Chapter 8

What's New in Climate Change 1995

With the global stakes enormous, it will be important to get the science of climate change right. The definitive 1990 *Climate Change: The IPCC Scientific Assessment* was a compendium of the best peer-reviewed basic science available at the time. Five years later, the Intergovernmental Panel on Climate Change summarized half a decade of further research in *Climate Change 1995*.

The skeptics who may have hoped that better science in the 1995 report would blow holes in global warming theories could only have been disappointed. It confirmed the central conclusion of the 1990 report, "that continued accumulation of anthropogenic greenhouse gases in the atmosphere would lead to climate change whose rate and magnitude were likely to have important impacts on natural and human systems."

Moreover, *Climate Change 1995* took an important step beyond the 1990 report with its suggestion that human-induced climate warming had already begun. That proposition was hailed triumphantly by warming true-believers as a vindication of their position. It also became the focus of an intense debate over the 1995 report's objectivity — with skeptics trying to discredit it by saying the finding of "discernible human influence" had been reached through a process more political than scientific.

To evaluate the IPCC report's objectivity, it is helpful to understand the process by which the report's language was produced (see sidebar, p.112). Hundreds of scientists from dozens of countries contributed to, and later reviewed, the draft. Numbers alone are not the whole story — both skeptics and believers have managed to come up with statements signed by large numbers of scientists. More telling, perhaps, is whether the scientists are making statements about a field they have studied closely… and how the report handles or resolves disagreements and uncertainties.

Climate Change 1995 was written, reviewed, and edited by scientists who were primarily accountable to other scientists. But it would be naïve to imagine that it was totally isolated from and immune to politics. Certainly there were many political and media voices trying to influence it before it was complete, and trying to interpret it afterward. The "discernible influence" language was publicized (not "leaked," since the IPCC process is supposed to be open and transparent) well before it was approved by Working Group I. And it is worth noting that the "working group" itself, which approves or accepts the summary and report, is made up of "delegates" representing participating nations — as distinguished from the

authors themselves. At the November 1995 Madrid meeting, delegates from Kuwait and Saudi Arabia, oil-producers who oppose reducing fossil fuel use, tried to weaken the language and emphasis uncertainties.

In the end, the 1995 report gains its credibility from following the scientific method. The 3-pound-15-ounce report (and that's just the paperback) is a relentless accumulation of research by hundreds of scientists in many fields. In science, almost everything is open to question, and the extensive and open review process (by experts in relevant fields) meant the report faced such challenges head-on.

The key finding of "discernible human influence" was the aspect of the report that got most of the media attention at the time. In fact, even that finding generated comparatively little media excitement, considering its significance as a landmark in the evolution of scientific thought about climate. But the 1995 IPCC science report was packed full of other important findings that got even less attention.

Taken together, the new data, findings, and conclusions added up to a big advance in understanding of the climate system and human influence on it. Yet many of these new answers raised new questions.

"Discernible Human Influence"

The finding of "discernible human influence" is important enough, ambiguous enough, and controversial enough to deserve some further discussion in this guide.

First, what basis did the authors of Chapter 8, the "detection and attribution" chapter, have for reaching this conclusion? What was the "balance of evidence" referred to in the IPCC report?

IPCC scientists broke the problem down into two main parts. The first was "detection" of global climate change large enough or significant enough so that it is unlikely to be the result of natural climate variability. The second was "attribution" — if significant climate change is detected, can it be demonstrated that it is caused by one particular mechanism (in this case, human activities) and not others?

The crudest approach to the detection problem involves simply looking at the yearly global average near surface temperature. (See Figure 3, p.16) The problem with any such detection study is how to distinguish the "signal" (unusual climate warming) from the background "noise" of natural year-to-year climate variability. While some studies, according to IPCC, "have claimed the detection of a highly significant change in observed global mean temperature over the last 100 years," nevertheless "none of these studies has convincingly demonstrated that this change can be uniquely attributed to anthropogenic influences."

But, as Chapter 8 put it: "The majority of these studies show that the observed change in global mean, annually averaged temperature over the last century is unlikely to be due entirely to natural fluctuations of the climate system."

Three things at least are worth noting about the background "noise" of climate variability. First, Earth's climate has been quite variable over the hundreds of millions of years that it has had a climate system something like today's, and these changes have occurred on many time scales. This makes it difficult to pick out a greenhouse warming signal which is not expected to be a lot bigger than natural variability. Second, many of the studies rely on models as well as direct measurements to quantify climate variability — which means the studies take on the fallibility of models as well as their strengths. Third, during the 1990s, scientists made significant progress in understanding natural climate variability, so that they could quantify variations caused by, say, volcanic dust, changing solar radiation, or the El Niño cycle and distinguish them from purely random variation.

By the early 1990s, detection-attribution studies were evolving beyond the crude search for an increase in global average temperature. Such studies looked for *patterns* of change in climate variables, rather than a single variable. How, for example, are temperature changes distributed over Earth in the three spatial dimensions? Is the observed warming greater near the poles than at the equator? Does the stratosphere cool while the near-surface air temperature warms? Computer models predict certain patterns of change in response to different disturbances, and the added detail holds promise for attributing a particular climate change to a particular cause. With a sufficiently detailed understanding, scientists hope to be able to construct a "fingerprint" for anthropogenic greenhouse warming that will distinguish it from other climate changes.

As pattern-based detection and attribution studies grew more sophisticated, they were able to look at more variables in more detail. The dimension of *time* was added, for example. Instrument observations, for example, have found nightly low temperatures to be increasing faster than mid-day high temperatures over much of the Northern Hemisphere land mass since the 1950s. This suggests that something is keeping the sun-heated land from re-radiating that heat back to space, an atmospheric "blanket" of sorts. Increased CO_2 concentrations, when added to cloud cover and sulfate aerosols, are enough to explain this pattern. If human emissions were changing climate, we would expect the agreement between model predictions and observed climate to increase as the years went on.

A further step in detecting climate change is building an understanding of natural climate variability, and then filtering natural variability out, through the use of models. What is left is the climate change human emissions might (theoretically at least) be expected to cause.

In essence, the 1995 IPCC Assessment report notes, real progress had been made since 1990 in understanding what the "signal" of anthropogenic climate change would look like — were it indeed to be detected.

Models had become more "relevant" or realistic on a number of fronts. Modellers learned to depict CO_2 as gradually increasing, rather than increasing all at once. They learned to couple atmospheric models to ocean models, and to model oceans more complexly and at greater depths. Other human impacts on climate started to be factored in: sulfate aerosols and stratospheric ozone reduction, for example. Paleoclimatic data helped improve the model's representation of natural variability. Modelers began applying advanced statistical techniques to distinguish "signal" from "noise" (natural variability). Even as scientists remained acutely aware of the limits and shortcomings of their models, they felt a growing confidence that they had some idea what human-induced climate change would look like. As better models were tested with real-world data, confidence grew further.

Real-world climate measurements only grew more abundant and sophisticated during the 1990s as the United States and other nations deployed a growing network of instruments on land and seas and in the skies. Researchers found "qualitative consistency" between model predictions and real data, although such fuzzy terms were less convincing than hard numbers.

Thus, the 0.3°C to 0.6°C increase in global mean surface temperature over the last 100 years was "in accord" with model predictions — that is, it certainly did not contradict them, even if it did not prove a human effect. Findings that North American nighttime low temperatures were increasing faster than daytime highs were also similar to model predictions One study found that the time of peak warmth in Central England had actually shifted to come about five days later in the year after about 1940, when human greenhouse gas and aerosol emissions increased abruptly.

The 1995 IPCC Assessment report reminds us that any unambiguous detection of anthropogenic climate change will only come through a "gradual accumulation of evidence." Considerable evidence had, by 1995, begun accumulating. For example, even as temperatures were increasing in the lower atmosphere, they seemed to be decreasing in the stratosphere — which would be expected in anthropogenic greenhouse warming. Some correspondence between predictions and measurements has also been found in the geographical distribution of climate change. Observed

climate that is "significantly different" from what models predict might be caused by natural internal climate variability alone.

Interpretation of *Climate Change 1995*

The "discernible influence" finding was the focus of considerable public attention. Even though it did not grab many front-page headlines, it got more press coverage than any other aspect *of Climate Change 1995.* This was not merely because of its scientific importance, but also because of its symbolic importance in a political debate driven by concerns far different from scientific truth. If human-induced global warming were to be definitively detected, then it might settle the debate between those arguing over whether human-induced warming was "real" or "not real."

Regrettably, but perhaps predictably, the "discernible influence" finding got as much or more attention in print from spinmeisters and special pleaders as it did from regular news reporters. The phrase itself, once it was approved as part of the "Summary for Policymakers" at the Madrid meeting of Working Group I in November 1995, got more attention on the op-ed pages than it had on the news pages.

An example was an op-ed piece in the December 26, 1995, *Washington Post* by Jessica Mathews, a long-time advocate of measures to address global warming, now President of the Carnegie Endowment for International Peace. "In a major event completely missed by the news media," she wrote, "global warming was officially declared underway last week." The headline, "Global Warming: No Longer in Doubt," and her assertion that the question had been answered "unequivocally," gave the column its main spin.

Of course, "doubt" was just what the global warming skeptics hoped to preserve. The *Climate Change 1995* chapter on detection and attribution (Chapter 8) was attacked by the Global Climate Coalition (GCC), a coalition of many industries (typically carbon-emitting or -producing ones). They claimed that the language of the chapter had been edited after it was accepted by the Working Group and IPCC, to conform with the "discernible influence" language approved by the full IPCC for the Policymakers Summary. GCC and Fred Singer, another warming skeptic, claimed the thrust of the revisions was to eliminate statements of uncertainty. IPCC officials said the changes were made in accordance with IPCC procedures, and that they did not change the thrust of the chapter, which they said still contained some 4-1/2 pages of caveats and qualifications.

One statement by the authors of Chapter 8 may help put the fuss in perspective: "Statements regarding the detection and attribution of an anthropogenic effect on climate are inherently probabilistic in nature. They

do not have simple 'yes-or-no' answers." (Just try telling that to your editor.) This may be the last thing special pleaders want to hear. And it is worth remembering that the "discernible" statement was so preliminary and tentative that the authors did not give a probability range for it.

So while the "discernible" statement was hardly "unequivocal," it still was a milestone of sorts. Certainly climate science had come a long way since 1988, when NASA's James Hansen told Congress he was "99 percent sure" global warming had arrived — without benefit of a published article to that effect or the agreement of his peers. With all the residual doubts, this still was a "consensus" statement by an authoritative scientific body that global warming had arrived.

In the end, it might be best to let the IPCC's language speak for itself — not just the "breakthrough" sentence, as one news story called it, but the whole paragraph which gives it context. Here it is:

> "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."

This is a list of key points that are new in *Climate Change 1995, The Science of Climate Change*. It is followed by summaries of findings and conclusions that stayed the same and of key uncertainties.

Summary of New Findings

- "The balance of evidence suggests a discernible human influence on global climate."
- "Greenhouse gases have continued to increase."
- The 1995 report lowered the 1990 IPCC estimate of global warming by about one-third. IPCC estimated that if the world continued "business as usual" in emitting greenhouse gases and aerosols, the mean global surface temperature would be about 2ºC warmer than 1990 by the year 2100. That's 3.6ºF. The 1990 IPCC estimate for the business-as-usual scenario was a warming of about 1ºC by 2025 and 3ºC before 2100.
- The IPCC reduced its estimate of the amount of sea level rise expected as a result of global warming. If the world continues "business as usual" emissions, the sea will rise about 50 cm (about 19.7

inches) by 2100. That estimate is about 25 percent lower than the one IPCC made in 1990. Depending on actual emissions, and how the planet actually responds to them, IPCC said sea level rise could range from 15 cm to 95 cm (that is, from 5.9 inches to 37.4 inches) by 2100. The IPCC estimates global sea level has risen by10 to 25 cm (3.9 to 9.8 inches) during the last century.

- The growth rates of carbon dioxide, methane, and nitrous oxide concentrations were low during the early 1990s. The reason is not clear.
- The rate at which atmospheric methane concentrations are growing had declined in the two decades before 1995, for reasons that are not clear. The growth in methane concentrations even stopped briefly in 1992, and the timing prompted speculation that the halt had been caused by the 1991 eruption of Mt. Pinatubo in the Phillipines. IPCC scientists also slightly increased their estimate of the speed with which methane is removed from the atmosphere. Still, methane concentrations are almost two and a half times greater than in pre-industrial times, higher than at any time in the last 160,000 years.
- Growth in concentration of CFCs has slowed to about zero.
- The net warming effect of CFCs (and HCFCs) is less than was originally estimated. The estimate was lowered. The direct effect of the CFCs themselves is greenhouse warming. But they also deplete stratospheric ozone (itself a greenhouse gas), reducing its greenhouse effect. CFCs and HCFCs at current concentrations would cause a direct radiative forcing of 0.25 Wm^{-2}, but after being offset by ozone depletion, this nets out to about 0.1 Wm^{-2}.
- The cooling effect of human-induced dust, previously neglected, is significant. Aerosols (microscopic airborne particles) from power plants, cars, fires, and other sources have a direct cooling effect of about 0.5 Wm^{-2} and indirect effects possibly that large as well. The cooling effect of aerosols is much shorter-lived than the warming effect of greenhouse gases, and it is largely focused on particular regions. In particularly dusty localities, it can be big enough to offset human-induced greenhouse warming.
- Nighttime temperatures over land have generally increased more than daytime temperatures. Daily minimum temperatures have generally increased more than daily maximums. And even though the surface and troposphere have warmed, the lower stratosphere has cooled. All these patterns are consistent with the “signature” or “fingerprint” by which scientists expect to distinguish human-induced greenhouse warming from natural variability.

Approaching "Consensus": How the IPCC Report Was Agreed On

Climate Change 1995 was produced by Working Group I of the Intergovernmental Panel on Climate Change, the group devoted to the science of climate change itself. Working Group II examined impacts, adaptation, and mitigation of climate change, while Working Group III examined economic and social dimensions of climate change.

Here are some excerpts from the report describing how it was agreed on.

"IPCC reports are formally described as 'approved' or 'accepted.' An 'approved' report has been subject to detailed, line-by-line discussion and agreement in a plenary meeting of the relevant IPCC Working Group. For practical reasons only short documents can be formally approved, and larger documents are 'accepted' by the Working Group, signifying its view that a report presents a comprehensive, objective and balanced view of the subject matter. In this report, the Summary for Policymakers has been approved, and the Technical Summary and Chapters 1 to 11 have been accepted, by Working Group I."

"This report was compiled between October 1994 and November 1995 by 78 lead authors from 20 countries. First drafts of the chapters were circulated for informal review by experts in early 1995, before further revision in March. At that time, drafts of the Summary for Policymakers and the Technical Summary were also prepared by the lead authors assisted by a few additional experts with experience of the science-policy interface. Formal review of the chapters and the summaries by governments, non-governmental organizations (NGOs) and individual experts took place during May to July. Over 400 contributing authors from 26 countries submitted draft text and information to the lead authors and over 500 reviewers from 40 countries submitted valuable suggestions for improvement during the review process. The hundreds of comments received were carefully analyzed and assimilated in a revised document that was distributed to countries and NGOs six weeks in advance of the fifth session of WGI in Madrid, 27-29 November 1995. There, the Summary for Policymakers was approved in detail and the rest of the report accepted. Participants included 177 delegates from 96 countries, representatives from 14 NGOs and 28 lead authors."

Summary of What Stayed the Same

- "that continued accumulation of anthropogenic greenhouse gases in the atmosphere would lead to climate change whose rate and magnitude were likely to have important impacts on natural and human systems."
- The atmospheric concentrations of greenhouse gases have grown since the industrial revolution (about 1750) — carbon dioxide by about 30 percent and methane by 145 percent.
- If carbon dioxide emissions continue at current levels, atmospheric concentrations will keep growing and reach 500 ppm, almost twice the pre-industrial concentration, by the year 2100.
- "many greenhouse gases remain in the atmosphere for a long time …for CO_2 and N_2O, many decades to centuries), hence they affect radiative forcing on long time-scales.
- "Global mean surface air temperature has increased by between 0.3 and 0.6°C since the late 19th century…."

Summary of Unanswered Questions, Uncertainties, and Research Needs

Climate Change 1995 also contains important assessments of what is *not* known (yet) about climate — the uncertainties and unanswered questions for further research. Despite popular notions about science being a source of certainty, doubt and uncertainty are actually inherent in the scientific process. In the policy arena, scientific uncertainty often becomes a "political football" with which both sides try to make field goals. This is especially true with the science behind environmental risks.

Reporters would do well to note which side in the debate, at any given time, is claiming the other side bears the burden of proof. Ultimately, how to act in the face of uncertainty (is it better to be safe than sorry?) is not a question science can answer; it must be decided on the basis of social values.

Here are some areas where the 1995 IPCC Assessment report says climate science needs to know more:

- Data from direct physical observations of the many parts of the global climate system. The data collection needs to be "systematic and sustained" to be useful. Useful measurements may often need to be global in scale, consistent in method, and continuous over periods longer than decades.
- Better understanding of aerosols (dust and droplets such as those that constitute smoke and acid rain) and how they affect the flow of solar radiation and heat.

- Understanding of what controls the distribution of clouds and of the role they play in greenhouse warming or cooling. Clouds are smaller than the resolution of most climate models, making it hard to factor them in realistically. Among many complexities is the way aerosols provide "seeds" for formation of the water droplets which constitute clouds.
- The hydrological cycle — rain, snow, evaporation, runoff, and soil moisture — as it affects climate.
- Land and sea feedbacks to the climate system.
- The behavior of land ice sheets.
- The coupling between atmosphere and ocean, and circulation within the ocean.
- The processes that add and remove carbon dioxide (and other greenhouse gases) to and from the atmosphere.
- The detection of climate change and attribution of observed climate change to particular causes.
- Regional patterns of climate change.

Stay Tuned

The international scientific community is busy addressing these questions. Another IPCC scientific assessment is underway, and this update is expected to be completed and published by 2001.