A BRIGHTER FUTURE

A Response to Don Wuebbles (Climatic Change, vol. 52, no. 4, 2002)

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Contrary to Wuebbles' thesis (2002), most of the media did not misunderstand the thrust of our recent paper (Hansen et al., 2000). We do indeed assert that a scenario is feasible in which the rate of global warming declines. We also posit that, with an understanding of the significant climate forcings, it is possible to achieve such a climatically brighter path with actions that are not 'economically wrenching', indeed, actions that make economic sense independent of global warming.

Our paper does not denigrate the 'business-as-usual' (BAU) scenario that has been popular in global climate model simulations. The BAU scenario provides a valuable warning of potential climate change if the world follows a path with climate forcings growing more and more rapidly. Our aim was to present a companion scenario that stimulates discussion of actions that help avoid a gloom and doom scenario. I tried to clarify our objectives in an 'Open Letter', which is made available from *Natural Science* (a web publication) at http://naturalscience.com/ns_let25.html. I summarize here key points of discussion.

Black Carbon (BC). One of our assertions is that BC (soot) plays a greater role in climate change than has been appreciated. We believe that the forcing due to BC is of the order of 1 W/m^2, rather than of the order of 0.1 W/m^2, as assumed by IPCC (1996).

My present estimate for global climate forcings caused by BC is: (1) 0.4 $\pm$ 0.2 W/m^2 direct effect, (2) 0.3 $\pm$ 0.3 W/m^2 semi-direct effect (reduction of low-level clouds due to BC heating; Hansen et al., 1997), (3) 0.1 $\pm$ 0.05 W/m^2 'dirty clouds' due to BC droplet nuclei, (4) 0.2 $\pm$ 0.1 W/m^2 snow and ice darkening due to BC deposition. These estimates will be discussed in a paper in preparation. The uncertainty estimates are subjective. The net BC forcing implied is 1 $\pm$ 0.5 W/m^2.

Air Pollution. Aerosols and tropospheric ozone (O_3) are not addressed by the Kyoto protocol. They should be. A reason proffered for excluding ozone is that its chemistry is so complex that 'most scientists' eyes glaze over' (Revkin, 2000). Perhaps the latter assertion is true. But it is not adequate reason to exclude air pollution from international climate negotiations. Our estimated anthropogenic global climate forcing due to BC (1 W/m^2) and O_3 (0.4 W/m^2) is comparable to the CO_2 forcing (1.4 W/m^2). One thesis in our paper is that halting the growth of air pollution can make a significant contribution to slowing global warming.

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Effects of air pollution on humans are large in the developed world and staggering in the developing world. A recent study (Kunzli et al., 2000) estimates that particulate air pollution in France, Austria and Switzerland takes 40,000 lives annually with health costs equal to 1.6% of the gross national products. An example for the developing world is the estimate (Smith, 2000) that 270,000 Indian children under 5 years old die annually from acute respiratory infections caused by air pollution. Most of the pollution in this latter case arises from indoor combustion for cooking and heating, a primary source of the cloud of pollutants now mushrooming from India and China. Aerosols and ozone also reduce agricultural productivity with costs of many billions of dollars.

Practical benefits of air pollution reduction accrue immediately, not in 100 years. We assert in our paper that this offers an opportunity to reduce the climate problem with a cooperative approach that has immediate clear benefits to both developing and developed countries.

Methane. We conclude that climate forcing by CH_4 is 0.7 W/m^2, fully half as large as the forcing by CO_2. Observed growth of CH_4 is not accelerating, contrary to assumptions in many climate scenarios. Indeed, the growth rate has declined by two-thirds in the past 20 years. However, future trends are uncertain.

The task of understanding CH_4 should be jumped on, like a chicken on a June bug. Yet research support has been minuscule. We need quantitative understanding of CH_4 sources and sinks to define optimum policies. It may be possible to find practices that reduce methane emissions while saving money. Farmers want cows and beasts of burden to produce milk, meat, and power, not methane. Rice growers seek food and fiber, not methane, but we must also compare impacts of altered practices on N_2O production. There is much potential for methane capture via improved mining and waste management practices.

Scenarios. Science works via iterative comparison of theory and observations. Differences found are not a problem – on the contrary, only by discovering and investigating these can our understanding advance. One problem with the IPCC reports is that each report produces new (and more numerous) greenhouse gas scenarios with little attempt to discuss what went wrong with the previous ones. As a result, dramatic changes that have occurred since the 1980s in prospects for future climate forcings receive inadequate attention.

Figure 1 shows climate forcing scenarios used for climate simulations in the 1980s (Hansen et al., 1988). The actual climate forcing in 2000 is close to that of scenario B, and the derivative (growth rate) is less than that of scenario B. Further slowdown is needed to achieve the path of the ‘alternative scenario’. The fact that the real world does not now *seem to be* following a path toward the median of the greenhouse gas amounts projected by Ramanathan et al. (1985) for 2030 in no way detracts from that paper, which, in my opinion, was one of the most stimulating papers in atmospheric sciences during recent decades. Indeed, to at least a small extent, one might credit the slowdown in climate forcing growth rates to the warning implicit in this and related papers.

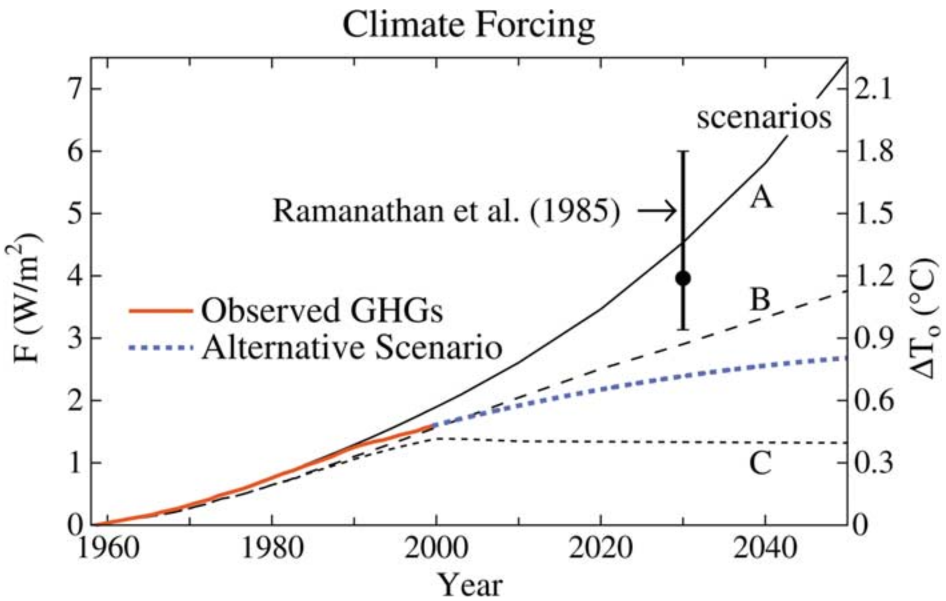

Figure 1. Greenhouse gas climate forcings for the scenarios A ('business as usual' or 'fast growth'), B ('slow growth') and C ('no growth') of Hansen et al. (1988) and the 'alternative scenario' of Hansen et al. (2000). Red curve shows actual climate forcing based on changes of CO_2, CH_4, N_2O, CFCs, stratospheric H_2O, and numerous trace gases. O_3 forcing is not included because of poor knowledge of changes and the expectation of partial cancellation between tropospheric increases and stratospheric decreases. Details are provided in a paper in preparation ('Climate forcings in the GISS SI2000 model'). The scale on the right gives the units for climate forcing employed by Hansen et al. (1988), ΔT_o (°C), the equilibrium global mean temperature change that would occur if there were no climate feedbacks, which differ from the forcing in W/m^2 by the factor: ΔT_o (°C) = 0.3 F(W/m^2).

Why have growth-rates fallen below BAU scenarios? One clear reason: the Montreal Protocol, which forced a phase-out of CFCs. That is an example of what we propose: actions useful for other reasons that also help to slow climate change. Reasons for the decline in the CH_4 growth rate need to be understood better. The apparent flattening of the CO_2 growth rate is probably due in part to an increased CO_2 sink, which may (or may not) be a temporary phenomenon.

CO_2 scenarios are the most critical. Our approach, characterized as naïve by Wuebbles, emphasizes observations. We note that the growth rate of CO_2 (fossil fuel) emissions has declined from about 4%/year to 1%/year in recent decades. It is noteworthy that the current IPCC (2001) scenarios have a growth rate in the 1990s that is almost double the observed rate of 0.8%/year (linear trend fit to 5-year running mean), but it is consistent with their failure to emphasize data. I will not characterize the IPCC approach defended by Wuebbles, but I note in my open letter the difficulty inherent in multiplying assumptions about population, economic development, and technology 50 or 100 years in the future. In my letter I specifically discuss their population estimates, which already appear to be unduly pessimistic.

Media and the Public. Wuebbles claims that the press misunderstood our paper. I believe that he fails to see the forest for the trees. The media do not always get technical details correct, as scientists know well. Moreover, media often have editorial positions and put their own spin on news stories. I complain in my open letter about an exceptional case in which *Nature* disguised their editorial position as a "news" article in which they report only criticisms of our paper. However, overall the media deserve credit for correctly conveying the thrust of our perspective on climate change. Indeed, the *Washington Post* editorial discussed in my open letter is, in my opinion, an astute assessment of the issues.

A basic problem is that we scientists have not informed the public well about the nature of research. There is no fixed "truth" delivered by some body of "experts". Doubt and uncertainty are the essential ingredient in science. They drive investigation and hypotheses, leading to predictions. Observations are the judge.

Sure, some things are known with higher confidence than others. Yet fundamental issues as well as details are continually questioned. The possibility of finding a new interpretation of data, which provides better insight into how something in nature works, is what makes science exciting. A new interpretation must satisfy all the data that the old theory fit, as well as make predictions that can be checked.

The suggestion that BC causes a forcing of about 1 W/m^2 is a possible example. Observations required to verify the forcing are extensive, because it is the sum of several effects. Perhaps recognition of the BC forcing will allow IPCC to include fully the negative direct and indirect forcings of sulfate and organic aerosols, something that they have been reluctant to do. There is still much to be learned.

In my letter I note the potential educational value of keeping an annual public scorecard of measured changes of (1) fossil fuel CO_2 emissions, (2) atmospheric CO_2 amount, (3) human-made climate forcing, and (4) global temperature. These are well-defined quantities with hypothesized relationships. It is possible to make the science understandable, and it may aid the discussions that will need to occur as years and decades pass. It may help us scientists too. I am curious, for example, whether the IPCC (1996) conclusion that fossil fuel CO_2 emissions must be cut by 80% to stabilize atmospheric CO_2 at 550 ppm will be supported by empirical data as it accumulates.

Strategic Considerations. Wuebbles states that our scenario can not be "used in any sense as a strategy, particularly given the inhomogeneities in the aerosol distribution and radiative forcing". We do not try to specify a detailed strategy for dealing with global warming (nor does Wuebbles or IPCC). However, we do present an outline of a strategy and argue that its elements are feasible.

It is impractical to stop CO_2 from increasing in the near term, as fossil fuels are the engine of the global economy. However, the decline of the growth rate of CO_2 emissions from 4 to 1%/year suggests that further reduction to constant emissions is feasible, especially since countries such as the United States have made only modest efforts at conservation. The potential economic and strategic gains from reduced energy imports themselves warrant the required efforts in energy conservation and development of alternative energy sources.

The other requirement in our alternative scenario is to stop the growth of non-CO_2 forcings, which means, primarily, air pollution and methane. The required actions make practical sense, but they will not happen automatically and defining the optimum approach requires research.

A strategic advantage of halting the growth of non-CO_2 forcings is that it will make it practical to stop the growth of climate forcings entirely, in the event that climate change approaches unacceptable levels. The rationale for that claim is that an ever-growing fraction of energy use is in the form of clean electrical energy distributed by electrical grids. If improved energy efficiency and non-fossil energy sources prove inadequate to slow climate change, we may choose to capture CO_2 at power plants for sequestration.

Global warming is a long-term problem. Strategies will need to be adjusted as we go along. However, it is important to start now with common sense economically sound steps that slow emissions of greenhouse gases, including CO_2, and air pollution. Early emphasis on air pollution has multiple immediate benefits, including the potential to unite interests of developed and developing countries. Barriers to energy efficiency need to be removed. Research and development of alternative energies should be supported, including a hard look at next generation nuclear power. Ultimately strategic decisions rest with the public and their representatives, but for that reason we need to make the science and alternative scenarios clearer.

Finally, an amusing thing about Wuebbles' criticism is the space devoted to noting that, even if there is some cancellation of global mean forcings by aerosols and gases, there may still be climate effects due to the geographical inhomogeneity of the net forcing. That's right. However, he fails to recognize that reduction of particulate air pollution will *reduce* this inhomogeneity, not increase it.

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