

DRAFT

U.S. Senate Committee on Commerce, Science and Transportation Hearing on ‘The Case for Climate Change Action’ October 1, 2003

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Introduction and Personal Perspective. If I may indulge in a personal note at the outset. It is a pleasure to appear again in front of both Senators McCain and Lieberman on climate change issues, having had that honor on several occasions since the mid 1980s with Senator McCain, and the mid 1990s with Senator Lieberman. As these hearing today are about the “case for action” on climate change, based on sound science assessment, I will try to emphasize aspects of the science of climate change less exhaustively covered by other witnesses, such as Dr. Tom Wigley of the National Center for Atmospheric Research, whose testimony on climate change science I fully associate myself with. Instead, I will focus more on as aspects of science so well stated by Senator Lieberman when I testified to the Senate Environment and Publics Works Committee, chaired by the late Senator Chaffee, in July 1997. At that time Senator Lieberman said:

“Changes in climate have major implications for human health, water resources, food supplies, infectious diseases, forests, fisheries, wildlife populations, urban infrastructure, and flood plains and coastal developments in the United States. Although uncertainties remain about where, when and how much climate might change as a result of human activities, the changes—when they happen—may have severe impacts on many sectors of the U.S. economy and on the environment. These are serious risks that we must start considering” (p. 15)

This statement is equally valid today, and can be further supported by substantially more scientific studies pointing out potentially serious climate impacts. I will briefly review some of these, and put them in the context of climate change cost/benefit analyses. But first, a brief statement about the climate change science itself.

While testifying to this Committee on May 8, 1989—with Senator McCain then being a member of the Committee—I recall a discussion about the problem of uncertainties and how long we should wait before action. Moreover, some debaters had asserted that there wasn’t enough direct evidence of human-induced climate change for strong policy actions. In response to senators from this committee on that point, I agreed that “most of our confidence that the future will change is about the heat trapping properties of gases, not based so much on the performance of the planet this century.

If we insist on waiting for the planet to catch up to what we expect it to do, it is another 10 to 20 years to prove that beyond doubt” (p.150)

Well, it is now 14 years since I said that. I believe the work of the Intergovernmental Panel on Climate Change (IPCC), the U.S. National Academy of Sciences (NAS) and others has amply demonstrated that, indeed, nature has “caught up” with our expectations of warming, and in fact added a few surprises such as rapid changes in

polar regions and devastating heat-wave induced deaths, even in modern, highly developed countries, like happened in France this past summer with ten thousand or more victims of that rare heat.

The surface warming trends are solidly grounded in observational science and consistent with human-induced pressures. It is scientifically well established that the Earth's surface air temperature has warmed significantly, by about 0.6 °C since 1860, and that an upward trend can be clearly discerned by plotting historical temperatures. Such a graph would show a rapid rise in temperature at the end of the twentieth century. This is supported by the fact that all but three of the ten warmest years on record occurred during the 1990s. But what has been learned only in the past half-decade is that this unusual warmth is not just for the past 140 years, but the past 2000, as Figure 1 displays.

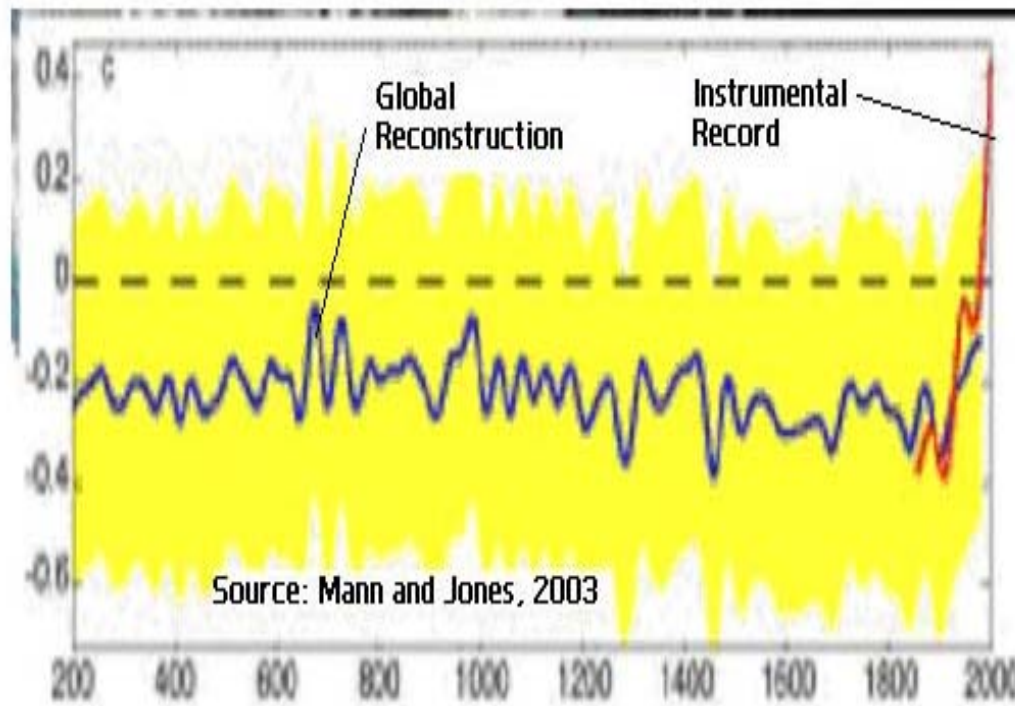


Figure 1. Two millennium reconstruction of global temperature changes in degrees Celsius (blue line), with 95% confidence band shown in yellow and the instrumental record in red. Notice that the last several decades of the 20th century exceed the range of temperatures over the past 2000 years. Source: Mann and Jones, 2003

The probability that the radical upward swing in temperature at the tail end of the 20th century being just a natural quirk of nature—as some “contrarians” and their political supporters contend—is an exceedingly low probability. If, as some assert, “the sun did it”, then what was the sun doing over the previous 2 millennia? It is rather perverse to expect such a radical behavior from the sun just now—when we have clear evidence of human-induced pressures coincident with the warming. While it cannot be ruled out as a possibility (at some low probability) that natural factors are responsible for the unusual warmth of the Earth’s surface at the end of the 20th century, we have much more likely explanations in the mix of natural and human-induced (anthropogenic) factors. More disquieting are projections for the 21st century if we continue business as usual for greenhouse gas emissions. It is for such reasons that I just expressed my personal satisfaction for having over the past two decades had the opportunity to testify to the Senators currently leading this effort to establish a meaningful climate change policy for the United States that actually will result in emissions reductions. In my personal opinion it is essential that we get on with the job of providing mandatory incentives to encourage the

amazing industrial and intellectual capacity of our country to fashion cost-effective solutions. I thank the Senators for having stayed with this issue over the long term.

In addition to observations of nature cooperating with theory by evidencing record warmth in the past few decades, it is well established that human activities have caused increases in radiative forcing, with radiative forcing defined as a change in the balance between radiation coming into and going out of the surface-atmosphere system. In the past few centuries, atmospheric carbon dioxide has increased by more than 30 percent, and virtually all climatologists agree that the cause is human activities, in particular, the burning of fossil fuels.

Despite the many well established aspects of the science of climate change (e.g., anthropogenic forcing of global warming), other aspects (e.g., detailed regional changes) are still being vigorously debated. The climate change debate is characterized by deep uncertainty, which results from factors such as lack of information, disagreement about what is known or even knowable, linguistic imprecision, statistical variation, measurement error, approximation, subjective judgment, and disagreement about structural models, among others (see Moss and Schneider, 2000). These problems are compounded by the global scale of climate change, which produces varying impacts at local scales, long time lags between forcing and its corresponding responses, very long-term climate variability that exceeds the length of most instrumental records, and the impossibility of before-the-fact experimental controls or empirical observations (i.e., there is no experimental or empirical observation set for the climate of, say, 2050 AD, meaning all our future inferences cannot be wholly “objective,” data-based assessments — at least not until 2050 rolls around). Moreover, climate change is not just a scientific topic but also a matter of public and political debate, and degrees of uncertainty may be played up or down (and further confused, whatever the case) by stakeholders in that debate.

Can We Define What is “Dangerous” Climate change? Article 2 of the UN Framework Convention on Climate Change (UNFCCC) states that: “The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”. The Framework Convention on Climate Change further suggests that “Such a level should be achieved within a time frame sufficient

- to allow ecosystems to adapt naturally to climate change,
- to ensure that food production is not threatened and
- to enable economic development to proceed in a sustainable manner.”

Thus, the term “dangerous anthropogenic interference” may be defined or characterized in terms of the consequences (or impacts) of climate change outcomes, which can be related to the levels and rates of change of climate parameters. These parameters will, in turn, be determined by the evolution of emissions and consequent atmospheric greenhouse gas concentrations. Evaluating the consequences of climate change outcomes to determine those that may be considered “dangerous” is a complex undertaking, involving substantial uncertainties as well as value judgments. In this context, the role of scientists is to assess the literature with a view to providing information that is policy-relevant, without being policy prescriptive.

Climate Sensitivity and Climate Scenarios to 2100 and Beyond. By how much will humans and natural changes in the Earth each contribute to future disturbance? The IPCC has attempted to tackle this controversial issue in its Special Report on Emission Scenarios (SRES), which contains a range of possible future climate scenarios based on different assumptions regarding economic growth, technological developments, and population growth, arguably the three most critical determinants of future climate change. These have been used to project the increases in CO₂ concentrations and temperature out to 2100. These and other climate change projections depend on detailed modeling. The most consistent way scientists codify knowledge is by constructing models made up of the many subcomponents of the climate system that reflect our best understanding of each subsystem. The system model as a whole cannot be directly verified before the fact —

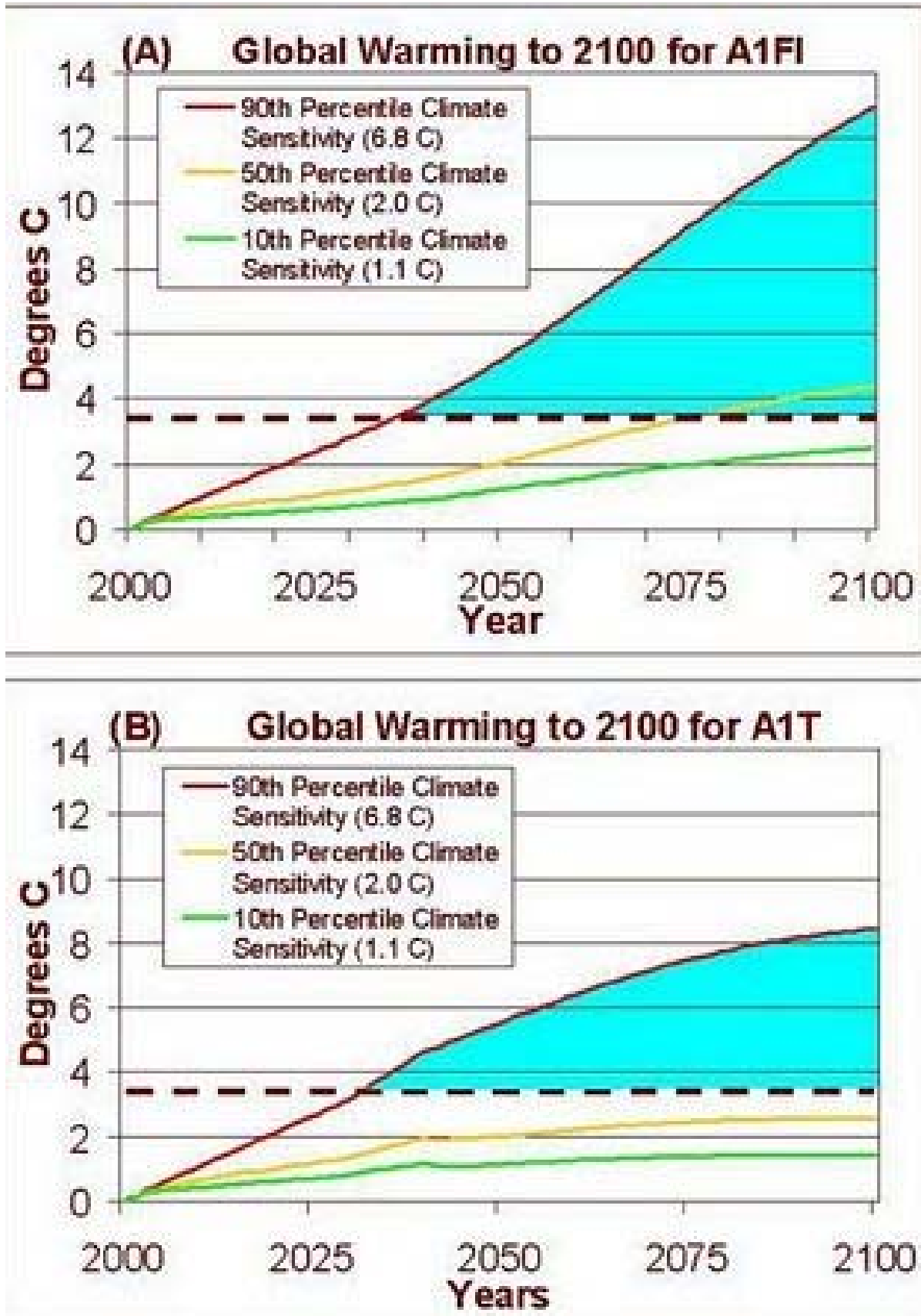
that is, before the future arrives — but it can be tested against historical situations that resemble what we believe will occur in the future.

While modeling has become both more complex and more accurate as computing abilities have advanced and more is understood about the climate problem, scientists still have to deal with an enormous amount of uncertainty, as mentioned above. In modeling, a major uncertainty is climate sensitivity, the amount by which the global mean surface air temperature will increase for a doubling of CO₂ concentrations. Many scientists have done extensive modeling and observational research on this subject over the past 20 years, and most have agreed that climate sensitivity probably falls somewhere within the IPCC's range of 1.5-4.5 °C. However, that old consensus is changing, as several recent studies (e.g., Andronova and Schlesinger, 2001, Forrest et al 2001) have estimated that climate sensitivity could be an alarming 6 °C or higher. (Remember that a 5-7 °C *drop* in temperature is what separates Earth's present climate from an ice age.)

The most comprehensive models of atmospheric conditions are three-dimensional, time-dependent simulators known as general circulation models (GCMs). Because of the complexity and computational costs of GCMs, simpler models are often constructed to explore the sensitivity of outcomes to plausible alternative assumptions for the structure of the climate system and the possible scenarios of human activities which cause climatic forcing (e.g., Wigley, testimony to this session). Together, the fan of possible climate scenarios and the probability distributions of possible climate sensitivities, determine what policy makers often want to know—by how much will it warm in, say, 2100 (or any other time) depending on what policies we choose to change emissions scenarios (e.g., Schneider, 2002). IPCC has addressed this issue in many of its assessments. The combined effects of uncertainties in emissions and uncertainties in climate sensitivity—what determines the range of potential future temperature changes at some future date—are also known as a “joint probability” estimation (i.e., sensitivity and emissions varied jointly).

Consider another simple way to approach this question of the joint probability of temperature rise to 2100 *and* crossing some “dangerous” warming threshold, to use the language of the UNFCCC—which, by the way, was signed by President Bush in 1992 and ratified by the Senate). Instead of using two probability distributions, an analyst could pick a high, medium, and low range for each factor and plot the results. For example, a glance at Andronova and Schlesinger's calculations shows that the 10 percentile value for climate sensitivity is 1.1 °C for a doubling of CO₂ (i.e., 4 W/m² of radiative forcing). 1.1 °C is, of course, below the IPCC's lower limit climate sensitivity value of 1.5 °C. However, this merely means that there is a 10 percent chance climate sensitivity will be 1.1 °C or less — that is, a 90% chance climate sensitivity will be 1.1 °C or *higher*. The 50th percentile result — that is, the value at which climate sensitivity is as likely to be above as below — is 2.0 °C. The 90th percentile value for climate sensitivity from Andronova and Schlesinger (2001) is 6.8 °C, meaning there is a 90% chance climate sensitivity is 6.8 °C or less, but there is still a very uncomfortable 10% chance it is even higher than 6.8 °C — a value well above the 4.5 °C figure that marks the top of the IPCC's range. Using these three values to represent a high, medium, and low climate sensitivity can produce three alternate projections of temperature over time, once an emissions scenario is decided on. In Root, Root and Schneider (in preparation), the three climate sensitivities just explained were combined with two SRES storylines: A1FI, the very high emissions, fossil fuel-intensive scenario; and A1T, the high technological innovation scenario, in which development and deployment of advanced technologies dramatically reduces the long term emissions. This comparison pair almost brackets the high and low ends of the 6 SRES representative scenarios' range of cumulative emissions to 2100, and since both are for the “A1 world,” the only major difference between them is the technology component — a “policy lever” that could be activated through the implementation of policies to encourage decarbonization—like the bill before this committee. Therefore, asking how different the evolution of projected climate is to 2100 for the two different scenarios is a very instructive exercise and can help in exploring in a partial way the different likelihood of crossing “dangerous” warming thresholds. To be conservative, I'll use a 3.5 °C threshold for “dangerous” climate change, though I'll show shortly it could be lower or higher.

Figure 3 — *Three climate sensitivities and two scenarios*



As noted in Figure 3 above, the three climate sensitivities — 10th, 50th and 90th percentiles — designated by Andronova and Schlesinger (2001) are combined with the radiative forcings for the A1FI and A1T scenarios. The dashed horizontal lines in both graphs represent the 3.5 °C threshold, and the blue shaded area marks the extent to which the two temperature change scenarios exceed that 3.5 °C threshold. These produce similar projections of warming for the first several decades of the 21st century, but diverge considerably— especially the high-sensitivity 90th percentile case — after mid-century. The 50th and 90th percentile A1FI cases both exceed a threshold of 3.5 °C warming before 2100, and the area shaded in blue is much more dramatic in the fossil intensive scenario than the technological innovation scenario. In fact, at 2100, when the A1T curves are stabilizing, the A1FI temperatures are still upwardly sloped — implying greater warming in the 22nd century. Thus, in order to fully assess “dangerous” climate change potential, simulations that cover well over 100 years are necessary since it is widely considered that warming above a few degrees Celsius is likely to be much more harmful than for changes below a few degrees (see Figure 5 below).

How Long is a “Long View”? The most striking feature of both scenarios in Fig 3 is the top (red) line, which rises very steeply above the other two lines below. That is because of the peculiar shape of the probability density function for climate sensitivity in Andronova and Schlesinger. [For those concerned with the technical details, that is because it has a long tail to the right due to the possibility that aerosols have been holding back not-yet-realized warming.] Also striking is that both the 10th and 50th percentile results for both the A1FI and A1T scenarios don’t differ much in 2050, but then diverge considerably by 2100. This has led some to declare (erroneously, in my view) that there is very little difference in climate change across scenarios or even among different climate models with different sensitivities. This is clearly wrong, for although both A1FI and A1T have emissions, and thus CO₂ concentration projections, that are not very different for the first several decades of the 21st century, they diverge after 2050, as does the temperature response. For the 90th percentile results, both the A1FI and the A1T temperature projections exceed the “dangerous” threshold of 3.5 °C at roughly the same time (around 2040), but the A1FI warming not only goes on to outstrip the A1T warming, but is still steeply sloped at 2100, implying warming beyond 13 °C in the 22nd century, which would undoubtedly leave a dramatic legacy of environmental change for distant posterity, and great ecological stress for nature.

This simple pair of figures shows via a small number of curves (6 in all) the probability of temperature changes over time for three climate sensitivity probabilities, but does not give probabilities for emissions scenarios themselves; only two are used to “bracket uncertainty,” and thus no joint probability can be gleaned from this exercise. This is the next step that needs to be taken by the research community. An MIT integrated assessment group (Webster et al, 2003) has already attempted it using a series of different models and expert judgments to fashion a probability distribution for future climate. That approach, I predict, will be the wave of the future in such analyses, but given the heavy model-dependence of any such results, individual “answers” will remain controversial and assumption-bound for a considerable time to come.

The likelihood of threshold-crossing is thus quite sensitive to the particular selection of scenarios and climate sensitivities used. However, in these bracketing studies the probability of crossing “dangerous” thresholds of climate change is typically tens of percent—a risk society will have to weigh against the costs of climate mitigation activities. As will be discussed shortly, that is a potentially high risk indeed.

If conventional economic discounting were applied, some present-day “rationalists” might argue that the present value of damages postponed for a century or so is virtually nil. But what if our behavior were to trigger irreversible changes in sea levels, ocean currents or the extinction of species (on civilization time scales)? Is it fair to future generations for us to leave them the simultaneous legacy of more wealth and severe ecosystem damage? That is the policy dilemma thoughtful analysts of the climate policy debate have to ponder, since the next few generations’ behaviors will precondition to a considerable extent the long-term evolution of the climate and the planetary ecosystems.

Model Validation. How can modelers be more confident in their model results? How do they know that they have taken into account all economically or ecologically or climatologically significant processes, and that they have satisfactorily “parameterized” processes whose size scales are below that of their models’ grid cells? The

answer lies in a variety of *model validation* techniques, most of which involve evaluating a model's ability to reproduce (for climate models, for example) known climatic conditions in response to known forcings. One form of model validation has to do with climatic response to volcanic eruptions. Major volcanic eruptions inject so much sulfuric haze and other dust into the stratosphere that they exert a global cooling influence that lasts several years and provide good tests for climate models. Such eruptions occur somewhat randomly, but there is typically one every decade or so, and they constitute natural “experiments” that can be used to test climate models. The last major volcanic eruption, of the Philippine volcano Mt. Pinatubo in 1991, was forecast by a number of climate modeling groups to cool the planet by several tenths of a degree Celsius. That is indeed what happened.

Figure 4: Predicted and observed changes in global temperature after the 1991 eruption of Mt. Pinatubo. (source: Hansen et al, 1996).

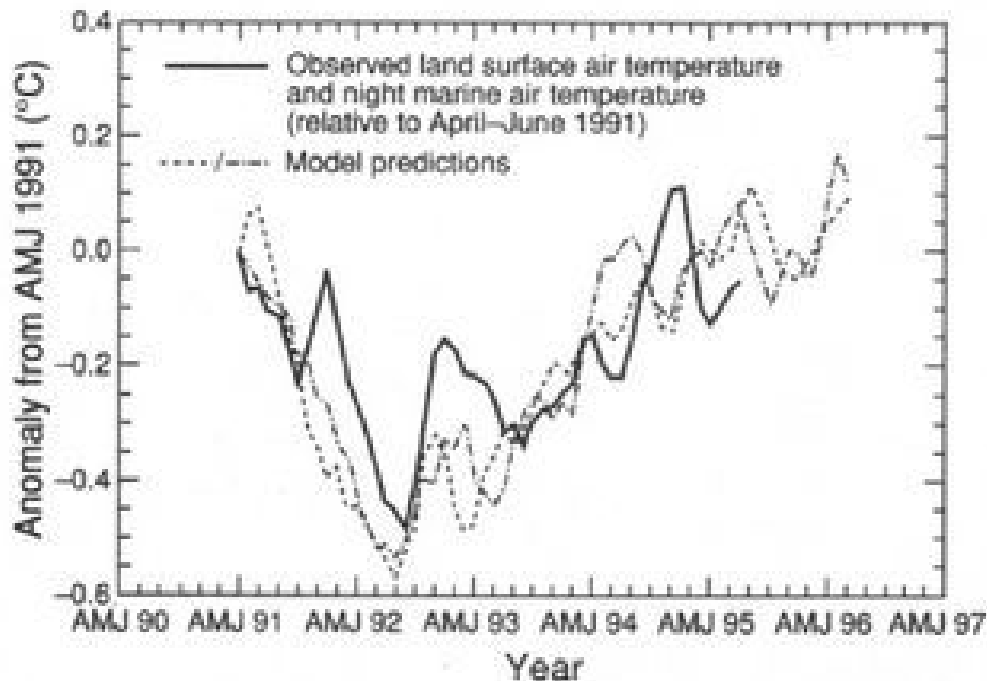


FIGURE Predicted and observed changes in global temperature after the 1991 eruption of Mt. Pinatubo in the Philippines. Solid curve is derived from measured air temperatures over land and ocean surfaces. Broken curves represent climate model runs with slightly different initial conditions. In both cases the models included the effect of dust injected into the atmosphere by the volcanic eruption. (From Hansen et al., 1992, as adapted from IPCC, 2001a.)

Figure 4 shows a comparison between actual observed global temperature variations and those predicted by a climate model, for a period of five years following the Mt. Pinatubo eruption. Now, a few tenths of a degree Celsius is small enough that the observed variation just might be a natural fluctuation. However, earlier eruptions including El Chichón in 1983 and Mt. Agung in 1963 were also followed by a marked global cooling of several tenths of a degree Celsius. Studying the climatic effects from a number of volcanic eruptions shows a clear and obvious correlation between major eruptions and subsequent global cooling. Furthermore, a very simple calculation shows that the negative forcing produced by volcanic dusts of several watts per square meter is consistent with the magnitude of cooling following major volcanic eruptions. Viewed in light of these data,

the graph above suggests that climate models do a reasonably good job of reproducing the large-scale climatic effects of volcanic eruptions on a few-year time scale.

Seasonality provides another natural experiment for testing climate models. Winter weather typically averages some fifteen degrees Celsius colder than summer in the Northern Hemisphere and five degrees colder in the Southern Hemisphere. (The Southern Hemisphere variation is lower because a much larger portion of that hemisphere is water, whose high heat capacity moderates seasonal temperature variations.) Climate models do an excellent job reproducing the timing and magnitude of these seasonal temperature variations, although the absolute temperatures they predict may be off by several degrees in some regions of the world. However, the models are less good at reproducing other climatic variations, especially those involving precipitation and other aspects of the hydrological cycle. Of course, reproducing the seasonal temperature cycle alone — since these variations come full circle in only one year — does not guarantee that models will accurately describe the climate variations over decades or centuries resulting from other driving factors such as increasing anthropogenic greenhouse gas concentrations. However, the fact that models do so well with seasonal variations is an assurance that the models' climate sensitivity is unlikely to be off by a factor of 5 - 10, as some greenhouse “contrarians” assert.

Climate Impacts. Let us consider some of the effect that might occur in our century if SRES emissions do occur and typical models are used to calculate the climatic consequences of those scenarios unfolding. These changes then allow us to estimate potential impacts of climate changes, and in turn, the “climate benefits” of mitigation that avoids some of those potential damages.

Table 1 is IPCCs summary of a number of such projected effects. It has allowed, via extensive literature assessments, the integrated assessment of “five reasons for concern” if climate changes as the joint variation of SRES scenarios and climate models—see Figure 5.

Table 1 — Projected effects of global warming during the 21st Century (adapted from IPCC 2001b, table SPM-1).

Projected Effect	Probability estimate	Examples of Projected Impacts with high confidence of occurrence (67 – 95% probability) in at least some areas
Higher maximum temperatures, more hot days and heat waves over nearly all land areas	Very likely (90-99%)	Increased deaths and serious illness in older age groups and urban poor Increased heat stress in livestock and wildlife Shift in tourist destinations Increased risk of damage to a number of crops Increased electric cooling demand and reduced energy supply reliability
Higher minimum temperatures, fewer cold days, frost days and cold waves over nearly all land areas	Very likely (90-99%)	Decreased cold-related human morbidity and mortality Decreased risk of damage to a number of crops, and increased risk to others Extended range and activity of some pest and disease vectors Reduced heating energy demand

More intense precipitation events	Very likely (90-99%) over many areas	Increased flood, landslide, avalanche, and mudslide damage Increased soil erosion Increased flood runoff increasing recharge of some floodplain aquifers Increased pressure on government and private flood insurance systems and disaster relief
Increased summer drying over most mid-latitude continental interiors and associated risk of drought	Likely (67-90%)	Decreased crop yields Increased damage to building foundations caused by ground shrinkage Decreased water resource quantity and quality Increased risk of forest fire
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities	Likely (67-90%) over some areas	Increased risks to human life, risk of infectious disease epidemics and many other risks Increased coastal erosion and damage to coastal buildings and infrastructure Increased damage to coastal ecosystems such as coral reefs and mangroves
Intensified droughts and floods associated with El Niño events in many different regions	Likely (67-90%)	Decreased agricultural and rangeland productivity in drought- and flood-prone regions Decreased hydropower potential in drought-prone regions
Increased Asian summer monsoon precipitation variability	Likely (67-90%)	Increase in flood and drought magnitude and damages in temperate and tropical Asia
Increased intensity of mid-latitude storms	Uncertain (current models disagree)	Increased risks to human life and health Increased property and infrastructure losses Increased damage to coastal ecosystems

Reasons for Concern About Climate Change Impacts.

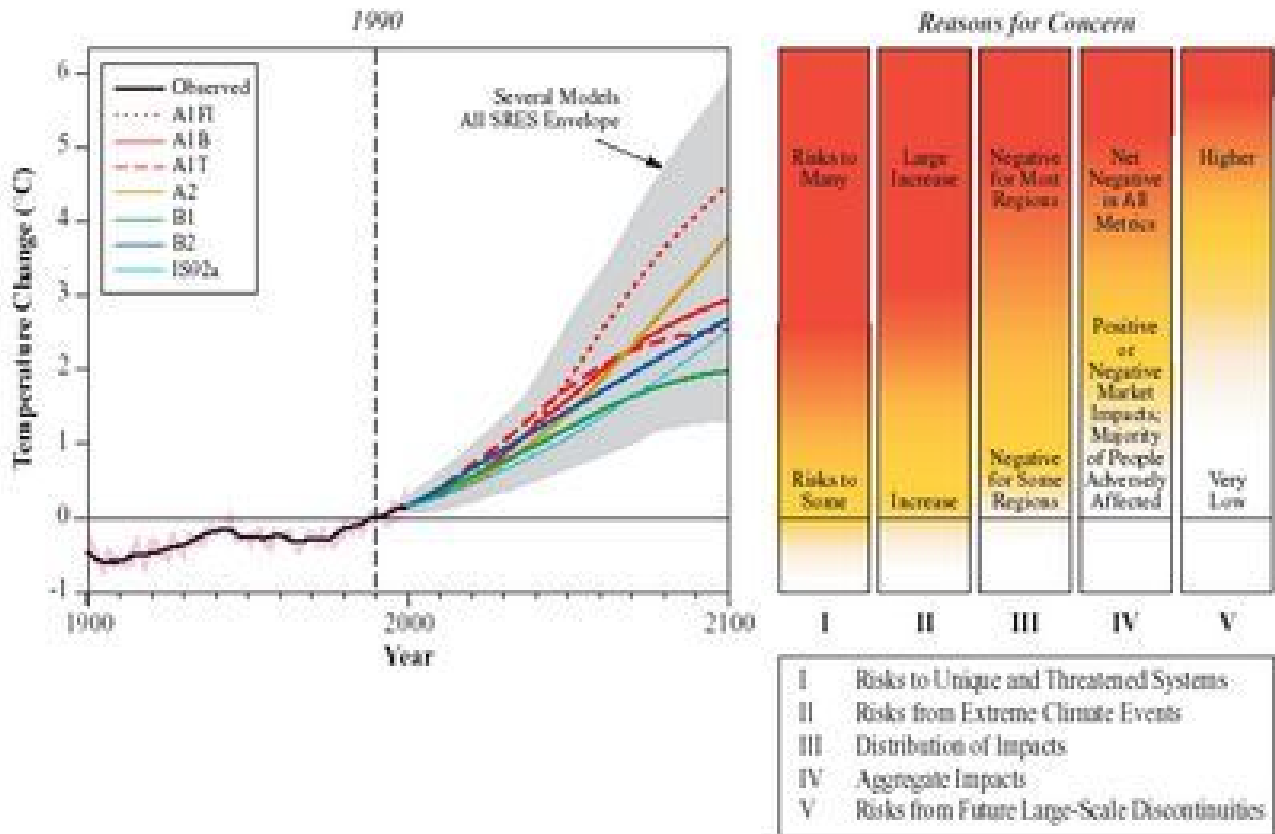


Figure 5 — Reasons for concern about climate change impacts (source: [IPCC WG 2 TAR, figure SPM-2](#)). The left part of the figure displays the observed temperature increase up to 1990 and the range of projected increases after 1990 as estimated by [IPCC, WG I \(IPCC, 2001a\)](#) for scenarios from the Special Report on Emission Scenarios. The right panel displays conceptualizations of five reasons for concern regarding climate change risks evolving through 2100. White indicates neutral or small negative or positive impacts or risks, yellow indicates negative impacts for some systems, and red means negative impacts or risks that are more widespread and/or greater in magnitude. This figure shows that the most potentially dangerous impacts (the red colors on the figure) typically occur after a few degrees warming — thus, my earlier (Fig 3) use of 3.5°C as a tentative “threshold” for serious climate damages is very conservative (the European Union has suggested a “dangerous” level for warming at about 2 °C). The risks of adverse impacts from climate change increase with the magnitude of climate change.

It is important that scientists continue to develop stronger models and probe the issue of climate sensitivity, as improvements in the science will lead to improvements in our understanding of the potential impacts of various levels of temperature change.

Despite uncertainties surrounding emission scenarios and climate sensitivity, the IPCC has projected that, if its latest estimate that the Earth's atmosphere will warm somewhere between 1.4 and 5.8 °C by 2100 is correct, likely effects will include: more frequent heat waves (and less frequent cold spells); more intense storms (hurricanes, tropical cyclones, etc.) and a surge in weather-related damage; increased intensity of floods and droughts; warmer surface temperatures, especially at higher latitudes; more rapid spread of disease; loss of farming productivity and/or movement of farming to other regions, most at higher latitudes; rising sea levels, which could inundate coastal areas and small island nations; and species extinction and loss of biodiversity (see table 1).

In What Units Can We Measure Climate Damage? Schneider, Kuntz-Duriseti, and Azar (2000) have argued that the best way to estimate the full extent of such damages comes from examining not just monetarily-quantifiable ("market") damage, but the "five numeraires": monetary loss (market category), loss of life, quality of life (including coercion to migrate, conflict over resources, cultural diversity, loss of cultural heritage sites, etc.), species and/or biodiversity loss, and distribution/equity. Assessing climate impacts in all these metrics should ensure a fairer, more accurate assessment of the actual costs of global warming.

This last numeraire, the issue of equity in climate change, is, and will likely continue to be, contentious. Climate change inequality will likely come in two forms. First, it will produce inequity in effects. Some countries or sectors within countries will benefit from a certain degree of warming, whereas others will be harmed by it. The developed countries, who are responsible for most of the greenhouse gases emitted into the atmosphere thus far, may not be affected as much as the developing countries for two reasons: First, there is usually higher adaptive capacity in richer, cooler countries than in poorer, warmer ones. Second, developing countries that have not yet experienced the economic fruits of the Victorian Industrial Revolution, and want their chance to emit and industrialize, fear that policies to restrict emissions will deny them their "fair share" of the atmospheric commons to use—quite literally—as a waste dump. One strategy to solve this problem is "technology leapfrogging," the transfer or development of cleaner technologies to developing countries on a much-accelerated time schedule (relative to the developments that have emerged over a century in now-rich countries). Moreover, as there are disparities in countries' abilities to pay for global warming-related problems, once again, the developing countries will be affected more yet have less of an ability to pay than the rich nations. While I agree it is essential to deal with climate policy at home—and thus personally applaud this bill before the committee today—we will have to join with other countries to fashion joint solutions shortly after that if we are to fashion global solutions.

Nature Is Responding Already. One of the numeraires was conservation of biodiversity. Very recent studies (e.g., Root et al 2003; Parmesan and Yohe, 2003) have shown that nature is already responding to climate trends of the past several decades. Figure 6, for example, shows by how many days each decade traits of plants and animals (such as dates of flowering of trees, migration times in the spring for birds or the range boundaries of butterflies) are already statistically significantly changed owing to observed climate trends. That warmer weather would make flowers bloom earlier is hardly surprising, but that "only" "0.6 °C warming to date has already caused a "discernible impact" of recent temperature trends on plants and animals is surprising. Moreover, it is sobering to consider what major movements would likely take place for species if the climate changes by several degrees or more—what Figure 5 suggests are major reasons for concern.

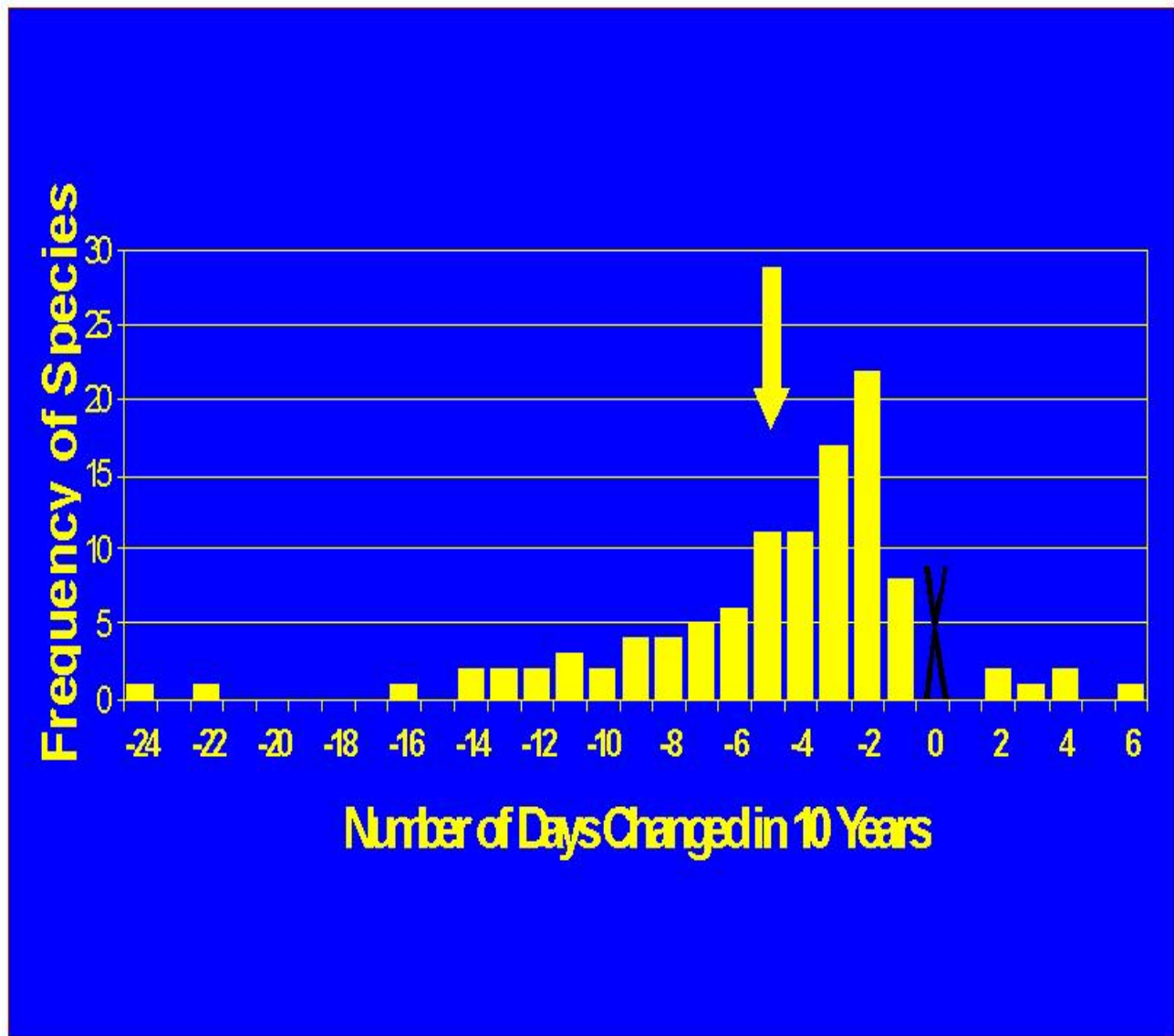
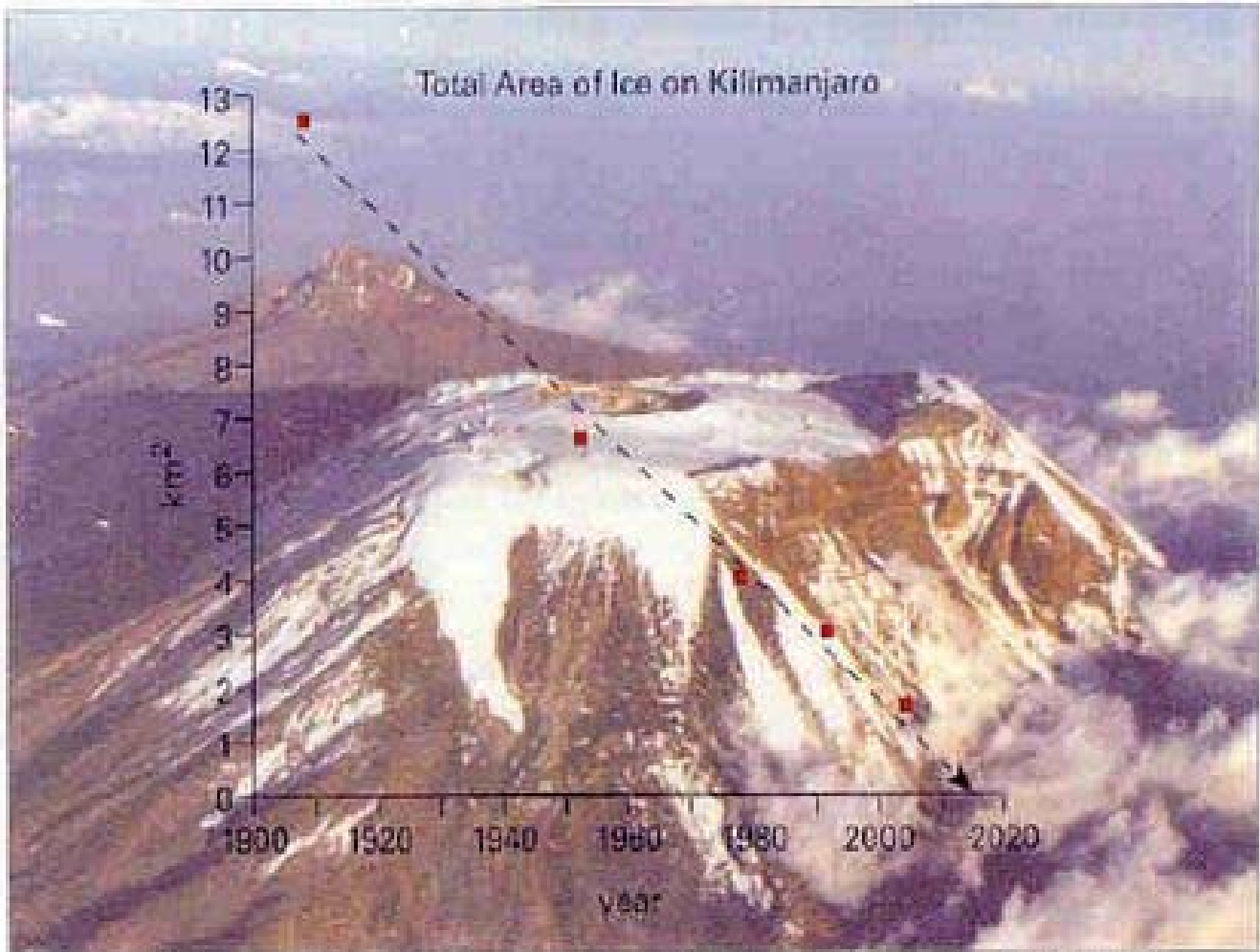


Figure 7. Frequency of species and groups of species with a temperature-related trait changing by number of days in 10 years for data gathered primarily since 1960. The arrow indicates the mean and the “x” indicates no data were tabulated for species showing no clear trait changes. This is a highly statistically significant result demonstrating that there has been a discernible impact of recent climate trends on plants and animals such that their vital activities that are linked to temperature are occurring earlier, in concert with global warming trends (Source, Root et al, 2003)

Another clear climate impact is the highly significant retreat of mountain glaciers. This is more than just the disruption of scenic beauty as the glaciers of Glacier National Park continue to disappear, but can be damaging to societies that suffer from flooding in the current glacier melting stage, and will suffer from lack of water when their accustomed supplies dry up as the glaciers disappear. Figure 8 shows this dramatically for the “snows of Kilimanjaro”, as they are now about 80-90% gone relative to a hundred years ago.

Figure 8 — *What will happen to the snows of Kilimanjaro?*



The extent of ice cover on Mt. Kilimanjaro decreased by 81% between 1912 and 2000. Disappearing paleoclimate archives such as this are a priority target of the Global Paleoclimate Observing System currently being proposed by PAGES scientists. For more information see the editorial in this issue of PAGES News. Photo: Captain G. Mazuka, Data: Lonnie Thompson.

Climate Surprises? Estimating climate damages that are expected to occur gradually and their effects is simple relative to forecasting "surprise" events and their consequences. The IPCC and others have stated that "dangerous" climate change, including surprises, are more likely to occur with more than a few degrees Celsius of additional warming. Surprises, better defined as "imaginable abrupt events", could include deglaciation and/or the alteration of ocean currents (the most widely-used example of the latter being the collapse of the Thermohaline Circulation, or THC, system in the North Atlantic). Rather than being ignored as unlikely, surprises and other irreversibilities like plant and animal extinctions should be treated like other climate change consequences by scientists performing risk assessments, where **risk** is defined as **probability x consequence**. The probability component of the risk equation will entail subjective judgment on the part of scientists, but this is far preferable to ignoring the risk equation entirely by pretending these risks didn't exist.

Policymakers will be better able to determine what is "dangerous" and formulate effective legislation to avoid such dangers if probabilities appear alongside scientists' projected consequences. These probabilities and consequences will vary regionally. In general, temperature rises are projected to be greatest in the subpolar regions, and to affect the polar winter more dramatically than the summer. Hotter, poorer nations (i.e., developing nations near the equator) are expected to suffer more dramatic effects from climate change than

their developed neighbors in the North. This is partly due to the lower expected adaptive capacities of future societies in developing nations when compared with their developed counterparts, which in turn depend on their resource bases, infrastructures, and technological capabilities. This implies that damages may be asymmetrically felt across the developed/developing country divide. The scenario in which climate change brings longer growing seasons to the rich northern countries and more intense droughts and floods to the poor tropical nations is clearly a situation ripe for increasing tensions in the twenty-first century. Ecosystems, especially those already stressed by land use pressures, are particularly vulnerable to rapid climate changes.

Regardless of the different levels of vulnerability and adaptive capacity that future societies are expected to have and the need for regional-level assessments that that implies, all people, governments, and countries should realize that "we're in this together." In all regions, people's actions today will have long-term consequences. Even if humanity completely abandons fossil fuel emissions in the 22nd century, essentially irreversible long-term concentration increases in CO₂ are projected to remain for a millennium or more. Thus, the surface climate will continue to warm from this greenhouse gas elevation, with a transient response of centuries before an equilibrium warmer climate is established. How large that equilibrium temperature increase is depends on both the final stabilization level of the CO₂ and the climate sensitivity.

One threat of a warmer climate would be an ongoing rise in sea level. Warmer atmospheric temperatures would lead to warming of ocean water (and corresponding volumetric expansion) until the heat is well-distributed throughout the oceans — a mixing time known to be on the order of 1,000 years. Instead of only up to a meter of sea level rise over the next century or two from thermal expansion of warmed ocean waters— and perhaps a meter or two more over the five or so centuries after that — significant global warming would likely trigger nonlinear events like a deglaciation of major ice sheets near the poles. That would cause many additional meters of rising seas for many millennia, and once started might not be reversible on the time scale of thousands of years.

Implications for Climate Policy Choices. In the face of such uncertainty, potential danger, and long-term effects of present actions, how should climate change policy be confronted? Climate change, like many other complex socio-technical are riddled with “deep uncertainties” in both probabilities and consequences that are not resolved today and may not be resolved to a high degree of confidence before we have to make decisions regarding how to deal with their implications. With imperfect, sometimes ambiguous, information on both the full range of climate change consequences and their associated probabilities, decision-makers must decide whether to adopt a "wait and see" policy approach or follow the "precautionary principle" and hedge against potentially dangerous changes in the global climate system. Since policymakers operate on limited budgets, they must determine how much to invest in climate protection versus other worthy improvement projects — e.g., new nature reserves or clean water infrastructure, education, health improvements etc.

Ultimately, the decision on whether or not to take actions on climate change entails a value judgment on the part of the policymaker regarding what constitutes "dangerous" climate change, ideally aided by complete risk assessments provided by scientists. Cost-benefit analyses (CBAs) are also useful in deciding the ifs and whats of climate change policy, but uncertainties, the need for multiple metrics (e.g., the “fine numeraires”) make this exercise difficult as well, especially when attempting to estimate the costs of surprise and other catastrophic events.

Any policies that are implemented should encourage, and possibly even go so far as to subsidize, technological change. Encouraging technological change through energy policies in particular is of critical importance when addressing climate change, since as Figure 3 showed, alternate energy-technology scenarios make a dramatic difference in the risk of long-term “dangerous” climate change potential.

Is It Really Too Expensive To Mitigate Global Warming? Christian Azar and I (Azar and Schnieder, 2002) developed a simple economy model and estimated the present value (discounted to 1990 and expressed in 1990 USD) of the costs to stabilize atmospheric CO₂ at 350 ppm, 450 ppm, and 550 ppm to be 18 trillion USD, 5 trillion USD, and 2 trillion USD respectively (see Azar & Schneider, 2002, which assumes a discount rate of

5% per yr). Obviously, 18 trillion USD is a huge cost. The output of the global economy in 1990 amounted to about 20 trillion USD. Seen from this perspective, these estimates of the costs of abatement tend to create the impression that we would, as critics suggest, have to make draconian cuts in our material standards of living in order to reduce emissions and achieve the desired levels of CO₂ concentration. These same critics view the cost estimates as unaffordable and politically impossible.

However, viewed from another perspective, an entirely different analysis emerges. In the absence of emission abatement and without any damages from climate change, GDP is assumed to grow by a factor of ten or so over the next 100 years, which is a typical convention used in long-run modeling efforts. (The plausibility of these growth expectations is not debated here, but the following analysis will show how GDP is expected to grow with and without climate stabilization policies.) If the 350 ppm target were pursued, the costs associated with it would only amount to a delay of two to three years in achieving this aforementioned tenfold global GDP increase. Thus, meeting a stringent 350 ppm CO₂ stabilization target would imply that global incomes would be ten times larger than today by April 2102 rather than 2100 (the date the tenfold increase would occur for the no-abatement-policies scenario). This trivial delay in achieving phenomenal GDP growth is replicated even in more pessimistic economic models. These models may be very conservative, given that most do not consider the ancillary environmental benefits of emission abatement (see Figure 9 below).

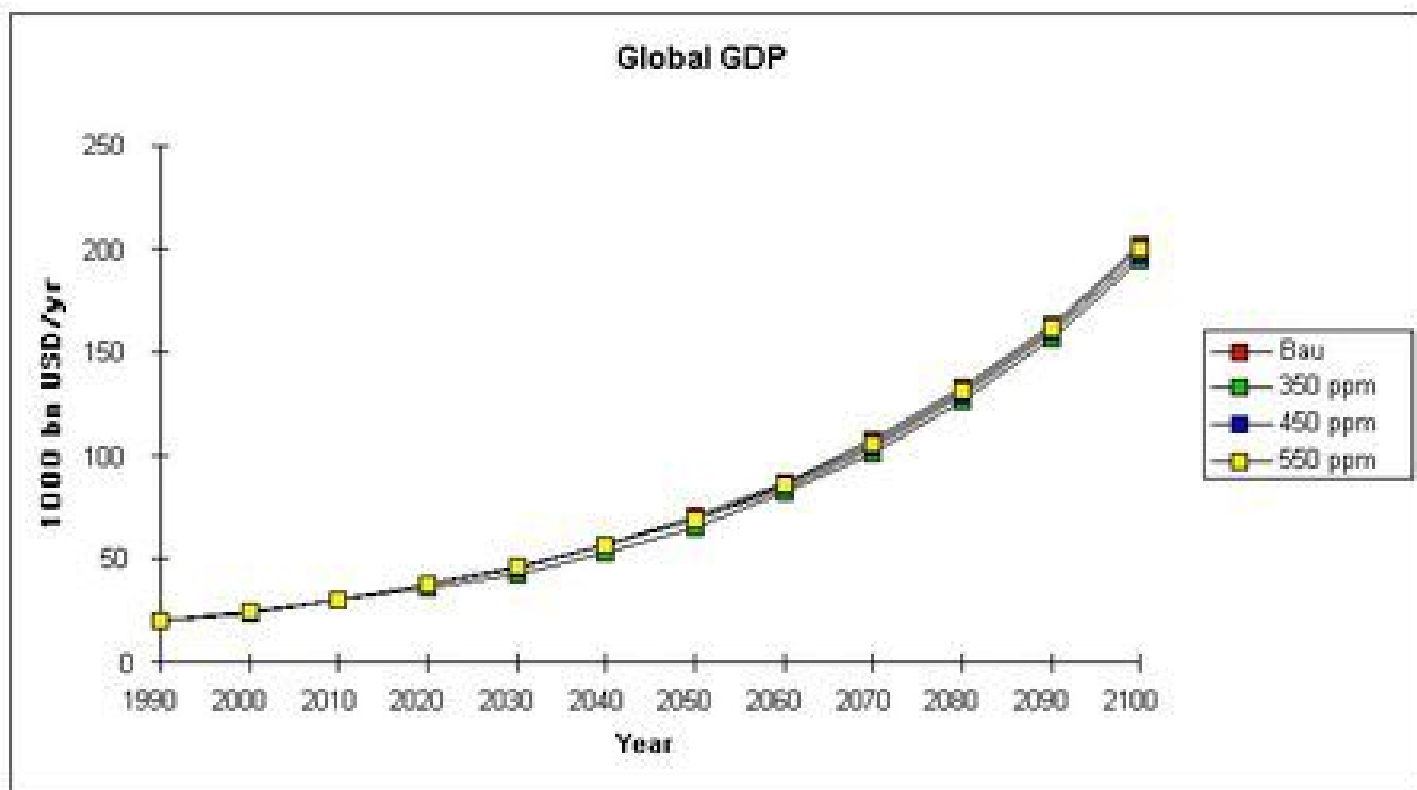


Figure 9—*Global income trajectories* under business as usual (BAU) and in the case of stabilizing the atmosphere at 350 ppm, 450 ppm, and 550 ppm. Observe that we have assumed rather pessimistic estimates of the cost of atmospheric stabilization (average costs to the economy assumed here are \$200/tC for 550 ppm target, \$300/tC for 450 ppm, and \$400/tC for 350 ppm) and that the environmental benefits in terms of climate change and reduction of local air pollution of meeting various stabilization targets have not been included. Source: [Azar & Schneider \(2002\)](#).

Representing the costs of stringent climate stabilization as a few short years of delay in achieving a monumental increase in wealth should have a strong impact on how policymakers, industry leaders, and the general public perceive the climate policy debate. Similar results can be presented for the Kyoto Protocol: the drop in GDP below "baseline" levels that would occur if the Kyoto Protocol were implemented ranges between

0.05% and 1%, depending on the region considered and the model used (see IPCC WG III, chapter 8, IPCC 2001c, p. 538). The drops in the growth rates for OECD countries over the next ten years would likely fall in the range of 0.005-0.1 percent per year below baseline scenario projections under the Kyoto Protocol. (It should be kept in mind that the uncertainties about baseline GDP growth projections are typically much larger than the presented cost-related deviations.)

Similar statements could well be made about the costs associated with this bill before the Committee—although I have not myself analyzed it, I strongly suspect that the loss of GDP from the costs incurred would be such a small fraction of typically projected GDP growth rates for the US, that only months of delay in growth would be felt on a base of large increases in personal income. Thus, this bill is likely to be an inexpensive “insurance premium” to slow down global warming and lower the likelihood of “dangerous” climate impacts.

To return to the analysis Azar and I did, assuming a growth rate of 2 percent per year in the absence of carbon abatement policies, implementation of the Kyoto protocol would imply that the OECD countries would get 20 percent richer (on an annual basis) by June 2010 rather than in January 2010, assuming the high-cost abatement estimate. Whether that is a big cost or a small cost is of course a value judgment, but it is difficult to reconcile with the strident rhetoric of some (e.g., Lindsey, 2001, who states on page 5 of this citation that “the Kyoto Protocol could damage our collective prosperity and, in so doing, actually put our long-term environmental health at risk.”) Similar statements about this bill have been made, and have been refuted by careful economic analyses RFF, 2003; MIT 2003). Clearly, such balanced assessments are what should guide the policy making process.

I thank the Committee for asking for my views on this important piece of legislation

Stephen Schneider

References:

Andronova, N.G. and M.E. Schlesinger, 2001: “Objective Estimation of the Probability Density Function for Climate Sensitivity”, *Journal of Geophysical Research*, 106:22605–22612.

Azar, C. and S.H. Schneider, 2002: “Are the Economic Costs of Stabilizing the Atmosphere Prohibitive?” *Ecological Economics*, 42:73-80.

Forest, C.E., P.H. Stone, A.P. Sokolov, M.R. Allen, and M.D. Webster, 2001: “Quantifying Uncertainties in Climate System Properties Using Recent Climate Observations”, *Science*, 295(5552):113-117.

Hansen, J. et al., 1996: “A Pinatubo Climate Modeling Investigation”, in Fiocco G., D. Fua, and G. Visconti (eds.) *The Mount Pinatubo Eruption: Effects on the Atmosphere and Climate*, Heidelberg, Germany: Springer-Verlag, 233-272, NATO ASI Series Vol. I 42.

IPCC, 2000: Emissions Scenarios - A Special Report of Working Group III of the Intergovernmental Panel on Climate Change [N. Nakicenovic et al (eds.)], Cambridge: Cambridge University Press, 599 pp.

IPCC 2001b: Impacts, Adaptation, and Vulnerability - Contribution of Working Group II to the IPCC Third Assessment Report, [J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, K.S. White (eds.)], Cambridge: Cambridge

Mann, M.E. and P.D. Jones, 2003: “Global Surface Temperatures Over the Past two Millennia”, *Geophys. Res. Letts.* (in press).

IPCC 2001c: Mitigation - Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O. Davidson, R. Swart, J. Pan (eds.)], Cambridge: Cambridge University Press, 752

Lindsey, L.B., 2001: Speech to a colloquium on Science and Technology Policy organized by the American Association for the Advancement of Science (AAAS), May 2001.

MIT 2003 (Integrated Assessment of the McCain/Lieberman bill using the MIT integrated assessment model) (get proper citation)

Moss, R.H. and Schneider, S.H., 2000: "Uncertainties in the IPCC TAR: Recommendations to Lead Authors for More Consistent Assessment and Reporting", in Pachauri R., T. Taniguchi, and K. Tanaka (eds.), Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of the IPCC, Geneva, Switzerland: World Meteorological Organization, 33-51.

Parmesan, C. & Yohe, G., 2003: "A Globally Coherent Fingerprint of Climate Change Impacts Across Natural Systems", Nature, 421, 37 - 42, (2003).

Resources For The Future (Analysis of McCain/ Lieberman Costs) (get proper citation)

Root, T.L., J.T. Price, K.R. Hall, S.H. Schneider, C. Rosenzweig, and J. A. Pounds, 2003: "Fingerprints' of Global Warming on Animals and Plants", Nature, 421:57-60.

Schneider, S.H., K. Kuntz-Duriseti, and C. Azar, 2000: "Costing Non-linearities, Surprises and Irreversible Events", Pacific and Asian Journal of Energy, 10(1):81-106.

Schneider, S.H., 2002a: "Can We Estimate the Likelihood of Climatic Changes at 2100?" Climatic Change, 52(4):441-451.

Webster, M. et al., 2003: "Uncertainty Analysis of Climate Change and Policy Response", Climatic Change, in press.

Site References follow (<http://www.stanford.edu/~shs>):

IPCC Reports

Climate Change 2001a: The Scientific Basis, Summary for Policy Makers - Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, C.A. Johnson (eds.)], Cambridge: Cambridge University Press, 881 pp.

Climate Change 2001b: Impacts, Adaptation, and Vulnerability - Contribution of Working Group II to the IPCC Third Assessment Report, [J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, K.S. White (eds.)], Cambridge: Cambridge University Press, 1032 pp.

Climate Change 2001c: Mitigation - Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O. Davidson, R. Swart, J. Pan (eds.)], Cambridge: Cambridge University Press, 752 pp.

Climate Change 2001d: Synthesis Report 2001- Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change [R.T. Watson and the Core Writing Team (eds.)], Cambridge: Cambridge University Press, 397 pp.

IPCC, 2000e: Emissions Scenarios - A Special Report of Working Group III of the Intergovernmental Panel on Climate Change [N. Nakicenovic and R. Swart (eds.)], Cambridge: Cambridge University Press, 599 pp.

IPCC, 1996a: Climate Change 1995: The Science of Climate Change, Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.)]. Cambridge: Cambridge University Press, 572 pp. (Summary for Policy Makers)

IPCC, 1996b: Impacts, Adaptation and Mitigation Options. IPCC, Working Group II, Cambridge: Cambridge University Press, 878 pp. (Summary for Policy Makers)

IPCC, 1996c: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the Second Assessment of the Intergovernmental Panel on Climate Change [J.P. Bruce, H. Lee, E.F. Haites (Eds.)], Cambridge University Press, UK. pp 448. (Summary for Policy Makers)

IPCC, 1992: Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment [Houghton, J.T., Callander B.A., and Varney S.K., (eds.)], Cambridge: Cambridge University Press, 205 pp.

Adams, G., 2003: "AGs from Maine, Conn., question lawsuit origins", Portsmouth Herald, 12 August.


[Associated Press article] Available online at


<http://www.seacoastonline.com/news/08122003/world/44413.htm>

Ainslie, G., 1991: "Derivation of 'Rational' Economic Behaviour From Hyperbolic Discount Curves", American Economic Association Papers and Proceedings, 81(2):334-40.


Alcamo, J. and E. Kreileman, 1996: "Emission Scenarios and Global Climate Protection", Global Environmental Change, 6:305-334.

Alexander, S.E., S.H. Schneider, and K. Lagerquist, 1997: "The Interaction of Climate and Life", in Daily, G.C. (ed.) Nature's Services: Societal Dependence on Natural Ecosystems, Washington, DC: Island Press, 71-92.

 Allegre, C.J. and S.H. Schneider, 1994: "The Evolution of the Earth", Scientific American, (271) 4:44-51.

 Allen, M., 1999: "Do-it-yourself climate prediction", Nature 401: 642. Available online at

http://www.climateprediction.net/science/pubs/nature_allen_141099.pdf

 Allen, M., 2003: "Climate Forecasting: Possible or Probable?" Nature 425: 242.

Anatta, 2000: "Population and wealth, more than climate, drive soaring flood costs", UCAR Quarterly, Winter 2000.

Andronova, N.G. and M.E. Schlesinger, 2001: "Objective Estimation of the Probability Density Function for Climate Sensitivity", Journal of Geophysical Research, 106:22605-22612.

Appell, D., 2003: "Hot Words", Scientific American Explore, June 24, 2003.

Arrow, K.J., W. Cline, K.G. Mäler, M. Munasinghe, R. Squitieri, and J. Stiglitz, 1996: "Intertemporal Equity, Discounting and Economic Efficiency", in Bruce, J.P., H. Lee, E.F. Haites (eds.) Climate Change 1995: Economic and Social Dimensions of Climate Change, Second Assessment of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press, 125-144.

- Ashton, J., Wang, X., 2003: "Equity and Climate: In Principle and Practice", in Beyond Kyoto: Advancing the International Effort Against Climate Change. Pew Center on Global Climate Change working papers series. Available online at: <http://www.pewclimate.org/docUploads/Beyond%5FKyoto%5FEquity%2Epdf>
- Austin, D., 1997: "Climate Protection Policies: Can We Afford to Delay?", World Resources Institute, Washington, DC., see <http://www.wri.org/wri/climate/cpp-home.html>
- Ayres, R.U., 1994: "On Economic Disequilibrium and Free Lunch", Environmental and Resource Economics, 4: 434-454.
- Azar C. and H. Dowlatabadi, 1999: "A Review of Technical Change in Assessment of Climate Policy", Annual Review of Energy and Environment, 24:513-544.
- Azar C. and O. Johansson, 1996: "Uncertainty and Climate Change - or The Economics of Twin Peaks", Presented at the Annual Conference of European Environmental and Resource Economists, June, Lisbon.
- Azar, C. and S.H. Schneider, 2002: "Are the Economic Costs of Stabilizing the Atmosphere Prohibitive?" Ecological Economics, 42:73-80.
- Azar, C. and H. Rodhe, 1997: "Targets for Stabilization of Atmospheric CO₂", Science, 276:1818-1819.
- Azar, C. and K. Lindgren, 2001: "Biomass Energy with Carbon Sequestration — Preliminary Estimates of Global Techno-Economic Potentials", Manuscript, Department of Physical Resource Theory, Chalmers, Göteborg.
- Azar, C. and T. Sterner, 1996: "Discounting and Distributional Considerations in the Context of climate Change", Ecological Economics, 19:169-185.
- Azar, C., 1998: "Are Optimal Emissions Really Optimal—Four Critical Issues for Economists in the Greenhouse", Environmental and Resource Economics, 11:301-315.
- Azar, C., K. Lindgren, and B. Andersson, 2000: "Hydrogen or Methanol in the Transportation Sector - a Global Scenario Study", Report to The Swedish Transport and Communications Research Board, 69 pp.
- Baliunas, S., 2002: "Warming Up to the Truth: The Real Story About Climate Change", Heritage Foundation, Lecture #758, Aug. 22, 2002. Available online at: <http://www.heritage.org/Research/EnergyandEnvironment/HL758.cfm>
- Baliunas, S., 2003: "Combating global warming would be a waste", Providence Journal, 25 July. Available online at http://www.projo.com/opinion/contributors/content/projo_20030725_25ctwarm.a5b51.html
- Barnett, T., Somerville, R., 2003: "The Bush administration versus global warming", San Diego Union-Tribune, 17 July. Available online at
- BBC News, 2001: "Anger at US climate retreat", BBC News online, 29 March. Available online at <http://news.bbc.co.uk/2/hi/science/nature/1248278.stm>
- Berger, A., Loutre, M.F., 2002: "An Exceptionally Long Interglacial Ahead?" Science 297: 1287-1288.
- Bertrand, C., Van Ypersele, J.-P., Berger, A., 2002: "Are Natural Climate Forcings Able to Counteract the Projected Anthropogenic Global Warming?" Climatic Change 55: 413-427. Available online at <http://ipsapp009.kluweronline.com/content/search/4592/66/4/fulltext.pdf>
- Blumenthal, R., and Rowe, G.S., 2003: "Re: Lawsuit by CEI", Letter to Attorney General John Ashcroft, 11 August.
- Boffey, P.M., J.E. Rodgers, and S.H. Schneider, 1999: "Bayesian Approaches to Characterizing Uncertainty", in Hassol, S.J. and J. Katzenberger (eds.), *Elements of Change 1996*, Aspen, Colorado: Aspen Global Change Institute, 136-139.
- Boffey, P.M., J.E. Rodgers, and S.H. Schneider, 1999: "Interpreting Uncertainty: A Panel Discussion", in Friedman, S.M., S. Dunwoody, C.L. Rodgers (eds.), *Communicating Uncertainty: Media Coverage of New and Controversial Science*, New Jersey, London: Lawrence Erlbaum Associates, 81-91.
- Bradley, R. S., 2003: Presentation, "Climate of the Last Millennium", HOLOCENE Working Group Workshop, Bjerknes Centre for Climate Research, August 2003.
- Bradley, R.S., Mann, M.E., 2003: "Are we heating the planet? PRO: Evidence of global warming is conclusive, and denial is dangerous", The News Tribune, 10 August. Available online at: <http://www.tribnet.com/opinion/story/3633509p-3665815c.html>

- Brechin, S.R., 2003: "Comparative Public Opinion and Knowledge on Global Climatic Change and the Kyoto Protocol: The U.S. verses the World?" *International Journal of Sociology and Social Policy* 23(10): 106-134. Abstract available online at: <http://fernando.emeraldinsight.com/vl=9637100/cl=44/nw=1/rpsv/cgi-bin/linker?ini=emerald&reqidx=/cw/mcb/0144333x/v23n10/s5/p106>
- Broecker, W.S., 1997: "Will Our Ride Into the Greenhouse Future be a Smooth One?" *GSA Today*, 7(5):11-17.
- Broecker, W.S., 1997a: "Thermohaline Circulation, the Achilles Heel of Our Climate System: Will Man-Made CO₂ Upset the Current Balance?" *Science*, 278(5343):1582-1588.
- Brown, M.A., Levine, M.D., Short, W., Koomey, J.G., 2001: "Scenarios for a clean energy future", *Energy Policy* 29: 1179-1196.
- Brown, P., Parkinson, B., 2000: "Protecting the Climate While Safeguarding the Economy", *Redefining Progress Backgrounder No. 3*, May. Available online at http://www.redefiningprogress.org/publications/pdf/clim_econ.pdf
- Campbell, D., 2003: "White House cuts global warming from report", *The Guardian Unlimited*, 20 June. Available online at: <http://www.guardian.co.uk/climatechange/story/0,12374,981127,00.html>
- Carter, T.R., M.L. Parry, H. Harasawa, and S. Nishioka, 1994: "IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations. **Summary for Policy Makers and a Technical Summary**", Department of Geography, University College London, UK and the Center for Global environmental Research, National Institute for Environmental Studies, Japan, 59 pp.
- Christianson, G., G. Arrhenius, S.H. Schneider, B. Bolin, D. Schindler, R. Bryson, H. Rodhe, J. Harte, F. Singer, B. Charlson, S. Levin, A. Jernelov, H. Apsimon, and J. Leggett, 2001: "Scientists Speculate on What Svante Arrhenius Would Have Worked on Today", *Ambio*, 3(3):150.
- Cicerone, R., 2000: "Human Forcing of Climate Change: Easing up on the Gas Pedal", *PNAS* 97(12):10304-6.
- Cicerone, R., et al, 2001: "Climate Change Science: an Analysis of Some Key Questions", Washington D.C.: National Academy Press, 42 pp., *Proceedings of the Committee on the Science of Climate Change, Division on Earth and Life Studies, National Research Council*. Also available at: <http://books.nap.edu/html/climatechange/climatechange.pdf>.
- Cline W., 1992: *The Economics of Global Warming*, Washington, DC: Institute of International Economics, 399 pp.
- Committee on Abrupt Climate Change, Ocean Studies Board, Polar Research Board, Board on Atmospheric Sciences and Climate, Division on Earth and Life Sciences, National Research Council, 2002: Abrupt Climate Change: Inevitable Surprises (Washington, D.C.: National Academies Press), 244 pp. Available online at <http://www.nap.edu/openbook/0309074347/html/>
- Committee on Estimating the Health-Risk-Reduction Benefits of Proposed Air Pollution Regulations, Board on Environmental Studies and Toxicology, National Research Council, 2002: Estimating the Public Health Benefits of Proposed Air Pollution Regulations (Washington, D.C.: National Academies Press), 170 pp. Available online at <http://books.nap.edu/books/0309086094/html/>
- Cox, P.M, Betts, R.A., Jones, C.D., Spall, S.A., Totterdell, I.J., 2000: "Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model", *Nature* 408: 184-187. Abstract available online at: http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v408/n6809/abs/408184a0_fs.html&dynoptions=doi1063735765
- Crowley, T.J., 2000: "Causes of Climate Change Over the Past 1000 Years", *Science* 289: 270-277. Available online at: <http://www-geol.unine.ch/cours/geol/crowleySci270.pdf>
- Crowley, T.J., Berner, R.A., 2001: "Enhanced: CO₂ and Climate Change", *Science* 292(5518): 870-872.
- Daily, G.C., 1997: *Nature's Services: Societal Dependence on Natural Ecosystems* (Washington, D.C.: Island Press), 392 pp.
- Daily, G.C. and K. Ellison, 2002: *The New Economy of Nature: The Quest to Make Conservation Profitable*, Washington, DC. Island Press, 260 pp.
- Danish Committees on Scientific Dishonesty, 2002: "Decision regarding complaint against Bjorn Lomborg." Available online at http://www.forsk.dk/uvvu/nyt/udtaldebat/bl_decision.htm

- Dawson, T.E. and F.S. Chapin III, 1993: "Grouping Plants by Their Form-Function Characteristics as an Avenue for Simplification in Scaling Between Leaves and Land Scapes", pp 313-319 in Ehleringer J.R. and C.B. Field (eds.), *Scaling Physiological Processes: Leaf to Globe*, New York: Academic Press.
- deMenocal, P. and G. Bond, 1997: "Holocene Climate Less Stable Than Previously Thought", *Eos Transactions, AGU*, 78(41): 447-454.
- Detroit News, The, 1998: "Loads of Media Coverage" Editorial, Detroit News, 22 November 1989.
- Dietz, T., Ostrom, E., Stern, P.C., 2003: "The Struggle to Govern the Commons", *Science*, in press.
- Dow, C., 2003: "Maine, Connecticut AGs Call on Ashcroft to Investigate White House Role in Lawsuit", News from Maine Attorney General Steven Rowe, 11 August. Available online at http://www.maine.gov/ag/press_release_pop_up.php?press_id=167
- Dowlatabadi, H., 1996: "Adaptive Strategies for Climate Change Mitigation: Implications for Policy Design and Timing", Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh.
- Downing, T.E. (ed.), 1996: "Climate Change and World Food Security", Heidelberg, Germany: Springer-Verlag, NATO ASI Series 137.
- Duffy, P.B., Doutriaux, C., Fodor, I.K., Santer, B.D., 2001: "Effect of Missing Data on Estimates of Near-Surface Temperature Change Since 1900", *Journal of Climate* 14(13): 2809-2814. Also available as LLNL technical report UCRL-JC-140272. Available online at: <http://www.llnl.gov/CASC/sapphire/pubs/climate01.pdf>
- Easterling, W.E., L.O. Mearns, and C. Hays, 2001: "Comparison of Agriculture Impacts of Climate Change Calculated from High and Low Resolution Climate Model Scenarios, Part II: The Effect of Adaptations", *Climatic Change*, 51:173-197.
- Economist, The, 2002: "Defending Science", 362(8258):15, 31.
- Edwards, P.N. and S.H. Schneider, 2001: "Self-Governance and Peer Review in Science-for-Policy: The Case of the IPCC Second Assessment Report", in Miller C., and P. Edwards (eds.), *Changing the Atmosphere: Expert Knowledge and Global Environmental Governance*, Cambridge: MIT Press, 219-246.
- Fisher, A.C., 2001: "Uncertainty, Irreversibility and the Timing of Climate Policy", Paper presented to the Pew Center for Global Climate Change, 10-12 October.
- Forest, C.E., P.H. Stone, A.P. Sokolov, M.R. Allen, and M.D. Webster, 2001: "Quantifying Uncertainties in Climate System Properties Using Recent Climate Observations", *Science*, 295(5552):113-117.
- Funtowicz, S.O. and J.R. Ravetz, 1993: "Three Types of Risk Assessment and the Emergence of Post-Normal Science", in Krimsky, S. and D. Golden (eds.), *Social Theories of Risk*, Westport, CT: Greenwood, 251-273.
- Georgia, P., 2003: "The Shaky Science Behind the Climate Change Sense of the Congress Resolution", Republican Policy Committee briefing, 2 June. Available online at <http://www.senate.gov/~rpc/releases/2003/ev060203.pdf>
- Gerlagh, R. and B.C.C. van der Zwaan, 2001: "The Effects of Ageing and an Environmental Trust Fund in an Overlapping Generations Model on Carbon Emission Reductions", *Ecological Economics*, 36(2):311-326.
- Giles, J., 2002: "When Doubt is a Sure Thing", *Nature*, 418:470-478.
- Gjerde, J., Grepperud, S., and S. Kverndokk, 1999: "Optimal Climate Policy Under the Possibility of a Catastrophe", *Resource and Energy Economics*, 21:289-317.
- Gleick, P.H. et al., 2000: "Water: The Potential Consequences of Climate Variability and Change for the Water Resources of the United States", Report of the Water Sector Assessment Team of the National Assessment of the Potential Consequences of Climate Variability and Change (for the U.S. Global Change Research Program), September. Available online at <http://www.pacinst.org/ncawater.pdf>
- Goulder L.H. and K. Mathai, 1999: "Optimal CO2 Abatement in the Presence of Induced Technological Change", *Journal of Environmental Economics and Management*, 39:1-38.
- Goulder, L.H. and S.H. Schneider, 1999: "Induced Technological Change and the Attractiveness of CO2 Abatement Policies", *Resource and Energy Economics*, 21:211-252.
- Green, K., 2001: "Should Scientists Advocate Public Policy? Stephen Schneider Ponders the Ethics", *Stanford Report*, 9 May, 2001.

- Grubb, M., 1993: "The Costs of Climate Change, Critical Elements", in Kaya, Y., Nakicenovic, N., Nordhaus, W.D., and Toth, F.L., (eds.), Costs, Impacts, and Benefits of CO2 Mitigation, 153-166. Proceedings of a workshop held at IIASA, September 1992, Laxenburg, Austria.
- Grubb, M., 1997: "Technologies, Energy Systems, and the Timing of CO2 Abatement: An Overview of Economic Issues", *Energy Policy*, 25:159-172.
- Grubb, M., T. Chapuis, and M.H. Duong, 1995: "The Economics of Changing Course. Implications of Adaptability and Inertia for Optimal Climate Policy", *Energy Policy*, 23:417-431.
- Grubler, A. and N. Nakicenovic, 2001: "Identifying Dangers in an Uncertain Climate", *Nature*, 412:15.
- Grubler, A., N. Nakicenovic, and D.G. Victor, 1999: "Modelling Technical Change: Implications for the Global Environment", *Annual Review of Energy and the Environment*, 24:545-69.
- Gumerman, E., Koomey, J.G., Brown, M.A., 2001: "Strategies for cost-effective carbon reductions: a sensitivity analysis of alternative scenarios", *Energy Policy* 29: 1313-1323.
- Ha-Duong, M., M. Grubb, and J.C. Hourcade, 1997: "Influence of Socioeconomic Inertia and Uncertainty on Optimal CO2-Emission Abatement", *Nature*, 390:270-273.
- Hakim, D., 2003: "Automakers Drop Suits Over Clean-Air Regulation", *New York Times* 12 August. Available online at <http://www.nytimes.com/2003/08/12/business/12AUTO.html?ex=1376020800&en=9cca1c6371f77212&ei=5007&partner=USERLAND>
- Hanemann, W.M., 2000: "Adaptation and its Measurement. An Editorial Comment", *Climatic Change*, 45(3-4):571-81. Quote on p. 575.
- Hannesson, R., 1998: "Petroleum Economics: Issues and Strategies of Oil and Natural Gas Production", Westport, CT: Quorum Books.
- Hansen J.E., et al., 2000: "Global Warming in the 21st century: An Alternative Scenario", *Proceedings of the National Academy of Sciences*, 97(18)9:875-880.
- Hansen, J. et al., 1996: "A Pinatubo Climate Modeling Investigation", in Fiocco G., D. Fua, and G. Visconti (eds.) *The Mount Pinatubo Eruption: Effects on the Atmosphere and Climate*, Heidelberg, Germany: Springer-Verlag, 233-272, NATO ASI Series Vol. I 42.
- Hansen, J., A. Lacis, R. Ruedy, and M. Sato, 1992: "Potential Climate Impact of Mount Pinatubo Eruption", *Geophys. Res. Lett.*, 19:215-218.
- Hansen, J.E., 2002: "A Brighter Future", *Climatic Change*, 52(4):435-440.
- Hare, B., 1997: "Fossil Fuels and Climate Protection — the Carbon Logic", Greenpeace International, Amsterdam.
- Harvey, L.D., 2000: "Climate and Global Environmental Change", Prentice Hall, Harlow, 240 pp.
- Harvey, L.D., 2000a: "Global Warming: The Hard Science", Prentice Hall, Harlow, 408 pp.
- Harvey, L.D., 2000b: "Upscaling in Global Change Research", *Climatic Change*, Dordrecht: Kluwer Academic Publishers, 44:(3)225-263.
- Hasselmann K., S. Hasselmann, R. Giering, V. Ocaña, and H. von Storch, 1997: "Sensitivity Study of Optimal CO₂ Emission Paths Using a Simplified Structural Integrated Assessment Model (SIAM)", *Climatic Change*, 37(2):345-386.
- Hasselmann, K., 1997: "On Multifingerprint Detection and Attribution of Anthropogenic Climate Change", *Climate Dynamics*, 13:601-611.
- Hasselmann, K., S. Hasselmann, R. Giering, V. Ocaña, and H. von Storch, 1997: "Sensitivity study of optimal CO₂ emission paths using a simplified structural integrated assessment model (SIAM)", *Climatic Change*, 37 (2): 345–386.
- Heal, G., 1997: "Discounting and Climate Change, an Editorial Comment", *Climatic Change*, 37(2):335-343. Quote on page 339.
- Heede, R., 2002: "Cool Citizens – Everyday Solutions to Climate Change – Household Solutions", Rocky Mountain Institute, Snowmass, CO. Available online at <http://www.rmi.org/images/other/C-CoolCitHouseSolBrief.pdf>

- Hewitson, B., 2003: "Developing Perturbations for Climate Change Impact Assessments", EOS 84(35): 337-348. Available online at <http://www.agu.org/journals/eo/eo0335/2003EO350001.pdf#anchor>
- Higgins, P.A.T., M. Mastrandrea, and S.H. Schneider, 2002: "Dynamics of Climate and Ecosystem Coupling: Abrupt Changes and Multiple Equilibria", *Philosophical Transactions of the Royal Society, London*, 357(1421):647-655.
- Hoffert, M.I., K. Caldeira, A.K. Jain, L.D.D. Harvey, E.F. Haites, S.D. Potter, M.E. Schlesinger, S.H. Schneider, R.G. Watts, T.M.L. Wigley, and D.J. Wuebbles, 1998: "Energy Implications of Future Stabilization of Atmospheric CO₂ Content", *Nature*, 395:881-884.
- Hoffert, M.I. and C. Covey, 1993: "Deriving Global Sensitivity From Palaeoclimate Reconstructions", *Nature*, 360:573-576.
- Holdren, J.P., 2003: "Comments by John P. Holdren on 'The Shaky Science Behind the Climate Change Sense of Congress Resolution'", 9 June. Not online but we have Word doc.
- Holling, C.S., 1973: "Resilience and Stability of Ecological Systems", *Annual Review of Ecology and Systematics*, 4:1-23.
- Holling, C.S., 1986: "The Resilience of Terrestrial Ecosystems: Local Surprise and Global Change", in Clark, W.C. and R.E. Munn, (eds.), *Sustainable Development of the Biosphere*. Cambridge: Cambridge University Press for the International Institute for Applied Systems Analysis, 292-317.
- Hoskins, B.J., 2003 : "Climate Change at Cruising Altitude?" *Science* 301: 469-470.
- Howarth, R.B., 2000: "Climate Change and International Fairness", in DeCanio, S.J., R.B. Howarth, A.H. Sanstad, S.H. Schneider, and S.L. Thompson, *New Directions in the Economics and Integrated Assessment of Global Climate Change*, pp. 43-58. Washington, D.C.: The Pew Center on Global Climate Change.
- Hoyt, D.V. and K.H. Schatten, 1997: "The Role of the Sun in Climate Change", Oxford: Oxford University Press, 279 pp.
- IIASA/WEC, 1995: "Global Energy Perspectives to 2050 and Beyond", World Energy Council, London, see link @ http://www.iiasa.ac.at/Research/ECS/docs/book_st/node1.html.
- Interlaboratory Working Group, 2000: "Scenarios for a Clean Energy Future", Oak Ridge National Laboratory (Oak Ridge, TN) and Lawrence Berkeley National Laboratory (Berkeley, CA), November. Report #s ORNL/CON-476 and LBNL-44029. Available online at http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm
- Janssen, M. and B. de Vries, 2000: "Meeting Climate Change Policy Targets and the Role of Technological Change", *Climatic Change*, 46:(1-2)1-28.
- Jarvis, P.G., 1993: "Prospects for Bottom-up Models", in Ehleringer, J.R. and C.B. Field (eds.), *Scaling Physiological Processes: Leaf to Globe*, New York: Academic Press, pp 117-126.
- Jones, P.D., T. J. Osborn, K. R. Briffa, 2001: "The Evolution of Climate Over the Last Millennium", *Science*, v.292(5517), pp.662, April 27, 2001
- Jones, P.D., M. New, D.E. Parker, S. Martin, and I.G. Rigor, 1999: "Surface air temperature and its changes over the past 150 years", *Reviews of Geophysics*, 37, 173-199, 1999.
- Jones, C.D., Cox, P.M., Essery, R.L.H., Roberts, D.L., Woodgate, M.J., 2003: "Strong carbon cycle feedbacks in a climate model with interactive CO₂ and sulphate aerosols", *Geophysical Research Letters* 30: 1479-1482. Abstract available at: <http://www.agu.org/pubs/crossref/2003/2003GL016867.shtml>
- Jones, P.D., Osborn, T.J., Briffa, K.R., 2001: "The Evolution of Climate Over the Last Millennium", *Science* 292(5517): 662. Abstract available online at <http://www.ngdc.noaa.gov/paleo/pubs/jones2001/jones2001.html>
- Jones, R.N., 2000: "Managing Uncertainties in Climate Change Projections: Issues for Impact Assessment", *Climatic Change*, 45(3-4):403-419.
- Kaiser, H.M., S. Riha, D. Wilks, D. Rossiter, R. Sampath, 1993: "A Farm-Level Analysis of Economic and Agronomic Impacts of Gradual Climate Warming", *American Journal of Agricultural Economics*, 75:387-398.
- Kalnay, E. and M. Cal, 2003: "Impact of Urbanization and Land-Use Change on Climate", *Nature*: 423, 528-31.
- Kazman, S., 1998: "Large Vehicles Are the Solution, Not the Problem", Editorial, *Wall Street Journal*, 12 March 1998.

- Keller, K., K. Tan, F.M.M. Morel, and D.F. Bradford, 2000: "Preserving the Ocean Circulation: Implications for Climate Policy", *Climatic Change*, 47(1-2):17-43. Also NBER working paper # w7476.
- Kennedy, D., D. Holloway, E. Weinthal, W. Falcon, P. Ehrlich, R. Naylor, M. May, S.H. Schneider, S. Fetter, and J.-S. Choi, 1998: "Environmental Quality and Regional Conflict", a Report to the Carnegie Commission on Preventing Deadly Conflict, New York: Carnegie Corporation, 72 pp.
- Kiehl J.T., and K.E. Trenberth, 1997: "Earth's Annual Global Mean Energy Budget", *Bulletin of the American Meteorological Society*, 78:197-208.
- Kinzig, A.P., J. Antle, W. Ascher, W. Brock, S. Carpenter, F. S. Chapin III, R. Costanza, K.L. Cottingham, M. Dove, H. Dowlatabadi, E. Elliot, K. Ewel, A. Fisher, P. Gober, N. Grimm, T. Groves, S. Hanna, G. Heal, K. Lee, S. Levin, J. Lubchenco, D. Ludwig, J. Martinez-Alier, W. Murdoch, R. Naylor, R. Norgaard, M. Oppenheimer, A. Pfaff, S. Pickett, S. Polasky, H.R. Pulliam, C. Redman, J.P. Rodrigez, T. Root, S.H. Schneider, R. Schuler, T. Scudder, K. Segersen, M.R. Shaw, D. Simpson, A.A. Small, D. Starrett, P. Taylor, S. van der Leeuw, D.H. Hall, and M. Wilson (eds.), 2000: "Nature and Society: An Imperative for Integrated Environmental Research", Executive Summary of the Proceedings of the National Science Foundation Workshop on Nature and Society, June, Tempe, Arizona, 69 pp. <http://lsweb.la.asu.edu/akinzig/NSFreport.pdf>.
- Kolstad C.D., D.L. Kelly, and G. Mitchell, 1999: "Adjustment Costs from Environmental Change Induced by Incomplete Information and Learning", Department of Economics, UCSB working paper.
- Kolstad, C.D., 1994: "George Bush vs. Al Gore: Irreversibilities in Greenhouse Gas Accumulation and Emission Control Investment", *Energy Policy*, 22:771-778.
- Kolstad, C.D., 1996a: "Learning and Stock Effects in Environmental Regulation: The Case of Greenhouse Gas Emissions", *Journal of Environmental Economics and Management*, 31:1-18.
- Kolstad, C.D., 1996b: "Fundamental Irreversibilities in Stock Externalities", *Journal of Public Economics*, 60 (2):221-233.
- Krause, F., Baer, P., DeCanio, S., 2001: "Cutting Carbon Emissions at a Profit: Opportunities for the U.S.", International Project for Sustainable Energy Paths (IPSEP) working paper, April. Available online at http://www.ipsep.org/flex_shortsum.pdf
- Krause, F., Koomey, J., Olivier, D., 2000: "Cutting Carbon Emissions While Making Money – Climate Saving Strategies for the European Union", International Project for Sustainable Energy Paths (IPSEP) working paper, February. Available online at <http://www.ipsep.org/carbon.pdf>
- Krauthammer, C., 1997: "Global Warming Fundamentalists", *Washington Post*, 5 December 1997: A27.
- Kristjansson, J.E., A. Staple, and J. Kristiansen, 2002: "A New Look at Possible Connections Between Solar Activity, Clouds and Climate", *Geophysical Research Letters*, 29(23):2107.
- Kuhn, T., 1962: *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press, 222 pp.
- Laut, P., 2003: "Solar Activity and Terrestrial Climate: An Analysis of Some Purported Correlations", forthcoming in *Journal of Atmospheric and Solar-Terrestrial Physics*.
- Layard, R. and Walters, A., 1978: "Microeconomic Theory", New York: McGraw Hill, 498 pp.
- Legates, D.R., 2003: "Global warming smear targets", *The Washington Times*, 25 August. Available online at <http://washingtontimes.com/commentary/20030825-090130-5881r.htm>
- Lempert, R. J. and M.E. Schlesinger, 2000: "Robust Strategies for Abating Climate Change", *Climatic Change*, 45(3-4):387-401.
- Levin, S.A., 1993: "Concepts of Scale at the Local Level", in Ehleringer J.R. and C.B. Field (eds.), *Scaling Physiological Processes: Leaf to Globe*, New York: Academic Press.
- Levy, D., 2001: "Schneider Ponders Whether Scientists Should Advocate Public Policy", *Stanford University News Service*, 8 May 2001.
- Lind, R.C., (ed.), 1982: "Discounting for Time and Risk in Energy Policy", Washington, D.C.: Resources for the Future, 257-71.
- Linden, H.R., 1996: "The Evolution of an Energy Contrarian", *Annual Review of Energy and the Environment* 21: 31-67.

-  Lindsey, L.B., 2001: Speech to a colloquium on Science and Technology Policy organized by the American Association for the Advancement of Science (AAAS), May 2001.
-  Lindzen, R., 1997: "Can increasing carbon dioxide cause climate change?" Proceedings of the National Academy of Science 94: 8335-8342. Available online at <http://www.pnas.org/cgi/reprint/94/16/8335.pdf>
- Lomborg, B., 2001: The Skeptical Environmentalist: Measuring the Real State of the World, Cambridge: Cambridge University Press, 540 pp.
-  Lovins, A.B., Lovins, L.H., 1997: "Climate: Making Sense and Making Money", Rocky Mountain Institute, Snowmass, CO. Available online at <http://www.rmi.org/images/other/C-ClimateMSMM.pdf>
-  Luntz, F., 2003: "The Environment: A Cleaner, Safer, Healthier America", memo to the White House. Available online at http://www.ewg.org/briefings/luntzmemo/pdf/LuntzResearch_environment.pdf
- Lynn, A., 2003. "Americans among most misinformed about global warming", University of Illinois at Urbana-Champaign press release. Available online at http://www.eurekalert.org/pub_releases/2003-09/uoia-aam090303.php
- Manabe, S., and R.J. Stouffer, 2000: "Study of Abrupt Climate Change by a Coupled Ocean-Atmosphere Model", Quaternary Science Reviews, 19:285-299.
-  Mann, M.E. and P.D. Jones, 2003: "Global Surface Temperatures Over the Past two Millennia", Geophys. Res. Letts. (in press).
-  Mann, M.E., Ammann, C.M., Bradley, R.S., Briffa, K.R., Crowley, T.J., Jones, P.D., Oppenheimer, M., Osborn, T.J., Overpeck, J. T., Rutherford, S., Trenberth, K.E., Wigley, T.M.L., 2003: "On Past Temperatures and Anomalous Late 20th Century Warmth", Eos, in press, 2003.
-  Mann, M. and Oppenheimer, M., 2003: "Memo on recent papers by Soon and Baliunas."
- Manne, A.S., R. Mendelsohn, and R.G. Richels, 1995: "MERGE: A Model for Evaluating Regional and Global Effects of GHG Reduction Policies", Energy Policy, 23:17-34.
- Manne, A.S. and R.G. Richels, 1997: "On Stabilizing CO2 Concentrations - Cost-Effective Emission Reduction Strategies", Environmental Modeling and Assessment, 2(1997):251-265.
- Manne, A.S. and G. Stephan, 1999: "Climate-Change Policies and International Rate-of-Return Differentials", Energy Policy, 27(6):309-316.
- Margolis, R.M. and D.M. Kammen, 1999a: "Evidence of Under-Investment in Energy R&D in the United States and the Impact of Federal Policy", Energy Policy, 27:10, 575-584.
- Margolis, R.M. and D.M. Kammen, 1999b: "The Energy Technology and R&D Policy Challenge", Science, 285:690-692.
- Markandya, A. and K. Halsnaes, 2000: "Costing Methodologies", in Pachauri, R., T. Taniguchi, and K. Tanaka (eds.), The Third Assessment Report: Cross Cutting Issues Guidance Papers, pp. 15-31. World Meteorological Organization, Geneva, Switzerland. Available on request from the Global Industrial and Social Progress Institute at <http://www.gispri.or.jp>.
- Masood, E., 1996: "Industry Warms to 'Flexible' Carbon Cuts", Nature, 383:657.
-  Mastrandrea, M.D. and S.H. Schneider, 2002: "Integrated Assessment of Abrupt Climatic Changes", Climate Policy, 1: 433-449.
- Mattsson, N. and C.O. Wene, 1997: "Assessing New Energy Technologies Using an Energy System Model with Endogenized Experience Curves", Journal of Energy Research, 21: 385-93.
-  McCright, A.M. and R.E. Dunlap, 2003: "Defeating Kyoto: The Conservative Movement's Impact on U.S. Climate Change Policy", forthcoming in Social Problems, 50.
- Mearns, L.O., R.W. Katz, and S.H. Schneider, 1984: "Changes in the Probabilities of Extreme High Temperature Events with Changes in Global Mean Temperature", Journal of Climate and Applied Meteorology, 23:1601-1613.
- Mendelsohn R., W. Morrison, M. Schlesinger, and N. Andronova, 2000: "Country-specific Market Impacts of Climate Change", Climatic Change, 45(3-4):553-569.

- Mendelsohn R., W. Nordhaus, and D. Shaw, 1996: "Climate Impacts on Aggregate Farm Value: Accounting for Adaptation", *Agricultural and Forest Meteorology*, 80:55-66.
- Mendelsohn, R., W. Nordhaus, and D. Shaw, 1994: "The Impact of Global Warming on Agriculture: A Ricardian Analysis", *The American Economic Review*, 84(4):753-71.
- Meyer, A., 2003: "Trading up to climate security", *Energy and Environmental Management*, May/June 2003, 16-17.
- Miller, A., Brown, P., 2000: "A Fair Climate for All", *Redefining Progress Climate Change Issue Brief*, November. Available online at: <http://www.rprogress.org/publications/afairclimateforall.pdf>
- Morgan G. and H. Dowlatabadi, 1996: "Learning from Integrated Assessment of Climate Change", *Climatic Change*, 34(3-4), 337-68.
- Morgan, M.G. and D.W. Keith, 1995: "Subjective Judgments by Climate Experts", *Environmental Science and Technology*, 29: 468-476.
- Morgan, M.G. and M. Henrion (eds.), 1990: "Uncertainty: a Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis", New York: Cambridge University Press, 344 pp.
- Moss, R.H. and S.H. Schneider, 1997: "Characterizing and Communicating Scientific Uncertainty: Moving Ahead from the IPCC Second Assessment", in Hassol S.J. and J. Katzenberger (eds.), *Elements of Change 1996*, Aspen, CO: Aspen Global Change Institute, 90-135.
- Moss, R.H. and Schneider, S.H., 2000: "Uncertainties in the IPCC TAR: Recommendations to Lead Authors for More Consistent Assessment and Reporting", in Pachauri R., T. Taniguchi, and K. Tanaka (eds.), *Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of the IPCC*, Geneva, Switzerland: World Meteorological Organization, 33-51.
- Nakicenovic, N., A. Grübler, S. Gaffin, T.T. Jung, T. Kram, T. Morita, H. Pitcher, K. Riahi, M. Schlesinger, P.R. Shukla, D. van Vuuren, G. Davis, L. Michaelis, R. Swart, and N. Victor, 2003: "IPCC SRES Revisited: A Response", *Energy and Environment*, Vol. 14, Nos. 2 & 3: 187-214.
- Narain, U. and A.C. Fisher, 2001: "Irreversibility, Uncertainty and Global Warming: a Theoretical Analysis", manuscript. Department of Agricultural and Resource Economics, Berkeley, University of California.
- National Academy of Sciences, 1991: *Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base*. Panel on Policy Implications of Greenhouse Warming, Committee on Science, Engineering, and Public Policy, Washington, D.C.: National Academy Press.
- National Assessment Synthesis Team, 2000: "US National Assessment of the Potential Consequences of Climate Variability and Change", US Global Change Research Program. Available online at <http://www.usgcrp.gov/usgcrp/nacc/default.htm>
- Nesmith, J., 2003: "Foes of Global Warming Theory Have Energy Ties", *Seattle Post-Intelligencer*, 6/2/03.
- Nesmith, J., 2003a: "Nonprofits Push Controversial Climate Study", *The Atlanta Journal-Constitution*, 5/31/03.
- Nitze, W., 2003: "A Year to Remember: Facing the Truth About Climate Change", *Climate Alert*, Summer 2003.
- Nordhaus W.D., 1997: "Discounting in Economics and Climate Change", *Editorial, Climatic Change*, 37(2)315-328.
- Nordhaus, W.D., 1992: "An Optimal Transition Path for Controlling Greenhouse Gases", *Science*, 258: 1315-1319.
- Nordhaus, W.D., 1994a: "Expert Opinion on Climatic Change", *American Scientist*, 82:45-51.
- Nordhaus, W.D., 1990: "Count Before You Leap: Economics of Climate Change", *The Economist*, pp. 19-22 (July 7).
- Nordhaus, W.D., 1994b: "Managing the Global Commons: the Economics of Climate Change", Cambridge: MIT Press, 1994.
- Nordhaus, W.D., 2001: "Climate Change - Global Warming Economics", *Science*, 294(5545):1283-1284.
- Obersteiner M., C. Azar, P. Kauppi, K. Mollersten, J. Moreira, S. Nilsson, P. Read, K. Riahi, B. Schlamadinger, Y. Yamagata, J. Yan, and J.P. van Ypersele, 2001: "Managing Climate Risk", *Science*, 294:(5543)786-787.


- Parmesan, C. & Yohe, G., 2003: "A Globally Coherent Fingerprint of Climate Change Impacts Across Natural Systems", *Nature*, 421, 37 - 42, (2003).
- Parson, E. A., 1996: "Three Dilemmas in the Integrated Assessment of Climate Change, an Editorial Comment", *Climatic Change*, 34:315-326.
- Pearce, F., 1996: "Sit Tight for 30 Years, Argues Climate Guru", *New Scientist*, 20 January.
- Peck, S.C. and T.J. Teisberg, 1993: "CO2 Emissions Control: Comparing Policy Instruments", *Energy Policy*, March 1993, pp. 222-30.
- Pielke Sr. R.A., G. Marland, R.A. Betts, T.N. Chase, J.L. Eastman, J.O. Niles, D.S. Niyogi, and S.W. Running, 2002: "The Influence of Land-Use Change and Landscape Dynamics on the Climate System: Relevance to Climate-Change Policy Beyond the Radiative Effect of Greenhouse Gases", *Phil. Trans. R. Soc. Lond., A* (2002) 360, 1705-1719.
- Pielke, Jr., R.A., and M.W. Downton, 2000: "Precipitation and damaging floods: Trends in the United States, 1932-1997", *Journal of Climate*, 13(20), 3625-3637.
- Pielke, R.A., Jr., and Landsea, C.W., 1998: "Normalized Hurricane Damages in the United States, 1925-97", *Weather Forecasting*, 13:351-61.
-  Pittock, R.N., R.N. Jones, and C.D. Mitchell, 2001: "Probabilities Will Help us Plan For Climate Change", *Nature*, 413:249.
-  Pittock, R.N., R.N. Jones, and C.D. Mitchell, 2001: Global Warming, the Truth Behind the Myth, New York: Perseus Publishing, 271 pp.
- Portney, P.R. and J.P. Weyant, eds., 1999: "Discounting and Intergenerational Equity", Washington, DC: Resources for the Future, 186 pp.
- Price, J., Glick, P., 2002: *The Birdwatcher's Guide to Global Warming*, American Bird Conservancy, 2002.
-  Prindle, B., 2003: "Bush's Climate Agreements: Business-As-Usual Widens the Carbon Gap", ACEEE Press Brief, 12 February. Available online at: <http://www.aceee.org/press/0302carbongap.htm>
-  Rahmstorf, S., 1996: "On the Freshwater Forcing and Transport of the Atlantic Thermohaline Circulation", *Climate Dynamics*, 12:799-811.
-  Rahmstorf, S., 1999: "Rapid Transitions of the Thermohaline Ocean Circulation - A Modelling Perspective", in *Reconstructing Ocean History: A Window Into the Future*, in Abrantes F. and A.C. Mix (eds.), Dordrecht (The Netherlands): Kluwer Academic/ Plenum Publishers, 139-149.
-  Rahmstorf, S., 1999a: "Shifting Seas in the Greenhouse?" *Nature*, 399:523-524.
- Rahmstorf, S., 2000: "The Thermohaline Ocean Circulation: A System with Dangerous Thresholds? An Editorial Comment", *Climatic Change*, 46(3):247-56.
-  Regalado, A., 2003: "Debating Global Warming – Global Warming Skeptics Are Facing Storm Clouds", *Wall Street Journal* 31 July. Available online at <http://w3g.gkss.de/G/Mitarbeiter/storch/CR-problem/cr.wsj.pdf>
- Reilly, J., W. Baethgen, F.E. Chege, S.C. van de Geijn, L. Erda, A. Iglesias, G. Kenny, D. Patterson, J. Rogasik, R. Rötter, C. Rozenzweig, W. Sombroek, and J. Westbrook. 1996: "Agriculture in a Changing Climate: Impacts and Adaptation", in *Intergovernmental Panel on Climate Change, Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis*. Cambridge: Cambridge University Press, 427-467.
- Report of the Study of Man's Impact on Climate (SMIC), 1971: *Inadvertent Climate Modification*, Massachusetts: MIT, 308 pp.
-  Reuters, 2003: "Panel: Danish Environmentalist Work 'Unscientific,'" Reuters 26 August. Available online at <http://www.planetark.org/dailynewsstory.cfm/newsid/22004/story.htm>
-  Revkin, A., 2003: "Republicans Aim for Softer, Greener Environmental Talk", *New York Times*, 2 March. Available online at http://www.southbaymobilization.org/newsroom/earth/howarticles/03.0302.GOPtoBush_KeepDenyingClimateScience.htm
- Revkin, A.C., 2002: "Government Outlines Plan for Research on Warming", *New York Times*, 13 November:A23.

- Richels, R. and J. Edmonds, 1995: "The Economics of Stabilizing Atmospheric CO₂-Concentrations", *Energy Policy*, 23:373-378
- Rijsberman, F.R. and R.J. Swart (eds), 1990: *Targets and Indicators of Climatic Change*, Stockholm Environment Institute, Box 1240, 105 14 Stockholm, Sweden.
-  Robinson, A. and Z. Robinson, 1997: "Science Has Spoken: Global Warming is a Myth", Editorial, *Wall Street Journal* 4 December 4, A22. <http://www.junkscience.com/news/robinson.htm>
-  Root, T.L. and S.H. Schneider, 1993: "Can Large-Scale Climatic Models be Linked with Multi-Scale Ecological Studies?" *Conservation Biology*, 7:256-270.
-  Root, T.L., and S.H. Schneider, 1995: "Ecology and Climate: Research Strategies and Implications", *Science*, 269:334-341.
-  Root, T.L., J.T. Price, K.R. Hall, S.H. Schneider, C. Rosenzweig, and J. A. Pounds, 2003: "Fingerprints' of Global Warming on Animals and Plants", *Nature*, 421:57-60. (See also the [Supplement](#).)
-  Root, T.L. and S.H. Schneider, 2003: "Strategic Cyclical Scaling: Bridging Five Orders of Magnitude Scale Gaps in Climatic and Ecological Studies", in Rotmans J. and D.S. Rothman (eds.), *Scaling Issues in Integrated Assessment*, Lisse, The Netherlands: Swets and Zeitlinger Publishers, 179-204.
- Rosenberg, N.J. (ed.), 1993: "Towards an Integrated Impact Assessment of Climate Change: The MINK Study", *Climatic Change*, (Special Issues) 24:1-173.
- Rosenberg, N.J., Scott M.J., 1994: "Implications of Policies to Prevent Climate Change for Future Food Security", *Global Environmental Change*, 4:49-62.
-  Rosenzweig, C.E., F. Tubiello, R. Goldberg, E. Mills, and J. Bloom, 2002a: "Increased Crop Damage in the US from Excess Precipitation Under Climate Change", *Global Environmental Change*, 12:197-202
-  Rosenzweig, C.E., F. Tubiello, R. Goldberg, E. Mills, and J. Bloom, 2002a: "No Deception in Global Warming Report", *Letters to the Editor*, *Wall Street Journal*, 25 June, A16.
-  Rosenzweig, C.E., F. Tubiello, R. Goldberg, E. Mills, and J. Bloom, 2002a: "The Impact of Global Warming on U.S. Agriculture: An Econometric Analysis", Department of Agricultural and Resource Economics and Policy Working Paper 936, University of California, Berkeley.
- Rosenzweig, C.E. and M. Parry, 1994: "Potential Impact of Climate Change on World Food Supply", *Nature*, 367:133-138.
- Rothman, D. S. and J. B. Robinson, 1997: "Growing Pains: A Conceptual Framework for Considering Integrated Assessments", *Environmental Monitoring and Assessment*, 46: 23-43.
- Rotmans, J. and M. van Asselt, 1996: "Integrated Assessment: A Growing Child on its Way to Maturity - An Editorial", *Climatic Change*, 34:327-336.
- Roughgarden, T. and S.H. Schneider, 1999: "Climate Change Policy: Quantifying Uncertainties for Damages and Optimal Carbon Taxes", *Energy Policy*, 27:415-429.
-  Sample, I., 2003: "Not just warmer: it's the hottest for 2,000 years", *The Guardian*. 1 September. <http://www.guardian.co.uk/print/0,3858,4744226-110970,00.html>
-  Sanchez, I., 2003: "Warming Study Draws Fire – Harvard scientists accused of politicizing research", *Harvard Crimson* 12 September. Available online at <http://www.thecrimson.com/article.aspx?ref=348723>
- Sanstad, A., 2000: "Endogenous Technological Change and Climate Policy Modeling", in DeCanio, S.J., Howarth, R.B., Sanstad, A.H., Schneider, S.H., and S.L. Thompson (eds.), *New Directions in the Economics and Integrated Assessment of Global Climate Change* pp. 59-80, Arlington, VA: The Pew Center on Global Climate Change.
-  Santer, B., 2003: "Contributions of Anthropogenic and Natural Forcing to Recent Tropopause Height Changes", Livermore, CA: Lawrence Livermore National Laboratory.
-  Santer et al, 2003a: "Influence of Satellite Data Uncertainties on the Detection of Externally Forced Climate Change", *Science* 300: 1280-1284. Available online at <http://www.cgd.ucar.edu/ccr/publications/santer.pdf>
-  Schlenker, W., W.M. Hanemann, and A.C. Fisher, 2003: *The Impact of Global Warming on U.S. Agriculture: An Econometric Analysis*, Department of Agricultural and Resource Economics and Policy Working Paper 936, University of California, Berkeley.

- Schneider S. H and Thompson S.L., 1985: "Future Changes in the Atmosphere", in Repetto, R. (ed.) *The Global Possible*. New Haven, CT: Yale University Press, pp. 397-430.
-  Schneider S.H. and S.L. Thompson, 2000: "A Simple Climate Model Used in Economic Studies of Global Change", in DeCanio S.J. , R.B. Howarth, A.H. Sanstad, S.H. Schneider, and S.L. Thompson, *New Directions in the Economics and Integrated Assessment of Global Climate Change*, Washington D.C.: Pew Center on Global Climate Change, 59-80.
- Schneider S.H., 1996c: "The Future of Climate: Potential for Interaction and Surprises", in Downing, T.E. (ed.) *Climate Change and World Food Security*, Heidelberg: Springer-Verlag, NATO ASI Series 137:77-113.
-  Schneider, S.H. and C. Azar, 2001: "Are Uncertainties in Climate and Energy Systems a Justification for Stronger Near-term Mitigation Policies?" in Erlich, E. (ed.), Proceedings of the Pew Center Workshop on The Timing of Climate Change Policies, 85-136. Washington D.C., 11-12 October 2001.
- Schneider, S.H. and K. Kuntz-Duriseti, 2001: "Facing Global Warming", *The World and I*, 16(6):131-139.
-  Schneider, S.H., 1986: "What Makes a Good Science Story?" in Friedman S.M. , S. Dunwoody, and C.L. Rogers (eds.), *Scientists and Journalists: Reporting Science as News*, New York: The Free Press, 103-115.
-  Schneider, S.H., 1987: "Global Warming Balance Sheet: What We Really Know", Letter to the Editor, *Christian Science Monitor*, 8 August, 1987.
<http://csmweb2.emcweb.com/durable/1997/08/08/opin/opin.2.html>.
-  Schneider, S.H., 2003a: "Abrupt Non-Linear Climate Change, Irreversibility and Surprise", OECD Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers, Working Party on Global and Structural Policies, 32 pp.
- Schneider, S.H., K. Kuntz-Duriseti, and C. Azar, 2000: "Costing Non-linearities, Surprises and Irreversible Events", *Pacific and Asian Journal of Energy*, 10(1):81-106.
-  Schneider, S.H. and T.L. Root, 2001: "Climate Change: Overview and Implications for Wildlife", in Schneider, S.H. and T.L. Root (eds.) *Wildlife Responses to Climate Change: North American Case Studies*, Washington D.C.: Island Press, 1-56.
-  Schneider, S.H, 1992: "Hot About Global Warming", *Washington Post*, 26 September:A19.
-  Schneider, S.H, 1993: "A Better Way to Learn", *Christian Science World Monitor Monthly*, April 1993: 31-35.
- Schneider, S.H. (Editor-in-Chief), 1996b: Encyclopedia of Climate and Weather, New York: Oxford University Press, 929 pp.
- Schneider, S.H. and L.E. Mesirov, 1976: The Genesis Strategy: Climate and Global Survival. New York: Plenum Publishing Corp., 419 pp. (paperback edition-New York: Delta; Italian edition, Milano: Mondadori; German edition, Frankfurt: S. Fisher).
- Schneider, S.H. and T.L. Root, 1996: "Ecological Implications of Climate Change Will Include Surprises", *Biodiversity and Conservation*, 5:1109-1119.
- Schneider, S.H. and T.L. Root, 1998: "Climate Change", in Mac M.J. and P.A. Opler, C.E. Pucket Haeker, and P.D. Doran (eds.), Status and Trends of the Nation's Biological Resources, U.S. Department of the Interior, U.S. Geological Survey, Reston, Va., 1:89-105.
- Schneider, S.H. and R. Londer, 1984: The Coevolution of Climate and Life, San Francisco, CA: Sierra Club Books, 563 pp.
-  Schneider, S.H. and T.L. Root (eds.), 2001a: *Wildlife Responses to Climate Change: North American Case Studies*, Washington D.C.: Island Press, 437 pp.
-  Schneider, S.H. and K. Kuntz-Duriseti, 2002: "Uncertainty and Climate Change Policy", Chapter 2 in Schneider, S.H., A. Rosencranz, and J.O. Niles, (eds.) *Climate Change Policy: A Survey*, Washington D.C.: Island Press, pp. 53-88.
-  Schneider, S.H. and L.H. Goulder, 1997c: "Achieving Low-cost Emissions Targets", *Nature*, 389:13-14.
-  Schneider, S.H. and P.J. Boston (eds.), 1992: Scientists on Gaia, Cambridge: MIT Press, 443 pp.
- Schneider, S.H., 1983: "CO₂, Climate and Society: A Brief Overview", in Chen R.S., E.M. Boulding, and S.H. Schneider, (eds.), *Social Science Research and Climatic Change: An Interdisciplinary Appraisal*, Dordrecht, The Netherlands: D. Reidel Publishing, 9-15.

- Schneider, S.H., 1989: "News Plays Fast and Loose With the Facts", Editorial, Detroit News, 5 December:10A.
- Schneider, S.H., 1989a: "The Greenhouse Effect: Science and Policy", Science, 243:771-781.
- Schneider, S.H., 1990: Global Warming, Are We Entering the Greenhouse Century? Cambridge: The Lutterworth Press, 343 pp. (Japanese edition: Diamond, Tokyo; U.K. edition: Lutterworth, Cambridge; Italian edition: Armenia Editore, Milano; Paperback version (1990): New York: Vintage Books, New York, 343 pp.
- Schneider, S.H., 1992a: "Introduction to Climate Modeling", in Trenberth, Climate System Modeling, 1992, Cambridge: University Press, England.
- Schneider, S.H., 1992b: "Values are Everything", Nuclear Guardianship Forum, 1:4 San Francisco Chronicle, 2 February.
- Schneider, S.H., 1993a. "Pondering Greenhouse Policy", Science 259, 1381.
- Schneider, S.H., 1993b: "Degrees of Certainty", National Geographic Research and Exploration, 9(2):173-181.
- Schneider, S.H., 1995: "Technological Opportunities for Humanity", Perspective, London Times Higher Education Supplement, 19, 6 October, 1995.
- Schneider, S.H., 1995a: "Evolutionary Organizational Models for Interdisciplinary Research and Teaching of Global Environmental Change", in Waddington D.J. (ed.), Global Environmental Change Science: Education and Training. New York: Springer-Verlag, 9-40. NATO ASI Series 1, 29.
- Schneider, S.H., 1996: "Don't Bet All Environmental Changes Will Be Beneficial", American Physical Society News Online News, August/September 1996. <http://www.aps.org/apsnews/0896/11592.html>.
- Schneider, S.H., 1996a: Laboratory Earth: A Brief History of Climate Change, (London: Weidenfeld and Nicolson), 256 pp. (reprint 2001), London: A Phoenix Paperback.
- Schneider, S.H., 1997: "Congressional Testimony: Climate Change Causes, Impacts and Uncertainties", Congressional Record, 10 July, 1997:D726-D729.
- Schneider, S.H., 1997a: "Defining and Teaching Environmental Literacy", Trends in Ecology and Evolution, 12(11): 457.
- Schneider, S.H., 1997b: "Integrated Assessment Modeling of Global Climate Change: Transparent Rational Tool for Policy Making or Opaque Screen Hiding Value-laden Assumptions?" Environmental Modeling and Assessment, 2(4):229-248.
- Schneider, S.H., 1998: "Cross-cutting Issues (BG5)", in Weber S.L. et al. (eds), Final Report of the IPCC Workshop on Rapid Non-linear Climate Change, 23-25. Proceedings of the IPCC Workshop on Rapid Non-linear climate Change, Noordwijkerhout, Netherlands, 31 March - 2 April 1998.
- Schneider, S.H., 1998a: "Twisted Revision", Editorial. Washington Post, 7 January 1998:A19.
- Schneider, S.H., 2001: "A Constructive Deconstruction of Deconstructionists: A Response to Demeritt", in Annals of the Association of American Geographers, 91(2):338-344.
- Schneider, S.H., 2001a: "Earth Systems: Engineering and Management", Nature, 409:417-421.
- Schneider, S.H., 2001b: "Environmental Surprise", in Smelser N.J. and P.B. Baltes (eds.), International Encyclopedia of the Social and Behavioral Sciences, New York: Elsevier Science Ltd., 4671-4675.
- Schneider, S.H., 2001c: "Is the 'Citizen-Scientist' an Oxymoron?" in Kleinman D. (ed.), Beyond the Science Wars: Science, Technology and Democracy, Albany, NY: State University of New York Press, 103-120.
- Schneider, S.H., 2001d: "What is 'Dangerous' Climate Change?" Nature, 411:17-19.
- Schneider, S.H., 2002a: "Can We Estimate the Likelihood of Climatic Changes at 2100?" Climatic Change, 52(4):441-451.
- Schneider, S.H., 2002b: "Editor's Note: The Gaia Hypothesis", Climatic Change, 52(4), iii.
- Schneider, S.H., 2002c: "Global Warming: Neglecting the Complexities", Scientific American, 286(1): 62-65.
- Schneider, S.H., 2002d: "Earth Systems: Engineering and Management", Chapter 20 in Schneider S.H., A. Rosencranz, and J.O. Niles (eds.) Climate Change Policy: A Survey, Washington D.C.: Island Press, 509-522.


Schneider, S.H., 2002e: "Global Climate Change in the Human Perspective", Chapter 6 in Bengtsson L.O. and C.U. Hammer (eds.) Geosphere-Biosphere Interaction and Climate, Proceedings of the Working Group of the Pontifical Academy of Sciences and the International Geosphere-Biosphere Programme. Cambridge, UK: Cambridge University Press, 318 pp.


 Schneider, S.H., 2002f: "Keeping Out of the Box", American Scientist, 90:496-498.

 Schneider, S.H., 2002g: "Modeling Climate Change Impacts and Their Related Uncertainties", in Cooper, R.N. and R. Layard (eds.), What the Future Holds: Insights from Social Sciences, Cambridge: MIT Press, 123-55.


Schneider, S.H., 2002h: "The Future and Natural Disasters", interview broadcast on EarthBeat, the Australian Broadcasting Corporation, Tuesday 11/19/2002—Real Audio.


Schneider, S.H., 2002i: "The Global Warming Controversy -- Can we Separate Scientific Signal From Political Noise?" (ASX video), a Presentation at Stanford University Computer Systems Laboratory, Jan 9, 2002. EE380 Colloquium.

 Schneider, S.H., 2003: "Imaginable Surprise", in Potter, T.D. (ed.), Handbook of Weather, Climate, and Water, John Wiley and Sons, 2003. Modified from Schneider, S.H., B.L. Turner, and H. Morehouse Garriga, 1998.

 Schneider, S.H., A. Rosencranz, and J.O. Niles, (eds.), 2002: "Climate Change Policy: A Survey", Washington D.C.: Island Press, 563 pp.


Schneider, S.H., B.L. Turner, and H. Morehouse Garriga, 1998: "Imaginable Surprise in Global Change Science", Journal of Risk Research, 1(2):165-185. See also: "Imaginable Surprise."


 Schneider, S.H., W.E. Easterling, and L. Mearns, 2000: "Adaptation: Sensitivity to Natural Variability, Agent Assumptions and Dynamic Climate Changes", Climatic Change, 45(1):203-221.

 Schneider, S.H. and T.L. Root, 2001b: "Introduction: the Rationale for the National Wildlife Federation Cohort of Young Scientists Studying Wildlife Responses to Climate Change", Wildlife Responses to Climate Change: North American Case Studies, Washington D.C.: Island Press, xi-xv.


Schultz P. A. and J.F. Kasting, 1997: "Optimal Reductions in CO₂-Emissions", Energy Policy, 25: 491-500.

Seidov, D. and M.A. Maslin, 1999: "Collapse of the North Atlantic Deep Water Circulation During the Heinrich Events", Geology, 27:23-26.


 Seitz, F., 1996: "Coverup in the Greenhouse?" Letter to the Editor, Wall Street Journal, 11 July, 1996:A15.

 Senate Foreign Relations Committee, 2003: "Sense of Congress on Climate Change." Available online at <http://energycommerce.house.gov/108/Markups/04022003/54.pdf>

 Shaviv, N.J., Veizer, J., 2003: "Celestial driver of Phanerozoic climate?" GSA Today 13(7): 4-10. Available online at <http://www.fiz.huji.ac.il/~shaviv/Ice-ages/GSAToday.pdf>

 Sherwood, K., Idso, C., 2003: "Editorial Commentary: Our Reply to a Climate-Alarmist Newspaper Editorial", CO₂ Science Magazine 6(30). Available online at http://www.co2science.org/edit/v6_edit/v6n30edit.htm

Simbeck, Dale, 2003: "Biggest Challenge for the Hydrogen Economy – Hydrogen Production & Infrastructure Costs", Presentation to the Aspen Global Change Institute Conference on Long-Term Technology Pathways to Stabilization of Greenhouse Gas Concentrations, Aspen, CO. 6-13 July 2003.

 Simon, J.L., 1996: "Resources and Population: A Wager", American Physical Society Online News, March 1996, THE BACK PAGE. <http://www.aps.org/apsnews/articles/11375.html>.

 Singer, F., 2000: "National Assessment of the Potential Impact of Climate Change: Climate Change Impacts on the United States", testimony to the Senate Committee on Commerce, Science and Transportation. Washington, D.C. 18 July. Available online at: <http://www.sepp.org/NewSEPP/senatetestimony.htm>


Solow, R. M., 1974b: "The Economics of Resources or the Resources of Economics", American Economic Review, 64(2), 1-14; Lind, R.C., ed., 1982; Richard Howarth, personal communication.

Solow, R.M., 1974a: "Intergenerational Equity and Exhaustible Resources", Review of Economic Studies (Symposium), 29-45.

Sonner, Scott, 2003: "Experts at US Conference on Global Warming Say Bush's Position 'Ludicrous,'" Associated Press. 26 July. Available at <http://www.commondreams.org/headlines03/0726-03.htm>.


- Soon, W. and S. Baliunas, 2003: "Reconstructing Climatic and Environmental Changes of the Past 1000 Years: A Reappraisal", *Energy & Environment*, 14:233-296, March 2003.
- Still, C.J., P.N. Foster, and S.H. Schneider, 1999: "Simulating the Effects of Climate Change on Tropical Montane Cloud Forests", *Nature*, 398:608-610.
- Stocker T.F. and O. Marchal, 2000: "Abrupt Climate Change in the Computer: is it Real?" *Proceedings of the National Academy of Sciences*, 97:1362-1365.
- Sun, S., Hansen, J.E., 2003: "Climate Simulations for 1951-2050 with a Couple Atmosphere-Ocean Model", *Journal of Climate* 16 (1 September): 2807-2826.
- Symons, J., 2003: "How Bush and Co. Obscure the Science", *Washington Post* 13 July: B04. Available online at: <http://www.washingtonpost.com/ac2/wp-dyn/A46181-2003Jul11?language=printer>
- Tett, Simon F.B., Peter A. Stott, Myles R. Allen, William J. Ingram and John F. B. Mitchell, 1999: "Causes of twentieth-century temperature change near the Earth's surface", *Nature* 399, 569 - 572 (1999).
- Thompson, N., 2003: "Science Friction", *Washington Monthly*, July/August 2003.
- Titus, J.G. and V.K. Narayanan, 1996: "The Risk of Sea Level Rise", *Climate Change*, 33:151-212.
- Toman, M.A, Morgenstern, R.D. and J. Anderson, 1999: "The Economics of 'When' Flexibility in the Design of Greenhouse Gas Abatement Policies", *Annual Review of Energy and the Environment*, 24:431-60.
- Toth, F., 2003: "Climate Policy in Light of Climate Science: The ICLIPS Project", *Climatic Change*, (1-2)56:7-36.
- Toth, F., et al., 1997: "The Tolerable Windows Approach to Integrated Assessments", Paper presented at the IPCC Asia-Pacific Workshop on Integrated Assessments.
- Trenberth, K., 2003: "Comment on 'Impact of urbanization and land-use change on climate' by E. Kalnay and M. Kai..." 16 June.
- Trenberth, K.E., (ed.), 1992: *Climate System Modeling*, Cambridge: Cambridge University Press, 788 pp.
- Ulph, A. and D. Ulph, 1997: "Global Warming, Uncertainty and Learning", *The Economic Journal*, 107:636-650.
- Union of Concerned Scientists, 2003: "Climate Change Science Adequately Reflected in the 'Climate Change Sense of the Congress Resolution'", 10 June.
- United Nations, 1992: *United Nations Framework Convention on Climate Change*.
- US Department of State, 2002: "US Climate Action Report." Available online at <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsUSClimateActionReport.html>
- U.S. Global Change Research Program, 1997: "Key Findings of the IPCC Second Assessment Report", Report by the Subcommittee on Global Change Research, Committee on Environment and Natural Resources, Research of the National Science and Technology Council, A Supplement to the President's Fiscal Year 1997 Budget.
- Varian, H.R., 1992: *Microeconomic Analysis*, 3rd. ed., New York: W.W. Norton, 506 pp.
- Vellinga, P., E. Mills, G. Berz, S. Huq, L. Kozak, J. Palutikof, B. Schanzenbacher, S. Shida, and Soler, G., 2001: "Insurance and other Financial Services", in IPCC, *Third Assessment Report of Working Group II: Impacts, Adaptation and Vulnerability*, Cambridge: Cambridge University Press, 417-450.
- WBGU, 1995: "Scenarios for Derivation of Global CO2 Reduction Targets and Implementation Strategies", Bremerhaven, Germany.
- Webster, M. et al., 2003: "Uncertainty Analysis of Climate Change and Policy Response", *Climatic Change*, in press.
- Weitzman, M.L., 2001: "Gamma Discounting", *The American Economic Review*, 91(1):260-271.
- Weyant, J., O. Davidson, H. Dowlatabadi, J. Edmonds, M. Grubb, E. A. Parson, R. Richels, J. Rotmlfus, P. R. Shukla, and R. S. J. Tol, 1996: "Integrated Assessment of Climate Change: An Overview and Comparison of Approaches and Results", in Bruce, J.P., H. Lee, E.F. Haites (eds.) *Climate Change 1995. Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, U.K.: Cambridge University Press: 367-396.

Weyant, J.P. (ed.), 1999: "The Costs of the Kyoto Protocol: A Multi-Model Evaluation", Special Issue of The Energy Journal.

 White House, The, 1997: "Global Climate Change, an East Room Roundtable", Proceedings of an East Room Roundtable on Global Climate Change, Washington D.C., 24 July 1997.


Wigley, T., R. Richels, and J. Edmonds, 1996: "Economics and Environmental Choices in the Stabilization of Atmospheric CO₂ Concentrations", *Nature*, 379:240-243.


Wigley, T.M.L. and S.C.B. Raper, 2001: "Interpretation of High Projections for Global-mean Warming", *Science*, 293:451-454.

 Will, G., 1996: "Al Gore's Green Guilt", *Washington Post*, 3 September 1996.

 Willems, J., 2003: "Bringing Down the Barriers", *Nature*, 422:470.

 Wolfson, R. and S.H. Schneider, 2002: "Understanding Climate Science", Chapter 1 in Schneider, S.H., A. Rosencranz, and J.O. Niles, (eds.), *Climate Change Policy: A Survey*, Washington D.C.: Island Press, 1-52.

 Wood, R.A., A.B., Keen, J.F.B. Mitchell, and J.M. Gregory, 1999: "Changing Spatial Structure of the Thermohaline Circulation in Response to Atmospheric CO₂ Forcing in a Climate Model", *Nature*, 399:572-575.

 Wuebbles, D. J., 2002: "Oversimplifying the Greenhouse: An Editorial Essay", *Climatic Change*, 52:431-434.

Wynne, B., 1992: "Uncertainty and Environmental Learning: Reconceiving Science and Policy in the Preventive Paradigm", *Global Environmental Change*, XX, 111-127. Quote on p. 111.

Yohe, G.W. and R. Wallace, 1996: "Near Term Mitigation Policy for Global Change Under Uncertainty: Minimizing the Expected Cost of Meeting Unknown Concentration Thresholds", *Environmental Modeling and Assessment*, 1(1-2):47-58.

Yohe, G.W., 1991: "Uncertainty, Climate Change, and the Economic Value of Information: An Economic Methodology for Evaluating the Timing and Relative Efficacy of Alternative Response to Climate Change with Application to Protecting Developed Property from Greenhouse-Induced Sea Level Rise", *Policy Science*, 24(3):245-269.

Zitner, A., Polakovic, G., Shogren, E., 2003: "Vehicular Geocide: EPA Declines to Regulate Greenhouse Gases", *Los Angeles Times*, 29 August. Summary available online at: <http://www.gristmagazine.com/daily/daily082903.asp>