Climate Change: The Uncertainties, the Certainties, and What They Imply About Action

THOMAS C. SCHELLING

First the uncertainties; then the certainties; then the urgencies; and finally, what do uncertainties imply about waiting for their resolution before acting.

The uncertainties are many and great. How much carbon dioxide may join the atmosphere if nothing is done about it? That depends on projections of population, economic growth, energy technology, and possible feedbacks from warming that reduce albedo—ice and snow cover, for example.

Winner of the 2005 Nobel Prize in Economics, Thomas C. Schelling has published widely on military strategy and arms control, energy and environmental policy, climate change, nuclear proliferation, terrorism, organized crime, foreign aid and international trade, conflict and bargaining theory, racial segregation and integration, the military draft, health policy, tobacco and drugs policy, and ethical issues in public policy and in business.

Next, how much average warming globally is to be expected from some specified increase in the concentration of carbon dioxide and other "greenhouse" gases? For a quarter century the range of uncertainty has been about a factor of three. (As more becomes known, more uncertainties emerge. Clouds and oceans are active participants in ways unappreciated two decades ago.)

How will the average warming translate into changing climates everywhere: precipitation, evaporation, sunlight and cloud cover, temperature and humidity (daytime/nighttime, summer/winter) over oceans and plains and mountains, the frequency and severity of storms, of protracted droughts? Will rain replace snow in mountains, and melting of snow cover occur before irrigation can benefit?

What will be the impacts of such changes in climate on productivity, especially in agriculture, fisheries, and forests, and on comfort and health? Both the vectors and the pathogens of disease, especially in the tropics, will be affected, almost certainly for the worst. (Here productivity enters again: will malaria, river blindness, etc., have been overcome by advances in public health technology?) What will happen to ecological systems, to vulnerable species?

How well can people, businesses, governments, and communities adapt to the climate changes, especially in countries heavily dependent on food production, in countries with poor educational and technological attainment, poor fiscal or legal systems?

And of course, what are the likely costs of various mitigation strategies, mainly shifting to renewable energy sources and conserving energy, with technologies mostly not yet ready?

Finally, what will the world be like in 50, 75, or 100 years when climate change may become acute? Think back seventy-five years: what was the world like, compared with now? Will the world be as different from now in seventy-five years as it is now from seventy-five years ago? How would we, seventy-five years ago, have predicted the consequences of climate change in today's world, and who are "we" who might have predicted those consequences?

The uncertainties are immense, and I'll draw some conclusions shortly. But what are the certainties?

It has been known for a century that the planet Venus is so bathed in "greenhouse gases" that its surface temperature, hundreds of degrees above Earth's, does not allow water to exist in liquid form, and that Mars is so deficient in greenhouse gases that its temperature is too cold to allow water to exist in liquid form on its surface. Earth has been blessed with such a concentration of gases in the atmosphere that we have a climate consistent with liquid water and terrestrial life.

It has been known for a century that if a glassed chamber of carbon dioxide is subjected to infrared radiation—the radiation by which earth's heat, perpetually renewed by sunlight, is returned to space to keep our temperature even—the energy output is less than the energy input in direct proportion to the rise in temperature of the gas in the chamber. The greenhouse "theory," as it is sometimes disparagingly referred to, is established beyond responsible doubt.

So the basics of global warming are not in scientific dispute. There is serious uncertainty about the quantitative parameters, and there can be doubt whether the experienced warming of recent decades is entirely due to the "greenhouse effect," there being other conjectured possible solar influences. But the "theory" is not in doubt. (Incidentally, actual greenhouses don't work by the "greenhouse effect," but it is too late to change the terminology.)

If we know that the earth is ineluctably warming, with possible drastic effects on climates around the world, but not how fast or how far, what are the most urgent things to do about it? One, of course, is to keep studying the phenomena; huge advances in understanding of the climate phenomena and their ecological impact are occurring. It is a happy coincidence that concern for climate-affected greenhouse gases arose just as earth-reconnaissance satellites became available to study glaciers, forests, sea level, atmospheric and ocean temperatures, snow and ice albedo, sunlight-reflecting aerosols of sulfur, cloud reflectance, and all manner of things we need to understand.

Under "urgencies," I put energy research and development, especially government sponsored research and development (R and D), and most importantly multi-government R and D. We need, urgently, to better understand what alternatives to fossil fuels there will be, how much energy can be conserved, how to extract carbon dioxide from the atmosphere, and if necessary how to increase the earth's albedo, its reflectance of incoming sunlight.

There are two important ways to induce or provide the necessary research and development. One is to use the price system, the "market," letting private initiative finance and direct the work, through appropriate taxes, subsidies, rationing, and—most important—through convincing the private sector, firms and consumers, that fossil fuels are going to become progressively and, probably, drastically more costly as the decades go by.

The other is for R and D to be financed and directed, cooperatively with business, by governments. Some essential R and D will not be undertaken by private interests; the "market" will not induce the necessary outlays; the benefits cannot be "captured" by the investors. Examples are multitudinous, but one or two may suffice.

It has long been understood that carbon dioxide produced in large stationary plants like electric-power stations can be "captured" and piped to where it can be injected into underground caverns (or possibly ocean beds). In fact, carbon dioxide from such sources has been used for decades to stimulate the flow of oil from exhausting oil wells. Twenty-five years ago it was estimated that capturing the CO_2 output from power plants and injecting it underground would double the cost of electricity; it now appears that costs may be more modest. There are experiments underway, only a few, that should help to determine what technologies may prove most economical, not necessarily a single technology, but alternatives for different regions.

If it proves economical to "capture" and "sequester" carbon dioxide from stationary plants, and if adequate underground repositories can be found all over the world, a huge reduction of emissions into the atmosphere may make less drastic the need to curtail the use of coal. China, with huge coal deposits it plans to exploit, could greatly reduce its carbon emissions by this technology.

But the research and development that will be required, not only in the technology of capture, transport, injection, and sealing but in geologic exploration all over the world for sites suitable for permanent storage, will be beyond the purview of any private interest. This is one example of R and D that depends on government involvement, preferably multinational.

Another area of research that deserves attention, and will not receive it from the private sector, goes currently under the name of "geoengineering." (The subject requires an article of its own, but a few words can be offered here.) Some of the sunlight reaching the earth is absorbed by the ocean, the forests, the plains, the urban areas; some is reflected away. Forests absorb more than plains and deserts; arctic ice reflects more away than bare oceans. Some is reflected away by aerosols, particles in the atmosphere that often form the basis for droplets that are reflective.

It has long been known that some volcanic eruptions, namely those that produce lots of sulfur, can cool the earth significantly. Pinatubo, in the Philippines in the 1990s, had a noticeable effect. It is estimated that sulfur currently in the atmosphere, mainly from combustion of coal and oil, may be masking a significant part of the expected greenhouse effect—perhaps a significant fraction of a degree. The question arises naturally, could one offset some of the greenhouse effect, or all of it, by putting something in the stratosphere that could reflect incoming energy?

It has been estimated that to offset a doubling of the concentration of greenhouse gases would require reflecting away something like 1½ to 2 percent of incoming sunlight. (Not all the adverse effects of CO_2 would be offset: ocean acidity would be affected by continuing injections of CO_2.) Sulfur is not an attractive substance; when it comes down it is not healthful for people or fish. But the amount of sulfur that might be required, in annual injection into the stratosphere, is quite small because it stays up there longer compared with what is already being put into the lower atmosphere. It would make sense to do small, reversible experiments to ascertain what substances might, with what lifting technology, be put at what altitude, and to include the results in the global climate models to ascertain where—what latitudes and longitudes—would be most effective and most benign. Needless to say, this is not a task for the private sector, and some international sponsorship might be appropriate.

Now the critical question: what does uncertainty have to do with the question, proceed with costly efforts to reduce CO_2 abatement in a hurry, or wait until we know more?

In some public discourse, and in sentiments emanating from the Bush Administration, it appears to be accepted that uncertainty regarding global warming is a legitimate basis for postponement of any action until more is known. The action to be postponed is usually identified as "costly." (Little attention is paid to actions that have been identified as of little or no serious cost.) It is interesting that this idea that costly actions are unwarranted if the dangers are uncertain is almost unique to climate. In other areas of policy, such as terrorism, nuclear proliferation, inflation, or vaccination, some "insurance" principle seems to prevail: if there is a sufficient likelihood of sufficient damage we take some measured anticipatory action.

At the opposite extreme is the notion, often called the "precautionary principle" now popular in the European Union, that until something is guaranteed safe it must be indefinitely postponed despite substantial expected benefits. Genetically modified foods and feedstuffs are current targets. (One critic has expressed it as, "never do anything for the first time.") In this country the principle says that until a drug has proven absolutely safe it must be deferred indefinitely.

Neither of the two extreme principles—do nothing until we are absolutely sure it's safe; do nothing until we are absolutely sure the alternative is dangerous—makes economic sense, or any other kind. Weigh the costs, the benefits, and the probabilities as best all three are known, and don't be obsessed with either extreme tail of the distribution.

There are a few actions that the uncertainties make infeasible for now, and probably for a long time, and thus not worth attempting. Deciding now, through some multinational diplomatic process, what the ultimate ceiling on greenhouse gas concentrations must be to prevent, in the immortal words of the Framework Agreement, "dangerous anthropogenic interference with the climate system," as a basis for allotting quotas to participating nations, is in contradiction to the acknowledged uncertainty about the "climate sensitivity" parameter, with its factor of three in the range of uncertainty. Individual commentators have strong opinions, often quite low, but any nation's representatives can adduce substantial evidence in favor of twice that level.

The most terrifying possible consequence of global warming that has been identified is the possible "collapse" of the West Antarctic Ice Sheet. This is a body of ice that rests on the bottom of the sea and protrudes a kilometer or two above sea level. It is not floating ice; floating ice, when it melts, does nothing to sea level. This ice sheet is essentially an iceberg that has grown so large it rests on the bottom: there is enough of it above sea level that, if it glaciated into the ocean, it could raise sea level by something like twenty feet.

That would truly be a disaster. We might save Manhattan (expensively!) with dikes, as the Dutch have done for centuries, or Los Angeles or Copenhagen or Stockholm, or Boston or Baltimore. But dikes can't save Bangladesh: not only is there too much coastline, but dikes would produce fresh water floods. (Rivers cannot rise up over a dike to reach the sea.) And tens of millions of Bangladeshi would have to migrate or die.

Estimates of the likelihood of collapse, or the likely time of collapse, of the West Antarctic Ice Sheet have varied for three decades. Recent studies of the effect of ocean temperature on the movement of ground-based ice sheets are not reassuring. It has occasionally been proposed that the collapse might become irreversible before the world has taken action to mitigate warming. In my reading—this is not my profession, I just try to keep up with the latest research—the likelihood of collapse in this century is small. But uncertain!

How should we respond to that kind of uncertainty? Wait until the uncertainty has been resolved completely before we do anything, or act as if it's certain until we have assurance that there's no such danger?

Those two extremes are not the only alternatives!

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