

**The 1995 IPCC Report:
Broad Consensus or “Scientific Cleansing”?**¹

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In the spring of 1996, the Intergovernmental Panel on Climate Change (IPCC) released its Second Assessment Report (SAR) on the question of human impacts on the global climate system.² Like past IPCC assessments, the SAR had three parts: climate science (Working Group I), impacts of climate change (Working Group II), and economic and social dimensions (Working Group III).

The Global Climate Coalition (an energy industry lobby group) and a number of self-proclaimed “contrarian” scientists immediately launched a major, organized attack designed to discredit the conclusions of Working Group I as expressed in the SAR. They claimed that the IPCC had inappropriately altered a key chapter for political reasons. They alleged that the IPCC had “corrupted the peer review process” and violated its own procedural rules.

These accusations ignited a major debate — widely reported in the press — lasting several months. Were the charges true?

THE IPCC SECOND ASSESSMENT REPORT

The IPCC is an office of the United Nations Environment Programme and the World Meteorological Organization. It evaluates and synthesizes the scientific understanding of global climate change for national governments and United Nations agencies. Its goal is fairly to represent the full range of credible scientific opinion and, if possible, to identify a consensus view on the most likely scenario(s) within this range. The IPCC’s reports are intensively peer-reviewed. They are generally regarded as the single most authoritative source of

information on climate change and its potential impacts on environment and society.

Like all IPCC assessments, the SAR contained three “Summaries for Policymakers” (SPMs), one for each of the IPCC’s three Working Groups. Since the full SAR stretches to well over 2,000 pages of mostly dense technical prose, few outside the scientific community are likely either to read it in its entirety or to understand most of its details. Therefore, these summaries tend to become the basis for press reports and public debate. For this reason, the Working Groups consider their exact wording with extreme care before they are published. At the end of the IPCC report process, they are approved *word for word* by national government representatives at a plenary meeting attended by only a fraction of the lead authors.

The SPM for Working Group I, which assesses the state of the art in the physical-science understanding of climate change, contained the following now-famous paragraph:

Our ability to quantify the human influence on global climate is currently limited because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. These include the magnitude and patterns of long-term natural variability and the time-evolving pattern of forcing by, and response to, changes in concentrations of greenhouse gases and aerosols, and land surface changes. *Nevertheless, the balance of evidence suggests that there is a discernible human influence on global climate. (Italics added.)*³

Three-quarters of this paragraph consists of caveats about uncertainties and limitations of current understanding. Nonetheless, it marked the first time the IPCC had reached a consensus on two key points: first, that global warming is probably occurring (“detection”), and second, that human activity is more likely than not a significant cause (“attribution”). Like this summary paragraph, the body of the report discussed — frequently and at length — the large scientific uncertainties about attribution. The Working Group carefully crafted the “balance of evidence” sentence in the SPM to communicate the strong majority opinion that despite these uncertainties, studies were beginning to converge on a more definitive answer to the attribution question.

The SAR was fraught with political significance. Official publication of the full report occurred in early June, 1996. At that point the Second Conference of Parties (COP-2) to the 1992 Framework Convention on Climate Change was about to meet in Geneva. A sea change in American climate policy was widely rumored. Since the Reagan administration, official U.S. policy had sanctioned only voluntary, non-binding emissions targets and further scientific research. If the United States were to abandon its resistance to binding emissions targets, a strong international greenhouse policy would become much more likely. Since

the more-research, no-binding-targets position was officially based on assertions of high scientific uncertainty, the SAR's expressions of increased scientific confidence were viewed as critical.

The rumors proved correct. On July 17, 1996, U.S. Under-Secretary of State for Global Affairs Tim Wirth formally announced to COP-2 that the United States would now support "the adoption of a realistic *but binding* target" for emissions. The exact degree to which the IPCC SAR influenced this policy change cannot be known. But Wirth certainly gave the impression that the report was its proximate cause. He noted in his address that "the United States takes very seriously the IPCC's recently issued Second Assessment Report." He then proceeded to quote the SAR at length, proclaiming that "the science is convincing; concern about global warming is real."⁴

"A MAJOR DECEPTION ON GLOBAL WARMING"

On June 12, 1996, just days after formal release of the IPCC SAR and scant weeks before the COP-2 meeting in Geneva, the *Wall Street Journal* (WSJ) published an op-ed piece entitled "A Major Deception on Global Warming." The article was written by Frederick Seitz, President Emeritus of Rockefeller University. Seitz is not a climate scientist but a physicist. Nevertheless, his scientific credentials are formidable. He is a recipient of the National Medal of Science and a past President of both the National Academy of Sciences and the American Physical Society.

In his article, Seitz accused some IPCC scientists of the most "disturbing corruption of the peer-review process" he had ever witnessed.⁵

Seitz's Accusations

Seitz's proclaimed distress stemmed from the fact that the lead authors of the SAR's Chapter 8 — on detection and attribution — had altered some of its text *after* the November, 1995 plenary meeting of Working Group I (WGI), in Madrid, at which time the chapter was formally "accepted" by the Working Group. According to Seitz, since the scientists and national governments who accepted Chapter 8 were never given the chance to review the truly final version, these changes amounted to deliberate fraud and "corruption of the peer-review process." Not only did this violate normal peer review procedure, Seitz charged; it also violated the IPCC's own procedural rules.

Quoting several sentences deleted from the final version of the chapter, Seitz argued that the changes and deletions "remove[d] hints of the skepticism with which many scientists regard claims that human activities are having a major impact on climate in general and on global warming in particular." Without directly attributing motives, Seitz implied that the changes had been made in the interests of promoting a particular political agenda. Seitz said that Benjamin D.

Santer, lead author of Chapter 8, would have to shoulder the responsibility for the “unauthorized” changes. Seitz was not present at the IPCC meetings. He did not contact Santer or anyone else at the IPCC to verify that the changes were indeed “unauthorized” before publishing his op-ed piece.

Responses from Santer and the IPCC

Santer responded immediately, in a letter co-signed by some 40 other IPCC officials and scientists (myself among them - SHS). They said that Seitz had misinterpreted the IPCC rules of procedure. Rather than being “unauthorized,” they wrote, the post-Madrid changes were in fact *required* by IPCC rules, under which authors must respond to comments submitted during peer review or arising from discussions at the meetings.⁶

Commentators at the Madrid meeting had advised making changes to Chapter 8 for two reasons. First, they urged clarification of the meaning and scientific content of some passages in accordance with the recommendations of reviewers (including some criticisms introduced at the Madrid meeting itself). Second, they thought the structure of the chapter should be brought into conformity with that of other SAR chapters. In particular, a “Concluding Summary” was removed from the final version, since no other chapter contained a similar section. (Chapter 8, like all the rest, already had an “Executive Summary.”) Sir John Houghton, in his capacity as co-chairman of WGI, specifically authorized the changes.

Santer, in consultation with other Chapter 8 authors, made the suggested changes in early December. The entire SAR, including the newly revised Chapter 8, was “accepted” by the full IPCC Plenary at Rome later than month.

Santer made the changes himself, and the final version of the chapter was not reviewed again by others. However, as he and his colleagues continually stressed, this procedure was the normal and agreed IPCC process. Santer et al. pointed out that no one within the IPCC objected (or had ever objected) to this way of handling things. Replying separately in support of Santer and his colleagues, IPCC Chairman Bert Bolin and WGI Co-Chairmen John Houghton and L. Gylvan Meira Filho quoted the official U.S. government review of Chapter 8, which stated explicitly that “it is essential that... the chapter authors be prevailed upon to modify their text in an appropriate manner following discussion in Madrid.”⁷

Further Exchanges

The WSJ op-ed was not the first time charges of suppression of scientific uncertainty in Chapter 8 had been aired. On May 22, a few days before the Seitz op-ed appeared, the small journal *Energy Daily* reported the same allegations in considerably greater detail.⁸ The *Energy Daily* article also reported their source: a

widely circulated press release of the Global Climate Coalition (GCC, an energy industry lobby group).

In its June 13 issue, the prestigious science magazine *Nature* also reported on the GCC allegations.⁹ The *Nature* report, unlike the Seitz and *Energy Daily* articles, included explanations of the revision and review process from Santer and the IPCC. Under the hot-button headline “Climate report ‘subject to scientific cleansing,’” an accompanying editorial argued that the GCC analysis was politically motivated and generally false. But the editorial also noted that the Chapter 8 changes may have resulted “in a subtle shift... that... tended to favour arguments that aligned with [the SAR’s] broad conclusions.”¹⁰

The WSJ op-ed set off a lengthy chain of exchanges lasting several months. The main participants in the public controversy were Seitz, Santer, other Chapter 8 authors, the Chairmen of the IPCC (Sir John Houghton and Bert Bolin), and climate-change skeptics S. Fred Singer and Hugh Ellsaesser. Singer, in particular, made the charges of political motivation explicit. In a letter to the *Wall Street Journal*, he wrote that Chapter 8 had been “tampered with for political purposes.” The IPCC, he claimed, was engaged in a “crusade to provide a scientific cover for political action.”¹¹

Semi-privately, in electronic mail exchanges involving many additional participants (and widely copied to others), the debate became intense and sometimes quite bitter. Santer, who felt forced to defend himself, spent the majority of his summer time responding to the charges. Previously a quiet, private man known to scientists primarily as a proponent of the rigorous use of statistical methods, Santer rapidly became a public figure, submitting to dozens of interviews. The drain on his time and energy during this period kept him from his scientific work, he said.¹²

Both the public and the private exchanges themselves became objects of further press reports, widely disseminated by the news wire services. As they went on, the debate spread from the initial issues about peer review and IPCC procedure to include questions about the validity of Chapter 8’s scientific conclusions. Even before the report was formally published, climate-change contrarians had claimed that Chapter 8 dismissed or ignored important scientific results that disconfirmed the global warming hypothesis. They argued that the allegedly illegitimate changes to Chapter 8 made this problem even more acute.¹³

DID THE CHAPTER 8 AUTHORS VIOLATE IPCC RULES?

Seitz, the GCC, and others accused the authors of Chapter 8 of fraud on two counts. First, they alleged that the changes made to Chapter 8 after the final IPCC plenary violated the IPCC’s own rules of procedure. Second, and more seriously, they charged them with violating the fundamental standards of scientific peer

review. In this section, we argue that IPCC rules were not violated in the case of Chapter 8. In addition, we argue that *in practice* the process correctly reflects the essential tenets of peer review. However, we also show that the IPCC rules do not specify adequate closure mechanisms for the report drafting process. We demonstrate that the two-level certification process (“acceptance” and “approval” of IPCC documents) is poorly specified as well, and can even invite misinterpretation by determined critics.

In their responses to the Seitz/GCC charges, the Chapter 8 authors claimed that IPCC rules *required* them to make the changes advised immediately before and during the Madrid WGI Plenary. Analysis of the IPCC rules suggests that the real situation is more ambiguous. Yet they had three very good reasons for believing this to be the case.

First, the rules require authors to respond to commentary, to the best of their ability and as fully as possible.¹⁴ Working Group co-chairs have broad discretion to define this process and set time limits for it. Nowhere do IPCC rules explicitly address the question of when a report chapter becomes final (i.e., when all changes must cease). Therefore, Santer et al. correctly understood that the Working Group Chairs and the Plenary meeting itself would define the endpoint of the revision process.

Second, report chapters are “accepted” rather than “approved.” Acceptance constitutes IPCC certification that *the drafting and review process has been successfully completed*. It is an expression of trust in the authors and the process, and is explicitly distinguished from “approval,” or detailed review on a line-by-line basis. Operating under these definitions, the IPCC Plenary “approved” the WGI Summary for Policymakers (SPM), but “accepted” Chapter 8. In other words, Plenary acceptance did not imply word-for-word review of the chapter. Instead, it indicated trust that the authors had responded appropriately and sufficiently to the review process. Therefore, the Chapter 8 authors believed that the rules permitted them to make changes when explicitly requested to do so by the IPCC Plenary, or in response to peer comments received at or immediately prior to the Plenary.

Third, no IPCC member nation has ever seconded the Seitz/GCC objections.¹⁵ (Ninety-six countries were represented at the Madrid plenary.) From this, above all, we can safely infer that Santer et al. proceeded exactly as expected.

Santer et al. believed that they were following IPCC rules, and this made perfect sense within the well-established informal culture of the IPCC. However, a careful reading of the IPCC’s *formal* rules reveals that in fact the rules *neither allow nor prohibit* changes to a report after its formal acceptance. The legalistic Seitz/GCC reading of the rules is not, therefore, completely implausible — even if it was, as we believe, primarily a smokescreen to divert attention from the clear consensus that attribution could no longer be considered unlikely.

Our analysis suggests a significant flaw in the rules as currently written. While “approved” documents (the SPMs) clearly must not be altered once approved, there is no precisely defined closure mechanism for “accepted” documents (full-length Working Group reports and their constituent chapters).¹⁶ The Seitz/GCC attack has effectively demonstrated that a hybrid science/policy organization like the IPCC needs better, more explicit rules of procedure. This minor virtue aside, however, the Seitz/GCC reading violates the spirit and intent of the IPCC process.

The IPCC is run by scientists. Its participants think of it primarily as a scientific body. By the standards of many political organizations, its formal rules are not very extensive. They are also not very specific. They purposely leave undefined the meaning of key terms such as “expert” and important processes such as “taking into account” comments. Under the rules, Lead Authors carry full responsibility for report chapters, and the IPCC leadership retains very broad discretion, subject to Plenary “acceptance” and “approval” by national governments.

There are good reasons for this arrangement. Formal procedures are relatively unimportant in scientific culture. This is true because scientists belong to very small social groups endowed with extremely strong and deeply entrenched (informal) norms. In addition, since scientific methods and results are constantly changing, too much focus on formal rules would inhibit progress. Likewise, formal rules are not very important in the day-to-day functioning of the IPCC. Instead, *informal rules based on the everyday practices of scientific communities* guide the bulk of the work.

Maintaining this informality is quite important for effective scientific work. Yet it is not without dangers, especially in a situation where almost any scientific finding can have political implications. Just as in any other politicized realm, without clear procedures to ensure openness and full rights of participation, dissenters may find — or believe they have found — their voices ignored. One of the IPCC’s most important features is its openness and inclusivity; balancing this against scientific informality will require constant vigilance, and perhaps a reconsideration of the formal review process.

From the point of view of *political* legitimacy, then, acceptance of reports before final revision is clearly a risky proposition. But from the viewpoint of scientific legitimacy, ongoing revision is a normal feature of the research cycle. Even after a multi-stage review process, minor flaws can be found and improvements added. This is not unlike the common situation in which an author makes minor changes to the galley proofs of a manuscript — changes not subject to peer review. Thus, in the case of the IPCC, adding a final approval stage to the already long and cumbersome review process would be unlikely to add significantly to the scientific credibility of the final result. While it needs to revise

its rules to better protect itself from accusations of political capture, the IPCC must also, at all costs, avoid becoming a science-stifling, inflexible bureaucracy.

DID THE CHAPTER 8 REVISIONS “CORRUPT” THE PEER REVIEW PROCESS?

One of the most important informal, everyday practices of science is peer review. Seitz and the GCC accused the IPCC of violating this standard, too. Were they right?

In a typical peer review procedure, scientists write articles and submit them to a scientific journal. The journal editor sends the article to several referees, all of them experts in the authors’ field (“peers”). Most peer review is “blind,” meaning that referees do not know the authors’ identity. (Not all journals conform to this standard.) In most cases, the referees’ identity is kept secret from the author. However, some journal editors, like myself (SHS), encourage referees to reveal themselves. Since many scientific communities are quite small, referees and authors can often guess each other’s identity.

Referees may recommend acceptance, rejection, or acceptance after certain specified changes are made (“revise and resubmit”). The last of these responses is by far the most common. The authors then rewrite their article in response to the reviewers, and the editor serves as referee. The process usually goes back and forth several times, with several rounds of revision, until a suitable compromise is achieved among reviewers, authors and the editor. A similar process is normally applied to grant proposals.¹⁷

To decide whether Chapter 8 “corrupted” this process, let’s look at how it worked in IPCC Working Group I (WGI). In July of 1995, the third installment of the WGI drafting and review process for the SAR took place in Asheville, North Carolina. This meeting, like all other IPCC processes, was characterized by exceptional openness to critique, review, and revision. About six dozen climate scientists from dozens of countries took part. The meeting was designed to make explicit the points of agreement and difference among the scientists over exceedingly controversial and difficult issues, including Chapter 8 — the most controversial.

New lines of evidence had been brought to bear by three climate modeling groups around the world, each suggesting a much stronger possibility that a climate change signal has been observed and that its pattern (or fingerprint) is matched to anthropogenic changes. Ben Santer, as the Convening Lead Author of Chapter 8, had assembled the results of a number of modeling groups. He presented the results of his group’s effort not just to Chapter 8’s Lead Authors and contributors, as is typical in IPCC meetings, but to the entire scientific group assembled at Asheville.

In this setting, Santer had to explain this work not only to his most knowledgeable peers, but also to scores of others from diverse scientific communities. These included stratospheric ozone experts like Susan Solomon and Dan Albritton, satellite meteorologists like John Christy, and biosphere dynamics experts such as Jerry Melillo. Climatologists such as Tom Karl and I (SHS) were also present, along with the heads of national weather services and other officials from several countries who served on the IPCC's assessment team.

Not everybody was equally knowledgeable on the technical details of the debate, of course. Perhaps only 25 percent of those assembled had truly in-depth knowledge of the full range of details being discussed. However, all understood the basic scientific issues and most know how to recognize slipshod work -- to say nothing of a fraud or a "scientific cleansing" -- when they see it. Even the less familiar participants thus served an essential role: they acted as technically-skilled witnesses to the process of honest, open debate.

This remarkable session lasted for hours. (In fact, it was continued after dinner by roughly a dozen scientists, who spent nearly three hours discussing the final paragraph of the "Detection Section" of the Summary for Policymakers.)¹⁸ Though occasionally intense, it was always cordial, never polemical. As a result, the wording of Chapter 8 was changed. Ideas and concepts were somewhat altered, but basic conclusions by and large remained unchanged — because the vast bulk of those assembled were convinced that the carefully hedged statements the lead authors proposed were, in fact, an accurate reflection of the state of the science based upon all available knowledge, including the new results.

This was peer review at ten times the normal level of scrutiny! It would be practically inconceivable for the editor of a peer-reviewed journal to duplicate this process. A few referees and an editor can only hope to execute the reviewing role a fraction as well as the remarkable, open process at Asheville. Moreover, after the Asheville meeting, two more IPCC drafts were written and reviewed by hundreds of additional scientists from all over the globe.

An Open Process of Scientific Debate: Witnessing in Action

At Madrid, Santer presented Chapter 8's conclusions to the national delegates of 96 IPCC member nations. The conclusions were not presented alone, but followed a presentation to the plenary session of the scientific evidence contained in Chapter 8. Nevertheless, several countries objected to the Chapter 8 conclusions. Most of the objections came from OPEC or less-developed nations. One delegate, from Kenya, moved to have the chapter entirely dropped from the final report.

In response, the meeting's chair — following procedures often used at IPCC Plenary meetings to resolve disputes — called for a drafting group to revise the chapter as well as and the detection and attribution section of the Summary for

Policymakers. Nations complaining about the Chapter 8 draft were invited, indeed expected, to meet with Lead Authors, first to discuss the scientists' point of view and then to fashion new, mutually acceptable language.

This breakout group worked for the better part of a day. Delegates from over half a dozen countries — including the Kenyan who had publicly advocated dropping the chapter — met with about half a dozen Chapter 8 authors, including Santer, co-Lead Author Tom Wigley, and scientists Kevin Trenberth, Michael MacCracken, John Mitchell, and me (SHS). The Kenyan sat next to me. Initially, he was confused by the discussion and somewhat hostile. We had many side conversations about what was being discussed: models, data, statistical tests and various climate forcing scenarios. Although he was not a front-rank climate researcher, this delegate was a trained scientist. He began to grasp the nature of the Lead Authors' arguments, listening carefully to about half of the breakout meeting.

Ironically, the Saudi Arabian delegation sent no representative to this most controversial drafting group, even though Saudi Arabia had led the opposition in the plenary meeting. During the Chapter 8 debate, Saudi delegates often issued objections soon after receiving notes from the Global Climate Coalition representative. (Non-governmental organizations were also represented at Madrid. For example, S. Fred Singer — President of the Science & Environmental Policy Project and a self-proclaimed contrarian — raised a number of issues from the floor.)

Later in the plenary meeting, when Santer presented the drafting group's revised text, the Saudi delegates once again objected. Santer forcefully challenged them. Why, he asked, had no Saudi attended the breakout group — if their objections had some basis in science? The head Saudi delegate haughtily announced that he didn't have to account for his decisions about which drafting group to attend. Besides, he said, his was "only a small delegation" of a few people.

At this point the Kenyan delegate rose to speak. (I held my breath.) "I'm a member of a small delegation too," he said. (He was the only Kenyan representative.) "But somehow I managed to attend this most important drafting session. As a result, I am convinced that Chapter 8 is now well written and I have no objections to its inclusion in the report." (I paraphrase his words from memory.) The impact of his intervention was stunning, stopping with a few words what appeared to be a mounting movement of OPEC and LDC opposition to Chapter 8 before it could garner any further support.

Later on I privately congratulated the Kenyan for having the courage to object publicly, observe privately, and then re-evaluate his position before the entire plenary. He said he wasn't sure his country would approve of his stance, but having witnessed the debate process for several hours, he had become convinced it was honest and open. That was all he needed to change his opinion from preconceived skepticism to support of the Lead Authors' conclusions.

What this courageous delegate did was *the essence of good science*. He allowed his initial hypothesis to be subjected to new evidence, tested it, and found it wanting. He then listened to arguments for a different point of view, subjected them to the tests of evidence and debate, and reached a new conclusion.

Contrast this open IPCC process with that of the critics led by Seitz and the Global Climate Coalition. The latter first presented their technical counter-arguments in such “refereed scientific literature” as the editorial pages of the *Wall Street Journal*. Some even had the temerity to allege (falsely) that Chapter 8’s conclusions were based upon non-peer-reviewed articles.¹⁹ The Seitz/GCC group charged that the minor changes made to Chapter 8 during the post-Madrid revision process had somehow dramatically altered the report. Without a shred of evidence, Singer and others asserted that the changes were politically motivated “scientific cleansing.”

These irresponsible claims were not reviewed by a single independent, expert peer before being published — in the opinion pages of a business daily and a few news magazines. We leave it to readers to decide which are more credible: the reports of the IPCC, submitted to many rounds of extremely public, intensive peer review, or the op-ed pieces and pamphlets of Seitz, Singer, and the GCC.

WHAT ABOUT THE SCIENCE?

In a nutshell, the new evidence reported to IPCC and later published in *Nature* was based not upon new empirical or theoretical results, but on new ways of asking climate models the right questions.²⁰ In the past, critics such as the University of Virginia’s Pat Michaels had correctly argued that direct observational evidence of global warming effects (i.e. “signals”) in the climate record were not very well matched to CO₂-only model results. For example, CO₂-only models suggested that the Earth should have warmed up 1°C rather than the one-half degree C observed in the last century. Additionally, CO₂-only models suggested that the Northern Hemisphere would warm up more than the Southern Hemisphere. Such models also, however, suggested the stratosphere would cool as greenhouse gases increased. This clearly was happening (although at least part of that cooling can be attributed to stratospheric ozone depletion).²¹

The Earth’s warming of a half degree C during the 20th century could be explained simply by asserting the trend to be a natural fluctuation in the climate. The IPCC scientists attempted to estimate the likelihood that natural events were responsible for the observed surface warming. They concluded that this was possible, but improbable. Critics, meanwhile, simply asserted that the warming was natural, without characterizing the probability that this was the correct explanation. Even if it did go unchallenged in a number of op-ed articles, this is a scientifically meaningless claim.

What is the probability that a half-degree warming trend in this century is a natural accident? This cannot be answered by looking at the thermometer record alone, since a globally averaged record is not reliable for much more than a century, if that. It is like trying to determine the probability of “heads” in a coin flip by flipping it once. Instead, climate scientists look at proxy records of climate change over long periods of time, such as fluctuating time series of tree ring widths, the deposits left from the comings and goings of glaciers, and the fluctuations of various chemical constituents in ice cores. These records, while not direct measurements of global temperatures, are nonetheless proportional to components of the climate in different parts of the world, and provide a rich record of natural variability.

This record (as summarized in Chapter 3 of the SAR) suggests that the warming of the last century is not unprecedented.²² But it also is not common. Perhaps once in a millennium, such proxy records suggest, a half-degree C global century-long trend could occur naturally.²³ In my judgment (SHS), this circumstantial evidence implies that a global surface warming of half a degree has about an 80 to 90 percent likelihood of *not* being caused by the natural variability of the system.

Natural climatic forcing factors, such as energy output changes on the sun or peculiar patterns of volcanic eruptions, could cause the observed climate trend. However, each of these climate forcings has a peculiar signature or fingerprint. For example, energy increases from the sun would warm the surface, the lower atmosphere, and the stratosphere all at the same time. On the other hand, greenhouse gas forcing would cool the stratosphere while warming the troposphere. Aerosols from human activities, particularly the sulfates generated in coal- and oil-burning regions of the US Northeast, Europe, and China, would cool the troposphere mostly during the day and not at night, and would largely cool the Northern Hemisphere, especially in the summertime when the sun is stronger.

This aerosol effect has turned out to be very important. Indeed, adding sulfate aerosols to greenhouse gas increases in the models led to a dramatic boost in the confidence that could be attached to the circumstantial evidence associated with climatic fingerprints. That is, when the models were driven by both greenhouse gases globally, and sulfate aerosols regionally, no longer did the Northern Hemisphere warm up more than the Southern Hemisphere, or all parts of the high latitudes substantially more than the low latitudes. Instead, a different fingerprint pattern emerged. Moreover, this pattern in the models showed an increasing correlation with observations over time — precisely what one would expect in a noisy system in which the human forcing increases with time. By itself, the pattern still has roughly a 10 percent chance of being a random event. However, when taken together with good physical theory and knowledge of ice age-interglacial cycles, seasonal cycles, volcanic eruptions, and now more consistent fingerprints, the vast bulk of the scientific community felt it was not

irresponsible to assert that there was a higher likelihood that human climate signals had been detected. This is the basis for Chapter 8's now-famous claim that "the balance of evidence suggests a discernible human influence on climate."

At this point in the evolution of knowledge about the Earth's climate system, this is no longer a radical statement. It reflects a lowest-common-denominator consensus view of the vast majority of scientists. It does *not* say that a climate warming signal has been detected beyond any doubt. Neither we nor any other responsible scientists would make such a claim. But it does offer good reason to begin to plan, responsibly, for the possibility — which we now see as more likely than not — that the global climate will warm by at least one or two degrees during the next 50 years.

HOW SHOULD WE RESPOND TO CLIMATE-CHANGE CONTRARIANS?

To ignore contrarian critics would be inappropriate. Occasionally, non-conventional outlier opinions revolutionize scientific dogma (Galileo and Einstein being the most oft-cited examples). However, we believe that news stories are grossly misleading and irresponsible if they present the unrefereed opinions of contrarians as if they were comparable in credibility to the hundred-scientists, thousand-reviewer documents released by the IPCC. The general public cannot be relied upon to determine for themselves how to weigh these conflicting opinions. And to publish character-assassinating charges of "scientific cleansing" without checking the facts is simply unethical — at least in any system of ethics we respect.

The journalistic doctrine of "balance", while perhaps appropriate in two-party political systems where the "other side" must always get its equal coverage, is inappropriate if applied literally to multifaceted scientific debates. In climate science, wide ranges of probabilities are attached to a whole array of possible outcomes.²⁴ Scientific controversy simply can't be trivialized into a false dichotomy between those who assert that human effects are likely to produce a catastrophic, "end of the world" crisis, "balanced" against those who assert that at worst nothing will happen and at best it will all be good for us. "The end of the world" and "no impact at all" are *the two lowest-probability cases*.

This is not just a problem for journalists. It also affects scientists. In communication with the public, we sometimes tend to focus our attention on controversies at the cutting edge of the art, rather than present clear perspectives on what is well understood — separating what is truly known from what is merely probable and both of these from what is highly speculative. This, combined with the propensity of the media to focus on "dueling scientists" and extreme, outlier opinions, leads to a miscommunication of the actual nature of the scientific consensus.²⁵

This consensus is vital to the policy process. In essence, the policy question is to decide how much of current resources should be invested as a hedge against potential negative outcomes. This clearly is a value judgment. It is precisely the kind of judgment that the public and the policy establishment should make, but it can only be made if the decisionmakers — who are not, and are not going to become, experts — are aware of the best range-of-probability and range-of-consequences estimates of the responsible scientific community.

Faxes sent by special interests to every major journalist on the planet or every significant elected and unelected official — what we like to call the “one fax, one vote” syndrome — are not very good sources of truth. Vastly better is the work of groups such as the IPCC and the National Research Council, which although slow, deliberative, sometimes snobby, and occasionally dominated by strong personalities, are nonetheless the best representation of the scientific community’s current general opinion.

This kind of scientific consensus is not the same thing as “truth.” Once in a while, the contrarians are right. Indeed, we are certain that some aspects of the current vision of climate change will turn out to be of minor impact, while others will prove to be more serious than currently thought. That is why assessment needs to be a continuous process, and why all policymaking requires “rolling reassessment.” The IPCC, or its progeny, need to be reconvened every five years or so. Only with this input can the political process legitimately decide, and re-decide, to crank up its efforts at mitigation — or to crank them back down, depending upon what is learned in each new assessment about the climate system, the impact of climate change on environment and society, and the distribution of mitigation costs. This ongoing and open process of refinement of knowledge is the only way that a complex system can become adaptive. Only an adaptive system can minimize the likelihood of making major mistakes, either by overinvesting in environmental protection or by allowing nasty experiments to be performed on Laboratory Earth without any attempt to anticipate or slow down the potential negative, irreversible consequences.²⁶

NOTES

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² Houghton, J.J., Filho, L.G.M., et al., eds. 1996. *Climate Change 1995: The Science of Climate Change*. Cambridge, UK, Cambridge University Press.

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