

November 28, 2017

No. 237

A Veneer of Certainty Stoking Climate Alarm

In Private, Climate Scientists Are Much Less Certain than They Tell the Public

By *Rupert Darwall**

Foreword by Judith Curry, President of the Climate Forecast Applications Network and former Professor and Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology

While the nations of the world met in Bonn to discuss implementation of the Paris Climate Agreement, the Trump administration was working to dismantle President Obama's Clean Power Plan and to establish a climate "red team" to critically evaluate the scientific basis for dangerous human-caused climate change and the policy responses.

The mantra of "settled science" is belied by the inherent complexity of climate change as a scientific problem, the plethora of agents and processes that influence the global climate, and disagreements among scientists. Manufacture and enforcement of a "consensus" on the topic of human-caused climate change acts to the detriment of the scientific process, our understanding of climate change, and the policy responses. Indeed, it becomes a fundamentally anti-scientific process when debate, disagreement, and uncertainty are suppressed.

This essay by Rupert Darwall explores the expressions of public certainty by climate scientists versus the private expressions of uncertainty, in context of a small Workshop on Climate organized by the American Physical Society (APS). I was privileged to participate in this workshop, which included three climate scientists who support the climate change consensus and three climate scientists who do not—all of whom were questioned by a panel of distinguished physicists.

The transcript of the workshop is a remarkable document. It provides, in my opinion, the most accurate portrayal of the scientific debates surrounding climate change. While each of the six scientists agreed on the primary scientific evidence, we each had a unique perspective on how to reason about the evidence, what conclusions could be drawn and with what level of certainty.

Rupert Darwall's essay provides a timely and cogent argument for a red/blue team assessment of climate change that provides both sides with an impartial forum to ask questions and probe the other side's case. Such an assessment would both advance the science and open up the policy deliberations to a much broader range of options.

- *Judith Curry, Reno, Nevada, November 7, 2017*

* *Rupert Darwall is a strategy consultant and policy analyst. He read economics and history at Cambridge University and subsequently worked in finance as an investment analyst and in corporate finance before becoming a special adviser to the United Kingdom's Chancellor of the Exchequer. He has written extensively for publications on both sides of the Atlantic, including the Spectator, Wall Street Journal, National Review, and Daily Telegraph. He is the author of the books, The Age of Global Warming: A History (2013) and Green Tyranny: Exposing the Totalitarian Roots of the Climate Industrial Complex (2017).*

Introduction. How dependable is climate science? Global warming mitigation policies depend on the credibility and integrity of climate science. In turn, that depends on a deterministic model of the climate system in which it is possible to quantify the role of carbon dioxide (CO₂) with a high degree of confidence. This essay explores the contrast between scientists' expressions of public confidence and private admissions of uncertainty on critical aspects of the science that undergird the scientific consensus.

Instead of debating, highlighting and, where possible, resolving disagreement, many mainstream climate scientists work in a symbiotic relationship with environmental activists and the news media to stoke fear about allegedly catastrophic climate change, providing a scientific imprimatur for an aggressive policy response while declining to air private doubts and the systematic uncertainties.

Two Statements, Two Perspectives. Two statements by two players in the climate debate illustrate the gap between the certainty that we are asked to believe and a branch of science shot through with uncertainty. “Basic physics explains it. If global warming isn’t happening, then virtually everything we know about physics is wrong,” states Jerry Taylor, president of a group that advocates for imposing a carbon tax on the United States.¹ In so many words, Taylor says that the case for cutting carbon dioxide emissions is incontrovertible: Science demands conservatives support a carbon tax.

The second statement was made by an actual climate scientist, Dr. William Collins of the Lawrence Berkeley National Laboratory. Speaking in 2014 at an American Physical Society climate workshop, Collins, who was a lead author of the chapter evaluating climate models in the 2013 Intergovernmental Panel on Climate Change’s (IPCC) Fifth Assessment Report, talked of the challenges of dealing with several sources of uncertainty. “One of them is the huge uncertainties even in the historical forcings,” he said, referring to the natural and anthropogenic factors that affect the climate.² Commenting on the “structural certainty” of climate models, he observed that there were “a number of processes in the climate system we just do not understand from basic physical principles. ... We understand a lot of the physics in its basic form. We don’t understand the emergent behavior that results from it.”³

In an August 2017 TV interview with talk show host Bill Maher, former Vice President Al Gore pointed out that 14 years earlier, National Aeronautics and Space Administration (NASA) climate scientist James Hansen had said there were only 10 years left to avoid a tipping point. “Have we crossed a point of no return where this thing spins out of control?” Gore posited. “The scientists still tell us: No, we have not gotten to that point. We can still avoid the most catastrophic consequences if we start acting boldly now.”⁴

But some tipping points have unfortunately been passed. I’ll give you an example—a very large part of the West Antarctic ice sheet. Just two years ago they said, okay, that’s crossed the tipping point. It is now going to be gone no matter what we do—and that actually hit me pretty hard when that news came out because it does mean there’s going to be considerable sea level rise no matter what we do. But we still have the ability to control the pace of that disappearance.⁵

In fact, the speculative link between greenhouse gas emissions and changes in the West Antarctic ice sheet is, at best, extraordinarily attenuated. Gore's belief that humans can influence what happens there is fanciful. As we shall see, scientists abuse their standing to engage in political advocacy by lending their credibility to sensational claims often with little or no evidence while neglecting to mention competing explanations that don't fit the climate change story.

The 2014 APS Climate Workshop: A Perfect Venue for Open Debate. Things are different when climate scientists are on the stand alongside their peers who know the science as well as they do, but disagree with the conclusions they draw from the same body of knowledge. Such open debate was on display at the 2014 American Physical Society climate workshop, which took place in Brooklyn and lasted just over seven hours. A unique event in the annals of the climate debate, it featured three climate scientists who support the climate change consensus and three climate scientists who do not. That format required an unusual degree of honesty about the limitations of the current understanding of the climate system. For the most part, circumspection, qualification, and candid admissions of lack of knowledge were the order of the day.

The workshop participants debated the problematic role of computer projections of future temperature increases that form the basis of concern about future climate change. In particular, it highlighted the IPCC's dubious practice of manipulating models to produce politically favored results.

Sparks flew on the question of falsifiability. On one side, the failure of climate projections to match reality was taken to imply the need for more research and more data; on the other, to indicate that the assumptions made by consensus-supporting climate scientists need revising.

Drawing extensively from the 573-page transcript of the APS climate workshop, this paper examines the gap between how climate scientists debate with each other and how they speak to the media and the wider public. It tackles the following specific topics.

- **West Antarctic meltdown.** It starts with a major *New York Times* story on the supposed imminent demise of the West Antarctic ice sheet—a victim, it is implied, of mankind's hydrocarbon profligacy that will be met with biblical punishment in the form of rising sea levels and the flooding of coastal cities around the world. Nowhere is there any mention that West Antarctica sits atop areas of geothermal activity that, according to a recent study, is possibly the densest region of volcanoes in the world, a discovery which a *Washington Post* headline spun as “[a]nother climate-change nightmare: 91 new volcanoes beneath Antarctica's ice.”⁶
- **The enhanced greenhouse effect in perspective.** It then puts into perspective the “forcings”—the energy added to the climate system—from the enhanced greenhouse effect caused by human carbon dioxide emissions and compares them to those that are now thought to cause the succession of ice ages and interglacials.
- **The IPCC's use and abuse of climate models.** Climate models are the principal tools used by the IPCC to attribute climate change to human activity. The climate system might not be amenable to a reductionist treatment, but that is how climate

models work. Worse, for its temperature projections extending out to 2100, the IPCC uses values for carbon dioxide climate forcings that are known to be too high.

- **Can the climate consensus be wrong?** How do we know the climate consensus isn't wrong, is the question posed by Harvard historian of science Naomi Oreskes, a leading figure on the "consensus" side of the climate debate. A straightforward approach is to see how well the scientific consensus on previous environmental scares have stood the test of time.
- **Climate science and falsifiability.** Scientists from both sides at the APS workshop rejected the argument that falsifiability does not apply to climate science. In principle, a scientific hypothesis should be capable of being refuted by an empirical test. The course of the discussion revealed which side remains true to this fundamental principle of science.
- **John Christy's congressional testimony.** The analysis discussed at the APS workshop was further developed by Alabama state climatologist John Christy in his March 2017 congressional testimony. In it, Christy showed how the IPCC had suppressed analysis contradicting its headline claim that human activities contributed most of the observed warming over the past four decades.
- **Politicized science vs. red/blue team appraisals.** Christy's testimony and the APS workshop demonstrate that the IPCC scientific evaluation process is broken and its headline claims are biased and unbalanced. Opposition from consensus-supporting climate scientists to red/blue team appraisals, an approach adapted from military war-gaming by U.S. Environmental Protection Agency (EPA) Administrator Scott Pruitt, further illustrates the need to embed critical dialogue in climate science appraisals.
- **The need for informed consent.** The climate change consensus demands radical economic and social change. In a democracy, this requires the public's informed consent through their elected representatives. The politicized IPCC process lacks the integrity to discharge this function. From the start, the IPCC was created with an activist intent. Therefore, a new approach is needed to the critical evaluation of climate science and the claims on which the consensus rests.

West Antarctic Meltdown. West Antarctica has become the poster child of the media's climate change alarmism. Late in 2016, four *New York Times* journalists visited the West Antarctic ice sheet, which had been singled out by Al Gore as having passed a climate change tipping point. "Recent computer forecasts suggest that if greenhouse gas emissions continue at a high level, parts of Antarctica could break up rapidly," they wrote in a three-part story on their trip published in May. "Antarctica's collapse has the potential to inundate coastal cities across the globe."⁷ Scientists, they claim, now believe that West Antarctica is a disaster waiting to happen, if human-caused global warming has not already set the calamity in motion. "It's kind of a blowtorch on the underside of the ice shelf," one of the experts told them.⁸

Two climate scientists had done some computer modeling. If carbon dioxide emissions were drastically reduced in line with international climate goals, a catastrophe might not yet be inevitable, one of them claimed. "There's still a chance that all hell will break loose," Dr. Robert DeConto of the University of Massachusetts said. "But the model is suggesting

there's a way to reduce the risk of a big sea-level rise from Antarctica."⁹ The policy implications of this claim are not hard to discern.

This speculation depends on greenhouse gas emissions causing the ice sheet to disintegrate. However, the human causation story is not straightforward, as the *Times* report quietly concedes. The warmer water under the ice shelf has not been linked to global warming—"at least not directly."¹⁰ It had likely been there for centuries, so why had it not cooled down by now? Is something still warming the water? Stronger winds *might* be associated with global warming, which could be stirring them up.

Despite the presence of a figurative blowtorch under the West Antarctic ice sheet, the word "geothermal" appears nowhere in the *Times* piece. The area sits atop the West Antarctic Rift System, where, according to a 2014 paper by four University of Texas geophysicists, "geothermal fluxes are expected to be high, heterogeneous, possibly transient." Heat from the Earth's interior, they note, is "likely a significant factor in local, regional, and continental ice sheet stability."¹¹ Did the *Times* fly four of its journalists to Antarctica to report on geothermal fluxes? The word does not appear in their three-part report.

"I don't think the biblical deluge is just a fairy tale," a retired glaciologist told them. In language that, if used by a non-scientist, would be disregarded as activist hyperbole, he continued: "Some kind of major flood happened all over the world, and it left an indelible imprint on the collective memory of mankind."¹² The reportage was framed to stoke fear of mass inundation. The very existence of Miami, New York, Shanghai, and many other coastal cities, the report suggests, is tied to Antarctica's fate, unless mankind mends its ways.

The recent discovery of 91 volcanoes under West Antarctica was reported by the *Washington Post* as a human-caused climate change story. Only three quarters of the way through the story did the paper quote the remarkable third-year student at the University of Edinburgh, Max Van Wyk de Vries, who had made the discovery, saying that Antarctica as a whole had generally been doing better than most glaciers around the world. "It's not melting rapidly like glaciers in the Rockies or Alps," he said.¹³

The Enhanced Greenhouse Effect in Perspective. A rise in global sea level would be one of the most certain consequences of man-made global warming. The problem is that, according to a 2014 paper published in *Nature*, the rate of global sea level rise has been increasing for 200 years, since well before man-made global warming could have made any difference.¹⁴ Thus rising sea levels are consistent with anthropogenic warming but are not evidence of it. Scientists would need to find a further acceleration on top of the already occurring rise.

That has not happened yet. The paper's authors, drawn from universities in Florida, Britain, Australia, and Germany, point out that the lower end of the range of global sea-level rise projected by the IPCC is "broadly consistent" with a continuation of the average rate observed over the 20th century.¹⁵ The upper bound of a 980 centimeter rise for 2100 over 1986-2005 levels would require a major acceleration over the average 20th century rate. At

the earliest, it is likely that rates significantly higher than past ones would only become evident in global data sets later this decade or early in the next, and up to 60 years later in individual tide gauge records.

It could be an even longer wait for global warming to show up in tide gauge records. Some numbers help explain why and provide perspective on the enhanced greenhouse effect, principally from carbon dioxide emissions. According to NASA, the average amount of incoming solar radiation at the top of the Earth's atmosphere is 340 watts per square meter—equivalent to just under six 60-watt incandescent light bulbs. Of this, 77 watts per square meter is absorbed by the atmosphere and 163 watts per square meter absorbed by the Earth's surface to be re-radiated back into the atmosphere.¹⁶ In its Fifth Assessment Report, the IPCC reckoned that the forcing effect of the enhanced greenhouse gas effect (carbon dioxide and two dozen other greenhouse gases) in absorbing this outgoing radiation was 2.83 watts per square meter in 2011—less than 1 percent of incoming energy.¹⁷

Hypotheses about the warming effect of carbon dioxide in the atmosphere originated in the 19th century. The Irish physicist John Tyndall (1859) and the Swedish scientist Svante Arrhenius (1896) thought fluctuations in the amount of carbon dioxide in the atmosphere might explain the succession of ice ages, of roughly 100,000 years, and interglacials, relatively short periods of greater warmth lasting 15,000 to 20,000 years. In the 1920s, the Serb mathematician and astronomer Milutin Milanković developed an alternative theory based on three cyclical variations in the Earth's orbit altering the amount of solar radiation received at high latitudes correlating with the series of ice ages.¹⁸

How do current anthropogenic forcings—the extra energy from the enhanced greenhouse effect—and those caused by Milanković cycles compare? William Collins of the Lawrence Berkeley National Laboratory was asked this at the APS 2014 climate workshop by New York University theoretical physicist Steven Koonin, who served as undersecretary in the Department of Energy during President Obama's first term. As noted, the APS workshop is unique in the history of climate science: on one side, three experts subscribing to the consensus and three expert critical of it, moderated by non-climate scientists, including Koonin.

“In some cases, six watts,” answered Collins.

“Locally, it's 100 watts per square meter in the summer Arctic,” MIT's Dr. Richard Lindzen added from the IPCC critics' bench.¹⁹ Lindzen returned to the topic later in the session. Annually averaged over the globe, you had almost no forcing from the Milanković cycles getting a big climate response, Lindzen observed.²⁰ Averaging the annual change in radiative forcing caused by Milanković cycles over the entire globe conceals the magnitude of the change toward the poles. What Lindzen called the “currently fashionable paradigm” requires changes in CO₂ to produce the cycle of ice ages. Was the global climate so sensitive that forcings of 1.5 watts per square meter from the extra CO₂ found in ice cores sufficient to cause profound climate change? “I think that makes no sense,” Lindzen said.²¹

What Milanković understood was that the variation of incoming energy during Arctic summers could determine how much snow and ice survives the summer, so that ice sheets could build up over long periods of time. The 100 watts per square meter variations caused by Milanković cycles above 65 degrees North (the parallel that cuts Greenland's southern tip) is approximately the energy required to account for the melting and freezing of the ice over ice age time scales.

Localized changes of 100 watts per square meter—equivalent to nearly 30 percent of the energy of the Sun arriving at the top of the atmosphere—brought about genuine climate change. How plausible is it to believe 3 watts per square meter—less than 1 percent of incoming solar energy—is sufficient to bring about irreversible, potentially catastrophic changes in the world's climate? Sensitivity measurements from space show a “huge amount” of variability in clouds and other things, Lindzen argued. Why aren't there “degrees of freedom” that the system adjusts to small imbalances? “I think that is probably the way one ought to look at the climate system.”²²

The IPCC's Use and Abuse of Climate Models. That is not how the general circulation models (GCMs) used by the IPCC work or how inferences from them are interpreted and then projected into the world by the IPCC in what has been called the gold standard of climate science.²³ The discussion in Brooklyn shows that putting the words “gold standard” and “IPCC” in the same sentence demonstrates a serious misunderstanding of the reliability of IPCC-sanctioned climate science.

“It's clouds that prevent us from fundamentally in some reductive fashion understanding the climate system,” Princeton Atmospheric and Oceanic Sciences Professor Isaac Held, senior research scientist at the National Oceanic and Atmospheric Administration's (NOAA) Geophysical Fluid Dynamics Laboratory, declared from the IPCC climate consensus bench.²⁴ Collins made a similar point toward the end of the session. “My sense, to be honest with you, is that, and I think this all makes us a little bit nervous,” he said; “climate is not a problem that is amenable necessarily to reductionist treatment.”²⁵

Yet the IPCC's top-line judgment in its Fifth Assessment Report—that it is “extremely likely” that the human emissions of greenhouse gases are the dominant cause of the warming since the mid-20th century—was described by Dr. Ben Santer of the Lawrence Livermore National Laboratory, the third and most prominent of the IPCC consensus team, as likely to be conservative.²⁶ The basis for this claim? General circulation models. Santer, whose involvement in the IPCC dates back to his role editing the 1996 Second Assessment Report to remove passages deemed unhelpful to the Clinton administration's climate policy agenda, was the most bullish of the pro-consensus three throughout the workshop. It was very difficult to find model runs that produce less than half the observed warming, Santer said.

Santer's claim would have sounded impressive if earlier in the day Collins had not presented charts showing GCMs performing poorly in reproducing temperature trends in the first half of the 20th century.²⁷ Lindzen asked, what in the models causes the 1919-1940 warming? “Well, they miss the peak of the warming,” Held replied.²⁸ While the IPCC is extremely

certain that the late 20th century warming is mostly man-made, to this day it cannot collectively decide whether the earlier warming, which is of similar magnitude to the one that started in the mid-1970s, is predominantly man-made or natural. “It actually turns to be very hard to use the past as prologue,” Collins conceded before explaining: “We do not have a first principles theory that tells us what we have to get right in order to have an accurate projection.”²⁹ And, as Held noted, over the satellite era from 1979, GCMs over-estimated warming in the tropics and the Arctic.³⁰

There is a more fundamental objection to Santer’s position. General circulation models embody climate scientists’ current thinking about how the climate system works. Santer’s argument that only with man-made greenhouse gas forcings do GCMs reproduce late 20th century warming is tantamount to saying “because this is the only way we can explain the phenomenon, it must be true.” This logically requires all possible explanations to be known. That is an impossible standard to meet. It would mean science could never advance, as it implies that no new scientific hypotheses can or will be developed. If all possibilities are known from the start, science becomes solely an exercise in collecting and analyzing data—an important aspect of science, for sure, but not one that gives science its unique explanatory power and its capacity to advance.

Santer’s argument implies climate science is a closed system incapable of making the leaps that punctuate the history of scientific endeavor. In a 2008 paper, Lindzen noted that progress in climate science in solving actual scientific problems has moved at “a much slower rate” than might be expected.³¹ He highlights the role of fear in attracting federal funding to scientific research, something that has been happening since the 1960s: “The fact that fear provides little incentive for scientists to do anything more than perpetuate problems, significantly reduces the dependence of the scientific enterprise on unique skills and talents.”³² Reliance on fear as a motivator of funding has severely damaged the ability of science to usefully address problems, Lindzen argues, as “the solution of a scientific problem is rewarded by ending [financial] support. This hardly encourages the solution of problems or the search for actual answers.”³³

Climate science has a lot of ground to make up. The same models that are used to project future temperature rises do not even get the past right, a point made at the APS workshop by Alabama state climatologist John Christy from the critics’ side: “If the models can’t tell us *what* happened, how can they tell us *why* it happened?”³⁴

Nonetheless, projections derived from general circulation model are used to tell policy makers when greenhouse gas emissions must peak and by how much they must fall to avoid temperatures rising more than the two-degree Celsius increase above pre-industrial levels stipulated in the Paris climate treaty. Steven Koonin, chairing the APS workshop, read an extract from chapter 10 of the IPCC’s Fifth Assessment Report. Model-simulated responses to forcings—including greenhouse gas forcings—“can be scaled up or down.”³⁵ To match observations, some of the forcings in some of the models had to be scaled down. But when it came to making the centennial projections, the scaling factors were removed, probably resulting in a 25 to 30 percent over-projection of the 2100 warming, Koonin said.³⁶ Only the transcript does full justice to the exchange that followed.

Dr. Koonin: But if the model tells you that you got the response to the forcing wrong by 30 percent, you should use that same 30 percent factor when you project out a century.

Dr. Collins: Yes. And one of the reasons we are not doing that is we are not using the models as [a] statistical projection tool.

Dr. Koonin: What are you using them as?

Dr. Collins: Well, we took exactly the same models that got the forcing wrong and which got sort of the projections wrong up to 2100.

Dr. Koonin: So, why do we even show centennial-scale projections?

Dr. Collins: Well, I mean, it is part of the [IPCC] assessment process.³⁷

“It is part of the assessment process” is not a scientific justification for using assumptions that are known to be empirically wrong to produce projections that help drive the political narrative of a planet spinning toward a climate catastrophe.

Can the Climate Change Consensus Be Wrong? “The Scientific Consensus on Climate Change: How Do We Know We’re Not Wrong?” is the title of a 2007 essay by the Harvard historian of science Naomi Oreskes, a leading advocate for climate mitigation policies. “No one denies the fact of natural variability, but natural variability alone does not explain what we are now experiencing.”³⁸ At the APS workshop, NOAA’s Isaac Held took a more open-minded approach. “I worry,” he told the workshop, “Are there smoking guns out there that will change the consensus? I think we focused on two of them, the hiatus [in warming] and the tropical, upper tropospheric warming. Those are real issues. I don’t have the answer.”³⁹

Originally trained as a mining geologist, Oreskes has become the go-to academic for major media outlets, including the *New York Times* and *Washington Post*, for quotes and op-eds to validate the climate change catechism. Previously at the University of California, San Diego, her 2010 book *Merchants of Doubt*, co-written with Erik Conway, catapulted her to prominence and, in 2013, helped land her a full professorship at Harvard.

According to Oreskes, there are no valid scientific reasons for doubt. The only reason to think the rise in temperature and atmospheric carbon dioxide might be coincidental is “to avoid committing to action.”⁴⁰ In fact, her own words indicate a strong adherence to green ideology. “To deny that global warming is real is precisely to deny that humans have become geological agents, changing the most basic physical processes of the [E]arth,” Oreskes writes of the less than 1 percent of incoming solar energy retained in the atmosphere. “There are now so many of us cutting down so many trees and burning so many billions of tons of fossil fuels that we have indeed become geological agents.”⁴¹

Might the consensus on climate change be wrong? “The relevant question for us as citizens is not whether this scientific consensus *might* be mistaken but rather whether there is any reason to think that it *is* mistaken,” Oreskes asserts.⁴² The difference between these two options is meaningless, though, as the procedure is the same—look at previous examples

where the scientific consensus supported environmental alarm and see whether that consensus was right or wrong.

When so much store is put on deciding science by consensus, it makes sense to look at analogous episodes in the past and determine whether the consensus was solid or fallible then. This is what Oreskes and Conway do in *Merchants of Doubt* and this author does in *Green Tyranny* (October 2017). Both books examine two prior episodes—the acid rain scare of the 1970s and 1980s and the nuclear winter scare of the 1980s, but come to diametrically opposite conclusions on the consensus fueling them.

Like global warming, the scientific basis of the acid rain scare had been supported by numerous national academies. Oreskes and Conway assert the science is still valid by resorting to the simple expedient of not reporting the findings of the 10-year, \$500 million National Acid Precipitation Assessment Program that demonstrated it is not.⁴³

Oreskes's and Conway's performance on the nuclear winter scare is even worse. Sergei Tretyakov, a Russian spy who defected in 2000, revealed that the nuclear winter scare had been concocted by the KGB as part of a massive Soviet campaign to undercut the West's nuclear rearmament program in response to Soviet deployment of SS-20 missiles in Eastern Europe.⁴⁴ With a handful of exceptions, the scientists who aligned themselves with this effort would later be proponents of global warming. "The attack on nuclear winter was a dress rehearsal for bigger fights yet to come," according to Oreskes and Conway, along the way attacking the reputations of Reagan-era scientists who disputed the science of the nuclear winter.⁴⁵

What Oreskes and Conway omit from their account is that the "merchant of doubt" who administered the scientific *coup de grâce* on the science of the nuclear winter was none other than Stephen Schneider, to whom the IPCC's Fifth Assessment Report was dedicated. Oreskes and Conway knew that Schneider was co-author of the 1986 article as they cite an editorial in which it is discussed.

Climate Science and Falsifiability. "The true standard of impartiality," wrote Lord Charnwood in his classic biography of Lincoln, "is that he should conceal no fact which, in his own mind, tells against his views."⁴⁶ As a historian, Oreskes does not provide an account of the past that meets Charnwood's standard. As a science scholar, she rejects the principle of falsification in favor of consilience, the notion developed by the Victorian intellectual, William Whewell. Consilience describes the "jumping together" of different pieces of evidence from independent sources that point to the same conclusion, some of which were not contemplated in the formation of the hypothesis. According to the biologist Stephen Jay Gould, Charles Darwin's theory of evolution as the coordinating principle behind the history of life is the most brilliant example of the power of consilience.⁴⁷

In an essay commemorating the bicentenary of Darwin's birth, science writer Matt Ridley points out that 20th century DNA analysis has led to the "triumphant vindication" of Darwin's "inspired guesswork."⁴⁸ Until genetics, the idea that humans were closely related to chimpanzees was pure speculation. The study of genes could have falsified Darwin's

theory of non-random natural selection among random mutations. Genetics could have found no branching tree pattern in genomes, showing that common ancestors share different gene sequences in the same proportion. But it did find such a pattern, and Darwinism passed a sharp falsification test. As for climate science, we can be sure that if theories of man-made catastrophic climate change had passed a test, we would have heard all about it.

There is another important difference. Darwin, who once trained to be an Anglican clergyman, did not start with a theory of evolution that he subsequently set out to prove. It was his unquenchable interest in the natural world, his extraordinary powers of observation, and the astonishing originality of his mind that led him to make sense of his observations and deduce a mechanism to explain them. That is not how climate science works. Many climate scientists do not simply observe climate phenomena and then deduce explanations for their observations. When it comes to the theory that adding more carbon dioxide to the atmosphere leads to global warming, they start out with a preconceived premise and then seek out evidence confirming the theory.⁴⁹

For the same reason, climate scientists seek confirmatory evidence of global warming in shrinking ice caps, retreating glaciers and inferring past temperatures from tree rings. The risk of falling prey to confirmation bias accounts for the shoddy peer review of the “hockey stick” at the turn of the 21st century, a reconstruction of past temperature based on tree ring samples that showed what climate scientists wanted to see. It took two Canadian independent researchers from outside the field, Steven McIntyre and Ross McKittrick, to expose the contrivance that generated the hockey stick, which told a story of a 900-year trend of declining Northern Hemisphere temperatures followed by an abrupt uptick at the beginning of the 20th century. It was a prime example of the shortcomings of peer review.⁵⁰

It requires robust statistical analysis to attribute temperature rises to human activities. It matters whether future temperature rises are likely to be a lot or a little, and for that climate scientists have recourse to general circulation models. Falsification of climate models, Oreskes concedes, is “a bit of a problem,” because the accuracy of their forecasts will not be known for some time.⁵¹ GCMs that do not reproduce the past are not rejected. Rather, Oreskes says, their parameters are revised.

Not everyone agrees with Oreskes. “Folks often say models are not falsifiable. They cannot make predictions which we can actually test,” Ben Santer told the APS climate workshop. “That’s not true.”⁵² An earlier generation of climate scientists had identified changes in the pattern of vertical warming. This would indicate the fingerprint of human-induced warming because the distinctive pattern of a warming troposphere (the lowest portion of the atmosphere to about 50,000 ft.) and cooling stratosphere over the tropics would not have been caused by internal climate variability and volcanic activity. Twenty-eight control model runs of the dominant modes of natural variability do not generate this pattern on long time scales, Santer told the workshop.⁵³

John Christy revisited the troposphere warming above the tropics in his presentation to the workshop. “I am one of those people that builds climate data sets,” he said.⁵⁴ Referring to the tropical tropospheric “hot spot,” Christy told the group: “[I]f you want to look at

something that has a greenhouse signature from model simulations, that would be the place to do it, because it has the biggest signal, the most [atmospheric] mass.”⁵⁵ Comparing 102 model runs of the tropical mid-troposphere with data from weather balloons and satellites, in every case the computer runs are “much warmer” than the observations.⁵⁶

The IPCC’s solution in the Fifth Assessment Report was to say there was low confidence in the observations. Christy was unconvinced. “I don’t think that’s the case. I think we do have good information on observations and we have pretty good confidence.”⁵⁷ Santer argued the problem was the forcings, especially those in respect of aerosols (very small airborne particles) and the effect of ozone depletion. “We know beyond a shadow of the doubt that we got some of the forcings wrong systematically.”⁵⁸

A lively exchange developed between Christy and Santer. Georgia Tech’s Dr. Judith Curry, the third member of the critics’ bench, had crossed swords with Santer on whether the IPCC’s statement that more than half the observed warming was anthropogenic was more than expert judgment. In subsequent testimony to the House Science, Space, and Technology Committee, Curry explained:

Science is often *mis*characterized as the assembly and organization of data and as a collection of facts on which scientists agree. Science is *correctly* characterized as a process in which we keep exploring new ideas and changing our understanding of the world, to find new representations of the world that better explain what is observed. ... Science is driven by uncertainty, disagreement, and ignorance—the best scientists cultivate doubt.⁵⁹ [Emphases in original]

Curry’s approach to science stands firmly on the methods and philosophical standards of the scientific revolution—mankind’s single greatest intellectual achievement.

Christy went on to argue for a red team appraisal of the whole climate modeling enterprise, something he had been suggesting for 15 years. This encountered stiff opposition from IPCC-supporting scientists, who argued that that had already happened and was unnecessary. The discussion became heated, and Santer lost it, lashing out at Christy:

I would say, John, that unlike you, who just presented these discrepancies and threw up his hands and said, oh, we don’t understand these things, we have actually tried to understand these things, we have actually tried to understand why the differences exist and whether they are bona fide model response errors, whether they are forcing errors, whether they are internal variability errors.

So, I just don’t think it’s sufficient to just do the kind of analysis you have done, show discrepancies and say this proves that all models are wrong or are too sensitive to anthropogenic greenhouse gas concentrations. That is not helpful in advancing the state of the science.⁶⁰

In effect, Santer was tacitly conceding that consensus climate science and the models on which it relies are not sufficiently advanced to meet a falsification test. While the world is

asked to put its faith in climate model projections to justify the enormous costs of decarbonizing the world's economy, climate modeling remains a work in progress.

John Christy's Congressional Testimony. In 2017, Christy took his analysis of the model prediction of a tropical tropospheric hot spot to the House Science, Space, and Technology Committee. "To test this result we follow the traditional scientific method in which a claim (hypothesis) is made and then is tested against independent information to see if the claim can be sustained or whether it is falsified," Christy told the committee.⁶¹ Comparing model trends with the actual 38-year trend, the models failed to represent real world observations by "a highly significant amount."⁶²

The IPCC had these results in time for inclusion in chapter 10 of the IPCC Fifth Assessment Report. What to do with them? The inconvenient findings were relegated to an annex of supplementary material and fashioned into charts that are hard to understand, Christy told the committee.⁶³ They show model trends in which extra greenhouse gases are included lying completely outside the range of the observational trends, indicating that the GCMs, as hypotheses, failed a simple scientific-method test. It is hard to argue with Christy's conclusion: "That this information was not clearly and openly presented in the IPCC is evidence of a political process."⁶⁴ The IPCC then went on to increase its confidence in asserting that humans were causing the majority of climate change based on those very same models.

The finding that IPCC climate models perform better at matching observations without extra greenhouse gases is supported by a statistical analysis undertaken by Christy. Not only do its results falsify Oreskes's contention that those who argue that natural variability as a prime cause of temperature change are motivated solely by ideology, it also undermines the scientific basis of the Environmental Protection Agency's 2009 endangerment finding against carbon dioxide and five other greenhouse gases, which provides the EPA with the legal basis for regulating them.

In the endangerment finding, the Obama EPA had asserted that natural factors could not explain the observed warming. Christy's statistical analysis shows that they do explain 75 to 90 percent of the warming since 1979. Unlike the GCMs cooked up with extra greenhouse gas warming, trends produced by the statistical model are not statistically different from observational data. By contrast, climate models, on average, fail to reproduce the global average bulk temperature trend.⁶⁵ In a straight pass/fail empirical test, natural variability passes and consensus climate science fails.

Politicized Science vs. Red/Blue Team Appraisals. The APS workshop provides the strongest corrective to date to the politicized IPCC process. It revealed the IPCC's unscientific practice of using different assumptions for projecting future temperature increases from those used to get models to reproduce past temperature. One need not be a climate expert to see that something is seriously amiss with the near certainties promulgated by the IPCC. "I have got to say," Koonin remarked to climate modeler William Collins, "that this business is even more uncertain than I thought, uncertainties in the forcing,

uncertainties in the modelling, uncertainties in historical data. Boy, this is a tough business to navigate.”⁶⁶

Koonin came away championing Christy’s idea of a red/blue team appraisal, a term drawn from war-gaming assessments performed by the military rather than from politics, which EPA Administrator Scott Pruitt has since adopted.

A revealing indicator of its potential value is the response to it. A June 2017 *Washington Post* op-ed, condemned calls for red/blue team appraisals as “dangerous attempts to elevate the status of minority opinions.”⁶⁷ Two of the three authors we have already met—Santer and Oreskes. Ben Santer’s public positions are contradicted by the more private ones he took at the APS workshop. In a 2017 scientific paper, he attacked Scott Pruitt for claiming that satellite data had shown a leveling off of warming, “which some scientists refer to as the ‘hiatus.’”⁶⁸ One of those very scientists was Santer during the APS workshop (“So, using this method we remove ENSO [El Niño-Southern Oscillation] effects and the hiatus is still there.”).⁶⁹

Like Santer, Oreskes’s case against a red/blue assessment is also contradicted by her own arguments. Consilience is not so different from what happens in a legal case, Oreskes wrote in her 2007 paper on the rightness of the climate consensus. A prosecutor presents evidence that holds a consistent story. The defense need only show only that some element of the story is at odds with another. “In other words, scientists are more like lawyers than they might like to admit”—only in the case of climate science, Oreskes now argues the accused is not permitted a defense attorney. Even the medieval Catholic Church had a devil’s advocate to test the case for canonization.

Peer review of scientific papers is the best system we have, having served science well for several centuries, write Santer, Oreskes, and Kerry Emanuel, the op-ed’s third author. In her 2007 essay, Oreskes goes so far as to define science as the consensus of scientific experts derived from what she thinks is “the basic test for what it takes to be counted as scientific—namely, being published in a peer-reviewed journal”—a feature of all academic fields, scientific and non-scientific alike, and a reversion to the kind of appeals to authority that characterize pre-modern science.⁷⁰

Peer review and publication in academic journals are inevitably biased toward supporting the dominant paradigm of the day. In his 2008 paper on climate science, MIT’s Lindzen notes that disagreement with conclusions of the IPCC is a common basis for rejecting papers, “as long as the disagreement suggests reduced alarm.”⁷¹ Concern about peer review and the academics’ output predates the rise of global warming and is spread wider than the natural sciences. As the Nobel Prize-winning economist James Buchanan once noted: “Academic programs almost everywhere are controlled by rent-recipients who simply try to ape the mainstream work of their peers in the discipline.”⁷²

The nuclear winter scare, which turned out to be scientifically worthless, was based on two papers in *Science*, the peer-reviewed journal of the American Association for the Advancement of Science.⁷³ Having seen through the bogus peer-reviewed science of nuclear

winter, Emanuel should have known better than to put his name to an article extolling the peerless virtue of peer review.

After the APS workshop, it is understandable that Santer and other scientists supporting the consensus want to avoid a similar ordeal. It gave the IPCC's dirty linen a needed airing by revealing the shortcuts, the uncertainties, and dial-turning used to get politically acceptable results.

John Christy's congressional testimony showed how the IPCC buries inconvenient data that contradict the IPCC's carefully crafted key messages in its Summary for Policy Makers. Even that is a misnomer. Scientists prepare a draft, which is then redrafted in a conclave of representatives from the member governments, mostly officials from environment departments trying to get their ministers' views reflected in the final document. As Lord Turnbull, formerly the United Kingdom's top civil servant and a permanent secretary of the Department of the Environment, explained to the House of Lords: "In short, it is a summary *by* policymakers not *for* policymakers." [Emphasis added]⁷⁴

Might global warming turn out to be as wrong as the acid rain and nuclear winter scares? All three were originally weaponized for political purposes, the nuclear winter by the KGB in the 1980s to advance the Soviet Union's geostrategic interests and acid rain and global warming by Sweden in the 1970s. As I relate in my book, *Green Tyranny*, Sweden's Social Democrats had an ambitious civil nuclear power program and sought to bolster the case for it by launching a war against coal. Acid rain and then global warming were deployed in that war.

Due above all to Swedish efforts, for global warming, a formalized structure was conceived and established at the outset in order to manufacture the scientific consensus required to propel policy action.⁷⁵ Before he became the IPCC's first chair, Bert Bolin worked closely with two Swedish prime ministers and featured prominently in the acid rain scare. More than anyone else, Bolin brought the IPCC into being, writing later that he envisaged it as "an organ that provided an international meeting place for *scientists and politicians* to take responsibility for assessing the available knowledge concerning global climate change and its possible socio-economic implications."⁷⁶ [Emphasis in original] Records from secretive meetings at Villach in Austria and Bellagio in Italy that preceded its formal creation show how the IPCC had a political purpose hard-wired into its DNA at its conception.⁷⁷

Conclusion: Climate Policy's Democratic Deficit. Open debate is as crucial in science as it is in a democracy. It would be contrary to democratic principles to dispense with debate and rely on the consensus of experts. The latter mode of inquiry inevitably produces prepackaged answers. But, as we have seen, relying on "consensus" buttresses erroneous science rather than allow it to be falsified. The scientific consensus on acid rain turned out to be wrong and that on nuclear winter dangerously so. Had the Reagan administration followed the policy prescription of the scientists who were pushing it and backed away from the West's nuclear arms build-up, the Soviet Union may have prevailed militarily during the Cold War by succeeding in its strategic aim of splitting the Atlantic Alliance.

The IPCC is the institutional embodiment of the third scientific consensus. It was created to persuade, not provide objectivity and air disagreement. By contrast, the APS workshop gave both sides an impartial forum in which they could ask questions and probe the other side's case. In doing so, it did more to expose the uncertainty, disagreement, and ignorance—to borrow Judith Curry's words—around climate science than thousands of pages of IPCC assessment reports.

EPA Administrator Scott Pruitt's proposal for red/blue team assessment is a logical progression from the workshop. The hostile reaction it elicited from leading consensus advocates strongly suggests that they fear debate. Climate scientists whose mission is to advance scientific understanding have nothing to fear and much to gain. Those who seek to use climate science as a policy battering ram have good reason to feel uncomfortable at the prospect. The biggest winner from a red/blue team assessment will be the public. If people are to buy into policies that will drastically alter their way of life, they should be fully informed of the consequences and justifications. To do otherwise would represent a subversion of democracy.

Notes

¹ Kendra Pierre-Louis, "These conservatives want to convince you that climate change is real," *Popular Science*, May 1, 2017, <http://www.popsci.com/conservative-climate-change>.

² American Physical Society, "Climate Change Statement Review Workshop—Transcript of Proceedings," January 8, 2014, p. 32, <http://www.aps.org/policy/statements/upload/climate-seminar-transcript.pdf>.

³ *Ibid.*, pp. 35-36.

⁴ "Real Time with Bill Maher," HBO, August 4, 2017, <https://youtu.be/xHuK-VxBW3k>.

⁵ *Ibid.*

⁶ Avi Selk, "Another climate-change nightmare: 91 new volcanoes beneath Antarctica's ice," *Washington Post*, August 15, 2017, https://www.washingtonpost.com/news/speaking-of-science/wp/2017/08/15/another-climate-change-nightmare-dozens-of-volcanoes-beneath-antarcticas-thinning-ice/?utm_term=.6e24749b0d27

⁷ Justin Gillis, "Antarctic Dispatches—Part 1," *New York Times*, May 18, 2017, <https://www.nytimes.com/interactive/2017/climate/antarctica-virtual-reality.html?mcubz=1>.

⁸ Justin Gillis, "Antarctic Dispatches—Part 3," *New York Times*, May 18, 2017.

⁹ *Ibid.*

¹⁰ *Ibid.*

¹¹ Dustin Schroeder, Donald Blankenship, Duncan Young, and Enrica Quartini, "Evidence for elevated and spatially variable geothermal flux beneath the West Antarctic Ice Sheet," *PNAS*, Vol. 111, No.25 (June 24, 2014), <http://www.pnas.org/content/111/25/9070.full.pdf>. For those awaiting impending inundation from the blowtorch under the West Antarctic Ice Sheet, University of Texas researchers estimated geothermal fluxes under the Thwaites glacier of 0.1-0.2 watts per square meter, that is between one five hundredth and one thousandth of the energy that produces interglacials.

¹² Justin Gillis, "Antarctic Dispatches—Part 2," *New York Times*, May 18, 2017.

¹³ Selk.

¹⁴ Ivan Haigh, Thomas Wahl, Eelco Rohling, René Price, Charitha Pattiaratchi, Francisco Calafat, and Sönke Dangendorf, "Timescale for detecting a significant acceleration in sea level rise," *Nature Communications* (April 14, 2014).

¹⁵ Ivan Haigh, Thomas Wahl, Eelco Rohling, René Price, Charitha Pattiaratchi, Francisco Calafat, and Sönke Dangendorf, "Timescales for detecting a significant acceleration in sea level rise," *Nature Communications* (April 14, 2014), p. 2, <https://www.nature.com/articles/ncomms4635>.

¹⁶ National Aeronautics and Space Administration, "The Earth's Energy Budget Poster" (2016), https://science-edu.larc.nasa.gov/energy_budget/.

-
- ¹⁷ Gunnar Myhre, Drew D. Shindell et al, “Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis.” Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, p. 676,
https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf.
- ¹⁸ Rupert Darwall, *The Age of Global Warming: A History* (London: Quartet Books, 2013), pp. 27-28.
- ¹⁹ American Physical Society, p. 172.
- ²⁰ Ibid., p. 317.
- ²¹ Ibid., p. 316.
- ²² Ibid., pp. 316-318.
- ²³ Oren Cass, “The Problem with Climate Catastrophizing,” *Foreign Affairs*, March 21, 2017,
<https://www.foreignaffairs.com/articles/2017-03-21/problem-climate-catastrophizing>.
- ²⁴ American Physical Society, p. 329.
- ²⁵ Ibid., pp. 561-562.
- ²⁶ Ibid., pp. 491-492.
- ²⁷ Ibid., p. 54.
- ²⁸ Ibid., p. 466.
- ²⁹ Ibid., pp. 88-89.
- ³⁰ Ibid., p. 488.
- ³¹ Richard S. Lindzen, *Climate Science: Is it currently designed to answer questions?* Paper prepared for a meeting sponsored by Euresis (*Associazione per la promozione e la diffusione della cultura e del lavoro scientifico*) and the Templeton Foundation, November 29, 2008, revised September 21, 2012, p. 1,
<https://arxiv.org/ftp/arxiv/papers/0809/0809.3762.pdf>.
- ³² Ibid.
- ³³ Ibid., p. 21.
- ³⁴ American Physical Society, p. 334.
- ³⁵ Ibid., p. 253.
- ³⁶ Ibid., p. 259.
- ³⁷ Ibid., pp. 269-270.
- ³⁸ Naomi Oreskes, “The Scientific Consensus on Climate Change: How Do We Know We’re Not Wrong?” (2007), p.73,
<https://www.lpl.arizona.edu/sites/default/files/resources/globalwarming/oreskes-chapter-4.pdf>.
- ³⁹ American Physical Society, “Climate Change Statement Review Workshop – Transcript of Proceedings,” January 8, 2014, p.487
- ⁴⁰ Oreskes, p. 73.
- ⁴¹ Ibid., p. 93.
- ⁴² Ibid., p.80
- ⁴³ Pete Earley, *Comrade J: The Untold Secrets of Russia Master Spy in America after the End of the Cold War* (New York: G.P. Putnam’s Sons, 2007).
- ⁴⁴ Ibid., p. 114
- ⁴⁵ Naomi Oreskes and Erik M. Conway, *Merchants of Doubt* (New York: Bloomsbury Press, 2011), p. 65.
- ⁴⁶ Lord Charnwood, *Abraham Lincoln: A Biography* (New York: Henry Holt and Company, 1917), p. 8.
- ⁴⁷ Stephen Jay Gould, *The Hedgehog, the Fox and the Magister’s Pox* (New York: Harmony Book, 2003), p. 211.
- ⁴⁸ Matt Ridley, “Modern Darwins,” *National Geographic*, February 2009,
<http://ngm.nationalgeographic.com/2009/02/darwin-legacy/ridley-text>.
- ⁴⁹ Darwall, *The Age of Global Warming*, p. 113.
- ⁵⁰ Ibid., pp. 200-224.
- ⁵¹ Oreskes, p. 85.
- ⁵² American Physical Society, pp. 178-179. Santer’s claim that the hot spot is unique to man-made warming is incorrect. Rather, it is due to condensation in rising air and the resulting latent heat release (the moist adiabatic lapse rate). The concept of the hot spot is relative—the troposphere warming faster than surface warming. This suggests that the surface temperature record in the tropics overstates any actual warming there. It also implies that the general circulation models used by Santer in his analysis are faulty in not producing a hot spot with non-anthropogenic warming.
- ⁵³ Ibid., p. 203.
- ⁵⁴ Ibid., p. 330.

-
- ⁵⁵ Ibid., p. 335.
- ⁵⁶ Ibid., p. 343.
- ⁵⁷ Ibid., p. 30.
- ⁵⁸ Ibid., p. 272.
- ⁵⁹ Judith A Curry, Statement to the Committee on Science, Space and Technology of the United States House of Representatives, March 29, 2017, p. 3, <https://science.house.gov/sites/republicans.science.house.gov/files/documents/HHRG-115-SY-WState-JCurry-20170329.pdf>.
- ⁶⁰ American Physical Society, pp. 502-503.
- ⁶¹ John R. Christy, Testimony to the U.S. House Committee on Science, Space, and Technology, March 29, 2017, p. 3, <https://science.house.gov/sites/republicans.science.house.gov/files/documents/HHRG-115-SY-WState-JChristy-20170329.pdf>.
- ⁶² Ibid., p. 7.
- ⁶³ Ibid., p. 8.
- ⁶⁴ Ibid., p. 9.
- ⁶⁵ Ibid., p. 11.
- ⁶⁶ American Physical Society, pp. 92-93.
- ⁶⁷ Benjamin Santer, Kerry Emanuel, and Naomi Oreskes, "Red teams and blue teams are no way to conduct climate science," *Washington Post*, June 21, 2017, https://www.washingtonpost.com/news/capital-weather-gang/wp/2017/06/21/attention-scott-pruitt-red-teams-and-blue-teams-are-no-way-to-conduct-climate-science/?utm_term=.8e697634d5c8.
- ⁶⁸ Benjamin D. Santer, Susan Solomon, Frank J. Wentz, Qiang Fu, Stephen Po-Chedley, Carl Mears, Jeffrey F. Painter, and Céline Bonfils, "Tropospheric Warming Over The Past Two Decades," *Scientific Reports*, May 24, 2017, <https://www.nature.com/articles/s41598-017-02520-7>.
- ⁶⁹ American Physical Society, p. 214.
- ⁷⁰ Oreskes, p. 93.
- ⁷¹ Lindzen, p. 16.
- ⁷² Quoted in Leland B Yeager, *Is the Market a Test of Truth and Beauty? Essays in Political Economy* (Auburn, Alabama: Nabu Press, 2011), p.251.
- ⁷³ R. P. Turco, O. B. Toon, T. P. Ackerman, J. B. Pollack, and Carl Sagan, "Nuclear Winter: Global Consequences of Multiple Nuclear Explosions," *Science* Vol. 222, No. 4630 (December 23, 1983) and Paul Ehrlich et al., "Long-term Biological Consequences of Nuclear War," *Science*, Vol. 222, No. 4630 (December 23, 1983), https://canvas.harvard.edu/files/2112592/download?download_frd=1&verifier=aFBR7DRZQpnbTm1SYxwnMFzucKN2OUUO73VDv6hh.
- ⁷⁴ Lords Hansard, Col. 1051, December 8, 2009, <https://publications.parliament.uk/pa/ld200910/ldhansrd/text/91208-0010.htm#091208120000161>.
- ⁷⁵ Rupert Darwall, *Green Tyranny: Exposing the Totalitarian Roots of the Climate Industrial Complex* (New York, 2017), pp. 122-128.
- ⁷⁶ Bert Bolin, *A History of the Science and Politics of Climate Change: The Role of the Intergovernmental Panel on Climate Change* (Cambridge, UK: Cambridge University Press, 2007), p. 39.
- ⁷⁷ Rupert Darwall, *Green Tyranny: Exposing the Totalitarian Roots of the Climate Industrial Complex* (New York, 2017), pp. 126-128.