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Global Climate Models and Their Limitations

Introduction

Because the earth-ocean-atmosphere system is so vast and complex, it is impossible to conduct a small-scale experiment that reveals how the world's climate will change as the air's greenhouse gas (GHG) concentrations continue to rise. As a result, scientists try to forecast the effect of rising GHG by looking backwards at climate history to see how the climate responded to previous "forcings" of a similar kind, or by creating computer models that define a "virtual" earth-ocean-atmosphere system and run scenarios or "story lines" based on assumptions about future events.

The Intergovernmental Panel on Climate Change (IPCC) places great confidence in the ability of general circulation models (GCMs) to simulate future climate and attribute observed climate change to anthropogenic emissions of greenhouse gases. It says "climate models are based on well-established physical principles and have been demonstrated to reproduce observed features of recent climate … and past climate changes … There is considerable confidence that Atmosphere-Ocean General Circulation Models (AOGCMs) provide credible quantitative estimates of future climate change, particularly at continental and larger scales" (IPCC, 2007-I, p. 591).

To be of any validity, GCMs must incorporate all of the many physical, chemical, and biological processes that influence climate in the real world, and they must do so correctly. A review of the scientific literature reveals numerous deficiencies and shortcomings in today's state-of-the-art models, some of which deficiencies could even alter the sign of projected climate change. In this chapter, we first ask if computer models are capable *in principle* of producing reliable forecasts and then examine three areas of model inadequacies: radiation, clouds, and precipitation.

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1.1. Models and Forecasting

J. Scott Armstrong, professor, The Wharton School, University of Pennsylvania and a leading figure in the discipline of professional forecasting, has pointed out that forecasting is a practice and discipline in its own right, with its own institute (International Institute of Forecasters, founded in 1981), peer-reviewed journal (*International Journal of Forecasting*), and an extensive body of research that has been compiled into a set of scientific procedures, currently numbering 140, that must be used to make reliable forecasts (*Principles of Forecasting: A Handbook for Researchers and Practitioners*, by J. Scott Armstrong, Kluwer Academic Publishers, 2001).

According to Armstrong, when physicists, biologists, and other scientists who do not know the rules of forecasting attempt to make climate predictions based on their training and expertise, their forecasts are no more reliable than those made by nonexperts, even when they are communicated through complex computer models (Armstrong, 2001). In other words, forecasts by scientists, even large numbers of very distinguished scientists, are not necessarily *scientific* forecasts. In support of his position, Armstrong and a colleague cite research by Philip E. Tetlock (2005), a psychologist and professor of organizational behavior at the University of California, Berkeley, who "recruited 288 people whose professions included 'commenting or offering advice on political and economic trends.' He asked them to forecast the probability that various situations would or would not occur, picking areas (geographic and substantive) within and outside their areas of expertise. By 2003, he had accumulated more than 82,000 forecasts. The experts barely if at all outperformed non-experts and neither group did well against simple rules" (Green and Armstrong, 2007). The failure of expert opinion to lead to reliable forecasts has been confirmed in scores of empirical studies (Armstrong, 2006; Craig *et al.*, 2002; Cerf and Navasky, 1998; Ascher, 1978) and illustrated in historical examples of incorrect forecasts made by leading experts (Cerf and Navasky, 1998).

In 2007, Armstrong and Kesten C. Green of Monash University conducted a "forecasting audit" of the IPCC Fourth Assessment Report (Green and Armstrong, 2007). The authors' search of the contribution of Working Group I to the IPCC "found no references … to the primary sources of information on forecasting methods" and "the forecasting procedures that were described [in sufficient detail to be evaluated] violated 72 principles. Many of the violations were, by themselves, critical."

One principle of scientific forecasting Green and Armstrong say the IPCC violated is "Principle 1.3 Make sure forecasts are independent of politics." The two authors write, "this principle refers to keeping the forecasting process separate from the planning process. The term 'politics' is used in the broad sense of the exercise of power." Citing David Henderson (Henderson, 2007), a former head of economics and statistics at the Organization for Economic Cooperation and Development (OECD), they say "the IPCC process is directed by non-scientists who have policy objectives and who believe that anthropogenic global warming is real and danger." They conclude:

> The forecasts in the Report were not the outcome of scientific procedures. In effect, they were the opinions of scientists transformed by mathematics and obscured by complex writing. Research on forecasting has shown that experts' predictions are not useful in situations involving uncertainty and complexity. We have been unable to identify any scientific forecasts of global warming. Claims that the Earth will get warmer have no more credence than saying that it will get colder.

Scientists working in fields characterized by complexity and uncertainty are apt to confuse the output of *models*—which are nothing more than a statement of how the modeler believes a part of the world works—with real-world trends and forecasts (Bryson, 1993). Computer climate modelers certainly fall into this trap, and they have been severely criticized for failing to notice that their models fail to replicate real-world phenomena by many scientists, including Balling (2005), Christy (2005), Essex and McKitrick (2007), Frauenfeld (2005), Michaels (2000, 2005, 2009), Pilkey and Pilkey-Jarvis (2007), Posmentier and Soon (2005), and Spencer (2008).

Canadian science writer Lawrence Solomon (2008) interviewed many of the world's leading scientists active in scientific fields relevant to climate change and asked them for their views on the reliability of the computer models used by the IPCC to detect and forecast global warming. Their answers showed a high level of skepticism:

- Prof. Freeman Dyson, professor of physics at the Institute for Advanced Study at Princeton University, one of the world's most eminent physicists, said the models used to justify global warming alarmism are "full of fudge factors" and "do not begin to describe the real world."

- Dr. Zbigniew Jaworowski, chairman of the Scientific Council of the Central Laboratory for Radiological Protection in Warsaw and former chair of the United Nations Scientific Committee on the Effects of Atomic Radiation, a world-renowned expert on the use of ancient ice cores for climate research, said the U.N. "based its global-warming hypothesis on arbitrary assumptions and these assumptions, it is now clear, are false."

- Dr. Richard Lindzen, a professor of meteorology at M.I.T. and member of the National Research Council Board on Atmospheric Sciences and Climate, said the IPCC is "trumpeting catastrophes that couldn't happen even if the models were right."

- Prof. Hendrik Tennekes, director of research at the Royal Netherlands Meteorological Institute, said "there exists no sound theoretical framework for climate predictability studies" used for global warming forecasts.

- Dr. Richard Tol, principal researcher at the Institute for Environmental Studies at Vrije Universiteit and adjunct professor at the Center for Integrated Study of the Human Dimensions of Global Change at Carnegie Mellon University, said the IPCC's Fourth Assessment Report is "preposterous ... alarmist and incompetent."

- Dr. Antonino Zichichi, emeritus professor of physics at the University of Bologna, former president of the European Physical Society, and one of the world's foremost physicists, said global warming models are "incoherent and invalid."

Princeton's Freeman Dyson has written elsewhere, "I have studied the climate models and I know what they can do. The models solve the equations of fluid dynamics, and they do a very good job of describing the fluid motions of the atmosphere and the oceans. They do a very poor job of describing the clouds, the dust, the chemistry, and the biology of fields and farms and forests. They do not begin to describe the real world that we live in" (Dyson, 2007).

Many of the scientists cited above observe that computer models can be "tweaked" to reconstruct climate histories after the fact, as the IPCC points out in the passage quoted at the beginning of this chapter. But this provides no assurance that the new model will do a better job forecasting *future* climates, and indeed points to how unreliable the models are. Individual climate models often have widely differing assumptions about basic climate mechanisms but are then "tweaked" to produce similar forecasts. This is nothing like how real scientific forecasting is done.

Kevin Trenberth, a lead author along with Philip D. Jones of chapter 3 of the Working Group I contribution to the IPCC's Fourth Assessment Report, replied to some of these scathing criticisms on the blog of the science journal *Nature*. He argued that "the IPCC does not make forecasts" but "instead proffers 'what if' projections of future climate that correspond to certain emissions scenarios," and then hopes these "projections" will "guide policy and decision makers" (Trenberth, 2007). He says "there are no such predictions [in the IPCC reports] although the projections given by the Intergovernmental Panel on Climate Change (IPCC) are often treated as such. The distinction is important."

This defense is hardly satisfactory. As Green and Armstrong point out, "the word 'forecast' and its derivatives occurred 37 times, and 'predict' and its derivatives occurred 90 times in the body of Chapter 8" of the Working Group I report, and a survey of climate scientists conducted by those same authors found "most of our respondents (29 of whom were IPCC authors or reviewers) nominated the IPCC report as the most credible source of forecasts (not 'scenarios' or 'projections') of global average temperature." They conclude that "the IPCC does provide forecasts." We agree, and add that those forecasts are unscientific and therefore likely to be wrong.

Additional information on this topic, including reviews of climate model inadequacies not discussed here, can be found at http://www.co2science.org/subject/m/subject_m.php under the heading Models of Climate.

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1.2. Radiation

One problem facing GCMs is how to accurately simulate the physics of earth's radiative energy balance. Of this task, Harries (2000) says "progress is excellent, on-going research is fascinating, but we have still a great deal to understand about the physics of climate."

Harries says "we must exercise great caution over the true depth of our understanding, and our ability to forecast future climate trends." As an example, he states that our knowledge of high cirrus clouds is very poor, noting that "we could easily have uncertainties of many tens of Wm^{-2} in our description of the radiative effect of such clouds, and how these properties may change under climate forcing." This state of affairs is disconcerting in light of the fact that the radiative effect of a doubling of the air's CO_2 content is in the lower single-digit range of Wm^{-2}, and, to quote Harries, "uncertainties as large as, or larger than, the doubled CO_2 forcing could easily exist in our modeling of future climate trends, due to uncertainties in the feedback processes." Because of the vast complexity of the subject, Harries says "even if [our] understanding were perfect, our ability to describe the system sufficiently well in even the largest computer models is a problem."

A related problem is illustrated by the work of Zender (1999), who characterized the spectral, vertical, regional and seasonal atmospheric heating caused by the oxygen collision pairs $O_2 \cdot O_2$ and $O_2 \cdot N_2$, which had earlier been discovered to absorb a small but significant fraction of the globally incident solar radiation. In addition, water vapor demers (a double molecule of H_2O) shows strong absorption bands in the near-infrared of the solar spectrum. Zender revealed that these molecular collisions lead