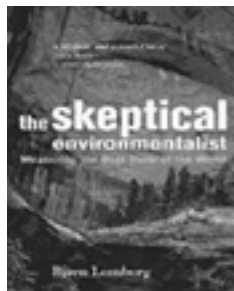


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Global Warming Questions and Decisions

By Peter T. Ittig, Feature Editor



The Skeptical Environmentalist
By Bjørn Lomborg
Cambridge University Press
2001, 515 pages
www.cambridge.org



Climate Action Report 2002
By U.S. Environmental Protection Agency
May 2002, 269 pages
www.epa.gov



Climate Change Science
By Committee on the Science of Climate Change, National Research Council
National Academy Press
2001, 42 pages
www.nap.edu



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There has been a great deal of heated discussion about "Global Warming" in recent years. This column considers three publications that treat this issue. One book is from Cambridge University Press, *The Skeptical Environmentalist*, by Bjørn Lomborg, Ph.D., a professor of statistics at the University of Aarhus in Denmark. Lomborg has published in the fields of game theory and computer simulation. In his book, he notes that "Climate change and especially global warming has become the overriding environmental concern since the 1990s." Also considered are the recent *Climate Action Report 2002* of the US Environmental Protection Agency (EPA) and the 2001 report of the US National Research Council (NRC), *Climate Change Science*. The EPA report will soon be available from the US Government Printing Office, but it is available now online free in pdf format at: <http://www.epa.gov/globalwarming/publications/car/index.html>. The NRC report is also available free online in html and pdf formats at: <http://www.nap.edu> or may be purchased for \$12 from the National Academy Press, which offers "over 2500 books online free."

The Questions

There are several basic questions related to climate change and global warming. First, there is the question of whether the planet is actually getting warmer. This is a difficult question due to the large amount of natural variation in the climate and the limited

historical record. Further, the natural variation (other than seasonal) is not well understood. For example, there may be significant variation in the energy output of the sun. There is also a well known problem in measuring a trend for a highly variable data series. The direction of the measured trend may depend upon the length of the time period examined in such a series. Lomborg notes that there was considerable concern about global cooling in the 1970s. The long history of the Earth appears to have been one of gradual cooling. The Earth was probably much warmer during the many millions of years that the dinosaurs roamed the Earth. The most recent geological period is the relatively cold Pleistocene epoch, which began about 1.6 million years ago, a period that covers the appearance of humans on the planet. The Pleistocene epoch is characterized by ice ages in long cycles of glacial and interglacial periods. The NRC report notes that "mean temperature variations at local sites

have exceeded 10°C (18°F) in association with the repeated glacial advances and retreats that occurred over the course of the past million years." Lomborg refers to eight glacial/interglacial cycles in the past million years. In the last, the so-called "Wisconsin" glaciation (115,000 to 10,000 years ago), glaciers came as far south as the present locations of Boston, New York, and London. The NRC refers to the "warmer interglacial periods like the present one that began around 10,000 years ago," a period that covers essentially all of recorded human history. There was a little ice age in the period 1645-1715, when the planet became substantially colder. Focusing *only* on the last century, the EPA and NRC reports conclude that the Earth has been getting a bit warmer. The EPA reports that over the last 100 years, "warming over the 48 contiguous states amounted to about 0.6°C (about 1°F)," although "there was cooling in the Southeast." The NRC report states that "global mean surface air temperature warmed by about 0.4-0.8°C (0.7-1.5°F) during the 20th century," although "The Northern Hemisphere as a whole experienced a slight cooling from 1946-75." The EPA states that sea level rose between 10-20cm (about 4-8 inches) in the last century, less in the Northeast than on the Mid-Atlantic coast (apparently due to shifting of the continent relative to the Earth's interior) and calls this rise "significantly more than the rate of rise that was typical over the last few thousand years."

A more difficult question concerns whether human activity is causing global warming. An easier related question concerns changes in the amount of carbon dioxide (CO₂) and other so-called "greenhouse" gases released into the air. The NRC report refers to CO₂ as "the greenhouse gas of most concern." Carbon dioxide is released when you exhale and when you burn carbon based fuels (e.g., oil, coal, natural gas, wood). In a section on the "Greenhouse Gas Inventory," the EPA report indicates that since 1750 (roughly the beginning of the industrial revolution) the concentration of CO₂ in the air has increased by 31% and the concentration of methane (CH₄) has increased by about 151%. Scary stuff! CO₂ is reported to be about 82% of total US greenhouse gas emissions. The report states that the increase in greenhouse gases "has... likely affected the

global climate system." However, the report commits a common statistical sin by reporting rates of change without reporting the current base amounts of gases in the atmosphere (the true inventory). For example, you might be impressed if I tell you that my savings grew by 30% last year. You might be *less* impressed if I add that the account grew from only \$100 to \$130. The EPA report does *not* mention that the atmosphere is composed of about 78% nitrogen, 21% oxygen, 1% argon (have you pulled out your calculator yet?), *less than 0.04% carbon dioxide* and *trace* amounts of other gases. Thus, the reported 31% increase for CO₂ is on a very tiny base. Why is there so little CO₂ in the air? A major reason is that CO₂ is pulled out of the atmosphere by green plants and used as a nutrient. Talking to your plants may help them to grow because they like the CO₂ in your breath! In fact, the EPA reports that "higher CO₂ concentrations generally enhance plant growth" and refers to "the CO₂ fertilization effect" in projections of higher farm productivity in the 21st century. There appears to be a complex feedback loop here; if there is more CO₂ in the air, the plants will remove it faster. The NRC report *does* include base amounts of greenhouse gases in the atmosphere in parts per million by volume (ppmv) with CO₂ "currently about 370 ppmv" or 0.037%, "and rising at a rate of 1.5 ppmv per year" or a rate of increase of 0.4% per year. The NRC report concludes that "Temperatures are, in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability."

Another basic issue concerns forecasting global warming. One way to do this is to first predict the increase in CO₂ in the atmosphere and then to project the resulting amount of warming from a computer model of the Earth. Both the NRC and the EPA refer to predictions obtained in this manner by the Intergovernmental Panel on Climate Change (IPCC), a UN agency. The predictions were done using complex computer models that offer a considerable amount of uncertainty. A basic difficulty is that the climate sensitivity to CO₂ is not well understood. The NRC reports that if the amount of CO₂ in the atmosphere were

doubled, the increase in temperature would be in the range of 1.5 to 4.5°C (2.7°F-8.1°F), "However, the true climate sensitivity remains uncertain." There are also serious difficulties in using complex multi-equation models for forecasting, rather than simpler time-series models (refer to the forecasting review in this column, Vol. 33, No. 1, 2002). Lomborg reports forecast errors by IPCC models that were used in 1990 to predict temperature increases in the year 2000. The projected increase was too high by a factor of 2. The models have since been adjusted to fit the recent data; however, there is a well known issue in forecasting concerning the difference between fit accuracy and true forecast accuracy. The NRC states that IPCC "predicted warming of 3°C (5.4°F) by the end of the 21st century is **consistent with assumptions**" (emphasis added). Lomborg severely criticizes the IPCC assumptions in Chapter 24 of his book, particularly the *assumed* 1% per year increase in the amount of CO₂ in the atmosphere. He also quotes an IPCC report that describes the IPCC "scenarios" as "an attempt at computer-aided storytelling." Note that the NRC estimate of a 1.5 ppmv per year rate of increase in the concentration of CO₂ is about 0.4% per year, which doubles in about 174 years, while the 1% rate of increase assumed by the IPCC results in doubling in about 70 years. The IPCC reports are not reviewed here, but summaries of the 2001 reports are available online free in pdf format at: <http://www.ipcc.ch/>.

Next, it is necessary to project the consequences of a global warming forecast. The EPA deals with this in a set of "scenarios" rather than forecasts. They then do "plausible projections" of potential changes for the 21st century based upon these scenarios by using computer simulations in a kind of "what if" analysis familiar to Decision Science practitioners. The simulations are a Canadian model and a British model, which offer substantially different projections. The scenarios examine the potential consequences of global average warming of 2.5 to 4°C (about 4.5-7°F), a range thought to be "about the mid-range of projected warming" in the next century. The EPA reports that global warming will have some beneficial aspects, including higher farm productivity due to higher levels of CO₂ in the air, a longer growing season

and milder winters. There would also be more rainfall, which will benefit some farming regions. A chapter on "Impacts & Adaptation" provides a review of the "potential negative and *positive* impacts and possible response options" (emphasis added). The report states, "Although changes in the environment will surely occur, our nation's economy should continue to provide the means for successful adaptation to climate changes." It is interesting that most of the expected warming is at the cool end, winter rather than summer, north rather than south. Lomborg notes that "there is a general strong trend that it is the cold temperatures that have warmed the most." There is also *no* evidence for an increase in extreme weather events due to global warming. The NRC reports that "In the near term, agriculture and forestry are likely to benefit from carbon dioxide fertilization."

Finally, it is necessary to deal with the important *decisions* about the appropriate response to global warming (the policy question). This requires a form of cost/benefit analysis of the tradeoff between the effects of global warming and the costs of various responses that might be undertaken. The possible responses include reductions in the use of carbon fuels (and when), various adaptation strategies and various research efforts (including research on alternative energy sources). Lomborg addresses the decision question with a thoughtful economic analysis. He reports that moderate global warming would probably be economically *beneficial* even after subtracting the costs of adaptation and he concludes that only a moderate response is appropriate at this time! Lomborg also explores the implications of adopting the restrictions of the proposed Kyoto treaty and concludes that it would have an enormous cost, but have only a marginal impact on global warming of about 0.15°C (0.27°F) by 2100 (or about a 6-year delay)! He recommends an "optimal" path that accepts some global warming and postpones most reductions in CO₂ emissions until later in the 21st century when alternative energy sources may be available. The controversial Kyoto treaty, which the US Senate rejected, proposed to roll back CO₂ emissions in the industrial countries to a level 5.2% below 1990 levels, while no limits were provided for developing countries

including China. The Kyoto reductions in the use of carbon-based fuels in industrial countries would probably be achieved through the imposition of enormous taxes and/or severe quotas on carbon based fuels in industrial countries, probably causing massive economic and social adjustments. Some industries would probably move to developing countries that are not subject to Kyoto restrictions. The massive adjustments would be necessary because the burning of carbon-based fuels not only provides energy to run motor vehicles and heat homes, but is also a major source of electricity. A switch to electric cars and electric heat actually does *not* eliminate the problem. Rather, an electric motor merely moves the CO₂ exhaust to the smokestack of a power plant. A switch to hydrogen fuel cells has a similar effect, since hydrogen is usually obtained by passing an electric current through water. This is merely a conversion of energy from one form to another with a substantial loss in the conversion process. Except for hydroelectric power, alternatives to carbon based fuels are dramatically more expensive at this time, though Lomborg shows that these alternatives are becoming relatively cheaper. Major reductions in the use of carbon based fuels now would require major social changes. IPCC reports discuss the advantages of switching to bicycles and to ships with sails. Lomborg argues that it is economically efficient to make only gradual adjustments. He concludes that current efforts and resources should focus on adaptation and on research that will reduce the cost of alternative sources of energy (esp. solar, wind, fusion).

Conclusions

The NRC report was prepared very quickly in response to a request from the Bush Administration in May 2001. The White House request asked for help "identifying the areas in the science of climate change where there are the greatest certainties and uncertainties" and requested a response "as soon as possible." The request also sought comments on aspects of the IPCC reports. The resulting report was issued *less than a month later* in June 2001! Major weaknesses of the NRC report are the lack of scientific references (perhaps due to the request by the White House for a fast response), the lack of policy recommendations (consid-

ered outside their mandate), and the failure to critically examine the assumptions of the IPCC. However, the NRC report appears to represent a summary of the current American scientific consensus on this issue. Persons interested in the field of global warming may wish to acquire the NRC report for that reason.

The EPA report provides a valuable discussion of possible impacts and adaptation to global warming in Chapter 6. The EPA report also includes a substantial bibliography as an appendix. Another appendix of the EPA report copies some material from the foreword and summary of the NRC report. A major weakness of the EPA report is the failure to explore the costs and benefits of various policy options for dealing with global warming.

The Lomborg book is a brilliant statistical and economic analysis. Lomborg extensively supports his conclusions with tables and graphs of relevant data from respectable sources. He cites his sources in a 71-page bibliography and in 82 pages of footnotes. There are sections on food, forests, water, energy, population, pollution, biodiversity and more. Lomborg shows that the world is doing much better in all of these areas than the newspaper headlines suggest and that the problems are manageable. He also argues that there are problems of bias in much that is published about global warming and environmental issues generally. Particularly, there is a conflict of interest issue and a values issue. The conflict of interest issue arises because a prediction that the sky is falling may be more likely to produce media attention and research grants. The values issue concerns the tendency of many environmentalists to favor the social changes that might arise in a world with less energy, including bicycles and ships with sails. Lomborg argues that such preferences should be stated explicitly and argued separately, rather than using global warming as a device to pursue a radical social agenda. Lomborg is also very critical of the frequent selective and biased use of time series data by environmentalists. The book makes a substantial contribution and is recommended reading for anyone interested in going beyond the newspaper headlines about global warming and other environmental issues. ■