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CLIMATE OF EXTREMES

Global Warming Science They Don't Want You to Know

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Contents

EPIGRAPH vii

PREFACE ix

FOREWORD: A Climate of Extremes 1

1. A Global Warming Science Primer 11
2. Our Changing Climate History 39
3. Hurricane Warning! 67
4. Sea-Level Rise and the Great Unfreezing World 99
5. Extreme Climate: Floods, Fires, and Droughts 147
6. Climate of Death and the Death of Our Climate 175
7. Pervasive Bias and Climate Extremism 195
8. Balancing Act: A Modest Proposal 221

REFERENCES AND SELECTED READINGS 229

INDEX 243

Preface

At the end of June 2009, I will be leaving the University of Virginia, as fine a public school as there is in the world. The university cannot guarantee me both academic freedom and a full salary from the Commonwealth of Virginia. My faculty position was ''Research Professor and State Climatologist, Department of Environmental Sciences.'' My salary was paid in its large majority by a separate line in the university's budget, labeled ''State Climatology Office,'' itself a part of the overall budget for the Commonwealth of Virginia.

I was appointed Virginia State Climatologist on July 7, 1980. Like most other State Climatologists, I was faculty at a major public institution, and the appointment was without term, although the faculty position itself was without academic tenure. It was nonetheless subject to the same review process (without teaching duties) for promotion to associate and then to full professor.

I served Republican and Democratic administrations. I met all the Virginia governors. I really liked Republican Governor George Allen. I told Governor Jim Gilmore, also a Republican, how fortunate I was to be able to speak the truth on climate change, even as it was becoming politically unpopular. I was incredibly impressed by the professional staff that served Democrat Mark Warner. His staff members were as good as or better than many federal staffers I have worked with.

Given the political nature of climate change, it was only a matter of time until some governor went after his State Climatologist. I'll be happy to say I brought it on myself. I'm articulate, chatty, and, thanks to the Cato Institute, have great access to TV, radio, and major news outlets. I fully used my privileges as a University of Virginia faculty member, which included the right to consult for whomever I wanted without jeopardizing my position or the academic freedom that went with it.

Which meant, of course, consulting for entities ranging from the Environmental Protection Agency to power producers with a dog in the global warming hunt. One of those was Intermountain Rural Electric Association, a small Colorado utility. When my work for them became public knowledge, Virginia Governor Timothy Kaine told me not to speak as State Climatologist when it came to global warming. If the State Climatologist is a political appointment, that's his call. If it is a lifetime honorific, it's not. But regardless of which of those it is, almost all my university salary was contingent upon my being State Climatologist.

The University of Virginia valiantly, if clumsily, attempted to paper this over. All of a sudden, I was told I should no longer refer to myself as Virginia State Climatologist. Instead, I should cite my seal of certification as Director of the Virginia State Climatology Office, given by the American Association of State Climatologists (AASC). The position of State Climatologist had apparently become a political appointment.

I wasn't asked to do the impossible, merely the impossibly awkward. The University of Virginia Provost wrote to me:

> You should refer to yourself as the "AASC-designated state climatologist" and your office as the "AASC-designated State Climatology Office," or if you prefer, "AASC-designated State Climatology Office at the University of Virginia." I recognize that the titles may be awkward but the message from the Governor's Office was very clear about what they expected.

Needless to say, this quickly became unworkable. Newspaper editors wouldn't suffer such encumbering verbiage, it didn't fit on a TV Chiron, and making a disclaimer every time I spoke about climate that my views didn't reflect those of the Commonwealth of Virginia or the University of Virginia (despite their being correct!) would never fit in a sound bite. So I had the choice of speaking on global warming and having my salary line terminated, or leaving.

Other State Climatologists soon had similar difficulties. George Taylor at Oregon State University, who is very popular with the AASC (and the only person ever elected to consecutive terms as president), was told that he was simply not to speak on global warming. Having read the playbook established by Governor Kaine in Virginia, Governor Ted Kulongoski (D) told Portland's KGW-TV that "Taylor's contradictions interfere with the state's stated goals to reduce greenhouse gases."

Taylor had long questioned glib statements about a 50 percent decline in Pacific Northwest snowpack, which were being made by climate alarmists worldwide. The 50 percent figure is only part of the story. That figure accrues if one starts the data in 1950 and ends in the mid-1990s. If one uses the entire set of snowpack data (1915–2004), a different picture emerges (Figure P. 1, bottom). Taylor was told to shut up as State Climatologist even though he was merely telling the truth.

Taylor resigned his Oregon State University position in February 2008.

David Legates, at the University of Delaware, was told by Governor Ruth Ann Minner (D) that he could no longer speak on global warming as State Climatologist. His faculty position is a regular tenured line in the geography department. He's free, as State Climatologist, to say anything about the weather, so long as there's no political implication. Unfortunately, as most State Climatologists will attest, most reporters specifically ask whether this or that unusual storm or unusually hot (or cold!) day is related to global warming. Scientists who refuse to answer that question don't get return calls.

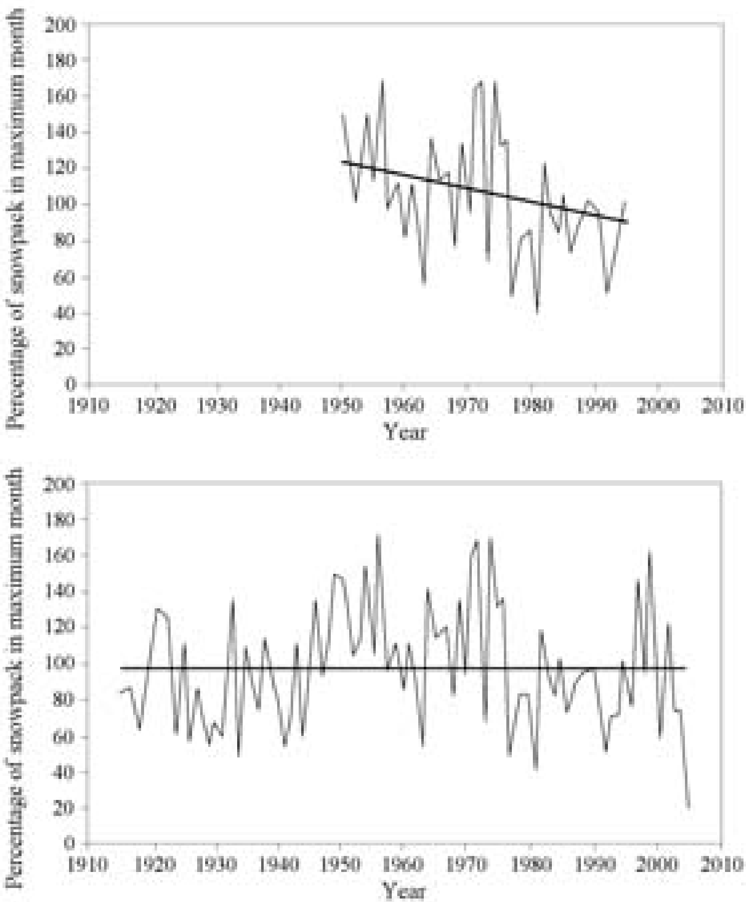
Minner was upset because Legates was an author of an amicus brief to the U.S. Supreme Court (Baliunas et al.) in its first global warming–related case, *Massachusetts v. U.S. Environmental Protection Agency.* Baliunas et al. sided with the federal government (namely the Environmental Protection Agency [EPA]), which maintained that it was not required to issue regulations reducing carbon dioxide emissions. Justice Antonin Scalia cited Baliunas et al. in his dissent, as the court voted 5-4 that it was within the EPA's purview to propose and then enforce carbon dioxide limitations.

So Legates stopped speaking about global warming as Delaware's State Climatologist.

Out West, things got even uglier. The Assistant State Climatologist for Washington, Mark Albright, was fired because, despite his boss's orders, he refused to stop e-mailing—to journalists, to inquiring citizens, to *anyone*—the entire snowfall record for the Cascade Mountains rather than the cherry-picked one. For e-mailing that record, the assistant state climatologist in Washington lost his job.

What had started with Oregon's George Taylor had migrated across the Columbia River.

Figure P. 1
SNOWPACK IN MAXIMUM WINTER MONTH, EXPRESSED AS DEPARTURE FROM THE 1971–2000 AVERAGE: FOR 1950–2004 (TOP) AND FOR 1915–2004 (BOTTOM)



SOURCE: Jones 2007.

NOTE: Using all the data back to 1915 clearly shows that the current era is hardly unusual, despite one very low reading in 2004.

State Climatologist Phil Mote terminated Albright. Both positions were in the University of Washington's atmospheric science department, one of the world's best. A senior member of that department, Professor Clifford Mass, commented, ''In all my years of doing science, I've never seen this sort of gag-order approach to doing science.''

What is so scary that some governors don't want you to know it?

Apparently it is this: The world is not coming to an end because of global warming. Further, we don't really have the means to significantly alter the temperature trajectory of the planet. All of this will be spelled out in considerable detail within the rest of this book.

Governors Kaine, Kulongoski, and Minner, this book's for you!

We would like to acknowledge the considerable effort put into the research for this manuscript by Chip Knappenberger and Robert E. Davis. Peter VanDoren, David Boaz, Sonja Boehmer-Christiansen provided invaluable review comments. Rola Brentlin and Jonathan Eidsness also provided insightful reviews. Amy Lemley cheerfully did some extensive copyediting, making a boring global warming story into something readable and, maybe, enjoyable. Thanks to all of you for all your help.

—Patrick J. Michaels
Washington, DC, September 2008

Foreword: A Climate of Extremes

Something about the global warming debate has changed, and changed for the worse. The debate itself has become a climate of extremes. Truth and fact no longer matter, outrageous exaggerations go unchallenged, unscientific speculation is unquestionably accepted, and nonbelievers lose their jobs.

Consider this interview with former Vice President Al Gore, on *Larry King Live*, May 22, 2007:

> UNIDENTIFIED WOMAN: Vice President Al Gore, what issues caused by climate change globally are likely to affect the United States security in the next 10 years?
>
> GORE: You know, even a one-meter increase, even a three-foot increase in sea level would cause tens of millions of climate refugees.
>
> If Greenland were to break up and slip into the sea or West Antarctica, or half of either and half of both, it would be a 20-feet increase, and that would lead to more than 450 million climate refugees.
>
> The direct impacts on the U.S. have already begun. Today, 49 percent of America is in conditions of drought or near-drought. And we have had droughts in the past, but the odds of serious droughts increase when the average temperatures go up, as they have been going up.
>
> We have fires in California, in Florida, in other states, unprecedented fire season last year, directly correlated with higher temperatures, which dry out the soils, dry out the vegetation.
>
> We have a very serious threat of losing enough soil moisture in a hotter world that agriculture here in the United States would be greatly affected. . . .

The fact is that there is not one shred of evidence in the scientific literature, or in climate history, indicating that sea level could possibly rise more than three feet (''one meter'') by 2017. The best estimate published by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2007, for the next 10 years, ranges between 0.8 and 1.7 *inches*.

The difference between Gore's conjecture about Greenland "in the next 10 years" and reality is stark. New satellites have found that Greenland is losing ice at a rate of 25 cubic miles per year. This information was published in *Science* in November 2006 by NASA scientist Scott Luthcke and many coauthors. The world's largest island has a total of 685,000 cubic miles of ice on it, meaning that the loss rate was measured at 0.4 percent per *century*. Gore had to know that. Any reference to Greenland's breaking up and slipping into the sea in 10 years is wild fantasy.

Despite this tiny increment of ice loss, these data, from a gravity-measuring satellite called GRACE, were greeted with some interest. It had long been thought that Greenland's ice was pretty much in balance, with the amount of ice accumulating in the center of its huge cap roughly equaling the amount being shed into the ocean. GRACE had indeed picked up an acceleration in the oceanic discharge.

But ice, like science, is pretty dynamic. A succeeding paper in *Science*, published by Ian Howat in early 2007, showed that the acceleration of ice loss detected by the satellite had reversed back to the presatellite rate, at least in the two major ice streams that Howat examined. Gore had to know that, too.

The IPCC'S 2007 "Fourth Assessment Report" on climate change includes a computer model projection for the loss of Greenland ice. It takes nearly 1,000 years to lose half its total. But the IPCC model assumes that the concentration of carbon dioxide in the atmosphere quadruples from its preindustrial background and then stays there for the entire time.

Right now, we're at 138 percent of the background, with an atmospheric concentration of 385 parts per million (ppm). Before the Industrial Revolution and for much of the period after the continents lost their massive Ice Age glaciers, the concentration hung around 280 ppm. It's highly debatable whether we could get to four times the background, or 1,120 ppm, even if we deliberately tried to do so. To maintain such a level for the next millennium assumes that we will still be burning fossil fuel—and at more than three times the current rate—in the year 3000. Even the Roman Curia wouldn't, in 1000 AD, have had the audacity to project the future state of the world for the next thousand years. Yet the United Nations (UN) blithely looks 1,000 years forward, making completely unfounded assumptions on energy use and human society. Many ''thousand-year'' political statements have been known to flop within a century, if not a decade.

Gore's statement about drought is wrong. He has to know that we have very good records about the area of the country under drought, back to 1895, reproduced here as Figure F. 1 (top). Figure F. 1 (bottom), on the same time scale, is the Northern Hemisphere's surface temperature history, from the IPCC. It's a waste of computing time to examine the correlation between the two in recent decades, because there isn't any.

Gore surely knew that, as the globe's temperature has risen since 1975, yields of almost all U.S. crops have increased significantly, and that they increased at a similar rate during the slight cooling of the Northern Hemisphere that took place from 1945 through 1975 (when some people worried about global cooling and a coming ice age). The American farmer is an adaptable creature, changing agricultural practices, and even crops themselves, faster than climate can change, and growing mainstay staples, such as corn, under a tremendous variety of climatic conditions. Many of our fresh vegetables come from a natural desert called California.

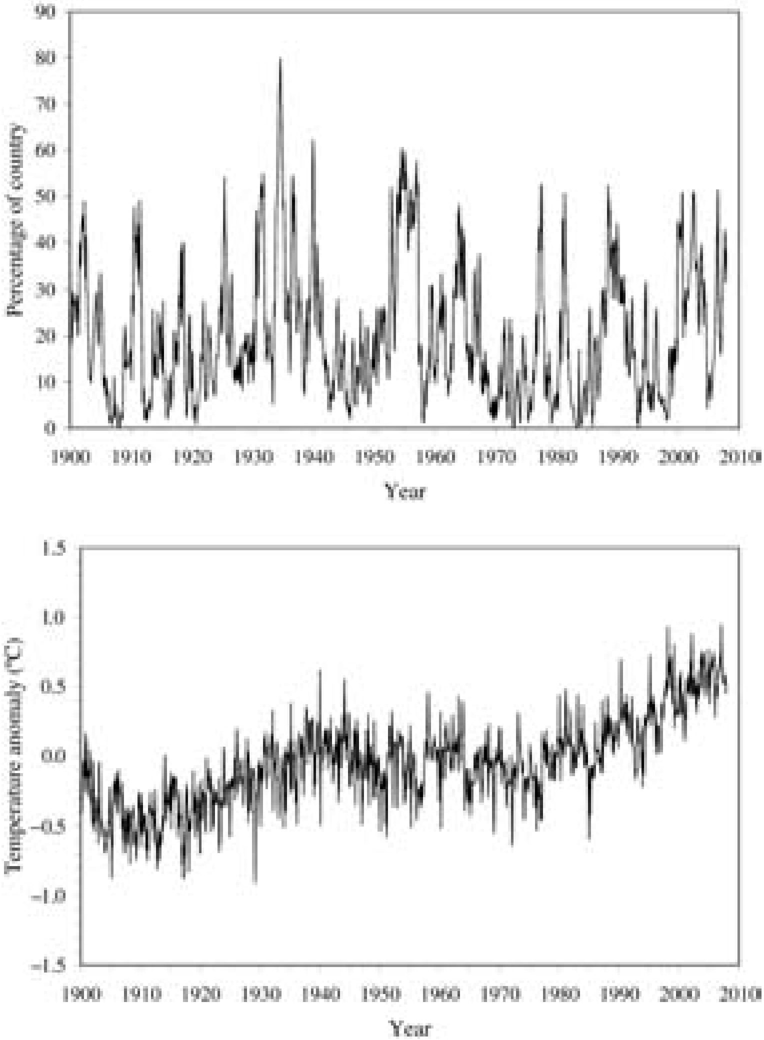
Ten years ago, Gore would have been called out for his remarks on *Larry King Live* as surely as he was for exaggerations about the Internet or embellishments about his college love life. But no more.

For many, the truth no longer matters when it comes to climate change. Science fiction movies such as *The Day After Tomorrow* or Gore's own *An Inconvenient Truth* cause the horde to clamor for action on global warming.

How did we get to such an extreme world?

We have written several books on this subject, contrasting facts, perceptions, and reality about global warming. Most recently, in late 2004, the Cato Institute published Michaels' *Meltdown: The Predictable Distortion of Global Warming by Scientists, Politicians, and the Media*. Since that writing, the political and physical climates have changed, as evinced by the preceding vignette. Michaels initially set out to simply revise *Meltdown*, but soon realized that so much new information has surfaced, and so many scientific changes have occurred, in

Figure F. 1
PERCENTAGE OF THE LOWER 48 STATES EXPERIENCING SEVERE (OR WORSE) DROUGHT (TOP) AND NORTHERN HEMISPHERE TEMPERATURES FROM THE IPCC (BOTTOM), JANUARY, 1900–AUGUST, 2008



SOURCE: National Climatic Data Center 2008 (top), http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp; Intergovernmental Panel on Climate Change 2007 (bottom) and updates.

a mere four years, that an entirely new book was required, one that would quantitatively analyze the scientific literature.

The rhetoric has changed. Discourse has degenerated into demagoguery. *Threatening* demagoguery.

Why has it become so politically risky to *not* view global warming as an unmitigated disaster?

In its larger incarnation, the political process is merely an instrument that adapts to public perception. Elected officials who do not echo popular perceptions risk losing the next election. Those who hold unpopular views on political matters, elected or not, no matter what the issue, will be ostracized because (1) they are an embarrassment to the process, and (2) they could conceivably change perception, forcing political flip-flops.

As a result, almost all that the public hears or reads about global warming is bad news. For the last two years, it seems that the Drudge Report has featured a global warming item almost every day. *Hurricanes are stronger and more frequent. Greenland is shedding ice at an alarming rate. So is Antarctica. Droughts and floods are increasing. If we don't do something drastic about our changing climate, it will soon be too late.* In 2007, actor Leonardo DiCaprio announced that global warming could ultimately cause the extinction of *Homo sapiens*.

Indeed, the political process has already responded. A 2005 energy bill, passed by a Republican congress and signed by a Republican president, mandated the production of massive amounts of ethanol from corn. It is easy to demonstrate, as did Tiffany Groode and John Haywood from MIT, that ethanol is a loser. It's used as a substitute for gasoline. But it turns out that the overall production cycle results in *more* carbon dioxide emissions than if one simply burned gasoline. Yet the ethanol mandate was sold as, among other things, a cure for global warming. That political process now has a clear mindset, and, needless to say, a lot of people are upset if they hear that ethanol won't solve anything and will actually contribute to global warming.

Then there is the charge that skeptical global warming scientists are ''deniers'' (named for Holocaust deniers), a peculiarly vicious label originally given to those who claim there's simply no such thing as human-induced global warming. We don't believe these people are correct, but we also haven't found one Nazi among them. They have their scientific reasons, although their argument is quite a stretch, given the nature of climate change in the last several decades.

How Perception of Extremes Evolves

How did the perceived climate of extremes develop? Is it because of a need, on the part of some scientists, to hype the lurid aspects of climate change at the expense of the more mundane? Do the publicity arms of universities or federal agencies, usually not stocked with scientists, get carried away with their rhetoric and emphasize extreme results?

Climate models, or compendia of models, usually give a range of expected temperature changes for doubling atmospheric carbon dioxide. But far too often, only the most extreme result enters the public discourse. Here's an example, courtesy of BBC Radio's Simon Cox and Richard Vadon.

It was January 2005, and Oxford University's David Stainforth and a large number of colleagues had just published a paper in *Nature*, which described a huge number of computerized simulations of global warming. Stainforth and colleagues created a virtual community of thousands of computer model users called climate*prediction*.net. They put out a a press release that only mentioned the most extreme value. Most of them predicted about 3°C (5.4°F) of global warming for doubling atmospheric carbon dioxide, but there were a very few outliers extending up to 11°C (19.8°F).

Climate*prediction*.net produced a press release about its work on January 26, 2005. There is only one sentence referring to future temperature: ''The first results from climate*prediction*.net, a global experiment using computing time donated by the general public, show that average temperatures could eventually rise by up to 11°C.''

''Up to 11°C.'' When the press dutifully reported this figure (and no other one, which was understandable, given that there was no other number in the press release), Myles Allen, an author of the paper and principal investigator for climate*prediction*.net, then blamed the press! ''If journalists decide to embroider on a press release without referring to the paper which

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the press release is about, then that's really the journalists' problem. We can't as scientists guard against that.'' In fact, journalists did *not* embroider climate*prediction*.net's press release. They merely quoted it.

Cox and Vadon then presented several unnamed climate scientists along with the press release and the original paper. According to the BBC, ''All were critical of the prominence given to the prediction that the world could heat up by 11°C.''

One (unnamed) scientist told the BBC: ''I agree the 11°C figure was unreasonably hyped. It's a difficult line for all scientists to tread, as we need something 'exciting' to have any chance of publishing . . . to justify our funding.''

That doesn't happen every time, and plenty of scientists will be entirely straight when communicating to the public about the range of their climate results and their confidence in them. But in this case, climate*prediction*.net's press release did the world a disservice by using only one high figure. Ask yourself this: Which press release will get more attention, one saying that ''most computer simulations of global warming predict a total warming of about 3°C (5.4°F),'' or one that says, ''The earth could warm by as much as 11°C (19.8°F)''?

Readers or viewers of news stories on climate change should beware every time they hear the phrase ''as much as.'' There's obviously a range underneath the word ''as,'' and, for some reason, the scientist, publicist, or reporter does not want you to know what it is.

Recently the definition has been expanded. The charge of ''denier'' is also thrown at those who argue that human-induced climate change is indeed real, but that this will not necessarily lead to an environmental apocalypse. And that's our stand. The data lead us to conclude that anthropogenic global warming (AGW) is indeed real, but relatively modest. We're not arguing against AGW, but rather against DAGW (*dangerous* anthropogenic global warming).

As Steven Hayward and Ken Green of the American Enterprise Institute have written, ''Anyone who does not sign up 100 percent behind the catastrophic scenario is deemed a 'climate change denier.''' *Boston Globe* columnist Ellen Goodman wrote, in November 2006, ''Let's just say that global warming deniers are now on a par with Holocaust deniers.''

The existence of a mere hurricane now cries for a lynching. In December 2006, London *Guardian* columnist George Monbiot offered the view that ''every time someone dies as a result of floods in Bangladesh, an airline executive should be dragged out of his office and drowned.''

Even those who claim that there is little, if any, human influence on climate do not in fact deny the existence of climate change itself. The evidence for warmer recent times is incontrovertible. In the mid-19th century, glaciers threatened villagers in the Alps. Not 125 years later, the ice had retreated so far up the mountain that Julie Andrews, in *The Sound of Music*, crossed the Alps in dress shoes.

Perhaps all debate on climate change is irrelevant. After all, the standard argument from the political class in Washington is that ''The science is settled,'' and that it's time to move on to policy. President Bush sees ethanol as a panacea for global warming, dependence on foreign oil, and international tension. So does Barack Obama. John McCain was the original author of S. 2191 (The name of John Warner [R-VA] was substituted when McCain became a viable Presidential candidate), a bill that mandated a reduction in carbon dioxide emissions to 70 percent below current levels by 2050. Sen. Barbara Boxer (D-CA), chair of the powerful Senate Environment and Public Works Committee, believes we can reduce emissions of carbon dioxide by 90 percent by 2050—only 42 years from now—if we simply pass a law saying we will do so. *How* we can accomplish this goal does not appear in any legislation or documentation, because no one in fact knows how to achieve such reductions.

How did we get to a world of apocalyptics and deniers, a world that is also one of impossible or ineffective policies on climate change? In other words, how did we get to such a climate of extremes?

The answer, it turns out, is purely logical. We bought it with our tax dollars, and we will pay the consequences for decades. There was no conspiracy (or at least no effective one). Rather, our extreme world of today is the result of ''science as usual,'' hyped up on the steroids of massive public funding.

This book's first chapter describes the science of global warming, something that many readers already know by heart. If you do (and you'd rather not reminisce), skip to chapter 2, which describes our temperature histories and how they have changed over time. We detail six revisions to global records, each of which produces more global warming from the same original data. Having the revisions all in one direction, from three independent methods of temperature monitoring, is like tossing six heads or tails in a row. The odds are a little less than 1 in 50. So the continual upward-revising of warming trends in the same data possibly reflects something real that in reality is improbable.

Hurricanes are the subject of chapter 3, where we track the contentious controversy about whether or not they are made worse or more frequent because of global warming. Thanks to massive Hurricane Katrina's pillage of the Mississippi and Alabama gulf coasts (and her destruction of a criminally weak levy system in New Orleans), everyone seems to *know* that global warming was the cause, rather than merely being a passive bystander to the ruin of a city built several feet below sea level, literally sitting in wait of its destruction.

Chapter 4 deals with sea-level rise and melting ice, with particular emphasis on the disaster du jour, which is that Greenland is going to suddenly lose almost all its ice, perhaps before 2100, resulting in more than 20 feet of sea-level rise. It turns out there is hardly any data in support of this hypothesis, and an army of facts arrayed against it. But it is the specter of a Greenland disaster that is behind most of the current calls for dramatic cuts in carbon dioxide emissions. Antarctica also displays some screwy behavior that seems inconsistent and certainly confounds the myriad climate models that predict it should be warming smartly and experiencing increasingly heavy blizzards.

Forest fires, floods, and the various and sundry disasters associated with storms other than hurricanes are the subject of chapter 5. Here we detail some real whoppers laid on the public by elected officials you would think might know better. In the world of global warming, fact-checking has become fantasy, and perceptions have become the opposite of reality.

Chapter 6's title, "Climate of Death and the Death of Our Climate," refers to the phenomenon of warming-related deaths, such as the massive human die-off in France in the summer of 2003. It turns out that the weather anomaly that caused it was a tiny bubble of hot air embedded in a relatively cool summer around the planet. We describe the phenomenon of adaptation—something obvious to every economist but virtually ignored by every climatologist—in which succeeding heat waves kill fewer and fewer people, providing evidence that the response to changing climate is both political and technological.

In chapter 7, we describe ''publication bias,'' which is an attempt to answer the question, ''Why is all the news we read about global warming bad?'' There is a voluminous literature on natural biases in the scientific literature, and there are multiple causes. Curiously, climatologists claim to be immune from bias in their literature. But in making that claim, they are saying that they don't do something that virtually everyone else does, which is to publish more ''positive'' results (in this case, those fingering global warming for something) than ''negative'' ones (in which no relationship with global warming is discovered). There are several incentives for doing so, including the simple desire for (and professional requirement of) publication.

Chapter 8 proposes a modest solution to provide some balance between the mountain of bad news about climate change and the molehill of good news. We'll bet, for example, that if peer reviewers could no longer hide behind a cloak of anonymity, then a lot of biased shenanigans would stop. Finally, like any authors, we sum up our book with some stirring prose and bid you a good night's sleep.

1. A Global Warming Science Primer

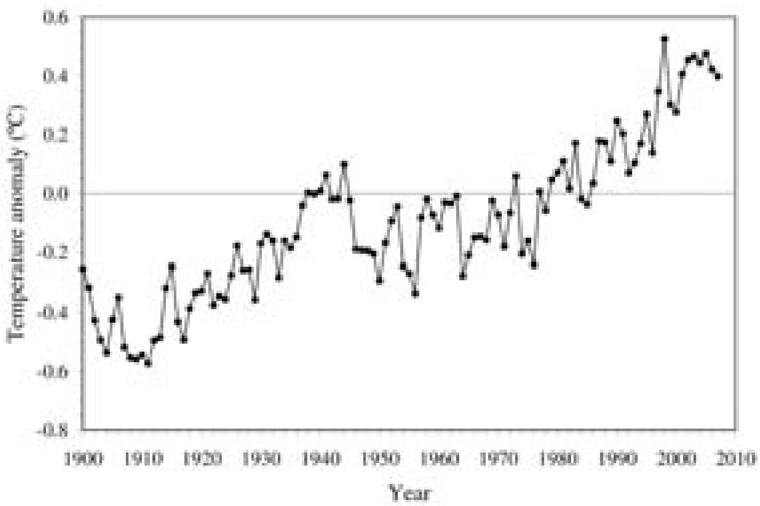
Earth's mean surface temperature is doubtlessly warmer than it was 100 years ago. Get over it.

What matters is (1) how much it has warmed, (2) how much of that warming is caused by human activity, and (3) how the relationship between that activity and present temperatures can be translated into a reliable estimate of future warming and its effects.

The temperature changes. But so does the way in which temperature data are processed. We will demonstrate that fact in chapter 2. For now, however, we'll rely on existing histories.

Let's start out with a standard reference temperature history, the ground-based record from the United Nations' Intergovernmental Panel on Climate Change (IPCC) (Figure 1.1).

Figure 1.1
GLOBAL TEMPERATURE DEPARTURE FROM THE 1961–90 AVERAGE, 1900–2007



SOURCE: IPCC 2007.

The IPCC history shows two distinct periods of warming, one roughly from 1910 through 1945, and then another that begins rather abruptly in about 1975. Their warming rates are statistically indistinguishable. In the last three decades ending in 2005, the warming rate was 0.178°C ± 0.021°C per decade (0.320°F ± 0.038°F). In the period 1916–45, the rate was 0.151°C ± 0.014°C per decade (0.272°F ± 0.025°F). Each of these is the observed trend plus or minus the statistical margin of error associated with it.

If those figures were the results of a political poll, the pundits would call it a tie—within the poll's range of error. Similarly, with temperature trends, adding in the ''plus'' to the first warming and subtracting the ''minus'' in the second reveals that the rate of warming in recent decades cannot be discriminated from the warming that occurred during a period of similar length in the early 20th century.

Their causes are very likely quite different, however. That said, one thing is for sure: the first warming was associated with a far smaller change in atmospheric carbon dioxide levels than the recent one. After all, we had not added very much carbon dioxide to the atmosphere before World War II.

Modeled vs. Observed Warming

Are recently observed climate changes consistent with computer models of climate change? That depends on where you look. If you examine surface temperatures observed at weather stations or as estimated from satellites, you'll conclude that the models can provide some quantitative guidance for the future. That doesn't mean that the models have all the answers, but it does suggest that they are largely sufficient.

There's another view—namely, that the models may have accurately captured much of the surface temperature change, but that they have missed the vertical dimension. If that's the case, then the match with surface temperatures is fortuitous—or worse.

Let's start with the first notion: that the models have something useful to tell us about future warming.

It's quite easy to demonstrate that the natures of the two periods of warming are quite different—and that the first one was probably caused by changes in the sun, whereas the second one has more of a relationship to human-caused emission of carbon dioxide and other greenhouse gases. We say ''more of'' because there are still other factors involved, such as a smaller solar effect and changes in land use, such as turning a ''naturally'' vegetated surface into a farmed one.

Greenhouse-effect warming occurs because certain constituents of our atmosphere, mainly carbon dioxide and water, are molecules whose shape allows them to absorb, and then release, radiation emanating from the earth's surface.

Bodies give off radiation that is proportional to their temperature. The hotter a body is, the more energetic the energy emitted. The sun, at 6,000°C (10,800°F), emits largely in the visible wavelengths of the universal electromagnetic spectrum (which is why our eyes evolved to ''see'' sunlight), as well as in the ultraviolet range (the energetic wavelengths that cause sunburn). The much cooler earth (with an average surface temperature of 15°C [27°F]) radiates largely in the less energetic infrared wavelengths (no one gets ''earthburn''). Carbon dioxide and water vapor resonate with this low-frequency radiation and absorb some of it. The molecule reaches an unstable, physically ''excited'' state and then releases the packet of energy either up and out to space, or back down toward the surface. Consequently, greenhouse gases ''recycle'' the warming radiation of the earth in the lower atmosphere, resulting in a warmer surface and lower atmosphere than there would be in their absence. Another consequence is that the layer above most of the carbon dioxide—the stratosphere—cools because more radiation has been ''trapped'' below.

The mathematical relationship between the concentration of a greenhouse gas and surface temperature rise has been known for more than a century. The function is logarithmic, which means that the first increments of a greenhouse gas produce the greatest warming, and then increasingly large allotments are required to maintain that rate of warming. You can plot this function on your old graphing calculator or look it up on myriad websites.

Water vapor and carbon dioxide are known to behave quite similarly with regard to potential warming, so they can be (partly) considered to behave as the same greenhouse gas. As a result, atmospheres that are poor in both carbon dioxide and water vapor will respond strongly to the first new increments of either, because of the logarithmic nature of the temperature change. Again, increasingly large amounts of greenhouse gas would be necessary to maintain the same rate of warming.

Plenty of places on earth met this qualification before we put a lot of carbon dioxide in the air. Siberia and northwestern North America in winter are virtually devoid of water vapor: indeed, cold air can hold hardly any before it dumps it onto the ground in the form of frost or snow. It turns out that these are the places that have seen the biggest warming in recent decades. (Note: Antarctica, however, is not warming—a special case described in chapter 4). Further the warming rate in (dry) winter is much greater than it is in (moist) summer, consistent with greenhouse-effect theory.

Carbon dioxide concentrations in our atmosphere were approximately 280 parts per million (ppm) from the end of the last Ice Age to the beginning of the Industrial Revolution. Since then, they have risen to around 385 ppm, or a net increase of about 38 percent. In the 20th century, roughly three-fourths of the increase in atmospheric concentration took place after World War II.

There are several other emissions that alter the transmission of radiation through the atmosphere. On a molecule-for-molecule basis, methane, which is in much lower concentration, is 23 times more efficient at warming the lower atmosphere than is carbon dioxide. Its concentration has increased from about 875 parts per billion (ppb) around 1900, rising linearly to around 1,750 ppb by the 1980s. The increase was thought to have resulted from cow flatulence, coal mining, and leaky gas pipes (mainly in the former Soviet Union). Even so, none of these could possibly explain what happened after the late 1980s (see ''Methane and the Perils of Scientific 'Consensus''').

Other industrial emissions are thought to counter the warming effect of greenhouse gases. A major cooler is something called sulfate aerosol—a particulate effluent emitted largely from coal-burning power plants. The relative cooling effect of sulfate is only ''known'' to a very broad range, from no cooling to nearly 2°C (3.6°F), which is very convenient, because it allows modelers to ''choose'' a value that, when added to the warming effects from carbon dioxide, methane, and a few other minor actors, forces a climate model's historical output to match the observed record shown in Figure 1.1.

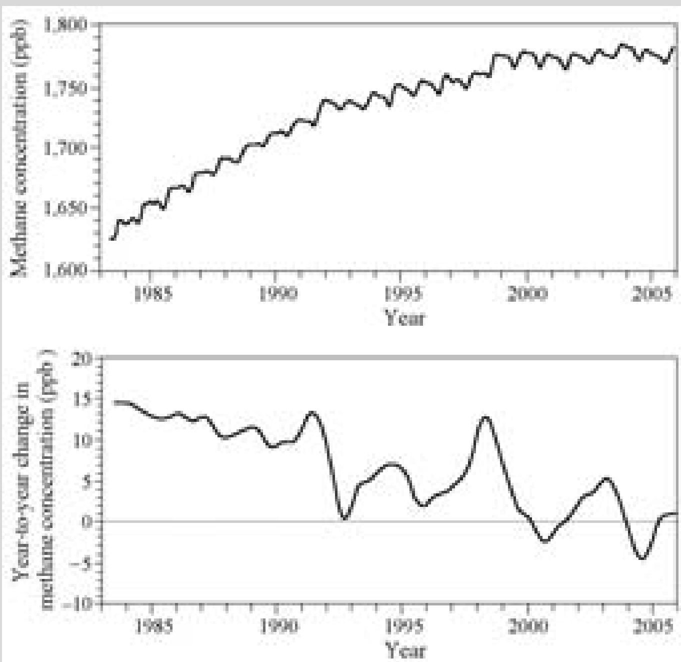
At any rate, carbon dioxide still remains the biggest contributor to warming. A common counterargument is that most of the recent warming is a result of changes in the sun. But ''solar'' warmings should be a lot different from ''greenhouse'' ones. Rather than being

Methane and the Perils of Scientific "Consensus"

The increase in methane was remarkably constant from the early 20th century through the late 1980s. Every global climate projection assumed a similar increase would continue at least for another half-century.

No one disagreed. But, as if nature wanted to humble climate scientists, the rate of increase began to decline about 20 years ago, and the concentration of methane in the atmosphere has actually *dropped* in recent years (Figure 1.2). Nonetheless, IPCC's projections continue to show an increase (Figure 1.3).

Figure 1.2
ATMOSPHERIC METHANE CONCENTRATION, 1983–2006 (TOP), AND CHANGE IN METHANE FROM YEAR TO YEAR (BOTTOM)



SOURCE: Adapted from IPCC 2007.

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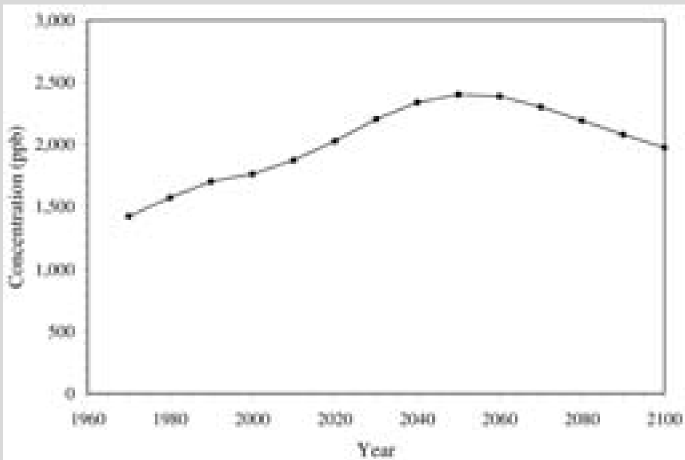
Figure 1.3
THE IPCC'S MIDRANGE METHANE SCENARIO THROUGH 2100



SOURCE: IPCC 2007.

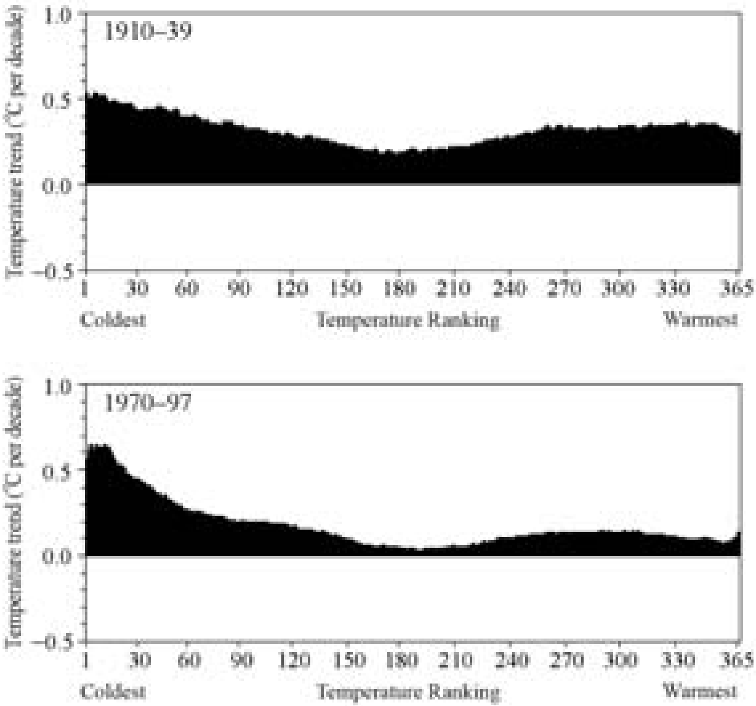
concentrated only in lower atmosphere, solar warming should be distributed in a way that is more uniform, heating both the lower atmosphere and the stratosphere, in which cooling has been observed in recent decades (see below for other complications!). Nor would a solar warming preferentially warm the winters so much as a greenhouse warming would.

An innovative analysis of U.S. temperatures illustrates the difference between the solar and carbon dioxide–induced warming.

As in the global temperature record (Figure 1.1), there are three distinct modes of behavior in the U.S. temperature history: a period of early-century warming, a midcentury cooling, and a final warming beginning in the 1970s.

The 365 black bars in each plot in Figure 1.4 are the rates of temperature change on the coldest night of the year (day 1) to the warmest (day 365). Note that these plots are *not* showing January 1

Figure 1.4
TREND IN NIGHTTIME LOW TEMPERATURES, 1910–39 (TOP) AND 1970–97 (BOTTOM)



SOURCE: Knappenberger, Michaels, and Davis 2001.
NOTE: Day 1 is the coldest night, day 2 is the second-coldest, etc.

on the left through December 31 on the right; rather, they are arranging the data from the coldest day in each year to the warmest one. So the left side of each graph shows the trend in the coldest nights of the year, and the right side shows the trend in the hottest nights.

The top of Figure 1.4 is during the warming of the early 20th century (1910–39) and shows very little change in the trend of temperatures from the coldest (left) to the warmest nights (right). The bottom shows for the second warming, 1970 through 1997 (the last

Temperature Variability and Global Warming: Another Look

If the coldest nights are warming preferentially, then day-to-day variation in temperature must be dropping. Martin Beniston and Stéphane Goyette, of Switzerland's University of Geneva, recently published an investigation of the phenomenon of *decreasing* variability with greenhouse warming. They begin their article by noting, ''It has been assumed in numerous investigations related to climatic change that a warmer climate may also be a more variable climate; such statements are often supported by climate model results.''

They looked at low- and high-elevation temperature records for Switzerland and found the same thing we did for the United States—that the variability of temperature is decreasing, and that the decrease is concurrent with the increase in anthropogenic greenhouse gases.

They concluded:

> This investigation, carried out for a low (Basel) and a high (Saentis) elevation site in Switzerland, has shown that contrary to what is commonly hypothesized, climate variability does not necessarily increase as climate warms. Indeed, it has been shown that the variance of temperature has actually decreased in Switzerland since the 1960s and 1970s at a time when mean temperatures have risen considerably. Nevertheless, these findings are consistent with the temperature analysis carried out by Michaels et al. (1998), whose results also do not support the hypothesis that temperatures have become more variable as global temperatures have increased during the 20th century.

year in this particular study). Note how the coldest nights are warming up, much more than any others. This is the way greenhouse warming is supposed to work—and indeed is what has happened.

In the recent era, cold nights are warming much more so than hot ones. In other words, temperatures are becoming *less* variable. (A global examination of this phenomenon was published in our 2000 book, *The Satanic Gases.*)

We are not saying that the sun has had no influence on recent temperatures, but rather that the solar influence was clearly much greater during the warming of the early 20th century.

Nicola Scafetta and Bruce West, from Duke University, published an interesting paper along these lines in *Geophysical Research Letters* in 2006. Like many skeptical scientists, they prefer observed relationships to theoretical models. Scafetta and West examined the relationship between cycles in solar variations and cycles in temperatures using data back to the 17th century. Bottom line: ''We estimate that the sun contributed as much as 45 percent to 50 percent of the 1900–2000 global warming and 25 percent to 30 percent of the 1980–2000 global warming.''

Do the math. If 25 percent of recent warming is caused by the sun, and 50 percent of total warming since 1900 has the same cause, then 75 percent of the warming of the early 20th century should have had a solar origin. In 2007, using a different solar history and long-term temperature history, Scafetta and West duplicated their 2006 findings.

In sum, you can't throw the sun out completely when dealing with the recent warming, but it is not a majority contributor. That said, the bigger the solar impact, the smaller the human effect. The more ''something else'' is causing warming, the less sensitive the climate is to greenhouse emissions.

At any rate, the assumption that the majority of recent warming is from greenhouse changes remains the grounding rock of the notion that the models are providing some useful guidance with regard to 21st-century temperatures.

Because greenhouse gases tend to trap radiation close to the surface, there's less of a flux through the stratosphere, the layer of the atmosphere that begins about seven miles in altitude in our latitude. The stratosphere should cool slightly at the same time the surface warms. But if the sun gets warmer, so should the stratosphere. In fact, however, there is no record of stratospheric temperature that shows significant recent warming.

Both satellite and weather balloon data show stratospheric cooling, but carbon dioxide is only one cause. Changes in stratospheric composition owing to a slight loss of ozone have also contributed to cooling.

The ozone loss is hypothesized to have been caused by the breakdown of chlorofluorocarbon (CFC) refrigerants. The ban on these, a UN treaty known as the Montreal Protocol, is often cited as an example of successful global environmental regulation. If we managed to regulate CFCs, the reasoning goes, we can do the same for carbon dioxide. In reality the two are hardly analogous. CFCs are one of any number of chemicals that can be used for cooling, so substitutes exist; carbon dioxide, however, is the respiration of our fossil fuel–powered civilization. There is no politically and economically acceptable substitute currently available.

Nature of Observed and Future Warming

It is quite obvious from Figure 1.1 (and Figure 1.8, later in this chapter) that the rate of planetary warming since the mid-1970s has been quite constant (despite a lack of warming since 1998—the warmest year in the record). Computer models also tend to predict a constant rate of warming.

Figure 1.5 (see insert) is taken from the most recent IPCC report, published in 2007. It is the various warming projections from different computer models for the ''midrange'' scenario for future carbon dioxide emissions.

The IPCC's midrange scenario assumes that a ''balance'' of fossil and nonfossil sources of power evolves over the century, unlike its other scenarios, which are almost exclusively fossil-powered, or else presume the use of very little carbon-based energy by the end of the century.

Note that the projected rate of temperature change tends to remain the same once it is established (Figure 1.5; see insert); what the various computer models do is simply project *different* rates of constant change.

Figure 1.5 (see insert) also includes observed temperature changes from the IPCC's most recent iteration of the global history. (Note the discussion in chapter 2 about how this record itself has been altered and probably slightly overestimates recent warming). These figures are from the beginning of the recent warming, from 1977 through 2007. Note that they are also a straight line, but a line that tracks beneath the average of the climate models.

This would be the forecast of people who accept the fact that models tend to predict constant rates of warming (just different rates for different models), and combine that with the observed constant rate of surface warming, which yields a temperature change for the

The Wisdom of a Crowd (of Models)?

James Surowiecki's 2005 classic, *The Wisdom of Crowds,* demonstrates repeatedly that ensembles of independent estimates tend, over time, to perform better than a randomly selected individual one when asked to estimate some unknown quantity.

The common example pertains to the number of jelly beans in a jar. Whereas each of 100 people will almost certainly guess a different number, the real number will come close to the average of the 100 guesses.

People who teach weather forecasting are intimately familiar with this concept. Each student's forecasts are quantitatively evaluated, as are the average of all the students' forecasts. One student or another (or the group) may make the best forecast for an individual day. But when averaged over the long haul, the ''group average'' forecast is the likely winner.

This also applies to weather forecasting models. But it may apply to climate models only in a very special fashion.

In the daily weather forecast, it is well known that an ''ensemble'' of different computer models or different runs of the same model tends to perform better, over the long haul, than any individual model or run. That's because the models are indeed like individuals in a crowd in that they are ''unbiased.''

''Unbiased'' means that the models (or the people) have no inherent problem that will make them systematically over- or underestimate temperature (or the number of jelly beans). But climate model ensembles can clearly have bias. For example, when climate models have been ''intercompared'' (as in the ''Coupled Model Intercomparison Project'' studies published initially by the U.S. National Center for Atmospheric Research's Gerald Meehl in 2000), they were all fed more carbon dioxide than was known to be accumulating in the atmosphere. Consequently, when compared with observed temperatures, they tended to predict more warming than was actually observed, a fact emphasized repeatedly in *Meltdown.*

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>
> But both in those studies and in the model collection shown in Figure 1.5 (see insert), which uses a different carbon emission scenario (though the same one is applied to all models), the ensemble behavior resembles nature in that the warming is at a constant (rather than an increasing) rate.
>
> This increases confidence in a forecast of warming that is indeed at the constant rate that has been observed for decades (subject to the post-1998 behavior described later).

21st century of about 1.7°C (3.1°F). This is about 40 percent less warming than the average projection given in Figure 1.5 (see insert).

There's a certain logic on behalf of the use of the models for some guidance for 21st-century temperatures, which can be summarized as follows: Both models and observations show a linear (constant) warming, but the observed warming is below the average model rate. Perhaps the ''sensitivity'' of temperature to changes in atmospheric carbon dioxide has simply been overestimated.

Has Global Warming Stopped?

Googling ''global warming'' will get you about 23 million hits. Most are of the gloom-and-doom variety. But not all of them. One thread that has emerged over the last year on many climate and policy blogs is that global warming ''stopped'' in 1998.

That's true (Figure 1.6) but caution is advised: 1998 saw one of the largest El Niños in recent history, and the associated suppression of the cold upwelling off of South America induced a huge temperature spike—one that was never exceeded in the subsequent decade. A plot of the year-to-year temperature change since then (Figure 1.6) clearly shows no obvious upward or downward trend.

That leads us to a fairly fearless forecast: The next big El Niño is likely to produce a temperature above that of 1998, resetting the global record. But in general, the same pokey warming trend that was established more than three decades ago will still be the rule.

In 2000, one of us (Michaels) published a paper in *Geophysical Research Letters*, showing that almost all the fluctuations around the warming trend that began in 1977 could be explained by the

"El Niño" in the Temperature History

Every global warming book will refer repeatedly to "El Niño," which has been blamed for floods, droughts, fires, diseases, and just about everything else—so many things, in fact, that Laurence Kalkstein, a well-known climatologist recently retired from the University of Delaware, used to deride it as the "Vitamin E" of climate.

El Niño is a slowing or even a reversal of the trade winds across the Pacific Ocean. No one knows exactly why it happens (the proof being that forecasts of impending El Niños are pretty lousy). Given that the trades are the largest single climate phenomenon on earth, slowing them has an awful lot of downstream effects, including spiking global temperature. It earned its name because there is a normal seasonal weakening of the trades that takes place in December—around Christmas—meriting the obvious title, The (male) Child. When an El Niño occurs, this normal weakening is extended throughout the year.

The trade winds are associated with a strong east-to-west current from South America, across much of the tropical Pacific. This current drags up cold water from beneath the surface, which is one reason why much of the Pacific shore of tropical South America isn't nearly as hot as one might think it should be.

When El Niño occurs, this cold "upwelling" is suppressed, and instead, the waters off of South America, and westward across much of the Pacific, become unusually hot. Needless to say, global average temperature rises. One of the biggest El Niños in the last 100 years occurred in 1998, and the temperature peak is quite evident in Figure 1.1. The year 1998 remains the warmest year in the global record, so warm that the succeeding decade shows no net warming trend whatsoever.

Of course, when El Niño stops and the cold upwelling returns, there's a lot of cold water waiting under the surface, and global temperatures drop. This phenomenon, not surprisingly, is called La Niña, and can be seen in the 1999 and 2000 temperatures.

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El Niño *is* actually correlated with a lot of weather anomalies pretty far from the tropical Pacific. For example, it usually (but not always) results in a much wetter-than-normal winter in Southern California.

Nature is pretty attuned to this natural fluctuation. For example, seeds of many plants in the Southwestern desert require the physical disturbance caused by a flood in order to germinate, so it's fair to say that El Niño makes the desert bloom. But (as described in chapter 5) the desert is, well, usually pretty dry, so that when El Niño goes away there's an unusually large amount of vegetation left to dehydrate and ultimately combust. So, though the chain of causation isn't rock solid (in some El Niño years, rainfall isn't enhanced), it seems plausible to blame an unusually vigorous fire-year in the Los Angeles basin on recent El Niño activity. Given that El Niños have been around forever (meaning many, many millions of years), Nature has been able to take advantage of their disturbance of normal weather regimes.

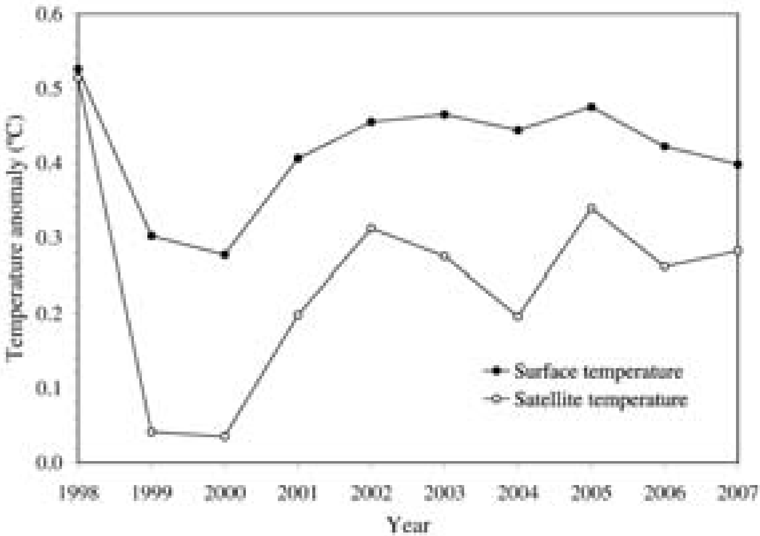
An El Niño year tends to be one in which global temperatures are elevated above a rather smooth trend. Will the next big El Niño year reset the global temperature record? And how important *is* a ''warming trend'' that takes over a decade to reset successive high temperature records?

magnitude of El Niño, changes in the sun's output as evinced by sunspots, and the amount of dust in the stratosphere contributed by big volcanoes.

Note the phrase ''fluctuations around the warming trend.'' We're saying, whatever the cause (though it is probably carbon dioxide), there is a warming trend in the data, and the temperature changes around that trend are best explained by the other three variables.

So, to test if the warming trend has indeed ''stopped,'' we ran our old model, which ended in 1997, and asked it to predict monthly temperature variations from either a continuation of the warming trend already established or a cessation of that trend at the end of 1997.

Figure 1.6
GLOBAL SURFACE AND SATELLITE TEMPERATURES, 1998–2007

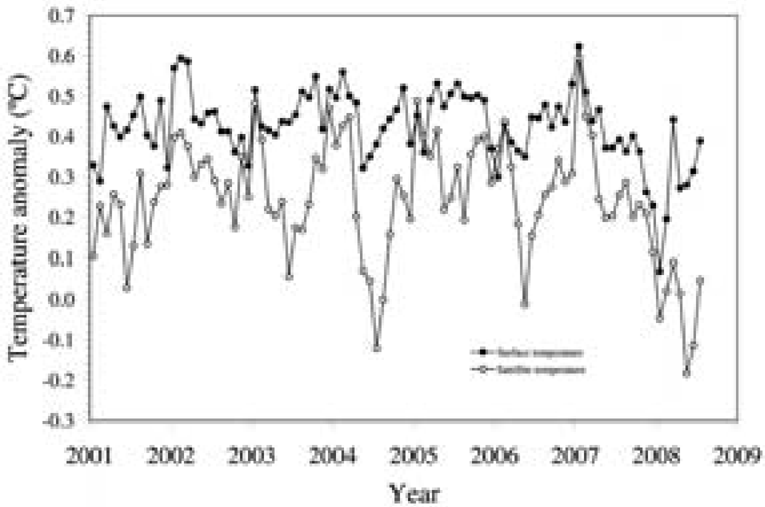


SOURCE: IPCC 2007 (surface temperature); University of Alabama-Huntsville 2007 (satellite temperatures), http://vortex.nsstc.uah.edu/data/msu/t21t/tltglhmam_5.2.

Which model predicted better? It was the one that assumed that the warming trend continued through 2008. Models that assumed temperatures were flat from 1998 to 2008 predicted surface temperatures to be lower than they were actually observed to be. In other words, El Niño and the sun conspired to halt the warming trend in the first decade of the 21st century. But in the future, they could behave in an equal and opposite fashion, as they did in 1998, creating a huge (but temporary) spike in global temperatures.

Rather than starting in the big El Niño year of 1998, perhaps it's fairer to start in 2001, after global temperatures recovered from the big El Niño–La Niña warming and cooling cycle. Figure 1.7 shows monthly temperature departures from average for two different records, the IPCC history and the University of Alabama-Huntsville satellite history (known as the UAH record). The two are offset

Figure 1.7
MONTHLY TEMPERATURE DEPARTURES FROM AVERAGE TEMPERATURE FOR THE IPCC RECORD AND THE UNIVERSITY OF ALABAMA–HUNTSVILLE SATELLITE, JANUARY 2001–JULY 2008



SOURCE: IPCC and updates 2007 (surface); University of Alabama-Huntsville 2008 (satellite), http://vortex.nsstc.uah.edu/data/msu/t2lt/tltglhmam_5.2.

because they are referenced to different averages. The IPCC is referenced to its 1961–90 mean, and the satellite record, which begins in 1979, is referenced to its 1979–97 average.

The period 2001–07 is the longest interval in which the IPCC record has shown no change since 1956–62. At the time, we had only increased atmospheric carbon dioxide 14 percent above its preindustrial value, compared with approximately 35 percent by 2006. Clearly the sun and El Niño are still capable of halting a warming trend, but they don't have nearly enough power to send temperatures back to where they were in about 1900.

Because of an additional finding, published in *Nature* in 2008 by Noah Keenlyside of Germany's Leipzig Institute of Marine Science, the implications of the recent lack of warming are remarkable. Keenlyside found that natural processes in the earth's oceans are likely to continue to offset much global warming through the middle of the next decade. If that is true, then we will have gone nearly two decades without any warming.

This is an arrow through the heart of the IPCC's ''scientific consensus,'' and a serious blow to reliance upon the models. Take a look at Figure 1.5 (see insert). Is there a two-decade period in which *any* model predicts no warming? Obviously not! Aside from observed data, these models are our only guide to the future, and they clearly can no longer provide scientific cover for any policies predicated upon the notion of dangerous anthropogenic global warming (DAGW).

There's a further problem. The large warming that climate models produce is mainly a result of an increase in atmospheric water vapor that results from a much smaller warming produced by carbon dioxide itself. The source of that water vapor, of course, is the ocean. If the planet does not warm up for 20 years, there is a further, longer delay in the so-called water-vapor feedback, because the ocean cannot warm up instantaneously.

AGW (anthropogenic global warming), yes. But DAGW? We think not!

Reasons to Disbelieve the Models

The earth's atmosphere extends far above the planetary surface, and it is the vertical distribution of temperature—from the surface to the stratosphere (about 36,000 feet at our latitude)—that determines a lot of our weather. That zone is known as the troposphere, and it is where almost all the weather action takes place.

For example, when the difference between surface- and upper-tropospheric temperature is great, then the surface air is very buoyant compared with what is above it. Put simply, hot air rises and cold air sinks. The warmer the surface air, the more it is likely to rise. As a result, large amounts of air can bubble up. As air moves up, it cools, eventually to the point at which clouds form. The most common signature of a relatively warm surface overlain by a cold upper troposphere is the atmosphere's most visible bubble—the common thunderstorm.

Those who are skeptical of model projections point to a phenomenal mismatch between model predictions for temperatures above the surface and actual observations of them.

Is It Warming *Faster* than Predicted?

Much of the discussion in this chapter indicates that surface warming is taking place at a relatively constant rate (the current hiatus notwithstanding). But that's not what we read in one of the nation's most prominent newspapers.

A few years ago the *Washington Post*'s advertising slogan was, "If you don't get it, you don't get it." When it comes to global warming trends, it's the *Post* that doesn't "get it."

On January 29, 2006, *Post* global warming reporter Juliet Eilperin wrote that "[the] Earth is warming much faster than some researchers had predicted."

Where did this assertion come from? Certainly not from the earth's temperature history from the Intergovernmental Panel on Climate Change.

For the past 30-plus years—the period during which the earth's rising temperature has been most strongly associated with human activity—the average rate of warming (1977–2007) as measured by the IPCC record has been 0.168°C $\pm$ 0.017°C per decade (0.320°F $\pm$ 0.031°F) (Figure 1.8). Although there is a certain degree of annual variation around this trend, the overall rise has been incredibly steady; in other words, there is no appreciable trend to the trend (Figure 1.9). That means that the earth is warming at a constant, or linear, rate, *not* one that is accelerating. This is by and large the same behavior that the vast majority of climate models predict the earth's temperature will display when forced with ever-increasing amounts of carbon dioxide.

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There's no doubt that getting the vertical temperature change right is central to accurately projecting the changes in weather that should accompany global warming. If the rate of temperature decline with height is projected to become smaller, then there will be fewer thunderstorms and a much more drought-prone world. If the opposite is true, the future is replete with lush vegetation fed by increasing

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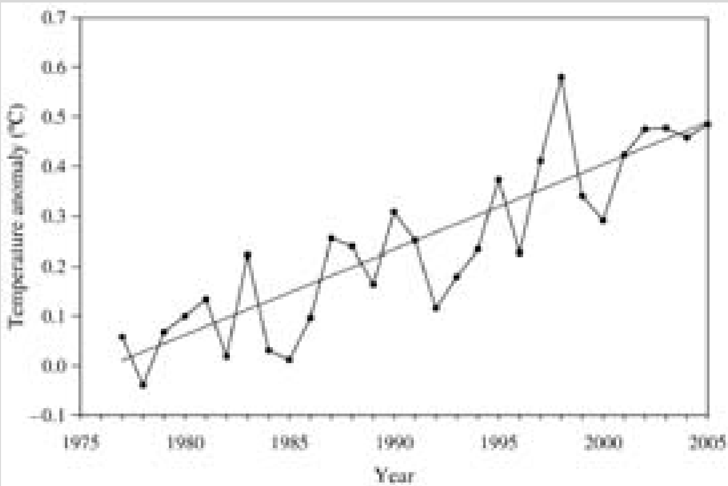
Figure 1.8
GLOBALLY-AVERAGED SURFACE TEMPERATURE DEPARTURE FROM THE 1961–90 AVERAGE



SOURCE: IPCC 2001 and updates.

NOTE: These anomalies were available at the time of the *Washington Post*'s January 2006 article.

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rainfall during the growing season, when thunderstorms tend to occur.

The most recent (and very persuasive) evidence against the models was demonstrated late in 2007 in the *International Journal of Climatology* by University of Rochester's David Douglass and three colleagues—including John Christy, who developed the satellite-based temperature history discussed in chapter 2.

''The models are seen to disagree with the observations,'' Douglass et al. conclude. ''We suggest, therefore, that projections of future climate based on these models be viewed with much caution.''

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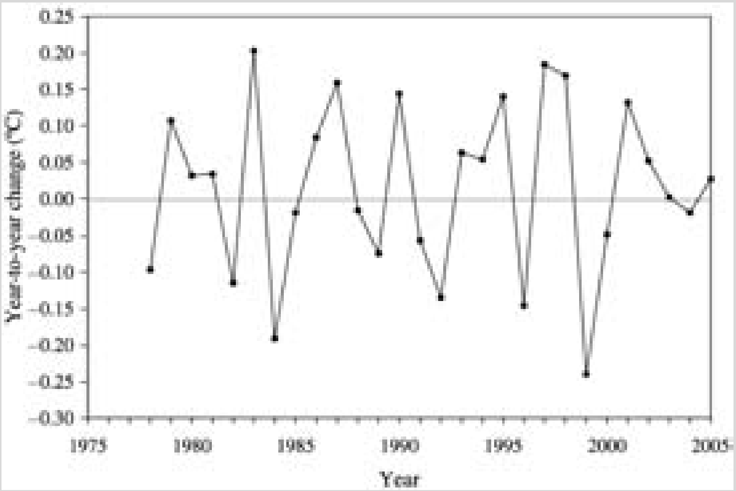
Figure 1.9
Year-to-Year Change in Annual Globally Averaged Temperature Anomalies, 1978–2005



Source: IPCC 2001 and updates.

Who are Eilperin's researchers? If we turn to the "Third Assessment Report" of the Intergovernmental Panel on Climate Change (IPCC)—widely taken as the "consensus of scientists" at the time of Eilperin's article—it states, "The globally averaged surface temperature is projected to increase by 1.4°C to 5.8°C [2.5°F to 10.4°F] over the period 1990 to 2100." That is equivalent to a rise of 0.13°C to 0.53°C (0.235°F to 0.95°F) per decade. Compare that with the observed rate of warming we've established; clearly, the warming is running very close to the *lowest* end of the IPCC warming range.

Rather, the predicted mean warming rate is clearly higher than the *observed* one. Even NASA's James Hansen, the world's most quoted global warming scientist (and a person whom

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Eilperin has lionized in other *Post* articles), has argued that the warming rate over the next 50 years would be 0.15°C per decade ± 0.05°C (0.27°F ± 0.09°F), assuming only very modestly mandated changes in emissions.

Instead of hyping a nonissue, the *Post* would have done a far greater service by reporting in January 2006 that the earth's annual average temperature for the year 2005 fell *exactly* along the linear trend line established during the past 30 years (Figure 1.8) and as such, acted to further support the notion that the earth's temperature is warming up *less* than most people have predicted, assuming that the membership of the IPCC includes most climate people.

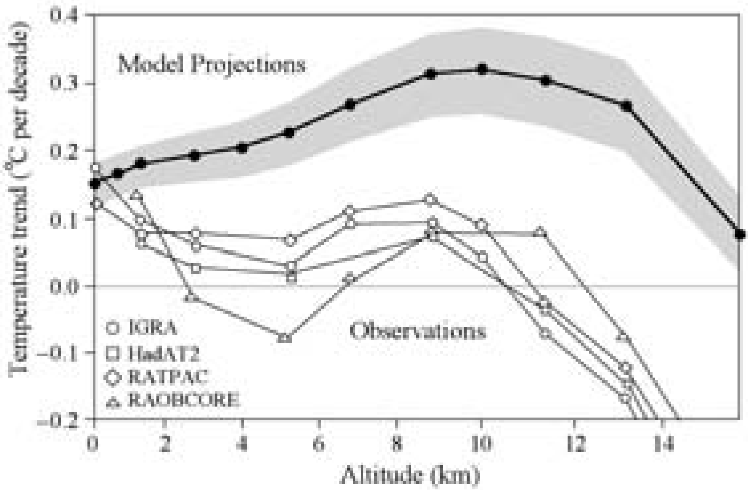
Climate models predict that the greatest warming should occur above the surface, not at or near the surface where we live. In 2000, the National Research Council examined this issue of the differential warming in various layers of the atmosphere and concluded that the surface was warming far more than the lower atmosphere; that pattern is not consistent with model predictions, and no obvious explanation was apparent.

The Douglass et al. team gathered output from models, surface observations, and balloon and satellite records, over the period 1979–2004, from which they calculated model-based and observed temperature trends at the surface and various altitudes in the tropical atmosphere. They focused on the tropics (20°N to 20°S) because "Much of the earth's global mean temperature variability originates in the tropics, which is also the place where the disparity between model results and observations is most apparent."

Trends from the models and observations agree at the surface but totally disagree from just above the surface to 14 kilometers (km) (8.7 miles) above the surface (Figure 1.10)

The models all predict far more warming around 10 km (6.2 miles) up in the atmosphere than is predicted at the surface. But all the observational evidence shows no such pattern whatsoever. In fact, there's a lot of *cooling* being observed at high altitudes rather than warming.

Figure 1.10
MODELED (FILLED CIRCLES) VS. OBSERVED (OPEN SYMBOLS) TEMPERATURE TRENDS FOR THE SATELLITE ERA (°C PER DECADE)



SOURCE: Adapted from Douglass et al. 2007.

NOTE: Observed temperatures begin in 1979. The model average comes from an ensemble of 22 model simulations from the most widely used models from throughout the world. The light gray area is the range of +2 and −2 standard errors round the mean from the 22 models, which is the 95 percent confidence band for the true model average. The acronyms refer to various observational databases.

Douglass et al. conclude:

> Model results and observed temperature trends are in disagreement in most of the tropical troposphere, being separated by more than twice the uncertainty of the model mean. In layers near 5 km [3.1 miles], the modeled trend is 100 percent to 300 percent higher than observed, and, above 8 km [5.0 miles], modeled and observed trends have opposite signs. On the whole, the evidence indicates that model trends in the troposphere are very likely inconsistent with observations that indicate that, since 1979, there is no significant long-term amplification factor relative to the surface.

The difference between surface and upper-tropospheric temperatures is increasing, not decreasing. The implications are huge.

For example, an atmosphere with a greater difference between the surface and upper layers is a more unstable one and will produce more precipitation.

An inaccurate precipitation forecast has huge implications for climate change predictions. Generally speaking, away from the high-latitude land areas (which are too cold to dry out much), places that get more rain have a wetter surface than those that do not. That means that more of the sun's energy is directed toward evaporation of water than toward a direct heating of the surface. (You can observe this phenomenon at the beach: Dry sand at noon will burn your feet, but wet sand will not).

So the amount of rainfall is a determinant of surface temperature. So is the amount of cloudiness. Everything else being equal, an atmosphere with more vertical motion (i.e., one where the surface is relatively warm compared with the upper layers) is one with more clouds. In the tropics, that means cooler days. Again, to specify the surface temperature correctly, it seems one has to get the vertical distribution of temperature correct also.

So how can the models get the surface temperature correct if they so dramatically miss the rest of the tropical atmosphere?

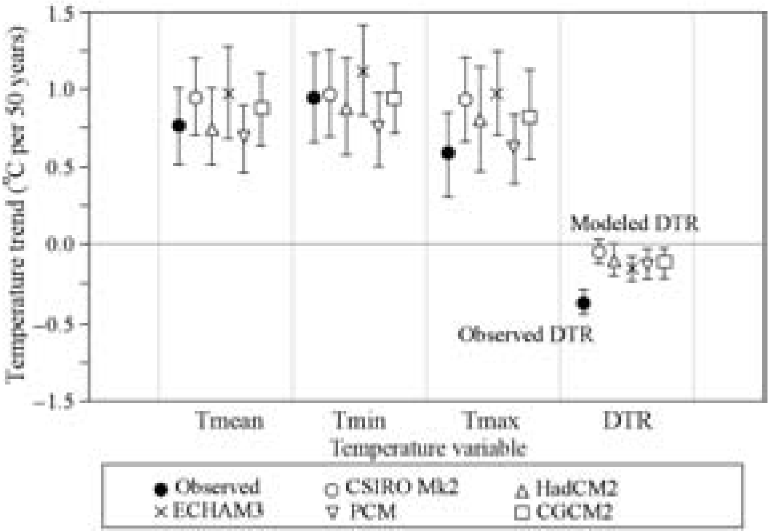
Intraday Temperature Issues

Clearly one signal consistent with greenhouse changes is an increase in the coldest temperatures, and that appears to have been observed (with the notable exception of Antarctica; see chapter 4). But the models have also overestimated vertical changes in temperature. Are there any other important aspects of climate change that they have gotten wrong?

One of the most prominent greenhouse-gas signals is the daily temperature range (DTR), which is the difference between the high and low temperature. Over most of the globe's land regions, that range has been declining over time—and the decline is thought to be a global warming indicator. Both maximum and minimum temperatures are rising, but the rise in daily low temperatures has occurred at a much greater rate, so the temperature range has gotten narrower.

This trend is related to increasing greenhouse gas levels because, everything else being equal, an atmosphere with higher greenhouse gas concentrations will have elevated nighttime temperatures. The

Figure 1.11
MODELED AND OBSERVED TRENDS IN MEAN, HIGH, LOW, AND DAILY TEMPERATURE RANGE, 1951–2000



SOURCE: Braganza, Karoly, and Arblaster 2004.

NOTE: Acronyms refer to various models.

surface cools less at night because the earth's ability to radiate away heat from the lower layers is compromised by increasing greenhouse gases.

But climate models do not accurately replicate this effect. Take, for example, a 2004 study by Australian scientist Karl Braganza and two coauthors from the United States published in *Geophysical Research Letters*. The authors gathered data from all the global land areas with sufficiently long periods of record (forcing them to exclude Greenland, Antarctica, part of India, and most of Africa and South America), and compared the observed global decadal trends in maximum and minimum temperature and DTR with the output of five climate models in which the observed changes in 20th-century greenhouse gas and other atmospheric chemicals were simulated.

The results of the comparisons are summarized in Figure 1.11. Although the climate models, in aggregate, do a good job of reproducing the observed trend in minimum temperature, they overestimate the trend in maximum temperature. Each model does increase the daily high temperatures, but at a slower rate than the low temperatures. Actual observations show a much smaller increase in the daily highs. The net effect of that discrepancy on DTR is that none of the models can properly simulate the observed trend in DTR, which is declining at a rate greater than the models indicate it should be.

The critical issue here is that, given that DTR is really an indicator of greenhouse warming, the models must be mischaracterizing some very fundamental processes that are key to being able to accurately model our climate at all. In this case, the models can hardly distinguish between the rates of day vs. night warming, while, in reality, high temperatures are increasing more slowly than models predict them to.

The flaw in the greenhouse models may be related to cloudiness. Cloud cover over land areas increased during the last half of the 20th century. Cloudy afternoons are generally cooler than clear afternoons, so clouds could account for this large discrepancy between climate models and reality.

Of course, you could argue that you really can't model earth's climate without getting cloud cover correct, given that clouds have an awful lot to do with both planetary temperature and precipitation. You could even argue that, because of this cloud problem, the models might be getting the trends in minimum temperature correct by dumb luck, given that the fundamental physics are not correct.

The bottom line? Over global land areas, nighttime low temperatures are rising faster than daytime highs, and that trend is consistent with increasing greenhouse gas levels. Climate models are incapable of correctly reproducing the observed trends, and as a result are showing that daytime high temperatures are increasing faster than they are in reality. That error is present, in all likelihood, because the models have not properly captured some fundamental physical component of earth's climate.

Model ''Tuning''

Can computer models be ''tuned'' to produce the right surface temperature? And could doing so make the upper layers in the computer model's atmosphere go haywire? Further, can aspects of a model be manipulated to give an expected output? How could that be done?

Go back to Figure 1.1, which is the IPCC's surface temperature history. Let's stipulate that it's correct (though the next chapter will raise plenty of questions). Carbon dioxide has been increasing throughout the 20th and 21st centuries, with relatively modest increases in the earlier years compared with what is being observed now.

If carbon dioxide were the sole driver of climate change, then the temperature would have changed in a similar fashion, with a constant rate of warming as carbon dioxide increases as a small exponent.

Obviously, the temperature history does not mimic what would be caused by the effect of carbon dioxide alone. That has been recognized for at least 20 years. *Sound and Fury*, Michaels' first book on global warming, cited a 1987 paper by Thomas Wigley that indicated that something other than carbon dioxide had to be influencing temperature. Whatever that "something" was, it had to enhance warming in the early 20th century, and then limit it or cause cooling in the midcentury.

That "something" is hypothesized to be finely divided particulate matter, usually in the form of sulfate aerosol. It is thought that such particles reflect away the sun's energy. The source: fossil fuels!

Fossil fuels, especially coal, contain some sulfur. When burned, the sulfur combines with oxygen, which, through a series of chemical reactions, ultimately appears as a finely divided dust, called sulfate aerosol, which is thought to create a cooling effect. Because there wasn't nearly so much coal combusted in the early 20th century as there is now, either carbon dioxide's or the sun's warming (the latter being more important than the former at that time) wouldn't be very attenuated by sulfates—not until the world industrialized, which was contemporaneous with World War II. And so, the story goes, sulfate cooling dominated carbon dioxide warming until the late 1970s, when carbon dioxide won the day.

This explanation is commonly invoked to explain the warming of the early 20th century, followed by a slight cooling to the mid-1970s, and the subsequent second warming which continued through 1998. Sulfur compounds emanating from coal-fired power plants are also thought to be responsible for (remember this one?) acid rain. So, the story goes on further, the sulfate effect was reduced (at least in North America and Europe) as "scrubbers" were put on the power plants to wash out the sulfur compounds before they could acidify precipitation. In other words, cleaning up coal enhances warming.

So there are two "knobs" on global warming models that can interact and produce something that mimics the surface temperature history.

One is the sensitivity of the temperature to changes in carbon dioxide, or the amount of temperature change expected for each increment of carbon dioxide. There's plenty of debate about exactly what this value is, so it can be specified as either high or low, depending upon the model. The other knob is the countering effect of sulfate aerosol. If the two knobs are adjusted just right, a model can show warming in the early 20th century, a cooling in the middle of the century driven by uncontrolled coal combustion, and another warming in the late 20th century as coal is cleaned up and carbon dioxide continues to increase.

The problem is that no one really knows the magnitude of the sulfate effects. Nor do we know precisely how the effects are distributed vertically. For example, sulfate aerosol is hygroscopic, meaning that it tends to gather water. Yes, that's right: It accomplishes "cloud seeding"—because water droplets cannot form unless they have a "condensation nucleus" to condense around. Simply put, sulfate aerosol should produce more water droplets in clouds.

The more cloud droplets there are, given a finite amount of moisture, the smaller each individual droplet is. And smaller droplets are more reflective, making whiter clouds, which should create even more cooling than would result from the sulfate itself. The brighter the cloud, the more the sun's energy is kept from reaching (and warming) the surface.

It therefore might be easy to specify the surface temperature by turning the carbon dioxide and sulfate knobs, though doing so might result in major errors in the vertical temperature calculation. How much of that has gone on is anyone's guess.

Those who seriously doubt the models have quite a point. "Believers" may be placing too much faith in the models because of (1) the apparent match with surface temperatures and (2) the fact that both observed and modeled surface temperature changes are occurring at a constant (rather than an increasing) rate. But the vertical temperature forecast errors make the match between the models and the surface history a possibly fortuitous result of model tuning.

The current state of global warming science is far from "settled." It's true that both modeled and observed *surface* temperatures are rising at a constant rate, but the models are clearly predicting too high a rate of increase. Again, perhaps the "sensitivity" of climate to carbon dioxide has simply been overestimated.

This is actually a minor problem, considering the problems with the vertical distribution of temperature and the daily temperature range. The former calls into question the scientific basis for any model projections of changes in cloudiness or rainfall. And if *those* are questionable, then any match with surface warming may be fortuitous. What's more, the fact that *none* of the IPCC's midrange models (Figure 1.5; see insert) generates a warming-free 15-year period in the 21st century, which is happening right now, is very disturbing.

Readers will note that we did not make a single argument for simply taking the model results at face value. That's because it is obvious that, in general, the models have predicted too much warming in recent decades.

Another noteworthy aspect of this chapter's discussion is that much of the work showing the problems with the models is "new" to our audience. Why has there been so little publicity about this good news? Do scientists—and the journalists who write about their work—tend to write about only "bad" news? Keep these questions in mind as you read the rest of this book.