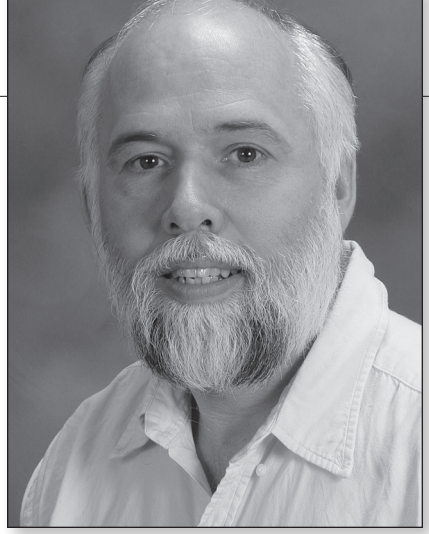

By Craig M. Pease

A Climate of Uncertainty

Good scientific research inevitably produces more questions than it answers. Wouldn't it be a great if the economy grew like the supply of unanswered questions? Science is grounded on ever-increasing uncertainty.

Yet all too often financial, political, or legal interests manipulate the public perception of scientific uncertainty. A recent House Committee on Oversight and Government Reform report on political interference with global climate change science quotes from an American Petroleum Institute communications plan: "Victory will be achieved when . . . average citizens 'understand' uncertainties in climate science [and] recognition of uncertainties becomes part of the 'conventional wisdom.'"

Although the Intergovernmental Panel on Climate Change's third and fourth reports, written in 2001 and 2007, respectively, predict a comparable temperature increase from doubling atmospheric carbon dioxide, the fourth report nonetheless states that "uncertainties and upper ranges for [predicted] temperature [increases] are larger mainly because the broader range of available models suggests stronger climate-carbon cycle feedbacks." While the third report provides a worse-case scenario, or upper bound, on possible sea level rise over the course of this century, the fourth does not.

What went wrong? Did anything go wrong? Might the temperature and sea level predictions of the fourth report also underestimate the true uncertainty? Did the scientific data somehow become worse over the last six years?

We do have more data now on the Earth's climate than we did then, and their quality is better. Importantly, though, what scientists seek is not more data on temperature and sea level themselves, but rather data on the geological and biological processes causing these variables to change. Lawyers distinguish between the outcome of a trial (whether plaintiffs or defendants prevail), and the processes used to achieve this endpoint, as defined by legal rules, procedures, statutes, and case law. Scientists too focus on processes — albeit physical, not legal — and scientific predictions follow from an understanding of underlying processes.

In the study of scientific processes, feedback loops are key. Human body temperature is regulated by a negative feedback loop. If my temperature increases above 37 degrees Celsius, I sweat and my temperature decreases. If my temperature dips below 37, I shiver and my temperature increases. By contrast, positive feedback loops are all important in climate science. Change begets more change, not the reverse.

Positive feedback loops amplify policymakers' mistakes, yet are often poorly understood

By itself, doubling of atmospheric carbon dioxide would only produce about a 1 degree Celsius temperature increase. However, as temperature begins to rise, more water evaporates, increasing atmospheric water vapor —a greenhouse gas — and driving a further increase in temperature. This is the most important positive feedback. But it is not the only one. It and a veritable rogue's gallery of other positive feedback loops bring the total increase up to 3 degrees Celsius, more or less.

For example, the oceans and terrestrial vegetation together absorb about half of the carbon dioxide within several decades of its emission. But the IPCC predicts that the ocean carbon dioxide sink will start to saturate, because increasing temperature will slow ocean circulation, thereby reducing transport of carbon dioxide to the deep ocean. This is one of the IPCC's "stronger climate-carbon cycle feedbacks." Similarly, glacial meltwater lubricates Greenland's glacier-rock interface, accelerating the slide of its glaciers down to the North Atlantic, at a rate much faster than what the third IPCC report authors envisioned. (Strictly speaking this is amplification without feedback.)

Even if fully understood, positive feedbacks present a real policy challenge, as they will amplify policymakers' mistakes. Yet often they are not settled science. On page 288 of a recent *Nature* I read that the future will bring faster ocean circulation, and on page 298 I read the exact opposite. What is worse, we undoubtedly do not even have a complete catalog of all the relevant positive feedback loops. Ponder the confusion that would arise if lawyers were continually discovering new rules and procedures. Fortunately, the law relies heavily on precedent, so legal process changes slowly and is mostly known.

Rather diabolically, these positive feedbacks amplify not only the effects of anthropogenic carbon dioxide emissions, but also the errors, oversights, and approximations inherent in climate science itself. Like the Hindu deity Shiva, who simultaneously presents several dissimilar personalities, so too is it that positive feedbacks are at once of paramount concern to policymakers, yet are themselves responsible for inhibiting effective policy.

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