nature' (retrieved on April 1, 2000, from the World Wide Web: http://www.greeningearthsociety.org/about.htm).

References

Anderson, J. W., 1997a. The history of climate change as a political issue, 12 August, available online: http://www.weathervane.rff.org/features/feature005.html [1 April 2000].

Anderson, J. W., 1997b. Climate Change, Clinton and Kyoto, November, Resources for the Future, Washington DC, available online: http: //www.rff.org/reports/PDF_files/climate_primer.pdf [1 April 2000].

Balling, R. C., 1992. *The Heated Debate* (San Francisco: Pacific Research Institute).

Boehmer-Christiansen, S., 1994. Global climate protection policy: the limits of scientific advice, Part I. *Global Environmental Change*, 4, 140–159.
Brown, P., 1996. *Global Warming* (London: Blandford).
Christianson, G. E., 1999. *Greenhouse: the 200-year story of global warming* (New York: Walker & Company).
Courtney, R., 1999. Global warming: how it all began, 9 May, available online: http://www.vision.net.au/~daly/history.htm [31 March 2000].
Gelbspan, R., 1997. *The Heat is On* (Reading, MA: Addison Wesley).
Global Change, 1997. Pat Michaels: horseman of the anti-apocalypse. (Oakland, CA: Pacific Institute for Studies in Development, Environment and Security) electronic edition, available online: http://www.globalchange.org/profall/97sep19f.htm [31 March 2000].
Gore, A., 1986. Beat the heat before it's too late. *Washington Post*, 6 July, B6.
Gore, A., 1989. Testimony before US Senate Committee on Commerce, Science and Transportation. *Climate Surprises: Hearing before the Subcommittee on Science, Technology, and Space*, 101st Cong., 1st sess., 8 May.
Handel, D. and Risbey, J. S., 1992a. Reflections on more than a century of climate change research. *Climatic Change*, 21, 91–96.
Handel, D. and Risbey, J. S., 1992b. An annotated bibliography on the greenhouse effect and climate change. *Climatic Change*, 21, 97–255.
Hansen, J., Fung, I., Lacis, A., Rind, D., Lebedeff, S., Ruedy, R., Russell, G. and Stone, P., 1988a. Global climate changes as forecast by Goddard Institute for Space Studies three-dimensional model. *Journal of Geophysical Research*, 93, 9341–9364.
Hansen, J. E., 1988b. Testimony before US Senate Committee on Energy and Natural Resources. *Greenhouse Effect and Global Climate Change: Hearing before the Committee on Energy and Natural Resources*, 100th Cong., 1st sess., 23 June.
Hansen, J. E., 1988c. Testimony before US House Committee on Energy and Commerce. *Energy Policy Implications of Global Warming: Hearing before the Subcommittee on Energy and Power*, 100th Cong., 2nd sess., 7 July and 22 September.
Hansen, J. E., 1989a. Free for all: I'm not being an alarmist about the greenhouse effect. *Washington Post*, 11 February, A23.
Hansen, J. E., 1989b. Testimony before US Senate Committee on Commerce, Science, and Transportation. *Climate Surprises: Hearing before the Subcommittee on Science, Technology, and Space*, 101st Cong., 1st sess., 8 May.
Hansen, J., Sato, Mki., Glascoe, J. and Ruedy, R., 1998a. A common-sense climate index: is climate changing noticeable? *Proceedings of the National Academy of Sciences*, 95, 4113–4120.
Hansen, J., Sato, Mki., Lacis, A., Ruedy, R., Tegen, I. and Matthews, E., 1998b. Climate forcings in the Industrial era. *Proceedings of the National Academy of Sciences*, 95, 12753–12758.
Hansen, J. E., 1998c. Book review of Sir John Houghton's *Global Warming: The Complete Briefing*. *Journal of Atmospheric Chemistry*, 30, 409–412.
Hansen, J. E., 1998d. The global warming debate, 30 December, available online: http://www.giss.nasa.gov/edu/gwdebate/ [27 April 2000].
Hansen, J. E., 1998e. Global temperature trends: 1998 global surface temperature smashes record, 12 December, available online: http://www.giss.nasa.gov/research/observe/surftemp/1998.html [31 March 2000].
Hansen, J. E., 2000. Global temperature trends: Continued global warmth in 1999, available online: http://www.giss.nasa.gov/research/observe/surftemp/ [12 January 2000].
Hart, D. M. and Victor, D. G., 1993. Scientific elites and the making of US policy for climate change research, 1957–74. *Social Studies of Science*, 23, 643–80.
Hecht, A. D. and Tirpak, C., 1995. Framework agreement on climate change: a scientific and policy history. *Climatic Change*, 29, 371–402.
Idso, S. B.,, 1989. *Carbon dioxide and global change: earth in transition* (Tempe, AZ: IBR Press).
IPCC WGI., 1990. *Climate Change: The IPCC Assessment* (Cambridge: Cambridge University Press).
IPCC WGI., 1996. *Climate Change 1995: The Science of Climate Change* (Cambridge: Cambridge University Press).
Kerr, R., 1989. Hansen vs. the world on greenhouse threat. *Science*, 244, On-line: Lexis-Nexis.
Levitas, S., 2000. Warming of the world ocean. *Science*, 287, 2225–2229.
Lore, D., 1996. Warming theorists not backing off. *Columbus Dispatch*, 1 November, on-line: Lexis-Nexis.
Marshall, E., 1989. Researchers irked by changes to testimony. *Science*, 12 May, on-line: Lexis-Nexis.
Michaels, P. J., 1986. Greenhouse effect? Then why is it colder? *Washington Post*, 15 June, F2.
Michaels, P. J., 1989. The greenhouse climate of fear. *Washington Post*, 8 January, C3.
Michaels, P. J., 1992. *Sound and fury* (Washington, DC: Cato Institute).
Michaels, P. J., 1998a. Inhaling a decade of hot air vapors. *Washington Times*, 28 June, B1, online: Lexis-Nexis.
Michaels, P. J., 1998b. Long hot year: latest science debunks global warming hysteria. *Policy Analysis*, 329 (Washington, DC: Cato Institute), December 31.
Michaels, P. J., 1998c. Prepared testimony of Patrick J. Michaels, Professor of Environmental Sciences, University of Virginia and Senior Fellow in Environmental Studies at CATO Institute before the House committee on small business. *Federal News Service*, 29 July, on-line: Lexis-Nexis.

MICHAELS, P. J. and BALLING, R. C., 2000. *The Satanic Gases: Clearing the Air about Global Warming* (Washington, DC: Cato Institute).
NATIONAL RESEARCH COUNCIL, 2000. *Reconciling Observations of Global Temperature Change*, available online: http://books.nap.edu/books/0309068916/html [31 March 2000].
OPPENHEIMER, M. and BOYLE, R., 1990. *Dead Heat: The Race Against the Greenhouse Effect* (New York: HarperCollins Publishers).
PATERSON, M., 1996. *Global Warming and Global Politics* (New York: Routledge).
PEARCE, F., 1997. Greenhouse wars. *New Scientist*, 19 July, 38, on-line: Lexis-Nexis.
SEABROOK, J., 2000. Selling the weather. *The New Yorker*, 3 April, 44–53.
SHABECOFF, P., 1988. Global warming has begun, expert tells senate. *New York Times*, 24 June, A1.
SINGER, S. F., 1997. *Hot Talk Cold Science: Global Warming's Unfinished Debate* (Oakland, CA: Independent Institute).
STEVENS, W. K., 1999. *The Change in the Weather* (New York: Delacorte Press).
TUCKER, B., 1997. Science friction: the politics of global warming. *National Interest*, Fall, 78–87.
VICTOR, D. G., 1995. On writing good histories of climate change and testing social science theories. *Climatic Change*, 29, 363–369.
WILDAVSKY, A., 1992. Global warming as a means of achieving an egalitarian society: an introduction. In R. C. Balling, *The Heated Debate* (San Francisco: Pacific Research Institute), xv–xxxvi.