

THE MYTH OF THE 1970s GLOBAL COOLING SCIENTIFIC CONSENSUS

BY THOMAS C. PETERSON, WILLIAM M. CONNOLLEY, AND JOHN FLECK

There was no scientific consensus in the 1970s that the Earth was headed into an imminent ice age. Indeed, the possibility of anthropogenic warming dominated the peer-reviewed literature even then.

THE MYTH. When climate researcher Reid Bryson stood before the members of the American Association for the Advancement of Science in December 1972, his description of the state of scientists' understanding of climate change sounded very much like the old story about the group of blind men trying to describe an elephant. The integrated enterprise of climate science as we know it today was in its infancy, with different groups of scientists feeling blindly around their

piece of the lumbering climate beast. Rigorous measurements of increasing atmospheric carbon dioxide were available for the first time, along with modeling results suggesting that global warming would be a clear consequence. Meanwhile, newly created global temperature series showed cooling since the 1940s, and other scientists were looking to aerosols to explain the change. The mystery of waxing and waning ice ages had long entranced geologists, and a cohesive explanation in terms of orbital solar forcing was beginning to emerge. Underlying this discussion was a realization that climate could change on time scales with the potential for significant effects on human societies, and that human activities could trigger such changes (Bryson 1974).

Bryson laid out the following four questions that still stand today as being central to the climate science enterprise:

- i) How large must a climate change be to be important?
- ii) How fast can the climate change?
- iii) What are the causal parameters, and why do they change?
- iv) How sensitive is the climate to small changes in the causal parameters?

AFFILIATIONS: PETERSON—NOAA/National Climatic Data Center, Asheville, North Carolina; CONNOLLEY—British Antarctic Survey, National Environment Research Council, Cambridge, United Kingdom; FLECK—*Albuquerque Journal*, Albuquerque, New Mexico

CORRESPONDING AUTHOR: Thomas C. Peterson, NOAA/National Climatic Data Center, 151 Patton Avenue, Asheville, NC 28803

E-mail: Thomas.C.Peterson@noaa.gov

The abstract for this article can be found in this issue, following the table of contents.

DOI:10.1175/2008BAMS2370.1

In final form 8 February 2008
©2008 American Meteorological Society

Despite active efforts to answer these questions, the following pervasive myth arose: there was a consensus among climate scientists of the 1970s that either global cooling or a full-fledged ice age was imminent (see the “Perpetuating the myth” sidebar). A review of the climate science literature from 1965 to 1979 shows this myth to be false. The myth’s basis lies in a selective misreading of the texts both by some members of the media at the time and by some observers today. In fact, emphasis on greenhouse warming dominated the scientific literature even then. The research enterprise that grew in response to the questions articulated by Bryson and others, while considering the forces responsible for cooling, quickly converged on the view that greenhouse warming was likely to dominate on time scales that would be significant to human societies (Charney et al. 1979). However, perhaps more important than demonstrating that the global cooling myth is wrong, this review shows the remarkable way in which the individual threads of climate science of the time—each group of researchers pursuing their own set of

questions—was quickly woven into the integrated tapestry that created the basis for climate science as we know it today.

RECOGNITION OF A PROBLEM: THE POTENTIAL FOR WARMING.

In 1965, when U.S. President Lyndon Johnson asked the members of his President’s Science Advisory Committee (PSAC) to report on the potential problems of environmental pollution, climate change was not on the national agenda. The polluting effects of detergents and municipal sewage, the chronic problems associated with urban air pollution, and the risks associated with pesticides dominated public discourse about humanity’s impact on the environment. However, in a 23-page appendix, which today appears prescient, the committee’s Environmental Pollution Panel laid out the following stark scenario: emissions of carbon dioxide from the burning of fossil fuels could rapidly reshape Earth’s climate (Revelle et al. 1965).

The panel’s members had two new tools at their disposal that had not been available just a few years

PERPETUATING THE MYTH

The following are examples of modern writers perpetuating the myth of the 1970s global cooling scientific consensus.

Citing Singer (1998) as their source of information, Singer and Avery (2007) indicate that the National Academy of Science (1975) experts exhibited “hysterical fears” about a “finite possibility” that a serious worldwide cooling could befall the Earth, and that Ponte (1976) captured the “then-prevailing mood” by contending that the Earth may be on the brink of an ice age.

Balling (1992) posits,

Could the [cold] winters of the late 1970s be the signal that we were returning to yet another ice age? According to many outspoken climate scientists in the late 1970s, the answer was absolutely yes—and we needed action now to cope with the coming changes . . . However, some scientists were skeptical, and they pointed to a future of global *warming*, not cooling, resulting from a continued build up of greenhouse gases. These scientists were in the minority at the time.

According to Horner (2007), the massive funding of climate change research was prompted by “‘consensus’ panic over ‘global cooling.’” This was “three decades ago—when the media were fanning frenzy about global cooling” (Will 2008) or, as Will (2004) succinctly put it, “the fashionable panic was about global cooling.” “So, before we take global warming as a scientific truth, we should note that the opposite theory was once scientific verity” (Bray 1991).

In a narrative, Crichton (2004) put it this way:

“Just think how far we have come!” Henley said. “Back in the 1970s, all the climate scientists believed an ice age was coming. They thought the world was getting colder. But once the notion of global *warming* was raised, they immediately recognized the advantages. Global warming creates a crisis, a call to action. A crisis needs to be studied, it needs to be funded . . .”

According to Michaels (2004),

Thirty years ago there was much scientific discussion among those who believed that humans influenced the . . . reflectivity [which would] cool the earth, more than . . . increasing carbon dioxide, causing warming. Back then, the “coolers” had the upper hand because, indeed, the planet was cooling . . . But nature quickly shifted gears . . . Needless to say, the abrupt shift in the climate caused almost as abrupt a shift in the balance of scientists who predictably followed the temperature.

Giddens (1999) states,

Yet only about 25 or so years ago, orthodox scientific opinion was that the world was in a phase of global cooling. Much the same evidence that was deployed to support the hypothesis of global cooling is now brought into play to bolster that of global warming — heat waves, cold spells, unusual types of weather.

before. The first up-to-date global temperature reconstructions had recently become available, allowing them to consider the twentieth century's somewhat confusing temperature trends (Somerville et al. 2007). More importantly, they had access to carbon dioxide data that Charles David Keeling and his colleagues had been collecting since 1957 on Mauna Loa, Hawaii, and in Antarctica (Pales and Keeling 1965; Brown and Keeling 1965). The data showed "clearly and conclusively," in the panel's words, that atmospheric carbon dioxide was rising as a result of fossil fuel burning. Human activities, the panel concluded, were sufficient in scale to impact not just the immediate vicinity where those activities were taking place. Industrial activities had become a global, geophysical force to be recognized and with which to be reckoned. With estimated recoverable fossil fuel reserves sufficient to triple atmospheric carbon dioxide, the panel wrote, "Man is unwittingly conducting a vast geophysical experiment." With the emission of just a fraction thereof, emissions by the year 2000 could be sufficient to cause "measurable and perhaps marked" climate change, the panel concluded (Revelle et al. 1965).

THE GLOBAL TEMPERATURE RECORDS: A COOLING TREND. Efforts to accumulate and organize global temperature records began in the 1870s (Somerville et al. 2007). The first analysis to show long-term warming trends was published in 1938. However, such analyses were not updated very often. Indeed, the Earth appeared to have been cooling for more than 2 decades when scientists first took note of the change in trend in the 1960s. The seminal work was done by J. Murray Mitchell, who, in 1963, presented the first up-to-date temperature reconstruction showing that a global cooling trend had begun in the 1940s. Mitchell used data from nearly 200 weather stations, collected by the World Weather Records project under the auspices of the World Meteorological Organization, to calculate latitudinal average temperature. His analysis showed that global temperatures had increased fairly steadily from the 1880s, the start of his record, until about 1940, before the start of a steady multidecade cooling (Mitchell 1963).

By the early 1970s, when Mitchell updated his work (Mitchell 1972), the notion of a global cooling trend was widely accepted, albeit poorly understood. The first satellite records showed increasing snow and ice cover across the Northern Hemisphere from the late 1960s to the early 1970s. This trend was capped by unusually severe winters in Asia and parts of North America in 1972 and 1973 (Kukla and Kukla 1974),

which pushed the issue into the public consciousness (Gribbin 1975). The new data about global temperatures came amid growing concerns about world food supplies, triggering fears that a planetary cooling trend might threaten humanity's ability to feed itself (Thompson 1975). It was not long, however, before scientists teasing apart the details of Mitchell's trend found that it was not necessarily a global phenomenon. Yes, globally averaged temperatures were cooling, but this was largely due to changes in the Northern Hemisphere. A closer examination of Southern Hemisphere data revealed thermometers heading in the opposite direction (Damon and Kunen 1976).

NEW REVELATIONS ABOUT THE ICE AGES. While meteorologists were collecting, analyzing, and trying to explain the temperature records, a largely separate group of scientists was attacking the problem from a paleoclimate perspective, assembling the first detailed understanding of the Earth's ice age history. The fact that parts of the Northern Hemisphere had once been covered in ice was one of the great realizations of nineteenth-century geology. Even more remarkable was the realization that the scars on the landscape had been left by not one but several ice ages. Climate clearly was capable of remarkable variability, beyond anything humanity had experienced in recorded history.

It was not until the mid-twentieth century that scientists finally assembled the details of the coming and going of the last ice ages. The geologists' classic story had suggested four short ice ages over the Quaternary, with long warm periods between them. However, analysis of coral, cores from ice caps and the ocean floor, along with the application of newly developed radiometric techniques, forced a radical reevaluation. Climate was far more variable, with long ice ages punctuated by short interglacial periods (Broecker et al. 1968; Emiliani 1972). The new work went beyond filling in gaps in scientists' knowledge of the past. It laid the foundation of an explanation for why ice age cycles occurred. Building on earlier work (e.g., Adhémar 1842; Croll 1875), Serbian engineer and geophysicist Milutin Milankovitch calculated that highly regular changes in the tilt of Earth's axis and the eccentricity of its orbit around the sun would change the distribution of sunlight hitting the Earth's surface, leading to the waxing and waning of ice ages (Milankovitch 1930). Milankovitch's work won few converts, in part because it did not match geologists' understanding of the history of the ice ages. However, the new dating of the ice's ebbs and flows led

to new interest in Milankovitch's ideas (e.g., Ericson et al. 1964; Damon 1965). "The often-discredited hypothesis of Milankovitch must be recognized as the number-one contender in the climatic sweepstakes," Wallace Broecker wrote (Broecker et al. 1968). It took the rest of the science world a while to catch up with Broecker, but by the late 1970s they had (Hays et al. 1976; Kerr 1978; Weart 2003).

Because Milankovitch's astronomical metronome was predictable over thousands of years, climate scientists could now begin talking about predicting the onset of the next ice age. And they did. Members of the Climate: Long-range Investigation, Mapping and Prediction (CLIMAP) project lived up to their project's name with a "prediction" of sorts; in the absence of possible anthropogenic warming, "the long-term trend over the next several thousand years is toward extensive Northern Hemisphere glaciation" (Hays et al. 1976).

CARBON DIOXIDE. Mid-nineteenth-century British naturalist John Tyndall was fascinated by the new emerging evidence of past ice ages, and believed he had found a possible explanation for such dramatic changes in Earth's climate: changes in the composition of the atmosphere. Some molecules, he realized, could absorb thermal radiation, and as such could be the cause for "all the mutations of climate which the researches of geologists reveal" (Weart 2003; Tyndall 1861; Somerville et al. 2007). In 1896 Swedish scientist Svante Arrhenius calculated that a doubling of atmospheric carbon dioxide would raise global temperatures 5°–6°C. However, he figured it would take 3,000 yr of fossil fuel burning to do it (Weart 2003). Thus continued what would be a century of scientific debate and uncertainty, both about the effect of such so-called "greenhouse gases" and the possibility that the burning of fossil fuels could contribute substantially to their concentration (Landsberg 1970). It was not until the second half of the twentieth century that scientists finally had the tools to begin measuring the concentrations of those greenhouse gases in sufficient detail to begin evaluating their effects.

Using funding available through the International Geophysical Year, Charles David Keeling was able to overcome problems of local interference in carbon dioxide measurements in 1957 by establishing stations in Antarctica and atop Mauna Loa. By 1965, his data were sufficient to show an unambiguous trend. Keeling's observation also showed that atmospheric carbon dioxide was increasing far faster than Arrhenius's 70-yr-old estimate. That was enough for members of the U.S. President's Scientific Advisory

Committee to pronounce the possibility that increasing carbon dioxide could "modify the heat balance of the atmosphere to such an extent that marked changes in climate, not controllable through local or even national efforts, could occur" (Revelle et al. 1965).

The PSAC scientists had a new tool for understanding the implications—the first preliminary results of newly developing climate models. The same year the PSAC report came out, Syukuro Manabe and Richard Wetherald developed the first true three-dimensional climate model. The results were raw at the time the PSAC report was written, but within 2 yr, the first seminal modeling results from the Geophysical Fluid Dynamics Laboratory team were published. Given their simplifying constraints, they found that a doubling of atmospheric carbon dioxide would raise global temperature 2°C (Manabe and Wetherald 1967). Within a decade, the models' sophistication had grown dramatically, enough for Manabe and Wetherald to conclude that high latitudes were likely to see greater warming in a doubled-CO₂ world, and that the intensity of the hydrologic cycle could be expected to increase significantly (Manabe and Wetherald 1975). The accumulating evidence of the new carbon dioxide record and the modeling results was enough for Wallace Broecker to ask in 1975, "Are we on the brink of a pronounced global warming?" Broecker's answer was a resounding "yes" (Broecker 1975).

AEROSOLS. In December 1968, a group of scientists convened in Dallas, Texas, for a "Symposium on Global Effects of Environmental Pollution" (Singer 1970). Reid Bryson showed the panel a remarkable graph illustrating the correlation between rising levels of dust in the Caucasus and the rising output of the Russian economy over the previous three decades. It was the foundation for an argument leading from human activities to dust to changing climate. Atmospheric pollution caused by humans was sufficient, Bryson argued, to explain the decline in global temperatures identified earlier in the decade by J. Murray Mitchell (Bryson and Wendland 1970).

Also on the symposium panel was Mitchell himself, and he disagreed. Mitchell's calculations suggested that particulates added to the atmosphere were insufficient to explain the cooling seen in his temperature records. However, he raised the possibility that, over time, cooling caused by particulates could overtake warming caused by what he called the "the CO₂ effect" (Mitchell 1970).

In 1971, S. Ichiaque Rasool and Stephen Schneider wrote what may be the most misinterpreted and mis-

used paper in the story of global cooling (Rasool and Schneider 1971). It was the first foray into climate science for Schneider, who would become famous for his work on climate change. Rasool and Schneider were trying to extend the newly developed tool of climate modeling to include the effects of aerosols, in an attempt to sort out two potentially conflicting trends—the warming brought about by increasing carbon dioxide and the cooling potential of aerosols emitted into the Earth’s atmosphere by industrial activity.

The answer proposed by Rasool and Schneider to the questions posed by Bryson and Mitchell’s disagreement was stark. An increase by a factor of 4 in global aerosol concentrations, “which cannot be ruled out as a possibility,” could be enough to trigger an ice age (Rasool and Schneider 1971). Critics quickly pointed out flaws in Rasool and Schneider’s work, including some they acknowledged themselves (Charlson et al. 1972; Rasool and Schneider 1972). Refinements, using data on aerosols from volcanic eruptions, showed that while cooling could result, the original Rasool and Schneider paper had overestimated cooling while underestimating the greenhouse warming contributed by carbon dioxide (Schneider and Mass 1975; Weart 2003). Adding to the confusion at the time, other researchers concluded that aerosols would lead to warming rather than cooling (Reck 1975; Idso and Brazel 1977).

It was James Hansen and his colleagues who found what seemed to be the right balance between the two competing forces by modeling the aerosols from Mount Agung, a volcano that erupted in Bali in 1963. Hansen and his colleagues fed data from the Agung eruption into their model, which got the size and timing of the resulting pulse of global cooling correct. By 1978, the question of the relative role of aerosol cooling and greenhouse warming had been sorted out. Greenhouse warming, the researchers concluded, had become the dominant forcing (Hansen et al. 1978; Weart 2003).

MEDIA COVERAGE. When the myth of the 1970s global cooling scare arises in contemporary discussion over climate change, it is most often in the form of citations not to the scientific literature, but to news media coverage. That is where U.S. Senator James Inhofe turned for much of the evidence to support his argument in a U.S. Senate floor speech in 2003 (Inhofe 2003). Chief among his evidence was a frequently cited *Newsweek* story: “The cooling world” (Gwynne 1975). The story drew from the latest global temperature records, and suggested that cooling “may portend a drastic decline for food production.” Citing

the Kuklas’ work on increasing Northern Hemisphere snow and ice, and Reid Bryson’s concerns about a long-term cooling trend, the *Newsweek* story juxtaposes the possibility of cooling temperatures and decreasing food production with rising global populations. Other articles of the time featured similar themes (see “Popular literature of the era” sidebar).

Even cursory review of the news media coverage of the issue reveals that, just as there was no consensus at the time among scientists, so was there also no consensus among journalists. For example, these are titles from two *New York Times* articles: “Scientists ask why world climate is changing; major cooling may be ahead” (Sullivan 1975a) and “Warming trend seen in climate; two articles counter view that cold period is due” (Sullivan 1975b). Equally juxtaposed were *The Cooling* (Ponte 1976), which was published the year after *Hothouse Earth* (Wilcox 1975).

However, the news coverage of the time does reflect what *New York Times* science writer Andrew Revkin calls “the tyranny of the news peg,” based on the idea that reporters need a “peg” on which to hang a story. Developments that are dramatic or new tend to draw the news media’s attention, Revkin argues, rather than the complexity of a nuanced discussion within the scientific community (Revkin 2005). A handy peg for climate stories during the 1970s was the cold weather.

SURVEY OF THE PEER-REVIEWED LITERATURE. One way to determine what scientists think is to ask them. This was actually done in 1977 following the severe 1976/77 winter in the eastern United States. “Collectively,” the 24 eminent climatologists responding to the survey “tended to anticipate a slight global warming rather than a cooling” (National Defense University Research Directorate 1978). However, given that an opinion survey does not capture the full state of the science of the time, we conducted a rigorous literature review of the *American Meteorological Society’s* electronic archives as well as those of *Nature* and the scholarly journal archive *Journal Storage (JSTOR)*. To capture the relevant topics, we used global temperature, global warming, and global cooling, as well as a variety of other less directly relevant search terms. Additionally, in order to make the survey more complete, even at the expense of no longer being fully reproducible by electronic search techniques, many references mentioned in the papers located by these searches were evaluated, as were references mentioned in various history-of-science documents. Because the time period attributed to the global cooling consen-

sis is typically described as the 1970s, the literature search was limited to the period from 1965 through 1979. While no search can be 100% complete, this methodology offers a reasonable test of the hypothesis that there was a scientific consensus in the 1970s regarding the prospect of imminent global cooling. Such a consensus would be easily shown by both the presence of many articles describing global cooling projections and the absence of articles projecting global warming.

One measure of the relevance of a paper to a developing scientific consensus is the number of citations it receives. For that reason, a citation analysis of the papers found in our survey was undertaken. Not all of the citations may be supportive of the paper in question, but they do help indicate which papers dominated the thinking of the day. Because the period assessed ended in 1979 and it takes time for citations to start appearing, the citation count was extended

through 1983. The gray literature of conference proceedings were not authoritative enough to be included in the literature search. However, a few prestigious reports that may not have been peer reviewed have been included in this literature survey because they clearly represent the science of their day.

Our literature survey was limited to those papers projecting climate change on, or even just discussing an aspect of climate forcing relevant to, time scales from decades to a century. While some of these articles make clear predictions of global surface temperature change by the year 2000, most of these articles do not. Many of the articles simply examined some aspect of climate forcing. However, it was generally accepted that both CO₂ and anthropogenic aerosols were increasing. Therefore, for example, articles that estimated temperature increases resulting from doubling CO₂ or temperature decreases resulting from anthropogenic aerosols would be listed in

POPULAR LITERATURE OF THE ERA

There are too many potential newspaper articles to adequately assess and, because they report on current events, even articles in the same paper by the same author separated by only a few months can be quite different. For example, the following are titles from two *New York Times* articles: "Scientists ask why world climate is changing; major cooling may be ahead" (Sullivan 1975a) and "Warming trend seen in climate; two articles counter view that cold period is due" (Sullivan 1975b). The most frequently cited magazine articles are described below. While these articles described the past climate and a distant future of another ice age, the following is a review only of their decadal-to-century-scale global temperature projections.

Science Digest's 1973 article "Brace yourself for another Ice Age" (Colligan 1973) primarily focused on ice ages and global cooling, with the warning that "the end of the present interglacial period is due 'soon.'" However, it clarified that "'soon' in the context of the world's geological time scale could mean anything from two centuries to 2,000 years, but not within the lifetime of anyone now alive." The article also mentioned that "scientists seem to think that a little more carbon dioxide in the atmosphere could warm things up a good deal."

Time Magazine (1974) ominously worried that "climatological Cassandras are becoming increasingly apprehensive, for the weather aberrations they are studying may be the harbinger of another ice age." However, only one scientist was indicated by name issuing any sort of projection: "Some scientists like Donald Oilman, chief of the National Weather Service's long-range-prediction group, think that the cooling trend may be only temporary."

Science News's 1975 article "Climate change: Chilling possibilities" (Douglas 1975) mainly discussed the new findings that raised the possibility of "the approach of a full-blown 10,000-year ice age." However, it also put these results into perspective with statements such as "the cooling trend observed since 1940 is real enough . . . but not enough is known about the underlying causes to justify any sort of extrapolation," and "by the turn of the century, enough carbon dioxide will have been put into the atmosphere to raise the temperature of earth half a degree."

The 1975 *Newsweek* article (Gwynne 1975) quotes four scientists by name and none of them offered a projection of the future; three discussed observations of the recent cooling and one the relation-

ship between climate and agriculture. The article did, however, state that "seemingly disparate [weather] incidents represent the advance signs of fundamental changes in the world's weather," though "meteorologists disagree about the cause and extent of the cooling trend." The article states that there was an "almost unanimous" view that the cooling trend would "reduce agricultural productivity for the rest of the century," and it even discussed possible solutions such as spreading black soot on the Arctic ice cap.

In 1976, *National Geographic Magazine* published an article entitled "What's happening to our climate?" In this article, Matthews (1976) discusses projections on the relevant time frame from four different scientists. Reid Bryson of the University of Wisconsin believed that the critical factor was cooling caused by aerosols generated by an exploding population. If Willi Dansgaard of the University of Copenhagen is correct—that western Europe's climate lags 250 yr behind Greenland's—"Europe could be in for a cooler future," although he cautions that man-made atmospheric pollution "may completely change the picture." The "cooling trend of world climate" was documented in the 1960s by

Table 1 as warming or cooling articles, respectively. The neutral category in Table 1 includes papers that project no change, that discuss both warming and cooling influences without specifically indicating which are likely to be dominant, or that state not enough is known to make a sound prediction. Articles were not included in the survey if they examined the climate impacts of factors that did not have a clear expectation of imminent change, such as increases in volcanic eruptions or the creation of large fleets of supersonic aircraft.

The survey identified only 7 articles indicating cooling compared to 44 indicating warming. Those seven cooling articles garnered just 12% of the citations. Graphical representations of this survey are shown in Fig. 1 for the number of articles and Fig. 2 for the number of citations. Interestingly, only two of the articles would, according to the current state of climate science, be considered “wrong” in the sense of

getting the wrong sign of the response to the forcing they considered—one cooling (Bryson and Dittberner 1976) and one warming (Idso and Brazel 1977) paper—and both were immediately challenged (Woronko 1977; Herman et al. 1978). As climate science and the models progressed over time, the findings of the rest of the articles were refined and improved, sometimes significantly, but they were not reversed.

Given that even a cursory examination of Fig. 1 reveals that global cooling was never more than a minor aspect of the scientific climate change literature of the era, let alone the scientific consensus, it is worth examining the ways in which the global cooling myth persists. One involves the simple misquoting of the literature. In a 2003 *Washington Post* op-ed piece, former Energy Secretary James Schlesinger quoted a 1972 National Science Board report as saying, “Judging from the record of the past interglacial ages, the present time of high temperatures should be drawing to an

J. Murray Mitchell Jr., of the National Oceanic and Atmospheric Administration (NOAA). Now, he notes, “carbon dioxide pollution may be contributing to an opposite, or warming, tendency.” And last, “it is possible that we are on the brink of a several-decade-long period of rapid warming,” observes Dr. Wallace S. Broecker of Columbia University’s Lamont-Doherty Geological Observatory. “If the natural cooling trend bottoms out . . . global temperature would begin a dramatic rise . . . this warming would, by the year 2000, bring average global temperatures beyond the range experienced during the past 1,000 years.”

There were also lay books on climate change, some of which received rather scathing reviews in the scientific literature. For example, discussing *The Climatic Threat: What’s Wrong with our Weather?* (Gribbin 1978a), Wigley (1978) wrote that the average reader “cannot possibly know how incompletely the author reviews the field he discusses, how uncritical and selective are his references to the scientific literature, how much he has mixed sound well accepted work with controversial opinion and speculation, and how often the cautious, tentative words of others are represented as established fact.” Note also, “A casual

reader” of *Climates of Hunger: Mankind and the World’s Changing Weather* (Bryson and Murray 1977) “will not get a balanced picture of the current climatic debate” (Gribbin 1978b). Kellogg’s (1979) review of Halacy (1978) that also comments on Calder (1974), stated that

Halacy, in *Ice and Fire?* Like Calder, has chosen to write a book whose central theme is the prediction of a global cooling as the beginning of a new ice age—perhaps occurring very quickly. . . . Furthermore, even a non-expert will notice that he has blurred his timescales cleverly (as did Nigel Calder, whom he quotes extensively), giving the impression that the advent of an ice age could occur in a matter of a decade or so—perhaps it will take a century if we are lucky.

Landsberg (1976) also took Calder’s book, *The Weather Machine*, to task, stating that “he quotes his favorite scientists at length, and then covers himself by a sentence at the end that there are others with diverging opinions . . . The amount of half-digested meteorology, such as the potential dust effect in the atmosphere, is formidable.”

A common feature of the popular articles and books is the probable negative impacts of climate variability on agriculture, which was felt to be stressed already by population pressures. The book, *The Genesis Strategy* (Schneider 1976) takes this further and argues for a policy resilient to any future changes in climate, though without predicting either warming or cooling. A more extreme book, *The Cooling* (Ponte 1976), predicts that cooling could lead to billions of deaths by 2050, but struggles to find any good source for predictions of such a cooling; it is also somewhat undermined by its own preface by Reid Bryson, which states that “there are very few pages that, as a scientist, I could accept without questions of accuracy, of precision, or of balance.” On the other side, the book *Hothouse Earth* (Wilcox 1975) has both polar ice caps melting due to anthropogenic global warming (Landsberg 1976) and the 1973 Charlton Heston film *Soylent Green* “imagines the Earth of 2022 as a dried-up wasteland where the greenhouse effect, brought about by an exponentially growing population and unchecked industry, has led to the destruction of the environment” (Bertram 2006).

TABLE I. Cooling, neutral, and warming papers as defined in the text followed by the number of times they have been cited up through 1983.

Year	Cooling papers	Neutral papers	Warming papers
1965			Revelle et al. (1965)
1966			
1967	McCormick and Ludwig (1967): 67		Manabe and Weatherald (1967): 306
1968			
1969			Sellers (1969): 191
1970		Landsberg (1970): 83	Benton (1970): 0; Report of the Study of Critical Environmental Problems (1970): 130
1971	Barrett (1971): 14; Rasool and Schneider (1971): 144		Mitchell (1971): 81
1972	Hamilton and Seliga (1972): 12	Charlson et al. (1972): 0; Lowry (1972): 0; National Science Board (1972): 0; Rasool and Schneider (1972): 0	Budyko (1972): 36; Machta (1972): 31; Mitchell (1972): 36; Sawyer (1972): 8
1973		Sellers (1973): 104	
1974	Chýlek and Coakley (1974): 38	Bryson (1974): 113; Hobbs et al. (1974): 22; Weare et al. (1974): 12; Willett (1974): 0	Federal Council for Science and Technology Interdepartmental Committee for Atmospheric Sciences (1974): 1; Kellogg and Schneider (1974): 30; Sellers (1974): 33
1975		National Academy of Sciences (1975): 0	Broecker (1975): 54; Manabe and Wetherald (1975): 211; Ramanathan (1975): 63; Reck (1975): 13; Schneider and Mass (1975): 82; Schneider (1975): 94; Thompson (1975): 49
1976	Bryson and Dittberner (1976): 31	Shaw (1976): 6	Budyko and Vinnikov (1976): 0; Damon and Kunen (1976): 29; Mitchell (1976): 50; Wang et al. (1976): 89
1977	Twomey (1977): 19	Bryson and Dittberner (1977): 0	Flohn (1977): 7; Idso and Brazel (1977): 1; Lee and Snell (1977): 8; National Academy of Sciences (1977): 1; Nordhaus (1977): 13; Panel on Energy and Climate (1977): 78; Woronko (1977): 1
1978		Herman et al. (1978): 0; Mason (1978a): 0; Miles (1978): 8; Ramanathan and Coakley (1978): 44; Shutts and Green (1978): 3	Budyko et al. (1978): 0; Cooper (1978): 0; Gilchrist (1978): 5; Idso and Brazel (1978): 2; Mason (1978b): 0; Mercer: (1978): 48; Ohring and Adler (1978): 25; Stuiver (1978): 101
1979		Choudhury and Kukla (1979): 4; Sagan et al. (1979): 25	Berger (1979): 6; Charney et al. (1979): 50; Houghton (1979): 0; Hoyt (1979): 13; Rotty (1979): 1

end . . . leading into the next glacial age” (Schlesinger 2003). The quote repeatedly appeared other places in the political debate over climate change, including the floor of the U.S. Senate where Inhofe (2003) followed up that quote by stating, “That was the same timeframe that the global-warming alarmists are concerned about global warming.” The actual report, however, shows that the original context, rather than supporting the global cooling myth, discusses the full state of the science at the time, as described earlier. The words not extracted by Schlesinger and Inhofe are highlighted with italics:

Judging from the record of the past interglacial ages, the present time of high temperatures should be drawing to an end, *to be followed by a long period of considerably colder temperatures* leading to the next glacial age some

20,000 years from now. However, it is possible, or even likely, that human interference has already altered the environment so much that the climatic pattern of the near future will follow a different path. For instance, widespread deforestation in recent centuries, especially in Europe and North America, together with increased atmospheric opacity due to man-made dust storms and industrial wastes, should have increased the Earth’s reflectivity. At the same time increasing concentration of industrial carbon dioxide in the atmosphere should lead to a temperature increase by absorption of infrared radiation from the Earth’s surface. When these human factors are added to such other natural factors as volcanic eruptions, changes in solar activity, and resonances within the hydro-atmosphere, their effect can only be estimated in terms of direction, not of amount (National Science Board 1972).

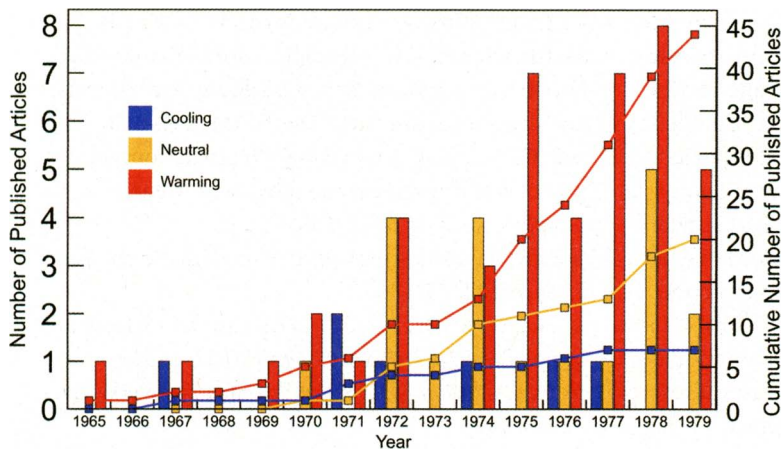


FIG. 1. The number of papers classified as predicting, implying, or providing supporting evidence for future global cooling, warming, and neutral categories as defined in the text and listed in Table 1. During the period from 1965 through 1979, our literature survey found 7 cooling, 20 neutral, and 44 warming papers.

Underlying the selective quotation of the past literature is an example of what political scientist Daniel Sarewitz calls “scientization” of political debate: the selective emphasis on particular scientific “facts” to advance a particular set of political values (Sarewitz 2004). In this case, the primary use of the myth is in the context of attempting to undermine public belief in and support for the contemporary scientific consensus about anthropogenic climate change by appeal to a past “consensus” on a closely related topic that is alleged to have been wrong (see “Perpetuating the myth” sidebar).

INTEGRATING CLIMATE SCIENCE IN THE LATE 1970s. When James D. Hays and colleagues published their landmark 1976 paper linking variations in the Earth’s orbit to the ice ages, they offered the following two caveats:

Such forecasts must be qualified in two ways: First, they apply only to the natural component of future climatic trends—and not to anthropogenic effects such as those due to the burning of fossil fuels. Second, they describe only the long-term trends, because they are linked to orbital variations with periods of 20,000 years and longer. Climatic oscillations at higher frequencies are not predicted (Hays et al. 1976).

As the various threads of climate research came together in the late 1970s into a unified field of study—ice ages, aerosols, greenhouse forcing, and the global temperature trend—greenhouse forcing was coming to be recognized as the dominant term in the climate change equations for time scales from decades to centuries. That was the message from B. John Mason of the British Meteorological Office when he stood before members of the Royal Society in London on 27 April 1978 to deliver a review lecture on the state of the science. Taking his audience through the details of how the new computer climate models worked and what they showed, Mason ticked off the follow-

ing now-familiar list of climate variables: variations in the Earth’s orbit, aerosols, and the rapid increase in greenhouse gases. The effect of the latter, he said, was by far the largest, and more detailed study of the issue “now deserves high priority” (Mason 1978b).

In July 1979 in Woods Hole, Massachusetts, Jule Charney, one of the pioneers of climate modeling, brought together a panel of experts under the U.S. National Research Council to sort out the state of the science. The panel’s work has become iconic as a foundation for the enterprise of climate change study that followed (Somerville et al. 2007). Such reports are a traditional approach within the United States for eliciting expert views on scientific questions of political and public policy importance (Weart 2003). In this case, the panel concluded that the potential

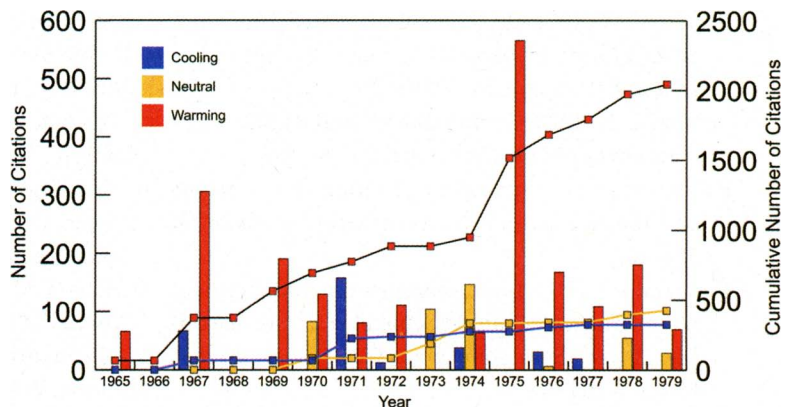


FIG. 2. The number of citations for the articles shown in Fig. 1 and listed in Table 1. The citation counts were from the publication date through 1983 and are graphed on the year the article was published. The cooling papers received a total of 325 citations, neutral 424, and warming 2,043.

damage from greenhouse gases was real and should not be ignored. The potential for cooling, the threat of aerosols, or the possibility of an ice age shows up nowhere in the report. Warming from doubled CO₂ of 1.5°–4.5°C was possible, the panel reported. While there were huge uncertainties, Verner Suomi, chairman of the National Research Council's Climate Research Board, wrote in the report's foreword that he believed there was enough evidence to support action: "A wait-and-see policy may mean waiting until it is too late" (Charney et al. 1979). Clearly, if a national report in the 1970s advocates urgent action to address global warming, then the scientific consensus of the 1970s was not global cooling.

ACKNOWLEDGMENTS. We appreciate Byron Gleason for his detailed review of the article; librarian Mara Sprain for her invaluable assistance; André Berger, Spencer Weart, and Neville Nicholls for providing valuable insights and additional references; Mike Wallace for his cogent review, which precipitated considerable additional and much needed work; and two anonymous reviewers whose comments improved the paper. This project prompted us to reread many articles by the great climatologists of past decades such as Mikhail Budyko, Charles David Keeling, Helmut Landsberg, Syukuro Manabe, B. John Mason, and J. Murray Mitchell, which made us realize the debt of gratitude we owe to these pioneers.

REFERENCES

- Adhémar, J. A., 1842: *Révolutions de la Mer: Déluges Périodiques*. Carilian-Goeury et V. Dalmont, 184 pp.
- Balling, R. C., Jr., 1992: *The Heated Debate: Greenhouse Prediction versus Climate Reality*. Pacific Research Institute for Public Policy, 195 pp.
- Barrett, E. W., 1971: Depletion of short-wave irradiance at the ground by particles suspended in the atmosphere. *Sol. Energy*, **13**, 323–337.
- Benton, G. S., 1970: Carbon dioxide and its role in climate change. *Proc. Natl. Acad. Sci.*, **67**, 898.
- Berger, A., 1979: Spectrum of climatic variations and their causal mechanisms. *Geophys. Surv.*, **3**, 351–402.
- Bertram, D., 2006: More than just one inconvenient truth. *The Australian*, 14 September. [Available online at www.news.com.au/story/0,23599,20407484-5007146,00.html.]
- Bray, A. J., 1991: The Ice Age cometh. *Policy Review*, No. 58, 82–84.
- Broecker, W. S., 1975: Climate change: Are we on the brink of a pronounced global warming? *Science*, **189**, 460–463.
- , D. L. Thurber, J. Goddard, T.-L. Ku, R. K. Matthews, and K. J. Mesoilella, 1968: Milankovitch hypothesis supported by precise dating of coral reefs and deep-sea sediments. *Science*, **159**, 297–300.
- Brown, C. W., and C. D. Keeling, 1965: The concentration of atmospheric carbon dioxide in Antarctica. *J. Geophys. Res.*, **70**, 6077–6085.
- Bryson, R. A., 1974: A perspective on climatic change. *Science*, **184**, 753–760.
- , and W. M. Wendland, 1970: Climatic effects of atmospheric pollution. *Global Effects of Environmental Pollution*, S. F. Singer, Ed., Springer-Verlag/D. Reidel, 130–138.
- , and G. J. Dittberner, 1976: A non-equilibrium model of hemispheric mean surface temperature. *J. Atmos. Sci.*, **33**, 2094–2106.
- , and —, 1977: Reply. *J. Atmos. Sci.*, **34**, 1821–1824.
- , and T. J. Murray, 1977: *Climates of Hunger: Mankind and the World's Changing Weather*. American University Publishers Group, 171 pp.
- Budyko, M. I., 1972: The future climate. *Eos, Trans. Amer. Geophys. Union*, **53**, 868–874.
- , and K. Y. Vinnikov, 1976: Global warming. *Sov. Meteor. Hydrol.*, **7**, 12–20.
- , —, O. A. Drozdov, and N. A. Yefimova, 1978: Impending climatic change (in Russian). *Izv. Acad. Sci., USSR, Ser. Geogr.*, **6**, 5–20; English translation: 1979, *Sov. Geogr.*, **7**, 395–411.
- Calder, N., 1974: *The Weather Machine*. BBC, 143 pp.
- Charlson, R. J., H. Harrison, and G. Witt, 1972: Aerosol concentrations: Effects on planetary temperatures. *Science*, **175**, 95–96.
- Charney, J. G., and Coauthors, 1979: *Carbon Dioxide and Climate: A Scientific Assessment*. National Academy of Science, 22 pp.
- Choudhury, B., and G. Kukla, 1979: Impact of CO₂ on cooling of snow and water surfaces. *Nature*, **280**, 668–671.
- Chýlek, P., and J. A. Coakley Jr., 1974: Aerosols and climate. *Science*, **183**, 75–77.
- Colligan, D., 1973: Brace yourself for another ice age. *Sci. Digest*, **73** (2), 57–61.
- Cooper, C. F., 1978: What might man-induced climate change mean? *Foreign Affairs*, **56**, 500–520.
- Crichton, M., 2004: *State of Fear*. Avon Books, 672 pp.
- Croll, J., 1875: *Climate and Time in Their Geological Relations*. Appleton, 186 pp.
- Damon, P. E., 1965: Pleistocene time scales. *Science*, **148**, 1037–1039.
- , and S. M. Kunen, 1976: Global cooling? *Science*, **193**, 447–453.
- Douglas, J. H., 1975: Climate changes: Chilling possibilities. *Science News*, **107**, 138–140.

- Emiliani, C., 1972: Quaternary paleotemperatures and the duration of the high-temperature intervals. *Science*, **178**, 398–401.
- Ericson, D. B., M. Ewing, and G. Wollin, 1964: The Pleistocene Epoch in deep-sea sediments. *Science*, **146**, 723–732.
- Federal Council for Science and Technology, Interdepartmental Committee for Atmospheric Sciences, 1974: *Report of the Ad Hoc Panel on the Present Interglacial*. 22 pp.
- Flohn, H., 1977: Climate and energy: A scenario to a 21st century problem. *Climatic Change*, **1**, 5–20.
- Giddins, A., 1999: *Runaway World*. BBC Reith Lectures. [Available online at http://news.bbc.co.uk/hi/english/static/events/reith_99/week2/week2.htm.]
- Gilchrist, A., 1978: Numerical simulation of climate and climatic change. *Nature*, **276**, 342–245.
- Gribbin, J., 1975: Cause and effects of global cooling. *Nature*, **254**, 14.
- , 1978a: *The Climatic Threat: What's Wrong with Our Weather?* Fontana, 206 pp.
- , 1978b: Climatic shifts. *Nature*, **271**, 785.
- Gwynne, P., 1975: The cooling world. *Newsweek*, 28 April.
- Halacy, D. S., 1978: *Ice or Fire? Surviving Climatic Change*. Harper and Row, 212 pp.
- Hamilton, W. L., and T. A. Seliga, 1972: Atmospheric turbidity and surface temperature on the polar ice sheets. *Nature*, **235**, 320–322.
- Hansen, J. E., W.-C. Wang, and A. A. Lacis, 1978: Mount Agung eruption provides test of a global climatic perturbation. *Science*, **199**, 1065–1068, doi:10.1126/science.199.4333.1065.
- Hays, J. D., J. Imbrie, and N. J. Shackleton, 1976: Variations in the Earth's orbit: Pacemaker of the ice ages. *Science*, **194**, 1121–1132.
- Herman, B. M., S. A. Twomey, and D. O. Staley, 1978: Atmospheric dust: Climatological consequences. *Science*, **201**, 378.
- Hobbs, P. V., H. Harrison, and E. Robinson, 1974: Atmospheric effects of pollutants. *Science*, **183**, 909–915.
- Horner, C. C., 2007: *The Politically Incorrect Guide to Global Warming and Environmentalism*. Regnery Publishing, 350 pp.
- Houghton, J. T., 1979: Greenhouse effects of some atmospheric constituents. *Philos. Trans. Roy. Soc. London, Math. Phys. Sci.*, **290A**, 515–521.
- Hoyt, D. V., 1979: An empirical determination of the heating of the Earth by the carbon dioxide greenhouse effect. *Nature*, **282**, 388–390.
- Idso, S. B., and A. J. Brazel, 1977: Planetary radiation balance as a function of atmospheric dust: Climatological consequences. *Science*, **198**, 731–733.
- , and —, 1978: Atmospheric dust: Climatological consequences. *Science*, **201**, 378–379.
- Inhofe, J., cited 2003: Science of climate change. *Congressional Record*, No. 149, S10012–S10023. [Available online at wais.access.gpo.gov.]
- Kellogg, W. W., 1979: Prediction of a global cooling. *Nature*, **280**, 615.
- , and S. H. Schneider, 1974: Climate stabilization: For better or for worse? *Science*, **186**, 1163–1172.
- Kerr, R. A., 1978: Climate control: How large a role for orbital variations? *Science*, **201**, 144–146.
- Kukla, G. J., and H. J. Kukla, 1974: Increased surface albedo in the Northern Hemisphere. *Science*, **183**, 709–714.
- Landsberg, H. E., 1970: Man-made climatic changes. *Science*, **170**, 1265–1274.
- , 1976: Whence global climate: Hot or cold? An essay review. *Bull. Amer. Meteor. Soc.*, **57**, 441–443.
- Lee, P. S., and F. M. Snell, 1977: An annual zonally averaged global climate model with diffuse cloudiness feedback. *J. Atmos. Sci.*, **34**, 847–853.
- Lowry, W. P., 1972: Atmospheric pollution and global climatic change. *Ecology*, **53**, 908–914.
- Machta, L., 1972: Mauna Loa and global trends in air quality. *Bull. Amer. Meteor. Soc.*, **53**, 402–420.
- Manabe, S., and R. T. Weatherald, 1967: Thermal equilibrium of the atmosphere with a given distribution of relative humidity. *J. Atmos. Sci.*, **24**, 241–259.
- , and —, 1975: The effects of doubling the CO₂ concentration on the climate of a general circulation model. *J. Atmos. Sci.*, **32**, 3–15.
- Mason, B. J., 1978a: The World Climate Programme. *Nature*, **276**, 339–342.
- , 1978b: Review lecture: Recent advances in the numerical prediction of weather and climate. *Proc. Roy. Soc. London, Math. Phys. Sci.*, **363A**, 297–333.
- Mathews, S. W., 1976: What's happening to our climate? *Natl. Geogr. Mag.*, **150**, 576–615.
- McCormick, R. A., and J. H. Ludwig, 1967: Climate modification by atmospheric aerosols. *Science*, **156**, 1358–1359.
- Mercer, J. H., 1978: West Antarctic ice sheet and CO₂ greenhouse effect: A threat of disaster. *Nature*, **271**, 321–325.
- Michaels, P. J., 2004: *Meltdown: The Predictable Distortion of Global Warming by Scientists, Politicians, and the Media*. Cato Institute, 271 pp.
- Milankovitch, M., 1930: *Mathematische Klimalehre und Astronomische Theorie der Klimaschwankungen*. Vol. 1, Part A, *Handbuch der Klimatologie*, W. Koppen and R. Geiger, Eds., Gebruder Borntraeger, 176 pp.
- Miles, M. K., 1978: Predicting temperature trend in the Northern Hemisphere to the year 2000. *Nature*, **276**, 356.

- Mitchell, J. M., Jr., 1963: On the world-wide pattern of secular temperature change. *Changes of Climate: Proceedings of the Rome Symposium Organized by UNESCO and the World Meteorological Organization*, UNESCO, 161–181.
- , 1970: A preliminary evaluation of atmospheric pollution as a cause of the global temperature fluctuation of the past century. *Global Effects of Environmental Pollution*, S. F. Singer, Ed., Springer-Verlag/D. Reidel, 139–155.
- , 1971: The effects of atmospheric aerosols on climate with special reference to temperature near the Earth's surface. *J. Appl. Meteor.*, **10**, 703–714.
- , 1972: The natural breakdown of the present interglacial and its possible intervention by human activities. *Quart. Res.*, **2**, 436–445.
- , 1976: An overview of climatic variability and its causal mechanisms. *Quat. Res.*, **6**, 481–494.
- National Academy of Sciences, 1975: *Understanding Climatic Change*. U.S. Committee for the Global Atmospheric Research Program, National Academy Press, 239 pp.
- , 1977: *Climate, Climatic Change, and Water Supply*. Panel on Water and Climate of the National Research Council, 132 pp.
- National Defence University, Research Directorate, 1978: *Climate Change to the Year 2000: A Survey of Expert Opinion*. U.S. Government Printing Office, 109 pp.
- National Science Board, 1972: *Patterns and Perspectives in Environmental Science*. National Science Foundation, 426 pp.
- Nordhaus, W. D., 1977: Economic growth and climate: The carbon dioxide problem. *Amer. Econ. Rev.*, **67**, 341–346.
- Ohring, G., and S. Adler, 1978: Some experiments with a zonally averaged climate model. *J. Atmos. Sci.*, **35**, 186–205.
- Pales, J. C., and C. D. Keeling, 1965: The concentration of atmospheric carbon dioxide in Hawaii. *J. Geophys. Res.*, **70**, 6053–6076.
- Panel on Energy and Climate, 1977: *Energy and Climate*. National Research Council, National Academy of Sciences, 158 pp.
- Ponte, L., 1976: *The Cooling*. Prentice-Hall, 306 pp.
- Ramanathan, V., 1975: Greenhouse effect due to chlorofluorocarbons: Climatic implications. *Science*, **190**, 50–52.
- , and J. A. Coakley Jr., 1978: Climate modeling through radiative convective models. *Rev. Geophys. Space Phys.*, **16**, 465–489.
- Rasool, S. I., and S. H. Schneider, 1971: Atmospheric carbon dioxide and aerosols: Effects of large increases on global climate. *Science*, **173**, 138–141.
- , and —, 1972: Aerosol concentrations: Effect on planetary temperatures. *Science*, **175**, 96.
- Reck, R. A., 1975: Aerosols and polar temperature change. *Science*, **188**, 728–730.
- Report of the Study of Critical Environmental Problems, 1970: *Man's Impact on the Global Environment*. Massachusetts Institute of Technology Press, 319 pp.
- Revelle, R., W. Broecker, H. Craig, C. D. Keeling, and J. Smagorinsky, 1965: *Restoring the Quality of Our Environment: Report of the Environmental Pollution Panel*. President's Science Advisory Committee, The White House, 317 pp.
- Revkin, A. C., 2005: The daily planet: Why the media stumble over the environment. *A Field Guide for Science Writers*, D. Blum, M. Knudson, and R. M. Henig, Eds., Oxford University Press, 222–228.
- Rotty, R. M., 1979: Atmospheric CO₂ consequences of heavy dependence on coal. *Environ. Health Perspect.*, **33**, 273–283.
- Sagan, C., O. B. Toon, and J. B. Pollack, 1979: Anthropogenic albedo changes and the Earth's climate. *Science*, **206**, 1363–1368.
- Sarewitz, D., 2004: How science makes environmental controversies worse. *Environ. Sci. Policy*, **7**, 385–403.
- Sawyer, J. S., 1972: Man-made carbon dioxide and the “greenhouse” effect. *Nature*, **239**, 23–26.
- Schlesinger, J., 2003: Climate change: The science isn't settled. *Washington Post*, 7 July, A17.
- Schneider, S. H., 1975: On the carbon dioxide–climate confusion. *J. Atmos. Sci.*, **32**, 2060–2066.
- , 1976: *The Genesis Strategy: Climate and Global Survival*. Plenum Press, 419 pp.
- , and C. Mass, 1975: Volcanic dust, sunspots, and temperature trends. *Science*, **190**, 741–746.
- Sellers, W. D., 1969: A global climatic model based on the energy balance of the earth–atmosphere system. *J. Appl. Meteor.*, **8**, 392–400.
- , 1973: A new global climatic model. *J. Appl. Meteor.*, **12**, 241–254.
- , 1974: A reassessment of the effect of CO₂ variation on a simple global climatic model. *J. Appl. Meteor.*, **13**, 831–833.
- Shaw, G. E., 1976: Properties of the background global aerosol and their effects on climate. *Science*, **192**, 1334–1336.
- Shutts, G. J., and J. S. A. Green, 1978: Mechanisms and models of climatic change. *Nature*, **276**, 339–342.
- Singer, S. F., Ed., 1970: *Global Effects of Environmental Pollution*. Springer-Verlag/D. Reidel, 218 pp.
- , 1998: Scientists add to heat over global warming. *Washington Times*, 5 May.

- , and D. T. Avery, 2007: *Unstoppable Global Warming Every 1,500 Years*. Rowman and Littlefield, 260 pp.
- Somerville, R., H. Le Treut, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson, and M. Prather, 2007: Historical overview of climate change. *Climate Change 2007: The Physical Science Basis*, S. Solomon et al., Eds., Cambridge University Press, 93–127.
- Stuiver, M., 1978: Atmospheric carbon dioxide and carbon reservoir changes. *Science*, **199**, 253–258.
- Sullivan, W., 1975a: Scientists ask why world climate is changing; major cooling may be ahead. *New York Times*, 21 May.
- , 1975b: Warming trend seen in climate; two articles counter view that cold period is due. *New York Times*, 14 August.
- Thompson, L. M., 1975: Weather variability, climate change, and grain production. *Science*, **188**, 535–541.
- Time Magazine*, 1974: Another ice age? 24 June. [Available online at www.time.com/time/magazine/article/0,9171,944914,00.html.]
- Twomey, S., 1977: The influence of pollution on the shortwave albedo of clouds. *J. Atmos. Sci.*, **34**, 1149–1152.
- Tyndall, J., 1861: On the absorption and radiation of heat by gases and vapours, and on the physical connection. *Philos. Mag.*, **22**, 277–302.
- Wang, W. C., Y. L. Yung, A. A. Lacis, T. Mo, and J. E. Hansen, 1976: Greenhouse effects due to man-made perturbations of trace gases. *Science*, **194**, 685–690.
- Weare, B. C., R. L. Temkin, and F. M. Snell, 1974: Aerosols and climate: Some further considerations. *Science*, **186**, 827–828.
- Weart, S., cited 2003: The Discovery of Global Warming. [Available online at www.aip.org/history/climate/.]
- Wigley, T. M. L., 1978: Climatic change. *Nature*, **272**, 788.
- Wilcox, H. A., 1975: *Hothouse Earth*. Praeger Publishers, 181 pp.
- Will, G. F., 2004: Global warming? Hot air. *Washington Post*, 23 December.
- , 2008: March of the polar bears. *Washington Post*, 22 May.
- Willett, H. C., 1974: Do recent climatic fluctuations portend an imminent ice age? *Geofis. Int.*, **14**, 265–302.
- Woronko, S. F., 1977: Comments on “A non-equilibrium model of hemispheric mean surface temperature.” *J. Atmos. Sci.*, **34**, 1820–1821.

Can't come to
Capitol Hill for the
monthly
Environmental
Science
Seminar
Series
hosted by AMS?

Then try the next
best thing...

www.ametsoc.org/seminar

Find summaries,
vodcasts, podcasts,
reports, and
presentations at
your fingertips.

NEW FROM AMS BOOKS!

"Somerville is one of the world's top climate scientists. His book is the ultimate resource for students, educators, and policy makers seeking to understand one of the most critical issues of our times."

— James Gustave Speth, dean of the Yale University School of Forestry and Environmental Studies and author of *The Bridge at the Edge of the World*

The Forging Air: *Understanding Environmental Change, 2nd ed.*

BY RICHARD C. J. SOMERVILLE

This perfectly accessible little book humanizes the great environmental issues of our time...and gets timelier by the minute. Richard Somerville, Distinguished Professor Emeritus at Scripps Institution of Oceanography, UCSD, and IPCC Coordinating Lead Author, presents in clear, jargon-free language the remarkable story of the science of global change.

Updated and revised with the latest climate science and policy developments. Topics include:

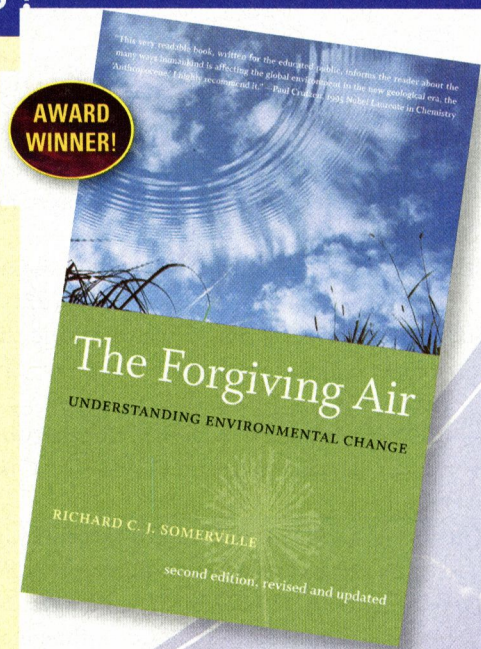
- Ozone hole
- Acid rain
- Air pollution
- Greenhouse effect

LIST \$22 MEMBER \$16 © 2008, PAPERBACK, 224 PAGES, ISBN 978-1-878220-85-1, AMS CODE: TFA

ORDER TODAY!

amsorder@ametsoc.org 617-227-2426 ext. 686

Or see the order form at the back of this magazine.



AMS BOOKS

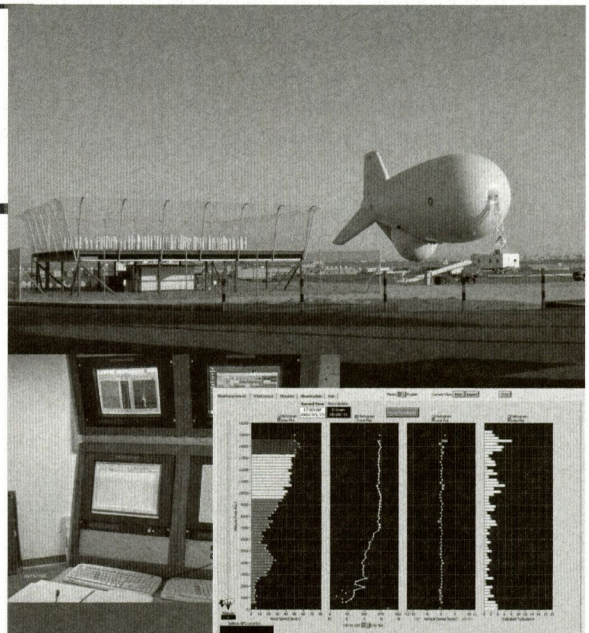
RESEARCH APPLICATIONS HISTORY



The new generation of modern wind profiler systems ...

- ❖ Digital IF processing technology
- ❖ Solid state, steerable antenna system
- ❖ Highest quality data products
- ❖ Robust, user-friendly interfaces
- ❖ Expandable & scalable design
- ❖ Improved reliability & cost performance
- ❖ Systems operating worldwide

DeTect



DeTect, Inc.

Meteorological Systems Group
Longmont Colorado USA

Tel. 303.684.6458

Web www.DeTect-inc.com