

Cato Institute Policy Analysis No. 307: The Consequences of Kyoto

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Executive Summary

Last December the United States agreed at a United Nations meeting in Kyoto, Japan, to reduce its emissions of greenhouse gases by 7 percent below 1990 levels. That reduction, to be achieved mainly by cutting the combustion of fossil fuels, will lower emission levels 41 percent below where they will likely be in the year 2010 if the trend observed since 1990 continues.

The Kyoto agreement--if fully complied with--would likely reduce the gross domestic product of the United States by 2.3 percent per year. However, according to a climate model of the National Center for Atmospheric Research recently featured in *Science*, the Kyoto emission-control commitments would reduce mean planetary warming by a mere 0.19 degree Celsius over the next 50 years. If the costs of preventing additional warming were to remain constant, the Kyoto Protocol would cost a remarkable 12 percent of GDP per degree of warming prevented annually over a 50-year period.

The Kyoto Protocol will have no discernible effect on global climate--in fact, it is doubtful that the current network of surface thermometers could distinguish a change on the order of .19 degree from normal year-to-year variations. The Kyoto Protocol will result in no demonstrable climate change but easily demonstrable economic damage.

Introduction

For more than a century scientists have known about the possibility that man-made carbon dioxide emissions may cause an increase in the average temperature of the atmosphere. But widespread public concern about global warming did not exist until the late 1980s when high temperatures, predictions from general atmospheric circulation computer models, and concern about the greenhouse effect jointly attracted public attention. In 1988 the United Nations established the Intergovernmental Panel on Climate Change (IPCC), which issued its first climate report in 1990. In late 1989 the UN approved a resolution calling for an environmental summit, which was held in Rio de Janeiro in June 1992. At that meeting, the attending nations agreed to participate in the Framework Convention on Climate Change, an ongoing series of meetings the purpose of which is to develop agreements that reduce greenhouse gas emissions. The summit last December in Kyoto, the third since Rio, set targets for North America, Europe, Japan, Australia, and New Zealand.^{[\[1\]](#)}

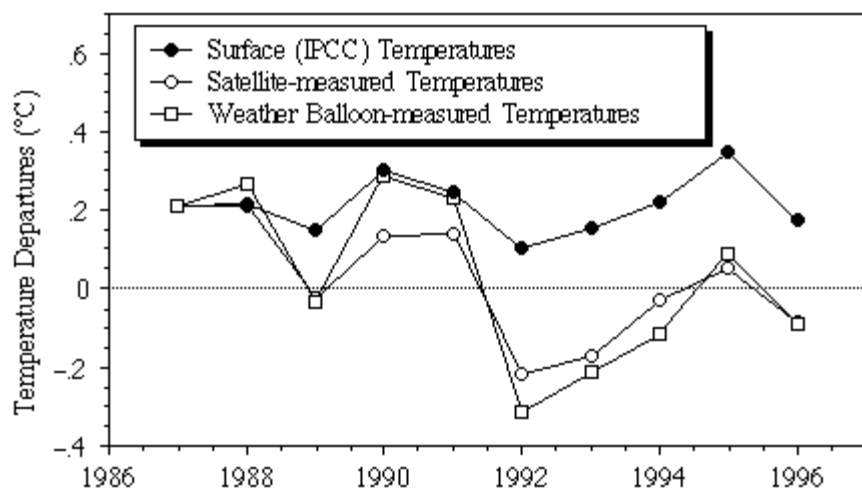
An Overview of the Scientific Debate

Concern about global warming has been driven largely by computer models that predict major climatic dislocation if current trends in anthropogenic greenhouse gas emissions continue. The first *Scientific Assessment* of the IPCC stated that "when the latest atmospheric models are run with the present concentrations of greenhouse gases, their simulation

of climate is generally realistic on large scales." [__](#) Global climate models in use at the time predicted that the globe's mean temperature should have already risen by 1.3°C to 2.3°C since the major greenhouse emissions began in the late 19th century (the larger figure is for the Northern Hemisphere, where most of us live). [\[3\]](#) Those models provided the technical background for the Framework Convention on Climate Change, signed in 1992 in Rio.

The observed warming since the late 19th century is 0.6°C, or about one-third of the predicted warming of 1.8°C to 2.3°C. In addition, since 1986 the mean temperature of the earth has shown no significant warming, despite popular perceptions to the contrary. Three independent measures--temperature measured at the earth's surface, [\[4\]](#) temperature of the lower atmosphere measured by weather balloons, [\[5\]](#) and temperature of the lower atmosphere measured by orbiting satellites [\[6\]](#)--all show no statistically significant change (Figure 1).

Figure 1
Global Temperature Departures from 1982-91 Mean (C)



Nearly 10 years ago I argued that forecasts of dramatic and deleterious global warming were likely to be in error because of the very modest climate changes that had been observed to that date. [\[7\]](#) Further, I argued that climate change would occur in the winter and at night, rather than in the summer, and that the change could be benign or even beneficial for both the economy and the global environment. I estimated that the likely warming, based on the observed data, would be between 1.0°C and 1.5°C as a result of doubling the natural CO₂ greenhouse effect. My forecast has proven closer to the mark than that of the IPCC.

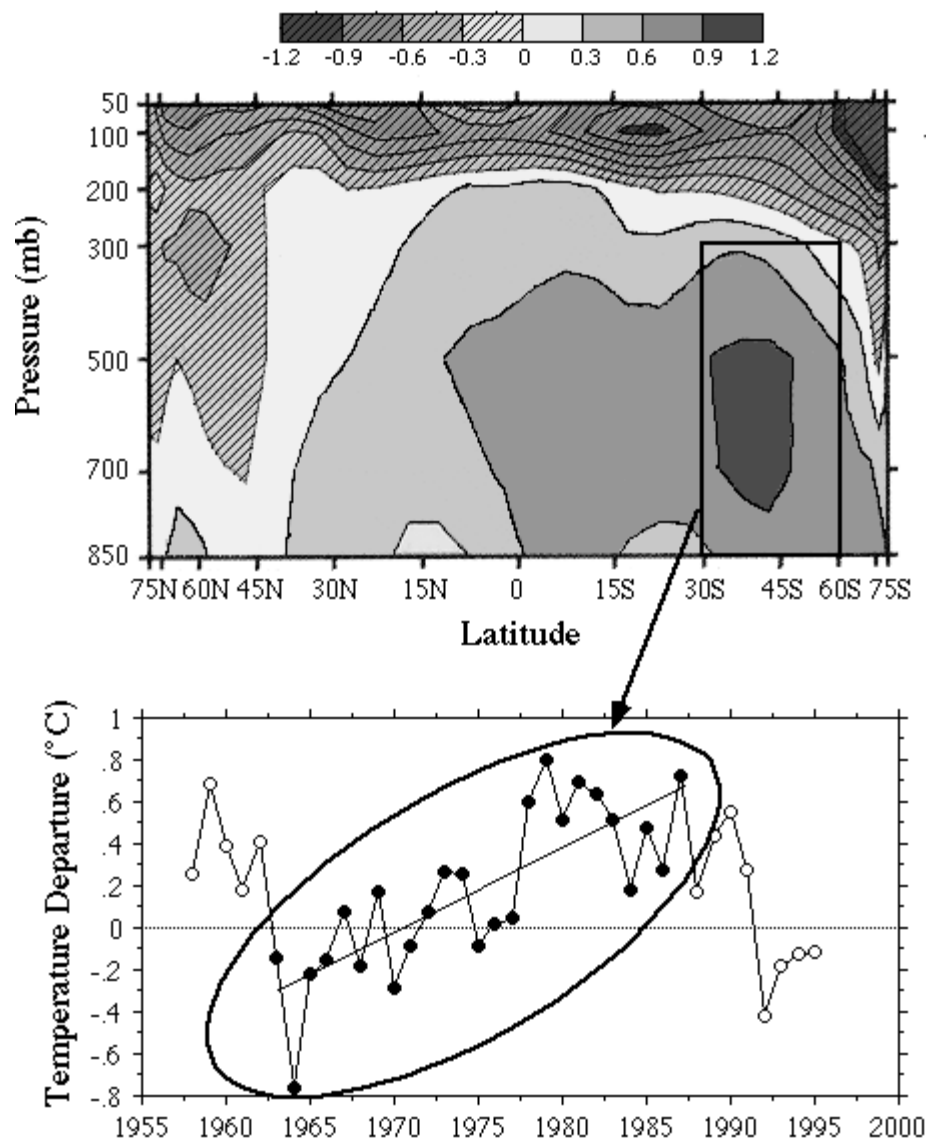
By 1995, in its second full assessment of climate change, the IPCC admitted the validity of its critics' position: "When increases in greenhouse gases only are taken into account . . . most [climate models] produce a greater mean warming than has been observed to date, unless a lower climate sensitivity [to the greenhouse effect] is used. . . . There is growing evidence that increases in sulfate aerosols are partially counteracting the [warming] due to increases in greenhouse gases." [\[8\]](#)

The IPCC is presenting two alternative hypotheses: Either the amount of warming was simply overestimated, or some other anthropogenic emission is preventing the warming from being observed. Which is more likely to be true?

Are sulfate aerosols responsible for the now-admitted dearth of warming? Several attempts have been made to demonstrate that they are. The most prominent, which appeared in *Nature* on July 4, 1996, seemed to bolster the argument that sulfates were masking the expected warming. [\[9\]](#)

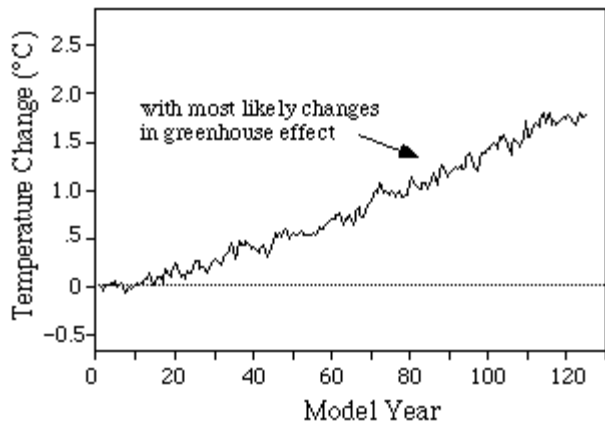
Figure 2
Temperature Trend from 1963 to 1987 by Latitude and Altitude (°C)

Temperature Trend from 1963-1987 ($^{\circ}\text{C}$)



That study relied on annual weather balloon data from 1963 through 1987. The most striking characteristic of the data was a rapid warming of the lower atmosphere of the middle of the Southern Hemisphere, where virtually no sulfates exist to counter greenhouse warming. That particular paper received widespread publicity because it was published a mere week before an important UN meeting on climate change in Geneva. At that meeting Under Secretary of State Timothy Wirth stated, largely because of the *Nature* article, that "the science is convincing" on global warming.^[10]

Figure 3
Global Temperature Change ($^{\circ}\text{C}$)



However, if the entire record of weather balloon data, from 1958 through 1995, is used, the middle of the Southern Hemisphere exhibits no change whatsoever.^[11] Figure 2 shows the warming observed by B. D. Santer et al. from 1963 to 1987 (top). The highlighted region in the Southern Hemisphere shows the strong observed warming. The entire temperature history over the same region from 1957 to 1995 shows no significant warming trend (bottom). However, the period that was chosen for study by Santer et al. (filled circles) warms dramatically.

The senior author of the original study told the December 1996 meeting of the American Geophysical Union that the correspondence between the sulfate-greenhouse model and reality vanished because greenhouse warming in the Northern Hemisphere had overwhelmed sulfate cooling since 1987. That was reiterated in the July 16, 1997, issue of *New Scientist*.^[12] However, because no net change exists in any of the temperature records in the past decade (Figure 1), that statement is clearly wrong.

The default option--that it's simply not going to warm as much as the earlier projections had indicated--is increasingly attractive. And new climate models, which seem to fit the observed history more accurately, are consistent with this conclusion. Figure 3 shows temperature changes projected by the new model from the NCAR, as published in the May 16, 1997, issue of *Science*.^[13] The figure shows changes using the increase in annual greenhouse gas emissions, given by the IPCC in *Climate Change 1995*, of 0.7 percent per year. The temperature change in that model is less than one-half of that in earlier models.

Trends in Observed Temperature Data

Greenhouse physics predicts that the driest air masses should respond first and most strongly to changes induced by human activities. That has been known since the pioneering studies of Tyndall in the 1800s.^[14] Those air masses, in fact, are generally the coldest air masses, such as the great high-pressure system that dominates Siberia in the winter and its only slightly more benign cousin in northwestern North America. When the jet stream attains a proper orientation, it is the latter air mass that migrates south and kills orange trees in Florida.

A look at the trends in the satellite data--our only truly global record of lower atmosphere temperature--is remarkably revealing. A statistically significant global cooling trend (Figure 4) exists over the 18.8-year period of record. Monthly average global temperature departures from the 1982-91 means as measured by satellites show a statistically significant decline since measurements began in 1979. That has occurred during a period when the earth should have warmed 0.6°C according to greenhouse global climate models and 0.35°C according to sulfate-greenhouse global climate models.

A latitudinal breakdown of the satellite data is also very revealing (Figure 5). There is a sharp warming of the midlatitude land areas of the Northern Hemisphere. These are largely the regions that should show sulfate cooling, if *Climate Change 1995* is to be believed. On the other hand, almost every latitude band in the Southern Hemisphere, where greenhouse warming should operate unfettered, either shows no change or is cooling.

Figure 4
Global Satellite-Measured Temperature Departures (C) from 1982-91 Mean

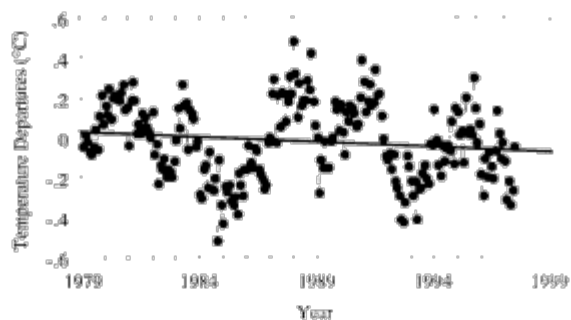
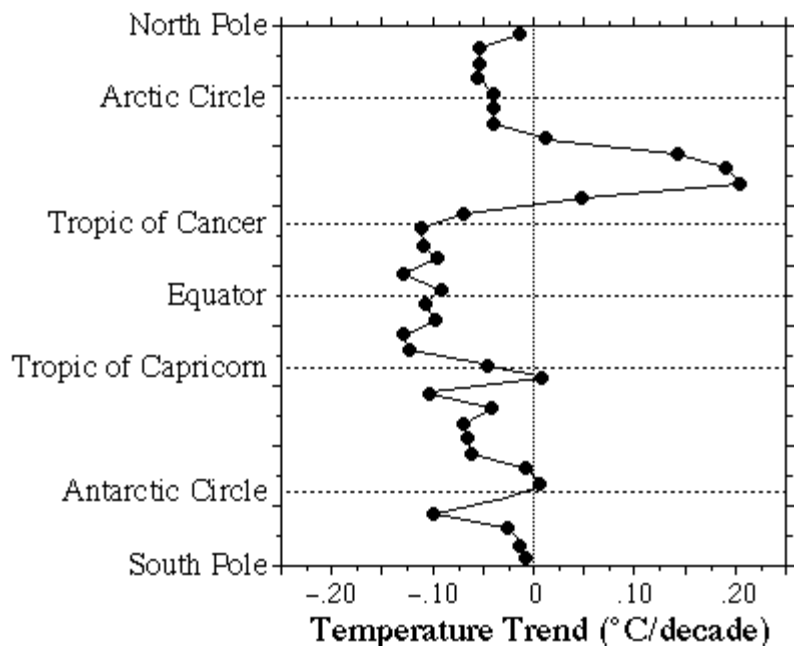


Figure 5
Satellite Temperature Trends by Latitude Bands (C/decade)



The reliability of the satellite data is quite apparent when annual readings are compared to those from weather balloons that gather data from between 5,000 and 30,000 feet (Figure 6). Temperatures measured by satellites match up nearly perfectly with temperatures measured from weather balloons in the layer between 5,000 ft. and 30,000 ft. But perhaps more interesting is a comparison of winter minus summer temperature changes (the greater the difference, the more warming is concentrated in winter) over the period for which both satellite and ground-based temperature data are available, 1979 to the present (Figure 7). The correspondence is nearly as remarkable as is the agreement between the satellite and the weather-balloon data.

Figure 6
Satellite and Weather-Balloon Temperature Trends (departure from the 1982-91 satellite average in °C)

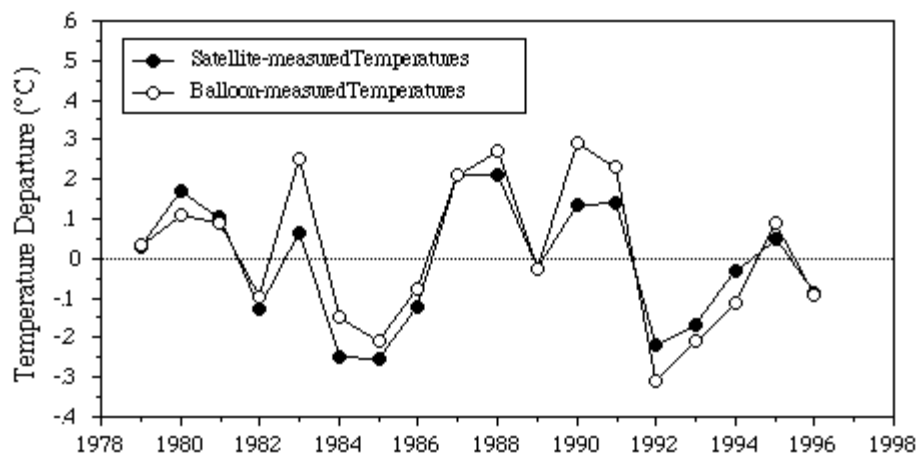
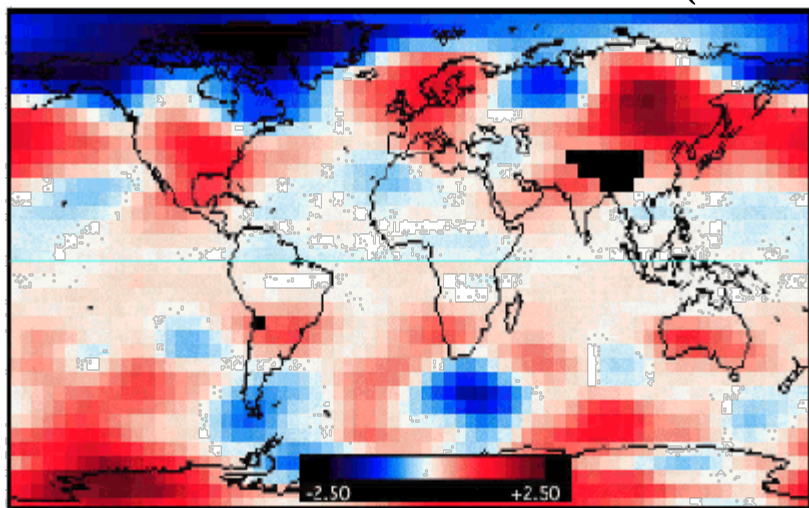
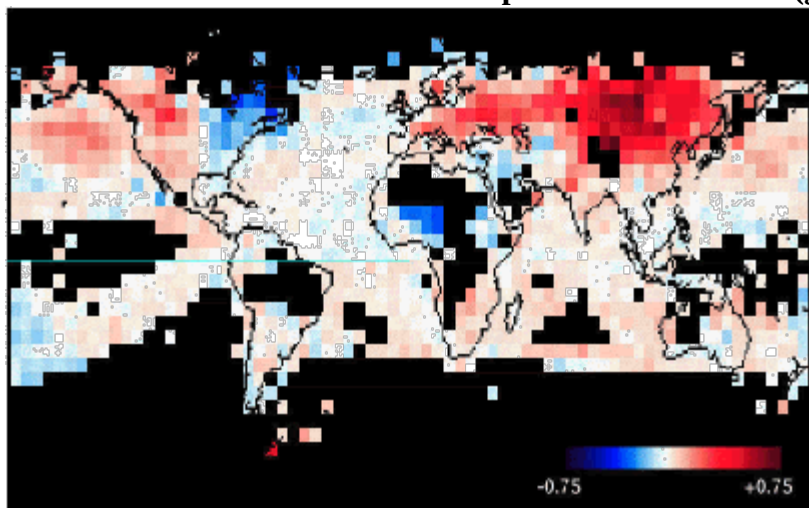


Figure 7
Summer Trends Subtracted from Winter Trends (satellite and ground-based data)



Note: Redder shades indicate greater winter warming.

Figure 8
Trends in Summer and Winter Temperature Differences (ground data)



Another way to appreciate observed change in a frame of reference longer than the satellite record is to look at the ground-based thermometers for the last 50 years. In Figure 8, the summer temperature changes are subtracted from changes in winter temperatures, as in Figure 7, but surface temperature data since 1946 are used. The redder the map,

the more pronounced the warming in the winter in comparison with the summer. All of these observations are consistent with the first alternative proposed in 1995 by the IPCC--that the climate is less sensitive to greenhouse changes than previously thought--rather than the facile explanation that sulfate aerosol somehow canceled the warming.

The most likely explanation for the now-acknowledged discrepancy between temperature observations and climate-model predictions is that the sensitivity of global temperature to greenhouse-effect changes was overestimated. There are several reasons why this occurred, but perhaps the most compelling is that all of the general circulation climate models that have (to date) been referenced by the IPCC incorporate substantial "flux adjustments" for the transport of heat from the equator to the poles. In plain language, those models have to be "adjusted" arbitrarily in order to keep them from producing unrealistic climates. Generally (but not always), an additional increment of heat moving northward is required. In the absence of such adjustments, the models predict temperatures too cold in the polar regions and too warm in the tropics.^[15] Note that the model depicted in Figure 3, which produces substantially reduced warming, is not "flux adjusted."

***The Administration's Program and the Kyoto Accord:
How Much Warming Is Theoretically Prevented?***

Table 1 gives two estimates of the future equivalent CO₂ concentration in the atmosphere, in parts per million (ppm).^[16] The first, labeled No Controls, assumes a continuation of the rate at which emissions increase currently (0.7 percent per year). The second, labeled Kyoto Protocol, assumes reduction of emissions to 7 percent below 1990 levels during the 2008-2012 period and maintenance of that level of emissions thereafter. The amount of warming "saved" by the emissions reduction mandated by the Kyoto Protocol is infinitesimal: 0.19°C. It is doubtful that this change could even be extracted from the ground-based temperature measurements, because of interannual climatic noise.

Table 1
Projected Effective CO₂ Increase and Resulting Temperature Savings

Year	No Controls (ppm)	Kyoto Protocol (ppm)	Difference (ppm)	Temperature Savings (°C)
1990	440	440	0	0.000
2000	472	472	0	0.000
2005	489	487	2	0.007
2010	506	501	5	0.017
2020	542	528	14	0.049
2030	582	555	27	0.094
2040	624	582	42	0.146
2047	655	602	53	0.185

Based on NCAR model results and the IPCC "best guess" emission scenario with no emission controls.

The Kyoto Protocol directs the United States to reduce emissions to 7 percent below 1990 levels on average for the period 2008-2012. In Table 1, I assume that the entire world does the same.^[17] That is clearly not going to be the case, so the estimates of temperature change represent the absolute maximum reductions that will occur given my interpretation of the NCAR model.^[18]

As of this writing, nations that will be responsible for an aggregate of more than 25 percent of all greenhouse emissions by 2010 (China, India, Australia, and the developing Pacific Rim, with the exception of Japan) are not committed to any reductions by then. A more likely estimate would be 75 percent of all the reductions in warming projected in the Kyoto Protocol scenario.

The minute reductions in warming pale in comparison with the costs of the Kyoto agreement. Charles River Associates estimates the reduction in GDP of the Kyoto Protocol at 2.3 percent per year.^[19] The total reduction in temperature, even under the very optimistic scenario of 0.19C, yields a cost per degree saved, on a 50-year horizon, of 2.3/0.19 or about 12 percent of GDP per year.

The magnitude of the economic cost becomes apparent if one realizes that a 7 percent reduction in emission levels below 1990 values is roughly the U.S. emission level in 1979. In other words, the society of 2008--a mere 3,600 days from now--must operate on the greenhouse emissions of 1979.

Some simple thought experiments emphasize the enormity of that undertaking.^[20] Between 1979 and 2008, the population of the United States will have grown by 25 percent, or roughly 62 million people. Those individuals will occupy approximately 16 million new homes and apartments. Assuming that, say, electrical lighting becomes 20 percent more efficient over this period, the lights for 80 percent (nearly 13 million) of those homes have to be turned off in order to get back to 1979 emission levels.

What about automobiles? If every car and truck on the road averaged around 36 miles per gallon in 2008, the transportation sector could meet the Kyoto mandate.^[21] But almost all the vehicles being purchased now will still be on the road in 2008, so the corporate average fuel economy of new cars in the year 2008 would have to be about 60 mpg to produce a 36 mpg average economy for the entire stock of cars and trucks.

What Should Be Done?

How will the United States meet its obligations under the Kyoto Protocol? It is now acknowledged that the effective carbon tax required to reduce emissions the proposed amount is on the order of \$150/ton of carbon,^[22] and the Clinton administration has specifically ruled out any direct carbon tax at this time. Instead, in his 1999 federal budget, the president has requested \$6.3 billion in new spending and tax credits.^[23] Over five years \$2.7 billion would be spent on research and development to reduce the use of energy in industrial processes; for heating, cooling, and lighting buildings; and by automobiles. Spending on solar and wind sources of electricity also would increase. Tax credits totaling \$3.6 billion would be given for the purchase of heating, cooling, and lighting equipment and automobiles that use less energy. Under the president's proposal, cars that double current fuel efficiency would be eligible for a \$3,000 tax credit in the year 2000, and cars with triple current fuel efficiency would receive a credit of \$4,000 in 2003.

Is this what we really want? I think not. As we debate this issue in Congress, there are probably 10,000 people tinkering and thinking about fuel cells, hydrogen power, and undreamed-of exotica that will eventually displace our current energy system. Let's save citizens' money. Let's allow them to invest in the future, take the risks, and reap the rewards. Better to do that than to tax them to solve a problem that is not all that imminent and will, in any case, resolve itself faster if we just get out of the way.

Notes

1. The 5.2 percent reduction in the overall emissions of developed countries will be realized through national reductions of 8 percent by Switzerland, many Central and East European States, and the European Union; 7 percent by the United States; and 6 percent by Canada, Hungary, Japan, and Poland. Russia, New Zealand, and Ukraine are to stabilize their emissions at 1990 levels. Norway may increase emissions by up to 1 percent, Australia by up to 8 percent, and Iceland by up to 10 percent. See the text of the Kyoto Protocol at <http://www.cnn.com/SPECIALS/1997/global.warming/stories/treaty>. For a summary, see "Industrialized Countries to Cut Greenhouse Gas Emissions by 5.2 Percent by Legally Binding Agreement Reached by Kyoto Climate Change Conference," UN press release, December 11, 1997.

2. J. T. Houghton, G. J. Jenkins, and J. J. Ephraums, eds., *Climate Change: The IPCC Scientific Assessment* (New York: Cambridge University Press, 1990), p. xxviii.

3. J. F. B. Mitchell and T. C. Johns, "On modification of Global Warming by Sulfate Aerosols," *Journal of Climate* 10 (1997): 245-66.

4. J. T. Houghton et al., eds., *Climate Change 1995: The Science of Climate Change* (New York: Cambridge University Press, 1996), p. 143.
5. Weather Balloon data are from U.S. Department of Energy, *Trends 93* (Washington: U.S. Department of Energy, 1993), and updates from J. Angell, National Oceanic and Atmospheric Administration.
6. Satellite data are from R. W. Spencer and J. R. Christy, "Precise Monitoring of Global temperature Trends from Satellites," *Science* 247 (1990): 1558-62, and updates.
7. Patrick J. Michaels, Testimony, in *Global Warming: Hearing before the Subcommittee on Energy and Power before the Subcommittee on Energy Conservation and Power of the House Committee on Energy and Commerce*, 101st Cong., 1st sess., February 21, 1989, pp. 78-111.
8. J. T. Houghton et al., p. 295.
9. B. D. Santer et al., "A Search for Human Influences on the Thermal Structure of the Atmosphere," *Nature* 382 (July 4, 1996): 39-45.
10. "State Department Calls for 'Binding' Reductions in Emissions," *World Climate Report* 1, no. 22, (August 5, 1996): 1.
11. P. J. Michaels and P. C. Knappenberger, "Human Effect on Global Climate?" *Nature* 384 (1996): 522-23.
12. F. Pearce, "Greenhouse Wars," *New Scientist* 139 (July 16, 1997): 38-43.
13. The NCAR model assumes that greenhouse emissions increase at the rate of 1.0 percent per year. Over the last several decades effective greenhouse emissions have increased 0.7 percent per year, a figure that is highly consistent with median IPCC estimates. The 0.7 percent figure was used to generate the temperature projections in this paper.
14. J. Tyndall, "On the Absorption and Radiation of Heat by Gases and Vapors, and on the Physical Connexion of Radiation, Absorption, and Conduction," *Philosophical Magazine* 22 (1861): 169-94.
15. A very few of the most recent models do not require this type of adjustment. These models, including the NCAR version the predictions of which are detailed in Figure 3, predict considerably less warming than their adjusted counterparts. See R. A. Kerr, "Model Gets It Right without Fudge Factors," *Science* 276 (May 16, 1997): 1041.
16. Methane, chlorofluorocarbons, and nitrogen oxides are also "greenhouse" gases. Their emissions are converted to CO₂ equivalents using standard conversion factors. See National Research Council, pp. 5-6.
17. I also assume that the time-behavior of the NCAR model is roughly linear through these increments of greenhouse gas, a characteristic common to almost all climate models.
18. See notes 13 and 17.
19. Charles River Associates, cited in "Kyoto: Damn the Economy! Full Speed Ahead!" *World Climate Report* 3, no. 8, (January 5, 1998): 1-2.
20. Robert Stavins, professor of public policy, John F. Kennedy School of Government, Harvard University, estimates that U.S. CO₂ output would have to be reduced by 40 percent. Quoted in Christina Duff, "Accord May Cool U.S. Economy, Experts Warn," *Wall Street Journal*, December 11, 1997, p. A2.
21. These calculations assume that cars currently get 26 mpg. Thirty-six mpg would be 40 percent more efficient.
22. Robert Stavins, comments quoted in Martha Hamilton and Curt Supplee, "The Price of Achieving Kyoto Goals,"

Washington Post, December 12, 1997, p. A41.

23. Details of the spending and tax proposals come from Allan Freedman, "Global Warming Plan Meets Wall of Opposition," *Congressional Quarterly Weekly Report* 56 (February 7, 1998): 320.